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Application form

Environmental Protection Act 1994

Submission of a progressive rehabilitation and closure plan

This is the approved form for a progressive rehabilitation and closure plan (PRC plan) under section 126C of the Environmental Protection Act 1994 for a site-specific application for a mining activity relating to a mining lease.

Only use this application form if you are required to submit a PRC plan, where:

- You are applying for a new site-specific environmental authority for a mining activity relating to a mining lease.

  OR

- The administering authority has included the requirement to submit a proposed PRC plan in an information request for a new site-specific environmental authority for a mining activity relating to a mining lease.

  OR

- You completed a PRC plan as part of an EIS process and are submitting the PRC plan in the approved form as required under section 126C.

  OR

- You have an existing site-specific environmental authority for a mining activity relating to a mining lease and have received a transition notice from the administering authority[1] in accordance with section 754 of the *Environmental Protection Act 1994* (EP Act).

  OR

- Where none of the above apply: you have an existing site-specific environmental authority for a mining activity, you do not otherwise have a PRCP schedule approved yet one is required, and any of the following applies:
  - You have failed to comply with a transition notice;
  - You did not receive a transition notice as required under the legislation;
  - The administering authority has refused your proposed PRCP schedule.

Before completing this application form it is recommended that you:

- Read the Guideline – Progressive Rehabilitation and Closure Plans (ESR/2019/4964[2]), which explains the information you are required to provide with this application.
- Have a pre-lodgement meeting. To request a pre-lodgement meeting, please fill out and lodge the form Application for pre-lodgement services (ESR/2015/1664).

[1] The Department of Environment, Science and Innovation is the administering authority under the *Environmental Protection Act 1994*.
[2] This is the publication number. The publication number can be used as a search term to find the latest version of a publication at **www.qld.gov.au**.

Queensland Government

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If you require assistance in answering any part of this form, or have any questions about your application, please contact the relevant business centre. Contact details are at the end of this form (Section 10).

Privacy statement
The administering authority is collecting the information on this approved form to process your application for a PRC plan. The collection of information is authorised under Chapter 3 and Chapter 5 of the EP Act. Some of the information may be disclosed to the Department of Resources and Queensland Treasury for the purpose of processing this application or the Rehabilitation Commissioner in accordance with s444J of the EP Act the if accessing the information is necessary or convenient to be done in the performance of the Commissioner's functions.

Please note that the administering authority is required to keep this application on a register of documents open for inspection by members of the public under section 541 of the EP Act, and must permit a person to take extracts from the register pursuant to section 542 of the EP Act.

Your personal information will not be otherwise disclosed to any other parties unless authorised or required by law. For queries about privacy matters please email privacy@des.qld.gov.au or telephone 13 74 68.

Definitions of terms used in this form	
(Where there is inconsistency between the definition of terms used here and the terms used in the EP Act, the terms in the EP Act apply)	
Available for improvement	In relation to land in an improvement area for a non-use management area, means land in the improvement area that is not being mined, other than land to which any of the following applies– a) the land is being used for operating infrastructure or machinery for mining, including, for example, a dam or water storage facility; b) the land is identified in the PRCP schedule or the application for an environmental authority relating to the schedule as containing a probable or proved ore reserve that is to be mined within 10 years after the land would otherwise have become available for improvement; c) the land is required for the mining of a probable or proved reserve mentioned in paragraph (b).
Available for rehabilitation	For a rehabilitation area, means land in the area is not being mined, unless– a) the land is being used for operating infrastructure or machinery for mining, including, for example, a dam or water storage facility; or b) the land is identified in the PRCP schedule or the application for an environmental authority relating to the schedule as containing a probable or proved ore reserve, under section 126D(6) of the EP Act, that is to be mined within 10 years after the land would otherwise have become available for rehabilitation; or ba) the land is required for the mining of a probable or proved reserve mentioned in paragraph (b); or c) the land contains permanent infrastructure identified in the proposed PRCP schedule as remaining on the land for a post-mining land use.
Land outcome document	For land, means the following documents relating to the land– a) an environmental authority for a resource activity on the land; b) a document made under a condition of an environmental authority

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	mentioned in paragraph (a), if– i. the document relates to the management of a void within the meaning of section 126D of the EP Act on the land, or the rehabilitation of the land; and ii. the document was received by the administering authority before the assent date; and iii. the administering authority has not, within 20 business days after the assent date, given notice to the environmental authority holder that the document is insufficient in a material particular relevant to a matter mentioned in subparagraph (i); and iv. before the assent date, the document has not been superseded; c) a document made under a condition of an environmental authority mentioned in paragraph (a), if– i. the document relates to the management of a void within the meaning of section 126D of the EP Act on the land, or the rehabilitation of the land; and ii. the environmental authority requires the document to be given to the administering authority on a stated day that is on or after the assent date, or does not state a day when the document must be given; and iii. the document is received by the administering authority within three years after the assent date; and iv. the administering authority does not, within 20 business days after receiving the document, give the environmental authority holder a notice that the document is insufficient in a material particular relevant to a matter in subparagraph (i); d) a report evaluating an EIS under the *State Development and Public Works Organisation Act 1971*, section 34D; e) an EIS assessment report; f) a written agreement between the holder of an environmental authority mentioned in paragraph (a) and the State that is in force on the assent date.
Improvement area	For a non-use management area, means an area of land in the non-use management area to which a management milestone relates.
Management milestone	For a non-use management area, means each significant event or step necessary to– a) achieve best practice management of the area; and b) minimise risks to the environment.
Non-use management area	Means an area of land the subject of a PRC plan that cannot be rehabilitated to a stable condition after all relevant activities for the PRC plan carried out on the land have ended.
Post-mining land use	For land the subject of a PRC plan, means the purpose for which the land will be used after all relevant activities for the PRC plan carried out on the land have ended.
PRC plan	For land the subject of a mining lease, means a progressive rehabilitation and closure plan for the land that consists of – a) the rehabilitation planning part of the PRC plan; and

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	b) the PRCP schedule for the PRC plan, including any conditions imposed on the schedule.
PRCP schedule	For a PRC plan, means a schedule of the plan that – a) complies with section 126D of the EP Act; and b) is approved under chapter 5, part 5, division 2 of the EP Act, with or without conditions.
Proposed PRC plan	For an application, a proposed PRC plan means a PRC plan proposed for land the subject of a mining lease that: (a) complies with Chapter 5, part 2, division 3; and (b) either – accompanies the application; or is submitted for the application after the application is made
Rehabilitation area	For land the subject of a post-mining land use, means an area of the land to which a rehabilitation milestone for the post-mining land use relates.
Rehabilitation milestone	For the rehabilitation of land, means each significant event or step necessary to rehabilitate the land to a stable condition.

The fields marked with an asterisk * are mandatory. If they are not completed then your application may be considered not properly made under section 128 of the EP Act.

Section 1 – Environmental authority details

Does this application relate to an existing environmental authority for a mining activity relating to a mining lease approved through a site-specific application?*	☐ No – Provide the reference number for your environmental authority application:	AR Insert.
	☒ Yes – Provide your environmental authority number:	EPML00717813

Section 2 – Applicant details

Details of the applicant are to be provided in this section.

If there is an agent acting on behalf of the applicant, details of the agent are to be provided. An agent could be a consultant or contractor for the environmental authority holder.

The person nominated as the application contact will receive correspondence relating to this application.

NAME / COMPANY NAME* Whitehaven Blackwater Pty Ltd	TRADING NAME (*IF AN ORGANISATION) Whitehaven Blackwater Pty Ltd
REGISTERED BUSINESS ADDRESS / RESIDENTIAL ADDRESS (NOT A POST OFFICE BOX) * Level 28, 259 George Street, Sydney NSW 2000	POSTAL ADDRESS (*WHERE DIFFERENT) Level 28, 259 George Street, Sydney NSW 2000
ABN / ACN (*IF AN ORGANISATION) 66 672 142 997 / 672 142 997	NAME OF APPLICATION CONTACT* Brendan Dillon
EMAIL* BDillon@whitehavencoal.com.au	TELEPHONE* 0436 648 938

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☒ INDICATE IF YOU WANT TO RECEIVE CORRESPONDENCE VIA EMAIL
☒ INDICATE IF THIS FORM IS BEING COMPLETED BY AN AGENT FOR THE ENVIRONMENTAL AUTHORITY HOLDER*
NOTE: If an agent is nominated, please provide evidence of appointment by the authority holder/s.

Section 3 – Website address		
If this application relates to an application for a new site-specific environmental authority for a mining activity, would you like to use the details on the environmental application form?	☐ No – Provide details below.	
	☐ Yes – Go to next section.	
Provide the website address for the application notice and application documents.	Insert.	
Provide details of the contact person if technical assistance is required.	NAME Insert.	TELEPHONE Insert.
	EMAIL Insert.	

Section 4 – Non-use management areas (new environmental authority applications only)	
Does this application for a proposed PRC plan include a NUMA justified under section 126D(2)(b) of the EP Act? *	☐ No – Go to next section.
	☐ Yes
Has a public interest evaluation been carried out by a qualified entity for the NUMA(s)? *	☐ No – Go to next section.
	☐ Yes
Has the proposed NUMA(s) changed since the public interest evaluation was carried out in the EIS? *	☐ No – Go to next section.
	☐ Yes – Provide details below.
How has the proposed NUMA(s) changed since the public interest evaluation was carried out?	Please provide details below. Insert.

Section 5 – PRC plan structure	
The PRC plan must be prepared in accordance with the structure/format shown in Appendix 1 of this application form.	
Requirement	**Requirement met?**
Include a cover page that complies with Appendix 1 of this application form.	☒ Yes
Include a table of contents that complies with Appendix 1 of this application form.	☒ Yes

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Section 6 – PRC plan Checklist *			
The PRC plan must meet the information requirements stated in section 3 of the Guideline – Progressive Rehabilitation and Closure Plans (ESR/2019/4964), and sections 126C and 126D of the EP Act (note there is a limited exception for transitional PRC plans). All PRC plan requirements are mandatory. For each requirement, insert a reference to the section of the PRC plan which satisfies the requirement. Justification must be provided for any requirement for which the response is Not Applicable (NA). If more space is required, please attach a separate sheet.			
PRC plan Requirement	**Requirement met? (Yes / NA)**	**PRC Plan Section No.**	**Justification**
Rehabilitation planning part of the PRC plan The rehabilitation planning part of the PRC plan must include the information required under section 126C the EP Act, including information requirements described in the Guideline – Progressive Rehabilitation and Closure Plans (ESR/2019/4964) in accordance with section 126C(1)(j) of the EP Act.			
Project description *Note: For existing mines transitioning to the PRC plan framework, pre-disturbance information collected as part of an EIS process or original environmental authority application should be included. If this information is unable to be provided, or cannot be developed because of the mine's life stage, this should be clearly explained in this section of the rehabilitation planning part of the PRC plan.*			
Describe the following:			
• each resource tenure, including the area of each tenure, to which the application relates;	Yes	3.1.1.2	Insert.
• the relevant activities to which the application relates;	Yes	3.1.4.1	Insert.
• the likely duration of the relevant activities	Yes	3.1.4.1, Appendix 4.1	Insert.

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Include a detailed description, including maps, of how and where the relevant activities are to be carried out.	Yes	3.1.1.3, 3.1.4.1, Appendix 4.1	Insert.
Consultation			
Include details of the consultation undertaken by the applicant in developing the proposed PRC plan.	Yes	3.2	Insert.
Include details of how the applicant will undertake ongoing consultation in relation to the rehabilitation to be carried out under the plan.	Yes	3.2	Insert.
Post-mining land use			
State the extent to which each proposed post-mining land use identified in the proposed PRCP schedule for the plan is consistent with the outcome of consultation with the community in developing the PRC plan.	Yes	3.2, 3.3	Insert.
State the extent to which each proposed post-mining land use identified in the proposed PRCP schedule for the plan is consistent with any strategies or plans for the land of a local government, the State or the Commonwealth.	Yes	3.2, 3.3.4	Insert.
Non-use management area *Note for Transitional PRC plans: The holder is not required to comply with a requirements under section 126C(1)(g) or (h) or 126D(2) or (3) for the proposed PRCP schedule for the plan in relation to land if a land outcome document identifies the outcome for the land as the same, or substantially similar to, the outcome for the land if it were a non-use management area.*			
State the extent to which each proposed non-use management area identified in the PRCP schedule for the plan is consistent with the outcome of consultation with the community in developing the PRC plan.	Yes	3.2, 3.4.2	Insert.

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State the extent to which each non-use management area identified in the PRCP schedule for the plan is consistent with any strategies or plans for the land of a local government, the State or the Commonwealth.	Yes	3.4.5	Insert.
For each proposed non-use management area, state the reasons the applicant considers the area cannot be rehabilitated to a stable condition because of a matter mentioned in section 126D(2).	NA	3.4.4, Appendices	As outlined in section 754(3) of the EP Act and Section 6.3.2 of the PRCP Guidelines 'a NUMA will be taken to be pre-approved if a land outcome, the same or substantially similar to a NUMA, is contained in a 'land outcome document'.' This is the case for the Blackwater Mine due to the residual voids being authorised under Schedule E (conditions E10, E11 and E12) of the EA (as the primary LOD) and further detailed in the Residual Void Investigation report (BMA, 2020) which was submitted in accordance with these conditions. Both of these LODs are attached to this PRCP application.
For each matter mentioned in the requirement above, include copies of reports or other evidence relied on by the proponent for each proposed non-use management area.	NA	Appendices	Further to the above justification, the EA is the primary LOD for the Blackwater Mine and the Residual Void Investigation report (BMA, 2020) is a secondary LOD. Both of these LODs are attached to this application.

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Rehabilitation and management methodology *Note: Section 3.5 of the Guideline – Progressive Rehabilitation and Closure Plans (ESR/2019/4964) outlines the range of information that must be included as appendices to the rehabilitation planning part of the PRC plan.*			
For each post-mining land use, state the applicant's proposed methods or techniques for rehabilitating the land to a stable condition in a way that supports the rehabilitation milestones under the proposed PRCP schedule.	Yes	3.3.3, 3.5	Insert.
For each non-use management area, state the applicant's proposed methodology for achieving best practice management of the area to support the management milestones under the proposed PRCP schedule for the area.	Yes	3.4.3, 3.4.4, 3.5.3	Insert.
Risk assessment			
Identify the risks of a stable condition for land described as a post-mining land use not being achieved, and how the applicant intends to manage or minimise the risks.	Yes	3.6	Insert.
PRCP Guideline			
Include any other information prescribed by the administering authority in the Guideline – Progressive Rehabilitation and Closure Plans (ESR/2019/4964).	Yes	See other sections	Insert.
Include the spatial information required in the Guideline – Progressive Rehabilitation and Closure Plans (ESR/2019/4964). See Attachment 1 of this form for details on how spatial information must be submitted.	Yes	spatialsubmit@des.qld.gov.au	All spatial information will be prepared and submitted in accordance with the guideline 'Spatial Information Submission' (ESR/2018/4337).

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Other information			
Include the other information the administering authority reasonably considers necessary to decide whether to approve the PRCP schedule.	Select.	See other sections	Insert.
PRCP Schedule The proposed PRCP schedule must comply with section 126D of the EP Act, and be written in accordance with the Guideline – Progressive Rehabilitation and Closure Plans (ESR/2019/4964). The administering authority will assess the proposed PRCP schedule in conjunction with the rehabilitation planning part of the PRC plan and other application documents, and decide whether to approve the proposed PRCP schedule, with or without conditions, or refuse the proposed PRCP schedule.			
Include a PRCP schedule prepared using the PRCP schedule template (ESR/2019/5103[3]).	Yes	Appendix 4.1	Insert.
Include maps showing all of the land mentioned in the PRCP schedule, as it relates to being progressively rehabilitated.	Yes	Appendix 4.1	Insert.

Section 7 – Non-use management areas (transitional applications only) [4]	
Does this application for a proposed PRC plan include a NUMA? *	☐ No – Go to next section. ☒ Yes
Does the relevant environmental authority or any other land outcome document identify an outcome for the land that is the same, or substantially similar, to the outcome for the land if it were a NUMA under a PRCP schedule?	☐ No – Go to next section. ☒ Yes

[3] This is the publication number. The publication number can be used as a search term to find the latest version of a publication at www.qld.gov.au.
[4] Transitional applications mean the holder of an existing EA for an ineligible mining activity relating to a mining lease that has been issued a transition notice and is transitioning into the new PRC plan framework.

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Does the environmental authority or any other land outcome document state sufficient detail to identify either the location or the area of the land to which the outcome relates?	☒ No – Provide details below. ☐ Yes – Provide the document name(s) in Section 8.
If the area is not identified – how will the total area of the land to which the outcome relates be minimised? *	See PRC Plan sections 3.4.3, 3.4.4, 3.5.3.4, 3.5.3.5
If the location is not identified – how will the environmental authority holder ensure the location of the land to which the outcome relates minimises risks to the environment? *	See PRC Plan sections 3.4.4, 3.6

Section 8 – Transitional PRC plan requirements (transitional applications only) [4]

In accordance with transitional provisions in the EP Act, an applicant with an existing environmental authority is able to transition aspects of the PRCP schedule from existing land outcome documents. Indicate below any information that is being transitioned from a land outcome document.

PMLU/NUMA	Rehabilitation /Improvement area	Milestone Reference	Identify which of the below is being transitioned from a land outcome document		Land outcome document	Page No.
			Land outcome	Milestone criteria		
Cattle grazing	RA2 - spoil dumps, NCPP TSF, Laleham TSF, Bottom Dam TSF and R36 Rejects	RM3 RM4 RM5 RM6 RM7 RM8	☒	☒	• Environmental Authority EPML00717813 • Residual Void Investigation Report (BMA, 2020)	In EA: 16-18
	RA4 – infrastructure areas (CHPP North, coal	RM1 RM2 RM3 RM4	☒	☒	• Environmental Authority EPML00717813 • Residual Void Investigation Report (BMA, 2020)	In EA: 16-18

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	stockpiles, TLO, Thermal Coal Plant, workshops, administration buildings, laydown yards, roads, mine water dams)	RM5 RM6 RM7 RM8				
	RA7 – existing rehabilitation	RM6 RM7 RM8	☒	☒	• Environmental Authority EPML00717813 • Residual Void Investigation Report (BMA, 2020)	In EA: 16-18
Woodland habitat	RA1 – spoil dumps and Ramp 72 TSF	RM3 RM4 RM5 RM6 RM7 RM8	☒	☒	• Environmental Authority EPML00717813 • Residual Void Investigation Report (BMA, 2020)	In EA: 16-18
	RA5 – infrastructure areas (CHPP South, coal stockpiles , roads, laydown yards, workshops, administration	RM1 RM2 RM3 RM4 RM5 RM6 RM7 RM8	☒	☒	• Environmental Authority EPML00717813 • Residual Void Investigation Report (BMA, 2020)	In EA: 16-18

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	buildings, mine water dams, exploration, historic subsidence areas)					
	RA6 – existing rehabilitation	RM6 RM7 RM8	☒	☒	• Environmental Authority EPML00717813 • Residual Void Investigation Report (BMA, 2020)	In EA: 16-18
Watercourse	RA3 – creek diversions and crossings	RM1 RM3 RM4 RM5 RM6 RM7 RM8	☒	☒	• Environmental Authority EPML00717813	In EA: 18
NUMA	IA1 - Residual voids	MM1 MM3 MM4	☒	☒	• Environmental Authority EPML00717813 • Residual Void Investigation Report (BMA, 2020)	In EA: 20
	IA2 - Ramp 74 TSF and Bonnie Doon TSF	MM1 MM2 MM3 MM4	☒	☒	• Environmental Authority EPML00717813 • Residual Void Investigation Report (BMA, 2020)	In EA: 20
Each land outcome document must be submitted with this approved form						

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☒ All land outcome documents identified above have been attached to this approved form.
Is the land outcome in the PRCP considered the same or substantially similar to the land outcome provided in the LOD?
☒ **Yes** ☐ **No**
If no, please identify the land outcome:
As per section 755B of the EP Act, the notification stage under chapter 5, part 4 applies for the assessment process because the outcome for land under a land outcome document is different to the outcome for the land under the proposed PRCP schedule.

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Section 9 – Declaration*

Note: If you have not told the truth in this application you may be prosecuted.

I declare that:

- I am the holder of the environmental authority, or authorised signatory for the holder of the environmental authority.
- The information I have provided is true and correct to the best of my knowledge.
- I understand that it is an offence under section 480 of the *Environmental Protection Act 1994* to give to the administering authority or an authorised person a document containing information that I know, or ought reasonably to know, is false or misleading in a material particular.
- I understand that under section 480A of the *Environmental Protection Act 1994* that, if I am required to give a document to the administrating authority or an authorised person, it is an offence to give a document that I know or ought reasonably to know, contains incomplete information in a material particular.
- I understand that failure to provide sufficient information may result in the application being refused. I understand that an incomplete application may be invalid. Invalid applications will be returned without processing and will only be processed if resubmitted with all invalidating issues addressed.
- I understand that all information supplied on or with this application form may be disclosed publicly in accordance with the *Right to Information Act 2009* and the *Evidence Act 1977*.
- I will comply with all conditions and milestones of my approved PRCP schedule as well as any relevant provisions in the *Environmental Protection Act 1994*.
- I understand that I am responsible for managing the environmental impacts of these activities, and that approval of this application is not an endorsement by the administering authority of the effectiveness of management practices proposed or implemented.

Where an agreement is in place between all holders of the environmental authority, one holder can sign on behalf of the other joint holders. Please tick the checkbox below.

☒ I HAVE AUTHORITY TO SIGN THIS FORM ON BEHALF OF ALL THE JOINT HOLDERS OF THE ENVIRONMENTAL AUTHORITY.

Applicant's signature

APPLICANT'S NAME	POSITION	COMPANY / ORGANISATION
Dan Iliffe	Regional General Manager Operations	Whitehaven Blackwater Pty Ltd
APPLICANT'S SIGNATURE Signed by: Dan Iliffe F38D3F79E5A6433...		DATE November 11, 2024 | 12:10 PM A

Joint holder(s) signature if applicable

NAME, POSITION AND COMPANY NAME	SIGNATURE	DATE
Insert.		Select.
NAME, POSITION AND COMPANY NAME	SIGNATURE	DATE
Insert.		Select.

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OR ☐ I HAVE ATTACHED A DOCUMENT THAT PROVIDES THE REQUIRED INFORMATION FOR ALL JOINT HOLDERS.

Where the environmental authority holder is a company, this form must be signed by an authorised person for that company. Where there is more than one holder of the environmental authority, this declaration is to be signed by all holders, unless there is an agreement between all holders that one can sign on behalf of the other(s).

If you are signing on behalf of the environmental authority holder(s) you must provide a letter of authorisation.

Section 10 - Submission

Please submit your completed application form and supporting material to the Department of Environment, Science and Innovation office that services the industry applicable to your environmental authority.

A list of business centres can be found at www.des.qld.gov.au using the words 'business centres' as a search term.

Enquiries:

Minerals Business Centre
PO Box 7230
Cairns QLD 4870
Phone: 07 4222 5352
Fax: 07 4222 5070
Email: ESCairns@des.qld.gov.au

Coal Business Centre
PO Box 3028
Emerald QLD 4720
Phone: 07 4987 9320
Email: CRMining@des.qld.gov.au

The latest version of this publication and other publications referenced in this document can be found at **www.qld.gov.au** using the relevant publication number (ESR/2019/4957 for this form) or title as a search term.

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Appendix 1–PRC plan structure

Appendix 1 describes the formatting/structural requirements for a completed PRC plan. This includes the information required in a PRC plan cover page and table of contents, and the structure of a PRC plan.

A PRC plan must include the following sections in the order listed:

1. **Cover page:** This section must include the following information:
   - Title of the project
   - Document title
   - Version number
   - Document ID number
   - Date of submission
   - Tenure number(s)
   - Environmental authority holder name
   - Environmental authority holder contact details.
2. **Table of contents:** This section must include the following information:
   - Sections of PRC plan
   - Sub-sections of PRC plan
   - Figures, tables and maps (as applicable).
3. **Rehabilitation planning part**
   - 3.1. **Project planning**: This section will include baseline information, site location details, a description of the project and information on rehabilitation/improvement planning.
   - 3.2. **Community consultation**: This section will include information on stakeholder consultation including a community consultation register and community consultation plan. The community consultation register must include consultation dates, identification of each community member, description of consultation type (workshop, quarterly meetings, etc.), information provided to the community, issues raised/discussed by the community, how issues have been considered, decisions/outcomes of engagement, and commitments made by the applicant. The community consultation plan must include the objectives for community consultation, how the community will be engaged, proposed consultation frequency, what information will be released for community consultation, and how feedback/comments will be considered.
   - 3.3. **Post-mining land use**: This section will include the assessment of PMLU options, methodology for determining PMLU options, and details of each nominated PMLU. It must be consistent with the outcome of consultation with the community in developing the plan, and any strategies or plans for the land of a local government, the State or the Commonwealth.
   - 3.4. **Non-use management areas (if applicable)**: This section will include the justification for the NUMA and details of each nominated NUMA. In providing justification for the NUMA, it must:
     - state the reasons the applicant considers the area cannot be rehabilitated to a stable condition
     - include copies of reports or other evidence relied on by the applicant for each proposed non-use management area
     - state the extent to which the proposed non-use management area is consistent with the outcome of consultation with the community in developing the plan, and
     - state the extent to which the non-use management area is consistent with any strategies or plans for the land of a local government, the State or the Commonwealth.
     - The detail of each nominated NUMA must include information demonstrating that the proposed footprint of each NUMA is as small as practicable, an assessment of the NUMA location options, a description of the proposed location of each NUMA and the environmental values of the

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surrounding environment, and evidence showing how the proposed location will prevent or minimise environmental harm.

3.5. Rehabilitation management methodology: This section will include information describing how the proposed rehabilitation and management methodology have been developed and will be implemented. For each proposed post-mining land use for land, state the proposed methods or techniques for rehabilitating the land to a stable condition in a way that supports the rehabilitation milestones under the proposed PRCP schedule. This should include details of the general rehabilitation practices, tailings storage facilities, voids, underground mining and built infrastructure. For each proposed NUMA, state the proposed methodology for achieving best practice management of the area to support the management milestones under the proposed PRCP schedule for the area.

3.6. Risk assessment: This section will include a risk assessment that identifies the risk of a stable condition for land not being achieved and a risk treatment plan outlining how the applicant will manage or minimise the risk. All proposed NUMAs should also have a completed risk assessment. If rehabilitation trials are planned, this is also where relevant details must be given.

3.7. Monitoring and maintenance: This section will include a monitoring and maintenance program that identifies and describes the monitoring systems that will be undertaken to demonstrate a milestone and milestone criteria have been achieved. It must include timing of when each rehabilitation or management milestone is to be achieved and be accompanied by maps outlining the relevant land.

4. **Appendices and attachments**: The completed PRCP schedule and any relevant required reports/plans are to be included in this section. The Progressive Rehabilitation and Closure Plan Schedule template (ESR/2019/5103) should be included.

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Attachment 1—Spatial data requirements for PRC plan

Attachment 1 provides guidance on the required content of spatial information (shapefiles) for the submission of a PRC plan. This attachment should be read in conjunction with the department's guideline: Spatial Information Submission (ESR/2018/4337). To obtain a copy of the guideline, the spreadsheet containing the schema (in Table 2) and a shapefile template for PCR plans are available on the Queensland Government's website at www.qld.gov.au, using the search term "submission of spatial information'. The following sections provide information about the required fields and attributes for datasets.

Required files—Table 1

The applicant must submit shapefiles detailing the following:

- the location and maximum extent of disturbance footprint for the mine life
- the PMLU and NUMAs for the area within the resource tenure(s)
- the rehabilitation and improvement areas within the resource tenure(s)
- any sensitive receptors
- extent of a floodplain
- existing rehabilitation (if the PRC plan is for an existing environmental authority).

A minimum of one (1) shapefile must be submitted for a PRC plan, detailing the above-listed information, as outlined within Table 1. Each file must be named in accordance with the requirements outlined within the department's guideline: Spatial Information Submission (ESR/2018/4337).

Where the PRC plan relates to a site where a NUMA or floodplain are not present, this should be stated in the spatial information submission email to which the relevant spatial files are attached.

Table 1: Shapefile checklist

File	Spatial information requirement	Schema	Example file name (e.g. using submission date of 30 June 2020)
1	PRC plan – polygon	Table 2	EPPR00372556_PRCP_PY_30062020

Where:

- PRCP = PRC plan
- PY = polygon (geometry)

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Table 2: Schema for PRC plan

Field Name	Type	Length	Definition	Domain Values[5]	Domain Value Description	Mandatory/ Optional
PERMIT_REF	TEXT	50	The alpha-numeric environmental authority number relevant to the spatial information (if this PRC plan does not relate to an existing EA, please provide the relevant application number instead).			Mandatory
PROCESS	TEXT	4	The relevant process spatial data is being submitted for	PRCP	Progressive rehabilitation and closure plan	Mandatory
SITE_NAME	TEXT	254	Site name relating to the environmental authority.			Mandatory
SITE_ID	TEXT	20	This field contains a unique identifier for the spatial feature, which has been generated by the applicant.			Mandatory
FEATURE	TEXT	10	This field contains the land use feature on site which this polygon or point is describing. Select the relevant option of either post-mining land use, rehabilitation area, non-use management area, improvement area, maximum disturbance footprint, sensitive receptor, existing rehabilitation or floodplain using the codes specified.	PMLU	Post-mining land use	Mandatory
				REHAB_AREA	Rehabilitation area	Mandatory
				NUMA	Non-use management area	Mandatory if the PRC plan schedule proposes or changes a non-use management area
				IMPRV_AREA	Improvement area	Mandatory if the PRC plan schedule proposes or changes a non-use management area

[5] If blank, populate based on Attribute type & definition

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				FOOTPRINT	Maximum disturbance footprint over mine life	Mandatory
				SR	Sensitive receptor	Mandatory
				EX_REH	Existing rehabilitation	Mandatory if the application is for an existing EA and there is existing rehabilitation undertaken
				FLDP	Floodplain	Mandatory if there is a floodplain located within the EA boundary
FEAT_DESC	TEXT	254	Feature description		This field provides a description of the feature identified in 'FEATURE'.	Mandatory
PMLU_TYPE	TEXT	10	This field provides a description of the post mining land use type. If PMLU_TYPE is 'Other' additional information in the comments field is required.	GRAZ	Grazing	Mandatory for each PMLU.
				NAT_ECO	Native ecosystem	
				WTR_ST	Water storage	
				REC	Recreation	
				HB_ECS	Habitat and ecosystem services	
				AGRI	Agriculture	
				FOR	Forestry	
				CROP	Cropping	
				PERM_INFRA	Permanent infrastructure	
				IND	Industrial	
				LNDFL	Landfill	
				Oth	Other	
DATE_SUBMT	DATE	dd/mm/yyyy	Date of submission. This field identifies the date the spatial information was submitted.		Date of submission	Mandatory
SOURCE	TEXT	5	This field identifies the source of the spatial information and the capture	DIG	Digitising (Tracing over Ortho Imagery)	Mandatory

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			methodology for the spatial information provided.	GPSD	GPS Differential Survey	
				GPSND	GPS Non Differential Survey	
				RTK	Real-Time Kinematic (RTK) Survey	
				UK	Unknown	
AREA_HA	DOUBLE	N/A	This field indicates the area in Hectares. (Polygon only)			Mandatory if GEOMETRY = polygon.
COMMENTS	TEXT	254	A free text field has been provided to include any additional information the proponent wishes to provide in relation to the data.			Mandatory if PMLU_TYPE = Oth

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Authorisation letter to nominate an Authorised Holder Representative for dealings with Queensland Government

Queensland Government
C/- Executive Director, Permits and Licensing
Department of Environment, Science and Innovation
GPO Box 2454,
Brisbane QLD 4001

BM Alliance Coal Operations Pty Ltd (**BMACO**) is the manager and agent for and on behalf of the **CQCA JV Participants** comprising BHP Coal Pty Ltd ACN 010 595 721, Umal Consolidated Pty Ltd ACN 000 767 386, BHP Queensland Coal Investments Pty Ltd ACN 098 876 825, Mitsubishi Development Pty Ltd ACN 009 779 873, QCT Investment Pty Ltd ACN 010 487 831, QCT Mining Pty Ltd ACN 010 487 831 and QCT Resources Pty Limited ACN 010 808 705.

The CQCA JV Participants are currently the holders of the below mentioned resource authorities. The CQCA JV Participants and South Blackwater Coal Pty Ltd (ACN 011 026 154) (**SBC**) are currently the holders of the below mentioned environmental authority (**EA**). Each of the CQCA JV Participants and SBC nominates that the following Authorised Holder Representative (**AHR**), including through their employees, representatives or agents can undertake activities and transactions with the Queensland Government under the *Environmental Protection Act 1994* (**EP Act**), the *Environmental Protection Regulation 2019* (**EP Regulation**) and associated Queensland legislation on behalf of the authority holders pursuant to the terms of this letter.

Details of Authorised Holder Representative

Name of Authorised Holder Representative - individual or, if Authorised Holder Representative is a company, company name Whitehaven Blackwater Pty Ltd	The Authorised Holder Representative is an individual who is at least 18 years old X Yes
	Organisation number (e.g. ACN/ARBN etc.) ACN 672 142 997
Key contact name (complete if the Authorised Holder Representative is a company) Morgana Gidley-Baird	
Key contact's position (complete if the Authorised Holder Representative is a company) General Manager – Environment	
Other AHR employees, representatives or agents authorised to act on the AHR's behalf (set out all individuals (including contractors) who are authorised agents of the AHR) Lynden Cini (Superintendent – Group Environment) Daniel Iliffe (RGM Operations)	
Residential or registered business address (not a post office box) Level 28, 259 George Street, Sydney NSW 2000	Phone +61 448 464 587
Postal address (if different from above) GPO Box 3224, Brisbane QLD 4000	

Docusign Envelope ID: 821F9DF5-A726-49EF-A4F5-D0366D37D573

Email
MGidleyBaird@whitehavencoal.com.au

Details of Applications

This authorisation applies only to the following authority applications (**Relevant Authorities**):

No.	Blackwater resource authorities
1.	ML1759
2.	ML1760
3.	ML70329
4.	ML70104
5.	ML1762
6.	ML70103
7.	ML1800
8.	ML1761

No.	Blackwater environmental authority
1.	EPML00717813

Authorised Activities

The AHR nominated above has the authority to undertake all tasks related to the management of the Relevant Authorities, including the following activities and transactions:

1. Providing responses to requests for information from the Department of Resources and the Department of Environment, Science and Innovation relating to the Relevant Authorities.

2. Completing and submitting notices, reports, returns, letters and other information or communications relating to the Relevant Authorities.

3. Completing and submitting transactions in respect of the Relevant Authorities, including the payment of annual fees and completion of annual returns.

4. Granting access to the “MyMinesOnline” computer system to employees of the AHR (or its related entities), and representatives of the AHR, provided that such access is restricted to performing the AHR’s responsibilities as the AHR.

5. Requesting and obtaining access to information concerning the calculation of royalties in respect of the Relevant Authorities.

6. Requesting and obtaining reports lodged on the GSQ Portal regarding the Relevant Authorities.

7. Submission of a progressive rehabilitation and closure plan under the *Environmental Protection Act*

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1994 (Qld).

8. Application for a decision on the estimated rehabilitation cost under the *Environmental Protection Act 1994* (Qld).

Applicants/authority holders - Acknowledgements

I/we acknowledge that if there are changes to the authority, or there are changes in the ownership of the Relevant Authorities, a new letter of authority will be completed and submitted to the Queensland Government, C/- Executive Director, Permits and Licensing and to the Queensland Government, C/- Executive Director, Georesources. Unless and until such notification is received, the Queensland Government will be entitled to continue to rely on the authority.

I/we acknowledge that if the authority is no longer required, written advice will be given to the Queensland Government, C/- Executive Director, Permits and Licensing and to the Queensland Government, C/- Executive Director, Georesources. Unless and until such notification is received, the Queensland Government will be entitled to continue to rely on the authority.

I/we acknowledge that it is our responsibility to be informed of any actions undertaken by the AHR and to inform the AHR of any actions I/we take.

I/we acknowledge that in regard to any activities and transactions under the EP Act, the EP Regulation or any associated Queensland legislation, any legislative requirement to notify either the applicant, or the holder of an environmental authority, may be met by notifying the AHR, except where legislatively provided to the contrary, whether expressly or impliedly.

I/we acknowledge that it is an offence under the EP Act for a person to give false, misleading or incomplete documents or statements.

Details of applicants/authority holders making this authorisation

Name - individual or director / company secretary if the applicant/holder is a company Toni Wiltshire	I am at least 18 years old X Yes
Position Company Secretary	
Organisation name BM Alliance Coal Operations Pty Ltd as manager and agent for the CQCA JV Participants	Organisation number (e.g. ACN/ARBN etc.) ABN 67 096 412 752
Residential or registered business address (not a post office box) Level 14, 480 Queen Street, Brisbane, QLD 4000	Phone + 61 7 3622 4699
Postal address (if different from above) GPO Box 1389, Brisbane, QLD 4001	
Email: Toni.Wiltshire@bhp.com	
Signature Digitally signed by Maria Joyce DN: cn=Maria Joyce, c=AU, email=maria.joyce@bhp.com Date: 2024.11.06 14:04:33 +10'00' Director (Alt.) Maria Joyce (Print name)	Date

Docusign Envelope ID: 821F9DF5-A726-49EF-A4F5-D0366D37D573

Signature	Date
J.Wiltshire Location: Brisbane; Company Secretary ~~Director~~/Secretary* *delete whicheever is not applicable* Toni Wiltshire (Print name)	5 November 2024

Signed in accordance with section 127 of the *Corporations Act 2001* (Cth) and in respect of the Relevant Authorities.

Name - individual or director / company secretary if the applicant/holder is a company	I am at least 18 years old
Ian Humphris	X Yes
Position	
Director	
Organisation name	**Organisation number (e.g. ACN/ARBN etc.)**
South Blackwater Coal Pty Ltd	ACN 011 026 154
Residential or registered business address (not a post office box)	**Phone**
Level 28, 259 George Street, Sydney NSW 2000	(02) 8222 1100
Postal address (if different from above)	
As above	
Email	
companysecretary@whitehavencoal.com.au	
Signature	**Date**
DocuSigned by: Ian Humphris 59BBA25E8A0B435... Ian Humphris, Director, South Blackwater Coal Pty Ltd	November 8, 2024 | 3:52 PM AEDT
Signature	**Date**
DocuSigned by: Timothy Burt A81B20B45B77495... Timothy Burt, Company Secretary, South Blackwater Coal Pty Ltd	November 8, 2024 | 5:07 PM AEDT

Signed in accordance with section 127 of the *Corporations Act 2001* (Cth) and only in respect of EPML00717813.

AHR – Acknowledgements

The AHR acknowledges that they understand and accept the responsibilities of the AHR as defined in this letter.

The AHR nominates that the individuals specified below are authorised to act upon the AHR's behalf to the full extent of this authorisation.

The AHR acknowledges that unless and until the AHR notifies the department otherwise, the Queensland Government will be entitled to rely upon the authority as evidence that these individuals are the authorised agents of the AHR.

The AHR agrees if there are changes to the authority, or there are changes in the ownership of the Relevant Authorities, they will complete a new letter of authority and submit it to the Queensland Government, C/- Executive Director, Permits and Licensing and to the Queensland Government, C/- Executive Director, Georesources. Unless and until such notification is received, the Queensland Government will be entitled to continue to rely on this authority.

The AHR acknowledges that it is their responsibility to be informed of any actions undertaken by the applicants/holders and to inform the applicants/holders of any actions the AHR takes.

The AHR acknowledges that in regard to any activities and transactions under the EP Act, the Regulation or any associated Queensland legislation, any legislative requirement to notify either the applicant, or the holder of an environmental authority, may be met by notifying the AHR, except where legislatively provided to the contrary, whether expressly or impliedly.

The AHR acknowledges that it is an offence under the EP Act for a person to give false, misleading or incomplete documents or statements.

The AHR acknowledges the following privacy information:

Privacy

All information provided will be used for the purpose of managing the applications or EAs to which the authorisation relates. In accordance with section 540 of the EP Act, details of the application or EA will be made publicly available on a register, and this will include publication of details of both the applicant/holder and the AHR.

When an AHR is nominated or authorised to deal with an application or EA, all information provided as part of that process will be available on the EA record. This means that should the EA, or the AHR be transferred to another person, all information related to the EA, including historical information, will comprise the EA record and will be accessible to the current EA holder or AHR.

In the event that the Relevant Authorities are transferred, or the AHR is replaced, all existing personal information provided will be retained as part of the Relevant Authorities and will be available to the new holder where requested and historical information about holders and representatives will remain searchable on the public register in accordance with section 542 of the EP Act.

All personal information will be managed in accordance with the Information Privacy Act 2009 and will not be used for other purposes or disclosed to other entities without consent unless authorised or required by law. For more privacy information go to https://www.des.qld.gov.au/help/legal/privacy.

Name – individual or company director/secretary if the Authorised Holder Representative is a company	I am at least 18 years old
Ian Humphris	X Yes
	Organisation number (e.g. ACN/ARBN etc.)
	ACN 672 142 997
Position	
Director	
Company name	
Whitehaven Blackwater Pty Ltd	
Signature DocuSigned by: Ian Humphris 59BBA25E8A0D435...	Date
	November 8, 2024 | 3:52 PM AEDT

Docusign Envelope ID: 821F9DF5-A726-49EF-A4F5-D0366D37D573

Director Ian Humphris (Print name)	
Signature DocuSigned by: Timothy Burt A81B26B45B77495... Director/Secretary* *delete whicheever is not applicable* Timothy Burt (Print name)	Date November 8, 2024 | 5:07 PM AEDT

Signed in accordance with section 127 of the *Corporations Act 2001* (Cth).

Whitehaven

Blackwater Mine

PROGRESSIVE REHABILITATION AND CLOSURE PLAN

Date: 16 May 2025

Whitehaven Coal Limited
ABN 68 124 425 396

Level 28, 259 George Street, Sydney NSW 2000

+61 2 8222 1100
info@whitehavencoal.com.au
www.whitehavencoal.com.au

Cover page

As required by the Department of Environment, Tourism, Science and Innovation (DETSI) Application form 'Submission of a progressive rehabilitation and closure plan' (ESR/2019/4957, Version 4.03, 11 July 2023), the following information is provided as a cover page to this progressive rehabilitation and closure plan (PRCP).

Requirement	Details
Title of the project	Blackwater Mine
Document title	Blackwater Mine – Progressive Rehabilitation and Closure Plan
Version number	2.00
Document ID number	00003905
Date of submission	24 March 2025
Tenure number(s)	ML1759, ML1760, ML1761, ML1762, ML1767, ML1771, ML1772, ML1773, ML1792, ML1800, ML1812, ML1829, ML1860, ML1862, ML1907, ML70091, ML70103, ML70104, ML70139, ML70167, ML70329
EA holder name	Whitehaven Blackwater Pty Ltd South Blackwater Coal Limited
EA holder contact details	Dan Iliffe

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GLOSSARY OF TERMS AND ABBREVIATIONS

Key terms and abbreviations, and associated definitions used in this report are listed below.

Abbreviation	Description
3P grasses	Native and naturalised exotic grass species that are perennial, palatable, and productive (3P) plants to stock
AEP	Annual exceedance probability
AMD	Acid and Metalliferous Drainage
AMWU	Australian Manufacturing Workers Union
ANC	Acid neutralising capacity
ARR	Australian Rainfall and Runoff
ASC	Australian Soil Classification
BOM	Bureau of Meteorology
BMA	BHP Mitsubishi Alliance - BM Alliance Coal Operations Pty Ltd (BMA)
BWM	Blackwater Mine
CCP	Community Consultation Plan
CEC	Cation exchange capacity
CHPP	Coal handling and preparation plant
CHRC	Central Highlands Regional Council
CQRP	Central Queensland Regional Plan 2013
CSIRO	Commonwealth Scientific and Industrial Research Organisation (Australia)
CSM	Conceptual site model
DCCEEW	Department of Climate Change, Energy, the Environment and Water (Commonwealth)
DEM	Digital elevation model
DES	Department of Environment and Science (Queensland
DESI	Department of Environment, Science and Innovation (Queensland) (Administrating Authority for the PRCP Version 1 submission provided by Whitehaven 15 November 2024)
DETSI	Department of Environment, Tourism, Science and Innovation (Queensland) (Administrating Authority for this PRCP submission)
DILGP	Department of Infrastructure, Local Government and Planning (Queensland)
DLGP	Department of Local Government and Planning (Queensland)
DM	Dry matter (with reference to vegetation)
DoR	Department of Resources (Queensland) (previously referred to as the Department of Natural Resources, Mines and Energy)
DSDIP	Department of State Development, Infrastructure and Planning (Queensland)
DSI	Detailed Site Investigation
DSITI	Department of Science, Information Technology and Innovation (Queensland)
TMR	Transport and Main Roads (Queensland)
EA	Environmental Authority (in terms of the *Environmental Protection Act 1994,* Queensland)
EC	Electrical conductivity
EIS	Environmental Impact Statement

Abbreviation	Description
EMP	Environmental Management Plan
EMR	Queensland Environmental Management Register
EP Act	*Environmental Protection Act 1994* (Queensland)
EP Regulation	*Environmental Protection Regulation 2019* (Queensland)
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth)
EPP	*Environmental Protection (Water and Wetland Biodiversity) Policy 2019* (Queensland)
ERAs	Environmentally relevant activities
ESA	Environmentally sensitive area
ESP	Exchangeable sodium percentage
FoS	Factor of safety
FRREMP	Fitzroy Basin Regional Receiving Environment Monitoring Program
GDE	Groundwater Dependant Ecosystem
GMA	Groundwater Management Zone
IA	Improvement area
IDC	Index of Diversion Condition
IPD	In-pit dump
LGA	Local Government Area
LOD	Land outcome document
LSA	Land suitability assessment
MERFP Act	*Mineral and Energy Resources (Financial Provisioning) Act 2018* (Queensland)
MIA	Mine infrastructure area
MIBC	Methyl isobutyl carbinol
ML	Mining Lease
MM	Management milestone
MSES	Matters of state environmental significance
NAF	Non-acid forming
NC Act	*Nature Conservation Act 1992* (Queensland)
NUMA	Non-use management area
OOPD	Out-of-pit dump
PAF	Potentially acid-forming
PFAS	Perfluoroalkyl and Polyfluoroalkyl Substances
PMLU	Post-mining land use
PRCP	Progressive Rehabilitation and Closure Plan
Product coal	Coal produced from the CHPP after being washed/processed. Coal that is ready for sale
PSI	Preliminary site investigation
QA/QC	Quality Assurance and Quality Control
Qld	Queensland
RA	Rehabilitation area

Abbreviation	Description
RE	Regional ecosystems
REMP	Receiving Environment Monitoring Program
RM	Rehabilitation milestone
ROM	Run-of-mine
RRR	Residual risk rating (with reference to the risk assessment)
SMP	Site Management Plan
SPR	Source-pathway-receptor
TDS	Total dissolved solids
TEC	Threatened ecological communities
TLO	Train load-out
TSF	Tailings storage facility
VM Act	*Vegetation Management Act 1999* (Queensland)
WBNM	Watershed Bounded Network Model
WEPP	Water Erosion Prediction Program
WQOs	Water quality objectives

2 Introduction

2.1 Purpose

Persons (including organisations) carrying out mining activities in Queensland are legally obligated to rehabilitate the land. The Queensland Government has introduced a package of reforms to improve rehabilitation and financial assurance outcomes in the resource sector; a key element of which was the *Mineral and Energy Resources (Financial Provisioning) Act 2018* (Qld) (MERFP Act). The MERFP Act includes provisions to introduce new requirements under the *Environmental Protection Act 1994* (Qld) (EP Act) for the progressive rehabilitation and closure of mined land. These requirements include the development of a Progressive Rehabilitation and Closure Plan (PRCP), to plan for how and where activities will be carried out, in a way that maximises the progressive rehabilitation of the land to a stable condition and provides for the condition to which the land must be rehabilitated. The PRCP is comprised of two parts:

1. A rehabilitation planning part (PRC Plan); and
2. The PRCP schedule.

This document fulfils the requirements for the rehabilitation planning part for Blackwater Mine (BWM) (also referred to as the 'site'). The purpose of the rehabilitation planning part is to support and justify the development of the PRCP schedule and detail how progressive rehabilitation and closure will be carried out over the entire site and on a rehabilitation and improvement basis. The rehabilitation planning part is not approved by the administering authority but must be submitted to support the PRCP schedule. The PRCP schedule is approved by the administering authority and operates separately from the Environmental Authority (EA). The PRCP schedule (number 2 above) is provided separately to this document in the spreadsheet templated provided by DETSI. Key elements of the schedule are included in Appendix 4.1 of this document.

As stated in the PRCP Statutory Guideline (ESR2019/4964, Version 3.01, 16 September 2024) "*the EA authorises the carrying out of an environmentally relevant activity (ERA) and includes conditions to avoid, mitigate, or manage environmental harm that could occur during an activity. The PRCP schedule contains milestones and conditions that relate to the completion of progressive rehabilitation and mine closure. Both the EA and the PRCP schedule apply to the entire life of the mining activities, irrespective of when the underlying tenure expires. As per section 202E of the EP Act, where there is an inconsistency between an EA and a PRCP schedule the EA prevails to the extent of the inconsistency*".

When submitting a site-specific application for an EA for a new mining activity relating to a mining lease, applicants are required to develop and submit a proposed PRCP as part of their application. In the case of existing EA holders, the MERFP Act includes transitional provisions for the application of a PRCP. BWM, as an existing mine operating under an approved EA, requires a transitional PRCP. This is discussed further in Section 2.2 below.

On 11 November 2024, Whitehaven BWM submitted a PRC Plan and PRCP Schedule application to the administering authority for assessment. On 25 November 2024, the Department of Environment, Tourism, Science and Innovation (DETSI) issued a *Not Properly Made (NPM) Application Notice*, outlining the reasons the application was considered not properly made and specifying the actions required to address the identified issues.

Following receipt of the NPM Notice, Whitehaven engaged with DETSI through an initial meeting held 04 December 2024 to clarify the matters raised. A formal response addressing the NPM matters was submitted via a memorandum dated 24 March 2025. A follow-up meeting was held on 25 March 2025, and DETSI subsequently provided feedback on 28 March 2025, which included additional requests for information and clarification.

In response, Whitehaven submitted a second memorandum on 30 April 2025, further seeking to address the outstanding matters. On 09May 2025, DETSI issued further correspondence outlining remaining observations. In addition, DETSI also advised that,subject to the submission of the additional information to address the observations, the matters raised in the NPM Notice would be considered resolved for the purposes of re-lodgement of the PRCP application.

On 16 May 2025, Whitehaven submitted a response to DETSI's 09 May 2025 correspondence, addressing the final observations and confirming the close-out of NPM matters.

Accordingly, this updated PRC Plan, PRCP Schedule, and relevant appendices have been revised to incorporate the information provided in the submissions dated 24 March 2025, 30 April 2025 and 16 May 2025.

2.2 Transitional provisions

Part 27, Chapter 13 of the EP Act sets out the transitional provisions following the commencement of the MERFP Act. Under these provisions, BM Alliance Coal Operations Pty Ltd (BMA) (former owners of BWM) were a 'mining EA holder' at the commencement of the MERFP Act, and therefore was "*the holder of an environmental authority (EPML00717813) for a mining activity relating to a mining lease authorising operations*" at BWM (section 750, EP Act). As BWM had an approved EA, the site fell under the ambit of the requirements of a transitional PRCP. A Transition Notice for BWM was issued to BMA by the administrating authority, dated 13 December 2021. The Transitional Notice required submission of the BWM PRCP and PRCP schedule by 15 November 2024. On 2 April 2024, Whitehaven Blackwater Pty Ltd (Whitehaven) acquired BWM from BMA. At the time of the PRCP Version 1 submission, the transfer of the EA from BMA to Whitehaven had not yet been completed, however Whitehaven had authority from BMA to act as an agent on behalf of BMA in relation to submission of the PRCP. On 28 January 2025 the EA was successfully transferred from BMA to Whitehaven by the administering authority.

In accordance with the transitional provisions under the MERFP Act, existing rehabilitation and closure outcomes in Land Outcome Documents (LODs) (as defined in section 750 of the EP Act) can be transitioned into the PRCP. The primary LOD for BWM is the site's EA, with the secondary LOD being the *Residual Void Investigation* report (BMA, 2020). Where there is an inconsistency between these documents the primary LOD prevails to the extent of the inconsistency. In alignment with the transitional provisions and the PRCP Statutory Guideline requirements, the following process for transitioning the rehabilitation and closure outcomes from the BWM LODs into the site's PRCP schedule has been followed:

- Identified rehabilitation and closure outcomes in the LOD (EA EPML00717813)
- Identified post-mining land uses (PMLUs) and non-use management areas (NUMAs)
- Defined rehabilitation areas within the PMLUs, and improvement areas within the NUMA
- Identified milestones to achieve the PMLUs and manage the NUMA
- Identified milestone criteria for showing success or completion of the PMLU or NUMA
- Identified when the first milestone must commence and completion dates for the milestones.

2.3 Scope

This transitional PRCP applies to BWM, a metallurgical coal mine located in the Bowen Basin, Queensland, operated by Whitehaven Blackwater Pty Ltd (Whitehaven). BWM has pre-approved post-mine land uses (PMLUs) and non-use management areas (NUMAs). These are addressed within the LODs documents (and discussed in Sections 3.3, 3.4 and 3.5.3.7), and can be transitioned into the PRCP schedule. Therefore, the following requirements do not apply:

- *Complete the information requirements under section 126C(1)(j) of the EP Act for the PMLUs and NUMA (information the administering authority reasonably considers necessary to decide whether to approve the PRCP schedule); and*
- *Comply with sections 126C(1)(g) or (h) (justification of the NUMA) or 126D(2) (evidence to support justification of the NUMA and it being subject to a public interest evaluation, PIE) or 126D(3) (voids in floodplains) of the EP Act.*

For the purposes of the PRCP, BWM comprises the areas covering Mining Lease (ML) ML1759, ML1760, ML1761, ML1762, ML1767, ML1771, ML1772, ML1773, ML1792, ML1800, ML1812, ML1829, ML1860, ML1862, ML1907, ML70091, ML70103, ML70104, ML70139, ML70167, ML70329. This transitional PRCP does not apply to other lands owned by Whitehaven or offset properties that do not contain ERAs.

This transitional PRCP has been prepared for BWM in accordance with the requirements of the MERFP Act, the EP Act and the PRCP Statutory Guideline (DESI, 2024).

Table 1 shows compliance with the requirements by listing the relevant sections in this PRCP addressing each requirement. The PRCP schedule is provided separately from this document in the spreadsheet template provided by DESI. Key elements of this schedule are included in Appendix 4.1 of this document.

2.4 Knowledge base refinement

Compilation of this PRCP has been supported by the rehabilitation and closure-related knowledge base for BWM at the time of submission of this PRCP. Relevant studies contributing to this knowledge base have been referenced throughout this PRCP, with key studies/resources provided in Appendices 4.1-4.17.

As highlighted by the International Council of Mining and Metals (ICMM) in the Integrated Mine Closure Good Practice Guide, 2nd Edition (2019), "*the collection, updating, use and review of the knowledge base is considered an ongoing and iterative process over the mine life, and will be used to inform iterative refinement and improvement of the rehabilitation and closure planning process over time*". As the rehabilitation and closure knowledge base for BWM develops over the life of the operation, it will be used to inform the ongoing refinement of the plans for rehabilitation and closure. Therefore, it is understood that the PRCP is a dynamic document and will be updated as required.

Table 1 Compliance with PRCP statutory guideline requirements

PRCP Statutory Guideline Requirements	Section in PRCP
3.1 PROJECT PLANNING	
Legislative Requirements In accordance with section 126C(1)(b) and (c)(ii) of the EP Act, the rehabilitation planning part of the PRCP must include a description of:	
• each resource tenure, including the area of each tenure	3.1.1.2
• relevant activities to which the application relates	3.1.4.1
• duration of relevant activities	3.1.4.1
• how and where the relevant activities were carried out, including maps	3.1.1.3
Baseline Information The following information about the site, where relevant, is considered necessary by the administering authority (as per section 126C(1)(j) of the EP Act) to decide whether to approve the PRCP schedule:	
• site topography (locally and regionally)	3.1.2.1
• climate (general and specific (rain, evaporation, temperatures)) including long-term projections	3.1.2.2
• geological setting	3.1.2.3
• site hydrology and fluvial networks	3.1.2.3
• groundwater levels and properties	3.1.2.6
• soil types, properties and productivity	3.1.2.7
• land stability (pre-existing land degradation/erosion and predisposition to ongoing stability issues)	3.1.2.8
• vegetation communities and ecological data (including existing regional ecosystem mapping)	3.1.2.9
• fauna presence and populations	3.1.2.10
• pre-mining land use	3.1.2.11
• identification of underlying landholders	3.1.2.12
Project Description The project description must include the following details:	
• mining tenements	3.1.1.2
• primary mine features/infrastructure on site (e.g. TSF, waste rock dump, etc.)	3.1.1.3
• type of mining operation	3.1.1.4
• proposed duration of operation as a whole	3.1.1.5

PRCP Statutory Guideline Requirements	Section in PRCP
Design for Closure The rehabilitation planning part of the PRCP for new or expanding sites must include a description of how certain aspects have been designed for closure. Note: Transitional PRCPs are not required to demonstrate design for closure for existing or approved disturbance, and as such this section is not applicable to BWM.	
Rehabilitation/Improvement Planning In order to meet the legislative requirements in sections 126C(1)(b) and (c)(ii) of the EP Act, the rehabilitation planning part must include:	
• identification of all relevant activities on the mine site	3.1.4.1
• the predicted duration of each of the relevant activities proposed for the mine site	3.1.4.1
• the size/extent of the relevant activities	3.1.1
• whether the different relevant activities can be progressively rehabilitated	3.1.4.1
Applicability to Transitional PRCPs Under section 126C(1)(j) of the EP Act, transitional PRCPs must also include the following details about any existing rehabilitation already completed at the time of submission of the proposed PRCP:	
• a description of the rehabilitation works previously carried out	3.1.4.2
• when the rehabilitation works commenced and were completed	3.1.4.2
• whether the rehabilitation has been applied for or approved as progressively certified under the EP Act	3.1.4.2
Spatial Information The following spatial information must be submitted as part of the PRCP:	
• location and maximum extent of disturbance footprint for the mine life	4.1.1
• the PMLUs and NUMAs for the area within the resource tenures	4.1.1
• any sensitive receptors	4.1.1
• Spatial Information outlining the rehabilitation and improvement areas that correspond with the proposed PRCP schedule, for a 10-year period (minimum)	4.1.1
3.2 COMMUNITY CONSULTATION	
Legislative Requirement In accordance with section 126C(1)I(iii) and (iv) of the EP Act, the rehabilitation planning part of the PRCP must include:	
• details of the consultation undertaken by the applicant in developing the proposed PRCP, and	3.1.4.2.1, Appendix 4.4
• details of how the applicant will undertake ongoing consultation in relation to the rehabilitation to be carried out under the plan.	3.1.4.2.1, Appendix 4.4
Note where there are land outcomes have been identified in a land outcome document, the applicant must include details of any previous community consultation undertaken or advise if previous consultation has not been recorded or is unknown. To comply with section 126C(1)(c)(iii) of the EP Act, the rehabilitation planning part must include a community consultation register identifying the consultation carried out in developing the PRCP. The community consultation register must include:	
• previous consultation (history of community engagement)	3.1.4.2.1, Appendix 4.4
• consultation date(s)	3.1.4.2.1, Appendix 4.4
• identification of each community member	3.1.4.2.1, Appendix 4.4
• description of consultation type (workshop, quarterly meetings, etc.)	3.1.4.2.1, Appendix 4.4
• information provided to the community	3.1.4.2.1, 3.2.2, Appendix 4.4
• issues raised/discussed by the community	3.1.4.2.1, 3.2.2, Appendix 4.4

PRCP Statutory Guideline Requirements	Section in PRCP
• how issues have been considered	3.1.4.2.1, 3.2.2, Appendix 4.4
• decisions/outcomes of engagement	3.1.4.2.1, 3.2.2, Appendix 4.4
• commitments made by the applicant	3.1.4.2.1, 3.2.2, Appendix 4.4
To comply with section 126C(1)(c)(iv) of the EP Act, the rehabilitation planning part must include a community consultation plan detailing how ongoing consultation will be carried out in relation to the rehabilitation to be carried out under the PRCP. The community consultation plan must include details of:	
• the objectives for community consultation	3.1.4.2.1, Appendix 4.4
• how the community will be engaged	3.1.4.2.1, Appendix 4.4
• proposed consultation frequency	3.1.4.2.1, Appendix 4.4
• what information will be released for community consultation	3.1.4.2.1, Appendix 4.4
• how feedback/comments will be considered	3.1.4.2.1, Appendix 4.4
3.3 POST-MINING LAND USE	
Legislative Requirements In accordance with section 126C(1)(d) of the EP Act, the rehabilitation planning part of the PRCP must state the extent to which each post-mining land use for land identified in the PRCP schedule for the plan is consistent with:	
a) the outcome of consultation with the community in developing the plan, and	3.3.2
b) any strategies or plans for the land of a local government, the State or the Commonwealth.	3.3.4
An applicant must propose a PMLU for all land within the relevant resource tenures of the EA (this includes land that will be undisturbed). Note where a PMLU has been previously addressed in a land outcome document and is able to be transitioned into the PRCP schedule, the applicant is not required to complete the information requirements under section 126C(1)(j) of the EP Act in this section for those PMLUs.	
The description of proposed PMLUs must include (where relevant), but is not limited to:	
• a description of the use of the land	3.3.3
• if applicable, the specific vegetation types (e.g. RE 13.2.9) or land suitability classification (e.g. Class 4)	3.3.3
• identification of any permanent or essential management infrastructure to be included as part of the PMLU	3.5.5.1
• success criteria for measuring whether the PMLU has been achieved successfully.	3.3.3
3.4 NON-USE MANAGEMENT AREAS	
Legislative Requirements In accordance with sections 126C(1)(d), (g) and (h) of the EP Act, for each proposed non-use management area, the rehabilitation planning part of the PRCP must:	
• state the reasons the applicant considers the area cannot be rehabilitated to a stable condition (g)	3.4.1
• include copies of reports or other evidence relied on by the applicant for each proposed non-use management area (h)	3.4.1 and the EA
• state the extent to which the proposed non-use management area is consistent with the outcome of consultation with the community in developing the plan (d)	3.4.2
• state the extent to which the non-use management area is consistent with any strategies or plans for the land of a local government, the State or the Commonwealth (d)	3.4.5

PRCP Statutory Guideline Requirements	Section in PRCP
Note where a NUMA has already been identified in a land outcome document and is able to be transitioned into the PRCP schedule, the applicant is not required to comply with sections 126C(1)(g) or (h) or 126D(2) or (3) of the EP Act, nor complete the information requirements under section 126C(1)(j) of the EP Act, for those NUMAs. Requirements under section 126C(1)(d) still apply.	
The proposed PRCP must include a detailed description of the nominated NUMA(s) for the site. The description must include, but is not limited to:	
• description of the land at surrender	3.4.3
• any relevant safety features	3.4.3
• success criteria for measuring whether the NUMA has achieved sufficient improvement (in which each of the following is minimised: ○ the risk of the area collapsing, eroding or subsiding; ○ the need to actively manage the area; and ○ access to the area by an animal or person by, for example, fencing the boundary of the area)	3.4.4
3.5 VOIDS IN FLOOD PLAINS	3.5.3.7
Legislative requirement In accordance with section 126D(3) of the EP Act, if land the subject of the proposed PRCP schedule will contain a void situated wholly or partly in a flood plain, the schedule must provide for the rehabilitation of the land to a stable condition.	
Note that section 754(3) excludes the operation of section 126D(3) and that a voids in floodplains assessment has been conducted to address section 3.4 of the PRCP Guideline which provides that the applicant is required to carry out flood plain modelling in circumstances where the location of the NUMA is not identified in the EA.	
PRCP Guideline (Section 3.4) Section 41C of the EP Regulation states the decision considerations for a void situated wholly or partly in a flood plain. A void is considered to be located in a flood plain if the flood plain modelling shows that, when all relevant activities carried out on the land have ended, the land is the same height as, or lower than, the level modelled as the peak water level 0.1% AEP for a relevant watercourse under the guideline Australian Rainfall and Runoff (2019)(ARR). If a void has been identified as a NUMA in a land outcome document but the location is not identified, the applicant is required to carry out floodplain modelling in accordance with this section of the guideline. While the provision in the EP Act relating to voids located within a floodplain having to rehabilitate to a stable condition does not apply, the PRC Plan must include how the proposed location of the void minimises risks to the environment. Therefore, the floodplain modelling is required to support the assessment of the proposed location of the void. If there are no land outcomes identified in a land outcome document, the applicant is required to carry out floodplain modelling in accordance with this section of the guideline.	3.5.3.7.5
3.6 REHABILITATION AND MANAGEMENT METHODOLOGY	
Legislative requirement In accordance with section 126C(1)(e) and (i), the rehabilitation planning part of the PRCP must:	
• For each proposed post-mining land use for land, state the proposed methods or techniques for rehabilitating the land to a stable condition in a way that supports the rehabilitation milestones under the proposed PRCP schedule.	3.5
• For each proposed non-use management area, state the proposed methodology for achieving best practice management of the area to support the management milestones under the proposed PRCP schedule for the area.	3.5
Hydrogeology Assess the hydrogeology of the site and all connected strata and develop a conceptual model of the mine site's groundwater systems. This information must be integrated into the design of rehabilitation strategies and choice of PMLU or NUMA. The hydrogeological assessment should include the following steps:	

PRCP Statutory Guideline Requirements	Section in PRCP
• determining the groundwater occurrence including the existence of, and depth to, aquifers and aquitards	3.1.2.6.2, 3.5.1.1.3
• locating groundwater recharge and discharge locations locally and regionally	3.1.2.6.3, 3.6.1.1.3
• groundwater quality within each of the aquifers and from surface expressions (i.e. seeps and springs)	3.1.2.6.3
• current and potential future uses of groundwater including existing groundwater extraction bores	3.1.2.6.4
• groundwater flow direction and velocity, including field tests to determine hydraulic conductivity	3.5.1.1.4
• the development of potentiometric mapping and hydrostratigraphic cross-sections	3.5.1.1.5
• groundwater modelling to determine contaminant transport and potential changes to groundwater level from dewatering or waste storage	3.5.1.1.4
Flooding In addition to floodplain modelling, the applicant must also assess the flooding susceptibility and influence across the site.	
If flooding is a consideration, develop a hydrologic model of the catchment and a hydraulic model of the proposed mining area.	
When assessing flooding, you must at least:	
• consider the location of domains in relation to potential flood levels	3.5.1.2
• consider alteration of flow upstream and downstream	3.5.1.2.2
• model flood levels (including probable maximum flood levels) for a range of design storm events	3.5.1.2.3
• develop a flooding risk profile	3.5.1.2.5
Soil and Capping Material Assessment A soil assessment must be carried out that, at a minimum, identifies and characterises the following:	
• the quality and quantity of available resources (such as topsoil, clay material and competent rock) required to complete the target rehabilitation methodology	3.5.1.4.1 3.5.1.4.2
• the location (i.e. with respect to haul distance) and accessibility of cover material (i.e. is the material located on the tenure or are other approvals required?)	3.5.1.4.2 3.5.1.4.3
• an assessment to determine the need for ameliorants and fertilisers	3.5.1.4.1
• the relationship between soils and vegetation ecosystems for the PMLU and rehabilitation methodology	3.5.1.4.2
Waste Characterisation The rehabilitation planning part must include a description of the following:	
• Describe contaminants that can pose a risk to the environment, such as contaminants associated with AMD, neutral mine drainage and saline mine drainage	3.5.1.3.1
• Demonstrate that the sampling regime meets best practice standards, is spatially representative of all material being mined (i.e. the ore body, exposed pit walls and overburden etc.) and is representative of all lithologies	3.5.1.3.2
• Landform design must include a waste placement strategy	3.5.1.5.10
• Describe how mine waste streams can be classified confidently based on environmental risk and management requirements	3.5.1.3.2
• Describe the generation of block models and estimation of the volume of mine waste based on waste type (i.e. level of environmental risk)	3.5.1.3.4

PRCP Statutory Guideline Requirements	Section in PRCP
• Provide recommendations for the management and mitigation of waste streams to manage environmental risk and achieve proposed rehabilitation methods and objectives.	3.5.1.3.5
• Maintain a database to store the characteristics of each rock type	3.5.1.3.2
• Characterise materials based on both static tests and kinetic tests	3.5.1.3.2
• Conceptual site model for waste rock dumps, stockpiles, and TSFs must identify site-specific factors that may result in geochemical risks, including consideration of natural and anthropogenic processes that influence management controls	3.5.1.3.4
Landform Design The final landform design must include:	
• 3D design plans of the final landform	3.5.1.5.1
• method of determining landform design	3.5.1.5.2
• modelling predicting the long-term stability of the final landform design	3.5.1.5.5
• method of construction	3.5.1.5.6
• Quality Assurance/Quality Control (QA/QC) requirements	3.5.1.5.8
• trial methodology to verify the predicted success of the final landform design	3.5.1.5.9
• limitations and assumptions of the landform design	3.5.1.5.10
Key considerations of the landform design report must also include:	
• structure location, footprint and height (including proposed lift heights) – these factors may be influenced by location of environmental values, local topography, location of sensitive receptors or visual impact	3.5.1.5.2
• whether the structure requires a lining to prevent water or air ingress and minimise the potential for seepage release and/or a seepage collection system	3.5.1.5.2
• whether the landform is 'water-retaining' or 'water-shedding', considering rainfall patterns, and intensity, and the composition and texture of the waste	3.5.1.5.2, 3.5.1.5.4
• the identification of materials available for landform rehabilitation including their ability to achieve the required landform design outcomes	3.5.1.5.3, 3.5.1.4, 3.5.2.3.2
• erosion assessments to determine landform heights, gradients, profiles, and material placement	3.5.1.5.5, Appendix 4.8
• slope profile design considering the interactions between soil erodibility, rainfall erosivity, landform height, gradient and vegetation cover to identify acceptable erosion rates over a long-term average	3.5.1.5.5, Appendix 4.8
• settling and subsidence over time, which may impact the availability of areas for rehabilitation	3.5.1.5.10
• hydrological and hydrogeological assessments	3.5.1.5.4
• a waste placement strategy developed to mitigate environmental and rehabilitation risks during the construction and decommissioning phase	3.5.1.5.8
• specific landform requirements committed to in stakeholder consultation, mine planning or other sources, which could include rock incorporation, designed flow paths, aesthetic considerations, non-linear batter slopes and targeted placement of materials	3.1.4.2.1, 3.3.2, 3.4.2, Appendix 4.4
• monitoring to determine performance of control measures (i.e. liners or seepage collection systems)	3.5.1.5.9
Provide an analysis of future stability based on the factors described above (e.g. landform evolution modelling).	Appendix 4.8
Cover Design The cover design should include:	
• identification and specification of the objectives of the cover system	3.5.1.6

PRCP Statutory Guideline Requirements	Section in PRCP
• a detailed description of the design including the thickness of each layer	3.5.2.3.1
• a detailed description of construction methodology including any proposed staging of the cover system	3.5.2.3.1
• a quantitative assessment that identifies the location and quantity of proposed capping material available on site	3.5.2.3.1
• proposed QA/QC for the construction of the cover system including the timely implementation of corrective actions where deviations from the design are identified	3.5.2.3.5
Water Management The rehabilitation planning part must include a description of the following:	
• a description of the contaminants that pose a risk to environmental values of the receiving environment	3.5.1.7.2
• source, pathway and fate of contaminants that have the potential to impact environmental values	3.5.1.7.2, 3.5.1.7.3, 3.5.1.7.4
• infiltration and seepage intervention and collection controls	3.5.1.7.2
• surface water diversions and long-term management requirements	3.5.1.7.5
• dewatering requirements	3.5.1.7.7
• on-going water management and reduction requirements (i.e. treatment)	3.5.1.7.7
Revegetation The Revegetation Plan must propose activities to establish self-sustaining vegetation communities appropriate for the intended PMLU.	
The Revegetation Plan must:	
• propose activities to establish self-sustaining vegetation communities appropriate for the intended PMLUs	3.5.1.8
• Articulate revegetation objectives	3.5.1.8.1
• Identify key flora species appropriate for the PMLUs	3.5.1.8.4, 3.5.1.8.5, 3.5.1.8.6, Appendix 4.1
• Identify species of conservation significance	3.1.2.9, 3.1.2.10
• Identify fauna habitat or use requirements, including monitoring and management plan	3.5.1.8.2
• Include evidence and justification for analogue sites of the monitoring plan	3.7.1.3.1
• Describe works for establishing and managing revegetation	3.5.1.8
• Identify appropriate plant/seed mixes and their source	3.5.1.8.3, Appendix 4.1
• Identify seed density application rate and timing of seeding	3.5.1.8.4, 3.5.1.8.5, 3.5.1.8.6, Appendix 4.1
• Identify proposed locations of any infrastructure required to protect revegetation	3.5.1.8.1
• Identify the growth media suitable to sustain the PMLUs and their availability	3.5.1.4.1, 3.5.1.4.2
• Identify topsoil depth requirements	3.5.1.8.4, 3.5.1.8.5, 3.5.1.8.6, 3.5.1.4.2, Appendix 4.1
The following elements must be included in the site preparation strategies:	
• the application and incorporation of ameliorants (if required for chemical balance) and bulk ameliorants such as gypsum, lime and other organic materials	3.5.1.4.3
• spreading of growth medium layer (topsoil, topsoil/rock mix, or suitable waste if appropriate) to a depth suitable for the target vegetation	3.5.1.4.3
• the application of seed, fertiliser and, where applicable, irrigation.	3.5.1.4.3, 3.5.1.8

PRCP Statutory Guideline Requirements	Section in PRCP
Tailings Storage Facilities The tailings require characterisation to determine the geochemistry, rheology and geotechnical parameters that influence the rehabilitation or management strategies and the capacity of the site to support revegetation.	
The geotechnical characterisation of tailings must also include:	
• Particle size distribution analysis based on conditions in the TSF. Particle size distribution of tailings affects their hydraulic sorting down the tailings beach and their settling, consolidation and desiccation on atmospheric exposure	3.5.2.2.3
• Specific gravity testing. The specific gravity of tailings affects their hydraulic sorting down the tailings beach, and their settling and consolidation	3.5.2.2.3
• Atterberg limit testing to determine the plasticity of the tailings, which affects their settling, consolidation and desiccation on atmospheric exposure	3.5.2.2.3
• The moisture content and dry density profiles with depth of the indicative tailings. The dry density profile indicates the efficiency to which the available storage volume for tailings is utilised. Rheological testing to determine the pumpability of the tailings	3.5.2.2.2, 3.5.2.2.3
• Settling testing of the tailings used as an indicator of the settling density of the tailings	3.5.2.2.3
• Shear strength testing of the indicative tailings, both peak and remoulded shear strengths. The shear strength profile of deposited tailings affect their bearing capacity on rehabilitation	3.5.2.2.2, 3.5.2.2.3
• Consolidation testing of the tailings to estimate their consolidated density and saturated hydraulic conductivity	3.5.2.2.3
• Soil water characteristic curve testing to assess the unsaturated behaviour of the tailings on desiccation and calculate the unsaturated hydraulic conductivity function	3.5.2.2.3
• Instrumented column testing of the tailings to assess their settling, self-weight consolidation and desiccation	3.5.2
• The design for a TSF must include relevant elements: ○ lining of TSF (i.e. embankments and base of structure) ○ leak detection systems ○ cellular design of TSF ○ seepage collection systems ○ design storage allowance ○ spillway location ○ designing TSF for progressive rehabilitation	3.5.2.1, 3.5.2.3
Voids For mine sites with voids, the rehabilitation planning part must include a void closure plan that includes, but is not limited to, the following:	
• options available for minimising final void area and volume (where a final void is proposed)	3.5.3.4
• proposed final dimensions of the void (i.e. depth, length and width)	3.5.3.2, 3.5.3.5
• pit wall geotechnical and geochemical stability, considering the effects of long-term erosion and weathering of the pit wall and the effects of significant hydrological events	3.5.3.2.1, 3.5.3.2.2, 3.5.3.3.3
• proposed final slope angles of high wall, low wall and end walls of each final void	3.5.3.2
• void hydrology, addressing the long-term water balance and water level in the voids, stratification connections to groundwater resources and potential for overflow	3.5.3.3
• groundwater modelling to determine whether the void is acting as a sink or a source for groundwater	3.5.3.3.2
• a water balance study including an assessment of void surface and groundwater interactions such as:	3.5.3.3.1

PRCP Statutory Guideline Requirements	Section in PRCP
○ groundwater lowering/reduction in hydraulic head (from new voids e.g. caves/karst systems)	3.5.1.1.3, 3.5.3.3.2
○ cones of depression and associated impacts	3.5.3.3.2
○ the drainage and flooding behaviours of surface waters in the vicinity of the void	3.5.1.2.2
○ the potential extent of flooding and implications of interactions with the void	3.5.1.2.3
○ a conceptual model that incorporates all projected inflows, outflows, and recharge rates	3.5.1.5.4
○ water storage and long-term water balance	3.5.3.3.1 3.5.3.3
○ each of the major water fluxes into and out of the void	3.5.3.3
○ the sources of surface water within the mine catchment that are likely to influence the water quality in the void	3.5.3.3.2, 3.5.1.7.2, 3.5.1.7.3
○ predicted water quality in the long term including potential stratification	3.5.3.3.3
• a 3D void design plan	3.5.3.1, 3.5.1.5.1, 3.5.1.5.1
• rehabilitation strategies	3.5.3.6, 3.5.1.4, 3.5.3.4, 3.5.3.6
Underground mining The rehabilitation planning part must include:	
• a geotechnical study	3.5.4.2
• an assessment of groundwater interactions and potential lowering of groundwater levels that includes: • consideration of the potential exposure of previously saturated geological formations to air - leading to AMD generation • consideration of measures to avoid or minimise groundwater discharges to the surface through appropriate mine access planning, including post mining sealing off of tunnels, shafts, adits, boreholes, and other openings	3.5.4.4 3.5.4.5
• the development of a hydrogeological conceptual model	3.5.1.1.5
• subsidence analysis and modelling and a subsidence vegetation/habitat impact assessment	3.5.4.3
• consideration of how potential entries to underground workings will be sealed (i.e. through some form of capping or back filling)	3.5.4.5
• how surface ponding and cracking will be mitigated	3.5.4.3
• identification of post-closure stabilisation of underground workings in order to manage the potential for unplanned surface subsidence and unplanned ground collapse such as sinkholes and pot holing	3.5.4.2
Built Infrastructure The rehabilitation planning part must include:	
• Identification of infrastructure that will be decommissioned and the methods for decommissioning	3.5.5.1
• A description of infrastructure that will remain post rehabilitation and the identification of ongoing maintenance requirements	3.5.5.1
• Evidence of agreement for any infrastructure that will have ownership transferred	3.5.5.1
3.7 RISK ASSESSMENT	
Legislative requirement In accordance with section 126C(1)(f) of the EP Act, the rehabilitation planning part of the PRCP must identify the risks of a stable condition for land described as a post-mining land use not being achieved, and how the applicant intends to manage or minimise the risks.	

PRCP Statutory Guideline Requirements	Section in PRCP
Identify sources of risk, areas of impacts, events and their causes and their potential consequences	3.6.1
Determine causes and sources of risk, their positive and negative consequences, and the likelihood that those consequences can occur. The level of confidence in the analysis and any assumptions made should be clearly identified in the risk assessment	3.6.1
Determine what risks need to be managed and prioritised.	3.6.1
Risk treatment must detail:	
• the reasons for selecting the treatment option	3.6.1.3
• those responsible for the approval and implementation of the plan	3.6.1.3
• proposed actions	3.6.1.3
• resource requirements	3.6.1.3
• performance measures and constraints	3.6.1.3
• reporting and monitoring requirements	3.6.1.3
• timing and scheduling	3.6.1.3
3.8 MONITORING AND MAINTENANCE	
• The rehabilitation planning part must contain a monitoring and maintenance program that identifies and describes the monitoring systems that will be carried out in order to demonstrate a milestone and milestone criteria have been achieved.	3.7
• The program must include, where relevant to the milestone and milestone criteria (but is not limited to):	
○ schedule of monitoring, reporting and review for each milestone	3.7.1.2
○ description of methodologies and standards, which could include field-based assessments and the application of new remote sensing, GIS and other relevant emerging technologies	3.7.1.3
○ monitoring that enables the repeatable collection of relevant statistically valid data	3.7.1.4
○ monitoring using appropriate quality assurance and data management processes and systems	3.7.1.5
○ regular analysis of site data including multi-year comparison trends and bench-marking against analogue/reference sites	3.7.1.3.8
○ contingency strategies if monitoring data indicates milestone criteria are not being met	3.7.1.4, 3.7.1.6
○ post-closure monitoring to ensure milestone criteria has been demonstrated	3.7.1.6
○ intent of monitoring reports, such as provision of results and key findings	3.7.1.6
• Describe the processes and activities that will be used to determine the biophysical state of rehabilitation and closure	3.7.1.6
• Standardised and repeatable approach to the measurement of certain biophysical attributes and processes must be identified that can be compared against the PRCP schedule	3.7.1.3
• If there has/is any monitoring or maintenance of areas already rehabilitated, details must be included in the PRCP	3.1.4.2

3 Rehabilitation planning part

3.1 Project planning

Legislative Requirement

In accordance with Section 126C(1)(b) and (c)(ii) of the EP Act, the rehabilitation planning part of the PRC Plan must include a description of:

- *each resource tenure, including the area of each tenure*
- *the relevant activities to which the application relates*
- *the likely duration of the relevant activities*
- *how and where the relevant activities are to be carried out, including maps.*

PRCP Guideline

- *The following spatial information must be submitted as part of the PRC Plan:*
- *the location and maximum extent of disturbance footprint for the mine life*
- *the PMLUs and NUMAs for the area within the resource tenures*
- *any sensitive receptors.*

In addition to the list above, the PRC Plan must include spatial information outlining the rehabilitation and improvement areas that correspond to the proposed PRCP Schedule. The spatial information must show the locations of the rehabilitation and improvement areas for a 10-year period (minimum).

_____

All spatial information must be prepared and submitted in accordance with the guideline 'Spatial Information Submission' (ESR/2018/4337).

3.1.1 Project description

3.1.1.1 Geographic location

BWM is a metallurgical coal mine located approximately 20 kilometres (km) south-west of the town of Blackwater and 75 km to the east of Emerald in the Bowen Basin, Central Queensland (Qld) (Figure 1).

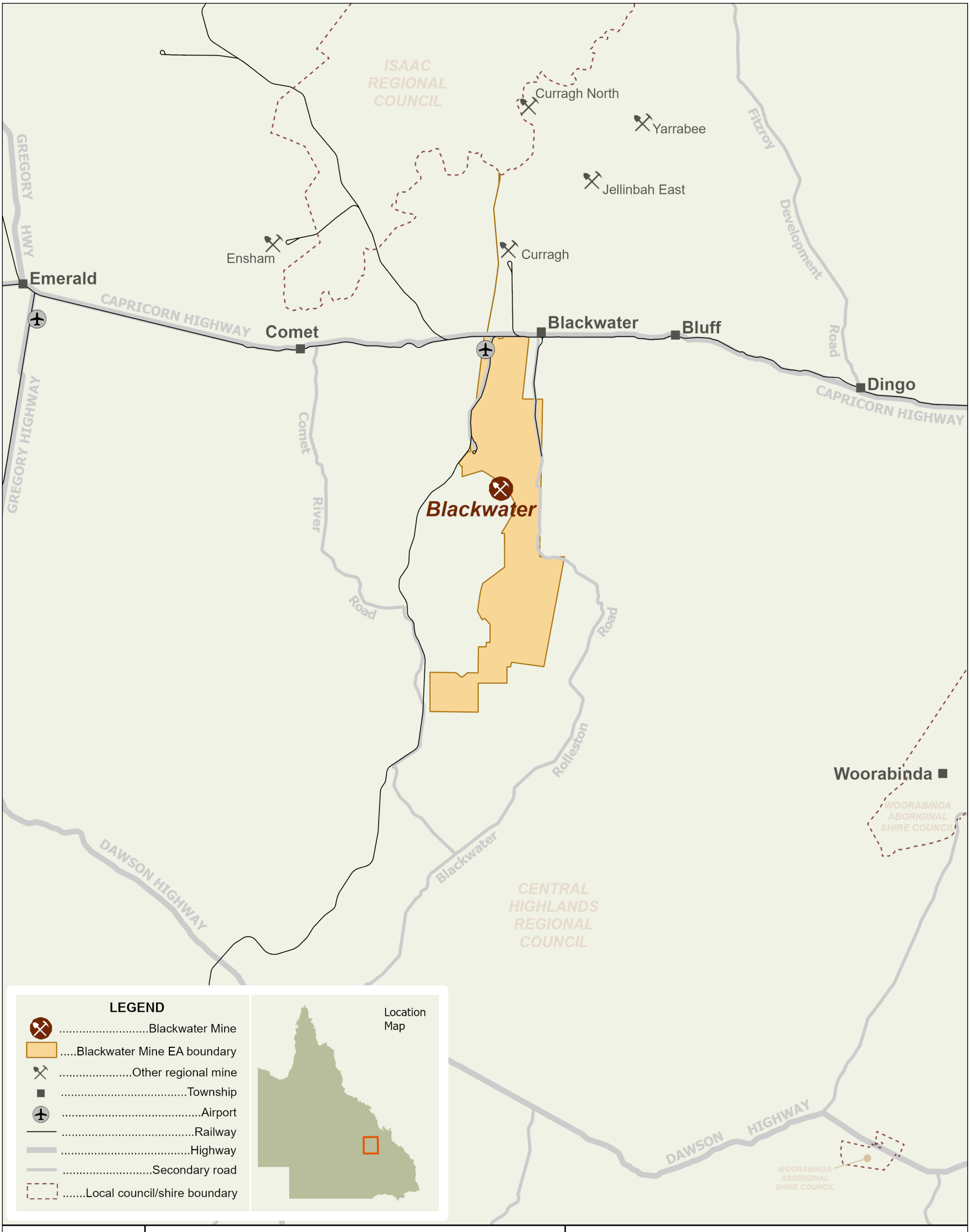

Figure 1 BWM location map

3.1.1.2 Mining tenements

BWM is located on twenty-one mining leases (MLs) as shown in Table 2 and illustrated in Figure 2.

Table 2 BWM mining tenements

Lease number	Permit name	Date granted	Total area (ha)	Lease expiry
ML1759	Blackwater Mine	2 December 1965	13,525	31-Dec-29
ML1760	Blackwater	1 January 1967	160.6	31-Dec-29
ML1761	Mackenzie River	1 February 1967	3.0427	31-Jan-30
ML1762	South Blackwater	01 May 1969	7,247.52	31-Jul-32
ML1767	South Blackwater Mine	19 September 1968	1,139.696	31-Aug-33
ML1771	Sirius Creek	12 October 1978	7,208.665	31-Oct-20
ML1772	South Blackwater Mine	25 March 1976	77.6491	31-Aug-33
ML1773	Laleham	25 September 1975	1,487.726	31-Aug-33
ML1792	Terang	15 January 1976	2406	31-Jan-38
ML1800	Wilpeena Mining Lease	10 May 1979	200.2657	31-May-21*
ML1812	Terang No. 2	28 September 1978	128	30-Sep-41
ML1829	Torgara	22 March 1979	32	31-Mar-21*
ML1860	Togara No. 2	25 March 1982	666.6	31-Mar-24*
ML1862	Mimosa	25 March 1982	628.7	31-Mar-24*
ML1907	Marshmead	1 August 1981	844.4	31-Aug-33
ML70091	Western	23 June 1994	809.3	31-Aug-33
ML70103	Wilpeena West	17 August 1995	134.7	30-Sep-41
ML70104	Sugarloaf	4 July 1996	274.1	31-Jul-22*
ML70139	South Marshmead	24 October 2002	946.3	31-Oct-23*
ML70167	Buckles	31 January 2002	3,754	31-Jan-23*
ML70329	Comet	9 August 2009	324.5	31-Aug-37

**Mining lease renewals have been lodged*

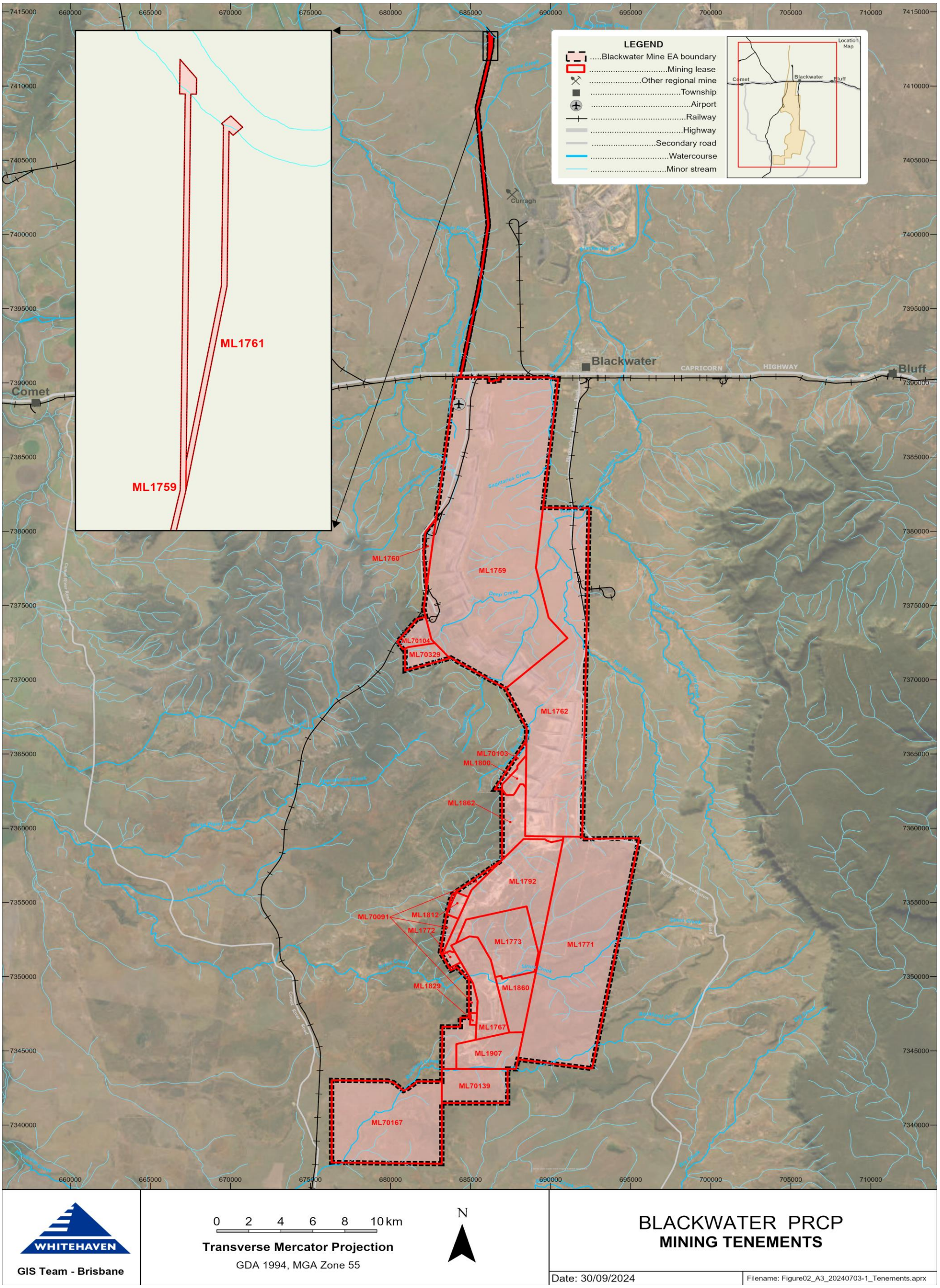

Figure 2 BWM mining tenements

3.1.1.3 Primary mine features and infrastructure

The current primary features and infrastructure at BWM are summarised in Table 3, with the site layout illustrated in Figure 3 and Figure 4.

Table 3 Primary mine features and infrastructure at BWM

Mine domain	Mine feature name
Pits and spoil dumps	• Boonie Doon Pit and spoil dump • Mimosa Pit and spoil dump • Sagittarius Pit and spoil dump • Burngrove Pit and spoil dump • Airstrip Pit and spoil dump • Besgrove Pit and spoil dump • Deep Creek Pit and spoil dump • Stewarton Pit and spoil dump • Tannyfoil Pit and spoil dump • Wilpeena Pit and spoil dump • Blackdown Pit and spoil dump • Terang Pit and spoil dump • Kenmare Pit and spoil dump • Laleham Pit and spoil dump • Togara Pit and spoil dump • Marshmead Pit and spoil dump
Underground mining areas (all historic)	• Kenmare 1 + 2 • Laleham • Sirius Creek No. 1 and No. 2 • Ballamoo • Clutha trial mine
Stockpiles	• Run-of-mine (ROM) coal stockpiles • Coal stockpiles • Topsoil stockpiles
Tailings storage facilities (TSFs) and rejects	• Boonie Doon TSF (in-pit) • NCPP TSF • Ramp 72 TSF • Laleham TSF • Ramp 74 TSF (in-pit) • Bottom Dam TSF (and ROM3 Rejects Area) • Ramp 36 Rejects
Dams	• Mine-affected water dams • Sediment dams • Process water dams
Creek diversions	• Deep Creek Diversion • Sirius Creek Diversion • Taurus Creek Diversion • Burngrove Creek Diversion • Rockland Creek Diversion

Mine domain	Mine feature name
Processing infrastructure	• North Coal Processing Plant (NCPP) • South Coal Processing Plant (SCPP) • Thermal Coal Plant (TCP) • Conveyors and transfer stations • Stackers and reclaimers
Rail infrastructure	• Rail line • Train load-out facility • Conveyors
General Infrastructure	• Administration, warehouse, crib • Workshops • Sheds • Fuel, oil and chemical storage • Fuel and wash bays • Power lines • Switchyards and substations • Communication and lighting towers • Sewage treatment plant • Fences
General disturbance	• Laydown areas • Access roads • Haul roads • Drains • Exploration
Rehabilitated areas	• Spoil dumps • Creek diversions and crossings • Heavy infrastructure areas • Stockpiles • Roads • General infrastructure • Surface areas above historic underground mines • Explorations areas • Existing rehabilitation • TSFs and rejects

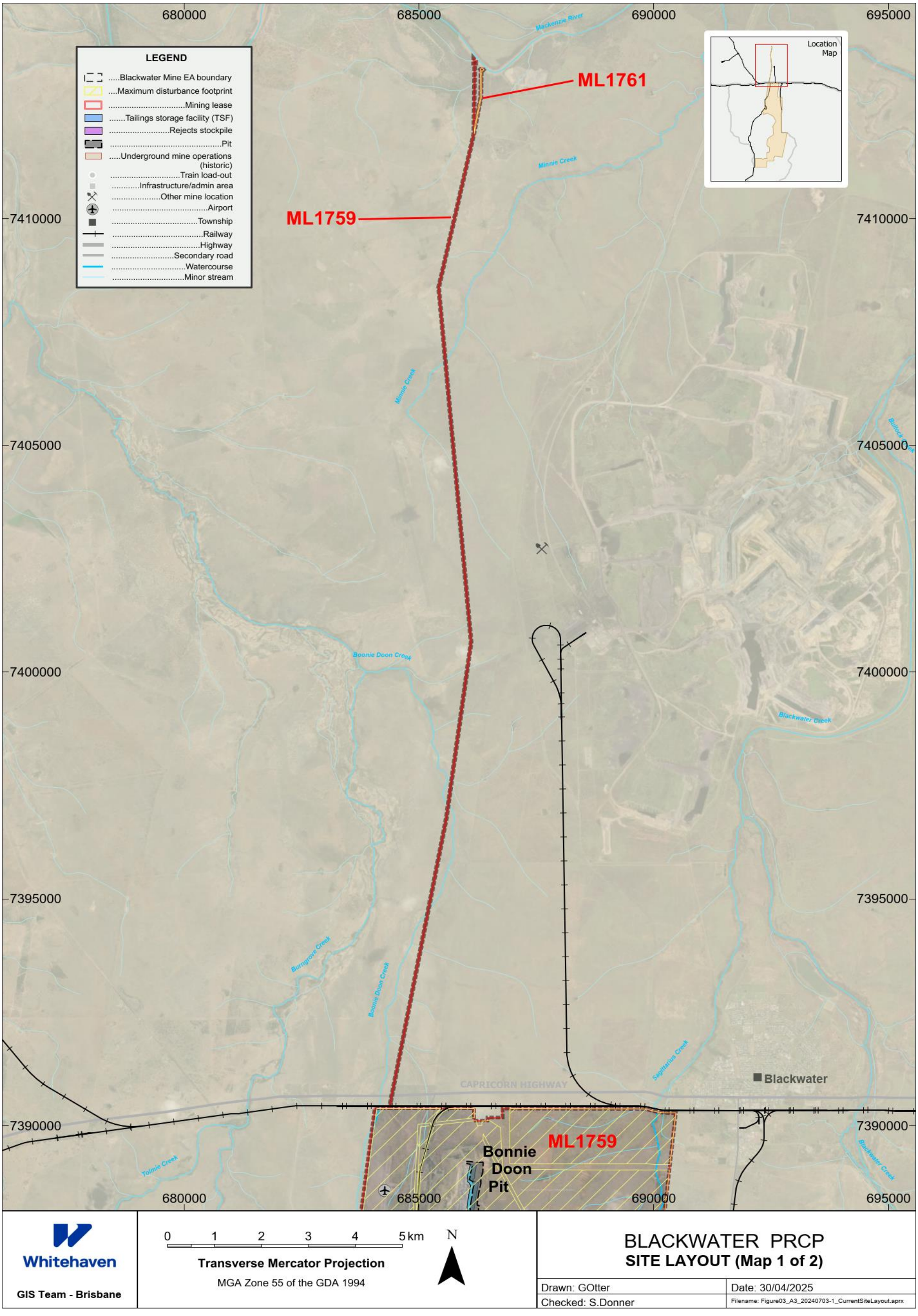

Figure 3 BWM site layout (North)

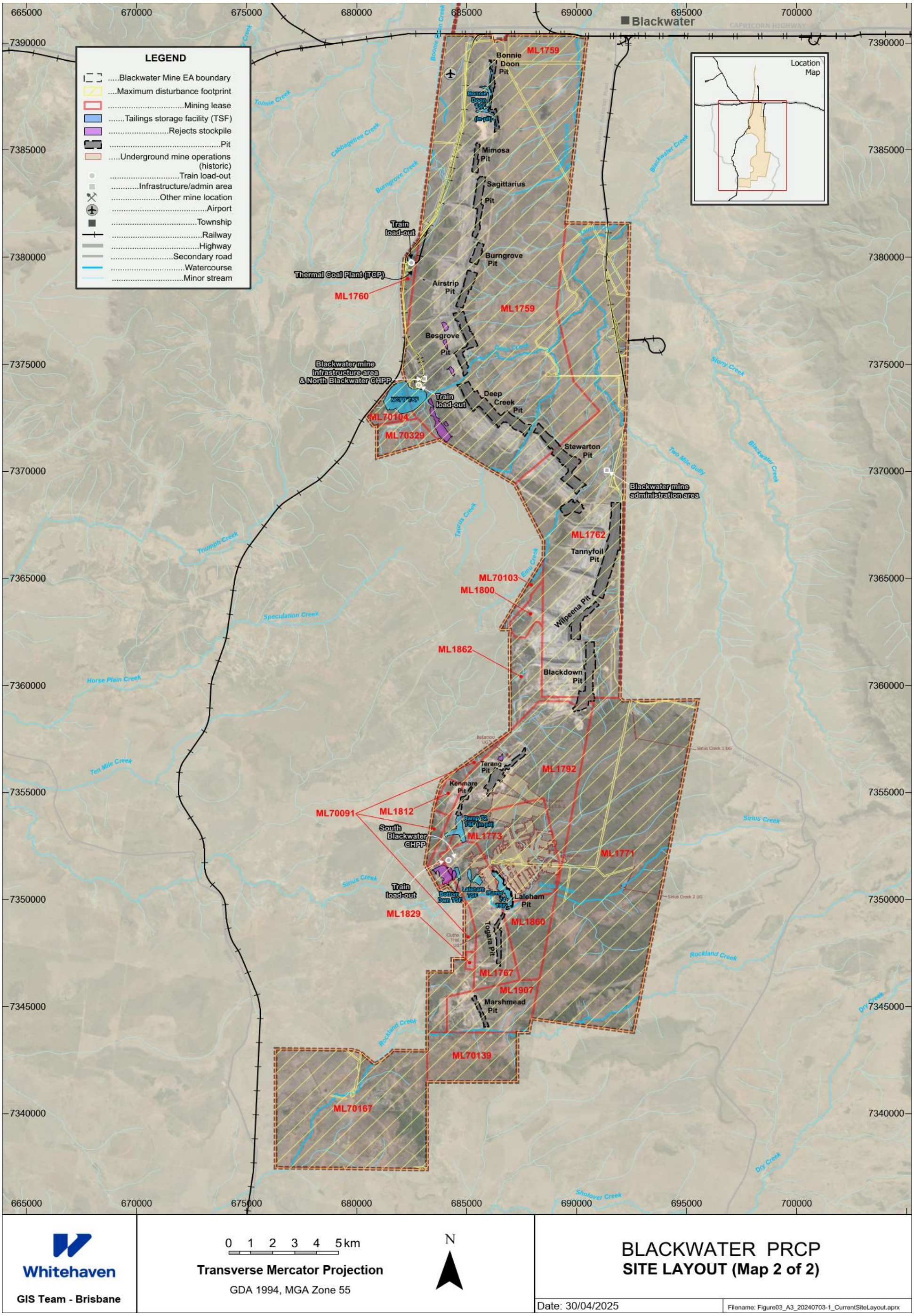

Figure 4 BWM site layout (North, Central and South)

3.1.1.4 Type of mining operation

BWM is a conventional open cut strip mine using both draglines and truck and shovel fleets.

Mining involves the removal and stockpiling of topsoil, drilling and blasting of overburden and interburden, mining of overburden and interburden by draglines and truck and shovel fleets, and mining of the coal by truck and shovel fleets.

The overburden and interburden are placed in spoil dumps within the void of the previous strips. As mining progresses down-dip and the pits get deeper, the spoil dumps increase in height to dump as much material in-pit as possible and to reduce out-of-pit dumping. For deep mines, this limits the amount of area available for progressive rehabilitation to the final outside spoil dump slopes until spoil dumps reach the final height, as more spoil material continues to be dumped on higher benches. Due to the large size of the BWM spoil dumps, the outside spoil dump areas (the areas to be rehabilitated) are only a small proportion of the operational dump surface as the dumps advance Figure 5.

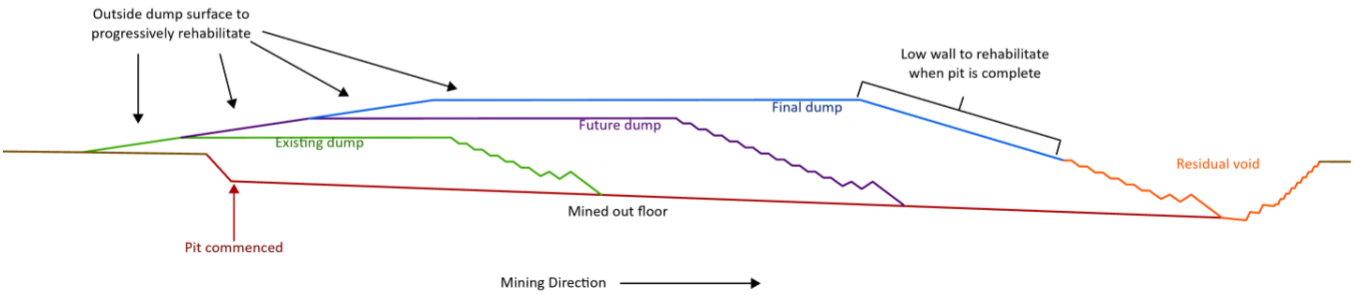

Figure 5 Indicative dump progression during life-of-mine (illustrative purposes only)

Coal is hauled from the pits to the coal handling and preparation plant (CHPP) ROM area, or to designated stockpiles. The coal is processed at the CHPP to produce a predominantly hard coking coal product - BWC (Blackwater Coke) and BWW (Blackwater Weak), for the export market. Product coal is loaded onto coal trains via an existing train load-out facility located adjacent to the CHPP and product stockpiles.

Coal waste fines are disposed of in dedicated TSFs, and coarse rejects are disposed of within the spoil dumps.

Product coal is transported by rail to the Port of Gladstone for export.

3.1.1.5 Proposed duration of the operation

Operations at BWM commenced in 1967. Based on current life-of-mine planning, approved extents (per the operation's EA area), are planned to be mined until 2113. This timeline assumes mining continues at current mining rates. Variations to the planned mining rates due to business or market conditions or refined resource information may change the proposed duration. Where necessary, a PRCP amendment will be submitted to the administering authority.

3.1.2 Baseline information

PRCP Guideline (Section 3.1)

In addition to the legislative requirements, the following information about the site, where relevant, is considered necessary by the administering authority (as per section 126C(1)(j) of the EP Act) to decide whether to approve the PRCP Schedule:

- *site topography (locally and regionally)*
- *climate (general and specific (rain, evaporation, temperatures)) including long-term projections*
- *geological setting*
- *site hydrology and fluvial networks*
- *groundwater levels and properties*
- *soil types, properties, and productivity*
- *land stability (pre-existing land degradation/erosion and predisposition to ongoing stability issues)*
- *vegetation communities and ecological data (including existing regional ecosystem mapping)*
- *fauna presence and populations*
- *pre-mining land use*
- *identification of underlying landholders*

Transitional PRC Plans must include any baseline information collected as part of an EIS process or original EA application. If this information is unavailable, the reasons should be explained in this section of the rehabilitation planning part. Transitional PRC Plans are not required to demonstrate how aspects of the mine site have been designed for closure for existing or approved disturbance. However, any expansion to an existing site must demonstrate how it has been designed for closure. The rehabilitation/improvement planning must include data from when mining first commenced up until planned surrender. The transitional provisions of the EP Act include an exceptional circumstance for when land is available for rehabilitation.

3.1.2.1 Site topography

The most prominent topographic feature in the region is the Blackdown Tablelands (also known as the Blackdown Ranges) – a sandstone plateau situated about 10 km east of BWM mine, which rises abruptly from the surrounding plains to an elevation of approximately 900 metres Australian Height Datum (mAHD); however, most of the Tablelands have an elevation of around 340 to 400 mAHD. The relatively steep slopes associated with the Blackdown Tablelands contrast with the generally lower relief areas west of the ranges at BWM, particularly throughout the northern half of the site.

A topographic divide runs through the site and separates the mine into a distinct northern catchment area that drains to Blackwater Creek, and a southern area that flows to the Comet River. The topography of the mine site consists of gently undulating plains in the north, with gravelly ironstone ridgelines and hills to the south (see Figure 6).

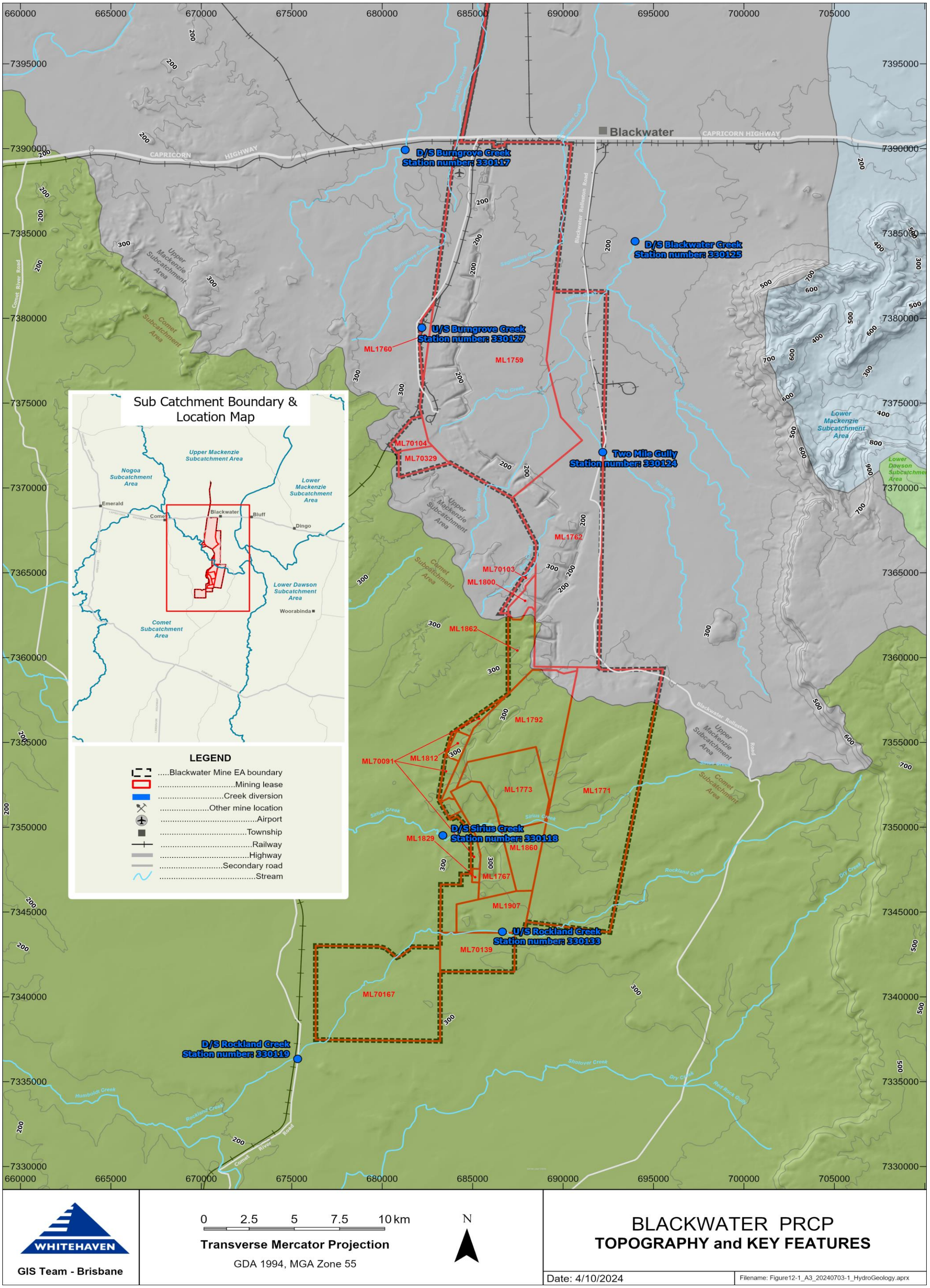

Figure 6 Topography and key features

3.1.2.2 Climate

BWM is located in a semi-arid climatic zone, which is characterised by high summer temperatures, warm dry winters and a distinct wet and dry season; with higher rainfall and higher evaporation occurring over the summer months (December to February). Climate data is available from the Bureau of Meteorology (BOM) weather stations near Blackwater township [Blackwater water treatment plant (station ID 035290) from 1995 to 2010, Blackwater airport (station ID 035134)] from April 2023 to present; and Emerald Airport (station ID 035264) between 1981 to present) (BOM, 2024). A summary of climate data at BWM is provided in Table 4 and Figure 7.

3.1.2.2.1 Temperature

Average maximum temperatures range from approximately 23°C in June/July to 34°C in December/ January, with average minimum temperatures ranging from approximately 9°C in June/July to 22°C in December/January.

3.1.2.2.2 Rainfall

The average annual rainfall is approximately 547 mm at Blackwater Township and about 561 mm at Emerald.

Rainfall events are often associated with thunderstorms, which are typically short-lived, intense and have variable coverage. Sustained rainfall over a large landscape area is experienced when tropical lows with cyclonic activity occur in coastal areas. However, periods of prolonged drought do occur within the region

3.1.2.2.3 Evaporation

The average annual evaporation is approximately 2000 mm for the area. As would be expected for the region, the evaporation rate is highest in the summer months (December/January) and lowest in the cooler months (June/July).

Table 4 Average total monthly rainfall, evaporation and evapotranspiration (Jan 1970-Oct 2023)

Average total monthly	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Rainfall (mm)	88	75	48	29	32	23	22	16	24	46	59	83	547
Evaporation (class A Pan) (mm)	230	186	189	149	115	91	99	131	172	214	222	241	2,037
Evapotranspiration (Moreton's areal actual) (mm)	134	113	106	68	43	31	35	52	71	98	115	134	999

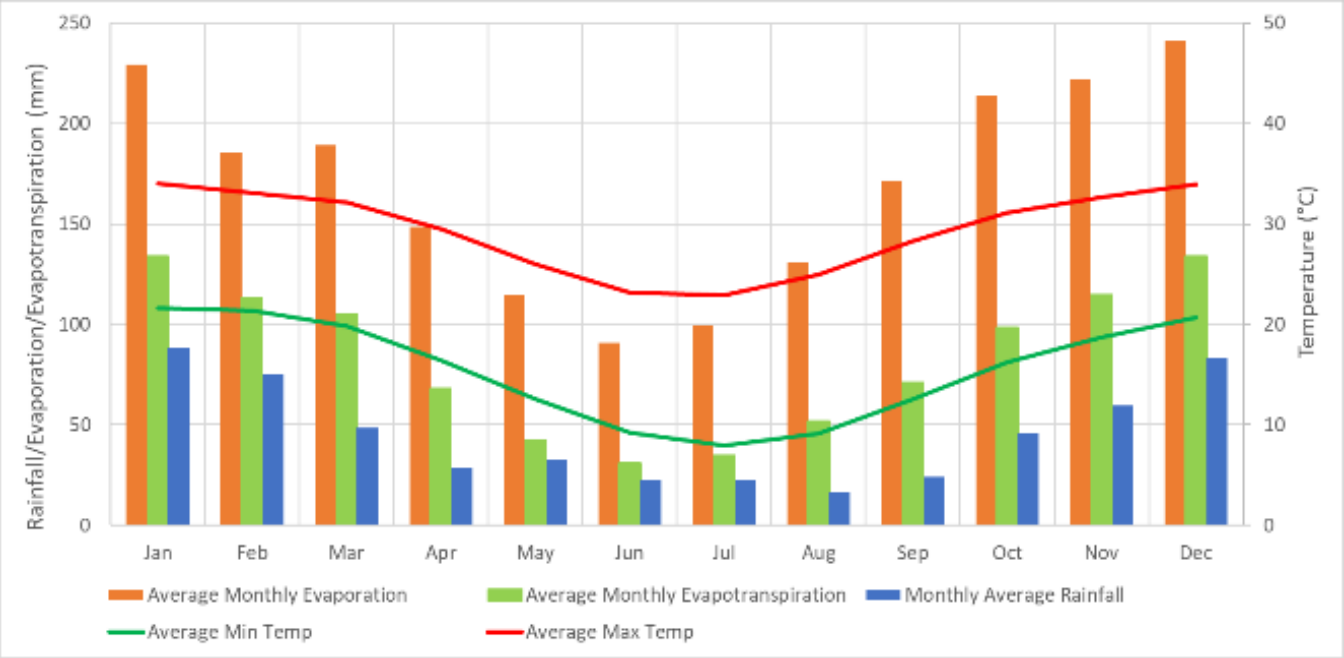

Figure 7 Average monthly evaporation, evapotranspiration, rainfall and temperature (Jan 1970 to Oct 2023)

3.1.2.2.4 Wind

Wind records for Emerald Airport for January-April show an easterly predominance of moderate strength (1-20 km/h), with south-easterlies dominating in May-July. East to north-easterly winds predominate for August-December with strong gusts increasing from October to December over 100km/h. Daily mean wind speeds are consistently of moderate strength (1-20 km/h).

3.1.2.2.5 Long-term climate projections

To account for potential future climate uncertainties this PRCP is supported by technical studies that have utilised climate change modelling and adaptation measures within their hydrologic designs and mine water planning.

3.1.2.3 Geology

3.1.2.3.1 Regional geology

BWM is located in the Bowen Basin, one of five major foreland sedimentary basins formed along the eastern side of Australia during the Permian geologic period. The north-south oriented Bowen Basin stretches from Townsville in the north to the Queensland-New South Wales border in the south and is the largest productive coal basin in Australia.

The stratigraphic sequence across the Study Area primarily comprises unconsolidated Quaternary-aged sediments that unconformably overlie consolidated Triassic and Permian-aged sequences. The Tertiary sediments and basalt, and Quaternary alluvium are present as the cover that overlays the consolidated basal units. At the eastern extents of the Study Area, the Triassic-aged Clematis Group outcrops with a dramatic change in topography associated with the comparatively weathering-resistant sandstones of that geologic unit.

The stratigraphic sequence of the Study Area, from youngest to oldest, primarily comprises unconsolidated Quaternary-aged sediments that unconformably overlie consolidated Triassic and Permian-aged sequences, as presented in Figure 8, Figure 9 and Table 5

3.1.2.3.2 Structural geology

The structural geology in the region is characterised by gently folded consolidated sediments and a major north to north-west striking fault system which forms the Jellinbah Thrust fault system (AGE, 2013). A series of easterly dipping thrust faults occur parallel to the Jellinbah Thrust, including the Shotover Fault (occurring to the east of the Study Area where the Clematis Group outcrops) and the Como Fault that runs through the Curragh Mine (- Reference the Solid Geology Figure below) (Mallet et al., 1985). Regionally the structure is defined as a faulted monoclinal limb (AGE, 2013).

The strata in the vicinity of the Project Area are heavily influenced by a series of easterly dipping, north to northwest striking faults (AGE, 2008). The Shotover Fault at the southeastern boundary of the Study Area is of major importance as there is a displacement of up to 3,000 m (AGE, 2013). Locally, thrust faulting that occurs within the BWM may be attributed to thrusts occurring in the footwall of the Shotover Fault. Local structure is influenced by strike-slip movement of basement rocks. Local fault displacement is reported to be less than five meters on average but can reach up to 20 m (AGE, 2008).

Table 5 Summary of stratigraphy in the study area

Age	Unit	Thickness (m)	Description
Quaternary	Alluvium	0.5-12	Alluvium - silt, clay, sand and gravel.
Tertiary	Basalt	30	Weathered basalt soils, residual basalt. Moderately weathered and fresh basalt.
	Sediments/ sedimentary units	30	Clays, sandstones, sands, gravels, often poorly consolidated (Tu, Te(w), Tf and TQa). Regional mapping shows highly weathered Tertiary sediments display some areas of duricrust (Td) and partially cemented fanglomerate (Tf)
Triassic	Clematis Group	100-800	Weathering resistant medium to coarse grained quartzose to sublabile and micaceous sandstone, siltstone, mudstone and conglomerate.
	Rewan Group	50-300	Lithic sandstone, pebbly lithic sandstone, green to reddish brown mudstone and minor volcanilithic pebble conglomerate (at base); deposited in a fluvial-lacustrine environment. Occurs 2-6 m above the Aries seam.
Permian	Rangal Coal Measures	100	Feldspathic and lithic sandstone, carbonaceous mudstone, siltstone, tuff and coal seams. Coal seams include the Aries, Castor, Pollux and Orion and Pisces seams. The Pollux and Orion seams commonly coalesce into a single seam, which is referred as the Argo seam.
	Burngrove Formation	170	Sandstones, siltstones and mudstones, and banded coal seams frequently interbedded with tuff and tuffaceous mudstones. Coal seams include the Virgo and Leo seams.

3.1.2.4 Geological setting

Blackwater sits on the eastern flanks of the Comet Ridge, a major regional anticline. The sediments at BWM strike north-south, with an average dipping towards the east of 3-5° (although there are significantly steeper areas associated with faulting) however, the strike and dip direction change from South Marshmead to Humboldt. The lithology at BWM is characterised by typical basin-fill sediments, comprising mudstone, claystone, siltstone, sandstone (typically fine- to medium-grained), carbonaceous sediments and coal seams.

Minor basalt is encountered within Tertiary-age material. Excluding the far southern area that has not been mined (and is subject to development approval), the depth to base of weathering averages about 23 m below natural surface throughout but ranges from about 10-60 m below natural surface, depending on the local topography. Depth to base of weathering is generally highest in the far southern area (not currently mined), with an average depth to base of weathering of about 45 m below natural surface.

The economic coal seams in the Blackwater area are contained within the late Permian-age Rangal Coal Measures. The Rangal Coal Measures are underlain by the Burngrove Formation (which outcrops west of the site) and are overlain by the Early Triassic-age Rewan Formation. In some areas at the southern end of the mine, the Rangal Coal Measures are unconformably overlain by up to 45 m of partially consolidated Cainozoic (Tertiary) sands, gravels, basalts and clays. Elsewhere on the mine, Tertiary cover is usually much thinner. Most areas on the mine are also capped by a thin veneer of Quaternary-age sediments (typically alluvial sediments).

Blackwater mine currently exposes three principal seam groups from the Rangal Coal Measures – called the tops, middles and lowers [historically, the southern BWM area (what was once called South BWM) named these seam groups Aries (tops), Castor (middles), Pollux/Orion/Argo (lowers)]. The northern end of the mine predominately mines the lower seam group, the central area mines the middle the top, middle and lower seam groups and the southern area mines all three seam groups. The seams split and re-join through the mine often creating upper and lower sub-sections of itself, typically called riders (e.g. Top Rider, Middle Rider).

Geological cross-sections through the existing pits and proposed pit areas (including current topography) are provided in Attachment A of Appendix 4.7. The seam groups are shown in the geological sections.

Due to the generally eastward dip of the seams (southward dip in the three southern-most pits) and the nature of the seams splitting and coalescing, the location of the weathered zone varies from pit to pit (north to south) and also from west (start of mining) to east (current and future mining).

The geology of the study area is discussed in the detailed report – *Blackwater Mine Transitional PRC Plan Hydrogeology Assessment* provided in Appendix 4.2 (SLR, 2024).

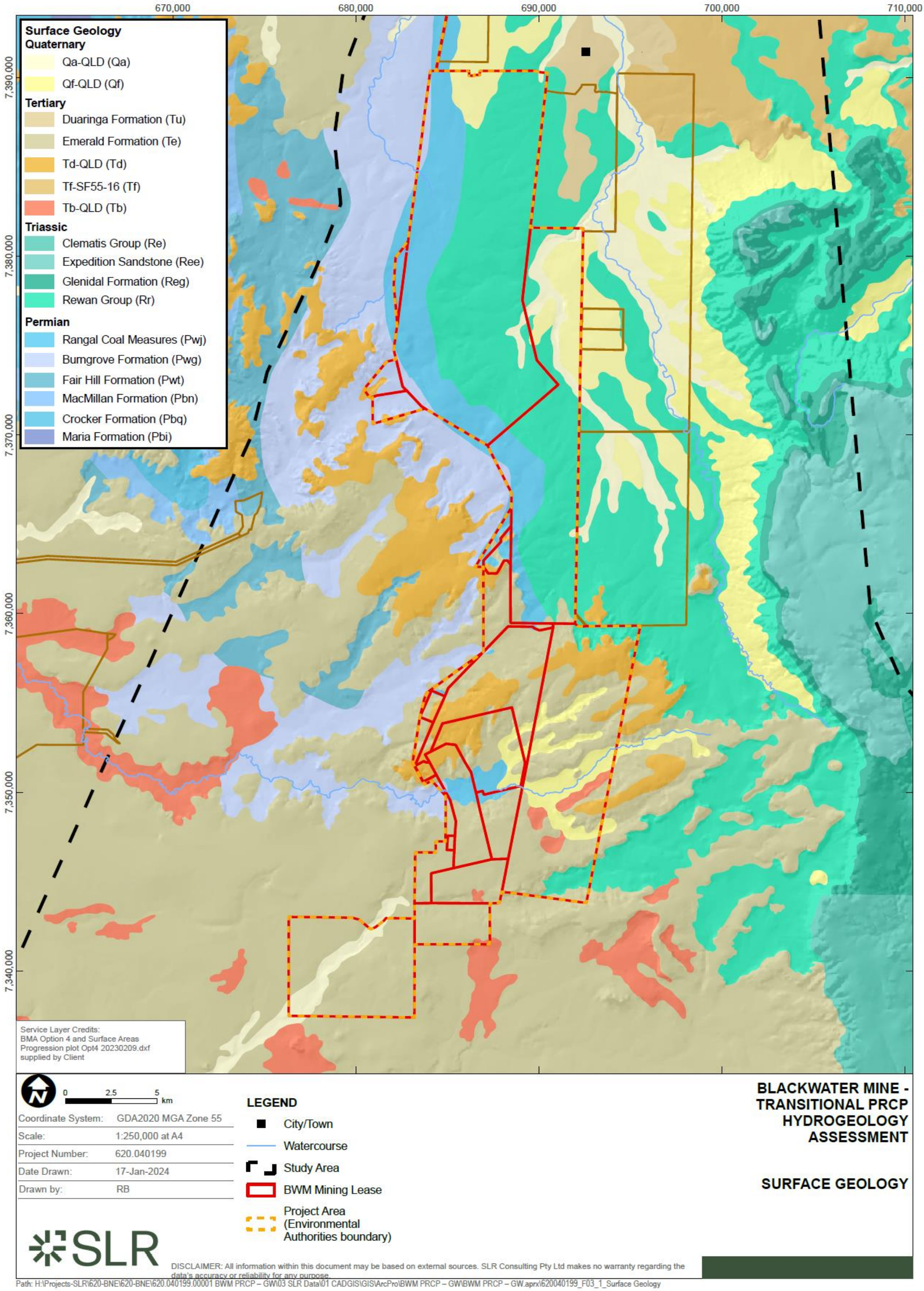

Figure 8 BWM surface geology

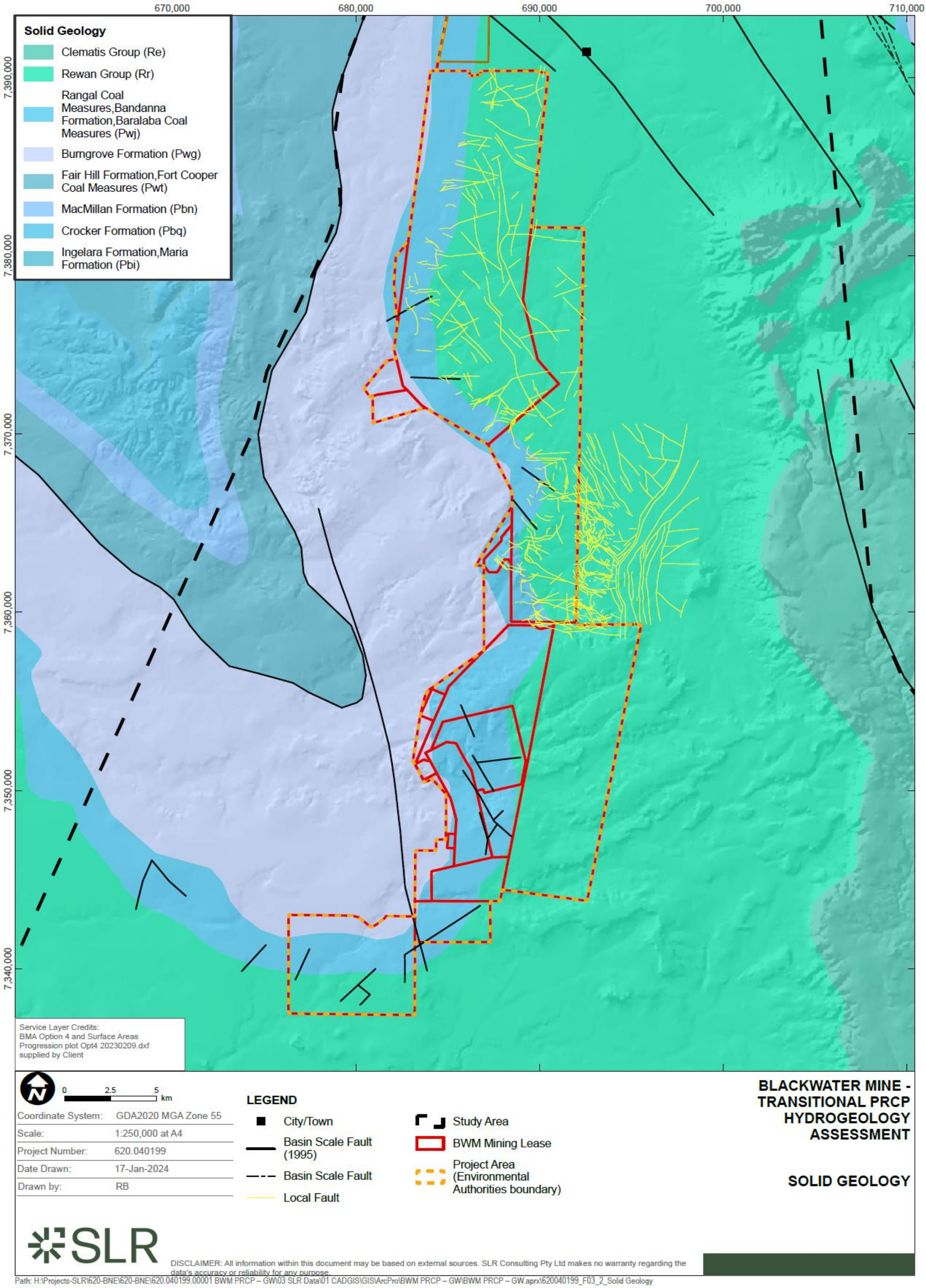

Figure 9 BWM solid geology

3.1.2.5 Site hydrology and fluvial networks

3.1.2.5.1 Site hydrology

The BWM EA area straddles both the Mackenzie River and Comet River sub-basins of the Fitzroy Basin. The northern portion of the site, down to the southern end of the Stewarton/Ballamoo residual void, is in the Mackenzie Southern Tributaries catchment. Surface drainage from this northern portion of BWM generally runs in a northerly direction through Blackwater Creek to the Mackenzie River. The southern portion of the BWM is in the Comet Eastern Tributaries catchment, which generally drains in a westerly direction towards the Comet River, which in turn flows to the north before its confluence with the Mackenzie River.

Blackwater Mine is traversed by a number of tributaries, which flow intermittently with extreme variability in flow, both seasonally and annually. Ephemeral creeks are utilised by rural properties for stock as well as supporting a range of ecological processes and functions. These values are described by WBM (1999 and 2001). The Bedford Weir was constructed to harvest water from the Mackenzie River to supply water for local industry and community needs.

Although the water quality of streams may have been altered due to clearing, agricultural use and the regulation of stream flows not related to mining activity, it is recognised that mining may magnify impacts. The water quality of creeks has been recorded for many years. Table 6 shows measured pH and EC values for selected creeks upstream of operations. The values are considered natural (or background) values and are derived from historical monitoring data from rising stage sampler sites. Actual monitoring data varies considerably.

Table 6 Water quality of selected creeks upstream of operations

Source	Median pH	Median EC (µS/cm)	Range of EC values (µS/cm)
Sirius Creek	6.8	677	58-1900
Rockland Creek	6.8	125	69-900
Taurus and Emu Creeks	7.3	190	20-1200
Burngrove Creek	7.9	150	20-280
Two Mile Creek	7.5	90	50-190

Source: Residual Void Investigation (BMA, 2020)

Surface water resources in the vicinity of the mine site are scheduled under the *Environmental Protection (Water and Wetland Biodiversity) Policy 2019* (Qld) (EPP Water). Details of the prescribed water Environmental Values (EVs) and Water Quality Objectives (WQOs) are contained in the following Department of Environment and Heritage Protection (DEHP) documents:

- Mackenzie River Sub-basin Environmental Values and Water Quality Objectives Basin No. 130 (part), including all waters of the Mackenzie River Sub-basin September 2011.
- Comet River Sub-basin Environmental Values and Water Quality Objectives Basin No. 130 (part), including all waters of the Comet River Sub-basin September 2011.

EVs of the sub-catchments at BWM are summarised in Table 7.

Table 7 BWM surface water environmental values

Sub-catchment	Aquatic ecosystems	Irrigation	Farm supply/ use	Stock water	Aquaculture	Human consumer	Primary recreation	Secondary recreation	Visual recreation	Drinking water	Industrial use	Cultural and spiritual value
Mackenzie Southern Tributaries	✓	-	✓	✓	-	✓	✓	✓	✓	✓	✓	✓
Comet Eastern Tributaries	✓	✓	✓	✓	-	✓	✓	✓	✓	✓	✓	✓

The northern portion of BWM predominantly lies at the top of the local creek catchments with surface runoff from the eastern side draining towards Sagittarius and Taurus Creeks and the western side draining to Burngrove Creek. Sagittarius, Taurus and Burngrove Creeks run in a northerly direction towards the Mackenzie River.

The surface water drainage within the southern portion of BWM generally runs from east to west and the site falls within the local creek catchments of Sirius and Rockland creeks. Sirius Creek runs through a diversion channel to the south of the Laleham Pit/Ramp 72 tailings storage before running in a north-westerly direction towards the Comet River. Rockland Creek traverses the site to the south of Marshmead Pit, through the Rockland Creek Dam and a diversion channel. Rockland Creek beyond the EA boundary flows in a south westerly direction towards Comet River.

The watercourses and drainage lines present within the BWM EA area are highly ephemeral, with flows only occurring for short periods during and immediately after rainfall events. The watercourses that intersect BWM are summarised in Table 8 and shown in Figure 10.

Table 8 Watercourses and key drainage lines within and immediately surrounding BWM

Watercourse	Details	Description
Northern catchment creeks		
Sagittarius Creek and unnamed tributaries	Non-perennial Minor Strahler stream order: 1-3	• The upstream tributaries originate on the eastern side of the Bonnie Doon, Mimosa and Sagittarius pits. • Sagittarius Creek passes to the west of the Blackwater township, before its confluence with Blackwater Creek. • The portion of Sagittarius Creek within the BWM EA area is an unmapped drainage feature under the Water Act (2000). • Non-mining related farm-type dams are present on the minor tributaries.
Bonnie Doon Creek	Non-perennial Minor Strahler stream order: 1-2	• The upper reaches of the Bonnie Doon Creek catchment include the western side of the Bonnie Doon Pit and the Blackwater Airport. • Confluence with Burngrove Creek to the north of BWM.
Burngrove Creek and unnamed tributaries	Non-perennial Minor Strahler stream order: 1-3	• The upper reaches of Burngrove Creek and its tributaries drain the local catchment area to the west of Besgrove, Airstrip and Sagittarius pits. • Burngrove Creek drains in a northerly direction before its confluence with the Mackenzie River. • A small portion of Burngrove Creek within the EA area is an unmapped drainage feature under the Water Act (2000).

Watercourse	Details	Description
		• Within the EA boundary, select tributaries have been diverted through drains on the western side of the mining operations. • Burngrove Creek also flows through the Burngrove Creek Retention Dam which was previously part of the mine's water management system.
Taurus Creek and unnamed tributaries	Non-perennial Minor Strahler stream order: 1-4 Catchment area: 297 km^2 Main stream length: 22 km	• The headwaters of Taurus Creek are located to the west of BWM and flow in a north-easterly direction through a diversion between Deep Creek and Stewarton pits. • The Taurus Creek diversion includes an excavated storage called the R42 Water Point Dam (R42 Dam) in the upstream section of the diversion immediately prior to flowing between the two pits. The creek is also impounded downstream of the diversion by New Taurus Creek Dam • The Taurus Creek confluence with Blackwater Creek is located in the proximity of the northeastern corner of ML1762.
Emu Creek	Non-perennial Minor Strahler stream order: 1-3	• Pre-mining, Emu Creek was a tributary of Two Mile Gully. Currently, the creek is diverted on the western side of Stewarton Pit and flows north before draining into Taurus Creek on the western side of the operations.
Deep Creek and unnamed tributaries	Non-perennial Minor Strahler stream order: 1-2	• The tributaries originate to the west of BWM and flow in a north easterly direction through a diversion channel between Besgrove and Deep Creek pits. • Deep Creek has a confluence with Taurus Creek on the eastern side of ML1759.
Two Mile Gully and unnamed tributaries	Non-perennial Minor Strahler stream order: 1-4 Catchment area: 172 km^2 Main stream length: 23 km	• Located on the eastern side of the current operational area, the local catchment includes areas to the east of Blackdown, Wilpeena, Tannyfoil and Stewarton pits. Confluence with Taurus Creek within ML1762.
Blackwater Creek	Non-perennial Major Strahler stream order: 5 Catchment area: 760 km^2 Main stream length: 57 km	• Located to the east of the EA, it is the major watercourse that collects surface runoff from the northern portion of the EA. • Taurus Creek flows into Blackwater Creek to the east of the EA area. • Blackwater Creek flows to the north past the Township of Blackwater before its confluence with the Mackenzie River. • Blackwater Creek is not located within the EA boundary.
Southern catchment creeks		
Sirius Creek and tributaries (including Speculation Creek)	Non-perennial Minor Strahler stream order: 1-4 Catchment area: 207 km^2 Main stream length: 34 km	• Sirius Creek drains in an east to west direction into the Comet River to the west of BWM. • The headwaters of Sirius Creek are located on the eastern side of the EA and flows are directed through a diversion to the south of Laleham Pit (Ramp 74) and through Old Cut 4 Dam (which forms part of the water licence).
Rockland Creek and tributaries	Non-perennial Minor Strahler stream order: 1-3	• Rockland Creek is an ephemeral tributary of the Comet River. It drains in an east to west direction into the Comet River to the west of BWM. The headwaters of Rockland Creek are located at the base of the Shotover Range to the east of BWM.

Watercourse	Details	Description
		• Flows through Rockland Creek are currently regulated through the Rockland Creek Dam and directed to the south of Marshmead Pit via a diversion.

Of the above creeks, Burngrove Creek, Deep Creek and Taurus Creek in the northern catchment and Sirius Creek and Rockland Creek in the southern catchment are the most significant watercourses within and surrounding BWM. All other minor and unnamed tributaries flow into one of these five key watercourses.

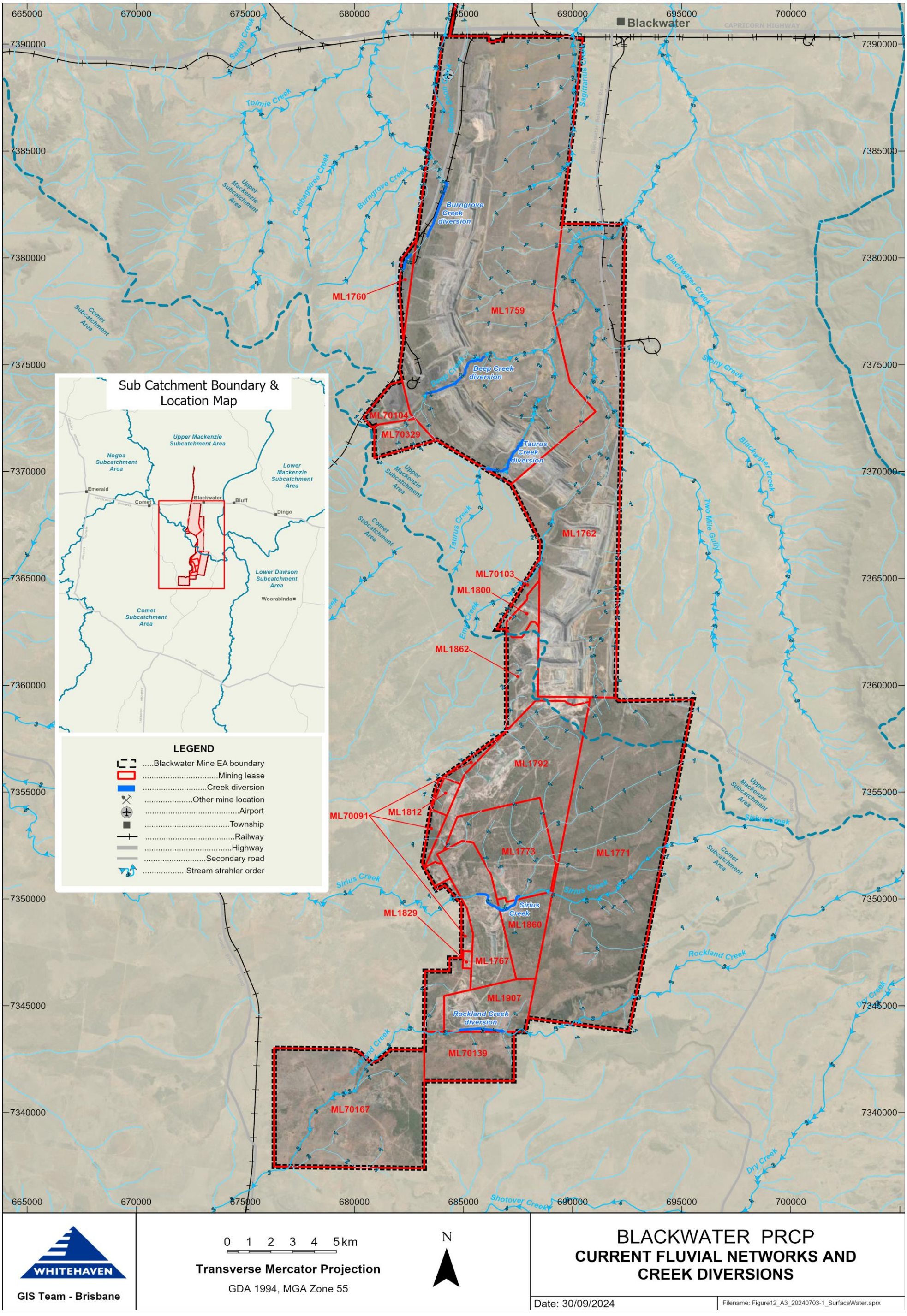

Figure 10 BWM current fluvial network and creek diversions

3.1.2.5.2 Water licences

The following water licences are associated with the BWM mining operations:

- Diversion of watercourses (creek diversions shown in Figure 63).
- Interfering with the flow of water by impounding.
- Taking of water.

Water licences applicable to the BWM operation are summarised in Table 9.

Table 9 Water licences applicable to BWM

Authorisation number	Authorisation activity	Authorised purpose	Expiry date
40137F	Licence to interfere by diversion - Burngrove Creek	Divert the course of flow	30/06/2111
606739	Licence to interfere by diversion -Burngrove Creek	Divert the course of flow	30/06/2111
51464F	Licence to interfere by impounding - embankment or wall - Burngrove Creek (Burngrove Creek Retention Dam)	Impound water	30/06/2111
603608	Licence to take water - Burngrove Creek	Industrial	30/06/2111
52652F	Licence to interfere by diversion - Sirius Creek	Divert the course of flow	30/06/2111
409112	Licence to interfere by diversion - Taurus Creek	Divert the course of flow	30/06/2111
57721WF	Licence to interfere by impounding – embankment or wall - Taurus Creek (Taurus Creek Dam)	Impound water	30/06/2111
57720WF	Licence to take water - Taurus Creek (Taurus Creek Pump)	Industrial	30/06/2111
57711WF	Licence to interfere by diversion - Rockland Creek	Divert the course of flow	30/06/2111
609051	Licence to interfere by diversion - Deep Creek	Divert the course of flow	30/06/2111
57801WF	Licence to interfere by impounding - embankment or wall - Deep Creek (New Deep Creek Dam)	Impound water	30/06/2111
100883	Licence to take water – Deep Creek (New Deep Creek Dam Pump)	Impound water	30/06/2111
52648F	Licence for water harvesting – Shotover Creek	Stock watering, water harvesting	30/06/2011
52649F	Licence for water harvesting – Shotover Creek	Stock watering, water harvesting	30/06/2011

In accordance with Section 334ZP of the *Mineral Resources Act 1989* (Qld) and Section 1283 of the *Water Act 2000* (Qld), a water license for the taking of, or interfering with, underground water is considered granted where the taking of underground water, required for the safe extraction of the resource or due to evaporative loses on an approved mining project, began prior to commencement of the *Water Act 2000*. As BWM commenced operations prior to 2000, a water license in addition to those listed in the above table is considered to be granted for the taking and interfering of underground water.

3.1.2.5.3 Fluvial water quality

The water quality of the streams within the BWM catchments has been altered over time due to many years of bush clearing, agricultural activities, mining and rural/urban development.

Surface water quality within the fluvial network that intersects BWM has previously been assessed through a Receiving Environment Monitoring Program (REMP), undertaken in accordance with site-specific EA Conditions (F22-F24). The REMP reports and associated surface water quality results have been supplied to the administering authority as part of the EA's annual reporting requirements. The 2022 REMP report includes water quality data for the period 2010 to 2021.

Since 2022, surface water monitoring has been undertaken as part of the wider Fitzroy Basin Regional Receiving Environment Monitoring Program (FRREMP), which aims to provide a more regional and consistent monitoring approach to coal mines throughout the basin.

The background surface water quality results are reflective of the upstream catchment and land uses, which primarily consist of grazing and woodland habitat.

3.1.2.6 Hydrogeology

A hydrogeological assessment, including conceptual and numerical modelling, has been undertaken to support the development of this PRCP. The report, *Blackwater Mine Transitional PRC Plan Hydrogeology Assessment*, is provided in Appendix 4.2 (SLR, 2024). In addition, Appendix 4.2 also includes the following report which was prepared in response to the DETSI NPM Notice received 25 November 2024: *Bottom Dam Tailings Storage Facility and Sirius Creek Preliminary Hydrogeological Review and Investigation – Revision 3.0* (SLR 2025).

3.1.2.6.1 Hydrogeological units

Groundwater at BWM comprises the following key hydrogeological units:

- Alluvium – Alluvial deposits are associated with local creeks. In recent years, the alluvium local to the mine site has been found to be limited in extent, and dry. The alluvium forms a localised unconfined aquifer when saturation is found.
- Tertiary Sediments and Basalt – Unconsolidated surface layer of weathered rock (also termed regolith) including Tertiary strata and basalt flows, which may provide a preferential flow pathway for groundwater, if the groundwater table exceeds the base of weathering. The unit forms an unconfined aquifer when saturated.
- Clematis Group – Forms an unconfined aquifer where it outcrops at the eastern margin of the Study Area.
- Rewan Group – Considered a regional scale aquitard, however, local permeability testing indicates hydraulic conductivity values may be higher in the upper weathered zone of the unit.
- Rangal Coal Measures – Coal seams of this unit form the primary regional aquifer. Groundwater flow is primarily within the coal seams (via interconnected cleats and fractures), which are confined by low permeability overburden and interburden that essentially form aquitards. The coal measures are highly locally faulted resulting in "compartmentalisation" with coal seams juxtaposed against lower permeability interburden.
- Burngrove Formation – Coal seams of this unit form a regional scale aquifer in conjunction with low permeability overburden and interburden that essentially form aquitards. Considered the basement formation for the purposes of this assessment.

3.1.2.6.2 Groundwater monitoring network

Douglas Partners (1998) investigated local bores in the South Blackwater area and indicated limited data exists for groundwater prior to mining. The available data has been presented on Table 10 and indicate the BWM groundwater monitoring network bores for which data is available for this baseline assessment.

The assessment excluded local shallow contaminant investigation bores (subject to separate investigations for this PRCP), and bores characterised as unsuitable to support the EA monitoring program in GHD (2023).

The monitoring data for this assessment was collected from 51 monitoring bores (Figure 11) and the period for which groundwater quality and groundwater level data is available from these bores is indicated below.

Information on the monitoring bore network is in Table 10 and can be summarised as:

- Quaternary Sediments, including seven monitoring bores (four of which are dry) installed at depths ranging from 7 to 16 mBGL, with available data during 2021-2023.
- Tertiary Sediments and Basalt, including four monitoring bores (one of which is dry) installed at depths from 9.5 to 117 mBGL, with available data during 2009-2023.
- Triassic Rewan Group, including five monitoring bores (one of which is dry) installed at depths ranging from 15 to 97 mBGL, with available data during 2020-2023.
- Rangal Coal Measures, including 29 monitoring bores installed at depths ranging from 25 to 234 mBGL, with available data during 2009-2023.
- Burngrove Formation, including four monitoring bores installed at depths ranging from 18 to 73 mBGL, with available data during 2011-2023.

Groundwater level trends for each of the geological units are presented in graphs in Appendix 4.2.

Table 10 Details of the BWM groundwater monitoring network

Bore	Easting[1]	Northing[1]	TOC (mAHD)	Depth (mBGL)	Screened Interval (mBGL)	Monitored Unit	Area	Status	Data Availability (dates)			
									min WL	max WL	min WQ	max WQ
BWM_MB03_01	692229	7381513	181.76*	12	8-11	Alluvium	North	Active (dry)	-	-	-	-
MB19BWM07A	689280	7376878	198*	7	4-7	Alluvium	North	Active (dry)	-	-	-	-
BWM_MB01_01	688102	7343658	261.35	85	-	Alluvium	South	Active	17-03-2023	29-06-2023	17-03-2023	20-07-2023
MB19BWM_21A	679959	7341095	236.24*	15	9-15	Alluvium	South	Active	31-01-2023	18-07-2023	-	-
MB19BWM_26A	683557	7333190	225.86*	15.5	9-15	Alluvium	South	Active	31-01-2023	31-01-2023	-	-
MB19BWM_19A	677021	7338034	223.55*	14	9-12	Alluvium	South	Active (dry)	-	-	-	-
MB19BWM_14A	672849	7334842	204.94*	15	6-7	Alluvium	South	Active (dry)	-	-	-	-
MB20BWM01A	685396	7388909	186.949	9.5	6.5-9.5	Tertiary	North	Active (dry)	-	-	-	-
BWM_MB22_01	687988	7356077	340	117	-	Tertiary	South	Active	17-03-2023	17-03-2023	17-03-2023	17-03-2023
BWM_P4	684097	7352905	283.8*	15.5	12.5-15.5	Tertiary	South	Active	26-01-2023	28-09-2023	26-01-2023	28-09-2023
BWM_P5	684024	7352865	278.52*	15	12-15	Tertiary	South	Active	26-01-2023	28-09-2023	26-01-2023	28-09-2023
MB21	684901	7350806	263.8	31	25-31	Tertiary	South	Active	31-08-2009	21-08-2023	26-09-2012	21-08-2023
MB19BWM02A	690128	7390183	168.5	17	12-15	Rewan	North	Active	01-07-2020	17-08-2023	30-06-2020	28-09-2023
MB19BWM04R	688316	7383605	203.6	80	71-80	Rewan	North	Active	30-06-2020	21-06-2023	30-06-2020	26-09-2023
MB19BWM25P	689260	7376880	192.6	20	17-20	Rewan	North	Active	01-07-2020	22-06-2023	30-06-2020	26-09-2023
MB19BWM05A	688502	7383612	203	15	9-15	Rewan	North	Active (dry)	-	-	-	-
MB19BWM_16R	669188	7338151	225.09*	97	87-93	Rewan	South	Active	31-01-2023	17-07-2023	31-01-2023	12-09-2023
FY16_PZ_2	686713	7387551	199.73	103.7	100.7-103.7	RCM coal	North	Active	26-11-2020	21-06-2023	26-11-2020	27-09-2023
FY16_PZ_3	686322	7388368	196	81.5	72.5-81.5	RCM	North	Active	25-11-2020	21-06-2023	-	-
FY16_PZ_4	686206	7389573	190.97	53	50-53	RCM coal	North	Active	25-11-2020	21-06-2023	25-11-2020	27-09-2023
FY16_PZ_5	685481	7389164	187.23	52.5	49.5-52.5	RCM coal	North	Active	25-11-2020	21-06-2023	25-11-2020	27-09-2023
MB1	686332	7387081	201.1	60	54-60	RCM coal	North	Active	01-09-2009	14-08-2023	26-09-2012	14-08-2023
MB20BWM02P2	686321	7388395	192.7	66	60-66	RCM coal	North	Active	25-02-2021	21-06-2023	25-02-2021	27-09-2023
MB20BWM03P1	686489	7387297	199.3	86	80-86	RCM O/I	North	Active	24-03-2021	21-06-2023	10-02-2021	27-09-2023
MB20BWM03P2	686490	7387289	199.4	109	98-107	RCM coal	North	Active	25-02-2021	14-08-2023	10-02-2021	27-09-2023
MB19BWM01P	690038	7390282	169.6	192	168-171	RCM coal	North	Active	01-07-2020	17-08-2023	29-07-2020	28-09-2023
MB19BWM03P	688455	7383474	202.7	234	222.5-231.5	RCM coal	North	Active	30-06-2020	21-06-2023	30-06-2020	26-09-2023
MB19BWM06P	687699	7379465	214.6	192	180-186	RCM coal	North	Active	30-06-2020	21-06-2023	-	-
MB19BWM27P	688959	7376560	198.5	200	180-189	RCM coal	North	Active	01-07-2020	18-08-2023	30-06-2020	26-09-2023
MB20BWM05P	686191	7389571	190.5	47	41-47	RCM O/I	North	Active (dry)	29-09-2021	21-06-2023	22-11-2022	27-09-2023
MB20BWM02P1	686325	7388395	192.6	36	30-36	RCM O/I	North	Active (dry)	24-03-2021	21-06-2023	-	-
MB19BWM08P	691543	7370740	224.6	198	184-190	RCM coal	Central	Active	29-06-2020	15-08-2023	30-06-2020	26-09-2023
MB18	691538	7370788	221.3	40.6	37.6-40.6	RCM O/I	Central	Active	01-09-2009	15-08-2023	28-09-2012	15-08-2023
BWM_MB14_02	683798	7350460	268	150	144-150	RCM O/I	South	Active	17-02-2023	27-09-2023	17-02-2023	27-09-2023
BWM_MB19_01	683795	7350479	264	80	-	RCM O/I	South	Active	24-05-2023	24-05-2023	18-03-2023	24-05-2023
BWM_MB01_02	687416	7344930	250	50	-	RCM coal	South	Active	17-02-2023	17-02-2023	18-02-2023	16-08-2023
BWM_MB16_03	682875	7340186	293	113	-	RCM coal	South	Active	31-01-2023	18-07-2023	31-01-2023	12-09-2023
MB19BWM_10P	684498	7342227	292	113.7	96.5-102.5	RCM coal	South	Active	22-03-2023	15-05-2023	28-02-2023	15-05-2023
BWM_MB04_01	686258	7350405	261.35*	28.5	22-28	RCM O/I	South	Active	29-01-2023	28-09-2023	29-01-2023	28-09-2023
PB19BWM_02P	670202	7342221	228.51*	72	62-68	RCM coal	South	Active	01-02-2023	14-08-2023	01-02-2023	12-09-2023
MB19BWM_24P	670210	7342224	228.3*	75.6	62-68	RCM coal	South	Active	01-02-2023	17-07-2023	01-02-2023	12-09-2023
MB19BWM_15P	669193	7338135	225.27*	140	131.7-137.7	RCM coal	South	Active	21-02-2023	17-07-2023	31-01-2023	12-09-2023
MB19BWM_18P	677018	7338057	223.58*	86.7	78.5-84.5	RCM coal	South	Active	01-02-2023	18-07-2023	01-02-2023	12-09-2023
BWM_MB21_02	686042	7342136	306.9	129.4	123-129	RCM coal	South	Active	06-03-2023	06-03-2023	03-03-2023	03-03-2023

Bore	Easting[1]	Northing[1]	TOC (mAHD)	Depth (mBGL)	Screened Interval (mBGL)	Monitored Unit	Area	Status	Data Availability (dates)			
									min WL	max WL	min WQ	max WQ
BWM_MB21_03	686039	7342144	306.9	163.9	153-159	RCM coal	South	Active	06-03-2023	06-03-2023	02-03-2023	02-03-2023
MB19BWM_25P_B	683532	7333202	225.79*	137.7	127-133	RCM coal	South	Active	31-01-2023	15-05-2023	31-01-2023	07-09-2023
BWM_MB14_01	683798	7350471	268	25	18-24	RCM O/I	South	Active	28-01-2023	27-09-2023	28-01-2023	27-09-2023
MB16	687966	7352289	281.5	109	40-109 (open hole)	UG Workings (RCM)	South	Active	20-10-2009	06-11-2022	20-10-2009	18-02-2023
BG No.2 BG	684413	7384618	211.87	38.5	32.3-38.5	Burngrove	North	Active	19-01-2012	18-08-2023	26-09-2012	18-08-2023
BG No.1 AP	684107	7387738	200.46	72.9	63.6-72.9	Burngrove	North	Active	19-01-2012	18-08-2023	26-09-2012	18-08-2023
MB24	683770	7350808	285.6	18	-	Burngrove	South	Active	27-01-2023	27-09-2023	27-01-2023	27-09-2023

*O/I = overburden/interburden; [1]Coordinate system: GCA 2020 Zone 55; *Ground Level*

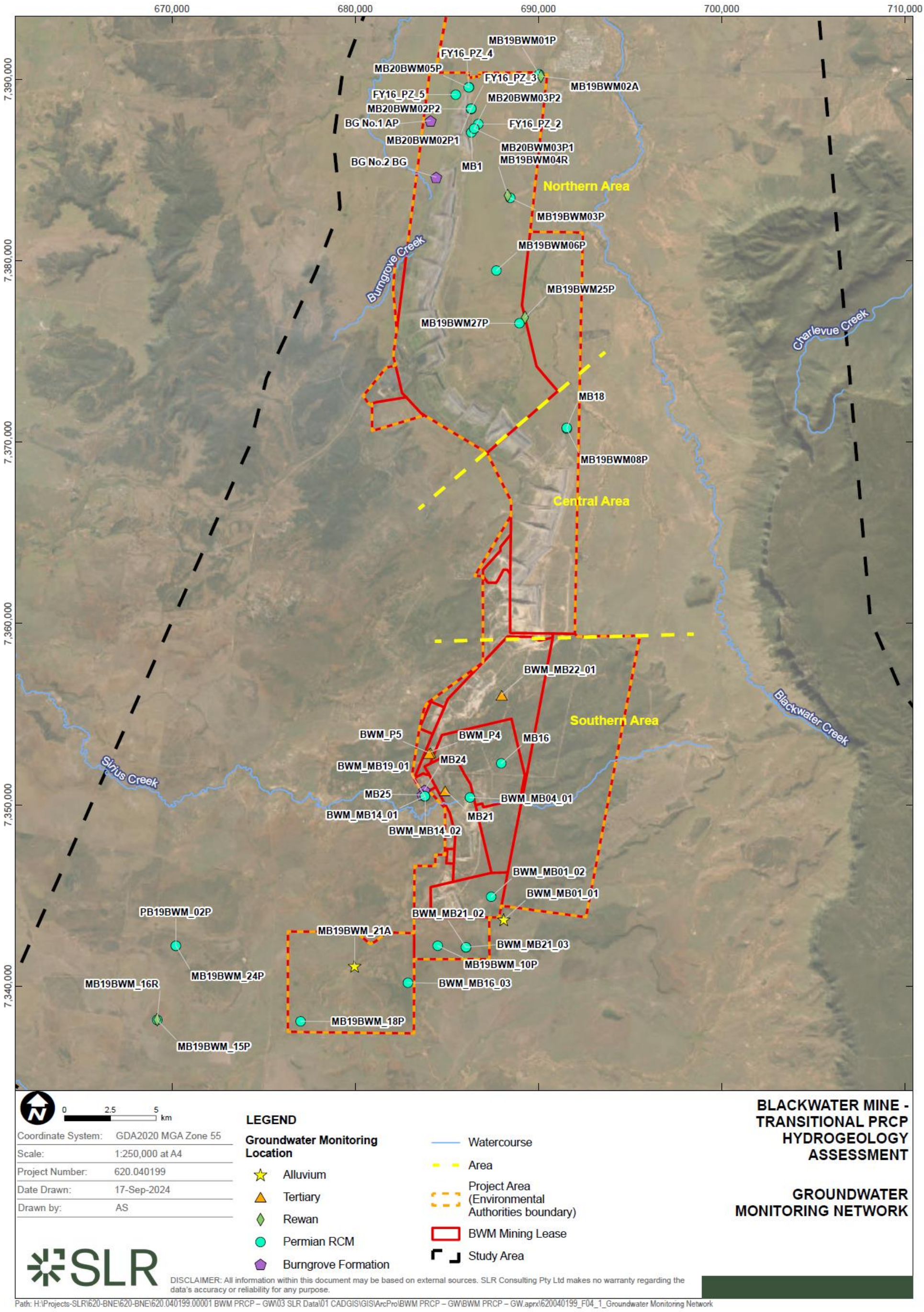

Figure 11 BWM groundwater monitoring network locations

3.1.2.6.3 Groundwater quality and type

Groundwater aquifers with suitable groundwater quality for stock watering are generally limited to isolated low-yielding alluvial aquifers. Very few porous rock-type aquifer systems exist within the Bowen Basin coal system, which is confirmed by the lack of high-yielding, groundwater bores on surrounding properties. Groundwater associated with coal seams is moderately to highly saline and is not used (BMA 2020).

Douglas Partners (1998) investigated local bores in the South Blackwater area and summarised available data for each but overall, limited data exists for groundwater prior to mining. From limited analytical results of groundwater, salt levels as indicated by electrical conductivity are generally in the range of 1,000 to 1,500 µs/cm EC levels are much higher than this in groundwater in this area. Most samples are neutral to slightly alkaline with pH ranging from 7.1 to 7.7.

The physicochemical results from groundwater sampling at BWM (between 2009-2023, refer to Appendix 4.2, Table 4-1) indicates the water chemistry is typically pH-neutral for all geological formations where groundwater is encountered. Sampling targeted Quaternary Sediments, Tertiary Sediments and Basalt, Triassic Rewan Group, Rangal Coal Measures and Burngrove Formation hydrogeological units. Limited data from the alluvial zone indicates a pH of approximately 5 to 6 – consistent with recent rainwater recharge.

Groundwater associated with most geological (and hydrogeological) units has salinity levels (measured as electrical conductivity (EC)), ranging from brackish to saline – median EC approximately 13,000 µS/cm in the non-coal zones of the Rangal Coal Measures; approximately 18,000 µS/cm in the coal seams of the Rangal Coal Measures; to nearly 34,000 µS/cm in the Rewan Group. The Tertiary sediments have the lowest salinity (median of approximately 7300 µS/cm). Major ions in groundwater at BWM are generally dominated by sodium and chloride. Limited data from the alluvial zone indicates a sodium-calcium-chloride-bicarbonate water type – consistent with rainwater recharge.

The existing concentrations of some dissolved metals in the groundwater are above the water quality guidelines (95% protection) for freshwater ecosystems (ANZG, 2018; QWQG, 2006). Slightly elevated concentrations of some elements in groundwater in Permian coal measures in the Bowen Basin are not uncommon and are considered to be naturally occurring.

The water quality from the monitoring wells located at and close to BWM indicates that, generally, the water is unsuitable for human consumption as assessed against the Australian Drinking Water Guidelines (HMRC-NRMMC 2011). Local groundwater use is primarily for livestock purposes owing to the variable salinity levels and generally low yields.

3.1.2.6.4 Groundwater use

BWM is located within the Fitzroy Basin under the *Water Plan (Fitzroy Basin) 2011*. The Highlands groundwater management area (GMA) consists of the following:

- Highlands Groundwater Unit 1, containing the aquifers of the Quaternary alluvium associated with the Sandy Creek Alluvium sub-area (to the distant northwest of BWM but not located within the Study Area); and
- Highlands Groundwater Unit 2, containing all subartesian aquifers within the Highlands GMA other than the aquifers included in Highlands Groundwater Unit 1.

Groundwater resources are scheduled under the EPP Water as Comet Groundwaters (for the southern part of BWM within the Comet sub-catchment (DEHP, 2011a)) and Mackenzie Groundwaters (for the northern part of BWM). Table 11 summarises BWM's groundwater EVs, noting that these are limited to farm supply/use, stock water and industrial use (i.e. mining). Aquatic ecosystems may also be associated with shallow alluvial systems.

Table 11 BWM groundwater environmental values

Fitzroy Basin Water Plan (WQ1310) Sub-catchment	Aquatic ecosystems	Irrigation	Farm supply/ use	Stock water	Aquaculture	Human consumer	Primary recreation	Secondary recreation	Visual recreation	Drinking water	Industrial use	Cultural and spiritual value
Comet Groundwaters	✓	✓	✓	✓	-	-	✓	-	-	✓	✓	✓
Mackenzie Groundwaters	✓	✓	✓	✓	-	-	-	-	-	✓	✓	✓
Potentially Locally Applicable based on EMM (2019) bore census	✓	-	✓	✓	-	-	-	-	-	-	✓	-

The EPP Water provides WQOs for the scheduled EVs in WQ1310 (Appendix 4.2). The objectives for groundwaters within the GMA – Zone 35 and 36 management area of the Water Plan (Fitzroy Basin) 2011 are for sustainable management to maintain ecological values and enable maintenance and ongoing use of the resources through water allocations and licensing.

3.1.2.6.5 Groundwater receptors

Anthropogenic

A search of the Queensland Government's Registered Groundwater Bore Database (GWDB) (DRDMW, 2023) and the Bureau of Meteorology's National Groundwater Information System (NGIS) (BoM, 2017) was carried out for registered bores in and around the BWM ML. The search returned 313 bores with registered uses as mine monitoring (190 bores), petroleum exploration (3 bores), sub-artesian monitoring (23 bores), water resources investigation (3 bores), water supply (28 bores), unknown (32 bores) and decommissioned (34 bores). The location of private water supply bores (i.e. those 28 bores listed in the GWDB as water supply) and potential water supply bores (i.e. those 32 bores listed as unknown) are shown Figure 12

A landholder bore census was conducted at BWM by EMM (2019). The census identified 12 unregistered bores, with all but one located west of BWM. The results of the survey indicated that 10 of the bores were in use while the other two were not in use.

Environmental

Desktop mapping and field investigations (EMM, 2023a) of potential aquatic and terrestrial groundwater dependent ecosystems (GDEs) identify the areas illustrated in Figure 13 with possible high, moderate, and low potential for groundwater interaction that occurs in the vicinity of BWM. These include:

- Two springs associated with the Clematis Group outcrop escarpment, approximately 15 km south-east of BWM.
- The riparian terrestrial vegetation associated with Taurus Creek on the eastern margin of the site.
- A very small area of narrow linear communities that fringe Sagittarius Creek, with vegetation types consisting primarily of poplar box (*Eucalyptus populnea*), forest red gum (*Eucalyptus tereticornis*), or river red gum (*Eucalyptus camaldulensis*).

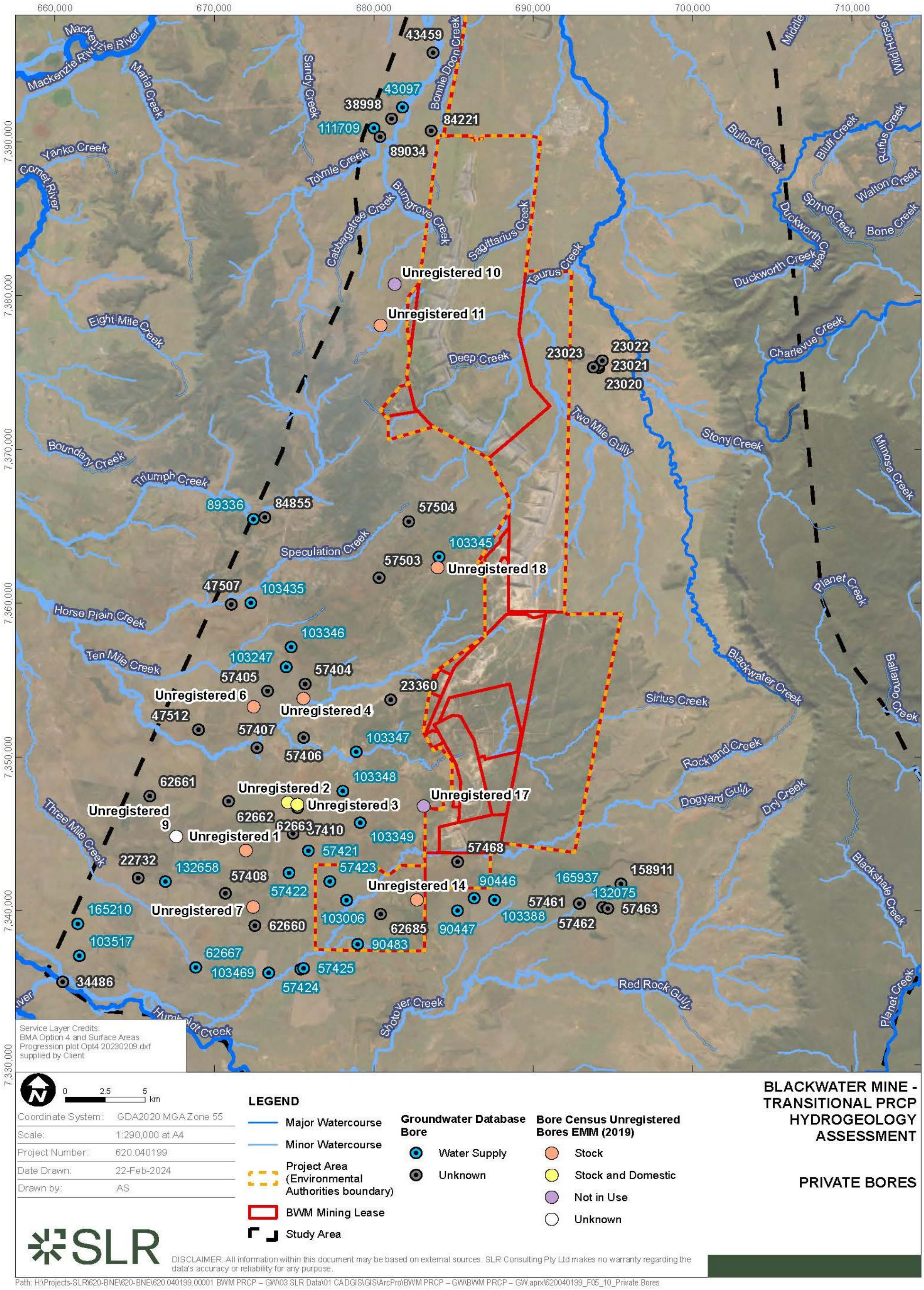

Figure 12 Private bores at BWM

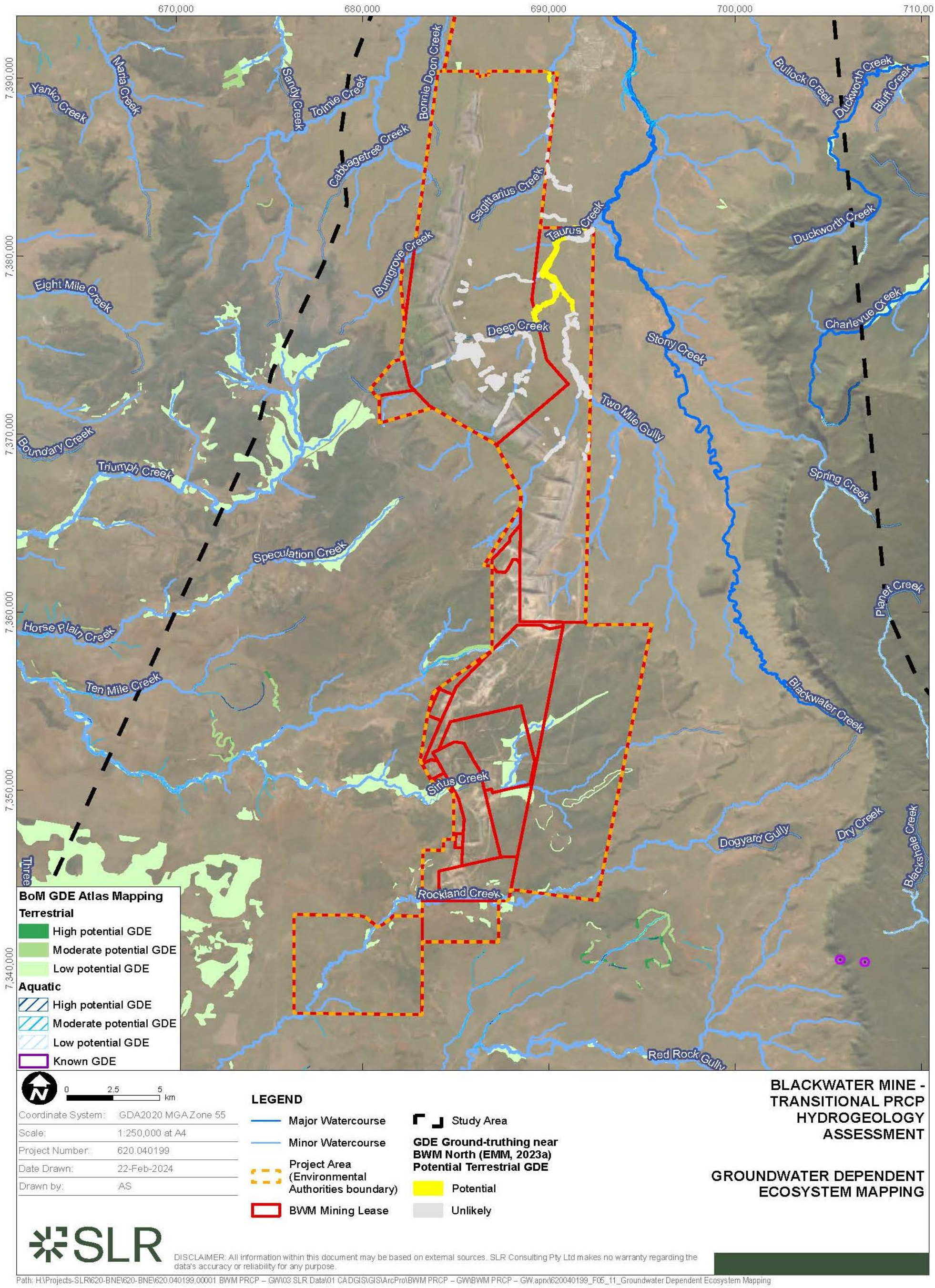

Figure 13 BWM groundwater dependent ecosystem

3.1.2.7 Soil types, properties and productivity

3.1.2.7.1 Soil types

Regional soil mapping of the mine identifies two broad soil groups across the BWM project area (QLD Department of Resources, 2023), as summarised in Table 12, with Figure 14 illustrating the broad Australian Soil Classification (ASC) types. Further detail is provided in Appendix 4.3 *Blackwater Mine Material Characterisation Study* (Landloch, 2023).

Table 12 Summary of BWM soil types

Soil landscape code	Australian soil classification	Land suitability class	Description
MM7	Vertosol, Dermosol	3	Dark and yellow friable earths with friable brown soils.
SI12	Chromosol, Sodosol	5	Complex range of soils occurring. Dominant soils are sandy to loamy duplex soils.

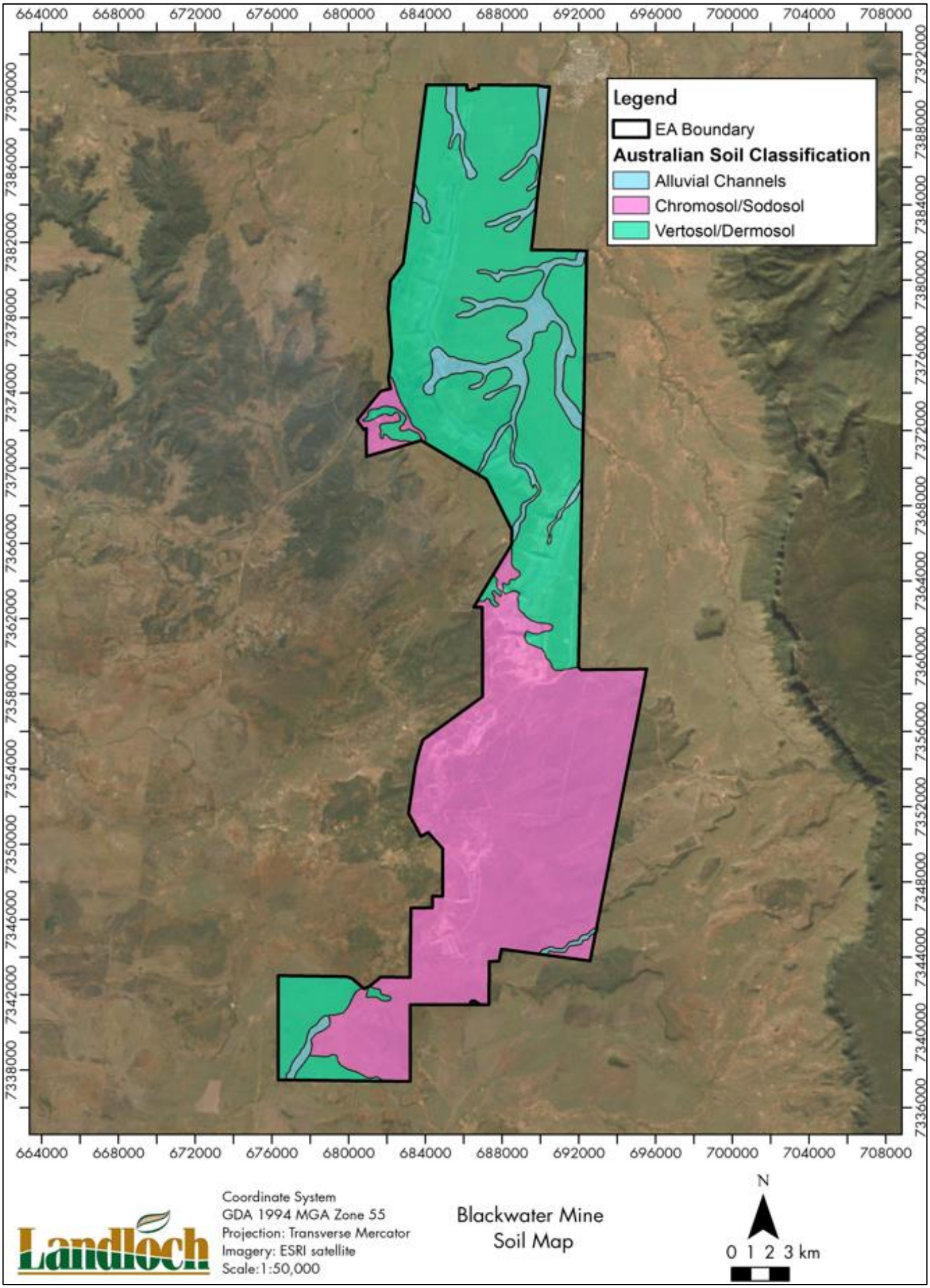

Figure 14 BWM soil mapping units (Australian Soil Classification)

3.1.2.7.2 Properties and productivity

Several soil surveys have been undertaken at BWM, resulting in the identification of 26 soil landscape units (SLUs) across the mine site (Landloch, 2023). A consolidated summary of the SLUs is provided in Table 13.

Table 13 Summary of soil landscape units details for BWM

SLU	Soil details	Vegetation description	Grazing suitability class
A1	Uniform brown clay or texture contrast soils on alluvial material in and adjacent to active drainage lines.	Mixed brigalow, yellowwood, poplar box and sandalwood. River red gum and Moreton Bay ash in creek channel.	2/3
B1	Gently undulating plains with cracking and non-cracking uniform clays and areas of gilgai developed from weathered non-quartzrose Permian sedimentary rocks and Tertiary sediments.	Brigalow, blackbutt with associated bottle tree, poplar box and yellowwood.	2
B2	Undulating plains and rises of generally on-cracking clays with significant surface gravel.	Brigalow with blackbutt, ooline, sandalwood, Leichardt bean, carissa. Includes areas of undulating ridges and stony Yapunyah.	3
B2v	Reddish brown texture contrast soils with thin sandy or loamy surface layers over well-structured alkaline clay subsoils and gravel.	Main vegetation is brigalow and associated species which include poplar box.	3/4
B3	Soils are reddish brown non-cracking clays often with a hard setting sandy surface. Often quite shallow to weathered sediments.	Regrowth of brigalow, yellowwood, whitewood, occasionally poplar box. Ooline was present in original vegetation.	3
C1	Yellowish brown cracking and non-cracking uniform clays situated on gentle undulating plains with deep effective rooting depth.	Buffel grass with vegetation regrowth, consisting of mainly brigalow.	2
C1v	Yellowish brown cracking and non-cracking clays with reddish clays at depth situated on gentle undulating plains.	Buffel grass with vegetation regrowth	5
C1gv	Brown to dark brown cracking and non-cracking uniform clays situated on gentle undulating pains with microrelief present in the form of gilgai and melon holes of varying sizes.	Whipsick brigalow, brigalow, and buffel grass.	5
D1	Grayish and minor dull yellow non-cracking clays situated on gentle undulating plains with deep effective rooting depth of approximately 45-60cm with soft lime and calcium carbonate present.	Buffel grass and brigalow.	4
D1gv	Grayish and minor dull yellow non-cracking uniform lays on gentle undulating plains with an effective rooting depth of approximately 45-60 cm with normal gilgai present.	Whipsick brigalow, brigalow, and buffel grass.	4
D2	Brownish black and black medium hard cracking clay situated on gentle undulating plains with deep effective rooting depth of approximately 70-80 cm with soft lime and calcium carbonate present	Bauhinia, broom bush, yellowwood and minor brigalow.	3

SLU	Soil details	Vegetation description	Grazing suitability class
D3	Light-medium to medium clays overlying sand lenses near drainage, creek lines, and minor depressions.	Brigalow, whitewood.	4
D4	Cracking light to medium uniform brown clays over gentle underlying plains with no microrelief present.	Buffel grass.	3
D4sv	Cracking light to light medium brown clays over gentle undulating plains with no microrelief present, however, is located on a slope greater than 3%.	Buffel grass.	3
D4rv	Cracking medium to light brown clays over gentle undulating plains within shallow depressions and overland runoff with gravels and cobbles present.	Buffel grass, acacia.	3
D5	Sandy clay loam overlying light brown clays along gently undulating plains.	Whipstick brigalow, Bauhinia, buffel grass.	3
E1	Shallow, rocky earths with some areas of gravelly and shallow texture contrast soils on the mesa margins.	Dominated with lancewood and areas of Dawson gum, poplar box or yapunyah.	4/5
E2	Open ironbark with associated Acacias on hard-setting red sandy duplex of the tablelands.	Narrowleaf ironbark, yapunyah with associated acacias.	4
E3	Sandy texture contrast soils usually with hard-setting, gravelly surface and with erosive yellowish clays subsoils with are gravelly. Includes areas of shallow gravelly ridges and exposes bedrock.	Mixed scrub of poplar box, brigalow and sandalwood.	3
E4	Deeper loamy red earths on undulating plains.	Open silver leaf ironbark.	2
E5	Loamy red and yellow earths usually underlain with lateritic gravel before 60 cm depth on uplands and mesa tops.	Mainly narrowleaf ironbark and bloodwood with a variety of wattles and other species.	3
F1	Alluvial creek areas with loam and silty soil profiles.	Brigalow, poplar box, bottle trees.	4
F2	Active alluvial plains with loas and clayey sand with soft to firm sandy surface.	Mount Coolabah, minor brigalow.	3
F3	Brown silty clay loams on silty clays on gentle undulating plains. Calcium carbonate present in subsoils.	Buffel grass.	2
R1	Rocky outcrop/hill	Mixed vegetation	5
S1	Texture contrast and gradational soils situated on gentle undulating plains.	Buffel grass with very minor vegetation regrowth observed.	4

3.1.2.8 Land stability

The pre-mining topography at BWM was generally flat to undulating and is consistent with the regional landscape. Land adjacent to the mine and within the Bowen Basin indicates surface erosion is common upon disturbance of soils and vegetation from cattle grazing. Land within and around BWM has a long history of disturbance due predominantly to vegetation clearing related to agricultural activities (pasture management and cattle grazing), mining and rural development. Details for pre-mining land use and soils has been described by Gunn et al (1967) and Emmerton. B.R. (1999). Summaries of this information are included in the Blackwater Environmental Management Plan (2008). Basically, a range of soils and land types existed prior to mining. Land use was moderate density grazing on Brigalow clay soils and lower density grazing on eucalypt plains and Tertiary lateritic rises. Much of this land had been cleared or thinned for pastures before extensive open-cut mining commenced.

3.1.2.9 Vegetation communities and ecological data

Several ecological studies have been undertaken within the BWM site. Since the approval of the mine, the following studies have been undertaken in relation to the broader vegetation communities and ecological values on the BWM site:

- Blackwater Terrestrial Ecology Survey Report Flora and Fauna Seasonal Surveys - Blackwater Mine Expansion (ML1759 and ML1762) (EMM, 2020a)
- Blackwater Terrestrial Ecology Survey Report Flora and Fauna Seasonal Surveys - Blackwater M ine Southern Expansion (EMM, 2020b)
- Field Ecology Survey Report - Blackwater Mine (EMM, 2019a)
- Blackwater Mine 3D Seismic Ecology Survey and Impact Assessment (EMM, 2019b)
- Blackwater Mine Ramp 74 Levee Ecological Survey Report (EMM, 2019c)
- A Review of Habitat Values for Biodiversity and Species of Conservation Significance – BMA Blackwater Mine (Ecoserve & LAMR, 2006)
- The baseline vegetation communities and ecological values of the BWM site have been described based on the results of the previous ecological studies as well as updated desktop searches of the following Queensland Government databases:
- Regional ecosystem mapping (DES, 2023a)
- Matters of State Environmental Significance (DES, 2023b)
- Maps of environmentally sensitive areas (DES, 2023c)
- Wildlife Online database (DES, 2023d)

3.1.2.9.1 Regional ecosystems

The remnant vegetation cover on the BWM site has been altered over time due to pre-mining clearing for agricultural land use purposes and historical clearing for approved mining activities.

The regional ecosystems on BWM have been ground-truthed and mapped as part of the broader previous ecological surveys (EMM, 2020a; EMM, 2020b; EMM, 2019a; EMM, 2019b; EMM, 2019c and Ecoserve & LAMR, 2006)

The highest disturbance to regional ecosystems to date is associated with areas cleared for mining activities and associated infrastructure through a long central strip of site extending north to south (Figure 15). There are however larger tracts of regional ecosystems mapped along the south-western and south-eastern section of the mine including regional ecosystems adapted to Cainozoic lateritic duricrust (Land Zone 7) and Tertiary-early Quaternary loamy and sandy plains and plateaus (Land zone 5) including:

- RE11.5.3 *Eucalyptus populnea* and/or *Eucalyptus melanophloia* and/or *Corymbia clarksoniana* on Cainozoic sand plains and/or remnant surfaces
- RE11.5.9 *Eucalyptus crebra* and other *Eucalyptus* spp. and *Corymbia* spp. woodland on Cainozoic sand plains and/or remnant surfaces
- RE11.5.16 *Acacia harpophylla* and/or *Casuarina cristata* open forest in depressions on Cainozoic sand plains and remnant surfaces
- RE11.7.1 *Acacia harpophylla* and/or *Casuarina cristata* and *Eucalyptus thozetiana* or *Eucalyptus microcarpa* woodland on lower scarp slopes on Cainozoic lateritic duricrust
- RE11.7.2 *Acacia* spp. woodland on Cainozoic lateritic duricrust. Scarp retreat zone
- RE11.7.4 *Eucalyptus decorticans* and/or *Eucalyptus* spp., *Corymbia* spp., *Acacia* spp., *Lysicarpus angustifolius* woodland on Cainozoic lateritic duricrust
- RE11.7.6 *Corymbia citriodora* or *Eucalyptus crebra* woodland on Cainozoic lateritic duricrust

The remnant vegetation adjacent to the BWM extends from the southern end of the BWM EA boundary to approximately Ramp 56 in the north. Much of the remaining vegetation to the east and west of the central mining strip to the north of Ramp 56 has been largely cleared for cattle grazing. Nonetheless, several smaller remnant and high value patches of brigalow regrowth associated with RE11.4.9 and RE11.9.5 remain as well as narrow sections of remnant vegetation along drainage lines.

The ground-truthed regional ecosystems returned on BWM as a result of previous ecological assessments have been mapped in Figure 15 and are listed in Table 14 along with their associated *Vegetation Management Act 1999* (Qld) *(VM Act)* class and biodiversity status (EMM, 2020a; EMM, 2020b; EMM, 2019a; EMM, 2019b; EMM, 2019c and Ecoserve & LAMR, 2006).

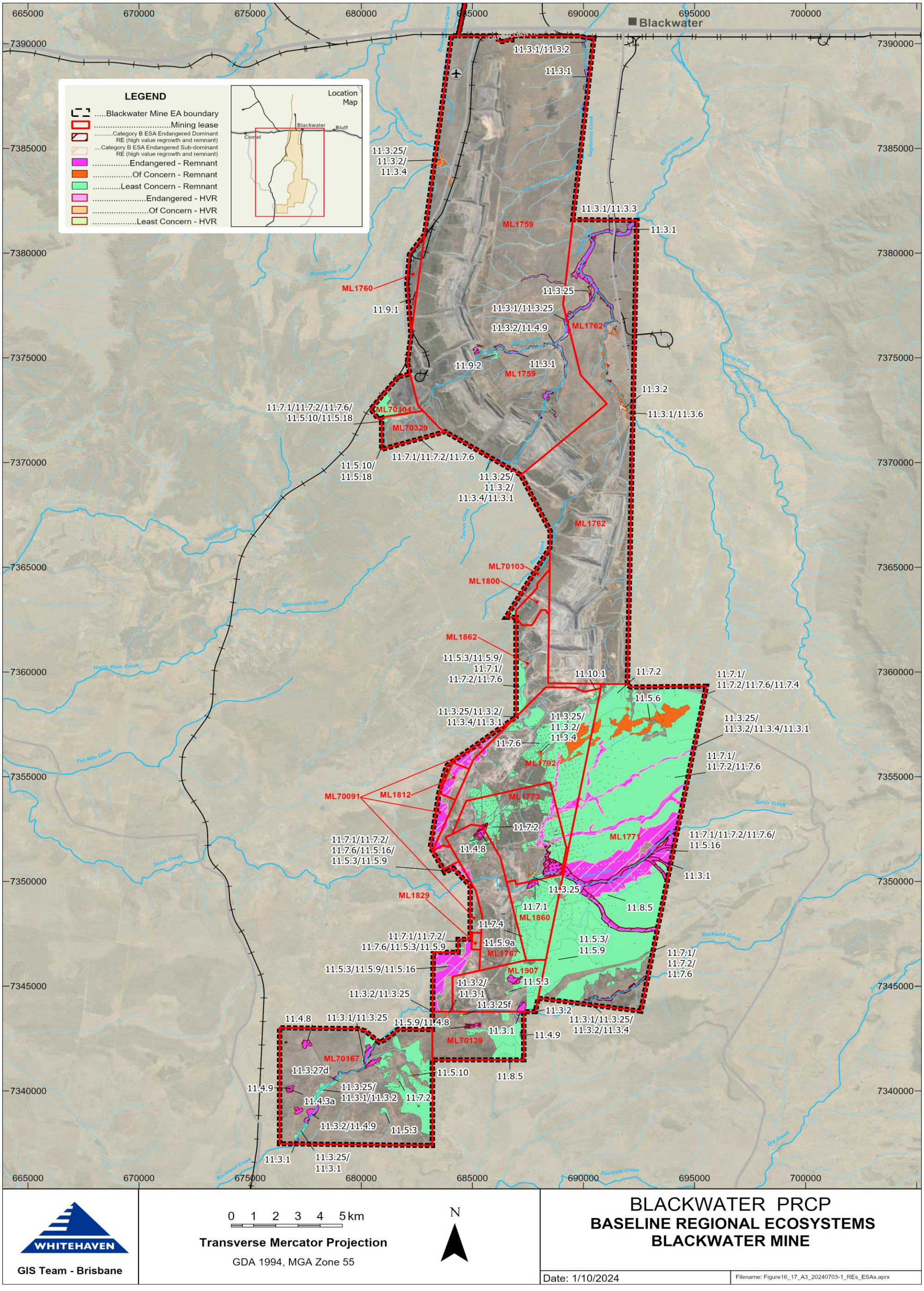

Figure 15 BWM baseline regional ecosystem

Table 14 Regional ecosystems recorded during baseline assessments at BWM

Regional ecosystem descriptions	RE Code	Remnant/ High Value Regrowth (HVR)	RE VM Act class	RE Biodiversity status
Acacia harpophylla and/or *Casuarina cristata* open forest on alluvial plains	11.3.1	Remnant	Endangered	Endangered
Eucalyptus populnea woodland on alluvial plains	11.3.2	Remnant	Of concern	Of concern
Eucalyptus tereticornis or *E. camaldulensis* woodland fringing drainage lines	11.3.25	Remnant	Least concern	Of concern
Main river channels. Open water or exposed stream beds and bars. Usually devoid of emergent vegetation although scattered trees and shrubs such as *Melaleuca viminalis* or *Melaleuca* spp. May be present and aquatic species may be abundant, particularly in water holes and lagoons.	11.3.25f	Remnant	Least concern	Of concern
Eucalyptus camaldulensis and/or *E. tereticornis* woodland. A range of sedges and grasses occur in the ground layer including *Fimbristylis vagans, Myriophyllum striatum, Nitella pseudoflabellata* and *Pseudoraphis sp.* Occurs fringing large lakes.	11.3.27d	Remnant	Least concern	Of concern
Eucalyptus platyphylla, *Corymbia clarksoniana* woodland on alluvial plains	11.3.35	Remnant	Least concern	No concern at present
Eucalyptus tereticornis and/or *Eucalyptus* spp. woodland on alluvial plains	11.3.4	Remnant	Of concern	Of concern
Eucalyptus melanophloia woodland on alluvial plains	11.3.6	Remnant	Of concern	Of concern
Acacia harpophylla and/or *Casuarina cristata* shrubby open forest on Cainozoic clay plains	11.4.3	Remnant	Endangered	Endangered
Eucalyptus populnea with *Acacia harpophylla* and/or *Casuarina cristata* open forest to woodland on Cainozoic clay plains	11.4.7	Remnant	Endangered	Endangered
Eucalyptus cambageana woodland to open forest with *Acacia harpophylla* or *A. argyrodendron* on Cainozoic clay plains	11.4.8	Remnant	Endangered	Endangered
Larger gilgai provides ephemeral wetland habitat.	11.4.8a	Remnant	Endangered	Endangered
Acacia harpophylla shrubby woodland with *Terminalia oblongata* on Cainozoic clay plains	11.4.9	Remnant	Endangered	Endangered
Acacia harpophylla, Lysiphyllum carronii +/- Casuarina cristata open forest to woodland. Occurs on level to gently undulating Cainozoic plains, including weathered basalt.	11.4.9a	Remnant	Endangered	Endangered
Eucalyptus populnea and/or *E. melanophloia* and/or *Corymbia clarksoniana* on Cainozoic sand plains and/or remnant surfaces	11.5.3	Remnant HVR	Least concern	No concern at present
Triodia spp. hummock grassland on Cainozoic sand plains and/or remnant surfaces	11.5.6	Remnant	Of concern	Of concern
Eucalyptus crebra and other *Eucalyptus* spp. and *Corymbia* spp. woodland on Cainozoic sand plains and/or remnant surfaces	11.5.9	Remnant	Least concern	No concern at present
Eucalyptus melanophloia woodland. Occurs on Cainozoic sandplains formed on plateaus and broad crests of hills and ranges.	11.5.9a	Remnant	Least concern	No concern at present
Eucalyptus crebra, *E. tenuipes*, *Lysicarpus angustifolius +/- Corymbia* spp. woodland. Occurs on Cainozoic sandplains formed on plateaus and broad crests of hills and ranges.	11.5.9b	Remnant	Least concern	No concern at present
Melaleuca tamariscina tall open shrubland to low woodland on Cainozoic sand plains and/or remnant surfaces	11.5.10	Remnant	Of concern	Of concern
Semi-evergreen vine thicket on Cainozoic sand plains and/or remnant surfaces	11.5.15	Remnant	Least concern	Endangered
Acacia harpophylla and/or *Casuarina cristata* open forest in depressions on Cainozoic sand plains and remnant surfaces	11.5.16	Remnant	Endangered	Endangered
Micromyrtus capricornia open shrubland on Cainozoic sand plains and/or remnant surfaces	11.5.18	Remnant	Of concern	Of concern
Acacia harpophylla and/or *Casuarina cristata* and *Eucalyptus thozetiana* or *E. microcarpa* woodland on lower scarp slopes on Cainozoic lateritic duricrust	11.7.1	Remnant	Least concern	Of concern
Acacia spp. woodland on Cainozoic lateritic duricrust. Scarp retreat zone	11.7.2	Remnant	Least concern	No concern at present
Eucalyptus decorticans and/or *Eucalyptus* spp., *Corymbia* spp., *Acacia* spp., *Lysicarpus angustifolius* woodland on Cainozoic lateritic duricrust	11.7.4	Remnant	Least concern	No concern at present
Shrubland on natural scalds on deeply weathered coarse-grained sedimentary rocks	11.7.5	Remnant	Least concern	No concern at present
Corymbia citriodora or *Eucalyptus crebra* woodland on Cainozoic lateritic duricrust	11.7.6	Remnant	Least concern	No concern at present
Eucalyptus orgadophila open woodland on Cainozoic igneous rocks	11.8.5	Remnant	Least concern	No concern at present
Dichanthium sericeum grassland on Cainozoic igneous rocks	11.8.11	Remnant	Of concern	Of concern
Semi-evergreen vine thicket and microphyll vine forest on Cainozoic igneous rocks	11.8.13	Remnant	Endangered	Endangered
Acacia harpophylla Eucalyptus cambageana woodland to open forest on fine-grained sedimentary rocks	11.9.1	Remnant	Endangered	Endangered
Acacia harpophylla and/or *Casuarina cristata* open forest to woodland on fine-grained sedimentary rocks	11.9.5	Remnant	Endangered	Endangered

3.1.2.9.2 Environmentally sensitive areas

Category B environmentally sensitive areas (ESAs) are defined under Schedule 19 of the *Environmental Protection Regulation 2019* (Qld) to include Endangered regional ecosystems based on the biodiversity status identified in the 'Regional ecosystem description database'.

The following ground-truthed regional ecosystems with an Endangered biodiversity status are associated with Category B ESAs on BWM (Figure 15):

- RE 11.3.1 *Acacia harpophylla* and/or *Casuarina cristata* open forest on alluvial plains
- RE 11.4.3 *Acacia harpophylla* and/or *Casuarina cristata* shrubby open forest on Cainozoic clay plains
- RE 11.4.7 *Eucalyptus populnea* with *Acacia harpophylla* and/or *Casuarina cristata* open forest to woodland on Cainozoic clay plains
- RE 11.4.8 *Eucalyptus cambageana* woodland to open forest with *Acacia harpophylla* or *Acacia argyrodendron* on Cainozoic clay plains
- RE 11.4.8a Larger gilgai provides ephemeral wetland habitat.
- RE 11.4.9 *Acacia harpophylla* shrubby open forest to woodland with *Terminalia oblongata* on Cainozoic clay plains
- RE 11.4.9a *Acacia harpophylla, Lysiphyllum carroni*i +/- *Casuarina cristata* open forest to woodland. Occurs on level to gently undulating Cainozoic plains, including weathered basalt.
- RE 11.5.15 *Semi-evergreen vine thicket* on Cainozoic sand plains and/or remnant surfaces
- RE11.5.16 *Acacia harpophylla* and/or *Casuarina cristata* open forest in depressions on Cainozoic sand plains and remnant surfaces
- RE 11.8.13 *Semi-evergreen vine thicket* and microphyll vine forest on Cainozoic igneous rocks
- RE 11.9.1 *Acacia harpophylla*, *Eucalyptus cambageana* woodland to open forest on fine-grained sedimentary rocks
- RE 11.9.5 *Acacia harpophylla* and/or *Casuarina cristata* open forest to woodland on fine-grained sedimentary rocks

3.1.2.9.3 State significant flora species

The following threatened fauna species listed under the NC Act are known to occur on BWM based on the results of previous ecological surveys:

- *Solanum elachophyllum* (Endangered NC Act)
- *Solanum dissectum* (Endangered NC Act)
- *Cadellia pentastylis* (ooline) (Vulnerable NC Act)
- *Cerbera dumicola* (Near Threatened NC Act)

Solanum elachophyllum is a small shrub that occurs almost exclusively on cracking clay soils in association with brigalow communities including either *Eucalyptus thozetiana* or Dawson Gum (*Eucalyptus cambageana*).

Solanum elachophyllum has been recorded on BWM site most frequently on clay or loamy soils in fragmented non-remnant vegetation in association with brigalow (EMM, 2020a).

Solanum dissectum is a perennial shrub 0.3 to 1 m high that occurs in open forests and woodlands of brigalow or *Eucalyptus thozetiana* on solodic clay soils. It has been recorded during previous ecological surveys on BWM site in endangered RE11.4.8 (EMM, 2019c).

Ooline is a tree growing to 10 m (rarely to 25 m) with dark, hard and scaly bark. Ooline has been previously recorded on the lower scarps of RE11.7.1 and RE11.7.2 to the east of the South Blackwater Industrial Area (Ecoserve & LAMR, 2006).

Cerbera dumicola is a shrub or small tree growing to 4 m high that occurs across a range of habitats in central and southern Queensland. It occurs in woodlands of *Eucalyptus thozetiana, Acacia shirleyi* and/or *Acacia catenulata* on sandstone hills, plateaus, and acidic soils. It also occurs in semi-deciduous notophyll-microphyll vine forests. It has been recorded on the BWM in RE11.7.2.

3.1.2.10 Fauna presence and populations

3.1.2.10.1 State significant fauna species

The following threatened fauna species listed under the NC Act are known to occur on BWM based on the results of previous ecological surveys:

- Koala (*Phascolarctos cinereus*) (Endangered NC Act)
- Ornamental snake (*Denisonia maculata*) (Vulnerable NC Act)
- Squatter pigeon (*Geophaps scripta scripta*) (Vulnerable NC Act)
- White-throated needle tail (*Hirundapus caudacutus*) (Vulnerable NC Act)
- Fork-tailed swift (*Apus pacificus*) (Special Least Concern NC Act)
- Rufous fantail (*Rhipidura rufifrons*) (Special Least Concern NC Act)
- Short-beaked echidna (*Tachyglossus aculeatus*) (Special Least Concern NC Act)
- Australian painted snipe (*Rostratula australis*) (Endangered NC Act)
- Latham's Snipe (*Gallinago hardwickii*) (Special Least Concern NC Act)

Koalas have been recorded on BWM during a number of previous ecology surveys (EMM, 2020a; EMM, 2020b). Koalas have been recorded in Rockland Creek and Shotover Creek in the south and scratches have been previously recorded on blue gums *(Eucalyptus tereticornis)* adjacent to Taurus Creek in the north (EMM, 2020a; EMM, 2020b). Known habitat is mapped along the creek lines where records of individuals or signs of scratches and scats have occurred (EMM, 2020b) as well as other drainage lines supporting narrow fringing *Eucalyptus* spp. forests and woodlands. Koala habitat has been mapped on BWM in association with remnant and high value regrowth regional ecosystems containing preferred koala feed tree species including; *Eucalyptus camaldulensis, Eucalyptus tereticornis, E. populnea, E. coolabah. E. melanophloia, E. crebra, and Corymbia citriodora* (Kerswell, Evans, & Appleby, 2020) (Figure 16)

The ornamental snake has been recorded on BWM in its preferred habitat during previous ecological surveys (EMM, 2020a). Preferred habitat for the ornamental snake includes remnant of regrowth brigalow or *E. coolabah* woodlands and open forests with deep cracking clays associated with moist areas, particularly gilgai (melon-hole) mounds, and depressions on Land Zone 4 and/or wetland margins (DCCEEW, 2023; Kerswell, Evans, & Appleby, 2020). Suitable ornamental snake habitat on BWM has been mapped in areas of remnant and regrowth woodlands with gilgai (Figure 16).

The squatter pigeon is a ground-dwelling bird species that prefers eucalypt woodlands with a sparse native grass cover within close proximity to water (DCCEW, 2023). Squatter pigeons have been recorded in suitable habitats on BWM during previous ecological surveys (Ecoserve & LAMR, 2006). Suitable squatter pigeon habitat on BWM has been mapped in (Figure 16).

The Australian painted snipe and Latham's snipe may occur in shallow freshwater wetlands, of both an ephemeral and permanent nature across all states of Australia. Both species have been previously recorded in preferred wetland habitats on the BWM sites in areas of gilgai and/or farm dams (EMM, 2020a; EMM, 2020b; Ecoserve & LAMR, 2006).

Short-beaked echidna has been recorded during a number of previous ecology surveys on BWM (Ecoserve & LAMR, 2006). This species occurs in a wide range of habitats and is likely to occupy remnant and regrowth habitats within the BWM site.

A number of migratory bird species including the white-throated needletail, fork-tailed swift and rufous fantail have been previously recorded within or flying over BWM (EMM, 2019b; Ecoserve & LAMR, 2006). These migratory species are seasonal visitors and can occur in a broad range of habitats from open woodlands and forests to wetlands and/or are highly mobile being observed only flying over the BWM site.

The rehabilitation approach includes areas adjoining undisturbed Endangered or Of Concern regional ecosystems or threatened species habitats to be rehabilitated to a woodland habitat PMLU wherever possible. This approach will provide connectivity between rehabilitated areas and existing vegetation and habitat values. Similarly, areas rehabilitated to a watercourse PMLU will connect existing riparian habitat values for several conservation significant species (e.g. koalas).

Areas adjoining undisturbed threatened fauna species habitats will be rehabilitated to a woodland habitat PMLU wherever possible, and disturbed areas of watercourses will be rehabilitated to a watercourse PMLU. Woodland habitat and watercourse revegetation rehabilitation will include a combination of *Eucalyptus* spp, *Corymbia* spp and non-Eucalyptus framework tree species and woody understorey species that will provide broad habitat values for more highly mobile fauna taxa including birds and mobile mammals (e.g. kangaroos and wallabies), as well as longer term foraging and shelter opportunities for common fauna species and several species of conservation significance (e.g. koala, echidna).

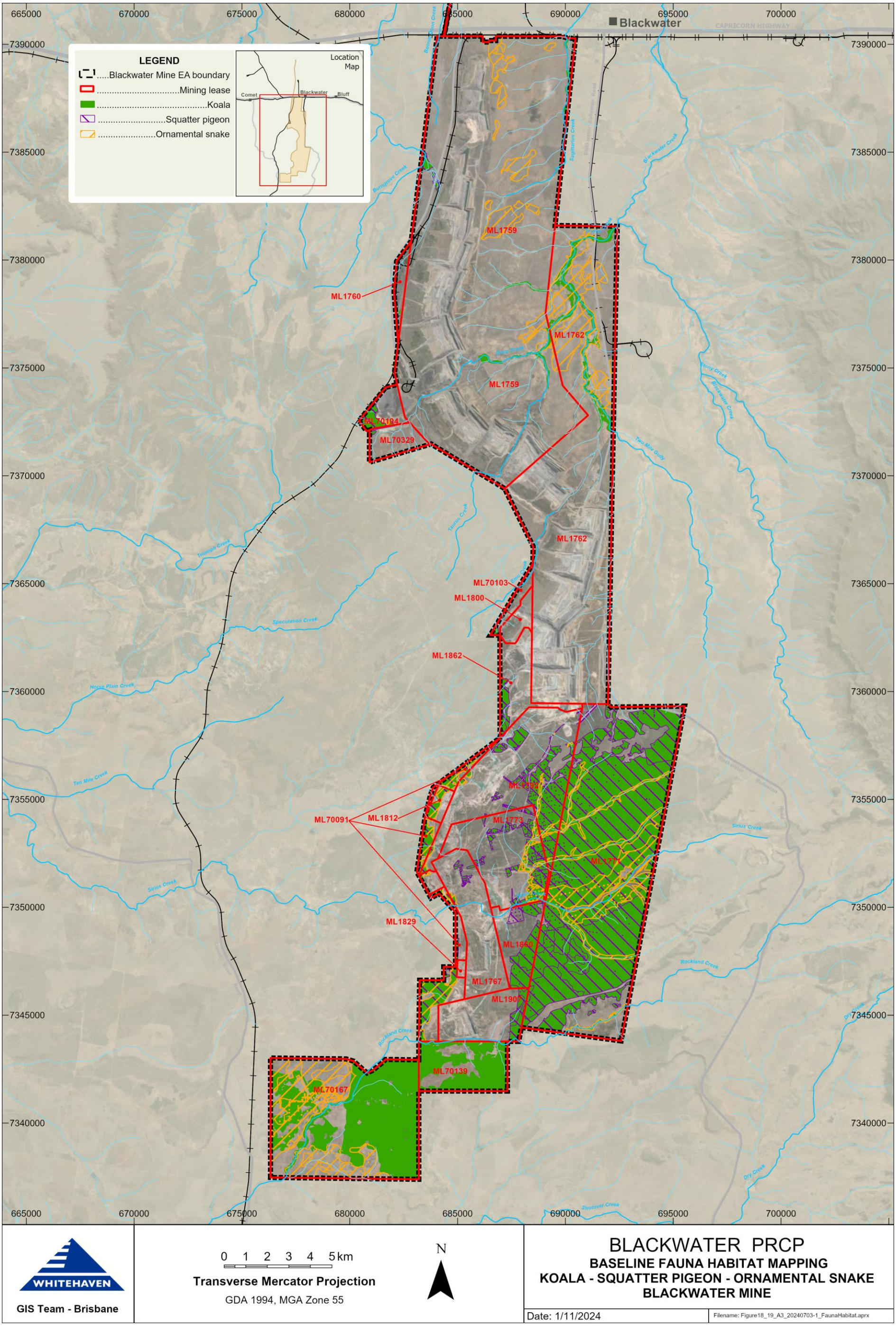

Figure 16 BWM baseline fauna habitat mapping for koala, ornamental snake and squatter pigeon

3.1.2.11 Pre-mining land use

Although large areas of remnant bushland (Brigalow and/or eucalypt scrub) still exist within the BWM MLs (mainly in the southern area), land within and around BWM has a long history of disturbance due predominantly to vegetation clearing related to agricultural activities (pasture management and cattle grazing), mining and rural development. Details for pre-mining land use and soils has been described by Gunn et al (1967) and Emmerton. B.R. (1999). Summaries of this information are included in the Blackwater Environmental Management Plan (2008). Basically, a range of soils and land types existed prior to mining. Land use was moderate density grazing on Brigalow clay soils and lower density grazing on eucalypt plains and Tertiary lateritic rises. Much of this land had been cleared or thinned for pastures before extensive open-cut mining commenced.

3.1.2.12 Underlying landholders

Most of the land within the BWM EA boundary is currently owned by Whitehaven Blackwater Pty Ltd. Other owners of land within the EA boundary include:

- One private landowner (Taurus Homestead (land lease) and Stewarton Homestead (freehold))
- Central Highlands Regional Council (CHRC) (Lawn Cemetery) (reserve)
- QCoal Pty Ltd (land used by the Koorilgah Mine Balloon Railway) (land lease)
- BMA (two properties, Terang and Aviemore)
- Owners of utilities (land lease), including:
    - Sunwater Ltd
    - Queensland Rail (QR) (Laleham Branch Railway and Kinrola Branch Railway)
    - Ergon Energy Corporation Ltd
    - State of Queensland (Bauhinia Branch Railway, microwave tower at CHPP, Telstra Amplitel microwave tower, (West Bedford weir)
- Holders of non-Whitehaven related easements within the EA boundary include:
    - Ergon Energy Corporation Ltd (power supply)
    - Powerlink (power supply)
    - Sunwater Ltd (water supply)
    - Aurizon (railway)
    - Central Highlands Regional Council (access)

The underlying landholders for BWM leases are shown in Figure 17 and Figure 18.

There are 12 lessees and agistment licensees within the EA boundary, with of the licensees being owners of nearby properties. An additional agistment licence area applies to land that is adjacent to the western EA boundary.

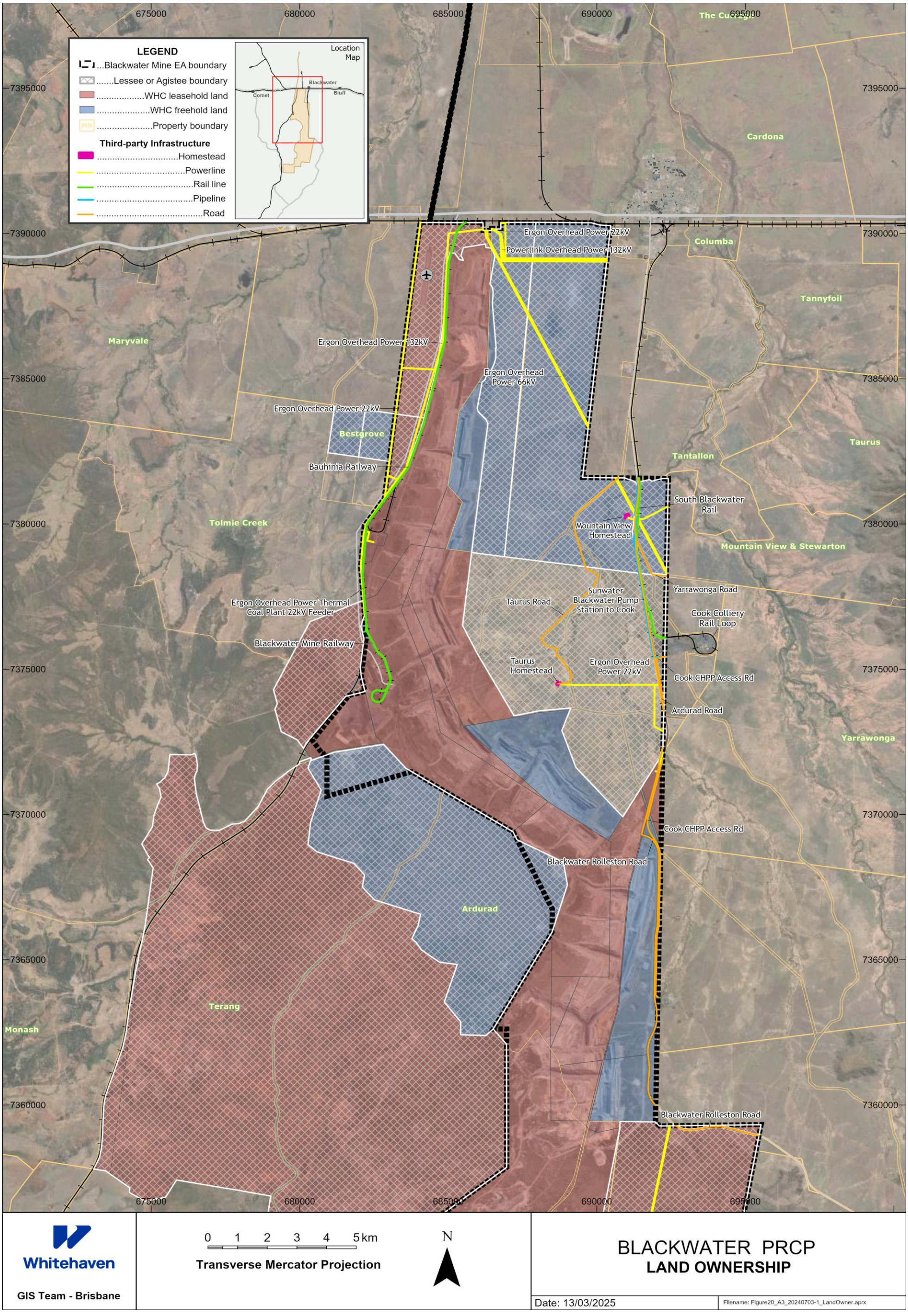

Figure 17 BWM land ownership (North and Central)

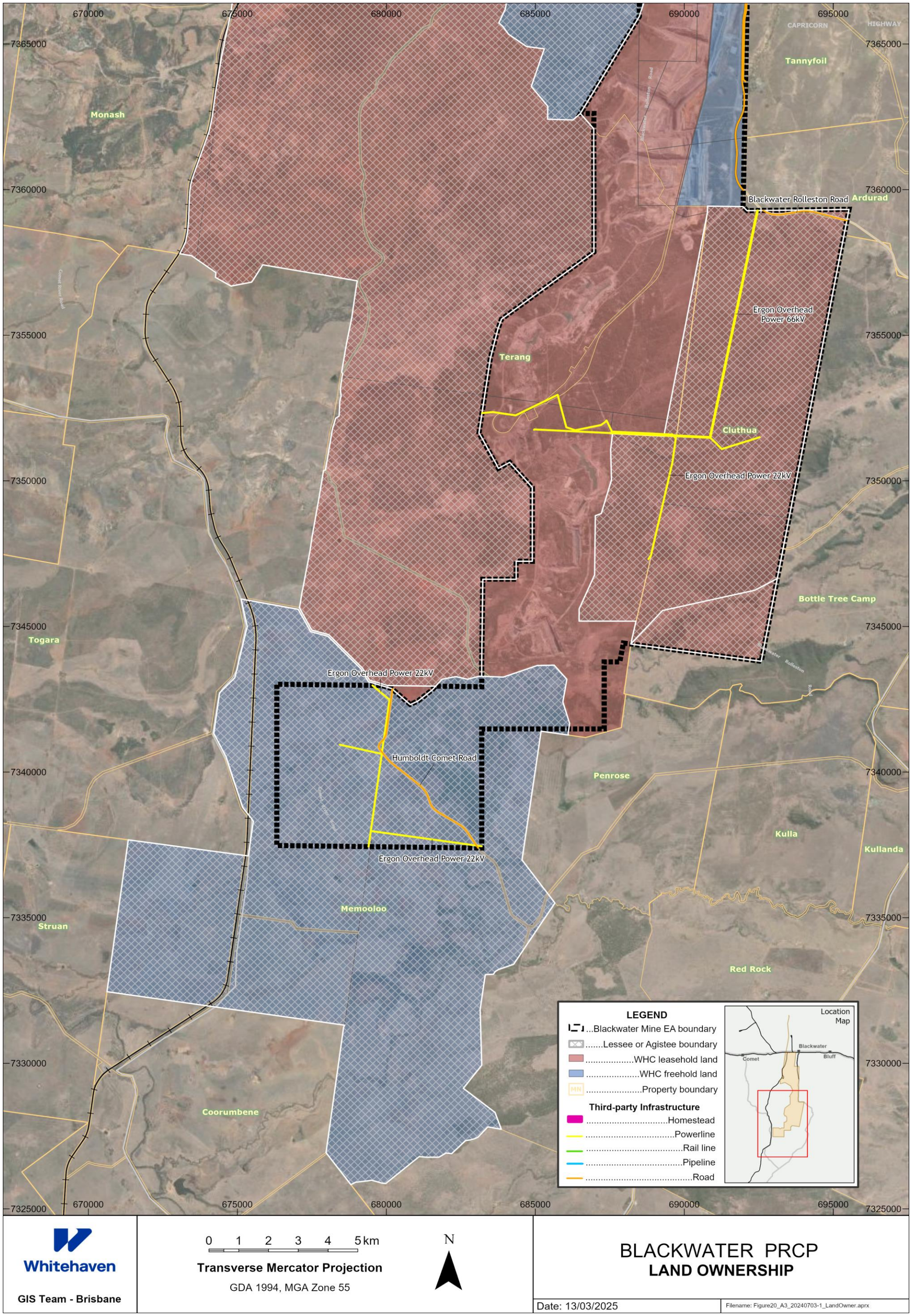

Figure 18 BWM land ownership (Central and South)

3.1.3 Design for closure

As the BWM PRCP is subject to transitional PRC Plan arrangements, it is not required to demonstrate how aspects of the mine site have been designed for closure for existing or approved disturbance (PRCP Guideline, Section 3.1).

However, this PRCP has been developed to manage progressive rehabilitation of the BWM site, aiming to minimise long-term management requirements as well as associated closure costs. Importantly, a focused design for closure underpins all sections of this plan, including:

- Engagement with relevant stakeholders to define suitable PMLUs and NUMAs.
- Defining and implementing rehabilitation practices based on identified risks that could influence the achievement of milestone criteria.
- Demonstrating a successful rehabilitation trajectory towards the achievement of these milestone criteria by ongoing site monitoring and maintenance.

3.1.4 Rehabilitation and improvement planning

Legislative Requirement

In accordance with sections 126C(1)(b) and (c)(ii) of the EP Act, the rehabilitation planning part must include:

- *identification of all relevant activities on the mine site*
- *the predicted duration of each of the relevant activities proposed for the mine site*
- *the size/extent of the relevant activities*
- *whether the different relevant activities can be progressively rehabilitated.*

PRCP Guideline (Section 3.1)

Under section 126C(1)(j) of the EP Act, transitional PRC Plans must also include the following details about any existing rehabilitation already completed at the time of submission of the proposed PRC Plan:

- *a description of the rehabilitation works previously carried out*
- *when the rehabilitation works commenced and were completed*
- *whether the rehabilitation has been applied for or approved as progressively certified under the EP Act.*

3.1.4.1 Relevant activities requiring rehabilitation, duration and progressive rehabilitation

A relevant activity for a PRC Plan is defined in the EP Act as the relevant activities to be carried out on land the subject of the plan. The relevant activities at BWM that will require rehabilitation, the predicted duration and availability for progressive rehabilitation are detailed in Table 15 and illustrated in Figure 19 and Figure 20.

Due to the long life of the operation, Blackwater Mine does not have any agreements in place for mining related infrastructure that may have ownership transferred in the future. Formal agreements for the transfer of mining related infrastructure ownership will be developed and secured over time as the mine progresses through the rehabilitation milestones associated with the PRCP Schedule. In the instance that no agreements are in place and the intent is not to retain the infrastructure, rehabilitation will be carried out as defined in the PRC Plan and PRCP Schedule, and in support of the proposed PMLU for the relative area.

It is also important to mention that Figure 19 and Figure 20 include mapping insets which show areas defined by the legend as *"Existing retained third-party infrastructure subject to potential future re-alignment".* This information is shown to denote areas where the potential future realignment of third-party infrastructure may be required to enable mining activities in accordance with the PRC Plan. Any future realignment of these areas, and also potentially other areas not currently defined, would be subject to future agreement between Whitehaven and the relevant owner. For clarity, should future mining activities not progress in these areas, the infrastructure will remain in place and any future decisions, including for decommissioning and rehabilitation, will be at the discretion of the owner.

Based on current life-of-mine planning, mining at BWM is planned to conclude in 2113. Progressive rehabilitation works are underway across BWM and are expected to continue beyond the cessation of mining as defined in the PRCP Schedule (Appendix 4.1).

Table 15 Relevant activities requiring rehabilitation at BWM

Relevant activity	Predicted duration	Availability for progressive rehabilitation
Spoil dumps	Varying: utilised from the start of the PRCP Schedule until the end of mining	• Progressive rehabilitation has commenced. • Progressive rehabilitation areas become available as dump areas reach final position and are no longer required for associated infrastructure or access requirements. • Due to the depth of the mining operation and the size of the spoil dumps, areas become available as per the indicative dump progression shown in Figure 5 • Progressive rehabilitation is maximised by scheduling rehabilitation as soon as practicable after land becomes available. • Low-wall areas become available once mining in each pit is complete.
Residual voids	Utilised until the end of mining	• Available for improvement once the low-wall spoil rehabilitation is complete for each pit and any partial backfill for flood mitigation is complete.
TSFs and rejects	Varying, depending on design capacity	• Available once planned tailings deposition and/or dumping of spoil within or above each TSF reaches the final TSF or spoil dump position, and required studies to inform rehabilitation methods have been completed and the area is no longer required for associated infrastructure or access requirements.
Creek diversions and crossings	Varying: with the latest utilised until the end of rehabilitation activities	• Depending on the location in relation to mining and closure activities. Areas are available at the end of mining or after major rehabilitation activities are complete.
Mine dams	Varying: with the latest utilised until the end of rehabilitation activities	• Available when no longer required for water management.
CHPP and associated infrastructure; coal stockpiles	Utilised until the end of mining	• Available once coal processing is complete.
Workshop; buildings and other infrastructure areas	Varying: with the latest utilised until the end of rehabilitation activities	• Availability dependent on the use and location. The majority will be available at the end of the major rehabilitation activities. Some areas may be available earlier, such as at the end of mining or coal processing.
Train loadout (TLO) and rail infrastructure (excluding third-party infrastructure)	Utilised until the end of coal loading	• Surrounding area is available once coal loading is complete and infrastructure is removed by third-party owners.
Roads; laydown and general disturbance	Varying: with the latest utilised until the end of rehabilitation activities	• Availability dependent on the use and location. Typically, areas will be available either at the end of mining or coal processing or after the major rehabilitation activities are complete.

Relevant activity	Predicted duration	Availability for progressive rehabilitation
Exploration	Western areas are planned until 2025; other areas likely in the future	• Available within six months after exploration activities are complete (*as per Eligibility criteria and standard conditions for exploration and mineral development projects, or its successor*). • Exploration areas not planned to be mined and within designated Rehabilitation Areas, will be rehabilitated in accordance with the *Eligibility criteria and standard conditions for exploration and mineral development projects'* or its successor.

It is noted that the BWM EA includes the following condition regarding the commencement of progressive rehabilitation:

- E4: *"Progressive rehabilitation must commence within three (3) years when areas become available for rehabilitation".*

All areas are included in the PRCP Schedule for rehabilitation as soon as practicable after land becomes available. For infrastructure and general disturbance areas, rehabilitation is scheduled the year after the land becomes available to allow for final planning. Spoil dump areas are scheduled within three years after the land becomes available to allow for final settlement, planning and availability of resources (and as aligned to EA Condition E4).

3.1.4.2 Existing rehabilitation

When open-cut operations commenced at BWM most overburden was removed by electric draglines. Initially, (i.e. prior to the introduction of pre-stripping with truck-and-shovel) areas of rehabilitation were generally constructed by regrading dragline spoil rows to undulating plains and rises which were seeded to improved pastures, trees and shrubs.

Methods used since the commencement of more formal rehabilitation in about 1980 have included spoil regrading with scrapers and draglines in addition to more common techniques using large dozers. Subsequently, extensive areas have since been rehabilitated by regrading spoil with dozers to long uniform slopes. BWM ML conditions initially required that lands disturbed by mining should be 'reinstated to no less than its former value for grazing'. Hence, rehabilitation efforts focused predominantly on the establishment of pasture-based grazing systems. There are however several areas, particularly in South Blackwater (Figure 21), that have been historically rehabilitated to a woodland habitat largely focused on the establishment of native Eucalyptus and Acacia species.

Over time, BWM has progressively advanced 1,929ha of existing rehabilitation towards the achievement of the nominated PMLUs and rehabilitation milestones outlined in the PRCP Schedule (see Appendix 4.1). The existing rehabilitation hectares completed for the cattle grazing and woodland habitat PMLUs consist of:

- 1,200 ha for cattle grazing
- 729 ha for woodland habitat

A summary of existing rehabilitation area performance is provided in Appendix 4.17 and within this PRC Plan. Cattle grazing rehabilitation performance is discussed in Section 3.1.4.2.1 and woodland habitat performance in Section 3.1.4.2.2. These summaries are based on the results of rehabilitation monitoring conducted between 2018-2024.

The PRCP schedule provided in Appendix 4.1 (see RA6 and RA7) lists the associated rehabilitation milestone criteria existing rehabilitation areas are progressing towards. Routine rehabilitation monitoring will continue to be implemented as discussed in Section 3.7.1.2 to identify any maintenance/corrective actions required to enable the rehabilitated areas to achieve the milestone criteria.

Applications will be made to the administrating authority for areas identified as being suitable for progressive rehabilitation certification under the EP Act as a result of ongoing monitoring.

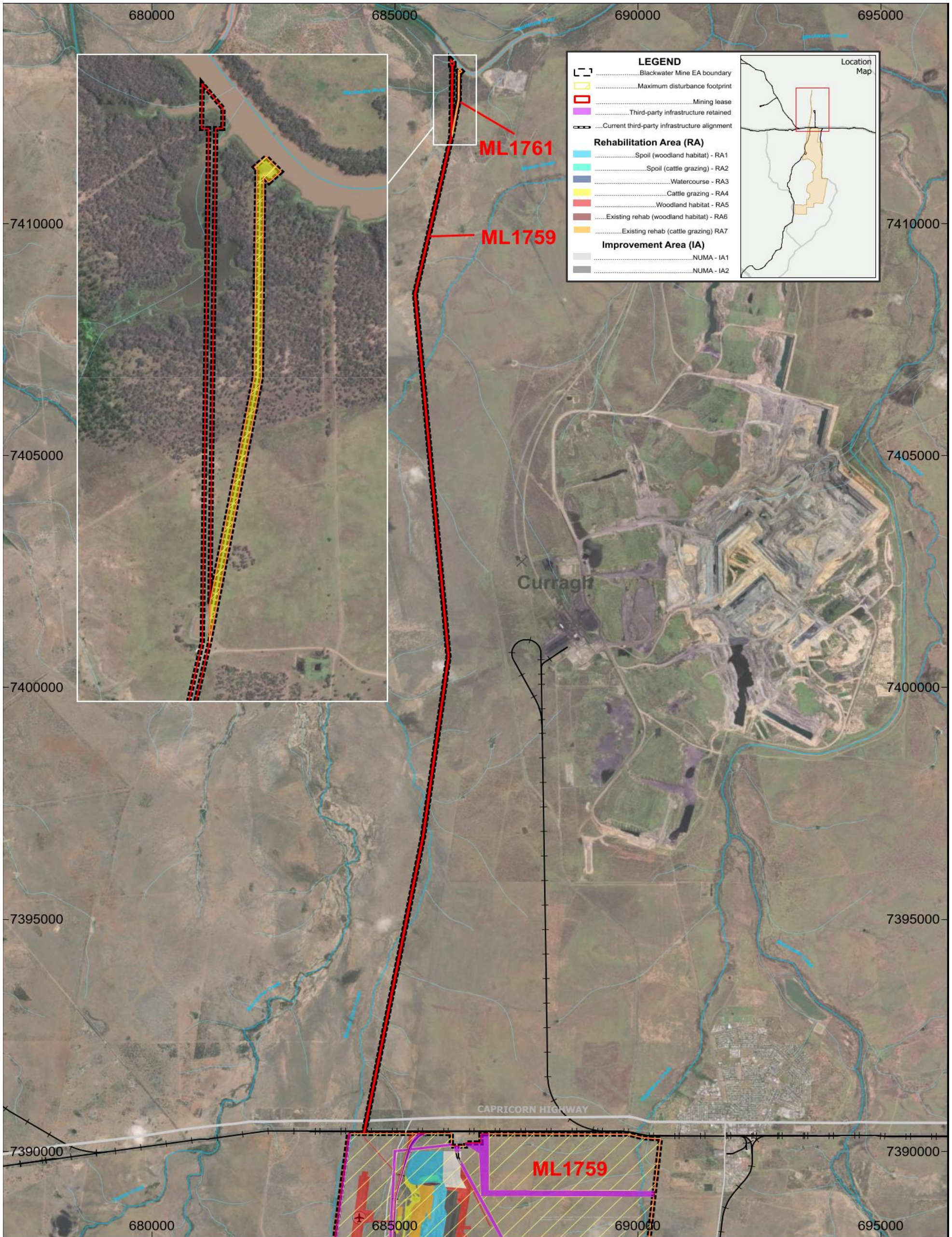

Figure 19 Reference map - indicative areas available for rehabilitation (BWM North)

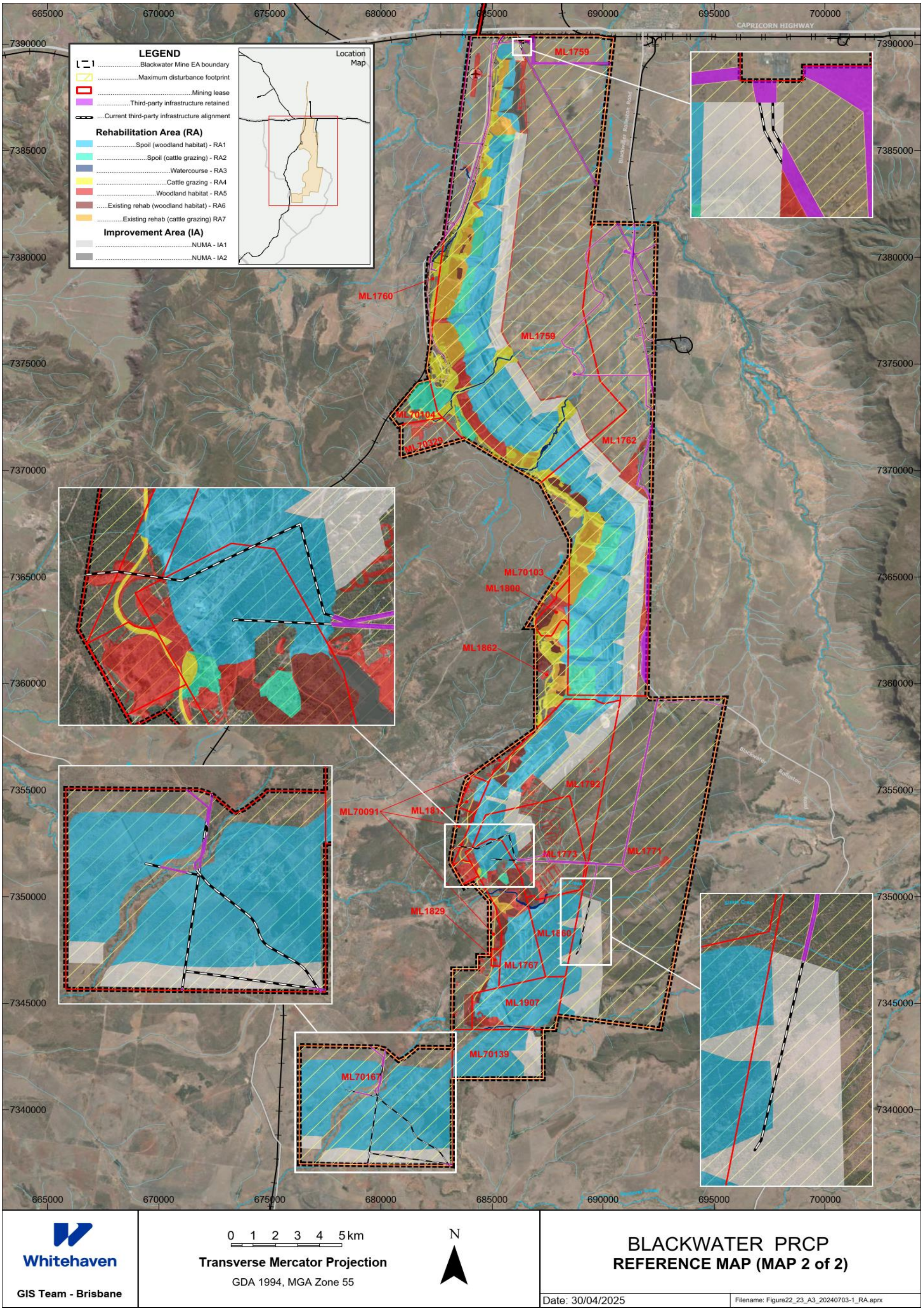

Figure 20 Reference map - indicative areas available for rehabilitation (BWM North, Central and South)

3.1.4.2.1 Existing Cattle Grazing Rehabilitation

The results of monitoring of existing cattle grazing rehabilitation areas have been summarised below as it relates to the following criteria:

- land suitability class ≤3 (Short, 2023)
- land condition Good (A) or Fair (B) (DES, 2022a)

The raw land suitability class data has been provided for all cattle grazing sites assessed between 2022 and 2024 to DETSI in the Blackwater Coal Mine Rehabilitation Monitoring RFI Response (WHC, 2025a). The land suitability class results are summarised in Figure 22 with the results of rehabilitation monitoring sites represented in the light blue bars and the cattle grazing reference sites in dark blue bars. The results indicate that the majority of the existing cattle grazing is classed between LSC 4 and 5. It is important to note that in accordance with Short (2023) land suitability is scored on the most limiting factor. The results of a review of the raw data (WHC, 2025a) indicate that many sites are limited by low available Phosphorus (P) in 0.1m of the rehabilitated soil profile as well as moderate to higher pH in 0.1m of the rehabilitated soil profile. Other limiting factors include percent slope and exchangeable sodium percent (ESP) in 0.1 and/or subsoil erosion associated with high >23% ESP at 0.5m depth. Whilst available Phosphorus (P) can be ameliorated through application of fertiliser, it is important to note that both cattle grazing reference sites are also limited by low available P which can therefore be considered evidence of a pre-mining limitation. Furthermore, both reference sites are also limited by high moderate to higher pH in 0.1m which can also be considered a pre-mining condition.

Whilst not a current completion criterion in the BWM EA, areas of cattle grazing have also been assessed against 'land condition' criteria based on the *Queensland Reef Quality Program Reef Protection Regulations Farming in Reef Catchments Grazing Guide Version 2* (DES, 2022a). The results of the grazing land condition monitoring are provided in attachment four and five and have been summarised in Figure 23 with the results of rehabilitation monitoring sites represented in the blue bars and the cattle grazing reference sites in purple bars. Whilst land condition is not a completion criterion in the BWM EA, it is an important criterion for monitoring the condition of grazing lands in Central Queensland (DES, 2022a). The results indicate the majority of the cattle grazing is in Good (A) or Fair (B) land condition.

It is however important to note that the majority of cattle grazing in Good (A) or Fair (B) land condition only supports one preferred, perennial and palatable (3P) grass species predominantly buffel grass (*Cenchrus ciliaris*). The BWM PRCP addresses this issue for all future cattle grazing requiring at least four 3P species of pasture grass to be sown.

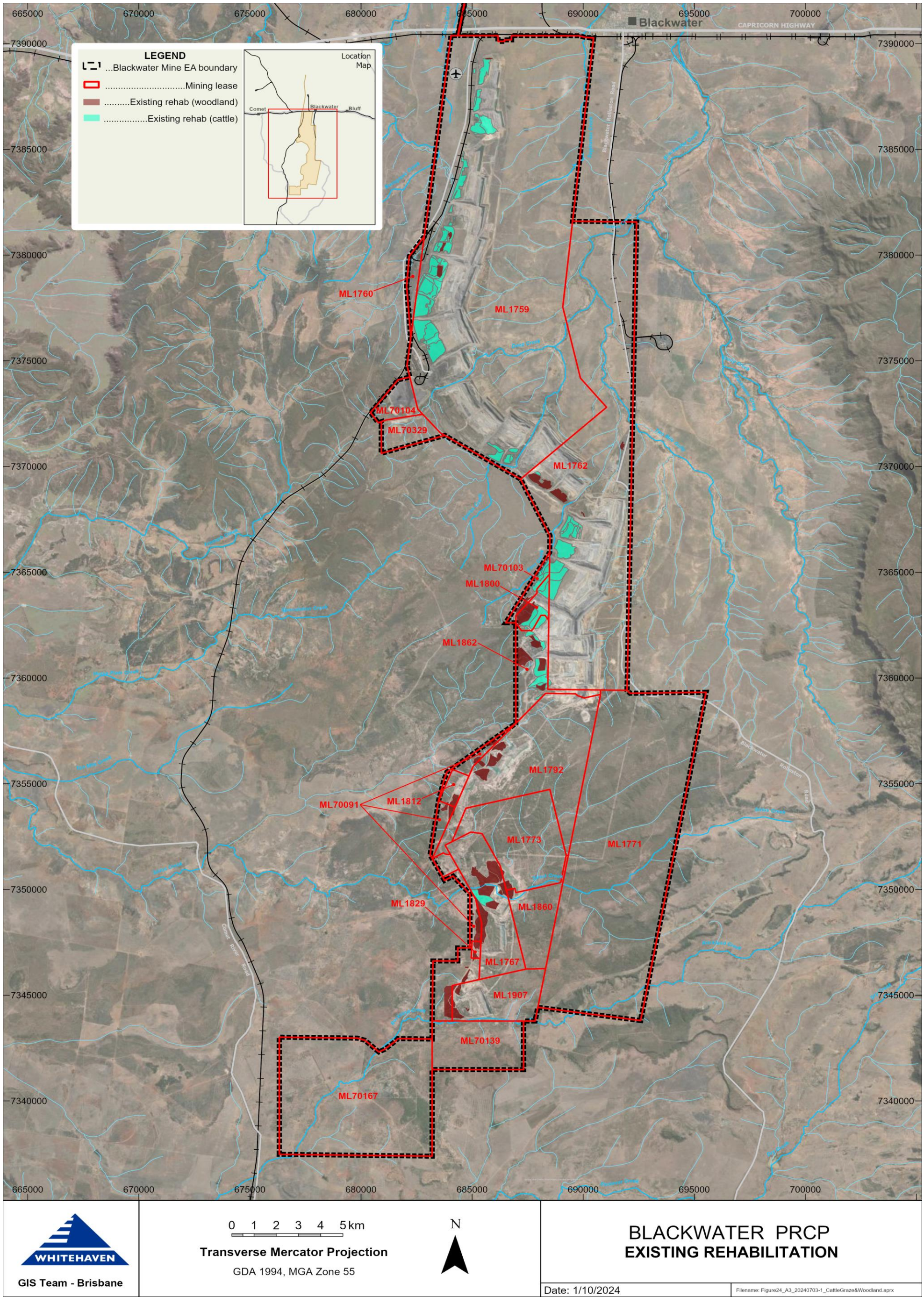

Figure 21 Existing rehabilitation

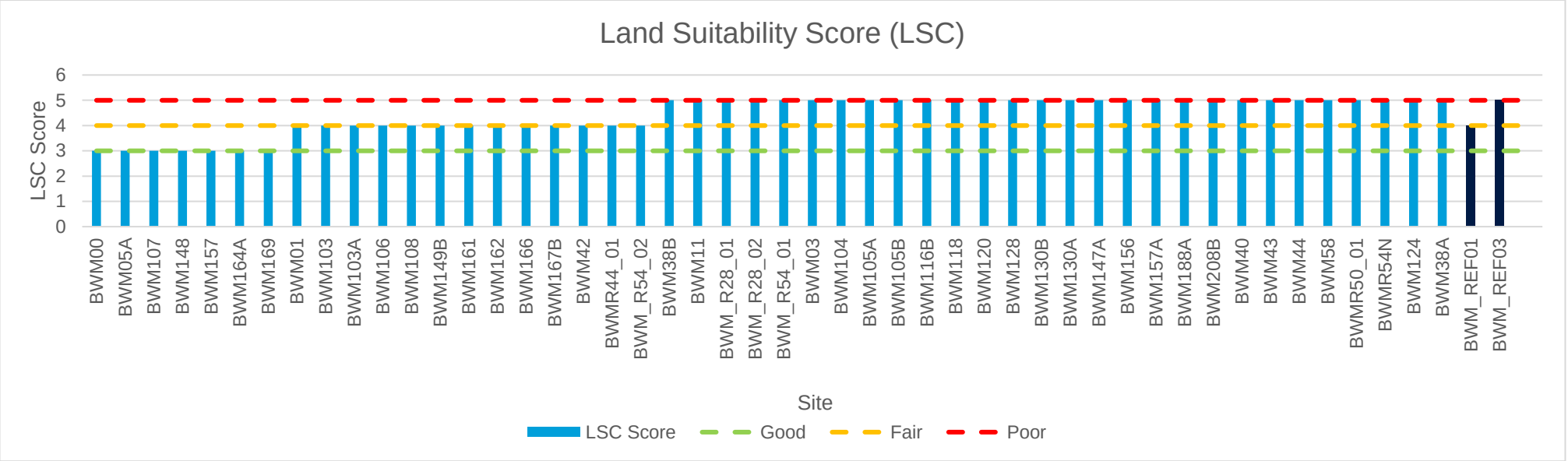

Figure 22 Land suitability class results 2022-2024

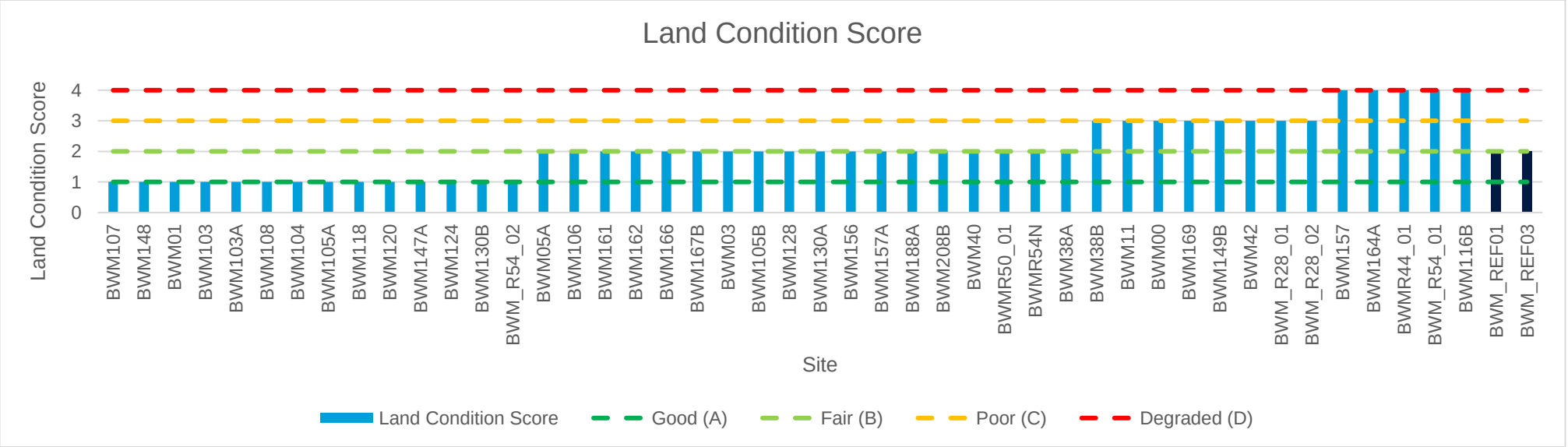

Figure 23 Land condition monitoring results 2022-2024

3.1.4.2.2 Existing Woodland Habitat Rehabilitation

Table E1 of the BWM EA requires all woodland areas to meet 'native bushland habitat characteristics' including ≥2 tree, ≥3 shrub and ≥4 grass species richness as well as ≥16% canopy cover. The raw woodland habitat data has been provided for all woodland habitat sites assessed between 2022 and 2024 to DETSI in the Blackwater Coal Mine Rehabilitation Monitoring RFI Response (WHC, 2025a).

A summary of the overall results for all woodland habitat sites have been presented for each of the native bushland habitat characteristics with the rehabilitation site results represented by the blue bars and the woodland habitat reference sites represented by the purple bass as follows:

- Species richness:
  - Trees ≥2 (Figure 24)
  - Shrubs ≥3 (Figure 25)
  - Grasses ≥4 (Figure 26)
- Tree canopy cover ≥16% (Figure 27)

A summary of erosional stability of woodland habitat has also been provided in Figure 28 based on the following EA criteria:

- Groundcover (steep slopes, >15%) ≥80%
- Groundcover (lesser slopes, ≤15%) ≥50%

The results of the woodland habitat monitoring indicate that the majority of the existing woodland habitat sites are performing well with ≥2 tree species, ≥3 shrub species, ≥16% tree canopy cover and total ground cover (%) over slope consistent with the EA requirements. It is however important to note grass species' richness is quite low across many of the woodland sites. Mine soils and spoils are often contaminated with exotic pasture grasses and historically rehabilitation focused primarily on trees and shrubs with exotic pasture species. Native grasses have only become available in commercial quantities over the last ten or so years. For this reason, both exotic and native grasses are considered justified for older areas of rehabilitation >10 years.

The woodland habitat analysis also considers invasive plant species cover and recruitment of the canopy species.. The majority of the woodland rehabilitation is low in invasive plant cover and has evidence of recruitment of canopy species. Despite the low presence of invasive plans BWM is conducting weed control in woodland areas and is also focusing on a control program of Leucaena.

In December 2024 BWM lodged a woodland habitat progressive certification application for 65.6 ha of historic woodland habitat rehabilitation associated with rehabilitation areas BWM25, BWM33 and BWM180 (LEC, 2024b). The application demonstrated the conditions of the environmental authority have been complied and the land has been satisfactory rehabilitated. Satisfactory rehabilitation is safe, stable, non-polluting and able to sustain the agreed post-mining land use. In addition to demonstrating compliance with the rehabilitation success criteria, the application also described the ongoing environmental management requirements and presented a detailed assessment of environmental risks associated with the rehabilitation.

BWM intend to continue to maintain woodland habitat and pursue further progressive certification application for woodland habitat that complies with the BWM EA.

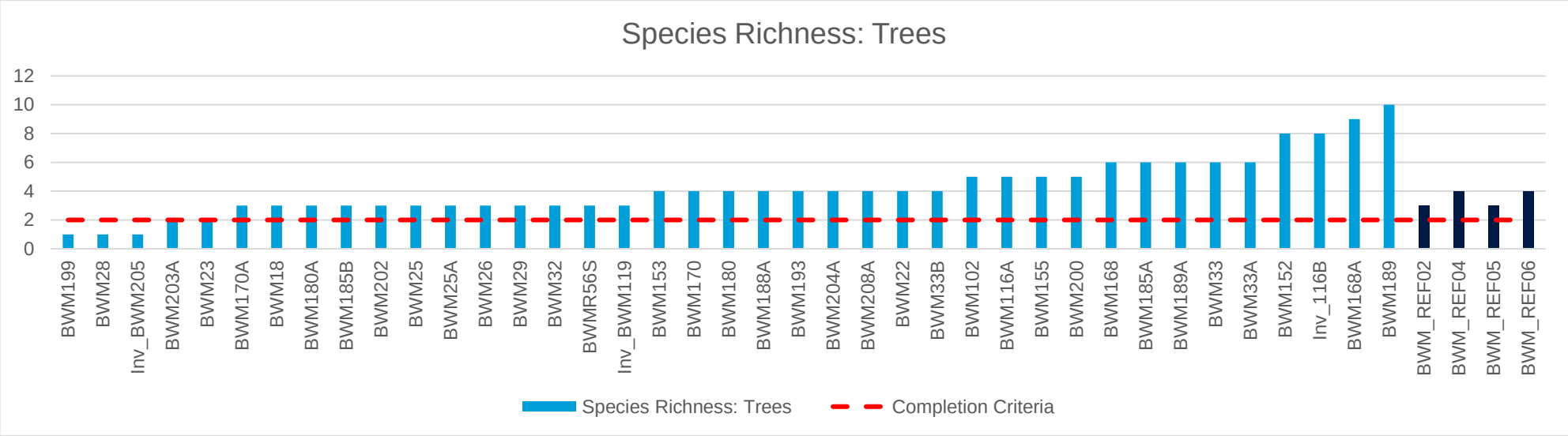

Figure 24 BWM woodland habitat rehabiliaition tree species richness 2022-2024

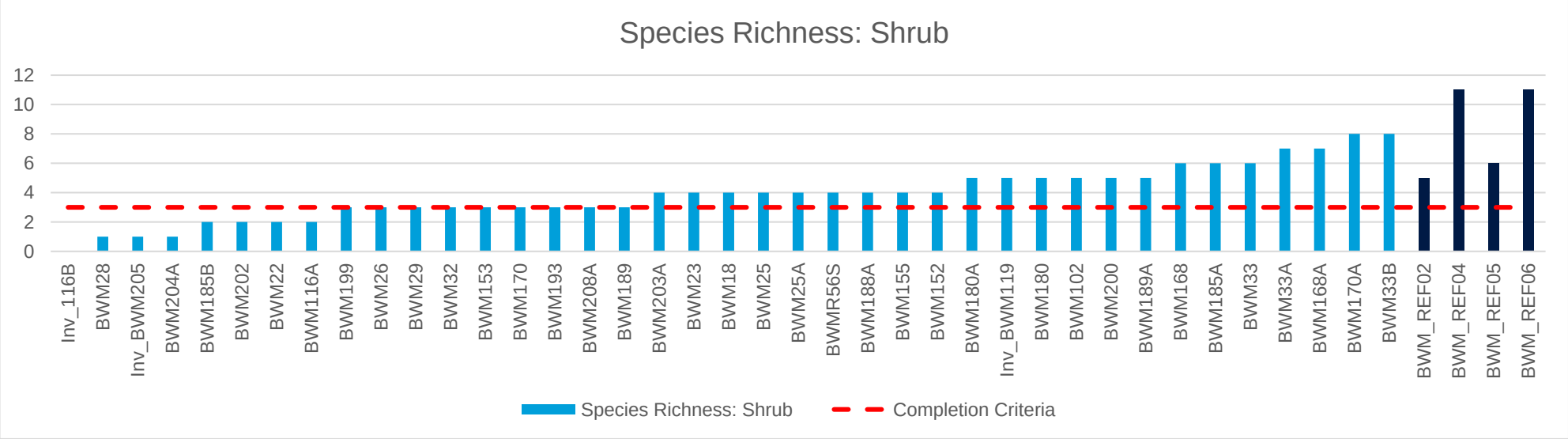

Figure 25 BWM woodland habitat rehabilitation shrub species richness 2022-2024

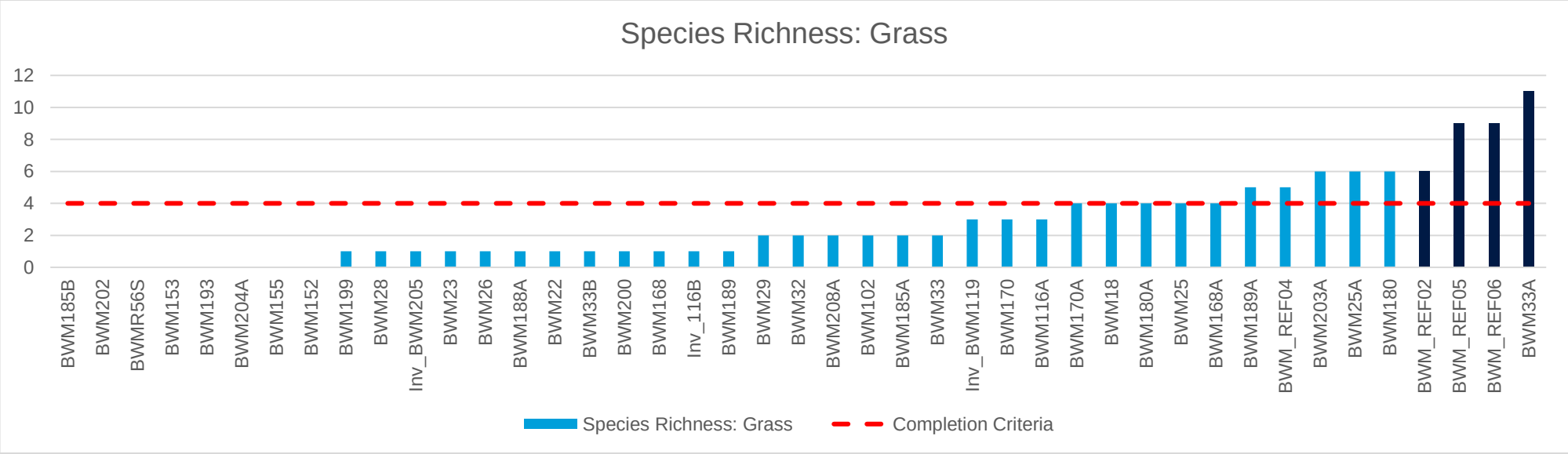

Figure 26 BWM woodland habitat rehabilitation grass species richness 2022-2024

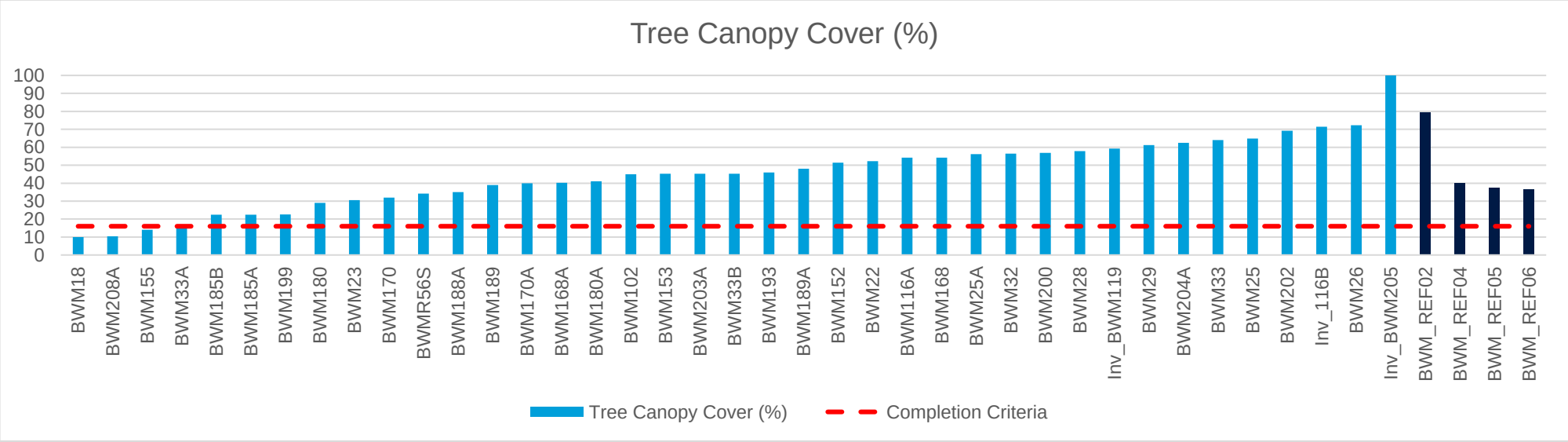

Figure 27 BWM woodland habitat rehabilitation tree canopy cover percent (%) 2022-2024

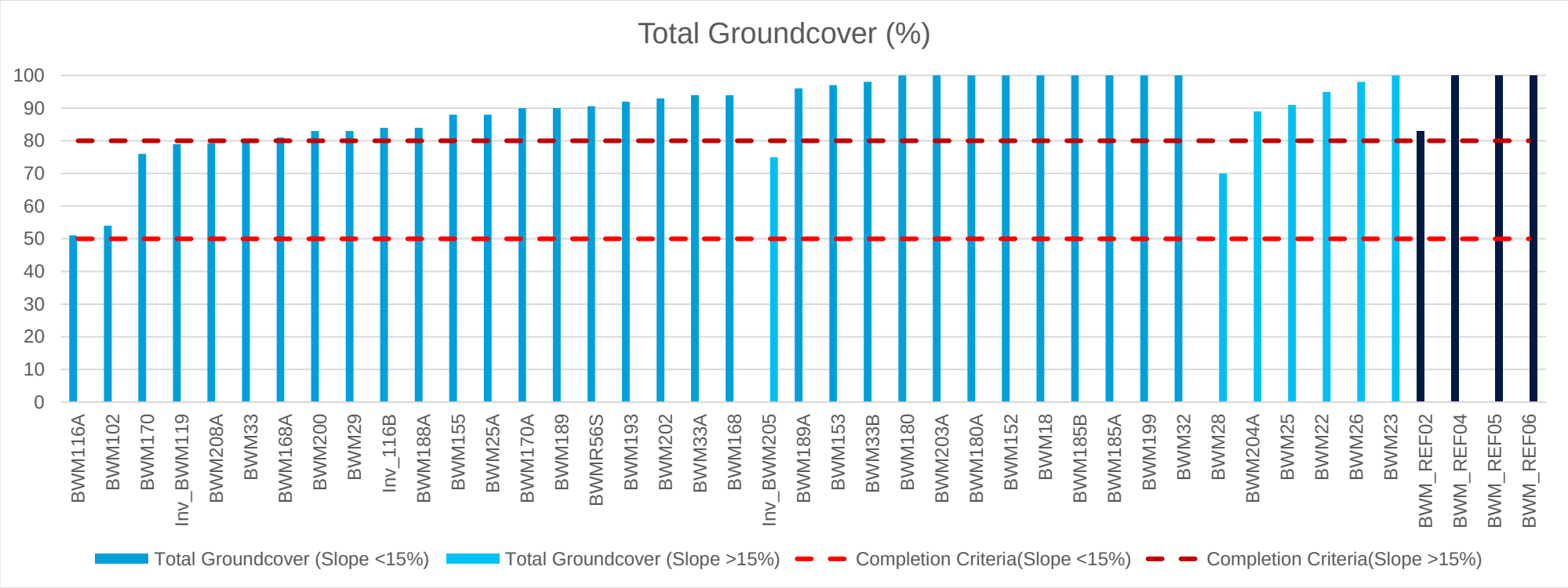

Figure 28 BWM woodland habitat rehabilitation total ground cover (%) over slope 2022-2024

3.2 Community consultation

Legislative Requirement

In accordance with section 126C(1)(c)(iii) and (iv) of the EP Act, the rehabilitation planning part of the PRC Plan must include:

- details of the consultation undertaken by the applicant in developing the proposed PRC Plan, and
- details of how the applicant will undertake ongoing consultation in relation to the rehabilitation to be carried out under the plan.

PRCP Guideline (Section 3.5)

In developing the proposed PRC Plan, the community should at least be engaged on the plan for the mine, PMLUs or NUMAs, areas of disturbance, rehabilitation and management methods, progressive rehabilitation, and closure timeframes. Ongoing community consultation should continue throughout the stages of the mine life so that progressive rehabilitation and the socio-economic and environmental impacts related to mine closure can be discussed with the community.

Community consultation carried out through different processes (such as an EIS) may be used to address the requirements in section 126C(1)(c) of the EP Act. The details of this consultation must be provided in the rehabilitation planning part of the proposed PRC Plan).

Transitional PRC Plans are still required to meet the legislative requirements in section 126C(1)(c) of the EP Act. All proposed PRC Plans must contain a community consultation plan regardless of whether the site has an existing EA.

To support the development of this PRCP a Community Consultation Plan (CCP) directed the consultation approach, and a supporting consultation register has been maintained throughout the process. The CCP and register are provided in Appendix 4.4 – *Community Consultation Plan and Register*.

The CCP documents the iterative consultation process to enable ongoing PRCP-related engagement identifying stakeholders[1] considered to have a genuine, demonstratable and legitimate interest in the ongoing rehabilitation and closure planning at BWM. Table 3.1 of Appendix 4.4 describes the stakeholders, existing relationships and potential areas of interest with respect to the site's PRCP.

The Community Consultation Register (Appendix 4.4) is compliant with section 126(1)(c)(iii) of the EP Act and includes:

- Identification of each community member/stakeholder
- Previous engagement with the community
- Consultation relevant to the PRCP development, including:
    - Consultation date(s)
    - Description of consultation type (e.g. letter, meeting)
    - Information provided to the community
- Engagement outcomes, including:
    - Issues raised by/discussed with the community
    - How issues have been considered
    - Decisions/outcomes of the engagement
    - Commitments made to address feedback

3.2.1 Consultation to date

Operations commenced at BWM in 1967. At this time, from a regulatory perspective, an Environmental Impact Statement (EIS) and associated community consultation were not required. However, the following consultations relevant to rehabilitation and closure planning have subsequently taken place prior to the development of this transitional PRCP:

[1]Noting that the documented mine relationships capture those predominantly developed by BMA as the previous site owner (until end-March 2024).

- During 2018, BMA engaged with DESI to implement the current EA conditions in relation to PMLUs and the required acceptance criteria for those PMLUs, which were included in the EA - reflected in Table E1: Rehabilitation Requirements.
- During 2020-2022, ongoing engagement with DESI in relation to how the PRCP Guideline elements (particularly regarding transitional arrangements) and the current EA conditions related to rehabilitation and closure would transition to BMA's PRC Plans.
- During 2023, high level information about the BWM PRCP planning process was provided by BMA to the Central Highlands Regional Council (CHRC) and the Central Highlands Development Corporation (CHDC).
- On an ongoing basis, prior to the divestment of the BWM to Whitehaven on 2 April 2024, BMA engaged with nearby landholders on land management and lease/licence conditions, and on operational, environmental management and/or water matters, as required.

Historically, community consultation was conducted and resulted in the agreed PMLUs and NUMAs that are included in the conditions of the EA. Consultation and engagement conducted by BMA was to transition the PMLUs and NUMAs within the EA to the PRCP. Refer to the previous engagement column in the Community Consultation Register (Appendix 4.4) for further information.

During the 2024 PRCP engagement, the following information was broadly shared across the different stakeholder groups:

- PRCP requirements and timing for BWM
- The PRCP's purpose and scope
- Commitment to progressive rehabilitation
- PMLU options
- Inclusion of residual voids to be transitioned as non-use management areas (NUMAs)
- As the new owner, Whitehaven Coal Pty Ltd is responsible for the PRCP and consultation
- Opportunity to discuss the PRCP and seek information

Overall where there was feedback and enquiries, the PMLU following rehabilitation was identified as grazing lands and recorded as an outcome of the engagement. Whitehaven Pty Ltd has committed to providing updates on the PRCP process and progressive rehabilitation.

3.2.2 Community consultation register and outcomes of stakeholder engagement

The community consultation register provided in Appendix 4.4 is compliant with section 126C(1)(c)(iii) of the EP Act and includes:

- Identification of each community member/stakeholder
- Previous engagement with the community
- Consultation date(s)
- Description of consultation type
- Information provided to the community
- Issues raised/discussed by the community
- How issues have been considered
- Decision/outcomes of engagement
- Commitments made

The stakeholders identified as part of this register are considered as having a genuine, demonstrable and legitimate interest in the ongoing rehabilitation and closure planning at BWM. Table 16 summarises identified stakeholders and the outcomes from PRC Plan related engagements. Further detail is provided in the Community Consultation Register available in Appendix 4.4.

Table 16 Identified stakeholders and outcomes from BWM PRCP engagements

Stakeholder	Outcomes from BWM PRC Plan engagement
Gaangalu Nation People - have a Registered Native Title (NT) claim (QC2012/009) and BWM Cultural Heritage Management Plan (CHMP).	— Ongoing engagement according to the consultation protocol developed with the Gaangalu Nation People during 2023-2024. — Noted key interests in environmental management and mine rehabilitation. — Ongoing Traditional Owners' access to land within the EA area in accordance with the terms of the registered Indigenous Land Use Agreement.
Underlying landowners	— Continue to make available land within the MLs for grazing under the licence agreement with the landowner. — Landholders and cattle will be excluded from affected areas while land disturbance is occurring. — As disturbed land becomes available, it will be rehabilitated to a state suitable for the approved post-mining land use e.g. grazing, woodland, water courses, or managed as a non-use management area. — Whitehaven Blackwater will engage with BMA regarding any relevant progressive rehabilitation and closure activities that may affect BMA-owned land.
Licensees of land within the BWM EA area	— Grazing is considered a PMLU in areas where disturbed land would be rehabilitated to enable this use.
Nearby landowners (within 5km)	— Regular community updates will be used to provide information about PRC planning and implementation.
Blackwater community	— Provide community updates on PRC planning where there are substantive changes or updates to the PRC plan.
Central Highlands community members, groups and businesses	— Continue providing community information and opportunities for feedback as part of future PRC planning processes.
BWM	— Cooperation between BWM GM and the Whitehaven Blackwater Pty. Ltd.'s Closure Planning team will continue during PRC plan implementation and updates to the PRC plan. — Continue to update the workforce as PRC plans are implemented and updated.
Local government	— Ongoing engagement with Central Highlands Regional Council (CHRC) regarding PRC planning, with updates provided at meetings between Whitehaven Blackwater Pty. Ltd. and CHRC. — Consult CHRC on management plans if rehabilitation and/or closure activities impact CHRC assets including road management and recycling facilities. — Future engagement with CHRC will include discussions of rehabilitation methods and milestones.
Utility owners	Maintain correspondence regarding progressive rehabilitation activities with: — Sunwater as they affect the Blackwater Pipeline, and undertake consultation regarding crossing/interface agreements, if required. — Department of Main Roads Queensland (DTMR) as they affect Capricorn Highway and Ardurad (Blackwater-Rolleston) Road, and undertake consultation regarding crossing/interface agreements, if required. — CHRC as they affect Council roads and road reserves, and undertake consultation regarding crossing/interface agreements, if required. — Ergon Energy as they affect Ergon Energy assets, and undertake consultation regarding agreements about energy infrastructure, if required. — Powerlink as they affect Powerlink assets, and undertake consultation regarding crossing/interface agreements, if required. — Telstra Amplitel as they affect Telstra Amplitel assets, and undertake consultation about telecommunications infrastructure agreements, if required. — Telstra Vocus as they affect Telstra Vocus's assets, and undertake consultation about internet infrastructure agreements, if required. Advise of any substantive changes to closure planning or the rehabilitation schedule as part of future PRC planning processes: — Queensland Rail — Aurizon Network — Total Energies, as an adjoining landholder
Adjacent and nearby mining interests	Update the following as PRC Plans are implemented and revised: — QCoal — Coronado Curragh Pty. Ltd
Petroleum tenement holders	Advise of any substantive changes to closure or rehabilitation schedule as part of future PRC planning processes: — Bow CSG Pty. Ltd — Comet Ridge Mahalo entities — Adjacent petroleum tenement holders
Queensland government agencies	— The PRC plan will be completed in accordance with Whitehaven Blackwater's agreements with DETSI. A copy of the PRC plan and updates on any substantive future changes to the PRC Plan will be provided to: — DDG Georesources, with annual updates to the Department of Resources as per the CCP — Director Native Title Services and Coal Hub, Rockhampton — Executive Director, Minerals and Coal Information and opportunities for feedback as part of the future PRC planning process will be provided to: — Interested government agencies — Department of Agriculture and Fisheries
Queensland government representatives	Provide updates on any substantive future changes to the PRC Plan to: — Office of the Minister — Office of the Shadow Minister — The Member for Burdekin — The Member for Gregory
Federal government	Provide updates on any substantive future changes to the PRC Plan to the Office of the Minister.

Relationship with PRCP Schedule

BWM has transitional provisions and approved land outcomes identified in the EA. Specific community engagement on BWM's PMLUs, NUMAs and rehabilitation approach has been undertaken prior to submission of the BWM transitional PRCP, and consultation will continue as per the process documented in the CCP. Achievement of the PMLUs of cattle grazing, woodland habitat and watercourse, and inclusion of voids as NUMAs is in line with engagement completed to date.

3.3 Post-mining land uses

Legislative Requirement

In accordance with section 126C(1)(d) of the EP Act, the rehabilitation planning part of the PRC Plan must state the extent to which each post-mining land use for land identified in the PRC PLAN schedule for the plan is consistent with:

1. *the outcome of consultation with the community in developing the plan, and*
2. *any strategies or plans for the land of a local government, the State or the Commonwealth.*

PRCP Guideline (Section 3.2)

A PMLU is defined under section 112 of the EP Act as the purpose for which the land will be used after all relevant activities for the PRC Plan carried out on the land have ended. Relevant activity for a PRC Plan is defined in the EP Act as the relevant activities to be carried out on land the subject of the plan. It is not the intention of this definition to include third-party activities or assets that continue to exist once mining activities have ceased, such as third- party pipeline easements, power easements or overlapping tenures for other EAs.

The rehabilitation planning part of the PRC Plan must include a detailed description of the nominated PMLU(s) for the site. The description must include (where relevant), but is not limited to:

- *a description of the use of the land*
- *if applicable, the specific vegetation types (e.g. RE 13.2.9) or land suitability classification (e.g. Class 4)*
- *identification of any permanent or essential management infrastructure to be included as part of the PMLU*
- *completion criteria for measuring whether the PMLU has be successfully achieved*

Where a PMLU has been previously addressed in a land outcome document and is able to be transitioned into the PRCP Schedule, the holder is not required to complete the information requirements under section 126C(1)(j) of the EP Act in this section for those PMLUs.

However, the legislative requirements under section 126C(1)(d) of the EP Act still apply. All PMLUs transitioned into the PRCP Schedule must still meet the requirements of a PMLU explained in this section, particularly that the PMLU can be rehabilitated to a stable condition.

Where PMLUs have not been pre-approved, the applicant must include all of the requirements stated in this section.

3.3.1 Regulatory context

Determining the appropriate PMLUs is a critical first step in mine rehabilitation planning. It supports and informs the remainder of the proposed PRCP, including rehabilitation and management strategies, and the PRCP schedule. Mining is a temporary land use, and therefore it is important to consider a future land use that aligns with social, economic, and environmental expectations for the site, as per Section 126C(1)(d) of the EP Act. Criteria for all PMLUs to be adopted for BWM will align with the requirements of the EP Act as described. The EP Act and EP Regulation contain several additional sections that need to be complied with, as further described below.

3.3.1.1 Section 111A of the EP Act 1994

For a proposed PMLU to be accepted, the PRCP must demonstrate that the land can be rehabilitated to a stable condition in accordance with the following definition from Section 111A of the EP Act:

Land is in a stable condition if:

- The land is safe and structurally stable, and
- There is no environmental harm being caused by anything on or in the land, and
  a) The land can sustain a PMLU.

This PRCP provides the pathway through which the above conditions can be achieved for the nominated PMLUs described in Section 3.3.2.

3.3.1.2 EP Regulation

The EP Regulation requires that each PMLU:

a) Is viable, having regard to the use of land in the surrounding region, and

b) Satisfies at least one of the following:

   i. The use is consistent with how the land was used before a mining activity was carried out on the land;

   ii. The use is consistent with a development approval relating to the land;

   iii. The use is consistent with a use of the land, other than a use that is mining, permitted under a State or Commonwealth Act, including, for example, a planning instrument under the Planning Act; and/or

   iv. The use will deliver or is aimed at delivering a beneficial environmental outcome.

3.3.1.3 Transitional PRCP context

In accordance with the transitional provisions under the MERFP Act, existing rehabilitation and closure outcomes in land outcome documents (LODs) (as defined in section 750 of the EP Act) can be transitioned into the PRCP. The primary LOD for BWM is the site's EA, with the secondary LOD being the *Residual Void Investigation* report (BMA, 2020). Where there is an inconsistency between these documents the primary LOD prevails to the extent of the inconsistency.

In alignment with the transitional provisions and the PRCP Statutory Guideline requirements, the following process for transitioning the rehabilitation and closure outcomes from the BWM EA into the site's PRCP schedule has been followed:

- Identified rehabilitation and closure outcomes in the LOD (EA EPML00717813)
- Identified post-mining land uses (PMLUs) and non-use management areas (NUMAs)
- Defined rehabilitation areas within the PMLUs, and improvement areas within the NUMA
- Identified milestones to achieve the PMLUs and manage the NUMA
- Identified milestone criteria for showing success or completion of the PMLU or NUMA
- Identified when the first milestone must commence and completion dates for the milestones.

3.3.2 Community considerations

As demonstrated in Section 3.1.4.2.1, the proposed final landform use concept (including the approved PMLUs in the EA and the NUMAs) was presented to external stakeholders for consideration and sourcing of alternatives that may provide value to the community post-mining. Achievement of the PMLUs is aligned with this engagement, in particular, the underlying landowners expect disturbed land to become rehabilitated to a state suitable for the approved PMLU such as grazing or is managed as a non-use management area. Additionally, the PMLUs are consistent with historical and surrounding land uses. The local landscape is largely a mosaic of agricultural land, townships and native vegetation (though fragmented, with no habitat corridors or connectivity within or adjacent to BWM that would require habitat connectivity as part of the final landform).

3.3.3 Nominated PMLUs

Three approved PMLUs under EA EPML00717813 have been transitioned into the BWM PRCP:

- Cattle grazing
- Woodland habitat
- Watercourse

The cattle grazing PMLU is predominantly planned for the lower gradient areas disturbed by mining activities, areas that require shallow rooted species and areas where significant clearing occurred prior to mining. The woodland habitat PMLU is planned for areas where cattle grazing is unsuitable (e.g. steeper slopes) and for disturbed areas near existing vegetation communities. The watercourse PMLU is planned for areas where existing watercourses run through BWM and the associated creek diversions.

In terms of third-party infrastructure associated with roads, rail, power, water and communications supply to landowners or townships, these areas do not have a defined PMLU and the rehabilitation of these areas is not included in this PRC Plan. These areas have been undisturbed by mining activities and may continue to exist once mining activities have ceased, subject to the owner's discretion. Table 49 and Figure 19, Figure 20, Figure 55 and Figure 56 outline the third-party owned land and assets (infrastructure) which is located within the BWM mining leases which will not be rehabilitated under this PRC Plan.

The proposed post-mining land use concept for BWM is illustrated in Figure 29 and Figure 30 and the PMLUs are listed in Table 17 along with their associated rehabilitation areas and milestones.

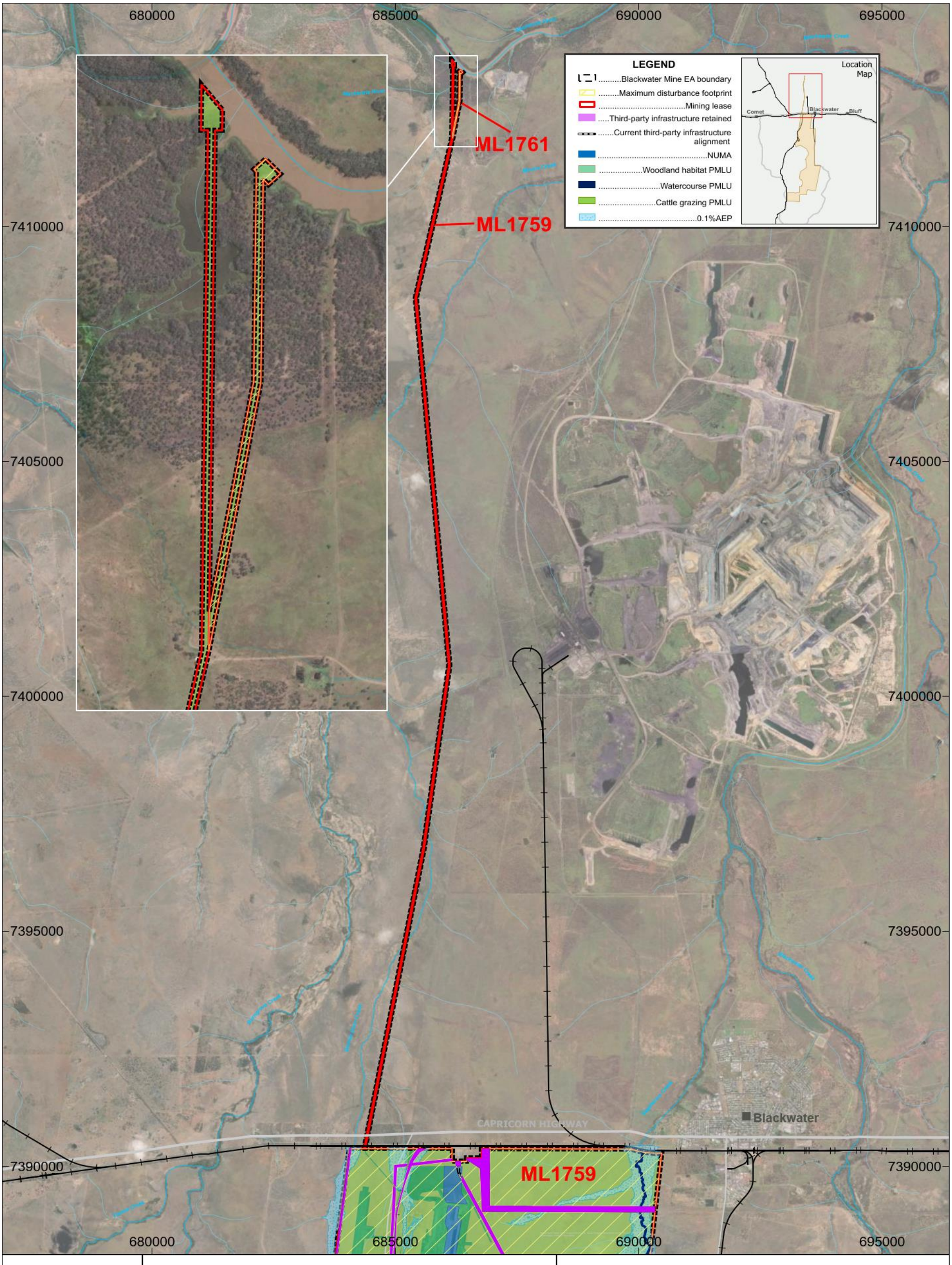

Figure 29 Final site design - locations of BWM PMLUs and NUMAs (North)

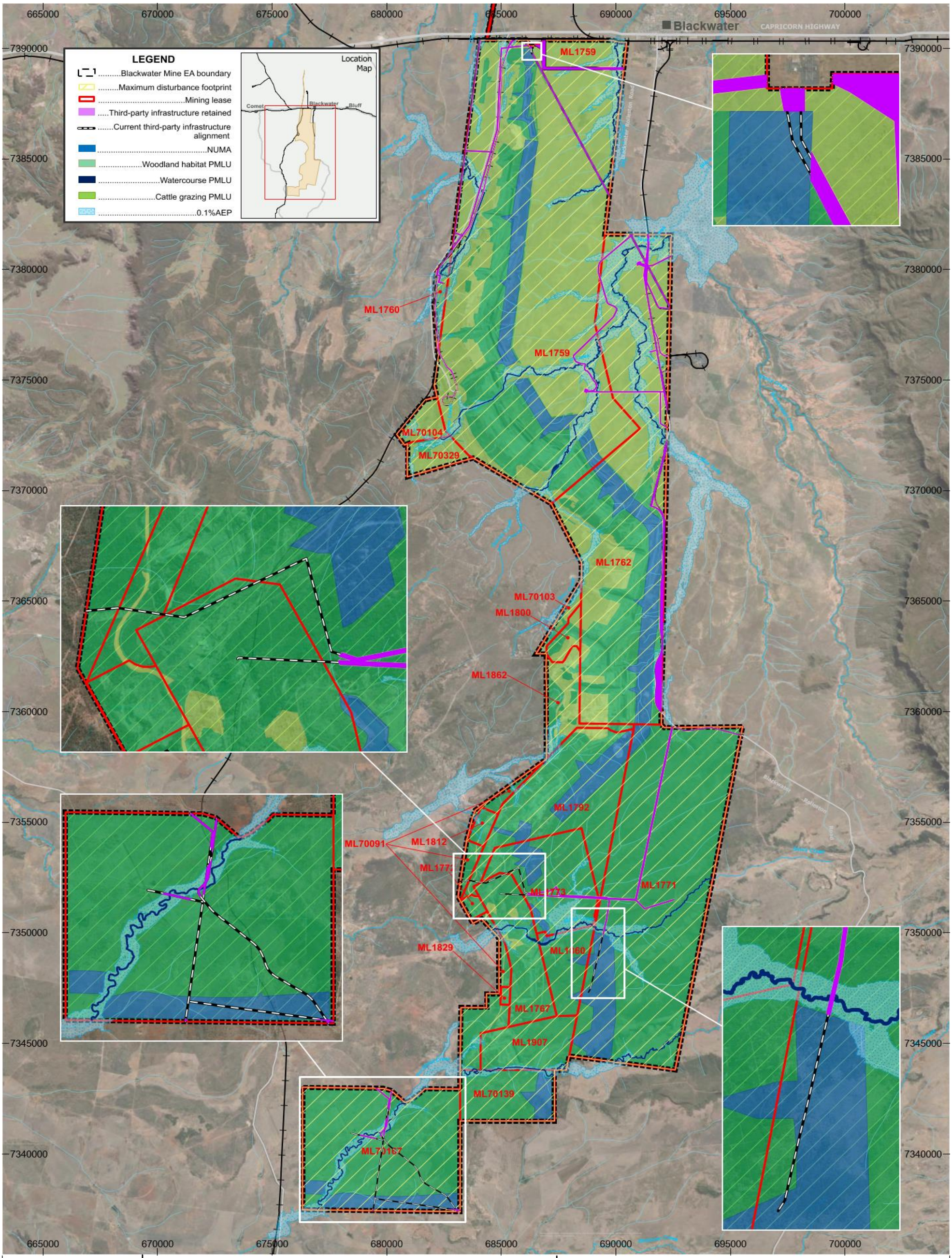

Figure 30 Final site design - locations of BWM PMLUs and NUMAs (North, Central and South)

Table 17 Nominated PMLUs and their associated rehabilitation milestones

PMLU	Rehabilitation Area (RA)	Milestones	Progressively rehabilitated
Cattle grazing	RA2 - spoil dumps, NCPP TSF, Laleham TSF, Bottom Dam TSF and R36 Rejects	RM3 – bulk earthworks and landform reshaping RM4 – surface preparation RM5 – revegetation RM6 – achievement of surface requirements RM7 – achievement of PMLU to a safe, stable, non-polluting and self-sustaining condition RM8 – surface water and groundwater demonstrates non-polluting landform	Yes
	RA4 – infrastructure areas (CHPP North, coal stockpiles, TLO, Thermal Coal Plant, workshops, administration buildings, laydown yards, roads, mine water dams)	RM1 – infrastructure decommissioning and removal RM2 – remediation and/ or management of contaminated land RM3 – bulk earthworks and landform reshaping RM4 – surface preparation RM5 – revegetation RM6 – achievement of surface requirements RM7 – achievement of PMLU to a safe, stable, non-polluting and self-sustaining condition RM8 – surface water and groundwater demonstrates non-polluting landform	No, rehabilitation completed upon closure once infrastructure no longer required.
	RA7 – existing rehabilitation	RM6 – achievement of surface requirements RM7 – achievement of PMLU to a safe, stable, non-polluting and self-sustaining condition RM8 – surface water and groundwater demonstrates non-polluting landform	N/A
Woodland habitat	RA1 – spoil dumps and Ramp 72 TSF	RM3 – bulk earthworks and landform reshaping RM4 – surface preparation RM5 – revegetation RM6 – achievement of surface requirements RM7 – achievement of PMLU to a safe, stable, non-polluting and self-sustaining condition RM8 – surface water and groundwater demonstrates non-polluting landform	Yes
	RA5 –infrastructure areas (CHPP South, coal stockpiles, roads, laydown yards, workshops, administration buildings, mine water dams, exploration, historic subsidence areas)	RM1 – infrastructure decommissioning and removal RM2 – remediation and/ or management of contaminated land RM3 – bulk earthworks and landform reshaping RM4 – surface preparation RM5 – revegetation RM6 – achievement of surface requirements RM7 – achievement of PMLU to a safe, stable, non-polluting and self-sustaining condition RM8 – surface water and groundwater demonstrates non-polluting landform	No, rehabilitation completed upon closure once infrastructure no longer required.
	RA6 – existing rehabilitation	RM6 – achievement of surface requirements RM7 – achievement of PMLU to a safe, stable, non-polluting and self-sustaining condition RM8 – surface water and groundwater demonstrates non-polluting landform	N/A
Watercourse	RA3 – creek diversions and crossings	RM1 – infrastructure decommissioning and removal RM3 – bulk earthworks and landform reshaping RM4 – surface preparation RM5 – revegetation RM6 – achievement of surface requirements RM7 – achievement of PMLU to a safe, stable, non-polluting and self-sustaining condition RM8 – surface water and groundwater demonstrates non-polluting landform	No, rehabilitation completed upon closure once diversions are no longer required

3.3.3.1 Cattle grazing (future and existing)

Areas with this PMLU will be rehabilitated to support beef cattle grazing. At BWM, cattle grazing is predominately planned for the lower gradient areas disturbed by mining activities, areas that require shallow rooted species and/or areas where significant clearing occurred prior to mining. Within the BWM MLs, the total proposed cattle grazing PMLU area is approximately 14,219 ha, of which approximately 2,987 ha are to be rehabilitated as part of RA2 and RA4. The total cattle grazing PMLU also includes 1,200 ha of existing rehabilitation in RA7.

The relevant EA acceptance criteria have been transitioned into the PRCP Schedule as the rehabilitation milestone criteria for the final milestone of achieving a safe, stable, non-polluting and self-sustaining PMLU condition for cattle grazing. To ensure the planned rehabilitation is suitable for sustainable cattle grazing, a land suitability assessment will be completed, using the Bowen Basin Technical paper 1 (revised cattle grazing rule set) (Short, 2023) which was completed for cattle grazing on rehabilitated coal mining land in Queensland. However, for the areas at BWM that have existing rehabilitation for cattle grazing in place before the development of this PRCP (areas as defined in RA7), these areas will instead be assessed against the indicators associated with land condition as described in the *Queensland Reef Protection Regulations Farming in Reef Catchments Grazing Guide* (DES, 2022a).

Revegetation for cattle grazing PMLU will be based on seeding native and naturalised exotic species that are preferred, palatable and productive (3P) grasses and legumes cognisant of grazing best management practice. Species availability may vary, however at least four preferred pasture grass species, including two preferred native pasture grasses, and two legumes will be seeded.

3.3.3.2 Woodland habitat (future and existing)

Areas with this PMLU will be rehabilitated to support woodland habitat. At BWM, woodland habitat PMLU is planned for elevated landforms associated with the spoil dumps (RA1), and general disturbance areas near existing vegetation communities (RA5). Within the BWM MLs, the total proposed woodland habitat PMLU area is approximately 22,590 ha, of which approximately 11,938 ha is to be rehabilitated as part of RA1 and RA5. The total cattle grazing PMLU also includes 729 ha of existing rehabilitation in RA6.

When targeting vegetation communities for this PMLU, consideration is given to the regulatory constraints of the approvals, the surrounding land uses (specifically connectivity with existing native vegetation), and the quantity and quality of growth media resources (topsoil and spoil). Areas targeting native vegetation do not attempt to recreate a specific, recognised regional ecosystem (RE) or Threatened Ecological Community (TEC). However, species mixes used for rehabilitation have been selected based on the species found within REs in the surrounding region.

Where possible, BWM is aiming for woodland habitat revegetation to achieve characteristics of the surrounding natural historic RE 11.7.2. Where woodland habitat aligned to RE11.7.2 is not possible due to seed availability, soils or spoils variability, the remaining areas of woodland habitat have been planned based on a 'hybrid' woodland habitat ecosystem as defined by Spain, Nuske, Gagen and Purtill (2023). This will be achieved through revegetation with key framework tree, shrub and grass species known to occur within representative regional ecosystems within and surrounding the mine site. This approach aims to achieve a 'hybrid' woodland habitat ecosystem with characteristics of both the representative regional ecosystems within and surrounding the mine site, as well as species that are better adapted to the macro climatic (i.e. drought, fire, flooding rains, climate change) and microclimatic factors associated with the final landforms (i.e. growth media, physical and chemical variation, variation in slope, aspect, altitude).

The relevant EA acceptance criteria have been transitioned into the PRCP Schedule as the rehabilitation milestone criteria for the final milestone of achieving a safe, stable, non-polluting and self-sustaining PMLU condition for woodland habitat.

3.3.3.3 Watercourse

Areas with this PMLU will be rehabilitated to provide riparian habitat. Within the BWM MLs, the total proposed watercourse PMLU area is approximately 476 ha, of which 93 ha is to be rehabilitated as part of RA3.

The watercourses that transverse through BWM, and any associated diversions, are assigned a watercourse PMLU. These include Burngrove Creek, Deep Creek, Rockland Creek, Taurus Creek, Two Mile Gully, Blackwater Creek and Sirius Creeks (Section 3.1.2.5). The lateral limits of the watercourse PMLU were defined based on the following considerations:

- Aerial imagery of the watercourses and associated riparian vegetation (Section 3.1.2.9)
- Strahler stream orders (Section 3.1.2.5)
- Flood modelling (Section 3.5.1.2)
- Creek diversion designs (Section 3.5.1.7)

Where possible, BWM is aiming for riparian habitat revegetation to achieve characteristics of the riparian revegetation zones for natural watercourses. These zones are defined as follows, and include the dominant flora species found in the area:

- Upper bank: defines the lateral limits of both sides of the watercourse or diversion. It does not include the land adjacent. The upper bank generally extends down the riparian profile and is dominated by taller *Eucalyptus* spp, with a mixed woody and grassy understorey.
- Mid bank: occurs between the upper and lower banks and will vary in size depending on the watercourse geomorphology or diversion design. The mid bank may include benches created from high flow events. The vegetation on the mid bank comprises a mix of species including scattered *Eucalyptus spp.*, as well as species that are more adapted to periodic inundation of water and can withstand some disturbance from floods (i.e. *Melaleuca* spp).
- Lower bank (including bank toe) commences at the edge of the low flow channel or stream bed and extends up the bank to the area affected by more regular lower flows. The vegetation in the lower bank is dominated by scattered trees adapted to wetter environments (i.e. Melaleuca spp) and a high ground cover of grasses, reeds, sedges and rushes.

The relevant EA acceptance criteria have been transitioned into the PRCP Schedule as the rehabilitation milestone criteria for the final milestone of achieving a safe, stable, non-polluting and self-sustaining PMLU condition for watercourse.

3.3.4 Regional planning integration

3.3.4.1 Central Queensland Regional Plan

BWM falls under the statutory Central Queensland Regional Plan 2013 (CQRP) (Department State Development, Infrastructure and Planning, 2013), developed to support economic growth, development and liveable communities while protecting natural resources and reconciling State interests outlined in the State Planning Policy (2017). The CQRP aims to protect priority agricultural land uses (PALUs) while supporting co-existence opportunities for the resources sector through the mapping of priority agricultural areas (PAAs) and provide certainty for the future of towns, through the identification of Priority Living Areas (PLAs).

Though BWM is not mapped within a PAA or PLA (excluding a small area mapped as PLA in the north-east corner of ML1759, as part of the Blackwater township), the proposed PMLUs of cattle grazing, woodland habitat and watercourses are consistent with the aim of the CQRP, in returning the disturbed land to agricultural land uses and native vegetation and enabling the opportunity for continued economic growth in the region.

Of additional note, under the Queensland Biodiversity Planning Assessments (BPAs) BWM is mapped within the Brigalow Belt Bioregion (v2.1). However, no BWM MLs contain vegetation of State or regional significance under the BPA for this region.

3.3.4.2 Local Government Area

BWM is located within the Central Highlands Regional Council (CHRC) Local Government Area (LGA) and is covered by the Central Highlands Regional Council Planning Scheme 2016 (Central Highlands Regional

Council, 2016). Under this scheme, BWM is located within land mapped as the Rural Zone, which is for primary production uses ranging from cattle grazing and cropping to the extractive industry and animal industries. The purpose of the Rural Zone code is to:

- Provide for rural uses and activities; and
- Provide for other uses and activities that are compatible with-
- Existing and future rural uses and activities; and
- The character and environmental features of the zone; and
- Maintain the capacity of land for rural uses and activities by protecting and managing significant natural resources and processes.

Strategic outcomes for the Rural Zone, as noted in Section 3.8.1 of the CHRC Planning Scheme, include:

a. *Rural places in the Central Highlands accommodate a diverse range of activities, including irrigated and dry land horticulture, pastoral industries, intensive animal industries, tourism and the natural resources sector, that continue to have a significant role in the economic development of the region.*

b. *Agricultural production and rural activities that contribute to the local and regional economy are protected from encroachment by incompatible land uses.*

c. *Opportunities for new value-adding and related rural industries are encouraged and nurtured, including greater sophistication in existing processing operations, expansion of beef cattle production (including organic beef operations), intensive animal industries where environmental and amenity impacts are appropriately managed, and the expansion of existing, as well as the establishment of new, horticultural and aquaculture operations, resulting in increased export volumes or supplies to processing operations.*

The Rural Zone primarily accommodates pastoral industries and the expansion of beef cattle production and therefore, the proposed PMLUs of cattle grazing, mixed with woodland habitat and watercourses (where cattle grazing is not viable and to ensure connection to existing vegetation in the area) are compatible with the planning scheme.

Relationship with PRCP Schedule

The proposed PMLUs for BWM are consistent with pre-mining land uses, current adjacent land uses and PMLUs already approved as part of the site's EA. These PMLUs can also be aligned to future land use development outcomes defined as part of State and regional plans.

The PMLU extents consider the post-mining landform, growth media, pre-mining land uses, existing vegetation, ecological values, watercourses and surrounding public infrastructure.

The approved EA acceptance criteria for cattle grazing, woodland habitat and watercourse have been transitioned to the milestone criteria for achieving these PMLUs.

3.4 Non-use management areas

Legislative Requirement

In accordance with sections 126C(1)(d), (g) and (h) of the EP Act, for each proposed non-use management area, the rehabilitation planning part of the PRC Plan must:

- *state the reasons the applicant considers the area cannot be rehabilitated to a stable condition*
- *include copies of reports or other evidence relied on by the applicant for each proposed non-use management area*
- *state the extent to which the proposed non-use management area is consistent with the outcome of consultation with the community in developing the plan, and*
- *state the extent to which the non-use management area is consistent with any strategies or plans for the land of a local government, the State or the Commonwealth.*

PRCP Guideline (Section 3.3)

A NUMA is defined in the EP Act as an area of land the subject of a PRC Plan that cannot be rehabilitated to a stable condition after all relevant activities for the PRC Plan carried out on the land have ended. Proposed NUMAs must be justified under the criteria set out in section 126D(2) of the EP Act.

The rehabilitation planning part of the PRC Plan must also include:

a) information demonstrating that the proposed footprint of each NUMA is as small as practicable

b) an assessment of the NUMA location options, having regard to the constraint of the resource location, with an analysis of the potential environmental harm and sensitivity of the surrounding environment of each option

c) a description of the proposed location of each NUMA and the environmental values of the surrounding environment

d) evidence showing how the proposed location will prevent or minimise environmental harm.

In accordance with section 126D(1)(c) of the EP Act, the applicant must develop and implement management milestones within the PRCP Schedule which achieve best practice management and minimise environmental harm for any NUMAs contained in the proposed PRC Plan. As part of the development of management milestones, the applicant must conduct a NUMA specific risk assessment to identify and quantify risks and associated controls. The risk assessment should have an overarching goal of identifying and controlling any significant risks to the community and the environment.

The proposed PRC Plan must include a detailed description of the nominated NUMA(s) for the site. The description must include, but is not limited to:

- *description of the land at surrender*
- *any relevant safety features*
- *completion criteria for measuring whether the NUMA has achieved sufficient improvement.*

Where a NUMA has already been identified in a land outcome document and is able to be transitioned into the PRCP Schedule, the applicant is not required to comply with sections 126C(1)(g) or (h) or 126D(2) or (3) of the EP Act. NUMAs transitioned into the PRCP Schedule are not required to complete the information requirements under section 126C(1)(j) of the EP Act in this section for those NUMAs. However, the legislative requirements under section 126C(1)(d) of the EP Act still apply.

Where a NUMA has not been pre-approved and is proposed as part of the transition into the PRC Plan, the applicant must include all of the requirements identified in this section.

3.4.1 Context

Section 754 (3) of the EP Act excludes the operation of sections 126C(1)(g) and (h) and 126D(2) and (3) where an outcome for land has been identified under a LOD and where the outcome for the land is the same as, or substantially similar to, the outcome for the land if it were a NUMA under a PRCP schedule. Conditions E10, E11 and E12 of the EA, which is the primary LOD for BWM, identify residual voids as an outcome for land. The EA defines 'residual void' to mean 'an open pit resulting from the removal of ore and/or waste rock that will remain following the cessation of all mining activities and completion of rehabilitation processes'. Given the EA expressly contemplates residual voids as a rehabilitation outcome and the residual voids are the same as, or substantially similar to, a NUMA, section 754(3) of the EP Act

operates to exclude the operation of sections 126C(1)(g) and (h) 126D(2) or (3) of the EP Act for this PRCP Further, per Section 3.3 of the latest PRCP Guideline, section 126C(1)(j) of the EP Act does not apply to NUMAs transitioning into a PRCP schedule. However, the legislative requirements under Section 126C(1)(d) of the EP Act remain applicable. As the LOD (i.e., the EA) for BWM does not state the area or the location of the proposed NUMAs, pursuant to section 754(4) of the EP Act, the PRCP must state how the total area will be minimised and how the location of the proposed NUMAs will minimise risks to the environment. This is discussed further in the following sections.

3.4.2 Community considerations

As discussed in Section 3.1.4.2.1 and Appendix 4.4 specific community engagement and consultation on BWM's PMLUs, NUMAs and rehabilitation approach has been undertaken prior to submission of the BWM transitional PRCP. The consultation showed the inclusion of residual voids within the final landform to be transitioned as non-use management areas. No concerns were raised by stakeholders.

3.4.3 Nominated NUMAs

The BWM NUMAs include the 11 residual voids listed below and as depicted in Figure 29a and 27b.

Ramp 8

- Bonnie Doon
- Mimosa/Besgrove
- Deep Creek
- Stewarton/Ballamoo
- Kenmare
- Laleham
- Togara/North Marshmead
- South Marshmead
- Comet Downs East
- Kennedy West

The proposed improvement areas for the BWM NUMAs are provided in Table , along with their associated management milestones.

Table 18 NUMAs, improvement areas and management milestones

NUMA	Improvement Area (IA)	Management Milestones
NUMA	IA1 - Residual voids	MM1 – achievement of structural stability MM3 – achievement of surface requirements MM4 – achievement of sufficient improvement
	IA2 - Ramp 74 TSF and Bonnie Doon TSF	MM1 – achievement of structural stability MM2 – installation of cover system MM3 – achievement of surface requirements MM4 – achievement of sufficient improvement

The total proposed NUMA area is approximately 3,967 ha. This NUMA area has been minimised by reducing the number of ramp voids through backfilling during the mining operations, and backfilling sections of the residual voids at the end of mining (further detail provided in Section 3.5.3). The NUMAs will be designed to be safe and structurally stable, as follows:

- the residual voids remain below natural ground level (high-wall, end-walls, low-wall and floor);

- the associated wall setbacks at natural ground level are to achieve a factor of safety (FoS) of 1.5; and
- a safety bund and fence will be installed.

3.4.4 Minimising the extent and environmental impacts

To minimise residual void areas and volumes, the pits will be progressively backfilled during operation. Ramp voids will be progressively backfilled, minimising the number of ramps remaining in the residual voids. In-pit tailings emplacement at Laleham and Bonnie Doon will also reduce the residual void extent. Once mining is complete, residual void areas and volumes will be further reduced by additional backfill. Partial backfilling is planned where required to prevent flood ingress (Section 3.5.1.2.3). The extent of backfilling will depend on the mining sequence of the final strips which may change during the remaining operational period as new geological data becomes available and market factors change.

Groundwater, void and flood studies have been undertaken as part of this PRCP to assess, refine and optimise the BWM NUMA locations and extent, and to minimise the potential for environmental harm. These studies have resulted in the iterative refinement of the NUMA design, as documented below. The preliminary NUMA locations and extent were based on mining the full resource extent and were used as the basis for the following void studies:

- Void in floodplain modelling (Section 3.5.3.7)
- Initial void water balance modelling
- Initial void water quality modelling
- Initial void geotechnical assessment

Based on the outputs of these initial PRCP studies, the set-back of the high-wall and end-wall from the lease boundary and watercourses was increased for all residual voids, to achieve structural stability of Factor of Safety (FoS) ≥1.5 within the NUMA extents.

The refined NUMA locations and reduced extent were then used as the basis for updated studies:

- Updated void water balance modelling (Section 3.5.3)
- Updated void water quality modelling (Section 3.5.3)
- Updated void geotechnical assessment (Section 3.5.3)
- Groundwater modelling (Section 3.5.1.1)
- Rehabilitation flood modelling (Section 3.5.1.2)

The final NUMA locations and extent were further optimised based on the outcomes of the updated studies. This resulted in the following final modifications to minimise the potential for environmental harm:

- Residual void catchments will be minimised as far as practicable, including building a free-draining closure landform to limit the potential for surface ponding and, therefore, reduce catchment area reporting to the residual voids.
- Partial void backfilling will be used to mitigate the risk of flooding into the residual voids up to the 0.1% AEP flood level.
- Limiting the planned mining extents of Bonnie Doon and Laleham Pits to reduce final residual void extents and limit impacts on local water resources.

The studies presented in this PRCP support the final locations and extent of the NUMAs. The NUMAs will not present an unacceptable risk of environmental harm outside of the tenure boundary due to:

- The residual voids are modelled to have flood immunity up to a 0.1% AEP flood level (Section 3.5.1.2)
- Updated numerical groundwater modelling predicts the residual voids will stabilise as groundwater sinks over time. Direct evaporation from the surface of the void lakes is anticipated to maintain

void lake levels such that they are lower than the surrounding groundwater levels in the long-term equilibrium state (Sections 3.5.1.1.4 and 3.5.3.3.2)

- Updated numerical groundwater modelling predicts long-term pit water levels will remain below the spill point, thereby minimising the risk of residual voids overtopping and releasing void water to surface waters and/or the receiving environment (Section 3.5.3.3)
- The residual voids will be designed to achieve structural stability, with a minimum FoS ≥ 1.5 used as guidance for void closure planning (Section 3.5.3.2), and there will be a safety bund, fencing and warning signage erected around the NUMAs to prevent public access.

3.4.5 Regional planning integration

3.4.5.1 Central Queensland Regional Plan

The statutory Central Queensland Regional Plan 2013 (CQRP) (Department State Development, Infrastructure and Planning, 2013) states the region's greatest competitive industry strengths are the coal and agricultural industries. An aim of the CQRP is to maximise the productive use of key mining resources whilst still providing for liveable communities. It is understood that mining is a temporary land use and is often in conflict with agricultural land use. To resolve this conflict, it is preferred to minimise the long-term impact on the productivity of agricultural land from resource activities wherever possible.

3.4.5.2 Local Government Area

The CHRC has a strong history and connection with mining and the resources sector, positioning the region as a gateway to mining and exploration activities. The mining, petroleum and extractive resources industry includes underground and open-cut thermal and coking coal mining, minerals and CSG extraction, quarrying, and gemstones extraction, with the Central Queensland region's greatest competitive industry strengths being in the coal, CSG/LNG and agricultural sectors (Department State Development, Infrastructure and Planning, 2013).

3.4.5.3 Summary

Overall, BWM is mapped within a Rural Zone under the CHRC but is not mapped as a PAA under the CQRP, however it is surrounded by agricultural land. To align with the CQRP and CHRC, wherever possible, BWM will minimise the extent of the NUMAs remaining in the landscape by backfilling where mine planning allows and will ensure residual voids do not present an unacceptable risk of environmental harm outside the NUMA extent, through their design as groundwater sinks with flood protection to 0.1%AEP with a safety bund, fencing and warning signage erected to prevent public access. In addition, residual voids will not be excluded from future land use if their rehabilitation is enabled by advances in technology.

Relationship with PRCP Schedule
The proposed NUMAs for BWM are designed to be safe, structurally stable and minimise the risk of environmental harm. Retention of residual voids as pre-approved NUMAs, that are part of the rehabilitated landscape, is consistent with the BWM LOD.

3.5 Rehabilitation and management methodology

Legislative Requirement

In accordance with section 126C(1)(e) and (i), the rehabilitation planning part of the PRC Plan must:

- *For each proposed post-mining land use for land, state the proposed methods or techniques for rehabilitating the land to a stable condition in a way that supports the rehabilitation milestones under the proposed PRCP Schedule.*
- *For each proposed non-use management area, state the proposed methodology for achieving best practice management of the area to support the management milestones under the proposed PRCP Schedule for the area.*

PRCP Guideline (Section 3.6)

The proposed rehabilitation or management methodologies will underpin the development of the milestone criteria and support how the proposed PMLU will be achieved or the NUMA will be managed. As per section 126C(1)(j) of the EP Act, the administering authority requires information describing how the proposed rehabilitation or management methodologies have been developed and will be implemented.

This section identifies a number of studies or reports that must be provided in the proposed PRC Plan. If any of the required information outlined below is not relevant to the specific operation, the applicant must provide justification in the PRC Plan outlining why the information is not required.

PRCP Guideline (Section 3.6.1)

This section outlines the range of information that the administering authority considers is necessary to underpin the development of the rehabilitation or management methodologies applicable to new and existing mines for most domains. The applicant must include the information as appendices to the rehabilitation planning part.

3.5.1 General rehabilitation practices

3.5.1.1 Hydrogeology

PRCP Guideline (Section 3.6.1)

Assess the hydrogeology of the site and all connected strata, and develop a conceptual model of the mine site's groundwater systems. This information must be integrated into the design of rehabilitation strategies and choice of PMLU or NUMA.

As mentioned in Section 3.1.2.6, a hydrogeological assessment including conceptual and numerical modelling has been undertaken to support the development of this PRC Plan. The detailed report, *Blackwater Mine Transitional PRC Plan Hydrogeology Assessment* (SLR, 2024), is provided in Appendix 4.2. In addition to this, Appendix 4.2 also includes the following report which was prepared in response to the DETSI NPM Notice received 25 November 2024: *Bottom Dam Tailings Storage Facility and Sirius Creek Preliminary Hydrogeological Review and Investigation – Revision 3.0* (SLR 2025).

The main objective of the hydrogeological assessments undertaken was to assess the potential groundwater-related impacts at BWM at the completion of mining and until conditions stabilise post-rehabilitation (i.e. groundwater equilibrium). The focus was on demonstrating the suitability of the final landform for the intended PMLUs with respect to the BWM groundwater system by demonstrating that:

- The final landform is non-polluting with respect to groundwater:
- There are minimal additional impacts to groundwater receptors post-closure caused by the final landform that has not already occurred as a result of approved mining.

3.5.1.1.1 Hydrogeological units

A list of the key hydrogeological units present within and immediately surrounding BWM is in Section 3.1.2.6. and described in more detail in Appendix 4.2.

3.5.1.1.2 Groundwater modelling

To support the assessment of potential groundwater impacts, numerical groundwater modelling has been undertaken in accordance with the Australian Groundwater Modelling Guidelines (Barnett et al. 2012), the MDBC Groundwater Flow Modelling Guideline (MDBC, 2001) and the IESC Explanatory Note for Uncertainty Analysis (Peeters and Middlemis, 2023). The model was developed using a Geographic Information System (GIS) in conjunction with MODFLOW-USG, which is distributed by the United States Geological Survey (USGS).

The objectives of the predictive numerical modelling were to:

- Assess groundwater inflow to the final landform's residual voids.

- Simulate the level and rate of recovery of the residual void lakes, and the level and rate of mining-related groundwater drawdown recovery in the groundwater system surrounding the residual voids.
- Simulate the level and rate of groundwater recovery within historic underground mine workings relevant to the PRC Plan.
- Identify areas of potential risk, such as private supply bores or GDEs, where groundwater impact mitigation/control measures may be necessary post-closure.

The BWM numerical model developed by SLR (2023b) was revised to ensure the model was fit for purpose and was based on the final iteration of the site-wide landform design. The groundwater model setup, underlying assumptions/limitations, model performance, calibration and model results are provided in Appendix 4.2.

Climate-related boundary conditions (i.e. recharge and evapotranspiration) in the recovery model were set constant for the duration of the recovery model, at their values consistent with the previous predictive mining model (SLR, 2023b). Recharge and evapotranspiration were not applied to the final voids (or associated in-pit tailings emplacement) in the groundwater model as the void water balance model (WSP, 2024) used iteratively with the groundwater model accounts for these boundary conditions (see Section 3.5.3.3). Climate sensitivity and three climate scenarios were adopted, as summarised in Table 19.

Table 19 Modelled climate scenarios

Climate scenario	Climate model	IPCC RCP scenario[1]	WSP (2024) realisation
Wetter	ACCESS1-0Q	4.5	R#1
Mid	ACCESS1-0Q	8.5	R#4
Drier	MPI-ESM-LRQ	8.5	R#6

1. Intergovernmental Panel on Climate Change (IPCC) Representative Concentration Pathway (RCP), refer https://sedac.ciesin.columbia.edu/ddc/ar5_scenario_process/RCPs.html

Void lake levels were included within the groundwater model as part of an iterative modelling approach between the groundwater model and the water balance model (Section 3.5.3.7.3). The modelling results identify the residual voids generally develop into long-term sinks for all climate change scenarios modelled. Stabilised lake levels remain below the recovered groundwater levels.

3.5.1.1.3 Groundwater levels

Groundwater levels surrounding the residual voids are controlled by the predicted residual void lake levels, which in turn are controlled by the rate of evaporation from the void lakes balancing mostly surface inflows and some groundwater inflows to the lakes (WSP, 2024), including a component of groundwater that moves out of the natural geological formations into the residual voids via the spoil (Section 3.5.3.3). That is, predicted groundwater levels surrounding the residual voids are a function of predicted lake levels, which are mostly dominantly controlled by surface water fluxes and maintained by evaporation.

The water table is predicted to remain depressed in the immediate vicinity of the residual voids in the long term, driven by the ongoing groundwater discharge to the residual void lakes and governed by the lake elevations themselves. That is, long-term inwards groundwater flow gradients are maintained post-mining for the water table.

The following summarises the model-predicted stabilised groundwater levels for the Aries, Castor and Pollux Seams (main groundwater-bearing units surrounding the final landform):

- The Aries Seam is predicted to remain ‘dry’ in the long term across most of the mined area, with some saturation present predominantly along the east of the Bonnie Doon, Mimosa/Besgrove, Deep Creek, Stewarton/Ballamoo, Laleham and Togara residual void areas and also within/surrounding the South Marshmead, Kennedy West and Comet Downs residual void areas.

- The Castor Seam is predicted to remain dry across much of the area to the west of the mined area. However, it remains saturated along most of the eastern margin of the mined area and within the south near the South Marshmead, Kennedy West and Comet Downs residual void areas.
- West of Mimosa/Besgrove and Deep Creek residual voids, saturation is predicted in the model layer that formerly represented the Castor Seam but now represents emplaced spoil within former mining pits. Dominant flow gradients in the Castor Seam are again apparent towards the southern end of the Stewarton/Ballamoo residual void and surrounding the Togara and South Marshmead residual voids within the Aries Seam along the east of the BWM Area.
- Predicted Pollux Seam groundwater levels show steeper gradients surrounding the southern and western side of the Stewarton/Ballamoo residual void, the Kenmare, Togara, South Marshmead, Comet Downs and Ramp 8 residual voids and along the western side of the Mimosa Besgrove and Deep Creek residual voids. Gradients in the Pollux Seam are relatively flatter surrounding the Bonnie Doon residual void, to the east of Mimosa Besgrove, Deep Creek and Stewarton Residual voids and surrounding the Laleham and Kennedy West residual voids.

Predictive hydrographs generated from the hydrogeological model have been used to evaluate changes in groundwater levels over time. The predictive hydrographs indicate the following:

- The vast majority of groundwater level drawdown in the Permian Coal Measures occurs pre-closure as a result of active extractive mining operations.
- Post-closure, groundwater levels in the deeper coal seams at the north-eastern part of the BWM area adjacent to the residual voids recover from their lowest point that occurred during mining.
- Most groundwater units across the BWM area show persistent drawdown post-recovery. The Aries Seam near Laleham residual void also becomes desaturated during mining and remains dry to the end of the recovery simulation.

The hydrographs demonstrate very little effect on groundwater levels from the residual void inflow flux variability in the early post-closure period.

3.5.1.1.4 Flow path simulation

An analysis of the water movement (particle movement) was undertaken to simulate and assess the movement and fate of water particles through the groundwater system post-mining. Several particles were placed on the final landform and within the residual voids in the recovery groundwater model and the mod-PATH3DU code (S.S. Papadopulos & Associates, Inc., 2018) was used to simulate particle pathways along the groundwater flow field during recovery (i.e. 500 years). To run the mod-PATH3DU code the transient head outputs from the groundwater flow model were used by mod-PATH3DU to simulate particle flow path lines.

Particles situated within the shallower saturated layers at the beginning of the post-mining simulation generally move progressively toward deeper layers representing the Permian coal measures (or backfilled spoil where the coal measures have been mined out) over the post-mining period. However, particles that begin in the Pollux seam and other deeper layers often are observed to move upwards to shallower layers over the course of the recovery simulation as the saturated water levels in the spoil and aquifers adjacent to the residual voids recover to their long-term post-mining equilibrium state. The flow path analysis indicates the particles generally move toward the void lakes, with most of the particles captured in the voids.

Particles that begin their simulation in the spoil adjacent to the voids or in the underground mines near Laleham residual void migrate towards or are captured by the residual voids within the recovery simulation and are therefore not predicted to leave the BWM area or escape to the wider groundwater system. Some particles are shown to migrate into layers that underlie the residual voids due to the desaturation or vertical gradients early in the recovery simulation. However, these particles do not migrate outside of the BWM area during the recovery simulation.

The PRC Plan Version 1 submission (11 November 2024) reported that some simulated particles placed at and near to Bottom Dam west of the Laleham residual void migrate out of the BWM area towards Sirius Creek, with these particles commencing the simulation too far from the residual void lakes to be captured

by their associated hydraulic gradients. Following the Not Properly Made Notice received from DETSI 25 November 2024, SLR Consulting Australia Pty Ltd (SLR) were engaged to undertake a preliminary hydrogeological assessment of the conceptual relationship between the historical Bottom Dam Tailings Storage Facility (TSF) and Sirius Creek. The objective of the work was to conceptually assess current hydrogeological conditions at a local scale which was not possible in the site-wide Transitional PRC Plan Hydrogeology Assessment, and to identify if there was a plausible potential pathway for subsurface hydraulic connection between the Bottom Dam TSF and Sirius Creek as predicted by the model.

The report is provided as an addendum to Appendix 4.2, and it indicates that overall, both historical and current data suggests that surface water recharge processes in the area are dominated by episodic inputs from streamflow and flooding, with minimal contributions from groundwater, and that the hydrogeological setting supports limited connectivity between Bottom Dam TSF, Sirius Creek, and the regional groundwater system. In addition, the results modelled near Bottom Dam TSF are considered as a conservative first pass assessment of risk prior to any local scale remedial measures, and that this work provides the most accurate representation of the relationship between Bottom Dam TSF and Sirius Creek, forming a better basis for understanding the local groundwater dynamics than the numerical groundwater model.

The SLR report concluded that there is a highly limited potential for hydraulic connection between the Bottom Dam TSF and Sirius Creek.

There is very little difference between the predicted particle movements for the Drier Climate scenario and Wetter Climate scenario, and the Mid Climate scenario. The predicted particle movement of the Mid Climate Scenario is presented in Figure 31.

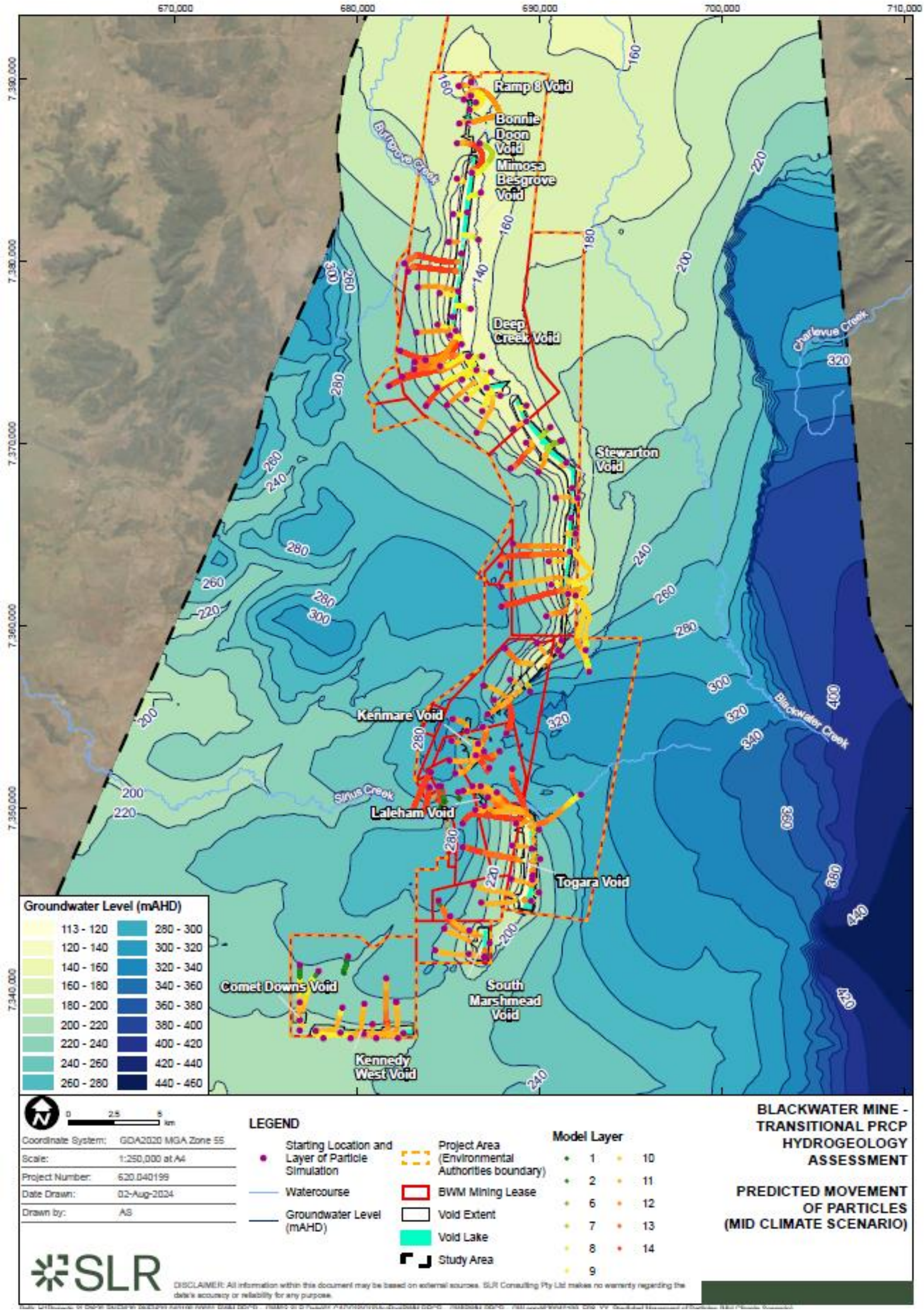

Figure 31 Predicted movement of particles (mid climate scenarios)

3.5.1.1.5 Conceptual site model

End-of-mining

A hydrogeological conceptual site model representing the PRC Plan extent of mining and approved activities on the last day of mining at BWM is illustrated in Figure 32 and Figure 33. The key hydrogeological features present at the end of mining that are relevant to the discussion of potential groundwater impacts post-mining are:

- Groundwater level drawdown occurs within the Rangal Coal Measures, associated with passive dewatering into the active BWM mine pit and other surrounding mines. The magnitude of this drawdown will be most significant near the pits and underground workings. At BWM, the groundwater drawdown extends northwards, eastwards and southwards of BWM by several kilometres and interacts with drawdown from nearby mines.
- Mine pits capture any seepage from spoil emplacements due to the hydraulic gradient orientated towards the void.
- Limited potential for groundwater level drawdown in the alluvium and Tertiary due to limited saturation, and poor lateral connection of water-bearing zones.
- No groundwater level drawdown of the alluvium away from BWM.
- Limited potential for groundwater level drawdown impacts to potential terrestrial GDEs due to the limited potential for groundwater level drawdown in the alluvium and Tertiary.
- No potential for groundwater quality impacts outside of BWM associated with spoil dumps and/or in-pit tailings emplacements due to the inward groundwater flow gradients towards the pit voids capturing all potential seepage.

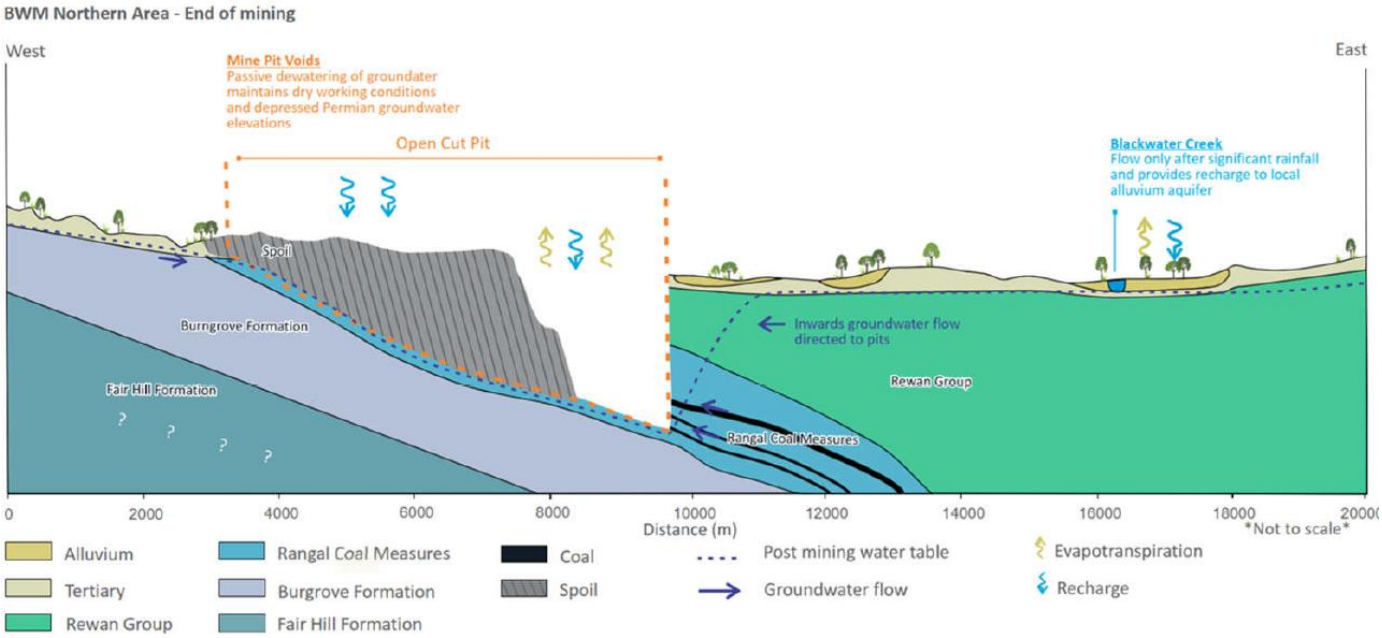

Figure 32 Conceptual hydrogeological site model of BWM at last day of mining – BWM northern area

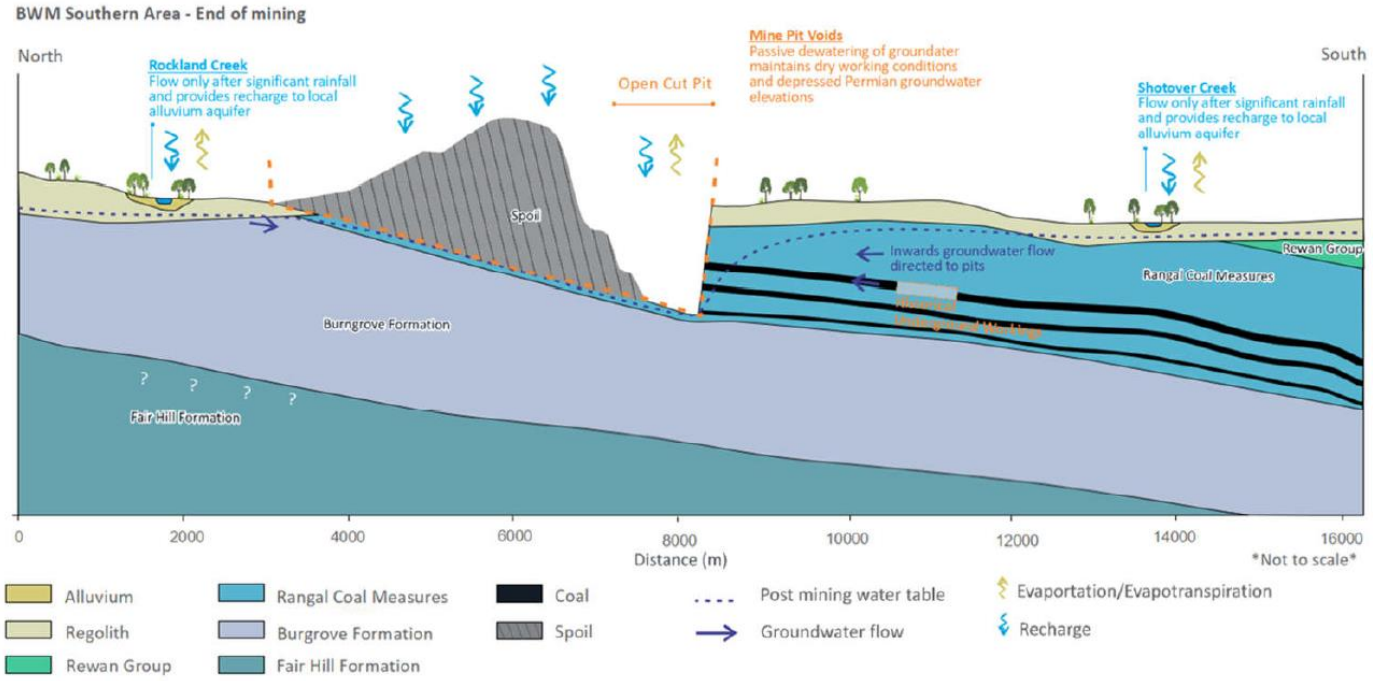

Figure 33 Conceptual hydrogeological site model of BWM at last day of mining – BWM southern area

Post-mining conceptual site model

An evaluation of the source-pathway-receptor (SPR) linkages based on the modelling results for the post-mining environment, where groundwater conditions have stabilised, has identified the following key features:

- Residual void lake levels stabilise below shallow post-Permian strata, including the base of surficial weathering and shallow hydrostratigraphic units (i.e. alluvium and Tertiary strata).
- Partial groundwater system recovery outside the residual voids, primarily in the Rangal Coal Measures.
- Continued groundwater drawdown within the Rangal Coal Measures associated with evaporative discharge from the void lakes, resulting in continued inwards hydraulic flow gradients in the coal measures and ongoing groundwater discharge to the residual voids. Hence, residual voids continue to capture any seepage from spoil dumps and in-pit tailings.
- Re-flooding of historical underground workings will take place (for those workings not already flooded).
- Little to no additional impact on surficial aquifers, including the alluvial aquifers, caused by the final closure landform.
- Little to no impact on environmental receptors caused by the final closure landform.
- Little to no impact on anthropogenic receptors caused by the final closure landform.

Visual representations of the post-mining conceptual site model (CSM) are provided in Figure 34 and Figure 35.

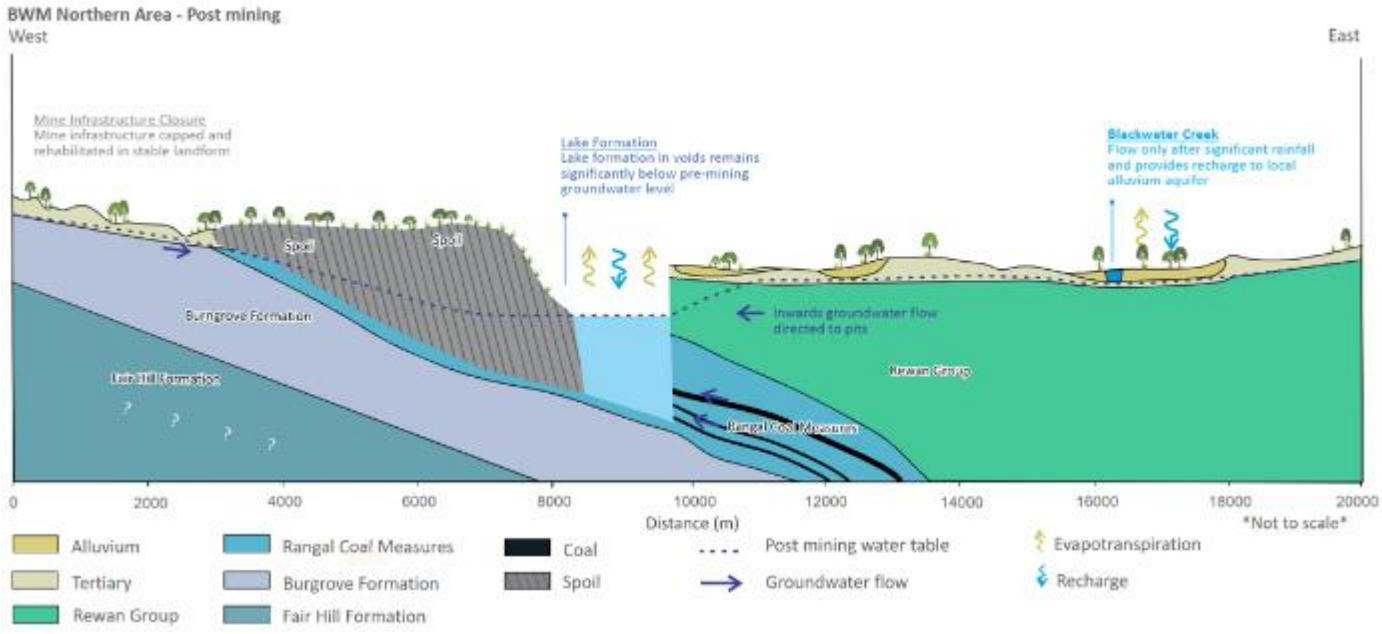

Figure 34 Conceptual hydrogeological site model of BWM post-mining – BWM northern area

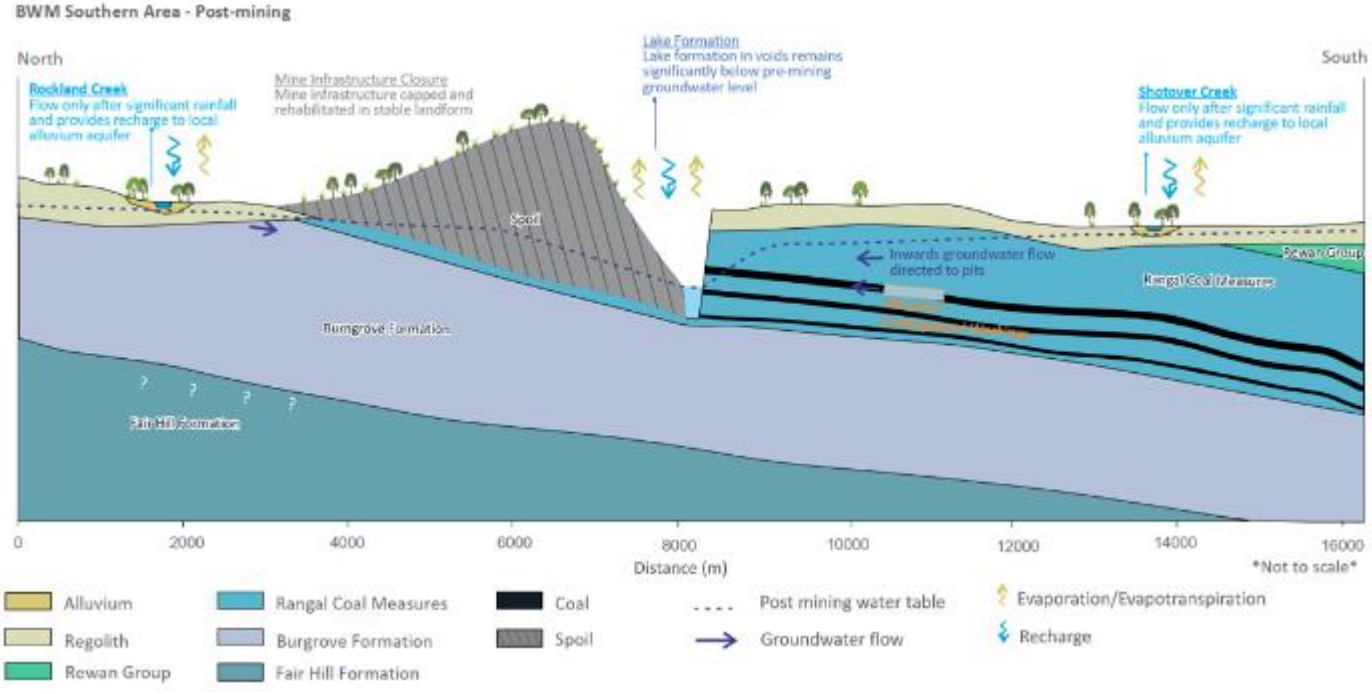

Figure 35 Conceptual hydrogeological site model of BWM post-mining – BWM southern area

Relationship with PRCP Schedule

Groundwater, once stabilised, will flow to the residual voids, which will act as sinks. Seepage from the spoil dumps, TSFs, MIA and CHPP will be collected within the residual voids, and any contaminants within the residual voids - except for an area west of the Laleham residual void and Bottom Dam TSF/rejects area (these areas are subject to additional investigation to determine appropriate rehabilitation activities), are not predicted to impact areas beyond the mining tenements.

Modelled groundwater drawdown around the residual voids is a result of the approved mining activities, with the closure landform not resulting in additional drawdown.

The closure landform will have little to no additional impact on environmental or anthropogenic receptors. Groundwater is not anticipated to require any active management post-mining. Confirmation of groundwater quality, and the relationship between the void lakes and groundwater elevations to demonstrate the development of the residual voids as sinks, will be completed through planned rehabilitation monitoring.

3.5.1.2 Flooding

PRCP Guideline (Section 3.6.1)

Section 3.4 of this guideline requires flood plain modelling for the purpose of voids located within a flood plain being rehabilitated to a stable condition. In addition to this, the applicant must also assess the flooding susceptibility and influence across the site. If flooding is a consideration, develop a hydrologic model of the catchment and a hydraulic model of the proposed mining area. Knowledge of flooding is integral to the rehabilitation planning process, including the placement and design of mine domains.

_____

When assessing flooding, you must at least:

- *consider the location of domains in relation to potential flood levels*
- *consider alterations of flow upstream and downstream*
- *model flood levels (including probable maximum flood levels) for a range of design storm events*
- *develop a flooding risk profile*

A rehabilitation flood assessment, including consideration of flow alteration, modelling flood levels for a range of design storm events and development of a flooding risk profile, has been undertaken to support the development of this PRC Plan. The detailed report, *Blackwater Mine PRCP Rehabilitation Flood Assessments* (SLR, 2024), is in Appendix 4.6.

The flood modelling was undertaken using an iterative approach with the closure landform design development. Information from the initial round of rehabilitation flood modelling was used to inform further development of the closure landform design.

The amended landform design included the following:

- landform refinements, i.e. partial backfill of the residual voids,
- increased stand-off distances from mining leases and watercourses,
- removal of culverts and other infrastructure from watercourses/floodplains, and
- changes to landforms to provide increased protection from flood waters.

Upon finalising the landform design, the flood modelling was re-run and the flood risk profile and other interpretations were amended to reflect the final closure landform design, as presented within this PRC Plan.

3.5.1.2.1 Flood modelling methodology

The hydrologic and hydraulic modelling undertaken to support this PRC Plan was based on existing models (GHD, 2021). Hydrologic modelling had been undertaken for each of the watercourses at the site using XP-RAFTS. A review of these models found them to be of adequate detail and able to produce reasonable results for the existing site conditions.

Calibration of the Speculation Creek and Burngrove Creek models was undertaken and used to determine parameters for the entire site, noting that variability in catchment conditions may exist. Validation was also carried out for the Speculation Creek and Burngrove Creek hydrologic models, which showed reasonable comparisons with empirically determined peak flow estimates. While limitations in the hydrologic modelling calibration and validation processes were noted, the XP-RAFTS models were considered appropriate for use in this assessment.

TUFLOW 2D (an industry standard software hydraulic modelling package) hydraulic models were developed to determine flood behaviour around the closure landform. The site was modelled in seven separate model domains (Sagittarius Creek, Bonnie Doon Creek, Burngrove Creek, Blackwater Creek (including Taurus Creek and Two Mile Gully), Speculation Creek, Sirius Creek and Rockland Creek). A review of the TUFLOW models revealed the models produced reasonable results.

The XP-RAFTS model was simulated for the 39%, 2%, 1%, 0.1% Annual Exceedance Probability (AEP), and Probable Maximum Flood (PMF) events. Storm durations between 1 hour to 36 hours and ten temporal patterns for each duration were run in accordance with Australian Rainfall and Runoff (ARR) 2019.

As pre-mining topography was not available, the alteration of flows was considered by comparing the catchment area of the XP-RAFTS model between the existing and final closure state landform scenarios.

The effects of climate change were considered as part of the hydrologic analysis. Sensitivity analyses were carried out with respect to the modelled design rainfall Intensity-Frequency-Duration data. The three scenarios were modelled based on the methodology outlined in Australian Rainfall and Runoff 2019:

- 6% increase in rainfall intensity,
- 11% increase in rainfall intensity, and
- 20% increase in rainfall intensity.

Hydrographs for each scenario for the 0.1% AEP events were extracted and utilised as inflows in the hydraulic model.

3.5.1.2.2 Alteration of flows

Table 20 summarises the change in catchment areas and generally shows marginal reductions in catchment areas for the local watercourses. The largest increase in the catchment area is Burngrove Creek; however, the percentage increase is 6.4%, which is unlikely to result in significant increases in flows within the watercourse. The 10.3% reduction of Bonnie Doon Creek catchment area is also not expected to result in material changes to flows due to the smaller catchment size and the creek merging with Burngrove Creek ~10 km downstream of the Capricorn Highway.

The total change in catchment areas between the existing and final closure state landform scenarios is approximately a 2.3 km² reduction, which is a change of about 0.2%. It was therefore concluded the minimal changes in the catchment area are unlikely to result in significant alterations of flows downstream of site.

Table 20 XP-RAFTS Model Results – Existing Scenario vs PRCP Model Landform Scenario

Location	Change in catchment area (km²)	Change in catchment area (%)
Sagittarius Creek	-1.0	-2.3%
Bonnie Doon Creek	-2.4	-10.3%
Burngrove Creek	5.0	6.4%
Blackwater Creek*	3.0	0.6%
Speculation Creek	1.2	2.1%
Sirius Creek	-4.1	-2.5%
Rockland Creek	-4.0	-2.5%
Total	-2.3	-0.2%

* Includes the Blackwater Creek, Taurus Creek and Two Mile Gully RAFTS model areas.

For the local watercourses, the upstream boundary of the catchment is either within the site or the existing scenario and the rehabilitation scenario is identical. Therefore, there will be no alteration to upstream flows in the final closure state landform when compared to the existing scenario.

3.5.1.2.3 Flood ingress to voids

The TUFLOW model results were studied to identify any locations where surface water flows were shown to enter the final voids. Table 21 summarises the findings, which show that ingress is only expected to occur in the PMF event. Peak flood inundation extents for the 0.1% AEP + 20% rainfall intensity climate change scenario are illustrated in Figure 36.

Table 21 BWM void inundation summary

Void	Design event leading to floodwater ingress
Ramp 8	None
Bonnie Doon	None
Mimosa/Besgrove	PMF
Deep Creek	PMF
Stewarton/Ballamoo	PMF
Kenmare	None
Laleham	PMF
Togara/North Marshmead	PMF
South Marshmead	PMF
Kennedy West	PMF
Comet Downs East	PMF

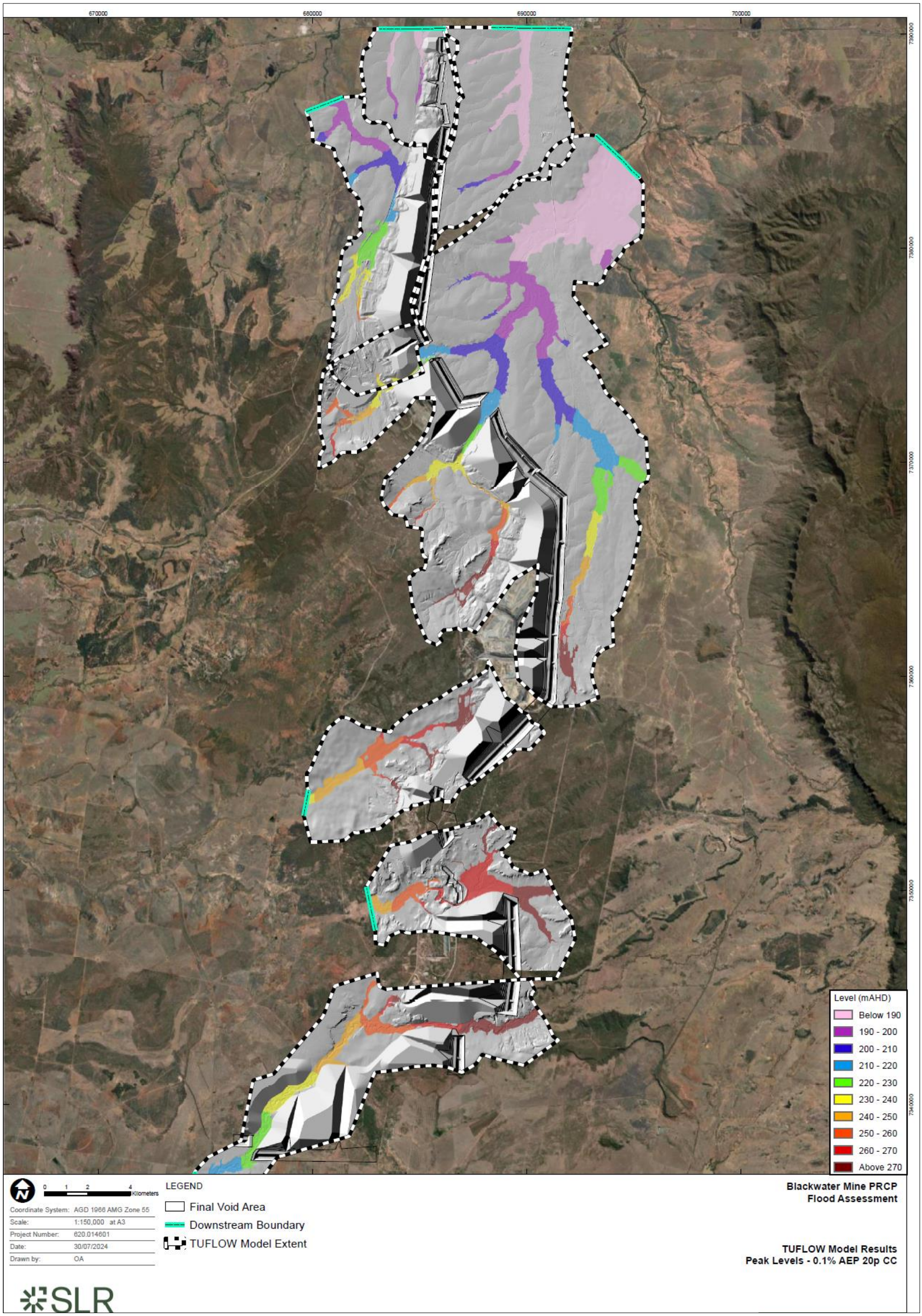

Figure 36 BWM TUFLOW model results - inundation extents - 0.1% AEP + 20% rainfall intensity increase even

3.5.1.2.4 Scour and erosion potential

The ACARP 2002 Guidelines provide indicative parameter thresholds for scour potential in diversions in the Bowen Basin. This criterion is directed towards diversion design which, although is not the purpose of this assessment, also provides a general indication of scour and erosion potential in all waterways in the Bowen Basin. It was therefore utilised in the analysis of the hydraulic model results. The events listed in the guidelines are the 2- and 50-year Annual Recurrence Interval (ARI) events, which translate to 39% and 2% AEP events respectively.

The hydraulic modelling results show shear stress, stream power and velocities above the ACARP Guidelines for both the 2% and 50% AEP events in the following areas of the site. These results are commonly observed in natural undisturbed watercourses.

- Burngrove Creek model: The low sinuosity and concentration of flow through the narrow, straight channel adjacent to the Bonnie Doon and Ramp 8 voids is the likely cause of these exceedances. While there appears to be some vegetation existing within the channel, further establishment of vegetation will improve the stability of the diversion reach. This location is not adjacent to any areas of the closure landform which would be susceptible to erosion. While there appears to be some vegetation existing within the channel, further establishment of vegetation as part of the rehabilitation plan will improve the stability of the diversion reach.
- Taurus, Sirius and Rockland Creek models: The constructed diversions or modified watercourses of Deep Creek diversion, Emu Creek, Sirius Creek diversion, and Rockland Creek downstream of Rockland Dam are areas of exceedance. In some areas, these constructed channels are located in narrow reaches between the toes of rehabilitated spoil dumps, resulting in the possibility of scour against the final closure state landform. However, the diversions will be engineered at the detailed design phase (3.5.1.7.5) to prevent scour and erosion from occurring and vegetation will be established as part of the rehabilitation plan.
- Two Mile Gully model: The exceedance locations occur in the natural watercourse and are not impacted by the final closure state landform. This creek is well vegetated, and no channel deepening has occurred within the watercourse, further indicating the diversion is not likely to be susceptible to erosion or scour in the long-term future.
- At locations where the watercourses are constricted through a road or railway embankment.

Although these locations may be subject to potential erosion in frequent flood events, appropriate scour and erosion protection measures have been considered as part of the iterative closure state landform design.

3.5.1.2.5 Flood risk profile

A Flooding Risk Profile (FRP) was developed for the BWM post-closure conditions, based on the results of the hydraulic model as applied to the Whitehaven Coal HSE Risk Management Procedure. Details of the flood risk profile are in Appendix 4.6 and the BWM PRC Plan Risk Assessment (Section 3.6).

Through the iterative landform and modelling approach, the closure landform was refined to minimise the potential for environmental harm and to create a stable landform. As a result of this process, the flood risk profile identified low risk levels associated with flooding and the BWM closure landform. Therefore, no critical controls were required.

Relationship with PRCP Schedule
The interaction between flooding and the proposed final closure landform presents a low risk. The closure landform provides an appropriate level of protection from inundation to the residual voids, flooding does not adversely impact the stability of the final closure landform and cumulative flows from the BWM rehabilitated area are similar to existing conditions.

3.5.1.3 Waste characterisation

PRCP Guideline (Section 3.6.1)

Characterise mine wastes in a report that describes the likely physical behaviour and chemical reactivity of the waste materials under the conditions in which they would be stored. The report must address the constituent elements present, and their likely future speciation and mobility.

All mined material should be classified on its propensity to be potentially acid or non-acid forming, to generate neutral metalliferous or saline drainage, and its susceptibility to weathering.

A material characterisation assessment has been undertaken to support the development of this PRC Plan. The detailed report – *Blackwater Mine PRCP Environmental Geochemical Characterisation and Risk Assessment of Mineral Waste* (Terrenus Earth Sciences, 2024), is provided in Appendix 4.7.

The objective of the assessment is to evaluate the geochemical nature of mineral waste currently at BWM and mineral waste likely to be present at closure and identify relevant environmental issues/opportunities that may be associated with mining, handling and storing mineral waste to inform appropriate rehabilitation and management strategies.

3.5.1.3.1 Background

BWM has three main types of mineral waste. Geochemical characteristics and potential hazards associated with mineral waste materials on site are discussed by type:

Spoil (overburden and interburden) currently comprises ~99% of all mineral waste at BWM and includes weathered waste (Tertiary and Permian-age) and fresh (unweathered) waste (all Permian-age). On average, ~40% of spoil is weathered/oxidised and the remaining (~60%) is fresh, with the proportion of weathered to fresh spoil varying throughout the site. In the northern half of the site, the proportion of weathered to fresh spoil is 25% weathered to 75% fresh. In the southern half of the site, the proportion is 49% weathered to 51% fresh.

Tailings are generated at the NCPP (and previously also at the SCPP) from processing ROM coal and typically represent the clay, silt and fine sand fractions of ROM waste. Throughout operations at BWM, tailings have been disposed of as a slurry into several TSFs. Tailings comprise ~0.5% of all mineral waste throughout the life of mine.

Rejects are generated at the NCPP (and previously at the SCPP) from processing ROM coal and typically represent coarser and rockier seam roof, partings and floor material. Rejects are trucked to several locations for disposal in spoil dumps. Historically, rejects were also disposed of in rejects dumps, such as Ramp 36 rejects dump and Bottom Dam TSF [mixed tailings and rejects]. Some rejects have been used in the construction of TSF embankments and infrastructure pads (e.g. ROM and coal stockpile pads). Rejects comprise ~0.5% of all mineral waste throughout the life of mine.

Coal is included in the assessment. However, it is generally not considered mineral waste, except for small quantities of sub-economic seams that may report to the spoil dumps, and remnant coal exposed on pit highwalls (such as in residual voids).

Mineral waste and coal samples underwent geochemical assessment with regard to their potential to generate acid and metalliferous drainage (AMD), which includes:

- acid drainage (AD),
- neutral and metalliferous drainage (NMD), and
- saline drainage (SD).

Additionally, samples have been assessed with regard to their potential to generate salinity (non-oxidative) and, for spoil materials, their sodicity and dispersion potential.

Each sample was characterised using their respective sulfur content and acid neutralising capacity (ANC) as non-acid forming (NAF), NAF-sulfur (NAF-S), potentially acid forming (PAF), PAF-low capacity (PAF-LC), or uncertain (UC) according to the criteria in Table 22.

Table 22 AD classification criteria for mineral waste

AD classification	Sulfur content (%)	NAPP (kg H_2SO_4)	ANC/MPA ratio	NAGpH
NAF	≤0.01	-	-	-
	≤1	<0	≥2	-
	≤1	<0	-	≥4.5
NAF-S	>1	<0	≥2	-
	>1	<0	-	<4.5
PAF-LC	≤1	0-10	<2	-
	-	0-10	-	<4.5
PAF	-	≥10	<2	-
	-	≥10	-	<4.5
UC	Any result outside of the above criteria, or results that appear to significantly conflict with the expected result based on lithology or mineralogy			

Mine domains that are potential sources of AMD and salinity at closure are:

- residual voids,
- spoil dumps,
- the Ramp 36 reject dump, and
- TSFs.

Each of these final landforms will contain a variable proportion of spoil, rejects, tailings and coal depending on operational practices and planned LoM waste management.

Spoil dump landforms will be comprised of mined overburden and interburden disposed behind the active mining face to form a low-wall spoil dump, which will be reshaped to form the final closure landform.

- Mimosa-Besgrove, Deep Creek, Stewarton-Ballamoo, Kenmare and Togara-North Marshmead spoil landforms contain a small proportion of existing or planned future rejects (between 0.2-1.9%, depending on the landform).
- Kenmare spoil landform also comprises ~1% existing tailings (Ramp 72 in-pit TSF).

TSF landforms will comprise tailings (predominantly), with some rejects:

- NCPP TSF includes ~80% tailings, 19% rejects (forming the basis of most of the embankments), and 1% spoil/fill material mainly within embankments.
- Laleham TSF includes approximately 90% tailings, 9% rejects (embankments) and 1% spoil/fill material (embankments). Bottom Dam and ROM 3 Area rejects (no geochemical data currently available – data to be gathered as part of a current environmental and engineering investigation).
- The Ramp 36 rejects dump landform will contain 99% rejects and 1% fill (assumed to be spoil).

All residual voids (except for Bonnie Doon and Laleham) will have pit/void floors comprising the P & L Lower seam group (conservatively assumed to be coal). Bonnie Doon and Laleham will have tailings on the pit/void floors.

3.5.1.3.2 Geochemical assessment of mineral waste

The geochemical characteristics of each waste type were assessed with respect to their ability to generate AMD using both historical data (defined as pre-2019) and data from a more recent sampling and analytical program (2020 onwards). In total, the data included:

- 3,081 samples of non-carbonaceous spoil and 260 samples of carbonaceous spoil to assess spoil and ROM coal (and pit walls and floor).

- 643 tailings samples, comprising 280 'fresh' tailings samples collected from the NCPP and 363 'aged' tailings samples collected from geochemical and geotechnical investigation drill holes within several TSFs.
- 265 rejects samples, comprising 48 'fresh' rejects samples collected from the NCPP and 217 'aged' rejects samples collected from geochemical and geotechnical investigation drill-holes and test pits within NCPP TSF, Laleham TSF, Ramp 36 rejects dump, Kenmare Pit rejects dump and Red Dam area (surface samples).
- 54 'fill' samples and 19 'natural ground' samples collected from geochemical and geotechnical investigation drill holes within the above-ground TSFs (NCPP TSF and Laleham TSF) and Ramp 36 rejects dump. Fill (spoil) material is often used as part of TSF embankment construction.

Assessment methodology

The environmental testing protocol included a variety of analytical techniques that are consistent with industry and regulatory accepted guidelines (e.g. GARD Guide [INAP, 2009]):

- The overburden/interburden samples were selected from drill cores representative of the vertical and lateral geological variability encountered at BWM.
- Tailings and rejects samples from the CHPPs were collected over several years to ensure that the mineral waste variability was captured at the plant. Tailings and rejects samples collected from the TSFs were representative of the vertical and spatial distribution of these materials at each TSF to capture the temporal and lateral variability of the tailings and rejects deposited in the TSFs.

Static testing was conducted on mineral waste samples to assess AMD potential and metal and metalloid content. Initial testing was done on all samples and included analysis of:

- pH and EC on a 1:5 solid:water dispersion,
- net acid-producing potential (NAPP), including:
    - total S for calculating maximum potential acidity (MPA), and
    - ANC.

In addition, further static testing was conducted on selected samples to get more in-depth knowledge of the geochemistry of BWM mineral waste.

Kinetic testing was conducted on tailings samples, which included:

- Oxygen consumption and CO2 generation analysis ("Kinetic OxCon Tests") on 5 fresh and 1 aged NCPP tailings samples, and 3 composite carbonaceous spoil samples from drill cores.
- Kinetic leaching tests of 5 fresh and 1 aged NCP tailings samples (exact same samples as the OxCon tests) following a modified AMIRA (2002) method.
- Tailings liquor samples collected from the NCPP decant pond from 2020-2023 and analysed for typical water quality parameters.

More details of the static and kinetic testing of mineral waste are in Appendix 4.7.

3.5.1.3.3 Geochemical classification of mineral waste

AMD potential

The test work results were used to understand the geochemical properties of each material type (source) and assign an AMD classification. This data has been used to infer the geochemical hazard by each mineral waste type in their relative proportions within each landform. The geochemical risk of each landform was assessed using an SPR approach, as detailed in Section 3.5.1.3.4.

Key findings from the geochemical assessment were:

Non-carbonaceous spoil (3,081 samples, 92% of all spoil)

- Is expected to generate pH-neutral to highly alkaline run-off and seepage, typical for mine spoil in the Bowen Basin.
- Has a very low AMD potential:
    - 96% of samples were classified as non-acid forming (NAF), and 2% of samples were classified as UC(NAF).
- Is not enriched in total metals and metalloids.

Carbonaceous spoil (260 samples, < 8% of all spoil):

- Is expected to generate pH-alkaline to highly alkaline run-off and seepage.
- Has a generally low potential to generate AMD.
    - Carbonaceous spoil associated with coal seams has a greater potential to generate low-level AMD.
    - 85% of carbonaceous spoil samples were classified as NAF, and 2% of samples were classified as UC(NAF).
    - The remaining 13% of samples were classified as PAF, PAF-LC, UC(PAF), or NAF-S.
- Almost all PAF and NAF-S carbonaceous spoil samples were associated with coal seams and could potentially end up as coarse reject if mined with ROM coal.
- Has an overall low ANC and little to no enrichment in total metals and metalloids.

Tailings (643 samples)

- Total S, ANC and pH differed between fresh tailings and aged tailings.

The overall AMD potential of both tailings sources is generally similar. The following discussion only differentiates between the two where the differences were significant. Otherwise, the AMD potential of tailings is discussed as a bulk material.

- 53% of tailings have a moderate-high AMD potential. 47% of tailings have a low AMD potential.
- Fresh tailings from the NCPP are expected to generate pH-alkaline to highly alkaline run-off and seepage. Aged tailings have generally lower pH compared to fresh tailings, i.e. moderately acidic to alkaline. This is most likely from oxidation processes consuming readily available neutralising minerals.
- The total S concentration is low-moderate, with median values of 0.77% and 0.53% for fresh and aged tailings, respectively. Total S content was generally larger in the fresh tailings compared to the aged tailings. This could be due to several different reasons, such as:
    - Sulfide oxidation and neutralisation reactions generate sparingly and/or readily soluble sulfate. This leads to sulfur loss through the leaching of sulfate minerals (e.g. jarosite, alunite and gypsum) and/or soluble salts (e.g. melanterite and copiapite).
    - Difference in initial geochemistry of ROM coal of different sources.
    - In the fresh tailings samples, ~68% of the total S is present as sulfide (S_{Cr}). Comparatively, only 48% of the total S is present as S_{Cr} in the aged tailings samples.
        - This is typical and expected, supporting that the aged tailings in the TSFs are being oxidised after deposition.
- Fresh tailings have moderate-high ANC (median 32 kg H_2SO_4/t) compared to aged tailings, which have low-moderate ANC (median 16 kg H_2SO_4/t).
    - This is likely related to ANC being consumed via buffering of acidity generated by sulfide oxidation and/or sulfate leaching.
- 56% of tailings samples are classified as PAF, PAF-LC, UC(PAF) or NAF-S. 44% are classified as NAF or UC(NAF).

  - Of the PAF and NAF-S tailings samples, ~75% were classified as UC(PAF) or PAF-LC.
- Total metal and metalloid content are generally low compared to the average elemental abundance in soil in the earth's crust according to Bowen (1979).
- Kinetic leach testing with deionised water showed that all fresh tailings and half of the aged tailings have low soluble metal and metalloid content and near-neutral to alkaline pH.
  - The remaining half of the aged tailings produced moderate to elevated metal and metalloid concentrations and all, but one strongly acidic sample had weakly to moderately acidic pH.
  - In saline leaching conditions, all tailings' samples produced low concentrations of soluble metals and metalloids.

Rejects (265 samples)

- About half of the rejects have a moderate-high AMD potential. The remaining half have a low-moderate AMD potential.
- Fresh rejects from the NCPP are expected to generate strongly alkaline run-off and seepage. Aged rejects have a lower pH compared to fresh rejects and are expected to generate weakly acidic to alkaline run-off and seepage.
- Fresh rejects have generally moderate-very high ANC (median 40 kg H_2SO_4/t). Aged rejects have low-high ANC (median 17 kg H_2SO_4/t).
- 51% of rejects (all aged rejects) are classified as PAF, PAF-LC, UC(PAF) or NAF-S. The remaining half are classified as NAF or UC(NAF).
  - All fresh rejects are classified as NAF.
  - Of the 'PAF' and NAF-S tailings samples (all being aged rejects), about two-thirds were classified as UC(PAF) or PAF-LC.
- Peroxide leaching on 20 aged rejects samples (19 samples from Ramp 72 TSF and 1 sample from Laleham TSF) of predominantly 'PAF' classifications showed that almost all rejects samples are weakly to strongly acidic and have moderate to elevated metal and metalloid concentrations.
  - Under acidic conditions, these materials have the potential to generate elevated metal and metalloid loads. Sulfate and salinity loads are not expected to be high due to the generally low total S concentration (with some exceptions).

Salinity, sodicity and dispersion potential

Non-carbonaceous spoil has modest cation exchange capacity (CEC) values and generally high exchangeable sodium percentage (ESP) values, resulting in almost all samples being classified as strongly sodic and the few remaining samples being classified as sodic and, therefore, with potential for dispersion.

Carbonaceous spoil has comparable CEC and ESP values to non-carbonaceous spoil. The main difference is that the weathered carbonaceous spoil has lower CEC and ESP compared to the fresh carbonaceous spoil. Based on the moderate to high sodicity values, carbonaceous spoil is expected to be sodic with potential for dispersion.

Tailings samples have $EC_{1:5}$ values ranging from 97 to 8,900 µS/cm, with median and 90th percentile $EC_{1:5}$ values of 711 and 1,510 µS/cm, respectively. There is generally little difference in $EC_{1:5}$ values between fresh and aged tailings, and both types have low-moderate total S content. Tailings are generally slightly to moderately saline with a low to low-moderate potential for SD (from sulfide oxidation).

Rejects have $EC_{1:5}$ values ranging from 143 to 2,830 µS/cm, with median and 90th percentile $EC_{1:5}$ values of 754 and 1,950 µS/cm, respectively. Fresh rejects samples are generally non-saline while aged rejects are non-saline to moderately saline. Most fresh rejects have low total S content, while most aged rejects have low to low-moderate total S content. Based on total S concentrations, the potential for SD (from sulfide oxidation) is low to low-moderate for rejects.

3.5.1.3.4 Geochemical risk of final landforms

A geochemical source hazard assessment was conducted on mineral waste at BWM to support an SPR assessment. The source hazard score is a formula that considers the propensity to generate AMD, the AMD capacity (severity) and the quantity (volume) of material that could produce AMD.

The AMD source hazard scores are as follows:

- Non-carbonaceous spoil: Low
- Carbonaceous spoil: Low-Moderate
- Tailings: Moderate-High (score ranged from Moderate-High to High depending on TSF facility, but was generally Moderate-High)
- Rejects: Moderate (score ranged from Low-Moderate to Moderate-High depending on rejects facility, but was generally Moderate)
- Coal: Low-Moderate

The potential environmental risk posed by each landform containing variable proportions of each mineral waste type was determined. This risk is determined by considering the following factors:

- geochemical source hazard of the landform (as described above),
- potential environmental and human health receptors of AMD from the landform, and
- potential pathways between the source (landform) and the receptor.

The outcome of this assessment informed the development of appropriate management and rehabilitation measures for relevant landforms at closure.

A key element of the CSM developed as part of the hydrogeological assessment (Appendix 4.2) was that the residual voids at BWM will be groundwater sinks.

A conceptual facility model (CFM) was developed for each TSF and rejects dump to illustrate potential run-off and seepage pathways and surface water and groundwater receptors associated with these key mineral waste facilities, based on the following AMD hazard score for the landforms:

- Each of the spoil landforms (except Kenmare) poses a Low AMD hazard, with AMD generation rated as Highly Unlikely.
    - The Kenmare spoil landform (Ramp 72 in-pit tailings and rejects within Kenmare pit (to be buried within the Kenmare spoil landform)) poses a High AMD hazard, with AMD generation rated as Highly Likely (Figure 41).
- NCPP TSF – prior to rehabilitation – has a Moderate-High AMD source hazard with the likelihood of AMD generation from the landform rated as Probably/Likely (Figure 37).
- Laleham TSF – prior to rehabilitation – has a Moderate-High AMD source hazard with the likelihood of AMD generation from the landform rated as Probably/Likely (Figure 38).
- Bottom Dam TSF and rejects area is undergoing environmental and engineering assessment programs, which will guide the rehabilitation and closure planning for this area. Prior to rehabilitation (i.e. currently), this area has been conservatively assigned a Moderate-High AMD source hazard with the likelihood of AMD generation from the landform rated as Probable/Likely (Figure 39).
- Ramp 36 rejects dump – prior to rehabilitation – has a Moderate AMD source hazard with the likelihood of AMD generation from the landform rated as Probably/Likely (Figure 40).
- AMD generation from residual voids (except Bonnie Doon and Laleham) is Unlikely. AMD generation from Bonnie Doon (Figure 42) and Laleham (Figure 43) is Probable/Likely. The tailings within these voids will be capped/covered at end of mining and no tailings will be exposed post-closure. As such, the potential of AMD generation from the floor of these voids post-closure would

be lower. Should these tailings floors become submerged by groundwater (post-closure), the likelihood of AMD generation from the tailings floor of these voids would be lower.

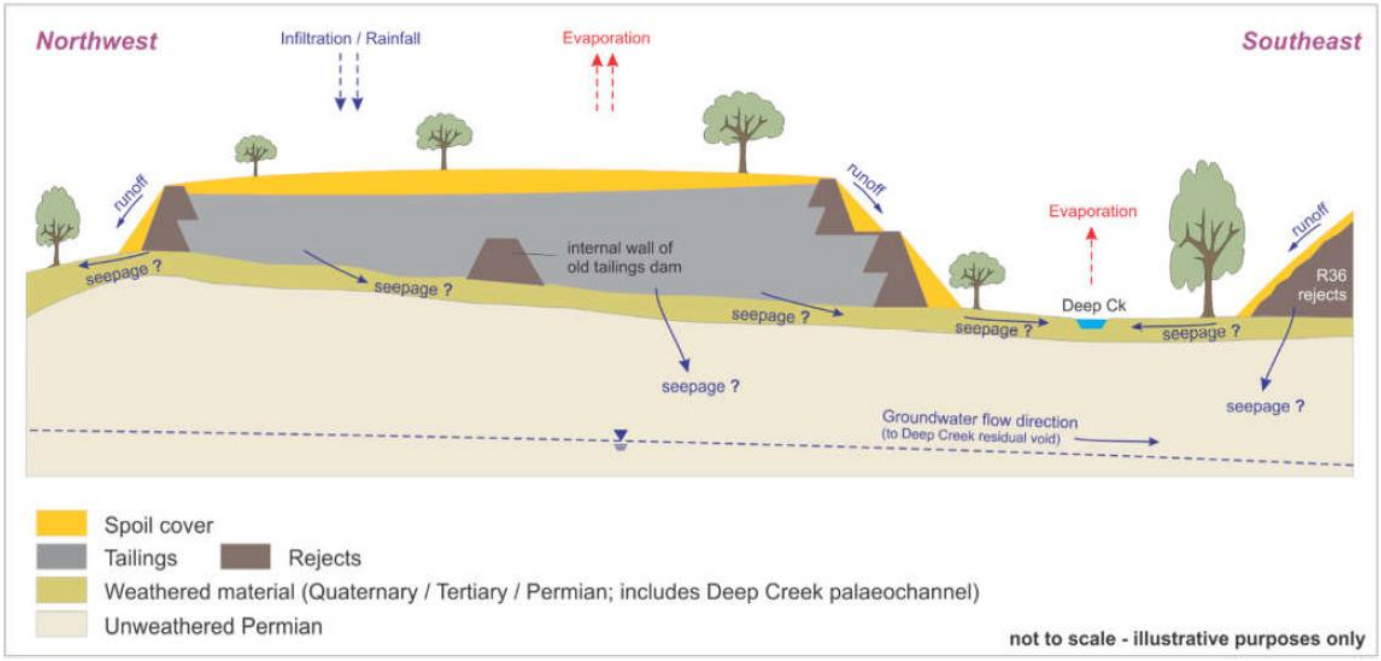

Figure 37 Post-closure SPR conceptual facility model for NCPP TSF

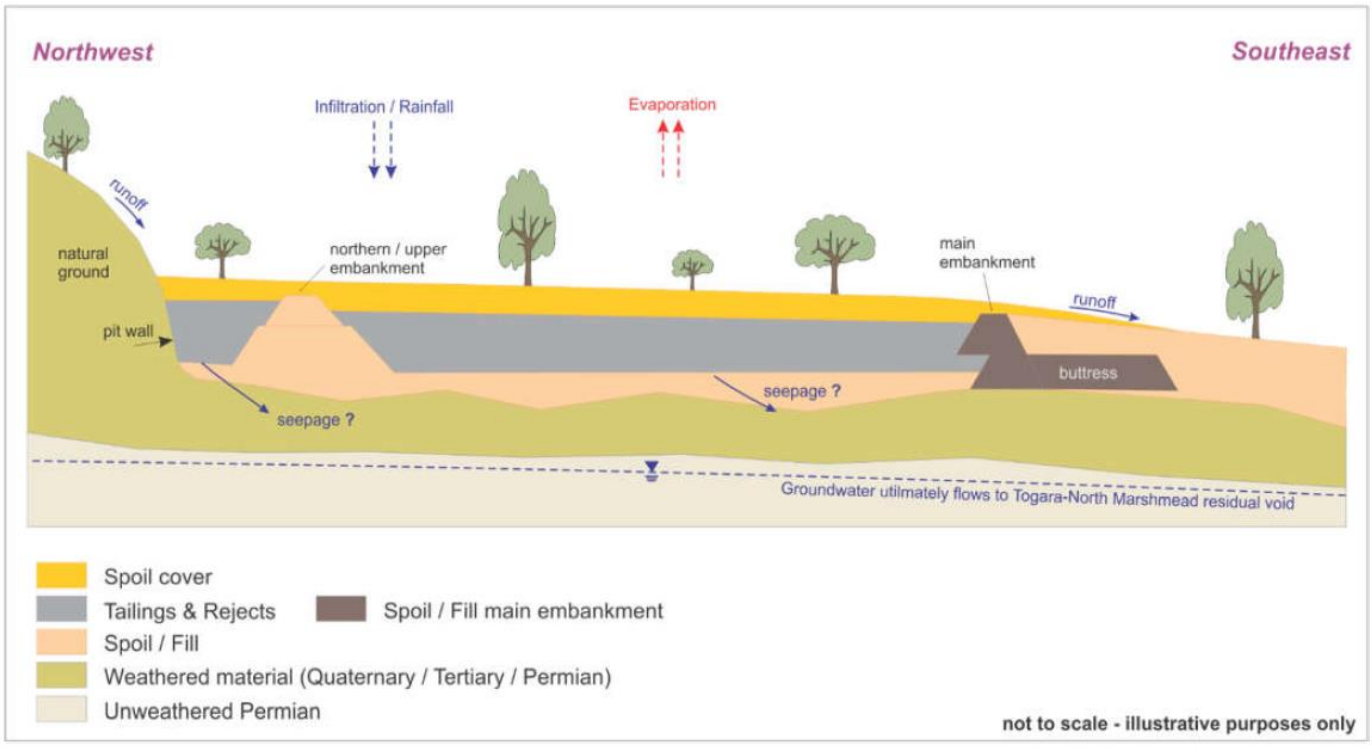

Figure 38 Post-closure SPR conceptual facility model for Laleham TSF

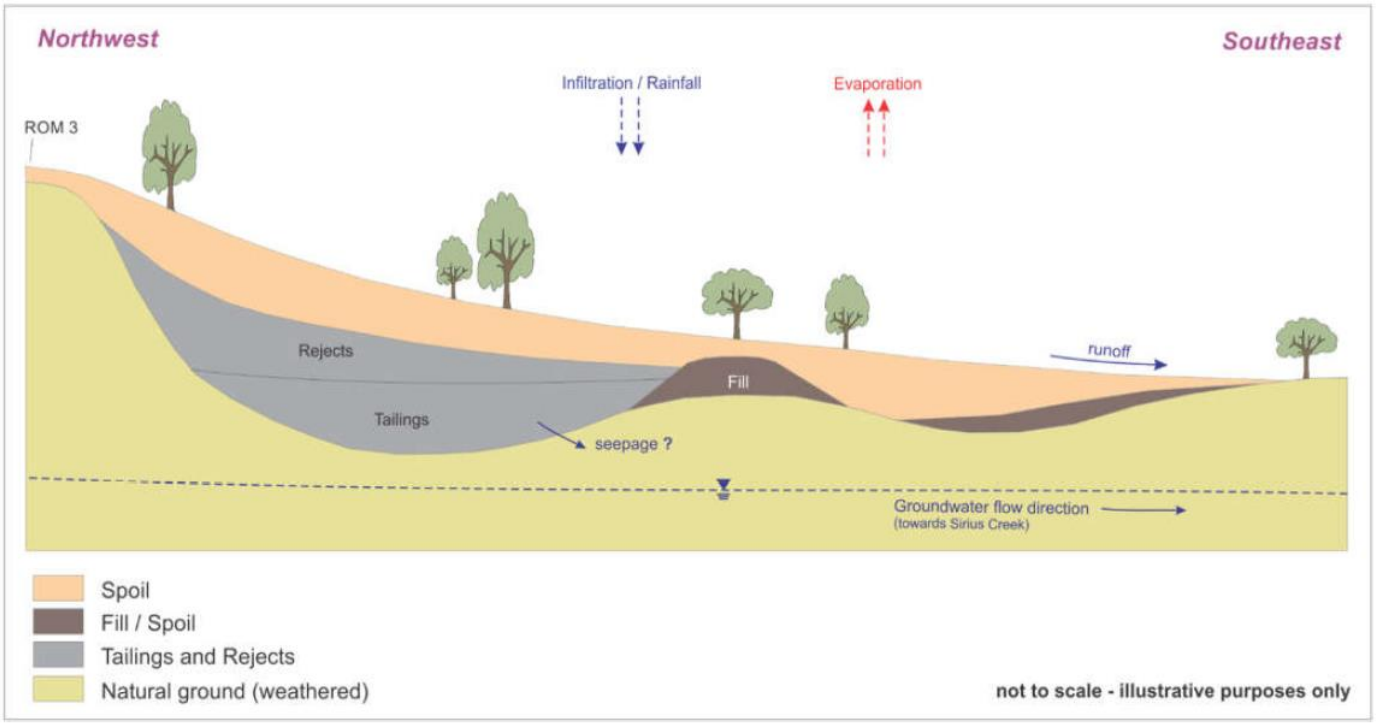

Figure 39 Post-closure SPR conceptual facility model for Bottom Dam TSF and rejects

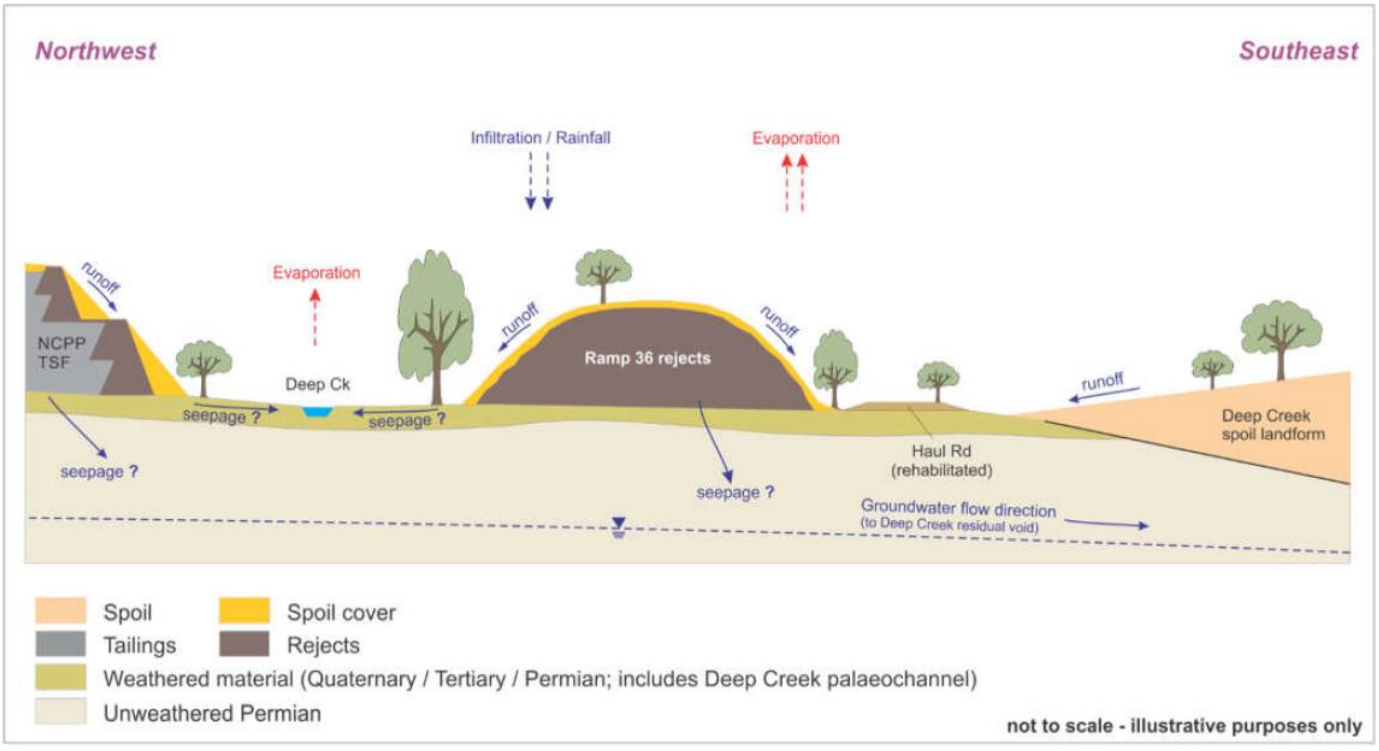

Figure 40 Post-closure SPR conceptual facility model for Ramp 36 rejects dump

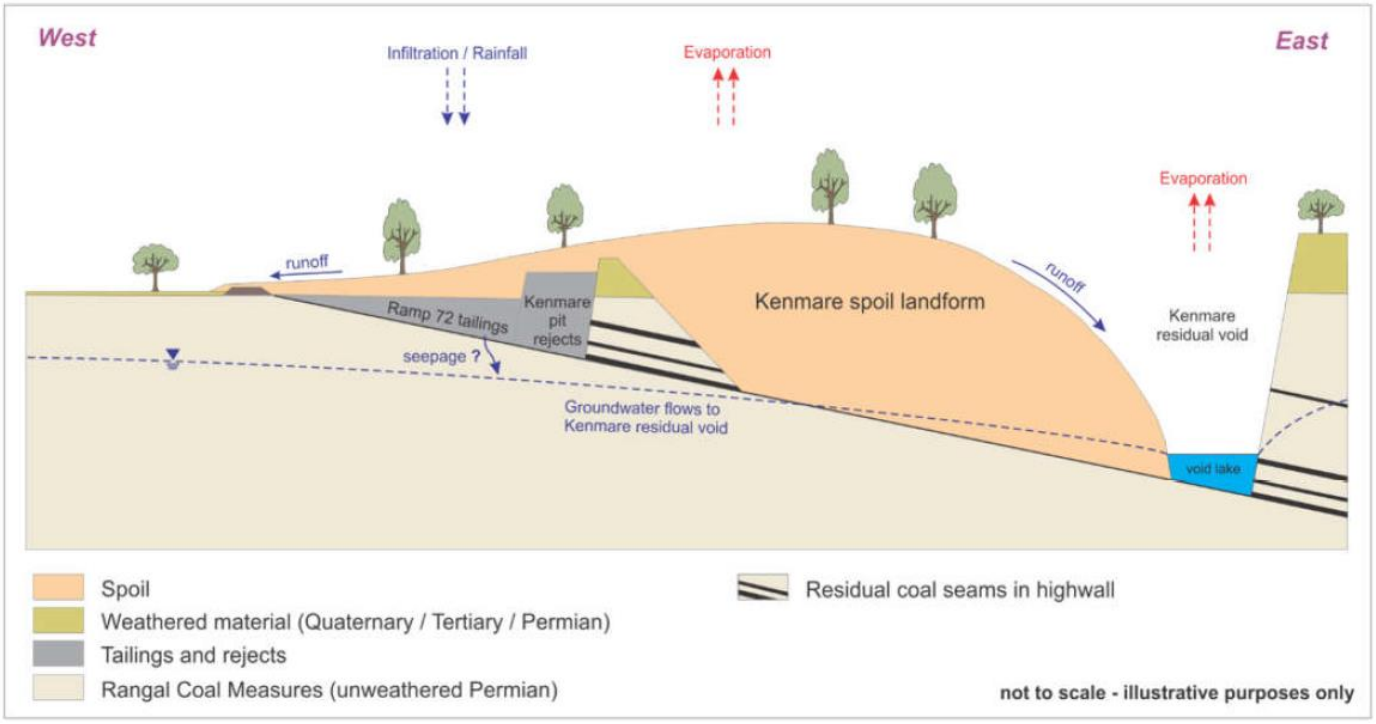

Figure 41 Post-closure SPR conceptual facility model for Ramp 72 TSF buried with the Kenmare spoil landform

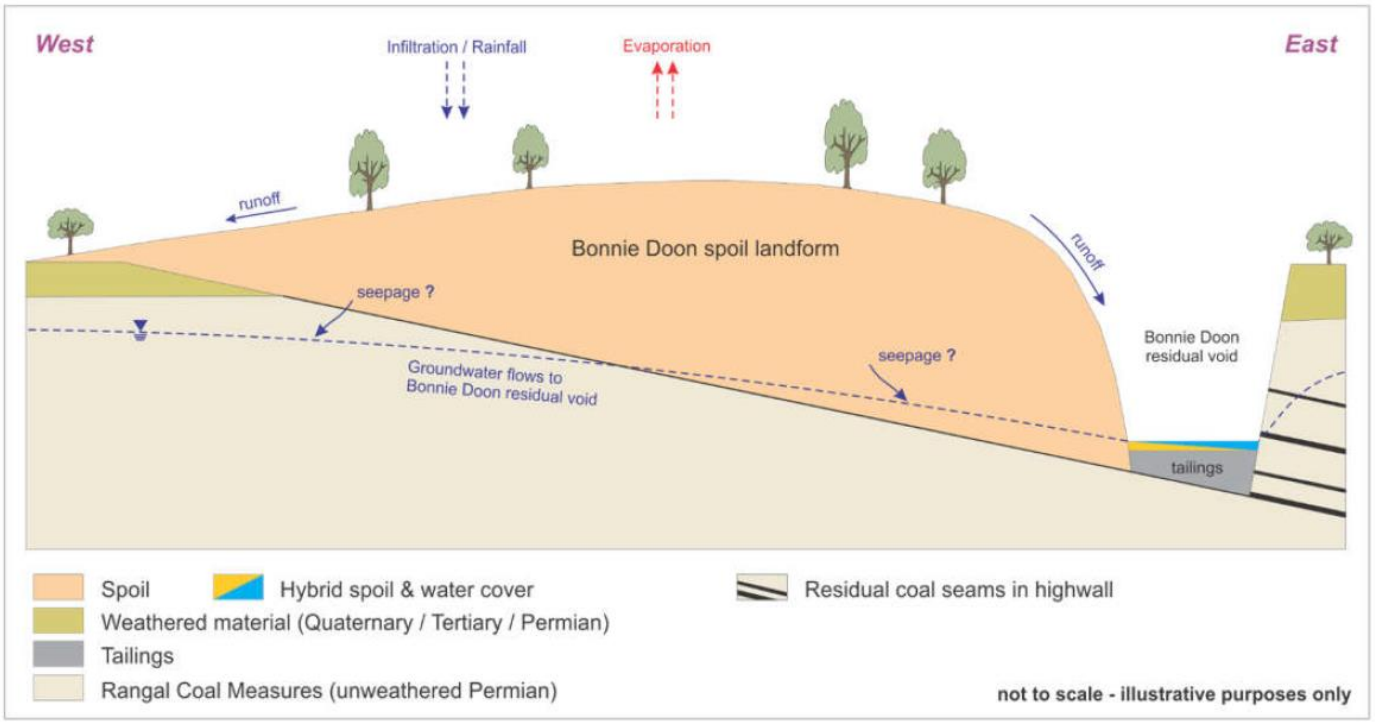

Figure 42 Post-closure SPR conceptual facility model for Bonie Doon spoil landform and Bonnie Doon in-pit TSF (Bonnie Doon residual void)

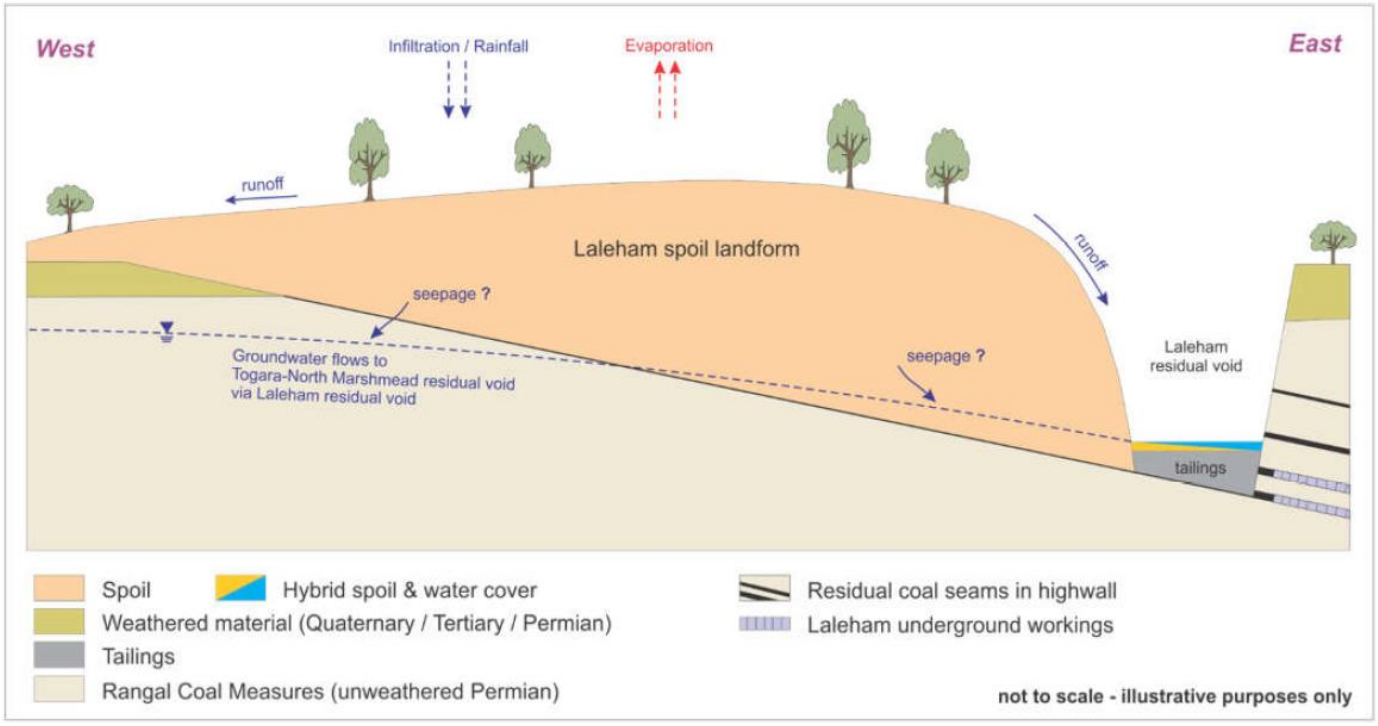

Figure 43 Post-closure SPR conceptual facility model for Laleham spoil landform and Ramp 74 in-pit TSF (Laleham residual void)

A detailed description of the CFMs is in Appendix 4.7. Plausible pathways and receptors for potential geochemical hazards posed by BWM features are provided in Table 23.

Table 23 Possible pathways and receptors for potential geochemical hazards posed by BWM features

Potential Pathways	Receptors
Spoil landforms — Surface water run-off from spoil landforms into nearby creeks — Seepage from spoil landforms via shallow permeable strata into nearby creeks — Seepage from spoil landforms into the residual voids — Surface water run-off and seepage from void highwalls into residual voids *TSF and rejects landforms* — Surface water run-off from TSF or rejects landforms into nearby creeks — Seepage from TSF or rejects landforms via shallow permeable strata into nearby creeks — Seepage from TSF or rejects landforms via groundwater into residual voids	— Bonnie Doon Creek west of Ramp 8 and Bonnie Doon spoil landforms, flowing north — Burngrove Creek and tributaries west of Mimosa-Besgrove spoil landform, flowing north — Deep Creek, flowing west to east across the site between Mimosa-Besgrove and Deep Creek spoil landforms — Taurus Creek, flowing west to east across the site between Deep Creek and Stewarton-Ballamoo spoil landforms — Emu Creek and its un-named tributaries, a collective of tributaries located west of the Stewarton-Ballamoo spoil landform, which flows north into Taurus Creek — Sirius Creek flows generally east to west across the site between the Laleham void and the Togara-North Marshmead spoil landform — All minor un-named creeks on both sides of BWM between the southern end of the Stewarton-Ballamoo spoil landform and Laleham void drain into Sirius Creek — Rockland Creek flows east to west across the site between Togara-North Marshmead and South Marshmead spoil landforms, and northeast to southwest between Comet Downs East and Kennedy West spoil landforms

The SPR has conservatively assumed that shallow permeable strata are plausible pathways linking a potential AMD source to deeper groundwater via downward migration and linking a potential AMD source to nearby creeks via lateral migration. However, shallow permeable strata are assumed to be an implausible final receptor of run-off and seepage from final landforms and final voids. That is, the assumption based on the information available is that AMD (source) entering shallow permeable strata (however (un)likely) will ultimately find its way into deeper groundwater [residual voids] and/or local surface water features.

Based on the above, the overall SPR risk ratings are as follows:

- Rehabilitated spoil landforms:
  - AMD: Low
  - Non-oxidative salinity: Low
- Rehabilitated NCPP TSF:
  - AMD: Low to Medium
  - Non-oxidative salinity: Low
- Rehabilitated Laleham TSF:
  - AMD: Low
  - Non-oxidative salinity: Low
- Rehabilitated Bottom Dam TSF and rejects landform:
  - AMD: Low
  - Non-oxidative salinity: Low
- Ramp 36 rejects landform
  - AMD: Low to Medium
  - Non-oxidative salinity: Low

- Residual voids (on water quality of voids):
    - AMD: Low to Low-Medium

3.5.1.3.5 Management and rehabilitation measures

Based on the geochemical assessment, Table 24 summarises the identified geochemical management and/or rehabilitation measures to mitigate the potential environmental risk of the rehabilitated landforms. Details of management and rehabilitation measures (concept cover designs) are in Sections 3.5.1.6 for spoil and 3.5.2.3 for tailings.

Table 24 Geochemical management and rehabilitation measures to mitigate potential environmental risk by the BWM rehabilitated landforms

Rehabilitated landform	Environmental hazard rating (AMD source hazard)	Management and/or rehabilitation measures
Spoil landforms	Low	No specific AMD management measures in addition to standard spoil placement and landform reshaping (Section 3.5.1.5)
Kenmare spoil landform (with buried Ramp 72 tailings)	High	Buried with spoil, within the Kenmare spoil landform
NCPP TSF	Moderate-High	Engineered spoil cover
Laleham TSF		Engineered spoil cover
Bottom Dam (and ROM 3 rejects)	Moderate-High	Cap Bottom Dam with ROM 3 rejects Engineered spoil cover
Ramp 36 rejects landform	Moderate	Engineered spoil cover
Bonnie Doon NUMA (Bonnie Doon in-pit TSF)	Moderate-High	Spoil and water cover (hybrid cover)
Laleham NUMA (Ramp 74 in-pit TSF)		

Relationship with PRCP Schedule
The environmental risks posed by the spoil-related mineral wastes likely to be present at closure are low. As such, no specific AMD management measures (e.g., alkaline amendment or engineered capping systems) are expected to be required to manage mineral waste during rehabilitation and closure. For those mineral wastes with identified environmental hazards rated as moderate to high (TSFs, rejects), conceptual covers have been designed to reduce this risk.

3.5.1.4 Soil and capping material

PRCP Guideline (Section 3.6.1)

The rehabilitation and management methodology should include that soil assessment activities are supplemented by additional surveys conducted at appropriate intervals to assess soil resources in planned disturbance areas. In addition to the assessment of soils, the proposed rehabilitation methodologies in the rehabilitation planning part must also address topsoil management. Topsoil management must ensure sufficient topsoil quantity and quality is available in those instances that waste rock or tailings cannot support the proposed PMLU. Integrated soil and waste rock characterisation and mapping should form the foundation of the rehabilitation strategies. The available soil resources and capping material should be assessed prior to the commencement of operations.

A growth media assessment was undertaken to support the development of this PRC Plan. The detailed report, *Blackwater Mine Materials Characterisation Study* (Landloch, 2023), is provided in Appendix 4.3.

3.5.1.4.1 Quality of available resources

Available rehabilitation resources at BWM include soil and waste (spoil) materials (Landloch, 2023).

Soil

Clay topsoils account for 75% of stockpile samples assessed and are evenly distributed across the mine. Generally, the clay soil samples have similar properties, but minor inclusions of sands and loams were observed at some stockpiles. This is likely a result of topsoils from minor texture contrast soil units being stripped with the more dominant clays. There are both light and heavy clay-textured soils at BWM.

Gravelly clay topsoils account for 15% of stockpile samples and are located within the southern portion of the mine. These soils have similar properties to the clay topsoils except for a higher gravel content. The gravelly clay soils are likely to be more erosion-resistant than the clay topsoils.

Loam topsoils account for 10% of stockpile samples and are located in the southern portion of the mine. These materials have a degree of variability, but due to the limited volumes present, they have been grouped together to aid their management.

Generally, the stockpiled soil is of adequate quality for use as a primary growth medium. The main limitations of using stockpiled soils in rehabilitation are low fertility and, for clay-dominated topsoil, sodicity.

Table 25 summarises the key chemical and physical properties of the available soil types at BWM (Landloch, 2023).

Table 25 Summary of key chemical and physical properties for soils at BWM

Analysis	Loam	Clay	Gravelly clay
Chemical properties			
pH_w	Strongly acidic to slightly alkaline (4.8-7.7)	Moderate to strongly alkaline (8-9)	Moderate to strongly alkaline (8.1-9)
$EC_{1:5}$ (dS/m)	Low to moderate (0.1-0.3)	Low to moderate (0.2-0.5)	Low to moderate (0.2-0.7)
Chloride (mg/kg)	Very low (<65)	Very low to moderate (60-463)	Very low to high (58-642)
Exchangeable sodium percentage ESP (%)	Non-sodic (0.7-4.7)	Non-sodic to sodic (3.3-13.6)	Non-sodic to Strongly sodic (4.5-16.6)
Total N (mg/kg)	Low (680-1450)	Low to moderate (760-1930)	Low (840-1420)
Available P (mg/kg)	Low to moderate (10-24)	Low to moderate (6-36)	Low (840-1420)
Available K (mg/kg)	Low to moderate (124-232)	Low to moderate (115-270)	Low (125-180)
Total Organic Carbon (TOC) (%)	Low to high (0.8-1.9)	Low to high (0.9-2.1)	Low to moderate (0.9-1.6)
Effective Cation Exchange Capacity (ECEC) (meq/10 g)	Low (3-10.4)	Moderate to high (13.7-27)	Low to high (12-28.2)
Ca/Mg ratio	Low Ca to balanced (2.5-4.6)	Low Ca (1.9-3.6)	Low Ca (1.4-3.4)
Physical properties			
Clay content (%)	10-30	>35	>35
Rock content (%)	10-30	<20	20-50
Dispersion (EAT)	Slightly dispersive to slaking (3b-5)	Slightly dispersive to stable (3b-7)	Slightly dispersive to slaking (3b-5)
Permeability	Moderate	Low to moderate	Moderate

Analysis	Loam	Clay	Gravelly clay
Associated regional soil	Sl12 (Sodosol)	MM7 (Dermosol/Vertosol)	MM7 (Dermosol/Vertosol)
Associated SLU	B2v, D5, E1, E2, E3, E4, E5, F1, F2, F3 and S1	A1, B1, B3, C1, C1v, C1gv, D1, D1gv, D2, D3, D4 and D4SV	B2, D4rv, E1 and R1

***** Chemical properties for topsoil are based on average 10th and 90th percentile values for all stockpile samples analysed (Landloch, 2023)

Waste (spoil) materials

Fresh Permian materials are generally rocky and consist primarily of sandstone and siltstone. It is considered the most suitable waste for placement close to the final rehabilitated surface. It also has the potential to be used as rock armour to greatly increase batter slope resistance to erosion and to stabilise steeper areas.

Weathered Permian materials have a lower abundance and smaller rock content than fresh Permian. The rock consists primarily of low-durability mudstone and sandstone. It can be susceptible to capillary rise of salts if profile leaching is limited. Weathered Permian materials are considered suitable for use as a secondary growth material but should be capped with a primary growth material to prevent its exposure at the final rehabilitated surface.

Tertiary materials are weathered and often highly saline, strongly sodic, and prone to dispersion when compared to the fresh Permian. Placement of Tertiary material close to the final rehabilitated surface will be limited due to its susceptibility to erosion and potential toxicities to plant growth. However, with targeted testing, it could be potentially mixed with more competent rock to form a marginal secondary growth medium where required.

Based on the above, Permian materials (both fresh and weathered) have a high potential to be used as secondary growth media, through varying degrees of amelioration. Where primary growth media availability is limited, an ameliorated topsoil/fresh Permian spoil mix could function as a primary growth media to support a woodland PMLU.

The key chemical and physical properties of BWM spoil are summarised in Table 26 (Landloch, 2023).

Table 26 Summary of key chemical and physical properties for spoils at BWM

Analysis	Fresh Permian	Weathered Permian	Tertiary
Chemical properties			
pH_w	Strongly alkaline (8.4-9.8, but can be highly acidic)	Strongly acidic to strongly alkaline (5-9.9, can be <5)	Strongly acidic to strongly alkaline (5-9.4, more often strongly acidic)
$EC_{1:5}$ (dS/m)	Low to extreme (0.19-2.3)	Low to extreme (0.1-3.3)	Low to extreme (0.35-2.2)
Estimated ANC*	Reasonable	Reasonable	N/A
ECEC	Low to adequate	Low to adequate	Adequate
ESP (%)	Non-sodic to strongly sodic (3-30)	Non-sodic to strongly sodic (3-33)	Sodic to strongly sodic (14-30)
Ca/Mg (ratio)	Very low to low Ca, (0.3-1.9)	Very low to low Ca (0.3-1.4)	Very low to low Ca (0.4-2.1)
Fertility	Low to moderate	Low to moderate	Low
Physical properties			
Clay content (%)	20-40	15-45	>35
Rock content (%)	<74	30-60	10-20
Permeability	Moderate	Moderate	Low
Dispersed potential	Moderate to high	Moderate to high	High to extreme

Analysis	Fresh Permian	Weathered Permian	Tertiary
Dispersion risk	Moderate to high	Moderate to high	High

***** ANC estimates were taken from the BMA Blackwater Mine Overburden Quality assessment (GTES, 2007)

3.5.1.4.2 Quantity of available resources

During mining operations, topsoil is stripped according to the recommended depths from the pre-mining soil surveys. The topsoil is either spread directly in rehabilitation areas or stockpiled progressively for later use in rehabilitation. Existing topsoil stockpiles are located throughout the MLs and can be readily accessed for loading and haulage to rehabilitation areas.

The location of topsoil stockpiles (as of August 2021) and the associated soil management groups are provided in Appendix 4.3. Stockpile locations and volumes will vary throughout the life of the operation as stockpiled topsoil is used for rehabilitation and new stockpiles are created as mining advances. The spatial location of stockpiles is recorded in a geographic information system and a volume inventory is maintained.

The volume of topsoil available for rehabilitation includes the volume of topsoil currently stockpiled at the site (5,287,574 m^3 as of latest survey in April 2024) plus the future topsoil which is to be stripped through advancement of the mine. Future advancement is estimated to cover an area of 8,020 ha, which at a conservative 0.15m topsoil strip depth, equates to 12,030,000 m^3 of future topsoil availability. In consideration of current and future topsoil volumes, approximately 17,300,000 m^3 of topsoil is available for rehabilitation.

The rehabilitation at BWM requires growth media (soil and spoil) to support vegetation establishment for the planned PMLUs. The volume of growth media required for the rehabilitation of each PMLU is provided in Table 27. The volumes required are inclusive only of disturbance areas where topsoil has previously been stripped or is planned to be stripped in future according to the current mine plan. Changes to the mine plan will require update of these numbers.

Table 27 BWM growth media volumes for PMLUs

PMLU	Area requiring growth media (ha)	Growth media depth (m)	Growth media volume required (m^3)
Cattle grazing	3,083	>0.15	4,624,500
Woodland habitat	12,143	>0.10	12,143,000
Watercourse	93	>0.15	139,500
		Total growth media required	**16,907,000**
		Total topsoil available	**17,317,574**
		Balance	**410,574**

Based on the information above there is sufficient growth media available to satisfy rehabilitation requirements. At minimum depth there is a site-wide surplus of topsoil.

In terms of applying growth media to the respective PMLUs, topsoil will preferentially be allocated to areas to be rehabilitated under the cattle grazing and watercourse PMLUs. For the woodland habitat PMLU, various options are available for growth media application to yield the best outcome for the land to be rehabilitated. For example, through the rehabilitation planning process it may be established that an area of rehabilitation will achieve the best outcome (safe, stable, non-polluting and self-sustaining) through the application of either topsoil only, topsoil combined with fresh Permian, or fresh Permian only.

3.5.1.4.3 Resource management

An assessment of the growth media characteristics will be completed by an AQP to determine the amelioration requirements to suit the revegetation plan (Section 3.5.1.8). The required growth media depth, amelioration options and surface treatment requirements to support the establishment of vegetation for each PMLU are in Table 28.

Table 28 Growth media ameliorant options and surface treatments for the BWM PMLUs

PMLU	Growth media	Ameliorant options	Surface treatments
Cattle grazing	Topsoil – minimum depth of 150 mm is sufficient to store moisture and nutrients to initiate and sustain pasture growth	— Elemental sulfur — Manures — Urea — Diammonium phosphate — Superphosphate — Fertiliser — Gypsum — Incorporated organic matter — Surface mulching (e.g. hay mulch)	— Ameliorate growth media as recommended by an AQP (if required) — Rip on contour — Direct seed as per seed mixes and rates for cattle grazing revegetation (Section 3.5.1.8.4)
Woodland habitat	Growth media (topsoil, fresh Permian, topsoil/fresh Permian mix) – minimum depth of 100mm. If using topsoil only maximum depth of 150 mm to limit the effects of competition on woodland species due to the potential loads of exotic pasture species	— Elemental sulfur — Manures — Superphosphate — Fertiliser — Gypsum — Incorporated organic matter — Surface mulching (e.g. hay mulch)	— Ameliorate growth media as recommended by an AQP (if required) — Deep rip on contour to incorporate rock — Direct seed as per seed mixes and rates for woodland habitat revegetation (Section 3.5.1.8.6)
Watercourse	Topsoil – minimum depth of 150 mm to encourage a vegetative cover to provide erosion resistance	— Elemental sulfur — Manures — Superphosphate — Gypsum — Incorporated organic matter — Surface mulching (i.e. hay mulch)	— Ameliorate growth media as recommended by an AQP (if required) — Rip on contour as required — Direct seed as per seed mixes and rates for watercourse revegetation (Section 3.5.1.8.6)

Relationship with PRCP Schedule

Physical and chemical properties of the soil and spoil materials available onsite meet the requirements to establish the PMLUs of cattle grazing, woodland habitat and watercourse. Based on the growth media volumes available at BWM, rehabilitation requirements will be satisfied. Any amelioration requirements will be determined by an AQP.

3.5.1.5 Landform design

PRCP Guideline (Section 3.6.1)

The final landform design must be based on the proposed PMLUs and NUMAs and demonstrate that the land will be safe and structurally stable.

All landform designs have been guided by an objective to achieve long-term stability, and the performance of the design concept was tested using appropriate analyses of long-term stability. As BWM is a transitional site, with existing progressive rehabilitation areas that have been designed and reviewed for actual performance, the design concept has not only been informed by theoretical modelling and analysis, but also reflects observation of on-ground practices. As such, formal rehabilitation trials are not proposed to test the

overall landform design concept and instead the historical record has been used to guide rehabilitation practices. However, small scale modifications of rehabilitation practices may be applied from year-to-year, and consequential site practices adjusted, as the actual performance of areas with different prescriptions continue to inform the overarching design concept.

Landform design assessments have been undertaken to support the development of this PRCP. The detailed report, *Erosion and Landform Evolution Simulations to Support Waste Landform Design: Blackwater Mine* (Landloch, 2024) is provided in Appendix 4.8. In addition, Appendix 4.8 also includes the following report which was prepared in response to the DETSI NPM Notice received 25 November 2024: *Landform Evolution Modelling Simulations to Support Tailings Storage Facility Design (2025)*.

Landform design considers the landform development and reshaping of all relevant activity areas after the removal of infrastructure, and prior to placement of growth media and seeding.

The final closure landform design has been refined based on the outcomes of the studies undertaken to support this PRC Plan. The major refinements included changes to the mining limits to ensure geotechnical stability of the residual voids is achieved (Section 3.5.3.2), residual void extents to mitigate the risk of flooding (Section 3.5.1.2) and spoil dump slope angles for erosional stability (Section 3.5.1.5.5).

3.5.1.5.1 3D design

The conceptual 3D closure landform design for BWM is presented in Figure 44.

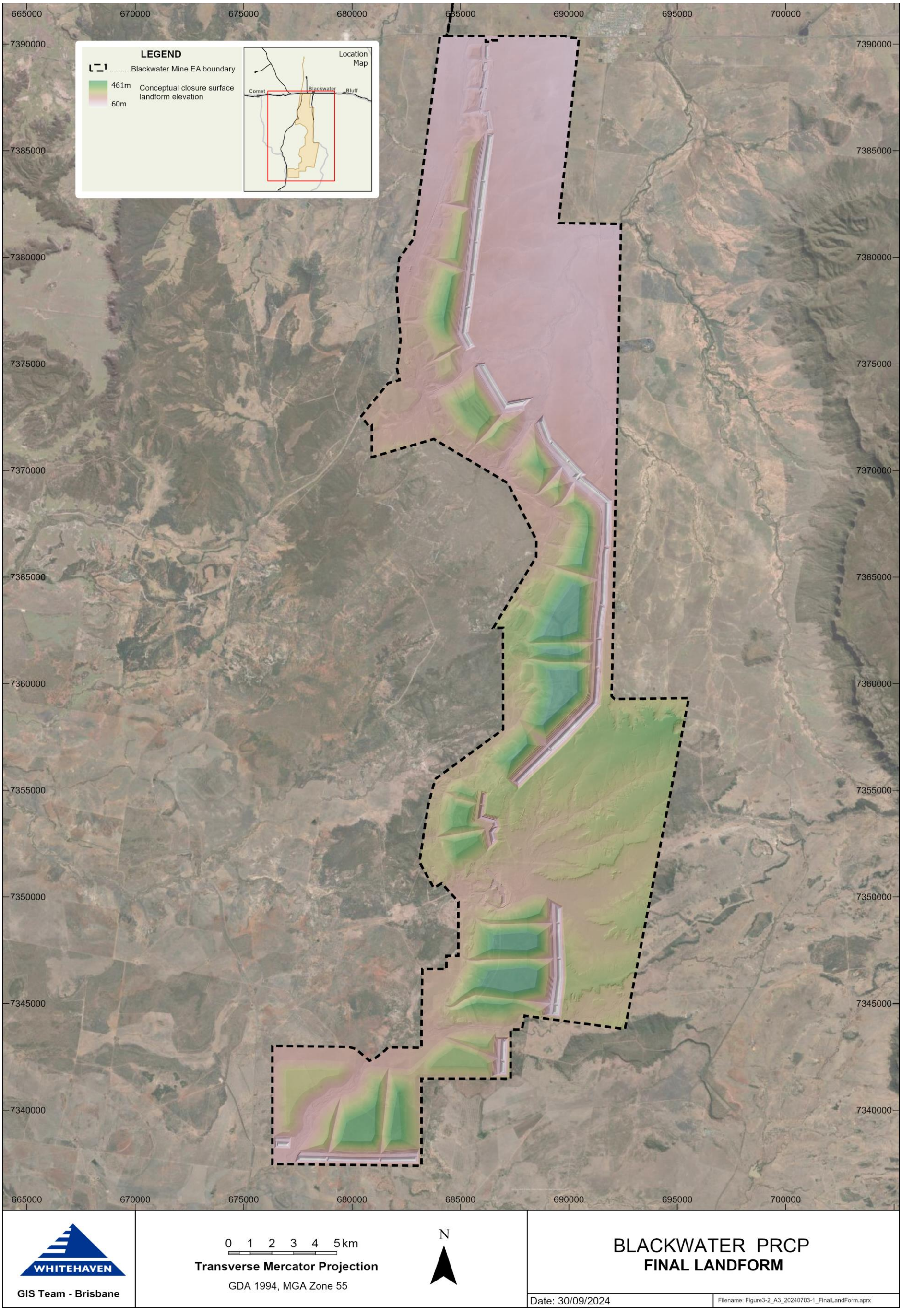

Figure 44 BMW Conceptual 3D closure landform design

3.5.1.5.2 Method of determining landform design

The relevant activities (Section 3.1.4.1) considered when determining the landform design are detailed in Table 29.

Table 29 Landform structures at BWM and proposed designs

Landform structure	Landform design considerations
Spoil dumps	• Maximum dump heights varying from 120 m up to 180 m above ground level to fit the waste scheduled to be mined • 20m dump lift heights • Dump slopes are to be reshaped to be free-draining with a maximum 15% slopes or up to a maximum 30% slopes with rock on the final landform surface (refer to erosion modelling Section 3.5.1.5.5)
TSFs, rejects landforms	• Earthworks to support the application of engineered spoil cover (Section 165) (NCPP TSF, Laleham TSF, Bottom Dam TSF/rejects landform, Ramp 36 rejects) • Bury tailings within spoil landform (see above design considerations) (Ramp 72 TSF beneath Kenmare spoil landform)
Residual voids	• Set-back of the high-wall and end-wall to achieve structural stability of FoS ≥ 1.5 within the NUMA extents (Section 3.5.3.2). • Flood mitigation to a level 1 m above the 0.1% AEP flood levels where required to prevent flood ingress (Section 3.5.1.2): • Deep Creek residual void: northern extent • Laleham residual void: north-eastern extent, including a landform structure along the high-wall • Togora/North Marshmead residual void: northern extent • Stewarton/Ballamoo residual void: eastern extent • The landform structures along the high-wall should not be constructed out of dispersive material and will have the same geometry and maintenance requirements as other landforms.
Infrastructure and general areas: — CHPPs and associated infrastructure, — workshop, — buildings, — stockpile areas, — laydown areas, — roads, — mine dams, — drains, — exploration drill holes	Area will be reshaped to be free-draining with maximum 12% slopes.

Removal of infrastructure (Section 3.5.5) and contaminated land requirements (Section 3.5.5.4) will be completed where required, prior to reshaping of the final landform. After reshaping the final landform, the required growth media and ameliorants are applied to support the PMLU (Section 3.5.1.4), the area is seeded (Section 3.5.1.8), and monitoring and maintenance is completed to ensure rehabilitation is tracking to a stable condition (Section 3.7).

3.5.1.5.3 Materials available for landform rehabilitation

The landform at BWM utilises materials available on-site that will achieve the required landform stability. Rock will be utilised on the steeper final landform slopes to improve the erosion resistance (Section 3.5.1.5.3). Rock will be sourced from the mined overburden and interburden, with sufficient quantity available on-site for the planned rehabilitation. Rock will be used directly in rehabilitation areas or stockpiled when required to ensure sufficient quantity for the planned rehabilitation.

Growth media details to support revegetation are included in Section 3.5.1.4.

3.5.1.5.4 Hydrological and hydrogeological assessments

Except for the catchment into the residual voids, the final closure landform will predominately be water shedding. Rehabilitation will include:

Reshaping of the spoil dumps and TSFs with no permanent berms or water management on slopes.

Removing and reshaping rehabilitated mine water dams to be free-draining.

Removal of any road culverts and fill material from within the watercourse extents.

A rehabilitation flood assessment, including hydrologic and hydraulic modelling, has been completed for the closure landform (Section 3.5.1.2). The flooding risk profile developed as part of this assessment identified the risks to the landform from flooding to be low with mitigation measures in place. Mitigation includes partial backfill and landform structures to mitigate the risk of flooding into the residual voids up to the 0.1% AEP flood level. Landform structures are permanent structures that will be constructed with the same materials, procedures and geometry as other spoil landforms and require no more maintenance than other rehabilitated areas. These landforms will be designed by an AQP based on the latest flood modelling and materials data prior to construction.

The floodwater interaction with the spoil dumps is at the extremity of the flooding extent with relatively low velocities and flood heights (Section 3.5.1.2). Outer landform slopes that interact with flood waters up to a 0.1% AEP will incorporate controls, if required, to minimise potential instability of the landform from interaction with floodwaters.

A hydrogeological assessment (Section 3.5.1.1), including numerical modelling, and pit lake water balance modelling (Section 3.5.3.3.1) identified that the residual voids, once the pit lakes and groundwater have stabilised, will continue to act as sinks. Therefore, groundwater in the proximity of the residual voids will remain depressed and will not impact the landforms outside of the residual voids.

3.5.1.5.5 Long-term landform stability

Material testing, erosion modelling and landform evolution modelling of the spoil dumps and tailings storage facilities have been completed by Landloch to establish the slope profiles for the materials at BWM to ensure long-term landform stability (Appendix 4.8). The studies included:

- Simulations of runoff and erosion for a range of spoil dump landform and tailings storage facility landformoptions using the Water Erosion Prediction Program (WEPP).
- Derivation of parameters for the SIBERIA landform evolution model.
- Landform evolution simulations using SIBERIA for the 3D landform of the BWM spoil dumps and tailings storage facilities, which were designed based on the WEPP results.

The runoff and erosion simulations using the WEPP model and the landform evolution simulations using the SIBERIA model indicate that the proposed spoil dumps and tailings storage facility slope profiles at BWM can be expected to be stable over the long term, provided the correct soils and target levels of vegetation cover are achieved.

3.5.1.5.6 Method of construction

The majority of the spoil dumps are dumped within the mined-out pits and comprise dragline spoil piles at the base of the dump (~80 m high) with haul trucks dumping ~20 m lifts above the dragline spoil.

3.5.1.5.7 Waste placement strategy

Waste rock materials available for use in landform construction and rehabilitation at BWM include:

- fresh Permian,
- weathered Permian, and
- Tertiary materials.

Fresh Permian materials are generally rocky and consist primarily of sandstone and siltstone. It is considered the most suitable material for placement close to the final rehabilitated surface and will be used to construct inward facing (low wall) batters on:

- R8M;
- Boonie Doon;
- Mimosa/Besgrove;
- Deep Creek;
- Stewart/Ballamoo;
- Kenmare;
- Laleham;
- Togara/North Marshmead;
- South Marshmead;
- Kennedy West; and
- Comet Downs East.

Weathered Permian materials are lower in abundance and have a larger smaller-sized rock content than fresh Permian. The rock consists primarily of low-durability mudstone and sandstone and can be susceptible to capillary rise of salts if profile leaching is limited. Weathered Permian materials are considered suitable for use as a secondary growth material but should be capped with a primary growth material to prevent its exposure at the final rehabilitated surface.

Tertiary materials are weathered and often highly saline, strongly sodic and prone to dispersion when compared to the fresh Permian. Placement of Tertiary materials close to the final rehabilitated surface is not recommended (Appendix 4.3).

Soils available for use at the surface of rehabilitated waste landforms include light clay and heavy clay topsoils.

- Heavy clay topsoil will be used for outward-facing batters on:
    - R8N;
    - Boonie Doon;
    - Mimosa/Besgrove;
    - Deep Creek; and
    - Stewarton/Ballamoo.

- Light clay topsoil will be used for outward-facing batters on:
    - Kenmare;
    - Laleham;
    - Togara/North Marshmead;
    - South Marshmead;
    - Kennedy West; and
    - Comet Downs East.

3.5.1.5.8 Quality assurance/quality control

The proposed actions referenced in Table 29 are the key controls that will be put in place to manage the landform risks associated with achieving the PMLUs. Quality assurance and quality control activities are built into all necessary execution and verification activities of these controls. Monitoring and reporting processes verify controls and ensure that controls are executed effectively (Section 3.7).

3.5.1.5.9 Trial methodology

Modelling has indicated the proposed landforms will be stable over the long term, provided the target levels of vegetation cover are achieved. Monitoring will verify if the landforms are on a trajectory towards achievement of the milestone criteria and eventual certification, or whether corrective actions, maintenance or changes to the rehabilitation methodology are required.

3.5.1.5.10 Limitations and assumptions

The limitations and assumptions of the final closure landform design include:

- The final closure landform is dependent on the mining schedule, which can change due to increased geological knowledge as mining progresses, and market factors. These changes may result in differences to the landform, such as varying heights or ramp locations, but the key considerations to ensure long-term stability, such as slope profiles and materials, will be maintained in the final closure landform design.
- The landform has been designed with maximum dump heights to ensure all modelling is conservative. It is not expected that all areas of the spoil dumps will reach these heights.
- A swell factor of 25% has been assumed for the dump scheduling. This is a standard factor based on experience in the Bowen Basin Angle of repose of the spoil material is 37°.
- Landform evolution modelling has been completed up to 300 years based on the best available inputs at this time

Due to the size of the spoil dumps and dumping in lifts, the majority of settlement of the ‘constructed’ landforms is expected to occur during placement with only minor settlement expected after rehabilitation. According to ACARP project C19022 (Williams, 2015), spoil settlement consists of three components: self-weight settlement (80% occurs during placement and decreases exponentially with time); collapse settlement (most occurs during placement); and degradation settlement (variable timeframe depending on material, but most may occur during placement and approaches a limit over time). The landform will be monitored to ensure a free-draining landform is maintained where required.

Relationship with PRCP Schedule
The landform has been designed to conservatively represent the BWM final closure landform and minimise risk, with slopes appropriate for the materials available on-site.

3.5.1.6 Cover design

PRCP Guideline (Section 3.6.1)

A cover design is required for the surface treatment of a mine landform or other waste material. Exposure of waste rock, low-grade ore, heap leach material or tailings can result in chemical reactions that cause an acidic, neutral or alkaline discharge with elevated metal or sulfate concentration. The management of mined and waste material to ensure contaminants are not released to the receiving environment is critical to rehabilitation success.

Hence, the cover system design must be appropriate for the type(s) of waste the project will generate and reflect a risk-based approach.

Where waste has the potential for AMD, neutral mine drainage or saline mine drainage, an appropriate cover system must be designed taking into consideration:

- *results from geochemical characterisation*
- *type and physical characteristics of the material being covered (from the material balance developed for the site)*
- *site conditions*
- *availability of suitable cover materials (both quality and quantity)*
- *criteria for discharge (i.e. to protect environmental values)*
- *suitable vegetation.*

The cover design should include:

- *identification and specification of the objectives of the cover system*
- *a detailed description of the design including the thickness of each layer*
- *a detailed description of construction methodology including any proposed staging of the cover system*
- *a quantitative assessment that identifies the location and quantity of proposed capping material available on site*
- *proposed QA/QC for the construction of the cover system including the timely implementation of corrective actions where deviations from the design are identified.*

A cover system is required where there is potential for materials to cause AD, NMD and/or SD to ensure contaminants are not released to the receiving environment.

As detailed in Section 3.5.1.3, the main types of waste materials at BWM include spoil, rejects and tailings. Tailings and rejects are disposed of in dedicated TSFs and/or rejects landforms and are addressed in Section 3.5.2. This section considers the risk associated with the spoil materials.

The spoil is placed predominantly in spoil dumps within the mined-out pits and the rejects are buried within the spoil extents during operations. The geochemical assessment by Terrenus (2024) (Appendix 4.7) found that 96% of non-carbonaceous spoil is NAF and is not enriched in metals and metalloids and can therefore be considered inert. 85% of carbonaceous spoil was found to be NAF and 13% was found to be PAF. Since less than 8% of spoil material is carbonaceous, the total amount of PAF spoil material is only around 1%.

Considering the waste materials within the spoil landforms, the large quantities of inert spoil and the methods of disposal, the geochemical assessment concluded that no specific AMD management measures are required for the spoil dumps (Section 3.5.1.3).

Any PAF or dispersive spoil will be placed appropriately in the spoil dumps (i.e. not at the surface) and not used in the construction of embankments or cover systems at BWM.

QA/QC for the construction of the TSF cover systems are in Section 3.5.2.3.5.

If any additional cover systems are deemed to be required in the future, appropriate and detailed construction designs will be developed.

Relationship with PRCP Schedule
The geochemical assessment of the spoil materials on-site concluded that no specific AMD management measures are required.

3.5.1.7 Water management

PRCP Guideline (Section 3.6.1)

The management of surface and groundwater is a key consideration in achieving long-term rehabilitation success. The rehabilitation planning part must include a description of the following:

- *a description of the contaminants that pose a risk to environmental values of the receiving environment*
- *source, pathway and fate of contaminants that have the potential to impact environmental values*
- *infiltration and seepage intervention and collection controls*
- *surface water diversions and long-term management requirements*
- *dewatering requirements*
- *on-going water management and reduction requirements (i.e. treatment).*

3.5.1.7.1 Context

The landform design for BWM is intended to provide landforms that meet the nominated PMLU and NUMA milestone criteria without the need for ongoing active water management or dewatering. The following key considerations, which are discussed in more detail in the relevant sections of this PRC Plan, have been taken into account in the assessment of ongoing water management requirements post-mining:

- The final landform surfaces will be free-draining where appropriate to prevent impacts, with runoff allowed to flow to the surrounding watercourses or residual voids (Section 3.5.1.5)
- All mining-related dams be decommissioned and removed, and the rehabilitated areas will be free-draining (Sections 3.5.1.5 and 6.5)
- Final residual voids will remain as NUMAs and will establish and stabilise into long-term groundwater sinks with catchments minimised to what is practical and possible (Section 3.5.3)
- Rehabilitated landforms provide residual void flood protection up to and including a 0.1% AEP flood event (Section 3.5.1.2)
- TSFs are either capped and rehabilitated to a stable landform, buried by spoil during mining operations or managed as part of NUMAs (Sections 3.5.1.5 and 3.5.2)
- The acid-neutralising capacity of the spoils is sufficient to neutralise acid-forming materials within the spoil dumps (Section 3.5.1.3)

Modelling of flow paths through particle tracking simulations within groundwater over a recovery period, within and surrounding the mining operations (including from the MIA, CHPPs and TSFs), indicate the groundwater within the tenement will migrate toward the residual voids (NUMAs) and not into receiving environments (Section 3.5.1.1).

Contaminated land investigations (RM2) will be undertaken at the completion of mining to confirm the suitability of the site for the PMLUs and provide additional information on source areas, preferential pathways and potential risks associated with migration of contaminants

Forward work plans and any required realignment and rehabilitation works will be undertaken to render the creek diversions at BWM to a suitable condition, supporting their progression to a relinquishable state (Section 3.5.1.7.4)

Conceptual site models that assess SPR linkages have been prepared for relevant technical studies including hydrogeology (Section 3.5.1.1) and waste characterisation (Section 3.5.1.3) and show a low likelihood of complete exposure pathways to off-tenement receptors.

3.5.1.7.2 Contaminants and sources

Since BWM operations commenced in 1967, heavy industrial-type activities have occurred on the site. This includes the operation and maintenance of processing facilities, vehicles, and other plant infrastructure required to support the extraction and processing of coal. It also includes the storage, use, and disposal of a variety of hazardous materials.

BWM's facilities have and will continue evolving with modern engineering and environmental standards; however, the duration and nature of the operations increase the likelihood of contaminated land being present at closure. Therefore, it is considered likely that contaminated land will be present at closure which will require investigation and some remediation. In line with the requirements of the EP Act and the EA, areas of identified land contamination that present an unacceptable risk to human health or the environment during the operations will be subject to investigation and remediation efforts, where appropriate. Remediation works will be undertaken to render the area suitable for operational land use. Further contaminated land investigations and remediation works are likely to be required at BWM upon decommissioning of infrastructure.

The predominant hazardous materials identified to have a potential to cause contamination at BWM and impact PMLUs and/or the receiving environment include:

- Hydrocarbons, such as diesel, oils, greases, methyl isobutyl carbinol (MIBC) and other solvents.
- Aqueous film-forming foams from historical use of products containing Perfluoroalkyl and Polyfluoroalkyl Substances (PFAS) species of concern.
- Nitrogen associated with explosive formulation.
- Carbonaceous materials.

Current operational water management includes the segregation of water from mine operational areas from non-mine affected areas. Water from mine operational areas is collected within on-site mine dams and recycled within the mine operations, or released under the conditions of the EA.

Mine-affected water includes:

- pit water,
- TSF water,
- CHPP water, and
- runoff from areas such as the CHPPs and MIA.

Mine-affected water dams have the potential to accumulate impacted water and sediments and therefore are a potential secondary source of contamination. Contaminants of concern within the dams include those potential contaminants listed above, as well as metal, metalloids and salinity. All mine-affected water dams will be assessed for potential accumulation of contaminants and appropriately decommissioned to form free-draining areas.

Contaminated land investigations will be undertaken to assess areas for potential contamination (RM2). This investigation will assess the range of potential contaminants that are utilised or generated during operations and will provide an assessment of the risk presented to the achievement of the PMLUs and the receiving environment.

3.5.1.7.3 Pathway of contaminants

With the exception of the catchment of the residual voids, the final landform surfaces will be free-draining where appropriate, directly to the surrounding watercourses. Any contaminants present at the surface of the closure landform have the potential to be mobilised through surface water runoff, generation of airborne particulate and direct contact with the PMLUs. Contaminated land assessments at the completion of mining will inform required remediation works to manage identified unacceptable risks associated with potential pathways to surface contamination.

Prior to rehabilitation, runoff from areas generating sediment-laden water or mine-affected water is captured within the mine water management system. Dams and other infrastructure within the mine water management system will be assessed for potential contaminants, decommissioned and rehabilitated as part of mine closure. The surface of mine dam rehabilitation areas will be free-draining.

Modelling of flow paths through groundwater particle tracking indicates that groundwater within the tenement, including those areas containing the MIAs, CHPPs, TSFs, rejects landforms and spoil dumps,

will migrate towards the residual voids post-mining. During the initial stabilisation phase of the groundwater and pit lakes, the more dynamic climate-influenced pit lakes (when compared to groundwater) may result in some variability in the flux between groundwaters and pit lakes. Outflows (mainly within the first 20 years post-mining) are predominantly into the spoil dumps, prior to the recovery of groundwater within the spoil. Flow path modelling indicates that these events do not result in the loss of groundwaters beyond the tenement, with groundwaters returning to the residual voids which, once stabilised, will continue to act as sinks post-closure (Sections 3.5.1.1 and 3.5.3).

3.5.1.7.4 Fate of contaminants

Any contamination remaining post-mining that presents an unacceptable risk to the nominated PMLUs, or the receiving environment will be subject to investigation and remediation. Where appropriate, draft Site Management Plans (SMPs) will be prepared in accordance with the requirements of the EP Act. The SMPs will be submitted to the administering authority for consideration where any ongoing management of contamination is required.

3.5.1.7.5 Surface water diversions

BWM has diversions within five watercourses: Deep, Sirius, Taurus, Burngrove, and Rockland creeks, which were designed and constructed to enable mining. These diversions, some of which have multiple diverted reaches (and multiple water licences), will remain at closure.

Each creek diversion has been assessed against the EA watercourse PMLU goals of being safe, stable, non-polluting and self-sustaining. The assessments concluded that diversions in two of the watercourses (Deep and Burngrove creeks), in their current alignments, are expected to progress towards the EA PMLU goals. The diversion details and forward work plan commitments for relinquishment for these creek diversions are summarised in Table 30.

The other three diversions (Sirius, Taurus and Rocklands) require realignment and/or rehabilitation. Diversion concept designs, based on both the DNRME (2019) and ACARP (2014) guidelines, have been developed for these diversions:

- PRCP Concept Design Report - Sirius Creek (Engeny, 2024a) (Appendix 4.9)
- PRCP Concept Design Report - Taurus Creek (Engeny, 2024b) (Appendix 4.10)
- PRCP Concept Design Report - Rockland Creek (Engeny, 2024c) (Appendix 4.11)

The forward work plan commitments for the relinquishment of these creek diversions requiring re-alignment are summarised in

Table 31.

Prior to commencing any creek diversion rehabilitation construction works, all applicable environmental approvals, including those required under the *Water Act 2000* (Qld), will be obtained.

Table 30 Forward work plans for creek diversions retaining their current alignment

Details	Deep Creek	Burngrove Creek
Water licence(s)	609051	40137F
River catchment	Fitzroy River	Fitzroy Basin
Upstream catchment (km^2)	23 km^2	20 km^2
Year of construction	1990s (upstream diversion sub-reach) Hatch, 2001 (downstream diversion sub-reach) Engeny, 2018 (Stage 2 Deep Creek Diversion)	Late 1980s and 2012
Diversion length (km)	Current diversion length – 2.5 km Planned diversion length – 3.4 km	8.7 km
Diversion assessment outcome	Deep Creek diversion at Blackwater Mine currently achieves, or will progress towards achieving, the relevant performance criteria and objectives	Diversion in its existing alignment is meeting or will continue progressing towards achieving the EA watercourse PMLU goals. Therefore, in a closure state, the diversion will remain in its current form.
Operational phase	Will be monitored on a regular basis to maintain and/or improve its existing condition and continue to inform the closure landform.	Will be monitored on a regular basis to maintain and/or improve its existing condition and continue to inform the closure state.
Forward work plan – diversion construction	Construction of the Stage 2 Deep Creek Diversion and associated remedial works within the original diversion reach.	N/A
Forward work plan – infrastructure	Removal of the low-level and haul road crossings, and flood protection levees (Ramps 30S and 34S levees cannot be removed until these ramps have been backfilled). This takes into consideration EA Condition E6, which states that: *The Rehabilitation Management Plan must ensure the final landform adjacent to Deep Creek (Ramp 30S and Ramp 34S) is consistent with the Functional Design Report: Deep Creek Diversion Functional Design Report dated March 2018 (BW02-ENY-7210-RPT-00002) and allows for any future change in watercourse alignment".*	Removal of two access roads- and four rail line crossings Removal and rehabilitation of adjacent haul road and TCP area Removal of the Burngrove Creek Retention Dam.
Forward work plan – final landform	Re-grade, topsoil and revegetate the original diversion batters, and adjacent spoil dumps. (These cannot be undertaken until Ramps 30S and 34S flood protection levees have been removed, aligned to the requirements of EA Condition E6).	N/A

Table 31 Forward work plans for creek diversions requiring realignment and rehabilitation

Details	Sirius Creek	Taurus Creek	Rockland Creek
Water licence(s)	52651F	409112WF	57711WF
River catchment	Fitzroy River	Mackenzie River	Fitzroy River
Upstream catchment (km^2)	100 km^2	2.2 km^2	80 km^2
Year of construction	1977-1978	2001-2002 (approximately)	1993 (assumed)
Diversion length (km)	1.4 km	2.2 km	Approximately 2 km
Diversion assessment outcome	In its current alignment, the diversion is not able to achieve the objectives that are directly related to the EA PMLU requirements. This led to the development of a concept design for the remediation of the current diversion, resulting in an alternative alignment.	The assessment outcome found that the diversion, in its current alignment, is not able to achieve the defined assessment objectives which are directly related to the EA PMLU requirements. This led to the development of a concept design for the remediation of the current diversion, resulting in an alternative alignment.	The diversion in its current state was assessed in the original framework and found to not achieve a relinquishable state. This triggered the need for a remediation concept design of the diversion which will meet the overall relinquishment objectives.
Operational phase	Will be monitored on a regular basis to maintain and/or improve its existing condition and continue to inform the closure landform.	Will be monitored on a regular basis to maintain and/or improve its existing condition and continue to inform the closure landform.	Will be monitored on a regular basis to maintain and/or improve its existing condition and continue to inform the closure landform (see Section 3.7.1.3.9).
Forward work plan – diversion design & rehabilitation	The diversion remediation concept has been designed in accordance with the DNRME hydraulic design criteria for permanent diversions (DNRME, 2019) and presents hydraulic parameters within threshold values for 2-year ARI and 50-year ARI events. The geomorphic features, including stream length and grade, for the remediation concept design were chosen to be similar to the natural pre-mining channel, including vegetation of the natural surrounding ecosystem to meet the DNRME (2019) guideline objectives for permanent watercourse diversions.	Programs for monitoring and revegetation/rehabilitation of the diversion will be maintained throughout the operational phase of the mine	Programs for monitoring and revegetation/rehabilitation of the diversion will be maintained throughout the operational phase of the mine
Forward work plan – infrastructure	Mine infrastructure that interacts with the diversion during operations (Old Cut 4 Dam) and future mine infrastructure will be removed prior to closure.	Mine infrastructure that interacts with the diversion during operations and future mine infrastructure will be removed prior to closure.	As mining progresses in the vicinity of the remediation alignment diversion, the out-of-pit spoil dumps will be progressively reprofiled and regraded to a slope less susceptible to erosion, ensuring a sufficient buffer to the diversion reach. Removal and rehabilitation of adjacent mine infrastructure areas including levees, haul roads and sediment dams.

Details	Sirius Creek	Taurus Creek	Rockland Creek
Forward work plan – final landform	The surrounding landform will be used for potentially ‘grazing’ and ‘woodland’ or similar purposes in closure and allows for hydraulic performance, water quality and a sediment transport regime within the diversion that is representative of the natural watercourse reaches. Programs for monitoring and revegetation/ rehabilitation of the diversion will be maintained throughout the operational phase of the mine.	The surrounding landform will be used for potentially ‘grazing’ and ‘woodland’ or similar purposes in closure and allows for hydraulic performance, water quality and a sediment transport regime within the diversion that is representative of the natural watercourse reaches.	The surrounding landform will be used for potentially ‘grazing’ and ‘woodland’ or similar purposes in closure and allows for hydraulic performance, water quality and a sediment transport regime within the diversion that is representative of the natural watercourse reaches.

3.5.1.7.6 Water storages

There will be no water storage facilities retained at closure.

3.5.1.7.7 On-going water management

On completion of rehabilitation works, ongoing water management/dewatering is not envisaged to be required due to the following:

- The surface of the closure landform, excluding the residual voids, will be free-draining where required
- Contamination will be remediated and/or appropriately managed
- The residual voids will generally continue to act as long-term sinks capturing and containing any groundwater seepage from the site, and will not overtop or interconnect with groundwater aquifers
- Creek diversions will be re-aligned where required and rehabilitated to form a stable landform that allows relinquishment of the water licences.

Relationship with PRCP Schedule
The landform design with residual voids will provide a landscape that does not require any ongoing active water management. The creek diversions will be realigned, where required, and rehabilitated to form a stable watercourse PMLU that allows for the relinquishment of the water licences.

3.5.1.8 Revegetation

PRCP Guideline (Section 3.6.1)

The revegetation plan must propose activities that will establish self-sustaining vegetation communities that are appropriate for the intended PMLU (e.g. natural ecosystems, grazing, forestry and some agricultural and other land uses). Revegetation should, therefore, not only establish a ground cover, but also, in some domains, establish associated fauna habitat and other ecological services.

The rehabilitation planning part must include details of the site preparation required for rehabilitation activities.

3.5.1.8.1 Revegetation objectives

The overall objective of revegetation at BWM is to return previously disturbed land to their intended PMLU by achieving the following:

- Rehabilitated areas are reshaped to support revegetation of plant species known to occur in the region, or on similar landforms and soils;
- Rehabilitated areas are geotechnically safe, stable and non-polluting; and
- Vegetation is self-sustaining after closure and rehabilitation activities are completed.

For the nominated PMLUs specifically, the objectives of revegetation are as follows:

- For the cattle grazing PMLU, the grazing capacity is enhanced after closure and rehabilitation activities are completed;
- For the woodland habitat PMLU, to maximise the self-sustaining capacity of the vegetation through the use of plant species native to the region, on similar landforms, or similar soils, and that are thus adapted to the conditions likely to be experienced within the nominated rehabilitation areas over the long term; and

- For the watercourse PMLU, to maximise the contribution of revegetation to the safe, stable, and sustainable objectives of slope and surface rehabilitation along waterways.

The revegetation objectives and criteria for the PMLUs of cattle grazing, woodland habitat and watercourse are consistent with the rehabilitation requirements of the EA, as transitioned into the BWM PRCP. No infrastructure is proposed to support the revegetation plan.

3.5.1.8.2 Fauna habitat and use requirements

There are no existing obligations to establish fauna habitat and/or fauna use in the rehabilitation areas for BWM. However, areas adjoining undisturbed threatened fauna species habitats will be rehabilitated to a woodland habitat PMLU wherever possible, and disturbed areas of watercourses will be rehabilitated to a watercourse PMLU.

Woodland habitat and watercourse revegetation will provide long-term connectivity values for threatened fauna species, including koalas, squatter pigeons and ornamental snakes (Figure 16).

3.5.1.8.3 Revegetation seed provenance

The provenance is considered important for all species. Seeds will be sourced as locally as possible from natural populations. Although the local provenance boundary locations may differ between species, seed should ideally be obtained from the Brigalow Belt North bioregion.

Proof of provenance will be sought from the seed supplier(s) along with germination and viability certificates for all purchased seeds.

3.5.1.8.4 Cattle grazing revegetation

Areas of cattle grazing are predominately planned for the lower gradient areas disturbed by mining activities, areas that require shallow rooted species and/or areas where there was significant clearing prior to mining (RA2, RA4).

The growth media for cattle grazing will be pre-stripped topsoil, spread over rehabilitated landforms at a depth ≥ 150 mm, and ameliorated if recommended by an AQP (refer to Section 3.5.1.4.3). The recommended revegetation species mix for cattle grazing PMLU is based on seeding native and naturalised exotic species that are preferred, palatable and productive (3P) grasses and legumes cognisant of grazing best management practice (DES, 2022a; Future Beef, 2022). Preferred pasture species have been recommended based on species known to occur on BWM, as well as a selection of pasture species suitable for the soil management group described in Section 3.5.1.4.2 and Appendix 4.3.

A seeding rate of 16 kg/ha of coated pasture seed and 4 kg/ha of uncoated legume seed is recommended for a cattle grazing PMLU (Table 32). All seed mixes will also include 5 kg/ha of Japanese millet *(Echinochloa esculenta*) or similar as a sterile cover crop to protect soils from erosion. The cover crop will establish quickly on the exposed surfaces and work to provide a root system that will stabilise the surface and prevent erosion until new seedlings have been established. The roots will also create pores in the surface to allow water to penetrate the ground, allowing infiltration and reducing overland flow on the surface.

Species availability may vary, however at least four preferred pasture grass species, including two preferred native pasture grasses, and two legumes listed in Table 32 are required. The cattle grazing seed mix composition and seeding rates may be adjusted based on the results of ongoing rehabilitation monitoring. Pasture seed mixes are recommended to be sown in the warmer months of the year from September to March, when the probability of rainfall is highest, thereby assisting germination and sustaining establishment.

No seeding or use of Leucaena (*Leucaena leucocephala*) is proposed at BWM.

Table 32 Recommended species list and seeding rates for cattle grazing

Scientific name	Common name	Cracking clays and heavy loams/clays	Light loams/sands	Seeding rate (kg/ha)
Astrebla lappulacea, A, squarrosa, A. elymoides	Mitchell grasses (curly, bull and hoop)	✓	-	2[c] (per species)
Bothriochloa bladhii	forest blue grass	-	✓	4[c]
*Bothriochloa insculpta cvv. Bisset**	Bisset creeping blue grass	✓	✓	4[c]
*Chloris gayana cvv. Callide**	Callide Rhodes grass	✓	✓	4[c]
*Chloris gayana cvv. Katambora**	Katambora Rhodes grass	✓	✓	4[c]
Dichanthium sericeum subsp. sericeum	Queensland blue grass	✓	-	4[c]
Digitaria brownii	cotton panic	-	✓	2[c]
Heteropogon contortus	black spear grass	✓	✓	2
*Megathyrsus maximus var. pubiglumis**	green panic	-	✓	4[c]
*Panicum coloratum var. makarikariense**	bambatsi Panic	✓	-	4[c]
*Setaria incrassata**	purple pigeon	✓	-	4c
*Urochloa mosambicensis**	Sabi grass	-	✓	4c
Grass species - Total seed weight coated (kg/ha)				**16c**
*Stylosanthes seabrana**	stylo	✓	-	2
*Macroptilium bracteatum**	burgundy bean	✓	-	2
*Stylosanthes hamata**	shrubby stylo	-	✓	2
Chamaecrista rotundifolia	Wynn cassia	-	✓	2
Rhynchosia minima var. minima	rhynchosia	✓	✓	2
Rhynchosia minima var. australis	rhynchosia	✓	✓	2
Legume species - Total seed weight uncoated (kg/ha)				**4**
Echinochloa esculenta	Japanese millet	✓	✓	5 c

*c Assumes seed is coated. If not coated, use half the prescribed rate; * Naturalised exotic pasture species*

3.5.1.8.5 Woodland habitat revegetation

Areas of woodland habitat PMLU are planned on landforms associated with the spoil dumps (RA1) and areas near existing vegetation communities (RA5). The approach to woodland habitat revegetation and the

woodland habitat monitoring method discussed in Section 3.7.1, has strongly considered the following recent OQMRC publications:

- Evaluating native ecosystem rehabilitation options in Queensland (Spain C., Nuske, Gagen, & Purtill, 2023)
- Native ecosystem rehabilitation in Queensland Implications for leading practice (OQMRC, 2023)

Where possible, BWM has aligned its approach to woodland habitat revegetation to achieve characteristics of the surrounding natural historic RE 11.7.2 "*Acacia* spp. woodland on Cainozoic lateritic duricrust. Scarp retreat zone (Queensland Herbarium, 2018)." There is approximately > 1400 ha of RE11.7.2 surrounding the BWM site in particular to the south of the BWM site (Figure 15). Furthermore, several existing areas of historic rehabilitation on BWM south are dominated or co-dominated *Acacia shirleyi* and/or *Acacia catenulata* woodland to low open forest on post-coal mining landforms which strongly aligns with RE11.7.2. It is important to note that seed availability may limit the opportunity for seeding large areas of the woodland habitat aligned to RE11.7.2.

Where woodland habitat aligned to RE11.7.2 is not possible due to seed availability, soils or spoils variability, the remaining areas of woodland habitat have been planned based on a 'hybrid' woodland habitat ecosystem as defined by Spain, Nuske, Gagen and Purtill (2023). This will be achieved through revegetation with key framework tree, shrub and grass species known to occur within representative regional ecosystems within and surrounding the mine site. This approach aims to achieve a 'hybrid' woodland habitat ecosystem with characteristics of both the representative regional ecosystems within and surrounding the mine site, as well as species that are better adapted to the macro climatic (i.e. drought, fire, flooding rains, climate change) and microclimatic factors associated with the final landforms (i.e. growth media, physical and chemical variation, variation in slope, aspect, altitude). The approach to the hybrid woodland habitat revegetation strongly considers the selection of key framework tree, shrub and grass species that are adapted to the growth media and rehabilitation landforms from the following representative regional ecosystems known to occur within or surrounding BWM (Section 3.1.2.9.1) on hilly, rocky terrain and/or substrates with poorer soils that best align with the woodland habitat rehabilitation landforms:

- RE 11.5.3 – *Eucalyptus populnea* and/or *E. melanophloia* and/or *Corymbia clarksoniana* on Cainozoic sand plains and/or remnant surfaces
- RE 11.5.9 *Eucalyptus crebra* and other *Eucalyptus* spp. and *Corymbia* spp. woodland on Cainozoic sand plains and/or remnant surfaces
- For RA5, where the final landform is similar to the pre-mining landform, the rehabilitation should aim to achieve a woodland habitat similar to the surrounding vegetation communities as recommended by an AQP.

The spoil dumps are elevated, sloped anthropogenic landforms comprised of mudstones, claystones, siltstones and sandstones (Section 3.5.1.5). These landforms vary from pre-mining landforms and do not align with any specific land zone under the regional ecosystem framework (Wilson & Taylor, 2012).

As discussed in Section 3.5.1.4, the growth media options for woodland habitat rehabilitation includes pre-stripped topsoil and Permian waste rock (spoil). Woodland habitat growth media will be ameliorated, if recommended by an AQP, prior to deep ripping and seeding (Section 3.5.1.4). The growth media depth will be a minimum of 100 mm. Note if topsoil is to be utilised as a standalone growth media (no mix of fresh Permian spoil), the topsoil depth will be between 100mm to 150mm to limit the effects of competition on woodland species due to the potential loads of exotic pasture species (i.e. buffel grass) (Emmerton et al., 2016a) and to provide the best chance of successful establishment of woody species (Emmerton et al., 2016b; Spargo and Doley, 206).

The woodland habitat revegetation species are known to occur in the representative regional ecosystems based on their listing in the relevant Regional Ecosystem Technical Descriptions (Queensland Herbarium, 2018). The species selection for the woodland habitat revegetation areas has also considered ecological functional groupings according to the role or function they perform in both rehabilitation and non-mined environments (Emmerton et al., 2016a and 2016b) (Table 33). Short-lived Acacia spp. (i.e. wattles) have been excluded from the species mix, with seeds of intermediate lifespan Acacia spp. reduced, and these

species were replaced by increased quantities of key framework tree species and shrubby understorey species to provide longer-term ecosystem resilience, structure and function (Emmerton et al., 2016b). Competitive pasture species have also been excluded from the seed mix and only non-aggressive and native grass species have been recommended (Emmerton et al., 2016b). It is important to note that the woodland habitat seed mix composition and seeding rates may be adjusted based on the results of ongoing woodland habitat rehabilitation monitoring.

Table 33 Life form and functional groups assigned to species based on their structural form or ecological function

Life form and functional group	Code	Explanatory notes
Framework trees		
Eucalypt/ Bloodwood (*Corymbia*) species	E/C	*Eucalyptus*, *Corymbia*, and occasionally *Angophora* species (of any height) which can form an upper storey and often form recognisable vegetation communities but may exist within other communities
Non-eucalypt, non-acacia species	NE/NA	Non-eucalypt, non-wattle species (of any height) which can form recognisable communities, or which may exist in isolation and can become part of the upper storey
Long lived acacias	LLA	Wattle species that may form recognisable communities or exist as part of the upper storey in other communities (e.g. *Acacia shirleyi, Acacia rhodoxylon*)
Woody understory components		
Shrubby understorey	SU	A shrub is defined as a woody plant that is multi-stemmed from the base (or within 200mm from ground level) up to 8 m in height or if single-stemmed, less than 2 m tall (Eyre, et al., 2015). Therefore, an understorey shrub may include species that are sometimes regarded as small trees
Groundcover shrubs	GCS	Shrubs which form a groundcover
Vines/creepers	V/C	Vines or creepers that are perennial and have a woody component
Intermediate lifespan acacias	ILA	Sub-dominant wattles (*Acacia spp*.) which do not form a community in undisturbed natural ecosystems but can become dominant in rehabilitation areas
Short lifespan wattles	SLA	Wattles prevalent as an understorey in eucalypt communities with some level of disturbance and are relatively short lived (≤ 10 years)
Introduced woody perennials	IWP	Introduced woody species potentially becoming weeds in some circumstances
Groundcover components		
Competitive pasture grasses	CPG	Aggressive introduced pasture grass species (considered to detract from ecosystem values)
Introduced grasses	IG	Less competitive naturalised species (less aggressive than the CPG group)
Native grasses	NG	Perennial and annual native grasses. Includes grass-like plants (e.g. genera include: *Cyperus, Dianella* and *Lomandra*)

The recommended woodland habitat revegetation species mix for achieving areas of woodland habitat associated with a natural historic RE11.7.2 dominated or co-dominated by *Acacia shirleyi* and/or *Acacia catenulata* woodland to low open forest on coal mining landforms have been listed in Table 34 along with the associated life form and functional group, preferred growth media and recommended seeding rates.

The *Acacia shirleyi* and/or *Acacia catenulata* woodland to low open forest on coal mining landforms revegetation plan includes 6 kg/ha of framework tree species, 4 kg/ha of woody understory species and 10 kg/ha of grasses. Planting will also include the addition of a sterile cover crop (e.g. Japanese millet or

similar) seeded at least 5 kg/ha to provide initial groundcover. Seed availability may vary; however, seed mixes should ensure that at least four species of framework tree species are included in the mix and at least 4 kg/ha is comprised of *Acacia shirleyi* and *Acacia catenulata*. At least a further five species from the woody understorey species and grasses species listed in Table 34 must also be included and sown at the overall rates to achieve the required species richness.

The recommended woodland habitat species for achieving areas of woodland habitat associated with a hybrid ecosystem have been listed in

Table 35 along with the associated life form and functional group, preferred growth media and recommended seeding rates.

The woodland habitat revegetation plan includes 6 kg/ha of framework tree species, 4 kg/ha of woody understory species and 10 kg/ha of grasses. Planting will also include the addition of a sterile cover crop (e.g. Japanese millet or similar) seeded at least 5 kg/ha to provide initial groundcover. Seed availability may vary; however, seed mixes should ensure that at least six species from each of the main revegetation groups listed in

Table 35, including framework tree species, woody understorey species and grasses, are sown at the overall recommended rate to achieve the required species richness.

For RA5, rehabilitation should aim to achieve woodland habitat similar to the surrounding vegetation communities. The revegetation seed mix for RA5 is to be recommended by an AQP based on the location of the rehabilitation in relation to the surrounding vegetation community and should consider the species and the rates listed in Table 34 or

Table 35.

Revegetation species and rates for woodland habitat may be adjusted by an AQP, to ensure continuous improvement of the rehabilitation outcomes, based on the results of ongoing monitoring (Section 3.7).

The preferred seeding timing for woodland habitat is either April/May or September/early October when there is sufficient soil moisture in the profile. Sowing in cooler months offers longer periods of surface moisture resulting from rain events, as well as reduced grass competition. Seeding may be undertaken at other opportune times, such as for unseasonal climatic conditions.

Table 34 Recommended species list and seeding rates for woodland habitat Acacia shirleyi and/or Acacia catenulata woodland to low woodland to low open forest tree canopy on coal mining landforms (RE 11.7.2 mix)

Species name	Common name	Life form and functional group code	Cracking clays and heavy loams/clays	Light loams/ sands	Seed rates (kg/ha)
Acacia catenulata	bendee	LLA	✓	✓	1-2
Acacia shirleyi	lancewood	LLA	✓	✓	3-4
Acacia rhodoxylon	rosewood	LLA	✓	✓	0.3-0.5
Alphitonia excelsa	red ash	NE/NA	✓	✓	0.3-0.5
Angophora leiocarpa	smooth barked apple	E/C	-	✓	0.3-0.5
*Corymbia citriodora subsp. citriodora**	lemon scented gum	E/C	✓	✓	0.3-0.5
Corymbia clarksoniana	Clarkson's bloodwood	E/C	✓	✓	0.3-0.5
Corymbia dallachiana	Dallachy's gum	E/C	✓	✓	0.3-0.5
Eucalyptus crebra	narrow leaved ironbark	E/C	✓	✓	0.3-0.5
Eucalyptus exserta	Queensland peppermint	E/C	-	✓	0.3-0.5

Species name	Common name	Life form and functional group code	Cracking clays and heavy loams/clays	Light loams/ sands	Seed rates (kg/ha)
Framework tree species - total seed weight uncoated (kg/ha)					6
Alstonia constricta	bitterbark	SU/NE/NA	✓	✓	0.3-0.5
Breynia oblongifolia	*coffee bush*	*SU*	✓	✓	0.3-0.5
Capparis lasiantha, C. canescens, C. loranthifolia.	wait-a-while	V/C	✓	✓	0.2-0.5
Carissa ovata	currant bush	GCS	✓	✓	0.3-1
*Cassia brewsteri**	Leichhardt bean	SU	✓	✓	0.3-0.5
Eremophila mitchellii	false sandalwood	SU/NE/NA	✓	✓	0.3-0.5
Erythroxylon australe	cocaine tree	SU	✓	✓	0.2-0.5
Geijera parvifolia	wilga	SU/NE/NA	-	✓	0.3-0.5
Hakea lorea	bootlace oak	SU/NE/NA	✓	✓	0.3-0.5
Petalostigma pubescens	quinine	SU/NE/NA	✓	✓	0.3-0.5
Woody understory species - total seed weight uncoated (kg/ha)					4
Aristida spp. (i.e. A. calycina, A. latifolia, A. ramosa, A. caput-medusae, A. jerichoensis, A. personata, A. calycina)	three awned spear grass	NG	-	✓	1-2
Chrysopogon fallax	golden beard grass	NG	✓	✓	2-3
*Cynodon dactylon var. dactylon**	couch	IG	✓	✓	2-3
Entolasia stricta	Wiry panic	NG	▤	✓	2-3
Panicum effusum	hairy panic	NG	✓	✓	2-3
Panicum decompositum	Native millet	NG	-	✓	2-3
Paspalidium distans	shot grass	NG	-	✓	2-3
Grass species - total seed weight uncoated (kg/ha)					10
Echinochloa esculenta	Japanese millet	Cover crop	✓	✓	5

*Species adapted to moderate to high salinity tolerance (DERM, 2011)

Table 35 Recommended species list and seeding rates for woodland habitat associated with a hybrid ecosystem (RE 11.5.3/RE 11.5.9)

Species name	Common name	Life form and functional group code	Cracking clays & heavy loams/ clays	Light loams/ sands	Seed rates (kg/ha)
Acacia rhodoxylon	rosewood	LLA	-	✓	0.3-1
Alphitonia excelsa	red ash	NE/NA	✓	✓	0.3-0.5
Angophora leiocarpa	smooth-barked apple	E/C	-	✓	0.3-0.5
Atalaya hemiglauca	whitewood	NE/NA	✓	✓	0.3-0.5

Species name	Common name	Life form and functional group code	Cracking clays & heavy loams/ clays	Light loams/ sands	Seed rates (kg/ha)
Corymbia clarksoniana	Clarkson's bloodwood	E/C	✓	✓	0.3-1
Corymbia dallachiana	Dallachy's gum	E/C	✓	✓	0.3-0.5
Corymbia erythrophloia	red bloodwood	E/C	✓	✓	0.3-1
Eucalyptus crebra	narrow-leaved ironbark	E/C	✓	✓	0.6-2
Eucalyptus melanophloia	silver leaved ironbark	E/C	✓	✓	0.3-1
Eucalyptus populnea	poplar box	E/C	✓	✓	0.3-0.5
Lysiphyllum carronii	red bauhinia	NE/NA	✓	✓	0.3-0.5
Lysiphyllum hookeri	white bauhinia	NE/NA	✓	✓	0.2-0.5
Terminalia oblongata	yellowwood	NE/NA	✓	✓	0.2-0.5
Framework tree species - total seed weight uncoated (kg/ha)					6
Acacia excelsa	ironwood wattle	LLA	✓	✓	0.3-0.5
Acacia conferta	crowded-leaf wattle	ILA	-	✓	0.3-0.5
Acacia sericophylla	desert oak	ILA	-	✓	0.3-0.5
Breynia oblongifolia	coffee bush	SU	X	X	0.3-0.5
Capparis lasiantha, C. canescens, C. loranthifolia.	wait-a-while	V/C	✓	✓	0.2-0.5
Carissa ovata	currant bush	GCS	✓	✓	0.3-1
*Cassia brewsteri**	Leichhardt bean	SU	✓	✓	0.3-0.5
*Dodonaea viscosa**	sticky hop bush	SU	✓	✓	0.3-0.5
Eremophila mitchellii	false sandalwood	SU/NE/NA	✓	✓	0.3-0.5
Erythroxylon australe	cocaine tree	SU	✓	✓	0.2-0.5
Geijera parvifolia	wilga	SU	✓	✓	0.2-0.5
Grevillea striata	beefwood	SU/NE/NA	-	✓	0.3-0.5
Grewia latifolia	dogs balls	SU	✓	✓	0.3-0.5
Hakea lorea	bootlace oak	SU/NE/NA	✓	✓	0.3-0.5
Jasminum didymum	native jasmine	V/C	✓	✓	0.3-0.5
Petalostigma pubescens	quinine	SU/NE/NA	✓	✓	0.3-0.5
Pittosporum angustifolium	Gumby Gumby	SU/NE/NA	X	X	0.3-0.5
Senna artemisioides	silver cassia	SU	✓	✓	0.3-0.5
Woody understory species - total seed weight uncoated (kg/ha)					4

Species name	Common name	Life form and functional group code	Cracking clays & heavy loams/ clays	Light loams/ sands	Seed rates (kg/ha)
Aristida spp. (i.e. A. calycina, A. latifolia, A. ramosa, A. caput-medusae, A. jerichoensis, A. personata, A. calycina)	three awned spear grass	NG	-	✓	1-2
Bothriochloa decipiens var. decipiens	pitted blue grass	NG	✓	✓	1-2
Bothriochloa bladhii	forest blue grass	NG	✓	✓	1-2
Bothriochloa ewartiana	desert bluegrass	NG	✓	✓	1-2
Chrysopogon fallax	golden beard grass	NG	✓	✓	1-2
Cymbopogon refractus	barbwire grass	NG	✓	✓	1-2
*Cynodon dactylon var. dactylon**	couch	IG	✓	✓	1-2
Panicum effusum	hairy panic	NG	✓	✓	1-2
Panicum queenslandicum	Yabila grass	NG	✓	✓	1-2
Themeda triandra	kangaroo grass	NG	✓	✓	1-2
Grass species - total seed weight uncoated (kg/ha)					10
Echinochloa esculenta	Japanese millet	Cover crop	✓	✓	5

*Species adapted to moderate to high salinity tolerance (DERM, 2011)

3.5.1.8.6 Watercourse revegetation

Watercourse revegetation activities will be implemented to establish riparian vegetation associated with a watercourse PMLU for the following areas:

- Future creek diversions.
- Existing creek diversions requiring additional revegetation activities.
- Natural watercourses that have been disturbed by mining activities.

Existing creek diversions that have previously been revegetated are discussed in Section 3.5.1.7.5 and will be monitored to inform routine maintenance requirements (Section 3.7.1.3.7).

The revegetation zones for natural watercourses (Figure 45) are defined as follows:

- Upper bank: defines the lateral limits of both sides of the watercourse or diversion. It does not include the land adjacent. The upper bank generally extends down the riparian profile and is dominated by taller *Eucalyptus spp*, with a mixed woody and grassy understorey.
- Mid bank: occurs between the upper and lower banks and will vary in size depending on the watercourse geomorphology or diversion design. The mid bank may include benches created from high flow events. The vegetation on the mid bank comprises a mix of species including scattered *Eucalyptus spp.*, as well as species that are more adapted to periodic inundation of water and can withstand some disturbance from floods (i.e. *Melaleuca spp*).

- Lower bank (including bank toe) commences at the edge of the low flow channel or stream bed and extends up the bank to the area affected by more regular lower flows. The vegetation in the lower bank is dominated by scattered trees adapted to wetter environments (i.e. Melaleuca spp) and a high ground cover of grasses, reeds, sedges and rushes.

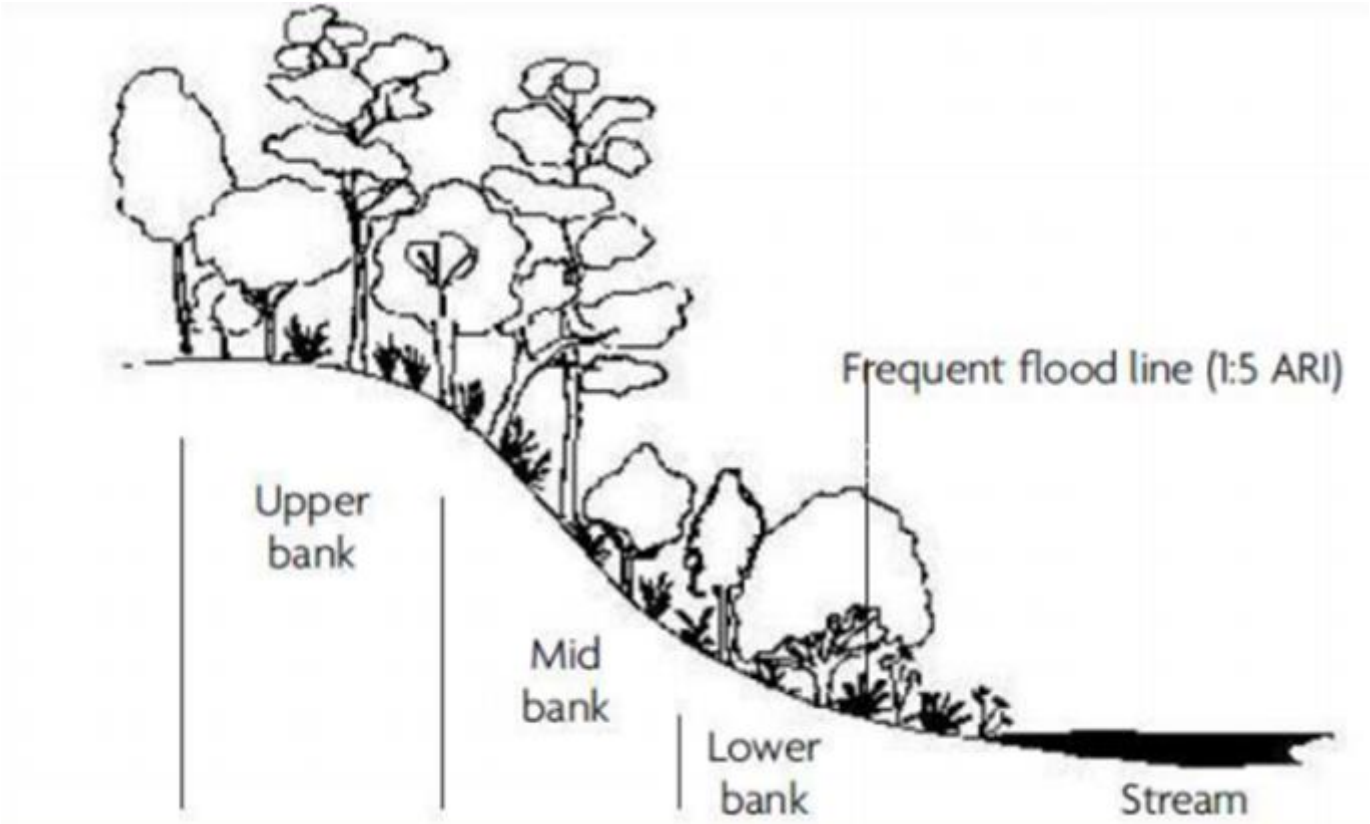

Figure 45 Typical riparian revegetation plantings zone (Vegetation Matters, 2014)

Growth media for watercourses will be pre-stripped topsoil, spread over rehabilitated landforms at a depth ≥ 150 mm, and ameliorated if recommended by an AQP (refer to Section 3.5.1.4).

The watercourse revegetation species are based on selecting framework trees, woody understorey and groundcover species associated with the predominant natural watercourse RE 11.3.25 occurring on the BWM site (Figure 15).

The recommended watercourse revegetation species and seeding rates are listed in Table 36 and Table 37. The planned seeding rate for upper and mid banks is 20 kg/ha comprised of 6 kg/ha uncoated framework tree, 4 kg/ha uncoated woody understorey species and 10 kg/ha uncoated grasses and other groundcover species.

The planned seeding rate for lower banks is 15 kg/ha comprised of 5 kg/ha uncoated framework tree and 10 kg/ha uncoated ground species. The revegetation on the lower banks has been designed to establish a higher percentage of ground cover species, including grasses and rushes. Competitive pasture species have been excluded from the seed mix and only non-aggressive grass species are recommended. Short-lived wattle species have also been excluded from the seed mix.

Planting in all revegetation zones will also include the addition of a sterile cover crop (e.g. Japanese millet or similar) seeded at 5 kg/ha.

The preferred seeding timing for watercourse revegetation is August to October. There is a low chance of frost and less likelihood of significant rainfall in this period allowing the best opportunity for vegetation to establish in a relatively non-erosive period.

Table 36 Recommended species list and seeding rates for watercourse revegetation – upper and mid banks

Species name	Common name	Life form and functional group code	Seed rate (kg/ha - uncoated weight)
*Acacia stenophylla**	river myall	LLA	0.5 - 1
Alphitonia excelsa	red ash	NE/NA	0.5 - 1
Angophora floribunda	rough barked apple	E/C	0.5 - 1
Angophora leiocarpa	smooth barked apple	E/C	0.5 - 1
Angophora subvelutina	broadleaf apple	E/C	0.5 - 1
*Casuarina cristata**	belah	E/C	0.5 - 1
*Casuarina cunninghamiana**	river she oak	NE/NA	0.5 - 1
*Corymbia tessellaris**	Moreton Bay ash	NE/NA	0.5 - 1
*Eucalyptus camaldulensis subsp. obtusa**	river red gum	E/C	1 - 2
Eucalyptus coolabah subsp. coolabah	Coolabah	E/C	1 - 2
Eucalyptus melanophloia	silver leaved ironbark	E/C	0.5 - 1
Eucalyptus populnea	poplar box	E/C	0.5 - 1
*Eucalyptus tereticornis subsp. tereticornis**	Queensland blue gum	E/C	0.5 - 1
Lysiphyllum hookeri	white bauhinia	NE/NA	0.5 - 1
*Melaleuca bracteata**	black tea tree	NE/NA	0.5 - 1
Terminalia oblongata	yellowwood	NE/NA	0.5 - 1
Framework tree species - total seed weight uncoated (kg/ha)			**6**
Carissa ovata	current bush	GCS	0.5 - 1
Acacia excelsa	ironwood wattle	ILA	0.5 - 1
Acacia fasciculifera	scaly bark	ILA	0.5 - 1
*Cassia brewsteri**	Leichardt bean	SU	0.5 - 1
Dodonaea viscosa	sticky hop bush	SU	0.5 - 1
Eremophila mitchellii	false sandalwood	SU	0.5 - 1
Erythroxylum australe	cocaine tree	SU	0.5 - 1

Species name	Common name	Life form and functional group code	Seed rate (kg/ha - uncoated weight)
Ficus coronata	creek sandpaper fig	SU	0.5 - 1
Ficus fraseri	white sandpaper fig	SU	0.5 - 1
Ficus opposita	sandpaper fig	SU	0.5 - 1
Grevillea striata	beefwood	SU	0.5 - 1
Grewia latifolia	dogs balls	SU	0.5 - 1
Hakea lorea	bootlace oak	SU	0.5 - 1
Mallotus philippensis	red kamala	SU	0.5 - 1
Petalostigma pubescens	quinine	SU	0.5 - 1
Woody understorey species - total seed weight uncoated (kg/ha)			**4**
Cymbopogon refractus	barbwire grass	NG	1-2
Bothriochloa bladhii	forest blue grass	NG	1-2
Capillipedium spicigerum	scented top	NG	0.2 - 0.5
*Cynodon dactylon**	couch	IG	2
Dichanthium sericeum subsp. sericeum	Queensland bluegrass	NG	1-2
Digitaria brownii	cotton panic	NG	1-2
Eulalia aurea	silky brown top	NG	1-2
Eustrephus latifolius	wombat vine	V/C	0.5-1
Heteropogon contortus	bunched speargrass	NG	1-2
Jasminum simplicifolium subsp. australiense	stiff jasmine	V/C	1-2
Lomandra longifolia	mat rush	NG	1-2
Panicum effusum	hairy panic	NG	1-2
Paspalidium distans	shot grass	NG	1-2
Rhynchosia minima	Rhynchosia	V/C	1-2
Themeda triandra	kangaroo grass	NG	1-2
Ground species - total seed uncoated (kg/ha)			**10**
Echinochloa esculenta	Japanese millet	Cover crop	5

** Species adapted to moderate to high salinity tolerance (DERM, 2011)*

Table 37 Recommended species list and seeding rates for watercourse revegetation – lower banks

Species name	Common name	Life form and functional group code	Seed rate (kg/ha - uncoated weight)
*Casuarina cunninghamiana**	river she oak	NE/NA	0.5-1
*Melaleuca bracteata**	black tea tree	NE/NA	0.5-1
Melaleuca fluviatilis	weeping tea-tree	NE/NA	0.5-1
*Melaleuca linariifolia**	snow in summer	NE/NA	0.5-1
*Melaleuca leucadendra**	broad-leaved tea tree	NE/NA	0.5-1
*Melaleuca viminalis**	red bottlebrush	NE/NA	0.5-1
Melaleuca trichostachya	flax-leaf paperbark	NE/NA	0.5-1
Lophostemon suaveolens	swamp box	NE/NA	0.5-1
Framework tree species - total seed weight uncoated (kg/ha)			**5**
Cymbopogon refractus	barbwire grass	NG	0.5-1
Dichanthium sericeum subsp. sericeum	Queensland bluegrass	NG	1-2
Themeda triandra	kangaroo grass	NG	0.5-1
Bothriochloa bladhii subsp. bladhii	forest blue grass	NG	1-2
Lomandra longifolia	spiny-headed mat rush	NG	2-3
Eustrephus latifolius	wombat vine	V/C	0.5-1
*Cyperus spp. (C. gracilis, C. polystachyos)***	sedge	NG	2-3
*Cynodon dactylon**	couch	IG	2-3
Ground species - total seed weight uncoated (kg/ha)			**10**
Echinochloa esculenta	Japanese millet	Cover crop	5

** Species adapted to moderate to high salinity tolerance (DERM, 2011) ** Bank toe area only*

Relationship with PRCP Schedule
The revegetation approach for the PMLUs focuses on the selection and establishment of suitable species based on the growth media and rehabilitated landforms. Woodland habitat and watercourse rehabilitation strongly consider the inclusion of framework tree species, woody understorey and grass species from regional ecosystems occurring within or surrounding BWM on similar landforms and substrates. The recommended species will best support achievement of the cattle grazing, woodland habitat and watercourse PMLUs' revegetation objectives.

3.5.2 Tailings storage facilities

PRCP Guideline (Section 3.6.2)

The tailings require characterisation to determine the geochemistry, rheology and geotechnical parameters that influence the rehabilitation or management strategies and the capacity of the site to support revegetation.

The design for a TSF must include the relevant elements:

- *lining of TSF (i.e. embankments and base of structure)*
- *leak detection systems*
- *cellular design of TSF*
- *seepage collection systems*
- *design storage allowance*
- *spillway location*
- *designing TSF for progressive rehabilitation.*

3.5.2.1 Tailings context

The purpose of a CHPP is to improve the quality of Run-of-Mine (ROM) coal to meet particular product coal specifications. Some of the processes used to achieve this generate fine-grained residue, called tailings, mixed with water. Coal tailings typically consist of sand, silt and clay-sized fragments of rock and coal. Tailings are commonly disposed of by pumping as slurry to permanent storage facilities, which are either earth-embankment dams or in-ground mining voids. Some newer CHPPs produce tailings paste or filter cake instead of slurries but it is often not practical or economical to retrofit such processes to an existing CHPP.

Prior to 2000, the current Blackwater Mine was two separately owned and operated mines. Consequently, there were two CHPPs, SCPP in the south which ceased processing coal in 2008 and NCPP which is now the processing plant for all ROM coal. As of 2024, about 6% of ROM coal reports as tailings, which is about 0.8 Mtpa.

There are six TSFs at BWM, as shown in Figure 46. Laleham, Ramp 72, Ramp 74 and Bottom Dam received tailings from the SCPP and are currently inactive. NCPP and Bonnie Doon are the current active storage facilities.

In the future, tailings may be further used to backfill mined-out voids at BWM as per EA condition D6. This would help decrease the NUMA extent (Section 3.4.4). If this occurs, tailings placement and management procedures will follow the same procedures as existing TSFs (Section 3.5.2.3).

Key aspects of the TSFs are provided in Table 38. All the TSFs in the southern part of the mine were commissioned while the operation was under different ownership and management. In general, they appear to have met accepted practice at that time but there is little documentation. NCPP and Bonnie Doon TSFs have more comprehensive design documentation and reflect recent improvements in storage practice. In particular, the operational plan for Bonnie Doon has recently been amended to facilitate planned rehabilitation.

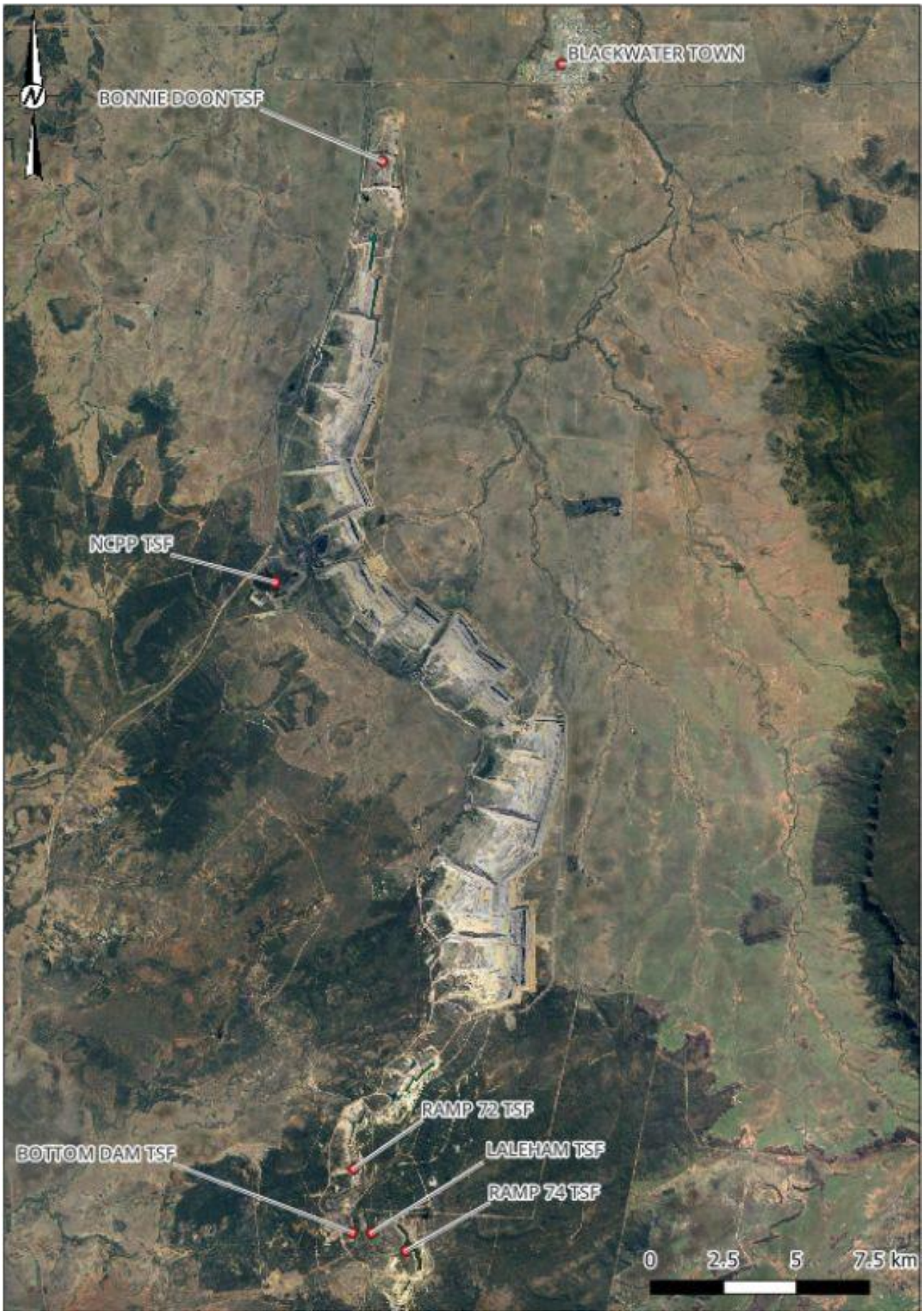

Figure 46 Locations of BWM TSFs

Table 38 Summary of BWM TSFs

TSF name	Storage capacity	Type	Status	Tailings depth (m)	Lining	Spillway location	Cellular design	Design storage allowance	Leak detection	Seepage collection	Progressive rehabilitation
NCPP	~26,000 ML (full capacity)	Downslope embankment	Active (emergency use)	32	Natural foundation	South-west	Single cell	Not required	By observation and groundwater bore monitoring	Pond at eastern toe	May commence after becoming inactive
Ramp 72	~6,000 ML (current capacity)	In-pit	Inactive	~40	Pit walls	West, near top of ramp	Single cell	1:20 AEP 116 ML		Blanket drain in embankment	Not feasible; will receive spoil from future mining
Ramp 74	5,470 ML (current capacity)	In-pit	Inactive TSF and active water handling	32	Pit walls	Ramp at west	Single cell	1:20 AEP 1,644 ML		N/A (no seepage identified)	May commence when no longer required for water storage
Laleham	2.24 ML (up to spillway invert)	In-pit and hillside embankment	Inactive	9 (in aboveground cell)	Pit walls and natural foundation	East	Two cells	Not required		N/A (no seepage identified)	Has commenced
Bonnie Doon	~14,600 ML (design full capacity)	In-pit	Active	60	Pit walls	North-west, on natural ground	Single cell	Not required		Dewatering bored will be installed if necessary	Not feasible until tailings deposition ceases
Bottom Dam	N/A	Hillside embankment	Inactive	15	Natural foundation	Pipe culvert to Duck Pond to east	Single cell	Not assigned		N/A (no seepage identified)	Can commence when ROM3 coarse rejects are re-handled

3.5.2.1.1 NCPP TSF

NCPP is an active above-ground (turkey's nest) TSF located at the west and south-west (upslope) of the NCPP and rail loop and bounded by a minor public road at the north-west. The TSF is approximately 1.4 km long and 1.7 km wide, with a footprint of about 198 ha. Depth of tailings ranges up to 32 m. The deposited tailings beach down to a decant pond inside the southern wall of the dam.

The original tailings dam commenced in 1970 and comprised a single earth fill embankment across Deep Creek. The facility has been raised and extended in various stages since then, with downstream and upstream wall lifts constructed of earth fill and, in recent decades, mainly coarse rejects. A final small raise was constructed in 2022, and active tailings deposition ceased in 2023. However, the facility remains available for emergency disposal.

The final landform design for the TSF is a stand-alone elevated landform surrounded by undisturbed and rehabilitated land at pre-mining elevation. The following influence rehabilitation considerations for the facility:

Prior to mining and outside the area of mine disturbance, the dominant land use has been low-intensity grazing.

Footprint constraints, including rail loop to the north, NCPP and MIA to the east, and the ML boundary (with a minor public road and rail line) immediately to the west.

The Deep Creek diversion is located about 300 m south of NCPP TSF, with the creek channel flowing north to within about 60 m of the eastern wall toe before flowing eastward through a culvert under the main mine haul road.

Regulated vegetation (endangered regional ecosystem comprising acacia-dominated open forest, woodland or shrublands) is mapped to the south-west of the TSF; regulated vegetation (riverine) is mapped along Deep Creek.

Geology mapped for the footprint of NCPP TSF is regolith weathered from the Burngrove Formation that stratigraphically underlies the Rangal Coal Measures, with a small area of cemented Tertiary sediment along the western edge. Given this context, the NCPP TSF is unlikely to be hydraulically connected to any significant aquifers.

3.5.2.1.2 Ramp 72 TSF

Ramp 72 TSF is an inactive in-pit (with saddle dam) tailings and coarse rejects storage facility located just north of the TLO into South Blackwater. The pit section of the facility is about 950 m long and 150 m wide, while the ramp section is about 650 m long with a width opening from 50 m at the top of the ramp to 160 m where it joins the pit. The depth of tailings ranges from a couple of metres at the top of the ramp to about 40 m in-pit, and the coarse rejects in the southern end are about 16 m thick over the tailings.

Ramp 72 TSF was mined before 1985. Tailings were discharged to the pit from the early 1990s until December 2001. During this time, a 4 m high embankment was constructed at the top (western end) of the ramp to contain the decant pond as the tailings level rose slightly above natural ground level and the decant drained to that end of the ramp. Coarse rejects were dumped into the southern end of the pit over the tailings from about 200 until they reached a couple of metres below pre-mining ground level. In 2010, the embankment was raised 6 m to better contain rainfall runoff from the pit and surrounding catchment. Currently, the tailings and rejects are mainly below ground level, with rainfall and runoff intermittently stored over the wastes behind the above-ground embankment.

The BWM final closure landform involves burying Ramp 72 TSF under a new spoil dump generated from the mining down-dip (east) of the previous pit. The depth of spoil over SCPP waste will range from at least 5 m at the top of the ramp to more than 100 m at the current high wall. The closest residual void (Kenmare) will be about 1.2 km east of Ramp 72 TSF. The following influence rehabilitation considerations for the facility:

- Prior to mining the land use was mainly low-intensity grazing.

- Footprint constraints, including the rail line at the south, a mine access/haul road at the west, other mine voids at the north and presently, highwall spoil at the east. (As mentioned above, at closure the Kenmare new residual void will be located further east, with in-pit spoil dumped in between). The southern rail loop is about 1 km to the south-west with an old mine building and the SCPP at the eastern side of the loop.
- In this part of the mine, the pre-mining ground surface and its watercourses drain from east to west, and a natural drainage line flows from the top of the ramp into Sirius Creek which is approximately 4 km downstream, to the south-west. That drainage line is mapped as regulated vegetation (endangered regional ecosystem comprising remnant acacia-dominated woodland to open forest on gilgai clay plains).

Geology mapped for the footprint of Ramp 72 TSF is cemented Tertiary sediment (duricrust) on deeply weathered regolith. The planned future mining will remove Tertiary and Permian overburden down to the coal floor; consequently, any seepage from Ramp 72 TSF would be eastward through in-pit spoil to the Kenmare residual void.

3.5.2.1.3 Ramp 74 TSF

Ramp 74 is an inactive in-pit TSF, within Laleham Pit, with no above-ground storage. The pit was mined prior to 2001. The northern half of the pit is aligned roughly north-west to south-east while the southern part is nearly north to south. The northern end-wall is about 1.8 km south-west of the SCPP, with various small mine-affected water dams and Laleham TSF in between.

Ramp 74 TSF is about 1.9 km long and has a footprint of about 41 ha. It is estimated that the depth of tailings varies from about 24 m in the south to 32 m in the north. The beach angle of the tailings is approximately 0.6%.

From December 2001 until 2008, tailings were discharged from the northern end-wall and allowed to beach down toward the southern end. Based on the site geological model, the tailings surface is below the base of weathering except at the location of the pre-mining alignment of Sirius Creek, and it is more than 10 m below spill level. Since tailings deposition ceased, the pit has at times been used to store excess mine-affected water.

The BWM EA Condition D6 allows for tailings disposal in pits or voids. Furthermore, the EA – as the site LOD, supports the retention of residual voids as NUMAs. Hence, the proposed closure outcome for Ramp 74 TSF is a NUMA (Laleham residual void). Although rehabilitation measures are not required for a NUMA, the following have been considered for conceptualisation of management milestones:

- Prior to mining, the dominant regional land use was low-intensity grazing.
- The facility is not located in close proximity to any third-party infrastructure; a power line easement to the SCPP that passes about 0.4 km north of the northern end-wall is the only key structure. Unmined ground east of the highwall slopes gently toward the pit.
- Prior to mining, Sirius Creek flowed east-to-west across the southern area of the pit. The Sirius Creek diversion was constructed around the southern end-wall. An upgraded creek diversion and associated flood protection structures have been designed but the alignment near Ramp 74 TSF will not change greatly.
- A significant area of land east of the highwall is uncleared woodland mapped as MSES-regulated vegetation (Category B – endangered) comprising sub-dominant shrubby open forest. A smaller area about 1 km south of the TSF (on the other side of Sirius Creek is mapped as high ecological significance wetlands comprising dominant endangered open forest.

The site geological model shows typically a 10-20 m depth of Tertiary Quaternary soil and rock overlying weathered Permian rock with unweathered Permian Rangal Coal Measures generally 20-25 m below pre-mining ground level. The exception is at the original channel of Sirius Creek, where the depth of weathering increases to about 35 m.

The tailings surface is more than 10 m below surrounding ground level and more than 5 million cubic meters (MCM) of spoil would be required to completely backfill the void. No further mining is planned in the vicinity. The spoil that was produced from the Ramp 74 pit has been rehabilitated up to the low-wall and re-handling from that source would have a negative environmental outcome.

3.5.2.1.4 Bonnie Doon TSF

Boonie Doon is an active in-pit TSF located at the northern end of BWM's current mining operations (within Bonnie Doon Pit). The TSF comprises four straight pit sections connected by two ramps (R10 and R12). The TSF is 2.7 km long and has a footprint of about 42 ha. When filled, the depth of tailings will range from about 25 m in the north to 60 m at the southern end. The location of tailings discharge and the decant pond may change throughout the operational life but by closure, the tailings surface will drain toward the north with a beach slope in the order of 1-1.5%.

The lowest part of the mined pit floor is RL119 m. Tailings deposition commenced in December 2023 and will continue until the tailings reach RL160 m just north of Ramp 10, beaching down from about RL179 m at the southern end of the pit. The maximum tailings elevation was reduced from the level specified in the initial design plan, to keep the operating tailings and decant pond levels below the base of weathering exposed in the highwall (ranging from RL172 m to RL185 m), and to ensure that the storage facility remains a post-closure groundwater sink.

Similarly to Ramp 74 TSF, the proposed closure outcome for Bonnie Doon TSF is a NUMA (Bonnie Doon residual void). Although rehabilitation measures are not required for a NUMA, the following have been considered for conceptualisation of management milestones:

- Prior to mining, the dominant land use was low-intensity grazing.
- There are no notable footprint constraints for the facility. The northern end of the TSF is about 1.5 km south of the Capricorn Highway and 5 km south-west of the town of Blackwater. The two pit ramps run about 1 km down from the main mine access road to the west and the mine's rail line is at the western side of the road.
- Sagittarius Creek is located about 3.7 km east of the TSF highwalls and flows northward. Several unnamed gullies (that are defined drainage features under the *Water Act 2000* (Qld)) collect overland flow from the area east of the TSF and feed it into the creek.
- Regulated vegetation (Category R – GBR riverine) is mapped along the upslope ends of some of those drainage features but there are no other Matters of State Environmental Significance near the TSF.

Geology mapped for the footprint of Boonie Doon TSF shows that most of the highwall edging into the Triassic Rewan Formation overburden overlies the mined Permian Rangal Formation. The exception is at the northern end, where Quaternary alluvium comprising sheetwash and flood-out sheets is mapped. Hence, Bonnie Doon TSF, like all pits mined at Blackwater, intersects the unmined portions of coal seam aquifers but may also contact shallow local aquifer(s) in the surface alluvium.

The final tailings surface will be 20-40 m below surrounding ground level. Within the current life-of-mine plan, there will not be mining close to Bonnie Doon Pit when the TSF is undergoing closure; hence, no close-haul spoil will be produced at the time. Much of the spoil that was produced by mining Bonnie Doon Pit is already under rehabilitation, so re-handling enough of that spoil to fill the TSF to ground level would be counterproductive and costly.

3.5.2.1.5 Bottom Dam TSF (and ROM 3 Area Rejects)

The ROM 3 Area coarse rejects dump is located against an east-facing natural slope about 0.7 km south of the SCPP. The dump batter is at angle of repose and about 38 m high; the flat top ranges up to 120 m wide and the total footprint is 5.5 ha.

Bottom Dam TSF abuts the eastern toe of the rejects dump. It is bound by sloping ground at the north, a 6 m high earth fill embankment at the east and a spoil dump at the south. The footprint of Bottom Dam TSF is 3.2 ha. Geotechnical drilling suggests that the storage is up to 15 m deep.

Bottom Dam was originally a process water storage forming part of the SCPP water management system, which was in use in the 1970s and 1980s. It received overflow from No.1 Dam (upslope to the north) and then through a culvert to Duck Pond at the east. The TSF also received coal fines and other sediment washed in from No.1 Dam and the rejects dump, but it was not designated as a TSF until after 2012.

The tailings surface is close to the embankment crest level and is relatively flat except for a small sump around the culvert to Duck Pond. Scrubby mid-storey has established over more than half of the tailings surface. Recent geotechnical investigation showed a desiccated surface crust typically 1-2 m thick.

For the final closure landform, it is planned to push the rejects down over the tailings to create a slope abutting the Tertiary ridge with runoff draining freely to the south and south-east. The following influence rehabilitation considerations for the facility:

- Prior to mining the dominant land use on the mining lease was low-intensity grazing, with significant areas of uncleared woodland.
- Some of the woodland habitat remains in the vicinity of ROM3 Area/Bottom Dam TSF and is mapped as Category B regulated vegetation (endangered and of-concern eucalyptus woodland to open forest).

The combined Waste Storage Facility (WSF) is in the middle of the South Blackwater MIA, with the ROM 3 Area and the SCPP on natural high ground to the west and north respectively. Other mine dams are located immediately to the east, adjacent to the Laleham TSF, with a spoil dump immediately to the south. Natural ground drains to the south-east, towards Sirius Creek.

Geology mapped for the footprint of the TSF is Emerald Formation Tertiary weathered siltstone and claystone; the ridge to the west and north has Tertiary duricrust, and Sirius Creek runs through regolith of Permian Burngrove formation. Hence, the TSF is unlikely to have a direct hydrogeologic connection with Sirius Creek.

3.5.2.1.6 Laleham TSF

Laleham is an inactive TSF with in-pit and above-ground sections, the latter being formed by embankments across a hillslope. It is located about 1.2 km south-east of the SCPP.

The in-pit section was present in 1984, while the embankment was under construction roughly at the same time. The tailings surface was capped with clayey spoil by the end of 1994; however, the exposed (downstream) embankment slope has not been structurally modified since its original construction.

The TSF is approximately 0.4 km long and 0.6 km wide, with a footprint of about 13 ha. The depth of tailings in the in-pit section is not known but the main embankment is about 10 m high. The capped surfaces are generally flat, except for a depression at the eastern side of the above-ground section that was likely caused by tailings consolidation.

The final closure landform is planned to re-handle spoil from some of the smaller nearby dumps to cover the TSF and create a broad mound abutting the natural sandstone ridge, draining south to Sirius Creek. The following influence rehabilitation considerations for the facility:

- Prior to mining, the dominant land use was low-intensity grazing.

The in-pit area of the TSF wraps around the end of a laterised sandstone ridge to the north, which is the highwall of the historical mining area. The facility is further constrained by two small mine water dams (Duck Pond and Fish Bowl) located 100-200 m to the west. The eastern side of the above-ground part of the TSF is bounded by a road around the western toe of the Ramp 74 northern in-pit spoil dump; Ramp 74 TSF is about 700 m east of Laleham TSF. There are several vegetated spoil dumps around the southern side of the TSF, with Sirius Creek at the southern side of those about 35 m from the Laleham TSF.

Regulated vegetation is mapped on the sandstone ridge and an area to the south-west of the TSF, described as an endangered acacia-dominated open forest and of-concern eucalypt open forest respectively.

Geology mapped for the footprint of Laleham TSF is Emerald Formation Tertiary sediment, with Rangal Formation sub-cropping south of Sirius Creek. Over the forty years since tailings were first deposited in-pit, there have been no reports of seepage from the TSF being detected in Sirius Creek. This is supported by the following report available in Appendix 4.2: *Bottom Dam Tailings Storage Facility and Sirius Creek Preliminary Hydrogeological Review and Investigation – Revision 3.0* (SLR 2025).

The Ramp 36 Rejects Dump is a long narrow waste facility located south-east of the NCPP TSF on the southern side of Deep Creek and the western side of the main haul road. It has a footprint of 72 ha with a high mound at the southern end reaching about 30 m above surrounding ground levels. The batters in that area are at angle-of-repose.

It is understood that the facility received coarse rejects over the period 1967-2007 and that rejects were also removed from the facility at times to use in the construction of wall lifts on the NCPP TSF.

The final landform design for Ramp 36 is a stand-alone elevated landform with about the same footprint as the current facility. Some coarse rejects will be moved within that area to flatten slopes down to the same gradients being applied to spoil dumps.

3.5.2.2 Tailings characterisation

Historically, little testing of tailings was undertaken at South Blackwater Mine. There were a few investigations carried out on the northern NCPP TSF but those were done to support the design of wall lifts and were limited in scope and location. Since 2020, geochemical and geotechnical studies have been undertaken at NCPP, Laleham, Ramp 72 and Bottom Dam TSFs to extend the knowledge base for rehabilitation. Ramp 74 and Bonnie Doon TSFs have not yet been sampled because they cannot presently be safely accessed – Ramp 74 contains mine water over the tailings and Bonnie Doon is the main active facility. However, inherent tailings characteristics are dictated by the feed coal and the plant processes, rather than by the storage facility, so results obtained for the other facilities are considered sufficient for planning and preliminary design.

Properties of tailings at Blackwater Mine that could influence management and rehabilitation practices are summarised in the following sections.

3.5.2.2.1 Geochemical properties

The geochemistry of tailings at Blackwater Mine is described in Section 3.5.1.3. In summary:

- About half of the tailings material has moderate to high potential to generate AMD when it is able to oxidise. The remaining half has a relatively low potential to generate AMD.
- Fresh tailings have been assessed as generally slightly saline, while aged tailings were generally slightly to moderately saline.

A detailed geochemical assessment of the tailings is in Appendix 4.7.

3.5.2.2.2 Rheological properties

Rheological testing has been carried out on tailings from NCPP, Laleham and Bottom Dam TSFs. All samples displayed shear thinning behaviour as shear rates increased, with shear viscosity decreasing by about three orders of magnitude over the shear rates investigated. The results are consistent with those obtained on samples from several other coal mines in the Bowen Basin and, therefore, it is expected the rheological behaviour would be similar for tailings from other TSFs at Blackwater Mine.

Rheological characterisation primarily relates to pumpability and flow behaviour soon after deposition and therefore has limited relevance to the long-term behaviour in TSFs. It may provide an indication of the

relative potential for liquefaction in the period from deposition to closure; however, any tendency to flow behaviour reduces over time as the tailings consolidate past a critical state.

3.5.2.2.3 Geotechnical characteristics

Geotechnical properties for tailings should be considered in the following two groups:

- Those that are inherent to the material regardless of its situation (e.g. particle size distribution, plasticity and specific gravity)
- In-situ properties that are affected by the inherent characteristics but also by the stress conditions and moisture distribution within the TSF (e.g. moisture content and dry density, settling density, shear strength and consolidation). Stress and moisture are governed by containment, the weight of overlying material, the location of drainage paths, and time since deposition.

While the inherent properties are essentially constant for a particular sample of tailings, in-situ properties may vary with location and time. Some in situ properties may be monitored during the operation of the TSF to assess the effectiveness of deposition practices, but strength and moisture-density profiles are most useful when measured after deposition has finished and close to when detailed rehabilitation works are being designed and undertaken.

Inherent properties

Test results for inherent geotechnical properties are presented in Figure 47, Figure 48 and Figure 49. Tailings from the NCPP are typical of the Bowen Basin, with size distributions showing comparable proportions of sand and silt, while samples from SCPP contained significantly more silt and less sand. However, as is also typical of Bowen Basin coal tailings, Atterberg Limits results suggest that about half the material behaves plastically, that is, like clay rather than silt. Consequently, in accordance with AS1726:2017 Geotechnical Site Investigations, tailings at Blackwater Mine are described as mainly ranging from low liquid limit Silty Sand to intermediate plasticity Silty Clay.

With regards to specific gravity, samples from SCPP had significantly lower values, which indicates a greater proportion of coal in those tailings. This outcome is understandable in the context of tailings from the SCPP being older on average because recent CHPP upgrades have tended to improve coal recovery, resulting in less coal being lost as tailings.

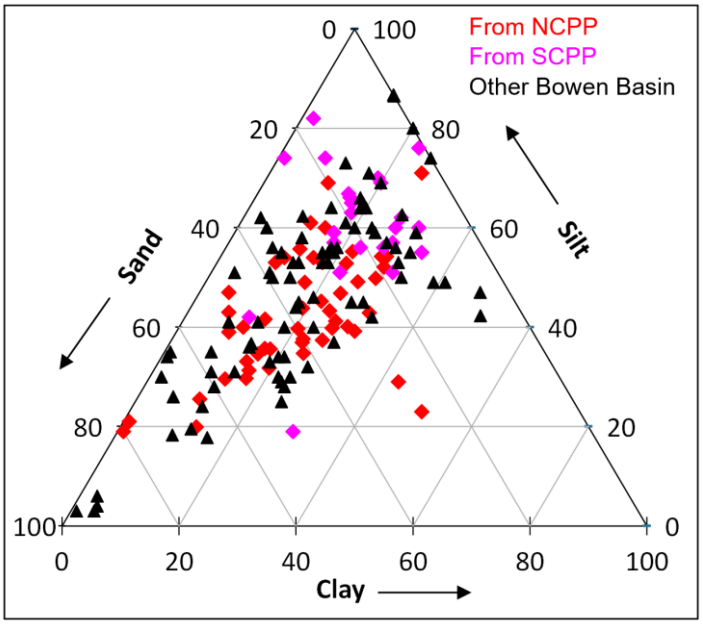

Figure 47 Tailings particle size distribution

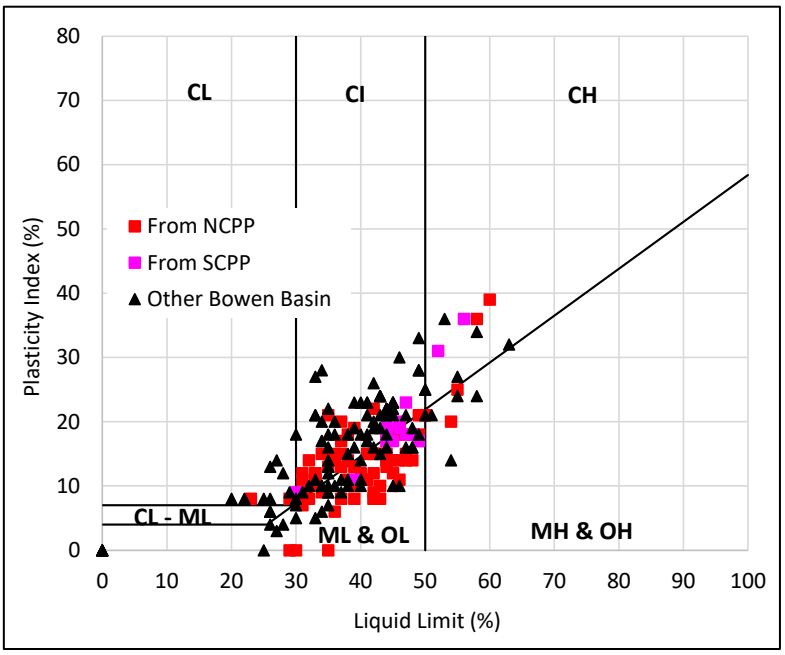

Figure 48 Tailings Atterberg limits

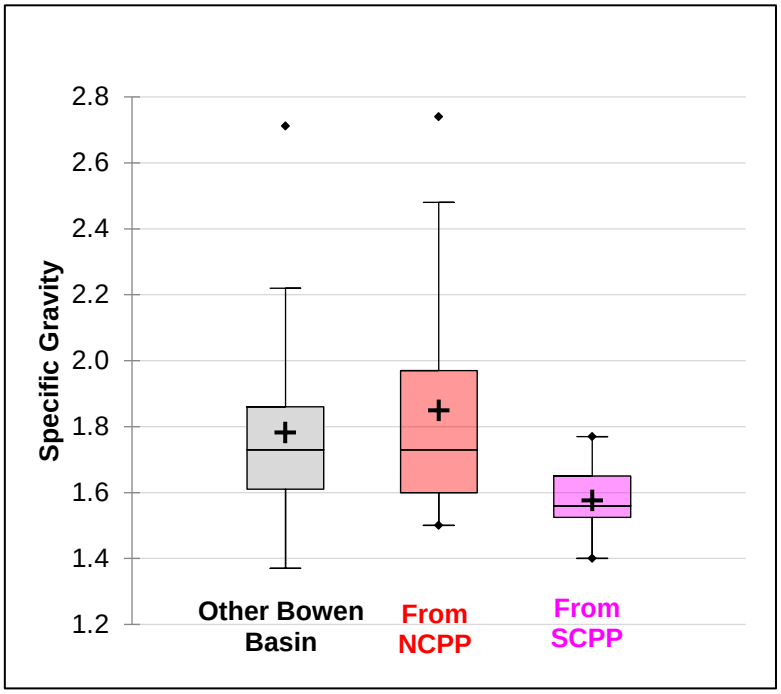

Figure 49 Tailings specific gravities

In-situ properties

Dry density and moisture content may be used in computations for consolidation settlement but they give only approximate and indirect indication of shear strength. Results for tailings samples from Blackwater Mine are in Figure 50. The higher dry densities for NCPP tailings might reflect sample bias caused by the test holes being mainly located close to walls, but regardless of the cause, the difference is not sufficient to materially change the rehabilitation strategy. The higher moisture content values for SCPP tailings could be due to the finer size grading and/or less attention having been paid to dewatering the tailings during TSF operation.

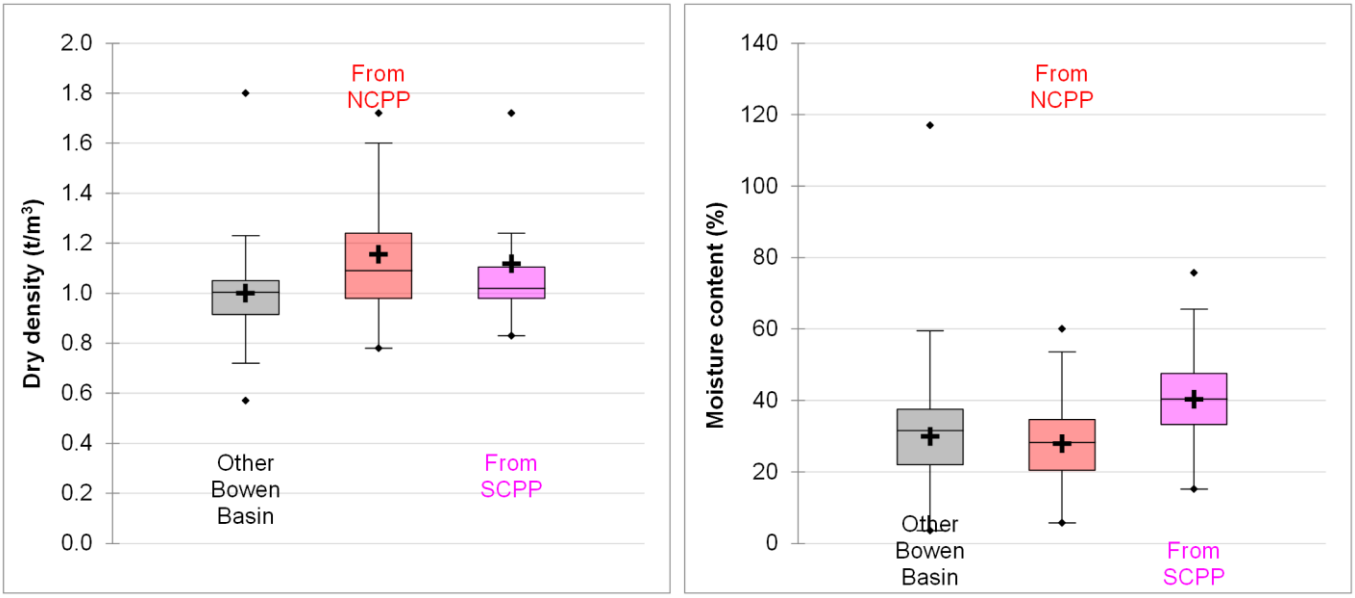

Figure 50 Tailings dry density and moisture content

To date, cone penetrometer testing, to provide strength profiles, has been carried out on NCPP, Laleham, Ramp 72 and Bottom Dam TSFs. Most of the tests were located close to walls, where the tailings are likely to be coarser, shallower, and therefore stronger. Strength profiles also change with time since deposition, as the tailings consolidates and gets dewatered. Consequently, more useful strength profiles would be measured shortly before capping is planned to commence. For information, the profiles measured showed generally 1-3 m of surface crust (but sometimes more and less) overlying tailings that varied from soft to firm-stiff.

Settling characteristics are relevant to the performance of TSFs in their operational phase - specifically, how the tailings solids beach, how quickly the surface water clears and can be decanted, and the volume of decant water that can be recovered. Settling behaviour is observed during operations and testing would only be undertaken if issues were experienced. This was not the case at any facility at Blackwater Mine. By the time a TSF reaches closure, the tailings will have settled and hence settling is not an important property in the context of rehabilitation and closure planning.

Consolidation and desiccation parameters, obtained from laboratory oedometer tests and soil water characteristic curve (SWCC) tests respectively, are not in-situ measurements but are used with other in-situ data to predict settlement (as distinct from settling) and densification over time.

Oedometer consolidation tests have been reported for five samples, with the following median parameter values:

- Compression Index C_c = 0.14
- Recompression Index C_r = 0.02
- Coefficient of permeability k_{sat} = $2*10^{-9}$ m/s
- Coefficient of consolidation c_v = 60 m^2/yr (varied over a wide range)

These values are close to the median of collated results measured for coal tailings in the Bowen Basin.

The results of the SWCC testing are in Figure 51 These indicate a difference between tailings from NCPP and NCPP that would be consistent with the difference in particle size distribution. However, SWCC results are very sensitive to sample preparation and test procedures so the outcome of a small number of tests from different laboratories should be treated with caution.

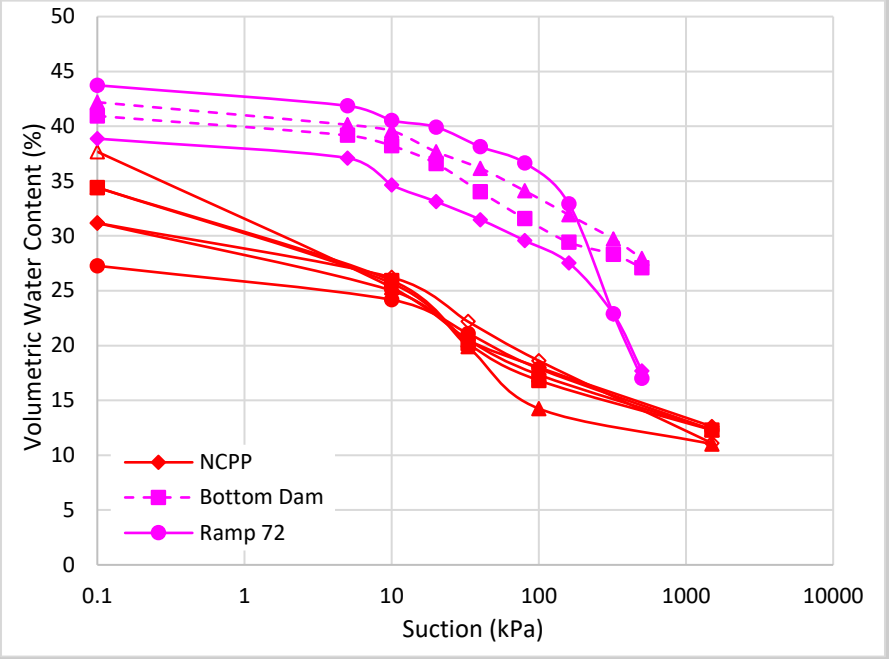

Figure 51 Tailings SWCC results

3.5.2.3 Rehabilitation and closure design context

3.5.2.3.1 Cover design considerations

A cover system over material with the potential to generate AMD and/or salinity will ideally:

- Allow shallow rainfall infiltration to support vegetation and reduce erosion from runoff.
- Not allow infiltration to seep down to the material.
- Not allow solutes such as metals and metalloids from the material to flow upward into the root zone or surface waters.
- Decrease oxygen penetration to restrict acid-generating reactions.

However, the above criteria impose conflicting requirements on cover materials: high permeability allows initial infiltration but low permeability limits deeper seepage; greater clay content reduces permeability, but lower clay content reduces matric (capillary) water suction potential. For example, clay-rich spoil from Tertiary and weathered Permian overburden/interburden could be placed to achieve low permeability but doing so would increase its tendency to allow upward water movement due to capillary action (matric suction potential). Conversely, gravelly spoil would have less tendency to promote upward water movement but might be too permeable to prevent deep infiltration into the tailings.

Water is the most effective barrier to oxygen penetration – either as a permanent water cover or, more commonly, filling pore spaces in the cover material and the tailings themselves. This again presents a conflict in the tailings; maintaining saturation would decrease oxygen movement but dewatering promotes strength gain. In the cover, a higher clay content generally leads to increased water-holding capacity and a higher degree of saturation.

The outcome of this is that a multi-layer cover system is often required, with different spoil types placed to utilise the desirable properties of each and to balance the conflicting requirements. An alternative would be a thick cover of undifferentiated spoil, with the depth of material compensating for poorer cover properties.

3.5.2.3.2 Available rehabilitation materials estimate

The quantities of weathered and unweathered spoil available will be sufficient to allow the selection of suitable cover materials.

The following is a rough estimate of available spoil for rehabilitation. Based on BWM's geologic boundaries along the planned final highwalls, the thickness of Tertiary/weathered overburden ranges from about 15-60 m. A 40 km long pit will be more than 120 m deep in the middle of the mine. Future mining of a strip 60 m wide will produce more than 1 Mm^3 of Tertiary/weathered spoil and 10 Mm^3 of fresh Permian spoil per kilometre of length. 1 Mm^3 of inert spoil would provide 2 m depth of cover over 50 ha of CHPP waste.

3.5.2.3.3 Conceptual cover design

Table 39 provides conceptual cover designs for the TSFs. Key aspects of the construction of these designs are in Appendix 4.12. Detailed designs will be completed shortly before each TSF is rehabilitated, and these will address all relevant aspects of the function of the TSFs within the post-mining landscape.

Table 39 Concept cover designs for rehabilitation and closure of the BWM TSFs

TSF	Rehabilitation objective	Concept cover design	Key design considerations
NCPP	To create a landform that permanently contains tailing solids and limits any release of solutes to levels that will not cause environmental harm and can support a PMLU of grazing.	Stand-alone elevated landform, with multi-system cover, comprising: — Gravelly fresh Permian base — Clay-rich spoil from Tertiary and weathered overburden as a lower permeability layer — Fresh Permian soil (lower salinity and sodicity) as subsoil layer (subject to chemical amelioration)	Bulk shaping comprising low clay content spoil and/or coarse rejects with low AMD potential will be spread over crusted tailings. Thickness will be as needed to provide a mounded, free-draining subsurface. The spoil/rejects will have minimal compaction to limit moisture suction potential. A 1 m minimum thickness layer of selected weathered Permian and/or Tertiary spoil will be spread and worked to be at least ten times less permeable than material above and below it. The surface will be shaped to shed any deep infiltration out of the landform when constructed and after consolidation settlement has occurred. This will require the surface of the layer to extend over the crests of the engineered embankments so that any such drainage would exit the landform. A 2 m minimum thickness of more permeable material such as gravelly fresh Permian spoil will be placed over the low permeability layer. The thickness may be greater than 2 m if needed to maintain separation between the vegetation rooting zone and the low permeability layer, and to allow a final ground surface that will shed rainfall without ponding with slopes not greater than those on rehabilitated spoil emplacement areas. Topsoil and erosion management practices are consistent with those on rehabilitated spoil emplacement areas.
Ramp 72	To bury the facility in a larger spoil landform.	Ramp 72 TSF will be buried under a new spoil dump (Kenmare spoil dump), including: — Gravelly spoil or coarse rejects as an initial support layer — General spoil placement.	1.5 m thickness of gravelly spoil or coarse – for example, spoil from fresh non-carbonaceous sandstone-siltstone overburden and/or interburden - over the exposed tailings. Spoil, 3.5 m thick at the top of the ramp, 5 m thick over coarse rejects and as required over the remainder of the TSF, dumped and spread in such a way that dispersive spoil with high fines content is not placed in the outer 1 m of the landform (spoil may be chemically ameliorated to achieve this). Final surface gradients, topsoil, vegetation and erosion management practices consistent with those on the adjoining rehabilitated spoil areas in the closure landform.
Ramp 74	To create a stable landform that permanently contains tailing solids and limits any release of solutes to levels that will not cause environmental harm.	NUMA within Laleham residual void	5 m minimum thickness of spoil will be placed over the tailings, from the northern end of the TSF to nominally 650 m north of the residual void's southern end-wall. The spoil layer will be battered down at an assumed to be angle of 1:3 for planning purposes (to be determined more exactly by stability analyses at detailed design). A pit lake will be established south from the spoil batter to act as a permanent water cover with a minimum dept of 1 m over the tailings that are not covered by spoil.
Laleham	To create a landform that permanently contains tailing solids, limits any release of solutes to levels that will not cause environmental harm, and can support a managed PMLU of grazing.	Capped with spoil	5 m thickness of spoil (including that already placed), dumped and spread in such a way that dispersive spoil with high fines content is not placed in the outer 1 m of the landform. This may be achieved by selective placement or by chemically treating the top metre of spoil to reduce sodicity. Final surface gradients, topsoil, vegetation and erosion management practices consistent with those on the adjoining rehabilitated spoil areas in the mine's closure landform.
Bonnie Doon	To create a stable landform that permanently contains tailing solids and limits any release of solutes to levels that will not cause environmental harm.	NUMA within Bonnie Doon residual void	The final tailings elevations in the TSF will be RL160m at the end of R10, with the surface sloping down to the north and up to the south. 5 m minimum thickness of spoil will be placed over the tailings, from the southern end of the TSF to nominally 150 m south of the end-wall at R10. The spoil layer will be battered down at an angle assumed to be 1:3 for planning purposes (to be determined by stability analyses at detailed design). A pit lake will be established north from the spoil batter to act as a permanent water cover with a minimum depth of 1 m over the tailings that are not covered by spoil.
Bottom Dam (and ROM 3 Area Rejects)	To create a landform that permanently contains tailing solids, limits any release of solutes to levels that will not cause environmental harm, and can support a managed PMLU of grazing.	1. Push ROM 3 Area rejects down over the tailings to flatten the slope and fill the existing shallow surface depression 2. Cover with spoil	5 m thick spoil, dumped and spread in such a way that dispersive spoil with high fines content is not placed in the outer 1 m of the landform. This may be achieved by selective placement or by chemically treating the top metre of spoil to reduce sodicity. Final surface gradients, topsoil, vegetation and erosion management practices consistent with those on the adjoining rehabilitated spoil areas in the mine's closure landform.
Ramp 36 Rejects Dump	To create a landform that permanently contains tailing solids, limits any release of solutes to levels that will not cause environmental harm, and can support a managed PMLU of grazing.	Reshaped and covered with spoil within its existing footprint	5 m thickness of spoil, dumped and spread in such a way that dispersive spoil with high fines content is not placed in the outer 1 m of the landform. This may be achieved by selective placement or by chemically treating the top metre of spoil to reduce sodicity. Final surface gradients, topsoil, vegetation and erosion management practices consistent with those on the adjoining rehabilitated spoil areas in the mine's closure landform.

3.5.2.3.4 Consolidation considerations

Tailings consolidation settlement will vary with tailings depth and water content profile (or conversely, density profile) and with cover thickness, and is expected to occur over a long timeframe – potentially decades. Conceptually, where relevant, this settlement can be accommodated by making the relevant layers of the cover thicker in the areas where greater settlement is predicted so that mounded interfaces and surfaces will remain mounded after the settlement has occurred.

The magnitude and rate of consolidation settlement depend on composition (size grading), existing pre-consolidation, and the disposition of drainage paths, all of which vary within the three-dimensional tailings deposit. Consequently, estimates are not included in the conceptual cover design; instead, the settlement will be assessed and allowed for as part of the detailed design, especially by adaptive design revision during the construction phase.

Coarse rejects do not experience consolidation settlement. Due to the uncompacted nature of the waste, there may be some settlement due to the weight of the cover layer but most of this will occur as the cover is constructed and does not need to be addressed in design.

3.5.2.3.5 QA/QC of cover construction

In the *BWM WSF Cover Designs* report by HG (2024) (Appendix 4.12), potential hazards and controls surrounding TSF cover performance are described. Key items in the report are:

- To decrease the risk of seepage hazards of the tailings cover, recharge of tailings moisture may need to be restricted post-mining, for example by direct cut-off or construction of collection trenches.
- To prevent adverse effects on vegetation growing on the TSF post-closure landform, the cover system will be designed to provide a barrier between tailings solutes and topsoil/subsoil layers.
- The cover system should accommodate consolidation settling appropriately.

Relationship with PRCP Schedule

Of the six tailings facilities at BWM, only three (NCPP, Laleham and Bottom Dam) will remain as above-ground structures in the closure landform with engineered spoil covers. The Ramp 36 rejects landform will also have an engineered spoil cover.

Ramp 72 TSF will be buried beneath the Kenmare spoil landform, and the Ramp 74 and Bonnie Doon tailings are to be managed with hybrid covers as part of the Laleham and Bonnie Doon NUMAs, respectively.

The concept cover designs detailed in this PRC Plan will be refined to detailed designs by the end of mining, for application of the required covers.

3.5.3 Voids

PRCP Guideline (Section 3.6.3)

The information requirements of this domain are dependent on the nature of the proposed PMLU or NUMA for the void. For mine sites with voids, the rehabilitation planning part must include a void closure plan, which includes options for minimising final void area and volume; final void dimensions; pit wall geotechnical and geochemical stability, final slope angles, void hydrology, groundwater modelling, water balance and predicted long-term water quality.

A geotechnical report should focus on how the void will achieve post-closure slopes that will exhibit stability characteristics consistent with the planning and design of the post-closure mine void.

If floodwaters are likely to move over backfilled material, an assessment of the hydraulic properties must be conducted to assess whether instability may occur.

The rehabilitation and management strategies in the plan must include the supervision, verification and auditing of engineering works carried out to achieve the post-closure void landform, to ensure construction is consistent with the geotechnical design.

The rehabilitation and management strategy must also include confirmation that the post-closure landform demonstrates the level of stability as specified by the design.

A Void Closure Plan was compiled to support the development of this PRCP. The detailed plan, *Whitehaven Coal Void Closure Plan – Blackwater Mine* (WSP, 2024), is provided in Appendix 4.13.

3.5.3.1 Context

As per the EA, a residual void is “an open pit resulting from the removal of coal and waste rock that will remain following the cessation of all mining activities and completion of rehabilitation processes”. Therefore, for this PRCP, a residual void is considered to be the remaining mined out pit below ground level after backfilling.

For BWM, there are eleven residual voids in the final closure landform herein referred to as the BWM residual voids. The residual voids are documented below and represented as a 3D landform in Figure 52:

- Ramp 8
- Bonnie Doon
- Mimosa/Besgrove
- Deep Creek
- Stewarton/Ballamoo
- Kenmare
- Laleham
- Togara/North Marshmead
- South Marshmead
- Comet Downs East
- Kennedy West

As set out in Section 3.4 of this PRCP, Section 754(3) and (4) of the EP Act apply to all eleven residual voids. The NUMA extents achieve an area that is safe and structurally stable and includes additional set-backs from the void low-wall, high-wall and end-wall crests if required to achieve wall geotechnical stability (FoS = 1.5), and safety bunds and fences.

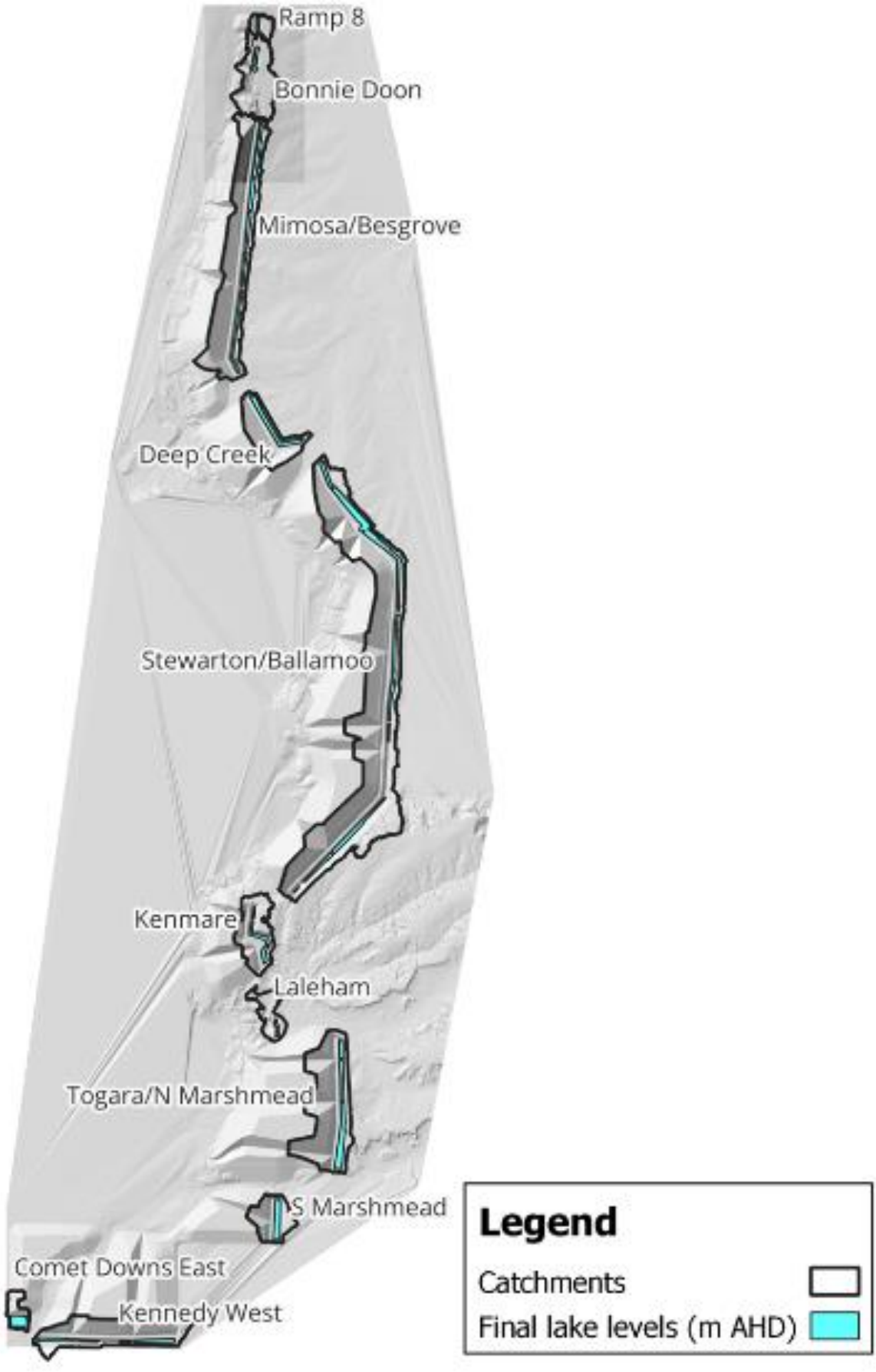

Figure 52 3D depiction of BWM residual voids and void lakes

3.5.3.2 Geotechnical stability

The Void Closure Plan includes a geotechnical stability analysis of the proposed residual void low-walls, high-walls and end-walls. The analysis determined the FoS of the walls and, if required, the set-back distances for long-term pit wall stability for the high-walls, end-walls and low-walls to meet the minimum FoS of 1.5.

3.5.3.2.1 Low-wall stability

The low-wall stability analysis results are shown in Table 40. The as-dumped design of the residual void low-walls meets the minimum FoS for all residual voids. Therefore, the low-walls of the final closure state landforms can be considered stable for all residual voids.

Table 40 Summary of BWM residual low-wall stability analysis

Pit	Low-wall spoil height (m)	Low-wall floor dip* (°)	Minimum FoS	
			Overall slope (global stability)	Slope outside NUMA (local stability)
Ramp 8	94	2.7	2.08	3.38
Bonnie Doon	90	5.2	2.50	3.62
Mimosa/Besgrove	261	3.8	1.68	2.35
Deep Creek	280	1.1	1.93	2.58
Stewarton/Ballamoo				
— North	322	3.0	1.85	2.62
— South	300	4.6	1.99	2.26
Kenmare	233	2.1	1.58	2.43
Laleham	40	4.8	1.67	2.99
Togara/Marshmead North	351	2.2	1.56	2.93
Marshmead South	253	1.2	1.55	4.03
Kennedy West	305	1.5	1.76	2.22
Comet Downs East	191	0.1	1.60	2.74

3.5.3.2.2 High-wall stability

The high-wall and end-wall analysis results are shown in Table 41. The as-mined design of the residual void high-walls and end-walls do not all meet the minimum FoS and therefore additional set-back distance has been included in the final closure landform design to ensure the minimum FoS is achieved. This will ensure that no assets (Whitehaven, third-party, or of significant environmental value) are within this boundary at closure.

Table 41 Summary of BWM residual void high-wall and end-wall stability analysis

Pit	Average wall depth (m)	Average FoS (computed at 60º wall angle)	Average set-back from toe of wall to achieve FoS = 1.5 (m) (computed at 60º wall angle)
Ramp 8	72	2.23	99
Bonnie Doon	73	2.24	101
Mimosa/Besgrove	137	1.67	156
Deep Creek	133	1.65	149
Stewarton/Ballamoo	158	1.63	188
Kenmare	146	1.89	188
Laleham	26	2.83	-
Togara/North Marshmead	213	1.54	366
South Marshmead	186	1.65	328
Kennedy West	117	1.99	150
Comet Downs East	133	1.73	157

3.5.3.3 Void hydrology

3.5.3.3.1 Water balance

A dedicated void water balance model based on the final closure landform design (Section 3.5.1.5) was completed for the period 2035-2599 (564 years). This was done to understand water balance behaviour, including climate change considerations, within the residual voids over time (Appendix 4.13). Key findings are summarised below and provided in Table 42:

- The mean equilibrium is reached by the end of the simulation period for all residual voids (after 2599), except for Ramp 8 and Comet Downs East. However, for these voids, the mean inflows and outflows are close enough to represent the achievement of equilibrium.
- In the long-term, void lake elevations of each residual void remain below the base elevation of shallow geological formations, which is an indicative level that the voids will behave as groundwater sinks.

Table 42 Water balance results for the BWM residual voids water balance modelling

Residual void	Stabilisation (from 2100)	Year when TDS content exceeds the trigger value[1]	Void lake level (range[2]) (mAHD)	Spill level (mAHD)	Freeboard to spill level – min (m)	Base elevation of shallow geologic formation (mAHD)	Freeboard to shallow geologic formation (m)	Long-term behaviour (groundwater)
Ramp 8	Mean water levels start to stabilise, with simulated mean inflows of 140 ML/year being similar to outflows of 141 ML/year Although a steady state is not achieved by the end of the simulation, mean inflow and outflow are close enough to represent achievement of equilibrium	2070	153-154	189	35	174.5	20.5	Sink
Bonnie Doon	Mean water levels start to stabilise, with simulated mean inflows of 283 ML/year being the same as mean outflows of 283 ML/year Mean water balance has reached an equilibrium	2080	159-62	190	28	171	19	Sink
Mimosa/ Besgrove	Mean water levels start to stabilise, with simulated mean inflows of 2,035 ML/year being the same as mean outflows of 2,035 ML/year Mean water balance has reached an equilibrium	2120	116-118	199	81	179	20	Sink
Deep Creek	Mean water levels start to stabilise, with simulated mean inflows of 931 ML/year being the same as mean outflows of 931 ML/year. Mean water balance has reached an equilibrium	2080	140-41	212	71	203.5	8.5	Sink
Stewarton/ Ballamoo	Mean water levels start to stabilise, with simulated mean inflows of 4,321 ML/year being similar to the mean outflows of 4,323 ML/year Although a steady state is not achieved by the end of the simulation, mean inflow and outflow are close enough to represent achievement of equilibrium	2120	144-146	216	70	203	13	Sink
Kenmare	Mean water levels start to stabilise, with simulated mean inflows of 573 ML/year being the same as mean outflows of 573 ML/year Mean water balance has reached an equilibrium.	2110	220-221	300	79	261	39	Sink
Laleham	Mean water levels start to stabilise, with simulated mean inflows of 131 ML/year being the same as mean outflows of 131 ML/year Mean water balance has reached an equilibrium Potential for this residual void to interact with shallow geological formation (base of weathering). However, groundwater flows and the WBM results do not indicate this is occurring (WSP, 2024)	2100	236-238	262	24	237	25	Sink
Togara/ North Marshmead	Mean water levels start to stabilise, with simulated mean inflows of 1,652 ML/year being similar to the mean outflows of 1,649 ML/year Although a steady state is not achieved by the end of the simulation, mean inflow and outflow are close enough to represent achievement of equilibrium	2130	156-157	270	113	232	38	Sink
South Marshmead	Mean water levels start to stabilise, with simulated mean inflows of 672 ML/year being similar to the mean outflows of 671 ML/year Although a steady state is not achieved by the end of the simulation, mean inflow and outflow are close enough to represent achievement of equilibrium	2110	180-182	267	85	189	78	Sink
Kennedy West	Mean water levels start to stabilise, with simulated mean inflows of 846 ML/year being the same as mean outflows of 846 ML/year Mean water balance has reached an equilibrium	2110	141-143	218	75	181	37	Sink
Comet Downs East	Mean water levels start to stabilise, with simulated mean inflows of 471 ML/year being similar to the mean outflows of 475 ML/year Although a steady state is not achieved by the end of the simulation, mean inflow and outflow are close enough to represent achievement of equilibrium	2110	182-183	222	39	192	30	Sink

[1] TDS EA trigger value = 26,505 mg/L

[2] Lake level ranges are for the final 20 years of the WBM simulation

3.5.3.3.2 Groundwater modelling

Numerical groundwater modelling (Section 3.5.1.1 and Appendix 4.2) shows the establishment of sustained inward hydraulic flow gradients to the voids. The hydraulic gradient is driven by the evaporative discharges from void lakes, which stabilise below the modelled groundwater elevations and the shallow hydrogeological units, (i.e. alluvium, basalt and Tertiary). Therefore, once the void lakes and groundwater levels have stabilised, the model results indicate the residual voids will continue to act as groundwater sinks, supporting the outcomes of the void water balance modelling.

Flow path simulation modelling undertaken in conjunction with the numerical groundwater modelling indicates the residual voids will collect and retain water associated with spoil and tailings deposition, underground mine workings and residual void lakes. Therefore, the residual voids will retain potentially contaminated seepage from the mining operations and minimise the potential for environmental harm beyond the mining tenement boundary. The PRC Plan Version 1 submission (11 November 2024) reported that the exception to this is the specific location of Bottom Dam, west of Laleham residual void, with groundwater predicted to migrate towards Sirius Creek outside of the BWM. As discussed in Section 3.5.1.1.4 (above), following the Not Properly Made Notice received from DETSI 25 November 2024, SLR Consulting Australia Pty Ltd (SLR) were engaged to undertake a preliminary hydrogeological assessment of the conceptual relationship between the historical Bottom Dam Tailings Storage Facility (TSF) and Sirius Creek. The objective of the work was to conceptually assess current hydrogeological conditions at a local scale which was not possible in the site-wide Transitional PRC Plan Hydrogeology Assessment, and to identify if there was a plausible potential pathway for subsurface hydraulic connection between the Bottom Dam TSF and Sirius Creek as predicted by the model. The report is provided as an addendum to Appendix 4.2 and it concludes that there is a highly limited potential for hydraulic connection between the Bottom Dam TSF and Sirius Creek.

As mining activity ends in different years for each void, the duration over which groundwater levels in spoil and aquifers adjacent to the residual voids remain suppressed after mine closure in 2113 varies. For most voids, except for Comet Downs void, the groundwater levels are predicted to recover within approximately 40-140 years after closure. During this time, groundwater fluxes to the voids are largely controlled by the difference between the predicted spoil groundwater levels and the predicted WSP (2024) residual void lake levels that rise and fall periodically according to:

- The day-on-day climatic simulation within the WSP (2024) water balance model; and
- How the daily timestep water balance results are translated to the groundwater model's more simplified stress period setup.

During these early model stress periods prior to equilibrium, fluxes between the voids and adjacent spoil and bedrock formations are more temporally variable than towards the end of the recovery simulation. Despite this variability, all voids still behave as net groundwater sinks for both spoil and non-spoil groundwater sources. The one exception to this is Deep Creek, which in the first 100 years post-closure is predicted to temporarily lose void water to surrounding natural geology before the flow gradient is reversed and the void reaches equilibrium as a net sink.

Predicted equilibrium groundwater inflows to each of the voids for the three climate scenarios indicate that across all the voids, spoil contributes between 26-100% of the total net inflows to the void. The equilibrium groundwater inflows to each of the voids represent approximately 7-60% of the total volumetric inflow to each residual void's water balance, indicating that groundwater inflows are not the dominant driver of predicted residual void lake levels except in the case of Comet Downs East residual void.

The equilibrium sink behaviour of the residual voids is driven by evaporative losses from the void lakes predicted by the WSP (2024) water balance model. The direct evaporation from the surface of the void lake maintains void lake levels that are lower than the surrounding groundwater levels in the long-term equilibrium state.

All residual voids, excluding Kennedy West, are predicted to behave as groundwater sinks at post-closure equilibrium with no net outflows to spoil or bedrock. The Kennedy West residual void is predicted to lose void water to surrounding natural geology at a small rate of 107 m^3/day at equilibrium. The predicted lake elevation at the adjacent Comet Downs residual void is much lower than at the Kennedy West void, resulting

in a hydraulic gradient between the two voids. Therefore, the outwards water flux from the Kennedy West void is driven by, and would eventually be captured by the adjacent Comet Downs void.

3.5.3.3.3 Water quality

The *Void Closure Plan* (Appendix 4.13) includes an analysis of the void water quality (i.e. geochemical stability). A more in-depth void water quality study was completed in 2024, *Geochemical Void Water Quality Report – Blackwater Mine* (WSP, 2024) (Appendix 4.14).

The following are the key findings in both reports regarding the residual voids:

- Evapo-concentration processes will drive water quality.
- Acidic conditions are unlikely to develop (due to no significant sources of acid generation associated with surface water hydrology of the BWM closure landform), with pH conditions being stable over time.
- TDS concentration increases over time, resulting in predicted hypersaline conditions.
- Lake depth coupled with predicted hypersaline conditions indicate that all residual voids may become stratified.
- Trigger values for dissolved metals and metalloids will be exceeded for Al, Sb, Hg, Mo and Se in all void lakes. However, Hg and Se values may not be accurate as they were modelled using values of half the limit of detection, which is likely to be an overestimate.

In summary, all residual voids generally stabilise as groundwater sinks over time and do not present an unacceptable risk of environmental harm beyond the tenure boundary.

3.5.3.4 Options for minimising final void areas and volumes

The pits will be progressively backfilled during the operation to minimise final void areas and volumes. Ramp voids will be progressively backfilled, minimising the number of ramps remaining in the final voids. In-pit tailings emplacement at Laleham and Bonnie Doon also reduces the final void extent.

Once mining is complete, final void areas and volumes will be further reduced by additional backfill. Partial backfilling is planned where required to prevent flood ingress (Section 3.5.1.2.3). The extent of backfilling will depend on the mining sequence of the final strips which may change during the remaining operational period as new geological data becomes available and market factors change.

As BWM has significant mine life remaining, opportunities for further backfilling of the residual voids may be refined over the life of the operation and finalised as mining approaches the final strips.

3.5.3.5 Final void dimensions and wall angles

Outcomes of the void geotechnical and geochemical stability analyses, void water balance modelling, and site-wide hydrogeological and rehabilitation flood modelling resulted in the optimisation of the residual void dimensions towards minimising the extent and location of the NUMAs.

Average void dimensions and wall angles, measured from the wall toe to the wall crest at ground level, are shown in Table 43.

Table 43 Proposed BWM residual void dimensions and overall wall angles

Residual void	Indicative maximum width (m)	Indicative maximum length (m)	Indicative maximum void depth (m)
Ramp 8	220	800	34
Bonnie Doon	220	3,460	9
Mimosa/Besgrove	480	10,250	53
Deep Creek	540	3,590	54

Residual void	Indicative maximum width (m)	Indicative maximum length (m)	Indicative maximum void depth (m)
Stewarton/Ballamoo	320	19,700	84
Kenmare	420	3,290	62
Laleham	190	1,940	2
Togara/North Marshmead	610	5,340	88
South Marshmead	640	1,780	77
Comet Downs East	270	5,630	43
Kennedy West	564	734	93

Note: Dimensions are indicative of measurements at void crests/spill elevations and do not represent full NUMA extents

The residual void high-wall and end-wall profiles will remain as the final excavated as-mined wall profile, with numerous mining benches of varying face angles and heights. Each mining bench is offset with berms of varying widths, reducing overall final wall angles to approximately 32-45°. These wall angles may vary with the final geotechnical design, which will be developed as mining approaches the final pit limits to ensure it is based on the latest material and geotechnical data.

The final low-wall profile within the NUMA area will remain as the final as-dumped profile, with dragline spoil and truck dump lifts within the NUMA area remaining at the angle of repose. The truck dump lifts are offset from the dragline spoil by two spoil peaks and each truck dump lift is offset, reducing the overall low-wall angle to approximately 21°. This wall angle may vary with the final geotechnical design which will be developed as mining approaches the final pit limits, to ensure it is based on the latest material, pit floor and geotechnical data.

The NUMA extents achieve an area that is safe and structurally stable and includes the additional set-backs from the void wall crests if required to achieve a minimum FoS of 1.5, plus a safety bund (Section 3.5.3.6). Set-backs from the void high-wall and end-wall crests are required for all pits and additional set-back is required for the Togara/North Marshmead and South Marshmead high-wall. For all voids, the low-walls achieve a minimum FoS of 1.5 for slopes outside the NUMA.

3.5.3.6 Improvement and management strategies

To eliminate the risk of any injury or damage within the NUMA area from the reshaping and rehabilitation activities, residual voids will become available for improvement once each respective pit has completed the following:

- mining,
- reshaping of the spoil dump low-wall outside of the NUMA area (RA1, RA2), and
- any partial backfill for flood mitigation.

All eleven residual voids will be retained as NUMAs. To support the attainment of residual voids that are safe and do not present an unacceptable risk of off-tenure environmental harm, the improvements and/or management activities provided in Table 44 will be undertaken.

Table 44 Improvement and/or management strategies for the BWM residual voids

Closure aspect	Closure objective			Improvement and/or management strategy
	Safe	Stable	Non-polluting	
Geotechnical stability	✓	✓	-	As mining approaches the final limits, re-assess the geotechnical wall designs and setbacks based on the latest available data by an AQP. Review and adjust the mine plan and final closure state landform, if needed, to account for any revised setback requirements. Use a minimum FoS of 1.5 as guidance for ongoing void closure planning. (This may be refined over the mine life should industry research provide optimised guidance on observational methods and consequence assessments.)
Void hydrology	-	-	✓	Residual void catchments are minimised as far as practicable. At the cessation of mining activities: Review and update the void water balance modelling, incorporating identified changes to the closure landform and spill point elevations, rainfall and evaporation, surface water runoff, groundwater inflows, and climate projections. Implement management strategies if future modelling identifies an unacceptable risk of environmental harm outside the tenure boundary (not identified in current modelling). Obtain certification from an AQP that the residual voids will not cause environmental harm outside the tenure boundary. Identify and implement mitigation measures for appropriate protection works of landforms where floodwaters from watercourses interact with final closure state landforms.
Void hydrogeology	-	-	✓	At the cessation of mining activities: Review and update the groundwater modelling, incorporating updated void WBM outputs and in-field groundwater sampling data, as required. Implement management strategies if future modelling identifies an unacceptable risk of environmental harm outside the tenure boundary (not identified in current modelling). Obtain certification from an AQP that, upon completion of mining, residual voids do not present an unacceptable risk of environmental harm outside of the relevant tenure boundary.
Void water quality	-	-	✓	At the cessation of mining activities, review and update the void geochemical assessment including additional or refined data from in-pit surface water samples, surface- and groundwater samples, and biochemical modelling. Although not identified in current modelling, if future modelling identifies an unacceptable risk of environmental harm outside the tenure boundary, then management strategies are to be developed and implemented. Obtain certification from an appropriately qualified person that the residual voids will not present an unacceptable risk of environmental harm beyond the tenure boundary.
Geochemical stability	✓	✓	-	At the cessation of mining activities, assess the spontaneous combustion propensity of the remaining in-situ coal. If spontaneous combustion propensity is high and an unacceptable risk is present, management strategies are to be developed and implemented.

Closure aspect	Closure objective			Improvement and/or management strategy
	Safe	Stable	Non-polluting	
Void access control	✓	-	-	At the cessation of mining activities: Construct a safety bund at the geotechnical set-back distance. Erect fencing and signage around the safety bund. Obtain certification from an AQP that the residual void is safe for humans and livestock.

Relationship with PRCP Schedule
The eleven BWM residual voids will be managed as NUMAs. Long-term geotechnical stability of low-walls, end-walls and high-walls is achieved within the NUMA extents. The residual voids will not overtop and will generally stabilise to be ongoing groundwater sinks post-mining and will not present an unacceptable risk of environmental harm outside of the tenure boundary. The geotechnical stability and safety requirements, as well as water levels and water quality, will be managed in terms of the management milestones specified in the PRCP Schedule.

3.5.3.7 Voids in floodplains

Legislative Requirement
In accordance with section 126D(3) of the EP Act, if land the subject of the proposed PRCP Schedule will contain a void situated wholly or partly in a flood plain, the schedule must provide for the rehabilitation of the land to a stable condition.

PRCP Guideline (Section 3.4)
*Section 41C of the EP Regulation states the decision considerations for a void situated wholly or partly in a flood*plain. A void is considered to be located in a floodplain if the floodplain modelling shows that, when all relevant activities carried out on the land have ended, the land is the same height as, or lower than, the level modelled as the peak water level 0.1% AEP for a relevant watercourse under the guideline Australian Rainfall and Runoff (2019)(ARR).

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Where a land outcome document has a pre-approved land outcome for a void with a location specified, floodplain modelling is not required. If a void has been identified as a NUMA in a land outcome document but the location is not identified, the applicant is required to carry out flood plain modelling in accordance with this section of the guideline. While the provision in the EP Act relating to voids located within a floodplain having to rehabilitate to a stable condition does not apply, the PRC Plan must include how the proposed location of the void minimises risks to the environment. Therefore, the floodplain modelling is required to support the assessment of the proposed location of the void.
If there are no land outcomes identified in a land outcome document, the applicant is required to carry out floodplain modelling in accordance with this section of the guideline.

Section 754(3) of the EP Act excludes the operation of section 126D(3) and, therefore, a voids in floodplains assessment was conducted to address Section 3.4 of the PRCP Guideline which states that the applicant is required to carry out floodplain modelling in circumstances where the location of the NUMA is not identified in the EA.

A voids in floodplain assessment was done by appropriately qualified persons (AQPs) to support the development of this PRCP. The detailed report, *Blackwater Mine Progressive Rehabilitation and Closure Plan Voids in Floodplain Report* (SLR, 2024), is in Appendix 4.5.

3.5.3.7.1 Background

The BWM closure landform includes 11 residual voids (Figure 29a and 27b) as pre-approved NUMAs:

- Ramp 8
- Boonie Doon
- Mimosa/Besgrove
- Deep Creek

- Stewarton/Ballamoo
- Kenmare
- Laleham
- Togara/North Marshmead
- South Marshmead
- Comet Downs East, and
- Kennedy West

Since the locations of these voids are not explicitly stated in any LODs, a void in floodplain assessment was undertaken.

As a conservative approach, the void extents used for modelling were the preliminary extents of the final voids. That is, prior to any final landform design considerations, such as partial backfilling to provide for flood protection. These preliminary extents are considered the maximum possible, and the final proposed residual void extents have since been reduced and refined based on the outcomes of the studies undertaken to support this PRC Plan to reduce the environmental impact (Section 3.4.4). Details on the closure landform and rehabilitation approaches are in Sections 3.5.1.5 and 3.5.3.2, respectively.

3.5.3.7.2 Relevant watercourses

A 'relevant watercourse' is defined as (State of Queensland, 2022):

> *(a) a watercourse classified as stream order 4 or higher under the Strahler stream order classification system; or*
>
> *(b) if a watercourse mentioned in paragraph (a) is permanently diverted under—*
>
> *(i) a condition, or proposed condition, of an environmental authority mentioned in the Water Act 2000* (Qld)*, section 98; or*
>
> *(ii) a water licence or proposed water licence under the Water Act 2000* (Qld)*;*
>
> *(iii) the watercourse as permanently diverted.*

Five relevant watercourses with a Strahler stream order greater than four are present within BWM and/or its catchments, which have the potential to influence flooding within BWM. See Section 3.1.2.5 for a detailed description of watercourses at BWM.

The relevant watercourses that were modelled as part of the voids in floodplain assessment include:

- Blackwater Creek,
- Two Mile Gully,
- Taurus Creek (downstream of junction with Two Mile Gully),
- Sirius Creek, and
- Unnamed Tributary of Sirius Creek.

3.5.3.7.3 Voids in flood plains landform

The intent of the voids in flood plain modelling is to represent the flood plain within the tenement without 'artificial features' as defined by the State of Queensland (2022). As BWM commenced operations in 1967, there is limited detailed information available for the pre-mining topography of the site.

The landform used for voids in floodplain modelling was developed using a Digital Elevation Model (DEM) and available LiDAR topographic data of relevant areas. The model landform DEM was developed to represent the pre-mining topography within the ML and existing and future topography outside of the ML, including adjacent MLs where applicable.

As required for this assessment, existing off-tenements and future artificial features that have the potential to impact the floodplain were assessed for their potential to influence flood hydraulics at BWM, and where appropriate, have been included within the modelled landform. These include:

- Blackwater Rolleston Road
- Blackwater Railway System

As described above, as a conservative approach, the location and footprint of the residual voids within the voids in the floodplain modelling landform were the initial design locations; these represent the maximum footprint before the refinement of the landform. The development of the final closure landform has reduced the extent of the residual voids, when compared to that modelled, through partial backfilling and placement of landforms such as spoil dumps and in-pit TSFs.

3.5.3.7.4 Modelling method

Hydrologic modelling was undertaken to estimate runoff hydrographs at various locations throughout the catchments of relevant watercourses. The model was developed using the Watershed Bounded Network Model Version 2019 (WBNM), which is an industry-standard rainfall runoff routing software package.

The catchment of Blackwater Creek contains the catchments of Two Mile Gully and Taurus Creek. Two Mile Gully is a tributary of Taurus Creek. Similarly, the catchment of Sirius Creek contains the catchment of the unnamed tributary which was identified as a relevant watercourse.

The 1% and 0.1% Annual Exceedance Probability (AEP) events were simulated using the hydrologic model. For each AEP event, a range of storm durations and temporal patterns were simulated. The 0.1% AEP event was the primary design storm event for this assessment. In accordance with ARR, the Probable Maximum Flood (PMF) temporal pattern was adopted for the 0.1% AEP event.

Results of the model were verified against peak flows produced by Quantile Regression Technique (QRT) calculations and Regional Flood Frequency Estimation (RFFE). The validation was carried out at focal points on the relevant watercourses. the peak flows produced by the WBNM model were comparable to the results of the QRT calculations, and RFFE. The WBNM model produced higher peak flows when compared to the flood estimations from QRT and RFFE, although the peak flows were comfortably within the upper confidence limit of the RFFE results. Based on the above information and findings, the WBNM model was considered appropriate for use for the purposes of the assessment.

Two hydraulic models of the relevant watercourses were also developed to assess pre-mining flood extents. The industry standard hydrodynamic modelling software TUFLOW (build 2023-03-AB) was utilised for the hydraulic modelling with the sub-grid sampling (SGS) feature to provide an increased definition of model terrain and flow conveyance. The hydraulic models included:

- Two Mile Gully Model, covering:
  - Two Mile Gully,
  - Taurus Creek, and
  - Blackwater Creek.
- Sirius Creek Model, covering:
  - Sirius Creek, and
  - unnamed tributary of Sirius Creek.

Further details on the models, including their calibration, assumptions and parameters are provided in Appendix 4.2.

3.5.3.7.5 Assessment results

The results of the void in floodplain assessment of the pre-mining landform identified the proposed NUMA associated with the Laleham residual void would be partially located within the 0.1% AEP inundation extent

of Sirius Creek (Figure 53). The remaining residual voids are located outside the floodplain in the 0.1% AEP event.

Although the Togara/North Marshmead residual void is marginally affected by the 0.1% AEP event inundation extent, this occurs in a reach of Sirius Creek where the watercourse stream order is less than 4 and is therefore acceptable according to the requirements of the PRCP Guidelines.

To mitigate the environmental impact and flooding interactions of residual voids at BWM, the final landform extent of the Laleham residual void has been reduced and refined. This will be facilitated through partial backfilling of the Laleham pit and placement of landform structures. Further void final landform details are in the Void Closure Plan (Appendix 4.13) and updated flood assessments are in the Progressive Rehabilitation and Closure Plan Rehabilitation Flood Assessments report by SLR (2024) (Appendix 4.6).

Results of the 0.1% AEP flood modelling using the amended final landform of the Laleham residual void are in Figure 54.This model also included a 20% increased rainfall intensity to account for potential future climate change scenarios. The updated model shows that the Laleham residual void is no longer predicted to be in the Sirius Creek floodplain extent.

Relationship with PRCP Schedule
The location and extent of the residual voids, combined with other aspects of the landform design, including strategic placement of spoil dump and landform structures provide protection to the residual voids from flood events up to and including a 0.1% AEP and minimise risks to the environment, as per the transitional requirements for voids in flood plains.

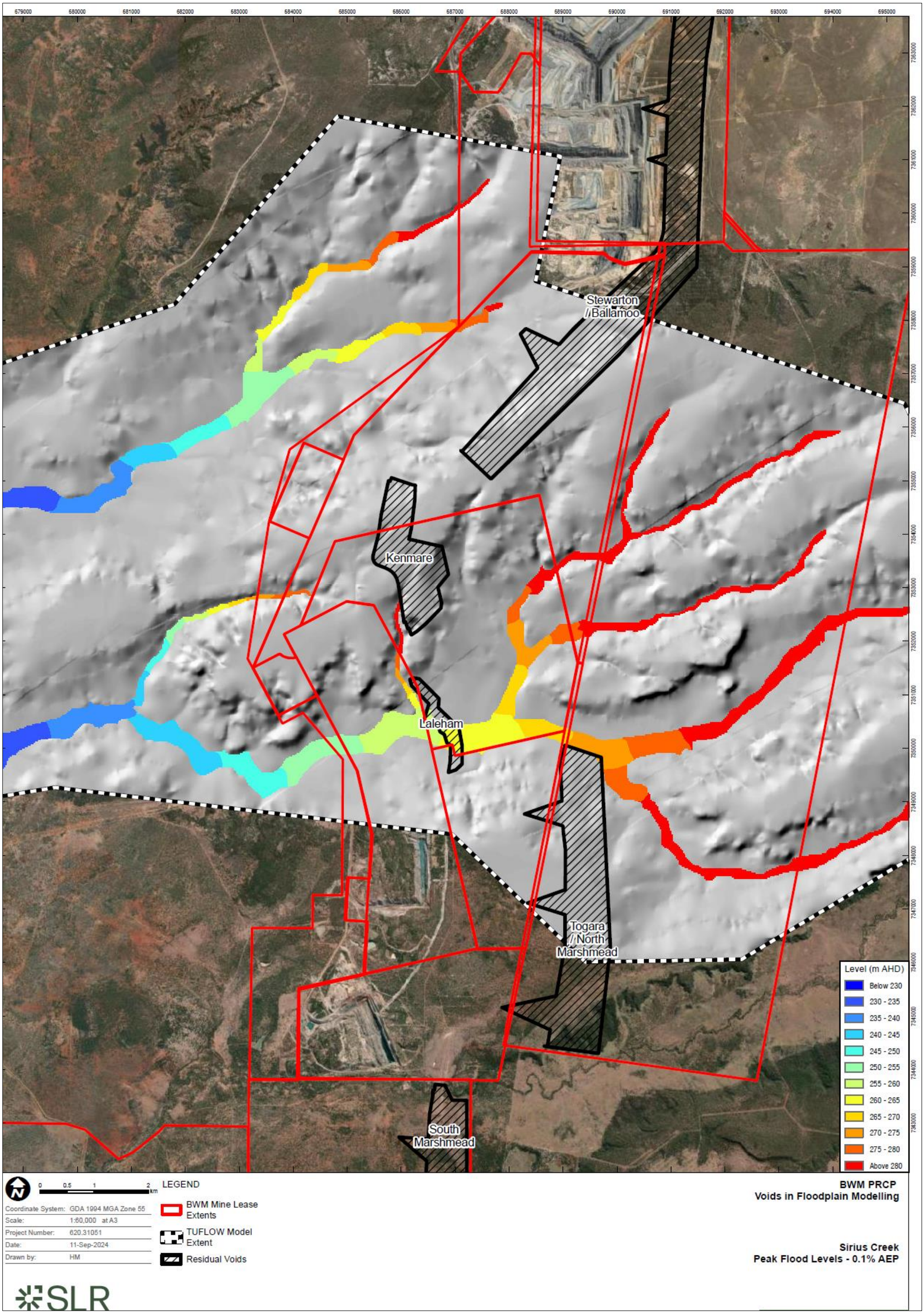

Figure 53 0.1% AEP inundation extent of Sirius Creek before reduction of the Laleham void extent

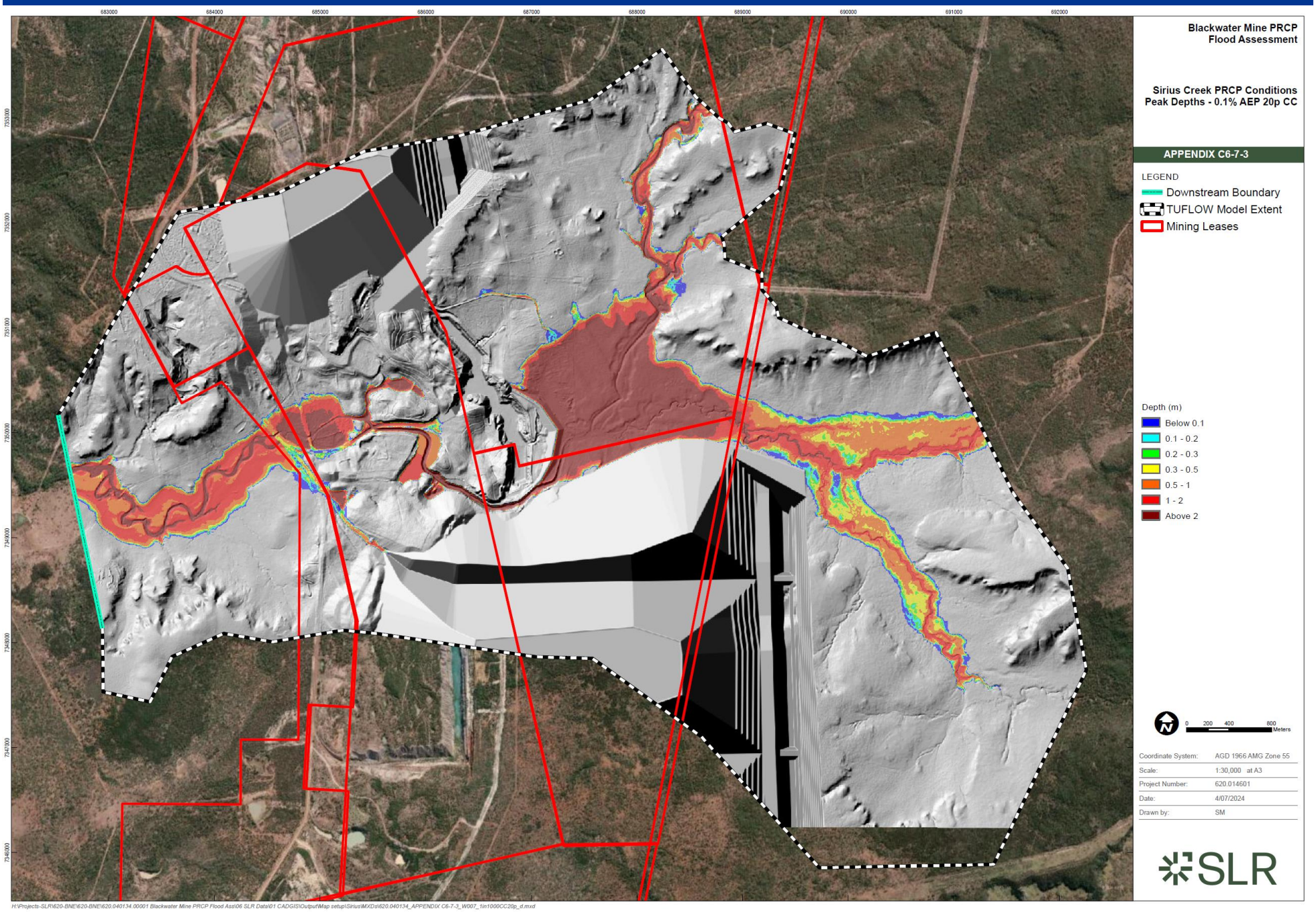

Figure 54 0.1% AEP inundation extent of Sirius Creek after reduction of the Laleham void extent, also including 20% increased rainfall intensity (climate change scenario)

3.5.4 Underground mining

PRCP Guideline (Section 3.6.4)

For underground mining operations, the rehabilitation planning part must include:

- *a geotechnical study*
- *an assessment of groundwater interactions and potential lowering of groundwater levels*
- *the development of a hydrogeological conceptual model*
- *subsidence analysis and modelling and a subsidence vegetation/habitat impact assessment*
- *consideration of how potential entries to underground workings will be sealed (i.e. through some form of capping or backfilling)*
- *how surface ponding and cracking will be mitigated*
- *identification of post-closure stabilisation of underground workings in order to manage the potential for unplanned surface subsidence and unplanned ground collapse such as sinkholes and pot holing.*

A *Geotechnical Considerations for Closure of Underground Mines at Blackwater* (Byrnes Geotechnical, 2024) has been compiled to support the development of this PRC Plan. The detailed report is provided in Appendix 4.16.

3.5.4.1 Context

No active underground mining is being undertaken at BWM. The details of the historic underground mines located within the Blackwater MLs is provided in Table 45. The location of these workings is provided in

Table 45 Summary of historic underground mines at BWM

Underground mine	Operating timeline	Mining method
Kenmare 1 + 2	1994-1997	Longwall
Laleham	1969-2001	Pillar extraction Bord-and-pillar
Sirius Creek No. 1 and No. 2	1970s*	Bord-and-pillar
Ballamoo	1970s*	Bord-and-pillar (headings only)
Clutha Trial mine	1970s*	Single 80 m heading only

*Assumed

For this assessment, only the Kenmare and Laleham historic underground workings were analysed. The other areas were omitted due to the following:

- Sirius Creek No. 1 was a 900 m single entry until it intersected the Aries Seam at about 300 m depth where a line of 18 m wide pillars were formed. Being a single row of pillars, their stability is very high – *it is assessed that these will never collapse and there will be no associated surface subsidence*.
- Sirius Creek No. 2 utilised 2 of 6 m wide roadways with a 15.2 m wide pillar until it intersected the pit bottom at about 200 m depth, at which point pillars were formed on 30 m centres (24 m solids). The limited lateral extent of the pillars, together with their width means that they have high levels of stability – *it is assessed that these will never collapse and there will be no associated surface subsidence*.
- Ballamoo mine extended about 190 m from the Ballamoo highwall and involved 5 headings. No pillars were formed. The headings were located on 30 m centres with 7 m wide roads and will be buried with backfill as part of the closure landform. As the maximum mining depths were in the order of 50 m, *no pillar instability is anticipated* even when they are buried by backfill.
- Clutha Trial mine was a single 80 m heading. Mining never progressed at this location.

3.5.4.2 Stability assessment

An assessment of the current and ongoing stability of the underground workings was undertaken to determine the risk of subsidence at closure and, specifically, the impact on the overlying PMLU (of woodland habitat).

For operational reasons, the pillars in the main access roadways (Mains pillars) were designed with high levels of stability and a design life in excess of 50 years. Typically, Mains pillars are dimensioned with a FoS > 2.0, with industry experience agreeing that the probability of failure is better than 1:1,000,000. It is valid to conclude that these Mains pillars have not and will not collapse.

In both legacy pillar mines and longwall mines, some pillars were designed to collapse as an integral part of the mining system. For example, longwall chain pillars and some pillars in pillar extraction mines. These will have already collapsed, and associated surface subsidence was developed. Some pillars have intermediate levels of stability. Typically, during mining operations, the heuristics applied to pillar stability relate to a ratio of pillar strength:pillar load. Typical thresholds used for mine design are presented in Table 46.

Table 46 Industry pillar stability thresholds

Stability	FoS	Implied probability of collapse (within 50 years)
Immediate collapse	< 1.0	1:1
Short-term	> 1.2	1:10
Pillar formed in advance	> 1.6	1:1,000
Long-term	> 2.11	1:1,000,000

From a rock mechanic perspective, the ultimate strength of a pillar relates to the frictional restraint that can be developed once any cohesive strength is lost (for example by overstressing or weathering). If a very much lower-bound frictional strength of 12° is adopted for coal it would follow that the width-to-height ratio of a coal pillar would need to be 4.7 for the pillar to completely collapse (by lateral displacement) assuming that the loading is purely vertical; this is similar to the upper bound in the database of failed pillars. Based on this, it has been assumed that for the historic bord-and-pillar workings (Laleham) and longwall workings (Kenmare), long-term stability will be present if the FoS is > 1.6 and/or the aspect ratio of the pillars is > 4.7.

Based on the above, Table 47 provides the outcomes of the pillar stability analysis for Kenmare and Laleham, indicating that:

- There is some potential for further subsidence above pillars C, F, G, N and P (all Laleham)
- However, due to the depths of cover being mostly in excess of 30 m for both the Laleham and Kenmare portal areas, pot-hole risk is highly unlikely to occur.

Table 47 Pillar stability analyses for the Kenmare and Laleham historic underground workings

Location	Depth (m)	Width:Height ratio	FoS
Pillar A Kenmore Mains	110	5.5	3.58
Pillar B Laleham Aries First Workings 1	150	5.0	2.19
Pillar C Laleham Aries First Workings 2	170	3.1	1.14
Pillar D Laleham Aries First Workings 3	160	4.4	1.70
Pillar E Laleham Aries First Workings 4	140	3.9	1.69
Pillar F Laleham Aries First Workings 5	120	2.8	1.58
Pillar G Laleham Aries First Workings 6	130	2.5	1.27
Pillar H Laleham Aries Mains	130	9.2	5.08
Pillar I Laleham Pollux 1 North Mains	170	9.0	3.48

Location	Depth (m)	Width:Height ratio	FoS
Pillar J Laleham Pollux 303 Panel Split Pillars	150	3.8	1.69
Pillar K Laleham Pollux 3 South Panel Split Pillars	140	3.8	1.99
Pillar L Laleham Pollux 4 South Panel	120	3.8	2.30
Pillar M Laleham Pollux East Headings	80	8.1	6.13
Pillar N Laleham Pollux 111 Panel Split Pillars	165	3.5	1.39
Pillar O Laleham Pollux 1 East	170	8.1	3.03
Pillar P Laleham Pollux 100 Panel Split Pillars	160	2.8	1.16

When considering flooding impacts on pillar stability:

- Laboratory analysis indicates a measurable decrease in uniaxial compressive strength on saturation of coal measure rocks. However, it is assessed that this strength loss will not add materially to the consideration for the stability of the pillars in Laleham.
- There is a possibility of a reduction in the floor strength of the roadways which would result in a reduction in the bearing strength of the pillar floor system. The reduction in roadway floor strength may be relatively small so the impact on pillar stability will be minor unless the impacted layer is very thick and initial floor stability is low. The available information on the Aries and Pollux seams suggests that the floor strengths are well in excess of those that could be associated with this type of failure mechanism.
- Lastly, in contrast to the above, there will be an overall trend for an increase in stability related to a buoyancy effect as the water level rises above the coal seam. The result is that any decrease in stability will be temporary while the material at or below seam level softens and the water level is such that there is no buoyancy effect. Over time as the water level rises above the coal seam level, buoyancy will dominate and stability will increase beyond that at mine closure. It is valid to include consideration of buoyancy when using the available method to estimate pillar loading.

3.5.4.3 Surface deformations

Mining subsidence results in the following deformation and associated impacts at the surface which can, in turn, impact the functionality of the overlying PMLU (woodland habitat for areas above the underground workings):

- Downward vertical movements.
- Change in surface slope angles.
- Vertical steps and compression humps.
- Surface cracking.

Subsidence prediction assessment of the Kenmare and Laleham historic underground workings indicate that across both areas:

- The level of vertical subsidence, change in slope, and tensile/compressive strains expressed relative to the area defined by the 20 mm vertical subsidence level. The maximum change in slope is 4.8° (8%).
- The nature of the rib parallel cracking associated with both, longwall and pillar extraction shows cracks up to 200-250 mm wide with depths sometimes over 2 m. It was observed during the inspection (May 2023) that the cracking does not appear to have adversely impacted vegetation growth. The mining was concluded more than 20 years ago but there is no obvious natural remediation of the cracking; this is attributed to the surface geology – duricrust (Czl) or sandstone/mudstones of the Emerald Formation (Czoem).

The surface above Laleham extraction panels where the surface geology appears to be Quaternary (Qrc) are shallow linear “trenches” that are interpreted to have been large tensile cracks that have “self-healed” over the years through rainfall and sediment migration.

3.5.4.4 Hydrogeological interactions

Based on the assessment of water levels recorded in pump holes in May 2023, the following was determined:

- Kenmare 1 workings are flooded - any strength losses due to inundation have already developed, with no hazard of additional collapses.
- Kenmare 2 appears to be flooded (due to minimal separation distance from Kenmare 1) – any strength losses due to inundation have already developed, with no hazard of additional collapses.

3.5.4.5 Seals and bulkheads

Mine seals are used to manage or limit water and gas flows as well as to control physical access to parts of the mine. For BWM, these are relevant to portal entrances and ventilation shafts.

For Kenmare 1, the Statutory Mine Plan (Plan of Abandonment) submitted to the Mines Department in 2001 shows seals at about 142 m from the portal entrance in both the “Man & Materials” & “Conveyor” drifts. A survey of the “Man & Materials” drift that was conducted on 19 October 2023 showed that the drift has filled (floor to roof) with silt to a distance of about 70 m from the entrance.

The main ventilation shaft for Kenmare 1 is annotated as sealed on the statutory mine abandonment plan and there is a plaque glued to the concrete plug on top of the shaft.

For Kenmare 2, Kenmare 2 retreated the longwall face into an existing surface excavation which has since been incorporated into the surface operation.

The Laleham portals have been either dozed in or dumped over.

Sirius Creek No. 1 was closed soon after opening and the portal entries are no longer visible. Re-excavation is not recommended. At Sirius Creek No. 2, permanent seals appear to have been installed at about 1150 m from the portal entrance in both the Man & Materials and Conveyor drifts. The symbols appear to indicate an “Explosion Proof Stopping” on the statutory mine plans submitted to the Mines Department in 1976.

The Clutha portal is located at the outcrop of the Aries Seam. It was a single entry only, approximately 80 m long. Recommendations for closure include removal of the arches and lagging bords and then backfill using fill sourced from the immediate area.

Relationship with PRCP Schedule
Most of the workings in Laleham and Kenmare have been assessed to be in a stable condition given that the end of underground mining was more than 20 years ago; this has allowed for flooding of the workings and most surface subsidence to have already occurred. Rehabilitation activities will be limited to care and maintenance until the achievement of a woodland habitat PMLU can be demonstrated.

3.5.5 Built infrastructure

PRCP Guideline (Section 3.6.5)

The administering authority’s expectation of rehabilitation relating to built infrastructure is that it will be decommissioned, demolished, salvaged and/or disposed of unless it is being formally retained by the landholder to achieve an appropriate PMLU.

The rehabilitation planning part must include:

- *Identification of infrastructure that will be decommissioned and the methods for decommissioning.*
- *A description of infrastructure that will remain post rehabilitation and the identification of ongoing maintenance requirements.*
- *Evidence of agreement for any infrastructure that will have ownership transferred.*

3.5.5.1 Context

In accordance with EA condition E21: *"All infrastructure constructed by or for the EA holder during the mining activities including water storage structures, must be removed from the site prior to surrender, except where agreed in writing by the post-mining landowner/landholder"*. However, the EA further notes that *"this is not applicable where the landowner/landholder is also the environmental authority holder"* (Section 3.1.2.12).

Due to the long life of the operation, BWM does not currently have any agreements in place for mining related infrastructure that may have ownership transferred in the future. Should formal agreements for the transfer of mining related infrastructure ownership be required in the future, these will be developed and secured as the mine progresses through the rehabilitation milestones associated with the PRCP Schedule. In the instance that no agreements are in place and the intent is not to retain the infrastructure, rehabilitation will be carried out as defined in the PRC Plan and PRCP Schedule, and in support of the proposed PMLU for the relative area. Table 48 details the infrastructure associated with the mining activities at BWM.

Infrastructure not constructed for mining purposes, such as dams for grazing, gates, cattle grates, stock handling/watering areas, access tracks, fire breaks etc, will not be removed as part of rehabilitation works.

Priority will be to repurpose, salvage or recycle any infrastructure to be removed. Demolition and disposal within the mining voids or spoil dumps, will only be undertaken when repurpose, salvage or recycle alternatives are deemed by Whitehaven not to be viable. This approach is in line with the waste and resource management hierarchy outlined in the Queensland Waste Management and Resource Recovery Strategy created under the *Waste Reduction and Recycling Act 2011* (Qld).

The timing of the decommissioning and removal of the infrastructure is based on the proposed timing of the BWM operation, processing of the final coal and rehabilitation activities. Further detail on the rehabilitation stages after decommissioning of the infrastructure, such as landform reshape, surface preparation, revegetation and monitoring, are covered in the relevant sections of this PRC Plan and PRCP Schedule.

Table 48 Infrastructure associated with the approved BWM activities

Category		Infrastructure
Built infrastructure	Steel, concrete and brick infrastructure	— CHPPs — Conveyors and transfer stations — Stackers and reclaimers — Surge bins and hoppers — Tunnels — Various buildings e.g. administration, crib rooms, warehouse, laboratory, storage, sheds — Workshops — Fuel, oil, chemical and water storage — Fuel and wash bays — Fences
	Supporting services	— Pipes and pumps — Power lines — Switchyard and substations — Communication and lighting towers — Concrete pads and bitumen — Culverts
Water infrastructure	Supporting services	— Mine-affected water dams — Raw water dams — Sediment dams — Drains

In terms of third-party infrastructure associated with roads, rail, power, water and communications supply to landowners or townships, these areas do not have a defined PMLU and the rehabilitation of these areas

is not included in this PRC Plan. These areas have been undisturbed by mining activities and may continue to exist once mining activities have ceased, subject to the owner's discretion. Table 49 and Figure 19, Figure 20, Figure 55 and Figure 56 outline the third-party owned land and assets (infrastructure) which is located within the BWM mining leases which will not be rehabilitated under this PRC Plan.

In relation to Figure 19 and Figure 20, it is important to note that the legend and mapping insets within this figure show areas defined as *"Existing retained third-party infrastructure subject to potential future re-alignment".* These areas are shown to denote where the potential future realignment of third-party infrastructure may be required to enable mining activities in accordance with the PRC Plan. Any future realignment of these areas, and also potentially other areas not currently defined, would be subject to future agreement between Whitehaven and the relevant owner. For clarity, should future mining activities not progress in these areas, the infrastructure will remain in place and any future decisions, including for decommissioning and rehabilitation, will be at the discretion of the owner.

Table 49 Third-party owned land and assets within BWM Mining Leases

Infrastructure Item	Owner/Operator	Relevant Land Tenure/Rights	Within Surface Area Rights?	Authorised under BWM EA (as ERA)?
Bauhinia Railway	Crown lease held by Department of Transport and Main Roads. Subleased to Aurizon Network Pty Ltd.	Aligns with area of Easement KSP257940 held by Aurizon for railway and also Lot 76 HT561, being a Crown lease held by Department of Transport and Main Roads and subleased to Aurizon Network Pty Ltd.	Part	No – railway constructed and used in accordance with Crown lease and sublease held by Aurizon Network Pty Ltd.
	Freehold title owned by Department of Transport and Main Roads. Subleased to Aurizon Network Pty Ltd.	Aligns with Lot 1SP185514 held by the Department of Transport and Main Roads and subleased to Aurizon Network Pty Ltd.	No	No – surface not included in ML over the subject area.
Ergon overhead power 132kV	Ergon Energy Corporation Ltd	Aligns with area of Easement CSP173050 (EMT 708522588) held by Ergon Energy Corporation Ltd for power supply	Yes	No – powerline constructed under authority of registered easement.
Ergon overhead power Thermal Coal Plant 22kV Feeder	Ergon Energy Corporation Ltd	Aligns with Lot 22HT600, which is subject to Lands Lease TL0/231769 held by WHC. Certificate of title for Lot 22HT600 records easement in gross No 708522588 to Ergon Energy burdening Lot 22 on HT600 over easements A and C on SP173050 and easements U AND UU on SP173047. Certificate of title for Lot 22HT600 also records easement in gross No 714916062 to Ergon Energy burdening the land over easements AR and AT on SP255267.	No	No – powerline constructed under authority of registered easement.
Ergon overhead power 66kV	Ergon Energy Corporation Ltd	Aligns with Easement BH456 (EMT 601358555) held by Ergon Energy Corporation Ltd for power supply	Yes	No – powerline constructed under authority of registered easement.
South Blackwater Rail	Crown lease held by Department of Transport and Main Roads. Subleased to QR Network Pty Ltd.	Aligns with Lands Leases 35HT240, 36HT243, 7HT243 held by Department of Transport and Main Roads and subleased to QR Network Pty Ltd.	No	No – railway constructed and used in accordance with Crown lease and sublease held by QR Network Pty Ltd.
Ardurad Road	Central Highlands Regional Council	Public road corridor. Aligns with Compensation Agreement between WHC (subject to assignment from BMA) and Central Highlands Regional Council.	Yes	No – public road subject to road reserve and managed by Council
Sunwater Blackwater pump station to Cook	Sunwater Ltd	Aligns with Lands Lease VAP17084 (PO241302) held by Sunwater Ltd	Yes	No – pump station is subject to terms of lands lease
Yarrawonga Road	Central Highlands Regional Council	Public road corridor. Aligns with Compensation Agreement between WHC (subject to assignment from BMA) and Central Highlands Regional Council	Part	No – public road subject to road reserve and managed by Council
Cook Colliery Rail Loop	Constellation Mining Pty Ltd	Aligns with Lands Lease TL 0/233298 (Lot 30HT640) held by Constellation Mining Pty Ltd	No	No – activities subject to Lands Lease TL 0/233298 (Lot 30HT640) held by Constellation Mining Pty Ltd
Cook Colliery CHPP Access Road	Constellation Mining Pty Ltd	Aligns with Lands Lease TL 0/233298 (Lot 25HT635) held by Constellation Mining Pty Ltd	No	No – activities subject to Lands Lease TL 0/233298 (Lot 25HT635) held by Constellation Mining Pty Ltd
South Blackwater Rail	South Blackwater Coal Pty Ltd, Constellation Mining Pty Ltd	Aligns with Lands Lease TL 0/234784 (Lot 9HT545) held by South Blackwater Coal Pty Ltd, road reserve for Blackwater Rolleston Road, Lands Lease TL 0/233298 (Lot 27HT637) held by Constellation Mining Pty Ltd, Lands Lease TL 0/233298 (Lot 6SP179577) held by Constellation Mining Pty Ltd	No	No – rail activities carried out under authority of lands lease.
Blackwater-Rolleston Road	Central Highlands Regional Council	Aligns with the road reserve for Blackwater Rolleston Road and Lands Lease TL 0/233298 (Lot 6/SP179577) held by Constellation Mining Pty Ltd	No	No – public road subject to road reserve and managed by Council
Blackwater Mine Railway	Freehold title owned by Department of Transport and Main Roads. Subleased to QR Network Pty Ltd.	Aligns with Lot 22HT562 held by the Department of Transport and Main Roads and subleased to QR Network Pty Ltd.	No	No – surface not included in ML over the subject area.
PowerLink Overhead Power 132kV	Powerlink / Ergon Energy Corporation Ltd	Infrastructure located within easements EMT 602656588 and EMT 602656587 held by Ergon Energy Corporation Ltd for power supply.	Yes	No – existing infrastructure for power supply unrelated to mining activities.
Ergon Overhead Power 22kV	Ergon Energy Corporation Ltd	Does not fall within any easements shown in existing spatial data.	Yes, in parts	No – where powerlines do not link to mine infrastructure

Infrastructure Item	Owner/Operator	Relevant Land Tenure/Rights	Within Surface Area Rights?	Authorised under BWM EA (as ERA)?
Ergon Overhead Power 66kV	Ergon Energy Corporation Ltd	Aligns with easement EMT602811179 held by Ergon and does not appear to relate to mining operations or infrastructure.	Yes, in parts	No – existing infrastructure for power supply unrelated to mining activities.
Ergon Overhead Power 66kV	Ergon Energy Corporation Ltd	Do not fall within any easements shown in existing spatial data but do not appear to relate to mining operations or infrastructure.	Yes, in parts	No – existing infrastructure for power supply unrelated to mining activities.
Taurus Road	Central Highlands Regional Council	Subject to compensation agreement with Council for works within road corridor.	Yes	No – public road subject to road reserve and managed by Council
MountainView Homestead access Road	Whitehaven Blackwater Pty Ltd	Private access road to homestead owned by WHC	Yes	No – road is for access to homestead and not associated with mining activities.
Humboldt Comet Road	Central Highlands Regional Council	Subject to compensation agreement with Council for works within road corridor.	Yes	No – public road subject to road reserve and managed by Council
Taurus Homestead	Third-party	Privately owned by third-party and subject to compensation agreement.	Yes	No – Existing homestead not affected by mining operations
MountainView Homestead	Whitehaven Blackwater Pty Ltd	Privately owned by WHC	Yes	No – Existing homestead not affected by mining operations

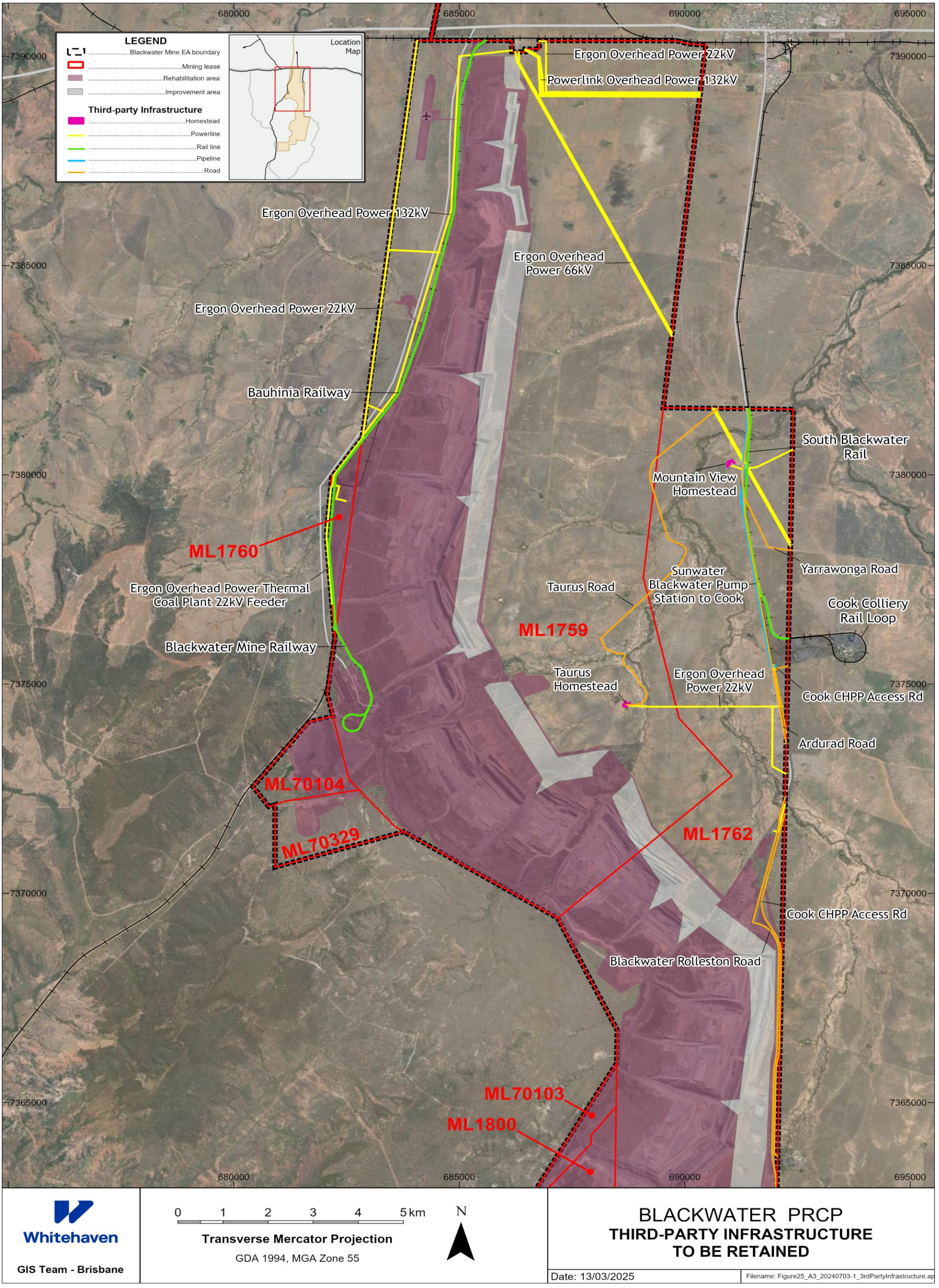

Figure 55 Third-party infrastructure to be retained (BWM North and Central)

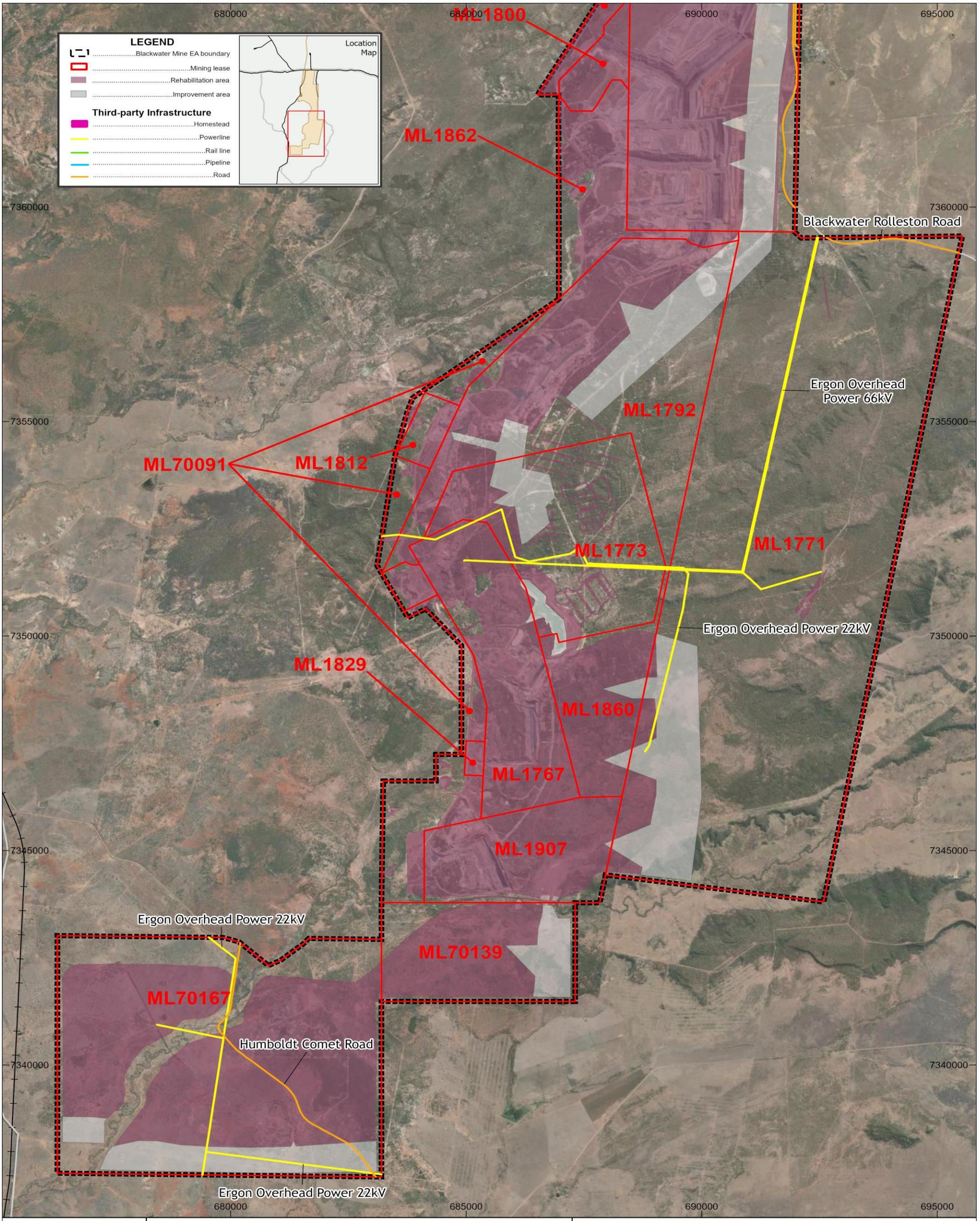

Figure 56 Third-party infrastructure to be retained (BWM Central and South)

3.5.5.2 Built infrastructure

Decommissioning of the built infrastructure with no beneficial use to the PMLU will follow the resource management hierarchy and will include:

- Disconnecting services
- Removing surface built and service infrastructure through salvage or recycling activities, or demolishing and burying in the mining voids or spoil dumps
- Removing below-ground built and service infrastructure to a depth of 0.5 m below the surface and recycling, or burying in the mine void or spoil dumps, or covering to a minimum depth of 0.5 m to enable the establishment of the PMLUs
- Removing concrete to a depth of 0.5 m below the surface and recycling, or burying in the mine void or spoil dumps, or covering to a minimum depth of 0.5 m to enable the establishment of the PMLUs
- Removing bitumen and recycling, or burying it in the mining voids or spoil dumps
- Disposing of demolition-related putrescible and hazardous wastes at an appropriately licenced facility.

3.5.5.3 Water infrastructure

Decommissioning of the water-related infrastructure constructed for the mining activities with no beneficial use to the PMLU will include:

- Removing any remaining water to the residual voids or in accordance with:
    - EA F25: *"Mine affected water may be piped or trucked or transferred by some other means that does not contravene the conditions of this environmental authority and deposited into artificial water storage structures, such as farm dams or tanks, or used directly at properties owned by the environmental authority holder or a third party (with the written consent of the third party with agreed water quality limits)".*
- Disposing of mine dam sediment according to the results of an assessment by an AQP
- Removing any mine dam liners
- Breaching mine dam walls and reshaping of the area to make it free-draining.

3.5.5.4 Contaminated land

Mining operations at BWM commenced in 1967, prior to the enactment of modern environmental legislative requirements and standards. Therefore, pre-mining baseline contaminated land data and records pertaining to historical environmental incidents/management from the earlier BWM operations are not available.

Operations at BWM since the commencement of mining/exploration have included heavy industrial activities and supporting infrastructure including the following:

- Drilling/exploration
- Extraction and processing of coal
- Chemical storage
- Waste storage and disposal
- Sewage treatment
- Operation of a variety of plant/equipment and maintenance workshops
- Laydown yards and scrap yards

- Petroleum product storage and dispensing
- Explosive production, storage and use
- Mineral waste (tailings, rejects) storage and disposal

The nature of these types of operations, which include the storage, handling, use and disposal of hazardous materials, particularly over BWM's historical and planned operations, have the potential to result in the contamination of land. Lot 5 on SP199760, Lot 5 on HT620, Lot 6 on SP185517, Lot 6 on HT204, Lot 12 on SP185512, Lot2237 on PH1600, Lot 15 on HT304 and Lot 24 on CP855505, are listed on the Queensland Environmental Management Register for a range of notifiable activities including:

- Chemical storage
- Landfill
- Petroleum product or oil storage
- Engine reconditioning works
- Mine wastes
- Abrasive blasting
- Scrap yards
- Waste storage, treatment or disposal
- Explosive production or storage
- Metal treatment of coating

At the time of the contaminated land searches (October 2023), the searched properties were not listed on the Queensland Contaminated Land Register and did not have Site Management Plans attached to the register listings.

The current BWM EA provides for the conditional on-site disposal of various wastes including:

- Rejects and tailings
- Water or sediment containing hydrocarbons
- Bulk rubber
- Inert waste.
- Poly-pipe and other plastic
- Fibreglass
- Treated and untreated timber
- Asphalt
- Asbestos

Current management of contaminated land is undertaken in accordance with the EP Act (1994) and the EA conditions that require the reporting of releases of hazardous contaminants and monitoring of surface water, sediment and groundwater on a regular basis.

3.5.5.4.1 Contaminated land assessment

In accordance with the EA conditions, during operations, contaminants must not be released in a manner that constitutes environmental harm, and spillage of any wastes, contaminants or other materials must be cleaned up as quickly as practicable, stored in accordance with relevant standards and handled in a way that prevents environmental harm.

At completion of mining operations and prior to landform reshaping, surface preparation and revegetation, a contaminated land assessment will be undertaken in accordance with the National Environment Protection (Assessment of Site Contamination) Measure. The contaminated land investigation will assess the site for the presence of contamination with the potential to adversely impact the nominated PMLUs

and/or environmental values. Should land contamination be identified, the potential risks will be assessed and, where required, remediation will be undertaken and/or a Site Management Plan developed to allow the ML area to be safely utilised for the nominated PMLUs (Section 3.3).

Relationship with PRCP Schedule

Surface infrastructure not beneficial to the PMLU will be decommissioned and removed. Below-ground infrastructure will be removed if required to a depth of 0.5 m or covered to enable the establishment of the PMLU.

A contaminated land assessment will be undertaken at the completion of operations and prior to final landform development and shaping. Remediation and/or management of any identified contamination that has the potential to present unacceptable risks to the nominated PMLU or environmental values, will be undertaken.

3.6 Risk assessment

Legislative Requirement

In accordance with section 126C(1)(f) of the EP Act, the rehabilitation planning part of the PRC Plan must identify the risks of a stable condition for land described as a post-mining land use not being achieved, and how the applicant intends to manage or minimise the risks.

PRCP Guideline (Section 3.7)

As per section 126C(1)(j) of the EP Act, the administering authority considers it necessary for the proposed PRC Plan to contain a risk assessment of all proposed NUMAs. The risk assessment must be carried out to identify the risks of the NUMA causing environmental harm and not being safe and structurally stable and detail how the applicant intends to manage and minimise the identified risks.

The AS ISO 31000:2018 Risk Management – Guidelines (Standards Australia, 2018) describes risk assessment as the overall process of risk identification, risk analysis, risk evaluation and risk treatment. Each of these aspects must be included in the risk assessment in the rehabilitation planning part.

Information requirements in this section apply to all applicants whether or not they are an existing EA holder. Existing holders may have the required information available from previously submitted plans/reports/applications that, if still valid, can be used in the PRC Plan.

3.6.1 Identifying, assessing and treating risks

3.6.1.1 Risk methodology

A risk-based approach to BWM PRC Planning has been undertaken in terms of the method described in Figure 57.

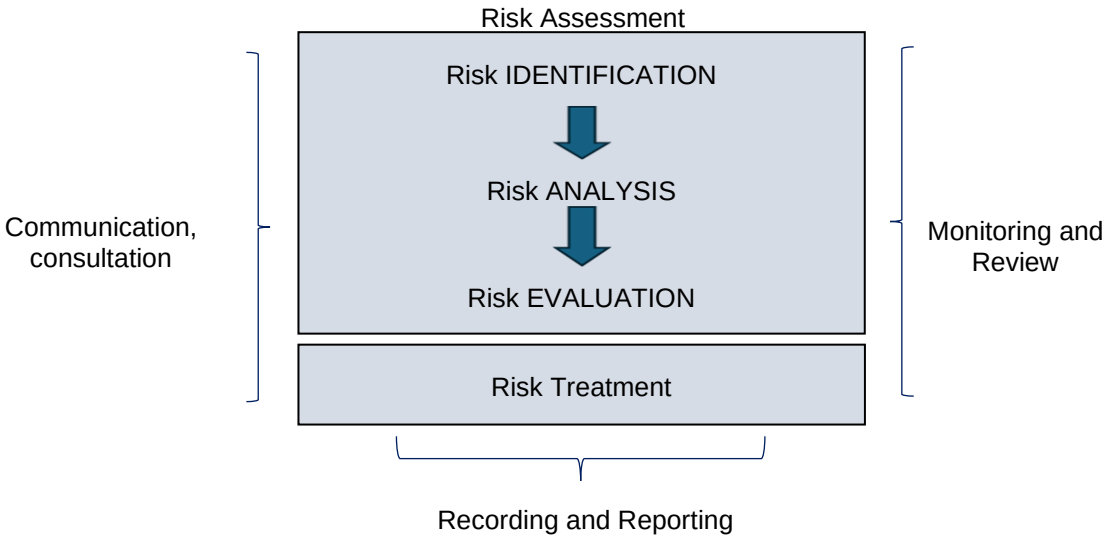

Figure 57 ISO 31000-compliant risk-based approach followed for the BWM PRC Plan

3.6.1.2 Risk identification

The risk event - a stable condition for land described as a PMLU not being achieved - was assessed per ISO 31000 methodology described in Figure 57 above, where stable condition is defined as per section 111A of the EP Act:

- The land is safe and structurally stable,
- There is no environmental harm being caused by anything on or in the land, and
- The land can sustain a PMLU

For BWM, the PMLUs being assessed are cattle grazing, woodland habitat and watercourse (Section 3.3).

In addition, the risk event - NUMA does not achieve safe and structurally stable condition or causes environmental harm - was assessed per ISO 31000 methodology described in Figure 57 above.

The full risk assessment is included in BWM PRCP Risk Assessment in Appendix 4.15.

3.6.1.3 Risk analysis, evaluation and relevant treatments

The Whitehaven likelihood vs. consequence, as well as the outcomes of the residual risk ratings matrix are in Figure 58 and Figure 59 respectively. Table 50 and Table 51 provide full detail of risk analysis, risk evaluation and risk treatment for PMLUs and NUMAs at relevant scenarios. Worst case outcomes were assessed for each scenario, preventative and mitigating controls identified, and the resultant residual risk rating was calculated.

			Consequence Rating				
			1. Negligeable	2. Minor	3. Medium	4. Major	5. Catastrophic
Likelihood	The unwanted event has occurred frequently; occurs in order of one or more times per year & is likely to reoccur within one year.	5. Almost certain	M5	H10	H15	C20	C25
	The unwanted event has occurred infrequently; occurs in order of less than once per year & is likely to reoccur within five years.	4. Likely	L4	M8	H12	H16	C20
	The unwanted event has happened at some time; or could happen within 10 years.	3. Possible	L3	M6	M9	H12	H15
	The unwanted event has happened at some time; or could happen within 20 years.	2. Unlikely	L2	L4	M6	M8	H10
	The unwanted event has never been known to occur; or is highly unlikely to occur within 20 years.	1. Rare	L1	L2	L3	L4	M5

Figure 58 Whitehaven risk likelihood vs. consequence table

Control Effectiveness

Effectiveness Rating	Description
Effective	• Controls are well designed and appropriate for the risk; • Controls are largely "preventative" and address the root causes; • Management believes that they are effective and reliable at all times; • Nothing more to be done except review and monitor the existing controls.
Improvement Required	• Most controls are designed correctly and are in place and effective; • Controls may only treat some of the root causes of the risk, and/or are not currently effective and/or there may be an over-reliance on "reactive" controls; • Management has doubts about operational effectiveness and reliability; • More work is required to improve operating effectiveness.
Ineffective	• Significant control gaps or no credible control; • Either controls do not treat root causes, are non-existent or, if they exist, they are ineffective; • Management has no confidence that any degree of control is being achieved due to poor control design; • Very limited or no operational effectiveness.

Risk Management Action

Residual Risk Rating	Minimum Control Effectiveness requirement	Action Required when minimum control effectiveness requirement not met	Escalation & Approval of Treatment Plan	Acceptance Authority
Critical	Effective	Risk treatment plan must be in place immediately. Risk reviewed monthly by Risk Owner.	Report to ARMC and Managing Director for review and approval of the treatment plan.	CEO/MD
High	Effective	Risk treatment must be considered. Risk reviewed quarterly by Risk Owner.	Report to ARMC and Managing Director. Report to Executive General Manager for review and approval of associated treatment plan.	EGM
Moderate	Effective	Risk treatment may be considered. Risk reviewed annually by Risk Owner.	Report to General Manager for review and approval of associated treatment plan.	GM
Low	Improvement Required	No risk treatment required. Risk reviewed annually by Risk Owner.	Report to Risk Owner.	Risk Owner

Figure 59 Whitehaven residual risk rating matrix

The risk treatments for each scenario that are necessary for achieving a stable condition for the land described as the PMLUs are in Table 50.

Table 50 Necessary risk treatments identified to achieve a stable condition for the PMLUs

Aspect	Risk treatment
Risk event: Stable condition (safe, stable, non-polluting and sustainable) for land described as a post-mining land (reference BWM EA Table E1 - cattle grazing, woodland habitat, watercourse, water storage) use is not achieved	
PMLU Scenario 1. Landform failure	
Reasons for selecting treatment option	Material testing and modelling indicate these treatments achieve a stable condition for the proposed final landform
Responsibility for plan: Approval Implementation	Mine planning Site operations
Proposed actions	— Materials characterisation — Growth media assessment by an AQP to determine ameliorant and physical treatment requirements — Landform designed for materials available onsite and what can be achieved based on their properties — PMLU selected based on what is most appropriate for landform and materials

Aspect	Risk treatment
	— Groundcover of vegetation and rock to provide erosion resistance — Rehabilitation monitoring and maintenance
Resource requirements	— Available material inventory — Erosion modelling — Equipment capabilities — Survey — Rehabilitation monitoring data — AQP to undertake growth media assessment
Performance measures and constraints	— Comparison against design — Tracking against milestone criteria
Reporting and monitoring	Rehabilitation monitoring
Risk timing and scheduling	From commencement of rehabilitation activities to final achievement of PMLU
PMLU Scenario 2. Alteration of hydrogeological conditions	
Reasons for selecting treatment option	Studies and analysis performed show that these treatments achieve a stable condition for the proposed final landform
Responsibility for plan: Approval Implementation	Site operations Environment team
Proposed actions	— All imported hazardous materials are to be stored and used in accordance with relevant standards and removed from site on completion of mining — At the completion of operations, all stored hazardous materials and infrastructure within the MIA and CHPP, that have the potential to release contaminants to groundwater, will be appropriately recycled or disposed of — Contaminated land investigation to be undertaken at the completion of operations to identify contamination that has the potential to cause impacts to groundwater — Implementation of remediation and/or management plans as required to reduce potential groundwater impact risks — Mine affected water dams to be decommissioned (including investigation for potential contamination and groundwater impacts). — Groundwater monitoring to be undertaken in accordance with EA conditions — Appropriate management, placement, and monitoring of waste (spoil, tailings, rejects) during operations — Landforms constructed to minimise the potential for flooding of the residual voids
Resource requirements	— Monitoring bores maintained and monitoring undertaken
Performance measures and constraints	— Operational EA condition for groundwater contaminant trigger levels
Reporting and monitoring	Monitoring at defined frequency Reporting under existing EA requirements
Risk timing and scheduling	From establishment of landforms with sampling as per PRCP monitoring program

Aspect	Risk treatment
PMLU Scenario 3. Alteration of surface water systems	
Reasons for selecting treatment option	Studies and analysis performed show that these treatments achieve a stable condition for the proposed final landform
Responsibility for plan: Approval Implementation	Site operations Environment team
Proposed actions	— All imported hazardous materials to be stored and used in accordance with relevant standards and removed from site on completion of operations — Mine affected water dams to be decommissioned and areas rehabilitated — Surface water monitoring to be undertaken in accordance with EA conditions — A contaminated land investigation will be undertaken at the completion of operations and remediation works undertaken as appropriate — Rehabilitation of disturbed areas will be undertaken as soon as possible after land become available — Rehabilitation and monitoring of disturbed reaches of creeks undertaken — Appropriate management, placement, and monitoring of waste (spoil, tailings, rejects) during operations — Landforms constructed to minimise the potential for flooding of the residual voids
Resource requirements	— AQP to undertake surface water sampling — Sampling equipment and infrastructure to allow collection of samples during runoff events
Performance measures and constraints	— Surface water (rainfall runoff) milestone criteria and WQO
Reporting and monitoring	Monitoring when surface water flows are available Reporting under existing EA requirements
Risk timing and scheduling	During runoff events
PMLU Scenario 4. Failure of creek diversions to meet closure objectives	
Reasons for selecting treatment option	Studies and analysis performed show that these treatments will achieve a stable condition for the proposed watercourse PMLU
Responsibility for plan: Approval Implementation	Site operations Environment team
Proposed actions	— Creek diversion remediation concept designs to be progressed to functional designs when rehabilitation of surrounding areas commences. — Construction of any remediation diversion channels in line with the final functional designs — Removal and remediation of any mine infrastructure that presents an unacceptable risk to the diversion attaining a relinquishable state (i.e. culverts and dams) — Rehabilitation of surrounding landforms — Surface water monitoring to be undertaken

Aspect	Risk treatment
	— Creek diversion monitoring to relevant IDC standard and maintenance to be undertaken
Resource requirements	— AQP to progress concept designs to functional designs, including flood modelling — Creek diversion monitoring and maintenance — Collection and analysis of water samples
Performance measures and constraints	— Watercourse geomorphic index and riparian vegetation index milestone criteria — Surface water (rainfall runoff) milestone criteria and WQO
Reporting and monitoring	Creek diversion monitoring Surface water quality data
Risk timing and scheduling	As scheduled frequencies from commencement of rehabilitation activities to final achievement of PMLU
PMLU Scenario 5. Contaminated land impacting on environmental receptors, rehabilitation and attainment of PMLUs	
Reasons for selecting treatment option	Studies and analysis performed show that additional works are required to reduce contaminated land risks and to achieve a stable condition for the proposed final landform
Responsibility for plan: Approval Implementation	Site operations
Proposed actions	— Environmental monitoring and reporting as per the EP Act and existing EA requirements. — Contaminated land investigation at time of closure
Resource requirements	— SQP to undertake contaminated land investigations and oversee on-going monitoring requirements — Sample collection, laboratory analyses and engineering controls
Performance measures and constraints	— Attainment of surface water milestone criteria and a site suitability statement
Reporting and monitoring	Contaminated land investigation report and reporting of water quality as per EA
Risk timing and scheduling	Contaminated land Investigation at closure and water sampling as per PRCP monitoring program
PMLU Scenario 6. Flooding influences on rehabilitation and final landforms	
Reasons for selecting treatment option	Studies and analysis performed show that these treatments achieve a stable condition for the proposed final landform
Responsibility for plan: Approval Implementation	Site operations
Proposed actions	— Removal of infrastructure from watercourses, decommissioning of dams and remediation/management of contaminated material where required — Design of landforms informed by flood modelling, within flood extents that are safe and stable — Establishment of vegetation suitable for the environment and reduces erosion risks

Aspect	Risk treatment
	— Undertake monitoring for potential landform risks and undertake rectification works to attain PRC plan milestone criteria
Resource requirements	— AQP to undertake monitoring of final landforms post flood events
Performance measures and constraints	— No flooding damage to landforms up to a 0.1% AEP event
Reporting and monitoring	Rehabilitation monitoring
Risk timing and scheduling	As per PRCP monitoring program
PMLU Scenario 7. Rehabilitated landforms result in alteration of flood hydrology upstream and downstream	
Reasons for selecting treatment option	Studies and analysis performed show that these treatments achieve a stable condition for the proposed final landform. Flood modelling indicated some variability when compared to pre-mining flows. This is partially due to the coarseness of the pre-mining landform data, approved diversions such as Spring Creek and Southern Creek and reduction of catchment due to NUMA voids. Upstream flows would not be altered.
Responsibility for plan: Approval Implementation	Site operations
Proposed actions	— Removal of infrastructure within watercourse alignments (e.g. culverts) that could adversely impact flows and decommissioning of dams — Landform design informed by flood modelling and establishment of landforms that are stable — Undertake monitoring and maintenance works where required to maintain landforms — Provide appropriate level of flood protection through landforms for the residual voids
Resource requirements	— AQP to undertake monitoring of final landforms post flood events
Performance measures and constraints	— No unacceptable damage to infrastructure or ecosystems as a result of final landform
Reporting and monitoring	Not required
Risk timing and scheduling	Not required
PMLU Scenario 8. Insufficient or inappropriate growth media and rock resources required for rehabilitation activities	
Reasons for selecting treatment option	Studies and analysis performed show that these treatments achieve a stable condition for the proposed final landform
Responsibility for plan: Approval Implementation	Technical Services Environment team Site operations
Proposed actions	— Management of topsoil and rock stockpiling — Management of rehabilitation material application — Review of the growth media and rock resource quantities periodically during operations — Growth media assessment by suitably qualified person to determine ameliorant and fertiliser requirements

Aspect	Risk treatment
	— Application of ameliorants and fertilisers as per assessment — Rehabilitation monitoring and maintenance
Resource requirements	— Topsoil inventory — Burden model — Survey — Equipment capabilities — Rehabilitation monitoring data — AQP to undertake growth media assessment
Performance measures and constraints	Tracking against milestone criteria
Reporting and monitoring	Rehabilitation monitoring
Risk timing and scheduling	From planning of soil stripping to final achievement of PMLU
PMLU Scenario 9. Insufficient management of mineral waste	
Reasons for selecting treatment option	Studies and analysis performed show that these treatments achieve a stable condition for the proposed final landform
Responsibility for plan: Approval Implementation	Environment team Engineering team Site operations
Proposed actions	— Waste characterisation during operations — Surface and groundwater monitoring during operation — Ongoing sampling during operations — Reject material appropriately placed in spoil dumps. — In-situ geochemical monitoring of landforms — Rehabilitation monitoring and maintenance
Resource requirements	— Data from waste characterisation — Mineral waste sampling data — Rehabilitation monitoring data — Surface and groundwater monitoring data — In-situ geochemical monitoring data
Performance measures and constraints	— Tracking against surface water milestone criteria
Reporting and monitoring	Rehabilitation monitoring Waste characterisation sampling and analysis Surface and groundwater monitoring
Risk timing and scheduling	Throughout operations to final achievement of PMLU
PMLU Scenario 10. Inadequate and/or inappropriate revegetation	
Reasons for selecting treatment option	Studies and analysis performed show that these treatments achieve a stable condition for the proposed final landform
Responsibility for plan: Approval	Environment team Site operations

Aspect	Risk treatment
Implementation	
Proposed actions	— Growth media assessment by suitably qualified person to determine ameliorant and fertiliser requirements for the PMLU — Management of seed selection, provenance and quality — Rehabilitation monitoring and maintenance
Resource requirements	— Rehabilitation and reference site monitoring data — Seeds — AQP to undertake growth media assessment
Performance measures and constraints	— Tracking against milestone criteria
Reporting and monitoring	Rehabilitation and reference site monitoring
Risk timing and scheduling	From rehabilitation seeding to final achievement of PMLU
PMLU Scenario 11. Failure of TSF rehabilitation	
Reasons for selecting treatment option	Rehabilitation monitoring and performance tracking showed that the constructed rehabilitated landform will achieve PMLU criteria
Responsibility for plan: Approval Implementation	Site operations Dam engineers
Proposed actions	— Rehabilitation monitoring and maintenance — Corrective actions, if identified as being needed
Resource requirements	— Monitoring program — Maintenance and remediation where rehabilitation outcomes do not meet planned performance criteria
Performance measures and constraints	— Comparison against design — Tracking against milestone criteria
Reporting and monitoring	As per the PRCP Schedule
Risk timing and scheduling	Ongoing monitoring of rehabilitation success towards achievement of PMLU
PMLU Scenario 12. Failure of TSF cover (NCPP TSF)	
Reasons for selecting treatment option	Studies and analysis performed show that these treatments are what is recommended to achieve a safe and structurally stable condition for the proposed final landform
Responsibility for plan: Approval Implementation	Environment team Site operations
Proposed actions	— Undertake a preliminary contaminated land assessment prior to the completion of the approved activities, conduct a detailed site investigation and develop remediation plan if required — Rehabilitation monitoring and maintenance
Resource requirements	— Rehabilitation monitoring data — SQP to undertake contaminated land investigations and oversee on-going monitoring requirements

Aspect	Risk treatment
Performance measures and constraints	— Tracking against remediation and management of contaminated land milestone criteria
Reporting and monitoring	Rehabilitation monitoring
Risk timing and scheduling	Throughout operations to final achievement of PMLU
PMLU Scenario 13. Deterioration of built infrastructure conditions	
Reasons for selecting treatment option	Studies and analysis performed show that these treatments are what is recommended to achieve a stable condition for the proposed final landform
Responsibility for plan: Approval Implementation	Environment team Site operations
Proposed actions	— Undertake a preliminary contaminated land assessment prior to the completion of the approved activities, conduct a detailed site investigation and develop remediation plan if required — Rehabilitation monitoring and maintenance
Resource requirements	— Rehabilitation monitoring data — SQP to undertake contaminated land investigations and oversee on-going monitoring requirements
Performance measures and constraints	— Tracking against remediation and management of contaminated land milestone criteria
Reporting and monitoring	Rehabilitation monitoring
Risk timing and scheduling	Throughout operations to final achievement of PMLU

The risk treatments for each scenario that are necessary for achieving a safe and structurally stable NUMA are in

Table 51.

Table 51 Necessary risk treatments identified to achieve a safe and structurally stable NUMA that does not cause environmental harm

Aspect	Risk treatment
Risk event: NUMA does not achieve safe and structurally stable condition or causes environmental harm	
NUMA Scenario 1. Void walls do not achieve geotechnical stability	
Reasons for selecting treatment option	Studies and analysis performed show that these treatments achieve a safe and structurally stable condition for the NUMA
Responsibility for plan: Approval Implementation	Mine planning Site operations
Proposed actions	— Geotechnical assessment to be completed by an appropriately qualified person — Wall designs based on geotechnical assessment. — Pit floor treatments as required during operations to improve low-wall stability. — Geotechnical monitoring during operations.

Aspect	Risk treatment
	— Updated geotechnical assessment to be completed as mining approaches final limits and wall design and NUMA extent adjusted if required. — NUMA extents designed to include the required FoS limit. — Bunding, fencing and signage placed at FoS limit.
Resource requirements	— Geotechnical assessment
Performance measures and constraints	— Tracking against milestone criteria
Reporting and monitoring	Geotechnical monitoring
Risk timing and scheduling	From final mining to relinquishment
NUMA Scenario 2: Uncontrolled access to NUMA	
Reasons for selecting treatment option	Studies and analysis performed show that these treatments achieve a safe and structurally stable condition for the NUMA
Responsibility for plan: Approval Implementation	Site operations
Proposed actions	— Safety bund, fencing and signage placed at FoS limit where required to restrict access
Resource requirements	— Monitoring and maintenance
Performance measures and constraints	— Tracking against milestone criteria
Reporting and monitoring	Document visual inspection
Risk timing and scheduling	From final mining to relinquishment
NUMA Scenario 3. Uncontrolled flooding into residual voids	
Reasons for selecting treatment option	Studies and analysis performed show that these treatments achieve a safe and structurally stable condition for the NUMA
Responsibility for plan: Approval Implementation	Mine planning Site operations/dam engineer
Proposed actions	— Flood modelling completed by AQP — Flood mitigation (partial backfill and/or landform structures) designed to correct flood event — Flood mitigation installed
Resource requirements	— Flood modelling
Performance measures and constraints	— Tracking against milestone criteria
Reporting and monitoring	Document visual inspection
Risk timing and scheduling	From final mining to relinquishment
NUMA Scenario 4. Water in the void causes environmental harm outside of the mining tenure	

Aspect	Risk treatment
Reasons for selecting treatment option	Studies and analysis performed show that these treatments achieve a safe and structurally stable condition for the NUMA
Responsibility for plan: Approval Implementation	Mine planning Site operations
Proposed actions	— Modelling completed by AQP — Flood mitigation designed to provide protection for a 0.1% AEP event — Groundwater quality and level monitoring until relinquishment — Water quality monitoring
Resource requirements	— Groundwater and void lake water balance modelling
Performance measures and constraints	— Tracking against milestone criteria
Reporting and monitoring	Groundwater level and quality monitoring Water quality monitoring
Risk timing and scheduling	From final mining to relinquishment

Relationship with PRCP Schedule
A risk-based approach has been adopted to develop the milestones in the PRCP Schedule. This is primarily driven by a residual risk rating. Should a risk event materialise, the additional proposed actions identified in this risk section will be implemented and, where necessary, adjusted accordingly (in line with the risk treatment identified in this section).

3.6.2 Rehabilitation trials

PRCP Guideline (Section 3.7.1)

In accordance with section 126C(1)(j) of the EP Act, if rehabilitation trials are planned, the rehabilitation planning part must state:

- *the objective of the trial(s)*
- *the trial design including, but not limited to, the location, underlying land characteristics and potential issues*
- *the details of how the trial(s) will be carried out*
- *when the trial(s) will commence*
- *the duration of the trial(s)*
- *how the trial(s) will be assessed for success*
- *how the results of the trial(s) will be incorporated into rehabilitation strategies and the development of milestones, and*
- *where the trials have previously been carried out by the applicant.*

The information requirements in this section will apply to all applicants, whether or not they are an existing EA holder, who have planned or commenced rehabilitation trials. Existing EA holders can provide details of any rehabilitation trials that have occurred prior to the submission of the proposed PRC plan.

BWM has supported and participated in extensive research programs and trials targeting specific rehabilitation activities over many years, however no rehabilitation trials are currently underway. Current rehabilitation practices will be executed in line with the PRCP rehabilitation milestone criteria for each PMLU.

3.7 Monitoring and maintenance

PRCP Guideline (Section 3.8)

Under section 126C(1)(j) of the EP Act, the administering authority considers monitoring and maintenance necessary to decide if the PRC Plan is consistent with the requirements of the legislation. The rehabilitation planning part must contain a monitoring and maintenance program that identifies and describes the monitoring systems that will be carried out in order to demonstrate a milestone and milestone criteria have been achieved. The program must include, where relevant to the milestone and milestone criteria (but is not limited to):

- *schedule of monitoring, reporting and review for each milestone*
- *description of methodologies and standards, which could include field-based assessments and the application of new remote sensing, GIS and other relevant emerging technologies*
- *monitoring that enables the repeatable collection of relevant statistically valid data*
- *monitoring using appropriate quality assurance and data management processes and systems*
- *regular analysis of site data including multi-year comparison trends and bench-marking against analogue/reference sites*
- *contingency strategies if monitoring data indicates milestone criteria are not being met*
- *post-closure monitoring to ensure milestone criteria has been demonstrated*
- *intent of monitoring reports, such as provision of results and key findings*

The information requirements in this section will apply to all applicants whether or not they are an existing EA holder. However, existing holders may already have the required information available from previously submitted plans/reports/applications that, if still valid, could be used in the PRC Plan. If there has/is any monitoring or maintenance of areas already rehabilitated, details must be included in the PRC Plan.

3.7.1 Rehabilitation monitoring program

This section focuses on the monitoring methods used to assess progressive rehabilitation at BWM, and which will be used to demonstrate achievement of the rehabilitation milestones and ultimately the desired PMLU. The schedule of monitoring, reporting and review for the rehabilitation and improvement milestones is provided in Table 59, at the end of this section.

3.7.1.1 Purpose

The purpose of rehabilitation monitoring at BWM is to assess and ensure the rehabilitation strategies, designs and treatments achieve acceptable rehabilitation outcomes, including fulfilling statutory and corporate compliance requirements. In addition, implementation of the rehabilitation monitoring program provides an opportunity to identify improvements of both rehabilitation processes, execution and monitoring methodologies.

The objective of the rehabilitation monitoring program is to validate if the current state of mine rehabilitation is progressing towards achieving the intended PMLU and relevant rehabilitation criteria. This is achieved by assessing a range of rehabilitation functional characteristics. These characteristics are then assessed against key performance indicators to provide a detailed understanding of current rehabilitation performance and trajectory, i.e. is rehabilitation condition likely to improve or decline over time.

3.7.1.2 Monitoring schedule

3.7.1.2.1 Rehabilitation monitoring

There are two phases of rehabilitation monitoring undertaken at BWM, conducted under the Rehabilitation Monitoring Program – Initial and Major Monitoring Methodology (WHC-QLD-PRO-COAL):

1. Initial monitoring, undertaken at newly established rehabilitation sites (Year 1 or within 12 months of rehabilitation being completed, and year 2), to categorise the site, develop baseline data and identify any risks to rehabilitation success;
2. Major monitoring, conducted approximately two years after initial monitoring (Year 3) to provide a detailed assessment of the current state of rehabilitation, and then conducted every four years.

Monitoring is undertaken on an annual basis for the first three-years to primarily the trajectory of rehabilitation as it relates to stability, vegetation establishment and achieving initial surface requirements (RM6). This approach allows a timely assessment of rehabilitation post initial seeding and provides critical

information to determine if rehabilitation is on track towards achieving surface requirements or if maintenance is required.

Additional rehabilitation parameters are included into the monitoring program in years three, five, 10 and five-yearly thereafter, to assess and track the performance of rehabilitation in relation to achievement of surface requirements (RM6) and achievement of PMLU to a stable condition (RM7 and RM8). The phased approach of the monitoring program enables regular analysis of rehabilitation monitoring data, including multi-year comparison of trends.

Monitoring of cattle grazing and woodland habitat reference sites is also undertaken for the parameters listed in Table 52 and is implemented as per the monitoring schedule from Year 3.

Table 52 Cattle grazing and woodland habitat PMLU monitoring schedule and measured rehabilitation parameters

Rehabilitation parameter	Monitoring schedule				
	Year 1	Year 2	Year 3	Year 5	Year 10+ (5-yearly thereafter)
Cattle grazing and woodland habitat PMLUs					
Landform and erosion	✓	✓	✓	✓	✓
Soil and spoil	✓	-	✓	✓	✓
Groundcover	✓	✓	✓	✓	✓
Invasive plants	✓	✓	✓	✓	✓
Cattle grazing PMLU					
Grazing Land Suitability Assessment	✓	-	✓	✓	✓
Land Condition	-	-	✓	✓	✓
Woodland habitat PMLU					
Species richness	✓	✓	✓	✓	✓
Tree stem count/basal area	-	-	✓	✓	✓
Tree height	-	-	✓	✓	✓
Tree canopy and shrub cover	-	-	✓	✓	✓
Recruitment	-	-	✓	✓	✓

Rehabilitation monitoring on BWM has been undertaken since 2018 in accordance with the Rehabilitation Monitoring Program – Initial and Major Monitoring Methodology (WHC-QLD-PRO-COAL) and associated subsequent versions to determine the performance of rehabilitation against the updated EA completion criteria for a cattle grazing and woodland habitat PMLU. Prior to 2018, monitoring was undertaken under a different methodology and compared to different completion criteria.

As explained in Section 3.1.4.2 and Appendix 4.17, BWM has 1,929 ha of existing rehabilitation, where a total of 1,497 ha has been monitored between 2018-2024. Upcoming rehabilitation monitoring programs will focus on assessing areas not yet monitored as well as new areas ≤3 years old.

3.7.1.2.2 Surface water monitoring

Surface water monitoring will be undertaken annually and assessed against the rehabilitation acceptance criteria listed in the EA Table E1, which have been transitioned to the PRCP as milestone criteria for achievement of PMLU to a stable condition (RM7) in line with the transitional provisions applicable to this PRCP.

3.7.1.2.3 Groundwater monitoring

During operations, groundwater monitoring will continue as per the applicable EA conditions.

Upon completion of surface preparation (RM6), for all areas post-mining, rehabilitation groundwater monitoring will be undertaken quarterly and will include:

- Groundwater quality monitoring, with at least one monitoring event representative of the dry season and one monitoring event representative of the wet season each year
- Groundwater level and void lake height as per groundwater quality monitoring schedule
- The above will be undertaken for the first 5 years after attainment of surface preparation for all areas. Thereafter, the groundwater data will be assessed to determine if there is a need to continue groundwater monitoring to demonstrate achievement of the criteria at EA surrender.

3.7.1.3 Methodologies

The monitoring program has been designed to obtain accurate and meaningful data that provides a snapshot of current rehabilitation performance. The data is sufficient to provide feedback to operational personnel on the effectiveness of rehabilitation construction methods, identify rehabilitation remediation and maintenance requirements, develop and continually refine rehabilitation criteria, provide an understanding of the trajectory of rehabilitation and to satisfy regulatory requirements.

The initial and major monitoring involves assessment of three key rehabilitation indicators:

- Vegetation,
- Soil, and
- Erosion.

These are discussed in more detail the following sections.

3.7.1.3.1 Rehabilitation monitoring site establishment

Permanent rehabilitation monitoring sites (plots) are established as part of the initial rehabilitation monitoring (Year 1) and will be assessed during all phases of rehabilitation monitoring. The permanent field monitoring sites will be selected using the following criteria:

- Representative of rehabilitation slope
- Accessible (vehicle access preferred)
- Low risk of site being disturbed by mining activity in the future
- Selection of suitable reference sites for cattle grazing, woodland habitat and watercourse PMLUs.

Rehabilitation monitoring plots will be established as per Figure 60. Photographs of the monitoring plot will be taken towards the north, south, east and west from the centre of the central 10m transect. All field data will be captured using tablets with GIS capabilities.

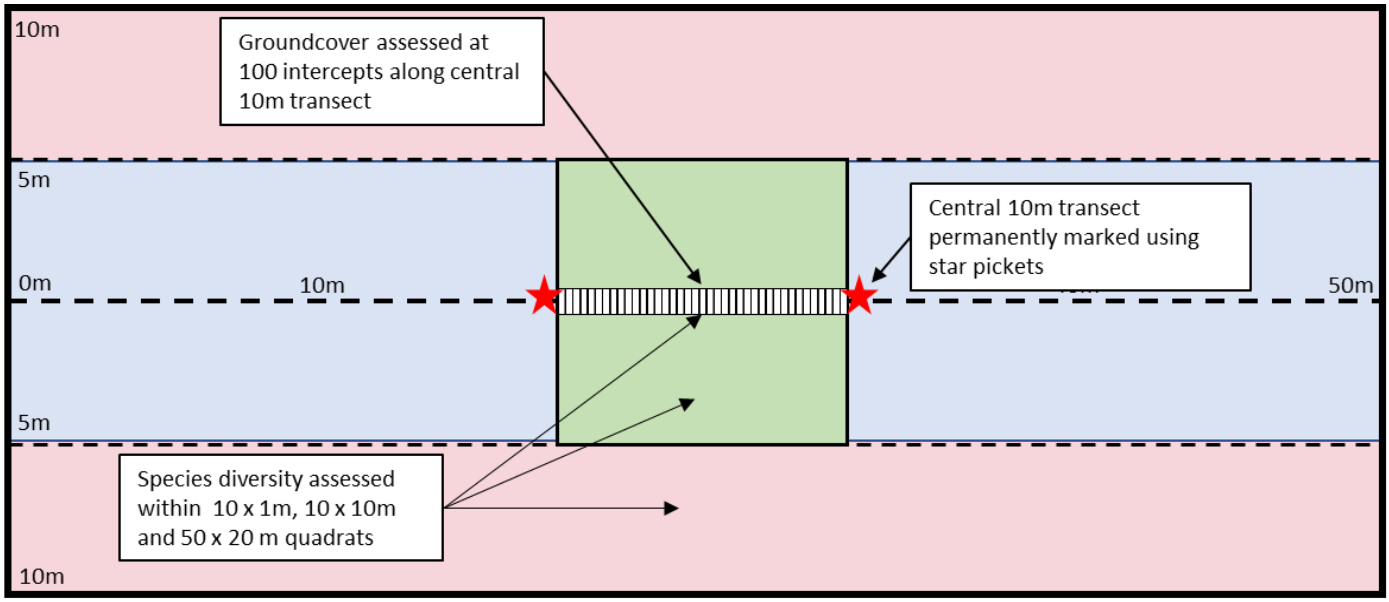

Figure 60 Major monitoring vegetation monitoring plot

3.7.1.3.2 Landform and erosion

Landform and erosion will be assessed as part of all monitoring phases (Table 53) Prior to commencing the field monitoring work, a desktop assessment using LiDAR data and aerial imagery will be completed to develop a DEM to assess the rehabilitated slope against the landform design (Year 1), and the ongoing monitoring of the landform and slopes.

The desktop analysis will identify potential areas of major ponding due to dump settlement, areas of deposition (where the ground level has increased over time), as well as the progression of erosion features such as developing gullies.

Field-based erosion monitoring will be conducted at the permanent monitoring sites, as well as any new areas identified in the desktop assessment. If erosion is present, an erosion monitoring transect will be established by running a 50 m tape perpendicular to the slope and across the erosional activity identified by the LiDAR analysis.

The following aspects will be recorded per erosion transect:

- Erosion severity
- Erosion type
- State of erosion
- Soil and spoil

The parameters detailed in Table 53 will be analysed during all monitoring events for soils and spoils. Soil profile pits or cores will be located within close proximity to the permanent rehabilitation monitoring sites. Surface sampling depth refers to the layer at 0-10 cm; and sub-surface sampling depth refers to layers at 10-30 cm, 30-60 cm and 90-100 cm.

Table 53 Soil and spoil analysis parameters for rehabilitation monitoring

Category	Analyte	Purpose of analyte	Depth	
			Surface	Sub-surface
Acidity/alkalinity	pH	Identify anomalies that may affect plant growth and sustainability.	✓	✓
Salinity	EC	Identify leaching profile. High salinity can lead to poor vegetation germination and establishment, reduced plant growth and vigour.	✓	✓
Exchangeable cations	CEC	Major factor in soil fertility. Controls soil stability, nutrient availability and buffers soil's chemical properties.	✓	✓
	ESP	ESP is a measure of the abundance of Na ions on the soil's cation exchange complex. Sodicity in soils can lead to slaking and dispersion which impact soil structure and stability.	✓	✓
Organic matter	Organic carbon	An indicator of soil nutrient stores and a contributor to improvements in soil structure. Increases in organic carbon is a key indicator of rehabilitation success.	✓	-
Major elements	Total nitrogen	Indicator of soil nutrient store and is also a major plant nutrient.	✓	-
	Nitrate-Nitrogen (Available nitrogen)	Nitrate is one of the primary forms of nitrogen that plants can readily absorb and utilize for growth.	✓	-
	Extractable phosphorous (Colwell method)	Indicator of phosphorous readily available to plants.	✓	-
	Total phosphorous	Indicator of total store of phosphorous, some of which is readily available. Key indicator of potential for long-term success or failure of rehabilitation.	✓	-

3.7.1.3.3 Groundcover

Groundcover will be assessed at the permanent rehabilitation monitoring sites as part of all monitoring events. Groundcover type is recorded as either live cover (with species recorded), standing dry cover, organic litter (including leaves, hay and woody debris (i.e. logs or dead timber)), rocks, or bare ground. The percentage of total groundcover (anything in contact with the soil surface) is calculated.

3.7.1.3.4 Species diversity and vegetation composition

Species diversity and vegetation composition will be assessed at the permanent rehabilitation monitoring sites as part of all monitoring events. All germinants present at the time of monitoring will be identified to the species level where possible, and species richness will be assessed by recording the total number of flora species accumulating across the length of the monitoring plot. A total species list will be generated for the monitoring site.

Invasive plants

An invasive plant is a prohibited or restricted matter under the *Biosecurity Act 2014* (Qld) and is defined as a species that has, or is likely to have, an adverse impact on a biosecurity consideration because of the introduction, spread or increase in population size of the species in an area. A complete list of invasive plant species is listed in Schedule 2, Part 2 (Restricted matter – invasive biosecurity matter) of the *Biosecurity Act 2014* (Qld).

Invasive plants will be assessed at the permanent rehabilitation monitoring sites and reference sites as part of all monitoring phases. The presence and percent cover of invasive plants, calculated as a percentage of the total vegetation cover, will be recorded at each site. Of particular focus for BWM will be the Leucaena (*Leucaena leucocephala*) stem density assessment, which will be undertaken by counting the number of Leucaena stems > 2 m in height within the monitoring plot.

3.7.1.3.5 Cattle grazing specific rehabilitation parameters

Grazing land suitability assessment (future cattle grazing)

A land suitability assessment will be undertaken at Year 1 to assess if ameliorants are working or if further treatments may be required. Ongoing grazing land suitability assessments will be undertaken as part of all monitoring events from Year 3. Based on the monitoring data, land suitability class will be rated 1 to 5 as per the soil limitations and land attributes in

Grazing land condition (existing cattle grazing)

For existing rehabilitated cattle grazing areas, grazing 'land condition' will be assessed at the permanent cattle grazing rehabilitation monitoring sites from Year 3. This allows at least two seasons after seeding for pasture species to establish. Land condition will be assessed and rated Good (A), Fair (B), Poor (C) or Degraded (D) as described in the *Queensland Reef Protection Regulations Farming in Reef Catchments Grazing Guide* (DES, 2022a).

Land condition requires monitoring of the following aspects:

- Groundcover – calculated as the percentage of soil surface covered by live cover, standing dry cover and organic litter (including leaves, hay and woody debris).
- Pasture condition – including estimated % dry matter (DM) yield of preferred pasture species, annual grasses, undesirable grasses and other weeds.
- Soil condition and erosion – assessed as per Section 3.7.1.3.2 and rated as per Table 53.

3.7.1.3.6 Woodland habitat specific rehabilitation parameters

The woodland habitat rehabilitation monitoring parameters are consistent with the QBEIS Tertiary level assessment as recommended for monitoring hybrid native ecosystems in the 'Evaluating methods for assessing native ecosystem mine rehabilitation success – Technical Paper (Spain, Nuske, & Gagen, 2023)' released in March 2023 by the Office of the Queensland Mine Rehabilitation Commissioner. The following section details specific parameters monitored for woodland habitat rehabilitation and reference sites.

Areas of woodland habitat associated with a hybrid ecosystem are monitored against existing woodland habitat completion criteria under the BWM EA.

Areas of woodland habitat rehabilitation with characteristics of a natural historic regional ecosystem (i.e. RE11.7.2) are assessed using Tertiary level vegetation assessments as per the 'Methodology for Surveying and Mapping Vegetation Communities and Regional ecosystem in Queensland. Version 7 (Neldner, et al., 2023)' and modified BioCondition method excluding parameters unlikely to be achieved in mine site rehabilitation in the short term including large trees and coarse woody debris (Eyre, 2015).

This approach could also be considered 'leading practice' based on the Evaluating Native Ecosystem Rehabilitation Options in Queensland Technical paper released by Office of the Queensland Mine Rehabilitation Commissioner (OQMRC) whereby leading practice is considered achievement of a natural REs wherever possible with abiotic and biotic characteristics of the RE that was present pre-mining (OQMRC, 2023).

Species richness

All woody species are recorded for each survey plot. Species richness will be assessed at the permanent rehabilitation monitoring sites as part of all monitoring phases. Species richness includes a full floristic assessment and count of trees, shrubs, grasses (native and exotic) and other ground species at each site.

Tree canopy height

Tree canopy height and height range will be assessed at the permanent rehabilitation monitoring sites from Year 3. Tree canopy height (measured to the top of the highest leaves) refers to the median canopy height for trees in the canopy layer (Eyre, et al., 2015).

Tree and shrub canopy cover

Tree canopy cover will be assessed at the permanent rehabilitation monitoring sites from Year 3. Canopy cover is recorded using the line intercept method at each monitoring site. The crown of each tree (single-stemmed woody plant greater than 2 m tall) (Eyre, et al., 2015) is recorded and summed as a total canopy distance and converted to a percent cover.

Shrub cover will be assessed at the permanent rehabilitation monitoring sites from Year 3. The crown of each shrub (i.e. woody plant that is multi-stemmed from the base (or within 200 mm from ground level) or if single stemmed, less than 2 m tall) (Eyre, et al., 2015) is recorded using the line intercept method and summed as a total shrub distance and converted to a percent cover at each monitoring site.

Recruitment

Recruitment will be assessed at the permanent rehabilitation monitoring sites from Year 3. Recruitment of canopy species is assessed by observing the proportion of the dominant canopy species regenerating (<5 cm diameter at breast height) at each monitoring site.

Ground cover

Ground cover will be assessed in woodland habitat sites at five 1 x 1m quadrats, 10m apart on alternate sides of the centre-line of a 50m transect. Ground cover is assessed for native perirenal grass, other native grass, native forb & other, native shrub (<1m), exotic grass, exotic forb & other, leaf & stick litter, rocks, bare ground and cryptogamswith an average value derived over the five quadrats.

3.7.1.3.7 Watercourse monitoring

Watercourse monitoring will be conducted at BWM to assess the performance of the creek diversions and rehabilitated watercourses disturbed by mining activities. The purpose of the monitoring is to assess the performance of the rehabilitated watercourses in achieving watercourse surface requirements (RM6) and the final PMLU milestone criteria (RM7).

Watercourse monitoring will be undertaken in accordance with the Index of Diversion Condition (IDC) methodology which is outlined in the Monitoring and Evaluation Program for Bowen Basin River Diversions (ID&A, 2001). The IDC is a quantitative monitoring method used to measure the geomorphic and riparian vegetation condition of creek diversions; however, it can be utilised for both diverted and rehabilitated reaches of watercourses. For rehabilitated watercourses, a modified IDC method, with a reduced number of monitoring points within each reach, is required due to the reduced impact area.

The BWM watercourse monitoring schedule is in Table 54. The monitoring schedule indicates the IDC parameters are measured in Year 1, Year 2, Year 5 and then 5-yearly thereafter.

The IDC methodology encompasses:

- Visual inspection of the diversion/rehabilitated watercourse and upstream and downstream reaches (i.e. reference sites).
- Assessment of geomorphic index and riparian vegetation index at nominated monitoring points within the diversion/rehabilitated watercourse, upstream and downstream reaches.
- Determination of reach-averaged geomorphic index and riparian vegetation index and overall IDC scores for the diversion/rehabilitated watercourse, upstream and downstream reaches.
- Comparison of the geomorphic index and riparian vegetation index and overall IDC scores for the diversion/rehabilitated watercourse reaches to the relative upstream and downstream reaches.

Table 54 Watercourse PMLU monitoring schedule and measured rehabilitation parameters

Monitoring parameters		Monitoring schedule			
Parameter	**Monitoring details**	**Year 1**	**Year 2**	**Year 5**	**Year 10+ (5-yearly thereafter)**
Groundcover					
Groundcover	Groundcover (%)	✓	✓	✓	✓
Geomorphic index parameters					
Stream width	Width of high flow channel (m) Width of active channel (m) Width of low flow channel (m)	✓	✓	✓	
Bank condition	Presence of erosion	✓	✓	✓	✓
Piping of banks	Presence of piping on the banks	✓	✓	✓	✓
Bed condition	Presence of aggradation or degradation within the channel bed	✓	✓	✓	✓
Spoil piles	Proximity of spoil dumps in relation to the monitoring point	✓	✓	✓	✓
Recovery	Presence or absence of benches with/without vegetation	✓	✓	✓	✓
Instream structures	Stability of each identified instream structure	✓	✓	✓	✓
Riparian vegetation index parameters					
Riparian zone	Width of riparian zone (m)	✓	✓	✓	✓
Structural intactness	Over-storey, understorey and ground cover (% density)	✓	✓	✓	✓
Regeneration	Presence or absence of regeneration on banks	-	✓	✓	✓
Longitudinal continuity	Assess the gaps in the riparian vegetation corridor along the banks	✓	✓	✓	✓

3.7.1.3.8 Reference sites

Cattle grazing reference sites

Cattle grazing reference sites have been established at the locations shown in Figure 61 and Figure 62.**Figure 61 BWM cattle grazing and woodland habitat reference sites (North)**The reference sites were monitored in 2023 and will continue to be monitored, in accordance with the cattle grazing monitoring requirements outlined in Section 3.7.1.3.5. Existing cattle grazing reference site results have been summarised in Table 55 as it relates to the ranges of groundcover, preferred pasture species, dry matter yields, land condition and land suitability classes that have been recorded as a result of ongoing monitoring (BMA, 2023). Additional or alternative cattle grazing reference sites may be established in the future.

Land suitability for cattle grazing was assessed and scored against the criteria under the *Rehabilitated mined land suitability for beef cattle grazing in the Bowen Basin Technical paper 1* (revised cattle grazing rule set) (Highlands Environmental , 2023). Minor changes to the revised cattle grazing rule set are as follows:

- PAWC in ERD boundary between LSC 3 and 4 changed from 60-45 mm to 60-40 mm
- Inclusion of sub-classes rockiness percentages criteria for gravel, cobbles, stones and boulders.
- PAF material location boundaries changed: LSC1 = < 3 m, LSC2 = 3-2 m, LSC3 = 2-0.9 m, LSC4 = 0.9-0.6 m, LSC5 = < 0.6 m

An assessment of grazing land condition was also undertaken in areas of cattle grazing rehabilitation and reference sites in accordance with *Queensland Reef Quality Program Reef Protection Regulations Farming in Reef Catchments Grazing Guide Version 2* (DES, 2022a).

Table 55 BWM cattle grazing reference sites

BWM cattle grazing reference sites	
	
Reference Site – BWM_REF01	Reference Site – BWM_REF03
Mean Slope: <2%	Mean Slope: <2%
Total Groundcover: 100%	Total Groundcover: 100%
Trees: *Acacia harpophylla* (brigalow), *Atalaya hemiglauca (whitewood)*	Trees: *None observed*
Shrubs: *Capparis lasiantha, Acacia harpophylla* (brigalow), *Atalaya hemiglauca* (whitewood)	Shrubs: *Capparis lasiantha, Atalaya hemiglauca (whitewood), Citrus glauca (native lime bush), Acacia harpophylla* (brigalow), *Senna artemisioides*
Exotic Grasses: *Cenchrus ciliaris* (buffel grass*), *Bothriochloa pertusa* (Indian couch*) Native Grasses: *Aristida sp.* (wiregrasses)	Exotic Grasses: *Cenchrus ciliaris* (buffel grass*), Native Grasses: *Aristida calycina* (dark wiregrass)
Invasive Plants: *Harrisia martinii* (Harrisia cactus*)	Invasive Plants: *Harrisia martinii (Harrisia cactus*)*
Dry matter yield kg/ha: 2800	Dry matter yield kg/ha: 3000
Land Condition: Fair (B)	Land Condition: Fair (B)
Land Suitability Class: 4	Land Suitability Class: 5
Site Limitations: Reference site (REF01) with lower Colwell P to 0.1m (<8 mg/kg) and slightly alkaline at pH 8.7	Site Limitations: Reference site (REF03) has low Colwell P to 0.1m (<5 mg/kg) otherwise the site has no other limiting factors

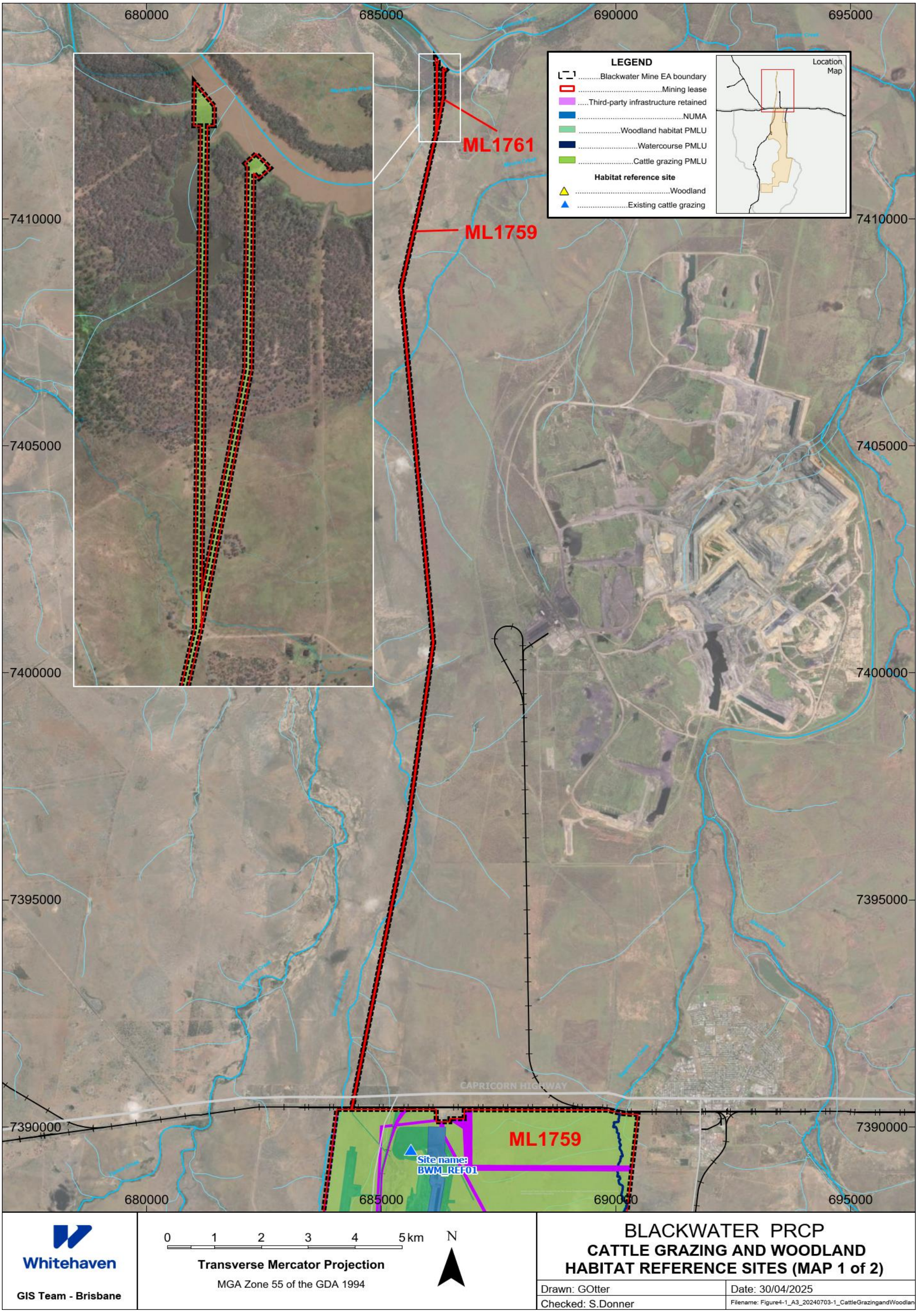

Figure 61 BWM cattle grazing and woodland habitat reference sites (North)

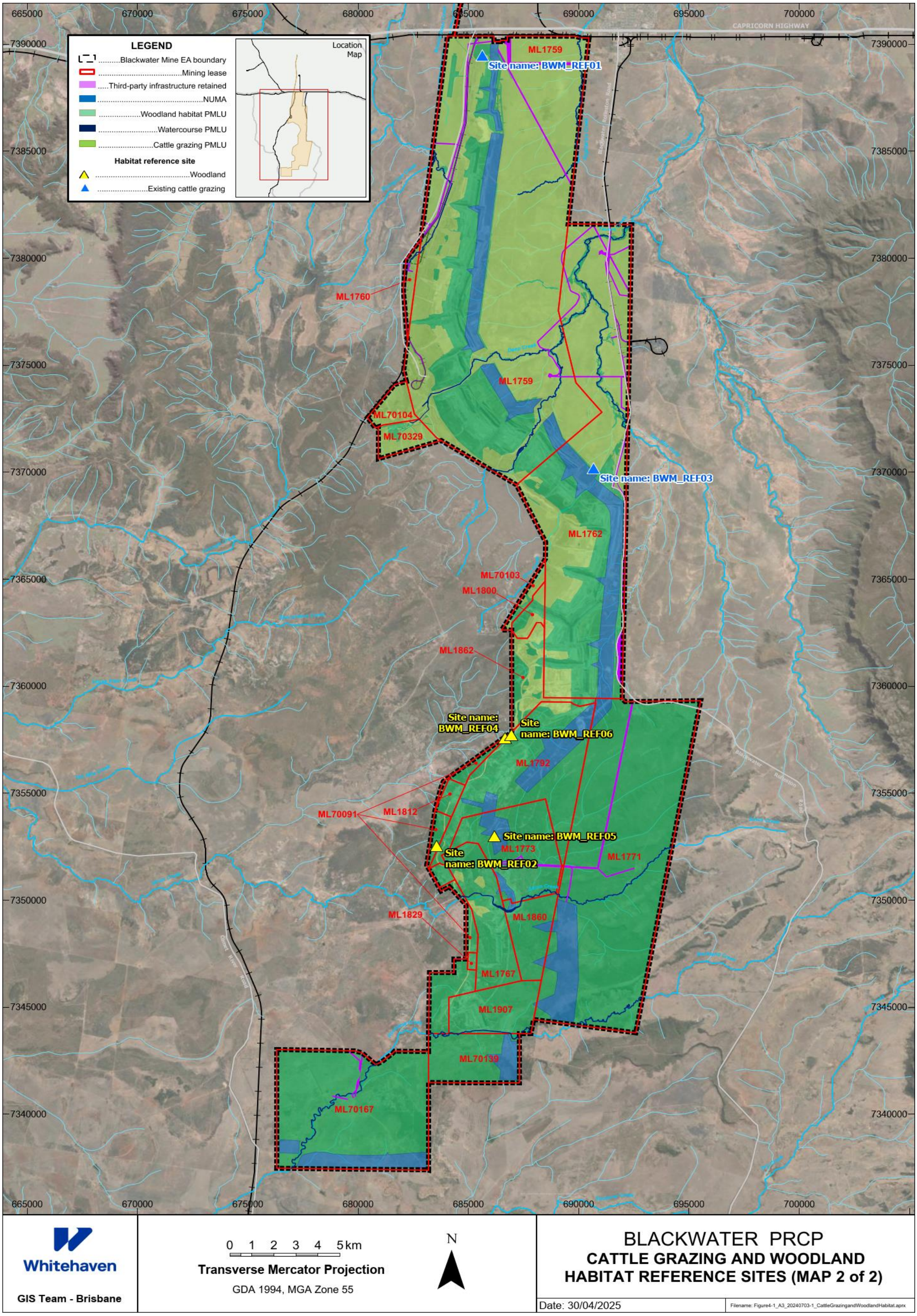

Figure 62 BWM cattle grazing and woodland habitat reference sites (North, Central and South)

Woodland habitat reference sites

Woodland habitat reference sites have been established in areas of remnant vegetation undisturbed by mining as shown in Figure 61 and Figure 62.

A summary of existing woodland habitat reference site results on BWM has been provided in Table 56. Additional or alternative woodland habitat reference sites may be established in the future.

Table 56 BWM woodland habitat reference sites

BWM woodland habitat reference sites			
			
Reference Site – BWM_REF02	Reference Site – BWM_REF05	Reference Site – BWM_REF04	Reference Site – BWM_REF06
Mean Slope: 10%	Mean Slope: 10%	Mean Slope: 4%	Mean Slope: 4%
Regional Ecosystem: 11.7.2	Regional Ecosystem: 11.7.2	Regional Ecosystem: 11.5.9/11.5.3	Regional Ecosystem: 11.5.3
Total Groundcover: 93%	Total Groundcover: 95%	Total Groundcover: 100%	Total Groundcover: 100%
Tree Canopy Cover: 69.2%	Tree Canopy Cover: 52.2%	Tree Canopy Cover: 45.2%	Tree Canopy Cover: 30.6%
Tree Species: *Corymbia citriodora* (lemon scented gum), *Acacia shirleyi* (lancewood), *Acacia catenulata* (bendee) *Evidence of recruitment: Yes*	Tree Species: *Acacia shirleyi (lancewood), Corymbia citriodora subsp. citriodora (lemon scented gum), Eucalyptus crebra (narrow leaved ironbark)* *Evidence of recruitment: Yes*	Tree Species: *Eucalyptus crebra* (narrow leaved ironbark), *Eucalyptus populnea* (poplar box), *Acacia rhodoxylon* (rosewood), *Corymbia tessellaris* (Moreton Bay ash) *Evidence of recruitment: Yes*	Tree Species: *Eucalyptus populnea (poplar box), Eucalyptus crebra (narrow leaved ironbark), Acacia excelsa (ironwood), Eucalyptus decorticans* *Evidence of recruitment: Yes*
Shrub species: *Everistia vacciniifolia, Erythroxylon australe* (dogwood), *Acacia shirleyi* (lancewood), *Hovea sp, Phebalium glandulosum, Beyeria viscosa.*	Shrub species: *Everistia vacciniifolia, Eucalyptus shirleyi (silver leaved ironbark), Psydrax oleifolia (psydrax), Geijera parviflora (wilga), Bertya opponens, Croton phebalioides.*	Shrub species: *Erythroxylon australe* (dogwood), *Eremophila mitchellii* (false sandalwood), *Croton insularis* (croton), *Carissa ovata* (currant bush), *Geijera salicifolia, Acacia leiocalyx* (black wattle), *Hakea lorea* (bootlace oak), *Cassia brewsteri* (Leichhardt bean), *Grevillea striata* (beefwood), *Dodonaea viscosa* (hopbush), *Santalum lanceolatum* (sandalwood)	Shrub species: *Dodonaea viscosa (hopbush), Eremophila mitchellii (false sandalwood), Owenia acidula (emu apple), Grewia latifolia, Cassia brewsteri (Leichhardt bean), Erythroxylon australe (dogwood), Petalostigma pubescens (quinine bush), Acacia leiocalyx (black wattle), Psydrax oleifolia (psydrax), Grevillea striata (beefwood), Denhamia cunninghamii*

BWM woodland habitat reference sites			
Exotic Grasses: *Cenchrus ciliaris* (buffel grass*) Native Grasses: *Aristida caput-medusae* (many headed wiregrass), *Aristida calycina* (dark wiregrass), *Cymbopogon refractus* (barbwire grass), *Aristida sp.* (wiregrasses), *Ancistrachne uncinulata* (hooky grass)	Exotic Grasses: *Cenchrus ciliaris (buffel grass*), Cenchrus pennisetformis* Native Grasses: *Aristida calycina (dark wiregrass), Digitaria sp. (finger panic grass), Aristida sp. (wiregrasses), Eragrostis sp. (lovegrasses), Aristida caput-medusae (many headed wiregrass), Entolasia stricta, Ancistrachne uncinulata (hooky grass)*	Exotic Grasses: *Cenchrus ciliaris* (buffel grass*), *Melinis repens (*red natal grass*) Native Grasses: *Aristida calycina* (dark wiregrass), *Aristida caput-medusae* (many headed wiregrass), *Heteropogon contortus* (black spear grass)	Exotic Grasses: *Megathyrsus maximus var. pubiglumis (green panic*), Cenchrus ciliaris (buffel grass*), Melinis repens (red natal grass*)* Native Grasses: *Digitaria brownii (cotton panic), Enneapogon pallidus (nine awn pale bottle washer), Chrysopogon fallax (golden beard grass), Aristida calycina (dark wiregrass), Aristida sp. (wiregrasses), Digitaria sp. (finger panic grass)*
Invasive Plants: *None observed*	Invasive Plants: *Opuntia sp. (tree pear*)*	Invasive Plants: *Harrisia martinii* (Harrisia cactus*), Opuntia stricta (tree pear*)	Invasive Plants: *Harrisia martinii* (Harrisia cactus*), Opuntia stricta (tree pear*)

Watercourse reference sites

Watercourse reference sites have been established in the existing creek diversions associated with Burngrove-, Taurus, Deep-, Sirius- and Rockland creek diversions as shown in Figure 63. Reference sites will be monitored in accordance with the watercourse monitoring requirements outlined in Section 3.7.1.3.7. Where revegetation is required in a natural watercourse, a reduced number of reference sites (compared to the IDC method (ID&A, 2001)) will be established due to the reduced impact area. New watercourse reference sites will be established in relatively unmodified upstream sections of each watercourse.

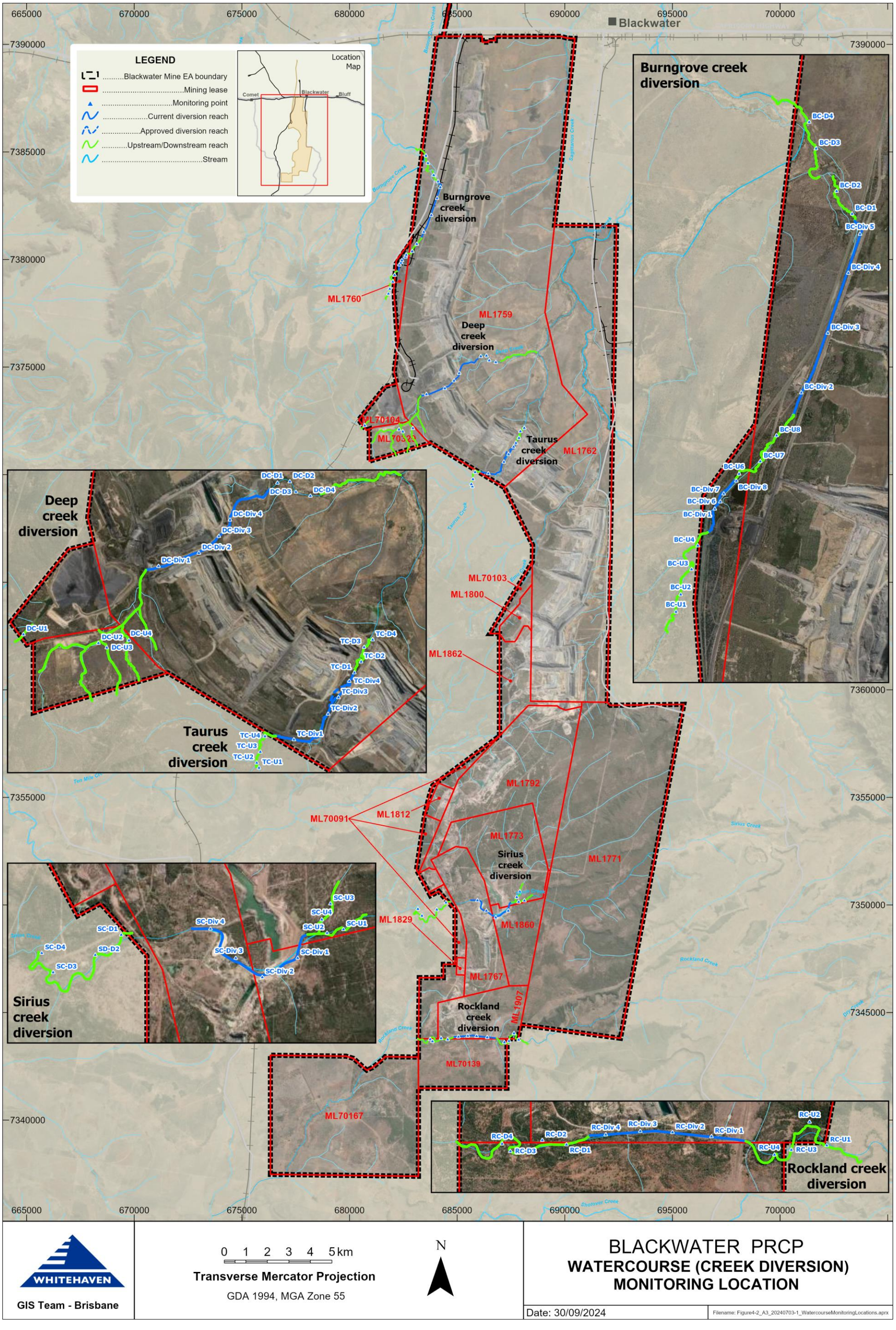

Figure 63 BWM watercourse (creek diversion) monitoring

3.7.1.3.9 Surface water monitoring

In line with the BWM EA Table E1 Rehabilitation Requirements, surface water monitoring will be undertaken for all PMLUs for pH, EC and turbidity to demonstrate achievement of PMLU to a stable condition.

Water quality monitoring will be undertaken in accordance with the *Monitoring and Sampling Manual: Environmental Protection (Water) Policy 2009* (DES, 2018).

Surface water sample locations

Surface water sampling will be undertaken within the watercourse sample locations listed in Table 57 and shown in Figure 64, when safe to do so after suitable rainfall events. In addition to the listed watercourse sample locations, downstream surface water sampling locations may also be selected to better target individual areas of rehabilitation, while active disturbance areas remain in the wider catchment. This will enable an assessment of the individual rehabilitation areas for compliance with the milestone criteria.

Table 57 Rehabilitation surface water sample locations

Station number	Description	Indicators	Latitude	Longitude
330125	D/S Blackwater Creek	pH, EC, flow rate	-23.6382	148.9017
330124	Two Mile Gully	pH, EC, flow rate	-23.7506	148.8857
330118	D/S Sirius Creek	pH, EC, flow rate	-23.9556	148.8019
330133	U/S Rockland Creek	pH, EC, flow rate	-24.0065	148.8349
330119	D/S Rockland Creek	pH, EC, flow rate	-24.0754	148.7246
330127	U/S Burngrove Creek	pH, EC, flow rate	-23.6856	148.7867
330117	D/S Burngrove Creek	pH, EC, flow rate	-23.5911	148.7764

The surface water monitoring locations may be amended as required to account for changes to upstream land uses/stream dynamics or to improve the effectiveness of the monitoring program.

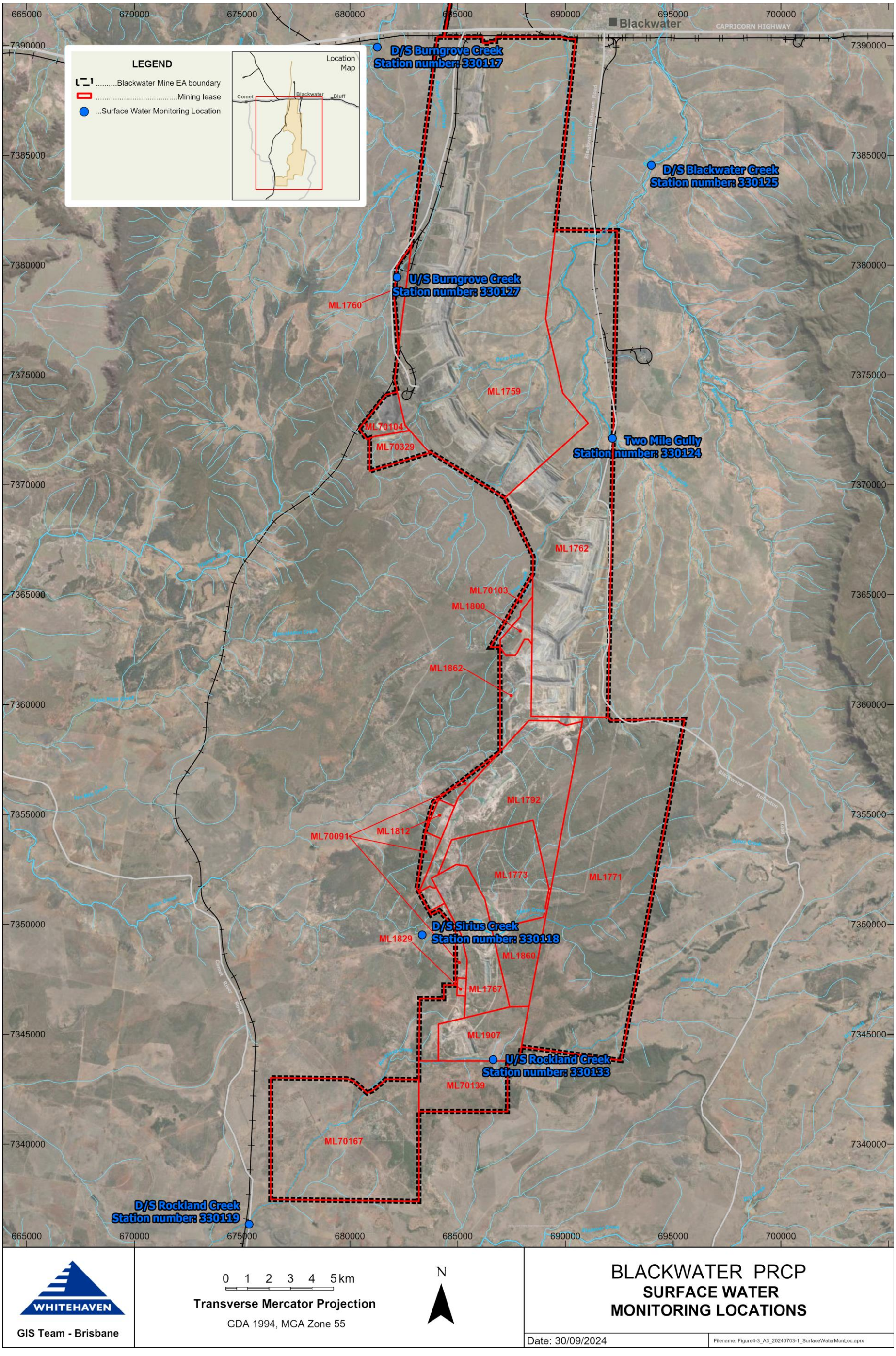

Figure 64 BWM rehabilitation surface water monitoring locations

3.7.1.3.10 Groundwater monitoring

Groundwater quality

In line with the *Guideline for Progressive Certification for Resource Activities* (DES, 2022b), deep drainage water quality will be "addressed holistically for a site at surrender". The objective and acceptance criteria for groundwater are not considered relevant to the progressive rehabilitation of discrete packages of rehabilitated land due to the scale and nature of groundwater aquifers. Therefore, the EA deep drainage acceptance criteria for rehabilitation will be applied only at the completion of mining operations and applied holistically for the entire BWM area. Groundwater monitoring during operations will continue as per the applicable EA conditions.

Groundwater quality monitoring will be undertaken to support the surrender of the BWM EA in accordance with EA Table E1 Rehabilitation Requirements for the Post Mining Land Use. The goal is a non-polluting objective where the electrical conductivity (EC) indicator Acceptance Criteria is not significantly different to:

- The EPP (Water and Wetland Biodiversity) schedule documents WQOs for relevant groundwater chemistry zones, or
- Local WQOs developed in accordance with the Queensland Water Quality Guidelines.

Groundwater levels

Monitoring of groundwater levels will focus on the relationship between the Permian groundwater level recovery and the void lake levels. Groundwater level/gradient trends over time will be assessed against the more dynamic pit lake levels to demonstrate that residual voids are progressing to a stabilised state, where they will act as ongoing sinks for groundwater thus minimising the potential for an unacceptable risk of environmental harm (MM4).

Due to the timeframes involved in the stabilisation of the void lakes and groundwater levels surrounding the mining voids, the groundwater level monitoring intends to show progress towards the development of long-term sinks and not to confirm the attainment of long-term sinks. Demonstrating the progress towards the development of long-term sinks is to be done through the assessment of trends and comparison to groundwater and void lake water balance model predictions by AQPs.

Groundwater monitoring locations

The existing groundwater monitoring bores are described in Section 3.1.2.63.5.1.1 and the locations of the compliance bores, as per the latest EA, are in Figure 11

The comparison has been made between the existing monitoring bores and EA compliance bore list. The indication is that 11 of the compliance bores have been installed with the remaining 14 monitoring bores, yet to be drilled, at selected or yet to be determined locations. The highlighted cells in the table indicate the bores that have been drilled and correlate with the existing monitoring bore list

The ongoing groundwater monitoring will continue on the existing bores that provide a geographical distribution across BWM and coverage of the key hydrogeological units. The groundwater monitoring bore network will include selected bores existing at closure, and include bores installed specifically to close data gaps and to replace bores that may have been lost due to mining disturbances or otherwise are not operational.

Bores proposed to be installed as part of the rehabilitation monitoring program will be dependent on safe access and the presence of the target hydrogeological unit (e.g. alluvium) at the selected location.

The groundwater monitoring bore network to be utilised for assessment at the completion of mining operations is provided in Table 58 and Appendix 4.1 (Attachment 3). Existing bore locations utilised as part of the groundwater monitoring network are presented in Figure 65.

The groundwater monitoring program may be amended to include additional bores to better assess hydrogeological conditions or to replace lost or damaged bores, as required. Bores proposed to be installed as part of the rehabilitation monitoring program will depend on safe access and the presence of the target hydrogeological unit (e.g. alluvium) at the selected location.

Table 58 Groundwater monitoring bore locations

Monitoring points	Hydrogeological unit	Easting (GDA2020)	Northing (GDA2020)	Ground level surface RL (m)	Screened interval RL (m)	Monitoring frequency
MB1[1]	Permian coal (Rangal Coal Measure, ARS, TU seam)	686331	7387081	TBC	TBC	Monthly until Final Contaminant Limits are reflected in EA, then Quarterly thereafter
MB21[1]	Tertiary Sediments	684900	7350806	TBC	TBC	Monthly until Final Contaminant Limits are reflected in EA, then Quarterly thereafter
MB18[1]	Permian Sandstone	691537	7370788	TBC	TBC	Monthly until Final Contaminant Limits are reflected in EA, then Quarterly thereafter.
BWM_MB02_01[1]	Permian Interburden	691748	7362714	TBC	TBC	Monthly until Final Contaminant Limits are reflected in EA, then Quarterly thereafter.
BWM_MB02_02[1]	Permian Coal (Rangal Coal Measure, Castor, M54 seam)	691736	7362716	TBC	TBC	Monthly until Final Contaminant Limit is reflected in EA, then Quarterly thereafter.
BWM_MB03_01[1]	Alluvium	692229	7381517	TBC	TBC	Monthly until Final Contaminant Limit is reflected in EA, then Quarterly thereafter.
BWM_MB03_02[1]	Rewan Group	692232	7381522	TBC	TBC	Monthly until Final Contaminant Limit is reflected in EA, then Quarterly thereafter.
BWM_MB12_01[1]	Tertiary Sediments	TBC	TBC	TBC	TBC	Monthly until Final Contaminant Limit is reflected in EA, then Quarterly thereafter.
BWM_MB12_02[1]	Permian Coal (Rangal Coal Measure, Castor, P04 seam)	TBC	TBC	TBC	TBC	Monthly until Final Contaminant Limit is reflected in EA, then Quarterly thereafter
BWM_MB14_01[1]	Permian Interburden	TBC	TBC	TBC	TBC	Monthly until Final Contaminant Limit is reflected in EA, then Quarterly thereafter.
BWM_MB14_02[1]	Permian Interburden	TBC	TBC	TBC	TBC	Monthly until Final Contaminant Limit is reflected in EA, then Quarterly thereafter.
BWM_MB15_01[1]	Tertiary sediments	TBC	TBC	TBC	TBC	Monthly until Final Contaminant Limit is reflected in EA, then Quarterly thereafter.
BWM_MB17_01[1]	Basalt	TBC	TBC	TBC	TBC	Monthly until Final Contaminant Limit is reflected in EA, then Quarterly thereafter.
BWM_MB17_02[1]	Tertiary (BUTE)	TBC	TBC	TBC	TBC	Monthly until Final Contaminant Limit is reflected in EA, then Quarterly thereafter.
MB19BWM01P[1]	Permian Coal (Rangal Coal Measure, Aries Seam (ARS), Top seams)	690037	7390282	TBC	TBC	Monthly until Final Contaminant Limits are reflected in EA, then Quarterly thereafter
MB19BWM02A[1]	Rewan Group	690127	7370183	TBC	TBC	Monthly until Final Contaminant Limit is reflected in EA, then Quarterly thereafter.
MB19BWM08P[1]	Permian Coal (Rangal Coal Measure, Aries Seam (ARS), Top seams) & Siltstone	691542	7370740	TBC	TBC	Monthly until Final Contaminant Limits are reflected in EA, then Quarterly thereafter
MB19BWM27P[1]	Permian Coal (Rangal Coal Measure, Aries Seam (ARS), Top seams) & Siltstone	688958	7376560	TBC	TBC	Monthly until Final Contaminant Limits are reflected in EA, then Quarterly thereafter
MB20BWM03P2[1]	Permian (Rangal Coal Measure, Castor and Pollux, L41 seam)	686499	7387293	TBC	TBC	Monthly until Final Contaminant Limits are reflected in EA, then Quarterly thereafter
BG-1[1]	Burngrove Formation	683994	7387562	TBC	TBC	Monthly until Final Contaminant Limits are reflected in EA, then Quarterly thereafter
BG-2[1]	Burngrove Formation	684300	7384442	TBC	TBC	Monthly until Final Contaminant Limits are reflected in EA, then Quarterly thereafter
Bore upgradient of Red Dam (as per condition I17)	TBC	TBC	TBC	TBC	TBC	
Bore downgradient of Red Dam (as per condition I17)	TBC	TBC	TBC	TBC	TBC	
Bore upgradient of NCPP Tailings Dam (as per condition I18)	TBC	TBC	TBC	TBC	TBC	
Bore downgradient of NCPP Tailings Dam (as per condition I18)	TBC	TBC	TBC	TBC	TBC	

[1]Contaminant limits have not yet been developed for these bores due to the limited available monitoring dataset. Monthly monitoring will occur until a suitable dataset is available to set contaminant limits.

* 'TBC' has been included for coordinates that require confirmation. The final location coordinates will be provided to the administering authority in accordance with condition I14 of Environmental Authority EPML00717813. TBC has also been included for Ground Level Surface RL (m) and Screened Interval RL (m), which will be provided in accordance with conditions I2 and I12.

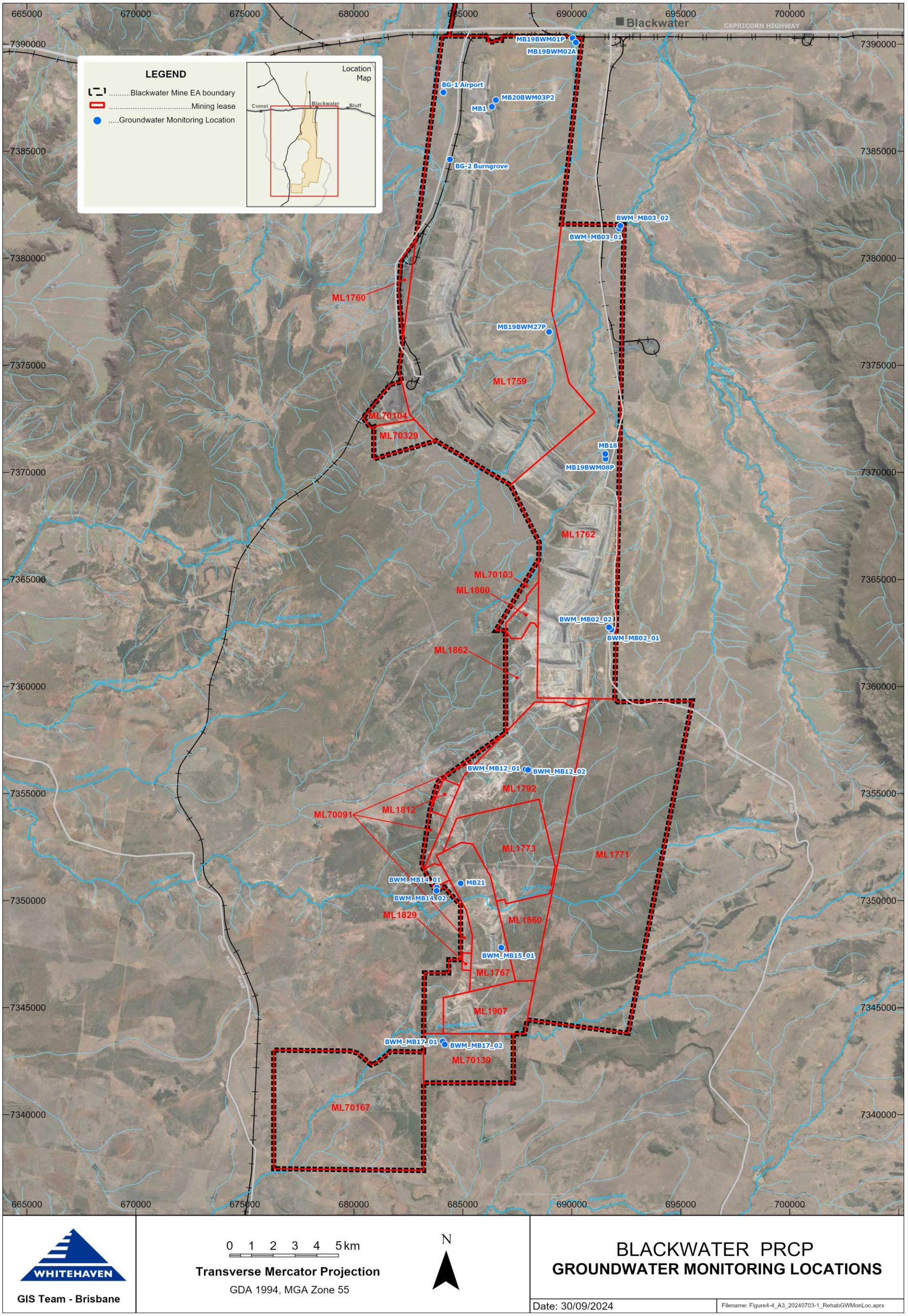

Figure 65 BWM rehabilitation groundwater monitoring location

3.7.1.3.11 Remote sensing and technology

The current rehabilitation monitoring program is highly dependent on the capture and analysis of field data. Future advances in monitoring could include developments in remote sensing, technology and/or digital data capture which may be incorporated into the program, wherever practical.

3.7.1.4 Data analysis and reporting

Rehabilitation monitoring data will be collected and analysed by an AQP and assessed against the milestone criteria as provided in Table 59

The data will be analysed to identify changes and trends, as well as map the trajectory of rehabilitation to identify whether it is on track to achieve the milestone criteria or requires corrective actions or maintenance.

The rehabilitation data will be stored and processed within internal geospatial and document management systems.

3.7.1.5 Quality assurance and quality control

A dedicated QA/QC process will be followed as part of BWM's ongoing rehabilitation monitoring. The process provides for the initial execution of the rehabilitation in accordance with the rehabilitation plan, followed by verification of the execution against the rehabilitation plan.

Based on the verification outcomes, allowance is made for the implementation of corrective actions, as needed. All rehabilitated areas then undergo rehabilitation monitoring; and subsequent execution of maintenance actions identified through the monitoring. This process allows for a repetitive execution-verification-corrective action-monitoring QA/QC approach, to ensure rehabilitation areas progress on a trajectory towards achievement of milestone criteria and eventual certification

3.7.1.6 Maintenance

Maintenance will be implemented when monitoring identifies issues with the rehabilitation, or when milestone criteria are not being met. To select the most appropriate corrective actions, rehabilitation monitoring data will be analysed to identify the likely cause/s. Required maintenance/corrective actions will be entered into Whitehaven's work management system for actioning and record management.

To support ongoing operations, temporary and/or minor disturbance activities may be required within rehabilitated areas in some circumstances. This temporary and/or minor disturbance will occur without a PRCP Amendment and rehabilitation will be managed as part of maintenance works. Temporary and/or minor disturbance can occur within rehabilitated areas to the extent reasonably necessary for roads, fences, underground services, low-impact telecommunications facilities, electrical sub-stations, transmission grid works and supply network works, storage depots, pipelines, groundwater bores, monitoring and investigations, exploration, or similar minor infrastructure and ancillary facilities for any of the listed minor infrastructure.

Maintenance works will be planned and executed as soon as practicable and within at least six months of the completion of the temporary and/or minor disturbance within rehabilitated areas. Maintenance works may include removing infrastructure, reshaping the area, reestablishing growth media (e.g. respreading stripped topsoil/replacement of spoil), applying seed mix aligned to the PMLU, weed control or managing erosion. These rehabilitated areas will continue to be monitored as per the monitoring program outlined in this section.

It is understood that BWM are undertaking ongoing maintenance of rehabilitation areas based on prioritised works recommended from annual monitoring. From a maintenance perspective, BWM is currently undertaking a Leucaena management program targeting areas of high density Leucaena identified during the 2022-2024 monitoring program. It is expected ongoing maintenance including control of outliers of Leucaena, erosion control and reseeding will follow on from the weed management programs in cattle grazing PMLU areas returned from monitoring with rehabilitated land in Poor (C) or Degraded (D) condition based on the results of annual monitoring.

Table 59 Schedule of monitoring, reporting and review for rehabilitation and management milestones

Criteria	Monitoring Methods	Frequency	Contingency/Maintenance	Reporting	Review
RM1 Infrastructure decommissioning and removal					
Redundant services (water, electricity, gas, etc.) disconnected and removed	Trained and competent person/s to review services documentation, complete visual inspection and document	Once, upon closure	Arrange disconnection by an AQP	Services inspection report Internal	Upon receipt of report
Redundant buildings demolished and removed	Trained and competent person/s to review services documentation, complete visual inspection and document	Once, upon closure	Arrange removal by an AQP	Services inspection report Internal	Upon receipt of report
All hardstand, concrete and bitumen within 0.5 m of the final landform surface removed	Trained and competent person/s to review services documentation, complete visual inspection and document	Once, upon closure	Arrange removal by an AQP	Services inspection report Internal	Upon receipt of report
No below-ground built or service infrastructure within 0.5 m of the final landform surface	Trained and competent person/s to review services documentation, complete visual inspection and document	Once, upon closure	Arrange decommissioning by an AQP	Services inspection report Internal	Upon receipt of report
Mine water dams decommissioned	Trained and competent person/s to conduct visual inspection, review of water and sediment monitoring records, review of legal agreements/ licencing in place and document	Prior to decommissioning/ relinquishment (water and sediment quality), visual inspection to be conducted upon completion of decommissioning where applicable (structures)	Arrange remediation of contaminated sediment and decommissioning by an AQP	Water management decommissioning report Internal	Upon completion of sediment remediation and inspection by an APQ or RPEQ (where applicable)
Watercourse crossings and culverts removed	Trained and competent person/s to conduct visual inspection, review of water and sediment monitoring records, review of legal agreements/ licencing in place and document	Prior to decommissioning/ relinquishment (water and sediment quality), visual inspection to be conducted upon completion of decommissioning where applicable (structures)	Arrange remediation of contaminated sediment, arrange decommissioning (if involving RPEQ) by an AQP	Water management decommissioning report Internal	Upon completion of sediment remediation and inspection by an APQ or RPEQ (where applicable)
RM2 Identification and remediation of contaminated land					
Contaminated Land Investigation Document completed in accordance with the *Environmental Protection Act 1994*, including: 1. Site Suitability Statement confirming the suitability of the property for the PMLUs; and 2. Audit Certification.	Review water and soil quality assessments and monitoring to identify any contamination.	Once, upon closure	Arrange a preliminary site investigation (PSI) by an AQP. Arrange detailed site investigation (DSI) by an AQP if identified as required in the PSI. Arrange remediation or management of contaminated land if identified in the PSI/ DSI.	Contaminated Land Investigation Document Internal	Upon receipt of the Contaminated Land Investigation Document and site suitability statement.
Contaminated Land Investigation Document including a Site Investigation Report and, where required, a Validation Report and/or a draft Site Management Plan.	Review Site Validation Report	Upon receipt of Site Validation Report	Arrange continued remediation if required	Site Validation Report and/ or Site Management Plan Internal	Upon auditor sign off, confirming the land does not present an unacceptable risk to proposed future land uses or the environment

Criteria	Monitoring Methods	Frequency	Contingency/Maintenance	Reporting	Review
RM3 Bulk earthworks and landform reshaping					
Construction of landforms completed to achieve design intent: 1. For cattle grazing PMLU: a. Landforms reshaped with 70% of slopes ≤20% gradient. 2. For woodland habitat PMLU: a. Landforms reshaped with maximum 30% slopes. 3. For watercourse PMLU: a. Disturbed natural watercourse bed and banks returned to a profile similar to the pre-disturbance condition. 4. For Tailings Storage Facilities (TSFs) and reject dumps: a. Capping of at least 2 meters of competent benign spoil is to occur; and b. Cover surface is free draining and does not display surface ponding.	Visual inspection by a trained and competent person/s during construction and document, survey/ LiDAR of landform and document	Upon completion of landform	Re-shape landform to design specifications prior to applying growth media	As constructed landform report Internal	Upon completion of re-shaping and associated report
RM4 Surface preparation					
In areas where topsoil has previously been removed, topsoil and or growth media is in place at a minimum depth of: a. 150 mm for the cattle grazing PMLU and watercourse PMLU; and b. 100 mm for the woodland habitat PMLU.	Trained and competent person/s to complete visual inspection and document	Upon completion of placement	Re-place or place growth media to specifications	Growth media inspection report Internal	Upon re-placement
Assessment of growth media characteristics and the development of an amelioration plan is completed by an AQP prior to placement on the landform.	An AQP will scope and complete soil sampling, review NATA accredited soil laboratory documentation and rehabilitation records	Prior to use of growth media and upon completion of amelioration	Arrange completion of assessment and/ or ameliorate/ re-ameliorate	Amelioration plan Internal	Upon receipt of report
Any amelioration/ fertilisation recommended as a result of the soil assessment have been applied at the recommended rates	Composite soil sampling, review amelioration documentation, rehabilitation records	Upon completion of amelioration	Re-ameliorate or ameliorate	Amelioration assessment report Internal	Upon receipt of report
Rip on contour at a minimum depth of ≥300 mm.	Trained and competent person/s to complete visual inspection and document	Upon completion of growth media placement	Rework to specifications; re-place growth media if required	Internal	Upon rework
RM5 Revegetation					
Seed mix constitutes target flora species for each PMLU, as provided in Section 3.5.1.8 and Appendix 4.1 (Attachment 1): 1. For cattle grazing PMLU: a. At least four (4) species of 3P (preferred, palatable and perennial) grasses, including at least two (2) native species, and two (2) legume species are to be seeded per cattle grazing rehabilitation area. 2. For woodland habitat PMLU: a. Include at least six (6) species from revegetation lists for framework trees,	Trained and competent person/s to review supplier credentials and seed mix specification against the Revegetation Plan (part of PRCP) and rehabilitation records	Prior to seeding	Re-seed or seed according to specifications Seek alternative supplier if does not meet standards required or not reliable.	Revegetation report (including documentation of seed mix applied, seeding timing and method, and seed mix rates) Internal	Upon completion of re-seeding

Criteria	Monitoring Methods	Frequency	Contingency/Maintenance	Reporting	Review
woody understorey (shrub) species grass species. 3. For watercourse PMLU: a. Complete seeding in accordance with recommended watercourse species mixes for upper, mid banks and lower banks.					
Seed mix is applied in accordance with the recommended seeding rates for each PMLU 1. For cattle grazing PMLU: a. Minimum seeding rates for cattle grazing of at least 16 kg/ha of coated pasture seed and 4 kg/ha of uncoated legume seed are to be used, unless adjusted by an AQP. 2. For woodland habitat PMLU: a. Minimum seeding rates of 6 kg/ha tree species, 4 kg/ha of woody understorey species and 10 kg/ha of grasses to be used unless adjusted by an AQP. 3. For watercourse PMLU: a. Minimum seeding rates for upper and mid banks of 6 kg/ha tree species, 4 kg/ha of woody understorey species and 10 kg/ha of grasses and other ground species. **b.** Minimum seeding rates for lower banks of 5 kg/ha tree species, 10 kg/ha of grasses and other ground species.	Trained and competent person/s to review application rates, timing and methodology (e.g., applicator used) and rehabilitation records	Prior to seeding	Re-seed or seed according to specifications	Revegetation report (including documentation of seed mix applied, seeding timing and method, and seed mix rates) Internal	Upon completion of re-seeding
RM6 Achievement of surface requirements					
Restricted invasive plant species[1] comprise <5% of total vegetation groundcover, with the exception of *Parthenium hysterophorus* which must not exceed 10% of vegetation groundcover and be assessed by an AQP as appropriately managed.	An AQP to complete rehabilitation monitoring, outlined in Section 3.7.1	As per the rehabilitation monitoring schedule outlined in Section 3.7.1.2	Arrange corrective actions as required	Rehabilitation monitoring report Internal	Upon completion of corrective actions and as per the rehabilitation monitoring schedule outlined in Section 3.7.1.2
An AQP certifies that there is no active gully erosion greater than 1m depth.	An AQP to complete rehabilitation monitoring, outlined in Section 3.7.1	As per the rehabilitation monitoring schedule outlined in Section 3.7.1.2	Arrange corrective actions as required	Rehabilitation monitoring report Internal	Upon completion of corrective actions and as per the rehabilitation monitoring schedule outlined in Section 3.7.1.2
Groundcover is established in accordance with the criteria for each PMLU below: 1. For cattle grazing PMLU: a. Groundcover[2]: >50% established and self-sustaining vegetation cover, of which at least 50% of vegetative dry matter is comprised of 3P pasture species as listed in Section 3.5.1.8 and Appendix 4.1 (Attachment 1). 2. For woodland habitat PMLU: a. Groundcover: i. >15% slopes must achieve ≥80% groundcover	An AQP to complete rehabilitation monitoring, outlined in Section 3.7.1	As per the rehabilitation monitoring schedule outlined in Section 3.7.1.2	Arrange corrective actions as required	Rehabilitation monitoring report Internal	Upon completion of corrective actions and as per the rehabilitation monitoring schedule outlined in Section 3.7.1.2

Criteria	Monitoring Methods	Frequency	Contingency/Maintenance	Reporting	Review
ii. ≤15% slopes must achieve ≥50% groundcover					
For watercourse habitat PMLU: a) Riparian index (as part of the IDC assessment) is greater or equal to upstream or downstream values b) Geomorphic index (as part of the IDC assessment) is greater or equal to upstream or downstream values	An AQP to complete rehabilitation monitoring, outlined in Section 3.7.1	As per the rehabilitation monitoring schedule outlined in Section 3.7.1.2	Arrange corrective actions as required	Rehabilitation monitoring report Internal	Upon completion of corrective actions and as per the rehabilitation monitoring schedule outlined in Section 3.7.1.2
RM7 Achievement of PMLU to a safe, stable, non-polluting and self-sustaining condition					
Restricted invasive plant species[1] comprise <5% of total vegetation groundcover, with the exception of *Parthenium hysterophorus* which must not exceed 10% of vegetation groundcover and be assessed by an AQP as appropriately managed.	An AQP to complete rehabilitation monitoring, outlined in Section 3.7.1	As per the rehabilitation monitoring schedule outlined in Section 3.7.1.2	Arrange corrective actions as required	Rehabilitation monitoring report Internal	Upon completion of corrective actions and as per the rehabilitation monitoring schedule outlined in Section 3.7.1.2
Risk assessment completed by an AQP confirms safety hazards in rehabilitation are not significantly different to surrounding unmined landscapes subject to the same land use	Review AQP certification	Upon receipt of certification	Arrange corrective actions as required	Internal	Upon completion of corrective actions
An AQP certifies that there is no active gully erosion greater than 1m depth.	An AQP to complete rehabilitation monitoring, outlined in Section 3.7.1	As per the rehabilitation monitoring schedule outlined in Section 3.7.1.2	Arrange corrective actions as required	Rehabilitation monitoring report Internal	Upon completion of corrective actions and as per the rehabilitation monitoring schedule outlined in Section 3.7.1.2
Rehabilitation is assessed as geotechnically stable by an AQP minimum FoS ≥1.5 at the safety bund, unless an alternative is justified by an AQP	Geotechnical inspection by AQP	Upon completion of geotechnical inspection	Arrange remediation as required	Geotechnical report Internal	Upon completion of remediation
Groundcover is established in accordance with the criteria for each PMLU below: 1. For cattle grazing PMLU: a. Groundcover: > 50% established and self-sustaining vegetation cover, of which at least 50% of vegetative dry matter is comprised of 3P pasture species as listed in Section 3.5.1.8.4 2. For woodland habitat PMLU: a. Groundcover: i. >15% slopes must achieve ≥80% groundcover ii. ≤15% slopes must achieve ≥50% groundcover	An AQP to complete rehabilitation monitoring, outlined in Section 3.7.1	As per the rehabilitation monitoring schedule outlined in Section 3.7.1.2	Arrange corrective actions as required	Rehabilitation monitoring report Internal	Upon completion of corrective actions and as per the rehabilitation monitoring schedule outlined in Section 3.7.1.2
For cattle grazing PMLU: a. Leucaena >2m high: stem density is <250 stems per hectare (1 per 40m^2) mean total area	An AQP to complete rehabilitation monitoring, outlined in Section 3.7.1	As per the rehabilitation monitoring schedule outlined in Section 3.7.1.2	Arrange corrective actions as required	Rehabilitation monitoring report Internal	Upon completion of corrective actions and as per the rehabilitation monitoring schedule outlined in Section 3.7.1.2
For existing rehabilitation with a cattle grazing PMLU: a) Grazing land condition is assessed as Good (A) condition if ungrazed, or Fair (B) if under a	An AQP to complete rehabilitation monitoring, outlined in Section 3.7.1	As per the rehabilitation monitoring schedule outlined in Section 3.7.1.2	Arrange corrective actions as required	Rehabilitation monitoring report Internal	Upon completion of corrective actions and as per the rehabilitation monitoring schedule outlined in Section 3.7.1.2

Criteria	Monitoring Methods	Frequency	Contingency/Maintenance	Reporting	Review
grazing regime as per the ABCD Land Condition Framework (DES 2022a).					
For future rehabilitation with a cattle grazing PMLU: a) Land suitability class is assessed in accordance with the 'Rehabilitated mined land suitability for cattle grazing in the Bowen Basin (Short 2023).' Land suitability assessed by AQP is ≤3 or if ≥4 is not different from pre-mining and/or if ≥4 is limited by the same limiting factors present in representative reference sites.	An AQP to complete rehabilitation monitoring, outlined in Section 3.7.1	As per the rehabilitation monitoring schedule outlined in Section 3.7.1.2	Arrange corrective actions as required	Rehabilitation monitoring report Internal	Upon completion of corrective actions and as per the rehabilitation monitoring schedule outlined in Section 3.7.1.2
For woodland habitat PMLU: a) Species richness: trees ≥2; shrubs ≥3; grasses ≥4* b) Tree canopy cover: ≥16%	An AQP to complete rehabilitation monitoring, outlined in Section 3.7.1	As per the rehabilitation monitoring schedule outlined in Section 3.7.1.2	Arrange corrective actions as required	Rehabilitation monitoring report Internal	Upon completion of corrective actions and as per the rehabilitation monitoring schedule outlined in Section 3.7.1.2
For watercourse habitat PMLU: a) Riparian index (as part of the IDC assessment) is greater or equal to upstream or downstream values b) Geomorphic index (as part of the IDC assessment) is greater or equal to upstream or downstream values	An AQP to complete rehabilitation monitoring, outlined in Section 3.7.1	As per the rehabilitation monitoring schedule outlined in Section 3.7.1.2	Arrange corrective actions as required	Rehabilitation monitoring report Internal	Upon completion of corrective actions and as per the rehabilitation monitoring schedule outlined in Section 3.7.1.2
RM8 Surface water and groundwater demonstrates non-polluting landform					
Rainfall runoff from rehabilitated areas that reports to the receiving environment is not significantly different to upstream values for the following: pH, EC and turbidity.	An AQP to review surface water quality data	As per the surface water monitoring schedule outlined in Section 0	Arrange corrective actions as required	Surface water monitoring report Internal	Upon completion of corrective actions and as per the surface water monitoring schedule outlined in Section 0
Deep drainage groundwater quality results monitored quarterly at, but not limited to, the monitoring locations specified in 3.7.1.3.10 and Appendix 4.1 (Attachment 3), for electrical conductivity (EC), for a minimum of five (5) consecutive years, must not exceed (a) the EPP (Water) schedule documents water quality objectives for relevant groundwater chemistry zones; or (b) local water quality objectives developed in accordance with the Queensland Water Quality Guidelines, for three (3) consecutive results	An AQP to review groundwater quality and level data	As per the groundwater monitoring schedule outlined in Section 3.7.1.2.3	Arrange corrective actions as required	Groundwater monitoring report Internal	Upon completion of corrective actions and as per the groundwater monitoring schedule outlined in Section 3.7.1.2.3
MM1 Achievement of structural stability					
The required high-wall, end-wall and low-wall set-back achieves a minimum FoS ≥ 1.5 at the safety bund as certified by an AQP	Geotechnical inspection by AQP	Upon completion of geotechnical inspection	Arrange remediation as required	Geotechnical report Internal	Upon completion of remediation
MM2 Installation of cover system					
Engineering plans for hybrid cover systems (water/ spoil) have been designed by an AQP, to achieve the following criteria: a. Minimum 2 m cover thickness, where using spoil; and	Review AQP design	Upon completion of AQP design	Re-design hybrid cover systems as required	Cover system report Internal	Upon completion of re-design

Criteria	Monitoring Methods	Frequency	Contingency/Maintenance	Reporting	Review
b. Minimum 1 m depth permanent water cover, where tailings not covered by spoil;					
An AQP has certified that the cover system is built/ installed as designed and has completed an 'As Constructed' engineering report for each cover system.	Visual inspection by an AQP during construction	Upon construction of cover systems	Re-shape covers to design specifications prior to applying growth media, as required	'As Constructed' engineering report Internal	Upon completion of cover systems
MM3 Achievement of surface requirements					
Access to highwalls is restricted by a bund, constructed at the geotechnical set-back, to the following specifications: a. Minimum height of 2 m; and b. Minimum base width of 4 m.	Visual inspection by an AQP	Annually	Re-construct as required	Void safety controls monitoring report Internal	Annually, and upon re-construction
Access to highwalls is restricted by fencing with warning signage erected around the perimeter of the safety bund, where required, to warn of void related risks and deter public access	Visual inspection by an AQP	Annually	Re-install fencing as required	Void safety controls monitoring report Internal	Annually, and upon re-installation
MM4 Achievement of sufficient improvement					
Certification by AQP that: a) groundwater / void lake monitoring confirms the residual voids are acting as long-term groundwater sinks. b) residual voids and TSFs have effective management measures in place to ensure they are safe to humans and livestock. c) residual voids and TSFs will not present an unacceptable risk of environmental harm outside of the tenure boundary.	Review of AQP certification/s	Upon receipt of certification/s	Arrange remediation as directed by AQP	Relevant AQP reports Internal	Upon completion of remediation

[1]*Defined by the Biosecurity Act 2014 (Qld)*

[2]*Groundcover: anything in contact with the soil surface, for example, live cover, standing dry cover, organic litter (including leaves, hay, woody debris) or rocks*

**Existing rehabilitation may contain a mixture of native and exotic grass species*

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4 Appendices and attachments

Appendix 4.1 – PRCP Schedule

Legislative Requirement

In accordance with section 126D(1) of the EP Act, the PRCP Schedule in the PRC Plan must:

a) describe the area of each resource tenure either a post-mining land use or non-use management area, and
b) for each post-mining land use state:
  i. each rehabilitation milestone required to achieve a stable condition, and
  ii. when each rehabilitation milestone is to be achieved, and
c) for each non-use management area state:
  i. each management milestone, and
  ii. when each management milestone is to be achieved, and
d) include maps showing the land mentioned in (a), (b) and (c).

PRCP Guideline (Section 3.8)

Under section 126C(1)(j) of the EP Act, the administering authority considers monitoring and maintenance necessary to decide if the PRC plan is consistent with the requirements of the legislation. The rehabilitation planning part must contain a monitoring and maintenance program that identifies and describes the monitoring systems that will be carried out in order to demonstrate a milestone and milestone criteria have been achieved. The program must include, where relevant to the milestone and milestone criteria (but is not limited to):

- *schedule of monitoring, reporting and review for each milestone*
- *description of methodologies and standards, which could include field-based assessments and the application of new remote sensing, GIS and other relevant emerging technologies*
- *monitoring that enables the repeatable collection of relevant statistically valid data*
- *monitoring using appropriate quality assurance and data management processes and systems*
- *regular analysis of site data including multi-year comparison trends and bench-marking against analogue/reference sites*
- *contingency strategies if monitoring data indicates milestone criteria are not being met*
- *post-closure monitoring to ensure milestone criteria has been demonstrated*
- *intent of monitoring reports, such as provision of results and key findings*

The information requirements in this section will apply to all applicants whether or not they are an existing EA holder. However, existing holders may already have the required information available from previously submitted plans/reports/applications that, if still valid, could be used in the PRC Plan. If there has/is any monitoring or maintenance of areas already rehabilitated, details must be included in the PRC Plan.

4.1.1 Spatial Information

The following spatial information has been prepared and submitted with this PRCP in accordance with the guideline 'Spatial Information Submission' (ESR/2018/4337 Version 6.00) (DES 2024):

- Location and maximum extent of disturbance footprint for the mine life;
- PMLU and NUMAs for the area within the resource tenure/s;
- Rehabilitation and improvement areas within the resource tenure/s (for a 10-year period minimum);
- Any sensitive receptors under the EA;
- Extent of floodplain; and
- Existing rehabilitation.

The administering authority requires that the shape files and the associated attribute information are submitted in a defined format (schema) to ensure consistency in the data being received from sites across Queensland. The schema requirements outlined in Attachment 1 of the PRCP approved form have been followed, and each geometry type has been submitted in a separate file. Files have been named in accordance with the guideline 'Spatial Information Submission' (ESR/2018/4337 Version 6.00) (DES 2024).

4.1.2 PRCP Schedule

A copy of the PRCP Schedule is provided in the following sections of this Appendix. Accompanying maps are also provided as required by the PRCP Guidelines.

Post-mining land uses (PMLU)															
Rehabilitation area	RA1														
Relevant activities	Spoil Dumps and Tailings Storage Facility (TSF) (Ramp 72 TSF)														
Total rehabilitation area size (ha)	10,455														
Commencement of first milestone: RM3	1-Jul-27														
PMLU	Woodland Habitat														
Date area is available	1/07/2027	1/07/2030	1/07/2032	1/07/2035	1/07/2040	1/07/2045	1/07/2050	1/07/2055	1/07/2060	1/07/2065	1/07/2070	1/07/2075	1/07/2080	1/07/2085	1/07/2090
Cumulative area available (ha)	56	170	479	1,024	1,569	2,114	2,757	3,425	4,092	4,760	5,427	6,095	6,762	7,430	8,097
Milestone completed by	10/12/2030	10/12/2032	10/12/2035	10/12/2040	10/12/2045	10/12/2050	10/12/2055	10/12/2060	10/12/2065	10/12/2070	10/12/2075	10/12/2080	10/12/2085	10/12/2090	10/12/2095
Milestone Reference	**Cumulative area achieved (ha)**														
RM3	56	170	479	1,024	1,569	2,114	2,757	3,425	4,092	4,760	5,427	6,095	6,762	7,430	8,097
RM4	0	56	325	806	1,351	1,896	2,490	3,158	3,825	4,493	5,160	5,828	6,495	7,163	7,830
RM5	0	0	142	588	1,133	1,678	2,223	2,891	3,558	4,226	4,893	5,561	6,228	6,896	7,563
RM6	0	0	0	142	588	1,133	1,678	2,223	2,891	3,558	4,226	4,893	5,561	6,228	6,896
RM7	0	0	0	0	0	0	0	142	588	1,133	1,678	2,223	2,891	3,558	4,226
RM8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Date area is available	1/07/2095	1/07/2100	1/07/2105	1/07/2110											
Cumulative area available (ha)	8,765	9,432	10,100	10,455											
Milestone completed by	10/12/2100	10/12/2105	10/12/2110	10/12/2115	10/12/2120	10/12/2125	10/12/2130	10/12/2135	10/12/2140	10/12/2145	10/12/2150	10/12/2155			
Milestone Reference	**Cumulative area achieved (ha)**														
RM3	8,765	9,432	10,100	10,455											
RM4	8,498	9,165	9,833	10,455											
RM5	8,231	8,898	9,566	10,233	10,455										
RM6	7,563	8,231	8,898	9,566	10,233	10,455									
RM7	4,893	5,561	6,228	6,896	7,563	8,231	8,898	9,566	10,233	10,455					
RM8	0	0	0	0	0	0	0	0	0	0	0	10,455			

Post-mining land uses (PMLU)															
Rehabilitation area	RA2														
Relevant activities	Spoil Dumps and TSFs/Rejects (NCPP TSF, Laleham TSF, Bottom Dam TSF, R36 Rejects)														
Total rehabilitation area size (ha)	1,221														
Commencement of first milestone: RM3	1-Jul-25														
PMLU	Cattle Grazing														
Date area is available	1/07/2025	1/07/2027	1/07/2030	1/07/2032	1/07/2035	1/07/2040	1/07/2045	1/07/2050	1/07/2055	1/07/2060	1/07/2065	1/07/2070	1/07/2075	1/07/2080	1/07/2085
Cumulative area available (ha)	177	328	328	416	496	636	750	850	950	950	950	988	988	988	988
Milestone completed by	10/12/2027	10/12/2030	10/12/2032	10/12/2035	10/12/2040	10/12/2045	10/12/2050	10/12/2055	10/12/2060	10/12/2065	10/12/2070	10/12/2075	10/12/2080	10/12/2085	10/12/2090
Milestone Reference	**Cumulative area achieved (ha)**														
RM3	177	328	328	416	496	636	750	850	950	950	950	988	988	988	988
RM4	0	328	328	328	456	576	710	810	910	950	950	988	988	988	988
RM5	0	59	328	328	426	516	666	770	870	950	950	970	988	988	988
RM6	0	0	0	59	328	426	516	666	770	870	950	950	970	988	988
RM7	0	0	0	0	0	0	59	328	426	516	666	770	870	950	950
RM8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Date area is available	1/07/2090	1/07/2095	1/07/2100	1/07/2105	1/07/2110	1/07/2115	1/07/2120								
Cumulative area available (ha)	988	1,006	1,006	1,006	1,006	1,006	1,221								
Milestone completed by	10/12/2095	10/12/2100	10/12/2105	10/12/2110	10/12/2115	10/12/2120	10/12/2125	10/12/2130	10/12/2135	10/12/2140	10/12/2145	10/12/2150	10/12/2155		
Milestone Reference	**Cumulative area achieved (ha)**														
RM3	988	1,006	1,006	1,006	1,006	1,006	1,221								
RM4	988	1,006	1,006	1,006	1,006	1,006	1,191	1,221							
RM5	988	988	1,006	1,006	1,006	1,006	1,006	1,221							
RM6	988	988	988	1,006	1,006	1,006	1,006	1,006	1,221						
RM7	970	988	988	988	988	988	1,006	1,006	1,006	1,006	1,006	1,221			
RM8	0	0	0	0	0	0	0	0	0	0	0	0	1,221		

Post-mining land uses (PMLU)															
Rehabilitation area	RA3														
Relevant activities	Creek Diversions and Crossings														
Total rehabilitation area size (ha)	130														
Commencement of first milestone: RM1	1-Jul-32														
PMLU	Watercourse														
Date area is available	1/07/2032	1/07/2035	1/07/2040	1/07/2045	1/07/2050	1/07/2055	1/07/2060	1/07/2065	1/07/2070	1/07/2075	1/07/2080	1/07/2085	1/07/2090	1/07/2095	1/07/2100
Cumulative area available (ha)	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27
Milestone completed by	10/12/2035	10/12/2040	10/12/2045	10/12/2050	10/12/2055	10/12/2060	10/12/2065	10/12/2070	10/12/2075	10/12/2080	10/12/2085	10/12/2090	10/12/2095	10/12/2100	10/12/2105
Milestone Reference	**Cumulative area achieved (ha)**														
RM1	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27
RM3	0	27	27	27	27	27	27	27	27	27	27	27	27	27	27
RM4	0	27	27	27	27	27	27	27	27	27	27	27	27	27	27
RM5	0	27	27	27	27	27	27	27	27	27	27	27	27	27	27
RM6	0	0	27	27	27	27	27	27	27	27	27	27	27	27	27
RM7	0	0	0	0	0	0	27	27	27	27	27	27	27	131	27
RM8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Date area is available	1/07/2105	1/07/2110													
Cumulative area available (ha)	27	130													
Milestone completed by	10/12/2110	10/12/2115	10/12/2120	10/12/2125	10/12/2130	10/12/2135	10/12/2140	10/12/2145	10/12/2150	10/12/2155					
Milestone Reference	**Cumulative area achieved (ha)**														
RM1	27	130													
RM3	27	27	130												
RM4	27	27	130												
RM5	27	27	90	130											
RM6	27	27	27	90	130										
RM7	27	27	27	27	27	27	27	90	130						
RM8	0	0	0	0	0	0	0	0	0	130					

Post-mining land uses (PMLU)															
Rehabilitation area	RA4														
Relevant activities	Infrastructure areas (CHPP North, coal stockpiles, TLO, Thermal Coal Plant, workshops, administration buildings, laydown yards, roads, mine water dams)														
Total rehabilitation area size (ha)	1,537														
Commencement of first milestone: RM1	1-Jul-25														
PMLU	Cattle Grazing														
Date area is available	1/07/2025	1/07/2027	1/07/2030	1/07/2032	1/07/2035	1/07/2040	1/07/2045	1/07/2050	1/07/2055	1/07/2060	1/07/2065	1/07/2070	1/07/2075	1/07/2080	1/07/2085
Cumulative area available (ha)	44	61	133	134	198	263	354	364	400	618	835	838	838	838	838
Milestone completed by	10/12/2027	10/12/2030	10/12/2032	10/12/2035	10/12/2040	10/12/2045	10/12/2050	10/12/2055	10/12/2060	10/12/2065	10/12/2070	10/12/2075	10/12/2080	10/12/2085	10/12/2090
Milestone Reference	**Cumulative area achieved (ha)**														
RM1	44	61	133	134	198	263	354	364	400	618	835	838	838	838	838
RM2	44	61	133	134	198	263	354	364	400	618	835	838	838	838	838
RM3	0	44	61	134	156	241	312	364	364	531	748	838	838	838	838
RM4	0	44	44	124	134	219	274	364	364	444	661	838	838	838	838
RM5	0	0	44	44	134	177	252	333	364	377	574	792	838	838	838
RM6	0	0	0	0	44	134	177	252	333	364	377	574	792	838	838
RM7	0	0	0	0	0	0	0	44	134	177	252	333	364	377	574
RM8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Date area is available	1/07/2090	1/07/2095	1/07/2100	1/07/2105	1/07/2110	1/07/2115	1/07/2120								
Cumulative area available (ha)	838	838	838	838	947	1,457	1,537								
Milestone completed by	10/12/2095	10/12/2100	10/12/2105	10/12/2110	10/12/2115	10/12/2120	10/12/2125	10/12/2130	10/12/2135	10/12/2140	10/12/2145	10/12/2150	10/12/2155		
Milestone Reference	**Cumulative area achieved (ha)**														
RM1	838	838	838	838	947	1,457	1,537								
RM2	838	838	838	838	947	1,457	1,537								
RM3	838	838	838	838	838	1,253	1,537								
RM4	838	838	838	838	838	1,049	1,537								
RM5	838	1,537	838	838	838	886	1,355	1,537							
RM6	838	838	838	838	838	838	886	1,355	1,537						
RM7	792	838	838	838	838	838	838	838	838	886	1,355	1,537			
RM8	0	0	0	0	0	0	0	0	0	0	0	0	1,537		

Post-mining land uses (PMLU)															
Rehabilitation area	RA5														
Relevant activities	Infrastructure areas (CHPP South, coal stockpiles , roads, laydown yards, workshops, administration buildings, mine water dams, exploration, historic subsidence areas)														
Total rehabilitation area size (ha)	1,471														
Commencement of first milestone: RM1	1-Jul-25														
PMLU	Woodland Habitat														
Date area is available	1/07/2025	1/07/2027	1/07/2030	1/07/2032	1/07/2035	1/07/2040	1/07/2045	1/07/2050	1/07/2055	1/07/2060	1/07/2065	1/07/2070	1/07/2075	1/07/2080	1/07/2085
Cumulative area available (ha)	81	407	518	591	652	652	652	757	838	838	838	838	838	838	925
Milestone completed by	10/12/2027	10/12/2030	10/12/2032	10/12/2035	10/12/2040	10/12/2045	10/12/2050	10/12/2055	10/12/2060	10/12/2065	10/12/2070	10/12/2075	10/12/2080	10/12/2085	10/12/2090
Milestone Reference	**Cumulative area achieved (ha)**														
RM1	81	407	518	591	652	652	652	757	838	838	838	838	838	838	925
RM2	81	407	518	591	652	652	652	757	838	838	838	838	838	838	925
RM3	0	117	407	520	652	652	652	710	827	838	838	838	838	838	838
RM4	0	45	117	413	622	652	652	663	780	838	838	838	838	838	838
RM5	0	0	45	229	560	652	652	652	733	838	838	838	838	838	838
RM6	0	0	0	0	229	560	652	652	652	733	838	838	838	838	838
RM7	0	0	0	0	0	0	0	0	229	560	652	652	652	733	838
RM8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Date area is available	1/07/2090	1/07/2095	1/07/2100	1/07/2105	1/07/2110	1/07/2115									
Cumulative area available (ha)	1,119	1,160	1,160	1,160	1,235	1,471									
Milestone completed by	10/12/2095	10/12/2100	10/12/2105	10/12/2110	10/12/2115	10/12/2120	10/12/2125	10/12/2130	10/12/2135	10/12/2140	10/12/2145	10/12/2150	10/12/2155		
Milestone Reference	**Cumulative area achieved (ha)**														
RM1	1,119	1,160	1,160	1,160	1,235	1,471									
RM2	1,119	1,160	1,160	1,160	1,235	1,471									
RM3	1,039	1,160	1,160	1,160	1,160	1,460	1,471								
RM4	969	1,160	1,160	1,160	1,160	1,310	1,471								
RM5	882	1,079	1,160	1,160	1,160	1,160	1,471								
RM6	838	882	1,079	1,160	1,160	1,160	1,160	1,471							
RM7	838	838	838	838	838	882	1,079	1,160	1,160	1,160	1,160	1,471			
RM8	0	0	0	0	0	0	0	0	0	0	0	0	1,471		

Post-mining land uses (PMLU)															
Rehabilitation area	RA6														
Relevant activities	Existing Rehabilitation														
Total rehabilitation area size (ha)	727														
Commencement of first milestone: RM6	1-Jul-25														
PMLU	Woodland Habitat														
Date area is available	1/07/2025	1/07/2027	1/07/2030	1/07/2032											
Cumulative area available (ha)	291	291	291	727											
Milestone completed by	10/12/2027	10/12/2030	10/12/2032	10/12/2035	10/12/2040	10/12/2045	10/12/2050	10/12/2055	10/12/2060	10/12/2065	10/12/2070	10/12/2075	10/12/2080	10/12/2085	10/12/2090
Milestone Reference	**Cumulative area achieved (ha)**														
RM6	291	291	291	727											
RM7	0	0	0	0	0	0	291	727							
RM8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Date area is available															
Cumulative area available (ha)															
Milestone completed by	10/12/2095	10/12/2100	10/12/2105	10/12/2110	10/12/2115	10/12/2120	10/12/2125	10/12/2130	10/12/2135	10/12/2140	10/12/2145	10/12/2150	10/12/2155		
Milestone Reference	**Cumulative area achieved (ha)**														
RM6															
RM7															
RM8	0	0	0	0	0	0	0	0	0	0	0	0	727		

Post-mining land uses (PMLU)															
Rehabilitation area	RA7														
Relevant activities	Existing Rehabilitation														
Total rehabilitation area size (ha)	1,200														
Commencement of first milestone: RM6	1-Jul-25														
PMLU	Cattle Grazing														
Date area is available	1/07/2025	1/07/2027	1/07/2030	1/07/2032											
Cumulative area available (ha)	639	639	725	1,200											
Milestone completed by	10/12/2027	10/12/2030	10/12/2032	10/12/2035	10/12/2040	10/12/2045	10/12/2050	10/12/2055	10/12/2060	10/12/2065	10/12/2070	10/12/2075	10/12/2080	10/12/2085	10/12/2090
Milestone Reference	**Cumulative area achieved (ha)**														
RM6	639	639	725	1,200											
RM7	0	0	0	0	0	639	1,200								
RM8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Date area is available															
Cumulative area available (ha)															
Milestone completed by	10/12/2095	10/12/2100	10/12/2105	10/12/2110	10/12/2115	10/12/2120	10/12/2125	10/12/2130	10/12/2135	10/12/2140	10/12/2145	10/12/2150	10/12/2155		
Milestone Reference	**Cumulative area achieved (ha)**														
RM6															
RM7															
RM8	0	0	0	0	0	0	0	0	0	0	0	0	1200		

Post-mining land uses (PMLU)															
Rehabilitation area	IA1														
Relevant activities	Voids (Ramp 8, Mimosa/Besgrove, Deep Creek, Stewarton/Ballamoo, Kenmare, Togara/North Marshmead, South Marshmead, Comet Downs East, Kennedy West)														
Total rehabilitation area size (ha)	3,806														
Commencement of first milestone: MM1	1-Jul-45														
PMLU	NUMA														
Date area is available	1/07/2045	1/07/2050	1/07/2055	1/07/2060	1/07/2065	1/07/2070	1/07/2075	1/07/2080	1/07/2085	1/07/2090	1/07/2095	1/07/2100	1/07/2105	1/07/2110	1/07/2115
Cumulative area available (ha)	204	204	234	234	234	234	234	599	765	2,245	3,086	3,753	3,753	3,753	3,806
Milestone completed by	10/12/2050	10/12/2055	10/12/2060	10/12/2065	10/12/2070	10/12/2075	10/12/2080	10/12/2085	10/12/2090	10/12/2095	10/12/2100	10/12/2105	10/12/2110	10/12/2115	10/12/2120
Milestone Reference	**Cumulative area achieved (ha)**														
MM1	204	204	234	234	234	234	234	599	765	2,245	3,086	3,753	3,753	3,753	3,806
MM3	204	204	234	234	234	234	234	599	765	2,245	3,086	3,753	3,753	3,753	3,806
MM4	0	204	204	234	234	234	234	234	599	765	2,245	3,086	3,753	3,753	3,753

Date area is available															
Cumulative area available (ha)															
Milestone completed by	10/12/2125														
Milestone Reference	**Cumulative area achieved (ha)**														
MM1															
MM3															
MM4	3,806														

Post-mining land uses (PMLU)															
Rehabilitation area	IA2														
Relevant activities	Voids and TSFs with cover system (Ramp 74 TSF and Bonnie Doon TSF)														
Total rehabilitation area size (ha)	161														
Commencement of first milestone: MM1	1-Jul-45														
PMLU	NUMA														
Date area is available	1/07/2045	1/07/2050	1/07/2055												
Cumulative area available (ha)	102	102	161												
Milestone completed by	10/12/2050	10/12/2055	10/12/2060	10/12/2065	10/12/2070	10/12/2075									
Milestone Reference	**Cumulative area achieved (ha)**														
MM1	102	102	161												
MM2	0	0	102	102	161										
MM3	0	0	102	102	161										
MM4	0	0	0	102	102	161									

Date area is available															
Cumulative area available (ha)															
Milestone completed by															
Milestone Reference	**Cumulative area achieved (ha)**														
MM1															
MM2															
MM3															
MM4															

Rehabilitation Area Milestones

Milestone Reference	Rehabilitation milestone	Milestone criteria
RM1	Infrastructure decommissioning and removal	1.1 With the exception of any infrastructure to remain as part of the post-mining land use (PMLU) or where infrastructure is agreed to be retained by the landholder as evidenced by a signed landholder agreement , the following are complete: a. All services (water, electricity, gas, etc) disconnected and removed; b. All buildings demolished and removed; c. All hardstand, concrete and bitumen within 0.5 m of the final landform surface removed; d. No below-ground built or service infrastructure within 0.5 m of the final landform surface; e. Mine water dams decommissioned; and f. Watercourse crossings and culverts removed.
RM2	Remediation and/or management of contaminated land	2.1 Contaminated Land Investigation Document completed in accordance with the *Environmental Protection Act 1994* , including: a. Site Suitability Statement confirming the suitability of the property for the PMLUs; and b. Audit Certification. 2.2 Contaminated Land Investigation Document including a Site Investigation Report and, where required, a Validation Report and/or a draft Site Management Plan.
RM3	Bulk earthworks and landform reshaping	3.1 For cattle grazing PMLU: a. Landforms reshaped with 70% of slopes ≤20% gradient. 3.2 For woodland habitat PMLU: a. Landforms reshaped with maximum 30% slopes. 3.3 For watercourse PMLU: a. Disturbed natural watercourse bed and banks returned to a profile similar to the pre-disturbance condition. 3.4 For Tailings Storage Facilities (TSFs) and reject dumps: a. Capping of at least 2 meters of competent benign spoil is to occur; and b. Cover surface is free draining and does not display surface ponding.
RM4	Surface preparation	4.1 In areas where topsoil has previously been removed, topsoil and or growth media is in place at a minimum depth of: a. 150 mm for the cattle grazing PMLU and watercourse PMLU; and b. 100 mm for the woodland habitat PMLU. 4.2 Assessment of growth media characteristics and the development of an amelioration plan is completed by an AQP prior to placement on the landform. 4.3 Ameliorant and physical treatments are applied as identified in RM4(b). 4.4 Rip on contour at a minimum depth of ≥300 mm.

Milestone Reference	Rehabilitation milestone	Milestone criteria
RM5	Revegetation	5.1 For cattle grazing PMLU: a. Complete seeding in accordance with recommended pasture mix and seeding rates for cattle grazing PMLU as per Attachment 1 - Seed Mix Species List and Seeding Rates. b. At least four (4) species of 3P (preferred, palatable and perennial) grasses, including at least two (2) native species, and two (2) legume species are to be seeded per cattle grazing rehabilitation area. c. Minimum seeding rates for cattle grazing of at least 16kg/ha of coated pasture seed and 4 kg p/ha of uncoated legume seed are to be used, unless adjusted by an AQP. 5.2 For woodland habitat PMLU: a. Complete seeding in accordance with recommended woodland habitat species mixes and seeding rates as per Attachment 1 - Seed Mix Species List and Seeding Rates, or as recommended by an AQP if revegetation is targeting a specific regional ecosystem. b. Minimum seeding rates of 6 kg/ha tree species, 4 kg/ha of woody understorey species and 10 kg/ha of grasses to be used unless adjusted by an AQP. c. Include at least six (6) species from revegetation lists for framework trees, woody understorey (shrub) species grass species as per Attachment 1 - Seed Mix Species List and Seeding Rates, or as recommended by an AQP. 5.3 For watercourse PMLU: a. Complete seeding in accordance with recommended watercourse species mixes and seeding rates as per Attachment 1 - Seed Mix Species List and Seeding Rates. b. Minimum seeding rates for upper and mid banks of 6 kg/ha tree species, 4 kg/ha of woody understorey species and 10 kg/ha of grasses and other ground species. c. Minimum seeding rates for lower banks of 5 kg/ha tree species, 10 kg/ha of grasses and other ground species.
RM6	Achievement of surface requirements	6.1 For all PMLUs: a. Restricted invasive plant species[1] comprise <5% of total vegetation groundcover , with the exception of *Parthenium hysterophorus* which must not exceed 10% of vegetation groundcover and be assessed by an AQP as appropriately managed. b. An AQP certifies that there is no active gully erosion greater than 1m depth. 6.2 For cattle grazing PMLU: a. Groundcover[2]: >50% established and self-sustaining vegetation cover, of which at least 50% of vegetative dry matter is comprised of 3P pasture species as listed in Attachment 1 - Seed Mix Species List and Seeding Rates. 6.3 For woodland habitat PMLU: a. Groundcover: i. >15% slopes must achieve ≥80% groundcover ii. ≤15% slopes must achieve ≥50% groundcover 6.4 For watercourse habitat PMLU: a. Riparian index (as part of the IDC assessment) is greater or equal to upstream or downstream values b. Geomorphic index (as part of the IDC assessment) is greater or equal to upstream or downstream values

Milestone Reference	Rehabilitation milestone	Milestone criteria
RM7	Achievement of PMLU to a safe, stable, non-polluting and self-sustaining condition	7.1 For all PMLUs: a. Risk assessment completed by an AQP confirms safety hazards in rehabilitation are not significantly different to surrounding unmined landscapes subject to the same land use. b. Restricted invasive plant species[1] comprise <5% of total vegetation groundcover , with the exception of *Parthenium hysterophorus* which must not exceed 10% of vegetation groundcover and be assessed by an AQP as appropriately managed. c. An AQP certifies that there is no active gully erosion greater than 1m depth. 7.2 For the existing rehabilitation cattle grazing PMLU (RA7): a. Rehabilitation is assessed as geotechnically stable by an AQP minimum FoS ≥1.5 at the safety bund, unless an alternative is justified by an AQP b. Groundcover: >50% established and self-sustaining vegetation groundcover, of which at least 50% of vegetative dry matter yield is comprised of 3P pasture species. c. Grazing land condition is assessed as Good (A) condition if ungrazed, or Fair (B) if under a grazing regime as per Attachment 2 – ABCD Land Condition Framework (DES 2022a). d. Leucaena >2m high: stem density is <250 stems per hectare (1 per 40m^2) mean total area 7.3 For future cattle grazing PMLU (RA2, RA4): a. Rehabilitation is assessed as geotechnically stable by an AQP minimum FoS ≥1.5 at the safety bund, unless an alternative is justified by an AQP b. Groundcover: >50% c. Greater than 50% of the vegetative dry matter yield is comprised of 3P grasses. d. Land suitability class is assessed in accordance with the 'Rehabilitated mined land suitability for cattle grazing in the Bowen Basin (Short 2023).' Land suitability assessed by AQP is ≤3 or if ≥4 is not different from pre-mining and/or if ≥4 is limited by the same limiting factors present in representative reference sites. e. Leucaena >2m high: stem density is <250 stems per hectare (1 per 40m^2) mean total area. 7.4 For existing and future woodland habitat PMLU (RA1, RA5, RA6): a. Rehabilitation is assessed as geotechnically stable by an AQP minimum FoS ≥1.5 at the safety bund, unless an alternative is justified by an AQP. b. Groundcover: i. >15% slopes must achieve ≥80% groundcover ii. ≤15% slopes must achieve ≥50% groundcover c. Species richness: trees ≥2; shrubs ≥3; grasses ≥4* d. Tree canopy cover: ≥16% 7.5 For watercourse PMLU: a. Geomorphic index score: greater than or equal to upstream or downstream values (IDC method) b. Riparian vegetation index score: greater than or equal to upstream or downstream values (IDC method) **Existing rehabilitation may contain a mixture of native and exotic grass species*
RM8	Surface water and groundwater demonstrates non-polluting landform	8.1 Rainfall runoff from rehabilitated areas that reports to the receiving environment is not significantly different to upstream values for the following: pH, EC and turbidity. 8.2 Groundwater quality results monitored quarterly at, but not limited to, the monitoring locations specified in Attachment 3– Groundwater Monitoring Locations , for all quality characteristics listed in Attachment 4 – Groundwater Quality Limits , for a minimum of five (5) consecutive years. The limits in Attachment 4 must not be exceeded, for three (3) consecutive results.

[1] *Defined by the Biosecurity Act 2014 (Qld)*

[2] *Groundcover: anything in contact with the soil surface, for example, live cover, standing dry cover, organic litter (including leaves, hay, woody debris) or rocks*

Attachment 1: Seed Mix Species List and Seeding Rates

Recommended species list and seeding rates for cattle grazing PMLU		
Scientific name	**Common name**	**Seeding rate (kg/ha)**
Astrebla lappulacea, A, squarrosa, A. elymoides	Mitchell grasses (curly, bull and hoop)	2[c] (per species)
Bothriochloa bladhii	forest blue grass	4[c]
*Bothriochloa insculpta cvv. Bisset**	Bisset creeping blue grass	4[c]
*Chloris gayana cvv. Callide**	Callide Rhodes grass	4[c]
*Chloris gayana cvv. Katambora**	Katambora Rhodes grass	4[c]
Dichanthium sericeum subsp. sericeum	Queensland blue grass	4[c]
Digitaria brownii	cotton panic	2[c]
Heteropogon contortus	black spear grass	2
*Megathyrsus maximus var. pubiglumis**	green panic	4[c]
*Panicum coloratum var. makarikariense**	bambatsi Panic	4[c]
*Setaria incrassata**	purple pigeon	4c
*Urochloa mosambicensis**	Sabi grass	4c
Grass species - Total seed weight coated (kg/ha)		**16c**
*Stylosanthes seabrana**	stylo	2
*Macroptilium bracteatum**	burgundy bean	2
*Stylosanthes hamata**	shrubby stylo	2
Chamaecrista rotundifolia	Wynn cassia	2
Rhynchosia minima var. minima	rhynchosia	2
Rhynchosia minima var. australis	rhynchosia	2
Legume species - Total seed weight uncoated (kg/ha)		**4**
Echinochloa esculenta	Japanese millet	5 c
c Assumes seed is coated. If not coated, use half prescribed rate; Naturalised exotic pasture species*		

Recommended species list and seeding rates for woodland PMLU (RE 11.7.2 mix)		
Species name	**Common name**	**Seeding rate (kg/ha)**
Acacia catenulata	bendee	1-2
Acacia shirleyi	lancewood	3-4
Acacia rhodoxylon	rosewood	0.3-0.5
Alphitonia excelsa	red ash	0.3-0.5
Angophora leiocarpa	smooth barked apple	0.3-0.5
*Corymbia citriodora subsp. citriodora**	lemon scented gum	0.3-0.5
Corymbia clarksoniana	Clarkson's bloodwood	0.3-0.5
Corymbia dallachiana	Dallachy's gum	0.3-0.5
Eucalyptus crebra	narrow leaved ironbark	0.3-0.5
Eucalyptus exserta	Queensland peppermint	0.3-0.5
Framework tree species - total seed weight uncoated (kg/ha)		**6**
Alstonia constricta	bitterbark	0.3-0.5
Breynia oblongifolia	*coffee bush*	0.3-0.5
Capparis lasiantha, C. canescens, C. loranthifolia.	wait-a-while	0.2-0.5
Carissa ovata	currant bush	0.3-1
*Cassia brewsteri**	Leichhardt bean	0.3-0.5
Eremophila mitchellii	false sandalwood	0.3-0.5
Erythroxylon australe	cocaine tree	0.2-0.5
Geijera parvifolia	wilga	0.3-0.5
Hakea lorea	bootlace oak	0.3-0.5
Petalostigma pubescens	quinine	0.3-0.5
Woody understory species - total seed weight uncoated (kg/ha)		**4**
Aristida spp. (i.e. A. calycina, A. latifolia, A. ramosa, A. caput-medusae, A. jerichoensis, A. personata, A. calycina)	three awned spear grass	1-2
Chrysopogon fallax	golden beard grass	2-3
*Cynodon dactylon var. dactylon**	couch	2-3
Entolasia stricta	Wiry panic	2-3
Panicum effusum	hairy panic	2-3
Panicum decompositum	Native millet	2-3
Paspalidium distans	shot grass	2-3
Grass species - total seed weight uncoated (kg/ha)		**10**
Echinochloa esculenta	Japanese millet	5
** Species adapted to moderate to high salinity tolerance (DERM, 2011)*		

Recommended species list and seeding rates for woodland PMLU (hybrid RE 11.5.3/ RE 11.5.9)		
Species name	**Common name**	**Seeding rate (kg/ha)**
Acacia rhodoxylon	rosewood	0.3-1
Alphitonia excelsa	red ash	0.3-0.5
Angophora leiocarpa	smooth barked apple	0.3-0.5
Atalaya hemiglauca	whitewood	0.3-0.5
Corymbia clarksoniana	Clarkson's bloodwood	0.3-1
Corymbia dallachiana	Dallachy's gum	0.3-0.5
Corymbia erythrophloia	red bloodwood	0.3-1
Eucalyptus crebra	narrow leaved ironbark	0.6-2
Eucalyptus melanophloia	silver leaved ironbark	0.3-1
Eucalyptus populnea	poplar box	0.3-0.5
Lysiphyllum carronii	red bauhinia	0.3-0.5
Lysiphyllum hookeri	white bauhinia	0.2-0.5
Terminalia oblongata	yellowwood	0.2-0.5
Framework tree species - total seed weight uncoated (kg/ha)		**6**
Acacia excelsa	ironwood wattle	0.3-0.5
Acacia conferta	crowded-leaf wattle	0.3-0.5
Acacia sericophylla	desert oak	0.3-0.5
Breynia oblongifolia	coffee bush	0.3-0.5
Capparis lasiantha, C. canescens, C. loranthifolia.	wait-a-while	0.2-0.5
Carissa ovata	currant bush	0.3-1
*Cassia brewsteri**	Leichhardt bean	0.3-0.5
*Dodonaea viscosa**	sticky hop bush	0.3-0.5
Eremophila mitchellii	false sandalwood	0.3-0.5
Erythroxylon australe	cocaine tree	0.2-0.5
Geijera parvifolia	wilga	0.2-0.5
Grevillea striata	beefwood	0.3-0.5
Grewia latifolia	dogs balls	0.3-0.5
Hakea lorea	bootlace oak	0.3-0.5
Jasminum didymum	native jasmine	0.3-0.5
Petalostigma pubescens	quinine	0.3-0.5
Pittosporum angustifolium	Gumby Gumby	0.3-0.5
Senna artemisioides	silver cassia	0.3-0.5
Woody understory species - total seed weight uncoated (kg/ha)		**4**
Aristida spp. (i.e. A. calycina, A. latifolia, A. ramosa, A. caput-medusae, A. jerichoensis, A. personata, A. calycina)	three awned spear grass	1-2
Bothriochloa decipiens var. decipiens	pitted blue grass	1-2
Bothriochloa bladhii	forest blue grass	1-2
Bothriochloa ewartiana	desert bluegrass	1-2
Chrysopogon fallax	golden beard grass	1-2
Cymbopogon refractus	barbwire grass	1-2
*Cynodon dactylon var. dactylon**	couch	1-2
Panicum effusum	hairy panic	1-2
Panicum queenslandicum	Yabila grass	1-2
Themeda triandra	kangaroo grass	1-2
Grass species - total seed weight uncoated (kg/ha)		**10**
Echinochloa esculenta	Japanese millet	5
** Species adapted to moderate to high salinity tolerance (DERM, 2011)*		

Recommended species list and seeding rates for watercourse PMLU (upper and mid banks)		
Species name	**Common name**	**Seed rate (kg/ha uncoated)**
*Acacia stenophylla**	river myall	0.5 - 1
Alphitonia excelsa	red ash	0.5 - 1
Angophora floribunda	rough barked apple	0.5 - 1
Angophora leiocarpa	smooth barked apple	0.5 - 1
Angophora subvelutina	broadleaf apple	0.5 - 1
*Casuarina cristata**	belah	0.5 - 1
*Casuarina cunninghamiana**	river she oak	0.5 - 1
*Corymbia tessellaris**	Moreton Bay ash	0.5 - 1
*Eucalyptus camaldulensis subsp. obtusa**	river red gum	1-2
Eucalyptus coolabah subsp. coolabah	Coolabah	1-2
Eucalyptus melanophloia	silver leaved ironbark	0.5 - 1
Eucalyptus populnea	poplar box	0.5 - 1
*Eucalyptus tereticornis subsp. tereticornis**	Queensland blue gum	0.5 - 1
Lysiphyllum hookeri	white bauhinia	0.5 - 1
*Melaleuca bracteata**	black tea tree	0.5 - 1
Terminalia oblongata	yellowwood	0.5 - 1
Framework tree species - total seed weight uncoated (kg/ha)		**6**
Carissa ovata	current bush	0.5 - 1
Acacia excelsa	ironwood wattle	0.5 - 1
Acacia fasciculifera	scaly bark	0.5 - 1
*Cassia brewsteri**	Leichardt bean	0.5 - 1
Dodonaea viscosa	sticky hop bush	0.5 - 1
Eremophila mitchellii	false sandalwood	0.5 - 1
Erythroxylum australe	cocaine tree	0.5 - 1
Ficus coronata	creek sandpaper fig	0.5 - 1
Ficus fraseri	white sandpaper fig	0.5 - 1
Ficus opposita	sandpaper fig	0.5 - 1
Grevillea striata	beefwood	0.5 - 1
Grewia latifolia	dogs balls	0.5 - 1
Hakea lorea	bootlace oak	0.5 - 1
Mallotus philippensis	red kamala	0.5 - 1
Petalostigma pubescens	quinine	0.5 - 1
Woody understorey species - total seed weight uncoated (kg/ha)		**4**
Cymbopogon refractus	barbwire grass	1-2
Bothriochloa bladhii	forest blue grass	1-2
Capillipedium spicigerum	scented top	0.2 - 0.5
*Cynodon dactylon**	couch	2
Dichanthium sericeum subsp. sericeum	Queensland bluegrass	1-2
Digitaria brownii	cotton panic	1-2
Eulalia aurea	silky brown top	1-2
Eustrephus latifolius	wombat vine	0.5-1
Heteropogon contortus	bunched speargrass	1-2
Jasminum simplicifolium subsp. australiense	stiff jasmine	1-2
Lomandra longifolia	mat rush	1-2
Panicum effusum	hairy panic	1-2
Paspalidium distans	shot grass	1-2
Rhynchosia minima	Rhynchosia	1-2
Themeda triandra	kangaroo grass	1-2
Ground species - total seed uncoated (kg/ha)		**10**
Echinochloa esculenta	Japanese millet	5
** Species adapted to moderate to high salinity tolerance (DERM, 2011)*		

Recommended species list and seeding rates for watercourse PMLU (lower banks)		
Species name	**Common name**	**Seed rate (kg/ha - uncoated weight)**
*Casuarina cunninghamiana**	river she oak	0.5-1
*Melaleuca bracteata**	black tea tree	0.5-1
Melaleuca fluviatilis	weeping tea-tree	0.5-1
*Melaleuca linariifolia**	snow in summer	0.5-1
*Melaleuca leucadendra**	broad-leaved tea tree	0.5-1
*Melaleuca viminalis**	red bottlebrush	0.5-1
Melaleuca trichostachya	flax-leaf paperbark	0.5-1
Lophostemon suaveolens	swamp box	0.5-1
Framework tree species - total seed weight uncoated (kg/ha)		**5**
Cymbopogon refractus	barbwire grass	0.5-1
Dichanthium sericeum subsp. sericeum	Queensland bluegrass	1-2
Themeda triandra	kangaroo grass	0.5-1
Bothriochloa bladhii subsp. bladhii	forest blue grass	1-2
Lomandra longifolia	spiny-headed mat rush	2-3
Eustrephus latifolius	wombat vine	0.5-1
*Cyperus spp. (C. gracilis, C. polystachyos)***	sedge	2-3
*Cynodon dactylon**	couch	2-3
Ground species - total seed weight uncoated (kg/ha)		**10**
Echinochloa esculenta	Japanese millet	5
** Species adapted to moderate to high salinity tolerance (DERM, 2011) ** Bank toe area only*		

Attachment 2: ABCD Land Condition Framework

The ABCD land condition framework

(*Grazing Guide version 2, Department of Environment, Innovation and Science, 2022*)

Good condition (A)	Fair condition (B)
Often above 70% groundcover	Minimum 50% groundcover, but often less than 70% groundcover
Good density of perennial grasses (less than 30% bare ground), dominated by 3P grasses	Decreased density of perennial grasses (bare ground > 30% but < 50%), not dominated by 3P grasses
Few weeds, no significant infestations	Increased weeds, no significant infestations
Good soil condition, no erosion	Decline in soil condition, signs of erosion and susceptibility to erosion

Attachment 3: Groundwater Monitoring Locations

Monitoring points	Hydrogeological unit	Easting (GDA2020)	Northing (GDA2020)
MB1[1]	Permian coal (Rangal Coal Measure, ARS, TU seam)	686331	7387081
MB21[1]	Tertiary Sediments	684900	7350806
MB18[1]	Permian Sandstone	691537	7370788
BWM_MB02_01[1]	Permian Interburden	691748	7362714
BWM_MB02_02[1]	Permian Coal (Rangal Coal Measure, Castor, M54 seam)	691736	7362716
BWM_MB03_01[1]	Alluvium	692229	7381517
BWM_MB03_02[1]	Rewan Group	692232	7381522
BWM_MB12_01[1]	Tertiary Sediments	TBC	TBC
BWM_MB12_02[1]	Permian Coal (Rangal Coal Measure, Castor, P04 seam)	TBC	TBC
BWM_MB14_01[1]	Permian Interburden	TBC	TBC
BWM_MB14_02[1]	Permian Interburden	TBC	TBC
BWM_MB15_01[1]	Tertiary sediments	TBC	TBC
BWM_MB17_01[1]	Basalt	TBC	TBC
BWM_MB17_02[1]	Tertiary (BUTE)	TBC	TBC
MB19BWM01P[1]	Permian Coal (Rangal Coal Measure, Aries Seam (ARS), Top seams)	690037	7390282
MB19BWM02A[1]	Rewan Group	690127	7370183
MB19BWM08P[1]	Permian Coal (Rangal Coal Measure, Aries Seam (ARS), Top seams) & Siltstone	691542	7370740
MB19BWM27P[1]	Permian Coal (Rangal Coal Measure, Aries Seam (ARS), Top seams) & Siltstone	688958	7376560
MB20BWM03P2[1]	Permian (Rangal Coal Measure, Castor and Pollux, L41 seam)	686499	7387293
BG-1[1]	Burngrove Formation	683994	7387562
BG-2[1]	Burngrove Formation	684300	7384442
Bore upgradient of Red Dam (as per condition I17)	TBC	TBC	TBC
Bore downgradient of Red Dam (as per condition I17)	TBC	TBC	TBC
Bore upgradient of NCPP Tailings Dam (as per condition I18)	TBC	TBC	TBC
Bore downgradient of NCPP Tailings Dam (as per condition I18)	TBC	TBC	TBC

NOTES:

1.Contaminant limits have not yet been developed for these bores due to the limited available monitoring dataset. Monthly monitoring will occur until a suitable dataset is available to set contaminant limits.

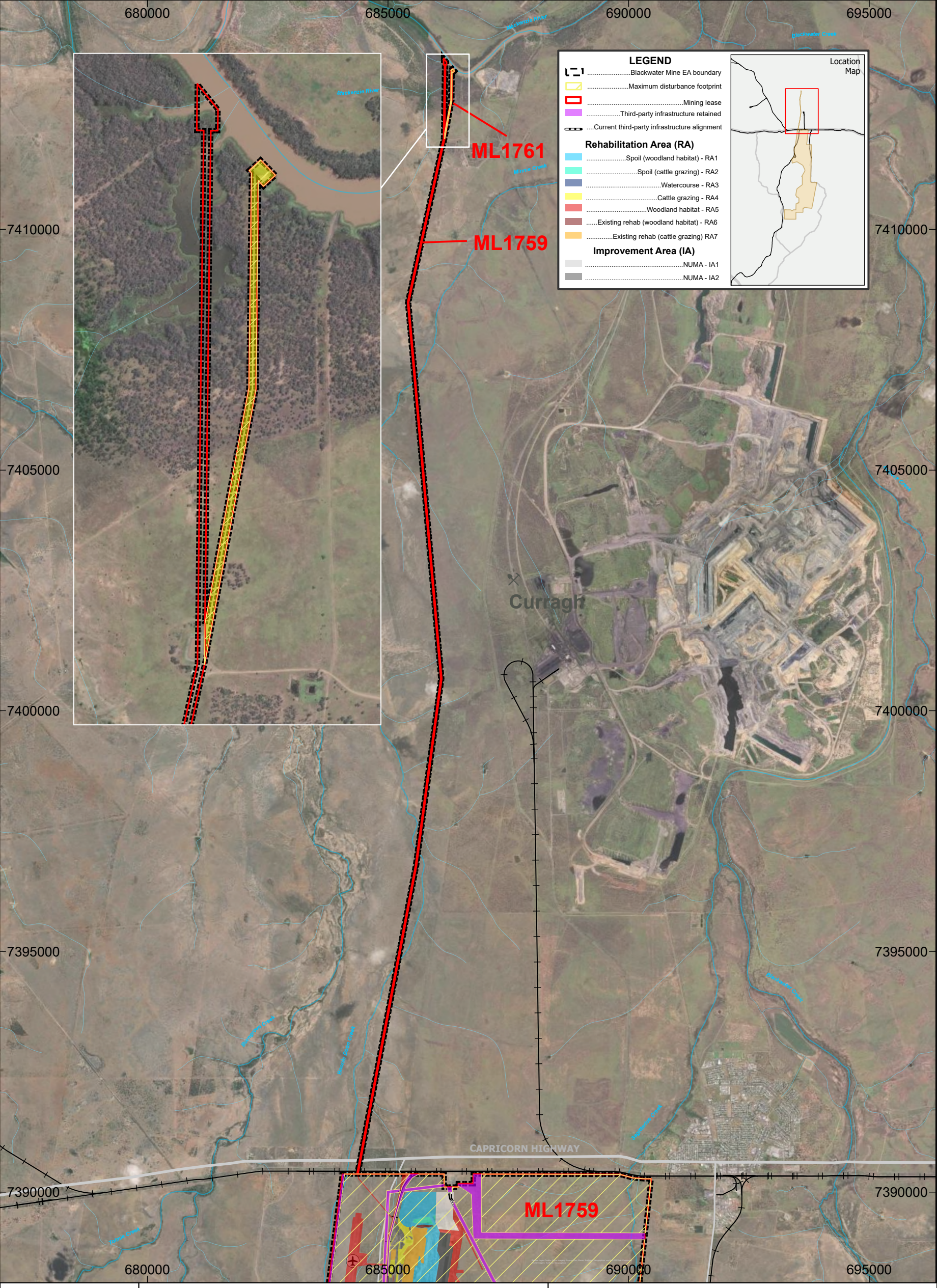
* 'TBC' has been included for coordinates that require confirmation. The final location coordinates will be provided to the administering authority in accordance with condition I14. TBC has also been included for Ground Level Surface RL (m) and Screened Interval RL (m), which will be provided in accordance with conditions I2 and I12.

Attachment 4: Groundwater Quality Limits

Acceptance criteria	Indicator
Deep drainage is not significantly different to (a) the EPP (Water) schedule documents water quality objectives for relevant groundwater chemistry zones; or, (b) local water quality objectives developed in accordance with the Queensland Water Quality Guidelines.	EC

Improvement Area Milestones

Milestone Reference	Management milestone	Milestone criteria
MM1	Achievement of structural stability	1.1 The required high-wall, end-wall and low-wall set-back achieves a minimum FoS ≥ 1.5 at the safety bund as certified by an AQP.
MM2	Installation of cover system	2.1 Engineering plans for hybrid cover systems (water/ spoil) have been designed by an AQP, to achieve the following criteria: a. Minimum 2 m cover thickness, where using spoil; and b. Minimum 1 m depth permanent water cover, where tailings not covered by spoil; 2.2 An AQP has certified that the cover system is built/ installed as designed and has completed an 'As Constructed' engineering report for each cover system.
MM3	Achievement of surface requirements	3.1 Access to highwalls is restricted by a bund, constructed at the geotechnical set-back, to the following specifications: a. Minimum height of 2 m; and b. Minimum base width of 4 m. 3.2 Access to highwalls is restricted by fencing and signage erected around the perimeter of safety bund, where required.
MM4	Achievement of sufficient improvement	4.1 Certification from an AQP that: a. groundwater / void lake monitoring confirms the residual voids are acting as long-term groundwater sinks. b. residual voids and TSFs have effective management measures in place to ensure they are safe to humans and livestock. c. residual voids and TSFs will not present an unacceptable risk of environmental harm outside of the tenure boundary.



Whitehaven

GIS Team - Brisbane

0 1 2 3 4 5 km

Transverse Mercator Projection

MGA Zone 55 of the GDA 1994

N

BLACKWATER PRCP

REFERENCE MAP (MAP 1 of 2)

Drawn: GOtter	Date: 30/04/2025
Checked: S.Donner	Filename: Figure22_23_A3_20240703-1_RA.aprx

LEGEND

- Blackwater Mine EA boundary
- Maximum disturbance footprint
- Mining lease
- Third-party infrastructure retained
- Current third-party infrastructure alignment

Rehabilitation Area (RA)

- Spoil (woodland habitat) - RA1
- Spoil (cattle grazing) - RA2
- Watercourse - RA3
- Cattle grazing - RA4
- Woodland habitat - RA5
- Existing rehab (woodland habitat) - RA6
- Existing rehab (cattle grazing) RA7

Improvement Area (IA)

- NUMA - IA1
- NUMA - IA2

Location Map

CAPRICORN HIGHWAY

Blackwater Rolleston Road

ML1759
ML1760
ML1759
ML70104
ML70329
ML1762
ML70103
ML1800
ML1862
ML70091
ML1811
ML1792
ML1773
ML1771
ML1829
ML1860
ML1767
ML1907
ML70139
ML70167

665000 670000 675000 680000 685000 690000 695000 700000

7390000 7385000 7380000 7375000 7370000 7365000 7360000 7355000 7350000 7345000 7340000

Whitehaven

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0 1 2 3 4 5 km

Transverse Mercator Projection

GDA 1994, MGA Zone 55

N

BLACKWATER PRCP

REFERENCE MAP (MAP 2 of 2)

Date: 30/04/2025

Filename: Figure22_23_A3_20240703-1_RA.aprx

LEGEND

- Blackwater Mine EA boundary
- Mining lease
- Rehabilitation area 1 (RA 1)
- Rehabilitation area - other
- Improvement area

Location Map

ML1760
ML1759
ML70104
ML70329
ML1762
ML70103
ML1800
ML1862
ML1792
ML70091
ML1812
ML1773
ML1771
ML1829
ML1860
ML1767
ML1907
ML70139
ML70167

CAPRICORN HIGHWAY

Blackwater Rolleston Road

665000 670000 675000 680000 685000 690000 695000 700000

7390000 7385000 7380000 7375000 7370000 7365000 7360000 7355000 7350000 7345000 7340000

Whitehaven

GIS Team - Brisbane

0 1 2 3 4 5 km

Transverse Mercator Projection

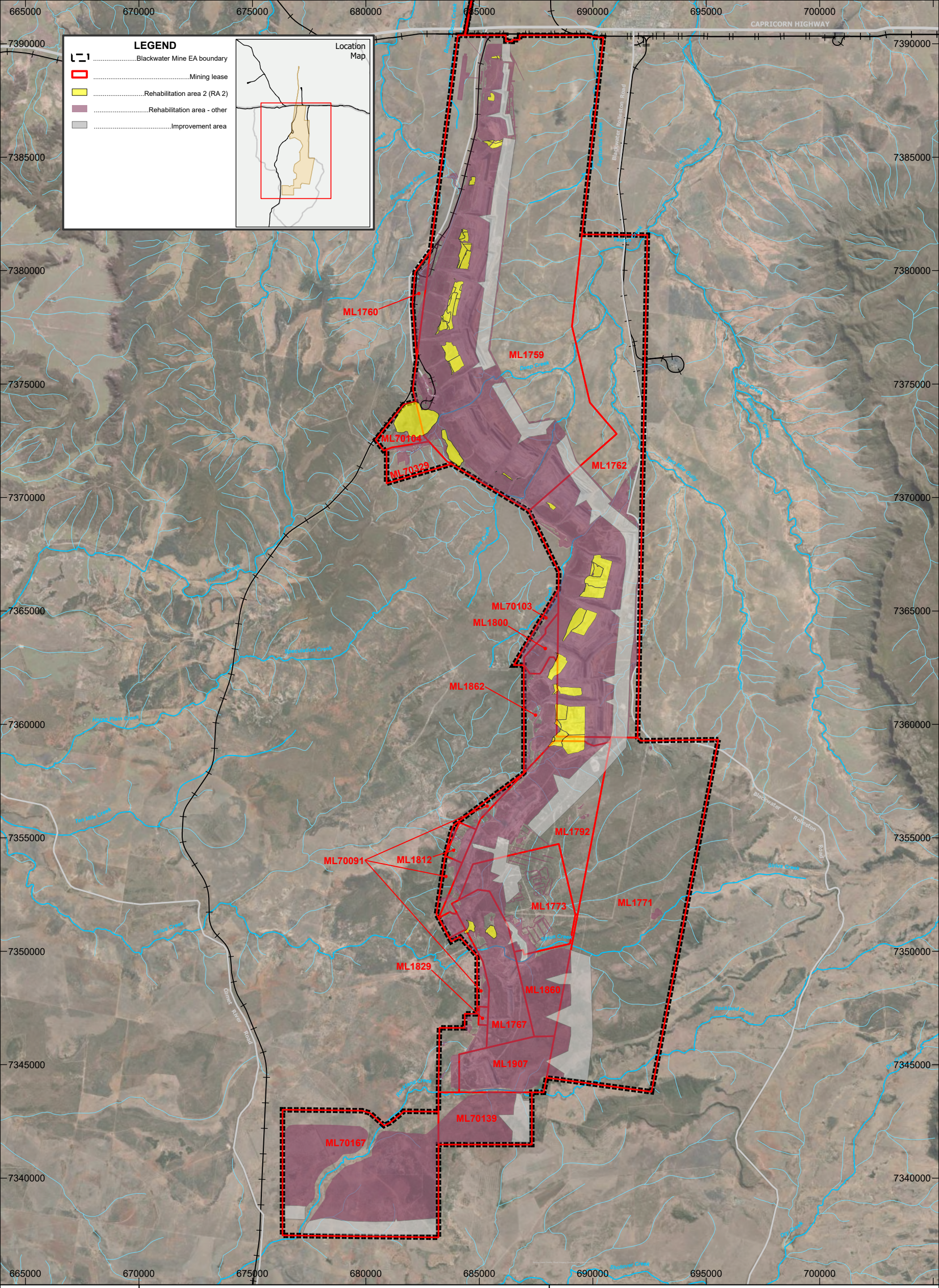
GDA 1994, MGA Zone 55

N

BLACKWATER PRCP
REHABILITATION AREA 1 (RA 1)

Date: 30/04/2025

Filename: Figure22_23_A3_20240703-1_RA.aprx



Whitehaven

GIS Team - Brisbane

0 1 2 3 4 5 km

Transverse Mercator Projection

GDA 1994, MGA Zone 55

N

BLACKWATER PRCP

REHABILITATION AREA 2 (RA 2)

Date: 30/04/2025

Filename: Figure22_23_A3_20240703-1_RA.aprx

LEGEND

- Blackwater Mine EA boundary
- Mining lease
- Rehabilitation area 3 (RA 3)
- Rehabilitation area - other
- Improvement area

Location Map

ML1760
ML1759
ML70104
ML70329
ML1762
ML70103
ML1800
ML1862
ML1792
ML70091
ML1812
ML1773
ML1771
ML1829
ML1860
ML1767
ML1907
ML70139
ML70167

CAPRICORN HIGHWAY

Blackwater Rolleston Road

Comet River Road

665000 670000 675000 680000 685000 690000 695000 700000

7390000 7385000 7380000 7375000 7370000 7365000 7360000 7355000 7350000 7345000 7340000

0 1 2 3 4 5 km

Transverse Mercator Projection

GDA 1994, MGA Zone 55

N

Whitehaven

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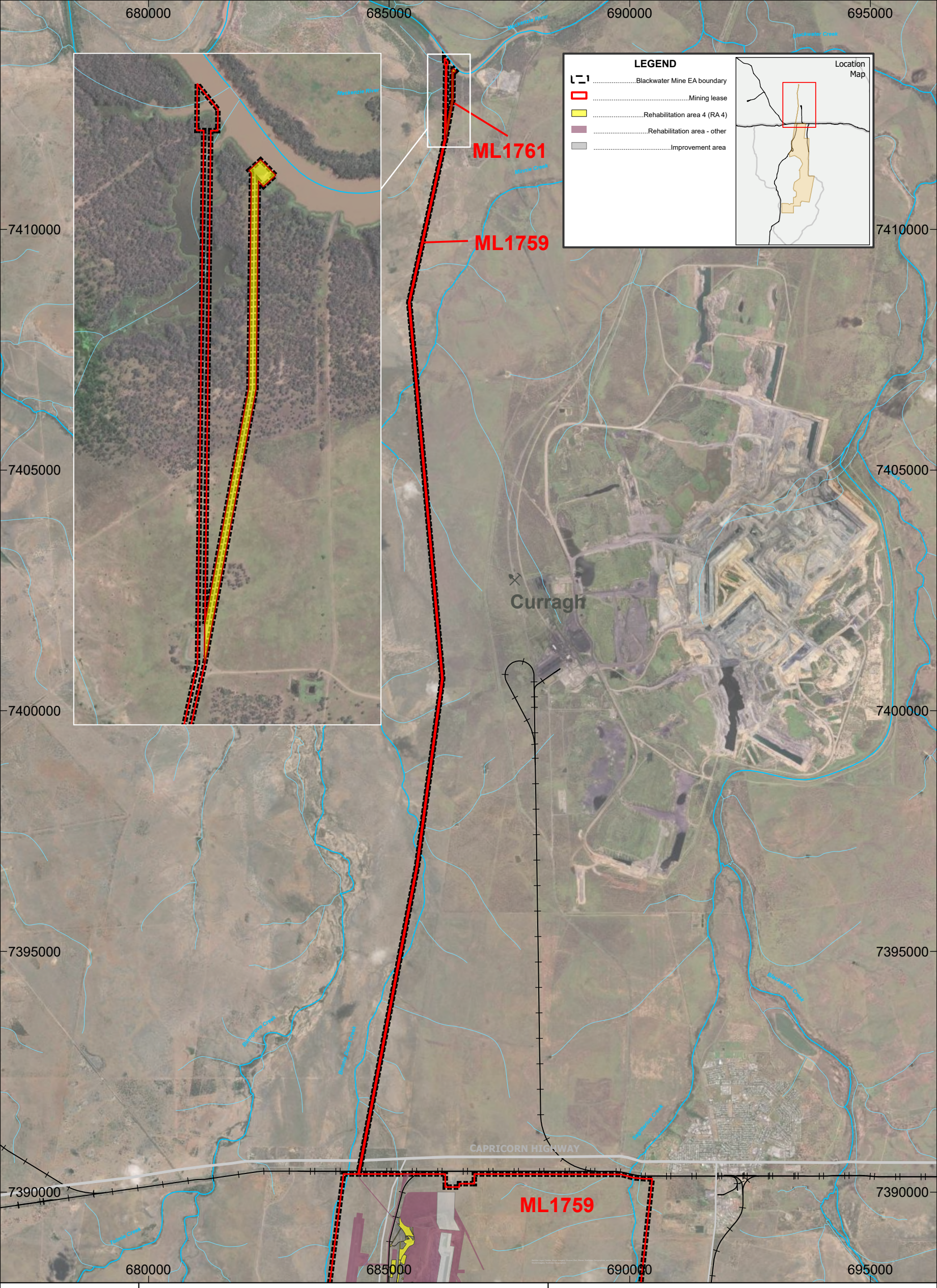
BLACKWATER PRCP

REHABILITATION AREA 3 (RA 3)

Date: 30/04/2025

Filename: Figure22_23_A3_20240703-1_RA.aprx



Whitehaven

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0 1 2 3 4 5 km

Transverse Mercator Projection

MGA Zone 55 of the GDA 1994

N

BLACKWATER PRCP

REHABILITATION AREA 4 (RA 4) (MAP 1 of 2)

Drawn: GOtter	Date: 30/04/2025
Checked: S.Donner	Filename: Figure22_23_A3_20240703-1_RA.aprx

LEGEND

- Blackwater Mine EA boundary
- Mining lease
- Rehabilitation area 4 (RA 4)
- Rehabilitation area - other
- Improvement area

Location Map

ML1759
ML1760
ML1759
ML70204
ML70329
ML1762
ML70103
ML1800
ML1862
ML1792
ML70091
ML1812
ML1773
ML1771
ML1829
ML1860
ML1767
ML1907
ML70139
ML70167

CAPRICORN HIGHWAY
Blackwater Rolleston Road
Comet River Road

665000 670000 675000 680000 685000 690000 695000 700000
7390000 7385000 7380000 7375000 7370000 7365000 7360000 7355000 7350000 7345000 7340000

0 1 2 3 4 5km

Transverse Mercator Projection

GDA 1994, MGA Zone 55

N

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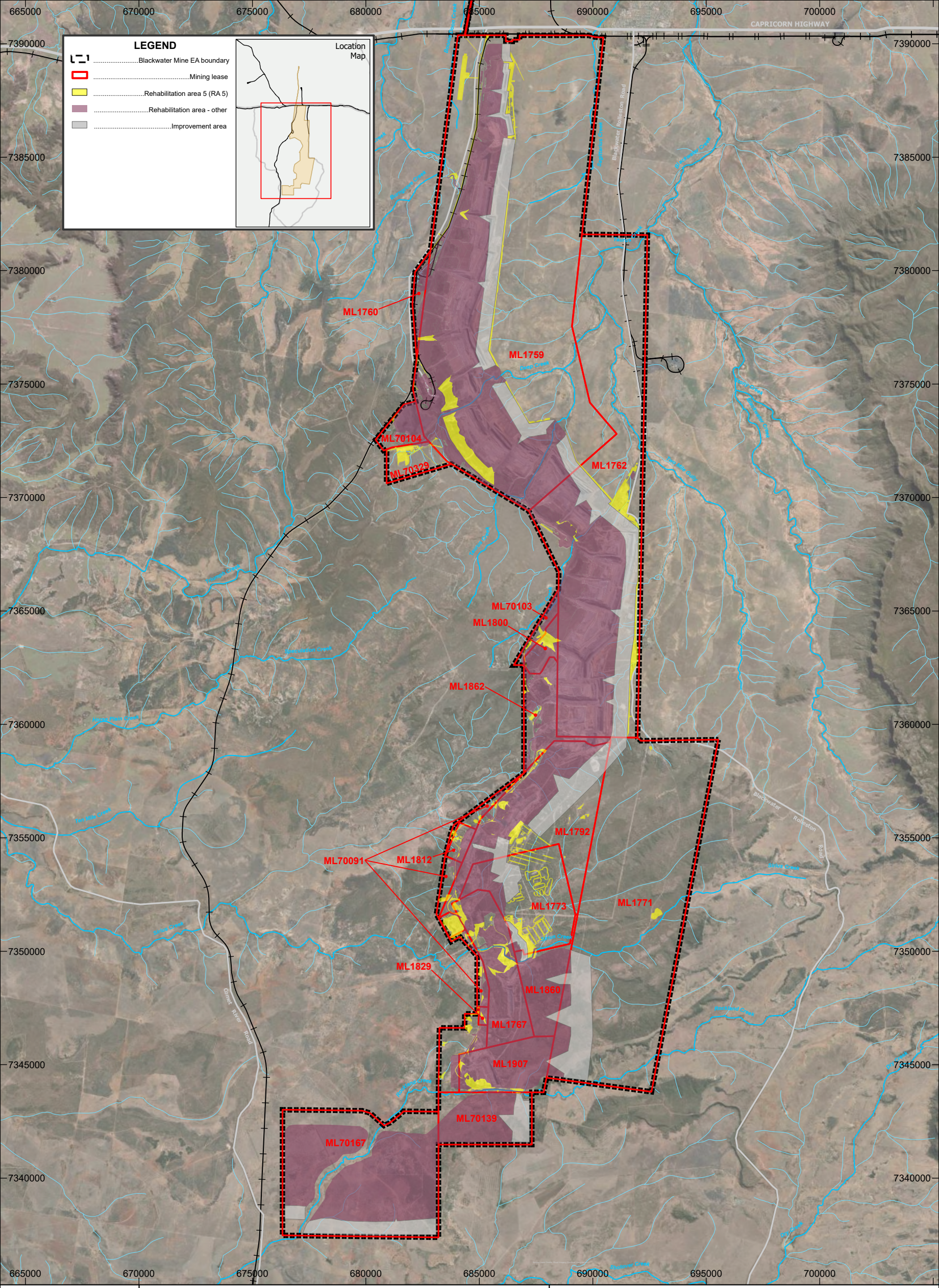
BLACKWATER PRCP

REHABILITATION AREA 4 (RA 4) (MAP 2 of 2)

Date: 30/04/2025

Filename: Figure22_23_A3_20240703-1_RA.aprx



Whitehaven

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0 1 2 3 4 5 km

Transverse Mercator Projection

GDA 1994, MGA Zone 55

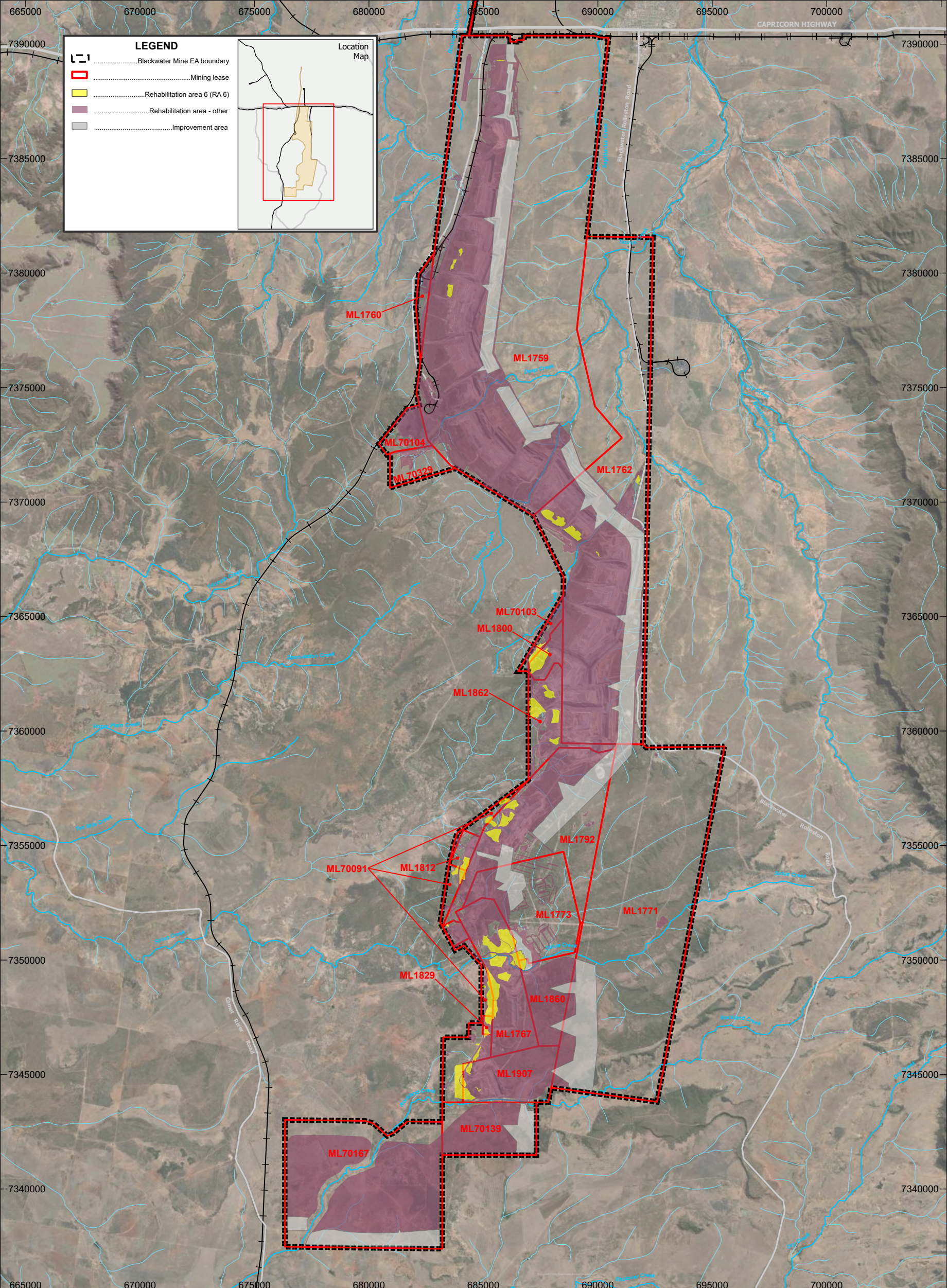
N

BLACKWATER PRCP

REHABILITATION AREA 5 (RA 5)

Date: 30/04/2025

Filename: Figure22_23_A3_20240703-1_RA.aprx



Whitehaven

GIS Team - Brisbane

0 1 2 3 4 5 km

Transverse Mercator Projection

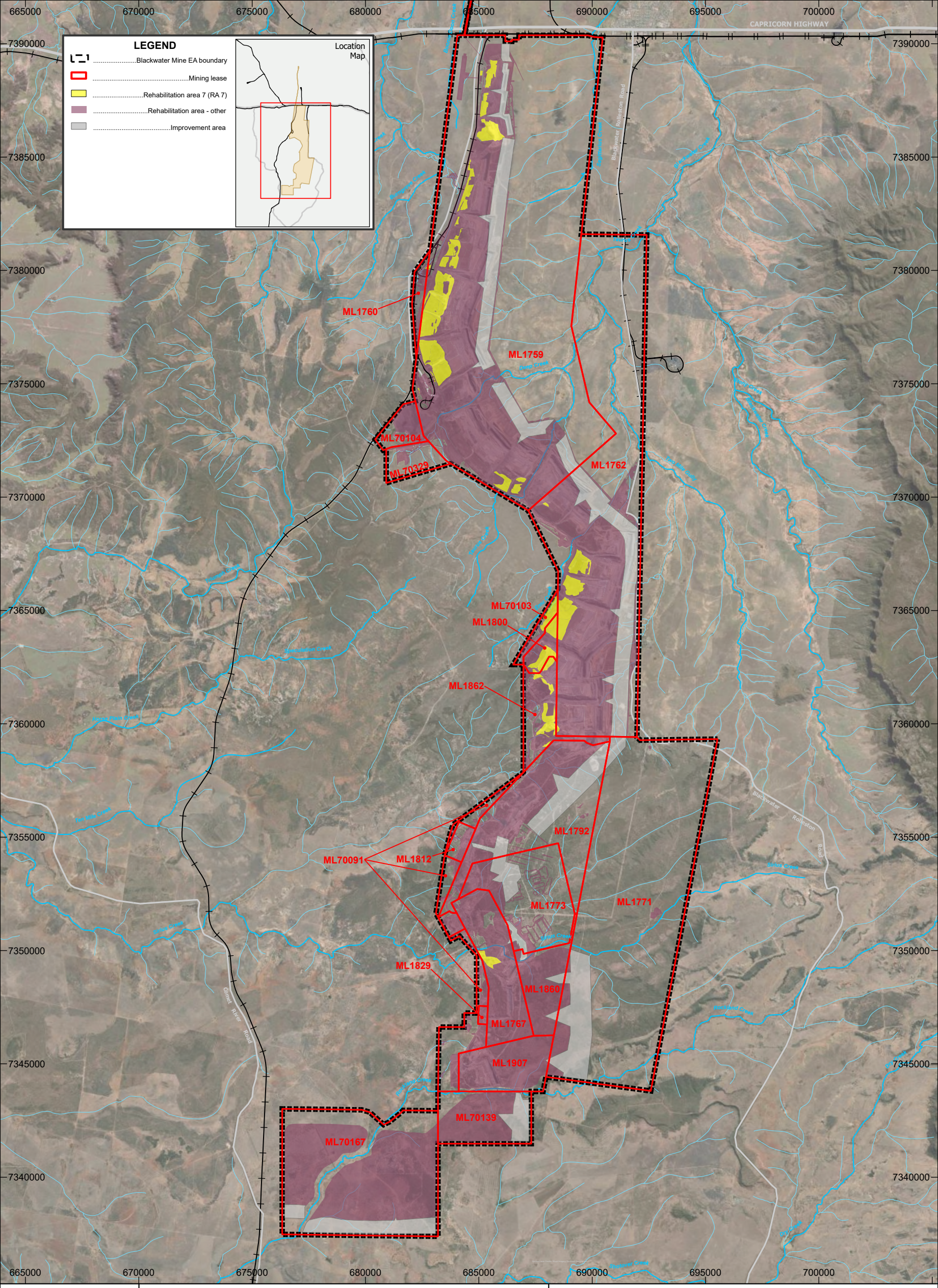
GDA 1994, MGA Zone 55

N

BLACKWATER PRCP
REHABILITATION AREA 6 (RA 6)

Date: 30/04/2025

Filename: Figure22_23_A3_20240703-1_RA.aprx



Whitehaven

GIS Team - Brisbane

0 1 2 3 4 5 km

Transverse Mercator Projection

GDA 1994, MGA Zone 55

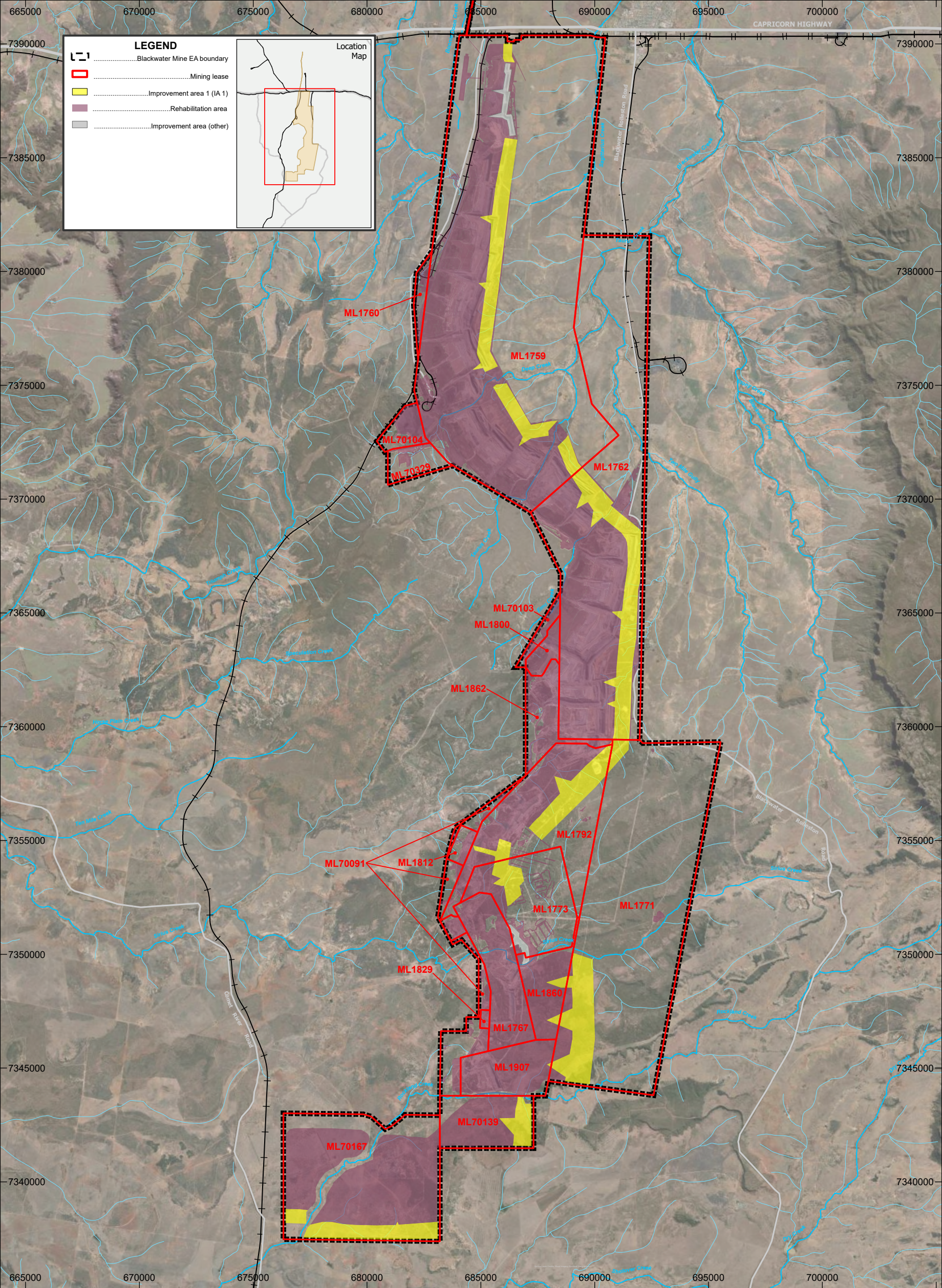
N

BLACKWATER PRCP

REHABILITATION AREA 7 (RA 7)

Date: 30/04/2025

Filename: Figure22_23_A3_20240703-1_RA.aprx



Whitehaven

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0 1 2 3 4 5 km

Transverse Mercator Projection

GDA 1994, MGA Zone 55

N

BLACKWATER PRCP
IMPROVEMENT AREA 1 (IA 1)

Date: 30/04/2025

Filename: Figure22_23_A3_20240703-1_RA.aprx

LEGEND

- Blackwater Mine EA boundary
- Mining lease
- Improvement area 2 (IA 2)
- Rehabilitation area
- Improvement area (other)

Location Map

ML1760
ML1759
ML70104
ML70329
ML1762
ML70103
ML1800
ML1862
ML1792
ML70091
ML1812
ML1773
ML1771
ML1829
ML1860
ML1767
ML1907
ML70139
ML70167

CAPRICORN HIGHWAY

Blackwater Rolleston Road

Comet River Road

665000 670000 675000 680000 685000 690000 695000 700000

7390000 7385000 7380000 7375000 7370000 7365000 7360000 7355000 7350000 7345000 7340000

0 1 2 3 4 5 km

Transverse Mercator Projection

GDA 1994, MGA Zone 55

N

Whitehaven

GIS Team - Brisbane

BLACKWATER PRCP
IMPROVEMENT AREA 2 (IA 2)

Date: 30/04/2025

Filename: Figure22_23_A3_20240703-1_RA.aprx

Appendix 4.2 – Hydrogeology Assessment

This appendix includes the following reports:

- *Bottom Dam Tailings Storage Facility and Sirius Creek Preliminary Hydrogeological Review and Investigation – Revision 3.0* (SLR, 15 May 2025). This report was provided in response to the PRCP Not Properly Made Notice provided by DETSI on 25 November 2024.
- *Blackwater Mine Transitional PRC Plan Hydrogeology Assessment* (SLR, 2024)

Bottom Dam Tailings Storage Facility & Sirius Creek

Preliminary Hydrogeological Review and Investigation

Whitehaven Coal Limited

Blackwater Mine
Blackwater, QLD, 4717

Prepared by:

SLR Consulting Australia

SLR Project No.: 620.010199.00013

15 May 2025

Revision: 3.0

Revision Record

Revision	Date	Prepared By	Checked By	Authorised By
1.0	12 March 2025	K. Gibson, S. Hulbert	D Lyons	D Lyons
2.0	7 April 2025	K. Gibson, S. Hulbert	D Lyons	D Lyons
3.0	15 May 2025	S. Hulbert	D Lyons	D Lyons

Basis of Report

This report has been prepared by SLR Consulting Australia (SLR) with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with Whitehaven Coal Limited (the Client). Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

This report is for the exclusive use of the Client. No warranties or guarantees are expressed or should be inferred by any third parties. This report may not be relied upon by other parties without written consent from SLR.

SLR disclaims any responsibility to the Client and others in respect of any matters outside the agreed scope of the work.

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Appendices

Appendix A Bore Logs

1.0 Introduction

1.1 Background

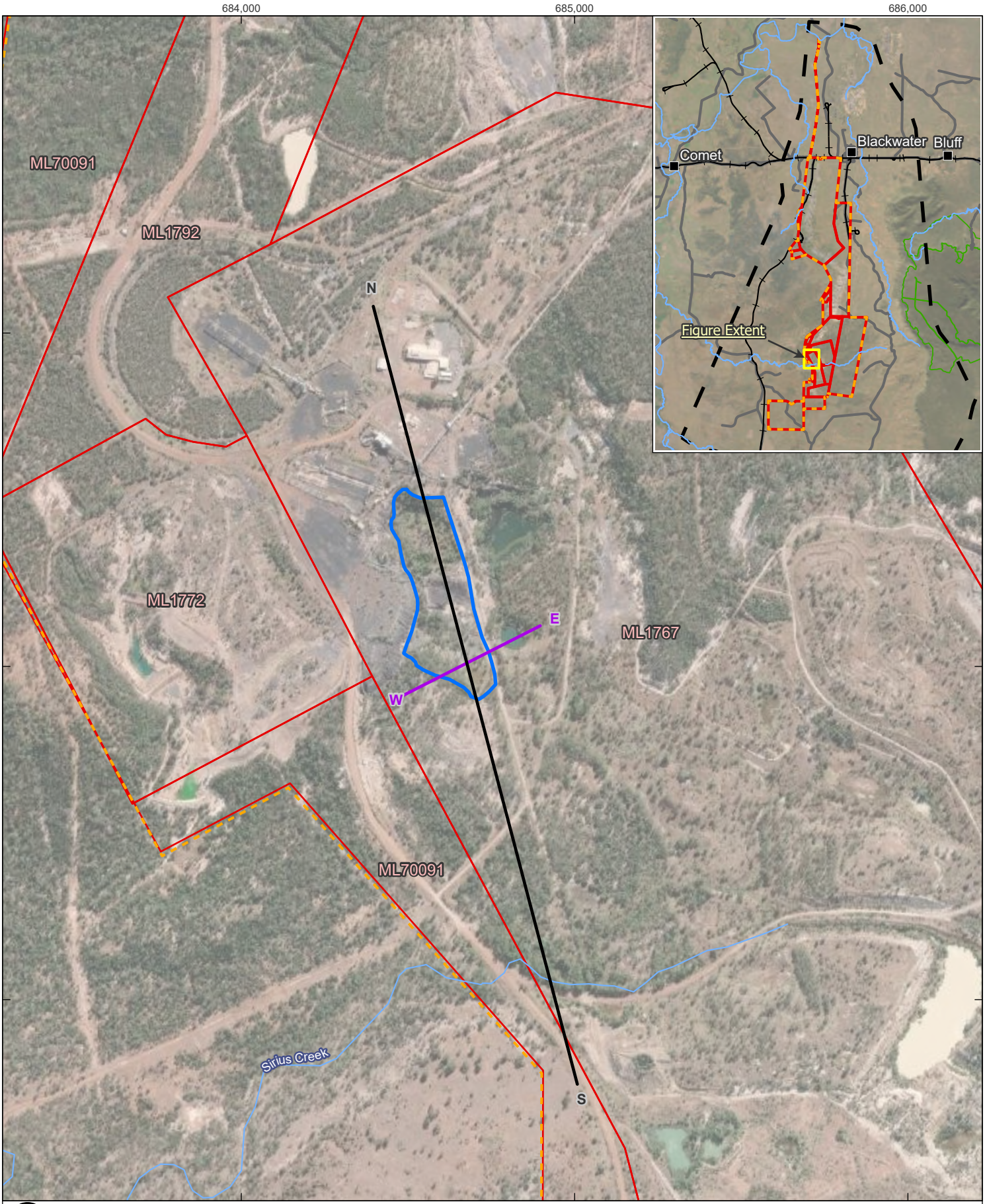
SLR Consulting Australia Pty Ltd (SLR) has been engaged by Whitehaven Blackwater Pty Ltd a subsidiary of Whitehaven Coal Limited (WHC) to undertake a preliminary hydrogeological assessment of the conceptual relationship between the historical Bottom Dam Tailings Storage Facility (TSF) and Sirius creek at Blackwater Mine (BWM). The intent of this investigation is to provide input into a response to an Information Request (IR) related to the BWM Transitional Progressive Rehabilitation and Closure Plan (PRC Plan).

Groundwater modelling and particle tracking carried out in support of the Transitional PRC Plan Hydrogeology Assessment (SLR, 2024) identified that residual voids in the post-mining landform across the BWM will generally act as groundwater "sinks," except in the vicinity of the historic Bottom Dam TSF. Modelling suggests that some groundwater may migrate from the Bottom Dam TSF area towards Sirius Creek located 750 m southeast of Bottom Dam (SLR, 2024).

The initial objective of the works presented herein is to conceptually assess current hydrogeological conditions at a local scale not possible in the site-wide Transitional PRC Plan Hydrogeology Assessment and identify if there a plausible potential pathway for subsurface hydraulic connection between the Bottom Dam TSF and Sirius Creek as predicted by the model. The scope of this work involves a focussed desktop review of the data available at the time of the investigation, to explore local information to conceptualise the system and identify the likely groundwater – surface water interaction at Sirius Creek, and thus the possible flow pathways from the TSF.

Subsequently, the findings of the SLR (2024) model will be reviewed in consideration of the local conceptualisation presented herein, and a discussion presented.

The location of Bottom Dam TSF and Sirius Creek in relation to BWM as well as bores installed in the vicinity of Bottom Dam and Sirius Creek, relevant to this review, are shown in Figure 1-1.



0 250 500 m

Coordinate System:	GDA2020 MGA Zone 55
Scale:	1:15,000 at A4
Project Number:	620.040199
Date Drawn:	07-Apr-2025
Drawn by:	AS

LEGEND

- Section (W-E)
- Section (N-S)
- Watercourse
- Bottom Dam Tailings Storage Facility (TSF)
- BWM Mining Lease
- Project Area (Environmental Authorities boundary)

BLACKWATER MINE - BOTTOM DAM TSF AND SIRIUS CREEK INVESTIGATION

LOCATION AND SECTIONS OF BOTTOM DAM TAILINGS STORAGE FACILITY

SLR

DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.

FIGURE 1-1

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040199.00001 BWM PRCP – GW\03 SLR Data\01 CADGIS\GIS\ArcPro\BWM PRCP – GW\BWM PRCP – GW.aprx\620040199_F01_01 Location Plan Bottom Dam

1.2 Information Request

The specific IR commentary that this investigation is responding to is replicated here for completeness:

Tailings Storage Facility

(Reason 2):

Section 3.6.2 of the PRCP Guideline requires that 'proposed tailings management options must minimise interactions between the tailings and the surrounding environment to prevent the release of contaminants to the receiving environment '.

Flow path simulations presented in the *Transitional PRC Plan Hydrogeology Assessment* (SLR 2024a) (Appendix 4.2 of the Rehabilitation Planning Part) conclude that:

'water associated with spoil and tailings deposition, underground mine workings or open cut residual void lakes is not predicted migrate away from the BWM Area, with the residual voids acting as passive containment for groundwater which has passed through the mine workings. The ***exception to this is the specific location of Bottom Dam, west of Laleham residual void, with groundwater predicted to migrate towards Sirius Creek outside of the BWM Area****. The environmental risk associated with this prediction is addressed within the PRC Plan's tailings cover design and geochemistry assessments (Henderson Geotech, 2024, and Terrenus Earth Sciences, 2024)'* (SLR 2024a, p. 128)

Terrenus Earth Science (2024) reiterate that 'there are plausible surface water receptors; and the run-off and seepage pathways linking the source (Bottom Dam TSF/rejects final landform) to these receptors (Sirius Creek) have been identified' (p. xvii) and state:

'Environmental and engineering investigations of this area are underway to support rehabilitation and closure planning and, as such, no geochemical data specifically from Bottom Dam was available for this waste characterisation assessment. The final landform of the greater Bottom Dam area is also to be determined, subject to the outcome of the engineering and environmental investigation programs' (p. xiv).

Terrenus Earth (2024, p. 80) state:

'..until a detailed geochemical assessment is undertaken, Bottom Dam area (comprising TSF and rejects) is conservatively assumed to pose a ***Moderate-High AMD [Acid Mine Drainage] hazard, with AMD generation rated as Probable/Likely****.*

The Concept Cover Design (Henderson Geotech, 2024, p. 16) states:

'…there is the ***possibility of shallow seepage out of the TSF and into Sirius Creek****, although there is not a clear hydrogeologic connection. If seepage did occur, the rate would decrease over time since tailings deposition has ceased, and a cover system designed to minimize deep infiltration would also reduce long-term seepage.*

The statement that 'a clear hydrogeologic connection' contradicts the flow path modelling presented by SLR in the Hydrogeology Assessment (2024a).

(Action 2):

Provide a Rehabilitation Planning Part in accordance with Section 3.6.2 of the PRCP Guideline which details tailings management options which minimise interactions between the tailings and the surrounding environment to prevent the release of contaminants to the receiving environment.

2.0 Local Site Background

2.1 Surface Features

2.1.1 Sirius Creek

Sirius Creek is the primary surface drainage feature within the southern BWM area, situated in the Comet River sub-catchment of the Mackenzie River catchment. Sirius Creek is located approximately 750 m south of Bottom Dam at an elevation of ~255 mAHD (Figure 1-1). The creek flows from east to west across the southern portion of the Blackwater Mine Project Area. It is classified as an ephemeral watercourse, exhibiting intermittent flow that occurs predominantly in response to high-intensity rainfall events (AGE, 2003). Under dry conditions, the creek bed remains dry, with surface water present only for limited durations following significant precipitation. It is noted that Schedule F of the BWM Environmental Authority (EA) permits the release of mine affected water to Sirius Creek.

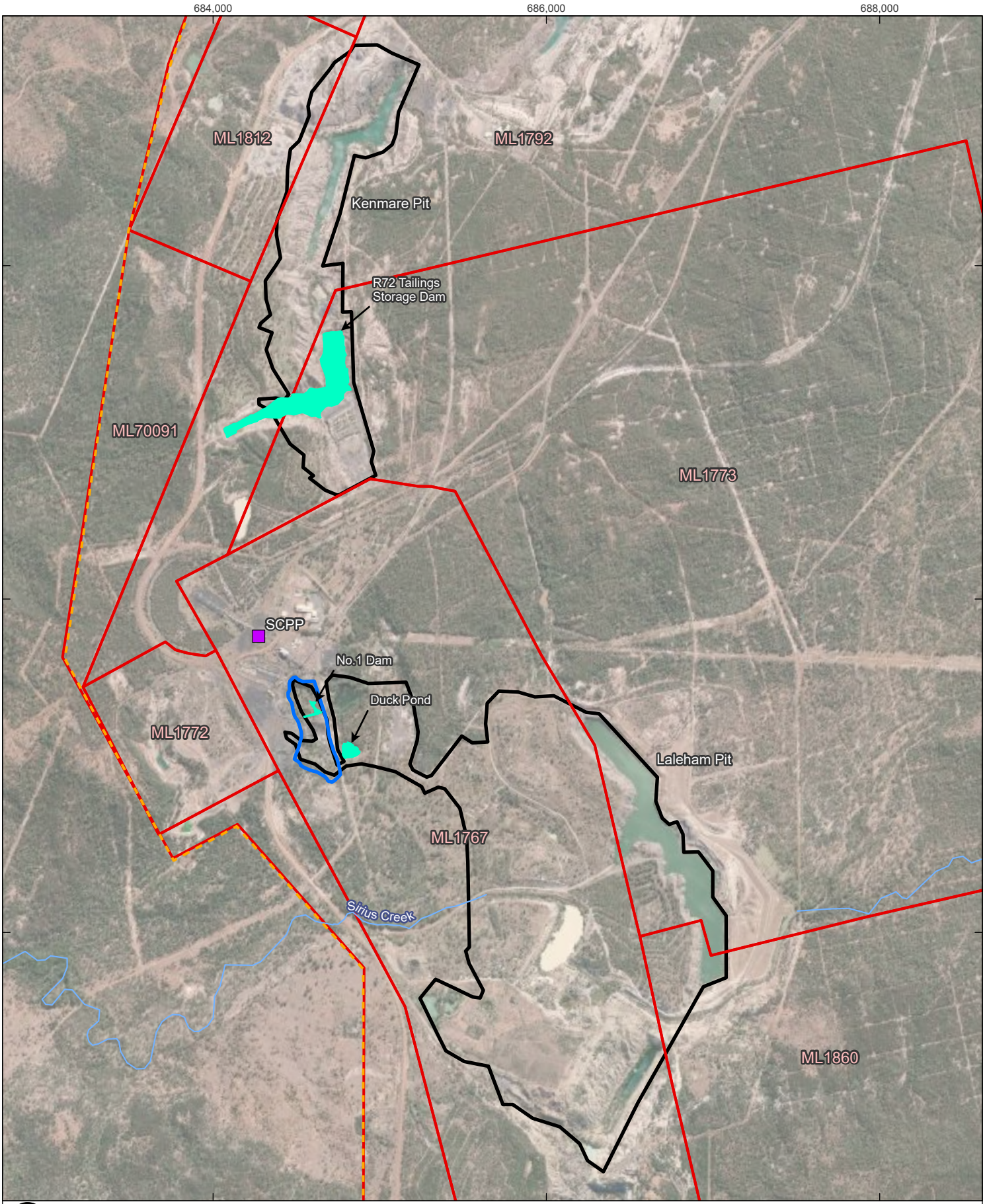
2.1.2 Bottom Dam

The Bottom Dam TSF is a historic tailings storage facility situated in the southern area of the Blackwater Mine (BWM), south of ROM 3 and near the southern coal handling and preparation plant (SCPP) (Figure 2-1). Covering approximately 1.6 ha, the Bottom Dam TSF has an estimated total storage volume of 0.2 Mm^3, while the broader Bottom Dam TSF area spans approximately 10 ha with a total reject volume estimated at less than 1 Mm^3 (Terrenus Earth Sciences, 2024). Geotechnical drilling indicates that the storage depth reaches up to 15 m.

The Bottom Dam TSF is bordered by sloping ground to the north, a 6-m-high earthfill embankment to the east, and a spoil dump to the south. It is located at an elevation of approximately 270 mAHD (estimated from 1 m digital elevation model (DEM)), and lies 37 m below the elevated natural ground of ROM 3, situated to the northwest. Duck Pond is positioned immediately to the east. The tailings surface is relatively flat, except for a small sump near the culvert that connects to Duck Pond. Vegetation, primarily scrubby mid-storey species, has naturally established across more than half of the tailings surface, which is underlain by a desiccated surface crust approximately 1–2 m thick.

The Bottom Dam TSF was originally constructed as a process water storage facility within the SCPP water management system, the Bottom Dam TSF received overflow from No. 1 Dam (located upslope to the north) and drained via a culvert into Duck Pond, east of the mine road. Over time, coal fines and sediment washed from No. 1 Dam and the rejects dump also accumulated at Bottom Dam. It was formally designated as a TSF after 2012 and subsequently received a mixture of tailings and coal rejects, estimated in equal proportions. These materials, generated at the SCPP, are assumed to have environmental geochemical characteristics similar to those observed in other storage facilities, such as Ramp 72 TSF, Kenmore Pit, and Laleham Pit. It is unknown when the TSF was decommissioned from use.

Pre-mining land use in the area primarily consisted of low-intensity grazing, with significant portions of uncleared woodland.



0 250 500 m

Coordinate System:	GDA2020 MGA Zone 55
Scale:	1:30,000 at A4
Project Number:	620.040199
Date Drawn:	12-Mar-2025
Drawn by:	AS

LEGEND

- SCPP
- Water Storage Area
- Bottom Dam Tailings Storage Facility (TSF)
- Pit Extent
- Watercourse
- Project Area (Environmental Authorities boundary)
- BWM Mining Lease

BLACKWATER MINE - BOTTOM DAM TSF AND SIRIUS CREEK INVESTIGATION

SURFACE FEATURES

SLR

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FIGURE 2-1

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040199.00001 BWM PRCP – GW\03 SLR Data\01 CADGIS\GIS\ArcPro\BWM PRCP – GW\BWM PRCP – GW.aprx\620040199_F02_01 Surface Features

2.2 Hydrogeology

The surficial hydrostratigraphic units underlying the Bottom Dam TSF and relevant to this investigation include Alluvium, Tertiary deposits, and the underlying Permian Burngrove Formation. Bore details and location of the bores targeting these units are provided in Table 2-1, Table 2-2 and Figure 2-3. Bore logs are provided in Appendix A.

Alluvium:

- Alluvium, where sporadically present, forms a relatively thin, porous aquifer system with variable permeability. Drilling investigations indicate that the spatial extent of alluvial deposits is more limited than suggested by regional surface geology maps, with thicknesses ranging from 0 to 12 m. These deposits are primarily associated with local creeks and, when saturated, form a localised unconfined aquifer. However, recent observations indicate that where present, the alluvium within the BWM area is dry and of limited extent.
- There is no evidence of Alluvium present at Bottom Dam.
- Only one bore, BWM_MB136_01, has encountered Alluvium along Sirius Creek. The geological log indicates alluvium at 0 – 0.2 metres, overlying predominantly clayey sand interpreted as Tertiary sediments. The bore screens the Permian Burngrove Formation, logged from 6 – 8.3 metres beneath the Tertiary sediments. The bore is screened at 4 – 7 m below ground level (mBGL). This bore was recorded as dry at the time of installation (late 2024) and again more recently at the end of January 2025.
- As discussed, the alluvium is often found to be limited in extent and thickness, and predominantly unsaturated. It may become temporarily saturated following rainfall recharge and occasional seepage from ephemeral creek streamflow.
- Where the alluvium is saturated it is expected to potentially facilitate recharge to the underlying geological units. Discharge is generally considered to be via evapotranspiration and leakage to underlying aquifers.

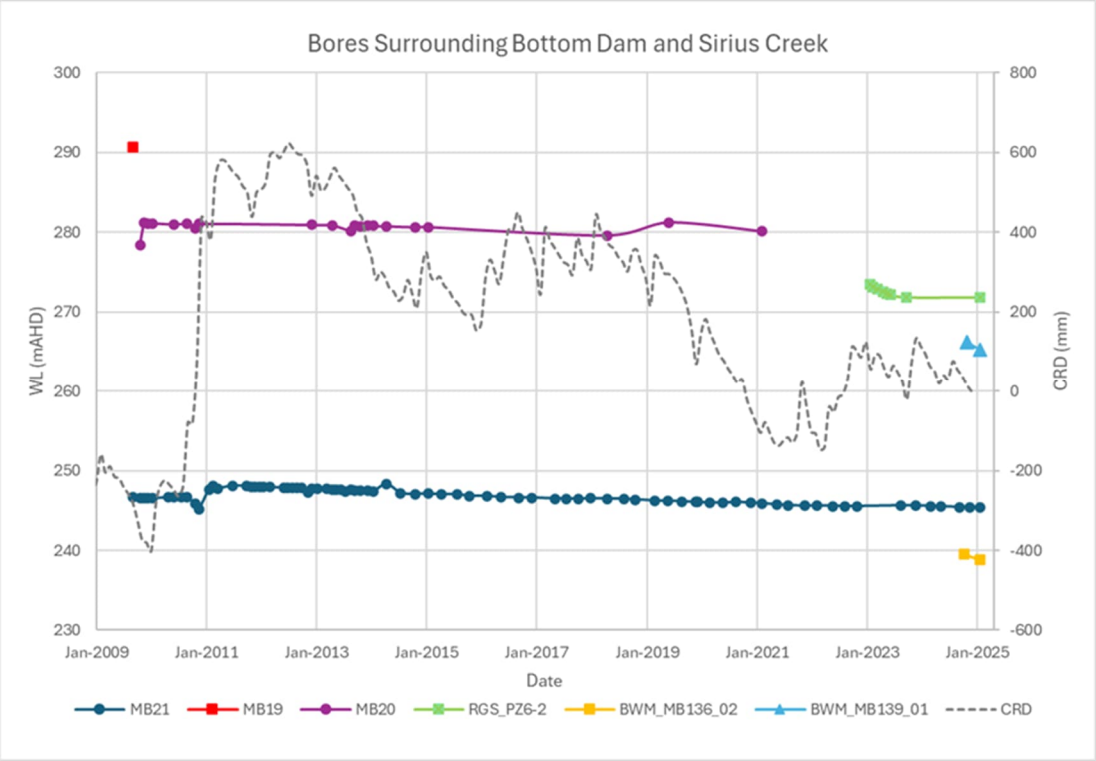
Tertiary:

- Tertiary deposits regionally at BWM consist dominantly of claystones and mudstones, typically ranging from 5 to 50 m in thickness. The unconsolidated surface layer, which includes weathered Tertiary strata and some basalt flows, may provide preferential flow pathways for groundwater if the water table rises above the base of weathering. When saturated, this unit functions as an unconfined aquifer, though its permeability is generally low.
- Bores screening the Tertiary sediments within the local study area are generally dry. This indicates that although the Tertiary deposits are persistent across the region, they do not form a saturated continuous aquifer. Rather, there are potentially isolated areas where saturation occurs.
- Given the discontinuous nature of the saturated Tertiary, it is not reasonable to define groundwater flow regimes, specifically at the local study scale.
- The longest recorded Tertiary groundwater level time series is available for bores MB20 (located 850 m upgradient/northwest of the Dam) and MB21 (350 m downgradient/southeast of Bottom Dam). Neither of these bores have available logs to confirm the screened unit, and more recent co-located drilling indicate these bores may be mis-attributed to this aquifer. However, temporal data from these bores is

presented for completeness and indicate relatively stable groundwater levels since 2009, with a gradual background decline of approximately 1 m over this period (Figure 2-2). This decline is likely attributable to below-average rainfall conditions observed during 2013–2016 and 2018–2022. Notably, no significant changes in these groundwater levels were observed following conversion of Bottom Dam to a TSF in 2012 or its subsequent decommissioning (date unknown, however at some point between commencement in 2012 and current status).

- Seven bores are recorded as “dry”, indicating that the Tertiary sediments are not continuously saturated across the study area (see Table 2-1).

Figure 2-2 Hydrograph of Tertiary bores around Bottom Dam and Sirius Creek



Permian:

- Permian deposits regionally at BWM underly the Tertiary sediments and form a continuous hydrostratigraphic unit. The Permian is typically saturated, hosting the regional water table. Groundwater flow in the Permian strata is expected to be consistent with the regional topographic gradient and follow a south-southeasterly directions.

Table 2-1 Details of Bores surrounding Bottom Dam and Sirius Creek and applicable to the investigation

Bore ID	Easting1	Northing1	Ground level (mAHD)	Log?	Depth (m)	Screened Interval	Screened unit	Water Level (mTOC)	Used in N-S Cross Section
BWM_MB119_01	684198	7350590	281	yes	19	15.5 - 18.5	Tertiary	Dry[2]	no
BWM_MB121_01	684202	7350959	306	yes	18.5	10.5 - 16.5	Tertiary	Dry[2]	no
BWM_MB123_01	683965	7351157	306	yes	8.8	5.2 - 8.2	Tertiary	Dry[2]	no
BWM_MB132_01	684573	7351281	288	yes	19	12.5-18.5	Tertiary	Dry[2]	yes
BWM_MB132_02	684591	7351283	288	yes	29.5	22-29	Permian (Burngrove formation, overburden)	19.93	yes
BWM_MB133_00	684655	7351045	275	yes	12	5.2-11.2	Spoil (coal tailings)	5.22	yes
BWM_MB133_01	684651	7351045	275	yes	18	14.5-17.5	Spoil (mine rejects)	5.47	yes
BWM_MB133_02	684648	7351044	275	yes	28.5	22-28	Permian (underburden, below Rangal Coal Measures)	20.13	yes
BWM_MB135_01	684895	7350808	264	yes	12	6.5-9.5	Tertiary	Dry	yes
BWM_MB136_01	684837	7350128	255	yes	8.3	4.0-7.0	Permian (Burngrove Formation, overburden)	Dry	yes
BWM_MB136_02	684603	7350311	255	yes	21.5	15.0-21.0	Permian (Burngrove Formation, overburden)	15.8	yes
BWM_MB138_01	684738	7350977	275	yes	14	10.5-13.5	Spoil (mine rejects)	13.61	yes
MB19	684418	7351975	311	no	19.7	13.7-19.7	NO LOG	Dry[3]	yes
MB20	684428	7351856	312	no	31.6	25.6-31.6	NO LOG	Dry[3]	yes
MB21	684905	7350813	264	no	30.69	25-31	NO LOG	18.38	no
BWM_MB135_02	684899	7350805	279	yes	24	17-23	Permian	20.1	yes

[1] Coordinates GDA 2020 Zone 55 [2]Bore recorded as “Dry” since installation [3]Bore Recorded as “Dry” in January 2025
*Ground Level

Table 2-2 Geological interpretations of bores surrounding Bottom Dam TSF and Sirius Creek

Bore ID	Easting1	Northing1	Interpreted Geological Unit Intersection (mBGL)					Screened Interval	Screened unit
			Alluvial	Spoil (coal tailings)	Spoil (mine rejects)	Tertiary	Permian		
BWM_MB119_01	684198	7350590				0-19		15.5 - 18.5	Tertiary
BWM_MB121_01	684202	7350959				0-18.5		10.5 - 16.5	Tertiary
BWM_MB123_01	683965	7351157				0-8.8		5.2 - 8.2	Tertiary
BWM_MB132_01	684573	7351281				0-19		12.5-18.5	Tertiary
BWM_MB132_02	684591	7351283				0-19	19 - 29.50	22-29	Permian (Burngrove Formation, overburden)
BWM_MB133_00	684655	7351045		0-12				5.2-11.2	Spoil (coal tailings)
BWM_MB133_01	684651	7351045		0-13	13-18			14.5-17.5	Spoil (mine rejects)
BWM_MB133_02	684648	7351044		0-13	13-20		20-28.5	22-28	Permian (underburden, below Rangal Coal Measures)
BWM_MB135_01	684895	7350808			0-4	4-10		6.5-9.5	Tertiary
BWM_MB136_01	684837	7350128	0-0.2			0.2-6	6-8.3	4.0-7.0	Permian (Burngrove Formation, overburden)
BWM_MB136_02	684603	7350311				0-8	8-21.5	15.0-21.0	Permian (Burngrove Formation, overburden)
BWM_MB138_01	684738	7350977		0-8.3	8.3-14			10.5-13.5	Spoil (mine rejects)
MB19	684418	7351975						13.7-19.7	NO LOG
MB20	684428	7351856						25.6-31.6	NO LOG
MB21	684905	7350813						25-31	NO LOG
BWM_MB135_02	684899	7350805			0-5.5	5.5-10	10-24	17-23	Permian

[1] Coordinates GDA 2020 Zone 55



0 250 500 m

Coordinate System:	GDA2020 MGA Zone 55
Scale:	1:15,000 at A4
Project Number:	620.040199
Date Drawn:	04-Apr-2025
Drawn by:	AS

LEGEND

Groundwater Monitoring Bore

- Spoil (mine rejects)
- Spoil (coal tailings)
- Tertiary
- Permian

- Watercourse
- Bottom Dam Tailings Storage Facility (TSF)
- BWM Mining Lease
- Project Area (Environmental Authorities boundary)

BLACKWATER MINE - BOTTOM DAM TSF AND SIRIUS CREEK INVESTIGATION

GROUNDWATER MONITORING BORE AND SCREENED UNIT

SLR

DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.

FIGURE 2-3

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040199.00001 BWM PRCP – GW\03 SLR Data\01 CADGIS\GIS\ArcPro\BWM PRCP – GW\BWM PRCP – GW.aprx\620040199_F02_02 GW Monitoring Bottom Dam

3.0 Conceptualisation

A hydrogeological conceptual model for the area surrounding Bottom Dam and Sirius Creek is illustrated in Figure 3-1. This conceptualisation integrates monitoring data with an understanding of local hydrogeological conditions presented in Section 2.0.

3.1 Alluvium

The alluvial deposits in the area are very localised and limited in extent, and predominantly unsaturated. Any localised saturation which may occur within the alluvium is transient, occurring only in response to recharge from rainfall and surface water drainage lines, with saturation persisting for short periods. Discharge from the alluvial deposits, when temporarily saturated, is expected to be via evaporation or leakage downwards to the underlying aquifers.

3.2 Tertiary

Similarly, the Tertiary sediments in the study area is largely unsaturated, with bore monitoring data indicating dry conditions at most local bore locations.

Where saturated Tertiary exists, groundwater have shown minimal fluctuation over time, with no significant rises in response to rainfall events, further supporting limited connectivity between surface water and groundwater.

3.3 Permian

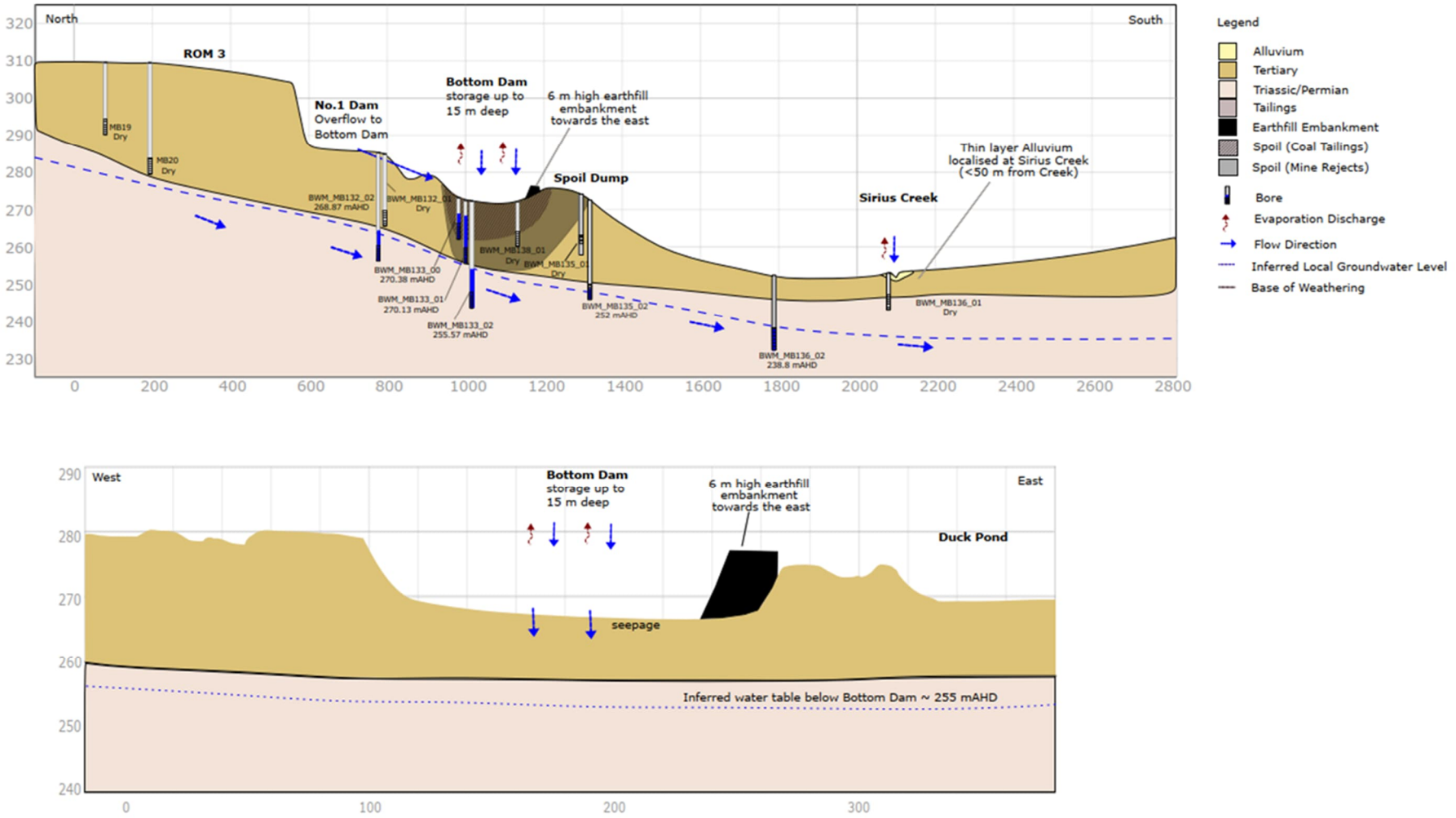
The Permian aquifer locally forms the water table aquifer. The water table below Bottom Dam is approximately 270 mAHD, which is below the creek's elevation of approximately 255 mAHD. As such, groundwater beneath Bottom Dam cannot physically discharge to Sirius Creek as hydraulic gradients do not allow this to occur.

3.4 Summary

Overall, surface water-groundwater interactions in this area are assessed to be minimal. The ephemeral nature of the creek, combined with its elevation above the groundwater table, reduces the likelihood of groundwater discharge into Sirius creek from the Permian (via the Tertiary) aquifer. Instead, recharge processes are primarily driven by surface water inputs, such as streamflow and flooding, rather than contributions from groundwater.

Consequently, local scale conceptualisation does not support the potential movement of groundwater from Bottom Dam TSF to Sirius Creek as the key factors such as groundwater levels, aquifer properties, and recharge mechanisms indicate no potential pathway for connectivity between these features.

Figure 3-1 North-South and West-East cross sections through Bottom Dam



4.0 Flow Path Simulation Modelling

4.1 Overview

Flow path simulation modelling presented by SLR (2024) is a numerical predictive analysis used to assess the movement water through the groundwater system post-mining, at a scale appropriate to the PRC Plan (i.e. site-wide). In this modelling, a number of water 'particles' were placed on the BWM final landform and residual voids in the model and the mod-PATH3DU code (S.S. Papadopulos & Associates, Inc., 2018) was used to simulate particle pathways along the groundwater flow field during the simulated post-mining period (i.e. 500 years). The numerical groundwater model and subsequent particle tracking presented in the PRC Plan did not incorporate the closure strategy outlined in the PRC Plan for Bottom Dam TSF.

The particles were placed at the surface of the model and released at the start of the post-mining simulation, with the movement recorded during the post-mining simulation. Although it is stated that the particles are placed "at the surface", the modelling code automatically moves the particles to the shallowest saturated layer at the commencement of the simulation. MOD-PATH3DU was configured to release the particles at the midpoint between the base of the first saturated layer and the water table.

4.2 Predicted Movement

Overall, the PRC Plan's groundwater modelling indicated that the particles generally move toward the void lakes across the BWM final landform, with the majority of particles captured by the voids (see Figure 4-1).

The variation to this were the simulated particles placed at or near Bottom Dam TSF west of the Laleham residual void, which appeared to migrate out of the BWM Area towards Sirius Creek, with these particles commencing the simulation too far from the residual void lakes to be captured by their associated hydraulic gradients.

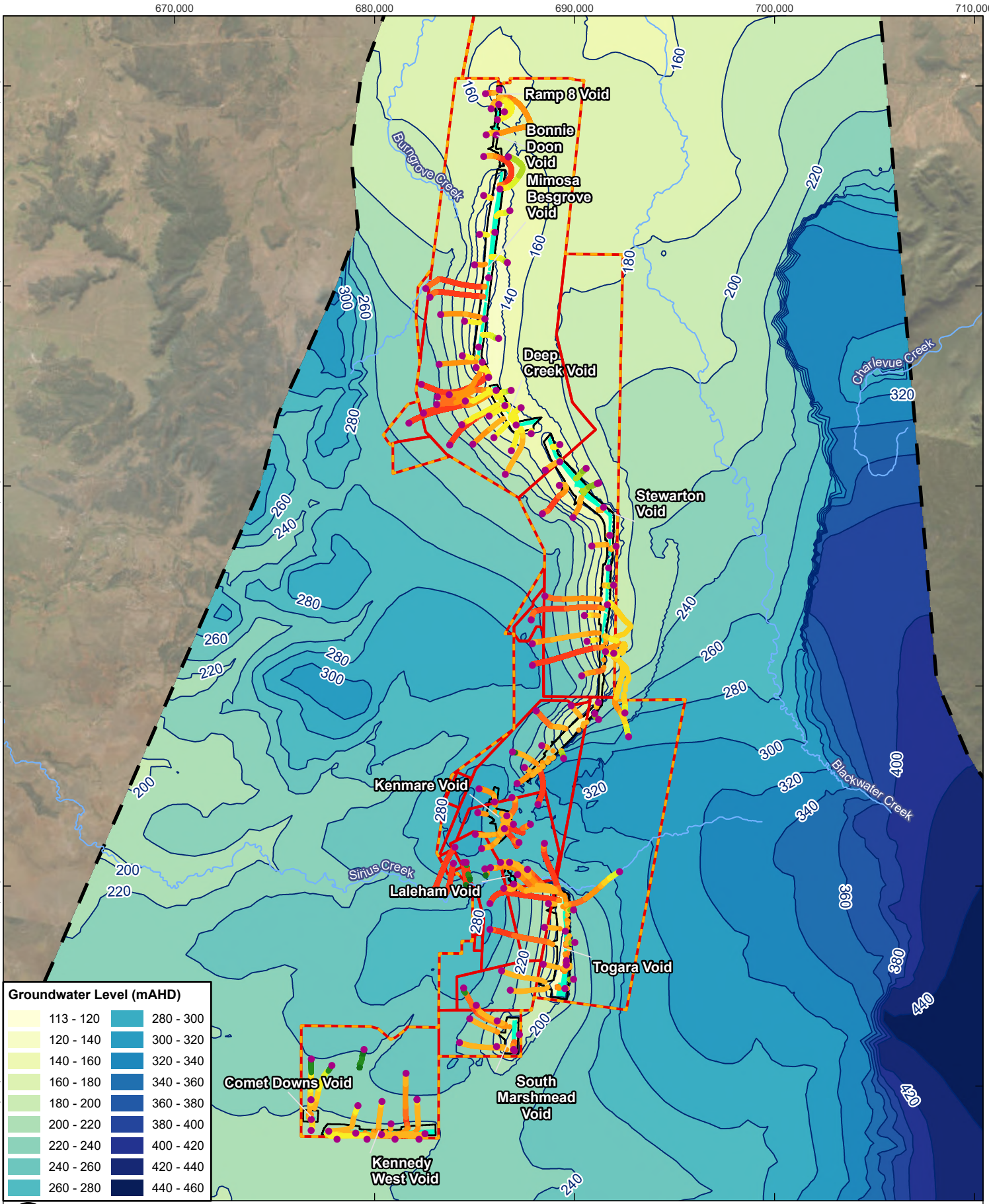
Figure 4-2 shows the particles in question near to Bottom Dam TSF, the path of movement and layer in which they are travelling. Table 4-1 provides the model layering set-up.

It is important to note that the model layer in which the particles commenced their migration from is Layer 14 (Burngrove Formation), i.e. below the Tertiary sediments (Layer 2). Particle movement continued within Layer 14 for approximately 80 years, before an emergence into Layer 2 prior to cessation of the post-mining simulation.

Table 4-1 Model Layering Details (SLR, 2024)

Model Layer	Geologic Formation	Hydrogeologic Unit	Present in the BWM Area
1	Alluvium/Tertiary	Surface cover and Tertiary	Yes
2	Alluvium/ Weathered zone	Weathered zone / Regolith	Yes
3	Clematis Group	Triassic	No
4	Rewan Group (Upper)	Triassic	No
5	Rewan Group (Middle)	Triassic	Yes (in part)
6	Rewan Group (Lower)	Triassic	Yes (in part)
7	Rangal Coal Measures	Overburden	Yes (in part)

Model Layer	Geologic Formation	Hydrogeologic Unit	Present in the BWM Area
8		Aries seam	Yes (in part)
9		Interburden	Yes (in part)
10		Castor seam	Yes (in part)
11		Interburden	Yes (in part)
12		Pollux seam	Yes (in part)
13		Underburden	Yes (in part)
14	Burngrove Formation	Permian	Yes



Coordinate System:	GDA2020 MGA Zone 55
Scale:	1:250,000 at A4
Project Number:	620.040199
Date Drawn:	12-Mar-2025
Drawn by:	AS

BLACKWATER MINE - BOTTOM DAM TSF AND SIRIUS CREEK INVESTIGATION

PREDICTED MOVEMENT OF PARTICLES (MID CLIMATE SCENARIO)

SLR

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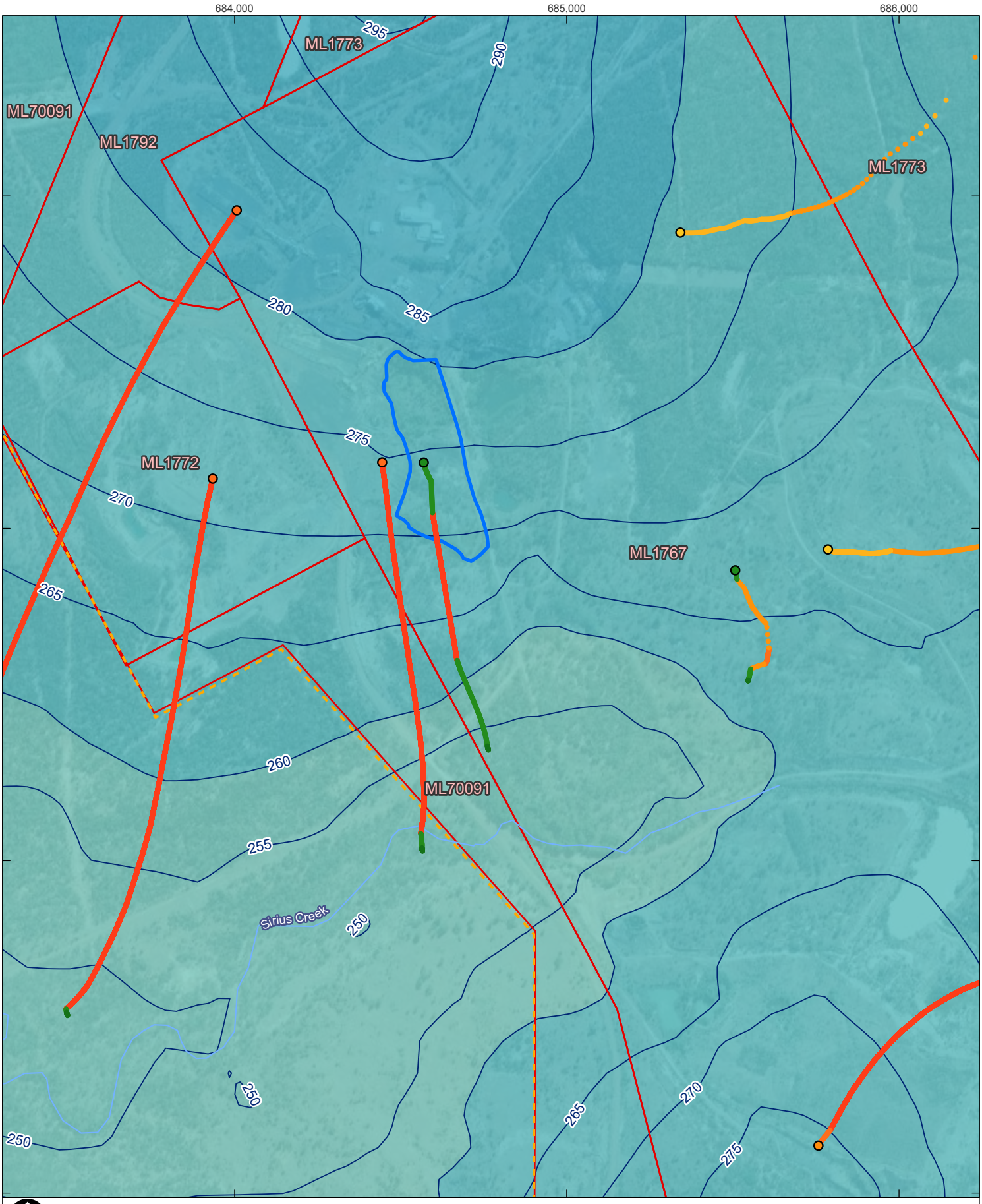
FIGURE 4-1

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040199.00001 BWM PRCP – GW\03 SLR Data\01 CADGIS\GIS\ArcPro\BWM PRCP – GW\BWM PRCP – GW.aprx\620040199_F0X_04_Predicted Movement of Particles (Mid Climate Scenario) Bottom



0 250 500 m

Coordinate System:	GDA2020 MGA Zone 55
Scale:	1:15,000 at A4
Project Number:	620.040199
Date Drawn:	06-Mar-2025
Drawn by:	AS

LEGEND

- Watercourse
- Bottom Dam Tailings Storage Facility (TSF)
- BWM Mining Lease
- Project Area (Environmental Authorities boundary)

Model Layer

- 1
- 2
- 11
- 12
- 13
- 14

Groundwater Level (mAHD)

- 240 - 260
- 260 - 280
- 280 - 300

BLACKWATER MINE - BOTTOM DAM TSF AND SIRIUS CREEK INVESTIGATION

PREDICTED MOVEMENT OF PARTICLES BOTTOM DAM TAILINGS STORAGE FACILITY

SLR

DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.

FIGURE 4-2

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040199.00001 BWM PRCP – GW\03 SLR Data\01 CADGIS\GIS\ArcPro\BWM PRCP – GW\BWM PRCP – GW.aprx\620040199_F0X Particle Tracks for Bottom TSF

It can be seen the particle migration follows the groundwater flow gradients as indicated by the groundwater elevation contours. As the groundwater flow gradient steadies progressively over the post-mining period as it approaches equilibrium, the model naturally has to find a progression pathway for the particle. Towards the equilibrium point, the vertical flux in the model becomes preferential to horizontal flux, and the particle appears to migrate upwards to Layer 2 (representing the Tertiary weathered zone), around Sirius Creek.

It is clear from the conceptualisation that this upward vertical flux is not realistic of the system, and the groundwater system is highly unlikely to behave in this manner. At the termination point of the particle tracking, it is expected that Layer 2 would likely be dry. The upwards flux is therefore potentially driven by a simulation nuance in the change to unsaturated flow that the model adopts.

4.3 Comparison of Site-Wide Model Results with Local Conceptualisation

It can be concluded that the predicted movement of particles from Bottom Dam TSF to Sirius Creek as predicted by the model is not supported by the conceptual model for the system. The reasoning for this disconnect is multi-faceted, and includes the following factors:

- Scale of both conceptualisation and of the model in relation to specific features:
  - Scale of hydrogeological investigations and modelling is highly variable dependent upon the intent of the study. The boundary of the numerical groundwater model, utilised for the particle flow path simulation modelling in discussion here, was fit for purpose for its original intent, being BWM site to regional scale groundwater flow modelling. However, the groundwater model is not scaled to the specific level of local detail developed within this study, that is, refined sufficiently to represent small local scale features such as Bottom Dam TSF. It becomes necessary in developing a regional groundwater model that the nuances of small localised conceptualisation may not be captured in the broader site conceptualisation and model build.
- Data availability:
  - The local bore data used to develop the conceptualisation for this study was not available at the time of the initial model construction. Consequently, the model is not specifically calibrated to this information and therefore the model is reflective of the broader site to regional scale dataset and generalised hydrogeological principals rather than the local site-specific information.
- Intent of particle pathway modelling:
  - It is important to note, ‘particles’ are simply a marker for tracking groundwater flow patterns and potential flow pathways, and do not represent an actual contaminant or specific parameter. The ‘particle’ commencing flow in Layer 14 (Burngrove Formation) is unlikely to be representative of any contaminated water from the Bottom Dam TSF, as this layer is well below the base of the TSF and hydraulically disconnected from the upper shallow layers.

5.0 Conclusion

Historically, the hydrogeological conditions around Bottom Dam TSF and Sirius Creek have been characterised by limited connectivity between surface water and groundwater systems. Monitoring data from the one bore in Sirius Creek near to Bottom Dam TSF has consistently shown dry conditions, indicating that the alluvial deposits and underlying Tertiary here have remained predominantly unsaturated i.e. there is no alluvial aquifer associated with Sirius Creek. Locally, and of importance, beneath Sirius Creek the Tertiary sediments are unsaturated. The water table in the Permian aquifer indicates groundwater levels occur well below the Sirius Creek bed elevation.

Minimal fluctuations in groundwater levels over time suggest that the Tertiary sediments are not significantly influenced by surface water inputs, rainfall events, or other external recharge mechanisms. These observations highlight that the ephemeral nature of Sirius Creek and its elevation above the water table have historically prevented groundwater discharge to the creek.

Under current conditions, surface water-groundwater interactions remain limited. Groundwater flow in the area is southward, however the water table continues to lie well below the creek's elevation preventing discharge of groundwater to the creek. The alluvial deposits remain predominantly unsaturated, with any localised saturation being highly transient and reliant on surface water inputs during flow events or flooding. Similarly, the Tertiary sediments, where saturated, shows consistent, stable groundwater levels with no significant response to rainfall, confirming a lack of hydraulic connection to surface water systems. Further, the Tertiary sediments appears to be unsaturated in the area around Sirius Creek. The ephemeral nature of the creek further reinforces its role as a temporary recharge source during flow events rather than a discharge point for groundwater.

Overall, both historical and current data suggest that surface water recharge processes in this area are dominated by episodic inputs from streamflow and flooding, with minimal contributions from groundwater. The hydrogeological setting supports limited connectivity between Bottom Dam TSF, Sirius Creek, and the regional groundwater system.

The numerical groundwater model and subsequent particle tracking presented in the PRC Plan:

- Was based on a groundwater model designed for site to regional scale flow modelling, rather than local scale modelling at specific BWM features such that the model sufficiently represents the localised interaction of groundwater around Bottom Dam TSF and Sirius Creek specifically.
- did not incorporate the closure strategy outlined in the PRC Plan for Bottom Dam TSF.

As such the model results near Bottom Dam TSF are considered a conservative first pass assessment of risk prior to any local scale remedial measures.

The conceptual understanding presented herein, based on a review of local data, provides the most accurate representation of the relationship between Bottom Dam TSF and Sirius Creek and a better basis for understanding the local groundwater dynamics than the numerical groundwater model. Based on this, in conjunction with a review of the modelling processes and intent, it is concluded that there is highly limited potential for hydraulic connection between the Bottom Dam TSF and Sirius Creek.

6.0 References

Australasian Groundwater and Environmental (AGE) Consultants, 2003. Report on CBM Extraction – South Blackwater Area, Prepared for BMA. Project No. G1187

Henderson Geotech Pty Ltd, 2024. Concept Cover Designs for Waste Storage Facilities at Blackwater Mine

SLR, 2023b. Blackwater Mine – North Extension Project Groundwater Modelling Technical Report. Prepared for BMA. Report reference: 620.014301.00006-R02-v4.0_20231211.docx, December 2023.

SLR, 2024. Blackwater Mine – Transitional PRC Plan Hydrogeology Assessment. Prepared for Whitehaven Coal Limited. Report reference: 620.040199.00001-v3.1_16.09.2024.docx, September 2024.

S.S. Papadopulos & Associates, Inc., 2018. mod-PATH3DU, version 2.1.2. Rockville, Maryland

Terrenus Earth Sciences, 2024, Environmental Geochemical Characterisation and Risk Management of Mineral Waste, Blackwater Mine, prepared for Whitehaven Blackwater Pty Ltd, report ref: 24-063-178/R001

Appendix A Bore Logs

Bottom Dam Tailings Storage Facility & Sirius Creek

Preliminary Hydrogeological Review and Investigation

Whitehaven Coal Limited

SLR Project No.: 620.010199.00013

15 May 2025

REPORT OF STANDPIPE INSTALLATION: BWM_MB119_01

SHEET: 1 OF 1

CLIENT:	WHC	COORDS:	684084.8 m 7350413.1 m	DRILL RIG:	Geoprobe 8140LS sonic rig
PROJECT:	Blackwater South Site Investigation	SURFACE RL:	280.55 m DATUM: AHD	CONTRACTOR:	Legion Drilling
LOCATION:	Blackwater Mine	INCLINATION:	-90°	LOGGED: CS	DATE: 25/5/24
JOB NO:	PS213941	HOLE DEPTH:	19.00 m	CHECKED: BD	DATE: 2/10/24

Drilling				Field Material Description		Instrumentation Details
METHOD	WATER	DEPTH (metres)	DEPTH RL	GRAPHIC LOG	SOIL/ROCK MATERIAL DESCRIPTION	
SONIC		0	280.55		Topsoil/Fill - Silty SAND	0.00, RL280.55 — PVC stick up (0.75 m aGL) with well plug, encased in protective steel monument
			0.60			
			1.00		Sandy SILT	
					Tertiary Sediments - Silty SAND	
			1.60			
			278.95			
		2	2.10			
			278.45		Clayey SAND	
			3.10			
			277.45		Silty SAND	
		4	4.20			
			276.15		SANDSTONE	
			5.00			
			275.55		Clayey SANDSTONE	
		6				80/20 Cement/bentonite mix
			6.70			
			273.85			50 mm internal diameter class 12 uPVC solid casing
		8	8.00			
			272.55		SANDSTONE	
			9.00			
			9.30			
			271.25		Clayey SANDSTONE	
		10				
			10.50			
			270.05		SANDSTONE	
			11.80			
		12	268.75		Clayey SAND	
			12.50			
			268.05		SANDSTONE	
			13.50			
			267.05			
		14	14.00			14.00, RL266.55
			266.55		Silty SAND	Bentonite plug
			14.80			15.00, RL265.55
					Clayey SANDSTONE	
			15.30			
			265.25		SANDSTONE	
		16				Filter Pack - 2-3 mm washed graded gravel
			16.40			
			264.15			0.8 mm aperture, 5 mm spacing, factory slotted class 12 uPVC
			16.90			
			263.65		Clayey SANDSTONE	
		18				18.50, RL262.05
			19.00			19.00, RL261.55 — Sump - Class 12 uPVC solid casing, with endcap
			261.55		END OF BOREHOLE @ 19.00 m	

This report of standpipe installation must be read in conjunction with accompanying notes and abbreviations. It has been prepared for hydrogeological purposes only, without attempt to assess geotechnical properties or possible contamination. Any reference to geotechnical properties or potential contamination are for information only and do not necessarily indicate the presence or absence of the properties stated.

GAP gINT FN. F17
RL1

GAP 10.0.6 LIB.GLB Log GAP WELL 3 PS137749 BLACKWATER SOUTH SITE INVESTIGATION-OCT2-WELL INSTALL.GPJ <<DrawingFile>> 04/10/2024 10:21 10.03.00.09 Datgel Tools

REPORT OF STANDPIPE INSTALLATION: BWM_MB121_01

SHEET: 1 OF 1

CLIENT:	WHC	COORDS:	684088.4 m 7350782.4 m	DRILL RIG:	Geoprobe 8140LS sonic rig
PROJECT:	Blackwater South Site Investigation	SURFACE RL:	306.42 m DATUM: AHD	CONTRACTOR:	Legion Drilling
LOCATION:	Blackwater Mine	INCLINATION:	-90°	LOGGED: SK	DATE: 17/4/24
JOB NO:	PS213941	HOLE DEPTH:	18.50 m	CHECKED: BD	DATE: 2/10/24

Drilling				Field Material Description		Instrumentation Details
METHOD	WATER	DEPTH (metres)	DEPTH RL	GRAPHIC LOG	SOIL/ROCK MATERIAL DESCRIPTION	
SONIC		0	306.42		Topsoil - Silty CLAY	0.00, RL306.42 — PVC stick up (0.62 m aGL) with well plug, encased in protective monument
			1.00			
			305.42		Tertiary Sediments - SANDSTONE	
		2				
		4				80/20 Cement/bentonite mix
			5.00			
			301.42		CLAY	
			6.00			50 mm internal diameter class 12 uPVC solid casing
		6	300.42		SANDSTONE	
			7.50			
			298.92		SANDSTONE	
		8				9.00, RL297.42 — Bentonite plug
						10.00, RL296.42
		10				
		12				0.8 mm aperture, 5 mm spacing, factory slotted class 12 uPVC Filter Pack - 2-3 mm washed graded gravel
		14				
		16				16.50, RL289.92
						Sump - Class 12 uPVC solid casing, with endcap
						17.50, RL288.92
		18				Backfill - Natural backfill
			18.50			18.50, RL287.92
			287.92		END OF BOREHOLE @ 18.50 m	

This report of standpipe installation must be read in conjunction with accompanying notes and abbreviations. It has been prepared for hydrogeological purposes only, without attempt to assess geotechnical properties or possible contamination. Any reference to geotechnical properties or potential contamination are for information only and do not necessarily indicate the presence or absence of the properties stated.

GAP gINT FN. F17
RL1

GAP 10.0.6 LIB.GLB Log GAP WELL 3 PS137749 BLACKWATER SOUTH SITE INVESTIGATION-OCT2-WELL INSTALL.GPJ <<DrawingFile>> 04/10/2024 10:19 10.03.00.09 Datgel Tools

REPORT OF STANDPIPE INSTALLATION: BWM_MB123_01

SHEET: 1 OF 1

CLIENT:	WHC	COORDS: 683851.6 m 7350980.2 m	DRILL RIG: Comacchio GEO 900 sonic rig
PROJECT:	Blackwater South Site Investigation	SURFACE RL: 306.27 m DATUM: AHD	CONTRACTOR: Legion Drilling
LOCATION:	Blackwater Mine	INCLINATION: -90°	LOGGED: SK DATE: 20/4/24
JOB NO:	PS213941	HOLE DEPTH: 8.80 m	CHECKED: BD DATE: 2/10/24

Drilling				Field Material Description		Instrumentation Details
METHOD	WATER	DEPTH (metres)	DEPTH RL	GRAPHIC LOG	SOIL/ROCK MATERIAL DESCRIPTION	
SONIC		0	306.27		Fill	PVC stick up (0.73 m aGL) with well plug, encased in protective monument
			0.50			0.00, RL306.27
			305.77		Fill	80/20 Cement/bentonite mix
		3	3.50			50 mm internal diameter class 12 uPVC solid casing
			302.77		Tertiary Formation - SILCRETE	3.00, RL303.27
						Bentonite plug
		4				4.00, RL302.27
		5	5.50			Filter Pack - 2-3 mm washed graded gravel
			300.77		SILTSTONE	
		6				
		7				
		8				0.8 mm aperture, 5 mm spacing, factory slotted class 12 uPVC
						8.20, RL298.07
			8.80			Sump - Class 12 uPVC solid casing, with endcap
		9	297.47		END OF BOREHOLE @ 8.80 m	8.80, RL297.47

This report of standpipe installation must be read in conjunction with accompanying notes and abbreviations. It has been prepared for hydrogeological purposes only, without attempt to assess geotechnical properties or possible contamination. Any reference to geotechnical properties or potential contamination are for information only and do not necessarily indicate the presence or absence of the properties stated.

GAP 10.0.6 LIB.GLB Log GAP WELL 3 PS137749 BLACKWATER SOUTH SITE INVESTIGATION-OCT2-WELL INSTALL.GPJ <<DrawingFile>> 04/10/2024 10:12 10.03.00.09 Datgel Tools

REPORT OF STANDPIPE INSTALLATION: BWM_MB132_01

SHEET: 1 OF 1

CLIENT:	WHC	COORDS: 684460.4 m 7351104.4 m	DRILL RIG: Comacchio GEO 900 sonic rig
PROJECT:	Blackwater South Site Investigation	SURFACE RL: 287.65 m DATUM: AHD	CONTRACTOR: Legion Drilling
LOCATION:	Blackwater Mine	INCLINATION: -90°	LOGGED: SK DATE: 6/3/24
JOB NO:	PS213941	HOLE DEPTH: 19.00 m	CHECKED: BD DATE: 2/10/24

Drilling				Field Material Description		Instrumentation Details
METHOD	WATER	DEPTH (metres)	DEPTH RL	GRAPHIC LOG	SOIL/ROCK MATERIAL DESCRIPTION	
SONIC		0	287.65		Topsoil / Fill - Sandy GRAVEL	0.00, RL287.65 PVC stick up (0.97 m aGL) with well plug, encased in protective steel monument
		2	2.50 285.15		Tertiary Sediments - Sandy CLAY	
		4				80/20 Cement/bentonite mix
		6				50 mm internal diameter class 12 uPVC solid casing
		8				
		10	10.00 277.65		CLAYSTONE	10.50, RL277.15 Bentonite plug
		12				11.50, RL276.15
		14				Filter Pack - 2-3 mm washed graded gravel
	▽		15.00 272.65		SANDSTONE	
		16				0.8 mm aperture, 5 mm spacing, factory slotted class 12 uPVC
		18				18.50, RL269.15
			19.00 268.65		END OF BOREHOLE @ 19.00 m	19.00, RL268.65 Sump - Class 12 uPVC solid casing, with endcap

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GAP gINT FN. F17
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GAP 10.0.6 LIB.GLB Log GAP WELL 3 PS137749 BLACKWATER SOUTH SITE INVESTIGATION-OCT2-WELL INSTALL.GPJ <<DrawingFile>> 04/10/2024 10:21 10.03.00.09 Datgel Tools

REPORT OF STANDPIPE INSTALLATION: BWM_MB132_02

SHEET: 1 OF 1

CLIENT:	WHC	COORDS: 684477.8 m 7351106.0 m	DRILL RIG: Comacchio GEO 900 sonic rig
PROJECT:	Blackwater South Site Investigation	SURFACE RL: 287.88 m DATUM: AHD	CONTRACTOR: Legion Drilling
LOCATION:	Blackwater Mine	INCLINATION: -90°	LOGGED: SK DATE: 6/3/24
JOB NO:	PS213941	HOLE DEPTH: 29.50 m	CHECKED: BD DATE: 2/10/24

Drilling				Field Material Description		Instrumentation Details
METHOD	WATER	DEPTH (metres)	DEPTH RL	GRAPHIC LOG	SOIL/ROCK MATERIAL DESCRIPTION	
SONIC		0	287.88		Topsoil / Fill - Sandy GRAVEL	0.00, RL287.88 — PVC stick up (0.90 m aGL) with well plug, encased in protective steel monument
			2.50 285.38		Tertiary Sediments - Sandy CLAY medium plasticity	
		5				
		10	10.00 277.88		CLAYSTONE	80/20 Cement/bentonite mix; 50 mm internal diameter class 12 uPVC solid casing
		15	15.00 272.88		SANDSTONE	
			19.00 268.88		Permian (Burngrove Formation) - SANDSTONE	
		20	21.00 266.88		SILTSTONE	21.00, RL266.88; 22.00, RL265.88 — Bentonite plug
		25				Filter Pack - 2-3 mm washed graded gravel; 0.8 mm aperture, 5 mm spacing, factory slotted class 12 uPVC
			29.50 258.38		END OF BOREHOLE @ 29.50 m	29.00, RL258.88; 29.50, RL258.38 — Sump - Class 12 uPVC solid casing, with endcap
		30				

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GAP gINT FN. F17
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GAP 10.0.6 LIB.GLB Log GAP WELL 3 PS137749 BLACKWATER SOUTH SITE INVESTIGATION-OCT2-WELL INSTALL.GPJ <<DrawingFile>> 04/10/2024 10:29 10.03.00.09 Datgel Tools

REPORT OF STANDPIPE INSTALLATION: BWM_MB133_00

SHEET: 1 OF 1

CLIENT: WHC
PROJECT: Blackwater South Site Investigation
LOCATION: Blackwater Mine
JOB NO: PS213941

COORDS: 684541.9 m 7350868.4 m
SURFACE RL: 274.64 m DATUM: AHD
INCLINATION: -90°
HOLE DEPTH: 12.00 m

DRILL RIG: Geoprobe 8140LS sonic rig
CONTRACTOR: Legion Drilling
LOGGED: AL DATE: 8/5/24
CHECKED: BD DATE: 2/10/24

Drilling				Field Material Description		Instrumentation Details
METHOD	WATER	DEPTH (metres)	DEPTH RL	GRAPHIC LOG	SOIL/ROCK MATERIAL DESCRIPTION	
SONIC		0	274.64		Topsoil / Fill - Silty SAND	PVC stick up (0.86 m aGL) with well plug, encased in protective steel monument
			0.80 273.84		Mine Spoil - Coal TAILINGS	0.00, RL274.64
		2				80/20 Cement/bentonite mix
						50 mm internal diameter class 12 uPVC solid casing
		4				4.00, RL270.64
						Bentonite plug
		6				5.00, RL269.64
		8				Filter Pack - 2-3 mm washed graded gravel
		10				0.8 mm aperture, 5 mm spacing, factory slotted class 12 uPVC
						11.20, RL263.44
						Sump - Class 12 uPVC solid casing, with endcap
						11.70, RL262.94
		12	12.00 262.64		END OF BOREHOLE @ 12.00 m	12.00, RL262.64 Hole Collapse
		14				

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REPORT OF STANDPIPE INSTALLATION: BWM_MB133_01

SHEET: 1 OF 1

CLIENT: WHC
PROJECT: Blackwater South Site Investigation
LOCATION: Blackwater Mine
JOB NO: PS213941

COORDS: 684538.1 m 7350867.8 m
SURFACE RL: 274.68 m DATUM: AHD
INCLINATION: -90°
HOLE DEPTH: 18.00 m

DRILL RIG: Geoprobe 8140LS sonic rig
CONTRACTOR: Legion Drilling
LOGGED: AL DATE: 8/5/24
CHECKED: BD DATE: 2/10/24

Drilling				Field Material Description		Instrumentation Details
METHOD	WATER	DEPTH (metres)	DEPTH RL	GRAPHIC LOG	SOIL/ROCK MATERIAL DESCRIPTION	
SONIC		0	274.68		Topsoil / Fill - Silty SAND	PVC stick up (0.90 m aGL) with well plug, encased in protective steel monument
			0.80			
			273.88		Mine Spoil - Coal TAILINGS	
		2				
		4				
		6				
		8				
		10				
		12				
			13.00			
			261.68		Mine Spoil - Rejects	
		14				
			15.00			
			259.68			
			16.00			
		16	258.68			
			18.00			
		18	256.68		END OF BOREHOLE @ 18.00 m	

0.00, RL274.68

80/20 Cement/bentonite mix

50 mm internal diameter class 12 uPVC solid casing

13.00, RL261.68

Bentonite plug

14.00, RL260.68

Filter Pack - 2-3 mm washed graded gravel

0.8 mm aperture, 5 mm spacing, factory slotted class 12 uPVC

17.50, RL257.18

Sump - Class 12 uPVC solid casing, with endcap

18.00, RL256.68

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REPORT OF STANDPIPE INSTALLATION: BWM_MB133_02

SHEET: 1 OF 1

CLIENT:	WHC	COORDS: 684534.4 m 7350867.1 m	DRILL RIG: Geoprobe 8140LS sonic rig
PROJECT:	Blackwater South Site Investigation	SURFACE RL: 274.68 m DATUM: AHD	CONTRACTOR: Legion Drilling
LOCATION:	Blackwater Mine	INCLINATION: -90°	LOGGED: AL DATE: 7/5/24
JOB NO:	PS213941	HOLE DEPTH: 28.50 m	CHECKED: BD DATE: 2/10/24

Drilling				Field Material Description		Instrumentation Details
METHOD	WATER	DEPTH (metres)	DEPTH RL	GRAPHIC LOG	SOIL/ROCK MATERIAL DESCRIPTION	
SONIC		0	274.68		Topsoil / Fill - Silty SAND	0.00, RL274.68: PVC stick up (0.92 m aGL) with well plug, encased in protective steel monument
			0.80			
			273.88		Mine Spoil - Coal TAILINGS	
		5				
		10				80/20 Cement/bentonite mix; 50 mm internal diameter class 12 uPVC solid casing
			13.00			
			261.68		Mine Spoil - Rejects	
		15	15.00			
			259.68			
			16.00			
			258.68			
		20	20.00			
			254.68		Permian (Rangal Coal Measures) - Mudstone	20.50, RL254.18
			21.00			
			21.50		SILTSTONE	21.50, RL253.18: Bentonite plug
			253.18		SANDSTONE	
			22.50			
			252.18		Clayey SANDSTONE	
			24.00			
			250.68		Silty SANDSTONE	Filter Pack - 2-3 mm washed graded gravel
		25				0.8 mm aperture, 5 mm spacing, factory slotted class 12 uPVC
						28.00, RL246.68
			28.50			28.50, RL246.18: Sump - Class 12 uPVC solid casing, with endcap
			246.18		END OF BOREHOLE @ 28.50 m	

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REPORT OF STANDPIPE INSTALLATION: BWM_MB135_01

SHEET: 1 OF 1

CLIENT:	WHC	COORDS: 684781.9 m 7350631.2 m	DRILL RIG: Comacchio GEO 900 sonic rig
PROJECT:	Blackwater South Site Investigation	SURFACE RL: 262.87 m DATUM: AHD	CONTRACTOR: Legion Drilling
LOCATION:	Blackwater Mine	INCLINATION: -90°	LOGGED: SK DATE: 15/12/23
JOB NO:	PS213941	HOLE DEPTH: 10.00 m	CHECKED: BD DATE: 2/10/24

Drilling				Field Material Description		Instrumentation Details
METHOD	WATER	DEPTH (metres)	DEPTH RL	GRAPHIC LOG	SOIL/ROCK MATERIAL DESCRIPTION	
SONIC		0	262.87		Mine Spoil (Rejects) - Clayey SAND	PVC stick up (0.78 m aGL) with well plug, encased in protective steel monument
						0.00, RL262.87
		2				80/20 Cement/bentonite mix
						50 mm internal diameter class 12 uPVC solid casing
		4	4.00 258.87		Tertiary Sediments - Sandy CLAY	Bentonite plug
						5.50, RL257.37
		6				Filter Pack - 2-3 mm washed graded gravel
		8				0.8 mm aperture, 5 mm spacing, factory slotted class 12 uPVC
						9.50, RL253.37
		10	10.00 252.87		END OF BOREHOLE @ 10.00 m	Sump - Class 12 uPVC solid casing, with endcap
						10.00, RL252.87

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REPORT OF STANDPIPE INSTALLATION: BWM_MB136_01

SHEET: 1 OF 1

CLIENT:	WHC	COORDS: 684490.1 m 7350133.8 m	DRILL RIG: Geoprobe 8140LS sonic rig
PROJECT:	Blackwater South Site Investigation	SURFACE RL: 255.41 m DATUM: AHD	CONTRACTOR: Legion Drilling
LOCATION:	Blackwater Mine	INCLINATION: -90°	LOGGED: BD DATE: 21/7/24
JOB NO:	PS213941	HOLE DEPTH: 8.30 m	CHECKED: BD DATE: 2/10/24

Drilling				Field Material Description		Instrumentation Details
METHOD	WATER	DEPTH (metres)	DEPTH RL	GRAPHIC LOG	SOIL/ROCK MATERIAL DESCRIPTION	
SONIC		0	255.41		Alluvium - Silty SAND	0.00, RL255.41
			0.20 255.21		Clayey SAND	PVC stick up (0.85 m aGL) with well plug, encased in protective steel monument 80/20 Cement/bentonite mix
		1	1.30 254.11		Sandy CLAY	1.00, RL254.41 Bentonite plug
		2	2.00 253.41		Clayey SAND	2.00, RL253.41 50 mm internal diameter class 12 uPVC solid casing
		3				
		4				Filter Pack - 2-3 mm washed graded gravel
		5	4.80 250.61		SAND	
		6	6.00 249.41		Permian (Burngrove Formation) - SANDSTONE	0.8 mm aperture, 5 mm spacing, factory slotted class 12 uPVC
		7	7.00 248.41		Clayey SANDSTONE	7.00, RL248.41
		8				Sump - Class 12 uPVC solid casing, with endcap
			8.30 247.11		END OF BOREHOLE @ 8.30 m	8.00, RL247.41 Backfill - 2-3 mm washed graded gravel 8.30, RL247.11
		9				

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GAP gINT FN. F17
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GAP 10.0.6 LIB.GLB Log GAP WELL 3 PS137749 BLACKWATER SOUTH SITE INVESTIGATION-OCT2-WELL INSTALL.GPJ <<DrawingFile>> 04/10/2024 10:12 10.03.00.09 Datgel Tools

REPORT OF STANDPIPE INSTALLATION: BWM_MB136_02

SHEET: 1 OF 1

CLIENT:	WHC	COORDS:	684490.1 m 7350133.8 m	DRILL RIG:	Geoprobe 8140LS sonic rig
PROJECT:	Blackwater South Site Investigation	SURFACE RL:	254.65 m DATUM: AHD	CONTRACTOR:	Legion Drilling
LOCATION:	Blackwater Mine	INCLINATION:	-90°	LOGGED: BD	DATE: 27/4/24
JOB NO:	PS213941	HOLE DEPTH:	21.50 m	CHECKED: BD	DATE: 2/10/24

Drilling				Field Material Description		Instrumentation Details
METHOD	WATER	DEPTH (metres)	DEPTH RL	GRAPHIC LOG	SOIL/ROCK MATERIAL DESCRIPTION	
SONIC		0	254.65		Topsoil - Silty SAND	PVC stick up (0.66 m aGL) with well plug, encased in protective steel monument
			0.50			
			254.15		Tertiary - Sandy CLAY	
			1.60			
			253.05			
			3.00			
			251.65		Clayey SAND	
			4.90			
		5	249.75		Sandy CLAY	
			5.40			
			249.25		Clayey SAND	
			6.60			
			248.05		SAND	
			7.40			
			247.25		CLAY	
			8.00			
			246.65		Permian (Burngrove Formation) - Clayey SANDSTONE	
			8.50			
			246.15			
		10				
			12.60			
			242.05		SANDSTONE	
		15				
			17.50			
			237.15		SILTSTONE	
			18.60			
			236.05			
		20	20.00			
			234.65			
			21.50			
			233.15		END OF BOREHOLE @ 21.50 m	

0.00, RL254.65

80/20 Cement/bentonite mix

50 mm internal diameter class 12 uPVC solid casing

12.00, RL242.65

Bentonite plug

14.00, RL240.65

Filter Pack - 2-3 mm washed graded gravel

0.8 mm aperture, 5 mm spacing, factory slotted class 12 uPVC

21.00, RL233.65

21.50, RL233.15

Sump - Class 12 uPVC solid casing, with endcap

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REPORT OF STANDPIPE INSTALLATION: BWM_MB138_01

SHEET: 1 OF 1

CLIENT: WHC
PROJECT: Blackwater South Site Investigation
LOCATION: Blackwater Mine
JOB NO: PS213941

COORDS: 684625.2 m 7350799.7 m
SURFACE RL: 275.23 m DATUM: AHD
INCLINATION: -90°
HOLE DEPTH: 14.00 m

DRILL RIG: Geoprobe 8140LS sonic rig
CONTRACTOR: Legion Drilling
LOGGED: CS DATE: 9/5/24
CHECKED: BD DATE: 2/10/24

Drilling				Field Material Description		Instrumentation Details
METHOD	WATER	DEPTH (metres)	DEPTH RL	GRAPHIC LOG	SOIL/ROCK MATERIAL DESCRIPTION	
SONIC		0	275.23		FILL - Sandy CLAY	PVC stick up (0.93 m aGL) with well plug, encased in protective steel monument
			1.00			
			274.23		Mine Spoil - Coal tailings	
		2				
		4				80/20 Cement/bentonite mix
			5.50			50 mm internal diameter class 12 uPVC solid casing
			269.73			
		6				
			7.00			
			268.23			
		8				Bentonite plug
			8.30			
			266.93		Mine spoil (rejects) - Gravelly CLAY	
		10				
			10.40			
			264.83			
			11.50			Filter Pack - 2-3 mm washed graded gravel
			263.73			
		12				0.8 mm aperture, 5 mm spacing, factory slotted class 12 uPVC
			12.50			
			262.73			
						13.50, RL261.73
		14	14.00			Sump - Class 12 uPVC solid casing, with endcap
			261.23		END OF BOREHOLE @ 14.00 m	14.00, RL261.23

0.00, RL275.23
7.50, RL267.73
8.50, RL266.73

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REPORT OF STANDPIPE INSTALLATION: BWM_MB135_02

SHEET: 1 OF 1

CLIENT:	WHC	COORDS: 684785.6 m 7350627.7 m	DRILL RIG: Comacchio GEO 900 sonic rig
PROJECT:	Blackwater South Site Investigation	SURFACE RL: 262.88 m DATUM: AHD	CONTRACTOR: Legion Drilling
LOCATION:	Blackwater Mine	INCLINATION: -90°	LOGGED: SK DATE: 15/12/23
JOB NO:	PS213941	HOLE DEPTH: 24.00 m	CHECKED: BD DATE: 2/10/24

Drilling				Field Material Description		Instrumentation Details
METHOD	WATER	DEPTH (metres)	DEPTH RL	GRAPHIC LOG	SOIL/ROCK MATERIAL DESCRIPTION	
SONIC		0	262.88		Mine Spoil (Rejects) - Clayey SAND	0.00, RL262.88 PVC stick up (0.93 m aGL) with well plug, encased in protective steel monument
		5	5.50 257.38		Tertiary Sediments - Sandy CLAY	80/20 Cement/bentonite mix; 50 mm internal diameter class 12 uPVC solid casing
		10	10.00 252.88		Permian (Rangal Coal Measures) - Carbonaceous MUDSTONE	
		15	17.00			15.00, RL247.88 Bentonite plug; 16.00, RL246.88
			17.50 245.38		COAL SILTSTONE	Filter Pack - 2-3 mm washed graded gravel
		20	20.50 242.38		Carbonaceous SILTSTONE increased organic content, trace clay, moderaetly weathered	0.8 mm aperture, 5 mm spacing, factory slotted class 12 uPVC
			24.00 238.88		END OF BOREHOLE @ 24.00 m	23.00, RL239.88; 23.50, RL239.38 Sump - Class 12 uPVC solid casing, with endcap; 24.00, RL238.88 Backfill - 2-3 mm washed graded gravel
		25				

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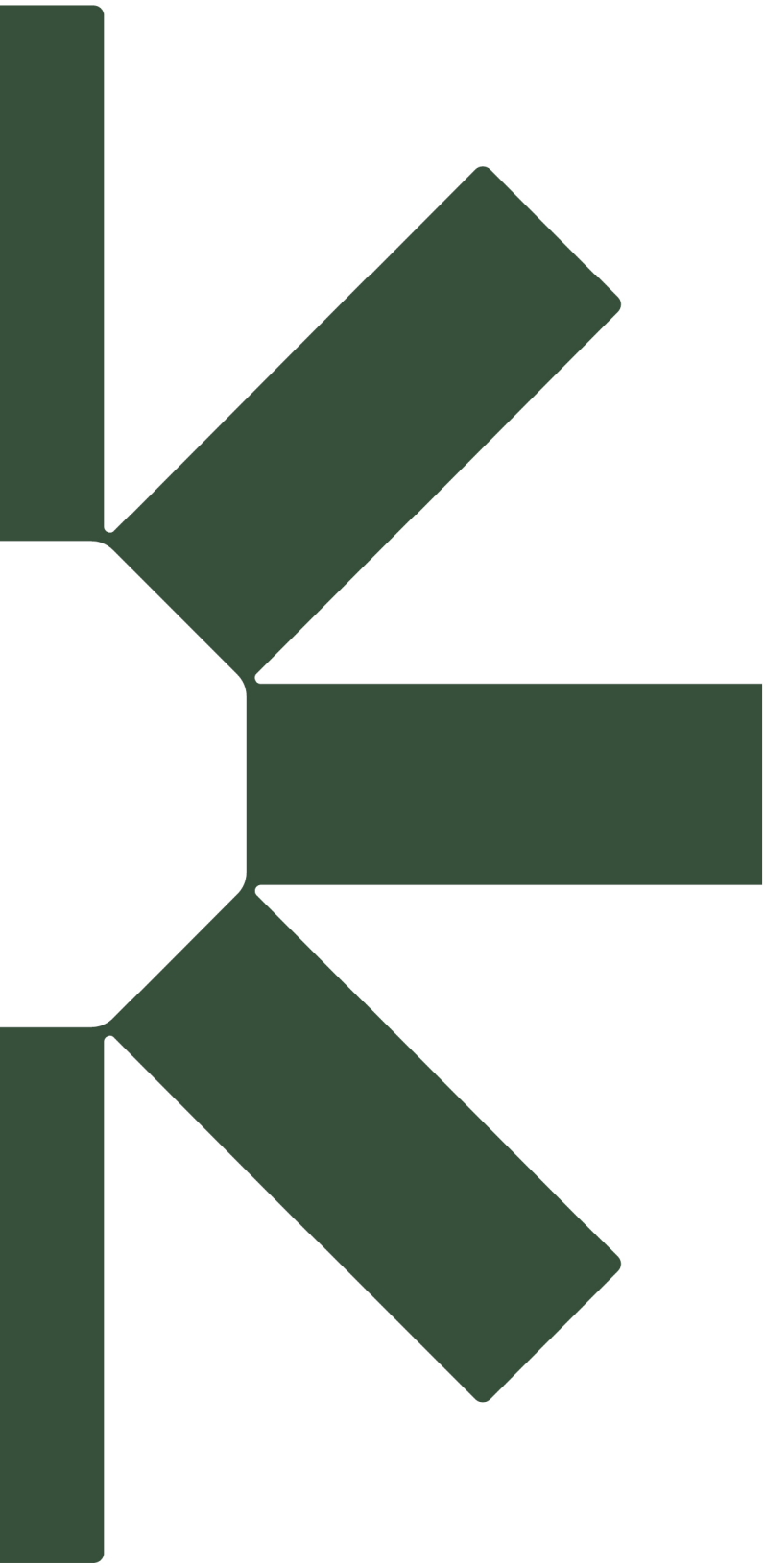

Making Sustainability Happen

Blackwater Mine

Transitional PRC Plan Hydrogeology Assessment

Whitehaven Coal Limited

Level 31, 12 Creek Street
Brisbane QLD 4000 Australia

Prepared by: Jade Darvell and Callum Sharp

SLR Consulting Australia

Level 16, 175 Eagle Street, Brisbane QLD 4000,
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SLR Project No.: 620.040199.00001

16 September 2024

Revision: 3.0

Revision Record

Revision	Date	Prepared By	Checked By	Authorised By
1.0	19 January 2024	Jade Darvell	Derwin Lyons	Derwin Lyons
2.0	9 August 2024	Jade Darvell Callum Sharp	Derwin Lyons	Derwin Lyons
3.0	16 September 2024	Derwin Lyons	Brian Rask	Derwin Lyons
	Click to enter a date.			
	Click to enter a date.			

Basis of Report

This report has been prepared by SLR Consulting Australia (SLR) with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with Whitehaven Coal Limited (the Client). Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

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Appendices

Appendix A **80th Percentile Summary Statistics and Comparison to Guideline Values**
Appendix B **Recovery Model Starting Heads**
Appendix C **Predictive Hydrographs Adjacent Final Void Lakes (Mid Climate Scenario)**
Appendix D **Predictive Hydrographs at Third-Party Bores**
Appendix E **Drier Climate Scenario Model Predictions**
Appendix F **Wetter Climate Scenario Model Predictions**

1.0 Introduction

1.1 Background

SLR Consulting Australia Pty Ltd (SLR) has been engaged by Whitehaven Coal Limited (WHC) subsidiary Whitehaven Blackwater Pty Ltd to undertake a hydrogeological assessment supporting the Blackwater Mine (BWM) transitional Progressive Rehabilitation and Closure Plan (PRC Plan). This hydrogeological assessment is undertaken in accordance with the relevant requirements of the Queensland Government Department of Environment and Science (DES) Guideline: Progressive Rehabilitation and Closure Plans (DES Reference: ESR/2019/4964, version 3.00, effective 4 April 2023) - "the Guideline" and will be integrated into the design of the rehabilitation strategies and selection of post mining land uses (PMLUs) and Non-use Management Areas (NUMAs) within the BWM PRC Plan. BWM is located south of the township of Blackwater in central Queensland (**Figure 1-1**).

The BWM produces up to approximately 19 million tonnes per annum of (Mtpa) of Run-of-Mine (RoM) coal equating to approximately 16 Mtpa of product coal. The BWM strike length includes mining occurring in a number of separate and/or adjoining pits (**Figure 1-2**). Existing infrastructure is located primarily on ML1760 and includes a Train Load-out Facility (TLF) and coal stockpiles, RoM stockpiles, Coal Handling and Preparation Plant (CHPP), water management infrastructure and supporting infrastructure (i.e., roads, powerlines, laydown areas, workshop and administration areas).

BWM operates under Environmental Authority (EA) EPML00717813. The following Mining Leases (ML's) intersect the EA (**Figure 1-1**):

- ML1759
- ML1760
- ML1761
- ML1762
- ML1767
- ML1771
- ML1772
- ML1773
- ML1792
- ML1800
- ML1812
- ML1829
- ML1860
- ML1862
- ML1907
- ML70091
- ML70103
- ML70104
- ML70139
- ML70167
- ML70329

The most recent hydrogeological study relevant to the BWM transitional PRC Plan is that undertaken for the BWM Northern Extension Project (NEP) (SLR, 2023a), that included a post-mining assessment. That body of work has been drawn upon as directly relevant to this hydrogeological assessment, including the development of conceptual and numerical groundwater models for BWM as documented within SLR (2023a and 2023b). It is worth noting that this hydrogeological assessment for the BWM transitional PRC Plan does not include consideration of the NEP, which was still undergoing approvals at the time of this assessment.

For the purposes of this report:

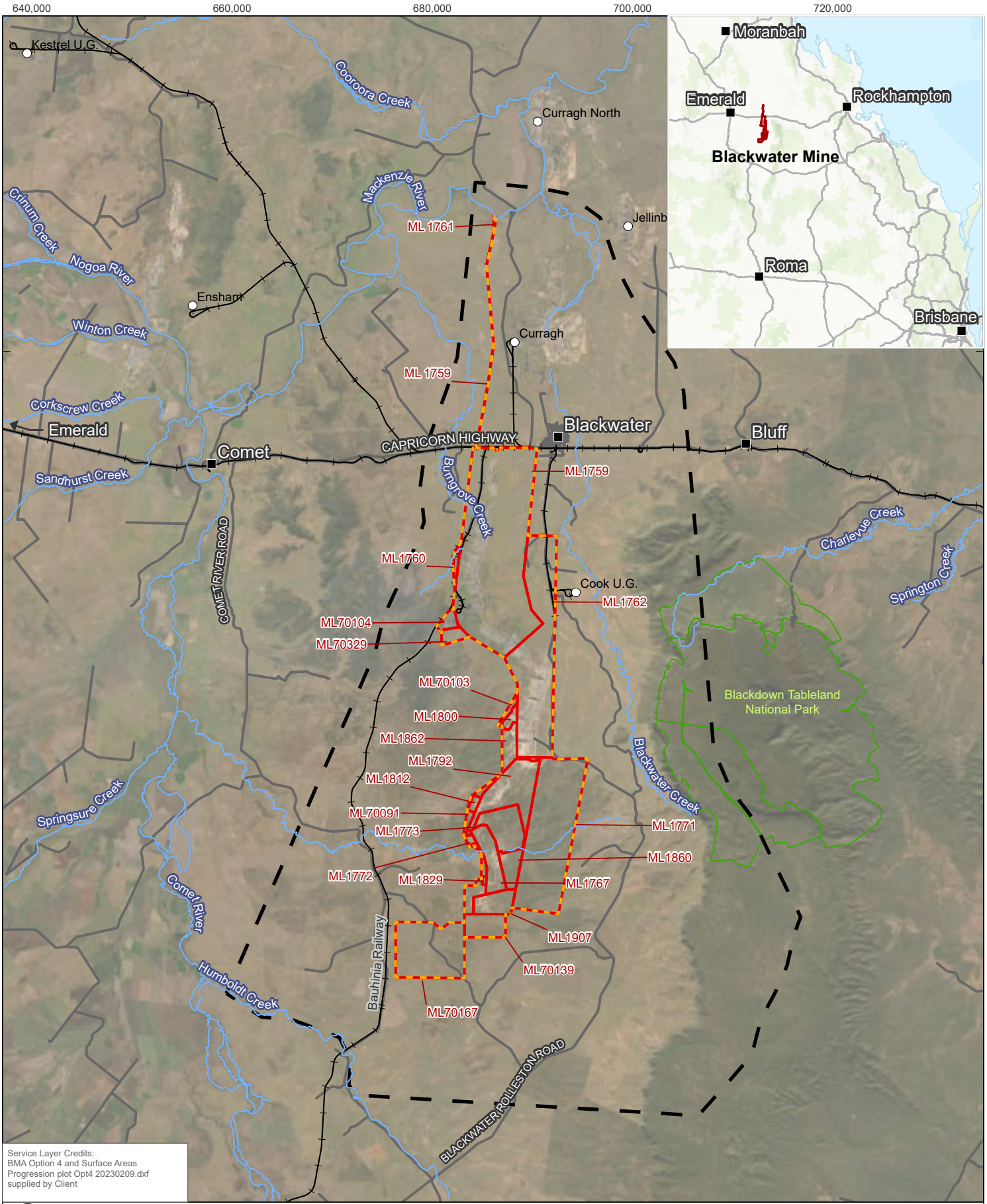
- The Project Area is synonymous with the EA boundary (i.e. the area subject to EA EPML00717813) and is shown on **Figure 1-1**.
- The “Study Area” is the regional area surrounding the Project Area considered in detail within this report (**Figure 1-1**). The Study Area is also synonymous with the numerical groundwater model domain as discussed in **Section 8.0**.

Mining commenced at BWM in 1967 and has included the extraction of coal through open cut strip mining from a series of pits (**Figure 1-2**). There was also a historical underground mining operation within the BWM Area called Kenmare Underground Mine (**Figure 1-2**).

1.2 Final Landform

The post-mining final landform relevant to this hydrogeological assessment, denoted “Final Landform Design 2.5” (Landform 2.5), was provided by WHC and is shown as **Figure 1-3**. The final landform contains 11 residual voids/void areas, as shown on **Figure 1-3**, from north to south:

- Ramp 8;
- Bonnie Doon (including in void tailings deposit);
- Mimosa/Besgrove;
- Deep Creek;
- Stewarton/Ballamoo;
- Kenmare;
- Laleham (including in void tailings deposit);;
- Togara/ North Marshmead;
- South Marshmead;
- Kennedy West; and
- Comet Downs East.



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Project Number:	620.040199
Date Drawn:	16-Jan-2024
Drawn by:	RB

LEGEND

- City/Town
- Coal Mine
- Railway
- Road
- Watercourse
- Study Area
- BWM Mining Lease
- Project Area (Environmental Authorities boundary)
- National Park

BLACKWATER MINE - TRANSITIONAL PRCP HYDROGEOLOGY ASSESSMENT

BLACKWATER MINE LOCATION

SLR

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FIGURE 1-1

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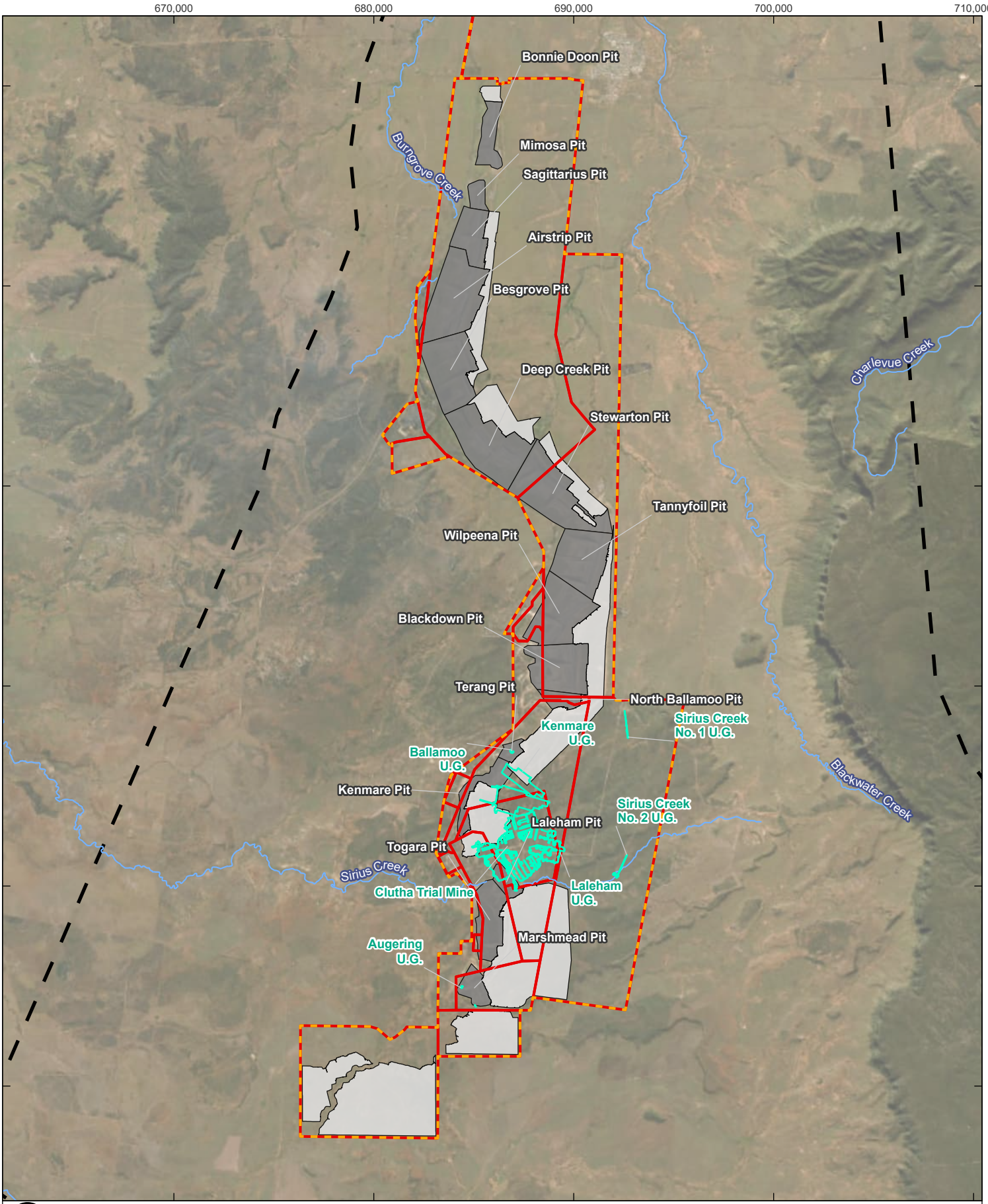
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Mimosa Pit
Sagittarius Pit
Airstrip Pit
Besgrove Pit
Deep Creek Pit
Stewarton Pit
Tannyfoil Pit
Wilpeena Pit
Blackdown Pit
Terang Pit
North Ballamoo Pit
Kenmare U.G.
Sirius Creek No. 1 U.G.
Ballamoo U.G.
Kenmare Pit
Sirius Creek No. 2 U.G.
Laleham Pit
Togara Pit
Laleham U.G.
Clutha Trial Mine
Marshmead Pit
Augering U.G.
Burngrove Creek
Charlevue Creek
Blackwater Creek
Sirius Creek
0
2.5
5
km
LEGEND
Watercourse
Historical Underground Mine
Project Area (Environmental Authorities boundary)
BWM Mining Lease
Future Pit Extent
Historical Pit Extent
Study Area
Coordinate System: GDA2020 MGA Zone 55
Scale: 1:250,000 at A4
Project Number: 620.040199
Date Drawn: 31-Jul-2024
Drawn by: AS
BLACKWATER MINE - TRANSITIONAL PRCP HYDROGEOLOGY ASSESSMENT
BWM MINING AREAS
SLR
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FIGURE 1-2
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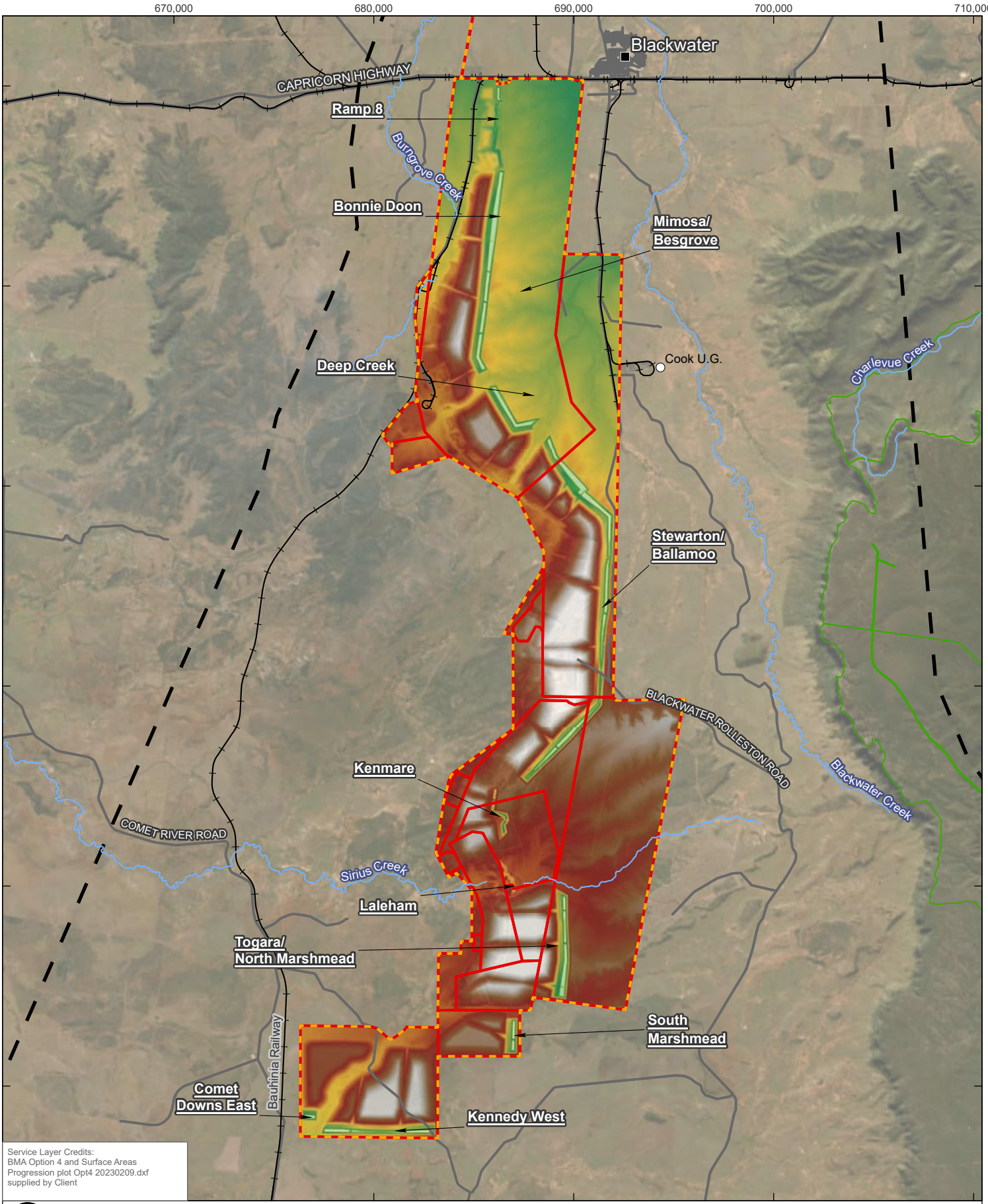

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Project Number:	620.040199
Date Drawn:	09-Aug-2024
Drawn by:	RB

LEGEND

- City/Town
- Coal Mine
- Railway
- Road
- Watercourse
- Study Area
- BWM Mining Lease
- Project Area (Environmental Authorities boundary)
- National Park

Final Landform Elevation (mAHD)

461

-10

BLACKWATER MINE - TRANSITIONAL PRCP HYDROGEOLOGY ASSESSMENT

POST MINING LANDFORM

SLR

DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.

FIGURE 1-3

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040199.00001 BWM PRCP – GW\03 SLR Data\01 CADGIS\GIS\ArcPro\BWM PRCP – GW\BWM PRCP – GW.aprx\620040199_F01_3_Post Mining Landform

1.3 Objectives

The main objective of the hydrogeological assessment is to assess the potential groundwater related impacts at BWM at completion of mining and until conditions stabilise post rehabilitation (i.e. groundwater equilibrium). A focus of the hydrogeological assessment is demonstrating suitability of the final landform for the intended post mining land uses (PLMUs) with respect of the BWM groundwater system. As such, the key specific objectives adopted in this assessment from which to demonstrate this suitability are:

- That the final landform is non-polluting with respect to groundwater:
    - The final landform overall is demonstrated to be a sink for groundwater, including groundwater contained within spoil.
    - Final void lake levels remain below shallow groundwater bearing units, i.e. there is sufficient freeboard to negate risk of void water discharge to any shallow groundwater system.
- That there are minimal additional impacts to groundwater receptors post-closure caused by the final landform that have not already occurred as a result of approved mining:
    - Little to no additional groundwater drawdown at potential Groundwater Dependant Ecosystem (GDE) locations.
    - Little to no additional groundwater drawdown at anthropogenic bore users.

Potential impacts associated with mine-related sources of potential groundwater contamination at BWM are being assessed for the PRC Plan by separate specific assessments, e.g. Terrenus Earth Science (2024). Therefore, this hydrogeology assessment focuses on the larger scale potential impacts to the site groundwater system.

1.4 Guideline Criteria

As discussed in **Section 1.1**, this hydrogeology assessment is undertaken consistent with the Guideline: Progressive Rehabilitation and Closure Plans (ESR/2019/4964). A cross reference between the relevant Guideline requirements with respect of groundwater and specific components of this assessment is provided in **Table 1-1**.

Table 1-1 Guideline Requirements

Guideline Requirement	Section of this Report
Section 3.6.1 General rehabilitation practices – Hydrogeology	
Determining the groundwater occurrence including the existence of, and depth to, aquifers and aquitards	**Section 4.0** **Section 4.3**
Locating groundwater recharge and discharge locations locally and regionally	**Section 4.3**
Groundwater quality within each of the aquifers and from surface expressions (i.e. seeps and springs)	**Section 5.0**
Current and potential future uses of groundwater including existing groundwater extraction bores	**Section 5.1.3** **Section 5.2**
Groundwater flow direction and velocity, including field tests to determine hydraulic conductivity	**Section 4.2**
The development of potentiometric mapping and hydro stratigraphic cross sections	**Section 4.3** **Section 6.0**
Groundwater modelling to determine contaminant transport and potential changes to groundwater level from dewatering or waste storage.	**Section 8.0**
Section 3.6.4 Underground mining – Hydrogeology	
An assessment of groundwater interactions and potential lowering of groundwater levels	**Section 8.2.5**
The development of a hydrogeological conceptual model	**Section 6.0** **Section 9.0**
A numerical model to enable analytical assessment of the hydrological evolution within the underground workings post closure	**Section 8.0**

2.0 Physical Setting

2.1 Climate

The climate of the Study Area is sub-humid/sub-tropical, with a distinct wet and dry season. Historical climate data was obtained for the period from January 1970 to October 2023 from the Scientific Information for Landowners (SILO) database (Queensland Government, 2023). Data from the BWM weather station is limited to a short record of rainfall data. Therefore, the SILO climate record for grid point data -23.70, 148.85, which lies within the boundaries of the Project Area, is used to understand long-term climate trends. Rainfall data from the BWM site weather station is only available for October 2017 to September 2018. A comparison between monthly rainfall, as recorded at the BWM site weather station, and monthly rainfall from the SILO climate record is presented on **Figure 2-1**. The two data sets generally correlate well over the overlapping period, which justifies using the SILO climate record data to understand long-term climate trends and the climate input for the Project groundwater modelling (**Section 8.0**).

Long-term average monthly rainfall, Moreton's areal actual evapotranspiration and Class A Pan evaporation from SILO is presented in **Table 2-1**. The Study Area is characterised by a long-term average rainfall of approximately 547 mm per year, with wetter conditions during the summer months of December, January and February and relatively dry conditions during the remainder of the year. As shown in **Figure 2-2** average monthly evaporation and evapotranspiration exceed rainfall in all months. Within the Study Area, the highest rate of evapotranspiration occurs along creek lines, where the water table is closer to ground surface and deeper-rooted vegetation is present.

To place rainfall over the years into an historical context, cumulative rainfall departure (CRD) was calculated for the period of January 1970 to October 2023 (**Figure 2-3**). This is a summation of the monthly departures of rainfall from the long-term average monthly rainfall. A rising slope in the CRD plot indicates periods of rainfall above the long-term average, as is the case from March 2022 to March 2023, whereas a falling slope indicates periods when rainfall is below the long-term average (e.g. February 2018 to September 2021). Rainfall volumes over the more recent period of the record (i.e. March 2023 to October 2023) have been lower than average, as is indicated by the falling slope in the CRD (**Figure 2-3**).

In addition, the CRD is used to assess the recharge of groundwater via rainfall. Where observed groundwater level trends mimic the pattern of the CRD curve, it is considered that natural fluctuations in the groundwater table can result from temporal changes in rainfall recharge to groundwater systems. Typically, changes in groundwater elevation can reflect the deviation between the long-term monthly (or yearly) average rainfall, and the actual rainfall, as illustrated by the CRD. The CRD and observed groundwater levels are discussed as a means to characterise climatic conditions within the assessment of groundwater levels (see **Section 4.3**).

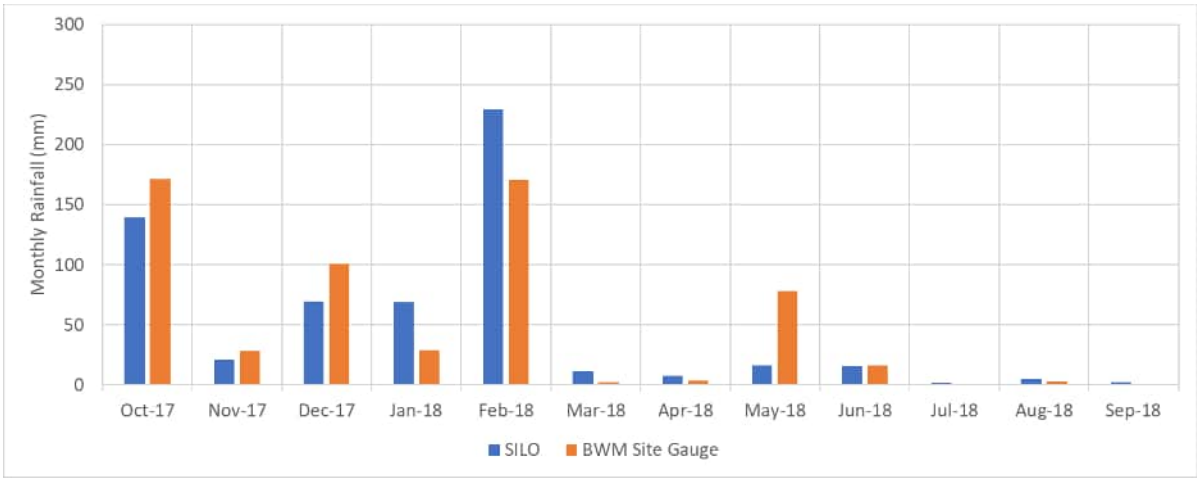


Figure 2-1 Monthly Rainfall at the BWM Site Station and SILO Data Location (2017-2018)

Table 2-1 Total Monthly Rainfall, Evaporation and Evapotranspiration (January 1970 to October 2023)

Average Total Monthly	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Rainfall (mm)	88	75	48	29	32	23	22	16	24	46	59	83	**547**
Evaporation (class A Pan) (mm)	230	186	189	149	115	91	99	131	172	214	222	241	**2,037**
Evapotranspiration (Moreton's areal actual) (mm)	134	113	106	68	43	31	35	52	71	98	115	134	**999**

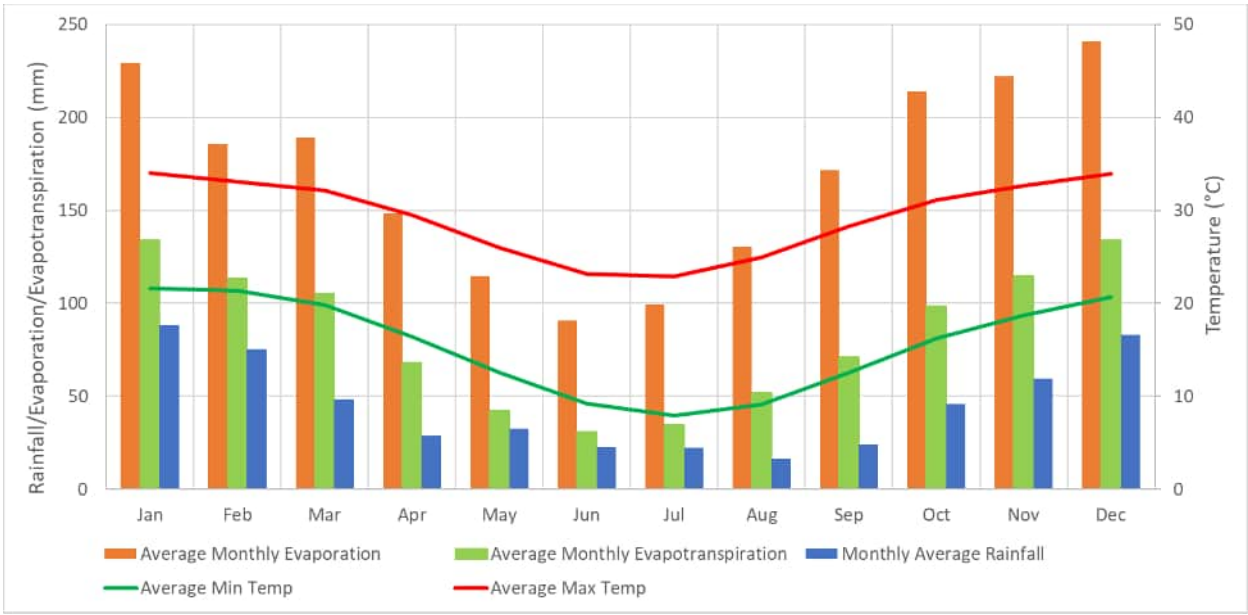


Figure 2-2 Average Monthly Evaporation, Evapotranspiration, Rainfall and Temperature (January 1970 to October 2023)

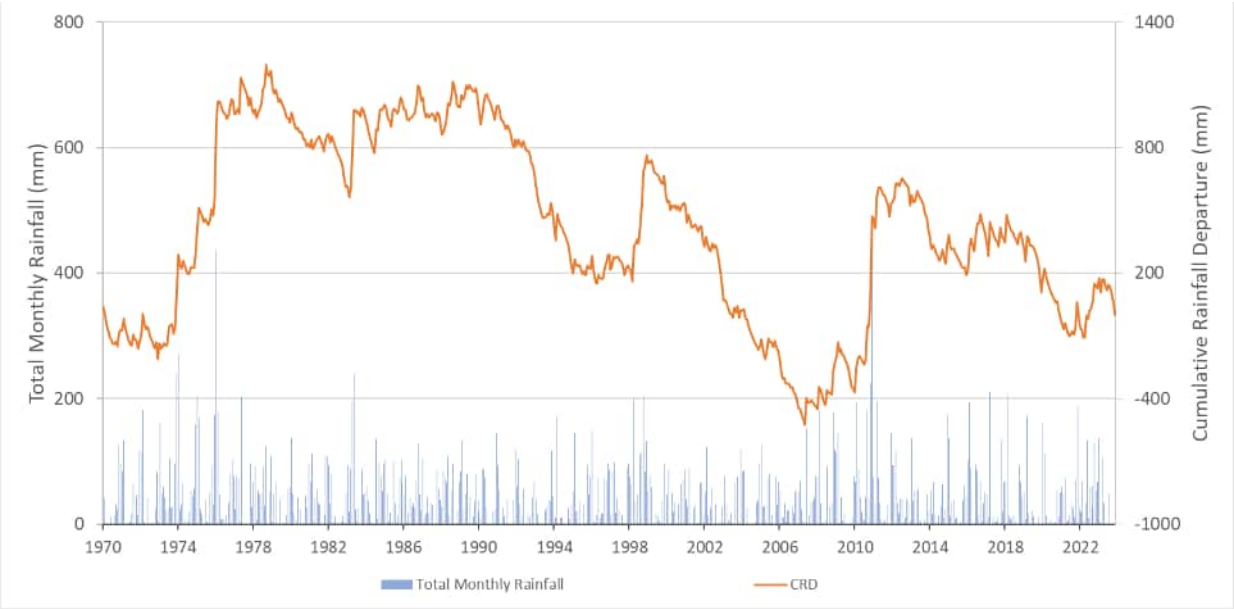


Figure 2-3 Cumulative Rainfall Departure and Total Monthly Rainfall

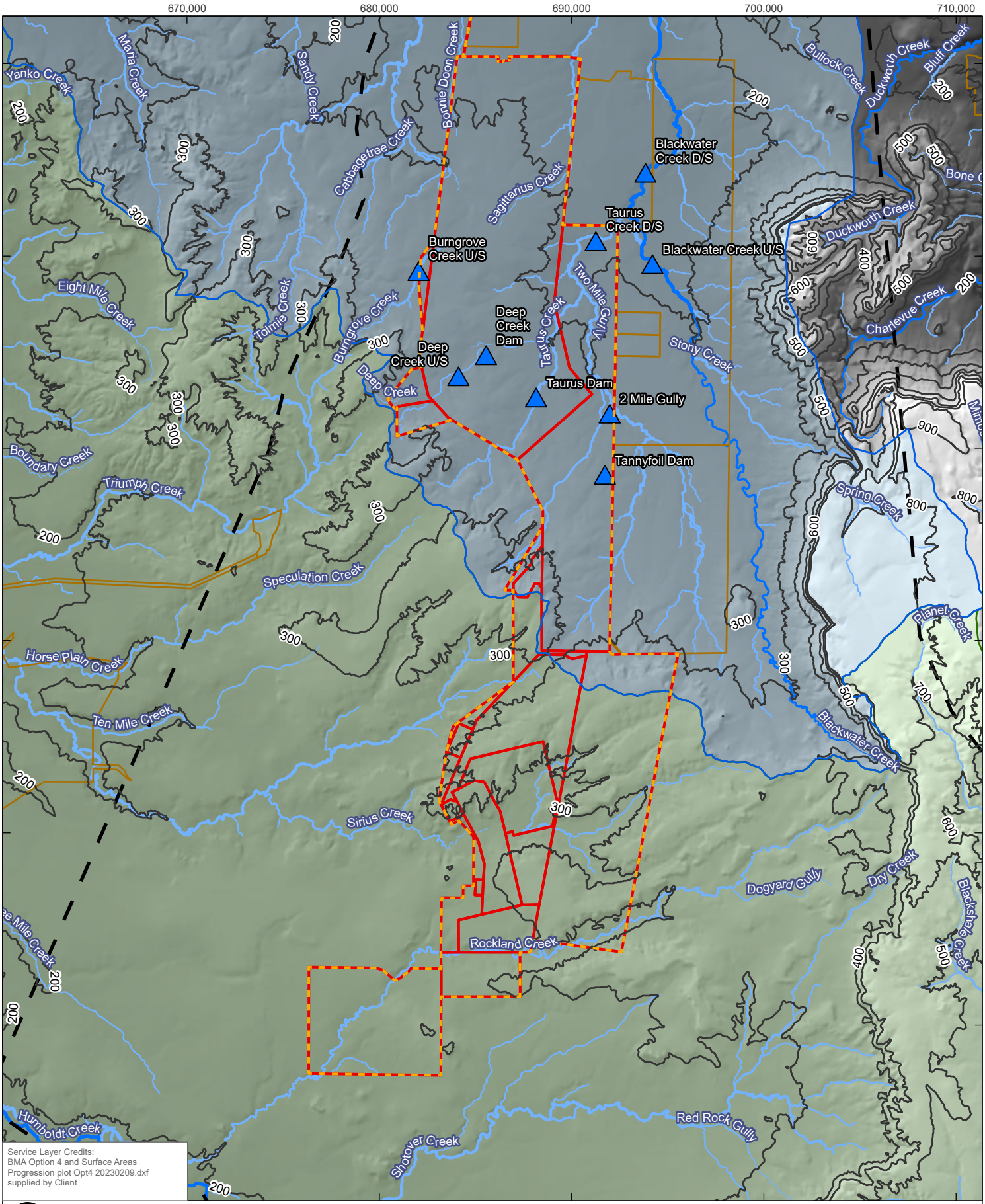
2.2 Topography and Drainage

The topography of the Study Area ranges from elevations of less than 200 mAHD to more than 800 mAHD. In the south of BWM, there are hills with elevations around 350 mAHD, which form the catchment divide between the Mackenzie and the Comet sub-catchments (**Figure 2-4**). Approximately 10 to 15 km to the east of BWM, toward the eastern boundary of the Study Area, there is an escarpment formed by outcrop of the Clematis Group sandstone, which reaches an elevation up to 750 mAHD.

As outlined above, the Project Area is located across two surface sub-catchments of the Fitzroy Basin Water Plan area:

- The Upper Mackenzie sub-catchment, which is located within the northern portion of BWM (**Figure 2-4**).
- The Comet sub-catchment, which is located within the southern portion of BWM (**Figure 2-4**).

The surface drainage of the Study Area comprises several ephemeral creeks that are tributaries of the Mackenzie and Comet Rivers. Creeks that flow in the Upper Mackenzie sub-catchment north of the catchment divide drain from south to north towards the Mackenzie River, whilst creeks that flow in the Comet sub-catchment south of the catchment divide drain from north to south towards the Comet River. The main surface drainage feature in the Project Area in the Upper Mackenzie sub-catchment is Blackwater Creek flowing south to north across the Project Area, whilst the main surface drainage feature in the Project Area in the Comet sub-catchment is Sirius Creek flowing east to west across the Project Area.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Yanko Creek
Maria Creek
Sandy Creek
Bonnie Doon Creek
Cabbagetree Creek
Sagittarius Creek
Blackwater Creek D/S
Taurus Creek D/S
Blackwater Creek U/S
Burngrove Creek U/S
Deep Creek Dam
Deep Creek U/S
Taurus Dam
2 Mile Gully
Tannyfoil Dam
Two Mile Gully
Taurus Creek
Stony Creek
Bullock Creek
Duckworth Creek
Bluff Creek
Chanlevue Creek
Eight Mile Creek
Tolmie Creek
Burngrove Creek
Deep Creek
Boundary Creek
Triumph Creek
Speculation Creek
Horse Plain Creek
Ten Mile Creek
Sirius Creek
Rockland Creek
Dogyard Gully
Dry Creek
Blackwater Creek
Spring Creek
Planet Creek
Blackshaw Creek
Red Rock Gully
Shotover Creek
Humboldt Creek
Service Layer Credits:
BMA Option 4 and Surface Areas Progression plot Opt4 20230209.dxf supplied by Client
0
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km
Coordinate System: GDA2020 MGA Zone 55
Scale: 1:260,000 at A4
Project Number: 620.040199
Date Drawn: 22-Feb-2024
Drawn by: RB
LEGEND
Surface Water Monitoring Site
Major Watercourse
Minor Watercourse
Topographic Contour (mAHD)
Study Area
BWM Mining Lease
Project Area (Environmental Authorities boundary)
Mining Lease
Fitzroy Basin (2011) Water Plan Sub-catchment
Comet
Upper Mackenzie
Fitzroy Basin (2011) Water Plan Sub-catchment
Comet
Upper Mackenzie
BLACKWATER MINE - TRANSITIONAL PRCP HYDROGEOLOGY ASSESSMENT
TOPOGRAPHY AND DRAINAGE
SLR
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FIGURE 2-4
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In the Study Area, creeks are ephemeral and have intermittent flow, typically only containing water after high intensity rainfall events (AGE, 2003). **Figure 2-5** shows the average daily water level in Blackwater Creek (Blackwater Creek D/S monitoring point as shown on **Figure 2-4**) compared to the daily rainfall (SILO climate record, refer to **Section 2.1**). After large rainfall events, generally considered to exceed approximately 30 mm/day, flow is recorded in the creek. Creek flows subsequently recede during drier periods.

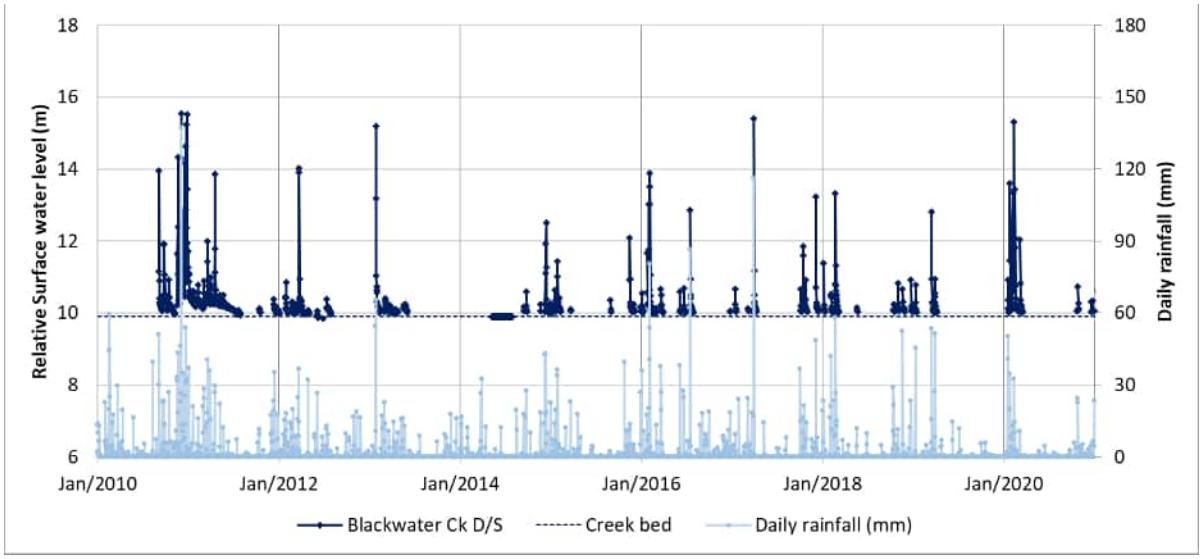


Figure 2-5 Average Daily Water Levels in Blackwater Creek D/S

2.3 BWM Mining

This section outlines the historical mine progression and future mining plan at BWM, as relevant to assessing the effect of BWM on the groundwater system post-closure. This is considered important since post-closure groundwater conditions will in part be dictated by the conditions that are present as a result of existing mining activities at the time of closure.

2.3.1 Historical Mining Activities

BWM began operations in 1967. **Table 2-2** lists the operating areas of BWM with the estimate of commencement date and target seams. **Figure 2-6** provides a locality plan and timing for historic BWM mining. Note that prior to the early 2000's, BWM operated as two separate mining operations, commonly denoted "Blackwater" and "South Blackwater", which were merged in late 2000 with BMA's acquisition of the South Blackwater operation.

In all pits, spoil is deposited to the west of mine void adjacent to the pit ramps. The primary mine operations area including stockpile, workshops, coal processing facility and three tailings storage areas (CHPP Tailings Storage in the north of BWM, and R72 Tailings Storage Dam and R74 Tailings Storage Dam in the central part of BWM; see **Section 2.3.3**).

In addition to open pit mining operations, there are multiple historical underground mines located within the Project Area as shown on **Figure 1-2** and detailed in **Table 2-2**.

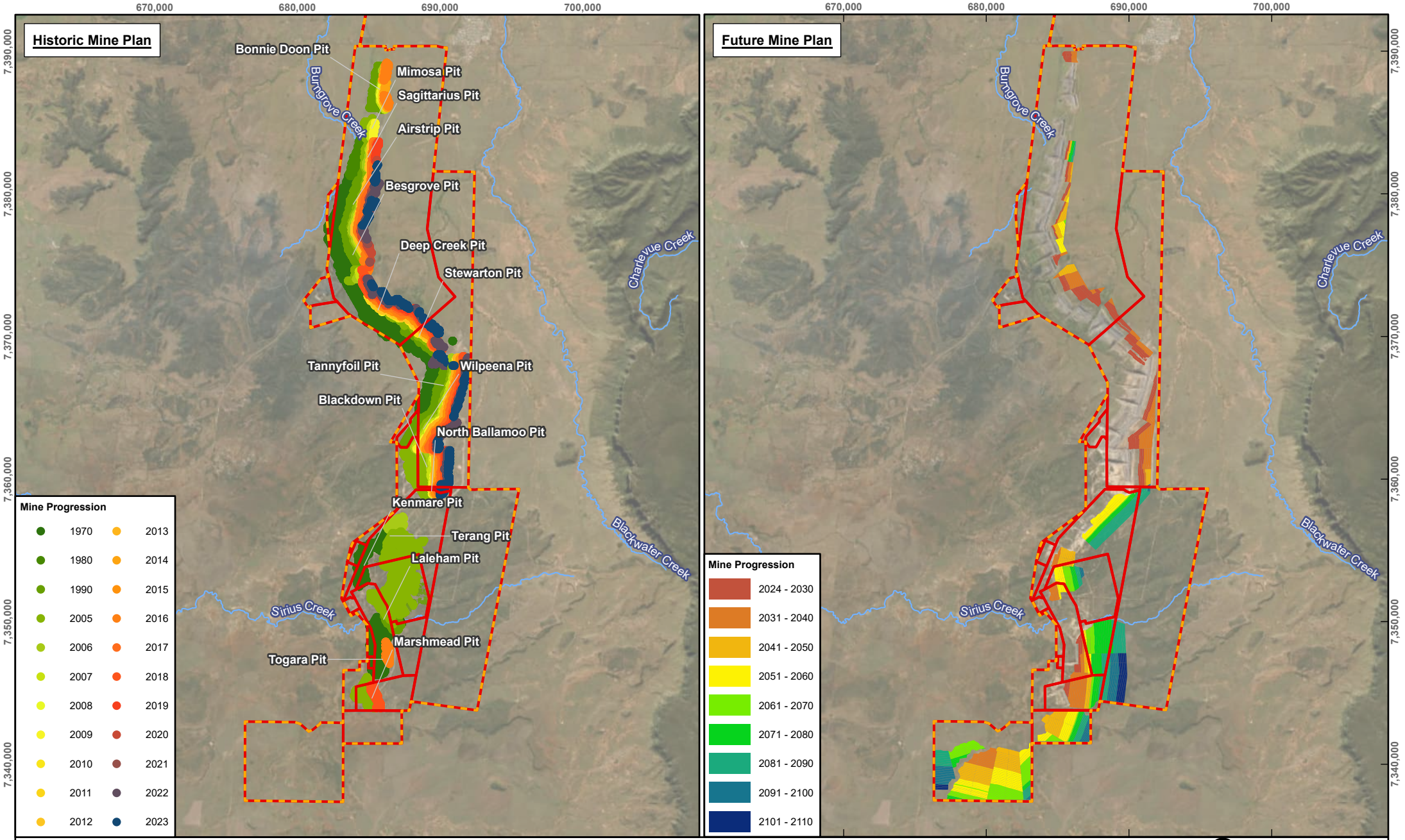
Table 2-2 BWM Historic Mining Areas and Basal Target Seams

Mine Area Name	Mining Commenced	Mining Completed	Deepest Target Seam
Open Pit Mining			
Bonnie Doon Pit/R08N	1998 – 2002	2016	P1U
Mimosa Pit	2002 - 2003		P1L (part of final void Mimosa/Besgrove)
Sagittarius Pit	1973 - 1978	2088	P1L (part of final void Mimosa/Besgrove)
Airstrip Pit	1973 - 1978	2061	P1L (part of final void Mimosa/Besgrove)
Besgrove Pit	1973 - 1978	2065	P1L (part of final void Mimosa/Besgrove)
Deep Creek Pit	1973	2049	P1L
Stewarton Pit	1973	2039	P1L (part of final void Stewarton/Ballamoo)
Tannyfoil Pit	1973 - 1978	2039	P1L (part of final void Stewarton/Ballamoo)
Wilpeena Pit	1973 - 1978	2040	P1L (part of final void Stewarton/Ballamoo)
Blackdown Pit	1984 - 1993	2048	P1L (part of final void Stewarton/Ballamoo)
North Ballamoo Pit	1984 - 1993	2094	P1L (part of final void Stewarton/Ballamoo)
Terang Pit	1973 - 1978	2090	L1
Kenmare Pit	prior to 1978	2094	L1
Laleham Pit	prior to 1973	2090	TR75
Togara Pit	1973 - 1984	2109	L10
Marshmead Pit	1984 - 1993	2109	L10
Underground Mining			
Kenmare Underground Mine	1994 - 1997^	Kenmare 1 2001^ Kenmare 2 incorporated to surface excavation^	Pollux^
Augering Underground Mine			
Ballamoo Underground Mine			
Clutha Trial Mine			Aries^
Laleham Underground Mine	1969^	2001*	Pollux^
Sirius Creek No. 1. Underground Mine		1970s*	Aries^
Sirius Creek No. 2. Underground Mine		1970s*	Aries^

^ Byrnes Geotechnical (2024)
* EMM (2021)

2.3.2 Current and Future Mining

Mining at BWM is expected to continue on the current approved operations until July 2113. The current mine plan, with polygons indicating timing for mine strip extraction is provided on **Figure 2-6**. This involves continued mining targeting economic areas of Rangal Coal Measures seams dipping down generally eastwards in the north and central parts of BWM and east/southeast in the southern part of BWM, with basal depth of mine void increasing in conjunction with the dipping geology.



Scale: 1:340,000 at A4
Coordinate System: GDA2020 MGA Zone 55

Date Drawn: 31-Jul-2024
Project Number: 620.040199

Watercourse

Project Area (Environmental Authorities boundary)

BWM Mining Lease

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BLACKWATER MINE - TRANSITIONAL PRCP HYDROGEOLOGY ASSESSMENT

HISTORICAL AND FUTURE MINE PROGRESSION

FIGURE 2-6

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040199.00001 BWM PRCP – GW\03 SLR Data\01 CADGIS\GIS\ArcPro\BWM PRCP – GW\BWM PRCP – GW.aprx\620040199_F02_6_Historical and Future Mine Progression without SA7

2.3.3 Surface Water Management

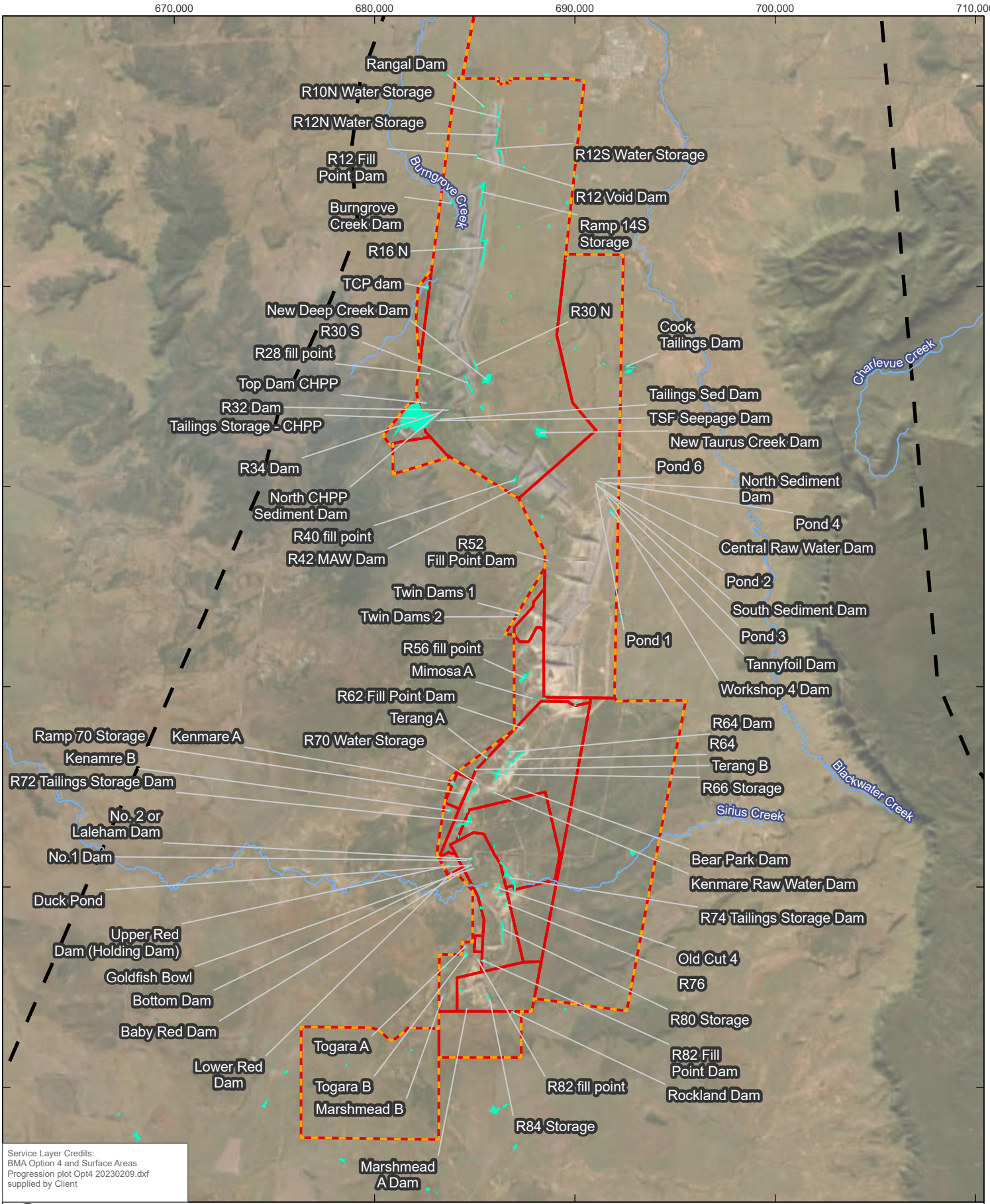
Surface water management practices are relevant to this hydrogeological assessment through potential for interaction in seepage to or from mining water handling areas. The water storage areas at BWM are shown on **Figure 2-7** and information for key surface water management locations considered to have potential to interact with local groundwater is provided in **Table 2-3**.

Table 2-3 BWM Key Surface Water Management Locations

Water Storage Name	Type	Area (ha)	Last Recorded Storage RL (mAHD)
Tailings Storage – CHPP	Tailings	147.1	
R16 N	Pit Water	29.3	114.2 (03-08-2022)
R74 Tailings Storage Dam	Tailings	23.9	246.4 (03-01-2024)
Ramp 14S Storage	Pit Water	17.4	178.9 (03-01-2024)
R64	Pit Water	14	280.2 (03-01-2024)
R72 Tailings Storage Dam	Tailings	12.1	287.4 (03-01-2024)
R66 Storage	Pit Water	10.3	279.9 (03-01-2024)
R30 S	Pit Water	9.3	137.8 (03-01-2024)
R70 Water Storage	Pit Water	9.1	276.6 (03-01-2024)
R80 Storage	Pit Water	8.9	233.0 (03-01-2024)
R12N Water Storage	Pit Water	7.2	131.9 (03-01-2024)
R12S Water Storage	Pit Water	6.5	136.1 (03-01-2024)
R30 N	Pit Water	4.9	
R84 Storage	Pit Water	4.7	212.8 (03-01-2024)
R10N Water Storage	Water	4	143.4 (03-01-2024)
R82 Fill Point Dam	Dam	2.6	
R76	Pit Water	2.5	240.3 (03-01-2024)

2.3.4 Mine Pit Groundwater Inflow

During active mining operations, groundwater inflows to active pit voids are generally small in volume and do not need to be actively managed via advance dewatering or other groundwater management methods, with evaporation from the pit walls and floors accounting for most of the groundwater volume. Small volumes of groundwater inflow requiring management within active mine pits, when they occur, are generally managed via the use of in-pit sumps to capture water that is then used or circulated via the Mine water management system for use in coal washing and for dust suppression purposes. Numerical groundwater modelling completed by SLR (2023b) indicated that groundwater inflows to the current BWM operation (year 2024) approximate 1,600 ML/year (~4.38 ML/day), and average approximately 1,000 ML/year (~2.74 ML/day) over the last 10 years.



Coordinate System:	GDA2020 MGA Zone 55
Scale:	1:250,000 at A4
Project Number:	620.040199
Date Drawn:	17-Jan-2024
Drawn by:	AS

BLACKWATER MINE - TRANSITIONAL PRCP HYDROGEOLOGY ASSESSMENT

CURRENT BWM WATER STORAGE AREAS

SLR

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FIGURE 2-7

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040199.00001 BWM PRCP – GW\03 SLR Data\01 CADGIS\GIS\ArcPro\BWM PRCP – GW\BWM PRCP – GW.aprx\620040199_F02_07_Current Blackwater Water Storage Areas

3.0 Geology

3.1 Regional Geology

BWM is located in the Bowen Basin, which is one of five major foreland sedimentary basins formed along the eastern side of Australia during the Permian geologic period. The Bowen Basin is the largest productive coal basin in Australia. The north-south oriented Bowen Basin stretches from Townsville in the north, to the Queensland-New South Wales border in the south.

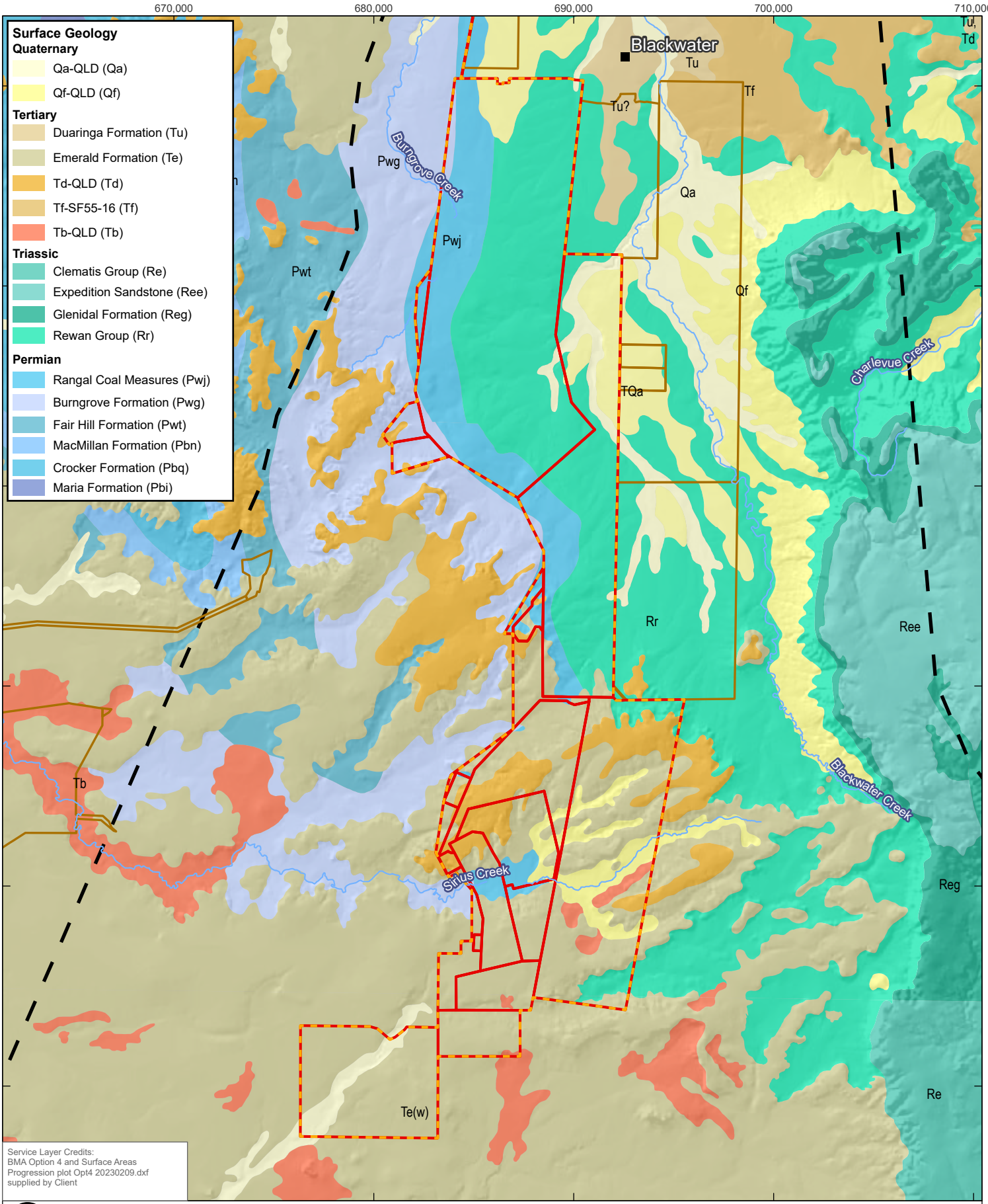
The stratigraphic sequence of the Study Area is presented in **Table 3-1**. From youngest to oldest, the stratigraphic sequence across the Study Area primarily comprises unconsolidated Quaternary aged sediments that unconformably overlie consolidated Triassic and Permian aged sequences (**Figure 3-1** and **Figure 3-2**).

Overlying the consolidated basal units, Tertiary sediments and basalt, and Quaternary alluvium, are present as cover. At the eastern extents of the Study Area, the Triassic aged Clematis Group outcrops with a dramatic change in topography associated with the comparatively weathering resistant sandstones of that geologic unit (refer to **Section 2.2**).

Each of the main stratigraphic units relevant to BWM are discussed in **Section 3.2.1** to **Section 3.2.6**, and the structural geology is discussed in **Section 3.1.1**.

Table 3-1 Summary of Stratigraphy in the Study Area

Age	Unit	Thickness (m)	Description
Quaternary	Alluvium	0.5 - 12	Alluvium - silt, clay, sand and gravel.
Tertiary	Basalt	30	Weathered basalt soils, residual basalt. Moderately weathered and fresh basalt.
	Sediments/ sedimentary units	30	Clays, sandstones, sands, gravels, often poorly consolidated (Tu, Te(w), Tf and TQa). Regional mapping shows highly weathered Tertiary sediments display some areas of duricrust (Td) and partially cemented fanglomerate (Tf)
Triassic	Clematis Group	100-800	Weathering resistant medium to coarse grained quartzose to sublabile and micaceous sandstone, siltstone, mudstone and conglomerate.
	Rewan Group	50-300	Lithic sandstone, pebbly lithic sandstone, green to reddish brown mudstone and minor volcanilithic pebble conglomerate (at base); deposited in a fluvial-lacustrine environment. Occurs 2-m to 6m above the Aries seam.
Permian	Rangal Coal Measures	100	Feldspathic and lithic sandstone, carbonaceous mudstone, siltstone, tuff and coal seams. Coal seams include the Aries, Castor, Pollux and Orion and Pisces seams. The Pollux and Orion seams commonly coalesce into a single seam, which is referred as the Argo seam.
	Burngrove Formation	170	Sandstones, siltstones and mudstones, and banded coal seams frequently interbedded with tuff and tuffaceous mudstones. Coal seams include the Virgo and Leo seams.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710,000
7,390,000
7,380,000
7,370,000
7,360,000
7,350,000
7,340,000
Surface Geology
Quaternary
Qa-QLD (Qa)
Qf-QLD (Qf)
Tertiary
Duaringa Formation (Tu)
Emerald Formation (Te)
Td-QLD (Td)
Tf-SF55-16 (Tf)
Tb-QLD (Tb)
Triassic
Clematis Group (Re)
Expedition Sandstone (Ree)
Glenidal Formation (Reg)
Rewan Group (Rr)
Permian
Rangal Coal Measures (Pwj)
Burngrove Formation (Pwg)
Fair Hill Formation (Pwt)
MacMillan Formation (Pbn)
Crocker Formation (Pbq)
Maria Formation (Pbi)
Blackwater
Tu
Tu?
Tf
Tu,
Td
Burngrove Creek
Pwg
Pwj
Pwt
Qa
Qf
TQa
Charlevue Creek
Rr
Ree
Tb
Blackwater Creek
Sirius Creek
Reg
Te(w)
Re
Service Layer Credits:
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Progression plot Opt4 20230209.dxf
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LEGEND
City/Town
Watercourse
Study Area
BWM Mining Lease
Project Area
(Environmental
Authorities boundary)
Coordinate System: GDA2020 MGA Zone 55
Scale: 1:250,000 at A4
Project Number: 620.040199
Date Drawn: 17-Jan-2024
Drawn by: RB
BLACKWATER MINE - TRANSITIONAL PRCP HYDROGEOLOGY ASSESSMENT
SURFACE GEOLOGY
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FIGURE 3-1
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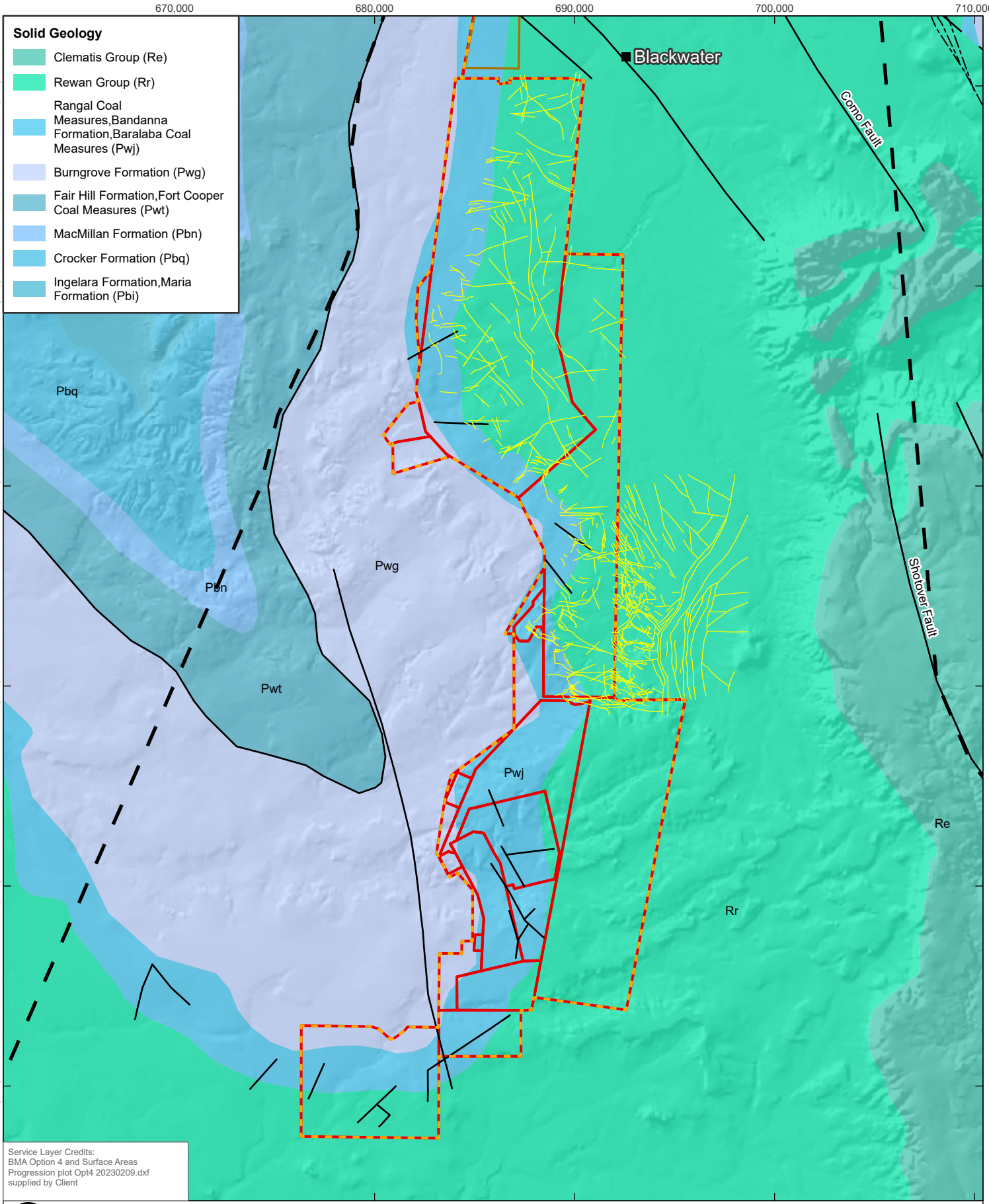

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BMA Option 4 and Surface Areas Progression plot Opt4 20230209.dxf supplied by Client

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Coordinate System:	GDA2020 MGA Zone 55
Scale:	1:250,000 at A4
Project Number:	620.040199
Date Drawn:	17-Jan-2024
Drawn by:	RB

LEGEND

- City/Town
- Basin Scale Fault (1995)
- Basin Scale Fault
- Local Fault
- Study Area
- BWM Mining Lease
- Project Area (Environmental Authorities boundary)

BLACKWATER MINE - TRANSITIONAL PRCP HYDROGEOLOGY ASSESSMENT

SOLID GEOLOGY

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FIGURE 3-2

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040199.00001 BWM PRCP – GW\03 SLR Data\01 CADGIS\GIS\ArcPro\BWM PRCP – GW\BWM PRCP – GW.aprx\620040199_F03_2_Solid Geology

3.1.1 Structural Geology

The structural geology in the region is characterised by gently folded consolidated sediments and a major north to north-west striking fault system which forms the Jellinbah Thrust fault system (AGE, 2013). A series of easterly dipping thrust faults occur parallel to the Jellinbah Thrust, including the Shotover Fault (occurring to the east of the Study Area where the Clematis Group outcrops) and the Como Fault that runs through the Curragh Mine (**Figure 3-2**) (Mallet et al., 1985). Regionally the structure is defined as a faulted monoclinal limb (AGE, 2013).

The strata in the vicinity of the Project Area is heavily influenced by a series of easterly dipping, north to northwest striking faults (AGE, 2008). The Shotover Fault at the southeastern boundary of the Study Area is of major importance as there is a displacement of up to 3,000 m (AGE, 2013). Locally, thrust faulting that occurs within the BWM may be attributed to thrusts occurring in the footwall of the Shotover Fault. Local structure is influenced by strike slip movement of basement rocks. Local fault displacement is reported to be less than five meters on average but can reach up to 20 m (AGE, 2008). **Figure 3-2** also shows the numerous local faults mapped within the Study Area.

3.2 Local Geology

The geology of the Project Area is discussed in **Sections 3.2.1** to **3.2.6** below.

3.2.1 Quaternary Sediments

The Quaternary alluvial sediments unconformably overlie the Triassic Rewan Group and Permian coal measures. The unit consists of a thin surficial cover of generally unconsolidated clays, silts, sands and gravels associated with floodplains of the major drainage channels, primarily Blackwater Creek. Drilling data from within the Study Area shows that the alluvial sequence varies from 0.5 to 12 m thick.

Recent drilling at BWM has shown that alluvium associated with the creeks, is not always present and extents are limited. In 2020, four bores were attempted to be installed into the alluvium near north BWM (Taurus Creek, Sagittarius Creek and Two Mile Gully), however only one drillhole at Taurus Creek found sufficient alluvial sediments (which was completed as a dry bore (AGE, 2020). In 2021 another bore targeted the alluvium at Sagittarius Creek, however upon drilling, the alluvial sediments were again found to be not sufficient at the site, so the bore was installed into the underlying Rewan Group instead (HydroFS, 2021). Further discussion of drilling attempts in the alluvium and groundwater occurrence is provided in **Section 4.3.1.** Based on these investigations, it is considered that the extent of the alluvium within the Study Area is likely smaller than mapped on the regional surface geology map (**Figure 3-1**).

3.2.2 Tertiary Sediments and Basalt

Tertiary sediments and basalt units unconformably overlie the Triassic and Permian units. The Tertiary sediments unit consists primarily of claystone, siltstone and sandstones. The unit varies in thickness ranging from 5 to 50 m with a maximum thickness of 115 m.

Based on drilling results, the Tertiary sediments in the southern Project Area are thicker on average than in the northern Project Area. In this area they primarily consist of claystone, siltstones, sandstones and interbedded basalt of the Emerald Formation.

Toward the south and southwest of the Project Area, basalt flows are present (**Figure 3-1**). The basalts have been described as having varying degrees of weathering and thickness, from moderately weathered thin flows (intersected in ML 70167 in the Humboldt area) to thicker and more fresh flows (intersected slightly further north in ML 70139 in the South

Marshmead area). The basalt flows vary in thickness ranging from to 10 to 42 m (AGE, 2003).

3.2.3 Triassic Clematis Group

The Clematis Group unconformably overlies the Rewan Group and outcrops on the eastern margins of the Study Area, where it forms an elevated plateau and escarpment (**Figure 3-2**).

The unit is comprised of weathering resistant medium to coarse grained quartzose to sublabile and micaceous sandstone, siltstone, mudstone and conglomerate. In the Study Area, the Clematis Group is made up of the Glenidal Formation and Expedition Sandstone members which are estimated to form an average thickness in the range of 100 to 800 m (Geoscience Australia, 2021).

3.2.4 Triassic Rewan Group

The Rewan Group overlies the Permian coal measures and occurs as in-fill material, thickening to the east with the dip of the coal measures, and thins to the west where the coal measures occur at outcrop (**Figure 3-1**).

Where present, the Rewan Group has a distinct greenish tint (non-marine deposits containing glauconite) and is composed of siltstone and mudstone, with interbeds of lithic and volcanic sandstones.

Based on exploration drill holes and groundwater bore holes in the Study Area, the Rewan Group is comprised of siltstone and mudstone, with interbeds of lithic and volcanic sandstones and is of variable thickness ranging between approximately 50 to 300 m.

3.2.5 Rangal Coal Measures

The Rangal Coal Measures (RCM) underlie the Rewan Group and outcrop to the west of the Project Area (**Figure 3-1**).

The unit consists of interbedded sandstone, siltstone, mudstone, and coal with tuff (towards the base) and has a thickness of up to 100 m in the Study Area. The three main economic coal seams include the Aries, Castor and Pollux Seams. This is the naming convention applied regionally, but for operational reasons, the coal seams follow a different naming convention at BWM. This naming convention is as follows: the Aries Seam is referred to as the Top Seam, the Castor Seam is referred to as the Middle Seam and the Pollux Seam is referred to as the Lower Seam.

The splitting and occurrence of these seams is shown in **Figure 3-3.** The principal coal seams in the BWM area (from top to bottom) are the Top Seam (also known as TFULL), Middle Seam (MFULL) and Middle split (MB), Lower Seam (LFULL) and Lower split (L01). Minor seams include the Upper Top (UT), Top Rider (TR), Middle Rider (MR) and Lower and Upper Rider (LUR) seams.

The Pollux and Orion seams create the thick Argo seam (CD) in the southern South Blackwater Mine area. To the north, the Orion and Pollux Seams coalesce into the Lower (LFULL) Seam. This seam splits into the lower split (L01) and the Middle seam (MFULL). Between the Deep Creek/Wilpeena and Blackwater pit areas the Middle Seam coalesces with the Aries and Castor Seams.

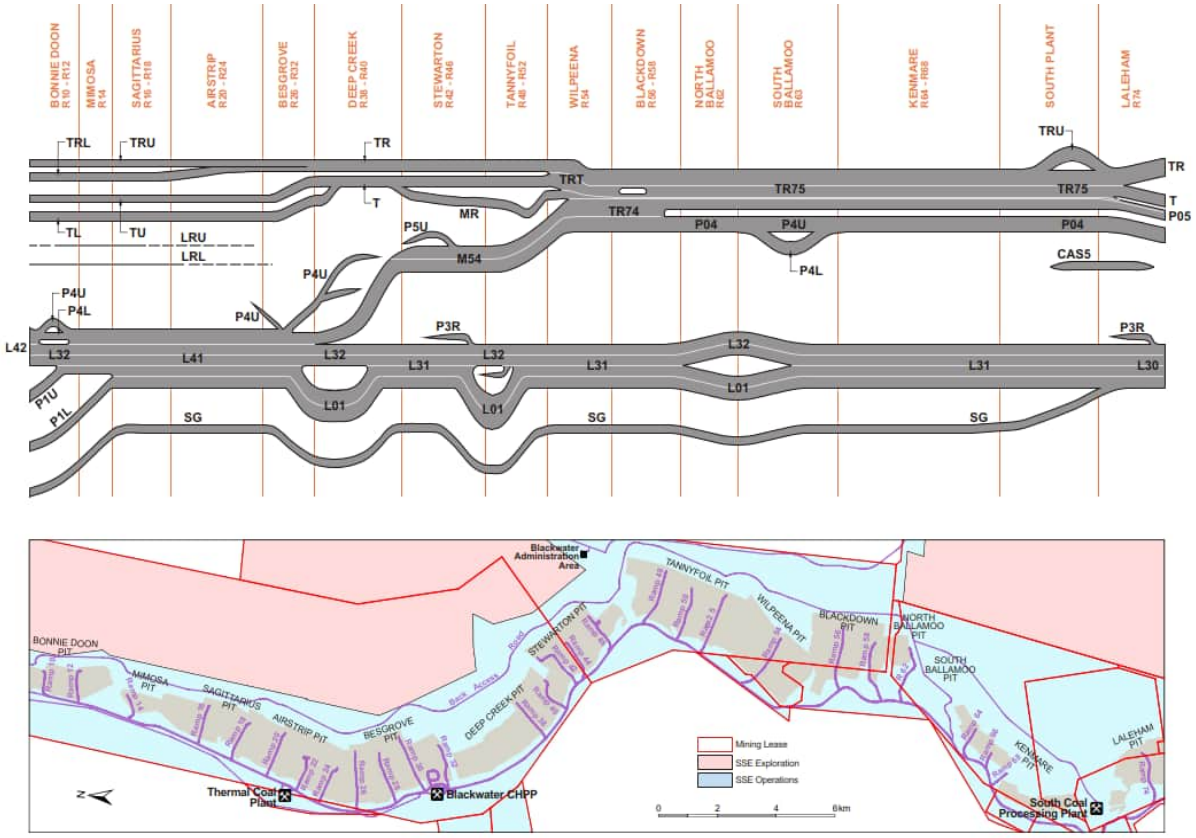


Figure 3-3 Schematic Seam Stratigraphy and Split Diagram (BMA, 2014)

3.2.6 Burngrove Formation

The Burngrove Formation is comprised of mudstone, siltstone, sandstone, coal and tuff. The RCM conformably overlie the coal bearing Burngrove Formation. The Burngrove Formation is equivalent to the Fort Cooper Coal Measures elsewhere in the Bowen Basin and is considered the basement formation for this assessment.

4.0 Hydrogeology

Based on the understanding of the geological setting presented in **Section 3.0** the hydrogeological regime relevant to BWM comprises the following key hydrogeological units:

- Alluvium – Alluvial deposits are associated with local creeks. In recent years, the alluvium local to the Project Area has been found to be limited in extent, and dry. The alluvium forms a localised unconfined aquifer when saturation is found.
- Tertiary Sediments and Basalt – Unconsolidated surface layer of weathered rock (also termed regolith) including Tertiary strata and basalt flows, which may provide a preferential flow pathway for groundwater, if the groundwater table exceeds the base of weathering. The unit forms an unconfined aquifer when saturated.
- Clematis Group – Forms an unconfined aquifer where it outcrops at the eastern margin of the Study Area.
- Rewan Group – Considered a regional scale aquitard, however local permeability testing indicates hydraulic conductivity values may be higher in the upper weathered zone of the unit.
- Rangal Coal Measures – Coal seams of this unit form the primary regional aquifer. Groundwater flow is primarily within the coal seams (via interconnected cleats and fractures), which are confined by low permeability overburden and interburden that essentially form aquitards. The coal measures are highly locally faulted resulting in "compartmentalisation" with coal seams juxtaposed against lower permeability interburden.
- Burngrove Formation – Coal seams of this unit form a regional scale aquifer in conjunction with low permeability overburden and interburden that essentially form aquitards. Considered the basement formation for the purposes of this assessment.

This section discusses each of the hydrogeological units relevant to BWM, covering hydraulic properties, groundwater distribution, flow, recharge and discharge/outflow, groundwater quality, and groundwater use.

4.1 BWM Groundwater Monitoring

Figure 4-1 and **Table 4-1** show the BWM groundwater monitoring network bores for which data is available for this assessment (excluding local shallow contaminant investigation bores that are the subject of a separate investigation for the PRC Plan as outlined in **Section 1.3**, as well as bores characterised as unsuitable to support the EA monitoring program by GHD (2023)). Suitable data for this assessment has been collected from 51 monitoring bores. The period for which groundwater quality and groundwater level data is available from these bores is also listed in the table.

The monitoring network is detailed in **Table 4-1** and can be summarised as:

- Quaternary Sediments – including seven monitoring bores (four of which are dry), installed at depths ranging from 7 to 16 mBGL, with available data between 2021 and 2023.
- Tertiary Sediments and Basalt – including four monitoring bores (one of which is dry), installed at depths from 9.5 to 117 mBGL, with available data between 2009 and 2023.
- Triassic Rewan Group – including five monitoring bores (one of which is dry), installed at depths ranging from 15 to 97 mBGL, with available data between 2020 and 2023.

- Rangal Coal Measures – including 29 monitoring bores, installed at depths ranging from 25 to 234 mBGL, with available data between 2009 and 2023.
- Burngrove Formation – including four monitoring bores, installed at depths ranging from 18 to 73 mBGL, with available data between 2011 and 2023.

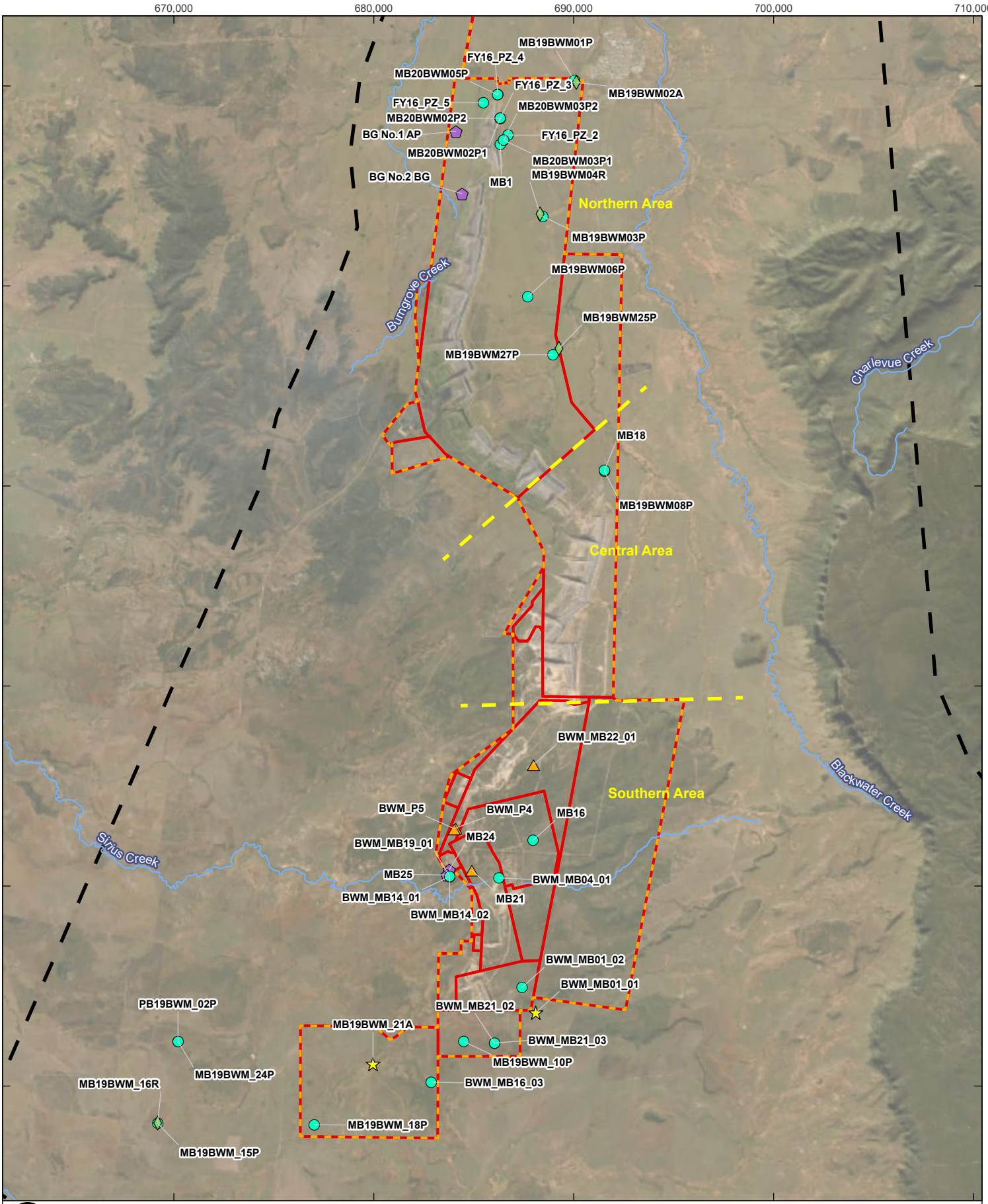
Table 4-1 BWM Groundwater Monitoring Network

Bore	Easting[1]	Northing[1]	TOC (mAHD)	Depth (mBGL)	Screened Interval (mBGL)	Monitored Unit	BWM Area	Status	Data Availability (dates)			
									min WL	max WL	min WQ	max WQ
BWM_MB03_01	692229	7381513	181.76*	12	8 - 11	Alluvium	North	Active (dry)	-	-	-	-
MB19BWM07A	689280	7376878	198*	7	4 - 7	Alluvium	North	Active (dry)	-	-	-	-
BWM_MB01_01	688102	7343658	261.35	85	-	Alluvium	South	Active	17-03-2023	29-06-2023	17-03-2023	20-07-2023
MB19BWM_21A	679959	7341095	236.24*	15	9 - 15	Alluvium	South	Active	31-01-2023	18-07-2023	-	-
MB19BWM_26A	683557	7333190	225.86*	15.5	9 - 15	Alluvium	South	Active	31-01-2023	31-01-2023	-	-
MB19BWM_19A	677021	7338034	223.55*	14	9 - 12	Alluvium	South	Active (dry)	-	-	-	-
MB19BWM_14A	672849	7334842	204.94*	15	6 - 7	Alluvium	South	Active (dry)	-	-	-	-
MB20BWM01A	685396	7388909	186.949	9.5	6.5 - 9.5	Tertiary	North	Active (dry)	-	-	-	-
BWM_MB22_01	687988	7356077	340	117	-	Tertiary	South	Active	17-03-2023	17-03-2023	17-03-2023	17-03-2023
BWM_P4	684097	7352905	283.8*	15.5	12.5 – 15.5	Tertiary	South	Active	26-01-2023	28-09-2023	26-01-2023	28-09-2023
BWM_P5	684024	7352865	278.52*	15	12 - 15	Tertiary	South	Active	26-01-2023	28-09-2023	26-01-2023	28-09-2023
MB21	684901	7350806	263.8	31	25 - 31	Tertiary	South	Active	31-08-2009	21-08-2023	26-09-2012	21-08-2023
MB19BWM02A	690128	7390183	168.5	17	12 -15	Rewan	North	Active	01-07-2020	17-08-2023	30-06-2020	28-09-2023
MB19BWM04R	688316	7383605	203.6	80	71 - 80	Rewan	North	Active	30-06-2020	21-06-2023	30-06-2020	26-09-2023
MB19BWM25P	689260	7376880	192.6	20	17 - 20	Rewan	North	Active	01-07-2020	22-06-2023	30-06-2020	26-09-2023
MB19BWM05A	688502	7383612	203	15	9 - 15	Rewan	North	Active (dry)	-	-	-	-
MB19BWM_16R	669188	7338151	225.09*	97	87 - 93	Rewan	South	Active	31-01-2023	17-07-2023	31-01-2023	12-09-2023

Bore	Easting[1]	Northing[1]	TOC (mAHD)	Depth (mBGL)	Screened Interval (mBGL)	Monitored Unit	BWM Area	Status	Data Availability (dates)			
									min WL	max WL	min WQ	max WQ
FY16_PZ_2	686713	7387551	199.73	103.7	100.7 - 103.7	RCM coal	North	Active	26-11-2020	21-06-2023	26-11-2020	27-09-2023
FY16_PZ_3	686322	7388368	196	81.5	72.5 - 81.5	RCM	North	Active	25-11-2020	21-06-2023	-	-
FY16_PZ_4	686206	7389573	190.97	53	50 - 53	RCM coal	North	Active	25-11-2020	21-06-2023	25-11-2020	27-09-2023
FY16_PZ_5	685481	7389164	187.23	52.5	49.5 - 52.5	RCM coal	North	Active	25-11-2020	21-06-2023	25-11-2020	27-09-2023
MB1	686332	7387081	201.1	60	54 - 60	RCM coal	North	Active	01-09-2009	14-08-2023	26-09-2012	14-08-2023
MB20BWM02P2	686321	7388395	192.7	66	60 - 66	RCM coal	North	Active	25-02-2021	21-06-2023	25-02-2021	27-09-2023
MB20BWM03P1	686489	7387297	199.3	86	80 - 86	RCM O/I	North	Active	24-03-2021	21-06-2023	10-02-2021	27-09-2023
MB20BWM03P2	686490	7387289	199.4	109	98 - 107	RCM coal	North	Active	25-02-2021	14-08-2023	10-02-2021	27-09-2023
MB19BWM01P	690038	7390282	169.6	192	168 - 171	RCM coal	North	Active	01-07-2020	17-08-2023	29-07-2020	28-09-2023
MB19BWM03P	688455	7383474	202.7	234	222.5 - 231.5	RCM coal	North	Active	30-06-2020	21-06-2023	30-06-2020	26-09-2023
MB19BWM06P	687699	7379465	214.6	192	180 - 186	RCM coal	North	Active	30-06-2020	21-06-2023	-	-
MB19BWM27P	688959	7376560	198.5	200	180 - 189	RCM coal	North	Active	01-07-2020	18-08-2023	30-06-2020	26-09-2023
MB20BWM05P	686191	7389571	190.5	47	41 - 47	RCM O/I	North	Active (dry)	29-09-2021	21-06-2023	22-11-2022	27-09-2023
MB20BWM02P1	686325	7388395	192.6	36	30 - 36	RCM O/I	North	Active (dry)	24-03-2021	21-06-2023	-	-
MB19BWM08P	691543	7370740	224.6	198	184 - 190	RCM coal	Central	Active	29-06-2020	15-08-2023	30-06-2020	26-09-2023
MB18	691538	7370788	221.3	40.6	37.6 – 40.6	RCM O/I	Central	Active	01-09-2009	15-08-2023	28-09-2012	15-08-2023
BWM_MB14_02	683798	7350460	268	150	144-150	RCM O/I	South	Active	17-02-2023	27-09-2023	17-02-2023	27-09-2023
BWM_MB19_01	683795	7350479	264	80	-	RCM O/I	South	Active	24-05-2023	24-05-2023	18-03-2023	24-05-2023
BWM_MB01_02	687416	7344930	250	50	-	RCM coal	South	Active	17-02-2023	17-02-2023	18-02-2023	16-08-2023
BWM_MB16_03	682875	7340186	293	113	-	RCM coal	South	Active	31-01-2023	18-07-2023	31-01-2023	12-09-2023
MB19BWM_10P	684498	7342227	292	113.7	96.5-102.5	RCM coal	South	Active	22-03-2023	15-05-2023	28-02-2023	15-05-2023

Bore	Easting[1]	Northing[1]	TOC (mAHD)	Depth (mBGL)	Screened Interval (mBGL)	Monitored Unit	BWM Area	Status	Data Availability (dates)			
									min WL	max WL	min WQ	max WQ
BWM_MB04_01	686258	7350405	261.35*	28.5	22 - 28	RCM O/I	South	Active	29-01-2023	28-09-2023	29-01-2023	28-09-2023
PB19BWM_02P	670202	7342221	228.51*	72	62 - 68	RCM coal	South	Active	01-02-2023	14-08-2023	01-02-2023	12-09-2023
MB19BWM_24P	670210	7342224	228.3*	75.6	62 - 68	RCM coal	South	Active	01-02-2023	17-07-2023	01-02-2023	12-09-2023
MB19BWM_15P	669193	7338135	225.27*	140	131.7 - 137.7	RCM coal	South	Active	21-02-2023	17-07-2023	31-01-2023	12-09-2023
MB19BWM_18P	677018	7338057	223.58*	86.7	78.5 - 84.5	RCM coal	South	Active	01-02-2023	18-07-2023	01-02-2023	12-09-2023
BWM_MB21_02	686042	7342136	306.9	129.4	123 - 129	RCM coal	South	Active	06-03-2023	06-03-2023	03-03-2023	03-03-2023
BWM_MB21_03	686039	7342144	306.9	163.9	153 - 159	RCM coal	South	Active	06-03-2023	06-03-2023	02-03-2023	02-03-2023
MB19BWM_25P_B	683532	7333202	225.79*	137.7	127 - 133	RCM coal	South	Active	31-01-2023	15-05-2023	31-01-2023	07-09-2023
BWM_MB14_01	683798	7350471	268	25	18-24	RCM O/I	South	Active	28-01-2023	27-09-2023	28-01-2023	27-09-2023
MB16	687966	7352289	281.5	109	40 – 109 (open hole)	UG Workings (RCM)	South	Active	20-10-2009	06-11-2022	20-10-2009	18-02-2023
BG No.2 BG	684413	7384618	211.87	38.5	32.3-38.5	Burngrove	North	Active	19-01-2012	18-08-2023	26-09-2012	18-08-2023
BG No.1 AP	684107	7387738	200.46	72.9	63.6-72.9	Burngrove	North	Active	19-01-2012	18-08-2023	26-09-2012	18-08-2023
MB24	683770	7350808	285.6	18	-	Burngrove	South	Active	27-01-2023	27-09-2023	27-01-2023	27-09-2023

O/I = overburden/interburden
1 Coordinates GDA 2020 Zone 55
* Ground Level



0 2.5 5 km

Coordinate System:	GDA2020 MGA Zone 55
Scale:	1:250,000 at A4
Project Number:	620.040199
Date Drawn:	17-Sep-2024
Drawn by:	AS

LEGEND

Groundwater Monitoring Location

- Alluvium
- Tertiary
- Rewan
- Permian RCM
- Burngrove Formation

- Watercourse
- Area
- Project Area (Environmental Authorities boundary)
- BWM Mining Lease
- Study Area

BLACKWATER MINE - TRANSITIONAL PRCP HYDROGEOLOGY ASSESSMENT

GROUNDWATER MONITORING NETWORK

SLR

DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.

FIGURE 4-1

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040199.00001 BWM PRCP – GW\03 SLR Data\01 CADGIS\GIS\ArcPro\BWM PRCP – GW\BWM PRCP – GW.aprx\620040199_F04_1_Groundwater Monitoring Network

4.2 Hydraulic Properties

Study Area groundwater hydraulic testing includes slug (rising and falling head) tests performed on monitoring bores as well as drill stem testing. This section includes a summary of the available field hydraulic data (**Section 4.2.1**) and comparison to reported hydraulic properties within literature ranges (**Section 4.2.2**).

4.2.1 Site-Specific Hydraulic Conductivity Data

The database of available field results for horizontal hydraulic conductivity (Kh) in the Study Area is presented graphically as **Figure 4-2**. Field tests from various sources are symbolised separately on the plot.

Figure 4-2 shows that the one available test for the alluvium has an estimated hydraulic conductivity result of 0.4 m/day.

Estimated hydraulic conductivity of the Tertiary strata ranges from 0.004 to 0.03 m/day.

Hydraulic conductivity estimates for the Rewan Group were variable, ranging from 0.0002 to a relatively high 31.6 m/day.

As shown on **Figure 4-2** the estimated hydraulic conductivity for the coal seams of the RCM are variable, ranging from 0.00003 to very high 66 m/day. Higher hydraulic conductivity estimates for the RCM are generally noted in the southern part of BWM, while hydraulic conductivities appear to be much lower in the north of BWM (EMM, 2021). This is supported by the more recent testing available for areas in the south of BWM conducted by AGE (2023) as shown on the figure.

Hydraulic conductivity estimates produced for the interburden of the RCM ranged from 0.75 to 1.75 m/day. These estimates were from pumping tests conducted by AGC (1990) as reported in EMM (2021), however the test depth is not reported and therefore they are not included in the figure.

Estimated hydraulic conductivity for the coal seams of the Burngrove Formation were at a very low 0.000017 m/day for two tests conducted in the Virgo and Leo/Aquarius Seams.

Figure 4-2 shows that the hydraulic conductivity of the RCM generally declines with depth, due to increasing overburden pressure reducing the aperture of secondary porosity features. This is typical of the Permian coal measures in the Bowen Basin (e.g. SLR, 2021).

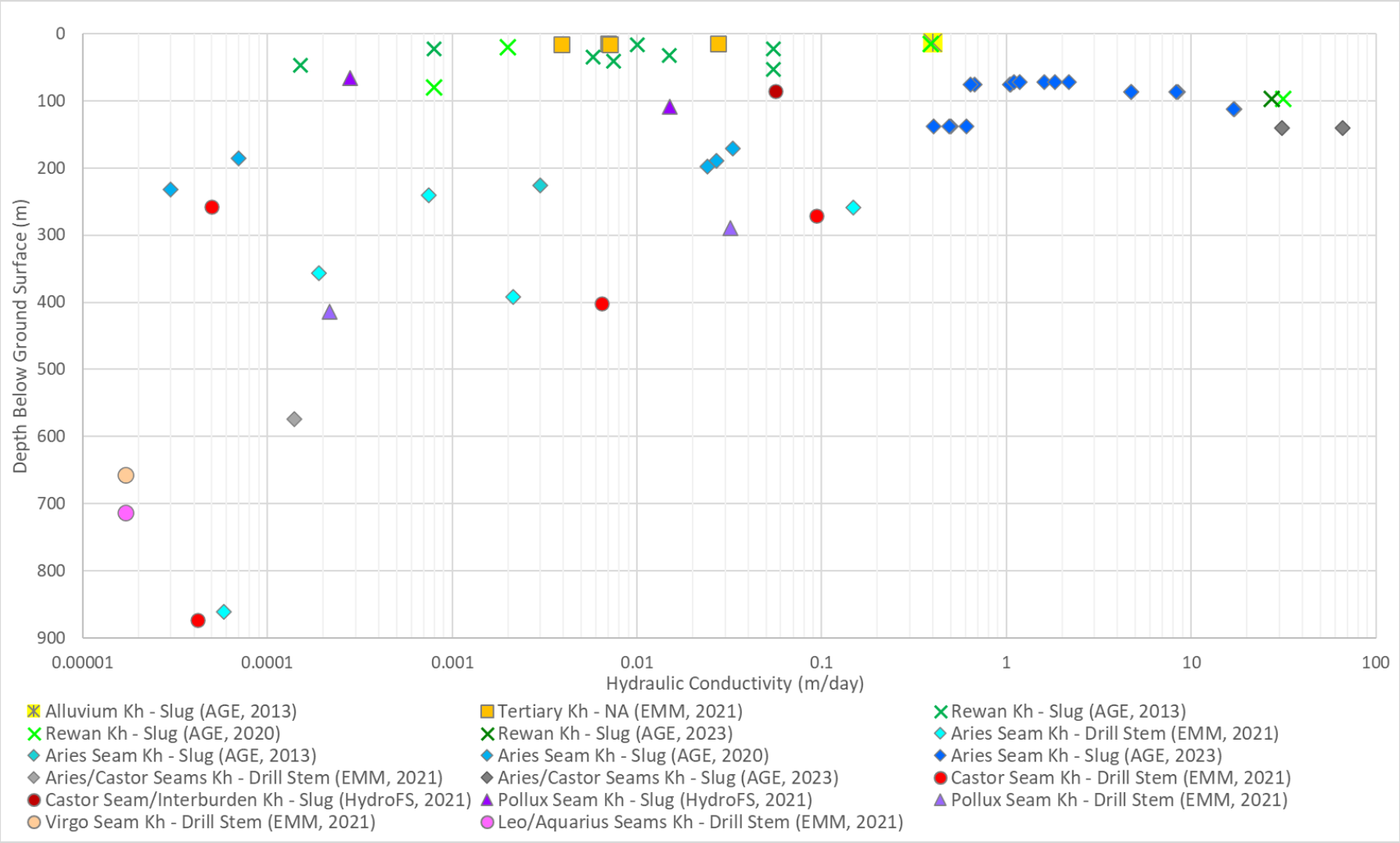
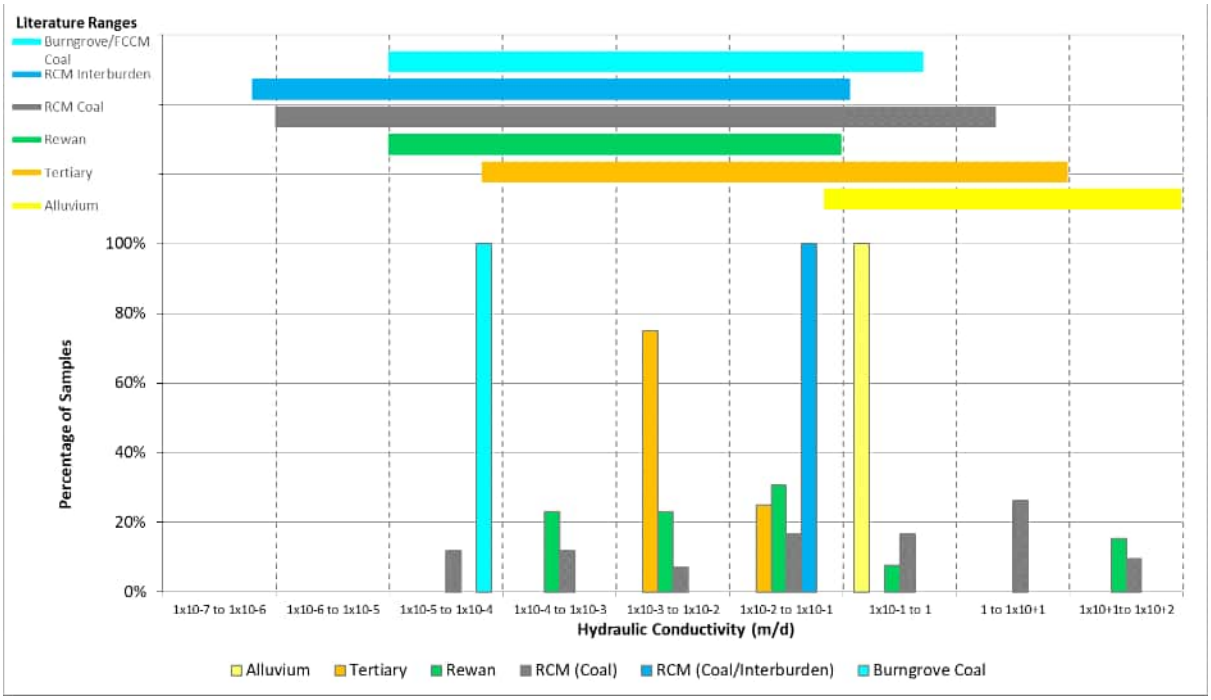


Figure 4-2 Graphical Summary of Results for all Site-Specific Hydraulic Conductivity Testing

4.2.2 Hydraulic Conductivity Ranges

A histogram of the spread of estimated horizontal hydraulic conductivity from field testing at BWM is presented in **Figure 4-3**. The results are compared to the range of horizontal hydraulic conductivity obtained from publicly available data based on a number of other studies within the Bowen Basin (SLR, 2023c).



RCM = Rangal Coal Measures, RCM IB = Rangal Coal Measures Interburden, FCCM = Fort Cooper Coal Measures

Figure 4-3 Histogram of Horizontal Hydraulic Conductivity Distribution

The comparison shows that the majority of field results for alluvium, Tertiary strata, Rewan Group, RCM and Burngrove Formation within the Study Area generally fall within the range of field data collected through other studies across the Bowen Basin. Results recorded from one bore in the Rewan Group (i.e. MB19BWM_16R) are higher than expected when compared to the documented ranges from literature, reflecting the fact that some parts of the Rewan Group has higher hydraulic conductivity. Results recorded for the RCM coal seams from two bores (BWM_MB16_03 and MB19BWM_15P) were also higher than expected when compared to literature values. It is expected that in general across the Study Area the coal seams of the RCM and Burngrove Formation have a higher hydraulic conductivity than the majority of the interburden/overburden, consistent with many other regional studies (e.g. SLR, 2021). This is due to the dual porosity of the coal seams, with a primary matrix porosity and a second (dominant) porosity provided by fractures (joints and cleats), which supports the concept of the coal seams themselves forming the dominant groundwater zones of the Permian units.

4.2.3 Faulting

As discussed in **Section 3.1.1**, the strata in the vicinity of the Project Area is heavily influenced by a series of easterly dipping, north to northwest striking faults.

As identified by Jourde et al. (2002), faulting can result in higher permeabilities within strata parallel with the fault plane, and lower permeabilities within strata perpendicular to the fault plane. However, this can also be dependent on whether faults are currently active (Paul et al., 2009). Faulting has been inactive within the Bowen Basin for over 140 million years

(Clark et al., 2011), indicating that the fault zones are less likely to act as conduits to flow; this relates to filling of the fractured pore spaces over time through hydrothermal alteration and mineralisation (Uysal et al., 2000). Drill core logs from the Bowen Basin generally show that where fractures and faults have been geologically logged, many fractures are “healed” with calcite and siderite. This indicates that although the system contains a fracture network, many of the existing fractures are cemented, which reduces the effective permeability of the fracture when compared to any open fracture network (SLR, 2021).

Site specific testing of the faults has not been undertaken to derive hydraulic properties of the fault zones or assess whether the faults act as conduits or barrier to groundwater flow. However, they are anticipated to act more as barriers than conduits because the faults compartmentalise the coal seam geology and Permian groundwater flow is dominated by water movement within these seams.

Based on a detailed literature review of the effect of faulting on groundwater flow, Coffey (2014) has developed a conceptual model for fault zone hydraulic characterisation in the Bowen Basin (**Figure 4-4**), largely based on Jourde et al. (2002) and Flodin et al., (2001). This conceptualisation provides a means of inferring hydraulic conductivities of the fault core and the fault damage zone from regional hydraulic conductivity, with the fault core typically one to three orders of magnitude lower conductivity than the regional host rock, and the damage zone approximately an order of magnitude higher.

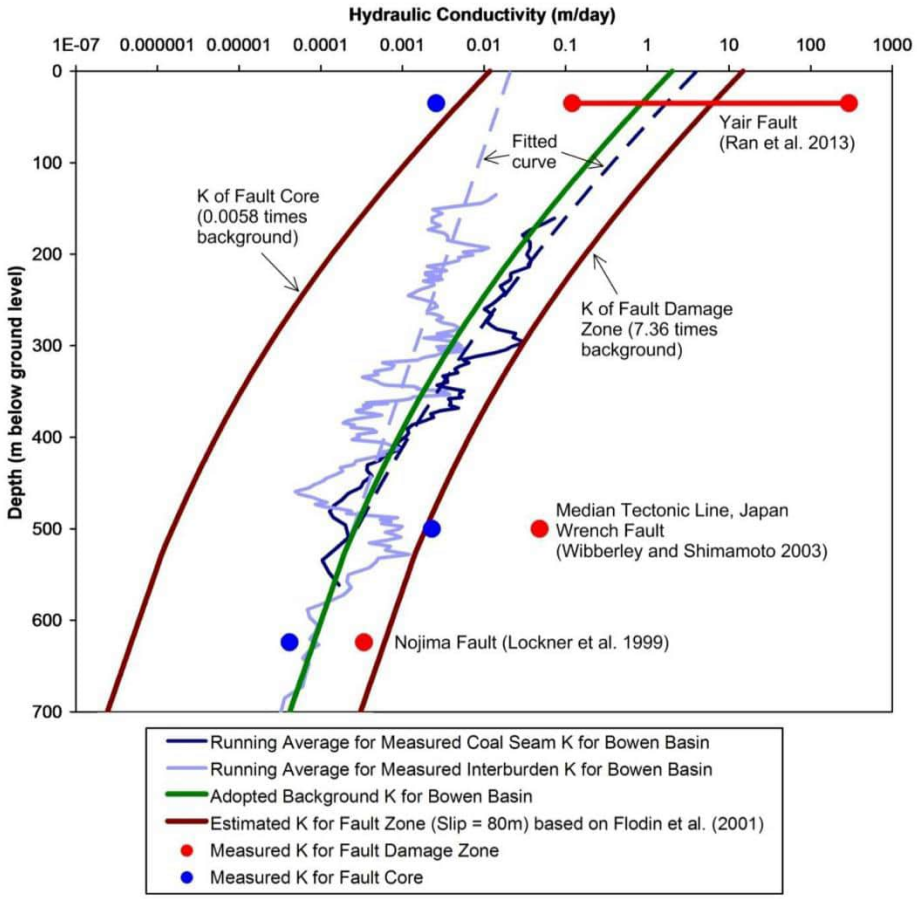


Figure 4-4 Faulting Conceptual Model Developed by Coffey (2014)

4.3 Groundwater Distribution, Flow, Rechange and Outflow

4.3.1 Quaternary Sediments

Based on recent drilling at BWM (**Section 3.2.1**), it is considered that the horizontal extent of the Quaternary alluvium within the Study Area is likely smaller than mapped on the regional surface geology map (**Figure 3-1**).

Recent drilling campaigns targeting the alluvium in the north of BWM (2020 and 2021) revealed either an absence of alluvium, and/or dry conditions. In 2020, four bores were planned to be installed into the alluvium at north BWM, however only one of the four locations (bore MB19BWM07A at Taurus Creek) was able to be installed into the alluvium, which was then found to be unsaturated (AGE, 2020). Two bores were planned to be installed into the Two Mile Gully alluvium but did not intersect alluvium and were grouted up. A further two bores targeting the Sagittarius Creek alluvium were attempted to be installed, with one intersecting alluvium (MB19BWM02A) that was found to be unsaturated, and the other (MB19BWM05A) intersecting possible alluvium or possible Tertiary sediments that were also unsaturated. These two drillholes in Sagittarius Creek were converted to monitoring bores targeting the shallow Rewan Group instead, where first shallow groundwater was found. Another bore (BWM_MB03_01) installed into the Taurus Creek alluvium, drilled in 2020 (EMM, 2021) has also been dry since installation.

In 2021, during an additional drilling campaign, bore MB20BWM01A initially targeted alluvium (near a small unnamed tributary of Bonnie Doon Creek) but again due to the lack of alluvial sediments at the site, the bore was installed into the water table in the shallow Rewan Group (HydroFS, 2021). In 2023, five additional bores were installed in the alluvium of Rockland Creek (four bores) and Shotover Creek (one bore) in the south of BWM, two of which (MB19BWM_14A and MB19BWM_19A) found the alluvium to be unsaturated.

Drilling results indicate that where the alluvium is present, it is generally dry, with saturated areas only found in few locations. There are six active BWM monitoring bores screened in the alluvium (**Figure 4-1**), however only three are saturated (**Figure 4-5** and **Figure 4-6**). The short data record available for these bores shows groundwater level elevations in these bores to range between approximately 15 to 16 mBTOC (210 and 245 mAHD) (**Figure 4-5** and **Figure 4-6**). The relatively deep recorded depth to groundwater of approximately 15 m below ground level where alluvial groundwater is encountered indicates a distinct lack of connection with any surface water features, and is also likely beyond the rooting depth of any terrestrial vegetation species.

Due to the general lack of saturated monitoring locations in the alluvium, and the limited period of data available, it is not possible to assess correlation with rainfall (and therefore recharge) based on these bores. However, based on a review of available groundwater level data for the neighbouring Minyango Project that was conducted by AGE (2013), recharge to the alluvium is suggested to be limited. Of the four bores installed into the alluvium at Minyango Project, three were also dry. The only bore that encountered water (Minyango-MB9) revealed a limited saturated thickness of less than 0.8 m, with a depth to water level of 10.8 mBGL. The monitoring data for MB9 showed a steady decline between December 2012 to September 2013, and showed no correlation with rainfall. AGE (2013) determined that, for bore MB9, recharge is likely limited by the surficial clay above alluvium and that the alluvium is likely compartmentalised, with limited connectivity between saturated alluvium areas, separated by clay lenses and outcropping bedrock. Where saturated, the alluvium may facilitate recharge to underlying geological units. Discharge from this aquifer is generally considered to be via evapotranspiration and leakage to underlying aquifers.

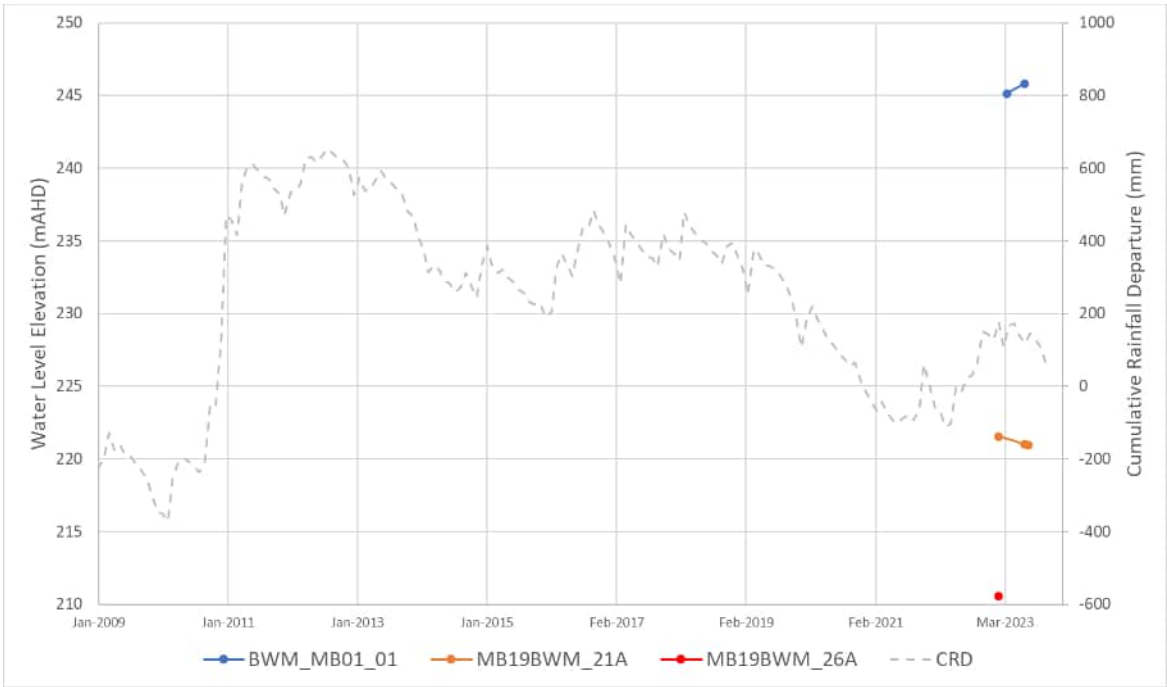


Figure 4-5 Groundwater Level (mAHD) – Alluvium

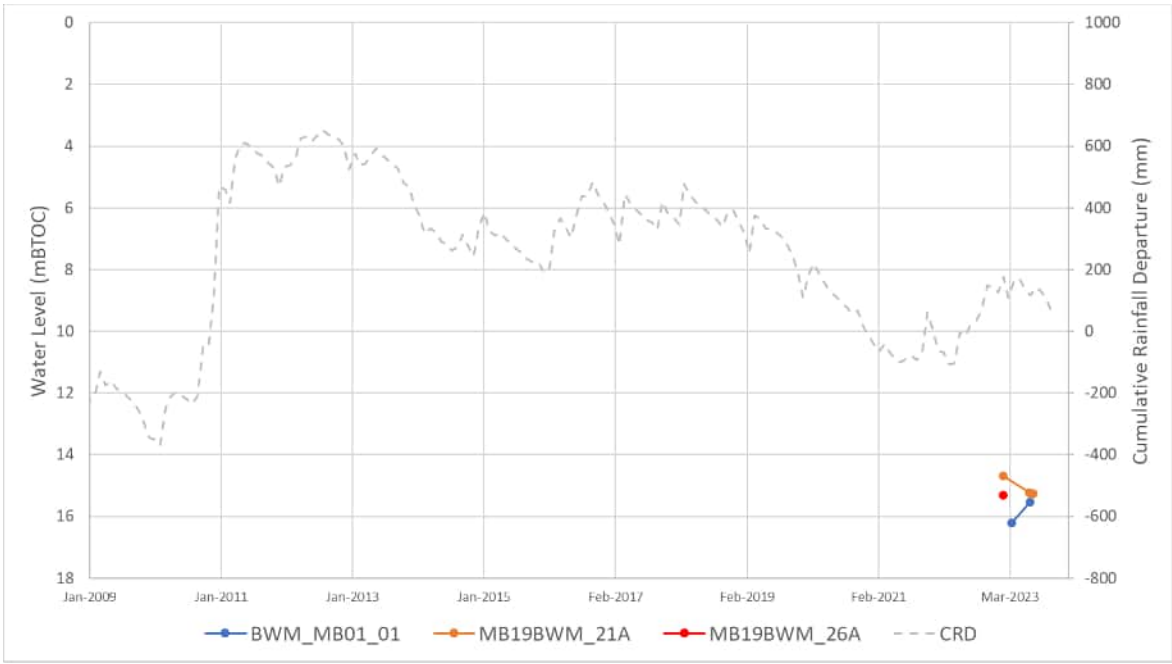


Figure 4-6 Groundwater Level (mBTOC) – Alluvium

Due to the general lack of saturated monitoring locations in the alluvium within the Study Area, it is not possible to map groundwater contours for this unit, nor is it likely that a widespread flow system in the alluvium exists. However, where saturation does exist, groundwater flow in the alluvium is expected to be controlled by topography and mimic surface water flow directions, with flow towards the north at North Blackwater and towards the southwest at South Blackwater.

4.3.2 Tertiary Sediments and Basalt

Recent monitoring data for bores screened in the Tertiary units within the Study Area are shown on (**Figure 4-1**). Bore BWM_MB22_01 is installed into the basalt while the other bores are installed in the Tertiary sediments. BWM_MB22_01, screened in the basalt, records a groundwater level of approximately 25 mBTOC and 315 mAHD, while groundwater levels in the Tertiary bores range from approximately 3 to 18 mBTOC 248 to 278 mAHD with one bore (MB20BWM01A) historically dry (**Figure 4-7** and **Figure 4-8**).

MB20BWM01A, located in the Northern BWM area, east of the Bonnie Doon Pit (**Figure 4-1**) was drilled in 2020 and has remained dry since installation. In this area, the Tertiary strata is expected to be mostly dry, as indicated by recent drilling (AGE, 2020 and HydroFS, 2021) as well as historical observations at Minyango (AGE, 2013).

Historical monitoring data at MB21 shows there has been a steady decrease in groundwater level since 2011, interrupted only by relatively short-term responses to large rainfall events. This long-term decline reflects a long-term response following the very high rainfall observed in 2011. Over the relatively short monitoring record at bores BWM_P5 and BWM_P4 a steady decrease in water levels is observed, in line with the decreasing rainfall trend (**Figure 4-7** and **Figure 4-8**.

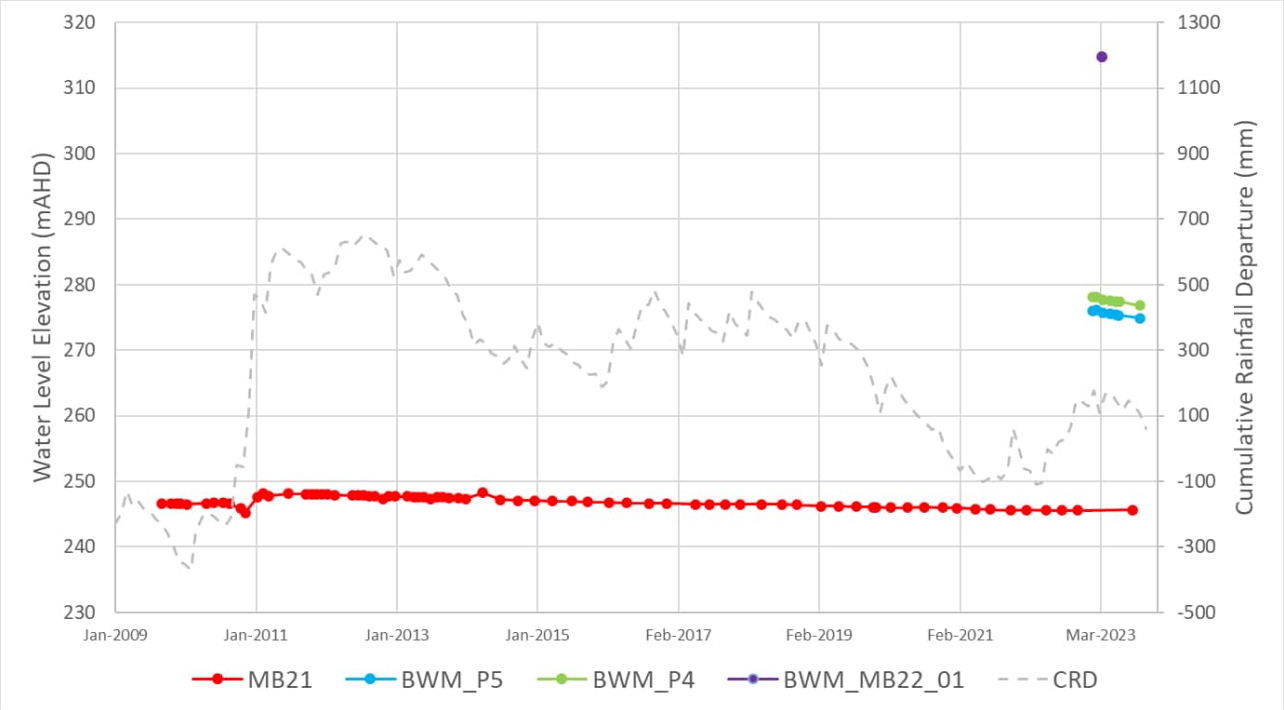


Figure 4-7 Groundwater Level (mAHD) – Tertiary Strata

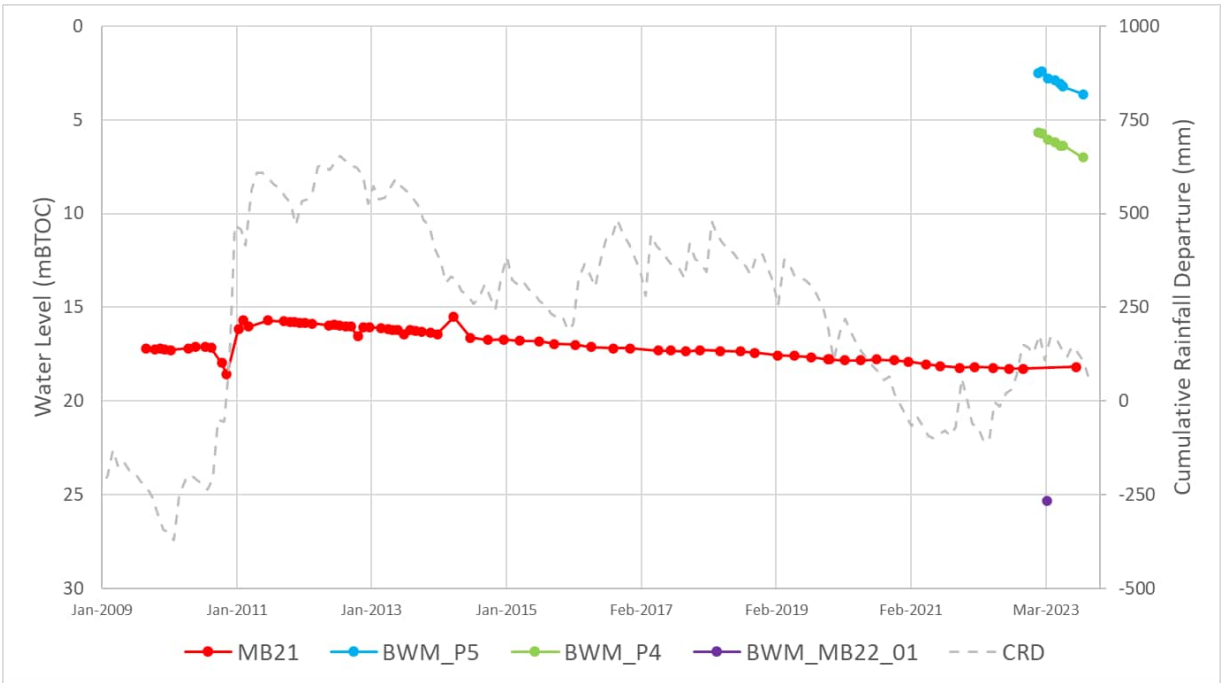


Figure 4-8 Groundwater Level (mBTOC) – Tertiary Strata

As with the alluvium, recharge to the Tertiary strata is expected to be low due to the presence of overlying clays. The saline groundwater quality of the Tertiary strata (see **Section 5.1.2**) supports the assumption of low recharge rates. Outflow from the Tertiary aquifer is considered to be primarily through evapotranspiration and limited leakage to underlying aquifers (where there are no substantial clay barriers).

Similar to the alluvium, groundwater flow in the Tertiary units is expected to be controlled by topography and flow towards the north at North Blackwater and towards the southwest at South Blackwater.

4.3.3 Triassic Clematis Group

There are no registered bores installed within the Clematis Group sandstone at the eastern margin of the Study Area, where the sandstone outcrops in elevated rugged areas in Arthur's Bluff State Forest, Shotover State Forest and Blackdown Tableland National Park. The aquifer forming Clematis Group sandstones are distinguished by coarse grain size, with less interbedded shale and siltstone than the non-aquifer forming Clematis Group units. Claystones of the Rewan Group directly underlie the Clematis Group, forming an aquitard between the Clematis Group and the deeper Permian Coal Measures.

4.3.4 Triassic Rewan Group

The Rewan Group is considered low yielding, with any groundwater having limited potential for beneficial use due to the typically fine-grained, clay-bound nature of the sediments. Regionally across the Bowen Basin, the Rewan Group is considered an aquitard (Arrow Energy, 2013). Despite acting as a regional aquitard, there are five active monitoring bores screened in the Rewan Group observing saturated horizons within the Study Area (**Figure 4-1**). Recent monitoring data for these bores shows groundwater level elevations to range from approximately 161 to 182 mAHD, with one bore (MB19BWM05A) dry since installation in 2020 (**Figure 4-9**).

Bores MB19BWM02A, MB19BWM25P exhibit groundwater level trends broadly in line with long-term climatic trends. MB19BWM04R contrasted to this, shows an increasing

groundwater level throughout the monitoring record, even during long periods of below average rainfall. There is only a short monitoring record available at MB19BWM_16R, which appears to show increasing water levels in line with the rainfall trend but at a faster rate than the other bores. It is noted that hydraulic testing at this bore yielded a much higher hydraulic conductivity than the other Rewan Group bores (refer **Section 4.2**). The trend exhibited at this bore is reflective of the heterogeneity across some parts of the formation. All bores in this unit do not respond to short term CRD peaks, indicating a degree of insulation from short term recharge events (**Figure 4-9**).

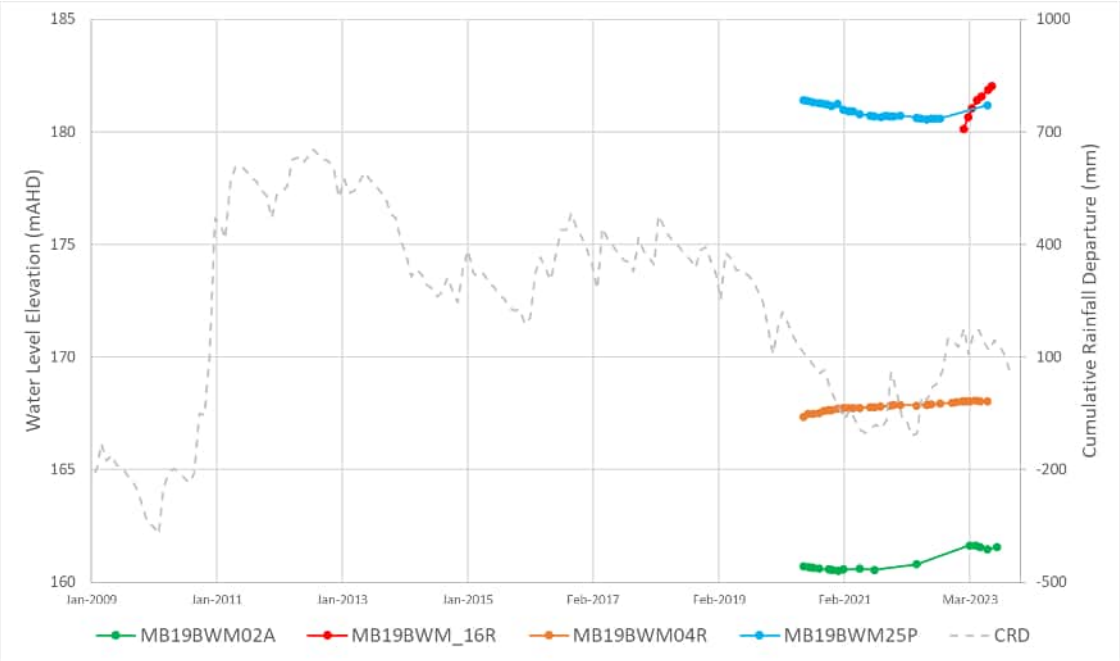


Figure 4-9 Groundwater Level (mAHD) – Rewan Group

Recharge to the Rewan Group is expected to occur via leakage from the overlying Quaternary and Tertiary units. Recharge rates are likely very low due to the low hydraulic conductivity of the interbedded fine grained clay horizons restricting infiltration. This is supported by elevated salinity (see **Section 5.1.2**) which is consistent with high groundwater residence times concentrating salts.

Outflow from this unit is expected to be through lateral flow, with low vertical hydraulic conductivity limiting potential leakage to underlying units. The suggested insulation of this unit from recharge events makes it unlikely that there would be short term (post-rainfall) groundwater pressure increases sufficient as to discharge to surface water features.

The four saturated monitoring bores grouped in the northern area indicate a flow toward the north of BWM (i.e. consistent with topographical gradients). Groundwater flow in the southern portion of BWM is also expected to follow topography, with a flow direction towards the south and southwest.

4.3.5 Rangal Coal Measures

Due to the abundance of available bores over a wide spatial spread, groundwater distribution, flow, recharge and outflow for the RCM is discussed separately for the North (**Section 4.3.5.1**), Central (**Section 4.3.5.2**), and South (**Section 4.3.5.3**) areas of BWM as shown on **Figure 4-1**.

4.3.5.1 BWM Northern Area

Groundwater levels are available for 13 bores screened in the coal seams and interburden of the RCM in the Northern BWM area, of which the groundwater elevation of four bores (screened within the coal seams) are presented on **Figure 4-10**. The groundwater elevation of nine bores in the Bonnie Doon area are presented on **Figure 4-11**.

In the Northern BWM area, **Figure 4-10** shows the general gradient for these bores is from south to north (i.e. higher water level in the south at MW19BWM27P and lowest water level at MB19BWM01P in the north). An exception to this is MB19BWM06P, which recorded the highest water levels; it is considered that this is potentially indicative of compartmentalisation of the coal seams.

As shown on **Figure 4-10**, while the monitoring period is relatively limited (less than five years) groundwater levels have remained relatively consistent, with a subdued reaction to long term climatic trends. Bore MB19BWM03P has displayed an anomalous response relative to other bores, with spurious fluctuations of up to 2 m between measurements, generally trending upwards. A comparison of the groundwater level trend at this bore with the CRD shows no correlation, with variability that is disconnected from the rainfall response. It is noted that this bore shows very slow groundwater level recovery following monitoring events, potentially indicating that the bore is observing a very low hydraulic conductivity horizon within the RCM.

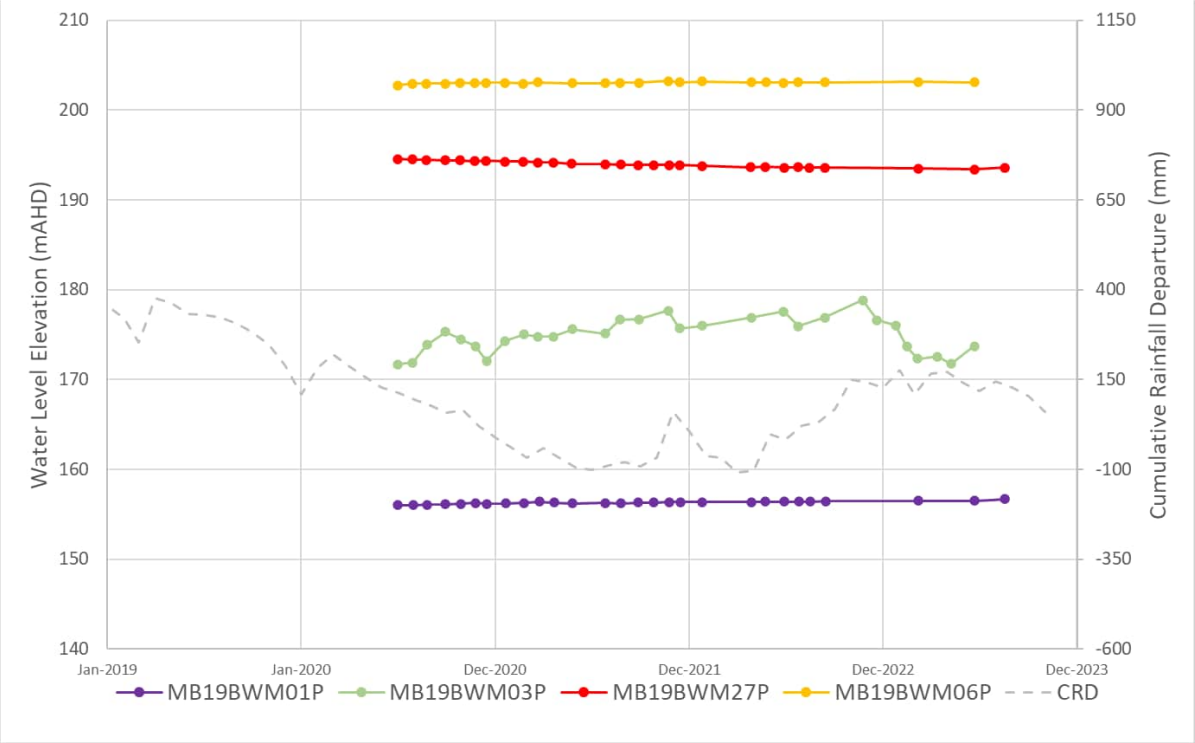


Figure 4-10 Groundwater Level (mAHD) – Rangal Coal Measures (Northern Area)

Hydrographs for ten RCM bores in the Bonnie Doon area are displayed in **Figure 4-11**. Seven of these bores targeting the RCM are screened in coal seams and three in the interburden (MB20BWM02P1 MB20BWM05P and MB20BWM03P1 (thin coal and mostly interburden)). The water level in the adjacent Bonnie Doon Pit lake (Ramp 10 and Ramp 12) is at between 128 and 142 mAHD (**Figure 4-11**).

Groundwater elevation at MB1, which has the longest monitoring record, has gradually increased since the cessation of Bonnie Doon Pit mining in 2016. Given it has a groundwater elevation well above the recorded pit water levels, this is considered to be a hydraulic response of the RCM recovering following the removal of dewatering stressors, rather than an indication of recharge from the pit lake. The other nine bores in the Bonnie Doon area were installed in 2020 and have a relatively short monitoring record. The groundwater levels in these bores vary from approximately 131 mAHD to 157 mAHD, within a relatively small area. This is reflective of the different horizons monitored by each bore, and the degree of compartmentalisation in the aquifer/aquitard system.

The bores MB20BWM02P1 (overburden) and MB20BWM02P2 (coal seam) show that whilst the bore monitoring the coal seam has a water elevation similar to that of the pit lake, the bore observing the interburden shows water levels 20 m above the pit lake level. Based on this observation, it is likely that the coal seams down dip (to the east) are well connected to the open cut pits, whereas the interaction with the lower permeability overburden is limited, consistent with it having more aquitard like properties. Vertical hydraulic gradients in this area remain consistently downwards due to this disconnect. MB20BWM02P2 water level shows some response to climatic trends, though there may be some hydraulic connection with the nearby pit lake, given proximity and coal seam outcrop.

Bores FY16_PZ_2, FY16_PZ_3 and FY16_PZ_4 show inconsistent measurements at the start of their monitoring datasets before settling into steady water levels that are relatively isolated from climatic response. This could be attributed to stabilisation of the local groundwater environment following bore installation.

Installed in roughly the same collar location, but in different points in the stratigraphy, MB20BWM03P1 and MB20BWM03P2 display similar water levels (around 142 mAHD). Initially, MB20BWM03P2 water level was around 0.5 m higher than MB20BWM03P1, however this reversed in 2022, likely due to a recovery response in the interburden stratigraphy.

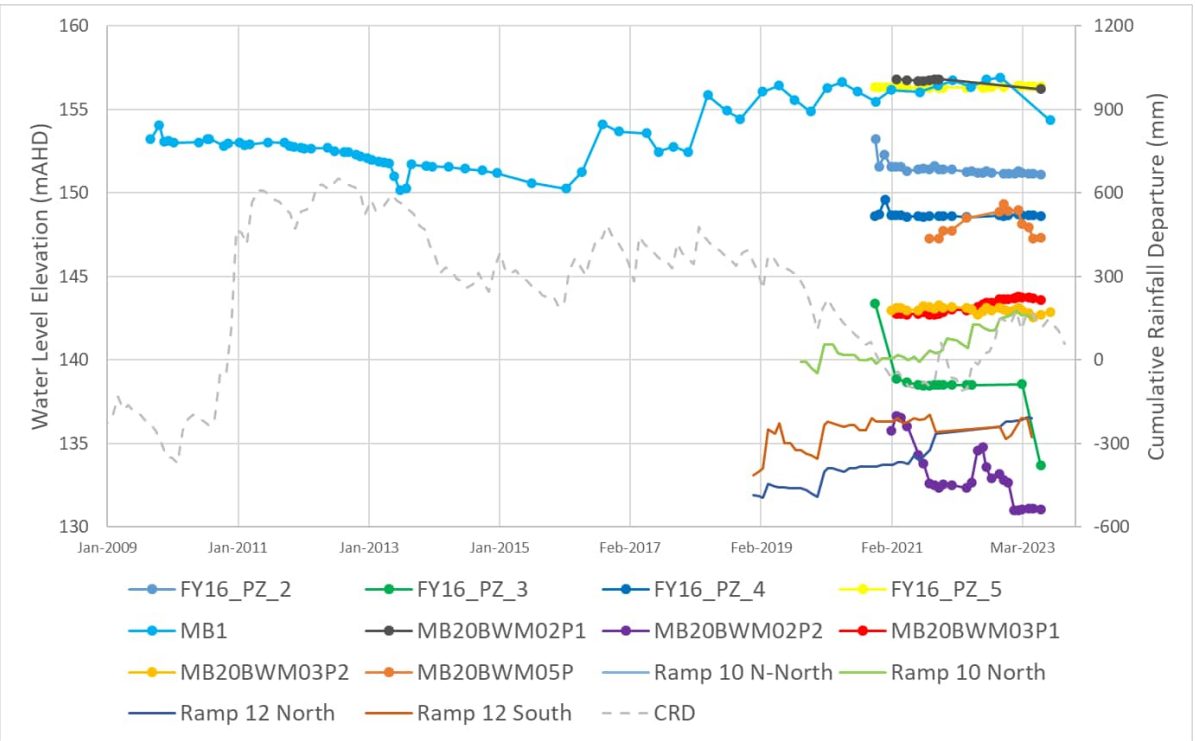


Figure 4-11 Groundwater Level (mAHD) – Rangal Coal Measures North (Bonnie Doon Area)

4.3.5.2 BWM Central Area

Groundwater levels for bores screened in the RCM in the central area of BWM (**Figure 4-1**) are shown on **Figure 4-12**. Historical groundwater elevations in these bores range between approximately 193 to 211 mAHD.

Bore MB18 which is screened in the overburden has the longest monitoring record and shows an overall increasing trend. It is noted that this bore shows a spurious step change from around March to September 2013, indicating a potential issue with the data before this period. MB18 (overburden) is located approximately 50m from MB19BWM08P (coal seam) with around 150 m vertical separation between screened intervals. MB19BWM08P shows a water level of around 211 mAHD, whereas the water level at MB18 is around 201 mAHD, indicating an upwards hydraulic gradient from the confined coal seams into the aquitard overburden material.

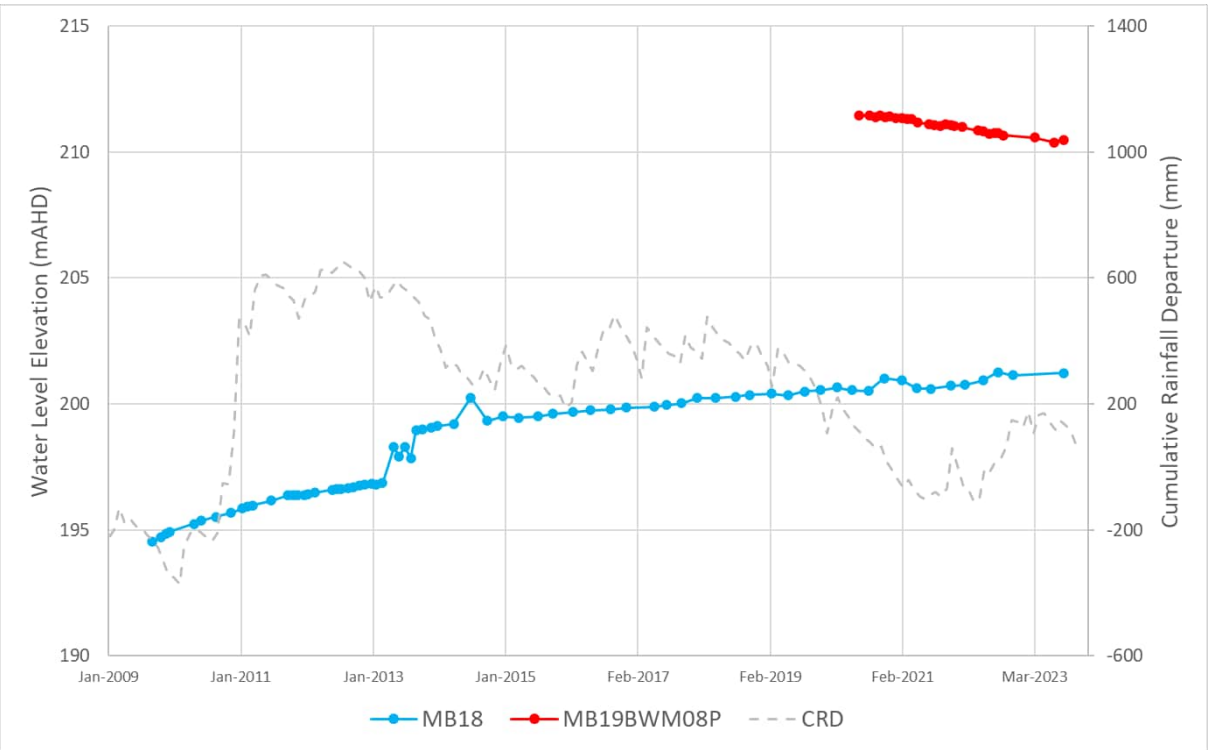


Figure 4-12 Groundwater Level (mAHD) – Rangal Coal Measures (Central Area)

4.3.5.3 BWM Southern Area

Groundwater levels for bores screened in the RCM in the southern area of BWM (**Figure 4-1**) are shown on **Figure 4-13**.

There is only a short monitoring record available (since 2023) for the 12 recently installed bores in this area (**Figure 4-1**). Historical groundwater elevations in these bores range from approximately 187 to 257 mAHD.

Notably, bore MB19BWM_25P_B installed near Shotover Creek records shallow groundwater levels within around 1 m of the surface.

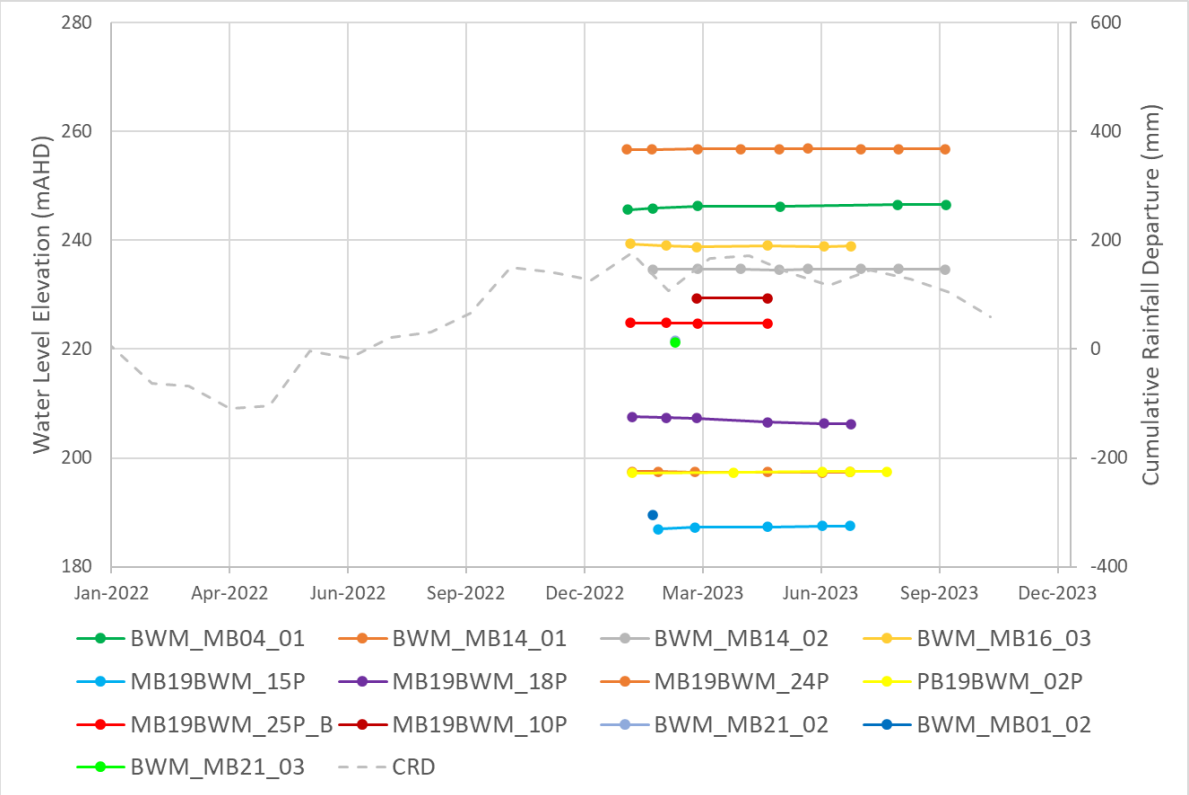


Figure 4-13 Groundwater Level (mAHD) – Rangal Coal Measures (Southern Area)

Groundwater levels for bore MB16 are shown in **Figure 4-14**. MB16 is suggested by EMM (2021) to monitor the Aries Seam (or Aries Seam workings) within the extent the historic Laleham Underground Mine, which extracted coal from the Aries to the Pollux Seams (Byrnes Geotechnical, 2024). Groundwater levels at MB16 were approximately 223 mAHD (58 mBGL) prior to 2015, after which a gradual increase in water level occurred to approximately 443 (39 mBGL) mAHD to 2018 before stabilising. This water level increase of approximately 19 m is likely to be related to partial recovery of water in the underground workings (EMM, 2021), i.e. reflooding. Groundwater levels at MB16 are noted to remain significantly lower in elevation than water storage elevations within the Kenmare pit (287.4 to 276.6 mAHD, see **Section 2.3.3**), suggesting there remains the potential for groundwater movement towards the underground workings from water stored in this pit. The groundwater levels at MB16 are also marginally lower in elevation than the most recent pit lake level recorded within the Ramp 74/Laleham pit (246.4 mAHD), though the difference is relatively small and suggests that the underground workings may have essentially reached close to hydraulic equilibrium with the Ramp 74/Laleham pit.

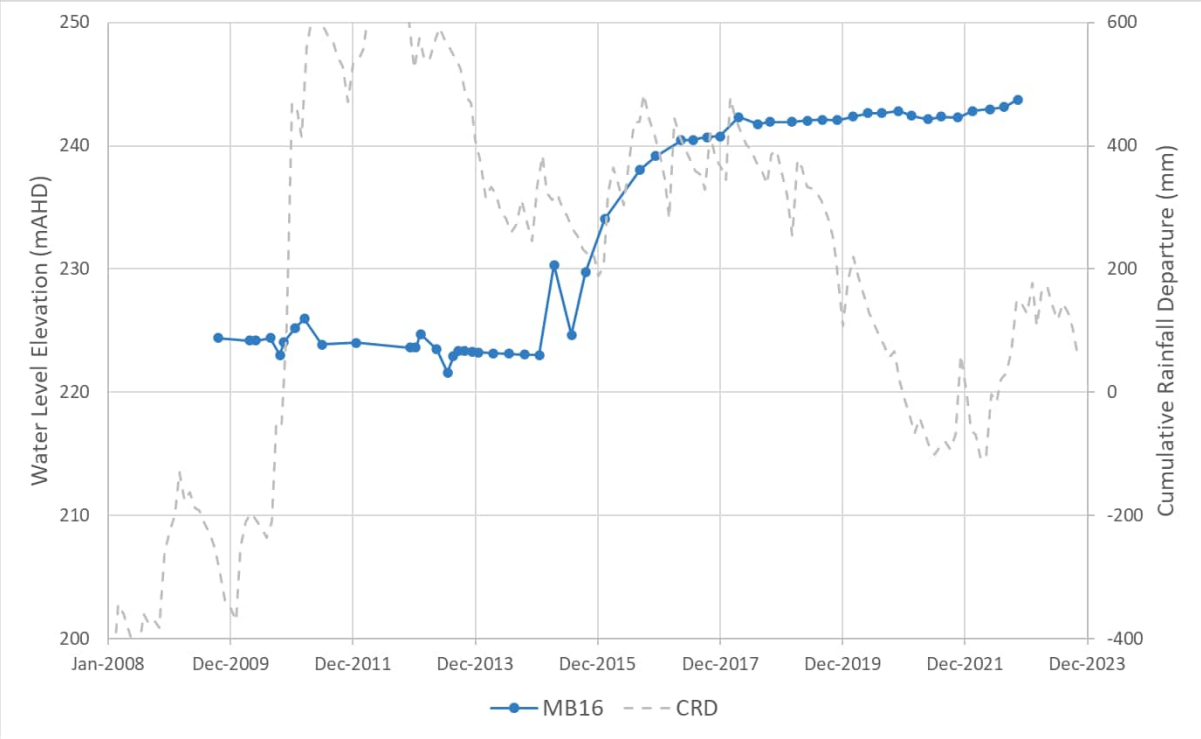


Figure 4-14 MB16 Groundwater Level (mAHD) – (Laleham Underground Mine)

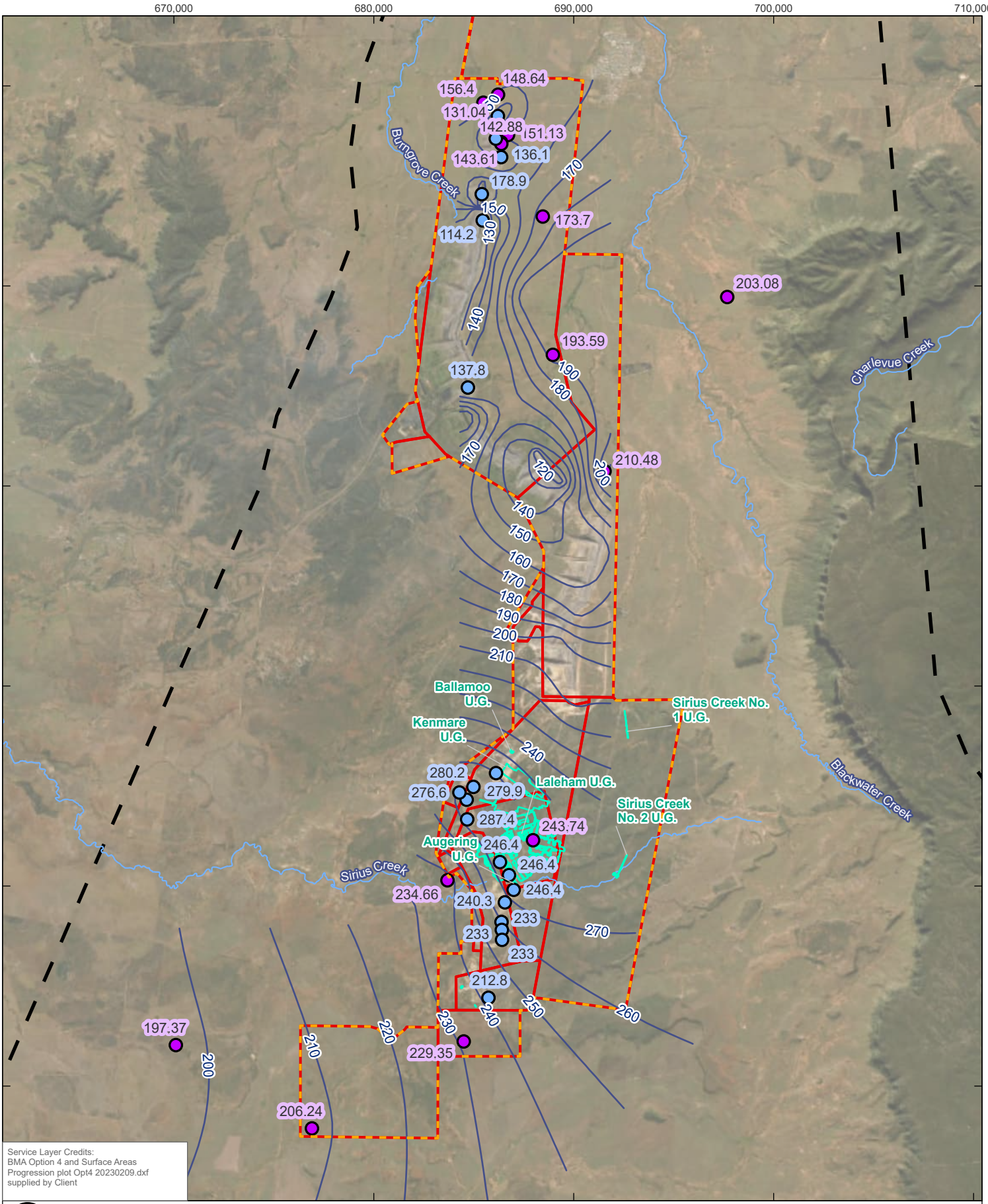
4.3.5.4 Summary

A comparison of groundwater level trends for all BWM bores screened in the RCM coal seams against the CRD indicates that the groundwater regime in the RCM coal seams is somewhat insulated from short term climatic effects, though depth and conductivity of the monitored horizon clearly influences this response. Through hydraulic connection with the mining areas, it is apparent that there is some response in regional groundwater levels to mining depressurisation.

Groundwater quality in the RCM coal seams is mostly saline (**Section 5.1.2**), which suggests long residence times related to low recharge rates and increased water-rock interaction. Recharge to the coal seams is expected to occur primarily via leakage from the overlying Quaternary and Tertiary units, with greater recharge occurring in areas where the seams subcrop and outcrop. Based on the inferred hydraulic gradients between overburden and coal seams, this is likely limited to the overburden horizons, with coal seam recharge occurring through mine surface water storages where the seams are hydraulically connected to the storages. Outflow from the RCM is considered to be primarily through inflow to active mining areas, with a small proportion of total outflow being through horizontal flow outside of the cone of depression formed by mining voids.

Groundwater level contours for the Aries Seam are shown in **Figure 4-15**. The contours are based on groundwater level measurements from bores screened in the Aries Seam, and on surveyed pit void water levels for March 2023. The Aries Seam was selected as it has the highest number of data points and most recent data available for analysis, and it is expected that other coal seams would exhibit similar flow patterns. Pit water levels were also included to assist with the interpretation of groundwater level contours in close proximity to the mined pits, and the observed water level elevation in the pits (where available) was used to infer the groundwater level in the Aries Seam directly adjacent to the pit, since there is direct hydraulic connection between the pit lakes and the coal seam. Likewise groundwater levels recorded at MB16 in the Laleham underground mine workings were included in the mapping.

The groundwater level contours show that in the northern and central parts of BWM, the flow direction within the Aries seam is locally predominantly towards the mine pits, consistent with discharge to the active mine pits. In the southern area of BWM, the flow direction within the Aries Seam is dominated by the local influence of elevated in-pit water storages at Kenmare Pit. In the far south, the potentiometric mapping indicates a groundwater divide present just north of Sirius Creek, consistent with the surface catchment divide (refer **Section 2.2**), with groundwater flow from northeast to southwest.



Coordinate System:	GDA2020 MGA Zone 55
Scale:	1:250,000 at A4
Project Number:	620.040199
Date Drawn:	09-Aug-2024
Drawn by:	RB

BLACKWATER MINE - TRANSITIONAL PRCP HYDROGEOLOGY ASSESSMENT

GROUNDWATER LEVEL CONTOURS – ARIES SEAM

SLR

DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.

FIGURE 4-15

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040199.00001 BWM PRCP – GW\03 SLR Data\01 CADGIS\GIS\ArcPro\BWM PRCP – GW\BWM PRCP – GW.aprx\620040199_F04_15_GWL Levels Aries Seam

4.3.6 Burngrove Formation

Figure 4-16 shows the groundwater level elevations for four bores installed in the Burngrove Formation at BWM. BG No.1 AP and BG No.2 BG are located in the north of the Project Area and MB24 and MB25, installed to monitor Red Dams are in the south (see **Figure 4-1**). All bores show little variation in groundwater level over the monitoring record, approximately 0.5 m for BG No.1 AP, 1 m for BG No.2 BG, and 0.2 m for MB24 and MB25. These variations are consistent with the overall long-term decline of the CRD over the corresponding monitoring record. Groundwater levels in these bores do not seem to respond to short term increases in the CRD, suggesting low rates of recharge in these areas. Recharge to the Burngrove Formation would occur primarily where the formation outcrops along the west of the Project Area (**Figure 3-1**). Outflow from this formation is expected to be through lateral flow in the direction of regional groundwater flow, with some upwards leakage to the depressurised RCM.

Based on the limited number of observed groundwater elevations, groundwater flow direction in the Burngrove Formation is suggested to be from south to north at BWM north, from BG No.2 BG (~189 mAHD) to BG No. 1 AP (~178 mAHD), and north to south at BWM south from MB24 (~277 mAHD) to MB25 (275 mAHD).

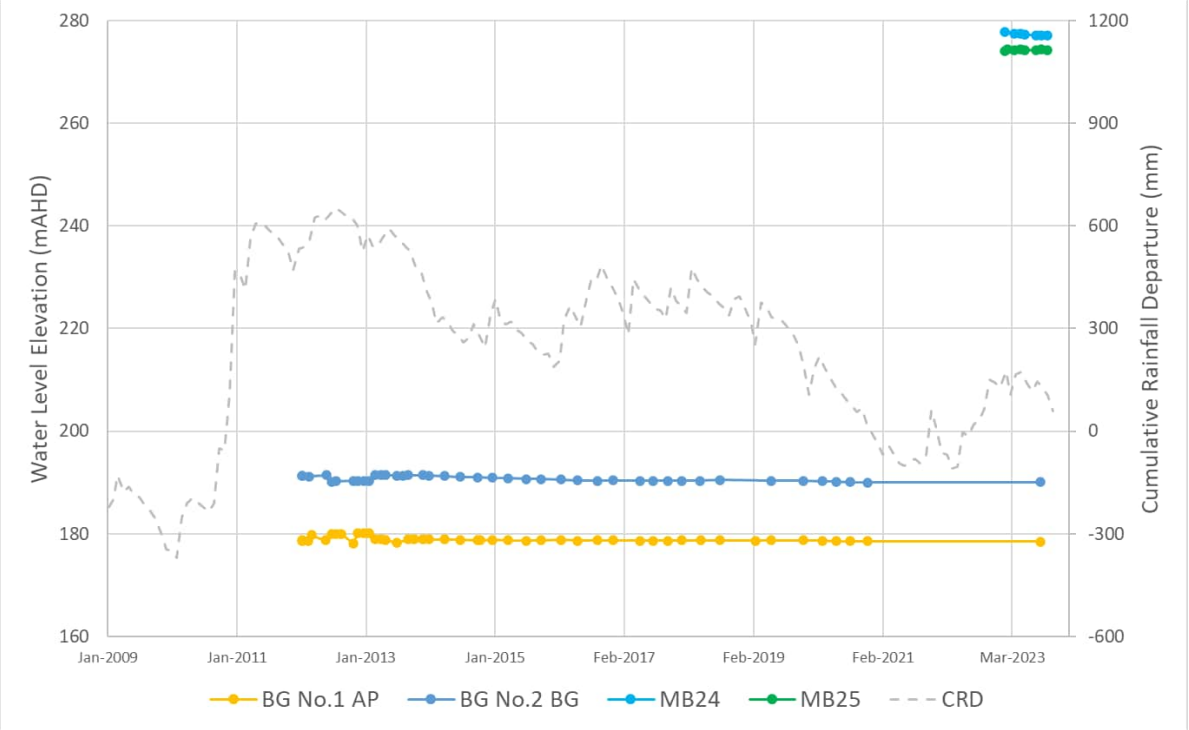


Figure 4-16 Groundwater Level (mAHD) – Burngrove Formation

5.0 Baseline Water Quality

5.1.1 Groundwater Typing

The proportions of major anions and cations were used to determine the hydrochemical facies of groundwaters sampled at BWM. The anion-cation balance, pH and EC of historical data from BWM monitoring bores is displayed on the Durov diagrams in **Figure 5-1** to **Figure 5-7**. The diagrams are split by aquifer and area, including bores in the alluvium (**Figure 5-1**), Tertiary (**Figure 5-2**), Rewan Group (**Figure 5-3**) and RCM at BWM north (**Figure 5-4**), RCM at BWM central (**Figure 5-5**), RCM at BWM south (**Figure 5-6**) and the Burngrove Formation (**Figure 5-7**). There is a high degree of observed variability in groundwater quality between hydrostratigraphic units, and between individual bores within individual hydrostratigraphic units.

Records from alluvium groundwater quality sampling only include one bore across three samples (**Figure 5-1**). The data from this bore shows a Na-Cl groundwater type with a neutral pH and variable EC results ranging from 6,900 to 23,800 µS/cm.

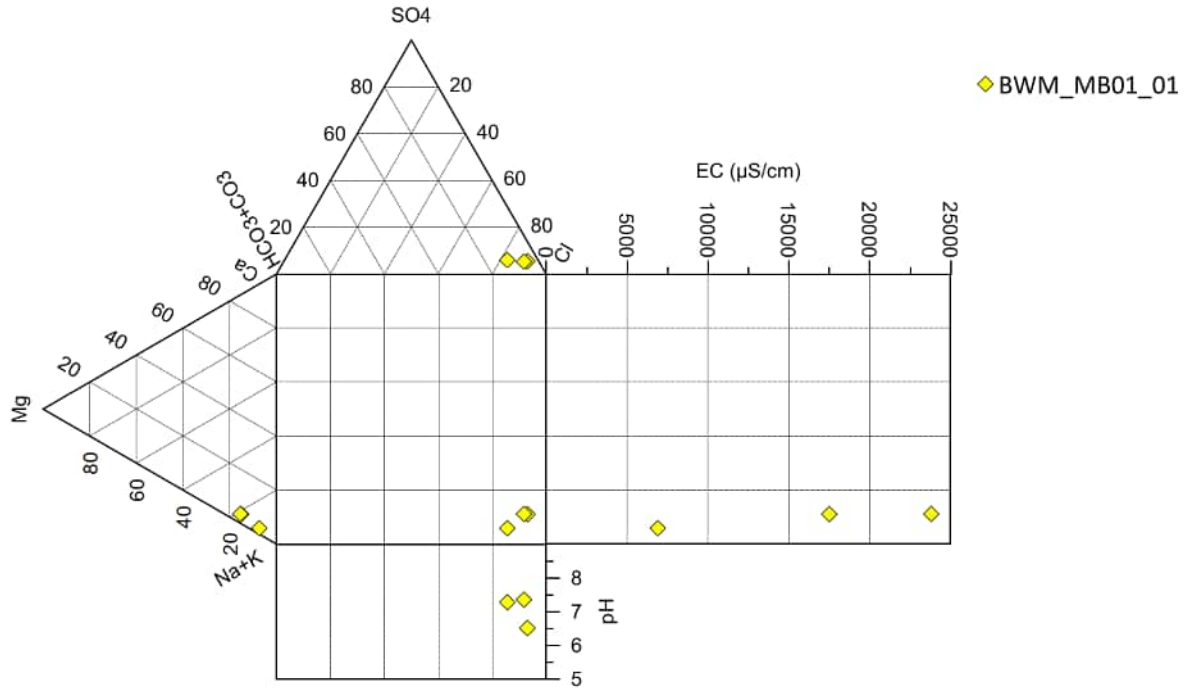


Figure 5-1 Durov Diagram – Alluvium

A Durov diagram for the monitoring bores screened within the Tertiary strata is presented as **Figure 5-2**. Bore BWM_MB22_01 is screened in the basalt, while the other bores are screened within the sediments/weathered strata of the Tertiary. These bores are located at BWM south, with BWM_P4 and BWM_P5 installed to monitor Ramp 72.

Historical groundwater data from the Tertiary strata bores shows an EC range of from 868 to 16,800 µS/cm with a median of 13,200 µS/cm. pH data ranges from 5.3 to 8.1 with a median of 6.4.

Bores MB21 and BWM_P4 recorded Na-Cl type groundwater, while BWM_P4 records Na-SO4 or Na-Mg-SO4 water type. The influence of SO4 on the groundwater chemistry sampled at BWM_P5, which is installed to monitor Ramp 72, suggests that the bore may be impacted by the tailings in the pit. Bore BWM_MB22_01, screened in the basalt, has a markedly different water chemistry than the other tertiary bores, recording Na-HCO3 water type **Figure 5-2**. The influence of HCO3 on the water chemistry of this bore, along with the comparatively fresh EC (868 µS/cm) is suggestive of direct rainfall recharge to the outcropping basalt at this location.

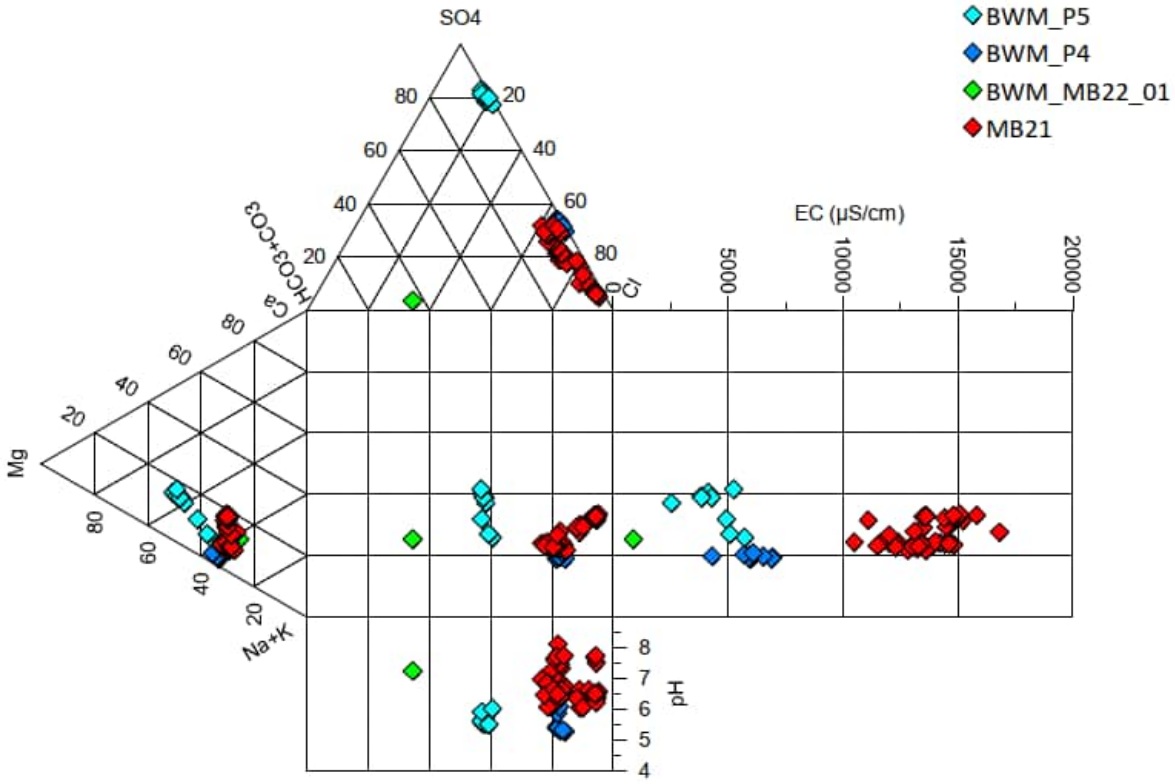


Figure 5-2 Durov Diagram – Tertiary Strata

Of the four bores screened in the Rewan Group, three record Na-Cl type groundwaters and one (MB19BWM25P) records Na-Cl-HCO3 type (**Figure 5-3**). This bore also records a lower EC of around 4,000 µS/cm, whereas the other three bores record ECs ranging approximately 30,000 to 40,000 µS/cm.

Recorded pH from bores in the Rewan Group ranges from mildly acidic to mildly alkaline (pH range 5.9 to 8.0), with a median pH of 6.8.

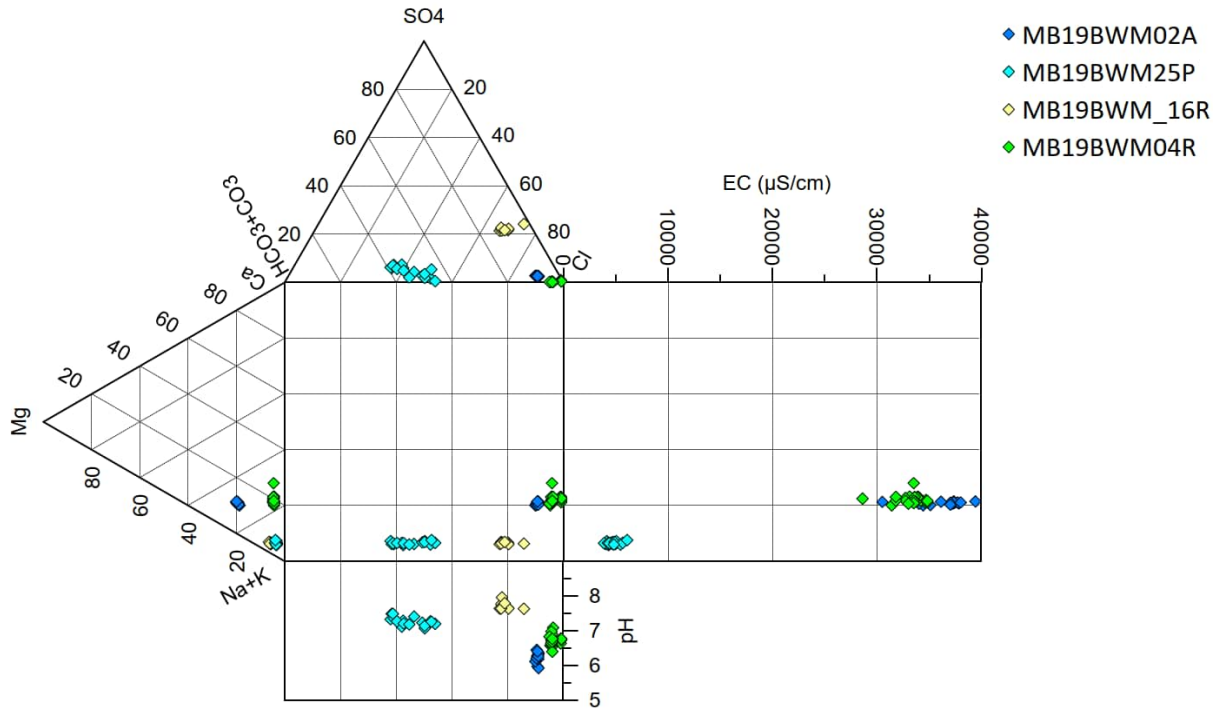


Figure 5-3 Durov Diagram – Rewan Group

The chemical analysis of groundwater from 27 bores targeting the RCM is shown on **Figure 5-4** to **Figure 5-6**. Results from these bores indicate that groundwater within this unit is generally Na-Cl water type. Exceptions to this the five recently installed bores at BWM south (MB19BWM_10P, BWM_MB16_03, BWM_MB01_02, BWM_MB14_02 and BWM_MB21_02). At BWM south, the aforementioned bores show distinctly different groundwater types, plotting as Na-Cl-HCO3 types. Groundwater in the RCM generally has a median EC of 16,800 µS/cm, but ranges from 851 to 36,900 µS/cm. Recorded pH is generally neutral (median value of 7.0), however the data ranges from values between 6 to 12. Outliers occur, with high pH (of between 9 and 12) at bores MB19BWM01P, MB19BWM03P, BWM_MB01_02 and BWM_MB16_03. The elevated pH at these bores is likely unrepresentative of natural conditions and may be due to water interaction with residual cement grout from the bore construction.

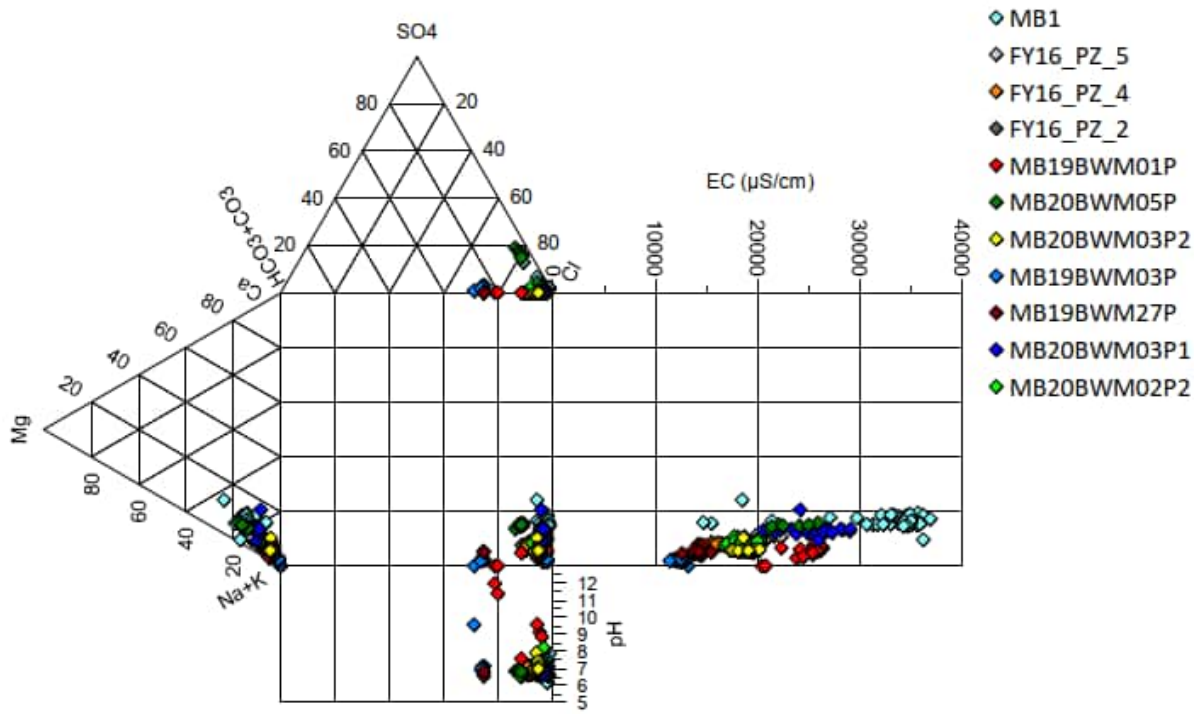


Figure 5-4 Durov Diagram – RCM (North BWM)

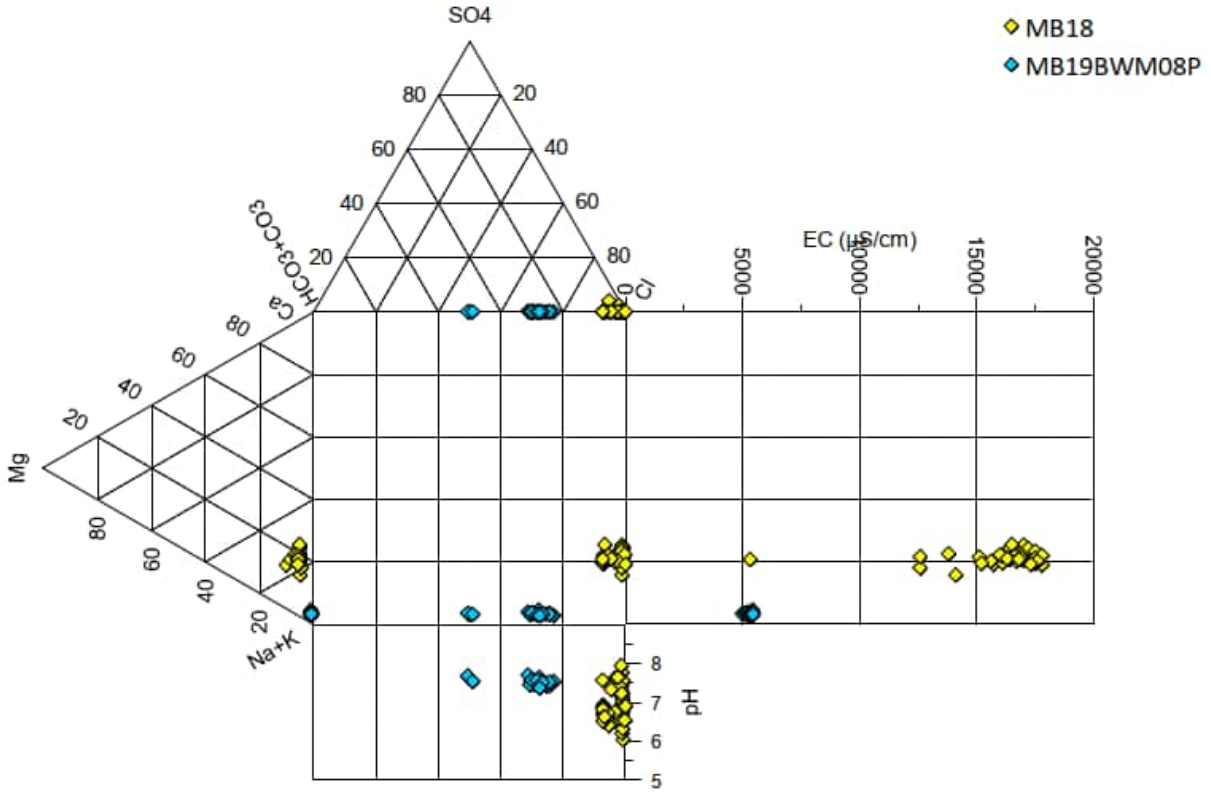


Figure 5-5 Durov Diagram – RCM (Central BWM)

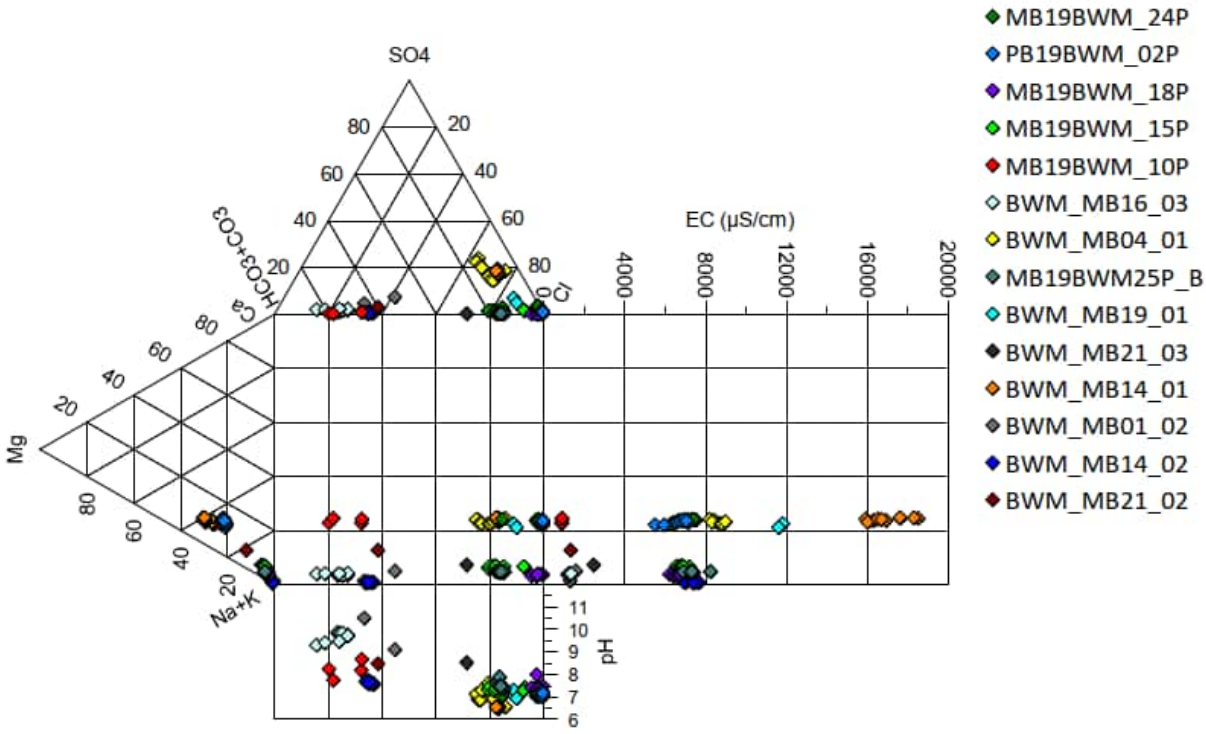


Figure 5-6 Durov Diagram – RCM (South BWM)

Groundwater from four bores screened in the Burngrove Formation record Na-Cl groundwater type (**Figure 5-7**). The results are tightly clustered which suggests that groundwater in the Burngrove Formation has a distinct water chemistry. Groundwater has a median EC of 12,000 µS/cm and ranges from 6,190 to 21,500 µS/cm. pH data shows a range from 5.0 to 8.6, with a median value of 7.2 indicating the groundwater pH is generally around neutral.

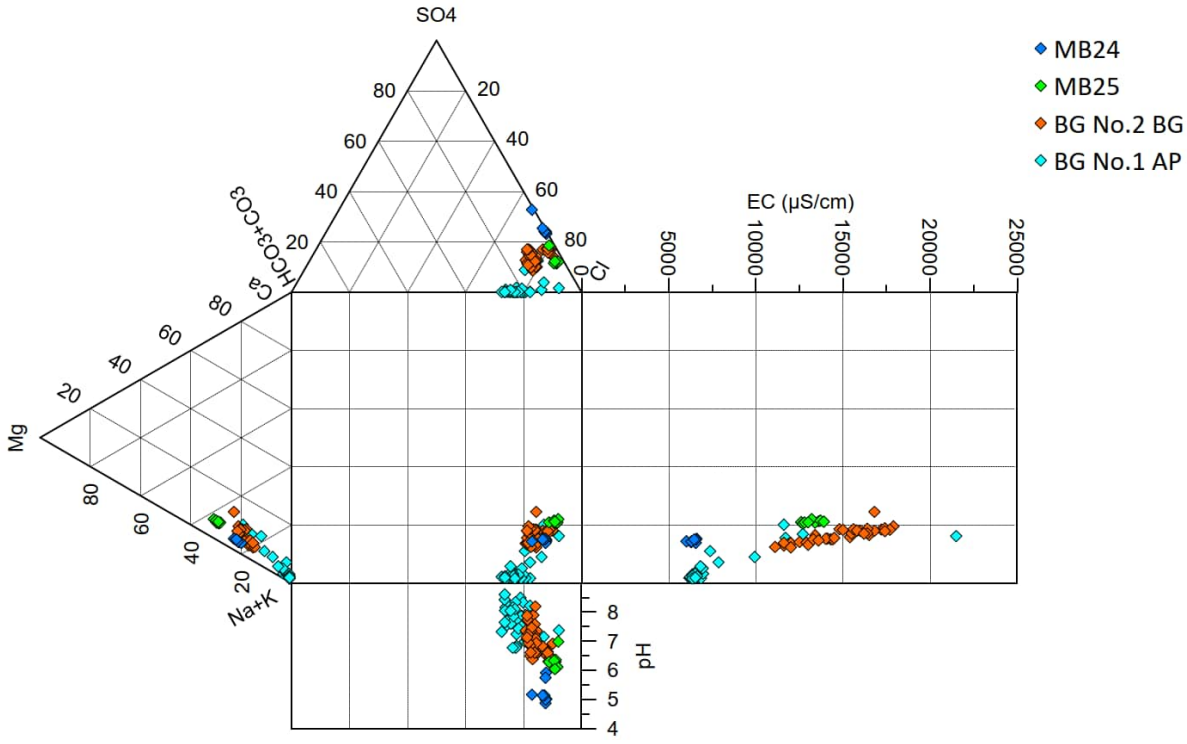


Figure 5-7 Durov Diagram – Burngrove Formation

5.1.2 Salinity

Salinity is a key constraint to water management and groundwater use by receptors and can be described by total dissolved solid (TDS) concentrations. **Figure 5-8** presents the TDS data associated with waters screened in the various hydrostratigraphic units for BWM monitoring bores. Salinity ranges represented on **Figure 5-8** are defined by the Food and Agriculture Organization of the United Nations (FAO, 2013).

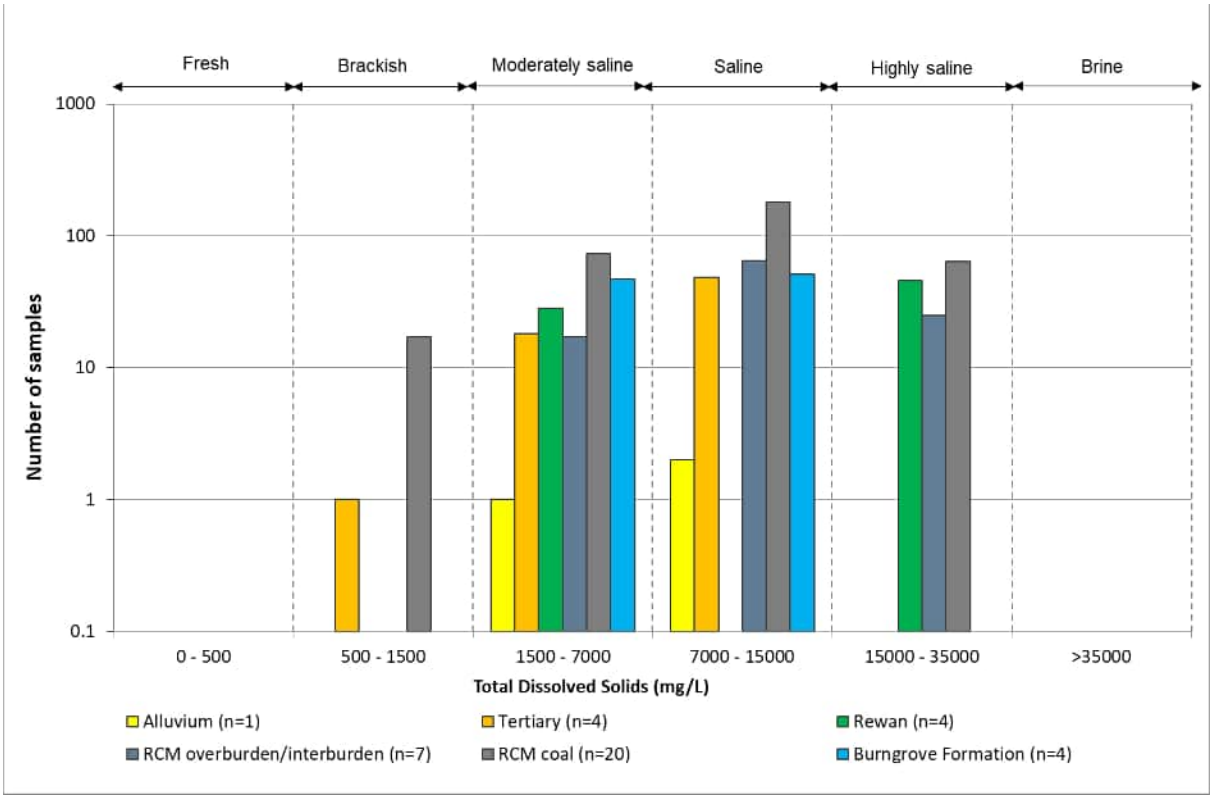
The graph shows that available data from one bore in the alluvium records TDS ranging from moderately saline to saline, with an average TDS of 8,983 mg/L and range between 4,250 mg/L and 11,600 mg/L.

Groundwater in the Tertiary strata ranges from fresh to saline, with an average TDS of 8,134 mg/L and range between 510 and 11,700 mg/L.

In the Rewan Group, groundwater ranges from moderately saline to saline, with an average TDS of 15,803 and range between 2,520 and 30,800 mg/L.

Within the RCM, groundwater ranges from brackish to highly saline, with bores that screen coal seams recording an average TDS of 10,979 and range between 503 to 28,900 mg/L, and bores screening interburden/overburden recording average TDS of 12,106 and range between 3,250 to 23,400 mg/L.

In the Burngrove Formation, groundwater ranges from moderately saline to saline, with an average TDS of 6,877 mg/L and range between 3,250 and 14,400 mg/L.



Note: n = number of bores

Figure 5-8 Salinity Ranking by Hydrostratigraphic Unit

5.1.3 Beneficial Groundwater Use

5.1.3.1 Potentially Relevant Environmental Values and Guidelines

The Project Area lies mainly within the Highlands Groundwater Management Area (GMA) of the Fitzroy Basin under the *Water Plan (Fitzroy Basin) 2011* (**Figure 5-9**). The Highlands GMA consists of the following:

- Highlands Groundwater Unit 1, containing the aquifers of the Quaternary alluvium associated with the Sandy Creek Alluvium sub-area (to the distant northwest of BWM but not located within the Study Area); and
- Highlands Groundwater Unit 2, containing all subartesian aquifers within the Highlands GMA other than the aquifers included in Highlands Groundwater Unit 1.

Volumetric limits apply to extraction of groundwater within the GMA for non-stock and domestic purposes.

Groundwater resources in the Study Area are also scheduled under the *Environmental Protection (Water and Wetland Biodiversity) Policy 2019* (EPP Water and Wetland Biodiversity), as Comet Groundwaters (for the southern part of BWM within the Comet sub-catchment (DEHP, 2011a)) and Mackenzie Groundwaters (for the northern part of BWM within the Upper Mackenzie sub-catchment (DEHP, 2011b)) of the Fitzroy Basin water plan (WQ1310) (**Figure 5-9**). The legislated environmental values (EVs) for these Groundwaters (**Table 5-1**) are:

- Aquatic ecosystems;
- Irrigation;
- Farm supply/use;
- Stock water;
- Primary recreation (Comet Groundwaters only);
- Drinking water;
- Industrial use; and
- Cultural and spiritual values.

Also shown in **Table 5-1** is a comparison of those WQOs to potentially applicable based on the results of the EMM (2019) bore census (see **Section 5.2.1**). EMM (2021) concluded that based on the bores that were surveyed in the 2019 bore census *"the environmental values for groundwater in the area are limited to farm supply/use, stock water and industrial use (.ie mining). Aquatic ecosystems may also be associated with shallow alluvial systems" (***Table 5-1**).

Table 5-1 Environmental Values of Comet and Mackenzie Groundwaters of the Fitzroy Basin

Environmental Values (DEHP, 2011a, 2011b)												
Fitzroy Basin Water Plan (WQ1310) Sub-catchment	Aquatic ecosystems	Irrigation	Farm supply/use	Stock water	Aquaculture	Human Consumer	Primary Recreation	Secondary Recreation	Visual Recreation	Drinking water	Industrial use	Cultural and spiritual values
Comet Groundwaters	☑	☑	☑	☑			☑			☑	☑	☑
Mackenzie Groundwaters	☑	☑	☑	☑						☑	☑	☑
Potentially Locally Applicable based on EMM (2019) bore census	☑		☑	☑							☑	

The EPP Water and Wetland Biodiversity provides water quality objectives (WQOs) for the scheduled EVs in WQ1310. WQOs are long-term goals for water quality management and the purpose of the WQOs is to support and protect EVs. They are numerical concentration levels or narrative statements of indicators established for receiving waters to support and protect the designated EVs for those waters. They are based on scientific criteria or water quality guidelines but may be modified by other inputs (e.g. social, cultural, economic).

Where groundwater quality analysis results exceed a particular WQO for a particular EV, it is considered indicative that the groundwater may be unsuitable for supporting that particular EV.

The WQ1310 WQOs for groundwater relevant to BWM are shown **Table 5-2**.

Table 5-2 Water Quality Objectives for Fitzroy Sub-basin Environmental Values

Water Quality Indicator	Unit	ADWG Guidelines[1]		Mackenzie River Sub-basin EVs			Comet River Sub-basin EVs		
		ADWG Guidelines Health	ADWG Guidelines Aesthetic	Irrigation[2]	Stock[3]	Aquatic 95%[4]	Irrigation[5]	Stock[6]	Aquatic 95%[4]
pH	-	-	6.5 to 8.5	-	-	6.5 to 8.5	-	-	6.5 to 8.5
TDS	mg/L	-	600		5000[7]	-		5000[7]	-
Chloride	mg/L	-	250	-	-	-	-	-	-
Sodium	mg/L	-	180	-	-	-	-	-	-
Aluminium	mg/L	-	0.2	5	5	0.055	5	5	0.055
Arsenic	mg/L	0.01	-	0.1	0.5	0.024	0.1	0.5	0.024
Beryllium	mg/L	0.06	-	0.1	-	-	0.1	-	-
Boron	mg/L	4	-	0.5	5	-	0.5	5	-
Cadmium	mg/L	0.002	-	0.01	0.01	0.0002	0.01	0.01	0.0002
Chromium	mg/L	0.05	-	0.1	1	0.001	0.1	1	0.001
Cobalt	mg/L	-	-	0.05	1	-	0.05	1	-
Copper	mg/L	2	1	0.2	1[6]	0.0014	0.2	1[6]	0.0014
Fluoride	mg/L	1.5	-	1	2	-	1	2	-
Iron	mg/L	-	0.3	0.2	-	-	0.2	-	-
Lead	mg/L	0.01	-	2	0.1	0.0034	2	0.1	0.0034
Lithium	mg/L	-	-	2.5	-	-	2.5	-	-
Manganese	mg/L	0.5	0.1	0.2	-	1.9	0.2	-	1.9
Mercury	mg/L	0.001	-	0.002	0.002	0.0006	0.002	0.002	0.0006
Molybdenum	mg/L	0.05	-	0.01	0.15	-	0.01	0.15	-
Nickel	mg/L	0.02	-	0.2	1	0.011	0.2	1	0.011
Selenium	mg/L	0.01	-	0.02	0.02	0.005	0.02	0.02	0.005
Silver	mg/L	0.1	-	-	-	0.05	-	-	0.05
Uranium	mg/L	0.02	-	0.01	0.2	-	0.01	0.2	-
Vanadium	mg/L	-	-	0.1	-	-	0.1	-	-
Zinc	mg/L	-	3	2	20	0.008	2	20	0.008

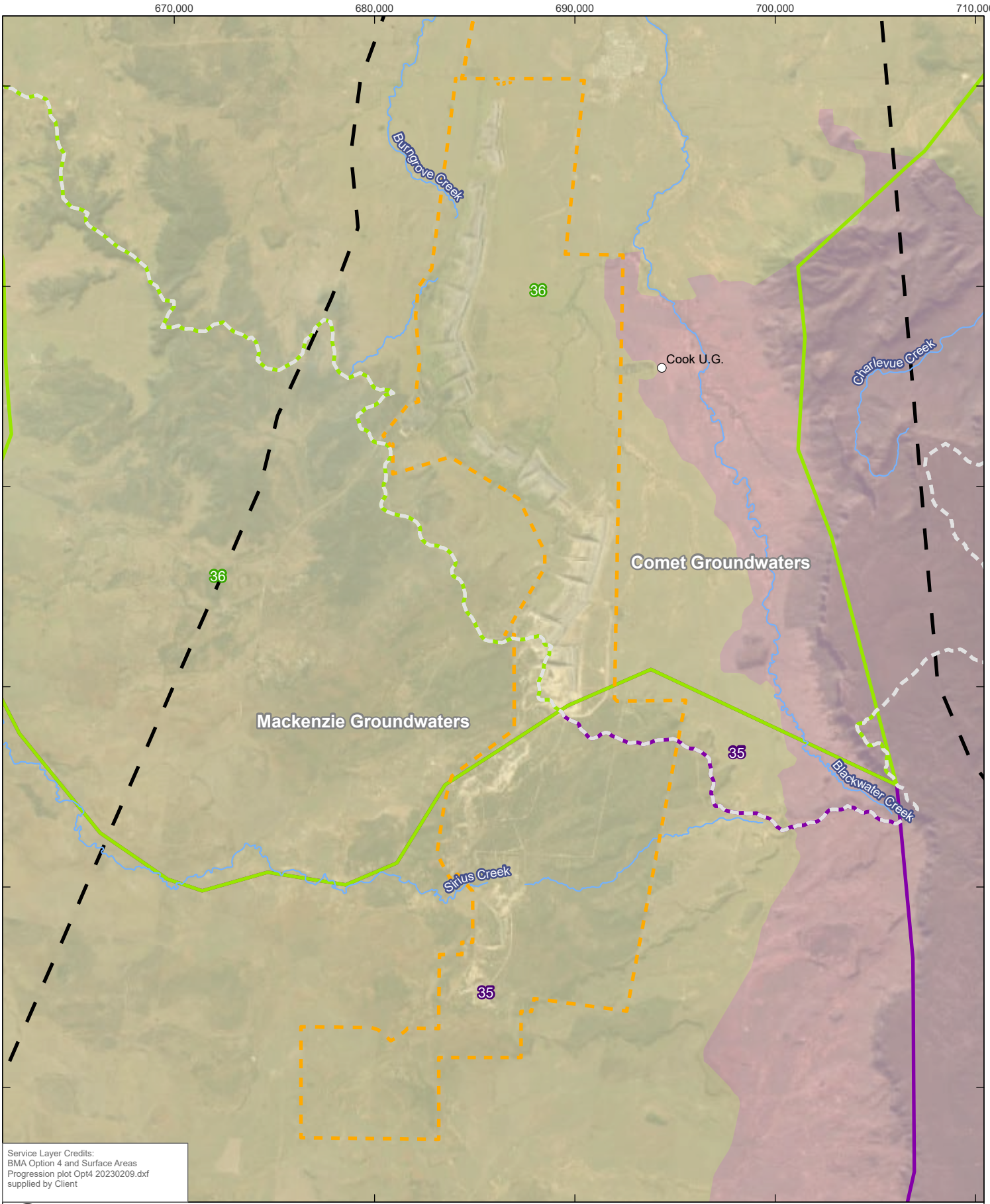
1. NHMRC, NRMMC (2011) Australian Drinking Water Guidelines
2. Table 9 of DEHP (2011b) Mackenzie River Sub-basin Environmental Values and Water Quality Objectives: Irrigation water (Long term value)
3. Table 10 and Table 11 of DEHP (2011b) Mackenzie River Sub-basin Environmental Values and Water Quality Objectives: Stock
value)
4. ANZG (2018) Aquatic ecosystem protection for moderately disturbed system (95% protection)
5. Table 9 of DEHP (2011a) Comet River Sub-basin Environmental Values and Water Quality Objectives: Irrigation water (Long term value)
6. Table 10 and Table 11 of DEHP (2011a) Comet River Sub-basin Environmental Values and Water Quality Objectives: Stock value)
7. Relevant guideline value for cattle

The EPP Water and Wetland Biodiversity also provides limited WQOs specifically for underground aquatic ecosystem protection in Fitzroy Basin groundwaters. These WQOs vary across the Fitzroy Basin and are defined on the basis of groundwater Chemistry Zones. The applicable Chemistry Zones for BWM include the Fitzroy Groundwater Zone 35 and Zone 36 (**Figure 5-9** and **Table 5-3**) which are characterised as sodic dominant at levels of dissolved material that classify general water quality as low to moderate salinity (Zone 36) and saline (Zone 35).

These WQOs are classified by groundwater depth ('shallow' being <30 m depth, and 'deep' being >30 m depth) and are summarised below. The management intent of each WQO zone is to maintain each of 20th, 50th and 80th percentile values.

Table 5-3 Fitzroy Basin Zone 35 and Zone 36 WQOs for groundwater resources (aquatic ecosystem protection) (DEHP, 2011a and 2011b)

Water Quality Indicator	Unit	Zone 35 Shallow Groundwater (<30m)			Zone 35 Deep Groundwater (<30m)			Zone 36 Shallow Groundwater (<30m)			Zone 36 Deep Groundwater (<30m)		
Percentile	-	20th	50th	80th	20th	50th	80th	20th	50th	80th	20th	50th	80th
EC	(µS/cm)	84	870	1983	4103	9375	13604	3100	6300	7410	3475	4150	7255
Hardness as CaCO3	(mg/L)	37	124	430	401	1216	1905	323	363	528	288	354	619
pH	(mg/L)	7.59	7.6	7.93	7.37	7.6	8.01	7.7	7.80	8.35	8.21	8.3	8.66
Alkalinity	(mg/L)	122	320	556	92	189	311	316	600	843	460	572	1322
Ca	(mg/L)	6	14	81	33	146	366	42	53	105	23	45	75
Mg	(mg/L)	3	27	58	45	204	226	46	56	72	44	74	106
Na	(mg/L)	59	113	256	465	1750	2555	590	1404	1511	520	830	1748
Cl	(mg/L)	54	86	392	1079	3316	5368	610	1885	2373	793	1000	1945
SO4	(mg/L)	5	11	25	0	20	122	2	5	120	84	115	210
HCO3	(mg/L)	42	333	646	126	268	376	372	732	1021	541	640	1549
NO3	(mg/L)	0.15	1.4	9.6	0	0.1	0.5	1	4.25	7.50	0.65	2	2.9
SiO2	(mg/L)	43	68	72	9	18	76	25	43	60	32	43	81
F	(mg/L)	0.1	0.2	0.5	0.06	0.3	0.5	0.285	0.3	0.39	0.31	0.4	1.12
Fe	(mg/L)	-	-	-	0	0.01	0.047	0.02	0.02	0.02	0.02	0.02	0.047
Mn	(mg/L)	-	-	-	0.01	0.04	2.495	0.02	0.045	0.07	0.02	0.02	0.047
Zn	(mg/L)	-	-	-	0.01	0.14	0.27	-	-	-	-	-	-
Cu	(mg/L)	-	-	-	0	0.005	0.01	-	-	-	-	-	-



Service Layer Credits:
BMA Option 4 and Surface Areas Progression plot Opt4 20230209.dxf supplied by Client

0 2.5 5 km

Coordinate System:	GDA2020 MGA Zone 55
Scale:	1:250,000 at A4
Project Number:	620.040199
Date Drawn:	18-Jan-2024
Drawn by:	AS

LEGEND

- Coal Mine
- Watercourse
- Project Area (Environmental Authorities boundary)
- Study Area
- WQ1310 - Fitzroy Basin Groundwater Zone

Groundwater Chemistry Zone

- Zone 35
- Zone 36

Groundwater Management Area

- Carnarvon Groundwater Management Area
- Highlands Groundwater Management Area

BLACKWATER MINE - TRANSITIONAL PRCP HYDROGEOLOGY ASSESSMENT

GROUNDWATER MANAGEMENT AREAS, FITZROY BASIN GROUNDWATER ZONES AND CHEMISTRY ZONES

FIGURE 5-9

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040199.00001 BWM PRCP – GW\03 SLR Data\01 CADGIS\GIS\ArcPro\BWM PRCP – GW\BWM PRCP – GW.aprx\620040199_F04_25_Groundwater Management Areas and Chemistry Zones

5.1.3.2 Comparison of Groundwater Quality to Potentially Relevant Guidelines

In order to understand the possible utilisation of groundwater resources within the Study Area, given the scheduled EVs discussed above the available groundwater quality data have been compared to the:

- Australian Drinking Water Guidelines (ADWG) (NRMMC, 2011).
- ANZG (2018) Aquatic ecosystem protection for moderately disturbed system (95% protection).
- Fitzroy Basin Groundwater Water Quality Objectives: Aquatic ecosystems (Zones 35 and Zone 36).
- Mackenzie and Comet River Sub-basin Environmental Values and Water Quality Objectives: stock and irrigation.

A comparison of these guidelines to the 80th percentile of available historical water quality data for each BWM monitoring bore is presented as **Appendix A**. A summary of **Appendix A** is provided in **Table 5-4** as the percentage of analysed bores with 80th percentile groundwater quality data above the relevant guideline for one or more analyte. This is further discussed in detail in the below text.

Table 5-4 Percentage of Analysed Bores in Aquifer with 80th Percentile Groundwater Quality Data Above Relevant Guideline for one or more Analyte (refer Appendix A)

Aquifer	Number of bores Analysed	ADWG Guidelines Health[1]	ADWG Guidelines Aesthetic[1]	Irrigation[2]	Stock[3]	Aquatic 95%[4]	80th %ile WQO limit
Alluvium	1	100%	100%	100%	100%	100%	100%
Tertiary	4	75%	50%	100%	25%	75%	100%
Rewan	4	100%	100%	100%	50%	100%	100%
Permian North	12	92%	50%	92%	92%	92%	92%
Permian South	14	100%	64%	86%	29%	71%	100%
Permian Central	2	100%	50%	100%	50%	100%	100%
Burngrove Formation	4	100%	0%	75%	50%	50%	100%

1. NHMRC, NRMMC (2011) Australian Drinking Water Guidelines
2. Table 9 of DEHP (2011a) Comet River Sub-basin / Table 9 of DEHP (2011b) Mackenzie River Sub-basin Environmental Values and Water Quality Objectives: Irrigation water (Long term value).
3. Table 10 and Table 11 of DEHP (2011b) Mackenzie River Sub-basin Environmental Values and Water Quality Objectives: Stock.
4. ANZG (2018) Aquatic ecosystem protection for moderately disturbed system (95% protection).
5. Fitzroy Basin Zone 35 and Zone 36 WQOs for groundwater resources (aquatic ecosystem protection) (DEHP, 2011a and 2011b)

Quaternary Sediments

Water quality data from one bore in the alluvium with available data shows that concentrations from most analytes are generally higher than the relevant Fitzroy Basin WQOs for aquatic ecosystem protection. Alluvium groundwater data also indicates it is generally not suitable for supporting the Aquatic Ecosystems EV with respect to copper and zinc. The 80th percentile concentrations of the alluvium data also indicate the alluvial groundwater is generally unsuitable to support the Drinking Water EV with respect to

chloride, sodium and manganese, uranium and TDS, the Irrigation EV with respect to boron, manganese and uranium, and the Stock Watering EV with respect to TDS (salinity).

Tertiary Sediments and Basalt

Water quality data is available from four tertiary bores, BWM_MB22_01 is screened in the basalt, while the other bores are screened within the sediments/weathered strata of the Tertiary. It is noted that BWM_P4 and BWM_P5 are installed to monitor Ramp 72 and may be impacted by the tailings in the pit.

The tertiary strata monitoring bore data shows that there are analyte concentrations higher than the relevant Fitzroy Basin WQOs for Aquatic Ecosystem protection across all four analysed bores (see **Appendix A**).

Tertiary monitoring data shows water quality above the Irrigation EV guideline with respect to boron, iron, cobalt, manganese, nickel or molybdenum (see **Appendix A**). Tertiary monitoring bore data also shows water quality data above the Drinking Water EV guideline, with respect to pH, chloride, iron, sodium, or TDS and above the Aquatic Ecosystems EV guideline with respect to pH, chromium, copper, manganese, nickel, zinc or selenium. The exception to this is bore BWM_MB22_01 which did not show any 80th percentile analyte concentrations above the Aquatic Ecosystems EV or Drinking Water EV guidelines. The monitoring data also shows that of the Tertiary bores, only one of four bores showed water quality above the Stock EV guideline (MB21 with respect to TDS, see **Appendix A**).

Triassic Rewan Group

Groundwater quality data from four bores screened in the Rewan Group shows that most analyte concentrations are generally higher than the relevant Fitzroy Basin WQOs for Aquatic Ecosystem protection. The data also indicates it is generally not suitable for supporting the Aquatic Ecosystems EV with respect to most relevant metals concentrations (**Appendix A**). The monitoring bore data also suggests that it is generally not suitable for supporting the Drinking Water, Stock, Irrigation EVs (**Appendix A**).

Rangal Coal Measures

As with the Alluvium, Tertiary and Rewan Group, RCM monitoring bore data shows concentrations of most analytes are generally higher than the relevant Fitzroy Basin WQOs for Aquatic Ecosystem protection.

RCM monitoring bore data generally suggests that RCM groundwater in the Project Area is unsuitable to support the Aquatic Ecosystems EVs with respect to pH, arsenic, cadmium, chromium, copper, nickel, lead, selenium or zinc (see **Appendix A**). The RCM monitoring bore data also generally suggests that RCM groundwater in the Project Area is also unsuitable to support the irrigation water EV with respect to boron, iron, molybdenum, manganese, selenium or uranium. The monitoring bore data shows 16 out of 28 bores with water quality generally above the Stock water EV guideline (including with respect to selenium, fluoride or TDS (**Appendix A**).

Burngrove Formation

Groundwater quality data is available from four bores screened in the Burngrove Formation. BG No.1 AP and BG No.2 BG are located in the north of the Project Area and MB24 and MB25, installed to monitor Red Dams are in the south.

Groundwater quality data from bores screened in the Burngrove Formation shows that most analyte concentrations are generally higher than the relevant Fitzroy Basin WQOs for Aquatic Ecosystem protection.

Burngrove Formation groundwater data also indicates it is generally not suitable for supporting the Aquatic Ecosystems EV with respect to selenium at bores BG No.2 BG and BG No.1 AP. The data also shows that groundwater from the Burngrove Formation is generally unsuitable to support the Drinking Water EV with respect to chloride, iron, manganese, sodium or TDS and the Irrigation EV with respect to boron, fluoride or iron. The monitoring bore data also suggests that it is unsuitable for supporting Stock Watering EV with respect to TDS at MB25 and BG No.2 BG.

Summary

In summary, the comparison of available groundwater quality data from the BWM monitoring bores shows that all hydrostratigraphic units at BWM generally exhibit water quality that exceeds some of the relevant parameter criteria for the scheduled EVs.

5.2 Groundwater Receptors

5.2.1 Anthropogenic

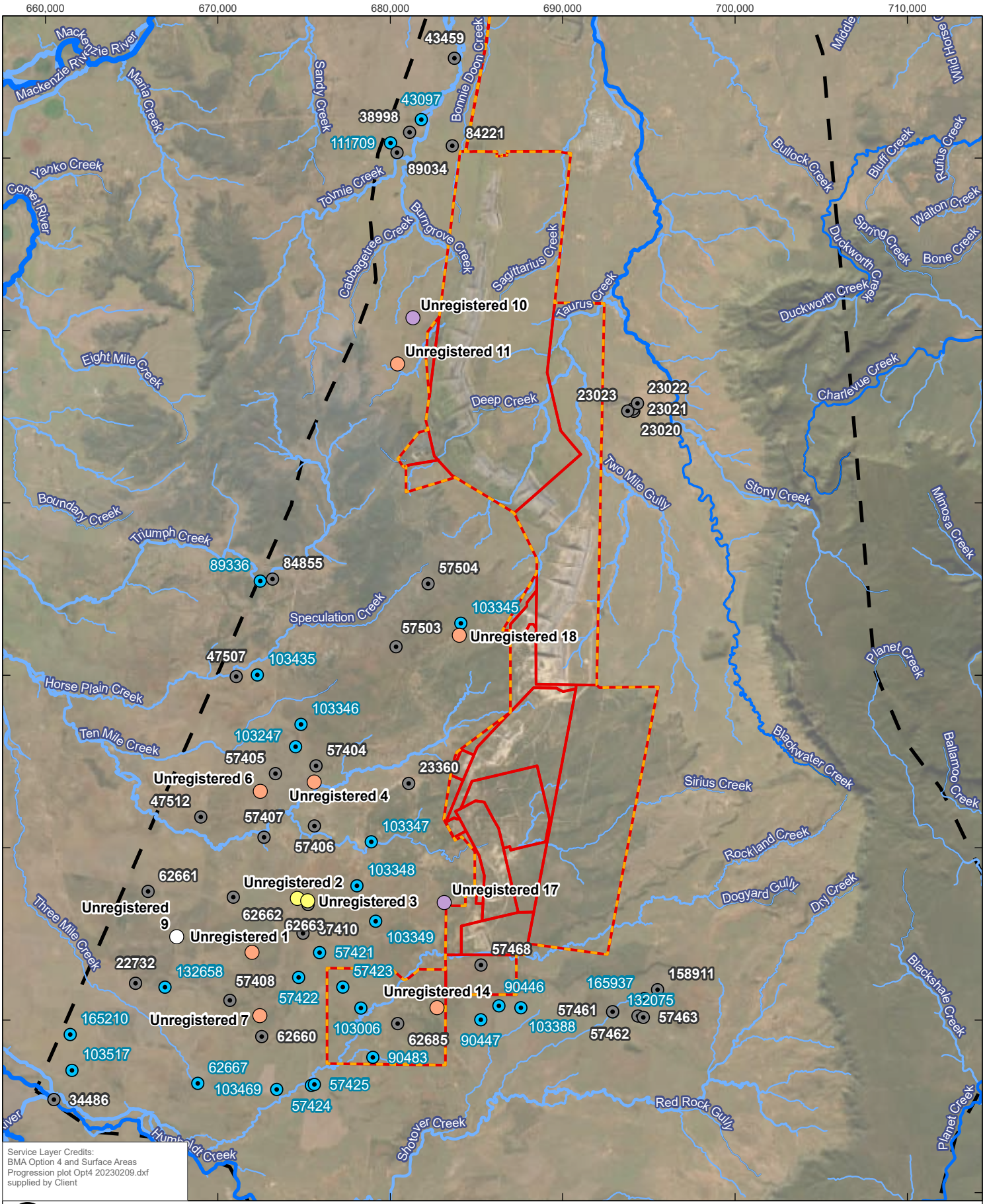
A search of the Queensland Government's Registered Groundwater Bore Database (GWDB) (DRDMW, 2023) and the Bureau of Meteorology's National Groundwater Information System (NGIS) (BoM, 2017) was carried out for registered bores within the Study Area. The search returned 313 bores with registered uses as mine monitoring (190 bores), petroleum exploration (3 bores), sub-artesian monitoring (23 bores), water resources investigation (3 bores), water supply (28 bores), unknown (32 bores) and decommissioned (34 bores). The location of private water supply bores (i.e. those 28 bores listed in the GWDB as water supply) and potential water supply bores (i.e. those 32 bores listed as unknown) are shown on **Figure 5-10**.

A landholder bore census was conducted at BWM by EMM (2019). The census identified 12 unregistered bores, with all but one located west of BWM (**Table 5-5** and **Figure 5-10**). The results of the survey indicated that 10 of the bores were in use while the other two were not in use.

Table 5-5 Unregistered Groundwater Bores identified by EMM (2019) Bore Census

Bore ID	Easting[1]	Northing[1]	Depth (mbGL)	Use	Assigned Aquifer	Comment
Unregistered 1	671980	7343932	33	stock	Basalt	-
Unregistered 2	674609	7347060	unknown	stock and domestic	Basalt	-
Unregistered 3	675207	7346921	unknown	stock and domestic	Basalt	-
Unregistered 4	675587	7353809	unknown	stock	Basalt/Burngrove Formation	-
Unregistered 6	672460	7353271	unknown	stock	Basalt/Burngrove Formation	-
Unregistered 7	672433	7340259	unknown	stock	Basalt/Rangal Coal Measures	-
Unregistered 9	667609	7344838	unknown	unknown	Rangal Coal Measures	-
Unregistered 10	681315	7380737	49	not in use	Burngrove Formation	-
Unregistered 11	680421	7378060	unknown	stock	Burngrove Formation	-
Unregistered 14	682713	7340723	unknown	stock	Basalt	-
Unregistered 17	683129	7346820	unknown	not in use	Unknown	Bore not used for 40 years. Bore is blocked approximately 1 m from surface.
Unregistered 18	684005	7362321	unknown	stock	Burngrove Formation	-

1 Coordinates GDA 2020 z55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7,340,000
7,330,000
Mackenzie River
Maria Creek
Sandy Creek
Bonnie Doon Creek
Middle
Wild Horse
Yanko Creek
Comet River
Tolmie Creek
Cabbagetree Creek
Burngrove Creek
Sagittarius Creek
Bullock Creek
Bluff Creek
Rufus Creek
Walton Creek
Spring Creek
Bone Creek
Duckworth Creek
Taurus Creek
Eight Mile Creek
Deep Creek
Charlevue Creek
Two Mile Gully
Stony Creek
Mimosa Creek
Boundary Creek
Triumph Creek
Speculation Creek
Planet Creek
Horse Plain Creek
Ten Mile Creek
Blackwater Creek
Ballamoo Creek
Sirius Creek
Rockland Creek
Dogyard Gully
Dry Creek
Three Mile Creek
Blackshale Creek
Red Rock Gully
Shotover Creek
Humboldt Creek
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Unregistered 11
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57405
57404
23360
Unregistered 6
Unregistered 4
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103347
57406
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103348
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LEGEND
Major Watercourse
Minor Watercourse
Project Area (Environmental Authorities boundary)
BWM Mining Lease
Study Area
Groundwater Database Bore
Water Supply
Unknown
Bore Census Unregistered Bores EMM (2019)
Stock
Stock and Domestic
Not in Use
Unknown
Coordinate System: GDA2020 MGA Zone 55
Scale: 1:290,000 at A4
Project Number: 620.040199
Date Drawn: 22-Feb-2024
Drawn by: AS
BLACKWATER MINE - TRANSITIONAL PRCP HYDROGEOLOGY ASSESSMENT
PRIVATE BORES
SLR
DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.
FIGURE 4-25
Path: H:\Projects-SLR\620-BNE\620-BNE\620.040199.00001 BWM PRCP – GW\03 SLR Data\01 CADGIS\GIS\ArcPro\BWM PRCP – GW\BWM PRCP – GW.aprx\620040199_F05_10_Private Bores

5.2.2 Environmental

5.2.2.1 Groundwater Dependent Ecosystems

National Atlas of Groundwater Dependent Ecosystems

A groundwater dependant ecosystem (GDE) is a natural ecosystem that requires “access to groundwater to meet all or some of their water requirements on a permanent or intermittent basis, so as to maintain their communities of plants and animals, ecosystem processes and ecosystem services” (Richardson, S., et al., 2011).

The BoM’s National Atlas of Groundwater Dependent Ecosystems (GDE Atlas) (BoM, 2017) classifies ecosystems based on the potential for dependence on groundwater through multiple lines of scientific evidence. Ecosystems have been mapped as either:

- High potential for groundwater dependence (indicating a strong possibility the ecosystem is interacting with groundwater);
- Moderate potential for groundwater dependence; or
- Low potential for groundwater dependence (indicating it is relatively unlikely the ecosystem will be interacting with groundwater and will include ecosystems that are not interacting with groundwater).

Desktop mapping of potential aquatic and terrestrial GDEs indicates that areas with possible high, moderate, and low potential for groundwater interaction occur in the vicinity of the Project Area (**Figure 5-11**).

Figure 5-11 shows that within the Study Area, approximately 15 km southeast of BWM there are two mapped known GDEs (springs) associated with the Clematis Group outcrop escarpment.

Local GDE Studies

Field investigations to verify the groundwater dependence of potential GDEs identified in the BoM GDE Atlas desktop mapping (i.e. ground-truthing investigations) have been undertaken in the vicinity of north BWM by EMM (2023a) for potential terrestrial GDEs, and EMM (2023b) for potential aquatic GDEs. The outcome of these investigations are summarised below. No ground-truthing local investigations have been undertaken in the vicinity of south BWM.

Field surveys were undertaken that identified and characterised remnant regional ecosystem terrestrial vegetation within the vicinity of north BWM. EMM (2023a) then utilised depth to groundwater table mapping prepared by RDM Hydro et al. (2023) and information on maximum plant rooting depths for the identified vegetation species to assess whether the groundwater table was within the potential rooting depths of the vegetation, and thus if the vegetation may be reliant at least in part on groundwater. **Figure 5-11** shows the area of ground-truthed regional ecosystems that EMM (2023a) found may represent terrestrial GDEs. As shown, the results of the work indicated that only the riparian terrestrial vegetation associated with Taurus Creek (a tributary of Blackwater Creek) on the eastern margin of the Project Area and a very small area along Sagittarius Creek to the north of the Project Area may represent a terrestrial GDE. The terrestrial vegetation in this area consists of narrow linear communities that fringe the creek, with potential Terrestrial GDE vegetation types consisting primarily of poplar box (Eucalyptus populnea), forest red gum (Eucalyptus tereticornis), or river red gum (E. camaldulensis) (EMM, 2023a).

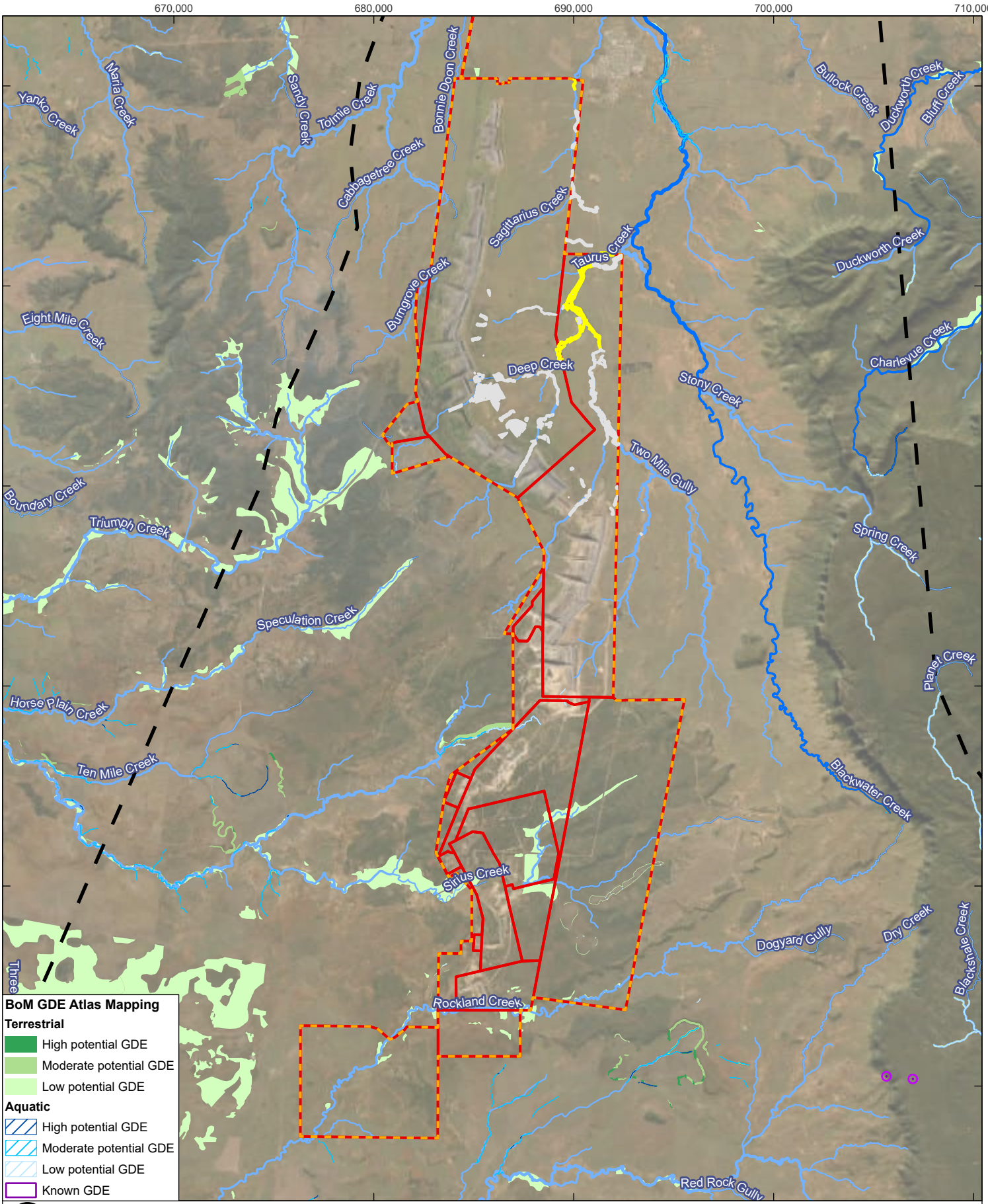
Further site specific information is required to verify mapped potential terrestrial GDEs are GDEs. Particularly, the assessment result indicating potential groundwater dependence

along Taurus Creek remains highly uncertain, given the distinct lack of monitoring bores in this area to confirm the depth to groundwater table mapping prepared by RDM Hydro et al. (2023) that EMM (2023a) adopted in the assessment. Furthermore, as stated above, no ground-truthing local investigations have been undertaken in the vicinity of south BWM.

Assessments to verify mapped potential aquatic GDEs include the field survey undertaken by EMM (2023b) in the vicinity of BWM North. The outcome of this survey is summarised by EMM (2023b) in the Aquatic Ecology Baseline Assessment Report as:

"Prolonged dry conditions in the lead-up to the December 2019 surveys provided ideal conditions for identifying surface expressions of groundwater (i.e aquatic GDEs). However, no flows, salt seeps, hydrophytes, or other obvious indicators of aquatic GDEs were encountered. Further, the concentration and relative proportion of major anions and cations in surface water samples collected from the survey area in December 2019 and May 2020 showed no obvious groundwater influence. Field verification of riparian vegetation and aquatic habitats of the survey area found no obvious on-ground indicators of aquatic GDEs."

That is, the field verification of aquatic habitats in the vicinity of north BWM found no indicators of aquatic GDEs (EMM, 2023b) indicating that the BoM GDE Atlas mapping of potential GDEs in this area is potentially erroneous.



0 2.5 5 km

Coordinate System:	GDA2020 MGA Zone 55
Scale:	1:250,000 at A4
Project Number:	620.040199
Date Drawn:	22-Feb-2024
Drawn by:	AS

LEGEND

- Major Watercourse
- Minor Watercourse
- Project Area (Environmental Authorities boundary)
- BWM Mining Lease
- Study Area

GDE Ground-truthing near BWM North (EMM, 2023a)
Potential Terrestrial GDE

- Potential
- Unlikely

BLACKWATER MINE - TRANSITIONAL PRCP HYDROGEOLOGY ASSESSMENT

GROUNDWATER DEPENDENT ECOSYSTEM MAPPING

SLR

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FIGURE 5-11

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040199.00001 BWM PRCP – GW\03 SLR Data\01 CADGIS\GIS\ArcPro\BWM PRCP – GW\BWM PRCP – GW.aprx\620040199_F05_11_Groundwater Dependent Ecosystem Mapping

6.0 Conceptual Site Models – End of Mining

A conceptual hydrogeological model (CHM) of the groundwater regime has been developed based on the review of the hydrogeological information for the Study Area presented in the above report sections. The CHM of the groundwater regime is discussed in the below sections as general (**Section 6.1**) and end of mining (**Section 6.2**)

Visual representations of the CHM for the groundwater regime have been developed based on the hydrogeological data review presented above. CHMs have been developed showing the end of mining at north BWM (**Figure 7-1**) and the end of mining at south BWM (**Figure 7-2**).

6.1 General

The Project is located within the southern part of the Bowen Basin, which comprises Permian aged coal measures that have been folded into a syncline structure that strikes in a north-west to south-east direction.

The main hydrostratigraphic units relevant to the Study Area include:

- Alluvium – Alluvial deposits are associated with local creeks. In recent years, the alluvium local to the Project Area has been found to be limited in extent, and dry. The alluvium forms a localised unconfined aquifer where saturated water levels (i.e. the water table) is above the base of the alluvium
- Tertiary Sediments and Basalt –- Unconsolidated surface layer of weathered rock (also termed regolith) including Tertiary strata and basalt flows, which may provide a preferential flow pathway for groundwater if the groundwater table exceeds the base of weathering. The unit forms an unconfined aquifer when saturated.
- Clematis Group – Forms an unconfined aquifer where it outcrops at the eastern margin of the Study Area.
- Rewan Group – Considered a regional scale aquitard, however local permeability testing indicates hydraulic conductivity values may be higher in the upper weathered zone of the unit.
- Rangal Coal Measures – Coal seams of this unit form the primary regional aquifer. Groundwater flow is primarily within the coal seams (via interconnected cleats and fractures), which are confined by low permeability overburden and interburden that essentially form aquitards. The coal measures are highly locally faulted resulting in “compartmentalisation” with coal seams juxtaposed against lower permeability interburden.
- Burngrove Formation – Coal seams of this unit form a regional scale aquifer in conjunction with low permeability overburden and interburden that essentially form aquitards. Considered the basement formation for the purposes of this assessment.

The alluvium is often found to be limited in extent and thickness, and unsaturated, but may become temporarily saturated following rainfall recharge and occasional seepage from ephemeral creek streamflow. Groundwater levels in the unconfined alluvium, where saturated, are expected to be a subdued reflection of topography, with flow toward the north at north BWM and towards the southwest at south BWM. In rare occasions where the alluvium is found to be saturated, groundwater is predominantly restricted to the coarser grained alluvium (that can more easily transmit water). The coarser grained areas of alluvium are separated by clay lenses and outcropping bedrock, with limited connectivity between areas of saturated alluvium. The alluvium is considered to be recharged predominantly via occasional ephemeral stream flow (i.e. losing conditions), or via flooding.

Recharge to the alluvium also occurs via direct rainfall infiltration which occurs rapidly where there are no substantial clay barriers in the shallow subsurface. Overall, recharge is expected to be low due to the presence of surficial clays. On a regional scale, outflow occurs via evapotranspiration from vegetation growing along creek beds. Minor short duration baseflow events after significant rainfall/flooding are possible, however there was no data available to support or reject this hypothesis. Despite extensive drilling targeting the alluvium, groundwater quality data is only available from one alluvium monitoring bore (due to limited extent of the alluvium and areas of saturation where it exists). Data from this bore suggests that water quality in the alluvium ranges from moderately saline to saline and is generally unsuitable to be used for drinking water, stock, or irrigation purposes.

Within the Tertiary units, the strata is typically unsaturated at north BWM but saturated in the south BWM area. Similar to the alluvium, groundwater flow in the Tertiary units is expected to be controlled by topography and flow towards the north at north BWM (where present), and towards the southwest at south BWM. As per the alluvium, recharge to the Tertiary strata is expected to be low due to the presence of overlying clays. Outflow from the Tertiary aquifer is considered to be primarily through evapotranspiration and leakage to underlying aquifers. Water quality data for the Tertiary units is highly variable, ranging from fresh to saline, but generally indicates that Tertiary groundwater is unsuitable to be used for drinking water or irrigation purposes, while the water quality data from three of the four bores in the suggested suitable use for stock water purposes.

The Rewan Group is considered a regional scale aquitard, though still contains some saturated horizons. Due to its typically fine grained nature, the Rewan Group generally exhibits a low vertical hydraulic conductivity, resulting in limited hydraulic connection between the unit and the underlying/overlying units. Groundwater level data from the four saturated monitoring bores grouped in the northern area of BWM indicates a groundwater flow direction towards the north, which is consistent with topographical gradients. Groundwater flow in the Rewan Group in the southern portion of BWM is also expected to follow topography, with a flow direction towards the south and southwest. Recharge is expected to occur predominantly via leakage from the overlying units. Recharge rates are likely very low due to the low hydraulic conductivity of the unit restricting infiltration. Outflow is expected to occur via lateral flow, with the low hydraulic conductivity limiting significant leakage to underlying units. Water quality in the Rewan Group ranges from moderately saline to saline and is indicated to be generally unsuitable to be used for drinking water, stock, or irrigation purposes.

The RCM forms the main regional aquifer in the Study Area. Within the RCM, coal seams form the main groundwater bearing units, with low hydraulic conductivity interburden generally confining the individual seams. The coal seams are dual porosity in nature, with the secondary (dominant) porosity provided by fractures (joints and cleats). Hydraulic conductivity of the coal decreases with depth due to increasing overburden pressure reducing the aperture of fractures. Due to the confining nature of the interburden layers, flow is primarily horizontal through the coal seams, and recharge primarily occurs where the unit sub-crops. Outflow primarily occurs through inflow to active mining areas. To a much lesser degree, outflow also occurs through horizontal flow outside of the cone of depression formed by mining voids. Groundwater flow direction in the RCM in the vicinity of mining is towards the mine pit voids, consistent with discharge to the active mine pits.

Across the parts of BWM south that are unmined to date, flow direction is south to southwest, with a groundwater divide evident consistent with the surface catchment divide that runs between central and south BWM. Groundwater quality in the RCM ranges from brackish to highly saline and is generally indicated to be unsuitable for drinking water or irrigation purposes, while the water quality data from just over half of the bores suggested suitable use for stock watering purposes.

Groundwater occurrence in the Burngrove Formation is similar to the RCM, with coal seams forming the main aquifer in conjunction with low permeability overburden and interburden that essentially form aquitards. Based on the limited available data, groundwater flow direction in the Burngrove Formation is suggested to be from south to north at BWM north and north to south at BWM south (i.e. consistent with topography). Recharge to the Burngrove Formation is expected to occur where the unit outcrops along the western margin of the Project Area. Outflow from this formation is expected to be through lateral flow in the direction of regional groundwater flow, with some upwards leakage to the depressurised RCM. Groundwater quality is suggested to range from moderately saline to saline and is generally indicated to be unsuitable for drinking water, stock, or irrigation purposes.

6.2 End of Mining

A visual representation of the end of mining conceptual hydrogeological model is provided as **Figure 7-1** for the northern area of BWM and **Figure 7-2** for the southern area of BWM. Based on an understanding of hydrogeological mechanisms and previous studies by SLR (2023a and 2023b), key features relevant to the discussion of potential groundwater impacts post-mining are likely to be:

- Groundwater level drawdown of the RCM, associated with passive dewatering into the active BWM mine pit voids. The magnitude of this drawdown will be most significant in the immediate vicinity of the pits, but extend northwards, eastwards and southwards of BWM by several kilometres.
- Mine pit voids capture any seepage from soil emplacements due to the hydraulic gradient orientated towards the mine void.
- Limited potential for groundwater level drawdown in the alluvium and Tertiary due to limited saturation, and poor lateral connection of water bearing zones.
- No groundwater level drawdown of the alluvium away from BWM.
- Limited potential for groundwater level drawdown impacts to potential terrestrial GDE’s due to the limited potential for groundwater level drawdown in the alluvium and Tertiary.
- No potential for groundwater quality impacts outside of BWM associated with spoil dumps, due to the inward groundwater flow gradients towards the pit voids capturing all potential seepage.

7.0 Potential Impacts

7.1 Groundwater System at End of Mining

The SLR (2023a and 2023b) work has been interrogated to provide an indication of the predicted nature of the groundwater system at the end of mining, and potential groundwater system impacts that may arise at the end of mining.

These can be summarised as:

- Groundwater level drawdown of the RCM, associated with passive dewatering into the active BWM mine pit voids. The magnitude of this drawdown will be most significant in the immediate vicinity of the pits, but extend northwards, eastwards and southwards of BWM by several kilometres.
- Mine pit voids capture any seepage from spoil emplacements due to the local hydraulic gradient orientated towards the mine voids.
- Limited potential for groundwater level drawdown in the alluvium and Tertiary strata due to limited saturation, and poor lateral connection of water bearing zones.
- No groundwater level drawdown of the alluvium away from BWM.
- Limited potential for groundwater level drawdown impacts to potential terrestrial GDE's due to the limited potential for groundwater level drawdown in the alluvium and Tertiary strata.
- No potential for groundwater quality impacts outside of BWM associated with spoil dumps, due to the inward groundwater flow gradients towards the pit voids capturing all potential seepage.

7.2 Groundwater System Post Mining

SLR (2023a) conducted a post-mining assessment of the NEP final voids in the north of BWM. The results of the assessment can be considered indicative of the potential impacts to the groundwater system in the post-closure period as relevant to this hydrogeology assessment, that will be investigated further by adopting the updated final landform for all of BWM consistent with the PRC Plan. The post-closure predicted groundwater system documented in the earlier work by SLR (2023a) can be summarised as:

- Residual void lake formation, with lake levels stabilising significantly below the pre-mining groundwater elevations and any shallow post-Permian strata, including the base of surficial weathering and shallow hydrostratigraphic units (i.e. alluvium and Tertiary strata).
- Partial groundwater system recovery outside the residual voids, primarily in the RCM. Ongoing groundwater discharge to the residual voids driven by the inwards hydraulic gradient between the void lakes and the surrounding groundwater system, and maintained by ongoing evaporative discharge from the void lakes keeping the residual void lakes as groundwater sinks.
- Potential for ongoing salinization of the residual void lakes.
- No potential for groundwater quality impacts outside of BWM associated with spoil dumps, due to the inward groundwater flow gradients towards the residual voids continuing to capture all potential seepage.

The remainder of this report focuses on the detailed assessment of the PRC Plans final landform, i.e. an update to the SLR (2023a) post-mining potential impacts discussed above.

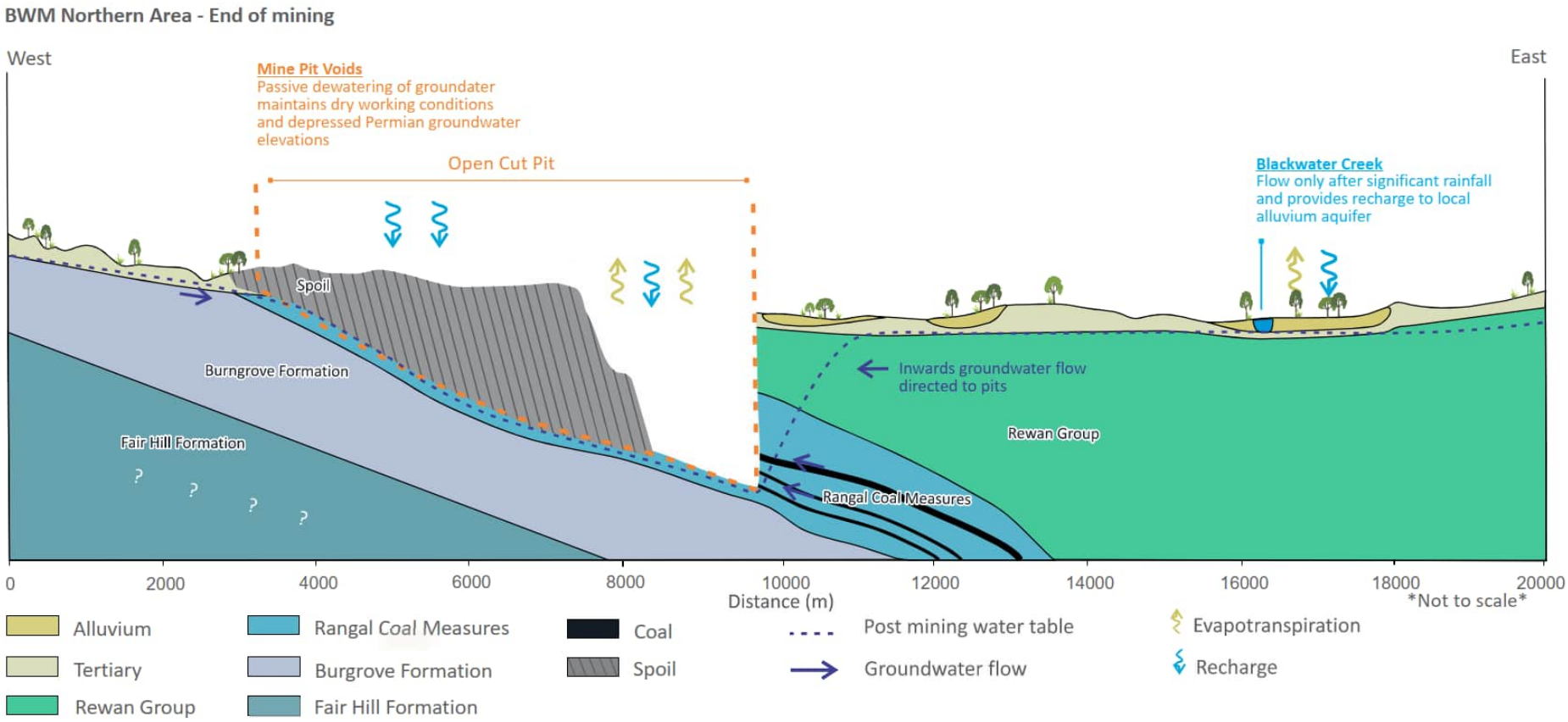


Figure 7-1 Conceptual Hydrogeological Model of BWM Groundwater System – BWM Northern Area (End of Mining)

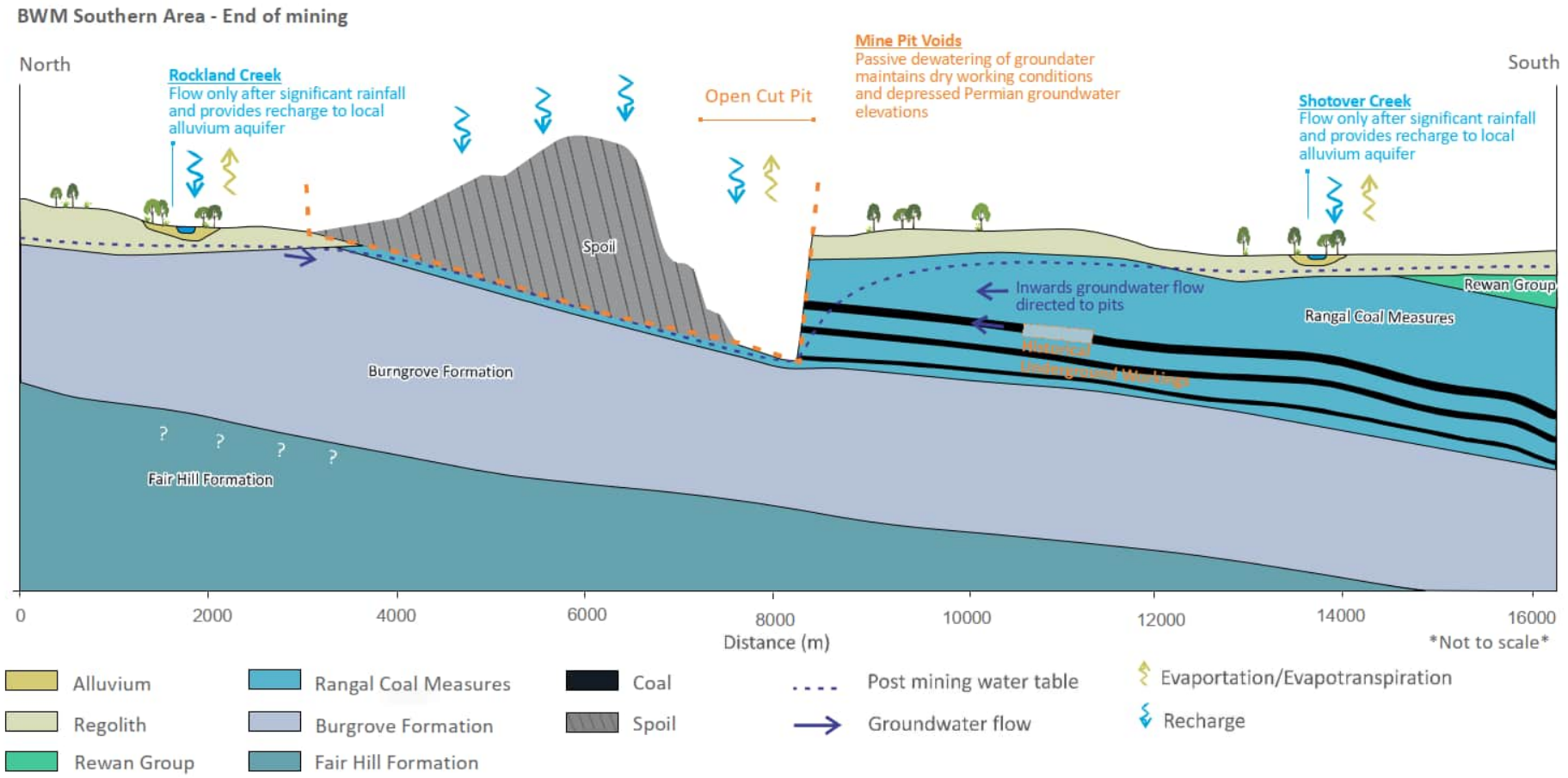


Figure 7-2 Conceptual Hydrogeological Model of BWM Groundwater System – BWM Southern Area (End of Mining)

8.0 Groundwater Modelling

In order to assess the potential post-closure groundwater impacts relevant to the PRC Plan, numerical groundwater modelling has been undertaken as described in the following sections.

8.1 Model Details

The BWM numerical groundwater model was adopted for the PRC Plan hydrogeological assessment. This section provides a summary of the design, development and adaptation of the BWM numerical groundwater model. Full details of the BWM numerical groundwater model adapted in this hydrogeological assessment are included within SLR (2023b).

The BWM numerical groundwater model was deemed appropriate for the purposes of the PRC Plan for the following reasons:

- Adoption of the MODFLOW-USG code in the existing model allows for sufficient refinement of the model grid around the entire of BWM operations such that the limitations of a regional model in terms of the grid design are mitigated.
- The model incorporates the northern BWM geologic model with model layer representation consistent with the geologic model.
- The model is robustly calibrated to BWM specific monitoring data as well as an extensive regional dataset including that collected at neighbouring mines.
- The model incorporates regional influences that may interact with the groundwater system (and model predictions) post-closure at BWM, including operations at the Curragh mine to the north (open-cut), underground mining at Cook Colliery east of BWM that are both considered to have a potential to interact with groundwater in the BWM Area given their proximity.
- The BWM model adopted for the BWM PRCP is the latest numerical model for BWM, developed for the Blackwater North Extension Project Groundwater Impact Assessment (SLR, 2023b).

8.1.1 Model Objectives

Numerical modelling was undertaken in support of this hydrogeology assessment for the PRC Plan to evaluate the potential impacts of Landform 2.5 (refer **Section 1.2**) on the groundwater regime. The objectives of the predictive modelling were to:

- Assess groundwater inflow to the final landform's residual voids;
- Simulate the level and rate of recovery of the residual void lakes, and the level and rate of mining-related groundwater drawdown recovery in the groundwater system surrounding the residual voids;
- Simulate the level and rate of groundwater recovery within historic underground mine workings relevant to the PRC Plan; and
- Identify areas of potential risk, such as private supply bores (**Section 5.2.1**) or GDEs (**Section 5.2.2**), where groundwater impact mitigation/control measures may be necessary post-closure.

8.1.2 Model Design

The numerical model was developed using a Geographic Information System (GIS) in conjunction with MODFLOW-USG, which is distributed by the United States Geological

Survey (USGS). MODFLOW-USG is a relatively new version of the popular MODFLOW code (McDonald and Harbaugh, 1988) developed by the USGS. MODFLOW is the most widely used code for groundwater modelling and has long been considered an industry standard.

The BWM numerical model developed by SLR (2023b) was revised to ensure the model was fit for purpose for the PRC Plan hydrogeological assessment. The updates to the model design that were undertaken for the hydrological assessment included:

- Grid – Local grid refinement was performed at two locations in the existing mesh:
    - Bonnie Doon area – The grid was refined immediately outside the eastern and northern edges of the Bonnie Doon residual void. This was to facilitate the potential for more detailed simulation of the Bonnie Doon tailings storage facility in the future, if deemed warranted. The refinement regime in this area consisted of a hexagonal 50m regular grid.
    - Laleham and Kenmare Historic Underground Mine area - With the proximity of these two underground mines and the surrounding open cut voids, the previous mesh resolution was deemed too coarse to appropriately capture the local flow dynamics between these various features. The grid refinement in this area consisted of a hexagonal 50m regular grid.
- Mine Progression – The open pit mine progression was updated to include all approved mining at BWM between end of calibration and closure.
- Tailings emplacement – In-pit tailings emplacement at Laleham and Bonnie Doon prior to closure was replicated in the model using River cell boundary conditions and relevant information provided by WHC.
- Final Landform – The post-mining landform was incorporated into the numerical model which includes 11 residual voids at closure.

These updates resulted in a model that was deemed suitable for representation of all historic and future mining at BWM, as well as the post-mining period, for the purposes of the PRC Plan.

Model layering is discretised into 14 layers as listed in **Table 8-1**. Those layers identified in the table as not present across the entire model domain are ‘pinched out’ within the MODFLOW-USG code.

Table 8-1 Model Layering (SLR, 2023b)

Model Layer	Geologic Formation	Hydrogeologic Unit	Present in the BWM Area
1	Alluvium/Tertiary	Surface cover and Tertiary	Yes
2	Alluvium/ Weathered zone	Weathered zone / Regolith	Yes
3	Clematis Group	Triassic	No
4	Rewan Group (Upper)	Triassic	No
5	Rewan Group (Middle)	Triassic	Yes (in part)
6	Rewan Group (Lower)	Triassic	Yes (in part)
7	Rangal Coal Measures	Overburden	Yes (in part)
8		Aries seam	Yes (in part)
9		Interburden	Yes (in part)
10		Castor seam	Yes (in part)
11		Interburden	Yes (in part)
12		Pollux seam	Yes (in part)
13		Underburden	Yes (in part)
14	Burngrove Formation	Permian	Yes

8.1.3 Model Calibration

The model includes a steady state and a transient calibration (2005 to 2022) as reported in SLR (2023b). In all, the calibration used 2,025 target heads from 59 bores. The transient warm up calibration captures historical mining at BWM, Curragh mine, Cook Colliery underground mine, Kenmare underground and Laleham underground mine, while the transient calibration captures historical mining at BWM and Curragh mine. Mining was represented in the model using the MODFLOW drain package, with the drain cells set to the base of the target coal seam for each pit, and within the target coal seam for underground mines. Calibration of the model was carried out with the objective being to replicate the groundwater levels measured at BWM, Currah, Cook Colliery, Kenmare underground and Laleham underground mines, as well as some registered bores, in accordance with Australian Groundwater Modelling Guidelines (Barnett et al., 2012).

Groundwater bores used for the calibration were weighted equally in the calibration so as not to bias model calibration to any one area/mine and potentially decrease model reliability elsewhere, but provide the most robust regional scale calibration possible given the regional cumulative hydrogeological impact framework. This approach also means that any data uncertainty associated with a single calibration point in any one model layer will not bias the calibration results, as all data for each layer from across the entire regional model domain is treated equally. Similarly, the calibration approach means that the influence on calibration performance of any perceived lack of local calibration points for a layer at any particular

mine site, or a relatively short monitoring record at any one monitoring site, is somewhat mitigated by the regional scale approach to calibration where calibration is aiming to achieve the best fit to all available data across any one model layer. The number of model calibration points and associated target head measurements for each layer is provided in **Table 8-1**.

Calibration for the model achieved a 11.68 m root mean square (RMS) error, equating to a 6.4% scaled root mean square (SRMS) error, which is within the recommended range (i.e. 10%) in the Australian Groundwater Modelling Guidelines (Barnett et al., 2012).

Table 8-2 Model Calibration Targets (SLR, 2023b)

Model Layer	Geologic Formation	Hydrogeologic Unit	Calibration Target Locations	Number of Target Head Measurements
1	Alluvium/Tertiary	Surface cover and Tertiary	33	1
2	Alluvium/ Weathered zone	Weathered zone / Regolith	552	19
3	Clematis Group	Triassic	----	----
4	Rewan Group (Upper)	Triassic	----	----
5	Rewan Group (Middle)	Triassic	1	1
6	Rewan Group (Lower)	Triassic	210	4
7	Rangal Coal Measures	Overburden	430	11
8		Aries seam	438	13
9		Interburden	36	1
10		Castor seam	26	1
11		Interburden	----	----
12		Pollux seam	80	3
13		Underburden	26	1
14	Burngrove Formation	Permian	193	4

8.1.4 Model Performance and Limitations

The groundwater modelling was conducted in accordance with the Australian Groundwater Modelling Guidelines (Barnett et al. 2012), the MDBC Groundwater Flow Modelling Guideline (MDBC 2001) and the IESC Explanatory Note for Uncertainty Analysis (Peeters and Middlemis, 2023).

The model confidence level (Class 1, Class 2 or Class 3 in order of increasing confidence) based on the Australian Groundwater Modelling Guidelines (Barnett et al. 2012) was previously widely used in the industry. The latest version of the IESC Explanatory Note for Uncertainty Analysis (Peeters and Middlemis, 2023) introduces a new concept on how model confidence can be assessed. The document also indicates that this change will follow in the next iteration of the Australian Modelling Guidelines and the new concept for assessing model confidence is hence applied for this model.

The latest version of the IESC Explanatory Note for Uncertainty Analysis defines a model fit for purpose when model results are:

- Usable -- Relevant to the decision-making process, providing information about the uncertainty in conceptualisations and modelling simulations in a way that allows decision-makers to understand the effects of uncertainty on project objectives and the effects of potential bias. The relevant Quantities of Interests (QoI) in this context are the groundwater inflows and drawdowns to assess licensing, site water management and drawdown impacts on bores.
- Reliable -- Demonstrate that the range of model outcomes is consistent with the system knowledge and honours historical observations, and provides objective evidence that uncertainties affecting decision-critical predictions of impacts on aquifer resources and dependent systems are not underestimated. The calibration performance was deemed acceptable, and a rigorous UA was undertaken to further improve confidence in the modelling outputs.
- Feasible -- Trade-offs due to budget, time and technical constraints are reasonable and justifiable within the risk context of the project. This study uses an existing calibrated numerical groundwater model for post-closure modelling. The SLR (2023b) BWM numerical model uses an updated mine progression, final landform and additional grid refinement near __ void. This model build and associated review process is deemed commensurate with the Project related risk to the groundwater environment.

In order to assess these three points above, the four sources of scientific uncertainty (structural, parametrisation, measurement error, predictions) have been qualitatively assessed with regards key aspects of the BWM groundwater model, as presented in **Table 8-3**.

Overall, the model captures depressurisation due to active mining. The model is numerically stable with no mass balance error. The model shows a good fit between observed and modelled groundwater levels (see **Section 8.1.3**). A depth dependence function was used for hydraulic conductivity, with the calibrated values showing a good fit to observed data as (see SLR, 2023b). Overall, the model is considered fit for purpose to achieve the objectives outlined in **Section 8.1.1** based on the data provided and the Project timeframe. In the future, groundwater monitoring data and studies of hydrogeologic properties of geologic units relevant to the numerical model may become available which could motivate changes to the structure and calibration of further iterations of the BWM numerical model.

The model sensitivity was explored for an array of parameters. This showed that these parameters were generally well constrained by the calibration. For the predictions, two parameters fell into the type 4 error, which has low identifiability, but high predictive uncertainty.

The uncertainty analysis was undertaken to add a likelihood estimate to the prediction for the main two quantities of interest, the groundwater inflows and predicted drawdowns in a multitude of relevant geological formations.

Table 8-3 Groundwater Model and Data Limitations

Type	Part	Status	Comment
Structural/ Conceptual	Grid and Model Extent	Fit for purpose	The model has an unstructured Voronoi grid that includes detailed cell refinement around site, neighbouring mines and along drainage features.
	Layers	Fit for purpose	Top of layer 1 incorporates site LiDAR data.
		Fit for purpose	Representation of alluvium based on the CSIRO Regolith mapping Wilford et al (2016) and refined based on site drill data.
	Conceptualisation – Geological Structure	Fit for purpose, future improvements possible where new data collected	The local structure of the geology is based on detailed data at site (BWM northern geology model), and regional model geometry (outside of the site geology model) interpolated based on publicly available data, such as geological mapping and the CSIRO Regolith data set. Geophysical surveys across the Project area have identified minor faulting in the BWM area. Faulting is typically confined to the coal seams of the Rangal Coal Measures. The minor faults show a displacement of up to 5m. Hence, no geological structures (i.e. faults) have been included within the Project area in the model other than through layer displacements from the site geological model. The main regional fault (Shot over fault) was included as the eastern model boundary. Displacements of up to 3,000m are reported at this fault. The Permian coal measures outcrop along the western edge of the site. Therefore, how this is captured within the model influences the model predictions. The structure of the coal seams was checked to ensure it matches observed and mapped geology. The predictions of drawdown adjacent to mining was checked and the model shows a good fit between modelled and observed trends.
	Conceptualisation – GDEs	Fit for purpose, future improvements possible	A GDE conceptualisation is provided in Section 5.2.2, SLR (2023a), EMM (2023a), EMM (2023b) and RDM Hydro (2023).
	Conceptualisation – Surface Water Groundwater Interactions	Fit for purpose	The groundwater -surface water interactions are conceptualised as limited. Due to the gauged creeks to be classified as ephemeral (SLR, 2023a), no long-term baseflow contribution from the groundwater is expected. Rather, surface water is expected to recharge the groundwater and after such recharge events, some minor baseflow contributions back into the creeks is possible.



Type	Part	Status	Comment
	Conceptualisation – Saturated Extent of Alluvium and Regolith	Fit for purpose future improvements possible	Site monitoring network includes one bore mapped within alluvium that was used to inform saturated extent of alluvium locally at site and for calibration targets. However, the alluvium in the area was found dry at this location. Other attempts to drill into the alluvium were abandoned, as either no alluvium was found or the alluvium was dry, or the bores were installed into the Rewan instead. The modelled groundwater levels in alluvium have hence no comparison available.
Parameterisation	Hydraulic Conductivity – Shallow layers	Fit for purpose, future improvements possible	The simulation of the Alluvium and Regolith in the model involves the use of zones in Layer 1 and Layer 2. In the calibration process, a single hydraulic property was assigned to the alluvium zone in layers 1 and 2. However, given the inferred heterogeneity in the alluvium system, it is likely that hydraulic parameters vary across this unit at different observation locations. The parameter zones current setup are inflexible in capturing the heterogeneity in the alluvium, potentially resulting in the model's inability to accurately replicate water level measurements in the alluvium. Future versions of the model could consider assessing the spatial variability of hydraulic parameters in the Alluvium and Regolith by incorporating pilot points. This enhancement would allow for a more accurate representation of the heterogeneity in the alluvial system, potentially improving the model's ability to replicate water level measurements.
	Hydraulic Conductivity – Depth Dependence	Fit for purpose	Field testing of hydraulic conductivity (horizontal and to a lesser extent vertical) has been conducted in the area. Hydraulic conductivity test results from the other sites within the model domain were also considered. The data shows a general decline in hydraulic conductivity with depth that is replicated in the model.
	Spoil Properties	Fit for purpose, future improvements possible	Limited site-specific data is available for the spoil. Spoil properties were adopted using the previous studies.
	Rivers	Fit for purpose, future improvements possible	Blackwater Creek stage height is changed temporally in the historical calibration model based on observed levels from site stream gauges, and long term annual average level assumed in the predictive model. Blackwater Creek records flow only for a few days per year. The simulation of river stage height involves representing it as the average stage over the entire model stress period. However, since the stress periods (i.e., time slices) in the model are quarterly or annual, the

Type	Part	Status	Comment
			stage height for Blackwater Creek persists in the model for a much longer period than it does in reality. This conservative design approach results in the simulation of what is naturally an ephemeral river reach as a perennial river in the model. Consequently, this leads to an overprediction of water levels in the alluvium along Blackwater Creek. All other watercourses within and in the vicinity of the Project area are ephemeral and only flow briefly after rainfall. Therefore, river stage height of zero was assigned to these watercourses in the model.
	Recharge	Fit for purpose	Recharge zonation is based on mapped surface geology and calibrated recharge rates.
Measurement Error	Observation Data Quality	Fit for purpose, future improvements possible	Bore logs and construction details available for many site bores, and long-term site water level data available for various units. Improvement in availability of specific details for some bores may improve confidence in observation data.
	Landholder Bore Data Quality	Fit for purpose, future improvements possible	Impacts on registered landholder bores are influenced by the assumptions of the bore design, target geology and use. Verification of landholder bore details may be required in future.
	Temporal spread	Fit for purpose	Timeseries water level data from the site as well as for the tertiary and Permian coal measures.
Scenario Uncertainties Future stresses/ conditions	Calibration	Fit for purpose	Transient warm-up (1970-2005) and transient (2005 to 2022) calibration model set up and a depth dependence function used and calibration to water levels conducted using automated (PEST) and manual methods.
	Predictive	Fit for purpose	Model captures approved and proposed open cut mining at BWM. The model also includes future mining at Blackwater South, Minyango and Curragh mines, mainly based on publicly available data. The actual future mine progression for these sites may vary.
	Sensitivity and uncertainty	Fit for purpose	Uncertainty analysis has been conducted by stochastic modelling using an adapted Monte Carlo method with modern software packages. The Latin Hypercube Sampling (LHS) method was used to create random realisations from parameter and PEST++ was used to orchestrate the model runs. The uncertainty analysis quantified the variability in predictions with changes in maximum predicted drawdowns, mine inflows, impact on alluvium flow and impacts on surface water flow.



8.2 PRC Plan Landform 2.5 Model

Post-mining groundwater impacts at BWM were investigated for the purposes of the PRC Plan hydrogeology assessment with a numerical groundwater recovery model for Landform 2.5 (i.e. 11 residual voids including two with emplaced tailings; refer **Section 1.2**).

8.2.1 Model Setup

The PRC Plan's proposed final landform 2.4 was replicated in the recovery model, including areas of spoil emplacement within mined out pits, the 11 proposed residual voids, and the two in-pit tailings emplacements at Bonnie Doon and Laleham. The distribution of modelled spoil emplacement is shown on **Figure 8-1**.

The recovery model commenced from the end of mining at BWM (end of the year 2113) and was run for 500 years over eight model stress periods. The model stress period setup is shown in **Table 8-4**

Table 8-4 Recovery Model Stress Periods

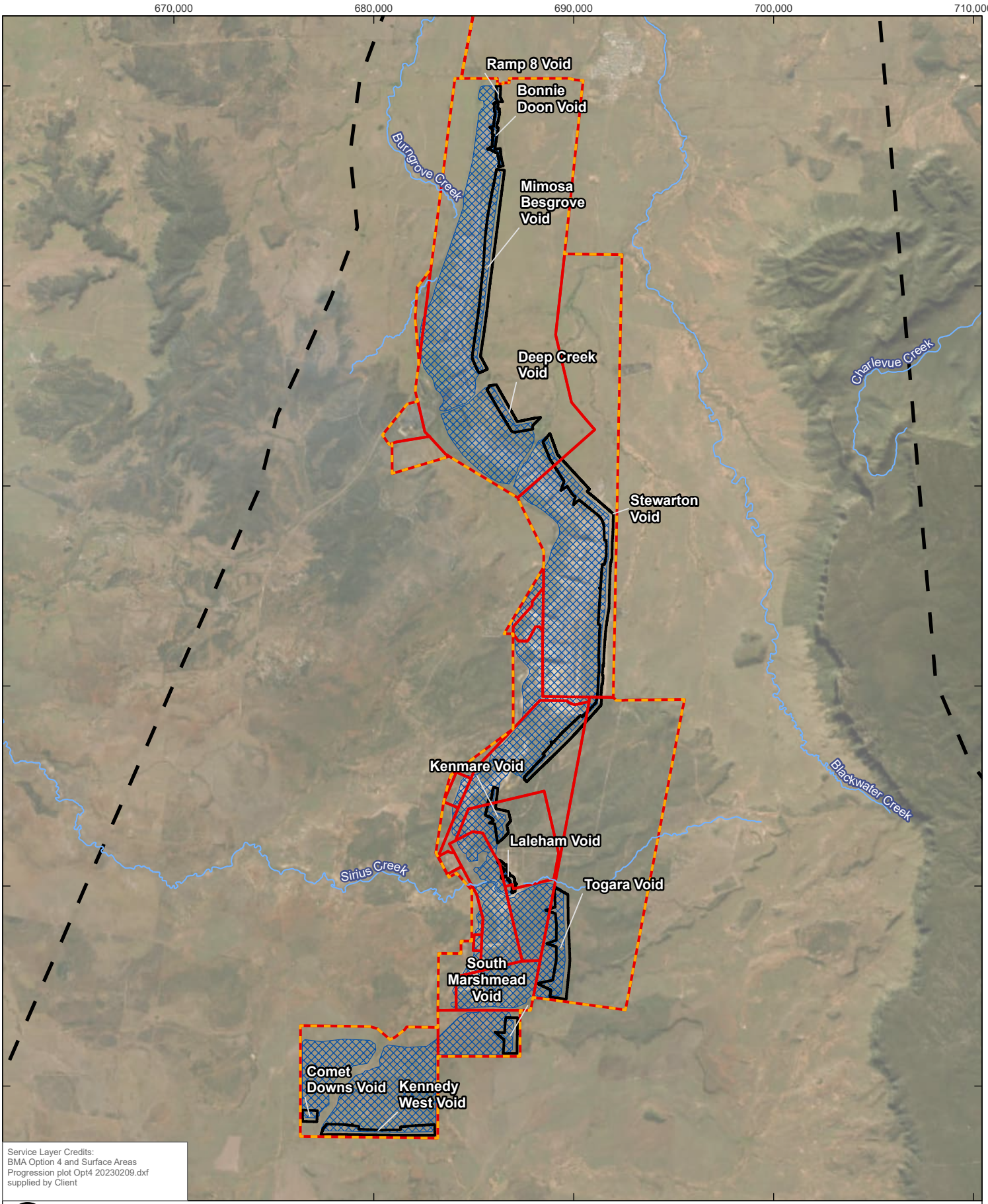
Stress Period	Stress Period Duration (Years)	Starting Year (Post-Mining)	Ending Year (Post-Mining)
169	1	2113	2114
170	1	2114	2115
171	35	2115	2150
172	50	2150	2200
173	50	2200	2250
174	150	2250	2400
175	100	2400	2500
176	110	2500	2610

The final recovery model adopted for reporting in this hydrogeology assessment used end of BWM mining predicted groundwater levels from the predictive mining model as the starting heads, and removed all drain cells simulating the proposed mining areas at BWM to allow groundwater levels to equilibrate. The starting heads for each relevant hydrostratigraphic unit are provided in **Appendix B**.

Climate related boundary conditions (i.e. recharge and evapotranspiration [ET]) in the recovery model were set constant for the duration of the recovery model, at their values consistent with the previous predictive mining model (SLR, 2023b). Recharge and ET were not applied to the final voids (or associated in-pit tailings emplacement) themselves in the groundwater model, since the WSP (2024) water balance model used iteratively with the groundwater model (see **Section 8.2.2**) accounts for these boundary conditions.

The hydraulic properties of the model cells representing in-pit tailings emplacements were assigned values of vertical and horizontal hydraulic conductivity of 6.8×10^{-3} m/day, specific yield of 0.1, and a storage coefficient of 1.0×10^{-4} m^{-1}.

The hydraulic properties of the residual void cells were converted to values representative of air. That is, the void cells were assigned high horizontal and vertical hydraulic conductivities (1,000 m/day) and storage parameters based on the compressibility of water (specific yield of 1.0, storage coefficient of 5.0×10^{-6} m^{-1}), to simulate free water movement within the residual void.



Service Layer Credits:
BMA Option 4 and Surface Areas Progression plot Opt4 20230209.dxf supplied by Client

0 2.5 5 km

Coordinate System:	GDA2020 MGA Zone 55
Scale:	1:250,000 at A4
Project Number:	620.040199
Date Drawn:	29-Jul-2024
Drawn by:	AS

LEGEND

- Watercourse
- BWM Mining Lease
- Study Area
- Project Area (Environmental Authorities boundary)
- Void Extent
- Spoil Extent

BLACKWATER MINE - TRANSITIONAL PRCP HYDROGEOLOGY ASSESSMENT

SIMULATED SPOIL EMPLACEMENT

SLR

DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.

FIGURE 8-1

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040199.00001 BWM PRCP – GW\03 SLR Data\01 CADGIS\GIS\ArcPro\BWM PRCP – GW\BWM PRCP – GW.aprx\620040199_F08_01_Simulated_Spoil_Emplacement

8.2.2 Integration with Residual Void Water Balance

Table 8-2 presents a conceptual diagram of the post-mining modelling setup adopted for this hydrogeological assessment. As shown in **Table 8-2**, the residual voids will accumulate water over time due to direct rainfall, surface water runoff and groundwater inflow from both spoil and natural rock as groundwater levels recover. Whilst the numerical groundwater model can reliably account for the groundwater inflow component, the surface components of direct rainfall, surface water runoff, as well as evaporative loss from the void lake, are considered to be better accounted for within a surface water balance model. This is due to the inherently more refined nature of simulating those surface components within a water balance model, as compared to a numerical groundwater model. This surface water modelling is discussed below.

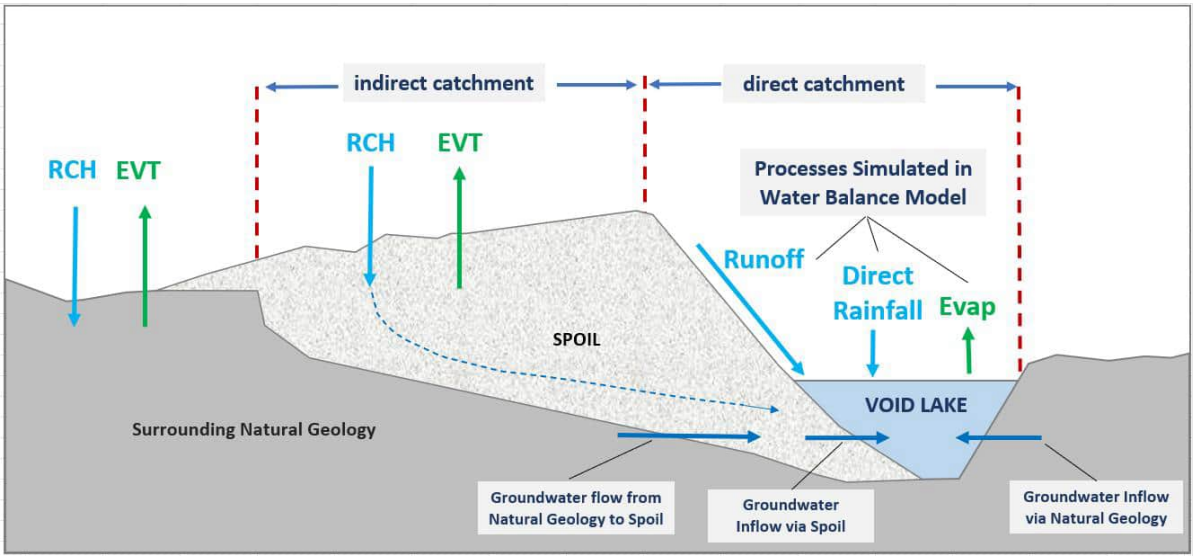


Figure 8-2 Residual Void Recovery Model Conceptual Diagram

The groundwater model was therefore used to predict the following fluxes to the residual voids:

- Groundwater inflow to the pit shell from the surrounding geology, including inflow from the natural geology to the spoil backfill and inflow from the natural geology directly to the residual voids; and
- Groundwater inflow originating from the indirect catchment (i.e. areas of spoil backfill that receive rainfall recharge that then flows through the spoil into the residual voids).

Void water levels were not predicted by the groundwater model but were estimated by the balance between groundwater inflow and the direct rainfall and rainfall runoff from the surrounding catchment against the evaporation loss from the lake surface through iterative surface water balance modelling (WSP, 2024). The WSP (2024) surface water balance modelling included climate sensitivity and three climate scenarios reported therein were adopted for the PRC Plan's groundwater model as shown in **Table 8-5**. That is, three sets of groundwater model predictions were generated for this hydrogeology assessment based on the three climate scenarios.

Table 8-5 Climate Scenarios Modelled

Climate Scenario	Climate Model	IPCC RCP Scenario[1]	WSP (2024) Realisation
Wetter	ACCESS1-0Q	4.5	R#1
Mid	ACCESS1-0Q	8.5	R#4
Drier	MPI-ESM-LRQ	8.5	R#6

1. Intergovernmental Panel on Climate Change (IPCC) Representative Concentration Pathway (RCP), refer https://sedac.ciesin.columbia.edu/ddc/ar5_scenario_process/RCPs.html

The iterative modelling approach was undertaken in a stepwise manner as follows:

1. The residual void lake levels with time were initially predicted by the WSP (2024) water balance model for the range of climate scenarios, incorporating surface water fluxes and processes and initial analytical estimates of groundwater inflows.
2. The initial daily surface water inflows derived by WSP (2024) were combined by SLR with predicted groundwater fluxes to the residual voids from the groundwater model, to produce a surrogate water balance model at a lower temporal resolution (i.e., matching the stress period setup of the groundwater model).
3. The predicted void and depressed landform lake levels from the SLR surrogate water balance model were applied as constant head boundary conditions in the groundwater model, and the groundwater model was re-run to obtain updated groundwater fluxes to the lakes.
4. The SLR surrogate water balance model was re-run with the updated groundwater fluxes, resulting in a new set of predicted lake levels.
5. Steps 4 and 5 were repeated by SLR until the time series of predicted lake levels for the residual void and depressed landforms stopped changing substantially between iterations.
6. The residual void lake levels with time were then again predicted by the WSP (2024) water balance model for the range of climate scenarios, incorporating surface water fluxes and processes and the Step 2 to Step 5 estimates of groundwater inflows.
7. To refine the prediction of residual void groundwater inflows to the residual voids, the daily residual void water elevations derived from the WSP (2024) water balance modelling (Step 6) were then replicated within the numerical groundwater model for the final landform using the time variant constant head boundary (CHD) condition, adopting a simplified average of the WSP (2024) daily results over the relevant groundwater model stress period length.
8. Revised predictions of the residual void lake levels with time were then made by the WSP (2024) water balance model, incorporating the numerical groundwater model predicted groundwater inflows (Step 7), and the surface water fluxes and processes.
9. To further refine the prediction of residual void groundwater inflows to the residual voids, three further iterations between the two models were then undertaken (repeating Steps 7 and 8).
10. Since the change in groundwater model predictions for fluxes to the residual voids with each subsequent iteration were considered small in relation to the effect on the resulting WSP (2024) void lake level predictions, it was considered by WHC that further iterations between the two models were not required and therefore the Step 9 groundwater model results were adopted for reporting in this hydrogeology assessment.

8.2.3 Residual Void Lake Recovery

Figure 8-3 through **Figure 8-13** provide a graphical representation of the final simulated recovery of water levels in the residual voids for the year 2113 onwards, based on the iterative groundwater and surface water balance modelling. As mining activity ends in different years for each void prior to the closure year of 2113, the duration over which residual void lake levels recover in the plots is variable. There between approximately 1 to 15 m range in equilibrium lake elevations between the three climate scenarios.

It should be noted that, as predicted groundwater inflow to the voids is between approximately 7% to 60% of the total volumetric inflow to the voids (see **Section 8.2.4**) within the water balance model, and therefore certain void lake levels are influenced more by surface water fluxes than groundwater inflow volumes, and vice versa. This is explored further in **Section 8.2.4**.

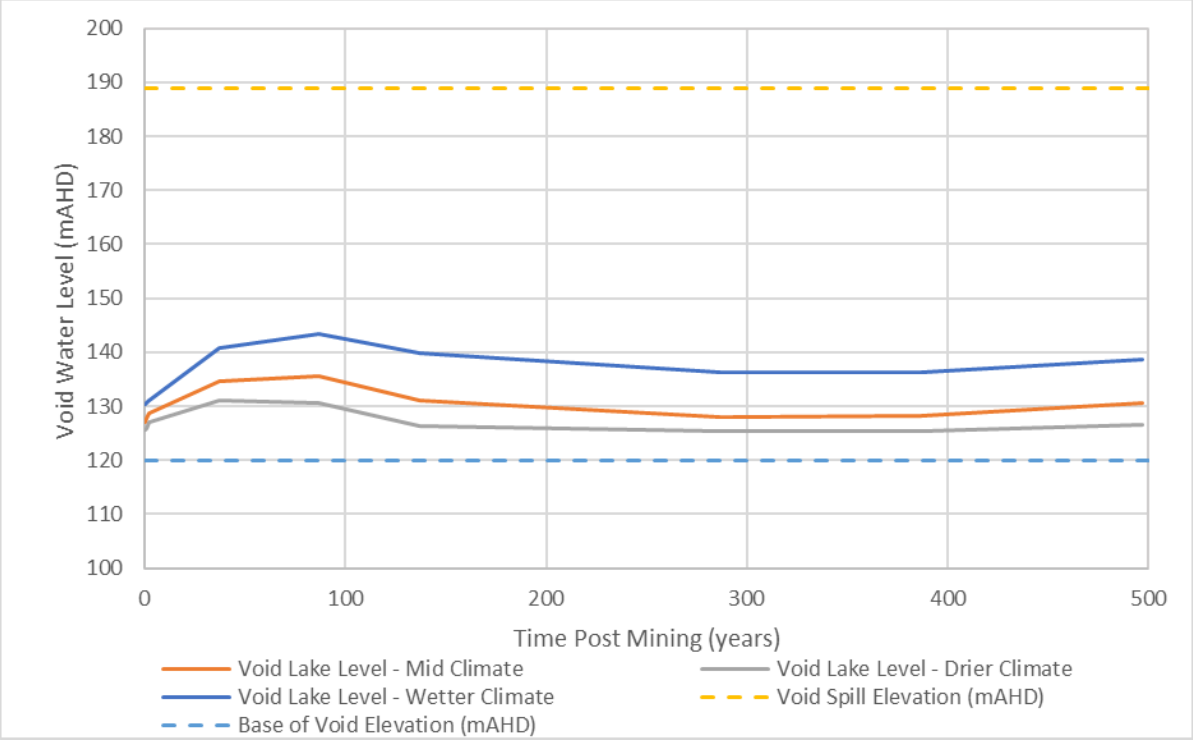


Figure 8-3 Simulated Void Water Level Recovery – Ramp 8 (based on WSP, 2024)

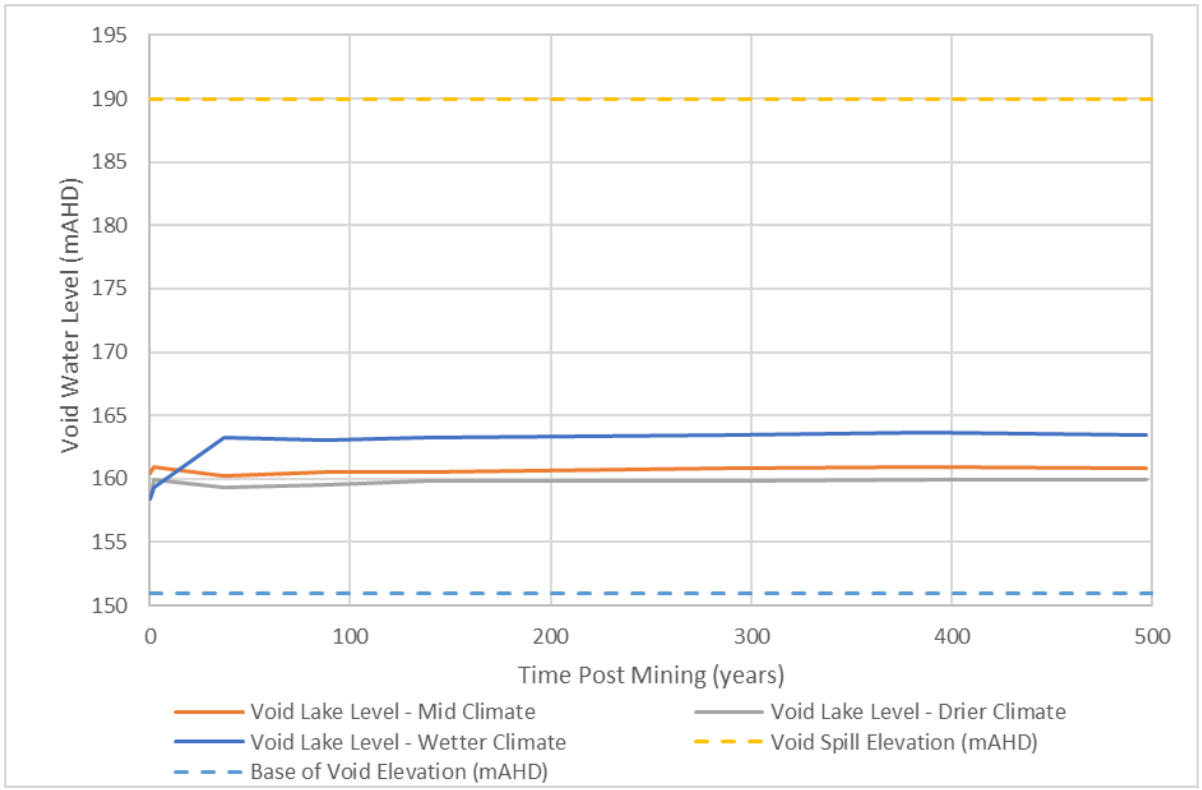


Figure 8-4 Simulated Void Water Level Recovery – Bonnie Doon (based on WSP, 2024)

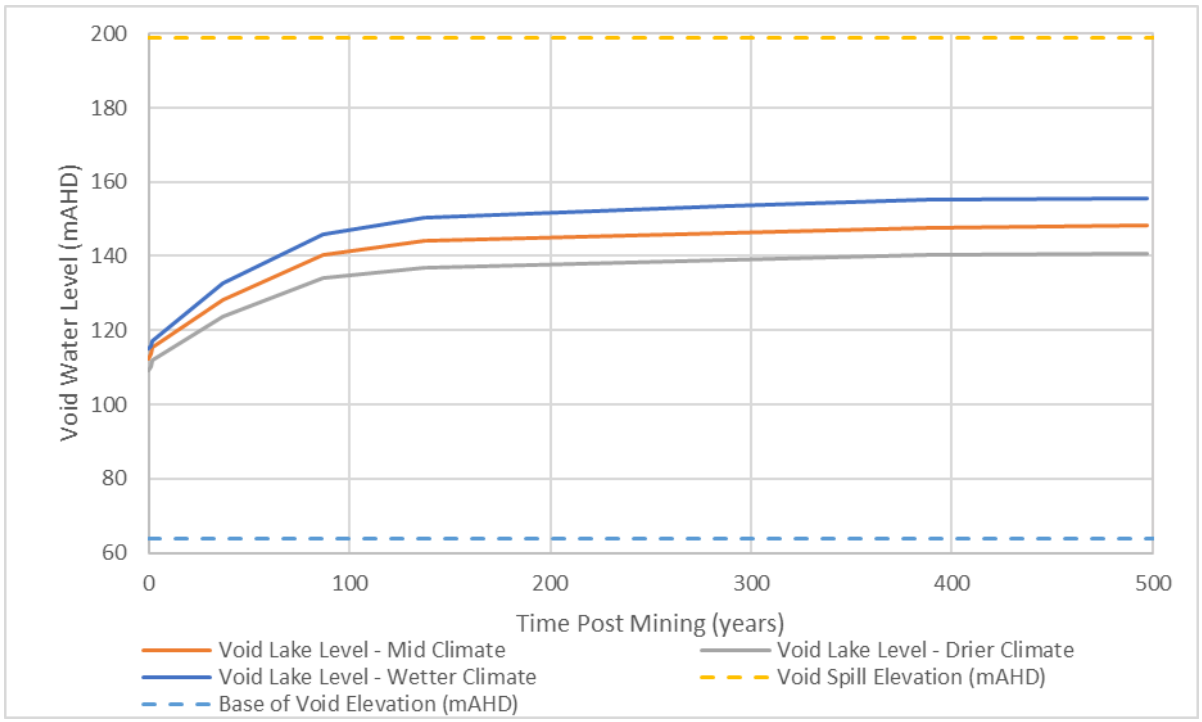


Figure 8-5 Simulated Void Water Level Recovery – Mimosa/Besgrove (based on WSP, 2024)

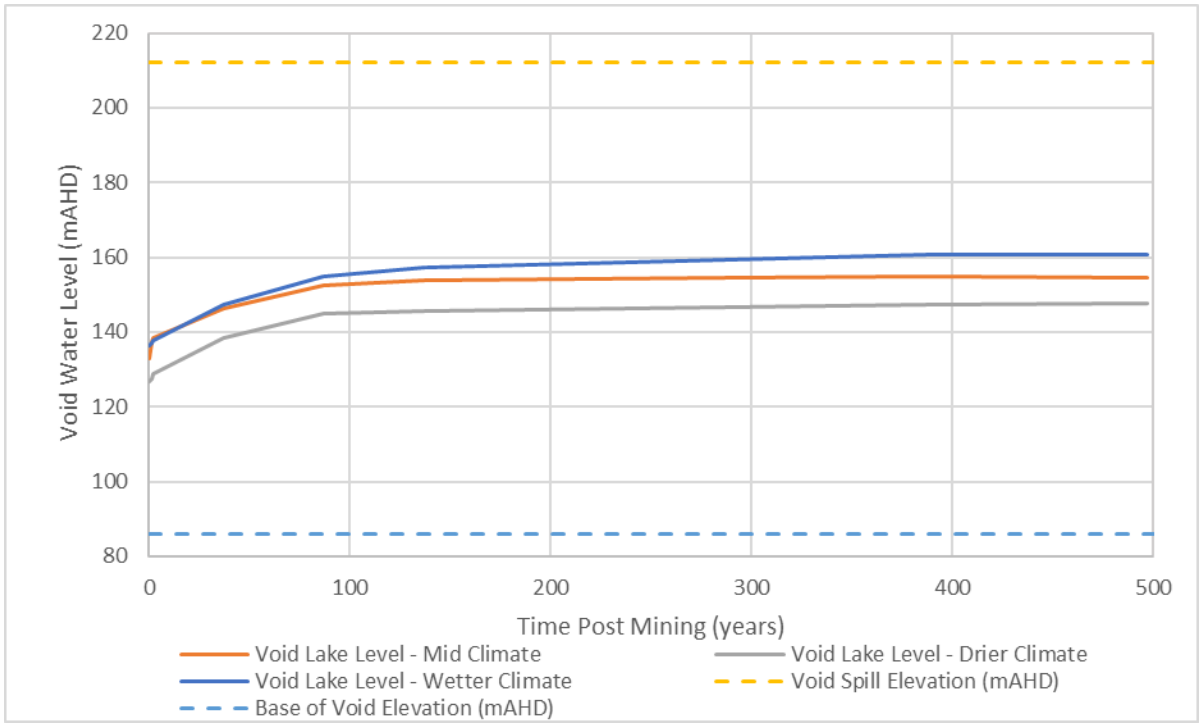


Figure 8-6 Simulated Void Water Level Recovery – Deep Creek (based on WSP, 2024)

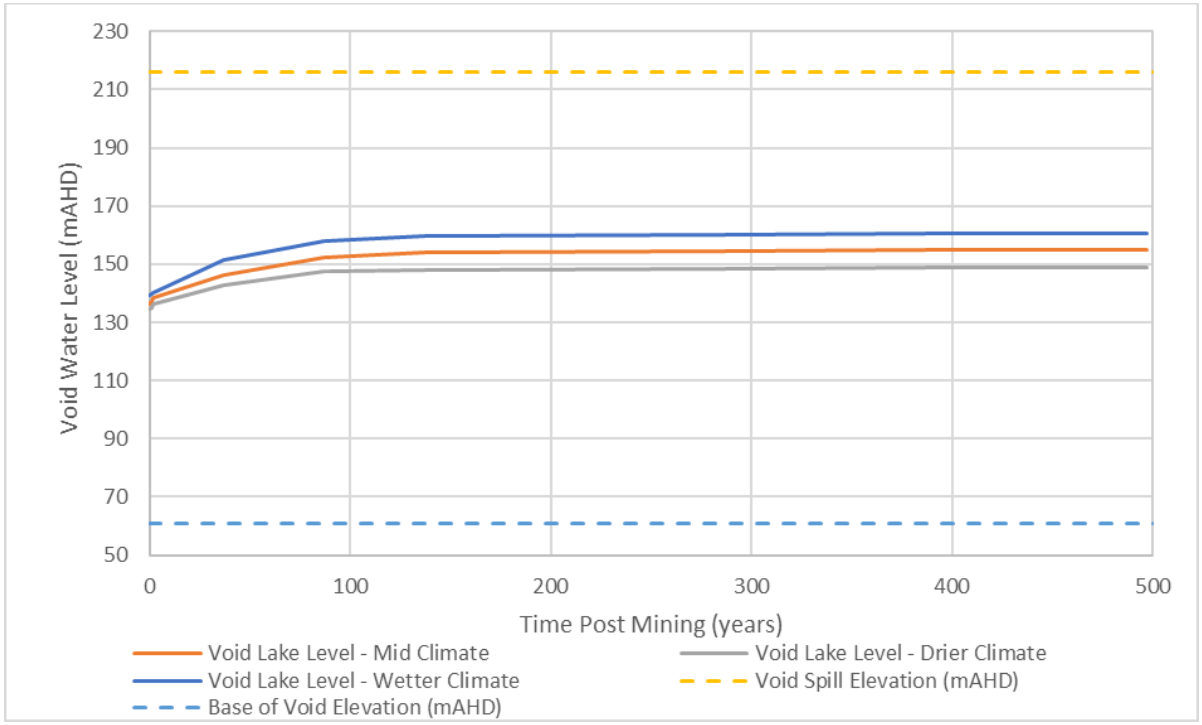


Figure 8-7 Simulated Void Water Level Recovery – Stewarton/Ballamoo (based on WSP, 2024)

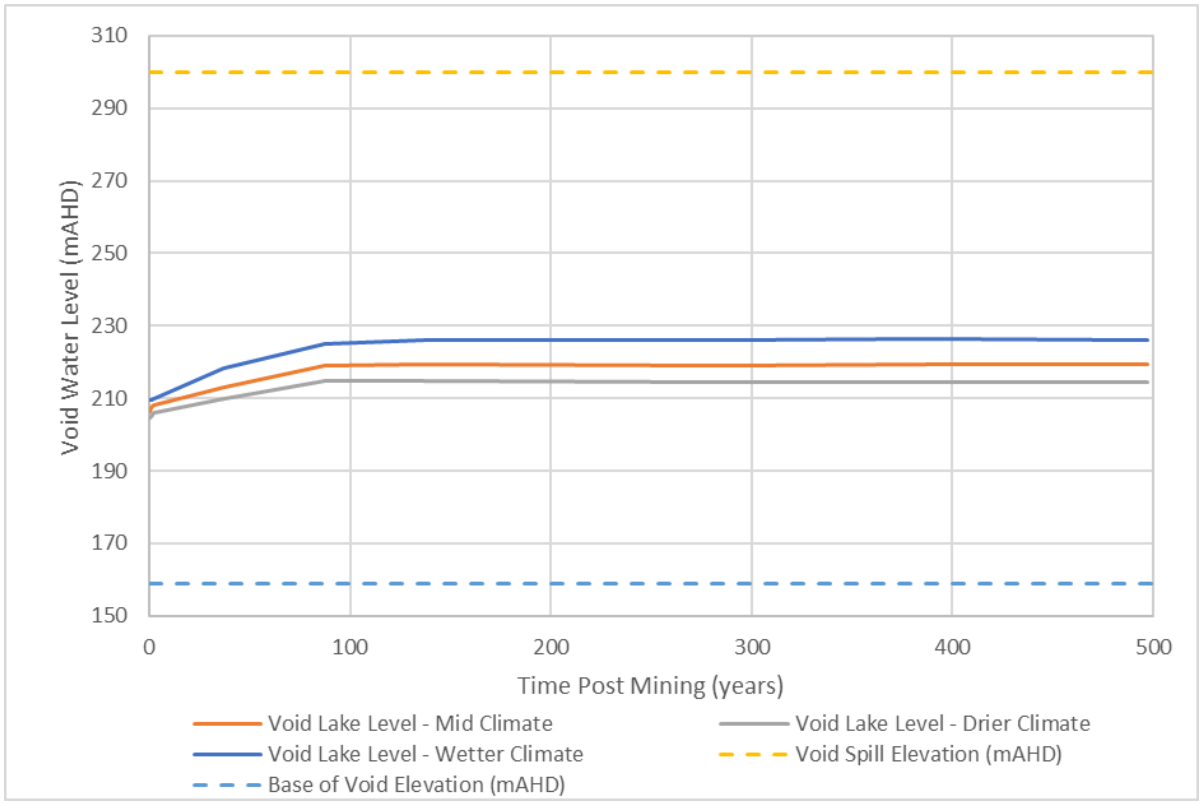


Figure 8-8 Simulated Void Water Level Recovery – Kenmare (based on WSP, 2024)

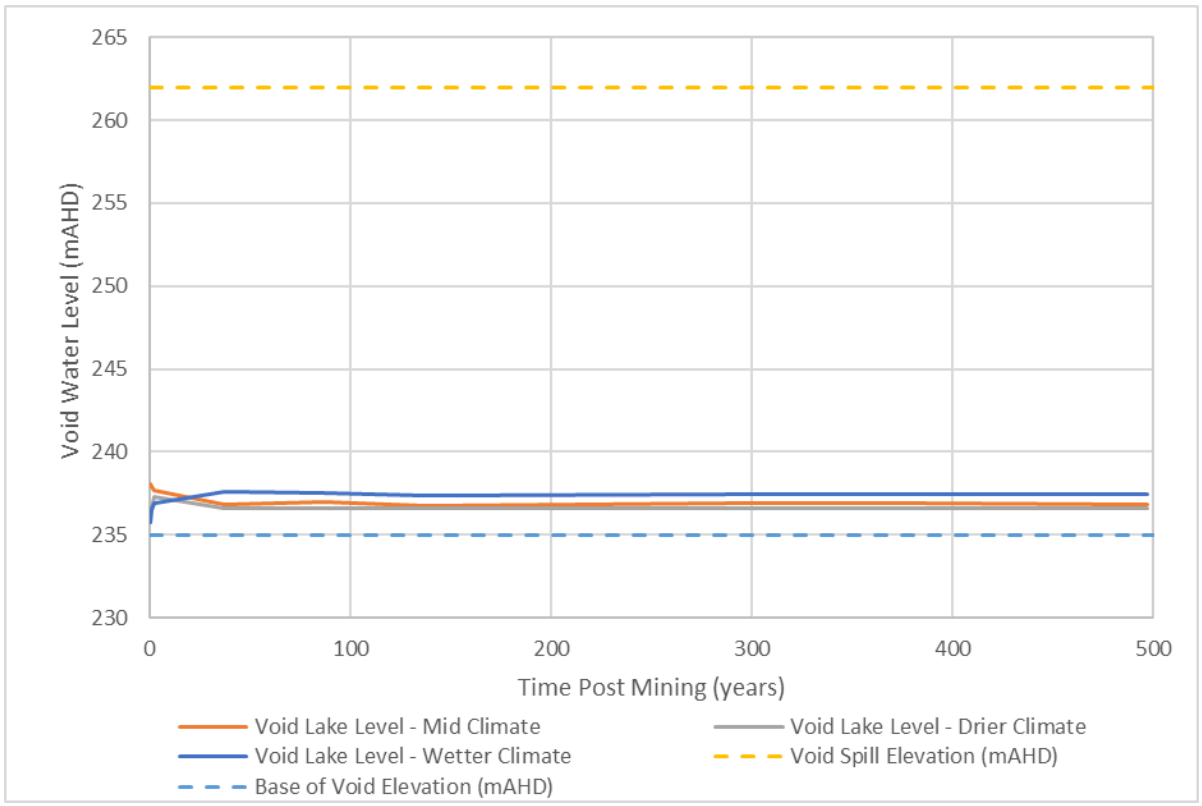


Figure 8-9 Simulated Void Water Level Recovery – Laleham (based on WSP, 2024)

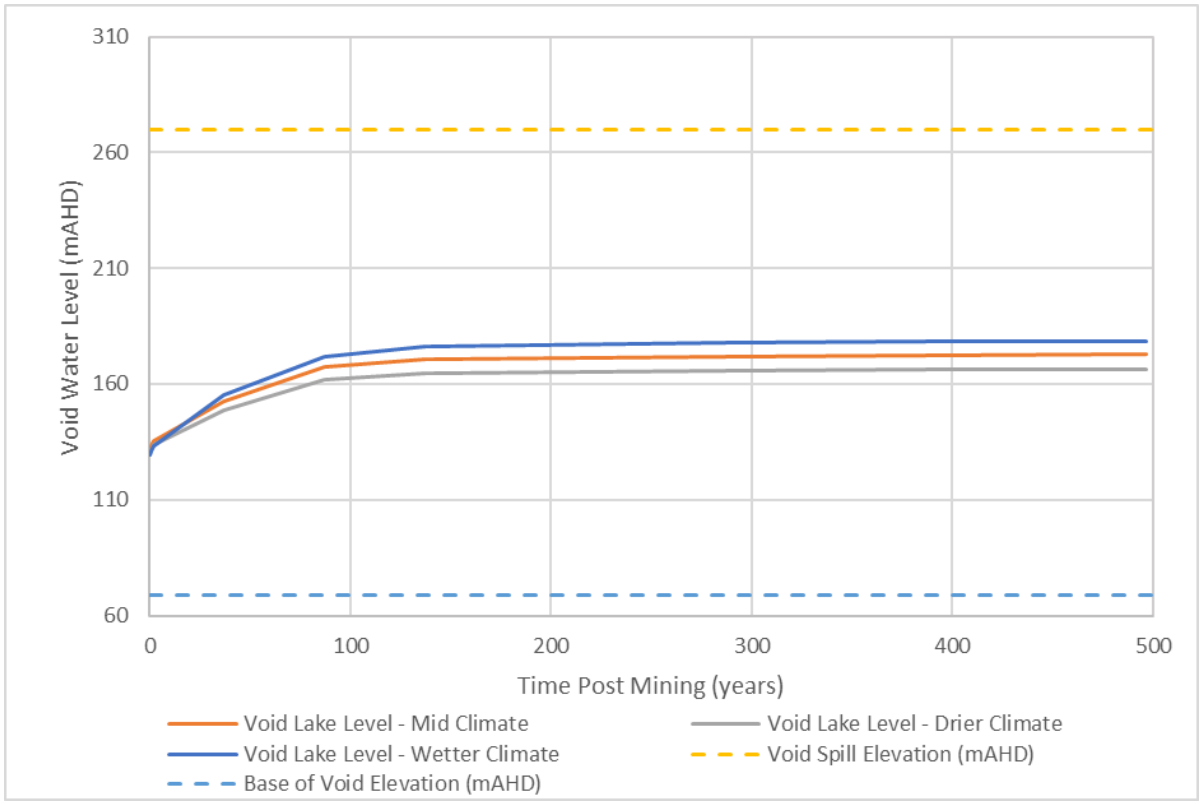


Figure 8-10 Simulated Void Water Level Recovery – Togara/North Marshmead (based on WSP, 2024)

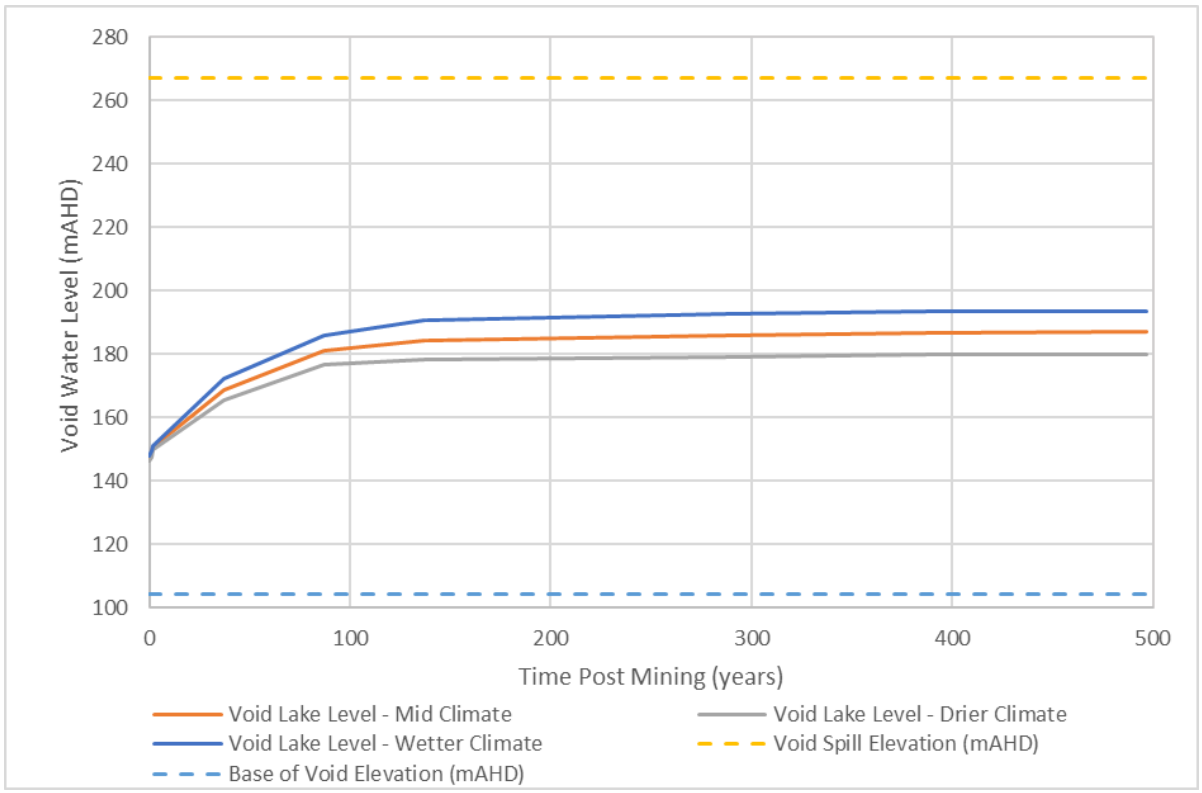


Figure 8-11 Simulated Void Water Level Recovery – South Marshmead (based on WSP, 2024)

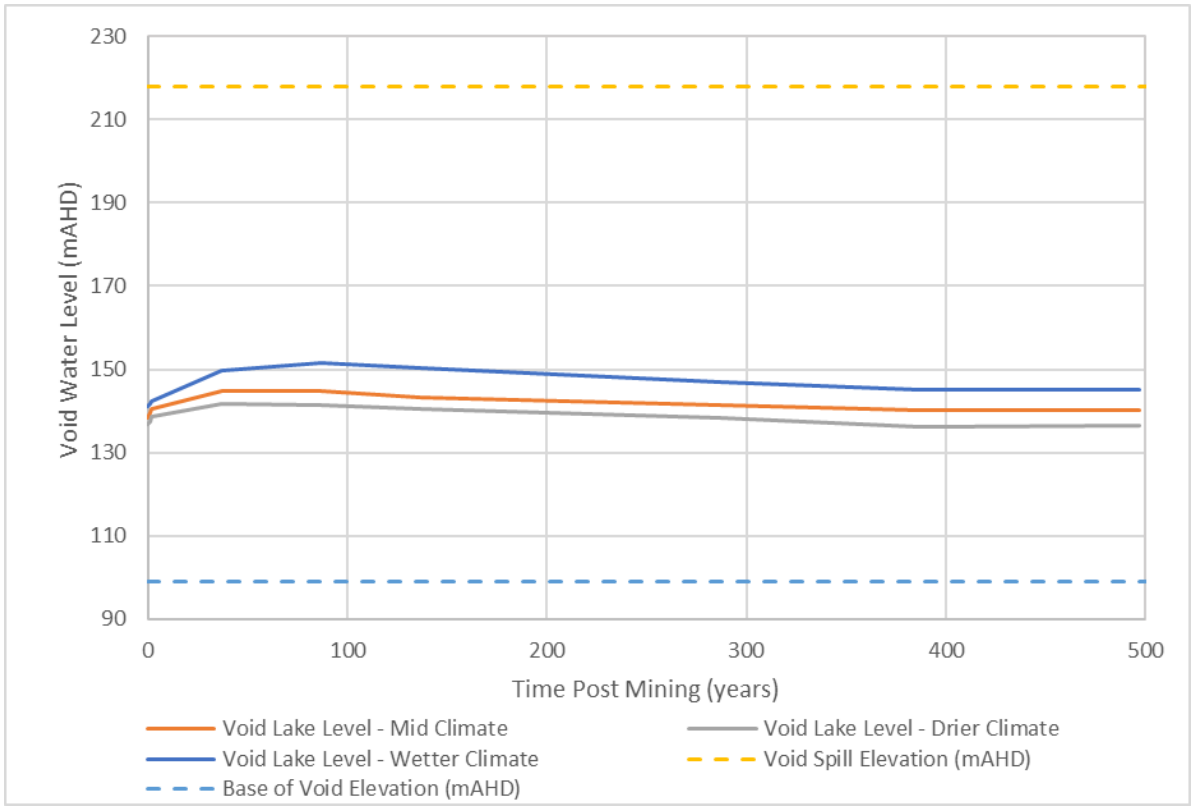


Figure 8-12 Simulated Void Water Level Recovery – Kennedy West (based on WSP, 2024)

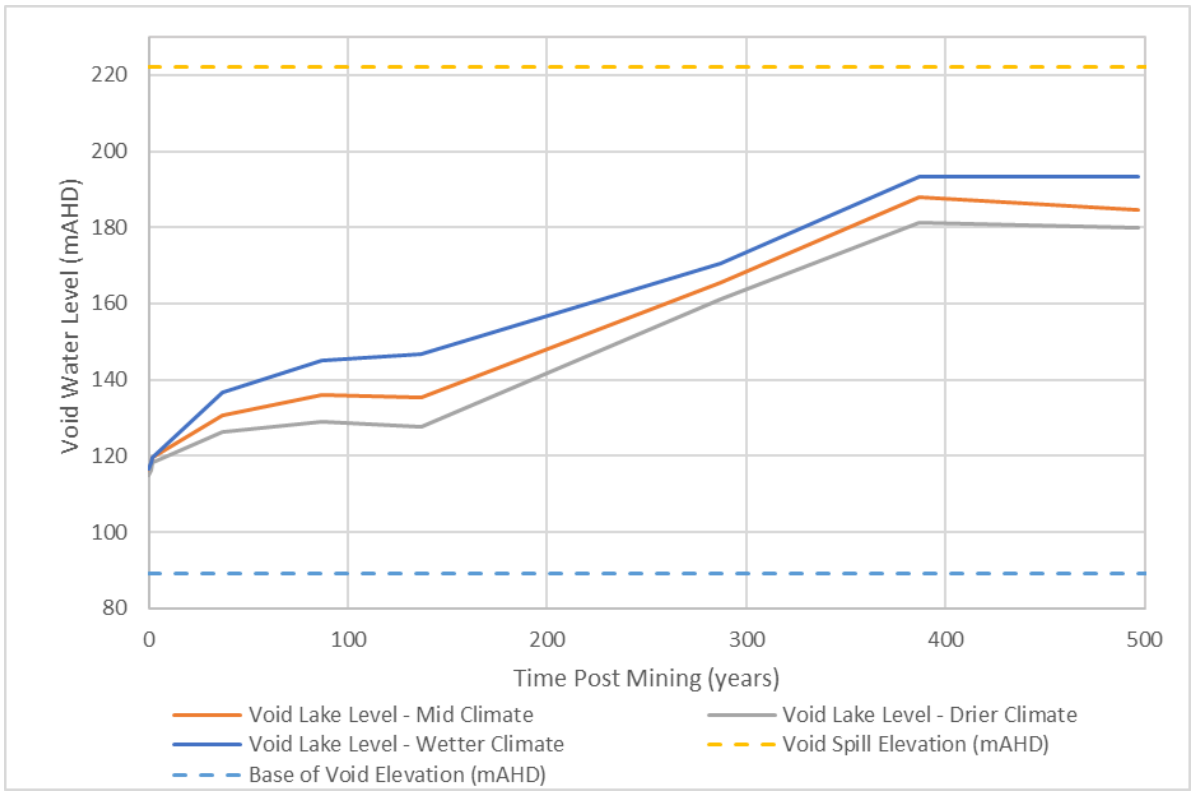


Figure 8-13 Simulated Void Water Level Recovery – Comet Downs East (based on WSP, 2024)

Figure 8-3 through **Figure 8-13** show that the residual void water level recovery is a process that takes decades to centuries with the recovery rate generally declining as the lakes reach equilibrium conditions. For the majority of the residual voids, equilibrium water level conditions are reached after approximately 40 to 140 years for all climate scenarios represented in the groundwater model, the exception being Comet Downs which shows that equilibrium water level conditions are reached after approximately 380 years. It is noted that the water level in Kennedy West void is considered to have mostly reached equilibrium within approximately 120 years though shows a very slight decline of around less than 1 m after this time due to the hydraulic gradient between the Kennedy West and Comet Downs void (refer **Section 8.2.4**). The predicted equilibrated water levels in the residual voids as shown in **Table 8-6** are calculated as the average water level in the final iteration of the WSP (2024) water balance model over the final model stress period at the end of recovery simulation.

Table 8-6 Equilibrated Water Levels in the Residual Voids

Climate Scenario	Residual Void	Initial water level (mAHD)	Approximate time to equilibrium (years)	Equilibrium water level (mAHD)[1]
Wetter	Ramp 8	131	120	139
	Bonnie Doon	159	40	163
	Mimosa/ Besgrove	116	140	155
	Deep Creek	137	140	161
	Stewarton/ Ballamoo	140	100	160
	Kenmare	210	100	226
	Laleham	236	60	237
	Togara/ North Marshmead	131	140	178
	South Marshmead	149	140	193
	Kennedy West	142	120	145
	Comet Downs East	118	380	193
Mid	Ramp 8	128	120	131
	Bonnie Doon	161	40	161
	Mimosa/ Besgrove	114	140	148
	Deep Creek	134	140	154
	Stewarton/ Ballamoo	137	100	155
	Kenmare	207	100	219
	Laleham	238	60	237
	Togara/ North Marshmead	133	140	173
	South Marshmead	149	140	187
	Kennedy West	140	120	140
	Comet Downs East	118	380	185
Drier	Ramp 8	126	120	127
	Bonnie Doon	159	40	160
	Mimosa/ Besgrove	110	140	141
	Deep Creek	127	140	148
	Stewarton/ Ballamoo	135	100	149
	Kenmare	205	100	214
	Laleham	237	60	237
	Togara/ North Marshmead	131	140	166
	South Marshmead	148	140	180
	Kennedy West	137	120	136
	Comet Downs East	116	380	180

1. Equilibrium void lake levels are derived from an average of the final iteration of the WSP (2024) water balance model levels over the final groundwater model stress period.

The freeboard for each of the residual voids (i.e. the difference in elevation between the long-term water levels in the residual voids and the landform crest spill level elevation) is as shown in **Table 8-6**. Predicted void lake levels remain significantly below the surface 'spill' level for each of the residual voids.

Table 8-7 Predicted Freeboard in the Residual Voids at Equilibrium

Climate Scenario	Residual Void	Freeboard (m)[1]
Wetter	Ramp 8	50
	Bonnie Doon	27
	Mimosa/ Besgrove	44
	Deep Creek	51
	Stewarton/ Ballamoo	56
	Kenmare	74
	Laleham	25
	Togara/ North Marshmead	92
	South Marshmead	74
	Kennedy West	73
	Comet Downs East	29
Mid	Ramp 8	58
	Bonnie Doon	29
	Mimosa/ Besgrove	51
	Deep Creek	57
	Stewarton/ Ballamoo	61
	Kenmare	81
	Laleham	25
	Togara/ North Marshmead	97
	South Marshmead	80
	Kennedy West	78
	Comet Downs East	37
Drier	Ramp 8	62
	Bonnie Doon	30
	Mimosa/ Besgrove	58
	Deep Creek	64
	Stewarton/ Ballamoo	67
	Kenmare	86
	Laleham	25
	Togara/ North Marshmead	104
	South Marshmead	87
	Kennedy West	82
	Comet Downs East	42

1. Freeboard is calculated by comparing the average lake levels from the final WSP (2024) water balance model results over the final groundwater model stress period with the void crest spill elevation.

The difference in elevation between the long-term water levels in the residual voids and the lowest point of the base of the shallow geologic formations (model layers 1 and 2) adjacent the voids is as shown in **Table 8-8**. Predicted residual void lake levels remain significantly below the base of the shallow geologic formations for each of the residual voids, even with the temporal fluctuations in void water levels predicted by the WSP (2024) water balance model. That is, there is never the potential for a flux of water to leave the residual voids and enter the shallow geologic formations.

The predicted lake levels in the Kenmare residual void remain above the elevation of the Kenmare Underground and Laleham Underground workings that would be exposed in the void highwall (i.e. of the Pollux Seam at approximately 195 and 156 mAHD respectively) both at the start of recovery (between 205 and 210 mAHD depending on climate scenario) and at equilibrium (between 214 and 226 mAHD depending on climate scenario). This indicates that the Kenmare Underground and Laleham Underground workings remain permanently flooded and there is no potential for oxidisation of the workings. The predicted lake levels in the Laleham residual void remain above the elevation of the Augering Underground workings that would be exposed in the void highwall (i.e. of the Pollux Seam at approximately 171 mAHD) both at the start of recovery (between 236 and 238mAHD depending on climate scenario) and at equilibrium (237 mAHD). This also indicates that the Augering Underground workings remain permanently flooded and there is no potential for oxidisation of the workings.

Table 8-8 Predicted Difference between Residual Void Water Levels and Shallow Formations

Climate Scenario	Residual Void	Lowest elevation of base of shallow unconsolidated sediments adjacent void (mAHD)	Difference between void lake level and lowest elevation of base of shallow unconsolidated sediments adjacent void (mAHD)[1]	
			Start of Post-Mining	Post-Mining Equilibrium
Wetter	Ramp 8	175.6	45.1	37.0
	Bonnie Doon	171.9	13.2	8.4
	Mimosa/ Besgrove	180.6	64.7	25.2
	Deep Creek	204.4	67.3	43.6
	Stewarton/ Ballamoo	202.7	63.0	42.3
	Kenmare	315.3	105.7	89.2
	Laleham	257.3	20.8	19.9
	Togara/ North Marshmead	260	128.9	81.8
	South Marshmead	268.3	119.0	74.8
	Kennedy West	202.9	61.3	57.7
	Comet Downs East	201.4	83.3	7.9
Mid	Ramp 8	175.6	47.8	45.0
	Bonnie Doon	171.9	11.3	11.1
	Mimosa/ Besgrove	180.6	66.8	32.4
	Deep Creek	204.4	70.2	50.0
	Stewarton/ Ballamoo	202.7	65.4	48.0
	Kenmare	315.3	107.9	96.1
	Laleham	257.3	19.4	20.5
	Togara/ North Marshmead	260	126.5	87.3
	South Marshmead	268.3	119.4	81.5
	Kennedy West	202.9	63.4	62.7
	Comet Downs East	201.4	83.5	16.8
Drier	Ramp 8	175.6	49.8	49.1
	Bonnie Doon	171.9	13.0	12.0
	Mimosa/ Besgrove	180.6	70.3	39.8
	Deep Creek	204.4	77.0	56.9
	Stewarton/ Ballamoo	202.7	67.5	53.8
	Kenmare	315.3	110.5	100.9
	Laleham	257.3	20.7	20.7
	Togara/ North Marshmead	260	128.5	93.7
	South Marshmead	268.3	120.8	88.5
	Kennedy West	202.9	65.6	66.4
	Comet Downs East	201.4	85.1	21.4

[1] A positive number means the base of model layer 2 is that many metres higher than the void lake level

8.2.4 Residual Void Groundwater Inflow

The final predicted groundwater inflows to the residual voids from the groundwater model are shown on **Figure 8-14** through **Figure 8-24**. As shown on the figures, the inflows are partitioned between that which flows into the residual voids through spoil, and that which flows into the residual voids through surrounding natural geological formations via highwalls and end walls that remain exposed to the voids.

As mining activity ends in different years for each void, the duration over which groundwater levels in spoil and aquifers adjacent to the residual voids remain suppressed after mine closure in the year 2113 is variable. For most voids, with the exception of Comet Downs void, the groundwater levels are predicted to recover within approximately 40 to 140 years after closure. During this time, groundwater fluxes to the voids are largely controlled by the difference between the predicted spoil groundwater levels and the predicted WSP (2024) residual void lake levels that rise and fall periodically (refer **Figure 8-14** through **Figure 8-24**) according to:

- the day-on-day climatic simulation within the WSP (2024) water balance model; and
- how the daily timestep water balance results are translated to the groundwater model's more simplified stress period setup.

During these early model stress periods prior to equilibrium, fluxes between the voids and adjacent spoil and bedrock formations is more temporally variable than towards the end of the recovery simulation, however despite this variability all voids still behave as net groundwater sinks for both spoil and non-spoil groundwater sources. The one exception to this is Deep Creek, which in the first 100 years post-closure is predicted to temporarily lose void water to surrounding natural geology before the flow gradient is reversed and the void reaches equilibrium as a net sink. The fate of this temporary post-closure outwards flux of void water is explored in **Section 8.2.6**.

Predicted equilibrium groundwater inflows to each of the voids for the three climate scenarios are presented in **Table 8-9**. Model results indicate that across all the voids, spoil contributes between 26% to 100% of the total net inflows to the void. The equilibrium groundwater inflows to each of the voids shown in **Table 8-9** represent approximately 7% to 60% of the total volumetric inflow to each residual void's water balance (**Table 8-10**), indicating that groundwater inflows are not the dominant driver of predicted residual void lake levels except in the case of Comet Downs East residual void.

The equilibrium sink behaviour of the residual voids is driven by evaporative losses from the void lakes predicted by the WSP (2024) water balance model. The direct evaporation from the surface of the void lake maintains void lake levels that are lower than the surrounding groundwater levels in the long-term equilibrium state. All residual voids excluding Kennedy West are predicted to behave as groundwater sinks at post-closure equilibrium with no net outflows to spoil or bedrock. However, the Kennedy West residual void is predicted to lose void water to surrounding natural geology at a very small rate of 0.1 ML/day at equilibrium. The predicted lake elevation at the adjacent Comet Downs residual void is much lower than at Kennedy West void (**Table 8-6**), resulting in a hydraulic gradient between the two voids. Therefore, the outwards water flux from the Kennedy West void is driven by, and would eventually be captured by, the adjacent Comet Downs void. The fate of this permanent post-closure outwards flux of void water from Kennedy West void is further explored in **Section 8.2.6**.

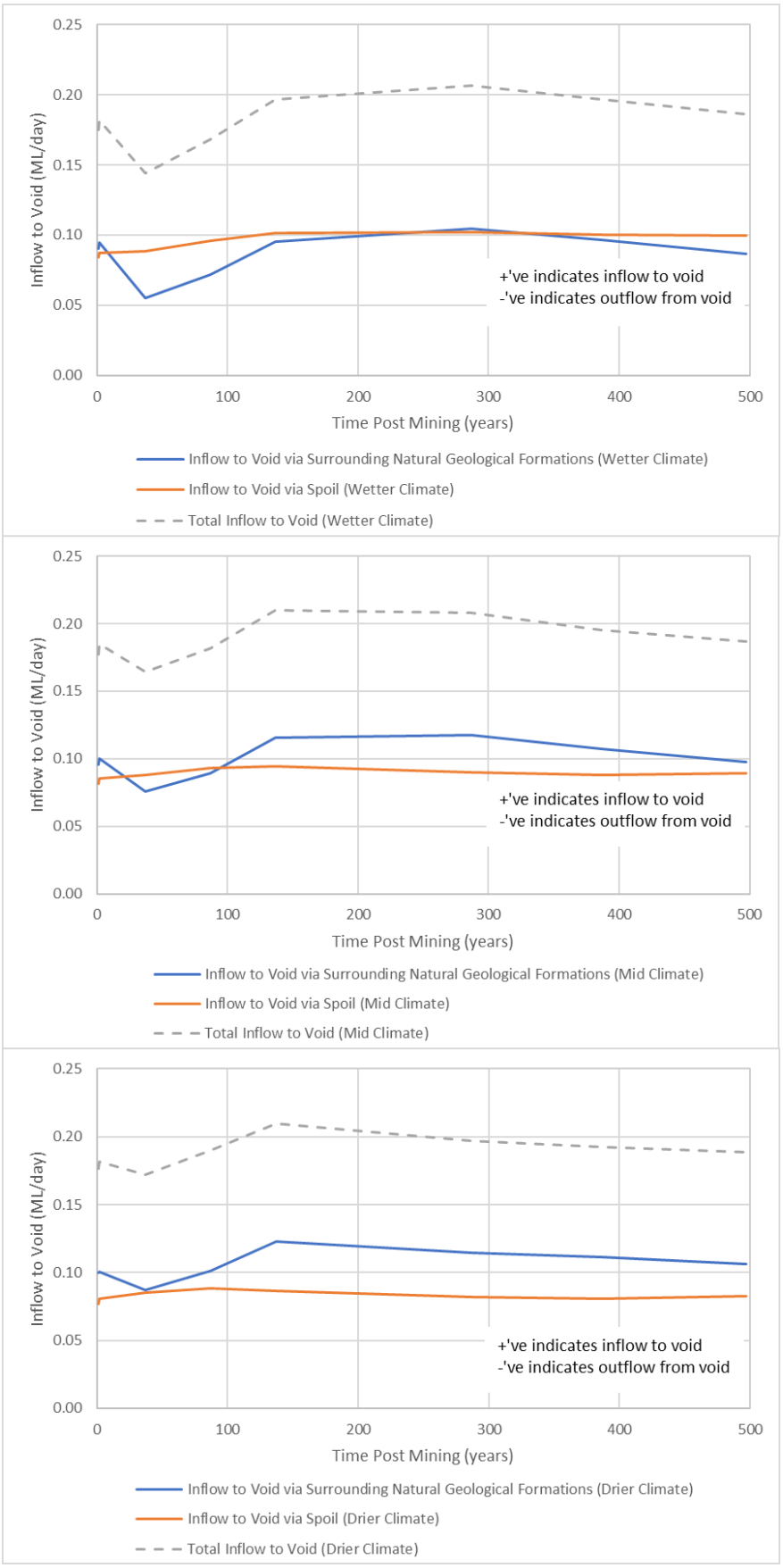


Figure 8-14 Predicted Void Groundwater Inflows – Ramp 8

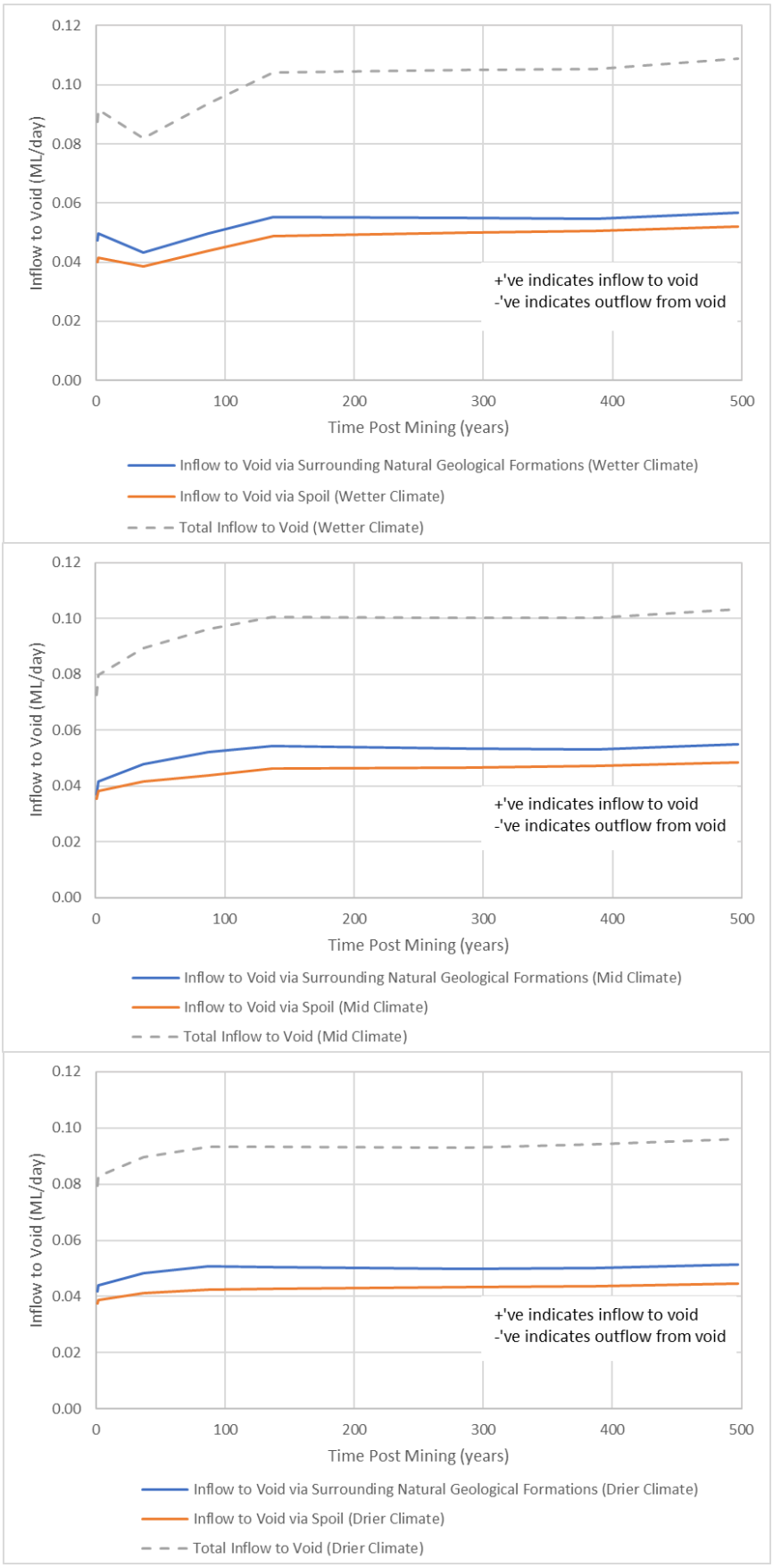


Figure 8-15 Predicted Void Groundwater Inflows – Bonnie Doon

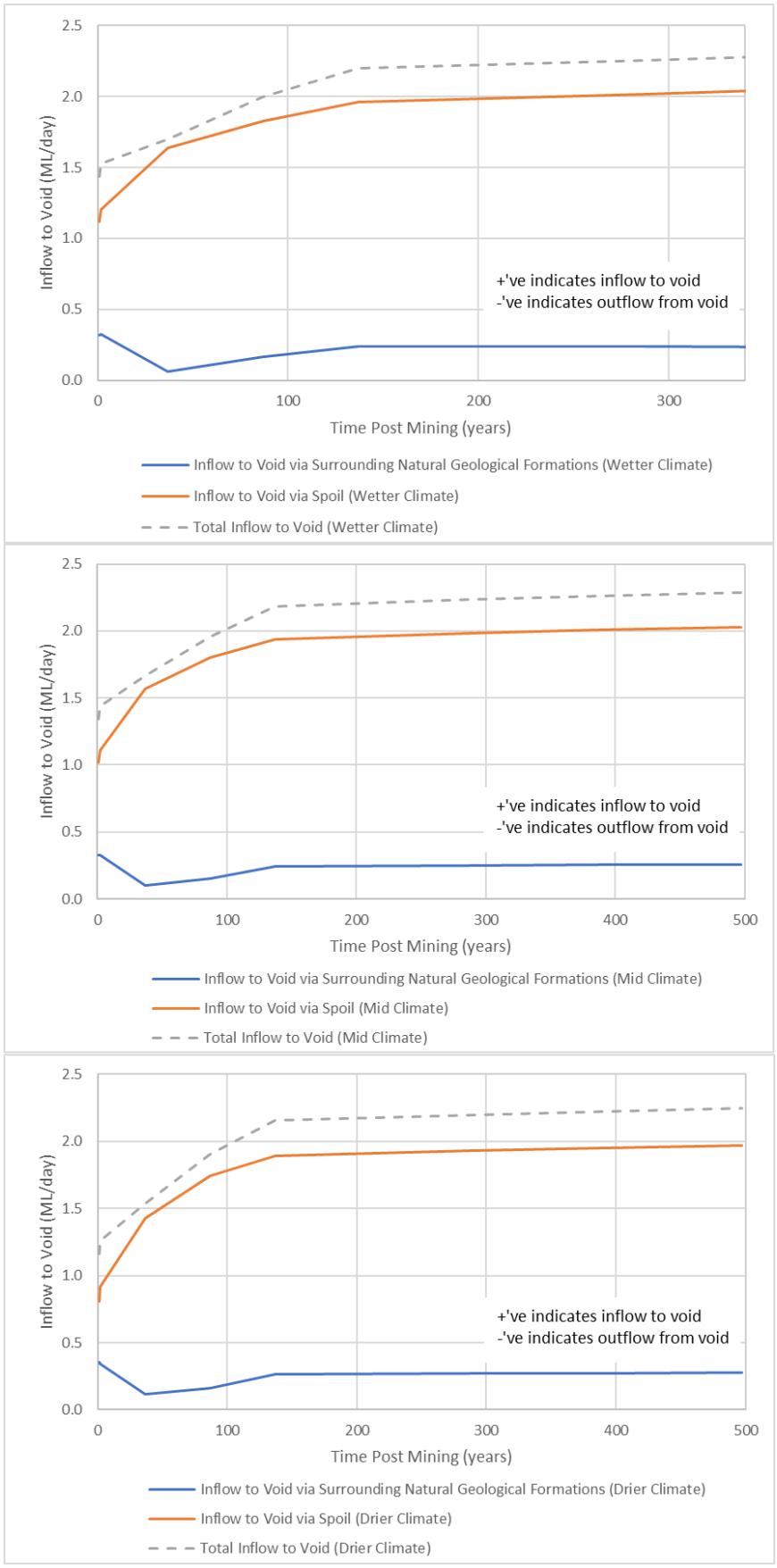


Figure 8-16 Predicted Void Groundwater Inflows – Mimosa/Besgrove

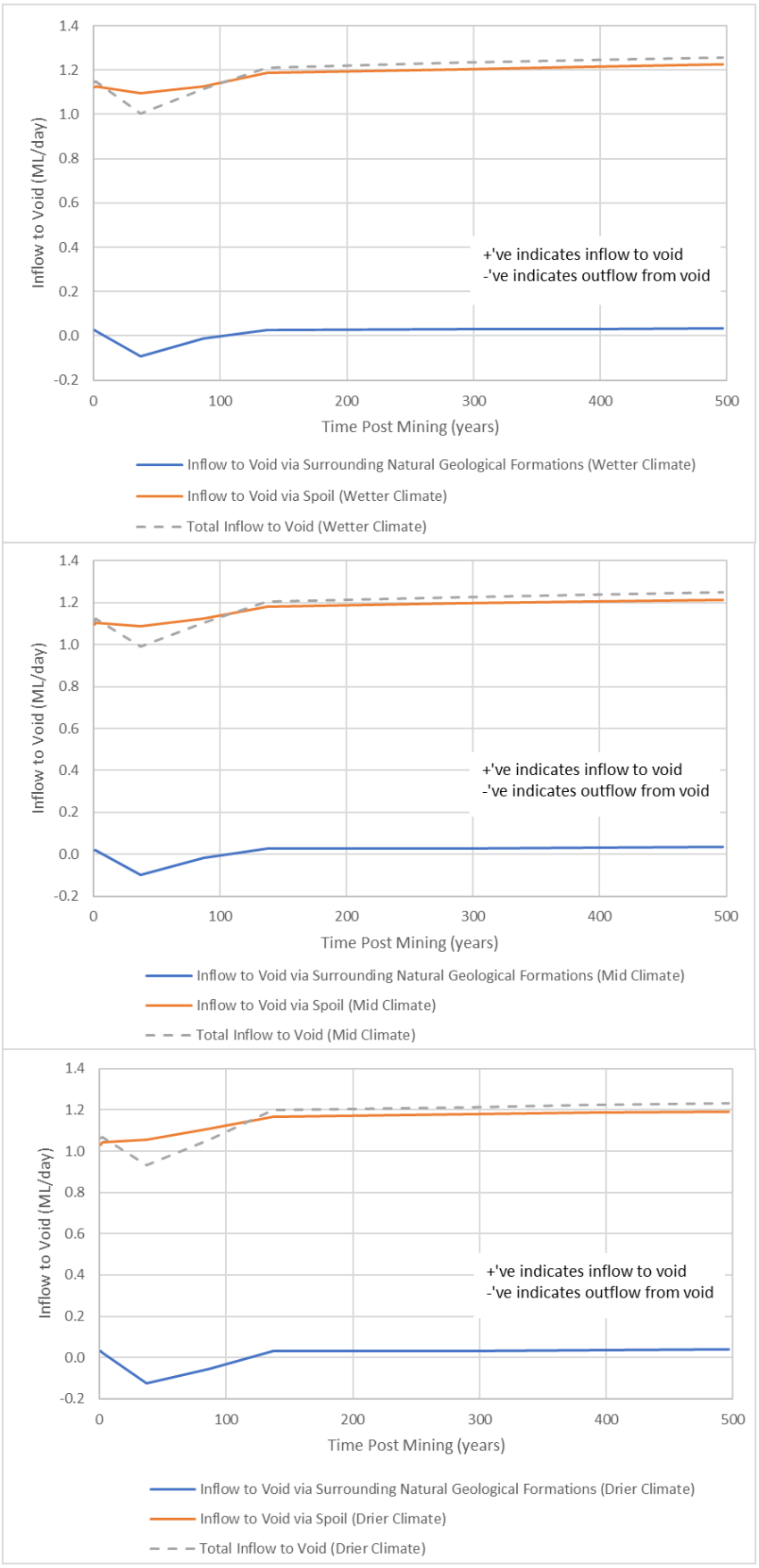


Figure 8-17 Predicted Void Groundwater Inflows – Deep Creek

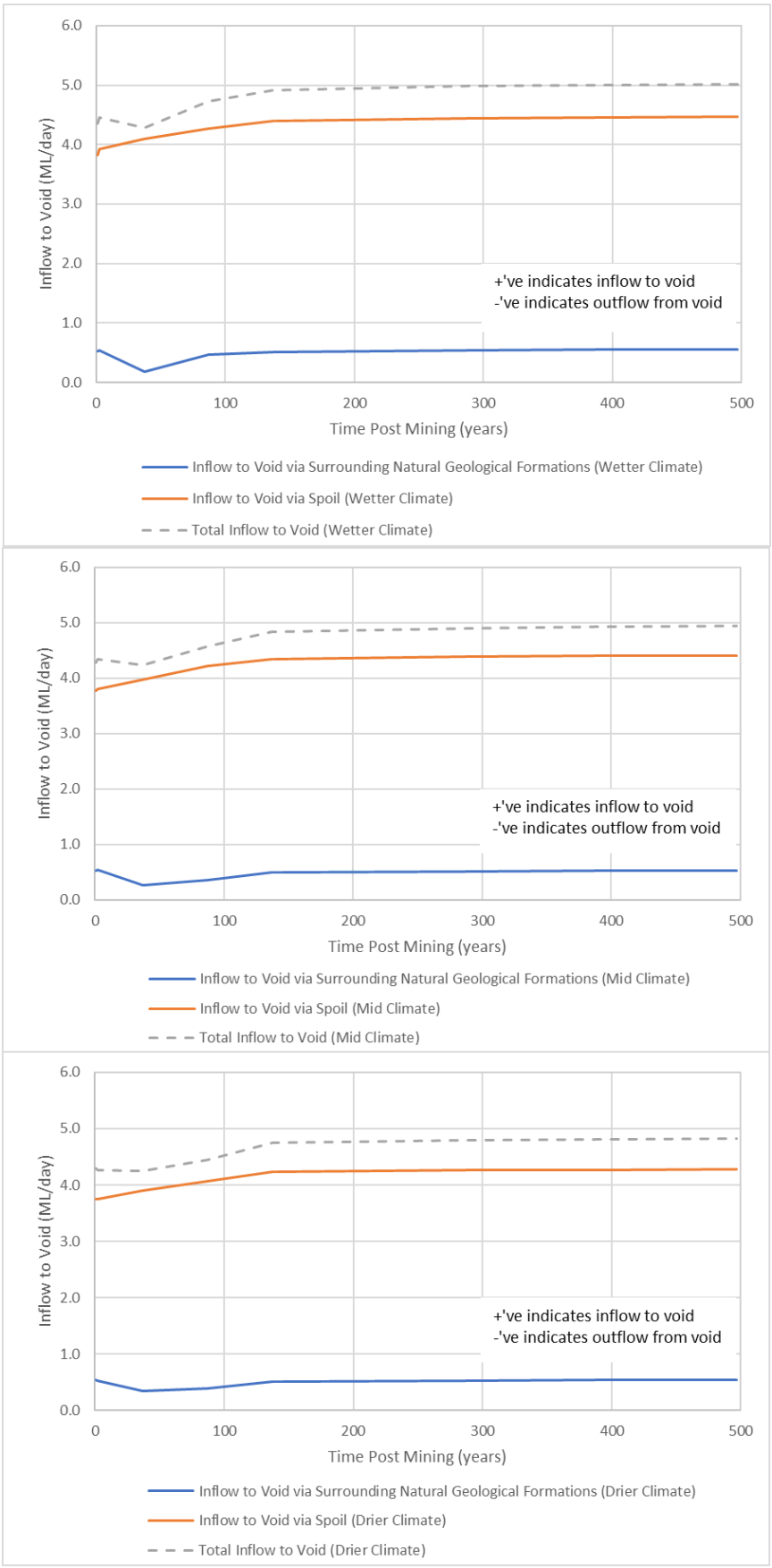


Figure 8-18 Predicted Void Groundwater Inflows – Stewarton/Ballamoo

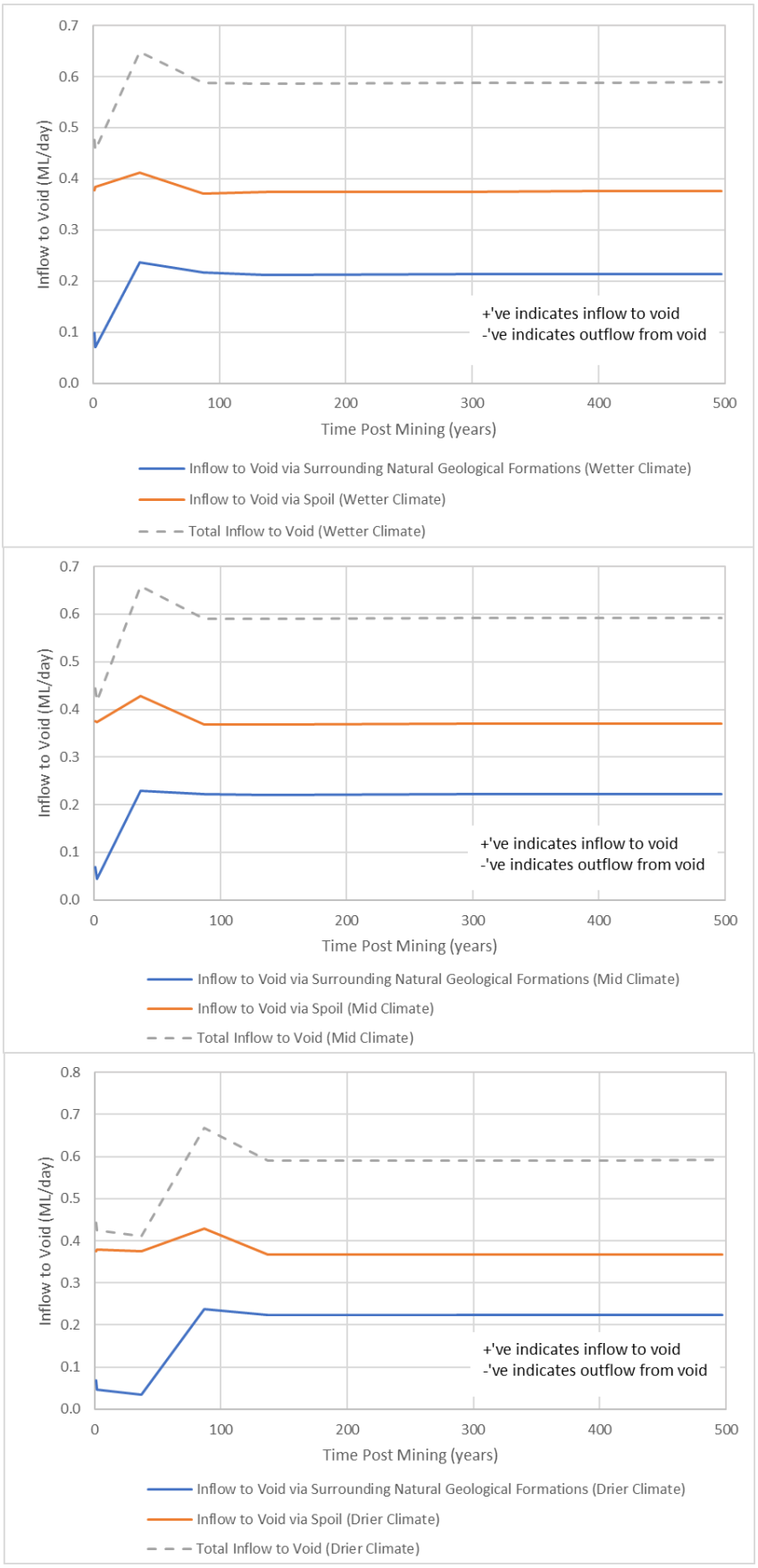


Figure 8-19 Predicted Void Groundwater Inflows – Kenmare

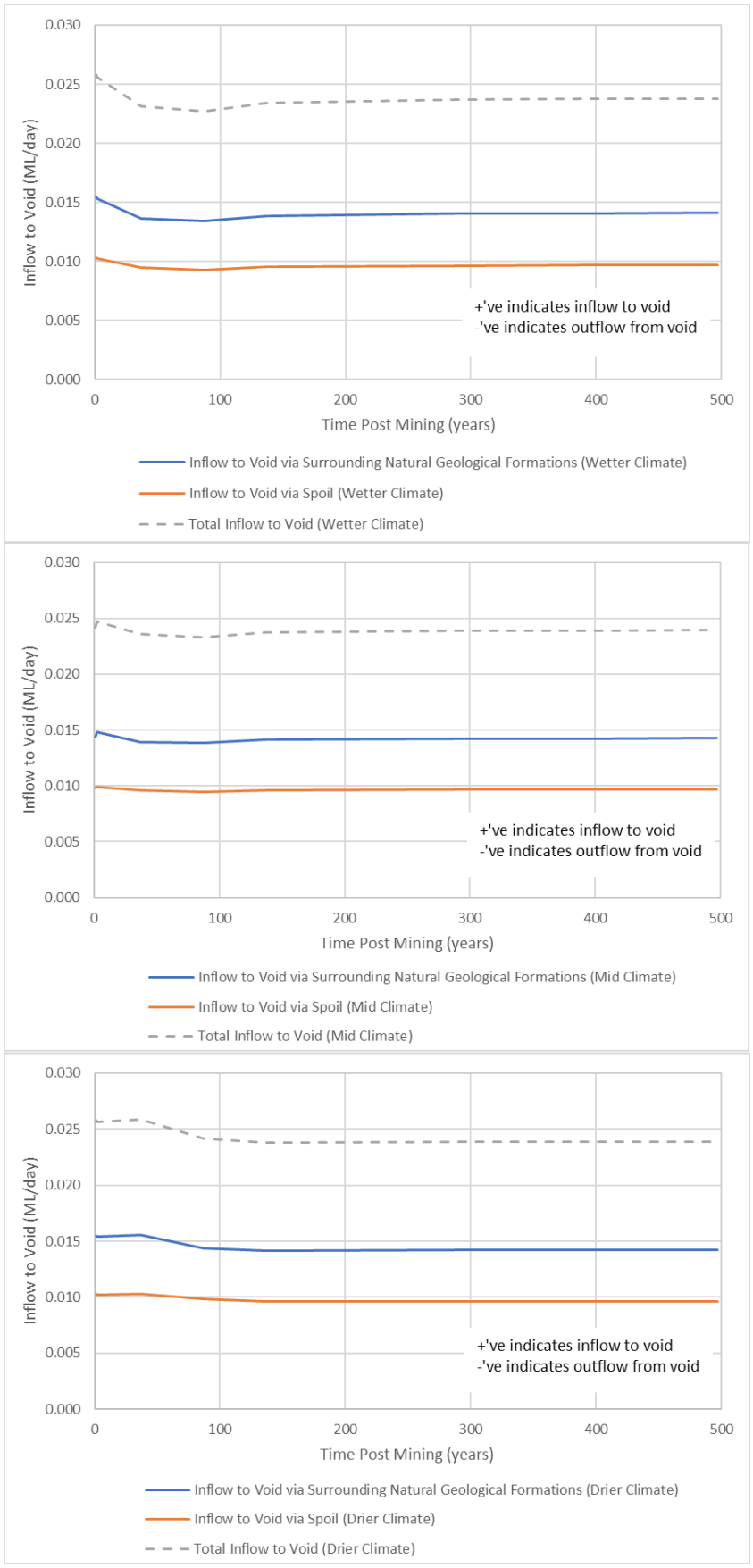


Figure 8-20 Predicted Void Groundwater Inflows – Laleham

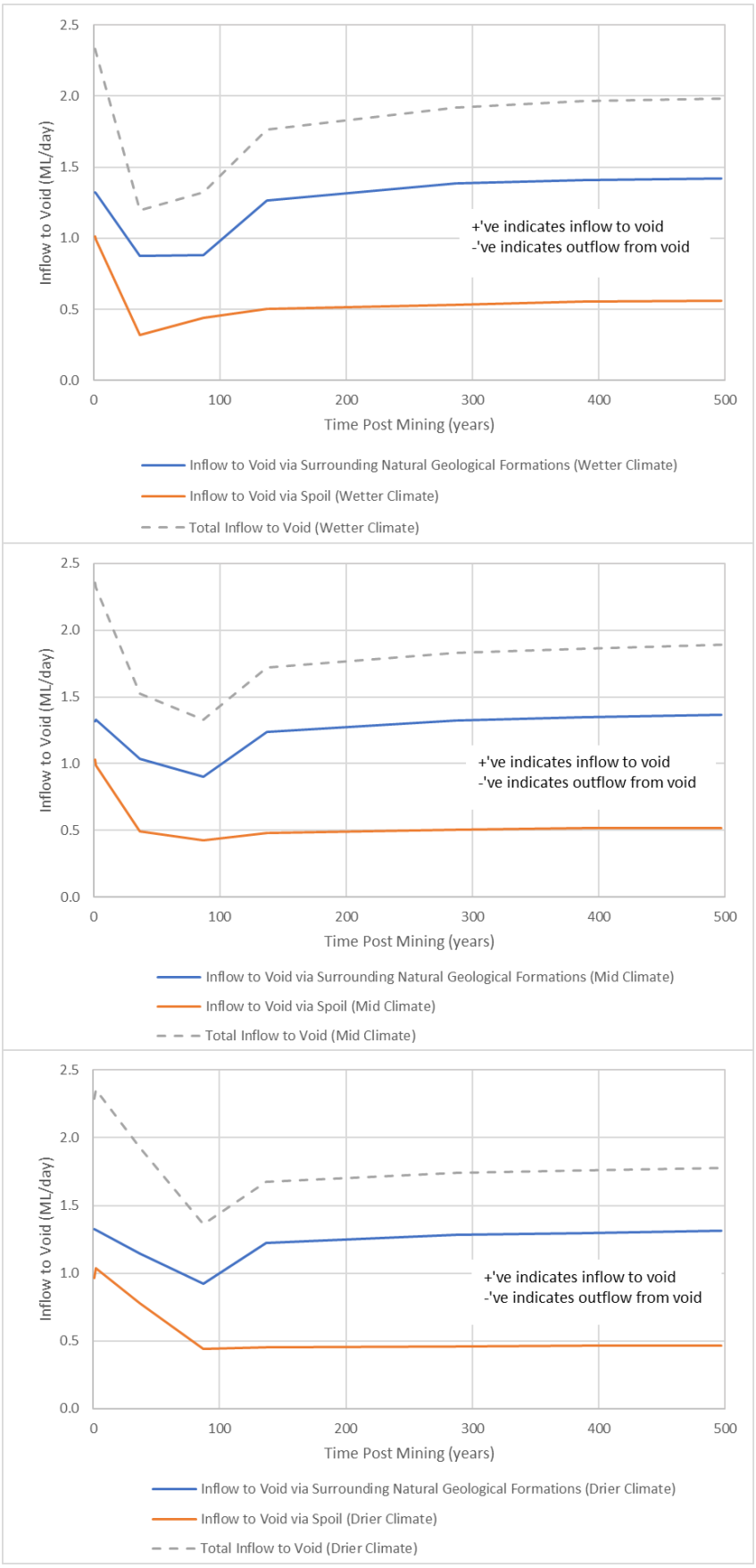


Figure 8-21 Predicted Void Groundwater Inflows – Togara / North Marshmead

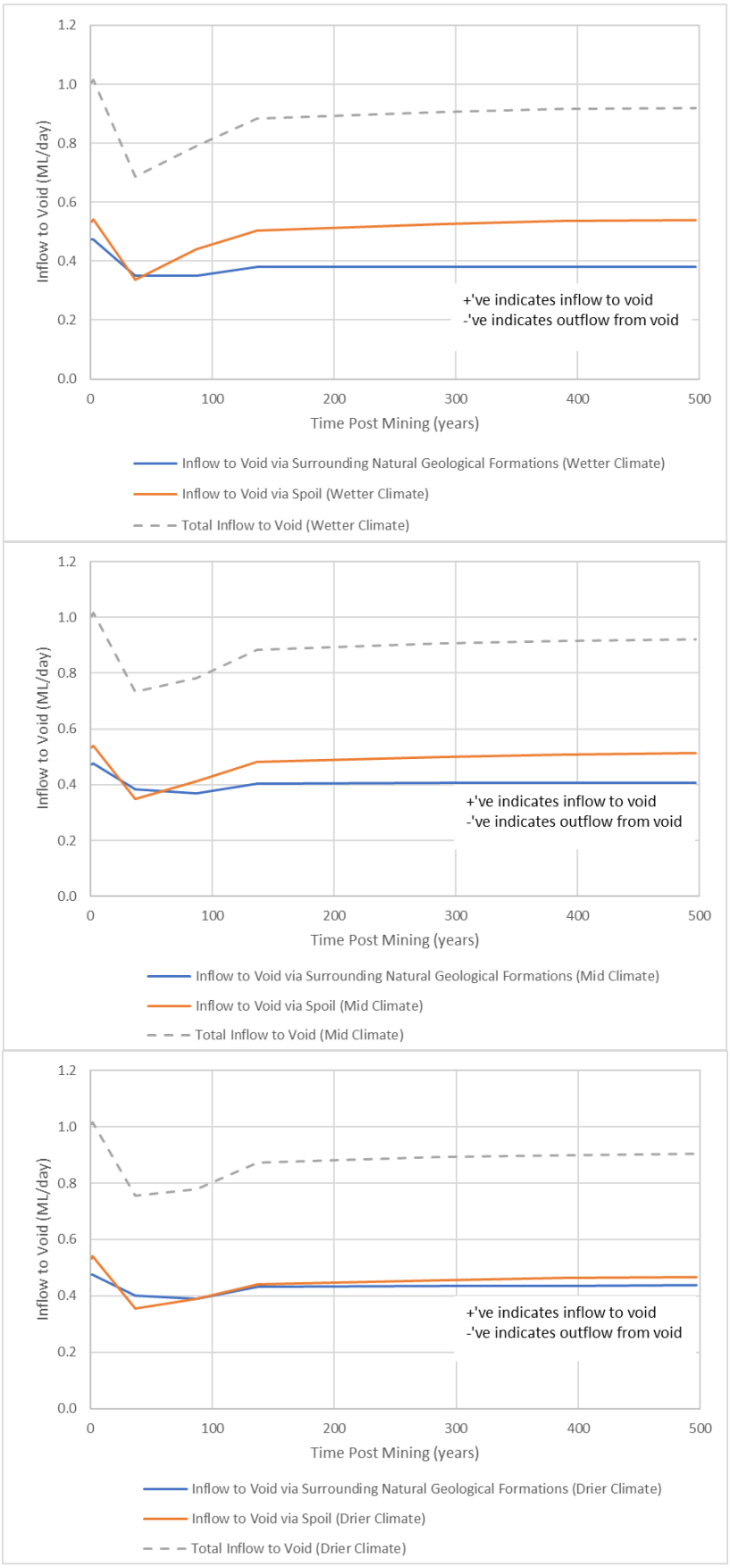


Figure 8-22 Predicted Void Groundwater Inflows – South Marshmead

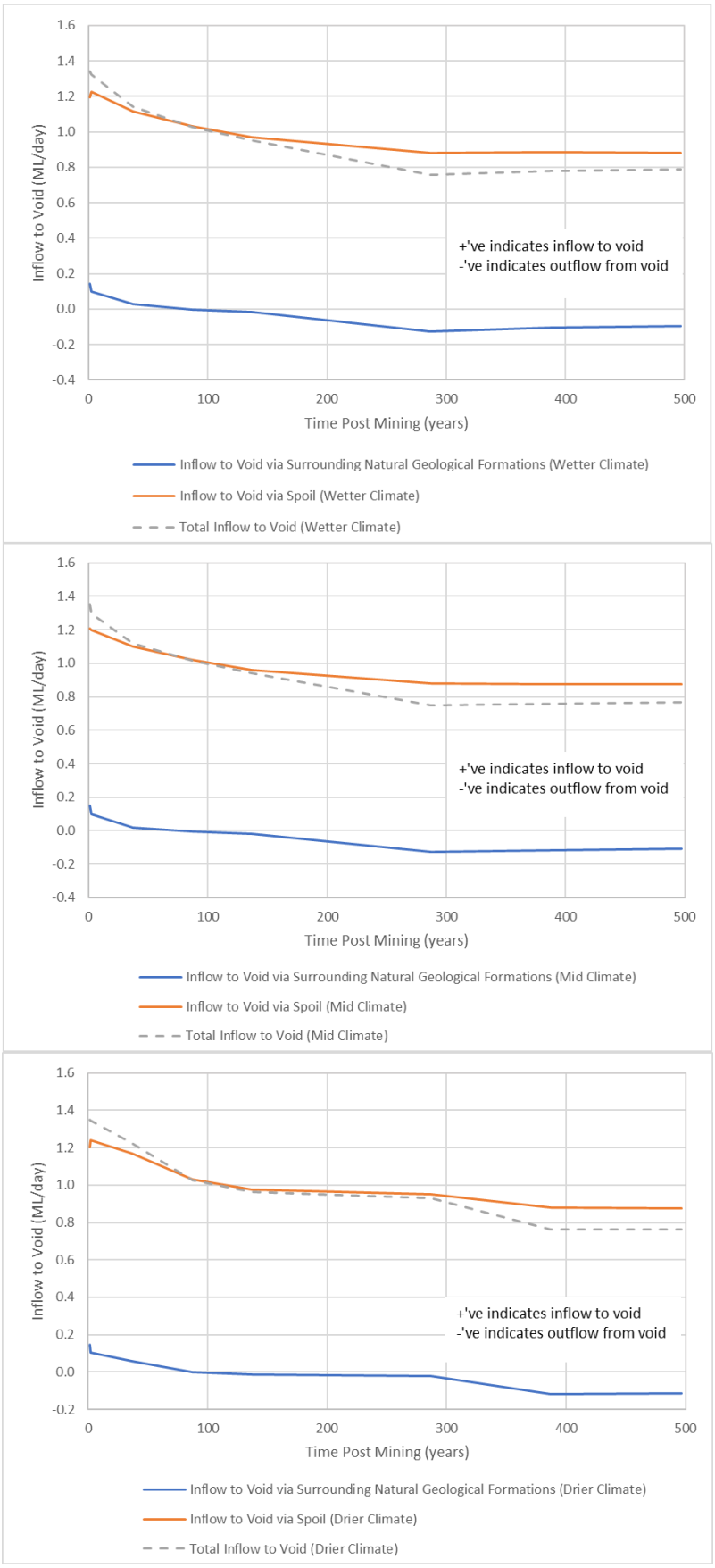


Figure 8-23 Predicted Void Groundwater Inflows – Kennedy West

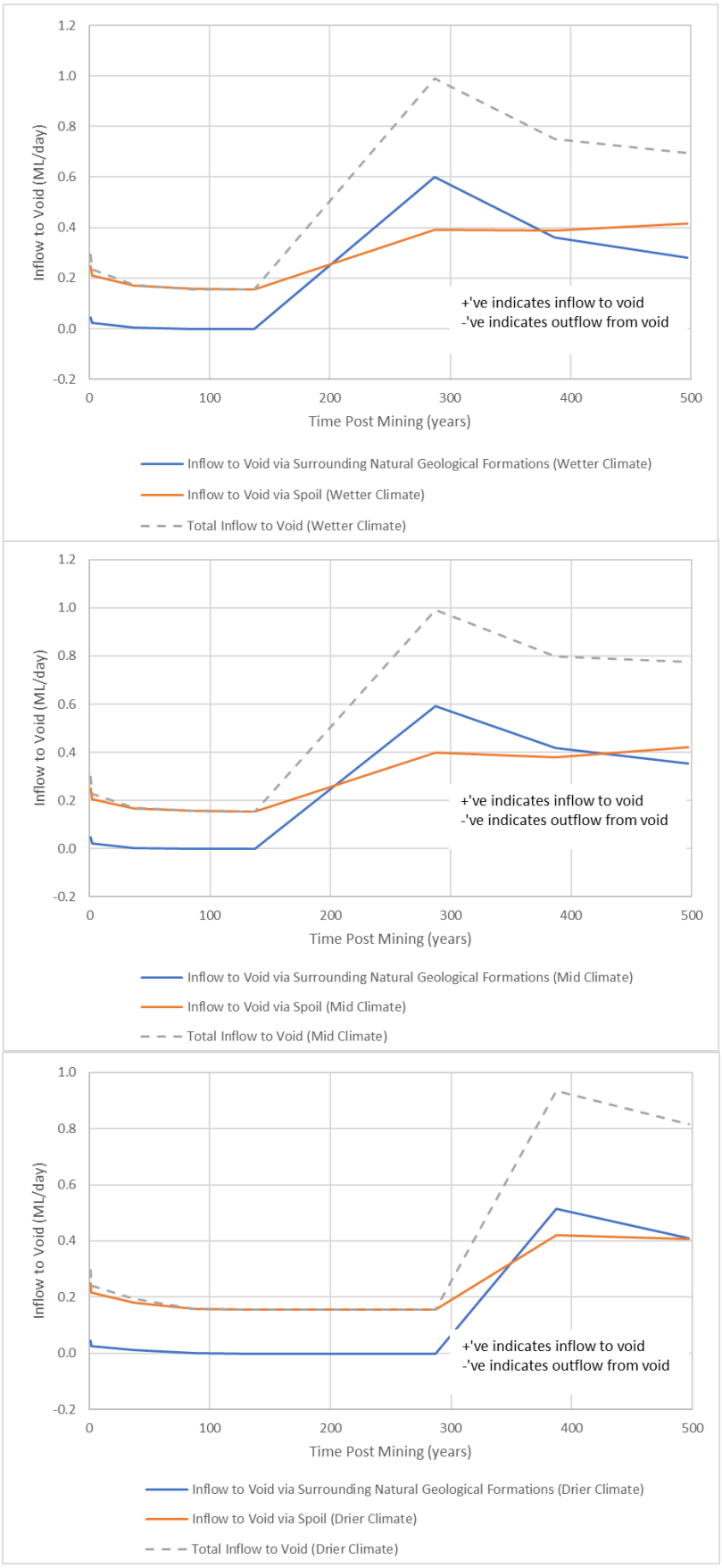


Figure 8-24 Predicted Void Groundwater Inflows – Comet Downs East

Table 8-9 Equilibrium Groundwater Inflow to the Residual Voids

Climate Scenario	Residual Void	Equilibrium Inflow Rate – Spoil (ML/day)	Equilibrium Inflow Rate – Natural Geological Formations (ML/day)	Equilibrium Inflow Rate – Total (ML/day)
Wetter	Ramp 8	0.10	0.09	0.19
	Bonnie Doon	0.05	0.06	0.11
	Mimosa/ Besgrove	2.09	0.24	2.33
	Deep Creek	1.23	0.03	1.26
	Stewarton/ Ballamoo	4.47	0.55	5.02
	Kenmare	0.38	0.21	0.59
	Laleham	0.01	0.01	0.02
	Togara/ North Marshmead	0.56	1.42	1.98
	South Marshmead	0.54	0.38	0.92
	Kennedy West	0.88	-0.09	0.79
	Comet Downs East	0.42	0.28	0.70
Mid	Ramp 8	0.09	0.10	0.19
	Bonnie Doon	0.05	0.05	0.10
	Mimosa/ Besgrove	2.03	0.26	2.28
	Deep Creek	1.21	0.03	1.25
	Stewarton/ Ballamoo	4.41	0.53	4.94
	Kenmare	0.37	0.22	0.59
	Laleham	0.01	0.01	0.02
	Togara/ North Marshmead	0.52	1.37	1.89
	South Marshmead	0.51	0.41	0.92
	Kennedy West	0.87	-0.11	0.77
	Comet Downs East	0.42	0.35	0.77
Drier	Ramp 8	0.08	0.11	0.19
	Bonnie Doon	0.04	0.05	0.10
	Mimosa/ Besgrove	1.97	0.28	2.25
	Deep Creek	1.19	0.04	1.23
	Stewarton/ Ballamoo	4.28	0.55	4.82
	Kenmare	0.37	0.22	0.59
	Laleham	0.01	0.01	0.02
	Togara/ North Marshmead	0.47	1.31	1.78
	South Marshmead	0.47	0.44	0.90
	Kennedy West	0.88	-0.11	0.76
	Comet Downs East	0.41	0.41	0.82

Table 8-10 Equilibrium Groundwater Contribution to the Residual Voids (Mid-Climate Scenario)

Residual Void	Approximate Groundwater Contribution to Total Void Inflow[1]
Ramp 8	49%
Bonnie Doon	13%
Mimosa/ Besgrove	41%
Deep Creek	49%
Stewarton/ Ballamoo	42%
Kenmare	38%
Laleham	7%
Togara/ North Marshmead	42%
South Marshmead	50%
Kennedy West	33%
Comet Downs East	60%

1. Based on volumetric inflows reported in WSP (2024)

8.2.5 Predicted Groundwater Levels

Groundwater level predictions and associated discussion presented herein is focussed primarily on the Mid Climate scenario with the Drier and Wetter scenario's reported as sensitivities. This is deemed appropriate given the relatively small difference in predicted residual void lake elevations (that drive groundwater levels) between the scenarios with respect to void lake levels that might pose a risk to the groundwater environment (refer **Section 8.2.2**).

8.2.5.1 Potentiometric Surface Mapping

The predicted equilibrium water table elevation adjacent the residual voids is shown on **Figure 8-25** for the Mid Climate scenario. Predicted groundwater levels for the main groundwater bearing units surrounding the final landform – the Aries, Castor and Pollux Seams of the Rangal Coal Measures (model layers 8, 10 and 12) and the Burngrove Formation (model layer 14) - are shown on **Figure 8-26** to **Figure 8-29**, again at equilibrium for the Mid Climate scenario.

Groundwater levels surrounding the residual voids are controlled by the predicted residual void lake levels, which in turn are controlled by the rate of evaporation from the void lakes balancing mostly surface inflows and some groundwater inflows to the lakes (WSP, 2024), including a component of groundwater that moves out of the natural geological formations into the residual voids via the spoil (refer **Table 8-9**). The conceptual relationship between these components is displayed in **Figure 8-2**. That is, predicted groundwater levels surrounding the residual voids are a function of predicted lake levels, which as discussed in **Section 8.2.3**, are mostly dominantly controlled by surface water fluxes and maintained by evaporation.

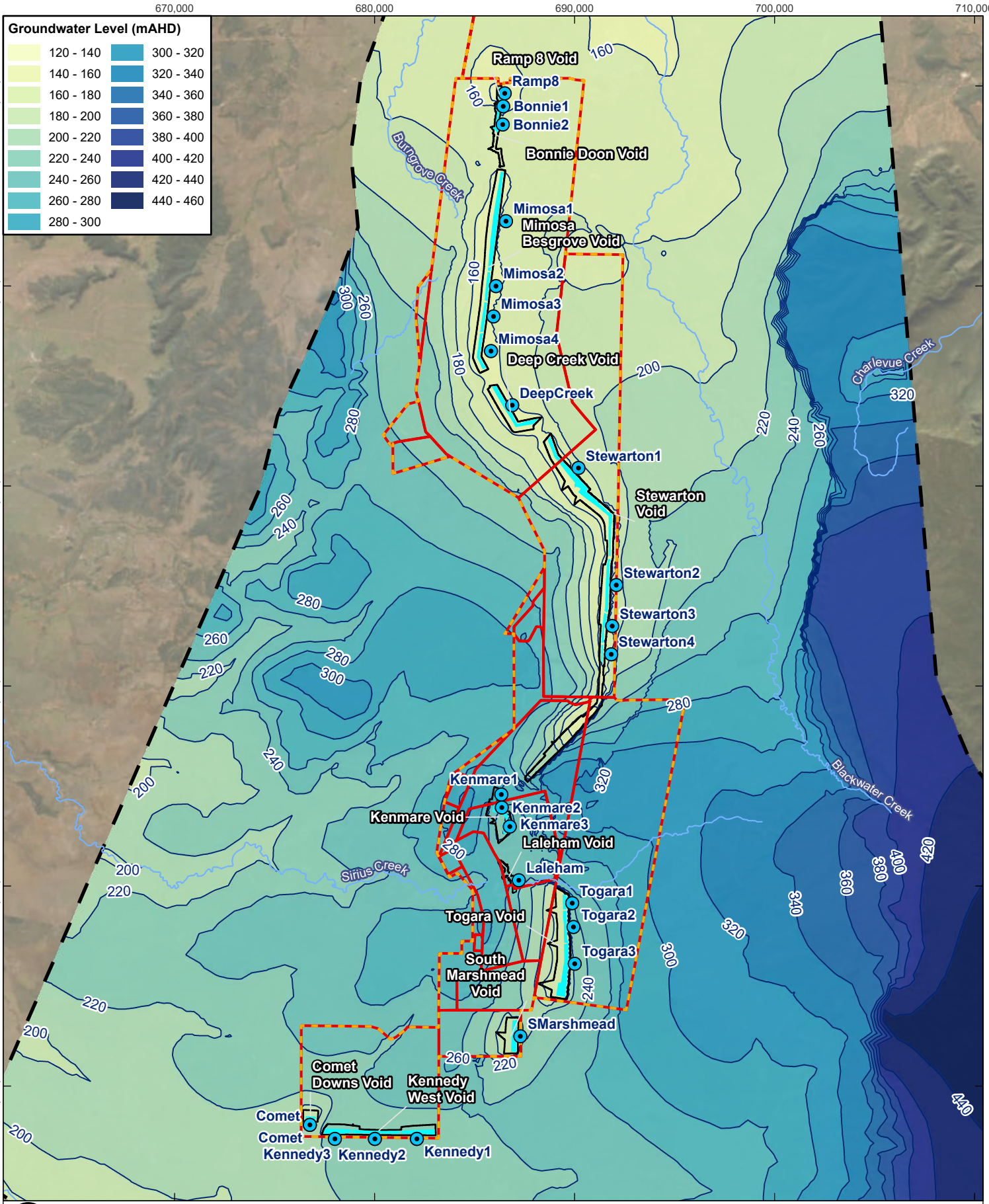
The predicted equilibrium water table elevation adjacent the residual voids is shown on **Figure 8-25** for the Mid Climate scenario. The water table is predicted to remain depressed

in the immediate vicinity of the residual voids in the long term, driven by the ongoing groundwater discharge to the residual void lakes and governed by the lake elevations themselves (**Figure 8-25**). That is, long term inwards groundwater flow gradients are maintained post-mining for the water table. Steepest water table gradients occur along the eastern sides of the Stewarton/Ballamoo and Togara residual voids and on the southeast corner of the South Marshmead residual void. Gradients in the natural rock away from the mining area and away from the residual voids are significantly shallower outside the BWM Area (with the exception of the steeper gradient observed distant to the east that occurs due to the Clematis Group escarpment). Relatively steep water table gradients also occur within the spoil emplacements to the west of the Ramp 8, Bonnie Doon, Mimosa/Besgrove, Deep Creek, Stewarton/Ballamoo, Kenmare, Laleham, Togara/North Marshmead and South Marshmead residual voids and to the north of the Kennedy West and Comet Downs residual voids.

Predicted groundwater levels for the Aries, Castor and Pollux Seams of the Rangal Coal Measures (model layers 8, 10 and 12) and for the Burngrove Formation (model layer 14) are shown on **Figure 8-26** to **Figure 8-29**, again at equilibrium for the Mid Climate scenario. Predicted groundwater levels for the Aries, Castor and Pollux Seams of the Rangal Coal Measures and for the Burngrove Formation indicate again that groundwater levels in the Permian sequence are predicted to remain depressed in the long term, driven by the ongoing groundwater discharge to the residual void lakes and governed by the lake elevations themselves.

The following summarises the model predicted stabilised groundwater levels as shown in **Figure 8-26** to **Figure 8-28** for the Aries, Castor and Pollux Seams:

- The Aries Seam is predicted to remain ‘dry’ in the long term across most of the mined area, with some saturation present predominantly along the east of the Bonnie Doon, Mimosa/Besgrove, Deep Creek, Stewarton/Ballamoo, Laleham and Togara residual void areas and also within/surrounding the South Marshmead, Kennedy West and Comet Downs residual void areas. Additionally, dominant flow gradients towards the southern end of the Stewarton/Ballamoo residual void and surrounding the Togara and South Marshmead residual voids are apparent within the Aries Seam along the east of the BWM Area (**Figure 8-26**).
- The Castor Seam is predicted to remain dry across much of the area to the west of the mined area, however remains saturated along most of the eastern margin of the mined area and within the south near the South Marshmead, Kennedy West and Comet Downs residual void areas. West of Mimosa/Besgrove and Deep Creek residual voids, saturation is predicted in the model layer (layer 10) that formerly represented the Castor Seam but now represents emplaced spoil within former mining pits. Dominant flow gradients in the Castor Seam are again apparent towards the southern end of the Stewarton/Ballamoo residual void and surrounding the Togara and South Marshmead residual voids within the Aries Seam along the east of the BWM Area (**Figure 8-27**).
- Predicted Pollux Seam groundwater levels show steeper gradients surrounding the southern and western side of the Stewarton/Ballamoo residual void, the Kenmare, Togara, South Marshmead, Comet Downs and Ramp 8 residual voids and along the western side of the Mimosa Besgrove and Deep Creek residual voids. Gradients in the Pollux Seam are relatively flatter surrounding the Bonnie Doon residual void, to the east of Mimosa Besgrove, Deep Creek and Stewarton Residual voids and surrounding the Laleham and Kennedy West residual voids (**Figure 8-28**). Some saturation is predicted west of the residual voids in the model layer (layer 12) that formerly represented the Aries Seam but now represents emplaced spoil within former mining pits.



0 2.5 5 km

Coordinate System:	GDA2020 MGA Zone 55
Scale:	1:250,000 at A4
Project Number:	620.040199
Date Drawn:	09-Aug-2024
Drawn by:	AS

LEGEND

- Hydrograph Location
- Watercourse
- Groundwater Level (mAHD)
- BWM Mining Lease
- Project Area (Environmental Authorities boundary)
- Study Area
- Void Extent
- Void Lake

BLACKWATER MINE - TRANSITIONAL PRCP HYDROGEOLOGY ASSESSMENT

PREDICTED WATER TABLE ELEVATION – POST-MINING EQUILIBRIUM (MID CLIMATE SCENARIO)

SLR

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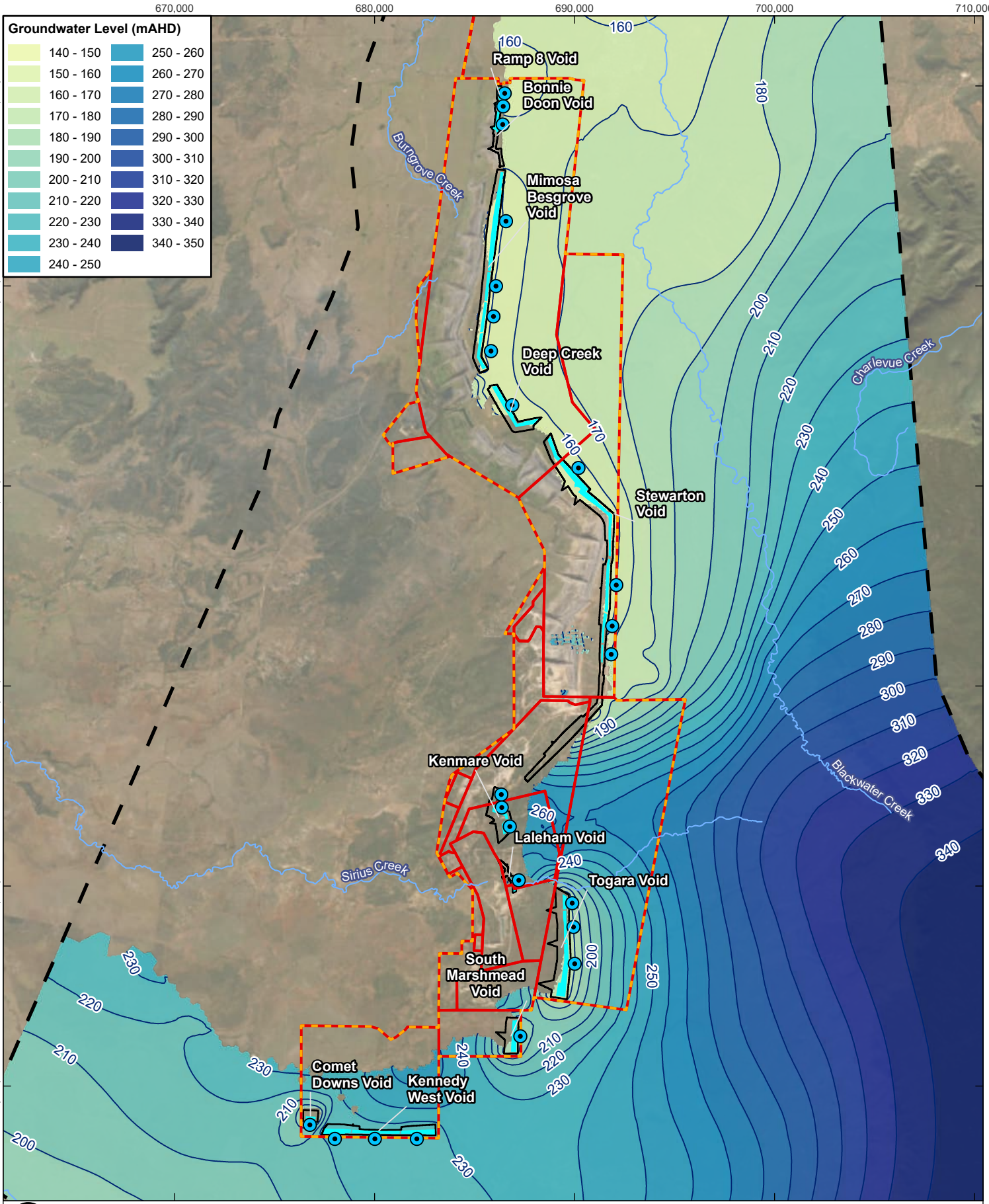
FIGURE 8-25

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040199.00001 BWM PRCP – GW\03 SLR Data\01 CADGIS\GIS\ArcPro\BWM PRCP – GW\BWM PRCP – GW.aprx\620040199_F08_25_Predicted Water Table Elevation – PME (Mid Climate Scenario)



0 2.5 5 km

Coordinate System:	GDA2020 MGA Zone 55
Scale:	1:250,000 at A4
Project Number:	620.040199
Date Drawn:	09-Aug-2024
Drawn by:	AS

LEGEND

- Hydrograph Location
- Watercourse
- Groundwater Level (mAHD)
- BWM Mining Lease
- Project Area (Environmental Authorities boundary)
- Study Area
- Void Extent
- Void Lake

BLACKWATER MINE - TRANSITIONAL PRCP HYDROGEOLOGY ASSESSMENT

PREDICTED GROUNDWATER LEVELS IN THE ARIES SEAM (LAYER 8) – POST-MINING EQUILIBRIUM (MID CLIMATE SCENARIO)

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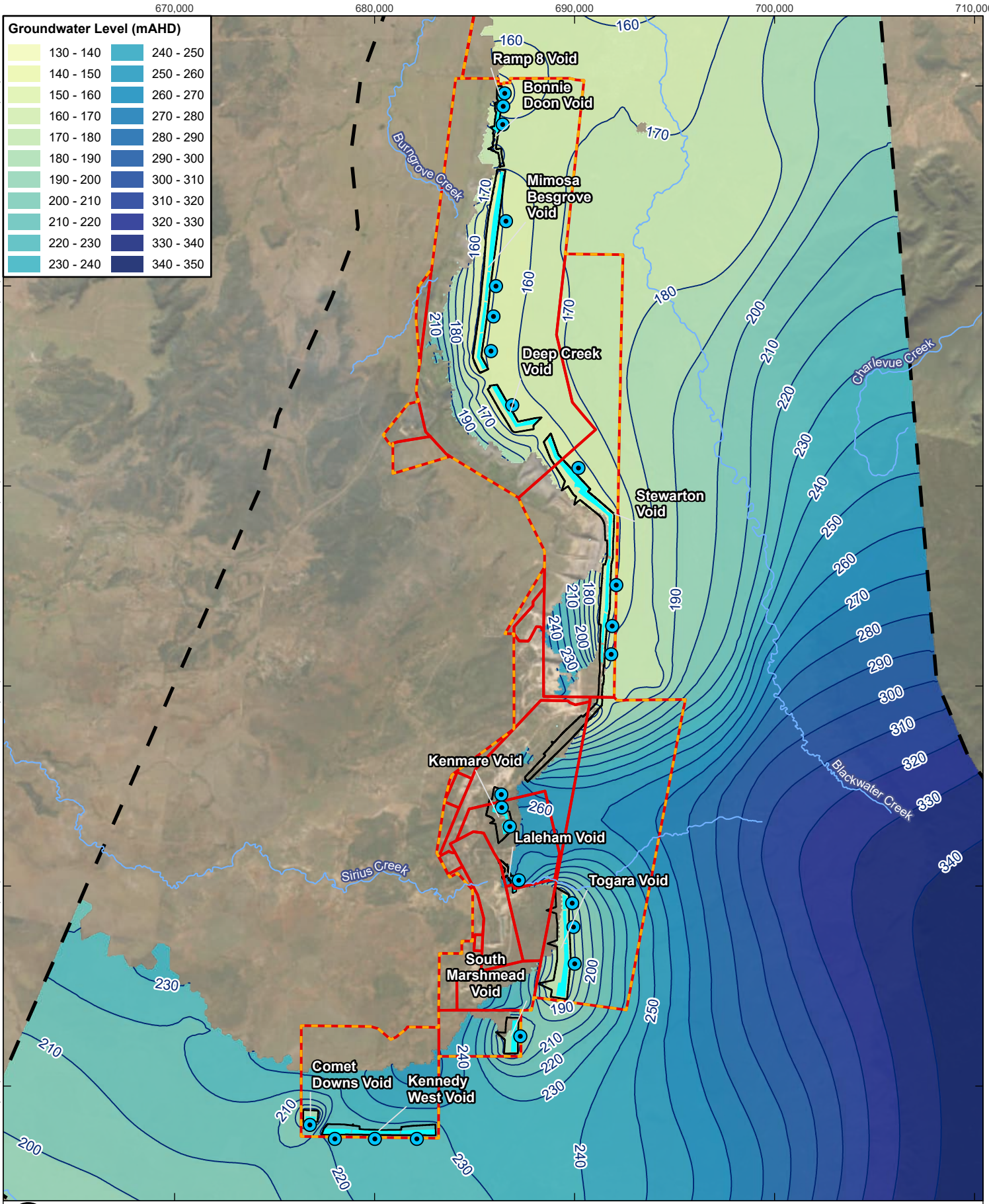
FIGURE 8-26

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040199.00001 BWM PRCP – GW\03 SLR Data\01 CADGIS\GIS\ArcPro\BWM PRCP – GW\BWM PRCP – GW.aprx\620040199_F08_26_Predicted Groundwater Levels in the Aries Seam (Layer 8) – PME (Mid Climate Scenario)



0 2.5 5 km

Coordinate System:	GDA2020 MGA Zone 55
Scale:	1:250,000 at A4
Project Number:	620.040199
Date Drawn:	09-Aug-2024
Drawn by:	AS

LEGEND

- Hydrograph Location
- Watercourse
- Groundwater Level (mAHD)
- BWM Mining Lease
- Project Area (Environmental Authorities boundary)
- Study Area
- Void Extent
- Void Lake

BLACKWATER MINE - TRANSITIONAL PRCP HYDROGEOLOGY ASSESSMENT

PREDICTED GROUNDWATER LEVELS IN THE CASTOR SEAM (LAYER 10) – POST-MINING EQUILIBRIUM (MID CLIMATE SCENARIO)

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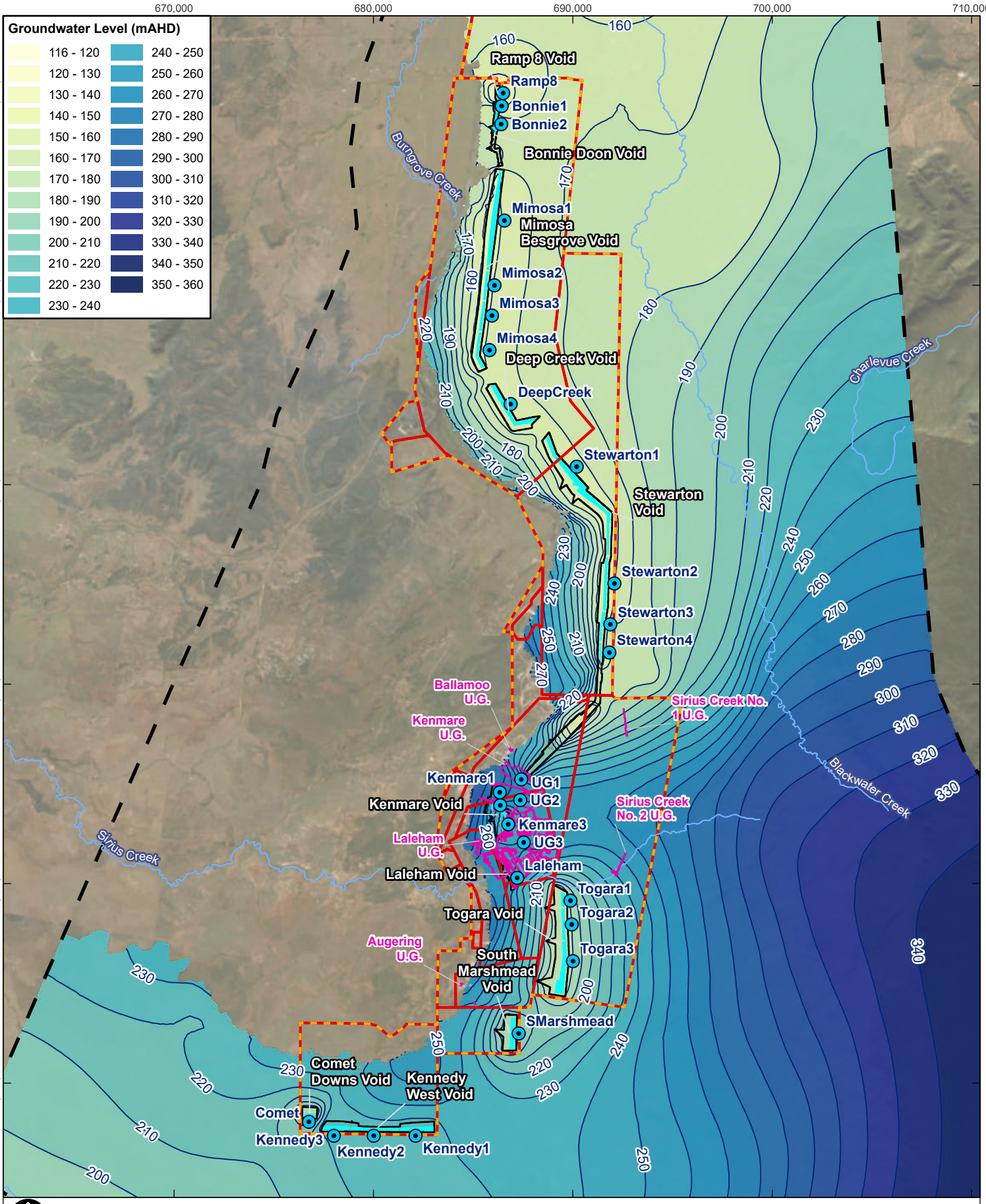
FIGURE 8-27

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040199.00001 BWM PRCP – GW\03 SLR Data\01 CADGIS\GIS\ArcPro\BWM PRCP – GW\BWM PRCP – GW.aprx\620040199_F08_27_Predicted Groundwater Levels in the Castor Seam (Layer 10) – PME (Mid Climate Scenario)



0 2.5 5 km

Coordinate System:	GDA2020 MGA Zone 55
Scale:	1:250,000 at A4
Project Number:	620.040199
Date Drawn:	09-Aug-2024
Drawn by:	AS

LEGEND

- Hydrograph Location
- Watercourse
- Groundwater Level (mAHD)
- Historical Underground Mine
- BWM Mining Lease
- Project Area (Environmental Authorities boundary)
- Study Area
- Void Extent
- Void Lake

BLACKWATER MINE - TRANSITIONAL PRCP HYDROGEOLOGY ASSESSMENT

PREDICTED GROUNDWATER LEVELS IN THE POLLUX SEAM (LAYER 12) – POST-MINING EQUILIBRIUM (MID CLIMATE SCENARIO)

SLR

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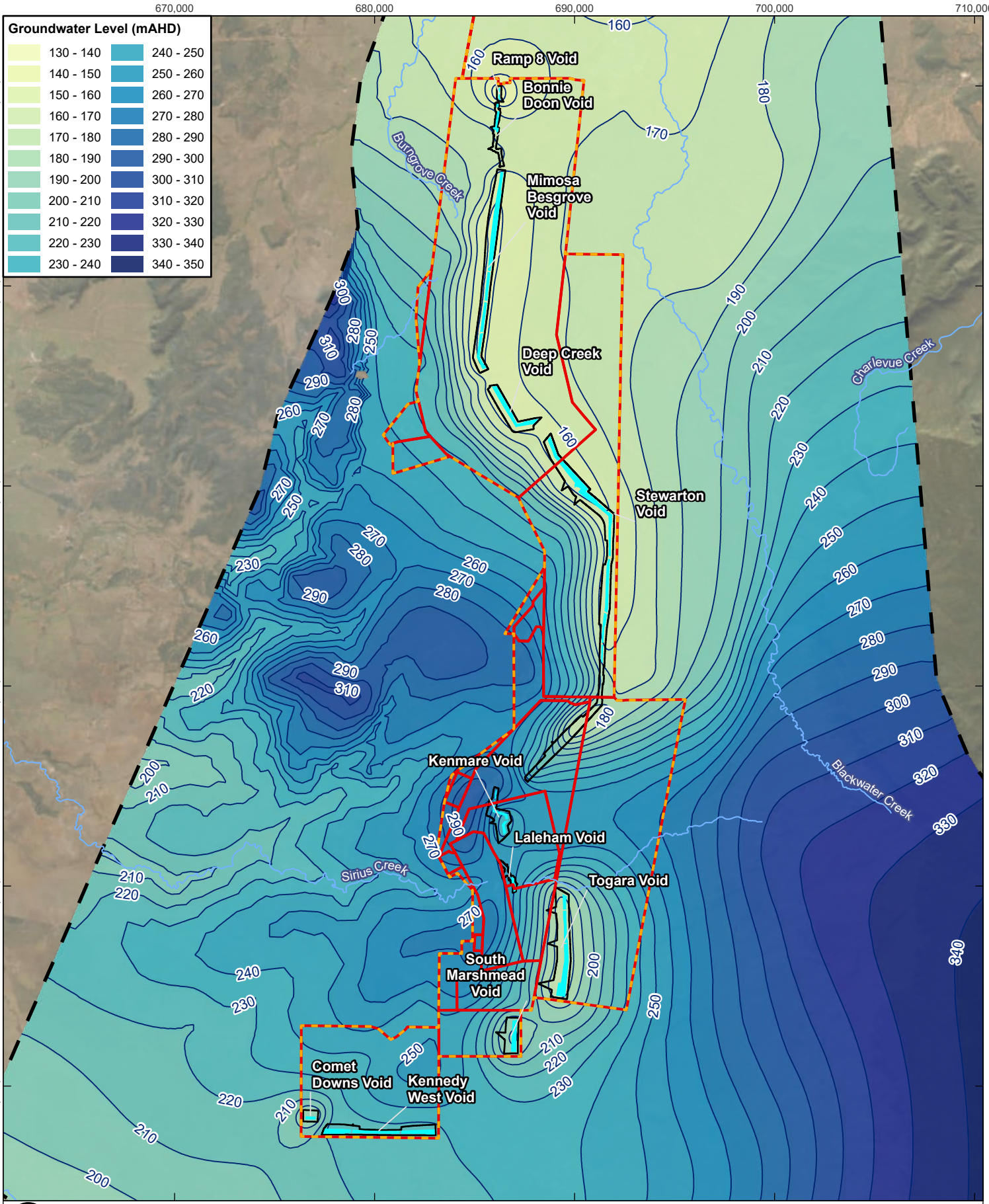
FIGURE 8-28

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040199.00001 BWM PRCP – GW\03 SLR Data\01 CADGIS\GIS\ArcPro\BWM PRCP – GW\BWM PRCP – GW.aprx\620040199_F08_28_Predicted Groundwater Levels in the Pollux Seam (Layer 12) – PME (Mid Climate Scenario)



0 2.5 5 km

Coordinate System:	GDA2020 MGA Zone 55
Scale:	1:250,000 at A4
Project Number:	620.040199
Date Drawn:	09-Aug-2024
Drawn by:	AS

LEGEND

- Watercourse
- Groundwater Level (mAHD)
- BWM Mining Lease
- Project Area (Environmental Authorities boundary)
- Study Area
- Void Extent
- Void Lake

BLACKWATER MINE - TRANSITIONAL PRCP HYDROGEOLOGY ASSESSMENT

PREDICTED GROUNDWATER LEVELS IN THE BURNGROVE FORMATION (LAYER 14) – POST-MINING EQUILIBRIUM (MID CLIMATE SCENARIO)

SLR

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FIGURE 8-29

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040199.00001 BWM PRCP – GW\03 SLR Data\01 CADGIS\GIS\ArcPro\BWM PRCP – GW\BWM PRCP – GW.aprx\620040199_F08_29_Predicted Groundwater Levels in the Burngrove Formation (Layer 14) – PME (Mid Climate Scenario)

8.2.5.2 Predictive Hydrographs Adjacent Void Lakes

Hydrographs showing the predicted change in groundwater levels over time for the shallow layers (Quaternary Sediments and Tertiary Sediments/Basalt) and the Aries, Castor and Pollux Seams of the Rangal Coal Measures just outside of the residual voids for the mid climate scenario are provided as **Appendix C**, with the hydrograph locations shown on **Figure 8-25** to **Figure 8-28.** Given their relatively significant north-south strike length, and east-west strike length at Kennedy West void, two or more sets of predictive hydrographs have been generated for the several of the residual voids, as shown on the figures these are numbered from north to south or from east to west in order of lowest number. Predictive hydrographs have also been generated for the Pollux Seam model layer intersected by the Kenmare, Laleham and Clutha Trial Mine underground workings, as shown in **Appendix C** with hydrograph locations shown on **Figure 8-28**.

The hydrographs demonstrate that the vast majority of groundwater level drawdown in the Permian Coal Measures occurs pre-closure as a result of active extractive mining operations. Post-closure groundwater levels in the deeper coal seams at the northeastern part of the BWM Area adjacent to the residual voids recover from their lowest point that occurred during mining. However, most groundwater units across the BWM Area show persistent drawdown post-recovery. The Aries Seam near Laleham residual void also becomes desaturated during mining and remains dry to the end of the recovery simulation.

The hydrographs demonstrate very little effect on groundwater levels from the residual void inflow flux variability in the early post-closure period as shown and discussed in **Section 8.2.4**.

The predictive hydrographs also show that:

For the Ramp 8 residual void:

- The shallower layers above the Aries Seam, as well as the Aries Seam, are predicted to remain dry post-mining with the base of the Aries Seam more than 30 m above the void lake level. By the end of the recovery simulation, groundwater levels in the Castor and Pollux Seams are 9 m and 7 m above the void lake level respectively.

For the Bonnie Doon residual void:

- The shallow layers are predicted to remain dry post-mining with the base of the Tertiary units more than 12 m above the void lake level. The Aries Seam is predicted to remain dry at the northern end (Bonnie1 hydrograph location) and to recover approximately 3 m above the void lake level further south (at the Bonnie2 hydrograph location). Groundwater levels in the Castor and Pollux Seams recover to approximately 12 m below the void lake level at the northern end (Bonnie1 hydrograph location), indicating the potential for outflow from the void lake, but are predicted to be approximately 3 m above the void lake level further south (at the Bonnie2 hydrograph location). It should be noted that the net flux over the post-mining simulation remains inwards for the Bonnie Doon void (refer **Section 8.2.4**), i.e. any outwards flux from the northern end of Bonnie Doon is recaptured by the void in the long term post-mining (as is shown by the particle tracking, see **Section 8.2.6**).

For the Mimosa/Besgrove residual void:

- The shallow layers are predicted to remain dry post-mining with the base of the Tertiary units more than 52 m above the void lake level. Lake levels are predicted to recover to within approximately 3 to 5 m below the predicted Aries Seam groundwater level, within approximately 2 to 3 m below the predicted Castor Seam groundwater level and within approximately 2 to 3 m below the predicted Pollux Seam groundwater level.

For the Deep Creek residual void:

- The shallower layers are predicted to remain dry post-mining with the base of the Tertiary units more than 59 m above the void lake level. Lake levels are predicted to recover to within approximately 1 m below the groundwater level elevations in the Pollux, Aries and Castor seams. It should be noted that even if groundwater level elevations are shown to recover to approximately similar to the lake level, the net flux over the post-mining simulation remains inwards for the Deep Creek void (refer **Section 8.2.4**), i.e. any outwards flux is recaptured by the void in the long term post-mining (as is shown by the particle tracking, see **Section 8.2.6**).

For the Stewarton/Ballamoo residual void:

- The shallower layers are predicted to remain dry post-mining with the base of the Tertiary units more than 55 m above the void lake level. Lake levels are predicted to recover to within approximately 2 to 16 m below predicted Aries and Castor Seam groundwater elevations just outside the voids northern end at Stewarton_1 and southern at Stewarton_4 respectively. Lake levels are predicted to recover to approximately 2 m to 12 m below the predicted Pollux Seam groundwater elevation just outside the void at the northern end at Stewarton_1 and southern at Stewarton_4 respectively.

For Kenmare void:

- The shallower layers are predicted to remain dry post-mining with the base of the Tertiary units more than 89 m above the void lake level. Similarly, the Aries and Castor Seams remain desaturated (except Kenmare_3 which shows some temporary saturation in the Castor Seam) with the base of the layers more than 66 m and 48 m above the void lake level respectively. Groundwater levels in the Pollux Seam are predicted to recover to approximately 16 m to 58 m above the void lake level at the southern (Kenmare_3) and northern (Kenmare_1) end of the void respectively.

For the Laleham void:

- The shallower layers and the Aries Seam are predicted to remain dry post-mining with the base of the Tertiary units more than 20 m above the void lake level. Lake levels are predicted to recover to approximately 9 m below the predicted Castor and Pollux Seam groundwater elevation just outside the void.

For the Togara residual void:

- The shallow layers are predicted to remain dry post-mining with the base of the Tertiary units more than 101 m above the void lake level. Lake levels are predicted to recover to approximately 7 to 8 m below the predicted Aries, Castor and Pollux Seam groundwater elevation just outside the void.

For the South Marshmead residual void:

- The shallow layers are predicted to remain dry post-mining with the base of the Tertiary units more than 112 m above the void lake level. Lake levels are predicted to recover to approximately 3 m below the predicted Aries, Castor and Pollux Seam groundwater elevation just outside the void.

For the Kennedy West residual void:

- The hydrograph locations for the shallow layers show that at the Kennedy_1 (Tertiary, model layer 1) hydrograph location the Tertiary units are predicted to remain dry post mining, with the base of the layer base 93 m above the void lake elevation. Slight saturation of approximately 1 m above the base of layer is observed at the end of recovery at the Kennedy_2 (Tertiary, model layer 1) hydrograph

location, with the predicted groundwater elevation approximately 85 m above the void lake elevation. Lake levels are predicted to recover to within approximately 7 to 14 m below the predicted Regolith groundwater elevation just outside the void.

- The hydrographs also show that groundwater elevations in the Aries, Castor and Pollux Seams are predicted to recover to between approximately 17 to 30 m, 34 to 47 m and 53 to 62 m above the void lake level respectively, with higher groundwater elevations observed to the west side just outside the void (Kennedy_3 hydrograph location) and lower groundwater elevations observed to the east side just outside the void (Kennedy_1 hydrograph location).

For the Comet Downs residual void:

- The hydrographs for the shallow layers show that Comet_Tertiary (model layer 1) is predicted to remain dry at the end of recovery with the base of the layer 29 m above the void lake elevation. The Comet_Regolith hydrograph (model layer 2) shows some saturation of approximately 2 m above the base of layer at the end of recovery with the predicted groundwater elevation approximately 20 m above the void lake elevation.
- Lake levels are predicted to recover to within approximately 10 m below the predicted Aries Seam groundwater elevation just outside the void, approximately 9 m below the predicted Castor Seam groundwater elevation just outside the void and to approximately 9 m below the predicted Pollux Seam groundwater elevation just outside the void

For the Kenmare, Laleham and Clutha Trial Mine underground workings:

- The underground workings are permanently flooded prior to the end of mining. Groundwater levels in the Pollux Seam show some drawdown post-closure before stabilising approximately 40 years after the end of mining at all three hydrograph locations.

It should also be noted that, even if the hydrographs discussed above show that predicted groundwater levels just outside the residual voids are approximately similar, or below the predicted void lake levels, the potentiometric surface mapping (**Figure 8-25** to **Figure 8-29**) shows that only few hundred metres further distant from the residual voids, groundwater levels will be higher than the void lake levels, which will hydraulicly prevent any void lake from travelling any further than that, or in areas with flatter gradients, such as near Bonnie Doon and Kennedy West any outwards flux is recaptured by the voids in the long term post-mining due to the hydraulic gradient between adjacent voids. This is further demonstrated by the particle tracking in **Section 8.2.6**.

In general, it is noted that increasing the head gradient toward the residual void lakes from the surrounding groundwater system could be achieved by reducing predicted void lake levels via deepening the residual voids and/or limiting surface water inputs to the voids, noting that surface water inputs represent approximately 40% to 93% of the total volumetric inflow to each residual void (**Section 8.2.4**). Further backfilling of the residual voids, particularly to above the coal seams or above surrounding groundwater levels, would increase the void lake level elevation and therefore be likely to increase the potential for outflow, and therefore result in poorer environmental outcomes, particularly in the event that beneficial evaporative control of groundwater gradients is lost, rather than offer a means to reduce the potential for groundwater impacts.

8.2.5.3 Groundwater Level Impacts to Potential Receptors

Predictive hydrographs have been derived from the groundwater model to understand the nature of likely groundwater level change in the interpreted source aquifer for identified potential natural and anthropogenic groundwater receptors in the vicinity of the Project Area (refer **Section 5.2**). The aim of the hydrographs is to assess the potential for additional impacts to these potential receptors in the period post-mining, i.e. identify additional potential impacts beyond those that have occurred during already approved mining operations that may be attributable to the PRC Plan's proposed final landform. The hydrographs are shown in **Figure 8-31** to **Figure 8-34** (Potential GDEs) and **Appendix D** (Third-Party bores) and locations shown in **Figure 8-30** for the mid climate scenario. Note there is negligible difference in the hydrographs for the drier or wetter climate scenarios and hence only the mid climate scenario is shown.

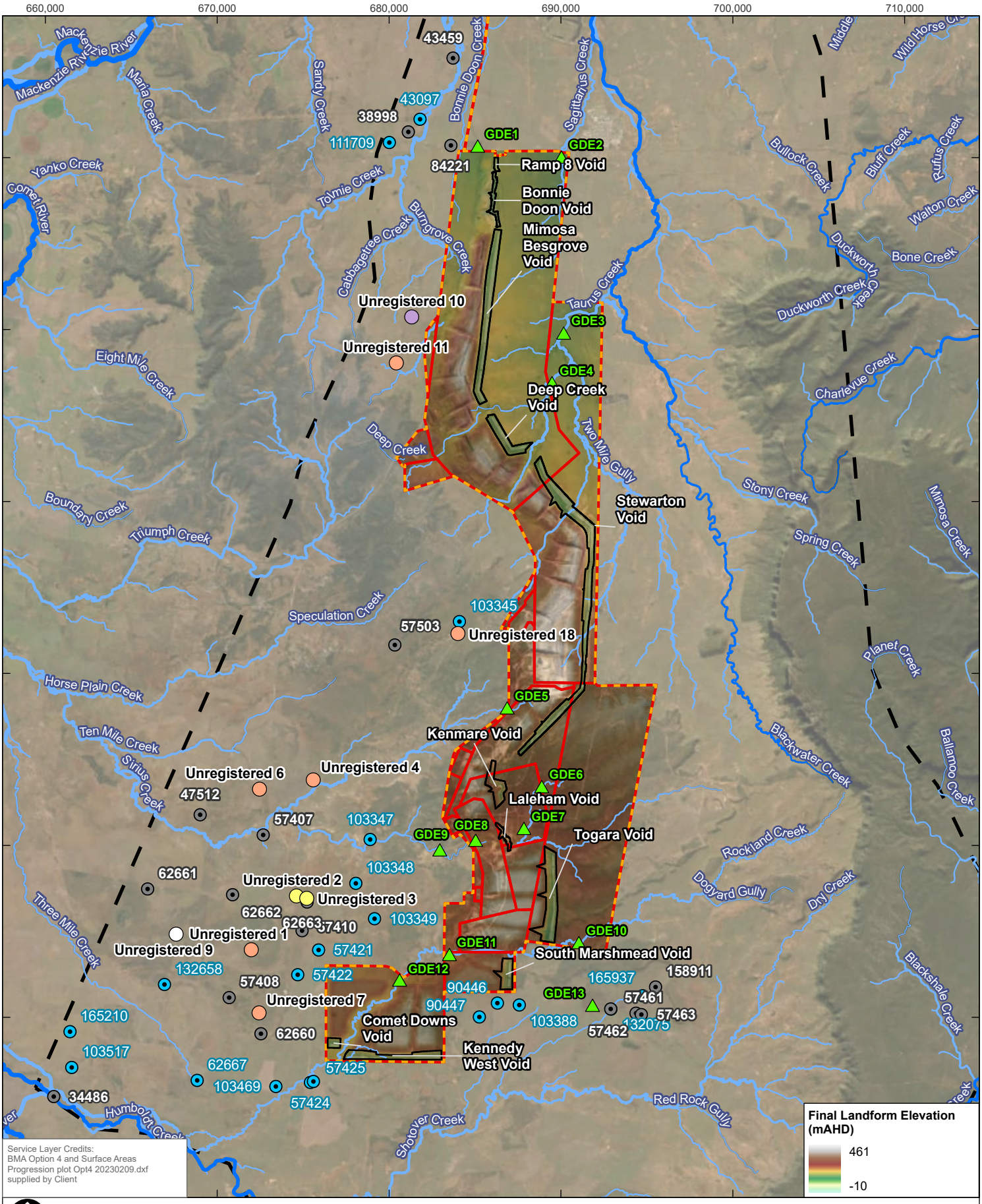
Potential GDEs

Predictive hydrographs for the water table at the potential GDE sites identified in and adjacent to the Project Area (refer **Section 5.2**) are shown in **Figure 8-31** to **Figure 8-34** with locations shown in **Figure 8-30**. The hydrographs indicate that several of the sites are unlikely to contain actual GDEs based on the significant predicted depth to groundwater of greater than approximately 8 to 10 m at those locations (sites GDE3 and GDE4 at Taurus Creek, GDE5 north of the Kenmare residual void, GDE12 downstream Rockland Creek and GDE13 east of the South Marshmead residual void). That is, it is considered that a depth to groundwater table of 8 to 10 m or more is most likely too deep to be accessed by Terrestrial vegetation and therefore any vegetation present there would not be a GDE.

Of the potential GDE sites, GDE1 near Bonnie Doon Creek, GDE2 downstream Sagittarius Creek, GDE6, GDE7, GDE8 and GDE9 near Sirius Creek, and GDE10 and GDE11 at Rockland Creek show relatively shallow predicted water table depths.

The hydrographs indicate (with the exception of GDE13 that is unlikely to be a GDE as discussed above) that much of the water table drawdown in the vicinity of potential GDEs is predicted to occur prior to the end of mining (i.e. associated with approved BWM mining operations), with any additional drawdown occurring over the post-mining period continuing the drawdown trends that commence prior to the end of mining. GDE7 is the only potential GDE to experience notable drawdown during the recovery simulation, with a decline in water level of up to approximately 6 m after the end of mining.

The shape of these hydrographs suggests that the additional drawdown impacts that occur in the post-mining period are residual impacts from approved previous active mining activities (i.e. a time lag from active mining), rather than new impacts caused by the PRC Plan's landform design; i.e. suggesting that the final landform is not contributing significantly to additional impacts at the potential GDE locations.


660,000
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710,000
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7,340,000
7,330,000
Mackenzie River
Maria Creek
Sandy Creek
Bonnie Doon Creek
Sagittarius Creek
Middle
Wild Horse Creek
Yanko Creek
Comet River
Tolmie Creek
Cabbagetree Creek
Burngrove Creek
Bullock Creek
Bluff Creek
Rufus Creek
Walton Creek
Duckworth Creek
Bone Creek
Taurus Creek
Eight Mile Creek
Deep Creek
Two Mile Gully
Charlevue Creek
Stony Creek
Mimosa Creek
Spring Creek
Boundary Creek
Triumph Creek
Speculation Creek
Planet Creek
Horse Plain Creek
Ten Mile Creek
Sirius Creek
Blackwater Creek
Ballamoo Creek
Rockland Creek
Dogyard Gully
Dry Creek
Three Mile Creek
Blackshale Creek
Humbolt Creek
Shotover Creek
Red Rock Gully
43459
43097
38998
111709
84221
GDE1
GDE2
Ramp 8 Void
Bonnie Doon Void
Mimosa Besgrove Void
Unregistered 10
Unregistered 11
GDE3
GDE4
Deep Creek Void
Stewarton Void
103345
57503
Unregistered 18
GDE5
Kenmare Void
Unregistered 6
47512
Unregistered 4
GDE6
Laleham Void
57407
103347
GDE7
GDE8
GDE9
Togara Void
103348
62661
Unregistered 2
Unregistered 3
62662
62663
57410
103349
Unregistered 1
Unregistered 9
57421
GDE10
GDE11
South Marshmead Void
132658
57408
57422
GDE12
90446
165937
158911
GDE13
57461
57463
Unregistered 7
90447
103388
132075
57462
165210
62660
Comet Downs Void
Kennedy West Void
103517
62667
57425
103469
57424
34486
Service Layer Credits:
BMA Option 4 and Surface Areas Progression plot Opt4 20230209.dxf supplied by Client
Final Landform Elevation (mAHD)
461
-10
0
2.5
5
km
LEGEND
Major Watercourse
Minor Watercourse
Project Area (Environmental Authorities boundary)
BWM Mining Lease
Study Area
Void Extent
Potential GDE – Hydrograph Location
Groundwater Database Bore
Water Supply
Unknown
Bore Census Unregistered Bores EMM (2019)
Stock
Stock and Domestic
Not in Use
Unknown
Coordinate System: GDA2020 MGA Zone 55
Scale: 1:290,000 at A4
Project Number: 620.040199
Date Drawn: 06-Aug-2024
Drawn by: RB
SLR
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BLACKWATER MINE - TRANSITIONAL PRCP HYDROGEOLOGY ASSESSMENT
POTENTIAL RECEPTOR PREDICTIVE HYDROGRAPH LOCATIONS
FIGURE 8-30
Path: H:\Projects-SLR\620-BNE\620-BNE\620.040199.00001 BWM PRCP – GW\03 SLR Data\01 CADGIS\GIS\ArcPro\BWM PRCP – GW\BWM PRCP – GW.aprx\620040199_F08_30_Potential Receptor Predictive Hydrograph Locations

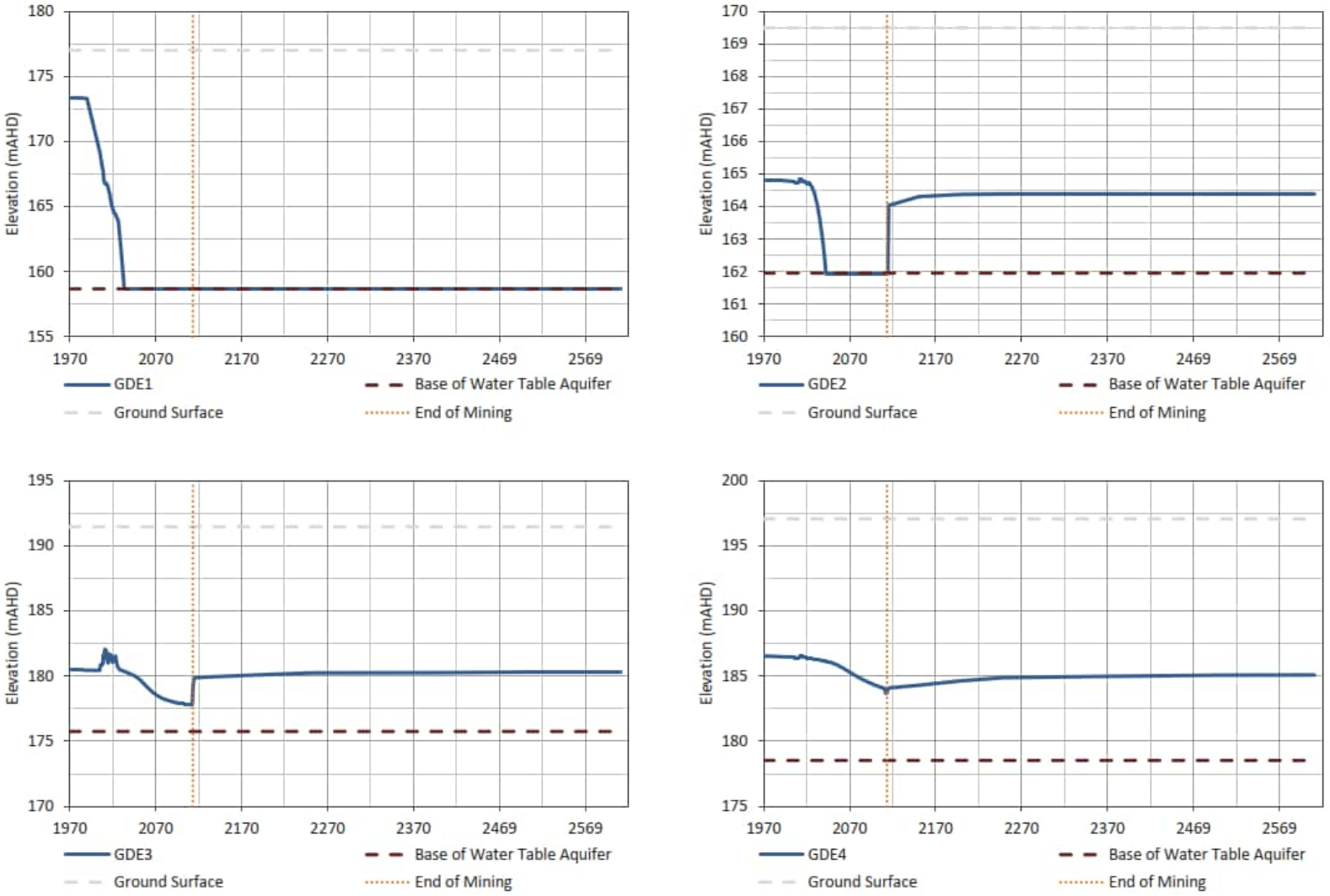


Figure 8-31 Water Table Hydrographs at Potential GDEs (GDE1 to GDE4)

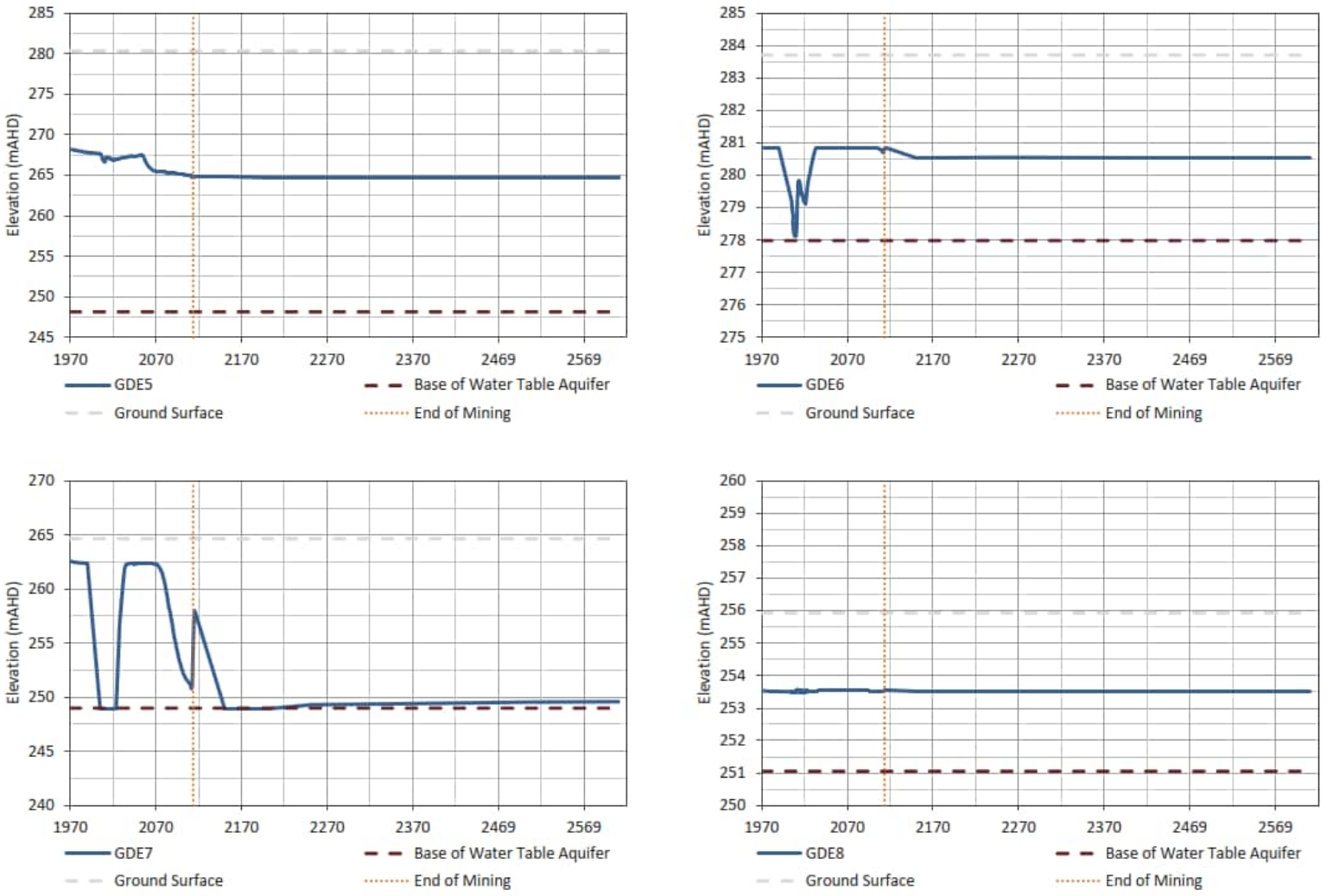


Figure 8-32 Water Table Hydrographs at Potential GDEs (GDE5 to GDE8)

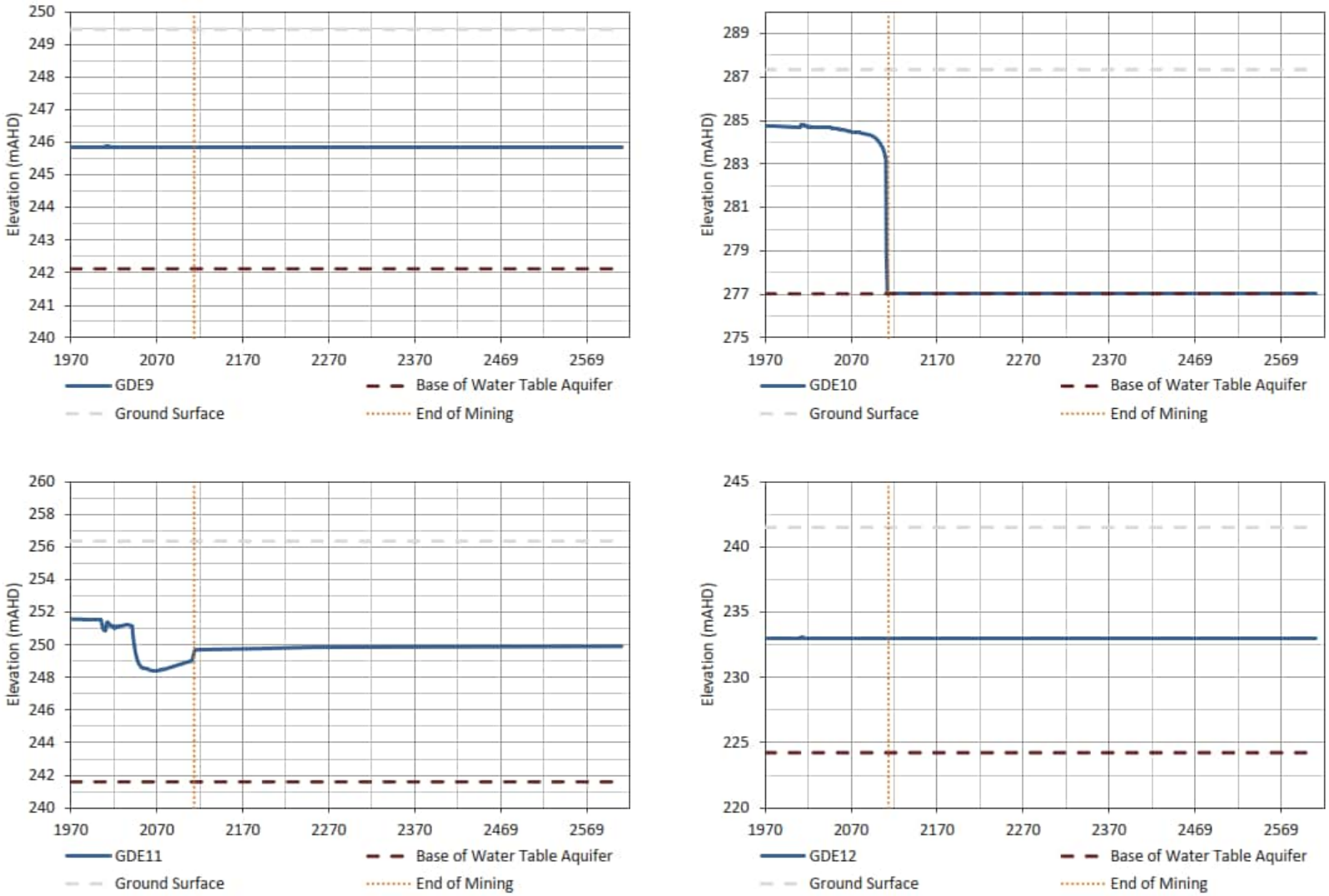


Figure 8-33 Water Table Hydrographs at Potential GDEs (GDE9 to GDE12)

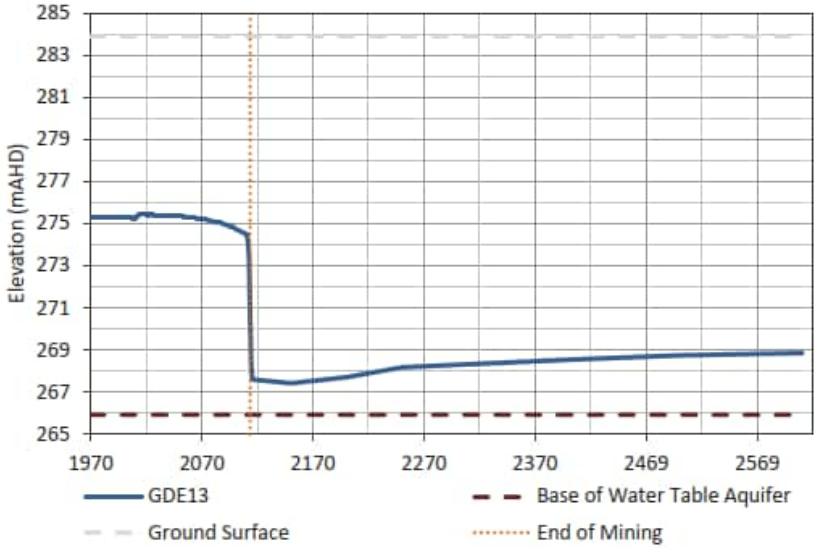


Figure 8-34 Water Table Hydrographs at Potential GDEs (GDE13)

Third Party Supply Bores

Predictive hydrographs for the 48 identified third party water supply bores surrounding the Project Area and within the Study Area with sufficient information to attribute a source aquifer (refer **Section 5.2.1**) are provided as **Appendix D** for the mid climate scenario with locations shown on **Figure 8-30**. Note there is negligible difference in the hydrographs for the drier or wetter climate scenarios and hence only the mid climate scenario is shown. It is noted that bores interpreted to be screened in formations below the base of the groundwater model are not considered as they are therefore interpreted to be below the base of the groundwater system that could be affected by BWM. The aim of the hydrographs is to assess the potential for additional impacts that would be recorded at these bores in the post-mining period. That is, to identify additional potential groundwater level impacts beyond those that have occurred during active mining operations through to closure in 2113, that may be attributable to the PRC Plans final landform.

As shown on the hydrographs of the bores interpreted to be in the weathered zone/regolith (model layer 2), bore 132075 is the only location predicted experience additional groundwater drawdown over the post-mining period greater than the relevant 2 m drawdown 'bore trigger threshold' for unconsolidated aquifers identified in Chapter 3 of the *Water Act 2000* (Water Act). This bore (132075) is predicted to experience a maximum of 2.7 m of additional drawdown over the post-mining period. This drawdown is considered to be related to a time lag from during-mining impacts. This theory is further supported by the trend observed at bore 103388, interpreted to be in the Rewan Formation and located between 132075 and the mining activity (**Figure 8-30**). The hydrograph for bore 103388 predicts up to 1.1 m of additional drawdown to occur during the post mining period as a result of a continuation of drawdown during the approved mining.

Hydrographs for bores 158911, 165937 and 57461 interpreted to be in the Rewan Formation and that are also located within this area east of approved mining and of 103388, and nearby to 132075 (**Figure 8-30**) show a maximum of up to 2.4, 2.6 and 2.7m of additional drawdown is predicted to occur during the post-mining period respectively. As with bore 132075 as discussed above, these trends are interpreted to be a continuation of drawdown from the approved mining. The predicted drawdown at these bores over the post-mining period are below the relevant 5 m drawdown 'bore trigger threshold' for consolidated aquifers identified in the Water Act.

The hydrographs for bores 57462 and 57463 also show groundwater levels in the Rewan Formation as the interpreted model target layer (layer 2) is dry and hence the next layer down is included in the hydrographs so that a conservative assessment of potential impact can be undertaken. As shown on the hydrographs for 57462 and 57463, up to 2.5 and 2.3 m of additional drawdown is predicted to occur at these bores over the post-mining period respectively.

As shown on the hydrographs, of the other bores interpreted to be screened in the Rewan Formation (34486, 103517 and 165210) there is negligible to no additional drawdown predicted to occur over the post-mining period.

Of the bores screened in the Rangal Coal Measures, the hydrographs show that 57425 and 57424 are predicted to experience a maximum of 7 m and 5.8 m of additional drawdown over post-mining period respectively. It is noted that after the end of mining at these bores it takes hundreds of years for the maximum drawdown to occur which is well beyond the expected service life for a groundwater bore. Of the other bores interpreted to be in the Rangal Coal Measures (132658, 57408, 62667 and Unregistered 9) none are predicted to experience additional drawdown greater than the relevant 5 m drawdown 'bore trigger threshold' for consolidated aquifers identified in the Water Act.

As shown on the hydrographs for bores interpreted to be in Burngrove Formation, a maximum of 4.1 m of additional drawdown is predicted to occur over the post-mining period (bore 103469) with no bores with predicted additional drawdown greater than the relevant 5 m drawdown 'bore trigger threshold' for consolidated aquifers identified in Chapter 3 of the Water Act 2000.

8.2.6 Flow Path Simulation

An analysis of the water movement within Landform 2.5 was undertaken to simulate and assess the movement and fate of water particles through the groundwater system post-mining. A number of particles were placed on the final landform and within the residual voids in the recovery groundwater model and the mod-PATH3DU code (S.S. Papadopulos & Associates, Inc., 2018) was used to simulate particle pathways along the groundwater flow field during recovery (i.e., 500 years). To run the mod-PATH3DU code the transient head outputs from the groundwater flow model were used by mod-PATH3DU to simulate particle flowpath lines.

Figure 8-35 shows the initial location of particles on Landform 2.5. With the exception of particles placed within the underground mine workings adjacent to Laleham, the particles were placed at the surface of the model and released at the start of the post-mining simulation, with the movement of the particles then recorded during the post-mining simulation. It should be noted that the mod-PATH3DU code automatically moves the particle from the model surface to the shallowest saturated layer at the commencement of the simulation. Mod-PATH3DU was configured to release the particles at the midpoint between the base of the first saturated layer and the water table. As shown on **Figure 8-35** for many of the particles this represents the Permian layers (including areas of spoil backfill in model layers that represent Permian units pre-mining) as the shallow layers (Layers 1 and 2) are unsaturated across much of the BWM Area at the commencement of the post-mining simulation. The particles placed in the underground mines were configured to begin their simulation in the Pollux seam (Layer 12) to simulate the fate of water beginning in the flooded underground workings after mine closure.

8.2.6.1 Mid Climate Scenario

Figure 8-36 shows the predicted movement of water particles in the 500 year recovery simulation of Landform 2.5 for the Mid Climate scenario. The colours along the predicted particle flow paths provides the model layer the particle was simulated to be moving through, with the green to red scale classification representing particles moving from shallow to deep model layers.

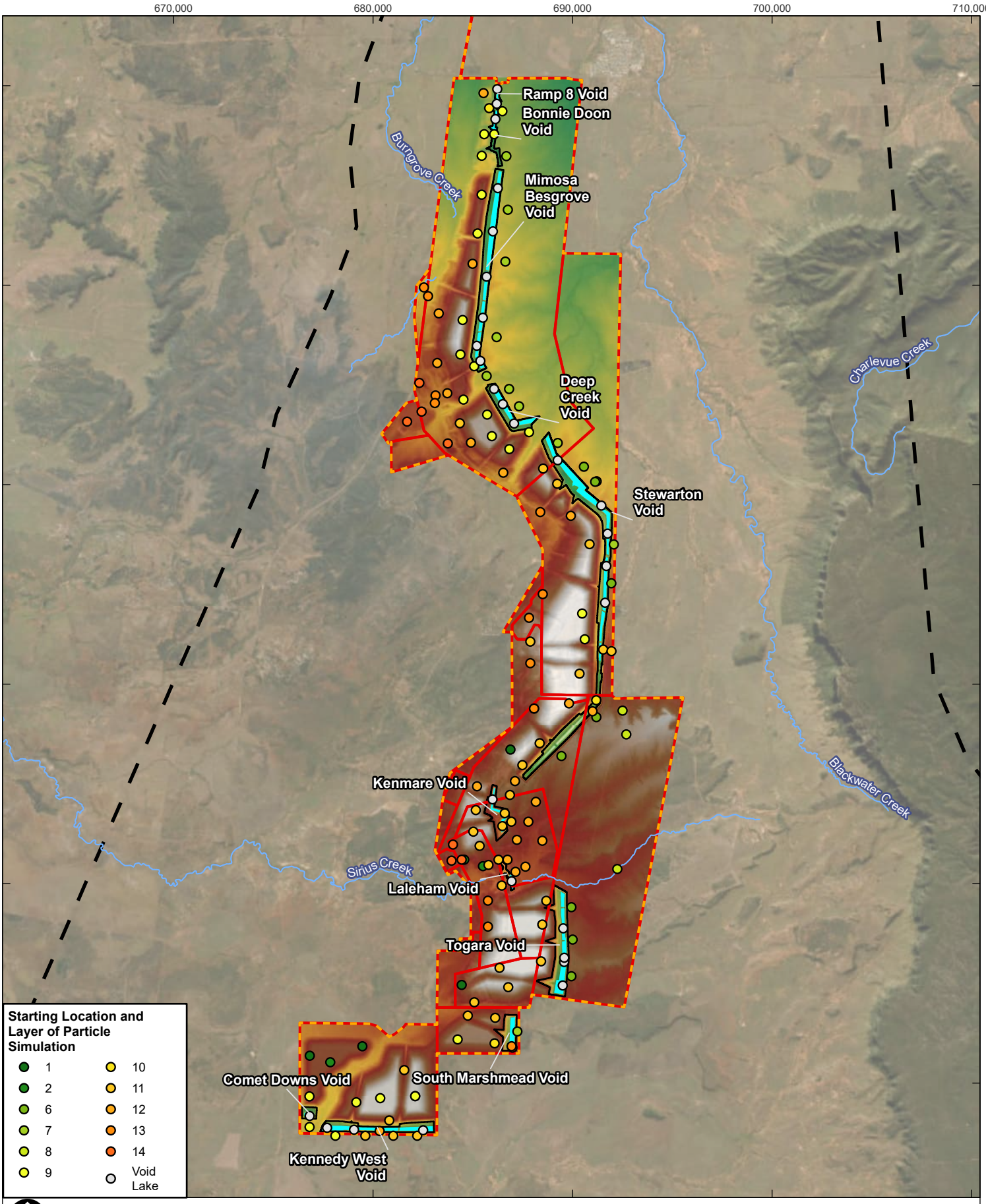
The colour changes along the paths on **Figure 8-36** indicate that particles situated within the shallower saturated layers at the beginning of the post-mining simulation generally move progressively toward deeper layers representing the Permian coal measures (or backfilled spoil where the coal measures has been mined out) over the post-mining period. However, particles which begin in the Pollux seam (Layer 12) and other deeper layers often are observed to move upwards to shallower layers over the course of the recovery simulation as the saturated water levels in the spoil and aquifers adjacent to the residual voids recover to their long term post-mining equilibrium state. The flow path analysis indicates the particles generally move toward the void lakes, with the majority of the particles captured in the voids.

Some simulated particles placed at and near to Bottom Dam west of the Laleham residual void migrate out of the BWM Area towards Sirius Creek, with these particles commencing the simulation too far from the residual void lakes to be captured by their associated hydraulic gradients. It should be noted that simulation of the PRC Plan's proposed closure strategy for Bottom Dam is not inherent in the groundwater modelling presented in this report, and therefore the modelling can be considered a conservative first pass assessment

of risk prior to any remedial measures. An assessment of the associated risk of the groundwater model prediction is provided in the PRC Plan's tailings cover design and geochemistry assessments (Henderson Geotech, 2024, and Terrenus Earth Sciences, 2024), along with the PRC Plan's relevant closure strategy and associated risk mitigation measures.

Particles which begin their simulation in the spoil adjacent to the voids or in the underground mines near Laleham migrate towards or are captured by the residual voids within the recovery simulation and are therefore not predicted to leave the BWM Area or escape to the wider groundwater system. Some particles are shown to migrate into Layers 13 and 14 (Pollux Underburden and Burngrove Formation) which underlie the residual voids due to the desaturation of Layer 12 or vertical gradients early in the recovery simulation. These particles however do not migrate outside of the BWM Area during the recovery simulation.

In summary, water associated with spoil and tailings deposition, underground mine workings or open cut residual void lakes is not predicted migrate away from the BWM Area, with the residual voids acting as passive containment for groundwater which has passed through the mine workings. The exception to this is the specific location of Bottom Dam, west of Laleham residual void, with groundwater predicted to migrate towards Sirius Creek outside of the BWM Area. The environmental risk associated with this prediction is addressed within the PRC Plan's tailings cover design and geochemistry assessments (Henderson Geotech, 2024, and Terrenus Earth Sciences, 2024).



0 2.5 5 km

Coordinate System:	GDA2020 MGA Zone 55
Scale:	1:250,000 at A4
Project Number:	620.040199
Date Drawn:	09-Aug-2024
Drawn by:	AS

LEGEND

- Watercourse
- BWM Mining Lease
- Study Area
- Project Area (Environmental Authorities boundary)
- Void Lake

Final Landform Elevation (mAHD)

461

-10

BLACKWATER MINE - TRANSITIONAL PRCP HYDROGEOLOGY ASSESSMENT

STARTING LOCATION OF PARTICLES (MID CLIMATE SCENARIO)

SLR

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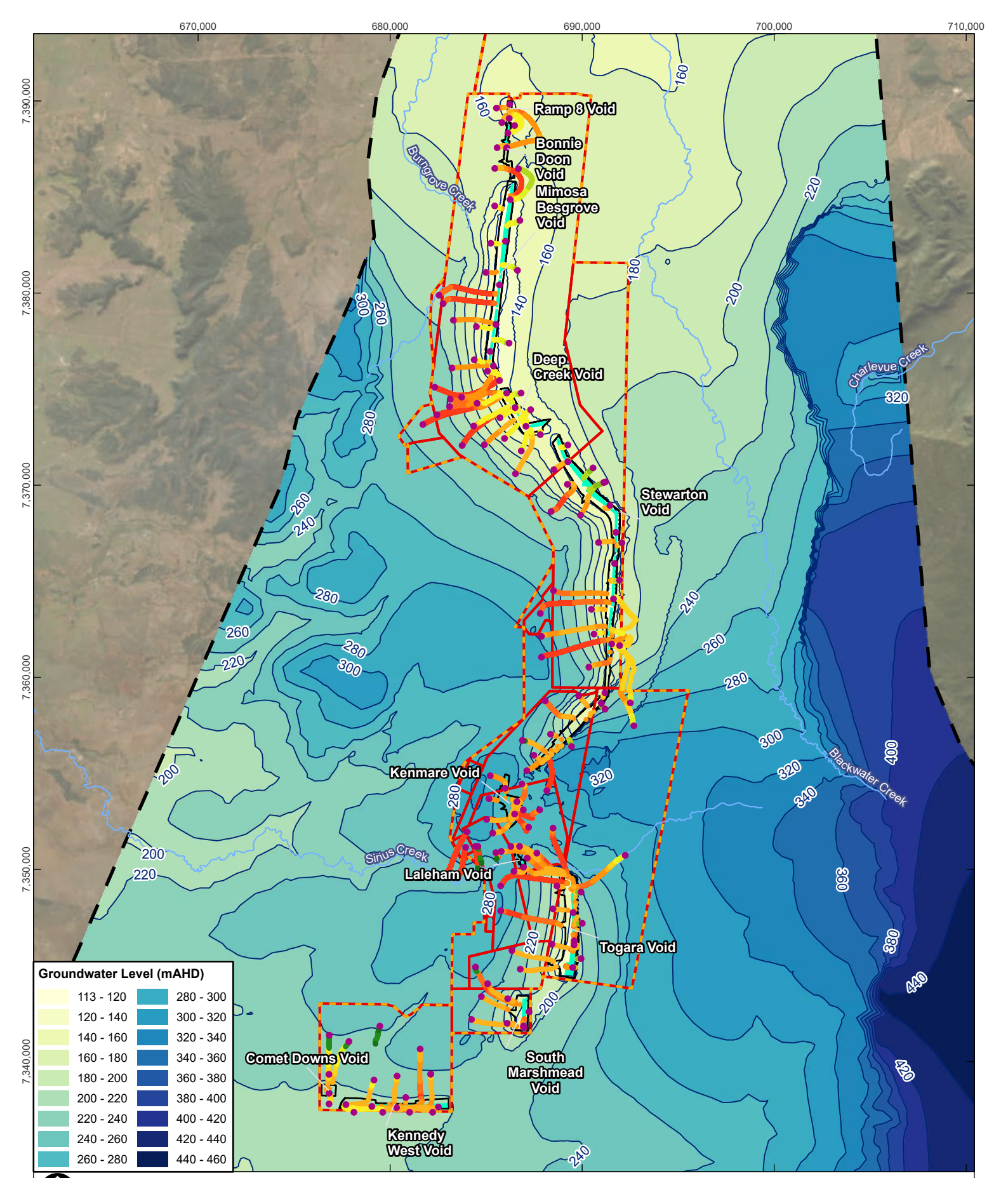
FIGURE 8-35

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040199.00001 BWM PRCP – GW\03 SLR Data\01 CADGIS\GIS\ArcPro\BWM PRCP – GW\BWM PRCP – GW.aprx\620040199_F08_35_Starting Location of Particles (Mid Climate Scenario)



Coordinate System:	GDA2020 MGA Zone 55
Scale:	1:250,000 at A4
Project Number:	620.040199
Date Drawn:	02-Aug-2024
Drawn by:	AS

BLACKWATER MINE - TRANSITIONAL PRCP HYDROGEOLOGY ASSESSMENT

PREDICTED MOVEMENT OF PARTICLES (MID CLIMATE SCENARIO)

SLR

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FIGURE 8-36

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040199.00001 BWM PRCP – GW\03 SLR Data\01 CADGIS\GIS\ArcPro\BWM PRCP – GW\BWM PRCP – GW.aprx\620040199_F08_XX_Predicted Movement of Particles (Mid Climate Scenario)

8.2.6.2 Climate Sensitivity

Flow path simulation results for the Drier Climate scenario and Wetter Climate scenario as shown in **Appendix D** and **Appendix E**, respectively.

As with the groundwater level predictions (**Section 8.2.5**), there is very little difference between the predicted particle movements for the Drier Climate scenario and Wetter Climate scenario, and the Mid Climate scenario discussed in **Section 8.2.6.1**. That is, with the exception of the Bottom Dam area west of Laleham residual void, all particles starting within the BWM Area/final landform remain within the landform regardless of climate scenario with no groundwater predicted to flow to the receiving environment.

9.0 Conceptual Site Model - Post Mining

A visual representation of the post mining conceptual hydrogeological model is provided as **Figure 9-1** for the northern area of BWM and **Figure 9-2** for the southern area of BWM. Based on the understanding of hydrogeological mechanisms and groundwater modelling presented in this report, key features relevant to the discussion of potential groundwater impacts post-mining include:

- Residual void lake formation, with lake levels stabilising significantly below any shallow post-Permian strata, including the base of surficial weathering and shallow hydrostratigraphic units (i.e. alluvium and Tertiary strata).
- Partial groundwater system recovery outside the residual voids, primarily in the Rangal Coal Measures.
- Continued groundwater drawdown within the Rangal Coal Measures, associated with evaporative discharge from the void lakes, resulting in continued inwards hydraulic flow gradients in the coal measures and ongoing groundwater discharge to the residual voids, keeping the residual void lakes as groundwater sinks.
- Potential for ongoing salinization of the residual void lakes associated with evaporative discharge from the lakes.
- Reflooding of historical underground workings.
- No potential for groundwater quality impacts outside of the BWM Area associated with residual voids or spoil emplacements, due to the inward groundwater flow gradients towards the residual voids continuing to capture all potential seepage.
- No potential for groundwater quality impacts outside of the BWM Area associated with in-pit tailings emplacements at Bonnie Doon and Laleham, due to the inward groundwater flow gradients towards the residual voids continuing to capture all potential seepage.
- Some potential for groundwater movement from the mine areas west of Laleham residual void towards Sirius Creek outside of the BWM Area, with this area subject to specific risk mitigation planning under the PRC Plan.

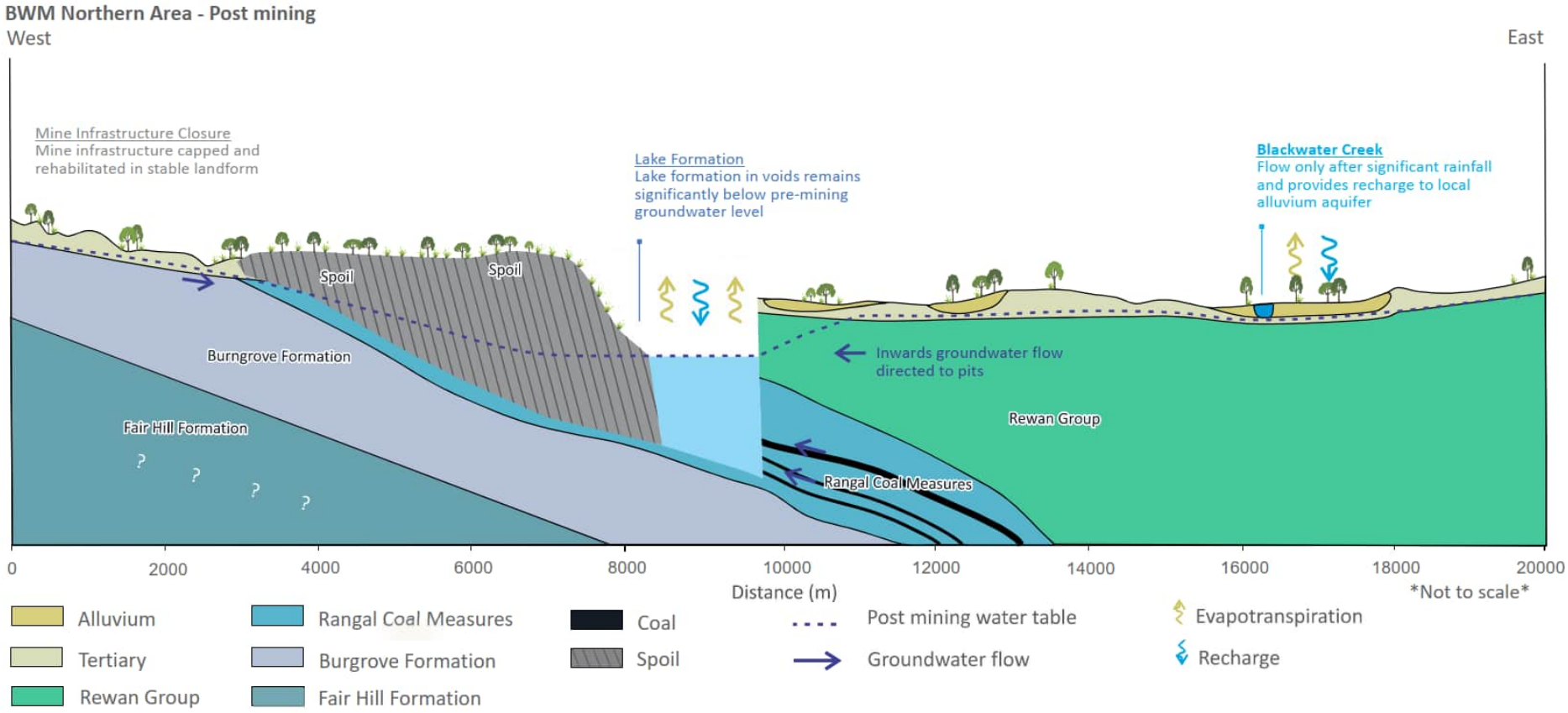

Figure 9-1 Conceptual Model of BWM Groundwater System – BWM Northern Area (Post Mining)

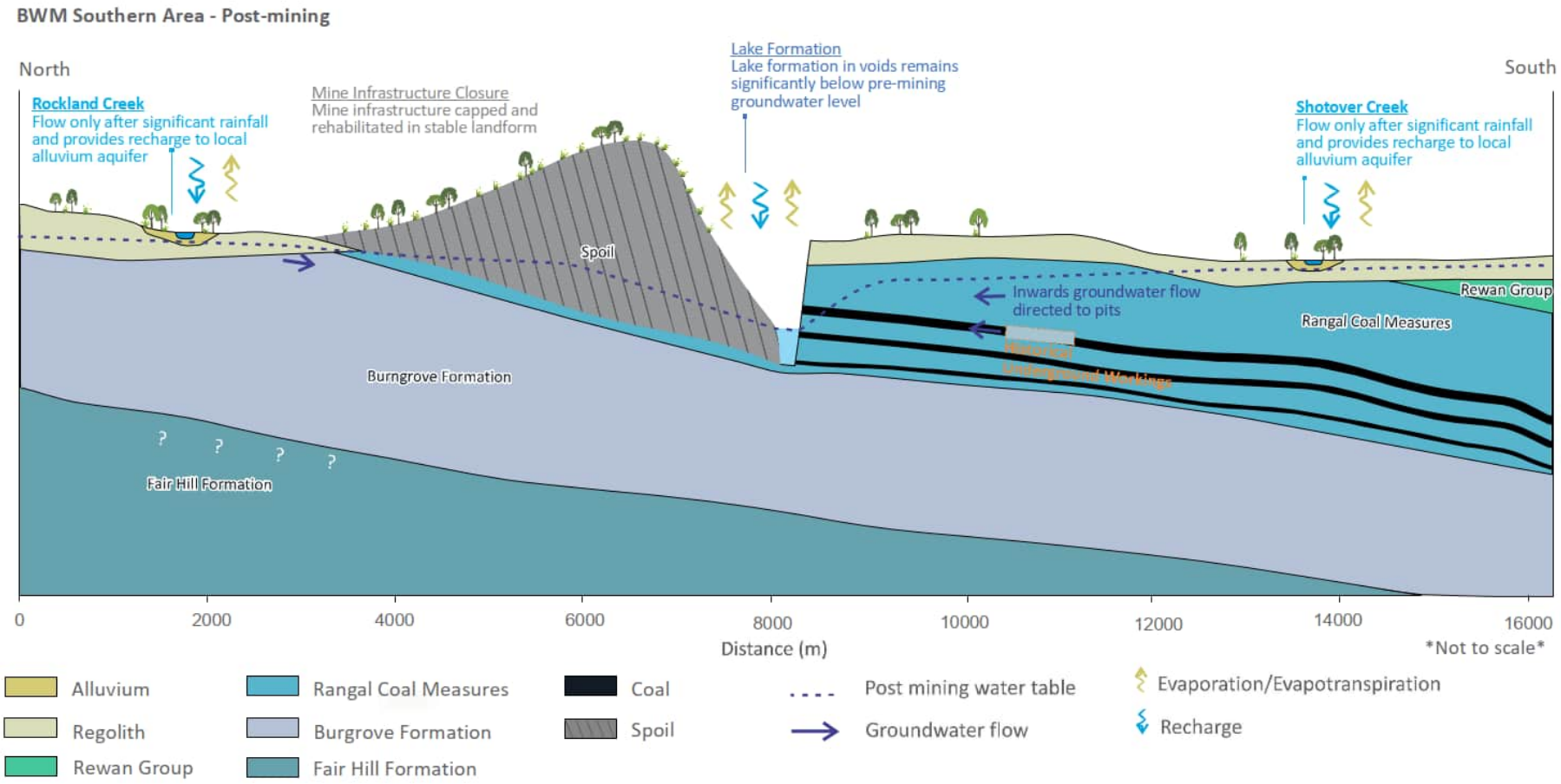

Figure 9-2 Conceptual Model of BWM Groundwater System – BWM Southern Area (Post Mining)

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Appendix A 80th Percentile Summary Statistics and Comparison to Guideline Values

Blackwater Mine

Transitional PRC Plan Hydrogeology Assessment

Whitehaven Coal Limited

SLR Project No.: 620.040199.00001

16 September 2024

Appendix A - 80th Percentile Summary Statistics and Comparison to Guideline Values

WQO Zone	Monitored Unit	Bore	pH (20th)	pH (80th)	TDS	EC	Ca	Cl	Na	Mg	SO4	Hardness as CaCO3	Alkalinity as CaCO3	HCO3	Nitrate as N	SiO2	Fluoride	Al (Diss)	Be (Diss)	B (Diss)	Cd (Diss)	Cr (Diss)	Co (Diss)	Cu (Diss)	Fe (Diss)	Pb (Diss)	Li (Diss)	Mn (Diss)	Hg (Diss)	Mo (Diss)	Ni (Diss)	Se (Diss)	Ag (Diss)	U (Diss)	V (Diss)	Zn (Diss)
Units					mg/L	µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Australian Drinking Water Guidelines (Aesthetic) (NHMRC, NRMMC, 2011)			6.5	8.5	600	-	-	250	180	-	-	-	-	-	-	-	-	0.2	-	-	-	-	-	1	0.3	-	-	0.1	-	-	-	-	-	-	-	-
Australian Drinking Water Guidelines (Health) (NHMRC, NRMMC, 2011)			-	-	-	-	-	-	-	-	-	-	-	-	1.5	-	0.06	4	0.002	0.05	-	2	-	0.01	-	0.5	0.001	0.05	0.02	0.01	0.1	0.02	-	-	-
Aquatic Ecosystem (95% Protection) (ANZG, 2018)			6.5	8.5	-	-	-	-	-	-	-	-	-	-	0.455	-	-	-	0.0002	0.001	-	0.0014	-	0.0034	-	1.9	0.0006	-	0.013	0.005	0.05	-	-	-	0.008
Irrigation (Fitzroy Basin WQO)			-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	5	0.1	0.5	0.01	0.1	0.05	0.2	0.2	2	2.5	0.2	0.002	0.01	0.2	0.02	-	0.01	0.1	2
Stock (Fitzroy basin WQO)			-	-	5000	-	-	-	-	-	-	-	-	-	-	-	2	5	-	5	0.01	1	1	1	-	0.1	-	-	0.002	0.15	1	0.02	-	0.2	-	20
Zone 35 Shallow Groundwater (<30m)			7.59	7.93	-	1983	81	392	256	58	25	430	556	646	9.6	72	0.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Zone 35 Deep Groundwater (>30m)			7.37	8.01	-	13604	366	5368	2555	226	122	1905	311	376	0.5	76	0.5	-	-	-	-	-	-	0.01	0.047	-	-	2.495	-	-	-	-	-	-	0.27
Zone 36 Shallow Groundwater (<30m)			7.7	8.35	-	7410	105	2173	1511	72	126	526	643	1021	7.5	60	0.39	-	-	-	-	-	-	-	0.02	-	-	0.07	-	-	-	-	-	-	-
Zone 36 Deep Groundwater (>30m)			8.21	8.66	-	2255	75	1945	1748	106	210	619	1322	1549	2.9	81	1.12	-	-	-	-	-	-	-	0.047	-	-	0.043	-	-	-	-	-	-	-
Zone 35 shallow	Alluvium	BWM_MB01_01	6.7	7.1	11400	21280	124.2	6030	3912	341	475		829	1011	0.16		0.76	0.005	0.0005	2.04	0.0001	0.0005	0.0056	0.0018		0.0005	0.08	0.534	0.00005	0.004	0.005	0.005	0.0005	0.00005	0.005	0.0536
Zone 35 shallow	Tertiary	MB21	6.4	7.0	14700	14800	514	4000	2370	589	1998		574	700	0.02		0.20	0.010	0.0005		0.00005			0.001		0.0005		0.0005	0.00005	0.001		0.01	0.001		0.018
Zone 35 shallow	Tertiary	BWM_P4	5.5	5.4	4462	6664	34	1908	925	265	1014		51	62	0.27		0.20	0.034	0.0014	0.48	0.00005	0.008	0.1228	0.0064	15.85	0.0005		2.478	0.00005	0.005	0.005	0.196	0.005	0.0010	0.005	0.129
Zone 35 shallow	Tertiary	BWM_P5	5.5	5.7	4544	5134	174	101	1450	325	2542		64	78	0.22		0.10	0.020	0.0005	0.70	0.00005	0.0024	0.6914	0.0005	81.25	0.0005		0.062	0.00005	0.0005	0.0005	0.005	0.0005	0.0005	0.005	0.083
Zone 35 deep	Tertiary	BWM_MB22_01	7.3	7.3	510	868	24	105	130	29	15		287	350	0.40		0.20	0.005	0.0005		0.00005	0.0005	0.0005	0.0005		0.0005		0.062	0.00005	0.013	0.0005	0.005	0.0005	0.0005	0.005	0.0025
Zone 35 deep	Rewan Group	MB19BWM04_16R	7.6	7.8	3730	4854	32	1076	965	34	483		300	347	0.25		0.24	0.010	0.0005	0.54	0.00005	0.0005	0.0005	0.002	0.11	0.0005	0.04	0.079	0.00005	0.004	0.003	0.005	0.0005	0.0040	0.005	0.043
Zone 36 shallow	Rewan Group	MB19BWM02A	6.2	6.4	39400	37700	988	15000	7400	1860	508	6862	454	554	0.03	14.4	0.10	0.050	0.005	0.69	0.0005	0.005	0.005	0.0414	0.364	0.005	0.13	0.102	0.0001	0.005	0.007	0.05	0.005	0.0025	0.050	0.3612
Zone 36 shallow	Rewan Group	MB19BWM03P	7.2	7.4	3352	5361	49	1402	1102	23	177	265	787	945	0.22	19.4	0.48	0.010	0.001	0.40	0.0001	0.001	0.001	0.001	0.24	0.001	0.25	0.202	0.0001	0.006	0.003	0.01	0.001	0.0005	0.010	0.0078
Zone 36 deep	Rewan Group	MB19BWM04R	6.6	6.8	24892	33900	1544	12500	6505	214	19	4784	119	145	0.02	16.5	0.20	0.050	0.005	0.34	0.0005	0.005	0.008	0.005	2.37	0.005	0.95	0.057	0.0001	0.009	0.018	0.05	0.005	0.0025	0.050	0.233
Zone 36 deep	RCM north	FY16_PZ_2	6.8	7.1	11700	18160	172	6490	3910	106	1	854	544	664	0.02	16.0	0.30	0.005	0.0005	0.38	0.0005	0.005	0.0005	0.0018	0.172	0.0005	1.46	0.027	0.00005	0.0024	0.006	0.005	0.0005	0.005	0.005	0.0034
Zone 36 deep	RCM north	FY16_PZ_4	6.7	6.9	10600	16400	121	5014	3444	188	14	1048	1070	1305	0.02	15.5	0.40	0.005	0.0005	0.59	0.00005	0.0005	0.0005	0.001	1.1	0.0005	1.58	0.049	0.00005	0.003	0.007	0.005	0.0005	0.0005	0.005	0.022
Zone 36 deep	RCM north	FY16_PZ_5	6.6	6.7	13700	21200	209	7550	4350	334	4	1952	798	974	0.02	13.9	0.20	0.005	0.0005	0.80	0.00005	0.005	0.0005	0.0068	1.16	0.0005	1.14	0.164	0.00005	0.003	0.013	0.005	0.0005	0.005	0.005	0.2214
Zone 36 deep	RCM north	MB1	6.6	6.9	26500	35640	761	13540	6585	716	367		368	449	0.02		0.05	0.050	0.025		0.00025	0.025	0.025	0.0025	4.01	0.025		0.124	0.0001	0.005	0.009	0.05	0.005	0.025	0.025	0.0125
Zone 36 deep	RCM north	MB19BWM01P	7.0	8.0	16600	26001	243	9214	5900	138	7	1180	660	801	0.03	21.6	0.30	0.050	0.005	0.46	0.0004	0.004	0.004	0.005	1.54	0.004	1.21	0.121	0.0001	0.0136	0.005	0.035	0.0035	0.0013	0.050	0.072
Zone 36 deep	RCM north	MB19BWM03P	7.0	7.2	6260	12900	54	3712	3014	14	107	190	1752	2125	0.02	18.1	0.60	0.010	0.001	0.37	0.0001	0.001	0.001	0.001	0.972	0.001	1.84	0.111	0.0001	0.0088	0.008	0.01	0.001	0.0005	0.010	0.165
Zone 36 deep	RCM north	MB19BWM27P	6.6	6.8	9348	14500	121	4424	3274	54	1	529	1896	2313	0.02	23.0	0.40	0.010	0.001	1.30	0.0002	0.001	0.007	0.0058	1.102	0.001	1.70	0.231	0.0001	0.004	0.013	0.01	0.001	0.0005	0.010	1.338
Zone 36 deep	RCM north	MB20BWM02P2	7.0	7.2	12800	19880	198	7144	4236	213	217	1338	579	707	0.02	41.5	0.50	0.005	0.0005	0.30	0.00005	0.0005	0.01	0.001	1.45	0.0005	0.96	0.753	0.00005	0.0039	0.012	0.005	0.0005	0.0039	0.005	0.114
Zone 36 deep	RCM north	MB20BWM03P1	6.7	6.9	20800	27240	542	10700	5560	361	4	2550	321	392	0.02	30.3	0.20	0.025	0.0025	0.35	0.00025	0.0025	0.014	0.0025	3.76	0.0025	1.47	0.656	0.00005	0.0078	0.009	0.025	0.0025	0.0040	0.025	0.262
Zone 36 deep	RCM north	MB20BWM03P2	6.8	7.0	12260	19340	163	6044	4304	104	2	957	584	712	0.02	20.5	0.40	0.005	0.0005	0.42	0.00005	0.0005	0.004	0.0164	0.932	0.0005	1.71	0.098	0.00005	0.0054	0.005	0.005	0.0005	0.0020	0.005	0.3584
Zone 36 deep	RCM north	MB20BWM05P	6.6	6.9	17620	25540	388	8028	5360	589	2214		673	821	33.31		0.36	0.025	0.0025		0.00028	0.0025	0.011	0.0025	0.025	0.0025		0.195	0.00005	0.0322	0.02	0.025	0.0025	0.0229	0.025	0.104
Zone 36 deep	RCM north	FY16_PZ_3																							0.025					0.0005		0.005	0.0005			
Zone 35 shallow	RCM south	BWM_MB14_01	6.5	6.6	22857	17880	365	5320	2764	728	1788		869	1060	0.02		0.05	0.014	0.0005	0.80	0.00005	0.005	0.002	0.0005	8.46	0.0005		1.402	0.00005	0.001	0.002	0.005	0.0005	0.0040	0.005	0.0174
Zone 35 shallow	RCM south	BWM_MB04_01	6.9	7.0	6027	8904	193	2294	1360	322	897		1008	1230	0.05		0.70	0.010	0.0005	0.70	0.00005	0.0005	0.0005	0.0005	0.025	0.0005		0.584	0.00005	0.0005	0.0011	0.005	0.0005	0.0005	0.005	0.0025
Zone 35 deep	RCM south	MB19_01	7.0	7.2	9437	11760	268	3894	1860	534	574		491	599	0.02		0.71	0.017	0.0005		0.00005	0.0005	0.02	0.0005		0.0005		0.255	0.00005	0.0096		0.005	0.0005	0.0005	0.005	0.0165
Zone 35 deep	RCM south	BWM_MB16_03	9.4	9.8	775	1284	6	155	287	6	21		450	445	0.02		1.20	0.014	0.0005	0.61	0.00005	0.0005	0.0005	0.004	0.025	0.0007	0.04	0.012	0.00005	0.0012	0.001	0.005	0.0005	0.0010	0.005	0.010
Zone 35 deep	RCM south	MB19BWM_15P	7.3	7.4	3810	6894	60	1864	1370	32	47		353	418	0.04		0.35	0.005	0.0005	0.94	0.00005	0.0005	0.002	0.0054	0.093	0.0005	0.10	0.136	0.00005	0.0074	0.004	0.005	0.0005	0.0020	0.005	0.1208
Zone 35 deep	RCM south	MB19BWM_25P_B	7.4	7.5	4090	7356	38	2126	1454	32	6		577	659	0.02		0.20	0.014	0.0005	0.63	0.00005	0.0005	0.0007	0.0011	0.394	0.0005	0.12	0.146	0.00005	0.004	0.002	0.005	0.0005	0.0005	0.005	0.0558
Zone 35 deep	RCM south	MB19BWM_18P	7.4	7.5	3754	6704	32	1764	1400	19	1		656	751	0.02		0.20	0.005	0.0005	0.74	0.00005	0.0005	0.0005	0.0005	0.236	0.0005	0.28	0.128	0.00005	0.0052	0.002	0.005	0.0005	0.005	0.005	0.0502
Zone 35 deep	RCM south	MB19BWM_24P	7.0	7.1	4700	7340	181	2302	1030	182	105		230	281	0.02		0.20	0.010	0.0005	0.66	0.00005	0.0005	0.004	0.005	2.66	0.0005	0.25	0.605	0.00005	0.0064	0.005	0.005	0.0005	0.0020	0.005	0.1208
Zone 35 deep	RCM south	PB19BWM_02P	7.6	7.2	4546	6958	160	2196	948	166	34		179	218	0.03		0.20	0.007	0.0005	0.60	0.00005	0.0005	0.003	0.0038	0.705	0.0005	0.06	0.451	0.00005	0.006	0.003	0.005	0.0005	0.0030	0.005	0.1012
Zone 35 deep	RCM south	BWM_MB14_02	7.6	7.7	4738	7542	7	1098	1992	8	25		3864	3368	0.02		1.40	0.016	0.0005	0.30	0.00005	0.0005	0.0008	0.0005	0.34	0.0005		0.011	0.00005	0.001	0.001	0.005	0.0005	0.0005	0.005	0.0025
Zone 35 deep	RCM south	BWM_MB01_02	9.4	9.7	886	1522	10	212	313	4	50		421	350	0.11		0.54	0.044	0.0005	0.20	0.00005	0.0105	0.0005	0.0009	0.025	0.0005		0.005	0.00005	0.0005	0.001	0.005	0.0005	0.0009	0.005	0.0029
Zone 35 deep	RCM south	MB19BWM_10P	8.0	8.4	519	895	24	116	130	25	4		303	359	0.02		0.54	0.007	0.0005	0.34	0.00005	0.0005	0.0005	0.0005		0.0005	0.02	0.161	0.00005	0.0286	0.002	0.005	0.0005	0.0005	0.005	0.0536
Zone 35 deep	RCM south	BWM_MB21_03	8.5	8.5	1360	2450	24	685	550	18	2		388	448	0.02		0.76	0.050	0.0005		0.00005	0.0005	0.0005	0.0005		0.0005		0.007	0.00005	0.002	0.001	0.005	0.0005	0.0005	0.005	0.0025
Zone 35 deep	RCM south	BWM_MB21_02	8.5	8.5	820	1310	22	217	305	24	24		499	562	0.02		0.50	0.005	0.0005		0.00005	0.0005	0.0005	0.0005		0.0005		0.007	0.00005	0.004	0.001	0.005	0.0005	0.0005	0.005	0.0025
Zone 36 deep	RCM central	MB18	6.6	7.2	9156	17400	649	2470	2555	117	3		120	146	0.09		0.20	0.010	0.0005		0.00005	0.0005	0.0005	0.0005	1.366	0.0005		0.249	0.0001	0.0014	0.001	0.01	0.001	0.0005	0.005	0.024
Zone 36 deep	RCM central	MB19BWM08P	7.4	7.6	3468	5404	33	1370	1216	6	2	109	769	962	0.02	17.8	0.50	0.010	0.001	1.52	0.0001	0.001	0.001	0.001	0.22	0.001	0.68	0.048	0.0001	0.003	0.003	0.01	0.001	0.0005	0.010	0.1292
Zone 36 deep	Burrgrove Formation	BG No.1 AP	7.2	7.9	4060	6950	40.8	1930	1516	27	30		691	817	0.02		0.60	0.010	0.0005		0.00005	0.0005	0.0005	0.0005	0.104	0.0005		0.101	0.0001	0.001	0.0005	0.01	0.001	0.0005	0.005	0.0060
Zone 36 deep	Burrgrove Formation	BG No.2 BG	6.6	7.4	11100	16420	305	5400	2937	454.4	1408		875	1068	0.02		0.20	0.010	0.0005		0.00005	0.0005	0.0005	0.0005	0.25	0.0005		0.0745	0.0001	0.001	0.0005	0.01	0.001	0.0005	0.005	0.0025
Zone 35 shallow	Burrgrove Formation	MB24	5.0	5.1	4156	6558	50	1660	1108	168	751		25	31	0.02		1.20		0.004	1.60					0.025				0.00005							
Zone 35 shallow	Burrgrove Formation	MB25	6.1	6.3	9454	13640	181	4374	2701	511	840		261	319	0.03		0.50		0.0005	1.50					0.41				0.00005							

Highlight cell indicates 80th Percentile is above criteria:

- Australian Drinking Water Guidelines (Aesthetic) (NHMRC, NRMMC, 2011)
- Australian Drinking Water Guidelines (Health) (NHMRC, NRMMC, 2011)
- Aquatic Ecosystem (95% Protection) (ANZG, 2018)
- Irrigation (Fitzroy Basin WQO)
- Stock (Fitzroy basin WQO)
- Zone 35 Shallow Groundwater (<30m)
- Zone 35 Deep Groundwater (>30m)
- Zone 36 Shallow Groundwater (<30m)
- Zone 36 Deep Groundwater (<30m)
- Multiple of above

Appendix B Recovery Model Starting Heads

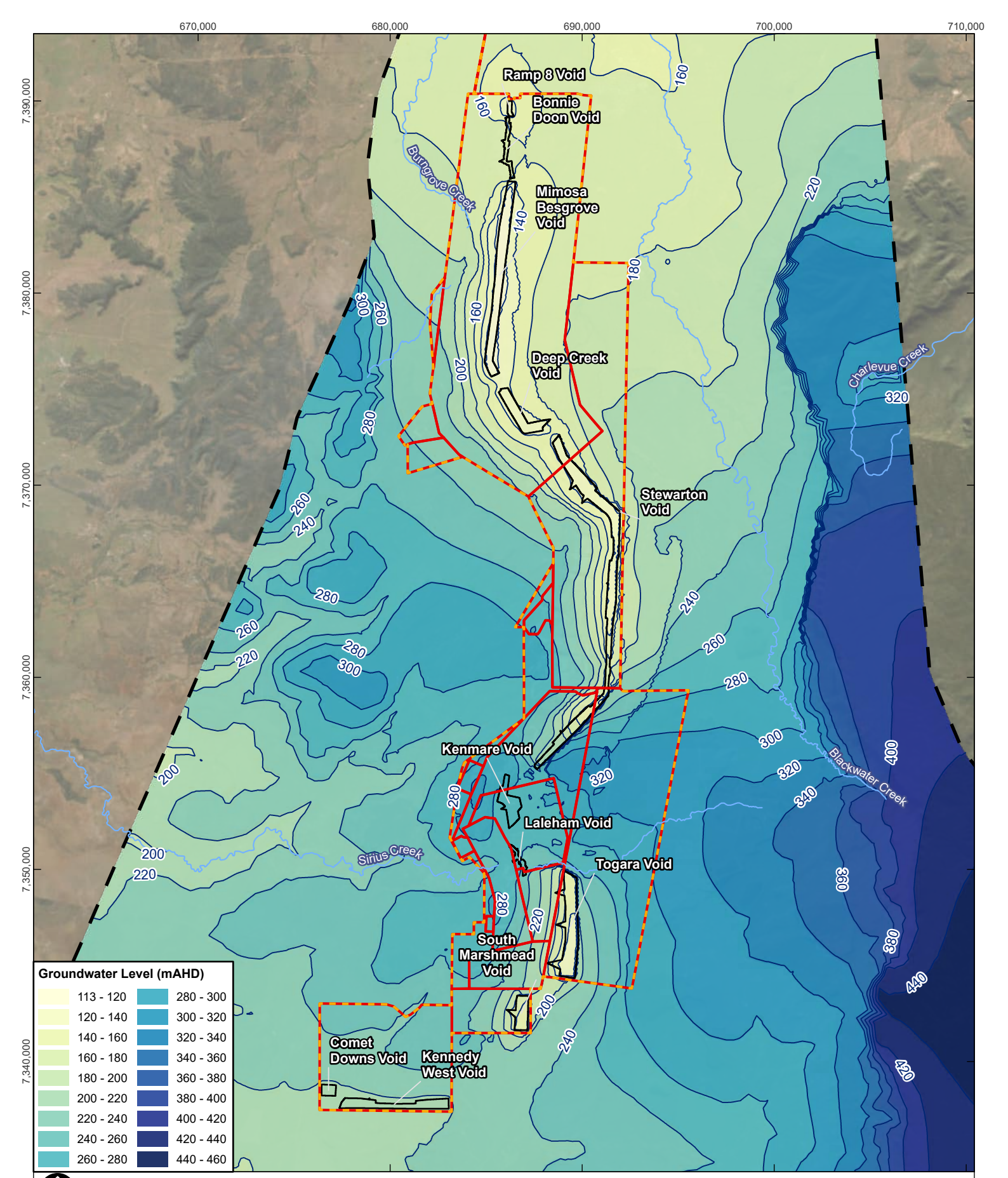
Blackwater Mine

Transitional PRC Plan Hydrogeology Assessment

Whitehaven Coal Limited

SLR Project No.: 620.040199.00001

16 September 2024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Ramp 8 Void
Bonnie Doon Void
Mimosa Besgrove Void
Deep Creek Void
Stewarton Void
Kenmare Void
Laleham Void
Togara Void
South Marshmead Void
Comet Downs Void
Kennedy West Void
Burngrove Creek
Charlevue Creek
Blackwater Creek
Sirius Creek
Groundwater Level (mAHD)
113 - 120
120 - 140
140 - 160
160 - 180
180 - 200
200 - 220
220 - 240
240 - 260
260 - 280
280 - 300
300 - 320
320 - 340
340 - 360
360 - 380
380 - 400
400 - 420
420 - 440
440 - 460
0
2.5
5
km
LEGEND
Watercourse
Groundwater Level (mAHD)
BWM Mining Lease
Project Area (Environmental Authorities boundary)
Study Area
Void Extent
Coordinate System: GDA2020 MGA Zone 55
Scale: 1:250,000 at A4
Project Number: 620.040199
Date Drawn: 30-Jul-2024
Drawn by: AS
BLACKWATER MINE - TRANSITIONAL PRCP HYDROGEOLOGY ASSESSMENT
END OF MINING GROUNDWATER LEVELS – WATER TABLE
SLR
DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.
FIGURE B-1
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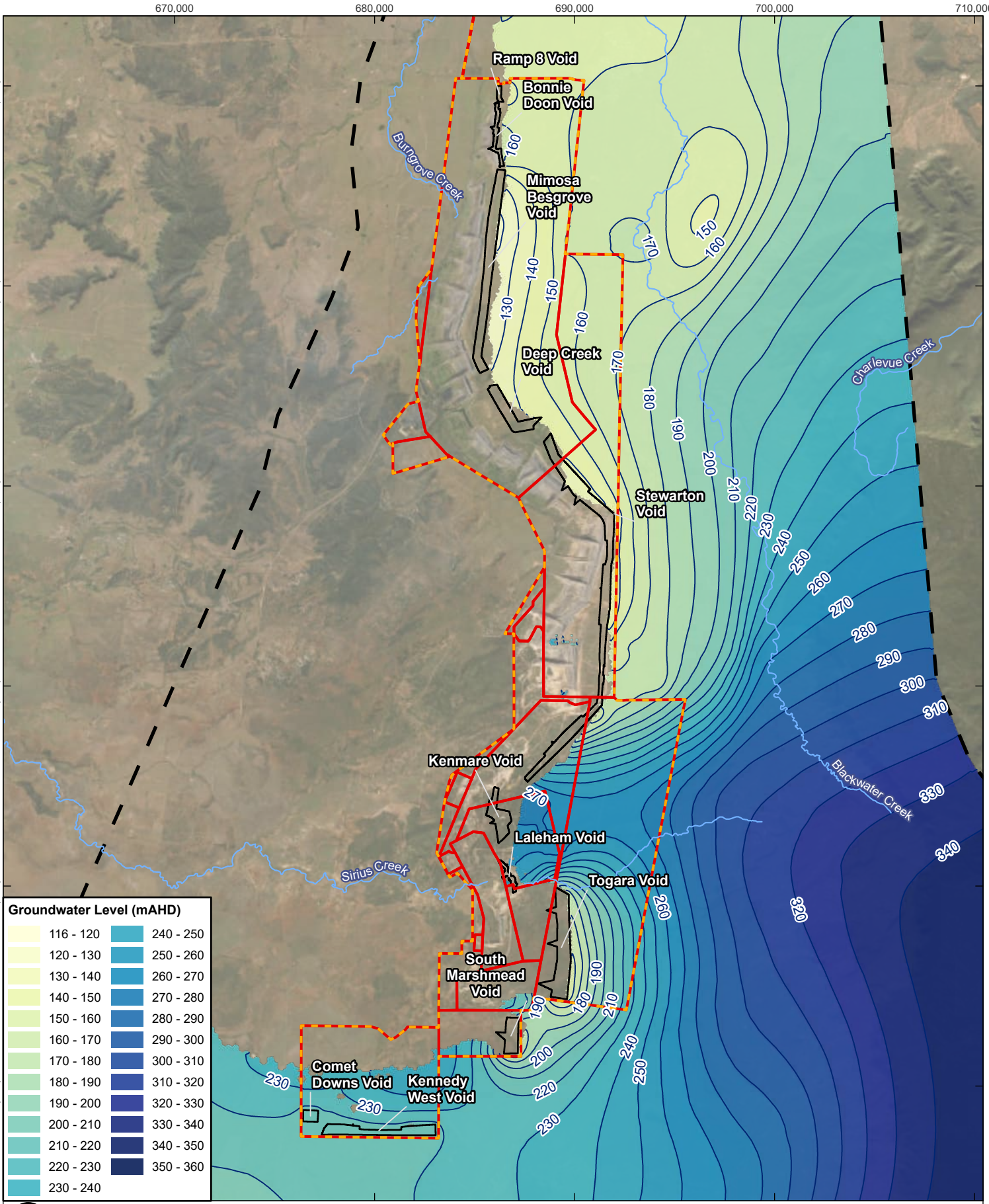


0 2.5 5 km

Coordinate System:	GDA2020 MGA Zone 55
Scale:	1:250,000 at A4
Project Number:	620.040199
Date Drawn:	30-Jul-2024
Drawn by:	AS

LEGEND

- Watercourse
- Groundwater Level (mAHD)
- BWM Mining Lease
- Project Area (Environmental Authorities boundary)
- Study Area
- Void Extent

BLACKWATER MINE - TRANSITIONAL PRCP HYDROGEOLOGY ASSESSMENT

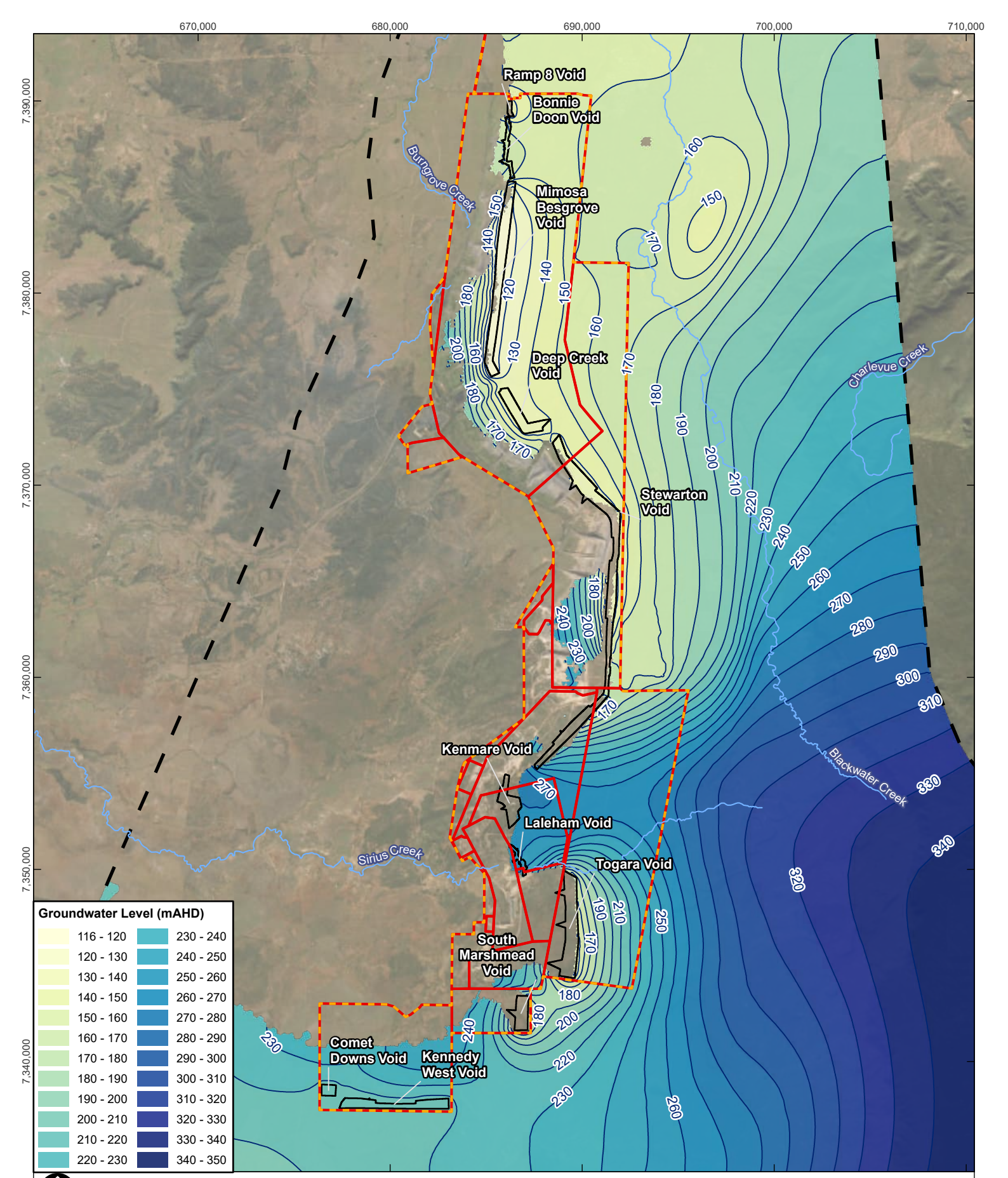
END OF MINING GROUNDWATER LEVELS – ARIES SEAM

SLR

DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.

FIGURE B-2

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040199.00001 BWM PRCP – GW\03 SLR Data\01 CADGIS\GIS\ArcPro\BWM PRCP – GW\BWM PRCP – GW.aprx\620040199_FB_02_End of Mining Groundwater Levels – Aries Seam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Ramp 8 Void
Bonnie Doon Void
Mimosa Besgrove Void
Deep Creek Void
Stewarton Void
Kenmare Void
Laleham Void
Togara Void
South Marshmead Void
Comet Downs Void
Kennedy West Void
Burngrove Creek
Charlevue Creek
Blackwater Creek
Sirius Creek
Groundwater Level (mAHD)
116 - 120
120 - 130
130 - 140
140 - 150
150 - 160
160 - 170
170 - 180
180 - 190
190 - 200
200 - 210
210 - 220
220 - 230
230 - 240
240 - 250
250 - 260
260 - 270
270 - 280
280 - 290
290 - 300
300 - 310
310 - 320
320 - 330
330 - 340
340 - 350
0
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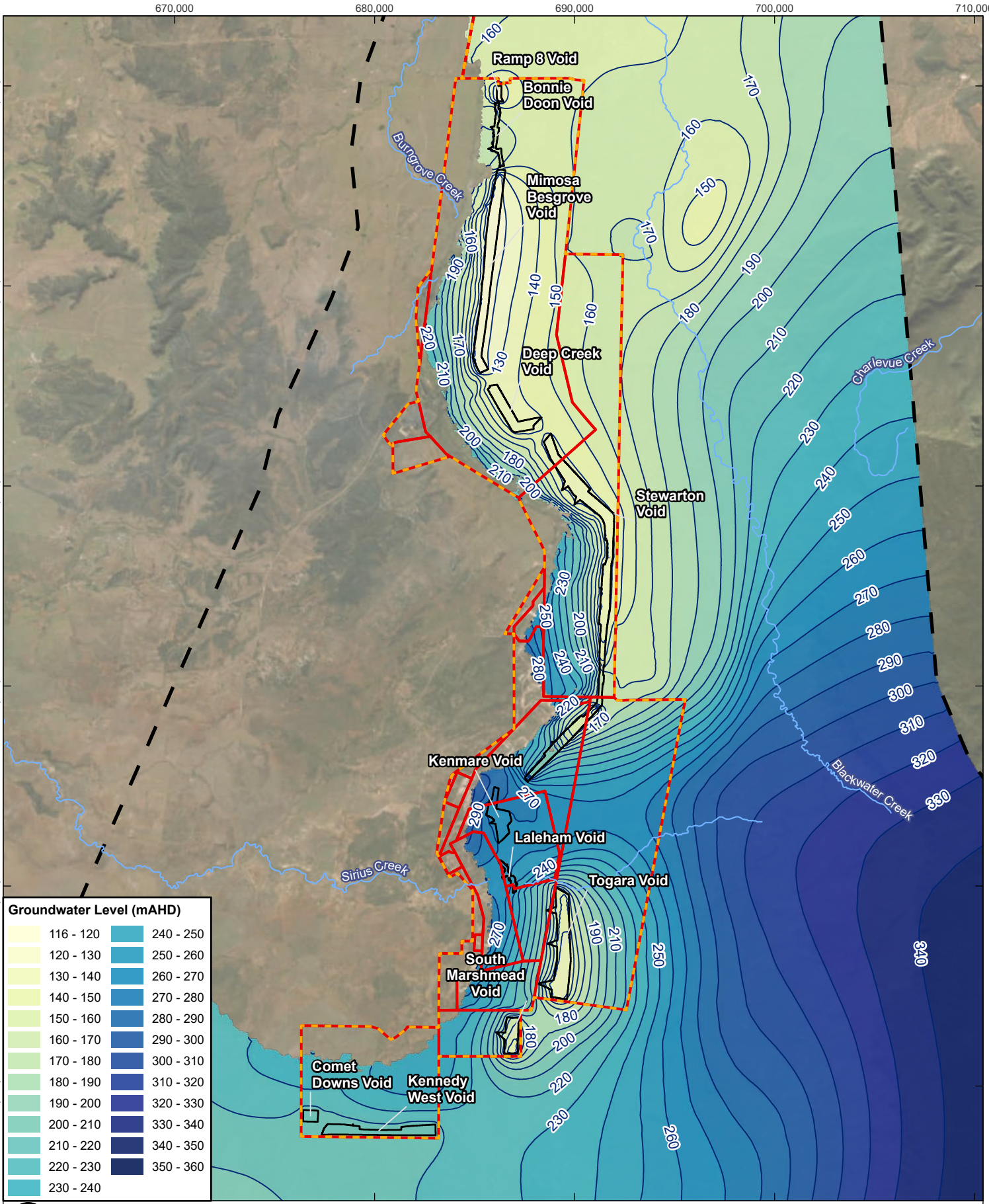
5
km
LEGEND
Watercourse
Groundwater Level (mAHD)
BWM Mining Lease
Project Area (Environmental Authorities boundary)
Study Area
Void Extent
Coordinate System: GDA2020 MGA Zone 55
Scale: 1:250,000 at A4
Project Number: 620.040199
Date Drawn: 30-Jul-2024
Drawn by: AS
BLACKWATER MINE - TRANSITIONAL PRCP HYDROGEOLOGY ASSESSMENT
END OF MINING GROUNDWATER LEVELS – CASTOR SEAM
SLR
DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.
FIGURE B-3
Path: H:\Projects-SLR\620-BNE\620-BNE\620.040199.00001 BWM PRCP – GW\03 SLR Data\01 CADGIS\GIS\ArcPro\BWM PRCP – GW\BWM PRCP – GW.aprx\620040199_FB_03_End of Mining Groundwater Levels – Castor Seam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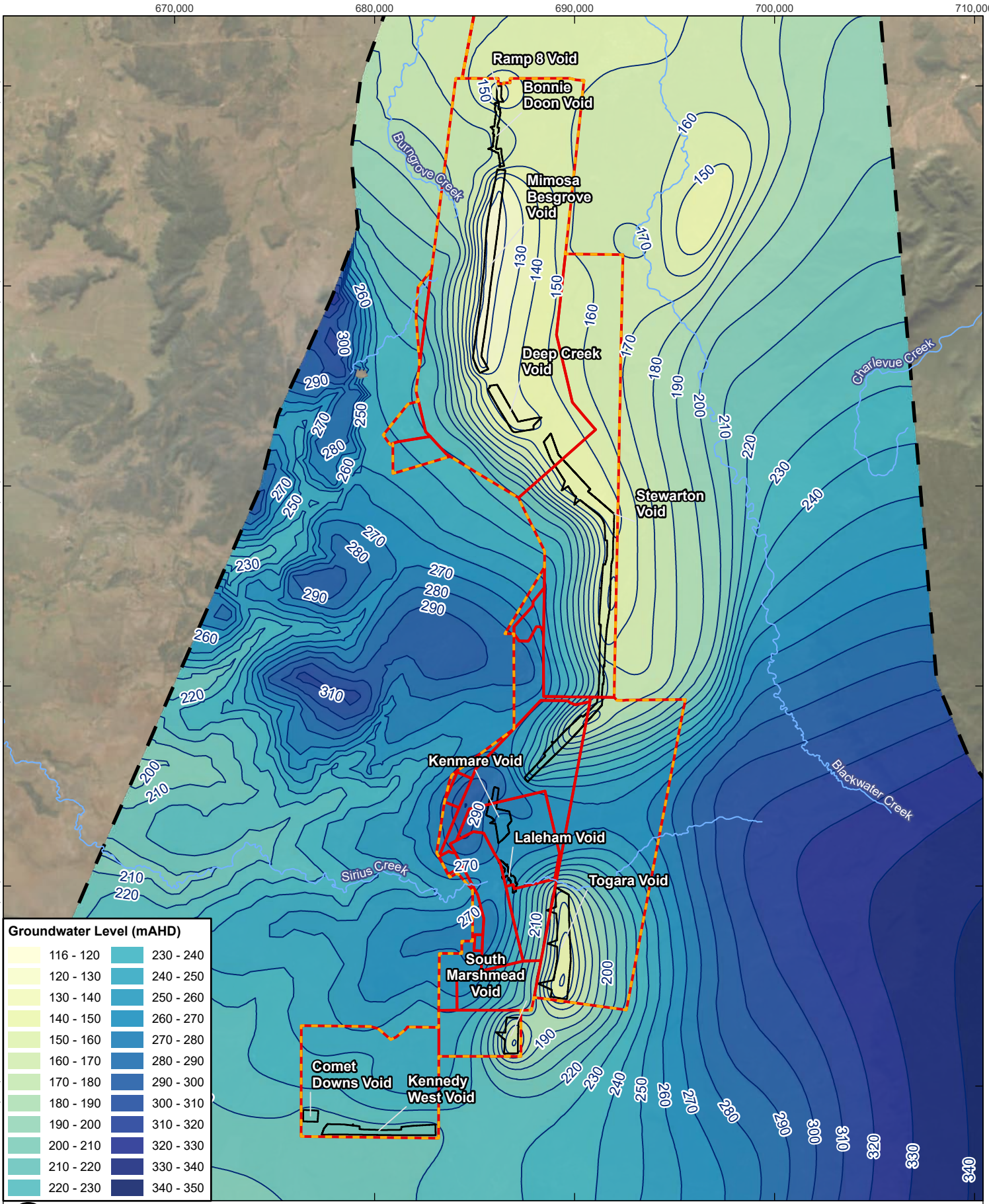
Ramp 8 Void
Bonnie Doon Void
Mimosa Besgrove Void
Deep Creek Void
Stewarton Void
Kenmare Void
Laleham Void
Togara Void
South Marshmead Void
Comet Downs Void
Kennedy West Void
Burngrove Creek
Charlevue Creek
Blackwater Creek
Sirius Creek
Groundwater Level (mAHD)
116 - 120
120 - 130
130 - 140
140 - 150
150 - 160
160 - 170
170 - 180
180 - 190
190 - 200
200 - 210
210 - 220
220 - 230
230 - 240
240 - 250
250 - 260
260 - 270
270 - 280
280 - 290
290 - 300
300 - 310
310 - 320
320 - 330
330 - 340
340 - 350
350 - 360
0
2.5
5
km
LEGEND
Watercourse
Groundwater Level (mAHD)
BWM Mining Lease
Project Area (Environmental Authorities boundary)
Study Area
Void Extent
Coordinate System: GDA2020 MGA Zone 55
Scale: 1:250,000 at A4
Project Number: 620.040199
Date Drawn: 30-Jul-2024
Drawn by: AS
BLACKWATER MINE - TRANSITIONAL PRCP HYDROGEOLOGY ASSESSMENT
END OF MINING GROUNDWATER LEVELS – POLLUX SEAM
SLR
DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.
FIGURE B-4
Path: H:\Projects-SLR\620-BNE\620-BNE\620.040199.00001 BWM PRCP – GW\03 SLR Data\01 CADGIS\GIS\ArcPro\BWM PRCP – GW\BWM PRCP – GW.aprx\620040199_FB_04_End of Mining Groundwater Levels – Pollux Seam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680,000
690,000
700,000
710,000
7,390,000
7,380,000
7,370,000
7,360,000
7,350,000
7,340,000
Ramp 8 Void
Bonnie Doon Void
Mimosa Besgrove Void
Deep Creek Void
Stewarton Void
Kenmare Void
Laleham Void
Togara Void
South Marshmead Void
Comet Downs Void
Kennedy West Void
Burngrove Creek
Charlevue Creek
Blackwater Creek
Sirius Creek
Groundwater Level (mAHD)
116 - 120
120 - 130
130 - 140
140 - 150
150 - 160
160 - 170
170 - 180
180 - 190
190 - 200
200 - 210
210 - 220
220 - 230
230 - 240
240 - 250
250 - 260
260 - 270
270 - 280
280 - 290
290 - 300
300 - 310
310 - 320
320 - 330
330 - 340
340 - 350
0
2.5
5
km
LEGEND
Watercourse
Groundwater Level (mAHD)
BWM Mining Lease
Project Area (Environmental Authorities boundary)
Study Area
Void Extent
Coordinate System: GDA2020 MGA Zone 55
Scale: 1:250,000 at A4
Project Number: 620.040199
Date Drawn: 30-Jul-2024
Drawn by: AS
BLACKWATER MINE - TRANSITIONAL PRCP HYDROGEOLOGY ASSESSMENT
END OF MINING GROUNDWATER LEVELS – BURNGROVE FORMATION
SLR
DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.
FIGURE B-5
Path: H:\Projects-SLR\620-BNE\620-BNE\620.040199.00001 BWM PRCP – GW\03 SLR Data\01 CADGIS\GIS\ArcPro\BWM PRCP – GW\BWM PRCP – GW.aprx\620040199_FB_05_End of Mining Groundwater Levels – Burngrove Formation

Appendix C Predictive Hydrographs Adjacent Final Void Lakes (Mid Climate Scenario)

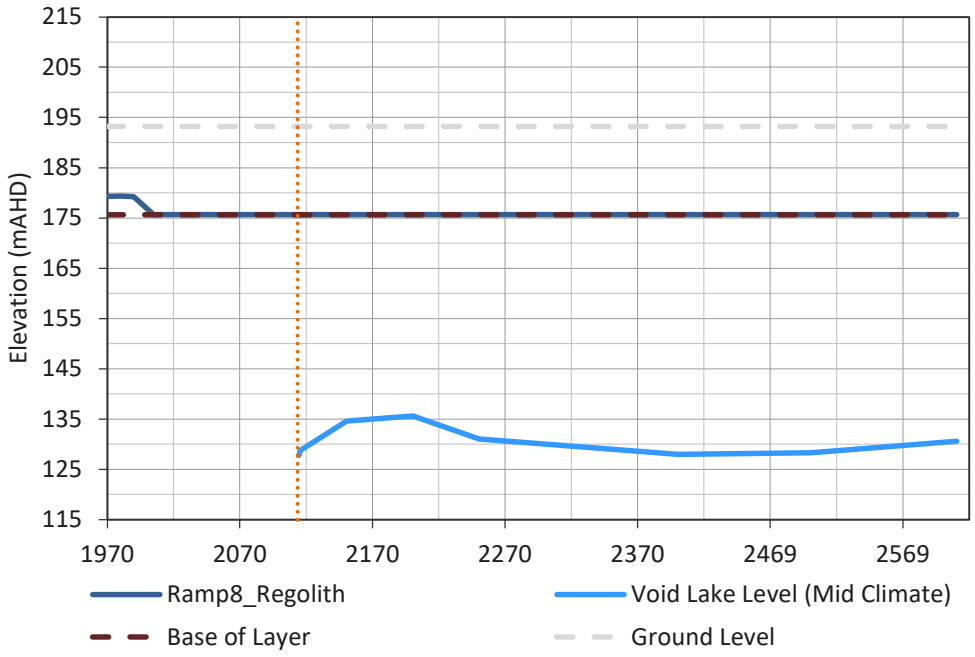
Blackwater Mine

Transitional PRC Plan Hydrogeology Assessment

Whitehaven Coal Limited

SLR Project No.: 620.040199.00001

16 September 2024


Elevation (mAHD)
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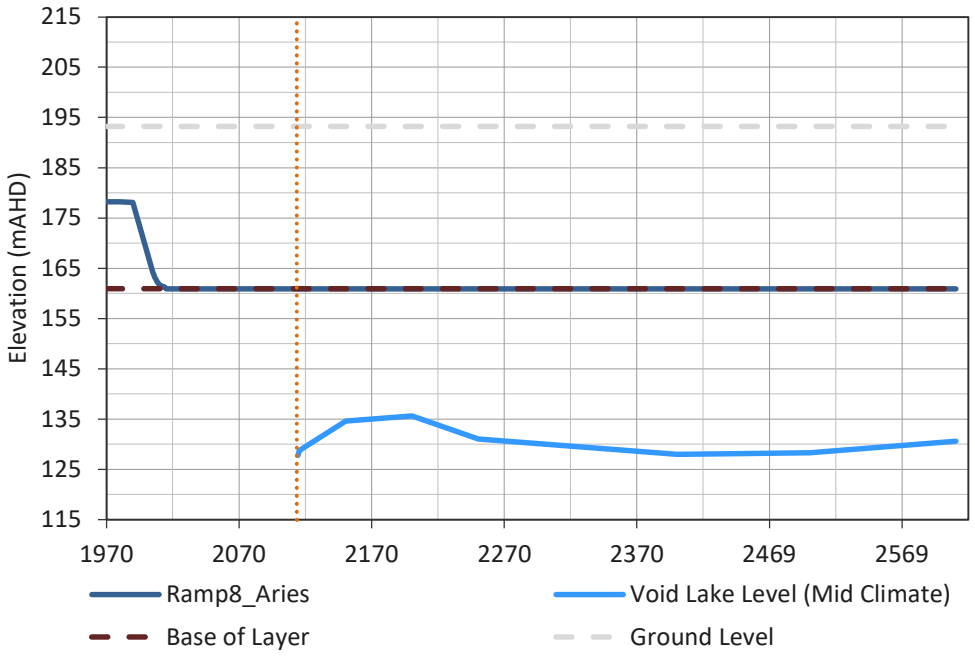
205
195
185
175
165
155
145
135
125
115
1970
2070
2170
2270
2370
2469
2569
Ramp8_Regolith
Void Lake Level (Mid Climate)
Base of Layer
Ground Level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165
155
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135
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1970
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2170
2270
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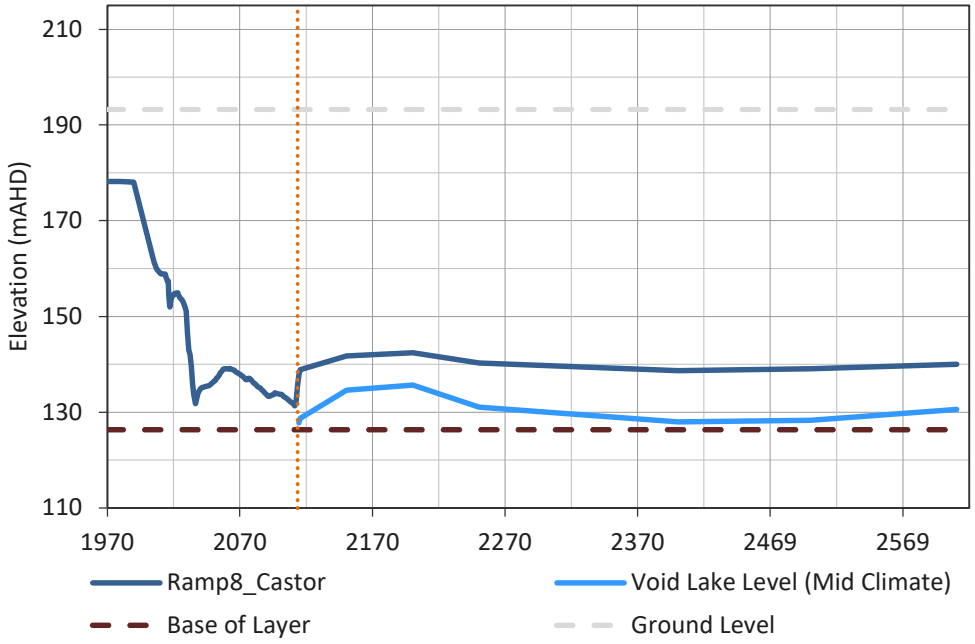
2469
2569
Ramp8_Aries
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


Elevation (mAHD)
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190
170
150
130
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2170
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2569
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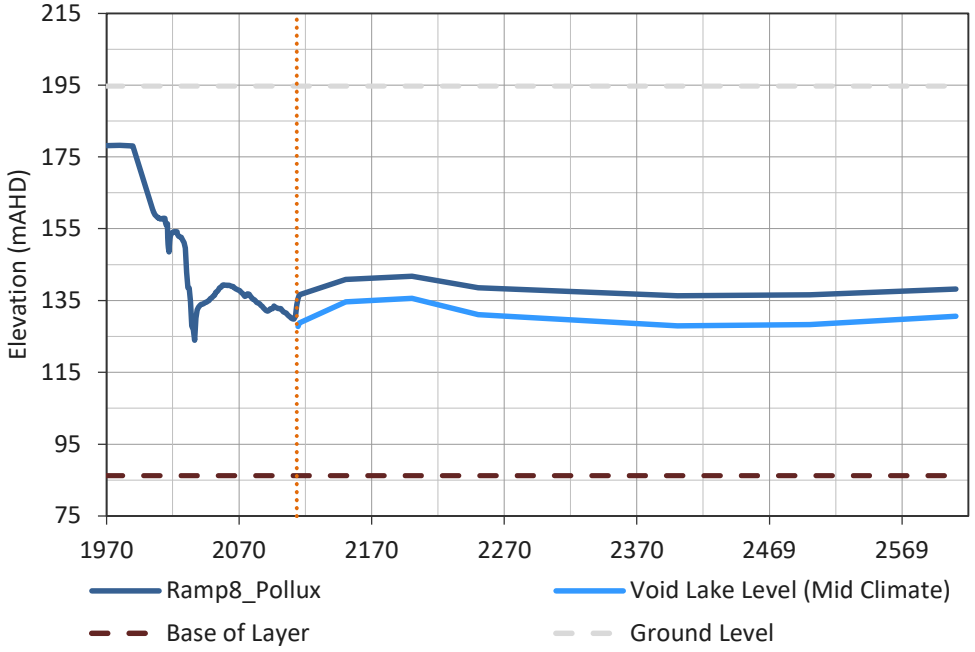
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


Elevation (mAHD)
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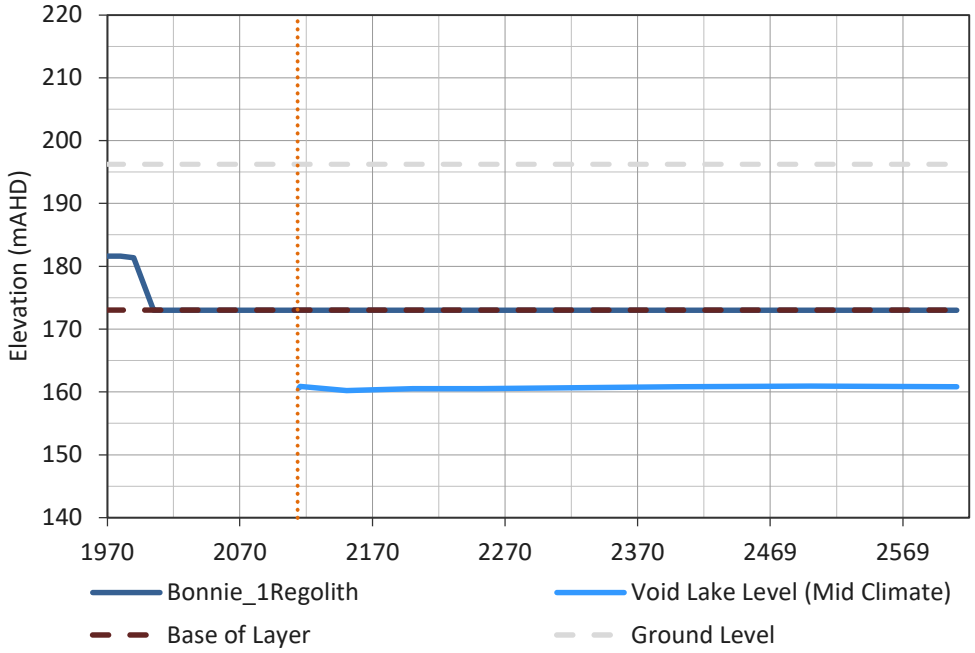
195
175
155
135
115
95
75
1970
2070
2170
2270
2370
2469
2569
Ramp8_Pollux
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


Elevation (mAHD)
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2170
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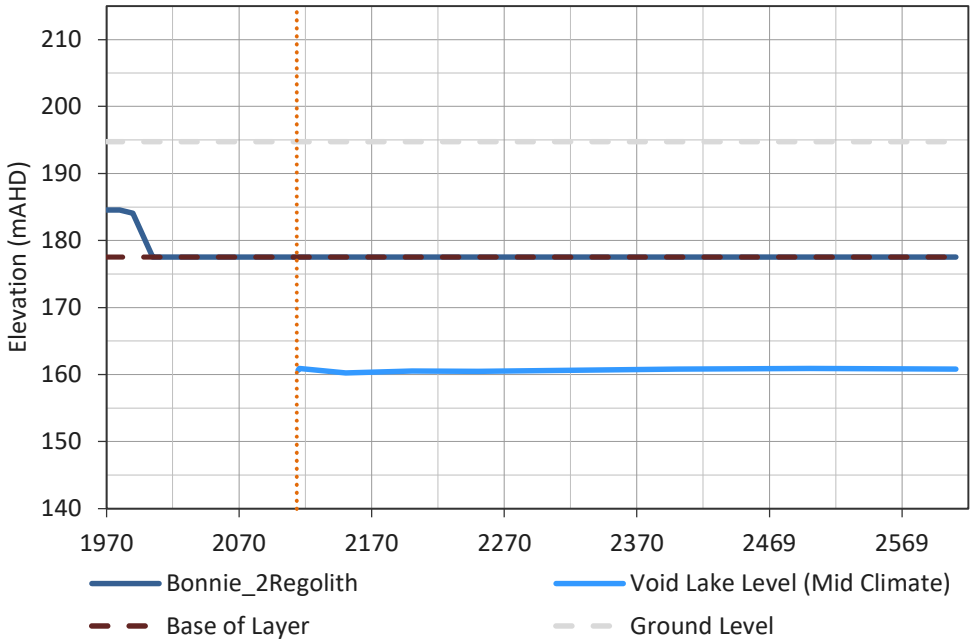
2469
2569
Bonnie_1Regolith
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


Elevation (mAHD)
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200
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180
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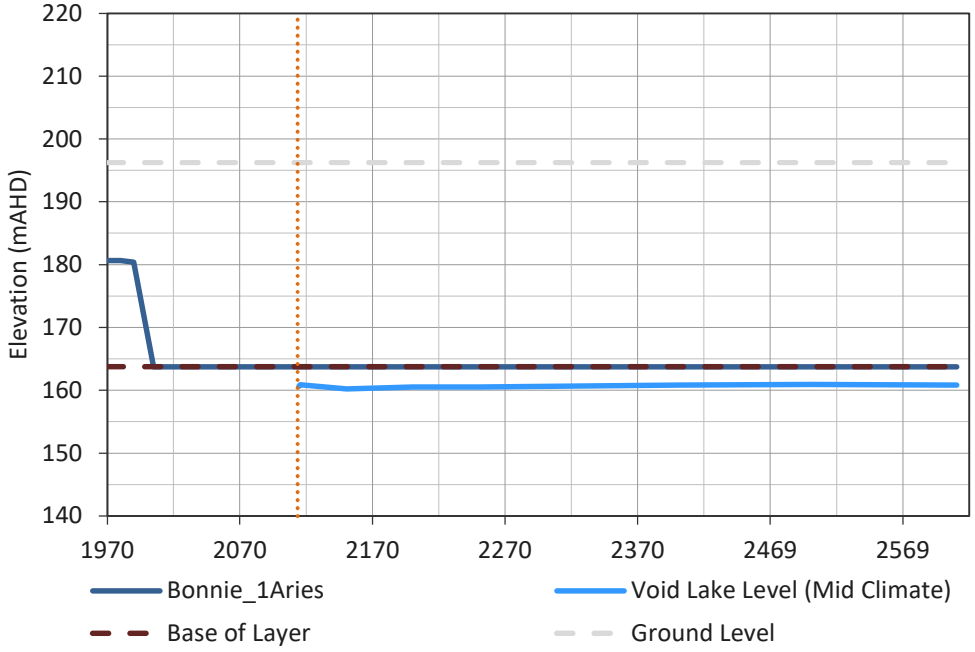
Bonnie_2Regolith
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


Elevation (mAHD)
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2170
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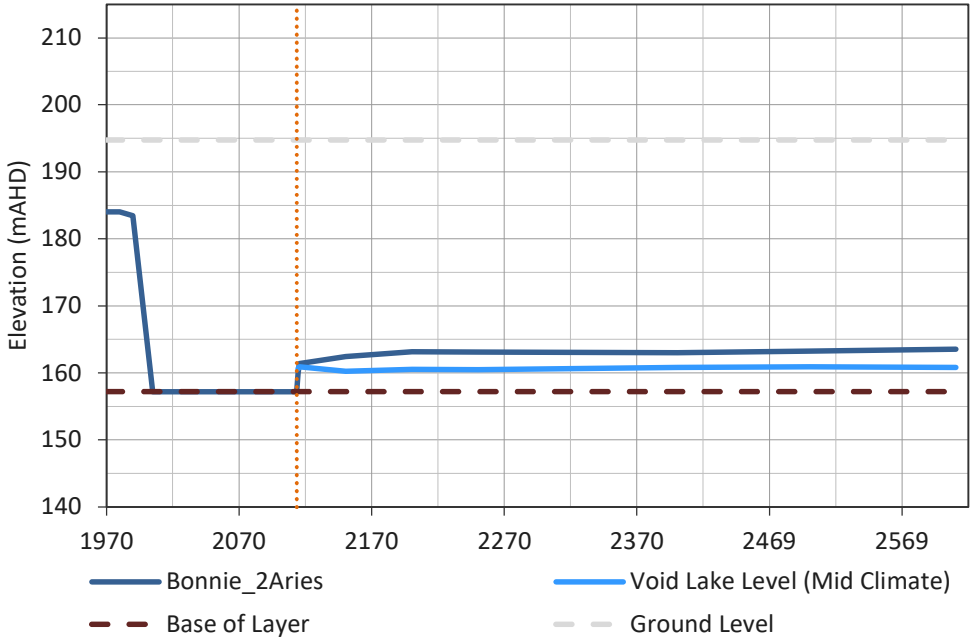
2469
2569
Bonnie_1Aries
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


Elevation (mAHD)
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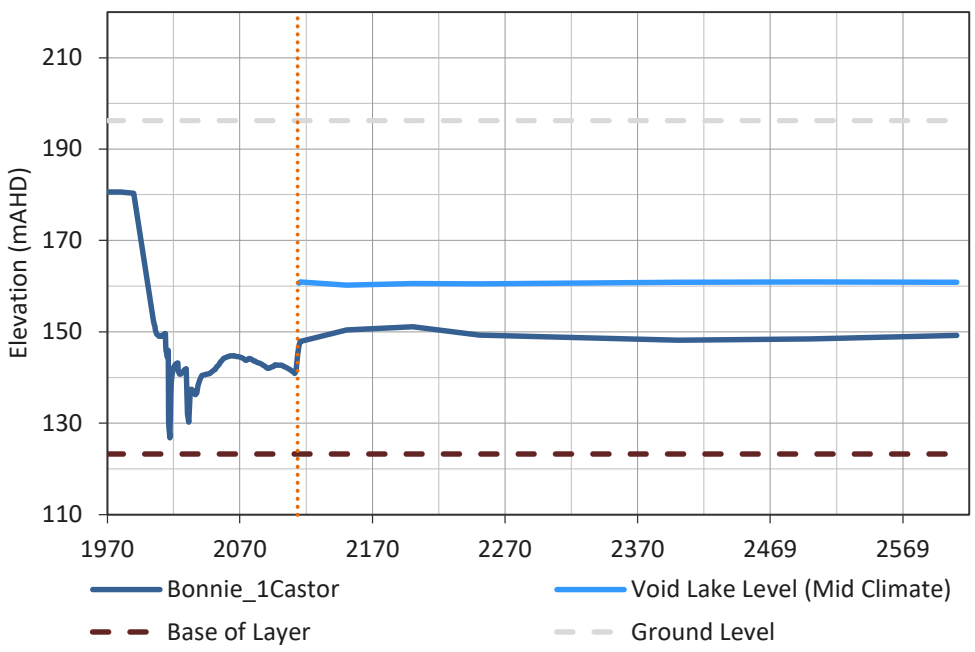
Bonnie_2Aries
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


Elevation (mAHD)
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150
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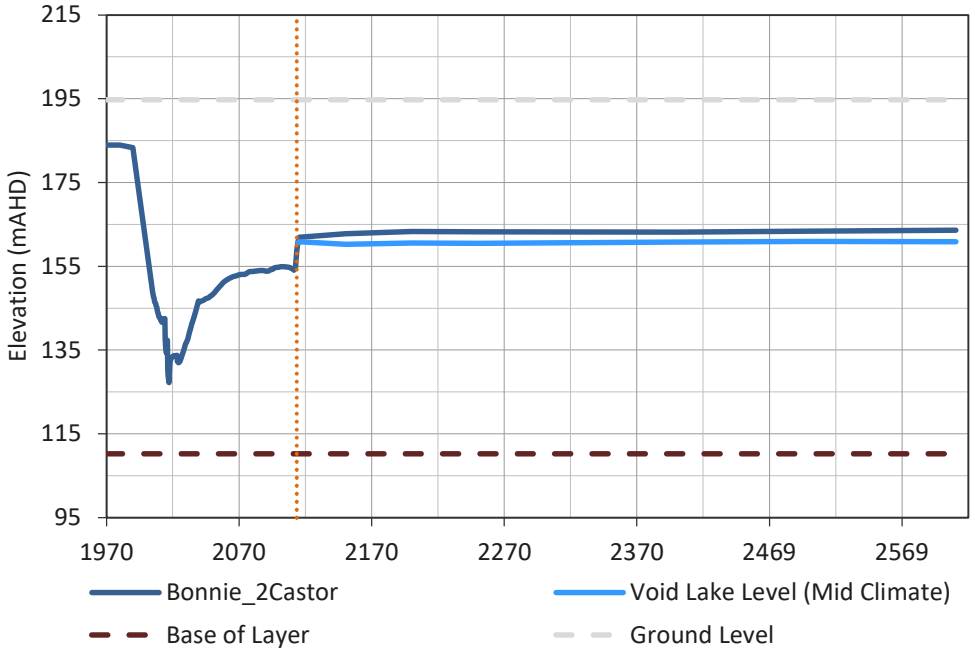
2070
2170
2270
2370
2469
2569
Bonnie_1Castor
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


Elevation (mAHD)
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195
175
155
135
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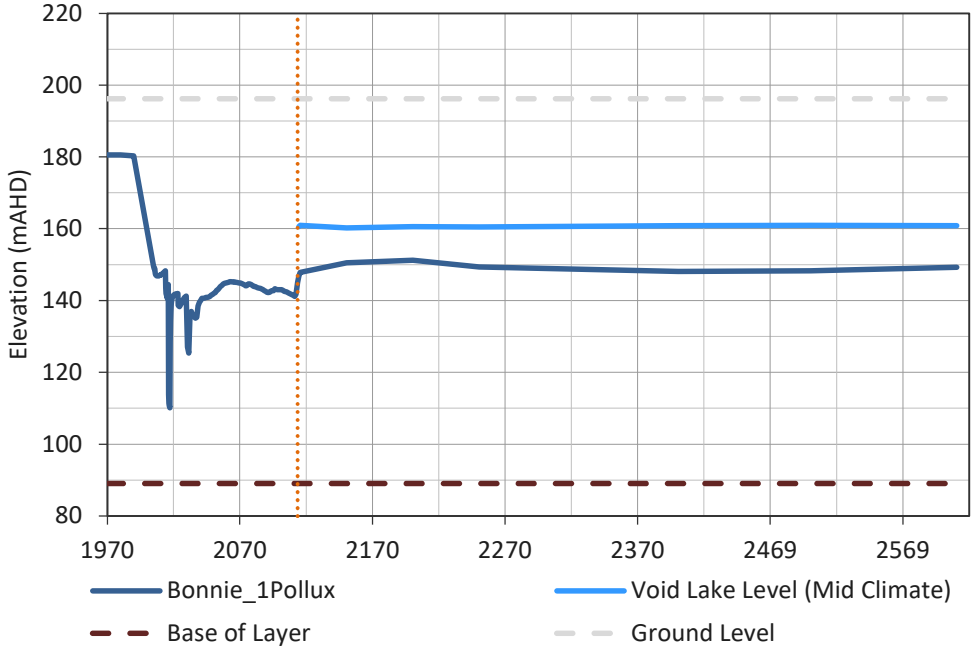
2170
2270
2370
2469
2569
Bonnie_2Castor
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


Elevation (mAHD)
220
200
180
160
140
120
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1970
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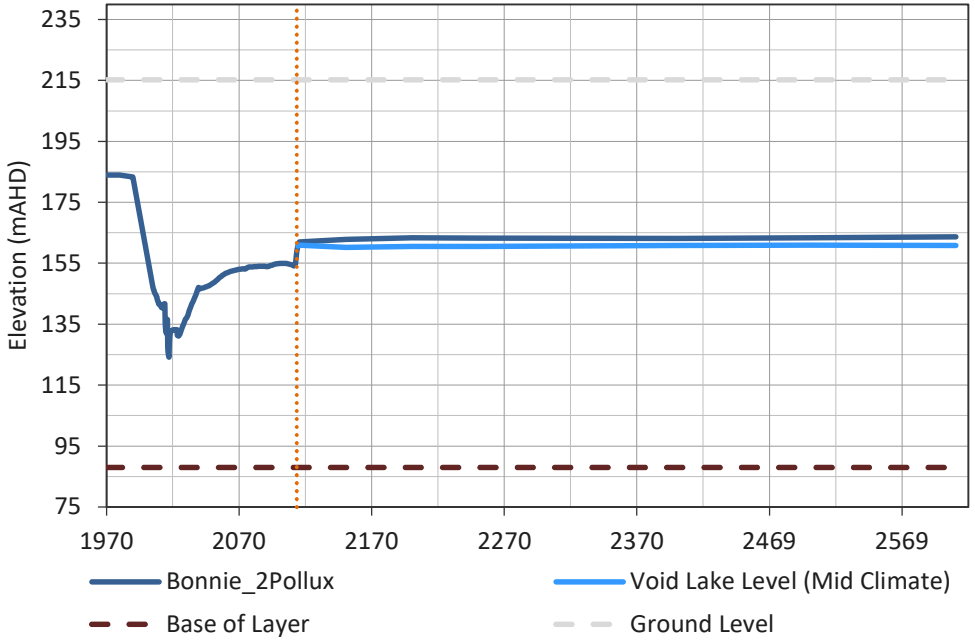
2170
2270
2370
2469
2569
Bonnie_1Pollux
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


Elevation (mAHD)
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175
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135
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1970
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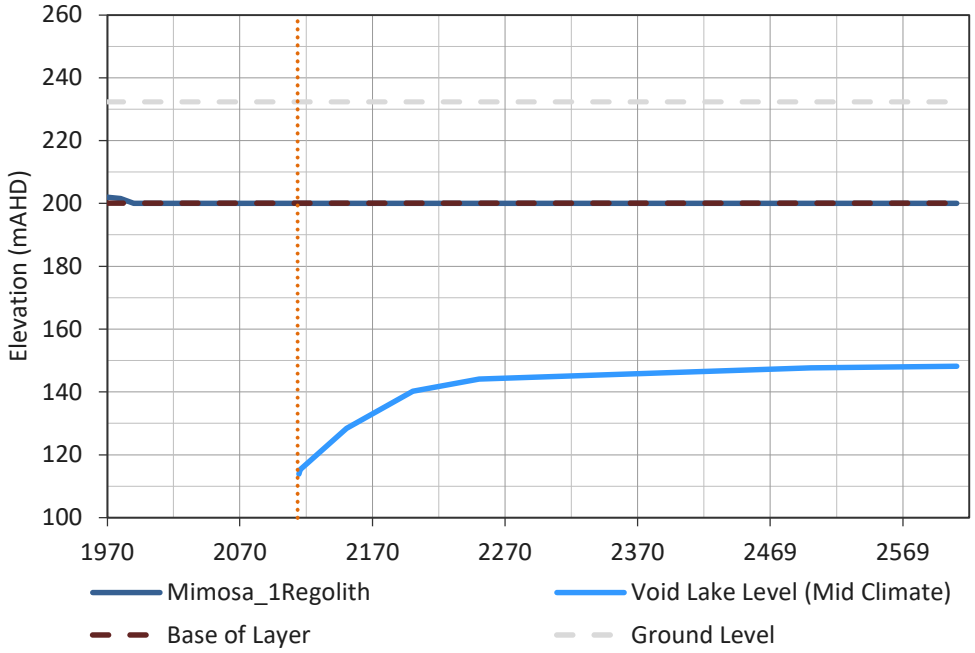
2170
2270
2370
2469
2569
Bonnie_2Pollux
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


Elevation (mAHD)
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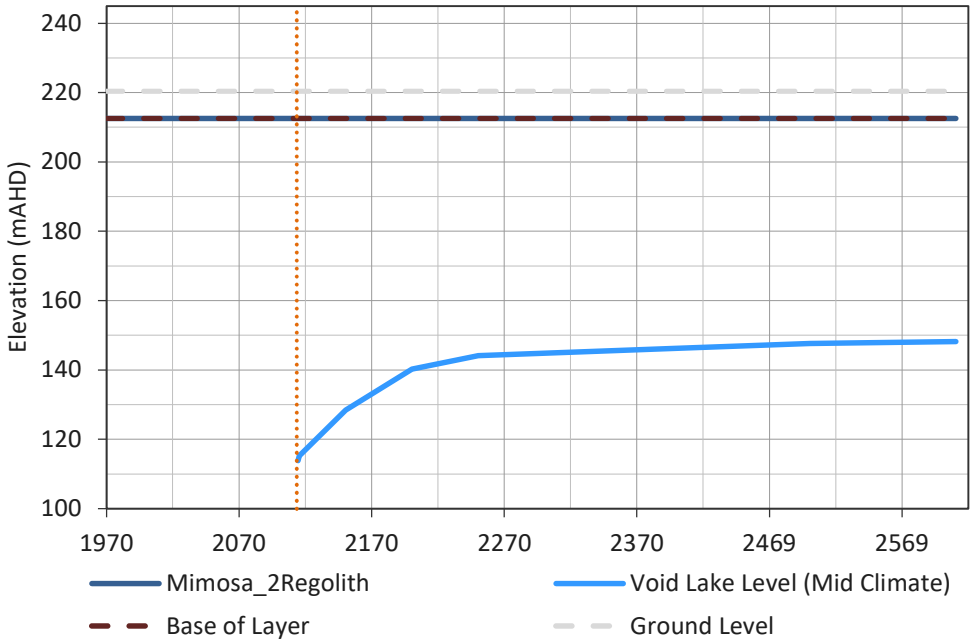
Mimosa_1Regolith
Void Lake Level (Mid Climate)
Base of Layer
Ground Level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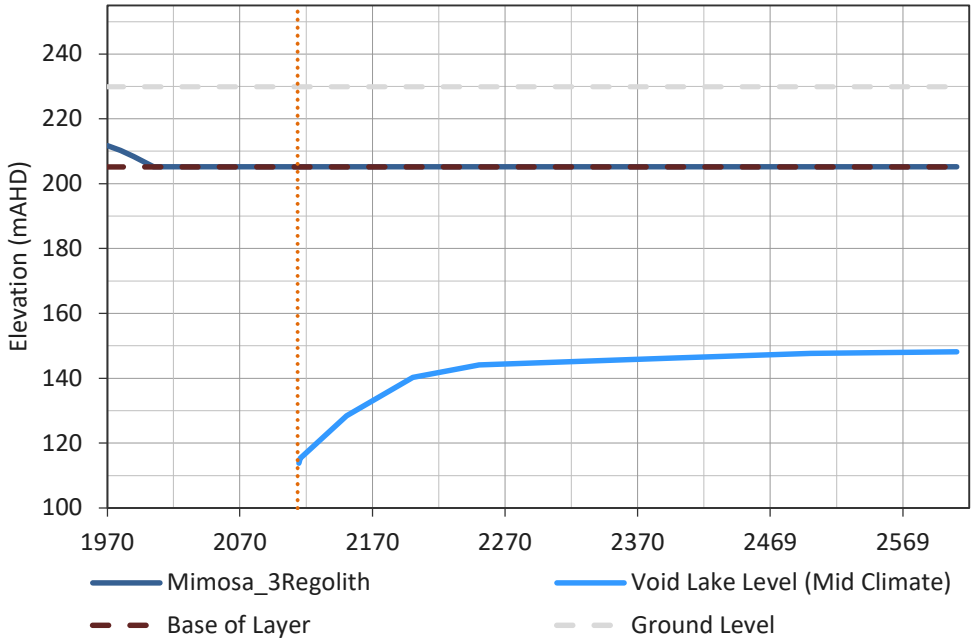
Mimosa_2Regolith
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


Elevation (mAHD)
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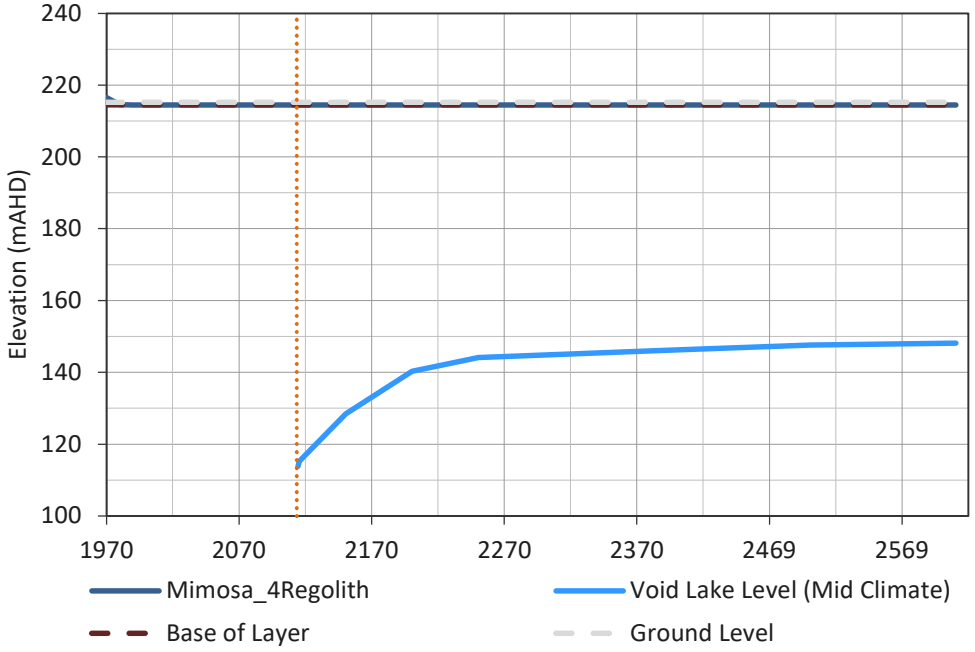
2569
Mimosa_3Regolith
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


Elevation (mAHD)
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180
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140
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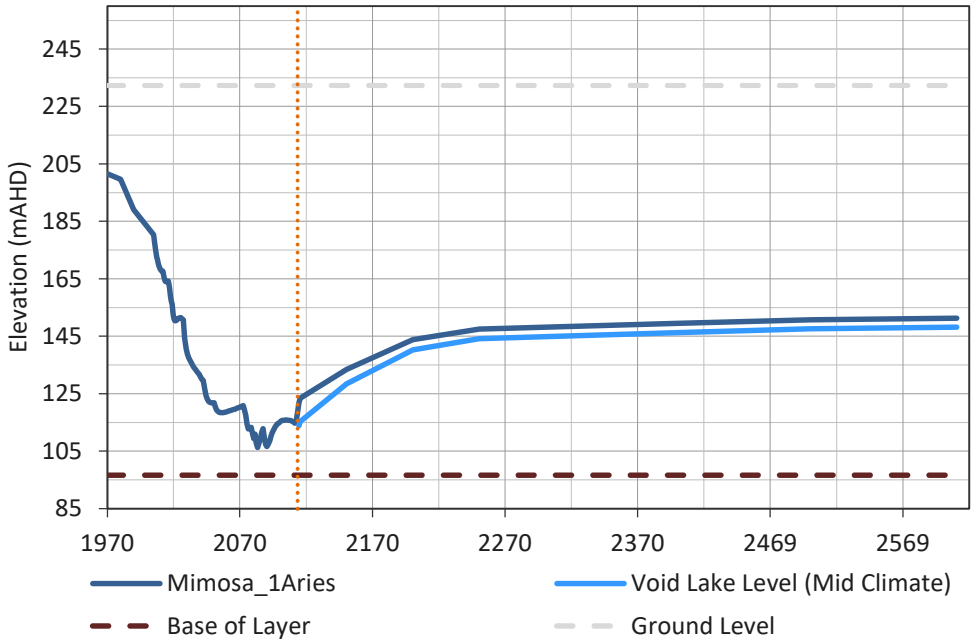
2370
2469
2569
Mimosa_4Regolith
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


Elevation (mAHD)
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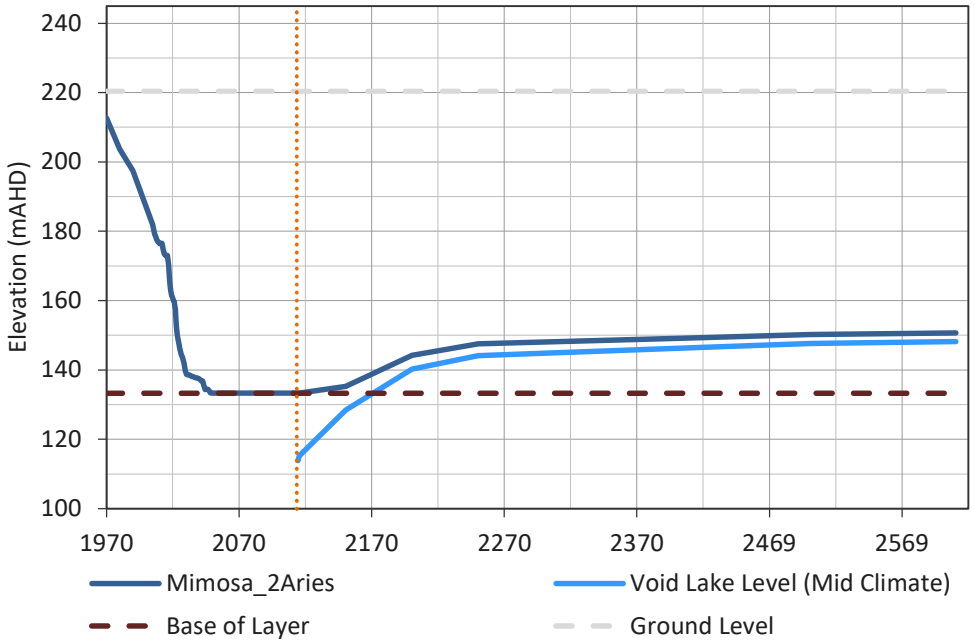
Mimosa_1Aries
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


Elevation (mAHD)
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180
160
140
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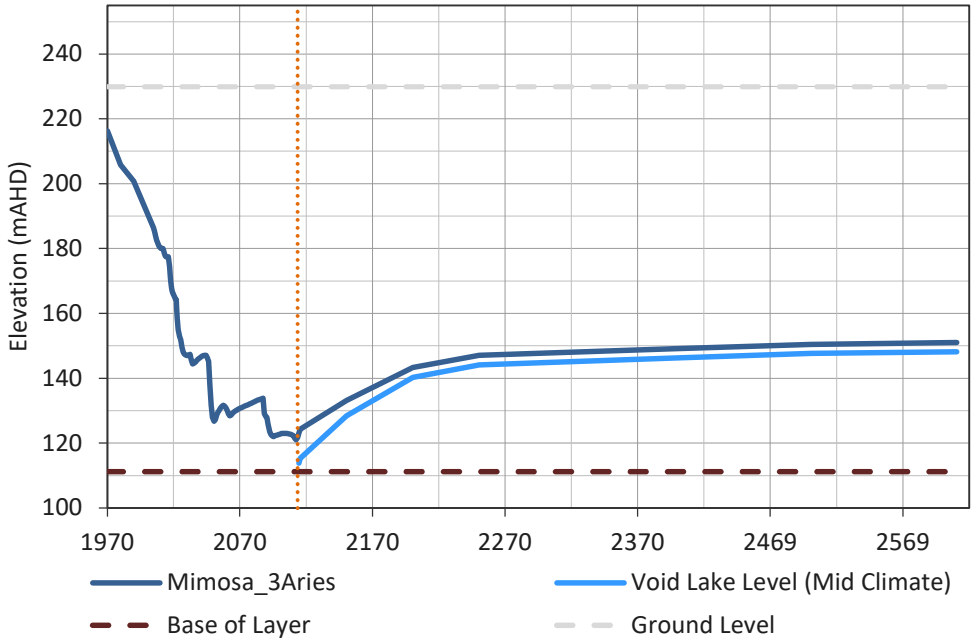
100
1970
2070
2170
2270
2370
2469
2569
Mimosa_2Aries
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


Elevation (mAHD)
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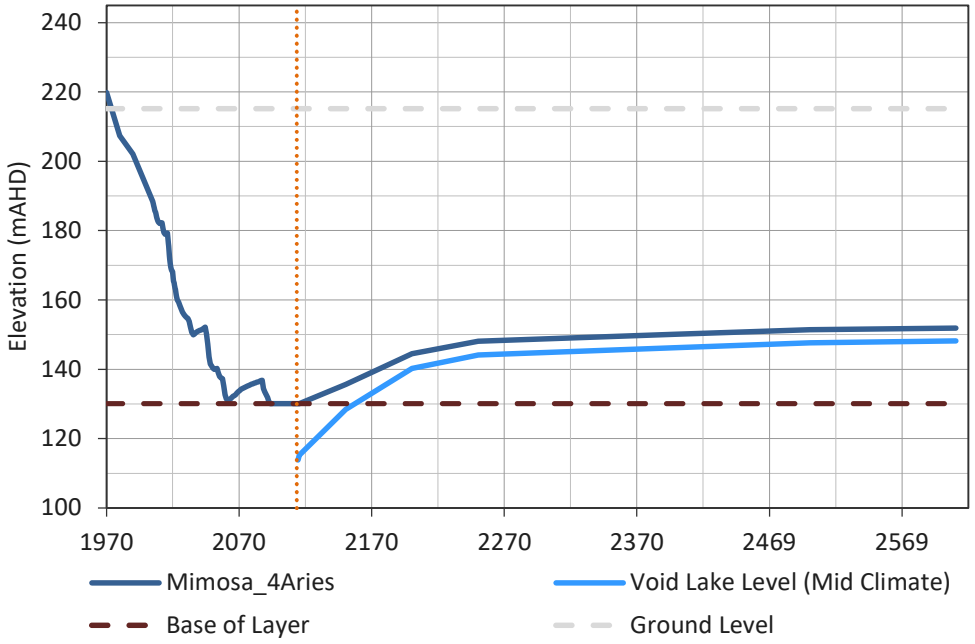
220
200
180
160
140
120
100
1970
2070
2170
2270
2370
2469
2569
Mimosa_3Aries
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


Elevation (mAHD)
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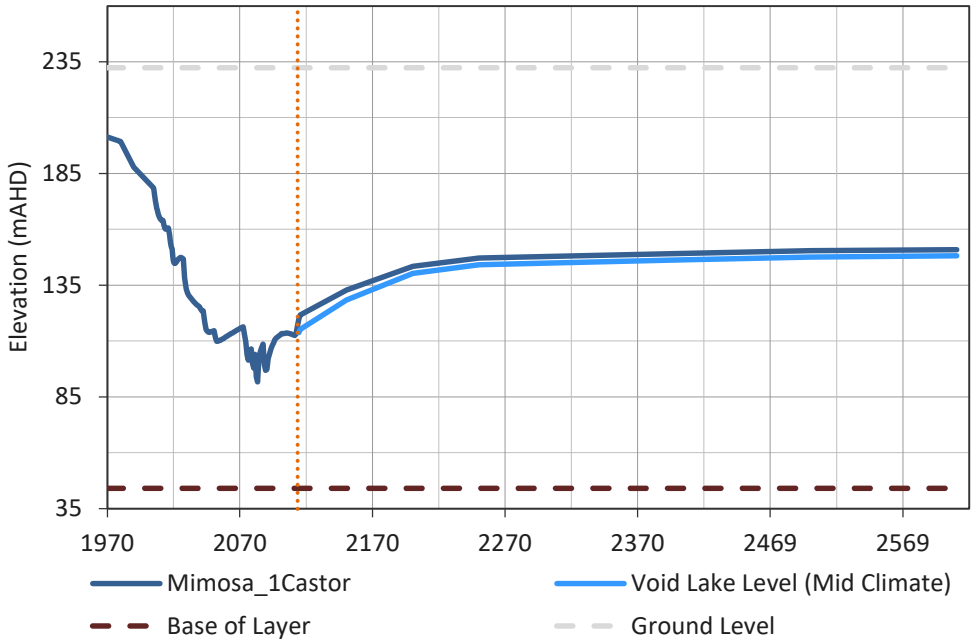
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


Elevation (mAHD)
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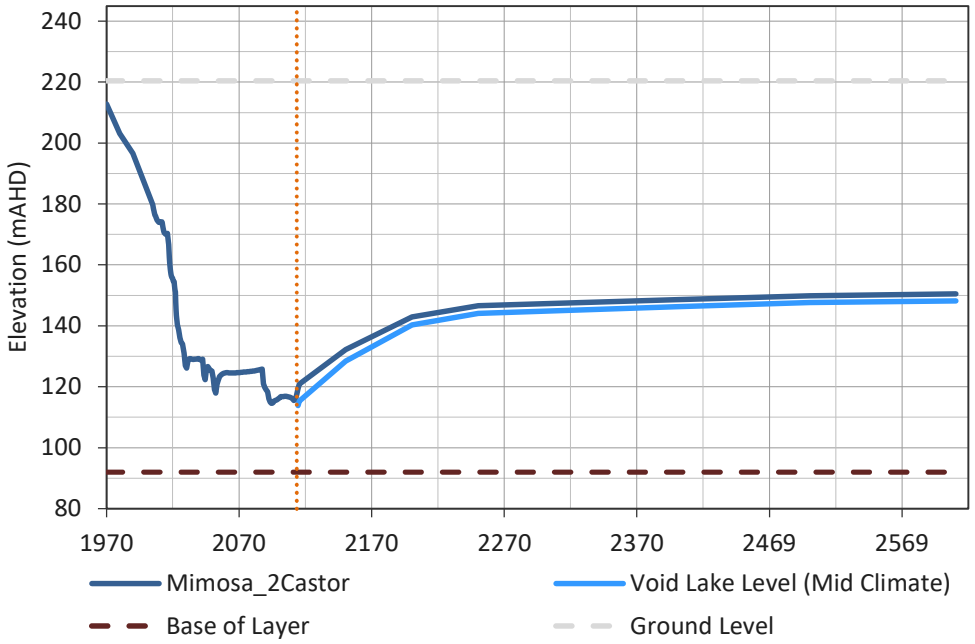
Mimosa_1Castor
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


Elevation (mAHD)
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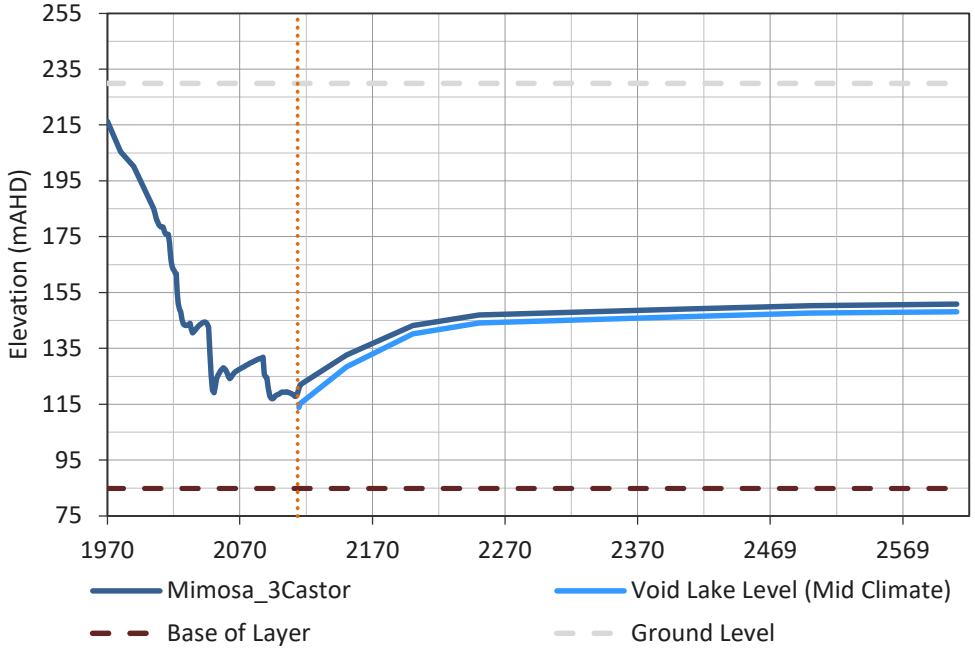
Mimosa_2Castor
Void Lake Level (Mid Climate)
Base of Layer
Ground Level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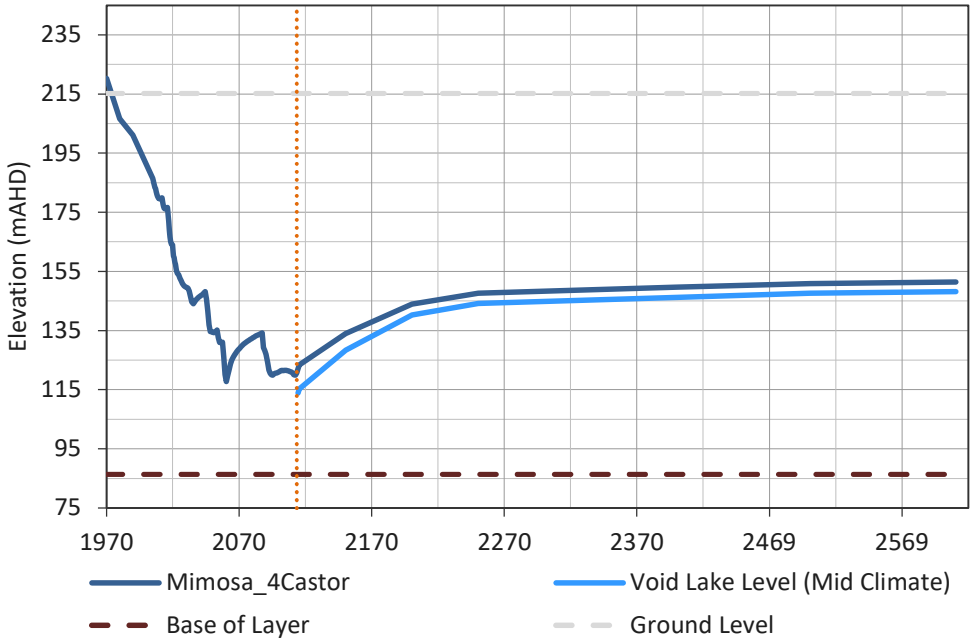
2569
Mimosa_3Castor
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


Elevation (mAHD)
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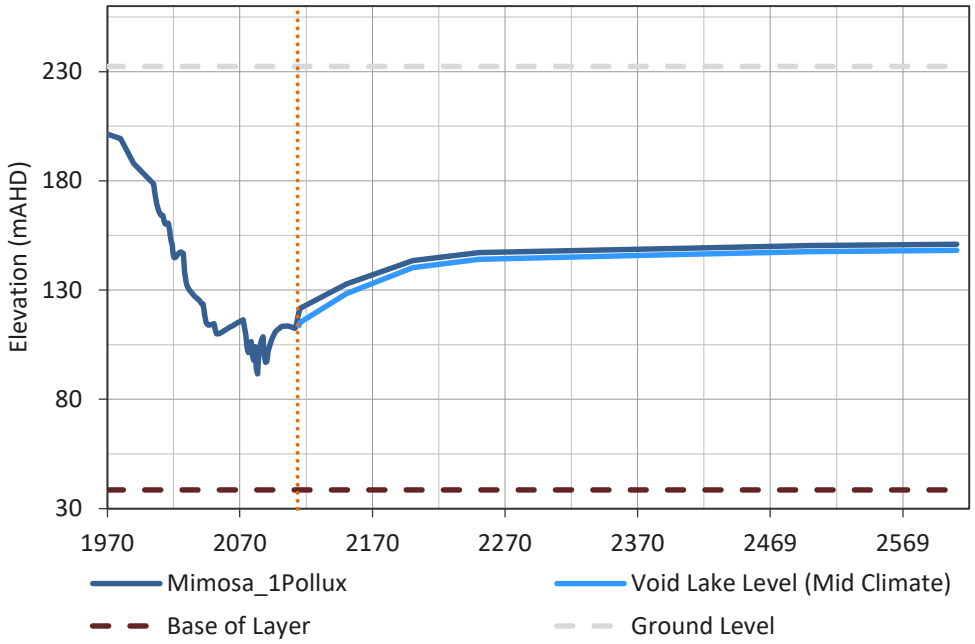
Mimosa_4Castor
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


Elevation (mAHD)
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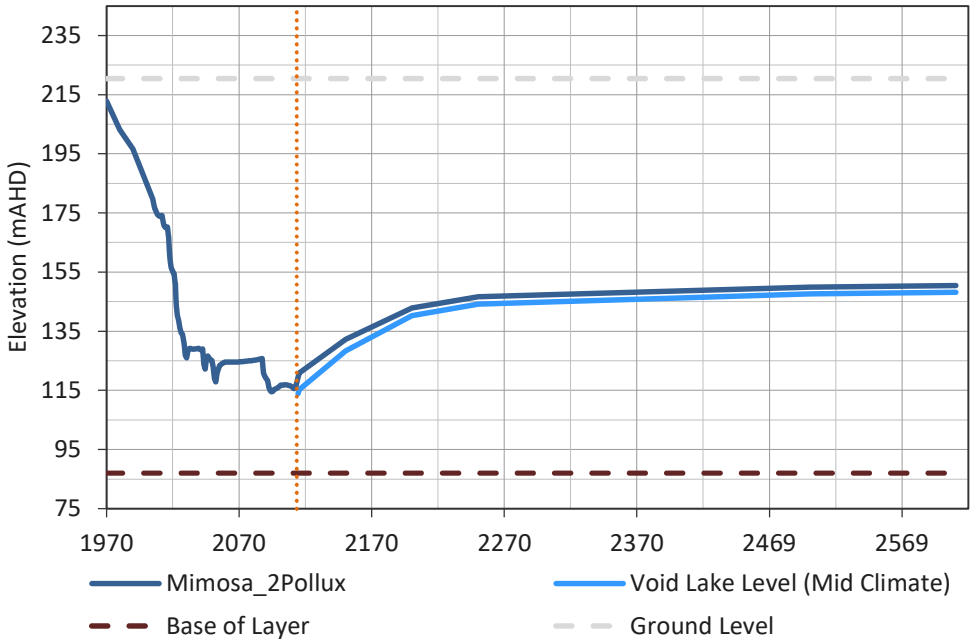
Mimosa_1Pollux
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


Elevation (mAHD)
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135
115
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75
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2170
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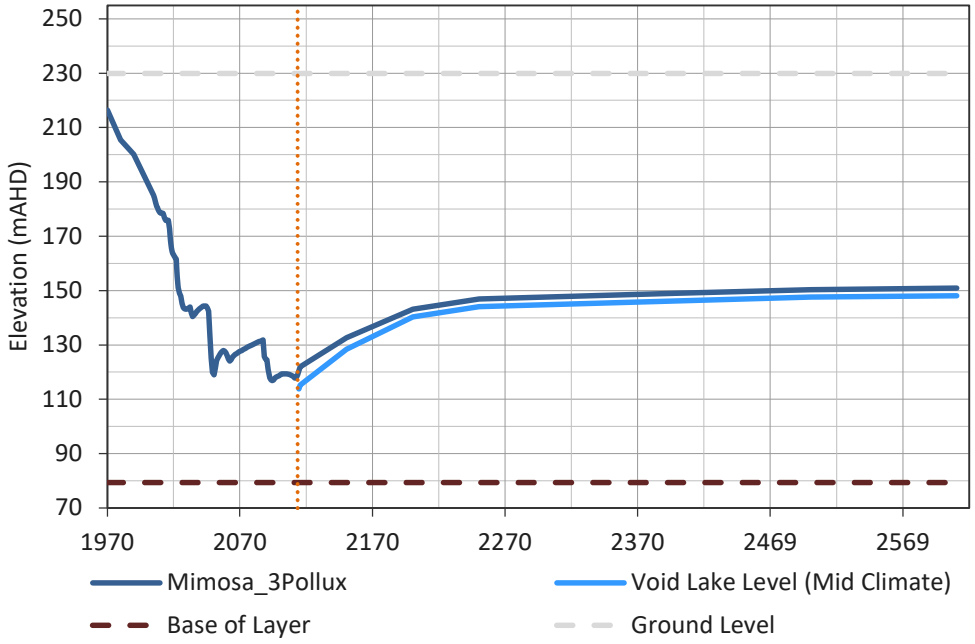
2569
Mimosa_2Pollux
Void Lake Level (Mid Climate)
Base of Layer
Ground Level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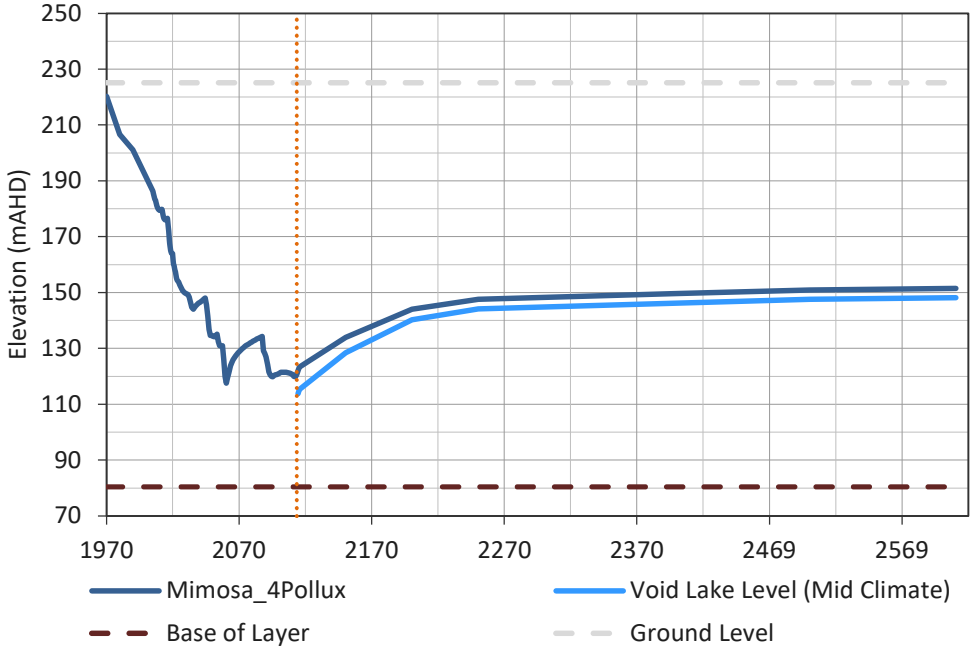
2569
Mimosa_3Pollux
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


Elevation (mAHD)
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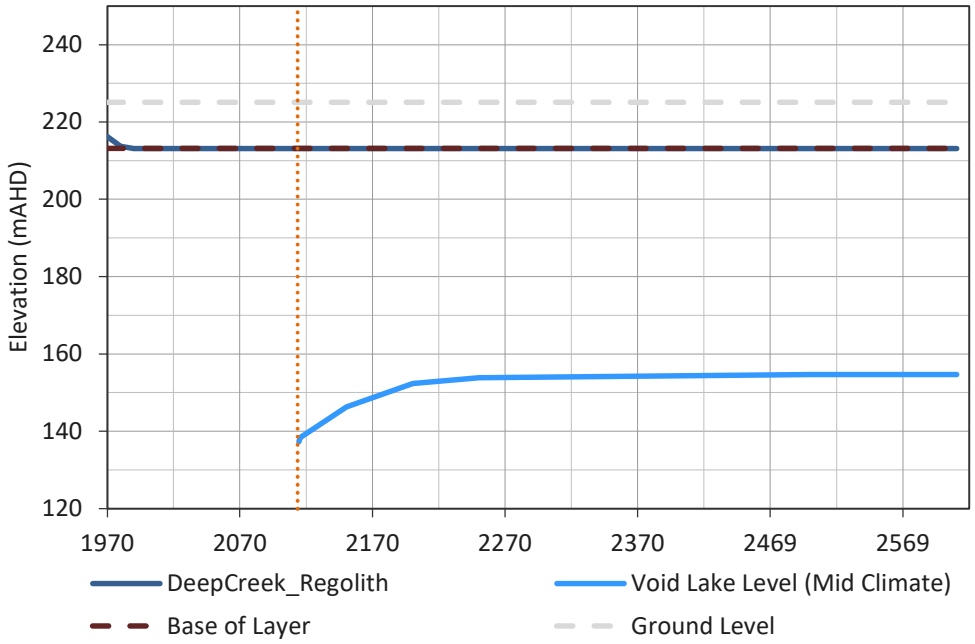
2569
Mimosa_4Pollux
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


240
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120
Elevation (mAHD)
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2270
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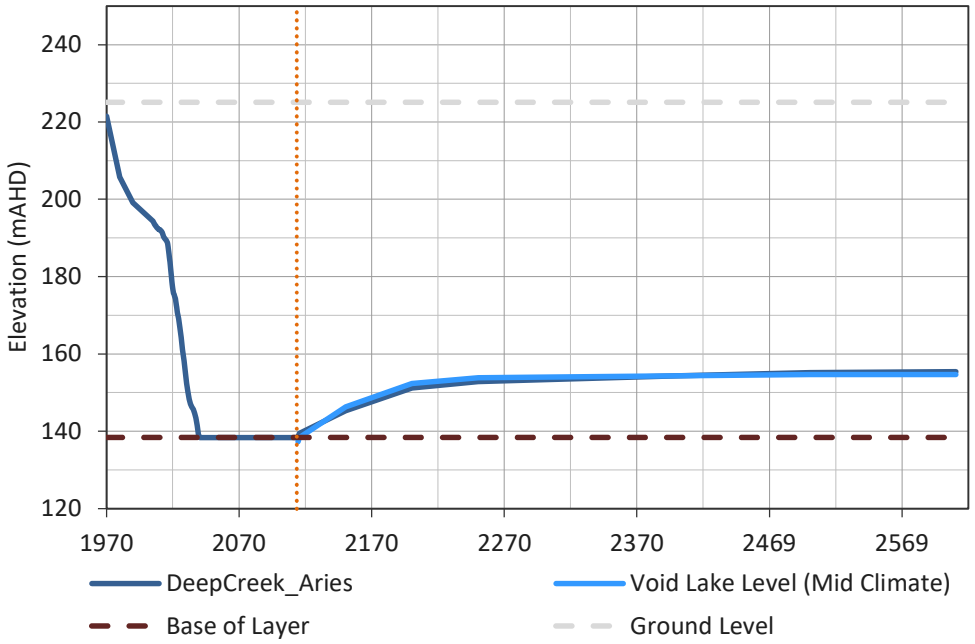
DeepCreek_Regolith
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


240
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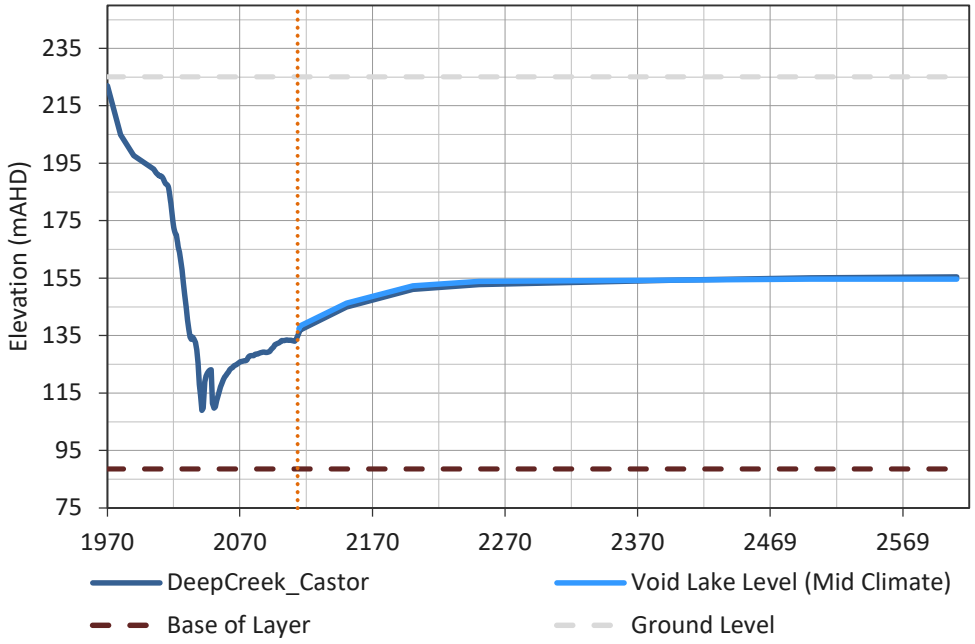
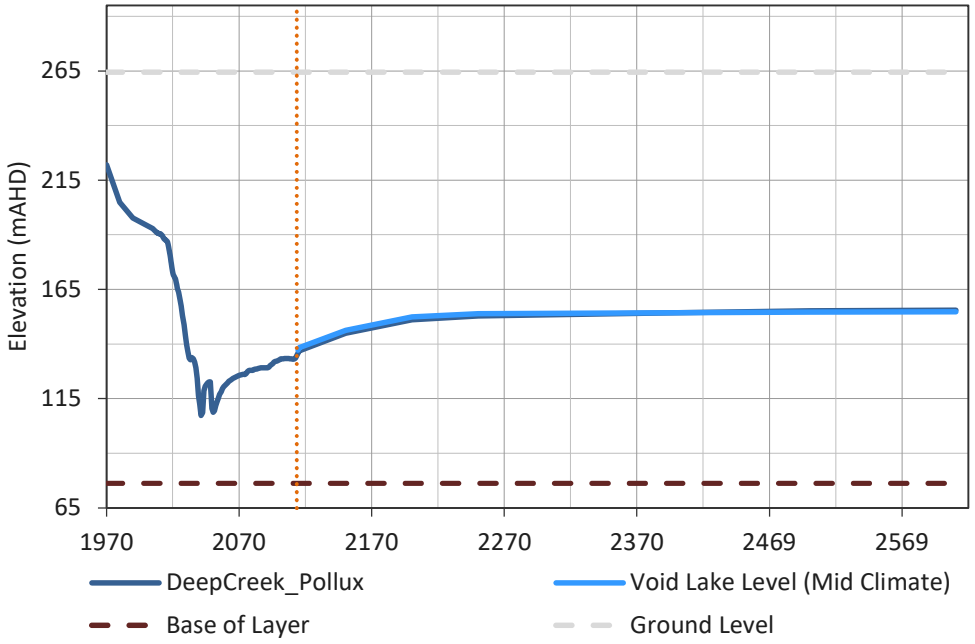
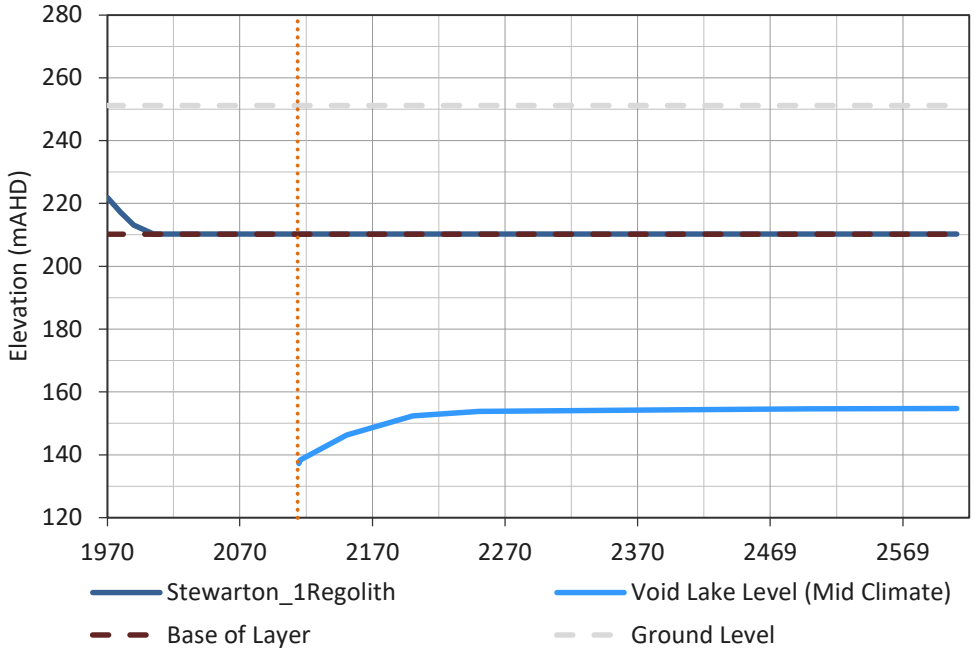
140
120
Elevation (mAHD)
1970
2070
2170
2270
2370
2469
2569
DeepCreek_Aries
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


235
215
195
175
155
135
115
95
75
Elevation (mAHD)
1970
2070
2170
2270
2370
2469
2569
DeepCreek_Castor
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


265
215
165
115
65
Elevation (mAHD)
1970
2070
2170
2270
2370
2469
2569
DeepCreek_Pollux
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


Elevation (mAHD)
280
260
240
220
200
180
160
140
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1970
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2170
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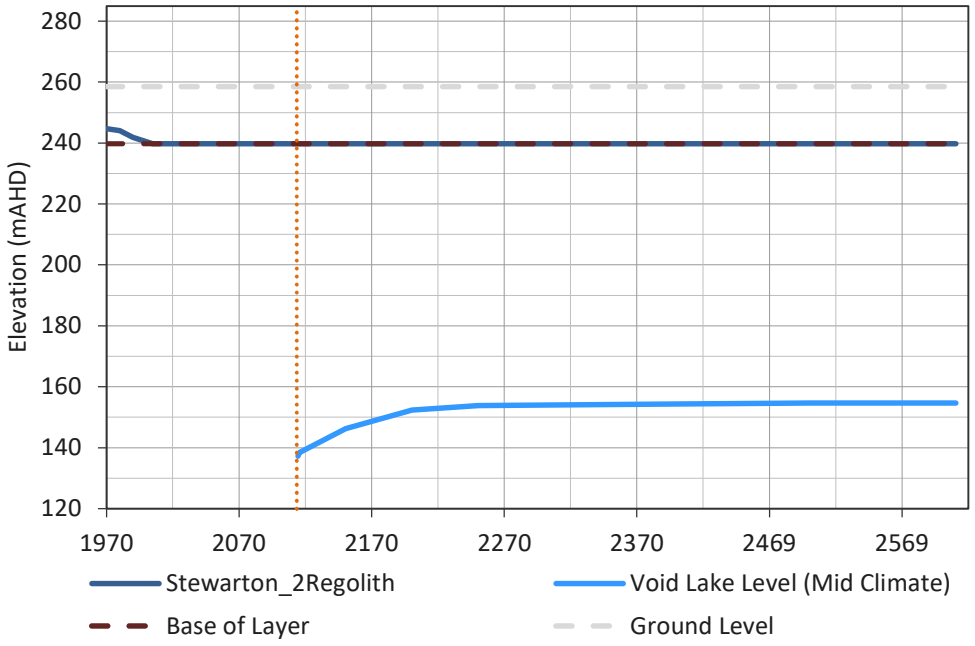
2370
2469
2569
Stewarton_1Regolith
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


Elevation (mAHD)
280
260
240
220
200
180
160
140
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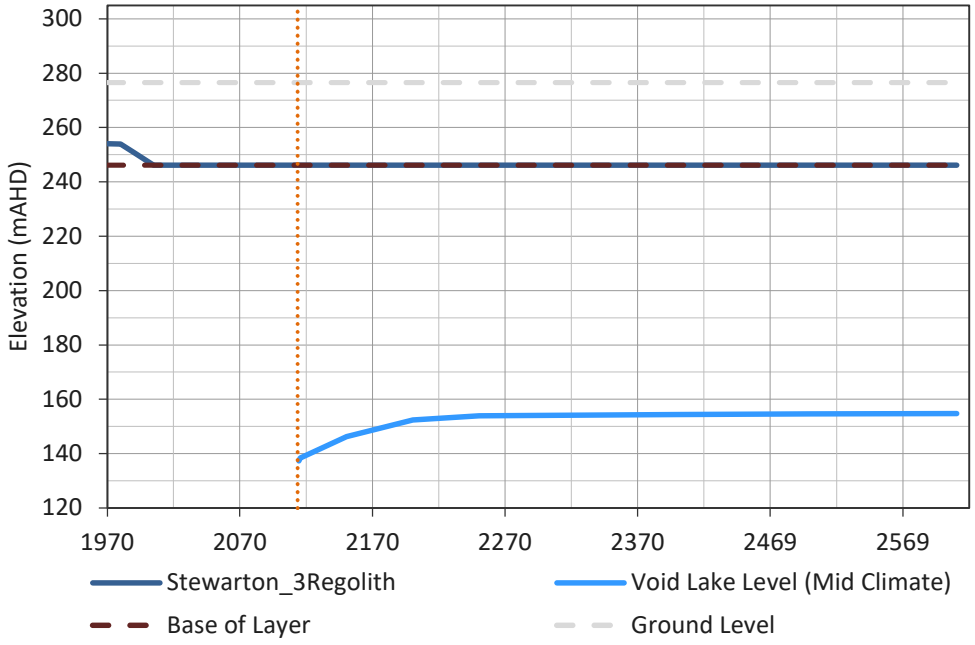
2469
2569
Stewarton_2Regolith
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


Elevation (mAHD)
300
280
260
240
220
200
180
160
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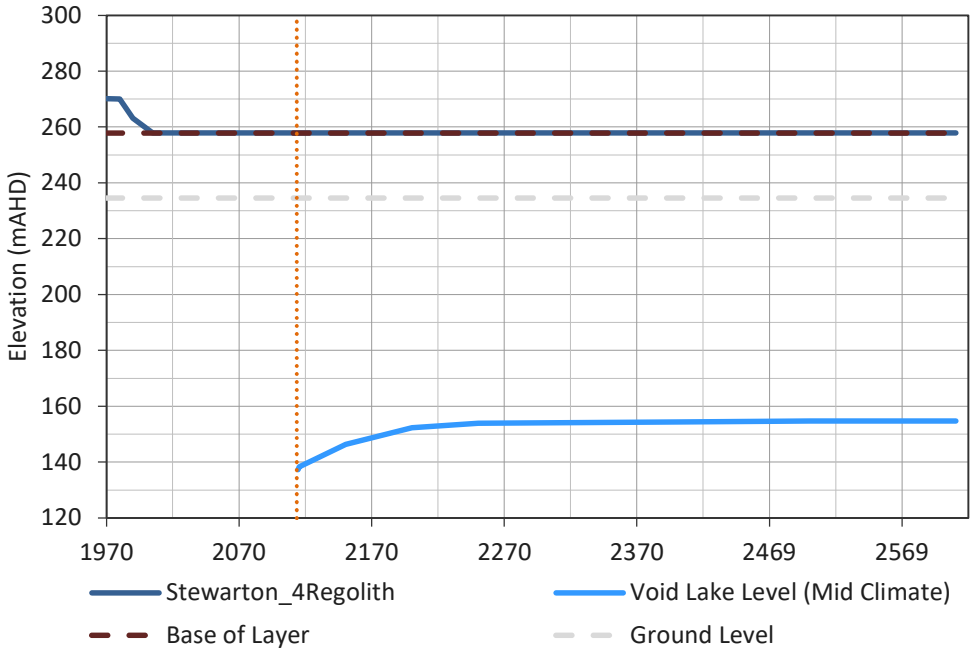
2469
2569
Stewarton_3Regolith
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


Elevation (mAHD)
300
280
260
240
220
200
180
160
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1970
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2270
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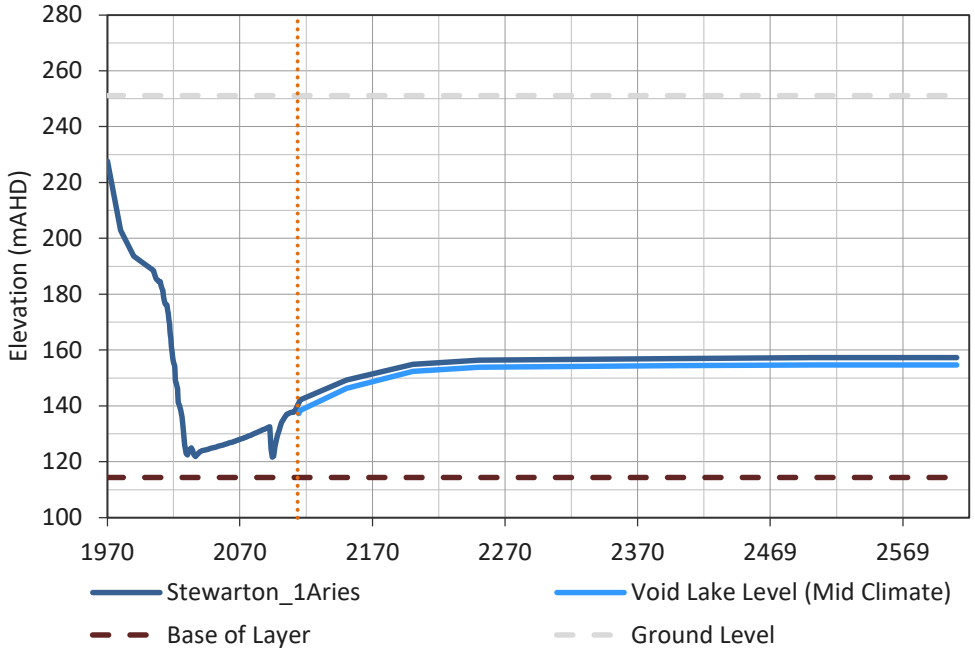
2469
2569
Stewarton_4Regolith
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


Elevation (mAHD)
280
260
240
220
200
180
160
140
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1970
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2170
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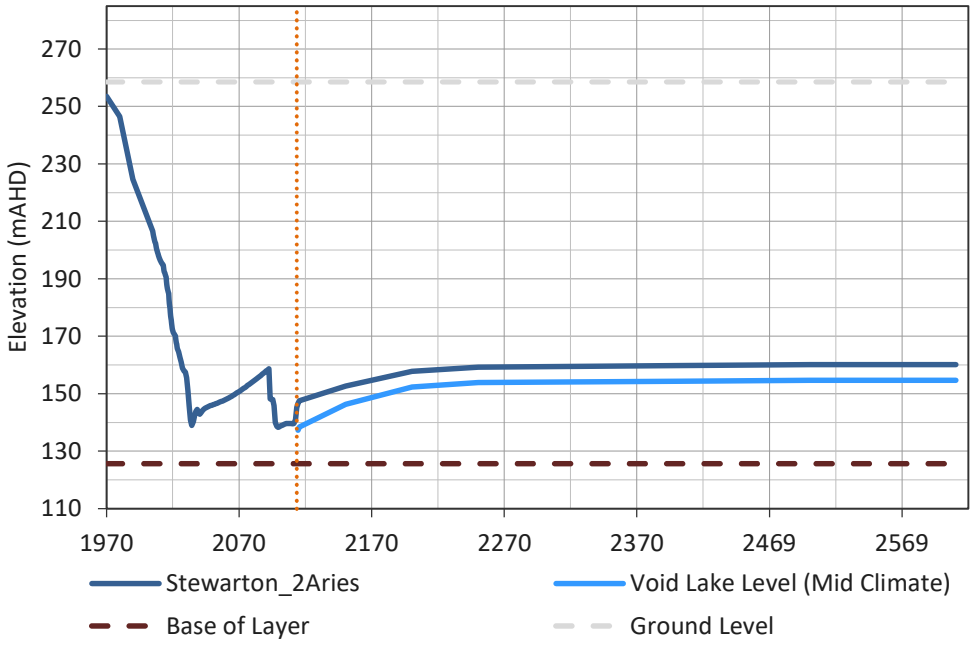
2469
2569
Stewarton_1Aries
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


Elevation (mAHD)
270
250
230
210
190
170
150
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1970
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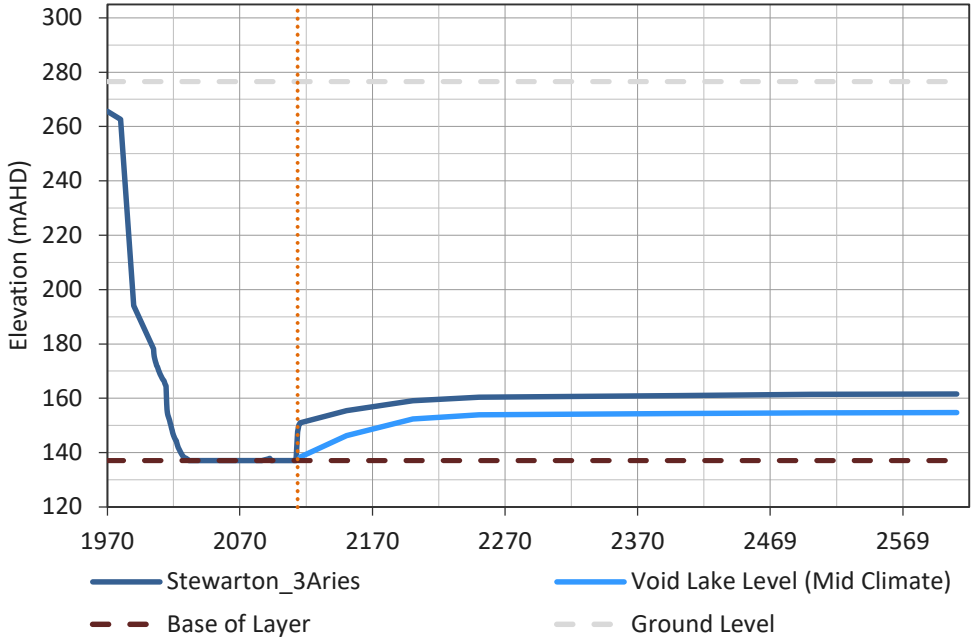
2170
2270
2370
2469
2569
Stewarton_2Aries
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


Elevation (mAHD)
300
280
260
240
220
200
180
160
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1970
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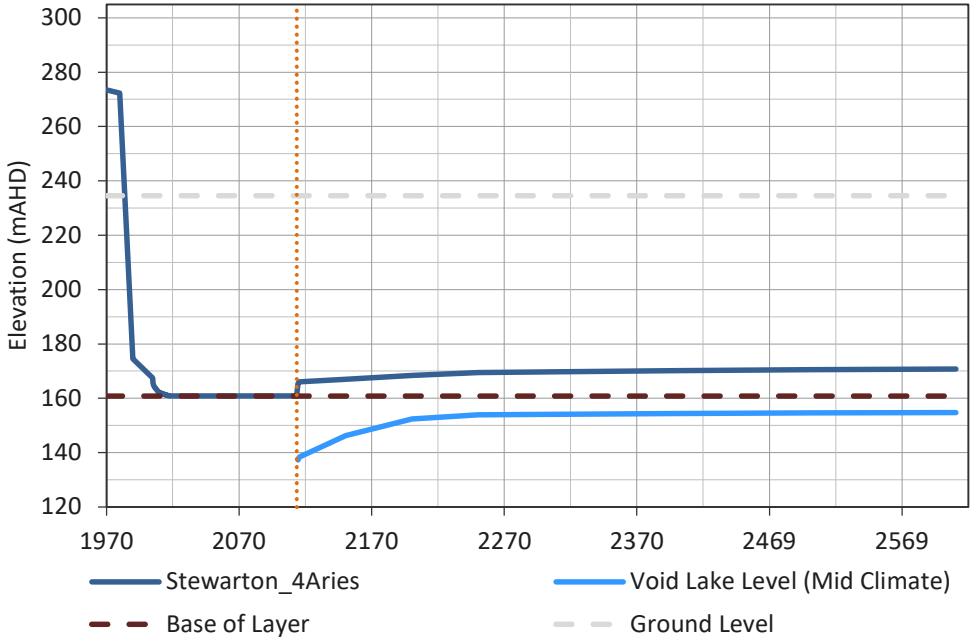
2170
2270
2370
2469
2569
Stewarton_3Aries
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


Elevation (mAHD)
300
280
260
240
220
200
180
160
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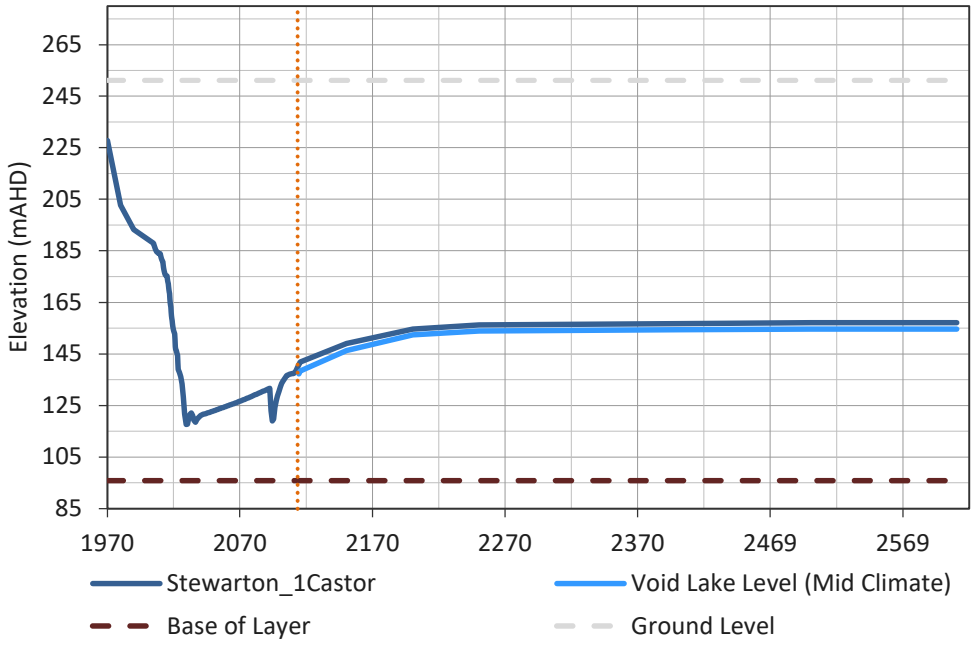
1970
2070
2170
2270
2370
2469
2569
Stewarton_4Aries
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


Elevation (mAHD)
265
245
225
205
185
165
145
125
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1970
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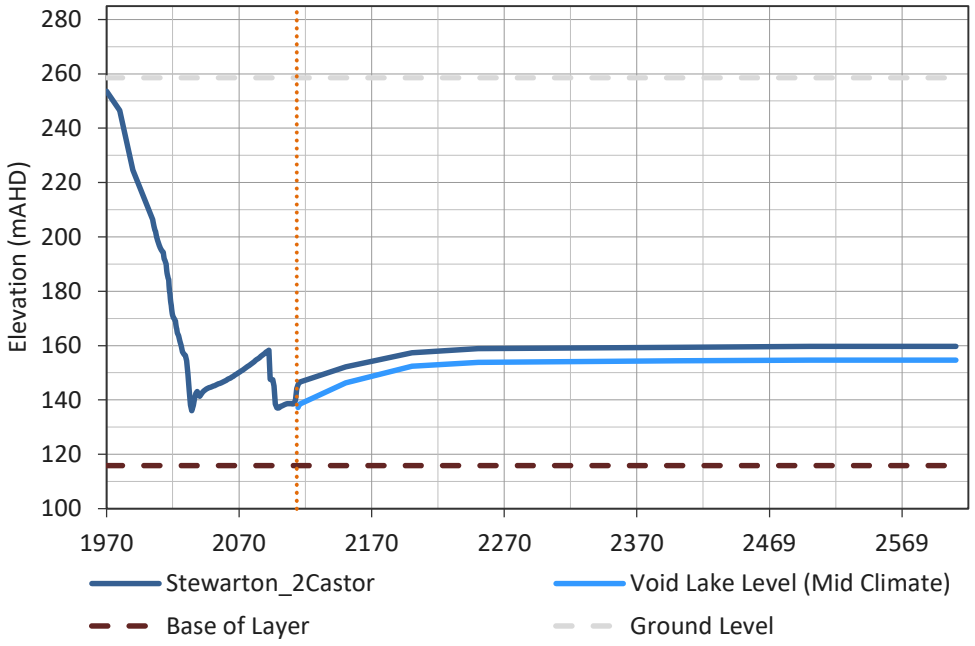
2170
2270
2370
2469
2569
Stewarton_1Castor
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


Elevation (mAHD)
280
260
240
220
200
180
160
140
120
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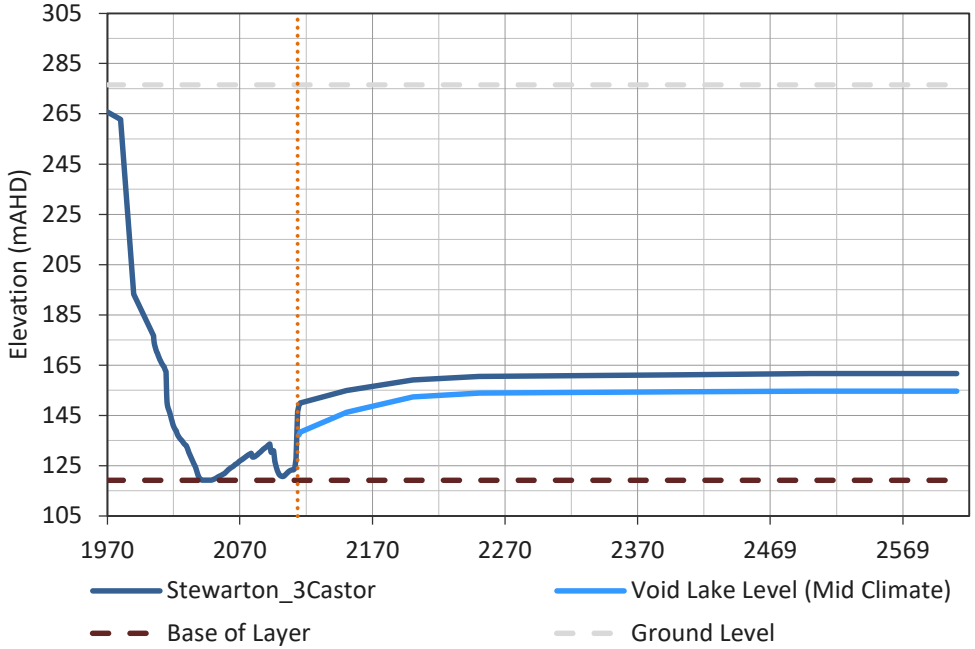
1970
2070
2170
2270
2370
2469
2569
Stewarton_2Castor
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


Elevation (mAHD)
305
285
265
245
225
205
185
165
145
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1970
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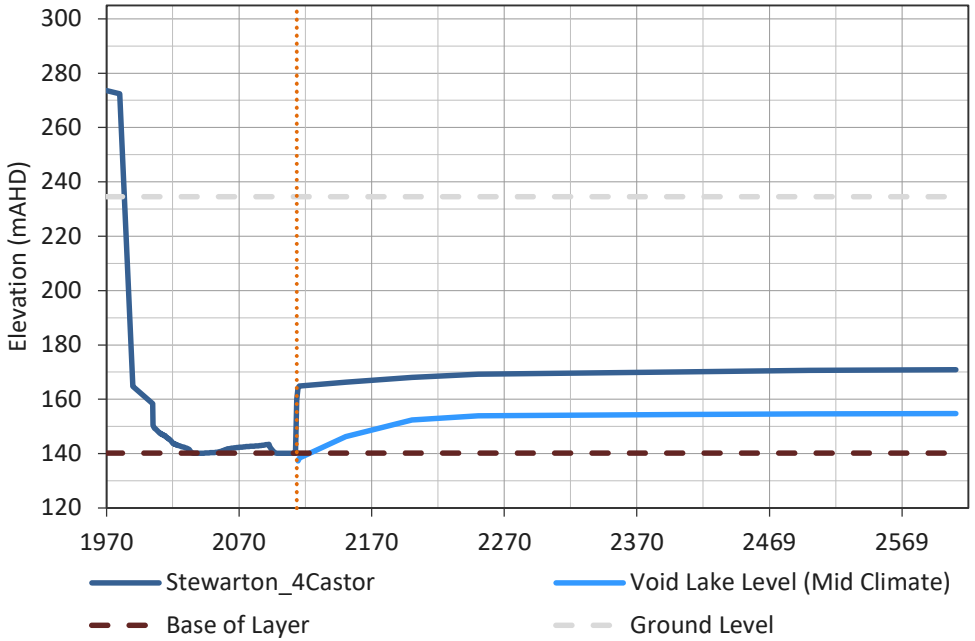
2170
2270
2370
2469
2569
Stewarton_3Castor
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


Elevation (mAHD)
300
280
260
240
220
200
180
160
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120
1970
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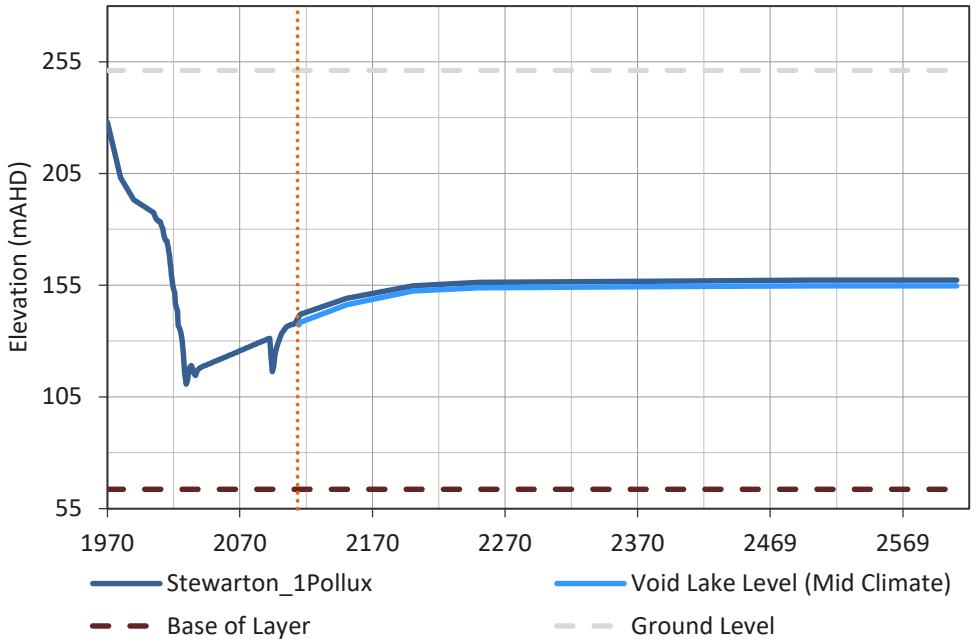
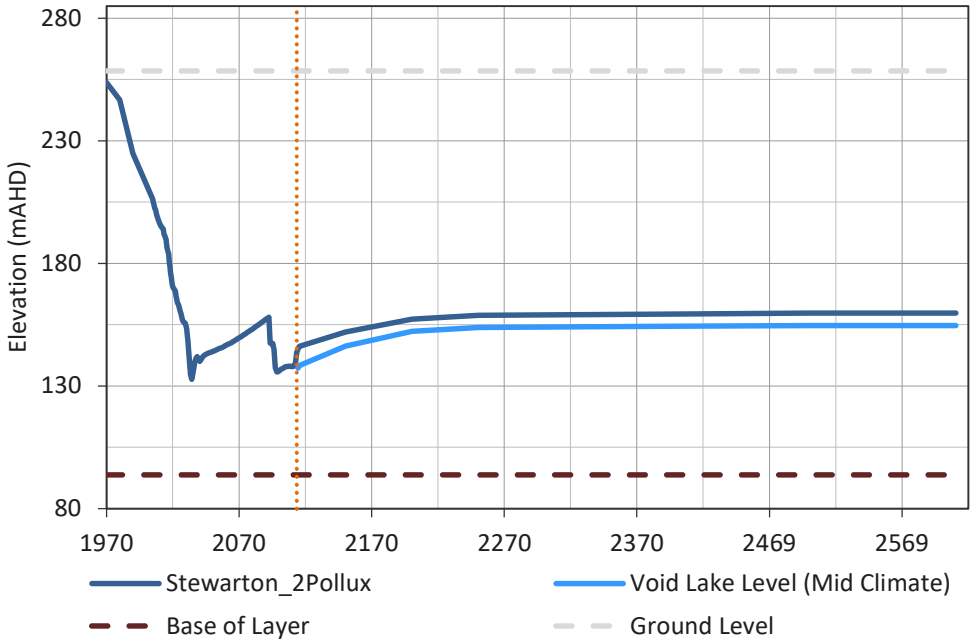
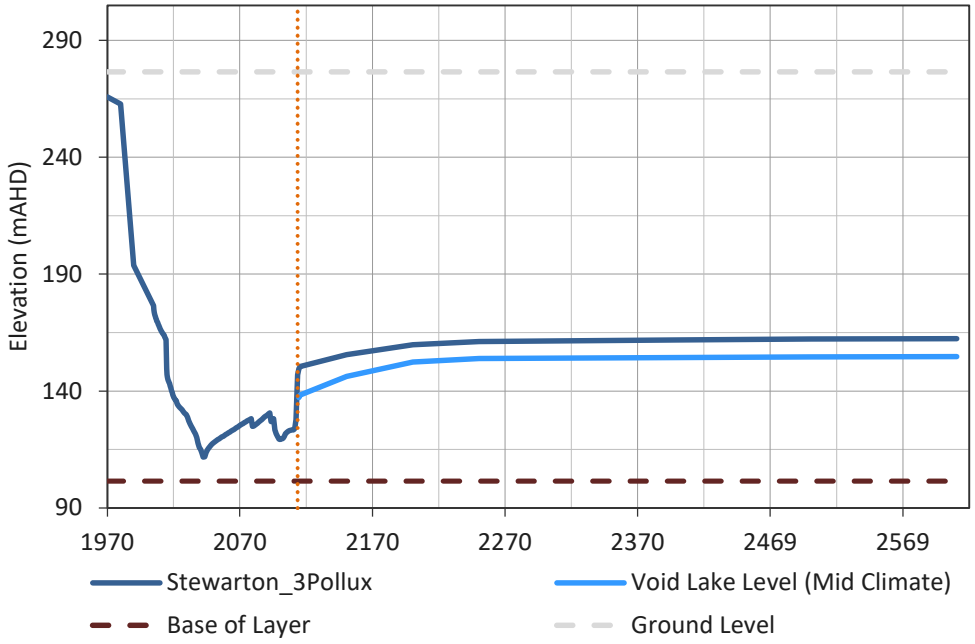
2170
2270
2370
2469
2569
Stewarton_4Castor
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


Elevation (mAHD)
255
205
155
105
55
1970
2070
2170
2270
2370
2469
2569
Stewarton_1Pollux
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


Elevation (mAHD)
280
230
180
130
80
1970
2070
2170
2270
2370
2469
2569
Stewarton_2Pollux
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


Elevation (mAHD)
290
240
190
140
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1970
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2170
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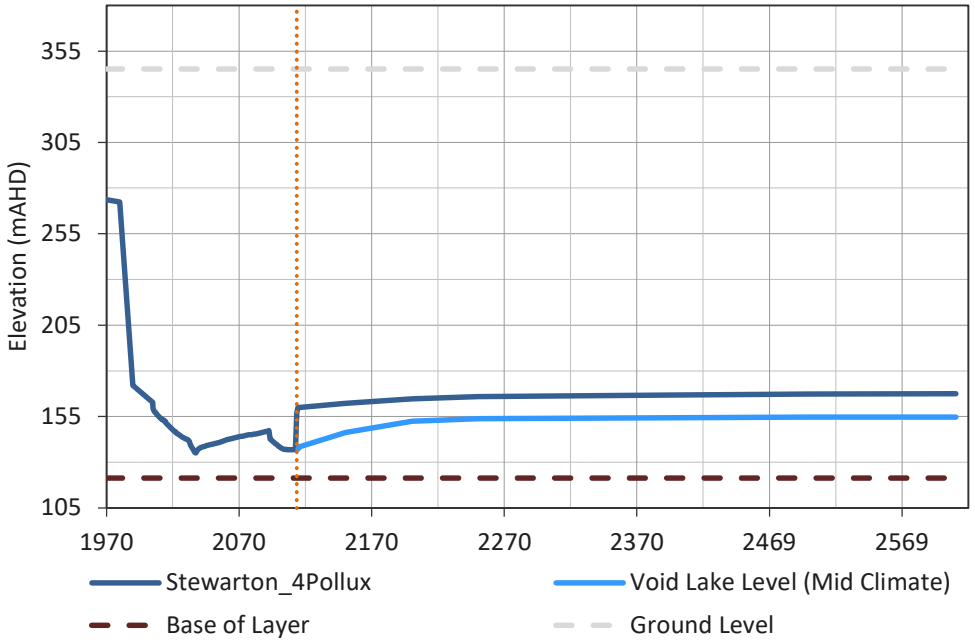
2370
2469
2569
Stewarton_3Pollux
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


Elevation (mAHD)
355
305
255
205
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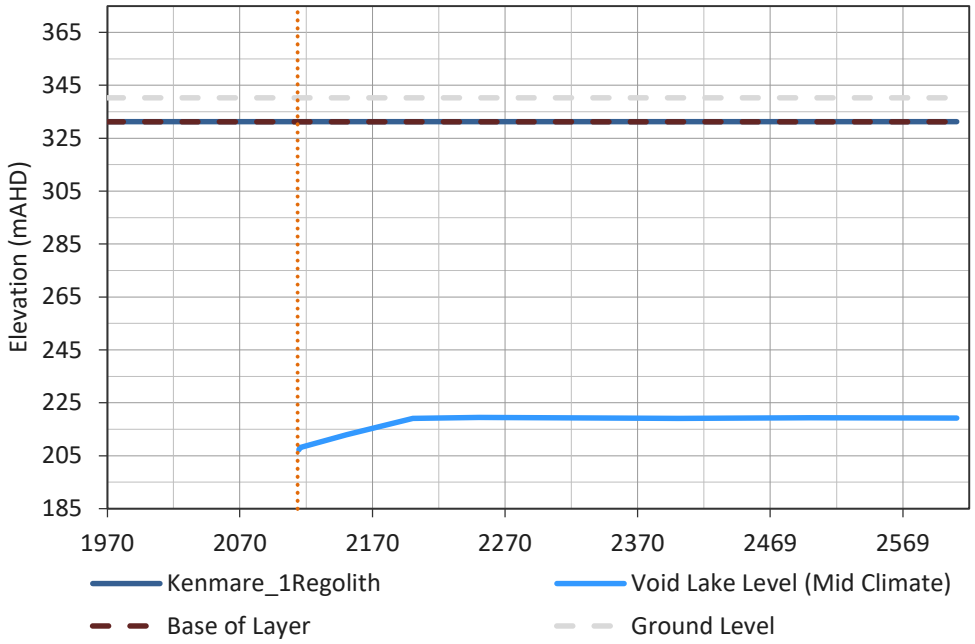
2569
Stewarton_4Pollux
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


Elevation (mAHD)
365
345
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305
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265
245
225
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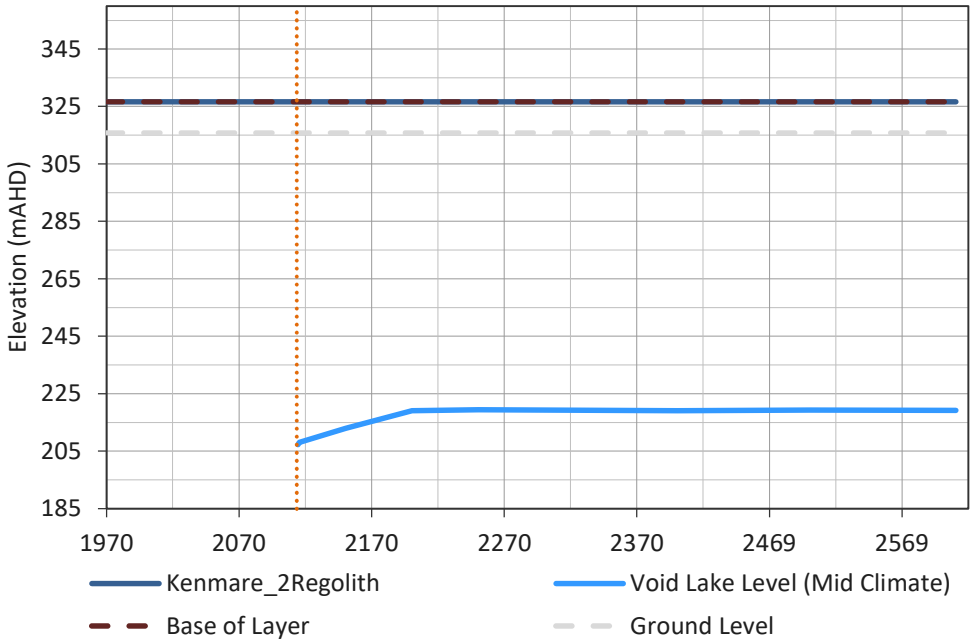
2170
2270
2370
2469
2569
Kenmare_1Regolith
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


Elevation (mAHD)
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325
305
285
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245
225
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2170
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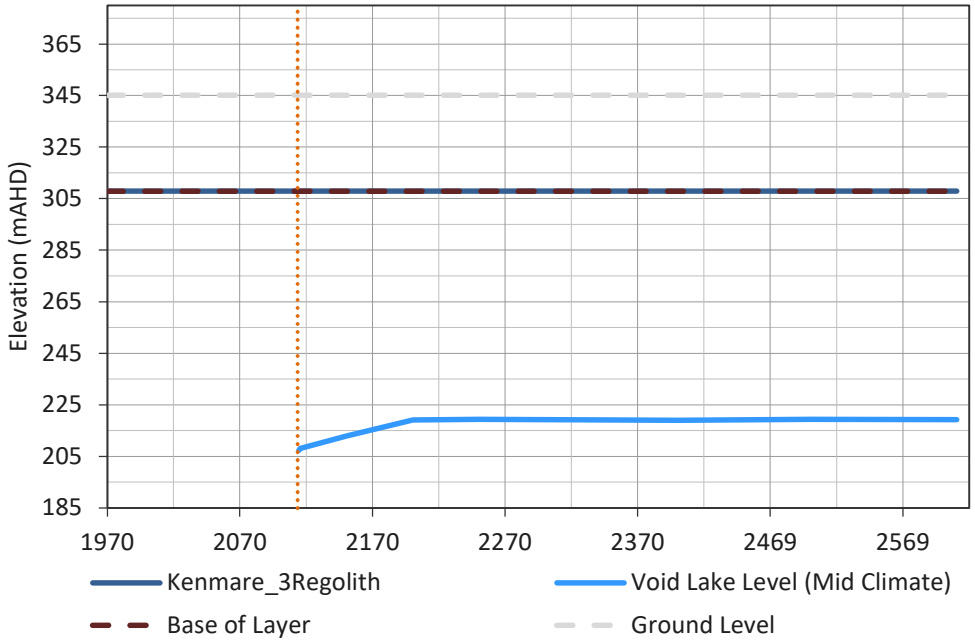
2469
2569
Kenmare_2Regolith
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


Elevation (mAHD)
365
345
325
305
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265
245
225
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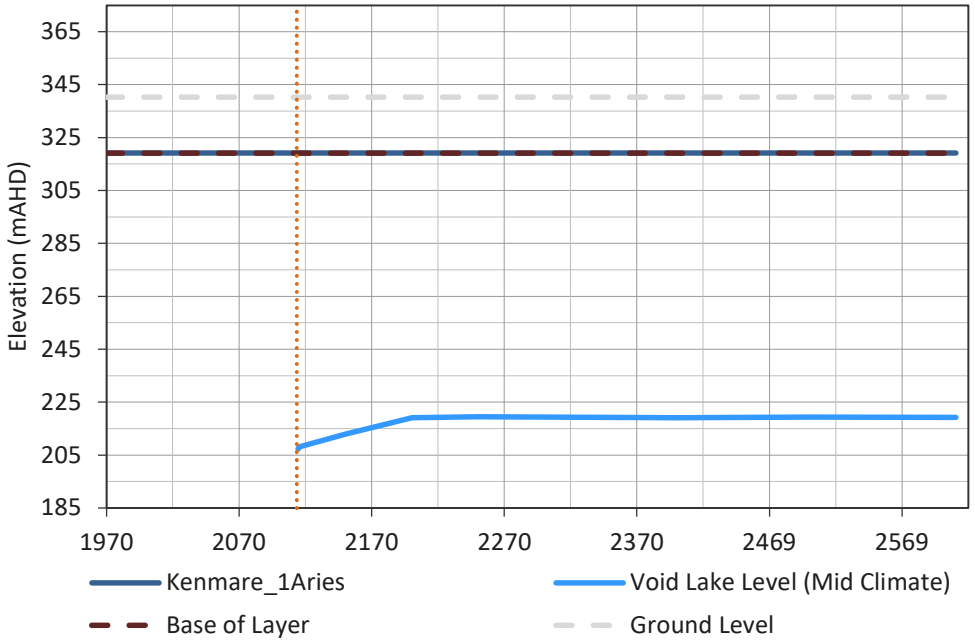
2569
Kenmare_3Regolith
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


Elevation (mAHD)
365
345
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305
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265
245
225
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2170
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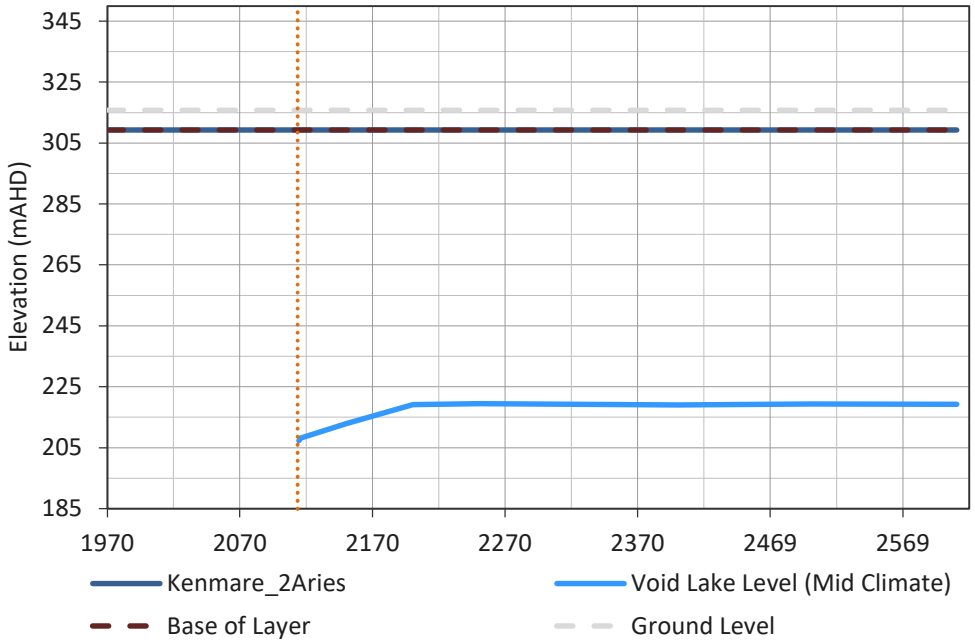
2569
Kenmare_1Aries
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


Elevation (mAHD)
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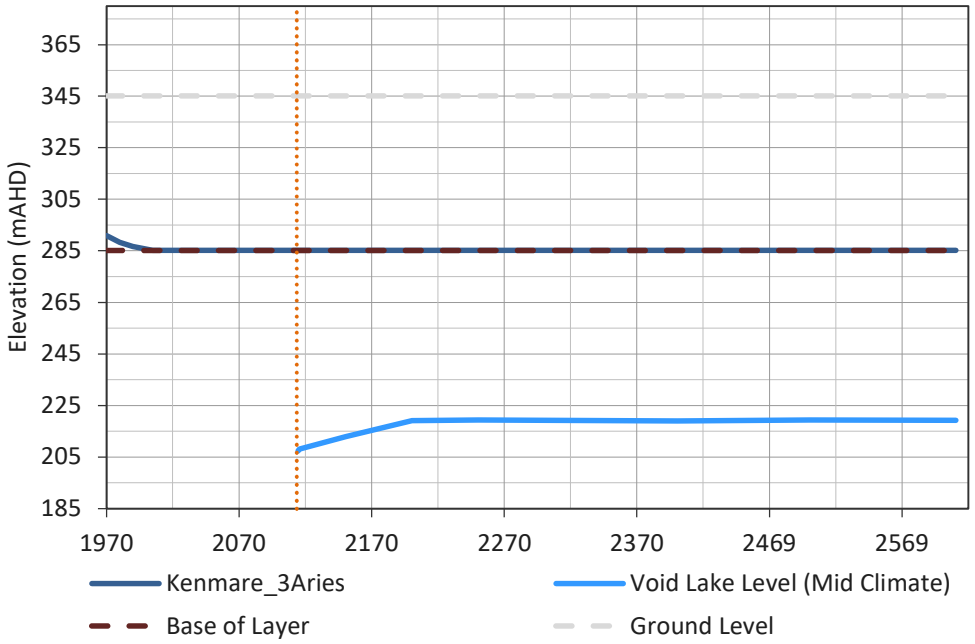
2569
Kenmare_2Aries
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


Elevation (mAHD)
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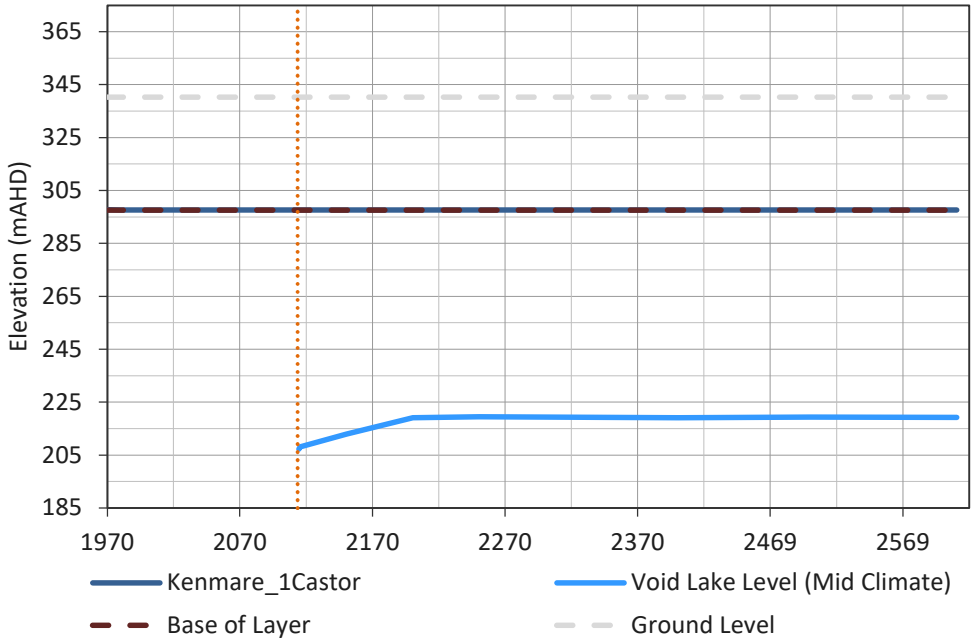
2569
Kenmare_3Aries
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


Elevation (mAHD)
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345
325
305
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265
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2170
2270
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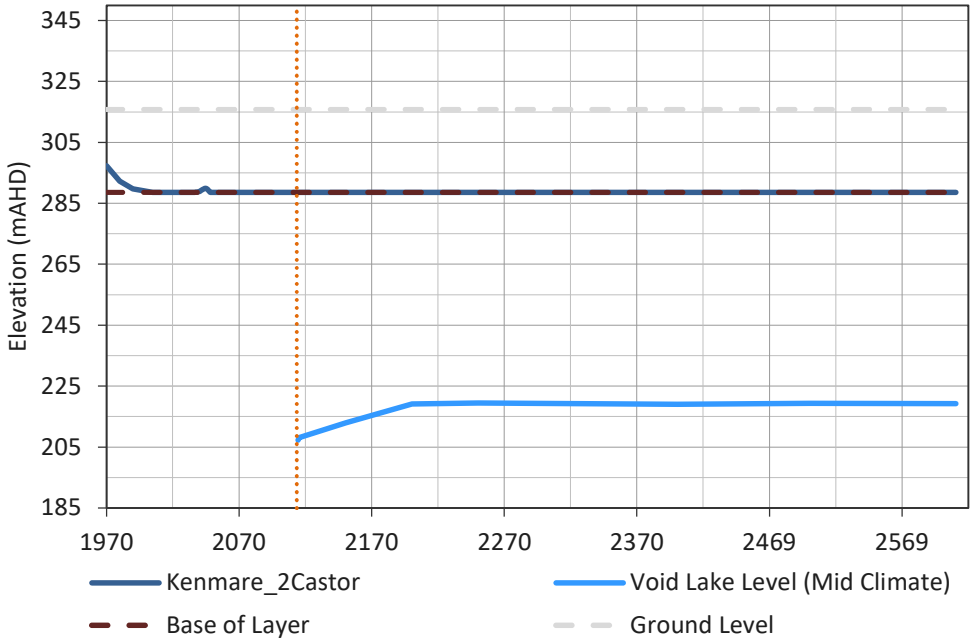
2469
2569
Kenmare_1Castor
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


Elevation (mAHD)
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245
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2170
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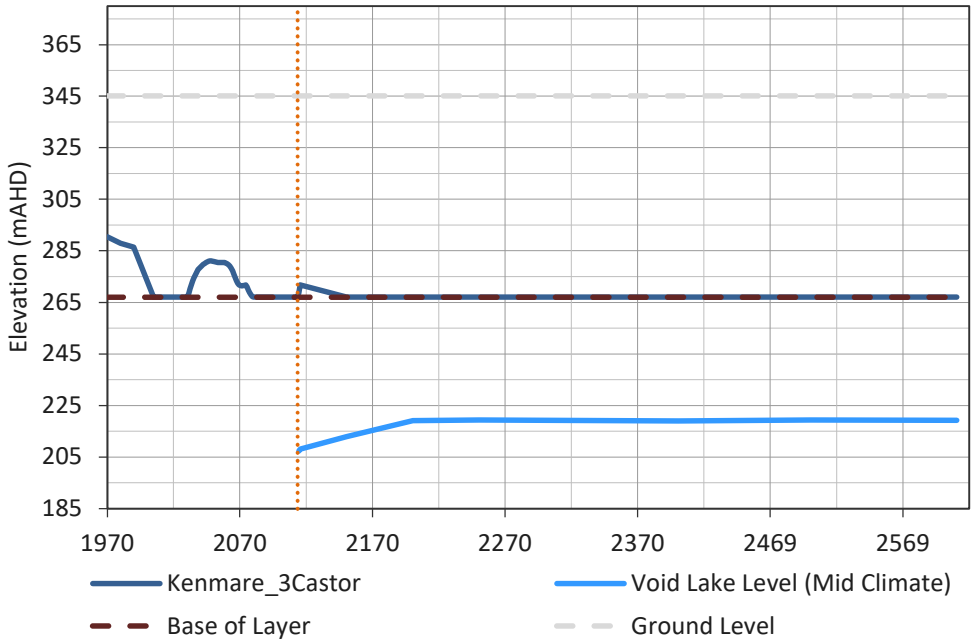
2469
2569
Kenmare_2Castor
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


Elevation (mAHD)
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225
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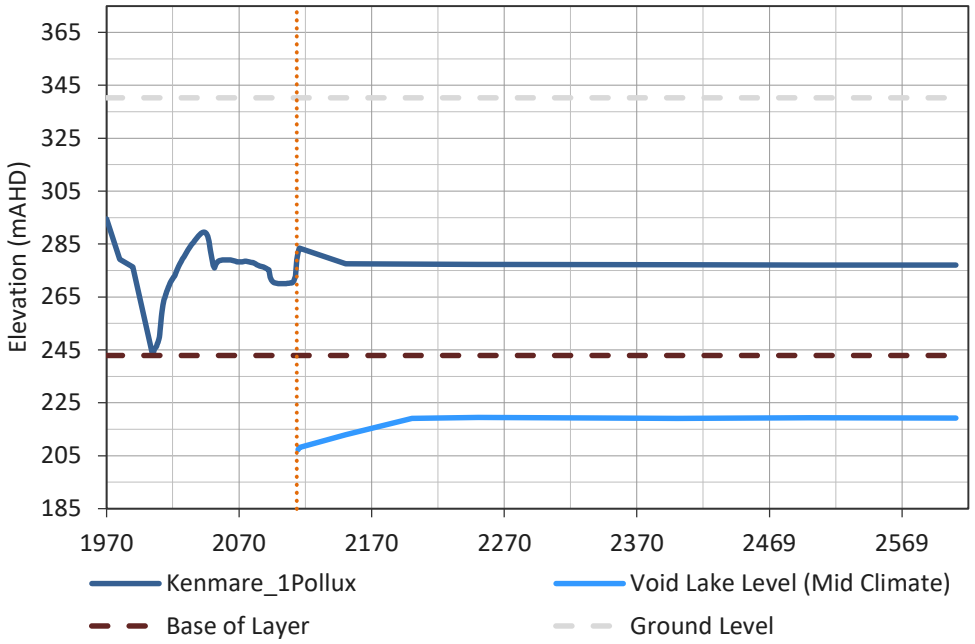
2469
2569
Kenmare_3Castor
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


Elevation (mAHD)
365
345
325
305
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265
245
225
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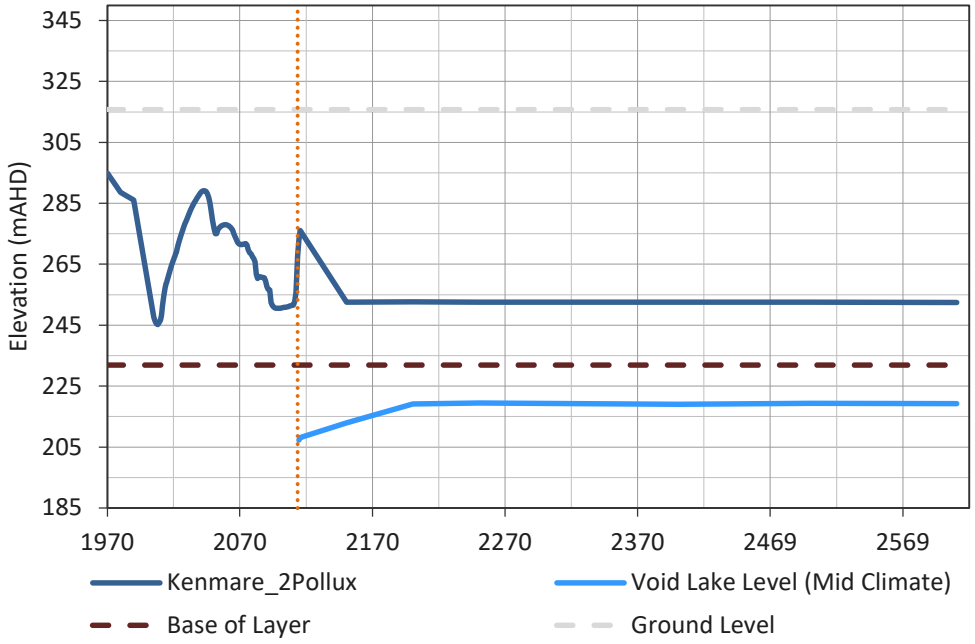
2170
2270
2370
2469
2569
Kenmare_1Pollux
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


Elevation (mAHD)
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325
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285
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245
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2170
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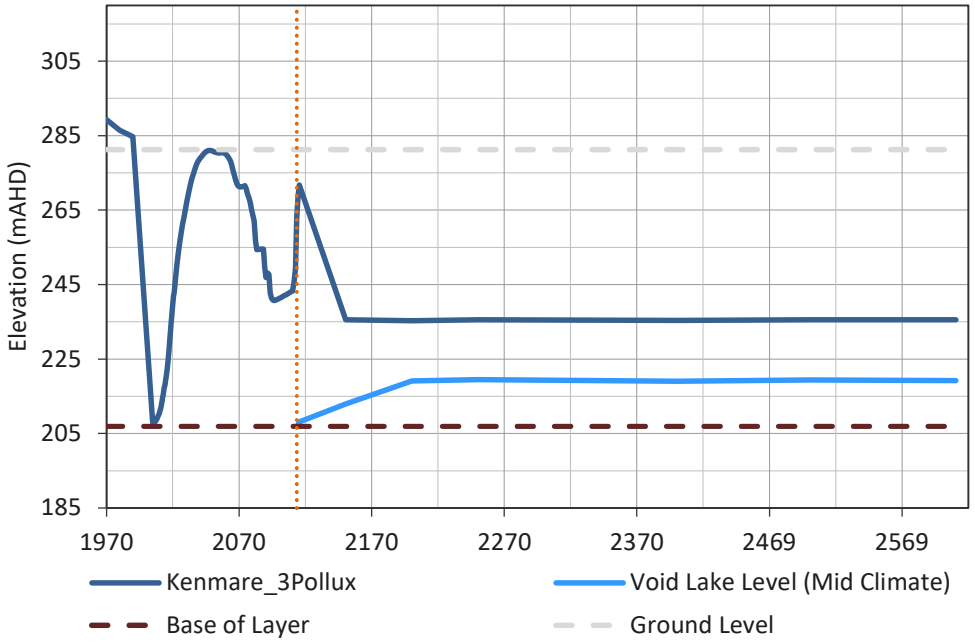
2469
2569
Kenmare_2Pollux
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


Elevation (mAHD)
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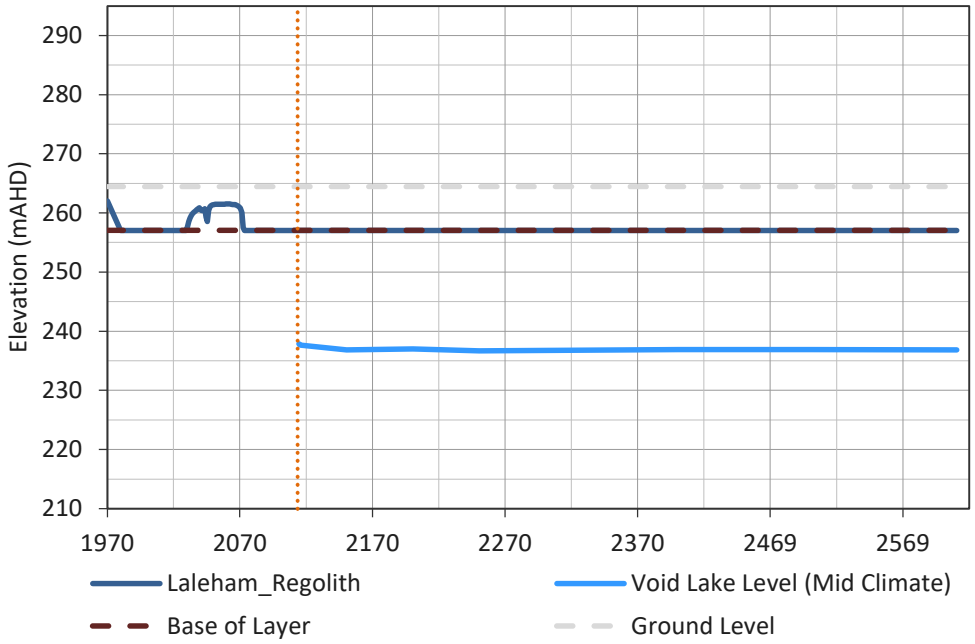
2469
2569
Kenmare_3Pollux
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


Elevation (mAHD)
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260
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240
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2170
2270
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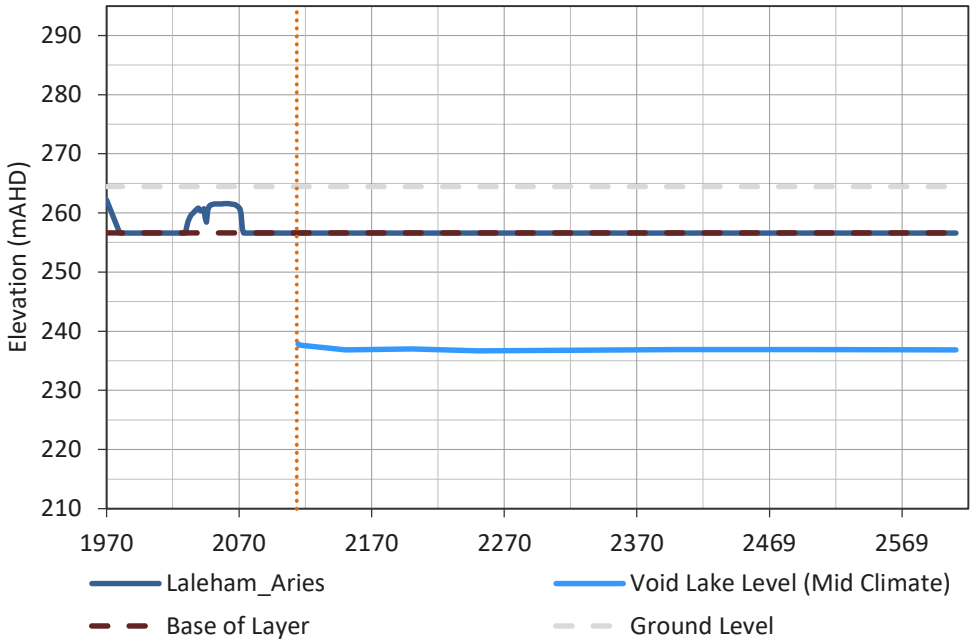
2469
2569
Laleham_Regolith
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


Elevation (mAHD)
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280
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260
250
240
230
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1970
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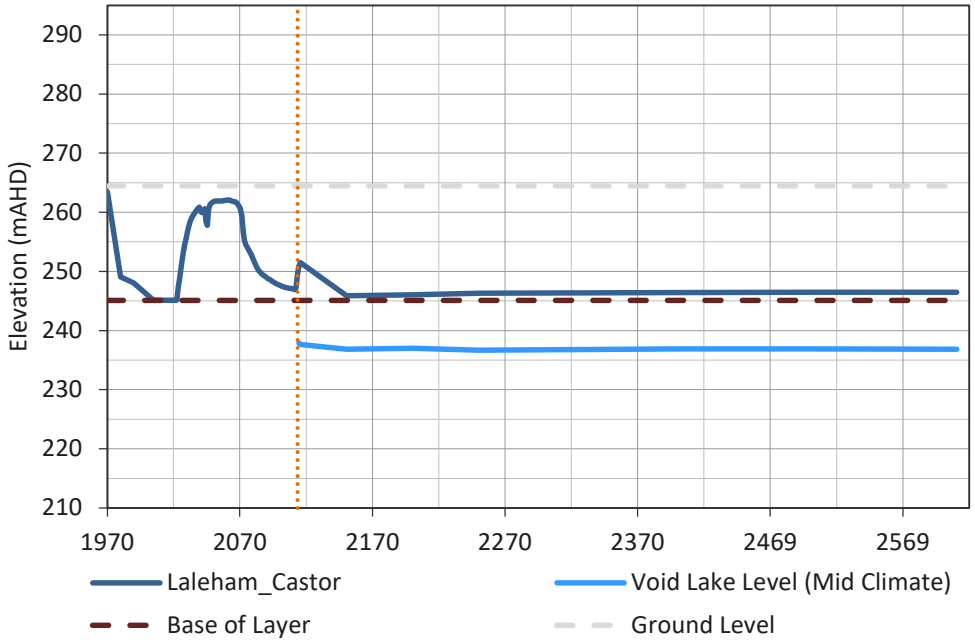
2170
2270
2370
2469
2569
Laleham_Aries
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


Elevation (mAHD)
290
280
270
260
250
240
230
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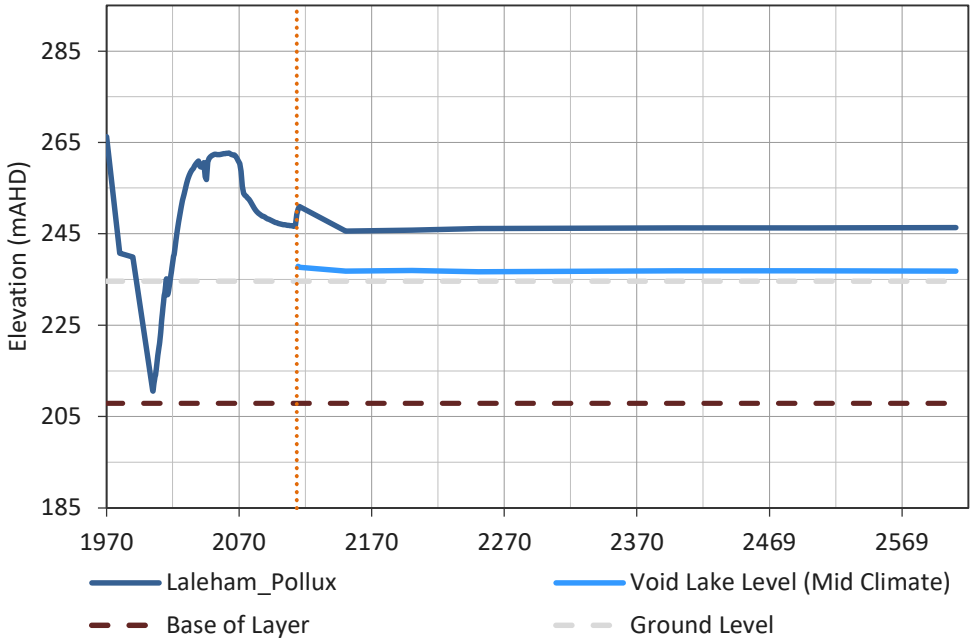
1970
2070
2170
2270
2370
2469
2569
Laleham_Castor
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


Elevation (mAHD)
285
265
245
225
205
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1970
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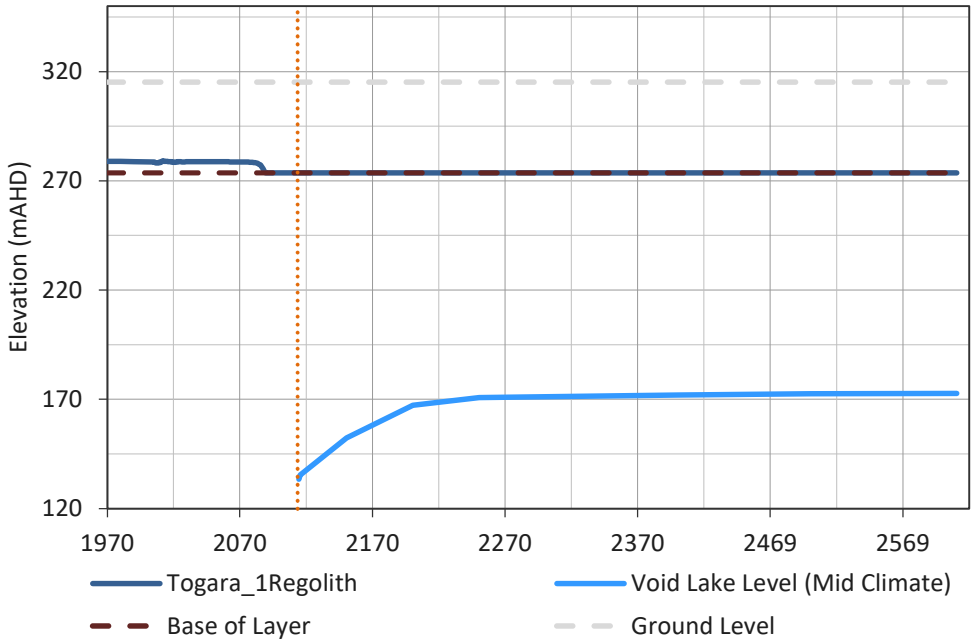
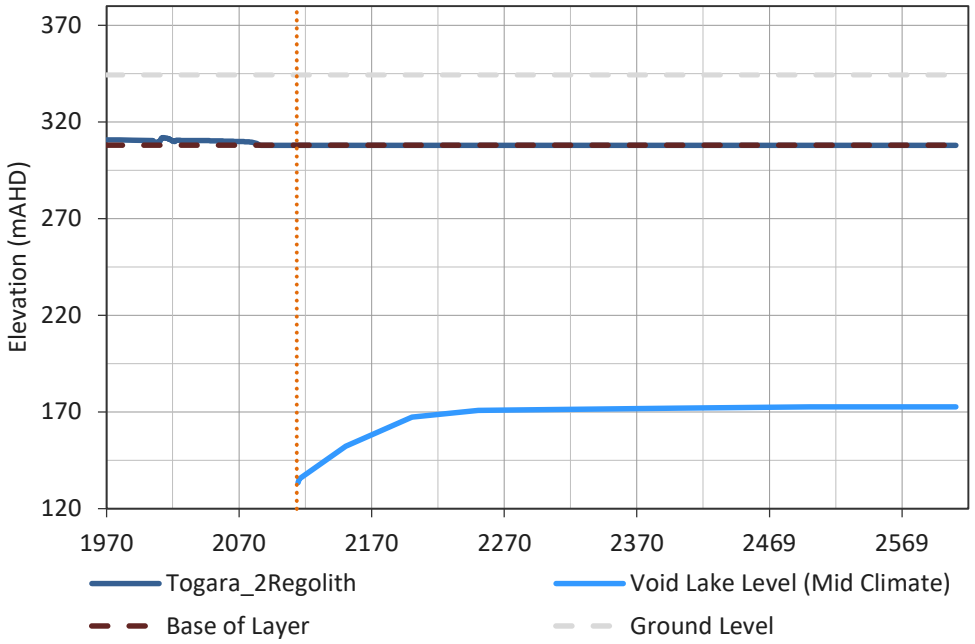
2170
2270
2370
2469
2569
Laleham_Pollux
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


Elevation (mAHD)
320
270
220
170
120
1970
2070
2170
2270
2370
2469
2569
Togara_1Regolith
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


Elevation (mAHD)
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320
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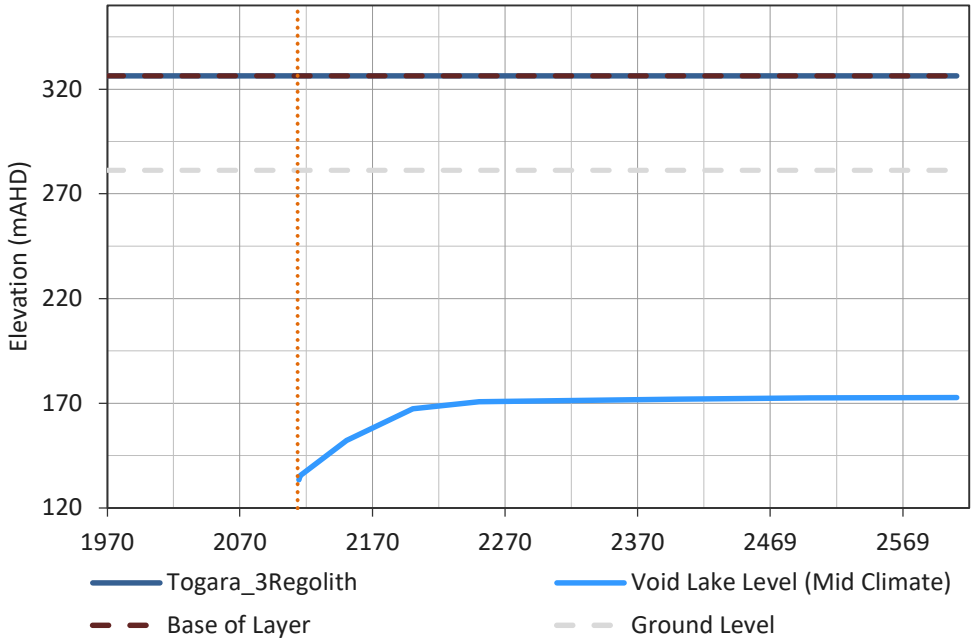
220
170
120
1970
2070
2170
2270
2370
2469
2569
Togara_2Regolith
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


Elevation (mAHD)
320
270
220
170
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1970
2070
2170
2270
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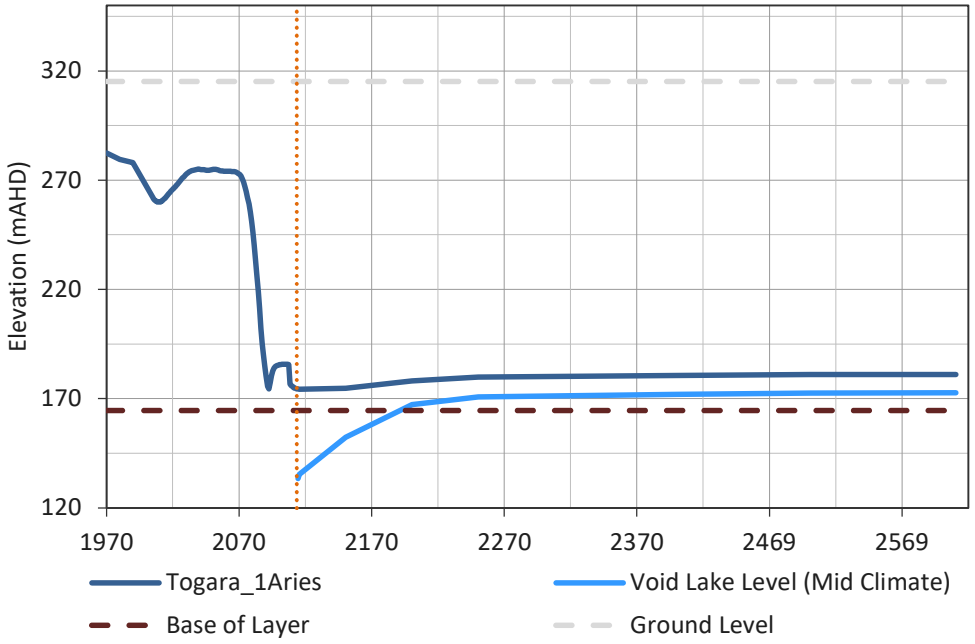
2469
2569
Togara_3Regolith
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


Elevation (mAHD)
320
270
220
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2170
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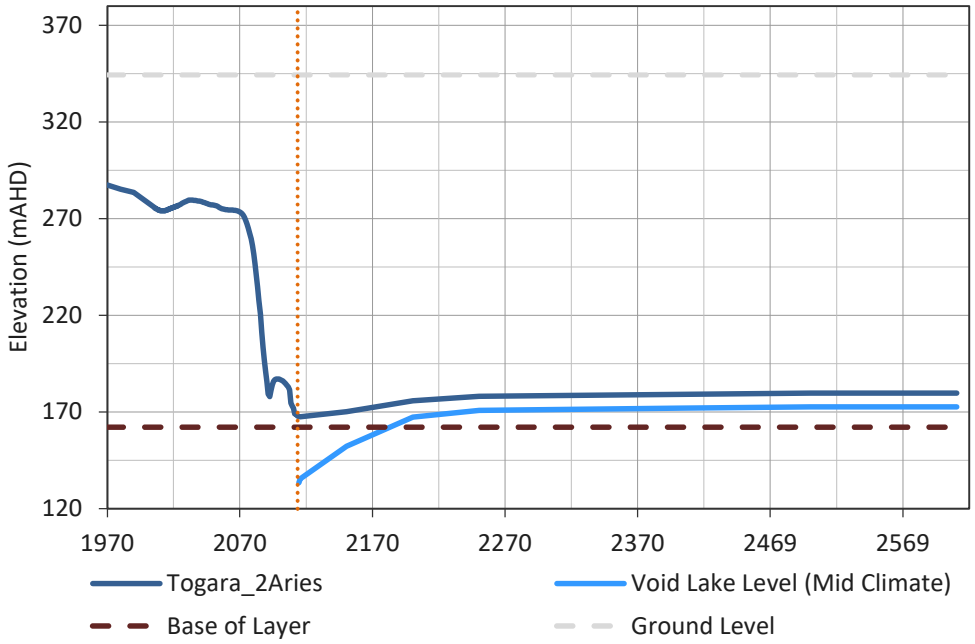
Togara_1Aries
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


Elevation (mAHD)
370
320
270
220
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2170
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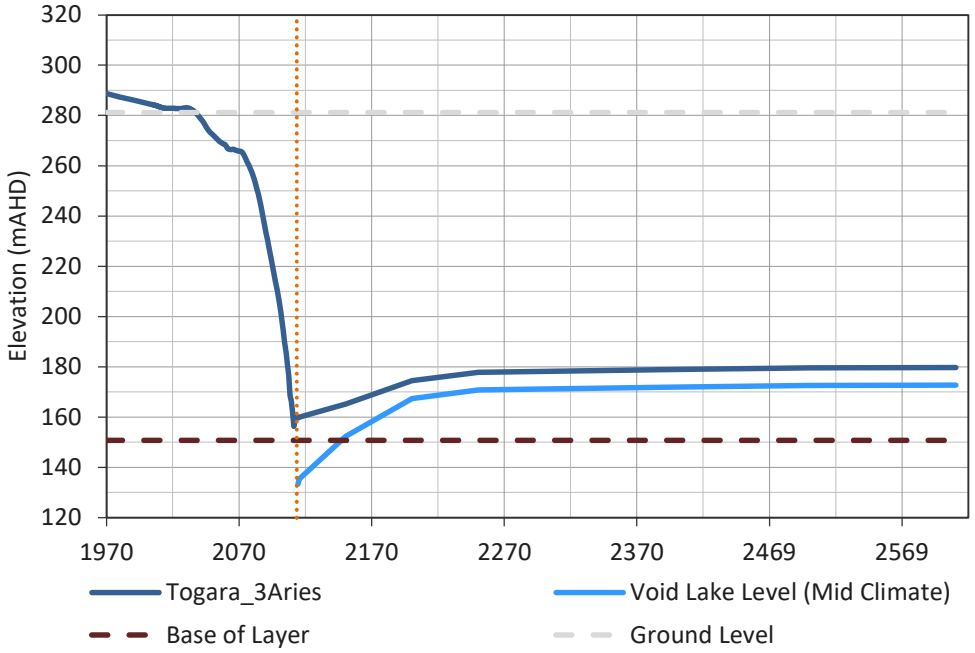
2569
Togara_2Aries
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


Elevation (mAHD)
320
300
280
260
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180
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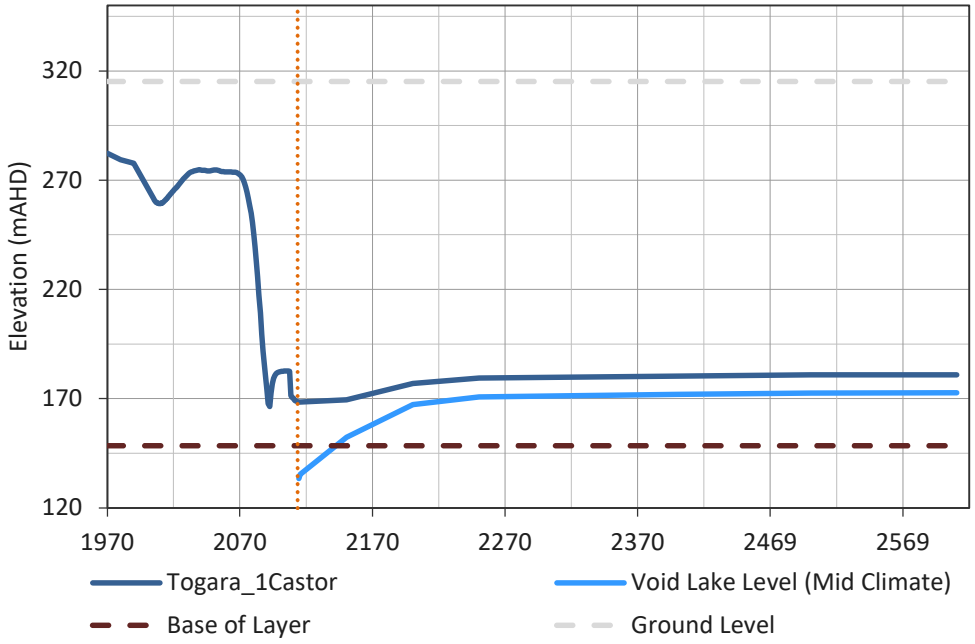
2569
Togara_3Aries
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


Elevation (mAHD)
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270
220
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2170
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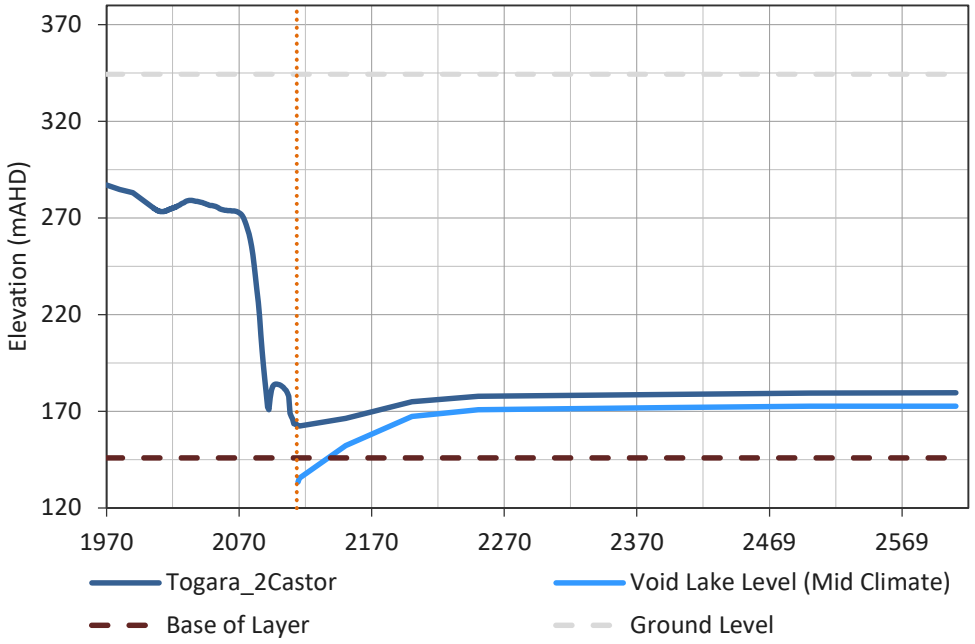
2569
Togara_1Castor
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


Elevation (mAHD)
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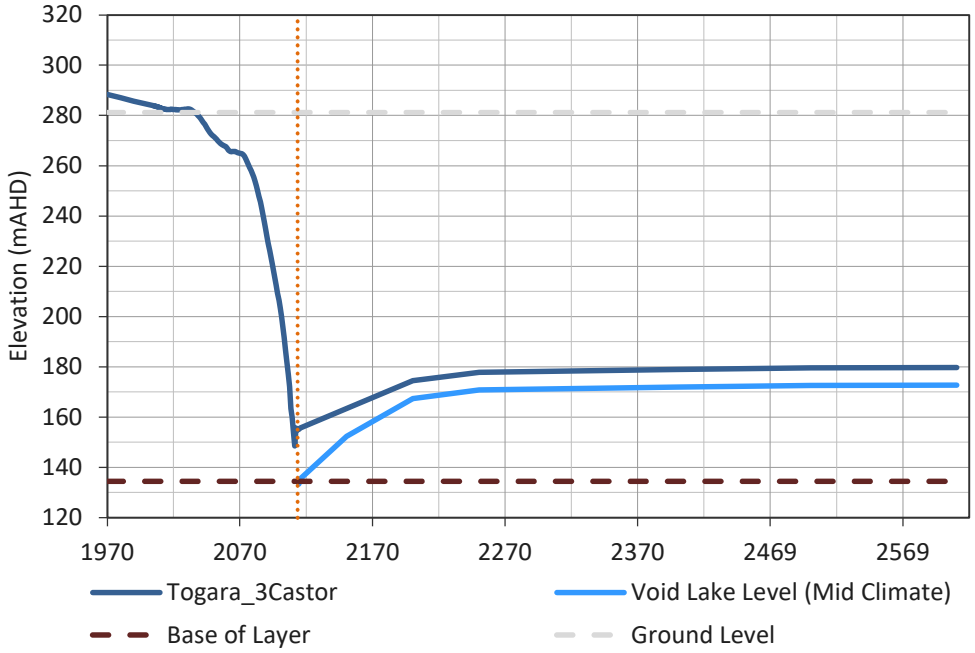
Togara_2Castor
Void Lake Level (Mid Climate)
Base of Layer
Ground Level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120
Elevation (mAHD)
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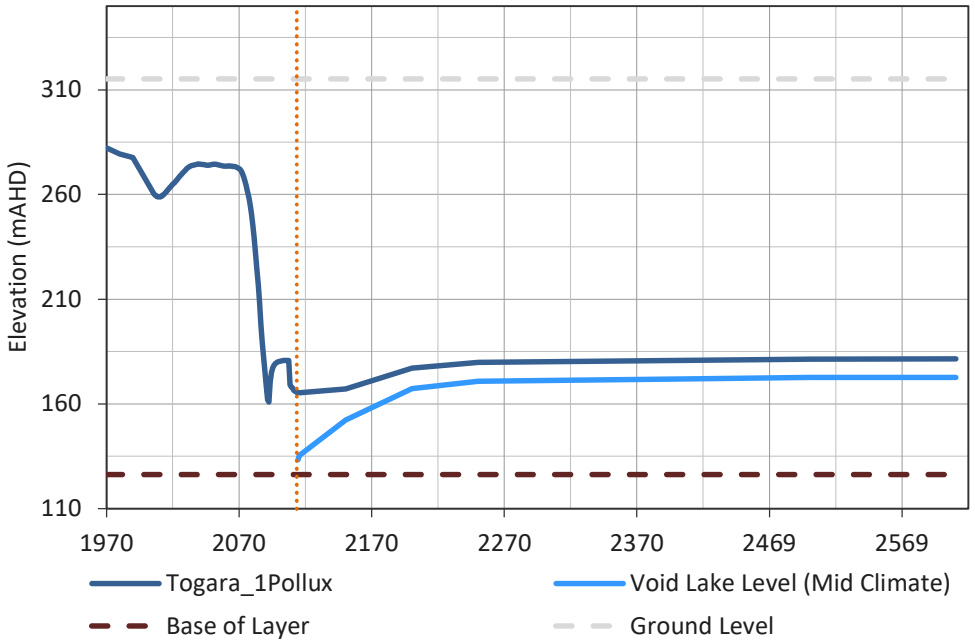
2469
2569
Togara_3Castor
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


310
260
210
160
110
Elevation (mAHD)
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2170
2270
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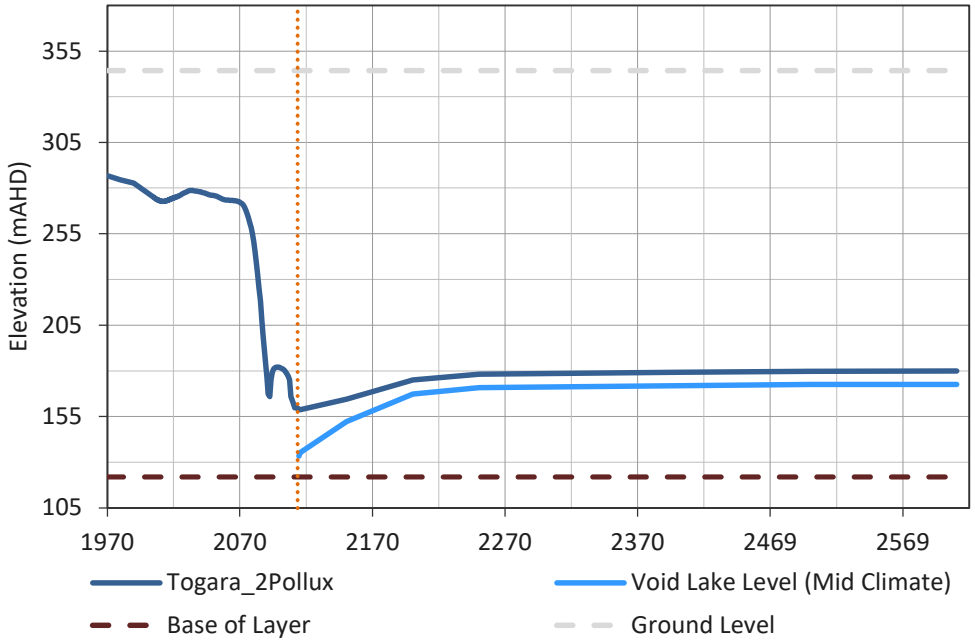
2469
2569
Togara_1Pollux
Void Lake Level (Mid Climate)
Base of Layer
Ground Level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155
105
Elevation (mAHD)
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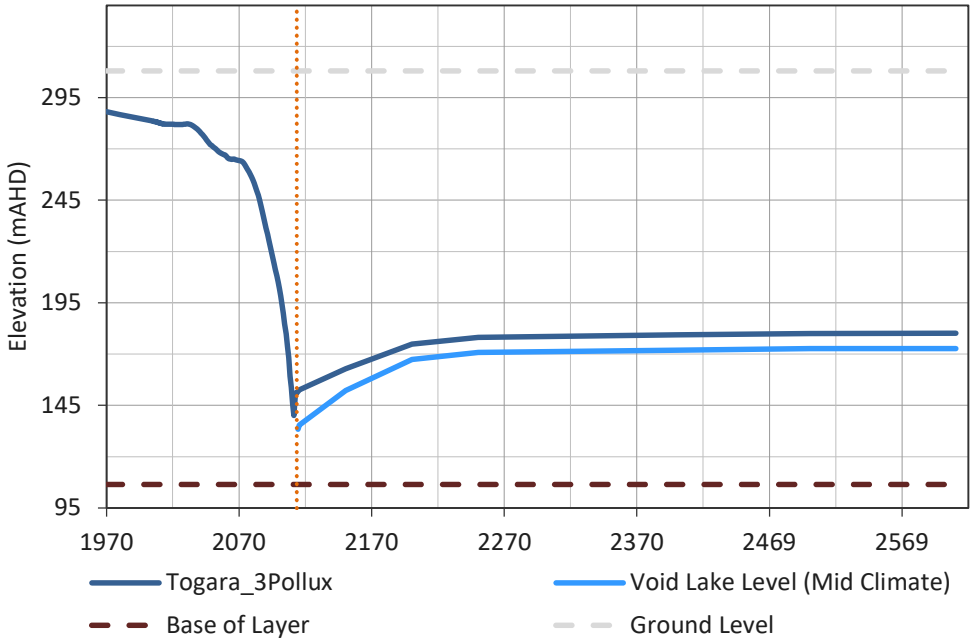
2469
2569
Togara_2Pollux
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


295
245
195
145
95
Elevation (mAHD)
1970
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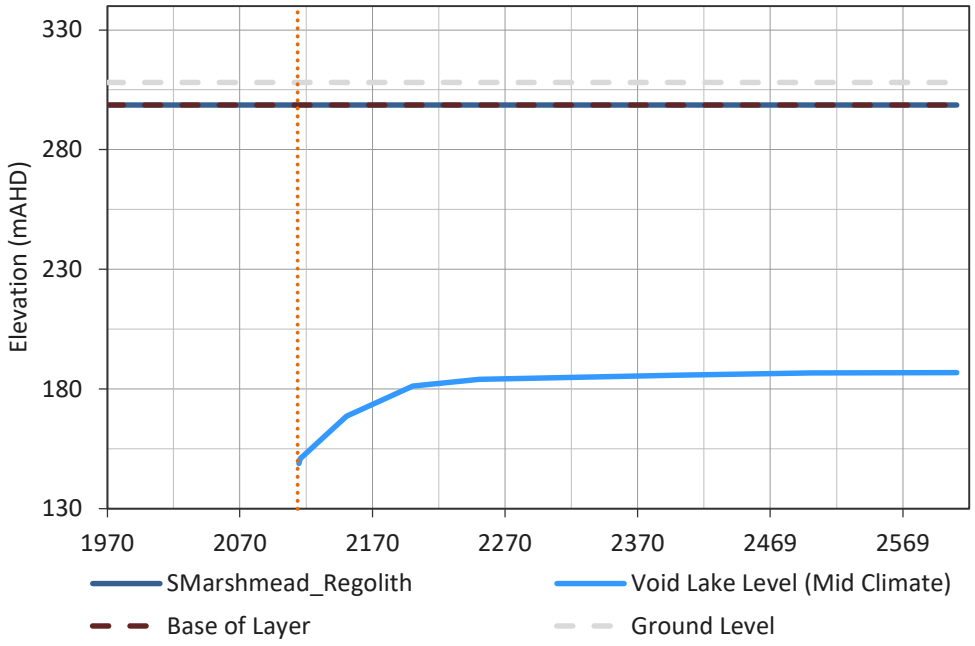
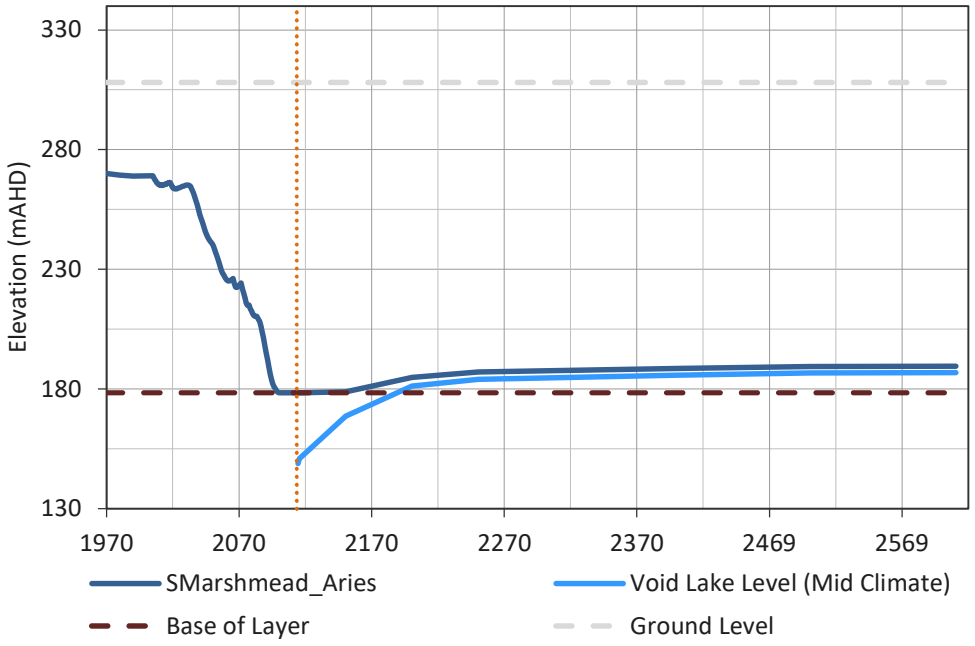
2270
2370
2469
2569
Togara_3Pollux
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


330
280
230
180
130
Elevation (mAHD)
1970
2070
2170
2270
2370
2469
2569
SMarshmead_Regolith
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


330
280
230
180
130
Elevation (mAHD)
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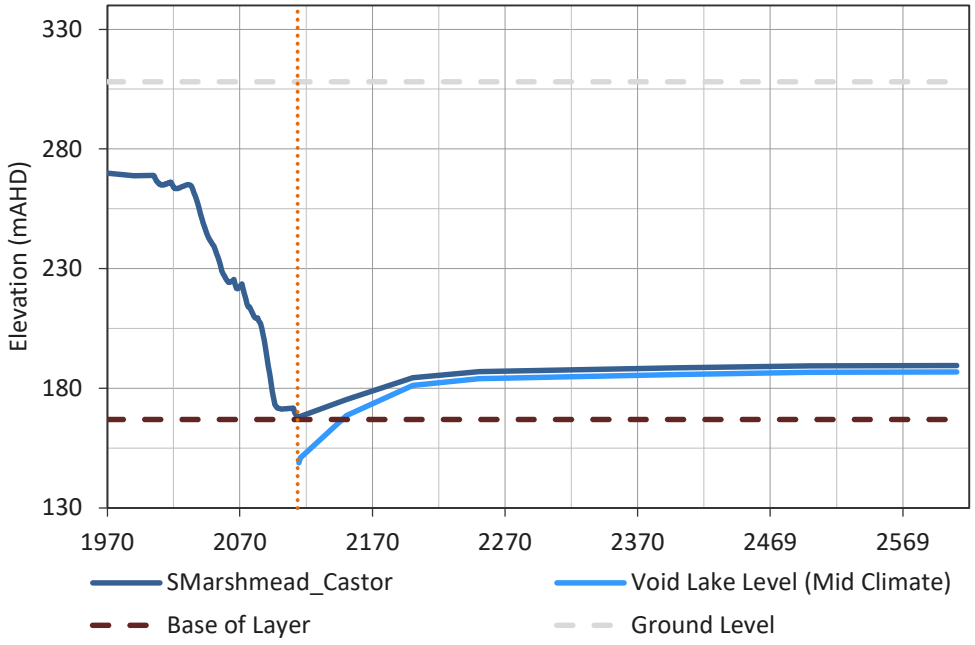
2070
2170
2270
2370
2469
2569
SMarshmead_Aries
Void Lake Level (Mid Climate)
Base of Layer
Ground Level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180
130
Elevation (mAHD)
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2170
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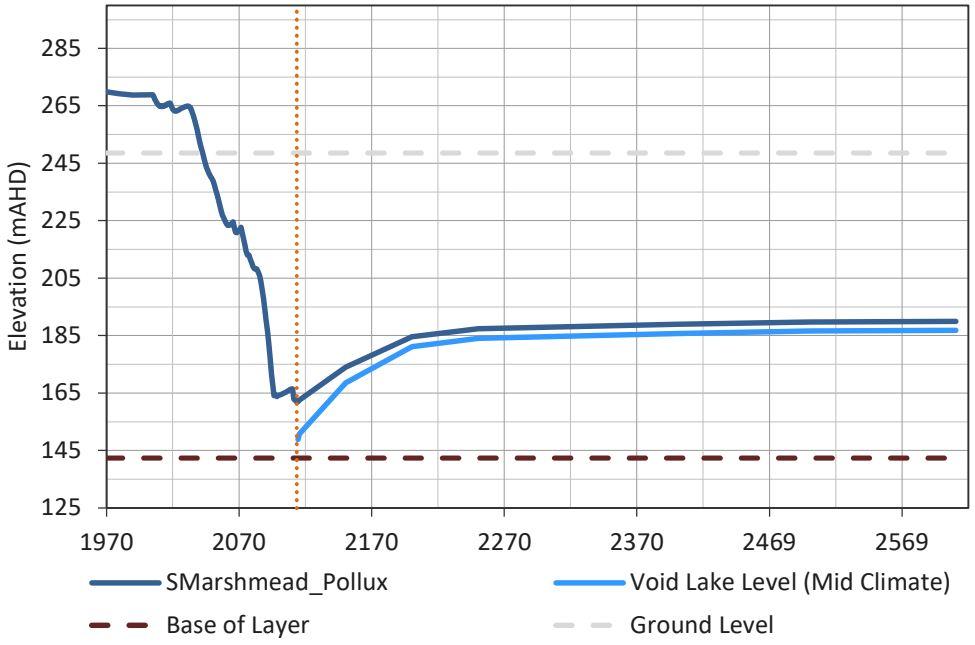
2370
2469
2569
SMarshmead_Castor
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


285
265
245
225
205
185
165
145
125
Elevation (mAHD)
1970
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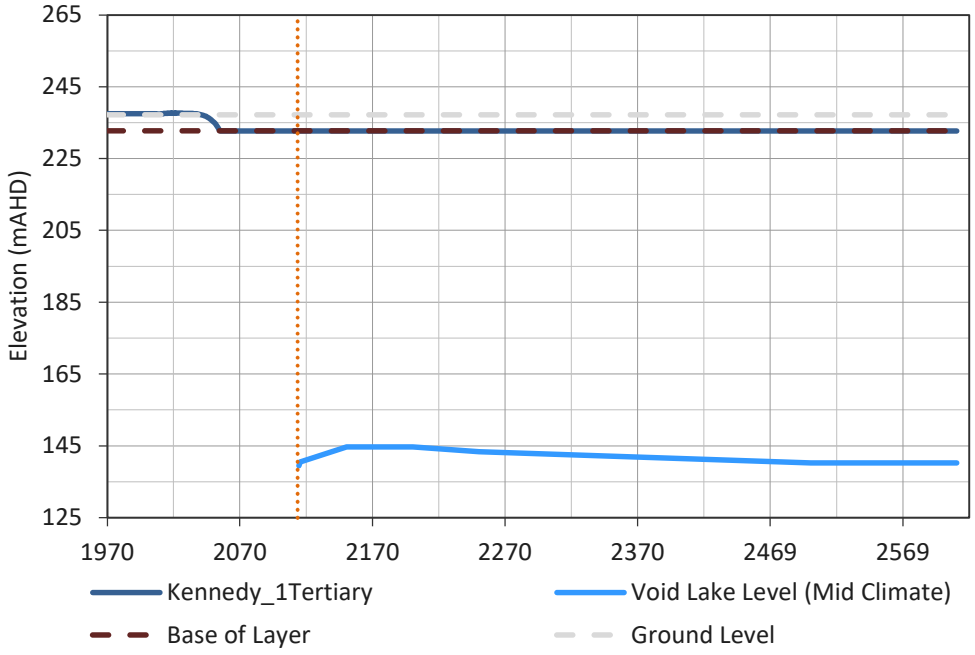
2170
2270
2370
2469
2569
SMarshmead_Pollux
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


265
245
225
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185
165
145
125
Elevation (mAHD)
1970
2070
2170
2270
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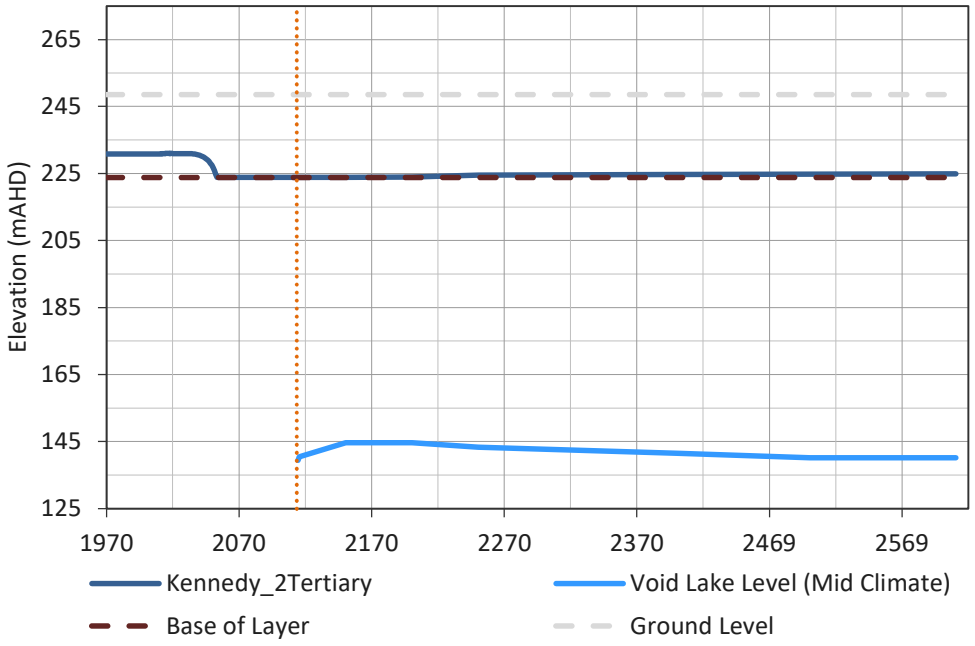
2469
2569
Kennedy_1Tertiary
Void Lake Level (Mid Climate)
Base of Layer
Ground Level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245
225
205
185
165
145
125
Elevation (mAHD)
1970
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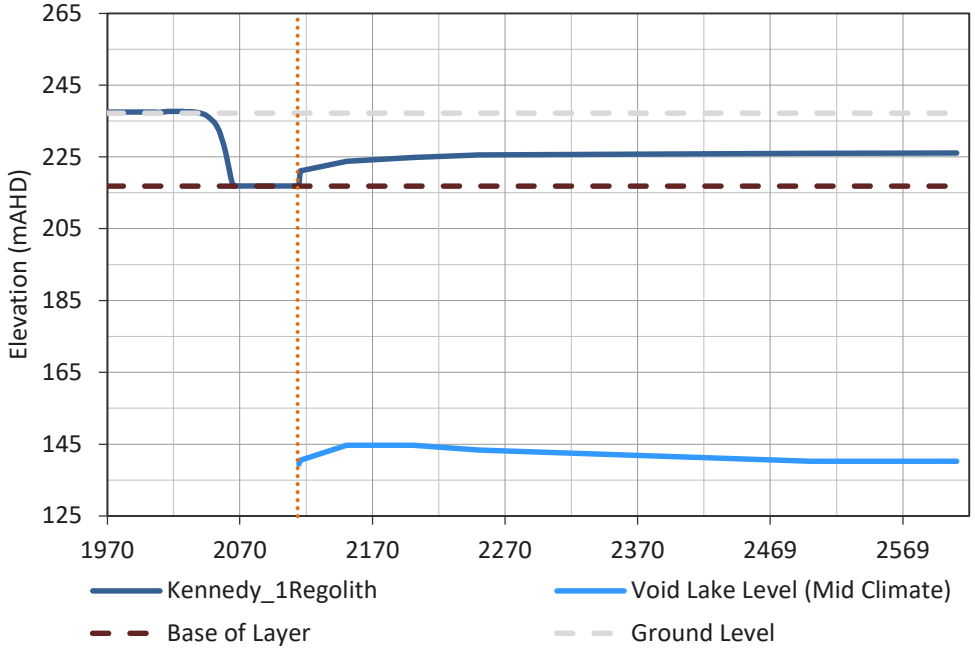
2170
2270
2370
2469
2569
Kennedy_2Tertiary
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


265
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205
185
165
145
125
Elevation (mAHD)
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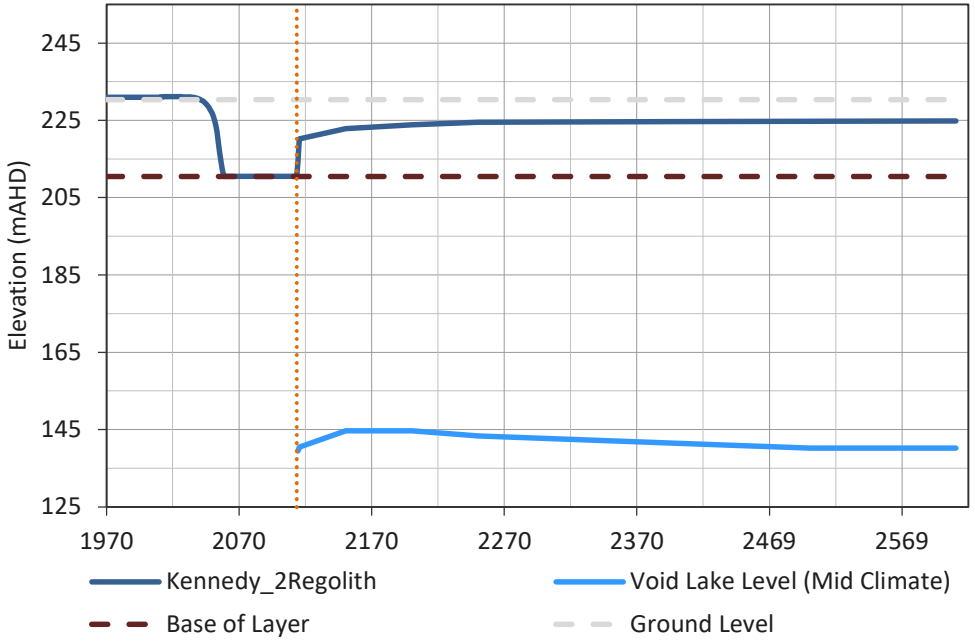
2070
2170
2270
2370
2469
2569
Kennedy_1Regolith
Void Lake Level (Mid Climate)
Base of Layer
Ground Level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165
145
125
Elevation (mAHD)
1970
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2270
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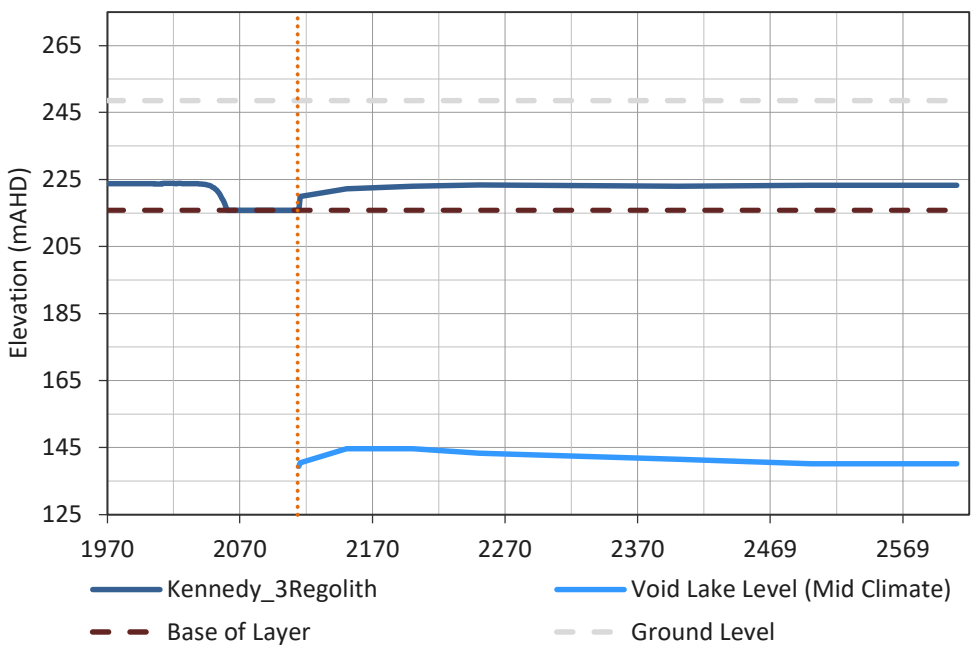
2469
2569
Kennedy_2Regolith
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


Elevation (mAHD)
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2270
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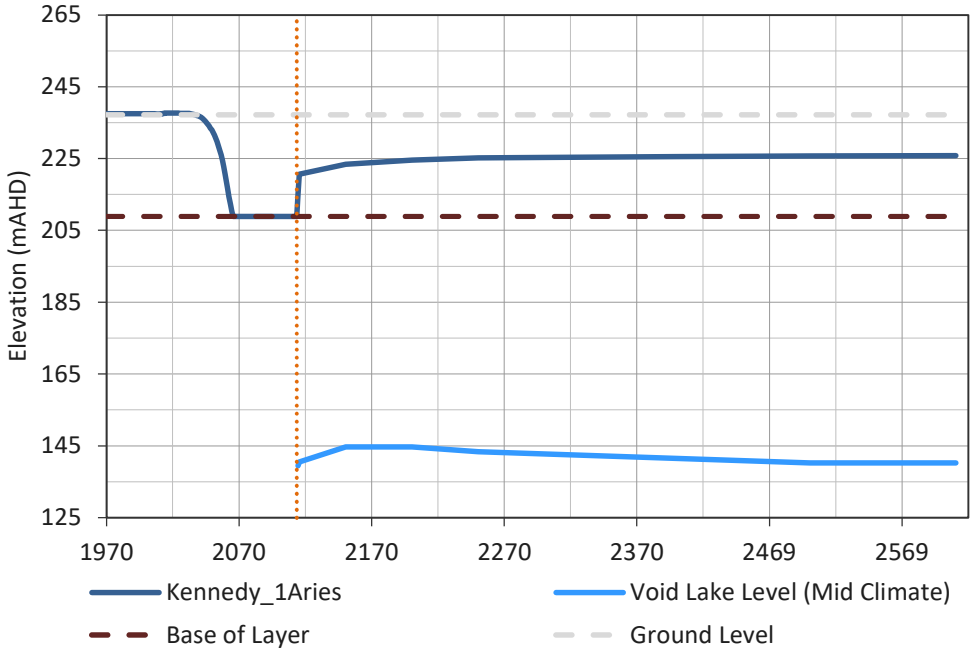
2469
2569
Kennedy_3Regolith
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


Elevation (mAHD)
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205
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165
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2170
2270
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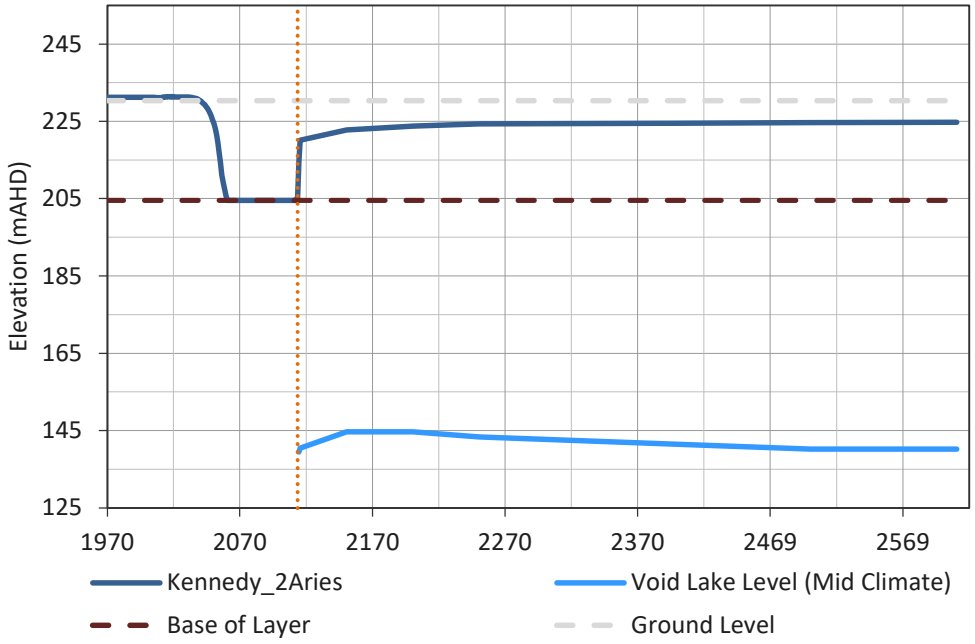
2469
2569
Kennedy_1Aries
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


Elevation (mAHD)
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225
205
185
165
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1970
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2170
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2370
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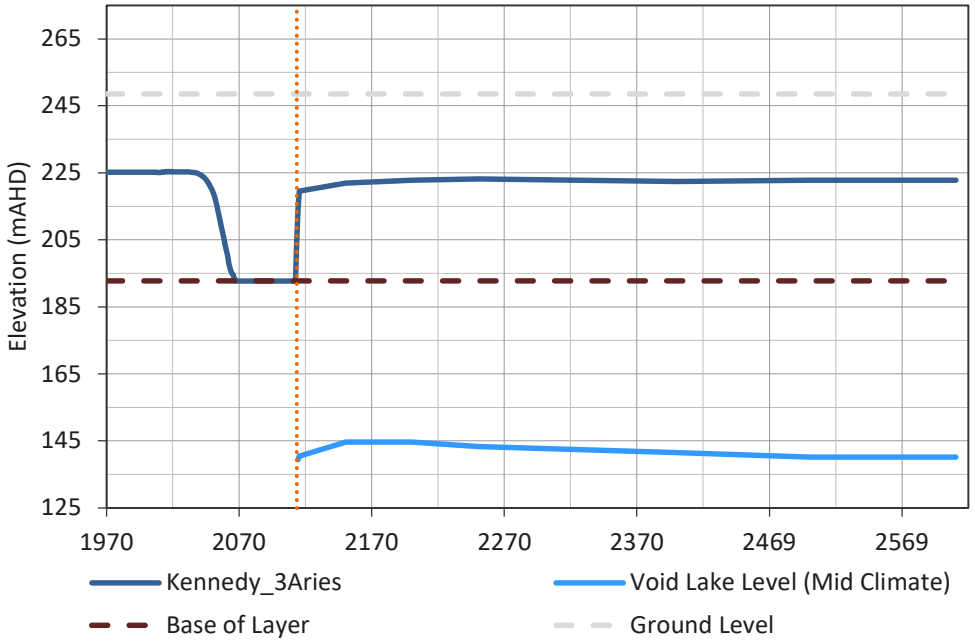
2569
Kennedy_2Aries
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


Elevation (mAHD)
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245
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205
185
165
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125
1970
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2170
2270
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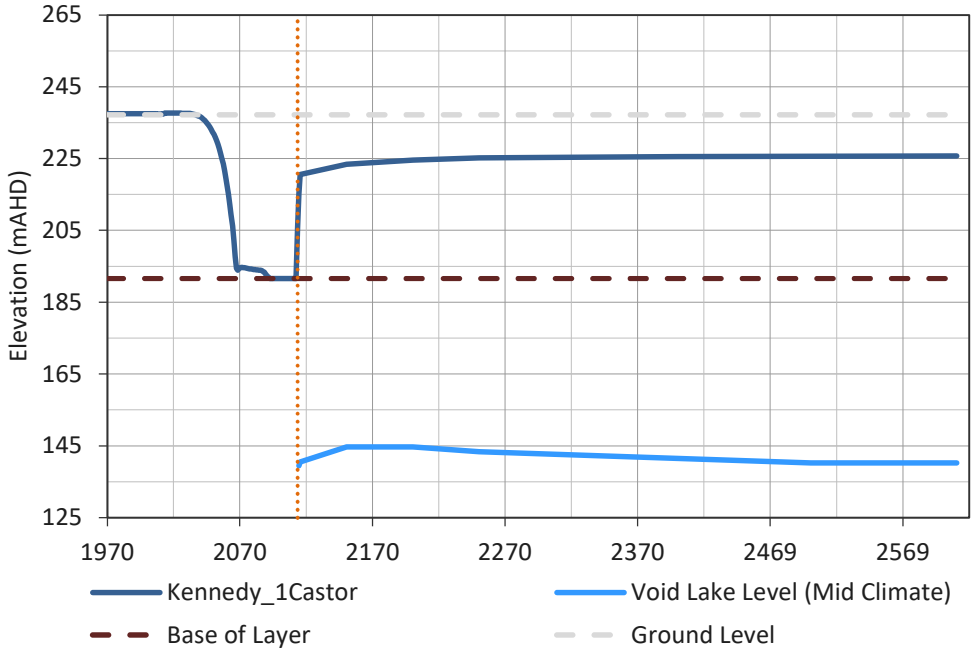
2469
2569
Kennedy_3Aries
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


265
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225
205
185
165
145
125
Elevation (mAHD)
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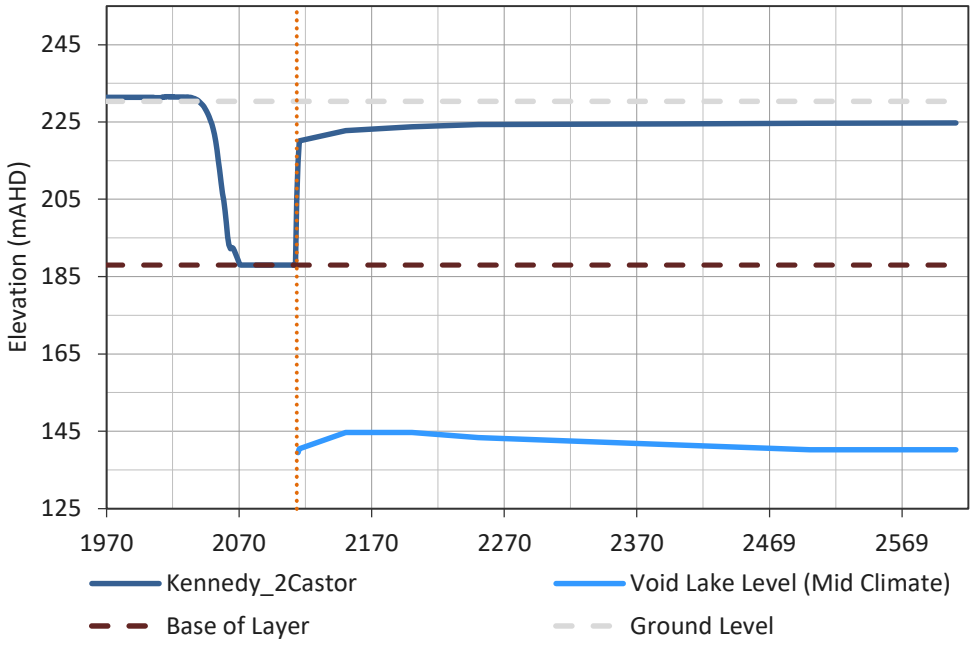
2070
2170
2270
2370
2469
2569
Kennedy_1Castor
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


245
225
205
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165
145
125
Elevation (mAHD)
1970
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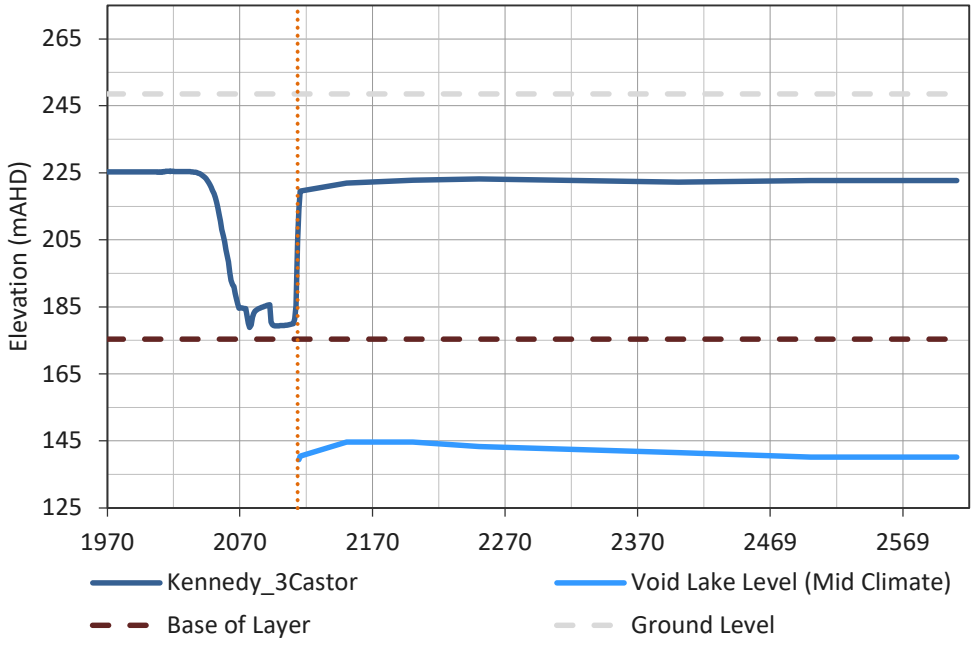
2170
2270
2370
2469
2569
Kennedy_2Castor
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


265
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145
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Elevation (mAHD)
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2170
2270
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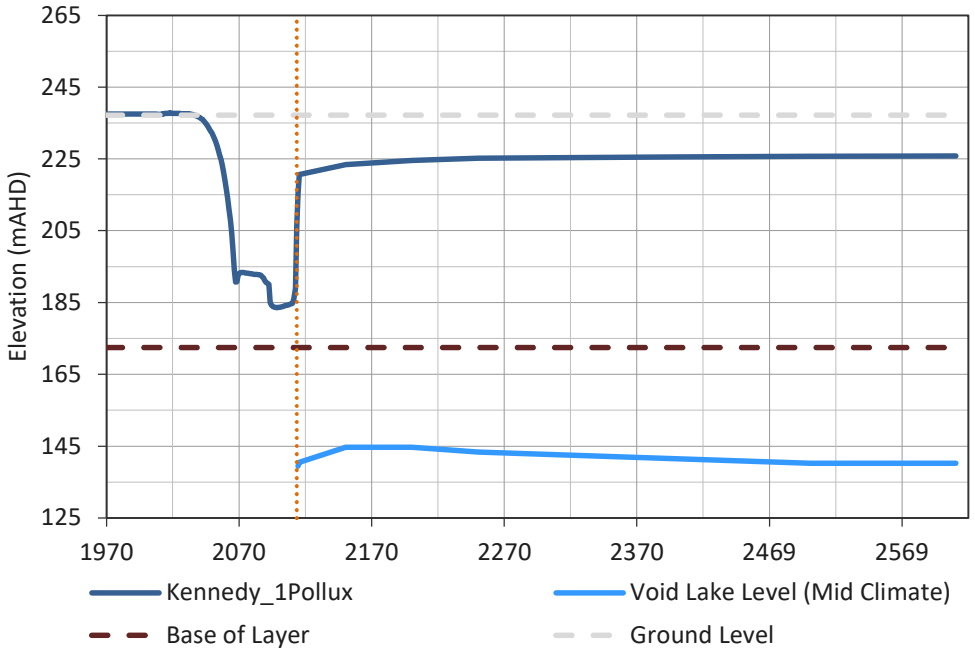
2569
Kennedy_3Castor
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


265
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225
205
185
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145
125
Elevation (mAHD)
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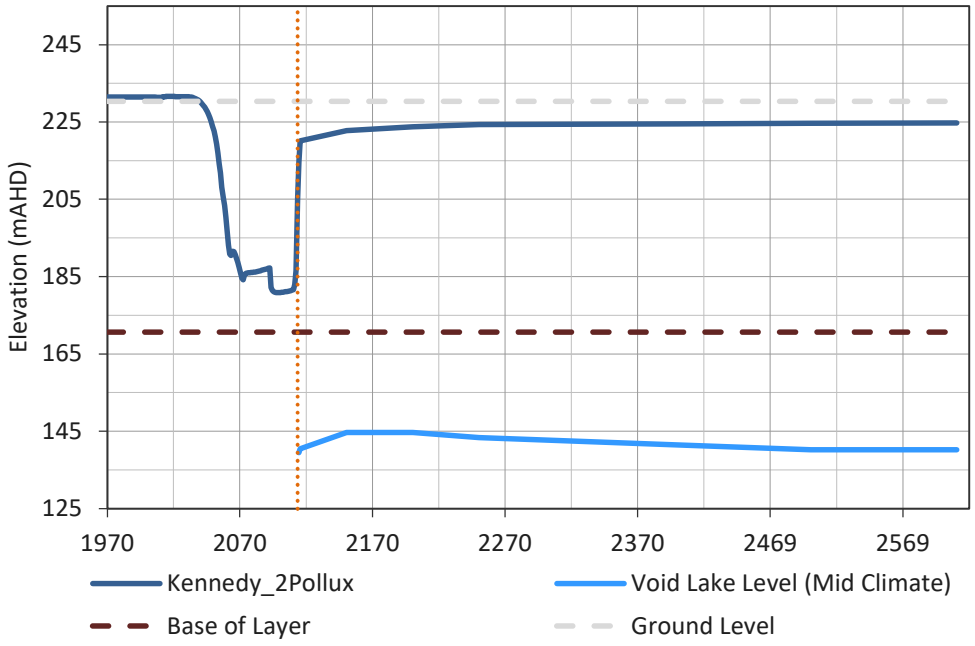
2170
2270
2370
2469
2569
Kennedy_1Pollux
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


Elevation (mAHD)
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185
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1970
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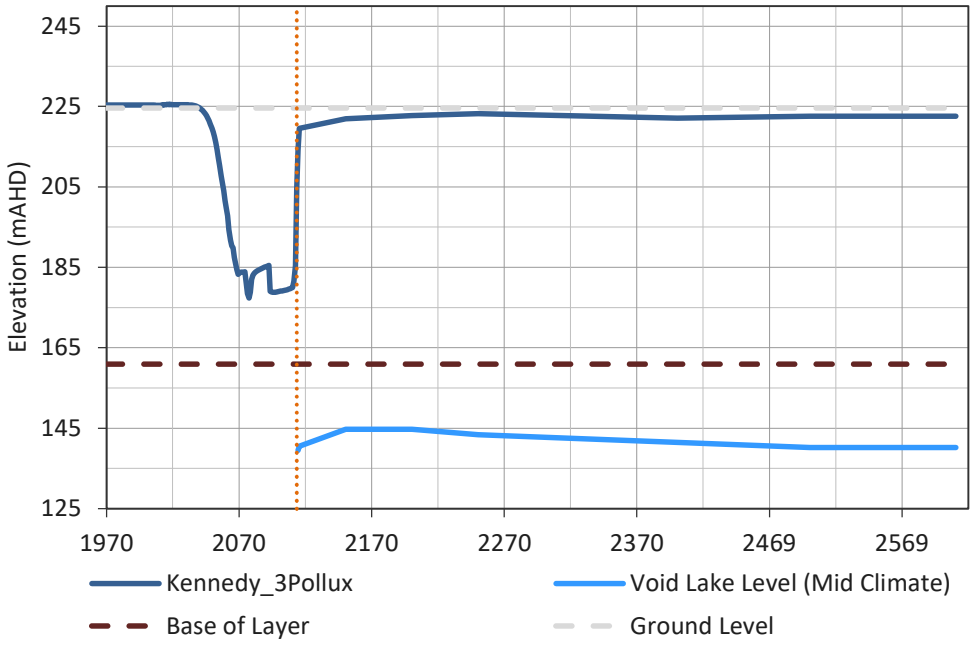
2370
2469
2569
Kennedy_2Pollux
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


Elevation (mAHD)
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2170
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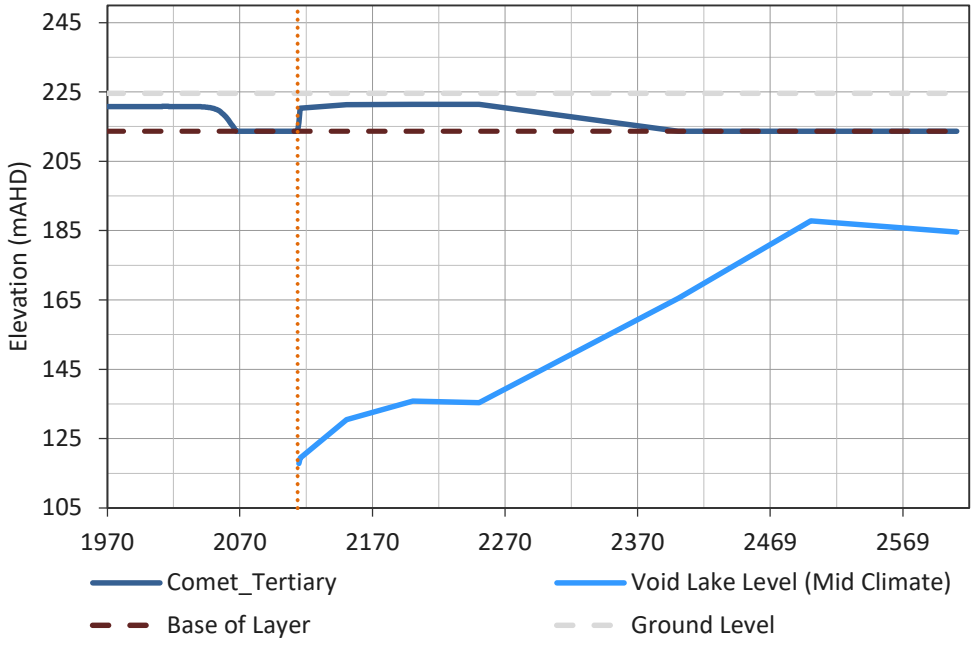
Kennedy_3Pollux
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


Elevation (mAHD)
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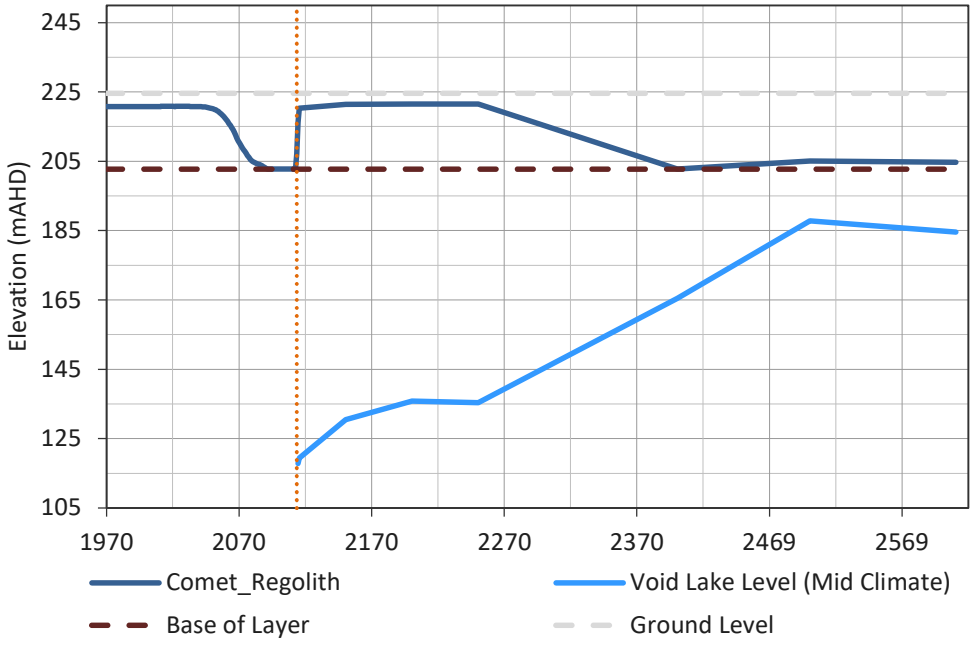
2170
2270
2370
2469
2569
Comet_Tertiary
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


Elevation (mAHD)
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185
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105
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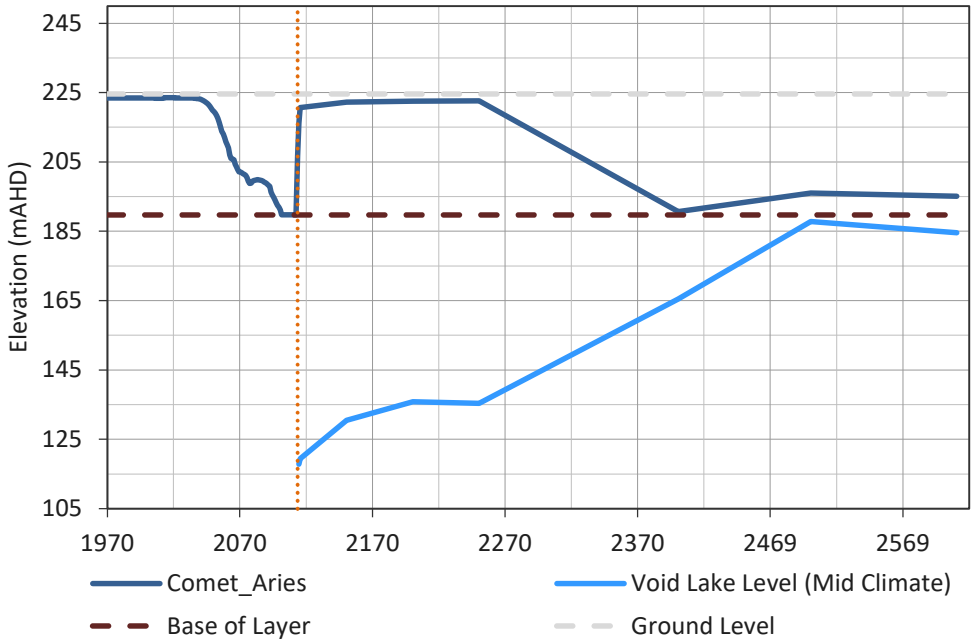
2170
2270
2370
2469
2569
Comet_Regolith
Void Lake Level (Mid Climate)
Base of Layer
Ground Level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165
145
125
105
Elevation (mAHD)
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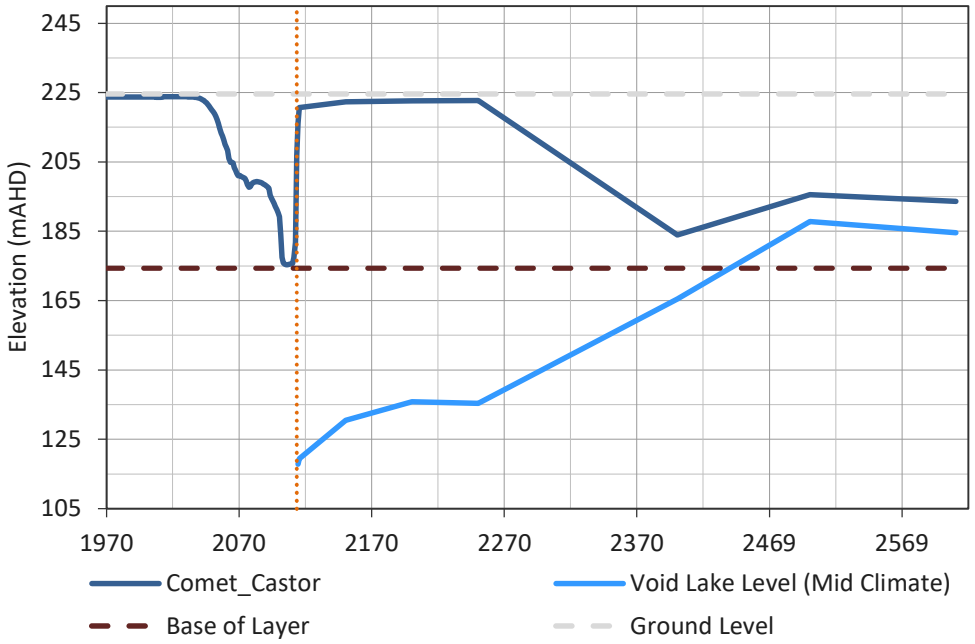
2170
2270
2370
2469
2569
Comet_Aries
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


245
225
205
185
165
145
125
105
Elevation (mAHD)
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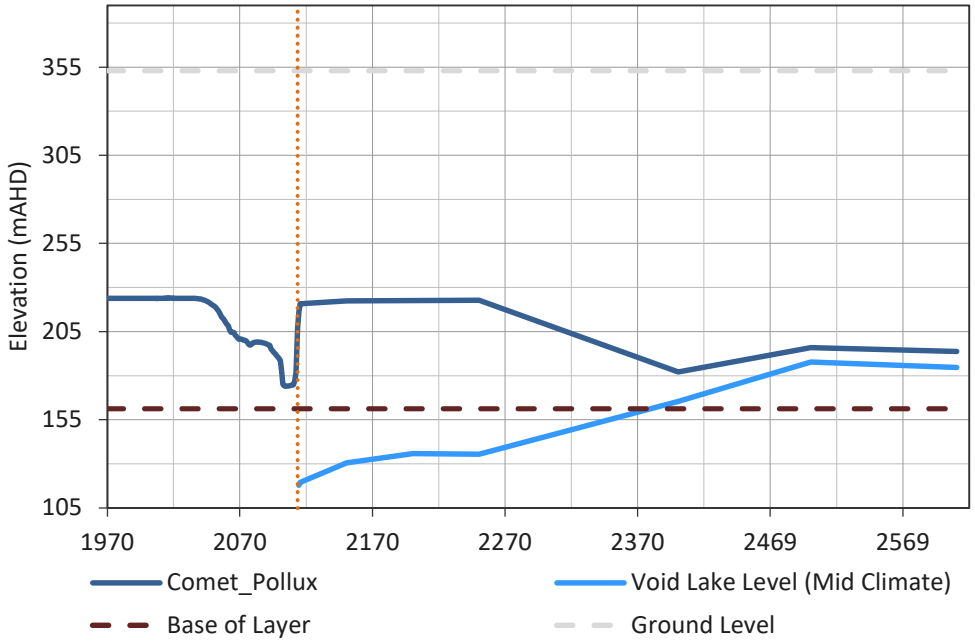
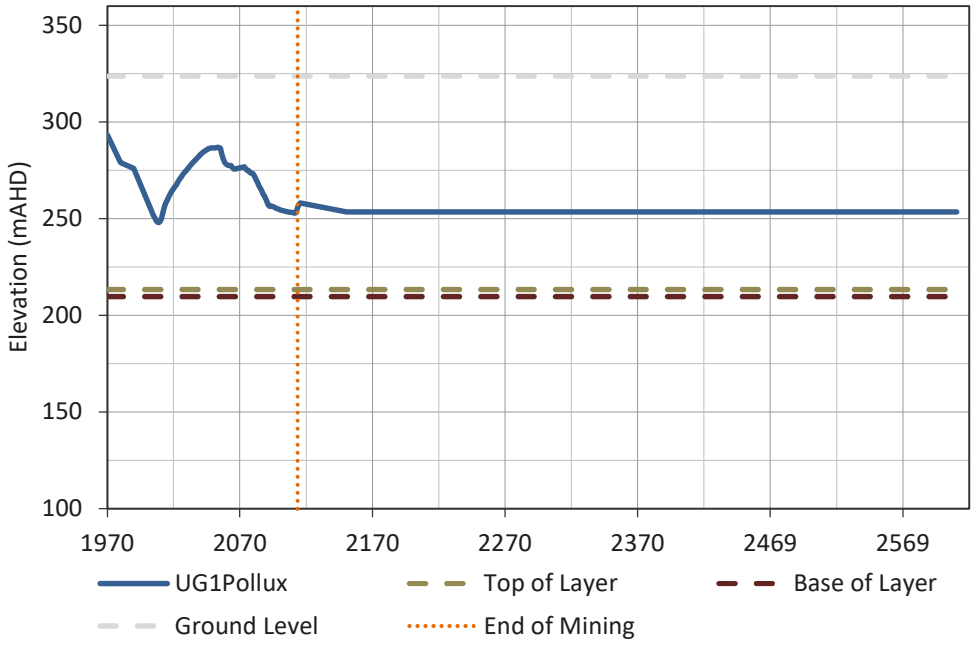
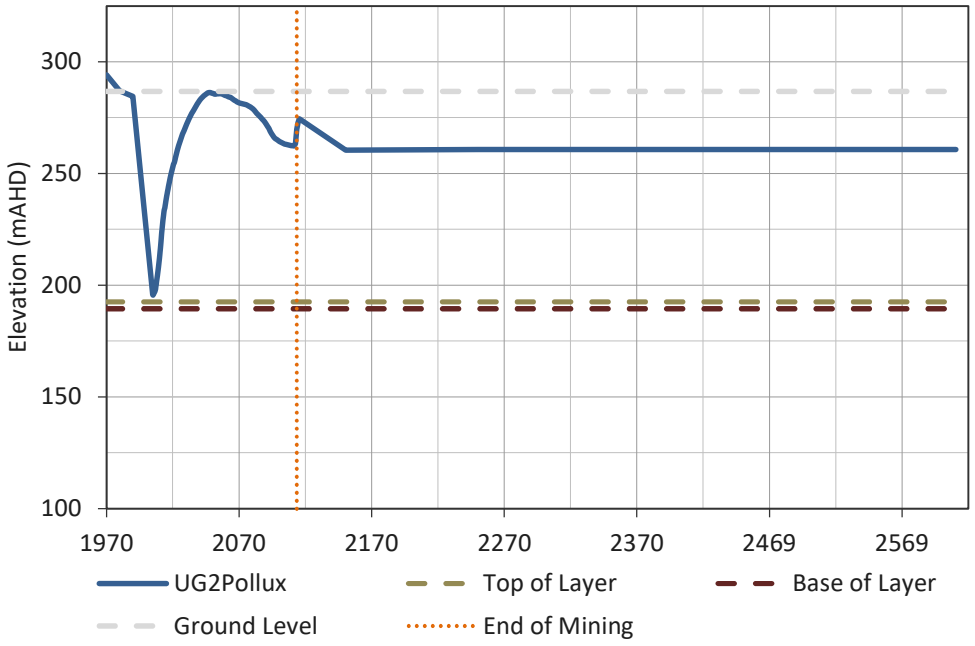
2070
2170
2270
2370
2469
2569
Comet_Castor
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


355
305
255
205
155
105
Elevation (mAHD)
1970
2070
2170
2270
2370
2469
2569
Comet_Pollux
Void Lake Level (Mid Climate)
Base of Layer
Ground Level


Elevation (mAHD)
350
300
250
200
150
100
1970
2070
2170
2270
2370
2469
2569
UG1Pollux
Top of Layer
Base of Layer
Ground Level
End of Mining


Elevation (mAHD)
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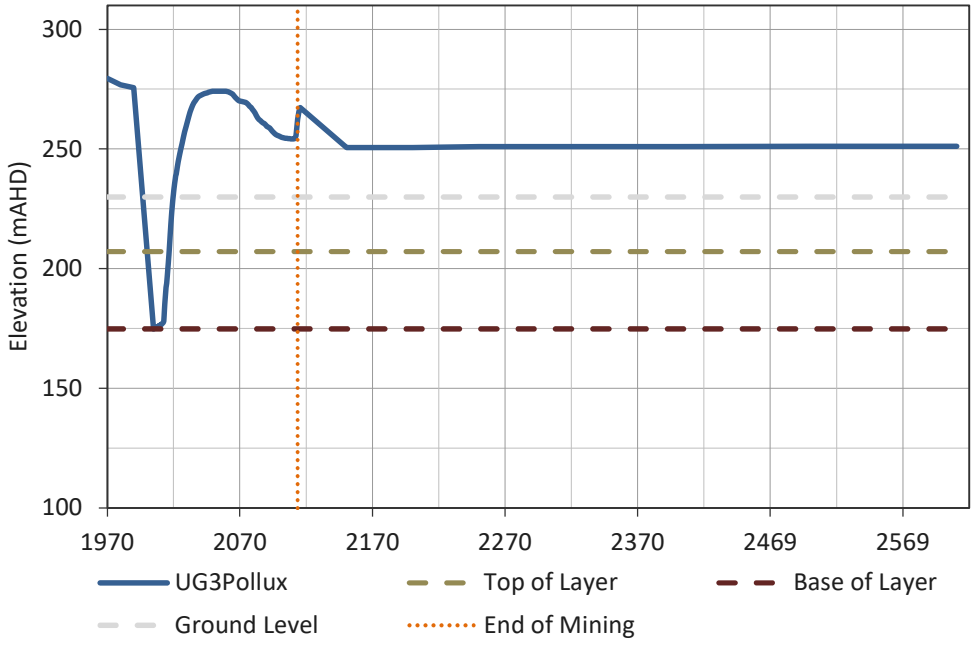
250
200
150
100
1970
2070
2170
2270
2370
2469
2569
UG2Pollux
Top of Layer
Base of Layer
Ground Level
End of Mining


Elevation (mAHD)
300
250
200
150
100
1970
2070
2170
2270
2370
2469
2569
UG3Pollux
Top of Layer
Base of Layer
Ground Level
End of Mining

Appendix D Predictive Hydrographs at Third-Party Bores

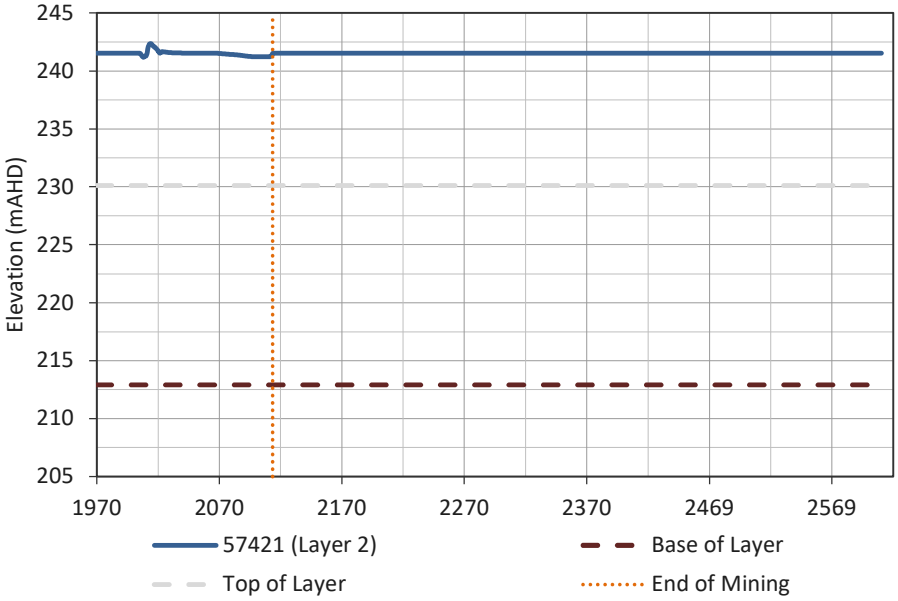
Blackwater Mine

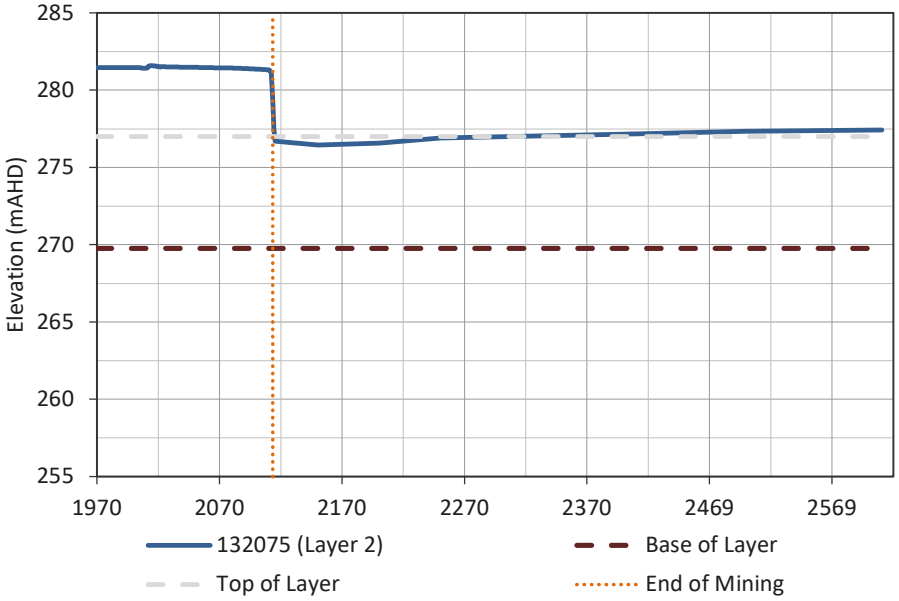
Transitional PRC Plan Hydrogeology Assessment

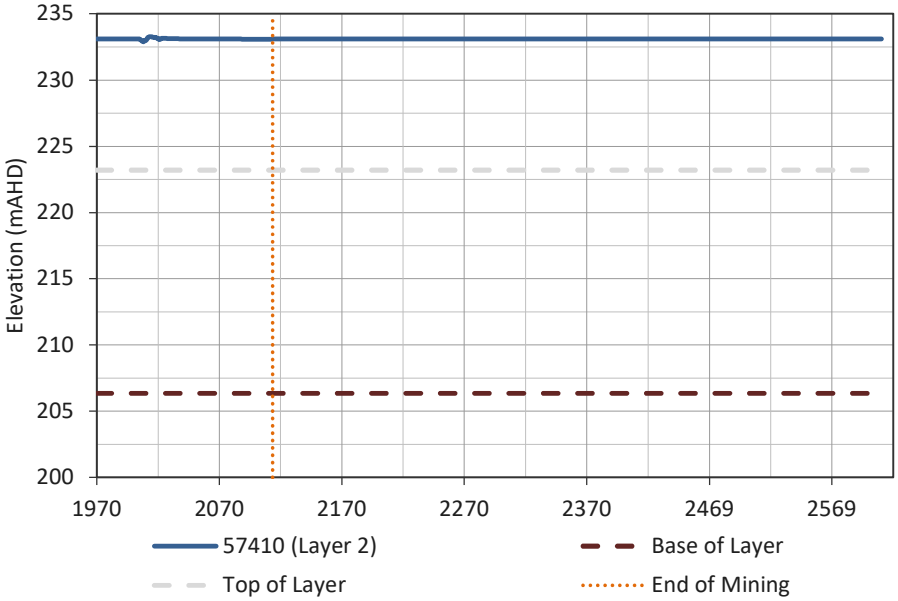
Whitehaven Coal Limited

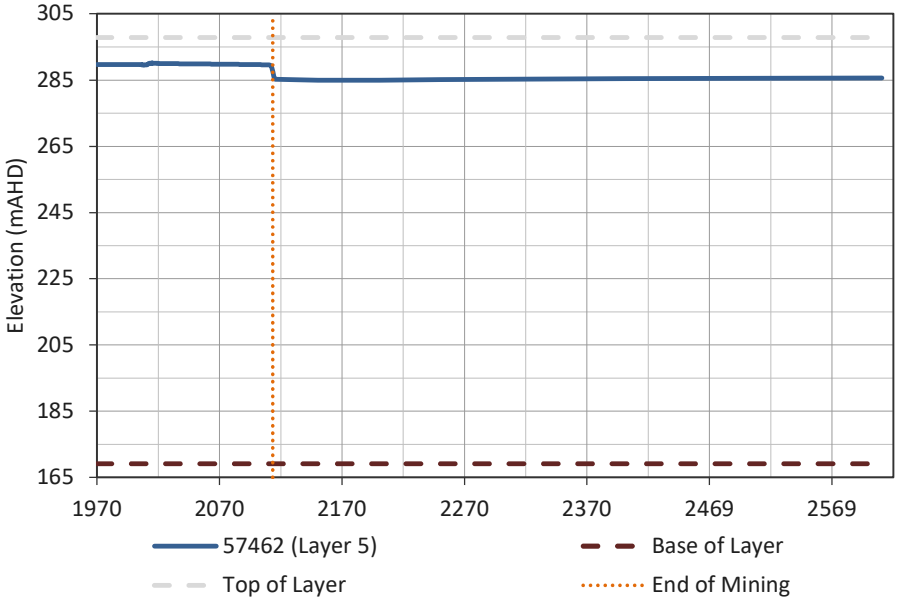
SLR Project No.: 620.040199.00001

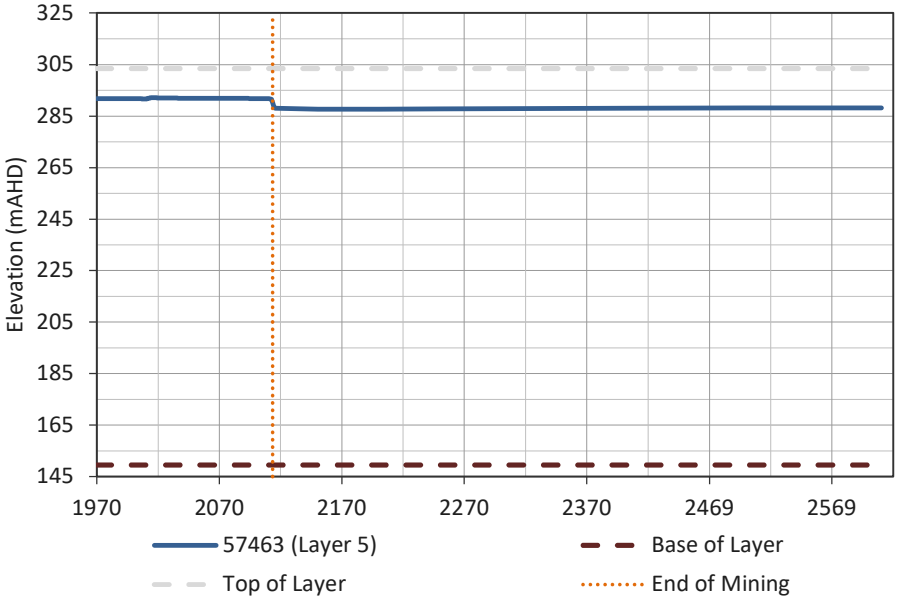
16 September 2024

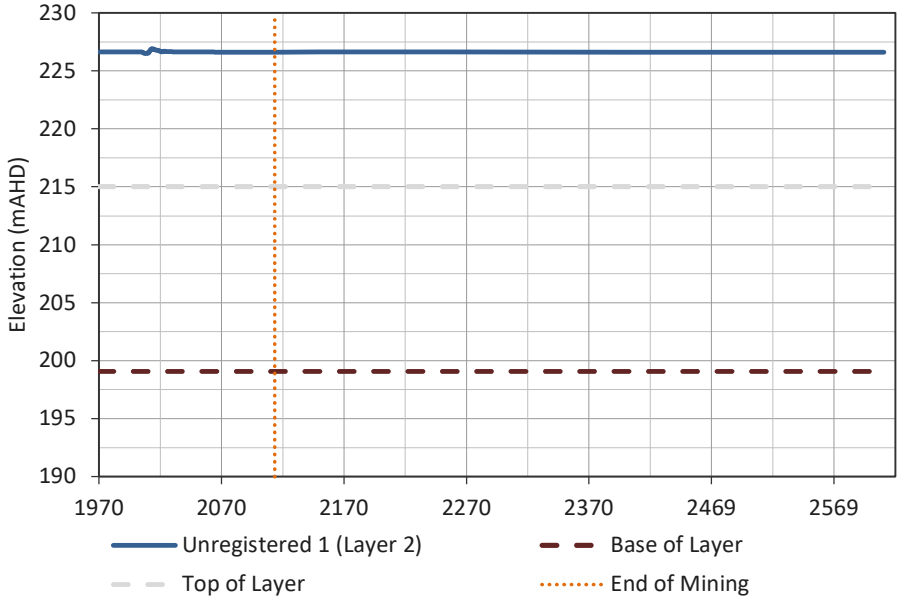

Elevation (mAHD)
245
240
235
230
225
220
215
210
205
1970
2070
2170
2270
2370
2469
2569
57421 (Layer 2)
Base of Layer
Top of Layer
End of Mining

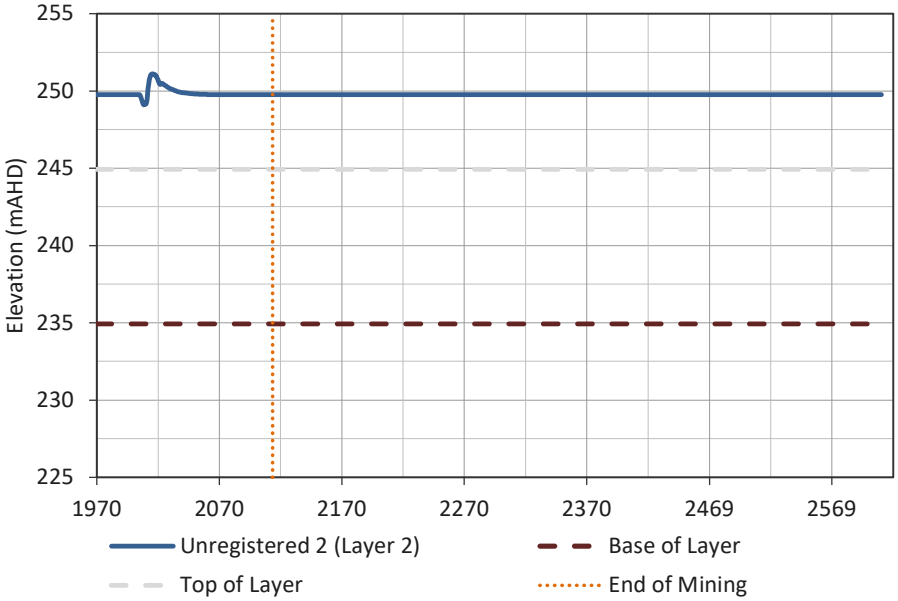

Elevation (mAHD)
285
280
275
270
265
260
255
1970
2070
2170
2270
2370
2469
2569
132075 (Layer 2)
Base of Layer
Top of Layer
End of Mining

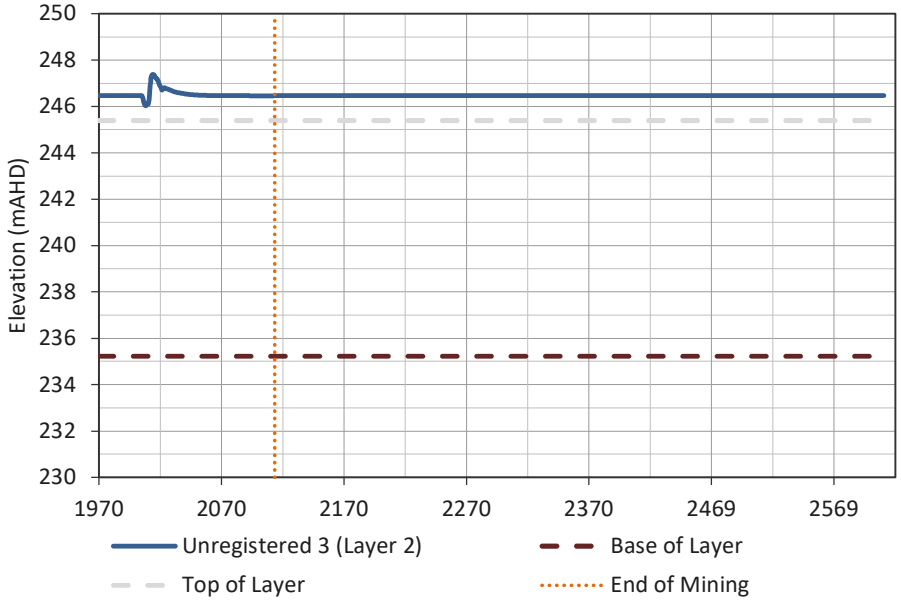

Elevation (mAHD)
235
230
225
220
215
210
205
200
1970
2070
2170
2270
2370
2469
2569
57410 (Layer 2)
Base of Layer
Top of Layer
End of Mining

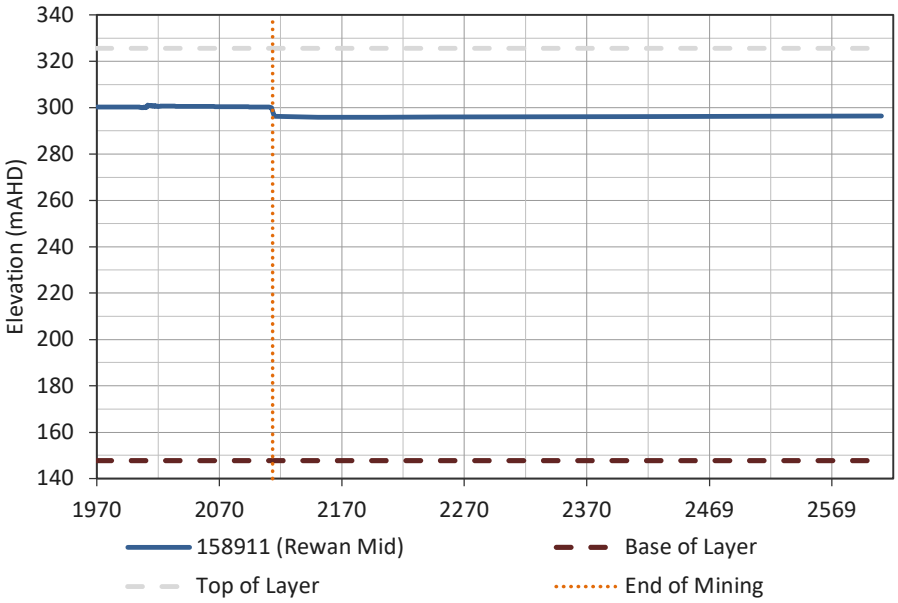

Elevation (mAHD)
305
285
265
245
225
205
185
165
1970
2070
2170
2270
2370
2469
2569
57462 (Layer 5)
Base of Layer
Top of Layer
End of Mining

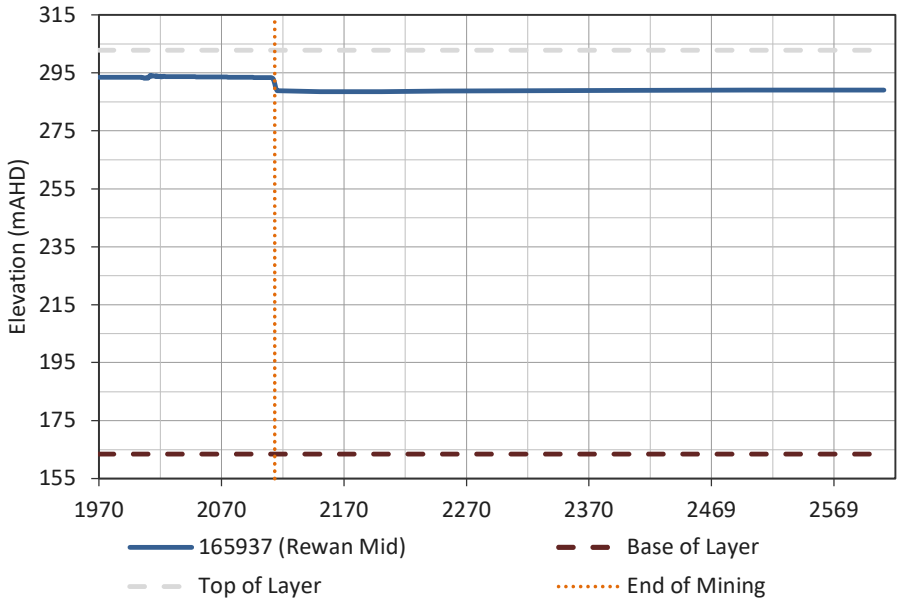

Elevation (mAHD)
325
305
285
265
245
225
205
185
165
145
1970
2070
2170
2270
2370
2469
2569
57463 (Layer 5)
Base of Layer
Top of Layer
End of Mining

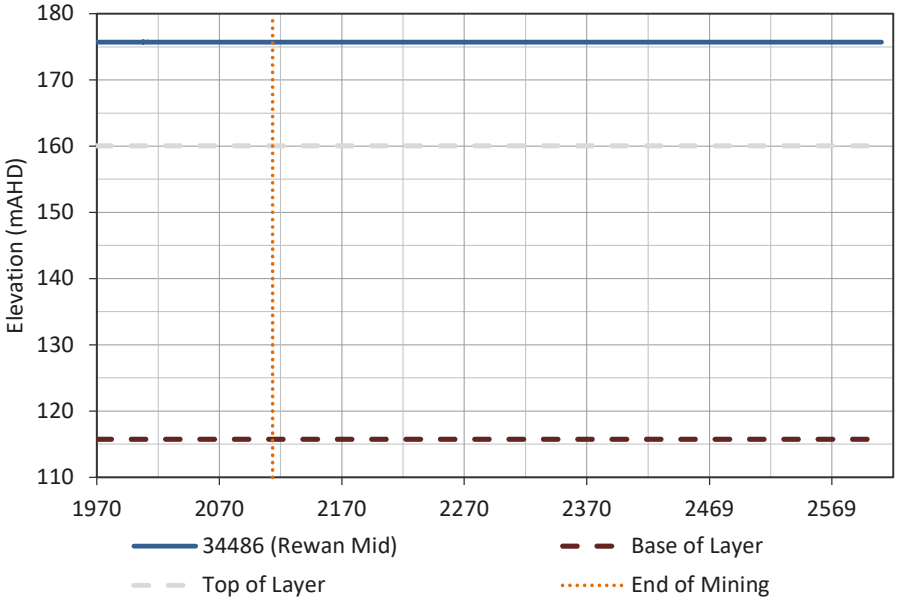

Elevation (mAHD)
230
225
220
215
210
205
200
195
190
1970
2070
2170
2270
2370
2469
2569
Unregistered 1 (Layer 2)
Base of Layer
Top of Layer
End of Mining

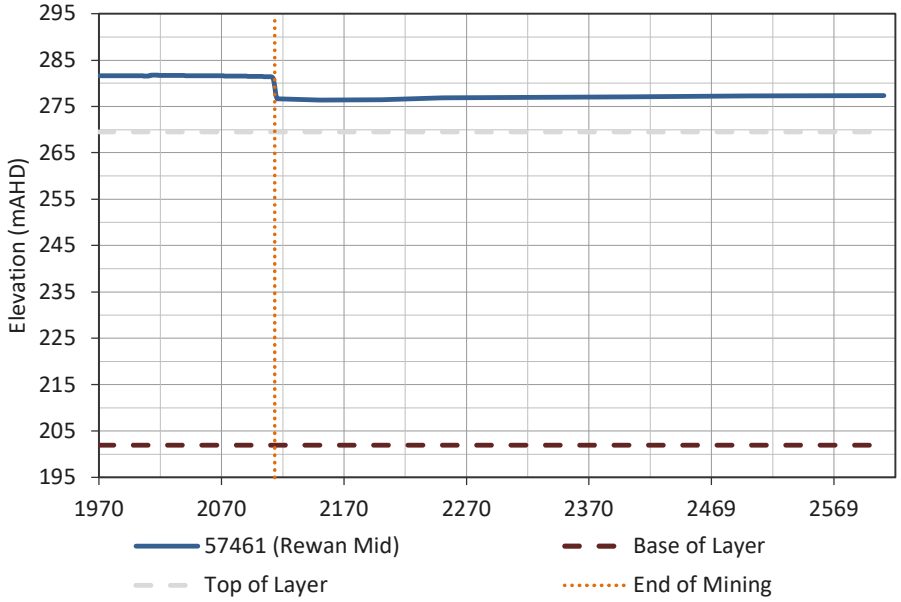

Elevation (mAHD)
255
250
245
240
235
230
225
1970
2070
2170
2270
2370
2469
2569
Unregistered 2 (Layer 2)
Base of Layer
Top of Layer
End of Mining

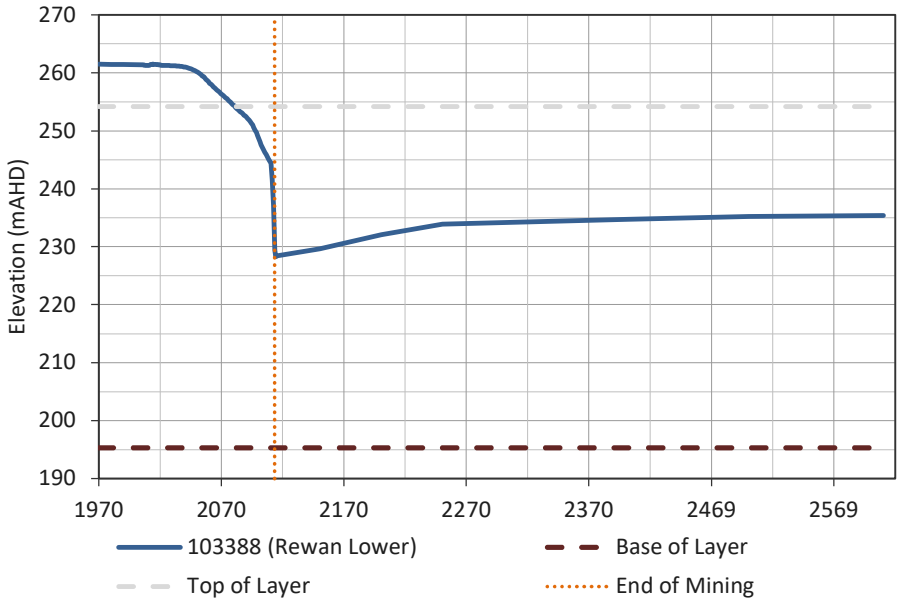

Elevation (mAHD)
250
248
246
244
242
240
238
236
234
232
230
1970
2070
2170
2270
2370
2469
2569
Unregistered 3 (Layer 2)
Base of Layer
Top of Layer
End of Mining

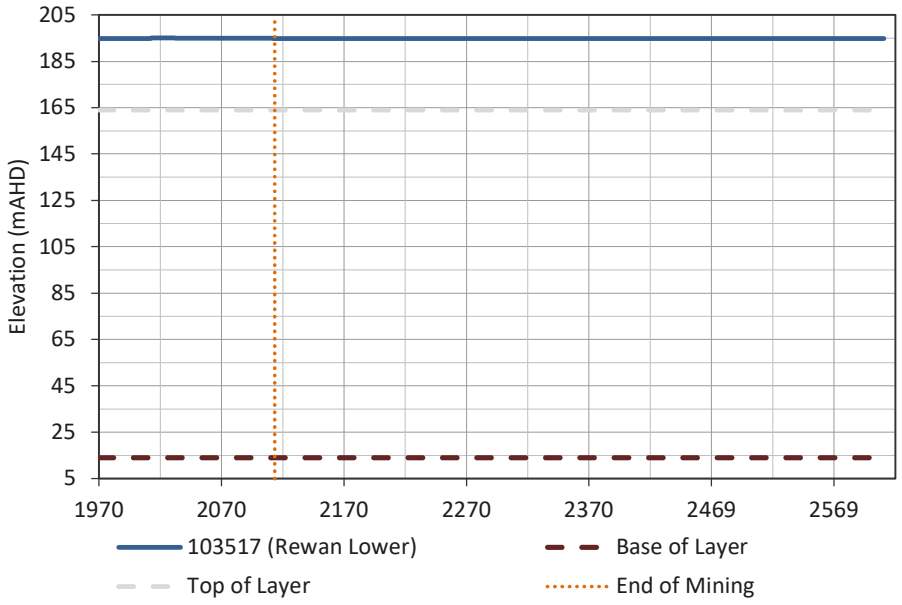

Elevation (mAHD)
340
320
300
280
260
240
220
200
180
160
140
1970
2070
2170
2270
2370
2469
2569
158911 (Rewan Mid)
Base of Layer
Top of Layer
End of Mining

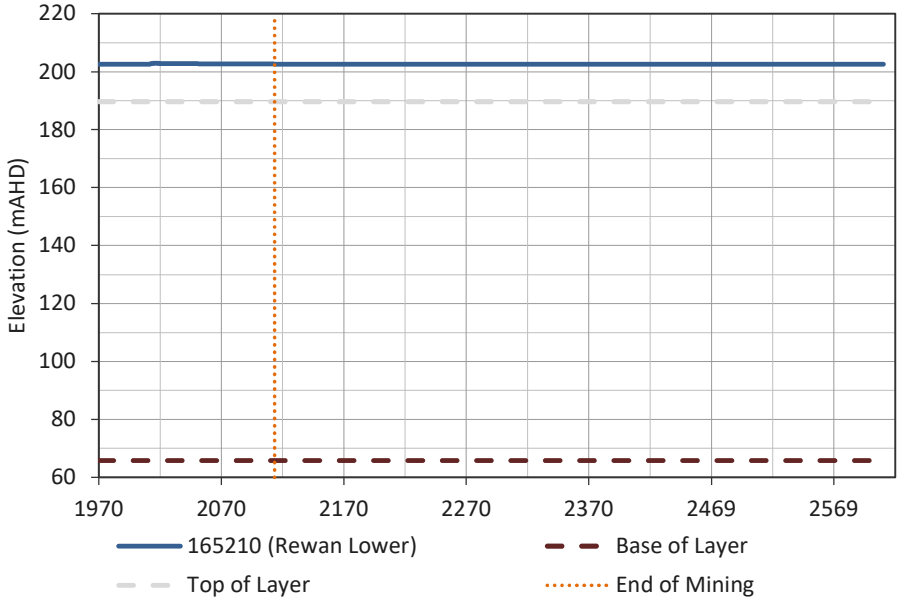

Elevation (mAHD)
315
295
275
255
235
215
195
175
155
1970
2070
2170
2270
2370
2469
2569
165937 (Rewan Mid)
Base of Layer
Top of Layer
End of Mining

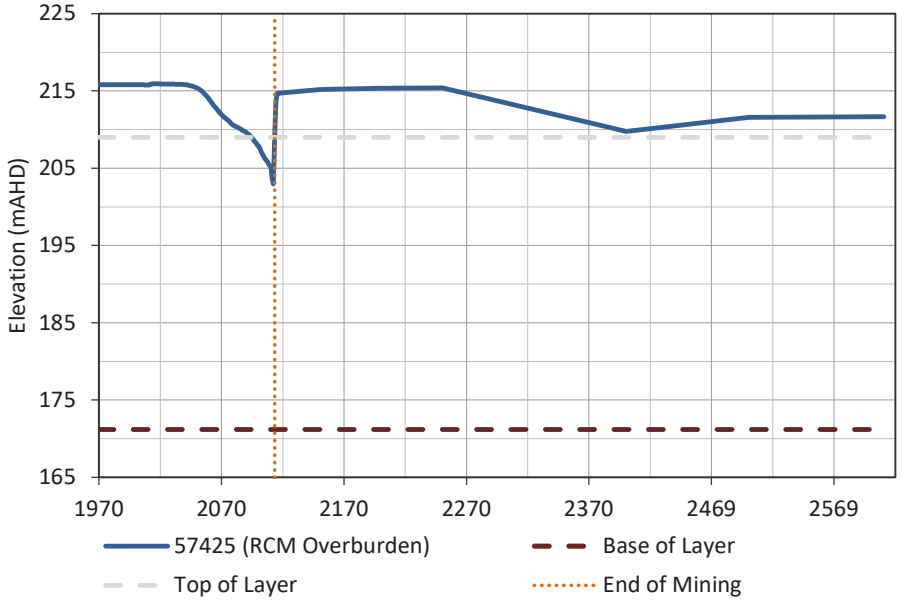

Elevation (mAHD)
180
170
160
150
140
130
120
110
1970
2070
2170
2270
2370
2469
2569
34486 (Rewan Mid)
Base of Layer
Top of Layer
End of Mining

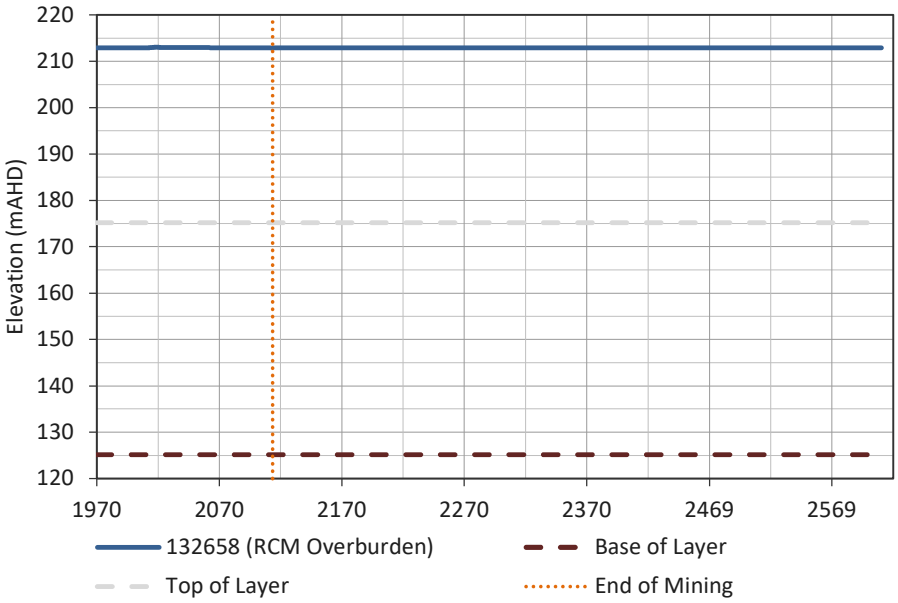

Elevation (mAHD)
295
285
275
265
255
245
235
225
215
205
195
1970
2070
2170
2270
2370
2469
2569
57461 (Rewan Mid)
Base of Layer
Top of Layer
End of Mining

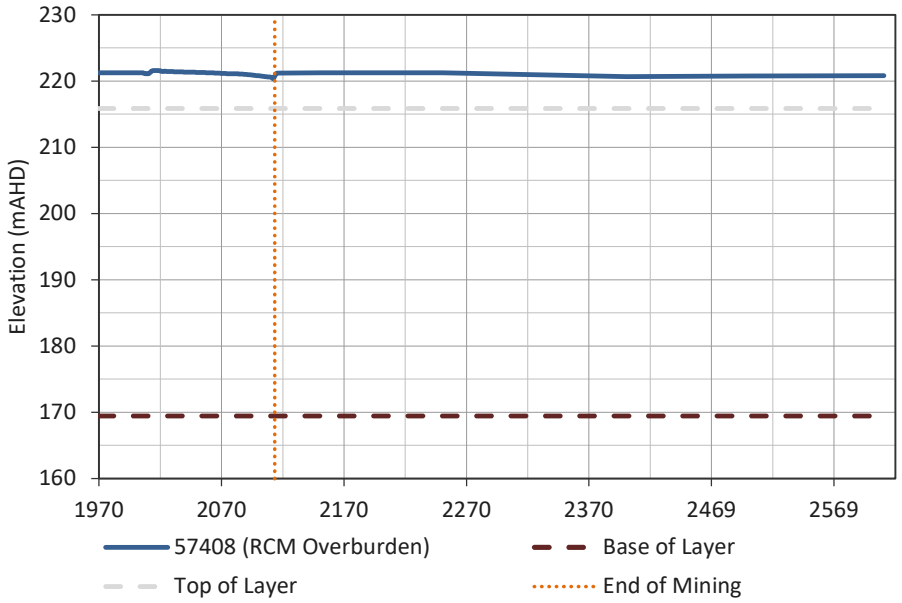

Elevation (mAHD)
270
260
250
240
230
220
210
200
190
1970
2070
2170
2270
2370
2469
2569
103388 (Rewan Lower)
Base of Layer
Top of Layer
End of Mining

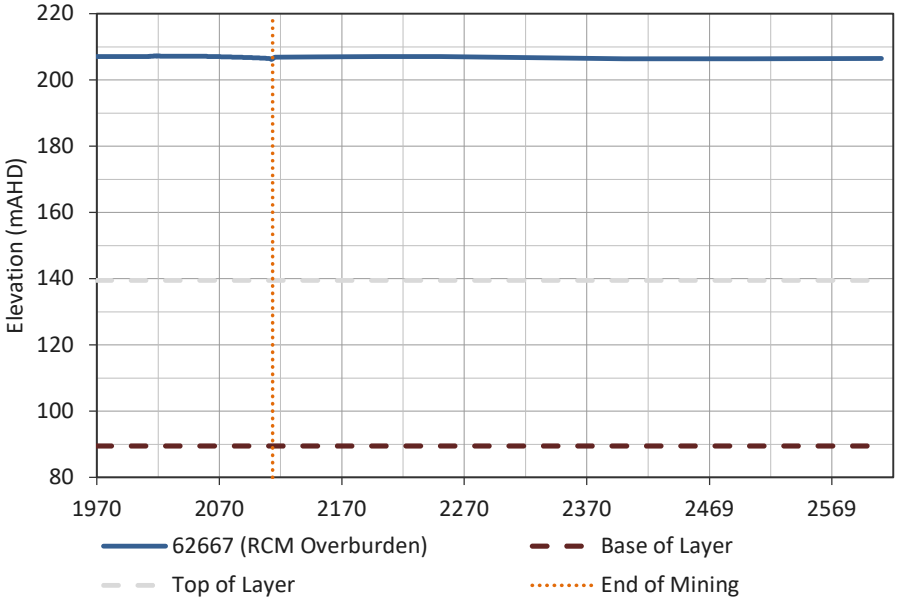

Elevation (mAHD)
205
185
165
145
125
105
85
65
45
25
5
1970
2070
2170
2270
2370
2469
2569
103517 (Rewan Lower)
Base of Layer
Top of Layer
End of Mining

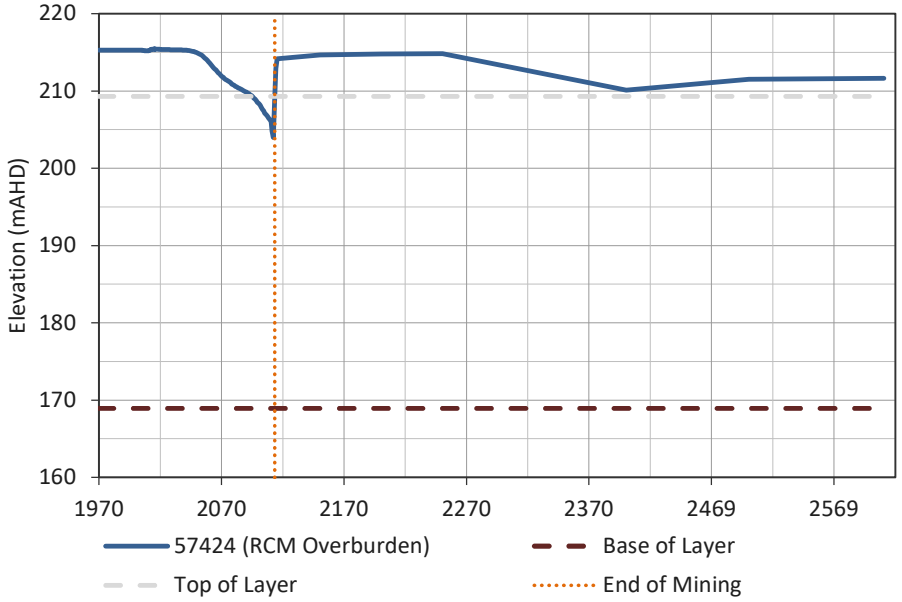

Elevation (mAHD)
220
200
180
160
140
120
100
80
60
1970
2070
2170
2270
2370
2469
2569
165210 (Rewan Lower)
Base of Layer
Top of Layer
End of Mining

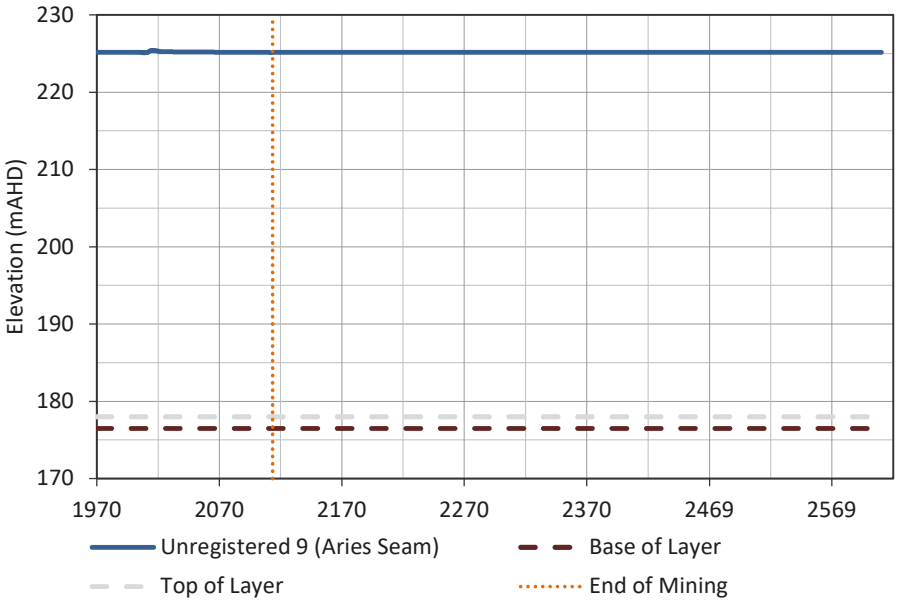

Elevation (mAHD)
225
215
205
195
185
175
165
1970
2070
2170
2270
2370
2469
2569
57425 (RCM Overburden)
Base of Layer
Top of Layer
End of Mining

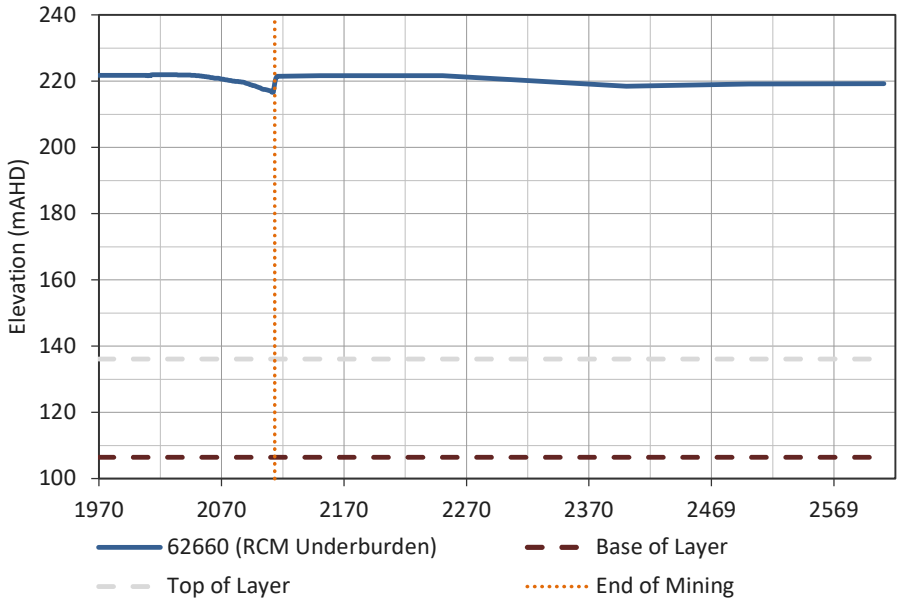

Elevation (mAHD)
220
210
200
190
180
170
160
150
140
130
120
1970
2070
2170
2270
2370
2469
2569
132658 (RCM Overburden)
Base of Layer
Top of Layer
End of Mining

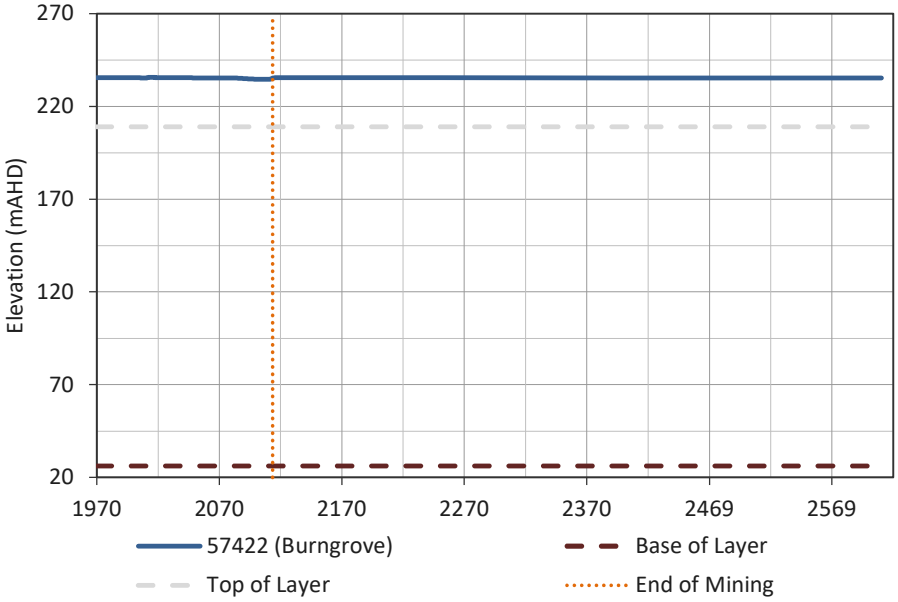

Elevation (mAHD)
230
220
210
200
190
180
170
160
1970
2070
2170
2270
2370
2469
2569
57408 (RCM Overburden)
Base of Layer
Top of Layer
End of Mining

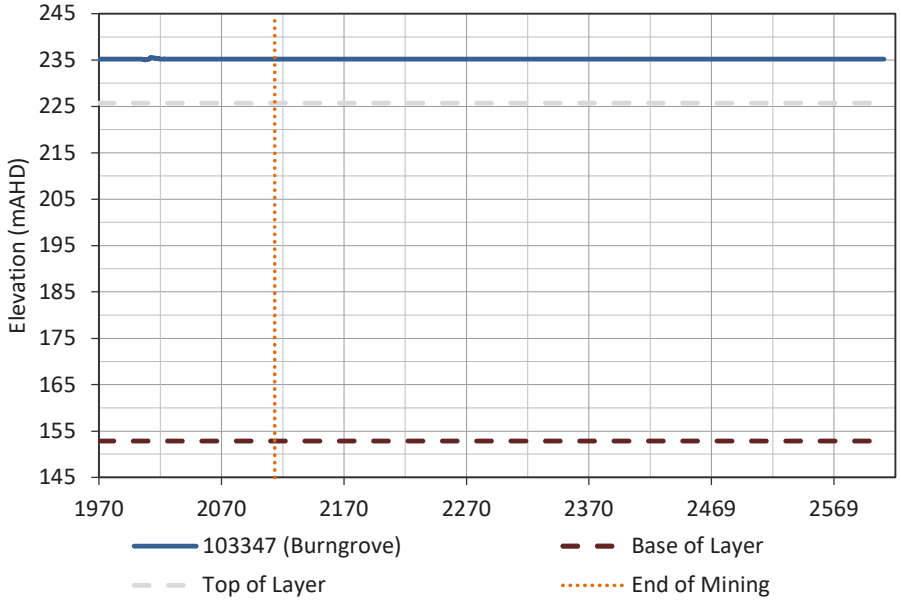

Elevation (mAHD)
220
200
180
160
140
120
100
80
1970
2070
2170
2270
2370
2469
2569
62667 (RCM Overburden)
Base of Layer
Top of Layer
End of Mining

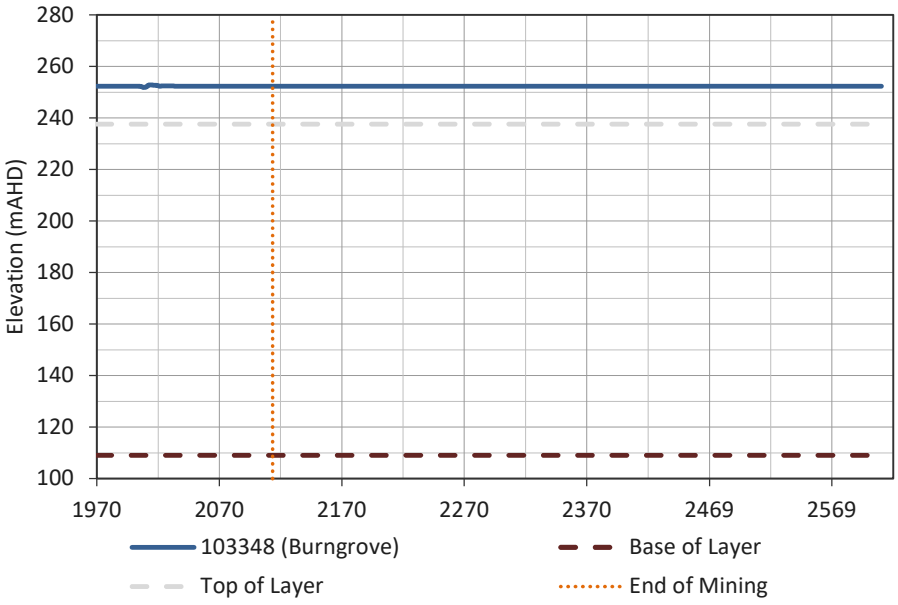

Elevation (mAHD)
220
210
200
190
180
170
160
1970
2070
2170
2270
2370
2469
2569
57424 (RCM Overburden)
Base of Layer
Top of Layer
End of Mining

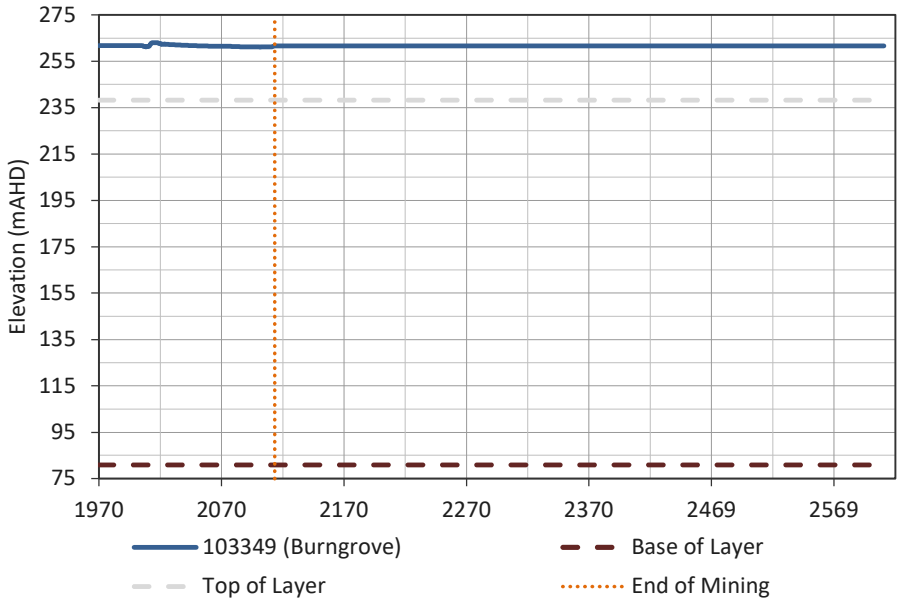

Elevation (mAHD)
230
220
210
200
190
180
170
1970
2070
2170
2270
2370
2469
2569
Unregistered 9 (Aries Seam)
Base of Layer
Top of Layer
End of Mining

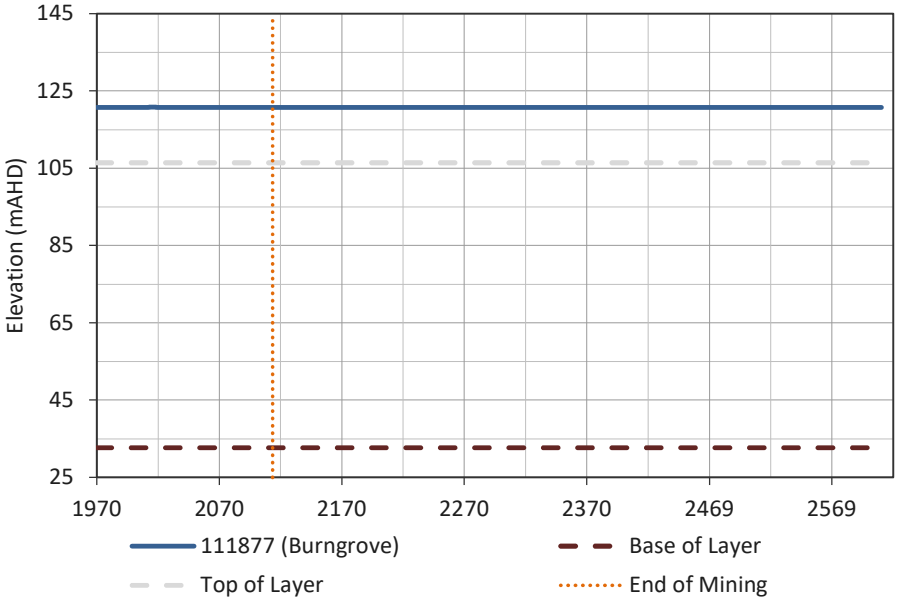

Elevation (mAHD)
240
220
200
180
160
140
120
100
1970
2070
2170
2270
2370
2469
2569
62660 (RCM Underburden)
Base of Layer
Top of Layer
End of Mining

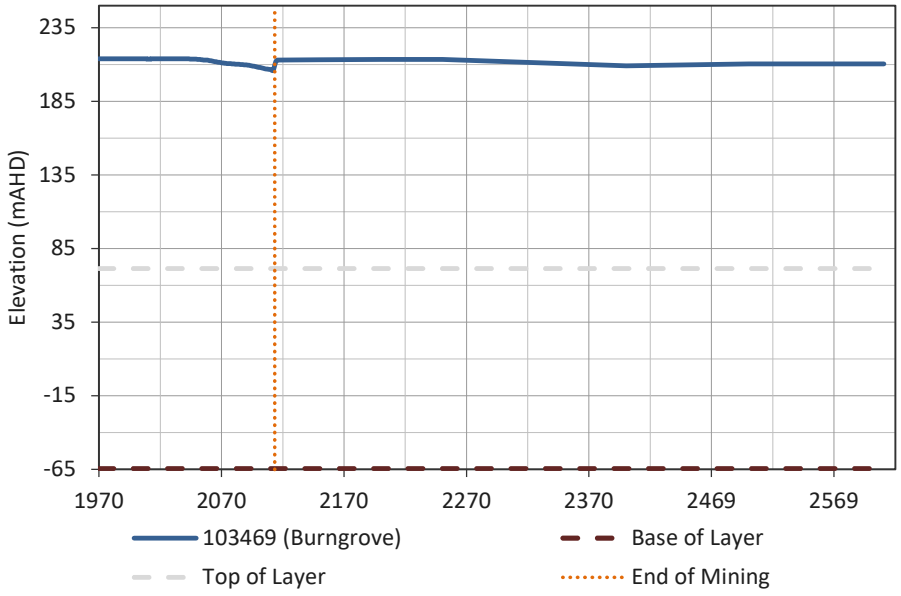

Elevation (mAHD)
270
220
170
120
70
20
1970
2070
2170
2270
2370
2469
2569
57422 (Burngrove)
Base of Layer
Top of Layer
End of Mining

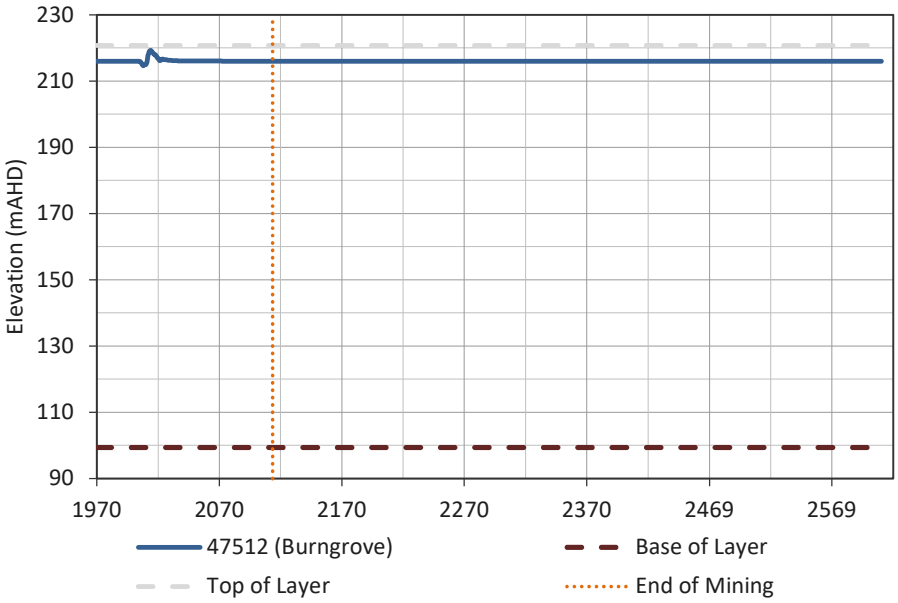

Elevation (mAHD)
245
235
225
215
205
195
185
175
165
155
145
1970
2070
2170
2270
2370
2469
2569
103347 (Burngrove)
Base of Layer
Top of Layer
End of Mining

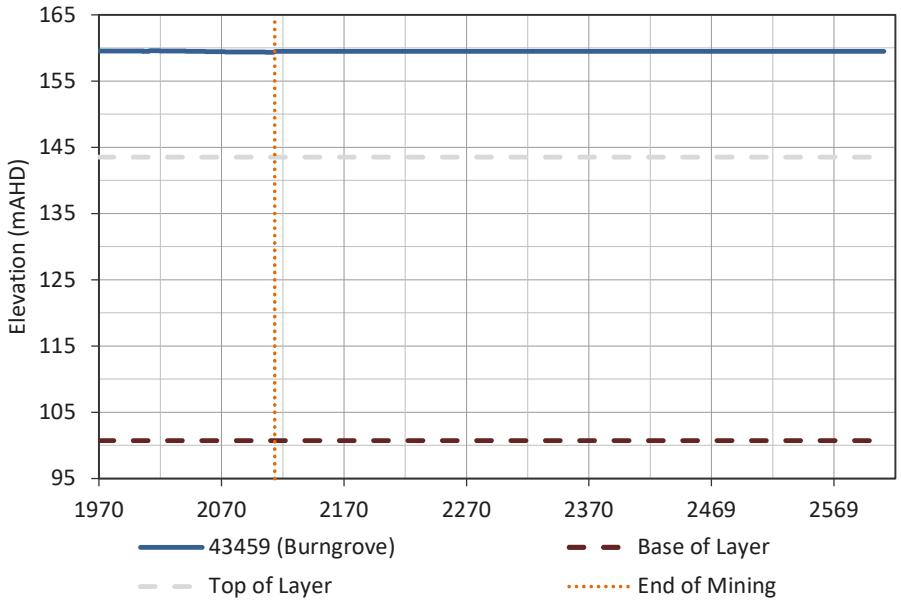

Elevation (mAHD)
280
260
240
220
200
180
160
140
120
100
1970
2070
2170
2270
2370
2469
2569
103348 (Burngrove)
Base of Layer
Top of Layer
End of Mining

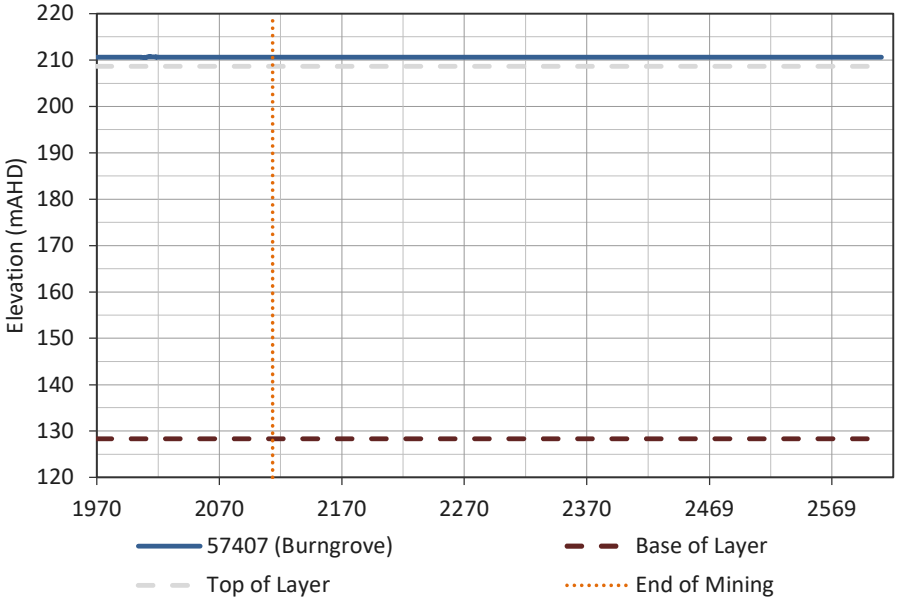

Elevation (mAHD)
275
255
235
215
195
175
155
135
115
95
75
1970
2070
2170
2270
2370
2469
2569
103349 (Burngrove)
Base of Layer
Top of Layer
End of Mining

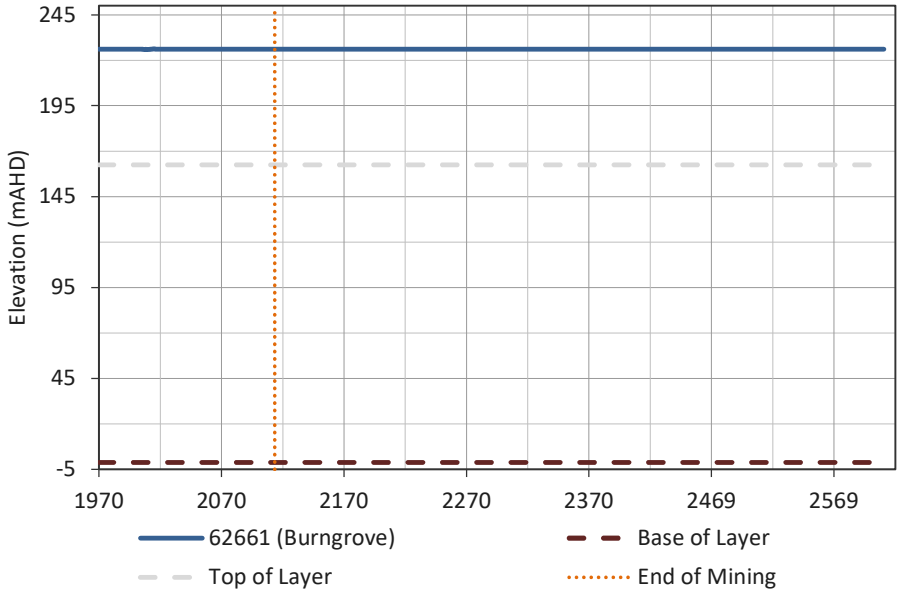

Elevation (mAHD)
145
125
105
85
65
45
25
1970
2070
2170
2270
2370
2469
2569
111877 (Burngrove)
Base of Layer
Top of Layer
End of Mining

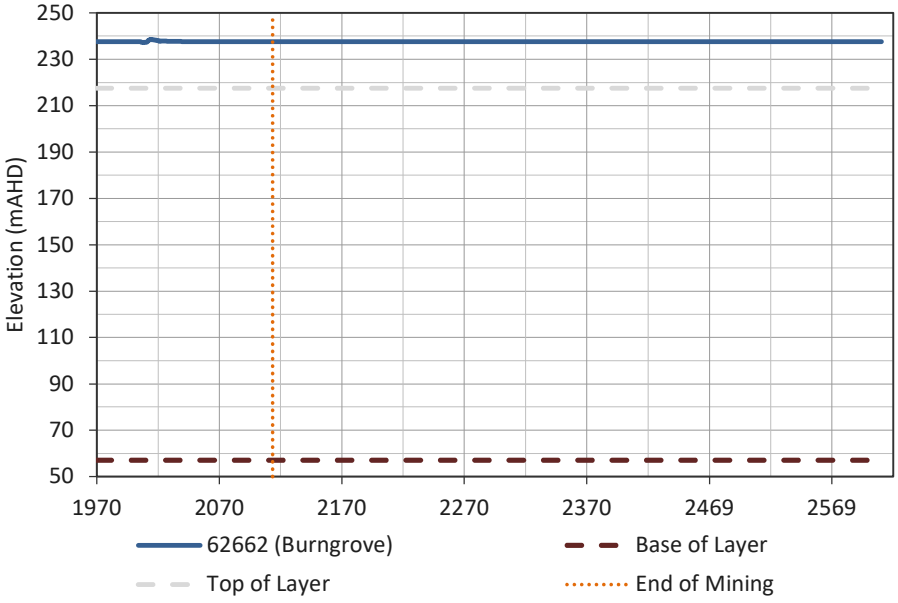

Elevation (mAHD)
235
185
135
85
35
-15
-65
1970
2070
2170
2270
2370
2469
2569
103469 (Burngrove)
Base of Layer
Top of Layer
End of Mining

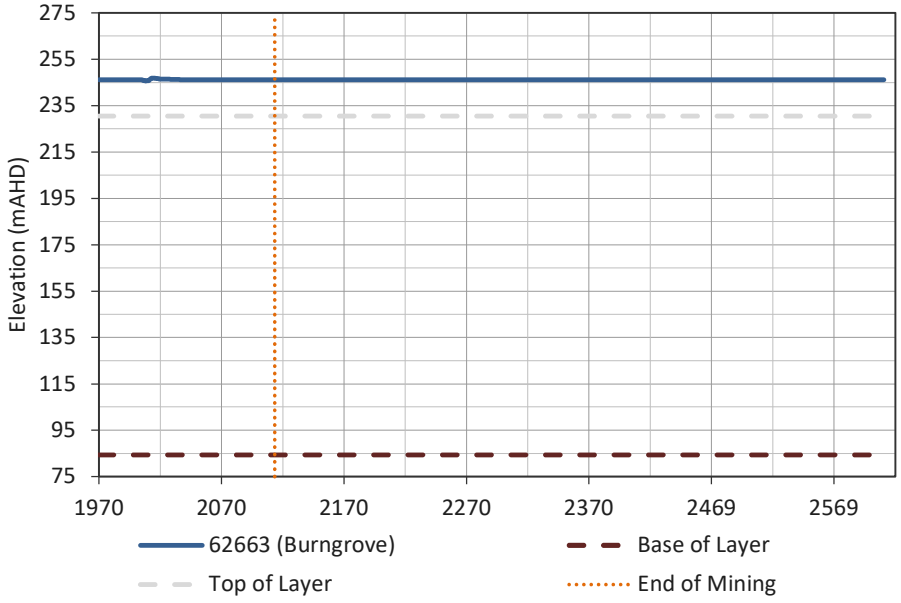

Elevation (mAHD)
230
210
190
170
150
130
110
90
1970
2070
2170
2270
2370
2469
2569
47512 (Burngrove)
Base of Layer
Top of Layer
End of Mining

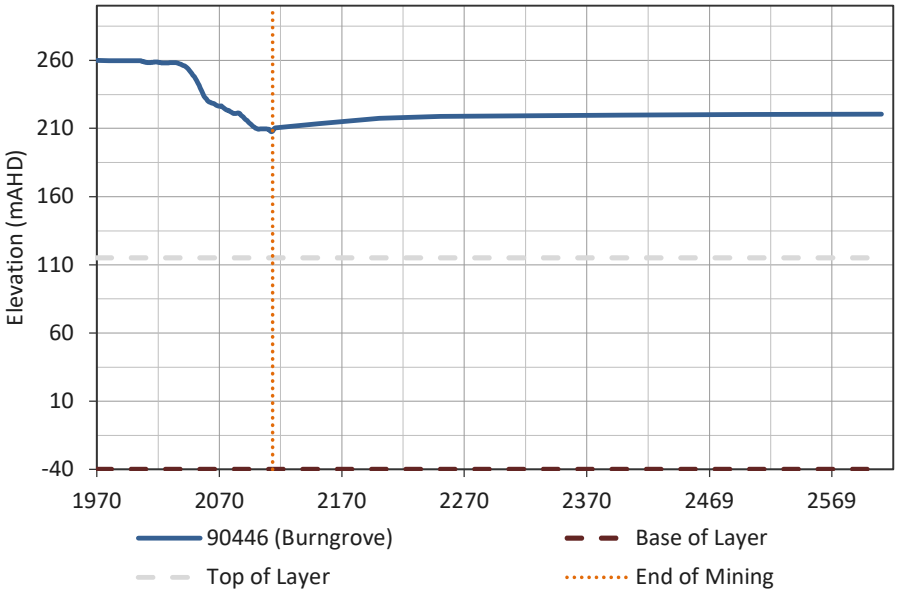

Elevation (mAHD)
165
155
145
135
125
115
105
95
1970
2070
2170
2270
2370
2469
2569
43459 (Burngrove)
Base of Layer
Top of Layer
End of Mining

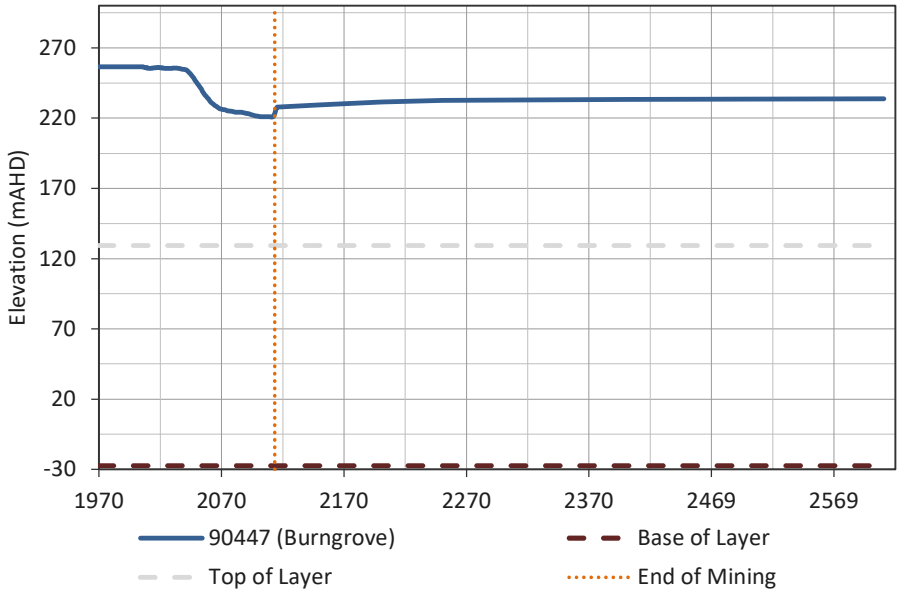

Elevation (mAHD)
220
210
200
190
180
170
160
150
140
130
120
1970
2070
2170
2270
2370
2469
2569
57407 (Burngrove)
Base of Layer
Top of Layer
End of Mining

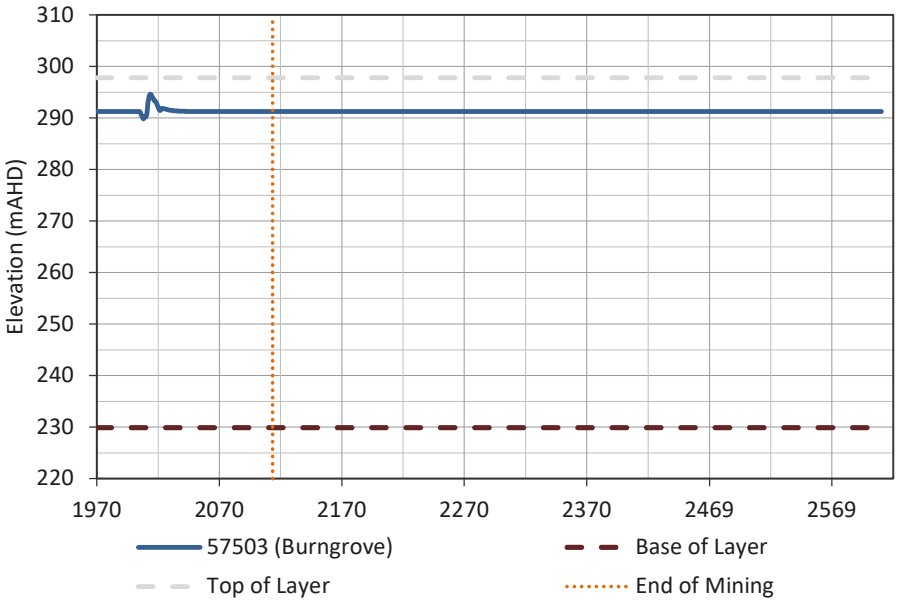

Elevation (mAHD)
245
195
145
95
45
-5
1970
2070
2170
2270
2370
2469
2569
62661 (Burngrove)
Base of Layer
Top of Layer
End of Mining

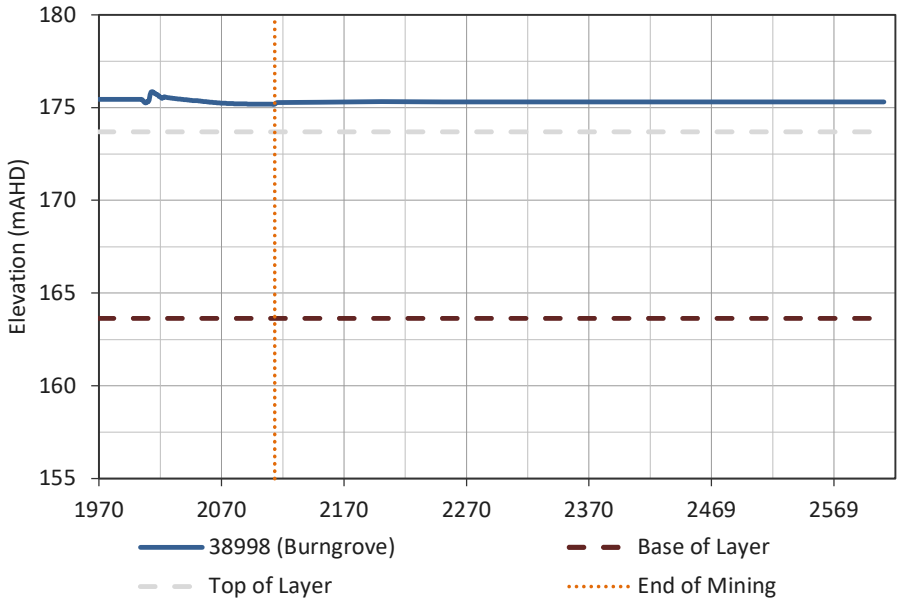

Elevation (mAHD)
250
230
210
190
170
150
130
110
90
70
50
1970
2070
2170
2270
2370
2469
2569
62662 (Burngrove)
Base of Layer
Top of Layer
End of Mining

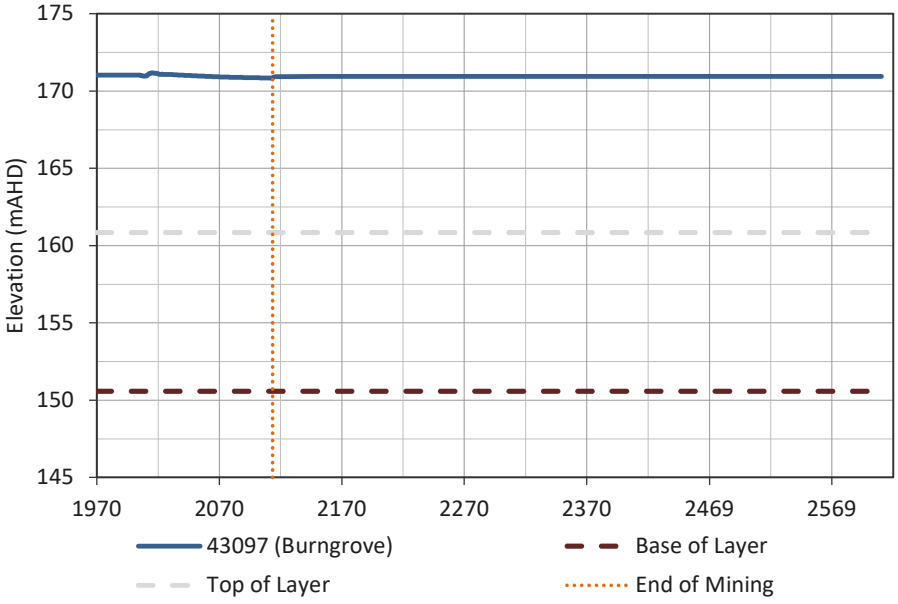

Elevation (mAHD)
275
255
235
215
195
175
155
135
115
95
75
1970
2070
2170
2270
2370
2469
2569
62663 (Burngrove)
Base of Layer
Top of Layer
End of Mining

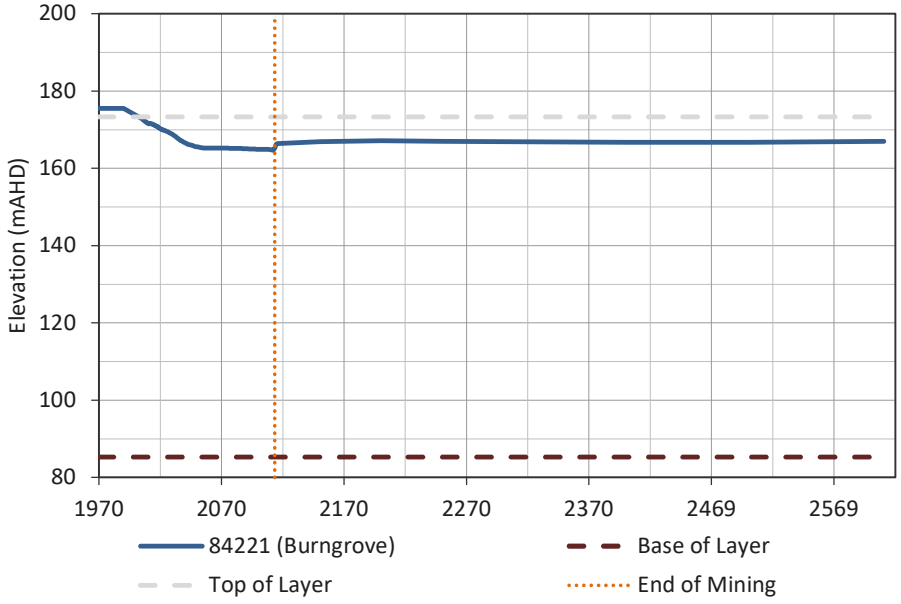

Elevation (mAHD)
260
210
160
110
60
10
-40
1970
2070
2170
2270
2370
2469
2569
90446 (Burngrove)
Base of Layer
Top of Layer
End of Mining

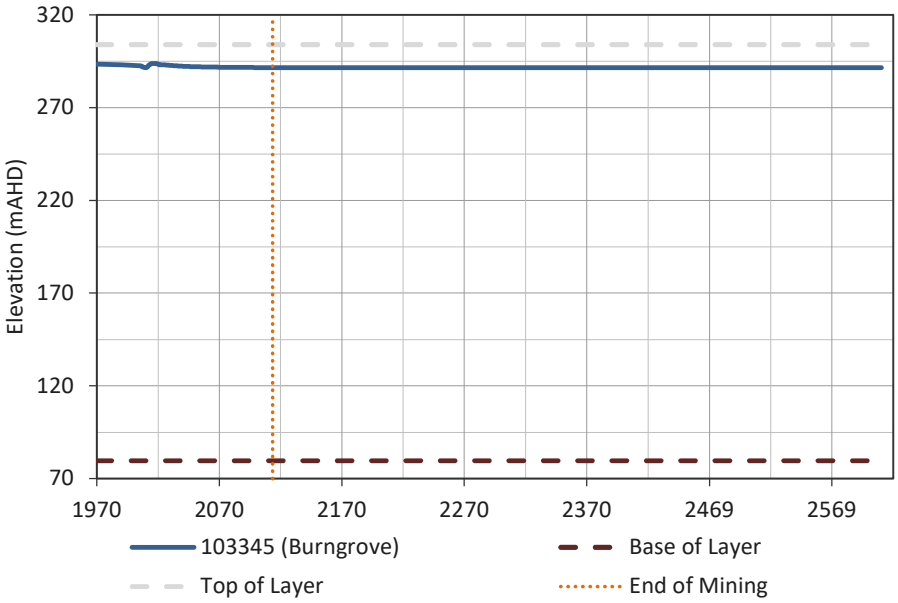

Elevation (mAHD)
270
220
170
120
70
20
-30
1970
2070
2170
2270
2370
2469
2569
90447 (Burngrove)
Base of Layer
Top of Layer
End of Mining

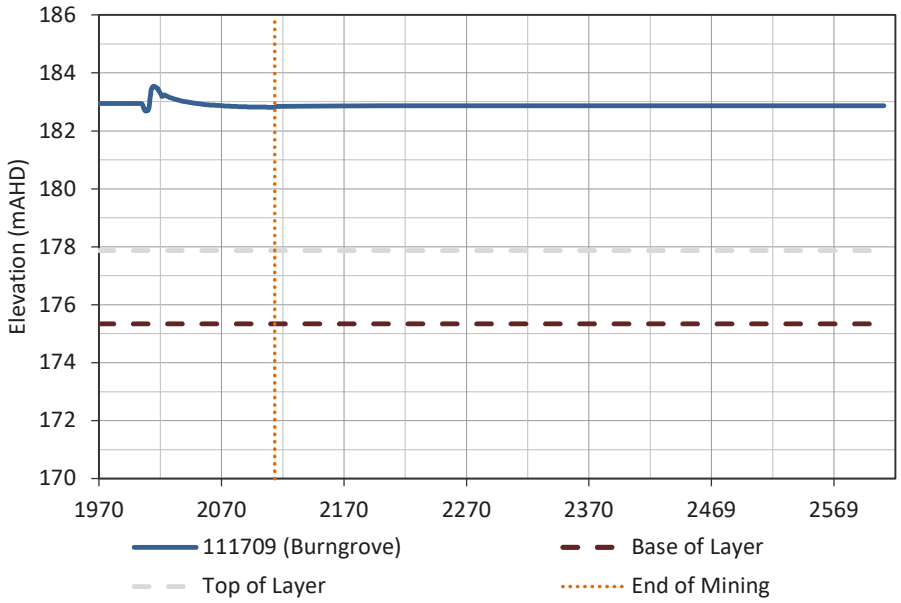

310
300
290
280
270
260
250
240
230
220
Elevation (mAHD)
1970
2070
2170
2270
2370
2469
2569
57503 (Burngrove)
Base of Layer
Top of Layer
End of Mining

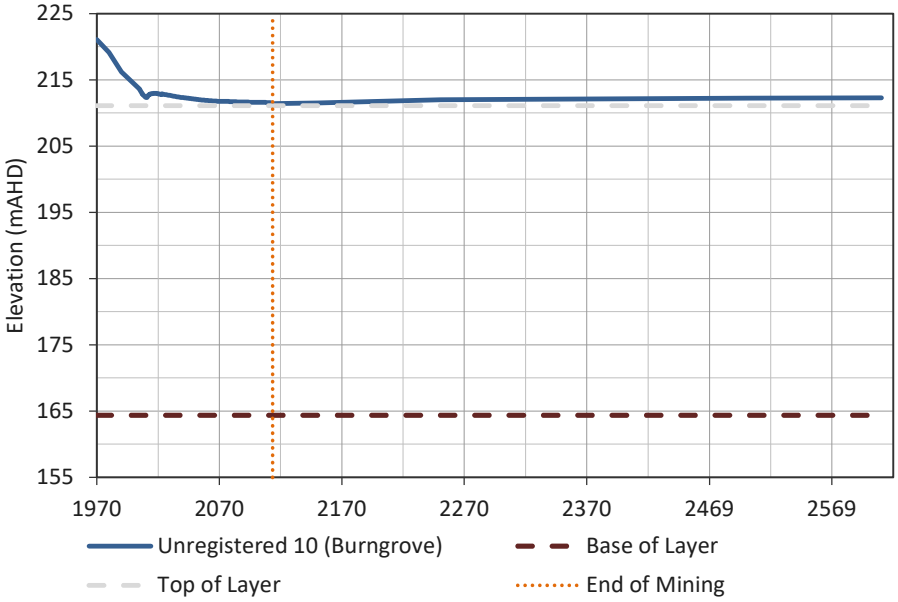

180
175
170
165
160
155
Elevation (mAHD)
1970
2070
2170
2270
2370
2469
2569
38998 (Burngrove)
Base of Layer
Top of Layer
End of Mining

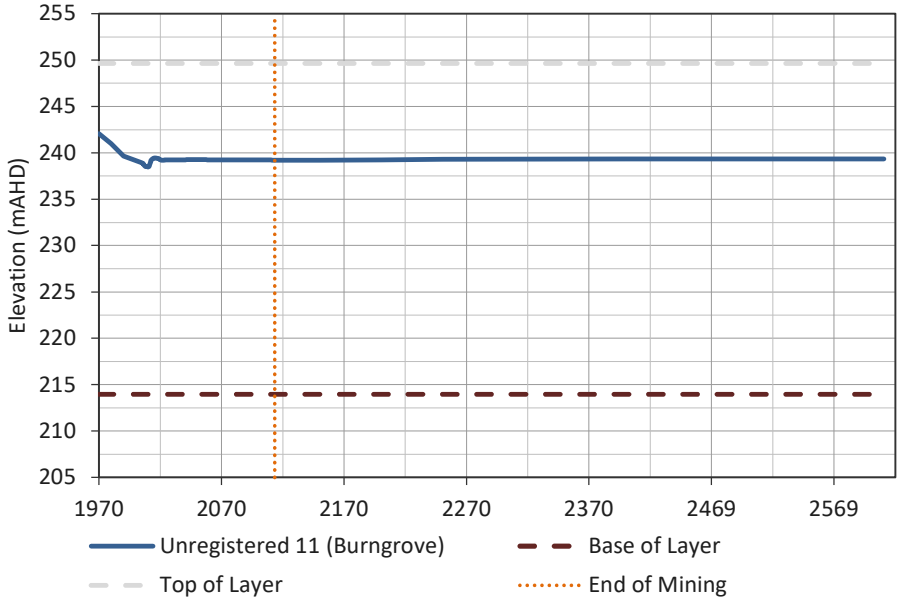

175
170
165
160
155
150
145
Elevation (mAHD)
1970
2070
2170
2270
2370
2469
2569
43097 (Burngrove)
Base of Layer
Top of Layer
End of Mining

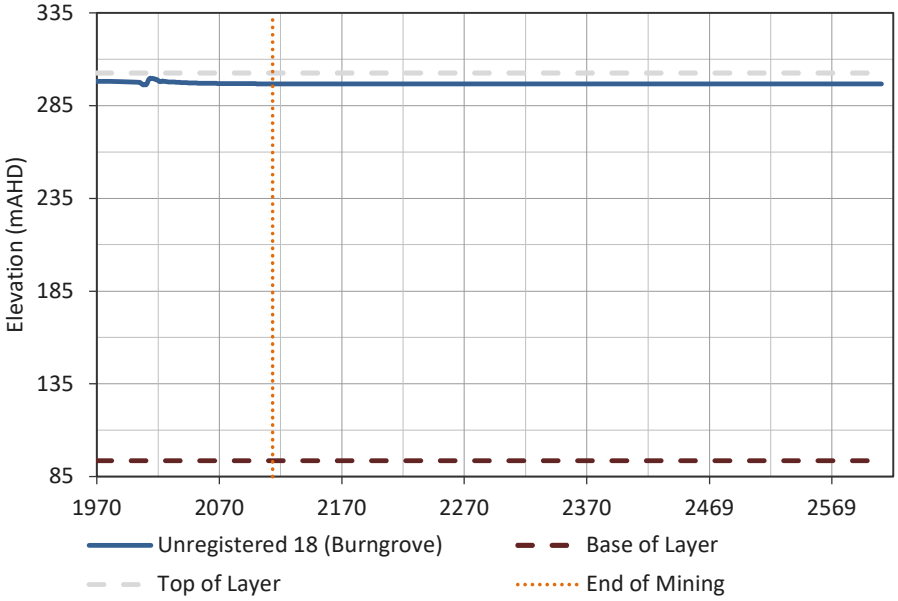

200
180
160
140
120
100
80
Elevation (mAHD)
1970
2070
2170
2270
2370
2469
2569
84221 (Burngrove)
Base of Layer
Top of Layer
End of Mining

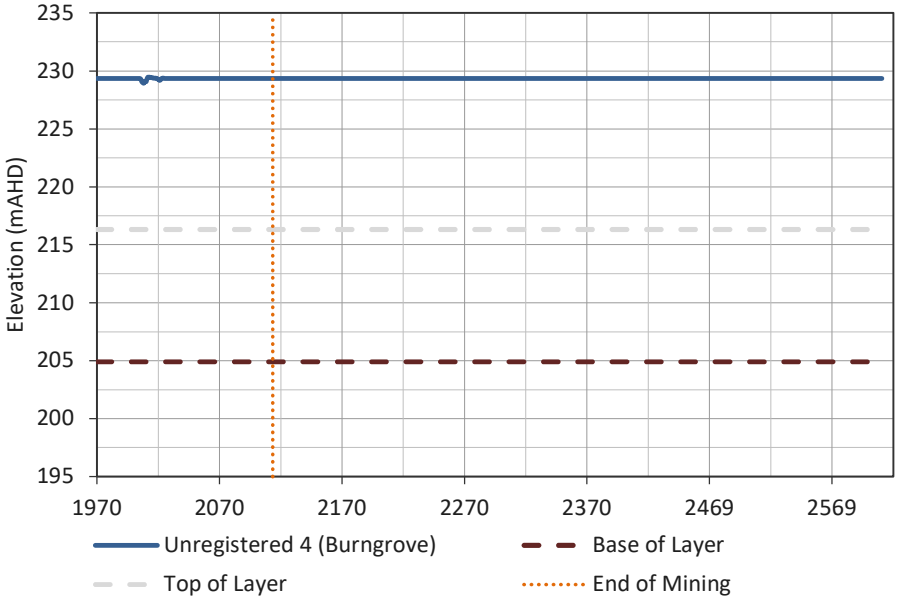

320
270
220
170
120
70
Elevation (mAHD)
1970
2070
2170
2270
2370
2469
2569
103345 (Burngrove)
Base of Layer
Top of Layer
End of Mining

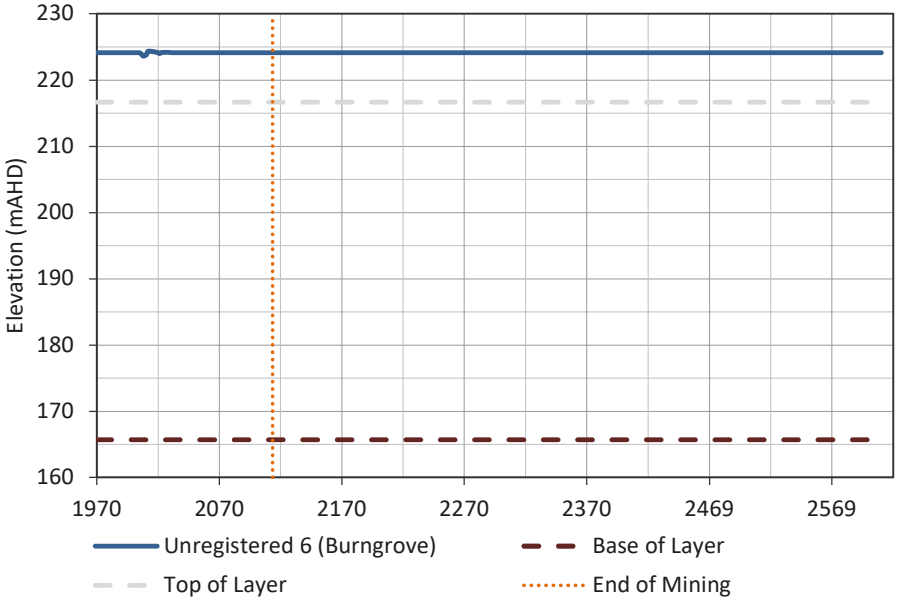

186
184
182
180
178
176
174
172
170
Elevation (mAHD)
1970
2070
2170
2270
2370
2469
2569
111709 (Burngrove)
Base of Layer
Top of Layer
End of Mining

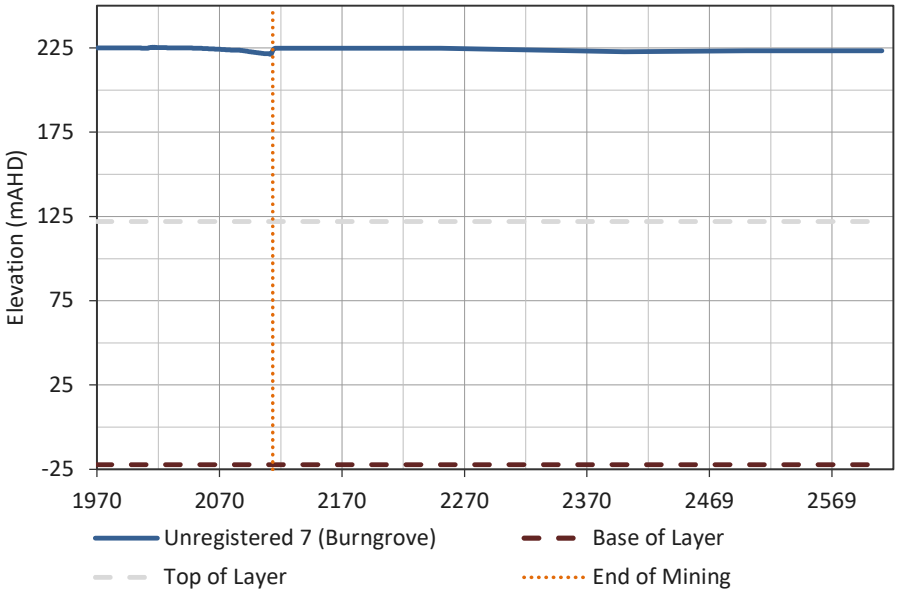

225
215
205
195
185
175
165
155
Elevation (mAHD)
1970
2070
2170
2270
2370
2469
2569
Unregistered 10 (Burngrove)
Base of Layer
Top of Layer
End of Mining

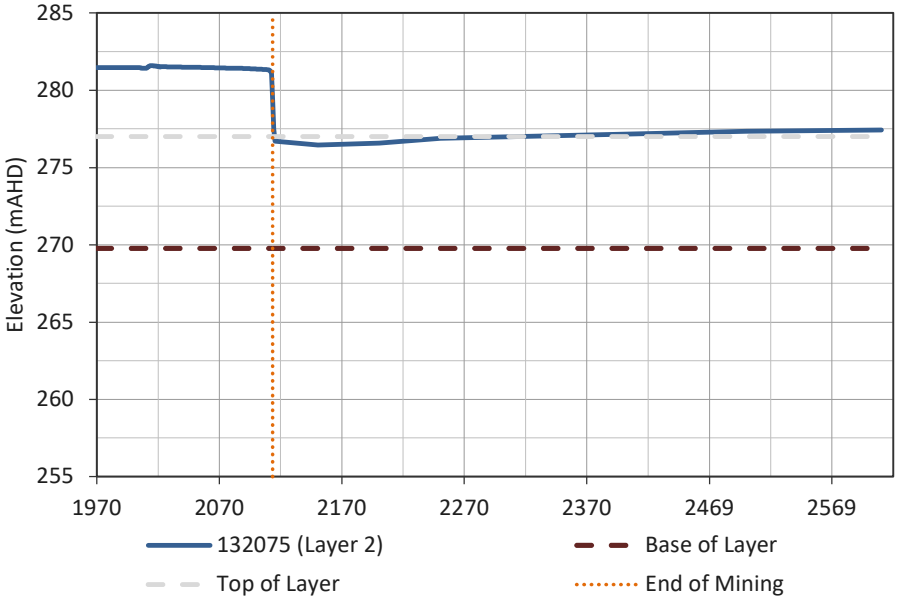

255
250
245
240
235
230
225
220
215
210
205
Elevation (mAHD)
1970
2070
2170
2270
2370
2469
2569
Unregistered 11 (Burngrove)
Base of Layer
Top of Layer
End of Mining


335
285
235
185
135
85
Elevation (mAHD)
1970
2070
2170
2270
2370
2469
2569
Unregistered 18 (Burngrove)
Base of Layer
Top of Layer
End of Mining


235
230
225
220
215
210
205
200
195
Elevation (mAHD)
1970
2070
2170
2270
2370
2469
2569
Unregistered 4 (Burngrove)
Base of Layer
Top of Layer
End of Mining


230
220
210
200
190
180
170
160
Elevation (mAHD)
1970
2070
2170
2270
2370
2469
2569
Unregistered 6 (Burngrove)
Base of Layer
Top of Layer
End of Mining


225
175
125
75
25
-25
Elevation (mAHD)
1970
2070
2170
2270
2370
2469
2569
Unregistered 7 (Burngrove)
Base of Layer
Top of Layer
End of Mining


285
280
275
270
265
260
255
Elevation (mAHD)
1970
2070
2170
2270
2370
2469
2569
132075 (Layer 2)
Base of Layer
Top of Layer
End of Mining

Appendix E Drier Climate Scenario Model Predictions

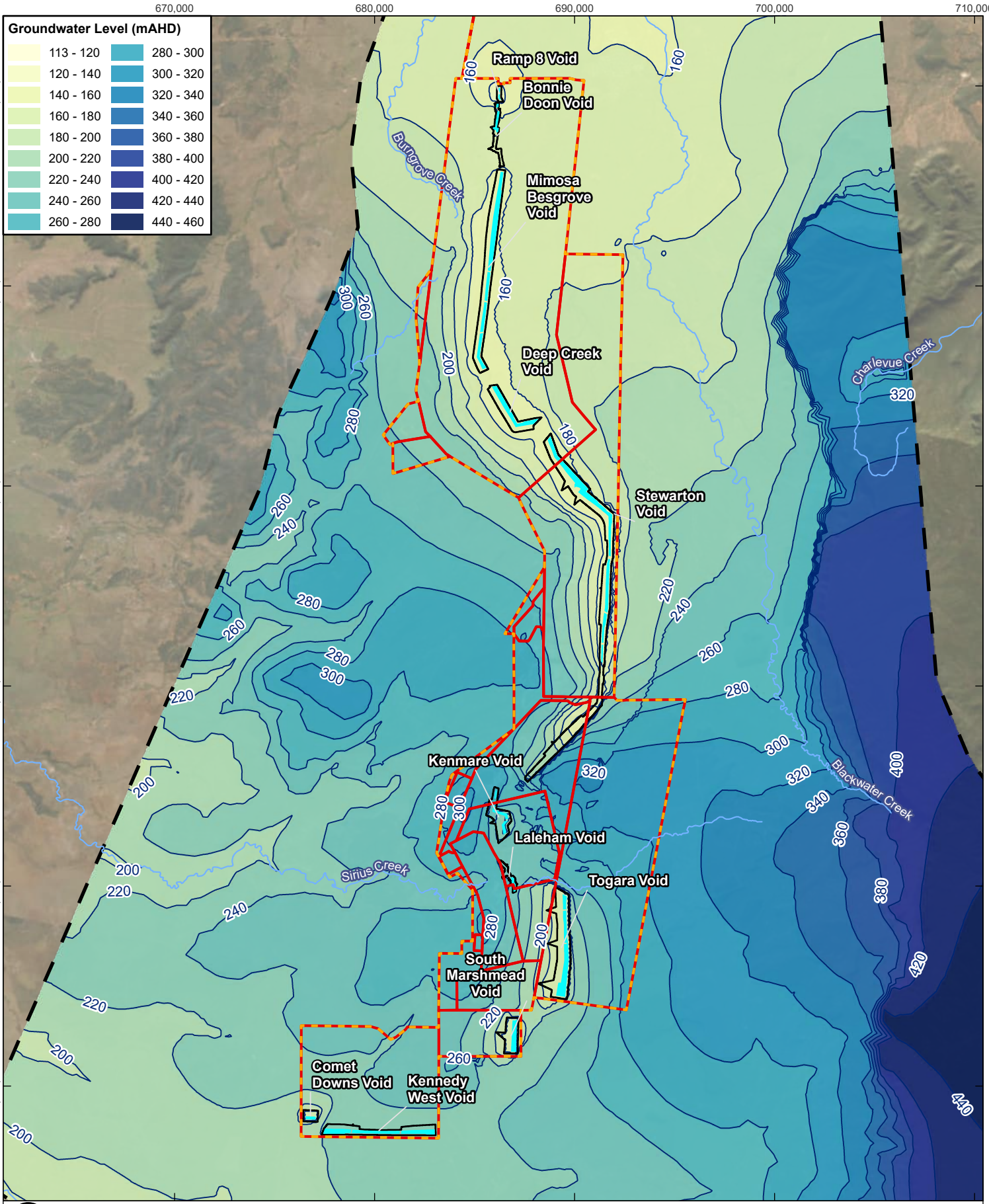
Blackwater Mine

Transitional PRC Plan Hydrogeology Assessment

Whitehaven Coal Limited

SLR Project No.: 620.040199.00001

16 September 2024



0 2.5 5 km

Coordinate System:	GDA2020 MGA Zone 55
Scale:	1:250,000 at A4
Project Number:	620.040199
Date Drawn:	09-Aug-2024
Drawn by:	AS

LEGEND

- Watercourse
- Groundwater Level (mAHD)
- BWM Mining Lease
- Project Area (Environmental Authorities boundary)
- Study Area
- Void Extent
- Void Lake

BLACKWATER MINE - TRANSITIONAL PRCP HYDROGEOLOGY ASSESSMENT

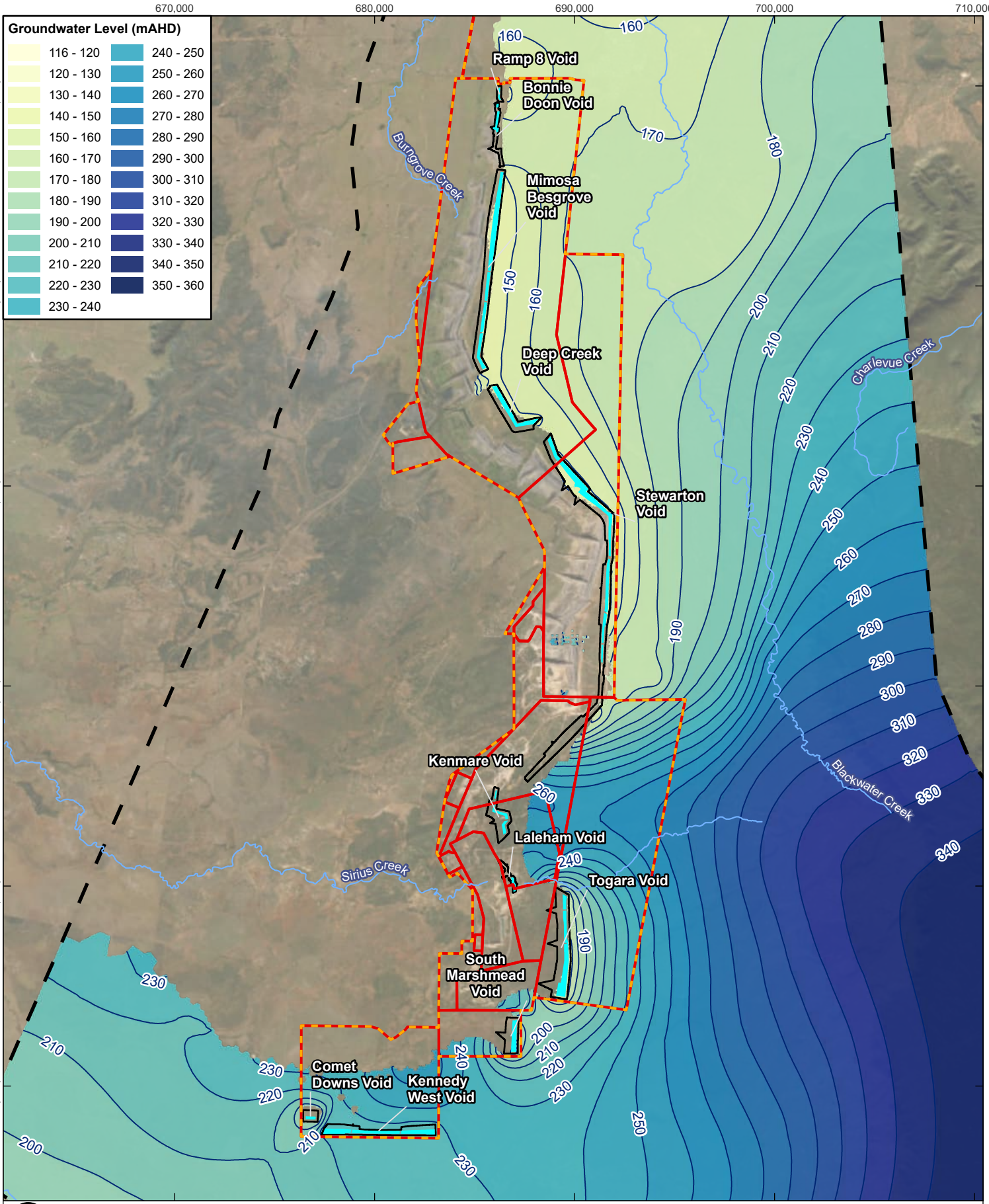
PREDICTED WATER TABLE ELEVATION – POST-MINING EQUILIBRIUM (DRIER CLIMATE SCENARIO)

SLR

DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.

FIGURE E-1

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040199.00001 BWM PRCP – GW\03 SLR Data\01 CADGIS\GIS\ArcPro\BWM PRCP – GW\BWM PRCP – GW.aprx\620040199_FE_01_Predicted Water Table Elevation – PME (Drier Climate Scenario)



0 2.5 5 km

Coordinate System:	GDA2020 MGA Zone 55
Scale:	1:250,000 at A4
Project Number:	620.040199
Date Drawn:	09-Aug-2024
Drawn by:	AS

LEGEND

- Watercourse
- Groundwater Level (mAHD)
- BWM Mining Lease
- Project Area (Environmental Authorities boundary)
- Study Area
- Void Extent
- Void Lake

BLACKWATER MINE - TRANSITIONAL PRCP HYDROGEOLOGY ASSESSMENT

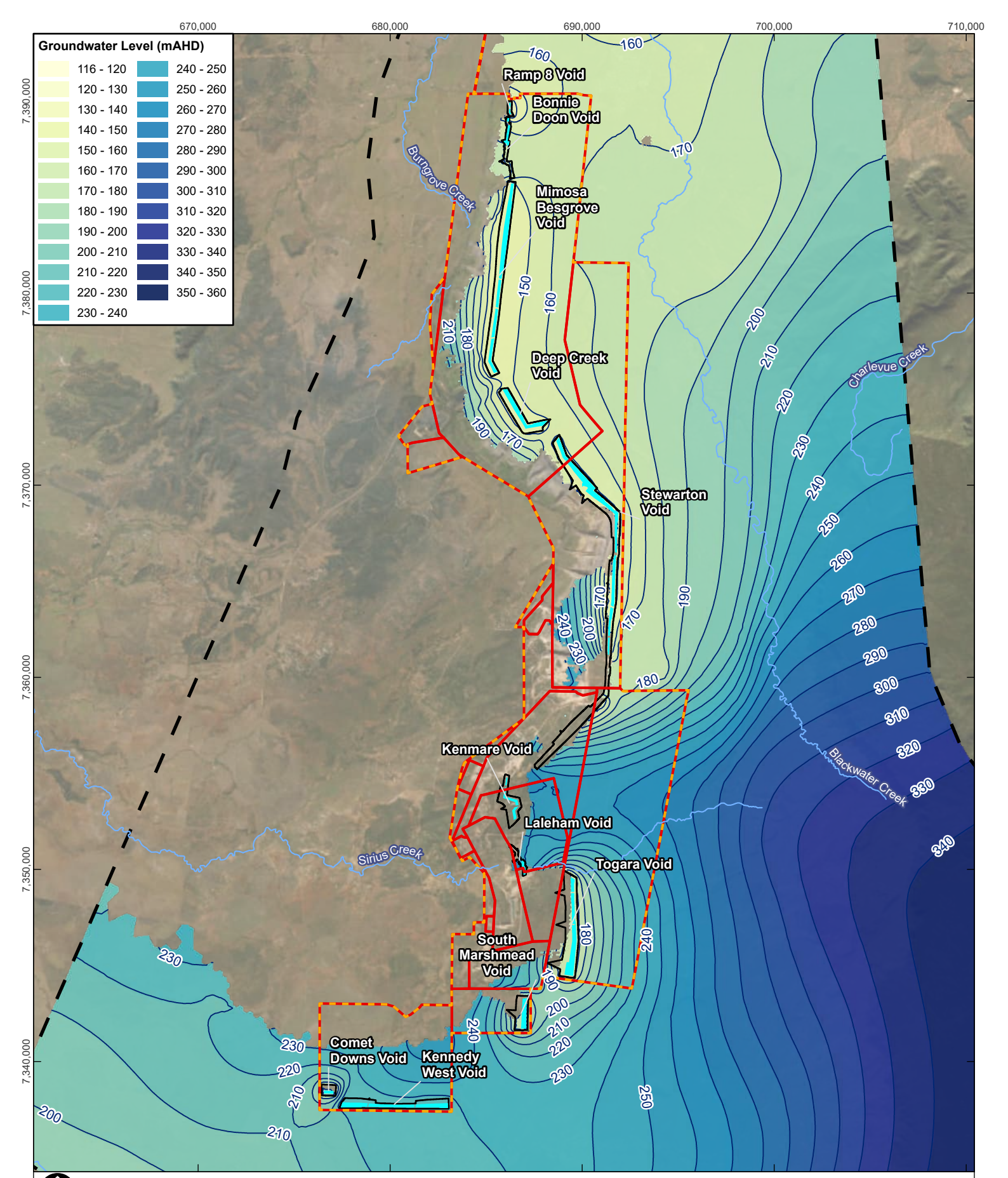
PREDICTED GROUNDWATER LEVELS IN THE ARIES SEAM (LAYER 8) – POST-MINING EQUILIBRIUM (DRIER CLIMATE SCENARIO)

SLR

DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.

FIGURE E-2

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040199.00001 BWM PRCP – GW\03 SLR Data\01 CADGIS\GIS\ArcPro\BWM PRCP – GW\BWM PRCP – GW.aprx\620040199_FE_02_Predicted Groundwater Levels in the Aries Seam (Layer 8) – PME (Drier Climate Scenario)



0 2.5 5 km

Coordinate System:	GDA2020 MGA Zone 55
Scale:	1:250,000 at A4
Project Number:	620.040199
Date Drawn:	09-Aug-2024
Drawn by:	AS

LEGEND

- Watercourse
- Groundwater Level (mAHD)
- BWM Mining Lease
- Project Area (Environmental Authorities boundary)
- Study Area
- Void Extent
- Void Lake

BLACKWATER MINE - TRANSITIONAL PRCP HYDROGEOLOGY ASSESSMENT

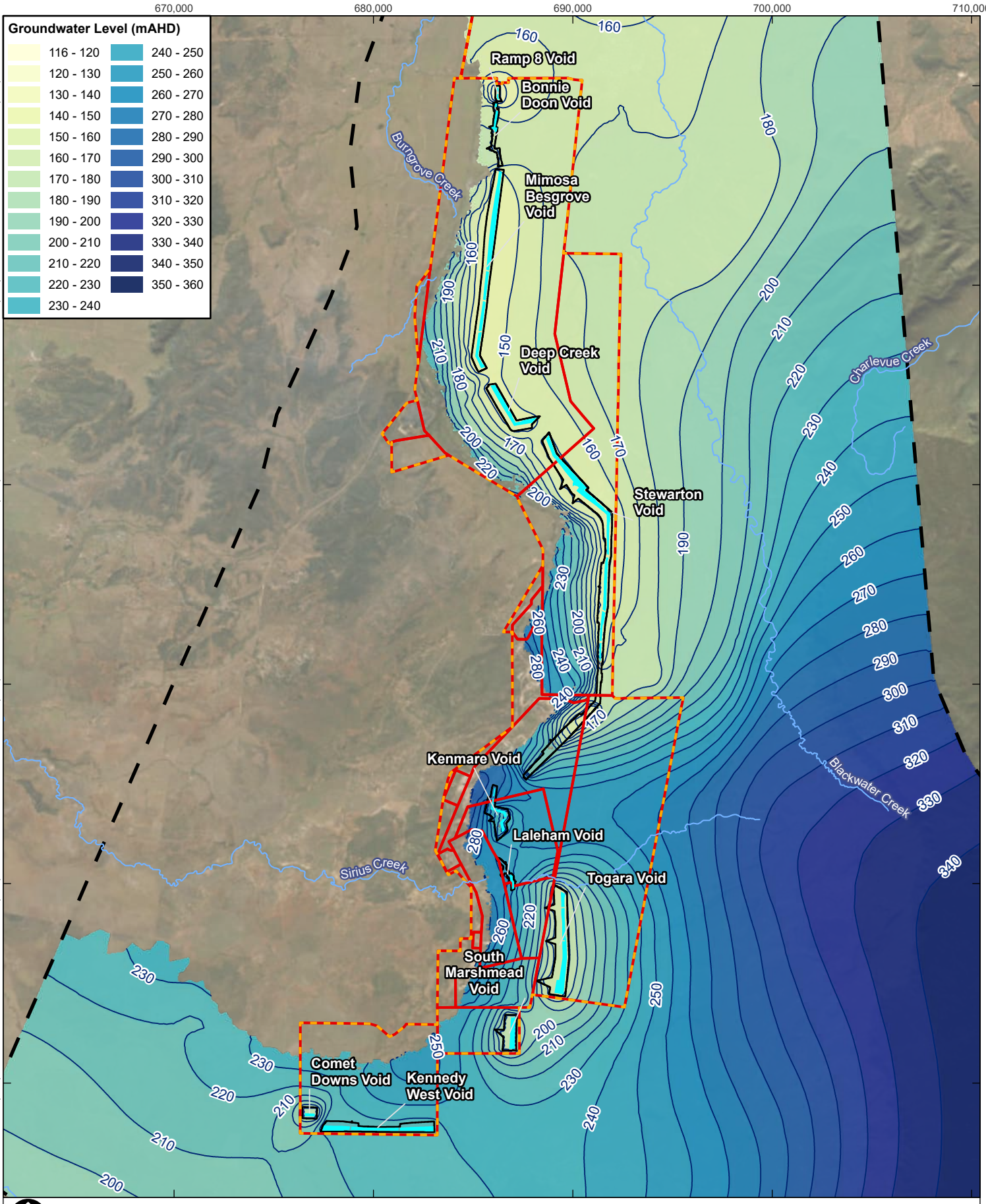
PREDICTED GROUNDWATER LEVELS IN THE CASTOR SEAM (LAYER 10) – POST-MINING EQUILIBRIUM (DRIER CLIMATE SCENARIO)

SLR

DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.

FIGURE E-3

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040199.00001 BWM PRCP – GW\03 SLR Data\01 CADGIS\GIS\ArcPro\BWM PRCP – GW\BWM PRCP – GW.aprx\620040199_FE_03_Predicted Groundwater Levels in the Castor Seam (Layer 10) – PME (Drier Climate Scenario)



0 2.5 5 km

Coordinate System:	GDA2020 MGA Zone 55
Scale:	1:250,000 at A4
Project Number:	620.040199
Date Drawn:	09-Aug-2024
Drawn by:	AS

LEGEND

- Watercourse
- Groundwater Level (mAHD)
- BWM Mining Lease
- Project Area (Environmental Authorities boundary)
- Study Area
- Void Extent
- Void Lake

BLACKWATER MINE - TRANSITIONAL PRCP HYDROGEOLOGY ASSESSMENT

PREDICTED GROUNDWATER LEVELS IN THE POLLUX SEAM (LAYER 12) – POST-MINING EQUILIBRIUM (DRIER CLIMATE SCENARIO)

SLR

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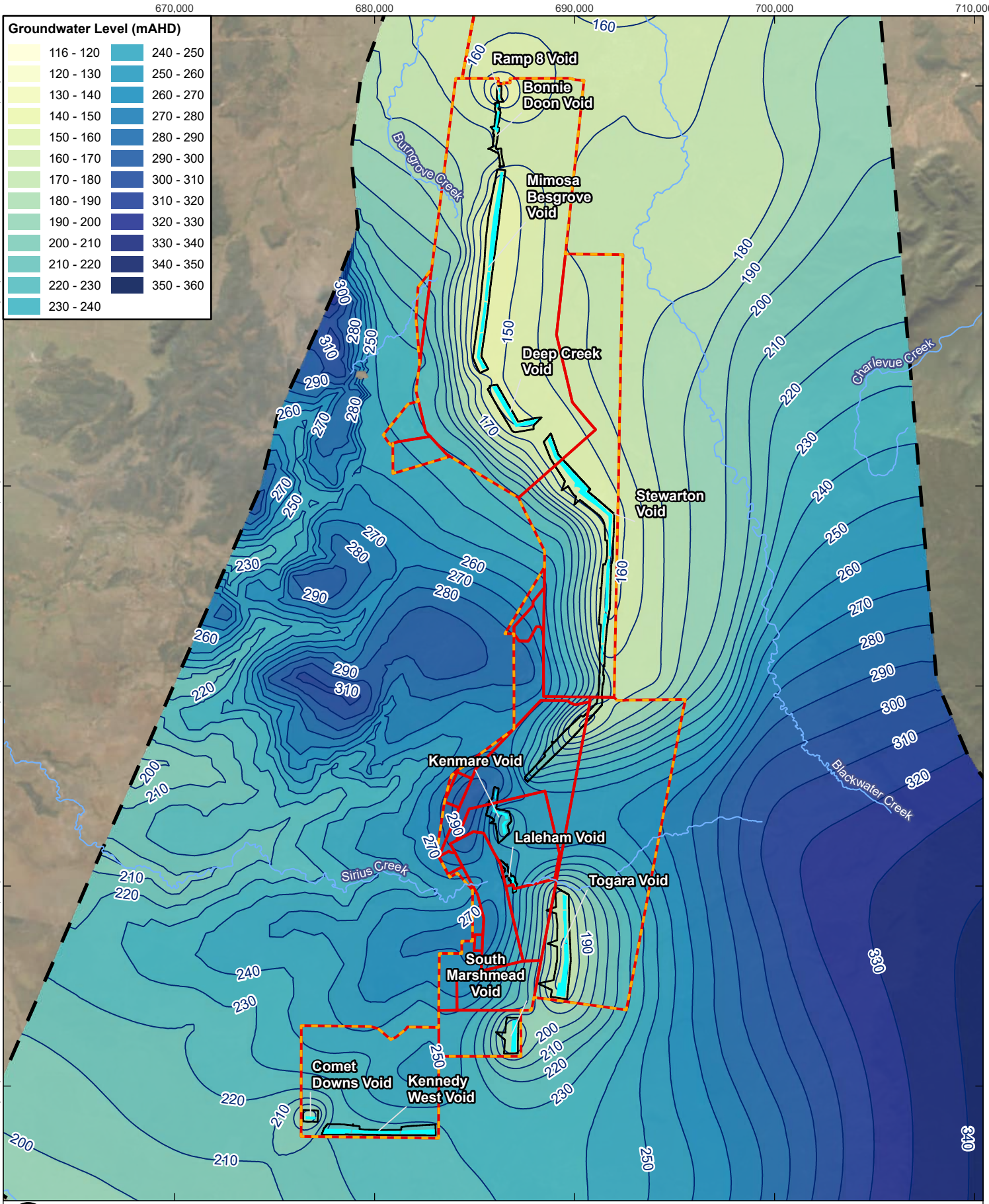
FIGURE E-4

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040199.00001 BWM PRCP – GW\03 SLR Data\01 CADGIS\GIS\ArcPro\BWM PRCP – GW\BWM PRCP – GW.aprx\620040199_FE_04_Predicted Groundwater Levels in the Pollux Seam (Layer 12) – PME (Drier Climate Scenario)



0 2.5 5 km

Coordinate System:	GDA2020 MGA Zone 55
Scale:	1:250,000 at A4
Project Number:	620.040199
Date Drawn:	09-Aug-2024
Drawn by:	AS

LEGEND

- Watercourse
- Groundwater Level (mAHD)
- BWM Mining Lease
- Project Area (Environmental Authorities boundary)
- Study Area
- Void Extent
- Void Lake

BLACKWATER MINE - TRANSITIONAL PRCP HYDROGEOLOGY ASSESSMENT

PREDICTED GROUNDWATER LEVELS IN THE BURNGROVE FORMATION (LAYER 14) – POST-MINING EQUILIBRIUM (DRIER CLIMATE SCENARIO)

SLR

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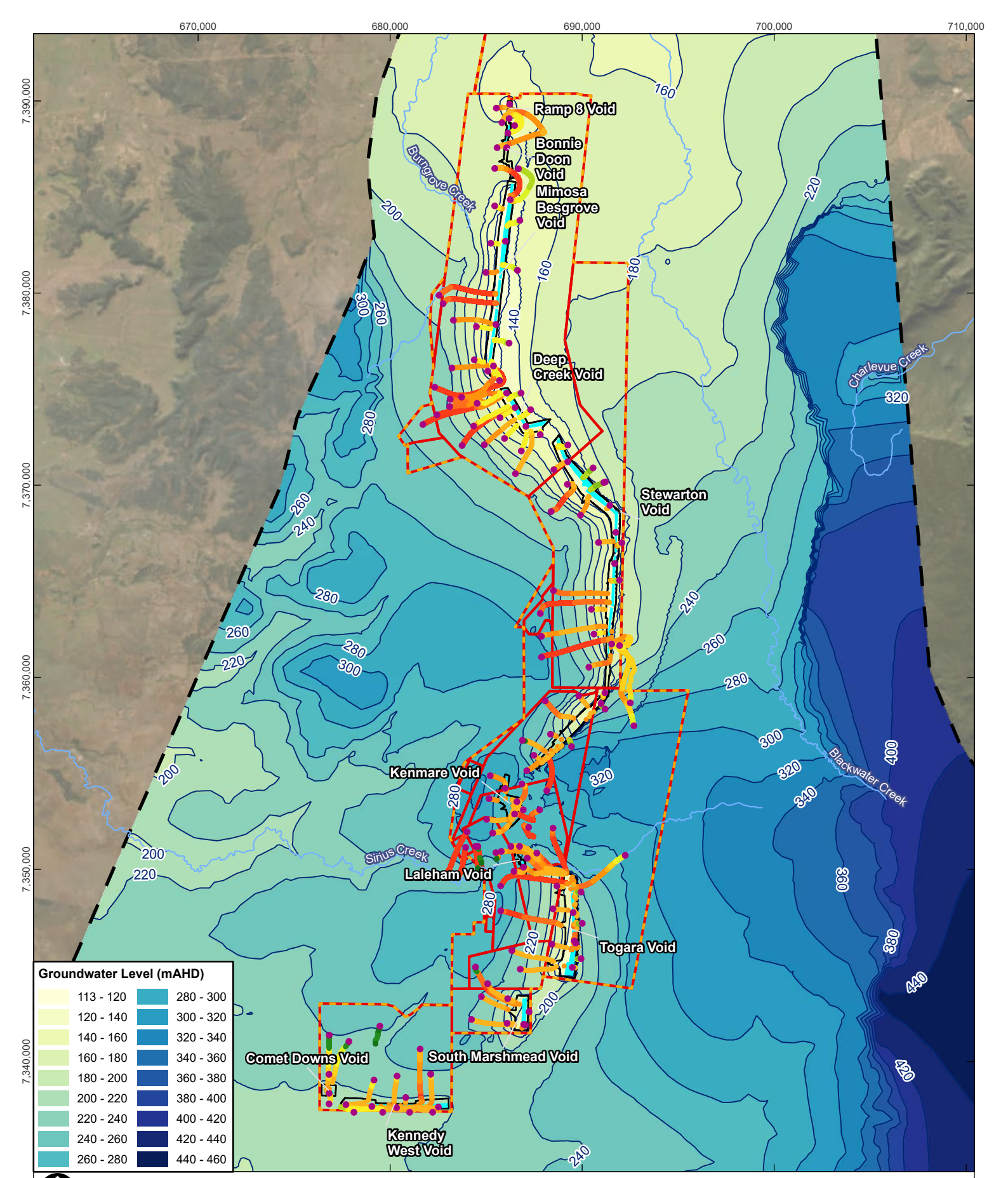
FIGURE E-5

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040199.00001 BWM PRCP – GW\03 SLR Data\01 CADGIS\GIS\ArcPro\BWM PRCP – GW\BWM PRCP – GW.aprx\620040199_FE_05_Predicted Groundwater Levels in the Burngrove Formation (Layer 14) – PME (Drier Climate Scenario)



Coordinate System:	GDA2020 MGA Zone 55
Scale:	1:250,000 at A4
Project Number:	620.040199
Date Drawn:	09-Aug-2024
Drawn by:	AS

BLACKWATER MINE - TRANSITIONAL PRCP HYDROGEOLOGY ASSESSMENT

PREDICTED MOVEMENT OF PARTICLES (DRIER CLIMATE SCENARIO)

SLR

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FIGURE E-6

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040199.00001 BWM PRCP – GW\03 SLR Data\01 CADGIS\GIS\ArcPro\BWM PRCP – GW\BWM PRCP – GW.aprx\620040199_FE_06_Predicted Movement of Particles (Drier Climate Scenario)

Appendix F Wetter Climate Scenario Model Predictions

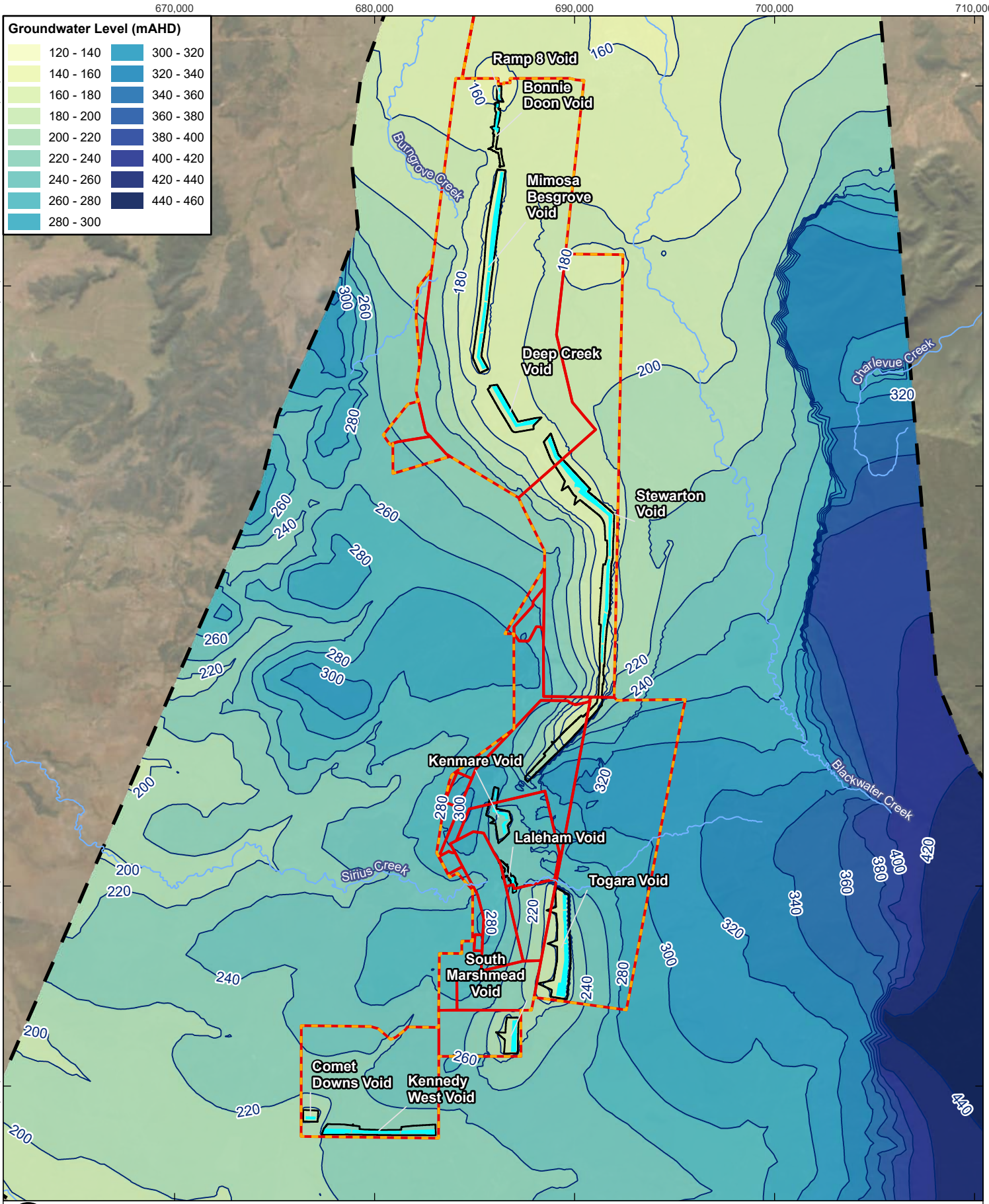
Blackwater Mine

Transitional PRC Plan Hydrogeology Assessment

Whitehaven Coal Limited

SLR Project No.: 620.040199.00001

16 September 2024



0 2.5 5 km

Coordinate System:	GDA2020 MGA Zone 55
Scale:	1:250,000 at A4
Project Number:	620.040199
Date Drawn:	09-Aug-2024
Drawn by:	AS

LEGEND

- Watercourse
- Groundwater Level (mAHD)
- BWM Mining Lease
- Project Area (Environmental Authorities boundary)
- Study Area
- Void Extent
- Void Lake

BLACKWATER MINE - TRANSITIONAL PRCP HYDROGEOLOGY ASSESSMENT

PREDICTED WATER TABLE ELEVATION – POST-MINING EQUILIBRIUM (WETTER CLIMATE SCENARIO)

SLR

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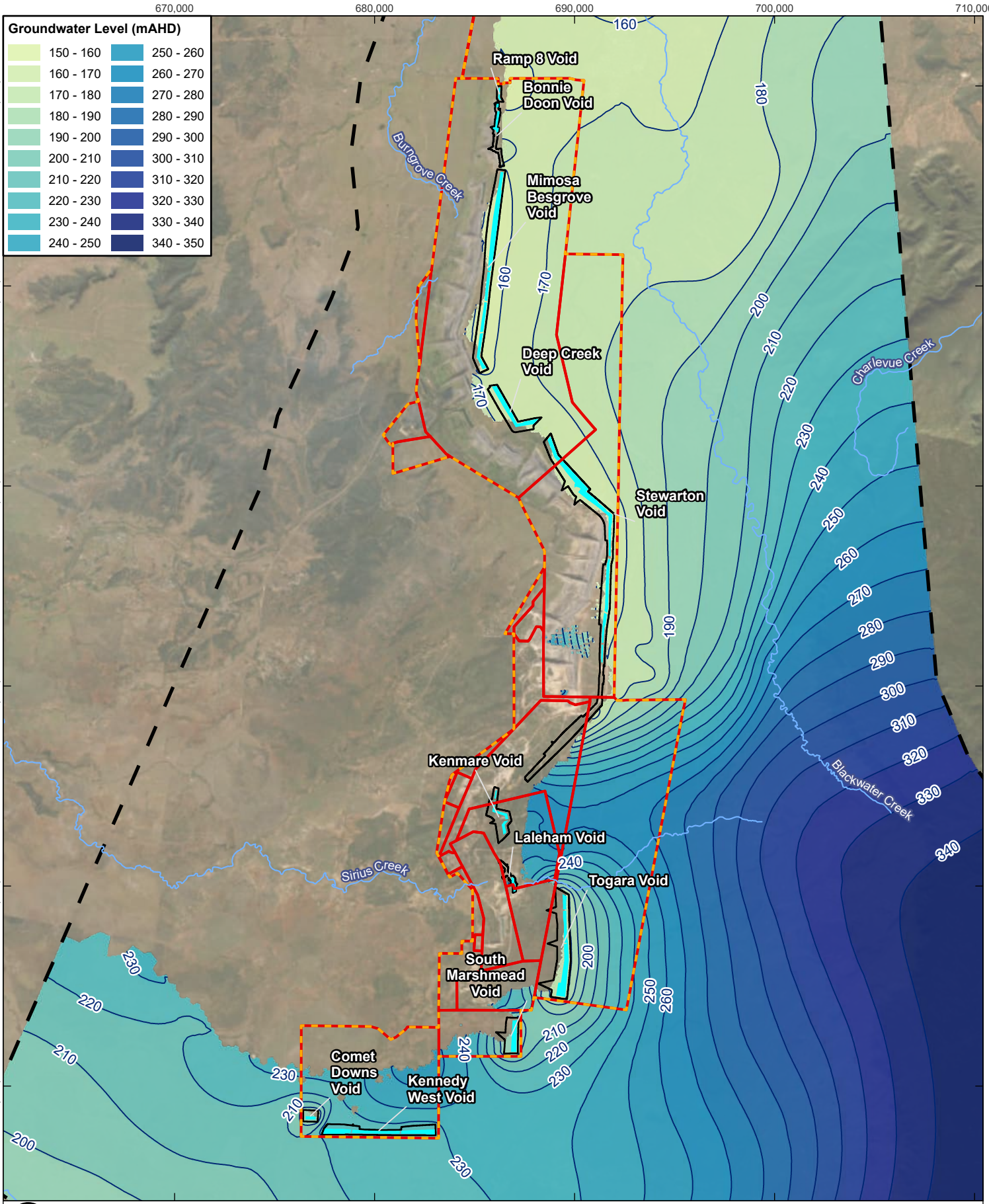
FIGURE F-1

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040199.00001 BWM PRCP – GW\03 SLR Data\01 CADGIS\GIS\ArcPro\BWM PRCP – GW\BWM PRCP – GW.aprx\620040199_FF_01_Predicted Water Table Elevation – PME (Wetter Climate Scenario)



0 2.5 5 km

Coordinate System:	GDA2020 MGA Zone 55
Scale:	1:250,000 at A4
Project Number:	620.040199
Date Drawn:	09-Aug-2024
Drawn by:	AS

LEGEND

- Watercourse
- Groundwater Level (mAHD)
- BWM Mining Lease
- Project Area (Environmental Authorities boundary)
- Study Area
- Void Extent
- Void Lake

BLACKWATER MINE - TRANSITIONAL PRCP HYDROGEOLOGY ASSESSMENT

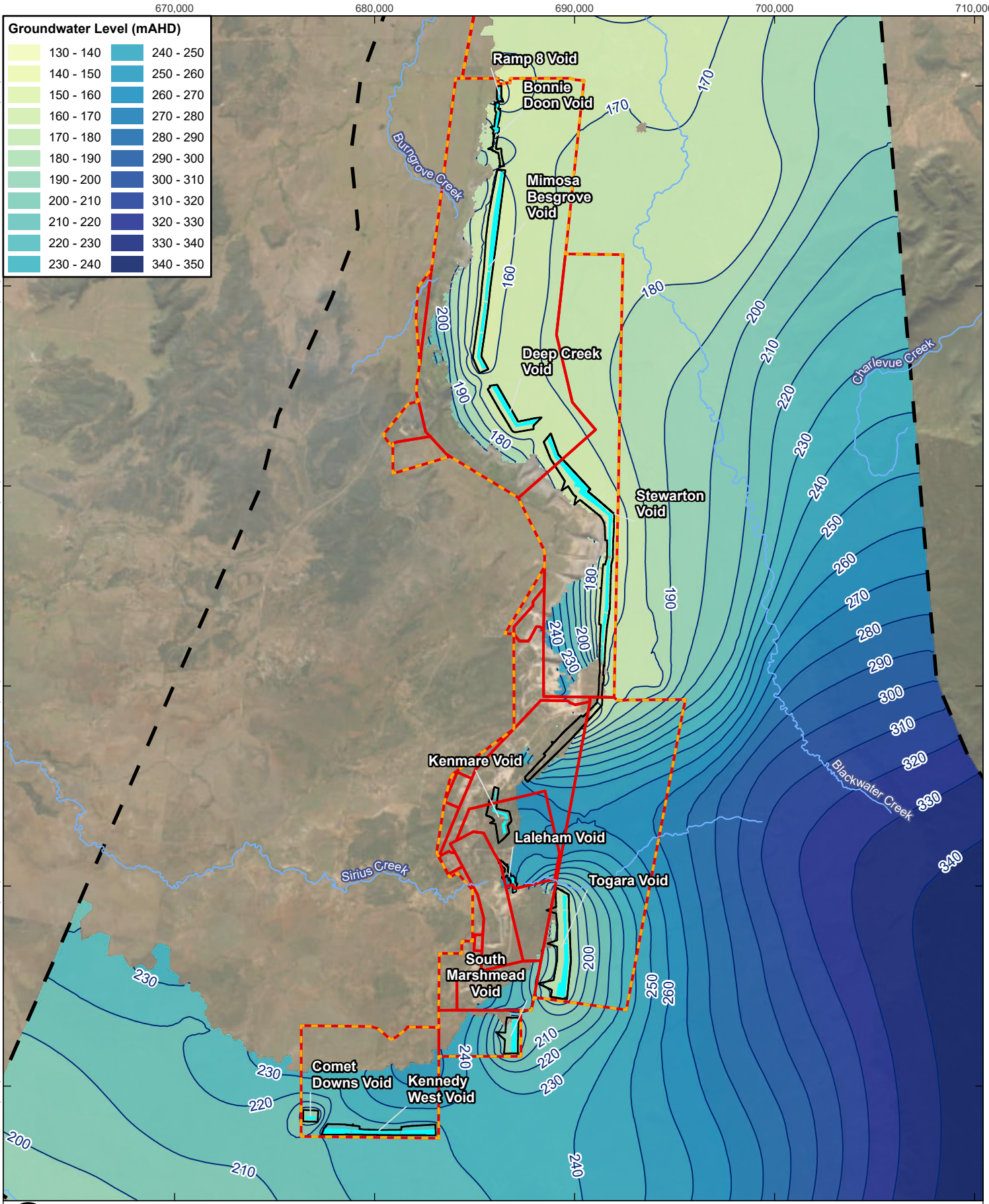
PREDICTED GROUNDWATER LEVELS IN THE ARIES SEAM (LAYER 8) – POST-MINING EQUILIBRIUM (WETTER CLIMATE SCENARIO)

SLR

DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.

FIGURE F-2

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040199.00001 BWM PRCP – GW\03 SLR Data\01 CADGIS\GIS\ArcPro\BWM PRCP – GW\BWM PRCP – GW.aprx\620040199_FF_02_Predicted Groundwater Levels in the Aries Seam (Layer 8) – PME (Wetter Climate Scenario)



0 2.5 5 km

Coordinate System:	GDA2020 MGA Zone 55
Scale:	1:250,000 at A4
Project Number:	620.040199
Date Drawn:	09-Aug-2024
Drawn by:	AS

LEGEND

- Watercourse
- Groundwater Level (mAHD)
- BWM Mining Lease
- Project Area (Environmental Authorities boundary)
- Study Area
- Void Extent
- Void Lake

BLACKWATER MINE - TRANSITIONAL PRCP HYDROGEOLOGY ASSESSMENT

PREDICTED GROUNDWATER LEVELS IN THE CASTOR SEAM (LAYER 10) – POST-MINING EQUILIBRIUM (WETTER CLIMATE SCENARIO)

SLR

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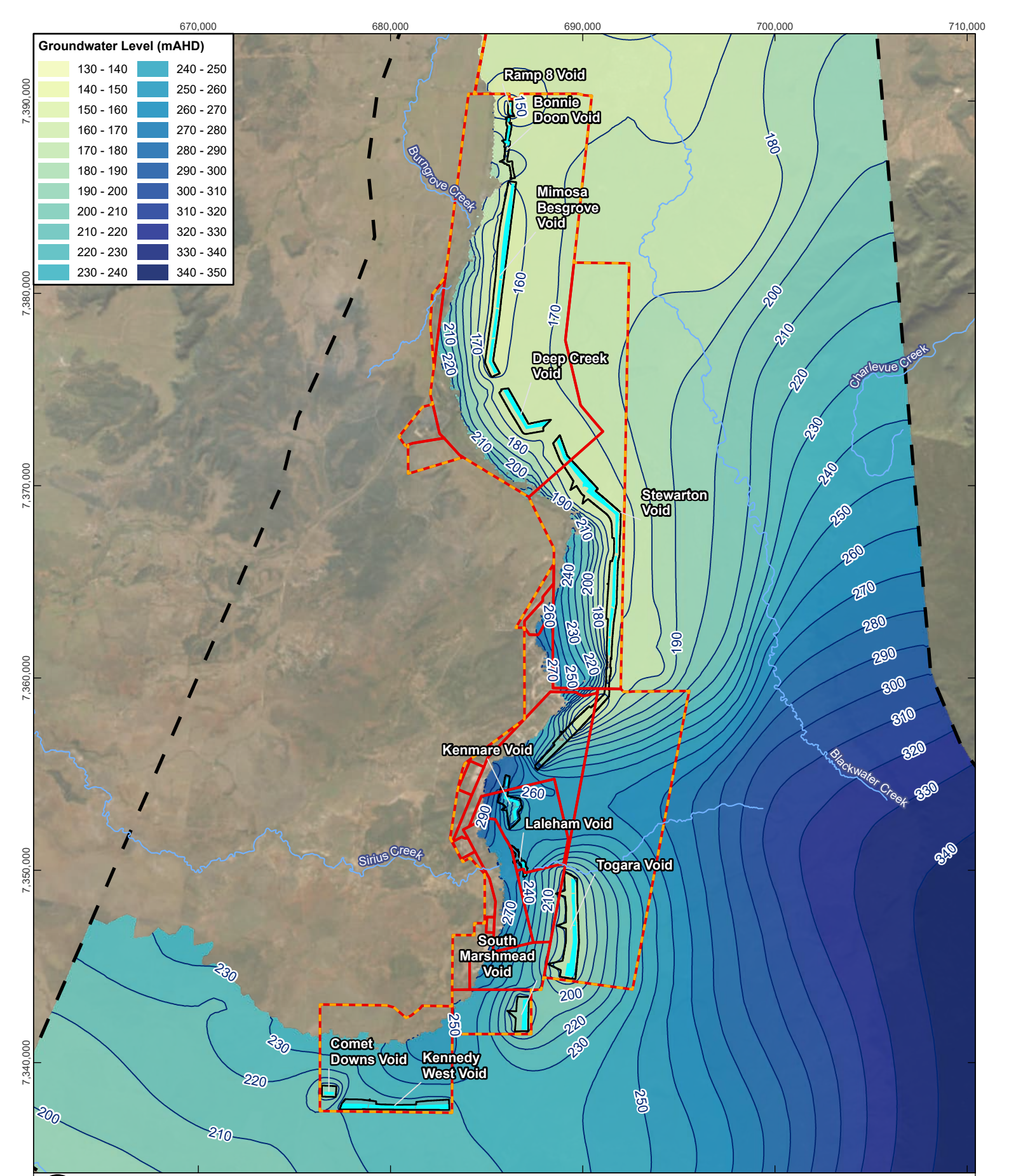
FIGURE F-3

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040199.00001 BWM PRCP – GW\03 SLR Data\01 CADGIS\GIS\ArcPro\BWM PRCP – GW\BWM PRCP – GW.aprx\620040199_FF_03_Predicted Groundwater Levels in the Castor Seam (Layer 10) – PME (Wetter Climate Scenario)



0 2.5 5 km

Coordinate System:	GDA2020 MGA Zone 55
Scale:	1:250,000 at A4
Project Number:	620.040199
Date Drawn:	09-Aug-2024
Drawn by:	AS

LEGEND

- Watercourse
- Groundwater Level (mAHD)
- BWM Mining Lease
- Project Area (Environmental Authorities boundary)
- Study Area
- Void Extent
- Void Lake

BLACKWATER MINE - TRANSITIONAL PRCP HYDROGEOLOGY ASSESSMENT

PREDICTED GROUNDWATER LEVELS IN THE POLLUX SEAM (LAYER 12) – POST-MINING EQUILIBRIUM (WETTER CLIMATE SCENARIO)

SLR

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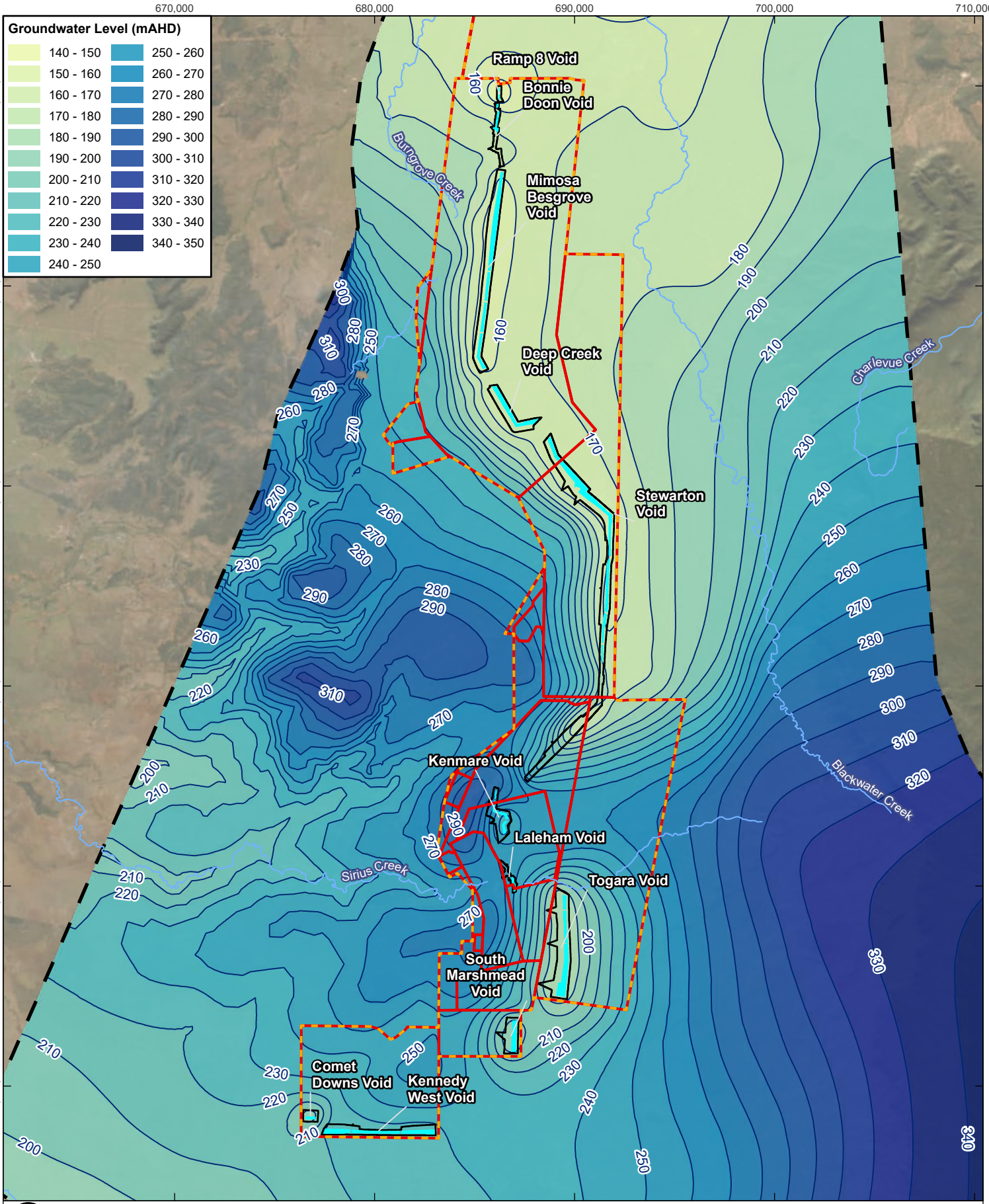
FIGURE F-4

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040199.00001 BWM PRCP – GW\03 SLR Data\01 CADGIS\GIS\ArcPro\BWM PRCP – GW\BWM PRCP – GW.aprx\620040199_FF_04_Groundwater Levels in the Pollux Seam (Layer 12) – PME (Wetter Climate Scenario)



0 2.5 5 km

Coordinate System:	GDA2020 MGA Zone 55
Scale:	1:250,000 at A4
Project Number:	620.040199
Date Drawn:	09-Aug-2024
Drawn by:	AS

LEGEND

- Watercourse
- Groundwater Level (mAHD)
- BWM Mining Lease
- Project Area (Environmental Authorities boundary)
- Study Area
- Void Extent
- Void Lake

BLACKWATER MINE - TRANSITIONAL PRCP HYDROGEOLOGY ASSESSMENT

PREDICTED GROUNDWATER LEVELS IN THE BURNGROVE FORMATION (LAYER 14) – POST-MINING EQUILIBRIUM (WETTER CLIMATE SCENARIO)

SLR

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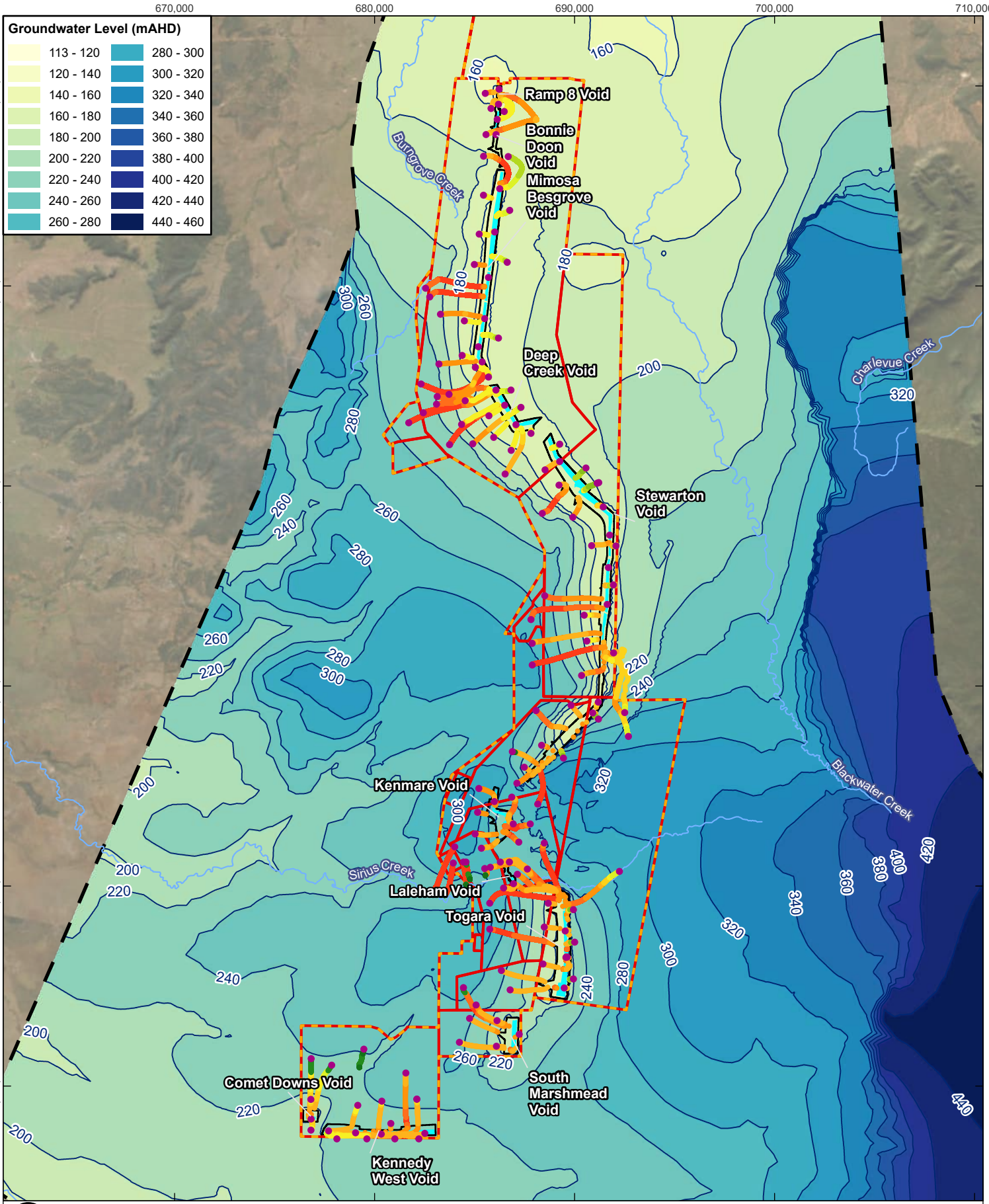
FIGURE F-5

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040199.00001 BWM PRCP – GW\03 SLR Data\01 CADGIS\GIS\ArcPro\BWM PRCP – GW\BWM PRCP – GW.aprx\620040199_FF_05_Predicted Groundwater Levels in the Burngrove Formation (Layer 14) – PME (Wetter Climate Scenario)



0 2.5 5 km

Coordinate System:	GDA2020 MGA Zone 55
Scale:	1:250,000 at A4
Project Number:	620.040199
Date Drawn:	09-Aug-2024
Drawn by:	AS

LEGEND

- Starting Location and Layer of Particle Simulation
- Groundwater Level (mAHD)
- Watercourse
- BWM Mining Lease
- Study Area
- Project Area (Environmental Authorities boundary)
- Void Extent
- Void Lake

Model Layer

1, 2, 6, 7, 8, 9, 10, 11, 12, 13, 14

BLACKWATER MINE - TRANSITIONAL PRCP HYDROGEOLOGY ASSESSMENT

PREDICTED MOVEMENT OF PARTICLES (WETTER CLIMATE SCENARIO)

SLR

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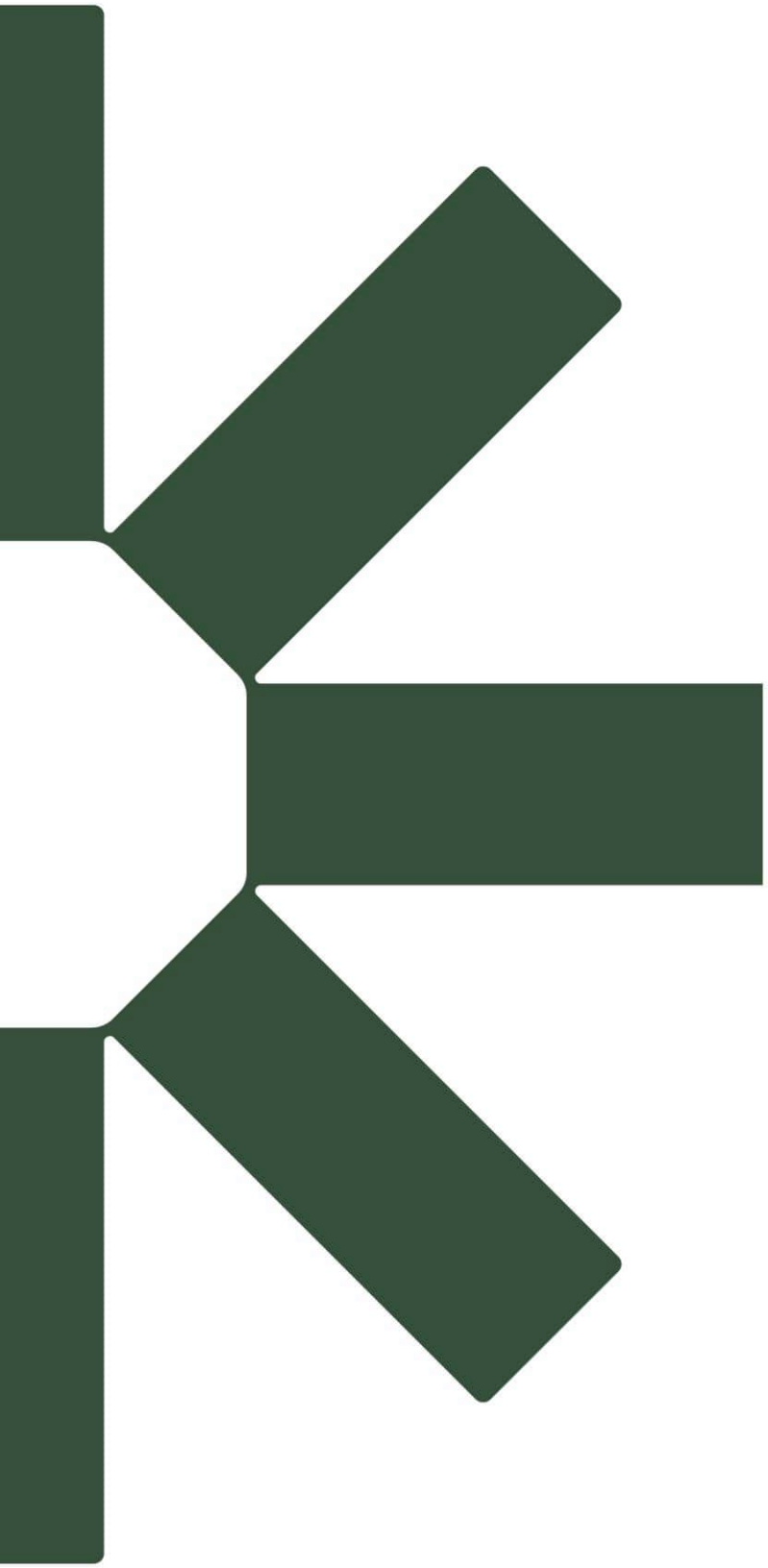
FIGURE F-6

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040199.00001 BWM PRCP – GW\03 SLR Data\01 CADGIS\GIS\ArcPro\BWM PRCP – GW\BWM PRCP – GW.aprx\620040199_FF_06_Predicted Movement of Particles (Wetter Climate Scenario)



Making Sustainability Happen

Whitehaven

Appendix 4.3 – Material Characterisation

BLACKWATER MINE – MATERIAL CHARACTERISATION STUDY

October 2023









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Project Number: 1447.21a8

Report Title: Blackwater Mine – Material Characterisation Study

Client: BM Alliance Coal Operations Pty Ltd

Review History

Version	Prepared by	Reviewed by	Date
Rev 0	L. McGrath	S. Buchanan	18.10.2023
Rev 1	L. McGrath	BHP	13.11.2023
Rev 2 (final)	L. McGrath	BHP	19.12.2023

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1 INTRODUCTION

BHP Mitsubishi Alliance (BMA) engaged Landloch to provide a material characterisation study of potential growth media at the Blackwater Mine (BWM). Specifically, the study is to evaluate the quality of materials for their use as growth media in rehabilitation.

To ensure rehabilitation success, the materials planned to be placed near the surface of the rehabilitated landforms need to be assessed for their suitability to support the vegetation required to meet the post-mining land use (PMLU).

1.1 Project description

BWM is a coal mine operated by BMA located to the south-west of the town of Blackwater in Queensland's Bowen Basin. Mining activities commenced in 1967 and consist of an open cut strip mine using dragline and truck and shovel fleets, and historic underground operations.

1.2 Scope of work

The scope of work involved the following tasks:

1. Review previous soil, waste, and land assessments undertaken at BWM.
2. Review available published soils, geology, and land data within the region.
3. Conduct a data gap analysis to determine information required to:
    a. Develop an inventory of materials available for rehabilitation; and
    b. Assess the suitability of materials as a plant growth media.
4. Sample and analyse the topsoil stockpiles to gain data and fill the identified information gaps.
5. Collate existing and newly acquired soil and spoil characterisation data.
6. Interpret data, characterise materials, and prepare a report.

2 DESKTOP REVIEW

2.1 Climate

The mine is situated in Queensland's sub-tropical climate zone that is characterised by high summer temperatures, warm dry winters and a distinct wet and dry season.

The closest meteorological recording station is located at Emerald Airport (Site No. 035264). Data from this station indicate mean seasonal temperature ranges from 21.5°C to 34.7°C in summer and 9.1°C to 25.5°C in winter, with a summer dominant rainfall pattern averaging a total of 560 mm annually (Bureau of Meteorology, 2023). Rainfall events are often associated with short-lived, intense thunderstorms. These high intensity rainfall events produce high runoff rates and can create conditions conducive to erosion. The area is also susceptible to prolonged periods of drought.

2.2 Topography

The topography of BWM consists of gentle undulating plains with gravelly ridgelines and hills. Several ephemeral creeks and gullies drain to the Mackenzie River in the east and Comet River in the west, and both are part of the Fitzroy Basin catchment. Most of the terrain within these catchments is undulating, with minor steep areas in the upper catchments.

2.3 Regional geology

Geoscience Australia mapping of the mine identifies four major geological units. Descriptions of each geological unit are provided in Table 1.

Table 1: Geological units and descriptions for BWM (Geoscience Australia, 2023).

Geological unit	Description
Pwj – Permian	Rangal Coal Measures, Bandanna Formation, Baralaba Coal Measures. Sandstone, siltstone, mudstone, coal, tuff and conglomerate.
Pwt – Permian	Fair Hill Formation, Fort Cooper Coal Measures. Sandstone, conglomerate, mudstone, carbonaceous shale, coal and cherty tuff.
Pwg – Permian	Burngrove Formation. Siltstone, coal and sandstone.
Rr – Triassic	Rewan Group. Siltstone and sandstone.

2.4 Waste materials

The waste materials at BWM consist of overburden/interburden materials (spoil), coal rejects and tailings.

2.4.1 Spoil material

The spoil material at BWM consists of tertiary/weathered materials and Permian materials.

Based on regional geology characteristics and spoil analysis data over the life of the mine, overburden/interburden geology at BWM can be broadly classified into:

- Tertiary/weathered materials: Cainozoic (Tertiary), ferruginous duricrusts and Quaternary calcareous sediments consisting of gravels, clays, sands, magnesite, laterite, and calcrete. These weathered materials are typically sodic, highly erodible, and prone to clay dispersion. They are known to have varying levels of salinity, but their main constraint is their high erosion risk.
- Permian materials: Permian sediments from the Blackwater Group, Rewan Group, and Emerald Formation to the south, consist of lithic sandstones, mudstones, pebble conglomerate, siltstones, shale, and mudstones. Carbonaceous zones are present close to the coal seams. The physical and chemical properties of these materials are highly variable. They are generally sodic, alkaline and have varying salinity, often reaching extremes where

carbonaceous inclusions are present. Some carbonaceous strata are acidic or acid forming. Erosion risk varies based on physical properties and sodicity, but generally the sandstones are more competent and resistant to weathering and erosion than the siltstones or mudstones. The predominantly fresh, medium to coarse grained grey sandstone materials are less saline and offer greater benefits to rehabilitation.

Characterisation studies were undertaken by B.R. Emmerton (1998) and GTES (December 2007). Generally, spoil materials at BWM were found to be:

- Adequate in acid neutralising capacity (ANC) to limit the risk of acid formation;
- Strongly acidic (most Tertiary and some weathered Permian) to strongly alkaline (most Permian and some Tertiary);
- Sodic to strongly sodic and dispersive;
- Potentially highly saline; and
- Low in fertility.

2.4.2 Coal rejects

Coarse coal rejects are emplaced within the spoil materials and are not currently used as a rehabilitation resource. Further investigation may identify some to be beneficial for rehabilitation use due to their high organic carbon and coarse physical structure. Alternatively, strategies may be developed in the future for mixing them with spoil of high ANC to produce a combined material that is more suitable for use as a growth medium.

2.4.3 Tailings

Tailings are not characterised in this report as they are not currently considered a rehabilitation resource.

2.5 Soils

2.5.1 Regional soils mapping

Regional soils mapping of the mine identifies two broad soil groups across the project area (State of Queensland (Department of Resources), 2023) These include:

- MM7 – Vertosol or Dermosol; and
- Sl12 – Sodosols or Chromosols.

Relevant details of these soil groups are provided in Table 2.

Table 2: Summary details of regional soils.

Soil Landscape Code	Description	Associated Australian Soil Classification (ASC)
MM7	Dark and yellow friable earths with friable brown soils.	Vertosol, Dermosol

Soil Landscape Code	Description	Associated Australian Soil Classification (ASC)
SI12	Complex range of soils occurring. Dominant soils are sandy to loamy duplex soils.	Sodosol, Chromosol

2.5.2 Recoverable soils

Several soil surveys have been undertaken across the mine area. These assessments include:

- CSR South Blackwater Mines: Evaluation of Soil Resources Existing Lease Areas, Report ENV-SBW-8604 (Environmental Services CSR Coal Division, 1986).
- CSR South Blackwater Mines: Mimosa Soils – An Assessment of Their Suitability for Use in Mine Site Rehabilitation, Report MEA-8801 (Mark Evans and Associates, 1988).
- Soil and Land Suitability Survey of the South Marshmead Lease Area MLA 70139 (Land Reclamation Services, 1997).
- Soil Stripping Survey, in Potential Disturbance Areas in Advance of Mining, Bonnie Doon Area, Blackwater Mine (B. R. Emmerton Pty. Ltd., 1999).
- Soils and Land Suitability Survey, BMA Blackwater Mine (Groundwork Environmental Management Services Pty. Ltd., 2001).
- Soils, Vegetation, and Land Suitability Survey, Kennedy Area, BMA Blackwater Mine (Groundwork Environmental Management Services Pty. Ltd., 2002).
- BMA Blackwater Mine: Assessment of Strategic Cropping Land (SKM, 2013).

Across all assessments a total of 26 soil landscape units (SLU) including variations, were identified within the mine area. A consolidated summary of all SLUs is provided in Table 3.

A soil map displaying broad ASC soil types for the BWM area is provided in Figure A9 (Appendix A). The data used to generate this map is a synthesis of soils data and mapping sourced from –

- existing soil assessments completed by the sources above;
- existing land systems information sourced from the QLD Globe online spatial data system (State of Queensland (Department of Resources), 2023); and
- a regional land resource assessment completed by (Burgess, 2003).

The map is Landloch's interpretation of the available soils information.

Table 3: Summary details of the SLUs developed in the previous soil assessments for BWM site.

SLU	Soil Details	Vegetation Description	Grazing Suitability Class
A1	Uniform brown clay or texture contrast soils on alluvial material in and adjacent to active drainage lines.	Mixed brigalow, yellowwood, poplar box and sandalwood. River red gum and Moreton Bay ash in creek channel.	2/3
B1	Gently undulating plains with cracking and non-cracking uniform clays and areas of gilgai developed from weathered non-quartzose Permian sedimentary rocks and Tertiary sediments.	Brigalow, blackbutt with associated bottle tree, poplar box and yellowwood.	2
B2	Undulating plains and rises of generally non-cracking clays with significant surface gravel.	Brigalow with blackbutt, ooline, sandalwood, Leichhardt bean, carissa. Includes areas of undulating ridges and stony Yapunyah.	3
B2v	Reddish brown texture contrast soils with thin sandy or loamy surface layer over well-structured alkaline clay subsoils and gravel.	Main vegetation is brigalow and associated species which include poplar box.	3/4
B3	Soils are reddish brown non-cracking clays often with a hard-setting sandy surface. Often quite shallow to weathered sediments.	Regrowth of brigalow, yellowwood, whitewood. Occasional poplar box. Ooline was present in original vegetation.	3
C1	Yellowish brown cracking and non-cracking uniform clays situated on gentle undulating plains with deep effective rooting depth.	Buffel grass with vegetation regrowth, consisting of mainly brigalow.	2
C1v	Yellowish brown cracking and non-cracking clays with reddish clays at depth situated on gentle undulating plains.	Buffel grass with vegetation regrowth.	5
C1gv	Brown to dark brown cracking and non-cracking uniform clays situated on gentle undulating plains with microrelief present in the form of gilgai and melon holes of varying sizes.	Whipstick brigalow, brigalow, and buffel grass.	5
D1	Grayish and minor dull yellow non-cracking clays situated on gentle undulating plains with deep effective rooting depth of approximately 45 – 60 cm with soft lime and calcium carbonate present.	Buffel grass and brigalow.	4
D1gv	Grayish and minor dull yellow cracking and non-cracking uniform clays on gentle undulating plains with effective rooting depth of approximately 45 – 60 cm with normal gilgai present.	Whipstick brigalow, broom bush, buffel grass.	4

SLU	Soil Details	Vegetation Description	Grazing Suitability Class
D2	Brownish black and black medium hard cracking clays situated on gentle undulating plains with deep effective rooting depth of approximately 70 – 80 cm with soft lime and calcium carbonate present.	Bauhinia, broom bush, yellowwood and minor brigalow.	3
D3	Light medium to medium clays overlying sand lenses near drainage, creek lines, and minor depressions.	Brigalow, whitewood.	4
D4	Cracking light to light medium uniform brown clays over gentle undulating plains with no microrelief present.	Buffel grass.	3
D4sv	Cracking light to light medium uniform brown clays over gentle undulating plains with no microrelief present, however, is located on a slope greater than 3%.	Buffel grass.	3
D4rv	Cracking medium to light brown clays over gentle undulating plains within shallow depressions and overland runoff with gravels and cobbles present.	Buffel grass, acacia.	3
D5	Sandy clay loam overlying light brown clays along gently undulating plains.	Whipstick brigalow, Bauhinia, buffel grass.	3
E1	Shallow, rocky earths with some areas of gravelly and shallow texture contrast soils on the mesa margins.	Dominated with lancewood and areas of Dawson gum, poplar box or yapunyah	4/5
E2	Open ironbark with associated Acacias on hard-setting red sandy duplex of the tablelands.	Narrowleaf ironbark, yapunyah with associated acacias.	4
E3	Sandy texture contrast soils usually with hard-setting, gravelly surface and with erosive yellowish clay subsoils which are gravelly. Includes areas of shallow gravelly ridges and exposed bedrock.	Mixed scrub of poplar box, brigalow and sandalwood.	3
E4	Deeper loamy red earths on undulating plains.	Open silver leaf ironbark	2
E5	Loamy red and yellow earths usually underlain with lateritic gravel before 60 cm depth on uplands and mesa tops.	Mainly narrowleaf ironbark and bloodwood with a variety of wattles and other species.	3
F1	Alluvial creek areas with loam and silty loam soil profiles.	Brigalow, poplar box, bottle trees.	4

SLU	Soil Details	Vegetation Description	Grazing Suitability Class
F2	Active alluvial plains with loams and clayey sand with soft to firm sandy surface.	Mount coolabah, minor brigalow.	3
F3	Brown silty clay loams on silty clays on gentle undulating plains. Calcium carbonate is present in subsoils.	Buffel grass.	2
R1	Rocky outcrop/hill	Mixed vegetation.	5
S1	Texture contrast and gradational soils situated on gentle undulating plains.	Buffel grass with very minor vegetation regrowth observed.	4

2.5.3 Stockpiled soils

Location and volume information on the current soil stockpiles was provided by BMA. The approximate volume of available stockpiled material is 5,510,886 m^3 (in April 2023). Locations of topsoil stockpiles on BWM are presented in Figure 1.



Figure 1: Stockpiled topsoil materials across BWM.

2.6 Post-mining land use

BMA's rehabilitation objectives for BWM are to create a safe, stable, non-polluting, and sustainable landscape with PMLUs in accordance with the EA:

- Cattle grazing
- Woodland habitat
- Water storage
- Watercourse

The predominant pre-mining land use was cattle grazing.

2.7 Revegetation methodology

Rehabilitation methods will vary between domains and PMLUs. Broadly, rehabilitation of disturbed areas will include:

- Respreading stockpiled or freshly stripped topsoil, or creating a growth media from spoil;
- Contour ripping;
- Seeding with an appropriate seed mix for the PMLU; and
- Applying appropriate fertiliser and ameliorants for plant establishment if required.

Where available, competent materials will be placed on steeper slopes to aid stability. A suitable seed mix will be used to establish a sustainable vegetation cover.

The material characterisation and landform design studies aim to identify and improve where possible:

- Growth media placement depth and soil profile depths relevant to the PMLU;
- Growth media preparation details; and
- Expected growth media amelioration activities.

More details on revegetation methodology can be found in the relevant section of the PRC Plan.

3 MATERIAL CHARACTERISATION METHODOLOGY

3.1 Materials

Soils and spoil materials were targeted for consideration as potential growth media. When considering the growth media at BWM, the quality of the stockpiled soil rather than the *in situ* topsoils is more representative of the material available for rehabilitation. Therefore, stockpiled soils were sampled by Landloch in a field program completed as part of this study. Spoil data collected by Landloch, as part of erodibility assessments for the Landform Design section of the PRC Plan, and data from previous studies were considered in the assessment of spoil materials as a potential growth media. All sampled materials were characterised in terms of their basic chemical and physical properties. Any materials with the potential to be used at the surface of a rehabilitated landform as a primary growth media were subjected to additional fertility assessments.

3.2 Stockpiled soils

3.2.1 Field program details

The field program was undertaken between 6 and 22 March 2023. Substantial rainfall events occurred within the sampling period, and the wet site conditions hindered the sample collection.

3.2.2 Sampling plan and intensity

The soil sampling plan is listed in Table 4 and the stockpile sampling locations are shown in Figures A1–A4 (Appendix A).

The sample density adopted is consistent with a 'high (detailed)' intensity (McKenzie *et al.* 2008) and assumes soil will be placed at an average depth of 0.1 – 0.15 m at rehabilitation. Using these criteria, Table 5 shows the sample density for the stockpiles. Stockpile location details are provided in Table B1 (Appendix B).

Table 4: Soil stockpile sampling plan.

Stockpile ID	Area (m^2)	Number of Sampling Sites	Stockpile ID	Area (m^2)	Number of Sampling Sites
2	300	1	152	31,754	1
10	278	1	156	32,017	1
12	3,568	1	157	15,535	1
17	13,343	2	161	5,113	1
18	19,318	2	163	24,576	1
30	426	1	165	16,242	1
31	1,346	1	166	39,926	1
34	6,020	1	169	20,870	1
41	1,245	2	170	14,518	1
45	8,385	1	171	25,479	1
46	1,534	1	176	28,197	1
47	3,089	1	188	33,699	1
48	15,287	1	191	14,473	1
52	6,858	1	210	26,743	1
55	7,330	1	214	33,364	1
57	672	1	216	26,139	1
58	2,723	1	218	21,309	1
59	6,487	1	219	1,2041	1
61	87,246	2	221	2,281	1

Stockpile ID	Area (m^2)	Number of Sampling Sites	Stockpile ID	Area (m^2)	Number of Sampling Sites
62	4,244	1	222	2,592	1
67	73,177	1	228	56,528	2
68	1,986	1	231	58,701	2
69	9,891	1	232	9,377	1
70	8,488	1	248	7,784	1
71	10,837	1	250	7,849	1
72	2,526	1	251	7,697	1
73	25,601	1	253	2,771	1
81	14,463	1	255	18,995	1
82	42,205	1	256	16,144	1
86	77,119	1	259	7,187	1
93	14,274	1	267	14,781	1
102	10,616	1	268	147,397	3
103	17,646	1	270	12,941	1
108	14,767	1	275	2,399	1
111	1,566	1	278	827	1
123	9,953	1	283	8,481	1
124	36,029	1	284	14,379	1
126	11,565	1	285	7,802	1
130	23,621	1	291	77,725	2
138	742	1	296	12,305	1
145	11,257	1	315	10,534	1
148	68,544	1			
Total					92

Table 5: Sample density for soil stockpiles.

Soil Volume (m^3)	Reinstatement Coverage (ha)	Total Samples	Sampling Density	Sampling Density	Survey Scale
5,510,886	3,674*	368	1 sample/ 14,975 m^3	1 sample/ 10 ha	1:25,000

* Based on a replacement depth of 0.15m

3.2.3 Sample collection

Samples of materials were taken from test pits and the depth of excavation was to the base of the stockpile, or to the limit of excavation (~3–5 m). Samples were collected at depth intervals of 0.5–1.0 m (e.g. 0.5–1.0 m, 1.5–2.0 m, 2.5–3.0 m etc.). Brief details and descriptions of the collected materials were recorded in the field. Sampling included composite and discrete samples, where each composite sample was composed of materials from three discrete samples.

3.2.4 Laboratory analysis

Laboratory analysis was undertaken by East West EnviroAg, a laboratory with National Association of Testing Authorities (NATA) and Australian Soil and Plant Analysis Council (ASPAC) accreditations. Analysis of composite samples used a 'topsoil suite' to characterise the soil nutrients and physico-chemical parameters of the materials. Laboratory analysis of discrete samples used a 'basic suite' of pH and salinity to indicate the heterogeneity (variability) within the stockpile and expose potential extreme values that may be masked in the testing of the composite samples. Laboratory analyses are described in Table 6.

Table 6: Laboratory analytical suites.

Analyses	Analysis Suite	
	Topsoil	Basic
pH_w and Electrical Conductivity ($EC_{1:5}$).	✓	✓
Exchangeable cations (with calculations of effective cation exchange capacity and exchangeable sodium percentage) and chloride	✓	
Total nitrogen and phosphorous; available phosphorous, potassium, and sulphur; trace nutrients (Cu, Zn, Mn, Fe, B), chloride, organic carbon, phosphorus buffer index (PBI), field texture	✓	
Dispersion potential	✓	
Total number of samples	92	276

3.3 Spoil materials

Geochemical and physical characterisation data for the spoil materials were collated from multiple assessments previously conducted for the project and from waste characterisation data collected as part of the PRC Plan preparation. Information sources included:

- Blackwater Mine, Soil and Spoil Assessment 1998 (B. R. Emmerton Pty Ltd, 1998);
- BMA Coal Blackwater Mine Overburden Quality (GTES Pty Ltd, December 2007)
- Targeted assessment of wastes and recommendations for rehabilitation at the former South Blackwater mine – BMA (Highlands Environmental , 2022);
- Environmental Geochemical Actions Related to the Draft Transitional Environmental Program (Terrenus Earth Sciences and RGS Environmental, 2010);
- Spoil data collected and analysed to inform Landloch's landform erodibility study as part of the PRC plan development; and
- Internal BMA spoil monitoring data.

4 FINDINGS

The two categories of materials available for rehabilitation were characterised as part of this assessment, and include:

1. Topsoil stockpiles; and
2. Spoil materials.

This section of the report provides information about these materials. Site location details are provided in Figures A1 – A4 (Appendix A) and in Table B1 (Appendix B). Stockpile description records are provided in Table B2–B3 and laboratory results are provided in Tables B4–B6 (Appendix B).

4.1 Topsoil stockpiles

A total of 368 samples were collected from 83 topsoil stockpiles. The 'topsoil suite' analysis was conducted on 92 samples and the 'basic suite' analysis was conducted on the remaining 276 samples.

Stockpiled topsoil for use in rehabilitation was categorised into three management groups:

1. Loam topsoil;
2. Clay topsoil; and
3. Gravelly clay topsoil.

A summary of key chemical and physical properties is presented in Table 7. Topsoil within each management group is detailed in the following sections.

Table 7: Summary of key chemical and physical properties for topsoils at BWM.

Analysis	Loam Topsoil	Clay Topsoil	Gravelly Clay Topsoil
Chemical Properties			
pH_w (pH Units)	Strongly acidic to slightly alkaline (4.8 – 7.7)	Moderate to strongly alkaline (8 – 9)	Moderate to strongly alkaline (8.1 – 9)
$EC_{1:5}$ (dS/m)	Low to moderate (0.1 – 0.3)	Low to moderate (0.2 – 0.5)	Low to moderate (0.2 – 0.7)
Chloride (mg/kg)	Very low (<65)	Very low to moderate (60 – 463)	Very low to high (58 – 642)
Exchangeable sodium percentage (ESP) (%)	Non-sodic (0.7 – 4.7)	Non-sodic to sodic (3.3 – 13.6)	Non-sodic to Strongly sodic (4.5 – 16.6)
Total N (mg/kg)	Low (680 – 1,450)	Low to moderate (760 – 1,930)	Low (840 – 1,420)
Available P (mg/kg)	Low to moderate (10 – 24)	Low to moderate (6 – 36)	Low to moderate (9 – 34)
Available K (mg/kg)	Low to moderate (124 – 232)	Low to moderate (115 – 270)	Low (125 – 180)

Analysis	Loam Topsoil	Clay Topsoil	Gravelly Clay Topsoil
Total Organic Carbon (TOC) (%)	Low to high (0.8 – 1.9)	Low to high (0.9 – 2.1)	Low to moderate (0.9 – 1.6)
Effective Cation Exchange Capacity (ECEC) (meg/100g)	Low (3 – 10.4)	Moderate to high (13.7 – 27)	Low to high (12 – 28.2)
Ca/Mg (ratio)	Low Ca to balanced (2.5 – 4.6)	Low Ca (1.9 – 3.6)	Low Ca (1.4 – 3.4)
Physical Properties			
Clay content (%)	10 – 30	>35	>35
Rock content (%)	10 – 30	<20	20 – 50
Dispersion (EAT)	Slightly dispersive to slaking (3b – 5)	Slightly dispersive to stable (3b – 7)	Slightly dispersive to slaking (3b – 5)
Permeability	Moderate	Low to Moderate	Moderate
Associated regional soil	SI12 (Sodosol)	MM7 (Dermososl/Vertosol)	MM7 (Dermososl/Vertosol)
Associated SLU	B2v, D5, E1, E2, E3, E4, E5, F1, F2, F3 and S1	A1, B1, B3, C1, C1v, C1gv, D1, D1gv, D2, D3, D4 and D4sv	B2, D4rv, E1 and R1

Note: Chemical properties for topsoil are based on average 10th and 90th percentile values for all stockpile samples analysed.

4.1.1 Loam topsoils

Loam soils account for 10% of samples assessed across BWM topsoil stockpiles and are scattered around the southern portion of the mine. These materials have a degree of variability, but due to the limited volumes present, have been grouped together to aid their management.

The soils are generally brown, reddish brown or greyish brown in colour, and have textures ranging from sandy loam to silty clay loam. Gravel content can be variable, ranging from 2 – 30% with gravel size generally being less than 60 mm in diameter. However, occasional cobbles and boulders can be present. The soils are susceptible to slaking and dispersion, thereby increasing the risk of erosion. Figures 2 – 5 illustrate representative loam topsoils and vegetation cover levels at BWM.

The main requirement for this soil is to ensure that its chemical fertility is managed to support vigorous vegetation growth in the initial stage of rehabilitation and maintain suitable levels of surface groundcover in the longer term. A suitable rock cladding can also be applied to reduce the erosion risk while vegetation establishes.

The loam soils would require different rehabilitation methods than the clay and gravelly clay soils. When this soil is to be used in rehabilitation, its chemical and physical limitations will need to be considered and managed.



Figure 2: Soil material excavated at sampling site 410973d.



Figure 3: Soil profile at sampling site 410950c.



Figure 4: Soil material at stockpile 410976.



Figure 5: Vegetation cover on topsoil stockpile 410950.

4.1.2 Clay topsoils

Clay topsoils account for 75% of samples assessed across BWM topsoil stockpiles and are distributed evenly throughout the mine area. Generally, these soils have relatively similar properties, but occasional minor inclusions of sands and loams were noted at varying stockpile depths. This is likely a result of topsoils from smaller texture contrast soil units being stripped simultaneously with the more dominant clays.

The soils are generally dark brown, reddish brown to brownish red or black in colour with occasional mottling and have textures ranging from light to medium heavy clay. Gravel content is generally less than 10% with gravel size being less than 60 mm in diameter. The soils often have vertic properties making them susceptible to slaking, thereby increasing the risk of erosion. Figures 6 – 9 illustrate representative clay topsoils and vegetation cover levels at BWM.

Stockpiled clay soils are often sodic and occasionally saline. In comparison to the other available soils, clay soils would be the preferred option for revegetation on sections of low erosion risk, such as low gradient areas on the tops of spoil dumps, where higher quality vegetation establishment and performance is required. If placed on steeper-gradient outer batter slopes, management of erosion risk during the period of vegetation establishment would be critical for rehabilitation success, and establishment of appropriate levels of persistent vegetation groundcover will be essential.

The main requirement for this soil is to ensure that its chemical fertility is managed to ensure vigorous vegetation growth in the initial stage of rehabilitation and maintain suitable levels of surface groundcover in the longer term. Any sodicity issues will also need to be addressed by incorporating gypsum prior to rehabilitation.



Figure 6: Soil material excavated at sampling site 410973d.



Figure 7: Soil profile at sampling site 410950c.



Figure 8: Soil material at stockpile 410976.



Figure 9: Vegetation cover on topsoil stockpile 410950.

4.1.3 Gravelly clay topsoils

Gravelly clay topsoils account for 15% of samples assessed across BWM topsoil stockpiles and are scattered around the southern portion of the mine. Generally, these soils have relatively similar properties to the clay topsoils, except for a higher gravel content. The soils are generally dark brown to reddish brown with some pale grey, yellow or red inclusions and occasional mottling. Textures range from light clay to medium heavy clay. The content of coarse fragments ranges from 20 – 50% with gravel and cobbles often present up to 200 mm in diameter. Like the clays, these soils are susceptible to slaking, thereby increasing the risk of erosion. However, this risk may be reduced by the higher rock content. Figures 10 – 13 illustrate representative clay topsoils and vegetation cover levels at BWM.

Stockpiled gravelly clay soils are often sodic and occasionally saline. In comparison to the other available soils, gravelly clay soils would be the preferred option for revegetation on batter slopes if the chemical limitations are addressed. Establishment of

appropriate levels of persistent vegetation groundcover will still be essential for long-term stability.

The main requirement for this soil is to ensure that its chemical fertility is managed to ensure vigorous vegetation growth in the initial stage of rehabilitation and maintain suitable levels of surface groundcover in the longer term. Any sodicity issues will also need to be addressed by incorporating gypsum prior to rehabilitation.



Figure 10: Soil material at stockpile 411080 (sampling site A).



Figure 11: Soil profile at stockpile 411080 (sampling site B).



Figure 12: Soil material at stockpile 410753.



Figure 13: Vegetation cover on topsoil stockpile 411080.

4.1.4 Stockpiles with limitations

Stockpiles 57, 166, 157, 191, 259 and 267 have elevated salts throughout the stockpile, particularly chloride-based salts. Groundcover observations (Table B2, Appendix B) indicate that high vegetation cover was present across the stockpiles at the time of sampling. The salts' concentrations are likely to affect seed germination rates, but once established, regional vegetation appears to be tolerant of salinity. If the stockpiled material is required for use as a growth medium, it is recommended that vegetation establishment initially favours species that tolerate saline soil conditions such as Rhodes grass (*Chloris gayana*).

4.2 Spoil materials

From the previous assessments detailed in Section 3.3, spoil material characteristics were found to be heterogeneous within each spoil type and across sampling areas. For this reason, spoil materials are categorised into three management groups that have broad similarities:

- Fresh Permian materials;
- Weathered Permian materials; and
- Tertiary materials.

A summary of key chemical and physical properties is presented in Table 8. Each spoil management group is described in further detail in the following sections.

Table 8: Summary of key chemical and physical properties for spoils at BWM.

Analysis	Fresh Permian	Weathered Permian	Tertiary
Chemical Properties			
pH_w	Strongly alkaline (8.4 – 9.8, but can be highly acidic)	Strongly acidic to strongly alkaline (5 – 9.9, can be <5)	Strongly acidic to strongly alkaline (5 – 9.4, more often strongly acidic)
$EC_{1:5}$ (dS/m)	Low to extreme (0.19 – 2.3)	Low to extreme (0.1 – 3.3)	Low to extreme (0.35 – 2.2)
Estimated Acid Neutralising Capacity (ANC)*	Reasonable	Reasonable	N/A
ECEC	Low – adequate	Low – adequate	Adequate
ESP (%)	Non–sodic to strongly sodic (3 – 30)	Non–sodic to strongly sodic (3 – 33)	Sodic to strongly sodic (14 – 30)
Ca/Mg (ratio)	Very low to low Ca, (0.3 – 1.9)	Very low to low Ca (0.3 – 1.4)	Very low to low Ca (0.4 – 2.1)
Fertility	Low to moderate	Low to moderate	Low
Physical Properties			
Clay content (%)	20 – 40	15 – 45	>35
Rock content (%)	Up to 74%	30 – 60%	10 – 20
Permeability	Moderate	Moderate	Low
Dispersion potential	Moderate to high	Moderate to high	High to extreme
Dispersion risk	Moderate to high	Moderate to high	Very high

* ANC estimates are taken from the *BMA Coal Blackwater Mine Overburden Quality* (GTES Pty Ltd, 2007) assessment.

4.2.1 Fresh Permian materials

Permian materials at BWM can vary depending on the degree of weathered inclusions. Generally, fresh Permian materials are rocky and consist primarily of sandstone and siltstone, with clay content in the fine fraction ranging from 20–40%, and the coarse rock fraction being up to 75% of the mass of the material. Water holding capacity and permeability are variable and depend on the clay content along with the volume and

composition of rock present. It is generally grey in colour but may vary to pale brown after some weathering. The material ranges from moderately to highly dispersive but this can occasionally be masked by the presence of saline lenses. The material is considered to have reasonable ANC potential. Figures 14 and 15 are representative of fresh Permian spoil at BWM.

Of the spoil management groups, fresh Permian materials are considered most suitable for placement close to the final rehabilitated surface for use as a secondary growth media. Due to the heterogeneity, discrete testing should be conducted prior to rehabilitation. Competent (durable), fresh Permian sandstone has potential to be used as a rock armour to greatly increase batter slope resistance to erosion and to stabilise steeper areas.



Figure 14: Fresh Permian sandstone material present at the mine. Large-sized competent rock is present throughout the stockpile.



Figure 15: Rocky fresh Permian material with weathered Permian inclusion that was sampled during erodibility studies.

4.2.2 Weathered Permian materials

Weathered Permian materials are the dominant spoil material at BWM and are highly variable in their characteristics depending on the strata location, presence of carbonaceous inclusions and degree of weathering. Generally, weathered Permian materials have a lower, finer rock content than fresh Permian. The rock consists primarily of fragile mudstone and sandstone, with clay content in the fine fraction ranging from 15 – 45% and the coarse rock fraction being 30 – 60% of the mass of the material. Similarly, to fresh Permian, the water holding capacity and permeability are variable and depend on the clay content along with the volume and composition of rock present. Data obtained from monitoring programs indicates this material can be susceptible to capillary rise of salts if infiltration is limited (GTES Pty Ltd, December 2007). It is generally pale brown to brown in colour, but colour can vary. The material ranges from moderately to highly dispersive but this can occasionally be masked by the presence of salts. It is considered to have reasonable ANC potential. Figures 16 and 17 are representative of fresh Permian spoil at BWM.

Weathered Permian materials are considered suitable as a secondary growth media but should be capped with a quality topsoil material to prevent exposure to the final rehabilitated surface. If exposed, this material will be susceptible to erosion due to the tendency to rapidly weather and disperse. For material with elevated salts, it is preferable to mix with more permeable materials to promote infiltration and leaching of salts. If more permeable material isn't available, placement should be limited to slopes less than 10%. Due to the heterogeneity, discrete testing should be conducted prior to rehabilitation.



Figure 16: Weathered Permian pre-strip material present at the mine. Weathered and partially weathered rock is present across the area.



Figure 17: Stockpiled weathered Permian material present at the mine. The material is coarsely grained with variable weathering throughout the profile.

4.2.3 Tertiary materials

Tertiary materials are a highly weathered material containing small portions of fragile (low durability) rock. Generally, it has a clay content above 35%, resulting in moderate to high water holding capacity. It is typically pale orange in colour. The materials are often highly saline and strongly sodic, making it prone to a hard setting surface (Figure 18). Compared to Permian materials, the weathered Tertiary material is more susceptible to slaking and dispersion.

Placement of this material close to the final rehabilitated surface is not recommended due to its susceptibility to erosion and potential toxicities to plant growth. However, targeted testing may identify suitable Tertiary materials that could potentially be mixed with more competent rock to form a marginal secondary growth medium where required.

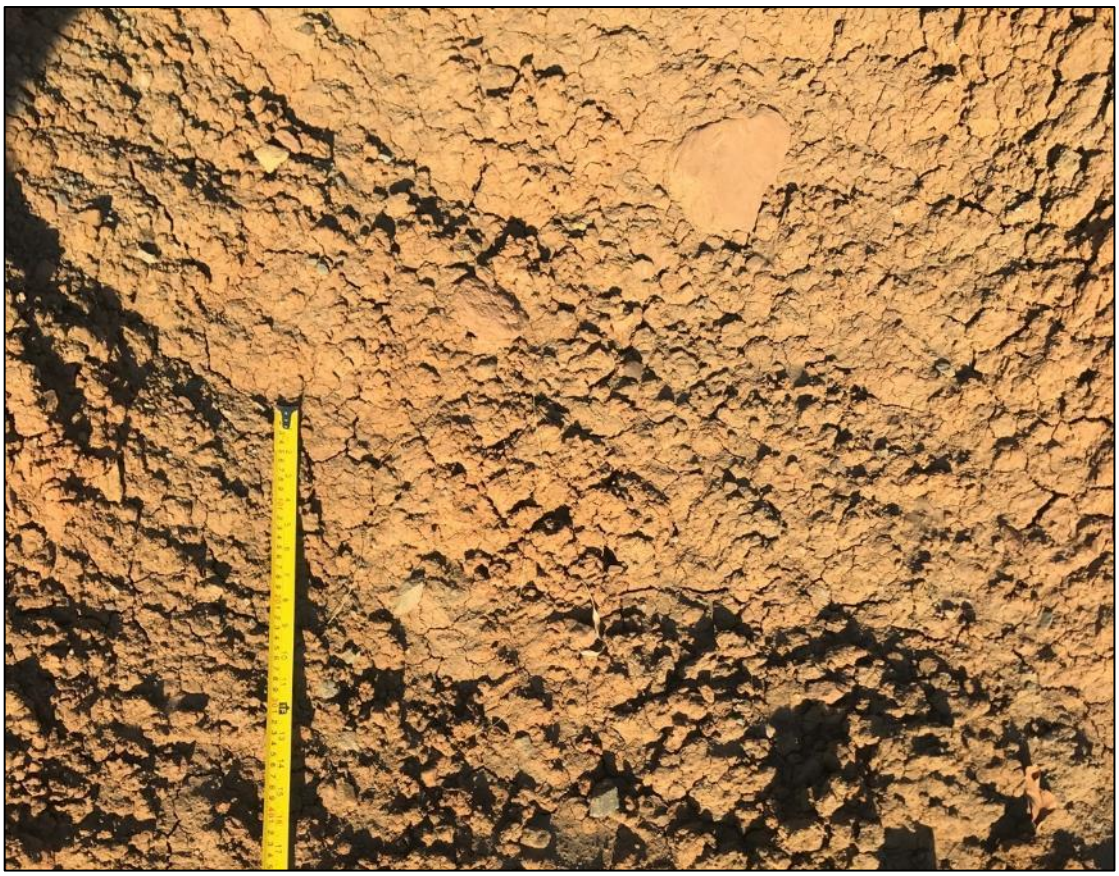

Figure 18: Hard setting Tertiary spoil stockpiled at the mine.

5 GROWTH MEDIA SUITABILITY AND AMELIORATION

The materials encountered have been classified according to their ability to support plant growth, as either *primary* or *secondary* growth media.

5.1 Primary growth media

Primary growth media infers the ability of materials to be used as a topsoil or topsoil surrogate. It is the upper-most layer placed over the rehabilitated area. It can be applied at various thicknesses depending on the PMLU and consists of surface soil (topsoil) materials recovered prior to mining and applied over the area, or a growth medium developed from subsoils or spoil materials, ameliorated to a standard suitable to support sustainable plant growth. It is typically higher in organic matter and macro- and micro-nutrients and has low to negligible limitations to plant growth. Its primary purpose is to provide nutrients and a stable surface for vegetation establishment.

If sufficient suitable primary growth media is not available, an alternative growth media may be derived by amelioration of suitable subsoils or spoil materials. Amelioration products and application rates for the primary growth media should be assessed by an appropriately qualified person prior to rehabilitation, and to also ensure the desired PMLU and vegetation is considered. Amelioration must address both the physical and chemical suitability of the material.

5.2 Secondary growth media

Secondary growth media infers the ability of materials to be used as a subsoil or subsoil surrogate. Typically, secondary growth media layers are capped with primary growth media. In the absence of subsoil, it may be a spoil material, or an intermediate layer of ameliorated spoil situated above un-ameliorated spoil material.

The main purpose of the secondary growth medium is to increase the soil water storage capacity in the root zone, and/or meet the soil depth criterion for certain vegetative PMLUs and target vegetation communities.

In some circumstances, secondary growth media may be able to be sufficiently improved by the addition of ameliorants (e.g. gypsum, lime, organic matter) to convert them to a primary growth medium.

5.3 Suitability classification

A four-class suitability system is applied in the evaluation of materials as growth media. These classes are defined as follows:

Class A – Good Quality

- Negligible limitations to plant growth.
- Good quality material for intended purpose.
- Nil to low levels of ameliorants will be required.

Class B – Fair Quality

- Minor limitations to plant growth.
- Reasonable quality material for intended purpose.
- Low to moderate levels of ameliorants may will be required.

Class C – Marginal Quality

- Moderate limitations to plant growth.
- Moderate to high levels of ameliorants may be required to improve material quality to support plant growth.

Class D – Not Suitable

- Severe limitations to plant growth.
- It will generally be uneconomic or unviable to amend these materials to the degree needed to support plant growth.

The suitability of materials as primary or secondary growth media is presented with recommendations in Table 9.

5.4 Fertiliser and ameliorants

Fertiliser and amelioration rates for spoil materials are dependent on the intended PMLU for each rehabilitated area. For example, cattle grazing requires the generation of

biomass and as such, nitrogen and phosphorus-based amendments would be recommended for these areas. As a guide to amelioration application for grazing, PMLU should aim to provide:

- Available phosphorus (Colwell) content of the growth media to within a target concentration of 25–40 mg/kg;
- An appreciable source of starter nitrogen;
- Adequate macro- and micronutrients; and
- Gypsum to reduce sodicity and potential for dispersion.

Amelioration recommendation for woodland areas should be assessed on a case-by-case basis and represent the specific requirements of the target vegetation community.

Table 9: Recommended fertiliser and ameliorant treatments for materials and growth media suitability classification.

Material	Limitations	Amendments	Suitability Class	
			Primary (1)	Secondary (2)
Loam topsoil	• Sometimes strongly acidic • Low ability to retain nutrients • Low N • Often low P, K and TOC • Sometimes low Ca	• Fertiliser and/or compost rates are to be determined by an appropriately qualified person prior to individual stockpiles being used in rehabilitation.	1A	2A
Clay topsoil	• Sometimes strongly alkaline • Often sodic and sometimes dispersive • Susceptible to slaking • Sometimes low N, P, K, TOC and Ca	• Gypsum: due to heterogeneity between stockpiles, rates should be calculated for individual stockpile prior to use. • Fertiliser and/or compost rates are to be determined by an appropriately qualified person prior to individual stockpiles being used in rehabilitation	1B	2A
Gravelly clay topsoil	• Sometimes strongly alkaline • Sometimes high chloride • Often sodic and sometimes dispersive • Susceptible to slaking • Low N, K and Ca • Sometimes low P and TOC	• Gypsum: due to heterogeneity between stockpiles, rates should be calculated for individual stockpile prior to use. • Fertiliser and/or compost rates are to be determined by an appropriately qualified person prior to individual stockpiles being used in rehabilitation.	1B	2A
Fresh Permian materials	• Strongly alkaline • Sometimes high salinity • Often strongly sodic and dispersive • Rock content up to 75% • Often low fertility and ability to retain nutrients	• Gypsum: due to heterogeneity between spoil samples, rates should be calculated for broad spoil areas after placement. • Bury all saline material to a depth greater than 2 m below the surface. • If to be used as a primary growth media further assessment by an appropriately qualified person is required to determine amelioration required.	1C/D	2B
Weathered Permian materials	• Often strongly acidic or strongly alkaline • Sometimes high salinity and potential for capillary rise • Often strongly sodic and dispersive	• Gypsum: due to heterogeneity between spoil samples, rates should be calculated for broad spoil areas after placement. • Chemical and physical variation: due to heterogeneity within the material, additional sampling should be completed prior to use in rehabilitation.	1D	2B/C

Material	Limitations	Amendments	Suitability Class	
			Primary (1)	Secondary (2)
	• Often low fertility and ability to retain nutrients • High variability in physical and chemical characteristics	• Bury all saline material to a depth greater than 2 m below the surface.		

Tertiary materials	• Often strongly acidic or strongly alkaline
	• Sometimes high salinity
	• Sodic or strongly sodic and dispersive
	• Low permeability
	• Low fertility
		• Most material is not suitable for placement in the upper soil profile.
		• Where no alternative is available:
		  ○ Mix with competent rock.
		  ○ Gypsum: due to heterogeneity between spoil samples, rates should be calculated for broad spoil areas after placement for rehabilitation.
		• Bury all saline material to a depth greater than 2 m below the surface.
			1D	2C/D

Notes:

- Class A – Good Quality: Negligible limitations to plant growth;
- Class B – Fair Quality: Minor limitations to plant growth;
- Class C – Marginal Quality: Moderate limitations to plant growth; and
- Class D – Not Suitable: Severe limitations to plant growth.

5.4.1 Fertiliser

A balanced NPK fertiliser such as Crop King 55 (N: ~13.5 %, P: ~15 %, K: 12.5 %) and slow-release nitrogen source such as Coated Urea (N: ~46 %) or organic compost is recommended to provide a balanced source of nutrients to plants during rehabilitation. Any composted material should comply with the Australian Standard for Composting (AS4454-2012).

Accurate application rates and fertiliser types based on the required nutrients should be determined by an appropriately qualified person prior to use in rehabilitation.

Fertiliser and mulch/compost should be applied at seeding. It can be broadcast with a spreader or applied hydraulically or pneumatically. Spreaders are typically suitable for slopes with gradients <35%, and hydraulic or pneumatic applications will be required for steeper slopes.

5.4.2 Gypsum

Gypsum application is recommended for sodic/dispersive materials or where calcium is low. It should be applied in a manner that allows for as thorough mixing as is practicable of the surface materials. Gypsum should be applied during the soil preparation stages prior to seeding and fertilising.

Depth of sodicity amelioration depends on erosion risk/land gradient. Generally, for slopes with gradients less than ~35%, incorporate gypsum into the upper 0.3 m depth of sodic materials.

Considering the annual rainfall at BWM is approximately 560 mm, it is expected that (as a 'rule of thumb') gypsum will dissolve at a rate of 0.5–1.0 t/ha/y. Hence, there is benefit in applying gypsum at the time materials are recovered (i.e. stripped) or as soon as is practical in the rehabilitation program to allow the gypsum to be as effective as possible.

6 SUMMARY AND RECOMMENDATIONS

This material characterisation report describes and characterises the materials identified on-site for use in rehabilitation using the topsoil stockpile assessment, erodibility studies, previous soil and spoil assessments, and other BWM project-related documents.

6.1 Soil stockpiles

Generally, the stockpiled soil is considered to be of adequate quality for use as a primary growth media. Due to the high degree of heterogeneity, the summarised laboratory data should be considered representative of the soils as a whole, and not representative of individual stockpiles. The sampling program is considered adequate to describe these materials into broad soil management groups. Therefore, any stockpile not included in this assessment should be sampled and characterised prior to use in rehabilitation.

The main limitations of the stockpiled soils for use in rehabilitation are low fertility and for clay dominated topsoil, sodicity.

Chemical fertility of the stockpiled soils is often low. A balanced NPK fertiliser or compost should be applied during rehabilitation to provide a starter source of nutrients for initial vegetation growth. Subsequent applications of fertiliser, particularly nitrogen, may be required to maintain adequate fertility levels and ensure vegetation is established in the long-term.

Amelioration of sodicity requires the thorough incorporation of gypsum. Due to the high degree of heterogeneity of measured sodicity within stockpiles, gypsum rates should be calculated for individual stockpiles prior to use in rehabilitation.

Amelioration products and application rates should be assessed by an appropriately qualified person prior to use for rehabilitation and to complement the desired PMLU.

6.2 Spoil materials

Generally, Permian materials, both fresh and weathered, have the highest potential to be used as secondary growth media through varying degrees of amelioration. Where possible, placement of Tertiary materials in the upper layer of the landform should be avoided.

Where primary growth media availability is limited, a topsoil/fresh Permian spoil mix may be adopted to form a primary growth media with potential to support a woodland PMLU, provided adequate amelioration is completed to negate any limiting properties of the spoil. If adopted, the chemical and physical properties and the overall viability of the proposed material should be assessed by a suitably qualified person before being applied to the broader rehabilitation.

All spoils with elevated salts will need to be managed to prevent capillary rise and subsequent accumulation of salts in the primary growth media. Maximising infiltration by limiting slope gradient or mixing with a more permeable material are considered the most practical approaches.

Due to the high degree of heterogeneity in the spoil materials, the summarised laboratory data should only be considered a guide to their suitability. Targeted sampling of spoil materials planned for use in the upper soil profile (i.e. primary or secondary growth media) should be conducted prior to rehabilitation.

Chemical fertility of all spoil materials is low and would benefit from an application of a balanced NPK fertiliser or compost.

6.3 Growth media for PMLU

Physical and chemical properties of the soil and spoil materials available on site meet the requirements to establish the primary PMLUs for rehabilitated areas of cattle grazing and woodland habitat. It is recommended that the growth media for each rehabilitation campaign be assessed by an appropriately qualified person prior to rehabilitation, to identify the required ameliorants and fertilisers.

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APPENDIX A: MAPS AND FIGURES

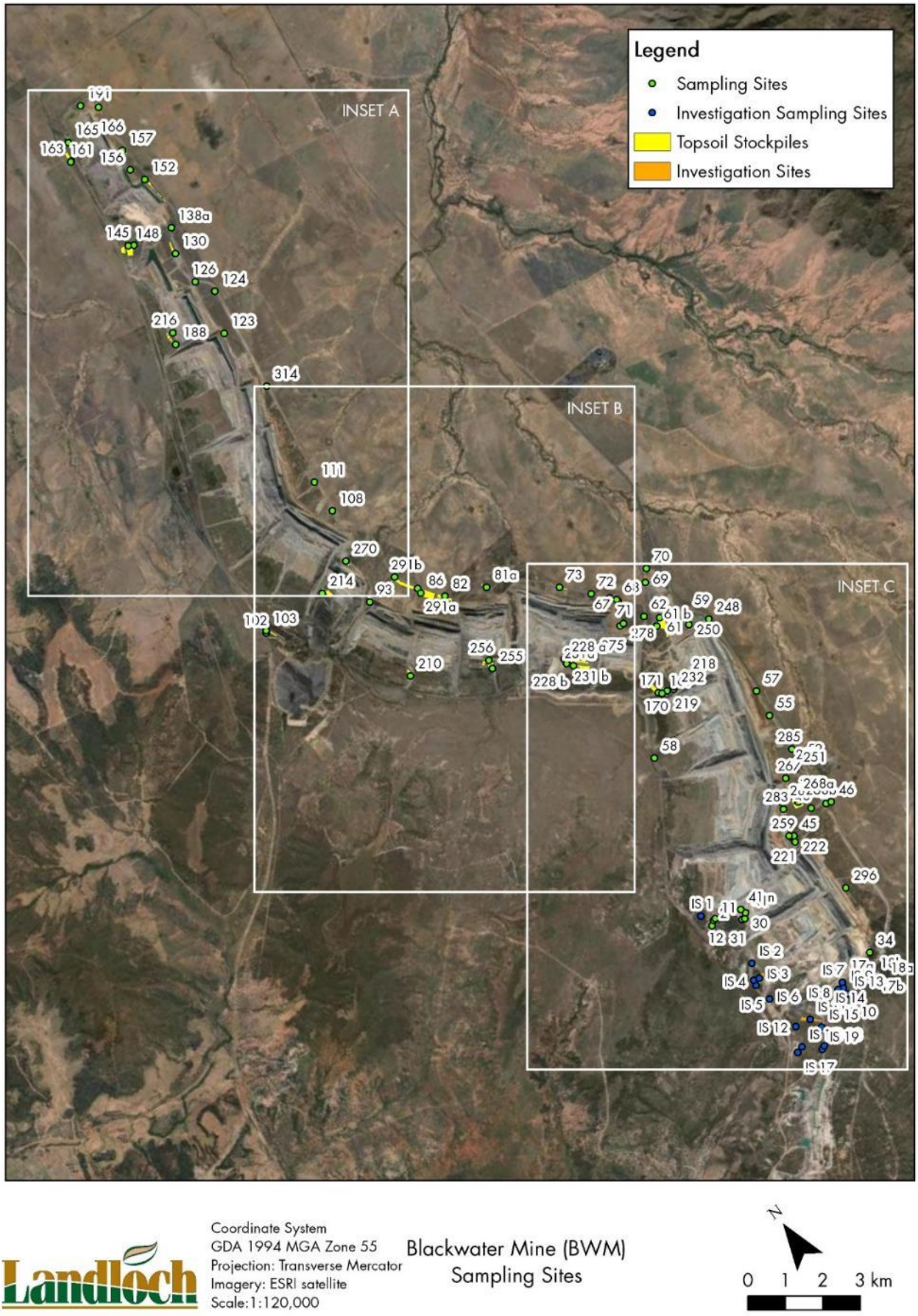

Figure A1: BWM topsoil stockpile sampling locations.



Figure A2: BWM soil stockpile sampling locations in the northern mine area (Inset A).



Figure A3: BWM soil stockpile sampling locations in the middle mine area (Insert B).



Figure A4: BWM soil stockpile sampling locations in the southern mine area (Insert C).

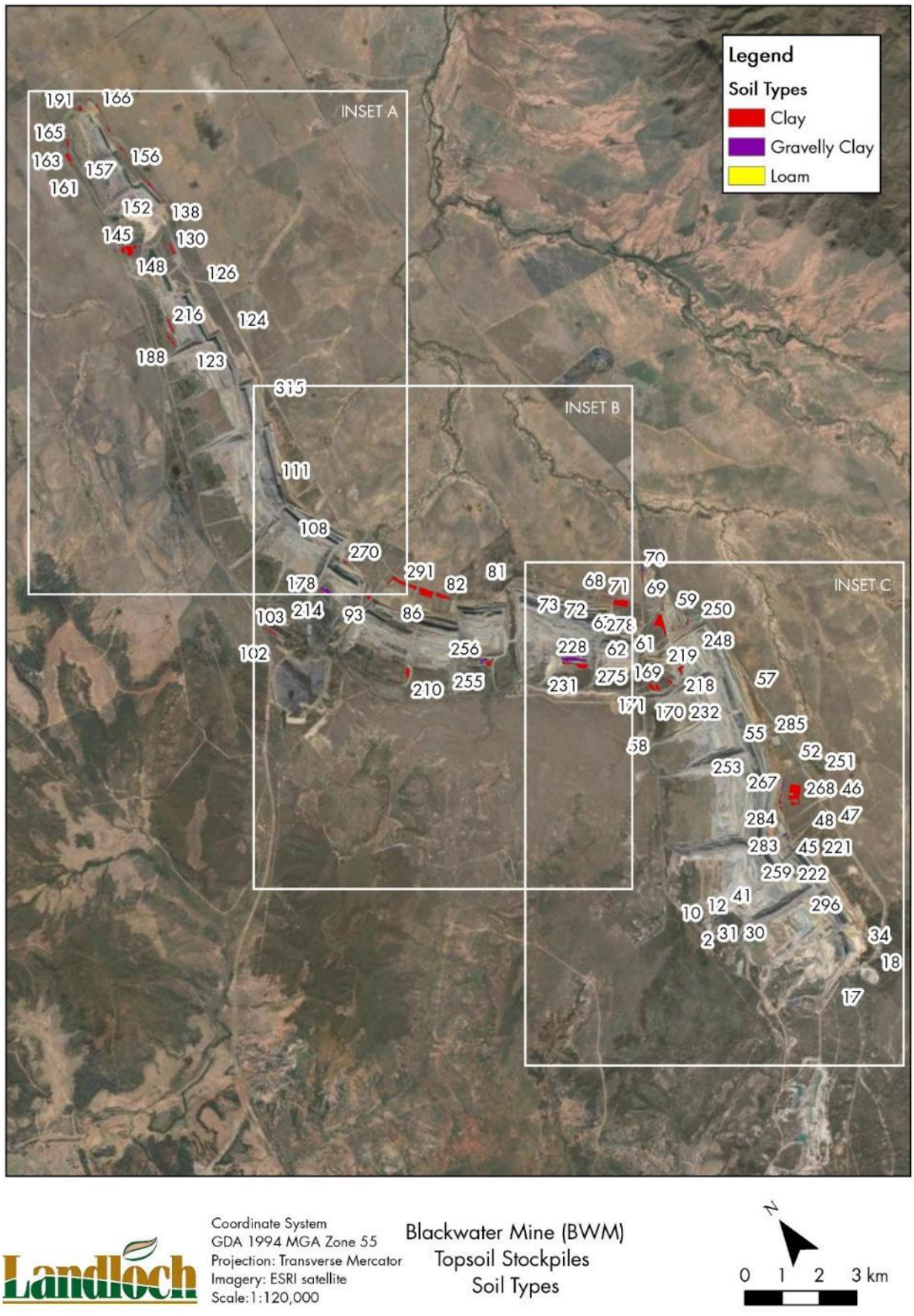

Figure A5: Distribution of stockpiled topsoil materials and stockpile identities at BWM.



Figure A6: Distribution of stockpiled soil materials and stockpile identities at BWM (Insert A).

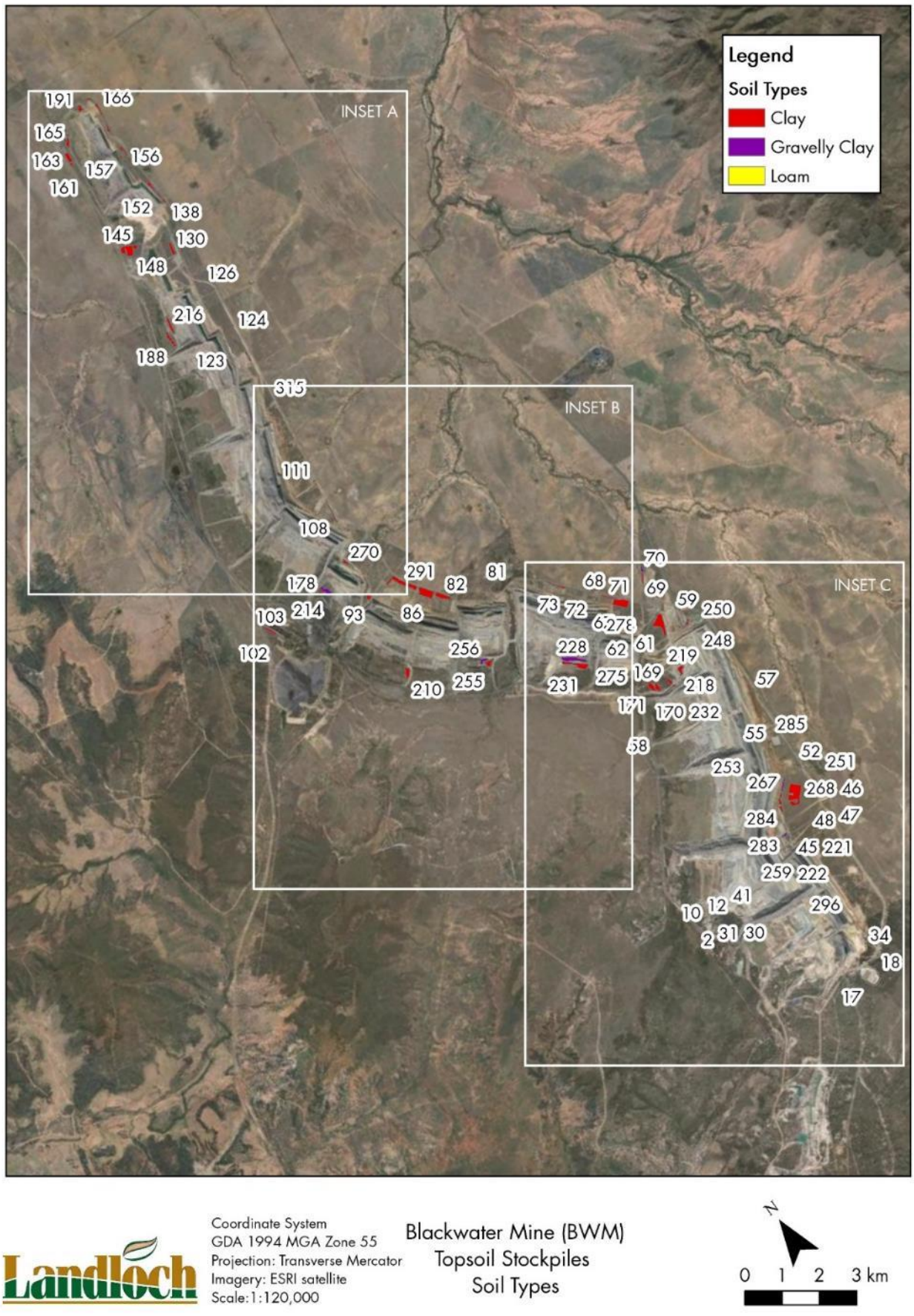

Figure A7: Distribution of stockpiled soil materials and stockpile identities at BWM (Insert B).

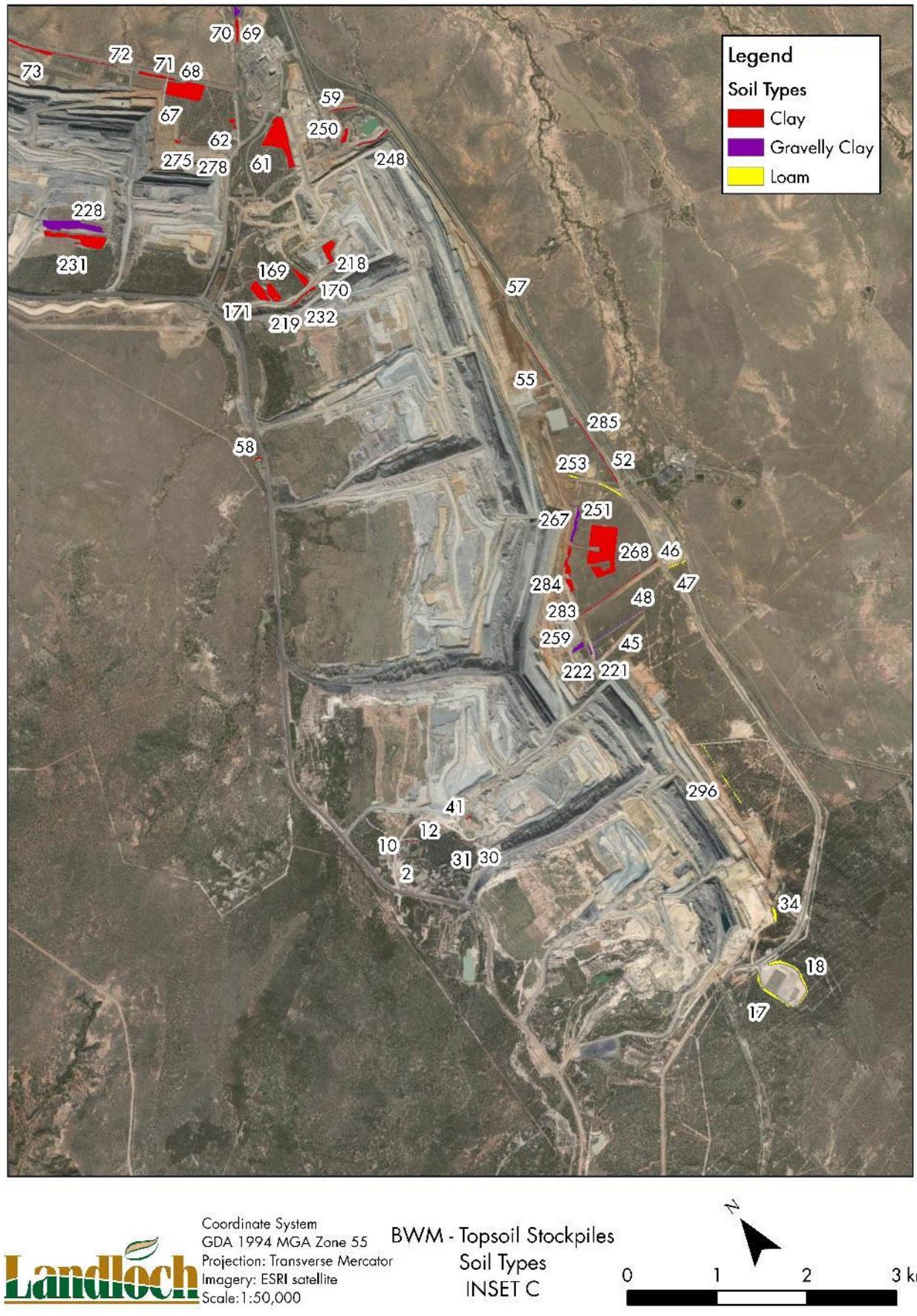

Figure A8: Distribution of stockpiled soil materials and stockpile identities at BWM (Insert C).

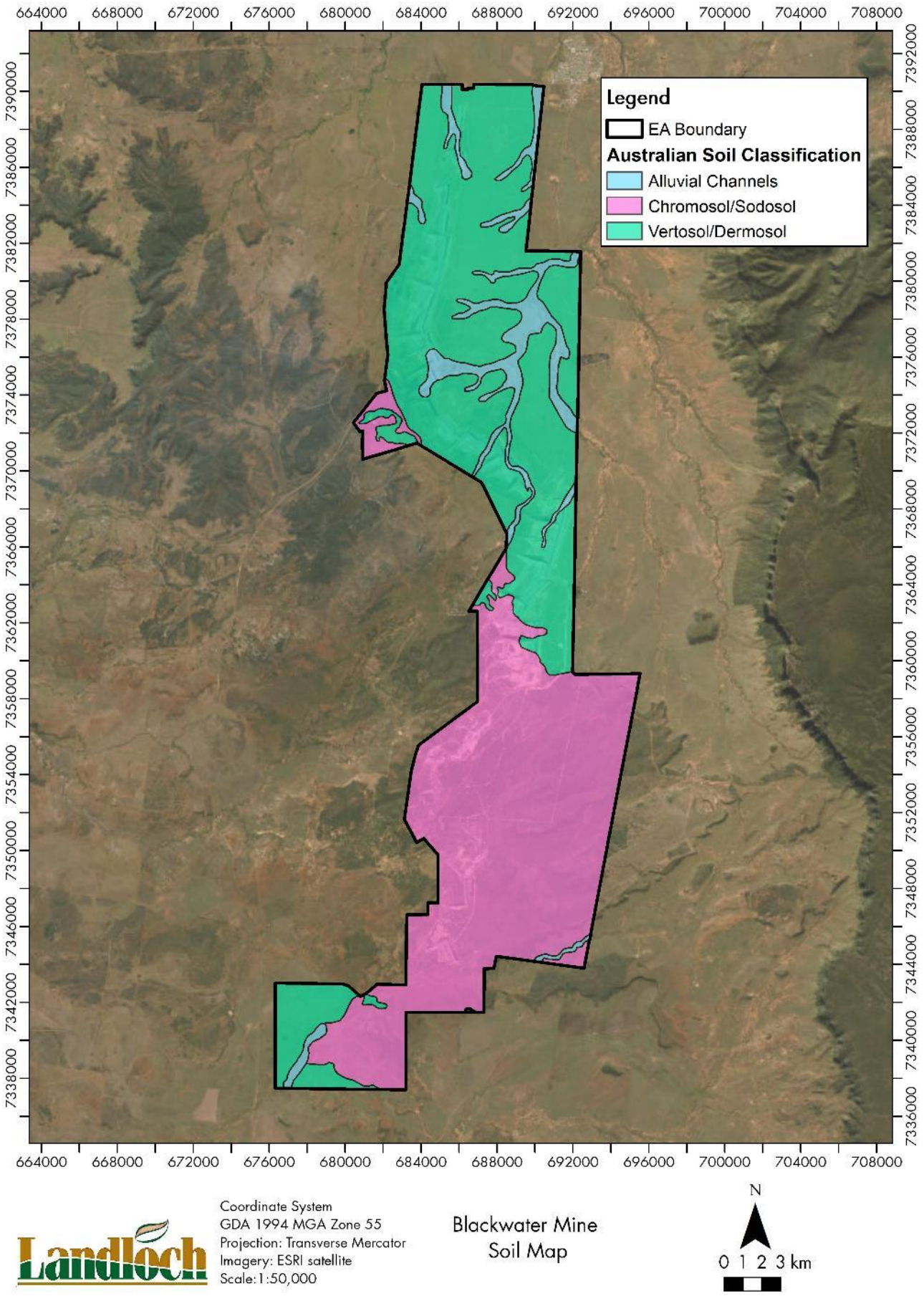

Figure A9: ASC soil mapping synthesised from existing soil assessments.

APPENDIX B: DATA TABLES

Table B1: Sampling site locations.

Site ID	Type	Latitude	Longitude
166	Topsoil stockpile	-23.59802818	148.8278925
191	Topsoil stockpile	-23.59525871	148.8241753
165	Topsoil stockpile	-23.60091782	148.8161545
163	Topsoil stockpile	-23.6050148	148.8141073
161	Topsoil stockpile	-23.60514069	148.8138643
156	Topsoil stockpile	-23.61475754	148.8255319
157	Topsoil stockpile	-23.60980225	148.8267107
152	Topsoil stockpile	-23.61862755	148.8272481
130	Topsoil stockpile	-23.63753891	148.822967
126	Topsoil stockpile	-23.64583206	148.8230632
124	Topsoil stockpile	-23.65038681	148.8259282
123	Topsoil stockpile	-23.66003227	148.821764
138a	Topsoil stockpile	-23.63183784	148.8258795
314	Topsoil stockpile	-23.67629051	148.8231125
111	Topsoil stockpile	-23.70185661	148.8192894
108	Topsoil stockpile	-23.70999146	148.8189732
270	Topsoil stockpile	-23.72184181	148.8144607
93	Topsoil stockpile	-23.73320198	148.8136208
291a	Topsoil stockpile	-23.73703957	148.8260059
291b	Topsoil stockpile	-23.73162842	148.822675
86	Topsoil stockpile	-23.73835182	148.8259969
81a	Topsoil stockpile	-23.74608803	148.8410505
82	Topsoil stockpile	-23.74221611	148.8307706
73	Topsoil stockpile	-23.75597	148.8568182
67	Topsoil stockpile	-23.76663017	148.8674779
71	Topsoil stockpile	-23.76489449	148.8660728
69	Topsoil stockpile	-23.76664925	148.876113
61	Topsoil stockpile	-23.77558899	148.8739726
61 b	Topsoil stockpile	-23.77689362	148.8720813
296	Topsoil stockpile	-23.85461235	148.8744966
48	Topsoil stockpile	-23.83402252	148.8787271
284	Topsoil stockpile	-23.82904434	148.8732071
268a	Topsoil stockpile	-23.82949066	148.8771785
268b	Topsoil stockpile	-23.83106232	148.8767802
256	Topsoil stockpile	-23.76095772	148.8307947
17a	Topsoil stockpile	-23.87491608	148.8650623
18a	Topsoil stockpile	-23.87794495	148.8689974
255	Topsoil stockpile	-23.76305962	148.830326
210	Topsoil stockpile	-23.75341988	148.8115358
102	Topsoil stockpile	-23.72528839	148.7867002
103	Topsoil stockpile	-23.72486877	148.7870308
214	Topsoil stockpile	-23.72504425	148.8046287
216	Topsoil stockpile	-23.65295792	148.8107479
188	Topsoil stockpile	-23.65569878	148.8096411

Site ID	Type	Latitude	Longitude
145	Topsoil stockpile	-23.63024521	148.8152339
148	Topsoil stockpile	-23.6295948	148.8138974
228 a	Topsoil stockpile	-23.7708931	148.8472299
228 b	Topsoil stockpile	-23.77192116	148.8473667
231 b	Topsoil stockpile	-23.77213669	148.8470965
70	Topsoil stockpile	-23.76402855	148.8783613
275	Topsoil stockpile	-23.77187538	148.8642506
278	Topsoil stockpile	-23.77187729	148.8652825
68	Topsoil stockpile	-23.76619911	148.8673287
72	Topsoil stockpile	-23.76157379	148.8626784
232	Topsoil stockpile	-23.79174614	148.8664496
62	Topsoil stockpile	-23.77323532	148.8707824
250	Topsoil stockpile	-23.78092384	148.8793256
248	Topsoil stockpile	-23.78253937	148.8843923
57	Topsoil stockpile	-23.80333519	148.8841401
55	Topsoil stockpile	-23.80994987	148.883361
285	Topsoil stockpile	-23.81966019	148.8832252
52	Topsoil stockpile	-23.82315636	148.8831367
47	Topsoil stockpile	-23.83518791	148.882622
251	Topsoil stockpile	-23.8242321	148.8810901
253	Topsoil stockpile	-23.82267189	148.8798111
267	Topsoil stockpile	-23.82462883	148.8776103
268c	Topsoil stockpile	-23.82899857	148.8765844
283	Topsoil stockpile	-23.8304863	148.8725547
221	Topsoil stockpile	-23.83710098	148.8702594
45	Topsoil stockpile	-23.83720398	148.8708987
222	Topsoil stockpile	-23.83860779	148.8702701
59	Topsoil stockpile	-23.77819061	148.8806264
218	Topsoil stockpile	-23.79071045	148.8708397
170	Topsoil stockpile	-23.79125404	148.8668312
219	Topsoil stockpile	-23.79116058	148.8648383
171	Topsoil stockpile	-23.79034042	148.862655
169	Topsoil stockpile	-23.79097176	148.8633755
58	Topsoil stockpile	-23.80288124	148.8522071
2	Topsoil stockpile	-23.84400177	148.8399913
11	Topsoil stockpile	-23.84314728	148.841079
12	Topsoil stockpile	-23.84300613	148.841662
31	Topsoil stockpile	-23.8467865	148.8473801
30	Topsoil stockpile	-23.84702873	148.8480939
41	Topsoil stockpile	-23.8459816	148.8490957
41 n	Topsoil stockpile	-23.8446579	148.8485737
34	Topsoil stockpile	-23.87069893	148.8701853
17b	Topsoil stockpile	-23.87491608	148.8650623
18b	Topsoil stockpile	-23.87794495	148.8689974
231a	Topsoil stockpile	-23.77213614	148.8470965
46	Topsoil stockpile	-23.83518819	148.882622
259	Topsoil stockpile	-23.79070999	148.8708397

Table B2: Ground observations and surface descriptions.

Site ID	Groundcover % (veg)	Veg/Litter	Cracks (width)	Cracks (depth)	Stoniness (abundance)	Stoniness (size)
166	60-80%	80/20	<5mm		10-20%	
191	60-80%	80/20	5-10mm		2-10%	
165	80-100%	60/40	5-10mm		2-10%	
163	80-100%	80/20	<5mm		<2%	2-6mm
161	80-100%	80/20	<5mm		<2%	2-6mm
156	60-80%	80/20	<5mm		<2%	2-6mm
157	80-100%	80/20	<5mm		<2%	2-6mm
152	80-100%	80/21	<5mm		<2%	
130	80-100%	80/20	<5mm		<2%	2-6mm
126	80-100%	80/20	<5mm		<2%	2-6mm
124	80-100%	80/20	<5mm		<2%	2-6mm
123	80-100%	80/20	<5mm		2-10%	2-6mm
138a	40-60%	60/40	<5mm		20-50%	2-6mm
314	80-100%	80/20	<5mm		2-10%	2-6mm
111	80-100%	80/20	<5mm		<2%	
108	80-100%	80/20	<5mm		2-10%	2-6mm
270	80-100%	80/20	<5mm		2-10%	2-6mm
93	80-100%	80/20	<5mm		<2%	2-6mm
291a	80-100%	80/20	<5mm		<2%	2-6mm
291b	80-100%	80/21	<5mm		<2%	2-6mm
86	60-80%	80/20	5-10mm	20-50mm	2-10%	2-6mm
81a	60-80%	80/20	5-10mm	10-20mm	2-10%	2-6mm
82	80-100%	80/20	5-10mm	10-20mm	2-10%	2-6mm
73	80-100%	80/20	<5mm	10-20mm	<2%	2-6mm
67	80-100%	80/20	<5mm		<2%	
71	80-100%	80/20	<5mm	10-20mm	<2%	2-6mm
69	80-100%	80/20	<5mm	10-20mm	<2%	2-6mm
61	80-100%	80/20	<5mm	10-20mm	<2%	2-6mm
61 b	80-100%	80/21	<5mm	10-20mm	<2%	2-6mm
296	60-80%	80/20	<5mm		2-10%	
48	80-100%	100/0				
284	80-100%	100/0	<5mm	<10mm	10-20%	<60mm
268a	80-100%	100/0	<5mm	<10mm	10-20%	<60mm
268b	80-100%	100/0	5-10mm	<10mm		<60mm
256	80-100%	100/0	5-10mm	<10mm	10-20%	<60mm
17a	40-60%	60/40			10-20%	<60mm
18a	40-60%	60/40			50-90%	<200mm
255	80-100%	100/0				
210	80-100%	100/0				
102	80-100%	100/0				
103	80-100%	100/0				
214	80-100%	100/0				
216	80-100%	100/0				
188	80-100%	100/0				
145	80-100%	100/0				

Site ID	Groundcover % (veg)	Veg/Litter	Cracks (width)	Cracks (depth)	Stoniness (abundance)	Stoniness (size)
148	80-100%	100/0	5-10mm	<10mm		
228 a	80-100%	100/0				
228 b	80-100%	100/0	5-10mm	<10mm	<2%	2-6mm
231 b	80-100%	100/0			<2%	2-6mm
70	80-100%	100/0				
275	80-100%	100/0	5-10mm	<10mm	2-10%	2-6mm
278	80-100%	100/0	5-10mm	<10mm	<2%	<60mm
68	80-100%	100/0			<2%	2-6mm
72	80-100%	100/0	<5mm			
232	80-100%	100/0			2-10%	<60mm
62	80-100%	100/0	5-10mm	<10mm	2-10%	<200mm
250	80-100%	100/0			2-10%	
248	80-100%	100/0				
57	80-100%	100/0	5-10mm	10-20mm	20-50%	<200mm
55	80-100%	100/0	5-10mm	<10mm	20-50%	2-6mm
285	80-100%	100/0	<5mm	<10mm	<2%	2-6mm
52	80-100%	100/0	<5mm	<10mm	2-10%	2-6mm
47	80-100%	100/0	<5mm	<10mm	<2%	2-6mm
251	80-100%	80/20			2-10%	<20mm
253	80-100%	100/0				
267	80-100%	100/0	5-10mm	<10mm	10-20%	2-6mm
268c	80-100%	80/20	5-10mm	<10mm	2-10%	2-6mm
283	80-100%	100/0				
221	80-100%	100/0	<5mm	<10mm	2-10%	<20mm
45	80-100%	100/0			10-20%	<60mm
222	80-100%	100/0			2-10%	<60mm
59	80-100%	100/0				
218	80-100%	100/0				
170	80-100%	100/0	<5mm	<10mm	20-50%	2-6mm
219	80-100%	100/0	5-10mm	<10mm	2-10%	2-6mm
171	80-100%	100/0				
169	80-100%	100/0	5-10mm	<10mm	2-10%	2-6mm
58	80-100%	100/0				
2	80-100%	100/0	<5mm	<10mm		<60mm
11	80-100%	100/0	5-10mm	<10mm		
12	80-100%	100/0	<5mm	<10mm	2-10%	2-6mm
31	80-100%	100/0				
30	60-80%	80/20	<5mm	<10mm	20-50%	2-6mm
41	60-80%	100/0				
41 n	80-100%	100/0				
34	80-100%	100/0				
17b	80-100%	100/0				
18b	80-100%	100/0				
231a	80-100%	100/0				
46	80-100%	100/0				
259	80-100%	100/0				

Table B3: Morphological description of stockpiled soil materials.

Site ID	Date	Layer Depth (m)	Texture Group 1o	Texture Field	Colour (rapid)		Total Coarse Fragment %	Coarse Fragments 1°			Coarse Fragments 2°			Sample Type
					Primary	Secondary		%	Size	Shape	%	Size (mm)	Shape	
166	6/03/2023	0.5	CLAY	Light Clay	Brown	Pale Brown	5-10	2-5	6-20	Sub-rounded	2-5	6-20	Sub-angular	Grab
		1	CLAY	Medium Clay	Brown	Orange	5-10	5-10	6-20	Sub-rounded	2-5	6-20	Sub-angular	Grab
		2	CLAY	Medium Clay	Brown	Orange	5-10	5-10	6-20	Sub-rounded	2-5	6-20	Sub-angular	Grab
		composite	CLAY											Composite
191	6/03/2023	0.5	CLAY	Medium Heavy Clay	Brown	Red	2-5	2-5	6-20	Sub-rounded				Grab
		1	CLAY	Medium Heavy Clay	Brown	Red	5-10	2-5	6-20	Sub-rounded				Grab
		2	CLAY	Medium Heavy Clay	Dark Brown	Red	2-5	2-5	6-20	Sub-rounded				Grab
		composite	CLAY											Composite
165	7/03/2023	0.5	CLAY	Medium Clay	Brown	Pale Brown	2-5	2-5	6-20	Sub-angular				Grab
		1	CLAY	Medium Clay	Brown	Pale Brown	2-5	2-5	6-20	Sub-angular				Grab
		1.8	CLAY	Medium Clay	Brown	Dark Grey	2-5	2-5	6-20	Sub-angular				Grab
		composite	CLAY											Composite
163	7/03/2023	0.5	CLAY	Light Medium Clay	Brown		2-5	2-5	6-20	Sub-angular				Grab
		1	CLAY	Light Medium Clay	Brown		2-5	2-5	6-20	Sub-angular				Grab
		2	CLAY	Light Clay	Brown		2-5	2-5	6-20	Sub-angular				Grab
		composite	CLAY											Composite
161	7/03/2023	0.5	CLAY	Medium Clay	Black		2-5	<2	6-20	Sub-angular				Grab
		1	CLAY	Medium Clay	Black		2-5	<2	6-20	Sub-angular				Grab
		2	CLAY	Medium Clay	Black		2-5	<2	6-20	Sub-angular				Grab
		composite	CLAY											Composite
156	7/03/2023	0.5	CLAY	Medium Clay	Brown									Grab
		1	CLAY	Medium Clay	Brown		2-5	<2	6-20	Sub-rounded				Grab
		2	CLAY	Light Medium Clay	Brown		2-5	<2	6-20	Sub-rounded				Grab
		composite	CLAY											Composite
157	7/03/2023	0.5	CLAY	Light Medium Clay	Pale Brown		2-5	<2	6-20	Sub-angular				Grab
		1	CLAY	Light Medium Clay	Pale Brown		5-10	<2	6-20	Sub-angular				Grab
		2	CLAY	Light Medium Clay	Pale Brown		2-5	<2	6-20	Sub-angular				Grab
		composite	CLAY											Composite
152	7/03/2023	0.5	CLAY	Light Medium Clay	Brown		0							Grab
		1	CLAY	Light Medium Clay	Brown		0							Grab
		2.5	CLAY	Light Medium Clay	Brown		<2	<2	6-20	Sub-rounded				Grab
		composite	CLAY											Composite
130	7/03/2023	0.5	CLAY	Light Medium Clay	Pale Brown		2-5	2-5	2-6	Sub-angular				Grab
		1	CLAY	Light Medium Clay	Pale Brown		2-5	2-5	6-20	Sub-angular				Grab
		1.8	CLAY	Light Medium Clay	Pale Brown		<2	2-5	2-6	Sub-angular				Grab
		composite	CLAY											Composite
126	7/03/2023	0.5	CLAY	Medium Clay	Dark Brown		0							Grab
		1	CLAY	Medium Clay	Dark Brown	Orange	2-5	<2	2-6	Sub-rounded				Grab
		2	CLAY	Medium Clay	Dark Brown	Orange	2-5	<2	6-20	Sub-rounded				Grab
		composite	CLAY											Composite
124	7/03/2023	0.5	CLAY	Light Medium Clay	Brown		0							Grab
		1	CLAY	Light Medium Clay	Brown		2-5	<2	2-6	Sub-rounded				Grab
		2	CLAY	Light Clay	Brown		0							Grab
		composite	CLAY											Composite
123	8/03/2023	0.5	CLAY	Medium Clay	Brown	Black	5-10	5-10	2-6	Sub-angular				Grab
		1.5	CLAY	Light Medium Clay	Brown		0							Grab
		3	CLAY	Light Clay	Brown		0							Grab
		composite	CLAY											Composite

Site ID	Date	Layer Depth (m)	Texture Group 1o	Texture Field	Colour (rapid)		Total Coarse Fragment %	Coarse Fragments 1°			Coarse Fragments 2°			Sample Type
					Primary	Secondary		%	Size	Shape	%	Size (mm)	Shape	
138 a	8/03/2023	1m a	GRAVELLY CLAY	Light Medium Clay	Pale Grey	Pale Yellow	30-40	10-20	20-60	Sub-angular	5-10	6-20	Sub-rounded	Grab
		1m b	GRAVELLY CLAY	Light Medium Clay	Pale Grey	Pale Orange	30-40	10-20	20-60	Sub-angular	5-10	6-20	Sub-rounded	Grab
		1m c	GRAVELLY CLAY	Light Medium Clay	Pale Grey	Pale Orange	30-40	10-20	20-60	Sub-angular	5-10	6-20	Sub-rounded	Grab
		composite	GRAVELLY CLAY											Composite
314*	8/03/2023	0.5	CLAY	Light Medium Clay	Brown		<2	<2	2-6	Sub-rounded				Grab
		1	CLAY	Light Medium Clay	Brown		0							Grab
		2	CLAY	Clay Loam	Brown		0							Grab
		composite	CLAY											Composite
111	8/03/2023	0.5	CLAY	Light Medium Clay	Dark Brown		<2	<2	6-20	Sub-rounded				Grab
		1.5	CLAY	Light Medium Clay	Dark Brown		0							Grab
		3	CLAY	Light Medium Clay	Dark Brown		0							Grab
		composite	CLAY											Composite
108	8/03/2023	0.5	CLAY	Light Medium Clay	Dark Grey	Red	<2	<2	6-20	Sub-rounded				Grab
		1.5	CLAY	Light Medium Clay	Dark Brown	Red	0							Grab
		3	CLAY	Light Clay	Pale Yellow	Pale Brown	0							Grab
		composite	CLAY											Composite
270	8/03/2023	0.5	CLAY	Light Medium Clay	Black	Red	5-10	5-10	60-200	Sub-angular				Grab
		1.5	CLAY	Medium Clay	Black		0							Grab
		3	CLAY	Medium Clay	Black		0							Grab
		composite	CLAY											Composite
93	8/03/2023	0.5	CLAY	Light Medium Clay	Dark Grey	Red	2-5	2-5	20-60	Sub-angular				Grab
		1	CLAY	Light Medium Clay	Dark Brown	Red	0							Grab
		2	CLAY	Medium Clay	Dark Brown	Red	0							Grab
		composite	CLAY											Composite
291	8/03/2023	0.5	CLAY	Light Medium Clay	Brown	Pale Red	<2	<2	2-6	Sub-rounded				Grab
		1.5	CLAY	Medium Clay	Brown	Dark Grey	0							Grab
		3	CLAY	Medium Clay	Brown	Dark Grey	0							Grab
		composite	CLAY											Composite
291 (b)	8/03/2023	0.5	CLAY	Medium Clay	Brown	Dark Grey	5-10	5-10	6-20	Sub-rounded				Grab
		1	CLAY	Medium Clay	Brown	Pale Red	5-10	5-10	6-20	Sub-angular				Grab
		2	CLAY	Medium Clay	Brown	Pale Grey	10-20	10-20	20-60	Sub-angular	5-10	6-20	Sub-rounded	Grab
		composite	CLAY											Composite
86	8/03/2023	0.5	CLAY	Light Medium Clay	Dark Brown		5-10	5-10	6-20	Sub-rounded				Grab
		1.5	CLAY	Light Medium Clay	Dark Brown		0							Grab
		3	CLAY	Medium Clay	Dark Brown		0							Grab
		composite	CLAY											Composite
81	9/03/2023	1m a	CLAY	Light Clay	Brown		2-5	5-10	6-20	Sub-rounded				Grab
		1m b	CLAY	Clay Loam Sandy	Brown		2-5	5-10	6-20	Sub-angular				Grab
		1m c	CLAY	Clay Loam	Brown		2-5	5-10	6-20	Sub-rounded				Grab
		composite	CLAY											Composite
82	9/03/2023	0.5	CLAY	Light Medium Clay	Brown	Pale Orange	2-5	2-5	2-6	Sub-rounded				Grab
		1.5	CLAY	Light Medium Clay	Brown	Pale Orange	0							Grab
		2.5	CLAY	Light Medium Clay	Brown	Pale Orange	0							Grab
		composite	CLAY											Composite
73	9/03/2023	0.5	CLAY	Light Medium Clay	Dark Brown		0							Grab
		1.5	CLAY	Light Medium Clay	Dark Brown		0							Grab
		3	CLAY	Light Medium Clay	Dark Brown		0							Grab
		composite	CLAY											Composite

Site ID	Date	Layer Depth (m)	Texture Group 1o	Texture Field	Colour (rapid)		Total Coarse Fragment %	Coarse Fragments 1°			Coarse Fragments 2°			Sample Type
					Primary	Secondary		%	Size	Shape	%	Size (mm)	Shape	
67	9/03/2023	0.5	CLAY	Medium Clay	Dark Brown		0							Grab
		1.5	CLAY	Light Medium Clay	Brown		<2	<2	6-20	Sub-rounded				Grab
		3	CLAY	Light Medium Clay	Brown		0							Grab
		composite	CLAY											Composite
71	9/03/2023	0.5	CLAY	Medium Clay	Brown	Pale Orange	2-5	2-5	6-20	Sub-rounded				Grab
		1.5	CLAY	Medium Clay	Brown	Pale Orange	0							Grab
		2.5	CLAY	Medium Clay	Brown	Pale Orange	0							Grab
		composite	CLAY											Composite
69	9/03/2023	0.5	CLAY	Light Medium Clay	Brown	Pale Orange	2-5	2-5	6-20	Sub-rounded				Grab
		1.5	CLAY	Light Medium Clay	Brown	Pale Orange	2-5	2-5	6-20	Sub-rounded				Grab
		3	CLAY	Medium Clay	Brown	Pale Orange	0							Grab
		composite	CLAY											Composite
61	9/03/2023	0.5	CLAY	Light Clay	Brown		<2	<2	2-6	Sub-rounded				Grab
		1.5	CLAY	Light Medium Clay	Brown		0							Grab
		3	CLAY	Light Medium Clay	Brown		0							Grab
		composite	CLAY											Composite
61 (b)	9/03/2023	0.5	CLAY	Light Medium Clay	Brown	Dark Grey	2-5	2-5	6-20	Sub-rounded				Grab
		1.5	CLAY	Light Medium Clay	Brown		0							Grab
		3	CLAY	Light Clay	Brown		0							Grab
		composite	CLAY											Composite
18a	14/03/2023	0.5	LOAM	Sandy Clay Loam	Grey	Brown	30-40	30-40	20-60	Sub-rounded				Grab
		1.5	LOAM	Sandy Clay Loam	Grey	Brown	30-40	30-40	20-60	Sub-rounded				Grab
		composite	LOAM				0							Composite
			LOAM											
18b	14/03/2023	0.5	LOAM	Sandy Clay Loam	Grey	Brown	30-40	30-40	20-60	Sub-rounded				Grab
		1.5	LOAM	Sandy Clay Loam	Grey	Brown	30-40	30-40	20-60	Sub-rounded				Grab
		composite	LOAM											Composite
			LOAM											
17a	14/03/2023	0.5	LOAM	Sandy Loam	Grey	Brown	10-20	10-20	20-60	Sub-rounded				Grab
		1.5	LOAM	Sandy Loam	Grey	Brown	10-20	10-20	20-60	Sub-rounded				Grab
		composite	LOAM											Composite
			LOAM											
17b	14/03/2023	0.5	LOAM	Sandy Loam	Grey	Brown	10-20	10-20	20-60	Sub-rounded				Grab
		1.5	LOAM	Sandy Loam	Grey	Brown	10-20	10-20	20-60	Sub-rounded				Grab
		composite	LOAM											Composite
			LOAM											
296	14/03/2023	0.5	LOAM	Clayey Sand	Red	Brown	30-40	30-40	20-60	Sub-rounded				Grab
		1.5	LOAM	Sandy Loam	Pale Red	Brown	30-40	30-40	20-60	Sub-rounded				Grab
		2.5	LOAM	Sandy Clay Loam	Pale Red	Brown	30-40	30-40	20-60	Sub-rounded				Grab
		composite	LOAM											Composite
48	14/03/2023	0.5	CLAY	Light Medium Clay	Dark Brown		0							Grab
		1.5	CLAY	Light Clay	Brown	Pale Red	0							Grab
		2.5	CLAY	Medium Clay	Brown	Red	0							Grab
		composite	CLAY											Composite
284	14/03/2023	0.5	CLAY	Light Clay	Red	Brown	10-20	5-10	20-60	Sub-rounded	5-10	6-20	Sub-rounded	Grab
		1.5	CLAY	Light Medium Clay	Pale Red	Brown	10-20	5-10	20-60	Sub-rounded	5-10	6-20	Sub-rounded	Grab
		2.5	CLAY	Medium Clay	Pale Red	Brown	5-10	5-10	20-60	Sub-angular	5-10	6-20	Sub-rounded	Grab
		composite	CLAY					0						Composite

Site ID	Date	Layer Depth (m)	Texture Group 1o	Texture Field	Colour (rapid)		Total Coarse Fragment %	Coarse Fragments 1°			Coarse Fragments 2°			Sample Type
					Primary	Secondary		%	Size	Shape	%	Size (mm)	Shape	
268a	14/03/2023	0.5	GRAVELLY CLAY	Light Medium Clay	Red	Brown	20-30	5-10	60-200	Sub-angular	10-20	6-20	Sub-rounded	Grab
		1.5	GRAVELLY CLAY	Light Medium Clay	Pale Red	Brown	20-30	10-20	60-200	Sub-angular	5-10	6-20	Sub-rounded	Grab
		2.5	GRAVELLY CLAY	Light Medium Clay	Pale Red	Brown	<2	<2	2-6	Sub-angular				Grab
		composite	GRAVELLY CLAY											Composite
268b	14/03/2023	0.5	GRAVELLY CLAY	Medium Heavy Clay	Red	Brown	30-40	20-30	6-20	Sub-rounded	10-20	60-200	Sub-angular	Grab
		1.5	GRAVELLY CLAY	Medium Heavy Clay	Pale Red	Brown	40-60	30-40	60-200	Sub-angular	5-10	20-60	Sub-angular	Grab
		2.5	GRAVELLY CLAY	Medium Heavy Clay	Pale Red	Brown	30-40	20-30	60-200	Sub-angular	5-10	6-20	Sub-rounded	Grab
		composite	GRAVELLY CLAY											Composite
256	15/03/2023	0.5	GRAVELLY CLAY	Light Clay	Red	Brown	20-30	10-20	20-60	Sub-rounded	10-20	6-20	Sub-angular	Grab
		1.5	GRAVELLY CLAY	Light Clay	Pale Red	Brown	20-30	10-20	20-60	Sub-rounded	10-20	6-20	Sub-angular	Grab
		2.5	GRAVELLY CLAY	Medium Clay	Pale Red	Brown	20-30	10-20	20-60	Sub-rounded	10-20	2-6	Sub-angular	Grab
		composite	GRAVELLY CLAY											Composite
255	15/03/2023	0.5	CLAY	Medium Clay	Red	Brown	0							Grab
		1	CLAY	Medium Clay	Red	Brown	0							Grab
		1.5	CLAY	Medium Clay	Red	Brown	0							Grab
		composite	CLAY											Composite
210	16/03/2023	0.5	CLAY	Medium Heavy Clay	Grey	Brown	2-5	2-5	20-60	Sub-angular			Sub-rounded	Grab
		1.5	CLAY	Medium Heavy Clay	Grey	Brown	2-5	2-5	6-20	Sub-angular				Grab
		2.5	CLAY	Medium Heavy Clay	Grey	Brown	2-5	2-5	6-20	Sub-angular				Grab
		composite	CLAY											Composite
102	16/03/2023	0.5	CLAY	Medium Heavy Clay	Red	Brown	<2	<2	2-6	Sub-angular				Grab
		1.5	CLAY	Medium Heavy Clay	Red	Brown	<2	<2	2-6	Sub-angular				Grab
		2.5	CLAY	Medium Heavy Clay	Red	Brown	<2	<2	2-6	Sub-angular				Grab
		composite	CLAY											Composite
103	16/03/2023	0.5	CLAY	Light Medium Clay	Red	Brown	5-10	5-10	20-60	Sub-angular				Grab
		1.5	CLAY	Light Clay	Pale Red	Brown	5-10	5-10	20-60	Sub-angular				Grab
		2.5	CLAY	Silty Loam	Pale Yellow	Brown	40-60	30-40	60-200	Sub-angular	20-30	20-60	Sub-angular	Grab
		composite	CLAY											Composite
214	16/03/2023	0.5	GRAVELLY CLAY	Medium Clay	Red	Brown	10-20	10-20	20-60	Sub-angular				Grab
		1.5	GRAVELLY CLAY	Medium Clay	Pale Red	Brown	20-30	5-10	60-200	Sub-angular	10-20	6-20	Sub-angular	Grab
		2.5	GRAVELLY CLAY	Medium Clay	Pale Red	Brown	40-60	20-30	60-200	Sub-angular	20-30	6-20	Sub-angular	Grab
		composite	GRAVELLY CLAY											Composite
216	16/03/2023	0.5	CLAY	Medium Clay	Red	Brown	10-20	10-20	6-20	Sub-angular				Grab
		1,5	CLAY	Medium Clay	Red	Brown	20-30	20-30	6-20	Sub-angular			Sub-rounded	Grab
		2.5	CLAY	Medium Clay	Red	Brown	5-10	5-10	6-20	Sub-angular				Grab
		composite	CLAY											Composite
188	16/03/2023	0.5	CLAY	Light Clay	Red	Brown	0							Grab
		1.5	CLAY	Light Clay	Red	Brown	0							Grab
		2.5	CLAY	Light Clay	Red	Brown	5-10	2-5	20-60	Sub-rounded	2-5	2-6	Sub-rounded	Grab
		composite	CLAY											Composite
145	17/03/2023	1m a	CLAY	Medium Clay	Grey	Brown	<2	<2	2-6	Sub-rounded				Grab
		1m b	CLAY	Medium Clay	Grey	Brown	<2	<2	2-6	Sub-rounded				Grab
		1m c	CLAY	Medium Clay	Grey	Brown	<2	<2	2-6	Sub-rounded				Grab
		composite	CLAY											Composite

Site ID	Date	Layer Depth (m)	Texture Group 1o	Texture Field	Colour (rapid)		Total Coarse Fragment %	Coarse Fragments 1°			Coarse Fragments 2°			Sample Type
					Primary	Secondary		%	Size	Shape	%	Size (mm)	Shape	
148	17/03/2023	1m a	CLAY	Light Medium Clay	Red	Brown	0							Grab
		1m b	CLAY	Light Medium Clay	Red	Brown	0							Grab
		1m c	CLAY	Light Medium Clay	Red	Brown	0							Grab
		composite	CLAY											Composite
228a	17/03/2023	0.5	GRAVELLY CLAY	Light Clay	Red	Brown	10-20	5-10	20-60	Sub-angular	5-10	6-20	Sub-rounded	Grab
		1.5	GRAVELLY CLAY	Light Clay	Red	Brown	10-20	5-10	20-60	Sub-angular	5-10	6-20	Sub-rounded	Grab
		2/01/1900	GRAVELLY CLAY	Light Medium Clay	Red	Brown	10-20	5-10	20-60	Sub-angular	5-10	6-20	Sub-rounded	Grab
		composite	GRAVELLY CLAY											Composite
228 b	17/03/2023	0.5	GRAVELLY CLAY	Light Medium Clay	Red	Brown	30-40	5-10	20-60	Sub-angular	20-30	6-20	Sub-angular	Grab
		1.5	GRAVELLY CLAY	Medium Clay	Pale Red	Brown	40-60	20-30	60-200	Sub-angular	20-30	20-60	Sub-angular	Grab
		2.5	GRAVELLY CLAY	Medium Clay	Pale Red	Brown	5-10	5-10	6-20	Sub-angular				Grab
		composite	GRAVELLY CLAY											Composite
231 a	17/03/2023	0.5	CLAY	Light Medium Clay	Red	Brown	5-10	5-10	6-20	Sub-angular				Grab
		1.5	CLAY	Light Medium Clay	Red	Brown	5-10	5-10	6-20	Sub-angular				Grab
		2.5	CLAY	Light Medium Clay	Red	Brown	5-10	5-10	6-20	Sub-angular				Grab
		composite	CLAY											Composite
231 b	17/03/2023	0.5	CLAY	Light Clay	Red	Brown	2-5	<2	20-60	Sub-angular	<2	6-20	Sub-angular	Grab
		1.5	CLAY	Light Clay	Red	Brown	2-5	<2	20-60	Sub-angular	<2	6-20	Sub-angular	Grab
		2 (on bag - 2-2.5r	CLAY	Light Clay	Red	Brown	2-5	<2	20-60	Sub-angular	<2	6-20	Sub-angular	Grab
		composite	CLAY											Composite
70	18/03/2023	0.5	GRAVELLY CLAY	Medium Clay	Dark Brown		20-30	5-10	60-200	Sub-angular	20-30	20-60	Sub-angular	Grab
		1.5	GRAVELLY CLAY	Medium Clay	Dark Brown		20-30	5-10	60-200	Sub-angular	20-30	20-60	Sub-angular	Grab
		2.5	GRAVELLY CLAY	Medium Clay	Dark Brown		20-30	5-10	60-200	Sub-angular	20-30	20-60	Sub-angular	Grab
		composite	GRAVELLY CLAY											Composite
275	18/03/2023	0.5	CLAY	Light Medium Clay	Dark Brown		0							Grab
		1.5	CLAY	Light Medium Clay	Brown	Pale Red	0							Grab
		2.5	CLAY	Light Medium Clay	Brown	Pale Red	0							Grab
		composite	CLAY		Dark Brown									Composite
278	18/03/2023	0.5	CLAY	Medium Heavy Clay	Dark Brown	Red	0							Grab
		1.5	CLAY	Medium Heavy Clay	Brown	Red	0							Grab
		2.5	CLAY	Medium Heavy Clay	Brown	Red	<2	<2	2-6	Sub-angular				Grab
		composite	CLAY											Composite
68	18/03/2023	0.5	CLAY	Light Medium Clay	Dark Brown		0							Grab
		1.5	CLAY	Clayey Sand	Brown	Pale Red	2-5	2-5	6-20	Sub-angular				Grab
		2.5	CLAY	Clayey Sand	Brown	Pale Red	2-5	2-5	6-20	Sub-angular				Grab
		composite	CLAY											Composite
72	18/03/2023	0.5	CLAY	Medium Clay	Brown	Red	0							Grab
		1.5	CLAY	Light Medium Clay	Brown	Red	0							Grab
		2.5	CLAY	Light Medium Clay	Brown	Red	2-5	2-5	2-6	Sub-angular				Grab
		composite	CLAY											Composite
232	18/03/2023	0.5	CLAY	Medium Clay	Brown	Red	5-10	5-10	20-60	Sub-angular				Grab
		1.5	CLAY	Medium Clay	Brown	Red	5-10	5-10	20-60	Sub-angular				Grab
		2.5	CLAY	Medium Clay	Brown	Red	5-10	5-10	20-60	Sub-angular				Grab
		composite	CLAY											Composite
62	18/03/2023	0.5	CLAY	Medium Heavy Clay	Dark Brown	Red	<2	<2	6-20	Sub-angular				Grab
		1.5	CLAY	Medium Heavy Clay	Brown	Red	<2	<2	6-20	Sub-angular				Grab
		2.5	CLAY	Medium Heavy Clay	Brown	Red	<2	<2	6-20	Sub-angular				Grab
		composite	CLAY											Composite

Site ID	Date	Layer Depth (m)	Texture Group 1o	Texture Field	Colour (rapid)		Total Coarse Fragment %	Coarse Fragments 1°			Coarse Fragments 2°			Sample Type
					Primary	Secondary		%	Size	Shape	%	Size (mm)	Shape	
250	18/03/2023	0.5	CLAY	Medium Clay	Dark Brown	Red	<2	<2	6-20	Sub-angular				Grab
		1.5	CLAY	Medium Clay	Brown	Red	<2	<2	6-20	Sub-angular				Grab
		2.5	CLAY	Medium Clay	Brown	Red	<2	<2	6-20	Sub-angular				Grab
		composite	CLAY											Composite
248	18/03/2023	0.5	CLAY	Light Medium Clay	Brown	Red	0							Grab
		1.5	CLAY	Light Medium Clay	Brown	Red	5-10	5-10	20-60	Sub-angular				Grab
		2.5	CLAY	Light Medium Clay	Brown	Red	5-10	2-5	20-60	Sub-angular				Grab
		composite	CLAY											Composite
57	18/03/2023	0.5	CLAY	Medium Heavy Clay	Dark Brown	Dark Grey	10-20	2-5	60-200	Sub-angular	5-10	2-6	Sub-angular	Grab
		1.5	CLAY	Medium Heavy Clay	Dark Brown	Dark Grey	10-20	2-5	60-200	Sub-angular	5-10	2-6	Sub-angular	Grab
		2.5	CLAY	Medium Heavy Clay	Dark Brown	Dark Grey	10-20	2-5	60-200	Sub-angular	5-10	2-6	Sub-angular	Grab
		composite	CLAY											Composite
55	19/03/2023	0.5	CLAY	Medium Heavy Clay	Dark Grey	Brown	<2	<2	2-6	Sub-angular				Grab
		1.5	CLAY	Medium Heavy Clay	Dark Grey	Brown	<2	<2	2-6	Sub-angular				Grab
		2.5	CLAY	Medium Heavy Clay	Dark Grey	Brown	<2	<2	2-6	Sub-angular				Grab
		composite	CLAY											Composite
285	19/03/2023	0.5	CLAY	Light Medium Clay	Red	Brown	<2	<2	2-6	Sub-rounded				Grab
		1.5	CLAY	Light Medium Clay	Red	Brown	<2	<2	2-6	Sub-rounded				Grab
		2.5	CLAY	Light Medium Clay	Red	Brown	<2	<2	6-20	Sub-rounded				Grab
		composite	CLAY											Composite
52	19/03/2023	0.5	CLAY	Light Medium Clay	Brown	Red	<2	<2	2-6	Sub-angular				Grab
		1.5	CLAY	Light Medium Clay	Brown	Red	<2	<2	6-20	Sub-angular				Grab
		2.5	CLAY	Light Medium Clay	Brown	Red	<2	<2	2-6	Sub-angular				Grab
		composite	CLAY											Composite
47	19/03/2023	0.5	LOAM	Clayey Sand	Red	Brown	<2	<2	2-6	Sub-angular				Grab
		1.5	LOAM	Clayey Sand	Red	Brown	<2	<2	2-6	Sub-angular				Grab
		2.5	LOAM	Sandy Clay Loam	Red	Brown	<2	<2	2-6	Sub-angular				Grab
		composite	LOAM											Composite
46	19/03/2023	0.5	LOAM	Clayey Sand	Red	Brown	<2	<2	2-6	Sub-angular				Grab
		1.5	LOAM	Light Clay	Red	Brown	<2	<2	2-6	Sub-angular				Grab
		2.5	LOAM	Light Clay	Red	Brown	<2	<2	2-6	Sub-angular				Grab
		composite	LOAM											Composite
251	19/03/2023	0.5	LOAM	Silty Loam	Pale Red	Brown	2-5	2-5	2-6	Sub-rounded				Grab
		1.5	LOAM	Silty Loam	Pale Red	Brown	2-5	2-5	2-6	Sub-rounded				Grab
		2.5	LOAM	Silty Loam	Pale Red	Brown	2-5	2-5	2-6	Sub-rounded				Grab
		composite	LOAM	Silty Loam										Composite
253	19/03/2023	0.5	LOAM	Silty Clay Loam	Red	Brown	<2	<2	2-6	Sub-rounded				Grab
		1.5	LOAM	Silty Clay Loam	Red	Brown	<2	<2	2-6	Sub-rounded				Grab
		2.5	LOAM	Silty Clay Loam	Red	Brown	<2	<2	2-6	Sub-rounded				Grab
		composite	LOAM											Composite
267	19/03/2023	0.5	GRAVELLY CLAY	Medium Heavy Clay	Red	Brown	40-60	40-60	20-60	Sub-rounded				Grab
		1.5	GRAVELLY CLAY	Medium Heavy Clay	Red	Brown	40-60	40-60	20-60	Sub-rounded				Grab
		2.5	GRAVELLY CLAY	Medium Heavy Clay	Red	Brown	40-60	40-60	20-60	Sub-rounded				Grab
		composite	GRAVELLY CLAY											Composite
268c	19/03/2023	0.5	CLAY	Medium Clay	Red	Brown	<2	<2	2-6	Sub-rounded				Grab
		1.5	CLAY	Medium Clay	Red	Brown	5-10	5-10	6-20	Sub-rounded				Grab
		2.5	CLAY	Medium Clay	Red	Brown	2-5	2-5	2-6	Sub-rounded				Grab
		composite	CLAY											Composite

Site ID	Date	Layer Depth (m)	Texture Group 1o	Texture Field	Colour (rapid)		Total Coarse Fragment %	Coarse Fragments 1°			Coarse Fragments 2°			Sample Type
					Primary	Secondary		%	Size	Shape	%	Size (mm)	Shape	
283	19/03/2023	0.5	CLAY	Medium Clay	Red	Brown	<2	<2	6-20	Sub-angular				Grab
		1.5	CLAY	Medium Clay	Red	Brown	5-10	2-5	60-200	Sub-angular	2-5	2-6	Sub-angular	Grab
		2.5	CLAY	Medium Clay	Red	Brown	5-10	2-5	20-60	Sub-angular	2-5	2-6	Sub-angular	Grab
		composite	CLAY											Composite
221	19/03/2023	0.5	GRAVELLY CLAY	Clayey Sand	Grey	Brown	40-60	30-40	60-200	Sub-angular	10-20	6-20	Sub-angular	Grab
		1.5	GRAVELLY CLAY	Light Clay	Grey	Brown	40-60	30-40	60-200	Sub-angular	10-20	6-20	Sub-angular	Grab
		2.5	GRAVELLY CLAY	Light Clay	Pale Red	Pale Grey	40-60	30-40	60-200	Sub-angular	10-20	6-20	Sub-angular	Grab
		composite	GRAVELLY CLAY											Composite
45	19/03/2023	0.5	GRAVELLY CLAY	Light Medium Clay	Pale Red	Pale Red	40-60	20-30	60-200	Sub-angular	20-30	20-60	Sub-angular	Grab
		1.5	GRAVELLY CLAY	Light Medium Clay	Pale Red	Pale Red	40-60	20-30	60-200	Sub-angular	20-30	20-60	Sub-angular	Grab
		2.5	GRAVELLY CLAY	Light Medium Clay	Pale Red	Pale Red	40-60	20-30	60-200	Sub-angular	20-30	20-60	Sub-angular	Grab
		composite	GRAVELLY CLAY											Composite
222	19/03/2023	0.5	GRAVELLY CLAY	Medium Clay	Red	Brown	40-60	30-40	60-200	Sub-angular	10-20	20-60	Sub-angular	Grab
		1.5	GRAVELLY CLAY	Medium Clay	Red	Brown	40-60	30-40	60-200	Sub-angular	10-20	20-60	Sub-angular	Grab
		2.5	GRAVELLY CLAY	Medium Clay	Red	Brown	40-60	30-40	60-200	Sub-angular	10-20	20-60	Sub-angular	Grab
		composite	GRAVELLY CLAY											Composite
259	19/03/2023	0.5	GRAVELLY CLAY	Medium Heavy Clay	Red	Brown	40-60	30-40	60-200	Sub-angular	10-20	6-20	Sub-angular	Grab
		1	GRAVELLY CLAY	Medium Heavy Clay	Red	Brown	40-60	30-40	60-200	Sub-angular	10-20	6-20	Sub-angular	Grab
		2	GRAVELLY CLAY	Medium Heavy Clay	Red	Yellow	40-60	30-40	60-200	Sub-angular	10-20	6-20	Sub-angular	Grab
		composite	GRAVELLY CLAY											Composite
59	20/03/2023	1ma	CLAY	Light Medium Clay	Brown	Red	0							Grab
		1 m b	CLAY	Light Medium Clay	Brown	Red	0							Grab
		1 m c	CLAY	Light Medium Clay	Red	Brown	0							Grab
		composite	CLAY											Composite
218	20/03/2023	0.5	CLAY	Light Clay	Red	Brown	<2	<2	2-6	Sub-angular				Grab
		1.5	CLAY	Light Clay	Red	Brown	0							Grab
		2.5	CLAY	Light Clay	Red	Brown	0							Grab
		composite	CLAY											Composite
170	20/03/2023	0.5	CLAY	Medium Heavy Clay	Brown	Red	0							Grab
		1.5	CLAY	Medium Heavy Clay	Brown	Red	0							Grab
		2.5	CLAY	Medium Heavy Clay	Brown	Red	0							Grab
		composite	CLAY											Composite
219	20/03/2023	0.5	CLAY	Medium Heavy Clay	Brown	Grey	0							Grab
		1.5	CLAY	Medium Heavy Clay	Brown	Grey	0							Grab
		2.5	CLAY	Medium Heavy Clay	Brown	Grey	0							Grab
		composite	CLAY											Composite
171	20/03/2023	0.5	CLAY	Medium Clay	Brown	Red	5-10	<2	200-600	Sub-angular	5-10	20-60	Sub-angular	Grab
		1.5	CLAY	Medium Clay	Brown	Red	5-10	5-10	20-60	Sub-angular				Grab
		2.5	CLAY	Medium Clay	Brown	Red	5-10	5-10	20-60	Sub-angular				Grab
		composite	CLAY											Composite
169	20/03/2023	0.5	CLAY	Medium Clay	Brown	Grey	<2	<2	6-20	Sub-angular				Grab
		1.5	CLAY	Medium Clay	Brown	Grey	<2	<2	6-20	Sub-angular				Grab
		2.5	CLAY	Medium Heavy Clay	Brown	Grey	<2	<2	6-20	Sub-angular				Grab
		composite	CLAY											Composite
58	20/03/2023	0.5	CLAY	Medium Clay	Brown	Grey	<2	<2	6-20	Sub-angular				Grab
		1.5	CLAY	Medium Clay	Brown	Grey	<2	<2	6-20	Sub-angular				Grab
		2.5	CLAY	Medium Clay	Brown	Grey	<2	<2	6-20	Sub-angular				Grab
		composite	CLAY											Composite

Site ID	Date	Layer Depth (m)	Texture Group 1o	Texture Field	Colour (rapid)		Total Coarse Fragment %	Coarse Fragments 1°			Coarse Fragments 2°			Sample Type
					Primary	Secondary		%	Size	Shape	%	Size (mm)	Shape	
2	20/03/2023	0.5	CLAY	Medium Heavy Clay	Red	Brown	0							Grab
		1.5	CLAY	Medium Heavy Clay	Red	Brown	0							Grab
		2.5	CLAY	Medium Heavy Clay	Red	Brown	0							Grab
		composite	CLAY											Composite
11	20/03/2023	0.5	CLAY	Medium Heavy Clay	Red	Brown	<2	<2	6-20	Sub-angular				Grab
		1.5	CLAY	Medium Heavy Clay	Red	Brown	<2	<2	6-20	Sub-angular				Grab
		2.5	CLAY	Medium Heavy Clay	Red	Brown	<2	<2	6-20	Sub-angular				Grab
		composite	CLAY											Composite
12	20/03/2023	0.5	CLAY	Medium Heavy Clay	Red	Brown	<2	<2	6-20	Sub-angular				Grab
		1.5	CLAY	Medium Heavy Clay	Red	Brown	<2	<2	6-20	Sub-angular				Grab
		2.5	CLAY	Medium Heavy Clay	Red	Brown	<2	<2	6-20	Sub-angular				Grab
		composite	CLAY											Composite
31	20/03/2023	0.5	CLAY	Light Clay	Red	Brown	0							Grab
		1.5	CLAY	Light Clay	Red	Brown	0							Grab
		2.5	CLAY	Light Clay	Red	Brown	0							Grab
		c	CLAY											Composite
30	20/03/2023	0.5	CLAY	Light Medium Clay	Red	Brown	5-10	5-10	20-60	Sub-angular				Grab
		1.5	CLAY	Light Medium Clay	Red	Brown	5-10	5-10	20-60	Sub-angular				Grab
		2.5	CLAY	Light Medium Clay	Red	Brown	5-10	5-10	20-60	Sub-angular				Grab
		composite	CLAY											Composite
41	20/03/2023	0.5	CLAY	Light Clay	Red	Brown	<2	<2	20-60	Sub-angular				Grab
		1.5	CLAY	Light Clay	Red	Brown	0							Grab
		2.5	CLAY	Light Clay	Red	Brown	0							Grab
		composite	CLAY											Composite
41 N	20/03/2023	0.5	CLAY	Light Clay	Red	Brown	0							Grab
		1.5	CLAY	Light Clay	Red	Brown	0							Grab
		2.5	CLAY	Light Clay	Red	Brown	0							Grab
		composite	CLAY											Composite
34	20/03/2023	0.5	LOAM	Sandy Loam	Pale Grey		20-30	10-20	60-200	Sub-angular	5-10	6-20	Sub-angular	Grab
		1.5	LOAM	Sandy Loam	Pale Grey		20-30	10-20	2-6	Sub-angular	5-10	6-20	Sub-angular	Grab
		2.5	LOAM	Sandy Loam	Pale Grey		20-30	10-20	2-6	Sub-angular	5-10	6-20	Sub-angular	Grab
		composite	LOAM											Composite

Table B4: Laboratory analysis data for loam topsoils. Part 1 of 3.

Table B4. Laboratory Results Loams											
	Lab No	230959-119		230959-122		230959-125		230959-128		230959-132	
	Sample ID	18a		18b		17a		17b		296	
	Sample Depth	Composite		Composite		Composite		Composite		Composite	
	Field Texture	SCL		SCL		SL		SL		SCL	
Analyses	**Unit**	-		-		-		-		-	
pH - Water	pH units	4.79	*VH.Acid*	4.66	*VH.Acid*	4.97	*VH.Acid*	5.09	*VH.Acid*	5.25	*H.Acid*
Electrical Conductivity	dS/m	0.08	*VL.Sal*	0.07	*VL.Sal*	0.05	*VL.Sal*	0.05	*VL.Sal*	0.1	*L.Sal*
Chloride	mg/kg	55.9	*VL.Sal*	38.6	*VL.Sal*	16.5	*VL.Sal*	43.6	*VL.Sal*	50.3	*VL.Sal*
Total Nitrogen - Kjeldahl	mg/kg	1570.0	*M*	1310.0	*L*	843.0	*L*	700.0	*L*	790.0	*L*
Total Phosphorus - Nitric/Perchloric	mg/kg	92.9	*	<40.0	*	70.5	*	104.0	*	102.0	*
Phosphorus - Colwell extr	mg/kg	16.5	*M*	18.3	*M*	30.5	*H*	21.9	*H*	10.7	*L*
Potassium - Colwell ext	mg/kg	135.00	*L*	147.00	*L*	96.00	*L*	147.00	*L*	124.00	*L*
Sulphur - KCl	mg/kg	11.9	*M*	10.7	*M*	6.7	*L*	9.8	*M*	10.4	*M*
Organic Carbon	%	2.44	*H*	1.94	*H*	1.11	*M*	1.01	*M*	1.03	*M*
Copper	mg/kg	0.21	*L*	<0.20	*L*	<0.20	*L*	<0.20	*L*	0.29	*L*
Iron	mg/kg	171.00	*	148.00	*	77.30	*	54.10	*	96.80	*
Manganese	mg/kg	5.22	*M*	3.22	*M*	5.00	*M*	5.26	*M*	3.88	*M*
Zinc	mg/kg	0.48	*L*	0.22	*L*	0.22	*L*	0.20	*L*	0.24	*L*
Boron	mg/kg	0.42	*VL*	0.38	*VL*	0.40	*VL*	0.34	*VL*	0.40	*VL*
Cation Extraction Method	Rayment& Lyons	15A1	*	15A1	*	15A1	*	15A1	*	15A1	*
Cation Exchange Capacity	meq/100g	4.3	*VL*	3.5	*VL*	2.3	*VL*	3.1	*VL*	3.8	*VL*
Ex Calcium Percent	%	33.33	*L*	10.94	*L*	54.13	*L*	50.93	*L*	57.43	*L*
Ex Magnesium Percent	%	8.01	*L*	2.40	*L*	8.66	*L*	15.17	*H*	23.27	*H*
Ex Potassium Percent	%	3.36	*Normal*	2.10	*Normal*	6.78	*H*	12.44	*H*	5.02	*H*
Ex Sodium Percent	%	1.1	*N.Sodic*	1.3	*N.Sodic*	1.9	*N.Sodic*	4.0	*N.Sodic*	4.7	*N.Sodic*
Ex Aluminium Percent	%	54.20	*VH*	83.30	*VH*	28.55	*H*	17.42	*M*	9.57	*L*
Exchangeable Calcium	mg/kg	287	*H*	75.9	*Normal*	249	*H*	319	*H*	436	*H*
Exchangeable Magnesium	mg/kg	41.4	*H*	10	*Normal*	23.9	*H*	57	*H*	106	*H*
Exchangeable Potassium	mg/kg	56.4	*H*	28.4	*H*	60.8	*H*	152	*H*	74.3	*H*
Exchangeable Sodium	mg/kg	10.9	*Sodic*	10	*Sodic*	10	*Sodic*	29.1	*H.Sodic*	41.1	*H.Sodic*
Exchangeable Aluminium	mg/kg	210.00	*FALSE*	260.00	*FALSE*	59.10	*VH*	49.10	*VH*	32.70	*H*
Exchangeable Calcium	meq/100g	1.44	*VL*	0.38	*VL*	1.25	*VL*	1.60	*VL*	2.18	*L*
Exchangeable Magnesium	meq/100g	0.35	*L*	0.08	*VL*	0.20	*VL*	0.48	*L*	0.88	*L*
Exchangeable Potassium	meq/100g	0.14	*VL*	0.07	*VL*	0.16	*VL*	0.39	*M*	0.19	*VL*
Exchangeable Sodium	meq/100g	0.05	*VL*	0.04	*VL*	0.04	*VL*	0.13	*L*	0.18	*L*
Exchangeable Aluminium	meq/100g	2.33	*E*	2.89	*E*	0.66	*E*	0.55	*E*	0.36	*E*
Calcium/Magnesium Ratio	-	4.2	*Balanced*	4.6	*Balanced*	6.3	*Balanced*	3.4	*Low Ca*	2.5	*Low Ca*
Emerson Aggregate	Class	5	*Slaking*	5	*Slaking*	5	*Slaking*	3b	*Slight Disp*	5	*Slaking*

	Highly acidic		Extremely alkaline		High salinity		Sodic		Strongly sodic

Table B4: Laboratory analysis data for loam topsoils. Part 2 of 3.

TABLE B4. Laboratory Results Loams											
	Lab No	230959-264		230959-268		230959-272		230959-276		230959-364	
	Sample ID	47		46		251		253		34	
	Sample Depth	Composite		Composite		Composite		Composite		Composite	
	Field Texture	LMC		LMC		LMC		LMC		SL	
Analyses	**Unit**	-		-		-		-		-	
pH - Water	pH units	6.76	*Neutral*	7.67	*L.Alk*	7.44	*L.Alk*	7.68	*L.Alk*	5.45	*H.Acid*
Electrical Conductivity	dS/m	0.17	*L.Sal*	0.32	*M.Sal*	0.22	*M.Sal*	0.18	*L.Sal*	0.04	*VL.Sal*
Chloride	mg/kg	28.8	*VL.Sal*	44.0	*VL.Sal*	64.9	*VL.Sal*	164.0	*L.Sal*	20.3	*VL.Sal*
Total Nitrogen - Kjeldahl	mg/kg	1245.0	*L*	1450.0	*L*	1240.0	*L*	888.0	*L*	627.0	*L*
Total Phosphorus - Nitric/Perchloric	mg/kg	380.0	*	401.0	*	286.0	*	131.0	*	63.7	*
Phosphorus - Colwell extr	mg/kg	13.6	*L*	21.9	*L*	14.2	*L*	9.35	*L*	<5.00	*L*
Potassium - Colwell ext	mg/kg	215.00	*M*	255.00	*M*	232.00	*M*	138.00	*L*	124.00	*L*
Sulphur - KCl	mg/kg	11.2	*M*	19.5	*H*	15.9	*H*	21.3	*VH*	7.8	*L*
Organic Carbon	%	1.22	*M*	1.21	*M*	1.12	*M*	0.82	*L*	0.69	*L*
Copper	mg/kg	0.73	*M*	0.75	*M*	0.67	*M*	0.59	*M*	<0.20	*
Iron	mg/kg	13.60	*	11.10	*	7.98	*	8.28	*	46.90	*
Manganese	mg/kg	12.30	*M*	6.95	*M*	7.43	*M*	7.40	*M*	2.34	*M*
Zinc	mg/kg	0.60	*M*	0.88	*M*	0.58	*L*	0.40	*L*	1.91	*M*
Boron	mg/kg	0.89	*L*	1.05	*M*	1.01	*M*	1.03	*M*	0.23	*VL*
Cation Extraction Method	Rayment& Lyons	15A1	*	15C1	*	15C1	*	15C1	*	15A1	*
Cation Exchange Capacity	meq/100g	10.4	*L*	8.8	*L*	8.1	*L*	6.3	*L*	3.2	*VL*
Ex Calcium Percent	%	75.86	*Normal*	73.06	*Normal*	74.32	*Normal*	72.18	*Normal*	66.52	*Normal*
Ex Magnesium Percent	%	19.27	*H*	20.03	*H*	18.42	*H*	18.72	*H*	24.62	*H*
Ex Potassium Percent	%	3.91	*Normal*	6.05	*H*	5.60	*H*	4.82	*Normal*	3.77	*Normal*
Ex Sodium Percent	%	0.7	*N.Sodic*	0.62	*N.Sodic*	1.38	*N.Sodic*	3.92	*N.Sodic*	2.8	*N.Sodic*
Ex Aluminium Percent	%	0.21	*VL*	0.25	*VL*	0.28	*VL*	0.35	*VL*	2.26	*VL*
Exchangeable Calcium	mg/kg	1581	*H*	1289	*H*	1197	*H*	906	*H*	422	*H*
Exchangeable Magnesium	mg/kg	241	*H*	212	*H*	178	*H*	141	*H*	93.7	*H*
Exchangeable Potassium	mg/kg	159	*H*	208	*H*	176	*H*	118	*H*	46.6	*H*
Exchangeable Sodium	mg/kg	17.9	*H.Sodic*	12.6	*Sodic*	25.5	*H.Sodic*	56.6	*H.Sodic*	20.7	*H.Sodic*
Exchangeable Aluminium	mg/kg	2.00	*VL*	2	*	2	*	2	*	6.45	*
Exchangeable Calcium	meq/100g	7.91	*M*	6.45	*M*	5.99	*M*	4.53	*L*	2.11	*L*
Exchangeable Magnesium	meq/100g	2.01	*M*	1.77	*M*	1.48	*M*	1.18	*M*	0.78	*L*
Exchangeable Potassium	meq/100g	0.41	*M*	0.53	*M*	0.45	*M*	0.30	*M*	0.12	*VL*
Exchangeable Sodium	meq/100g	0.08	*VL*	0.05	*VL*	0.11	*L*	0.25	*L*	0.09	*VL*
Exchangeable Aluminium	meq/100g	0.02	*VH*	0.02	*VH*	0.02	*VH*	0.02	*VH*	0.07	*E*
Calcium/Magnesium Ratio	-	3.9	*Low Ca*	3.6	*Low Ca*	4.0	*Balanced*	3.9	*Low Ca*	2.7	*Low Ca*
Emerson Aggregate	Class	5	*Slaking*	5	*Slaking*	5	*Slaking*	5	*Slaking*	3b	*Slight Disp*

	Highly acidic		Extremely alkaline		High salinity		Sodic		Strongly sodic

Table B4: Laboratory analysis data for loam topsoils. Part 3 of 3.

TABLE B4. Laboratory Results Loams														
	Lab No	Mean		LCL	UCL	Std Dev	Count	CI 95%	10%ile		90%ile		Min	Max
	Sample ID			95%	95%			(+/-)						
	Sample Depth													
	Field Texture													
Analyses	Unit													
pH - Water	pH units	6.0	M.acid	5.2	6.8	1.3	10	0.8	4.8	VH.Acid	7.7	L.Alk	4.7	7.7
Electrical Conductivity	dS/m	0.1	L.Sal	0.07	0.19	0.1	10	0.06	0.0	VL.Sal	0.2	M.Sal	0.0	0.3
Chloride	mg/kg	52.7	VL.Sal	27	79	42.0	10	26	19.9	VL.Sal	74.8	VL.Sal	16.5	164.0
Total Nitrogen - Kjeldahl	mg/kg	1066.3	L	859	1274	334.6	10	207	692.7	L	1462.0	L	627.0	1570.0
Total Phosphorus - Nitric/Perchloric	mg/kg	181.2	*	93	270	135.8	9	89	69.1	*	384.2	*	63.7	401.0
Phosphorus - Colwell extr	mg/kg	17.4	*	13	22	6.6	9	4	10.4	*	23.6	*	9.4	30.5
Potassium - Colwell ext	mg/kg	161.3	*	128	194	53.1	10	33	121.2	*	234.3	*	96.0	255.0
Sulphur - KCl	mg/kg	12.5	H	9.52	15.52	4.8	10	3.00	7.7	L	19.7	H	6.7	21.3
Organic Carbon	%	1.3	M	0.93	1.59	0.5	10	0.33	0.8	L	2.0	H	0.7	2.4
Copper	mg/kg	0.5	M	0.35	0.73	0.2	6	0.19	0.3	L	0.7	M	0.2	0.8
Iron	mg/kg	63.5	*	27	100	59.4	10	37	8.3	*	150.3	*	8.0	171.0
Manganese	mg/kg	5.9	M	4.14	7.66	2.8	10	1.76	3.1	M	7.9	M	2.3	12.3
Zinc	mg/kg	0.6	M	0.25	0.89	0.5	10	0.32	0.2	L	1.0	M	0.2	1.9
Boron	mg/kg	0.6	L	0.41	0.82	0.3	10	0.21	0.3	VL	1.0	M	0.2	1.1
Cation Extraction Method	Rayment& Lyons	*	*	*	*	*	*	*	*	*	*	*	*	*
Cation Exchange Capacity	meq/100g	5.4	VL	3.6	7.1	2.8	10	1.8	3.0	VL	9.0	L	2.3	10.4
Ex Calcium Percent	%	56.9	L	43.9	69.9	21.0	10	13.0	31.1	L	74.5	Normal	10.9	75.9
Ex Magnesium Percent	%	15.9	H	11.4	20.3	7.2	10	4.5	7.5	L	23.4	H	2.4	24.6
Ex Potassium Percent	%	5.4	H	3.6	7.1	2.8	10	1.8	3.2	Normal	7.3	H	2.1	12.4
Ex Sodium Percent	%	2.2	N.Sodic	1.3	3.2	1.5	10	0.9	0.7	N.Sodic	4.1	N.Sodic	0.6	4.7
Ex Aluminium Percent	%	19.6	M	2.1	37.2	28.4	10	17.6	0.2	VL	57.1	VH	0.2	83.3
Exchangeable Calcium	mg/kg	676.2	H	352.0	1000.4	523.1	10	324.2	231.7	H	1318.2	H	75.9	1581.0
Exchangeable Magnesium	mg/kg	110.4	H	60.5	160.3	80.5	10	49.9	22.5	H	214.9	H	10.0	241.0
Exchangeable Potassium	mg/kg	108.0	H	69.1	146.8	62.7	10	38.9	44.8	H	179.2	H	28.4	208.0
Exchangeable Sodium	mg/kg	23.4	H.Sodic	13.9	33.0	15.4	10	9.5	10.0	H.Sodic	42.7	H.Sodic	10.0	56.6
Exchangeable Aluminium	mg/kg	62.5	*	4.2	120.8	94.1	10	58.3	2.0	*	215.0	*	2.0	260.0
Exchangeable Calcium	meq/100g	3.4	L	1.8	5.0	2.6	10	1.6	1.2	VL	6.6	M	0.4	7.9
Exchangeable Magnesium	meq/100g	0.9	L	0.5	1.3	0.7	10	0.4	0.2	VL	1.8	M	0.1	2.0
Exchangeable Potassium	meq/100g	0.3	L	0.2	0.4	0.2	10	0.1	0.1	VL	0.5	M	0.1	0.5
Exchangeable Sodium	meq/100g	0.1	L	0.1	0.1	0.1	10	0.0	0.0	VL	0.2	L	0.0	0.2
Exchangeable Aluminium	meq/100g	0.7	E	0.0	1.3	1.0	10	0.6	0.0	VH	2.4	E	0.0	2.9
Calcium/Magnesium Ratio	-	3.9	Low Ca	3.2	4.5	1.0	10	0.6	2.7	Low Ca	4.7	Balanced	2.5	6.3
Emerson Aggregate	Class	5.0	*	*	*	*	*	*	*	*	*	*	*	*

	Highly acidic		Extremely alkaline		High salinity		Sodic		Strongly sodic

Table B5: Laboratory analysis data for clay topsoils. Part 1 of 12.

Table B5. Laboratory Results Clays													
	Lab No	230959-4		230959-8		230959-12		230959-16		230959-20		230959-24	
	Sample ID	166		191		165		163		161		156	
	Sample Depth	Composite		Composite		Composite		Composite		Composite		Composite	
	Field Texture	MC		MC		LC		LC		LC		LC	
Analyses	**Unit**	-		-		-		-		-		-	
pH - Water	pH units	8.02	*M.Alk*	8.66	*H.Alk*	9.08	*E.Alk*	8.43	*M.Alk*	8.66	*H.Alk*	9.05	*E.Alk*
Electrical Conductivity	dS/m	1.29	*E.Sal*	0.80	*VH.Sal*	0.23	*M.Sal*	0.36	*M.Sal*	0.40	*M.Sal*	0.21	*M.Sal*
Chloride	mg/kg	2019.0	*E.Sal*	1024.0	*H.Sal*	131.0	*L.Sal*	184.0	*L.Sal*	442.0	*M.Sal*	108.0	*L.Sal*
Total Nitrogen - Kjeldahl	mg/kg	645.0	*L*	517.0	*L*	616.0	*L*	1425.0	*L*	935.0	*L*	919.0	*L*
Total Phosphorus - Nitric/Perchloric	mg/kg	233.0		194.0	*	154.0	*	260.0	*	163.0	*	220.0	*
Phosphorus - Colwell extr	mg/kg	25.4	*L*	<5.00	*L*	5.2	*L*	20.5	*M*	10.1	*L*	8.0	*L*
Potassium - Colwell ext	mg/kg	158.00	*L*	103.00	*VL*	184.00	*M*	181.00	*M*	153.00	*L*	119.00	*VL*
Sulphur - KCl	mg/kg	84.6	*VH*	88.2	*VH*	31.0	*VH*	39.2	*VH*	33.7	*VH*	36.4	*VH*
Organic Carbon	%	0.96	*L*	1.10	*M*	0.93	*L*	1.71	*M*	1.14	*M*	1.37	*M*
Copper	mg/kg	1.11	*M*	1.27	*M*	0.59	*M*	0.79	*M*	0.53	*M*	1.05	*M*
Iron	mg/kg	15.50	*	8.86	*	13.70	*	15.00	*	11.70	*	12.30	*
Manganese	mg/kg	5.06	*M*	5.64	*M*	3.78	*M*	4.92	*M*	6.06	*M*	5.20	*M*
Zinc	mg/kg	0.20	*VL*	0.20	*VL*	<0.20	*L*	0.24	*VL*	<0.20	*L*	<0.20	*L*
Boron	mg/kg	2.55	*H*	2.55	*H*	1.65	*M*	1.45	*M*	1.58	*M*	2.75	*H*
Cation Extraction Method	Rayment& Lyons	15C1	*	15C1	*	15C1	*	15C1	*	15C1	*	15C1	*
Cation Exchange Capacity	meq/100g	17.0	*M*	20.5	*	19.2	*	20.6	*	18.1	*	18.6	*
Ex Calcium Percent	%	45.97	*L*	53.70	*	58.63	*	72.23	*	66.20	*	65.01	*
Ex Magnesium Percent	%	36.04	*H*	28.84	*	29.80	*	20.23	*	23.98	*	22.86	*
Ex Potassium Percent	%	1.87	*Normal*	1.10	*	0.77	*	1.61	*	1.41	*	1.45	*
Ex Sodium Percent	%	16.00	*H.Sodic*	16.26	*H.Sodic*	10.69	*Sodic*	5.83	*N.Sodic*	8.29	*Sodic*	10.57	*Sodic*
Ex Aluminium Percent	%	0.13	*VL*	0.11	*VL*	0.12	*VL*	0.11	*VL*	0.12	*VL*	0.12	*VL*
Exchangeable Calcium	mg/kg	1567	*H*	2200	*H*	2256	*H*	2975	*H*	2397	*H*	2413	*H*
Exchangeable Magnesium	mg/kg	737	*H*	709	*H*	688	*H*	500	*H*	521	*H*	509	*H*
Exchangeable Potassium	mg/kg	124	*H*	87.7	*H*	57.7	*H*	129	*H*	99.7	*H*	105	*H*
Exchangeable Sodium	mg/kg	627	*FALSE*	766	*FALSE*	473	*FALSE*	276	*FALSE*	345	*FALSE*	451	*FALSE*
Exchangeable Aluminium	mg/kg	2.0	*VL*	2.0	*VL*	2.0	*VL*	2.0	*VL*	2.0	*VL*	2.0	*VL*
Exchangeable Calcium	meq/100g	7.84	*M*	11.00	*H*	11.28	*H*	14.88	*H*	11.99	*H*	12.07	*H*
Exchangeable Magnesium	meq/100g	6.14	*H*	5.91	*H*	5.73	*H*	4.17	*H*	4.34	*H*	4.24	*H*
Exchangeable Potassium	meq/100g	0.32	*M*	0.22	*L*	0.15	*VL*	0.33	*M*	0.26	*L*	0.27	*L*
Exchangeable Sodium	meq/100g	2.73	*VH*	3.33	*VH*	2.06	*VH*	1.20	*H*	1.50	*H*	1.96	*H*
Exchangeable Aluminium	meq/100g	0.02	*VH*	0.02	*VH*	0.02	*VH*	0.02	*VH*	0.02	*VH*	0.02	*VH*
Calcium/Magnesium Ratio	-	1.3	*Low Ca*	1.9	*Low Ca*	2.0	*Low Ca*	3.6	*Low Ca*	2.8	*Low Ca*	2.8	*Low Ca*
Emerson Aggregate	Class	6.0	*Slaking*	6.0	*Slaking*	4.0	*Slaking*	5.0	*Slaking*	4.0	*Slaking*	4.0	*Slaking*

	Highly acidic		Extremely alkaline		High salinity		Sodic		Strongly sodic

Table B5: Laboratory analysis data for clay topsoils. Part 2 of 12.

Table B5. Laboratory Results Clays													
	Lab No	230959-28		230959-32		230959-36		230959-40		230959-44		230959-48	
	Sample ID	157		152		130		126		124		123	
	Sample Depth	Composite		Composite		Composite		Composite		Composite		Composite	
	Field Texture	LC		LC		LC		HC		LMC		ZCL	
Analyses	**Unit**	-		-		-		-		-		-	
pH - Water	pH units	8.49	*M.Alk*	8.54	*H.Alk*	8.76	*H.Alk*	8.48	*M.Alk*	8.59	*H.Alk*	8.52	*H.Alk*
Electrical Conductivity	dS/m	0.6	*H.Sal*	0.35	*M.Sal*	0.39	*M.Sal*	0.39	*M.Sal*	0.27	*M.Sal*	0.23	*M.Sal*
Chloride	mg/kg	658.0	*H.Sal*	181.0	*L.Sal*	421.0	*M.Sal*	395.0	*M.Sal*	171.0	*L.Sal*	34.8	*VL.Sal*
Total Nitrogen - Kjeldahl	mg/kg	747.0	*L*	1008.0	*L*	894.0	*L*	1020.0	*L*	1292.0	*L*	885.0	*L*
Total Phosphorus - Nitric/Perchloric	mg/kg	263.0	*	228.0	*	233.0	*	199.0	*	231.0	*	210.0	*
Phosphorus - Colwell extr	mg/kg	<5.00		9.04	*L*	<5.00		<5.00	*L*	15.6	*L*	<5.00	*L*
Potassium - Colwell ext	mg/kg	119.00	*VL*	123.00	*L*	106.00	*VL*	165.00	*L*	157.00	*L*	172.00	*M*
Sulphur - KCl	mg/kg	69.1	*VH*	44.6	*VH*	42.0	*VH*	36.5	*VH*	29.3	*VH*	22.2	*VH*
Organic Carbon	%	1.15	*M*	1.28	*M*	1.22	*M*	1.54	*M*	1.54	*M*	1.33	*M*
Copper	mg/kg	0.81	*M*	1.21	*M*	0.81	*M*	0.77	*M*	1.09	*M*	0.53	*M*
Iron	mg/kg	12.00	*	15.10	*	14.80	*	14.80	*	14.70	*	13.10	*
Manganese	mg/kg	4.06	*M*	8.16	*M*	3.92	*M*	5.52	*M*	6.16	*M*	6.86	*M*
Zinc	mg/kg	0.22	*VL*	0.20	*VL*	<0.20	*L*	<0.20	*L*	3.32	*M*	0.22	*VL*
Boron	mg/kg	2.80	*H*	1.65	*M*	2.50	*H*	2.30	*H*	3.00	*H*	1.60	*M*
Cation Extraction Method	Rayment& Lyons	15C1	*	15C1	*	15C1	*	15C1	*	15C1	*	15C1	*
Cation Exchange Capacity	meq/100g	18.2	*	20.5	*	14.3	*	14.3	*	16.4	*	12.1	*
Ex Calcium Percent	%	57.88	*	67.26	*	59.79	*	63.12	*	64.35	*	71.73	*
Ex Magnesium Percent	%	27.34	*	24.09	*	26.61	*	26.40	*	26.69	*	20.34	*
Ex Potassium Percent	%	1.54	*	1.18	*	1.46	*	1.70	*	1.88	*	2.08	*
Ex Sodium Percent	%	13.12	*Sodic*	7.36	*Sodic*	11.99	*Sodic*	8.62	*Sodic*	6.95	*Sodic*	5.66	*N.Sodic*
Ex Aluminium Percent	%	0.12	*VL*	0.11	*VL*	0.16	*VL*	0.16	*VL*	0.14	*VL*	0.18	*VL*
Exchangeable Calcium	mg/kg	2106	*H*	2764	*H*	1704	*H*	1801	*H*	2110	*H*	1740	*H*
Exchangeable Magnesium	mg/kg	597	*H*	594	*H*	455	*H*	452	*H*	525	*H*	296	*H*
Exchangeable Potassium	mg/kg	109	*H*	94.5	*H*	81.2	*H*	94.5	*H*	120	*H*	98.6	*H*
Exchangeable Sodium	mg/kg	549	*FALSE*	348	*FALSE*	393	*FALSE*	283	*FALSE*	262	*FALSE*	158	*FALSE*
Exchangeable Aluminium	mg/kg	2	*VL*	2	*VL*	2	*VL*	2	*VL*	2	*VL*	2	*VL*
Exchangeable Calcium	meq/100g	10.53	*H*	13.82	*H*	8.52	*M*	9.01	*M*	10.55	*H*	8.70	*M*
Exchangeable Magnesium	meq/100g	4.98	*H*	4.95	*H*	3.79	*H*	3.77	*H*	4.38	*H*	2.47	*M*
Exchangeable Potassium	meq/100g	0.28	*L*	0.24	*L*	0.21	*L*	0.24	*L*	0.31	*M*	0.25	*L*
Exchangeable Sodium	meq/100g	2.39	*VH*	1.51	*H*	1.71	*H*	1.23	*H*	1.14	*H*	0.69	*M*
Exchangeable Aluminium	meq/100g	0.02	*VH*	0.02	*VH*	0.02	*VH*	0.02	*VH*	0.02	*VH*	0.02	*VH*
Calcium/Magnesium Ratio	-	2.1	*Low Ca*	2.8	*Low Ca*	2.2	*Low Ca*	2.4	*Low Ca*	2.4	*Low Ca*	3.5	*Low Ca*
Emerson Aggregate	Class	4	*Slaking*	4	*Slaking*	4	*Slaking*	5	*Slaking*	4	*Slaking*	7	*Stable*

	Highly acidic		Extremely alkaline		High salinity		Sodic		Strongly sodic

Table B5: Laboratory analysis data for clay topsoils. Part 3 of 12.

Table B5. Laboratory Results Clays													
	Lab No	230959-56		230959-60		230959-64		230959-68		230959-72		230959-76	
	Sample ID	314		111		108		270		93		291	
	Sample Depth	Composite		Composite		Composite		Composite		Composite		Composite	
	Field Texture	LC		LC		LMC		LC		LC		LMC	
Analyses	**Unit**	-		-		-		-		-		-	
pH - Water	pH units	8.61	*H.Alk*	8.2	*M.Alk*	8.5	*H.Alk*	9.02	*E.Alk*	8.01	*M.Alk*	8.65	*H.Alk*
Electrical Conductivity	dS/m	0.17	*L.Sal*	0.32	*M.Sal*	0.29	*M.Sal*	0.44	*M.Sal*	0.44	*M.Sal*	0.2	*M.Sal*
Chloride	mg/kg	84.0	*VL.Sal*	370.0	*M.Sal*	215.0	*L.Sal*	454.0	*M.Sal*	63.2	*VL.Sal*	125.0	*L.Sal*
Total Nitrogen - Kjeldahl	mg/kg	1165.0	*L*	742.0	*L*	771.0	*L*	830.0	*L*	1630.0	*M*	1196.0	*L*
Total Phosphorus - Nitric/Perchloric	mg/kg	230.0	*	189.0	*	135.0	*	337.0	*	258.0	*	194.0	*
Phosphorus - Colwell extr	mg/kg	<5.00	*L*	<5.00	*L*	<5.00	*L*	<5.00	*L*	<5.00	*L*	19.4	*L*
Potassium - Colwell ext	mg/kg	176.00	*L*	111.00	*VL*	123.00	*L*	229.00	*M*	226.00	*M*	218.00	*M*
Sulphur - KCl	mg/kg	19.5	*H*	24.9	*VH*	21.7	*VH*	43.8	*VH*	57.3	*VH*	24.1	*VH*
Organic Carbon	%	1.69	*M*	1.13	*M*	1.23	*M*	1.38	*M*	3.24	*VH*	1.73	*M*
Copper	mg/kg	0.73	*M*	0.55	*M*	0.43	*M*	0.97	*M*	0.55	*M*	0.79	*M*
Iron	mg/kg	13.70	*	13.50	*	15.60	*	14.80	*	15.60	*	18.10	*
Manganese	mg/kg	6.82	*M*	6.48	*M*	6.14	*M*	5.62	*M*	5.76	*M*	5.20	*M*
Zinc	mg/kg	0.26	*VL*	<0.20	*L*	<0.20	*L*	<0.20	*L*	0.26	*VL*	0.20	*VL*
Boron	mg/kg	1.45	*M*	1.48	*M*	1.85	*M*	2.45	*H*	1.35	*M*	1.60	*M*
Cation Extraction Method	Rayment& Lyons	15C1	*	15C1	*	15C1	*	15C1	*	15C1	*	15C1	*
Cation Exchange Capacity	meq/100g	15.1	*	14.7	*	25.7	*	18.4	*	18.5	*	19.0	*
Ex Calcium Percent	%	66.37	*	67.53	*	60.02	*	57.33	*	80.26	*	66.54	*
Ex Magnesium Percent	%	24.30	*	22.24	*	29.91	*	26.05	*	15.39	*	24.53	*
Ex Potassium Percent	%	2.45	*	1.46	*	0.83	*	1.85	*	1.86	*	2.21	*
Ex Sodium Percent	%	6.74	*Sodic*	8.62	*Sodic*	9.15	*Sodic*	14.65	*H.Sodic*	2.37	*N.Sodic*	6.60	*Sodic*
Ex Aluminium Percent	%	0.15	*VL*	0.15	*VL*	0.09	*VL*	0.12	*VL*	0.12	*VL*	0.12	*VL*
Exchangeable Calcium	mg/kg	2003	*H*	1989	*H*	3080	*H*	2113	*H*	2973	*H*	2532	*H*
Exchangeable Magnesium	mg/kg	440	*H*	393	*H*	921	*H*	576	*H*	342	*H*	560	*H*
Exchangeable Potassium	mg/kg	144	*H*	84	*H*	83.5	*H*	133	*H*	134	*H*	164	*H*
Exchangeable Sodium	mg/kg	234	*FALSE*	292	*FALSE*	540	*FALSE*	621	*FALSE*	101	*FALSE*	289	*FALSE*
Exchangeable Aluminium	mg/kg	2	*VL*	2	*VL*	2	*VL*	2	*VL*	2	*VL*	2	*VL*
Exchangeable Calcium	meq/100g	10.02	*H*	9.95	*M*	15.40	*H*	10.57	*H*	14.87	*H*	12.66	*H*
Exchangeable Magnesium	meq/100g	3.67	*H*	3.28	*H*	7.68	*H*	4.80	*H*	2.85	*M*	4.67	*H*
Exchangeable Potassium	meq/100g	0.37	*M*	0.22	*L*	0.21	*L*	0.34	*M*	0.34	*M*	0.42	*M*
Exchangeable Sodium	meq/100g	1.02	*H*	1.27	*H*	2.35	*VH*	2.70	*VH*	0.44	*M*	1.26	*H*
Exchangeable Aluminium	meq/100g	0.02	*VH*	0.02	*VH*	0.02	*VH*	0.02	*VH*	0.02	*VH*	0.02	*VH*
Calcium/Magnesium Ratio	-	2.7	*Low Ca*	3.0	*Low Ca*	2.0	*Low Ca*	2.2	*Low Ca*	5.2	*Balanced*	2.7	*Low Ca*
Emerson Aggregate	Class	4	*Slaking*	5	*Slaking*	5	*Slaking*	4	*Slaking*	4	*Slaking*	5	*Slaking*

	Highly acidic		Extremely alkaline		High salinity		Sodic		Strongly sodic

Table B5: Laboratory analysis data for clay topsoils. Part 4 of 12.

Table B5. Laboratory Results Clays													
	Lab No	230959-80		230959-84		230959-88		230959-92		230959-96		230959-100	
	Sample ID	291 (b)		86		81		82		73		67	
	Sample Depth	Composite		Composite		Composite		Composite		Composite		Composite	
	Field Texture	HC		CL		LC		LC		LC		LMC	
Analyses	**Unit**	-		-		-		-		-		-	
pH - Water	pH units	8.93	*H.Alk*	8.3	*M.Alk*	7.15	*Neutral*	8.58	*H.Alk*	8.89	*H.Alk*	8.72	*H.Alk*
Electrical Conductivity	dS/m	0.44	*M.Sal*	0.28	*M.Sal*	0.13	*L.Sal*	0.29	*M.Sal*	0.17	*L.Sal*	0.46	*H.Sal*
Chloride	mg/kg	456.0	*M.Sal*	58.8	*VL.Sal*	73.7	*VL.Sal*	280.0	*L.Sal*	60.6	*VL.Sal*	444.0	*M.Sal*
Total Nitrogen - Kjeldahl	mg/kg	710.0	*L*	1420.0	*L*	784.0	*L*	1052.0	*L*	816.0	*L*	1050.0	*L*
Total Phosphorus - Nitric/Perchloric	mg/kg	213.0	*	252.0	*	223.0	*	247.0	*	161.0	*	242.0	*
Phosphorus - Colwell extr	mg/kg	<5.00	*L*	5.76	*L*	69.9	*H*	<5.00	*L*	<5.00	*L*	<5.00	*L*
Potassium - Colwell ext	mg/kg	111.00	*VL*	241.00	*M*	136.00	*L*	228.00	*M*	110.00	*VL*	130.00	*L*
Sulphur - KCl	mg/kg	38.0	*VH*	28.0	*VH*	13.1	*H*	26.8	*VH*	24.2	*VH*	51.7	*VH*
Organic Carbon	%	1.22	*M*	2.19	*H*	1.06	*M*	1.53	*M*	1.21	*M*	1.17	*M*
Copper	mg/kg	0.55	*M*	0.77	*M*	0.91	*M*	0.77	*M*	0.81	*M*	1.1	*M*
Iron	mg/kg	15.20	*	19.20	*	27.40	*	15.50	*	14.50	*	6.68	*
Manganese	mg/kg	3.74	*M*	6.56	*M*	10.40	*M*	5.99	*M*	6.60	*M*	5.81	*M*
Zinc	mg/kg	<0.20	*L*	0.28	*VL*	0.34	*L*	0.22	*VL*	<0.20	*L*	0.27	*VL*
Boron	mg/kg	3.15	*H*	1.60	*M*	1.90	*M*	1.85	*M*	1.65	*M*	1.28	*M*
Cation Extraction Method	Rayment& Lyons	15C1	*	15C1	*	15A1	*	15C1	*	15C1	*	15C1	*
Cation Exchange Capacity	meq/100g	21.0	*	18.5	*	17.7	*M*	18.2	*	20.9	*	28.9	*
Ex Calcium Percent	%	56.51	*	70.67	*	60.96	*L*	66.19	*	64.79	*	61.25	*
Ex Magnesium Percent	%	27.00	*	22.56	*	31.29	*H*	23.71	*	26.13	*	27.72	*
Ex Potassium Percent	%	0.88	*	2.33	*	1.79	*Normal*	1.93	*	1.08	*	0.90	*
Ex Sodium Percent	%	15.49	*H.Sodic*	4.31	*N.Sodic*	5.8	*N.Sodic*	8.05	*Sodic*	7.90	*Sodic*	10.05	*Sodic*
Ex Aluminium Percent	%	0.11	*VL*	0.12	*VL*	0.13	*VL*	0.12	*VL*	0.11	*VL*	0.08	*VL*
Exchangeable Calcium	mg/kg	2379	*H*	2610	*H*	2163	*H*	2410	*H*	2711	*H*	3539	*H*
Exchangeable Magnesium	mg/kg	682	*H*	500	*H*	666	*H*	518	*H*	656	*H*	961	*H*
Exchangeable Potassium	mg/kg	72.6	*H*	168	*H*	124	*H*	137	*H*	87.8	*H*	101	*H*
Exchangeable Sodium	mg/kg	750	*FALSE*	183	*FALSE*	238	*FALSE*	337	*FALSE*	380	*FALSE*	668	*FALSE*
Exchangeable Aluminium	mg/kg	2	*VL*	2	*VL*	2.00	*VL*	2	*VL*	2	*VL*	2	*VL*
Exchangeable Calcium	meq/100g	11.90	*H*	13.05	*H*	10.82	*H*	12.05	*H*	13.56	*H*	17.70	*H*
Exchangeable Magnesium	meq/100g	5.68	*H*	4.17	*H*	5.55	*H*	4.32	*H*	5.47	*H*	8.01	*VH*
Exchangeable Potassium	meq/100g	0.19	*VL*	0.43	*M*	0.32	*M*	0.35	*M*	0.23	*L*	0.26	*L*
Exchangeable Sodium	meq/100g	3.26	*VH*	0.80	*H*	1.03	*H*	1.47	*H*	1.65	*H*	2.90	*VH*
Exchangeable Aluminium	meq/100g	0.02	*VH*	0.02	*VH*	0.02	*VH*	0.02	*VH*	0.02	*VH*	0.02	*VH*
Calcium/Magnesium Ratio	-	2.1	*Low Ca*	3.1	*Low Ca*	1.9	*Low Ca*	2.8	*Low Ca*	2.5	*Low Ca*	2.2	*Low Ca*
Emerson Aggregate	Class	4	*Slaking*	5	*Slaking*	3b	*Slight Disp*	4	*Slaking*	4	*Slaking*	4	*Slaking*

	Highly acidic		Extremely alkaline		High salinity		Sodic		Strongly sodic

Table B5: Laboratory analysis data for clay topsoils. Part 5 of 12.

Table B5. Laboratory Results Clays													
	Lab No	230959-104		230959-108		230959-112		230959-116		230959-136		230959-140	
	Sample ID	71		69		61		61 (b)		48		284	
	Sample Depth	Composite		Composite		Composite		Composite		Composite		Composite	
	Field Texture	LMC		LMC		LMC		LMC		LMC		LMC	
Analyses	**Unit**	-		-		-		-		-		-	
pH - Water	pH units	8.43	*M.Alk*	8.87	*H.Alk*	8.74	*H.Alk*	8.75	*H.Alk*	6.67	*Neutral*	8.09	*M.Alk*
Electrical Conductivity	dS/m	0.19	*M.Sal*	0.21	*M.Sal*	0.35	*M.Sal*	0.36	*M.Sal*	0.21	*M.Sal*	0.44	*M.Sal*
Chloride	mg/kg	99.5	*VL.Sal*	81.1	*VL.Sal*	315.0	*M.Sal*	343.0	*M.Sal*	49.2	*VL.Sal*	280.0	*L.Sal*
Total Nitrogen - Kjeldahl	mg/kg	1260.0	*L*	1010.0	*L*	1230.0	*L*	1330.0	*L*	1310.0	*L*	1410.0	*L*
Total Phosphorus - Nitric/Perchloric	mg/kg	138.0	*	163.0	*	213.0	*	190.0	*	259.0	*	340.0	*
Phosphorus - Colwell extr	mg/kg	<5.00	*L*	<5.00	*L*	6.26	*L*	5.37	*L*	18.7	*L*	11.1	*L*
Potassium - Colwell ext	mg/kg	118.00	*VL*	154.00	*L*	148.00	*L*	136.00	*L*	207.00	*M*	192.00	*M*
Sulphur - KCl	mg/kg	7.6	*L*	11.0	*M*	12.3	*H*	11.5	*M*	12.0	*H*	26.8	*VH*
Organic Carbon	%	1.28	*M*	0.95	*L*	1.1	*M*	1.43	*M*	0.92	*L*	1.37	*M*
Copper	mg/kg	1.23	*M*	0.85	*M*	0.89	*M*	0.83	*M*	0.85	*M*	0.95	*M*
Iron	mg/kg	7.70	*	5.12	*	2.82	*	3.94	*	17.60	*	6.70	*
Manganese	mg/kg	13.80	*M*	7.22	*M*	5.04	*M*	5.16	*M*	15.00	*M*	7.28	*M*
Zinc	mg/kg	1.60	*M*	0.22	*VL*	<0.20	*L*	0.26	*VL*	0.42	*L*	0.62	*L*
Boron	mg/kg	0.96	*L*	0.98	*L*	0.64	*L*	1.34	*M*	1.06	*M*	1.36	*M*
Cation Extraction Method	Rayment& Lyons	15C1	*	15C1	*	15C1	*	15C1	*	15A1	*	15C1	*
Cation Exchange Capacity	meq/100g	28.9	*	25.2	*	25.4	*	25.5	*	13.9	*M*	19.0	*
Ex Calcium Percent	%	67.80	*	66.64	*	67.76	*	63.59	*	59.43	*L*	70.95	*
Ex Magnesium Percent	%	26.02	*	25.83	*	22.21	*	24.90	*	32.88	*H*	20.95	*
Ex Potassium Percent	%	0.86	*	0.69	*	1.44	*	1.26	*	2.23	*Normal*	2.47	*
Ex Sodium Percent	%	5.25	*N.Sodic*	6.75	*Sodic*	8.49	*Sodic*	10.16	*Sodic*	5.3	*N.Sodic*	5.51	*
Ex Aluminium Percent	%	0.08	*VL*	0.09	*VL*	0.09	*VL*	0.09	*VL*	0.16	*VL*	0.12	*VL*
Exchangeable Calcium	mg/kg	3918	*H*	3363	*H*	3442	*H*	3243	*H*	1657	*H*	2698	*H*
Exchangeable Magnesium	mg/kg	902	*H*	782	*H*	677	*H*	762	*H*	550	*H*	478	*H*
Exchangeable Potassium	mg/kg	96.4	*H*	67.9	*H*	143	*H*	125	*H*	121	*H*	183	*H*
Exchangeable Sodium	mg/kg	349	*FALSE*	392	*FALSE*	496	*FALSE*	596	*FALSE*	170	*FALSE*	241	*FALSE*
Exchangeable Aluminium	mg/kg	2	*VL*	2	*VL*	2	*VL*	2	*VL*	2.00	*VL*	2	*VL*
Exchangeable Calcium	meq/100g	19.59	*H*	16.82	*H*	17.21	*H*	16.22	*H*	8.29	*M*	13.49	*H*
Exchangeable Magnesium	meq/100g	7.52	*H*	6.52	*H*	5.64	*H*	6.35	*H*	4.58	*H*	3.98	*H*
Exchangeable Potassium	meq/100g	0.25	*L*	0.17	*VL*	0.37	*M*	0.32	*M*	0.31	*M*	0.47	*M*
Exchangeable Sodium	meq/100g	1.52	*H*	1.70	*H*	2.16	*VH*	2.59	*VH*	0.74	*H*	1.05	*H*
Exchangeable Aluminium	meq/100g	0.02	*VH*	0.02	*VH*	0.02	*VH*	0.02	*VH*	0.02	*VH*	0.02	*VH*
Calcium/Magnesium Ratio	-	2.6	*Low Ca*	2.6	*Low Ca*	3.1	*Low Ca*	2.6	*Low Ca*	1.8	*Low Ca*	3.4	*Low Ca*
Emerson Aggregate	Class	5	*Slaking*	4	*Slaking*	4	*Slaking*	4	*Slaking*	5	*Slaking*	5	*Slaking*

	Highly acidic		Extremely alkaline		High salinity		Sodic		Strongly sodic

Table B5: Laboratory analysis data for clay topsoils. Part 6 of 12.

Table B5. Laboratory Results Clays													
	Lab No	230959-160		230959-164		230959-168		230959-172		230959-180		230959-184	
	Sample ID	255		210		102		103		216		188	
	Sample Depth	Composite		Composite		Composite		Composite		Composite		Composite	
	Field Texture	LMC		LMC		LMC		LC		MC		MC	
Analyses	**Unit**	-		-		-		-		-		-	
pH - Water	pH units	8.92	*H.Alk*	8.73	*H.Alk*	8.73	*H.Alk*	9.2	*E.Alk*	8.76	*H.Alk*	8.58	*H.Alk*
Electrical Conductivity	dS/m	0.15	*L.Sal*	0.37	*M.Sal*	0.19	*M.Sal*	0.13	*L.Sal*	0.26	*M.Sal*	0.38	*M.Sal*
Chloride	mg/kg	67.5	*VL.Sal*	196.0	*L.Sal*	83.0	*VL.Sal*	13.1	*VL.Sal*	81.4	*VL.Sal*	257.0	*L.Sal*
Total Nitrogen - Kjeldahl	mg/kg	1450.0	*L*	1330.0	*L*	1310.0	*L*	922.0	*L*	1400.0	*L*	1540.0	*M*
Total Phosphorus - Nitric/Perchloric	mg/kg	529.0	*	296.0	*	357.0	*	525.0	*	277.0	*	231.0	*
Phosphorus - Colwell extr	mg/kg	49.3	*M*	7.14	*L*	11.6	*L*	8.47	*L*	12	*L*	8.91	*L*
Potassium - Colwell ext	mg/kg	173.00	*L*	161.00	*L*	142.00	*L*	130.00	*L*	180.00	*M*	120.00	*L*
Sulphur - KCl	mg/kg	9.2	*M*	80.0	*VH*	14.8	*H*	11.7	*M*	17.0	*H*	17.5	*H*
Organic Carbon	%	1.41	*M*	1.84	*H*	1.56	*M*	1.74	*M*	1.26	*M*	1.66	*M*
Copper	mg/kg	0.97	*M*	0.91	*M*	0.41	*M*	0.67	*M*	0.97	*M*	1.03	*M*
Iron	mg/kg	11.00	*	8.14	*	6.02	*	3.14	*	5.78	*	3.66	*
Manganese	mg/kg	6.10	*M*	5.20	*M*	4.72	*M*	3.94	*M*	5.48	*M*	4.36	*M*
Zinc	mg/kg	0.34	*L*	<0.20	*L*	<0.20	*L*	0.44	*L*	0.46	*L*	0.30	*L*
Boron	mg/kg	0.76	*L*	1.68	*M*	0.76	*L*	0.88	*L*	1.74	*M*	1.92	*M*
Cation Extraction Method	Rayment& Lyons	15C1	*	15C1	*	15C1	*	15C1	*	15C1	*	15C1	*
Cation Exchange Capacity	meq/100g	22.0	*	38.6	*	27.1	*	20.8	*	36.4	*	36.8	*
Ex Calcium Percent	%	69.77	*	71.99	*	72.55	*	58.47	*	71.60	*	71.38	*
Ex Magnesium Percent	%	21.80	*	18.90	*	22.48	*	35.64	*	21.82	*	22.53	*
Ex Potassium Percent	%	1.64	*	0.95	*	1.11	*	0.94	*	1.25	*	0.80	*
Ex Sodium Percent	%	6.68	*Sodic*	8.10	*Sodic*	3.78	*N.Sodic*	4.84	*N.Sodic*	5.27	*N.Sodic*	5.23	*N.Sodic*
Ex Aluminium Percent	%	0.10	*VL*	0.06	*VL*	0.08	*VL*	0.11	*VL*	0.06	*VL*	0.06	*VL*
Exchangeable Calcium	mg/kg	3068	*H*	5560	*H*	3937	*H*	2428	*H*	5218	*H*	5248	*H*
Exchangeable Magnesium	mg/kg	575	*H*	876	*H*	732	*H*	888	*H*	954	*H*	994	*H*
Exchangeable Potassium	mg/kg	141	*H*	143	*H*	117	*H*	76.2	*H*	177	*H*	114	*H*
Exchangeable Sodium	mg/kg	338	*FALSE*	719	*FALSE*	236	*FALSE*	231	*FALSE*	442	*FALSE*	442	*FALSE*
Exchangeable Aluminium	mg/kg	2	*VL*	2	*VL*	2	*VL*	2	*VL*	2	*VL*	2	*VL*
Exchangeable Calcium	meq/100g	15.34	*H*	27.80	*VH*	19.69	*H*	12.14	*H*	26.09	*VH*	26.24	*VH*
Exchangeable Magnesium	meq/100g	4.79	*H*	7.30	*H*	6.10	*H*	7.40	*H*	7.95	*H*	8.28	*VH*
Exchangeable Potassium	meq/100g	0.36	*M*	0.37	*M*	0.30	*M*	0.20	*VL*	0.45	*M*	0.29	*L*
Exchangeable Sodium	meq/100g	1.47	*H*	3.13	*VH*	1.03	*H*	1.00	*H*	1.92	*H*	1.92	*H*
Exchangeable Aluminium	meq/100g	0.02	*VH*	0.02	*VH*	0.02	*VH*	0.02	*VH*	0.02	*VH*	0.02	*VH*
Calcium/Magnesium Ratio	-	3.2	*Low Ca*	3.8	*Low Ca*	3.2	*Low Ca*	1.6	*Low Ca*	3.3	*Low Ca*	3.2	*Low Ca*
Emerson Aggregate	Class	3b	*Slight Disp.*	4	*Slaking*	4	*Slaking*	4	*Slaking*	4	*Slaking*	4	*Slaking*

	Highly acidic		Extremely alkaline		High salinity		Sodic		Strongly sodic

Table B5: Laboratory analysis data for clay soils. Part 7 of 12.

Table B5. Laboratory Results Clays													
	Lab No	230959-188		230959-192		230959-204		230959-208		230959-216		230959-220	
	Sample ID	145		148		231a		231b		275		278	
	Sample Depth	Composite		Composite		Composite		Composite		Composite		Composite	
	Field Texture	MC		MC		LMC		LMC		LMC		LMC	
Analyses	**Unit**	-		-		-		-		-		-	
pH - Water	pH units	8.63	*H.Alk*	8.83	*H.Alk*	8.67	*H.Alk*	8.46	*M.Alk*	8.74	*H.Alk*	8.47	*M.Alk*
Electrical Conductivity	dS/m	0.29	*M.Sal*	0.23	*M.Sal*	0.35	*M.Sal*	0.3	*M.Sal*	0.49	*H.Sal*	0.22	*M.Sal*
Chloride	mg/kg	153.0	*L.Sal*	162.0	*L.Sal*	409.0	*M.Sal*	214.0	*L.Sal*	523.0	*M.Sal*	82.6	*VL.Sal*
Total Nitrogen - Kjeldahl	mg/kg	1670.0	*M*	1460.0	*L*	2070.0	*M*	2290.0	*M*	1670.0	*M*	2010.0	*M*
Total Phosphorus - Nitric/Perchloric	mg/kg	231.0	*	247.0	*	243.0	*	521.0	*	332.0	*	274.0	*
Phosphorus - Colwell extr	mg/kg	5.32	*L*	12	*L*	24.6	*L*	38.2	*M*	20.1	*L*	14.2	*L*
Potassium - Colwell ext	mg/kg	177.00	*L*	123.00	*L*	184.00	*M*	263.00	*M*	201.00	*M*	256.00	*M*
Sulphur - KCl	mg/kg	33.6	*VH*	20.7	*VH*	15.3	*H*	26.9	*VH*	30.0	*VH*	13.8	*H*
Organic Carbon	%	1.73	*M*	1.41	*M*	2.27	*H*	2.49	*H*	1.41	*M*	2.04	*H*
Copper	mg/kg	0.82	*M*	0.83	*M*	0.47	*M*	0.43	*M*	0.91	*M*	0.81	*M*
Iron	mg/kg	6.13	*	7.18	*	5.73	*	5.30	*	7.50	*	6.65	*
Manganese	mg/kg	7.58	*M*	4.70	*M*	5.75	*M*	5.08	*M*	12.10	*M*	6.15	*M*
Zinc	mg/kg	0.38	*L*	0.28	*VL*	0.43	*L*	0.45	*L*	0.58	*L*	0.58	*L*
Boron	mg/kg	1.75	*M*	1.84	*M*	1.83	*M*	1.75	*M*	1.59	*M*	1.19	*M*
Cation Extraction Method	Rayment& Lyons	15C1	*	15C1	*	15C1	*	15C1	*	15C1	*	15C1	*
Cation Exchange Capacity	meq/100g	31.3	*	20.3	*	20.7	*	16.8	*	17.8	*	18.3	*
Ex Calcium Percent	%	75.15	*	64.06	*	68.32	*	73.77	*	65.00	*	70.39	*
Ex Magnesium Percent	%	17.95	*	26.68	*	20.86	*	19.20	*	21.40	*	23.27	*
Ex Potassium Percent	%	1.51	*	1.65	*	2.02	*	3.39	*	2.38	*	2.87	*
Ex Sodium Percent	%	5.32	*N.Sodic*	7.50	*Sodic*	8.70	*Sodic*	3.51	*N.Sodic*	11.09	*Sodic*	3.34	*N.Sodic*
Ex Aluminium Percent	%	0.07	*VL*	0.11	*VL*	0.11	*VL*	0.13	*VL*	0.12	*VL*	0.12	*VL*
Exchangeable Calcium	mg/kg	4709	*H*	2601	*H*	2833	*H*	2485	*H*	2313	*H*	2581	*H*
Exchangeable Magnesium	mg/kg	675	*H*	650	*H*	519	*H*	388	*H*	457	*H*	512	*H*
Exchangeable Potassium	mg/kg	184	*H*	131	*H*	163	*H*	223	*H*	165	*H*	205	*H*
Exchangeable Sodium	mg/kg	383	*FALSE*	350	*FALSE*	415	*FALSE*	136	*FALSE*	454	*FALSE*	141	*FALSE*
Exchangeable Aluminium	mg/kg	2	*VL*	2	*VL*	2	*VL*	2	*VL*	2	*VL*	2	*VL*
Exchangeable Calcium	meq/100g	23.55	*VH*	13.01	*H*	14.17	*H*	12.43	*H*	11.57	*H*	12.91	*H*
Exchangeable Magnesium	meq/100g	5.63	*H*	5.42	*H*	4.33	*H*	3.23	*H*	3.81	*H*	4.27	*H*
Exchangeable Potassium	meq/100g	0.47	*M*	0.34	*M*	0.42	*M*	0.57	*M*	0.42	*M*	0.53	*M*
Exchangeable Sodium	meq/100g	1.67	*H*	1.52	*H*	1.80	*H*	0.59	*M*	1.97	*H*	0.61	*M*
Exchangeable Aluminium	meq/100g	0.02	*VH*	0.02	*VH*	0.02	*VH*	0.02	*VH*	0.02	*VH*	0.02	*VH*
Calcium/Magnesium Ratio	-	4.2	*Balanced*	2.4	*Low Ca*	3.3	*Low Ca*	3.8	*Low Ca*	3.0	*Low Ca*	3.0	*Low Ca*
Emerson Aggregate	Class	5	*Slaking*	5	*Slaking*	4	*Slaking*	4	*Slaking*	4	*Slaking*	5	*Slaking*

	Highly acidic		Extremely alkaline		High salinity		Sodic		Strongly sodic

Table B5: Laboratory analysis data for clay soils. Part 8 of 12.

Table B5. Laboratory Results Clays													
	Lab No	230959-224		230959-228		230959-232		230959-236		230959-240		230959-244	
	Sample ID	68		72		232		62		250		248	
	Sample Depth	Composite		Composite		Composite		Composite		Composite		Composite	
	Field Texture	LMC		LMC		MC		MC		MC		LMC	
Analyses	**Unit**	-		-		-		-		-		-	
pH - Water	pH units	9.29	*E.Alk*	8.42	*M.Alk*	8.45	*M.Alk*	9.03	*E.Alk*	8.69	*H.Alk*	8.84	*H.Alk*
Electrical Conductivity	dS/m	0.32	*M.Sal*	0.37	*M.Sal*	0.4	*M.Sal*	0.48	*H.Sal*	0.26	*M.Sal*	0.27	*M.Sal*
Chloride	mg/kg	410.0	*M.Sal*	175.0	*L.Sal*	226.0	*L.Sal*	532.0	*M.Sal*	72.9	*VL.Sal*	200.0	*L.Sal*
Total Nitrogen - Kjeldahl	mg/kg	500.0	*L*	1540.0	*M*	1450.0	*L*	920.0	*L*	1230.0	*L*	1090.0	*L*
Total Phosphorus - Nitric/Perchloric	mg/kg	224.0	*	203.0	*	201.0	*	191.0	*	142.0	*	149.0	*
Phosphorus - Colwell extr	mg/kg	8.1	*L*	17.4	*L*	13.4	*L*	7.14	*L*	9.8	*L*	19.6	*L*
Potassium - Colwell ext	mg/kg	105.00	*VL*	167.00	*L*	162.00	*L*	132.00	*L*	190.00	*M*	143.00	*L*
Sulphur - KCl	mg/kg	27.1	*VH*	20.0	*VH*	31.3	*VH*	15.0	*H*	14.7	*H*	21.2	*VH*
Organic Carbon	%	0.43	*VL*	1.28	*M*	1.35	*M*	0.87	*L*	1.26	*M*	1.19	*M*
Copper	mg/kg	0.57	*M*	0.81	*M*	0.87	*M*	0.81	*M*	0.63	*M*	0.69	*M*
Iron	mg/kg	7.55	*	5.40	*	6.45	*	8.43	*	7.43	*	7.03	*
Manganese	mg/kg	5.58	*M*	12.30	*M*	4.55	*M*	5.30	*M*	3.43	*M*	4.13	*M*
Zinc	mg/kg	<0.20	*L*	0.63	*L*	0.35	*L*	0.28	*VL*	0.25	*VL*	<0.20	*L*
Boron	mg/kg	1.69	*M*	1.33	*M*	1.69	*M*	2.41	*H*	2.95	*H*	1.99	*M*
Cation Extraction Method	Rayment& Lyons	15C1	*	15C1	*	15C1	*	15C1	*	15C1	*	15C1	*
Cation Exchange Capacity	meq/100g	12.5	*	18.6	*	18.9	*	19.3	*	25.3	*	19.8	*
Ex Calcium Percent	%	55.12	*	65.78	*	68.74	*	54.07	*	67.87	*	66.09	*
Ex Magnesium Percent	%	26.79	*	26.41	*	23.47	*	28.24	*	24.54	*	23.99	*
Ex Potassium Percent	%	2.13	*	1.99	*	2.19	*	1.59	*	1.76	*	1.88	*
Ex Sodium Percent	%	15.78	*H.Sodic*	5.69	*N.Sodic*	5.49	*N.Sodic*	15.97	*H.Sodic*	5.75	*N.Sodic*	7.93	*Sodic*
Ex Aluminium Percent	%	0.18	*VL*	0.12	*VL*	0.12	*VL*	0.12	*VL*	0.09	*VL*	0.11	*VL*
Exchangeable Calcium	mg/kg	1382	*H*	2441	*H*	2592	*H*	2087	*H*	3430	*H*	2617	*H*
Exchangeable Magnesium	mg/kg	403	*H*	588	*H*	531	*H*	654	*H*	744	*H*	570	*H*
Exchangeable Potassium	mg/kg	104	*H*	144	*H*	161	*H*	120	*H*	173	*H*	145	*H*
Exchangeable Sodium	mg/kg	455	*FALSE*	243	*FALSE*	238	*FALSE*	709	*FALSE*	334	*FALSE*	361	*FALSE*
Exchangeable Aluminium	mg/kg	2	*VL*	2	*VL*	2	*VL*	2	*VL*	2	*VL*	2	*VL*
Exchangeable Calcium	meq/100g	6.91	*M*	12.21	*H*	12.96	*H*	10.44	*H*	17.15	*H*	13.09	*H*
Exchangeable Magnesium	meq/100g	3.36	*H*	4.90	*H*	4.43	*H*	5.45	*H*	6.20	*H*	4.75	*H*
Exchangeable Potassium	meq/100g	0.27	*L*	0.37	*M*	0.41	*M*	0.31	*M*	0.44	*M*	0.37	*M*
Exchangeable Sodium	meq/100g	1.98	*H*	1.06	*H*	1.03	*H*	3.08	*VH*	1.45	*H*	1.57	*H*
Exchangeable Aluminium	meq/100g	0.02	*VH*	0.02	*VH*	0.02	*VH*	0.02	*VH*	0.02	*VH*	0.02	*VH*
Calcium/Magnesium Ratio	-	2.1	*Low Ca*	2.5	*Low Ca*	2.9	*Low Ca*	1.9	*Low Ca*	2.8	*Low Ca*	2.8	*Low Ca*
Emerson Aggregate	Class	3b	*Slight Disp*	5	*Slaking*	4	*Slaking*	4	*Slaking*	4	*Slaking*	4	*Slaking*

	Highly acidic		Extremely alkaline		High salinity		Sodic		Strongly sodic

Table B5: Laboratory analysis data for clay soils. Part 9 of 12.

Table B5. Laboratory Results Clays													
	Lab No	230959-248		230959-252		230959-256		230959-260		230959-284		230959-288	
	Sample ID	57		55		285		52		268c		283	
	Sample Depth	Composite		Composite		Composite		Composite		Composite		Composite	
	Field Texture	LMC		LMC		LMC		LMC		LMC		HC	
Analyses	**Unit**	-		-		-		-		-		-	
pH - Water	pH units	8.9	*H.Alk*	9.02	*E.Alk*	8.44	*M.Alk*	7.99	*M.Alk*	8.88	*H.Alk*	8.55	*H.Alk*
Electrical Conductivity	dS/m	0.61	*H.Sal*	0.33	*M.Sal*	0.24	*M.Sal*	0.31	*M.Sal*	0.37	*M.Sal*	0.45	*H.Sal*
Chloride	mg/kg	760.0	*H.Sal*	230.0	*L.Sal*	62.3	*VL.Sal*	53.5	*VL.Sal*	365.0	*M.Sal*	405.0	*M.Sal*
Total Nitrogen - Kjeldahl	mg/kg	1070.0	*L*	960.0	*L*	1690.0	*M*	2340.0	*M*	1290.0	*L*	1370.0	*L*
Total Phosphorus - Nitric/Perchloric	mg/kg	150.0	*	103.0	*	287.0	*	499.0	*	147.0	*	227.0	*
Phosphorus - Colwell extr	mg/kg	6.26	*L*	<5.00	*L*	17.8	*L*	125	*H*	32.7	*M*	13	*L*
Potassium - Colwell ext	mg/kg	142.00	*L*	155.00	*L*	159.00	*L*	1660.00	*VH*	154.00	*L*	180.00	*M*
Sulphur - KCl	mg/kg	17.6	*H*	10.0	*M*	11.9	*M*	24.3	*VH*	7.5	*L*	21.5	*VH*
Organic Carbon	%	0.88	*L*	0.93	*L*	1.73	*M*	1.48	*M*	1.26	*M*	1.23	*M*
Copper	mg/kg	0.99	*M*	1.53	*M*	0.82	*M*	0.86	*M*	0.71	*M*	0.8	*M*
Iron	mg/kg	7.60	*	10.00	*	5.60	*	24.30	*	7.08	*	3.88	*
Manganese	mg/kg	7.03	*M*	5.20	*M*	7.14	*M*	8.64	*M*	4.15	*M*	4.08	*M*
Zinc	mg/kg	0.20	*VL*	6.33	*H*	0.33	*L*	1.84	*M*	0.23	*VL*	1.82	*M*
Boron	mg/kg	3.49	*H*	1.91	*M*	1.53	*M*	0.73	*L*	2.09	*H*	0.68	*L*
Cation Extraction Method	Rayment& Lyons	15C1	*	15C1	*	15C1	*	15C1	*	15C1	*	15C1	*
Cation Exchange Capacity	meq/100g	18.5	*	22.6	*	18.0	*	11.6	*	21.2	*M*	21.9	*M*
Ex Calcium Percent	%	52.82	*	60.19	*	72.55	*	61.52	*	57.40	*L*	58.37	*L*
Ex Magnesium Percent	%	29.74	*	25.26	*	21.27	*	21.18	*	28.22	*H*	31.06	*H*
Ex Potassium Percent	%	1.76	*	1.52	*	2.48	*	14.94	*	1.68	*Normal*	1.98	*Normal*
Ex Sodium Percent	%	15.56	*H.Sodic*	12.93	*Sodic*	3.58	*N.Sodic*	2.17	*N.Sodic*	12.59	*Sodic*	8.49	*Sodic*
Ex Aluminium Percent	%	0.12	*VL*	0.10	*VL*	0.12	*VL*	0.19	*VL*	0.10	*VL*	0.10	*VL*
Exchangeable Calcium	mg/kg	1957	*H*	2724	*H*	2610	*H*	1423	*H*	2434	*H*	2553	*H*
Exchangeable Magnesium	mg/kg	661	*H*	686	*H*	459	*H*	294	*H*	718	*H*	815	*H*
Exchangeable Potassium	mg/kg	127	*H*	134	*H*	174	*H*	674	*H*	139	*H*	169	*H*
Exchangeable Sodium	mg/kg	663	*FALSE*	673	*FALSE*	148	*FALSE*	57.6	*H.Sodic*	614	*FALSE*	427	*FALSE*
Exchangeable Aluminium	mg/kg	2	*VL*	2	*VL*	2	*VL*	2	*VL*	2	*	2	*
Exchangeable Calcium	meq/100g	9.79	*M*	13.62	*H*	13.05	*H*	7.12	*M*	12.17	*H*	12.77	*H*
Exchangeable Magnesium	meq/100g	5.51	*H*	5.72	*H*	3.83	*H*	2.45	*M*	5.98	*H*	6.79	*H*
Exchangeable Potassium	meq/100g	0.33	*M*	0.34	*M*	0.45	*M*	1.73	*H*	0.36	*M*	0.43	*M*
Exchangeable Sodium	meq/100g	2.88	*VH*	2.93	*VH*	0.64	*M*	0.25	*L*	2.67	*VH*	1.86	*H*
Exchangeable Aluminium	meq/100g	0.02	*VH*	0.02	*VH*	0.02	*VH*	0.02	*VH*	0.02	*VH*	0.02	*VH*
Calcium/Magnesium Ratio	-	1.8	*Low Ca*	2.4	*Low Ca*	3.4	*Low Ca*	2.9	*Low Ca*	2.0	*Low Ca*	1.9	*Low Ca*
Emerson Aggregate	Class	4	*Slaking*	4	*Slaking*	4	*Slaking*	4	*Slaking*	4	*Slaking*	4	*Slaking*

	Highly acidic		Extremely alkaline		High salinity		Sodic		Strongly sodic

Table B5: Laboratory analysis data for clay soils. Part 10 of 12.

Table B5. Laboratory Results Clays													
	Lab No	230959-308		230959-312		230959-316		230959-320		230959-324		230959-328	
	Sample ID	59		218		170		219		171		169	
	Sample Depth	Composite		Composite		Composite		Composite		Composite		Composite	
	Field Texture	LC		LC		LMC		LC		LC		LMC	
Analyses	**Unit**	-		-		-		-		-		-	
pH - Water	pH units	8.44	*M.Alk*	8.17	*M.Alk*	8.52	*H.Alk*	8.6	*H.Alk*	8.45	*M.Alk*	8.65	*H.Alk*
Electrical Conductivity	dS/m	0.08	*VL.Sal*	0.2	*M.Sal*	0.31	*M.Sal*	0.38	*M.Sal*	0.4	*M.Sal*	0.26	*M.Sal*
Chloride	mg/kg	33.4	*VL.Sal*	78.6	*VL.Sal*	268.0	*L.Sal*	273.0	*L.Sal*	329.0	*M.Sal*	75.2	*VL.Sal*
Total Nitrogen - Kjeldahl	mg/kg	902.0	*L*	1880.0	*M*	1310.0	*L*	1603.0	*M*	2020.0	*M*	1600.0	*M*
Total Phosphorus - Nitric/Perchloric	mg/kg	216.0	*	234.0	*	190.0	*	288.0	*	289.0	*	234.0	*
Phosphorus - Colwell extr	mg/kg	5.46	*L*	10.3	*L*	<5.00	*L*	10.9	*L*	11.9	*L*	<5.00	*L*
Potassium - Colwell ext	mg/kg	222.00	*M*	210.00	*M*	91.00	*VL*	215.00	*M*	392.00	*H*	345.00	*H*
Sulphur - KCl	mg/kg	9.3	*M*	9.8	*M*	18.8	*H*	21.9	*VH*	49.9	*VH*	18.3	*H*
Organic Carbon	%	0.61	*L*	1.93	*H*	1.36	*M*	1.62	*M*	2.6	*H*	1.55	*M*
Copper	mg/kg	0.78	*M*	0.97	*M*	0.96	*M*	1.02	*M*	0.8	*M*	0.92	*M*
Iron	mg/kg	3.92	*	19.30	*	2.82	*	3.02	*	6.54	*	10.80	*
Manganese	mg/kg	10.40	*M*	12.60	*M*	5.46	*M*	4.02	*M*	4.08	*M*	4.48	*M*
Zinc	mg/kg	1.94	*M*	0.74	*L*	1.90	*M*	1.84	*M*	1.82	*M*	1.84	*M*
Boron	mg/kg	0.46	*VL*	0.60	*L*	0.38	*VL*	0.71	*L*	0.76	*L*	1.14	*M*
Cation Extraction Method	Rayment& Lyons	15C1	*	15C1	*	15C1	*	15C1	*	15C1	*	15C1	*
Cation Exchange Capacity	meq/100g	7.2	*L*	18.1	*M*	19.2	*M*	26.5	*H*	26.8	*H*	23.5	*M*
Ex Calcium Percent	%	78.15	*Normal*	69.16	*Normal*	66.66	*Normal*	67.96	*Normal*	70.48	*Normal*	66.00	*Normal*
Ex Magnesium Percent	%	11.82	*Normal*	23.47	*H*	24.78	*H*	22.64	*H*	20.67	*H*	25.90	*H*
Ex Potassium Percent	%	6.49	*H*	2.89	*Normal*	1.11	*Normal*	1.93	*Normal*	3.09	*Normal*	2.64	*Normal*
Ex Sodium Percent	%	3.23	*N.Sodic*	4.35	*N.Sodic*	7.34	*Sodic*	7.39	*Sodic*	5.68	*N.Sodic*	5.37	*N.Sodic*
Ex Aluminium Percent	%	0.31	*VL*	0.12	*VL*	0.12	*VL*	0.08	*VL*	0.08	*VL*	0.09	*VL*
Exchangeable Calcium	mg/kg	1124	*H*	2500	*H*	2560	*H*	3607	*H*	3779	*H*	3101	*H*
Exchangeable Magnesium	mg/kg	102	*H*	509	*H*	571	*H*	721	*H*	665	*H*	730	*H*
Exchangeable Potassium	mg/kg	182	*H*	204	*H*	83	*H*	200	*H*	323	*H*	242	*H*
Exchangeable Sodium	mg/kg	53.5	*H.Sodic*	181	*FALSE*	324	*FALSE*	451	*FALSE*	350	*FALSE*	290	*FALSE*
Exchangeable Aluminium	mg/kg	2	*	2	*	2	*	2	*	2	*	2	*
Exchangeable Calcium	meq/100g	5.62	*M*	12.50	*H*	12.80	*H*	18.04	*H*	18.90	*H*	15.51	*H*
Exchangeable Magnesium	meq/100g	0.85	*L*	4.24	*H*	4.76	*H*	6.01	*H*	5.54	*H*	6.08	*H*
Exchangeable Potassium	meq/100g	0.47	*M*	0.52	*M*	0.21	*L*	0.51	*M*	0.83	*H*	0.62	*M*
Exchangeable Sodium	meq/100g	0.23	*L*	0.79	*H*	1.41	*H*	1.96	*H*	1.52	*H*	1.26	*H*
Exchangeable Aluminium	meq/100g	0.02	*VH*	0.02	*VH*	0.02	*VH*	0.02	*VH*	0.02	*VH*	0.02	*VH*
Calcium/Magnesium Ratio	-	6.6	*Balanced*	2.9	*Low Ca*	2.7	*Low Ca*	3.0	*Low Ca*	3.4	*Low Ca*	2.5	*Low Ca*
Emerson Aggregate	Class	5	*Slaking*	5	*Slaking*	4	*Slaking*	4	*Slaking*	4	*Slaking*	4	*Slaking*

	Highly acidic		Extremely alkaline		High salinity		Sodic		Strongly sodic

Table B5: Laboratory analysis data for clay topsoils. Part 11 of 12.

Table B5. Laboratory Results Clays													
	Lab No	230959-332		230959-336		230959-340		230959-344		230959-348		230959-352	
	Sample ID	58		2		11		12		31		30	
	Sample Depth	Composite		Composite		Composite		Composite		Composite		Composite	
	Field Texture	MC		LMC		HC		MC		LC		LMC	
Analyses	**Unit**	-		-		-		-		-		-	
pH - Water	pH units	8.57	*H.Alk*	8.51	*H.Alk*	8.37	*M.Alk*	8.59	*H.Alk*	7.32	*Neutral*	7.38	*Neutral*
Electrical Conductivity	dS/m	0.19	*M.Sal*	0.18	*L.Sal*	0.2	*M.Sal*	0.12	*L.Sal*	0.27	*M.Sal*	0.41	*M.Sal*
Chloride	mg/kg	70.8	*VL.Sal*	177.0	*L.Sal*	80.6	*VL.Sal*	25.6	*VL.Sal*	311.0	*M.Sal*	481.0	*M.Sal*
Total Nitrogen - Kjeldahl	mg/kg	1970.0	*M*	1910.0	*M*	2090.0	*M*	1680.0	*M*	1260.0	*L*	1780.0	*M*
Total Phosphorus - Nitric/Perchloric	mg/kg	272.0	*	332.0	*	340.0	*	308.0	*	523.0	*	425.0	*
Phosphorus - Colwell extr	mg/kg	13.6	*L*	7.61	*L*	13.6	*L*	35.8	*M*	132	*H*	21.1	*L*
Potassium - Colwell ext	mg/kg	287.00	*M*	232.00	*M*	311.00	*H*	225.00	*M*	293.00	*M*	289.00	*M*
Sulphur - KCl	mg/kg	27.4	*VH*	12.7	*H*	33.8	*VH*	7.5	*L*	29.7	*VH*	9.9	*M*
Organic Carbon	%	2.61	*H*	1.64	*M*	2.19	*H*	1.38	*M*	0.89	*L*	1.49	*M*
Copper	mg/kg	0.8	*M*	0.78	*M*	0.84	*M*	0.8	*M*	0.62	*M*	0.64	*M*
Iron	mg/kg	4.44	*	5.24	*	8.62	*	10.10	*	8.90	*	19.70	*
Manganese	mg/kg	3.92	*M*	7.62	*M*	10.00	*M*	12.20	*M*	12.80	*M*	23.30	*M*
Zinc	mg/kg	1.88	*M*	1.90	*M*	1.90	*M*	1.92	*M*	1.92	*M*	1.94	*M*
Boron	mg/kg	0.76	*L*	1.02	*M*	0.94	*L*	1.02	*M*	0.66	*L*	1.12	*M*
Cation Extraction Method	Rayment& Lyons	15C1	*	15C1	*	15C1	*	15C1	*	15C1	*	15C1	*
Cation Exchange Capacity	meq/100g	20.6	*M*	20.4	*M*	18.4	*M*	22.5	*M*	6.8	*L*	13.9	*M*
Ex Calcium Percent	%	72.41	*Normal*	75.64	*Normal*	74.33	*Normal*	73.00	*Normal*	68.87	*Normal*	30.07	*L*
Ex Magnesium Percent	%	21.84	*H*	19.66	*H*	20.53	*H*	22.41	*H*	20.71	*H*	58.39	*H*
Ex Potassium Percent	%	2.93	*Normal*	2.32	*Normal*	3.03	*Normal*	2.15	*Normal*	6.11	*H*	3.41	*Normal*
Ex Sodium Percent	%	2.71	*N.Sodic*	2.28	*N.Sodic*	1.98	*N.Sodic*	2.34	*N.Sodic*	3.98	*N.Sodic*	7.98	*Sodic*
Ex Aluminium Percent	%	0.11	*VL*	0.11	*VL*	0.12	*VL*	0.10	*VL*	0.32	*VL*	0.16	*VL*
Exchangeable Calcium	mg/kg	2978	*H*	3091	*H*	2739	*H*	3279	*H*	942	*H*	836	*H*
Exchangeable Magnesium	mg/kg	539	*H*	482	*H*	454	*H*	604	*H*	170	*H*	974	*H*
Exchangeable Potassium	mg/kg	235	*H*	185	*H*	218	*H*	188	*H*	163	*H*	185	*H*
Exchangeable Sodium	mg/kg	128	*FALSE*	107	*FALSE*	83.9	*H.Sodic*	121	*FALSE*	62.6	*H.Sodic*	255	*FALSE*
Exchangeable Aluminium	mg/kg	2	*	2	*	2	*	2	*	2	*	2	*
Exchangeable Calcium	meq/100g	14.89	*H*	15.46	*H*	13.70	*H*	16.40	*H*	4.71	*L*	4.18	*L*
Exchangeable Magnesium	meq/100g	4.49	*H*	4.02	*H*	3.78	*H*	5.03	*H*	1.42	*M*	8.12	*VH*
Exchangeable Potassium	meq/100g	0.60	*M*	0.47	*M*	0.56	*M*	0.48	*M*	0.42	*M*	0.47	*M*
Exchangeable Sodium	meq/100g	0.56	*M*	0.47	*M*	0.36	*M*	0.53	*M*	0.27	*L*	1.11	*H*
Exchangeable Aluminium	meq/100g	0.02	*VH*	0.02	*VH*	0.02	*VH*	0.02	*VH*	0.02	*VH*	0.02	*VH*
Calcium/Magnesium Ratio	-	3.3	*Low Ca*	3.8	*Low Ca*	3.6	*Low Ca*	3.3	*Low Ca*	3.3	*Low Ca*	0.5	*Low Ca*
Emerson Aggregate	Class	4	*Slaking*	4	*Slaking*	4	*Slaking*	4	*Slaking*	5	*Slaking*	5	*Slaking*

	Highly acidic		Extremely alkaline		High salinity		Sodic		Strongly sodic

Table B5: Laboratory analysis data for clay topsoils. Part 12 of 12.

Table B5. Laboratory Results Clays																		
	Lab No	230959-356		230959-360		**Mean**		**LCL**	**UCL**	**Std Dev**	**Count**	**CI 95%**	**10%ile**		**90%ile**		**Min**	**Max**
	Sample ID	41		41 N				**95%**	**95%**			**(+/-)**						
	Sample Depth	Composite		Composite														
	Field Texture	LC		LMC														
Analyses	**Unit**	-		-														
pH - Water	pH units	7.71	*L.Alk*	8.32	*M.Alk*	*8.5*	*H.Alk*	*8.4*	*8.6*	*0.5*	*68*	*0.1*	*8.0*	*M.Alk*	*9.0*	*H.Alk*	*6.7*	*9.3*
Electrical Conductivity	dS/m	0.13	*L.Sal*	0.28	*M.Sal*	*0.3*	*M.Sal*	*0.28*	*0.37*	*0.2*	*68*	*0.04*	*0.2*	*L.Sal*	*0.5*	*H.Sal*	*0.1*	*1.3*
Chloride	mg/kg	83.2	*VL.Sal*	118.0	*L.Sal*	*261.2*	*L.Sal*	*192*	*330*	*290.1*	*68*	*69*	*60.1*	*VL.Sal*	*463.5*	*M.Sal*	*13.1*	*2019.0*
Total Nitrogen - Kjeldahl	mg/kg	1070.0	*L*	1400.0	*L*	*1289.2*	*L*	*1186*	*1392*	*434.6*	*68*	*103*	*763.8*	*L*	*1928.0*	*M*	*500.0*	*2340.0*
Total Phosphorus - Nitric/Perchloric	mg/kg	290.0	*	336.0	*	*256.4*	*	*233*	*279*	*96.4*	*68*	*23*	*152.8*	*	*345.1*	*	*103.0*	*529.0*
Phosphorus - Colwell extr	mg/kg	10.9	*L*	21.7	*L*	*20.6*	*	*13*	*28*	*25.5*	*49*	*7*	*6.2*	*	*36.3*	*	*5.2*	*132.0*
Potassium - Colwell ext	mg/kg	195.00	*M*	245.00	*M*	*202.1*	*	*157*	*247*	*189.6*	*68*	*45*	*115.9*	*	*270.2*	*	*91.0*	*1660.0*
Sulphur - KCl	mg/kg	19.7	*H*	16.1	*H*	*26.6*	*VH*	*22.36*	*30.83*	*17.8*	*68*	*4.23*	*10.0*	*M*	*46.2*	*VH*	*7.5*	*88.2*
Organic Carbon	%	0.81	*L*	1.43	*M*	*1.4*	*M*	*1.32*	*1.56*	*0.5*	*68*	*0.12*	*0.9*	*L*	*2.1*	*H*	*0.4*	*3.2*
Copper	mg/kg	0.66	*M*	0.72	*M*	*0.8*	*M*	*0.77*	*0.87*	*0.2*	*68*	*0.05*	*0.6*	*M*	*1.1*	*M*	*0.4*	*1.5*
Iron	mg/kg	8.32	*	6.64	*	*10.2*	*	*9*	*11*	*5.4*	*68*	*1*	*3.9*	*	*16.2*	*	*2.8*	*27.4*
Manganese	mg/kg	12.50	*M*	8.32	*M*	*6.9*	*M*	*6.07*	*7.70*	*3.4*	*68*	*0.82*	*4.0*	*M*	*12.2*	*M*	*3.4*	*23.3*
Zinc	mg/kg	1.92	*M*	1.92	*M*	*1.0*	*M*	*0.68*	*1.26*	*1.1*	*53*	*0.29*	*0.2*	*VL*	*1.9*	*M*	*0.2*	*6.3*
Boron	mg/kg	0.56	*L*	0.44	*VL*	*1.5*	*M*	*1.37*	*1.72*	*0.7*	*68*	*0.17*	*0.7*	*L*	*2.6*	*H*	*0.4*	*3.5*
Cation Extraction Method	Rayment& Lyons	15C1	*	15C1	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Cation Exchange Capacity	meq/100g	5.2	*VL*	13.1	*M*	*20.0*	*M*	*18.6*	*21.5*	*6.2*	*68*	*1.5*	*13.7*	*M*	*26.9*	*H*	*5.2*	*38.6*
Ex Calcium Percent	%	68.96	*Normal*	65.90	*Normal*	*65.3*	*Normal*	*63.4*	*67.2*	*7.8*	*68*	*1.9*	*57.1*	*L*	*72.7*	*Normal*	*30.1*	*80.3*
Ex Magnesium Percent	%	18.91	*H*	26.08	*H*	*24.8*	*H*	*23.4*	*26.2*	*5.9*	*68*	*1.4*	*20.1*	*H*	*29.8*	*H*	*11.8*	*58.4*
Ex Potassium Percent	%	7.31	*H*	3.32	*Normal*	*2.2*	*Normal*	*1.8*	*2.7*	*2.0*	*68*	*0.5*	*0.9*	*L*	*3.2*	*Normal*	*0.7*	*14.9*
Ex Sodium Percent	%	4.39	*N.Sodic*	4.54	*N.Sodic*	*7.5*	*Sodic*	*6.6*	*8.4*	*3.8*	*68*	*0.9*	*3.3*	*N.Sodic*	*13.6*	*Sodic*	*2.0*	*16.3*
Ex Aluminium Percent	%	0.43	*VL*	0.17	*VL*	*0.1*	*VL*	*0.1*	*0.1*	*0.1*	*68*	*0.0*	*0.1*	*VL*	*0.2*	*VL*	*0.1*	*0.4*
Exchangeable Calcium	mg/kg	711	*H*	1731	*H*	*2633.3*	*H*	*2407.5*	*2859.1*	*950.2*	*68*	*225.8*	*1630.0*	*H*	*3658.6*	*H*	*711.0*	*5560.0*
Exchangeable Magnesium	mg/kg	117	*H*	411	*H*	*593.3*	*H*	*547.3*	*639.2*	*193.2*	*68*	*45.9*	*391.5*	*H*	*879.6*	*H*	*102.0*	*994.0*
Exchangeable Potassium	mg/kg	147	*H*	170	*H*	*150.0*	*H*	*130.8*	*169.1*	*80.5*	*68*	*19.1*	*83.9*	*H*	*204.3*	*H*	*57.7*	*674.0*
Exchangeable Sodium	mg/kg	52	*H.Sodic*	137	*FALSE*	*347.3*	*H.Sodic*	*301.9*	*392.6*	*190.7*	*68*	*45.3*	*116.8*	*H.Sodic*	*637.8*	*H.Sodic*	*52.0*	*766.0*
Exchangeable Aluminium	mg/kg	2	*	2	*	*2.0*	*	*#NUM!*	*#NUM!*	*0.0*	*68*	*#NUM!*	*2.0*	*	*2.0*	*	*2.0*	*2.0*
Exchangeable Calcium	meq/100g	3.56	*L*	8.66	*M*	*13.2*	*H*	*12.0*	*14.3*	*4.8*	*68*	*1.1*	*8.2*	*M*	*18.3*	*H*	*3.6*	*27.8*
Exchangeable Magnesium	meq/100g	0.98	*L*	3.43	*H*	*4.9*	*H*	*4.6*	*5.3*	*1.6*	*68*	*0.4*	*3.3*	*H*	*7.3*	*H*	*0.9*	*8.3*
Exchangeable Potassium	meq/100g	0.38	*M*	0.44	*M*	*0.4*	*M*	*0.3*	*0.4*	*0.2*	*68*	*0.0*	*0.2*	*L*	*0.5*	*M*	*0.1*	*1.7*
Exchangeable Sodium	meq/100g	0.23	*L*	0.60	*M*	*1.5*	*H*	*1.3*	*1.7*	*0.8*	*68*	*0.2*	*0.5*	*M*	*2.8*	*VH*	*0.2*	*3.3*
Exchangeable Aluminium	meq/100g	0.02	*VH*	0.02	*VH*	*0.0*	*VH*	*0.0*	*0.0*	*0.0*	*68*	*0.0*	*0.0*	*VH*	*0.0*	*VH*	*0.0*	*0.0*
Calcium/Magnesium Ratio	-	3.6	*Low Ca*	2.5	*Low Ca*	*2.8*	*Low Ca*	*2.6*	*3.0*	*0.9*	*68*	*0.2*	*1.9*	*Low Ca*	*3.6*	*Low Ca*	*0.5*	*6.6*
Emerson Aggregate	Class	5	*Slaking*	5	*Slaking*	*4.4*	*	*	*	*	*	*	*	*	*	*	*	*

	Highly acidic		Extremely alkaline		High salinity		Sodic		Strongly sodic

Table B6: Laboratory analysis data for gravelly clay topsoils. Part 1 of 3.

Table B6. Laboratory Results Gravelly clays													
	Lab No	230959-52		230959-144		230959-148		230959-156		230959-176		230959-196	
	Sample ID	138a		268a		268b		256		214		228a	
	Sample Depth	Composite		Composite		Composite		Composite		Composite		Composite	
	Field Texture	LC		LMC		MC		LMC		MC		MC	
Analyses	**Unit**	-		-		-		-		-		-	
pH - Water	pH units	9.04	*E.Alk*	7.96	*M.Alk*	8.82	*H.Alk*	8.46	*M.Alk*	8.28	*M.Alk*	8.85	*H.Alk*
Electrical Conductivity	dS/m	0.46	*H.Sal*	0.23	*M.Sal*	0.29	*M.Sal*	0.52	*H.Sal*	0.73	*H.Sal*	0.38	*M.Sal*
Chloride	mg/kg	211.0	*L.Sal*	138.0	*L.Sal*	206.0	*L.Sal*	464.0	*M.Sal*	470.0	*M.Sal*	387.0	*M.Sal*
Total Nitrogen - Kjeldahl	mg/kg	783.0	*L*	1270.0	*L*	1320.0	*L*	1290.0	*L*	1340.0	*L*	1290.0	*L*
Total Phosphorus - Nitric/Perchloric	mg/kg	488.0	*	326.0	*	147.0	*	400.0	*	269.0	*	199.0	*
Phosphorus - Colwell extr	mg/kg	6.04	*L*	10.2	*L*	9.8	*L*	9.8	*L*	<5.00	*L*	12.9	*L*
Potassium - Colwell ext	mg/kg	95.30	*VL*	183.00	*M*	135.00	*L*	162.00	*L*	135.00	*L*	126.00	*L*
Sulphur - KCl	mg/kg	122.0	*VH*	10.3	*M*	8.9	*M*	90.7	*VH*	130.0	*VH*	30.5	*VH*
Organic Carbon	%	1.33	*M*	1.14	*M*	1.44	*M*	1.53	*M*	2.22	*H*	1.02	*M*
Copper	mg/kg	1.02	*M*	0.89	*M*	0.83	*M*	1.01	*M*	0.88	*M*	0.76	*M*
Iron	mg/kg	17.40	*	11.00	*	5.92	*	5.90	*	4.84	*	6.96	*
Manganese	mg/kg	5.07	*M*	7.38	*M*	6.24	*M*	4.74	*M*	4.88	*M*	6.24	*M*
Zinc	mg/kg	0.66	*L*	0.46	*L*	0.28	*VL*	0.46	*L*	0.24	*VL*	0.29	*VL*
Boron	mg/kg	2.00	*H*	1.20	*M*	1.76	*M*	1.28	*M*	1.38	*M*	2.11	*H*
Cation Extraction Method	Rayment& Lyons	15C1	*	15C1	*	15C1	*	15C1	*	15C1	*	15C1	*
Cation Exchange Capacity	meq/100g	14.0	*	14.1	*	24.1	*	29.1	*	34.7	*	24.7	*
Ex Calcium Percent	%	45.39	*	66.15	*	60.56	*	69.87	*	68.44	*	60.05	*
Ex Magnesium Percent	%	35.48	*	26.39	*	28.21	*	20.23	*	23.18	*	28.38	*
Ex Potassium Percent	%	1.32	*	2.90	*	1.36	*	1.43	*	1.05	*	1.45	*
Ex Sodium Percent	%	17.65	*H.Sodic*	4.39	*	9.78	*Sodic*	8.40	*Sodic*	7.26	*Sodic*	10.03	*Sodic*
Ex Aluminium Percent	%	0.16	*VL*	0.16	*VL*	0.09	*VL*	0.08	*VL*	0.06	*VL*	0.09	*VL*
Exchangeable Calcium	mg/kg	1275	*H*	1859	*H*	2923	*H*	4070	*H*	4748	*H*	2966	*H*
Exchangeable Magnesium	mg/kg	598	*H*	445	*H*	817	*H*	707	*H*	965	*H*	841	*H*
Exchangeable Potassium	mg/kg	72.1	*H*	159	*H*	128	*H*	162	*H*	142	*H*	140	*H*
Exchangeable Sodium	mg/kg	570	*FALSE*	142	*FALSE*	543	*FALSE*	563	*FALSE*	579	*FALSE*	570	*FALSE*
Exchangeable Aluminium	mg/kg	2	*VL*	2	*VL*	2	*VL*	2	*VL*	2	*VL*	2	*VL*
Exchangeable Calcium	meq/100g	6.38	*M*	9.30	*M*	14.62	*H*	20.35	*VH*	23.74	*VH*	14.83	*H*
Exchangeable Magnesium	meq/100g	4.98	*H*	3.71	*H*	6.81	*H*	5.89	*H*	8.04	*VH*	7.01	*H*
Exchangeable Potassium	meq/100g	0.18	*VL*	0.41	*M*	0.33	*M*	0.42	*M*	0.36	*M*	0.36	*M*
Exchangeable Sodium	meq/100g	2.48	*VH*	0.62	*M*	2.36	*VH*	2.45	*VH*	2.52	*VH*	2.48	*VH*
Exchangeable Aluminium	meq/100g	0.02	*VH*	0.02	*VH*	0.02	*VH*	0.02	*VH*	0.02	*VH*	0.02	*VH*
Calcium/Magnesium Ratio	-	1.3	*Low Ca*	2.5	*Low Ca*	2.1	*Low Ca*	3.5	*Low Ca*	3.0	*Low Ca*	2.1	*Low Ca*
Emerson Aggregate	Class	3b	*Slight Disp*	5	*Slaking*	4	*Slaking*	4	*Slaking*	4	*Slaking*	4	*Slaking*

	Highly acidic		Extremely alkaline		High salinity		Sodic		Strongly sodic

Table B6: Laboratory analysis data for gravelly clay **top**soils. Part 2 of 3.

Table B6. Laboratory Results Gravelly clays													
	Lab No	230959-200		230959-212		230959-280		230959-292		230959-296		230959-300	
	Sample ID	228b		70		267		221		45		222	
	Sample Depth	Composite		Composite		Composite		Composite		Composite		Composite	
	Field Texture	MC		LMC		LMC		LC		LC		LC	
Analyses	**Unit**	-		-		-		-		-		-	
pH - Water	pH units	8.73	*H.Alk*	8.42	*M.Alk*	8.87	*H.Alk*	8.47	*M.Alk*	8.09	*M.Alk*	8.68	*H.Alk*
Electrical Conductivity	dS/m	0.52	*H.Sal*	0.17	*L.Sal*	0.52	*H.Sal*	0.28	*M.Sal*	0.24	*M.Sal*	0.22	*M.Sal*
Chloride	mg/kg	513.0	*M.Sal*	23.1	*VL.Sal*	675.0	*H.Sal*	72.5	*VL.Sal*	54.4	*VL.Sal*	91.4	*VL.Sal*
Total Nitrogen - Kjeldahl	mg/kg	1190.0	*L*	1150.0	*L*	1090.0	*L*	1480.0	*L*	1380.0	*L*	1430.0	*L*
Total Phosphorus - Nitric/Perchloric	mg/kg	286.0	*	298.0	*	197.0	*	415.0	*	462.0	*	346.0	*
Phosphorus - Colwell extr	mg/kg	9.35	*L*	56.3	*M*	<5.00	*L*	30.9	*M*	29.3	*M*	14.6	*L*
Potassium - Colwell ext	mg/kg	145.00	*L*	160.00	*L*	166.00	*L*	304.00	*H*	169.00	*L*	126.00	*L*
Sulphur - KCl	mg/kg	91.5	*VH*	31.0	*VH*	9.9	*M*	14.7	*H*	20.4	*VH*	17.9	*H*
Organic Carbon	%	1.61	*M*	0.84	*L*	1.41	*M*	1.24	*M*	1.19	*M*	1.38	*M*
Copper	mg/kg	1.01	*M*	1.53	*M*	0.71	*M*	0.86	*M*	0.82	*M*	0.66	*M*
Iron	mg/kg	7.23	*	22.10	*	6.13	*	4.96	*	5.16	*	3.30	*
Manganese	mg/kg	7.23	*M*	10.50	*M*	6.13	*M*	3.90	*M*	6.42	*M*	3.76	*M*
Zinc	mg/kg	0.48	*L*	0.28	*VL*	0.65	*L*	1.84	*M*	1.90	*M*	1.88	*M*
Boron	mg/kg	2.09	*H*	1.75	*M*	2.31	*H*	0.94	*L*	0.76	*L*	3.14	*H*
Cation Extraction Method	Rayment& Lyons	15C1	*	15C1	*	15C1	*	15C1	*	15C1	*	15C1	*
Cation Exchange Capacity	meq/100g	17.7	*	13.5	*	22.3	*M*	15.3	*M*	9.1	*L*	11.6	*L*
Ex Calcium Percent	%	57.42	*	68.07	*	53.21	*L*	65.86	*Normal*	71.95	*Normal*	65.47	*Normal*
Ex Magnesium Percent	%	27.93	*	26.26	*	32.30	*H*	25.25	*H*	18.92	*H*	25.67	*H*
Ex Potassium Percent	%	2.01	*	2.36	*	1.75	*Normal*	2.97	*Normal*	4.02	*Normal*	2.54	*Normal*
Ex Sodium Percent	%	12.51	*Sodic*	3.14	*N.Sodic*	12.64	*Sodic*	5.78	*N.Sodic*	4.86	*N.Sodic*	6.13	*Sodic*
Ex Aluminium Percent	%	0.13	*VL*	0.17	*VL*	0.10	*VL*	0.15	*VL*	0.24	*VL*	0.19	*VL*
Exchangeable Calcium	mg/kg	2032	*H*	1832	*H*	2375	*H*	2013	*H*	1312	*H*	1522	*H*
Exchangeable Magnesium	mg/kg	593	*H*	424	*H*	865	*H*	463	*H*	207	*H*	358	*H*
Exchangeable Potassium	mg/kg	139	*H*	124	*H*	152	*H*	177	*H*	143	*H*	115	*H*
Exchangeable Sodium	mg/kg	509	*FALSE*	97.3	*FALSE*	649	*FALSE*	203	*FALSE*	102	*FALSE*	164	*FALSE*
Exchangeable Aluminium	mg/kg	2	*VL*	2	*VL*	2	*	2	*	2	*	2	*
Exchangeable Calcium	meq/100g	10.16	*H*	9.16	*M*	11.88	*H*	10.07	*H*	6.56	*M*	7.61	*M*
Exchangeable Magnesium	meq/100g	4.94	*H*	3.53	*H*	7.21	*H*	3.86	*H*	1.73	*M*	2.98	*M*
Exchangeable Potassium	meq/100g	0.36	*M*	0.32	*M*	0.39	*M*	0.45	*M*	0.37	*M*	0.29	*L*
Exchangeable Sodium	meq/100g	2.21	*VH*	0.42	*M*	2.82	*VH*	0.88	*H*	0.44	*M*	0.71	*H*
Exchangeable Aluminium	meq/100g	0.02	*VH*	0.02	*VH*	0.02	*VH*	0.02	*VH*	0.02	*VH*	0.02	*VH*
Calcium/Magnesium Ratio	-	2.1	*Low Ca*	2.6	*Low Ca*	1.6	*Low Ca*	2.6	*Low Ca*	3.8	*Low Ca*	2.6	*Low Ca*
Emerson Aggregate	Class	4	*Slaking*	4	*Slaking*	4	*Slaking*	4	*Slaking*	4	*Slaking*	4	*Slaking*

	Highly acidic		Extremely alkaline		High salinity		Sodic		Strongly sodic

Table B6: Laboratory analysis data for gravelly clay topsoils. Part 3 of 3.

Table B6. Laboratory Results Gravelly clays																
	Lab No	230959-304		**Mean**		**LCL**	**UCL**	**Std Dev**	**Count**	**CI 95%**	**10%ile**		**90%ile**		**Min**	**Max**
	Sample ID	259				**95%**	**95%**			**(+/-)**						
	Sample Depth	Composite														
	Field Texture	LMC														
Analyses	**Unit**	-														
pH - Water	pH units	8.97	*H.Alk*	*8.6*	*H.Alk*	*8.4*	*8.8*	*0.3*	*13*	*0.2*	*8.1*	*M.Alk*	*9.0*	*H.Alk*	*8.0*	*9.0*
Electrical Conductivity	dS/m	1.01	*VH.Sal*	*0.4*	*M.Sal*	*0.30*	*0.56*	*0.2*	*13*	*0.13*	*0.2*	*M.Sal*	*0.7*	*H.Sal*	*0.2*	*1.0*
Chloride	mg/kg	1190.0	*H.Sal*	*345.8*	*M.Sal*	*168*	*524*	*327.8*	*13*	*178*	*58.0*	*VL.Sal*	*642.6*	*H.Sal*	*23.1*	*1190.0*
Total Nitrogen - Kjeldahl	mg/kg	683.0	*L*	*1207.4*	*L*	*1079*	*1336*	*237.0*	*13*	*129*	*844.4*	*L*	*1420.0*	*L*	*683.0*	*1480.0*
Total Phosphorus - Nitric/Perchloric	mg/kg	216.0	*	*311.5*	*	*253*	*370*	*107.4*	*13*	*58*	*197.4*	*	*452.6*	*	*147.0*	*488.0*
Phosphorus - Colwell extr	mg/kg	<5.00	*L*	*18.9*	*	*9*	*29*	*15.6*	*10*	*10*	*9.0*	*	*33.4*	*	*6.0*	*56.3*
Potassium - Colwell ext	mg/kg	147.00	*L*	*157.9*	*	*131*	*185*	*49.6*	*13*	*27*	*126.0*	*	*180.2*	*	*95.3*	*304.0*
Sulphur - KCl	mg/kg	30.3	*VH*	*46.8*	*VH*	*22.48*	*71.08*	*44.7*	*13*	*24.30*	*10.0*	*M*	*115.9*	*VH*	*8.9*	*130.0*
Organic Carbon	%	0.29	*EL*	*1.3*	*M*	*1.04*	*1.52*	*0.4*	*13*	*0.24*	*0.9*	*L*	*1.6*	*M*	*0.3*	*2.2*
Copper	mg/kg	0.78	*M*	*0.9*	*M*	*0.79*	*1.02*	*0.2*	*13*	*0.12*	*0.7*	*M*	*1.0*	*M*	*0.7*	*1.5*
Iron	mg/kg	2.60	*	*8.0*	*	*5*	*11*	*5.7*	*13*	*3*	*3.6*	*	*16.1*	*	*2.6*	*22.1*
Manganese	mg/kg	10.40	*M*	*6.4*	*M*	*5.22*	*7.54*	*2.1*	*13*	*1.16*	*4.1*	*M*	*9.8*	*M*	*3.8*	*10.5*
Zinc	mg/kg	1.94	*M*	*0.9*	*M*	*0.48*	*1.26*	*0.7*	*13*	*0.39*	*0.3*	*VL*	*1.9*	*M*	*0.2*	*1.9*
Boron	mg/kg	1.42	*M*	*1.7*	*M*	*1.35*	*2.05*	*0.6*	*13*	*0.35*	*1.0*	*L*	*2.3*	*H*	*0.8*	*3.1*
Cation Extraction Method	Rayment& Lyons	15C1	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Cation Exchange Capacity	meq/100g	16.9	*M*	*19.0*	*M*	*14.9*	*23.1*	*7.5*	*13*	*4.1*	*12.0*	*L*	*28.2*	*H*	*9.1*	*34.7*
Ex Calcium Percent	%	40.57	*L*	*61.0*	*L*	*55.8*	*66.2*	*9.6*	*13*	*5.2*	*47.0*	*L*	*69.6*	*Normal*	*40.6*	*72.0*
Ex Magnesium Percent	%	35.76	*H*	*27.2*	*H*	*24.5*	*30.0*	*5.1*	*13*	*2.8*	*20.8*	*H*	*34.8*	*H*	*18.9*	*35.8*
Ex Potassium Percent	%	2.25	*Normal*	*2.1*	*Normal*	*1.6*	*2.6*	*0.8*	*13*	*0.5*	*1.3*	*Normal*	*3.0*	*Normal*	*1.0*	*4.0*
Ex Sodium Percent	%	21.29	*H.Sodic*	*9.5*	*Sodic*	*6.6*	*12.4*	*5.4*	*13*	*2.9*	*4.5*	*N.Sodic*	*16.6*	*H.Sodic*	*3.1*	*21.3*
Ex Aluminium Percent	%	0.13	*VL*	*0.1*	*VL*	*0.1*	*0.2*	*0.1*	*13*	*0.0*	*0.1*	*VL*	*0.2*	*VL*	*0.1*	*0.2*
Exchangeable Calcium	mg/kg	1369	*H*	*2330.5*	*H*	*1742.9*	*2918.0*	*1080.8*	*13*	*587.5*	*1323.4*	*H*	*3849.2*	*H*	*1275.0*	*4748.0*
Exchangeable Magnesium	mg/kg	724	*H*	*615.9*	*H*	*492.5*	*739.4*	*227.1*	*13*	*123.5*	*371.2*	*H*	*860.2*	*H*	*207.0*	*965.0*
Exchangeable Potassium	mg/kg	148	*H*	*138.5*	*H*	*124.5*	*152.6*	*25.9*	*13*	*14.1*	*116.8*	*H*	*161.4*	*H*	*72.1*	*177.0*
Exchangeable Sodium	mg/kg	826	*FALSE*	*424.4*	*H.Sodic*	*290.7*	*558.1*	*246.0*	*13*	*133.7*	*110.0*	*H.Sodic*	*635.0*	*H.Sodic*	*97.3*	*826.0*
Exchangeable Aluminium	mg/kg	2	*	*2.0*	*	*#NUM!*	*#NUM!*	*0.0*	*13*	*#NUM!*	*2.0*	*	*2.0*	*	*2.0*	*2.0*
Exchangeable Calcium	meq/100g	6.85	*M*	*11.7*	*H*	*8.7*	*14.6*	*5.4*	*13*	*2.9*	*6.6*	*M*	*19.2*	*H*	*6.4*	*23.7*
Exchangeable Magnesium	meq/100g	6.03	*H*	*5.1*	*H*	*4.1*	*6.2*	*1.9*	*13*	*1.0*	*3.1*	*H*	*7.2*	*H*	*1.7*	*8.0*
Exchangeable Potassium	meq/100g	0.38	*M*	*0.4*	*M*	*0.3*	*0.4*	*0.1*	*13*	*0.0*	*0.3*	*L*	*0.4*	*M*	*0.2*	*0.5*
Exchangeable Sodium	meq/100g	3.59	*VH*	*1.8*	*H*	*1.3*	*2.4*	*1.1*	*13*	*0.6*	*0.5*	*M*	*2.8*	*VH*	*0.4*	*3.6*
Exchangeable Aluminium	meq/100g	0.02	*VH*	*0.0*	*VH*	*0.0*	*0.0*	*0.0*	*13*	*0.0*	*0.0*	*VH*	*0.0*	*VH*	*0.0*	*0.0*
Calcium/Magnesium Ratio	-	1.1	*Low Ca*	*2.4*	*Low Ca*	*2.0*	*2.8*	*0.8*	*13*	*0.4*	*1.4*	*Low Ca*	*3.4*	*Low Ca*	*1.1*	*3.8*
Emerson Aggregate	Class	4	*Slaking*	*4.1*	*	*	*	*	*	*	*	*	*	*	*	*

	Highly acidic		Extremely alkaline		High salinity		Sodic		Strongly sodic

Whitehaven

Appendix 4.4 – Community Consultation Plan and Register

Blackwater Mine

Progressive Rehabilitation and Closure Plan

Community Consultation Plan

July 2024

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Terms and abbreviations

Term/Abbreviation	Definition
BMA	BHP Billiton Mitsubishi Alliance
BWM	Blackwater Mine
CCP	Community Consultation Plan
CHMP	Cultural Heritage Management Plan
CHPP	Coal Handling and Processing Plant
CHRC	Central Highlands Regional Council
CHDC	Central Highlands Development Corporation
DDG	Deputy Director-General
DES	Department of Environment and Science, renamed as DESI (See below) in 2024 (Queensland)
DESI	Department of Environment Science and Innovation (Queensland) (DESI is the Queensland Authority responsible for assessing and approving PRC plans and schedules).
DoR	Department of Resources (Queensland)
DTMR	Department of Main Roads (Queensland)
EA	Environmental Authority
EIS	Environmental Impact Statement – primary approval document for major projects under the State Development and Public Organisations Act 1971 and EP Act
EP Act	Environmental Protection Act 1994 (Queensland)
GM	General Manager
ILUA	Indigenous Land Use Agreement
LGA	Local Government Area
LOA	Life-of-Asset
LOD	Land outcomes document
MERCP Act	Mineral and Energy Resources (Common Provisions) Act 2014 (Queensland)
MERFP Act	Mineral and Energy Resources (Financial Provisioning) Act 2018 (Queensland)
ML	Mining Lease
NUMA	Non-use management area – 'means an area of land the subject of a PRC plan that can not be rehabilitated to a stable condition after all relevant activities for the PRC plan carried out on the land have ended' (EP Act, Section 112)
PMLU	Post-mining land use – 'for land the subject of a PRC plan, means the purpose for which the land will be used after all relevant activities for the PRC plan carried out on the land have ended' (EP Act, Section 112)
PRC plan	Progressive Rehabilitation and Closure Plan
QR	Queensland Rail
TLO	Train load-out
WHC	Whitehaven Coal

1 Introduction

This document presents the Community Consultation Plan (CCP) to be delivered as part of the Blackwater Mine (BWM) Progressive Rehabilitation and Closure Plan (PRC plan). It includes:

- consultation requirements as part of PRC planning;
- the objectives and desired outcomes for community consultation in PRC planning for BWM;
- the consultation process and program, including proposed frequency of consultation;
- information to be released for community consultation; and
- how community feedback will be considered in PRC plan updates.

2 Community consultation requirements

2.1 BWM context

BWM is an open cut coking coal mine located approximately 4.5 km southwest of Blackwater in the Central Highlands Regional Council (CHRC) local government area (LGA). BWM commenced operations in 1967.

Mining activities occur across 21 mining leases (MLs), operating under Environmental Authority (EA) EPML00717813.

Whitehaven Blackwater acquired Blackwater Mine from BHP Mitsubishi Alliance (BMA) in April 2024 and is the holder of the resource authorities. Whitehaven Blackwater Pty. Ltd. (Whitehaven Blackwater) is a subsidiary of Whitehaven Coal (WHC).

Mining activities at BWM utilise draglines and supporting pre-strip and coal mining fleets to produce approximately 16 million tonnes per annuum (Mtpa) of product coal. Mining involves the removal and stockpiling of topsoil, drilling and blasting of overburden and interburden, mining of overburden and interburden by truck and shovel fleets, and mining of the coal by truck and shovel fleets.

A Coal Handling and Preparation Plant (CHPP), Thermal Coal Plant (TCP), train load-out (TLO) facilities, Mine Infrastructure Area (MIA) and other mine infrastructure service the existing mining operations.

Currently approved areas are planned to be mined for several decades. Disturbed land will be progressively rehabilitated as it becomes available. The timing of decommissioning and removal of the remaining infrastructure is after final mining.

Gaangalu Nation People have a registered Native Title application (QC2012/009) whose claim area includes BWM.

Most of the land within the EA is owned by Whitehaven Blackwater. Other owners of land within the EA area include:

- one private landowner;
- CHRC;
- QCoal Pty Ltd (land used by the Koorilgah Mine Balloon Railway);
- BMA (two properties, Terang and Aviemore); and
- owners of utilities (Sunwater, Queensland Rail [QR], Ergon Energy, and the State of Queensland with respect to microwave towers owned by Telstra).

A land ownership map is provided in Figure 2.1.

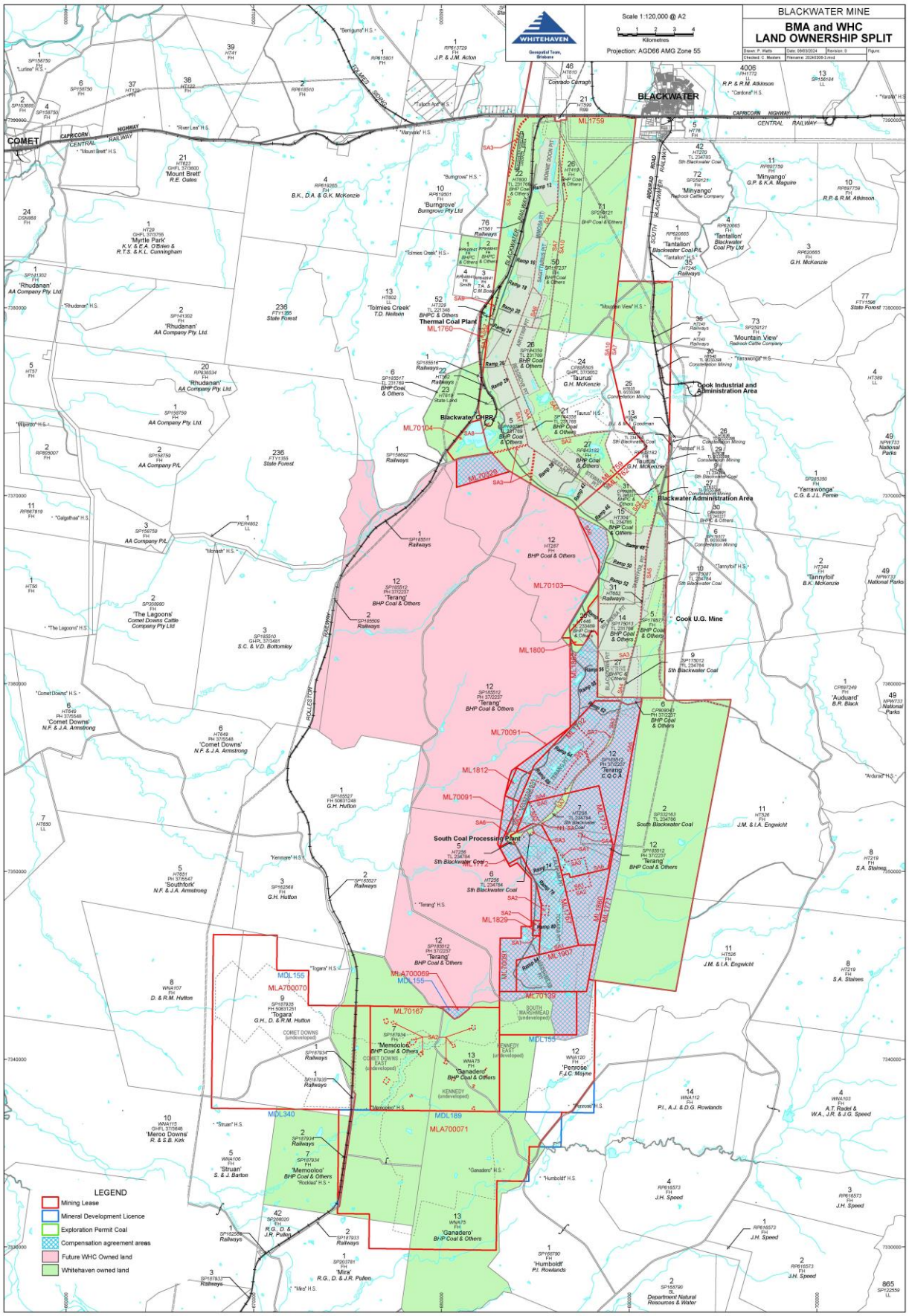

Figure 2.1: Land ownership

2.2 Regulatory requirements

2.2.1 PRC plan

BWM's PRC plan - and therefore this CCP - has been prepared under the *Mineral and Energy Resources (Financial Provisioning) Act 2018* (MERFP Act) transitional arrangements.

A PRC plan must be submitted under the MERFP Act as part of an application for an EA for a new mining activity relating to a mining lease, and when submitting an application for a Major EA amendment. The MERPF Act makes allowance for transitional provisions for existing mines, such as BWM, which includes providing a specified date by which a PRC plan must be developed and submitted to the Department of Environment Science and Innovation (DESI) for approval. The PRC plan for BWM is required for submission to DESI by 15 November 2024.

A PRC plan consists of two parts: a PRC plan and PRC plan Schedule. The PRC plan must include the information required under section 126C of the *Environmental Protection Act 1994* (EP Act) and is to provide evidence and justification to support the development of the proposed PRC plan Schedule. The PRC plan Schedule will include maps of rehabilitation and closure outcomes for the site and tables of time-based milestones. The intent of the PRC plan is to specify:

- site rehabilitation commitments, including the amount, type, location and time in which rehabilitation activities are to be completed; and
- mining activities, including duration, post-mining land uses and how rehabilitation will be carried out.

Transitional PRC plans are required to meet the legislative requirements in section 126C(1)(c) of the EP Act, including a community consultation plan, regardless of whether the site has an existing EA.

2.2.2 Consultation

EP Act section 126C(c) requires that, in addition to a proposed PRC plan Schedule and a detailed description of how and where the relevant activities are to be carried out, the PRC plan must include:

- details of the consultation undertaken by the applicant in developing the proposed PRC plan; and
- details of how the applicant will undertake ongoing consultation in relation to the rehabilitation to be carried out under the plan.

The *Guideline - Progressive rehabilitation and closure plans* (DES, 2019, last revised in April 2023) (*Guideline - PRC plans*) provides that 'community consultation is a key component of the PRC plan and is intended to ensure that anyone impacted by proposed rehabilitation and closure activities at the site has an opportunity to provide input to the planning process'. The *Guideline - PRC plans* requires that the applicant must attempt to consult all relevant members of the community, noting that 'the community may include, but are not limited to:

- affected landholders (such as underlying and adjoining land holders, and holders of land necessary for access to the land to which the proposed PRC plan relates);
- Traditional Owners;
- Local government; and
- local community groups'.

The Queensland Government's Information sheet ESR/2019/5101 Version 1: Community consultation for Progressive Rehabilitation and Closure Plan (November 2021, updated for Machinery of Government changes in February 2024) states that community members to be included in consultation must have a genuine, demonstrable and legitimate interest in:

- the land where the activity will occur;
- the land adjacent to where the activity will occur; or

- the land/amenities surrounding where the activity will occur that are likely to be impacted by the activity. (e.g. groundwater/drinking water users within the surrounding area or community located upstream or downstream of the activity).

Genuine interest may include direct impact interest (e.g. underlying and adjacent land holders), cultural interest (e.g. Traditional Owners), land use interest (e.g. overlapping tenure holders, or local government), or heritage, environmental, recreational or health interests (e.g. state or local government, or relevant community groups).

Under Section 126C(1)(d) of the EP Act, a PRC plan is required to state how the post mining land use (PMLU) is consistent with the outcomes of consultation with the community (DES, 2019). Where there are land outcomes identified in a land outcome document (LOD), the applicant must include the details of any previous community consultation undertaken (see Section 3.2.1).

2.2.3 Community Consultation Plan

To comply with section 126C(1)(c)(iii) of the EP Act, the PRC plan must include details of the consultation undertaken by the applicant in developing the proposed PRC plan. This includes previous consultation undertaken as part of existing EA approvals and/or regular engagement processes (see Section 3.2.1), and consultation undertaken as part of PRC plan development (see Section 3.2.2).

To comply with section 126C(1)(c)(iv) of the EP Act, and as described in the *Guideline - PRC plans*, the PRC plan must include a Community Consultation Plan (CCP). The CCP is required to detail how ongoing consultation will be undertaken in relation to the rehabilitation to be carried out under the PRC plan.

The CCP is required to detail how ongoing consultation will be undertaken in relation to the rehabilitation to be carried out under the PRC plan. The CCP must include details of:

- the objectives for community consultation;
- engagement type;
- proposed consultation frequency;
- what information will be released for community consultation; and
- how feedback/comments will be considered.

The *Guideline - PRC plans* notes that ongoing community consultation is expected to continue throughout the stages of the mine life so that progressive rehabilitation and the socio-economic and environmental impacts related to mine closure can be discussed with the community. Consultation is required prior to any PRC plan schedule amendments that are likely to impact the community, and the consultation register needs to be updated when this consultation is undertaken.

2.2.4 Community Consultation Register

The outcomes of consultation (how stakeholder inputs have informed the outcomes stated in the PRC plan are documented in the Community Consultation Register submitted as part of the PRC plan.

Under the Guideline - PRC plans Section 3.5, the Community Consultation Register is required to include:

- identification of community members;
- previous engagements with stakeholders;
- PRC plan development consultation:
    - description of consultation type (e.g., letter, meeting);
    - consultation date(s);
    - information provided to stakeholders;

- engagement outcomes:
    - issues raised/discussed;
    - how issues raised and the outcomes of engagement have been considered in decision making; and
    - commitments made by the Applicant.

3 Consultation on BWM's Transitional PRC plan

3.1 Stakeholder analysis

This section summarises stakeholders considered to have a genuine interest in BWM's PRC planning, who include:

- Gaangalu Nation People as the registered native title applicants and as a party to the Indigenous Land Use Agreement (ILUA);
- the private owner of freehold land within the EA area;
- landholders whose properties are within five km of the BWM EA area, including private landowners and licensees land owned by Whitehaven Blackwater Pty. Ltd;
- Blackwater residents, businesses and community organisations;
- BWM's workforce and suppliers;
- CHRC;
- Central Highlands Development Corporation (CHDC);
- BMA as the owner of properties within the EA area;
- owners and operators of utility assets within and adjacent to BWM, including Sunwater, QR, Aurizon Network, CHRC, Department of Transport and Main Roads (DTMR), Ergon Energy Ltd, Powerlink, and Telstra;
- Total Energies as the owner of a lot adjacent to the EA area that is approved for a solar farm development;
- adjacent and nearby mining tenement holders;
- gas tenement holders;
- Department of Resources (DoR) - Deputy Director-General (DDG) Georesources, Native Title and Coal Hub Director, and Executive Director, Minerals and Coal;
- DESI – Queensland Parks and Wildlife and Partnerships Regional Director, Mackay, with respect to the Blackwater Conservation Area; and
- Department of Agriculture and Fisheries (DAF) – DDG Fisheries and Forestry, with respect to the nearby Amaroo State Forest.

Table 3.1 documents the identified stakeholders and details on relationships with these stakeholders. It also provides stakeholders' potential areas of interest with respect to BWM's PRC planning. Further detail is provided in the BWM PRC plan Community Consultation Register.

Table 3.1: Stakeholders identified as having a genuine interest in BWM PRC planning

Stakeholder	Existing relationship	Potential areas of interest
Traditional Owners		
Gaangalu Nation People have a Registered NT claim (QC2012/009) and CHMP area which includes BWM.	BMA developed an ILUA with the Ghungalu People and Kangoulu People (the previous native title applicants) which is dated 31 May 2002. BMA met with the ILUA Coordinating Committee over time as required to address current and future planning issues. The commitments made as part of the ILUA continued to stand after ownership of BWM was transferred to Whitehaven Blackwater and are assigned to Whitehaven Blackwater. BMA also engaged with the Gaangalu Nation People Applicants Group to develop a consultation protocol (Ground Rules document) which commits Whitehaven Blackwater to negotiating a new partnership agreement and a Cultural Heritage Management Plan with the Gaangalu Nation People. Whitehaven Blackwater has commenced engagement with Gaangalu Nations People in accordance with the consultation protocol. Ongoing engagement will include discussion of the BWM PRC plans, including the progressive rehabilitation schedule and non-use management areas.	• ILUA commitments • PMLUs, NUMAs and landform/landscape • Future land access, land use and ownership of land within the BWM EA area • Land licences (current and future) for cattle agistment or other purposes • Environmental management/stewardship • Employment and business opportunities in rehabilitation, environmental management and monitoring • How operational management and/or rehabilitation could contribute to the future use of land disturbed by mining • Recognition and management of cultural heritage impacts • Native Title and land acquisition interests
Local government		
CHRC	BMA provided information about PRC planning to CHRC during 2023. CHRC owns land within the EA and is a party to agreements relating to roads and road reserves. Whitehaven Blackwater has commenced engagement with CHRC. In addition to updates on rehabilitation progress and management of closure impacts on local communities, PRC plan engagement with CHRC will include specific issues	• Alignment of rehabilitation plans with local and regional planning goals • Local employment • Effects on Council services and infrastructure • Local business opportunities in rehabilitation works • Environmental management /stewardship • Rehabilitation progress • Post-mining land use, forms and NUMAs

Stakeholder	Existing relationship	Potential areas of interest
	associated with Council-owned land, roads and road reserves within the EA area.	• Management of closure impacts on employment and businesses • Economic transformation (towards post-mining) and community sustainability • Potential cumulative impacts of closure of multiple mining assets in a similar timeframe e.g., job and population losses
Underlying private landowner		
One private landowner owns land within the EA area. Whitehaven Blackwater holds this land as lands lease. BMA owns two properties within the EA area.	Whitehaven Blackwater is engaging with the underlying landowner in support of a constructive working relationship. Whitehaven Blackwater has commenced engagement with the private landowner, and future engagement will include discussion of the PRC plan. This included discussion of progressive rehabilitation timeframes and non-use management areas i.e. residual voids. Whitehaven Blackwater and BMA have engaged regarding the future use and management of land that BMA has retained within the EA area.	• Environmental management and stewardship • PMLUs, NUMAs and landform/land scape • PRC plan schedule • Future access to and ownership of land • Water usage, quality and access to groundwater and surface water (e.g. water allocations, water pipelines, etc.) • Potential impacts on land, property and future business value relating to PMLUs, NUMAs and timing of impacts
Adjacent and nearby landholders		
Licensees of land within BWM EA area	Whitehaven Blackwater is commencing a process of engagement with licensees regarding licence terms and conditions, and will meet with them as and when required. All current licences for Whitehaven-owned land will be transitioned i.e., continued when their current terms are complete.	• Environmental management /stewardship • PMLUs, NUMAs and landform/landscape • PRC plan schedule • Future access to and ownership of land • Water usage, quality and access to groundwater and surface water (e.g. water allocations, water pipelines, etc.) • Future use of lease and licence areas
Private landowners within 5 km of EA area, including owners of properties in Blackwater, and owners of nearby homesteads, grazing and dryland cropping properties, and smaller rural lots.	Whitehaven Blackwater is commencing engagement with nearby landowners via letters and meetings, and will continue to engage with landowners via letters, meetings, emails and letter box drops, on an as-needed basis.	

Stakeholder	Existing relationship	Potential areas of interest
Blackwater residents, businesses and community groups		
• Homeowners and tenants • Businesses • Community groups	Whitehaven Blackwater has commenced engagement with the Blackwater and Central Highlands communities via media releases, newspapers advertisements, and social media. Whitehaven Blackwater will engage with Blackwater residents, businesses and community groups to develop a mutually supportive relationship. Engagement activities with community members will include community events and forums, and ongoing engagement processes such as partnerships with community organisations and industry bodies. BWM personnel and their families are an important part of the Blackwater community. Engagement with personnel is via toolbox talks and the Blackwater Mine site newsletter.	• Timing of closure • Rehabilitation obligations and progress • Environmental management /stewardship • Employment continuity • Post-mining landforms, and NUMAs • Management of closure impacts on employment and businesses • Economic and community sustainability • Local employment and business opportunities in rehabilitation works

CHDC	CHDC is the lead economic and business development agency for the Central Highlands LGA. CHDC's key interests include driving investment, attracting businesses and the sustainability of farms, agribusiness and tourism.
	
	Whitehaven Blackwater has commenced engagement with CHDC. Whitehaven Blackwater will engage with CHDC to develop a constructive relationship that enables meaningful engagement with CHDC to inform PRC planning over the longer term.
		• As above, with a particular focus on:
		  ▪ community and economic sustainability/transition
		  ▪ business and economic development opportunities

BWM operations		
BWM workforce	Whitehaven Blackwater maintains ongoing communication with its workforce through 'toolbox' talks and a Blackwater Mine site newsletter.	• Timing of closure • Rehabilitation obligations • Employment continuity • Management of closure impacts on employment and businesses • Economic and community sustainability • Local employment and business opportunities in rehabilitation works

Stakeholder	Existing relationship	Potential areas of interest
BWM suppliers	Whitehaven Blackwater's procurement team will implement communication and consultation strategies that will build relationships with BWM suppliers.	• Opportunities to participate in supply chain • Economic transformation (towards post-mining) • Economic and community sustainability • Loss of supply opportunities with closure
Utility owners		
Utility owners and easement holders with assets within the EA area • QR • Aurizon • DTMR • CHRC • DoR • Ergon Energy Corporation Ltd • Powerlink • Sunwater • Telstra Amplitel • Telstra Vocus Adjacent land approved for solar farm • Total Energies	Whitehaven Blackwater is developing working relationships with utility owners and easement holders and will continue issue-specific and transactional engagement with them. QR owns land on which Laleham Branch Railway and Kinrola Branch Railway are located, and holds easements within the EA accommodating railways, rail loops and sidings. Aurizon Network operates the rail infrastructure. DTMR owns and manages the Capricorn Highway and Ardurad (Blackwater -Rolleston) Road. Engagement with DTMR will be on an as-needed basis with respect to road interface and usage arrangements. DoR is the administrative authority for a stock route within the EA area. Ergon Energy Corporation Ltd owns land within the EA area and holds easements within EA for the purpose of power transmission infrastructure. Powerlink also holds an easement for power supply. Sunwater is a landowner and easement holder within the EA area, and owns and operates the Blackwater Water Pipeline. Telstra Amplitel and Telstra Vocus own and operate telecommunications infrastructure, on land owned by State of Queensland. Total Energies hold a development approval on land that is adjacent to the EA area, for the development and operation of a solar farm. The solar farm is yet to be developed.	• Impact on assets/asset value • Remediation of impacts on assets • Any service disruptions and mitigations • Crossing/interface agreements • Timeframe for decommissioning utilities that only service BWM (e.g. rail loop, electricity transmission, etc.) • Cost of decommissioning utilities
Adjoining/nearby resource interests		

Stakeholder	Existing relationship	Potential areas of interest
Nearby mining interests: • Curragh Mine to the north of Capricorn Highway (Coronado Curragh Pty Ltd) • Cook's Colliery to the east (QCoal) • Blackwater South Project to the south (Whitehaven Blackwater) Adjacent and nearby ATPs and PCA: • Bow CSG Pty Ltd • Bronco Energy Pty. Ltd. • Santos QNT Pty. Ltd • Comet Ridge Mahalo North Pty Ltd • Comet Ridge Mahalo Far East Pty Ltd • Comet Ridge Mahalo East Pty Ltd	Whitehaven Blackwater liaises with adjoining and nearby mining and resource interests on an as-needed basis. Cook's Colliery has an agreement with Whitehaven Blackwater to use BWM MLs to access their mine and owns land within the BWM EA area. Whitehaven Blackwater has a good neighbour agreement with Coronado Curragh Pty Ltd with respect to Curragh Mine, including the accommodation of the East Bedford water pipeline. Whitehaven Blackwater engages with nearby petroleum resource holders in accordance with *Mineral and Energy Resources (Common Provisions) Act 2014* (Queensland) (MERCPA) requirements for petroleum overlap activities.	• Future land use and ownership • Collaboration on good industry rehabilitation and closure practices • Cumulative impacts and opportunities of mine closures
Queensland Government		
Queensland government departments: • DoR - Deputy Director-General (DDG), Georesources • DAF – DDG, Fisheries and Forestry • DESI - MERPF Act team • DESI – Queensland Parks and Wildlife and Partnerships	Amaroo State Forest is in close proximity to BWM, which may be of interest to DAF. Blackwater Conservation Park is located to the near north of BWM, which may be of interest to Queensland Parks and Wildlife and Partnerships. DoR's Deputy Director-General Georesources has asked to be kept informed on PRC planning.	• Legislative compliance • Environmental risk management • Resource development • Employment opportunities • Public interest • Environmental management • Economic transformation (towards post-mining) • Financial assurance

Stakeholder	Existing relationship	Potential areas of interest
• Office of the Minister for Regional Development and Manufacturing and Minister for Water		• Future land use and landform • Company responses to stakeholder views
Offices of the Ministers: • Resources and Critical Minerals • Environment and the Great Barrier Reef, Science, and Innovation • Energy, and Clean Economy Jobs • Agricultural Industry Development and Fisheries and Minister for Rural Communities • Regional Development and Manufacturing, and Water Members of Parliament • Member for Gregory • Member for Burdekin and Shadow Minister for Natural Resources and Mines • Shadow Minister for Natural Resources and Mines • Shadow Minister for Environment and the Great Barrier Reef and Shadow Minister for Science and Innovation	Whitehaven Blackwater (or Whitehaven Coal) has conducted engagement with Ministers and Members of Parliament. Employment growth, sustainable communities and economic transitions are key priorities for Government stakeholders.	

3.2 PRC plan consultation

3.2.1 Pre-PRC plan development

BWM commenced operations in 1967. An EIS was not required to support provision of an EA for BWM at the time, and there was no requirement for consultation on rehabilitation.

The following rehabilitation and closure-related engagement took place for BWM prior to development of the transitional PRC plan:

- During 2018, BMA engaged with DES (as then known) to implement the current EA conditions in relation to post mining land uses and the required acceptance criteria for those PLMUs, which were included in the EA, reflected as Table E1: Rehabilitation Requirements;
- During 2020 – 2022, ongoing engagement with DESI in relation to how the PRCP Guideline elements (particularly regarding transitional arrangements) and the current EA conditions related to rehabilitation and closure would transition to BMA's PRC plans;
- During 2023, high level information about the BWM PRC plan process was provided by BMA to CHRC and CDHC; and
- On an ongoing basis, BMA engaged with nearby landholders on land management and lease/license conditions, and on operational, environmental management and/or water matters, as required.

3.2.2 PRC plan development

February-March 2024

Community consultation as part of initial PRC plan development by BMA commenced on 16 February, with stakeholder invited to contact the BMA team by 8 March 2024. Consultation included letters sent via post, email and a letter drop to all premises in the Blackwater postal area, with stakeholders including:

- Gaangalu Nation People Applicants Group as the registered native title applicants and as a party to the Indigenous Land Use Agreement (ILUA);
- the owner of underlying freehold land within the BWM EA area;
- landholders whose properties are within five km of the BWM EA area, including private landowners and licensees of BMA land;
- Blackwater residents, businesses and community organisations;
- owners of utility assets within and adjacent to BWM (Aurizon, QR, CHRC, Ergon Energy Ltd, Powerlink, Telstra and Sunwater);
- the owner of an adjacent approved but not yet built solar farm (Total Energies);
- CHRC;
- CHDC;
- owners of adjacent and nearby mining tenement holders;
- adjacent petroleum/gas tenement holders;
- DoR - Deputy Director-General (DDG) Georesources, Native Title and Coal Hub Director and Executive Director, Minerals and Coal;
- DAF – DDG Fisheries and Forestry, in respect to the nearby Amaroo State Forest; and
- DESI – Regional Director, Mackay, Queensland Parks and Wildlife and Partnerships, in respect to the Blackwater Conservation Area.

The following information was provided in letters to stakeholders:

- BWM's location and approved activities;
- Queensland Government requirements for mine rehabilitation and closure planning;
- the scope and purpose of the PRC plan;
- BMA's commitment to progressive rehabilitation;
- rehabilitation objective for BWM;
- EP Act requirements for rehabilitation;
- PRC plan requirements;
- progressive rehabilitation, with disturbed areas rehabilitated as soon as practical;
- approved post mining land use options;
- inclusion of residual voids as non-use management areas;
- timeframe for BMA's divestment of BWM;
- transfer of mine operations and rehabilitation to BWM's new Owner; and
- responsibility for future engagement on PRC plan.

The letter included an invitation to engage in further discussions about the PRC plan. There were no enquiries or feedback from stakeholders in response to the letter.

In addition to the letter box drop to Blackwater residents, businesses and community groups, BMA distributed information about the BWM PRC plan to BWM's workforce, Blackwater community members and BWM suppliers via:

- Coal Connect (an online weekly newsletter to all internal coal personnel);
- Community Connect (a bi-monthly newsletter distributed to more than 15,000 community members throughout the Bowen Basin); and
- BWM's site newsletter.

This information included:

- progressive rehabilitation as a key focus;
- PRC Plan requirements and purpose;
- timing for BWM PRC Plan development;
- commitment to ongoing engagement; and
- contact details for further information or queries.

There were no enquiries or feedback in response to communication via Coal Connect, Community Connect and the BWM site newsletter.

BMA met with the Gaangalu Nation People Applicants Group on 14 March 2024 to discuss the PRC plan, among other issues related to BWM. Issues raised included the timing for BWM's closure, reasons for doing PRC planning now, the timing for BWM's divestment to Whitehaven Blackwater, and the progress of consultation protocol. BMA provided information to Gaangalu Nation People about PRC plan requirements, BWM's closure timeframe, the timing for divestment, and progress with the consultation protocol.

The methods and outcomes of engagement are shown in the Community Consultation Register submitted as part of the PRC plan.

April-July 2024

Whitehaven Blackwater Pty. Ltd. has commenced engagement with Gaangalu Nation People according to the consultation protocol developed with them during 2023-2024. Future meetings with Gaangalu Nation People will include discussion about the BWM PRC plan.

Whitehaven Blackwater Pty. Ltd. has also commenced engagement with CHRC and CHDC. Future meetings with CHRC and CHDC will also include discussion about the BWM PRC plan.

Future engagement with stakeholders including the underlying landowner, nearby landowners and Blackwater community members via meetings, community forums and mail-outs to Blackwater residents, businesses owners and community organisations.

4 Future, ongoing PRC plan-related community consultation

Once the BWM transitional PRC plan has been approved, consultation as part of implementing the BWM PRC plan will be informed by the program documented in Table 4.1, which includes:

- consultation objectives;
- community members addressed by each objective;
- engagement type; and
- proposed frequency of consultation.

Whitehaven Blackwater will monitor progress against these objectives as part of its regular reviews of consultation commitments and outcomes.

Section 5 describes the information to be released to the community, and Section 6 describes how feedback or comments will be considered.

Table 4.1: Consultation program for PRC plan implementation

Consultation objective	**1. To engage stakeholders with a genuine interest in developing objectives and aspirations for post-mining land use and landform, and social value opportunities to be considered in PRC planning**	
Stakeholders	**Engagement type**	**Proposed consultation frequency**
Gaangalu Nation People	Meet with the Gaangalu Nation People Applicants' Group to provide an update on the PRC plan and progress with rehabilitation, and invite inputs and feedback on: • PMLUs, NUMAs and post-mining landforms, including any particular values or opportunities in specific disturbed areas • rehabilitation methods which would optimise future woodland habitat and/or grazing opportunities, and potential land management requirements • access to land within the EA area as provided in the ILUA and as agreed with the Coordinating Committee • rehabilitation methods, schedule and progress towards milestones • involvement of businesses owned by Gaangalu Nation People in rehabilitation works • the pipeline of opportunities relating to rehabilitation work and land management • the need for an Indigenous business capability development program to match rehabilitation opportunities, if this is required	As part of regular updates to a schedule agreed with the Applicants Group as relevant, and as required to address consultation requirements for amendment of the BWM PRC plan
Private owner of freehold land within BWM EA area	Advise the landowner in writing when the PRC plan is approved, including how to access the PRC plan.	Once-off
	Meet with the landowner to discuss any proposed changes to the PRC plan (as and when amended) that affect the landowners' interests in freehold land within the EA, and/or other areas within the EA area that are of interest to the landowner, e.g. • PMLUs, NUMAs and post-mining landforms, including any particular values or opportunities in specific disturbed areas • land that may be available for grazing or other purposes after rehabilitation • access to water resources • rehabilitation methods which would optimise future woodland habitat and/or grazing opportunities, and potential land management requirements • shared value initiatives, e.g., infrastructure retention, capacity building, environmental management, or research • rehabilitation methods, schedule and progress towards milestones.	As required to address PRC plan consultation requirements for amendment of the BWM PRC plan
	Correspond and meet with the landowner commencing five years prior to the forecast cessation of mining and as agreed with the landowner, to discuss: rehabilitation objectives and timeframes, PMLUs and NUMAs, land access and tenure arrangements, and other land use/management/rehabilitation issues as relevant to the private freehold land.	Five years prior to the forecast cessation of mining, and as agreed during pre-closure period

Consultation objective	**1. To engage stakeholders with a genuine interest in developing objectives and aspirations for post-mining land use and landform, and social value opportunities to be considered in PRC planning**	
Stakeholders	**Engagement type**	**Proposed consultation frequency**
	Correspond with the landowner to initiate the legal/statutory and consultation processes required to enable relinquishment of rights and interest in the freehold land within the EA area.	One year prior to the forecast cessation of mining
BMA as owner of properties within the EA area	Whitehaven Blackwater will engage with BMA regarding any relevant progressive rehabilitation and closure activities that may affect BMA-owned land, in accordance with its agreements with BMA.	As required to address PRC plan consultation requirements for amendment of the BWM PRC plan, and one year prior to the forecast cessation of mining
BMA	Engage with BMA regarding any planned rehabilitation and/or closure activities that would impact on BMA-owned properties or affect BMA's interests in properties within the EA area, via letter and/or meetings as agreed.	Six months prior to commencing activities that would impact BMA-owned properties
Nearby landowners (within 5 km of EA area), and licensees of land within or adjacent to the EA area	Advise adjacent and nearby landholders, including licensees, in writing when the PRC plan is approved, including how to access the PRC plan.	Once-off
	Advise in writing, and meet if requested, regarding any proposed changes to the BWM PRC plan (as and when amended) that have potential to affect landowners or licensees' interests in freehold land within or adjacent to the EA area.	As required to address PRC plan consultation requirements for amendment of the BWM PRC plan
	Communicate with licensees of land that is within or adjacent to the EA area during the terms of their licence, and seek their inputs on BWM's PRC plan schedule, PMLUs and NUMAs during PRC plan revisions and amendments.	As required to address PRC plan consultation requirements for amendment of the BWM PRC plan
	Correspond and if requested meet with adjacent landholders to the EA area (land owners and licensees of land owned by BWM's owner) during the pre-closure, closure/decommissioning and rehabilitation periods, to reduce the potential for works to impact on their amenity, land use, property access or access to water.	Five years prior to the forecast cessation of mining, at least annually, or as agreed with the landowner
BWM personnel	Keep the BWM workforce updated via internal newsletters/emails or toolbox talks if there are substantive changes to the PRC plan, e.g., significant changes in rehabilitation milestones or plans for the cessation of mining at BWM, and including a communication channel for personnel to ask questions or contribute to discussions about PRC planning and rehabilitation.	Ongoing engagement process
	Commencing five years prior to the forecast cessation of mining, provide regular updates to BWM personnel on the implementation of the PRC plan, and seek personnel's feedback on rehabilitation progress.	Five years prior to the forecast cessation of mining, at least annually
CHRC and CHDC	Provide information about BWM rehabilitation methods, the rehabilitation schedule and progress towards PRC plan milestones as part of regular meetings with CHRC and CHDC	Annually or as agreed with CHRC and CHDC

Consultation objective	**1. To engage stakeholders with a genuine interest in developing objectives and aspirations for post-mining land use and landform, and social value opportunities to be considered in PRC planning**	
Stakeholders	**Engagement type**	**Proposed consultation frequency**
	Meet with CHRC and CHDC as part of consultation on proposed amendments to the PRC plan, to invite their inputs and feedback on: • PMLUs, NUMAs and post-mining landforms • rehabilitation methods, schedule and progress towards milestones • impacts and opportunities pertaining to CHRC assets within the EA area • CHRC's strategic analysis and planning for the Central Highlands LGA and the BWM mining area • challenges, opportunities and community aspirations of relevance to mine closure and rehabilitation • CHRC and CHDC's intended economic and social transition approaches • shared value initiatives, e.g. infrastructure retention, capacity building, environmental management or research.	As required to address consultation requirements for amendment of the BWM PRC plan
	Prior to closure, and in addition to other matters as discussed as part of regular updates or PRC plan amendment-related consultation with CHRC, engage with CHRC to seek their inputs on: • any impacts of BWM closure and/or rehabilitation works on Council assets or services • any impacts of BWM closure and/or rehabilitation works on community amenity • rehabilitation methods and potential land/water management requirements.	Five years prior to the forecast cessation of mining, and thereafter as agreed with CHRC
Blackwater landowners, community members, business owners and community groups	Via workshops or focus groups, seek the involvement of community members, businesses and community groups in articulating community aspirations for rehabilitation, PMLUs and economic transformation opportunities related to PMLUs or NUMAs, including identifying local capacity for involvement in rehabilitation work.	As part of consultation for amendment of the BWM PRC plan
	Provide community updates on BWM's PRC plan if there are any substantive changes and associated PRC plan amendments required, via mail-out letters to Blackwater residents, landowners in the Blackwater area (within five km of BWM), and businesses and community groups located in Blackwater.	As required to address consultation requirements for amendment of the BWM PRC plan
Department of Agriculture and Fishing - Forestry	Provide written updates on PRC plan implementation and proposed amendments to the DDG, Fisheries and Forestry, inviting feedback on any considerations with regard to the Amaroo State Forest.	As part of consultation for amendments of the BWM PRC plan
DESI - Director, Queensland Parks and Wildlife and Partnerships	Provide written updates on PRC plan implementation and proposed amendments to DESI – Regional Director Mackay, Queensland Parks and Wildlife and Partnerships, inviting feedback on any considerations with regard to the Blackwater Conservation Area (National Park).	As part of consultation for amendments of the BWM PRC plan

Consultation objective:	**2. To support transparent access to information about BWM's PRC planning and implementation, enabling opportunities for the Blackwater community, BWM suppliers and government agencies and representatives to provide inputs and feedback on rehabilitation and closure outcomes**	
Stakeholders	**Engagement type**	**Proposed consultation frequency**
Blackwater landowners, community members, business owners, community groups	Using community forums such as interagency meetings, community meetings, supplier networks, partnership meetings and business network meetings, provide regular community updates on BWM PRC planning and implementation.	Ongoing engagement process
	Invite community members, business owners and community groups to provide input to planning for closure and rehabilitation, including PMLUs and management of closure impacts, via a workshop, community forum or other means.	Three years prior to the forecast cessation of mining
Local businesses and suppliers	Provide regular updates about business supply opportunities resulting from progressive rehabilitation work packages.	As relevant to the letting of rehabilitation work packages
	Participate in initiatives led by CHRC, industry or local communities which aim to harness social value from mine closure and rehabilitation planning, and/or work towards from economic transformation.	As requested
	Provide information about the pending closure of BWM and potential future supply opportunities as part of closure and rehabilitation to local businesses, Traditional Owner businesses and BWM suppliers.	Three years prior to decommissioning, subsequent consultation to be agreed
Elected representatives and Queensland Government agencies	Provide updates via letters and/or meetings on PRC planning to: • DESI PRC plan team • DESI – Regional Director, Mackay, Queensland Parks and Wildlife and Partnerships • DoR – DDG, Georesources • DoR - Director, Native Title Services and Coal Hub • DoR – Executive Director, Minerals and Coal • DAF - DDG, Fisheries and Forestry • Office of the Minister, Resources and Critical Minerals • Office of the Minister, Environment and the Great Barrier Reef, Science, and Innovation • Office of the Minister, Energy, and Clean Economy Jobs • Office of the Minister, Agricultural Industry Development and Fisheries and Minister for Rural Communities • Office of the Minister, Regional Development and Manufacturing, and Water • Member for Burdekin and Shadow Minister for Natural Resources and Mines • Shadow Minister for Environment and the Great Barrier Reef, and Shadow Minister for Science and Innovation • Member for Gregory	As requested, or as agreed with government representatives

Consultation objective	**3. To engage with utility owners and operators, and adjacent mining and energy tenement holders, to provide information about BWM's closure planning that supports them to manage their assets and interests**	
Stakeholders	**Engagement type**	**Proposed consultation frequency**
BWM GM	Involve internal BWM stakeholders in PRC plan processes to build capacity for community consultation on PRC plan issues and support effective delivery of PRC plans.	Ongoing
QR and Aurizon Network	Maintain correspondence with QR and Aurizon Network regarding progressive rehabilitation activities as they affect rail assets or operation, and undertake consultation regarding the decommissioning of the rail interface	As requested, or as agreed with representatives
Utility owners and operators: • QR • Aurizon • DTMR • CHRC • DoR • Ergon Energy • Powerlink • Sunwater • Telstra Amplitel • Telstra Vocus	Engage with utility owners and easement holders that have interests in land or infrastructure within the EA area to: • inform them of closure timelines and rehabilitation activities relevant to land or infrastructure in which they have an interest • seek inputs about potential impacts on utility/transport assets and/or service capacity, and any specific management measures to avoid impacts on utility assets and services, and initiate or update interface agreements as required and if rehabilitation will affect utilities	Initiated three years prior to decommissioning
	• Maintain engagement regarding progressive rehabilitation and undertake consultation regarding crossing/interface agreements, as required if rehabilitation will affect utilities.	Initiated three years prior to decommissioning
Nearby mining interests: • Coronado Curragh Pty Ltd • Qcoal Pty. Ltd. • South Blackwater Coal Adjacent ATP and PCA: • Bow CSG Pty Ltd • Bronco Energy Pty. Ltd. • Santos QNT Pty. Ltd • Comet Ridge Mahalo North Pty Ltd, Comet Ridge Mahalo Far East Pty Ltd, Comet Ridge Mahalo East Pty Ltd Adjacent planned solar farm: • Total Energies	• Write to advise adjacent and nearby resource and energy interests if there are any substantive changes to the closure and rehabilitation schedule in future iterations of the BWM PRC plan.	As required to address consultation requirements for the amendment of the BWM PRC plan

5 Information to be released for community consultation

Whilst many stakeholders in the Central Highlands region are well-informed about mining operations, there is less understanding of life-of-mine, rehabilitation and closure planning. The CCP recognises the following social context:

- talk of closure planning will lead to community concerns, requiring careful and consistent communication;
- PRC plan consultations by a range of companies for a variety of assets will represent considerable cumulative demands on stakeholders, and a coordinated, strategic approach will be required to manage consultation fatigue; and
- community members are becoming increasingly aware of climate change and the impacts of resource activities and energy policies on the environment.

Accordingly, community and stakeholder expectations with regards to mine rehabilitation are expected to increase over time, and need to be continuously understood.

Information to be released for community consultation, as part of future, ongoing BWM PRC planning and implementation will include:

- the rationale and scope for PRC planning;
- the approved mining activities, PMLUs and NUMAs for BWM;
- on-site activities and areas of disturbance;
- proposed rehabilitation methods, schedule and milestones;
- progress against rehabilitation milestones;
- alignment with long-term transformation planning occurring through CHRC, CHDC and others; and
- opportunities for community consultation as part of the PRC plan's implementation.

Communication tools could include:

- a holding statement for general enquiries;
- frequently asked questions and answers (FAQs) and a PRC planning fact sheet available to support consultation activities;
- face to face and virtual meetings, forums or workshops; and
- updates and fact sheets about PRC planning for BWM.

6 How feedback/comments will be considered

As noted in the *Guideline - PRC plans*, in addition to the Annual Return requirements that relate to EAs, if a PRCP Schedule applies to the activities then the Annual Return must also include an evaluation of the effectiveness of the PRC plan schedule, including the environmental management carried out under the schedule, for the year to which the annual return relates.

Whitehaven Blackwater will internally monitor and report on the progress and outcomes of progressive rehabilitation activities against rehabilitation milestones provided in the PRC plan Schedule. This monitoring will aim to demonstrate a successful rehabilitation trajectory towards achievement of the approved PMLU, and/or to inform corrective action where required.

As required, PRCP Schedule progress will be reported as part of Annual Return submissions to the DESI.

Information about rehabilitation progress will also be delivered as part of the consultation methods detailed in Table 4.1, and feedback will be documented in PRC plan updates or amendments.

The PRC plan Community Consultation Register will be updated as community consultation activities outlined in Table 4.1 are completed. Relevant stakeholder feedback recorded in the Community Consultation Register will be considered in framing and detailing future PRC plan amendments for BWM.

This may include feedback on, for example:

- vegetation species most suitable to the approved PMLUs;
- rehabilitation methods to protect cultural heritage and achieve optimal use for the PMLUs;
- the PRC plan (rehabilitation) schedule;
- water management (e.g. availability for beneficial use as part of the PMLUs, or adjacent uses); and/or
- development of business capacity programs to equip local and Indigenous businesses for rehabilitation works.

7 PRC plan CCP review

Review of the BWM PRCP will be undertaken as legislatively required. Review and update of the CCP, incorporating community feedback to date, will be aligned to any PRC plan updates or amendments.

Blackwater Mine PRC Plan - Community Consultation Register

COMMUNITY MEMBERS AND PREVIOUS ENGAGEMENT				PRC PLAN DEVELOPMENT ENGAGEMENT			ENGAGEMENT OUTCOMES			
Stakeholder Group	**Stakeholder Title**	**Organisation**	**Previous engagement**	**Consultation type**	**Consultation date**	**Information provided**	**Issues raised/discussed**	**How issues were considered**	**Decisions/outcomes of engagement**	**Commitments**
Traditional Owners	Gaangalu Nation People (registered native title claimants)	Gaangalu Nation People Applicants Group	BMA had regular engagement with Gaangalu Nation People on a range of issues including cultural heritage and community and economic development. This included meetings and correspondence with the native title Applicants Group and meetings of the Coordinating Committee, which has been ongoing with respect to ILUA matters since 2002. BMA developed a consultation protocol with Gaangalu Nation People, which will be implemented by Whitehaven Blackwater Pty. Ltd.	Letter, via email to Applicants Group	16/02/2024 14/03/2024	PRC plan requirements and timing for BWM Commitment to progressive rehabilitation PRC purpose and scope EPA's rehabilitation requirements Post mining land use options Inclusion of residual voids to be transitioned as non-use management areas New owner's responsibility for PRC plan and consultation Invitation to discuss the PRC plan	Timing for BWM's closure, and reasons for doing PRC planning now. Timing for BWM's divestment to Whitehaven Coal. Progress of consultation protocol.	BMA provided information to Gaangalu Nation People about PRC plan requirements, BWM's closure timeframe, the timing for divestment, and progress with the consultation protocol.	Whitehaven Blackwater Pty. Ltd. will engage with Gaangalu Nation People according to the consultation protocol developed with them during 2023-2024. It is expected that Traditional Owners' interest in environmental management and mine rehabilitation will be progressed as part of ongoing engagement with them. Traditional Owners will continue to have access to land within the EA area in accordance with the terms of the registered Indigenous Land Use Agreement.	Whitehaven Blackwater Pty. Ltd. will continue to consult with the Gaangalu Nation People, and seek their inputs on rehabilitation and PMLUs as part of PRC plan implementation and any future iterations of the PRC plan. Whitehaven Blackwater Pty. Ltd. will engage with Traditional Owners and Indigenous businesses to understand business capabilities and the pipeline of opportunities that relate to rehabilitation work and land management, and seek to involve Traditional Owners' businesses in supplying progressive rehabilitation works.
				Meeting to engage with the Gaangalu Nation People on WHC's future approval plans and to provide an overview on the BWM PRCP.	22/07/2024	Information was provided on WHC's future approval plans and in regards to post-mining land uses and non-use management areas as associated with the BWM PRCP.	The Gaangalu Nation People had several questions regarding the timing of the post-mining land uses and potential opportunities for their people to be involved in future rehabilitation work.	Whitehaven Blackwater provided information to the Gaangalu Nation People in relation to the whole PRCP process and details covered by the PRCP.	Whitehaven Blackwater will continue to engage with the Gaangalu Nation People through the PRCP process with a particular focus on PMLU's and future rehabilitation work..	Whitehaven Blackwater will continue to engage with the Gaangalu Nation People through the PRCP process with a particular focus on PMLU's and future rehabilitation work..
Underlying landowners	Underlying landowner, also a licensee of Whitehaven Blackwater-owned land	Private grazing business	BMA has had a long and constructive working relationship with the owner of land which underlies ML1759 and ML1762, regarding a land lease agreement, management and use of land within the BWM EA area, and an agistment licence held by the landowner for use of BMA-owned land for grazing.	Letter, via post	16/02/2024	BWM location and approved activities Queensland Government requirements for mine rehabilitation and closure planning Scope and purpose of PRC plan Commitment to progressive rehabilitation Rehabilitation objective for BWM EP Act requirements for rehabilitation PRC plan requirements Progressive rehabilitation with disturbed areas rehabilitated as soon as practical Approved post mining land use options Inclusion of voids as non-use management areas Timeframe for BMA's divestment of BWM Transfer of mine operations and rehabilitation to new Owner Responsibility for future engagement on PRC plan Invitation to seek information or discussion	No enquiries or feedback received. Areas of interest as indicated in previous engagement include use of land within the EA area under a licence agreement, and future use of disturbed land for grazing.	The landowner's interest in use of the land for grazing was considered in framing PMLUs.	Land within the MLs will continue to be available for grazing under the licence agreement with the landowner. Landholders and cattle will be excluded from affected areas while land disturbance is occurring. As disturbed land becomes available, it will be rehabilitated to a state suitable for the approved post-mining land use (PMLU) e.g. grazing, woodland, water courses, or managed as a non-use management area (NUMA).	Whitehaven Blackwater Pty. Ltd. will continue to engage with the underlying landowner and seek their inputs on BWM's rehabilitation schedule and approved PMLUs as part of PRC plan implementation and any future amendments of the PRC plan.
	Manager, Land Approvals and Tenements	BMA	BMA retains ownership of two properties within the EA area. Whitehaven Blackwater and BMA have engaged regarding the future use and management of land that BMA has retained within the EA area.	Various meetings and correspondence	January-April 2024	Management and future use of BMA-owned land within the BWM EA area	Management and future use of BMA-owned land within the BWM EA area	BMA's intentions for BMA-owned land within the BWM EA area have been considered in the PRC plan.	Whitehaven Blackwater will engage with BMA regarding any relevant progressive rehabilitation and closure activities that may affect BMA-owned land.	Whitehaven Blackwater Pty. Ltd will engage with BMA regarding any relevant progressive rehabilitation and closure activities that may affect BMA-owned land.
Licensees of land within BWM EA area	Licensee	Private grazing business	BMA engaged with licensees regarding licence terms and conditions, and matters relating to land use management, from time to time.	Letter, via letter drop	16/02/2024	As above	No enquiries or feedback were received. Areas of interest as indicated in previous engagements include use of land within the EA area for grazing under a licence agreement.	Licensees' interest in use of the land for grazing was considered in framing PMLUs.	Grazing is considered as a PMLU in areas where disturbed land would be rehabilitated to enable this use.	Whitehaven Blackwater Pty. Ltd. will continue to engage with licensees regarding licence agreements, as and when affected by rehabilitation and/or closure activities, and will keep licensees updated on PRC plan implementation.
	Licensee	Private grazing business	As above	Letter, via letter drop	16/02/2024	As above	As above	As above	As above	As above
	Licensee	Private grazing business	As above	Letter, via email	16/02/2024	As above	As above	As above	As above	As above
	Licensee	Private grazing business	As above	Letter, via email	16/02/2024	As above	As above	As above	As above	As above
	Licensee	Private grazing business	As above	Letter, via letter drop	16/02/2024	As above	As above	As above	As above	As above
	Licensee	Private grazing business	As above	Letter, via letter drop	16/02/2024	As above	As above	As above	As above	As above
	Licensee	Private grazing business	As above	Letter, via email	16/02/2024	As above	As above	As above	As above	As above
	Licensee	Private grazing business	As above	Letter, via letter drop	16/02/2024	As above	As above	As above	As above	As above
	Licensee	Private grazing business	As above	Letter, via post	16/02/2024	As above	As above	As above	As above	As above
	Licensee	Private grazing business	As above	Letter, via email	16/02/2024	As above	As above	As above	As above	As above
	Gaangalu Nation People	Traditional owners and cattle graziers	As per Row 4	Engagement as per Row 4	As per Row 4	As above	As per Row 4	As per Row 4	As per Row 4	As per Row 4
Nearby landowners (within 5 km)	Owners of land within 5 km of EA area	Private landowners	There are 50 private owners of rural properties located within 5 km of BWM's EA area. Properties include large private landholdings (primarily grazing and dryland cropping) and smaller hobby farms/rural living lots. Nearby landowners include licensees of BMA-owned land. BMA engaged with nearby landowners through letters, emails and letter box drops, on an as-needed basis.	Letter via post to five landholders Letter via email to five landholders Letter box drop to Blackwater postal area, inclusive of Blackwater township and private landholders within 5 km of EA area	Letter via email and post - 16/02/24 Letter drop to Blackwater postcode 19/02/24	As above	No feedback or enquiries were received. BMA's regular engagements with landholders indicated that their issues of interest include environmental management, land access under current land access and lease agreements, and access to land for grazing use whilst is not required for mining.	No issues raised.	Information about PRC planning and implementation will be made available to nearby landowners through regular community updates.	Whitehaven Blackwater Pty. Ltd. will continue to inform and consult with nearby landowners during the process of implementing and updating PRC plans.

COMMUNITY MEMBERS AND PREVIOUS ENGAGEMENT				PRC PLAN DEVELOPMENT ENGAGEMENT			ENGAGEMENT OUTCOMES			
Stakeholder Group	**Stakeholder Title**	**Organisation**	**Previous engagement**	**Consultation type**	**Consultation date**	**Information provided**	**Issues raised/discussed**	**How issues were considered**	**Decisions/outcomes of engagement**	**Commitments**
Blackwater community	Blackwater residents, business owners, and community organisations and groups	Various - private home ownership, tenants, businesses and community organisations and groups	BMA communicated with Blackwater residents, businesses and community organisations through stakeholder meetings, media and social media, and Community Connect, a regular newsletter. BMA conducted a range of engagement activities with community members, from one-off responses to enquiries, to community events and forums, and ongoing engagement processes such as partnerships with community organisations and industry bodies.	Letter box drop to approximately 2,300 premises in the Blackwater Postal Area Inclusion of information in 'Community Connect' which is distributed to 15,000 households Information available through Community Team and Community Hotline	19/02/2024 03/03/2024 16/02/24 - 1 April 2024	Letter as per content for underlying landowner and other stakeholders Community Connect and Community hotline: PRC plan requirements and timing for BWM Commitment to progressive rehabilitation PRC purpose and scope Divestment timing and new Owner's role Progress on BMA PRC planning for other assets Opportunity to seek further information and discussion	No feedback or enquiries were received.	No issues raised.	Whitehaven Blackwater Pty. Ltd. will provide community updates on PRC planning for BWM if there are any substantive changes or updates to the PRC plan.	Whitehaven Blackwater Pty. Ltd. will provide community updates on PRC planning, and seek the involvement of community members and groups in understanding community aspirations for rehabilitation, post mining land use and economic transformation. This will include identifying local capacity for involvement in rehabilitation work. Whitehaven Blackwater Pty. Ltd. will participate in initiatives led by CHRC, industry or local communities which aim to harness social value from mine closure and rehabilitation planning, and/or work towards from economic transformation.
Central Highlands community members, groups and businesses	CEO	Central Highlands Development Corporation	BMA engaged regularly with CHDC over the years, on a broad range of topics. BMA provided a preliminary overview of PRC planning requirements to CHDC in 2023.	Letter, via email	16/02/2024	As above	No feedback or enquiries were received.	No issues raised.	Whitehaven Blackwater Pty. Ltd. will continue to provide community information and opportunities for feedback as part of future PRC planning processes.	Whitehaven Blackwater Pty. Ltd. will continue to provide community information and opportunities for feedback as part of future PRC planning processes via letter or meetings.
BWM	General Manager	BWM	BMA's Closure Planning Team had regular consultation with BWM's General Manager.	Meeting to discuss PRC planning requirements and support for communication with personnel.	1/02/2024	Information was provided as for external stakeholders. Information was also provided on PRC Planning consultation requirements, and supporting information was provided to enable communication with BWM personnel.	PRC plan requirements Rehabilitation and post-mining land use Approved PMLUs Rehabilitation schedule	Agreement to ongoing engagement in PRC planning	Cooperation between BWM GM and the Whitehaven Blackwater Pty. Ltd.'s Closure Planning team will continue during PRC plan implementation and updates to the PRC plan	Whitehaven Blackwater Pty. Ltd. will involve the BWM GM in PRC planning, to build capacity for community engagement on PRC planning issues and support effective delivery of PRC plans.
	Mine personnel	BWM	BMA communicated with its personnel on a continual basis through toolbox talks, emails, safety meetings, Community Connect and Coal Connect, which are regular newsletters.	Information provided for distribution to personnel through Coal Connect and BWM site newsletter	16/02/2024	Coal Connect and site newsletter: PRC plan requirements and timing for BWM Commitment to progressive rehabilitation PRC purpose and scope Divestment timing and new Owner's role Progress on BMA PRC planning for other assets Opportunity to seek further information and discussion	No feedback or enquiries were received.	No issues raised.	Whitehaven Blackwater Pty. Ltd. will keep the workforce updated as PRC plans are implemented and updated.	Whitehaven Blackwater Pty. Ltd. will keep the BWM workforce updated if there are changes to the PRC plan, and as the PRC Plan reaches its renewal date. Whitehaven Blackwater Pty. Ltd. will provide a communication channel for personnel to ask questions or contribute to discussions about PRC planning and rehabilitation.
Local Government	Acting CEO	Central Highlands Regional Council	BMA had regular meetings with Council, and meets with Councillors and officers as-needed on specific issues. BMA provided a preliminary briefing to Council on PRC requirements in 2023.	Letter, via email and post	16/02/2024	BWM location and approved activities Queensland Government requirements for mine rehabilitation and closure planning Scope and purpose of PRC plan Commitment to progressive rehabilitation Rehabilitation objective for BWM EP Act requirements for rehabilitation PRC plan requirements Progressive rehabilitation with disturbed areas rehabilitated as soon as practical Approved post mining land use options Inclusion of voids as non-use management areas Timeframe for BMA's divestment of BWM Transfer of mine operations and rehabilitation to new Owner Responsibility for future engagement on PRC plan Invitation to seek information or discussion	No feedback or enquiries were received.	The engagement processes for implementation and any updates to the PRC plan will include consultation with CHRC. CHRC's road reserves are within the EA area, which will need to be considered in PRC planning. Prior information and consultation will be required with CHRC regarding the future use of roads and road reserves within the EA area.	CHRC will require ongoing engagement regarding PRC planning for BWM. PRC planning updates will be provided at meetings between Whitehaven Blackwater Pty. Ltd. and CHRC. Whitehaven Blackwater Pty. Ltd. will also consult CHRC on management plans if rehabilitation and/or closure activities would impact on CHRC assets including road management and recycling facilities. Future engagement with Council will include discussion of rehabilitation methods and milestones.	Whitehaven Blackwater Pty. Ltd. will engage with CHRC to understand Council's strategic planning for Central Highlands LGA and the BWM project area as relevant. Whitehaven Blackwater Pty. Ltd. will work with CHRC to develop an agreement addressing any closure/rehabilitation impacts affecting Council-owned land, roads, road reserves or other assets (e.g. waste management facilities), as relevant, and will update CHRC on PRC planning regularly. Whitehaven Blackwater Pty. Ltd. will work with Council and other stakeholders in future PRC plan consultations to identify and implement shared value opportunities.
Utility owners	Commercial Customers Manager	Sunwater	Sunwater's Blackwater Pipeline is located within the EA area. BMA's engagement with Sunwater was on an as-needed basis with respect to commercial arrangements.	Letter, via email	16/02/2024	As above	No feedback or enquiries were received.	Sunwater's Blackwater Pipeline is within the EA area, which will need to be considered in PRC planning.	Whitehaven Blackwater Pty. Ltd. will maintain correspondence with Sunwater regarding progressive rehabilitation activities as they affect the Blackwater Pipeline, and undertake consultation regarding crossing/interface agreements, if required.	Whitehaven Blackwater Pty. Ltd. will work with Sunwater to develop an agreement addressing any closure/rehabilitation impacts affecting the Blackwater Water Pipeline, as relevant.
	Manager Project Planning and Corridor Management	DTMR	DTMR owns the Capricorn Highway and Ardurad (Blackwater-Rolleston) Road. BMA's engagement with DTMR was on an as-needed basis with respect to road interface and usage arrangements.	Letter, via email	16/02/2024	As above	Acknowledgement of letter. Noted that In the vicinity of the mine, DTMR are responsible for Ardurad (Blackwater-Rolleston) Road and the Capricorn Highway.	The location and use of Capricorn Highway and Ardurad (Blackwater-Rolleston) Road will need to be considered in PRC planning.	Whitehaven Blackwater Pty. Ltd. will maintain correspondence with DTMR regarding progressive rehabilitation activities as they affect Capricorn Highway and Ardurad (Blackwater-Rolleston) Road, and undertake consultation regarding crossing/interface agreements, if required.	Whitehaven Blackwater Pty. Ltd. will work with DTMR to develop an agreement addressing any closure/rehabilitation impacts affecting the Capricorn Highway and/or Ardurad (Blackwater-Rolleston) Road, as relevant.
	Acting CEO	CHRC	CHRC owns roads and road reserves that intersect or are directly abutting the BWM EA area, including Yarrawonga Road, Tannyfoil Road, Taura's Road, Ardurad Road, Barlow Road, Humboldt Road and Un-named Roads. BMA engaged with CHRC to the terms of its agreements regarding roads and road reserves.	Letter, via email and meeting, as per previous entry for CHRC	16/02/2024	As above	No feedback or enquiries were received.	CHRC roads and road reserves that intersect or are directly abutting the BWM EA area will need to be considered in PRC planning.	Whitehaven Blackwater Pty. Ltd. will maintain correspondence with CHRC regarding progressive rehabilitation activities as they affect Council roads and road reserves, and undertake consultation regarding crossing/interface agreements, if required.	Whitehaven Blackwater Pty. Ltd. will work with CHRC to develop an agreement addressing any closure/rehabilitation impacts affecting Council roads or road reserves, as relevant.
	Senior Designer, Mackay/Whitsunday District	Queensland Rail	Queensland Rail owns four railways (Central, South Blackwater Mine, Blackwater Mine and Bauhinia), as well as two loops and two sidings, in the vicinity of the BWM EA area. BMA engagement with Queensland Rail included routine correspondence on commercial and statutory issues, with meetings held as required on specific issues.	Letter, via email and post	16/02/2024	As above	No feedback or enquiries were received.	Prior information and consultation will be required with Queensland Rail regarding the use and, as relevant, decommissioning of rail infrastructure within the EA area.	Whitehaven Blackwater Pty. Ltd. will advise Queensland Rail of any substantive changes to closure planning or the rehabilitation schedule as part of future PRC planning processes for BWM.	Whitehaven Blackwater Pty. Ltd. will maintain engagement with Queensland Rail regarding its progressive rehabilitation activities as they affect Queensland Rail assets, and undertake engagement regarding the decommissioning of rail infrastructure prior to its closure, in accordance with agreements between Whitehaven Blackwater Pty. Ltd. and Queensland Rail at the time.
	Senior Business Analyst, Network Asset Management	Aurizon Network	Aurizon Network operates Queensland Rails' assets in the vicinity of the BWM EA area. BMA engagement with Aurizon included routine correspondence on commercial and statutory issues, with meetings held as required on specific issues.	Letter, via email and post	16/02/2024	As above	No feedback or enquiries were received.	Prior information and consultation will be required with Aurizon Network regarding the use and, as relevant, decommissioning of rail infrastructure within the EA area.	Whitehaven Blackwater Pty. Ltd. will advise Aurizon Network of any substantive changes to closure planning or the rehabilitation schedule as part of future PRC planning processes for BWM.	Whitehaven Blackwater Pty. Ltd. will maintain engagement with Aurizon Network regarding its progressive rehabilitation activities as they affect rail operation, in accordance with agreements between Whitehaven Blackwater Pty. Ltd. and Aurizon Network at the time.

COMMUNITY MEMBERS AND PREVIOUS ENGAGEMENT				PRC PLAN DEVELOPMENT ENGAGEMENT			ENGAGEMENT OUTCOMES			
Stakeholder Group	**Stakeholder Title**	**Organisation**	**Previous engagement**	**Consultation type**	**Consultation date**	**Information provided**	**Issues raised/discussed**	**How issues were considered**	**Decisions/outcomes of engagement**	**Commitments**
	Major Customer Manager	Ergon Energy Corporation Ltd	Ergon Energy owns 22kV Feeders, 66kV Transmission Lines, substations and the Rolleston 132kV Transmission Line. BMA engagement with Ergon included routine correspondence on commercial and statutory issues.	Letter, via email	16/02/2024	As above	Acknowledgement of letter received. No feedback or enquiries were received.	No issues raised. Prior information and consultation will be required with Ergon Energy regarding the decommissioning/future use of power easements within the EA area, as relevant.	Whitehaven Blackwater Pty. Ltd. will maintain correspondence with Ergon Energy regarding progressive rehabilitation activities as they affect Ergon Energy assets, and undertake consultation regarding agreements about energy infrastructure, if required.	Whitehaven Blackwater Pty. Ltd. will advise and consult Ergon Energy regarding any impacts of closure/rehabilitation activities that may affect Ergon Energy's assets.
	Property Services and Management Team Leader	Powerlink	Powerlink owns 132kV Transmission Lines. BMA engagement with Powerlink included routine correspondence on commercial and statutory issues.	Letter, via email	16/02/2024	As above	No feedback or enquiries were received.	Prior information and consultation will be required with Powerlink regarding the decommissioning/future use of power easements within the EA.	Whitehaven Blackwater Pty. Ltd. will maintain correspondence with Powerlink regarding progressive rehabilitation activities as they affect Powerlink assets, and undertake consultation regarding crossing/interface agreements, if required.	Whitehaven Blackwater Pty. Ltd. will advise and consult Powerlink regarding any impacts of closure/rehabilitation activities that may affect Powerlink's assets.
	Sales Operations Manager	Telstra Amplitel	Telstra Amplitel owns three microwave towers within the EA area. There are no records of specific engagement with Telstra Amplitel regarding BWM.	Letter, via email	16/02/2024	As above	No feedback or enquiries were received.	Prior information and consultation will be required with Telstra Amplitel regarding the decommissioning/future use of telecommunications infrastructure within the EA area.	Whitehaven Blackwater Pty. Ltd. will maintain correspondence with Telstra Amplitel regarding progressive rehabilitation activities as they affect Telstra Amplitel assets, and undertake consultation about telecommunications infrastructure agreements, if required.	Whitehaven Blackwater Pty. Ltd. will advise and consult Telstra Amplitel regarding any impacts of closure/rehabilitation activities that may affect their assets.
	Head of Land Access, Major Projects	Telstra Vocus	Telstra Vocus owns a WiFi installation within the EA area. There are no records of specific engagement with Telstra Vocus regarding BWM.	Letter, via email and post	16/02/2024	As above	No feedback or enquiries were received.	Prior information and consultation will be required with Telstra Vocus regarding the decommissioning/future use of telecommunications infrastructure within the EA area, as relevant.	Whitehaven Blackwater Pty. Ltd. will maintain correspondence with Telstra Vocus regarding progressive rehabilitation activities as they affect Telstra Vocus's asset, and undertake consultation about internet infrastructure agreements, if required.	Whitehaven Blackwater Pty. Ltd. will advise and consult Telstra Vocus regarding any impacts of the closure/rehabilitation activity that may affect their assets.
	Senior Development Manager - REN Australia	Total Energies	Total Energies hold a development approval on 13HT602 adjacent to the EA area for the development and operation of a solar farm. The solar farm is yet to be installed.	Letter, via email	22/02/2024	As above	No feedback or enquiries were received.	No issues raised.	Whitehaven Blackwater Pty. Ltd. will advise Total Energies, as an adjoining landholder, of any substantive changes to the closure or rehabilitation schedule as part of future PRC planning processes for BWM.	Whitehaven Blackwater Pty. Ltd. will advise Total Energies of any substantive changes to closure or rehabilitation schedule as part of future PRC planning processes for BWM.
Adjacent and nearby mining interests	Tenement Manager	QCoal Services Pty Ltd	BWM's GM engaged with Cook's Colliery's General Manager on an as-needed basis, through emails, phone calls and meetings. QCoal and BMA had an agreement to use BWM MLs to access the Cook's Colliery mine. This agreement was transferred to Whitehaven Blackwater. ***(Confirm prior to submission)*** BMA engaged with QCoal as part of commercial and infrastructure agreements.	Letter via email	21/02/2024	As above	No feedback or enquiries were received.	No issues raised.	Whitehaven Blackwater Pty. Ltd. will keep QCoal updated as PRC Plans are implemented and revised.	Whitehaven Blackwater Pty. Ltd. will keep QCoal updated if there are substantive future changes to the PRC plan.
	Manager, Mine Engineering	Coronado Global Resources Inc.	Curragh Mine is located to the north of BWM. BMA had a good neighbour agreement with Coronado Global Resources Inc., including the accommodation of the East Bedford water pipeline. This agreement was transferred to Whitehaven Blackwater. ***(Confirm prior to submission)***	Letter via email	21/02/2024	As above	No feedback or enquiries were received.	No issues raised.	Whitehaven Blackwater Pty. Ltd. will keep Coronado Curragh Pty. Ltd updated as PRC Plans are implemented and revised.	Whitehaven Blackwater Pty. Ltd. will keep Coronado Curragh Pty. Ltd. updated if there are substantive future changes to the PRC plan, and as the PRC Plan reaches its renewal date.
Petroleum tenement holders	Tenement Manager/Authorised Holder Representative	Bow CSG Pty. Ltd.	Bow CSG hold an Authority to Prospect and Petroleum Commercial Area which include land within ML 1759 and ML1761. Both MLs were granted prior to the enactment of the Mineral and Energy Resources (Common Provisions) Act 2014, and both hold gaseous hydrocarbons rights. Where overlapped by these ATPs, the petroleum resource authority does not hold rights to access the hydrocarbons. BMA and Bow CSG communicated regarding tenure issues on an as-needed basis.	Letter, via email	14/03/2024	As above	No feedback or enquiries were received.	No issues raised.	Whitehaven Blackwater Pty. Ltd. will advise Bow CSG Pty. Ltd of any substantive changes to the closure or rehabilitation schedule as part of future PRC planning processes for BWM.	Whitehaven Blackwater Pty. Ltd. will advise Bow CSG Pty. Ltd of any substantive changes to closure or rehabilitation schedule as part of future PRC planning processes for BWM.
	Tenement Manager/Authorised Holder Representative	Comet Ridge Mahalo North Pty Ltd, Comet Ridge Mahalo Far East Pty Ltd and Comet Ridge Mahalo East Pty Ltd hold	Comet Ridge Mahalo entities hold three ATPs (ATP 2061, ATP 2048, ATP 2063) and PLA 1128 which includes land within the EA area in the north and east. As above, the BMA resource authorities hold gaseous hydrocarbon rights and therefore, where overlapped by these ATPs, the petroleum resource authority does not hold rights to access the hydrocarbons. BMA and Comet Ridge Mahalo entities communicated on an as-needed basis. BMA also engaged with Comet Ridge Maholo in relation to the Blackwater South Mining Lease applications.	Letter, via email	14/03/2024	As above	No feedback or enquiries were received.	No issues raised.	Whitehaven Blackwater Pty. Ltd. will advise Comet Ridge Mahalo entities of any substantive changes to the closure or rehabilitation schedule as part of future PRC planning processes for BWM.	Whitehaven Blackwater Pty. Ltd. will advise Comet Ridge Mahalo entities of any substantive changes to closure or rehabilitation schedule as part of future PRC planning processes for BWM.
	Tenement Manager/Authorised Holder Representative	Bronco Energy Pty Limited	Bronco Energy hold ATP804 and PCA 215 which are adjacent to the EA area. BMA did not have previous engagement with Bronco Energy regarding BWM.	Letter, via email	14/03/2024	As above	No feedback or enquiries were received.	No issues raised.	Whitehaven Blackwater Pty. Ltd. will advise adjacent petroleum tenement holders of any substantive changes to the closure or rehabilitation schedule as part of future PRC planning processes for BWM.	Whitehaven Blackwater Pty. Ltd. will advise adjacent petroleum tenement holders of any substantive changes to the closure or rehabilitation schedule as part of future PRC planning processes for BWM.
	Tenement Manager/Authorised Holder Representative	Santos QNT. Pty. Ltd.	Santos QNT. Pty. Ltd. hold ATPs and production licences to the south of the EA area (ATP 1191, PL 1082, PL 1083, PSL 2058, PL 1082, PL 1083). BMA engaged with Santos in relation to the Blackwater South Mining Lease applications.	Letter, via email	14/03/2024	As above	No feedback or enquiries were received.	No issues raised.	Whitehaven Blackwater Pty. Ltd. will advise adjacent petroleum tenement holders of any substantive changes to the closure or rehabilitation schedule as part of future PRC planning processes for BWM.	Whitehaven Blackwater Pty. Ltd. will advise adjacent petroleum tenement holders of any substantive changes to the closure or rehabilitation schedule as part of future PRC planning processes for BWM.
Queensland Government Agencies	PRC Planning Team	Department of Environment, Science and Innovation (DESI)	BMA engaged with DESI through meetings and correspondence regarding the preparation and delivery of the PRC Plan.	Pre-lodgement meetings	Meetings per schedule as agreed with DESI	Provision of draft PRC Plan and discussion of requirements	As per pre-lodgement meetings.	DESI feedback was considered in the development of the PRC Plan including the Community Consultation Plan	The PRC plan will be completed in accordance with Whitehaven Blackwater's agreements with DESI.	Whitehaven Blackwater Pty. Ltd. will comply with the legislative and regulatory requirements for PRC Plans.

COMMUNITY MEMBERS AND PREVIOUS ENGAGEMENT				PRC PLAN DEVELOPMENT ENGAGEMENT			ENGAGEMENT OUTCOMES			
Stakeholder Group	**Stakeholder Title**	**Organisation**	**Previous engagement**	**Consultation type**	**Consultation date**	**Information provided**	**Issues raised/discussed**	**How issues were considered**	**Decisions/outcomes of engagement**	**Commitments**
	Deputy Director-General Georesources	Department of Resources	BMA provided briefings to the Deputy Director-General Georesources on an as-needed basis, and met and corresponded with Department of Resources regarding resource development commitments. Department of Resources is the owner of a stock route (416CENT, 348CENT, 413CENT, 353CENT) within the EA area.	Letter via email	16/02/2024	BWM location and approved activities Queensland Government requirements for mine rehabilitation and closure planning Scope and purpose of PRC plan BMA's commitment to progressive rehabilitation Rehabilitation objective for BWM EP Act requirements for rehabilitation PRC plan requirements Progressive rehabilitation with disturbed areas rehabilitated as soon as practical Approved post mining land use options Inclusion of voids as non-use management areas Timeframe for BMA's divestment of BWM Transfer of mine operations and rehabilitation to new Owner Responsibility for future engagement on PRC plan Invitation to seek information or discussion	Acknowledgement of correspondence.		Whitehaven Blackwater Pty. Ltd. will provide a copy of the BWM PRC plan to DDG Georesources, and update the DDG Georesources on any substantive future changes to the PRC Plan. The PRC Plan's Community Consultation Plan includes provision of annual updates to Department of Resources.	Whitehaven Blackwater Pty. Ltd. will provide annual updates on PRC planning to the Deputy Director General, Georesources.
	Acting Director Native Title Services and Coal Hub, Rockhampton	Department of Resources	BMA provided briefings to the Acting Director Native Title Services and Coal Hub on an as-needed basis, and met and corresponded with Department of Resources regarding resource development commitments.	Letter via email	16/02/2024	As above	No feedback or enquiries were received.	No issues raised.	Whitehaven Blackwater Pty. Ltd. will provide a copy of the BWM PRC plan to the Director Native Title Services and Coal Hub, Rockhampton, and provide updates on any substantive future changes to the PRC Plan.	Whitehaven Blackwater Pty. Ltd. will provide updates on PRC planning to the Director Native Title Services and Coal Hub, Rockhampton as requested.
	Executive Director, Minerals and Coal	Department of Resources	As above.	Letter via email	16/02/2024	As above	No feedback or enquiries were received.	No issues raised.	Whitehaven Blackwater Pty. Ltd. will provide a copy of the BWM PRC plan to the Executive Director, Minerals and Coal, and provide updates on any substantive future changes to the PRC Plan.	Whitehaven Blackwater Pty. Ltd. will provide updates on PRC planning to the Executive Director, Minerals and Coal, as requested.
	Regional Director Queensland Parks and Wildlife Service and Partnerships - Mackay	DESI	BMA did not have an active relationship with QPSWSP with respect to BWM.	Letter via post	7/03/2024	As above	No feedback or enquiries were received.	No issues raised.	Whitehaven Blackwater Pty. Ltd. will continue to provide information to interested government agencies and opportunities for feedback as part of future PRC planning processes.	Whitehaven Blackwater Pty. Ltd. will continue to provide information to interested government agencies and opportunities for feedback as part of future PRC planning processes.
	Deputy Director-General, Fisheries and Forestry	Department of Agriculture and Fisheries	BMA did not have an active relationship with Department of Agriculture and Fisheries with respect to BWM.	Letter, via email and post	16/02/2024	As above	Acknowledgement of letter received. No feedback or enquiries were received.	No issues raised.	Whitehaven Blackwater Pty. Ltd. will continue to provide information and opportunities for feedback to Department of Agriculture and Fisheries as part of future PRC planning processes.	Whitehaven Blackwater Pty. Ltd. will provide updates on PRC planning to the DDG Fisheries and Forestry. as requested.
Queensland Government Representatives	Chief of Staff/Secretary	Office of the Minister for Resources and Critical Minerals	BMA provided briefings to the Minister's office on an as-needed basis.	Discussion of PRC plans as part of a future briefing	As part of regular meetings	As above	No feedback or enquiries were received.	No issues raised.	Whitehaven Blackwater Pty. Ltd. will update the Office of the Minister on any substantive future changes to the PRC Plan.	Whitehaven Blackwater Pty. Ltd. will provide updates on PRC planning to the Minister's office as requested.
	Chief of Staff/Secretary	Office of the Minister for Agriculture Industry Development and Fisheries and Minister Rural Communities	BMA provided briefings to the Minister's office on an as-needed basis.	Discussion of PRC plans as part of a future briefing	As part of regular meetings	As above	No feedback or enquiries were received.	No issues raised.	Whitehaven Blackwater Pty. Ltd. will update the Office of the Minister on any substantive future changes to the PRC Plan.	Whitehaven Blackwater Pty. Ltd. will provide updates on PRC planning to the Minister's office as requested.
	Chief of Staff/Secretary	Office of the Minister Energy, and Clean Economy Jobs	BMA provided briefings to the Minister's office on an as-needed basis.	Discussion of PRC plans as part of a future briefing	As part of regular meetings	As above	No feedback or enquiries were received.	No issues raised.	Whitehaven Blackwater Pty. Ltd. will update the Office of the Minister on any substantive future changes to the PRC Plan.	Whitehaven Blackwater Pty. Ltd. will provide updates on PRC planning to the Minister's office as requested.
	Chief of Staff/Secretary	Office of the Minister for Minister for the Environment, Science and Innovation	BMA provided briefings to the Minister's office on an as-needed basis.	Discussion of PRC plans as part of a future briefing	As part of regular meetings	As above	No feedback or enquiries were received.	No issues raised.	Whitehaven Blackwater Pty. Ltd. will update the Office of the Minister on any substantive future changes to the PRC Plan.	Whitehaven Blackwater Pty. Ltd. will provide updates on PRC planning to the Minister's office as requested.
	Chief of Staff/Secretary	Office of the Minister for Regional Development and Manufacturing and Minister for Water	BMA provided briefings to the Minister's office on an as-needed basis.	Discussion of PRC plans as part of a future briefing	As part of regular meetings	As above	No feedback or enquiries were received.	No issues raised.	Whitehaven Blackwater Pty. Ltd. will update the Office of the Minister on any substantive future changes to the PRC Plan.	Whitehaven Blackwater Pty. Ltd. will provide updates on PRC planning to the Minister's office as requested.
	Chief of Staff/Secretary	Shadow Minister for Environment and the Great Barrier Reef and Shadow Minister for Science and Innovation	BMA provided briefings to the Shadow Minister's office on an as-needed basis.	Discussion of PRC plans as part of a future briefing	As part of regular meetings	As above	No feedback or enquiries were received.	No issues raised.	Whitehaven Blackwater Pty. Ltd. will update the Office of the Shadow Minister on any substantive future changes to the PRC Plan.	Whitehaven Blackwater Pty. Ltd. will provide updates on PRC planning to the Minister's office as requested.
	Member for Burdekin - Dale Last MP	Queensland Parliament - Member for Burdekin and Shadow Minister for Natural Resources and Mines	BMA provided briefings to the Member for Burdekin/Shadow Minister's office on an as-needed basis.	Discussion of PRC plans as part of a future briefing	As part of regular meetings	As above	No feedback or enquiries were received.	No issues raised.	Whitehaven Blackwater Pty. Ltd. will update the Member for Burdekin and the Office of the Shadow Minister on any substantive future changes to the PRC Plan.	Whitehaven Blackwater Pty. Ltd. will provide updates on PRC planning to the Member's office as requested.
	Member for Gregory - Lachlan Millar MP	Queensland Parliament - Member for Gregory	BMA provided briefings to the Member for Gregory's office on an as-needed basis.	Discussion of PRC plans as part of a future briefing	As part of regular meetings	As above	No feedback or enquiries were received.	No issues raised.	Whitehaven Blackwater Pty. Ltd. will update the Member for Gregory on any substantive future changes to the PRC Plan.	Whitehaven Blackwater Pty. Ltd. will provide updates on PRC planning to the Member's office as requested.
Federal Government		Office of the Minister and Dep. Sec. Environment Protection, Department of Climate Change, Energy, the Environment and Water	BMA provided briefings to the Minister's office on an as-needed basis.	Discussion of PRC plans as part of a future briefing	As part of regular meetings	As above	No feedback or enquiries were received.	No issues raised.	Whitehaven Blackwater Pty. Ltd. will update the Office of the Minister on any substantive future changes to the PRC Plan.	Whitehaven Blackwater Pty. Ltd. will provide updates on PRC planning to the Minister's office as requested.

Whitehaven

Appendix 4.5 – Voids in Floodplain Modelling

Blackwater Mine Progressive Rehabilitation and Closure Plan

Voids in Floodplain Modelling

Whitehaven Blackwater Pty Ltd

Level 14, 480 Queen Street
Brisbane City, QLD, Australia
4000

Prepared by:

SLR Consulting Australia Pty Ltd

Level 16, 175 Eagle Street, Brisbane, QLD, Australia,
4000

SLR Project No.: 620.31051.00000

10 October 2024

Revision: R01-v3.4

Revision Record

Revision	Date	Prepared By	Checked By	Authorised By
R01-v3.4	10 October 2024	HM	MD	MD
R01-v3.3	30 September 2024	HM	MD	MD
R01-v3.2	11 September 2024	HM	MD	MD
R01-v3.1	19 August 2024	HM	MD	MD
R01-v3.0	3 June 2024	HM	MD	MD
R01-v2.0	11 March 2024	HM	MD	MD
R01-v1.0	20 September 2023	HM	MD	MD

Basis of Report

This report has been prepared by SLR Consulting Australia Pty Ltd (SLR) with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with Whitehaven Blackwater Pty Ltd (the Client). Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

This report is for the exclusive use of the Client. No warranties or guarantees are expressed or should be inferred by any third parties. This report may not be relied upon by other parties without written consent from SLR.

SLR disclaims any responsibility to the Client and others in respect of any matters outside the agreed scope of the work.

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Appendix A TUFLOW Model Results – Two Mile Gully

Appendix B TUFLOW Model Results – Sirius Creek

Acronyms and Abbreviations

1D	One dimensional
2D	Two dimensional
AEP	Annual Exceedances Probability
ARF	Aerial Reduction Factor
ARR	Australian Rainfall and Runoff
BoM	Bureau of Meteorology
BWM	Blackwater Mine
DR	Department of Resources
DEM	Digital Elevation Model
EA	Environmental Authority
EP	Environmental Protection
GSDM	Generalised Short Duration Method
GTSMR	Revised Generalised Tropical Storm Method
IFD	Intensity-Frequency-Duration
NUMA	Non-use Management Areas
PRCP	Progressive Rehabilitation and Closure Plan
PMLU	Post Mining Land Use
QRT	Quantile Regression Technique
RFFE	Regional Flood Frequency Estimate
SA	Source Area
WB	Whitehaven Blackwater Pty Ltd
WBNM	Watershed Bounded Network Model

1.0 Introduction

SLR was engaged by Whitehaven Blackwater Pty Ltd (WB) to undertake floodplain modelling at Blackwater Mine (BWM). The modelling was undertaken to inform the Transitional Progressive Rehabilitation and Closure Plan (PRCP) for BWM.

BWM is located in Central Queensland, approximately 170 kilometres west of Rockhampton. A number of local watercourses traverse the site, including Blackwater Creek. **Figure 1** illustrates the location of BWM and key surrounding features.

The assessment detailed in this document was undertaken specifically to address the voids in flood plain modelling as part of the PRCP requirements for BWM.

1.1 Aims and Objectives

Blackwater Mine requires a PRCP to be completed in accordance with BWM's Environmental Authority (EA) (No. EPML00717813). As part of the PRCP for BWM, it is proposed to incorporate eleven final voids as Non-Use Management Areas (NUMAs). **Figure 2** illustrates the location and extent of the proposed final voids at BWM.

To meet the requirements of the Environmental Protection Act 1994 (EP Act) and Environmental Protection Regulation 2019 (EP Regulation), floodplain modelling is required for all relevant watercourses in the vicinity of voids, to assess the flood immunity and extents for the final landform conditions.

The scope of this project is to undertake floodplain modelling of the relevant watercourses as defined by the EP Regulation in relation to the proposed voids, including the following key tasks:

- Undertake a catchment study for each proposed void in the floodplain, including determining the pre-mining landform and developing or updating hydrologic modelling to be consistent with the requirements of Australian Rainfall and Runoff (AR&R 2019). The study includes watercourses classified as stream order four or higher, and their contributing tributaries.
- Update and/or develop hydraulic models for the purpose of identifying flood risks posed to the proposed voids. The purpose of this is to define the baseline flood risks caused by the major creeks, which will be used to assess the inundation risk in the 0.1% Annual Exceedance Probability (AEP) flood event for each void, informed by the re-constructed pre-mining topography.
- Produce a Voids in Floodplain Model Report detailing the methodology and findings of the above assessments, including all relevant mapping of flood extents, levels and depths. GIS data and models will also be provided as an output of this assessment.

The assessments detailed in this report were undertaken and reviewed by appropriately qualified persons.

1.2 Input Data

Data for the assessment, including locations and extents of final voids, was provided by WB.

Further data was obtained for use in the assessment from public sources, including topographic data, rainfall data, catchment specific hydrologic data and watercourse data. Further detail on the data utilised in the assessment is provided in **Section 3.0**.

650000 660000 670000 680000 690000 700000 710000 720000

7420000 7410000 7400000 7390000 7380000 7370000 7360000 7350000 7340000 7330000 7320000

Mosquito Creek
Winton Creek
Boggy Creek
Mackenzie River
Cattle Creek
Sandy Creek
Mackenzie River
Comet River
Yanko Creek
Sandhurst Creek
Eight Mile Creek
Comet River
Minerva Creek
Minerva Creek
Comet River
Triumph Creek
Sirius Creek
Springsure Creek
Springsure Creek
Horse Plain Creek
Comet River
Comet River
Comet River
Orion Creek
Orion Creek
Comet River
Shotover Creek
Scrubbers Gully
Washpool Gully
Burngrove Creek
Burngrove Creek
Tolmie Creek
Blackwater Creek
Blackwater Creek
Blackwater Creek
Blackwater Creek
Blackwater Creek
Taurus Creek
Two Mile Gully
Sirius Creek
Capricorn Highway
Blackwater Rolleston Road
Lagoon Creek
Duckworth Creek
Charlevue Creek
Charlevue Creek
Story Creek
Hazelmere Creek
Wimosa Creek
Walter Creek
Henry Creek
Planet Creek
Central Creek
Taylors Creek

0 2.25 4.5 9 km

Coordinate System:	GDA 1994 MGA Zone 55
Scale:	1:300,000 at A3
Project Number:	620.31051.00000
Date:	18-Sep-2023
Drawn by:	HM

LEGEND

- BWM Mine Lease Extents
- Watercourses
- Roads
- Rail

BLACKWATER MINE PRCP VOIDS IN FLOODPLAIN MODELLING

Site Location

SLR

FIGURE 1

Service Layer Credits: Source: Esri, Maxar, Earthstar

H:\Projects-SLR\620-BNE\620-BNE\620.31051.00000 GRM BWM PRCP Voids in Floodplain Modelling\06 SLR Data\01 CADG\SIG\SIFigures\BWM\620031051_BWM_Figure01_SiteLoc_A3P.mxd

2.0 Legislation and Guidelines

This assessment has been undertaken in accordance with the following legislation and guidelines:

- *Environmental Protection Act 1994;*
- *Environmental Protection Regulation 2019;*
- *'Information Sheet – Environmental Protection Act 1994 – Voids in Flood Plains, Version 1.01'*, Department of Environment and Science, February 2024; and
- *'Guideline – Progressive Rehabilitation and Closure Plans, Version 3*', Department of Environment and Science, April 2023 (PRCP Guideline).

Section 126D(3) of the Environmental Protection Act 1994 (Qld) (EP Act) relevantly states:

'If land the subject of the proposed PRCP schedule will contain a void situated wholly or partly in a flood plain, the schedule must provide for the rehabilitation of the land to a stable condition.'

Section 126D of the EP Act does not apply to the BWM PRCP by virtue of section 754(3) of the EP Act.

The Environmental Protection Regulation 2019 section 41C(3) also states:

"The administering authority must treat the land as a flood plain to the extent the results of the flood plain modelling show that, when all relevant activities carried out on the land have ended, the land is the same height as, or lower than, the level modelled as the peak water level 0.1% AEP for a relevant watercourse under the ARR."

Further guidance is provided in the PRCP Guideline and the Voids in Flood Plains Information Sheet.

According to section 3.4 of the PRCP Guideline, floodplain modelling is required for the BWM PRCP, notwithstanding the operation of section 754(3) of the EP Act, as the location of the voids which are identified in the BWM EA as NUMAs have not been identified.

2.1 Applicability to the Project

Based on the review of the EP Act, EP Regulation, PRCP Guideline and the Voids in Floodplains information sheets, it is considered that the legislative requirements set out in **Table 1** are applicable to the project.

Table 1 Applicable Legislative Requirements

Requirement	Application to the Project	Source
For transitional sites, a floodplain assessment is required where: A void has been identified as a NUMA in a land outcome document but the location has not been specified; or Where there are no land outcomes in the land outcome document.	The PRCP for Blackwater Mine includes eleven final voids which are proposed to be developed as NUMAs. The voids are identified as a land outcome in the BWM EA. Therefore, floodplain assessment is required. The voids are: - Ramp 8 - Bonnie Doon - Mimosa/Besgrove - Deep Creek - Stewarton/Ballamoo - Kenmare - Togara/North Marshmead - SouthMarshmead - Laleham - Kennedy West - Comet Downs East	PRCP Guideline Section 3.4

Requirement	Application to the Project	Source
Floodplains associated with a stream order 4 or greater are required to be modelled.	The following watercourses are of Strahler stream order 4 or greater and may affect the proposed voids: Blackwater Creek Two Mile Gully Taurus Creek (downstream of junction with Two Mile Gully) Sirius Creek Unnamed Tributary of Sirius Creek Therefore, the above are relevant watercourses and floodplain modelling of the watercourses was undertaken.	Voids in Flood Plains Information Sheet Section 5.
The modelling must not include any artificial features on the site. However, the modelling must include all existing and approved artificial features that, at the time of modelling, are located outside of the mining tenure boundary.	A Digital Elevation Model (DEM) of the area was created to be used as the model landform for the assessment. The model landform DEM was developed to represent the pre-mining topography within the Mining Lease (ML), and existing and future topography outside of the ML, including on adjacent MLs where applicable. The topography outside of the ML included existing and future artificial features, based on available data.	Voids in Flood Plains Information Sheet Section 4.
The requirement for a flood assessment under section 3.6.1 of the Guideline applies to the post mining landform across the whole site irrespective of whether a PMLU or a NUMA are proposed. Furthermore, section 3.6.1 is not only required to indicate flood risk but also to demonstrate the final landform (including waste rock dumps and diversions) will remain in a stable condition in a range of flood flow conditions.	Not included in the scope of this assessment. A rehabilitation flood assessment was undertaken by SLR to address this requirement for BWM as detailed in 'Blackwater Mine – Progressive Rehabilitation and Closure Plan – Rehabilitation Flood Assessments', Version 2.1, (ref 620.040134.00000-R02-v2.1).	PRCP Guideline Section 3.6.1.

2.2 Definitions and Terminology

Table 2 provides the definitions and terminology that are utilised in this assessment, in accordance with the PRCP Guideline and the Voids in Flood Plains Information Sheet.

Table 2 Definitions and Terminology

Term	Definition	Source
Voids	An area of land to be excavated in carrying out a mining activity. Therefore, all voids (PMLU or NUMA) are subject to the requirements of the EP Act.	Section 126D of the EP Act.
Flood plain	A void is considered to be located in a flood plain if the flood plain modelling shows that, when all relevant activities carried out on the land have ended, the land is the same height as, or lower than, the level modelled as the peak water level in a 0.1% AEP for a relevant watercourse under the guideline Australian Rainfall and Runoff (2019) (ARR).	Section 41C of the EP Regulation; and PRCP Guideline Section 3.4.
Stable condition	The land is safe and structurally stable;	Section 126D(3) of the EP Act; and

Term	Definition	Source
	There is no environmental harm being caused by anything on or in the land; and The land can sustain a PMLU.	PRCP Guideline Section 3.6.3.
Relevant watercourse	a) A watercourse classified as stream order 4 or higher under the Strahler stream order classification system; or b) If a watercourse mentioned in paragraph (a) is permanently diverted under – (i) A condition, or proposed condition, of an environmental authority mentioned in the Water Act 2000, section 98; or (ii) A water license or proposed water license under the Water Act 2000; the watercourse as permanently diverted.	PRCP Guideline Section 8; and Voids in Flood Plains information Sheet Section 5.
Flood plain modelling	For land the subject of a PRCP schedule, means modelling of the landform of the land – a) Carried out under the ARR; (and) b) Excluding any artificial features for the land	PRCP Guideline Section 8; and Voids in Flood Plains information Sheet Section 4.
Artificial feature	For land the subject of a PRCP schedule, means – a) A structure or feature that is temporary and, under the PRCP schedule or otherwise, is to be removed from the land; or b) A structure or feature that, under the PRCP schedule, will require a level of maintenance after the land is surrendered that is greater than the level of maintenance that would be required for the land if the relevant activities the subject of the PRCP schedule had not been carried out; or c) A feature forming part of the landform of the land, other than the natural landform, if the feature interferes with or affects – i) A relevant watercourse; or ii) The natural flow of water on the land.	PRCP Guideline Section 8; and Voids in Flood Plains information Sheet Section 6.

3.0 Data

3.1 Available Data

A data package was provided to SLR by WB for use in the assessment. The package included:

- LiDAR topographic data 1m DEM;
- PRCP final void locations and extents;
- Hydraulic structure details.

Additional data was obtained from publicly available sources including:

- Fitzroy River catchment 25m DEM (Department of Resources (DR), 2023);
- Watercourse Lines – Queensland GIS dataset (DR, 2023);
- Design rainfall intensity-frequency-duration data (Bureau of Meteorology, 2023);
- Catchment hydrologic data (Australian Rainfall and Runoff (ARR) Data Hub, 2023).

The provided data was analysed for suitability for the purposes of this assessment. The outcomes of the review are detailed below.

3.2 Watercourses

A review of the existing watercourses in the vicinity of BWM was undertaken using hydrologic streamline data sourced from DR. The dataset contained Strahler Stream Order classifications for each watercourse, which ranged from order 1 to order 9 within the extent of the data, as illustrated in **Figure 2**. The reviewed data showed that the following watercourses are of Strahler stream order 4 or greater and may affect the proposed final voids:

- Blackwater Creek;
- Two Mile Gully;
- Taurus Creek (downstream of junction with Two Mile Gully);
- Sirius Creek; and
- Unnamed tributary of Sirius Creek.

Therefore, the above Creeks and tributaries are relevant watercourses and floodplain modelling was undertaken for each.

3.3 Topography and Landforms

Limited topographic data representing the pre-mining (natural) conditions within the BWM extents was available for use in the assessment. The available LiDAR 1m DEM topographic data generally represented pre-mining topographic conditions outside of the BWM extents, however within the extents represented mine affected topography. Therefore, the LiDAR data was not utilised to form the model landform within the BWM extents, but was adopted outside the BWM extents where appropriate.

The Fitzroy River catchment 25m DEM generally represented the pre-mining topographic conditions both within and outside the BWM extents. Therefore, the Fitzroy River 25m DEM was adopted as the primary topographic data set within the BWM extents.

3.4 Artificial Features

Review of the available topographic data showed the relevant watercourses were not significantly affected by artificial features outside the BWM extents. The artificial features that were included in the model landform were:

- Blackwater Rolleston Road;
- Blackwater Railway System.

The model landform is illustrated in **Figure 2**.

660000 670000 680000 690000 700000 710000

7390000 7380000 7370000 7360000 7350000 7340000 7330000

Comet River
Burngrove Creek
Burngrove Creek
To/mie Creek
Duckworth Creek
Taurus Creek
Blackwater Creek
Blackwater Creek
Blackwater Creek
Stony Creek
Charlewue Creek
Two Mile Gully
Triumph Creek
Horse Plain Creek
Sirius Creek
Shotover Creek
Planet Creek
Planet Creek
Comet River

0 1.5 3 6 km

Coordinate System:	GDA 1994 MGA Zone 55
Scale:	1:200,000 at A3
Project Number:	620.31051.00000
Date:	27-Feb-2024
Drawn by:	HM

LEGEND

- BWM Mine Lease Extents
- Stream Order < 4
- Stream Order >= 4
- Blackwater-Rolleston Road
- Blackwater System

BLACKWATER MINE PRCP
VOIDS IN FLOODPLAIN MODELLING

Model Landform and watercourse stream orders

SLR

FIGURE 2

Service Layer Credits:

H:\Projects-SLR\620-BNE\620-BNE\620.31051.00000 GRM BWM PRCP Voids in Floodplain Modelli\06 SLR Data\01 CADGIS\GIS\Figures\BWM\620.31051_BWM_Figure02_ModelLFandWatercourses_A3P_02.mxd

4.0 Hydrologic Modelling

4.1 Software

Hydrologic modelling was undertaken to estimate runoff hydrographs at various locations throughout the catchments of the relevant watercourses. The model was developed using the Watershed Bounded Network Model Version 2019 (WBNM). WBNM is an industry standard rainfall-runoff routing software package.

4.1.1 Catchment Characterisation

The catchment of Blackwater Creek contains the catchments of Two Mile Gully and Taurus Creek. Two Mile Gully is a tributary of Taurus Creek.

Simliarly, the catchment of Sirius Creek contains the catchment of the unnamed tributary which was identified as a relevant watercourse.

A summary of the key catchment characteristics under pre-mining conditions of each relevant watercourse, as applied in the WBNM model, are provided in **Table 3**.

Table 3 Pre-mining Catchment Characteristics

Catchment	Area (km²)	Main Stream Length (km)
Blackwater Creek	760	57
Taurus Creek	297	22
Two Mile Gully	172	23
Sirius Creek	146	23
Unnamed Tributary of Sirius Creek	61	11

A fraction impervious of 0% was adopted for the model area based on the existing catchment conditions outside the BWM extents and pre-mining conditions within the BWM extent.

The WBNM model layout is illustrated in **Figure 3**.

4.1.2 Storm Events

The 1% and 0.1% Annual Exceedance Probability (AEP) events were simulated using the hydrologic model. For each AEP event, a range of storm durations and temporal patterns were simulated.

The 0.1% AEP event was the primary design storm event for this assessment. In accordance with ARR, the Probable Maximum Flood (PMF) temporal pattern was adopted for the 0.1% AEP event. ARR recommends the Generalised Short Duration Method (GSDM) for events with a duration up to 6 hours, and the Revised Generalised Tropical Storm Method (GTSMR) for durations of 24 hours or more. There is no set guidance for which method to adopt for storms with durations between 6 and 24 hours, therefore the GSDM temporal pattern was adopted for all durations up to and including the 12 hour duration, and the GTSMR temporal patterns for durations of between 12 hours and 72 hours.

680000 690000 700000 710000

7390000 7380000 7370000 7360000 7350000

Dumout
BWC11
BWC10
SGC02
BWCTB02
BWC09
SGC01
BWCTB01
BWCTC01
TMG08
BWC08
TMGTB01
TMG07
BWC07
TMG06
DPC02
DPC03
BWC06
DPC01
TMG05
TAC03
DPCT01
STC03
TAC02
BWC05
TMGTC03
TACT01
TMG04
TAC01
TMGTA03
BWC04
STC02
TMGTD01
TMGTC02
TMG03
TMGTC01
TMGTA02
STC01
BWC03
STCT01
SRCT01
TMG02
TMGTA01
SRCT02
BWC02
TMG01
SRC01
SRSCTD01
SRC02
SRC03
BWCTA01
SRSCTC01
BWC01
SRC04
SRSCTB01
SRSCTC02
SRSCTF01
SRSC01
SRSCTB02
SRSCTE01
SRSC02
SRSC06
SRSC03
SRSC05
SRSC04
SRSCTA01
SRSCTA02

0 1 2 4 km

LEGEND

BWM Mine Lease Extents

WBNM Catchment Boundaries

Coordinate System:	GDA 1994 MGA Zone 55
Scale:	1:150,000 at A3
Project Number:	620.31051.00000
Date:	18-Sep-2023
Drawn by:	HM

SLR

BLACKWATER MINE PRCP
VOIDS IN FLOODPLAIN MODELLING

WBNM Model Layout

FIGURE 3

Service Layer Credits: Source: Esri, Maxar, Earthstar

H:\Projects-SLR\620-BNE\620-BNE\620.31051.00000 GRM BWM PRCP Voids in Floodplain Modelli\06 SLR Data\01 CADG\SIG\SIFigures\BWM\620310 51_BWM_Figure03_WBNM_A3P_02.mxd

4.1.3 Intensity-Frequency-Duration Rainfall Data

Rainfall Intensity-Frequency-Duration (IFD) data for the catchment was sourced from the BoM online IFD data portal for a range of AEPs.

Table 4 Design Rainfall Intensity Frequency Duration Data

Storm Duration (min)	Design AEP Event Rainfall Depth (mm)	
	1%	0.1%
60	85.7	140
90	98	160
120	107	175
180	120	197
270	134	221
360	145	239
540	162	268
720	176	291
1080	197	326
1440	215	352

4.1.4 Losses

An initial loss of 0 mm was applied given the expected antecedent catchment conditions in the 1% and 0.1% AEP events. A continual loss value of 1.3 mm/h was applied based on the data provided by the ARR Data Hub for the area.

4.1.5 Lag Parameter

A catchment lag parameter of 1.40 was adopted in the WBNM model. The WBNM documentation recommends that a lag parameter value between 1.30 and 1.80 is suitable for most catchments, therefore the value was within the recommended range.

4.1.6 Aerial Reduction Factor

Aerial reduction factors (ARF) were applied in the model based on the catchment area of the Blackwater and Sirius Creek catchment areas (refer Table 3). The model was simulated for each catchment with the appropriate ARF applied.

4.2 Validation

Results of the model were verified against peak flows produced by Quantile Regression Technique (QRT) calculations and Regional Flood Frequency Estimation (RFFE). The validation was carried out at focal points on the relevant watercourses, as illustrated in **Table 5.**

Table 5 WBNM Model Validation Results

Location	WBNM (m^3/s)	QRT (m^3/s)	RFFE (m^3/s)	RFFE Lower Confidence Limit (5%) (m^3/s)	RFFE Upper Confidence Limit (95%) (m^3/s)
BWC11 (Blackwater Creek downstream)	1,916	1,640	868	214	3,160
SRSC06 (Sirius Creek downstream)	625	507	536	180	2,500

As shown in **Table 5**, the peak flows produced by the WBNM model were comparable to the results of the QRT calculations, and RFFE. The WBNM model produced higher peak flows when compared to the flood estimations from QRT and RFFE, although the peak flows were comfortably within the upper confidence limit of the RFFE results.

Based on the above information and findings, the WBNM model was considered appropriate for use for the purposes of the assessment.

4.3 Results

The critical storm duration and peak flow produced for the 0.1% AEP event by the WBNM model at key reporting locations are detailed in **Table 6**.

Table 6 WBNM Model Results – Catchment Outlet Peak Flows and Critical Durations

Location	0.1% AEP Results	
	Flow (m^3/s)	Crit Dur (h)
BWC11	3,307	9
TMG07	1,457	9
SRSC06	1,005	6
SRC04	446	6

The flow hydrographs for all simulated storm events were extracted from the WBNM model and utilised as inflow conditions for the hydraulic model, as detailed in **Section 5.0**.

5.0 Hydraulic Modelling

5.1 Software

Hydraulic modelling was undertaken for the relevant watercourses.

The industry standard hydrodynamic modelling software TUFLOW (build 2023-03-AB) was utilised for the hydraulic modelling.

Details of the modelling approach, setup and results are provided below.

5.2 Model Extents

As outlined above, it was necessary to undertake hydraulic modelling of all relevant watercourses for the purposes of the assessment. This was achieved by developing two hydraulic models, identified as follows:

- **Two Mile Gully Model** covering:
  - Two Mile Gully
  - Taurus Creek
  - Blackwater Creek
- **Sirius Creek Model** covering:
  - Sirius Creek.
  - Unnamed tributary of Sirius Creek

5.3 Topography

The Two Mile Gully model topography was based on the provided BWM 1m LiDAR DEM. This was appropriate given the relevant watercourses were located outside the BWM extents, and the LiDAR data provided the most accurate representation of existing terrain in these areas. Local terrain modifications were applied to accurately represent the crest levels of Blackwater Rolleston Road at crossing locations.

The Sirius Creek model topography was based on the Fitzroy River 25m DEM data. The watercourses of Sirius Creek and the unnamed tributary of Sirius Creek are primarily located within the BWM mine extents. Therefore, the BWM 1m LiDAR DEM does not provide an accurate representation of the pre-mining terrain in these areas and could not be utilised.

As outlined above, the topography for each model was based on the best available data, and the model results are therefore limited to the accuracy of the adopted data.

5.4 Model Grid Cell Size

For the Two Mile Gully model, a grid cell size of 10m was adopted. A sub-grid sampling distance of 1m was adopted. This approach provided adequate resolution of waterway area and provided utilisation of the underlying 1m DEM.

For the Sirius Creek model a 25m grid cell size was adopted, which was the highest resolution available given the adopted 25m DEM was the underlying terrain data.

5.5 Hydraulic Roughness

The hydraulic roughness for the model was determined based on available aerial imagery. The Manning's n values adopted for the various land uses in the model are detailed in **Table 7**.



Table 7 TUFLOW Model Manning's n Values

Land use	Manning's n
Light Vegetation	0.06
Dense Vegetation	0.08
Sparsely Vegetated Creeks / Waterways	0.05
Water Surface / Hardstand	0.02

5.6 Boundaries

Flow hydrographs extracted from the WBNM model were applied as inflows to the TUFLOW models. They were applied as local or total hydrographs where appropriate.

Stage-discharge relationships were applied as the downstream boundary conditions in each model. The relationships were derived based on the flood surface gradient at each boundary location using the built-in functionality provided in TUFLOW.

In the Two Mile Gully model, the downstream boundary is located approximately 5.5 km downstream of the nearest final void. The boundary is also situated downstream of Blackwater Rolleston Road which acts as a significant hydraulic control. Peak flood levels at the downstream boundary were approximately 8 m lower than at the nearest final void location.

Similarly, in the Sirius Creek model the downstream boundary was located approximately 13 km downstream of the BWM extents, and peak flood levels at the boundary were approximately 40 m lower than in the vicinity of BWM.

Therefore, the downstream boundaries do not affect peak flood levels in the vicinity of the BWM final voids.

690000

700000

7390000

7380000

7370000

0 0.5 1 2 km

Coordinate System:	GDA 1994 MGA Zone 55
Scale:	1:75,000 at A3
Project Number:	620.31051.00000
Date:	20-Sep-2023
Drawn by:	HM

LEGEND

- BWM Mine Lease Extents
- Model Extent
- SA Inflows
- Downstream Boundary
- Culverts

BLACKWATER MINE PRCP
VOIDS IN FLOODPLAIN MODELLING

TUFLOW Model Layout
Two Mile Gully

FIGURE 4

Service Layer Credits: Source: Esri, Maxar, Earthstar

H:\Projects-SLR\620-BNE\620-BNE\620.31051.00000 GRM BWM PRCP Voids in Floodplain Modelling\06 SLR Data\01 CADG\SIG\SIFigures\BWM\620310 51_BWM_Figure04_TUFLOW_TMG_A3P_01.mxd

680000

690000

7370000

7360000

7350000

7340000

0 0.75 1.5 3 km

Coordinate System:	GDA 1994 MGA Zone 55
Scale:	1:100,000 at A3
Project Number:	620.31051.00000
Date:	20-Sep-2023
Drawn by:	HM

LEGEND

- BWM Mine Lease Extents
- Model Extent
- SA Inflows
- Downstream Boundary
- Reporting Locations

BLACKWATER MINE PRCP
VOIDS IN FLOODPLAIN MODELLING

TUFLOW Model Layout
Sirius Creek

FIGURE 5

Service Layer Credits: Source: Esri, Maxar, Earthstar

H:\Projects-SLR\620-BNE\620-BNE\620.31051.00000 GRM BWM PRCP Voids in Floodplain Model\06 SLR Data\01 CADGIS\GIS\Figures\BWM\620.31051_BWM_Figure05_TUFLOW_SRC_A3P_01.mxd

5.7 Results

The TUFLOW models were simulated for the 0.1% AEP event for a range of storm durations, including the critical storm durations as detailed in **Table 6**.

Peak flood levels, depths and velocities were extracted from the model results and are presented in **Appendix A** and **Appendix B** for Two Mile Gully and Sirius Creek respectively.

The floodplain extent for BWM, that is the modelled 0.1% AEP inundation extent, is illustrated in **Figure 6**. **Figure 7** and **Figure 8** illustrate the floodplain extents in the vicinity of Two Mile Gully and Sirius Creek respectively.

The Sirius Creek model results show the Laleham residual void is partially situated within the 0.1% AEP inundation extent, as shown in **Figure 8**.

The model results also show that the Togara/North Marshmead residual void is marginally affected by the 0.1% AEP event inundation extent, however this occurs in a reach of Sirius Creek where the watercourse stream order is less than 4, and therefore is acceptable in accordance with the requirements of the PRCP Guidelines.

670000 680000 690000 700000 710000

7380000 7370000 7360000 7350000 7340000

Ramp 8

Bonnie Doon

Mimosa / Besgrove

Deep Creek

Stewarton / Ballamoo

Kenmare

Laleham

Togara / North Marshmead

South Marshmead

Comet Downs East

Kennedy West

0 1 2 4 km

LEGEND

BWM Mine Lease Extents

Residual Void Extents

0.1% AEP Inundation Extent

Coordinate System:	GDA 1994 MGA Zone 55
Scale:	1:150,000 at A3
Project Number:	620.31051.00000
Date:	11-Sep-2024
Drawn by:	HM

SLR

BLACKWATER MINE PRCP VOIDS IN FLOODPLAIN MODELLING

TUFLOW Model Results
Modelled Inundation Extent
0.1% AEP Event

FIGURE 6

Service Layer Credits:

H:\Projects-SLR\620-BNE\620.31051.00000 GRM BWM PRCP Voids in Floodplain Model\06 SLR Data \01 CADGIS\GIS\Figures\BWM\620310 51_BWM_Figure06_Floodplain_All_withoutSA710_A3P_03.mxd

690000

7380000

7370000

Mimosa /
Besgrove

Deep
Creek

Stewarton
/ Ballamoo

0 0.5 1 2 km

LEGEND

- BWM Mine Lease Extents
- Model Extent
- Residual Void Extents
- 0.1% AEP Inundation Extent

Coordinate System:	GDA 1994 MGA Zone 55
Scale:	1:60,000 at A3
Project Number:	620.31051.00000
Date:	11-Sep-2024
Drawn by:	HM

SLR

BLACKWATER MINE PRCP
VOIDS IN FLOODPLAIN MODELLING

TUFLOW Model Results
Two Mile Gully Inundation Extent
0.1% AEP Event

FIGURE 7

Service Layer Credits: Source: Esri, Maxar, Earthstar

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690000

7360000

Stewarton
/ Ballamoo

Kenmare

Laleham

Togara
/ North
Marshmead

7350000

0 0.325 0.65 1.3 km

LEGEND

- BWM Mine Lease Extents
- Model Extent
- Residual Void Extents
- 0.1% AEP Event Inundation Extent

Coordinate System:	GDA 1994 MGA Zone 55
Scale:	1:40,000 at A3
Project Number:	620.31051.00000
Date:	11-Sep-2024
Drawn by:	HM

SLR

BLACKWATER MINE PRCP
VOIDS IN FLOODPLAIN MODELLING

TUFLOW Model Results
Sirius Creek Inundation Extent
0.1% AEP Event

FIGURE 8

Service Layer Credits: Source: Esri, Maxar, Earthstar

H:\Projects-SLR\620-BNE\620.31051.00000 GRM BWM PRCP Voids in Floodplain Model\06 SLR Data\01 CADGIS\GIS\Figures\BWM\620.31051_BWM_Figure08_Floodplain_SRC_withoutSA710_A3P_03.mxd

6.0 Groundwater Impact on Floodplain Extents

Consideration was made to the potential effects of groundwater on the floodplain extents. The floodplain extents were based on the peak 0.1% AEP event flood levels. During a flood event of this magnitude, any groundwater interaction with surface water would have a negligible impact on the resulting floodplain extents.

7.0 Conclusion

As part of the PRCP for Blackwater Mine, it is proposed to incorporate eleven final voids as NUMAs. Therefore, in accordance with the EP Act and EP Regulation and specifically section 3.4 of the PRCP Guideline, floodplain modelling has been undertaken for all relevant watercourses that may affect the voids.

Data for the assessment was provided by WB, and sourced from various public providers. The data was reviewed and modified for use where appropriate. Model landforms were developed to account for relevant artificial features outside of the BWM mine extents, and pre-mining topography within the mine extents based on the information available at the time of the study.

A hydrologic model was developed for the BWM covering the catchments of the relevant watercourses in the area, based on the Strahler stream order classification system in accordance with the PRCP Guideline. The model results were verified against peak flows generated by flood frequency estimates.

Hydraulic models were developed for Two Mile Gully, including Taurus Creek, and Sirius Creek. Hydrographs from extracted from the hydrologic models at relevant locations were applied as inflows to the hydraulic models.

The results of the hydraulic models provided the predicted 0.1% AEP flood event inundation extent based on the model landform. Predicted peak flood levels and depths were also produced by the hydraulic models. The results showed the proposed NUMA voids are located outside the floodplain, with the exception of the Laleham void.



8.0 Limitations

This report, including the hydrologic and hydraulic modelling, is not necessarily suitable for application for purposes other than as detailed above.

This Voids in Floodplain Assessment has relied upon, and assumed accurate, information which was received from WB and other sources. Except where noted, no verification of accuracy of the information has been carried out. In the event that some of the information which was relied upon for this assessment is found to be inaccurate, then some or all of the findings may change.

Although the analyses undertaken as detailed in this report were done so with the appropriate care and professionalism, this report shall only be used for the purposes intended. The analyses detailed in the sections above were undertaken solely for the purpose of addressing the requirements for voids in floodplain modelling for Blackwater Mine in accordance with:

- *Environmental Protection Act 1994;*
- *Environmental Protection Regulation 2019;*
- *'Information Sheet – Environmental Protection Act 1994 – Voids in Flood Plains, Version 1.01', Department of Environment and Science, February 2024; and*
- *'Guideline – Progressive Rehabilitation and Closure Plans, Version 3', Department of Environment and Science, April 2023.*

This report should be read in full and no excerpts are to be taken as representative of the findings. This report has been prepared on behalf of Whitehaven Blackwater Pty Ltd and SLR accepts no liability or responsibility whatsoever for, or in respect of, any use of, or reliance upon, this report by any third party.

Appendix A TUFLOW Model Results – Two Mile Gully

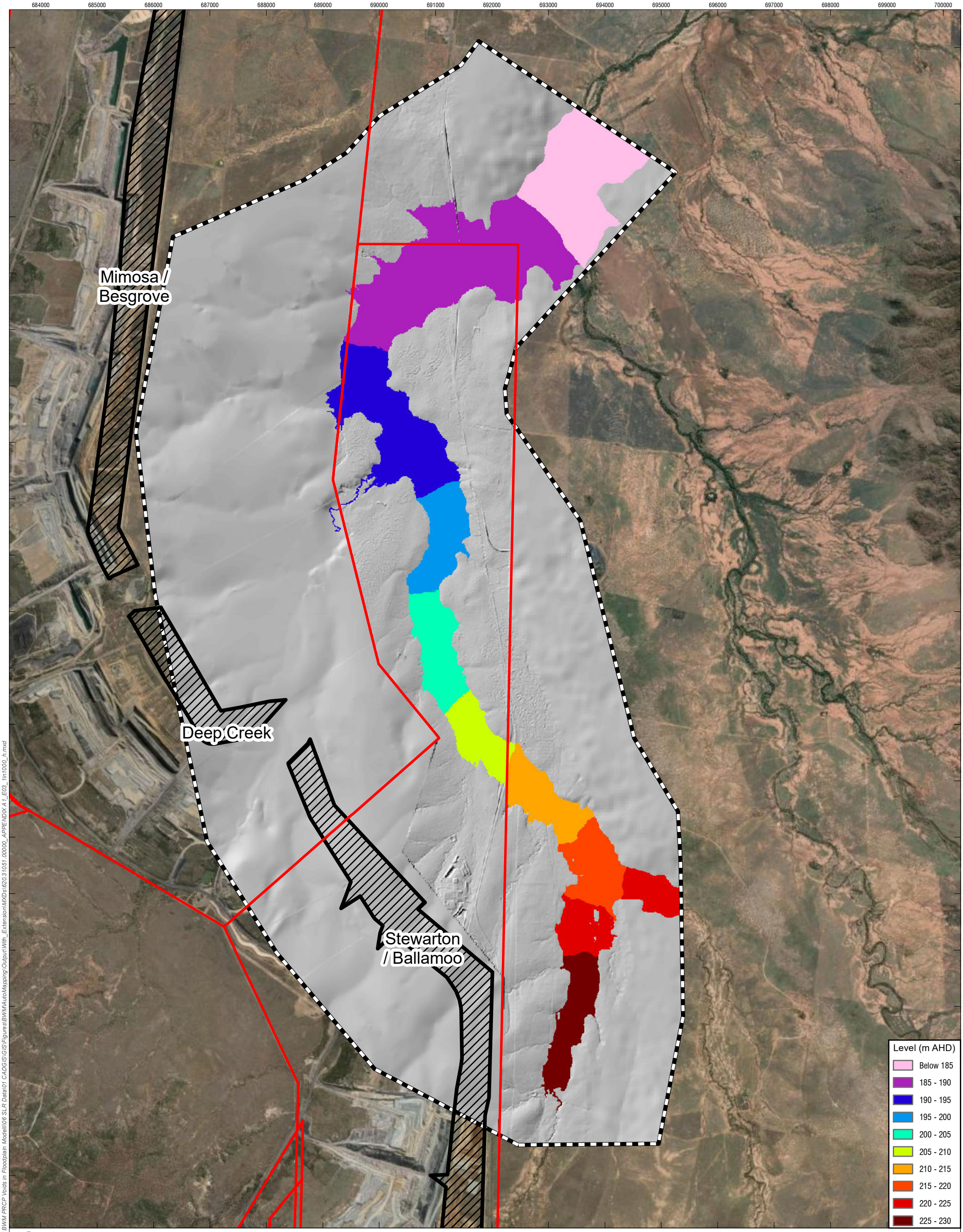
Blackwater Mine Progressive Rehabilitation and Closure Plan

Voids in Floodplain Modelling

Whitehaven Blackwater Pty Ltd

SLR Project No.: 620.31051.00000

10 October 2024



H:\Projects-SLR\620-BNE\620.31051.00000 GRM BWM PRCP Voids in Floodplain Modelling\06 SLR Data\01 CADG\SIG\SIFigures\BWMAutoMapping\Output\With_Extension\MXDs\620.31051.00000_APPENDIX A1_E03_1in1000_h.mxd

0 0.5 1 2 km

Coordinate System:	GDA 1994 MGA Zone 55
Scale:	1:60,000 at A3
Project Number:	620.31051
Date:	11-Mar-2024
Drawn by:	HM

LEGEND

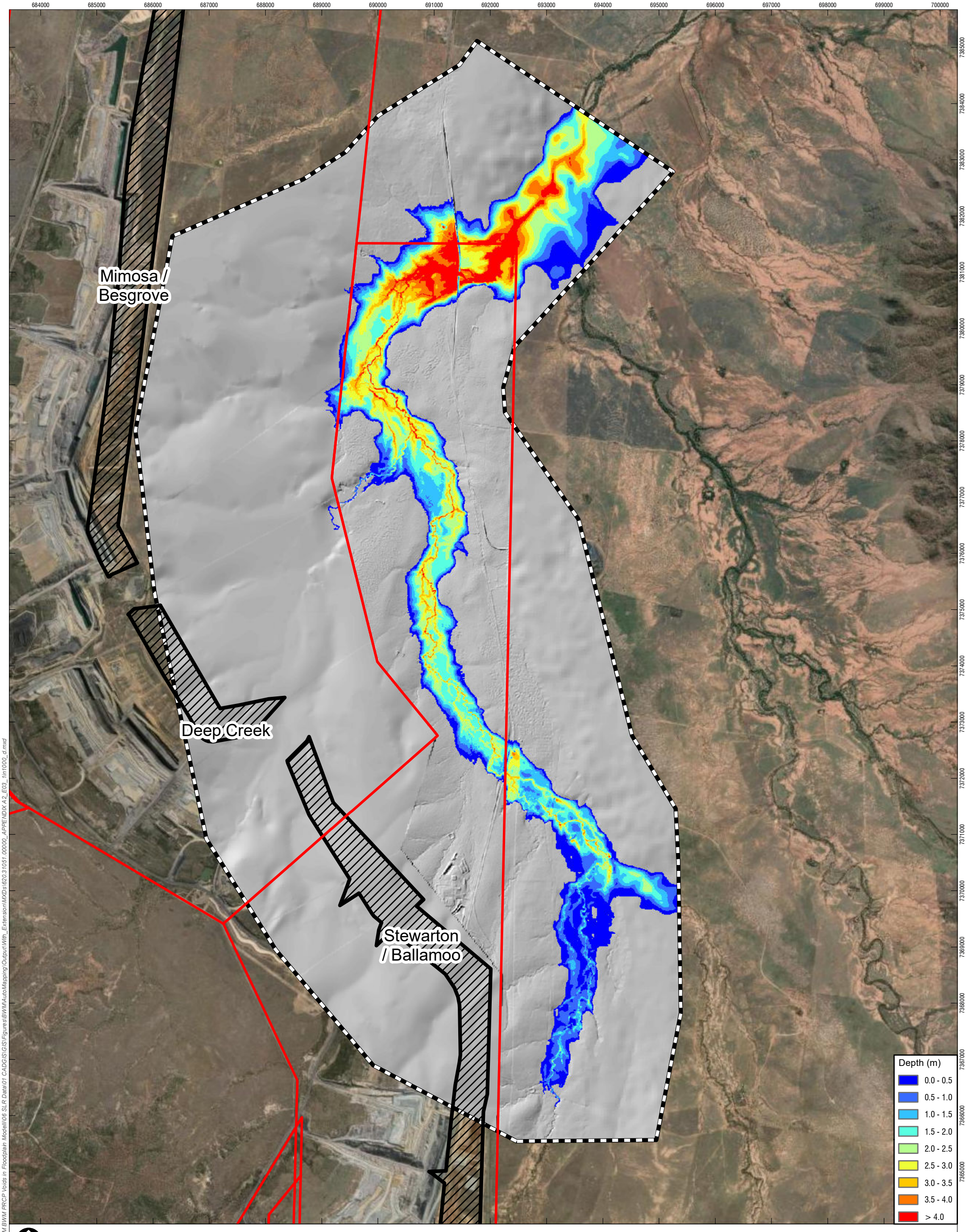
- BWM Mine Lease Extents
- TUFLOW Model Extent
- Residual Voids

SLR

BWM PRCP
Voids in Floodplain Modelling

Two Mile Gully
Peak Flood Levels - 0.1% AEP

APPENDIX A1



0 0.5 1 2 km

LEGEND

- BWM Mine Lease Extents
- TUFLOW Model Extent
- Residual Voids

Coordinate System:	GDA 1994 MGA Zone 55
Scale:	1:60,000 at A3
Project Number:	620.31051
Date:	11-Mar-2024
Drawn by:	HM

SLR

BWM PRCP
Voids in Floodplain Modelling

Two Mile Gully
Peak Flood Depths - 0.1% AEP

APPENDIX A2

H:\Projects-SLR\620-BNE\620.31051.00000 GRM BWM PRCP Voids in Floodplain Modelli\06 SLR Data\01 CADGIS\GIS\Figures\BWMAutoMapping\Output\With_Extension\MXDs\620.31051.00000_APPENDIX A2_E03_1in1000_d.mxd

684000 685000 686000 687000 688000 689000 690000 691000 692000 693000 694000 695000 696000 697000 698000 699000 700000

7385000 7384000 7383000 7382000 7381000 7380000 7379000 7378000 7377000 7376000 7375000 7374000 7373000 7372000 7371000 7370000 7369000 7368000 7367000 7366000 7365000

Mimosa / Besgrove

Deep Creek

Stewarton / Ballamoo

Velocity (m/s)
- 0.0 - 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 2.5
- > 2.5

0 0.5 1 2 km

LEGEND
- BWM Mine Lease Extents
- TUFLOW Model Extent
- Residual Voids

Coordinate System:	GDA 1994 MGA Zone 55
Scale:	1:60,000 at A3
Project Number:	620.31051
Date:	11-Mar-2024
Drawn by:	HM

SLR

BWM PRCP
Voids in Floodplain Modelling

Two Mile Gully
Peak Flood Velocities - 0.1% AEP

APPENDIX A3

H:\Projects-SLR\620-BNE\620.31051.00000 GRM BWM PRCP Voids in Floodplain Modelli\06 SLR Data\01 CADGIS\GIS\Figures\BWMAutoMapping\Output\With_ExtensionMXDs\620.31051-00000_APPENDIX A3_E03_1in1000_v.mxd

Appendix B TUFLOW Model Results – Sirius Creek

Blackwater Mine Progressive Rehabilitation and Closure Plan

Voids in Floodplain Modelling

Whitehaven Blackwater Pty Ltd

SLR Project No.: 620.31051.00000

10 October 2024

679000 680000 681000 682000 683000 684000 685000 686000 687000 688000 689000 690000 691000 692000 693000 694000 695000

7363000 7362000 7361000 7360000 7359000 7358000 7357000 7356000 7355000 7354000 7353000 7352000 7351000 7350000 7349000 7348000 7347000 7346000 7345000 7344000 7343000

Stewarton
/Ballamoo

Kenmare

Laleham

Togara
/ North
Marshmead

South
Marshmead

Level (m AHD)
- Below 230
- 230 - 235
- 235 - 240
- 240 - 245
- 245 - 250
- 250 - 255
- 255 - 260
- 260 - 265
- 265 - 270
- 270 - 275
- 275 - 280
- Above 280

0 0.5 1 2 km

LEGEND
- BWM Mine Lease Extents
- TUFLOW Model Extent
- Residual Voids

Coordinate System:	GDA 1994 MGA Zone 55
Scale:	1:60,000 at A3
Project Number:	620.31051
Date:	11-Sep-2024
Drawn by:	HM

BWM PRCP
Voids in Floodplain Modelling

Sirius Creek
Peak Flood Levels - 0.1% AEP

SLR

APPENDIX B1

H:\Projects-SLR\620-BNE\620.31051.00000 GRM BWM PRCP Voids in Floodplain Model\06 SLR Data\01 CAD\GIS\GIS\Figures\BWM\AutoMapping\Output\With_Extension\MXDs\620.31051.00000_APPENDIX B1_E01_1in1000_h.mxd

679000 680000 681000 682000 683000 684000 685000 686000 687000 688000 689000 690000 691000 692000 693000 694000 695000

7363000 7362000 7361000 7360000 7359000 7358000 7357000 7356000 7355000 7354000 7353000 7352000 7351000 7350000 7349000 7348000 7347000 7346000 7345000 7344000 7343000

Stewarton
/Ballamoo

Kenmare

Laleham

Togara
/ North
Marshmead

South
Marshmead

Depth (m)
- 0.0 - 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 2.5
- 2.5 - 3.0
- 3.0 - 3.5
- 3.5 - 4.0
- > 4.0

0 0.5 1 2 km

LEGEND
- BWM Mine Lease Extents
- TUFLOW Model Extent
- Residual Voids

Coordinate System:	GDA 1994 MGA Zone 55
Scale:	1:60,000 at A3
Project Number:	620.31051
Date:	11-Sep-2024
Drawn by:	HM

BWM PRCP
Voids in Floodplain Modelling

Sirius Creek
Peak Flood Depths - 0.1% AEP

SLR

APPENDIX B2

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679000 680000 681000 682000 683000 684000 685000 686000 687000 688000 689000 690000 691000 692000 693000 694000 695000

7363000 7362000 7361000 7360000 7359000 7358000 7357000 7356000 7355000 7354000 7353000 7352000 7351000 7350000 7349000 7348000 7347000 7346000 7345000 7344000 7343000

Stewarton
/Ballamoo

Kenmare

Laleham

Togara
/ North
Marshmead

South
Marshmead

Velocity (m/s)
- 0.0 - 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 2.5
- > 2.5

0 0.5 1 2 km

LEGEND
- BWM Mine Lease Extents
- TUFLOW Model Extent
- Residual Voids

Coordinate System:	GDA 1994 MGA Zone 55
Scale:	1:60,000 at A3
Project Number:	620.31051
Date:	11-Sep-2024
Drawn by:	HM

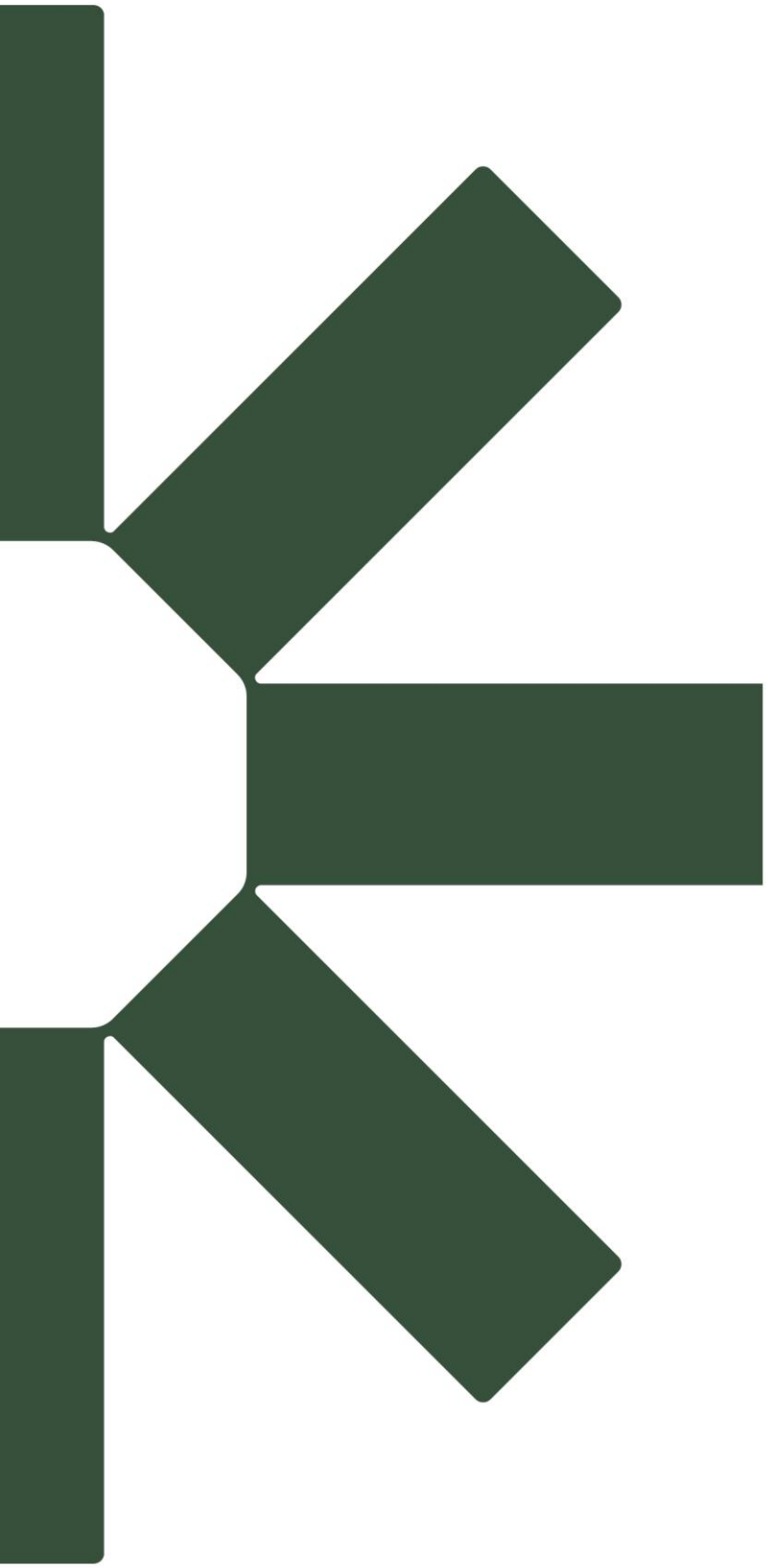
BWM PRCP
Voids in Floodplain Modelling

Sirius Creek
Peak Flood Velocities - 0.1% AEP

SLR

APPENDIX B3

H:\Projects-SLR\620-BNE\620.31051.00000 GRM BWM PRCP Voids in Floodplain Model\06 SLR Data\01 CADGIS\GIS\Figures\BWM\AutoMapping\Output\With_Extension\MXDs\620.31051.00000_APPENDIX B3_E01_1in1000_v.mxd



Making Sustainability Happen

Whitehaven

Appendix 4.6 – Rehabilitation Flood Assessments

Blackwater Mine

Progressive Rehabilitation and Closure Plan
Rehabilitation Flood Assessments

Whitehaven Blackwater Pty Ltd (WB)

Level 14, 480 Queen Street
Brisbane City QLD 4000

Prepared by:

SLR Consulting Australia

Level 16, 175 Eagle Street, Brisbane QLD 4000,
Australia

SLR Project No.: 620.040134.00000

10 October 2024

Revision: 2.1

Revision Record

Revision	Date	Prepared By	Checked By	Authorised By
2.1	30 July 2024	SM	MD	HM
2.0	27 September 2024	SM	MD	HM
2.1	10 October 2024	SM	MD	HM

Basis of Report

This report has been prepared by SLR Consulting Australia (SLR) with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with Whitehaven Blackwater Pty Ltd (WB) (the Client). Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

This report is for the exclusive use of the Client. No warranties or guarantees are expressed or should be inferred by any third parties. This report may not be relied upon by other parties without written consent from SLR.

SLR disclaims any responsibility to the Client and others in respect of any matters outside the agreed scope of the work.

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Appendices

Appendix A XP-RAFTS Model Set up Tables and Figures
Appendix B TUFLOW Model Setup Figures
Appendix C TUFLOW Model Results
Appendix D Flooding Risk Profile

Acronyms and Abbreviations

1D	One dimensional
2D	Two dimensional
AEP	Annual Exceedances Probability
ARF	Aerial Reduction Factor
ARR	Australian Rainfall and Runoff
BoM	Bureau of Meteorology
BWM	Blackwater Mine
DR	Department of Resources
DEM	Digital Elevation Model
EA	Environmental Authority
EP	Environmental Protection
FRP	Flooding Risk Profile
GSDM	Generalised Short Duration Method
GTSMR	Revised Generalised Tropical Storm Method
IFD	Intensity-Frequency-Duration
MFL	Maximum Foreseeable Loss
NUMA	Non-use Management Areas
PRCP	Progressive Rehabilitation and Closure Plan
PMLU	Post Mining Land Use
QRT	Quantile Regression Technique
RFFE	Regional Flood Frequency Estimate
RMG	Risk Management Guidelines
RRR	Residual Risk Rating
SA	Source Area
WB	Whitehaven Blackwater Pty Ltd
WBNM	Watershed Bounded Network Model

1.0 Introduction

Blackwater Mine (BWM) is located approximately 20 kilometres (km) south-west of Blackwater in the Bowen Basin, Queensland (**Figure 1**). BWM's Mining Leases (MLs) include ML1759, ML1760, ML1761, ML1762, ML1767, ML1771, ML1772, ML1773, ML1792, ML1800, ML1812, ML1829, ML1860, ML1862, ML1907, ML70091, ML70103, ML70104, ML70139, ML70167 and ML70329 (**Figure 1**).

BWM has been in operation since 1967 and operates in accordance with, amongst other authorisations, Environmental Authority (EA) EPML00717813, granted under the Environmental Protection Act 1994 (Qld) (EP Act). BWM produces up to 16 million tonnes per annum (Mtpa) of product coal.

1.1 Scope of Work

SLR was contracted by Whitehaven Blackwater Pty Ltd (WB) to support the preparation of the Blackwater Mine (BWM) Progressive Rehabilitation and Closure Plan (PRCP). Specifically, the scope of work involved undertaking flood modelling of BWM in accordance with Section 3.6.1 of 'Guideline – Progressive Rehabilitation and Closure Plans', Department of Environment and Science (DES) (The Guideline). Section 3.6.1 of The Guideline provides the following direction on general rehabilitation practices in relation to flooding:

- Consider the location of domains in relation to potential flood levels;
- Consider alteration of flow upstream and downstream;
- Model flood levels (including probable maximum flood levels) for a range of design storm events; and
- Develop a flooding risk profile.

This report details the assessments undertaken including hydrologic and hydraulic modelling of relevant watercourses at BWM to address the above points.

1.2 Site Details

Blackwater Mine, which covers an area of approximately 42,000 ha is located approximately 5 km south-west of the township of Blackwater, in the Bowen Basin, Queensland. Blackwater Mine is located in the catchment of the Fitzroy River.

A number of local watercourses traverse the site, including Sagittarius Creek, Bonnie Doon Creek, Burngrove Creek, Blackwater Creek, Taurus Creek, Two Mile Gully, Speculation Creek, Sirius Creek, and Rockland Creek. **Figure 1** shows the location of BWM and key surrounding features.

1.3 Relevant Documentation

This assessment was undertaken in accordance with the following guidelines and documentation:

- Environmental Protection Act 1994;
- Environmental Protection Regulation 2019;
- 'Guideline – Progressive Rehabilitation and Closure Plans, Version 3', Department of Environment and Science, April 2023 (PRCP Guideline);

- ‘Information Sheet – Environmental Protection Act 1994 – Voids in Flood Plains, Version 1.01’, Department of Environment and Science, February 2024 (Voids in Flood Plains Information Sheet);
- ‘Australian Rainfall and Runoff: A guide to Flood estimation’, Geoscience Australia, 2019 (ARR); and
- ‘Bowen Basin River Diversions – Design and Rehabilitation Criteria’, Australian Coal Association Research Program, July 2002 (ACARP 2002).

660000 670000 680000 690000 700000 710000 720000

7420000 7410000 7400000 7390000 7380000 7370000 7360000 7350000 7340000

Moranbah
Emerald
Rockhampton
Roma
Brisbane

Mackenzie River
Blackwater Creek
Jelli
Eas
Ensham
Curragh
Nogoa River
Comet River
Blackwater
Capricorn Highway
Duckworth Creek
Bluff
Comet
Thermal Coal Plant
ML 1759
ML 1760
ML 70104
ML 1762
ML 1800
ML 70103
ML 7357
ML 1812
ML 1772
ML 1860
ML 1771
ML 1907
ML 70139
ML 70167
ML 1767
BLACKWATER
Cook U.G.
ML 70329
ML 1862
ML 1792
ML 1773
ML 70091
ML 1829
Charlevue Creek
Mimosa Creek
Blackdown Tableland National Park
Blackwater - Rolleston Road
Humboldt Creek
Comet River Road
Planet Creek

0 1 2 4 6 Kilometers

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:250,000 at A3
Project Number:	620.014601
Date:	14/05/2024
Drawn by:	SM

LEGEND

- City/Town
- Coal Mine
- Railway
- Road
- Watercourse
- Mining Leases
- National Park
- Cadastre

Blackwater Mine PRCP Flood Assessment

Project Location

FIGURE 1

H:\Projects-SLR\620-BNE\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\General\Location_MapTemplate_A3P_v002.mxd

1.4 Assumptions and Limitations

This assessment was undertaken specifically for the purposes for undertaking floodplain modelling of relevant watercourses in accordance with the requirements of the EP Act and EP Regulation. The following assumptions and limitations apply to this assessment.

- The accuracy of the assessment is reliant on the accuracy of the utilised data, as detailed in **Section 3.0**. SLR has assumed all source data to be fit for purpose and sufficiently accurate for the purpose of this assessment. Except where noted, no verification of accuracy of the information has been carried out. In the event that some of the information which was relied upon for this assessment is found to be inaccurate, then some or all of the findings may change.
- Generation of the model landform for the assessment was undertaken in accordance with the PRCP Guidelines. Hydraulic modelling was undertaken only for the post-mining landform conditions.
- Although the analyses undertaken as detailed in this report were done so with the appropriate care and professionalism, this report shall only be used for the purposes intended. The analyses detailed in this report were undertaken solely for the purpose of addressing the requirements for general rehabilitation practices for Blackwater Mine in accordance with the relevant documentation as detailed in **Section 2.0**.
- This report should be read in full, and no excerpts are to be taken as representative of the findings. This report has been prepared on behalf of WB and SLR accepts no liability or responsibility whatsoever for, or in respect of, any use of, or reliance upon, this report by any third party.
- The Flood Risk Profile outlined in this report was undertaken specifically in accordance with the WB Risk Framework (refer **Appendix D**), and therefore may not be applicable with other risk assessment methodologies.
- The TUFLOW model results for velocity bed shear stress and stream power are calculated using a depth-averaged approach for each model grid cell. Results of the TUFLOW hydraulic model were therefore utilised for general indication (only) of watercourse stability. TUFLOW does not account for geomorphological processes including watercourse re-alignment, therefore the assessment was based on the assumption of static topographic conditions.
- Groundwater levels in the area will have no significant effect on the outcomes of the flood modelling.

1.5 Document Structure

The structure of this report is set out as follows:

- **Section 1** – Introduction
- **Section 2** – Relevant legislation and guidelines;
- **Section 3** – Data Review and Gap Analysis, including details of the model landform;
- **Section 4** – Hydrologic Modelling;
- **Section 5** – Hydraulic Modelling;
- **Section 6** – Flood Risk profile; and
- **Section 7** – Conclusions.

2.0 Legislation and Guidelines

2.1 Relevant Legislation and Guidelines

The relevant documentation for this assessment is detailed in **Section 1.3**. Key details in the context of the assessment are provided below.

Section 126D(3) of the Environmental Protection Act 1994 (Qld) (EP Act) relevantly states:

'If land the subject of the proposed PRCP schedule will contain a void situated wholly or partly in a flood plain, the schedule must provide for the rehabilitation of the land to a stable condition.'

Section 126D of the EP Act does not apply to the BWM PRCP by virtue of section 754(3) of the EP Act.

The Environmental Protection Regulation 2019 Section 41C(3) also states:

'*The administering authority must treat the land as a flood plain to the extent the results of the flood plain modelling show that, when all relevant activities carried out on the land have ended, the land is the same height as, or lower than, the level modelled as the peak water level 0.1% AEP for a relevant watercourse under the ARR*'

Further guidance is provided in the PRCP Guideline and the Voids in Flood Plains Information Sheet.

Sections 3.4 and 3.6.1 of the PRCP Guideline both require a floodplain assessment to be carried out. Specifically, Section 3.4 requires a Void in Floodplain assessment for all unapproved Non-Use Management Area (NUMA) voids (i.e. floodplain assessment of the pre-mining landform), whilst Section 3.6.1 requires a post-mining landform assessment irrespective whether a post-mining land use (PMLU) or NUMA is proposed. This assessment was undertaken only to address the requirements of Section 3.6.1.

The hydrologic and hydraulic analyses were undertaken in accordance with ARR 2019.

2.2 Applicability to the Project

Based on the review of the EP Act, EP Regulation, PRCP Guideline and the Voids in Floodplains Information Sheet, it is considered that the legislative requirements set out in **Table 1** are applicable to the project.

Table 1 Applicable Legislative Requirements

Requirement	Application to the Project	Source
For transitional sites, a floodplain assessment is required where: - A void has been identified as a NUMA in a land outcome document but the location has not been specified; or - Where there are no land outcomes in the land outcome document.	The PRCP for Blackwater Mine includes eleven final voids which are proposed to be developed as NUMAs. The voids are identified as a land outcome in the BWM EA. Therefore, floodplain assessment is required. A Voids in Floodplain assessment was previously undertaken by SLR as detailed in 'Blackwater Mine Progressive	PRCP Guideline Section 3.4

Requirement	Application to the Project	Source
	Rehabilitation and Closure Plan – Voids in Floodplain Report', 2024 (ref 620.31051.00000-R01-v3.0).	
The requirement for a flood assessment under Section 3.6.1 of the Guideline applies to the post mining landform across the whole site irrespective of whether a PMLU or a NUMA are proposed. Furthermore, Section 3.6.1 is not only required to indicate flood risk but also to demonstrate the final landform (including waste rock dumps and diversions) will remain in a stable condition in a range of flood flow conditions.	The PRCP for Blackwater Mine includes eleven final voids which are considered to be pre-approved NUMAs and therefore will be retained in the post-mining landform where it can be shown the voids are in a stable condition. Therefore, a flood assessment is required to show that the proposed voids will remain in a stable condition following the closure of BWM. The voids are: • Ramp 8 • Bonnie Doon • Mimosa/Besgrove • Deep Creek • Stewarton/Ballamoo • Kenmare • Togara/North Marshmead • South Marshmead • Laleham • Kennedy West • Comet Downs East The void locations are shown in **Figure 2**.	PRCP Guideline Section 3.6.1

2.3 Definitions and Terminology

Table 2 provides the definitions and terminology that are utilised in this assessment, in accordance with the PRCP Guideline and the Voids in Flood Plains Information Sheet.

Table 2 Definitions and Terminology

Term	Definition	Source
Voids	An area of land to be excavated in carrying out a mining activity. Therefore, all voids (PMLU or NUMA) are subject to the requirements of the EP Act.	Section 126D of the EP Act
Stable condition	• The land is safe and structurally stable;	Section 126D(3) of the EP Act; and PRCP Guideline Section 3.6.3.

Term	Definition	Source
	• There is no environmental harm being caused by anything on or in the land; and • The land can sustain a PMLU.	
Artificial feature	For land the subject of a PRCP schedule, means – (a) A structure or feature that is temporary and, under the PRCP schedule or otherwise, is to be removed from the land; or (b) A structure or feature that, under the PRCP schedule, will require a level of maintenance after the land is surrendered that is greater than the level of maintenance that would be required for the land if the relevant activities the subject of the PRCP schedule had not been carried out; or (c) A feature forming part of the landform of the land, other than the natural landform, if the feature interferes with or affects – (i) A relevant watercourse; or (ii) The natural flow of water on the land.	PRCP Guideline Section 8; and Voids in Flood Plains Information Sheet Section 6.

3.0 Data Review and Gap Analysis

3.1 Available Data

The following data was provided to SLR by WB for use in this assessment:

- Digital elevation model (DEM) of BWM proposed post-closure final landform (PRCP Landform).
- Existing topography for BWM (March 2023).
- XP-RAFTS hydrological models for Sagittarius Creek, Bonnie Doon Creek, Burngrove Creek, Blackwater Creek, Taurus Creek, Two Mile Gully, Speculation Creek, Sirius Creek, and Rockland Creek.
- TUFLOW Hydraulic models for Sagittarius Creek, Bonnie Doon Creek, Burngrove Creek, Blackwater Creek (including Taurus Creek and Two Mile Gully), Speculation Creek, Sirius Creek, and Rockland Creek.
- Blackwater Mine Flood Study (GHD 2021).
- WB Risk Assessment guidelines.

Additional data was obtained for publicly available sources as follows:

- 1 second SRTM Derived Hydrological Digital Elevation Model topographic data (Geoscience Australia).
- Rainfall intensity-frequency-duration (IFD) data for the area (Bureau of Meteorology (BoM)).
- Catchment specific hydrologic data (ARR Data Hub).
- ‘Bowen Basin River Diversions – Design and Rehabilitation Criteria’ (Australian Coal Association Research Program (ACARP), 2002).

3.2 Watercourses

A review of the available data was undertaken to identify the watercourse that may affect flooding conditions at BWM. The following watercourses were included in the assessment:

- Sagittarius Creek;
- Bonnie Doon Creek;
- Burngrove Creek;
- Blackwater Creek;
- Taurus Creek;
- Two Mile Gully;
- Speculation Creek;
- Sirius Creek; and
- Rockland Creek.

3.3 Landform

For the purposes of the hydrologic modelling, a landform DEM was developed which utilised the following topographic datasets, layered in order from bottom to top:

- SRTM DEM (outside BWM extents only);
- Overview DEM (1 m resolution) covering wider catchments around BWM (2022);
- Existing topography (1 m resolution) for BWM (March 2023); and
- BWM PRCP Landform DEM (1 m resolution).

3.4 Previous Studies

Existing scenario hydrologic and hydraulic models of the BWM site were developed for the Blackwater Mine Flood Study (GHD 2021). SLR reviewed the report along with these models to assess their suitability for use in this project.

Hydrologic modelling had been undertaken for each of the watercourses at the site (**Section 3.2**) using XP-RAFTS. Review of these models found them to be of adequate detail and able to produce reasonable results for the existing site conditions. The flood study details calibration of the Speculation Creek and Burngrove Creek models. These calibrations were used to determine parameters for the entire site and it was stated that variability in catchment conditions may exist. Validation was also carried out in the flood study for the Speculation Creek and Burngrove Creek hydrologic models, which showed reasonable comparisons with empirically determined peak flow estimates. While limitations in the hydrologic modelling calibration and validation processes were noted, the XP-RAFTS models were considered appropriate for use in this assessment.

The flood study utilised TUFLOW for existing scenario hydraulic modelling. The site was modelled in seven separate model domains, as follows:

- Sagittarius Creek;
- Bonnie Doon Creek;
- Burngrove Creek;
- Blackwater Creek (including Taurus Creek and Two Mile Gully);
- Speculation Creek;
- Sirius Creek; and
- Rockland Creek.

While no verification was included in the flood study, review of the TUFLOW models revealed the models produced reasonable results.

It was concluded that the existing XP-RAFTS and TUFLOW models developed for the flood study were suitable for use in this assessment and were therefore adopted.

4.0 Hydrologic Modelling

4.1 Software

The existing XP-RAFTS hydrologic models for the BWM catchments were adapted for this assessment. These models were provided by WB and assumed to be fit for purpose and sufficiently accurate. XP-RAFTS version 2018.1.1 was adopted to estimate runoff hydrographs through the BWM project site. XP-RAFTS is an industry standard rainfall-runoff routing program. Storm Injector Version 1.3.9 was utilised to assist in setup and analysis of ARR 2019 design storm ensembles and to review model results.

4.2 Model Setup

4.2.1 Catchment

The hydrologic model covers a total of 1043 km^2. Sub-catchments for the XP-RAFTS model were delineated based on the model landform DEM detailed in **Section 3.3**. An overview of the XP-RAFTS model layouts is shown in **Figure 2**.

The total catchment area for each watercourse is detailed in **Table 3**. As the modelling represents a post-closure scenario, it was assumed that the entire catchment would be in a fully rehabilitated or natural state. Therefore, all of the catchments were modelled as fully pervious.

Table 3 XP-RAFTS Model Catchment Areas

Catchment	Total Area (km^2)
Sagittarius Creek	42.31
Bonnie Doon Creek	20.88
Burngrove Creek	84.33
Blackwater Creek	255.5
Taurus Creek	147.1
Two Mile Gully	118.5
Speculation Creek	61.55
Sirius Creek	158.0
Rockland Creek	155.1
Total	**1,043**

670000 680000 690000 700000 710000

7390000 7380000 7370000 7360000 7350000 7340000

Ramp 8
Bonnie Doon
Mimosa / Besgrove
Deep Creek
Stewarton / Ballamoo
Kenmare
Laleham
Togara / North Marshmead
South Marshmead
Comet Downs East
Kennedy West

Sandy Creek
Burngrove Creek
Bonnie Doon Creek
Sagittarius Creek
Bullock Creek
Maria Creek
Tolmie Creek
Cabbagetree Creek
Duckworth Creek
Bluff Creek
Rufus Creek
Walton Creek
Bone Creek
Spring Creek
Eight Mile Creek
Taurus Creek
Charlevue Creek
Blackwater Creek
Two Mile Gully
Stony Creek
Triumph Creek
Speculation Creek
Horse Plain Creek
Ten Mile Creek
Mimosa Creek
Planet Creek
Ballamoo Creek
Sirius Creek
Dogyard Gully
Rockland Creek
Dry Creek
Blackshale Creek
Red Rock Gully
Shotover Creek

0 1 2 4 Kilometers

LEGEND

- Final Void Area
- Watercourse
- Mining Leases
- Bonnie Doon
- Burngrove
- Sagittarius
- Taurus
- Two Mile Gully
- Speculation
- Rockland
- Sirius
- Blackwater

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:175,000 at A3
Project Number:	620.014601
Date:	14/05/2024
Drawn by:	SM

SLR

Blackwater Mine PRCP Flood Assessment

XP-RAFTS Overall Model Layouts

FIGURE 2

H:\Projects-SLR\620-BNE\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\RAFTS\RAFTS_OVERALL_MapTemplate_NSA_A3P_v002.mxd

4.3 Design Storm Analysis

4.3.1 Design Storm Events

The XP-RAFTS model was simulated for the 39%, 2%, 1%, 0.1% Annual Exceedance Probability (AEP), and PMP events. Storm durations between 1 hour to 36 hours and ten temporal patterns for each duration were run in accordance with ARR 2019.

For each AEP-duration combination, the design storm temporal pattern which produced a peak flow nearest to the mean peak flow of the suite of 10 temporal patterns was adopted as the design storm. Preference was given to flows greater than the mean, with a bias factor of 2 applied. The adopted temporal pattern event for each creek was selected based on the focal points in the waterways as given in **Table 4**.

Table 4 XP-RAFTS Model – Adopted Focal Points for Temporal Pattern Selection

Catchment	Node ID
Sagittarius Creek	603
Bonnie Doon Creek	180
Burngrove Creek	652
Blackwater Creek	N/A*
Taurus Creek	4522, 4598
Two Mile Gully	4237
Speculation Creek	689
Sirius Creek	621
Rockland Creek	719

* The Blackwater Creek, Taurus Creek and Two Mile Gully XP-RAFTS model areas are combined in one hydraulic model, with the proposed voids being located within the Taurus and Two Mile Gully regions. Therefore, the Blackwater Creek was not used a focal point. Instead, the temporal patterns for Blackwater Creek were adopted from the Taurus Creek and Two Mile Gully focal points.

4.3.2 Intensity-Frequency-Duration Data

Rainfall Intensity-Frequency-Duration (IFD) data for the catchment was sourced from the Bureau of Meteorology (BoM) online IFD data portal. The IFD data adopted in the model is provided in **Table A-1** in **Appendix A.**

4.3.3 Losses

Rainfall initial losses for the catchment were sourced from the ARR Online DataHub. The initial loss for each design storm event was calculated by subtracting the median pre-burst rainfall depth from the global catchment initial loss, in accordance with the methodology outlined in ARR. A continuing loss of 1.2 mm/h was adopted for all events as per the Blackwater Mine Flood Study (GHD 2021).

No initial losses were adopted for events rarer than the 1% AEP event and the adopted global initial loss values for other AEP events are shown in **Table 5**.

Table 5 Design Rainfall Initial Losses

Catchment	Initial Loss (mm)
Sagittarius Creek	30
Bonnie Doon Creek	30
Burngrove Creek	38
Blackwater Creek	36
Taurus Creek	42
Two Mile Gully	42
Speculation Creek	51
Sirius Creek	51
Rockland Creek	51

4.3.4 Lag Links

The lag links in the XP-RAFTS model were maintained from the existing models. Where there were new sub-catchments, the lag links were calculated based on a velocity ranging from 1.5 m/s to 1.8 m/s as described in the BWM Flood Study (GHD 2021).

4.3.5 Temporal Patterns

Ten temporal patterns for each storm duration were run in accordance with ARR 2019. The temporal patterns adopted for each AEP event is listed in **Table 6**. For catchments larger than 75 km^2, areal temporal patterns were used from the 12 hour duration events and point temporal patterns were adopted for storms shorter than 12 hours. For the 0.1% AEP events, the Generalised Short Duration Method (GSDM) and Revised Generalised Tropical Storm Method (GTSMR) temporal patterns were adopted, as per ARR 2019 recommendations.

Table 6 Adopted Temporal Patterns

AEP event	Temporal Pattern
39%	Frequent
2%	Rare
1%	Rare
0.1%	GSDM and GTMSR

4.3.6 Areal Reduction Factor

The Areal Reduction Factor (ARF) was calculated for each design storm event in accordance with ARR 2019 for the most downstream point of each catchment, as per the BWM Flood Study (GHD 2021). The ARF value for the 50% AEP event was applied to the 39% AEP event, as this was the closest AEP; note that there was no significant difference between 50% and 20% AEP ARF values for all durations. All of the ARF values are listed in **Table A-2** in **Appendix A**.

4.3.7 Probable Maximum Precipitation Event

A Probable Maximum Precipitation (PMP) analysis was undertaken. The PMP rainfall depths from the BWM Flood Study were reviewed. The short duration event (less than 24 hours) values for Sirius Creek did not appear to align with the other catchments. SLR undertook an assessment of the PMP rainfall depths for Sirius Creek, the results of which were adopted for the PRCP hydrology as they aligned well with the BWM Flood Study values for the other catchments.

The largest depths of all the other catchments for each duration were adopted for Blackwater Creek. PMP Rainfall depths were adopted for both the GSDM and GTSMR. The PMP rainfall depths are listed in **Table 7**.

Table 7 PMP Rainfall Depths for Design Storm Durations

Catchment	Rainfall Depth (mm)					
	1 hour	6 hours	12 hours	18 hours	24 hours	72 hours
Sagittarius Creek	360	650	820	900	990	1780
Bonnie Doon Creek	360	690	840	920	990	1790
Burngrove Creek	330	620	800	890	980	1760
Blackwater Creek	410	800	880	920	990	1790
Taurus Creek	310	590	780	870	960	1730
Two Mile Gully	410	800	880	920	950	1700
Speculation Creek	340	630	800	880	960	1740
Sirius Creek	130	250	600	770	950	1690
Rockland Creek	300	580	760	860	950	1690
Sirius Creek*	300	710	800	890	950	1700

*Revised by SLR as outlined above.

4.4 Validation

The results of the hydrologic and hydraulic models were verified against the peak flows produced by Rational Method, Quantile Regression Technique (QRT) calculations and Regional Flood Frequency Estimation (RFFE). The TUFLOW results were compared along with the XP-RAFTS flows to allow for differences in the routing between the models.

It is noted that Rational Method is no longer supported by ARR 2019 and that ARR 1987 states that this method is not suitable for rural catchments greater than 25 km^2. However, Rational Method estimations have been included in the model validation to support the QRT and RFFE estimates.

Validation was undertaken for the following creeks:

- Sagittarius Creek;
- Bonnie Doon Creek;
- Taurus Creek;
- Two Mile Gully;
- Sirius Creek;

- Rockland Creek;
- Burngrove Creek;
- Speculation Creek; and
- Sagittarius Creek.

The Rational Method parameters adopted in the calculations are listed in **Table 8** and the peak flows for each method are listed in **Table 9**.

Table 8 Rational Method Parameters

Parameter	Sagittarius	Bonnie Doon	Blackwater	Taurus	Two Mile Gully	Sirius	Rockland
Catchment Area (ha)	4,230	2,090	25,550	14,720	11,850	15,990	15,510
Stream Length (km)	13.18	7.5	32	20	22	35.8	46
Equal Area Slope (%)	0.54	0.40	0.22	0.70	0.32	0.67	0.28
Rainfall Intensity[1] I_{10} (mm/h)	56.3	56.3	56.3	56.3	56.3	56.3	56.3
C_{10}	0.66	0.66	0.66	0.66	0.66	0.66	0.66
Time of concentration (min)	375	243	912	477	628	854	1,313

Table 9 Model Results – Validation of 2% AEP Peak Flows

Location	XP-RAFTS (m^3/s)	TUFLOW (m^3/s)	Rational Method (m^3/s)	QRT (m^3/s)	RFFE (m^3/s)
Sagittarius	210	170	180	190	170
Bonnie Doon	49	51	62	67	84
Taurus	460	440	370	340	370
Two Mile Gully	460	430	360	370	440
Sirius	410	270	350	370	430
Rockland	470	460	280	400	380
Burngrove	330	270	270	290	290
Speculation	240	200	260	230	420

As shown in **Table 9**, the peak flows produced by the models were generally comparable to the results of the Rational Method and QRT calculations for the modelled catchments. Most models appear to slightly overestimate the peak flow rates compared to the empirical calculation methods, which was considered to be conservative for this assessment.

While the results comparison with the flows expected from the RFFE method showed a greater variance, all peak flows generated from the models were within the 90% confidence limits of the RFFE.

The most significant variations in the comparisons were the Sirius Creek TUFLOW results and the Rockland Creek Rational Method estimate. The peak flow rate from the Sirius Creek TUFLOW model is significantly lower than the XP-RAFTS result and the estimates from the other methods, which is likely due to the large ponding area and confinement of flow through the diversion. The low Rational Method flow rate for Rockland Creek likely stems from the long stream length compared to the catchment area. This resulted in a long time of concentration and therefore lower flow estimate than the other methods as well as the model results.

Based on the above, and the results of the existing hydrologic model calibration (GHD 2021), the models were considered appropriate for use for the purposes of the assessment.

4.5 Results

The critical storm duration and peak flow produced for each AEP event by the XP-RAFTS model at key reporting locations for each creek are detailed in **Table** and **Table** .

Table 10 XP-RAFTS Model Results – Critical Durations

Location	Critical Duration (h)				
	39%	2%	1%	0.1%	PMP
Sagittarius Creek (603)	12	6	6	3	1
Bonnie Doon Creek (180)	12	6	6	3	1
Burngrove Creek (652)	18	6	6	2	1
Taurus Creek (4522)	24	6	6	3	1
Taurus Creek (4598)	24	6	6	2	1
Two Mile Gully (4237)	24	6	6	6	1
Speculation Creek (689)	24	6	6	3	1
Sirius Creek (621)	18	18	6	3	6
Rockland Creek (719)	18	18	12	6	6

Table 11 XP-RAFTS Model Results – Peak Flows

Location	Flow (m^3/s)				
	39%	2%	1%	0.1%	PMP
Sagittarius Creek (603)	52.8	206	252	449	1762
Bonnie Doon Creek (180)	7.14	26.3	32.8	61.3	254
Burngrove Creek (652)	41.5	149	184	454	1312
Taurus Creek (4522)	32.3	136	169	308	1272
Taurus Creek (4598)	73.9	294	375	675	2534
Two Mile Gully (4237)	18.4	77.9	97	181	996

Location	Flow (m^3/s)				
	39%	2%	1%	0.1%	PMP
Speculation Creek (689)	10.3	44.3	60	110	478
Sirius Creek (621)	33.2	196	248	469	2049
Rockland Creek (719)	95.2	518	625	1174	4270

4.6 Climate Change Assessment

The effects of climate change were considered as part of the hydrologic analysis. Sensitivity analyses were carried out with respect to the modelled design rainfall Intensity-Frequency-Duration data. The three scenarios were modelled based on the methodology outlined in Australian Rainfall and Runoff 2019:

- 6% increase in rainfall intensity;
- 11% increase in rainfall intensity; and
- 20% increase in rainfall intensity.

Hydrographs for each scenario for the 0.1% AEP events were extracted and utilised as inflows in the hydraulic model. Results of the climate change model runs are included in **Appendix C**.

4.7 Consideration of Alteration of Flows

In accordance with Section 3.6.1 of the PRCP Guidelines, consideration of flows upstream and downstream should be considered. As pre-mining topography was not available for the site, the alteration of flows was considered by comparing the catchment area of the XP-RAFTS model between the existing and final landform scenarios.

Table 12 summarises the percentage change in catchment area and generally shows marginal reductions catchment areas for the local watercourses. The largest increase in catchment area is Burngrove Creek; however, the percentage increase is approximately 6.4%, which is unlikely to result in significant increases to flows within the watercourse. The 10.3% reduction of Bonnie Doon Creek catchment area is also not expected to result in material changes to flows due to the smaller catchment size and the creek merging with Burngrove Creek approximately 10 km downstream of the Capricorn Highway.

The total change in catchment areas between the existing and final landform scenarios is approximately a 2.3 km² reduction, which is a change of about 0.2%. It was therefore concluded that the minimal changes in catchment area are unlikely to result in significant alterations of flows downstream of the site.

Table 12 XP-RAFTS Model Results – Existing Scenario vs PRCP Model Landform Scenario

Location	Change in Catchment Area (km²)	Change in Catchment Area (%)
Sagittarius Creek	-1.0	-2.3%
Bonnie Doon Creek	-2.4	-10.3%
Burngrove Creek	5.0	6.4%

Location	Change in Catchment Area (km²)	Change in Catchment Area (%)
Blackwater Creek*	3.0	0.6%
Speculation Creek	1.2	2.1%
Sirius Creek	-4.1	-2.5%
Rockland Creek	-4.0	-2.5%
Total	**-2.3**	**-0.2%**

* Includes the Blackwater Creek, Taurus Creek and Two Mile Gully RAFTS model areas.

For the local watercourses, the upstream boundary of the catchment is either within the site or the existing scenario and rehabilitation scenario are identical. Therefore, there will be no alteration to upstream flows in the final landform when compared to the existing scenario.

5.0 Hydraulic Modelling

5.1 Software

The hydrodynamic modelling software TUFLOW (Build 2023-03-AB) was used for the hydraulic modelling. TUFLOW is capable of linking one dimensional (1D) and two dimensional (2D) domains and the sub-grid sampling (SGS) feature provides increased definition of model terrain, which improves estimate of flow conveyance. This enables model resolution to be improved without significant increases in model run times.

5.2 Model Setup

The existing TUFLOW models for the BWM catchments were adapted for this assessment. These models were provided by WB and assumed to be fit for purpose and sufficiently accurate, with the minor flaws identified in **Section 3.4** being rectified. Seven hydraulic models were developed, which covered the following creeks:

1. Sagittarius Creek
2. Bonnie Doon Creek
3. Burngrove Creek
4. Blackwater Creek, Two Mile Gully and Taurus Creek
5. Speculation Creek
6. Sirius Creek
7. Rockland Creek

5.2.1 Topography

The model landform DEM received from WB was used as the topography for the model. A model grid of 5m was chosen for all models except the Blackwater Creek TUFLOW model, which adopted a model grid of 10 m. There are some narrow creeks with channel widths of 1 to 20 m across the TUFLOW models. A sub-grid sampling distance of 1 m was adopted which was considered to provide adequate resolution for the purposes of this assessment. The final landform DEM is shown in **Figure 3** and the model landforms are shown in **Appendix B**.

5.2.2 Hydraulic Roughness

The hydraulic roughness for the model was maintained from the original model but modified for areas where the final landform had changed the land use. The model hydraulic roughness is shown in **Appendix B**. The Manning's n values adopted in the model are listed in **Table** .

Table 13 TUFLOW Model Manning's n Values

Land Use	Manning's n
Short grass	0.04
Bare land	0.03
Sparse trees	0.06
Dense trees	0.08

Land Use	Manning's n
Tailings	0.03
Creeks	0.05
Hardstand / Paved Roads / Concrete	0.02
Access Haul Roads / Rail embankment	0.03
Buildings	0.50
PRCP Landform	0.04
Water surfaces	0.02

5.2.3 Inflows

Flow hydrographs for the TUFLOW model were extracted from the XP-RAFTS model. The hydrographs were applied as inflow boundaries via source area polygons or polylines as total or local inflows at appropriate locations, as shown in **Appendix B**.

5.2.4 Downstream Boundaries

Downstream model boundaries were applied as stage-discharge relationships based on the water surface gradient in the vicinity of the boundaries. The stage-discharge relationships are automatically calculated using the TUFLOW in-built functionality. The downstream boundaries are shown in **Appendix B**.

5.2.5 Hydraulic Structures

Existing culverts were removed apart from the two TMR culverts in the Blackwater Creek model at the Blackwater Rolleston Road crossings of Two Mile Gully and Taurus Creek. The culverts are shown in **Appendix B**.

5.2.6 Critical Duration Assessment

A range of design storm events was simulated in the hydraulic models for a range of AEPs which include 39%, 2%, 0.1% and PMF (Probable Maximum Flood). Three sensitivity cases were also run for the 0.1% AEP. As there were many areas of interest, a range of durations were used to create a maximum grid for each AEP. Durations between 30 minutes and 36 hours were run for each model.

670000 680000 690000 700000

7390000 7380000 7370000 7360000 7350000 7340000

0 1 2 4 Kilometers

LEGEND

Final Void Area

Topography (mAHD)

High: 460

Low: 60

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:150,000 at A3
Project Number:	620.014601
Date:	2/07/2024
Drawn by:	OA

SLR

Blackwater Mine PRCP Flood Assessment

Hydraulic Model Topography

FIGURE 3

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\TUFLOW SetupINSA710_DEM_MapTemplate_A3P_v002.mxd

5.3 Results

Peak water surface levels, depth and velocities for the seven model areas for each AEP were extracted from the TUFLOW models. The results for all parameters for all flood events are shown in **Appendix C**.

5.3.1 Flood Ingress to Voids

The TUFLOW model results were studied to identify any locations where surface water flows were shown to enter the final voids. **Table 14** summarises the findings, which shows that ingress is only expected to occur in the PMF event. Peak flood inundation extents for the 0.1% AEP + 20% rainfall intensity climate change scenario are illustrated in **Figure 4**.

Table 14 Void Inundation Summary

Void	Most Frequent Modelled Event Resulting in Ingress
Ramp 8	None
Bonnie Doon	None
Mimosa/Besgrove	PMF
Deep Creek	PMF
Stewarton/Ballamoo	PMF
Kenmare	None
Laleham	PMF
Togara/North Marshmead	PMF
South Marshmead	PMF
Kennedy West	PMF
Comet Downs East	PMF

5.3.2 Scour and Erosion Potential

The ACARP 2002 Guidelines provide indicative parameter thresholds for scour potential in diversions in the Bowen Basin. This criterion, which is provided in **Table 15**, is directed towards diversion design, which although is not the purpose of this assessment, also provides general indication of scour and erosion potential in all waterways in the Bowen Basin. It was therefore utilised in the analysis of the hydraulic model results. The events listed in the guidelines are the 2 and 50 year Annual Recurrence Interval (ARI) events, which translate to the 39% and 2% AEP events respectively.

Table 15 ACARP Design Criteria for Bowen River Basin Diversion

Scenario	Parameter	ACARP Criteria
2 year ARI (39% AEP)	Velocity (m/s)	<1.5
	Shear Stress (N/m²)	<40
	Stream Power (W/m²)	<60
50 year ARI (2% AEP)	Velocity (m/s)	<2.5
	Shear Stress (N/m²)	<80

Scenario	Parameter	ACARP Criteria
	Stream Power (W/m²)	<150

Peak bed shear stress, stream power and velocities were extracted from the hydraulic model results for the 39% and 2% AEP events, as illustrated in **Appendix C** and summarised in **Table 16** and **Table 17**.

It is noted that the hydraulic model results for velocity, bed shear stress and stream power are calculated using a depth-averaged approach within each model grid cell and are therefore appropriate for use as indicative information only.

It should be noted that as these results are the maximum values for each parameter throughout the model simulation period. As such, the values summarised in **Table 16** and **Table 17** and shown in **Appendix C** are considered as conservative estimates of the likely scour and erosion potential.

Table 16 39% AEP TUFLOW Model Results – ACARP Design Criteria

Parameter	Watercourse							
	Sagittarius Creek	Bonnie Doon Creek	Burngrove Creek	Taurus Creek	Two Mile Gully	Speculation Creek	Sirius Creek	Rockland Creek
Velocity (m/s)	<1.5	<1.5	Areas >1.5, isolated areas >2.5	Areas >1.5, isolated areas >2.5	Isolated areas >1.5	<1.5	Areas >1.5, isolated areas >2.5	Areas >1.5, isolated areas >2.5
Shear Stress (N/m²)	<40	<40	Areas >40, isolated areas >80	Areas >40, isolated areas >80	Areas >40, isolated areas >80	Isolated areas >40	Areas >40, isolated areas >80	Areas >40, isolated areas >80
Stream Power (W/m²)	<60	<60	Areas >60, isolated areas >150	Areas >60, isolated areas >150	Areas >60, isolated areas >150	<60	Areas >60, isolated areas >150	Areas >60, isolated areas >150

Table 17 2% AEP TUFLOW Model Results – ACARP Design Criteria

Parameter	Watercourse							
	Sagittarius Creek	Bonnie Doon Creek	Burngrove Creek	Taurus Creek	Two Mile Gully	Speculation Creek	Sirius Creek	Rockland Creek
Velocity (m/s)	<2.5	<2.5	Areas >2.5	Areas >2.5	Isolated areas >2.5	<2.5	Areas >2.5	Areas >2.5
Shear Stress (N/m²)	<80	Isolated areas >80	Areas >80	Areas >80	Isolated areas >80	Isolated areas >80	Areas >80	Areas >80
Stream Power (W/m²)	<150	Isolated areas >150	Areas >150	Areas >150	Isolated areas >150	Isolated areas >150	Areas >150	Areas >150

The hydraulic modelling results show shear stress, stream power and velocities above the ACARP criteria for both the 2% and 50% AEP events in various areas of the site (refer **Appendix B4**). Narrow reaches and flow constrictions within the Burngrove Creek, Taurus Creek, Two Mile Gully, Sirius Creek and Rockland Creek models appear to be the most likely locations for results to exceed the ACARP guideline values. These locations may be subject to potential erosion in frequent flood events.

The most significant location within the Burngrove Creek model is the narrow, straight channel adjacent to the Bonnie Doon and Ramp 8 voids. The low sinuosity and concentration of flow through this reach is the likely cause of these exceedances. While there appears to be some vegetation existing within the channel, further establishment of vegetation as part of the rehabilitation plan will improve the stability of the diversion reach. This location is not adjacent to any areas of the landform which would be susceptible to erosion; however, the Blackwater System Railway is approximately 70 m to the west and may eventually be impacted by erosion and scour if unmitigated.

Areas of exceedance results from the Taurus, Sirius and Rockland Creek models are predominantly within the following constructed diversions or modified watercourses:

- Deep Creek diversion;
- Emu Creek diversion;
- Sirius Creek diversion; and
- Rockland Creek downstream of Rockland Dam

In some areas, these constructed channels are located in narrow reaches between toes of rehabilitated waste rock dumps (as illustrated in **Figure 5**, **Figure 6** and **Figure 7**), therefore the possibility of scour presents a risk to the stability of the final landform. Therefore, it is anticipated that the channels will be engineered at the detailed design phase to prevent scour and erosion from occurring and vegetation will be established as part of the rehabilitation plan.

Other key locations of ACARP guidance exceedances are at locations where the watercourse is constricted through a road or railway embankment.

The exceedance locations within the Two Mile Gully model occur in the natural watercourse and are not impacted by the final landform. This creek is well vegetated and no channel deepening has occurred within the watercourse, further indicating the diversion is not likely to be susceptible to erosion or scour in the long-term future.

Areas where the ACARP criteria are exceeded, as identified above and in **Table 16**, **Table 17** and **Appendix C**, it is anticipated that appropriate scour and erosion protection will be included at the detailed design phase.

The large velocity, shear stress and stream power results at the downstream boundary of the Blackwater Creek TUFLOW model is an artefact of model boundary conditions and not a result of the proposed final landform.

670000 680000 690000 700000

7390000 7380000 7370000 7360000 7350000 7340000

Level (mAHD)
- Below 190
- 190 - 200
- 200 - 210
- 210 - 220
- 220 - 230
- 230 - 240
- 240 - 250
- 250 - 260
- 260 - 270
- Above 270

0 1 2 4 Kilometers

LEGEND
- Final Void Area
- Downstream Boundary
- TUFLOW Model Extent

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:150,000 at A3
Project Number:	620.014601
Date:	30/07/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

TUFLOW Model Results
Peak Levels - 0.1% AEP 20p CC

SLR

FIGURE 4

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682000 683000 684000 685000 686000 687000 688000 689000 690000

7376000 7375000 7374000 7373000 7372000 7371000 7370000 7369000 7367000 7366000 7368000

Deep Creek Diversion

Emu Creek Diversion

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Bed Shear Stress (N/m²)
- 0 - 20
- 20 - 40
- 40 - 60
- 60 - 80
- > 80

0 400 800 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:30,000 at A3
Project Number:	620.040134
Date:	30/07/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Deep Creek & Emu Creek Diversions Peak Bed Shear Stress - 2% AEP

SLR

FIGURE 5

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685000
686000
687000
688000
7351000
7350000
7349000
Sirius Creek Diversion

Blackwater Mine PRCP Flood Assessment

Sirius Creek Diversion Peak Bed Shear Stress - 2% AEP

FIGURE 6

LEGEND

- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Bed Shear Stress (N/m²)

- 0 - 20
- 20 - 40
- 40 - 60
- 60 - 80
- > 80

0 150 300 Meters

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:10,000 at A3
Project Number:	620.014601
Date:	30/07/2024
Drawn by:	SM

SLR

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Blackwater Mine PRCP Flood Assessment

Rockland Creek Diversion Peak Bed Shear Stress - 2% AEP

FIGURE 7

683000 684000 685000 686000 687000 688000 689000

7346000 7345000 7344000 7343000 7342000 7341000

Rockland Creek Diversion

LEGEND

- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Bed Shear Stress (N/m²)

- 0 - 20
- 20 - 40
- 40 - 60
- 60 - 80
- > 80

0 300 600 Meters

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:20,000 at A3
Project Number:	620.014601
Date:	30/07/2024
Drawn by:	SM

SLR

H:\Projects-SLR\620-BNE\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\TUFLOW Setup\620.040134_RocklandCk_02p_bss.mxd

6.0 Flooding Risk Profile

A Flooding Risk Profile (FRP) was developed for the BWM post-closure conditions. The FRP was based on the results of the hydraulic model (as detailed in **Section 5.0**), as applied to the Whitehaven Blackwater Pty Ltd HSE Risk Management Procedure. The Workplace Risk Assessment and Control (WRAC) and results of the FRP assessment are provided in **Appendix D**.

The risk assessment was undertaken using the methodology outlined in the RMG as follows:

1. Establish the context.
2. Risk identification – sources, causes and consequences.
3. Risk analysis – level of exposure and maximum reasonable consequence.
4. Risk evaluation – determination of risk acceptability and treatment requirements.
5. Risk treatment – assessment of the residual risk with treatment controls in place.

A summary of the identified flood risks, causes, impacts, possible mitigation measures and residual risk ratings (RRR) are detailed in **Table 18**. As shown, the RRR for each identified flood risk Low.

Table 18 Flood Risk Profile Summary

Identified Risk	Cause	Impacts	Mitigation / Prevention Measures	Residual Risk Rating
Scour and erosion of waterways	Cumulation of flow events eroding and scouring the channel, undercutting the landform.	Ingress into the final void & associated impacts to hydrologic regime and failure of rail embankment.	Reformation, vegetation and scour protection of waterway.	Low
Void ingress (PMF only): • Mimosa/ Besgrove • Deep Creek • Stewarton/ Ballamoo • Togara/North Marshmead • South Marshmead • Laleham • Kennedy West • Comet Downs East	Rare flood inundation extent reaching the final void area.	Ingress into the final void & associated impacts to hydrologic regime.	Stable landform design features to prevent ingress. E.g., backfill void, stable bunding structure.	Low
Floodwaters in contact with rehab dump	Flood inundation extent reaching and eroding the rehab dump area.	Ingress into the final void & associated impacts to hydrologic regime.	Design of rehabilitation dump areas adjacent to flowpaths to prevent erosion and scour.	Low
Alteration of flows upstream of site	Change in watercourse	Habitat impacted upstream of site.	Landform design developed to	Low

Identified Risk	Cause	Impacts	Mitigation / Prevention Measures	Residual Risk Rating
	behaviour as a result of final landform design.		minimise alteration of hydrology.	
Alteration of flows downstream of site	Change in watercourse behaviour as a result of final landform design.	Habitat and water users impacted downstream of site.	Landform design developed to minimise alteration of hydrology.	Low

7.0 Conclusion

SLR was contracted by WB to support the preparation of the Blackwater Mine Progressive Rehabilitation and Closure Plan (PRCP). The assessment detailed in this report was undertaken to address Section 3.6.1 of the PRCP Guideline, which relates to the analysis of flooding as part of the PRCP.

A model landform was developed for the project, which was based on the post-mining surface provided by WB and included the proposed final voids and rehabilitated dump areas.

Using the model landform, existing hydrologic models were modified for the Sagittarius Creek, Bonnie Doon Creek, Burngrove Creek, Blackwater Creek, Taurus Creek, Two Mile Gully, Speculation Creek, Sirius Creek, and Rockland Creek catchments. The models were verified against results of empirical flow estimation methods. The hydrologic models were simulated for a suite of storm events including a range of temporal patterns, storm durations and AEP events including the 0.1% AEP and climate change scenarios.

Hydraulic models covering Sagittarius Creek, Bonnie Doon Creek, Burngrove Creek, Blackwater Creek (including Taurus Creek and Two Mile Gully), Speculation Creek, Sirius Creek, and Rockland Creek were developed from existing TUFLOW models. The model topography was based on the model landform for the purpose of assessment the post-mining flooding conditions in accordance with Section 3.6.1 of the PRCP Guideline. Flow hydrographs produced by the hydrologic models were utilised as inflows for the hydraulic model.

The results of the hydraulic model showed no inundations to the final voids from floodwaters for the 0.1% AEP event including the 6%, 11% and 20% rainfall depth increase climate change scenarios. Hydraulic model results showed evidence of scour and erosion potential, particularly in Burngrove Creek, Taurus Creek, Sirius Creek and Rockland Creek. While the model results may be considered as conservative estimates of the scour and erosion potential, reformation, vegetation and scour protection should be considered for these areas.

A Flood Risk Profile was developed based on the hydrologic and hydraulic model results. The FRP adopted the framework provided in Whitehaven Blackwater Pty Ltd HSE Risk Management Procedure. The outcome of the FRP showed the residual risk ratings of the identified flood risks are categorised as Low.

Appendix A XP-RAFTS Model Set up Tables and Figures

Blackwater Mine

Progressive Rehabilitation and Closure Plan Rehabilitation Flood Assessments

Whitehaven Blackwater Pty Ltd (WB)

SLR Project No.: 620.040134.00000

10 October 2024

Table A-1: IFD for Individual Catchments

	Duration	39%	2%	1%	0.1%
Sagittarius Creek	1 h	39	76.5	85.6	127
	1.5 h	43.7	87	97.8	145
	2 h	46.9	94.6	107	158
	3 h	51.5	106	120	178
	4.5 h	56.4	118	134	199
	6 h	60.3	127	145	216
	9 h	66.4	142	162	243
	12 h	71.4	154	176	264
	18 h	79.4	174	199	298
	24 h	85.9	190	217	323
	30 h	91.4	203	233	346
	36 h	96.1	215	246	364

	Duration	39%	2%	1%	0.1%
Bonnie Doon Creek	1 h	38.7	76.3	85.5	127
	1.5 h	43.3	86.7	97.5	145
	2 h	46.5	94.2	106	158
	3 h	51.1	105	119	177
	4.5 h	56	117	133	198
	6 h	59.8	126	144	215
	9 h	66	141	161	242
	12 h	71.1	154	176	263
	18 h	79.4	173	198	297
	24 h	86.1	190	217	323
	30 h	91.7	203	232	346
	36 h	96.6	215	246	364

	Duration	39%	2%	1%	0.1%
Burngrove Creek	1 h	38.7	76.5	85.7	126
	1.5 h	43.4	86.9	97.8	144
	2 h	46.6	94.5	107	157
	3 h	51.2	105	119	176
	4.5 h	56.1	118	134	198
	6 h	60	127	145	215
	9 h	66.3	142	162	241
	12 h	71.4	154	176	262
	18 h	79.7	174	199	295
	24 h	86.4	190	217	321
	30 h	92	204	233	343
	36 h	96.7	215	246	361

	Duration	39%	2%	1%	0.1%
Blackwater Creek	1 h	38.7	75.9	85	124
	1.5 h	43.5	86.6	97.3	142
	2 h	46.9	94.4	106	156
	3 h	51.9	106	120	176
	4.5 h	57.2	119	136	199
	6 h	61.5	130	148	217
	9 h	68.2	147	168	246
	12 h	73.7	160	183	269
	18 h	82.5	183	209	306
	24 h	89.5	201	230	336
	30 h	95.4	216	247	361
	36 h	100	229	261	382

	Duration	39%	2%	1%	0.1%
Taurus Creek	1 h	39.1	76.8	86	126
	1.5 h	43.8	87.4	98.2	144
	2 h	47.1	95	107	157
	3 h	51.7	106	120	176
	4.5 h	56.6	118	134	198
	6 h	60.4	127	145	214
	9 h	66.3	142	162	240
	12 h	71.1	154	176	260
	18 h	78.8	172	197	291
	24 h	85	187	214	315
	30 h	90.1	200	228	335
	36 h	94.4	211	240	351

	Duration	39%	2%	1%	0.1%
Two Mile Gully	1 h	39.3	76.6	85.7	125
	1.5 h	44.1	87.2	98	143
	2 h	47.4	94.9	107	156
	3 h	52	106	120	176
	4.5 h	56.9	118	134	197
	6 h	60.6	127	144	213
	9 h	66.3	141	161	238
	12 h	70.8	152	174	257
	18 h	78.1	170	195	287
	24 h	83.8	185	211	310
	30 h	88.6	197	225	328
	36 h	92.7	207	236	344

	Duration	39%	2%	1%	0.1%
Speculation Creek	1 h	39.1	77.6	87	126
	1.5 h	43.8	88.3	99.3	144
	2 h	47.1	96	108	157
	3 h	51.8	107	122	176
	4.5 h	56.7	119	136	198
	6 h	60.5	129	147	214
	9 h	66.4	143	164	239
	12 h	71.1	155	177	259
	18 h	78.7	174	199	289
	24 h	84.7	188	215	312
	30 h	89.7	200	229	331
	36 h	93.9	211	240	347

	Duration	39%	2%	1%	0.1%
Sirius Creek	1 h	39.1	78	87.4	126
	1.5 h	43.9	88.6	99.7	144
	2 h	47.2	96.3	109	157
	3 h	51.8	107	122	177
	4.5 h	56.7	119	136	197
	6 h	60.4	129	147	213
	9 h	66.2	143	164	238
	12 h	70.9	154	177	258
	18 h	78.3	173	198	287
	24 h	84.2	187	214	310
	30 h	89.1	199	227	328
	36 h	93.3	209	238	344

	Duration	39%	2%	1%	0.1%
Rockland Creek	1 h	39.1	78.4	87.9	127
	1.5 h	43.9	89.1	100	145
	2 h	47.2	96.8	109	158
	3 h	51.8	108	122	177
	4.5 h	56.7	120	136	198
	6 h	60.4	129	147	214
	9 h	66.2	143	164	238
	12 h	70.9	155	177	258
	18 h	78.4	173	198	287
	24 h	84.3	188	214	310
	30 h	89.3	200	228	329
	36 h	93.6	210	239	345

Table A-2: ARF for Individual Catchments

	Duration	39%	2%	1%	0.1%
Sagittarius Creek	1 h	0.88	0.84	0.83	0.81
	1.5 h	0.90	0.86	0.85	0.81
	2 h	0.91	0.86	0.85	0.82
	3 h	0.93	0.87	0.86	0.82
	4.5 h	0.94	0.89	0.88	0.85
	6 h	0.95	0.92	0.91	0.89
	9 h	0.96	0.94	0.94	0.93
	12 h	0.96	0.95	0.94	0.93
	18 h	0.97	0.96	0.96	0.95
	24 h	0.97	0.97	0.97	0.97
	30 h	0.97	0.97	0.97	0.97
	36 h	0.97	0.97	0.97	0.97

	Duration	39%	2%	1%	0.1%
Bonnie Doon Creek	1 h	0.904	0.871	0.863	0.839
	1.5 h	0.922	0.882	0.873	0.845
	2 h	0.932	0.887	0.878	0.846
	3 h	0.945	0.895	0.885	0.849
	4.5 h	0.955	0.914	0.905	0.876
	6 h	0.962	0.936	0.930	0.912
	9 h	0.969	0.955	0.952	0.942
	12 h	0.974	0.959	0.956	0.946
	18 h	0.974	0.966	0.965	0.960
	24 h	0.973	0.973	0.973	0.973
	30 h	0.976	0.976	0.976	0.976
	36 h	0.977	0.977	0.977	0.977

	Duration	39%	2%	1%	0.1%
Burngrove Creek	1 h	0.84	0.79	0.78	0.75
	1.5 h	0.87	0.81	0.80	0.76
	2 h	0.88	0.82	0.81	0.77
	3 h	0.90	0.83	0.82	0.77
	4.5 h	0.92	0.86	0.85	0.81
	6 h	0.93	0.89	0.89	0.86
	9 h	0.94	0.92	0.92	0.90
	12 h	0.95	0.93	0.92	0.91
	18 h	0.95	0.94	0.94	0.93
	24 h	0.95	0.95	0.95	0.95
	30 h	0.96	0.96	0.96	0.96
	36 h	0.96	0.96	0.96	0.96

	Duration	39%	2%	1%	0.1%
Blackwater Creek	1 h	0.77	0.71	0.70	0.65
	1.5 h	0.80	0.73	0.72	0.67
	2 h	0.82	0.75	0.73	0.68
	3 h	0.85	0.77	0.75	0.69
	4.5 h	0.87	0.80	0.79	0.74
	6 h	0.89	0.84	0.83	0.80
	9 h	0.91	0.88	0.88	0.86
	12 h	0.92	0.89	0.89	0.87
	18 h	0.92	0.91	0.91	0.90
	24 h	0.93	0.93	0.93	0.93
	30 h	0.94	0.94	0.94	0.94
	36 h	0.94	0.94	0.94	0.94

	Duration	39%	2%	1%	0.1%
Taurus Creek	1 h	0.82	0.77	0.76	0.72
	1.5 h	0.84	0.79	0.77	0.73
	2 h	0.86	0.80	0.78	0.74
	3 h	0.88	0.81	0.80	0.74
	4.5 h	0.90	0.84	0.83	0.79
	6 h	0.91	0.88	0.87	0.84
	9 h	0.93	0.91	0.90	0.89
	12 h	0.94	0.92	0.91	0.90
	18 h	0.94	0.93	0.93	0.92
	24 h	0.95	0.95	0.95	0.95
	30 h	0.95	0.95	0.95	0.95
	36 h	0.95	0.95	0.95	0.95

	Duration	39%	2%	1%	0.1%
Two Mile Gully	1 h	0.82	0.77	0.76	0.73
	1.5 h	0.85	0.79	0.78	0.74
	2 h	0.87	0.80	0.79	0.74
	3 h	0.89	0.82	0.80	0.75
	4.5 h	0.91	0.85	0.83	0.79
	6 h	0.92	0.88	0.87	0.85
	9 h	0.93	0.91	0.91	0.89
	12 h	0.94	0.92	0.91	0.90
	18 h	0.94	0.93	0.93	0.92
	24 h	0.95	0.95	0.95	0.95
	30 h	0.95	0.95	0.95	0.95
	36 h	0.96	0.96	0.96	0.96

	Duration	39%	2%	1%	0.1%
Speculation Creek	1 h	0.85	0.81	0.80	0.77
	1.5 h	0.88	0.83	0.81	0.78
	2 h	0.89	0.83	0.82	0.78
	3 h	0.91	0.85	0.83	0.79
	4.5 h	0.92	0.87	0.86	0.82
	6 h	0.93	0.90	0.89	0.87
	9 h	0.95	0.93	0.92	0.91
	12 h	0.95	0.93	0.93	0.92
	18 h	0.95	0.95	0.94	0.94
	24 h	0.96	0.96	0.96	0.96
	30 h	0.96	0.96	0.96	0.96
	36 h	0.96	0.96	0.96	0.96

	Duration	39%	2%	1%	0.1%
Sirius Creek	1 h	0.80	0.75	0.74	0.70
	1.5 h	0.83	0.77	0.76	0.71
	2 h	0.85	0.78	0.77	0.72
	3 h	0.87	0.80	0.78	0.73
	4.5 h	0.89	0.83	0.82	0.77
	6 h	0.91	0.87	0.86	0.83
	9 h	0.92	0.90	0.89	0.88
	12 h	0.93	0.91	0.90	0.89
	18 h	0.94	0.93	0.92	0.91
	24 h	0.94	0.94	0.94	0.94
	30 h	0.95	0.95	0.95	0.95
	36 h	0.95	0.95	0.95	0.95

	Duration	39%	2%	1%	0.1%
Rockland Creek	1 h	0.80	0.75	0.74	0.70
	1.5 h	0.83	0.77	0.76	0.71
	2 h	0.85	0.78	0.77	0.72
	3 h	0.88	0.80	0.78	0.73
	4.5 h	0.90	0.83	0.82	0.77
	6 h	0.91	0.87	0.86	0.83
	9 h	0.92	0.90	0.90	0.88
	12 h	0.93	0.91	0.90	0.89
	18 h	0.94	0.93	0.92	0.92
	24 h	0.94	0.94	0.94	0.94
	30 h	0.95	0.95	0.95	0.95
	36 h	0.95	0.95	0.95	0.95

685000 686000 687000 688000 689000 690000 691000 692000 693000

7390000 7389000 7388000 7387000 7386000 7385000 7384000 7383000 7382000 7381000

605 608 602 610 613 615 623 625 628 633 630 640 645 638 650 648 643 653 658 655 660 663 665 670 668 673

Sagittarius Creek

Blackwater Creek

Taurus Creek

0 400 800 Meters

LEGEND

- RAFTS Catchments
- Mining Leases
- Watercourse

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:30,000 at A3
Project Number:	620.014601
Date:	9/04/2024
Drawn by:	OA

SLR

Blackwater Mine PRCP Flood Assessment

Sagittarius Creek Model XP-RAFTS Setup

APPENDIX A1

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7392000 7391000 7390000 7389000 7388000 7387000 7386000 7385000 7384000

Burngrove Creek

Bonnie Doon Creek

Burngrove Creek

4 167 169 172 1 13 177 164 201 174 200 182 192 195 199 198 197

0 250 500 Meters

LEGEND

- RAFTS Catchments
- Mining Leases
- Watercourse

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:25,000 at A3
Project Number:	620.014601
Date:	9/04/2024
Drawn by:	OA

SLR

Blackwater Mine PRCP Flood Assessment

Bonnie Doon Creek Model XP-RAFTS Setup

APPENDIX A2

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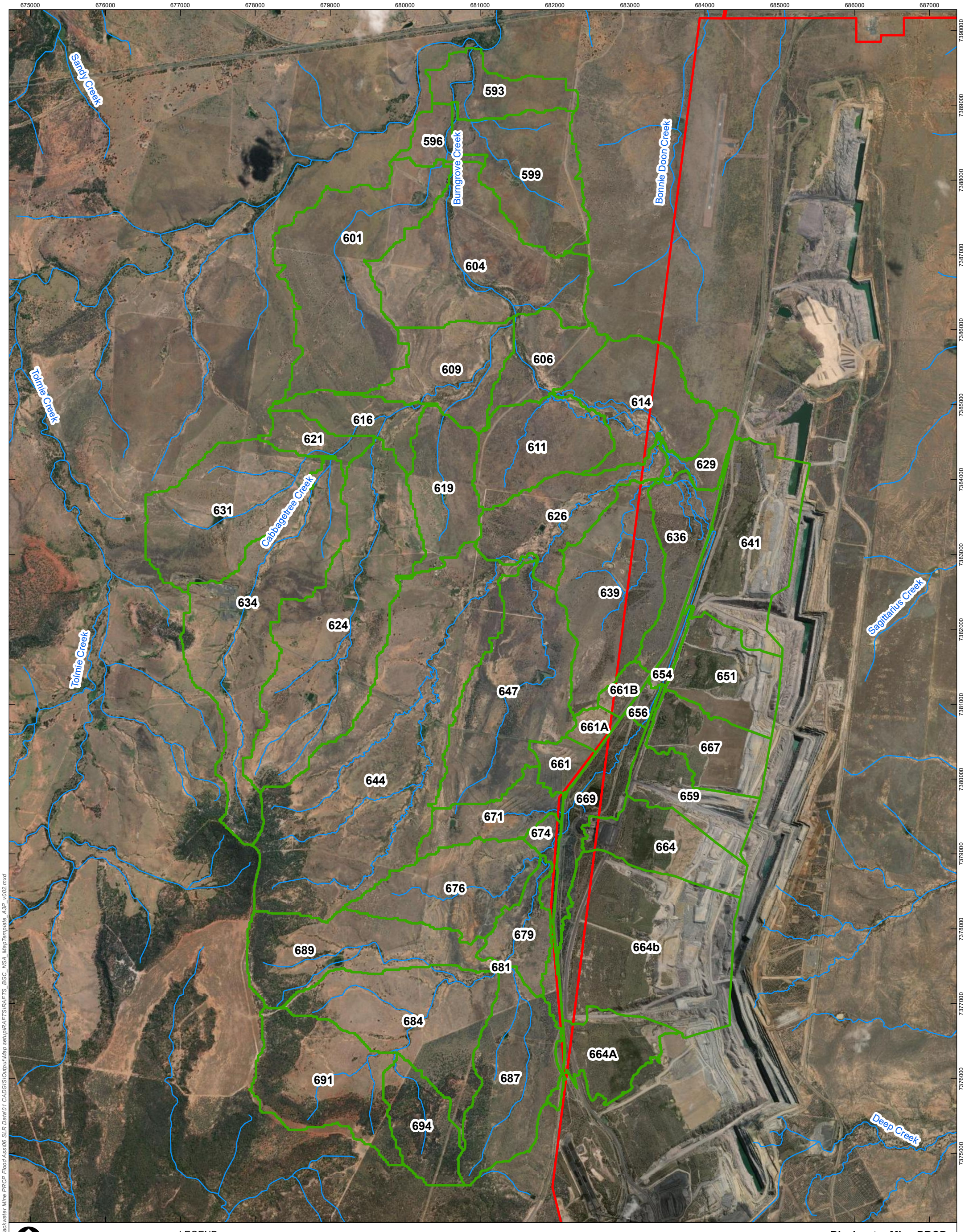

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0 500 1,000 Meters

LEGEND

- RAFTS Catchments
- Mining Leases
- Watercourse

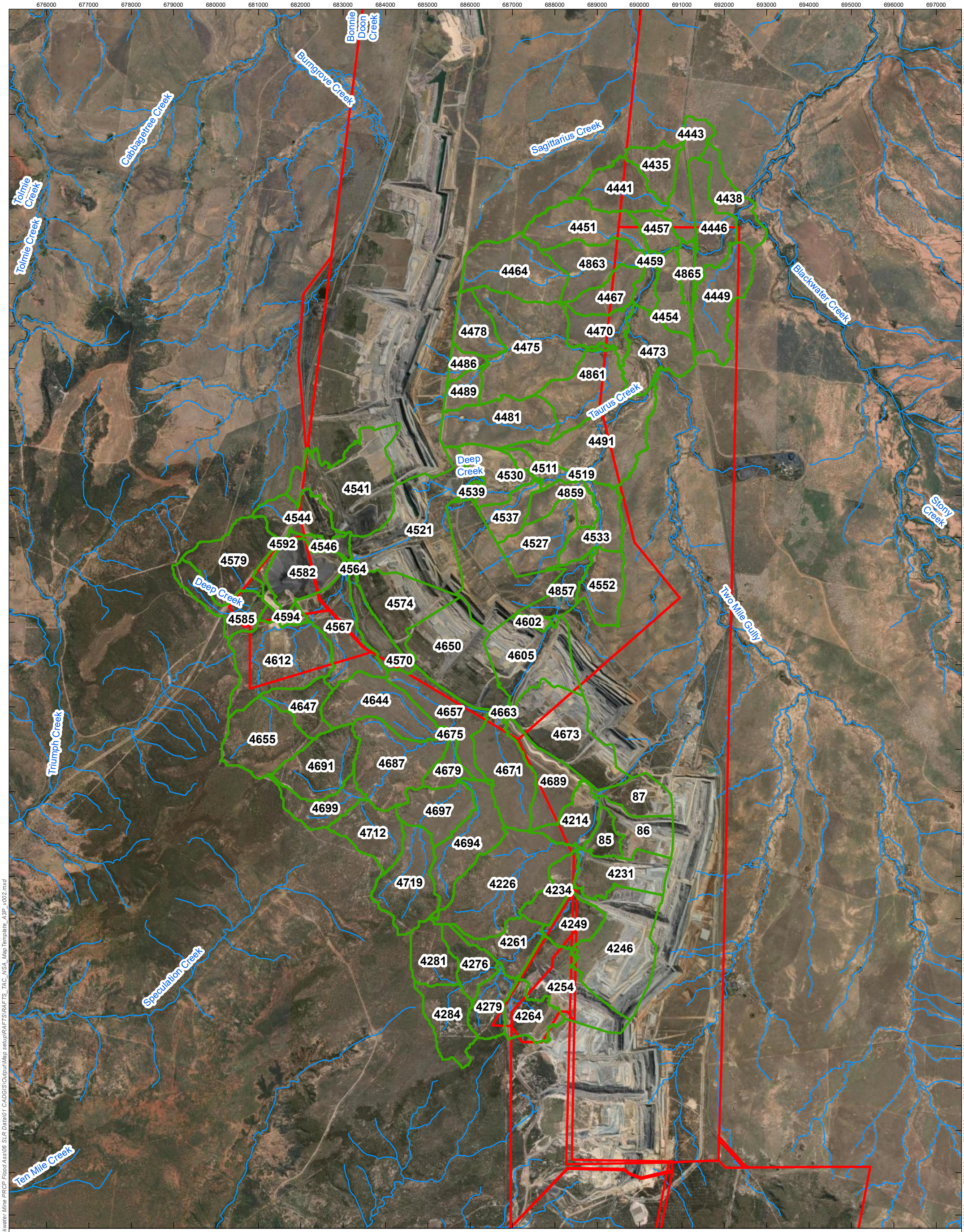
Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:45,000 at A3
Project Number:	620.014601
Date:	9/04/2024
Drawn by:	OA

SLR

Blackwater Mine PRCP Flood Assessment

Burngrove Creek Model XP-RAFTS Setup

APPENDIX A3



0 1,000 2,000 Meters

LEGEND

- RAFTS Catchments
- Mining Leases
- Watercourse

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:80,000 at A3
Project Number:	620.014601
Date:	9/04/2024
Drawn by:	OA

SLR

Blackwater Mine PRCP Flood Assessment

Taurus Creek Model XP-RAFTS Setup

APPENDIX A4

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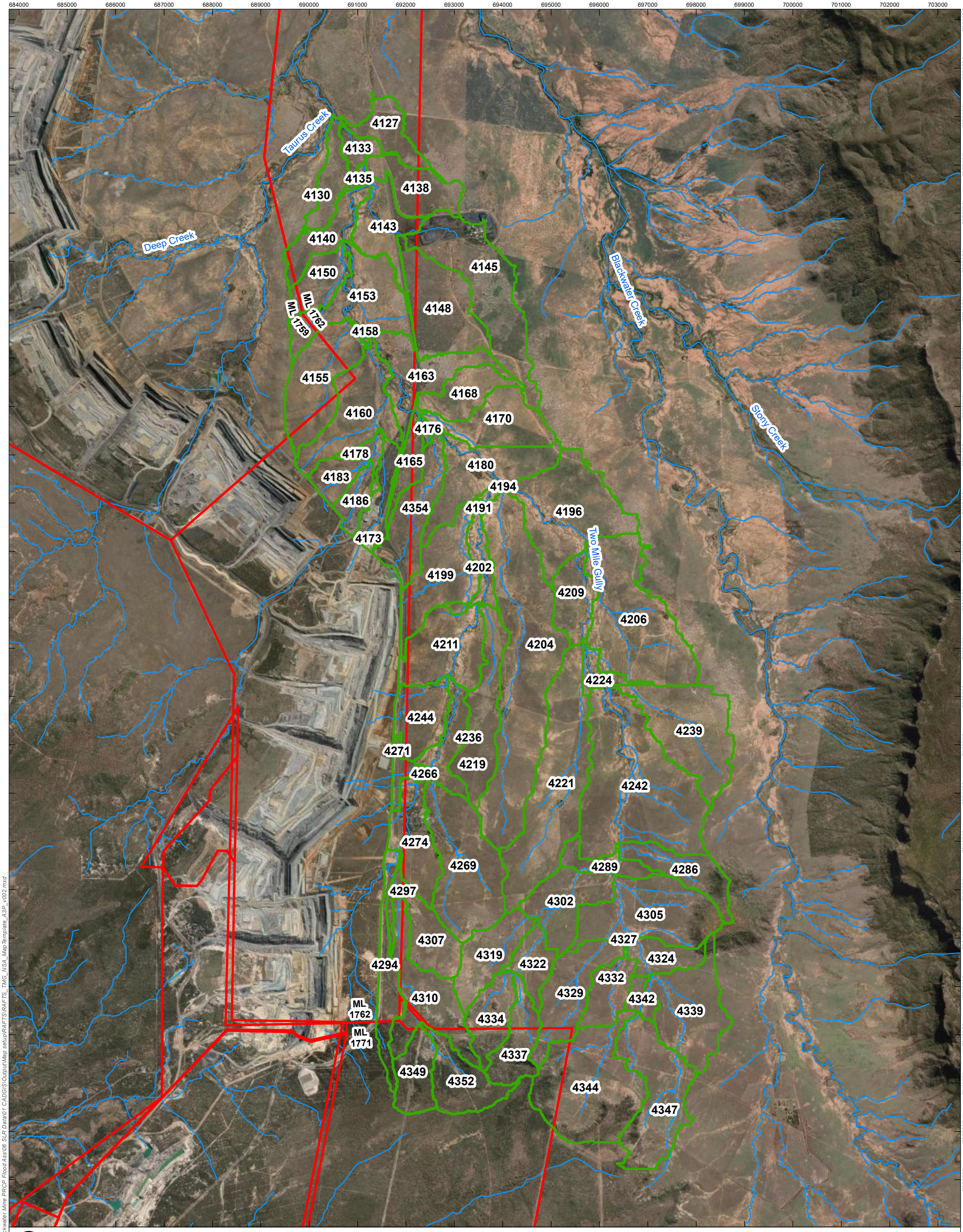

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0 1,000 2,000 Meters

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:70,000 at A3
Project Number:	620.014601
Date:	9/04/2024
Drawn by:	OA

LEGEND

- RAFTS Catchments
- Mining Leases
- Watercourse

Blackwater Mine PRCP Flood Assessment

Two Mile Gully Model XP-RAFTS Setup

SLR

APPENDIX A5

678000 679000 680000 681000 682000 683000 684000 685000 686000 687000 688000 689000 690000

7364000 7363000 7362000 7361000 7360000 7359000 7358000 7357000 7356000 7355000 7354000 7353000 7352000 7351000 7350000 7349000

Speculation Creek

49
667
669
664
672
677
688B
675
685
682
696A
688
699
696
703A
707
720
715
703
723
710
773
45
731
729
726
717
734
47
746
743
737
756
748
48
761
741
759
764
46
754
50
770
771

Sirius Creek

Sirius Creek

0 500 1,000 Meters

LEGEND

- RAFTS Catchments
- Mining Leases
- Watercourse

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:45,000 at A3
Project Number:	620.014601
Date:	9/04/2024
Drawn by:	OA

SLR

Blackwater Mine PRCP Flood Assessment

Speculation Creek Model XP-RAFTS Setup

APPENDIX A6

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Blackwater Mine PRCP Flood Assessment

Sirius Creek Model XP-RAFTS Setup

APPENDIX A7

LEGEND

- RAFTS Catchments
- Mining Leases
- Watercourse

0 500 1,000 2,000 Meters

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:80,000 at A3
Project Number:	620.014601
Date:	9/04/2024
Drawn by:	SM

SLR

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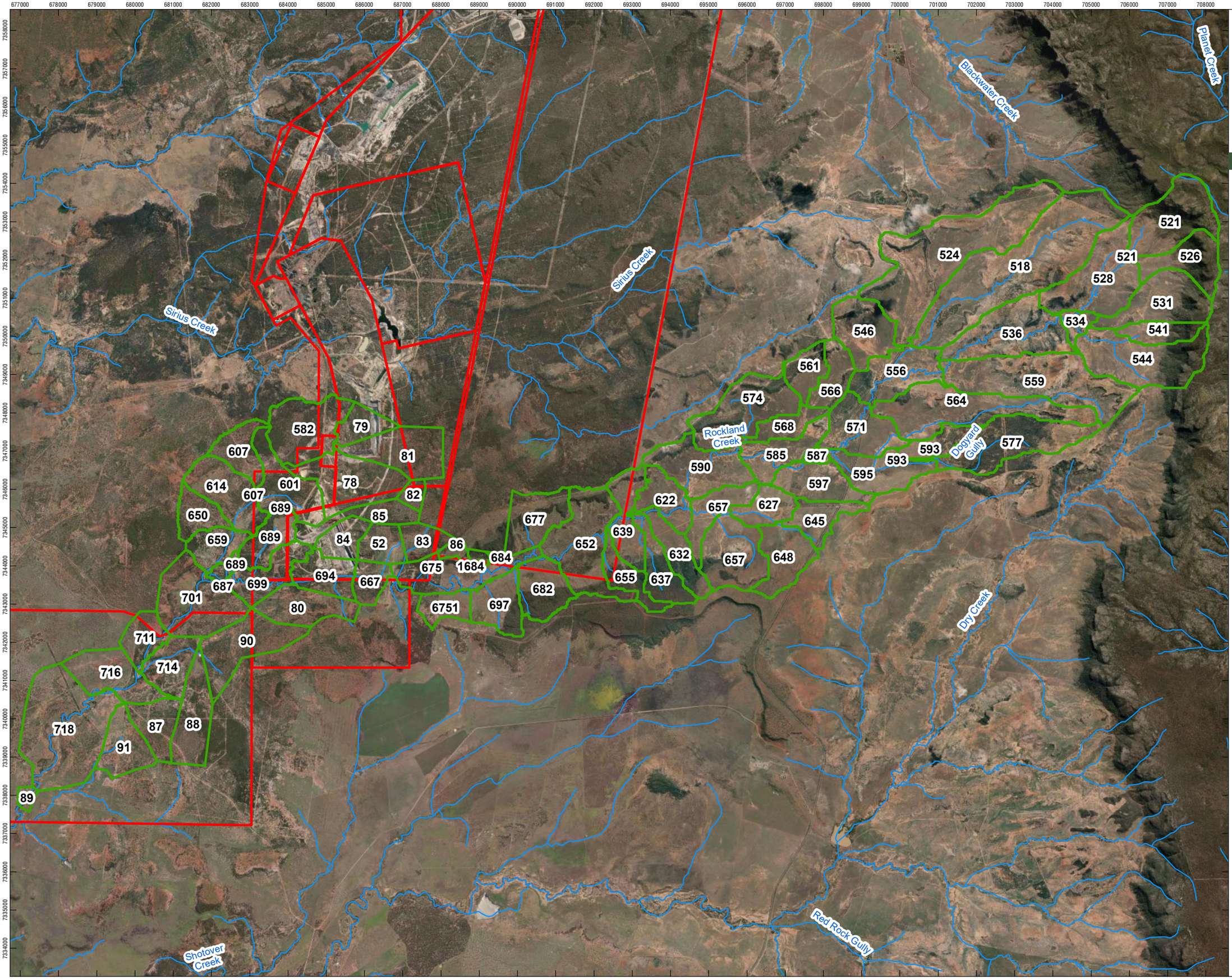
Blackwater Mine PRCP Flood Assessment

Rockland Creek Model XP-RAFTS Setup

APPENDIX A8

LEGEND

- XP-RAFTS Catchments
- Mining Leases
- Watercourse



0 500 1,000 2,000 Meters

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:90,000 at A3
Project Number:	620.014601
Date:	9/04/2024
Drawn by:	SM

SLR

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Appendix B TUFLOW Model Setup Figures

Blackwater Mine

Progressive Rehabilitation and Closure Plan Rehabilitation Flood Assessments

Whitehaven Blackwater Pty Ltd (WB)

SLR Project No.: 620.040134.00000

10 October 2024

685000 686000 687000 688000 689000 690000 691000 692000 693000

7390000 7389000 7388000 7387000 7386000 7385000 7384000 7383000 7382000 7381000

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

0 400 800 Meters

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:30,000 at A3
Project Number:	620.040134
Date:	2/07/2024
Drawn by:	OA

LEGEND

- Local Inflows
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Topography (mAHD)

High: 250

Low: 60

Blackwater Mine PRCP Flood Assessment

Sagittarius Creek Model TUFLOW Setup

SLR

APPENDIX B1-1

H:\Projects-SLR\620-BNE\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\TUFLOW Setup\SGC_TuflowSetup_A3P_v003.mxd

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7390000 7389000 7388000 7387000 7386000 7385000 7384000

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

0 250 500 Meters

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:20,000 at A3
Project Number:	620.040134
Date:	2/07/2024
Drawn by:	OA

LEGEND

- Local Inflows
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Topography (mAHD)

High: 325

Low: 75

Blackwater Mine PRCP Flood Assessment

Bonnie Doon Creek Model TUFLOW Setup

SLR

APPENDIX B1-2

H:\Projects-SLR\620-BNE\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\TUFLOW Setup\BDC_TuflowSetup_A3P_v003.mxd

677000 678000 679000 680000 681000 682000 683000 684000 685000 686000 687000 688000

7388000 7387000 7386000 7385000 7384000 7383000 7382000 7381000 7380000 7379000 7378000 7377000 7376000 7375000 7374000 7373000 7372000

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

0 500 1,000 Meters

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:45,000 at A3
Project Number:	620.040134
Date:	2/07/2024
Drawn by:	OA

LEGEND

- Local Inflows
- Culverts
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Topography (mAHD)

High: 430

Low: 65

Blackwater Mine PRCP Flood Assessment

Burngrove Creek Model TUFLOW Setup

SLR

APPENDIX B1-3

H:\Projects-SLR\620-BNE\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CAD\GIS\Output\Map setup\TUFLOW Setup\BGC_TuflowSetup_A3P_v003.mxd

678000 679000 680000 681000 682000 683000 684000 685000 686000 687000 688000 689000 690000 691000 692000 693000 694000 695000 696000 697000 698000 699000

7386000 7385000 7384000 7383000 7382000 7381000 7380000 7379000 7378000 7377000 7376000 7375000 7374000 7373000 7372000 7371000 7370000 7369000 7368000 7367000 7366000 7365000 7364000 7363000 7362000 7361000 7360000 7359000 7358000

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

0 1,000 2,000 Meters

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:80,000 at A3
Project Number:	620.040134
Date:	2/07/2024
Drawn by:	OA

LEGEND

- Local Inflows
- Culverts
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Topography (mAHD)

High: 460

Low: 60

Blackwater Mine PRCP Flood Assessment

Blackwater Creek Model TUFLOW Setup

SLR

APPENDIX B1-4

H:\Projects-SLR\620-BNE\620.040134 00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\TUFLOW Setup\BWC_TuflowSetup_A3P_v004.mxd

679000 680000 681000 682000 683000 684000 685000 686000 687000 688000 689000 690000 691000

7364000 7363000 7362000 7361000 7360000 7359000 7358000 7357000 7356000 7355000 7354000 7353000 7352000 7351000 7350000 7349000

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

0 500 1,000 Meters

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:45,000 at A3
Project Number:	620.040134
Date:	2/07/2024
Drawn by:	OA

LEGEND

- Local Inflows
- Culverts
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Topography (mAHD)

High: 460

Low: 100

Blackwater Mine PRCP Flood Assessment

Speculation Creek Model TUFLOW Setup

APPENDIX B1-5

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CAD\GIS\Output\Map setup\TUFLOW Setup\SPC_TuflowSetup_A3P_v004.mxd

683000 684000 685000 686000 687000 688000 689000 690000 691000 692000

7353000 7352000 7351000 7350000 7349000 7348000 7347000 7346000

Blackwater Mine PRCP Flood Assessment

Sirius Creek Model TUFLOW Setup

APPENDIX B1-6

LEGEND

- Local Inflows
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Topography (mAHD)

High: 450

Low: 95

0 200 400 800 Meters

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:30,000 at A3
Project Number:	620.014601
Date:	2/07/2024
Drawn by:	SM

SLR

H:\Projects-SLR\620-BNE\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\TUFLOW Setup\SRC_TuflowSetup_A3L_v003.mxd

674000 675000 676000 677000 678000 679000 680000 681000 682000 683000 684000 685000 686000 687000 688000 689000 690000 691000

7347000 7346000 7345000 7344000 7343000 7342000 7341000 7340000 7339000 7338000 7337000 7336000 7335000 7334000

Blackwater Mine PRCP Flood Assessment

Rockland Creek Model TUFLOW Setup

APPENDIX B1-7

LEGEND

- Local Inflows
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Topography (mAHD)

- High: 450
- Low: 70

0 300 600 1,200 Meters

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:50,000 at A3
Project Number:	620.014601
Date:	2/07/2024
Drawn by:	SM

SLR

H:\Projects-SLR\620-BNE\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\TUFLOW Setup\RLC_TuflowSetup_A3L_v003.mxd

Appendix C TUFLOW Model Results

Blackwater Mine

Progressive Rehabilitation and Closure Plan Rehabilitation Flood Assessments

Whitehaven Blackwater Pty Ltd (WB)

SLR Project No.: 620.040134.00000

10 October 2024

685000 686000 687000 688000 689000 690000 691000 692000 693000

7390000 7389000 7388000 7387000 7386000 7385000 7384000 7383000 7382000 7381000

Level (m AHD)
- Below 170
- 170 - 174
- 174 - 178
- 178 - 182
- 182 - 186
- 186 - 190
- 190 - 194
- 194 - 198
- 198 - 202
- Above 202

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

0 400 800 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:30,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Sagittarius Creek PRCP Conditions Peak Levels - 39% AEP

SLR

APPENDIX C1-1-1

H:\Projects-SLR\620-BNE\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CAD\GIS\Output\Map setup\Sagittarius\MXDs\620.040134_APPENDIX C1-1-1_N004_39p_h.mxd

685000 686000 687000 688000 689000 690000 691000 692000 693000

7390000 7389000 7388000 7387000 7386000 7385000 7384000 7383000 7382000 7381000

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Level (m AHD)
- Below 170
- 170 - 174
- 174 - 178
- 178 - 182
- 182 - 186
- 186 - 190
- 190 - 194
- 194 - 198
- 198 - 202
- Above 202

0 400 800 Meters

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:30,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Blackwater Mine PRCP Flood Assessment

Sagittarius Creek PRCP Conditions Peak Levels - 2% AEP

SLR

APPENDIX C1-1-2

H:\Projects-SLR\620-BNE\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CAD\GIS\Output\Map setup\Sagittarius\MXDs\620.040134_APPENDIX C1-1-2_N004_02p_h.mxd

685000 686000 687000 688000 689000 690000 691000 692000 693000

7390000 7389000 7388000 7387000 7386000 7385000 7384000 7383000 7382000 7381000

Level (m AHD)
- Below 170
- 170 - 174
- 174 - 178
- 178 - 182
- 182 - 186
- 186 - 190
- 190 - 194
- 194 - 198
- 198 - 202
- Above 202

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

0 400 800 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:30,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Sagittarius Creek PRCP Conditions Peak Levels - 0.1% AEP

SLR

APPENDIX C1-1-3

H:\Projects-SLR\620-BNE\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CAD\GIS\Output\Map setup\Sagittarius\MXDs\620.040134_APPENDIX C1-1-3_N004_1in1000_h.mxd

685000 686000 687000 688000 689000 690000 691000 692000 693000

7390000 7389000 7388000 7387000 7386000 7385000 7384000 7383000 7382000 7381000

Level (m AHD)
- Below 170
- 170 - 174
- 174 - 178
- 178 - 182
- 182 - 186
- 186 - 190
- 190 - 194
- 194 - 198
- 198 - 202
- Above 202

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

0 400 800 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:30,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Sagittarius Creek PRCP Conditions Peak Levels - PMP

SLR

APPENDIX C1-1-4

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CAD\GIS\Output\Map setup\Sagittarius\MXDs\620.040134_APPENDIX C1-1-4_N004_PMP_h.mxd

685000 686000 687000 688000 689000 690000 691000 692000 693000

7390000 7389000 7388000 7387000 7386000 7385000 7384000 7383000 7382000 7381000

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Depth (m)
- Below 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 2
- Above 2

0 400 800 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:30,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Sagittarius Creek PRCP Conditions Peak Depths - 39% AEP

SLR

APPENDIX C1-2-1

H:\Projects-SLR\620-BNE\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CAD\GIS\Output\Map setup\Sagittarius\MXDs\620.040134_APPENDIX C1-2-1_N004_39p_d.mxd

685000 686000 687000 688000 689000 690000 691000 692000 693000

7390000 7389000 7388000 7387000 7386000 7385000 7384000 7383000 7382000 7381000

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Depth (m)
- Below 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 2
- Above 2

0 400 800 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:30,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Sagittarius Creek PRCP Conditions Peak Depths - 2% AEP

SLR

APPENDIX C1-2-2

H:\Projects-SLR\620-BNE\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CAD\GIS\Output\Map setup\Sagittarius\MXDs\620.040134_APPENDIX C1-2-2_N004_02p_d.mxd

685000 686000 687000 688000 689000 690000 691000 692000 693000

7390000 7389000 7388000 7387000 7386000 7385000 7384000 7383000 7382000 7381000

Depth (m)
- Below 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 2
- Above 2

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

0 400 800 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:30,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Sagittarius Creek PRCP Conditions Peak Depths - 0.1% AEP

SLR

APPENDIX C1-2-3

H:\Projects-SLR\620-BNE\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CAD\GIS\Output\Map setup\Sagittarius\MXDs\620.040134_APPENDIX C1-2-3_N004_1in1000_d.mxd

685000 686000 687000 688000 689000 690000 691000 692000 693000

7390000 7389000 7388000 7387000 7386000 7385000 7384000 7383000 7382000 7381000

Depth (m)
- Below 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 2
- Above 2

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

0 400 800 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:30,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Sagittarius Creek PRCP Conditions Peak Depths - PMP

SLR

APPENDIX C1-2-4

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Sagittarius\MXDs\620.040134_APPENDIX C1-2-4_N004_PMP_d.mxd

685000 686000 687000 688000 689000 690000 691000 692000 693000

7390000 7389000 7388000 7387000 7386000 7385000 7384000 7383000 7382000 7381000

Velocity (m/s)
- Below 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 2.5
- 2.5 - 3.0
- 3.0 - 3.5
- Above 3.5

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

0 400 800 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:30,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Sagittarius Creek PRCP Conditions Peak Velocities - 39% AEP

SLR

APPENDIX C1-3-1

H:\Projects-SLR\620-BNE\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CAD\GIS\Output\Map setup\Sagittarius\MXDs\620.040134_APPENDIX C1-3-1_N004_39p_v.mxd

685000 686000 687000 688000 689000 690000 691000 692000 693000

7390000 7389000 7388000 7387000 7386000 7385000 7384000 7383000 7382000 7381000

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Velocity (m/s)
- Below 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 2.5
- 2.5 - 3.0
- 3.0 - 3.5
- Above 3.5

0 400 800 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:30,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Sagittarius Creek PRCP Conditions Peak Velocities - 2% AEP

SLR

APPENDIX C1-3-2

H:\Projects-SLR\620-BNE\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CAD\GIS\Output\Map setup\Sagittarius\MXDs\620.040134_APPENDIX C1-3-2_N004_02p_v.mxd

685000 686000 687000 688000 689000 690000 691000 692000 693000

7390000 7389000 7388000 7387000 7386000 7385000 7384000 7383000 7382000 7381000

Velocity (m/s)
- Below 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 2.5
- 2.5 - 3.0
- 3.0 - 3.5
- Above 3.5

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

0 400 800 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:30,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Sagittarius Creek PRCP Conditions Peak Velocities - 0.1% AEP

SLR

APPENDIX C1-3-3

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CAD\GIS\Output\Map setup\Sagittarius\MXDs\620.040134_APPENDIX C1-3-3_N004_1in1000_v.mxd

685000 686000 687000 688000 689000 690000 691000 692000 693000

7390000 7389000 7388000 7387000 7386000 7385000 7384000 7383000 7382000 7381000

Velocity (m/s)
- Below 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 2.5
- 2.5 - 3.0
- 3.0 - 3.5
- Above 3.5

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

0 400 800 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:30,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Sagittarius Creek PRCP Conditions Peak Velocities - PMP

SLR

APPENDIX C1-3-4

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CAD\GIS\Output\Map setup\Sagittarius\MXDs\620.040134_APPENDIX C1-3-4_N004_PMP_v.mxd

685000 686000 687000 688000 689000 690000 691000 692000 693000

7390000 7389000 7388000 7387000 7386000 7385000 7384000 7383000 7382000 7381000

Bed Shear Stress (N/m²)
- 0 - 20
- 20 - 40
- 40 - 60
- 60 - 80
- > 80

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

0 400 800 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:30,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Sagittarius Creek PRCP Conditions Peak Bed Shear Stress - 39% AEP

SLR

APPENDIX C1-4-1

H:\Projects-SLR\620-BNE\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CAD\GIS\Output\Map setup\Sagittarius\MXDs\620.040134_APPENDIX C1-4-1_N004_39p_ bss.mxd

685000 686000 687000 688000 689000 690000 691000 692000 693000

7390000 7389000 7388000 7387000 7386000 7385000 7384000 7383000 7382000 7381000

Bed Shear Stress (N/m²)
- 0 - 20
- 20 - 40
- 40 - 60
- 60 - 80
- > 80

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

0 400 800 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:30,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Sagittarius Creek PRCP Conditions Peak Bed Shear Stress - 2% AEP

SLR

APPENDIX C1-4-2

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CAD\GIS\Output\Map setup\Sagittarius\MXDs\620.040134_APPENDIX C1-4-2_N004_02p_bss.mxd

685000 686000 687000 688000 689000 690000 691000 692000 693000

7390000 7389000 7388000 7387000 7386000 7385000 7384000 7383000 7382000 7381000

Stream Power (W/m²)
- 0 - 60
- 60 - 90
- 90 - 120
- 120 - 150
- >150

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

0 400 800 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:30,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Sagittarius Creek PRCP Conditions Peak Stream Power - 39% AEP

SLR

APPENDIX C1-5-1

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CAD\GIS\Output\Map setup\Sagittarius\MXDs\620.040134_APPENDIX C1-5-1_N004_39p_sp.mxd

685000 686000 687000 688000 689000 690000 691000 692000 693000

7390000 7389000 7388000 7387000 7386000 7385000 7384000 7383000 7382000 7381000

Stream Power (W/m²)
- 0 - 60
- 60 - 90
- 90 - 120
- 120 - 150
- >150

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

0 400 800 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:30,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Sagittarius Creek PRCP Conditions Peak Stream Power - 2% AEP

SLR

APPENDIX C1-5-2

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CAD\GIS\Output\Map setup\Sagittarius\MXDs\620.040134_APPENDIX C1-5-2_N004_02p_sp.mxd

685000 686000 687000 688000 689000 690000 691000 692000 693000

7390000 7389000 7388000 7387000 7386000 7385000 7384000 7383000 7382000 7381000

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Level (m AHD)
- Below 170
- 170 - 174
- 174 - 178
- 178 - 182
- 182 - 186
- 186 - 190
- 190 - 194
- 194 - 198
- 198 - 202
- Above 202

0 400 800 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:30,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Sagittarius Creek PRCP Conditions Peak Levels - 0.1% AEP 06p CC

SLR

APPENDIX C1-6-1

H:\Projects-SLR\620-BNE\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CAD\GIS\Output\Map setup\Sagittarius\MXDs\620.040134_APPENDIX C1-6-1_N004_1in1000CC06p_h.mxd

685000 686000 687000 688000 689000 690000 691000 692000 693000

7390000 7389000 7388000 7387000 7386000 7385000 7384000 7383000 7382000 7381000

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Level (m AHD)
- Below 170
- 170 - 174
- 174 - 178
- 178 - 182
- 182 - 186
- 186 - 190
- 190 - 194
- 194 - 198
- 198 - 202
- Above 202

0 400 800 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:30,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Sagittarius Creek PRCP Conditions Peak Levels - 0.1% AEP 11p CC

SLR

APPENDIX C1-6-2

H:\Projects-SLR\620-BNE\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CAD\GIS\Output\Map setup\Sagittarius\MXDs\620.040134_APPENDIX C1-6-2_N004_1in1000CC11p_h.mxd

685000 686000 687000 688000 689000 690000 691000 692000 693000

7390000 7389000 7388000 7387000 7386000 7385000 7384000 7383000 7382000 7381000

Level (m AHD)
- Below 170
- 170 - 174
- 174 - 178
- 178 - 182
- 182 - 186
- 186 - 190
- 190 - 194
- 194 - 198
- 198 - 202
- Above 202

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

0 400 800 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:30,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Sagittarius Creek PRCP Conditions Peak Levels - 0.1% AEP 20p CC

SLR

APPENDIX C1-6-3

H:\Projects-SLR\620-BNE\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CAD\GIS\Output\Map setup\Sagittarius\MXDs\620.040134_APPENDIX C1-6-3_N004_1in1000CC20p_h.mxd

685000 686000 687000 688000 689000 690000 691000 692000 693000

7390000 7389000 7388000 7387000 7386000 7385000 7384000 7383000 7382000 7381000

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Depth (m)
- Below 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 2
- Above 2

0 400 800 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:30,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Sagittarius Creek PRCP Conditions Peak Depths - 0.1% AEP 06p CC

SLR

APPENDIX C1-7-1

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CAD\GIS\Output\Map setup\Sagittarius\MXDs\620.040134_APPENDIX C1-7-1_N004_1in1000CC06p_d.mxd

685000 686000 687000 688000 689000 690000 691000 692000 693000

7390000 7389000 7388000 7387000 7386000 7385000 7384000 7383000 7382000 7381000

Depth (m)
- Below 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 2
- Above 2

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

0 400 800 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:30,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Sagittarius Creek PRCP Conditions Peak Depths - 0.1% AEP 11p CC

SLR

APPENDIX C1-7-2

H:\Projects-SLR\620-BNE\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CAD\GIS\Output\Map setup\Sagittarius\MXDs\620.040134_APPENDIX C1-7-2_N004_1in1000CC11p_d.mxd

685000 686000 687000 688000 689000 690000 691000 692000 693000

7390000 7389000 7388000 7387000 7386000 7385000 7384000 7383000 7382000 7381000

Depth (m)
- Below 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 2
- Above 2

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

0 400 800 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:30,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Sagittarius Creek PRCP Conditions Peak Depths - 0.1% AEP 20p CC

SLR

APPENDIX C1-7-3

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CAD\GIS\Output\Map setup\Sagittarius\MXDs\620.040134_APPENDIX C1-7-3_N004_1in1000CC20p_d.mxd

685000 686000 687000 688000 689000 690000 691000 692000 693000

7390000 7389000 7388000 7387000 7386000 7385000 7384000 7383000 7382000 7381000

Velocity (m/s)
- Below 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 2.5
- 2.5 - 3.0
- 3.0 - 3.5
- Above 3.5

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

0 400 800 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:30,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Sagittarius Creek PRCP Conditions Peak Velocities - 0.1% AEP 06p CC

SLR

APPENDIX C1-8-1

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Sagittarius\MXDs\620.040134_APPENDIX C1-8-1_N004_1in1000CC06p_v.mxd

685000 686000 687000 688000 689000 690000 691000 692000 693000

7390000 7389000 7388000 7387000 7386000 7385000 7384000 7383000 7382000 7381000

Velocity (m/s)
- Below 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 2.5
- 2.5 - 3.0
- 3.0 - 3.5
- Above 3.5

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

0 400 800 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:30,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Sagittarius Creek PRCP Conditions Peak Velocities - 0.1% AEP 11p CC

SLR

APPENDIX C1-8-2

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Sagittarius\MXDs\620.040134_APPENDIX C1-8-2_N004_1in1000CC11p_v.mxd

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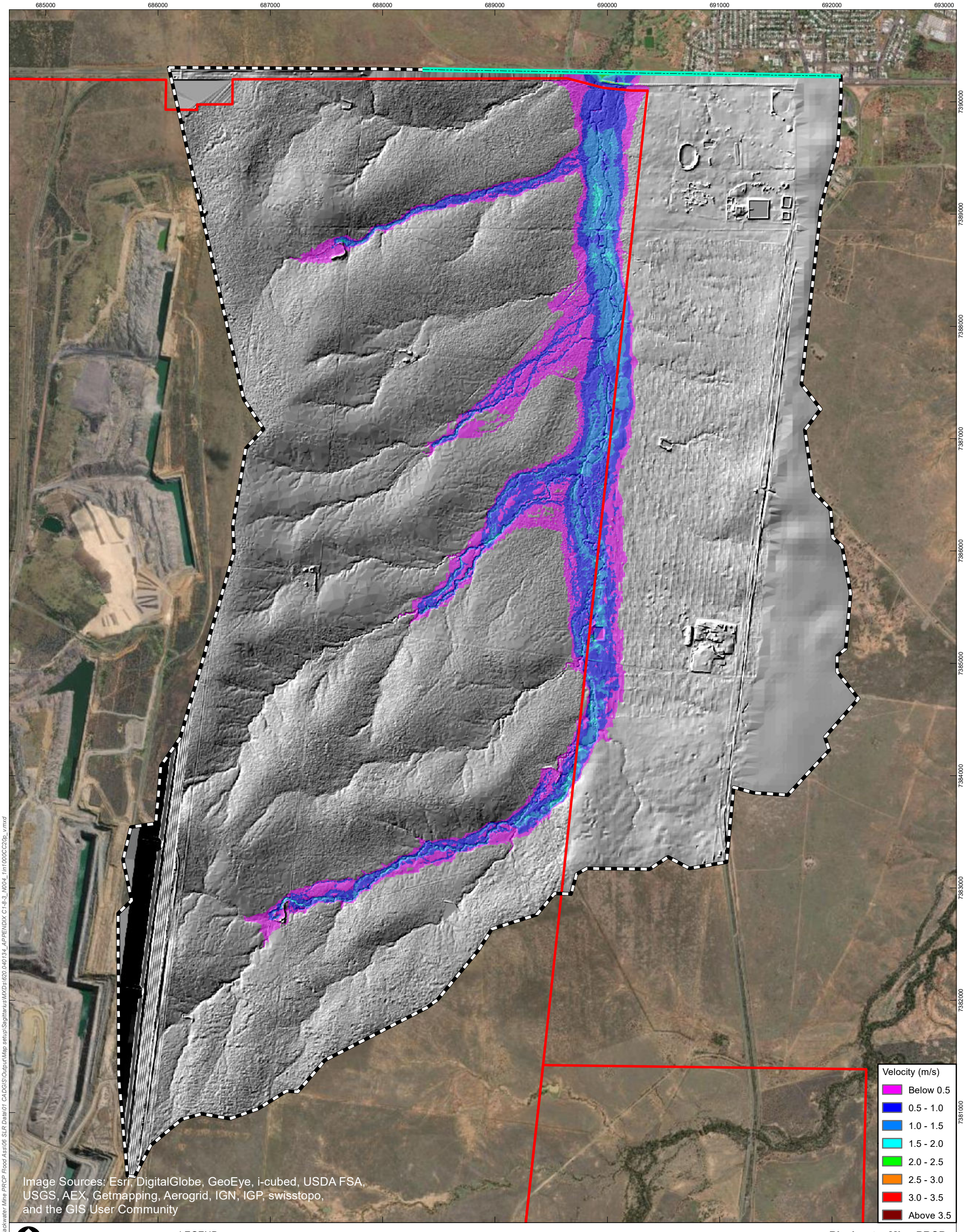
7390000 7389000 7388000 7387000 7386000 7385000 7384000 7383000 7382000 7381000



0 400 800 Meters

LEGEND

- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:30,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Sagittarius Creek PRCP Conditions Peak Velocities - 0.1% AEP 20p CC

SLR

APPENDIX C1-8-3

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CAD\GIS\Output\Map setup\Sagittarius\MXDs\620.040134_APPENDIX C1-8-3_N004_1in1000CC20p_v.mxd

682000 683000 684000 685000 686000 687000

7390000 7389000 7388000 7387000 7386000 7385000 7384000

Level (m AHD)
- Below 182
- 182 - 184
- 184 - 186
- 186 - 188
- 188 - 190
- 190 - 192
- 192 - 194
- 194 - 196
- 196 - 198
- Above 198

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

0 250 500 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:20,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Bonnie Doon Creek PRCP Conditions Peak Levels - 39% AEP

SLR

APPENDIX C2-1-1

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\OutputMap setup\Bonnie Doon\MXDs\620.040134_APPENDIX C2-1-1_N006_39p_h.mxd

682000 683000 684000 685000 686000 687000

7390000 7389000 7388000 7387000 7386000 7385000 7384000

Level (m AHD)
- Below 182
- 182 - 184
- 184 - 186
- 186 - 188
- 188 - 190
- 190 - 192
- 192 - 194
- 194 - 196
- 196 - 198
- Above 198

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

0 250 500 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:20,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Bonnie Doon Creek PRCP Conditions Peak Levels - 2% AEP

SLR

APPENDIX C2-1-2

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Bonnie Doon\MXDs\620.040134_APPENDIX C2-1-2_N006_02p_h.mxd

682000 683000 684000 685000 686000 687000

7390000 7389000 7388000 7387000 7386000 7385000 7384000

Level (m AHD)
- Below 182
- 182 - 184
- 184 - 186
- 186 - 188
- 188 - 190
- 190 - 192
- 192 - 194
- 194 - 196
- 196 - 198
- Above 198

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

0 250 500 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:20,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Bonnie Doon Creek PRCP Conditions Peak Levels - 0.1% AEP

SLR

APPENDIX C2-1-3

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Bonnie Doon\MXDs\620.040134_APPENDIX C2-1-3_N006_1in1000_h.mxd

682000 683000 684000 685000 686000 687000

7390000 7389000 7388000 7387000 7386000 7385000 7384000

Level (m AHD)
- Below 182
- 182 - 184
- 184 - 186
- 186 - 188
- 188 - 190
- 190 - 192
- 192 - 194
- 194 - 196
- 196 - 198
- Above 198

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

0 250 500 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:20,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Bonnie Doon Creek PRCP Conditions Peak Levels - PMP

SLR

APPENDIX C2-1-4

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Bonnie Doon\MXDs\620.040134_APPENDIX C2-1-4_N006_PMP_h.mxd

682000 683000 684000 685000 686000 687000

7390000 7389000 7388000 7387000 7386000 7385000 7384000

Depth (m)
- Below 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 2
- Above 2

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

0 250 500 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:20,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Bonnie Doon Creek PRCP Conditions Peak Depths - 39% AEP

SLR

APPENDIX C2-2-1

H:\Projects-SLR\620-BNE\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Bonnie Doon\MXDs\620.040134_APPENDIX C2-2-1_N006_39p_d.mxd

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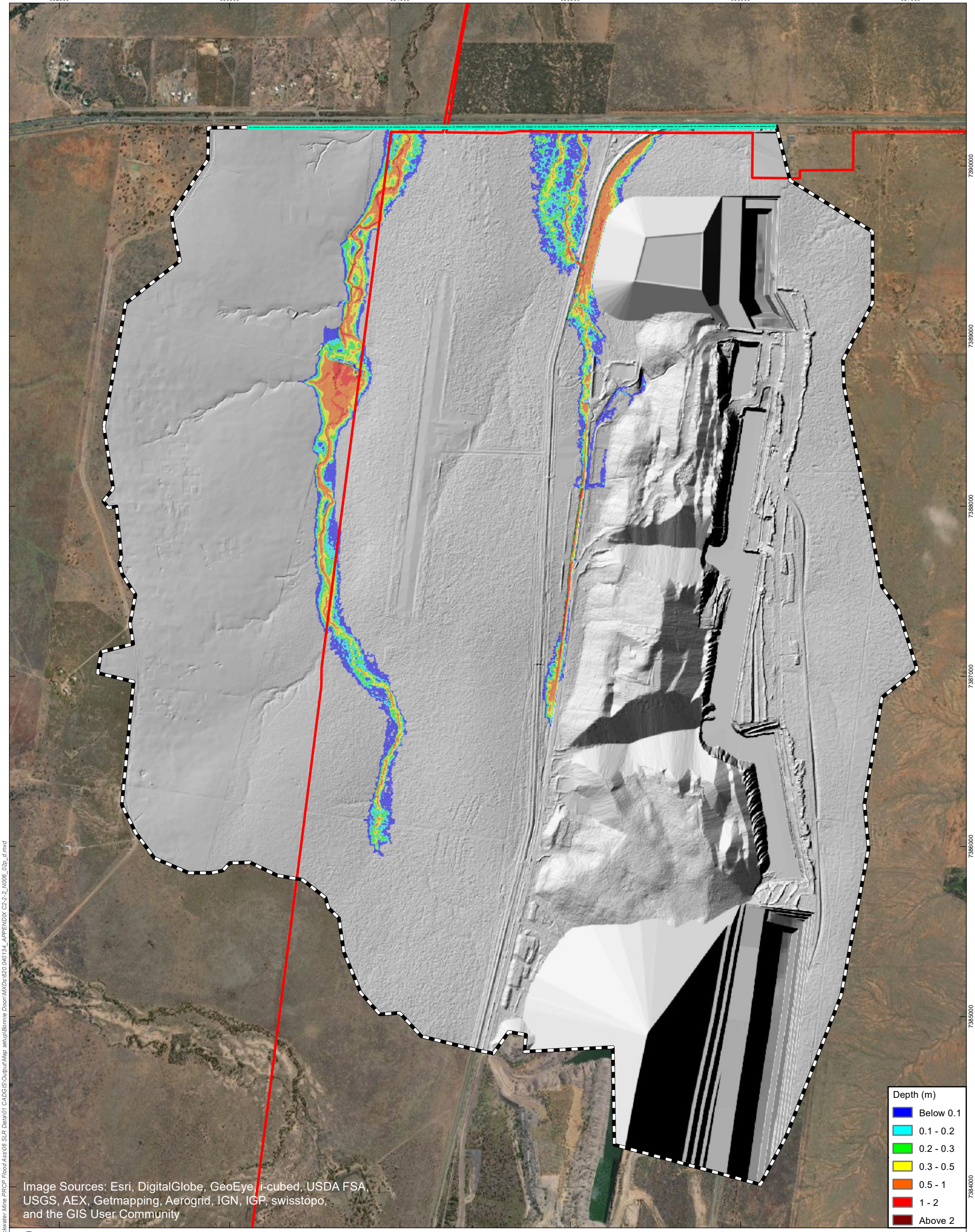
7390000 7389000 7388000 7387000 7386000 7385000 7384000



0 250 500 Meters

LEGEND

- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:20,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Bonnie Doon Creek PRCP Conditions Peak Depths - 2% AEP

SLR

APPENDIX C2-2-2

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Bonnie Doon\MXDs\620.040134_APPENDIX C2-2-2_N006_02p_d.mxd

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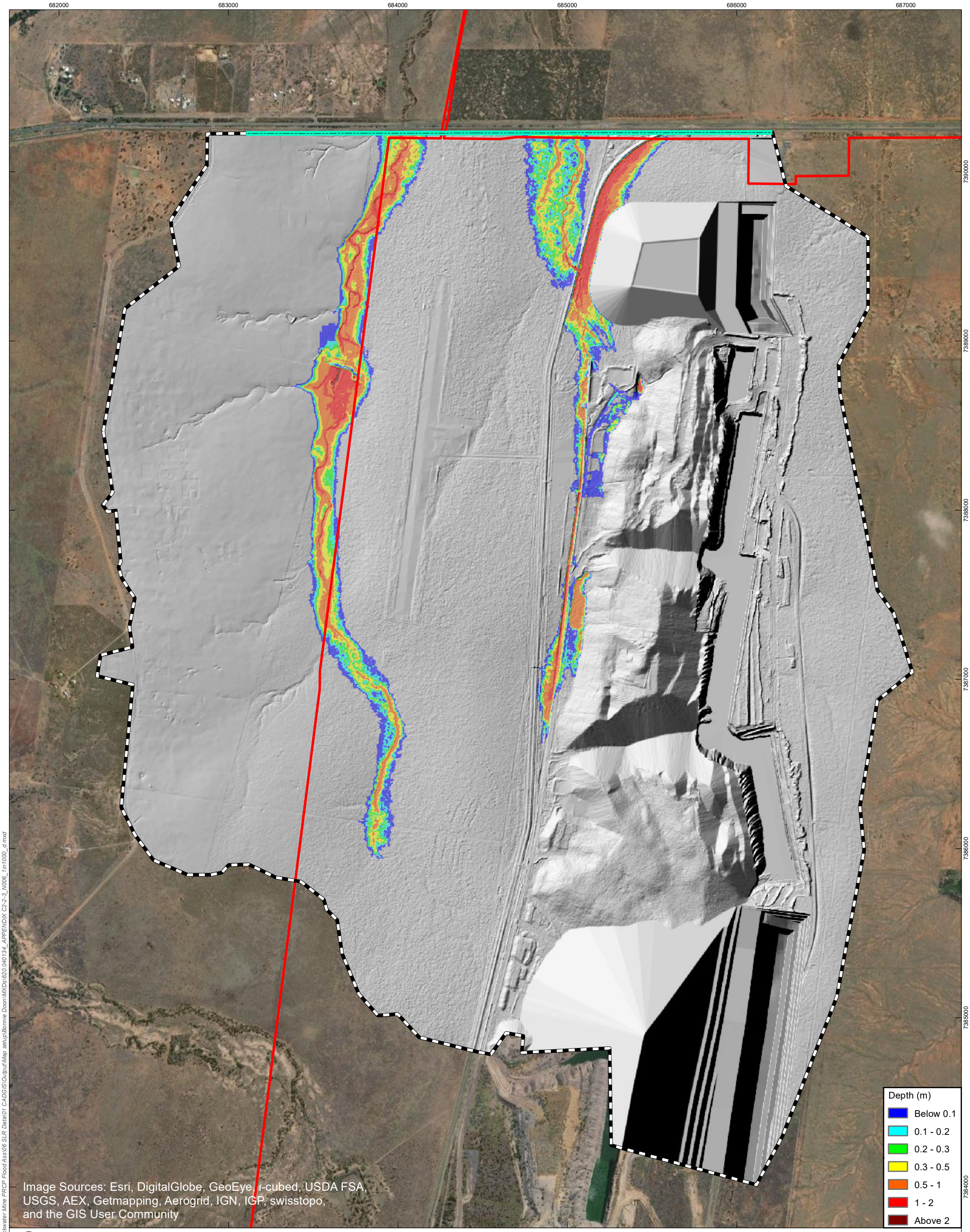
7390000 7389000 7388000 7387000 7386000 7385000 7384000



0 250 500 Meters

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:20,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

LEGEND

- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Blackwater Mine PRCP Flood Assessment

Bonnie Doon Creek PRCP Conditions Peak Depths - 0.1% AEP

SLR

APPENDIX C2-2-3

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Bonnie Doon\MXDs\620.040134_APPENDIX C2-2-3_N006_1in1000_d.mxd

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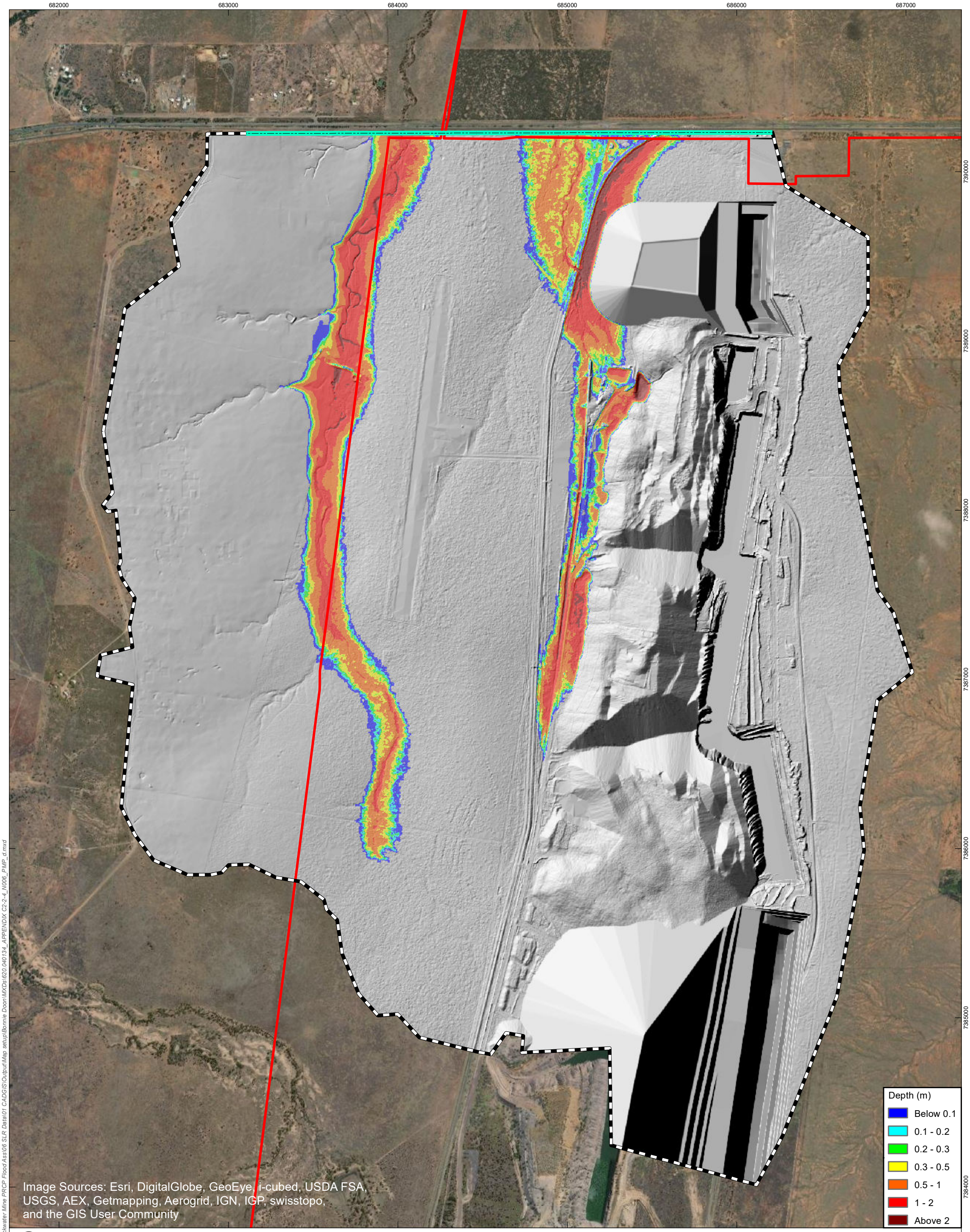

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

0 250 500 Meters

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:20,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

LEGEND

- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Blackwater Mine PRCP Flood Assessment

Bonnie Doon Creek PRCP Conditions Peak Depths - PMP

SLR

APPENDIX C2-2-4

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Bonnie Doon\MXDs\620.040134_APPENDIX C2-2-4_N006_PMP_d.mxd

682000
683000
684000
685000
686000
687000
7390000
7389000
7388000
7387000
7386000
7385000
7384000

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Velocity (m/s)
- Below 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 2.5
- 2.5 - 3.0
- 3.0 - 3.5
- Above 3.5

0 250 500 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:20,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Bonnie Doon Creek PRCP Conditions Peak Velocities - 39% AEP

SLR

APPENDIX C2-3-1

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Bonnie Doon\MXDs\620.040134_APPENDIX C2-3-1_N006_39p_v.mxd

682000 683000 684000 685000 686000 687000

7390000 7389000 7388000 7387000 7386000 7385000 7384000

Velocity (m/s)
- Below 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 2.5
- 2.5 - 3.0
- 3.0 - 3.5
- Above 3.5

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

0 250 500 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:20,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Bonnie Doon Creek PRCP Conditions Peak Velocities - 2% AEP

SLR

APPENDIX C2-3-2

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Bonnie Doon\MXDs\620.040134_APPENDIX C2-3-2_N006_02p_v.mxd

682000 683000 684000 685000 686000 687000

7390000 7389000 7388000 7387000 7386000 7385000 7384000

Velocity (m/s)
- Below 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 2.5
- 2.5 - 3.0
- 3.0 - 3.5
- Above 3.5

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

0 250 500 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:20,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Bonnie Doon Creek PRCP Conditions Peak Velocities - 0.1% AEP

SLR

APPENDIX C2-3-3

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Bonnie Doon\MXDs\620.040134_APPENDIX C2-3-3_N006_1in1000_v.mxd

682000 683000 684000 685000 686000 687000

7390000 7389000 7388000 7387000 7386000 7385000 7384000

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Velocity (m/s)
- Below 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 2.5
- 2.5 - 3.0
- 3.0 - 3.5
- Above 3.5

0 250 500 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:20,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Bonnie Doon Creek PRCP Conditions Peak Velocities - PMP

SLR

APPENDIX C2-3-4

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Bonnie Doon\MXDs\620.040134_APPENDIX C2-3-4_N006_PMP_v.mxd

682000
683000
684000
685000
686000
687000
7390000
7389000
7388000
7387000
7386000
7385000
7384000

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Bed Shear Stress (N/m²)
- 0 - 20
- 20 - 40
- 40 - 60
- 60 - 80
- > 80

0 250 500 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:20,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Bonnie Doon Creek PRCP Conditions Peak Bed Shear Stress - 39% AEP

SLR

APPENDIX C2-4-1

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Bonnie Doon\MXDs\620.040134_APPENDIX C2-4-1_N006_39p_bss.mxd

682000 683000 684000 685000 686000 687000

7390000 7389000 7388000 7387000 7386000 7385000 7384000

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Bed Shear Stress (N/m²)
- 0 - 20
- 20 - 40
- 40 - 60
- 60 - 80
- > 80

0 250 500 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:20,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Bonnie Doon Creek PRCP Conditions Peak Bed Shear Stress - 2% AEP

SLR

APPENDIX C2-4-2

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Bonnie Doon\MXDs\620.040134_APPENDIX C2-4-2_N006_02p_bss.mxd

682000
683000
684000
685000
686000
687000

7390000
7389000
7388000
7387000
7386000
7385000
7384000

Stream Power (W/m²)
0 - 60
60 - 90
90 - 120
120 - 150
>150

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

0 250 500 Meters

LEGEND

- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:20,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Bonnie Doon Creek PRCP Conditions Peak Stream Power - 39% AEP

SLR

APPENDIX C2-5-1

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Bonnie Doon\MXDs\620.040134_APPENDIX C2-5-1_N006_39p_sp.mxd

682000 683000 684000 685000 686000 687000

7390000 7389000 7388000 7387000 7386000 7385000 7384000

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Stream Power (W/m²)
- 0 - 60
- 60 - 90
- 90 - 120
- 120 - 150
- >150

0 250 500 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:20,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Bonnie Doon Creek PRCP Conditions Peak Stream Power - 2% AEP

SLR

APPENDIX C2-5-2

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Bonnie Doon\MXDs\620.040134_APPENDIX C2-5-2_N006_02p_sp.mxd

682000 683000 684000 685000 686000 687000

7390000 7389000 7388000 7387000 7386000 7385000 7384000

Level (m AHD)
- Below 182
- 182 - 184
- 184 - 186
- 186 - 188
- 188 - 190
- 190 - 192
- 192 - 194
- 194 - 196
- 196 - 198
- Above 198

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

0 250 500 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:20,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Bonnie Doon Creek PRCP Conditions Peak Levels - 0.1% AEP 06p CC

SLR

APPENDIX C2-6-1

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Bonnie Doon\MXDs\620.040134_APPENDIX C2-6-1_N006_1in1000CC06p_h.mxd

682000 683000 684000 685000 686000 687000

7390000 7389000 7388000 7387000 7386000 7385000 7384000

Level (m AHD)
- Below 182
- 182 - 184
- 184 - 186
- 186 - 188
- 188 - 190
- 190 - 192
- 192 - 194
- 194 - 196
- 196 - 198
- Above 198

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

0 250 500 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:20,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Bonnie Doon Creek PRCP Conditions Peak Levels - 0.1% AEP 11p CC

SLR

APPENDIX C2-6-2

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Bonnie Doon\MXDs\620.040134_APPENDIX C2-6-2_N006_1in1000CC11p_h.mxd

682000 683000 684000 685000 686000 687000

7390000 7389000 7388000 7387000 7386000 7385000 7384000

Level (m AHD)
- Below 182
- 182 - 184
- 184 - 186
- 186 - 188
- 188 - 190
- 190 - 192
- 192 - 194
- 194 - 196
- 196 - 198
- Above 198

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

0 250 500 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:20,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Bonnie Doon Creek PRCP Conditions Peak Levels - 0.1% AEP 20p CC

SLR

APPENDIX C2-6-3

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Bonnie Doon\MXDs\620.040134_APPENDIX C2-6-3_N006_1in1000CC20p_h.mxd

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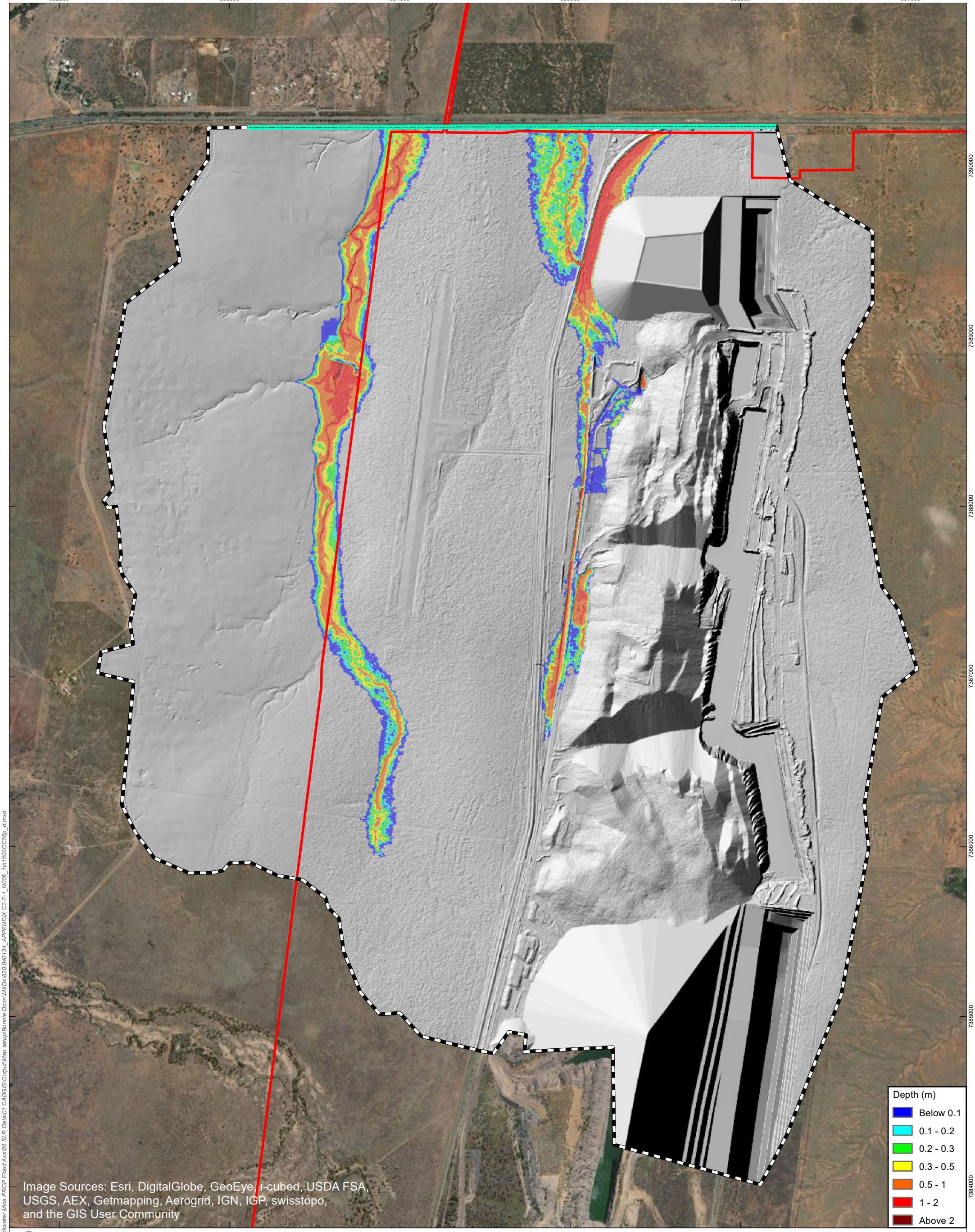
7390000 7389000 7388000 7387000 7386000 7385000 7384000



0 250 500 Meters

LEGEND

- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:20,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Bonnie Doon Creek PRCP Conditions Peak Depths - 0.1% AEP 06p CC

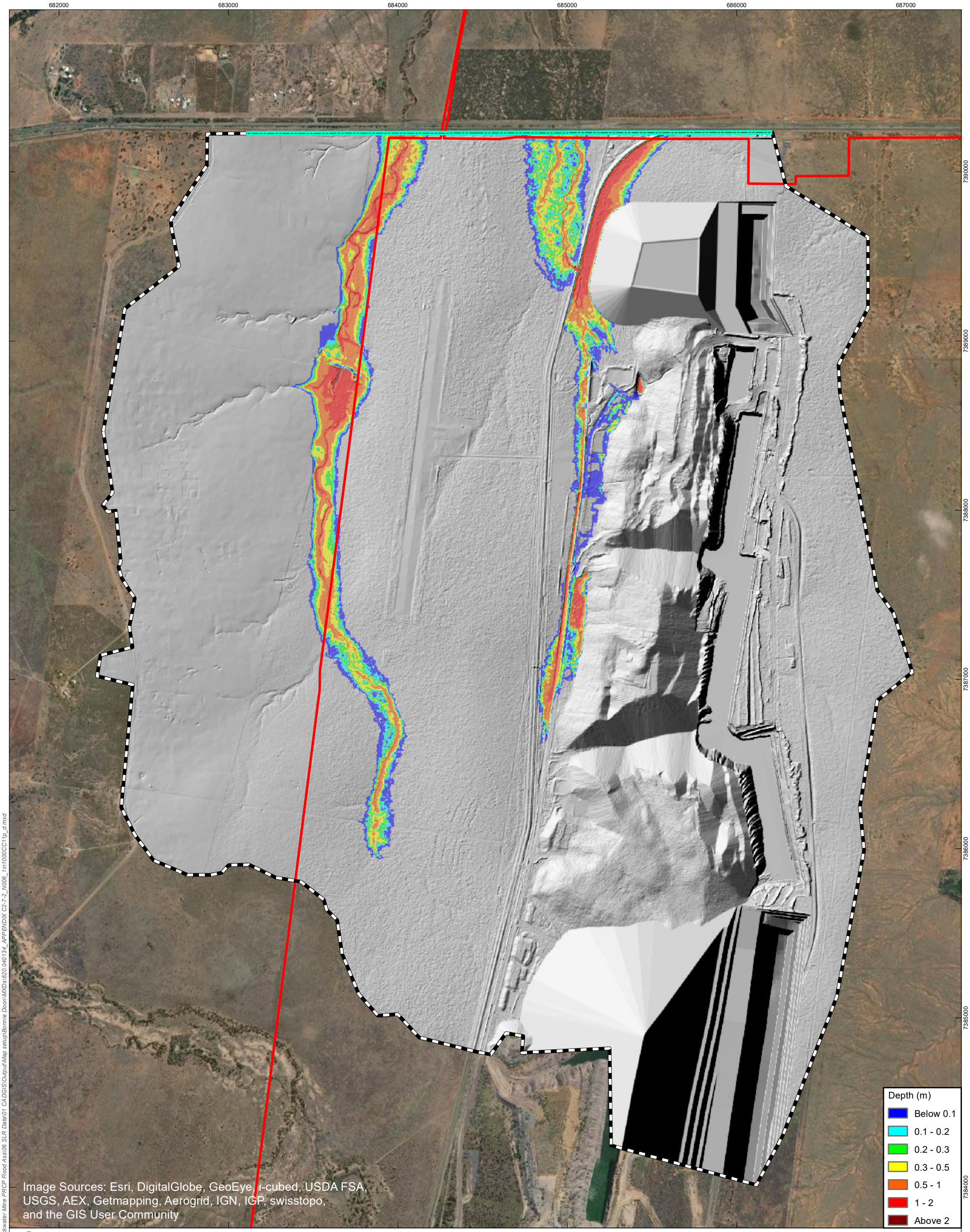
SLR

APPENDIX C2-7-1

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Bonnie Doon\MXDs\620.040134_APPENDIX C2-7-1_N006_1in1000CC06p_d.mxd

682000 683000 684000 685000 686000 687000

7390000 7389000 7388000 7387000 7386000 7385000 7384000



0 250 500 Meters

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:20,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

LEGEND

- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Blackwater Mine PRCP Flood Assessment

Bonnie Doon Creek PRCP Conditions Peak Depths - 0.1% AEP 11p CC

SLR

APPENDIX C2-7-2

H:\Projects-SLR\620-BNE\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Bonnie Doon\MXDs\620.040134_APPENDIX C2-7-2_N006_1in1000CC11p_d.mxd

682000 683000 684000 685000 686000 687000

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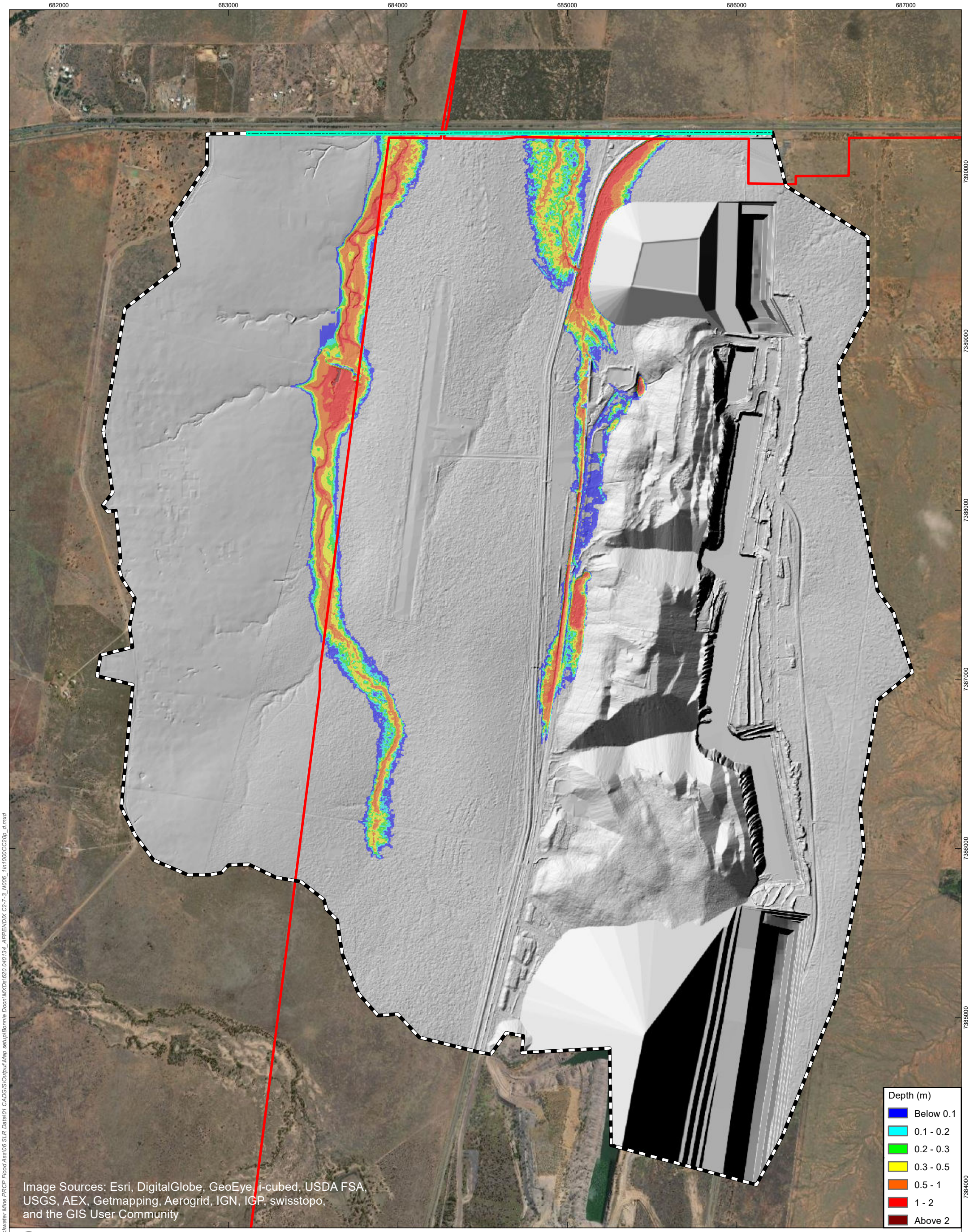


0 250 500 Meters

LEGEND

- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:20,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Bonnie Doon Creek PRCP Conditions Peak Depths - 0.1% AEP 20p CC

SLR

APPENDIX C2-7-3

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Bonnie Doon\MXDs\620.040134_APPENDIX C2-7-3_N006_1in1000CC20p_d.mxd

682000 683000 684000 685000 686000 687000

7390000 7389000 7388000 7387000 7386000 7385000 7384000

Velocity (m/s)
- Below 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 2.5
- 2.5 - 3.0
- 3.0 - 3.5
- Above 3.5

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

0 250 500 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:20,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Bonnie Doon Creek PRCP Conditions Peak Velocities - 0.1% AEP 06p CC

SLR

APPENDIX C2-8-1

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Bonnie Doon\MXDs\620.040134_APPENDIX C2-8-1_N006_1in1000CC06p_v.mxd

682000 683000 684000 685000 686000 687000

7390000 7389000 7388000 7387000 7386000 7385000 7384000

Velocity (m/s)
- Below 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 2.5
- 2.5 - 3.0
- 3.0 - 3.5
- Above 3.5

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

0 250 500 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:20,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Bonnie Doon Creek PRCP Conditions Peak Velocities - 0.1% AEP 11p CC

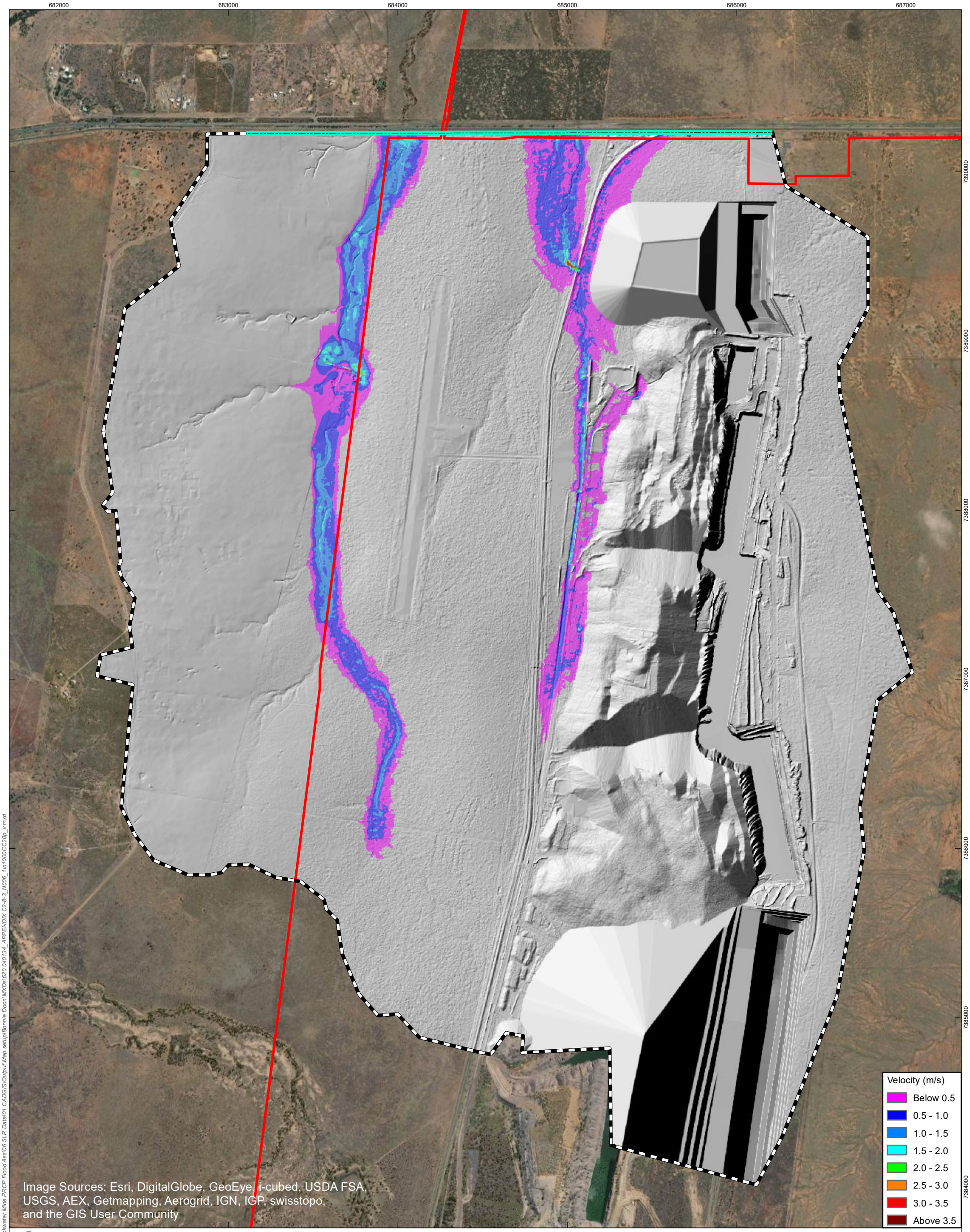
SLR

APPENDIX C2-8-2

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Bonnie Doon\MXDs\620.040134_APPENDIX C2-8-2_N006_1in1000CC11p_v.mxd

682000 683000 684000 685000 686000 687000

7390000 7389000 7388000 7387000 7386000 7385000 7384000



0 250 500 Meters

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:20,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

LEGEND

- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Blackwater Mine PRCP Flood Assessment

Bonnie Doon Creek PRCP Conditions Peak Velocities - 0.1% AEP 20p CC

SLR

APPENDIX C2-8-3

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Bonnie Doon\MXDs\620.040134_APPENDIX C2-8-3_N006_1in1000CC20p_v.mxd

677000 678000 679000 680000 681000 682000 683000 684000 685000 686000 687000 688000

7388000 7387000 7386000 7385000 7384000 7383000 7382000 7381000 7380000 7379000 7378000 7377000 7376000 7375000 7374000 7373000 7372000

Level (m AHD)
- Below 195
- 195 - 200
- 200 - 205
- 205 - 210
- 210 - 215
- 215 - 220
- 220 - 225
- 225 - 230
- 230 - 235
- Above 235

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

0 500 1,000 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:45,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

SLR

Blackwater Mine PRCP Flood Assessment

Burngrove Creek PRCP Conditions Peak Levels - 39% AEP

APPENDIX C3-1-1

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Burngrove\MXDs\620.040134_APPENDIX C3-1-1_N006_39p_h.mxd

677000 678000 679000 680000 681000 682000 683000 684000 685000 686000 687000 688000

7388000 7387000 7386000 7385000 7384000 7383000 7382000 7381000 7380000 7379000 7378000 7377000 7376000 7375000 7374000 7373000 7372000

Level (m AHD)
- Below 195
- 195 - 200
- 200 - 205
- 205 - 210
- 210 - 215
- 215 - 220
- 220 - 225
- 225 - 230
- 230 - 235
- Above 235

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

0 500 1,000 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:45,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

SLR

Blackwater Mine PRCP Flood Assessment

Burngrove Creek PRCP Conditions Peak Levels - 2% AEP

APPENDIX C3-1-2

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Burngrove\MXDs\620.040134_APPENDIX C3-1-2_N006_02p_h.mxd

677000 678000 679000 680000 681000 682000 683000 684000 685000 686000 687000 688000

7388000 7387000 7386000 7385000 7384000 7383000 7382000 7381000 7380000 7379000 7378000 7377000 7376000 7375000 7374000 7373000 7372000

Level (m AHD)
- Below 195
- 195 - 200
- 200 - 205
- 205 - 210
- 210 - 215
- 215 - 220
- 220 - 225
- 225 - 230
- 230 - 235
- Above 235

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

0 500 1,000 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:45,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

SLR

Blackwater Mine PRCP Flood Assessment

Burngrove Creek PRCP Conditions Peak Levels - 0.1% AEP

APPENDIX C3-1-3

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Burngrove\MXDs\620.040134_APPENDIX C3-1-3_N006_1in1000_h.mxd

677000 678000 679000 680000 681000 682000 683000 684000 685000 686000 687000 688000

7388000 7387000 7386000 7385000 7384000 7383000 7382000 7381000 7380000 7379000 7378000 7377000 7376000 7375000 7374000 7373000 7372000

Level (m AHD)
- Below 195
- 195 - 200
- 200 - 205
- 205 - 210
- 210 - 215
- 215 - 220
- 220 - 225
- 225 - 230
- 230 - 235
- Above 235

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

0 500 1,000 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:45,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

SLR

Blackwater Mine PRCP Flood Assessment

Burngrove Creek PRCP Conditions Peak Levels - PMP

APPENDIX C3-1-4

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Burngrove\MXDs\620.040134_APPENDIX C3-1-4_N006_PMP_h.mxd

677000 678000 679000 680000 681000 682000 683000 684000 685000 686000 687000 688000

7388000 7387000 7386000 7385000 7384000 7383000 7382000 7381000 7380000 7379000 7378000 7377000 7376000 7375000 7374000 7373000 7372000

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Depth (m)
- Below 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 2
- Above 2

0 500 1,000 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:45,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

SLR

Blackwater Mine PRCP Flood Assessment

Burngrove Creek PRCP Conditions Peak Depths - 39% AEP

APPENDIX C3-2-1

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Burngrove\MXDs\620.040134_APPENDIX C3-2-1_N006_39p_d.mxd

677000 678000 679000 680000 681000 682000 683000 684000 685000 686000 687000 688000

7388000 7387000 7386000 7385000 7384000 7383000 7382000 7381000 7380000 7379000 7378000 7377000 7376000 7375000 7374000 7373000 7372000

Depth (m)
- Below 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 2
- Above 2

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

0 500 1,000 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:45,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

SLR

Blackwater Mine PRCP Flood Assessment

Burngrove Creek PRCP Conditions Peak Depths - 2% AEP

APPENDIX C3-2-2

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Burngrove\MXDs\620.040134_APPENDIX C3-2-2_N006_02p_d.mxd

677000 678000 679000 680000 681000 682000 683000 684000 685000 686000 687000 688000

7388000 7387000 7386000 7385000 7384000 7383000 7382000 7381000 7380000 7379000 7378000 7377000 7376000 7375000 7374000 7373000 7372000

Depth (m)
- Below 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 2
- Above 2

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

0 500 1,000 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:45,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

SLR

Blackwater Mine PRCP Flood Assessment

Burngrove Creek PRCP Conditions Peak Depths - 0.1% AEP

APPENDIX C3-2-3

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Burngrove\MXDs\620.040134_APPENDIX C3-2-3_N006_1in1000_d.mxd

677000 678000 679000 680000 681000 682000 683000 684000 685000 686000 687000 688000

7388000 7387000 7386000 7385000 7384000 7383000 7382000 7381000 7380000 7379000 7378000 7377000 7376000 7375000 7374000 7373000 7372000

Depth (m)
- Below 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 2
- Above 2

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

0 500 1,000 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:45,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

SLR

Blackwater Mine PRCP Flood Assessment

Burngrove Creek PRCP Conditions Peak Depths - PMP

APPENDIX C3-2-4

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Burngrove\MXDs\620.040134_APPENDIX C3-2-4_N006_PMP_d.mxd

677000 678000 679000 680000 681000 682000 683000 684000 685000 686000 687000 688000

7388000 7387000 7386000 7385000 7384000 7383000 7382000 7381000 7380000 7379000 7378000 7377000 7376000 7375000 7374000 7373000 7372000

Velocity (m/s)
- Below 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 2.5
- 2.5 - 3.0
- 3.0 - 3.5
- Above 3.5

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

0 500 1,000 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:45,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

SLR

Blackwater Mine PRCP Flood Assessment

Burngrove Creek PRCP Conditions Peak Velocities - 39% AEP

APPENDIX C3-3-1

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Burngrove\MXDs\620.040134_APPENDIX C3-3-1_N006_39p_v.mxd

677000 678000 679000 680000 681000 682000 683000 684000 685000 686000 687000 688000

7388000 7387000 7386000 7385000 7384000 7383000 7382000 7381000 7380000 7379000 7378000 7377000 7376000 7375000 7374000 7373000 7372000

Velocity (m/s)
- Below 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 2.5
- 2.5 - 3.0
- 3.0 - 3.5
- Above 3.5

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

0 500 1,000 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:45,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

SLR

Blackwater Mine PRCP Flood Assessment

Burngrove Creek PRCP Conditions Peak Velocities - 2% AEP

APPENDIX C3-3-2

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Burngrove\MXDs\620.040134_APPENDIX C3-3-2_N006_02p_v.mxd

677000 678000 679000 680000 681000 682000 683000 684000 685000 686000 687000 688000

7388000 7387000 7386000 7385000 7384000 7383000 7382000 7381000 7380000 7379000 7378000 7377000 7376000 7375000 7374000 7373000 7372000

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Velocity (m/s)
- Below 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 2.5
- 2.5 - 3.0
- 3.0 - 3.5
- Above 3.5

0 500 1,000 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:45,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Burngrove Creek PRCP Conditions Peak Velocities - 0.1% AEP

SLR

APPENDIX C3-3-3

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Burngrove\MXDs\620.040134_APPENDIX C3-3-3_N006_1in1000_v.mxd

677000 678000 679000 680000 681000 682000 683000 684000 685000 686000 687000 688000

7388000 7387000 7386000 7385000 7384000 7383000 7382000 7381000 7380000 7379000 7378000 7377000 7376000 7375000 7374000 7373000 7372000

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Velocity (m/s)
- Below 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 2.5
- 2.5 - 3.0
- 3.0 - 3.5
- Above 3.5

0 500 1,000 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:45,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

SLR

Blackwater Mine PRCP Flood Assessment

Burngrove Creek PRCP Conditions Peak Velocities - PMP

APPENDIX C3-3-4

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Burngrove\MXDs\620.040134_APPENDIX C3-3-4_N006_PMP_v.mxd

677000 678000 679000 680000 681000 682000 683000 684000 685000 686000 687000 688000

7388000 7387000 7386000 7385000 7384000 7383000 7382000 7381000 7380000 7379000 7378000 7377000 7376000 7375000 7374000 7373000 7372000

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Bed Shear Stress (N/m²)
- 0 - 20
- 20 - 40
- 40 - 60
- 60 - 80
- > 80

0 500 1,000 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:45,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Burngrove Creek PRCP Conditions Peak Bed Shear Stress - 39% AEP

SLR

APPENDIX C3-4-1

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Burngrove\MXDs\620.040134_APPENDIX C3-4-1_N006_39p_bss.mxd

677000 678000 679000 680000 681000 682000 683000 684000 685000 686000 687000 688000

7388000 7387000 7386000 7385000 7384000 7383000 7382000 7381000 7380000 7379000 7378000 7377000 7376000 7375000 7374000 7373000 7372000

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Bed Shear Stress (N/m²)
- 0 - 20
- 20 - 40
- 40 - 60
- 60 - 80
- > 80

0 500 1,000 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:45,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

SLR

Blackwater Mine PRCP Flood Assessment

Burngrove Creek PRCP Conditions Peak Bed Shear Stress - 2% AEP

APPENDIX C3-4-2

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Burngrove\MXDs\620.040134_APPENDIX C3-4-2_N006_02p_bss.mxd

677000 678000 679000 680000 681000 682000 683000 684000 685000 686000 687000 688000

7388000 7387000 7386000 7385000 7384000 7383000 7382000 7381000 7380000 7379000 7378000 7377000 7376000 7375000 7374000 7373000 7372000

Stream Power (W/m²)
- 0 - 60
- 60 - 90
- 90 - 120
- 120 - 150
- >150

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

0 500 1,000 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:45,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

SLR

Blackwater Mine PRCP Flood Assessment

Burngrove Creek PRCP Conditions Peak Stream Power - 39% AEP

APPENDIX C3-5-1

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Burngrove\MXDs\620.040134_APPENDIX C3-5-1_N006_39p_sp.mxd

677000 678000 679000 680000 681000 682000 683000 684000 685000 686000 687000 688000

7388000 7387000 7386000 7385000 7384000 7383000 7382000 7381000 7380000 7379000 7378000 7377000 7376000 7375000 7374000 7373000 7372000

Stream Power (W/m²)
- 0 - 60
- 60 - 90
- 90 - 120
- 120 - 150
- >150

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

0 500 1,000 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:45,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Burngrove Creek PRCP Conditions Peak Stream Power - 2% AEP

SLR

APPENDIX C3-5-2

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Burngrove\MXDs\620.040134_APPENDIX C3-5-2_N006_02p_sp.mxd

677000 678000 679000 680000 681000 682000 683000 684000 685000 686000 687000 688000

7388000 7387000 7386000 7385000 7384000 7383000 7382000 7381000 7380000 7379000 7378000 7377000 7376000 7375000 7374000 7373000 7372000

Level (m AHD)
- Below 195
- 195 - 200
- 200 - 205
- 205 - 210
- 210 - 215
- 215 - 220
- 220 - 225
- 225 - 230
- 230 - 235
- Above 235

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

0 500 1,000 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:45,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

SLR

Blackwater Mine PRCP Flood Assessment

Burngrove Creek PRCP Conditions Peak Levels - 0.1% AEP 06p CC

APPENDIX C3-6-1

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Burngrove\MXDs\620.040134_APPENDIX C3-6-1_N006_1in1000CC06p_h.mxd

677000 678000 679000 680000 681000 682000 683000 684000 685000 686000 687000 688000

7388000 7387000 7386000 7385000 7384000 7383000 7382000 7381000 7380000 7379000 7378000 7377000 7376000 7375000 7374000 7373000 7372000

Level (m AHD)
- Below 195
- 195 - 200
- 200 - 205
- 205 - 210
- 210 - 215
- 215 - 220
- 220 - 225
- 225 - 230
- 230 - 235
- Above 235

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

0 500 1,000 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:45,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

SLR

Blackwater Mine PRCP Flood Assessment

Burngrove Creek PRCP Conditions Peak Levels - 0.1% AEP 11p CC

APPENDIX C3-6-2

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Burngrove\MXDs\620.040134_APPENDIX C3-6-2_N006_1in1000CC11p_h.mxd

677000 678000 679000 680000 681000 682000 683000 684000 685000 686000 687000 688000

7388000 7387000 7386000 7385000 7384000 7383000 7382000 7381000 7380000 7379000 7378000 7377000 7376000 7375000 7374000 7373000 7372000

Level (m AHD)
- Below 195
- 195 - 200
- 200 - 205
- 205 - 210
- 210 - 215
- 215 - 220
- 220 - 225
- 225 - 230
- 230 - 235
- Above 235

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

0 500 1,000 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:45,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

SLR

Blackwater Mine PRCP Flood Assessment

Burngrove Creek PRCP Conditions Peak Levels - 0.1% AEP 20p CC

APPENDIX C3-6-3

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Burngrove\MXDs\620.040134_APPENDIX C3-6-3_N006_1in1000CC20p_h.mxd

677000 678000 679000 680000 681000 682000 683000 684000 685000 686000 687000 688000

7388000 7387000 7386000 7385000 7384000 7383000 7382000 7381000 7380000 7379000 7378000 7377000 7376000 7375000 7374000 7373000 7372000

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Depth (m)
- Below 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 2
- Above 2

0 500 1,000 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:45,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

SLR

Blackwater Mine PRCP Flood Assessment

Burngrove Creek PRCP Conditions Peak Depths - 0.1% AEP 06p CC

APPENDIX C3-7-1

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Burngrove\MXDs\620.040134_APPENDIX C3-7-1_N006_1in1000CC06p_d.mxd

677000 678000 679000 680000 681000 682000 683000 684000 685000 686000 687000 688000

7388000 7387000 7386000 7385000 7384000 7383000 7382000 7381000 7380000 7379000 7378000 7377000 7376000 7375000 7374000 7373000 7372000

Depth (m)
- Below 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 2
- Above 2

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

0 500 1,000 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:45,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

SLR

Blackwater Mine PRCP Flood Assessment

Burngrove Creek PRCP Conditions Peak Depths - 0.1% AEP 11p CC

APPENDIX C3-7-2

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Burngrove\MXDs\620.040134_APPENDIX C3-7-2_N006_1in1000CC11p_d.mxd

677000 678000 679000 680000 681000 682000 683000 684000 685000 686000 687000 688000

7388000 7387000 7386000 7385000 7384000 7383000 7382000 7381000 7380000 7379000 7378000 7377000 7376000 7375000 7374000 7373000 7372000

Depth (m)
- Below 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 2
- Above 2

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

0 500 1,000 Meters

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:45,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Blackwater Mine PRCP Flood Assessment

Burngrove Creek PRCP Conditions Peak Depths - 0.1% AEP 20p CC

SLR

APPENDIX C3-7-3

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Burngrove\MXDs\620.040134_APPENDIX C3-7-3_N006_1in1000CC20p_d.mxd

677000 678000 679000 680000 681000 682000 683000 684000 685000 686000 687000 688000

7388000 7387000 7386000 7385000 7384000 7383000 7382000 7381000 7380000 7379000 7378000 7377000 7376000 7375000 7374000 7373000 7372000

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Velocity (m/s)
- Below 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 2.5
- 2.5 - 3.0
- 3.0 - 3.5
- Above 3.5

0 500 1,000 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:45,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

SLR

Blackwater Mine PRCP Flood Assessment

Burngrove Creek PRCP Conditions Peak Velocities - 0.1% AEP 06p CC

APPENDIX C3-8-1

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Burngrove\MXDs\620.040134_APPENDIX C3-8-1_N006_1in1000CC06p_v.mxd

677000 678000 679000 680000 681000 682000 683000 684000 685000 686000 687000 688000

7388000 7387000 7386000 7385000 7384000 7383000 7382000 7381000 7380000 7379000 7378000 7377000 7376000 7375000 7374000 7373000 7372000

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Velocity (m/s)
- Below 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 2.5
- 2.5 - 3.0
- 3.0 - 3.5
- Above 3.5

0 500 1,000 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:45,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Burngrove Creek PRCP Conditions Peak Velocities - 0.1% AEP 11p CC

SLR

APPENDIX C3-8-2

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Burngrove\MXDs\620.040134_APPENDIX C3-8-2_N006_1in1000CC11p_v.mxd

677000 678000 679000 680000 681000 682000 683000 684000 685000 686000 687000 688000

7388000 7387000 7386000 7385000 7384000 7383000 7382000 7381000 7380000 7379000 7378000 7377000 7376000 7375000 7374000 7373000 7372000

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Velocity (m/s)
- Below 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 2.5
- 2.5 - 3.0
- 3.0 - 3.5
- Above 3.5

0 500 1,000 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:45,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Burngrove Creek PRCP Conditions Peak Velocities - 0.1% AEP 20p CC

SLR

APPENDIX C3-8-3

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Burngrove\MXDs\620.040134_APPENDIX C3-8-3_N006_1in1000CC20p_v.mxd

678000 679000 680000 681000 682000 683000 684000 685000 686000 687000 688000 689000 690000 691000 692000 693000 694000 695000 696000 697000 698000 699000

7386000 7385000 7384000 7383000 7382000 7381000 7380000 7379000 7378000 7377000 7376000 7375000 7374000 7373000 7372000 7371000 7370000 7369000 7368000 7367000 7366000 7365000 7364000 7363000 7362000 7361000 7360000 7359000 7358000

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Level (m AHD)
- Below 190
- 190 - 200
- 200 - 210
- 210 - 220
- 220 - 230
- 230 - 240
- 240 - 250
- 250 - 260
- 260 - 270
- Above 270

0 1,000 2,000 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:80,000 at A3
Project Number:	620.040134
Date:	19/09/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Blackwater Creek PRCP Conditions Peak Levels - 39% AEP

SLR

APPENDIX C4-1-1

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Blackwater\MXDs\620.040134_APPENDIX C4-1-1_N009_39p_h.mxd

678000 679000 680000 681000 682000 683000 684000 685000 686000 687000 688000 689000 690000 691000 692000 693000 694000 695000 696000 697000 698000 699000

7386000 7385000 7384000 7383000 7382000 7381000 7380000 7379000 7378000 7377000 7376000 7375000 7374000 7373000 7372000 7371000 7370000 7369000 7368000 7367000 7366000 7365000 7364000 7363000 7362000 7361000 7360000 7359000 7358000

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Level (m AHD)
- Below 190
- 190 - 200
- 200 - 210
- 210 - 220
- 220 - 230
- 230 - 240
- 240 - 250
- 250 - 260
- 260 - 270
- Above 270

0 1,000 2,000 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:80,000 at A3
Project Number:	620.040134
Date:	19/09/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Blackwater Creek PRCP Conditions Peak Levels - 2% AEP

SLR

APPENDIX C4-1-2

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Blackwater\MXDs\620.040134_APPENDIX C4-1-2_N009_02p_h.mxd

678000 679000 680000 681000 682000 683000 684000 685000 686000 687000 688000 689000 690000 691000 692000 693000 694000 695000 696000 697000 698000 699000

7386000 7385000 7384000 7383000 7382000 7381000 7380000 7379000 7378000 7377000 7376000 7375000 7374000 7373000 7372000 7371000 7370000 7369000 7368000 7367000 7366000 7365000 7364000 7363000 7362000 7361000 7360000 7359000 7358000

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Level (m AHD)
- Below 190
- 190 - 200
- 200 - 210
- 210 - 220
- 220 - 230
- 230 - 240
- 240 - 250
- 250 - 260
- 260 - 270
- Above 270

0 1,000 2,000 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:80,000 at A3
Project Number:	620.040134
Date:	19/09/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Blackwater Creek PRCP Conditions Peak Levels - 0.1% AEP

SLR

APPENDIX C4-1-3

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Blackwater\MXDs\620.040134_APPENDIX C4-1-3_N009_1in1000_h.mxd

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7386000 7385000 7384000 7383000 7382000 7381000 7380000 7379000 7378000 7377000 7376000 7375000 7374000 7373000 7372000 7371000 7370000 7369000 7368000 7367000 7366000 7365000 7364000 7363000 7362000 7361000 7360000 7359000 7358000

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Level (m AHD)
- Below 190
- 190 - 200
- 200 - 210
- 210 - 220
- 220 - 230
- 230 - 240
- 240 - 250
- 250 - 260
- 260 - 270
- Above 270

0 1,000 2,000 Meters

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:80,000 at A3
Project Number:	620.040134
Date:	19/09/2024
Drawn by:	OA

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Blackwater Mine PRCP Flood Assessment

Blackwater Creek PRCP Conditions Peak Levels - PMP

SLR

APPENDIX C4-1-4

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Blackwater\MXDs\620.040134_APPENDIX C4-1-4_N009_PMP_h.mxd

678000 679000 680000 681000 682000 683000 684000 685000 686000 687000 688000 689000 690000 691000 692000 693000 694000 695000 696000 697000 698000 699000

7386000 7385000 7384000 7383000 7382000 7381000 7380000 7379000 7378000 7377000 7376000 7375000 7374000 7373000 7372000 7371000 7370000 7369000 7368000 7367000 7366000 7365000 7364000 7363000 7362000 7361000 7360000 7359000 7358000

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Depth (m)
- Below 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 2
- Above 2

0 1,000 2,000 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:80,000 at A3
Project Number:	620.040134
Date:	19/09/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Blackwater Creek PRCP Conditions Peak Depths - 39% AEP

SLR

APPENDIX C4-2-1

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Blackwater\MXDs\620.040134_APPENDIX C4-2-1_N009_39p_d.mxd

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7386000 7385000 7384000 7383000 7382000 7381000 7380000 7379000 7378000 7377000 7376000 7375000 7374000 7373000 7372000 7371000 7370000 7369000 7368000 7367000 7366000 7365000 7364000 7363000 7362000 7361000 7360000 7359000 7358000

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Depth (m)
- Below 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 2
- Above 2

0 1,000 2,000 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:80,000 at A3
Project Number:	620.040134
Date:	19/09/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Blackwater Creek PRCP Conditions Peak Depths - 2% AEP

SLR

APPENDIX C4-2-2

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Blackwater\MXDs\620.040134_APPENDIX C4-2-2_N009_02p_d.mxd

678000 679000 680000 681000 682000 683000 684000 685000 686000 687000 688000 689000 690000 691000 692000 693000 694000 695000 696000 697000 698000 699000

7386000 7385000 7384000 7383000 7382000 7381000 7380000 7379000 7378000 7377000 7376000 7375000 7374000 7373000 7372000 7371000 7370000 7369000 7368000 7367000 7366000 7365000 7364000 7363000 7362000 7361000 7360000 7359000 7358000

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Depth (m)
- Below 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 2
- Above 2

0 1,000 2,000 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:80,000 at A3
Project Number:	620.040134
Date:	19/09/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Blackwater Creek PRCP Conditions Peak Depths - 0.1% AEP

SLR

APPENDIX C4-2-3

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Blackwater\MXDs\620.040134_APPENDIX C4-2-3_N009_1in1000_d.mxd

678000 679000 680000 681000 682000 683000 684000 685000 686000 687000 688000 689000 690000 691000 692000 693000 694000 695000 696000 697000 698000 699000

7386000 7385000 7384000 7383000 7382000 7381000 7380000 7379000 7378000 7377000 7376000 7375000 7374000 7373000 7372000 7371000 7370000 7369000 7368000 7367000 7366000 7365000 7364000 7363000 7362000 7361000 7360000 7359000 7358000

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Depth (m)
- Below 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 2
- Above 2

0 1,000 2,000 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:80,000 at A3
Project Number:	620.040134
Date:	19/09/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Blackwater Creek PRCP Conditions Peak Depths - PMP

SLR

APPENDIX C4-2-4

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Blackwater\MXDs\620.040134_APPENDIX C4-2-4_N009_PMP_d.mxd

678000 679000 680000 681000 682000 683000 684000 685000 686000 687000 688000 689000 690000 691000 692000 693000 694000 695000 696000 697000 698000 699000

7386000 7385000 7384000 7383000 7382000 7381000 7380000 7379000 7378000 7377000 7376000 7375000 7374000 7373000 7372000 7371000 7370000 7369000 7368000 7367000 7366000 7365000 7364000 7363000 7362000 7361000 7360000 7359000 7358000

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Velocity (m/s)
- Below 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 2.5
- 2.5 - 3.0
- 3.0 - 3.5
- Above 3.5

0 1,000 2,000 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:80,000 at A3
Project Number:	620.040134
Date:	19/09/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Blackwater Creek PRCP Conditions Peak Velocities - 39% AEP

SLR

APPENDIX C4-3-1

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Blackwater\MXDs\620.040134_APPENDIX C4-3-1_N009_39p_v.mxd

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7386000 7385000 7384000 7383000 7382000 7381000 7380000 7379000 7378000 7377000 7376000 7375000 7374000 7373000 7372000 7371000 7370000 7369000 7368000 7367000 7366000 7365000 7364000 7363000 7362000 7361000 7360000 7359000 7358000

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Velocity (m/s)
- Below 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 2.5
- 2.5 - 3.0
- 3.0 - 3.5
- Above 3.5

0 1,000 2,000 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:80,000 at A3
Project Number:	620.040134
Date:	19/09/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Blackwater Creek PRCP Conditions Peak Velocities - 2% AEP

SLR

APPENDIX C4-3-2

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Blackwater\MXDs\620.040134_APPENDIX C4-3-2_N009_02p_v.mxd

678000 679000 680000 681000 682000 683000 684000 685000 686000 687000 688000 689000 690000 691000 692000 693000 694000 695000 696000 697000 698000 699000

7386000 7385000 7384000 7383000 7382000 7381000 7380000 7379000 7378000 7377000 7376000 7375000 7374000 7373000 7372000 7371000 7370000 7369000 7368000 7367000 7366000 7365000 7364000 7363000 7362000 7361000 7360000 7359000 7358000

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Velocity (m/s)
- Below 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 2.5
- 2.5 - 3.0
- 3.0 - 3.5
- Above 3.5

0 1,000 2,000 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:80,000 at A3
Project Number:	620.040134
Date:	19/09/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Blackwater Creek PRCP Conditions Peak Velocities - 0.1% AEP

SLR

APPENDIX C4-3-3

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Blackwater\MXDs\620.040134_APPENDIX C4-3-3_N009_1in1000_v.mxd

678000 679000 680000 681000 682000 683000 684000 685000 686000 687000 688000 689000 690000 691000 692000 693000 694000 695000 696000 697000 698000 699000

7386000 7385000 7384000 7383000 7382000 7381000 7380000 7379000 7378000 7377000 7376000 7375000 7374000 7373000 7372000 7371000 7370000 7369000 7368000 7367000 7366000 7365000 7364000 7363000 7362000 7361000 7360000 7359000 7358000

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Velocity (m/s)
- Below 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 2.5
- 2.5 - 3.0
- 3.0 - 3.5
- Above 3.5

0 1,000 2,000 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:80,000 at A3
Project Number:	620.040134
Date:	19/09/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Blackwater Creek PRCP Conditions Peak Velocities - PMP

SLR

APPENDIX C4-3-4

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\BlackwaterMXDs\620.040134_APPENDIX C4-3-4_N009_PMP_v.mxd

678000 679000 680000 681000 682000 683000 684000 685000 686000 687000 688000 689000 690000 691000 692000 693000 694000 695000 696000 697000 698000 699000

7386000 7385000 7384000 7383000 7382000 7381000 7380000 7379000 7378000 7377000 7376000 7375000 7374000 7373000 7372000 7371000 7370000 7369000 7368000 7367000 7366000 7365000 7364000 7363000 7362000 7361000 7360000 7359000 7358000

Bed Shear Stress (N/m²)
- 0 - 20
- 20 - 40
- 40 - 60
- 60 - 80
- > 80

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

0 1,000 2,000 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:80,000 at A3
Project Number:	620.040134
Date:	19/09/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Blackwater Creek PRCP Conditions Peak Bed Shear Stress - 39% AEP

SLR

APPENDIX C4-4-1

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\BlackwaterMXDs\620.040134_APPENDIX C4-4-1_N009_39p_bs.mxd

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7386000 7385000 7384000 7383000 7382000 7381000 7380000 7379000 7378000 7377000 7376000 7375000 7374000 7373000 7372000 7371000 7370000 7369000 7368000 7367000 7366000 7365000 7364000 7363000 7362000 7361000 7360000 7359000 7358000

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Bed Shear Stress (N/m²)
- 0 - 20
- 20 - 40
- 40 - 60
- 60 - 80
- > 80

0 1,000 2,000 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:80,000 at A3
Project Number:	620.040134
Date:	19/09/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Blackwater Creek PRCP Conditions Peak Bed Shear Stress - 2% AEP

SLR

APPENDIX C4-4-2

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Blackwater\MXDs\620.040134_APPENDIX C4-4-2_N009_02p_bss.mxd

678000 679000 680000 681000 682000 683000 684000 685000 686000 687000 688000 689000 690000 691000 692000 693000 694000 695000 696000 697000 698000 699000

7386000 7385000 7384000 7383000 7382000 7381000 7380000 7379000 7378000 7377000 7376000 7375000 7374000 7373000 7372000 7371000 7370000 7369000 7368000 7367000 7366000 7365000 7364000 7363000 7362000 7361000 7360000 7359000 7358000

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Stream Power (W/m²)
- 0 - 60
- 60 - 90
- 90 - 120
- 120 - 150
- >150

0 1,000 2,000 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:80,000 at A3
Project Number:	620.040134
Date:	19/09/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Blackwater Creek PRCP Conditions Peak Stream Power - 39% AEP

SLR

APPENDIX C4-5-1

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\BlackwaterMXDs\620.040134_APPENDIX C4-5-1_N009_39p_sp.mxd

678000 679000 680000 681000 682000 683000 684000 685000 686000 687000 688000 689000 690000 691000 692000 693000 694000 695000 696000 697000 698000 699000

7386000 7385000 7384000 7383000 7382000 7381000 7380000 7379000 7378000 7377000 7376000 7375000 7374000 7373000 7372000 7371000 7370000 7369000 7368000 7367000 7366000 7365000 7364000 7363000 7362000 7361000 7360000 7359000 7358000

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Stream Power (W/m²)
- 0 - 60
- 60 - 90
- 90 - 120
- 120 - 150
- >150

0 1,000 2,000 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:80,000 at A3
Project Number:	620.040134
Date:	19/09/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Blackwater Creek PRCP Conditions Peak Stream Power - 2% AEP

SLR

APPENDIX C4-5-2

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Blackwater\MXDs\620.040134_APPENDIX C4-5-2_N009_02p_sp.mxd

678000 679000 680000 681000 682000 683000 684000 685000 686000 687000 688000 689000 690000 691000 692000 693000 694000 695000 696000 697000 698000 699000

7386000 7385000 7384000 7383000 7382000 7381000 7380000 7379000 7378000 7377000 7376000 7375000 7374000 7373000 7372000 7371000 7370000 7369000 7368000 7367000 7366000 7365000 7364000 7363000 7362000 7361000 7360000 7359000 7358000

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Level (m AHD)
- Below 190
- 190 - 200
- 200 - 210
- 210 - 220
- 220 - 230
- 230 - 240
- 240 - 250
- 250 - 260
- 260 - 270
- Above 270

0 1,000 2,000 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:80,000 at A3
Project Number:	620.040134
Date:	19/09/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Blackwater Creek PRCP Conditions Peak Levels - 0.1% AEP 06p CC

SLR

APPENDIX C4-6-1

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\BlackwaterMXDs\620.040134_APPENDIX C4-6-1_N009_1in1000CC06p_h.mxd

678000 679000 680000 681000 682000 683000 684000 685000 686000 687000 688000 689000 690000 691000 692000 693000 694000 695000 696000 697000 698000 699000

7386000 7385000 7384000 7383000 7382000 7381000 7380000 7379000 7378000 7377000 7376000 7375000 7374000 7373000 7372000 7371000 7370000 7369000 7368000 7367000 7366000 7365000 7364000 7363000 7362000 7361000 7360000 7359000 7358000

Level (m AHD)
- Below 190
- 190 - 200
- 200 - 210
- 210 - 220
- 220 - 230
- 230 - 240
- 240 - 250
- 250 - 260
- 260 - 270
- Above 270

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

0 1,000 2,000 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:80,000 at A3
Project Number:	620.040134
Date:	19/09/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Blackwater Creek PRCP Conditions Peak Levels - 0.1% AEP 11p CC

SLR

APPENDIX C4-6-2

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\BlackwaterMXDs\620.040134_APPENDIX C4-6-2_N009_1in1000CC11p_h.mxd

678000 679000 680000 681000 682000 683000 684000 685000 686000 687000 688000 689000 690000 691000 692000 693000 694000 695000 696000 697000 698000 699000

7386000 7385000 7384000 7383000 7382000 7381000 7380000 7379000 7378000 7377000 7376000 7375000 7374000 7373000 7372000 7371000 7370000 7369000 7368000 7367000 7366000 7365000 7364000 7363000 7362000 7361000 7360000 7359000 7358000

Level (m AHD)
- Below 190
- 190 - 200
- 200 - 210
- 210 - 220
- 220 - 230
- 230 - 240
- 240 - 250
- 250 - 260
- 260 - 270
- Above 270

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

0 1,000 2,000 Meters

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:80,000 at A3
Project Number:	620.040134
Date:	19/09/2024
Drawn by:	OA

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Blackwater Mine PRCP Flood Assessment

Blackwater Creek PRCP Conditions Peak Levels - 0.1% AEP 20p CC

SLR

APPENDIX C4-6-3

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\BlackwaterMXDs\620.040134_APPENDIX C4-6-3_N009_1in1000CC20p_h.mxd

678000 679000 680000 681000 682000 683000 684000 685000 686000 687000 688000 689000 690000 691000 692000 693000 694000 695000 696000 697000 698000 699000

7386000 7385000 7384000 7383000 7382000 7381000 7380000 7379000 7378000 7377000 7376000 7375000 7374000 7373000 7372000 7371000 7370000 7369000 7368000 7367000 7366000 7365000 7364000 7363000 7362000 7361000 7360000 7359000 7358000

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Depth (m)
- Below 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 2
- Above 2

0 1,000 2,000 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:80,000 at A3
Project Number:	620.040134
Date:	19/09/2024
Drawn by:	OA

SLR

Blackwater Mine PRCP Flood Assessment

Blackwater Creek PRCP Conditions Peak Depths - 0.1% AEP 06p CC

APPENDIX C4-7-1

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Blackwater\MXDs\620.040134_APPENDIX C4-7-1_N009_1in1000CC06p_d.mxd

678000 679000 680000 681000 682000 683000 684000 685000 686000 687000 688000 689000 690000 691000 692000 693000 694000 695000 696000 697000 698000 699000

7386000 7385000 7384000 7383000 7382000 7381000 7380000 7379000 7378000 7377000 7376000 7375000 7374000 7373000 7372000 7371000 7370000 7369000 7368000 7367000 7366000 7365000 7364000 7363000 7362000 7361000 7360000 7359000 7358000

Depth (m)
- Below 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 2
- Above 2

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

0 1,000 2,000 Meters

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:80,000 at A3
Project Number:	620.040134
Date:	19/09/2024
Drawn by:	OA

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Blackwater Mine PRCP Flood Assessment

Blackwater Creek PRCP Conditions Peak Depths - 0.1% AEP 11p CC

SLR

APPENDIX C4-7-2

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\BlackwaterMXDs\620.040134_APPENDIX C4-7-2_N009_1in1000CC11p_d.mxd

678000 679000 680000 681000 682000 683000 684000 685000 686000 687000 688000 689000 690000 691000 692000 693000 694000 695000 696000 697000 698000 699000

7386000 7385000 7384000 7383000 7382000 7381000 7380000 7379000 7378000 7377000 7376000 7375000 7374000 7373000 7372000 7371000 7370000 7369000 7368000 7367000 7366000 7365000 7364000 7363000 7362000 7361000 7360000 7359000 7358000

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Depth (m)
- Below 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 2
- Above 2

0 1,000 2,000 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:80,000 at A3
Project Number:	620.040134
Date:	19/09/2024
Drawn by:	OA

SLR

Blackwater Mine PRCP Flood Assessment

Blackwater Creek PRCP Conditions Peak Depths - 0.1% AEP 20p CC

APPENDIX C4-7-3

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Blackwater\MXDs\620.040134_APPENDIX C4-7-3_N009_1in1000CC20p_d.mxd

678000 679000 680000 681000 682000 683000 684000 685000 686000 687000 688000 689000 690000 691000 692000 693000 694000 695000 696000 697000 698000 699000

7386000 7385000 7384000 7383000 7382000 7381000 7380000 7379000 7378000 7377000 7376000 7375000 7374000 7373000 7372000 7371000 7370000 7369000 7368000 7367000 7366000 7365000 7364000 7363000 7362000 7361000 7360000 7359000 7358000

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Velocity (m/s)
- Below 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 2.5
- 2.5 - 3.0
- 3.0 - 3.5
- Above 3.5

0 1,000 2,000 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:80,000 at A3
Project Number:	620.040134
Date:	19/09/2024
Drawn by:	OA

SLR

Blackwater Mine PRCP Flood Assessment

Blackwater Creek PRCP Conditions Peak Velocities - 0.1% AEP 06p CC

APPENDIX C4-8-1

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADG\SIOutputMap setup\BlackwaterMXDs\620.040134_APPENDIX C4-8-1_N009_1in1000CC06p_v.mxd

678000 679000 680000 681000 682000 683000 684000 685000 686000 687000 688000 689000 690000 691000 692000 693000 694000 695000 696000 697000 698000 699000

7386000 7385000 7384000 7383000 7382000 7381000 7380000 7379000 7378000 7377000 7376000 7375000 7374000 7373000 7372000 7371000 7370000 7369000 7368000 7367000 7366000 7365000 7364000 7363000 7362000 7361000 7360000 7359000 7358000

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Velocity (m/s)
- Below 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 2.5
- 2.5 - 3.0
- 3.0 - 3.5
- Above 3.5

0 1,000 2,000 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:80,000 at A3
Project Number:	620.040134
Date:	19/09/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Blackwater Creek PRCP Conditions Peak Velocities - 0.1% AEP 11p CC

SLR

APPENDIX C4-8-2

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\OutputMap setup\BlackwaterMXDs\620.040134_APPENDIX C4-8-2_N009_1in1000CC11p_v.mxd

678000 679000 680000 681000 682000 683000 684000 685000 686000 687000 688000 689000 690000 691000 692000 693000 694000 695000 696000 697000 698000 699000

7386000 7385000 7384000 7383000 7382000 7381000 7380000 7379000 7378000 7377000 7376000 7375000 7374000 7373000 7372000 7371000 7370000 7369000 7368000 7367000 7366000 7365000 7364000 7363000 7362000 7361000 7360000 7359000 7358000

Velocity (m/s)
- Below 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 2.5
- 2.5 - 3.0
- 3.0 - 3.5
- Above 3.5

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

0 1,000 2,000 Meters

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:80,000 at A3
Project Number:	620.040134
Date:	19/09/2024
Drawn by:	OA

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Blackwater Mine PRCP Flood Assessment

Blackwater Creek PRCP Conditions Peak Velocities - 0.1% AEP 20p CC

SLR

APPENDIX C4-8-3

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADG\SIOutputMap setup\BlackwaterMXDs\620.040134_APPENDIX C4-8-3_N009_1in1000CC20p_v.mxd

679000 680000 681000 682000 683000 684000 685000 686000 687000 688000 689000 690000 691000

7364000 7363000 7362000 7361000 7360000 7359000 7358000 7357000 7356000 7355000 7354000 7353000 7352000 7351000 7350000 7349000

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Level (m AHD)
- Below 240
- 240 - 245
- 245 - 250
- 250 - 255
- 255 - 260
- 260 - 265
- 265 - 270
- 270 - 275
- 275 - 280
- Above 280

0 500 1,000 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:45,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Speculation Creek PRCP Conditions Peak Levels - 39% AEP

SLR

APPENDIX C5-1-1

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\SpeculationMXDs\620.040134_APPENDIX C5-1-1_W004_39p_h.mxd

679000 680000 681000 682000 683000 684000 685000 686000 687000 688000 689000 690000 691000

7364000 7363000 7362000 7361000 7360000 7359000 7358000 7357000 7356000 7355000 7354000 7353000 7352000 7351000 7350000 7349000

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Level (m AHD)
- Below 240
- 240 - 245
- 245 - 250
- 250 - 255
- 255 - 260
- 260 - 265
- 265 - 270
- 270 - 275
- 275 - 280
- Above 280

0 500 1,000 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:45,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Speculation Creek PRCP Conditions Peak Levels - 2% AEP

SLR

APPENDIX C5-1-2

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Speculation\MXDs\620.040134_APPENDIX C5-1-2_W004_02p_h.mxd

679000 680000 681000 682000 683000 684000 685000 686000 687000 688000 689000 690000 691000

7364000 7363000 7362000 7361000 7360000 7359000 7358000 7357000 7356000 7355000 7354000 7353000 7352000 7351000 7350000 7349000

Level (m AHD)
- Below 240
- 240 - 245
- 245 - 250
- 250 - 255
- 255 - 260
- 260 - 265
- 265 - 270
- 270 - 275
- 275 - 280
- Above 280

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

0 500 1,000 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:45,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Speculation Creek PRCP Conditions Peak Levels - 0.1% AEP

SLR

APPENDIX C5-1-3

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Speculation\MXDs\620.040134_APPENDIX C5-1-3_W004_1in1000_h.mxd

679000 680000 681000 682000 683000 684000 685000 686000 687000 688000 689000 690000 691000

7364000 7363000 7362000 7361000 7360000 7359000 7358000 7357000 7356000 7355000 7354000 7353000 7352000 7351000 7350000 7349000

Level (m AHD)
- Below 240
- 240 - 245
- 245 - 250
- 250 - 255
- 255 - 260
- 260 - 265
- 265 - 270
- 270 - 275
- 275 - 280
- Above 280

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

0 500 1,000 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:45,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Speculation Creek PRCP Conditions Peak Levels - PMP

SLR

APPENDIX C5-1-4

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Speculation\MXDs\620.040134_APPENDIX C5-1-4_W004_PMP_h.mxd

679000 680000 681000 682000 683000 684000 685000 686000 687000 688000 689000 690000 691000

7364000 7363000 7362000 7361000 7360000 7359000 7358000 7357000 7356000 7355000 7354000 7353000 7352000 7351000 7350000 7349000

Depth (m)
- Below 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 2
- Above 2

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

0 500 1,000 Meters

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:45,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Blackwater Mine PRCP Flood Assessment

Speculation Creek PRCP Conditions Peak Depths - 39% AEP

SLR

APPENDIX C5-2-1

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Speculation\MXDs\620.040134_APPENDIX C5-2-1_W004_39p_d.mxd

679000 680000 681000 682000 683000 684000 685000 686000 687000 688000 689000 690000 691000

7364000 7363000 7362000 7361000 7360000 7359000 7358000 7357000 7356000 7355000 7354000 7353000 7352000 7351000 7350000 7349000

Depth (m)
- Below 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 2
- Above 2

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

0 500 1,000 Meters

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:45,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Blackwater Mine PRCP Flood Assessment

Speculation Creek PRCP Conditions Peak Depths - 2% AEP

SLR

APPENDIX C5-2-2

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Speculation\MXDs\620.040134_APPENDIX C5-2-2_W004_02p_d.mxd

679000 680000 681000 682000 683000 684000 685000 686000 687000 688000 689000 690000 691000

7364000 7363000 7362000 7361000 7360000 7359000 7358000 7357000 7356000 7355000 7354000 7353000 7352000 7351000 7350000 7349000

Depth (m)
- Below 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 2
- Above 2

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

0 500 1,000 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:45,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Speculation Creek PRCP Conditions Peak Depths - 0.1% AEP

SLR

APPENDIX C5-2-3

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\SpeculationMXDs\620.040134_APPENDIX C5-2-3_W004_1in1000_d.mxd

679000 680000 681000 682000 683000 684000 685000 686000 687000 688000 689000 690000 691000

7364000 7363000 7362000 7361000 7360000 7359000 7358000 7357000 7356000 7355000 7354000 7353000 7352000 7351000 7350000 7349000

Depth (m)
- Below 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 2
- Above 2

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

0 500 1,000 Meters

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:45,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Blackwater Mine PRCP Flood Assessment

Speculation Creek PRCP Conditions Peak Depths - PMP

SLR

APPENDIX C5-2-4

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\SpeculationMXDs\620.040134_APPENDIX C5-2-4_W004_PMP_d.mxd

679000 680000 681000 682000 683000 684000 685000 686000 687000 688000 689000 690000 691000

7364000 7363000 7362000 7361000 7360000 7359000 7358000 7357000 7356000 7355000 7354000 7353000 7352000 7351000 7350000 7349000

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Velocity (m/s)
- Below 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 2.5
- 2.5 - 3.0
- 3.0 - 3.5
- Above 3.5

0 500 1,000 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:45,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Speculation Creek PRCP Conditions Peak Velocities - 39% AEP

SLR

APPENDIX C5-3-1

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\SpeculationMXDs\620.040134_APPENDIX C5-3-1_W004_39p_v.mxd

679000 680000 681000 682000 683000 684000 685000 686000 687000 688000 689000 690000 691000

7364000 7363000 7362000 7361000 7360000 7359000 7358000 7357000 7356000 7355000 7354000 7353000 7352000 7351000 7350000 7349000

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Velocity (m/s)
- Below 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 2.5
- 2.5 - 3.0
- 3.0 - 3.5
- Above 3.5

0 500 1,000 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:45,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Speculation Creek PRCP Conditions Peak Velocities - 2% AEP

SLR

APPENDIX C5-3-2

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Speculation\MXDs\620.040134_APPENDIX C5-3-2_W004_02p_v.mxd

679000 680000 681000 682000 683000 684000 685000 686000 687000 688000 689000 690000 691000

7364000 7363000 7362000 7361000 7360000 7359000 7358000 7357000 7356000 7355000 7354000 7353000 7352000 7351000 7350000 7349000

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Velocity (m/s)
- Below 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 2.5
- 2.5 - 3.0
- 3.0 - 3.5
- Above 3.5

0 500 1,000 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:45,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Speculation Creek PRCP Conditions Peak Velocities - 0.1% AEP

SLR

APPENDIX C5-3-3

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\SpeculationMXDs\620.040134_APPENDIX C5-3-3_W004_1in1000_v.mxd

679000 680000 681000 682000 683000 684000 685000 686000 687000 688000 689000 690000 691000

7364000 7363000 7362000 7361000 7360000 7359000 7358000 7357000 7356000 7355000 7354000 7353000 7352000 7351000 7350000 7349000

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Velocity (m/s)
- Below 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 2.5
- 2.5 - 3.0
- 3.0 - 3.5
- Above 3.5

0 500 1,000 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:45,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Speculation Creek PRCP Conditions Peak Velocities - PMP

SLR

APPENDIX C5-3-4

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\SpeculationMXDs\620.040134_APPENDIX C5-3-4_W004_PMP_v.mxd

679000 680000 681000 682000 683000 684000 685000 686000 687000 688000 689000 690000 691000

7364000 7363000 7362000 7361000 7360000 7359000 7358000 7357000 7356000 7355000 7354000 7353000 7352000 7351000 7350000 7349000

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Bed Shear Stress (N/m²)
- 0 - 20
- 20 - 40
- 40 - 60
- 60 - 80
- > 80

0 500 1,000 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:45,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Speculation Creek PRCP Conditions Peak Bed Shear Stress - 39% AEP

SLR

APPENDIX C5-4-1

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Speculation\MXDs\620.040134_APPENDIX C5-4-1_W004_39p_bss.mxd

679000 680000 681000 682000 683000 684000 685000 686000 687000 688000 689000 690000 691000

7364000 7363000 7362000 7361000 7360000 7359000 7358000 7357000 7356000 7355000 7354000 7353000 7352000 7351000 7350000 7349000

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Bed Shear Stress (N/m²)
- 0 - 20
- 20 - 40
- 40 - 60
- 60 - 80
- > 80

0 500 1,000 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:45,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Speculation Creek PRCP Conditions Peak Bed Shear Stress - 2% AEP

SLR

APPENDIX C5-4-2

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\SpeculationMXDs\620.040134_APPENDIX C5-4-2_W004_02p_bss.mxd

679000 680000 681000 682000 683000 684000 685000 686000 687000 688000 689000 690000 691000

7364000 7363000 7362000 7361000 7360000 7359000 7358000 7357000 7356000 7355000 7354000 7353000 7352000 7351000 7350000 7349000

Stream Power (W/m²)
- 0 - 60
- 60 - 90
- 90 - 120
- 120 - 150
- >150

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

0 500 1,000 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:45,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Speculation Creek PRCP Conditions Peak Stream Power - 39% AEP

SLR

APPENDIX C5-5-1

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Speculation\MXDs\620.040134_APPENDIX C5-5-1_W004_39p_s.p.mxd

679000 680000 681000 682000 683000 684000 685000 686000 687000 688000 689000 690000 691000

7364000 7363000 7362000 7361000 7360000 7359000 7358000 7357000 7356000 7355000 7354000 7353000 7352000 7351000 7350000 7349000

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Stream Power (W/m²)
- 0 - 60
- 60 - 90
- 90 - 120
- 120 - 150
- >150

0 500 1,000 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:45,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Speculation Creek PRCP Conditions Peak Stream Power - 2% AEP

SLR

APPENDIX C5-5-2

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Speculation\MXDs\620.040134_APPENDIX C5-5-2_W004_02p_sp.mxd

679000 680000 681000 682000 683000 684000 685000 686000 687000 688000 689000 690000 691000

7364000 7363000 7362000 7361000 7360000 7359000 7358000 7357000 7356000 7355000 7354000 7353000 7352000 7351000 7350000 7349000

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Level (m AHD)
- Below 240
- 240 - 245
- 245 - 250
- 250 - 255
- 255 - 260
- 260 - 265
- 265 - 270
- 270 - 275
- 275 - 280
- Above 280

0 500 1,000 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:45,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Speculation Creek PRCP Conditions Peak Levels - 0.1% AEP 06p CC

SLR

APPENDIX C5-6-1

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\SpeculationMXDs\620.040134_APPENDIX C5-6-1_W004_1in1000CC06p_h.mxd

679000 680000 681000 682000 683000 684000 685000 686000 687000 688000 689000 690000 691000

7364000 7363000 7362000 7361000 7360000 7359000 7358000 7357000 7356000 7355000 7354000 7353000 7352000 7351000 7350000 7349000

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Level (m AHD)
- Below 240
- 240 - 245
- 245 - 250
- 250 - 255
- 255 - 260
- 260 - 265
- 265 - 270
- 270 - 275
- 275 - 280
- Above 280

0 500 1,000 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:45,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Speculation Creek PRCP Conditions Peak Levels - 0.1% AEP 11p CC

SLR

APPENDIX C5-6-2

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\SpeculationMXDs\620.040134_APPENDIX C5-6-2_W004_1in1000CC11p_h.mxd

679000 680000 681000 682000 683000 684000 685000 686000 687000 688000 689000 690000 691000

7364000 7363000 7362000 7361000 7360000 7359000 7358000 7357000 7356000 7355000 7354000 7353000 7352000 7351000 7350000 7349000

Level (m AHD)
- Below 240
- 240 - 245
- 245 - 250
- 250 - 255
- 255 - 260
- 260 - 265
- 265 - 270
- 270 - 275
- 275 - 280
- Above 280

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

0 500 1,000 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:45,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Speculation Creek PRCP Conditions Peak Levels - 0.1% AEP 20p CC

SLR

APPENDIX C5-6-3

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\SpeculationMXDs\620.040134_APPENDIX C5-6-3_W004_1in1000CC20p_h.mxd

679000 680000 681000 682000 683000 684000 685000 686000 687000 688000 689000 690000 691000

7364000 7363000 7362000 7361000 7360000 7359000 7358000 7357000 7356000 7355000 7354000 7353000 7352000 7351000 7350000 7349000

Depth (m)
- Below 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 2
- Above 2

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

0 500 1,000 Meters

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:45,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Blackwater Mine PRCP Flood Assessment

Speculation Creek PRCP Conditions Peak Depths - 0.1% AEP 06p CC

SLR

APPENDIX C5-7-1

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\SpeculationMXDs\620.040134_APPENDIX C5-7-1_W004_1in1000CC06p_d.mxd

679000 680000 681000 682000 683000 684000 685000 686000 687000 688000 689000 690000 691000

7364000 7363000 7362000 7361000 7360000 7359000 7358000 7357000 7356000 7355000 7354000 7353000 7352000 7351000 7350000 7349000

Depth (m)
- Below 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 2
- Above 2

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

0 500 1,000 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:45,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Speculation Creek PRCP Conditions Peak Depths - 0.1% AEP 11p CC

SLR

APPENDIX C5-7-2

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\SpeculationMXDs\620.040134_APPENDIX C5-7-2_W004_1in1000CC11p_d.mxd

679000 680000 681000 682000 683000 684000 685000 686000 687000 688000 689000 690000 691000

7364000 7363000 7362000 7361000 7360000 7359000 7358000 7357000 7356000 7355000 7354000 7353000 7352000 7351000 7350000 7349000

Depth (m)
- Below 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 2
- Above 2

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

0 500 1,000 Meters

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:45,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Blackwater Mine PRCP Flood Assessment

Speculation Creek PRCP Conditions Peak Depths - 0.1% AEP 20p CC

SLR

APPENDIX C5-7-3

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\SpeculationMXDs\620.040134_APPENDIX C5-7-3_W004_1in1000CC20p_d.mxd

679000 680000 681000 682000 683000 684000 685000 686000 687000 688000 689000 690000 691000

7364000 7363000 7362000 7361000 7360000 7359000 7358000 7357000 7356000 7355000 7354000 7353000 7352000 7351000 7350000 7349000

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Velocity (m/s)
- Below 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 2.5
- 2.5 - 3.0
- 3.0 - 3.5
- Above 3.5

0 500 1,000 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:45,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Speculation Creek PRCP Conditions Peak Velocities - 0.1% AEP 06p CC

SLR

APPENDIX C5-8-1

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\SpeculationMXDs\620.040134_APPENDIX C5-8-1_W004_1in1000CC06p_v.mxd

679000 680000 681000 682000 683000 684000 685000 686000 687000 688000 689000 690000 691000

7364000 7363000 7362000 7361000 7360000 7359000 7358000 7357000 7356000 7355000 7354000 7353000 7352000 7351000 7350000 7349000

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Velocity (m/s)
- Below 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 2.5
- 2.5 - 3.0
- 3.0 - 3.5
- Above 3.5

0 500 1,000 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:45,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Speculation Creek PRCP Conditions Peak Velocities - 0.1% AEP 11p CC

SLR

APPENDIX C5-8-2

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Speculation\MXDs\620.040134_APPENDIX C5-8-2_W004_1in1000CC11p_v.mxd

679000 680000 681000 682000 683000 684000 685000 686000 687000 688000 689000 690000 691000

7364000 7363000 7362000 7361000 7360000 7359000 7358000 7357000 7356000 7355000 7354000 7353000 7352000 7351000 7350000 7349000

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Velocity (m/s)
- Below 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 2.5
- 2.5 - 3.0
- 3.0 - 3.5
- Above 3.5

0 500 1,000 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:45,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Speculation Creek PRCP Conditions Peak Velocities - 0.1% AEP 20p CC

SLR

APPENDIX C5-8-3

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Speculation\MXDs\620.040134_APPENDIX C5-8-3_W004_1in1000CC20p_v.mxd

683000 684000 685000 686000 687000 688000 689000 690000 691000 692000

7353000 7352000 7351000 7350000 7349000 7348000 7347000 7346000

Blackwater Mine PRCP Flood Assessment

Sirius Creek PRCP Conditions Peak Levels - 39% AEP

APPENDIX C6-1-1

LEGEND

- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Level (m AHD)

- Below 250
- 250 - 255
- 255 - 260
- 260 - 265
- 265 - 270
- 270 - 275
- 275 - 280
- 280 - 285
- 285 - 290
- Above 290

0 200 400 800 Meters

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:30,000 at A3
Project Number:	620.014601
Date:	4/07/2024
Drawn by:	SM

SLR

H:\Projects-SLR\620-BNE\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Sirius\MXDs\620.040134_APPENDIX C6-1-1_W007_39p_h.mxd

683000 684000 685000 686000 687000 688000 689000 690000 691000 692000

7353000 7352000 7351000 7350000 7349000 7348000 7347000 7346000

Blackwater Mine PRCP Flood Assessment

Sirius Creek PRCP Conditions Peak Levels - 2% AEP

APPENDIX C6-1-2

LEGEND

- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Level (m AHD)

- Below 250
- 250 - 255
- 255 - 260
- 260 - 265
- 265 - 270
- 270 - 275
- 275 - 280
- 280 - 285
- 285 - 290
- Above 290

0 200 400 800 Meters

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:30,000 at A3
Project Number:	620.014601
Date:	4/07/2024
Drawn by:	SM

SLR

H:\Projects-SLR\620-BNE\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Sirius\MXDs\620.040134_APPENDIX C6-1-2_W007_02p_h.mxd

683000 684000 685000 686000 687000 688000 689000 690000 691000 692000

7353000 7352000 7351000 7350000 7349000 7348000 7347000 7346000

Blackwater Mine PRCP Flood Assessment

Sirius Creek PRCP Conditions Peak Levels - 0.1% AEP

APPENDIX C6-1-3

LEGEND

- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Level (m AHD)

- Below 250
- 250 - 255
- 255 - 260
- 260 - 265
- 265 - 270
- 270 - 275
- 275 - 280
- 280 - 285
- 285 - 290
- Above 290

0 200 400 800 Meters

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:30,000 at A3
Project Number:	620.014601
Date:	4/07/2024
Drawn by:	SM

SLR

H:\Projects-SLR\620-BNE\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Sirius\MXDs\620.040134_APPENDIX C6-1-3_W007_1in1000_h.mxd

683000 684000 685000 686000 687000 688000 689000 690000 691000 692000

7353000 7352000 7351000 7350000 7349000 7348000 7347000 7346000

Blackwater Mine PRCP Flood Assessment

Sirius Creek PRCP Conditions Peak Levels - PMP

APPENDIX C6-1-4

LEGEND

- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Level (m AHD)

- Below 250
- 250 - 255
- 255 - 260
- 260 - 265
- 265 - 270
- 270 - 275
- 275 - 280
- 280 - 285
- 285 - 290
- Above 290

0 200 400 800 Meters

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:30,000 at A3
Project Number:	620.014601
Date:	4/07/2024
Drawn by:	SM

SLR

H:\Projects-SLR\620-BNE\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Sirius\MXDs\620.040134_APPENDIX C6-1-4_W007_PMP_h.mxd

683000 684000 685000 686000 687000 688000 689000 690000 691000 692000

7353000 7352000 7351000 7350000 7349000 7348000 7347000 7346000

Blackwater Mine PRCP Flood Assessment

Sirius Creek PRCP Conditions Peak Depths - 39% AEP

APPENDIX C6-2-1

LEGEND

- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Depth (m)

- Below 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 2
- Above 2

0 200 400 800 Meters

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:30,000 at A3
Project Number:	620.014601
Date:	4/07/2024
Drawn by:	SM

SLR

H:\Projects-SLR\620-BNE\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Sirius\MXDs\620.040134_APPENDIX C6-2-1_W007_39p_d.mxd

683000 684000 685000 686000 687000 688000 689000 690000 691000 692000

7353000 7352000 7351000 7350000 7349000 7348000 7347000 7346000

Blackwater Mine PRCP Flood Assessment

Sirius Creek PRCP Conditions Peak Depths - 2% AEP

APPENDIX C6-2-2

LEGEND

- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Depth (m)

- Below 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 2
- Above 2

0 200 400 800 Meters

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:30,000 at A3
Project Number:	620.014601
Date:	4/07/2024
Drawn by:	SM

SLR

H:\Projects-SLR\620-BNE\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Sirius\MXDs\620.040134_APPENDIX C6-2-2_W007_02p_d.mxd

683000 684000 685000 686000 687000 688000 689000 690000 691000 692000

7353000 7352000 7351000 7350000 7349000 7348000 7347000 7346000

Blackwater Mine PRCP Flood Assessment

Sirius Creek PRCP Conditions Peak Depths - 0.1% AEP

APPENDIX C6-2-3

LEGEND

- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Depth (m)

- Below 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 2
- Above 2

0 200 400 800 Meters

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:30,000 at A3
Project Number:	620.014601
Date:	4/07/2024
Drawn by:	SM

SLR

H:\Projects-SLR\620-BNE\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Sirius\MXDs\620.040134_APPENDIX C6-2-3_W007_1in1000_d.mxd

683000 684000 685000 686000 687000 688000 689000 690000 691000 692000

7353000 7352000 7351000 7350000 7349000 7348000 7347000 7346000

Blackwater Mine PRCP Flood Assessment

Sirius Creek PRCP Conditions Peak Depths - PMP

APPENDIX C6-2-4

LEGEND

- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Depth (m)

- Below 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 2
- Above 2

0 200 400 800 Meters

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:30,000 at A3
Project Number:	620.014601
Date:	4/07/2024
Drawn by:	SM

SLR

H:\Projects-SLR\620-BNE\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Sirius\MXDs\620.040134_APPENDIX C6-2-4_W007_PMP_d.mxd

683000 684000 685000 686000 687000 688000 689000 690000 691000 692000

7353000 7352000 7351000 7350000 7349000 7348000 7347000 7346000

Blackwater Mine PRCP Flood Assessment

Sirius Creek PRCP Conditions Peak Velocities - 39% AEP

APPENDIX C6-3-1

LEGEND

- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Velocity (m/s)

- Below 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 2.5
- 2.5 - 3.0
- 3.0 - 3.5
- Above 3.5

0 200 400 800 Meters

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:30,000 at A3
Project Number:	620.014601
Date:	4/07/2024
Drawn by:	SM

SLR

H:\Projects-SLR\620-BNE\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Sirius\MXDs\620.040134_APPENDIX C6-3-1_W007_39p_v.mxd

683000 684000 685000 686000 687000 688000 689000 690000 691000 692000

7353000 7352000 7351000 7350000 7349000 7348000 7347000 7346000

Blackwater Mine PRCP Flood Assessment

Sirius Creek PRCP Conditions Peak Velocities - 2% AEP

APPENDIX C6-3-2

LEGEND

- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Velocity (m/s)

- Below 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 2.5
- 2.5 - 3.0
- 3.0 - 3.5
- Above 3.5

N

0 200 400 800 Meters

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:30,000 at A3
Project Number:	620.014601
Date:	4/07/2024
Drawn by:	SM

SLR

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683000 684000 685000 686000 687000 688000 689000 690000 691000 692000

7353000 7352000 7351000 7350000 7349000 7348000 7347000 7346000

Blackwater Mine PRCP Flood Assessment

Sirius Creek PRCP Conditions Peak Velocities - 0.1% AEP

APPENDIX C6-3-3

LEGEND

- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Velocity (m/s)

- Below 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 2.5
- 2.5 - 3.0
- 3.0 - 3.5
- Above 3.5

0 200 400 800 Meters

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:30,000 at A3
Project Number:	620.014601
Date:	4/07/2024
Drawn by:	SM

SLR

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683000 684000 685000 686000 687000 688000 689000 690000 691000 692000

7353000 7352000 7351000 7350000 7349000 7348000 7347000 7346000

Blackwater Mine PRCP Flood Assessment

Sirius Creek PRCP Conditions Peak Velocities - PMP

APPENDIX C6-3-4

LEGEND

- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Velocity (m/s)

- Below 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 2.5
- 2.5 - 3.0
- 3.0 - 3.5
- Above 3.5

0 200 400 800 Meters

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:30,000 at A3
Project Number:	620.014601
Date:	4/07/2024
Drawn by:	SM

SLR

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683000 684000 685000 686000 687000 688000 689000 690000 691000 692000

7353000 7352000 7351000 7350000 7349000 7348000 7347000 7346000

Blackwater Mine PRCP Flood Assessment

Sirius Creek PRCP Conditions Peak Bed Shear Stress - 39% AEP

APPENDIX C6-4-1

LEGEND

- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Bed Shear Stress (N/m²)

- 0 - 20
- 20 - 40
- 40 - 60
- 60 - 80
- > 80

N

0 200 400 800 Meters

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:30,000 at A3
Project Number:	620.014601
Date:	4/07/2024
Drawn by:	SM

SLR

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683000 684000 685000 686000 687000 688000 689000 690000 691000 692000

7353000 7352000 7351000 7350000 7349000 7348000 7347000 7346000

Blackwater Mine PRCP Flood Assessment

Sirius Creek PRCP Conditions Peak Bed Shear Stress - 2% AEP

APPENDIX C6-4-2

LEGEND

- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Bed Shear Stress (N/m²)

- 0 - 20
- 20 - 40
- 40 - 60
- 60 - 80
- > 80

N

0 200 400 800 Meters

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:30,000 at A3
Project Number:	620.014601
Date:	4/07/2024
Drawn by:	SM

SLR

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683000 684000 685000 686000 687000 688000 689000 690000 691000 692000

7353000 7352000 7351000 7350000 7349000 7348000 7347000 7346000

Blackwater Mine PRCP Flood Assessment

Sirius Creek PRCP Conditions Peak Stream Power - 39% AEP

APPENDIX C6-5-1

LEGEND

- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Stream Power (W/m²)

- 0 - 60
- 60 - 90
- 90 - 120
- 120 - 150
- >150

0 200 400 800 Meters

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:30,000 at A3
Project Number:	620.014601
Date:	4/07/2024
Drawn by:	SM

SLR

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683000 684000 685000 686000 687000 688000 689000 690000 691000 692000

7353000 7352000 7351000 7350000 7349000 7348000 7347000 7346000

Blackwater Mine PRCP Flood Assessment

Sirius Creek PRCP Conditions Peak Stream Power - 2% AEP

APPENDIX C6-5-2

LEGEND

- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Stream Power (W/m²)

- 0 - 60
- 60 - 90
- 90 - 120
- 120 - 150
- >150

N

0 200 400 800 Meters

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:30,000 at A3
Project Number:	620.014601
Date:	4/07/2024
Drawn by:	SM

SLR

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683000 684000 685000 686000 687000 688000 689000 690000 691000 692000

7353000 7352000 7351000 7350000 7349000 7348000 7347000 7346000

Blackwater Mine PRCP Flood Assessment

Sirius Creek PRCP Conditions Peak Levels - 0.1% AEP 06p CC

APPENDIX C6-6-1

LEGEND

- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Level (m AHD)

- Below 250
- 250 - 255
- 255 - 260
- 260 - 265
- 265 - 270
- 270 - 275
- 275 - 280
- 280 - 285
- 285 - 290
- Above 290

0 200 400 800 Meters

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:30,000 at A3
Project Number:	620.014601
Date:	4/07/2024
Drawn by:	SM

SLR

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683000 684000 685000 686000 687000 688000 689000 690000 691000 692000

7353000 7352000 7351000 7350000 7349000 7348000 7347000 7346000

Blackwater Mine PRCP Flood Assessment

Sirius Creek PRCP Conditions Peak Levels - 0.1% AEP 11p CC

APPENDIX C6-6-2

LEGEND

- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Level (m AHD)

- Below 250
- 250 - 255
- 255 - 260
- 260 - 265
- 265 - 270
- 270 - 275
- 275 - 280
- 280 - 285
- 285 - 290
- Above 290

0 200 400 800 Meters

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:30,000 at A3
Project Number:	620.014601
Date:	4/07/2024
Drawn by:	SM

SLR

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683000 684000 685000 686000 687000 688000 689000 690000 691000 692000

7353000 7352000 7351000 7350000 7349000 7348000 7347000 7346000

Blackwater Mine PRCP Flood Assessment

Sirius Creek PRCP Conditions Peak Levels - 0.1% AEP 20p CC

APPENDIX C6-6-3

LEGEND

- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Level (m AHD)

- Below 250
- 250 - 255
- 255 - 260
- 260 - 265
- 265 - 270
- 270 - 275
- 275 - 280
- 280 - 285
- 285 - 290
- Above 290

0 200 400 800 Meters

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:30,000 at A3
Project Number:	620.014601
Date:	4/07/2024
Drawn by:	SM

SLR

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683000 684000 685000 686000 687000 688000 689000 690000 691000 692000

7353000 7352000 7351000 7350000 7349000 7348000 7347000 7346000

Blackwater Mine PRCP Flood Assessment

Sirius Creek PRCP Conditions Peak Depths - 0.1% AEP 06p CC

APPENDIX C6-7-1

LEGEND

- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Depth (m)

- Below 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 2
- Above 2

0 200 400 800 Meters

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:30,000 at A3
Project Number:	620.014601
Date:	4/07/2024
Drawn by:	SM

SLR

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683000 684000 685000 686000 687000 688000 689000 690000 691000 692000

7353000 7352000 7351000 7350000 7349000 7348000 7347000 7346000

Blackwater Mine PRCP Flood Assessment

Sirius Creek PRCP Conditions Peak Depths - 0.1% AEP 11p CC

APPENDIX C6-7-2

LEGEND

- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Depth (m)

- Below 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 2
- Above 2

N

0 200 400 800 Meters

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:30,000 at A3
Project Number:	620.014601
Date:	4/07/2024
Drawn by:	SM

SLR

H:\Projects-SLR\620-BNE\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Sirius\MXDs\620.040134_APPENDIX C6-7-2_W007_1in1000CC11p_d.mxd

683000 684000 685000 686000 687000 688000 689000 690000 691000 692000

7353000 7352000 7351000 7350000 7349000 7348000 7347000 7346000

Blackwater Mine PRCP Flood Assessment

Sirius Creek PRCP Conditions Peak Depths - 0.1% AEP 20p CC

APPENDIX C6-7-3

LEGEND

- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Depth (m)

- Below 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 2
- Above 2

0 200 400 800 Meters

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:30,000 at A3
Project Number:	620.014601
Date:	4/07/2024
Drawn by:	SM

SLR

H:\Projects-SLR\620-BNE\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Sirius\MXDs\620.040134_APPENDIX C6-7-3_W007_1in1000CC20p_d.mxd

683000 684000 685000 686000 687000 688000 689000 690000 691000 692000

7353000 7352000 7351000 7350000 7349000 7348000 7347000 7346000

Blackwater Mine PRCP Flood Assessment

Sirius Creek PRCP Conditions Peak Velocities - 0.1% AEP 06p CC

APPENDIX C6-8-1

LEGEND

- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Velocity (m/s)

- Below 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 2.5
- 2.5 - 3.0
- 3.0 - 3.5
- Above 3.5

0 200 400 800 Meters

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:30,000 at A3
Project Number:	620.014601
Date:	4/07/2024
Drawn by:	SM

SLR

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683000 684000 685000 686000 687000 688000 689000 690000 691000 692000

7353000 7352000 7351000 7350000 7349000 7348000 7347000 7346000

Blackwater Mine PRCP Flood Assessment

Sirius Creek PRCP Conditions Peak Velocities - 0.1% AEP 11p CC

APPENDIX C6-8-2

LEGEND

- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Velocity (m/s)

- Below 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 2.5
- 2.5 - 3.0
- 3.0 - 3.5
- Above 3.5

0 200 400 800 Meters

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:30,000 at A3
Project Number:	620.014601
Date:	4/07/2024
Drawn by:	SM

SLR

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683000 684000 685000 686000 687000 688000 689000 690000 691000 692000

7353000 7352000 7351000 7350000 7349000 7348000 7347000 7346000

Blackwater Mine PRCP Flood Assessment

Sirius Creek PRCP Conditions Peak Velocities - 0.1% AEP 20p CC

APPENDIX C6-8-3

LEGEND

- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Velocity (m/s)

- Below 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 2.5
- 2.5 - 3.0
- 3.0 - 3.5
- Above 3.5

0 200 400 800 Meters

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:30,000 at A3
Project Number:	620.014601
Date:	4/07/2024
Drawn by:	SM

SLR

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674000 675000 676000 677000 678000 679000 680000 681000 682000 683000 684000 685000 686000 687000 688000 689000 690000 691000

7347000 7346000 7345000 7344000 7343000 7342000 7341000 7340000 7339000 7338000 7337000 7336000 7335000 7334000

Blackwater Mine PRCP Flood Assessment

Rockland Creek PRCP Conditions Peak Levels - 39% AEP

APPENDIX C7-1-1

LEGEND

- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Level (m AHD)

- Below 225
- 225 - 230
- 230 - 235
- 235 - 240
- 240 - 245
- 245 - 250
- 250 - 255
- 255 - 260
- 260 - 265
- Above 265

0 300 600 1,200 Meters

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:50,000 at A3
Project Number:	620.014601
Date:	4/07/2024
Drawn by:	SM

SLR

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Blackwater Mine PRCP Flood Assessment

Rockland Creek PRCP Conditions Peak Levels - 2% AEP

APPENDIX C7-1-2

674000 675000 676000 677000 678000 679000 680000 681000 682000 683000 684000 685000 686000 687000 688000 689000 690000 691000

7347000 7346000 7345000 7344000 7343000 7342000 7341000 7340000 7339000 7338000 7337000 7336000 7335000 7334000

LEGEND

- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Level (m AHD)

- Below 225
- 225 - 230
- 230 - 235
- 235 - 240
- 240 - 245
- 245 - 250
- 250 - 255
- 255 - 260
- 260 - 265
- Above 265

0 300 600 1,200 Meters

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:50,000 at A3
Project Number:	620.014601
Date:	4/07/2024
Drawn by:	SM

SLR

H:\Projects-SLR\620-BNE\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Rockland\MXDs\620.040134_APPENDIX C7-1-2_W008_02p_h.mxd

674000 675000 676000 677000 678000 679000 680000 681000 682000 683000 684000 685000 686000 687000 688000 689000 690000 691000

7347000 7346000 7345000 7344000 7343000 7342000 7341000 7340000 7339000 7338000 7337000 7336000 7335000 7334000

Blackwater Mine PRCP Flood Assessment

Rockland Creek PRCP Conditions Peak Levels - 0.1% AEP

APPENDIX C7-1-3

LEGEND

- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Level (m AHD)

- Below 225
- 225 - 230
- 230 - 235
- 235 - 240
- 240 - 245
- 245 - 250
- 250 - 255
- 255 - 260
- 260 - 265
- Above 265

0 300 600 1,200 Meters

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:50,000 at A3
Project Number:	620.014601
Date:	4/07/2024
Drawn by:	SM

SLR

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674000 675000 676000 677000 678000 679000 680000 681000 682000 683000 684000 685000 686000 687000 688000 689000 690000 691000

7347000 7346000 7345000 7344000 7343000 7342000 7341000 7340000 7339000 7338000 7337000 7336000 7335000 7334000

Blackwater Mine PRCP Flood Assessment

Rockland Creek PRCP Conditions Peak Levels - PMP

APPENDIX C7-1-4

LEGEND

- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Level (m AHD)

- Below 225
- 225 - 230
- 230 - 235
- 235 - 240
- 240 - 245
- 245 - 250
- 250 - 255
- 255 - 260
- 260 - 265
- Above 265

0 300 600 1,200 Meters

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:50,000 at A3
Project Number:	620.014601
Date:	4/07/2024
Drawn by:	SM

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Blackwater Mine PRCP Flood Assessment

Rockland Creek PRCP Conditions Peak Depths - 39% AEP

APPENDIX C7-2-1

674000 675000 676000 677000 678000 679000 680000 681000 682000 683000 684000 685000 686000 687000 688000 689000 690000 691000

7347000 7346000 7345000 7344000 7343000 7342000 7341000 7340000 7339000 7338000 7337000 7336000 7335000 7334000

LEGEND

- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Depth (m)

- Below 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 2
- Above 2

N

0 300 600 1,200 Meters

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:50,000 at A3
Project Number:	620.014601
Date:	4/07/2024
Drawn by:	SM

SLR

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Blackwater Mine PRCP Flood Assessment

Rockland Creek PRCP Conditions Peak Depths - 2% AEP

APPENDIX C7-2-2

674000 675000 676000 677000 678000 679000 680000 681000 682000 683000 684000 685000 686000 687000 688000 689000 690000 691000

7347000 7346000 7345000 7344000 7343000 7342000 7341000 7340000 7339000 7338000 7337000 7336000 7335000 7334000

LEGEND

- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Depth (m)

- Below 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 2
- Above 2

0 300 600 1,200 Meters

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:50,000 at A3
Project Number:	620.014601
Date:	4/07/2024
Drawn by:	SM

SLR

H:\Projects-SLR\620-BNE\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Rockland\MXDs\620.040134_APPENDIX C7-2-2_W008_02p_d.mxd

Blackwater Mine PRCP Flood Assessment

Rockland Creek PRCP Conditions Peak Depths - 0.1% AEP

APPENDIX C7-2-3

674000 675000 676000 677000 678000 679000 680000 681000 682000 683000 684000 685000 686000 687000 688000 689000 690000 691000

7347000 7346000 7345000 7344000 7343000 7342000 7341000 7340000 7339000 7338000 7337000 7336000 7335000 7334000

LEGEND

- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Depth (m)

- Below 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 2
- Above 2

N

0 300 600 1,200 Meters

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:50,000 at A3
Project Number:	620.014601
Date:	4/07/2024
Drawn by:	SM

SLR

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674000 675000 676000 677000 678000 679000 680000 681000 682000 683000 684000 685000 686000 687000 688000 689000 690000 691000

7347000 7346000 7345000 7344000 7343000 7342000 7341000 7340000 7339000 7338000 7337000 7336000 7335000 7334000

Blackwater Mine PRCP Flood Assessment

Rockland Creek PRCP Conditions Peak Depths - PMP

APPENDIX C7-2-4

LEGEND

- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Depth (m)

- Below 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 2
- Above 2

N

0 300 600 1,200 Meters

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:50,000 at A3
Project Number:	620.014601
Date:	4/07/2024
Drawn by:	SM

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674000 675000 676000 677000 678000 679000 680000 681000 682000 683000 684000 685000 686000 687000 688000 689000 690000 691000

7347000 7346000 7345000 7344000 7343000 7342000 7341000 7340000 7339000 7338000 7337000 7336000 7335000 7334000

Blackwater Mine PRCP Flood Assessment

Rockland Creek PRCP Conditions Peak Velocities - 39% AEP

APPENDIX C7-3-1

LEGEND

- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Velocity (m/s)

- Below 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 2.5
- 2.5 - 3.0
- 3.0 - 3.5
- Above 3.5

N

0 300 600 1,200 Meters

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:50,000 at A3
Project Number:	620.014601
Date:	4/07/2024
Drawn by:	SM

SLR

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674000 675000 676000 677000 678000 679000 680000 681000 682000 683000 684000 685000 686000 687000 688000 689000 690000 691000

7347000 7346000 7345000 7344000 7343000 7342000 7341000 7340000 7339000 7338000 7337000 7336000 7335000 7334000

Blackwater Mine PRCP Flood Assessment

Rockland Creek PRCP Conditions Peak Velocities - 2% AEP

APPENDIX C7-3-2

LEGEND

- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Velocity (m/s)

- Below 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 2.5
- 2.5 - 3.0
- 3.0 - 3.5
- Above 3.5

N

0 300 600 1,200 Meters

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:50,000 at A3
Project Number:	620.014601
Date:	4/07/2024
Drawn by:	SM

SLR

H:\Projects-SLR\620-BNE\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Rockland\MXDs\620.040134_APPENDIX C7-3-2_W008_02p_v.mxd

Blackwater Mine PRCP Flood Assessment

Rockland Creek PRCP Conditions Peak Velocities - 0.1% AEP

APPENDIX C7-3-3

674000 675000 676000 677000 678000 679000 680000 681000 682000 683000 684000 685000 686000 687000 688000 689000 690000 691000

7347000 7346000 7345000 7344000 7343000 7342000 7341000 7340000 7339000 7338000 7337000 7336000 7335000 7334000

LEGEND

- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Velocity (m/s)

- Below 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 2.5
- 2.5 - 3.0
- 3.0 - 3.5
- Above 3.5

N

0 300 600 1,200 Meters

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:50,000 at A3
Project Number:	620.014601
Date:	4/07/2024
Drawn by:	SM

SLR

H:\Projects-SLR\620-BNE\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Rockland\MXDs\620.040134_APPENDIX C7-3-3_W008_1in1000_v.mxd

674000 675000 676000 677000 678000 679000 680000 681000 682000 683000 684000 685000 686000 687000 688000 689000 690000 691000

7347000 7346000 7345000 7344000 7343000 7342000 7341000 7340000 7339000 7338000 7337000 7336000 7335000 7334000

Blackwater Mine PRCP Flood Assessment

Rockland Creek PRCP Conditions Peak Velocities - PMP

APPENDIX C7-3-4

LEGEND

- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Velocity (m/s)

- Below 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 2.5
- 2.5 - 3.0
- 3.0 - 3.5
- Above 3.5

N

0 300 600 1,200 Meters

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:50,000 at A3
Project Number:	620.014601
Date:	4/07/2024
Drawn by:	SM

SLR

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Blackwater Mine PRCP Flood Assessment

Rockland Creek PRCP Conditions Peak Bed Shear Stress - 39% AEP

APPENDIX C7-4-1

674000 675000 676000 677000 678000 679000 680000 681000 682000 683000 684000 685000 686000 687000 688000 689000 690000 691000

7347000 7346000 7345000 7344000 7343000 7342000 7341000 7340000 7339000 7338000 7337000 7336000 7335000 7334000

LEGEND

- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Bed Shear Stress (N/m²)

- 0 - 20
- 20 - 40
- 40 - 60
- 60 - 80
- > 80

N

0 300 600 1,200 Meters

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:50,000 at A3
Project Number:	620.014601
Date:	4/07/2024
Drawn by:	SM

SLR

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Blackwater Mine PRCP Flood Assessment

Rockland Creek PRCP Conditions Peak Bed Shear Stress - 2% AEP

APPENDIX C7-4-2

674000 675000 676000 677000 678000 679000 680000 681000 682000 683000 684000 685000 686000 687000 688000 689000 690000 691000

7347000 7346000 7345000 7344000 7343000 7342000 7341000 7340000 7339000 7338000 7337000 7336000 7335000 7334000

LEGEND

- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Bed Shear Stress (N/m²)

- 0 - 20
- 20 - 40
- 40 - 60
- 60 - 80
- > 80

0 300 600 1,200 Meters

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:50,000 at A3
Project Number:	620.014601
Date:	4/07/2024
Drawn by:	SM

SLR

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Blackwater Mine PRCP Flood Assessment

Rockland Creek PRCP Conditions Peak Stream Power - 39% AEP

APPENDIX C7-5-1

674000 675000 676000 677000 678000 679000 680000 681000 682000 683000 684000 685000 686000 687000 688000 689000 690000 691000

7347000 7346000 7345000 7344000 7343000 7342000 7341000 7340000 7339000 7338000 7337000 7336000 7335000 7334000

LEGEND

- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Stream Power (W/m²)

- 0 - 60
- 60 - 90
- 90 - 120
- 120 - 150
- >150

N

0 300 600 1,200 Meters

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:50,000 at A3
Project Number:	620.014601
Date:	4/07/2024
Drawn by:	SM

SLR

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Blackwater Mine PRCP Flood Assessment

Rockland Creek PRCP Conditions Peak Stream Power - 2% AEP

APPENDIX C7-5-2

674000 675000 676000 677000 678000 679000 680000 681000 682000 683000 684000 685000 686000 687000 688000 689000 690000 691000

7347000 7346000 7345000 7344000 7343000 7342000 7341000 7340000 7339000 7338000 7337000 7336000 7335000 7334000

LEGEND

- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Stream Power (W/m²)

- 0 - 60
- 60 - 90
- 90 - 120
- 120 - 150
- >150

0 300 600 1,200 Meters

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:50,000 at A3
Project Number:	620.014601
Date:	4/07/2024
Drawn by:	SM

SLR

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Blackwater Mine PRCP Flood Assessment

Rockland Creek PRCP Conditions Peak Levels - 0.1% AEP 06p CC

APPENDIX C7-6-1

674000 675000 676000 677000 678000 679000 680000 681000 682000 683000 684000 685000 686000 687000 688000 689000 690000 691000

7347000 7346000 7345000 7344000 7343000 7342000 7341000 7340000 7339000 7338000 7337000 7336000 7335000 7334000

LEGEND

- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Level (m AHD)

- Below 225
- 225 - 230
- 230 - 235
- 235 - 240
- 240 - 245
- 245 - 250
- 250 - 255
- 255 - 260
- 260 - 265
- Above 265

0 300 600 1,200 Meters

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:50,000 at A3
Project Number:	620.014601
Date:	4/07/2024
Drawn by:	SM

SLR

H:\Projects-SLR\620-BNE\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Rockland\MXDs\620.040134_APPENDIX C7-6-1_W008_1in1000CC06p_h.mxd

674000 675000 676000 677000 678000 679000 680000 681000 682000 683000 684000 685000 686000 687000 688000 689000 690000 691000

7347000 7346000 7345000 7344000 7343000 7342000 7341000 7340000 7339000 7338000 7337000 7336000 7335000 7334000

Blackwater Mine PRCP Flood Assessment

Rockland Creek PRCP Conditions Peak Levels - 0.1% AEP 11p CC

APPENDIX C7-6-2

LEGEND

- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Level (m AHD)

- Below 225
- 225 - 230
- 230 - 235
- 235 - 240
- 240 - 245
- 245 - 250
- 250 - 255
- 255 - 260
- 260 - 265
- Above 265

0 300 600 1,200 Meters

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:50,000 at A3
Project Number:	620.014601
Date:	4/07/2024
Drawn by:	SM

SLR

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Blackwater Mine PRCP Flood Assessment

Rockland Creek PRCP Conditions Peak Levels - 0.1% AEP 20p CC

APPENDIX C7-6-3

LEGEND

- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Level (m AHD)

- Below 225
- 225 - 230
- 230 - 235
- 235 - 240
- 240 - 245
- 245 - 250
- 250 - 255
- 255 - 260
- 260 - 265
- Above 265

0 300 600 1,200 Meters

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:50,000 at A3
Project Number:	620.014601
Date:	4/07/2024
Drawn by:	SM

SLR

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Blackwater Mine PRCP Flood Assessment

Rockland Creek PRCP Conditions Peak Depths - 0.1% AEP 06p CC

APPENDIX C7-7-1

LEGEND

- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Depth (m)

- Below 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 2
- Above 2

0 300 600 1,200 Meters

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:50,000 at A3
Project Number:	620.014601
Date:	4/07/2024
Drawn by:	SM

SLR

674000 675000 676000 677000 678000 679000 680000 681000 682000 683000 684000 685000 686000 687000 688000 689000 690000 691000

7347000 7346000 7345000 7344000 7343000 7342000 7341000 7340000 7339000 7338000 7337000 7336000 7335000 7334000

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674000 675000 676000 677000 678000 679000 680000 681000 682000 683000 684000 685000 686000 687000 688000 689000 690000 691000

7347000 7346000 7345000 7344000 7343000 7342000 7341000 7340000 7339000 7338000 7337000 7336000 7335000 7334000

Blackwater Mine PRCP Flood Assessment

Rockland Creek PRCP Conditions Peak Depths - 0.1% AEP 11p CC

APPENDIX C7-7-2

LEGEND

- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Depth (m)

- Below 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 2
- Above 2

N

0 300 600 1,200 Meters

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:50,000 at A3
Project Number:	620.014601
Date:	4/07/2024
Drawn by:	SM

SLR

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674000 675000 676000 677000 678000 679000 680000 681000 682000 683000 684000 685000 686000 687000 688000 689000 690000 691000

7347000 7346000 7345000 7344000 7343000 7342000 7341000 7340000 7339000 7338000 7337000 7336000 7335000 7334000

Blackwater Mine PRCP Flood Assessment

Rockland Creek PRCP Conditions Peak Depths - 0.1% AEP 20p CC

APPENDIX C7-7-3

LEGEND

- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Depth (m)

- Below 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 2
- Above 2

0 300 600 1,200 Meters

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:50,000 at A3
Project Number:	620.014601
Date:	4/07/2024
Drawn by:	SM

SLR

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Blackwater Mine PRCP Flood Assessment

Rockland Creek PRCP Conditions Peak Velocities - 0.1% AEP 06p CC

APPENDIX C7-8-1

LEGEND

- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Velocity (m/s)

- Below 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 2.5
- 2.5 - 3.0
- 3.0 - 3.5
- Above 3.5

N

0 300 600 1,200 Meters

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:50,000 at A3
Project Number:	620.014601
Date:	4/07/2024
Drawn by:	SM

SLR

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Blackwater Mine PRCP Flood Assessment

Rockland Creek PRCP Conditions Peak Velocities - 0.1% AEP 11p CC

APPENDIX C7-8-2

LEGEND

- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Velocity (m/s)

- Below 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 2.5
- 2.5 - 3.0
- 3.0 - 3.5
- Above 3.5

N

0 300 600 1,200 Meters

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:50,000 at A3
Project Number:	620.014601
Date:	4/07/2024
Drawn by:	SM

SLR

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Blackwater Mine PRCP Flood Assessment

Rockland Creek PRCP Conditions Peak Velocities - 0.1% AEP 20p CC

APPENDIX C7-8-3

LEGEND

- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Velocity (m/s)

- Below 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 2.5
- 2.5 - 3.0
- 3.0 - 3.5
- Above 3.5

N

0 300 600 1,200 Meters

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:50,000 at A3
Project Number:	620.014601
Date:	4/07/2024
Drawn by:	SM

SLR

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Appendix D Flooding Risk Profile

Blackwater Mine

Progressive Rehabilitation and Closure Plan Rehabilitation Flood Assessments

Whitehaven Blackwater Pty Ltd (WB)

SLR Project No.: 620.040134.00000

10 October 2024

WHC-FRM-RISK MATRIX

Whitehaven Coal Risk Assessment Criteria (Risk Matrix)

The risk assessment criteria is used to evaluate the significance or importance of risk to Whitehaven Coal and is used to determine whether a specified level of risk is acceptable. The criteria reflects the Whitehaven Coal Risk Appetite, STRIVE values, policies, and standards; and where applicable has been influenced by external standards and legislation. At Whitehaven Coal a Material Risk refers to

- Risk Event with a Residual Risk Rating of HIGH or CRITICAL; and/or,
- Risk Event with a Consequence Category of HEATH & SAFETY and a Consequence Rating of Major or Catastrophic (fatality risk).

Consequence Categories

			Consequence Rating				
			1. Negligeable	2. Minor	3. Medium	4. Major	5. Catastrophic
Consequence Categories	Health & Safety		First Aid from injury or occupational illness.	Medical Treatment from injury or occupational illness.	Lost time from disabling injury or occupational illness / multiple medical treatments / restricted work.	Fatality (≤5) / permanent incapacity due to injury or occupational illness.	Multiple fatalities (≥6), multiple cases of permanent incapacity due to injury or occupational illness.
	Environment		No lasting environmental impact (typically <24hr).	Short term environmental impact (typically <week), requires minor remediation.	Medium term environmental impact (typically <year), requires moderate remediation.	Long term environmental impact (2 to 10 years), requires significant remediation.	Unconfined and widespread environmental damage or effect (permanent; >10 years), requires major remediation.
	Legal & Compliance		Minor administrative breach of regulation without action.	Breach of law / regulation or non-compliance, minor legal issues, minor litigation possible.	Serious breach of law / regulation, regulatory investigation, enforcement action.	Major breach of law / regulation and prosecution at operational level, suspension of licence.	Major litigation / prosecution at business level, loss of licence.
	Reputation & Community		Negligible media interest. Public concern restricted to local complaints. Low level repairable impact to common place structures.	Local media coverage. Verified complaint received from an internal or external stakeholder. Impact to low significance cultural heritage.	Media coverage at regional level. Local Stakeholder action resulting in regional public concern. Permanent impact to items of cultural significance.	Media coverage at national level. Campaign from government and / or high-profile NGOs threatening continuity of operations. Significant impact to items of cultural significance.	Media coverage at international level. Sustained campaign from government and / or high-profile NGOs threatening business continuity. Major irreparable impact to highly valuable items of cultural significance.
	Projects (Schedule, Project CAPEX)		Minimal delay to one or more of the project's critical path activities and/or impact project CAPEX.	Minor delay to one or more of the project's critical path activities and/or impact project CAPEX.	Delay to one or more of the project's critical path activities and/or impact project CAPEX.	Significant delay to one or more of the project's critical path activities and/or impact project CAPEX.	Extreme delay to one or more of the project's critical path activities and/or impact project CAPEX.
	Business Interruption & Equipment Damage		No measurable operational impact to the business.	Minor damage, capital impact, business disruption, and/ or degradation of production.	Moderate damage, capital impact, business disruption and/ or degradation of production.	Major damage, capital impact, business interruption and/ or degradation of production.	Extensive damage, capital impact and/ or business interruption,serious threat to long term viability of the business.
	Financial	Revenue	<$5m	$5m - $15m	$15m - $75m	$75m - $400m	>$400m
		EBITDA	<$1m	$1m - $15m	$15m - $30m	$30m - $200m	>$200m
		NPV	<$5m	$5m - $25m	$25m - $150m	$150m - $1b	>$1b

Risk Matrix

			Consequence Rating				
			1. Negligeable	2. Minor	3. Medium	4. Major	5. Catastrophic
Likelihood	The unwanted event has occurred frequently; occurs in order of one or more times per year & is likely to reoccur within one year.	5. Almost certain	M5	H10	H15	C20	C25
	The unwanted event has occurred infrequently; occurs in order of less than once per year & is likely to reoccur within five years.	4. Likely	L4	M8	H12	H16	C20
	The unwanted event has happened at some time; or could happen within 10 years.	3. Possible	L3	M6	M9	H12	H15
	The unwanted event has happened at some time; or could happen within 20 years.	2. Unlikely	L2	L4	M6	M8	H10
	The unwanted event has never been known to occur; or is highly unlikely to occur within 20 years.	1. Rare	L1	L2	L3	L4	M5

WHC-FRM-RISK MATRIX

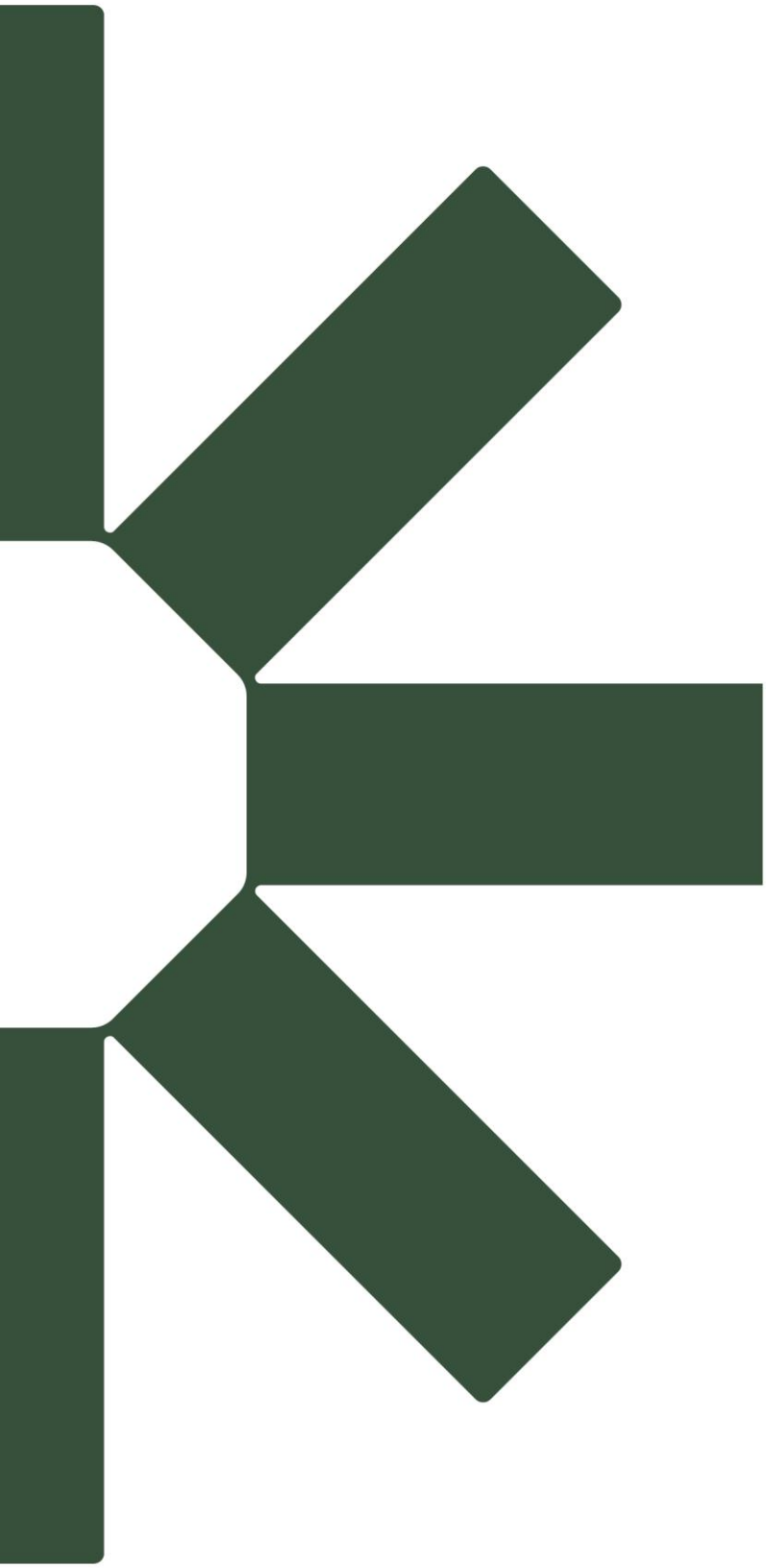
Control Effectiveness

		Description
Effectiveness Rating	**Effective**	• Controls are well designed and appropriate for the risk; • Controls are largely "preventative" and address the root causes; • Management believes that they are effective and reliable at all times; • Nothing more to be done except review and monitor the existing controls.
	Improvement Required	• Most controls are designed correctly and are in place and effective; • Controls may only treat some of the root causes of the risk, and/or are not currently effective and/or there may be an over-reliance on "reactive" controls; • Management has doubts about operational effectiveness and reliability; • More work is required to improve operating effectiveness.
	Ineffective	• Significant control gaps or no credible control; • Either controls do not treat root causes, are non-existent or, if they exist, they are ineffective; • Management has no confidence that any degree of control is being achieved due to poor control design; • Very limited or no operational effectiveness.

Risk Management Action

		Minimum Control Effectiveness requirement	Action Required when minimum control effectiveness requirement not met	Escalation & Approval of Treatment Plan	Acceptance Authority
Residual Risk Rating	**Critical**	Effective	Risk treatment plan must be in place immediately. Risk reviewed monthly by Risk Owner.	Report to ARMC and Managing Director for review and approval of the treatment plan.	CEO/MD
	High	Effective	Risk treatment must be considered. Risk reviewed quarterly by Risk Owner.	Report to ARMC and Managing Director. Report to Executive General Manager for review and approval of associated treatment plan.	EGM
	Moderate	Effective	Risk treatment may be considered. Risk reviewed annually by Risk Owner.	Report to General Manager for review and approval of associated treatment plan.	GM
	Low	Improvement Required	No risk treatment required. Risk reviewed annually by Risk Owner.	Report to Risk Owner.	Risk Owner

CONSIDERATIONS AND INITIAL RISK EVALUATION									CONTROL INPUT AND RESIDUAL RISK EVALUATION							
	Risk Event	Risk Category		Cause & Impact		Assessment of Risk without controls in place			Control Input		Assessment of Risk with controls in place					
Ref / ID # A value must be entered for every row	Hazard or Risk A value must be entered for every row	Existing Material Risk	Material Risk Category	How could it happen? (Causes)	What Could Happen (Impacts)	Inherent Likelihood	Inherent Consequence	Inherent Risk Assessment	Control Name	Hierachy of Control	Consequence Category	Control Effectiveness	Residual Consequence	Residual Likelihood	Current Risk Assessment
1	RE1	Taurus Creek Diversion Scour	Environment_Climate_Change_and_Community	Cumulation of flow events eroding and scouring the channel, undercutting the rehab dump area	Ingress into the final void & associated impacts to hydrologic regime	Possible	Major	H12	Appropriate scour protection works in impacted reaches	Engineering	ENV - Level 4 Long term environmental impact (2 to 10 years), requires significant remediation.	Effective	Major	Rare	L4
2	RE2	Sirius Creek Diversion Scour	Environment_Climate_Change_and_Community	Cumulation of flow events eroding and scouring the channel, undercutting the stable landform	Ingress into the final void & associated impacts to hydrologic regime	Possible	Major	H12	Appropriate scour protection works in impacted reaches	Engineering	ENV - Level 4 Long term environmental impact (2 to 10 years), requires significant remediation.	Effective	Major	Rare	L4
3	RE3	Rockland Creek Diversion Scour	Environment_Climate_Change_and_Community	Cumulation of flow events eroding and scouring the channel, undercutting the stable landform or redirecting the channel into the void	Ingress into the final void & associated impacts to hydrologic regime	Possible	Major	H12	Appropriate scour protection works in impacted reaches	Engineering	ENV - Level 4 Long term environmental impact (2 to 10 years), requires significant remediation.	Effective	Major	Rare	L4
4	RE4	Burngrove Creek Diversion Scour	Health_and_Safety	Cumulation of flow events eroding and scouring the channel, undercutting the rail embankment	Failure of rail embankment	Possible	Major	H12	Appropriate scour protection and/or reshaping works in impacted reaches	Engineering	H&S - Level 4 Fatality (≤5) / permanent incapacity due to injury or occupational illness..	Effective	Major	Rare	L4
5	RE5	Mimosa/Besgrove Final Void floodwater ingress	Environment_Climate_Change_and_Community	Rare flood inundation extent reaching the final void area	Ingress into the final void & associated impacts to hydrologic regime	Rare	Major	L4	Stable landform design features to prevent ingress. E.g. backfill void, stable bunding structure.	Engineering	ENV - Level 4 Long term environmental impact (2 to 10 years), requires significant remediation.	Effective	Major	Rare	L4
6	RE5	Deep Creek Final Void floodwater ingress	Environment_Climate_Change_and_Community	Rare flood inundation extent reaching the final void area	Ingress into the final void & associated impacts to hydrologic regime	Rare	Major	L4	Stable landform design features to prevent ingress. E.g. backfill void, stable bunding structure.	Engineering	ENV - Level 4 Long term environmental impact (2 to 10 years), requires significant remediation.	Effective	Major	Rare	L4
7	RE5	Stewarton / Ballamoo Final Void floodwater ingress	Environment_Climate_Change_and_Community	Flood inundation extent reaching the final void area	Ingress into the final void & associated impacts to hydrologic regime	Unlikely	Major	M8	Stable landform design features to prevent ingress. E.g. backfill void, stable bunding structure.	Engineering	ENV - Level 4 Long term environmental impact (2 to 10 years), requires significant remediation.	Effective	Major	Rare	L4
8	RE5	Laleham Final Void floodwater ingress	Environment_Climate_Change_and_Community	Flood inundation extent reaching the final void area	Ingress into the final void & associated impacts to hydrologic regime	Unlikely	Major	M8	Stable landform design features to prevent ingress. E.g. backfill void, stable bunding structure.	Engineering	ENV - Level 4 Long term environmental impact (2 to 10 years), requires significant remediation.	Effective	Major	Rare	L4
9	RE5	Togara/North Marshmead Final Void floodwater ingress	Environment_Climate_Change_and_Community	Flood inundation extent reaching the final void area	Ingress into the final void & associated impacts to hydrologic regime	Unlikely	Major	M8	Stable landform design features to prevent ingress. E.g. backfill void, stable bunding structure.	Engineering	ENV - Level 4 Long term environmental impact (2 to 10 years), requires significant remediation.	Effective	Major	Rare	L4
10	RE5	South Marshmead Final Void floodwater ingress	Environment_Climate_Change_and_Community	Flood inundation extent reaching the final void area	Ingress into the final void & associated impacts to hydrologic regime	Likely	Major	H16	Stable landform design features to prevent ingress. E.g. backfill void, stable bunding structure.	Engineering	ENV - Level 4 Long term environmental impact (2 to 10 years), requires significant remediation.	Effective	Major	Rare	L4
11	RE5	Comet Downs East Final Void floodwater ingress	Environment_Climate_Change_and_Community	Flood inundation extent reaching the final void area	Ingress into the final void & associated impacts to hydrologic regime	Unlikely	Major	M8	Stable landform design features to prevent ingress. E.g. backfill void, stable bunding structure.	Engineering	ENV - Level 4 Long term environmental impact (2 to 10 years), requires significant remediation.	Effective	Major	Rare	L4
12	RE5	Kennedy West Final Void floodwater ingress	Environment_Climate_Change_and_Community	Flood inundation extent reaching the final void area	Ingress into the final void & associated impacts to hydrologic regime	Unlikely	Major	M8	Stable landform design features to prevent ingress. E.g. backfill void, stable bunding structure.	Engineering	ENV - Level 4 Long term environmental impact (2 to 10 years), requires significant remediation.	Effective	Major	Rare	L4
13	RE6	Mimosa/Besgrove - floodwaters in contact with rehab dump (Burngrove Creek)	Environment_Climate_Change_and_Community	Rare flood inundation extent reaching and eroding the rehab dump area, causing failure	Ingress into the final void & associated impacts to hydrologic regime	Rare	Major	L4	Design of rehabilitation dump areas adjacent to flowpaths to prevent erosion and scour.	Engineering	ENV - Level 4 Long term environmental impact (2 to 10 years), requires significant remediation.	Effective	Major	Rare	L4
14	RE6	Mimosa/Besgrove - floodwaters in contact with rehab dump (Taurus Creek)	Environment_Climate_Change_and_Community	Flood inundation extent reaching and eroding the rehab dump area, causing failure	Ingress into the final void & associated impacts to hydrologic regime	Rare	Major	L4	Design of rehabilitation dump areas adjacent to flowpaths to prevent erosion and scour.	Engineering	ENV - Level 4 Long term environmental impact (2 to 10 years), requires significant remediation.	Effective	Major	Rare	L4
15	RE6	Deep Creek - floodwaters in contact with rehab dump (Taurus Creek)	Environment_Climate_Change_and_Community	Flood inundation extent reaching and eroding the rehab dump area, causing failure	Ingress into the final void & associated impacts to hydrologic regime	Unlikely	Major	M8	Design of rehabilitation dump areas adjacent to flowpaths to prevent erosion and scour.	Engineering	ENV - Level 4 Long term environmental impact (2 to 10 years), requires significant remediation.	Effective	Major	Rare	L4
16	RE6	Stewarton/Ballamoo - floodwaters in contact with rehab dump (Taurus Creek)	Environment_Climate_Change_and_Community	Flood inundation extent reaching and eroding the rehab dump area, causing failure	Ingress into the final void & associated impacts to hydrologic regime	Possible	Major	H12	Design of rehabilitation dump areas adjacent to flowpaths to prevent erosion and scour.	Engineering	ENV - Level 4 Long term environmental impact (2 to 10 years), requires significant remediation.	Effective	Major	Rare	L4
17	RE6	Stewarton/Ballamoo - floodwaters in contact with rehab dump (Speculation Creek)	Environment_Climate_Change_and_Community	Flood inundation extent reaching and eroding the rehab dump area, causing failure	Ingress into the final void & associated impacts to hydrologic regime	Unlikely	Major	M8	Design of rehabilitation dump areas adjacent to flowpaths to prevent erosion and scour.	Engineering	ENV - Level 4 Long term environmental impact (2 to 10 years), requires significant remediation.	Effective	Major	Rare	L4
18	RE6	Laleham - floodwaters in contact with rehab dump	Environment_Climate_Change_and_Community	Rare flood inundation extent reaching and eroding the rehab dump area, causing failure	Ingress into the final void & associated impacts to hydrologic regime	Rare	Major	L4	Design of rehabilitation dump areas adjacent to flowpaths to prevent erosion and scour.	Engineering	ENV - Level 4 Long term environmental impact (2 to 10 years), requires significant remediation.	Effective	Major	Rare	L4
19	RE6	Togara/North Marshmead - floodwaters in contact with rehab dump (Sirius Creek)	Environment_Climate_Change_and_Community	Flood inundation extent reaching and eroding the rehab dump area, causing failure	Ingress into the final void & associated impacts to hydrologic regime	Rare	Major	L4	Design of rehabilitation dump areas adjacent to flowpaths to prevent erosion and scour.	Engineering	ENV - Level 4 Long term environmental impact (2 to 10 years), requires significant remediation.	Effective	Major	Rare	L4
20	RE6	Togara/North Marshmead - floodwaters in contact with rehab dump (Rockland Creek)	Environment_Climate_Change_and_Community	Flood inundation extent reaching and eroding the rehab dump area, causing failure	Ingress into the final void & associated impacts to hydrologic regime	Unlikely	Major	M8	Design of rehabilitation dump areas adjacent to flowpaths to prevent erosion and scour.	Engineering	ENV - Level 4 Long term environmental impact (2 to 10 years), requires significant remediation.	Effective	Major	Rare	L4
21	RE6	South Marshmead - floodwaters in contact with rehab dump	Environment_Climate_Change_and_Community	Flood inundation extent reaching and eroding the rehab dump area, causing failure	Ingress into the final void & associated impacts to hydrologic regime	Unlikely	Major	M8	Design of rehabilitation dump areas adjacent to flowpaths to prevent erosion and scour.	Engineering	ENV - Level 4 Long term environmental impact (2 to 10 years), requires significant remediation.	Effective	Major	Rare	L4
22	RE6	Comet Downs East - floodwaters in contact with rehab dump	Environment_Climate_Change_and_Community	Flood inundation extent reaching and eroding the rehab dump area, causing failure	Ingress into the final void & associated impacts to hydrologic regime	Unlikely	Major	M8	Design of rehabilitation dump areas adjacent to flowpaths to prevent erosion and scour.	Engineering	ENV - Level 4 Long term environmental impact (2 to 10 years), requires significant remediation.	Effective	Major	Rare	L4
23	RE6	Kennedy West - floodwaters in contact with rehab dump	Environment_Climate_Change_and_Community	Flood inundation extent reaching and eroding the rehab dump area, causing failure	Ingress into the final void & associated impacts to hydrologic regime	Rare	Major	L4	Design of rehabilitation dump areas adjacent to flowpaths to prevent erosion and scour.	Engineering	ENV - Level 4 Long term environmental impact (2 to 10 years), requires significant remediation.	Effective	Major	Rare	L4
24	RE7	Alteration of flows upstream of site	Environment_Climate_Change_and_Community	Change in watercourse behaviour as a result of final landform design	Habitat impacted upstream of site	Unlikely	Medium	M6	Landform design developed to minimise alteration of hydrology.	Engineering	ENV - Level 1 No lasting environmental impact (typically <24hr).	Effective	Minor	Rare	L2
25	RE8	Alteration of flows downstream of site	Environment_Climate_Change_and_Community	Change in watercourse behaviour as a result of final landform design	Habitat and water users impacted downstream of site	Likely	Medium	H12	Landform design developed to minimise alteration of hydrology.	Engineering	ENV - Level 1 No lasting environmental impact (typically <24hr).	Effective	Minor	Unlikely	L4



Making Sustainability Happen

Whitehaven

Appendix 4.7 – Waste Characterisation

TERRENUS
EARTH SCIENCES

Blackwater Mine

Environmental Geochemical Characterisation and Risk Assessment of Mineral Waste

Supporting information for the:

Progressive Rehabilitation and Closure Plan

Prepared for:

Whitehaven Blackwater Pty Ltd

TERRENUS
EARTH SCIENCES

Environmental Geochemical Characterisation and Risk Assessment of Mineral Waste

BLACKWATER MINE

Prepared for:

Whitehaven Blackwater Pty Ltd

DOCUMENT CONTROL

Report Title	Environmental Geochemical Characterisation and Risk Assessment of Mineral Waste		
Project Name	Blackwater Mine		
Job Number	24-063-178	**Client**	Whitehaven Blackwater Pty Ltd
Report Number	24-063-178 / R001		
Author	Dr. Ian P. Swane (Terrenus Earth Sciences)		

DOCUMENT ISSUE

Document Status	Issued To	Date Issued
DRAFT v0	BWM and Whitehaven Coal	12 August 2024
FINAL	BWM and Whitehaven Coal	18 September 2024

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Acknowledgements:

Terrenus acknowledges the support of Dr. Karan Jain from *Mine Waste Management* for assistance with data compilation and preliminary assessment; and Dr. Marilena Stimpfl from *BHP Closure Planning* for review and commentary of a preliminary version of this report.

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EXECUTIVE SUMMARY

This report serves to document and discuss the environmental geochemical characteristics of mineral waste materials associated with Blackwater Mine (BWM), as supporting information for the progressive rehabilitation and closure plan (PRCP) for BWM. Until April 2024, BWM was owned and operated by BHP companies, before transferring to Whitehaven Coal. All geochemical data presented herein was collected by/for BHP prior to Whitehaven Coal taking ownership.

The objective of the assessment is to evaluate the geochemical nature of mineral waste currently at BWM and mineral waste likely to be present at closure, and identify relevant environmental issues/opportunities that may be associated with mining, handling and storing mineral waste to inform appropriate rehabilitation and management strategies.

BWM administration and industrial area is located approximately 75 kilometres (km) southeast of Emerald township and about 20 km south of Blackwater township, in central Queensland. BWM is flanked on the east, west and south by pastoral leases; and bounded to the north by Capricorn Highway and Blackwater township. BWM commenced operations in 1967.

BWM comprises typical open-pit coal mining facilities, such as open pits, waste rock (spoil) dumps, tailings storage facilities (TSFs), rejects dumps, coal stockpiles, coal processing facilities, rail loadout facilities, process water and raw water dams, surface water drains and administration areas. The southern area of BWM also contains historic (closed/inactive) underground mining areas.

Current activities of relevance to this waste characterisation report comprise:

- Disposal of spoil to in-pit spoil dumps behind the active mining face (in-pit low-wall spoil disposal);
- Run-of-mine (ROM) coal processing at the north coal handling and preparation plant (NCPP), which produces two mineral waste types:
- Tailings. Clay, silt and very fine to medium-grain sized sand material; disposed as a slurry.
- Rejects. Coarse sand to cobble-sized material.
- Thermal ROM coal processing at the thermal coal plant (TCP), which produces rejects.
- Disposal of tailings from NCPP to Bonnie Doon Pit (now Bonnie Doon in-pit TSF); [active from late 2023];
- Disposal of rejects from NCPP and TCP to spoil dumps; Rejects from NCPP have been used in construction of TSF embankments and infrastructure pads;
- Short-term storage of ROM coal on the ROM Pad;
- Short-term storage of product coal on the product coal stockpile, awaiting off-site transport by rail;
- The operation of raw water and process water dams and sediment control structures as stipulated in the EA.

Historic activities of relevance to this waste characterisation report comprise:

- Disposal of tailings from NCPP to the above-ground NCPP TSF; [inactive since late 2023];
- Disposal of rejects from NCPP and TCP to rejects dumps (primarily Ramp 36 rejects dump and TCP rejects dump);

- ROM coal processing at the south coal handling and preparation plant (SCPP), which produced tailings and rejects similar to NCPP. The SCPP received ROM coal from open cut and underground mining operations in the southern BWM area (what was then called South BWM). SCPP has been inactive since the early 2000s;
- Disposal of tailings from SCPP to the above-ground Laleham TSF, two in-pit TSFs (Kenmare Pit - Ramp 72 TSF; and Laleham Pit - Ramp 74 TSF) and Bottom Dam TSF (gully southeast of the SCPP ROM 3 pad). Tailings from NCPP were also disposed into Ramp 74 TSF;
- Disposal (rehandling) of mixed 'aged' tailings and rejects (originally from SCPP) into the southern end of Kenmare Pit (Ramp 72 Pit);
- Disposal of rejects from SCPP onto ROM Pad 3 and into Bottom Dam area adjacent to Bottom Dam TSF.

Material types and quantities

BWM has three main types of mineral waste, and the geochemical characteristics and potential hazards associated with mineral waste materials on site are discussed by type:

- Spoil (overburden and interburden) currently comprises approximately 99% of all mineral waste at BWM and includes weathered waste (Tertiary and Permian-age) and fresh (unweathered) waste (all Permian-age). On average, approximately 40% of spoil is weathered/oxidised and the remaining (approximately 60%) is fresh, with the proportion of weathered to fresh spoil varying throughout the site. In the northern half of the site the proportion of weathered to fresh spoil is about 25% weathered to 75% fresh, whereas in the southern half of the site the proportion of weathered to fresh spoil is about 49% weathered to 51% fresh.
- Tailings are generated at the NCPP (and previously also at the SCPP) from processing ROM coal and typically represent the clay, silt and fine sand fractions of ROM waste. Throughout operations at BWM, tailings has been disposed as a slurry into a number of TSFs – the current (active) TSF being Bonnie Doon in-pit TSF. Tailings comprises approximately 0.5% of all mineral waste at BWM – with this approximated proportion expected for the remaining life of asset mine plan.
- Rejects are generated at the NCPP (and previously also at the SCPP) from processing ROM coal and typically represents coarser and rockier seam roof, partings and floor material. Rejects are trucked to several locations for disposal into spoil. Historically, rejects were also disposed onto rejects dumps, such as Ramp 36 rejects dump and Bottom Dam TSF [mixed tailings and rejects]. Some rejects have been used in construction of TSF embankments and infrastructure pads (eg. ROM and coal stockpile pads). Rejects comprise approximately 0.5% of all mineral waste at BWM – with this approximated proportion expected for the remaining life of asset mine plan.

Coal is also included in the assessment; however, coal is generally not considered mineral waste, with the exception of small quantities of sub-economic seams that may report to the spoil dumps, and remnant coal exposed on pit highwalls (such as in residual voids).

AMD Potential of Mineral Waste and Coal

Mineral waste samples have undergone environmental geochemical characterisation and assessment with regard to their potential to generate acid and metalliferous drainage (AMD), which comprises acid drainage (AD), neutral and metalliferous drainage (NMD) and/or saline drainage (SD) [salinity due to sulfate derived from sulfide oxidation]. Additionally, samples have been assessed with regard to their

potential to generate salinity (non-oxidative) and, for spoil materials, their sodicity and dispersion potential.

AMD potential of spoil – non-carbonaceous

Non-carbonaceous spoil, which comprises about 92% of spoil, is expected to generate pH-neutral to highly alkaline contact water (run-off and seepage), which is typical for mine spoil in the Bowen Basin.

Based on the results from 3081 samples, non-carbonaceous spoil has a very low potential to generate AMD as either AD and/or NMD and/or SD, but for a small proportion that is assessed to have a higher potential to generate AMD (as AD, NMD and/or SD). However, in consideration of the mixing and dispersion of a small volume of waste at higher potential for AMD within the broader spoil material, the overall potential for non-carbonaceous spoil to generate AMD is assessed to be low.

The total sulfur (S) concentration of non-carbonaceous spoil is very low, with a 90th percentile total S concentration of 0.06%. As such, and combined with moderate to high acid neutralising capacity (ANC) values (median 40 kg H_2SO_4/t), which is significantly higher than the MPA (median 0.6 kg H_2SO_4/t), approximately 96% of non-carbonaceous spoil samples tested were classified as non-acid forming (NAF), with a further approximately 2% of samples classified as UC(NAF) [uncertain, but expected to be NAF]. Less than 3% of non-carbonaceous spoil samples were classified as either potentially acid forming (PAF), PAF-LC [PAF, low capacity], UC(PAF) [uncertain, but expected to be PAF] or NAF-S [NAF, but with total S greater than 1%].

The test-work has demonstrated that the ANC is generally expected to be about 37-75% available under field conditions, with iron-dolomite/dolomite and calcite being the main carbonate mineral contributing to the acid buffering potential of the non-carbonaceous spoil. Overall, non-carbonaceous spoil has excess acid neutralising capacity and is expected to be bulk acid consuming.

Total metal and metalloid concentrations from 391 non-carbonaceous spoil samples tested are very low compared to average element abundance in soil in the earth's crust. However, 19 samples were significantly enriched with regard to one or more of arsenic (As), barium (Ba), beryllium (Be), cobalt (Co), chromium (Cr), mercury (Hg), S, selenium (Se) and/or tungsten (W). The enrichment in one or more of these elements in a small proportion of samples is not cause for concern. Of the samples displaying elemental enrichment, there was no correlation with AMD classifications of these samples. In summary, non-carbonaceous spoil has low enrichment in total metals and metalloids compared to unmineralised rocks.

Soluble multi-element results (from 391 samples) indicate that leachate from this material is expected to contain low concentrations of soluble metals and metalloids. One PAF-LC sample produced elevated soluble metal concentrations. Another 10 samples released moderate soluble metals concentrations for one or more of aluminium (Al), iron (Fe), Co, manganese (Mn), nickel (Ni) and/or zinc (Zn). Peroxide leaching undertaken on five non-carbonaceous spoil samples showed that PAF material has the potential to generate low pH leachate (AD) with moderate sulfate and soluble metal and metalloid concentrations.

AMD potential of spoil – carbonaceous

Carbonaceous spoil represents less than 8% of spoil material at BWM and – as a bulk material – is expected to generate pH-alkaline to highly alkaline contact water (run-off and seepage), similar to non-carbonaceous spoil.

Based on the results from 260 samples, carbonaceous spoil has a generally low potential to generate AD and/or NMD and/or SD. Some carbonaceous spoil – mostly associated with coal seams – has a greater potential to generate low-level AD and/or NMD and/or SD.

The total S concentration of carbonaceous spoil is low, with a 90th percentile total S concentration of 0.44%. As such, and combined with generally moderate ANC values (median 20 kg H_2SO_4/t) and relatively low MPA values (median 4 kg H_2SO_4/t), approximately 85% of carbonaceous spoil samples (220 out of 260 samples) were classified as NAF, with a further 5 samples (approximately 2% of samples) classified as UC(NAF). The remaining 13% (approximately) of samples were classified as PAF, PAF-LC, UC(PAF) or NAF-S. Almost all of the 'PAF' and NAF-S carbonaceous spoil samples were closely associated with coal seams and could potentially end up as coarse reject if mined with ROM coal.

The test-work undertaken has demonstrated that the ANC is generally expected to be about 17-40% available under field conditions, with iron-dolomite/dolomite and calcite being the main carbonate minerals contributing to the acid buffering potential of carbonaceous spoil. Overall, carbonaceous spoil has relatively modest acid neutralising capacity.

Total metal and metalloid concentrations from 54 carbonaceous spoil samples tested are very low compared to average element abundance in soil in the earth's crust, and very similar to the assay concentrations from non-carbonaceous spoil. Ten samples were significantly enriched with regard to one or more of As, Be, Cu, Hg, S and/or U. Of the samples displaying elemental enrichment, there was no correlation with AMD classifications of these samples. In summary, carbonaceous spoil has low enrichment in total metals and metalloids compared to unmineralised rocks.

Soluble multi-element results (from 54 samples) indicate that, with few exceptions, leachate from carbonaceous spoil is expected to contain low concentrations of soluble metals and metalloids – similar to non-carbonaceous spoil samples. Peroxide [NAG] leaching undertaken on three carbonaceous spoil samples (one PAF and two NAF) showed that the PAF sample has the potential to generate low pH leachate (AD) with elevated sulfate and soluble metal and metalloid concentrations. The two NAF samples that underwent peroxide leaching produced leachate with near-neutral to alkaline pH and with low to moderate soluble metals concentration.

AMD potential of tailings

The geochemical characteristics differed between fresh tailings from the NCPP versus aged tailings from TSFs for different parameters – particularly total S (and, by inference, MPA), ANC and pH. However, the overall geochemical (AMD) hazard posed by tailings from the two sources (fresh vs aged) was generally similar. As such, the discussion that follows only differentiates between the two tailings sources where the differences between the two sources was significant for some parameters and worthy of discussion. Else, the AMD potential of tailings is discussed as a bulk material.

Based on the results from 643 samples, approximately 53% of tailings has a moderate to high potential to generate AMD as either AD and/or NMD and/or SD, and remaining 47% (approximately) has a relatively low potential to generate AMD as either AD and/or NMD and/or SD.

Fresh tailings from the NCPP are expected to generate pH-alkaline to highly alkaline contact water (run-off and seepage). Overall, aged tailings have lower pH compared to fresh tailings, however the pH in aged tailings ranged from moderately acidic to pH-alkaline. The difference in pH observed between fresh and aged tailings (and the differences within the aged tailings) may be due to a number of

factors, however the most likely cause is oxidation processes consuming readily available neutralising minerals, leading to aged tailings generally having a low(er) acid neutralising potential.

The total S concentration of tailings is generally low-moderate, with median values of 0.77% and 0.53% for fresh and aged tailings, respectively. Overall, the total S concentration was higher in the fresh tailings compared to the aged tailings. The reasons for differences in total S between the fresh versus aged tailings is unclear and potential processes that could account for differences in total S concentration are:

- Sulfide oxidation and neutralisation reactions ongoing within the TSFs, which generate sparingly and / or readily soluble sulfate. Therefore, sulfur mass loss could have occurred from aged tailings due to leaching of sulfate minerals, such as jarosite, alunite and/or gypsum and/or readily soluble acid salts (eg. iron sulfate 'salts' such as melanterite or copiapite).
- Change in geochemistry of ROM coal being processed. That is, ROM coal becoming more S-rich over time due to a change in the relative proportions of the various coal seams/plys being mined and processed.
- Addition of sulfate via salt precipitation within tailings during drying / evaporation of slurry water (liquor) [laboratory bias].

In the fresh tailings samples about 68% (median value) of the total S is present as sulfide (Scr). Comparatively, only 48% (median value) of the total S is present as Scr in the aged tailings samples. The difference in the proportion of total S as Scr between fresh versus aged tailings is typical and expected – supporting the suggestion that the aged tailings in the TSFs are being oxidised since deposition (sulfide oxidised to sulfate).

Just as there were notable differences between the total S concentrations in fresh versus aged tailings, so too with the ANC values of fresh versus aged tailings. Fresh tailings had generally moderate to high ANC values (median 32 kg H_2SO_4/t) compared to aged tailings, which had generally low to moderate ANC values (median 16 kg H_2SO_4/t). The reason behind the lower ANC observed in aged tailings (compared to fresh tailings) is not well understood. However, it is likely related to ANC being consumed via buffering of acidity generated by sulfide oxidation and/or sulfate leaching. Other processes that could account for a difference in ANC between fresh and aged tailings include inherent differences in the geochemical properties of the coal from earlier mining compared to recent mining, and/or – related to ROM coal differences; and it may also be partially due to differences in processing methods between the NCPP and the SCPP.

Based on the above generally low-moderate total S values (and, therefore, MPA values) combined with a wide range of ANC values resulted in approximately 56% of tailings samples being classified as PAF, PAF-LC, UC(PAF) or NAF-S – with the remaining 44% (approximately) classified as NAF or UC(NAF). Of the 'PAF' and NAF-S tailings samples, about 75% were classified as UC(PAF) or PAF-LC.

The test-work undertaken has demonstrated that the ANC in fresh tailings is expected to be about 47-67% available under field conditions, compared to about 14-66% available for aged tailings. Iron-dolomite/dolomite and calcite are expected to be the main carbonate minerals contributing to the acid buffering potential of tailings.

With few exceptions, the total metal and metalloid concentrations from 56 tailings samples tested are generally low compared to average element abundance in soil in the earth's crust. About 30% of the fresh and aged tailings samples were significantly enriched (GAI $\geq$3) with regard to S, which is

consistent with the ABA data. The GAI values also show that a considerable number of tailings samples tested had minor enrichment (GAI = 1 or 2) with regard to one or more of Ag, B, Be, Cd, Hg, Mn and/or S. There was no clear correlation found between AMD classifications of the tailings samples compared to elemental enrichment.

Solubility data indicate that under freshwater (deionised water) leaching conditions all fresh tailings and approximately half of the aged tailings are expected to have low soluble metals concentrations and have near-neutral to alkaline pH. The remaining half of the aged tailings samples produced moderate to elevated metals concentration and, with exception of one sample which had highly acidic pH, all samples had weakly to moderately acidic pH. Under saline leaching conditions tailings produced low concentrations of soluble metals and metalloids.

Peroxide leaching undertaken on 48 tailings samples [about 60% classified as 'PAF' or NAF-S, and the remainder classified as NAF or UC(NAF)] showed that when exposed to highly oxidising conditions a significant proportion of tailings can produce weakly to highly acidic leachate with elevated soluble metals and metalloid concentrations. However, about one-third of tailings samples appeared to be influenced to some degree by the presence of organic acids, due to the samples' high organic carbon concentration. The presence of organic acids likely accounts, to some degree, for the acidity and 'elevated' soluble metals and metalloid concentrations evident in these tailings. Nevertheless, PAF tailings [including tailings classified as UC(PAF)] have typically produced moderate to elevated soluble metals and metalloid concentrations from the freshwater and peroxide leaching tests. These results indicate that PAF tailings have the potential to generate low pH leachate (AD), however the salinity (sulfate) loads are not expected to be high – due to generally low total S concentrations (with minor exceptions).

AMD potential of rejects

Based on the results from 265 samples, about half of the rejects have a moderate to high potential to generate AMD as either AD and/or NMD and/or SD, whereas the remaining half of rejects has a relatively low to low-moderate potential to generate AMD as either AD and/or NMD and/or SD.

Fresh rejects from the NCPP are expected to generate highly pH-alkaline contact water (run-off and seepage). Aged rejects (from Ramp 36 rejects dump, TSFs and a small number of rejects in the Red Dam area) has lower pH compared to fresh rejects and is expected to generate weakly acidic to pH-alkaline contact water (run-off and seepage). The difference in pH observed between fresh and aged rejects – with the latter showing generally lower pH – may be due to a number of factors, however the most likely cause is oxidation processes consuming readily available neutralising minerals, leading to aged rejects having a low(er) acid neutralising potential.

The total S concentration of fresh rejects was generally low (median value = 0.28%) compared to aged rejects, which had low to low-moderate total S values (median value = 0.77%). Aged rejects have come from multiple locations (different ROM coal) and processed from different CHPPs (NCPP and SCPP).

In the fresh rejects samples about 74% (median value) of the total S is present as sulfide (Scr). Comparatively, only 45% (median value) of the total S is present as Scr in the aged rejects samples. The difference in the proportion of total S as Scr between fresh versus aged rejects is typical and expected – supporting the suggestion that the aged rejects in the TSFs and rejects dump(s) are being oxidised since deposition (sulfide oxidised to sulfate). Aged rejects may have been in place for nominally 5 to 30 years.

Just as there were notable differences between the total S concentrations in fresh versus aged rejects, so too with the ANC values of fresh versus aged rejects. Fresh (NCPP) rejects had generally moderate to very high ANC values (median 40 kg H_2SO_4/t) compared to aged rejects, which had generally low to high ANC values (median 17 kg H_2SO_4/t). The reason behind the lower ANC observed in aged rejects (compared to fresh rejects) is not well understood. However, it is likely related to ANC being consumed via buffering of acidity generated by sulfide oxidation and/or sulfate leaching. Other processes that could account for a difference in ANC between fresh and aged rejects include inherent differences in the geochemical properties of the coal from earlier mining compared to recent mining, and/or – related to ROM coal differences; and it may also be partially due to differences in processing methods between the NCPP and the SCPP.

Based on the above generally low to low-moderate total S values (and, therefore, MPA values) combined with a wide range of ANC values resulted in approximately 51% of rejects samples (all being aged rejects) being classified as PAF, PAF-LC, UC(PAF) or NAF-S – with the remaining half (approximately) classified as NAF or UC(NAF). All fresh rejects were classified as NAF. Of the 'PAF' and NAF-S tailings samples (all being aged rejects), about two-thirds were classified as UC(PAF) or PAF-LC.

The test-work undertaken has demonstrated that the ANC in fresh rejects is expected to be about 50-78% available under field conditions, compared to about 11-58% available for aged rejects. Iron-dolomite/dolomite and calcite are expected to be the main carbonate minerals contributing to the acid buffering potential of rejects.

No fresh rejects samples were significantly enriched with metals or metalloids. Three out of 13 aged rejects samples were significantly enriched with regard to S, which is consistent with ABA data for these samples. One aged rejects sample was significantly enriched with regard to Se. There was no correlation found between AMD classifications of the reject samples compared to elemental enrichment.

All fresh rejects samples (n=15) have low soluble metals concentrations and have near-neutral to alkaline pH. Approximately half of the aged rejects samples also have low soluble metals concentrations and have near-neutral to alkaline pH – the same general statistics as for the aged tailings samples. The remaining half (approximately) of aged rejects samples had varying geochemical characteristics ranging from moderately acidic to mildly alkaline with soluble metals concentrations ranging from low to elevated – with the highest soluble metals concentrations associated with acidic (low pH) conditions. Aged rejects are sourced from a variety of locations, however 62% of samples (with soluble metals data) are from Ramp 72 TSF – Kenmare pit rejects), and these aged rejects samples had a wide range of soluble metals concentrations. Almost all 'acidic' aged rejects were from Ramp 72 – Kenmare pit rejects.

Peroxide leaching undertaken on 20 aged rejects samples (19 samples from Ramp 72 TSF and 1 sample from Laleham TSF) of predominantly 'PAF' classifications showed that almost all rejects samples were weakly to highly acidic and had moderate to elevated metals concentration. The results suggest that under acid/acidic conditions, materials represented by these aged reject samples are capable of generating elevated metal and metalloid loads for several metals/metalloids, however the sulfate (and salinity) loads are not expected to be high – due to the generally low total S concentration (with some exceptions).

AMD potential of coal

Coal is not regarded as waste and ROM coal remains on-site for a relatively short period of time. However, some minor coal seams/plys will report directly as waste, and remnant coal (seams) will be exposed on the highwalls of residual voids at closure.

Coal represents about 5% of all lithological material at BWM (ie. about 2% to 7% of the highwall meterage, depending on the void). Assuming the large majority of this will report as ROM coal, we can conservatively assume that coal will represent a very small proportion of mineral waste (ie. 1-2% at the most), which will most likely report directly to spoil.

Based on the results from 370 samples, ROM coal is assessed as having a moderate potential to generate AMD as either AD, NMD and/or SD. A small proportion of coal would have a moderate to high potential to generate AMD. ROM coal, as a bulk material, is expected to generate pH-alkaline to highly alkaline contact water (run-off and seepage).

The total S concentration of coal is generally low (90th percentile total S concentration of 0.45%) and approximately 12% (median value) of the total S is present as sulfide (Scr), with the bulk of the total S likely present as organic S, which does not contribute to AMD. Coal samples have a wide range of ANC values; however, the median ANC is low (median = 11 kg H_2SO_4/t). As such, 64% of coal samples were classified as NAF or UC(NAF). One sample was classified as NAF-S. The remaining 36% (approximately) of samples were classified as PAF, PAF-LC or UC(PAF) and were from all seam groups. The AMD classification is based on total S, which for coal samples likely leads to highly conservative classification given that most sulfur in coal is organic S, not sulfidic S. These results suggest that coal stored on the ROM pad, coal located within pit walls and un-economic coal seam material reporting as spoil (mixed with non-coal spoil) would likely be bulk NAF.

Assay data for 64 coal samples show that the total metal and metalloid concentrations are generally low compared to average element abundance in soil in the earth's crust. Three coal samples were significantly enriched with regard to one or more of As and/or S, however it is not a cause of concern.

Soluble multi-element results from 64 coal samples tested indicate that contact water (run-off and seepage) from coal is expected to contain low concentrations of soluble metals and metalloids. Five 'PAF' coal samples produced weakly to moderately acidic pH with moderate to elevated soluble metals concentrations and two PAF-LC samples produced weakly to moderately acidic pH with low soluble metals concentrations. These results indicate that 'PAF' coal is capable of generating AD and/or SD/NMD.

Salinity, Sodicity and Dispersion Potential of Mineral Waste and Coal

Salinity, sodicity and dispersion potential of spoil – non-carbonaceous

Non-carbonaceous spoil samples (n=377) had cation exchange capacity (CEC) values (median = 9.6 meq/100g) and generally high exchangeable sodium percentage (ESP) values (median = 30%), resulting in almost all samples being classified as 'strongly sodic' and the few remaining samples being classified as 'sodic'. Non-carbonaceous spoil is expected to be strongly sodic with potential for dispersion (based on the high sodicity values). Emerson aggregate class testing was also carried out on 377 non-carbonaceous spoil samples to directly measure dispersion, which found that about 75% of the samples displayed 'some dispersion'. The remaining samples had Emerson aggregate class values suggesting the samples were non-dispersive.

Non-carbonaceous spoil has modest cation exchange capacity (CEC) values and generally high exchangeable sodium percentage (ESP) values, resulting in almost all samples being classified as 'strongly sodic' and the few remaining samples being classified as 'sodic' and, therefore, with potential for dispersion. Based on Emerson aggregate class testing to directly measure dispersion, about 75% of the samples displayed some degree of dispersion – consistent with the dispersion predictions from the ESP results.

Salinity, sodicity and dispersion potential of spoil – carbonaceous

Carbonaceous spoil has generally low median and 90th percentile $EC_{1:5}$ values of 336 and 519 μS/cm, respectively, and has low total S concentrations. On this basis, contact water (run-off and seepage) is expected to be similar to non-carbonaceous spoil. That is, generally non-saline to slightly saline, primarily as a result of dissolution of geogenic salts more so than from sulfide oxidation (sulfate salinity).

Carbonaceous spoil samples had comparable CEC and ESP values to non-carbonaceous spoil – with the main difference being the weathered carbonaceous samples having much lower CEC and ESP compared to the fresh carbonaceous samples. This resulted in most fresh carbonaceous samples being classified as 'strongly sodic' whereas the weathered samples were classified as 'non-sodic'. As such, and based solely on the moderate to high sodicity values, carbonaceous spoil is expected to be sodic (to some degree) with potential for dispersion. Based on Emerson aggregate class testing to directly measure dispersion, about two-thirds of the samples displayed some degree of dispersion – consistent with the dispersion predictions from the ESP results.

Salinity potential of tailings

Tailings samples (n=643) have $EC_{1:5}$ values ranging from 97 to 8900 μS/cm, with median and 90th percentile $EC_{1:5}$ values of 711 and 1512 μS/cm, respectively. There is generally little difference in $EC_{1:5}$ values between fresh and aged tailings, with both types being generally slightly to moderately saline (median = 708 μS/cm; 90th percentile = 1480 μS/cm) – and both tailings types have low-moderate total S concentrations. Therefore, tailings are generally slightly to moderately saline with a low to low-moderate potential for SD (from sulfide oxidation).

Salinity potential of rejects

Rejects samples (n=265) have $EC_{1:5}$ values ranging from 143 to 2830 μS/cm, with median and 90th percentile $EC_{1:5}$ values of 754 and 1946 μS/cm, respectively. Fresh rejects samples were all generally non-saline whereas aged rejects had $EC_{1:5}$ values ranging from non-saline to moderately saline. Most fresh rejects have low total S concentrations, whereas most aged rejects have low to low-moderate total S concentrations. Therefore, based on the total S concentration from all rejects samples, the potential for SD (from sulfide oxidation) is low to low-moderate.

Salinity potential of coal

Coal samples (n=370) have $EC_{1:5}$ values ranging from less than 50 to 722 μS/cm, with median and 90th percentile $EC_{1:5}$ values of 96 and 275 μS/cm, respectively. Coal has generally low total S concentrations. On this basis, contact water (run-off and seepage) from coal, as a bulk material, is expected to be non-saline.

Geochemical Source Hazard Assessment of Mineral Waste and Coal

A geochemical source hazard assessment was applied to the source material types comprising carbonaceous and non-carbonaceous spoil, tailings, rejects and coal (where relevant). The source hazard score is a formula that takes into account the propensity to generate AMD, the AMD capacity (severity) and the quantity (volume) of material that could produce AMD. The AMD source hazard scores are as follows:

- Spoil – non-carbonaceous: AMD source hazard score = **Low**
- Spoil – carbonaceous: AMD source hazard score = **Low-Moderate**
- Tailings: AMD source hazard score = **Moderate-High** (score ranged from Moderate-High to High depending upon the TSF facility, but was generally Moderate-High)
- Rejects: AMD source hazard score = **Moderate** (score ranged from Low-Moderate to Moderate-High depending upon the rejects facility, but was generally Moderate)
- Coal: AMD source hazard score = **Low-Moderate**

When combined, and taking into account the proportion of material that could generate AMD relative to the total proportion of all materials in a final landform (spoil or TSF or rejects landform and residual voids), the AMD hazard score for the landforms, void highwalls and void floors at closure has been determined.

Spoil landforms

There are 11 spoil landforms at GRBM that will remain at closure:

- Ramp 8
- Bonnie Doon
- Mimosa-Besgrove
- Deep Creek
- Stewarton-Ballamoo
- Kenmare
- Laleham
- Togara-North Marshmead
- South Marshmead
- Kennedy West
- Comet Downs East

Each landform will have a similar construction, comprising mined overburden and interburden disposed behind the active mining face to form a low-wall spoil dump, which will be reshaped to form a final spoil landform.

Mimosa-Besgrove, Deep Creek, Stewarton-Ballamoo, Kenmare and Togara-North Marshmead spoil landforms contain a small proportion of existing or planned future rejects (between 0.2% and 1.9%, depending on the landform). Kenmare spoil landform also comprises approximately 1% existing tailings, located at Ramp 72 in-pit TSF.

Taking into account material quantities (proportions) and expected proportion of PAF and NAF-S materials reporting to each individual landform:

- Each of the 11 spoil landforms poses a **Low** AMD hazard, with AMD generation rated as **Highly Unlikely**.

The 'Low' AMD hazard is largely a result of less than 2% of non-carbonaceous spoil samples being classified as PAF of some type (or NAF-S) – and non-carbonaceous spoil comprises the overwhelming majority of mineral waste within each spoil landform.

Regarding Kenmare spoil landform specifically, the intrinsic AMD hazard of Ramp 72 TSF/tailings and rejects located at the southern end of the existing Kenmare pit – both of which will be contained (buried) within Kenmare spoil landform – is rated **High** with the likelihood to generate AMD rated **Highly Likely** – due to AMD (as AD) having been observed from Ramp 72 TSF and from rejects within the existing Kenmare Pit. Ramp 72 TSF and the rejects disposal area at the southern end of Kenmare pit are both within the Kenmare pit (void) shell. Rejects located near Ramp 70 within Kenmare spoil landform (at the northern end of the landform) pose a **Moderate** AMD hazard, with the likelihood to generate AMD rated **Probable/Likely**.

NCPP TSF landform

NCPP TSF is a large 'turkey's nest' style TSF with confining embankments on all sides, a base footprint of approximately 200 ha and has a total volume of approximately 26 Mm^3. NCPP TSF operated from approximately 1970 to 2023.

The source materials within NCPP TSF includes tailings, which are estimated to comprise approximately 80% of the landform; and rejects, which are estimated to comprise about 19% of the landform and form the basis of most of the embankments. The TSF landform also includes a small proportion (approximately 1 %) of spoil/fill material, predominantly within embankments.

Investigative drilling coupled with near-surface sampling has demonstrated that some tailings in the field at NCPP TSF are generating AMD (as AD and SD). Oxidation fronts are present in the TSF as demonstrated by decreasing sulfide concentrations from surface down, consumption of ANC, presence of secondary minerals generated through sulfide oxidation, and acid contact pH water.

The source hazard assessment for the mineral wastes within NCPP TSF landform has utilised the same general methodology as applied to the spoil landforms and other TSF and reject landforms. The source hazard assessment has found the tailings within NCPP TSF landform poses a **High** AMD source hazard; and rejects poses a **Low-Moderate** AMD source hazard. Fill material poses a moderate AMD source hazard. On this basis, and taking into account material quantities (proportions):

- NCPP TSF landform (currently, without a rehabilitation cover) poses a **Moderate-High** AMD hazard, with AMD generation rated as **Highly Likely**, the highest landform AMD likelihood category under the applied scoring procedure – noting that AMD has already been observed at/from this TSF. The AMD hazard is considered to predominantly lie with the tailings, and lesser so the rejects.

The AMD hazard score for the tailings and rejects materials is considered to be conservative and the landform domain AMD hazard score for NCPP TSF is also considered to be conservative.

Laleham TSF landform

Laleham TSF is largely constructed over spoil/fill (and also backfills a small pit). The TSF partly fills the upper reaches of a southeasterly plunging gully. The TSF abuts natural ground on the north and northwest, and overlies spoil/fill on the south and southeast. The TSF has a total area of approximately 12 ha and a total volume of approximately 4 Mm^3. The TSF operated from the late-1970s to the late-1980s, primarily receiving tailings from Laleham underground operation. Between 1990 and 1994 a thin spoil/soil cap was placed over the TSF and seeded/revegetated. This TSF has undergone rehabilitation and revegetation since decommissioning, however additional rehabilitation is assumed to be required prior to closure.

The source materials within Laleham TSF includes tailings, which are estimated to comprise approximately 90% of the landform; and rejects, which are estimated to comprise about 4% of the landform. The TSF embankments (main embankment and upper embankment) are predominantly constructed from spoil and fill material, which comprise about 6% of the TSF.

Investigative drilling has demonstrated that tailings in the field at Laleham TSF are generating AMD (as AD and SD). Oxidation fronts are present in the TSF as demonstrated by decreasing sulfide concentrations from surface down, consumption of ANC, presence of secondary minerals generated through sulfide oxidation, and acid contact pH water.

The source hazard assessment for the mineral wastes within Laleham TSF landform has utilised the same general methodology as applied to the spoil landforms and other TSF and reject landforms. The source hazard assessment has found the tailings within Laleham TSF landform poses a **Moderate-High** AMD source hazard; and rejects pose a **Moderate** AMD source hazard. Fill material poses a low-moderate AMD source hazard. Evidence of AMD (as AD) is present from over 25% of the tailings samples collected from within the TSF. On this basis, and taking into account material quantities (proportions):

- Laleham TSF landform (currently, without a final rehabilitation cover[1]) poses a **Moderate-High** AMD hazard, with AMD generation rated as **Probable/Likely**. The AMD hazard is considered to predominantly lie with the tailings, and lesser so the rejects.

The AMD hazard score for the tailings and rejects materials is considered to be conservative and the landform domain AMD hazard score for Laleham TSF is also considered to be conservative.

Bottom Dam TSF and rejects landform

Bottom Dam TSF is a small historic tailings dam south of ROM 3 near the SCPP in the southern area of BWM. Adjacent to the TSF, and in the general vicinity of the TSF (including on ROM 3), are rejects dumps. ROM 3 is an elevated natural ground area northwest of Bottom Dam TSF and situated approximately 37 m above (higher than) the TSF.

The TSF (specifically) occupies an area of approximately 1.6 ha (with an estimated total volume of approximately 0.2 Mm^3). The overall Bottom Dam TSF/rejects area is approximately 10 ha, with an overall tailings/rejects volume estimated at less than 1 Mm^3 (indicatively 0.6 to 0.8 Mm^3), based on preliminary investigations. Environmental and engineering investigations of this area are underway to support rehabilitation and closure planning and, as such, no geochemical data specifically from Bottom Dam was available for this waste characterisation assessment. The final landform of the greater Bottom Dam area is also to be determined, subject to the outcome of the engineering and environmental investigation programs.

Tailings and rejects in Bottom Dam TSF/rejects were generated from the SCPP and are reasonably assumed to have environmental geochemical characteristics comparable to tailings and rejects located within Ramp 72 TSF and Kenmare pit (and also potentially Laleham TSF). Tailings and rejects in the Bottom Dam area are estimated to be in approximately equal proportions.

1 Laleham TSF currently has a spoil cover, however additional rehabilitation is expected to be required to meet post-closure rehabilitation criteria. As such, the AMD hazard assessment of Laleham TSF takes into consideration the existing cover material, however considers the facility to be 'unrehabilitated'.

As such, and until a detailed geochemical assessment is undertaken, Bottom Dam area (comprising TSF and rejects) is conservatively assumed to pose a **Moderate-High** AMD hazard, with AMD generation rated as **Probable/Likely**. This is based on tailings posing a moderate-high to high AMD source hazard and rejects posing a moderate to moderate-high AMD source hazard – as per the AMD source hazard for tailings and rejects located within Laleham TSF (tailings) and Ramp 72 TSF [Kenmare pit] (tailings and rejects).

The assumed (preliminary) AMD hazard score for the tailings and rejects materials in Bottom Dam area is considered to be conservative and the landform domain AMD hazard score for Bottom Dam area (TSF and rejects combined) is also considered to be conservative.

Ramp 36 rejects landform

Ramp 36 rejects dump will remain as a 'stand-alone' rejects landform at closure. The dump is located approximately one km south of the NCPP and about 350 m southeast of NCPP TSF. The dump occupies an area of approximately 60 ha with a total estimated volume of approximately 10 Mm^3. The dump operated from approximately 1967 (start of mining at BWM) intermittently through until 2007. During this time, rejects have been taken (quarried) from the dump for use elsewhere on site – primarily for construction of the NCPP TSF embankments.

Ramp 36 rejects dump essentially comprises only rejects (approximately 99% by volume). A small amount of 'fill' (assume spoil) is also present and has been conservatively estimated to comprise about 1% of the landform.

The source hazard assessment for the mineral wastes within the rejects dump has utilised the same general methodology as applied to the spoil and TSF landforms. The source hazard assessment has found the rejects within the dump poses a **Moderate** AMD source hazard. Fill material has been assessed as posing a low AMD source hazard. Taking into account material quantities (proportions):

- Ramp 36 rejects dump (currently, without a rehabilitation cover) poses a **Moderate** AMD hazard, with AMD generation rated as **Probable/Likely**. The AMD hazard lies with the rejects, which comprise essentially all of the dump.

The AMD hazard score for the rejects materials is considered to be conservative and the landform domain AMD hazard score for the rejects dump is also considered to be conservative.

Residual voids

There are 11 pit groups at GRBM that will remain at closure as residual voids, corresponding to the spoil landforms as previously identified:

- Ramp 8 void
- Bonnie Doon void
- Mimosa-Besgrove void
- Deep Creek void
- Stewarton-Ballamoo void
- Kenmare void
- Laleham void
- Togara-North Marshmead void
- South Marshmead void
- Kennedy West void
- Comet Downs East void

Excluding the Bonnie Doon and Laleham residual voids that have tailings on the pit/void floor, the floor of all residual voids at closure will be the P & L Lower seam group, which is currently the floor of most/all existing pits.

Environmental geochemical data, coal quality data and drill-hole geological logs have been used to aid in the assessment of AMD risk associated with residual void highwalls and floors.

The highwall hazard assessment has found that approximately 4% to 7% of the void highwall in all voids is estimated to be PAF, which includes material classified as UC(PAF), PAF-LC and NAF-S. As such, the assessment has found that the likelihood of AMD generation from the void highwalls is **Unlikely**, and any expression of AMD from the highwall is likely to be localised.

Excluding Bonnie Doon and Laleham voids, the floor of all residual voids will be the P & L (lower) seam. Assuming the floor of each of these voids is coal – which is a highly conservative assumption – the void floor AMD hazard assessment has found that approximately 25% of the floor of these voids where coal is exposed is estimated to be 'PAF', which includes material classified as PAF, UC(PAF), PAF-LC and NAF-S. As such, the conservative assessment has found that the likelihood of AMD generation from the floor of these voids where coal is exposed is **Unlikely**. Should these coal floors become submerged by groundwater (post-closure), the likelihood for AMD generation from the floor of these voids would be lower. In practice, mining takes all coal to the bottom the seam, therefore very little coal would be expected to remain on the floor of these voids.

Bonnie Doon and Laleham voids have tailings as the void floor and the source hazard assessment – based on the AMD hazard posed by tailings – has found that approximately 48% of the floor of Bonnie Doon void and 56% of the floor of Laleham void is estimated to be 'PAF' [tailings], which includes tailings classified as PAF, PAF-LC, UC(PAF) and/or NAF-S. AMD generation from the floor of these TSF voids is **Probable/Likely**. The tailings within these voids will be capped/covered at end of mining and no tailings will be exposed post-closure. As such, the likelihood for AMD generation from the floor of these voids post-closure would be lower. Should these tailings floors become submerged by groundwater (post-closure), the likelihood for AMD generation from the tailings floor of these voids would be lower.

Geochemical Source-Pathway-Receptor (SPR) Assessment

The source-pathway-receptor (SPR) assessment includes the likelihood of the event occurring (eg. the likelihood of AMD impacting a local creek), the severity of the event (should it occur) and the calculated risk rating (likelihood times severity). A risk rating was calculated for each spoil landform, each TSF landform, Ramp 36 rejects landform, and each residual void with respect to plausible surface water and groundwater receptors.

Conceptual site model and conceptual facility models

A post-mining conceptual site model (CSM), which applies generically to the spoil landforms and their respective residual voids at BWM, and the relationship these facilities have with surface water and groundwater in the district, has been produced by SLR Consultants (2024).

The CSM assists with the SPR assessment with regard to potential environmental geochemical impacts from mineral waste facilities. A key element of the CSM based on the SLR (2024) hydrogeological assessment (which included groundwater modelling with particle tracking) was that the residual voids at BWM will be groundwater 'sinks' for all areas except Bottom Dam area (ie. excluding Bottom Dam area, groundwater at BWM will flow into/towards the residual voids, and the voids will be the receptors of seepage from all BWM facilities). The groundwater model identified a hydrogeological connection between groundwater in the vicinity of Bottom Dam area and the weathered alluvial strata within Sirius Creek approximately 750 m south of Bottom Dam area.

A conceptual facility model (CFM) has been developed for each TSF and for Ramp 36 rejects dump to illustrate potential run-off and seepage pathways and surface water and groundwater receptors associated with these key mineral waste facilities.

Plausible pathways and receptors

Note: the assessment of shallow groundwater at BWM – particularly where shallow permeable strata may be not present in some areas, discontinuous and/or not interconnected – is limited by/to the distribution of the shallow bore network, which is sporadic. Therefore, despite the apparent low likelihood of substantial connection between shallow permeable strata and surface water features, the SPR assessment has adopted a highly conservative approach and assumed a plausible pathway may exist between shallow permeable strata and surface water features. All creeks at BWM are ephemeral. The surface water features (creeks) at BWM that are plausible receptors of run-off and/or seepage are:

- Bonnie Doon Creek west of Ramp 8 and Bonnie Doon spoil landforms, flowing north;
- Burngrove Creek and tributaries west of Mimosa-Besgrove spoil landform, flowing north;
- Deep Creek, flows west to east across the site between Mimosa-Besgrove and Deep Creek spoil landforms;
- Taurus Creek, flows west to east across the site between Deep Creek and Stewarton-Ballmoo spoil landforms;
- Emu Creek and its' un-named tributaries, a collective of tributaries located west of Stewarton-Ballmoo spoil landform, which flow north into Taurus Creek;
- Sirius Creek, flows generally east to west across the site between Laleham void and Togara-North Marshmead spoil landform. All of the minor un-named creeks on both sides of BWM between the southern end of Stewarton-Ballamoo spoil landform and Laleham void drain into Sirius Creek; and
- Rockland Creek, flows east to west across the site between Togara-North Marshmead and South Marshmead spoil landforms, and northeast to southwest between Comet Downs East and Kennedy West spoil landforms.

With regard to the spoil landforms, the plausible mechanisms for AMD affected water and/or non-oxidative salinity, if any, to report to receptors are:

- Surface water run-off from spoil landforms into nearby creeks;
- Seepage from spoil landforms via shallow permeable strata into nearby creeks;
- Seepage from spoil landforms into the residual voids; and
- Surface water run-off and seepage from void highwalls into residual voids.

With regard to the TSF and rejects landforms, the plausible mechanisms for AMD affected water and/or non-oxidative salinity, if any, to report to receptors are:

- Surface water run-off from TSF or rejects landforms into nearby creeks;
- Seepage from TSF or rejects landforms via shallow permeable strata into nearby creeks; and
- Seepage from TSF or rejects landforms via groundwater into residual voids – excluding Bottom Dam TSF/rejects area, whereby seepage into groundwater reports to Sirius Creek.

The SPR has conservatively assumed that shallow permeable strata are a plausible pathway linking a potential AMD source to deeper groundwater via downwards migration and linking a potential AMD source to nearby creeks via lateral migration. However, shallow permeable strata are assumed to be an implausible final receptor of run-off and seepage from final landforms and final voids. That is, the assumption based on information available is that AMD (source) entering shallow permeable strata (however (un)likely) will ultimately find its' way into deeper groundwater [residual voids] and/or local surface water features.

SPR risk rating of rehabilitated spoil landforms

There are plausible surface water and residual void receptors associated with final spoil landforms; and the run-off and seepage pathways linking the sources (final spoil landforms) to these receptors have been identified. With respect to AMD, the overall SPR risk rating from final spoil landforms is **Low**. With respect to non-oxidative salinity the overall SPR risk from final spoil landforms is also rated as **Low**.

Where landforms contain buried tailings and/or rejects, and especially if those buried tailings/rejects are located close to the edge of the landform and/or close to a creek, the risk rating with respect to AMD potentially making its way via shallow permeable strata into surface water features close to the buried tailings/rejects was rated as **Low to Medium**. This applies to Kenmare spoil landform (containing Ramp 72 tailings and Kenmare pit rejects) and Mimosa-Besgrove spoil landform (containing Deep Creek [Ramp 32] rejects dump).

SPR risk rating of rehabilitated NCPP TSF landform

There are plausible surface water and residual void receptors; and the run-off [and shallow seepage] pathways linking the source (NCPP TSF final landform) to these receptors have been identified. Groundwater modelling (SLR, 2024) shows that seepage from NCPP TSF landform would report to Deep Creek residual void. With respect to AMD, the overall SPR risk rating from the post-closure TSF final landform is **Low to Medium**. The 'Medium' risk rating applies to AD and SD associated with seepage via shallow permeable strata. With respect to non-oxidative salinity the overall SPR risk from NCPP TSF final landform is rated as **Low**.

SPR risk rating of rehabilitated Laleham TSF landform

There are plausible surface water and residual void receptors; and the run-off and shallow seepage pathways linking the source (Laleham TSF final landform) to these receptors have been identified. Groundwater modelling (SLR, 2024) shows that seepage from Laleham TSF landform would ultimately report to Togara-North Marshmead residual void. With respect to AMD, the overall SPR risk rating from the post-closure TSF final landform is **Low**. With respect to non-oxidative salinity the overall SPR risk from Laleham TSF final landform is also rated as **Low**.

SPR risk rating of rehabilitated Bottom Dam TSF and rejects landform

There are plausible surface water receptors; and the run-off and seepage pathways linking the source (Bottom Dam TSF/rejects final landform) to these receptors (Sirius Creek) have been identified. Groundwater modelling (SLR, 2024) shows that seepage from Bottom Dam TSF/rejects area would report to Sirius Creek. With respect to AMD, the overall SPR risk rating from the post-closure Bottom Dam final landform is **Low**. With respect to non-oxidative salinity the overall SPR risk from the post-closure Bottom Dam final landform is also rated as **Low**.

SPR risk rating of rehabilitated Ramp 36 rejects landform

There are plausible surface water and residual void receptors; and the run-off and shallow seepage pathways linking the source (Ramp 36 rejects final landform) to these receptors (Deep Creek) have been identified. Groundwater modelling (SLR, 2024) shows that seepage from Ramp 36 rejects landform would report to Deep Creek residual void. With respect to AMD, the overall SPR risk rating from the post-closure rejects final landform is **Low to Medium**. The 'Medium' risk rating applies to AD and SD associated with seepage via shallow permeable strata. With respect to non-oxidative salinity the overall SPR risk from the post-closure rejects final landform is also rated as **Low**.

SPR risk rating of residual voids

Modelling undertaken by SLR (2024) shows the final voids to be 'sinks' – receiving surface water run-off and seepage from spoil landforms and surface water run-off from void highwalls. Each residual void is expected to receive inflow from the Permian groundwater aquifer.

The AMD assessment has found that it's unlikely that undiluted salinity or AMD from a flooded post-closure residual void floor (including covered tailings) would impact on residual void water quality to any significant degree, as other processes such as evapoconcentration are the key drivers of void lake water quality. Therefore, the AMD SPR risk rating on the overall water quality of the residual voids is **Low to Low-Medium**. A "Low to Medium" risk rating has been conservatively applied to the risk of AD and/or NMD/SD due to the AMD risk associated with tailings within Bonnie Doon and Laleham voids.

Water reporting to residual voids is expected to remain within the residual voids (excluding evaporative loss). Modelling undertaken by SLR (2024) shows that seepage from the void lake (of each void) into groundwater, if any, would be limited.

Management and Rehabilitation Measures

The assessment has found that the environmental risks posed by spoil landforms likely to be present at closure are generally low. As such – for most spoil landforms – no specific AMD management measures (eg. alkaline amendment or engineered capping systems) are expected to be required to manage mineral wastes during rehabilitation and closure – outside of operational mixing/burial of PAF waste amongst NAF waste, spoil placement and landform reshaping activities already proposed (refer below and to the main volume of the PRCP).

The AMD source hazard associated with Ramp 72 tailings and Kenmare pit rejects buried within Kenmare landform is high and, as such, rehabilitation of tailings and rejects within Kenmare ramp/pit will require specific AMD management measures – and the assessment program currently underway at Kenmare Pit will address the rehabilitation requirements of these facilities. Once rehabilitated, the post-closure environmental risk posed by Kenmare spoil landform is expected to decrease.

The landform domain AMD hazard posed by NCPP TSF, Laleham TSF and Bottom Dam TSF is moderate-high to high; and for Ramp 36 Rejects dump is moderate. These stand-alone landforms will require specific AMD management measures to manage these facilities post-closure.

The AMD hazard posed by tailings in Bonnie Doon in-pit TSF and Ramp 74 (Laleham) in-pit TSF is moderate-high and, as such, in-pit tailings will also require specific AMD management measures to manage these voids post-closure.

Decommissioning and rehabilitation activities related to mineral waste will be addressed as part of the milestone criteria for infrastructure, remediation of contaminated land, landform design, surface preparation and revegetation, where necessary.

Proposed mineral waste management and rehabilitation activities of relevance to this waste characterisation report comprise the following actions. Refer to the main volume of the PRCP and Henderson Geotech (2024) for detailed information.

- Pits: will remain as residual voids under 11 groups:
    - Ramp 8 void
    - Bonnie Doon void (in-pit TSF)
    - Mimosa-Besgrove void
    - Deep Creek void
    - Stewarton-Ballamoo void
    - Kenmare void
    - Laleham void (in-pit TSF)
    - Togara-North Marshmead void
    - South Marshmead void
    - Kennedy West void
    - Comet Downs East void
- Spoil dumps: will be reshaped into 11 final spoil landforms (as related to their respective voids listed above) and seeded.
- Bonnie Doon in-pit TSF will be covered by a spoil and water cover (hybrid cover). The optimal type and thickness of cover to manage the AMD hazard of Bonnie Doon in-pit TSF (tailings) will be determined following further assessment prior to covering.
- Laleham (Ramp 74) in-pit TSF will be covered by a spoil and water cover (hybrid cover). The optimal design and thickness of cover to manage the AMD hazard of Ramp 74 in-pit TSF (tailings) will be determined following further assessment prior to covering.
- NCPP TSF (out-of-pit; above ground; stand-alone) will be covered by an engineered spoil cover. The optimal design and thickness of spoil cover to manage the AMD hazard of the out-of-pit NCPP TSF will be determined following further assessment prior to covering.
- Laleham TSF (in-pit; above ground; stand-alone) will be covered by spoil. The optimal design and thickness of spoil cover to manage the AMD hazard of the TSF will be determined following further assessment prior to covering.
- Ramp 72 in-pit TSF will be covered by spoil within Kenmare spoil landform. The optimal design and thickness of spoil cover to manage the AMD hazard of the in-pit TSF will be determined following further assessment prior to covering.
- Bottom Dam TSF/rejects (out-of-pit; above ground; stand-alone). Rejects currently on ROM 3 will be relocated onto Bottom Dam TSF forming a rejects cap, which will then be covered by a spoil cover. The optimal design and thickness of spoil cover to manage the AMD hazard of Bottom Dam TSF/rejects area will be determined following further assessment prior to covering.
- Kenmare in-pit rejects will be covered by spoil within Kenmare spoil landform. The optimal design and thickness of spoil cover to manage the AMD hazard of these in-pit rejects will be determined following further assessment prior to covering.
- Ramp 36 rejects (above ground; stand-alone) will be covered by a spoil cover. The optimal design and thickness of spoil cover to manage the AMD hazard of the rejects dump will be determined following further assessment prior to covering.
- All other rejects (in-spoil disposal): Managed during operations (disposed within spoil) and progressively covered by spoil. No additional remediation for the rejects (at closure) is required. The

optimal thickness of spoil cover to manage the AMD hazard of rejects will be determined following further assessment prior to covering.

- ROM pads: Remove remnant coal from ROM pads and dispose within spoil. All former ROM pads will be reshaped, covered with soil, ripped and seeded.
- Coal stockpiles: Remove remnant coal from coal stockpile pads and dispose within spoil. Cover with suitable soil material, rip and seed.

BLACKWATER MINE

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GLOSSARY of TERMS

Acid	A measure of hydrogen ion (H^+) concentration in water; generally expressed as pH.
Acidity	A measure of hydrogen concentration and latent acidity generated by metal hydroxylation, expressed as mg/L.
Acid-Base Account (ABA)	Evaluation of the balance between acid generation and acid neutralisation processes. Generally determined by the maximum potential acidity (MPA) and the inherent acid neutralising capacity (ANC), as defined below. See also ANC and MPA.
AMD	Acid and metalliferous drainage. AMD has three components: acid drainage (AD), pH-neutral and metalliferous drainage (NMD) and/or sulfide-derived saline drainage (SD) – and/or any combination of these, all generated by sulfide oxidation processes +/- neutralisation reactions.
ANC	Acid neutralising capacity, expressed as kg H_2SO_4 per tonne of rock/material. A measure of a sample's maximum potential ability to neutralise acid.
ANC/MPA ratio	Ratio of the acid neutralising capacity (ANC) to the maximum potential acidity (MPA) of a sample. Used to assess the risk of a sample generating acid conditions. See also ANC and MPA.
BWM	Blackwater mine. The name of the site subject to this PRCP.
CFM	Conceptual facility model.
CHPP	Coal handling and preparation plant. BWM has three CHPPs: the current (operational) CHPP, called NCPP, which is located near the BWM industrial area; a small thermal coal plant called TCP; and a disused (historic) CHPP called SCPP, which is located at the southern part of BWM [in the area referred to as South BWM].
Co-Disposal	The practice of disposing different waste types together. For example, disposing processed shale and waste rock together.
CSM	Conceptual site model.
EC	Electrical conductivity, expressed as μS/cm.
Interburden	Potential spoil material located between mined coal seams. See also Overburden, Mineral waste and Spoil.
Kinetic test	Procedure used to measure the geochemical/weathering behaviour of a sample of mine material over time.
Mineral waste	Material comprising mine spoil, ± coarse/fine reject, ± waste coal. Sometimes called 'mine waste' or 'mining waste'.
MPA	Maximum potential acidity. Calculated by multiplying the total sulfur (S) or sulfide-sulfur (Scr) content of a sample by 30.6 (stoichiometric factor) and expressed as kg H_2SO_4 per tonne of rock/material.
NAF	Non-acid forming. Geochemical classification criterion for a sample that would not generate acid conditions. A sample classified as NAF may, or may not, have a significant sulfur content but the availability of neutralising material within the sample is more than adequate to neutralise all the acid that theoretically could be produced by any contained sulfide minerals. As such, material classified as NAF is considered unlikely to be a source of acid(ic) drainage, however NAF material may still develop NMD and/or SD, depending on sulfur concentration.

NAG	Net acid generating test. A pulp sample is reacted with hydrogen peroxide to encourage rapid oxidation. Any acid generated through oxidation may be consumed by neutralising components in the sample. Any remaining acidity (after neutralising material is consumed) is measured and expressed as kg H_2SO_4/t. At the conclusion of the NAG test the resulting liquor is called peroxide (NAG) leachate, and can be analysed for various parameters, such as soluble metals.
NAPP	Net acid producing potential, expressed as kg H_2SO_4 per tonne of rock/material. Calculated by subtracting the ANC from the MPA.
NCPP	North coal handling and preparation plant; the current (operational) CHPP located near the BWM industrial area.
NMD	Neutral and metalliferous drainage. A component of AMD, NMD occurs where drainage is pH-neutral or higher yet contains elevated trace metals and metalloids in solution.
Org S	Organic sulfur.
Overburden	Mineral (mining) waste located above (overburden proper) or between (interburden) coal seams and reports to spoil dumps. Typically comprises non-coaly and non-carbonaceous material, such as sandstone, siltstone and claystone/mudstone, but also includes a small percentage of carbonaceous material (eg. carbonaceous siltstone) and sub-economic waste coal.
OxCon	Oxygen consumption test. A type of kinetic (dynamic) test for estimating the sulfide oxidation rates, acidity generation rates and carbonate neutralisation rates for sulfidic geological materials.
PAF	Potentially acid forming. Geochemical classification criterion for a sample that has the potential to generate acid conditions. A sample classified as PAF has an acid generating potential (MPA) that exceeds the inherent acid neutralising capacity (ANC) of the material. This means that such a material is likely to generate acidic drainage (AD) if exposed to atmospheric conditions. See also PAF-LC.
PAF-LC	Potentially acid forming (low capacity). Geochemical classification criterion for a sample that has the potential to generate relatively low-level AD.
PRCP	Progressive rehabilitation and closure plan.
Product coal	Coal produced from the CHPP after being washed/processed. Coal that is ready for sale.
Rejects	Coarse sand to coarse gravel-sized rock material produced during coal processing. Rejects are typically associated with the roof, floor and partings of coal seams and are separated from ROM coal in the CHPP. Contemporary rejects produced at BWM are disposed within spoil dumps in the general vicinity of the NCPP. Historic rejects have been disposed into rejects dumps (stockpiles) and within disused pits. Rejects have also been used in construction activities, such as TSF embankments and used for capping/construction of pads.
Rejects dump	Out-of-pit landform containing rejects.
Residual void	The term given to an open-pit after mining has ceased and any rehabilitation of the pit has been undertaken (ie. post-closure).
ROM	Run-of-mine. The term given to mined coal before being processed at the CHPP.
ROM pad	Location where ROM ore is temporarily stored pending processing at the CHPP.

S	Sulfur.
SCPP	South coal handling and preparation plant; a disused (historic) CHPP located at the southern part of BWM [in the area referred to as South BWM].
Scr	Chromium reducible sulfur. Analytical procedure to determine the sulfide-sulfur concentration in a sample. This typically represents the proportion of sulfur associated with sulfide (reactive) minerals.
SD	Saline drainage. A component of AMD, SD occurs where drainage is saline due to elevated sulfate as a result of sulfide oxidation and neutralisation reactions.
SO_4	Sulfate.
Spoil	Rock material overlying and between 'target' coal seams, which will report as waste. Waste rock overlying a coal seam is called overburden. Waste rock between mined coal seams is called interburden. See also Overburden and Interburden.
Spoil dump	In-pit or out-of-pit landform containing mineral waste.
SPR	Source-pathway-receptor.
Static test	Procedure for characterising the geochemical nature of a sample at one point in time. Static tests may include measurements of mineral and chemical composition of a sample and the Acid-Base Account.
Tailings	Very fine to medium grained sand, silt and clay-sized material, which is commonly coaly and carbonaceous, produced during coal washing. Tailings are associated with coal seams and are separated from ROM coal in the CHPP. Tailings produced at BWM are disposed within Tailings Storage Facilities (TSFs – also called tailings dams).
TCP	Thermal coal plant.
TSF	Tailings storage facility. A dam or pit used to dispose tailings. At BWM, tailings have been disposed into several above-ground and in-pit TSFs – the current (operational) TSF being Bonnie Doon in-pit TSF.
Uncertain	In the context of classifying a material (sample) as NAF or PAF. An 'Uncertain' (UC) classification applies when there is an apparent conflict in results such that neither NAF nor PAF classification can be given, or there is insufficient information to unequivocally classify as NAF or PAF. UC samples are given a tentative sub-classification as UC(NAF) or UC(PAF), where preliminary data suggests the sample may be NAF or PAF, respectively.
Waste ore	Sub-economical coal that reports directly to the spoil dumps as waste (ie. not ROM coal). Waste coal can be fresh or weathered (oxidised). All weathered/oxidised and coked (cindered) coal is waste.
Water extract	A method to determine the water-soluble parameters in soil. Solid samples undergo a bottle leach method where 10 g of pulped solid (100% passing 212 μm) is combined with 50 grams of de-ionised water (leaching fluid) into a glass bottle. Depending on the type of leaching undertaken the leaching fluid may be deionised water (DI water extract) or saline water (saline water extract). The 1:5 solution (1 part solid to 5 parts water) is tumbled end-over-end for one hour. Solutes are leached from the soil by the continuous suspension and agitation. The water extract solution is measured for pH and electrical conductivity (EC) prior to filtering for solute analysis (eg. metals/metalloids and major ions).

1 Introduction and Context

This report serves to document and discuss the environmental geochemical characteristics of mineral waste materials associated with Blackwater Mine (BWM), as defined under the current Environmental Authority (EA) EPML00717813. BWM is operated by Whitehaven Blackwater Pty Ltd. In this report the term 'mineral waste' refers to all geologic material generated by or associated with BWM during the course of mining, handling and processing coal.

It is a requirement of a Progressive Rehabilitation and Closure Plan (PRCP) that mineral waste is adequately characterised such that appropriate rehabilitation strategies can be selected and implemented. The PRCP guidance document: "*Guideline - Progressive Rehabilitation and Closure Plans*" (DES, 2023) outlines the requirements and considerations for producing a PRCP, including documenting the relevant aspects of mineral waste characterisation for the purposes of PRCPs.

1.1 Approach

The general approach to mineral waste characterisation and assessment includes the following key steps:

- Briefly describe the current/existing background information for BWM of relevance to the generation and ultimate storage/disposal of mineral waste materials;
- Document the methodology used to characterise mineral waste materials (samples);
- Present and discuss the geochemical results;
- Describe the potential environmental geochemical hazards with respect to mineral waste materials;
- Present the conceptual site model (CSM), which illustrates the relationship between AMD and salinity sources, potential environmental and human health receptors and plausible pathways between the AMD and salinity sources and the receptors (Source-Pathway-Receptor [SPR]) at closure;
- Present the acid and metalliferous drainage (AMD) and salinity SPR risk assessment undertaken on the mineral waste materials;
- Outline the AMD specific management and rehabilitation measures proposed for mineral waste materials; and
- Outline a forward work plan to address any gaps identified from the assessment.

1.2 Objective

The objective of the assessment is to evaluate the geochemical nature of mineral waste currently at BWM and mineral waste likely to be present at closure, and identify relevant environmental issues/opportunities that may be associated with mining, handling and storing mineral waste to inform appropriate rehabilitation and management strategies.

2 Background

2.1 Site Overview

BWM is located within the Bowen Basin in Central Queensland. The administration and industrial areas are located approximately 75 kilometres (km) southeast of Emerald township. The northern end of the mine at Bonnie Doon Pit is about 5 km southwest of Blackwater township. BWM is flanked on the east, west and south by pastoral leases; and bounded to the north by the Capricorn Highway. BWM is a very large mine with a strike length of approximately 65 km and is informally divided into two mining areas: north and south, based on historical ownership. The northern area of BWM is the current mining area - from Bonnie Doon Pit south to Blackdown Pit. The southern area includes existing (currently inactive) pits from Ballamoo South Pit (also known as Terang Pit) southwards to North Marshmead Pit, plus proposed pit areas at South Marshmead, Kennedy West and Comet Downs East.

BWM commenced operations in 1967 and comprises typical open-pit coal mining facilities, such as open pits, waste rock (spoil) dumps, tailings storage facilities (TSFs), rejects dumps, coal stockpiles, coal processing facilities, rail loadout facilities, process water and raw water dams, surface water drains and administration areas. There are also closed/inactive underground workings in the southern area of BWM. The key facilities and natural features at BWM of relevance to this waste characterisation report are shown on **Figure 1** (northern part of the mine) and **Figure 2** (southern part of the mine). [Also shown on Figures 1 and 2 are geochemical sampling locations and the locations of geological sections along and across each existing pit group and proposed new pit groups].

Current activities of relevance to this waste characterisation report comprise:

- Disposal of spoil to in-pit spoil dumps behind the active mining face (in-pit low-wall spoil disposal);
- Run-of-mine (ROM) coal processing at the north coal handling and preparation plant (NCPP), which produces two mineral waste types:
- Tailings. Clay, silt and very fine to medium-grain sized sand material; disposed as a slurry.
- Rejects. Coarse sand to cobble-sized material.
- Thermal ROM coal processing at the thermal coal plant (TCP), which produces a small amount of rejects.
- Disposal of tailings from NCPP to Bonnie Doon Pit (Ramp 12 in-pit TSF); [active since late 2023];
- Disposal of rejects from NCPP and TCP to spoil dumps; Rejects from NCPP have been used in construction of TSF embankments and infrastructure pads;
- Short-term storage of ROM coal on the ROM Pad and product coal on the product coal stockpile.

Historic activities of relevance to this waste characterisation report comprise:

- Disposal of tailings from NCPP to the above-ground NCPP TSF; [inactive since late 2023];
- Disposal of rejects from NCPP and TCP to rejects dumps (primarily Ramp 36 and TCP rejects dump);
- ROM coal processing at the south coal handling and preparation plant (SCPP), which produced tailings and rejects similar to NCPP. The SCPP received ROM coal from open cut and underground

mining operations in the southern BWM area (what was then called South BWM). SCPP has been inactive since the early 2000s.

- Disposal of tailings from SCPP to the above-ground Laleham TSF, two in-pit TSFs (Kenmare Pit - Ramp 72 TSF; and Laleham Pit - Ramp 74 TSF) and Bottom Dam TSF (gully southeast of the SCPP ROM 3 pad). Tailings from NCPP were also disposed into Ramp 74 TSF;
- Disposal (rehandling) of mixed 'aged' tailings and rejects (originally from SCPP) into the southern end of Kenmare Pit (Ramp 72 Pit);
- Disposal of rejects from SCPP onto ROM Pad 3 and into Bottom Dam area adjacent to Bottom Dam TSF.

An overview of the proposed mineral waste management and rehabilitation activities of relevance to this waste characterisation report are outlined in **Section 8**. Refer to the main volume of the PRCP for detailed information.

Figure 1. Project layout, geochemical sample locations and locations of geological sections for the northern BWM area

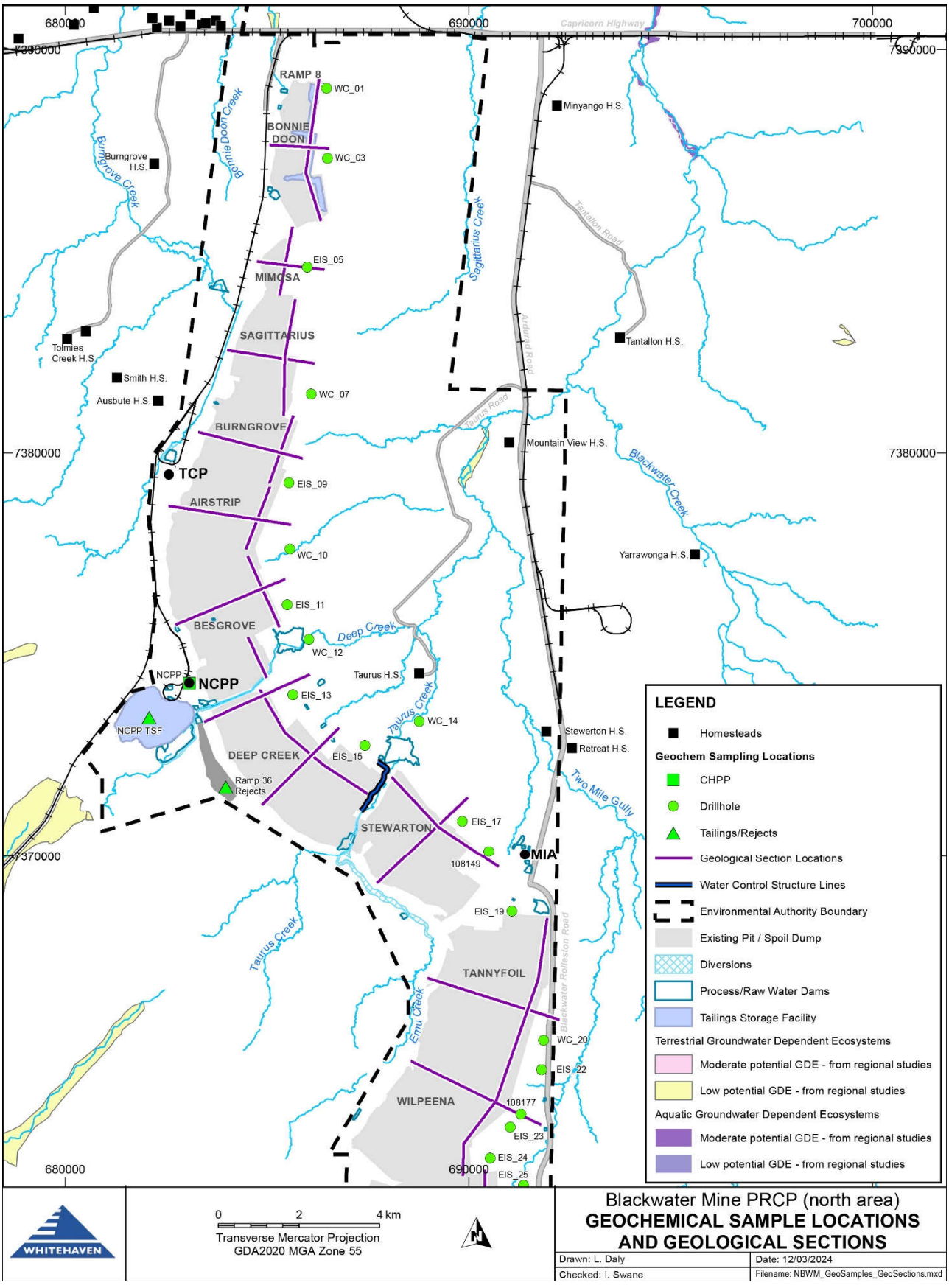
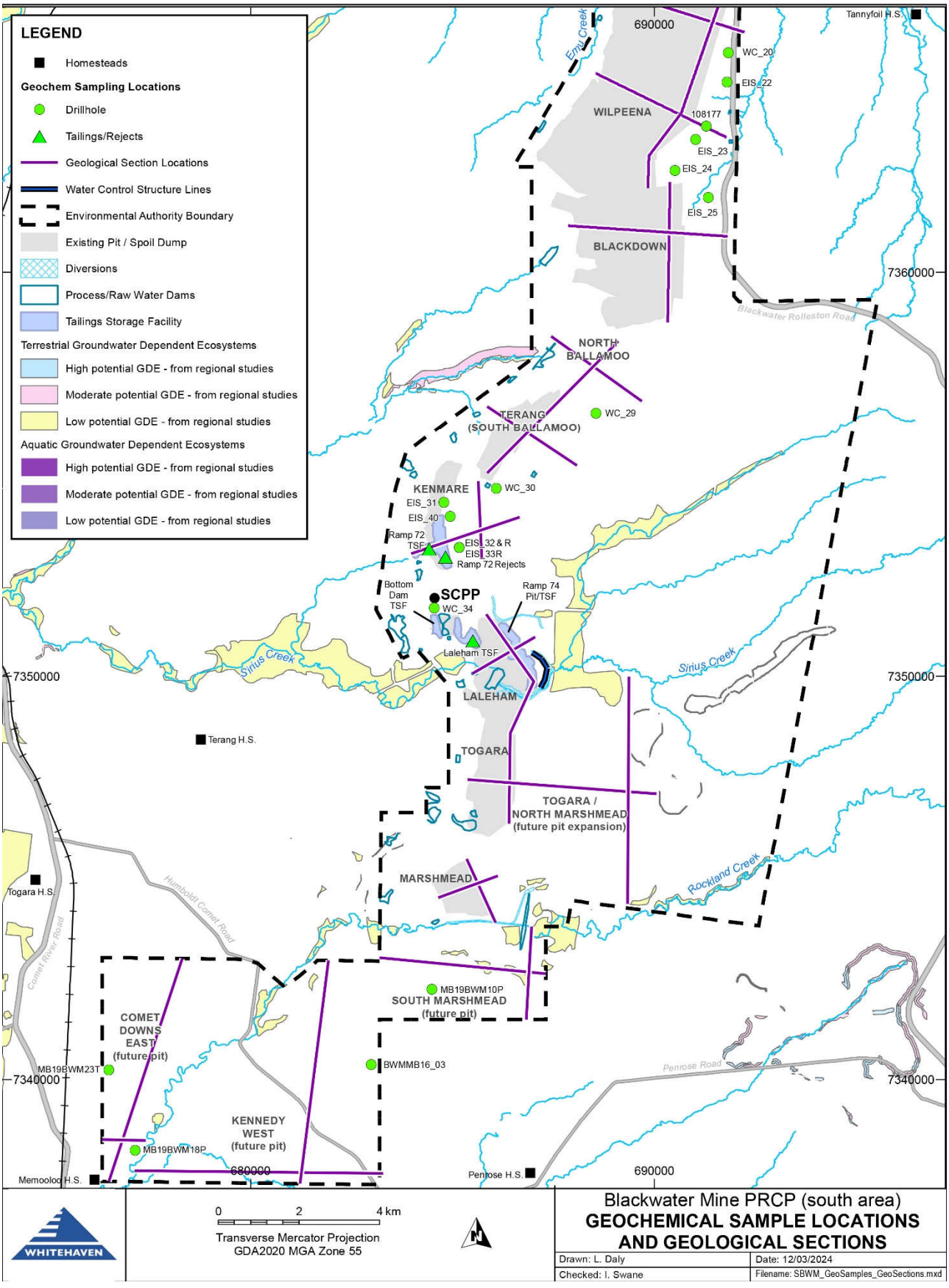


Figure 2. Project layout, geochemical sample locations and locations of geological sections for the southern BWM area



2.2 Mine Domains

The mine domains of direct relevance to mineral waste characterisation and management at BWM at closure are:

- Spoil landforms and their corresponding residual voids (spoil dumps and pits remaining at end of mine life):
  - Ramp 8 spoil landform and residual void;
  - Bonnie Doon spoil landform and residual void, which will include Bonnie Doon TSF within the void;
  - Mimosa-Besgrove spoil landform and residual void;
  - Deep Creek spoil landform and residual void;
  - Stewarton-Ballamoo spoil landform and residual void;
  - Kenmare spoil landform and residual void, which will include Ramp 72 TSF within the landform;
  - Laleham spoil landform and residual void, which will include Laleham TSF within the landform and Ramp 74 TSF within the void;
  - Togara-North Marshmead spoil landform and residual void;
  - South Marshmead spoil landform and residual void;
  - Kennedy West spoil landform and residual void;
  - Comet Downs East spoil landform and residual void.

  Bonnie Doon TSF (the current/active TSF within Bonnie Doon pit) and Ramp 74 TSF (Laleham pit) will remain within their respective residual voids. Ramp 72 TSF (within current Kenmare pit) will be buried by spoil during rehabilitation and will be incorporated by the Kenmare spoil landform.

  Note: spoil landforms are not 'discrete' (completely stand-alone) features. Instead, they should be thought of as zones within a single landform with a hummocky, rolling topography - higher spoil areas behind (west of) each residual void, where mining occurred - and lower between voids, where pit ramps were located.
- TSF landforms:
  - NCPP TSF (inactive/decommissioned; above-ground facility);
  - Laleham TSF (inactive/decommissioned and partially rehabilitated; above-ground facility);
  - Bottom Dam TSF [mixed tailings and rejects] (inactive/decommissioned; above-ground facility);
- Rejects landforms:
  - Ramp 36 rejects landform near Deep Creek (inactive/decommissioned; above-ground facility);
- TCP rejects will be relocated into the Mimosa-Besgrove spoil landform during rehabilitation of the TCP area and, as such, will not remain as a rejects landform post-closure.
- Coal stockpiles: ROM coal pad and stockpile; and Product coal pad and stockpile.

Material types and quantities

BWM has three main types of mineral waste, and the geochemical characteristics and potential hazards associated with mineral waste materials on site are discussed by type:

- Spoil (overburden and interburden) currently comprises approximately 99% of all mineral waste at BWM and includes weathered waste (Tertiary and Permian-age) and fresh (unweathered) waste (all Permian-age). On average, approximately 40% of spoil is weathered/oxidised and the remaining (approximately 60%) is fresh, with the proportion of weathered to fresh spoil varying throughout the site. In the northern half of the site the proportion of weathered to fresh spoil is about 25% weathered to 75% fresh, whereas in the southern half of the site the proportion of weathered to fresh spoil is about 49% weathered to 51% fresh.
- Tailings are generated at the NCPP (and previously also at the SCPP) from processing ROM coal and typically represent the clay, silt and fine sand fractions of ROM waste. Throughout operations at BWM, tailings have been disposed as a slurry into a number of TSFs – the current (active) TSF being Bonnie Doon in-pit TSF. Tailings comprises approximately 0.5% of all mineral waste at BWM – with this approximated proportion expected for the remaining life of asset mine plan.

Rejects are generated at the NCPP (and previously also at the SCPP) from processing ROM coal and typically represents coarser and rockier seam roof, partings and floor material. Rejects are trucked to several locations for disposal into spoil. Historically, rejects were also disposed onto rejects dumps, such as Ramp 36 rejects dump, TCP rejects dump and Bottom Dam TSF [mixed tailings and rejects]. Some rejects have been used in construction of TSF embankments and infrastructure pads (eg. ROM and coal stockpile pads). Rejects comprise approximately 0.5% of all mineral waste at BWM – with this approximated proportion expected for the remaining life of asset mine plan.

Coal is also included in the assessment; however, coal is generally not considered mineral waste, with the exception of small quantities of sub-economic seams that may report to the spoil dumps, and remnant coal exposed on pit highwalls (such as in residual voids).

2.3 Baseline Information

2.3.1 Topography

The most prominent topographic feature in the region is the Blackdown Tablelands (also known as the Blackdown Ranges) – a sandstone plateau situated about 10 km to the east of BWM mine, which rises abruptly from the surrounding plains to an elevation of approximately 900 metres Australian Height Datum (mAHD), however most of the Tablelands have an elevation of around 340 to 400 mAHD. The relatively steep slopes associated with the Blackdown Tablelands contrast with the generally lower relief areas west of the ranges at BWM, particularly throughout the northern half of the site.

Throughout the northern part of BWM the elevation is typically between 180 to 220 mAHD. Comparatively, the southern and southwestern area has much greater topographic relief, ranging from approximately 170 mAHD in the southwest of the PRCP area in the vicinity of Comet Downs East to approximately 390 mAHD at the eastern ML boundary between Blackdown and Terang pits (average approximately 300 mAHD for the southern area).

2.3.2 Climate

The following information about climate is general and provided for broad context. Refer to the main volume of the PRCP for detailed information about climate at BWM.

BWM is located within Queensland's semi-arid climatic zone, which is characterised by high summer temperatures, warm dry winters and generally distinct wet and dry seasons; with higher rainfall and higher evaporation occurring over the summer months (December to February).

Climate data is available from Bureau of Meteorology weather stations near Blackwater township [Blackwater water treatment plant (station ID 035290) and Blackwater airport (station ID 035134)], and from Emerald airport (station ID 035264) located about 70 km west of BWM.

Average maximum temperatures range from approximately 23°C in June/July to 34°C in December/January, with average minimum temperatures ranging from approximately 9°C in June/July to 22°C in January.

Average annual rainfall is approximately 547 mm at Blackwater township and about 561 mm at Emerald. Average annual evaporation is approximately 2000 mm for the district. As would be expected for the region, the evaporation rate is highest in the summer months (December/January) and lowest in the cooler months (June/July).

Rainfall events are often associated with thunderstorms, which are typically short-lived, intense and have variable coverage. Sustained rainfall over a large landscape area is experienced when tropical lows with cyclonic activity occur in coastal area. However, periods of prolonged drought do occur within the region.

2.3.3 Geology

The Blackwater sits on the eastern flanks of the Comet Ridge, a major regional anticline. Throughout most of BWM the sediments strike north-south and dip gently towards the east with average bedding dips of 3-5 degrees (although there are significantly steeper areas associated with faulting). In the far southern area the strike direction is west-east. The lithology at BWM is characterised by typical basin-fill sediments, comprising mudstone, claystone, siltstone, sandstone (typically fine- to medium-grained), carbonaceous sediments and coal seams.

In coal environments (ie. at coal mines) fresh carbonaceous materials typically have higher sulfide concentrations compared with fresh non-carbonaceous materials and, as such, typically pose a greater environmental geochemical hazard compared with fresh non-carbonaceous material. Comparatively, non-carbonaceous lithologies are essentially void of (or have negligible) carbonaceous material and thus have low or nil sulfide mineral concentration. The key exception is that non-carbonaceous materials located within coal seams or immediately above and below (within, say, 0.5m of) coal seams tend to have a higher sulfide concentration compared to bulk overburden/interburden located away from seams.

Minor basalt is encountered within Tertiary-age material. Excluding the far southern area that has not been mined (and is subject to development approval), the depth to base of weathering averages about 23 m below natural surface throughout but ranges from about 10 m to 60 m below natural surface, depending on the local topography. Depth to base of weathering is generally highest in the far southern

area (not currently mined), with an average depth to base of weathering of about 45 m below natural surface.

The economic coal seams in the Blackwater area are contained within the late Permian-age Rangal Coal Measures. The Rangal Coal Measures are underlain by the Burngrove Formation (which outcrops west of the site) and are overlain by the Early Triassic-age Rewan Formation. In some areas at the southern end of the mine the Rangal Coal Measures are unconformably overlain by up to 45 m of partially consolidated Cainozoic (Tertiary) sands, gravels, basalts and clays. Elsewhere on the mine, Tertiary cover is usually much thinner. Most areas on the mine are also capped by thin veneer of Quaternary-age sediments (typically alluvial sediments).

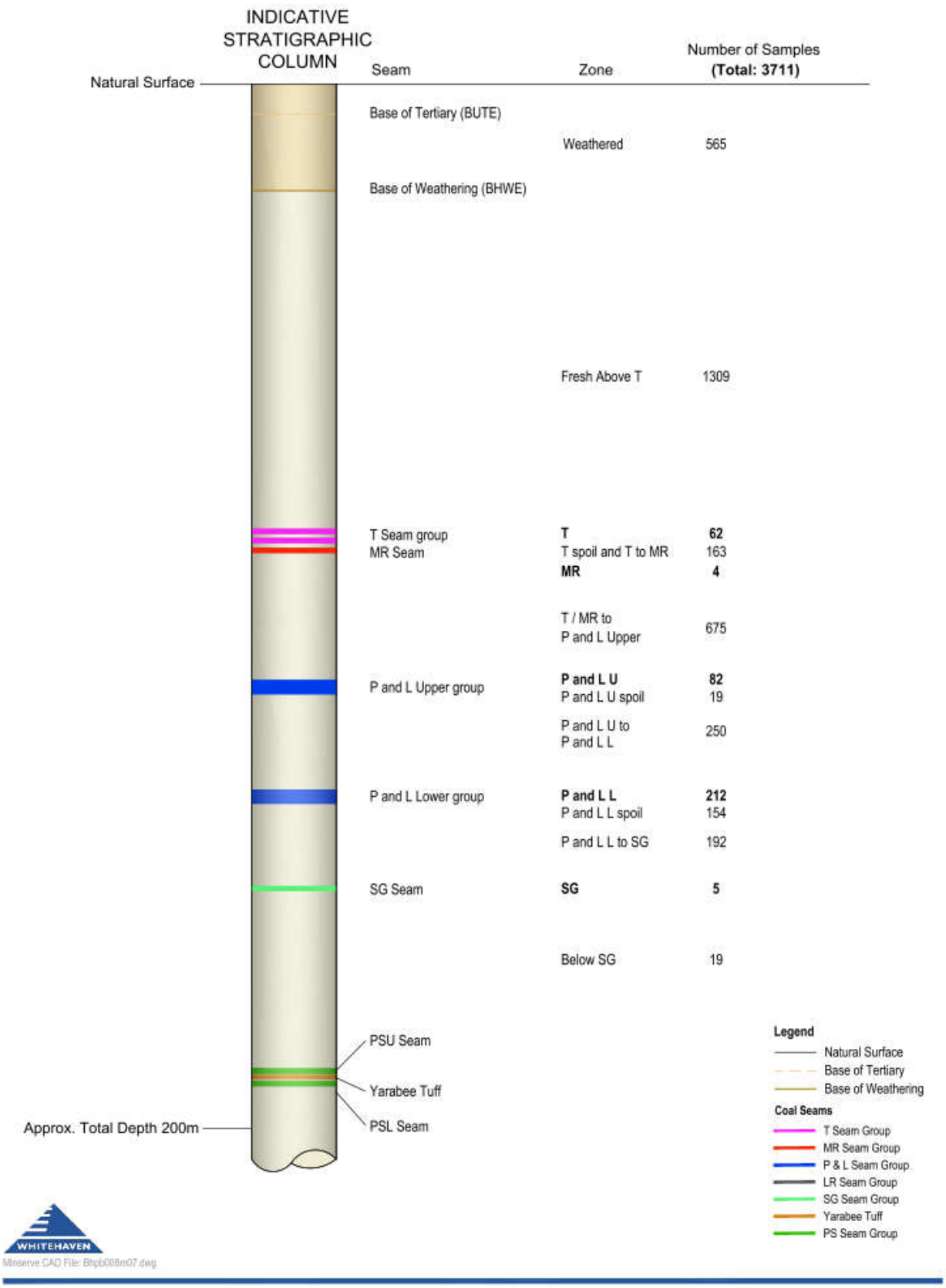
Blackwater mine currently exposes three principal seam groups from the Rangal Coal Measures – called the tops, middles and lowers [historically, the southern BWM area (what was once called South BWM) named these seam groups Aries (tops), Castor (middles), Pollux/Orion/Argo (lowers)]. The northern end of the mine predominately mines the lower seam group, whereas the central and southern areas mine all three seam groups. The seams split and re-join through the mine often creating upper and lower sub-sections of itself, typically called riders (eg. Top Rider, Middle Rider).

An indicative stratigraphic column showing the seam groups is provided in **Figure 3**, which also includes the number of geochemical samples collected from each overburden and interburden zone, and also from within each seam group (refer to **Section 4.3** for information regarding sample collection). The intention of the stratigraphic column is not to show each specific sub-seam and ply, but rather to provide an indication of the availability of environmental geochemical information throughout the general stratigraphic sequence from natural surface down to approximate pit depth.

Geological long-sections along the current highwall of the existing pits and the expected void highwalls of the proposed pits are provided at **Attachment A – Figures A1 to A7**. Geological cross-sections through the existing pits and proposed pit areas (including current topography) are provided at **Attachment A – Figures A8 to A14**. Refer to **Figures 1 and 2** for section locations. The seam groups are shown in the geological sections.

Due to the generally eastward dip of the seams (southward dip in the three southern-most pits) and the nature of the seams splitting and coalescing, the location of the weathered zone shown in the stratigraphic column (**Figure 3**) varies from pit to pit (north to south) and also from west (start of mining) to east (current and future mining). Refer to the geological long- and cross-sections in **Attachment A**.

Figure 3. Indicative stratigraphic column



2.3.4 Surface water / hydrology

The following information about surface water / hydrology is general and provided for broad context. Refer to the main volume of the PRCP for detailed information about surface water at BWM.

A topographic divide runs across the site approximately between Blackdown and Ballamoo South (Terang) pits, separating the mine into two distinct drainage catchments – a northern catchment area that drains east and north primarily to Blackwater Creek (and northwest via Burngrove Creek), and a southern area that predominantly flows south and west via Sirius Creek and Rockland Creek.

The surface drainage at BWM comprises a number of named and un-named ephemeral creeks that are tributaries of Blackwater Creek, Sirius Creek and Rockland Creek. To the north of the topographic divide the drainage direction is from south to north ultimately into the Mackenzie River, which is the main surface drainage in the region. To the south of the divide, creeks generally flow from north-east to south-west and then westward into the Comet River, which then drains into the Nogoa/McKenzie Rivers near the township of Comet, approximately 35 km west of Blackwater township.

All watercourses and tributaries within and in the vicinity of BWM are highly ephemeral and only flow briefly after rainfall. The creeks at BWM, from north to south, are shown on **Figures 1 and 2** and include:

Northern catchment creeks

- Burngrove Creek, flowing northwest from the Mimosa and Sagittarius pit area. All of the small un-named creeks west of Mimosa-Besgrove spoil landform drain north into Burngrove Creek (a tributary of McKenzie River);
- Various un-named creeks located in the highwall area between Bonnie-Doon Pit and Sagittarius Pit, which flow east and northeast into Sagittarius Creek (a tributary of Blackwater Creek);
- Various un-named creeks located in the highwall area between Burngrove Pit and Besgrove Pit, which flow east into Taurus Creek (a tributary of Blackwater Creek);
- Deep Creek, which flows west to east across the site between Besgrove and Deep Creek pits. Near the eastern ML boundary, Deep Creek flows into Taurus Creek (a tributary of Blackwater Creek). Small un-named creeks on the southern side of NCPP TSF (west of Deep Creek Rejects area) drain into Deep Creek;
- Taurus Creek, which flows west to east across the site between Deep Creek and Stewarton pits. Most of the small un-named creeks on the south-western side of Deep Creek Pit drain into Taurus Creek;
- Emu Creek and its' un-named tributaries, a collective of minor tributaries located west of Stewarton to Wilpeena pits, which flow north into Taurus Creek; and
- Various un-named creeks located in the highwall area between Stewarton Pit and Blackdown Pit, which flow north into Two Mile Gully (a tributary of Taurus Creek).

Southern catchment creeks

- Sirius Creek, which flows generally east to west across the site near Laleham Pit. All of the minor un-named creeks on both sides of the mine between Blackdown Pit and Laleham Pit drain into Sirius Creek; and

- Rockland Creek, which flows generally northeast to southwest across the site between Marshmead and Comet Downs East pits.

Of the above creeks, Burngrove Creek, Deep Creek and Taurus Creek in the northern catchment and Sirius Creek and Rockland Creek in the southern catchment are the most significant watercourses within and surrounding BWM. All other minor and un-named tributaries flow into one of these five key watercourses.

2.3.5 Groundwater / hydrogeology

The following information about groundwater / hydrogeology is general and provided for broad context. Refer to the main volume of the PRCP for detailed information about groundwater at BWM.

An aquifer is defined as a groundwater bearing formation sufficiently permeable to transmit and yield water in usable quantities. The Quaternary alluvial formations, Tertiary sediment and basalt formations, Rewan Group (Triassic age) and the Permian coal measures generally yield low sustainable volumes of poor-quality water. As such, these formations are not recognised as 'true' aquifers in the area. However, for the purpose of the discussion, groundwater-bearing zones at BWM are referred to as aquifers. The hydrogeological units at BWM are outlined in Table 1.

Table 1. Hydrogeological units

Age	Geological Unit	Aquifer
Quaternary	Undifferentiated alluvium (mainly clay, silt, sand and gravels) associated with floodplains of the major drainage channels	Sand and gravel deposits within the alluvium forming unconfined aquifer; Predominantly localised in pockets close to creeks (ie. not a continuous aquifer), therefore often dry during dry periods.
Tertiary & Triassic	Regolith: Undifferentiated colluvium and weathered units (clay, silt, sand, and weathered mudstone/siltstone/ sandstone. Basalt also present in the southern part of the site	Unconfined and largely unsaturated unit. Insignificant groundwater host.
Triassic	Rewan Group: Mudstones interbedded with siltstones and fine- to medium-grained sandstone.	Regional-scale aquitard (very low yielding)
Permian	Rangal Coal Measures: [overburden and interburden]. Mainly sandstone, siltstone and claystone	The low-permeability sandstone and siltstone interburden units (between coal seams) are typically dry or very low yielding (ie. have aquitard properties).
	Rangal Coal Measures: [coal seams]	The coal seams are identified as the primary aquifer; associated with secondary porosity through coal seam cleats/cracks and fissures/fractures associated with faults intersecting coal seams. The coal measures are highly faulted, resulting in groundwater compartmentalisation. Recharge is via direct infiltration where seams outcrop or sub-crop.
	Burngrove Formation: mudstone, siltstone, sandstone, coal and tuff. Equivalent to the Foot Cooper Coal Measures elsewhere in the Bowen Basin.	Coal seams of this unit form a regional-scale aquifer in conjunction with low permeability overburden and interburden, that essentially form aquitards. Considered the 'basement' formation at BWM.

The main factors influencing natural groundwater levels are groundwater recharge, evapotranspiration and regional flow patterns. Due to the heterogeneity and discontinuity (and often dry condition) of the Quaternary alluvium aquifers and Tertiary sediment and basalt units, the groundwater flow direction in these 'aquifers' cannot be determined on a regional scale – and is likely to be very local and topographically controlled, flowing from higher elevations to lower elevations – particularly in the southern half of BWM where there is greater topographic relief. Regionally, the groundwater flow direction within the Permian coal seams generally mimics the surface water flow direction. Prior to mining, groundwater flow in the northern half of BWM would have been generally towards the north and groundwater flow in the southern half of BWM would have been generally towards the southwest. Locally, these groundwater flow directions have been interrupted by mining, with current groundwater flow directions in the vicinity of the mine being towards the pits (ie. the pits are currently groundwater 'sinks'). Information available suggests the presence of impermeable faults at some locations have hydraulically compartmentalised the coal seams in these faulted areas. It is noted that Cook Underground Colliery (owned by QCoal group) located immediately east of BWM near Stewarton-Ballamoo residual void is likely a localised groundwater 'sink'.

Potential for groundwater-surface water interaction

Based on hydrogeological studies and conceptualisation of groundwater flow (refer to groundwater section of the PRCP), groundwater interaction with ephemeral creeks is considered to be unlikely – with the exception of Sirius Creek in the southern area of the mine. The extent of alluvium is limited, both horizontally and vertically, suggesting dry conditions for most of that unit and water tables significantly below the creek beds. The regolith (ie. weathered Tertiary sediments and weathered Rewan Group) is also unlikely to host significant groundwater. Where saturated, water levels in the regolith are several meters below the base of creek beds.

In the southern part of the site there is potential for intermittent hydraulic connectivity between the regolith and surface drainages during wet periods. However, the ephemeral nature of the creeks indicates a general lack of continual baseflow from groundwater into the creeks. Groundwater modelling with particle tracking (SLR, 2024) shows a hydrogeological connection between the Permian groundwater aquifer and shallow alluvium in the vicinity of Sirius Creek.

There is also the potential for interaction between mine surface water storages such as dams and pits (residual voids), and the hydrogeological units hydraulically connected to them.

Groundwater quality

The physico-chemical results from groundwater sampling at BWM indicate the water chemistry is typically pH-neutral for all geological formations where groundwater is encountered. Very limited data from the alluvial zone indicates a pH of approximately 5 to 6 – consistent with recent rainwater recharge.

Groundwater associated with most geological (and hydrogeological) units have salinity levels (measured as electrical conductivity (EC)), ranging from brackish to saline – median EC approximately 13,000 μS/cm in the non-coal zones of the Rangal Coal Measures; approximately 18,000 μS/cm in the coal seams of the Rangal Coal Measures; to nearly 34,000 μS/cm in the Rewan Group. The Tertiary sediments have the lowest salinity (median of approximately 7300 μS/cm). Major ions in groundwater at BWM are generally dominated by sodium and chloride. Very limited data from the alluvial zone indicates a sodium-calcium-chloride-bicarbonate water type – consistent with recent rainwater recharge.

The existing concentrations of some dissolved metals in the groundwater are above the water quality guidelines (95% protection) for freshwater ecosystems (ANZG, 2018; QWQG 2006). Slightly elevated concentrations of some elements in groundwater in Permian coal measures in the Bowen Basin are not uncommon and are considered to be naturally occurring.

The water quality from the monitoring wells located at and close to BWM indicates that, generally, the water is unsuitable for human consumption as assessed against the Australian Drinking Water Guidelines (HMRC-NRMMC 2011). Local groundwater use is primarily for livestock purposes owing to the variable salinity levels and generally low yields.

2.3.6 Potential environmental and human health receptors

A conceptual environmental geochemical model (source-pathway-receptor (SPR) model) for BWM identified the potential environmental and human health receptors and are discussed within this report. Of relevance to this assessment (ie. hazards and risks posed by AMD), the following potential receptors are noted.

Potential surface water receptors

The primary surface water features in the district are the Comet River, located approximately 30 km west of BWM; and the McKenzie River, located approximately 20 km northwest of the northern tip of BWM. Comet River flows north into McKenzie River. As explained in Section 2.3.4., the northern half of the site drains primarily east via Deep Creek and Taurus Creek (and lesser so northwest via Burngrove Creek), all of which eventually drain north into the McKenzie River. The southern half of the site drains west and southwest via Sirius Creek and Rockland Creek, which eventually drain into the Comet River, which flows north into the McKenzie River. Therefore, all of BWM eventually drains into the McKenzie River. BWM shares the McKenzie/Comet River Catchment with several other coal mines upstream of the Comet/McKenzie confluence (eg. Ensham Mine) and downstream (eg. Currah North, Jellinbah East and Yarrabee mines). The Comet and McKenzie rivers are implausible receptors for AMD due to their distance from BWM, however their tributaries proximal to the mine are potential receptors.

Potential groundwater receptors

Aquatic and terrestrial groundwater dependent ecosystems (from national assessment) are shown in Figures 1 and 2.

Potential domestic (human) receptors

There are a number of homesteads in the general vicinity of BWM, however none are close to any pits (residual voids), TSFs or spoil dumps and, as such, are considered to be implausible receptors of AMD. The nearest homestead to the current mining area is 'Ausbute' located about 1.3 km west of Burngrove Pit.

There are homesteads that are owned by Whitehaven that are located nearby or within current or future mining areas, or areas that may be impacted by mining. These include 'Memooloo' homestead, located approximately one km southwest of Comet Downs East residual void (noting that Comet Downs East is a future mining area that has not commenced), 'Mountainview' located inside the ML over 5 km east of Burngrove residual void and 'Taurus' homestead, located inside the ML approximately 1.6 km east of Deep Creek residual void. These homesteads are all a significant distance from the residual voids as described are considered to be implausible receptors of AMD.

There are homes/homesteads at Blackwater township – the main township northeast of Bonnie Doon Pit and a small group of properties on the northern side of Capricorn Highway northwest of Bonnie Doon Pit. The closest homes in this far northern BWM area are located approximately 290 m northwest and 380 m northeast of the ML boundary and approximately 2.2 km northwest and 4.8 km northeast of Bonnie Doon Pit. Bonnie Doon Pit is the active TSF and will not be expanded (ie. the 2.2 km / 4.8 km distance from Bonnie Boon Pit to the nearest residences will remain the same post closure as it currently is). Blackwater township and properties north of Bonnie Doon Pit are considered to be unlikely receptors for AMD from Bonnie Doon TSF (pit).

2.3.7 Acid and Metalliferous Drainage

Environmental geochemical information with regard to AMD from mineral waste materials at BWM has been sourced from the Coal Geochemical Database (hereafter called 'the geochemical database') and is presented and discussed within this report.

2.3.8 Salinity, Sodicity and Dispersion

Environmental geochemical information with regard to salinity, sodicity and dispersion of mineral waste materials at BWM has been sourced from the geochemical database and is presented and discussed within this report. Refer to the main volume of the PRCP for detailed information about soils and rehabilitation of spoil dumps at BWM.

3 Potential Environmental Geochemical Hazards

3.1 Acid and Metalliferous Drainage

The term 'AMD' is used to describe low-quality seepage or drainage (from soil and rock) that has been affected by the oxidation of sulfide minerals (eg. pyrite) and/or by the dissolution of acid generating sulfate minerals (primarily alunite and jarosite) and associated neutralisation reactions, if any. The term AMD is used to describe any drainage type affected by this process.

AMD may be produced when sulfide minerals (such as pyrite) are exposed to oxygen and water. Oxidation of sulfide minerals may result in the production of acid(ity), sulfate (SO_4) and, depending on mineralogy, the release of metals and salinity. AMD comprises three key components, which are defined below as per recognised Australian and international guidelines (INAP, 2009; DIIS, 2016). This assessment has adopted these definitions:

- Acid drainage (AD): where contact water is acidic and, in most cases, also contains 'elevated' concentrations of metals and metalloids. This drainage type is generated when the acid generating capacity exceeds the acid neutralisation capacity of a sample.
- Neutral and metalliferous drainage (NMD): where contact water is pH-neutral/alkaline and contains 'elevated' concentrations of metals and metalloids. This drainage type is generated when the acid neutralising capacity exceeds the acid generating capacity of a sample.
- Saline drainage (SD): where contact water contains elevated sulfate concentration due to oxidation of sulfide minerals, and very low metal/metalloid concentration. This drainage type is generated when the acid neutralising capacity vastly exceeds the acid generating capacity of a sample with high sulfide concentration.

Whether contact water is impacted by AD, NMD and/or SD largely depends on the relative proportion of acid generating minerals (sulfide / sulfate) and acid neutralising minerals (carbonate) in the source materials.

3.2 Salinity, Sodicity and Dispersion

An assessment of salinity characteristics of mineral waste materials has been undertaken on materials using available EC data from the geochemical database. An assessment of sodicity and dispersion characteristics of spoil materials has also been undertaken using exchangeable cation and Emerson Class data from overburden/interburden samples (data obtained from the geochemical database). Salinity released from the dissolution of geogenic salts (non-oxidative) is a separate and distinct process from SD associated with sulfide oxidation.

4 Assessment Methodology

This section provides the methodology used for the geochemical characterisation and assessment of mineral wastes and coal at BWM.

4.1 Information Review

Sampling and laboratory test-work has been undertaken by throughout the development and operation of BWM. The geochemical database contains all available geochemical data for mineral waste samples. All data has been compiled and reviewed specifically to support the PRCP, to provide a unified and consistent interpretation of all available data. Past characterisation reports are superseded by this review and assessment undertaken to support the PRCP.

4.2 Sample Collection

Drill-hole Samples – representing spoil, ROM coal, pit walls and pit floor

All data used to assess spoil and ROM coal (and pit walls and floor) has been derived from drill-hole sampling. Drill-hole samples have been collected from 32 drill-holes located throughout BWM (shown in Figures 1 and 2) drilled and sampled between 2020-2023.

The drillholes are distributed along strike (approximately north-south) and, as such, intersect all mined geological units along the entire site, with sampling undertaken from surface to full drill-hole depth (approximately to below the lowest mined seam). As such, the drill-hole samples that have undergone test-work are representative of the geology/stratigraphy at BWM from existing mining (disturbance) areas.

The BWM coal resource model provides an estimate of coal resources from current pit highwall through to the eastern extent of the mine (as currently approved). The resource model indicates that – at closure – the proportion of coal versus non-coal in the highwall of the residual voids is broadly consistent with the current proportions on the pit highwalls. The model also shows that the proportion of each seam group is expected to be broadly similar to current seam group proportions on the highwall of the current pits. As such, it is reasonable to assume that the mineral waste types assessed, and their relative proportions, are representative of the mineral waste types and proportions likely to be present at closure.

Geochemical data comprising, at minimum, total S, ANC, pH and electrical conductivity (EC) results is available for 3711 drill-hole samples collected from 32 drill-holes. Geochemical samples collected and tested were sourced from the following key mineral waste domains:

- Weathered, non-carbonaceous spoil. 554 samples.
- Weathered, carbonaceous spoil, including weathered coal. 9 samples.
- Fresh, non-carbonaceous spoil. 2527 samples.
- Fresh, carbonaceous spoil. 251 samples. These samples typically include carbonaceous siltstone, carbonaceous sandstone, carbonaceous mudstone and coaly shale, but also includes similar coaly and carbonaceous materials other than coal.
- Fresh, coal. 370 samples.

All samples collected for geochemical analysis were collected from core-drilling. Most samples were collected as discrete samples – typically a 15-25 cm interval of core within targeted sampling zones. Most drill-core samples were collected semi-continuously across the entire stratigraphic sequence from surface to full depth, with greater emphasis placed on those stratigraphy's posing a greater AMD hazard, such as carbonaceous spoil, plus material located within and very close to coal seams, which includes roof/parting/floor (carbonaceous and non-carbonaceous), and coal. Therefore, carbonaceous waste type is oversampled relative to its proportion in the stratigraphic sequence. For six (out of 32) drill-holes the entire drill-string was sampled (from surface to full depth), with sampled intervals ranging from approximately 0.1 m to 3.2 m based on lithological and seam boundaries.

It is understood that most fresh coal will report to ROM coal and be processed. A small fraction of coal will be mined as spoil (waste) due to coal quality and mining considerations, and a small proportion of coal will remain exposed in seams on pit walls and floor at closure. The coal samples discussed herein represent 'pure' coal and do not include associated roof, parting and floor samples that would ordinarily be mined with the seam as ROM coal. Carbonaceous roof, parting or floor samples are included in the 'fresh, carbonaceous' sample group.

The geochemical sampling locations are shown on **Figures 1 and 2** and the number of drill-hole samples from each stratigraphic zone is shown on **Figure 3** (indicative stratigraphic column).

Tailings Samples – representing very fine to fine-grained coal process waste

Geochemical data is available (within the geochemical database) for 643 tailings samples, comprising 280 'fresh' tailings samples collected from the NCPP and 363 'aged' tailings samples collected from geochemical and geotechnical investigation drillholes within several TSFs. Tailings data are presented and discussed as two groups being representative of:

- Fresh (NCPP) tailings samples; and
- Aged (TSF) tailings samples.

Tailings samples collected from the NCPP are deemed to be representative of 'fresh' tailings currently and recently produced at BWM. Tailings samples collected from TSFs are deemed to be representative of 'aged' tailings within the TSFs at BWM.

Most of the 'aged' tailings samples collected from TSFs were logged as 'dry to moist' or 'moist' at the time of sample collection.

A program is underway to collect (and analyse) additional 'aged' tailings samples from the tailings disposal areas at Kenmare Pit (Ramp 72 TSF) and from Bottom Dam TSF and rejects area. Data from this program will inform rehabilitation and closure planning of these areas.

Rejects Samples – representing mid- to very coarse coal process waste

Geochemical data is available (within the geochemical database) for 265 rejects samples, comprising 48 'fresh' rejects samples collected from the NCPP and 217 'aged' rejects samples collected from geochemical and geotechnical investigation drill-holes and test pits within NCPP TSF, Laleham TSF, Ramp 36 rejects dump, Kenmare Pit rejects dump and Red Dam area (surface samples). Rejects data are presented and discussed as two groups being representative of:

- Fresh rejects samples (from NCPP); and
- Aged rejects samples (from TSFs and rejects dumps). These samples were predominantly logged as 'dry' to 'moist' or 'moist' at the time of collection.

Rejects samples collected from the NCPP are deemed to be representative of 'fresh' rejects currently and recently produced at BWM. Rejects samples collected from TSFs and rejects dumps are deemed to be representative of 'aged' rejects that may be found in TSFs or at rejects disposal areas awaiting burial/rehabilitation.

A program is underway to collect (and analyse) additional 'aged' rejects samples from the rejects disposal areas at the southern ends of Kenmare Pit (Ramp 72 pit) and from Bottom Dam rejects. Data from this program will inform rehabilitation and closure planning of these areas.

Other Samples – representing general fill and natural ground

Geochemical data is available (within the geochemical database) for 54 'fill' samples and 19 'natural ground' samples collected from geochemical and geotechnical investigation drillholes within the above-ground TSFs (NCPP TSF and Laleham TSF) and Ramp 36 rejects dump. Fill (spoil) material is often used as part of TSF embankment construction. Fill samples were collected and analysed as part of the geochemical and geotechnical investigations. Fill samples were logged as 'dry' to 'dry/moist' at the time of collection. At the base of the investigation drillholes (base of the TSFs, below the base tailings or rejects) natural ground was encountered and was also sampled as part of the investigations. Natural ground samples were logged as 'moist' at the time of collection.

4.3 Sample Characterisation

The aim of the environmental geochemical test-work is to understand the geochemical characteristics of the mineral waste materials with respect to AMD, geogenic salinity, erosion and dispersion potential; and to inform management and closure options for these materials.

A phased approach was implemented to define the geochemical behaviour of the key material types generated at BWM, as discussed below.

Solid Samples – Static Tests

Tailings, rejects and overburden (spoil) samples have generally undergone similar test-work methods. Test-work was generally undertaken in stages, with most samples being subjected to 'screening' tests followed by more detailed test-work undertaken on selected samples.

The vast majority of the samples have undergone 'screening' tests (stage 1 tests) for:

- pH and electrical conductivity (EC) on 1:5 w:v water extracts (on pulps [100% passing 212 microns]);
- Net acid producing potential (NAPP) test, which comprises total sulfur (total S) and acid neutralising capacity (ANC) determination. The NAPP test provides the fundamental information about the theoretical maximum amount of acid-producing and acid-neutralising material that a sample could produce.

Based on the results of the screening tests, selected samples were subjected to some or all of the following tests:

- Total carbon (total C), and organic carbon (C-org);
- Total sulfate (SO_4);
- Sulfide (chromium reducible sulfur – Scr) – a test to determine the proportion of total S present as sulfide;
- Acid buffering characterisation curve (ABCC) - a test to determine the proportion of ANC that's in a readily-available form and to provide an indication of the carbonate mineralogy of the neutralising material;
- Net Acid Generation (NAG) [single addition] - a test that encourages the oxidation of a sample to determine if acid can be produced, and how much acid could be produced;
- Sequential net acid generation test (S-NAG) – a refinement of the single addition NAG test to resolve potential issues associated with incomplete oxidation of samples with high sulfide concentrations;
- Extended boil net acid generation test (NAG Extended) – a refinement of the NAG test to resolve uncertainty due to potential organic acid interference (where non-acid generating organic acids can provide false positive results in the NAG test);
- Total metals and metalloids by 4-acid (mixed) or 2-acid (aqua regia) digest with analysis by Inductively Coupled Plasma Mass Spectrometry (ICP-MS) and/or Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-AES) and Flow Injection Mercury System (FIMS);
- Quantitative x-ray diffraction (QXRD) – to determine the mineralogical composition;
- Short-term leaching tests, including:
    - Deionised water extract leach procedure – a 1 hour end-over-end bottle leach at 1:5 w:v (solid:water) ratio using de-ionised water, with filtered leachate analysed for:
        - Major and minor ions [calcium (Ca), magnesium (Mg), sodium (Na), potassium (K), SO_4, chloride (Cl) and fluoride (F)];
        - Alkalinity [total alkalinity, bicarbonate (HCO_3) and carbonate (CO_3)] and Acidity (pH dependent);
        - Soluble metals/metalloids [approximately 28 elements by ICP-MS, ICP-AES and FIMS].
    - Saline water extract leach procedure – a 1 hour end-over-end bottle leach at 1:5 w:v (solid:water) ratio using saline water (2 g/L NaCl), with filtered leachate analysed for the soluble analytes listed above.
    - Peroxide (NAG) leach – analysis of the solution on completion of the NAG or NAG Extended test, with filtered leachate analysed for the same (or similar) suite of soluble analytes as listed above.
- Exchangeable cations (Calcium [Ca], Magnesium [Mg], Sodium [Na], Potassium [K]) (with pre-treatment for salinity, if required). Results were used to calculate the cation exchange capacity (CEC);
- Emerson Aggregate Class testing.

Geochemical test work was undertaken by ALS Environmental (ALS) Brisbane, using National Association of Testing Authorities (NATA) accredited methods (where such accreditation exists). Mineralogical analysis (QXRD) was undertaken by a university (research) mineralogical laboratory in Melbourne (via Earth Systems Consulting).

Solid Samples – Kinetic OxCon Tests

Oxygen consumption and carbon dioxide (CO_2) generation (OxCon) test-work was undertaken by Earth Systems (Melbourne) on five 'fresh' tailings samples from NCPP, one 'aged' tailings sample collected from NCPP TSF, and three composite carbonaceous spoil samples from drill-cores. The samples were selected on the basis of earlier static test results.

OxCon is a laboratory-scale kinetic geochemical test for the estimation of sulfide oxidation rates, acidity generation rates and carbonate neutralisation rates for sulfidic geological materials.

Prior to the OxCon test the sample is 'washed' to remove any pre-existing salts and oxidation products (eg. sulfate). Test-work then involves isolating a known mass of sulfide-bearing material in a known volume of oxygen inside a sealed vessel and allowing sulfide oxidation to proceed. Once the test is initiated, oxygen in the vessel is consumed via sulfide oxidation. Oxygen consumption is measured directly and logged over the test-work period (1-8 weeks, depending upon the sample). Carbon dioxide generation is measured hourly and logged for estimation of the extent of acid neutralisation by carbonate minerals or the rate of biological organic carbon oxidation, if any, during testing.

At the conclusion of the OxCon test, the solid undergoes a bottle leaching procedure at a 1:2 solid:water ratio and the leachate was analysed to determine the pH, acidity/alkalinity and concentration of soluble metals/metalloids and salts.

Solid Samples – Kinetic Leaching Tests

Free-draining kinetic column leaching data is available for five fresh (NCPP) tailings samples and one 'aged' tailings sample collected from NCPP TSF. The samples were selected for column leaching test-work on the basis of earlier static test results. These are the same tailings samples that also underwent OxCon test-work.

Column leaching is a laboratory-scale kinetic geochemical test for the estimation of sulfide oxidation rates, acidity generation rates and element leaching – over time – for geological materials. The intent of the column leaching program was to characterise leachate from samples subjected to routine wetting and drying cycles, which simulates exposure to 'atmospheric conditions'. Crushed samples are loosely packed into a two litre funnel and a known quantity/mass of deionised water is slowly added to the top of each sample and the water allowed to slowly free-drain through the sample matrix and collected as 'column leachate'. The leachate collected from each column test was analysed to determine the pH, acidity/alkalinity and concentration of soluble metals/metalloids and salts. Between leaching (wetting) events the sample matrix was allowed to dry and oxidise using heat lamps. The column leaching test method was based upon a modified AMIRA (2002) method.

Tailings Liquor Samples

Tailings samples collected from the NCPP are collected as a slurry – representative of the tailings slurry that reports to TSFs for disposal. At the TSF the water drains to one end of the TSF – called a decant pond/area – and is collected for re-use in the NCPP. Geochemical data is available (in the geochemical database) for tailings liquor from 51 sampling events undertaken at the NCPP between August 2020 and August 2023. The liquor samples were analysed for a typical suite of water quality parameters, such as pH and EC, major cations and anions and soluble metals and metalloids

4.4 Geochemical Source Hazard Assessment

Geochemical data was assessed with regard to the samples potential to generate AMD. Only after making such an assessment to understand the potential AMD hazard can appropriate AMD-specific management measures be formulated to adequately mitigate the risks, as required.

AMD classification

The Acid-Base Account (ABA) method was used to assess the acid-neutralising and acid-generating characteristics of the samples in order to determine an acid (AD) classification for the mineral wastes.

The maximum potential acidity (MPA) and acid neutralising capacity (ANC) represent each side of the acid-base account. MPA is calculated from total S and is the theoretical maximum potential acidity that can be generated if all of the S, assumed to be associated entirely with pyritic sulfide, is able to oxidise and generate acid (H_2SO_4). ANC represents the theoretical maximum amount of acid-neutralising capacity of a sample assuming all neutralising material is in a readily available form. The net acid producing potential (NAPP) is the difference between the MPA and the ANC. In simple terms, a negative NAPP indicates an excess of ANC and the sample is likely to be non-acid forming (NAF) and a positive NAPP indicates an excess of MPA and the sample is likely to be potentially acid forming (PAF) – though there can be exceptions to this simplified interpretation. Note that NAF samples have the potential to generate NMD and SD, depending on the sulfur concentration.

Sample classification of mineral wastes follows some general rules. Samples were initially classified using Total S, NAPP and ANC/MPA ratio (and NAG data, where available), into three broad categories:

NAF Non-acid Forming;

PAF Potentially Acid Forming;

Uncertain Those samples with inconclusive results, leading to a degree of uncertainty about their ability to generate acid.

Where available, additional geochemical information such as pH, Scr, ABCC, NAG extended and NAG sequential results were used to resolve acid classification uncertainties. The general approach was to build in a level of conservatism in the preliminary classification, as shown in **Table 2**.

Table 2. Preliminary AMD classification criteria

Preliminary classification	Sulfur %	NAPP kg H2SO4/t	ANC/MPA ratio	NAGpH (if data available)
NAF	≤ 0.01	-	-	-
	≤ 1	< 0	≥ 2	-
	≤ 1	< 0	-	≥ 4.5
NAF-Sulfur (NAF-S)	> 1	< 0	≥ 2	-
	> 1	< 0	-	≥ 4.5
PAF – Low Capacity (PAF-LC)	≤ 1	≥ 0 and < 10	< 2	-
	-	≥ 0 and < 10	-	< 4.5
PAF	-	≥ 10	< 2	-
	-	≥ 10	-	< 4.5
Uncertain	Any result outside of the above criteria, or results that appear to significantly conflict with the expected result based on lithology or mineralogy			

Sulfur category

To ensure a consistent approach to describe the geochemical characteristics of the sample, specific total S cut-off values were used to discuss sulfur data, as shown in Table 3.

Table 3. Sulfur category and associated cut-off

Sulfur category	Total S (wt %)
Very low	< 0.1
Low	0.1 – 0.5
Low-moderate	0.5 – 1.0
Moderate	1.0 – 1.5
High	> 1.5

ANC category

To ensure a consistent approach to describe the geochemical characteristics of the sample, specific ANC cut-off values were used to discuss ANC data, as shown in Table 4.

Table 4. ANC category and associated cut-off

ANC category	ANC (kg H2SO4/t)
Very low	< 5
Low	5 - 15
Moderate	15 - 30
High	30 - 50
Very high	> 50

Soil pH type

Classifying whether a sample/material is acid, pH-neutral or alkaline or somewhere in between will depend upon the methods used to measure soil pH. Soil pH data is obtained from a 1:5 (w:v) water extract procedure typically on pulp samples. These soil pH types shown in Table 5 are used as an indicative guide.

Table 5. Soil pH type and associated cut-off

Soil pH type	pH 1:5
Highly acid	< 3.0
Moderately acid	3.0 – 4.5
Weakly acid	4.5 – 6.0
Near neutral	6.0 – 7.5
Alkaline	7.5 – 9.0
Highly alkaline	> 9.0

Soil salinity

The term 'soil' salinity (and 'soil' pH – refer below) is an industry-adopted term to refer to the salinity and pH measured on any solid geologic matrix, such as soil, spoil, rock, sediment, tailings, reject, etc. That is, in this context, the term 'soil' applies to all solid samples, not just shallow surface (root zone) material.

Classifying whether a sample/material is non-saline, highly saline, or somewhere in between will depend upon the methods used to measure soil salinity. Soil salinity data is obtained from a 1:5 (w:v) water extract procedure typically on pulp samples. The soil salinity classes shown in **Table 6** are expressed in units of microSiemens per centimetre (μS/cm) and are used as an indicative guide. The classes are broadly based on soil salinity classes reported by DME (1995).

Table 6. Soil salinity classification

Soil salinity classification	EC 1:5 (µS/cm)
Non-saline	< 450
Slightly saline	450 - 900
Moderately saline	900 - 2000
Saline	2000 – 4000
Strongly saline	> 4000

Mineralogy

Mineralogical data (QXRD) provides supporting information for the geochemical data, particularly with regard to sulfide and carbonate mineralogy of a sample, showing results for mineralogical forms (eg. what sulfide or carbonate minerals are present) and their concentrations (reported in weight %). These data also assist with interpretation of the ABA data.

Element enrichment

The total concentration for each element were compared to average element abundance in soil in the earth's crust (Bowen, 1979) to measure how the total elemental concentrations in the samples compare against average elemental concentrations in unmineralised soil (worldwide). Such a comparison is undertaken to identify samples that contain what may be regarded as 'elevated' concentrations of metals and metalloids to identify potential element of concern. However, enrichment in any metals/metalloids in the solids, does not translate to enhanced leachability or mobilization and/or bioavailability of that specific element.

From the comparison with average crustal abundance in rocks a geochemical abundance index (GAI) was calculated. The GAI quantifies an assay result for a particular element in terms of the average abundance for that element (in sedimentary rocks). The index, based on a log 2 scale, is expressed in seven integer increments (0 to 6), which correspond to enrichment factors from 0 to over 96 times average crustal abundance, as shown in **Table 7**.

As a general rule, a GAI greater than or equal to three indicates enrichment compared to unmineralised shale that may warrant further investigation to assess the mobility of these elements under laboratory conditions.

Table 7. Geochemical Abundance Index (GAI)

GAI	Enrichment factor	GAI	Enrichment factor
0	Less than 3-fold enrichment	4	24 to 48-fold enrichment
1	3 to 6-fold enrichment	5	48 to 96-fold enrichment
2	6 to 12-fold enrichment	6	Greater than 96-fold enrichment
3	12 to 24-fold enrichment		

Elements identified as enriched may not necessarily be a concern for revegetation and rehabilitation, human and animal health or drainage water quality. Similarly, if an element is not enriched it does not mean it would not be mobilised, because under some conditions (eg. low pH, reducing conditions) the geochemical behaviour of metals/metalloids such as Al, As, Cu, Cd and Zn can change (ie. become less or more mobile).

Solubility

Metal/metalloid mobility from samples has been assessed using deionised water and peroxide (NAG) leaching methods. The deionised water leaches assess the initial solubility under fresh water conditions, whereas the peroxide leach assesses the solubility after the samples have been oxidised.

The solubility data from bottle leaching provides an indication of likely solubility/release of salt and metals/metalloids under field pH and redox (oxidation) conditions (and/or low-pH conditions, where applicable). Peroxide (NAG) leachate data provides an indication of potential acidity and concentrations of metals and metalloids that could be released from samples that are fully and rapidly oxidised. This test provides an assumed 'worst case' scenario in term of metal/metalloid mobility.

To ensure a consistent approach to describe the samples geochemical characteristics, specific concentration cut-off values were used to discuss leachate composition as shown in **Table 8**. These same concentration cut-off values were also applied to tailings liquor data.

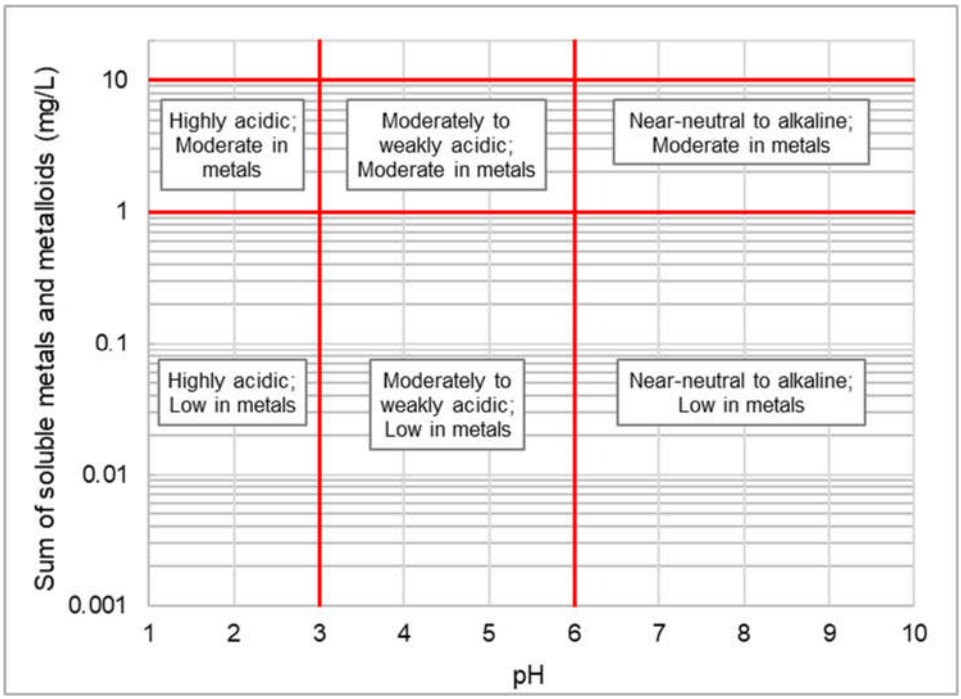
Table 8. Soluble trace element concentration category and associated cut-off

Classification	Trace element soluble concentration (mg/L)
Close to detection	≤ 0.001
Very low	> 0.001 – 0.05
Low	> 0.05 – 0.1
Moderate	> 0.1 – 1.0
High	> 1.0 – 10
Very high	> 10

A classification scheme initially developed by Ficklin *et al*. (1992) has been adapted to summarise major attributes of the solubility data by plotting pH against soluble metal and metalloid concentrations for groups of elements, with the classification scheme shown in **Figure 4**. The soluble metal and metalloid concentrations are shown as the sum of soluble metal concentrations for base metals (Cd + Co + Cu + Ni + Pb + Zn) and/or the sum of soluble As + Mn + Mo + Se. These two groups of

elements are chosen because they remain in solution across a wide range of pH and are not only associated with AD conditions, but also with NMD/SD conditions.

Figure 4. Classification of soluble metals and metalloids as a function of pH



No comparison is made between leachate results and water quality guideline values, such as ANZG (2018), as such a comparison is inappropriate. The guideline values provided in ANZG (2018) are for receiving water environments (eg. creeks), whereas the soluble element data in this assessment is 'point source' obtained from a finely pulped sample subjected to rigorous and artificial extraction to obtain a concentration approaching 'near maximum'. Furthermore, contact water will undergo a number of geochemical reactions along a pathway from source to receptor, including: retardation, adsorption and precipitation – and also likely dilution, which will attenuate the concentration as seepage/contact water migrates from the source. These processes are not accounted for in a laboratory setting.

Sodicity and dispersion

Potential spoil samples (representing material that is likely to report to final landform surfaces) are broadly classified with respect to sodicity on the basis of the exchangeable sodium percentage (ESP) value, as shown in Table 9 (after Northcote and Skene, 1972; Isbell, 2002):

Table 9. Sodicity classification

Sodicity classification	ESP (%)
Non-sodic	≤ 6
Sodic	6 – 14
Strongly sodic	> 14

The sodicity will depend upon a range of factors, such as clay mineralogy, soil sodium concentration, soil salinity and irrigation water (rainwater) chemistry, which may enhance or limit that potential for soil to be sodic or become sodic over time. Therefore, values of 6% ESP and 14% ESP to represent soils as being sodic or strongly sodic are used as a general guide only and should not be taken as definitive. Sodicity assessments only apply to materials likely to report to final landform surfaces, such as overburden/interburden (ie. not tailings, rejects or waste coal).

Sodicity information is broadly used to understand potential revegetation and dispersion aspects, and is supported by Emerson Aggregate Class test information, which provides a direct measure of soil slaking and dispersion based on the Standards Australia (2017) classification. Soils are divided into classes on the basis of their coherence in water and presence (or absence) of calcium-rich minerals (**Table 10**). Slaking occurs when dry soil crumbs, after being immersed in deionised water, break up and run along the bottom of the beaker into a flat pile. Most dry soil crumbs slake when immersed in deionised water. Dispersion describes the tendency for the clay fraction of a soil to go into colloidal suspension in deionised water. Materials are generally regarded as being dispersive (or prone to dispersion) if they have an Emerson Class number of three or less.

Table 10. Emerson classifications

Class	Description	Class	Description
1	Slaking and complete dispersion	5	No calcite or gypsum present; dispersion
2	Slaking and some dispersion	6	No calcite or gypsum present; flocculation
3	Dispersion [remoulded]	7	Non-slaking and swelling
4	Calcite or gypsum present; no dispersion	8	Non-slaking and non-swelling

4.4.1 Using coal quality data for AMD classification

Coal quality data has been used to aid with the assessment of AMD hazard associated with coal seams. In particular, the BWM coal quality database was used to supplement the geochemical database and provide additional understanding of the AMD potential of likely ROM coal, remnant coal, waste coal and rejects. Coal plys were grouped into their respective seam groups on a per-pit basis, such as T, MR, P & L Upper, P & L Lower, etc. for each pit group.

Total S concentrations can be used conservatively to assess the AMD hazard for any given sample; thus, statistical analyses were conducted on total S as a function of seam group and for all seams combined to define the AMD hazard of coal. The data were used to understand the sulfur grade range for each seam group to gain an understanding of the potential AMD hazard posed by each coal seam group (and by inference, potential tailing and reject materials). The results were then compared with detailed geochemical data available for coal, rejects and tailings to 'calibrate' the coal quality total sulfur data.

Coal samples from less than 20m depth were assumed to be completely or predominantly oxidised and were interpreted as 'weathered carbonaceous spoil' and, therefore, excluded from the assessment of potential ROM coal. Acid producing sulfate minerals, such as jarosite, may be present within weathered coal and carbonaceous material, however, mineralogical data available from BWM shows that jarosite is an insignificant mineral at BWM.

4.4.2 Residual void highwall assessment

An assessment of the AMD hazard associated with exposures of all lithological materials, such as remnant coal, weathered materials, fresh non-carbonaceous and carbonaceous overburden was undertaken - being representative of the highwall of the residual void associated with a given pit group.

The frequency of occurrence of relevant material types within each pit was determined from the stratigraphic distribution within selected drill holes under the assumption that the frequency of distribution of each material type is broadly indicative of their respective surface exposures on current highwalls. For example, if P & L Upper seam group had a frequency of occurrence (by meters) of 5% in the drill-hole data set, then the assumption is that the same coal seam group would represent approximately 5% of the surface exposure on the highwall. This method - whilst being relatively simple - provides an acceptable approximation with regard to which seam groups or mineral waste types are most likely to be significantly present in pit walls versus those material types most likely present in relatively minor proportions.

To estimate the proportion of key material domains on the highwalls in each void, exploration drill-holes in proximity to the current/recent highwall/s (and future void highwalls for undeveloped pits) were selected by BWM Coal Geology Planners for each pit. Most holes extended to depths approximating future pit floor depths. For existing pit areas, many drillholes were used for the assessment of each pit/void area. For the proposed future pit areas where limited drillhole data is currently available (ie. South Marshmead, Kennedy West and Comet Downs East proposed pit areas) the assessment was supplemented by estimating depths (thicknesses) of each stratigraphic zone based on the geological model for the southern BWM area.

Stratigraphy, age, weathering, location with respect to the water table, and major stratigraphic horizons (as recorded in the BWM coal geology database) were used to assign individual (discrete) lithological units to a material domain as follows:

- Weathered non-carbonaceous;
- Weathered, carbonaceous [includes weathered coal];
- Fresh, non-carbonaceous;
- Fresh, carbonaceous;
- Fresh, coal.

Coal plys were grouped into their respective seam groups, such as T, MR, P & L Upper/ Lower, etc.

For each void highwall, a statistical assessment was conducted on each drill-hole sub-set (as applicable to each pit group) to summarise the frequency of occurrence of drill core intervals as a function of each of the material groups listed above.

The inherent AMD hazard of each material group listed above was inferred from the geochemical database and coal quality database for similar material types. The combined AMD hazard for the material groups likely to be exposed on the highwall was then used to estimate the AMD hazard of the highwall at each pit.

4.4.3 Residual void floor assessment

An assessment of the AMD hazard associated with remnant coal exposed on the floor of each void was undertaken – being representative of the floor of the residual void associated with a given pit group.

As explained in **Section 4.4.1** coal quality data was assessed to understand the potential AMD hazard associated with coal. For the task of assessing the AMD hazard specific to pit floors (on a pit-group basis), only the coal quality data from the seam group likely to form the pit floors at a given pit group was assessed. At BWM the P & L Lower seam group forms the floor of all pits except Laleham pit.

At Laleham pit the TR seam (T seam group) forms the floor of the pit, however Laleham Pit contains tailings from NCPP – therefore the floor of this pit is now tailings (Ramp 74 TSF). Bonnie Doon Pit is currently the active TSF – therefore the floor of this pit is now tailings.

It is acknowledged that there are generally minor geochemical differences between the various plys of any given seam group. Also, the AMD hazard of the floor of a pit may change depending on whether a significant proportion of the pit floor resides on coal(ly) or non-carbonaceous material. Furthermore, the AMD hazard of any pit floor is not just associated with its surface exposure, but more so with the composition of the sub-drill zone, which represents an extensively fractured coal / interburden comprising the upper sections of a pit floor. For this assessment, the AMD hazard was estimated only for assumed surface exposures of coal / plys.

In practice, mining takes all coal to the bottom of the seam at the base of a pit, therefore very little coal would be expected to remain on the floor of the voids. However, the assessment has adopted a highly conservative position assuming the floor of each void is all coal, and the coal is completely exposed.

4.4.4 TSF assessment

At closure, NCPP TSF will remain as a discrete facility (TSF landform). This TSF is non-operational and will undergo rehabilitation prior to or during mine closure. Geochemical data from samples collected from within NCPP TSF were used to assess the geochemical AMD source hazard of this facility. The AMD source hazard was also assessed using tailings and rejects geochemical data from the NCPP representing 'fresh' tailings and 'fresh' rejects samples.

At closure, Laleham TSF will also remain as a TSF landform. This TSF has undergone preliminary rehabilitation and will undergo additional rehabilitation prior to or during mine closure. Geochemical data from samples collected from within Laleham TSF were used to assess the geochemical AMD source hazard of this facility. Very limited rejects data was available specifically from Laleham TSF. As such, the AMD source hazard was also assessed using rejects geochemical data from all of site.

Ramp 72 TSF will be buried by bulk spoil during mining operations and therefore, at closure, will not require specific remediation or rehabilitation as it will lie beneath the Kenmare spoil landform. Bonnie Doon Pit and Laleham Pit (both containing tailings) are assessed as voids with tailings floor.

Bottom Dam TSF/rejects facility is located in a gully on the southeastern side of SCPP ROM 3 (**Figure 2**) – with the total volume conservatively estimated at approximately 0.2 Mm^3. Bottom Dam area is currently undergoing an environmental and engineering assessment program and the results of this program will inform rehabilitation and closure planning.

4.4.5 Reject dump assessment

At closure, Ramp 36 rejects dump will remain as a discrete facility (rejects landform). This facility is non-operational. Ramp 36 rejects dump will undergo rehabilitation prior to or during mine closure. The AMD source hazard assessment of this facility has utilised geochemical data from reject samples collected the Ramp 36 rejects dump.

Other reject disposal areas (eg. Deep Creek rejects disposal area) are located within a spoil landform area and will be buried by spoil during mining operations.

TCP rejects (up to 0.1 Mm^3) will be relocated from the TCP into the Mimosa-Besgrove spoil landform during rehabilitation of the TCP area and, as such, will not remain as a rejects landform post-closure.

The southern end of Kenmare Pit contains a mix of tailings and rejects that were excavated from the old TSF at Red Dam and Upper Red Dam (and disposed into Kenmare Pit). These tailings/rejects are within the Kenmare spoil landform.

Rejects are disposed adjacent to, and in the general vicinity of, Bottom Dam TSF. Bottom Dam area is currently undergoing an environmental and engineering assessment program and the results of this program will inform rehabilitation and closure planning.

4.4.6 AMD hazard scoring

Estimating the AMD hazard is the first step in estimating the geochemical risk associated with potential sulfide oxidation of mineral wastes. A procedure has been developed[2] to standardise the AMD hazard assessment across material domains, with the process described below.

AMD hazard scoring and the AMD geochemical likelihood describe the Geochemical Hazard. The former describes the hazard for AMD generation and the latter describes the likelihood of an AMD event to occur.

A source material is a distinct material type (e.g. non-carbonaceous spoil or rejects or tailings), whereas a landform is a domain comprising one or more source material types (e.g. rejects disposed within non-carbonaceous spoil). AMD hazard scorings are assigned for individual source materials reporting to a landform as well as to landforms as a whole (i.e. landform AMD hazard score).

The likelihood of a landform developing AMD was determined based on the landform AMD hazard score. AMD hazard scores (Table 11) are estimated by analysing three key components, which are used to describe the geochemical hazard of a source material/landform:

- Geochemical propensity to generate AMD;
- AMD capacity; and
- AMD quantity.

2 The AMD hazard scoring matrix was developed by the author in conjunction with Dr. Marilena Stimpfl (BHP Closure Planning) for use in coal mining assessments.

Table 11. AMD hazard scoring matrix for landforms

Component	Rating		Definition
Propensity for AMD generation Per material type: - non-carb. - carb & coaly - rejects - tailings	1	Implausible	Geochemical properties suggest that the vast majority of the source material has a negligible potential for AMD generation (less than 5% of the samples classified as 'PAF' or NAF-S)
	5	Plausible	Geochemical properties suggest that a significant proportion of the source material may have potential for AMD generation (5-40% of the samples classified as 'PAF' or NAF-S)
	7	Expected	Geochemical properties suggest that the source material has a high potential for AMD generation, but AMD has not yet been observed in the field (due to lag time) - (>40% of the samples classified as 'PAF' or NAF-S)
	15	Certain	Evidence of AMD processes have been observed in the field from the source material
AMD **Capacity** Per material type: - non-carb. - carb & coaly - rejects - tailings	1	Low	Source material has a negligible potential for AMD generation. 'PAF' and NAF-S samples have 75th percentile total S less than 0.1%
	3	Low-Moderate	Assumed to be bulk NAF but sulfide bearing, with NAF samples having 75th percentile total S greater than 1% (ie. the material is predominantly NAF-S). AMD generated will be NMD and/or SD (related to sulfide oxidation), not AD.
	5	Moderate	'PAF' and NAF-S samples have 75th percentile total S ranging from 0.1% to 1.0% and with potential to generate AD.
	7	Moderate-High	'PAF' and NAF-S samples have 75th percentile total S ranging from 1.0% to 1.5% and with potential to generate AD.
	10	High	'PAF' and NAF-S samples have 75th percentile total S greater than 1.5% and with potential to generate AD.
AMD **Quantity** Per material type: - non-carb. - carb & coaly - rejects - tailings	1	Low	Source material rated LOW for AMD capacity; or less than 5% of source material reporting to a landform is rated LOW-MODERATE for AMD Capacity.
	3	Low-Moderate	Less than 5% of source material (in the landform) rated as Moderate for AMD capacity
	5	Moderate	Greater than 5% of source material (in the landform) rated as Low-Moderate or Moderate for AMD capacity
	7	Moderate-High	Less than 5% of source material (in the landform) rated as Moderate-High or High for AMD capacity
	10	High	Greater than 5% of source material (in the landform) rated as Moderate-High or High for AMD capacity
AMD Quantity Per residual void. Per highwall component. Per floor.	1	Low	Less than 10% of drill-hole meters of source material (or less than 10% of pit floor exposure) are classified as 'PAF' or NAF-S
	5	Low-Moderate	Between 10% and 30% of drill-hole meters of source material (or 10-30% of pit floor exposure) are classified as 'PAF' or NAF-S
	7	Moderate-High	Greater than 30% of drill-hole meters of source material (or greater than 30% of pit floor exposure) are classified as 'PAF' or NAF-S
	15	High	Evidence of AMD on highwall or floor of pit; or AMD affected water in pit

In undertaking the AMD hazard assessment, the assumption is that the source materials (within the landforms) will predominantly be dry or moist, but not wet or saturated. That is, the landforms will be unsaturated. This assumption is realistic, since most spoil landforms, rejects landforms and aged/inactive TSF landforms are generally unsaturated. This assumption is also conservative, since the potential for oxidation (to some degree) is assumed.

AMD Propensity is the geochemical propensity of a given material type to generate AMD. The propensity to generate AMD is determined based on the proportion of samples that have potential for AMD as determined from laboratory test-work and the subsequent assessment – the higher the percentage of materials that can generate AMD within a sample set, the greater the AMD propensity. This approach is conservative, since sampling is slightly skewed towards material types considered to pose a potentially higher AMD hazard, such as carbonaceous materials.

AMD Capacity represents the 'severity' of AMD generation, with total S concentrations used as a proxy for scoring this component, which represents a conservative approach as some sulfur is associated with non-acid generating minerals. For example, the higher the total S concentration in materials with potential for AMD, the higher the hazard, the higher the score. Furthermore, the AMD capacity also takes into account the type of drainage a source material can produce, i.e. AD, NMD and/or SD, where discrimination or prediction is possible. The various drainage types should be differentiated (where the data allows) to reflect the difference in impact severity and difficulty to manage or treat. For example, on an equal quantity basis, AD is likely going to cause more severe impacts than NMD or SD and therefore is assigned a higher score.

As a first approximation the AMD Capacity of each material type is estimated based on 75th percentile value of the total S concentration for the samples classified as PAF and NAF-S. This is a conservative assumption, as not all total S is associated with reactive minerals and choosing the 75th percentile total S value of PAF and NAF-S samples to assess the AMD capacity will attract a higher AMD Capacity scoring. For example, if two material types had the same proportion of samples with the same propensity for AMD, but one has a higher total S concentration associated with PAF and NAF-S materials, then this sample would receive a higher AMD Capacity score.

Generally, amongst Bowen Basin Permian- and Tertiary-age materials, a very small number of samples are classified as NAF-S – almost all samples with high total S (>1%) are typically classified as 'PAF' of some type. Therefore, AMD Capacity does take into consideration potential NMD/SD by including NAF-S samples with PAF samples, however the very few NAF-S samples (compared to PAF samples) means that NAF-S samples typically have a negligent bearing on the AMD Capacity of a material. For example, of the 4692 samples at BWM that underwent geochemical characterisation, only 24 samples were classified as NAF-S (approximately 0.5% of samples).

AMD Quantity is the amount of material that has the potential to generate AMD. The greater the volume of AMD generating material the greater the hazard scoring. The AMD Quantity scores are assigned to material types for each landform.

4.4.7 Landform AMD likelihood scoring

The likelihood of a landform generating AMD is estimated by analysing two key components:

- Source material AMD hazard score; and
- Landform AMD hazard score.

Source material AMD hazard score: Describes the potential for AMD generation by the respective material types within each landform. It is estimated from the weighted combined scores of each component used to describe the AMD source hazard:

  - Propensity to generate AMD. Assigned a 50% weighting (weighting = 1);
  - AMD capacity. Assigned a 25% weighting (weighting = 0.5); and
  - AMD quantity. Assigned a 25% weighting (weighting = 0.5).

Landform AMD hazard score: Describes the likelihood for AMD generation by each final landform and each residual void. It is estimated from the source material AMD hazard scores for each material type assumed to be present within that specific landform. At closure, BWM has 11 spoil landform and residual void domains, three TSF landform domains (NCPP TSF, Laleham TSF and Bottom Dam TSF [Bottom Dam TSF domain includes rejects]; and one rejects landform domain (Ramp 36 Rejects), as listed in Section 2.2.

- Landforms: the landform AMD hazard score is estimated from the weighted average of the source material AMD hazard and the proportion of PAF and NAF-S waste expected to report to the landform from each material type.
- Residual voids: the landform AMD hazard score is estimated from the average of the source material AMD hazard scores for each material type likely to be exposed on the highwall or floor of each residual void.

To support the assessment of the AMD closure risks, the landform AMD hazard score is assigned a likelihood score (Table 12) as consistent as possible with Whitehaven Coal's risk management methodology, which is aligned with ISO 31000. ISO 31000 is a family of standards relating to risk management codified by the International Organization for Standardization. For landforms and residual voids with AMD hazard scores between 10 and 20 a preliminary likelihood of 'Probable / Likely' is assigned unless/until kinetic data are available to provide a time frame for AMD generation. This likelihood can be revised as more data, such as kinetic or field data, becomes available.

Table 12. AMD hazard ranking and landform/void AMD likelihood ranking

Landform AMD hazard scores	Landform AMD likelihood
0 - 5	Highly Unlikely: Highly unusual; may occur in extreme circumstances
5 - 10	Unlikely: Known to occur, but only rarely
10 - 15	Probable: May reasonably occur
15 - 20	Likely: Could easily occur
>20	Highly Likely: Expected to occur

5 Results

Environmental geochemical data is available for 4692 samples – all of which have undergone a range of environmental geochemical tests. The samples are representative of the following mineral waste and coal groups:

Spoil

- Weathered Non-carbonaceous: Overburden. 554 drill-hole samples;
- Weathered Carbonaceous: Overburden/interburden [includes weath. coal]. 9 drill-hole samples;
- Fresh, Non-carbonaceous: Overburden/interburden. 2527 drill-hole samples;
- Fresh, Carbonaceous: Overburden/interburden. 251 drill-hole samples.

Coal

- Fresh Coal: Representative of ROM coal. 370 drill-hole samples

Tailings

- Fresh tailings from NCPP. 280 samples
- Aged tailings from the TSFs. 363 drill-hole samples

Rejects

- Fresh rejects from NCPP. 48 samples
- Aged rejects from various locations: 217 samples (in total) from NCPP TSF, Laleham TSF, Ramp 72 TSF, Ramp 36 rejects dump and Red Dam area.

Additional to the above waste material types, geochemical data is also available for 54 'fill' samples and 19 'foundation' samples collected from geotechnical investigation drill-holes within the TSFs. The fill samples are mostly from Laleham TSF and represents spoil material used to cover tailings and used as part of embankment construction. The foundation samples represent the base of the TSF (immediately below tailings) encountered during geotechnical investigations. This 'fill' and 'foundation' data is presented in the figures/graphs herein for context, however is not discussed in great detail.

5.1 Mineralogy

Data is available for 72 samples, comprising: 45 spoil samples, 20 tailings samples (9 fresh samples and 11 aged samples) and 7 rejects samples that underwent mineralogical analysis by Quantitative X-Ray Diffraction (QXRD).

The samples were selected to assess a broad range of mineral waste types. The results are summarised in **Figure 5** (spoil samples) and **Figure 6** (tailings and rejects samples). Most samples are dominated by clay, quartz minerals (silicate group minerals) and non-crystalline (amorphous) material, variable contributions of carbonate and other silicate minerals.

Figure 5. Mineral distribution within spoil samples

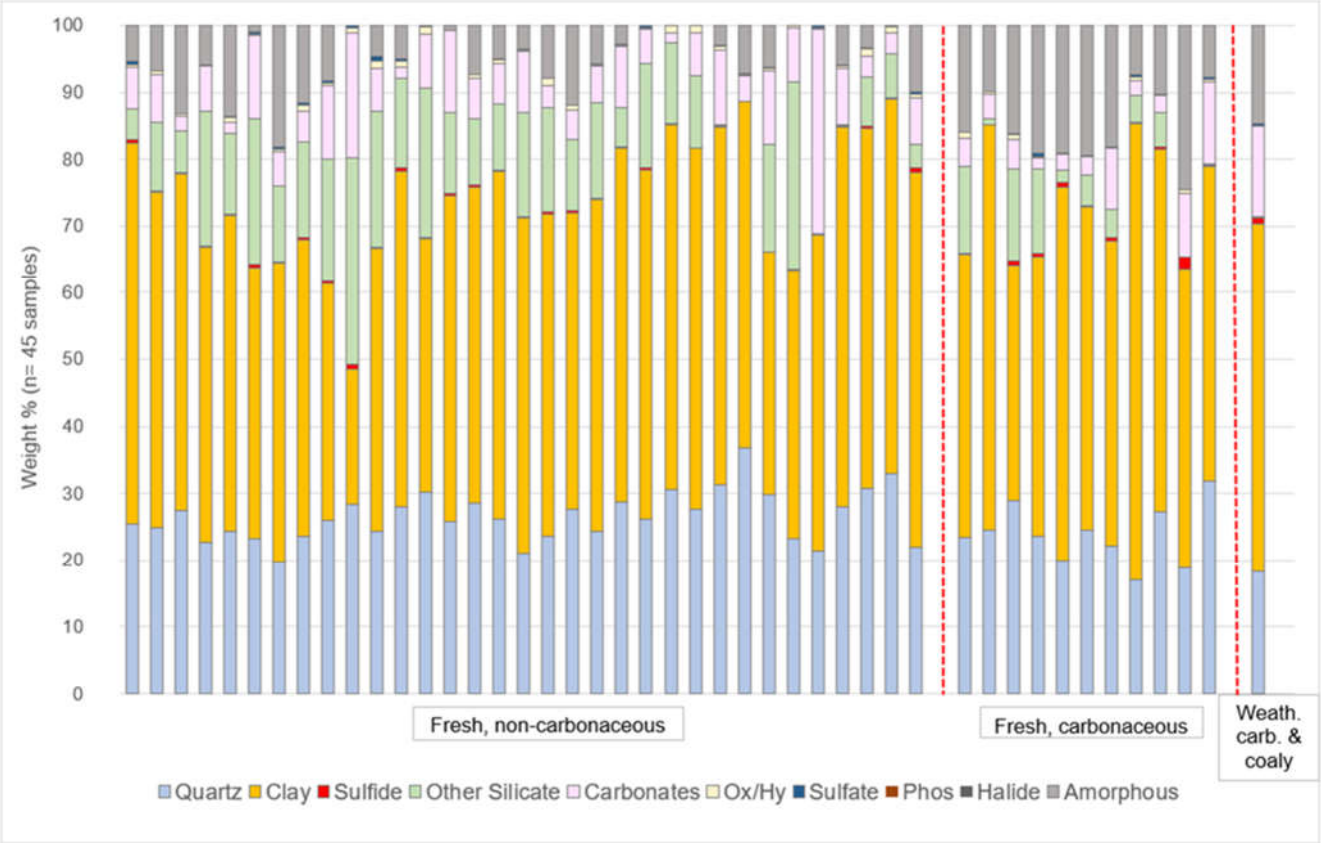
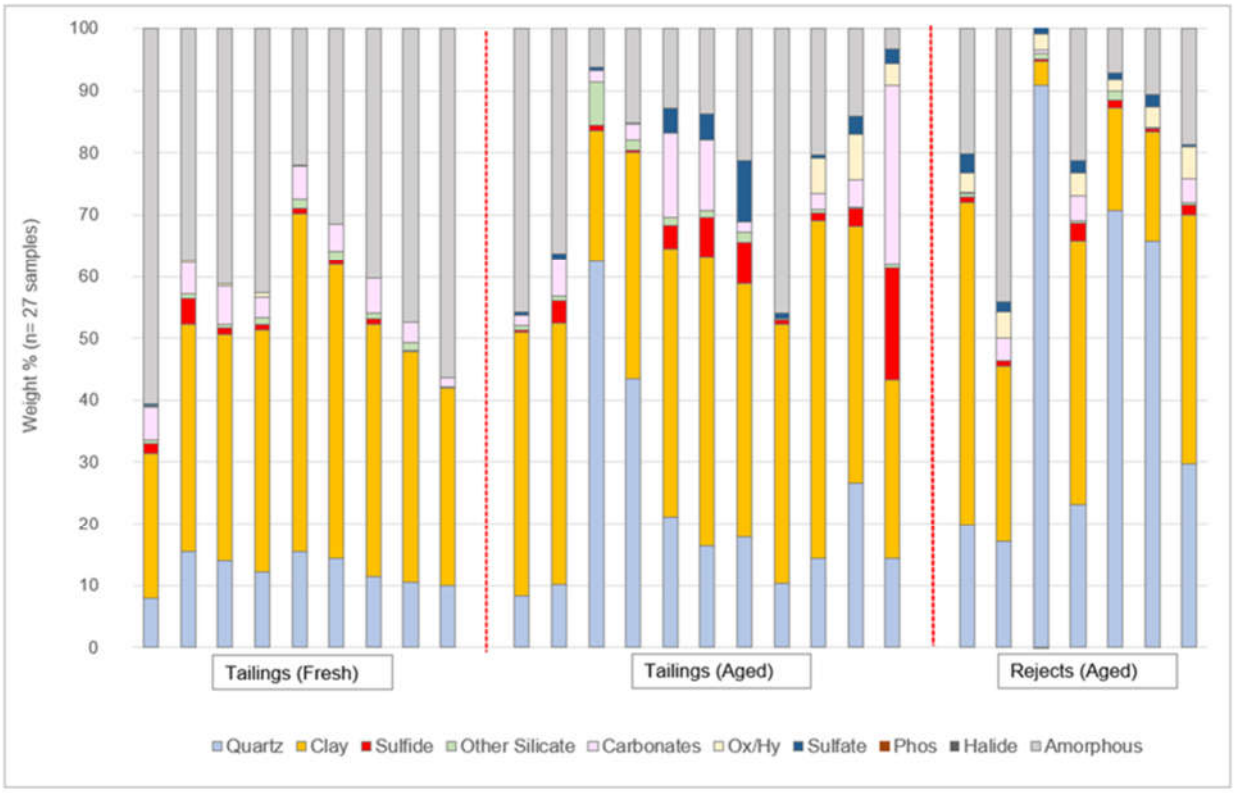


Figure 6. Mineral distribution within tailings and rejects samples



Most spoil samples have low sulfide mineral proportions as expected (median = 0.3%). Sulfide, where present, is present as pyrite and marcasite. All samples have low sulfate concentrations (median=0.25%), which is mostly present as jarosite in spoils, combination of jarosite and gypsum in rejects and combination of jarosite, gypsum, anhydrite and barite for tailings. The combination of jarosite and gypsum (+/- anhydrite) minerals in rejects and tailings is likely an indication of sulfide oxidation and naturalisation.

Amorphous (non-crystalline) material was detected in all samples, but generally present in greater proportions in the tailings and rejects samples (median = 21%) compared to the spoil (median = 6%). The nature of the non-crystalline material is largely unknown, although for tailings and carbonaceous waste it may be associated with organic carbon.

One carbonaceous 'spoil' sample – a seam roof sample – have high sulfide (pyrite) concentrations (1.8%) and was specifically selected for mineralogical test-work because of their high total S concentrations. Given the proximity of this sample to coal, it's likely that this sample would be mined as part of ROM coal and, therefore, is likely to represent 'potential' reject more so than spoil. That is, this sample is likely representative of rejects and not typical spoil.

The tailings and rejects samples generally have higher sulfide concentrations compared to the spoil samples (median = 0.9% for tailings fresh, median = 2.8% for tailings aged and median = 0.9% for rejects aged). Most fresh tailings samples have low sulfate concentrations, which is present as bassanite, jarosite and gypsum. The aged tailings and rejects samples had the higher sulfate concentrations, suggesting sulfide oxidation has occurred.

Across all material types, carbonate group minerals predominantly comprised calcite, ankerite (Fe-dolomite), siderite and rhodochrosite in variable proportions.

In summary, across all mineral types assessed, the key acid generating minerals are pyrite, marcasite and, to lesser extent, jarosite. The key acid neutralising minerals are iron-dolomite/dolomite and calcite. Although siderite is a carbonate, it provides no net acid neutralising capacity.

5.2 Acid-Base Accounting (Potential for AMD)

Acid-base accounting (ABA) is a theoretical balance between the potential for a sample to generate acid and neutralise acid, and is expressed in units of kilograms of sulfuric acid per tonne of sample (kg H2SO4/t). The ABA results for the samples that underwent geochemical characterisation are statistically summarised in **Table 13** (spoil) and **Table 14** (tailings, rejects and coal samples) and discussed in the following sections. TSF fill and natural ground samples had statistical values comparable to spoil.

Table 13. ABA results statistics for spoil samples

		Total S[1]	Scr[2] (S)	ANC	MPA[3]	NAPP	ANC/MPA	NAGpH[4]
		%		kg H_2SO_4/t			ratio	pH units
Spoil Weath[5]., non-carb[6].	Count (*n*)	*554*	*237 (237)*	*554*	*554*	*554*	*554*	*57*
	Maximum	0.69	0.69 (0.69)	408	21	18	2266	7.7
	95th percentile	0.07	0.04 (0.13)	86	2.1	0.5	357	7.1
	75th percentile	0.02	0.01 (0.03)	24	0.6	-1.9	83	6.6
	Median	**0.01**	**0.01 (0.02)**	**7.2**	**0.3**	**-6.4**	**21**	**6.0**
	25th percentile	0.01	0.01 (0.01)	2.8	0.2	-23	4.1	5.7
	5th percentile	<0.01	<0.01 (<0.01)	<0.5	0.2	-86	0.41	4.4
	Minimum	<0.01	<0.01 (<0.01)	<0.5	0.2	-406	<0.1	3.0
Spoil Weath., carb.	Count (*n*)	*9*	*8 (8)*	*9*	*9*	*9*	*9*	*5*
	Maximum	1.52	0.94 (1.52)	135	47	35	147	6.4
	95th percentile	1.19	0.80 (1.23)	89	36	24	96	6.4
	75th percentile	0.43	0.39 (0.50)	19	13	2.6	2.8	6.2
	Median	**0.38**	**0.13 (0.39)**	**14**	**12**	**-6.9**	**1.6**	**4.6**
	25th percentile	0.17	0.09 (0.18)	11	5.2	-10	0.8	3.7
	5th percentile	0.02	0.03 (0.07)	9.9	0.7	-85	0.4	2.7
	Minimum	0.02	0.01 (0.02)	9.0	0.6	-134	0.2	2.5
Spoil Fresh, non-carb.	Count (*n*)	*2527*	*1142 (1142)*	*2527*	*2527*	*2527*	*2527*	*54*
	Maximum	1.84	1.67 (1.84)	784	56	44	3337	8.8
	95th percentile	0.09	0.11 (0.15)	204	2.8	-11	408	8.5
	75th percentile	0.04	0.03 (0.04)	79	1.2	-25	122	7.6
	Median	**0.02**	**0.02 (0.03)**	**47**	**0.6**	**-46**	**62**	**6.1**
	25th percentile	0.02	0.02 (0.02)	26	0.6	-78	31	4.1
	5th percentile	<0.01	0.01 (0.01)	12	0.2	-203	8.2	2.7
	Minimum	<0.01	<0.01 (<0.01)	<0.5	0.2	-783	<0.1	2.6
Spoil Fresh, Carb.	Count (*n*)	*251*	*174 (174)*	*251*	*251*	*251*	*251*	*74*
	Maximum	2.58	1.79 (2.58)	300	79	61	456	9.2
	95th percentile	0.56	0.52 (0.69)	88	17	4.4	70	8.2
	75th percentile	0.26	0.21 (0.35)	37	7.8	-7.2	17	7.3
	Median	**0.12**	**0.17 (0.28)**	**21**	**3.7**	**-16**	**5.9**	**4.9**
	25th percentile	0.04	0.04 (0.12)	13	1.2	-32	2.4	3.6
	5th percentile	0.02	0.02 (0.03)	5.6	0.6	-78	0.7	2.6
	Minimum	<0.01	0.01 (0.01)	<0.5	0.2	-296	<0.1	2.3
Spoil ALL	Count (*n*)	*3341*	*1567 (1567)*	*3341*	*3341*	*3341*	*3341*	*194*
	Maximum	2.58	1.79 (2.58)	784	79	61	3337	9.2
	95th percentile	0.17	0.21 (0.35)	181	5.2	-0.8	379	8.2
	75th percentile	0.04	0.03 (0.06)	71	1.2	-18	110	6.8
	Median	**0.02**	**0.02 (0.03)**	**38**	**0.6**	**-37**	**51**	**5.9**
	25th percentile	0.02	0.02 (0.02)	20	0.6	-69	20	4.4
	5th percentile	<0.01	<0.01 (<0.01)	3.0	0.2	-177	1.6	2.7
	Minimum	<0.01	<0.01 (<0.01)	<0.5	0.2	-783	<0.1	2.3

[1] Total S values less than laboratory limit of reporting (LOR) were assigned a value of 0.5xLOR for statistical calculations.
[2] Scr was generally measured on potential spoil samples with total S greater than 0.1%. Values in parentheses are the total S statistics for samples with Scr results.
[3] MPA calculated from total S. [4] NAGpH is final pH as NAG single addition and/or NAG extended and/or Stage 1 Seq. NAG. NAG tests were generally undertaken on samples assigned a preliminary PAF, PAF-LC, UC(PAF) or 'Uncertain' classification.
[5] Weath.: weathered; [6] Carb.: carbonaceous.

Table 14. ABA results statistics for tailings, rejects and coal samples

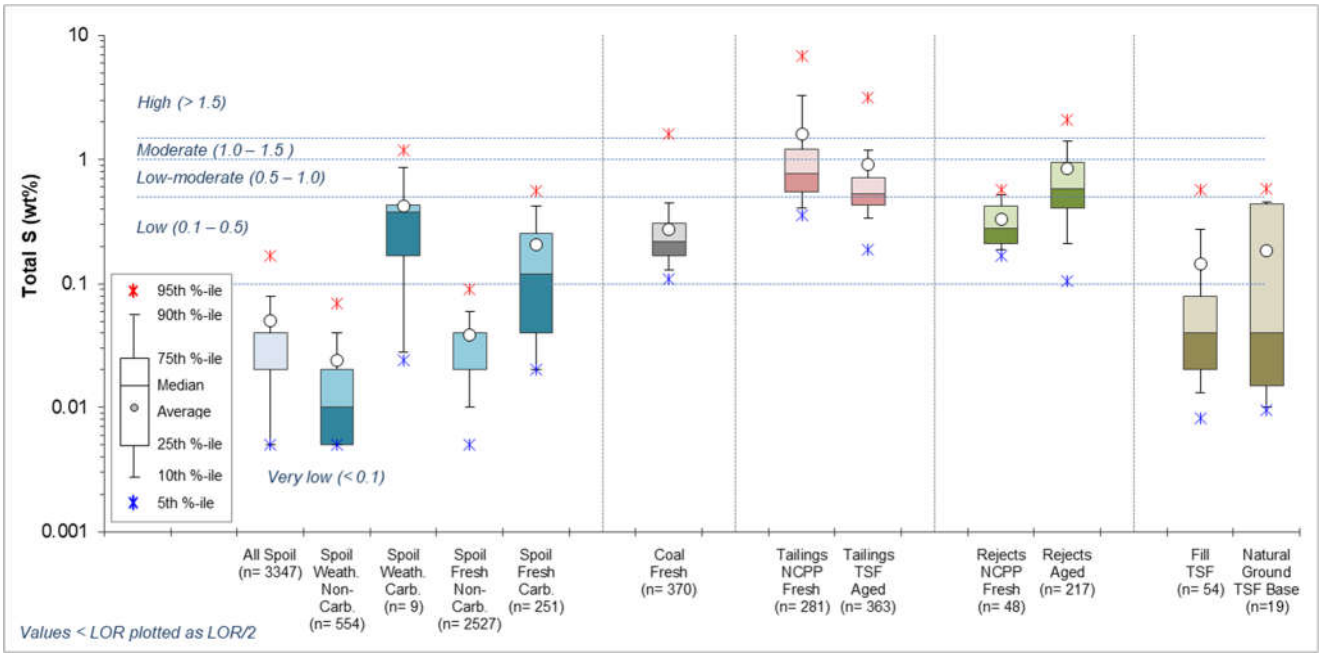
		Total S[1]	Scr[2] (S)	ANC	MPA[3]	NAPP	ANC/MPA	NAGpH[4]
		%		kg H_2SO_4/t			ratio	pH units
Tailings Fresh.	Count (*n*)	*281*	*280 (280)*	*279*	*281*	*279*	*279*	*263*
	Maximum	20.5	16.3 (20.50)	129	627	583	6.6	9.8
	95th percentile	6.80	5.45 (6.80)	65	208	117	3.1	9.0
	75th percentile	1.21	0.89 (1.21)	41	37	8.3	1.9	8.3
	Median	**0.77**	**0.53 (0.77)**	**32**	**24**	**-4.6**	**1.2**	**6.1**
	25th percentile	0.55	0.32 (0.55)	24	17	-15	0.8	3.3
	5th percentile	0.36	0.17 (0.36)	16	11	-27	0.3	2.4
	Minimum	0.20	0.08 (0.20)	<0.5	6.1	-51	<0.1	1.8
Tailings Aged	Count (*n*)	*363*	*321 (321)*	*363*	*363*	*363*	*363*	*103*
	Maximum	19.1	16.9 (19.1)	236	584	578	88	9.6
	95th percentile	3.16	1.94 (3.74)	36	97	58	2.7	6.7
	75th percentile	0.72	0.38 (0.7)	22	22	9.0	1.4	3.4
	Median	**0.53**	**0.25 (0.53)**	**16**	**16**	**1.8**	**0.9**	**2.9**
	25th percentile	0.43	0.15 (0.43)	11	13	-5.3	0.6	2.7
	5th percentile	0.19	0.03 (0.23)	5.9	5.8	-15	0.1	2.3
	Minimum	0.02	<0.01 (0.03)	<0.05	0.6	-208	<0.1	2.1
Rejects Fresh	Count (*n*)	*48*	*48 (48)*	*48*	*48*	*48*	*48*	*48*
	Maximum	0.78	0.63 (0.78)	86	24	-1.3	17	9.4
	95th percentile	0.57	0.47 (0.57)	77	17	-7.8	8.6	9.3
	75th percentile	0.42	0.34 (0.42)	47	13	-24	5.7	8.8
	Median	**0.28**	**0.20 (0.28)**	**40**	**8.6**	**-29**	**4.4**	**8.6**
	25th percentile	0.21	0.14 (0.21)	34	6.4	-37	2.8	8.4
	5th percentile	0.17	0.10 (0.17)	20	5.2	-64	2.0	7.9
	Minimum	0.14	0.05 (0.14)	13	4.3	-81	1.1	6.3
Rejects Aged	Count (*n*)	*217*	*177 (177)*	*217*	*217*	*217*	*217*	*77*
	Maximum	8.93	7.19 (8.93)	93	273	234	17	8.8
	95th percentile	2.07	1.52 (2.38)	47	63	48	4.7	8.7
	75th percentile	0.94	0.66 (1.03)	26	29	21	1.6	8.0
	Median	**0.58**	**0.31 (0.68)**	**17**	**18**	**1.6**	**0.9**	**5.3**
	25th percentile	0.41	0.07 (0.43)	10	13	-8.0	0.2	3.4
	5th percentile	0.11	0.02 (0.11)	5.2	3.2	-21	<0.1	2.6
	Minimum	0.02	0.01 (0.02)	<0.5	0.6	-56	<0.1	2.1
Coal Fresh	Count (*n*)	*370*	*357 (357)*	*370*	*370*	*370*	*370*	*204*
	Maximum	1.60	1.12 (1.6)	339	49	40.5	158	11.1
	95th percentile	0.62	0.37 (0.62)	94	19	7.5	12	8.3
	75th percentile	0.31	0.09 (0.32)	20	9.5	-0.2	2.9	6.1
	Median	**0.22**	**0.03 (0.22)**	**11**	**6.7**	**-3.5**	**1.5**	**3.7**
	25th percentile	0.17	0.02 (0.17)	7.4	5.2	-11	1.0	2.9
	5th percentile	0.11	0.01 (0.11)	0.6	3.4	-87	0.1	2.5
	Minimum	0.02	0.01 (0.02)	<0.5	0.6	-337	0.02	2.2

[1] Total S values less than laboratory limit of reporting (LOR) were assigned a value of 0.5xLOR for statistical calculations.
[2] Scr was generally measured on most tailings, rejects and coal samples. Values in parentheses are the total S statistics for samples with Scr results.
[3] MPA calculated from total S. [4] NAGpH is final pH as NAG single addition and/or NAG extended and/or Stage 1 Seq. NAG.

Sulfur and sulfide

The total sulfur (total S) distribution for all samples is presented in **Figure 7**. The total S concentration of spoil samples was generally very low to low – with a very low median value of 0.02% and low-moderate 95th percentile value of 0.17%. Carbonaceous spoil samples had higher total S values compared to non-carbonaceous spoil. Of the 3341 spoil samples, 6 samples (approximately 0.2% of all spoil samples) had high total S values (greater than 1.5%) and were all carbonaceous. Of these 6 samples, 5 samples were either closely associated with seams (ie. parting or thicker interburden between plys).

Figure 7. Sulfur (S) distribution



Total S concentration of most rejects and tailings samples was generally higher than most spoil samples (and expected) and also coal samples. NCPP tailings (fresh tailings) had slightly higher total S concentration overall compared to tailings samples from the TSFs (aged tailings). Comparatively, the total S concentration of the aged rejects from TSFs and reject dumps was much higher compared to NCPP rejects (fresh rejects). Total S concentration within the aged tailings is generally consistent with depth and spatial distribution throughout the TSFs where samples were collected. Therefore, differences between total S in fresh (NCPP) tailings versus aged (TSF) tailings is likely due to ROM coal geochemistry. The reasons for aged rejects having higher total S concentration (generally) compared to fresh rejects – where the opposite occurs with aged and fresh tailings – is unclear, although is likely due to ROM coal geochemistry. Many of the aged rejects samples have been sourced from NCPP TSF (primarily from within embankments), and most of the NCPP TSF embankments were constructed from older rejects stockpiled at Ramp 36 rejects dump.

Fill and natural ground material in the TSFs and natural ground samples from beneath the TSFs all have generally very low total S concentrations, as expected. Fill samples have total S distribution similar to spoil – as also expected.

Coal samples selected for test-work had relatively low total S values, with median, 75th and 90th percentile total S values of 0.22%, 0.31%, and 0.59 %, respectively. This sample subset has a total S distribution statistically equivalent to that of the larger BWM coal quality database. In particular, the 7495 coal samples from the BWM coal quality database have median, 75th and 90th percentile total S

values of 0.39%, 0.48% and 0.59%, respectively. Thus, the total S distribution in coal from the smaller geochemical dataset (n=370) is broadly comparable to the total S distribution in coal from the much larger coal quality dataset (n=7495).

Chromium reducible sulfur (Scr) data is available for 1561 spoil samples, 601 tailings samples, 225 rejects samples, 35 TSF fill samples and 357 coal samples. Scr was generally measured on samples with total S values greater than 0.1%. Where sulfide was measured in weathered samples, this was generally only in those samples described as being 'slightly' weathered. The total S and Scr distribution for spoil and coal samples is shown at **Figure 8** and for tailings, rejects and fill samples at **Figure 9**. Only total S values are shown for the same samples that underwent Scr tests.

Figure 8. Sulfur (S) and sulfide (Scr) distribution of spoil and coal samples

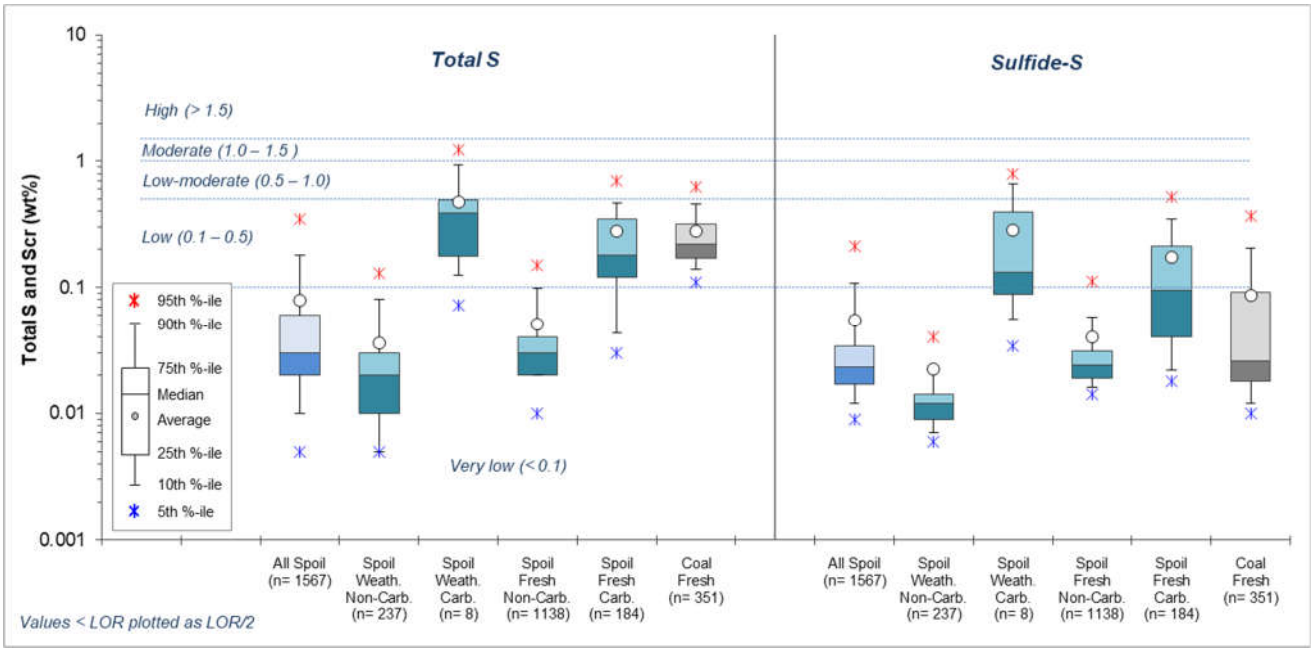
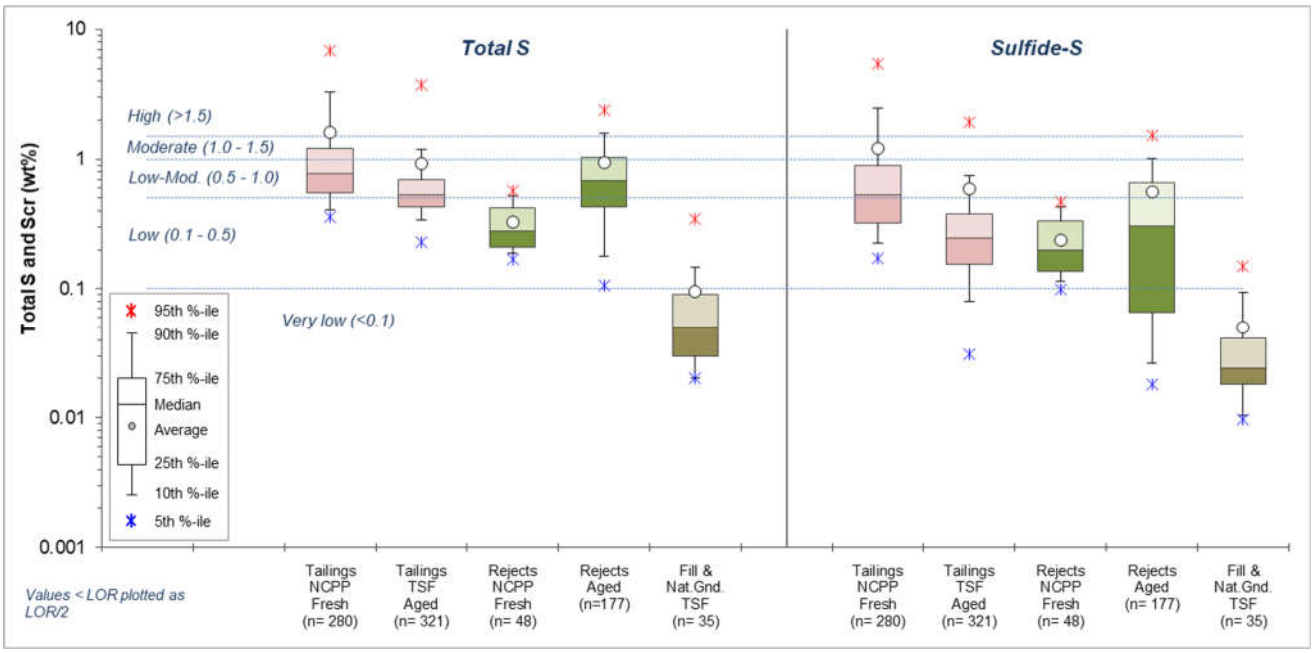


Figure 9. Sulfur (S) and sulfide (Scr) distribution of tailings, rejects and fill samples

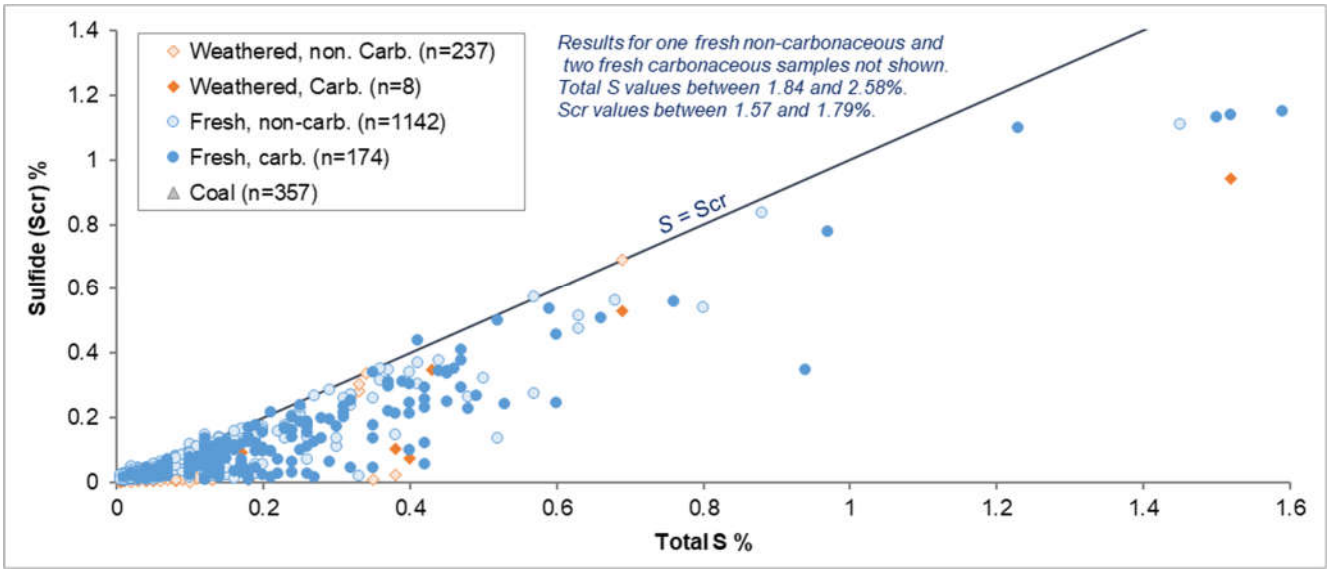


All spoil samples had Scr distributions only marginally lower than the total S distributions from the same group of samples. The Scr values for coal samples were generally lower compared to the total S values from the same samples.

Fresh (NCPP) tailings and rejects samples have Scr values only marginally lower than the total S values from the same samples. Comparatively, the Scr values for aged tailings and rejects are lower than the total S values from the same samples, suggesting that the aged tailings and rejects samples have likely oxidised to some extent. A similar trend, although not as pronounced, was observed in fill samples from the TSFs where the Scr values were lower than total S for the same samples.

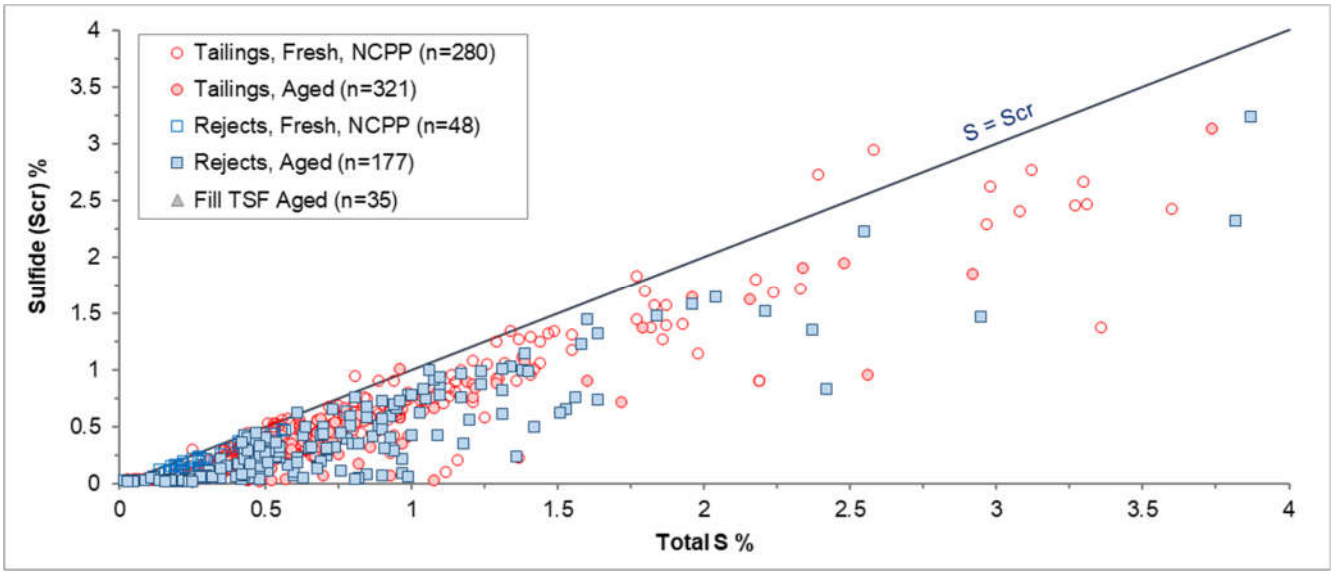
The relationship between Scr versus total S for spoil and coal samples where Scr data is available is shown in **Figure 10**. As a proportion of total S, Scr accounts for 85% (median value) of total S in spoil samples and 15% in coal samples. Of the spoil samples, Scr accounts for 83% (median value) of total S in weathered non-carbonaceous spoil, 87% in fresh non-carbonaceous spoil, 61% in weathered carbonaceous spoil and 63% of total S in carbonaceous spoil. This means that the proportion of acid generating sulfur is generally lowest in the coal and – to a lesser extent – the carbonaceous samples due to a greater proportion of these samples likely containing organic sulfur, compared to the non-carbonaceous samples (of which most were fresh and unoxidised). These results indicate that the maximum potential acidity (MPA) that could be generated by most samples from these material domains is generally low and that using total S as an indication of AMD hazard will result in a conservative outcome.

Figure 10. Sulfide (Scr) versus sulfur (S) for spoil and coal samples



The relationship between Scr versus total S for tailings, reject and TSF fill samples where Scr data is available is shown in **Figure 11**. As a proportion of total S, Scr accounts for 68% (median value) of total S in fresh (NCPP) tailings samples and 74% in fresh (NCPP) rejects samples. Comparatively, as a proportion of total S, Scr accounts for 48% (median value) in aged tailings and aged rejects samples. These results indicate that using total S as an indication of AMD hazard for all samples – but especially the aged samples – will result in a conservative outcome, since it is highly likely that some of the sulfide that may have been originally present in these aged tailings and rejects when they were fresh has oxidised to sulfate.

Figure 11. Sulfide (Scr) versus sulfur (S) for tailings, rejects and fill samples



Maximum potential acidity (MPA)

MPA is calculated from total S, therefore the MPA distribution for each material type mimics the total S distribution for the same samples (refer to **Figure 7**). Due to the generally very low to low total S (and Scr) values for spoil samples the MPA was correspondingly low, with 75th and 95th percentile MPA values of 1.2 and 5.2 kg H_2SO_4/t, respectively (n=3341 samples). As such, spoil represented by these samples is expected to have negligible potential to generate acid/acidity and negligible potential to release sulfate-derived salinity from sulfide oxidation. The small proportion of spoil with higher' MPA (as a result of the higher total S) would be well mixed throughout the bulk spoil and, as such, would not lead to spoil generating acid/acidity or sulfate-derived salinity.

Coal samples (n=370) produced MPA values generally higher than spoil – as expected by the higher total S values of coal samples. Coal samples had 75th and 95th percentile MPA values of 9.5 and 19 kg H_2SO_4/t, respectively. As discussed above, the proportion of total S associated with sulfide minerals in coal samples is low (15% of total S as Scr), with most sulfur likely associated with organic sulfur. Therefore, MPA values calculated from total S for coal samples is very conservative. By way of comparison, the 95th percentile MPA value for coal samples calculated from Scr (n=176) is 11 kg H_2SO_4/t – ie. about 60% of the 95th percentile MPA value calculated from total S.

Tailings and rejects had a wide range of total S values – ranging from low to moderate – depending on the material sub-type, which resulted in a correspondingly wide range of MPA values. For example, fresh (NCPP) tailings had a 75th percentile MPA of 37 kg H_2SO_4/t (n=281 samples). Comparatively, aged tailings had a slightly lower 75th percentile MPA of 22 kg H_2SO_4/t (n=363). Fresh (NCPP) rejects had a 75th percentile MPA of 13 kg H_2SO_4/t (n=48) whereas aged rejects had a much higher 75th percentile MPA of 29 kg H_2SO_4/t (n=217).

Acid neutralising capacity (ANC)

The ANC distribution for all samples is presented in **Figure 12**. The ANC values of spoil samples are typically well in excess of the MPA values and span a very large range, from less than 0.5 to 784 kg H_2SO_4/t, with a moderate to high median ANC value for spoil samples of 38 kg H_2SO_4/t and a 10th percentile value of 7 kg H_2SO_4/t, respectively. In other words, 90% of spoil samples have an ANC

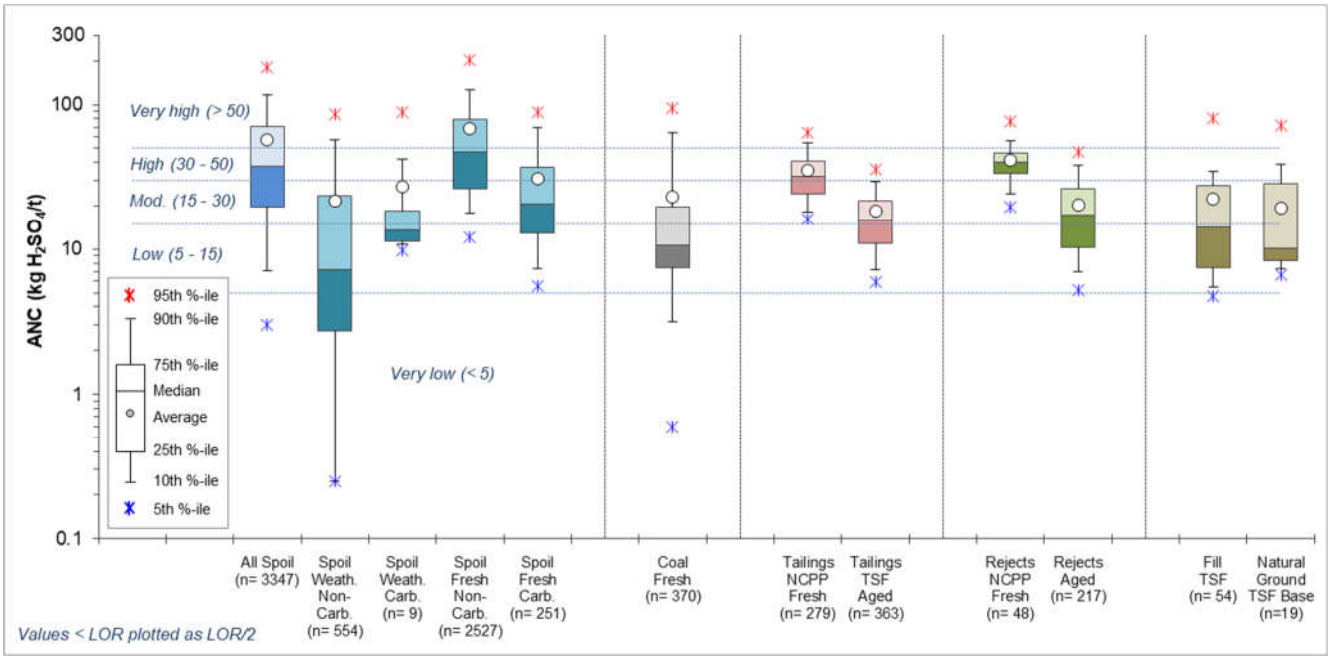
greater than 7 kg H_2SO_4/t which, if all ANC was readily available, would neutralise the acidity generated by material containing 0.23% S.

The ANC for the fresh (NCPP) tailings samples was generally moderate to high and for fresh (NCPP) rejects samples was generally high, with 10th percentile values of 18 and 24 kg H_2SO_4/t for fresh tailings and rejects, respectively. Comparatively, aged tailings and rejects had low to moderate ANC distribution with 10th percentile values for both material types of 7 kg H_2SO_4/t.

Coal samples had a wide range of ANC values from very low to high, but low overall with median and 10th percentile ANC values of 11 and 3 kg H_2SO_4/t, respectively.

TSF fill and natural ground samples from the TSFs generally had low to moderate ANC values with median values of 14 and 10 kg H_2SO_4/t, respectively – much lower than spoil samples.

Figure 12. Acid neutralising capacity (ANC) distribution

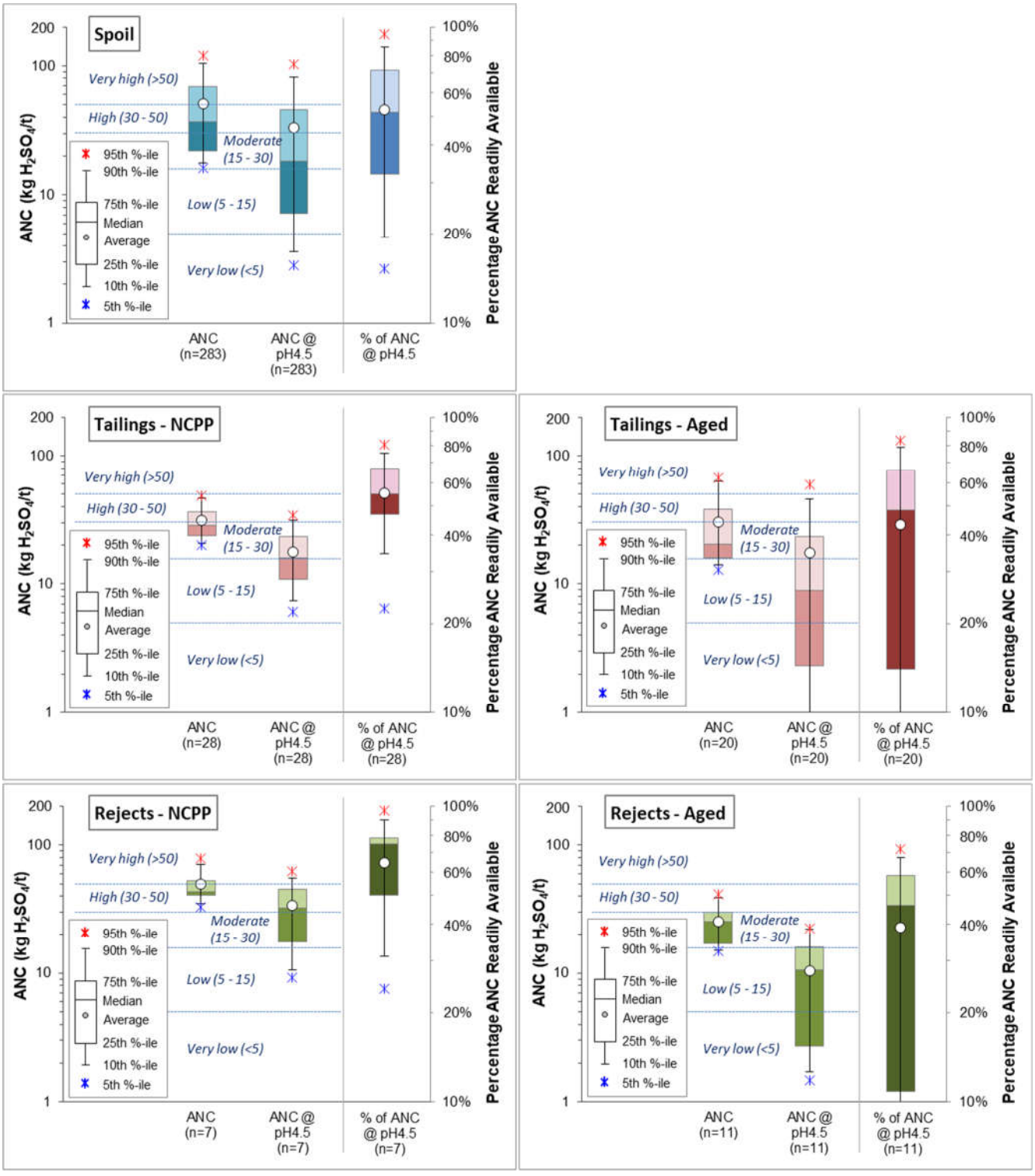


Available acid neutralising capacity

The availability of neutralising material is generally determined by the mineralogy of the sample – with calcite and dolomite (carbonate minerals) being more readily-available to neutralise acidity compared with, for example, silicates. Siderite, although a carbonate, has no net acid neutralising capacity. As such, ANC assumes that all ANC is readily available to neutralise acid, when this is rarely the case. Hence, ABCC (and mineralogical) test-work is undertaken to understand the effective ANC.

Acid buffering characterisation curve (ABCC) tests were undertaken on 283 spoil samples, 28 fresh (NCPP) tailings samples, 7 fresh (NCPP) rejects samples, 20 aged tailings samples and 11 aged rejects samples. ABCC results are used to assess the proportion of ANC that may be 'readily available' (ie. short-acting) in these materials under field conditions and provide some indication of what carbonate minerals are providing the ANC. 'Ready availability' is regarded as the proportion of ANC that is available for buffering reaction at pH 4.5. The results are summarised in Figure 13 for spoil, tailings and rejects samples.

Figure 13. Distribution of acid neutralising capacity (ANC) [total], ANC at pH4.5 and proportion (%) of ANC expected to be readily available



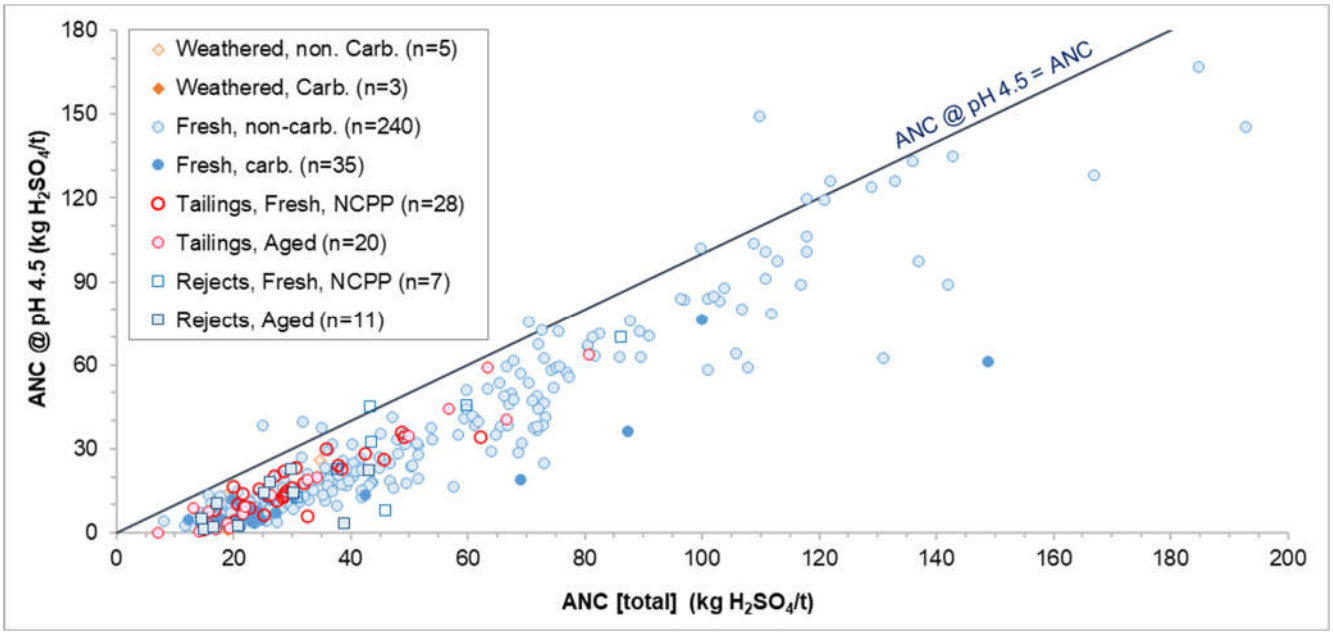
For the 283 spoil samples where ABCC data is available, the results showed that the proportion of ANC likely available under field conditions ranged from 10% to nominally 100% of the ANC, with a median of approximately 51%. The results suggest that generally, about 35% to 70% of the ANC is expected to be available under field conditions from spoil material – which is typical for spoil material from the Bowen Basin.

For the fresh tailings and rejects samples, the results showed that the proportion of ANC likely available under field conditions ranged from approximately 30-90% of the ANC, but overall (and based on the 25th and 75th percentile values), about 50-70% of the ANC is expected to be available under field conditions – fairly typical for fresh tailings and rejects from the Rangal Coal Measures.

Comparatively, the availability of ANC under field conditions for the aged tailings and rejects samples is very broad – ranging from essentially zero to nominally 100% – suggesting that the amount of ANC that may have already been consumed in the aged samples varies considerably.

The relationship between ANC @ pH 4.5 [ie. ABCC ANC] and ANC [total] (for samples where ABCC data is available) is shown in **Figure 14**.

Figure 14. ABCC ANC [ANC @ pH 4.5] versus ANC



ANC / MPA ratio

Generally, those samples with an ANC/MPA ratio greater than two are considered to have a negligible/low risk of acid generation (DIIS, 2016; INAP, 2009[3]), especially where sulfide concentrations are very low and reactive ANC is moderate to high – as is the case with the potential spoil samples.

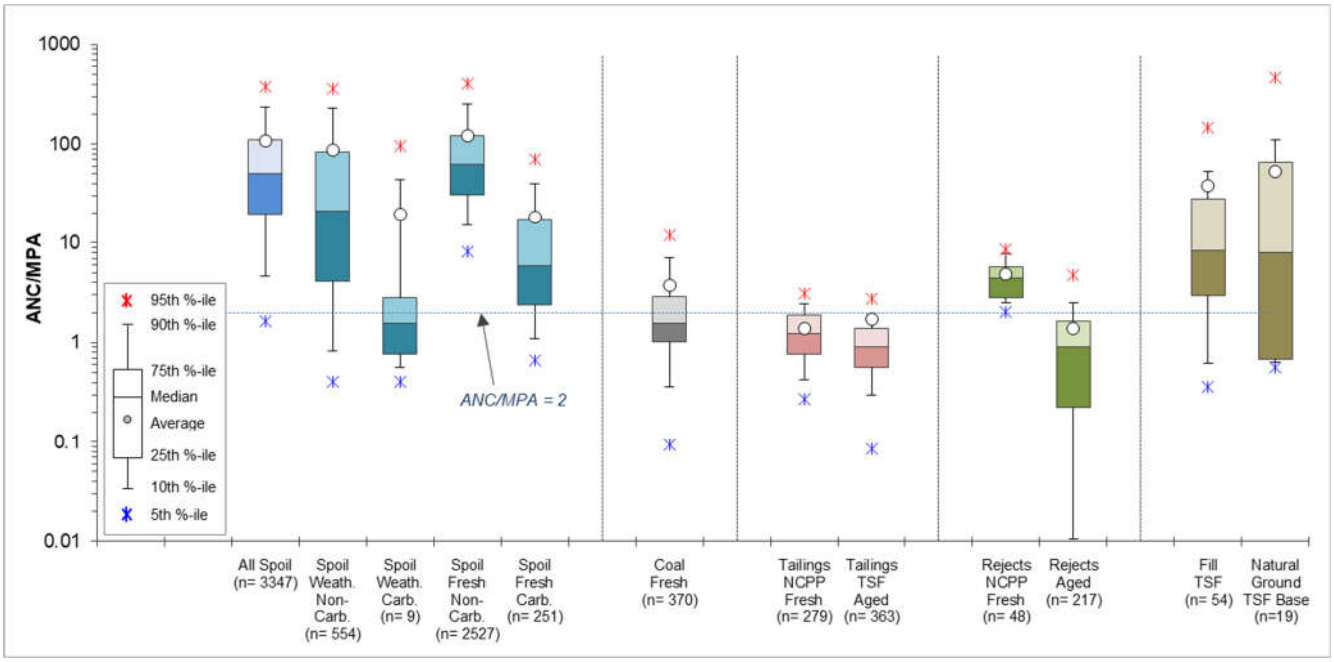
The results, illustrated in **Figure 15**, show that 3140 of the 3341 spoil samples (94% of spoil samples) have an ANC/MPA ratio greater than two – noting that 76% of all spoil samples are fresh non-carbonaceous. Approximately 79% of fresh carbonaceous spoil samples (199 out of 251 samples) have an ANC/MPA ratio greater than two. Fill and natural ground samples (from the TSFs) had similar ANC/MPA ratios to spoil samples.

Eighty six percent of all tailings samples (553 of 642 samples) and 60% of all coal samples had ANC/MPA ratios less than or equal to two. Most of the aged rejects samples also had ANC/MPA ratios

3 INAP (2009) considers that mine materials with an ANC/MPA ratio greater than two are likely to be NAF unless significant preferential exposure of sulfide minerals occurs along fracture planes, in combination with insufficiently reactive ANC.

less than or equal to two. Comparatively, most of the fresh (NCPP) rejects and other samples (fill and natural ground samples) have ANC/MPA ratios greater than two.

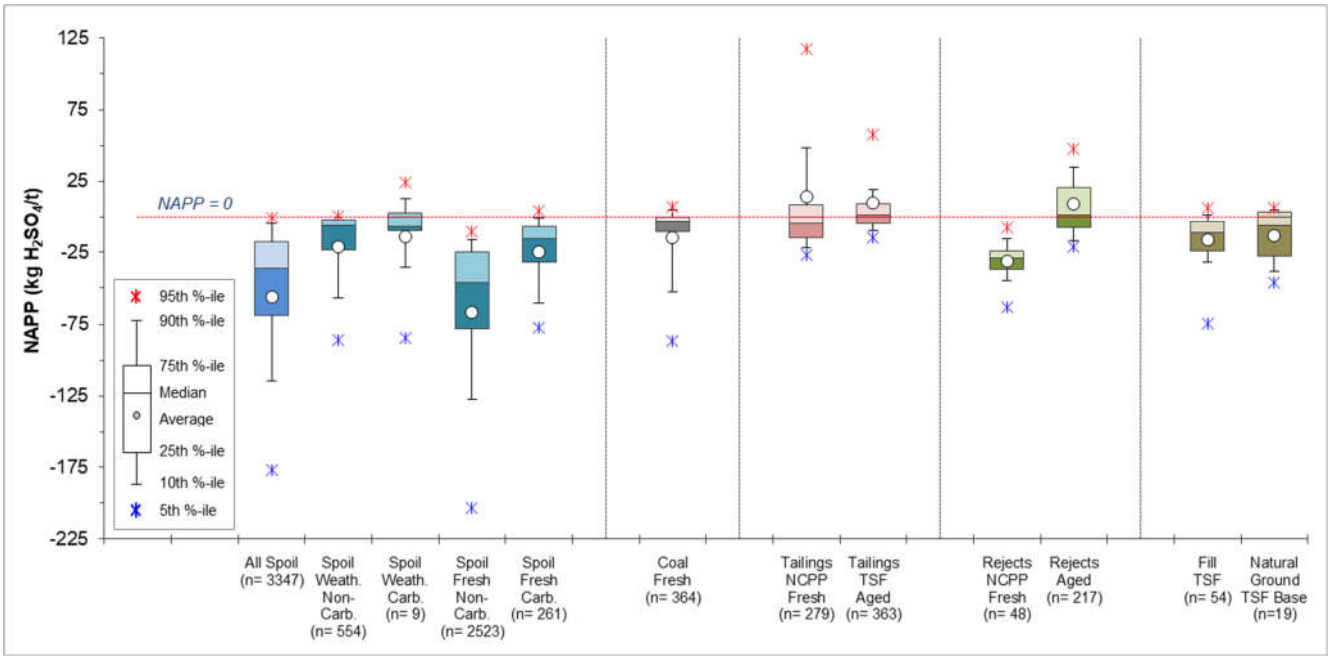
Figure 15. Distribution of the ratio of acid neutralising capacity (ANC) to maximum potential acidity (MPA) [ANC/MPA ratio]



Net acid producing potential (NAPP)

The NAPP distribution for all samples is presented in Figure 16.

Figure 16. Distribution of net acid producing potential (NAPP)



Based on the generally low MPA and higher ANC values (relative to the MPA), the calculated NAPP values are negative for the large majority of spoil samples. The results indicate that, overall, there is significantly excess neutralising capacity (ANC) compared to potential acidity (MPA) for spoil samples.

Tailings samples have a wide range of NAPP values from -27 to 117 kg H_2SO_4/t (5th and 95th percentile values, respectively), but overall range from low negative to low positive NAPP values (25th and 75th percentile values of -15 and 8 kg H_2SO_4/t, respectively). A similar trend was observed in aged rejects samples. Comparatively, almost all fresh rejects and TSF fill and natural ground samples reported negative NAPP values.

As evident in **Figure 16**, most of the coal samples reported negative NAPP values.

Net acid generation (NAG) capacity

NAG test results are used in conjunction with NAPP values in determining the acid classification of samples. The calculated NAPP value assumes that all sulfur (present as sulfide) will oxidise to generate acid (MPA) and that all neutralising material in a sample is in a readily available form to neutralise any acid that could be generated (ANC). Unlike the theoretical basis of the NAPP test, in a NAG test a sample is encouraged to oxidise by reaction with hydrogen peroxide and any acid generated through oxidation may be consumed by neutralising components in the sample. Any remaining acidity is measured and expressed as kg H_2SO_4/t.

Samples with NAGpH values greater than pH 4.5 are considered to be NAF. Samples with NAGpH values less than or equal to pH 4.5 (ie. acid-generating) would also be expected to have measurable NAG capacity (ie. NAG capacity greater than 0.1 kg H_2SO_4/t). As a guide, NAG capacity values between 0.1 and 5 kg H_2SO_4/t are considered 'low capacity' (AMIRA, 2002).

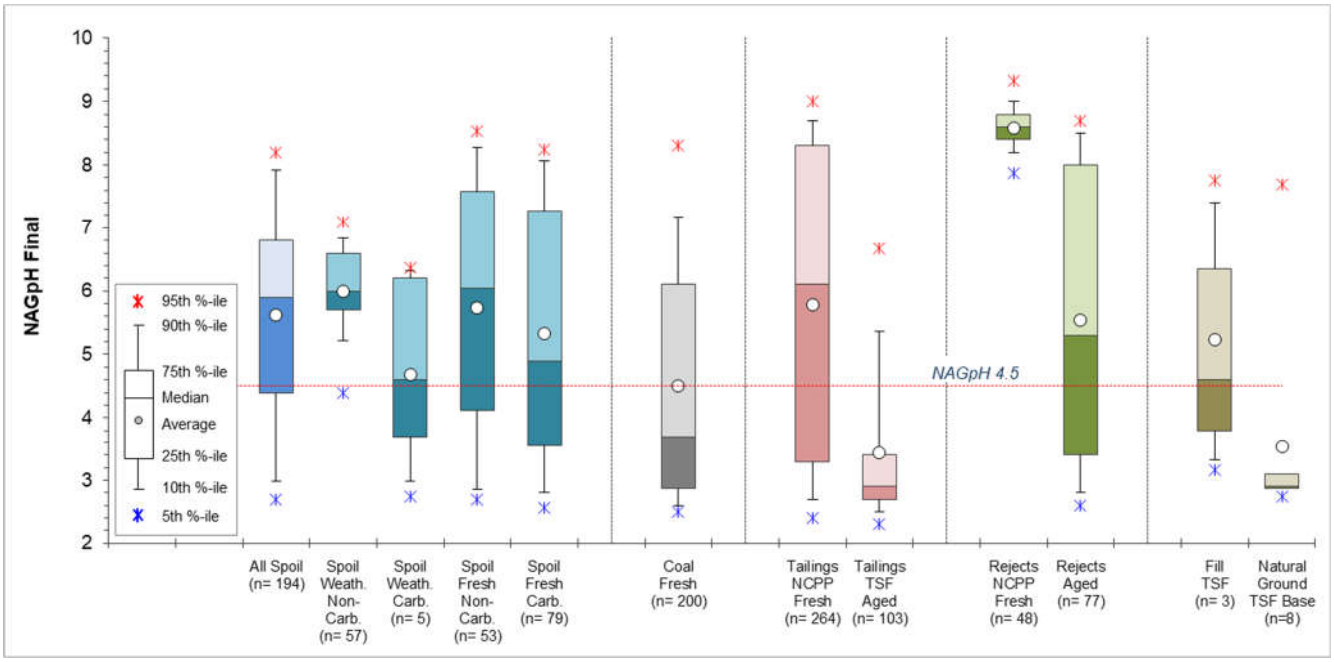
NAG test data is available for 190 spoil samples, 204 coal samples, 264 fresh tailings samples, 103 aged tailings samples, 48 fresh rejects samples, 77 aged rejects samples and 3 TSF fill samples and 8 natural ground samples from the base of TSF with the NAGpH distribution for these samples shown in **Figure 17**. Of the samples tested; 72% of spoil, 54% of fresh (NCPP) tailings, 9% of aged tailings, all fresh (NCPP) rejects, 53% of aged rejects, 67% of TSF fill and 13% of natural ground samples tested had NAGpH values greater than pH4.5.

As per general practice, NAG tests tend to be undertaken on samples with higher total S values and/or those samples potentially considered to have a greater potential to generate AMD, such as samples closely associated with coal seams, or tailings and rejects samples. As such, the proportion of samples with NAGpH values less than pH4.5 is not representing the actual proportion of material in the field that can generate acid conditions, but is indicative of the type of material (based on total S and ANC concentrations) that may generate AD under field conditions.

The NAG test can be influenced by organic acid (ie. organic acid can produce NAGpH between approximately pH 4 to 4.5, thus providing a 'false positive' for sulfuric acid). Organic acid is typically produced by samples with high organic carbon content – such as coal and highly carbonaceous samples. To attempt to resolve some of the uncertainty with the 'single addition' NAG test for coaly and highly carbonaceous samples, 240 samples underwent an Extended Boil NAG method (NAG Extended). Samples included 204 coal, 3 non-carbonaceous spoil, 6 coaly and carbonaceous spoil, 26 tailings and one reject sample.

Seventy (70) of these 240 samples (or 49% of samples) returned Extended NAGpH values greater than pH4.5, suggesting that for approximately half of the mostly coal and tailings samples tested the acidity generated in the 'single addition' NAG test was associated with the oxidation of organic carbon and not with sulfide oxidation.

Figure 17. Distribution of net acid generation pH (NAG single or NAG Extended or Stage 1 NAG Sequential)



AMD classification

The ABA results presented in this section have been used to classify the acid forming nature of the samples following the classification criteria outlined in Section 4.4 (Table 2). Additional relevant data, such as ABCC and Extended NAG test results were used to aid in the classification of samples where there was uncertainty following the preliminary AMD classification. The acid forming nature of these samples is summarised in Table 15.

Spoil

The classifications in Table 15 show that 97% of spoil samples were classified as NAF or were expected to be NAF [and have been classified as UC(NAF)]. These spoil samples and spoil material represented by these samples have very low sulfur concentration, significant excess ANC (relative to the MPA) and clearly have negligible capacity to generate AMD. Only 2% of spoil samples (82 out of 3341 samples) were classified as PAF, PAF-LC or UC(PAF). Two samples were classified as NAF-S.

Data show that potential spoil, as a bulk material, would be overwhelmingly NAF – and essentially all spoil away from seams (which is the overwhelming bulk of spoil) is expected to be NAF. Furthermore, the very low sulfur concentrations in spoil indicates that the sulfate concentration that could be generated in spoil from sulfide oxidation (in addition to any salinity unrelated to sulfide oxidation) would also be very low.

PAF spoil is mostly closely associated with seams, as seam roof, parting or floor, which may largely report to a CHPP as ROM coal and leave the CHPP as rejects. PAF spoil is also likely to be associated

with thicker interburden zones between seam plys of the same seam group. That is, PAF spoil is rarely encountered well away from seams.

Table 15. Geochemical classification of samples

Material Type	NAF	UC(NAF)	NAF-S	UC(PAF)	PAF-LC	PAF
	Number and (%) of samples					
Spoil, weath, non-carb. (n=554)	486 (88%)	40 (7%)	-	1 (<1%)	27 (5%)	-
Spoil, weathered carbonaceous (n=9)	6 (66%)	-	-	2 (22%)	-	1 (11%)
Spoil, fresh non-carbonaceous (n=2527)	2497(99%)	9 (<1%)	-	8 (<1%)	10 (<1%)	3 (<1%)
Spoil, fresh carbonaceous (n=251)	214(85%)	5 (2%)	2 (<1%)	16 (6%)	11 (4%)	3 (11%)
Spoil [all] (n=3341)	***3203 (96%)***	***54 (~2%)***	***2 (<1%)***	***27 (<1%)***	***48 (~1%)***	***7 (<1%)***
	3257 (97%)		***2 (<1%)***	***82 (2%)***		
Coal (n=370)	**233 (63%)**	**3 (<1%)**	**1 (<1%)**	**3 (<1%)**	**103 (28%)**	**27 (7%)**
	236 (64%)		***1 (<1%)***	***133 (36%)***		
Tailings, fresh, NCPP (n=280)	133 (48%)	13 (4%)	14 (5%)	50 (18%)	26 (9%)	44 (16%)
Tailings, aged, TSFs (n=363)	84 (23%)	56 (15%)	1 (<1%)	76 (21%)	106 (29%)	40 (11%)
Tailings [all] (n=643)	***217 (34%)***	***69 (11%)***	***15 (~2%)***	***126 (20%)***	***132 (21%)***	***84 (13%)***
	286 (44%)		***15 (~2%)***	***342 (53%)***		
Rejects, fresh, NCPP (n=48)	48 (100%)	-	-	-	-	-
Rejects, aged (n=217)	59 (27%)	24 (11%)	6 (~3%)	29 (13%)	52 (24%)	47 (22%)
Rejects [all] (n=265)	**107 (40%)**	**24 (9%)**	**6 (~2%)**	**29 (11%)**	**52 (20%)**	**47 (18%)**
	131 (49%)		***6 (~2%)***	***128 (48%)***		
Fill, aged, TSFs (n=54)	45 (83%)	4 (7.5%)	-	-	4 (7.5%)	1 (~2%)
Natural ground beneath TSFs (n=19)	12 (63%)	-	-	-	7 (37%)	-

Tailings

Approximately 53% of 643 tailing samples were classified as UC(PAF), PAF-LC or PAF and, of these 'PAF' samples, approximately 75% were classified as UC(PAF) or PAF-LC. About 43% of fresh (NCPP) tailings samples and 61% of aged (TSF) tailings samples were classified as 'PAF' of some type. Most of the aged tailings samples were logged as moist to wet at time of collection (excluding near-surface samples), and are therefore assumed to have not been subjected to significant oxidation – assuming deeper tailings were buried by overlying tailings soon after deposition. Fifteen tailings samples (almost all from the NCPP) were classified as NAF-S.

From an acid generating perspective a significant proportion (56%) of tailings were classified as 'PAF' (of some type) or NAF-S and, therefore, pose a potential AMD source hazard with respect to AD and/or NMD/SD. The relatively high proportion of 'PAF' tailings samples classified as UC(PAF) or PAF-LC

suggests that tailings, overall, are expected to generate low to moderate acidity loads if allowed to fully oxidise.

Rejects

The results show that all fresh rejects from the NCPP were classified as NAF; and approximately 38% of aged rejects were classified as NAF or UC(NAF). The remaining 62% of aged rejects had some type of broader 'PAF' classification, including six aged rejects samples classified as NAF-S. Therefore, from an acid generating perspective, almost two-thirds of the aged rejects pose a potential AMD source hazard with respect to AD and/or NMD/SD.

Coal

Compared to spoil, coal samples had marginally higher total S values and marginally lower ANC, which resulted in 36% of coal samples being classified as PAF, PAF-LC or UC(PAF) – including one sample classified as NAF-S. The proportion of PAF, PAF-LC, UC(PAF) and NAF-S samples is comparable across all coal seam groups being mined at BWM. It is worth noting that at least 80% of the coal samples classified as some form of 'PAF' [including the single sample classified as NAF-S] showed limited or uncertain capacity to generate acidity, suggesting that 'PAF' coal is unlikely to generate significant acid(ity). Furthermore, the Scr content of coal samples was generally low, suggesting that the 'PAF' (including PAF sub-groups) classification is conservative for most coal samples. On the other side of the acid-base account, it is recognised that ANC is likely an overestimate, however the AMD classification already takes this into account by assuming ANC is only 50% available (ie. the classification uses an ANC/MPA ratio of 2).

Approximately 64% of coal samples tested (236 out of 370 samples) were classified as NAF or UC(NAF), and seam material represented by these samples has very low sulfur values, excess ANC (relative to the MPA) and clearly has no capacity to generate acidity or release significant sulfate from sulfide oxidation.

These results suggest that coal represented by these samples and stored on a ROM pad, or located within pit walls or un-economic coal seam material reporting as spoil (mixed with non-coal spoil) would likely be bulk NAF. A small proportion of coal (from all seam groups) poses a greater, but relatively low, AMD source hazard.

Fill and Natural Ground

Fill samples from within the TSFs were predominantly NAF or UC(NAF), with less than 10% of fill samples conservatively classified as PAF-LC or PAF. Fill material is assumed to be 'general spoil' placed at various times over parts of the TSF during construction phases of TSF raises or as a temporary cover, before being overlain by tailings or rejects. Data show that fill material within the TSFs would be predominantly NAF. Furthermore, the very low sulfur concentrations in fill indicates that the sulfate concentration that could be generated in fill from sulfide oxidation (in addition to any salinity unrelated to sulfide oxidation) would also be very low.

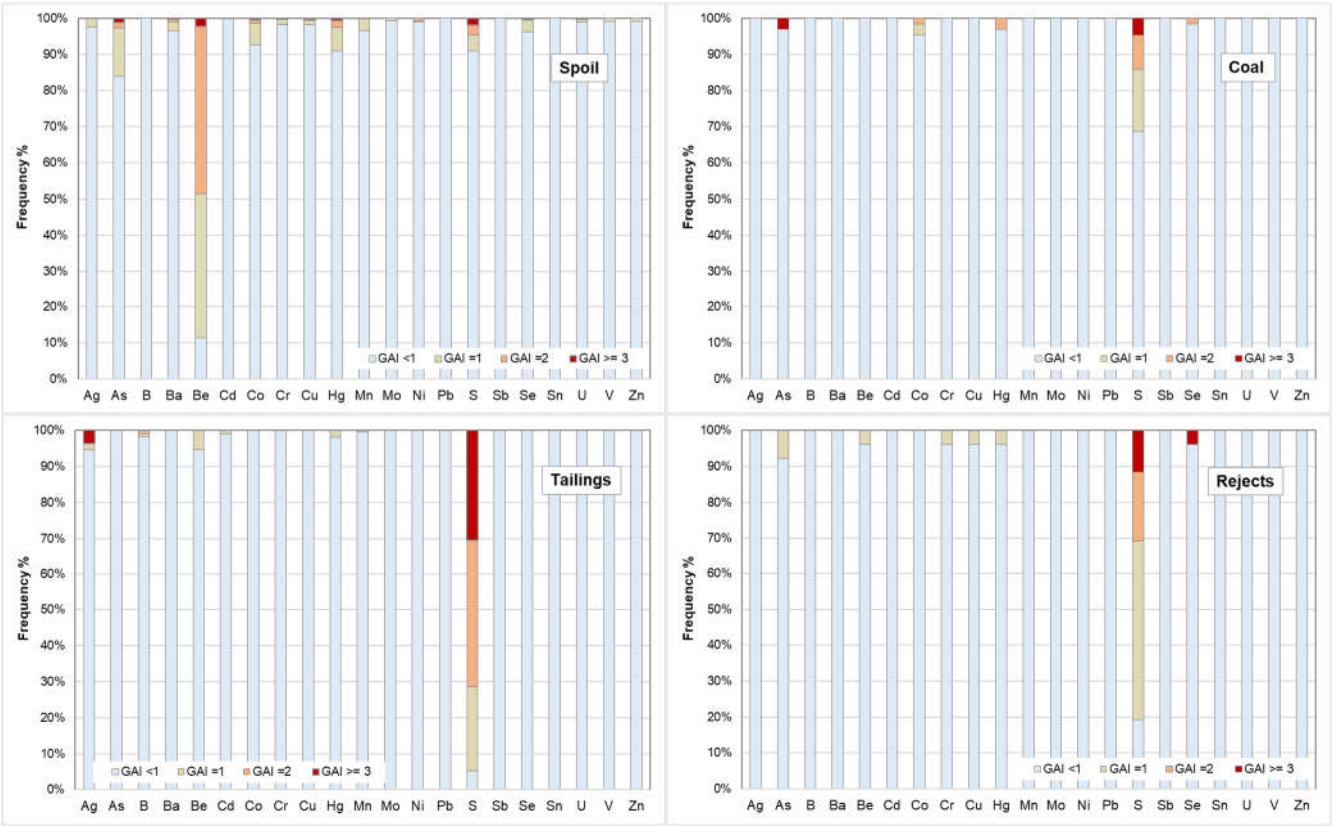
Twelve of 19 natural ground samples (from beneath the TSFs) were classified as NAF. The remaining 7 samples were conservatively classified as UC(PAF).

5.3 Total Metals and Metalloids

Multi-element (metal and metalloid) data is available for 582 samples, comprising 445 spoil samples [all four spoil groups represented], 64 coal samples, 26 rejects samples [13 fresh and 13 aged] and 56 tailings samples [42 fresh and 14 aged]. The degree of enrichment with respect to elements potentially of environmental interest for the spoil, coal, reject and tailings materials is shown in **Figure 18**.

The GAI values show that 10 (out of 445) spoil samples and two (out of 64) coal samples were significantly enriched [GAI ≥3] with regard to one or more of beryllium (Be) and/or sulfur (S). The level of S enrichment in these samples is consistent with the ABA data for these same samples. The enrichment in Be in a small number of samples is not cause for concern. Five spoil samples and two coal sample were significantly enriched with regards to arsenic (As). Three spoil samples were significantly enriched with regards to mercury (Hg) and one spoil sample was significantly enriched with regards to Uranium (U). Three coal and two spoil samples were also enriched with one or more of cobalt (Co), chromium (Cr), copper (Cu) and/or selenium (Se) – again, such enrichment in a very small number of samples is not cause for concern.

Figure 18. Frequency distribution of geochemical abundance indices (GAI) of selected elements in spoil, coal, tailings and rejects)



With regard to the degree of element enrichment in tailings samples, 13 out of 42 fresh (NCPP) tailings samples and four (out of 14) aged tailings samples were significantly enriched in S, with the degree of enrichment consistent with the ABA data for these same samples.

Comparatively, no fresh (NCPP) rejects samples were significantly enriched for any metals or metalloids. Three out of 13 aged rejects samples were significantly enriched with regard to S. One aged rejects sample was significantly enriched with regard to Se.

The GAI values also show that a considerable number of samples tested (of all material types) had minor enrichment (GAI = 1 or 2) with regard to one or more of As, Be, Co, Be, Co, Hg, S and/or Se and a much small number of samples had minor enrichment with regard to one or more of silver (Ag), barium (Ba), boron (B), cadmium (Cd), Cr, Cu, Mn, molybdenum (Mo), nickel (Ni), Se, U, vanadium (V) and/or zinc (Zn).

Overall, the results suggest that bulk mineral waste materials have generally low levels of metal and metalloid enrichment, which is consistent with Permian-age coal measures throughout Qld. A small proportion of samples (of all material types) have a higher degree of enrichment in some metals – notably Be – however enrichment in Be in these materials in not cause for concern.

5.4 Initial Solubility in Deionised Water

To evaluate the initial solubility of multi-elements in samples, water extract test results for pH and EC are available for 4691 samples, comprising: 3341 spoil samples, 370 coal samples, 642 tailings samples, 265 rejects samples, 54 TSF fill samples and 19 natural ground samples (from the base of TSFs). Test results for major ions and soluble metals/metalloids are available for 622 samples which comprise of 445 spoil samples, 64 coal samples, 15 fresh rejects samples, 34 aged rejects samples, 39 fresh tailings samples, 34 aged tailings samples and 2 TSF fill samples.

Therefore, a large dataset is available to assess the potential for leaching of salt and environmentally important elements from mineral wastes (spoil, tailings and rejects) and coal at BWM. Water extract tests provide a preliminary indication of the elements that may be readily mobilised from any given material type.

The samples underwent a 1:5 w:v (solid:water) deionised water bottle leach procedure on fine pulps. Note that the use of fine pulped materials in water extract tests will enable a high level of reaction and dissolution. The results from these tests are summarised and discussed below.

The test-work has found that bulk spoil is pH-alkaline, generally non-saline to slightly saline and has very low concentrations of soluble metals and metalloid concentrations – within the range typical for Tertiary and Permian overburden and interburden materials in Queensland. For most spoil samples, the soluble metals and metalloids are at concentrations below or marginally above the laboratory limit of reporting (LOR). Comparatively, tailings and rejects (fresh and aged) have a much wider range of solubility characteristics compared to spoil – as expected.

Electrical conductivity (EC) and pH

EC and pH data is available for 4691 samples at 1:5 w:v on pulp (**Figure 19**).

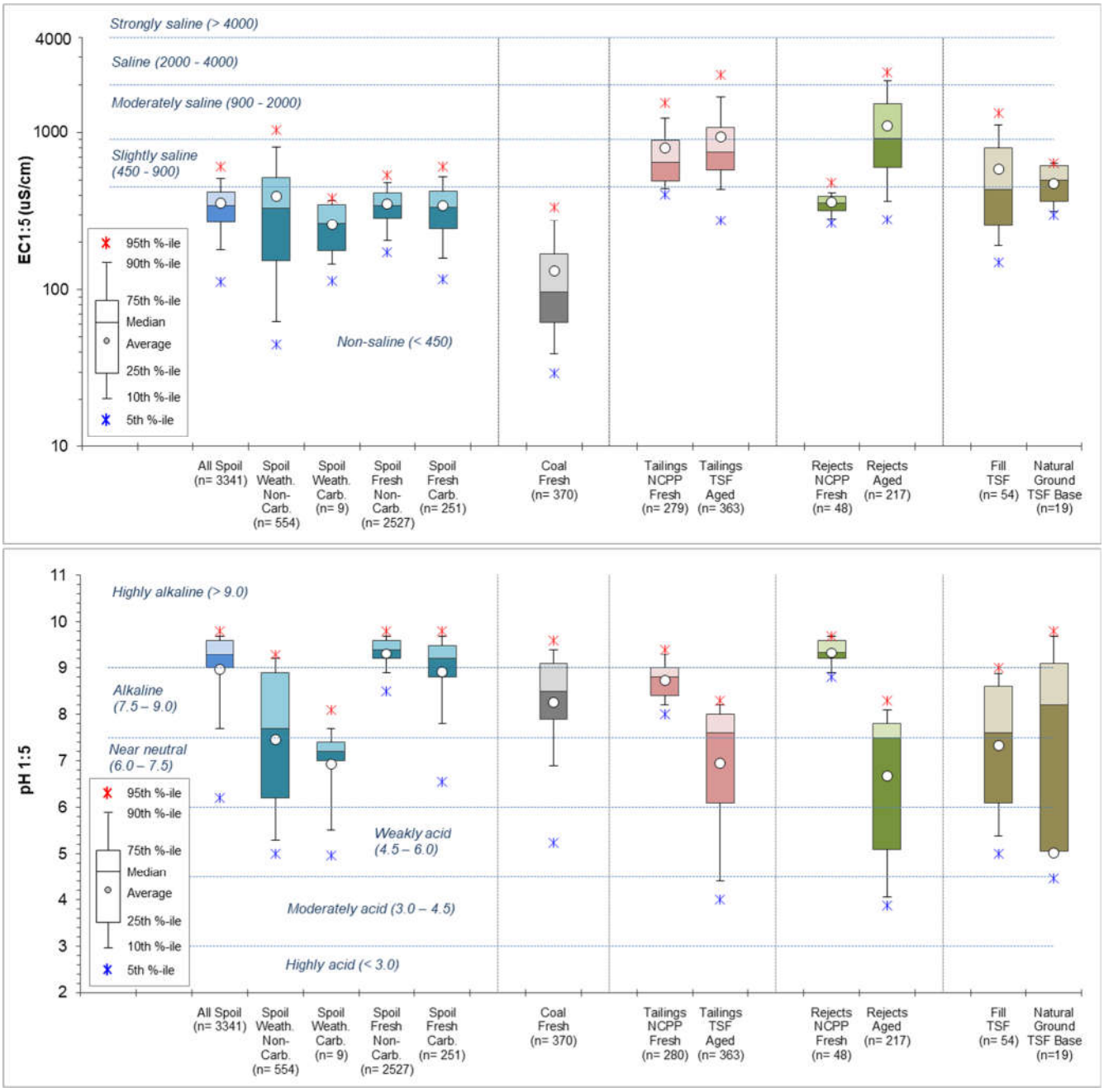
The $EC_{1:5}$ of 3341 spoil samples spanned a large range from less than 100 to 2790 μS/cm, with median, 75th and 90th percentile $EC_{1:5}$ values of 343, 419 and 513 μS/cm, respectively. As a bulk material, spoil is generally non-saline. These $EC_{1:5}$ results for spoil are common (if not typical) for Bowen Basin Permian and Tertiary material in the region.

There is generally little difference in $EC_{1:5}$ values between fresh and aged tailings, with fresh tailings (n=280) being slightly saline (median = 645 μS/cm) and aged tailings (n=363) being slightly to low-moderately saline (median = 748 μS/cm). Fresh rejects samples (n=48) were all generally non-saline whereas aged rejects (n=330) had $EC_{1:5}$ values ranging from non-saline to moderately saline. Fresh

tailings and rejects had median $EC_{1:5}$ values of 645 and 356 μS/cm respectively. Overall, bulk tailings and bulk rejects can be conservatively assumed to be slightly to moderately saline.

Coal samples (n=370) are non-saline.

Figure 19. Electrical conductivity (EC) and pH distribution



The $pH_{1:5}$ distribution by material type shows bulk spoil, coal, fresh tailings and fresh rejects samples to be alkaline to highly alkaline. These pH results are common – if not typical – for Bowen Basin Permian and Tertiary material in the region. Some weathered spoil has naturally low $pH_{1:5}$ results (weakly acidic to near-neutral), which is typical for some weathered materials and is not due to AMD processes.

Approximately 28% of aged tailings and rejects samples were acidic to varying degrees – ranging from highly acidic through to weakly acidic. Of the 580 aged tailings and rejects samples, 13% had $pH_{1:5}$

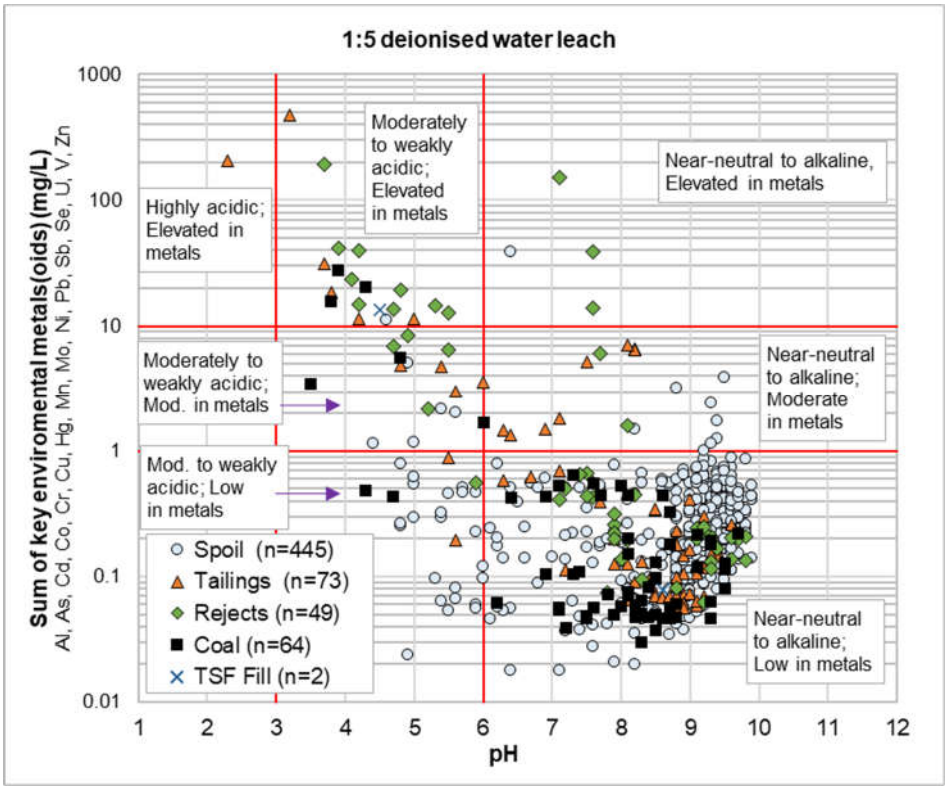
values between 4.5 and 6.0 (weakly acidic), 15% had $pH_{1:5}$ values between 3.0 and 4.5 (moderately acidic) and one aged tailings sample had $pH_{1:5}$ value less than pH 3.0 (pH 2.3 - highly acidic). In total, approximately 15% of all aged tailings and rejects samples had $pH_{1:5}$ values less than or equal to pH 4.5 and are classified as being moderately to highly acidic – evidence of sulfide oxidation and acid generation. Of these moderately to highly acidic aged tailings and rejects samples, most were from Laleham TSF and Ramp 72 TSF. Five samples (all tailings) were from NCPP TSF and three samples (all rejects) were from near surface rejects remaining near Red Dam [rejects located in the southern end of Ramp 72 pit (Kenmare pit) were excavated from Red Dam area in the early 2000s].

Soluble metals and metalloids

Deionised water extract (leaching) data for major ions and a broad suite of metals/metalloids is available for 445 spoil samples, 64 coal samples, 39 fresh tailings samples, 34 aged tailings samples (from NCPP TSF and Laleham TSF), 15 fresh rejects samples, 34 aged rejects samples (mostly from Ramp 72 – Kenmare pit rejects) and 2 TSF fill samples. All samples underwent a 1:5 w:v (solid:water) water extract procedure on pulps. All samples were analysed under ICP-MS method.

The sum of 16 environmentally important elements are plotted as a function of pH in **Figure 20**, in a modified version of what is referred to as a Ficklin plot (after Ficklin *et al.*, 1992). The 16 selected metals/metalloids comprise: aluminium [Al], antimony [Sb], arsenic [As], cadmium [Cd], cobalt [Co], chromium [Cr], copper [Cu], lead [Pb], mercury [Hg], manganese [Mn], molybdenum [Mo], nickel [Ni], selenium [Se], uranium [U], vanadium [V] and zinc [Zn].

Figure 20. Sum of key environmental metals versus pH in deionised water extracts



Approximately 94% of spoil samples have low soluble metals concentrations and have near-neutral to alkaline pH. Of the remaining spoil samples, most are near-neutral to alkaline pH but with moderate

metals concentrations. A small number of spoil samples are weakly acidic and with moderate or elevated metals concentrations.

Approximately 88% of coal samples produced near-neutral to alkaline pH with low soluble metals concentration. Five 'PAF' coal samples produced weakly to moderately acidic pH with moderate to elevated soluble metals concentrations and two PAF-LC samples produced weakly to moderately acidic pH with low soluble metals concentrations. These results indicate that 'PAF' coal is capable of generating AD and/or SD/NMD.

All fresh (NCPP) tailings samples and approximately 47% of the aged tailings samples have low soluble metals concentrations and have near-neutral to alkaline pH. Of the remaining 18 aged tailings samples, 10 samples have moderate metals concentrations and have near-neutral to alkaline pH; two samples have moderate metals concentration and have weakly to moderately acidic pH; five samples have elevated metals concentration and have weakly to moderately acidic pH; and the remaining sample had elevated metals concentration and had highly acidic pH. Generally, the NCPP TSF and Laleham TSF tailings samples had similar soluble metals concentrations, however the Laleham TSF samples had lower pH compared to the aged tailings samples from NCPP TSF.

All fresh (NCPP) rejects samples and approximately 47% of the aged rejects samples have low soluble metals concentrations and have near-neutral to alkaline pH – the same statistics as for the aged tailings samples. Of the remaining 18 aged rejects samples, four samples have moderate soluble metals concentration and are weakly to moderately acidic; two samples have moderate soluble metals concentration and have near-neutral to alkaline pH; nine samples have elevated soluble metals concentration and have weakly to acidic pH; and the remaining three aged rejects samples have elevated soluble metals concentration and have near-neutral to alkaline pH. Aged rejects are sourced from a variety of locations, however 62% of samples (with soluble metals data) are from Ramp 72 TSF – Kenmare pit rejects), and these aged rejects samples had a wide range of soluble metals concentrations. Almost all 'acidic' aged rejects were from Ramp 72 – Kenmare pit rejects.

Of the two TSF fill samples, one sample reported elevated soluble metals concentration with weakly to moderately acidic pH (and was classified as PAF-LC) and the other had near-neutral to alkaline pH with low soluble metals concentration.

In pH-neutral to alkaline waters, many metals/metalloids cannot remain in solution and, thus, trace metal/metalloid concentrations are generally low. Comparatively, in acid(ic) waters, many metals/metalloids are highly soluble and remain in solution and, thus, trace metal/metalloid concentrations are generally high. Notable exceptions to these general rules include elements such as As, Mn, Sb and Se, which remain soluble through a wide pH range. Other trace metals that are somewhat soluble under pH-neutral to alkaline conditions include Cd, Cr, Mo and Zn. As such, under the pH-alkaline conditions of the leach, the mobility of these elements would not be inhibited.

The median concentrations of major ions and environmentally important metals/metalloids in deionised water extracts are shown in **Table 16** for spoil, coal, tailings and rejects.

Table 16. Median concentrations of major ions and selected elements in deionised water extracts

Median concentration mg/L	Spoil (n=445)	Coal (n=64)	Tailings Fresh (n=39)	Tailings Aged (n=34)	Rejects Fresh (n=15)	Rejects Aged (n=34)
≤ 0.0001	Hg	-	Cd, Hg	Cd	Cd, Hg	Hg
≤ 0.001	Bi, Be, Cd, Cr, Co, Cu, Pb, Mn, Sb, Ni, U	As, Bi, Be, Cd, Cr, Co, Cu, Hg, Pb, Mn, Ni, Sb, U	Be, Bi, Cr, Co, Cu, Sb, Ni, Sn, U	Be, Bi, Sb, Cr, Hg, Mo, Sn, U	Be, Bi, Cr, Co, Cu, Pb, Mn, Ni, Sn, U	As, Be, Bi, Sb, Cd, Cr, Pb, Mo, Sn, U
≤ 0.01	Se, Sn, V, Zn	Al, Se, Sn, V, Zn	As, Pb, Mn, Se, V, Zn	As, Cu, Pb, Se, V	Sb, V, Zn	Cu, Se, V
≤ 0.1	As, B, Ba, Fe, Mo	B, Ba, Fe, Mo	Al, B, Ba, Fe, Mo	Al, B, Ba, Co, Fe, Ni, Zn	Al, As, B, Ba, Fe, Mo, Se	Ba, B, Co, Fe, Ni, Zn
≤ 1.0	Al, F	F, K	F	F, Mn	Ca, Mg, F	F, Al
≤ 10	Ca, Mg, K	Cl, Ca, Mg	Ca, Mg	-	Cl, K	Cl, Mn
≤ 100	SO_4, Cl, Na	SO_4, Na	K	Ca, Cl, Mg, Na, K	Na, SO4	K, Mg, Na
≤ 1000	-	-	Cl, Na, SO_4	SO_4	-	Ca, SO_4

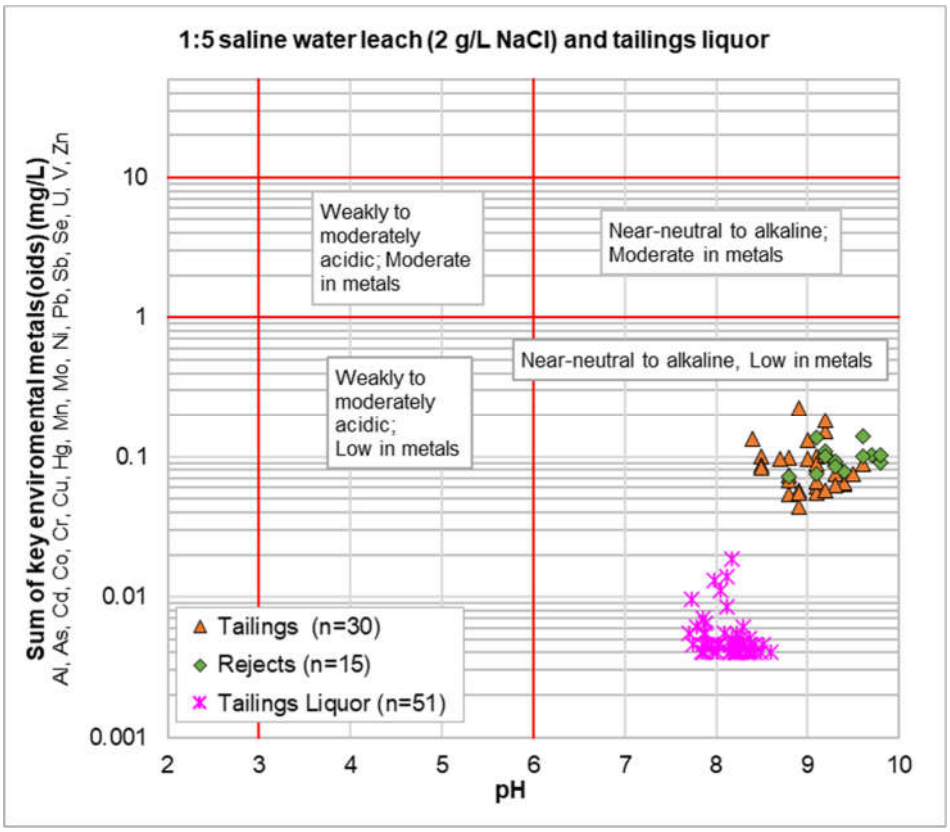
5.5 'Saline' Water Solubility of Tailings and Rejects

Thirty (30) fresh tailings and 15 fresh rejects samples from NCPP underwent a 1:5 w:v (solid:water) mildly saline (brackish) water extract procedure on pulps using a 2 g/L sodium chloride (NaCl) leaching solution. This leach was undertaken to determine the solubility of metals and metalloids under 'brackish' conditions – which better simulate the normal (brackish) water quality of the NCPP process water. Note that the salinity of NCPP process water varies from fresh to brackish on a day-to-day basis depending upon the source of the water from within the mine water management system.

The sum of the concentration of 16 environmentally important elements are plotted as a function of pH from the saline leach solution for tailings and rejects in **Figure 21** (along with the data for tailings liquor – **Section 5.6**). The 16 selected metals/metalloids are the same elements as per the 1:5 deionised water leach. The soluble metals and metalloid concentrations were very low and, in most cases, very similar to the concentrations from the de-ionised water (freshwater) leaching tests for these same samples. All samples had near-neutral to alkaline pH and were low in metals. For essentially all elements and major ions (excluding chloride and sodium) there was little difference between the soluble concentrations in the 'brackish' leachate compared to the freshwater leachate.

The results have shown that the solubility of tailings and rejects is low under 'brackish' leaching conditions.

Figure 21. Sum of key environmental metals versus pH in saline water extracts and tailings liquor



5.6 Characteristics of Tailings Liquor (Water)

Water quality data for tailings liquor is available for 51 tailings slurry samples collected from the NCPP (at the thickener underflow). The sum of the concentration of 16 environmentally important elements are plotted as a function of pH from the tailings liquor solution in **Figure 21** (along with the data for the saline leach solutions – **Section 5.5**). The 16 selected metals/metalloids are the same elements as per the 1:5 deionised water leach, saline water leach and peroxide leach.

All tailings liquor samples have near neutral to alkaline pH and low soluble metals concentrations. The liquor is highly saline, with EC values ranging from 2210 to 5410 μS/cm (median = 4220 μS/cm) and a median total dissolved solids (TDS) of 2700 mg/L. The dominant cation is Na and the dominant anions are Cl and SO_4 (equally dominant).

By comparison, the 2 g/L NaCl saline leach solution was less saline, with a median TDS for tailings and rejects 'saline' leach samples of 2113 mg/L and 2293 mg/L, respectively. The dominant cations and anions in the saline leach were Na and Cl, respectively, as expected due to the NaCl used to create the saline solution.

5.7 Peroxide Leachate Solutions

Peroxide leachate (NAG leach) data is available for 87 samples comprising:

- 2 weathered non-carbonaceous spoil samples classified as UC(NAF) and PAF-LC.

- 4 fresh non-carbonaceous spoil samples: one sample classified as UC(NAF), two samples classified as UC(PAF) and one sample classified as PAF.
- 3 fresh carbonaceous samples: two samples classified as UC(NAF) and one sample classified as UC(PAF).
- 8 coal samples: two samples classified as PAF, five samples classified as PAF-LC and one sample classified as UC(PAF);
- 48 tailings samples (28 fresh and 20 aged) of mixed classifications (NAF to PAF, including UC(NAF) and UC(PAF)). Aged samples are from NCPP TSF and Laleham TSF;
- 20 aged rejects samples (19 samples from Ramp 72 TSF and 1 sample from Laleham TSF) – all 'PAF' classes, except for four samples classified as NAF; and
- 2 other samples (1 fill sample from Laleham TSF and 1 natural ground sample from the base of Laleham TSF) both classified as NAF.

Peroxide leachate is the solution remaining from a single addition (standard) NAG test after the sample has been oxidised with peroxide to encourage oxidation and neutralising reactions, if ANC is available. The test encourages complete and rapid oxidation, with the resulting leach representing and assumed 'worse case' scenario in term of metal/metalloid mobility. The purpose of this test is to understand what metals/metalloids can be mobilised following full oxidation. The samples submitted for this test were selected to assess the hazard of similar waste type or to assist clarifying borderline geochemical properties.

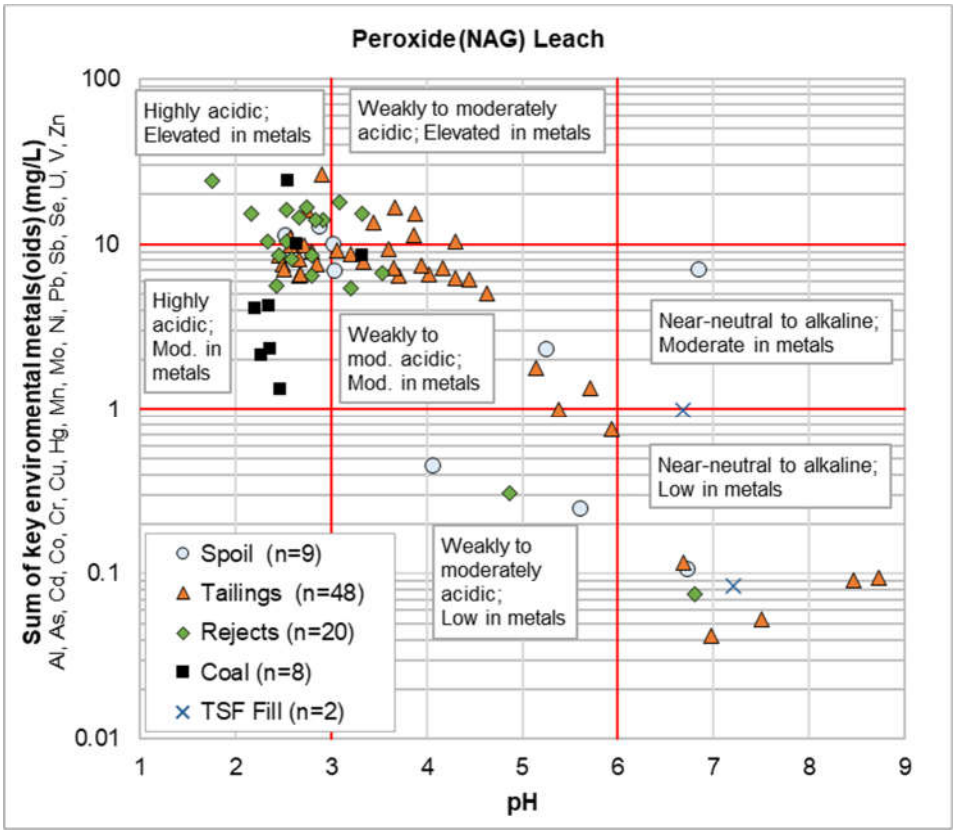
It must be noted that samples with potentially high organic carbon concentrations, such as coal, some tailings and some reject samples, may be influenced by organic acids producing acidity and correspondingly elevated soluble metals concentrations unrelated to AMD. As such, the results for coaly and highly carbonaceous samples should be interpreted with this in mind.

The sum of the concentration of 16 environmentally important elements are plotted as a function of pH from the peroxide leachate solution in Figure 22. The 16 selected metals/metalloids are the same elements as per the 1:5 deionised water leach, saline leach and tailings liquor.

Most samples have highly acidic to weakly acidic peroxide (NAG) leach pH and moderate to elevated soluble metals concentrations – primarily due to the low pH enhancing solubility. Approximately 82% of samples had pH less than 6.0 (ie. acidic to some degree). Of the 16 samples plotting with near-neutral to alkaline pH (and mostly also with low soluble metals), all were classified as NAF or UC(NAF) – their classification being confirmed by the peroxide leach. Of the remaining (bulk of) samples producing some level of acidic pH, approximately 80% were classified as PAF, PAF-LC or UC(PAF) – their classification being confirmed by the peroxide leach.

Most of the tailings samples and almost all of the rejects samples were weakly to highly acidic and had moderate to elevated metals concentrations. Extended NAG test results are available for 26 of the 48 tailings samples that underwent peroxide leaching. Of these, 13 tailings samples had extended NAG test results that showed the presence of organic acids in these samples (ie. producing extended NAGpH values greater than pH 4.5). Therefore, it's reasonable to conclude that many/most of these 13 samples (ie. nearly 30% of the tailings samples subjected to peroxide leaching) may be producing elevated metals partially as a result of organic 'acidity', not necessarily from AMD.

Figure 22. Sum of key environmental metals versus pH in peroxide (NAG) leachate solution



The median concentrations of major ions and environmentally important metals/metalloids in peroxide leachate solution from spoil, coal, tailings and rejects samples are shown in Table 17.

Table 17. Median concentrations of major ions and selected elements in deionised water extracts

Median concentration mg/L	Spoil (n=9)	Coal (n=8)	Tailings (n=48)	Rejects (n=20)
≤ 0.0001	Hg	Hg	-	-
≤ 0.001	As, Be, Bi, Cd, Sb, Sn, U	Cd, Sn	-	Sb, Bi, Sn, Hg
≤ 0.01	Co, Pb, Mo, Se	As, Be, Bi, Sb, Mo, Se, U	Hg	As, Be, Cd, Pb, Mo, Se, U
≤ 0.1	B, Cr, Cu, F, Mn, Ni, V	Cr, Co, Pb, V	Be, Bi, Cd, Sb, Sn, U	B, Cr, V
≤ 1.0	Ba, Cl, Fe, Zn	B, Ba, Cu, F, K, Mn, Ni, Zn	As, Pb, Li, Mo, Se	F, Ba, Co, Cu, Ni, Zn
≤ 10	Al, Ca, Mg, K	Al, Mg	B, Cr, Co, Cu, F, Ni, V	Al, Mg, Cl, K, Mn
≤ 100	SO_4, Na	Ca, Cl, Na, Fe	Cl, Mg, K, Al, Ba, Mn, Zn	Na, Ca, Fe
≤ 1000	-	SO_4	Ca, Na, Fe, SO_4	SO_4

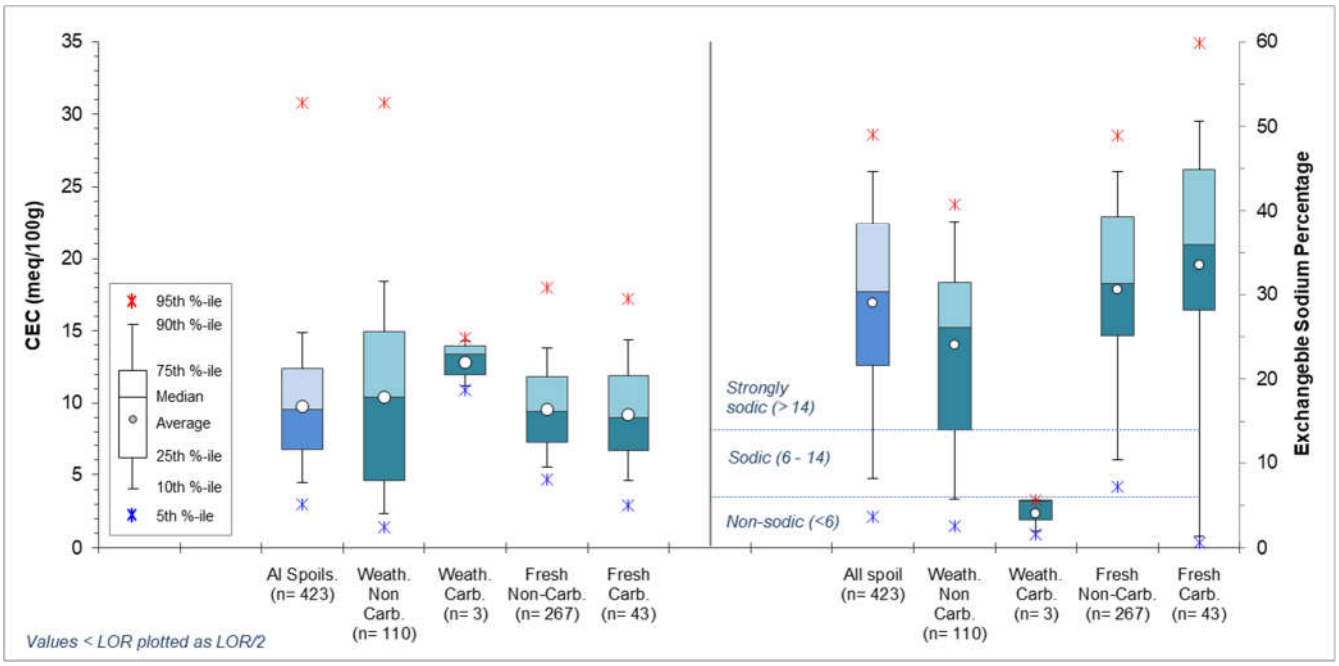
The results suggest that under acid/acidic conditions, materials represented by these samples are capable of generating elevated metal and metalloid loads for several metals/metalloids, however the

SO_4 (and salinity) loads are not expected to be high – due to the generally low total S concentrations (with exceptions for some tailings samples, and lesser so rejects). These data suggest that if PAF/PAF-LC material is allowed to oxidise without ANC available to buffer acidity, material similar to that tested might mobilise metals and metalloids at elevated concentrations, over time.

5.8 Cation Exchange Capacity, Sodicity and Dispersion Potential of Spoil

Exchangeable cation concentrations are used to evaluate the potential 'soil quality' of materials. Exchangeable cation data [as cation exchange capacity (CEC)] and exchangeable sodium percentage (ESP) is available for 423 spoil sample. The results are summarised in Figure 23.

Figure 23. Cation exchange capacity (CEC) distribution and exchangeable sodium percentage (ESP) distribution of spoil



The CEC spans a modest range from <1 to 30 milliequivalents per 100 grams (meq/100g), with a relatively low median CEC value of 9.6 meq/100g. There was generally little difference between the CEC of the different spoil types.

The ESP results range from less than 1% to 100%, with a median ESP of 30%. Approximately 92% of samples had ESP values greater than 6% and approximately 81% of samples had ESP values greater than 14%. Therefore, based on the ESP values alone, essentially all spoil is regarded as being 'sodic' to 'strongly sodic' and, as such, a significant proportion of mine spoil at BWM can be expected to have potential for dispersion.

All 423 spoil samples tested for ESP also underwent Emerson aggregate class tests to determine whether these samples were dispersive. Emerson aggregate class tests are a direct measure of soil dispersion, whereas ESP values are used as an indirect measure of the potential for a sample to have structural stability problems and hence may be dispersive. The results show that about 70% of samples (294 out of 423 samples) had some dispersion [slaking] (Class 2). Seventeen samples had an Emerson Class of 3 [dispersion] and two samples had an Emerson Class of 5 [dispersion; with calcite or gypsum present]. The remaining 26% of samples (110 out of 423 samples) were non-dispersive, with Emerson

Class numbers of 4, 6, 7 or 8. Refer to **Section 4.4** for class descriptions. Although these results show variability when compared to CEC and ESP results, they are closely aligned (ie. 70% of samples had some dispersion and 81% of spoils had ESP greater than 14%).

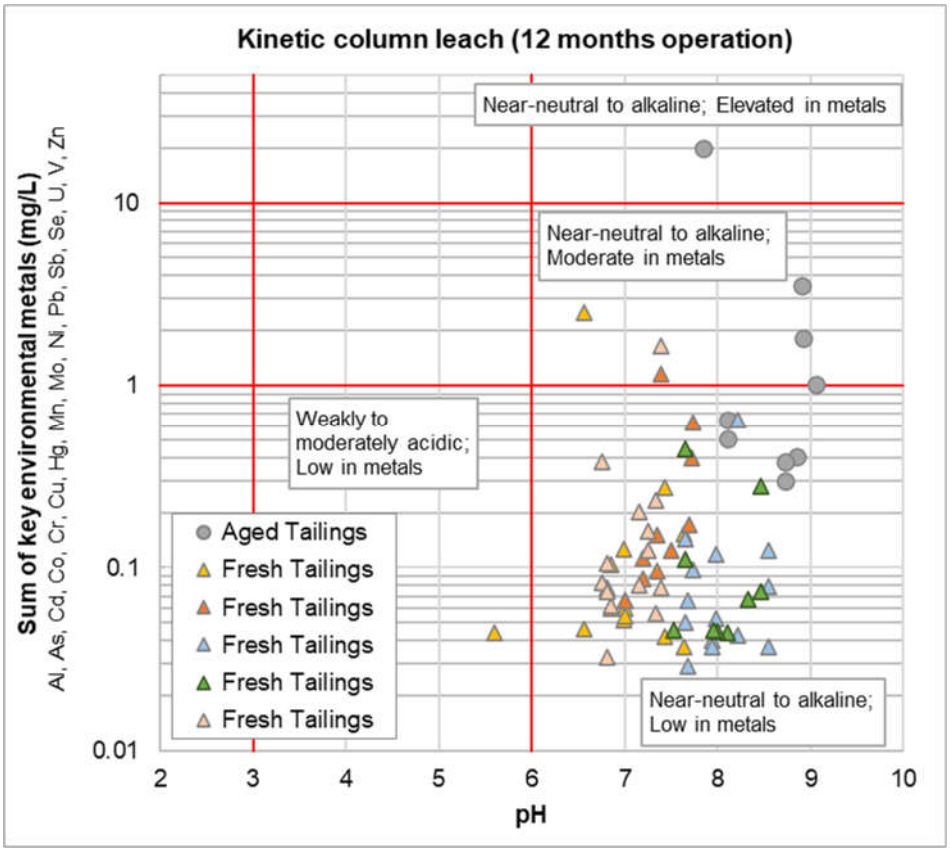
Based on the CEC, ESP and Emerson aggregate class test results, a significant proportion of spoil at BWM is expected to be strongly sodic and dispersive. These exchangeable cation (and Emerson aggregate class) results are common for Bowen Basin Permian and Tertiary material in the region – and highlight that spoil is likely to have mixed sodicity and dispersion potential.

5.9 Kinetic Column Leaching

Free-draining kinetic column leaching test-work data is available for six samples, comprising five fresh (NCPP) tailings samples and one aged tailings sample from NCPP TSF. The samples were selected for column leaching test-work on the basis of static test results and had a range of AMD classifications from NAF to PAF (based on the static test-work). The column leaching method followed a modified AMIRA (2002) method (modifications to the 'standard' method were needed due to the very fine particle size of the samples) and samples were leached at four-weekly intervals with moistening and drying steps between the leaching events. The aged tailings sample and two of the fresh tailings samples were leached for 32 weeks (9 leach cycles including initial flush). The remaining three fresh tailings samples were leached for 52 weeks (14 leach cycles including initial flush).

The sum of the concentration of 16 environmentally important elements are plotted as a function of pH from the column leaching solutions in **Figure 24**. The 16 selected metals/metalloids are similar to the elements as per the 1:5 deionised water leach, saline leach and peroxide leach.

Figure 24. Sum of key environmental metals versus pH in kinetic column leachate solution



Most of the leachate from fresh tailings samples have low soluble metals concentration with the exception of three leaching events that had moderate soluble metals concentration and were associated with the initial flush (solute concentrations are typically higher in the initial flush as pre-existing salts are leached). All fresh tailings samples had near neutral to alkaline pH.

For aged tailings sample, the initial flush was elevated in metals, followed by moderate metals concentration during first three leach cycles (ie. from week 0 to 12). Beyond the week 12 leach, the soluble metals concentration from aged tailings leachate was low. All aged tailings leachates were near-neutral to alkaline in pH.

The salinity of the samples (column leachate) for fresh tailings samples ranged from 563 to 9460 μS/cm with a moderately saline median value of 1230 μS/cm. The sulfate release rates for fresh tailings samples ranged from 22 mg/kg/week to 57 mg/kg/week.

For the aged tailings sample, the salinity ranged from 2110 to 6930 μS/cm with a saline median value of 2210 μS/cm. The aged tailings sample released sulfate at a rate of 147 mg/kg/week which was the highest among all samples leached.

The column leaching showed that none of the samples were acid forming (ie. generating AD) throughout the leaching period. The aged tailings sample released higher levels of salts and elevated metals concentration compared to fresh samples.

5.10 OxCon Test-work

Data is available for OxCon test-work undertaken on five fresh (NCPP) tailings samples, one aged tailings sample from NCPP TSF and three spoil composite samples from drill-core. The tailings samples are the same samples that also underwent kinetic column leaching (Section 5.9). The test-work is summarised in Table 18 which also shows the preliminary AMD classification based on the static test-work alone (ie. prior to the OxCon testing. The test-work found that:

- Two of the three spoil composite samples were confirmed to be NAF and are unlikely to generate AD or NMD (negligible risk) and are unlikely to be generating SD. One spoil composite spoil sample was found to be having low potential to generate AD or NMD and was unlikely to be generating SD.
- Two of the five fresh (NCPP) tailing samples were confirmed to be NAF and are unlikely to generate AD or NMD (negligible risk) and with a low/negligible risk of generating SD. The remaining three fresh tailings samples were confirmed as PAF or PAF-LC and were found to pose a moderate to moderate-high risk of generating AD and low potential for SD.
- The aged tailings sample from NCPP TSF was confirmed as PAF and found to pose high potential for generating AD and low potential for SD.

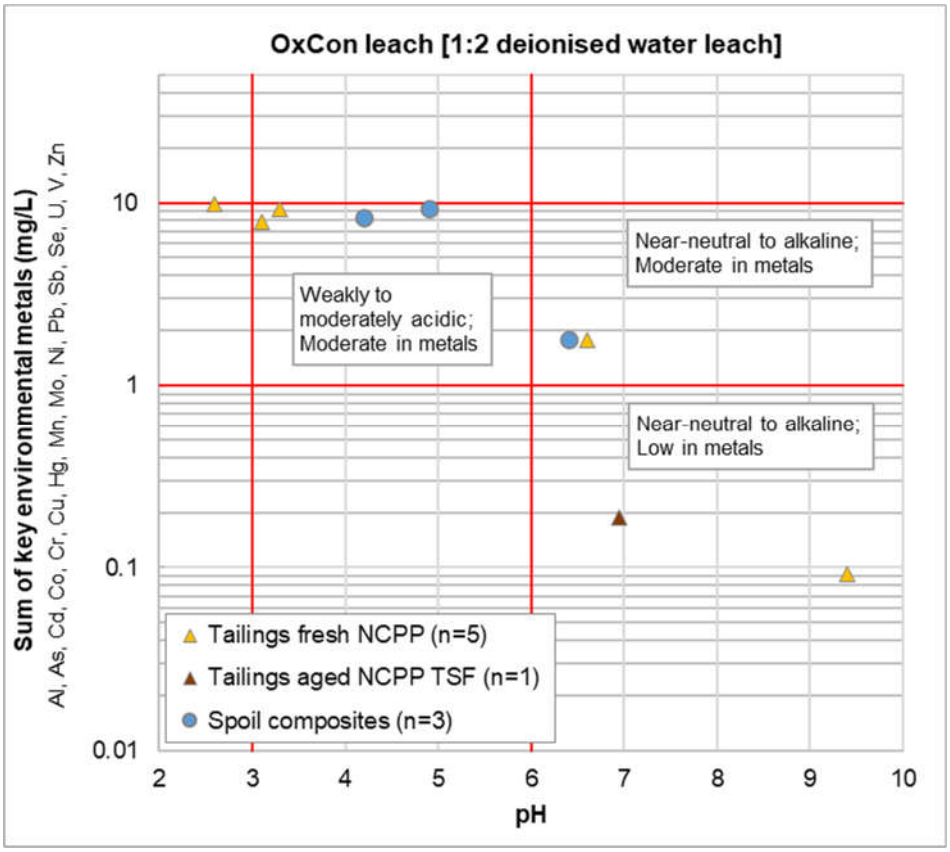
Table 18. Summary of OxCon results

Sample ID	Type / Source	Preliminary (pre-OxCon) AMD Classification	Avg. O2 consumption rate (mmol O2 /kg /day)	Max. acidity generation rate (kg H2SO4 /t /year)	Pyrite oxidation rate (wt.% pyrite /year)	Longevity of sulfide oxidation (years)	Lag time until ANC consumed (years)	Peak net acidity generation rate (kg H2SO4 /t /year)	AMD Classification based on OxCon Test
BWM_XTCM_Spoil	Spoil drillhole composites	UC(NAF) / PAF-LC	0.11	2.1	27	15	n/a	<0.1	NAF
BWM_EIS_13&31		PAF-LC	0.39	7.4	0.28	4	n/a	<0.1	NAF
BWM_EIS_31&33R		PAF-LC	0.60	12	0.34	4	~ 1.7	1.0	PAF-LC / UC(PAF)
BWM Tails 31-08-20	Tailings Fresh NCPP	PAF	0.48	9.3	55	10	~ 4	1.2	PAF-LC
BWM Tails 03-09-20		PAF	0.31	5.9	12	35	~ 9	2.1	PAF
BWM Tails 09-09-20		PAF-LC	0.51	9.7	80	5	< 1	8.3	PAF-LC
BWM Tails 04-09-20		NAF-S	0.60	11	53	10	n/a	<0.1	NAF
BWM Tails 18-10-20		NAF	0.43	8.2	0.57	2	n/a	<0.1	NAF
BWM-CPP-CPT51-INT06	Tailings aged NCPP TSF	PAF	0.63	12	11	38	~ 4	7.9	PAF

At the conclusion of the OxCon test, the solids underwent a bottle leaching procedure at a 1:2 solid:water ratio and the leachate was analysed to determine the pH, acidity/alkalinity and concentration of soluble metals/metalloids and salts. The sum of the concentration of 16 environmentally important elements are plotted as a function of pH from the post-OxCon leachate solution in Figure 25. The 16 selected metals/metalloids are the same elements as per the 1:5 deionised water leach, saline leach and peroxide leach.

As evident in Figure 25, three of the fresh tailings samples and two of the spoil samples were acidic to varying degrees and produced moderate metals concentrations – primarily due to the low pH enhancing solubility. The remaining spoil sample, the aged tailings sample (from NCPP TSF) and the two remaining fresh tailings samples all had near-neutral to alkaline pH, with low to moderate soluble metals concentrations.

Figure 25. Sum of key environmental metals versus pH in OxCon leachate solution



6 Summary of Geochemical Characteristics

The geochemical characteristics of mineral wastes (overburden/interburden [potential spoil], tailings and reject) from BWM have been assessed – as have the characteristics of coal samples that may report as ROM coal or as waste to the spoil dumps. The assessment was undertaken to understand the environmental geochemical characteristics of these samples, as being representative of their respective mineral waste types.

Within the context of this PRCP, spoil comprises essentially all of (approximately 99% of) the mineral waste at BWM; and tailings and rejects comprise approximately 0.5% each. The proportions of spoil, tailings and rejects are expected to remain approximately the same for the expected life of the operation. Spoil is overwhelmingly comprised of non-carbonaceous material. Carbonaceous spoil (of which almost all is unweathered) comprises less than 8% of spoil.

6.1 AMD Potential of Mineral Wastes and Coal

AMD potential of spoil – non-carbonaceous

Non-carbonaceous spoil, which comprises about 92% of spoil, is expected to generate pH-neutral to highly alkaline contact water (run-off and seepage), which is typical for mine spoil in the Bowen Basin.

Based on the results from 3081 samples, non-carbonaceous spoil has a very low potential to generate AMD as either AD and/or NMD and/or SD, but for a small proportion that is assessed to have a higher potential to generate AMD (as AD, NMD and/or SD). However, in consideration of the mixing and dispersion of a small volume of waste at higher potential for AMD within the broader spoil material, the overall potential for non-carbonaceous spoil to generate AMD is assessed to be low.

The total S concentration of non-carbonaceous spoil is very low, with a 90th percentile total S concentration of 0.06%. As such, and combined with moderate to high ANC values (median 40 kg H_2SO_4/t), which is significantly higher than the MPA (median 0.6 kg H_2SO_4/t), approximately 96% of non-carbonaceous spoil samples tested were classified as NAF, with a further approximately 2% of samples classified as UC(NAF). Less than 3% of non-carbonaceous spoil samples were classified as PAF, PAF-LC, UC(PAF) or NAF-S.

The test-work has demonstrated that the ANC is generally expected to be about 37-75% available under field conditions, with iron-dolomite/dolomite and calcite being the main carbonate mineral contributing to the acid buffering potential of the non-carbonaceous spoil. Overall, non-carbonaceous spoil has excess acid neutralising capacity and is expected to be bulk acid consuming.

Total metal and metalloid concentrations from 391 non-carbonaceous spoil samples tested are very low compared to average element abundance in soil in the earth's crust. However, 19 samples were significantly enriched with regard to one or more of As, Ba, Be, Co, Cr, Hg, S, Se and/or W. The enrichment in one or more of these elements in a small proportion of samples is not cause for concern. Of the samples displaying elemental enrichment, there was no correlation with AMD classifications of these samples. In summary, non-carbonaceous spoil has low enrichment in total metals and metalloids compared to unmineralised rocks.

Soluble multi-element results (from 391 samples) indicate that leachate from this material is expected to contain low concentrations of soluble metals and metalloids. One PAF-LC sample produced elevated soluble metal concentrations. Another 10 samples released moderate soluble metals concentrations for

one or more of Al, Fe, Co, Mn, Ni and/or Zn. Peroxide leaching undertaken on five non-carbonaceous spoil samples showed that PAF material has the potential to generate low pH leachate (AD) with moderate sulfate and soluble metal and metalloid concentrations.

AMD potential of spoil – carbonaceous

Carbonaceous spoil represents less than 8% of spoil material at BWM and – as a bulk material – is expected to generate pH-alkaline to highly alkaline contact water (run-off and seepage), similar to non-carbonaceous spoil.

Based on the results from 260 samples, carbonaceous spoil has a generally low potential to generate AD and/or NMD and/or SD. Some carbonaceous spoil – mostly associated with coal seams – has a greater potential to generate low-level AD and/or NMD and/or SD.

The total S concentration of carbonaceous spoil is low, with a 90th percentile total S concentration of 0.44%. As such, and combined with generally moderate ANC values (median 20 kg H_2SO_4/t) and relatively low MPA values (median 4 kg H_2SO_4/t), approximately 85% of carbonaceous spoil samples (220 out of 260 samples) were classified as NAF, with a further 5 samples (approximately 2% of samples) classified as UC(NAF). The remaining 13% (approximately) of samples were classified as PAF, PAF-LC, UC(PAF) or NAF-S. Almost all of the 'PAF' and NAF-S carbonaceous spoil samples were closely associated with coal seams and could potentially end up as coarse reject if mined with ROM coal.

The test-work undertaken has demonstrated that the ANC is generally expected to be about 17-40% available under field conditions, with iron-dolomite/dolomite and calcite being the main carbonate minerals contributing to the acid buffering potential of carbonaceous spoil. Overall, carbonaceous spoil has relatively modest acid neutralising capacity.

Total metal and metalloid concentrations from 54 carbonaceous spoil samples tested are very low compared to average element abundance in soil in the earth's crust, and very similar to the assay concentrations from non-carbonaceous spoil. Ten samples were significantly enriched with regard to one or more of As, Be, Cu, Hg, S and/or U. Of the samples displaying elemental enrichment, there was no correlation with AMD classifications of these samples. In summary, carbonaceous spoil has low enrichment in total metals and metalloids compared to unmineralised rocks.

Soluble multi-element results (from 54 samples) indicate that, with few exceptions, leachate from carbonaceous spoil is expected to contain low concentrations of soluble metals and metalloids – similar to non-carbonaceous spoil samples. Peroxide leaching undertaken on three carbonaceous spoil samples (one PAF and two NAF) showed that the PAF sample has the potential to generate low pH leachate (AD) with elevated sulfate and soluble metal and metalloid concentrations. The two NAF samples that underwent peroxide leaching produced leachate with near-neutral to alkaline pH and with low to moderate soluble metals concentration.

AMD potential of tailings

The geochemical characteristics differed between fresh tailings from the NCPP versus aged tailings from TSFs for different parameters – particularly total S (and, by inference, MPA), ANC and pH. However, the overall geochemical (AMD) hazard posed by tailings from the two sources (fresh vs aged) was generally similar. As such, the discussion that follows only differentiates between the two tailings sources where the differences between the two sources was significant for some parameters and worthy of discussion. Else, the AMD potential of tailings is discussed as a bulk material.

Based on the results from 643 samples, approximately 53% of tailings has a moderate to high potential to generate AMD as either AD and/or NMD and/or SD, and remaining 47% (approximately) has a relatively low potential to generate AMD as either AD and/or NMD and/or SD.

Fresh tailings from the NCPP are expected to generate pH-alkaline to highly alkaline contact water (run-off and seepage). Overall, aged tailings have lower pH compared to fresh tailings, however the pH in aged tailings ranged from moderately acidic to pH-alkaline. The difference in pH observed between fresh and aged tailings (and the differences within the aged tailings) may be due to a number of factors, however the most likely cause is oxidation processes consuming readily available neutralising minerals, leading to aged tailings generally having a low(er) acid neutralising potential.

The total S concentration of tailings is generally low-moderate, with median values of 0.77% and 0.53% for fresh and aged tailings, respectively. Overall, the total S concentration was higher in the fresh tailings compared to the aged tailings. The reasons for differences in total S between the fresh versus aged tailings is unclear and potential processes that could account for differences in total S concentration are:

- Sulfide oxidation and neutralisation reactions ongoing within the TSFs, which generate sparingly and / or readily soluble sulfate. Therefore, sulfur mass loss could have occurred from aged tailings due to leaching of sulfate minerals, such as jarosite, alunite and/or gypsum and/or readily soluble acid salts (eg. iron sulfate 'salts' such as melanterite or copiapite).
- Change in geochemistry of ROM coal being processed. That is, ROM coal becoming more S-rich over time due to a change in the relative proportions of the various coal seams/plys being mined and processed.
- Addition of sulfate via salt precipitation within tailings during drying / evaporation of slurry water (liquor) [laboratory bias].

In the fresh tailings samples about 68% (median value) of the total S is present as sulfide (Scr). Comparatively, only 48% (median value) of the total S is present as Scr in the aged tailings samples. The difference in the proportion of total S as Scr between fresh versus aged tailings is typical and expected – supporting the suggestion that the aged tailings in the TSFs are being oxidised since deposition (sulfide oxidised to sulfate).

Just as there were notable differences between the total S concentrations in fresh versus aged tailings, so too with the ANC values of fresh versus aged tailings. Fresh tailings had generally moderate to high ANC values (median 32 kg H_2SO_4/t) compared to aged tailings, which had generally low to moderate ANC values (median 16 kg H_2SO_4/t). The reason behind the lower ANC observed in aged tailings (compared to fresh tailings) is not well understood. However, it is likely related to ANC being consumed via buffering of acidity generated by sulfide oxidation and/or sulfate leaching. Other processes that could account for a difference in ANC between fresh and aged tailings include inherent differences in the geochemical properties of the coal from earlier mining compared to recent mining, and/or – related to ROM coal differences; and it may also be partially due to differences in processing methods between the NCPP and the SCPP.

Based on the above generally low-moderate total S values (and, therefore, MPA values) combined with a wide range of ANC values resulted in approximately 56% of tailings samples being classified as PAF, PAF-LC, UC(PAF) or NAF-S – with the remaining 44% (approximately) classified as NAF or UC(NAF). Of the 'PAF' and NAF-S tailings samples, about 75% were classified as UC(PAF) or PAF-LC.

The test-work undertaken has demonstrated that the ANC in fresh tailings is expected to be about 47-67% available under field conditions, compared to about 14-66% available for aged tailings. Iron-dolomite/dolomite and calcite are expected to be the main carbonate minerals contributing to the acid buffering potential of tailings.

OxCon test-work undertaken on five fresh and one aged tailing samples found that the two fresh tailings samples were confirmed to be NAF and were unlikely to be generating AD or NMD. The remaining three fresh tailings samples were confirmed to be PAF or PAF-LC and were found to pose a moderate to moderate-high risk of generating AD and low potential for SD. The aged tailings sample from NCPP TSF was confirmed as PAF and found to pose high potential for generating AD and low potential for SD.

With few exceptions, the total metal and metalloid concentrations from 56 tailings samples tested are generally low compared to average element abundance in soil in the earth's crust. About 30% of the fresh and aged tailings samples were significantly enriched (GAI $\geq$3) with regard to S, which is consistent with the ABA data. The GAI values also show that a considerable number of tailings samples tested had minor enrichment (GAI = 1 or 2) with regard to one or more of Ag, B, Be, Cd, Hg, Mn and/or S. There was no clear correlation found between AMD classifications of the tailings samples compared to elemental enrichment.

Solubility data indicate that under freshwater (deionised water) leaching conditions all fresh tailings and approximately half of the aged tailings are expected to have low soluble metals concentrations and have near-neutral to alkaline pH. The remaining half of the aged tailings samples produced moderate to elevated metals concentration and, with exception of one sample which had highly acidic pH, all samples had weakly to moderately acidic pH. Under saline leaching conditions tailings produced low concentrations of soluble metals and metalloids.

Peroxide leaching undertaken on 48 tailings samples [about 60% classified as 'PAF' or NAF-S, and the remainder classified as NAF or UC(NAF)] showed that when exposed to highly oxidising conditions a significant proportion of tailings can produce weakly to highly acidic leachate with elevated soluble metals and metalloid concentrations. However, about one-third of tailings samples appeared to be influenced to some degree by the presence of organic acids, due to the samples' high organic carbon concentration. The presence of organic acids likely accounts, to some degree, for the acidity and 'elevated' soluble metals and metalloid concentrations evident in these tailings. Nevertheless, PAF tailings [including tailings classified as UC(PAF)] have typically produced moderate to elevated soluble metals and metalloid concentrations from the freshwater and peroxide leaching tests. These results indicate that PAF tailings have the potential to generate low pH leachate (AD), however the salinity (sulfate) loads are not expected to be high – due to generally low total S concentrations (with minor exceptions).

AMD potential of rejects

Based on the results of 265 samples, about half of the rejects have a moderate to high potential to generate AMD as either AD and/or NMD and/or SD, whereas the remaining half of rejects has a relatively low to low-moderate potential to generate AMD as either AD and/or NMD and/or SD.

Fresh rejects from the NCPP are expected to generate highly pH-alkaline contact water (run-off and seepage). Aged rejects (from Ramp 36 rejects dump, TSFs and a small number of rejects in the Red Dam area) has lower pH compared to fresh rejects and is expected to generate weakly acidic to pH-alkaline contact water (run-off and seepage). The difference in pH observed between fresh and aged

rejects – with the latter showing generally lower pH – may be due to a number of factors, however the most likely cause is oxidation processes consuming readily available neutralising minerals, leading to aged rejects having a low(er) acid neutralising potential.

The total S concentration of fresh rejects was generally low (median value = 0.28%) compared to aged rejects, which had low to low-moderate total S values (median value = 0.77%). Aged rejects have come from multiple locations (different ROM coal) and processed from different CHPPs (NCPP and SCPP).

In the fresh rejects samples about 74% (median value) of the total S is present as sulfide (Scr). Comparatively, only 45% (median value) of the total S is present as Scr in the aged rejects samples. The difference in the proportion of total S as Scr between fresh versus aged rejects is typical and expected – supporting the suggestion that the aged rejects in the TSFs and rejects dump(s) are being oxidised since deposition (sulfide oxidised to sulfate). Aged rejects may have been in place for nominally 5 to 30 years.

Just as there were notable differences between the total S concentrations in fresh versus aged rejects, so too with the ANC values of fresh versus aged rejects. Fresh (NCPP) rejects had generally moderate to very high ANC values (median 40 kg H_2SO_4/t) compared to aged rejects, which had generally low to high ANC values (median 17 kg H_2SO_4/t). The reason behind the lower ANC observed in aged rejects (compared to fresh rejects) is not well understood. However, it is likely related to ANC being consumed via buffering of acidity generated by sulfide oxidation and/or sulfate leaching. Other processes that could account for a difference in ANC between fresh and aged rejects include inherent differences in the geochemical properties of the coal from earlier mining compared to recent mining, and/or – related to ROM coal differences; and it may also be partially due to differences in processing methods between the NCPP and the SCPP.

Based on the above generally low to low-moderate total S values (and, therefore, MPA values) combined with a wide range of ANC values resulted in approximately 51% of rejects samples (all being aged rejects) being classified as PAF, PAF-LC, UC(PAF) or NAF-S – with the remaining half (approximately) classified as NAF or UC(NAF). All fresh rejects were classified as NAF. Of the 'PAF' and NAF-S tailings samples (all being aged rejects), about two-thirds were classified as UC(PAF) or PAF-LC.

The test-work undertaken has demonstrated that the ANC in fresh rejects is expected to be about 50-78% available under field conditions, compared to about 11-58% available for aged rejects. Iron-dolomite/dolomite and calcite are expected to be the main carbonate minerals contributing to the acid buffering potential of rejects.

No fresh rejects samples were significantly enriched with metals or metalloids. Three out of 13 aged rejects samples were significantly enriched with regard to S, which is consistent with ABA data for these samples. One aged rejects sample was significantly enriched with regard to Se. There was no correlation found between AMD classifications of the reject samples compared to elemental enrichment.

All fresh rejects samples (n=15) have low soluble metals concentrations and have near-neutral to alkaline pH. Approximately half of the aged rejects samples also have low soluble metals concentrations and have near-neutral to alkaline pH – the same general statistics as for the aged tailings samples. The remaining half (approximately) of aged rejects samples had varying geochemical characteristics ranging from moderately acidic to mildly alkaline with soluble metals concentrations ranging from low to elevated – with the highest soluble metals concentrations associated with acidic (low pH) conditions. Aged rejects are sourced from a variety of locations, however 62% of samples (with soluble metals data) are from Ramp 72 TSF – Kenmare pit rejects), and these aged rejects samples had

a wide range of soluble metals concentrations. Almost all 'acidic' aged rejects were from Ramp 72 – Kenmare pit rejects.

Peroxide leaching undertaken on 20 aged rejects samples (19 samples from Ramp 72 TSF and 1 sample from Laleham TSF) of predominantly 'PAF' classifications showed that almost all rejects samples were weakly to highly acidic and had moderate to elevated metals concentration. The results suggest that under acid/acidic conditions, materials represented by these aged reject samples are capable of generating elevated metal and metalloid loads for several metals/metalloids, however the sulfate (and salinity) loads are not expected to be high – due to the generally low total S concentration (with some exceptions).

AMD potential of coal

Coal is not regarded as waste and ROM coal remains on-site for a relatively short period of time. However, some minor coal seams/plys will report directly as waste, and remnant coal (seams) will be exposed on the highwalls of residual voids at closure.

Coal represents about 5% of all lithological material at BWM (ie. about 2% to 7% of the highwall meterage, depending on the void; refer to **Section 7.1.4**, **Table 20**). Assuming the large majority of this will report as ROM coal, we can conservatively assume that coal will represent a very small proportion of mineral waste (ie. 1-2% at the most), which will most likely report directly to spoil.

Based on the results of 370 samples, ROM coal is assessed as having a moderate potential to generate AMD as either AD, NMD and/or SD. A small proportion of coal would have a moderate to high potential to generate AMD. ROM coal, as a bulk material, is expected to generate pH-alkaline to highly alkaline contact water (run-off and seepage).

The total S concentration of coal is generally low (90th percentile total S concentration of 0.45%) and approximately 12% (median value) of the total S is present as sulfide (Scr), with the bulk of the total S likely present as organic S, which does not contribute to AMD. Coal samples have a wide range of ANC values; however, the median ANC is low (median = 11 kg H_2SO_4/t). As such, 64% of coal samples were classified as NAF or UC(NAF). One sample was classified as NAF-S. The remaining 36% (approximately) of samples were classified as PAF, PAF-LC or UC(PAF) and were from all seam groups. The AMD classification is based on total S, which for coal samples likely leads to highly conservative classification given that most sulfur in coal is organic S, not sulfidic S. These results suggest that coal stored on the ROM pad, coal located within pit walls and un-economic coal seam material reporting as spoil (mixed with non-coal spoil) would likely be bulk NAF.

Assay data for 64 coal samples show that the total metal and metalloid concentrations are generally low compared to average element abundance in soil in the earth's crust. Three coal samples were significantly enriched with regard to one or more of As and/or S, however it is not a cause of concern.

Soluble multi-element results from 64 coal samples tested indicate that contact water (run-off and seepage) from coal is expected to contain low concentrations of soluble metals and metalloids. Five 'PAF' coal samples produced weakly to moderately acidic pH with moderate to elevated soluble metals concentrations and two PAF-LC samples produced weakly to moderately acidic pH with low soluble metals concentrations. These results indicate that 'PAF' coal is capable of generating AD and/or SD/NMD.

6.2 Salinity, Sodicity and Dispersion Potential of Mineral Wastes and Coal

Salinity, sodicity and dispersion potential of spoil – non-carbonaceous

Non-carbonaceous spoil has low median and 90th percentile $EC_{1:5}$ values of 344 and 513 μS/cm, respectively, and has very low total S concentrations. On this basis, contact water (run-off and seepage) is expected to be generally non-saline to slightly saline, as a result of dissolution of geogenic salts more so than from sulfide oxidation (sulfate salinity). Weathered non-carbonaceous spoil generally has similar $EC_{1:5}$ values compared to fresh non-carbonaceous spoil.

Non-carbonaceous spoil has modest CEC values and generally high ESP values, resulting in almost all samples being classified as 'strongly sodic' and the few remaining samples being classified as 'sodic' and, therefore, with potential for dispersion. Based on Emerson aggregate class testing to directly measure dispersion, about 75% of the samples displayed some degree of dispersion – consistent with the dispersion predictions from the ESP results.

Salinity, sodicity and dispersion potential of spoil – carbonaceous

Carbonaceous spoil has generally low median and 90th percentile $EC_{1:5}$ values of 336 and 519 μS/cm, respectively, and has low total S concentrations. On this basis, contact water (run-off and seepage) is expected to be similar to non-carbonaceous spoil. That is, generally non-saline to slightly saline, primarily as a result of dissolution of geogenic salts more so than from sulfide oxidation (sulfate salinity).

Carbonaceous spoil samples had comparable CEC and ESP values to non-carbonaceous spoil – with the main difference being the weathered carbonaceous samples having much lower CEC and ESP compared to the fresh carbonaceous samples. This resulted in most fresh carbonaceous samples being classified as 'strongly sodic' whereas the weathered samples were classified as 'non-sodic'. As such, and based solely on the moderate to high sodicity values, carbonaceous spoil is expected to be sodic (to some degree) with potential for dispersion. Based on Emerson aggregate class testing to directly measure dispersion, about two-thirds of the samples displayed some degree of dispersion – consistent with the dispersion predictions from the ESP results.

Salinity potential of tailings

Tailings samples (n=643) have $EC_{1:5}$ values ranging from 97 to 8900 μS/cm, with median and 90th percentile $EC_{1:5}$ values of 711 and 1512 μS/cm, respectively. There is generally little difference in $EC_{1:5}$ values between fresh and aged tailings, with both types being generally slightly to moderately saline (median = 708 μS/cm; 90th percentile = 1480 μS/cm) – and both tailings types have low-moderate total S concentrations. Therefore, tailings are generally slightly to moderately saline with a low to low-moderate potential for SD (from sulfide oxidation).

Salinity potential of rejects

Rejects samples (n=265) have $EC_{1:5}$ values ranging from 143 to 2830 μS/cm, with median and 90th percentile $EC_{1:5}$ values of 754 and 1946 μS/cm, respectively. Fresh rejects samples were all generally non-saline whereas aged rejects had $EC_{1:5}$ values ranging from non-saline to moderately saline. Most fresh rejects have low total S concentrations, whereas most aged rejects have low to low-moderate total S concentrations. Therefore, based on the total S concentration from all rejects samples, the potential for SD (from sulfide oxidation) is low to low-moderate.

Salinity potential of coal

Coal samples (n=370) have $EC_{1:5}$ values ranging from less than 50 to 722 μS/cm, with median and 90th percentile $EC_{1:5}$ values of 96 and 275 μS/cm, respectively. Coal has generally low total S concentrations. On this basis, contact water (run-off and seepage) from coal, as a bulk material, is expected to be non-saline.

7 Risk Assessment

7.1 Geochemical source hazard assessment of material types

7.1.1 Spoil landforms

There are 11 spoil landforms at BWM that will remain at closure (listed below from north to south) – seven associated with existing spoil dumps and four new landforms associated with future mining areas:

- Ramp 8 (future mining area);
- Bonnie Doon;
- Mimosa-Besgrove;
- Deep Creek;
- Stewarton-Ballamoo;
- Kenmare;
- Laleham;
- Togara-North Marshmead (partial existing spoil dumps and partial future mining area);
- South Marshmead (future mining area);
- Kennedy west (future mining area); and
- Comet Downs East (future mining area).

Each landform will have a similar construction, comprising mined overburden and interburden disposed behind the active mining face to form a low-wall spoil dump, which will be reshaped to form a final spoil landform.

Approximately 65% of all BWM rejects (to date) have been disposed into some of the spoil dumps during operations – primarily those spoil dumps located close to NCPP and SCPP. Of these, most (indicatively 90%) have been disposed into dedicated rejects disposal areas (eg. Ramp 32 in-spoil rejects dump), with the remainder co-disposed (widely distributed) throughout general spoil at spoil dumps dump near NCPP. Where rejects are present in spoil landforms, they'll comprise between 0.2 and 1.9% (average 0.6%) of the spoil landform based on current rejects quantities, estimated future rejects quantities and assumed future rejects disposal practices. Rejects disposed into the southern end of Kenmare pit (Ramp 72 pit) are within the Kenmare spoil landform and comprise approximately 5% of all current/existing rejects [and about 0.5% of the Kenmare post-closure spoil landform].

Ramp 72 TSF is an in-ramp TSF located within the current Kenmare pit shell – and comprises approximately 1% of the Kenmare landform. Rejects located within the southern end of the current Kenmare pit also comprises approximately 0.5% of the Kenmare landform. Ramp 72 TSF and the rejects located in the southern end of Ramp 72 pit (Kenmare pit) are collectively comprised of about 70% tailings and 30% rejects (estimated proportions).

The conceptual layout of the spoil landforms (and residual voids) at closure is shown in **Figure 26** (northern part of the mine) and **Figure 27** (southern part of the mine); including the locations of existing TSFs and Ramp 36 rejects dump. At closure, the current (and future) spoil dumps will be reshaped and seeded (refer to the PRC Plan for spoil dump rehabilitation details).

Figure 26. Conceptual closure landform for the northern BWM area

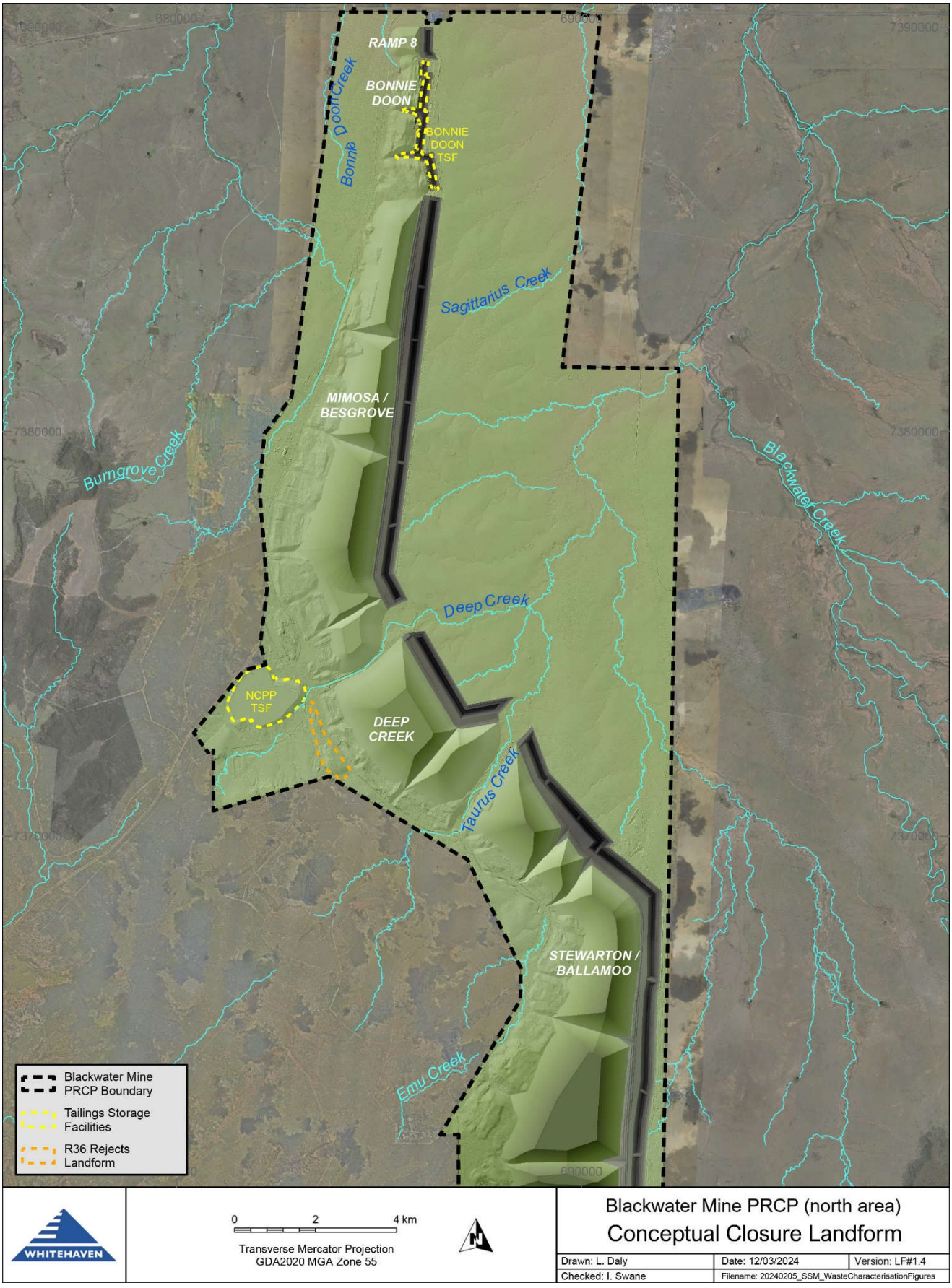
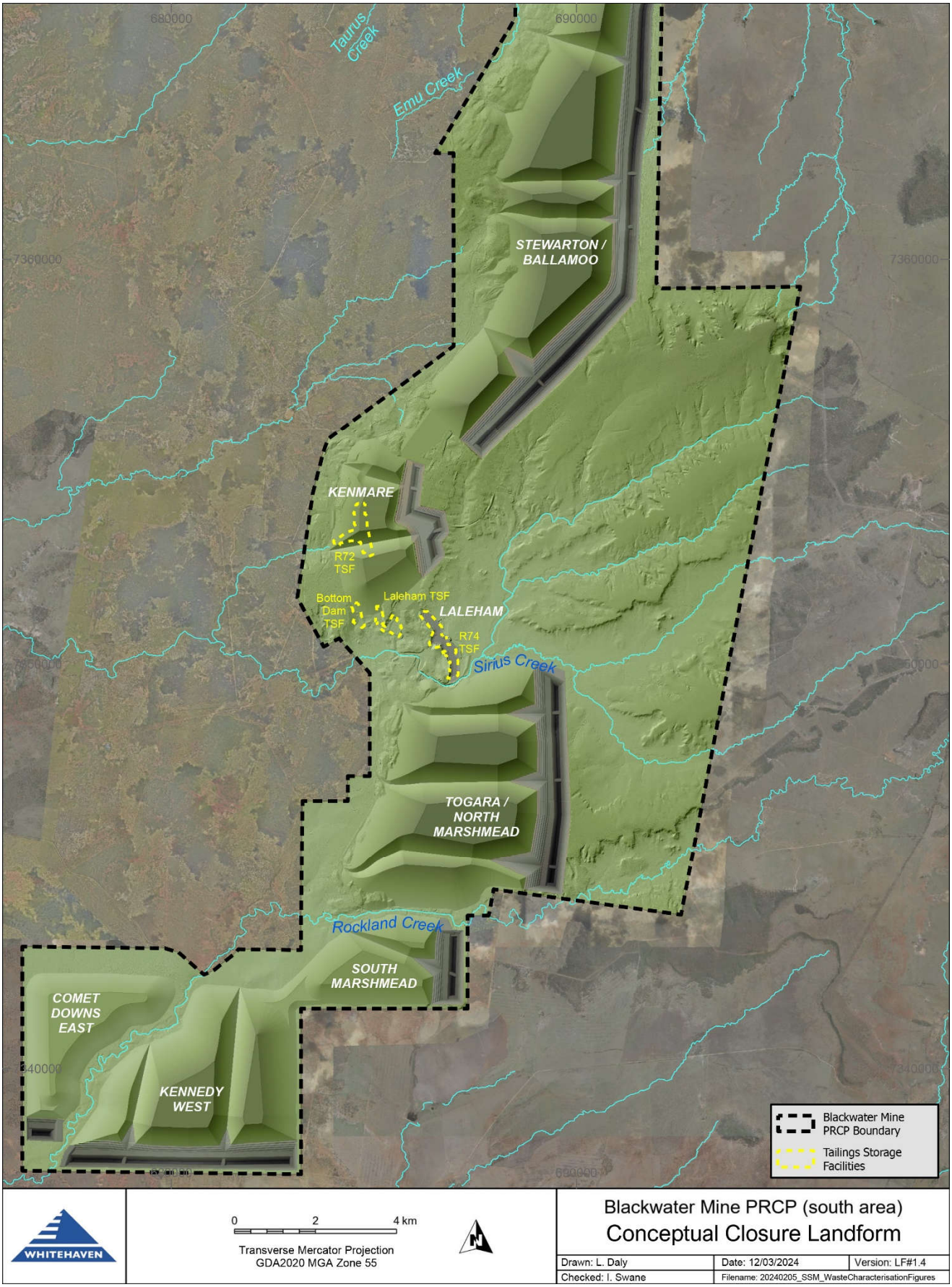


Figure 27. Conceptual closure landform for the southern BWM area



Approximately 30% of existing rejects are located at Ramp 36 rejects dump. Ramp 36 rejects dump is outside of a spoil landform and will remain as a stand-alone rejects landform at/post-closure.

TCP rejects (total volume less than 0.1 Mm^3) currently located near the TCP will be relocated into Mimosa-Besgrove spoil landform during rehabilitation of the TCP area.

The source materials within the spoil dumps predominantly comprise weathered and fresh spoil. The geochemical assessment has found that, from an environmental geochemical perspective, the geochemical differences between weathered and fresh materials are relatively minor. As such, the geochemical source hazard assessment has combined weathered and fresh non-carbonaceous spoil, and weathered and fresh carbonaceous spoil, as appropriate.

The source hazard assessment methodology outlined in **Section 4.4.6** (AMD hazard scoring) and **Section 4.4.7** (landform AMD likelihood scoring) has been applied to the spoil, rejects and tailings within each landform. Stratigraphic information from the BWM coal geology database was used to assess the proportion of carbonaceous lithologies relative to non-carbonaceous lithologies (and excluding coal) for each landform and void area – and from this, assign the same proportions to each spoil landform. The source materials, and their approximate proportions within each spoil landform, based on geological, mining and coal processing information, are summarised in **Table 19**.

Table 19. Source material proportions (%) within each spoil landform

Spoil landform	Spoil: Non-carbonaceous %	Spoil: Carbonaceous and/or coaly* %	Rejects %	Tailings %
Ramp 8**	96	4.0	none	none
Bonnie Doon	96	4.0	none	none
Mimosa-Besgrove	95	2.9	1.9	none
Deep Creek	96	3.0	0.8	none
Stewarton-Ballamoo	96	4.0	<0.2	none
Kenmare (includes Ramp 72 TSF and Kenmare pit rejects dump)	95	2.9	1.0	1.0
Laleham***	99	1.0	none	none
Togara-North Marshmead	94	6.0	<0.2	none
South Marshmead	98	2.0	none	none
Kennedy West	94	6.0	none	none
Comet Downs East	93	7.0	none	none

* Coaly material refers to obvious waste coal lithologies (ie. excludes potential ROM coal).

** Ramp 8 (future mining area) assessment was supplemented by data from Bonnie Doon.

*** Laleham TSF is located on the edge of (adjacent to) Laleham spoil dump, but is not included as part of the Laleham spoil landform. Laleham TSF is assessed as a 'stand-alone' TSF landform.

The assessment found that carbonaceous spoil (overburden/interburden) is estimated to comprise approximately 1% to 7% (average 4%) of spoil within each landform, with non-carbonaceous spoil

estimated to comprise the remaining 96% (approximately, on average) of all spoil. Assuming some fresh coal material currently assigned as 'coal' is not mined as ROM coal but remains as waste coal, the proportion of coaly and carbonaceous overburden in each landform is likely to be slightly higher. However, coal comprises approximately 5% of the stratigraphy at BWM, therefore if a small amount of coal was to report as 'waste' the increase to the proportion of carbonaceous spoil would minimal.

The total rejects volume to date plus the estimated rejects volume for the remaining life of mine (ie. total rejects producing for life of mine) ranges from less than 0.2% to 1.9% of the total spoil landform volume at closure (as relevant to each specific landform). Overall, rejects currently comprise about 0.5% of all mineral waste at BWM and a similar proportion is expected for future rejects.

The source hazard assessment, which describes the AMD hazard of individual material domains within each landform (ie. also takes into account material quantity), has found that non-carbonaceous spoil poses a **Low** AMD source hazard and carbonaceous spoil poses a **Low-Moderate** AMD source hazard. Where applicable, rejects generally pose a **Moderate** AMD source hazard within the spoil landforms – the AMD hazard score for rejects varied with location. Tailings are only located within Kenmare spoil landform and pose a **High** AMD source hazard. Rejects located within the southern end of Kenmare pit also pose a **High** AMD source hazard. The AMD hazard scoring tables for spoil landforms are provided in **Attachment B – Tables B1 to B11**.

Approximately 3% of spoil samples have been classified as PAF of some type (including NAF-S) (**Table 15**) – and almost all of this is from carbonaceous material, which comprises a minor proportion of spoil. Notably, almost all of the 'PAF'/NAF-S samples in overburden/interburden from drill-hole sampling were associated with seams as either roof, parting, floor or otherwise near-seam material (<1.5m above or below coal). As such, it is likely that a significant proportion of PAF spoil samples would be mined as part of ROM coal and would therefore end up as rejects instead of general spoil. Therefore, the AMD hazard score for spoil materials is considered to be conservative and consequently the final landform AMD hazard score also conservative.

On this basis, and taking into account material quantities (proportions) and expected proportion of PAF and NAF-S materials reporting to each individual landform, each of the 11 spoil landforms pose a **Low** AMD hazard, with AMD generation rated as **Highly Unlikely**. The 'Low' AMD hazard is largely a result of less than 2% of non-carbonaceous spoil samples being classified as PAF of some type (or NAF-S) – and non-carbonaceous spoil comprises the overwhelming majority of mineral waste within each spoil landform. Where rejects (and tailings) are present in specific landforms, their quantity (proportion of the landform) is very small and, as such, has a relatively minor affect in the overall landform AMD score.

Regarding Kenmare spoil landform specifically, the intrinsic AMD hazard of Ramp 72 TSF/tailings and rejects located at the southern end of the existing Kenmare pit – both of which will be contained (buried) within Kenmare spoil landform – is rated **High** with the likelihood to generate AMD rated **Highly Likely** – due to AMD (as AD) having been observed from Ramp 72 TSF and from rejects within the existing Kenmare Pit. Ramp 72 TSF and the rejects disposal area at the southern end of Kenmare pit are both within the Kenmare pit (void) shell. Rejects located near Ramp 70 within Kenmare spoil landform (at the northern end of the landform) pose a **Moderate** AMD hazard, with the likelihood to generate AMD rated **Probable/Likely**.

7.1.2 TSF landforms

NCPP TSF, Laleham TSF and Bottom Dam TSF/rejects will remain as stand-alone TSF landforms at closure and will not reside within a spoil landform. Ramp 72 TSF will be incorporated into Kenmare spoil landform. Refer to **Figure 1** and **Figure 26** for the location of NCPP TSF, and **Figure 2** and **Figure 27** for the location of Laleham TSF, Ramp 72 TSF and Bottom Dam TSF.

NCPP TSF

NCPP TSF is a large 'turkey's nest' style TSF with confining embankments on all sides, a base footprint of approximately 200 ha and has a total volume of approximately 26 Mm^3. NCPP TSF operated from approximately 1970 to 2023.

The source materials within NCPP TSF includes tailings, which are estimated to comprise approximately 80% of the landform; and rejects, which are estimated to comprise about 19% of the landform and form the basis of most of the embankments. The TSF landform also includes a small proportion (approximately 1 %) of spoil/fill material, predominantly within embankments.

Investigative drilling coupled with near-surface sampling has demonstrated that some tailings in the field at NCPP TSF are generating AMD (as AD and SD). Oxidation fronts are present in the TSF as demonstrated by decreasing sulfide concentrations from surface down, consumption of ANC, presence of secondary minerals generated through sulfide oxidation, and acid contact pH water.

The source hazard assessment for the mineral wastes within NCPP TSF landform has utilised the same general methodology as applied to the spoil landforms and other TSF and reject landforms. The source hazard assessment has found the tailings within NCPP TSF landform poses a **High** AMD source hazard; and rejects poses a **Low-Moderate** AMD source hazard. Fill material poses a moderate AMD source hazard. On this basis, and taking into account material quantities (proportions):

- NCPP TSF landform (currently, without a rehabilitation cover) poses a **Moderate-High** AMD hazard, with AMD generation rated as **Highly Likely**, the highest landform AMD likelihood category under the applied scoring procedure – noting that AMD has already been observed at/from this TSF. The AMD hazard is considered to predominantly lie with the tailings, and lesser so the rejects.

The AMD hazard score for the tailings and rejects materials is considered to be conservative and the landform domain AMD hazard score for NCPP TSF is also considered to be conservative. The AMD hazard scoring table for NCPP TSF landform is provided in **Attachment B – Table B12**.

Laleham TSF

Laleham TSF is largely constructed over spoil/fill (and also backfills a small pit). The TSF partly fills the upper reaches of a southeasterly plunging gully. The TSF abuts natural ground on the north and northwest, and overlies spoil/fill on the south and southeast. The TSF has a total area of approximately 12 ha and a total volume of approximately 4 Mm^3. The TSF operated from the late-1970s to the late-1980s, primarily receiving tailings from Laleham underground operation. Between 1990 and 1994 a thin spoil/soil cap was placed over the TSF and seeded/revegetated. This TSF has undergone rehabilitation and revegetation since decommissioning, however additional rehabilitation is assumed to be required prior to closure.

The source materials within Laleham TSF includes tailings, which are estimated to comprise approximately 90% of the landform; and rejects, which are estimated to comprise about 9% of the

landform. The TSF landform also includes a small proportion (approximately 1 %) of spoil/fill material, predominantly within embankments.

Investigative drilling has demonstrated that tailings in the field at Laleham TSF are generating AMD (as AD and SD). Oxidation fronts are present in the TSF as demonstrated by decreasing sulfide concentrations from surface down, consumption of ANC, presence of secondary minerals generated through sulfide oxidation, and acid contact pH water.

The source hazard assessment for the mineral wastes within Laleham TSF landform has utilised the same general methodology as applied to the spoil landforms and other TSF and reject landforms. The source hazard assessment has found the tailings within Laleham TSF landform poses a **Moderate-High** AMD source hazard. Very little rejects data specific to Laleham TSF were available – therefore the AMD source hazard assessment for rejects at Laleham TSF utilised the BWM aged rejects data, and found that rejects pose a **Moderate** AMD source hazard. Fill material poses a low-moderate AMD source hazard. Evidence of AMD (as AD) is present from over 25% of the tailings samples collected from within the TSF. On this basis, and taking into account material quantities (proportions):

- Laleham TSF landform (currently, without a final rehabilitation cover[4]) poses a **Moderate-High** AMD hazard, with AMD generation rated as **Probable/Likely**. The AMD hazard is considered to predominantly lie with the tailings, and lesser so the rejects.

The AMD hazard score for the tailings and rejects materials is considered to be conservative and the landform domain AMD hazard score for Laleham TSF is also considered to be conservative. The AMD hazard scoring table for Laleham TSF landform is provided in **Attachment B – Table B13**.

Bottom Dam TSF (and rejects)

Bottom Dam TSF is a small historic tailings dam south of ROM 3 near the SCPP in the southern area of BWM (**Figure 2**). Adjacent to the TSF, and in the general vicinity of the TSF, are rejects dumps. Rejects currently occupy an area north of the TSF, on top of ROM 3, and also loosely dumped over the eastern and southeastern walls (escarpment) of ROM 3. ROM 3 is an elevated natural ground area northwest of Bottom Dam TSF and situated approximately 37 m above (higher than) the TSF.

The TSF (specifically) occupies an area of approximately 1.6 ha (with an estimated total volume of approximately 0.2 Mm^3). The overall Bottom Dam TSF/rejects area is approximately 10 ha, with an overall tailings/rejects volume estimated at less than 1 Mm^3 (indicatively 0.6 to 0.8 Mm^3), based on preliminary investigations. Environmental and engineering investigations of this area are underway to support rehabilitation and closure planning and, as such, no geochemical data specifically from Bottom Dam was available for this waste characterisation assessment. The final landform of the greater Bottom Dam area is also to be determined, subject to the outcome of the engineering and environmental investigation programs.

Tailings and rejects in Bottom Dam TSF/rejects were generated from the SCPP and are reasonably assumed to have environmental geochemical characteristics comparable to tailings and rejects located

4 Laleham TSF currently has a spoil cover, however additional rehabilitation will be required to meet post-closure rehabilitation criteria. As such, the AMD hazard assessment of Laleham TSF takes into consideration the existing cover material, however considers the facility to be 'unrehabilitated'.

within Ramp 72 TSF and Kenmare pit (and also potentially Laleham TSF). Tailings and rejects in the Bottom Dam area are estimated to be in approximately equal proportions.

As such, and until a detailed geochemical assessment is undertaken, Bottom Dam area (comprising TSF and rejects) is conservatively assumed to pose a **Moderate-High** AMD hazard, with AMD generation rated as **Probable/Likely**. This is based on tailings posing a moderate-high to high AMD source hazard and rejects posing a moderate to moderate-high AMD source hazard – as per the AMD source hazard for tailings and rejects located within Laleham TSF (tailings) and Ramp 72 TSF [Kenmare pit] (tailings and rejects).

The assumed (preliminary) AMD hazard score for the tailings and rejects materials in Bottom Dam area is considered to be conservative and the landform domain AMD hazard score for Bottom Dam area (TSF and rejects combined) is also considered to be conservative.

7.1.3 Rejects landforms

Ramp 36 rejects dump will remain as a 'stand-alone' rejects landform at closure. The dump is located approximately one km south of the NCPP and about 350 m southeast of NCPP TSF (**Figure 1** and **Figure 26**). The dump occupies an area of approximately 60 ha with a total estimated volume of approximately 10 Mm^3. The dump operated from approximately 1967 (start of mining at BWM) intermittently through until 2007. During this time, rejects have been taken (quarried) from the dump for use elsewhere on site – primarily for construction of the NCPP TSF embankments.

Ramp 36 rejects dump essentially comprises only rejects (approximately 99% by volume). A small amount of 'fill' (assume spoil) is also present and has been conservatively estimated to comprise about 1% of the landform.

The source hazard assessment for the mineral wastes within the rejects dump has utilised the same general methodology as applied to the spoil and TSF landforms. The source hazard assessment has found the rejects within the dump poses a **Moderate** AMD source hazard. Fill material has been assessed as posing a low AMD source hazard. Taking into account material quantities (proportions):

- Ramp 36 rejects dump (currently, without a rehabilitation cover) poses a **Moderate** AMD hazard, with AMD generation rated as **Probable/Likely**. The AMD hazard lies with the rejects, which comprise essentially all of the dump.

The AMD hazard score for the rejects materials is considered to be conservative and the landform domain AMD hazard score for the rejects dump is also considered to be conservative. The AMD hazard scoring table for Ramp 36 rejects dump is provided in **Attachment B – Table B14**.

7.1.4 Residual voids – exposed walls and floor

There are 11 existing and future pit areas at BWM that will remain at closure as residual voids. Some existing pits will merge with existing neighbouring pits to form larger consolidated pits/voids. Also, some existing pits will merge with future pits to also form larger consolidated pits/voids. The voids don't have 'flat lying' floors and therefore the depth of each void varies along its length. The 11 residual voids remaining at closure are:

- Ramp 8 void approximately 0.7 km long and 70-75 m deep (at closure);
- Bonnie Doon void approximately 3.2 km long and 66-75 m deep (depth to tailings surface, assuming approximately 10 m maximum tailings thickness at southern end of void);
- Mimosa-Besgrove void approximately 10.2 km long and 110-160 m deep (at closure);
- Deep Creek void approximately 3.3 km long and 130-140 m deep (at closure);
- Stewarton-Ballamoo void approximately 19.8 km long and 110-230 m deep (at closure);
- Kenmare void approximately 2.7 km long and 115-165 m deep (at closure);
- Laleham void approximately 1.9 km long and 22-30 m deep (depth to tailings surface);
- Togara-North Marshmead void approximately 5.6 km long and 165-240 m deep (at closure);
- South Marshmead void approximately 2.1 km long and 155-190 m deep (at closure);
- Kennedy West void approximately 5.7 km long and 90-170 m deep (at closure); and
- Comet Downs East void approximately 0.9 km long and 133 m deep (at closure).

Excluding the Bonnie Doon and Laleham residual voids that have tailings on the pit/void floor, the floor of all residual voids at closure will be the P & L Lower seam group, which is currently the floor of most/all existing pits.

Environmental geochemical data, coal quality data and drill-hole geological logs have been used to aid in the assessment of AMD risk associated with residual void highwalls and floors, as explained in Sections 4.4.1 to 4.4.3.

The source materials within the highwall and floor of each residual void comprise weathered and fresh materials. Excluding coal, on average, approximately 40% of the overburden/interburden on each highwall is weathered/oxidised and the remaining (approximately 60%) is fresh, with the proportion of weathered to fresh overburden/interburden varying throughout the site. In the northern half of the site the proportion of weathered to fresh overburden/interburden is about 25% weathered to 75% fresh, whereas in the southern half of the site the proportion of weathered to fresh overburden/interburden is about 49% weathered to 51% fresh. As mining progresses the pits become only marginally deeper due to the generally low-angle dip of the seams. Therefore, the proportion of fresh material to weathered material at closure will remain broadly similar to current proportions.

The statistical distribution of residual void highwall materials and the proportion of exposed coal seam (groups) is summarised in Table 20.

The BWM coal resource model is used to estimate coal resources from current pit highwall (for existing pits) through to the eastern extent of the mine – and for future pit highwalls. The resource model indicates that – at closure – the proportion of coal versus non-coal in the highwall of all voids is consistent with the current proportions on the existing pit highwalls. The model also shows that the proportion of each seam group is expected to be similar to current seam group proportions on the highwall of all voids. As such, the proportions of the various mineral waste types on the residual void highwall and floor (of all voids) is not expected to change significantly from those shown in the current pits. Therefore, the overall AMD hazard posed by the highwall and floor (of all residual voids) at end of mining is expected to be similar to that shown for the current pits.

Based on the information from the coal geology database and the coal resource model, all current and future pit highwalls are dominated by weathered and fresh non-carbonaceous materials. The composition (proportions) of the seam groups exposed on the highwalls in the pits (including future pits – based on exploration drill-hole data) are also shown in Table 20.

Table 20. Estimated wall rock exposure as a function of material type for each residual void

Void	Weath, non-carb. %	Weath, carb./coal %	Fresh, non-carb. %	Fresh, carb./coal %	Unknown OB/IB %	Coal, fresh %	Coal seam groups Proportion of each seam group
Bonnie Doon (and Ramp 8*)	17	0.1	73	3.5	-	6.7	T seam: 0.8% MR seam: <0.1% P&L seam: 5.9%
Mimosa-Besgrove	20	0.6	70	1.2	2.4	5.4	T seam:0.8% MR seam: 0.1% P&L seam: 4.5%
Deep Creek	22	1.0	68	1.2	0.6	7.1	T seam: 1.1% MR seam: 1.5% P&L seam: 4.5%
Stewarton-Ballamoo	23	1.6	65	1.1	1.7	7.2	T seam: 1.1% MR seam: 2.4% P&L seam: 3.7%
Kenmare	25	<0.1	65	1.2	4.1	5.1	T seam: 2.1% P&L seam: 3.0
Laleham	11	<0.1	82	0.8	-	6.0	T seam: 2.8% P&L seam: 3.2%
Togara-North Marshmead	73	5.6	19	0.4	-	2.0	T seam: 0.3% P&L seam: 1.7%
South Marshmead	59	1.3	37	0.7	-	2.6	T seam: 0.2% P&L seam: 2.4%
Kennedy West	76	2.0	13	<0.1	6.8	1.9	T seam: - P&L seam: 1.9%
Comet Downs East	33	0.6	54	3.0	6.3	3.3	T seam: 1.0% P&L seam: 2.3%

* Unable to undertake a specific void assessment for Ramp 8 void (future mining area) due to insufficient data. Assume Ramp 8 void will have similar highwall and seam proportions to Bonnie Doon void.

The T and P & L seam groups are the dominant seam groups at BWM (and colloquially referred to as the 'tops' and 'bottoms', respectively) and are present in every pit/void, whereas the MR seam group is a relatively minor seam group (overall) and is only present in the northern pits/voids from Ramp 8 through to Blackdown pit (southern end of Stewarton-Ballamoo void). The relative proportions of the T, MR and P & L seam groups are shown in Table 20. Overall, remnant coal (seams) are expected to comprise between 2% and 7% of the highwalls in the residual voids.

Note that the source hazard assessment methodology outlined in Sections 4.4.1 to 4.4.7 has been applied to the materials expected to be exposed on the pit highwalls and floor at closure (ie. on the highwalls and floors of the residual voids).

The highwall hazard assessment has found that approximately 4% to 7% of the void highwall in all voids is estimated to be PAF, which includes material classified as UC(PAF), PAF-LC and NAF-S. As

such, the assessment has found that the likelihood of AMD generation from the void highwalls is **Unlikely**, and any expression of AMD from the highwall is likely to be localised.

Excluding Bonnie Doon and Laleham voids, the floor of all residual voids will be the P & L (lower) seam. Assuming the floor of each of these voids is coal – which is a highly conservative assumption – the void floor AMD hazard assessment has found that approximately 25% of the floor of these voids where coal is exposed is estimated to be 'PAF', which includes material classified as PAF, UC(PAF), PAF-LC and NAF-S. As such, the conservative assessment has found that the likelihood of AMD generation from the floor of these voids where coal is exposed is **Unlikely**. Should these coal floors become submerged by groundwater (post-closure), the likelihood for AMD generation from the floor of these voids would be lower. In practice, mining takes all coal to the bottom the seam, therefore very little coal would be expected to remain on the floor of these voids.

Bonnie Doon and Laleham voids have tailings as the void floor and the source hazard assessment – based on the AMD hazard posed by tailings – has found that approximately 48% of the floor of Bonnie Doon void and 56% of the floor of Laleham void is estimated to be 'PAF' [tailings], which includes tailings classified as PAF, PAF-LC, UC(PAF) and/or NAF-S. AMD generation from the floor of these TSF voids is **Probable/Likely**. The tailings within these voids will be capped/covered at end of mining and no tailings will be exposed post-closure. As such, the likelihood for AMD generation from the floor of these voids post-closure would be lower. Should these tailings floors become submerged by groundwater (post-closure), the likelihood for AMD generation from the tailings floor of these voids would be lower.

The AMD hazard scoring tables for the residual voids are provided in **Attachment B – Tables B15 to B25**.

7.2 Geochemical source-pathway-receptor assessment

7.2.1 Conceptual site model

A post-mining conceptual site model (CSM), which applies generically to the spoil landforms and their respective residual voids and the relationship these facilities have with surface water and groundwater in the district, has been produced by SLR Consultants (2024). The CSM for the northern part of the mine is provided in **Figure 28** and for the southern part of the mine in **Figure 29**.

The CSM assists with the source-pathway-receptor (SPR) assessment with regard to potential environmental geochemical impacts from mineral waste facilities. The CSM, which focuses on the relationship with surface water and groundwater (these being the most relevant pathways and receptors for AMD and salinity), is used to illustrate the relationship between potential sources of run-off and seepage (eg. spoil, tailings, rejects), plausible receptors (eg. creeks, groundwater) and the pathways between the two (eg. seepage, drainage).

Prior to mining, groundwater flow in the northern half of BWM would have been generally towards the north and groundwater flow in the southern half of BWM would have been generally towards the southwest. Locally, these groundwater flow directions have been interrupted by mining, with current groundwater flow directions in the vicinity of the mine being towards the pits (ie. the pits are currently groundwater 'sinks'). Permian groundwater flow at BWM largely follows the coal seams down-dip. Shallower groundwater that is likely associated with shallow permeable strata is likely to flow in a direction that broadly mimics surface topography.

Figure 28. Conceptual site model post-mining for the northern BWM area
(SLR, 2024)

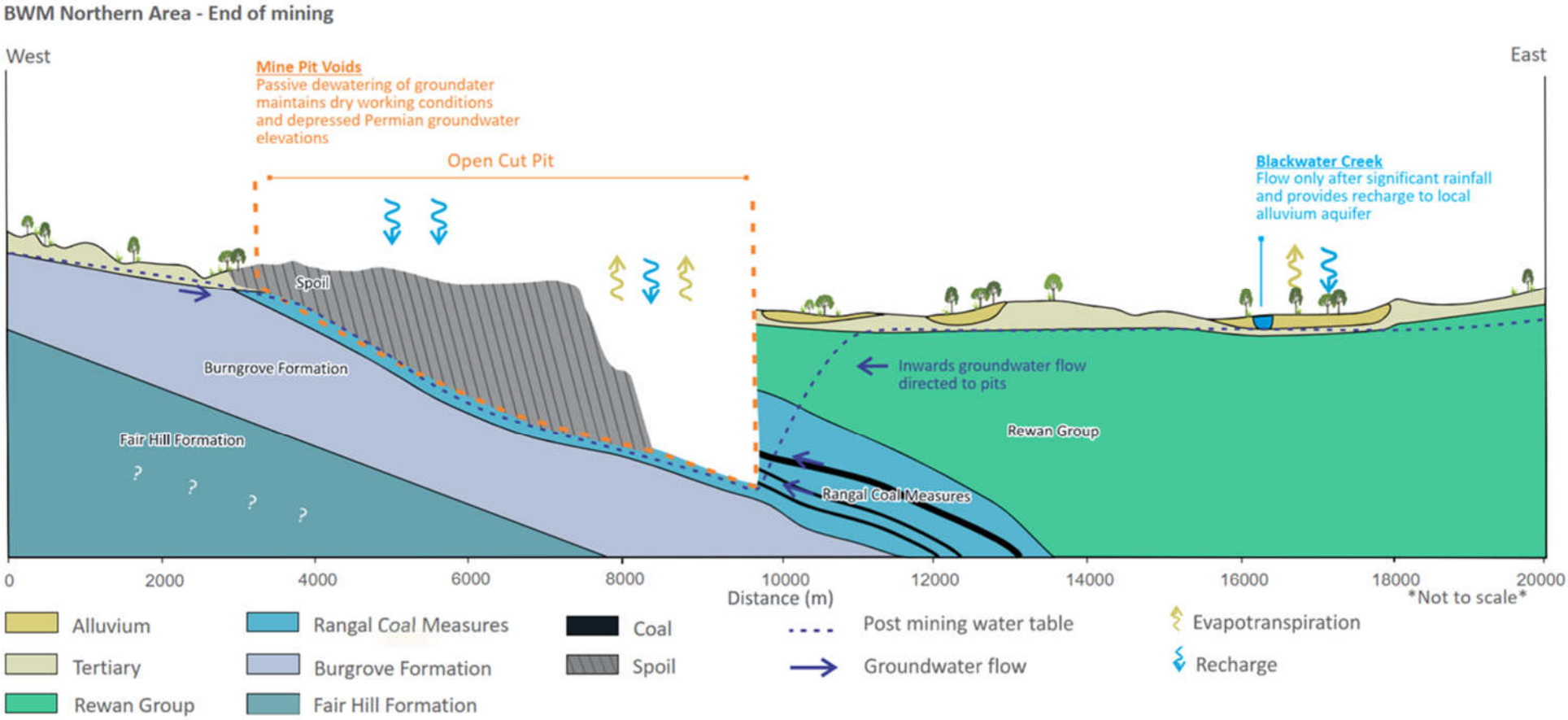
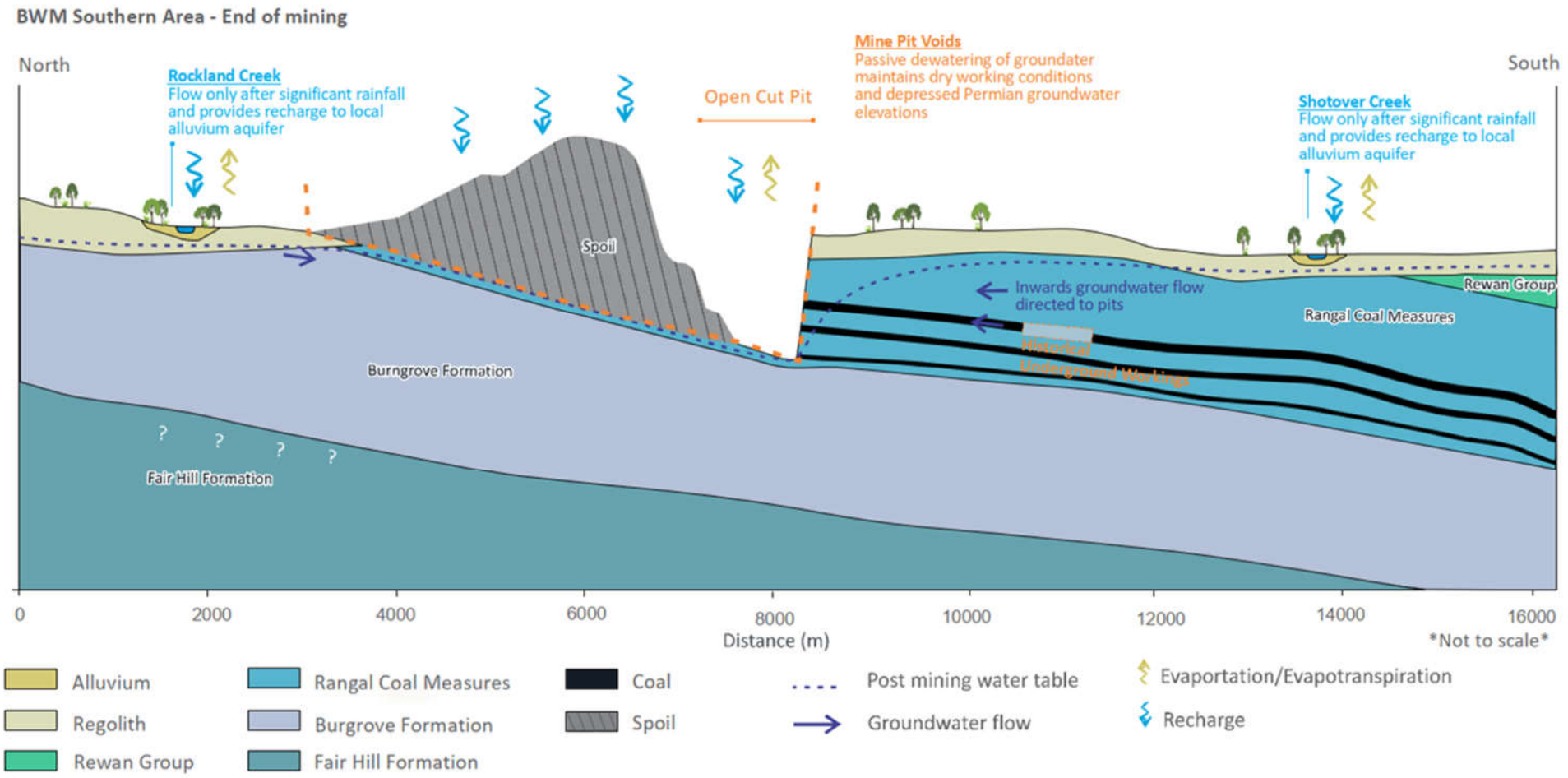


Figure 29. Conceptual site model post-mining for the southern BWM area
(SLR, 2024)



Groundwater modelling undertaken by SLR (2024) shows the residual voids will ultimately be groundwater 'sinks' – that is, the residual voids will be receptors of run-off and seepage from the spoil landforms and run-off from void highwalls, as illustrated in the CSM (**Figure 28** and **Figure 29**). The residual voids are classified as non-use management areas (NUMAs). The spoil landforms are located behind (generally west of) the residual voids and will drain into the voids. Seepage from the spoil landforms and the highwalls of the residual voids reports to the residual void. As such, the floor of residual voids (including the floor of Bonnie Doon and Laleham voids being tailings) are not likely AMD sources for groundwater receptors.

The hydrogeological assessment undertaken for the PRCP (SLR, 2024) indicates there may be shallow permeable strata present sporadically along (and/or near to) several creeks at BWM and – where present – shallow groundwater is expected to be below the base of all creeks in the area; suggesting that connectivity between shallow permeable strata and surface water features at BWM is unlikely. Furthermore, modelling (including particle tracking) undertaken by SLR for the PRCP found no evidence of post-closure connectivity between groundwater and surface water features – with the exception of a hydrogeological connection between groundwater in the vicinity of Bottom Dam area and the weathered alluvial strata within Sirius Creek approximately 750 m south of Bottom Dam area. The model suggests that – with the exception of Bottom Dam area – shallow groundwater (and by extension shallow seepage) migrating through the site will eventually report to the mine pits/voids. The general downward migration of shallow groundwater (and seepage) into deeper groundwater and towards the mine pits (residual voids) is logical, given the very large drawdown (sink) of the pits.

The assessment of shallow groundwater at BWM – particularly where shallow permeable strata may not be present in some areas or may be discontinuous – is limited by/to the distribution of the shallow bore network, which is sporadic. Therefore, despite the apparent low likelihood of substantial connection between shallow permeable strata and surface water features (in all areas at BWM except for Bottom Dam), the SPR assessment has adopted a highly conservative approach and assumed a plausible pathway *may exist* between shallow permeable strata and surface water features.

7.2.2 Conceptual facility models

A conceptual facility model (CFM) has been developed for each TSF and rejects landform to illustrate potential run-off and seepage pathways and surface water and groundwater receptors associated with these key mineral waste facilities post-closure.

- NCPP TSF – prior to rehabilitation – has a Moderate-High AMD source hazard with the likelihood of AMD generation from the landform rated as Probably/Likely. CFM shown at **Figure 30**.
- Laleham TSF – prior to rehabilitation – has a Moderate-High AMD source hazard with the likelihood of AMD generation from the landform rated as Probably/Likely. CFM shown at **Figure 31**.
- Bottom Dam TSF and rejects area is undergoing environmental and engineering assessment programs, which will guide the rehabilitation and closure planning for this area. Prior to rehabilitation (ie. currently), this area has been conservatively assigned a Moderate-High AMD source hazard with the likelihood of AMD generation from the landform rated as Probable/Likely (**Figure 32**) – and the CFM takes this AMD hazard and likelihood into account.
- Ramp 36 rejects dump – prior to rehabilitation – has a Moderate AMD source hazard with the likelihood of AMD generation from the landform rated as Probably/Likely. CFM shown at **Figure 33**.
- Ramp 72 TSF and Kenmare Pit rejects dump will be buried within Kenmare spoil landform and will form tailings and rejects components of the spoil landform. The concentrated nature of Ramp 72

tailings and Kenmare Pit rejects (which both have a High AMD source hazard) located at the base of the spoil landform warrants discussion with respect to SPR assessment. CFM shown at **Figure 34**.

- Deep Creek (Ramp 32) in-spoil rejects dump will be buried within the southern zone of Mimosa-Besgrove spoil landform. The concentrated nature of Deep Creek rejects (which has a Moderate-High AMD source hazard) located at the base of Ramp 32 and near the edge of the spoil landform close to Deep Creek warrants discussion with respect to SPR assessment. CFM shown at **Figure 35**.

Figure 30. Post-closure Source-Pathway-Receptor (SPR) conceptual facility model (CFM) for NCPP TSF landform

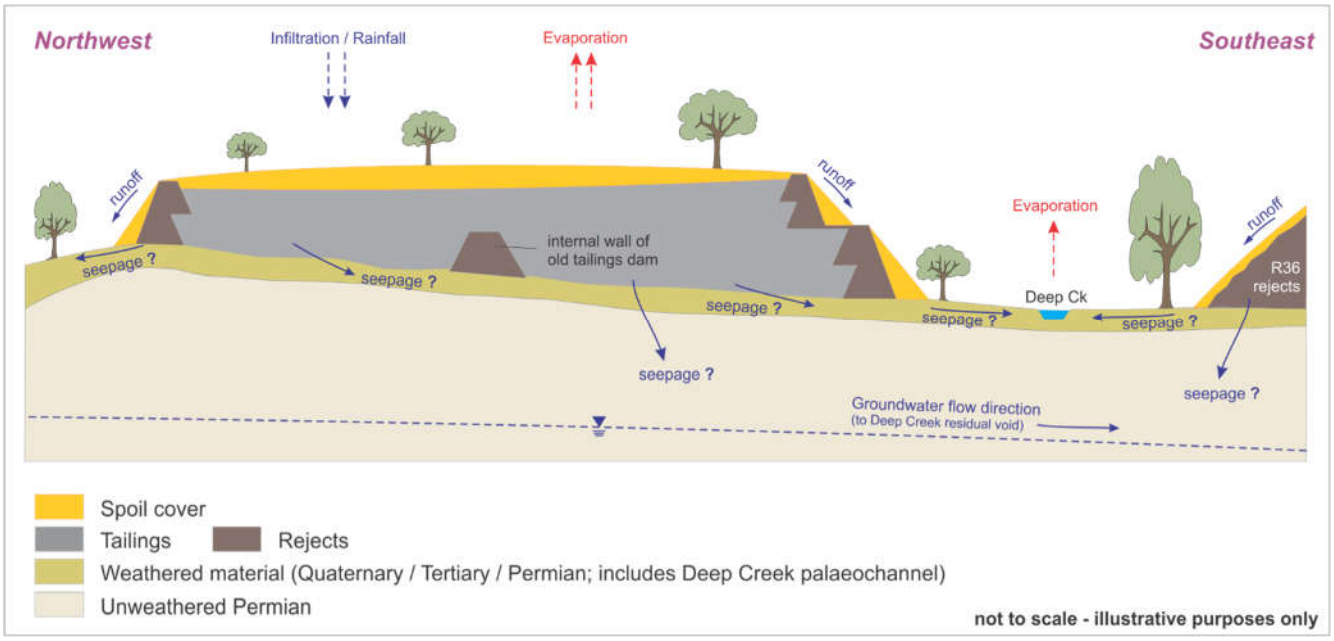


Figure 31. Post-closure Source-Pathway-Receptor (SPR) conceptual facility model (CFM) for Laleham TSF landform

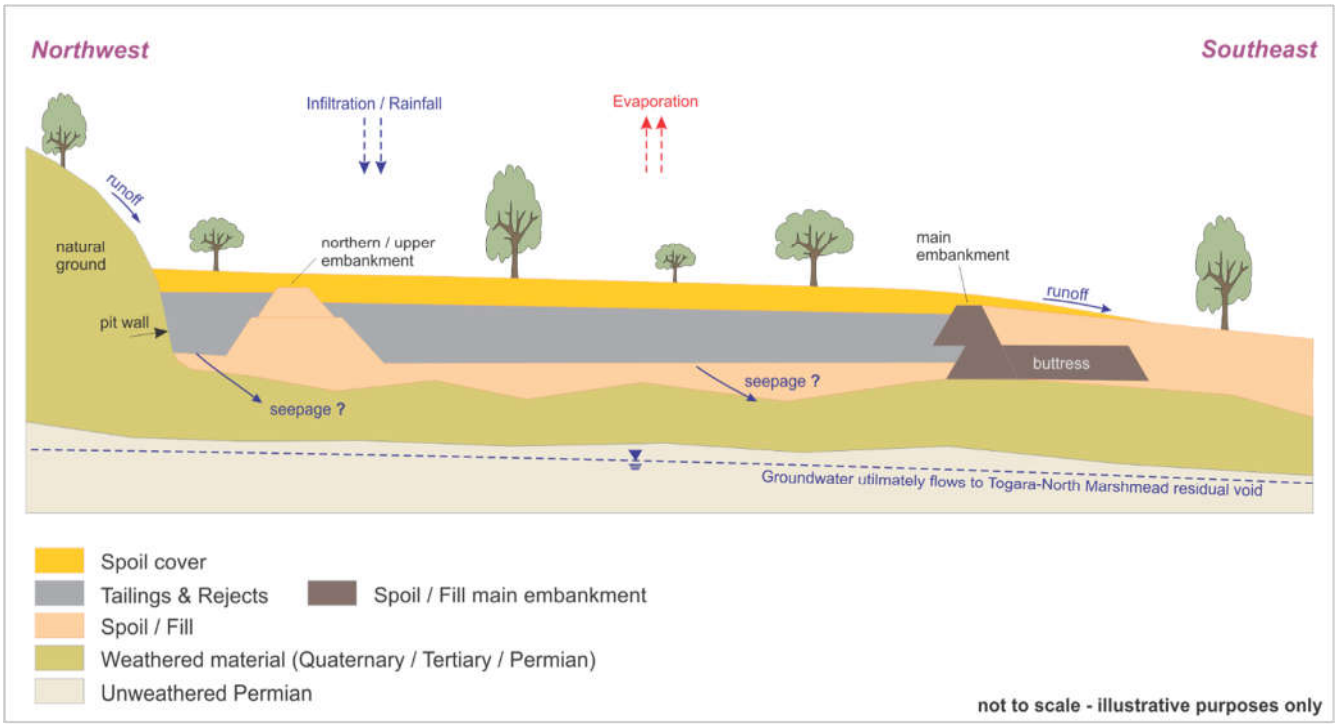


Figure 32. Post-closure Source-Pathway-Receptor (SPR) conceptual facility model (CFM) for Bottom Dam TSF and rejects landform

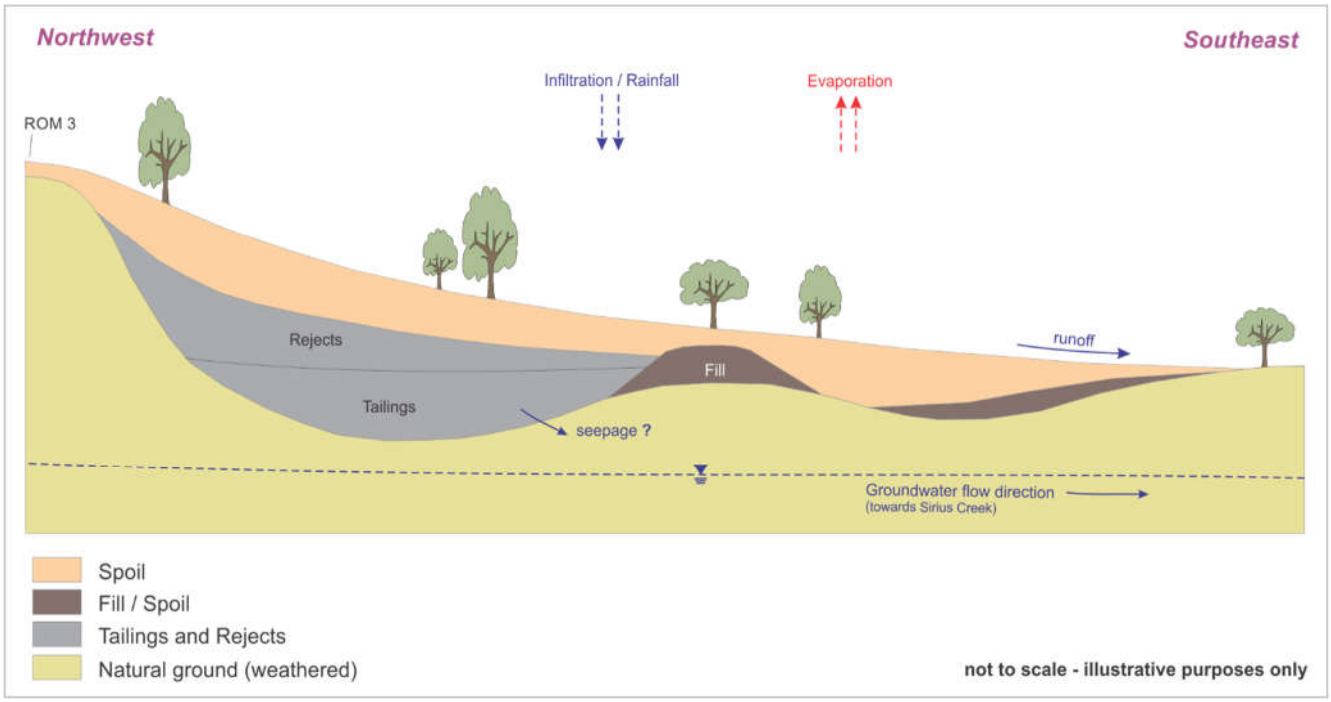


Figure 33. Post-closure Source-Pathway-Receptor (SPR) conceptual facility model (CFM) for Ramp 36 rejects landform

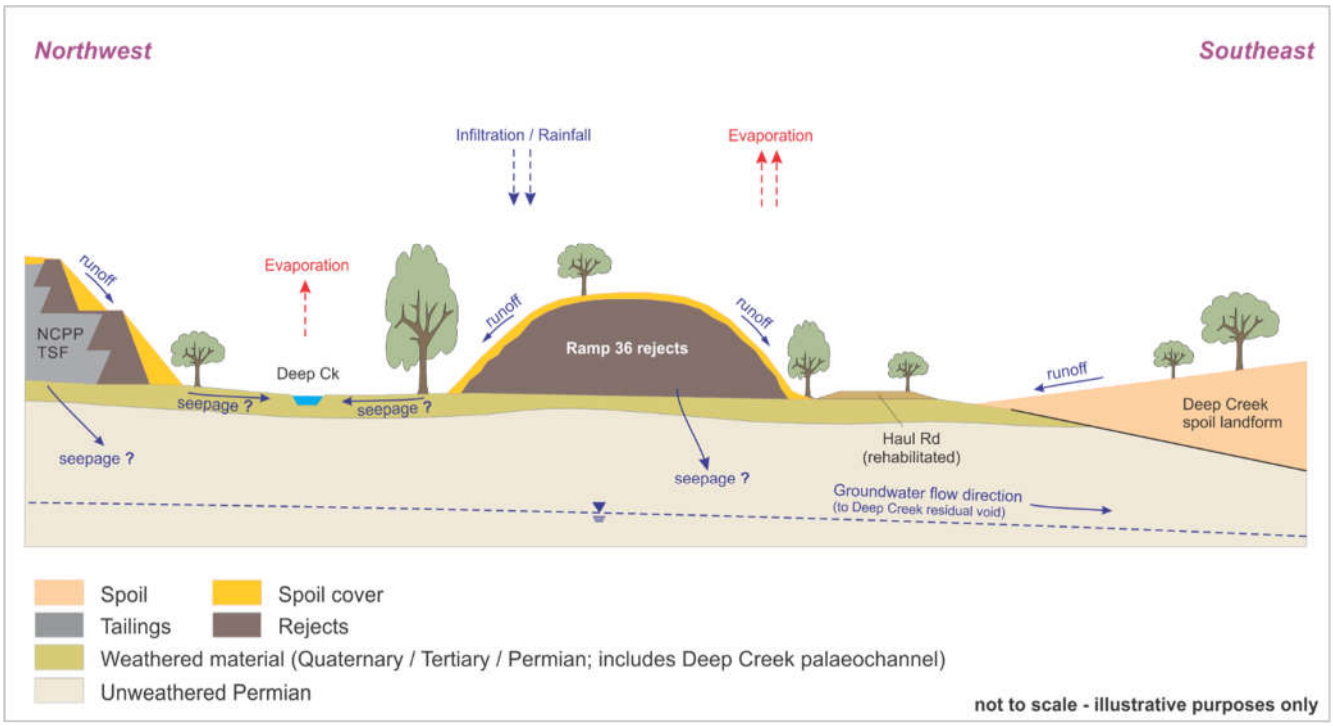


Figure 34. Post-closure Source-Pathway-Receptor (SPR) conceptual facility model (CFM) for Ramp 72 TSF buried within Kenmare spoil landform

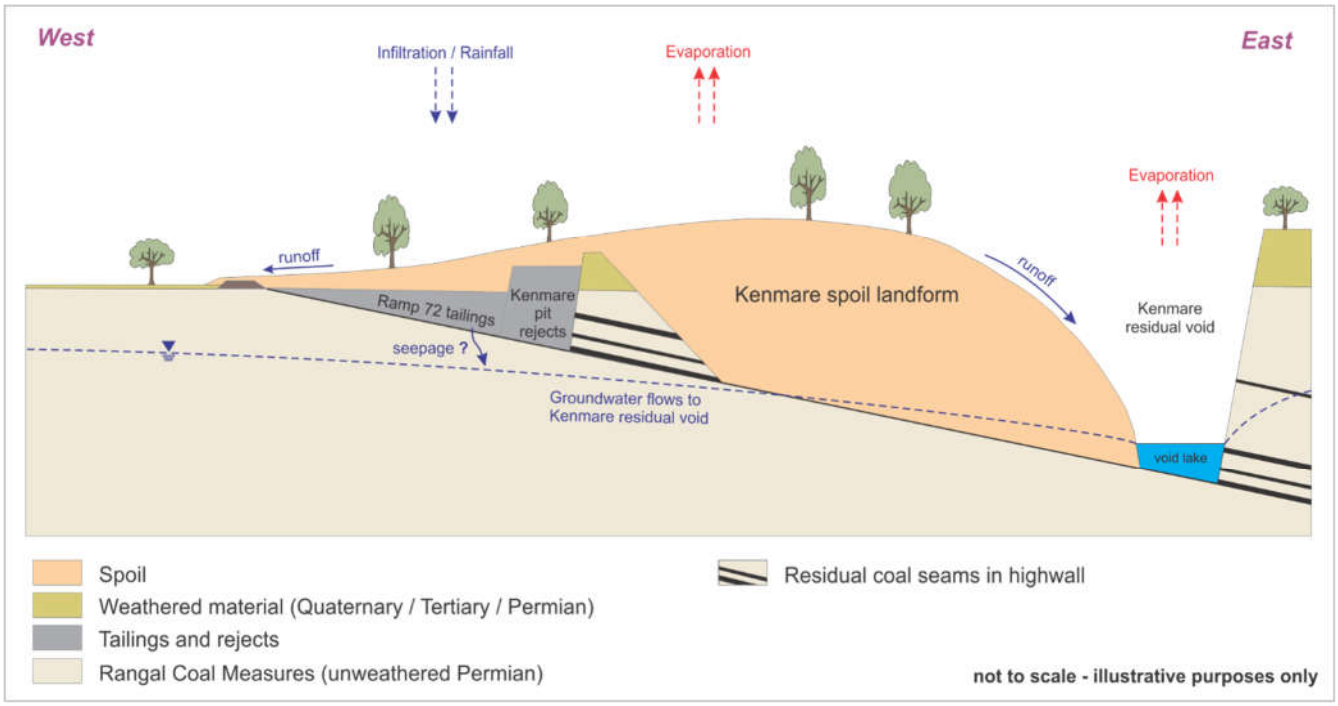
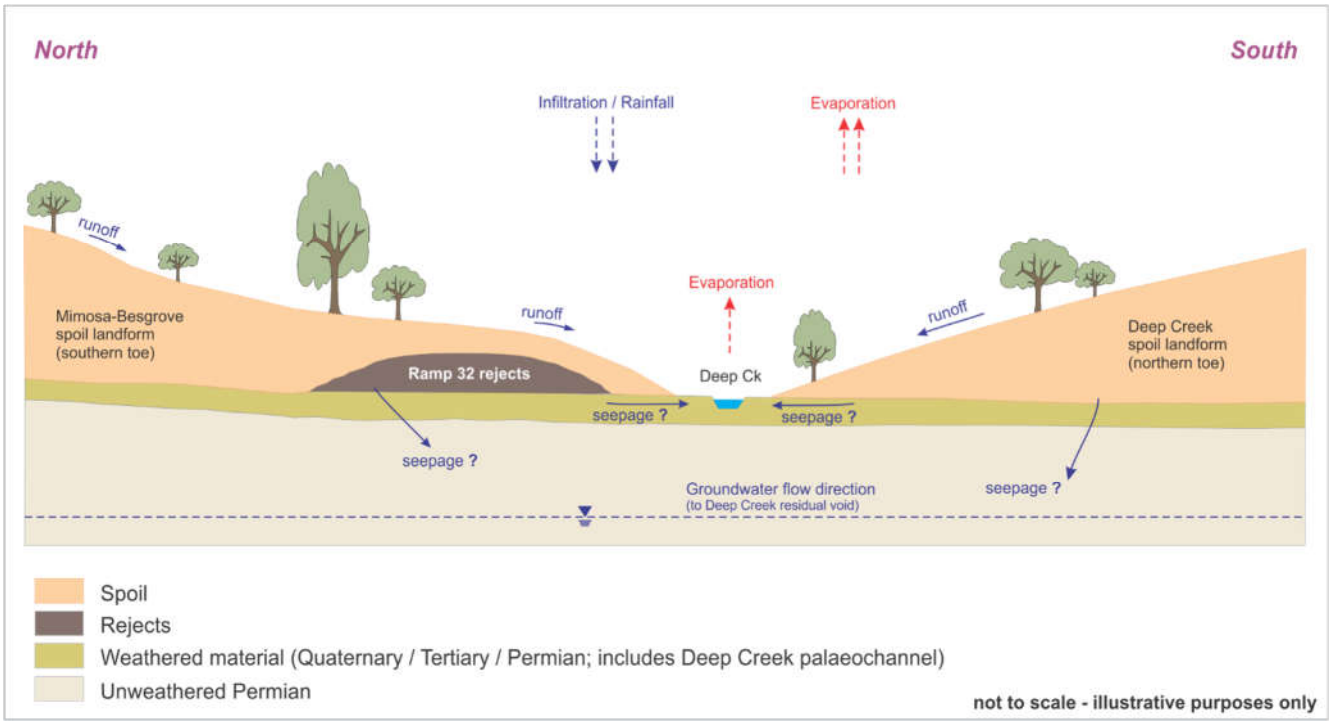


Figure 35. Post-closure Source-Pathway-Receptor (SPR) conceptual facility model (CFM) for Deep Creek [Ramp 32] rejects buried within Mimosa-Besgrove spoil landform



CFMs have also been produced for final void TSFs:

- Bonnie Doon spoil landform and residual void (TSF), with the likelihood of AMD generation from the unrehabilitated in-pit tailings rated as Probably/Likely. CFM shown at **Figure 36**.
- Laleham spoil landform and residual void (Ramp 74 TSF), with the likelihood of AMD generation from the unrehabilitated in-pit tailings rated as Probably/Likely. CFM shown at **Figure 37**.

*Note: the intent of the simplified CFM illustrations shown as **Figures 30 to 37** are to conceptualise potential surface water run-off and seepage pathways between key landform domains and potential receptors. The CFM figures are not to scale and may not be a true representation of the system at each location.*

CFMs have not been developed for general rejects co-disposed (broadly distributed) throughout spoil dumps/ landforms.

Figure 36. Post-closure Source-Pathway-Receptor (SPR) conceptual facility model (CFM) for Bonnie Doon spoil landform and final void TSF (Bonnie Doon TSF)

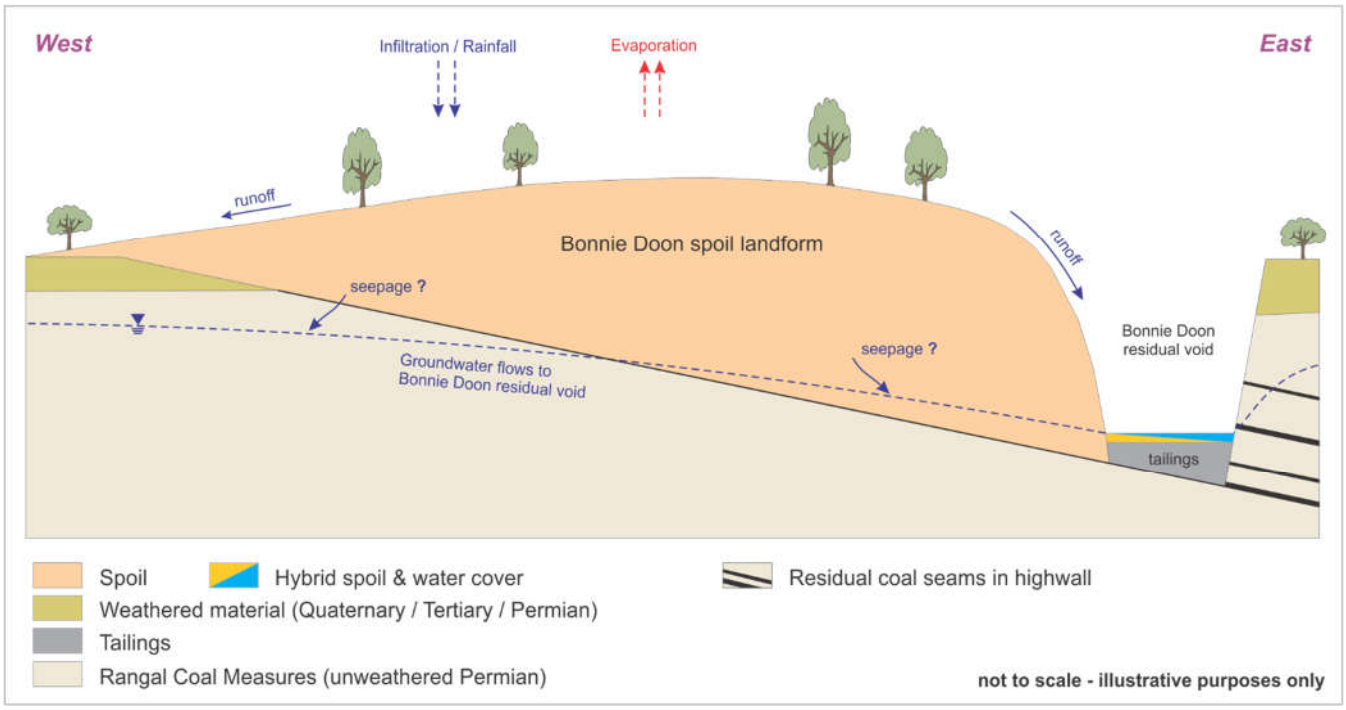
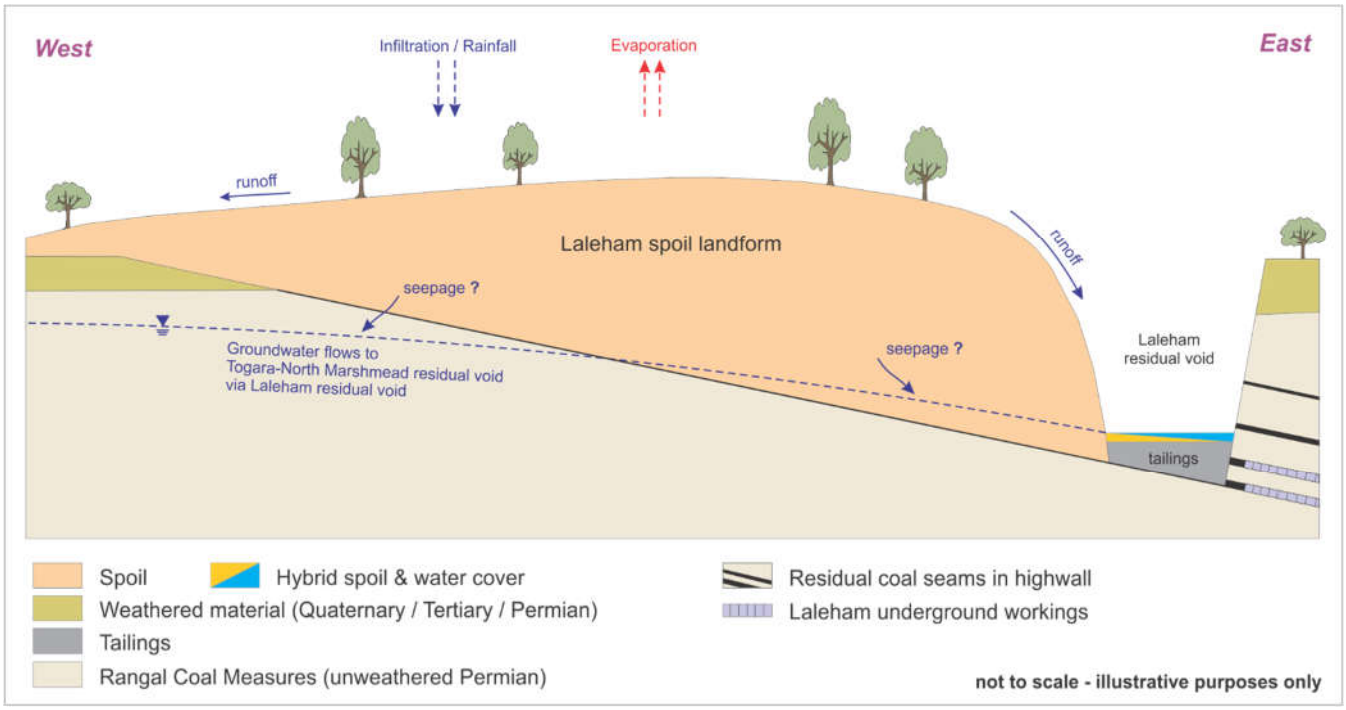


Figure 37. Post-closure Source-Pathway-Receptor (SPR) conceptual facility model (CFM) for Laleham spoil landform and final void TSF (Laleham / Ramp 74 TSF)



Groundwater modelling, including particle tracking, shows seepage from Laleham pit area (including Laleham spoil landform and Laleham TSF) ultimately flows into Togara-North Marshmead residual void, since this void is much larger and deeper (approximately 4 times deeper) compared to Laleham void and, therefore, is a much stronger groundwater sink compared to Laleham void.

7.2.3 Summary of sources, pathways and receptors

With regard to the spoil landforms, the plausible mechanisms for AMD affected water and/or non-oxidative salinity to report to receptors are identified in Table 21.

Table 21. Sources, potential receptors and pathways between the source and receptor (post-closure) for spoil landforms

Source Landform	Potential Pathways from Source	Potential Receptors from Source
Ramp 8	Surface water [run-off]	Bonnie Doon Creek via tributary (west) / Ramp 8 residual void
	Seepage [shallow permeable strata]	Bonnie Doon Creek via tributary (west)
	Seepage [groundwater]	Ramp 8 residual void
Bonnie Doon	Surface water [run-off]	Bonnie Doon Creek via tributary (northwest) / Bonnie Doon Creek (west) / Bonnie Doon residual void
	Seepage [shallow permeable strata]	Bonnie Doon Creek via tributary (northwest) / Bonnie Doon Creek (west)
	Seepage [groundwater]	Bonnie Doon residual void
Mimosa-Besgrove	Surface water [run-off]	Burngrove Creek via various tributaries (west) / Deep Creek (south) / Mimosa-Besgrove residual void
	Seepage [shallow permeable strata]	Burngrove Creek via various tributaries (west) / Deep Creek (south)
	Seepage [groundwater]	Mimosa-Besgrove residual void
Deep Creek	Surface water [run-off]	Deep Creek +/- via tributaries (north and northwest) / Taurus Creek via tributaries (southwest) / Taurus Creek (south) / Deep Creek residual void
	Seepage [shallow permeable strata]	Deep Creek +/- via tributaries (north and northwest) / Taurus Creek via tributaries (southwest) / Taurus Creek (south)
	Seepage [groundwater]	Deep Creek residual void
Stewarton/ Ballamoo	Surface water [run-off]	Taurus Creek (north) / Emu Creek[1] (west) / Sirius Creek via western tributaries / Stewarton-Ballamoo residual void
	Seepage [shallow permeable strata]	Taurus Creek (north) / Emu Creek[1] (west) / Sirius Creek via western tributaries
	Seepage [groundwater]	Stewarton-Ballamoo residual void
Kenmare	Surface water [run-off]	Sirius Creek via western tributaries (west) / Kenmare residual void
	Seepage [shallow permeable strata]	Sirius Creek via western tributaries (west)
	Seepage [groundwater]	Kenmare residual void

Source Landform	Potential Pathways from Source	Potential Receptors from Source
Laleham	Surface water [run-off]	Sirius Creek +/- via tributaries (north and west) / Laleham residual void
	Seepage [shallow permeable strata]	Sirius Creek +/- via tributaries (north and west)
	Seepage [groundwater]	Togara-North Marshmead residual void
Togara – North Marshmead	Surface water [run-off]	Sirius Creek (northwest and north) / Rockland Creek +/- tributaries (southwest and south) / Togara-North Marshmead residual void
	Seepage [shallow permeable strata]	Sirius Creek (north and west) / Rockland Creek +/- tributaries (west and south)
	Seepage [groundwater]	Togara-North Marshmead residual void
South Marshmead	Surface water [run-off]	Rockland Creek (north) / Shotover Creek tributary (south) / South Marshmead residual void
	Seepage [shallow permeable strata]	Rockland Creek (north) / Shotover Creek tributary (south)
	Seepage [groundwater]	South Marshmead residual void
Kennedy West	Surface water [run-off]	Rockland Creek +/- tributaries (west and north) / Kennedy West residual void
	Seepage [shallow permeable strata]	Rockland Creek +/- tributaries (west and north)
	Seepage [groundwater]	Kennedy West residual void
Comet Downs East	Surface water [run-off]	Rockland Creek +/- tributaries (east and west) / Comet Downs East residual void
	Seepage [shallow permeable strata]	Rockland Creek +/- tributaries (east and west toe)
	Seepage [groundwater]	Comet Downs East residual void

With regard to the TSF and rejects landforms, the plausible mechanisms for AMD affected water and/or non-oxidative salinity to report to receptors are identified in **Table 22**.

With regard to void highwalls (as a potential source of AMD affected water and/or non-oxidative salinity), the only plausible receptor is the void, via surface water [run-off] from the highwall.

Table 22. Sources, potential receptors and pathways between the source and receptor (post-closure) for TSF and reject landforms

Sources	Potential Pathways from Source	Potential Receptors from Source
TSF landforms		
NCPP TSF	Surface water [run-off]	Deep Creek (south and east)
	Seepage [shallow permeable strata]	Deep Creek (south and east)
	Seepage [groundwater]	Deep Creek residual void
Laleham TSF	Surface water [run-off]	Sirius Creek (south)
	Seepage [shallow permeable strata]	Sirius Creek (south)
	Seepage [groundwater]	Togara-North Marshmead residual void
Bottom Dam TSF [incl. rejects]	Surface water [run-off]	Sirius Creek (south)
	Seepage [shallow permeable strata]	Sirius Creek (south)
	Seepage [groundwater]	Sirius Creek (south)
Rejects landform		
Ramp 36 Rejects Dump	Surface water [run-off]	Deep Creek (west and north)
	Seepage [shallow permeable strata]	Deep Creek (west and north)
	Seepage [groundwater]	Deep Creek residual void

Risk matrix and risk ratings

A residual risk rating 'heat map' (Table 23) has been adopted to assess the risks associated with SPR from the 11 spoil landforms, three TSF landforms and Ramp 36 rejects landform. In reference to the risk matrix, the SPR assessment includes the likelihood of the event occurring, the severity of the event (should it occur) and the calculated risk rating (likelihood X severity).

Table 23. Risk matrix for SPR assessment

Risk Rating = Likelihood x Severity		Severity				
		S1	S2	S3	S4	S5
Likelihood	Highly Likely	Medium	Medium to High	High	High	High
	Likely	Low to Medium	Medium	Medium to High	High	High
	Probable	Low	Low to Medium	Medium	Medium to High	High
	Unlikely	Low	Low	Low to Medium	Medium	Medium to High
	Highly Unlikely	Low	Low	Low	Low to Medium	Medium

The risk ratings for the mineral waste landforms with respect to plausible receptors is shown in **Attachment C** and report sections as follows:

Surface water receptors of landform sources

- Spoil landforms with respect to plausible surface water receptors: **Table 21** and **Attachment C Tables C1 to C11** and discussed in **Section 7.2.4**;
- TSF and rejects landforms with respect to plausible surface water receptors: **Table 22** and **Attachment C Tables C12 to C15** and discussed in **Sections 7.2.5 to 7.2.8**.

Residual void receptors of landform sources

Groundwater modelling (SLR, 2024) has shown that the residual voids will be groundwater 'sinks'. As such, seepage into the Permian groundwater system from any/all facilities at BWM – excluding Bottom Dam TSF/rejects area – will ultimately report into the residual voids. Groundwater modelling shows that groundwater below Bottom Dam TSF/rejects area flows south and ultimately reports into Sirius Creek alluvium.

- Spoil landforms with respect to residual void receptors: **Table 21** and **Attachment C Tables C16 to C18** and discussed in **Section 7.2.4**;
- TSF and rejects landforms with respect to residual void receptors: **Table 22** and **Attachment C Table C19** and discussed in **Sections 7.2.5 to 7.2.8**.

Residual void receptors of highwalls and void floor sources

The risk ratings for the residual void highwall and floor (for each void) with respect to final void receptors is shown in **Attachment C Table C20** and discussed in **Section 7.2.9**. The potential impact of seepage from the residual voids into the Permian groundwater aquifer is discussed in the void closure plan (WSP, 2024).

7.2.4 SPR assessment of spoil landforms

Source materials hazard

The spoil landforms are comprised of approximately 93 to 99% non-carbonaceous overburden/interburden with coaly and carbonaceous material (predominantly in the form of carbonaceous spoil and reject) comprising the remaining 1 to 7% of the spoil landforms. Non-carbonaceous overburden/interburden in the Bowen Basin is widely recognised as posing a low to low-moderate AMD risk.

Rejects at BWM generally pose a moderate AMD source hazard. Where rejects form part of a spoil landform they comprise less than 2% of the landform (in most cases less than 1%). Rejects within the southern end of Kenmare pit – and therefore within the Kenmare spoil landform – pose a high AMD source hazard. These rejects within the southern end of Kenmare pit will form approximately 0.5% of the Kenmare landform, however they are concentrated in a relatively small area at the base of the landform adjacent to Ramp 72 TSF.

Tailings at BWM generally pose a moderate-high to high AMD hazard and, with regard to spoil landforms, tailings will only be present in Kenmare landform (within Ramp 72 TSF). Overall, Ramp 72 tailings will form approximately 1% of the Kenmare landform, however they are concentrated in a relatively small area at the base of the landform.

Spoil materials generally have low EC values and are expected to produce non-saline to slightly saline run-off and seepage, with release of (non-oxidative) salinity rated as a low hazard. Unoxidised rejects and tailings have low to moderate EC values and are expected to produce slightly to moderately saline run-off and seepage, with release of (non-oxidative) salinity rated as a low-moderate hazard. The overall low total S and generally excess ANC of the combined mineral waste – for all spoil landforms – results in a 'Low' AMD hazard score, with AMD generation rated as 'Highly Unlikely'. Tailings and rejects specifically within Kenmare spoil landform have higher AMD hazards scores, with AMD generation rated as 'Highly Likely'. With respect to non-oxidative salinity, all spoil landforms have generally low salinity, with SD generation rated as 'Unlikely'.

Pathways

Pathways from spoil landforms to plausible surface water and groundwater (residual void) receptors are shown in **Figures 26 and 27** (Post-closure landform), **Table 21** and **Attachment C Tables C1 to C11; and C16 to C18**.

Surface water

Surface water receptors (ephemeral creeks) are located adjacent to each spoil landform – ranging from less than 100 m to approximately 600 m from landform edges. Most surface water receptors were less than 200 m from landform edges. It is plausible for surface water run-off from final rehabilitated landforms to reach these creeks. Surface water receptors greater than about 600 m from landforms were considered to be implausible receptors. Refer to **Figures 26 and 27** and **Table 21** for surface water receptors associated with each spoil landform. Tailings (eg. Ramp 72 TSF) and rejects located within spoil landforms will be buried into spoil and therefore all run-off will likely be from general spoil (overburden/interburden) material and no tailings or rejects will be exposed to (or at risk of) surface water run-off.

Seepage / Groundwater)

The water table is expected to intersect the deeper zones of each in-pit spoil landform within the Permian coal measures (SLR, 2024). However, groundwater is captured by the residual void (as a groundwater sink). Therefore, although a direct connection is expected to exist between deeper parts of the final landforms and groundwater (the water table), this groundwater will report to the residual void – not to the broader aquifer.

As discussed in **Section 7.2.1**, it is plausible for seepage from the near-surface and unsaturated zone of the in-pit final landforms to migrate downwards into the water table. It is also plausible (however likely) that seepage may occur into discontinuous shallow permeable strata locally associated with existing creeks or palaeodrainage channels. Due to the highly discontinuous and/or not interconnected nature of shallow permeable strata at BWM, the understanding surrounding any potential link between shallow groundwater and surface water is limited. As such, whether seepage into shallow permeable strata would continue further downwards into deeper groundwater (primary aquifer) or, instead, report to nearby surface water features, is also somewhat unclear. Despite this potential limitation, the overall seepage gradient at BWM is downwards. Therefore, it is reasonably assumed that seepage from final landforms into shallow groundwater is 'Unlikely' to reach a surface water receptor.

In summary, the SPR has assumed a plausible (although unlikely) local seepage pathway may exist between a landform – such as seepage from a buried rejects dump or TSF – via shallow permeable strata into a nearby surface water receptor (ephemeral creek).

Receptors

Plausible receptors identified in this qualitative assessment include ephemeral creeks and the residual voids. Refer to **Attachment C Tables C1 to C11** for surface water receptors associated with each spoil landform and **Attachment C Tables C16 to C18** for residual void receptors.

Specific to buried Ramp 72 tailings/rejects in Kenmare spoil landform, refer to CFM **Figure 34**. Specific to buried Ramp 32 rejects in Mimosa-Besgrove spoil landform, refer to CFM **Figure 35**.

Due to the geochemical nature of the spoil landforms, the likelihood of AMD from spoil landforms to impact on the water quality of surface water receptors, residual voids or groundwater has been rated unlikely. The likelihood of non-oxidative salinity from spoil landforms to impact on the water quality of surface water receptors, residual voids or groundwater has also been rated unlikely. The overall risk rating is low.

Consideration was also made to people living in the homesteads near BWM. There are a number of homesteads in the general vicinity of BWM, however none are close to any pits or residual voids, TSFs or spoil dumps (final spoil landforms) and, as such, are considered to be implausible receptors of AMD or saline drainage for the final spoil landforms. The nearest homestead to the current mining area is '*Ausbute*' located about 1.3 km west of Burngrove Pit and cannot receive run-off or seepage from Mimosa-Besgrove spoil landform.

SPR risk rating of final spoil landforms

There are plausible surface water and residual void receptors; and the run-off [and shallow seepage] pathways linking the sources (final spoil landforms) to these receptors have been identified. With respect to AMD, the overall SPR risk rating from all final spoil landforms is **Low**. With respect to non-oxidative salinity the overall SPR risk from final spoil landforms is also rated as **Low**.

Where landforms contain buried tailings and/or rejects, and especially if those buried tailings/rejects are located close to the edge of the landform and/or close to a creek, the risk rating with respect to AMD potentially making its way via shallow permeable strata into surface water features close to the buried tailings/rejects was rated as **Low to Medium**. This applies to Kenmare spoil landform (containing Ramp 72 tailings and Kenmare pit rejects) and Mimosa-Besgrove spoil landform (containing Deep Creek [Ramp 32] rejects dump).

7.2.5 SPR assessment of NCPP TSF landform

Source materials hazard

Excluding the final cover/cap to be installed over NCPP TSF, the TSF landform is currently comprised of approximately 80% tailings, with the remainder being rejects (about 19%, as embankment material) and fill material (about 1%, also as embankment material). Tailings within the TSF pose a high AMD hazard and rejects (embankments) pose a moderate AMD hazard.

Source materials generally have low-moderate EC values and are expected to produce slightly to moderately saline run-off and seepage, with release of (non-oxidative) salinity rated as a low-moderate hazard. Overall, the hazard for AMD generation from the current NCPP TSF landform is 'Moderate-High' and the likelihood for AMD generation from the current landform is 'Highly Likely' (the highest 'likelihood' rating available under the applied AMD hazard scoring methodology) – noting that field evidence of AMD (as AD) exists at the facility. With respect to non-oxidative salinity, the TSF landform has a conservative hazard score of 'Probable/Likely'.

Pathways

Pathways from NCPP TSF landform to plausible surface water and groundwater (residual void) receptors are shown in **Figure 26** (Post-closure landform), **Figure 30** (CFM for NCPP TSF landform), **Table 22** and **Attachment C Table C12**.

Surface water

Deep Creek (an ephemeral creek) is located to the south and southeast of (and less than 100 m from) NCPP TSF landform and flows from west to east across the site. It is likely that surface water run-off from NCPP TSF landform will reach Deep Creek. The TSF will be covered with a spoil cover to manage the AMD source hazard, therefore all post-closure run-off from NCPP TSF landform will likely be from general spoil (overburden/interburden) material and no tailings or rejects will be exposed to (or at risk of) surface water run-off.

Shallow / Groundwater

As discussed earlier, this assessment has conservatively assumed it is plausible that seepage may occur into discontinuous shallow permeable strata associated with existing creeks or palaeodrainage channels. Whether seepage into shallow permeable strata would continue further downwards into the deeper (primary) aquifer or, instead, report through the shallow permeable strata into nearby surface water features (in this case, Deep Creek), is somewhat unclear. Despite this potential limitation, the overall seepage gradient at BWM is downwards and towards (into) residual voids – including from areas outside of a pit shell, such as NCPP TSF.

Groundwater modelling (SLR, 2024) shows that seepage from NCPP TSF landform would report to Deep Creek residual void. Therefore, it is reasonably assumed that the likelihood of seepage from

NCPP TSF final landform reaching a surface water receptor (eg. Deep Creek) via shallow groundwater is 'Unlikely'.

In summary, the SPR has assumed a plausible (although unlikely) local seepage pathway may exist between the NCPP TSF landform via shallow permeable strata into nearby ephemeral surface water receptors (such as Deep Creek).

Receptors

Plausible receptors of surface water run-off and seepage from NCPP TSF landform are shown in **Figure 26** (Post-closure landform), **Figure 30** (CFM for NCPP TSF landform), **Table 22** and **Attachment C Tables C12 and C19**.

Surface water

The only plausible surface water receptor identified in this qualitative assessment of NCPP TSF landform is ephemeral Deep Creek, located less than 100m from the TSF. This applies to potential surface water run-off and potential seepage through shallow permeable strata into the surface water receptor(s).

The rehabilitated TSF landform will have a spoil cover designed to manage the AMD hazard of the landform. The spoil cover has been conservatively assumed to pose a low-moderate AMD source hazard, based on a conservative AMD source hazard applied to general spoil. As such, the likelihood of AMD from the rehabilitated (post-closure) TSF landform to impact on the water quality of the surface water receptor(s) (via run-off or shallow seepage) has been rated unlikely. The likelihood of non-oxidative salinity from the TSF landform to impact on the water quality of the surface water receptor(s) has been rated unlikely.

Seepage / Groundwater

Seepage from NCPP TSF landform into groundwater will ultimately report to Deep Creek residual void. The likelihood of AMD and non-oxidative salinity from the rehabilitated (post-closure) TSF landform to impact on the water quality of Deep Creek residual void has been rated highly unlikely.

SPR risk rating of NCPP TSF landform

There are plausible surface water and residual void receptors; and the run-off [and shallow seepage] pathways linking the source (NCPP TSF final landform) to these receptors have been identified. Groundwater modelling (SLR, 2024) shows that seepage from NCPP TSF landform would report to Deep Creek residual void. With respect to AMD, the overall SPR risk rating from the post-closure TSF final landform is **Low to Medium**. The 'Medium' risk rating applies to AD and SD associated with seepage via shallow permeable strata. With respect to non-oxidative salinity the overall SPR risk from NCPP TSF final landform is rated as **Low**.

7.2.6 SPR assessment of Laleham TSF landform

Source materials hazard

Excluding the final cover/cap to be installed over Laleham TSF, the TSF landform is currently comprised of approximately 90% tailings, with the remainder being rejects (about 9%, partially as embankment material) and spoil/fill material (about 1%, as embankment material). The TSF has a thin spoil cover, which may require augmenting (thickening) with additional spoil during rehabilitation. Tailings within the current TSF pose a moderate-high AMD hazard and rejects pose a moderate AMD hazard.

Source materials generally have moderate EC values and are expected to produce moderately saline run-off and seepage, with release of (non-oxidative) salinity rated as a moderate hazard. Overall, the hazard for AMD generation from the current Laleham TSF landform is 'Moderate-High' and the likelihood for AMD generation from the landform is 'Probable Likely'. With respect to non-oxidative salinity, the TSF landform has a conservative hazard score of 'Probable/Likely'.

Pathways

Pathways from Laleham TSF landform to plausible surface water and groundwater (residual void) receptors are shown in **Figure 27** (Post-closure landform), **Figure 31** (CFM for Laleham TSF landform), **Table 22** and **Attachment C Tables C13 and C19**.

Surface water

Sirius Creek (an ephemeral creek) is located approximately 370 m south of Laleham TSF landform and flows from east to west across the site. It is plausible that surface water run-off from Laleham TSF landform could reach Sirius Creek.

The TSF is currently partially rehabilitated, however additional rehabilitation measures may be required. The rehabilitated TSF landform will have a spoil cover designed to manage the AMD hazard of the landform. Therefore, all post-closure run-off from the TSF landform will be from general spoil (overburden/interburden) material and no tailings or rejects will be exposed to (or at risk of) surface water run-off.

Seepage / Groundwater

As discussed earlier, this assessment has conservatively assumed it is plausible that seepage may occur into discontinuous shallow permeable strata associated with existing creeks or palaeodrainage channels. Whether seepage into shallow permeable strata would continue further downwards into the deeper (primary) aquifer or, instead, report through the shallow permeable strata into nearby surface water features (in this case, Sirius Creek), is somewhat unclear – especially given the distance to Sirius Creek (~370 m). Despite this potential limitation, the overall seepage gradient at BWM is downwards and towards (into) the residual voids. Therefore, it is reasonably assumed that the likelihood of seepage from Laleham TSF landform reaching a surface water feature via shallow groundwater is 'Unlikely'.

In summary, the SPR has assumed a plausible (although unlikely) local seepage pathway may exist between the Laleham TSF landform via shallow permeable strata into nearby surface water receptors (Sirius Creek).

Receptors

Plausible receptors of surface water run-off and seepage from Laleham TSF landform are shown in **Figure 27** (Post-closure landform), **Figure 31** (CFM for Laleham TSF landform), **Table 22** and **Attachment C Tables C13 and C19**.

Surface water

The only plausible surface water receptor identified in this qualitative assessment of Laleham TSF landform is ephemeral Sirius Creek, located approximately 370 m south of the TSF, with the Laleham spoil landform between the TSF and the creek. This applies to potential surface water run-off and potential seepage through shallow permeable strata into Sirius Creek.

The moderate distance to Sirius Creek from the TSF landform would likely preclude surface water or shallow seepage from having any significant impact on the water quality of Sirius creek. As such, the likelihood of AMD or non-oxidative salinity from the rehabilitated TSF landform to impact on the water quality of Sirius Creek (via run-off or shallow seepage) has been rated highly unlikely.

Seepage / Groundwater

Seepage from Laleham TSF landform into groundwater will ultimately report to Togara-North Marshmead residual void. The likelihood of AMD and non-oxidative salinity from the rehabilitated (post-closure) TSF landform to impact on the water quality of Togara-North Marshmead residual void has been rated highly unlikely.

SPR risk rating of Laleham TSF landform

There are plausible surface water and residual void receptors; and the run-off and shallow seepage pathways linking the source (Laleham TSF final landform) to these receptors have been identified. Groundwater modelling (SLR, 2024) shows that seepage from Laleham TSF landform would ultimately report to Togara-North Marshmead residual void. With respect to AMD, the overall SPR risk rating from the post-closure TSF final landform is **Low**. With respect to non-oxidative salinity the overall SPR risk from Laleham TSF final landform is also rated as **Low**.

7.2.7 SPR assessment of Bottom Dam TSF/rejects landform

Source materials hazard

Bottom Dam TSF/rejects area is currently undergoing an environmental and engineering assessment program and the results of this program will inform rehabilitation and closure planning. The dominant materials in the general Bottom Dam area comprise tailings and rejects, with potentially very minor spoil/fill materials. In the absence of sufficient geochemical data from Bottom Dam TSF/rejects for the current assessment, the AMD source hazard has conservatively assumed tailings and rejects in the Bottom Dam area pose a 'Moderate-High' AMD source hazard. This is based on tailings posing a moderate-high AMD source hazard and rejects posing a moderate to moderate-high AMD source hazard – as per the AMD source hazard for tailings and rejects located within Ramp 72 TSF (tailings), Kenmare Pit (rejects) and Laleham TSF (tailings and rejects). With respect to non-oxidative salinity, the Bottom Dam landform has been assigned a conservative hazard score of 'Probable/Likely'.

The assumed (preliminary) AMD hazard score for the tailings and rejects materials is considered to be conservative and the landform domain AMD hazard score for Bottom Dam TSF/rejects area is also considered to be conservative.

Pathways

Pathways from Bottom Dam TSF/rejects landform to plausible surface water receptors are shown in **Figure 27** (Post-closure landform), **Figure 32** (CFM for Bottom Dam TSF/rejects landform), **Table 22** and **Attachment C Table C14**.

Surface water

Sirius Creek (an ephemeral creek) is located approximately 750 m south of Bottom Dam area. Surface water run-off from the rehabilitated Bottom Dam TSF/rejects landform would be directed south. However – given the significant distance to Sirius Creek – it is unlikely that run-off and shallow seepage

from the rehabilitated landform could reach Sirius Creek (most likely to infiltrate into the soil or be evaporated along the flow path).

Bottom Dam area will undergo rehabilitation, including the design and installation of a spoil cover to manage the AMD hazard of the tailings and rejects. Therefore, all post-closure run-off from the rehabilitated Bottom Dam landform will be from general spoil (overburden/interburden) material and no tailings or rejects will be exposed to (or at risk of) surface water run-off.

Seepage / Groundwater

As discussed earlier, groundwater modelling [particle tracking] (SLR, 2024) has shown that groundwater beneath Bottom Dam TSF/rejects area is expected to flow south towards Sirius Creek and ultimately report into Sirius Creek alluvial, approximately 750 m south of Bottom Dam area. Therefore, it is conservatively assumed that the likelihood of seepage from Bottom Dam TSF/rejects landform reaching a surface water feature via shallow or deep groundwater is 'Probable/Likely'.

In summary, the SPR has assumed a seepage pathway may exist between the Bottom Dam TSF/rejects landform via groundwater into surface water receptors (Sirius Creek).

Receptors

Plausible receptors of surface water run-off and seepage from Bottom Dam TSF/rejects landform are shown in **Figure 27** (Post-closure landform), **Figure 32** (CFM for Bottom Dam TSF/rejects landform), **Table 22** and **Attachment C Table C14**.

Surface water

The only plausible surface water receptor identified in this qualitative assessment of Bottom Dam TSF/rejects landform is ephemeral Sirius Creek, located approximately 750 m south of Bottom Dam area. This applies to potential surface water run-off and potential seepage through shallow permeable strata into Sirius Creek.

The significant distance to Sirius Creek from the TSF/rejects landform would likely preclude surface water or shallow seepage (through shallow strata) from having any significant impact on the water quality of Sirius creek. As such, the likelihood of AMD or non-oxidative salinity from the rehabilitated TSF/rejects landform to impact on the water quality of Sirius Creek (via run-off) has been rated highly unlikely.

Seepage / Groundwater

Seepage from Bottom Dam TSF/rejects landform into groundwater is expected to ultimately report to Sirius Creek, approximately 750 m south of Bottom Dam area. However, the likelihood of AMD and non-oxidative salinity from the rehabilitated (post-closure) TSF landform to impact on the water quality of Sirius Creek has been rated unlikely.

SPR risk rating of Bottom Dam TSF/rejects landform

There is a plausible surface water receptor (Sirius Creek); and the run-off and seepage pathways linking the source (Bottom Dam TSF/rejects final landform) to this receptor have been identified. Groundwater modelling (SLR, 2024) shows that seepage from Bottom Dam area would report to Sirius Creek. With respect to AMD, the overall SPR risk rating from the post-closure TSF/rejects final landform is **Low**. With

respect to non-oxidative salinity the overall SPR risk from the post-closure TSF/rejects final landform is also rated as **Low**.

7.2.8 SPR assessment of Ramp 36 rejects landform

Source materials hazard

Excluding the final cover/cap to be installed over Ramp 36 rejects dump, the rejects landform is currently comprised of approximately 98% rejects, with the remainder being fill material (assumed about 2%). Rejects within the dump pose a Moderate AMD hazard.

Source materials (essentially all rejects) have moderate EC values and are expected to produce moderately saline run-off and seepage, with release of (non-oxidative) salinity rated as a moderate hazard. Overall, the hazard for AMD generation from the current Ramp 36 rejects landform is 'Moderate' and the likelihood for AMD generation from the landform is 'Probable/Likely'. With respect to non-oxidative salinity, the TSF landform has a conservative hazard score of 'Probable/Likely'.

Pathways

Pathways from Ramp 36 rejects landform to plausible surface water and groundwater (residual void) receptors are shown in **Figure 26** (Post-closure landform), **Figure 33** (CFM for Ramp 36 rejects landform), **Table 22** and **Attachment C Tables C15 and C19**.

Surface water

Deep Creek (an ephemeral creek) is located to the north of (and less than 100 m from) Ramp 36 rejects landform and flows from west to east across the site. It is likely that surface water run-off from the rejects landform will reach Deep Creek. The rejects dump will be covered with a spoil cover to manage the AMD source hazard, therefore all post-closure run-off from the rejects landform will likely be from general spoil (overburden/interburden) material and no rejects will be exposed to (or at risk of) surface water run-off.

Shallow / Groundwater

As discussed earlier, this assessment has conservatively assumed it is plausible that seepage may occur into discontinuous shallow permeable strata associated with existing creeks or palaeodrainage channels. Whether seepage into shallow permeable strata would continue further downwards into the deeper (primary) aquifer or, instead, report through the shallow permeable strata into nearby surface water features (in this case, Deep Creek), is somewhat unclear. Despite this potential limitation, the overall seepage gradient at BWM is downwards and towards (into) residual voids – including from areas outside of a pit shell, such as Ramp 36 rejects landform.

Groundwater modelling (SLR, 2024) shows that seepage from Ramp 36 rejects landform would report to Deep Creek residual void. Therefore, it is reasonably assumed that the likelihood of seepage from the final rejects landform reaching a surface water receptor (eg. Deep Creek) via shallow groundwater is 'Unlikely'.

In summary, the SPR has assumed a plausible (although unlikely) local seepage pathway may exist between Ramp 36 rejects landform via shallow permeable strata into nearby ephemeral surface water receptors (such as Deep Creek).

Receptors

Plausible receptors of surface water run-off and seepage from Ramp 36 rejects landform are shown in **Figure 26** (Post-closure landform), **Figure 33** (CFM for Ramp 36 rejects landform), **Table 22** and **Attachment C Tables C15 and C19**.

Surface water

The only plausible surface water receptor identified in this qualitative assessment of Ramp 36 rejects landform is ephemeral Deep Creek, located less than 100m from the TSF. This applies to potential surface water run-off and potential seepage through shallow permeable strata into the surface water receptor(s).

The rehabilitated rejects landform will have a spoil cover designed to manage the AMD hazard of the landform. The spoil cover has been conservatively assumed to pose a low-moderate AMD source hazard, based on a conservative AMD source hazard applied to general spoil. As such, the likelihood of AMD from the rehabilitated (post-closure) rejects landform to impact on the water quality of the surface water receptor(s) (via run-off or shallow seepage) has been rated unlikely. The likelihood of non-oxidative salinity from the rejects landform to impact on the water quality of the surface water receptor(s) has been rated unlikely.

Seepage / Groundwater

Seepage from Ramp 36 rejects landform into groundwater will ultimately report to Deep Creek residual void. The likelihood of AMD and non-oxidative salinity from the rehabilitated (post-closure) rejects landform to impact on the water quality of Deep Creek residual void has been rated highly unlikely.

SPR risk rating of Ramp 36 rejects landform

There are plausible surface water and residual void receptors; and the run-off and shallow seepage pathways linking the source (Ramp 36 rejects final landform) to these receptors (Deep Creek) have been identified. Groundwater modelling (SLR, 2024) shows that seepage from Ramp 36 rejects landform would report to Deep Creek residual void. With respect to AMD, the overall SPR risk rating from the post-closure rejects final landform is **Low to Medium**. The 'Medium' risk rating applies to AD and SD associated with seepage via shallow permeable strata. With respect to non-oxidative salinity the overall SPR risk from the post-closure rejects final landform is also rated as **Low**.

7.2.9 SPR assessment of residual voids

Source materials hazard

The surfaces of residual void highwalls are comprised of approximately 89% to 95% non-carbonaceous overburden/ interburden, 1% to 6% carbonaceous overburden/interburden (incl. sub-economic seams reporting to waste) and about 2% to 7% coal (seams). The proportion of weathered material in the current (and proposed future) pit/void highwalls varies throughout the site, ranging from approximately 17% to 25% in the northern pits/voids and approximately 25% to 75% in the southern pits/voids. Fresh and weathered non-carbonaceous overburden/interburden material in the Bowen Basin is widely recognised as posing a low AMD risk. Coal seams at BWM pose a low-moderate AMD risk.

Overall, the hazard for AMD generation from residual void highwalls is 'Low' and the likelihood for AMD generation from residual void highwalls is 'Unlikely'. The expression of AMD (if at all) from some highwall material is likely to be localised.

Generally, highwall materials have low EC values, with release of (non-oxidative) salinity rated as a low hazard.

The floor of Bonnie Doon and Laleham pits (voids) is tailings, of which approximately 48% (for Bonnie Doon) and 56% (for Laleham) is conservatively estimated to be PAF. These two in-pit TSFs (tailings voids) pose a moderate to moderate-high AMD hazard – which does not take into account potential mitigating factors, such as tailings flooding or the tailings being covered/capped with a suitable spoil and/or water cover. Should the tailings be submerged/covered/capped the void floor (tailings) would be expected to pose a low AMD hazard.

The floor of all other voids is comprised of P and L (Lower) seam and is conservatively estimated to comprise approximately 25% PAF coal – assuming 100% of the floor is coal and not some other material. In reality, all or most of the coal will be mined out and the void floor would not be expected to be dominated by coal. The void floors, as conservatively described, pose a low-moderate AMD hazard – which does not take into account potential mitigating factors, such as void floor flooding. Should the void floors be submerged (flooded), the void floor would be expected to pose a low AMD hazard.

Pathways

Surface water

There are no plausible pathways between the residual voids and surface water. For each void, surface water run-off from the highwall will report to the void.

Seepage / Groundwater

The residual voids will act as groundwater sinks and the water table will intersect the deeper zones of the residual voids, resulting in the formation of a relatively small void lake in each void (SLR, 2024; and

Figure 28) that will submerge the void floor and lower section of the void highwall. At Bonnie Doon and Laleham voids (TSFs), the post-closure water table will intersect and submerge most of the tailings. These in-pit tailings will be capped/covered to manage the AMD source hazard. For each void, seepage from the spoil landform and run-off from the highwall will report to the residual void.

Receptors

Modelling undertaken by SLR (2024) shows the final voids to be 'sinks' – receiving surface water run-off and seepage from spoil landforms and surface water run-off from void highwalls. Each residual void is expected to receive inflow from the Permian groundwater aquifer. The water quality of the void and potential impact of water seeping, if any, from the residual voids into the Permian groundwater aquifer is discussed in the void closure plan (WSP, 2024).

Excluding Bonnie Doon and Laleham voids (TSFs), the 'coal' floor of all other residual voids will be covered post-closure by water as rainfall and groundwater reporting to the void will form a void lake. As such, PAF coal will no longer be exposed to atmospheric conditions and the risk of AMD being generated is greatly reduced.

Bonnie Doon and Laleham voids contain tailings; and modelling shows the tailings will eventually be fully or partially covered post-closure by water as rainfall and groundwater report to the void. During rehabilitation, the tailings will be capped/covered such that tailings will no longer be exposed to atmospheric conditions and the risk of AMD being generated from tailings is greatly reduced – particularly during the early years post-closure as water levels in these two voids recover.

The likelihood of undiluted salinity or AMD from a flooded post-closure residual void floor (or covered/capped/flooded tailings floor) to impact on residual void water quality to any significant degree has been rated unlikely.

SPR risk rating of residual voids

The final receptor for seepage from the spoil landform (for each spoil landform) and run-off from the highwall (of each void) is the void lake / residual void. The AMD assessment has found that it's unlikely that undiluted salinity or AMD from a flooded post-closure residual void floor (including capped/covered/flooded tailings floor) would impact on residual void water quality to any significant degree, as other processes such as evapoconcentration are the key drivers of void lake water quality. Therefore, the AMD SPR risk rating on the overall water quality of the residual voids is **Low to Low-Medium** [**Attachment C Table C20**]. A "Low to Medium" risk rating has been conservatively applied to the risk of AD and/or NMD/SD due to the AMD risk associated with tailings within Bonnie Doon and Laleham voids.

Water reporting to residual voids is expected to remain within the residual voids (excluding evaporative loss). Modelling undertaken by SLR (2024) shows that seepage from the void lake (of each void) into groundwater, if any, would be limited.

8 Management and Rehabilitation Measures

The assessment has found that the environmental risks posed by spoil landforms likely to be present at closure are generally low. As such – for most spoil landforms – no specific AMD management measures (eg. alkaline amendment or engineered capping systems) are expected to be required to manage mineral wastes during rehabilitation and closure – outside of operational mixing/burial of PAF waste amongst NAF waste, spoil placement and landform reshaping activities already proposed (refer below and to the main volume of the PRCP).

The AMD source hazard associated with Ramp 72 tailings and Kenmare pit rejects buried within Kenmare landform is high and, as such, rehabilitation of tailings and rejects within Kenmare ramp/pit will require specific AMD management measures – and the assessment program currently underway at Kenmare Pit will address the rehabilitation requirements of these facilities. Once rehabilitated, the post-closure environmental risk posed by Kenmare spoil landform is expected to decrease.

The landform domain AMD hazard posed by NCPP TSF, Laleham TSF and Bottom Dam TSF is moderate-high to high; and for Ramp 36 Rejects dump is moderate. These stand-alone landforms will require specific AMD management measures to manage these facilities post-closure.

The AMD hazard posed by tailings in Bonnie Doon in-pit TSF and Ramp 74 (Laleham) in-pit TSF is moderate-high and, as such, in-pit tailings will also require specific AMD management measures to manage these voids post-closure.

Decommissioning and rehabilitation activities related to mineral waste will be addressed as part of the milestone criteria for infrastructure, remediation of contaminated land, landform design, surface preparation and revegetation, where necessary.

Proposed mineral waste management and rehabilitation activities of relevance to this waste characterisation report comprise the following actions. Refer to the main volume of the PRCP and Henderson Geotech (2024) for detailed information.

- Pits: will remain as residual voids under 11 groups:
    - Ramp 8 void
    - Bonnie Doon void (in-pit TSF)
    - Mimosa-Besgrove void
    - Deep Creek void
    - Stewarton-Ballamoo void
    - Kenmare void
    - Laleham void (in-pit TSF)
    - Togara-North Marshmead void
    - South Marshmead void
    - Kennedy West void
    - Comet Downs East void
- Spoil dumps: will be reshaped into 11 final spoil landforms (as related to their respective voids listed above) and seeded.
- Bonnie Doon in-pit TSF will be covered by a spoil and water cover (hybrid cover). The optimal design and thickness of cover to manage the AMD hazard of Bonnie Doon in-pit TSF (tailings) will be determined following further assessment prior to covering.
- Laleham (Ramp 74) in-pit TSF will be covered by a spoil and water cover (hybrid cover). The optimal design and thickness of cover to manage the AMD hazard of Ramp 74 in-pit TSF (tailings) will be determined following further assessment prior to covering.

- NCPP TSF (out-of-pit; above ground; stand-alone) will be covered by an engineered spoil cover. The optimal design and thickness of spoil cover to manage the AMD hazard of the out-of-pit NCPP TSF will be determined following further assessment prior to covering.
- Laleham TSF (in-pit; above ground; stand-alone) will be covered by spoil. The optimal design and thickness of spoil cover to manage the AMD hazard of the TSF will be determined following further assessment prior to covering.
- Ramp 72 in-pit TSF will be covered by spoil within Kenmare spoil landform. The optimal design and thickness of spoil cover to manage the AMD hazard of the in-pit TSF will be determined following further assessment prior to covering.
- Bottom Dam TSF/rejects (out-of-pit; above ground; stand-alone). Rejects currently on ROM 3 will be relocated onto Bottom Dam TSF forming a rejects cap, which will then be covered by a spoil cover. The optimal design and thickness of spoil cover to manage the AMD hazard of Bottom Dam TSF/rejects area will be determined following further assessment prior to covering.
- Kenmare in-pit rejects will be covered by spoil within Kenmare spoil landform. The optimal design and thickness of spoil cover to manage the AMD hazard of these in-pit rejects will be determined following further assessment prior to covering.
- Ramp 36 rejects (above ground; stand-alone) will be covered by a spoil cover. The optimal design and thickness of spoil cover to manage the AMD hazard of the rejects dump will be determined following further assessment prior to covering.
- All other rejects (in-spoil disposal): Managed during operations (disposed within spoil) and progressively covered by spoil. No additional remediation for the rejects (at closure) is required. The optimal thickness of spoil cover to manage the AMD hazard of rejects will be determined following further assessment prior to covering.
- ROM pads: Remove remnant coal from ROM pads and dispose within spoil. All former ROM pads will be reshaped, covered with soil, ripped and seeded.
- Coal stockpiles: Remove remnant coal from coal stockpile pads and dispose within spoil. Cover with suitable soil material, rip and seed.

9 Forward Work Program

The environmental geochemical characterisation and assessment of mineral waste samples outlined in this report is representative of the mineral waste materials likely to require rehabilitation at closure. However, BWM will continue to undertake sampling of likely mineral waste materials (and subsequent characterisation and assessment of those samples) during operations and into decommissioning – to validate the findings of the current assessment, ensure the risks continue to be understood and the management measures proposed are commensurate with the risks. Where required, management measures will be revised and implemented.

Environmental and engineering assessment programs are underway at Kenmare Pit rejects area and Bottom Dam TSF/rejects area to support rehabilitation and closure planning.

Further work may also be required prior to closure to better understand the relationship between shallow and deeper groundwater at BWM and between shallow groundwater and surface water systems at BWM.

Refer to the main volume of the PRCP for detailed information.

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Attachment A – Geological Sections

Pit and void highwall long-sections

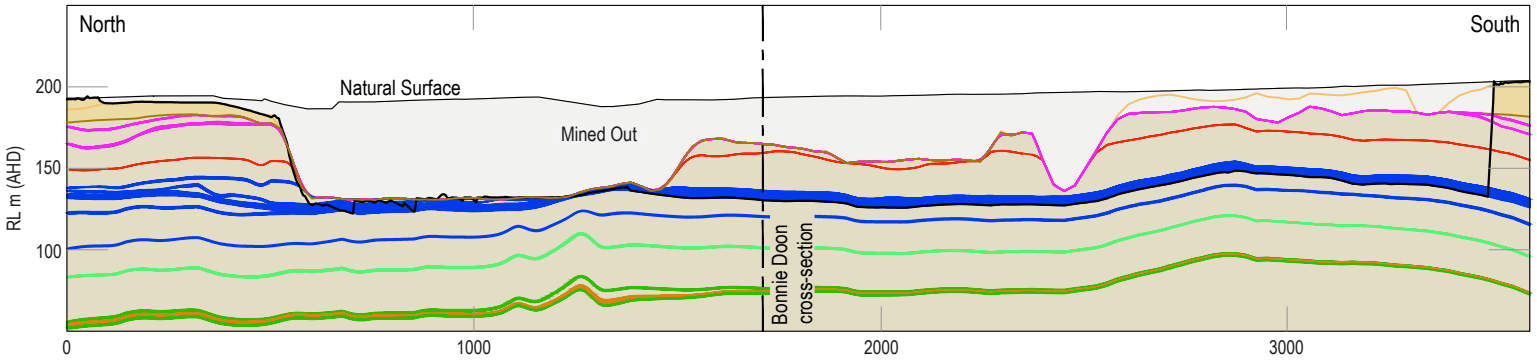
- Figure A1 Bonnie Doon, Mimosa and Sagittarius pits
- Figure A2 Burngrove, Airstrip and Besgrove North pits
- Figure A3 Besgrove South, Deep Creek and Stewarton pits
- Figure A4 Tannyfoil, Wilpeena and Blackdown pits
- Figure A5 Ballamoo North and Terang pit, Kenmare void, Laleham and Togara pits
- Figure A6 Marshmead pit and Togara-North Marshmead void
- Figure A7 South Marshmead, Kennedy West and Comet Downs East voids

Pit and void highwall cross-sections

- Figure A8 Bonnie Doon, Mimosa and Sagittarius pits
- Figure A9 Burngrove, Airstrip and Besgrove North pits
- Figure A10 Deep Creek pit at Ramp 34 and Ramp 38, and Stewarton pit
- Figure A11 Tannyfoil, Wilpeena and Blackdown pits
- Figure A12 Ballamoo North void, Terang pit and Kenmare pit
- Figure A13 Laleham Pit, Togara-North Marshmead pit/void and Marshmead pit
- Figure A14 Proposed pits: South Marshmead, Kennedy West and Comet Downs East

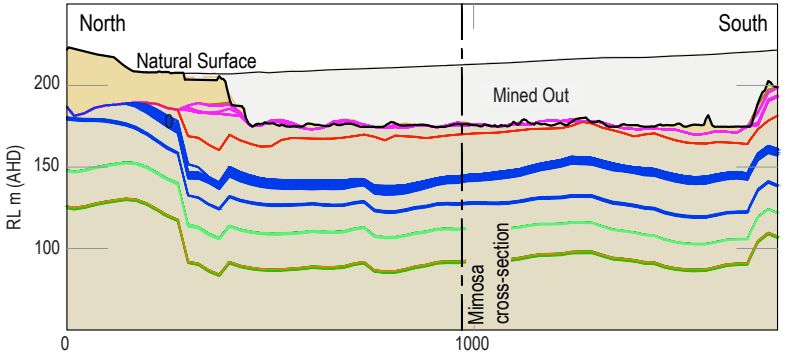
LONG-SECTION | Bonnie Doon Pit

Viewed Looking East (Vertical Exaggeration x4.0)



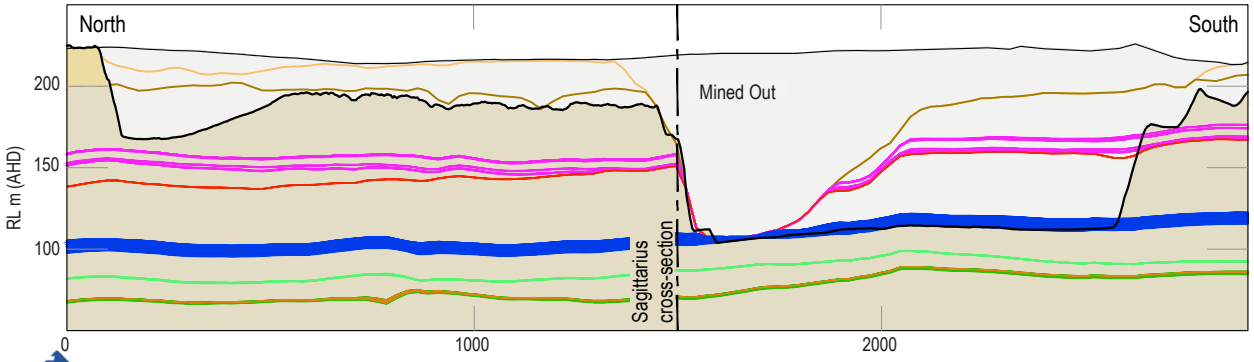
LONG-SECTION | Mimosa Pit

Viewed Looking East (Vertical Exaggeration x4.0)



LONG-SECTION | Sagittarius Pit

Viewed Looking East (Vertical Exaggeration x4.0)



Legend

- Natural Surface
- Base of Tertiary
- Base of Weathering
- Current Pit Shell

Coal Seams

- T Seam Group
- MR Seam Group
- P & L Seam Group
- LR Seam Group
- SG Seam Group
- Yarabee Tuff
- PS Seam Group

Vertical Scale

0 100m

Horizontal Scale

0 400m

(V/H = 4:1)

WHITEHAVEN

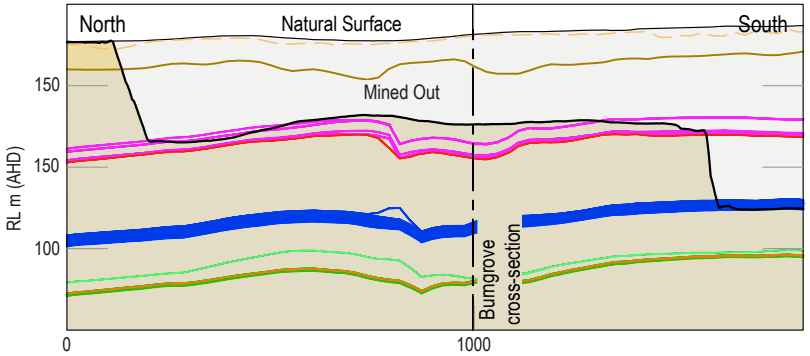
Minserve CAD File: Bhpb008m07.dwg

Pit highwall long-sections

Figure **A1**

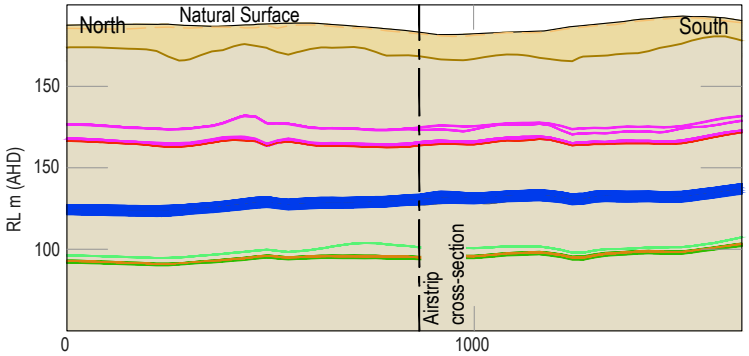
LONG-SECTION | Burngrove Pit

Viewed Looking East (Vertical Exaggeration x4.0)



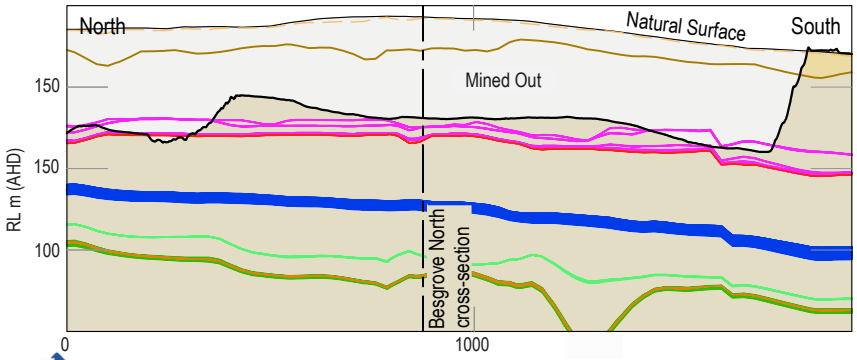
LONG-SECTION | Airstrip Pit

Viewed Looking East (Vertical Exaggeration x4.0)



LONG-SECTION | Besgrove North Pit

Viewed Looking East (Vertical Exaggeration x4.0)



Legend

- Natural Surface
- Base of Tertiary
- Base of Weathering
- Current Pit Shell

Coal Seams

- T Seam Group
- MR Seam Group
- P & L Seam Group
- LR Seam Group
- SG Seam Group
- Yarabee Tuff
- PS Seam Group

Vertical Scale

0 — 100m

Horizontal Scale

0 — 400m

(V/H = 4:1)

WHITEHAVEN

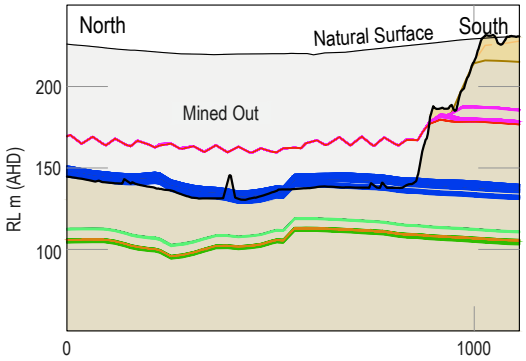
Minserve CAD File: Bhpb008m07.dwg

Pit highwall long-sections

Figure **A2**

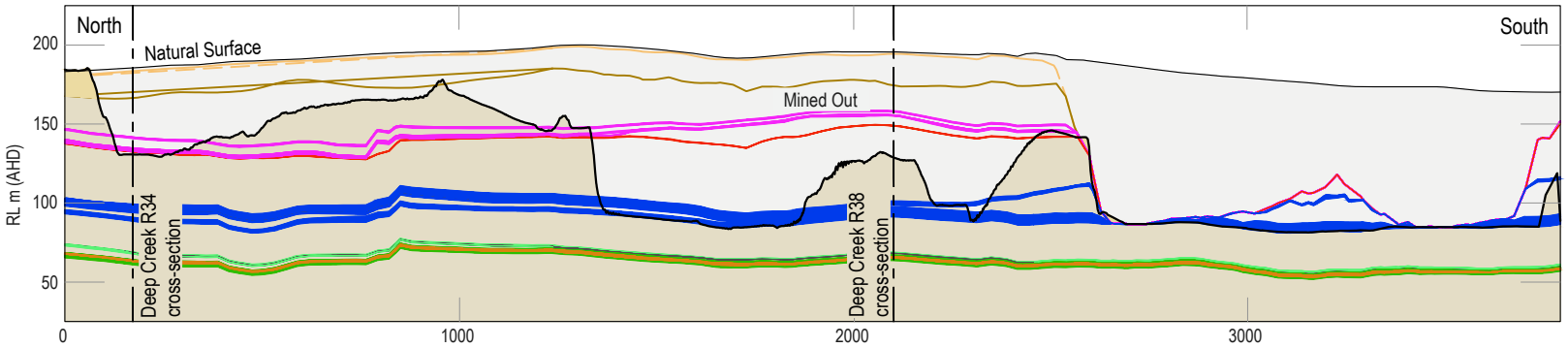
LONG-SECTION | Besgrove South Pit

Viewed Looking East (Vertical Exaggeration x4.0)



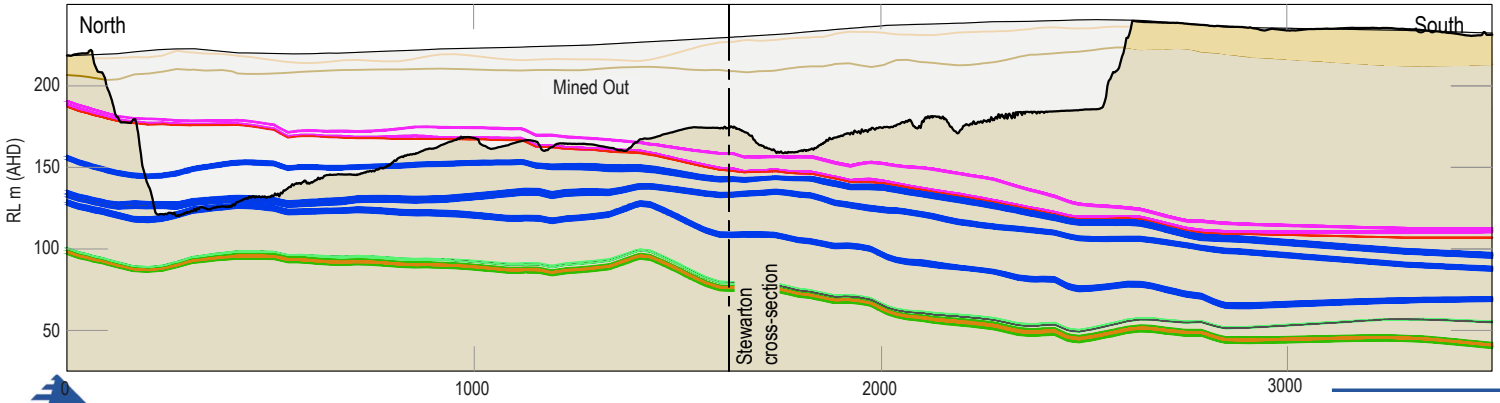
LONG-SECTION | Deep Creek Pit

Viewed Looking North East (Vertical Exaggeration x4.0)



LONG-SECTION | Stewarton Pit

Viewed Looking North East (Vertical Exaggeration x4.0)



Legend

- Natural Surface
- Base of Tertiary
- Base of Weathering
- Current Pit Shell

Coal Seams

- T Seam Group
- MR Seam Group
- P & L Seam Group
- LR Seam Group
- SG Seam Group
- Yarabee Tuff
- PS Seam Group

Vertical Scale

0 — 100m

Horizontal Scale

0 — 400m

(V/H = 4:1)

WHITEHAVEN

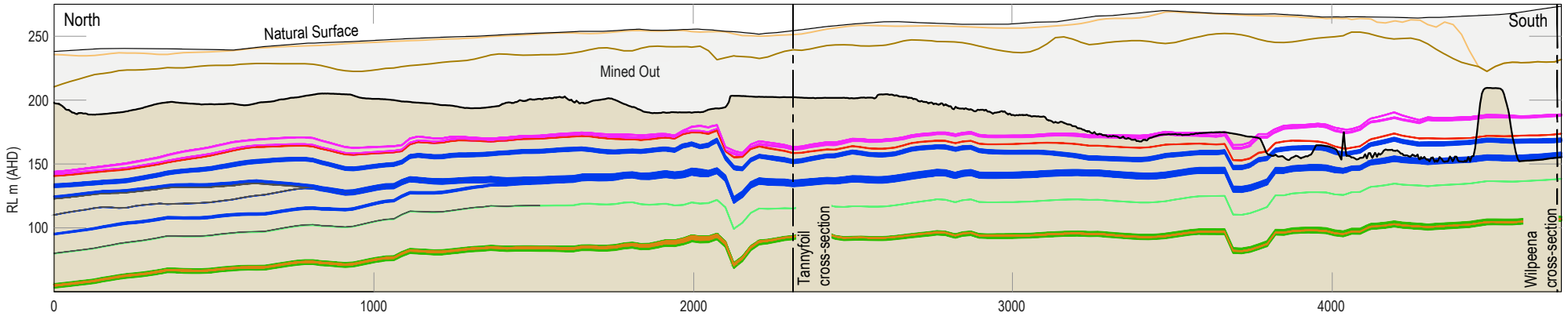
Minserve CAD File: Bhpb008m07.dwg

Pit highwall long-sections

Figure **A3**

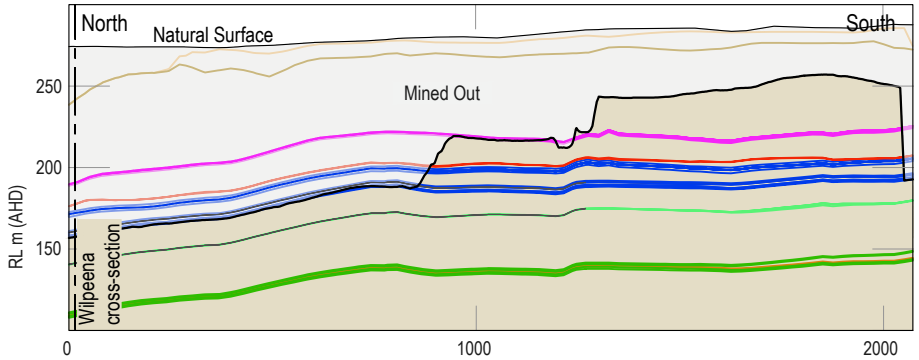
LONG-SECTION | Tannyfoil Pit

Viewed Looking East (Vertical Exaggeration x4.0)



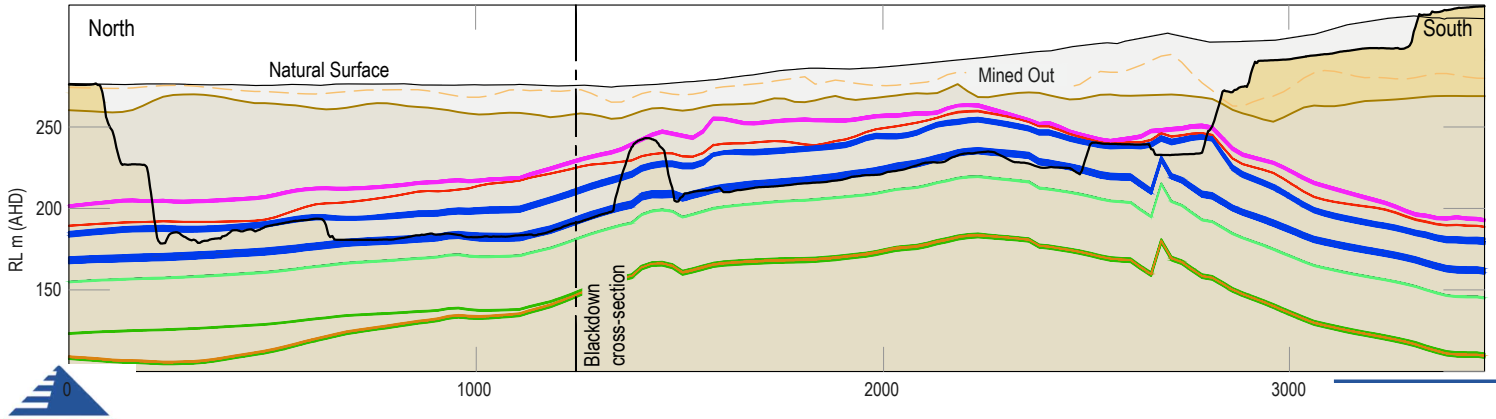
LONG-SECTION | Wilpeena Pit

Viewed Looking East (Vertical Exaggeration x4.0)



LONG-SECTION | Blackdown Pit

Viewed Looking East (Vertical Exaggeration x4.0)



Legend

- Natural Surface
- Base of Tertiary
- Base of Weathering
- Current Pit Shell

Coal Seams

- T Seam Group
- MR Seam Group
- P & L Seam Group
- LR Seam Group
- SG Seam Group
- Yarabee Tuff
- PS Seam Group

Vertical Scale

0 — 100m

Horizontal Scale

0 — 400m

(V/H = 4:1)

WHITEHAVEN

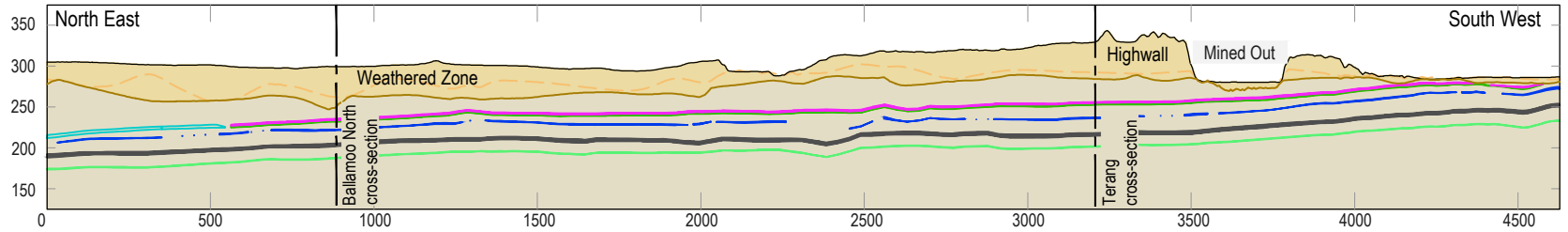
Minserve CAD File: Bhpb008m07.dwg

Pit highwall long-sections

Figure **A4**

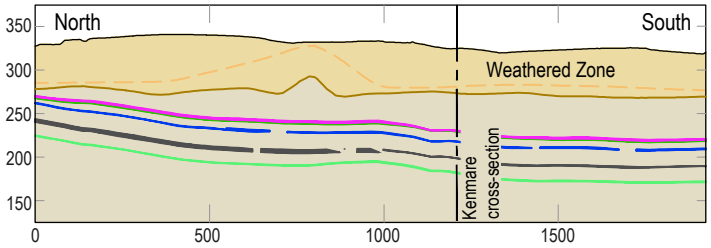
LONG-SECTION | Ballamoo North and Terang (Ballamoo South) Pit

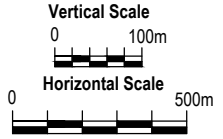
Viewed Looking South-East (Vertical Exaggeration x2.5)



LONG-SECTION | Kenmare void

Viewed Looking East (Vertical Exaggeration x2.5)





Legend

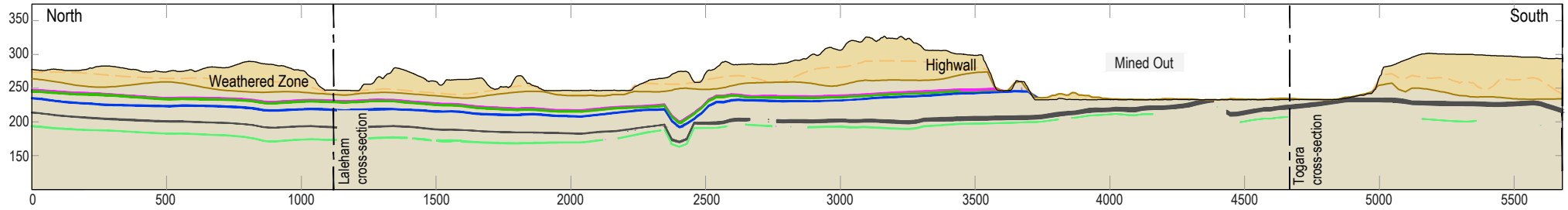
- Natural Surface
- Base of Tertiary
- Base of Weathering

Coal Seams

- T Seam Group
- P & L Seam Group
- LR Seam Group
- SG Seam Group
- PS Seam Group

LONG-SECTION | Laleham-Togara Pit

Viewed Looking East (Vertical Exaggeration x2.5)



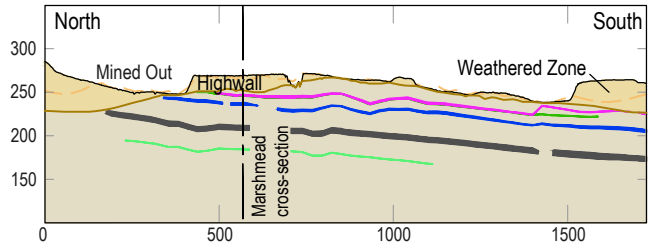
WHITEHAVEN

Minserve CAD File: Bhpb008m11 Blackwater - South.dwg

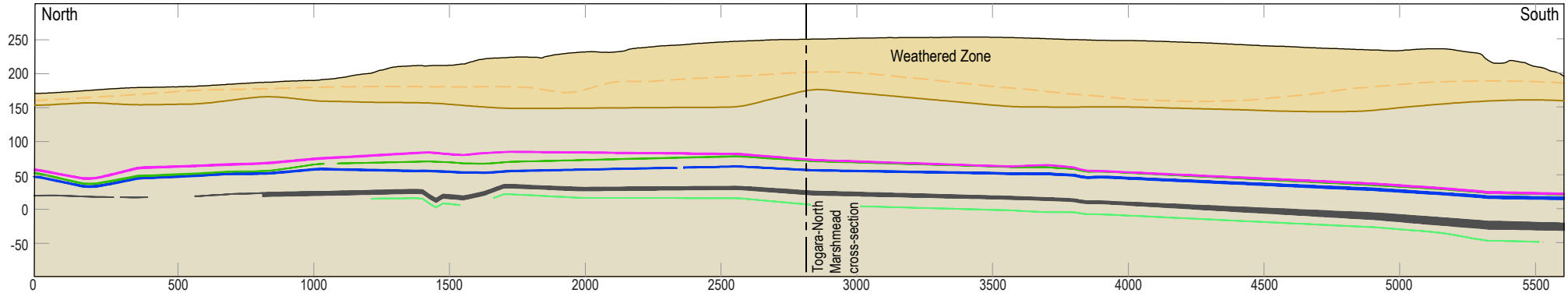
Pit highwall long-sections

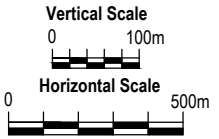
Figure **A5**

LONG-SECTION | Marshmead Pit
Viewed Looking North-East (Vertical Exaggeration x2.5)



LONG-SECTION | Togara-North Marshmead void
Viewed Looking East (Vertical Exaggeration x2.5)





Legend
- Natural Surface
- Base of Tertiary
- Base of Weathering

Coal Seams
- T Seam Group
- P & L Seam Group
- LR Seam Group
- SG Seam Group
- PS Seam Group

WHITEHAVEN

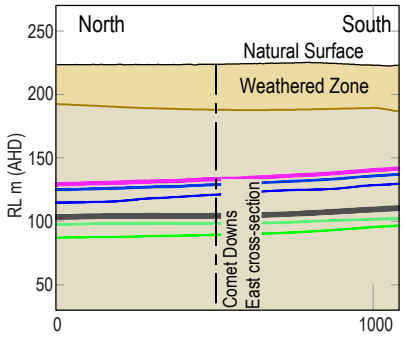
Minserve CAD File: Bhpb008m11 Blackwater - South.dwg

Pit highwall long-sections

Figure **A6**

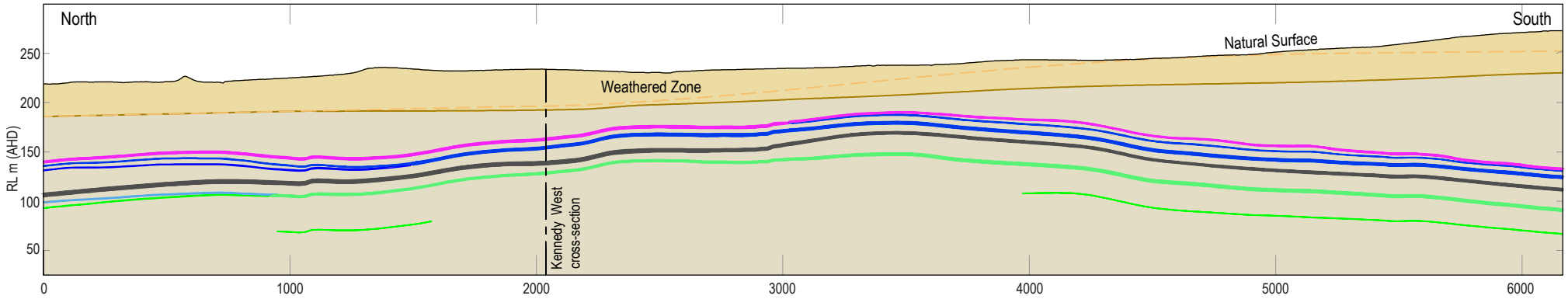
LONG-SECTION | Comet Downs East void

Viewed Looking East (Vertical Exaggeration x4.0)



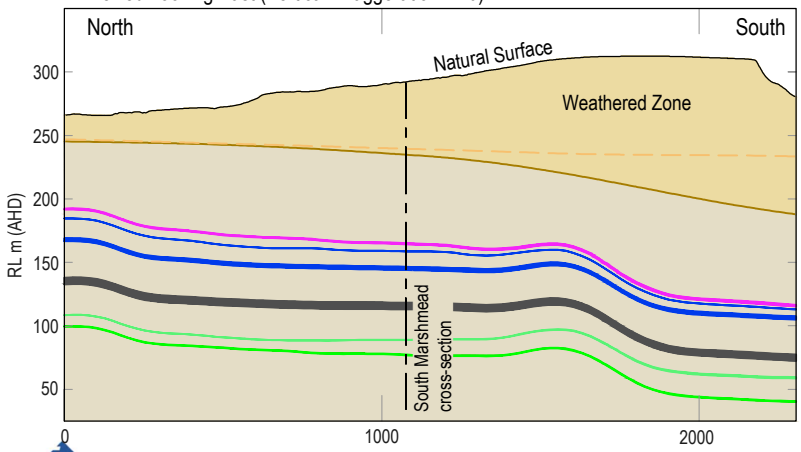
LONG-SECTION | Kennedy West void

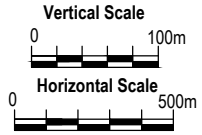
Viewed Looking East (Vertical Exaggeration x4.0)



LONG-SECTION | South Marshmead void

Viewed Looking East (Vertical Exaggeration x4.0)





Legend

- Natural Surface
- Base of Tertiary
- Base of Weathering

Coal Seams

- T Seam Group
- P & L Seam Group
- LR Seam Group
- SG Seam Group
- PS Seam Group

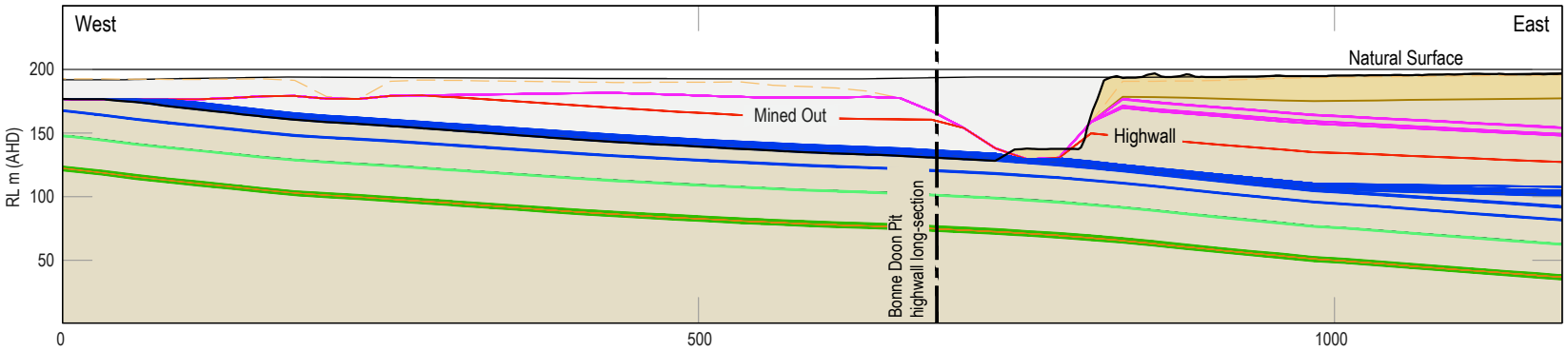
WHITEHAVEN

Minserve CAD File: Bhpb008m12-MDL Areas.dwg

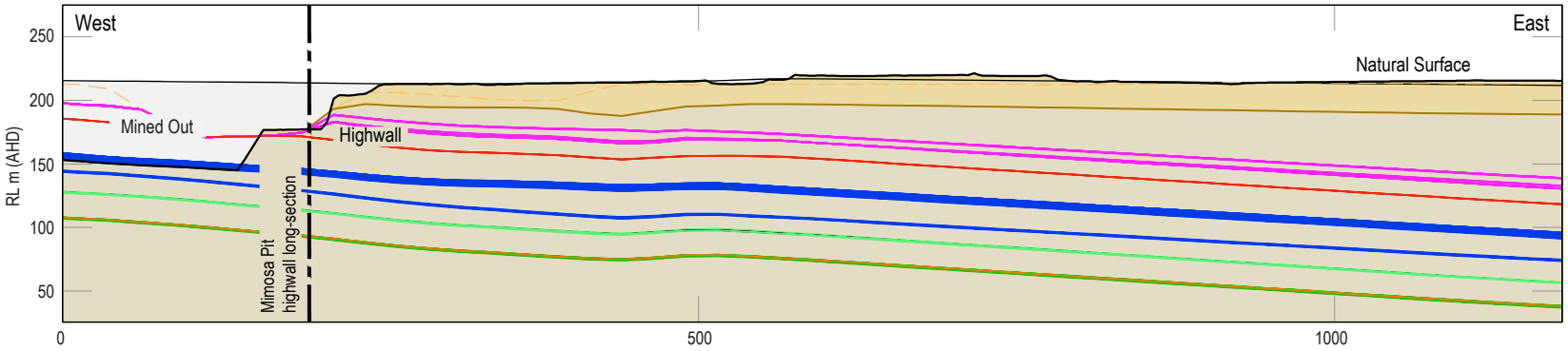
Void highwall long-sections

Figure **A7**

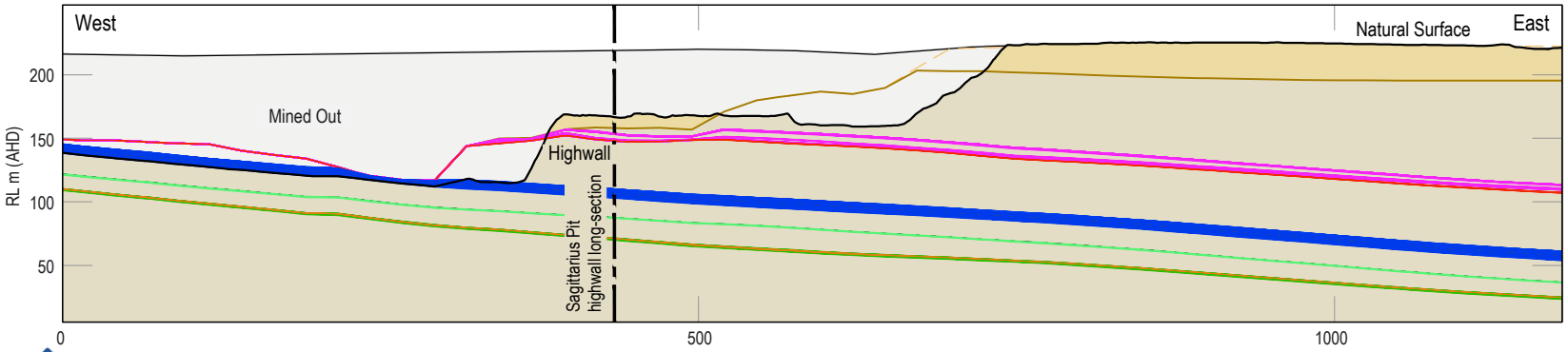
CROSS-SECTION | Bonnie Doon Pit
Viewed Looking North



CROSS-SECTION | Mimosa Pit
Viewed Looking North



CROSS-SECTION | Sagittarius Pit
Viewed Looking North



Legend

- Natural Surface
- Base of Tertiary
- Base of Weathering
- Current Pit Shell

Coal Seams

- T Seam Group
- MR Seam Group
- P & L Seam Group
- LR Seam Group
- SG Seam Group
- Yarabee Tuff
- PS Seam Group

Horizontal Scale
(V/H = 1)

0 100 200m

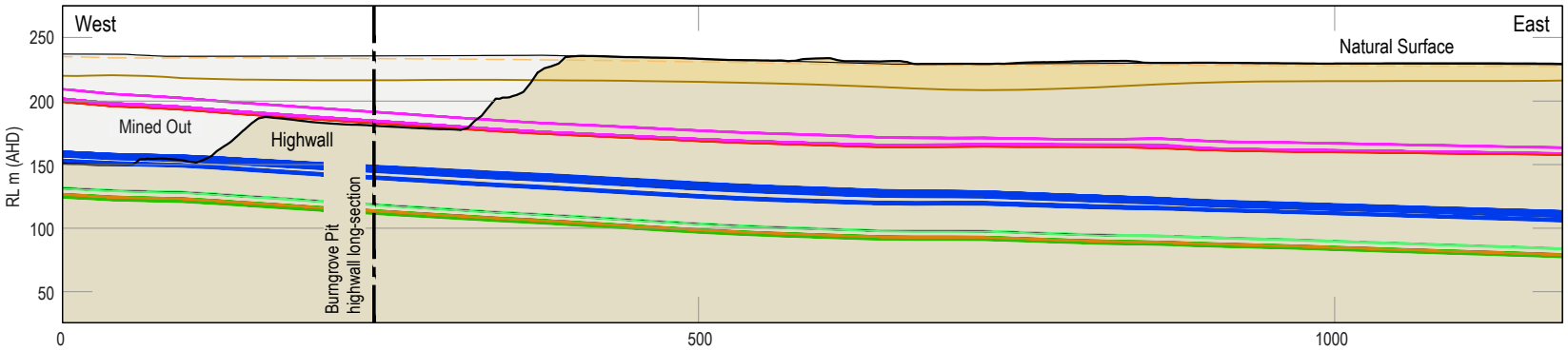
WHITEHAVEN

Minserve CAD File: Bhpb008m07.dwg

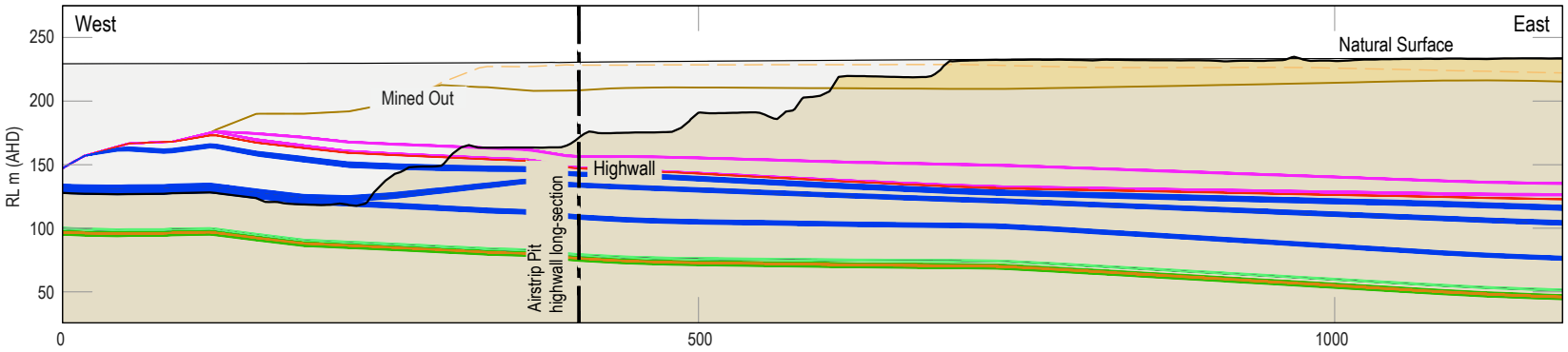
Pit cross-sections

Figure **A8**

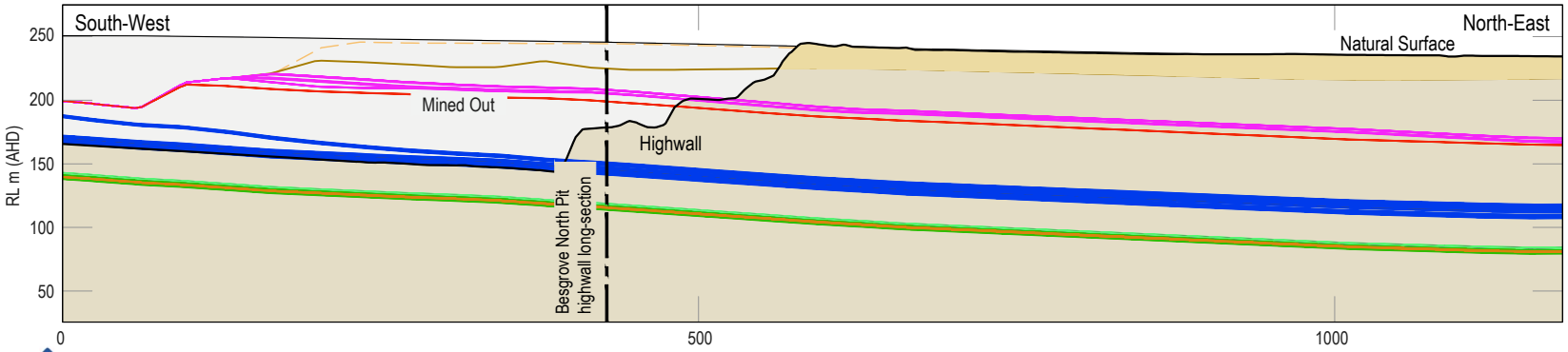
CROSS-SECTION | Burngrove Pit
Viewed Looking North



CROSS-SECTION | Airstrip Pit
Viewed Looking North



CROSS-SECTION | Besgrove North Pit
Viewed Looking North West



Legend

- Natural Surface
- Base of Tertiary
- Base of Weathering
- Current Pit Shell

Coal Seams

- T Seam Group
- MR Seam Group
- P & L Seam Group
- LR Seam Group
- SG Seam Group
- Yarabee Tuff
- PS Seam Group

Horizontal Scale
(V/H = 1)

0 100 200m

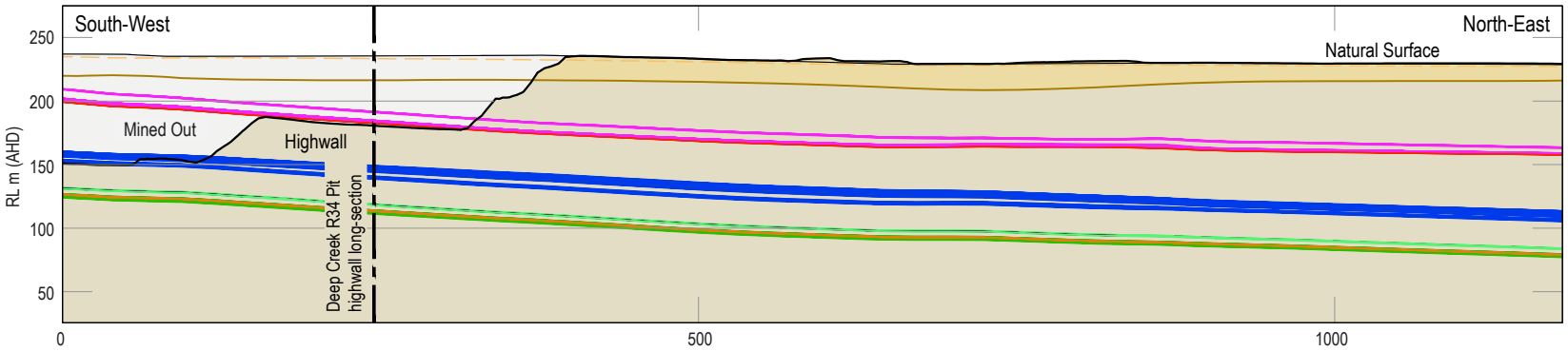
WHITEHAVEN

Minserve CAD File: Bhpb008m07.dwg

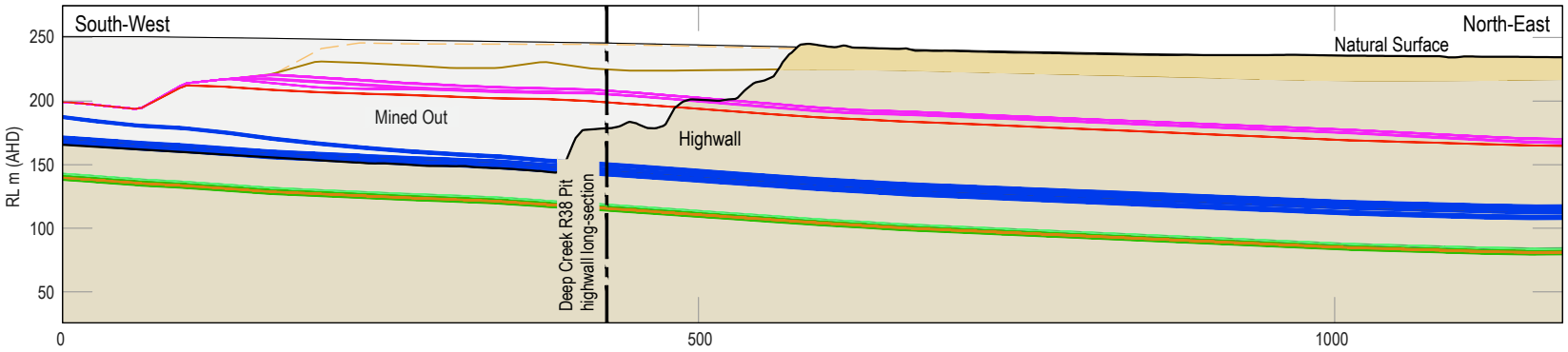
Pit cross-sections

Figure **A9**

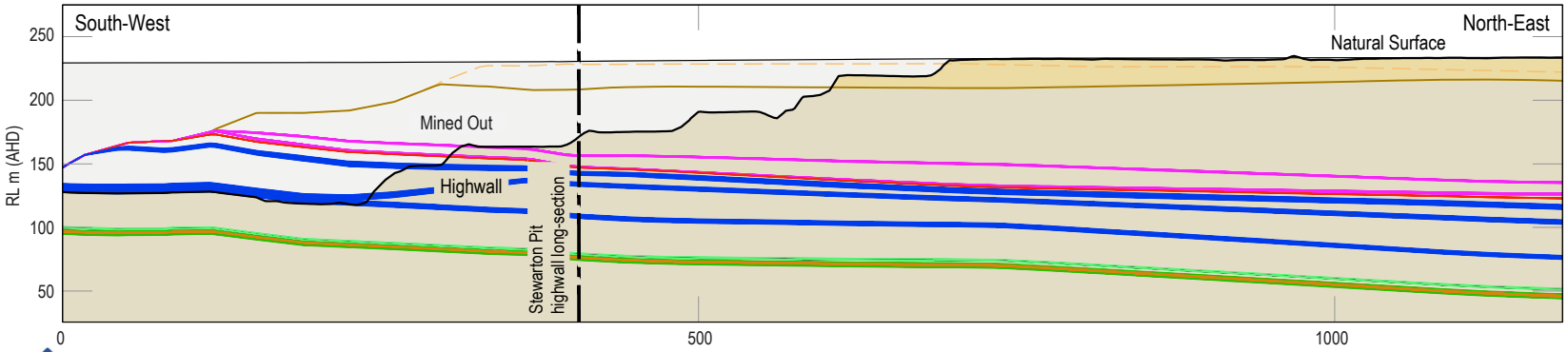
CROSS-SECTION | Deep Creek R34 Pit
Viewed Looking North



CROSS-SECTION | Deep Creek R38 Pit
Viewed Looking North



CROSS-SECTION | Stewarton Pit
Viewed Looking North West



Legend

- Natural Surface
- Base of Tertiary
- Base of Weathering
- Current Pit Shell

Coal Seams

- T Seam Group
- MR Seam Group
- P & L Seam Group
- LR Seam Group
- SG Seam Group
- Yarabee Tuff
- PS Seam Group

Horizontal Scale
(V/H = 1)

0 100 200m

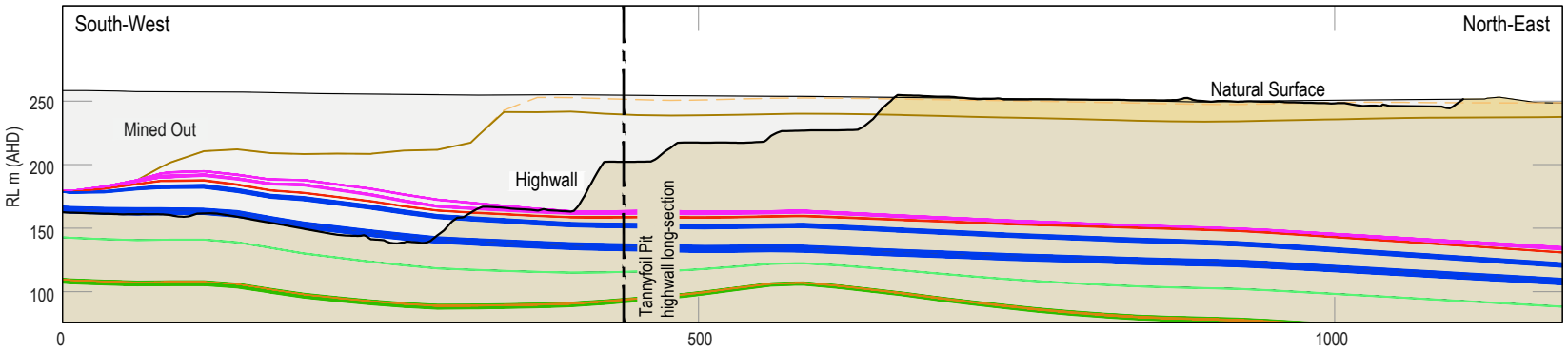
WHITEHAVEN

Minserve CAD File: Bhpb008m07.dwg

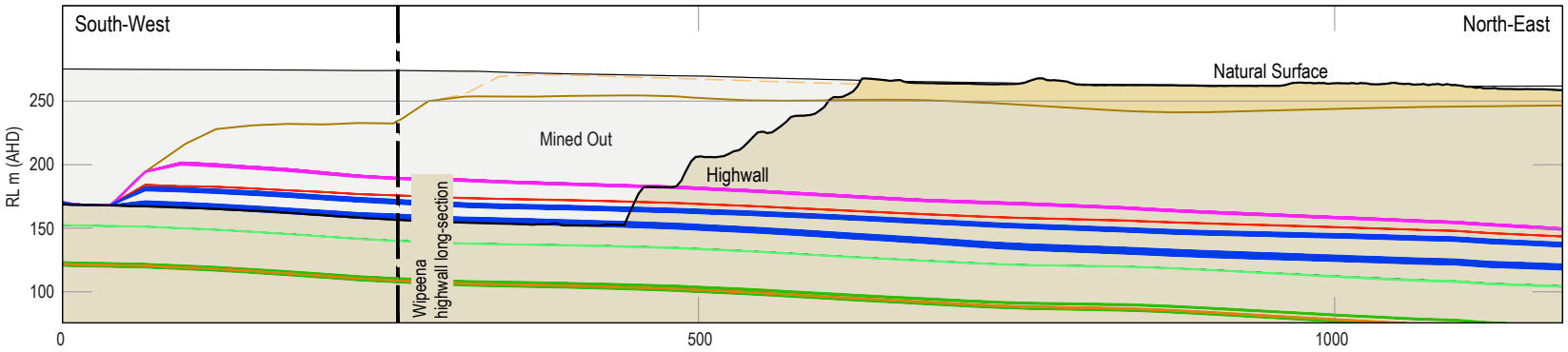
Pit cross-sections

Figure **A10**

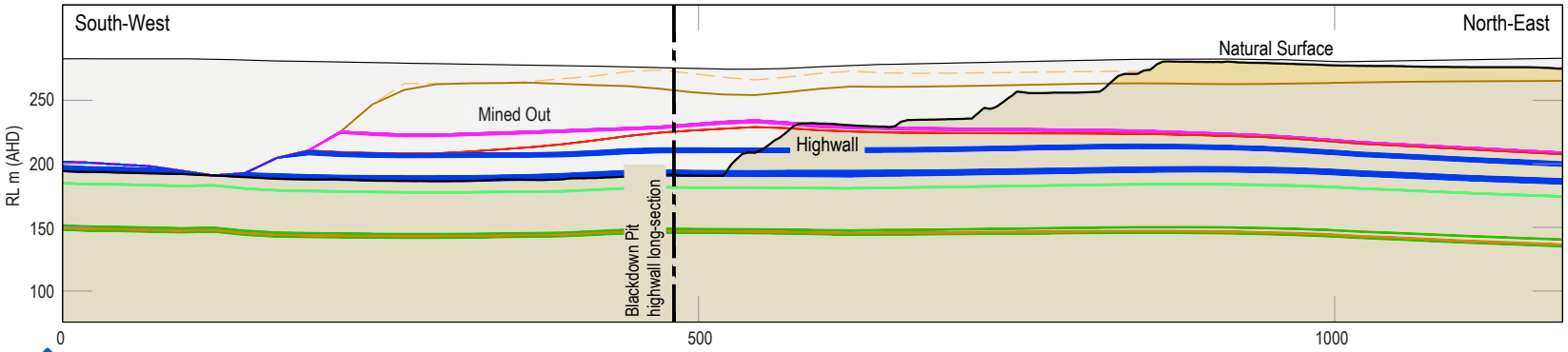
CROSS-SECTION | Tannyfoil Pit
Viewed Looking North



CROSS-SECTION | Wilpeena Pit
Viewed Looking North



CROSS-SECTION | Blackdown Pit
Viewed Looking North West



Legend

- Natural Surface
- Base of Tertiary
- Base of Weathering
- Current Pit Shell

Coal Seams

- T Seam Group
- MR Seam Group
- P & L Seam Group
- LR Seam Group
- SG Seam Group
- Yarabee Tuff
- PS Seam Group

Horizontal Scale
(V/H = 1)

0 100 200m

WHITEHAVEN

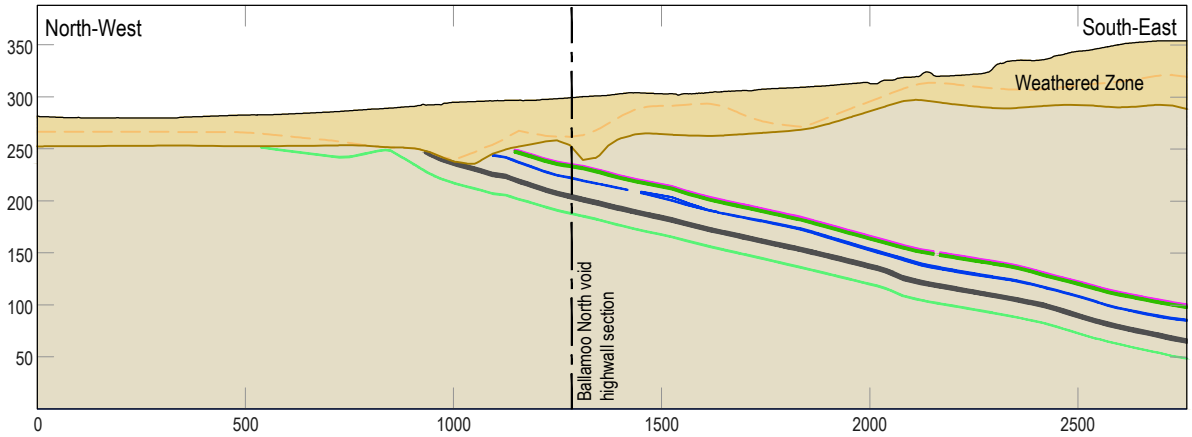
Minserve CAD File: Bhpb008m07.dwg

Pit cross-sections

Figure **A11**

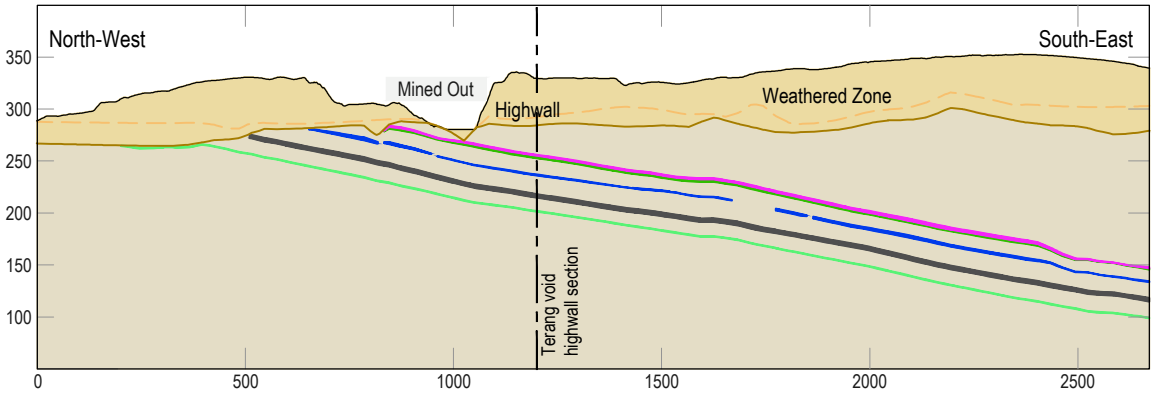
CROSS-SECTION | Ballamoo North Void

Viewed Looking North-East (Vertical Exaggeration x2.5)



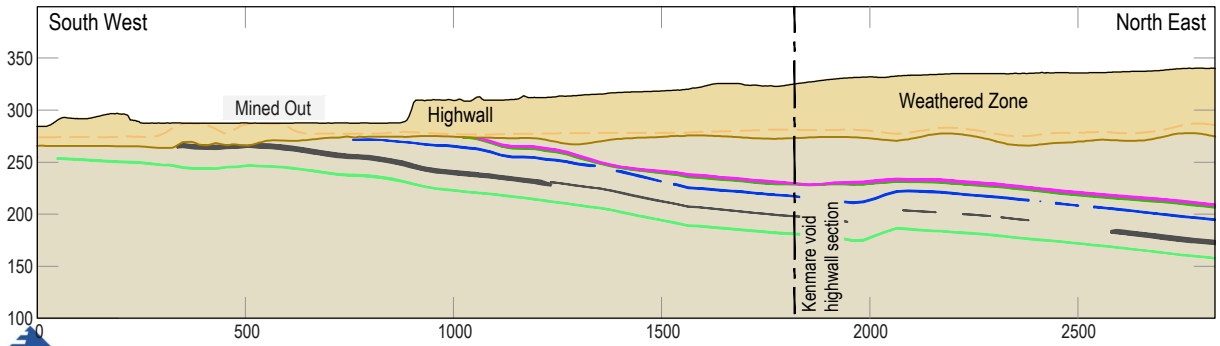
CROSS-SECTION | Terang Pit

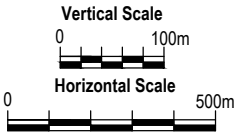
Viewed Looking North-East (Vertical Exaggeration x2.5)

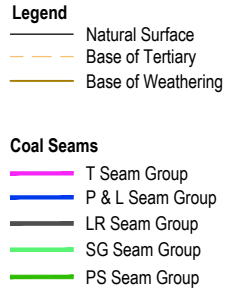


CROSS-SECTION | Kenmare Pit

Viewed Looking North-West (Vertical Exaggeration x2.5)







WHITEHAVEN

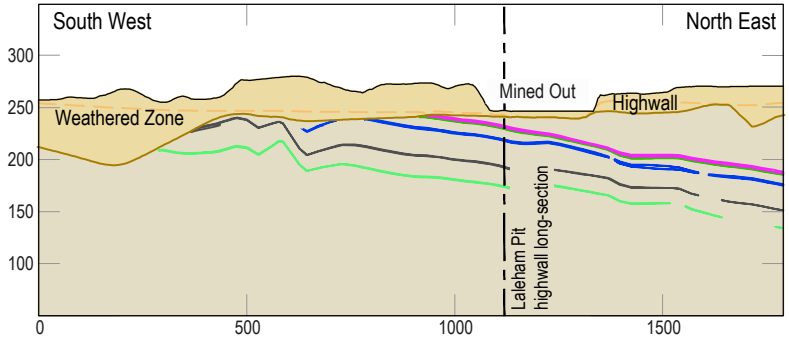
Minserve CAD File: Bhpb008m11-South.dwg

Pit cross-sections

Figure **A12**

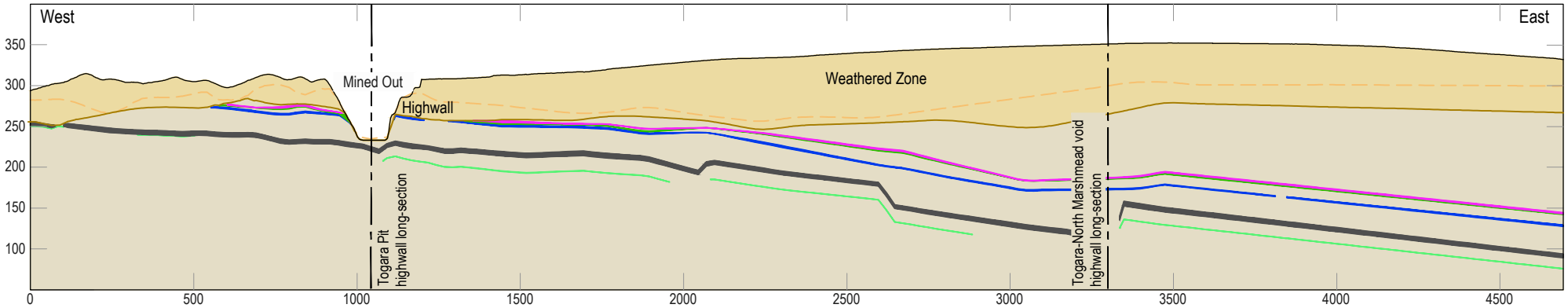
CROSS-SECTION | Laleham Pit

Viewed Looking North-West (Vertical Exaggeration x2.5)



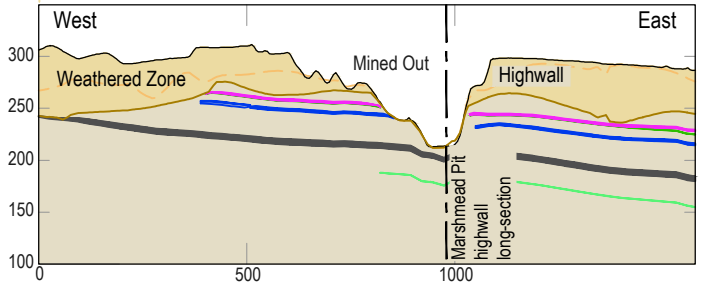
CROSS-SECTION | Togara Pit and Proposed Togara-North Marshmead Pit

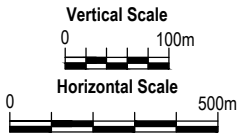
Viewed Looking North (Vertical Exaggeration x2.5)



CROSS-SECTION | Marshmead Pit

Viewed Looking North-West (Vertical Exaggeration x2.5)





Legend

- Natural Surface
- Base of Tertiary
- Base of Weathering

Coal Seams

- T Seam Group
- P & L Seam Group
- LR Seam Group
- SG Seam Group
- PS Seam Group

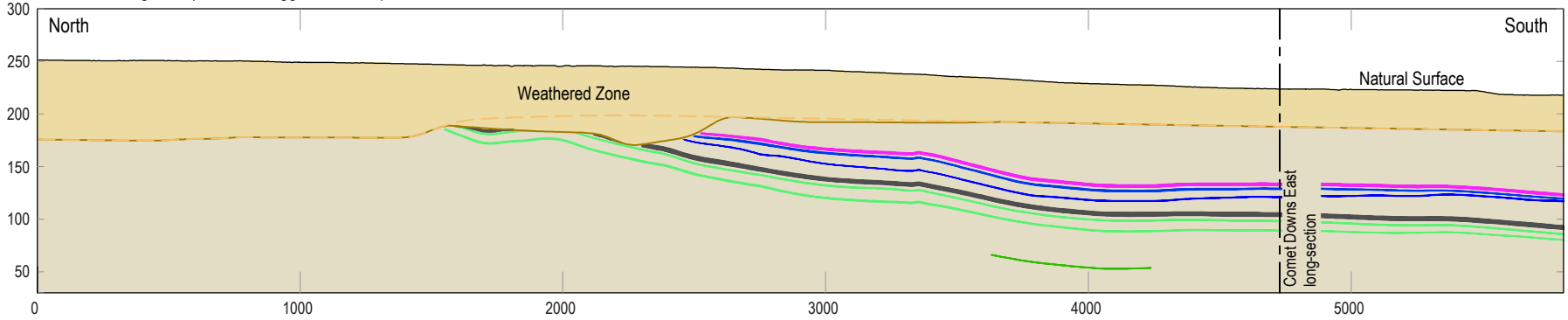
WHITEHAVEN

Minserve CAD File: Bhpb008m11 Blackwater - South.dwg

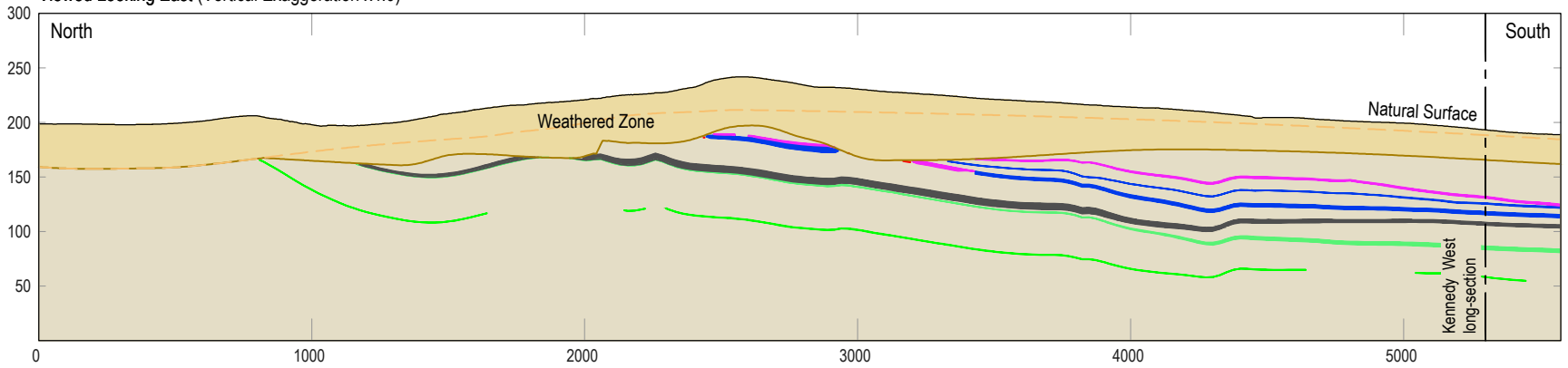
Pit cross-sections

Figure **A13**

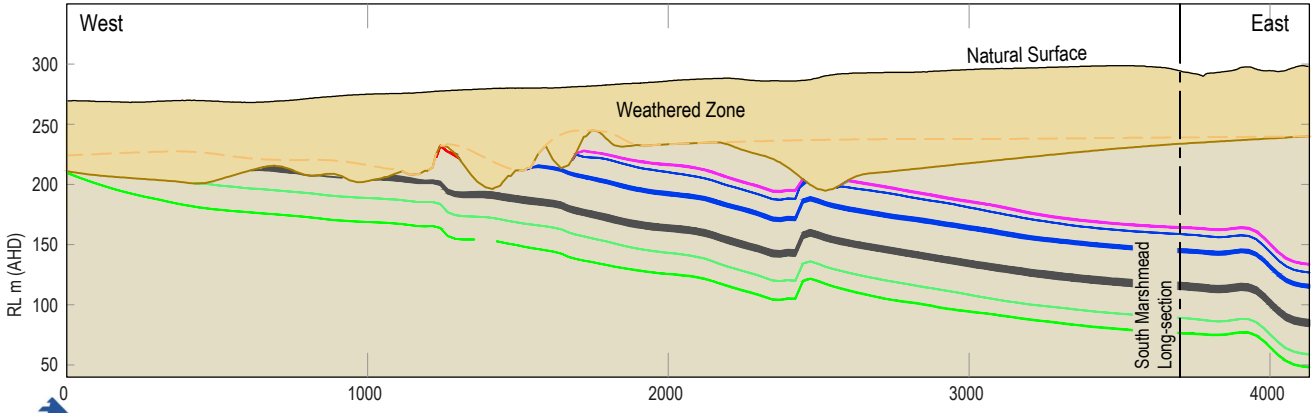
CROSS-SECTION | Comet Downs East Proposed Pit
Viewed Looking East (Vertical Exaggeration x4.0)



CROSS-SECTION | Kennedy West Proposed Pit
Viewed Looking East (Vertical Exaggeration x4.0)



CROSS-SECTION | South Marshmead Proposed Pit
Viewed Looking North (Vertical Exaggeration x4.0)



Legend
- Natural Surface
- Base of Tertiary
- Base of Weathering

Coal Seams
- T Seam Group
- P & L Seam Group
- LR Seam Group
- SG Seam Group
- PS Seam Group

Vertical Scale
0 — 100m

Horizontal Scale
0 — 500m

WHITEHAVEN

Minserve CAD File: Bhpb008m12-MDL Areas.dwg

Pit cross-sections

Figure **A14**

Attachment B – AMC Hazard Scoring Tables

AMD hazard and likelihood of AMD generation from spoil landforms

- Table B1 Ramp 8 final landform
- Table B2 Bonnie Doon final landform
- Table B3 Mimosa-Besgrove final landform
- Table B4 Deep Creek final landform
- Table B5 Stewarton-Ballamoo final landform
- Table B6 Kenmare final landform
- Table B7 Laleham final landform
- Table B8 Togara-North Marshmead final landform
- Table B9 South Marshmead final landform
- Table B10 Kennedy West final landform
- Table B11 Comet Downs East final landform

AMD hazard and likelihood of AMD generation from TSF landforms

- Table B12 NCPP TSF landform
- Table B13 Laleham TSF landform

AMD hazard and likelihood of AMD generation from rejects landform

- Table B14 Ramp 36 rejects landform

AMD hazard and likelihood of AMD generation from residual voids

- Table B15 Ramp 8 residual void walls and floor
- Table B16 Bonnie Doon residual void walls and floor
- Table B17 Mimosa-Besgrove residual void walls and floor
- Table B18 Deep Creek residual void walls and floor
- Table B19 Stewarton-Ballamoo residual void walls and floor
- Table B20 Kenmare residual void walls and floor
- Table B21 Laleham residual void walls and floor
- Table B22 Togara-North Marshmead residual void walls and floor
- Table B23 South Marshmead residual void walls and floor
- Table B24 Kennedy West residual void walls and floor
- Table B25 Comet Downs East residual void walls and floor

Table B1. AMD hazard scoring for source materials and likelihood for AMD generation from Ramp 8 final landform

Ramp 8: Landform components	Estimated material proportion within landform	% of samples classified as PAF	% of material in landform estimated to be PAF	Comment	AMD propensity rating	AMD capacity rating	AMD quantity rating	AMD hazard score	Landform AMD hazard score	Likelihood for AMD generation from Ramp 8 spoil landform
Non-carbonaceous spoil Distributed throughout	96%	1.6%	1.5%	Total S is low (75th percentile = 0.03%). NAF samples have a 75th percentile total S value of 0.03%. 'PAF' samples, which includes samples classified as PAF, PAF-LC, UC(PAF) or NAF-S, have a 75th percentile total S value of 0.33% (and AMD capacity is based on this number). Less than 2% of non-carbonaceous spoil is conservatively classified as 'PAF'. 75th percentile EC of non-carbonaceous spoil = 419 µS/cm. Most of the PAF material is associated with seams - as parting or within 1.5m above and below seams. Non-carbonaceous spoil is estimated to comprise approximately 96% of mineral waste in the landform. ANC is largely available under field conditions.	**1** Implausible	**5** Moderate	**3** Low-Moderate	**5** Low	**3.6** Low	General spoil, which comprises all of the landform, is overwhelmingly NAF with generally very low sulphur, excess neutralising capacity and low soluble metals concentration. Higher S materials are associated with seams and, as such, most PAF 'spoil' material is associated with seams - as parting or within 1.5m (typically) above and below seams and, as such, (and also due to seams being over-sampled) the percentage of 'PAF' spoil samples is not respresentative of the overall percentage of PAF in general spoil. Ramp 8 landform contains no rejects or tailings. Overall, about 2.1% of the final landform is conservatively estimated to be either PAF, PAF-LC or UC(PAF) material, which is widely distributed throughout the bulk NAF spoil. Non-carbonaceous and carbonaceous spoil are assigned low to low-moderate AMD capacity ratings based on the 75th percentile total S value for 'PAF' samples, however 'PAF' spoil comprises only a small proportion of the landform. The 75th percentile EC of the landform (based on the EC of the source materials proportionally represented) is estimated at 419 µS/cm. The hazard for AMD generation from Ramp 8 spoil landform is considered to be **LOW**. The likelihood for AMD generation from Ramp 8 spoil landform is rated **HIGHLY UNLIKELY**.
Coaly and/or carbonaceous spoil Distributed throughout	4.0%	13%	0.5%	Up to 13% of coaly and carbonaceous spoil is conservatively classified as 'PAF', which includes samples classified as PAF, PAF-LC, UC(PAF) or NAF-S. NAF samples have a 75th percentile total S value of 0.21%. 'PAF' samples have a 75th percentile total S value of 0.68% (and AMD capacity is based on this number). 75th percentile EC of carbonaceous spoil = 424 µS/cm. Carbonaceous spoil is estimated to comprise approximately 4% of mineral waste in the landform, and assumes all carbonaceous spoil is distributed amongst non-carbonaceous spoil. AMD quantity conservatively assumes proportion of PAF carbonaceous spoil samples approximates the proportion of carbonaceous spoil that is PAF.	**5** Plausible	**5** Moderate	**3** Low-Moderate	**9** Low-Moderate		
Rejects No current or future rejects disposed into Ramp 8 landform.	0%	46%	0%	No current or future rejects located within Ramp 8 landform.	**n/a**	**n/a**	**n/a**	**n/a**		
Tailings No current or future tailings disposed into Ramp 8 landform.	0%	49%	0%	No current or future tailings located within Ramp 8 landform.	**n/a**	**n/a**	**n/a**	**n/a**		

Table B2. AMD hazard scoring for source materials and likelihood for AMD generation from Bonnie Doon final landform

Bonnie Doon: Landform components	Estimated material proportion within landform	% of samples classified as PAF	% of material in landform estimated to be PAF	Comment	AMD propensity rating	AMD capacity rating	AMD quantity rating	AMD hazard score	Landform AMD hazard score	Likelihood for AMD generation from Bonnie Doon spoil landform
Non-carbonaceous spoil Distributed throughout	96%	1.6%	1.5%	Total S is low (75th percentile = 0.03%). NAF samples have a 75th percentile total S value of 0.03%. 'PAF' samples, which includes samples classified as PAF, PAF-LC, UC(PAF) or NAF-S, have a 75th percentile total S value of 0.33% (and AMD capacity is based on this number). Less than 2% of non-carbonaceous spoil is conservatively classified as 'PAF'. 75th percentile EC of non-carbonaceous spoil = 419 µS/cm. Most of the PAF material is associated with seams - as parting or within 1.5m above and below seams. Non-carbonaceous spoil is estimated to comprise approximately 96% of mineral waste in the landform. ANC is largely available under field conditions.	**1** Implausible	**5** Moderate	**3** Low-Moderate	**5** Low	**3.6** Low	General spoil, which comprises all of the landform, is overwhelmingly NAF with generally very low sulphur, excess neutralising capacity and low soluble metals concentration. Higher S materials are associated with seams and, as such, most PAF 'spoil' material is associated with seams - as parting or within 1.5m (typically) above and below seams and, as such, (and also due to seams being over-sampled) the percentage of 'PAF' spoil samples is not respresentative of the overall percentage of PAF in general spoil. Bonnie Doon landform contains no rejects or tailings. Overall, about 2.1% of the final landform is conservatively estimated to be either PAF, PAF-LC or UC(PAF) material, which is widely distributed throughout the bulk NAF spoil. Non-carbonaceous and carbonaceous spoil are assigned low to low-moderate AMD capacity ratings based on the 75th percentile total S value for 'PAF' samples, however 'PAF' spoil comprises only a small proportion of the landform. The 75th percentile EC of the landform (based on the EC of the source materials proportionally represented) is estimated at 419 µS/cm. The hazard for AMD generation from Bonnie Doon spoil landform is considered to be **LOW**. The likelihood for AMD generation from Bonnie Doon spoil landform is rated **HIGHLY UNLIKELY**.
Coaly and/or carbonaceous spoil Distributed throughout	4.0%	13%	0.5%	Up to 13% of coaly and carbonaceous spoil is conservatively classified as 'PAF', which includes samples classified as PAF, PAF-LC, UC(PAF) or NAF-S. NAF samples have a 75th percentile total S value of 0.21%. 'PAF' samples have a 75th percentile total S value of 0.68% (and AMD capacity is based on this number). 75th percentile EC of carbonaceous spoil = 424 µS/cm. Carbonaceous spoil is estimated to comprise approximately 4% of mineral waste in the landform, and assumes all carbonaceous spoil is distributed amongst non-carbonaceous spoil. AMD quantity conservatively assumes proportion of PAF carbonaceous spoil samples approximates the proportion of carbonaceous spoil that is PAF.	**5** Plausible	**5** Moderate	**3** Low-Moderate	**9** Low-Moderate		
Rejects No / negligible current or future rejects disposed into Bonnie Doon landform.	0%	46%	0%	No (or negligible) current or future rejects located within Bonnie Doon landform.	**n/a**	**n/a**	**n/a**	**n/a**		
Tailings No current or future tailings disposed into Bonnie Doon landform	0%	49%	0%	No current or future tailings located within Bonnie Doon landform. (excludes tailings disposed into Bonnie Doon pit/void)	**n/a**	**n/a**	**n/a**	**n/a**		

Table B3. AMD hazard scoring for source materials and likelihood for AMD generation from Mimosa-Besgrove final landform

Mimosa-Besgrove: Landform components	Estimated material proportion within landform	% of samples classified as PAF	% of material in landform estimated to be PAF	Comment	AMD propensity rating	AMD capacity rating	AMD quantity rating	AMD hazard score	Landform AMD hazard score	Likelihood for AMD generation from Mimosa-Besgrove spoil landform
Non-carbonaceous spoil Distributed throughout	95%	1.6%	1.5%	Total S is low (75th percentile = 0.03%). NAF samples have a 75th percentile total S value of 0.03%. 'PAF' samples, which includes samples classified as PAF, PAF-LC, UC(PAF) or NAF-S, have a 75th percentile total S value of 0.33% (and AMD capacity is based on this number). Less than 2% of non-carbonaceous spoil is conservatively classified as 'PAF'. 75th percentile EC of non-carbonaceous spoil = 419 µS/cm. Most of the PAF material is associated with seams - as parting or within 1.5m above and below seams. Non-carbonaceous spoil is estimated to comprise approximately 95% of mineral waste in the landform. ANC is largely available under field conditions.	**1** Implausible	**5** Moderate	**3** Low-Moderate	**5** Low	**2.7** Low	General spoil, which comprises approximately 98% of the landform, is overwhelmingly NAF with generally very low sulphur, excess neutralising capacity and low soluble metals concentration. Higher S materials are associated with seams and, as such, most PAF spoil material is associated with seams - as parting or within 1.5m (typically) above and below seams. As such (and also due to seams being over-sampled) the percentage of 'PAF' spoil samples is not respresentative of the overall percentage of PAF in general spoil. Overall, about 2.8% of the final landform is conservatively estimated to be either PAF, PAF-LC or UC(PAF) material, which is mostly widely distributed throughout the bulk NAF spoil. Non-carbonaceous and carbonaceous spoil are assigned low to low-moderate AMD capacity ratings based on the 75th percentile total S value for PAF samples, however PAF spoil comprises a very small proportion of the landform. Rejects - located at Ramp 32 rejects dump and throughout spoil between Ramps 22 to 26 - comprise a very small proportion of the landform (<2%), however, approximately 45% of rejects samples have been conservatively classified as 'PAF' of some type and are assessed as posing a moderate AMD source hazard. Current and future rejects disposed broadly within/amongst spoil will be buried by overwhemingly NAF spoil. The 75th percentile EC of the landform (based on the EC of the source materials proportionally represented) is estimated at 439 µS/cm. The hazard for AMD generation from Mimosa-Besgrove spoil landform is considered to be **LOW**. The likelihood for AMD generation from Mimosa-Besgrove spoil landform is rated **HIGHLY UNLIKELY**.
Coaly and/or carbonaceous spoil Distributed throughout	2.9%	13%	0.4%	Up to 13% of coaly and carbonaceous spoil is conservatively classified as 'PAF', which includes samples classified as PAF, PAF-LC, UC(PAF) or NAF-S. NAF samples have a 75th percentile total S value of 0.21%. 'PAF' samples have a 75th percentile total S value of 0.68% (and AMD capacity is based on this number). 75th percentile EC of carbonaceous spoil = 424 µS/cm. Carbonaceous spoil is estimated to comprise approximately 3% of mineral waste in the landform, and assumes all carbonaceous spoil is distributed amongst non-carbonaceous spoil. AMD quantity conservatively assumes proportion of PAF carbonaceous spoil samples approximates the proportion of carbonaceous spoil that is PAF.	**5** Plausible	**5** Moderate	**3** Low-Moderate	**9** Low-Moderate		
Rejects Concentrated within the spoil dump area at Ramp 32 rejects dump; and broadly distributed between Ramps 22 to 26. Future rejects assumed to be broadly distributed throughout landform.	1.9%	46%	0.9%	Up to 46% of all BWM rejects are conservatively classified as 'PAF', which includes samples classified as PAF, PAF-LC, UC(PAF) or NAF-S. AMD capacity is based on a 75th percentile S value of 1.24% ('PAF' samples). NAF samples have a 75th percentile S value of 0.54%. 75th percentile EC of rejects = 1430 µS/cm. Rejects comprise a small proportion of mineral waste in the landform - less than 2%. Approximately half of the current rejects are concentrated at Deep Creek (Ramp 32) rejects dump - the remaining half are disposed broadly within/amongst predominantly non-carbonaceous spoil. Future rejects will be broadly disposed amongst spoil.	**7** Expected	**7** Moderate-High	**7** Moderate-High	**14** Moderate		
Tailings No current or future tailings disposed into Mimosa-Besgrove landform	0%	49%	0%	No current or future tailings located within Mimosa-Besgrove landform.	**n/a**	**n/a**	**n/a**	**n/a**		

Table B4. AMD hazard scoring for source materials and likelihood for AMD generation from Deep Creek final landform

Deep Creek: Landform components	Estimated material proportion within landform	% of samples classified as PAF	% of material in landform estimated to be PAF	Comment	AMD propensity rating	AMD capacity rating	AMD quantity rating	AMD hazard score	Landform AMD hazard score	Likelihood for AMD generation from Deep Creek spoil landform
Non-carbonaceous spoil Distributed throughout	96%	1.6%	1.5%	Total S is low (75th percentile = 0.03%). NAF samples have a 75th percentile total S value of 0.03%. 'PAF' samples, which includes samples classified as PAF, PAF-LC, UC(PAF) or NAF-S, have a 75th percentile total S value of 0.33% (and AMD capacity is based on this number). Less than 2% of non-carbonaceous spoil is conservatively classified as 'PAF'. 75th percentile EC of non-carbonaceous spoil = 419 µS/cm. Most of the PAF material is associated with seams - as parting or within 1.5m above and below seams. Non-carbonaceous spoil is estimated to comprise approximately 96% of mineral waste in the landform. ANC is largely available under field conditions.	**1** Implausible	**5** Moderate	**3** Low-Moderate	**5** Low	**3.3** Low	General spoil, which comprises approximately 99% of the landform, is overwhelmingly NAF with generally very low sulphur, excess neutralising capacity and low soluble metals concentration. Higher S materials are associated with seams and, as such, most PAF spoil material is associated with seams - as parting or within 1.5m (typically) above and below seams. As such (and also due to seams being over-sampled) the percentage of 'PAF' spoil samples is not respresentative of the overall percentage of PAF in general spoil. Overall, about 2.3% of the final landform is conservatively estimated to be either PAF, PAF-LC or UC(PAF) material, which is widely distributed throughout the bulk NAF spoil. Non-carbonaceous and carbonaceous spoil are assigned low to low-moderate AMD capacity ratings based on the 75th percentile total S value for PAF samples, however PAF spoil comprises a very small proportion of the landform. Current rejects are broadly distributed throughout spoil, and future rejects are expetced to have similar broad distribution. Rejects comprise a very small proportion of the landform (<1%), however, approximately 45% of rejects samples have been conservatively classified as 'PAF' of some type and are assessed as posing a moderate AMD source hazard. Current and future rejects disposed broadly within/amongst spoil will be buried by overwhemingly NAF spoil. The 75th percentile EC of the landform (based on the EC of the source materials proportionally represented) is estimated at 427 µS/cm. The hazard for AMD generation from Deep Creek spoil landform is considered to be **LOW**. The likelihood for AMD generation from Deep Creek spoil landform is rated **HIGHLY UNLIKELY**.
Coaly and/or carbonaceous spoil Distributed throughout	3.0%	13%	0.4%	Up to 13% of coaly and carbonaceous spoil is conservatively classified as 'PAF', which includes samples classified as PAF, PAF-LC, UC(PAF) or NAF-S. NAF samples have a 75th percentile total S value of 0.21%. 'PAF' samples have a 75th percentile total S value of 0.68% (and AMD capacity is based on this number). 75th percentile EC of carbonaceous spoil = 424 µS/cm. Carbonaceous spoil is estimated to comprise approximately 3% of mineral waste in the landform, and assumes all carbonaceous spoil is distributed amongst non-carbonaceous spoil. AMD quantity conservatively assumes proportion of PAF carbonaceous spoil samples approximates the proportion of carbonaceous spoil that is PAF.	**5** Plausible	**5** Moderate	**3** Low-Moderate	**9** Low-Moderate		
Rejects Currently located broadly within the spoil dump area. Future rejects assumed to be broadly distributed throughout Deep Creek landform.	0.8%	46%	0.4%	Up to 46% of all BWM rejects are conservatively classified as 'PAF', which includes samples classified as PAF, PAF-LC, UC(PAF) or NAF-S. AMD capacity is based on a 75th percentile S value of 1.24% (PAF sampes). NAF samples have a 75th percentile S value of 0.54%. 75th percentile EC of rejects = 1430 µS/cm. Rejects comprise a very small proportion of mineral waste in the landform - less than 1% - and are disposed within/amongst predominantly non-carbonaceous spoil. The final spoil landform will essentially be comprised of (mostly non-carbonaceous) spoil.	**7** Expected	**7** Moderate-High	**7** Moderate-High	**14** Moderate		
Tailings No current or future tailings disposed into Deep Creek landform	0%	49%	0%	No current or future tailings located within Deep Creek landform.	**n/a**	**n/a**	**n/a**	**n/a**		

Table B5. AMD hazard scoring for source materials and likelihood for AMD generation from Stewarton-Ballamoo final landform

Stewarton-Ballamoo: Landform components	Estimated material proportion within landform	% of samples classified as PAF	% of material in landform estimated to be PAF	Comment	AMD propensity rating	AMD capacity rating	AMD quantity rating	AMD hazard score	Landform AMD hazard score	Likelihood for AMD generation from Stewarton-Ballamoo spoil landform
Non-carbonaceous spoil Distributed throughout	96%	1.6%	1.5%	Total S is low (75th percentile = 0.03%). NAF samples have a 75th percentile total S value of 0.03%. 'PAF' samples, which includes samples classified as PAF, PAF-LC, UC(PAF) or NAF-S, have a 75th percentile total S value of 0.33% (and AMD capacity is based on this number). Less than 2% of non-carbonaceous spoil is conservatively classified as 'PAF'. 75th percentile EC of non-carbonaceous spoil = 419 µS/cm. Most of the PAF material is associated with seams - as parting or within 1.5m above and below seams. Non-carbonaceous spoil is estimated to comprise approximately 96% of mineral waste in the landform. ANC is largely available under field conditions.	**1** Implausible	**5** Moderate	**3** Low-Moderate	**5** Low	**3.5** Low	General spoil, which comprises essentially all of the landform, is overwhelmingly NAF with generally very low sulphur, excess neutralising capacity and low soluble metals concentration. Higher S materials are associated with seams and, as such, most PAF spoil material is associated with seams - as parting or within 1.5m (typically) above and below seams. As such (and also due to seams being over-sampled) the percentage of 'PAF' spoil samples is not respresentative of the overall percentage of PAF in general spoil. Overall, about 2.1% of the final landform is conservatively estimated to be either PAF, PAF-LC or UC(PAF) material, which is mostly widely distributed throughout the bulk NAF spoil. Non-carbonaceous and carbonaceous spoil are assigned low to low-moderate AMD capacity ratings based on the 75th percentile total S value for PAF samples, however PAF spoil comprises a very small proportion of the landform. Rejects - currently located at Ramp 64 rejects dump - comprise a very small proportion of the landform (approximately 0.2%), however, approximately 45% of rejects (generally) have been conservatively classified as 'PAF' of some type and are assessed as posing a moderate AMD source hazard. Future rejects disposed broadly within/amongst spoil will be buried by overwhemingly NAF spoil. The 75th percentile EC of the landform (based on the EC of the source materials proportionally represented) is estimated at 421 µS/cm. The hazard for AMD generation from Stewarton-Ballamoo spoil landform is considered to be **LOW**. The likelihood for AMD generation from Stewarton-Ballamoo spoil landform is rated **HIGHLY UNLIKELY**.
Coaly and/or carbonaceous spoil Distributed throughout	4.0%	13%	0.5%	Up to 13% of coaly and carbonaceous spoil is conservatively classified as 'PAF', which includes samples classified as PAF, PAF-LC, UC(PAF) or NAF-S. NAF samples have a 75th percentile total S value of 0.21%. 'PAF' samples have a 75th percentile total S value of 0.68% (and AMD capacity is based on this number). 75th percentile EC of carbonaceous spoil = 424 µS/cm. Carbonaceous spoil is estimated to comprise approximately 4% of mineral waste in the landform, and assumes all carbonaceous spoil is distributed amongst non-carbonaceous spoil. AMD quantity conservatively assumes proportion of PAF carbonaceous spoil samples approximates the proportion of carbonaceous spoil that is PAF.	**5** Plausible	**5** Moderate	**3** Low-Moderate	**9** Low-Moderate		
Rejects Currently located at Ramp 64 (northern end of Terang pit [Ballamoo South pit]). Future rejects assumed to be broadly distributed throughout northern area of landform.	0.2%	46%	0.1%	Up to 46% of all BWM rejects are conservatively classified as 'PAF', which includes samples classified as PAF, PAF-LC, UC(PAF) or NAF-S. AMD capacity is based on a 75th percentile S value of 1.24% (PAF sampes). NAF samples have a 75th percentile S value of 0.54%. 75th percentile EC of rejects = 1430 µS/cm. Rejects comprise a very small proportion of mineral waste in the landform - less than 0.5% - and are disposed within/amongst predominantly non-carbonaceous spoil. The final spoil landform will essentially be comprised of (mostly non-carbonaceous) spoil.	**7** Expected	**7** Moderate-High	**7** Moderate-High	**14** Moderate		
Tailings No current or future tailings disposed into Stewarton-Ballamoo landform	0%	49%	0%	No current or future tailings located within Stewarton-Ballamoo landform.	**n/a**	**n/a**	**n/a**	**n/a**		

Table B6. AMD hazard scoring for source materials and likelihood for AMD generation from Kenmare final landform

Kenmare: Landform components	Estimated material proportion within landform	% of samples classified as PAF	% of material in landform estimated to be PAF	Comment	AMD propensity rating	AMD capacity rating	AMD quantity rating	AMD hazard score	Landform AMD hazard score	Likelihood for AMD generation from Kenmare spoil landform
Non-carbonaceous spoil Distributed throughout	95%	1.6%	1.5%	Total S is low (75th percentile = 0.03%). NAF samples have a 75th percentile total S value of 0.03%. 'PAF' samples, which includes samples classified as PAF, PAF-LC, UC(PAF) or NAF-S, have a 75th percentile total S value of 0.33% (and AMD capacity is based on this number). Less than 2% of non-carbonaceous spoil is conservatively classified as 'PAF'. 75th percentile EC of non-carbonaceous spoil = 419 µS/cm. Most of the PAF material is associated with seams - as parting or within 1.5m above and below seams. Non-carbonaceous spoil is estimated to comprise approximately 95% of mineral waste in the landform. ANC is largely available under field conditions.	**1** Implausible	**5** Moderate	**3** Low-Moderate	**5** Low	**2.6** Low	General spoil, which comprises approximately 98% of the landform, is overwhelmingly NAF with generally very low sulphur, excess neutralising capacity and low soluble metals concentration. Higher S materials are associated with seams and, as such, most PAF spoil material is associated with seams - as parting or within 1.5m (typically) above and below seams. As such (and also due to seams being over-sampled) the percentage of 'PAF' spoil samples is not respresentative of the overall percentage of PAF in general spoil. Overall, about 3.4% of the final landform is conservatively estimated to be either PAF, PAF-LC or UC(PAF) material, two-thirds of which is widely distributed throughout the bulk NAF spoil - and the remaining third as PAF rejects and tailings, which are concentrated at Ramp 72 (tailings) and at the southern end of the current Kenmare pit (rejects) and Ramp 70 (rejects). Non-carbonaceous and carbonaceous spoil are assigned low to low-moderate AMD capacity ratings based on the 75th percentile total S value for PAF samples, however PAF spoil comprises a very small proportion of the landform. Rejects located within the landform at Ramp 70; and rejects and tailings located within the landform in Kenmare pit (Ramp 72 pit) comprise a very small proportion of the landform (approximately 1% each for tailings and rejects). However, approximately 82% of rejects from Ramp 72 and 18% of tailings from Ramp 72 have been conservatively classified as 'PAF' of some type and are assessed as predominantly posing a high AMD source hazard. AMD (as AD) has been observed from Ramp 72 TSF and from rejects located in the southern end of Kenmare pit. No new (future) rejects or tailings are expected to be disposed into this landform. The 75th percentile EC of the landform (based on the EC of the source materials proportionally represented) is estimated at 426 µS/cm. Overall, the hazard for AMD generation from Kenmare spoil landform is considered to be **LOW** and the likelihood for AMD generation from Laleham spoil landform is rated **HIGHLY UNLIKELY.** However, the AMD source hazard for rejects located at Ramp 70 is **Moderate** and the AMD source hazard for buried rejects and tailings within Ramp 72 TSF and the southern end of current Kenmare pit is **HIGH**. The likelihood for AMD generation from Ramp 70 rejects buried within the kenmare spoil landform is **PROBABLE LIKELY**, whereas the likelihood for AMD generation from buried rejects and tailings within Ramp 72 TSF and the southern end of current Kenmare pit is **HIGHLY LIKELY**.
Coaly and/or carbonaceous spoil Distributed throughout	2.9%	13%	0.4%	Up to 13% of coaly and carbonaceous spoil is conservatively classified as 'PAF', which includes samples classified as PAF, PAF-LC, UC(PAF) or NAF-S. NAF samples have a 75th percentile total S value of 0.21%. 'PAF' samples have a 75th percentile total S value of 0.68% (and AMD capacity is based on this number). 75th percentile EC of carbonaceous spoil = 424 µS/cm. Carbonaceous spoil is estimated to comprise approximately 3% of mineral waste in the landform, and assumes all carbonaceous spoil is distributed amongst non-carbonaceous spoil. AMD quantity conservatively assumes proportion of PAF carbonaceous spoil samples approximates the proportion of carbonaceous spoil that is PAF.	**5** Plausible	**5** Moderate	**3** Low-Moderate	**9** Low-Moderate		
Rejects Within the spoil dump at Ramp 70. No future rejects disposed into Kenmare landform.	0.5%	92%	0.4%	Up to 92% of rejects (based on samples from Ramp 72) are conservatively classified as 'PAF', which includes samples classified as PAF, PAF-LC, UC(PAF) or NAF-S. AMD capacity is based on a 75th percentile S value of 1.19% ('PAF' sampes). NAF samples have a 75th percentile S value of 0.50%. 75th percentile EC of R72 rejects = 1500 µS/cm. Rejects comprise a small proportion of mineral waste in the landform - approximately 1%, of which over half is disposed as mixed fine- and coarse rejects within the southern end of Kenmare pit (R72 pit). The spoil landform will predominantly be comprised of (mostly non-carbonaceous) spoil. AMD as AD has been observed from rejects in Kenmare pit.	**7** Expected	**7** Moderate-High	**7** Moderate-High	**14** Moderate		
Rejects Southern end of Kenmare pit. No future rejects disposed into Kenmare landform.	0.5%		0.4%		**15** Certain	**7** Moderate-High	**7** Moderate-High	**22** High		
Tailings Ramp 72 TSF at base of landform. No future tailings disposed into Kenmare landform.	1.0%	59%	0.6%	59% of tailings from Ramp 72 TSF are conservatively classified as 'PAF', which includes samples classified as PAF, PAF-LC, UC(PAF) or NAF-S. Tailings comprise a very small proportion of the overall spoil landform (approx. 1%) - however are concentrated in one area (Ramp 72 TSF). 75th percentile EC of R72 tailings = 849 µS/cm. AMD capacity is based on a 75th percentile S value of 0.58%. Some tailings samples will generate AD. AMD quantity assumes proportion of PAF tailings samples approximates the proportion of tailings that are PAF. Tailings (TSF) will be buried by predominantly non-carbonaceous and NAF spoil. AMD as AD has been observed from Ramp 72 TSF.	**15** Certain	**5** Moderate	**3** Low-Moderate	**19** Moderate-High		

Table B7. AMD hazard scoring for source materials and likelihood for AMD generation from Laleham final landform

Laleham: Landform components	Estimated material proportion within landform	% of samples classified as PAF	% of material in landform estimated to be PAF	Comment	AMD propensity rating	AMD capacity rating	AMD quantity rating	AMD hazard score	Landform AMD hazard score	Likelihood for AMD generation from Laleham spoil landform
Non-carbonaceous spoil Distributed throughout	99%	1.6%	1.6%	Total S is low (75th percentile = 0.03%). NAF samples have a 75th percentile total S value of 0.03%. 'PAF' samples, which includes samples classified as PAF, PAF-LC, UC(PAF) or NAF-S, have a 75th percentile total S value of 0.33% (and AMD capacity is based on this number). Less than 2% of non-carbonaceous spoil is conservatively classified as 'PAF'. 75th percentile EC of non-carbonaceous spoil = 419 µS/cm. Most of the PAF material is associated with seams - as parting or within 1.5m above and below seams. Non-carbonaceous spoil is estimated to comprise approximately 99% of mineral waste in the landform. ANC is largely available under field conditions.	**1** Implausible	**5** Moderate	**3** Low-Moderate	**5** Low	**4.6** Low	General spoil, which comprises all of the landform, is overwhelmingly NAF with generally very low sulphur, excess neutralising capacity and low soluble metals concentration. Higher S materials are associated with seams. Over three quarters of PAF 'spoil' material is associated with seams - as parting or within 1.5m (typically) above and below seams and, as such, (and also due to seams being over-sampled) the percentage of 'PAF' spoil samples is not respresentative of the overall percentage of PAF in general spoil. Laleham landform contains no rejects or tailings. [Laleham TSF - located adjacent to the Laleham spoil landform - is assessed as a 'stand alone' TSF landform.] Overall, about 1.7% of the final landform is conservatively estimated to be either PAF, PAF-LC or UC(PAF) material, which is widely distributed throughout the bulk NAF spoil. Non-carbonaceous and carbonaceous spoil are assigned low to low-moderate AMD capacity ratings based on the 75th percentile total S value for PAF samples, however PAF spoil comprises only a small proportion of the landform. The 75th percentile EC of the landform (based on the EC of the source materials proportionally represented) is estimated at 419 µS/cm. The hazard for AMD generation from Laleham spoil landform is considered to be **LOW**. The likelihood for AMD generation from Laleham spoil landform is rated **HIGHLY UNLIKELY**.
Coaly and/or carbonaceous spoil Distributed throughout	1.0%	13%	0.1%	Up to 13% of coaly and carbonaceous spoil is conservatively classified as 'PAF', which includes samples classified as PAF, PAF-LC, UC(PAF) or NAF-S. NAF samples have a 75th percentile total S value of 0.21%. 'PAF' samples have a 75th percentile total S value of 0.68% (and AMD capacity is based on this number). 75th percentile EC of carbonaceous spoil = 424 µS/cm. Carbonaceous spoil is estimated to comprise approximately 1% of mineral waste in the landform, and assumes all carbonaceous spoil is distributed amongst non-carbonaceous spoil. AMD quantity conservatively assumes proportion of PAF carbonaceous spoil samples approximates the proportion of carbonaceous spoil that is PAF.	**5** Plausible	**5** Moderate	**3** Low-Moderate	**9** Low-Moderate		
Rejects No current or future rejects disposed into Laleham landform.	0%	46%	0%	No current or future rejects located within Laleham landform. Laleham TSF is assessed as a 'stand alone' TSF landform - refer to the AMD hazard assessment of Laleham TSF landform.	**n/a**	**n/a**	**n/a**	**n/a**		
Tailings No current or future tailings disposed into Laleham landform.	0%	49%	0%	No current or future tailings located within Laleham landform. Laleham TSF is assessed as a 'stand alone' TSF landform - refer to the AMD hazard assessment of Laleham TSF landform.	**n/a**	**n/a**	**n/a**	**n/a**		

Table B8. AMD hazard scoring for source materials and likelihood for AMD generation from Togara-North Marshmead final landform

Togara-North Marshmead: Landform components	Estimated material proportion within landform	% of samples classified as PAF	% of material in landform estimated to be PAF	Comment	AMD propensity rating	AMD capacity rating	AMD quantity rating	AMD hazard score	Landform AMD hazard score	Likelihood for AMD generation from Togara-North Marshmead spoil landform
Non-carbonaceous spoil Distributed throughout	94%	1.6%	1.5%	Total S is low (75th percentile = 0.03%). NAF samples have a 75th percentile total S value of 0.03%. 'PAF' samples, which includes samples classified as PAF, PAF-LC, UC(PAF) or NAF-S, have a 75th percentile total S value of 0.33% (and AMD capacity is based on this number). Less than 2% of non-carbonaceous spoil is conservatively classified as 'PAF'. 75th percentile EC of non-carbonaceous spoil = 419 µS/cm. Most of the PAF material is associated with seams - as parting or within 1.5m above and below seams. Non-carbonaceous spoil is estimated to comprise approximately 94% of mineral waste in the landform. ANC is largely available under field conditions.	**1** Implausible	**5** Moderate	**3** Low-Moderate	**5** Low	**3.2** Low	General spoil, which comprises essentially all of the landform, is overwhelmingly NAF with generally very low sulphur, excess neutralising capacity and low soluble metals concentration. Higher S materials are associated with seams and, as such, most PAF spoil material is associated with seams - as parting or within 1.5m (typically) above and below seams. As such (and also due to seams being over-sampled) the percentage of 'PAF' spoil samples is not respresentative of the overall percentage of PAF in general spoil. Overall, about 2.4% of the final landform is conservatively estimated to be either PAF, PAF-LC or UC(PAF) material, which is mostly widely distributed throughout the bulk NAF spoil. Non-carbonaceous and carbonaceous spoil are assigned low to low-moderate AMD capacity ratings based on the 75th percentile total S value for PAF samples, however PAF spoil comprises a very small proportion of the landform. Rejects - currently located within the landform at Ramps 76 and 84 - comprise a very small proportion of the landform (approximately 0.2%), however, approximately 45% of the rejects (generally) have been conservatively classified as 'PAF' of some type and are assessed as posing a moderate AMD source hazard. No new (future) rejects are expected to be disposed into this landform. The 75th percentile EC of the landform (based on the EC of the source materials proportionally represented) is estimated at 421 µS/cm. The hazard for AMD generation from Togara-North Marshmead spoil landform is considered to be **LOW**. The likelihood for AMD generation from Togara-North Marshmead spoil landform is rated **HIGHLY UNLIKELY**.
Coaly and/or carbonaceous spoil Distributed throughout	6.0%	13%	0.8%	Up to 13% of coaly and carbonaceous spoil is conservatively classified as 'PAF', which includes samples classified as PAF, PAF-LC, UC(PAF) or NAF-S. NAF samples have a 75th percentile total S value of 0.21%. 'PAF' samples have a 75th percentile total S value of 0.68% (and AMD capacity is based on this number). 75th percentile EC of carbonaceous spoil = 424 µS/cm. Carbonaceous spoil is estimated to comprise approximately 6% of mineral waste in the landform, and assumes all carbonaceous spoil is distributed amongst non-carbonaceous spoil. AMD quantity conservatively assumes proportion of PAF carbonaceous spoil samples approximates the proportion of carbonaceous spoil that is PAF.	**5** Plausible	**5** Moderate	**3** Low-Moderate	**9** Low-Moderate		
Rejects Currently located within the spoil dump area at Ramp 76 and Ramp 84. No future rejects disposed into Togara-North Marshmead landform.	0.2%	46%	0.1%	Up to 46% of all BWM rejects are conservatively classified as 'PAF', which includes samples classified as PAF, PAF-LC, UC(PAF) or NAF-S. AMD capacity is based on a 75th percentile S value of 1.24% (PAF sampes). NAF samples have a 75th percentile S value of 0.54%. 75th percentile EC of rejects = 1430 µS/cm. Rejects comprise a very small proportion of mineral waste in the landform - less than 0.5% - and are disposed within/amongst predominantly non-carbonaceous spoil. The final spoil landform will essentially be comprised of (mostly non-carbonaceous) spoil.	**7** Expected	**7** Moderate-High	**7** Moderate-High	**14** Moderate		
Tailings No current or future tailings disposed into Togara-North Marshmead landform	0%	49%	0%	No current or future tailings located within Togara-North Marshmead landform.	**n/a**	**n/a**	**n/a**	**n/a**		

Table B9. AMD hazard scoring for source materials and likelihood for AMD generation from South Marshmead final landform

South Marshmead: Landform components	Estimated material proportion within landform	% of samples classified as PAF	% of material in landform estimated to be PAF	Comment	AMD propensity rating	AMD capacity rating	AMD quantity rating	AMD hazard score	Landform AMD hazard score	Likelihood for AMD generation from South Marshmead spoil landform
Non-carbonaceous spoil Distributed throughout	98%	1.6%	1.6%	Total S is low (75th percentile = 0.03%). NAF samples have a 75th percentile total S value of 0.03%. 'PAF' samples, which includes samples classified as PAF, PAF-LC, UC(PAF) or NAF-S, have a 75th percentile total S value of 0.33% (and AMD capacity is based on this number). Less than 2% of non-carbonaceous spoil is conservatively classified as 'PAF'. 75th percentile EC of non-carbonaceous spoil = 419 µS/cm. Most of the PAF material is associated with seams - as parting or within 1.5m above and below seams. Non-carbonaceous spoil is estimated to comprise approximately 98% of mineral waste in the landform. ANC is largely available under field conditions.	**1** Implausible	**5** Moderate	**3** Low-Moderate	**5** Low	**4.2** Low	General spoil, which comprises all of the landform, is overwhelmingly NAF with generally very low sulphur, excess neutralising capacity and low soluble metals concentration. Higher S materials are associated with seams. Over three quarters of PAF 'spoil' material is associated with seams - as parting or within 1.5m (typically) above and below seams and, as such, (and also due to seams being over-sampled) the percentage of 'PAF' spoil samples is not respresentative of the overall percentage of PAF in general spoil. South Marshmead landform contains no rejects or tailings. Overall, less than 2% of the final landform is conservatively estimated to be either PAF, PAF-LC or UC(PAF) material, which is widely distributed throughout the bulk NAF spoil. Non-carbonaceous and carbonaceous spoil are assigned low to low-moderate AMD capacity ratings based on the 75th percentile total S value for PAF samples, however PAF spoil comprises a very small proportion of the landform. The 75th percentile EC of the landform (based on the EC of the source materials proportionally represented) is estimated at 419 µS/cm. The hazard for AMD generation from South Marshmead spoil landform is considered to be **LOW**. The likelihood for AMD generation from South Marshmead spoil landform is rated **HIGHLY UNLIKELY**.
Coaly and/or carbonaceous spoil Distributed throughout	2.0%	13%	0.3%	Up to 13% of coaly and carbonaceous spoil is conservatively classified as 'PAF', which includes samples classified as PAF, PAF-LC, UC(PAF) or NAF-S. NAF samples have a 75th percentile total S value of 0.21%. 'PAF' samples have a 75th percentile total S value of 0.68% (and AMD capacity is based on this number). 75th percentile EC of carbonaceous spoil = 424 µS/cm. Carbonaceous spoil is estimated to comprise approximately 2% of mineral waste in the landform, and assumes all carbonaceous spoil is distributed amongst non-carbonaceous spoil. AMD quantity conservatively assumes proportion of PAF carbonaceous spoil samples approximates the proportion of carbonaceous spoil that is PAF.	**5** Plausible	**5** Moderate	**3** Low-Moderate	**9** Low-Moderate		
Rejects South Marshmead is a proposed landform (currently doesn't exist). No future rejects disposed into South Marshmead landform.	0%	46%	0%	No current or future rejects located within South Marshmead landform.	**n/a**	**n/a**	**n/a**	**n/a**		
Tailings South Marshmead is a proposed landform (currently doesn't exist). No future tailings disposed into South Marshmead landform.	0%	49%	0%	No current or future tailings located within South Marshmead landform.	**n/a**	**n/a**	**n/a**	**n/a**		

Table B10. AMD hazard scoring for source materials and likelihood for AMD generation from Kennedy West final landform

Kennedy West: Landform components	Estimated material proportion within landform	% of samples classified as PAF	% of material in landform estimated to be PAF	Comment	AMD propensity rating	AMD capacity rating	AMD quantity rating	AMD hazard score	Landform AMD hazard score	Likelihood for AMD generation from Kennedy West spoil landform
Non-carbonaceous spoil Distributed throughout	94%	1.6%	1.5%	Total S is low (75th percentile = 0.03%). NAF samples have a 75th percentile total S value of 0.03%. 'PAF' samples, which includes samples classified as PAF, PAF-LC, UC(PAF) or NAF-S, have a 75th percentile total S value of 0.33% (and AMD capacity is based on this number). Less than 2% of non-carbonaceous spoil is conservatively classified as 'PAF'. 75th percentile EC of non-carbonaceous spoil = 419 µS/cm. Most of the PAF material is associated with seams - as parting or within 1.5m above and below seams. Non-carbonaceous spoil is estimated to comprise approximately 94% of mineral waste in the landform. ANC is largely available under field conditions.	**1** Implausible	**5** Moderate	**3** Low-Moderate	**5** Low	**3.2** Low	General spoil, which comprises all of the landform, is overwhelmingly NAF with generally very low sulphur, excess neutralising capacity and low soluble metals concentration. Higher S materials are associated with seams. Over three quarters of PAF 'spoil' material is associated with seams - as parting or within 1.5m (typically) above and below seams and, as such, (and also due to seams being over-sampled) the percentage of 'PAF' spoil samples is not respresentative of the overall percentage of PAF in general spoil. Kennedy West spoil landform contains no rejects or tailings. Overall, about 2.3% of the final landform is conservatively estimated to be either PAF, PAF-LC or UC(PAF) material, which is widely distributed throughout the bulk NAF spoil. Non-carbonaceous and carbonaceous spoil are assigned low to low-moderate AMD capacity ratings based on the 75th percentile total S value for PAF samples, however PAF spoil comprises a very small proportion of the landform. The 75th percentile EC of the landform (based on the EC of the source materials proportionally represented) is estimated at 419 µS/cm. The hazard for AMD generation from Kennedy West spoil landform is considered to be **LOW**. The likelihood for AMD generation from Kennedy West spoil landform is rated **HIGHLY UNLIKELY**.
Coaly and/or carbonaceous spoil Distributed throughout	6.0%	13%	0.8%	Up to 13% of coaly and carbonaceous spoil is conservatively classified as 'PAF', which includes samples classified as PAF, PAF-LC, UC(PAF) or NAF-S. NAF samples have a 75th percentile total S value of 0.21%. 'PAF' samples have a 75th percentile total S value of 0.68% (and AMD capacity is based on this number). 75th percentile EC of carbonaceous spoil = 424 µS/cm. Carbonaceous spoil is estimated to comprise approximately 6% of mineral waste in the landform, and assumes all carbonaceous spoil is distributed amongst non-carbonaceous spoil. AMD quantity conservatively assumes proportion of PAF carbonaceous spoil samples approximates the proportion of carbonaceous spoil that is PAF.	**5** Plausible	**5** Moderate	**3** Low-Moderate	**9** Low-Moderate		
Rejects Kennedy West is a proposed landform (currently doesn't exist). No future rejects disposed into Kennedy West landform.	0%	46%	0%	No current or future rejects located within Kennedy West landform.	**n/a**	**n/a**	**n/a**	**n/a**		
Tailings Kennedy West is a proposed landform (currently doesn't exist). No future tailings disposed into Kennedy West landform.	0%	49%	0%	No current or future tailings located within Kennedy West landform.	**n/a**	**n/a**	**n/a**	**n/a**		

Table B11. AMD hazard scoring for source materials and likelihood for AMD generation from Comet Downs East final landform

Comet Downs East: Landform components	Estimated material proportion within landform	% of samples classified as PAF	% of material in landform estimated to be PAF	Comment	AMD propensity rating	AMD capacity rating	AMD quantity rating	AMD hazard score	Landform AMD hazard score	Likelihood for AMD generation from Comet Downs East spoil landform
Non-carbonaceous spoil Distributed throughout	93%	1.6%	1.5%	Total S is low (75th percentile = 0.03%). NAF samples have a 75th percentile total S value of 0.03%. 'PAF' samples, which includes samples classified as PAF, PAF-LC, UC(PAF) or NAF-S, have a 75th percentile total S value of 0.33% (and AMD capacity is based on this number). Less than 2% of non-carbonaceous spoil is conservatively classified as 'PAF'. 75th percentile EC of non-carbonaceous spoil = 419 µS/cm. Most of the PAF material is associated with seams - as parting or within 1.5m above and below seams. Non-carbonaceous spoil is estimated to comprise approximately 93% of mineral waste in the landform. ANC is largely available under field conditions.	**1** Implausible	**5** Moderate	**3** Low-Moderate	**5** Low	**3.1** Low	General spoil, which comprises all of the landform, is overwhelmingly NAF with generally very low sulphur, excess neutralising capacity and low soluble metals concentration. Higher S materials are associated with seams. Over three quarters of PAF 'spoil' material is associated with seams - as parting or within 1.5m (typically) above and below seams and, as such, (and also due to seams being over-sampled) the percentage of 'PAF' spoil samples is not respresentative of the overall percentage of PAF in general spoil. Comet Downs East landform contains no rejects or tailings. Overall, about 2.4% of the final landform is conservatively estimated to be either PAF, PAF-LC or UC(PAF) material, which is widely distributed throughout the bulk NAF spoil. Non-carbonaceous and carbonaceous spoil are assigned low to low-moderate AMD capacity ratings based on the 75th percentile total S value for PAF samples, however PAF spoil comprises a very small proportion of the landform. The 75th percentile EC of the landform (based on the EC of the source materials proportionally represented) is estimated at 419 µS/cm. The hazard for AMD generation from Comet Downs East spoil landform is considered to be **LOW**. The likelihood for AMD generation from Comet Downs East spoil landform is rated **HIGHLY UNLIKELY**.
Coaly and/or carbonaceous spoil Distributed throughout	7.0%	13%	0.9%	Up to 13% of coaly and carbonaceous spoil is conservatively classified as 'PAF', which includes samples classified as PAF, PAF-LC, UC(PAF) or NAF-S. NAF samples have a 75th percentile total S value of 0.21%. 'PAF' samples have a 75th percentile total S value of 0.68% (and AMD capacity is based on this number). 75th percentile EC of carbonaceous spoil = 424 µS/cm. Carbonaceous spoil is estimated to comprise approximately 7% of mineral waste in the landform, and assumes all carbonaceous spoil is distributed amongst non-carbonaceous spoil. AMD quantity conservatively assumes proportion of PAF carbonaceous spoil samples approximates the proportion of carbonaceous spoil that is PAF.	**5** Plausible	**5** Moderate	**3** Low-Moderate	**9** Low-Moderate		
Rejects Comet Downs East is a proposed landform (currently doesn't exist). No future rejects disposed into Comet Downs East landform.	0%	46%	0%	No current or future rejects located within Comet Downs East landform.	**n/a**	**n/a**	**n/a**	**n/a**		
Tailings Comet Downs East is a proposed landform (currently doesn't exist). No future tailings disposed into Comet Downs East landform.	0%	49%	0%	No current or future tailings located within Comet Downs East landform.	**n/a**	**n/a**	**n/a**	**n/a**		

Table B12. AMD hazard scoring for source materials and likelihood for AMD generation from NCPP TSF landform (unrehabilitated)

NCPP TSF: Components (without cover)	Estimated material proportion within landform	% of samples classified as PAF	% of material in landform estimated to be PAF	Comment	AMD propensity rating	AMD capacity rating	AMD quantity rating	AMD source hazard score	Landform AMD hazard score (pre-rehabilitation)	Likelihood for AMD generation from NCPP TSF (before rehabilitation)
Tailings	80%	49%	39%	Based on data from 446 tailings samples from NCPP TSF and NCPP, up to 49% of tailings are conservatively classified as 'PAF', which includes samples classified as PAF, PAF-LC, UC(PAF) or NAF-S. AMD capacity is based on a 75th percentile S value of 2.19% ('PAF' samples). NAF samples have a 75th percentile S value of 0.69%. Conservatively assumes proportion of PAF tailings samples approximates the proportion of tailings in NCPP TSF that are PAF. Assumes equal distribution of PAF/NAF tailings throughout the TSF.	**15** High	**10** High	**10** High	**25** High	**19** Moderate-High	The hazard for AMD generation in the landform is based on the large majority (approximately 80%) of the landform being tailings, of which 49% is conservatively estimated to be PAF. Of the 'PAF' samples, about 70% are UC(PAF) or PAF-LC and, as such, are considered to have a relatively moderate capacity to generate significant acidity. However, AMD is evident (as AD, with pH <4.5) in tailings samples located at the TSF and in seepage from the toe of the TSF. Overall, about 41% of the NCPP TSF landform is conservatively estimated to be either PAF, PAF-LC, UC(PAF) or NAF-S material - most of which is tailings, which are assessed as posing a High AMD source hazard. Rejects are estimated to comprise about 19% of the TSF landform (as embankment material) and are assessed as posing a low-moderate AMD source hazard. The 75th percentile EC of the landform (based on the EC of the source materials proportionally represented) is estimated at 957 µS/cm. The hazard for AMD generation from NCPP TSF landform is conservatively considered to be **MODERATE-HIGH**. The likelihood for AMD generation from NCPP TSF landform is conservatively rated as **HIGHLY LIKELY**, the highest likelihood category - noting that AMD has already been observed from this TSF.
Rejects Primarily located within embankments	19%	8%	1.4%	Based on data from 92 rejects samples from NCPP TSF and NCPP, up to 8% of rejects are conservatively classified as 'PAF', which includes samples classified as PAF, PAF-LC, UC(PAF) or NAF-S. AMD capacity is based on a 75th percentile S value of 0.65% (PAF samples). NAF samples have a 75th percentile S value of 0.49%. Conservatively assumes proportion of PAF rejects samples approximates the proportion of rejects in NCPP TSF that are PAF. Assumes equal distribution of PAF/NAF rejects throughout the areas of the TSF where rejects are located (primarily embankments).	**5** Plausible	**5** Moderate	**3** Low-Moderate	**9** Low-Moderate		
Fill & Natural Ground Spoil fill within a TSF (typically part of an embankment) and/or natural ground material at the base of the TSF. Excludes existing cover/cap material on the surface of the TSF.	1%	8%	0.1%	Based on data from 26 fill (incl. natural ground) samples from NCPP TSF, up to 8% of fill is conservatively classified as PAF, PAF-LC or UC(PAF). AMD capacity is based on a 75th percentile S value of 1.4% (2 x PAF samples). NAF samples have a 75th percentile S value of 0.04%. Conservatively assumes proportion of PAF fill samples approximates the proportion of fill in NCPP TSF that are PAF. Assumes equal distribution of PAF/NAF fill throughout the areas of the TSF where fill is located (primarily embankments and immediately beneath the TSF).	**5** Plausible	**7** Moderate-High	**7** Moderate-High	**12** Moderate		

Table B13. AMD hazard scoring for source materials and likelihood for AMD generation from Laleham TSF landform (unrehabilitated)

Laleham TSF: Components (without cover)	Estimated material proportion within landform	% of samples classified as PAF	% of material in landform estimated to be PAF	Comment	AMD propensity rating	AMD capacity rating	AMD quantity rating	AMD source hazard score	Landform AMD hazard score (pre-rehabilitation)	Likelihood for AMD generation from Laleham TSF (before rehabilitation)
Tailings	90%	84%	76%	Based on data from 89 tailings samples from Laleham TSF, up to 84% of tailings are conservatively classified as 'PAF', which includes samples classified as PAF, PAF-LC, UC(PAF) or NAF-S. AMD capacity is based on a 75th percentile S value of 0.73% ('PAF' samples). NAF samples have a 75th percentile S value of 0.18%. Conservatively assumes proportion of PAF tailings samples approximates the proportion of tailings in Laleham TSF that are PAF. Assumes equal distribution of PAF/NAF tailings throughout the TSF.	**15** High	**5** Moderate	**5** Moderate	**20** Moderate-High	**17** Moderate-High	The hazard for AMD generation in the landform is based on the majority (90%) of the landform being tailings of which 84% is conservatively estimated to be PAF. Over 25% of tailings samples are displaying evidence of AD (pH <4.5), with associated evidence of sulphide oxidation (to sulphate) and consumption of ANC. Overall, about 80% of the current Laleham TSF landform (including the spoil/fill cover) is conservatively estimated to be either PAF, PAF-LC or UC(PAF) material - most of which is tailings, which are assessed as posing a moderate-high AMD source hazard. Rejects are estimated to comprise about 4% of the TSF landform and are assessed as posing a moderate AMD source hazard. Spoil/fill is estimated to comprise about 6% of the landform and is assessed as posing a low-moderate AMD source hazard. The 75th percentile EC of the landform (based on the EC of the source materials proportionally represented) is estimated at 1141 µS/cm. The hazard for AMD generation from Laleham TSF landform is conservatively considered to be **MODERATE-HIGH**. The likelihood for AMD generation from Laleham TSF landform is conservatively rated as **PROBABLE / LIKELY**.
Rejects	4.0%	55%	2.2%	Only two rejects samples from Laleham TSF have geochemical data. Therefore, based on data from 217 aged rejects samples from all of BWM site, up to 55% of rejects are conservatively classified as 'PAF', which includes samples classified as PAF, PAF-LC, UC(PAF) or NAF-S. AMD capacity is based on a 75th percentile S value of 1.28% (PAF samples). NAF samples have a 75th percentile S value of 0.56%. Conservatively assumes proportion of PAF rejects samples approximates the proportion of rejects in Laleham TSF that are PAF. Assumes equal distribution of PAF/NAF rejects throughout the areas of the TSF where rejects are located.	**7** Expected	**7** Moderate-High	**7** Moderate-High	**14** Moderate		
Fill & Natural Ground Spoil cap currently on the TSF and natural ground and fill material at the base of the TSF and within TSF embankments.	6.0%	21%	1.3%	Based on data from 47 fill (incl. natural ground) samples from Laleham TSF, up to 21% of fill & natural ground samples are conservatively classified as PAF, PAF-LC or UC(PAF). AMD capacity is based on a 75th percentile S value of 0.49%. NAF samples have a 75th percentile S value of 0.08%. Conservatively assumes proportion of PAF fill/natural samples approximates the proportion of fill in Laleham TSF that are PAF. Assumes equal distribution of PAF/NAF fill throughout the areas of the TSF where fill is located (primarily cover, embankments and immediately beneath the TSF).	**5** Plausible	**5** Moderate	**3** Low-Moderate	**9** Low-Moderate		

Table B14. AMD hazard scoring for source materials and likelihood for AMD generation from Ramp 36 rejects landform (unrehabilitated)

Ramp 36 rejects dump: Components (without cover)	Estimated material proportion within landform	% of samples classified as PAF	% of material in landform estimated to be PAF	Comment	AMD propensity rating	AMD capacity rating	AMD quantity rating	AMD source hazard score	Landform AMD hazard score (pre-rehabilitation)	Likelihood for AMD generation from Ramp 36 rejects dump (before rehabilitation)
Tailings No tailings disposed into Ramp 36 rejects landform.	0%	0%	0%	No tailings located within Ramp 36 rejects landform.	n/a	n/a	n/a	n/a	**13** Moderate	The hazard for AMD generation in the landform is based on the landform primarily essentially all rejects, of which 39% are conservatively estimated to be PAF or NAF-S. Of the 'PAF' samples, all except one are UC(PAF) with generally low S and, as such, are considered to have a relatively moderate capacity to generate significant acidity. Overall, about 38% of the Ramp 36 Rejects landform is conservatively estimated to be either PAF, PAF-LC, UC(PAF) or NAF-S material - all of which is rejects. The 75th percentile EC of the landform (based on the EC of the source materials proportionally represented) is estimated at 1489 µS/cm. The hazard for AMD generation from Ramp 36 Rejects landform is conservatively considered to be **MODERATE**. The likelihood for AMD generation from Ramp 36 Rejects landform is conservatively rated as **PROBABLE/LIKELY**.
Rejects Essentially all of the landform is comprised of rejects	99%	39%	38%	The rejects dump is comprised almost entirely of rejects with a small proportion of fill material. Based on data from 44 rejects samples from Ramp 36 rejects dump, up to 39% of rejects are conservatively classified as PAF, PAF-LC, UC(PAF) or NAF-S. AMD capacity is based on a 75th percentile S value of 1.31% (PAF and NAF-S samples). NAF samples have a 75th percentile S value of 0.74%. Conservatively assumes proportion of PAF and NAF-S rejects samples approximates the proportion of rejects in Ramp 36 rejects dump that are PAF and NAF-S. Assumes equal distribution of PAF/NAF rejects throughout the rejects dump.	**5** Plausible	**7** Moderate-High	**10** High	**14** Moderate		
Fill & Natural Ground Spoil fill within the rejcts dump and/or natural ground material at the base of the dump.	1%	0%	0%	Based on data from 4 fill samples from Ramp 36 rejects dump: All sampes were classified as NAF, with a very low 75th percentile S value of 0.06%. Proportion of fill in rejects dump is uncertain; 1% is a conservative estimate.	**1** Implausible	**1** Low	**1** Low	**2** Low		

Table B15. AMD hazard scoring for source materials and likelihood for AMD generation from Ramp 8 residual void walls and floor

Material domain	Material type	Proportion of drill-hole meterage on highwall by material type %	Above current water table (where known)	Below current water table (where known)	Proportion of drill-hole meterage (below base of weathering)	% of PAF sample by material type (environmental and/or coal database)	Comment	Estimated % PAF exposure on highwall	Comment	Geochemical Propensity for AMD	AMD Capacity Rating	AMD Quantity Rating	AMD Source Material Hazard Score	Likelihood for AMD generation from Ramp 8 void highwall
Ramp 8 Void Highwall	Weathered, non-carbonaceous	17%	100% (where known)	0% (where known)	0%	5.1%	Approximately 5% of weathered non-carbonaceous samples (28 samples out of 554) were UC(PAF) or PAF-LC [no "PAF" samples] (data from geochemical database). It is expected that weathered material is completely or predominantly oxidised and, as such, this material is overwhelmingly NAF.	0.8%	This material is expected to comprise approximately 17% of the void wall material by meterage. Assumed to be non-mineralised, with very low concentrations of reactive sulphide minerals. Small proportion of samples may be PAF (if so, likely low capacity). The potential for AMD from acid sulphate minerals (e.g. jarosite) is very low or negligible. Likely source of ANC. The 75th percentile total S value is 0.02%. AMD capacity based on PAF samples 75th percentile total S of 0.03%.	5	1	1	6	Highwall information is not available for Ramp 8, however the highwall is expected to be geologically comparable to Bonnie Doon Pit highwall. Based on Bonnie Doon highwall data, non-carb. rock is expected to have excess ANC, which should be sufficient to buffer AMD released from potential AMD sources exposed on the highwall, if any. The potential exposure of PAF materials on the highwall is estimated to represent approximately 4% (vertical meterage), with PAF domains expected to be largely confined to coal horizons/seams. Void wall run-off reporting to the residual void is unlikely to produce acidity. The hazard for AMD generation from Ramp 8 void highwall = **LOW-MODERATE**. The likelihood for AMD generation from Ramp 8 void highwall = **UNLIKELY**
	Weathered, carbonaceous & coaly	0.1%	100% (where known)	0% (where known)	0%	33%	Negligible proportion in highwall. Three out of 9 weathered carbonaceous/coaly samples were UC(PAF) and PAF (data from geochemical database). It is expected that weathered material is predominantly oxidised and, as such, this material is predominantly NAF or would pose a low AMD hazard.	<0.1%	This material is expected to comprise approximately 0.1% of the void wall material by meterage. Three (out of 9) samples were UC(PAF), and do not contain significant sulphide minerals. Being weathered, PAF materials are likely to be low capacity (i.e. PAF-LC). The potential for AMD from acid sulphate salts is low. The 75th percentile total S value is 0.43%. AMD capacity based on PAF samples 75th percentile total S of 1.11%.	5	7	1	9	
	Fresh, non-carbonaceous	73%	82% (where known)	18% (where known)	73%	0.8%	Less than 1% of fresh, non-carbonaceous samples were PAF (data from geochemical database) [21 out of 2527 samples]. Based on Bonnie Doon pit data, assume approximately 82% of this material is currently above the water table and would be potentially subject to oxidation.	0.6%	This material is estimated to comprise approximately 73% of the void wall material by meterage. Overall, fresh, non-carbonaceous spoil is overwhelmingly NAF with excess ANC. This material is likely to be an important source of ANC. Less than 1% of samples were PAF (of some type), and most were closely associated with coal seams (as roof, parting or floor). This material horizon is overwhelmingly NAF. The 75th percentile total S value for this material is 0.04%. AMD capacity based on PAF samples 75th percentile total S of 0.63%.	1	5	1	4	
	Fresh, carbonaceous	3.5%	81% (where known)	19% (where known)	3.5%	13%	Approximately 13% of fresh, carbonaceous samples (32 out of 251 samples) were UC(PAF), PAF-LC or PAF (data from geochemical database). Water table depths are not available for some highwall drillholes, however where known, approximately 81% of this material is currently above the water table and would be potentially subject to oxidation.	0.4%	Generation of AMD from fresh carbonaceous units cannot be excluded as 13% of the samples tested (all of BWM) were classed as PAF. However, this material is expected to comprise less than 4% of the void wall. Some carbonaceous overburden has excess ANC. The 75th percentile total S value for this material is 0.26%. AMD capacity based on PAF samples 75th percentile total S of 0.62%.	5	5	1	8	
	Coal (fresh)	6.7%	64% (where known)	36% (where known)	6.7%	36%	Approximately 36% of the 370 coal samples were UC(PAF), PAF-LC or PAF (data from geochemical database). Water table depths are not available for some highwall drillholes, however where known, approximately 64% of this material is currently above the water table and would be potentially subject to oxidation.	2.4%	Fresh coal is expected to comprise approximately 7% of the void wall material by meterage. Geochemical data is available for 370 coal samples sourced from across BWM seams, of which 134 samples were conservatively classified as PAF, PAF-LC, UC(PAF) or NAF-S. Of the 'PAF' samples, 80% were classified as PAF-LC. The 75th percentile S value for PAF coal samples is 0.34% (and AMD capacity is based on this value). The 75th percentile S value for all coal samples is 0.31%. With regard to the coal quality database (n=7495 samples), the 75th percentile total S value is 0.48% - higher, but generally consistent with the smaller geochemical database. The seams/plys likely to be exposed on the highwall are predominantly the T, MR and P & L seam groups.	5	5	1	8	
	Unknown	0.0%	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
	Estimated frequency of occurrence of PAF drill-hole intervals - assuming representativeness of surface exposure by drill-hole data							4.3%						

Material domain	Material type on void floor	Proportion of exposure on void floor % (assumed)	Above current water table	Below current water table	% Exposure (below base of weathering)	% of PAF sample by material type (environmental and/or coal database)	Comment	Estimated % PAF exposure on void floor	Comment	Geochemical Propensity for AMD	AMD Capacity Rating	AMD Quantity Rating	Likelihood for AMD generation from exposed Ramp 8 void floor
Ramp 8 Void Floor	Coal: P & L Lower seam	100%	0%	100%	100%	25%	PAF proportion estimated by applying a total S 'cut-off' of 0.43% to the coal quality data for P&L Lower seam samples (2792 samples). The S cut-off was based on the median total S value for PAF coal and rejects samples (combined) from the geochemical database. 700 out of 2792 P&L Lower samples had total S ≥0.43%. Based on the geochemical database, 36% of 370 coal samples were conservatively classifed as PAF. Whereas, based on the much larger coal quality database (2792 samples), 25% of the void floor is estimated to be PAF. All void floor is below the water table and would become submerged shortly after mining ceases.	25%	The floor of Ramp 8 void is expected to be P&L Lower seam group materials (coaly and carbonaceous materials), which has a 75th percentile total S value of 0.43% (based on 2792 P&L Lower samples in the coal quality database). Co-incidently, 0.43%S is the median total S for PAF coal and rejects samples (combined) from the geochemical database. AMD capacity is based on 75th percentile total S value of 0.86% for PAF coal and rejects samples (combined) from the geochemical database. Approximately 25% of P&L Lower seam coal samples from BWM have been classified as PAF. Limited data is available to assess the availability of ANC in coal samples, however ANC is largely available under field conditions from tailings and rejects samples - therefore coal would be expected to have similar ANC availability. Regardless, the potential for AMD generation from a moderate proportion of the void floor cannot be excluded - assuming the entire void floor comprises purely coal material. No allowance for pit flooding has been taken into account in this hazard assessment. Refer to report body for discussion regarding pit flooding.	5	5	3	9	Approximately 25% of the void floor may comprise PAF coal. The geochemical hazard for the void floor to develop AMD is low-moderate if the entire void floor comprises purely coal material (unlikely) and if the coal floor remains exposed to air (unlikely). As such, the actual AMD hazard post-closure will likely be lower than indicated. The likelihood for AMD generation from exposed Ramp 8 void floor = **UNLIKELY**

Table B16. AMD hazard scoring for source materials and likelihood for AMD generation from Bonnie Doon residual void walls and floor

Material domain	Material type	Proportion of drill-hole meterage on highwall by material type %	Above current water table (where known)	Below current water table (where known)	Proportion of drill-hole meterage (below base of weathering)	% of PAF sample by material type (environmental and/or coal database)	Comment	Estimated % PAF exposure on highwall	Comment	Geochemical Propensity for AMD	AMD Capacity Rating	AMD Quantity Rating	AMD Source Material Hazard Score	Likelihood for AMD generation from Bonnie Doon void highwall
Bonnie Doon Void Highwall	Weathered, non-carbonaceous	17%	100% (where known)	0% (where known)	0%	5.1%	Approximately 5% of weathered non-carbonaceous samples (28 samples out of 554) were UC(PAF) or PAF-LC [no "PAF" samples] (data from geochemical database). It is expected that weathered material is completely or predominantly oxidised and, as such, this material is overwhelmingly NAF.	0.8%	This material is expected to comprise approximately 17% of the void wall material by meterage. Assumed to be non-mineralised, with very low concentrations of reactive sulphide minerals. Small proportion of samples may be PAF (if so, likely low capacity). The potential for AMD from acid sulphate minerals (e.g. jarosite) is very low or negligible. Likely source of ANC. The 75th percentile total S value is 0.02%. AMD capacity based on PAF samples 75th percentile total S of 0.03%.	5	1	1	**6**	Non-carbonaceous rock is expected to have excess acid neutralising capacity, which should be sufficient to buffer AMD released from potential AMD sources exposed on the highwall, if any. The potential exposure of PAF materials on the highwall is estimated to represent approximately 4% (vertical meterage). PAF domains are expected to be largely confined to coal horizons/seams. However, these will be embedded in a matrix of NAF and ANC-rich materials. Void wall run-off reporting to the residual void is unlikely to produce acidity. The hazard for AMD generation from Bonnie Doon void highwall = **LOW-MODERATE**. The likelihood for AMD generation from Bonnie Doon void highwall = **UNLIKELY**
	Weathered, carbonaceous & coaly	0.1%	100% (where known)	0% (where known)	0%	33%	Negligible proportion in highwall. Three out of 9 weathered carbonaceous/coaly samples were UC(PAF) and PAF (data from geochemical database). It is expected that weathered material is predominantly oxidised and, as such, this material is predominantly NAF or would pose a low AMD hazard.	<0.1%	This material is expected to comprise approximately 0.1% of the void wall material by meterage. Three (out of 9) samples were UC(PAF), and do not contain significant sulphide minerals. Being weathered, PAF materials are likely to be low capacity (i.e. PAF-LC). The potential for AMD from acid sulphate salts is low. The 75th percentile total S value is 0.43%. AMD capacity based on PAF samples 75th percentile total S of 1.11%.	5	7	1	**9**	
	Fresh, non-carbonaceous	73%	82% (where known)	18% (where known)	73%	0.8%	Less than 1% of fresh, non-carbonaceous samples were PAF (data from geochemical database) [21 out of 2527 samples]. Water table depths are not available for some highwall drillholes, however where known, approximately 82% of this material is currently above the water table and would be potentially subject to oxidation.	0.6%	This material is estimated to comprise approximately 73% of the void wall material by meterage. Overall, fresh, non-carbonaceous spoil is overwhelmingly NAF with excess ANC. This material is likely to be an important source of ANC. Less than 1% of samples were PAF (of some type), and most were closely associated with coal seams (as roof, parting or floor). This material horizon is overwhelmingly NAF. The 75th percentile total S value for this material is 0.04%. AMD capacity based on PAF samples 75th percentile total S of 0.63%.	1	5	1	**4**	
	Fresh, carbonaceous	3.5%	81% (where known)	19% (where known)	3.5%	13%	Approximately 13% of fresh, carbonaceous samples (32 out of 251 samples) were UC(PAF), PAF-LC, PAF or NAF-S (data from geochemical database). Based on Bonnie Doon pit data, assume approximately 81% of this material is currently above the water table and would be potentially subject to oxidation.	0.4%	Generation of AMD from fresh carbonaceous units cannot be excluded as 13% of the samples tested (all of BWM) were classed as PAF. However, this material is expected to comprise less than 4% of the void wall. Some carbonaceous overburden has excess ANC. The 75th percentile total S value for this material is 0.26%. AMD capacity based on PAF samples 75th percentile total S of 0.62%.	5	5	1	**8**	
	Coal (fresh)	6.7%	64% (where known)	36% (where known)	6.7%	36%	Approximately 36% of the 370 coal samples were UC(PAF), PAF-LC or PAF (data from geochemical database). Based on Bonnie Doon pit data, assume approximately 64% of this material is currently above the water table and would be potentially subject to oxidation.	2.4%	Fresh coal is expected to comprise approximately 7% of the void wall material by meterage. Geochemical data is available for 370 coal samples sourced from across BWM seams, of which 134 samples were conservatively classified as PAF, PAF-LC, UC(PAF) or NAF-S. Of the 'PAF' samples, 80% were classified as PAF-LC. The 75th percentile S value for PAF coal samples is 0.34% (and AMD capacity is based on this value). The 75th percentile S value for all coal samples is 0.31%. With regard to the coal quality database (n=7495 samples), the 75th percentile total S value is 0.48% - higher, but generally consistent with the smaller geochemical database. The seams/plys likely to be exposed on the highwall are predominantly the T, MR and P & L seam groups.	5	5	1	**8**	
	Unknown	0.0%	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	**n/a**	
	Estimated frequency of occurrence of PAF drill-hole intervals - assuming representativeness of surface exposure by drill-hole data							4.3%						

Material domain	Material type on void floor	Proportion of exposure on void floor % (assumed)	Above current water table	Below current water table	% Exposure (below base of weathering)	% of PAF sample by material type (environmental and/or coal database)	Comment	Estimated % PAF exposure on void floor	Comment	Geochemical Propensity for AMD	AMD Capacity Rating	AMD Quantity Rating	Likelihood for AMD generation from exposed Bonnie Doon void floor
Bonnie Doon Void Floor	Tailings (from NCPP)	100%	0%	100%	100%	48%	No geochemical data is available from Bonnie Doon tailings specifically (Bonnie Doon Pit TSF). Based on geochemical data from NCPP tailings (being deposited into Bonnie Doon Pit), approximately 48% of tailings samples were 'PAF' or NAF-S (data from geochemical database) [134 out of 280 samples]. Assumes all tailings is below the post-closure water table and would become submerged after mining ceases - or would be capped/cover with a suitable thickness of spoil to minimise oxidation.	48%	The floor of Boonie Doon void is currently tailings and is expected to remain as such. 48% of NCPP tailings are conservatively classified as PAF, PAF-LC, UC(PAF) or NAF-S. 75th percentile EC of tailings = 891 µS/cm. AMD capacity is based on a 75th percentile S value of 2.53 for 'PAF' tailings. Some tailings samples will generate AD. AMD quantity assumes proportion of PAF tailings samples approximates the proportion of tailings that are PAF. ANC of tailings is largely available under field conditions. No allowance for pit flooding or potential cover over tailings has been taken into account in this hazard assessment. Refer to report body for discussion regarding tailings cover or pit flooding.	7	10	7	**16**	Approximately 48% of the void floor may comprise 'PAF' or NAF-S tailings.The geochemical hazard for the void floor to develop AMD is moderate-high if the tailings remains exposed to air (plausible). The likelihood for AMD generation from tailings on Bonnie Doon void floor = **PROBABLE/LIKELY**

Table B17. AMD hazard scoring for source materials and likelihood for AMD generation from Mimosa-Besgrove residual void walls and floor

Material domain	Material type	Proportion of drill-hole meterage on highwall by material type %	Above current water table (where known)	Below current water table (where known)	Proportion of drill-hole meterage (below base of weathering)	% of PAF sample by material type (environmental and/or coal database)	Comment	Estimated % PAF exposure on highwall	Comment	Geochemical Propensity for AMD	AMD Capacity Rating	AMD Quantity Rating	AMD Source Material Hazard Score	Likelihood for AMD generation from Mimosa-Besgrove void highwall
Mimosa-Besgrove Void Highwall	Weathered, non-carbonaceous	20%	67% (where known)	33% (where known)	0%	5.1%	Approximately 5% of weathered non-carbonaceous samples (28 samples out of 554) were UC(PAF) or PAF-LC [no "PAF" samples] (data from geochemical database). It is expected that weathered material is completely or predominantly oxidised and, as such, this material is overwhelmingly NAF.	1.0%	This material is expected to comprise approximately 20% of the void wall material by meterage. Assumed to be non-mineralised, with very low concentrations of reactive sulphide minerals. Small proportion of samples may be PAF (if so, likely low capacity). The potential for AMD from acid sulphate minerals (e.g. jarosite) is very low or negligible. Likely source of ANC. The 75th percentile total S value is 0.02%. AMD capacity based on PAF samples 75th percentile total S of 0.03%.	5	1	1	6	Non-carbonaceous rock is expected to have excess acid neutralising capacity, which should be sufficient to buffer AMD released from potential AMD sources exposed on the highwall, if any. The potential exposure of PAF materials on the highwall is estimated to represent approximately 4% (vertical meterage). PAF domains are expected to be largely confined to coal horizons/seams. However, these will be embedded in a matrix of NAF and ANC-rich materials. Void wall run-off reporting to the residual void is unlikely to produce acidity. The hazard for AMD generation from Mimosa-Besgrove void highwall = **LOW-MODERATE**. The likelihood for AMD generation from Mimosa-Besgrove void highwall = **UNLIKELY**
	Weathered, carbonaceous & coaly	0.6%	8% (where known)	92% (where known)	0%	33%	Negligible proportion in highwall. Three out of 9 weathered carbonaceous/coaly samples were UC(PAF) and PAF (data from geochemical database). It is expected that weathered material is prodominantly oxidised and, as such, this material is predominantly NAF or would pose a low AMD hazard.	0.2%	This material is expected to comprise approximately 0.6% of the void wall material by meterage. Three (out of 9) samples were UC(PAF), and do not contain significant sulphide minerals. Being weathered, PAF materials are likely to be low capacity (i.e. PAF-LC). The potential for AMD from acid sulphate salts is low. The 75th percentile total S value is 0.43%. AMD capacity based on PAF samples 75th percentile total S of 1.11%.	5	7	1	9	
	Fresh, non-carbonaceous	70%	64% (where known)	36% (where known)	70%	0.8%	Less than 1% of fresh, non-carbonaceous samples were PAF (data from geochemical database) [21 out of 2527 samples]. Water table depths are not available for some highwall drillholes, however where known, approximately 64% of this material is currently above the water table and would be potentially subject to oxidation.	0.6%	This material is estimated to comprise approximately 70% of the void wall material by meterage. Overall, fresh, non-carbonaceous spoil is overwhelmingly NAF with excess ANC. This material is likely to be an important source of ANC. Less than 1% of samples were PAF (of some type), and most were closely associated with coal seams (as roof, parting or floor). This material horizon is overwhelmingly NAF. The 75th percentile total S value for this material is 0.04%. AMD capacity based on PAF samples 75th percentile total S of 0.63%.	1	5	1	4	
	Fresh, carbonaceous	1.2%	69% (where known)	31% (where known)	1.2%	13%	Approximately 13% of fresh, carbonaceous samples (32 out of 251 samples) were UC(PAF), PAF-LC or PAF (data from geochemical database). Water table depths are not available for some highwall drillholes, however where known, approximately 69% of this material is currently above the water table and would be potentially subject to oxidation.	0.2%	Generation of AMD from fresh carbonaceous units cannot be excluded as 13% of the samples tested (all of BWM) were classed as PAF. However, this material is expected to comprise approximately 1.2% of the void wall. Some carbonaceous overburden has excess ANC. The 75th percentile total S value for this material is 0.26%. AMD capacity based on PAF samples 75th percentile total S of 0.62%.	5	5	1	8	
	Coal (fresh)	5.4%	20% (where known)	80% (where known)	5.4%	36%	Approximately 36% of the 370 coal samples were UC(PAF), PAF-LC or PAF (data from geochemical database). Water table depths are not available for some highwall drillholes, however where known, approximately 20% of this material is currently above the water table and would be potentially subject to oxidation.	2.0%	Fresh coal is expected to comprise approximately 5.4% of the void wall material by meterage. Geochemical data is available for 370 coal samples sourced from across BWM seams, of which 134 samples were conservatively classified as PAF, PAF-LC, UC(PAF) or NAF-S. Of the 'PAF' samples, 80% were classified as PAF-LC. The 75th percentile S value for PAF coal samples is 0.34% (and AMD capacity is based on this value). The 75th percentile S value for all coal samples is 0.31%. With regard to the coal quality database (n=7495 samples), the 75th percentile total S value is 0.48% - higher, but generally consistent with the smaller geochemical database. The seams/plys likely to be exposed on the highwall are predominantly the T, MR and P & L seam groups.	5	5	1	8	
	Unknown	2.4%	44%	55%	0.4%	0%	Lithology unknown. Approximately 18% of this material is below base of weathering (ie. fresh)	<0.1%	Negligible proportion; approximately 82% of this material is within weathered zone. Assume negligible PAF. Conservatively assume 'Moderate-High' AMD capacity.	1	7	1	5	
	Estimated frequency of occurrence of PAF drill-hole intervals - assuming representativeness of surface exposure by drill-hole data							3.9%						

Material domain	Material type on void floor	Proportion of exposure on void floor % (assumed)	Above current water table	Below current water table	% Exposure (below base of weathering)	% of PAF sample by material type (environmental and/or coal database)	Comment	Estimated % PAF exposure on void floor	Comment	Geochemical Propensity for AMD	AMD Capacity Rating	AMD Quantity Rating	Likelihood for AMD generation from exposed Mimosa-Besgrove void floor
Mimosa-Besgrove Void Floor	Coal: P & L Lower seam	100%	0%	100%	100%	25%	PAF proportion estimated by applying a total S 'cut-off' of 0.43% to the coal quality data for P&L Lower seam samples (2792 samples). The S cut-off was based on the median total S value for PAF coal and rejects samples (combined) from the geochemical database. 700 out of 2792 P&L Lower samples had total S ≥0.43%. Based on the geochemical database, 36% of 370 coal samples were conservatively classifed as PAF. Whereas, based on the much larger coal quality database (2792 samples), 25% of the void floor is estimated to be PAF. All void floor is below the water table and would become submerged shortly after mining ceases.	25%	The floor of Mimosa-Besgrove void is expected to be P&L Lower seam group materials (coaly and carbonaceous materials), which has a 75th percentile total S value of 0.43% (based on 2792 P&L Lower samples in the coal quality database). Co-incidently, 0.43%S is the median total S for PAF coal and rejects samples (combined) from the geochemical database. AMD capacity is based on 75th percentile total S value of 0.86% for PAF coal and rejects samples (combined) from the geochemical database. Approximately 25% of P&L Lower seam coal samples from BWM have been classified as PAF. Limited data is available to assess the availability of ANC in coal samples, however ANC is largely available under field conditions from tailings and rejects samples - therefore coal would be expected to have similar ANC availability. Regardless, the potential for AMD generation from a moderate proportion of the void floor cannot be excluded - assuming the entire void floor comprises purely coal material. No allowance for pit flooding has been taken into account in this hazard assessment. Refer to report body for discussion regarding pit flooding.	5	5	3	9	Approximately 25% of the void floor may comprise PAF coal. The geochemical hazard for the void floor to develop AMD is low-moderate if the entire void floor comprises purely coal material (unlikely) and if the coal floor remains exposed to air (unlikely). As such, the actual AMD hazard post-closure will likely be lower than indicated. The likelihood for AMD generation from exposed Mimosa-Besgrove void floor = **UNLIKELY**

Table B18. AMD hazard scoring for source materials and likelihood for AMD generation from Deep Creek residual void walls and floor

Material domain	Material type	Proportion of drill-hole meterage on highwall by material type %	Above current water table (where known)	Below current water table (where known)	Proportion of drill-hole meterage (below base of weathering)	% of PAF sample by material type (environmental and/or coal database)	Comment	Estimated % PAF exposure on highwall	Comment	Geochemical Propensity for AMD	AMD Capacity Rating	AMD Quantity Rating	AMD Source Material Hazard Score	Likelihood for AMD generation from Deep Creek void highwall
Deep Creek Void Highwall	Weathered, non-carbonaceous	22%	82% (where known)	18% (where known)	0%	5.1%	Approximately 5% of weathered non-carbonaceous samples (28 samples out of 554) were UC(PAF) or PAF-LC [no "PAF" samples] (data from geochemical database). It is expected that weathered material is completely or predominantly oxidised and, as such, this material is overwhelmingly NAF.	1.1%	This material is expected to comprise approximately 22% of the void wall material by meterage. Assumed to be non-mineralised, with very low concentrations of reactive sulphide minerals. Small proportion of samples may be PAF (if so, likely low capacity). The potential for AMD from acid sulphate minerals (e.g. jarosite) is very low or negligible. Likely source of ANC. The 75th percentile total S value is 0.02%. AMD capacity based on PAF samples 75th percentile total S of 0.03%.	5	1	1	6	Non-carbonaceous rock is expected to have excess acid neutralising capacity, which should be sufficient to buffer AMD released from potential AMD sources exposed on the highwall, if any. The potential exposure of PAF materials on the highwall is estimated to represent approximately 4.7% (vertical meterage). Most PAF domains are expected to be largely confined to coal horizons/ seams. However, these will be embedded in a matrix of NAF and ANC-rich materials. Void wall run-off reporting to the residual void is unlikely to produce acidity. The hazard for AMD generation from Deep Creek void highwall = **LOW-MODERATE**. The likelihood for AMD generation from Deep Creek void highwall = **UNLIKELY**
	Weathered, carbonaceous & coaly	1.0%	40% (where known)	60% (where known)	0%	33%	Negligible proportion in highwall. Three out of 9 weathered carbonaceous/coaly samples were UC(PAF) and PAF (data from geochemical database). It is expected that weathered material is prodominantly oxidised and, as such, this material is predominantly NAF or would pose a low AMD hazard.	0.3%	This material is expected to comprise approximately 1% of the void wall material by meterage. Three (out of 9) samples were UC(PAF), and do not contain significant sulphide minerals. Being weathered, PAF materials are likely to be low capacity (i.e. PAF-LC). The potential for AMD from acid sulphate salts is low. The 75th percentile total S value is 0.43%. AMD capacity based on PAF samples 75th percentile total S of 1.11%.	5	7	1	9	
	Fresh, non-carbonaceous	68%	63% (where known)	37% (where known)	68%	0.8%	Less than 1% of fresh, non-carbonaceous samples were PAF (data from geochemical database) [21 out of 2527 samples]. Water table depths are not available for some highwall drillholes, however where known, approximately 63% of this material is currently above the water table and would be potentially subject to oxidation.	0.5%	This material is estimated to comprise approximately 68% of the void wall material by meterage. Overall, fresh, non-carbonaceous spoil is overwhelmingly NAF with excess ANC. This material is likely to be an important source of ANC. Less than 1% of samples were PAF (of some type), and most were closely associated with coal seams (as roof, parting or floor). This material horizon is overwhelmingly NAF. The 75th percentile total S value for this material is 0.04%. AMD capacity based on PAF samples 75th percentile total S of 0.63%.	1	5	1	4	
	Fresh, carbonaceous	1.2%	45% (where known)	55% (where known)	1.2%	13%	Approximately 13% of fresh, carbonaceous samples (32 out of 251 samples) were UC(PAF), PAF-LC or PAF (data from geochemical database). Water table depths are not available for some highwall drillholes, however where known, approximately 45% of this material is currently above the water table and would be potentially subject to oxidation.	0.2%	Generation of AMD from fresh carbonaceous units cannot be excluded as 13% of the samples tested (all of BWM) were classed as PAF. However, this material is expected to comprise approximately 1.2% of the void wall. Some carbonaceous overburden has excess ANC. The 75th percentile total S value for this material is 0.26%. AMD capacity based on PAF samples 75th percentile total S of 0.62%.	5	5	1	8	
	Coal (fresh)	7.1%	30% (where known)	70% (where known)	7.1%	36%	Approximately 36% of the 370 coal samples were UC(PAF), PAF-LC or PAF (data from geochemical database). Water table depths are not available for some highwall drillholes, however where known, approximately 30% of this material is currently above the water table and would be potentially subject to oxidation.	2.6%	Fresh coal is expected to comprise approximately 7% of the void wall material by meterage. Geochemical data is available for 370 coal samples sourced from across BWM seams, of which 134 samples were conservatively classified as PAF, PAF-LC, UC(PAF) or NAF-S. Of the 'PAF' samples, 80% were classified as PAF-LC. The 75th percentile S value for PAF coal samples is 0.34% (and AMD capacity is based on this value). The 75th percentile S value for all coal samples is 0.31%. With regard to the coal quality database (n=7495 samples), the 75th percentile total S value is 0.48% - higher, but generally consistent with the smaller geochemical database. The seams/plys likely to be exposed on the highwall are predominantly the T, MR and P & L seam groups.	5	5	1	8	
	Unknown	0.6%	98%	2%	0%	0%	Lithology unknown. None of this material is below base of weathering (ie. all material is weathered)	<0.1%	Negligible proportion; all of this material is within weathered zone. Assume negligible PAF. Conservatively assume 'Moderate-High' AMD capacity.	1	7	1	5	
	Estimated frequency of occurrence of PAF drill-hole intervals - assuming representativeness of surface exposure by drill-hole data							4.7%						

Material domain	Material type on void floor	Proportion of exposure on void floor % (assumed)	Above current water table	Below current water table	% Exposure (below base of weathering)	% of PAF sample by material type (environmental and/or coal database)	Comment	Estimated % PAF exposure on void floor	Comment	Geochemical Propensity for AMD	AMD Capacity Rating	AMD Quantity Rating	Likelihood for AMD generation from exposed Deep Creek void floor	
Deep Creek Void Floor	Coal: P & L Lower seam	100%	0%	100%	100%	25%	PAF proportion estimated by applying a total S 'cut-off' of 0.43% to the coal quality data for P&L Lower seam samples (2792 samples). The S cut-off was based on the median total S value for PAF coal and rejects samples (combined) from the geochemical database. 700 out of 2792 P&L Lower samples had total S ≥0.43%. Based on the geochemical database, 36% of 370 coal samples were conservatively classifed as PAF. Whereas, based on the much larger coal quality database (2792 samples), 25% of the void floor is estimated to be PAF. All void floor is below the water table and would become submerged shortly after mining ceases.	25%	The floor of Deep Creek void is expected to be P&L Lower seam group materials (coaly and carbonaceous materials), which has a 75th percentile total S value of 0.43% (based on 2792 P&L Lower samples in the coal quality database). Co-incidently, 0.43%S is the median total S for PAF coal and rejects samples (combined) from the geochemical database. AMD capacity is based on 75th percentile total S value of 0.86% for PAF coal and rejects samples (combined) from the geochemical database. Approximately 25% of P&L Lower seam coal samples from BWM have been classified as PAF. Limited data is available to assess the availability of ANC in coal samples, however ANC is largely available under field conditions from tailings and rejects samples - therefore coal would be expected to have similar ANC availability. Regardless, the potential for AMD generation from a moderate proportion of the void floor cannot be excluded - assuming the entire void floor comprises purely coal material. No allowance for pit flooding has been taken into account in this hazard assessment. Refer to report body for discussion regarding pit flooding.	5	5	3	9	Approximately 25% of the void floor may comprise PAF coal. The geochemical hazard for the void floor to develop AMD is low-moderate if the entire void floor comprises purely coal material (unlikely) and if the coal floor remains exposed to air (unlikely). As such, the actual AMD hazard post-closure will likely be lower than indicated. The likelihood for AMD generation from exposed Deep Creek void floor = **UNLIKELY**

Table B19. AMD hazard scoring for source materials and likelihood for AMD generation from Stewarton-Ballamoo residual void walls and floor

Material domain	Material type	Proportion of drill-hole meterage on highwall by material type %	Above current water table (where known)	Below current water table (where known)	Proportion of drill-hole meterage (below base of weathering)	% of PAF sample by material type (environmental and/or coal database)	Comment	Estimated % PAF exposure on highwall	Comment	Geochemical Propensity for AMD	AMD Capacity Rating	AMD Quantity Rating	AMD Source Material Hazard Score	Likelihood for AMD generation from Stewarton-Ballamoo void highwall
Stewarton-Ballamoo Void Highwall	Weathered, non-carbonaceous	23%	64% (where known)	36% (where known)	0%	5.1%	Approximately 5% of weathered non-carbonaceous samples (28 samples out of 554) were UC(PAF) or PAF-LC [no "PAF" samples] (data from geochemical database). It is expected that weathered material is completely or predominantly oxidised and, as such, this material is overwhelmingly NAF.	1.2%	This material is expected to comprise approximately 23% of the void wall material by meterage. Assumed to be non-mineralised, with very low concentrations of reactive sulphide minerals. Small proportion of samples may be PAF (if so, likely low capacity). The potential for AMD from acid sulphate minerals (e.g. jarosite) is very low or negligible. Likely source of ANC. The 75th percentile total S value is 0.02%. AMD capacity based on PAF samples 75th percentile total S of 0.03%.	5	1	1	6	Non-carbonaceous rock is expected to have excess acid neutralising capacity, which should be sufficient to buffer AMD released from potential AMD sources exposed on the highwall, if any. The potential exposure of PAF materials on the highwall is estimated to represent approximately 5% (vertical meterage). Most PAF domains are expected to be largely confined to coal horizons/ seams. However, these will be embedded in a matrix of NAF and ANC-rich materials. Void wall run-off reporting to the residual void is unlikely to produce acidity. The hazard for AMD generation from Stewarton-Ballamoo void highwall = **LOW-MODERATE**. The likelihood for AMD generation from Stewarton-Ballamoo void highwall = **UNLIKELY**
	Weathered, carbonaceous & coaly	1.6%	10% (where known)	90% (where known)	0%	33%	Negligible proportion in highwall. Three out of 9 weathered carbonaceous/coaly samples were UC(PAF) and PAF (data from geochemical database). It is expected that weathered material is prodominantly oxidised and, as such, this material is predominantly NAF or would pose a low AMD hazard.	0.5%	This material is expected to comprise less than 2% of the void wall material by meterage. Three (out of 9) samples were UC(PAF), and do not contain significant sulphide minerals. Being weathered, PAF materials are likely to be low capacity (i.e. PAF-LC). The potential for AMD from acid sulphate salts is low. The 75th percentile total S value is 0.43%. AMD capacity based on PAF samples 75th percentile total S of 1.11%.	5	7	1	9	
	Fresh, non-carbonaceous	65%	59% (where known)	41% (where known)	65%	0.8%	Less than 1% of fresh, non-carbonaceous samples were PAF (data from geochemical database) [21 out of 2527 samples]. Water table depths are not available for some highwall drillholes, however where known, approximately 59% of this material is currently above the water table and would be potentially subject to oxidation.	0.5%	This material is estimated to comprise approximately 65% of the void wall material by meterage. Overall, fresh, non-carbonaceous spoil is overwhelmingly NAF with excess ANC. This material is likely to be an important source of ANC. Less than 1% of samples were PAF (of some type), and most were closely associated with coal seams (as roof, parting or floor). This material horizon is overwhelmingly NAF. The 75th percentile total S value for this material is 0.04%. AMD capacity based on PAF samples 75th percentile total S of 0.63%.	1	5	1	4	
	Fresh, carbonaceous	1.1%	43% (where known)	57% (where known)	1.1%	13%	Approximately 13% of fresh, carbonaceous samples (32 out of 251 samples) were UC(PAF), PAF-LC or PAF (data from geochemical database). Water table depths are not available for some highwall drillholes, however where known, approximately 43% of this material is currently above the water table and would be potentially subject to oxidation.	0.1%	Generation of AMD from fresh carbonaceous units cannot be excluded as 13% of the samples tested (all of BWM) were classed as PAF. However, this material is expected to comprise approximately 1.1% of the void wall. Some carbonaceous overburden has excess ANC. The 75th percentile total S value for this material is 0.26%. AMD capacity based on PAF samples 75th percentile total S of 0.62%.	5	5	1	8	
	Coal (fresh)	7.2%	37% (where known)	63% (where known)	7.2%	36%	Approximately 36% of the 370 coal samples were UC(PAF), PAF-LC or PAF (data from geochemical database). Water table depths are not available for some highwall drillholes, however where known, approximately 37% of this material is currently above the water table and would be potentially subject to oxidation.	2.6%	Fresh coal is expected to comprise approximately 7% of the void wall material by meterage. Geochemical data is available for 370 coal samples sourced from across BWM seams, of which 134 samples were conservatively classified as PAF, PAF-LC, UC(PAF) or NAF-S. Of the 'PAF' samples, 80% were classified as PAF-LC. The 75th percentile S value for PAF coal samples is 0.34% (and AMD capacity is based on this value). The 75th percentile S value for all coal samples is 0.31%. With regard to the coal quality database (n=7495 samples), the 75th percentile total S value is 0.48% - higher, but generally consistent with the smaller geochemical database. The seams/plys likely to be exposed on the highwall are predominantly the T, MR and P & L seam groups.	5	5	1	8	
	Unknown	1.7%	49%	51%	0.1%	0%	Lithology unknown. 7% of this material is below base of weathering (ie. fresh)	<0.1%	Negligible proportion; 93% of this material is within weathered zone. Assume negligible PAF. Conservatively assume 'Moderate-High' AMD capacity.	1	7	1	5	
	Estimated frequency of occurrence of PAF drill-hole intervals - assuming representativeness of surface exposure by drill-hole data							5.0%						

Material domain	Material type on void floor	Proportion of exposure on void floor % (assumed)	Above current water table	Below current water table	% Exposure (below base of weathering)	% of PAF sample by material type (environmental and/or coal database)	Comment	Estimated % PAF exposure on void floor	Comment	Geochemical Propensity for AMD	AMD Capacity Rating	AMD Quantity Rating	Likelihood for AMD generation from exposed Stewarton-Ballamoo void floor
Stewarton-Ballamoo Void Floor	Coal: P & L Lower seam	100%	0%	100%	100%	25%	PAF proportion estimated by applying a total S 'cut-off' of 0.43% to the coal quality data for P&L Lower seam samples (2792 samples). The S cut-off was based on the median total S value for PAF coal and rejects samples (combined) from the geochemical database. 700 out of 2792 P&L Lower samples had total S ≥0.43%. Based on the geochemical database, 36% of 370 coal samples were conservatively classifed as PAF. Whereas, based on the much larger coal quality database (2792 samples), 25% of the void floor is estimated to be PAF. All void floor is below the water table and would become submerged shortly after mining ceases.	25%	The floor of Stewarton-Ballamoo void is expected to be P&L Lower seam group materials (coaly and carbonaceous materials), which has a 75th percentile total S value of 0.43% (based on 2792 P&L Lower samples in the coal quality database). Co-incidently, 0.43%S is the median total S for PAF coal and rejects samples (combined) from the geochemical database. AMD capacity is based on 75th percentile total S value of 0.86% for PAF coal and rejects samples (combined) from the geochemical database. Approximately 25% of P&L Lower seam coal samples from BWM have been classified as PAF. Limited data is available to assess the availability of ANC in coal samples, however ANC is largely available under field conditions from tailings and rejects samples - therefore coal would be expected to have similar ANC availability. Regardless, the potential for AMD generation from a moderate proportion of the void floor cannot be excluded - assuming the entire void floor comprises purely coal material. No allowance for pit flooding has been taken into account in this hazard assessment. Refer to report body for discussion regarding pit flooding.	5	5	3	9	Approximately 25% of the void floor may comprise PAF coal. The geochemical hazard for the void floor to develop AMD is low-moderate if the entire void floor comprises purely coal material (unlikely) and if the coal floor remains exposed to air (unlikely). As such, the actual AMD hazard post-closure will likely be lower than indicated. The likelihood for AMD generation from exposed Stewarton-Ballamoo void floor = **UNLIKELY**

Table B20. AMD hazard scoring for source materials and likelihood for AMD generation from Kenmare residual void walls and floor

Material domain	Material type	Proportion of drill-hole meterage on highwall by material type %	Above current water table (where known)	Below current water table (where known)	Proportion of drill-hole meterage (below base of weathering)	% of PAF sample by material type (environmental and/or coal database)	Comment	Estimated % PAF exposure on highwall	Comment	Geochemical Propensity for AMD	AMD Capacity Rating	AMD Quantity Rating	AMD Source Material Hazard Score	Likelihood for AMD generation from Kenmare void highwall
Kenmare Void Highwall	Weathered, non-carbonaceous	25%	94% (where known)	6% (where known)	0%	5.1%	Approximately 5% of weathered non-carbonaceous samples (28 samples out of 554) were UC(PAF) or PAF-LC [no "PAF" samples] (data from geochemical database). It is expected that weathered material is completely or predominantly oxidised and, as such, this material is overwhelmingly NAF.	1.3%	This material is expected to comprise approximately 23% of the void wall material by meterage. Assumed to be non-mineralised, with very low concentrations of reactive sulphide minerals. Small proportion of samples may be PAF (if so, likely low capacity). The potential for AMD from acid sulphate minerals (e.g. jarosite) is very low or negligible. Likely source of ANC. The 75th percentile total S value is 0.02%. AMD capacity based on PAF samples 75th percentile total S of 0.03%.	5	1	1	6	Non-carbonaceous rock is expected to have excess acid neutralising capacity, which should be sufficient to buffer AMD released from potential AMD sources exposed on the highwall, if any. The potential exposure of PAF materials on the highwall is estimated to represent approximately 4% (vertical meterage). Most PAF domains are expected to be largely confined to coal horizons/ seams. However, these will be embedded in a matrix of NAF and ANC-rich materials. Void wall run-off reporting to the residual void is unlikely to produce acidity. The hazard for AMD generation from Kenmare void highwall = **LOW-MODERATE**. The likelihood for AMD generation from Kenmare void highwall = **UNLIKELY**
	Weathered, carbonaceous & coaly	0.01%	unk.	unk.	0%	33%	Negligible proportion in highwall. Three out of 9 weathered carbonaceous/coaly samples were UC(PAF) and PAF (data from geochemical database). It is expected that weathered material is prodominantly oxidised and, as such, this material is predominantly NAF or would pose a low AMD hazard.	<0.1%	This material is expected to comprise less than 0.01% of the void wall material by meterage. Three (out of 9) samples were UC(PAF), and do not contain significant sulphide minerals. Being weathered, PAF materials are likely to be low capacity (i.e. PAF-LC). The potential for AMD from acid sulphate salts is low. The 75th percentile total S value is 0.43%. AMD capacity based on PAF samples 75th percentile total S of 1.11%.	5	7	1	9	
	Fresh, non-carbonaceous	65%	10% (where known)	90% (where known)	65%	0.8%	Less than 1% of fresh, non-carbonaceous samples were PAF (data from geochemical database) [21 out of 2527 samples]. Water table depths are not available for some highwall drillholes, however where known, approximately 10% of this material is currently above the water table and would be potentially subject to oxidation.	0.5%	This material is estimated to comprise approximately 65% of the void wall material by meterage. Overall, fresh, non-carbonaceous spoil is overwhelmingly NAF with excess ANC. This material is likely to be an important source of ANC. Less than 1% of samples were PAF (of some type), and most were closely associated with coal seams (as roof, parting or floor). This material horizon is overwhelmingly NAF. The 75th percentile total S value for this material is 0.04%. AMD capacity based on PAF samples 75th percentile total S of 0.63%.	1	5	1	4	
	Fresh, carbonaceous	1.2%	12% (where known)	88% (where known)	1.2%	13%	Approximately 13% of fresh, carbonaceous samples (32 out of 251 samples) were UC(PAF), PAF-LC or PAF (data from geochemical database). Water table depths are not available for some highwall drillholes, however where known, approximately 12% of this material is currently above the water table and would be potentially subject to oxidation.	0.2%	Generation of AMD from fresh carbonaceous units cannot be excluded as 13% of the samples tested (all of BWM) were classed as PAF. However, this material is expected to comprise approximately 1.2% of the void wall. Some carbonaceous overburden has excess ANC. The 75th percentile total S value for this material is 0.26%. AMD capacity based on PAF samples 75th percentile total S of 0.62%.	5	5	1	8	
	Coal (fresh)	5.1%	16% (where known)	84% (where known)	5.1%	36%	Approximately 36% of the 370 coal samples were UC(PAF), PAF-LC or PAF (data from geochemical database). Water table depths are not available for some highwall drillholes, however where known, approximately 16% of this material is currently above the water table and would be potentially subject to oxidation.	1.8%	Fresh coal is expected to comprise approximately 5% of the void wall material by meterage. Geochemical data is available for 370 coal samples sourced from across BWM seams, of which 134 samples were conservatively classified as PAF, PAF-LC, UC(PAF) or NAF-S. Of the 'PAF' samples, 80% were classified as PAF-LC. The 75th percentile S value for PAF coal samples is 0.34% (and AMD capacity is based on this value). The 75th percentile S value for all coal samples is 0.31%. With regard to the coal quality database (n=7495 samples), the 75th percentile total S value is 0.48% - higher, but generally consistent with the smaller geochemical database. The seams/plys likely to be exposed on the highwall are predominantly the T and P & L seam groups.	5	5	1	8	
	Unknown	4.1%	99%	1%	1.7%	0%	Lithology unknown. 7% of this material is below base of weathering (ie. fresh)	<0.1%	Low proportion of the highwall; 55% of this material is within weathered zone. Assume negligible PAF. Conservatively assume 'Moderate-High' AMD capacity.	1	7	1	5	
	Estimated frequency of occurrence of PAF drill-hole intervals - assuming representativeness of surface exposure by drill-hole data							3.8%						

Material domain	Material type on void floor	Proportion of exposure on void floor % (assumed)	Above current water table	Below current water table	% Exposure (below base of weathering)	% of PAF sample by material type (environmental and/or coal database)	Comment	Estimated % PAF exposure on void floor	Comment	Geochemical Propensity for AMD	AMD Capacity Rating	AMD Quantity Rating	Likelihood for AMD generation from exposed Kenmare void floor	
Kenmare Void Floor	Coal: P & L Lower seam	100%	0%	100%	100%	25%	PAF proportion estimated by applying a total S 'cut-off' of 0.43% to the coal quality data for P&L Lower seam samples (2792 samples). The S cut-off was based on the median total S value for PAF coal and rejects samples (combined) from the geochemical database. 700 out of 2792 P&L Lower samples had total S ≥0.43%. Based on the geochemical database, 36% of 370 coal samples were conservatively classifed as PAF. Whereas, based on the much larger coal quality database (2792 samples), 25% of the void floor is estimated to be PAF. All void floor is below the water table and would become submerged shortly after mining ceases.	25%	The floor of Kenmare void is expected to be P&L Lower seam group materials (coaly and carbonaceous materials), which has a 75th percentile total S value of 0.43% (based on 2792 P&L Lower samples in the coal quality database). Co-incidently, 0.43%S is the median total S for PAF coal and rejects samples (combined) from the geochemical database. AMD capacity is based on 75th percentile total S value of 0.86% for PAF coal and rejects samples (combined) from the geochemical database. Approximately 25% of P&L Lower seam coal samples from BWM have been classified as PAF. Limited data is available to assess the availability of ANC in coal samples, however ANC is largely available under field conditions from tailings and rejects samples - therefore coal would be expected to have similar ANC availability. Regardless, the potential for AMD generation from a moderate proportion of the void floor cannot be excluded - assuming the entire void floor comprises purely coal material. No allowance for pit flooding has been taken into account in this hazard assessment. Refer to report body for discussion regarding pit flooding.	5	5	3	9	Approximately 25% of the void floor may comprise PAF coal. The geochemical hazard for the void floor to develop AMD is low-moderate if the entire void floor comprises purely coal material (unlikely) and if the coal floor remains exposed to air (unlikely). As such, the actual AMD hazard post-closure will likely be lower than indicated. The likelihood for AMD generation from exposed Kenmare void floor = **UNLIKELY**

Table B21. AMD hazard scoring for source materials and likelihood for AMD generation from Laleham residual void walls and floor

Material domain	Material type	Proportion of drill-hole meterage on highwall by material type %	Above current water table (where known)	Below current water table (where known)	Proportion of drill-hole meterage (below base of weathering)	% of PAF sample by material type (environmental and/or coal database)	Comment	Estimated % PAF exposure on highwall	Comment	Geochemical Propensity for AMD	AMD Capacity Rating	AMD Quantity Rating	AMD Source Material Hazard Score	Likelihood for AMD generation from Laleham void highwall
Laleham Void Highwall	Weathered, non-carbonaceous	11%	100% (where known)	0% (where known)	0%	5.1%	Approximately 5% of weathered non-carbonaceous samples (28 samples out of 554) were UC(PAF) or PAF-LC [no "PAF" samples] (data from geochemical database). It is expected that weathered material is completely or predominantly oxidised and, as such, this material is overwhelmingly NAF.	0.6%	This material is expected to comprise approximately 11% of the void wall material by meterage. Assumed to be non-mineralised, with very low concentrations of reactive sulphide minerals. Small proportion of samples may be PAF (if so, likely low capacity). The potential for AMD from acid sulphate minerals (e.g. jarosite) is very low or negligible. Likely source of ANC. The 75th percentile total S value is 0.02%. AMD capacity based on PAF samples 75th percentile total S of 0.03%.	5	1	1	6	Non-carbonaceous rock is expected to have excess acid neutralising capacity, which should be sufficient to buffer AMD released from potential AMD sources exposed on the highwall, if any. The potential exposure of PAF materials on the highwall is estimated to represent less than 4% (vertical meterage). Most PAF domains are expected to be largely confined to coal horizons/ seams. However, these will be embedded in a matrix of NAF and ANC-rich materials. Void wall run-off reporting to the residual void is unlikely to produce acidity. The hazard for AMD generation from Laleham void highwall = **LOW-MODERATE**. The likelihood for AMD generation from Laleham void highwall = **UNLIKELY**
	Weathered, carbonaceous & coaly	0.01%	unk.	unk.	0%	33%	Negligible proportion in highwall. Three out of 9 weathered carbonaceous/coaly samples were UC(PAF) and PAF (data from geochemical database). It is expected that weathered material is prodominantly oxidised and, as such, this material is predominantly NAF or would pose a low AMD hazard.	<0.1%	This material is expected to comprise less than 0.01% of the void wall material by meterage. Three (out of 9) samples were UC(PAF), and do not contain significant sulphide minerals. Being weathered, PAF materials are likely to be low capacity (i.e. PAF-LC). The potential for AMD from acid sulphate salts is low. The 75th percentile total S value is 0.43%. AMD capacity based on PAF samples 75th percentile total S of 1.11%.	5	7	1	9	
	Fresh, non-carbonaceous	82%	19% (where known)	81% (where known)	82%	0.8%	Less than 1% of fresh, non-carbonaceous samples were PAF (data from geochemical database) [21 out of 2527 samples]. Water table depths are not available for some highwall drillholes, however where known, approximately 19% of this material is currently above the water table and would be potentially subject to oxidation.	0.7%	This material is estimated to comprise approximately 82% of the void wall material by meterage. Overall, fresh, non-carbonaceous spoil is overwhelmingly NAF with excess ANC. This material is likely to be an important source of ANC. Less than 1% of samples were PAF (of some type), and most were closely associated with coal seams (as roof, parting or floor). This material horizon is overwhelmingly NAF. The 75th percentile total S value for this material is 0.04%. AMD capacity based on PAF samples 75th percentile total S of 0.63%.	1	5	1	4	
	Fresh, carbonaceous	0.8%	0% (where known)	100% (where known)	0.8%	13%	Approximately 13% of fresh, carbonaceous samples (32 out of 251 samples) were UC(PAF), PAF-LC or PAF (data from geochemical database). Water table depths are not available for some highwall drillholes, however where known, none of this material is currently above the water table and would be potentially subject to oxidation.	0.1%	Generation of AMD from fresh carbonaceous units cannot be excluded as 13% of the samples tested (all of BWM) were classed as PAF. However, this material is expected to comprise less than 1% of the void wall. Some carbonaceous overburden has excess ANC. The 75th percentile total S value for this material is 0.26%. AMD capacity based on PAF samples 75th percentile total S of 0.62%.	5	5	1	8	
	Coal (fresh)	6.0%	0% (where known)	100% (where known)	6.0%	36%	Approximately 36% of the 370 coal samples were UC(PAF), PAF-LC or PAF (data from geochemical database). Water table depths are not available for some highwall drillholes, however where known, none of this material is currently above the water table and would be potentially subject to oxidation.	2.2%	Fresh coal is expected to comprise approximately 6% of the void wall material by meterage. Geochemical data is available for 370 coal samples sourced from across BWM seams, of which 134 samples were conservatively classified as PAF, PAF-LC, UC(PAF) or NAF-S. Of the 'PAF' samples, 80% were classified as PAF-LC. The 75th percentile S value for PAF coal samples is 0.34% (and AMD capacity is based on this value). The 75th percentile S value for all coal samples is 0.31%. With regard to the coal quality database (n=7495 samples), the 75th percentile total S value is 0.48% - higher, but generally consistent with the smaller geochemical database. The seams/plys likely to be exposed on the highwall are predominantly the T and P & L seam groups.	5	5	1	8	
	Unknown	0.0%	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
	Estimated frequency of occurrence of PAF drill-hole intervals - assuming representativeness of surface exposure by drill-hole data							3.5%						

Material domain	Material type on void floor	Proportion of exposure on void floor % (assumed)	Above current water table	Below current water table	% Exposure (below base of weathering)	% of PAF sample by material type (environmental and/or coal database)	Comment	Estimated % PAF exposure on void floor	Comment	Geochemical Propensity for AMD	AMD Capacity Rating	AMD Quantity Rating	Likelihood for AMD generation from exposed Laleham void floor	
Laleham Void Floor	Tailings (from SCPP)	100%	0%	100%	100%	56%	No geochemical data is available from Laleham tailings (Laleham Pit TSF). Based on geochemical data from all BWM tailings, approximately 56% of tailings samples were PAF (data from geochemical database) [357 out of 643 samples]. Assumes all tailings is below the post-closure water table and would become submerged after mining ceases - or would be capped/cover with a suitable thickness of spoil and/or water cover to minimise oxidation.	56%	The floor of Laleham void is currently tailings and is expected to remain as such. 56% of all BWM tailings are conservatively classified as PAF, PAF-LC, UC(PAF) or NAF-S. 75th percentile EC of tailings = 988 µS/cm. AMD capacity is based on a 75th percentile S value of 1.38% for 'PAF' samples. Some tailings samples will generate AD. AMD quantity assumes proportion of PAF tailings samples approximates the proportion of tailings that are PAF. ANC of tailings is largely available under field conditions. No allowance for pit flooding or potential cover over tailings has been taken into account in this hazard assessment. Refer to report body for discussion regarding tailings cover or pit flooding.	7	7	7	14	Approximately 56% of the void floor may comprise PAF tailings.The geochemical hazard for the void floor to develop AMD is moderate if the tailings remains exposed to air (plausible). The likelihood for AMD generation from tailings on Laleham void floor = **PROBABLE/LIKELY**

Table B22. AMD hazard scoring for source materials and likelihood for AMD generation from Togara-North Marshmead residual void walls and floor

Material domain	Material type	Proportion of drill-hole meterage on highwall by material type %	Above current water table (where known)	Below current water table (where known)	Proportion of drill-hole meterage (below base of weathering)	% of PAF sample by material type (environmental and/or coal database)	Comment	Estimated % PAF exposure on highwall	Comment	Geochemical Propensity for AMD	AMD Capacity Rating	AMD Quantity Rating	AMD Source Material Hazard Score	Likelihood for AMD generation from Togara-North Marshmead void highwall
Togara-North Marshmead Void Highwall	Weathered, non-carbonaceous	73%	21% (where known)	79% (where known)	0%	5.1%	Approximately 5% of weathered non-carbonaceous samples (28 samples out of 554) were UC(PAF) or PAF-LC [no "PAF" samples] (data from geochemical database). It is expected that weathered material is completely or predominantly oxidised and, as such, this material is overwhelmingly NAF.	3.7%	This material is expected to comprise approximately 73 of the void wall material by meterage. Assumed to be non-mineralised, with very low concentrations of reactive sulphide minerals. Small proportion of samples may be PAF (if so, likely low capacity). The potential for AMD from acid sulphate minerals (e.g. jarosite) is very low or negligible. Likely source of ANC. The 75th percentile total S value is 0.02%. AMD capacity based on PAF samples 75th percentile total S of 0.03%.	5	1	1	**6**	Non-carbonaceous rock is expected to have excess acid neutralising capacity, which should be sufficient to buffer AMD released from potential AMD sources exposed on the highwall, if any. Approximately 80% of the void highwall is expected to be weathered material. The potential exposure of PAF materials on the highwall is estimated to represent approximately 6.5% (vertical meterage). Most PAF domains are expected to be largely confined to coal horizons/ seams. However, these will be embedded in a matrix of NAF and ANC-rich materials. Void wall run-off reporting to the residual void is unlikely to produce acidity. The hazard for AMD generation from Togara-North Marshmead void highwall = **LOW-MODERATE**. The likelihood for AMD generation from Togara-North Marshmead void highwall = **UNLIKELY**
	Weathered, carbonaceous & coaly	5.6%	8% (where known)	92% (where known)	0%	33%	Three out of 9 weathered carbonaceous/coaly samples were UC(PAF) and PAF (data from geochemical database). It is expected that weathered material is prodominantly oxidised and, as such, this material is predominantly NAF or would pose a low AMD hazard.	1.9%	This material is expected to comprise approximately 5.6% of the void wall material by meterage. Three (out of 9) samples were UC(PAF), and do not contain significant sulphide minerals. Being weathered, PAF materials are likely to be low capacity (i.e. PAF-LC). The potential for AMD from acid sulphate salts is low. The 75th percentile total S value is 0.43%. AMD capacity based on PAF samples 75th percentile total S of 1.11%.	5	7	1	**9**	
	Fresh, non-carbonaceous	19%	26% (where known)	74% (where known)	19%	0.8%	Less than 1% of fresh, non-carbonaceous samples were PAF (data from geochemical database) [21 out of 2527 samples]. Water table depths are not available for some highwall drillholes, however where known, approximately 26% of this material is currently above the water table and would be potentially subject to oxidation.	0.2%	This material is estimated to comprise approximately 19% of the void wall material by meterage. Overall, fresh, non-carbonaceous spoil is overwhelmingly NAF with excess ANC. This material is likely to be an important source of ANC. Less than 1% of samples were PAF (of some type), and most were closely associated with coal seams (as roof, parting or floor). This material horizon is overwhelmingly NAF. The 75th percentile total S value for this material is 0.04%. AMD capacity based on PAF samples 75th percentile total S of 0.63%.	1	5	1	**4**	
	Fresh, carbonaceous	0.4%	45% (where known)	55% (where known)	0.4%	13%	Approximately 13% of fresh, carbonaceous samples (32 out of 251 samples) were UC(PAF), PAF-LC or PAF (data from geochemical database). Water table depths are not available for some highwall drillholes, however where known, approximately 45% of this material is currently above the water table and would be potentially subject to oxidation.	<0.1%	Generation of AMD from fresh carbonaceous units cannot be excluded as 13% of the samples tested (all of BWM) were classed as PAF. However, this material is expected to comprise less than 0.5% of the void wall. Some carbonaceous overburden has excess ANC. The 75th percentile total S value for this material is 0.26%. AMD capacity based on PAF samples 75th percentile total S of 0.62%.	5	5	1	**8**	
	Coal (fresh)	2.0%	47% (where known)	53% (where known)	2.0%	36%	Approximately 36% of the 370 coal samples were UC(PAF), PAF-LC or PAF (data from geochemical database). Water table depths are not available for some highwall drillholes, however where known, approximately 47% of this material is currently above the water table and would be potentially subject to oxidation.	0.7%	Fresh coal is expected to comprise approximately 2% of the void wall material by meterage. Geochemical data is available for 370 coal samples sourced from across BWM seams, of which 134 samples were conservatively classified as PAF, PAF-LC, UC(PAF) or NAF-S. Of the 'PAF' samples, 80% were classified as PAF-LC. The 75th percentile S value for PAF coal samples is 0.34% (and AMD capacity is based on this value). The 75th percentile S value for all coal samples is 0.31%. With regard to the coal quality database (n=7495 samples), the 75th percentile total S value is 0.48% - higher, but generally consistent with the smaller geochemical database. The seams/plys likely to be exposed on the highwall are predominantly the T and P & L seam groups.	5	5	1	**8**	
	Unknown	0%	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	**n/a**	
	Estimated frequency of occurrence of PAF drill-hole intervals - assuming representativeness of surface exposure by drill-hole data							6.5%						

Material domain	Material type on void floor	Proportion of exposure on void floor % (assumed)	Above current water table	Below current water table	% Exposure (below base of weathering)	% of PAF sample by material type (environmental and/or coal database)	Comment	Estimated % PAF exposure on void floor	Comment	Geochemical Propensity for AMD	AMD Capacity Rating	AMD Quantity Rating	Likelihood for AMD generation from exposed Togara-North Marshmead void floor
Togara-North Marshmead Void Floor	Coal: P & L Lower seam	100%	0%	100%	100%	25%	PAF proportion estimated by applying a total S 'cut-off' of 0.43% to the coal quality data for P&L Lower seam samples (2792 samples). The S cut-off was based on the median total S value for PAF coal and rejects samples (combined) from the geochemical database. 700 out of 2792 P&L Lower samples had total S ≥0.43%. Based on the geochemical database, 36% of 370 coal samples were conservatively classifed as PAF. Whereas, based on the much larger coal quality database (2792 samples), 25% of the void floor is estimated to be PAF. All void floor is below the water table and would become submerged shortly after mining ceases.	25%	The floor of Togara-North Marshmead void is expected to be P&L Lower seam group materials (coaly and carbonaceous materials), which has a 75th percentile total S value of 0.43% (based on 2792 P&L Lower samples in the coal quality database). Co-incidently, 0.43%S is the median total S for PAF coal and rejects samples (combined) from the geochemical database. AMD capacity is based on 75th percentile total S value of 0.86% for PAF coal and rejects samples (combined) from the geochemical database. Approximately 25% of P&L Lower seam coal samples from BWM have been classified as PAF. Limited data is available to assess the availability of ANC in coal samples, however ANC is largely available under field conditions from tailings and rejects samples - therefore coal would be expected to have similar ANC availability. Regardless, the potential for AMD generation from a moderate proportion of the void floor cannot be excluded - assuming the entire void floor comprises purely coal material. No allowance for pit flooding has been taken into account in this hazard assessment. Refer to report body for discussion regarding pit flooding.	5	5	3	**9**	Approximately 25% of the void floor may comprise PAF coal. The geochemical hazard for the void floor to develop AMD is low-moderate if the entire void floor comprises purely coal material (unlikely) and if the coal floor remains exposed to air (unlikely). As such, the actual AMD hazard post-closure will likely be lower than indicated. The likelihood for AMD generation from exposed Togara-North Marshmead void floor = **UNLIKELY**

Table B23. AMD hazard scoring for source materials and likelihood for AMD generation from South Marshmead residual void walls and floor

Material domain	Material type	Proportion of drill-hole meterage on highwall by material type %	Above current water table (where known)	Below current water table (where known)	Proportion of drill-hole meterage (below base of weathering)	% of PAF sample by material type (environmental and/or coal database)	Comment	Estimated % PAF exposure on highwall	Comment	Geochemical Propensity for AMD	AMD Capacity Rating	AMD Quantity Rating	AMD Source Material Hazard Score	Likelihood for AMD generation from South Marshmead void highwall
South Marshmead Void Highwall	Weathered, non-carbonaceous	59%	100% (where known)	0% (where known)	0%	5.1%	Approximately 5% of weathered non-carbonaceous samples (28 samples out of 554) were UC(PAF) or PAF-LC [no "PAF" samples] (data from geochemical database). It is expected that weathered material is completely or predominantly oxidised and, as such, this material is overwhelmingly NAF.	3.0%	This material is expected to comprise approximately 59% of the void wall material by meterage. Assumed to be non-mineralised, with very low concentrations of reactive sulphide minerals. Small proportion of samples may be PAF (if so, likely low capacity). The potential for AMD from acid sulphate minerals (e.g. jarosite) is very low or negligible. Likely source of ANC. The 75th percentile total S value is 0.02%. AMD capacity based on PAF samples 75th percentile total S of 0.03%.	5	1	1	6	Non-carbonaceous rock is expected to have excess acid neutralising capacity, which should be sufficient to buffer AMD released from potential AMD sources exposed on the highwall, if any. The potential exposure of PAF materials on the highwall is estimated to represent less than 5% (vertical meterage). Most PAF domains are expected to be largely confined to coal horizons/ seams. However, these will be embedded in a matrix of NAF and ANC-rich materials. Void wall run-off reporting to the residual void is unlikely to produce acidity. The hazard for AMD generation from South Marshmead void highwall = **LOW-MODERATE**. The likelihood for AMD generation from South Marshmead void highwall = **UNLIKELY**
	Weathered, carbonaceous & coaly	1.3%	100% (where known)	0% (where known)	0%	33%	Negligible proportion in highwall. Three out of 9 weathered carbonaceous/coaly samples were UC(PAF) and PAF (data from geochemical database). It is expected that weathered material is prodominantly oxidised and, as such, this material is predominantly NAF or would pose a low AMD hazard.	0.4%	This material is expected to comprise approximately 1.3% of the void wall material by meterage. Three (out of 9) samples were UC(PAF), and do not contain significant sulphide minerals. Being weathered, PAF materials are likely to be low capacity (i.e. PAF-LC). The potential for AMD from acid sulphate salts is low. The 75th percentile total S value is 0.43%. AMD capacity based on PAF samples 75th percentile total S of 1.11%.	5	7	1	9	
	Fresh, non-carbonaceous	37%	100% (where known)	0% (where known)	37%	0.8%	Less than 1% of fresh, non-carbonaceous samples were PAF (data from geochemical database) [21 out of 2527 samples]. Water table depths are not available for some highwall drillholes, however where known, all of this material is currently above the water table and would be potentially subject to oxidation.	0.3%	This material is estimated to comprise approximately 37% of the void wall material by meterage. Overall, fresh, non-carbonaceous spoil is overwhelmingly NAF with excess ANC. This material is likely to be an important source of ANC. Less than 1% of samples were PAF (of some type), and most were closely associated with coal seams (as roof, parting or floor). This material horizon is overwhelmingly NAF. The 75th percentile total S value for this material is 0.04%. AMD capacity based on PAF samples 75th percentile total S of 0.63%.	1	5	1	4	
	Fresh, carbonaceous	0.7%	100% (where known)	0% (where known)	0.7%	13%	Approximately 13% of fresh, carbonaceous samples (32 out of 251 samples) were UC(PAF), PAF-LC or PAF (data from geochemical database). Water table depths are not available for some highwall drillholes, however where known, all of this material is currently above the water table and would be potentially subject to oxidation.	<0.1%	Generation of AMD from fresh carbonaceous units cannot be excluded as 13% of the samples tested (all of BWM) were classed as PAF. However, this material is expected to comprise less than 1% of the void wall. Some carbonaceous overburden has excess ANC. The 75th percentile total S value for this material is 0.26%. AMD capacity based on PAF samples 75th percentile total S of 0.62%.	5	5	1	8	
	Coal (fresh)	2.5%	100% (where known)	0% (where known)	2.5%	36%	Approximately 36% of the 370 coal samples were UC(PAF), PAF-LC or PAF (data from geochemical database). Water table depths are not available for some highwall drillholes, however where known, all of this material is currently above the water table and would be potentially subject to oxidation.	0.9%	Fresh coal is expected to comprise approximately 2.5% of the void wall material by meterage. Geochemical data is available for 370 coal samples sourced from across BWM seams, of which 134 samples were conservatively classified as PAF, PAF-LC, UC(PAF) or NAF-S. Of the 'PAF' samples, 80% were classified as PAF-LC. The 75th percentile S value for PAF coal samples is 0.34% (and AMD capacity is based on this value). The 75th percentile S value for all coal samples is 0.31%. With regard to the coal quality database (n=7495 samples), the 75th percentile total S value is 0.48% - higher, but generally consistent with the smaller geochemical database. The seams/plys likely to be exposed on the highwall are predominantly the T and P & L seam groups.	5	5	1	8	
	Unknown	0.0%	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	**n/a**	
	Estimated frequency of occurrence of PAF drill-hole intervals - assuming representativeness of surface exposure by drill-hole data							4.7%						

Material domain	Material type on void floor	Proportion of exposure on void floor % (assumed)	Above current water table	Below current water table	% Exposure (below base of weathering)	% of PAF sample by material type (environmental and/or coal database)	Comment	Estimated % PAF exposure on void floor	Comment	Geochemical Propensity for AMD	AMD Capacity Rating	AMD Quantity Rating	Likelihood for AMD generation from exposed South Marshmead void floor
South Marshmead Void Floor	Coal: P & L Lower seam	100%	0%	100%	100%	25%	PAF proportion estimated by applying a total S 'cut-off' of 0.43% to the coal quality data for P&L Lower seam samples (2792 samples). The S cut-off was based on the median total S value for PAF coal and rejects samples (combined) from the geochemical database. 700 out of 2792 P&L Lower samples had total S ≥0.43%. Based on the geochemical database, 36% of 370 coal samples were conservatively classifed as PAF. Whereas, based on the much larger coal quality database (2792 samples), 25% of the void floor is estimated to be PAF. All void floor is below the water table and would become submerged shortly after mining ceases.	25%	The floor of South Marshmead void is expected to be P&L Lower seam group materials (coaly and carbonaceous materials), which has a 75th percentile total S value of 0.43% (based on 2792 P&L Lower samples in the coal quality database). Co-incidently, 0.43%S is the median total S for PAF coal and rejects samples (combined) from the geochemical database. AMD capacity is based on 75th percentile total S value of 0.86% for PAF coal and rejects samples (combined) from the geochemical database. Approximately 25% of P&L Lower seam coal samples from BWM have been classified as PAF. Limited data is available to assess the availability of ANC in coal samples, however ANC is largely available under field conditions from tailings and rejects samples - therefore coal would be expected to have similar ANC availability. Regardless, the potential for AMD generation from a moderate proportion of the void floor cannot be excluded - assuming the entire void floor comprises purely coal material. No allowance for pit flooding has been taken into account in this hazard assessment. Refer to report body for discussion regarding pit flooding.	5	5	3	9	Approximately 25% of the void floor may comprise PAF coal. The geochemical hazard for the void floor to develop AMD is low-moderate if the entire void floor comprises purely coal material (unlikely) and if the coal floor remains exposed to air (unlikely). As such, the actual AMD hazard post-closure will likely be lower than indicated. The likelihood for AMD generation from exposed South Marshmead void floor = **UNLIKELY**

Table B24. AMD hazard scoring for source materials and likelihood for AMD generation from Kennedy West residual void walls and floor

Material domain	Material type	Proportion of drill-hole meterage on highwall by material type %	Above current water table (where known)	Below current water table (where known)	Proportion of drill-hole meterage (below base of weathering)	%of PAF sample by material type (environmental and/or coal database)	Comment	Estimated % PAF exposure on highwall	Comment	Geochemical Propensity for AMD	AMD Capacity Rating	AMD Quantity Rating	AMD Source Material Hazard Score	Likelihood for AMD generation from Kennedy West void highwall
Kennedy West Void Highwall	Weathered, non-carbonaceous	76%	92% (where known)	8% (where known)	0%	5.1%	Approximately 5% of weathered non-carbonaceous samples (28 samples out of 554) were UC(PAF) or PAF-LC [no "PAF" samples] (data from geochemical database). It is expected that weathered material is completely or predominantly oxidised and, as such, this material is overwhelmingly NAF.	3.9%	This material is expected to comprise approximately 76% of the void wall material by meterage. Assumed to be non-mineralised, with very low concentrations of reactive sulphide minerals. Small proportion of samples may be PAF (if so, likely low capacity). The potential for AMD from acid sulphate minerals (e.g. jarosite) is very low or negligible. Likely source of ANC. The 75th percentile total S value is 0.02%. AMD capacity based on PAF samples 75th percentile total S of 0.03%.	5	1	1	6	Non-carbonaceous rock is expected to have excess acid neutralising capacity, which should be sufficient to buffer AMD released from potential AMD sources exposed on the highwall, if any. The potential exposure of PAF materials on the highwall is estimated to represent approximately 6% (vertical meterage). Most PAF domains are expected to be largely confined to coal horizons/ seams. However, these will be embedded in a matrix of NAF and ANC-rich materials. Void wall run-off reporting to the residual void is unlikely to produce acidity. The hazard for AMD generation from Kennedy West void highwall = **LOW-MODERATE**. The likelihood for AMD generation from Kennedy West void highwall = **UNLIKELY**
	Weathered, carbonaceous & coaly	2.0%	92% (where known)	8% (where known)	0%	33%	Very low proportion in highwall. Three out of 9 weathered carbonaceous/coaly samples were UC(PAF) and PAF (data from geochemical database). It is expected that weathered material is predominantly oxidised and, as such, this material is predominantly NAF or would pose a low AMD hazard.	0.7%	This material is expected to comprise approximately 2% of the void wall material by meterage. Three (out of 9) samples were UC(PAF), and do not contain significant sulphide minerals. Being weathered, PAF materials are likely to be low capacity (i.e. PAF-LC). The potential for AMD from acid sulphate salts is low. The 75th percentile total S value is 0.43%. AMD capacity based on PAF samples 75th percentile total S of 1.11%.	5	7	1	9	
	Fresh, non-carbonaceous	13%	22% (where known)	78% (where known)	13%	0.8%	Less than 1% of fresh, non-carbonaceous samples were PAF (data from geochemical database) [21 out of 2527 samples]. Water table depths are not available for some highwall drillholes, however where known, approximately 22% of this material is currently above the water table and would be potentially subject to oxidation.	0.1%	This material is estimated to comprise approximately 13% of the void wall material by meterage. Overall, fresh, non-carbonaceous spoil is overwhelmingly NAF with excess ANC. This material is likely to be an important source of ANC. Less than 1% of samples were PAF (of some type), and most were closely associated with coal seams (as roof, parting or floor). This material horizon is overwhelmingly NAF. The 75th percentile total S value for this material is 0.04%. AMD capacity based on PAF samples 75th percentile total S of 0.63%.	1	5	1	4	
	Fresh, carbonaceous	0.01%	unk.	unk.	0.01%	13%	Negligible proportion in highwall. Approximately 13% of fresh, carbonaceous samples (32 out of 251 samples) were UC(PAF), PAF-LC or PAF (data from geochemical database).	<0.1%	Generation of AMD from fresh carbonaceous units cannot be excluded as 13% of the samples tested (all of BWM) were classed as PAF. However, this material is expected to comprise a negligible proportion of the void wall. Some carbonaceous overburden has excess ANC. The 75th percentile total S value for this material is 0.26%. AMD capacity based on PAF samples 75th percentile total S of 0.62%.	5	5	1	8	
	Coal (fresh)	1.9%	0% (where known)	100% (where known)	1.9%	36%	Approximately 36% of the 370 coal samples were UC(PAF), PAF-LC or PAF (data from geochemical database). Water table depths are not available for some highwall drillholes, however where known, none of this material is currently below the water table and would be potentially subject to oxidation.	0.7%	Fresh coal is expected to comprise approximately 2% of the void wall material by meterage. Geochemical data is available for 370 coal samples sourced from across BWM seams, of which 134 samples were conservatively classified as PAF, PAF-LC, UC(PAF) or NAF-S. Of the 'PAF' samples, 80% were classified as PAF-LC. The 75th percentile S value for PAF coal samples is 0.34% (and AMD capacity is based on this value). The 75th percentile S value for all coal samples is 0.31%. With regard to the coal quality database (n=7495 samples), the 75th percentile total S value is 0.48% - higher, but generally consistent with the smaller geochemical database. The seams/plys likely to be exposed on the highwall are predominantly the T and P & L seam groups.	5	5	1	8	
	Unknown	6.8%	100%	0%	1.7%	6%	Lithology unknown. All of this material is below base of weathering (ie. fresh). Assume %PAF based on average of fresh spoil materials	0.4%	All of this material is below base of weathering. Assume low PAF. Conservatively assume 'Moderate-High' AMD capacity. Conservative AMD hazard score.	5	5	1	8	
	Estimated frequency of occurrence of PAF drill-hole intervals - assuming representativeness of surface exposure by drill-hole data							5.7%						

Material domain	Material type on void floor	Proportion of exposure on void floor % (assumed)	Above current water table	Below current water table	%Exposure (below base of weathering)	%of PAF sample by material type (environmental and/or coal database)	Comment	Estimated % PAF exposure on void floor	Comment	Geochemical Propensity for AMD	AMD Capacity Rating	AMD Quantity Rating	Likelihood for AMD generation from exposed Kennedy West void floor	
Kennedy West Void Floor	Coal: P & L Lower seam	100%	0%	100%	100%	25%	PAF proportion estimated by applying a total S 'cut-off' of 0.43% to the coal quality data for P&L Lower seam samples (2792 samples). The S cut-off was based on the median total S value for PAF coal and rejects samples (combined) from the geochemical database. 700 out of 2792 P&L Lower samples had total S ≥0.43%. Based on the geochemical database, 36% of 370 coal samples were conservatively classifed as PAF. Whereas, based on the much larger coal quality database (2792 samples), 25% of the void floor is estimated to be PAF. All void floor is below the water table and would become submerged shortly after mining ceases.	25%	The floor of Kennedy West void is expected to be P&L Lower seam group materials (coaly and carbonaceous materials), which has a 75th percentile total S value of 0.43% (based on 2792 P&L Lower samples in the coal quality database). Co-incidently, 0.43%S is the median total S for PAF coal and rejects samples (combined) from the geochemical database. AMD capacity is based on 75th percentile total S value of 0.86% for PAF coal and rejects samples (combined) from the geochemical database. Approximately 25% of P&L Lower seam coal samples from BWM have been classified as PAF. Limited data is available to assess the availability of ANC in coal samples, however ANC is largely available under field conditions from tailings and rejects samples - therefore coal would be expected to have similar ANC availability. Regardless, the potential for AMD generation from a moderate proportion of the void floor cannot be excluded - assuming the entire void floor comprises purely coal material. No allowance for pit flooding has been taken into account in this hazard assessment. Refer to report body for discussion regarding pit flooding.	5	5	3	9	Approximately 25% of the void floor may comprise PAF coal. The geochemical hazard for the void floor to develop AMD is low-moderate if the entire void floor comprises purely coal material (unlikely) and if the coal floor remains exposed to air (unlikely). As such, the actual AMD hazard post-closure will likely be lower than indicated. The likelihood for AMD generation from exposed Kennedy West void floor = **UNLIKELY**

Table B25. AMD hazard scoring for source materials and likelihood for AMD generation from Comet Downs East residual void walls and floor

Material domain	Material type	Proportion of drill-hole meterage on highwall by material type %	Above current water table (where known)	Below current water table (where known)	Proportion of drill-hole meterage (below base of weathering)	% of PAF sample by material type (environmental and/or coal database)	Comment	Estimated % PAF exposure on highwall	Comment	Geochemical Propensity for AMD	AMD Capacity Rating	AMD Quantity Rating	AMD Source Material Hazard Score	Likelihood for AMD generation from Comet Downs East void highwall
Comet Downs East Void Highwall	Weathered, non-carbonaceous	33%	99% (where known)	1% (where known)	0%	5.1%	Approximately 5% of weathered non-carbonaceous samples (28 samples out of 554) were UC(PAF) or PAF-LC [no "PAF" samples] (data from geochemical database). It is expected that weathered material is completely or predominantly oxidised and, as such, this material is overwhelmingly NAF.	1.7%	This material is expected to comprise approximately 33% of the void wall material by meterage. Assumed to be non-mineralised, with very low concentrations of reactive sulphide minerals. Small proportion of samples may be PAF (if so, likely low capacity). The potential for AMD from acid sulphate minerals (e.g. jarosite) is very low or negligible. Likely source of ANC. The 75th percentile total S value is 0.02%. AMD capacity based on PAF samples 75th percentile total S of 0.03%.	5	1	1	6	Non-carbonaceous rock is expected to have excess acid neutralising capacity, which should be sufficient to buffer AMD released from potential AMD sources exposed on the highwall, if any. The potential exposure of PAF materials on the highwall is estimated to represent approximately 4% (vertical meterage). Most PAF domains are expected to be largely confined to coal horizons/ seams. However, these will be embedded in a matrix of NAF and ANC-rich materials. Void wall run-off reporting to the residual void is unlikely to produce acidity. The hazard for AMD generation from Comet Downs East void highwall = **LOW-MODERATE**. The likelihood for AMD generation from Comet Downs East void highwall = **UNLIKELY**
	Weathered, carbonaceous & coaly	0.6%	100% (where known)	0% (where known)	0%	33%	Negligible proportion in highwall. Three out of 9 weathered carbonaceous/coaly samples were UC(PAF) and PAF (data from geochemical database). It is expected that weathered material is prodominantly oxidised and, as such, this material is predominantly NAF or would pose a low AMD hazard.	0.2%	This material is expected to comprise less than 1% of the void wall material by meterage. Three (out of 9) samples were UC(PAF), and do not contain significant sulphide minerals. Being weathered, PAF materials are likely to be low capacity (i.e. PAF-LC). The potential for AMD from acid sulphate salts is low. The 75th percentile total S value is 0.43%. AMD capacity based on PAF samples 75th percentile total S of 1.11%.	5	7	1	9	
	Fresh, non-carbonaceous	54%	88% (where known)	12% (where known)	54%	0.8%	Less than 1% of fresh, non-carbonaceous samples were PAF (data from geochemical database) [21 out of 2527 samples]. Water table depths are not available for some highwall drillholes, however where known, approximately 88% of this material is currently above the water table and would be potentially subject to oxidation.	0.4%	This material is estimated to comprise approximately 54% of the void wall material by meterage. Overall, fresh, non-carbonaceous spoil is overwhelmingly NAF with excess ANC. This material is likely to be an important source of ANC. Less than 1% of samples were PAF (of some type), and most were closely associated with coal seams (as roof, parting or floor). This material horizon is overwhelmingly NAF. The 75th percentile total S value for this material is 0.04%. AMD capacity based on PAF samples 75th percentile total S of 0.63%.	1	5	1	4	
	Fresh, carbonaceous	3.0%	47% (where known)	53% (where known)	3.0%	13%	Approximately 13% of fresh, carbonaceous samples (32 out of 251 samples) were UC(PAF), PAF-LC or PAF (data from geochemical database). Water table depths are not available for some highwall drillholes, however where known, approximately 47% of this material is currently above the water table and would be potentially subject to oxidation.	0.4%	Generation of AMD from fresh carbonaceous units cannot be excluded as 13% of the samples tested (all of BWM) were classed as PAF. However, this material is expected to comprise approximately 3% of the void wall. Some carbonaceous overburden has excess ANC. The 75th percentile total S value for this material is 0.26%. AMD capacity based on PAF samples 75th percentile total S of 0.62%.	5	5	1	8	
	Coal (fresh)	3.3%	84% (where known)	16% (where known)	3.3%	36%	Approximately 36% of the 370 coal samples were UC(PAF), PAF-LC or PAF (data from geochemical database). Water table depths are not available for some highwall drillholes, however where known, approximately 84% of this material is currently above the water table and would be potentially subject to oxidation.	1.2%	Fresh coal is expected to comprise approximately 3.3% of the void wall material by meterage. Geochemical data is available for 370 coal samples sourced from across BWM seams, of which 134 samples were conservatively classified as PAF, PAF-LC, UC(PAF) or NAF-S. Of the 'PAF' samples, 80% were classified as PAF-LC. The 75th percentile S value for PAF coal samples is 0.34% (and AMD capacity is based on this value). The 75th percentile S value for all coal samples is 0.31%. With regard to the coal quality database (n=7495 samples), the 75th percentile total S value is 0.48% - higher, but generally consistent with the smaller geochemical database. The seams/plys likely to be exposed on the highwall are predominantly the T and P & L seam groups.	5	5	1	8	
	Unknown	6.3%	100%	0%	0%	0%	Lithology unknown. None of this material is below base of weathering (ie. all material is weathered)	<0.1%	All of this material is within weathered zone. Assume negligible PAF. Conservatively assume 'Moderate-High' AMD capacity.	1	7	1	5	
	Estimated frequency of occurrence of PAF drill-hole intervals - assuming representativeness of surface exposure by drill-hole data							3.9%						

Material domain	Material type on void floor	Proportion of exposure on void floor % (assumed)	Above current water table	Below current water table	% Exposure (below base of weathering)	% of PAF sample by material type (environmental and/or coal database)	Comment	Estimated % PAF exposure on void floor	Comment	Geochemical Propensity for AMD	AMD Capacity Rating	AMD Quantity Rating	Likelihood for AMD generation from exposed Comet Downs East void floor
Comet Downs East Void Floor	Coal: P & L Lower seam	100%	0%	100%	100%	25%	PAF proportion estimated by applying a total S 'cut-off' of 0.43% to the coal quality data for P&L Lower seam samples (2792 samples). The S cut-off was based on the median total S value for PAF coal and rejects samples (combined) from the geochemical database. 700 out of 2792 P&L Lower samples had total S ≥0.43%. Based on the geochemical database, 36% of 370 coal samples were conservatively classifed as PAF. Whereas, based on the much larger coal quality database (2792 samples), 25% of the void floor is estimated to be PAF. All void floor is below the water table and would become submerged shortly after mining ceases.	25%	The floor of Comet Downs East void is expected to be P&L Lower seam group materials (coaly and carbonaceous materials), which has a 75th percentile total S value of 0.43% (based on 2792 P&L Lower samples in the coal quality database). Co-incidently, 0.43%S is the median total S for PAF coal and rejects samples (combined) from the geochemical database. AMD capacity is based on 75th percentile total S value of 0.86% for PAF coal and rejects samples (combined) from the geochemical database. Approximately 25% of P&L Lower seam coal samples from BWM have been classified as PAF. Limited data is available to assess the availability of ANC in coal samples, however ANC is largely available under field conditions from tailings and rejects samples - therefore coal would be expected to have similar ANC availability. Regardless, the potential for AMD generation from a moderate proportion of the void floor cannot be excluded - assuming the entire void floor comprises purely coal material. No allowance for pit flooding has been taken into account in this hazard assessment. Refer to report body for discussion regarding pit flooding.	5	5	3	9	Approximately 25% of the void floor may comprise PAF coal. The geochemical hazard for the void floor to develop AMD is low-moderate if the entire void floor comprises purely coal material (unlikely) and if the coal floor remains exposed to air (unlikely). As such, the actual AMD hazard post-closure will likely be lower than indicated. The likelihood for AMD generation from exposed Comet Downs East void floor = **UNLIKELY**

Attachment B – SPR Assessment Tables

SPR assessment of post-closure spoil landform (source) to surface water (receptor)

- Table C1 Ramp 8 spoil landform
- Table C2 Bonnie Doon spoil landform
- Table C3 Mimosa-Besgrove spoil landform
- Table C4 Deep Creek spoil landform
- Table C5 Stewarton-Ballamoo spoil landform
- Table C6 Kenmare spoil landform
- Table C7 Laleham spoil landform
- Table C8 Togara-North Marshmead spoil landform
- Table C9 South Marshmead spoil landform
- Table C10 Kennedy West spoil landform
- Table C11 Comet Downs East spoil landform

SPR assessment of post-closure TSF and rejects landforms (source) to surface water (receptor)

- Table C12 NCPP TSF landform
- Table C13 Laleham TSF landform
- Table C14 Bottom Dam TSF (and rejects) landform
- Table C15 Ramp 36 rejects landform

SPR assessment of post-closure spoil landform (source) to residual void (receptor)

- Table C16 Ramp 8, Bonnie Doon, Mimosa-Besgrove and Deep Creek spoil landforms
- Table C17 Stewarton-Ballamoo, Kenmare, Laleham and Togara-North Marshmead spoil landforms
- Table C18 South Marshmead, Kennedy West and Comet Downs East spoil landforms

SPR assessment of post-closure TSF and rejects landform (source) to residual void (receptor)

- Table C19 TSF landforms (NCPP TSF, Laleham TSF and Ramp 36 rejects landform

SPR assessment of residual void highwall and floor (source) to residual void (receptor)

- Table C20 All residual voids

Table C1. Source-Pathway-Receptor (SPR) assessment of Ramp 8 spoil landform: surface water receptors via run-off and via shallow permeable strata (shallow groundwater)

Source	Pathway	Receptor	Event / potential harm	Likelihood of Event	Severity of Event	Risk Rating
Ramp 8 spoil landform (post-closure) Comprised of approximately 96% non-carbonaceous spoil and approximately 4% carbonaceous spoil. No rejects or tailings *AMD source hazard of landform is* ***Low*** *Salinity (non-oxidative) source hazard of landform:* ***Low***	From Ramp 8 spoil landform via surface water run-off into ephemeral tributary of Bonnie Doon Creek. Distance <100m to receptor (west). *Potential for AMD to enter surface water run-off:* ***Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to enter surface water run-off:* ***Unlikely***	Ephemeral creek (via surface water run-off): tributary of Bonnie Doon Creek @ western side of Ramp 8 spoil landform. *Potential for AMD to reach Bonnie Doon Creek:* ***Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach Bonnie Doon Creek:* ***Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting tributary of Bonnie Doon Creek [via run-off]	Highly Unlikely	S1	**Low**
			Neutral metalliferous drainage: Metals and metalloids impacting tributary of Bonnie Doon Creek [via run-off]	Unlikely	S1	**Low**
			Saline drainage (from sulfide oxidation): Salt (sulfate) impacting tributary of Bonnie Doon Creek [via run-off]	Highly Unlikely	S1	**Low**
			Saline drainage (non-oxidative): Salt impacting tributary of Bonnie Doon Creek [via run-off]	Unlikely	S1	**Low**
	From Ramp 8 spoil landform via seepage into shallow permeable strata then into ephemeral tributary of Bonnie Doon Creek. Distance <100m to receptor (west). *Potential for AMD to enter shallow groundwater:* ***Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to enter shallow groundwater:* ***Unlikely***	Ephemeral creek (via shallow permeable strata: tributary of Bonnie Doon Creek @ western side of Ramp 8 spoil landform. *Potential for AMD to reach Bonnie Doon Creek:* ***Highly Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach Bonnie Doon Creek:* ***Highly Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting tributary of Bonnie Doon Creek [via seepage]	Highly Unlikely	S1	**Low**
			Neutral metalliferous drainage: Metals and metalloids impacting tributary of Bonnie Doon Creek [via seepage]	Unlikely	S1	**Low**
			Saline drainage (from sulfide oxidation): Salt (sulfate) impacting tributary of Bonnie Doon Creek [via seepage]	Highly Unlikely	S1	**Low**
			Saline drainage (non-oxidative): Salt impacting tributary of Bonnie Doon Creek [via seepage]	Unlikely	S1	**Low**

Table C2. Source-Pathway-Receptor (SPR) assessment of Bonnie Doon spoil landform: surface water receptors via run-off and via shallow permeable strata (shallow groundwater)

Source	Pathway	Receptor	Event / potential harm	Likelihood of Event	Severity of Event	Risk Rating
Bonnie Doon spoil landform (post-closure) Comprised of approximately 96% non-carbonaceous spoil and approximately 4% carbonaceous spoil. No rejects or tailings *AMD source hazard of landform is* ***Low*** *Salinity (non-oxidative) source hazard of landform:* ***Low***	From Bonnie Doon spoil landform via surface water run-off into ephemeral Bonnie Doon Creek (and tributary). Distance <100m to receptor (northwest) and ~900m (west). *Potential for AMD to enter surface water run-off:* ***Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to enter surface water run-off:* ***Unlikely***	Ephemeral creek (via surface water run-off): Bonnie Doon Creek (and tributary) @ western side of Bonnie Doon spoil landform. *Potential for AMD to reach Bonnie Doon Creek:* ***Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach Bonnie Doon Creek:* ***Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting Bonnie Doon Creek and tributary [via run-off]	Highly Unlikely	S1	**Low**
			Neutral metalliferous drainage: Metals and metalloids impacting Bonnie Doon Creek and tributary [via run-off]	Unlikely	S1	**Low**
			Saline drainage (from sulfide oxidation): Salt (sulfate) impacting Bonnie Doon Creek and tributary [via run-off]	Highly Unlikely	S1	**Low**
			Saline drainage (non-oxidative): Salt impacting Bonnie Doon Creek and tributary [via run-off]	Unlikely	S1	**Low**
	From Bonnie Doon spoil landform via seepage into shallow permeable strata then into ephemeral Bonnie Doon Creek (and tributary). Distance <100m to receptor (northwest) and ~900 (west). *Potential for AMD to enter shallow groundwater:* ***Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to enter shallow groundwater:* ***Unlikely***	Ephemeral creek (via shallow permeable strata: Bonnie Doon Creek (and tributary) @ western side of Bonnie Doon spoil landform. *Potential for AMD to reach Bonnie Doon Creek:* ***Highly Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach Bonnie Doon Creek:* ***Highly Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting Bonnie Doon Creek and tributary [via seepage]	Highly Unlikely	S1	**Low**
			Neutral metalliferous drainage: Metals and metalloids impacting Bonnie Doon Creek and tributary [via seepage]	Unlikely	S1	**Low**
			Saline drainage (from sulfide oxidation): Salt (sulfate) impacting Bonnie Doon Creek and tributary [via seepage]	Highly Unlikely	S1	**Low**
			Saline drainage (non-oxidative): Salt impacting Bonnie Doon Creek and tributary [via seepage]	Unlikely	S1	**Low**

Table C3. Source-Pathway-Receptor (SPR) assessment of Mimosa-Besgrove spoil landform: surface water receptors via run-off and via shallow permeable strata (shallow groundwater)

Source	Pathway	Receptor	Event / potential harm	Likelihood of Event	Severity of Event	Risk Rating
Mimosa-Besgrove spoil landform (post-closure) Comprised of approximately 95% non-carbonaceous spoil; approximately 2.9% carbonaceous spoil; and approximately 1.9% rejects. Deep Creek rejects dump (now buried within landform) is located <100m from southern toe of landform No tailings *AMD source hazard of landform is* ***Low*** *Salinity (non-oxidative) source hazard of landform is* ***Low*** *[AMD source hazard of rejects alone is* ***Moderate****, which has implications, specifically, for buried rejects at Deep Creek (Ramp 32) rejects area [ie. largely concentrated in one area]. Buried Deep Creek rejects are located <100m from southern toe of landform, which is <100m from Deep Creek]* (***Figure 34***)	From Mimosa-Besgrove spoil landform via surface water run-off into ephemeral Burngrove Creek and tributaries. Distance <200m to receptor (west). *Potential for AMD to enter surface water run-off:* ***Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to enter surface water run-off:* ***Unlikely***	Ephemeral creek (via surface water run-off): tributaries of Burngrove Creek @ western side of Mimosa-Besgrove spoil landform. *Potential for AMD to reach tributaries of Burngrove Creek:* ***Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach tributaries of Burngrove Creek:* ***Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting tributaries of Burngrove Creek [via run-off]	Highly Unlikely	S1	Low
			Neutral metalliferous drainage: Metals and metalloids impacting tributaries of Burngrove Creek [via run-off]	Unlikely	S1	Low
			Saline drainage (from sulfide oxidation): Salt (sulfate) impacting tributaries of Burngrove Ck [via run-off]	Highly Unlikely	S1	Low
			Saline drainage (non-oxidative): Salt impacting tributaries of Burngrove Creek [via run-off]	Unlikely	S1	Low
	From Mimosa-Besgrove spoil landform via seepage into shallow permeable strata then into ephemeral Burngrove Creek and tributaries. Distance <200m to receptor (west). *Potential for AMD to enter shallow groundwater:* ***Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to enter shallow groundwater:* ***Unlikely***	Ephemeral creek (via shallow permeable strata: tributaries of Burngrove Creek @ western side of Mimosa-Besgrove spoil landform. *Potential for AMD to reach tributaries of Burngrove Creek:* ***Highly Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach tributaries of Burngrove Creek:* ***Highly Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting tributaries of Burngrove Creek [via seepage]	Highly Unlikely	S1	Low
			Neutral metalliferous drainage: Metals and metalloids impacting tributaries of Burngrove Creek [via seepage]	Unlikely	S1	Low
			Saline drainage (from sulfide oxidation): Salt (sulfate) impacting tributaries of Burngrove Ck [via seepage]	Highly Unlikely	S1	Low
			Saline drainage (non-oxidative): Salt impacting tributaries of Burngrove Creek [via seepage]	Unlikely	S1	Low
	From Mimosa-Besgrove spoil landform via surface water run-off into ephemeral Deep Creek. Distance <100m to receptor (south). *Potential for AMD to enter surface water run-off:* ***Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to enter surface water run-off:* ***Unlikely***	Ephemeral creek (via surface water run-off): Deep Creek @ southern side of Mimosa-Besgrove spoil landform. *Potential for AMD to reach Deep Creek:* ***Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach Deep Creek:* ***Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting Deep Creek [via run-off]	Highly Unlikely	S1	Low
			Neutral metalliferous drainage: Metals and metalloids impacting Deep Creek [via run-off]	Unlikely	S1	Low
			Saline drainage (from sulfide oxidation): Salt (sulfate) impacting Deep Creek [via run-off]	Highly Unlikely	S1	Low
			Saline drainage (non-oxidative): Salt impacting Deep Creek [via run-off]	Unlikely	S1	Low
	From Mimosa-Besgrove spoil landform via seepage into shallow permeable strata then into ephemeral Deep Creek. Distance <100m to receptor (south). *Potential for AMD to enter shallow groundwater:* ***Probable/Likely*** *Potential for salt (non-oxidative) >900 µS/cm to enter shallow groundwater:* ***Probable/Likely***	Ephemeral creek (via shallow permeable strata: Deep Creek @ southern side of Mimosa-Besgrove spoil landform. *Potential for AMD to reach Deep Creek:* ***Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach Deep Creek:* ***Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting Deep Creek [via seepage] Risk primarily lies with seepage from buried rejects concentrated at Deep Creek (R32) rejects area	Unlikely	S3	Low to Medium
			Neutral metalliferous drainage: Metals and metalloids impacting Deep Creek [via seepage] Risk primarily lies with seepage from buried rejects concentrated at Deep Creek (R32) rejects area	Unlikely	S3	Low to Medium
			Saline drainage (from sulfide oxidation): Salt (sulfate) impacting Deep Creek [via seepage] Risk primarily lies with seepage from buried rejects concentrated at Deep Creek (R32) rejects area	Unlikely	S3	Low to Medium
			Saline drainage (non-oxidative): Salt impacting Deep Creek [via seepage] Risk primarily lies with seepage from buried rejects concentrated at Deep Creek (R32) rejects area	Unlikely	S2	Low

Table C4. Source-Pathway-Receptor (SPR) assessment of Deep Creek spoil landform: surface water receptors via run-off and via shallow permeable strata (shallow groundwater)

Source	Pathway	Receptor	Event / potential harm	Likelihood of Event	Severity of Event	Risk Rating
Deep Creek spoil landform (post-closure) Comprised of approximately 96% non-carbonaceous spoil; approximately 3% carbonaceous spoil; and approximately 1% rejects. No tailings *AMD source hazard of landform is* ***Low*** *Salinity (non-oxidative) source hazard of landform is* ***Low*** *AMD source hazard of rejects alone is* ***Moderate****. Rejects are widely distributed throughout the landform and comprise a very low proportion of the landform.*	From Deep Creek spoil landform via surface water run-off into ephemeral Deep Creek. Distance <100m to receptor (north and northwest). *Potential for AMD to enter surface water run-off:* ***Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to enter surface water run-off:* ***Unlikely***	Ephemeral creek (via surface water run-off): Deep Creek @ northern and northwestern side of Deep Creek spoil landform. *Potential for AMD to reach Deep Creek:* ***Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach Creek:* ***Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting Deep Creek [via run-off]	Highly Unlikely	S1	**Low**
			Neutral metalliferous drainage: Metals and metalloids impacting Deep Creek [via run-off]	Unlikely	S1	**Low**
			Saline drainage (from sulfide oxidation): Salt (sulfate) impacting Deep Creek [via run-off]	Highly Unlikely	S1	**Low**
			Saline drainage (non-oxidative): Salt impacting Deep Creek [via run-off]	Unlikely	S1	**Low**
	From Deep Creek spoil landform via seepage into shallow permeable strata then into ephemeral Deep Creek. Distance <100m to receptor (north and northwest). *Potential for AMD to enter shallow groundwater:* ***Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to enter shallow groundwater:* ***Unlikely***	Ephemeral creek (via shallow permeable strata: Deep Creek @ northern and northwestern side of Deep Creek spoil landform. *Potential for AMD to reach Deep Creek:* ***Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach Creek:* ***Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting Deep Creek [via seepage]	Highly Unlikely	S1	**Low**
			Neutral metalliferous drainage: Metals and metalloids impacting Deep Creek [via seepage]	Unlikely	S1	**Low**
			Saline drainage (from sulfide oxidation): Salt (sulfate) impacting Deep Creek [via seepage]	Highly Unlikely	S1	**Low**
			Saline drainage (non-oxidative): Salt impacting Deep Creek [via seepage]	Unlikely	S1	**Low**
	From Deep Creek spoil landform via surface water run-off into ephemeral tributaries Taurus Creek. Distance ~400m to receptor (west). *Potential for AMD to enter surface water run-off:* ***Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to enter surface water run-off:* ***Unlikely***	Ephemeral creek (via surface water run-off): tributaries of Taurus Creek @ western side of Deep Creek landform. *Potential for AMD to reach tributaries of Taurus Creek:* ***Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach tributaries of Taurus Creek:* ***Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting tributaries of Taurus Creek [via run-off]	Highly Unlikely	S1	**Low**
			Neutral metalliferous drainage: Metals / metalloids impacting tributaries of Taurus Creek [via run-off]	Unlikely	S1	**Low**
			Saline drainage (from sulfide oxidation): Salt (sulfate) impacting tributaries of Taurus Ck [via run-off]	Highly Unlikely	S1	**Low**
			Saline drainage (non-oxidative): Salt impacting tributaries of Taurus Creek [via run-off]	Unlikely	S1	**Low**
	From Deep Creek spoil landform via seepage into shallow permeable strata then into ephemeral tributaries of Taurus Creek. Distance ~400m to receptor (west). *Potential for AMD to enter shallow groundwater:* ***Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to enter shallow groundwater:* ***Unlikely***	Ephemeral creek (via shallow permeable strata): tributaries of Taurus Creek @ western side of Deep Creek landform. *Potential for AMD to reach tributaries of Taurus Creek:* ***Highly Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach tributaries of Taurus Creek:* ***Highly Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting tributaries of Taurus Creek [via seepage]	Highly Unlikely	S1	**Low**
			Neutral metalliferous drainage: Metals / metalloids impacting tributaries of Taurus Creek [via seepage]	Unlikely	S1	**Low**
			Saline drainage (from sulfide oxidation): Salt (sulfate) impacting tributaries of Taurus Ck [via seepage]	Highly Unlikely	S1	**Low**
			Saline drainage (non-oxidative): Salt impacting tributaries of Taurus Creek [via seepage]	Unlikely	S1	**Low**
	From Deep Creek spoil landform via surface water run-off into ephemeral Taurus Creek. Distance <100m to receptor (south and southwest). *Potential for AMD to enter surface water run-off:* ***Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to enter surface water run-off:* ***Unlikely***	Ephemeral creek (via surface water run-off): Taurus Creek @ southern and southwestern side of Deep Creek spoil landform. *Potential for AMD to reach Taurus Creek:* ***Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach Taurus Creek:* ***Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting Taurus Creek [via run-off]	Highly Unlikely	S1	**Low**
			Neutral metalliferous drainage: Metals and metalloids impacting Taurus Creek [via run-off]	Unlikely	S1	**Low**
			Saline drainage (from sulfide oxidation): Salt (sulfate) impacting Taurus Creek [via run-off]	Highly Unlikely	S1	**Low**
			Saline drainage (non-oxidative): Salt impacting Taurus Creek [via run-off]	Unlikely	S1	**Low**
	From Deep Creek spoil landform via seepage into shallow permeable strata then into ephemeral Taurus Creek. Distance <100m to receptor (south and southwest). *Potential for AMD to enter shallow groundwater:* ***Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to enter shallow groundwater:* ***Unlikely***	Ephemeral creek (via shallow permeable strata: Taurus Creek @ southern and southwestern side of Deep Creek spoil landform. *Potential for AMD to reach Taurus Creek:* ***Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach Taurus Creek:* ***Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting Taurus Creek [via seepage]	Highly Unlikely	S1	**Low**
			Neutral metalliferous drainage: Metals and metalloids impacting Taurus Creek [via seepage]	Unlikely	S1	**Low**
			Saline drainage (from sulfide oxidation): Salt (sulfate) impacting Taurus Creek [via seepage]	Highly Unlikely	S1	**Low**
			Saline drainage (non-oxidative): Salt impacting Taurus Creek [via seepage]	Unlikely	S1	**Low**

Table C5. Source-Pathway-Receptor (SPR) assessment of Stewarton-Ballamoo spoil landform: surface water receptors via run-off and via shallow permeable strata (shallow groundwater)

Source	Pathway	Receptor	Event / potential harm	Likelihood of Event	Severity of Event	Risk Rating
Stewarton-Ballamoo spoil landform (post-closure) Comprised of approximately 96% non-carbonaceous spoil; approximately 4% carbonaceous spoil; and less than 0.2% rejects. No tailings *AMD source hazard of landform is* ***Low*** *Salinity (non-oxidative) source hazard of landform is* ***Low*** *AMD source hazard of rejects alone is* ***Moderate****. Rejects are widely distributed throughout the landform and comprise a very low proportion of the landform.*	From Stewarton-Ballamoo spoil landform via surface water run-off into ephemeral Taurus Creek. Distance <100m to receptor (north and northwest). *Potential for AMD to enter surface water run-off:* ***Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to enter surface water run-off:* ***Unlikely***	Ephemeral creek (via surface water run-off): Taurus Creek @ northern and northwestern side of Stewarton-Ballamoo spoil landform. *Potential for AMD to reach Taurus Creek:* ***Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach Taurus Creek:* ***Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting Taurus Creek [via run-off]	Highly Unlikely	S1	Low
			Neutral metalliferous drainage: Metals and metalloids impacting Taurus Creek [via run-off]	Unlikely	S1	Low
			Saline drainage (from sulfide oxidation): Salt (sulfate) impacting Taurus Creek [via run-off]	Highly Unlikely	S1	Low
			Saline drainage (non-oxidative): Salt impacting Taurus Creek [via run-off]	Unlikely	S1	Low
	From Stewarton-Ballamoo spoil landform via seepage into shallow permeable strata then into ephemeral Taurus Creek. Distance <100m to receptor (north and northwest). *Potential for AMD to enter shallow groundwater:* ***Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to enter shallow groundwater:* ***Unlikely***	Ephemeral creek (via shallow permeable strata: Taurus Creek @ northern and northwestern side of Stewarton-Ballamoo spoil landform. *Potential for AMD to reach Taurus Creek:* ***Highly Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach Taurus Creek:* ***Highly Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting Taurus Creek [via seepage]	Highly Unlikely	S1	Low
			Neutral metalliferous drainage: Metals and metalloids impacting Taurus Creek [via seepage]	Unlikely	S1	Low
			Saline drainage (from sulfide oxidation): Salt (sulfate) impacting Taurus Creek [via seepage]	Highly Unlikely	S1	Low
			Saline drainage (non-oxidative): Salt impacting Taurus Creek [via seepage]	Unlikely	S1	Low
	From Stewarton-Ballamoo spoil landform via surface water run-off into ephemeral Emu Creek. Distance <100m to receptor (west). *Potential for AMD to enter surface water run-off:* ***Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to enter surface water run-off:* ***Unlikely***	Ephemeral creek (via surface water run-off): Emu Creek @ western side of Stewarton-Ballamoo landform. *Potential for AMD to reach Emu Creek:* ***Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach Emu Creek:* ***Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting Emu Creek [via run-off]	Highly Unlikely	S1	Low
			Neutral metalliferous drainage: Metals and metalloids impacting Emu Creek [via run-off]	Unlikely	S1	Low
			Saline drainage (from sulfide oxidation): Salt (sulfate) impacting Emu Creek [via run-off]	Highly Unlikely	S1	Low
			Saline drainage (non-oxidative): Salt impacting Emu Creek [via run-off]	Unlikely	S1	Low
	From Stewarton-Ballamoo spoil landform via seepage into shallow permeable strata then into ephemeral Emu Creek. Distance <100m to receptor (west). *Potential for AMD to enter shallow groundwater:* ***Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to enter shallow groundwater:* ***Unlikely***	Ephemeral creek (via shallow permeable strata): Emu Creek @ western side of Stewarton-Ballamoo landform. *Potential for AMD to reach Emu Creek:* ***Highly Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach Emu Creek:* ***Highly Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting Emu Creek [via seepage]	Highly Unlikely	S1	Low
			Neutral metalliferous drainage: Metals and metalloids impacting Emu Creek [via seepage]	Unlikely	S1	Low
			Saline drainage (from sulfide oxidation): Salt (sulfate) impacting Emu Creek [via seepage]	Highly Unlikely	S1	Low
			Saline drainage (non-oxidative): Salt impacting Emu Creek [via seepage]	Unlikely	S1	Low
	From Stewarton-Ballamoo spoil landform via surface water run-off into ephemeral tributaries of Sirius Creek. Distance <100m to receptor (west and southwest). *Potential for AMD to enter surface water run-off:* ***Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to enter surface water run-off:* ***Unlikely***	Ephemeral creek (via surface water run-off): tributaries of Sirius Creek @ west and southwestern side of Stewarton-Ballamoo spoil landform. *Potential for AMD to reach tributaries of Sirius Creek:* ***Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach tributaries of Sirius Creek:* ***Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting tributaries of Sirius Creek [via run-off]	Highly Unlikely	S1	Low
			Neutral metalliferous drainage: Metals / metalloids impacting tributaries of Sirius Creek [via run-off]	Unlikely	S1	Low
			Saline drainage (from sulfide oxidation): Salt (sulfate) impacting tributaries of Sirius Ck [via run-off]	Highly Unlikely	S1	Low
			Saline drainage (non-oxidative): Salt impacting tributaries of Sirius Creek [via run-off]	Unlikely	S1	Low
	From Stewarton-Ballamoo spoil landform via seepage into shallow permeable strata then into ephemeral tributaries of Sirius Creek. Distance <100m to receptor (west and southwest). *Potential for AMD to enter shallow groundwater:* ***Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to enter shallow groundwater:* ***Unlikely***	Ephemeral creek (via shallow permeable strata: tributaries of Sirius Creek @ west and southwestern side of Stewarton-Ballamoo spoil landform. *Potential for AMD to reach tributaries of Sirius Creek:* ***Highly Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach tributaries of Sirius Creek:* ***Highly Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting tributaries of Sirius Creek [via seepage]	Highly Unlikely	S1	Low
			Neutral metalliferous drainage: Metals / metalloids impacting tributaries of Sirius Creek [via seepage]	Unlikely	S1	Low
			Saline drainage (from sulfide oxidation): Salt (sulfate) impacting tributaries of Sirius Ck [via seepage]	Highly Unlikely	S1	Low
			Saline drainage (non-oxidative): Salt impacting tributaries of Sirius Creek [via seepage]	Unlikely	S1	Low

Table C6. Source-Pathway-Receptor (SPR) assessment of Kenmare spoil landform: surface water receptors via run-off and via shallow permeable strata (shallow groundwater)

Source	Pathway	Receptor	Event / potential harm	Likelihood of Event	Severity of Event	Risk Rating
Kenmare spoil landform (post-closure) Comprised of approximately 95% non-carbonaceous spoil; approximately 3% carbonaceous spoil; approximately 1% rejects; and approximately 1% tailings. All tailings and about half of rejects are located at Ramp 72 TSF and southern end of Kenmare pit. *AMD source hazard of landform is **Low*** *Salinity (non-oxidative) source hazard of landform is **Low*** *AMD source hazard of Ramp 72 tailings and rejects alone is **Moderate-High to High**. This has implications for potential seepage from buried tailings and rejects within Ramp 72 TSF and Kenmare pit (**Figure 33**).* *AMD source hazard from Ramp 70 rejects alone is **Moderate.***	From Kenmare spoil landform via surface water run-off into ephemeral tributaries of Sirius Creek. Distance <100m to receptor (west / south / southwest). *Potential for AMD to enter surface water run-off: **Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to enter surface water run-off: **Unlikely***	Ephemeral creek (via surface water run-off): tributaries of Sirius Creek @ west / south / southwestern side of Kenmare spoil landform. *Potential for AMD to reach tributaries of Sirius Creek: **Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach tributaries of Sirius Creek: **Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting tributaries of Sirius Creek [via run-off]	Highly Unlikely	S2	**Low**
			Neutral metalliferous drainage: Metals and metalloids impacting tributaries of Sirius Creek [via run-off]	Unlikely	S2	**Low**
			Saline drainage (from sulfide oxidation): Salt (sulfate) impacting tributaries of Sirius Creek [via run-off]	Highly Unlikely	S2	**Low**
			Saline drainage (non-oxidative): Salt impacting tributaries of Sirius Creek [via run-off]	Unlikely	S2	**Low**
	From Kenmare spoil landform via seepage into shallow permeable strata then into ephemeral tributaries of Sirius Creek. Distance <100m to receptor (west / south / southwest). *Potential for AMD to enter shallow groundwater: **Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to enter shallow groundwater: **Unlikely***	Ephemeral creek (via shallow permeable strata: tributaries of Sirius Creek @ west / south / southwestern side of Kenmare spoil landform. *Potential for AMD to reach tributaries of Sirius Creek: **Highly Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach tributaries of Sirius Creek: **Highly Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting tributaries of Sirius Creek [via seepage] Risk primarily lies with seepage from buried tailings at Ramp 72 TSF and rejects within the southern end of Kenmare pit	Unlikely	S3	**Low to Medium**
			Neutral metalliferous drainage: Metals and metalloids impacting tributaries of Sirius Creek [via seepage] Risk primarily lies with seepage from buried tailings at Ramp 72 TSF and rejects within the southern end of Kenmare pit	Unlikely	S3	**Low to Medium**
			Saline drainage (from sulfide oxidation): Salt (sulfate) impacting tributaries of Sirius Creek [via seepage] Risk primarily lies with seepage from buried tailings at Ramp 72 TSF and rejects within the southern end of Kenmare pit	Unlikely	S3	**Low to Medium**
			Saline drainage (non-oxidative): Salt impacting tributaries of Sirius Creek [via seepage] Risk primarily lies with seepage from buried tailings at Ramp 72 TSF and rejects within the southern end of Kenmare pit	Unlikely	S2	**Low**

Table C7. Source-Pathway-Receptor (SPR) assessment of Laleham spoil landform: surface water receptors via run-off and via shallow permeable strata (shallow groundwater)

Source	Pathway	Receptor	Event / potential harm	Likelihood of Event	Severity of Event	Risk Rating
Laleham spoil landform (post-closure) Comprised of approximately 99% non-carbonaceous spoil and approximately 1% carbonaceous spoil. No rejects or tailings. *AMD source hazard of landform is* ***Low*** *Salinity (non-oxidative) source hazard of landform:* ***Low***	From Laleham spoil landform via surface water run-off into ephemeral Sirius Creek. Distance <100m to receptor (south / southwest). *Potential for AMD to enter surface water run-off:* ***Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to enter surface water run-off:* ***Unlikely***	Ephemeral creek (via surface water run-off): Sirius Creek @ south / southwestern side of Laleham spoil landform. *Potential for AMD to reach Sirius Creek:* ***Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach Sirius Creek:* ***Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting Sirius Creek [via run-off]	Highly Unlikely	S1	**Low**
			Neutral metalliferous drainage: Metals and metalloids impacting Sirius Creek [via run-off]	Unlikely	S1	**Low**
			Saline drainage (from sulfide oxidation): Salt (sulfate) impacting Sirius Creek [via run-off]	Highly Unlikely	S1	**Low**
			Saline drainage (non-oxidative): Salt impacting Sirius Creek [via run-off]	Unlikely	S1	**Low**
	From Laleham spoil landform via seepage into shallow permeable strata then into ephemeral Sirius Creek. Distance <100m to receptor (south / southwest). *Potential for AMD to enter shallow groundwater:* ***Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to enter shallow groundwater:* ***Unlikely***	Ephemeral creek (via shallow permeable strata: Sirius Creek @ south / southwestern side of Laleham spoil landform. *Potential for AMD to reach Sirius Creek:* ***Highly Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach Sirius Creek:* ***Highly Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting Sirius Creek [via seepage]	Highly Unlikely	S1	**Low**
			Neutral metalliferous drainage: Metals and metalloids impacting Sirius Creek [via seepage]	Unlikely	S1	**Low**
			Saline drainage (from sulfide oxidation): Salt (sulfate) impacting Sirius Creek [via seepage]	Highly Unlikely	S1	**Low**
			Saline drainage (non-oxidative): Salt impacting Sirius Creek [via seepage]	Unlikely	S1	**Low**

Laleham TSF is within the footprint and pit shell of Laleham spoil landform, but is conservatively assessed as a stand-alone TSF landform due to its location at the edge of the landform and the concentrated nature of tailings in one area of the landform (i.e. the SPR assessment of Laleham TSF has been undertaken separate to Laleham spoil landform). Refer to **Table C13**.

Table C8. Source-Pathway-Receptor (SPR) assessment of Togara-North Marshmead spoil landform: surface water receptors via run-off and via shallow permeable strata (shallow groundwater)

Source	Pathway	Receptor	Event / potential harm	Likelihood of Event	Severity of Event	Risk Rating
Togara-North Marshmead spoil landform (post-closure) Comprised of approximately 94% non-carbonaceous spoil; approximately 6% carbonaceous spoil; and approximately 0.2% rejects. No tailings *AMD source hazard of landform is* ***Low*** *Salinity (non-oxidative) source hazard of landform is* ***Low*** *AMD source hazard of rejects alone is* ***Moderate****. Rejects are widely distributed throughout the landform and comprise a very low proportion of the landform.*	From Togara-North Marshmead spoil landform via surface water run-off into ephemeral Sirius Creek. Distance <100m to receptor (north). *Potential for AMD to enter surface water run-off:* ***Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to enter surface water run-off:* ***Unlikely***	Ephemeral creek (via surface water run-off): Sirius Creek @ northern side of Togara-North Marshmead spoil landform. *Potential for AMD to reach Sirius Creek:* ***Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach Sirius Creek:* ***Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting Sirius Creek [via run-off]	Highly Unlikely	S1	**Low**
			Neutral metalliferous drainage: Metals and metalloids impacting Sirius Creek [via run-off]	Unlikely	S1	**Low**
			Saline drainage (from sulfide oxidation): Salt (sulfate) impacting Sirius Creek [via run-off]	Highly Unlikely	S1	**Low**
			Saline drainage (non-oxidative): Salt impacting Sirius Creek [via run-off]	Unlikely	S1	**Low**
	From Togara-North Marshmead spoil landform via seepage into shallow permeable strata then into ephemeral Sirius Creek. Distance <100m to receptor (north). *Potential for AMD to enter shallow groundwater:* ***Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to enter shallow groundwater:* ***Unlikely***	Ephemeral creek (via shallow permeable strata: Sirius Creek @ northern side of Togara-North Marshmead spoil landform. *Potential for AMD to reach Sirius Creek:* ***Highly Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach Sirius Creek:* ***Highly Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting Sirius Creek [via seepage]	Highly Unlikely	S1	**Low**
			Neutral metalliferous drainage: Metals and metalloids impacting Sirius Creek [via seepage]	Unlikely	S1	**Low**
			Saline drainage (from sulfide oxidation): Salt (sulfate) impacting Sirius Creek [via seepage]	Highly Unlikely	S1	**Low**
			Saline drainage (non-oxidative): Salt impacting Sirius Creek [via seepage]	Unlikely	S1	**Low**
	From Togara-North Marshmead spoil landform via surface water run-off into ephemeral Rockland Creek. Distance <100m to receptor (south). *Potential for AMD to enter surface water run-off:* ***Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to enter surface water run-off:* ***Unlikely***	Ephemeral creek (via surface water run-off): Rockland Creek @ southern side of Togara-North Marshmead spoil landform. *Potential for AMD to reach Rockland Creek:* ***Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach Rockland Creek:* ***Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting Rockland Creek [via run-off]	Highly Unlikely	S1	**Low**
			Neutral metalliferous drainage: Metals and metalloids impacting Rockland Creek [via run-off]	Unlikely	S1	**Low**
			Saline drainage (from sulfide oxidation): Salt (sulfate) impacting Rockland Creek [via run-off]	Highly Unlikely	S1	**Low**
			Saline drainage (non-oxidative): Salt impacting Rockland Creek [via run-off]	Unlikely	S1	**Low**
	From Togara-North Marshmead spoil landform via seepage into shallow permeable strata then into ephemeral Rockland Creek. Distance <100m to receptor (south). *Potential for AMD to enter shallow groundwater:* ***Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to enter shallow groundwater:* ***Unlikely***	Ephemeral creek (via shallow permeable strata: Rockland Creek @ southern side of Togara-North Marshmead spoil landform. *Potential for AMD to reach Rockland Creek:* ***Highly Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach Rockland Creek:* ***Highly Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting Rockland Creek [via seepage]	Highly Unlikely	S1	**Low**
			Neutral metalliferous drainage: Metals and metalloids impacting Rockland Creek [via seepage]	Unlikely	S1	**Low**
			Saline drainage (from sulfide oxidation): Salt (sulfate) impacting Rockland Creek [via seepage]	Highly Unlikely	S1	**Low**
			Saline drainage (non-oxidative): Salt impacting Rockland Creek [via seepage]	Unlikely	S1	**Low**

Table C9. Source-Pathway-Receptor (SPR) assessment of South Marshmead spoil landform: surface water receptors via run-off and via shallow permeable strata (shallow groundwater)

Source	Pathway	Receptor	Event / potential harm	Likelihood of Event	Severity of Event	Risk Rating
South Marshmead spoil landform (post-closure) Comprised of approximately 98% non-carbonaceous spoil and approximately 2% carbonaceous spoil. No rejects or tailings *AMD source hazard of landform is **Low*** *Salinity (non-oxidative) source hazard of landform is **Low***	From South Marshmead spoil landform via surface water run-off into ephemeral Rockland Creek. Distance <100m to receptor (north). *Potential for AMD to enter surface water run-off: **Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to enter surface water run-off: **Unlikely***	Ephemeral creek (via surface water run-off): Rockland Creek @ northern side of South Marshmead spoil landform. *Potential for AMD to reach Rockland Creek: **Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach Rockland Creek: **Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting Rockland Creek [via run-off]	Highly Unlikely	S1	**Low**
			Neutral metalliferous drainage: Metals and metalloids impacting Rockland Creek [via run-off]	Unlikely	S1	**Low**
			Saline drainage (from sulfide oxidation): Salt (sulfate) impacting Rockland Creek [via run-off]	Highly Unlikely	S1	**Low**
			Saline drainage (non-oxidative): Salt impacting Rockland Creek [via run-off]	Unlikely	S1	**Low**
	From South Marshmead spoil landform via seepage into shallow permeable strata then into ephemeral Rockland Creek. Distance <100m to receptor (north). *Potential for AMD to enter shallow groundwater: **Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to enter shallow groundwater: **Unlikely***	Ephemeral creek (via shallow permeable strata: Rockland Creek @ northern side of South Marshmead spoil landform. *Potential for AMD to reach Rockland Creek: **Highly Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach Rockland Creek: **Highly Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting Rockland Creek [via seepage]	Highly Unlikely	S1	**Low**
			Neutral metalliferous drainage: Metals and metalloids impacting Rockland Creek [via seepage]	Unlikely	S1	**Low**
			Saline drainage (from sulfide oxidation): Salt (sulfate) impacting Rockland Creek [via seepage]	Highly Unlikely	S1	**Low**
			Saline drainage (non-oxidative): Salt impacting Rockland Creek [via seepage]	Unlikely	S1	**Low**
	From South Marshmead spoil landform via surface water run-off into ephemeral tributary of Shotover Creek. Distance ~600m to receptor (south). *Potential for AMD to enter surface water run-off: **Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to enter surface water run-off: **Unlikely***	Ephemeral creek (via surface water run-off): tributary of Shotover Creek @ southern side of South Marshmead spoil landform. *Potential for AMD to reach tributary of Shotover Creek: **Highly Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach tributary of Shotover Creek: **Highly Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting tributary of Shotover Creek [via run-off]	Highly Unlikely	S1	**Low**
			Neutral metalliferous drainage: Metals and metalloids impacting tributary of Shotover Creek [via run-off]	Highly Unlikely	S1	**Low**
			Saline drainage (from sulfide oxidation): Salt (sulfate) impacting tributary of Shotover Creek [via run-off]	Highly Unlikely	S1	**Low**
			Saline drainage (non-oxidative): Salt impacting tributary of Shotover Creek [via run-off]	Highly Unlikely	S1	**Low**
	From South Marshmead spoil landform via seepage into shallow permeable strata then into ephemeral tributary of Shotover Creek. Distance ~600m to receptor (south). *Potential for AMD to enter shallow groundwater: **Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to enter shallow groundwater: **Unlikely***	Ephemeral creek (via shallow permeable strata: tributary of Shotover Creek @ southern side of South Marshmead spoil landform. *Potential for AMD to reach tributary of Shotover Creek: **Highly Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach tributary of Shotover Creek: **Highly Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting tributary of Shotover Creek [via seepage]	Highly Unlikely	S1	**Low**
			Neutral metalliferous drainage: Metals and metalloids impacting tributary of Shotover Creek [via seepage]	Highly Unlikely	S1	**Low**
			Saline drainage (from sulfide oxidation): Salt (sulfate) impacting tributary of Shotover Creek [via seepage]	Highly Unlikely	S1	**Low**
			Saline drainage (non-oxidative): Salt impacting tributary of Shotover Creek [via seepage]	Highly Unlikely	S1	**Low**

Table C10. Source-Pathway-Receptor (SPR) assessment of Kennedy West spoil landform: surface water receptors via run-off and via shallow permeable strata (shallow groundwater)

Source	Pathway	Receptor	Event / potential harm	Likelihood of Event	Severity of Event	Risk Rating
Kennedy West spoil landform (post-closure) Comprised of approximately 94% non-carbonaceous spoil and approximately 6% carbonaceous spoil. No rejects or tailings *AMD source hazard of landform is* ***Low*** *Salinity (non-oxidative) source hazard of landform:* ***Low***	From Kennedy West spoil landform via surface water run-off into ephemeral Rockland Creek. Distance ~100m to receptor (west). *Potential for AMD to enter surface water run-off:* ***Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to enter surface water run-off:* ***Unlikely***	Ephemeral creek (via surface water run-off): Rockland Creek @ western side of Kennedy West spoil landform. *Potential for AMD to reach Rockland Creek:* ***Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach Rockland Creek:* ***Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting Rockland Creek [via run-off]	Highly Unlikely	S1	**Low**
			Neutral metalliferous drainage: Metals and metalloids impacting Rockland Creek [via run-off]	Unlikely	S1	**Low**
			Saline drainage (from sulfide oxidation): Salt (sulfate) impacting Rockland Creek [via run-off]	Highly Unlikely	S1	**Low**
			Saline drainage (non-oxidative): Salt impacting Rockland Creek [via run-off]	Unlikely	S1	**Low**
	From Kennedy West spoil landform via seepage into shallow permeable strata then into ephemeral Rockland Creek. Distance ~100m to receptor (west). *Potential for AMD to enter shallow groundwater:* ***Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to enter shallow groundwater:* ***Unlikely***	Ephemeral creek (via shallow permeable strata: Rockland Creek @ western side of Kennedy West spoil landform. *Potential for AMD to reach Rockland Creek:* ***Highly Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach Rockland Creek:* ***Highly Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting Rockland Creek [via seepage]	Highly Unlikely	S1	**Low**
			Neutral metalliferous drainage: Metals and metalloids impacting Rockland Creek [via seepage]	Unlikely	S1	**Low**
			Saline drainage (from sulfide oxidation): Salt (sulfate) impacting Rockland Creek [via seepage]	Highly Unlikely	S1	**Low**
			Saline drainage (non-oxidative): Salt impacting Rockland Creek [via seepage]	Unlikely	S1	**Low**

Table C11. Source-Pathway-Receptor (SPR) assessment of Comet Downs East spoil landform: surface water receptors via run-off and via shallow permeable strata (shallow groundwater)

Source	Pathway	Receptor	Event / potential harm	Likelihood of Event	Severity of Event	Risk Rating
Comet Downs East spoil landform (post-closure) Comprised of approximately 93% non-carbonaceous spoil and approximately 7% carbonaceous spoil. No rejects or tailings *AMD source hazard of landform is* ***Low*** *Salinity (non-oxidative) source hazard of landform:* ***Low***	From Comet Downs East spoil landform via surface water run-off into ephemeral Rockland Creek. Distance ~100m to receptor (east) [and ~750m west to minor tributary]. *Potential for AMD to enter surface water run-off:* ***Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to enter surface water run-off:* ***Unlikely***	Ephemeral creek (via surface water run-off): Rockland Creek @ eastern side of Comet Downs East spoil landform [and ~750m west to minor tributary]. *Potential for AMD to reach Rockland Creek:* ***Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach Rockland Creek:* ***Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting Rockland Creek [via run-off]	Highly Unlikely	S1	**Low**
			Neutral metalliferous drainage: Metals and metalloids impacting Rockland Creek [via run-off]	Unlikely	S1	**Low**
			Saline drainage (from sulfide oxidation): Salt (sulfate) impacting Rockland Creek [via run-off]	Highly Unlikely	S1	**Low**
			Saline drainage (non-oxidative): Salt impacting Rockland Creek [via run-off]	Unlikely	S1	**Low**
	From Comet Downs East spoil landform via seepage into shallow permeable strata then into ephemeral Rockland Creek. Distance ~100m to receptor (east) [and ~750m west to minor tributary]. *Potential for AMD to enter shallow groundwater:* ***Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to enter shallow groundwater:* ***Unlikely***	Ephemeral creek (via shallow permeable strata: Rockland Creek @ eastern side of Comet Downs East spoil landform [and ~750m west to minor tributary]. *Potential for AMD to reach Rockland Creek:* ***Highly Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach Rockland Creek:* ***Highly Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting Rockland Creek [via seepage]	Highly Unlikely	S1	**Low**
			Neutral metalliferous drainage: Metals and metalloids impacting Rockland Creek [via seepage]	Unlikely	S1	**Low**
			Saline drainage (from sulfide oxidation): Salt (sulfate) impacting Rockland Creek [via seepage]	Highly Unlikely	S1	**Low**
			Saline drainage (non-oxidative): Salt impacting Rockland Creek [via seepage]	Unlikely	S1	**Low**

Table C12. Source-Pathway-Receptor (SPR) assessment of NCPP TSF landform: surface water receptors via run-off and via shallow permeable strata (shallow groundwater)

Source	Pathway	Receptor	Event / potential harm	Likelihood of Event	Severity of Event	Risk Rating
NCPP TSF landform (post-closure) (**Figure 29**) Excluding cover, the TSF is comprised of approximately 80% tailings; approximately 19% rejects; and approximately 1% fill. *AMD source hazard of landform is* ***Moderate-High*** *Salinity (non-oxidative) source hazard of landform is* ***Moderate*** TSF will have a spoil cover installed at an appropriate thickness to manage the AMD hazard of the landform. *AMD source hazard of the likely spoil cover is* ***Low-Moderate****.*	From NCPP TSF landform via surface water run-off into ephemeral Deep Creek. Distance <100m to receptor (south / southeast). *Potential for AMD to enter surface water run-off:* ***Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to enter surface water run-off:* ***Unlikely***	Ephemeral creek (via surface water run-off): Deep Creek @ south / southeastern side of NCPP TSF landform. *Potential for AMD to reach Deep Creek:* ***Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach Deep Creek:* ***Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting Deep Creek [via run-off]	Unlikely	S2	**Low**
			Neutral metalliferous drainage: Metals and metalloids impacting Deep Creek [via run-off]	Unlikely	S2	**Low**
			Saline drainage (from sulfide oxidation): Salt (sulfate) impacting Deep Creek [via run-off]	Unlikely	S2	**Low**
			Saline drainage (non-oxidative): Salt impacting Deep Creek [via run-off]	Unlikely	S2	**Low**
	From NCPP TSF landform via seepage into shallow permeable strata then into ephemeral Deep Creek. Distance <100m to receptor (south / southeast). *Potential for AMD to enter shallow groundwater:* ***Probable*** *Potential for salt (non-oxidative) >900 µS/cm to enter shallow groundwater:* ***Probable***	Ephemeral creek (via shallow permeable strata: Deep Creek @ south / southeastern side of NCPP TSF landform. *Potential for AMD to reach Deep Creek:* ***Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach Deep Creek:* ***Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting Deep Creek [via seepage]	Unlikely	S3	**Low to Medium**
			Neutral metalliferous drainage: Metals and metalloids impacting Deep Creek [via seepage]	Unlikely	S3	**Low to Medium**
			Saline drainage (from sulfide oxidation): Salt (sulfate) impacting Deep Creek [via seepage]	Unlikely	S3	**Low to Medium**
			Saline drainage (non-oxidative): Salt impacting Deep Creek [via seepage]	Unlikely	S2	**Low**

Table C13. Source-Pathway-Receptor (SPR) assessment of Laleham TSF landform: surface water receptors via run-off and via shallow permeable strata (shallow groundwater)

Source	Pathway	Receptor	Event / potential harm	Likelihood of Event	Severity of Event	Risk Rating
Laleham TSF landform (post-closure) (Figure 30) Excluding cover, the TSF is comprised of approximately 90% tailings; approximately 4% rejects; and approximately 6% spoil/fill. *AMD source hazard of landform is* ***Moderate-High*** *Salinity (non-oxidative) source hazard of landform is* ***Moderate*** TSF will have a spoil cover installed at an appropriate thickness to manage the AMD hazard of the landform. *AMD source hazard of the likely spoil cover is* ***Low-Moderate****.*	From Laleham TSF landform via surface water run-off into ephemeral Sirius Creek. Distance ~370m to receptor (south). *Potential for AMD to enter surface water run-off:* ***Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to enter surface water run-off:* ***Unlikely***	Ephemeral creek (via surface water run-off): Sirius Creek @ southern side of Laleham TSF landform. *Potential for AMD to reach Sirius Creek:* ***Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach Sirius Creek:* ***Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting Sirius Creek [via run-off]	Highly Unlikely	S2	**Low**
			Neutral metalliferous drainage: Metals and metalloids impacting Sirius Creek [via run-off]	Highly Unlikely	S2	**Low**
			Saline drainage (from sulfide oxidation): Salt (sulfate) impacting Sirius Creek [via run-off]	Highly Unlikely	S2	**Low**
			Saline drainage (non-oxidative): Salt impacting Sirius Creek [via run-off]	Highly Unlikely	S2	**Low**
	From Laleham TSF landform via seepage into shallow permeable strata then into ephemeral Sirius Creek. Distance ~370m to receptor (south). *Potential for AMD to enter shallow groundwater:* ***Probable*** *Potential for salt (non-oxidative) >900 µS/cm to enter shallow groundwater:* ***Probable***	Ephemeral creek (via shallow permeable strata: Sirius Creek @ southern side of Laleham TSF landform. *Potential for AMD to reach Sirius Creek:* ***Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach Sirius Creek:* ***Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting Sirius Creek [via seepage]	Highly Unlikely	S2	**Low**
			Neutral metalliferous drainage: Metals and metalloids impacting Sirius Creek [via seepage]	Highly Unlikely	S2	**Low**
			Saline drainage (from sulfide oxidation): Salt (sulfate) impacting Sirius Creek [via seepage]	Highly Unlikely	S2	**Low**
			Saline drainage (non-oxidative): Salt impacting Sirius Creek [via seepage]	Highly Unlikely	S2	**Low**

Table C14. Source-Pathway-Receptor (SPR) assessment of Bottom Dam TSF and rejects landform: surface water receptors via run-off and seepage/groundwater

Source	Pathway	Receptor	Event / potential harm	Likelihood of Event	Severity of Event	Risk Rating
Bottom Dam TSF and rejects landform (post-closure) (Figure 31) Excluding cover, the Bottom Dam area is estimated to be comprised of approximately 50% tailings and 50% rejects. *AMD source hazard of landform is assumed **Moderate-High*** *Salinity (non-oxidative) source hazard of landform is assumed **Moderate*** TSF/rejects area will have a spoil cover installed at an appropriate thickness to manage the AMD hazard of the landform. *AMD source hazard of the likely spoil cover is **Low-Moderate**.*	From Bottom Dam TSF/rejects landform via surface water run-off into ephemeral Sirius Creek. Distance ~750m to receptor (south). *Potential for AMD to enter surface water run-off: **Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to enter surface water run-off: **Unlikely***	Ephemeral creek (via surface water run-off): Sirius Creek ~750 m south of Bottom Dam landform. *Potential for AMD to reach Sirius Creek: **Highly Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach Sirius Creek: **Highly Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting Sirius Creek [via run-off]	Highly Unlikely	S1	Low
			Neutral metalliferous drainage: Metals and metalloids impacting Sirius Creek [via run-off]	Highly Unlikely	S1	Low
			Saline drainage (from sulfide oxidation): Salt (sulfate) impacting Sirius Creek [via run-off]	Highly Unlikely	S1	Low
			Saline drainage (non-oxidative): Salt impacting Sirius Creek [via run-off]	Highly Unlikely	S1	Low
	From Bottom Dam TSF/rejects landform via seepage into groundwater (Permian aquifer) then into ephemeral Sirius Creek. Distance ~750m to receptor (south). *Potential for AMD to enter groundwater: **Probable*** *Potential for salt (non-oxidative) >900 µS/cm to enter groundwater: **Probable***	Ephemeral creek (via seepage/groundwater: Sirius Creek ~750 m south of Bottom Dam landform. *Potential for AMD to reach Sirius Creek: **Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach Sirius Creek: **Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting Sirius Creek [via groundwater]	Unlikely	S1	Low
			Neutral metalliferous drainage: Metals and metalloids impacting Sirius Creek [via groundwater]	Unlikely	S1	Low
			Saline drainage (from sulfide oxidation): Salt (sulfate) impacting Sirius Creek [via groundwater]	Unlikely	S1	Low
			Saline drainage (non-oxidative): Salt impacting Sirius Creek [via groundwater]	Unlikely	S1	Low

Table C15. Source-Pathway-Receptor (SPR) assessment of Ramp 36 rejects landform: surface water receptors via run-off and via shallow permeable strata (shallow groundwater)

Source	Pathway	Receptor	Event / potential harm	Likelihood of Event	Severity of Event	Risk Rating
Ramp 36 rejects landform (post-closure) (**Figure 32**) Excluding cover, the rejects landform is comprised of approximately 99% rejects; and approximately 1% fill. No tailings. *AMD source hazard of landform is **Moderate*** *Salinity (non-oxidative) source hazard of landform is **Moderate*** Rejects dump will have a spoil cover installed at an appropriate thickness to manage the AMD hazard of the landform. *AMD source hazard of the likely spoil cover is **Low-Moderate**.*	From Ramp 36 rejects landform via surface water run-off into ephemeral Deep Creek. Distance <100m to receptor (north / northeast). *Potential for AMD to enter surface water run-off: **Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to enter surface water run-off: **Unlikely***	Ephemeral creek (via surface water run-off): Deep Creek @ north / northwestern side of Ramp 36 rejects landform. *Potential for AMD to reach Deep Creek: **Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach Deep Creek: **Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting Deep Creek [via run-off]	Unlikely	S2	Low
			Neutral metalliferous drainage: Metals and metalloids impacting Deep Creek [via run-off]	Unlikely	S2	Low
			Saline drainage (from sulfide oxidation): Salt (sulfate) impacting Deep Creek [via run-off]	Unlikely	S2	Low
			Saline drainage (non-oxidative): Salt impacting Deep Creek [via run-off]	Unlikely	S2	Low
	From Ramp 36 rejects landform via seepage into shallow permeable strata then into ephemeral Deep Creek. Distance <100m to receptor (north / northwest). *Potential for AMD to enter shallow groundwater: **Probable*** *Potential for salt (non-oxidative) >900 µS/cm to enter shallow groundwater: **Probable***	Ephemeral creek (via shallow permeable strata: Deep Creek @ south / southeastern side of Ramp 36 rejects landform. *Potential for AMD to reach Deep Creek: **Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach Deep Creek: **Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting Deep Creek [via seepage]	Unlikely	S3	Low to Medium
			Neutral metalliferous drainage: Metals and metalloids impacting Deep Creek [via seepage]	Unlikely	S2	Low
			Saline drainage (from sulfide oxidation): Salt (sulfate) impacting Deep Creek [via seepage]	Unlikely	S3	Low to Medium
			Saline drainage (non-oxidative): Salt impacting Deep Creek [via seepage]	Unlikely	S2	Low

Table C16. Source-Pathway-Receptor (SPR) assessment of Ramp 8, Bonnie Doon, Mimosa-Besgrove and Deep Creek spoil landforms: residual void receptors

Source	Pathway	Receptor	Event / potential harm	Likelihood of Event	Severity of Event	Risk Rating
Ramp 8 spoil landform Comprised of approximately 96% non-carbonaceous spoil and approximately 4% carbonaceous spoil. No rejects or tailings. *AMD source hazard of landform is **Low*** *Salinity (non-oxidative) source hazard of landform: **Low***	Seepage / percolation from Ramp 8 spoil landform into groundwater, which flows into Ramp 8 residual void. Residual void is expected to intersect the water table. Residual void is a groundwater 'sink', drawing all groundwater within the void groundwater catchment towards the residual void. *Potential for AMD to enter groundwater: **Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to enter groundwater: **Unlikely***	Ramp 8 residual void (NUMA). *Potential for AMD to reach residual void: **Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach residual void: **Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting Ramp 8 residual void water quality	Highly Unlikely	S1	**Low**
			Neutral metalliferous drainage: Metals and metalloids impacting Ramp 8 residual void water quality	Unlikely	S1	**Low**
			Saline drainage (from sulfide oxidation): Salt (sulfate) impacting Ramp 8 residual void water quality	Highly Unlikely	S1	**Low**
			Saline drainage (non-oxidative): Salt impacting Ramp 8 residual void water quality	Unlikely	S1	**Low**
Bonnie Doon spoil landform (post-closure) Comprised of approximately 96% non-carbonaceous spoil and approximately 4% carbonaceous spoil. No rejects or tailings. *AMD source hazard of landform is **Low*** *Salinity (non-oxidative) source hazard of landform: **Low***	Seepage / percolation from Bonnie Doon spoil landform into groundwater, which flows into Bonnie Doon residual void. Residual void is expected to intersect the water table. Residual void is a groundwater 'sink', drawing all groundwater within the void groundwater catchment towards the residual void. *Potential for AMD to enter groundwater: **Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to enter groundwater: **Unlikely***	Bonnie Doon residual void (NUMA). *Potential for AMD to reach residual void: **Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach residual void: **Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting Bonnie Doon residual void water quality	Highly Unlikely	S1	**Low**
			Neutral metalliferous drainage: Metals and metalloids impacting Bonnie Doon residual void water quality	Unlikely	S1	**Low**
			Saline drainage (from sulfide oxidation): Salt (sulfate) impacting Bonnie Doon residual void water quality	Highly Unlikely	S1	**Low**
			Saline drainage (non-oxidative): Salt impacting Bonnie Doon void water quality	Unlikely	S1	**Low**
Mimosa-Besgrove spoil landform (post-closure) Comprised of approx. 95% non-carb. spoil; approx. 2.9% carb. spoil; and approx. 1.9% rejects. No tailings. *AMD source hazard of landform is **Low*** *Salinity (non-oxidative) source hazard of landform is **Low*** *Rejects concentrated at R32 rejects dump, <100m from edge of spoil landform. AMD source hazard of rejects is **Moderate***	Seepage / percolation from Mimosa-Besgrove spoil landform into groundwater, which flows into Mimosa-Besgrove residual void. Residual void is expected to intersect the water table. Residual void is a groundwater 'sink', drawing all groundwater within the void groundwater catchment towards the residual void. *Potential for AMD to enter groundwater: **Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to enter groundwater: **Unlikely***	Mimosa-Besgrove residual void (NUMA). *Potential for AMD to reach residual void: **Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach residual void: **Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting Mimosa-Besgrove residual void water quality	Highly Unlikely	S1	**Low**
			Neutral metalliferous drainage: Metals and metalloids impacting Mimosa-Besgrove residual void water quality	Unlikely	S1	**Low**
			Saline drainage (from sulfide oxidation): Salt (sulfate) impacting Mimosa-Besgrove residual void water quality	Highly Unlikely	S1	**Low**
			Saline drainage (non-oxidative): Salt impacting Mimosa-Besgrove residual void water quality	Unlikely	S1	**Low**
Deep Creek spoil landform (post-closure) Comprised of approx. 96% non-carb. spoil; approx. 3% carb. spoil; and approx. 1% rejects. No tailings. *AMD source hazard of landform is **Low*** *Salinity (non-oxidative) source hazard of landform is **Low*** *AMD source hazard of rejects alone is **Moderate**. Rejects are distributed throughout the landform.*	Seepage / percolation from Deep Creek spoil landform into groundwater, which flows into Deep Creek residual void. Residual void is expected to intersect the water table. Residual void is a groundwater 'sink', drawing all groundwater within the void groundwater catchment towards the residual void. *Potential for AMD to enter groundwater: **Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to enter groundwater: **Unlikely***	Deep Creek residual void (NUMA). *Potential for AMD to reach residual void: **Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach residual void: **Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting Deep Creek residual void water quality	Highly Unlikely	S1	**Low**
			Neutral metalliferous drainage: Metals and metalloids impacting Deep Creek residual void water quality	Unlikely	S1	**Low**
			Saline drainage (from sulfide oxidation): Salt (sulfate) impacting Deep Creek residual void water quality	Highly Unlikely	S1	**Low**
			Saline drainage (non-oxidative): Salt impacting Deep Creek residual void water quality	Unlikely	S1	**Low**

Table C17. Source-Pathway-Receptor (SPR) assessment of Stewarton-Ballamoo, Kenmare, Laleham and Togara-North Marshmnead spoil landforms: residual void receptors

Source	Pathway	Receptor	Event / potential harm	Likelihood of Event	Severity of Event	Risk Rating
Stewarton-Ballamoo spoil landform (post-closure) Comprised of approx. 96% non-carb. spoil; approx. 4% carb. spoil; and less than 0.2% rejects. No tailings. *AMD source hazard of landform is **Low*** *Salinity (non-oxidative) source hazard of landform is **Low*** *AMD source hazard of rejects is **Moderate**. Rejects are distributed throughout spoil.*	Seepage / percolation from Stewarton-Ballamoo spoil landform into groundwater, which flows into Stewarton-Ballamoo residual void. Residual void is expected to intersect the water table. Residual void is a groundwater 'sink', drawing all groundwater within the void groundwater catchment towards the residual void. *Potential for AMD to enter groundwater: **Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to enter groundwater: **Unlikely***	Stewarton-Ballamoo residual void (NUMA). *Potential for AMD to reach residual void: **Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach residual void: **Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting Stewarton-Ballamoo residual void water quality	Highly Unlikely	S1	**Low**
			Neutral metalliferous drainage: Metals and metalloids impacting Stewarton-Ballamoo residual void water quality	Unlikely	S1	**Low**
			Saline drainage (from sulfide oxidation): Salt (sulfate) impacting Stewarton-Ballamoo residual void water quality	Highly Unlikely	S1	**Low**
			Saline drainage (non-oxidative): Salt impacting Stewarton-Ballamoo residual void water quality	Unlikely	S1	**Low**
Kenmare spoil landform (post-closure) Comprised of approx. 95% non-carb. spoil; approx. 3% carb. spoil; approx. 1% rejects; and approx. 1% tailings. *AMD source hazard of landform is **Low**.* *Salinity (non-oxidative) source hazard of landform is **Low**.* All tailings and about half of rejects are located at R72 TSF and southern end of Kenmare pit. *AMD source hazard of R72 tailings and rejects is **Moderate-High to High**.* *AMD source hazard of R70 rejects is **Moderate***	Seepage / percolation from Kenmare spoil landform into groundwater, which flows into Kenmare residual void. Residual void is expected to intersect the water table. Residual void is a groundwater 'sink', drawing all groundwater within the void groundwater catchment towards the residual void. *Potential for AMD to enter groundwater: **Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to enter groundwater: **Unlikely***	Kenmare residual void (NUMA). *Potential for AMD to reach residual void: **Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach residual void: **Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting Kenmare residual void water quality	Highly Unlikely	S1	**Low**
			Neutral metalliferous drainage: Metals and metalloids impacting Kenmare residual void water quality	Unlikely	S1	**Low**
			Saline drainage (from sulfide oxidation): Salt (sulfate) impacting Kenmare residual void water quality	Highly Unlikely	S1	**Low**
			Saline drainage (non-oxidative): Salt impacting Kenmare void water quality	Unlikely	S1	**Low**
Laleham spoil landform (post-closure) Comprised of approximately 99% non-carbonaceous spoil and approximately 1% carbonaceous spoil. No rejects or tailings. *AMD source hazard of landform is **Low*** *Salinity (non-oxidative) source hazard of landform: **Low***	Seepage / percolation from Laleham spoil landform into groundwater, which flows into Togara-North Marshmead residual void. Residual void is expected to intersect the water table. Residual void is a groundwater 'sink', drawing all groundwater within the void groundwater catchment towards the residual void. *Potential for AMD to enter groundwater: **Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to enter groundwater: **Unlikely***	Togara-North Marshmead residual void (NUMA). *Potential for AMD to reach residual void: **Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach residual void: **Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting Togara-Nth Marshmead residual void water quality	Highly Unlikely	S1	**Low**
			Neutral metalliferous drainage: Metals and metalloids impacting Togara-Nth Marshmead residual void water quality	Unlikely	S1	**Low**
			Saline drainage (from sulfide oxidation): Salt (sulfate) impacting Togara-Nth Marshmead residual void water quality	Highly Unlikely	S1	**Low**
			Saline drainage (non-oxidative): Salt impacting Togara-Nth Marshmead residual void water quality	Unlikely	S1	**Low**
Togara-North Marshmead spoil landform (post-closure) Comprised of approx. 94% non-carb. spoil; approx. 6% carb. spoil; and approx. 0.2% rejects. No tailings. *AMD source hazard of landform is **Low*** *Salinity (non-oxidative) source hazard of landform is **Low*** *AMD source hazard of rejects alone is **Moderate**. Rejects are distributed throughout the landform.*	Seepage / percolation from Deep Creek spoil landform into groundwater, which flows into Togara-North Marshmead residual void. Residual void is expected to intersect the water table. Residual void is a groundwater 'sink', drawing all groundwater within the void groundwater catchment towards the residual void. *Potential for AMD to enter groundwater: **Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to enter groundwater: **Unlikely***	Togara-North Marshmead residual void (NUMA). *Potential for AMD to reach residual void: **Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach residual void: **Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting Togara-Nth Marshmead residual void water quality	Highly Unlikely	S1	**Low**
			Neutral metalliferous drainage: Metals and metalloids impacting Togara-Nth Marshmead residual void water quality	Unlikely	S1	**Low**
			Saline drainage (from sulfide oxidation): Salt (sulfate) impacting Togara-Nth Marshmead residual void water quality	Highly Unlikely	S1	**Low**
			Saline drainage (non-oxidative): Salt impacting Togara-Nth Marshmead residual void water quality	Unlikely	S1	**Low**

Table C18. Source-Pathway-Receptor (SPR) assessment of South Marshmead, Kennedy West and Comet Downs East spoil landforms: residual void receptors

Source	Pathway	Receptor	Event / potential harm	Likelihood of Event	Severity of Event	Risk Rating
South Marshmead spoil landform (post-closure) Comprised of approximately 98% non-carbonaceous spoil and approximately 2% carbonaceous spoil. No rejects or tailings. *AMD source hazard of landform is **Low*** *Salinity (non-oxidative) source hazard of landform is **Low***	Seepage / percolation from South Marshmead spoil landform into groundwater, which flows into South Marshmead residual void. Residual void is expected to intersect the water table. Residual void is a groundwater 'sink', drawing all groundwater within the void groundwater catchment towards the residual void. *Potential for AMD to enter groundwater: **Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to enter groundwater: **Unlikely***	South Marshmead residual void (NUMA). *Potential for AMD to reach residual void: **Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach residual void: **Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting South Marshmead residual void water quality	Highly Unlikely	S1	**Low**
			Neutral metalliferous drainage: Metals and metalloids impacting South Marshmead residual void water quality	Unlikely	S1	**Low**
			Saline drainage (from sulfide oxidation): Salt (sulfate) impacting South Marshmead residual void water quality	Highly Unlikely	S1	**Low**
			Saline drainage (non-oxidative): Salt impacting South Marshmead residual void water quality	Unlikely	S1	**Low**
Kennedy West spoil landform (post-closure) Comprised of approximately 94% non-carbonaceous spoil and approximately 6% carbonaceous spoil. No rejects or tailings. *AMD source hazard of landform is **Low*** *Salinity (non-oxidative) source hazard of landform is **Low***	Seepage / percolation from Kennedy West spoil landform into groundwater, which flows into Kennedy West residual void. Residual void is expected to intersect the water table. Residual void is a groundwater 'sink', drawing all groundwater within the void groundwater catchment towards the residual void. *Potential for AMD to enter groundwater: **Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to enter groundwater: **Unlikely***	Kennedy West residual void (NUMA). *Potential for AMD to reach residual void: **Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach residual void: **Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting Kennedy West residual void water quality	Highly Unlikely	S1	**Low**
			Neutral metalliferous drainage: Metals and metalloids impacting Kennedy West residual void water quality	Unlikely	S1	**Low**
			Saline drainage (from sulfide oxidation): Salt (sulfate) impacting Kennedy West residual void water quality	Highly Unlikely	S1	**Low**
			Saline drainage (non-oxidative): Salt impacting Kennedy West void water quality	Unlikely	S1	**Low**
Comet Downs East spoil landform (post-closure) Comprised of approximately 93% non-carbonaceous spoil and approximately 7% carbonaceous spoil. No rejects or tailings. *AMD source hazard of landform is **Low*** *Salinity (non-oxidative) source hazard of landform is **Low***	Seepage / percolation from Comet Downs East spoil landform into groundwater, which flows into Comet Downs East residual void. Residual void is expected to intersect the water table. Residual void is a groundwater 'sink', drawing all groundwater within the void groundwater catchment towards the residual void. *Potential for AMD to enter groundwater: **Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to enter groundwater: **Unlikely***	Comet Downs East residual void (NUMA). *Potential for AMD to reach residual void: **Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach residual void: **Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting Comet Downs East residual void water quality	Highly Unlikely	S1	**Low**
			Neutral metalliferous drainage: Metals and metalloids impacting Comet Downs East residual void water quality	Unlikely	S1	**Low**
			Saline drainage (from sulfide oxidation): Salt (sulfate) impacting Comet Downs East residual void water quality	Highly Unlikely	S1	**Low**
			Saline drainage (non-oxidative): Salt impacting Comet Downs East residual void water quality	Unlikely	S1	**Low**

Table C19. Source-Pathway-Receptor (SPR) assessment of post-closure TSF and rejects landforms: residual void receptors

Source	Pathway	Receptor	Event / potential harm	Likelihood of Event	Severity of Event	Risk Rating
NCPP TSF landform (post-closure) Excluding cover, the TSF is comprised of approx. 80% tailings, approx. 19% rejects, and approx. 1% fill. *AMD source hazard of landform is **Moderate-High**. Salinity (non-oxidative) source hazard of landform is **Moderate**.* TSF will have a spoil cover installed at an appropriate thickness to manage the AMD hazard of the landform. *Assume AMD source hazard of the spoil cover is **Low-Moderate***	Seepage / percolation from NCPP TSF landform into groundwater, which flows into Deep Creek residual void. Residual void is expected to intersect the water table. Residual void is a groundwater 'sink', drawing all groundwater within the void groundwater catchment towards the residual void. *Potential for AMD to enter groundwater: **Probable*** *Potential for salt (non-oxidative) >900 µS/cm to enter groundwater: **Probable***	Deep Creek residual void (NUMA). *Potential for AMD to reach residual void: **Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach residual void: **Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting Deep Creek residual void water quality	Unlikely	S2	**Low**
			Neutral metalliferous drainage: Metals and metalloids impacting Deep Creek residual void water quality	Unlikely	S2	**Low**
			Saline drainage (from sulfide oxidation): Salt (sulfate) impacting Deep Creek residual void water quality	Unlikely	S2	**Low**
			Saline drainage (non-oxidative): Salt impacting Deep Creek residual void water quality	Unlikely	S2	**Low**
Laleham TSF landform (post-closure) Excluding cover, the TSF is comprised of approx. 90% tailings, approx. 4% rejects, and approx. 6% spoil/fill. *AMD source hazard of landform is **Moderate-High**. Salinity (non-oxidative) source hazard of landform is **Moderate**.* TSF will have a spoil cover installed at an appropriate thickness to manage the AMD hazard of the landform. *AMD source hazard of the likely spoil cover is **Low-Moderate**.*	Seepage / percolation from Laleham TSF landform into groundwater, which flows into Togara-North Marshmead residual void. Residual void is expected to intersect the water table. Residual void is a groundwater 'sink', drawing all groundwater within the void groundwater catchment towards the residual void. *Potential for AMD to enter groundwater: **Probable*** *Potential for salt (non-oxidative) >900 µS/cm to enter groundwater: **Probable***	Togara-North Marshmead residual void (NUMA). *Potential for AMD to reach residual void: **Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach residual void: **Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting Togara-Nth Marshmead residual void water quality	Unlikely	S2	**Low**
			Neutral metalliferous drainage: Metals and metalloids impacting Togara-Nth Marshmead residual void water quality	Unlikely	S2	**Low**
			Saline drainage (from sulfide oxidation): Salt (sulfate) impacting Togara-Nth Marshmead residual void water quality	Unlikely	S2	**Low**
			Saline drainage (non-oxidative): Salt impacting Togara-Nth Marshmead void water quality	Unlikely	S2	**Low**
Ramp 36 rejects landform (post-closure) Excluding cover, the rejects landform is comprised of approx. 99% rejects and 1% fill. No tailings. *AMD source hazard of landform is **Moderate**. Salinity (non-oxidative) source hazard of landform is **Moderate**.* Rejects dump will have a spoil cover installed at an appropriate thickness to manage the AMD hazard of the landform. *AMD source hazard of the likely spoil cover is **Low-Moderate**.*	Seepage / percolation from Ramp 36 rejects landform into groundwater, which flows into Deep Creek residual void. Residual void is expected to intersect the water table. Residual void is a groundwater 'sink', drawing all groundwater within the void groundwater catchment towards the residual void. *Potential for AMD to enter groundwater: **Probable*** *Potential for salt (non-oxidative) >900 µS/cm to enter groundwater: **Probable***	Deep Creek residual void (NUMA). *Potential for AMD to reach residual void: **Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach residual void: **Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting Deep Creek residual void water quality	Unlikely	S2	**Low**
			Neutral metalliferous drainage: Metals and metalloids impacting Deep Creek residual void water quality	Unlikely	S2	**Low**
			Saline drainage (from sulfide oxidation): Salt (sulfate) impacting Deep Creek residual void water quality	Unlikely	S2	**Low**
			Saline drainage (non-oxidative): Salt impacting Deep Creek residual void water quality	Unlikely	S2	**Low**

Groundwater modelling with particle tracking (SLR, 2024) shows that seepage from Bottom Dam TSF/rejects area into groundwater is expected to report to Sirius Creek (alluvium strata), not into a residual void. Refer to Table C14.

Table C20. Source-Pathway-Receptor (SPR) assessment of residual void highwall and floor: residual void receptors

Source	Pathway	Receptor	Event / potential harm	Likelihood of Event	Severity of Event	Risk Rating
Highwall and floor (tailings) of Bonnie Doon and Laleham residual voids (post-closure) Highwalls of these two voids are comprised of approximately: • 90% to 93% non-carbonaceous overburden/interburden; • <1% to 4% carbonaceous overburden/interburden; • 6% to 7% coal (residual coal seams). 'PAF' and NAF-S exposure on Bonnie Doon and Laleham void highwalls conservatively estimated at approximately 4% (vertical meterage). A proportion of this will be in lower seams, which will be buried by tailings and/or submerged. 'PAF' or NAF-S exposure on pit floors (tailings) conservatively estimated at approximately 48% (Bonnie Doon) and 56% (Laleham), however tailings will be submerged or capped/covered. *AMD source hazard from exposed highwalls is **Low-Moderate**.* *AMD source hazard from submerged or covered/capped tailings floor is **Moderate**.* *Salinity (non-oxidative) source hazard of the exposed highwalls and submerged or covered/capped tailings floor is **Moderate**.*	Surface water run-off from highwalls of Bonnie Doon and Laleham voids into their respective residual voids. *Potential for AMD to enter surface water run-off from highwall: **Probable*** *Potential for salt (non-oxidative) >900 µS/cm to enter surface water run-off from highwall: **Probable***	Bonnie Doon and Laleham residual voids (NUMA). *Potential for AMD to reach residual voids: **Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach residual voids: **Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting Bonnie Doon residual void water quality Low pH and metalliferous water impacting Laleham residual void water quality	Unlikely	S2	**Low**
			Neutral metalliferous drainage: Metals and metalloids impacting Bonnie Doon residual void water quality Metals and metalloids impacting Laleham residual void water quality	Unlikely	S2	**Low**
			Saline drainage (from sulfide oxidation): Salt (sulfate) impacting Bonnie Doon residual void water quality Salt (sulfate) impacting Laleham residual void water quality	Unlikely	S2	**Low**
			Saline drainage (non-oxidative): Salt impacting Bonnie Doon residual void water quality Salt impacting Laleham residual void water quality	Unlikely	S2	**Low**
Highwall and floor (coal) of all residual voids except Bonnie Doon and Laleham voids (post-closure) Highwalls of all non-tailings voids are comprised of approximately: • 87% to 95% non-carbonaceous overburden/interburden; • 1.2% to 6% carbonaceous overburden/interburden; • 2% to 7% coal (residual coal seams). 'PAF' and NAF-S exposure on highwalls conservatively estimated at between 4% to 7% (vertical meterage). A proportion of this will be in lower seams, which will be submerged. 'PAF' or NAF-S exposure on pit floors (coal) conservatively estimated at approximately 25%, however pit floors will be submerged. *AMD source hazard from exposed highwalls is **Low-Moderate**.* *AMD source hazard from submerged pit floors is **Moderate**.* *Salinity (non-oxidative) source hazard of the exposed highwalls and submerged pit floors is **Moderate**.*	Surface water run-off from highwalls of residual voids into residual voids. *Potential for AMD to enter surface water run-off from highwall: **Probable*** *Potential for salt (non-oxidative) >900 µS/cm to enter surface water run-off from highwall: **Probable***	All residual voids (NUMA). *Potential for AMD to reach residual voids: **Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach residual voids: **Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting residual void water quality	Unlikely	S2	**Low**
			Neutral metalliferous drainage: Metals and metalloids impacting residual void water quality	Unlikely	S2	**Low**
			Saline drainage (from sulfide oxidation): Salt (sulfate) impacting residual void water quality	Unlikely	S2	**Low**
			Saline drainage (non-oxidative): Salt impacting residual void water quality	Unlikely	S2	**Low**

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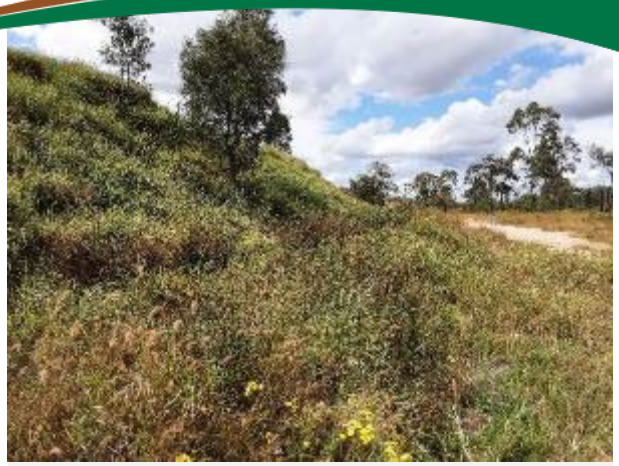
Appendix 4.8 – Landform Design

This appendix includes the following reports:

- *Landform Evolution Modelling Simulations to Support Tailings Storage Facility Design (2025).* This report was provided in response to the Not Properly Made Notice provided by DETSI on 25 November 2024.
- *Erosion and Landform Evolution Simulations to Support Waste Landform Design (2024)*



LANDFORM EVOLUTION MODELLING SIMULATIONS TO SUPPORT TAILINGS STORAGE FACILITY DESIGN: BLACKWATER MINE

March 2025

Whitehaven Coal Limited

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Project Number: 1035.24d

Report Title: Landform evolution modelling simulations to support Tailings Storage Facility design: Blackwater mine

Client: Whitehaven Coal Limited

Review History

Version Number	Prepared by:	Reviewed by:	Date:
Rev 0 (draft)	E. Howard	I. Kelder	23/02/2025
Rev 1 (final)	E. Howard		04/03/2025

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EXECUTIVE SUMMARY

Landloch has been engaged by Whitehaven Coal Limited (Whitehaven) to carry out SIBERIA landform evolution modelling for three (3) Tailings Storage Facilities (TSFs) at the Blackwater Coal Mine (Blackwater). The 3 TSFs that have been modelled are named Bottom Dam, Laleham, and NCPP.

SIBERIA LEM input parameters were previously derived for two soils present at Blackwater, heavy clay topsoil and light clay topsoil. SIBERIA LEM input parameters were derived through a process of laboratory-based erodibility testing, long-term WEPP (Water Erosion Prediction Project) runoff/erosion modelling, and analysis of 100 years of WEPP model output of daily runoff and erosion. This process is detailed as part of previous landform evolution modelling undertaken for waste landforms at Blackwater (Landloch 2024). In assigning SIBERIA parameters for each TSF, it was assumed that the topsoils and vegetation groundcover levels applied are spatially consistent with those applied in the previous landform evolution modelling work (Landloch 2024). As such, the following topsoils and vegetation groundcover levels were applied:

- Bottom Dam – Light clay topsoil with 50% vegetation cover;
- Laleham – Light clay topsoil with 50% vegetation cover; and
- NCPP – Heavy clay topsoil with vegetation groundcover levels of 70%.

SIBERIA LEM simulations indicate that the 3 proposed TSFs modelled (Bottom Dam, Laleham, and NCPP) have a low tendency for gully erosion (up to 300 years) provided the correct soils and the target levels of vegetation groundcover are achieved.

An area of increased gully erosion potential was identified in the southern section of the proposed Bottom Dam design. This increased risk is due to a steepening of the gradient in that area. This could be mitigated by further refinement of the design in this zone so that a fixed gradient is used, and a steepening gradient is avoided. Another area of increased erosion risk was identified in the northern portion of the design. However, these were model artefacts caused by imperfections in the DEM supplied. These erosion areas could be mitigated by refinement of the design input file in this zone to remove these artefacts. Once removed, the gully erosion modelled in this zone is likely to be reduced.

Some gully erosion was identified in isolated zones of the Laleham TSF. However, these were model artefacts caused by imperfections in the DEM supplied. These erosion areas could be mitigated by refinement of the design input file in these zones to remove these artefacts. Once removed, the gully erosion modelled in this zone is likely to be reduced.

The NCPP TSF design is predicted to erode at rates with a low tendency for gully erosion. However, it does erode at higher rates than either the Bottom Dam or Laleham TSFs. The increased gully erosion risk of the NCPP TSF design (relative to Bottom Dam and Laleham) is due to the use of the heavy clay topsoils and the presence of steeper-gradient outer slopes (20% rather than 15%) on some sections of the eastern side of the TSF. The increased gully erosion risk caused by the presence of steeper-gradient outer could be mitigated by further refinement of the design to lower the gradient of the outer slopes in that zone.

1 INTRODUCTION

Landloch has been engaged by Whitehaven Coal Limited (Whitehaven) to carry out SIBERIA landform evolution modelling for three (3) Tailings Storage Facilities (TSFs) at the Blackwater Coal Mine (Blackwater). The 3 TSFs that have been modelled are named:

1. Bottom Dam;
2. Laleham; and
3. NCPP.

This report briefly outlines the SIBERIA landform evolution modelling methods and provides the modelling results, including erosion statistics and visualisations.

2 MODELLING METHODS

2.1 The SIBERIA model

The SIBERIA landform evolution model predicts the long-term, 3D development of channels and hillslopes (e.g. landform batters) in a catchment based on runoff, erosion, and deposition.

SIBERIA has been successfully applied to explain aspects of the geomorphology of natural landforms (Willgoose 1994) and has been widely used to assess the evolution of constructed waste dumps on mine sites across Australia and overseas (Willgoose 1995; Willgoose and Riley 1993; Boggs *et al.* 2000; Hancock *et al.* 2003; Hancock and Willgoose 2004; Hancock 2004; Mengler *et al.* 2004; Hancock and Turley 2006). It has also been subjected to numerous validation studies. In general, the validation studies indicate that SIBERIA's predictions of landform evolution are reasonable provided the model is suitably parameterised (Hancock *et al.* 2000; Hancock *et al.* 2003). In one validation study (Hancock 2004) it was noted that erosion rates predicted by SIBERIA for a catchment in the Northern Territory compared favourably to erosion estimates derived using the caesium-137 method. As the two erosion assessment methods use independent input information, the reported agreement is particularly significant.

SIBERIA solves for two variables: elevation, from which slope geometries are determined, and an indicator function that determines where erosion features (channels) exist.

Changes to the predicted erosion features is governed by an activation threshold that is dependent on the runoff discharge and gradient of the slope. When the activation threshold is exceeded, an erosion feature is predicted to develop. In this way, it is possible for a modelled surface to initially have no erosion features and for rills/gullies to develop where the activation threshold is exceeded.

The rate at which rills and gullies develop is controlled by a channelisation function. SIBERIA does not directly input rainfall or material erodibility parameters. Rather, the SIBERIA input parameters define the channelisation function that is a function of both runoff and erosion (Willgoose *et al.* 1989). As a result, SIBERIA parameters are specific to both the climatic regime and the material being considered and must be derived for each specific material located within each specific climatic regime.

2.2 SIBERIA input parameters

SIBERIA predicts the long-term average change in elevation of a node (i.e. a point in the landscape) by predicting the volume of sediment lost from that node. The rate of sediment transport through a node (q_s in units of m^3/y) is determined by the equation:

$$q_s = \beta_1 \times q^{m_1} \times S^{n_1} \quad 1)$$

where β_1 is the sediment transport rate coefficient (unitless), q is discharge (m^3/y), m_1 is the discharge exponent (unitless), S is the slope (m/m), and n_1 is the slope exponent (unitless).

SIBERIA does not directly model discharge, but uses sub-grid effective parameterisation which relates discharge to the area draining through a node as:

$$q = \beta_3 \times A^{m_3} \quad 2)$$

where β_3 is the coefficient between discharge and area (unitless), A is area (m^2), and m_3 is the exponent of the area in discharge (unitless).

To run SIBERIA, the parameters β_1, m_1, n_1, β_3, and m_3 are needed. There is interaction between all 5 parameters, with the result that an almost infinite number of parameter sets will all show the same rate of erosion, though some aspects of the pattern of erosion that is predicted will vary. Fixed values for β_3, n_1, and m_3 are adopted where possible, reducing the difficulty of deriving parameter values. If the batter to be modelled is identical to the batter for which erosion data are available for calibration, m_3 and β_3 can be taken as 1.0, and for situations where slope gradient does not affect slope erodibility, n_1 can be taken as 1.5 (Willgoose pers. comm.). This is consistent with Kirkby (1971) who suggests values ranging from 1.3–2.0 are reasonable for soils.

Therefore, two key parameters require fitting against runoff and erosion data: β_1 and m_1. Effectively, the β_1 parameter could be described as an erosion rate parameter, as it primarily controls the rate of sediment movement. The m_1 parameter could be described as primarily controlling slope length responses of erosion.

2.3 Derivation of parameters

The β_1 and m_1 input parameters for SIBERIA are derived by fitting the SIBERIA model equations to time series data of runoff and erosion. However, in most instances, sufficient record lengths of these time series data are not available for the landforms being considered. This is particularly true for landform design planning where the landforms do not yet exist. Therefore, Landloch has developed an alternative approach for deriving the β_1 and m_1 SIBERIA input parameters:

a) Use measurements of material runoff and erosion from laboratory-based flume and rainfall simulations to derive calibrated WEPP model parameters.
b) Generate daily time-series data of runoff and erosion using WEPP set up with:
    a. Batter geometries consistent with the geometries of the landform being considered (allowing values for β_3, n_1, and m_3 to be fixed).
    b. A long-term climate sequence (100-years) that is site specific and that contains a frequent, infrequent, rare and very rare events.
c) Fit WEPP runoff and erosion output data to the SIBERIA model equations to derive values for β_1 and m_1 that are both material and site specific.

2.4 Surface soils and vegetation groundcover

SIBERIA LEM input parameters were previously derived for two soils present at Blackwater:

1. Heavy clay topsoil; and
2. Light clay topsoil.

SIBERIA LEM input parameters were derived through a process of laboratory-based erodibility testing, long-term WEPP (Water Erosion Prediction Project) runoff/erosion modelling, and analysis of 100 years of WEPP model output of daily runoff and erosion. This process is detailed as part of previous landform evolution modelling undertaken for waste landforms at Blackwater (Landloch 2024).

In assigning SIBERIA parameters for each TSF, it was assumed that the topsoils and vegetation groundcover levels applied be spatially consistent with those applied in the previous landform evolution modelling work (Landloch 2024). As such, the following topsoils and vegetation groundcover levels were applied:

- Bottom Dam – Light clay topsoil with 50% vegetation cover;
- Laleham – Light clay topsoil with 50% vegetation cover; and
- NCPP – Heavy clay topsoil with vegetation groundcover levels of 70%.

2.5 Model settings

The Digital Elevation Models (DEMs) modelled by SIBERIA included the landform surface meshed into the surrounding landscape. A random roughness (±10cm) was added to the DEMs prior to modelling. This was done to reduce triangulation gridding artefacts from the surface of the DEMs and to provide a more realistic surface for modelling (landform surfaces are not perfectly smooth).

The following SIBERIA outputs were produced for each landform modelled at years 50, 100, 150, 200, 250, and 300:

- Maximum depth of gullies at each output year with gullies defined as having a minimum depth of 0.3m;
- Average erosion (t/ha/y);
- Cumulative erosion (mm) for each output year
- Visual outputs showing the evolved DEM over which is draped the predicted material movement (erosion and deposition).

2.6 Modelling assumptions

The following assumptions apply to the SIBERIA modelling:

- The DEMs of the existing land surface and design files for the rehabilitation TSFs provided by Whitehaven are assumed to be accurate.
- Input parameters are based on a single material being present on the outer surface of the modelled landform. Light clay topsoil was applied to the surface

of the Bottom Dam and Laleham TSFs. Heavy clay topsoil was applied to the NCPP TSF.

- In considering vegetation groundcover this report specifically considers contact cover of vegetation on the soil surface. Practically, this means a combination of grass cover and anchored (not readily moved) surface litter.
- Vegetation groundcover levels for the light clay topsoil was 50%. Vegetation groundcover levels for the heavy clay topsoil was 70%.
- These vegetation groundcover levels are rapidly achieved and maintained in the long-term. It is assumed that soil management (including stripping, stockpiling, replacement, amendment, and fertilisation) will be carried out effectively to maximise early and continuing plant growth.
- During construction:
    - Batter slopes will not be formed with flow-concentrating profiles (e.g. variations in surface elevation such that there is cross-slope concentration of flow into consistent depressions running downslope).
    - Any cross-slope ripping will be carried out strictly on the contour.

3 SIBERIA MODEL SETUP

3.1 SIBERIA parameters

The SIBERIA model parameters used are shown in Table 1. These parameters were originally reported by Landloch (2024).

Table 1: Estimated SIBERIA parameters.

Material	Vegetation Groundcover (%)	m_1	β_1	n_1
Light clay topsoil	50	1.1127	0.00262	1.5
Heavy clay topsoil	70	1.2375	0.00360	1.5

3.2 Digital elevation models

Proposed 3D rehabilitation design files for the Bottom Dam, Laleham, and NCPP TSFs were provided to Landloch by Whitehaven (Figures 1–3). These rehabilitation landforms were designed based on WEPP model runoff/erosion results for the soils and vegetation groundcover levels that are to be applied.

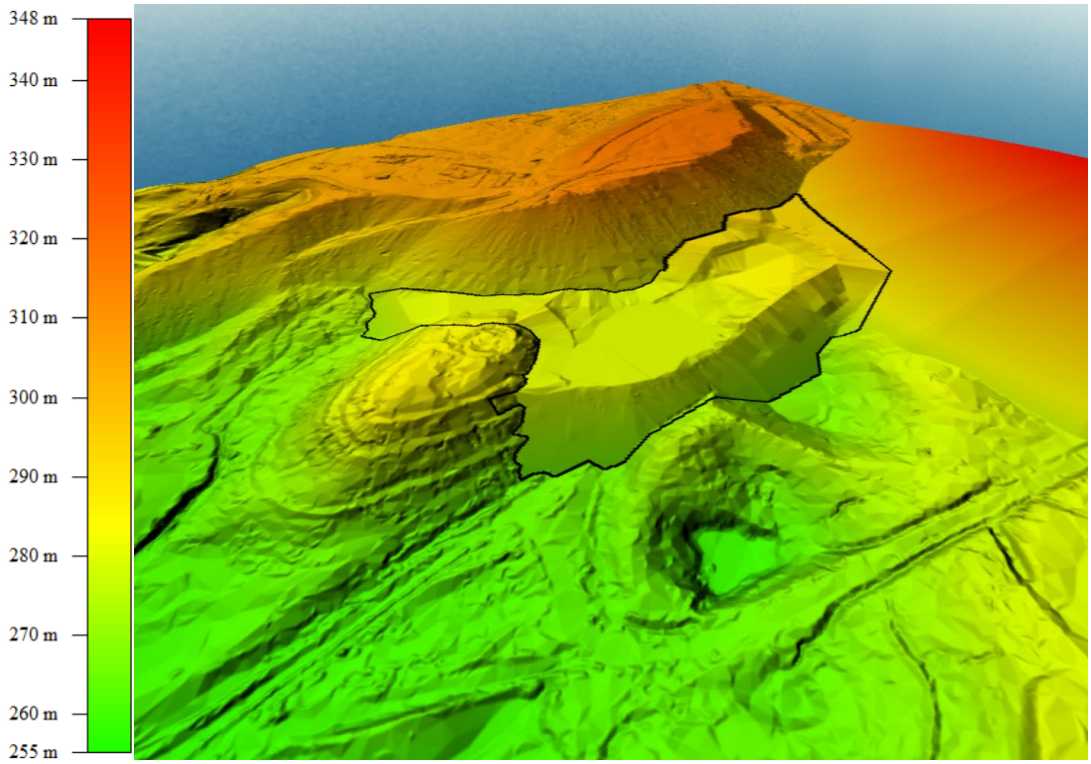

Figure 1: Digital elevation model of the Bottom Dam TSF. The black line shows the modelling domain considered within the SIBERIA LEM.

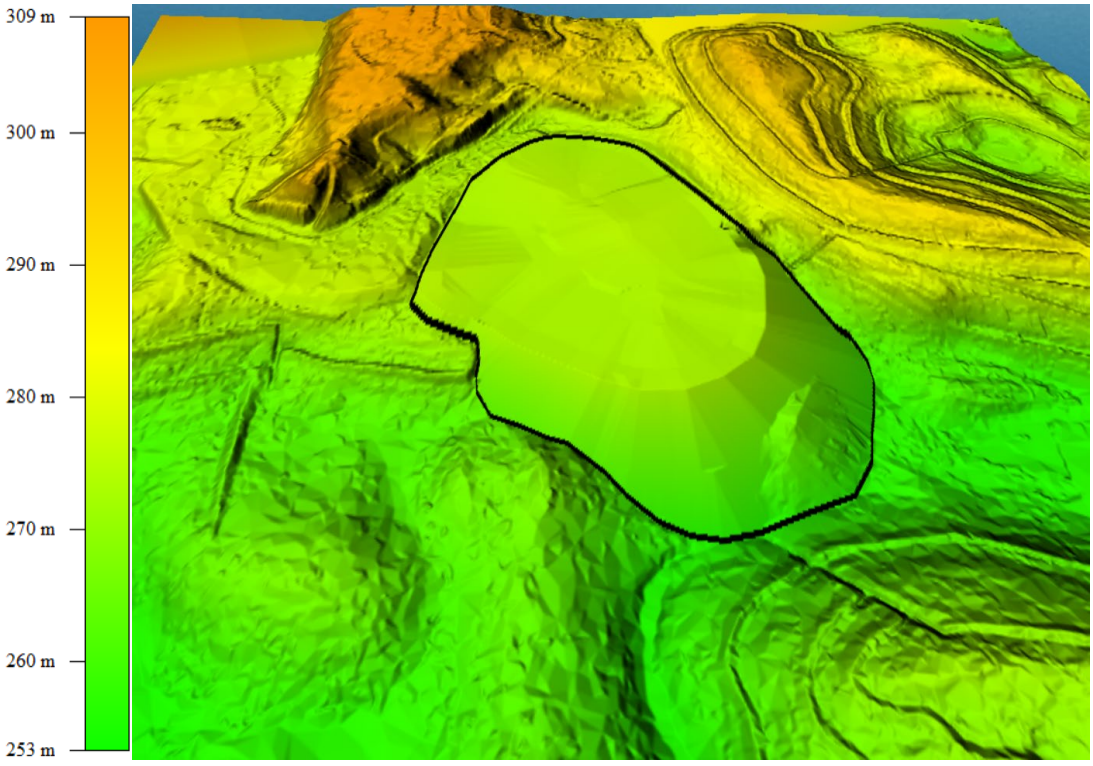

Figure 2: Digital elevation model of the Laleham TSF. The black line shows the modelling domain considered within the SIBERIA LEM.

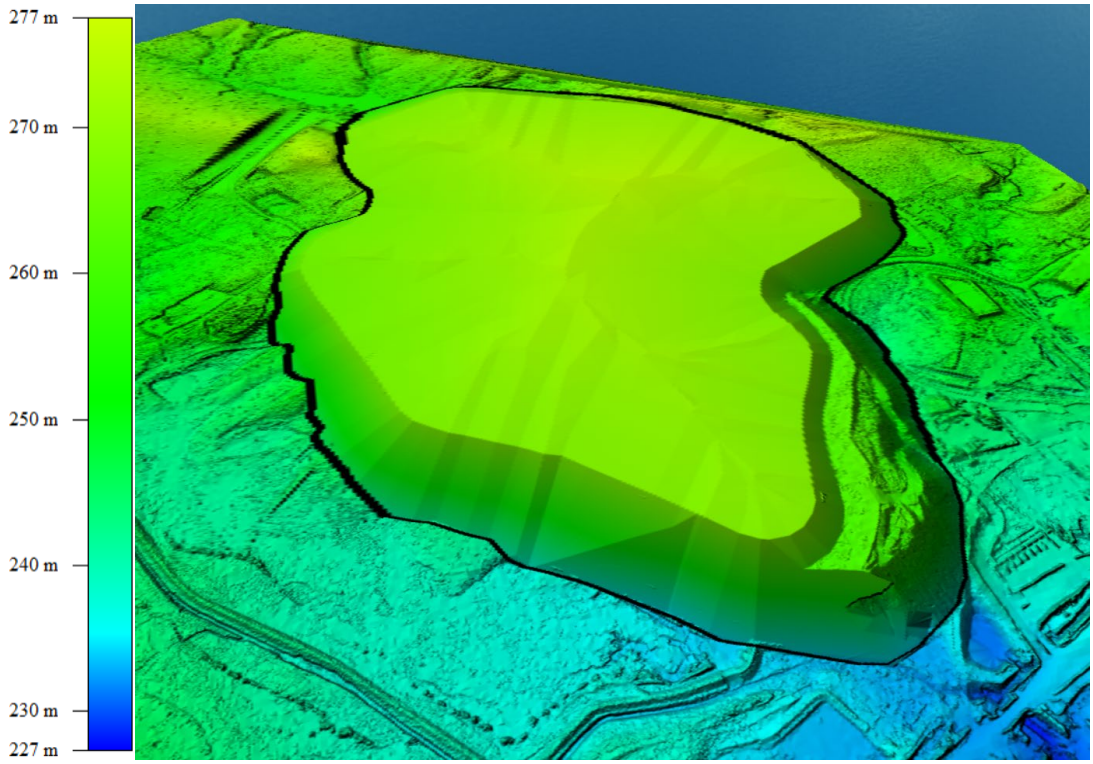

Figure 3: Digital elevation model of the NCPP TSF. The black line shows the modelling domain considered within the SIBERIA LEM.

4 SIBERIA LEM OUPUTS

Using input parameters derived for the soils and vegetation groundcover to be applied to the landforms, the SIBERIA LEM was run for a period of 300 years, with outputs being generated at 50, 100, 200, and 300 years within the simulation period.

At each output year, visualisations of rill/gully development were produced along with a table of maximum gully depths, average annual erosion rates, and cumulative average erosion depths. These rates and depths are calculated for the steep-gradient outer slopes within the modelling domain and exclude the low gradient landform top or berm areas (if they exist).

Negative material movements (i.e. erosion) that exceed 0.3m are considered gully erosion and are reported in the tables. The reported maximum gully depth is calculated as the average of the largest 1% of material movements.

Visualisations for 300 years are shown in the sections below. However, all visualisations (50, 100, 200, and 300 years) are provided in Appendix A.

4.1 Bottom Dam

Rehabilitation of the Bottom Dam TSF is planned to use light clay topsoil with 50% vegetation groundcover. The results shown in Table 2 indicate that at a vegetation groundcover level of 50%, predicted erosion rates of the steep-gradient outer slopes are low. The maximum gully depth after 300 years is predicted to be 0.4m (that is gullying is largely absent). The SIBERIA output indicates that the Bottom Dam rehabilitation design is not prone to significant levels of gully erosion if the surface conditions (material type and vegetation groundcover levels) are achieved.

Figure 4 shows SIBERIA output after 300 years of simulation. Some gully erosion is predicted to occur in the southern section of the TSF (circled in yellow). This is due to a steepening of the gradient in that area. This could be mitigated by further refinement of the design input file in this zone so that a fixed gradient is used, and a steepening gradient is avoided.

The gully erosion predicted to occur in the north (circled in purple) are model artefacts caused by imperfections in the DEM supplied (i.e. artificial elevation differences resulting from triangulation and/or gridding of the data). These erosion areas could be mitigated by refinement of the design input file in this zone to remove these artefacts. Once removed, the gully erosion modelled in this zone is likely to be reduced.

Table 2: Predicted erosion rates and gully depths for the Bottom Dam TSF.

Simulation year	Maximum gully depth (m)	Average annual erosion (t/ha/y)	Cumulative average erosion (mm)
Light clay topsoil with 50% vegetation groundcover			
50	-	0.5	3
100	-	0.4	5
200	0.3	0.4	10
300	0.4	0.3	14

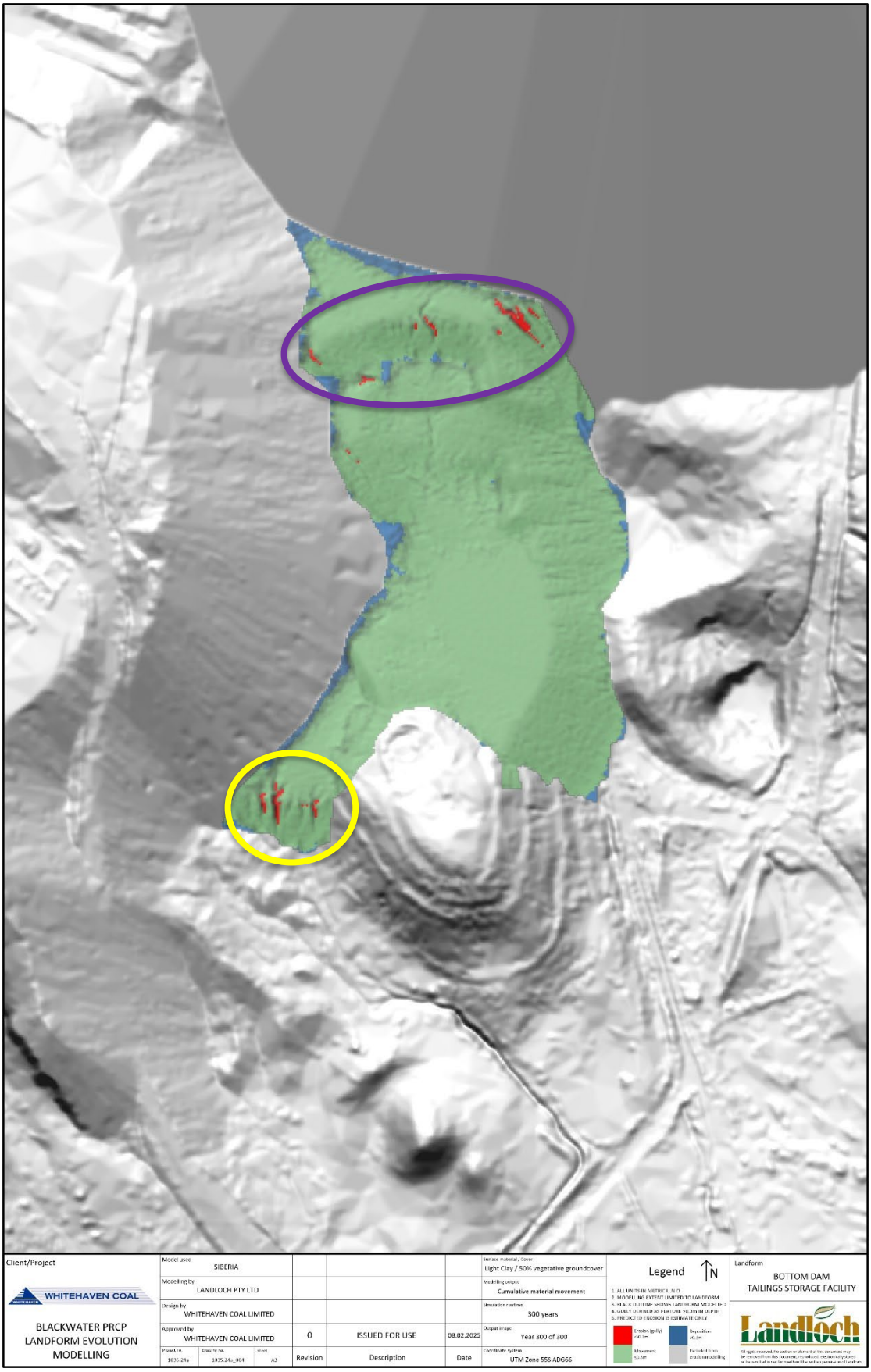

Figure 4: Predicted erosion and deposition depths of the Bottom Dam TSF rehabilitation landform after 300 years.

4.2 Laleham

Rehabilitation of the Laleham TSF is planned to use light clay topsoil with 50% vegetation groundcover. The results shown in Table 3 indicate that at a vegetation groundcover level of 50%, predicted erosion rates of the steep-gradient outer slopes are low. The maximum gully depth after 300 years is predicted to be <0.3m (that is gullying is absent). The SIBERIA output indicates that the Laleham rehabilitation design is not prone to significant levels of gully erosion if the surface conditions (material type and vegetation groundcover levels) are achieved.

Figure 5 shows SIBERIA output after 300 years of simulation. Some gully erosion is predicted to occur in isolated zones of the TSF (circled in yellow). These are model artefacts caused by imperfections in the DEM supplied (i.e. artificial elevation differences resulting from triangulation and/or gridding of the data). These erosion areas could be mitigated by refinement of the design input file in these zones to remove these artefacts. Once removed, the gully erosion modelled in this zone is likely to be reduced.

Table 3: Predicted erosion rates and gully depths for the Laleham TSF.

Simulation year	Maximum gully depth (m)	Average annual erosion (t/ha/y)	Cumulative average erosion (mm)
Light clay topsoil with 50% vegetation groundcover			
50	-	1.4	9
100	-	1.4	18
200	-	1.4	34
300	-	1.3	51



Figure 5: Predicted erosion and deposition depths of the Laleham TSF rehabilitation landform after 300 years.

4.3 NCPP

Rehabilitation of the NCPP TSF is planned to use heavy clay topsoil with 70% vegetation groundcover. The results shown in Table 4 indicate that at a vegetation groundcover level of 50%, predicted erosion rates of the steep-gradient outer slopes are low. The maximum gully depth after 300 years is predicted to be 0.6m.

The SIBERIA output indicates that the NCPP rehabilitation design is not prone to significant levels of gully erosion if the surface conditions (material type and vegetation groundcover levels) are achieved. However, it is more prone to erosion than either the Laleham or Bottom Dam TSF designs.

Figure 6 shows SIBERIA output after 300 years of simulation. The increased gully erosion risk of the NCPP TSF design (relative to Bottom Dam and Laleham) is due to:

1. The heavy clay topsoil being more erodible than the light clay topsoil, with gullies being triggered by the discharge of runoff generated on the lower-gradient TSF upper surface onto the steeper-gradient outer slopes; and
2. The presence of steeper-gradient outer slopes (20% rather than 15%) on sections of the eastern side of the TSF circled in yellow.

The increased gully erosion risk caused by the presence of steeper-gradient outer slopes (20% rather than 15%) on sections of the eastern side of the TSF could be mitigated by refinement of the design input file to lower the gradient of the outer slopes in that zone.

Table 4: Predicted erosion rates and gully depths for the NCPP TSF.

Simulation year	Maximum gully depth (m)	Average annual erosion (t/ha/y)	Cumulative average erosion (mm)
Heavy clay topsoil with 70% vegetation groundcover			
50	-	4.4	27
100	0.3	4.2	54
200	0.4	4.1	105
300	0.6	4.0	154

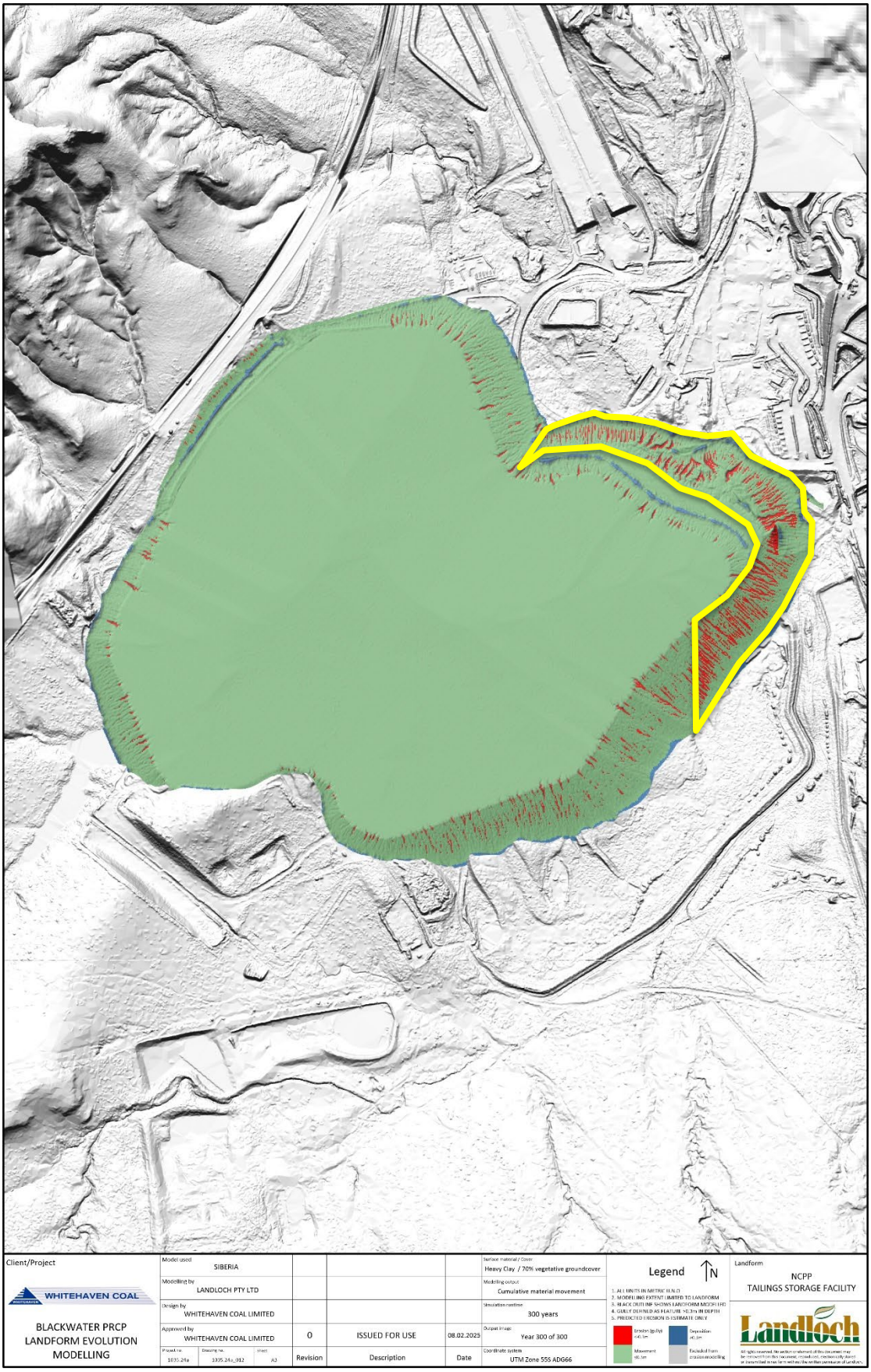

Figure 6: Predicted erosion and deposition depths of the NCPP TSF rehabilitation landform after 300 years.

5 CONCLUSIONS

SIBERIA LEM simulations indicate that the 3 proposed TSFs modelled (Bottom Dam, Laleham, and NCPP) have a low tendency for gully erosion (up to 300 years) provided the correct soils and the target levels of vegetation groundcover are achieved.

An area of increased gully erosion potential was identified in the southern section of the proposed Bottom Dam design. This increased risk is due to a steepening of the gradient in that area. This could be mitigated by refinement of the design input file in this zone so that a fixed gradient is used, and a steepening gradient is avoided. Another area of increased erosion risk was identified in the northern portion of the design. However, these were model artefacts caused by imperfections in the DEM supplied. These erosion areas could be mitigated by refinement of the design input file in this zone to remove these artefacts. Once removed, the gully erosion modelled in this zone is likely to be reduced.

Some gully erosion was identified in isolated zones of the Laleham TSF. However, these were model artefacts caused by imperfections in the DEM supplied. These erosion areas could be mitigated by refinement of the design input file in these zones to remove these artefacts. Once removed, the gully erosion modelled in this zone is likely to be reduced.

The NCPP TSF design is predicted to erode at rates with a low tendency for gully erosion. However, it does erode at higher rates than either the Bottom Dam or Laleham TSFs. The increased gully erosion risk of the NCPP TSF design (relative to Bottom Dam and Laleham) is due to the use of the heavy clay topsoils and the presence of steeper-gradient outer slopes (20% rather than 15%) on some sections of the eastern side of the TSF. The increased gully erosion risk caused by the presence of steeper-gradient outer could be mitigated by refinement of the design to lower the gradient of the outer slopes in that zone.

The model output has assumed the use of either a vegetated light clay or vegetated heavy clay soils as the surface material. These soils were found to be the dominant soils across Blackwater mine. However, if alternative growth media (e.g. different soil types, ameliorated subsoils, or manufactured growth media, etc.) are identified in the future and are to be used as part of rehabilitation, this modelling should be performed again using these alternatives.

The modelling has been completed to assess the performance of the rehabilitated TSFs with respect to erosional stability. While the landforms are predicted to have a low tendency for gully erosion, there is insufficient data to set site-specific erosion criteria. Whitehaven have committed to the establishment of site-specific erosion criteria that will be informed by site measurements of erosion from rehabilitated landforms.

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APPENDIX A: SIBERIA VISUALISATIONS

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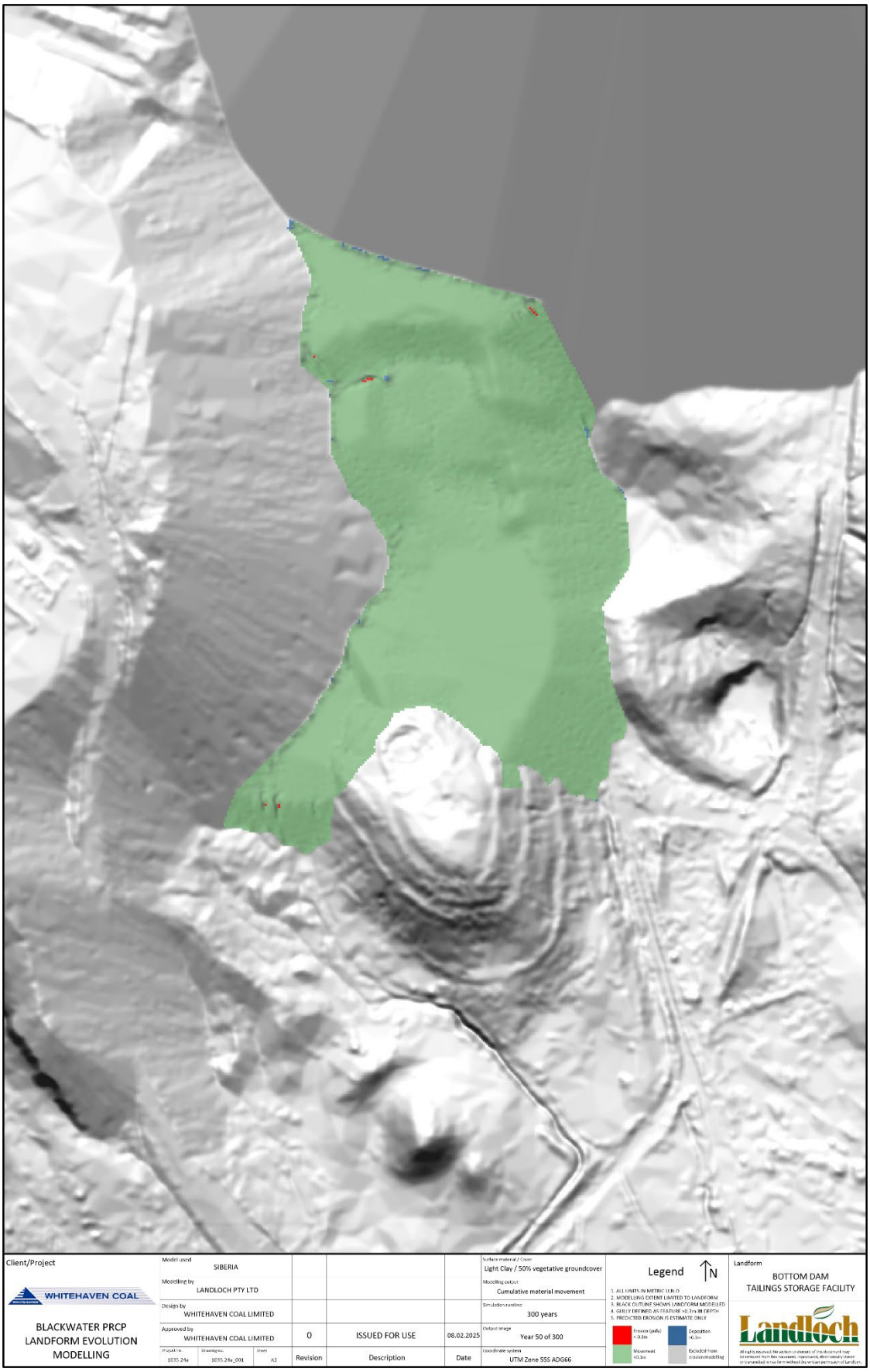


Figure A-1: Predicted erosion and deposition depths of the Bottom Dam TSF rehabilitation landform after 50 years.

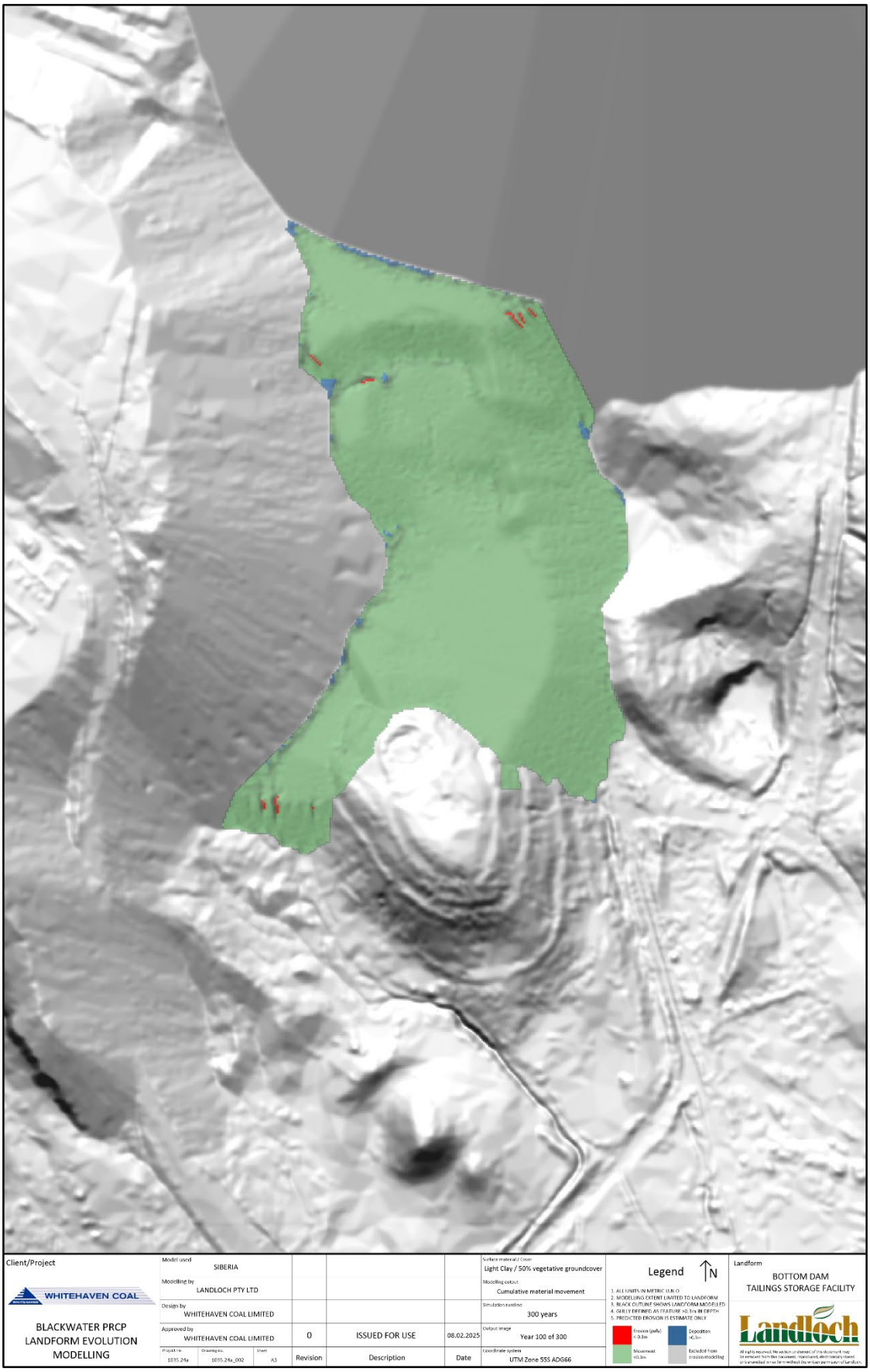


Figure A-2: Predicted erosion and deposition depths of the Bottom Dam TSF rehabilitation landform after 100 years.

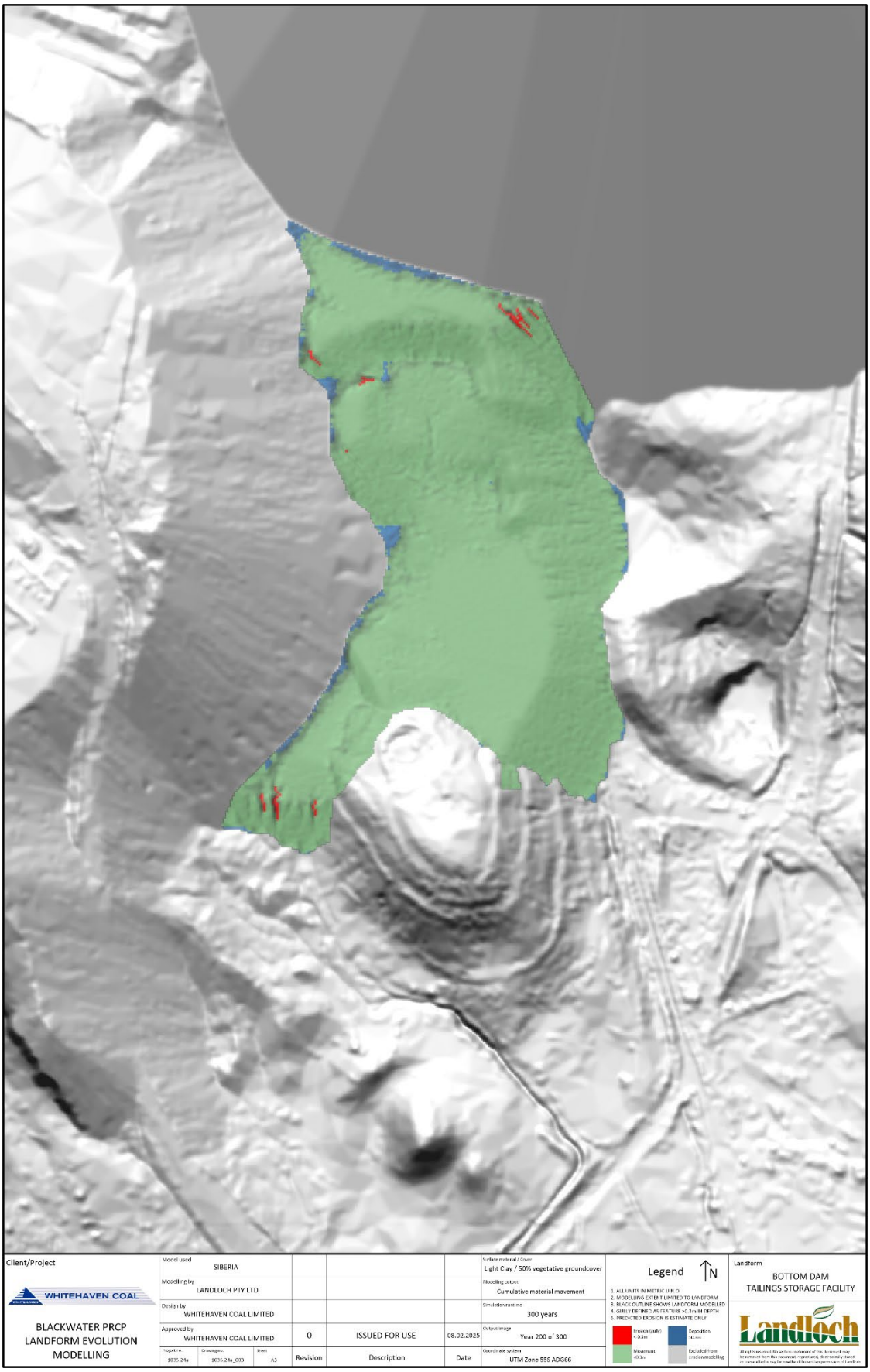


Figure A-3: Predicted erosion and deposition depths of the Bottom Dam TSF rehabilitation landform after 200 years.

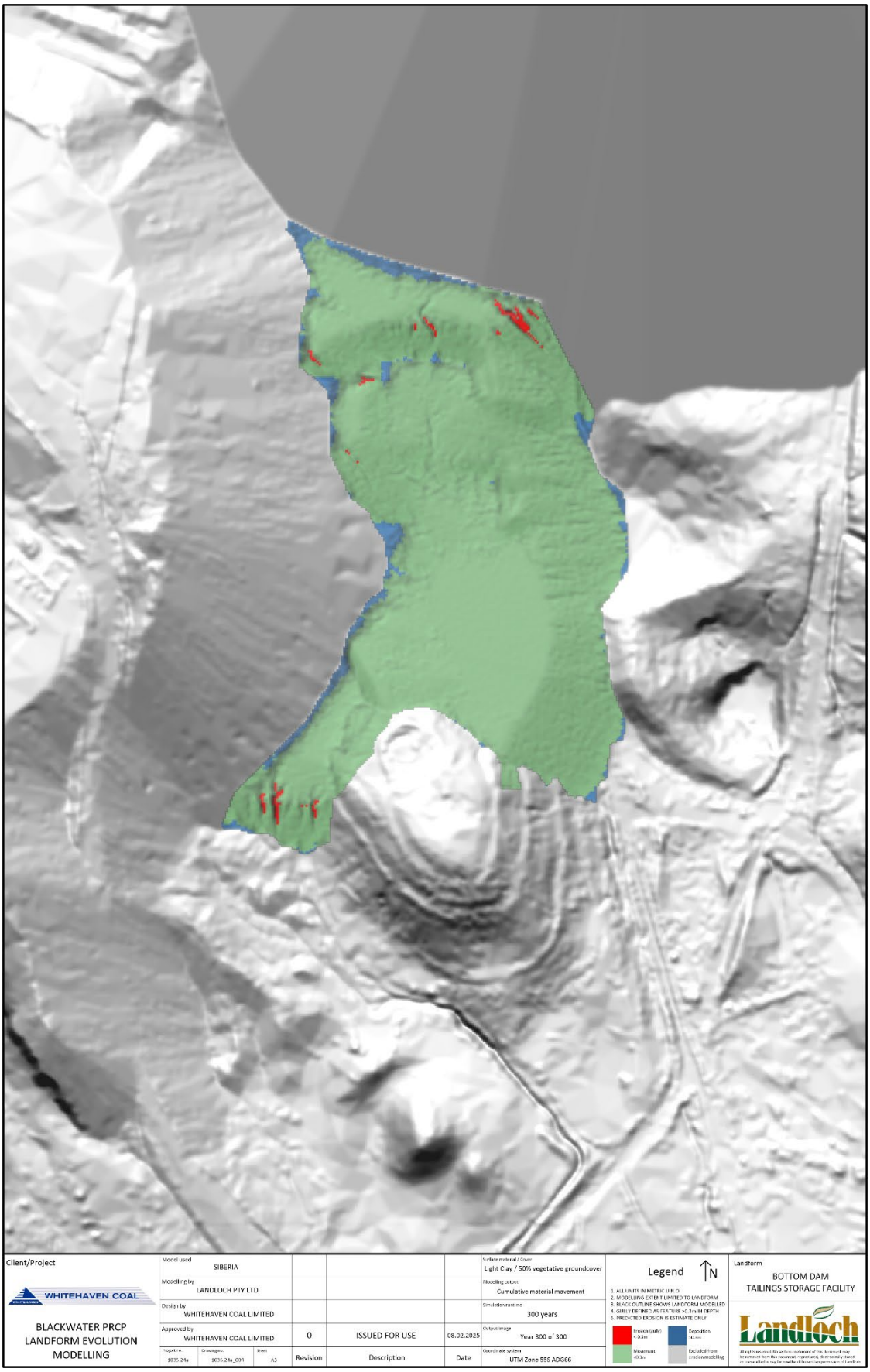


Figure A-4: Predicted erosion and deposition depths of the Bottom Dam TSF rehabilitation landform after 300 years.

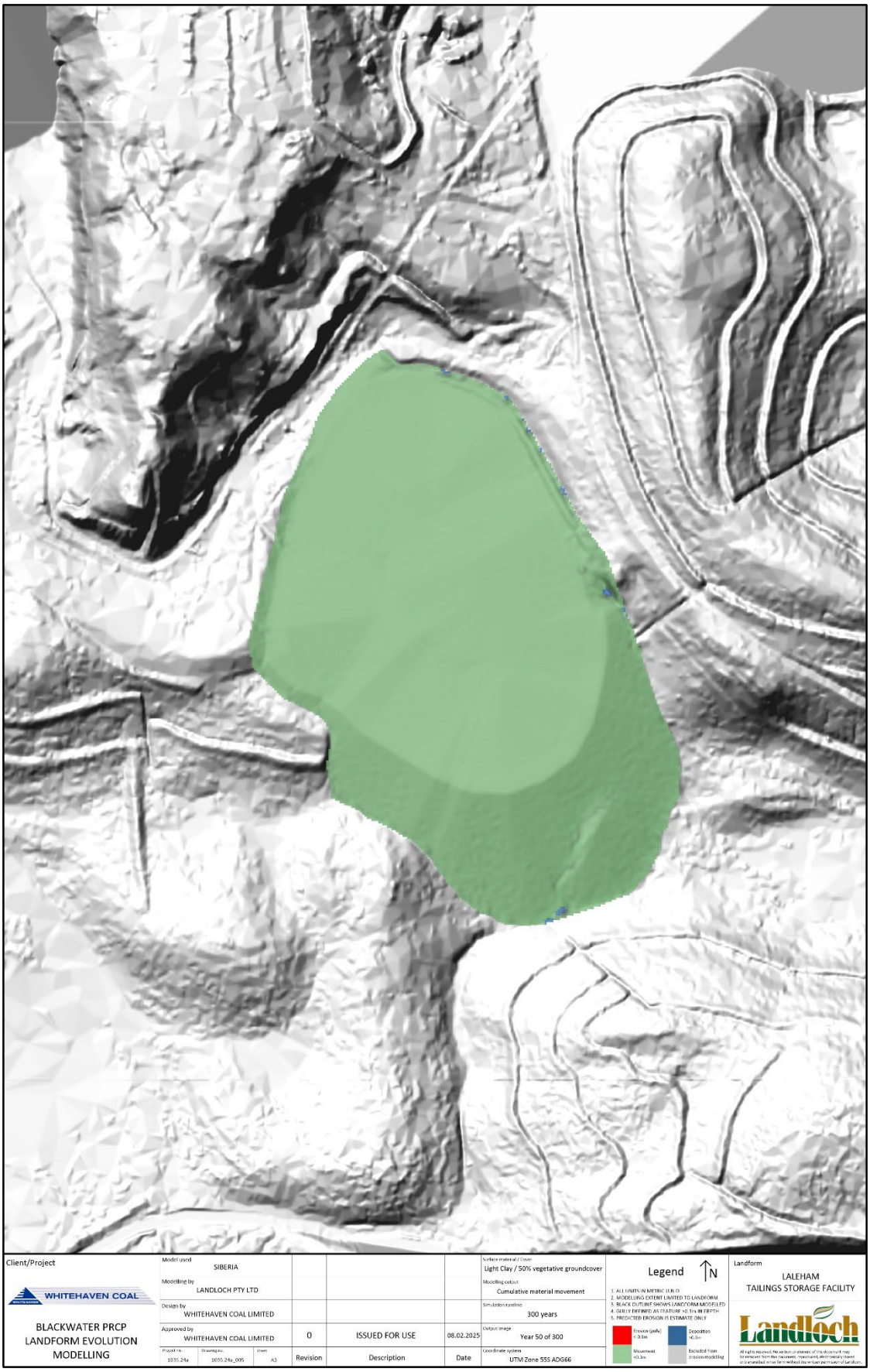


Figure A-5: Predicted erosion and deposition depths of the Laleham TSF rehabilitation landform after 50 years.

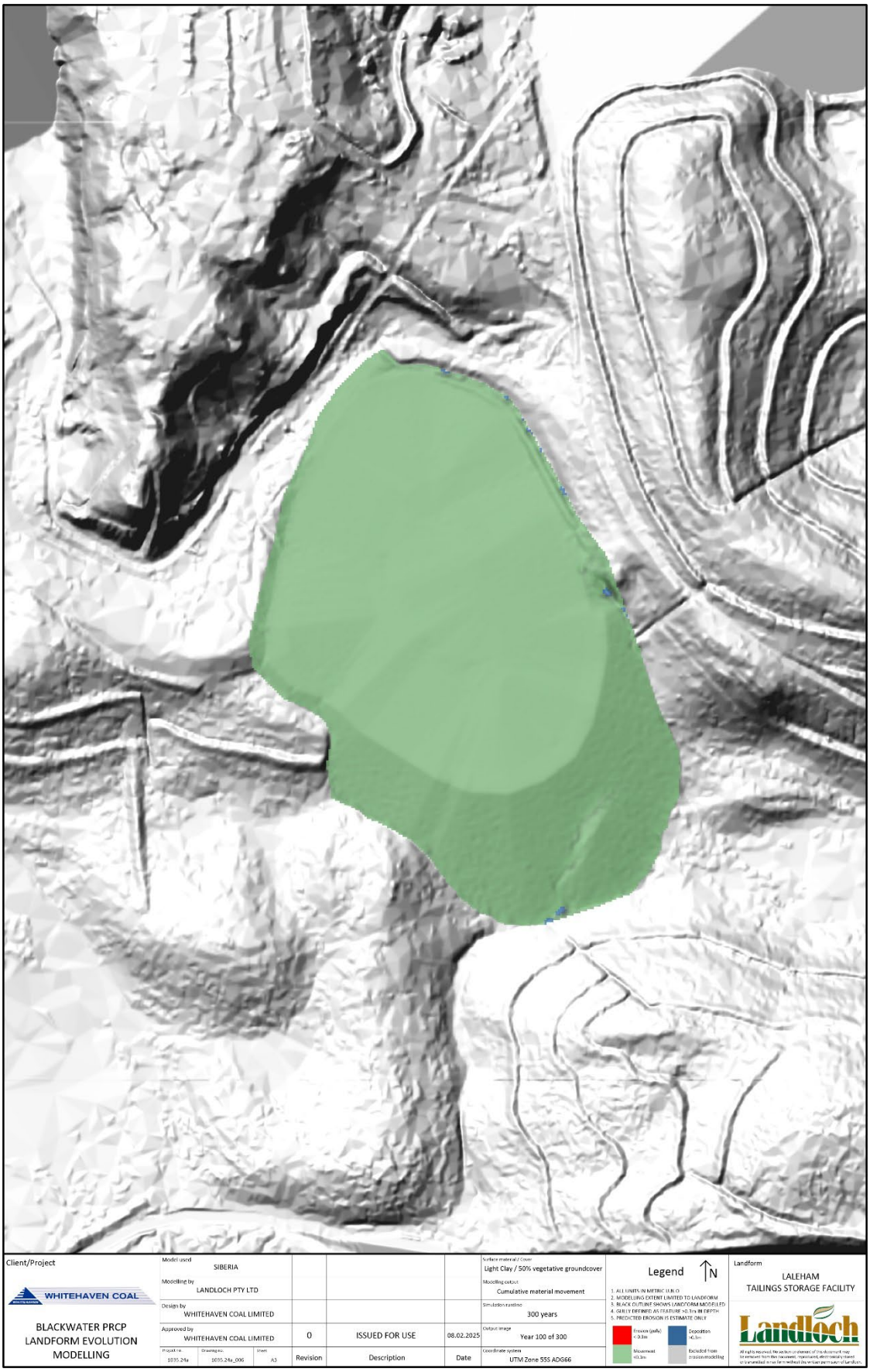


Figure A-6: Predicted erosion and deposition depths of the Laleham TSF rehabilitation landform after 100 years.

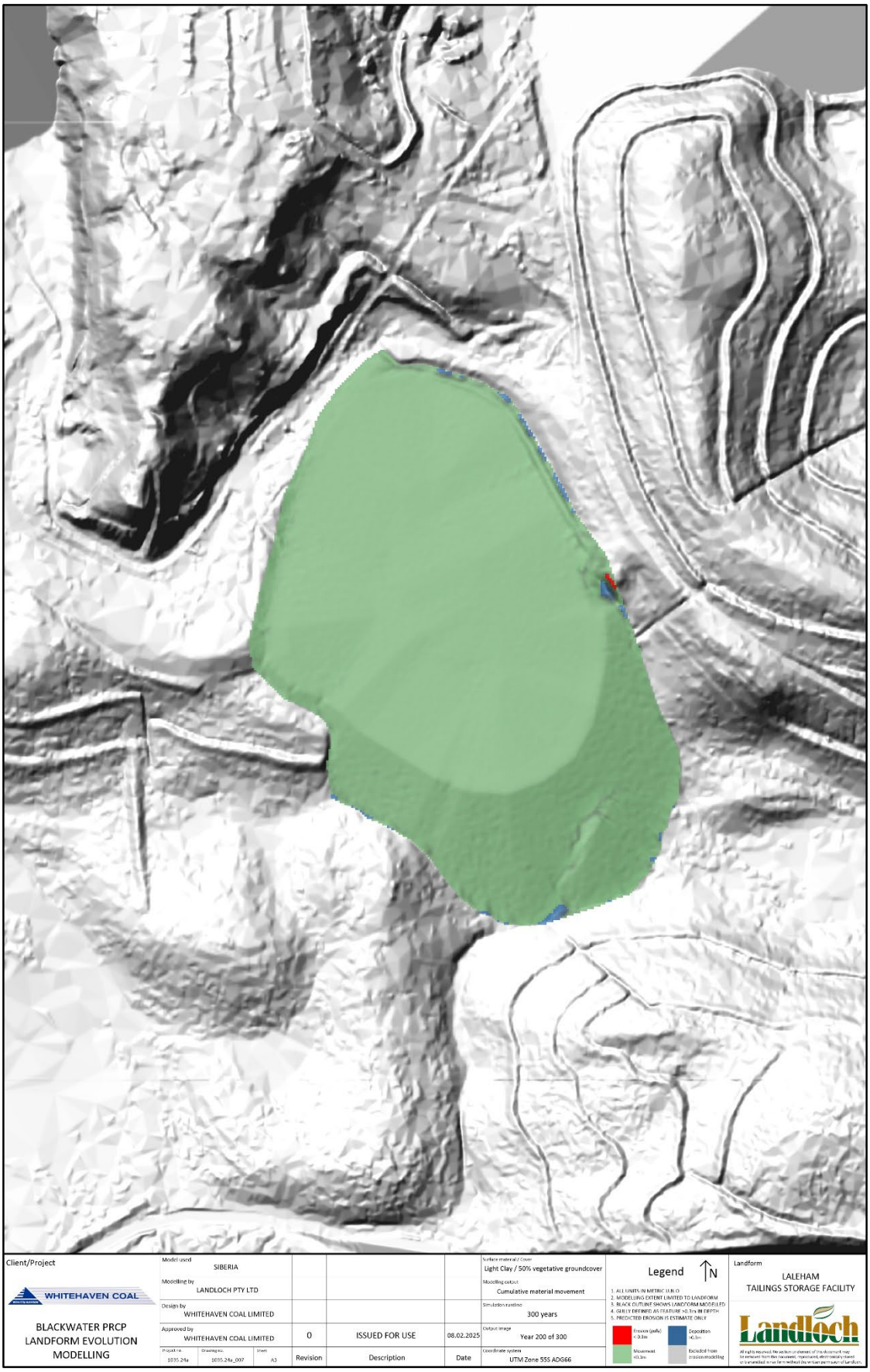


Figure A-7: Predicted erosion and deposition depths of the Laleham TSF rehabilitation landform after 200 years.

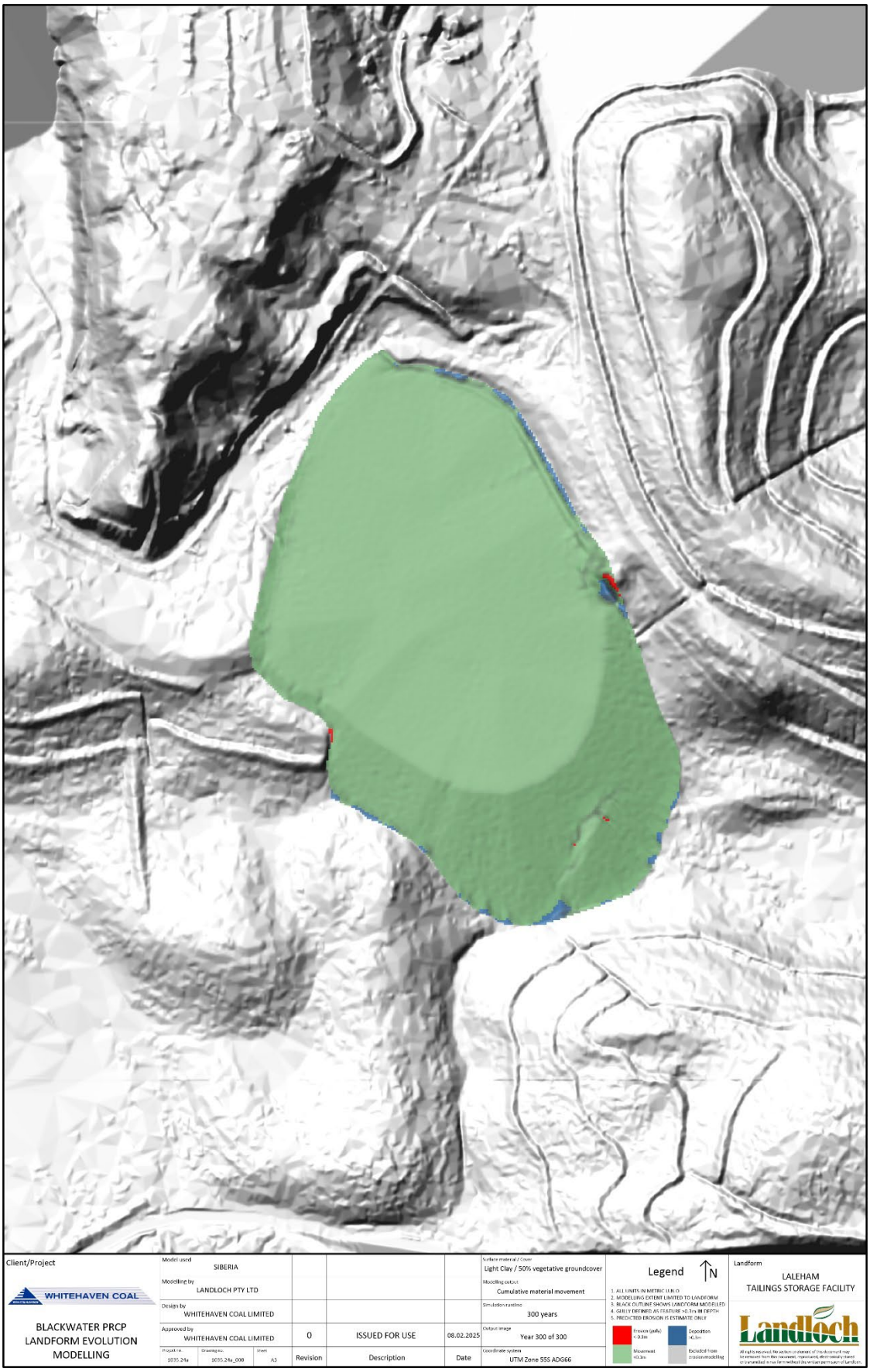


Figure A-8: Predicted erosion and deposition depths of the Laleham TSF rehabilitation landform after 300 years.



Figure A-9: Predicted erosion and deposition depths of the NCPP TSF rehabilitation landform after 50 years.



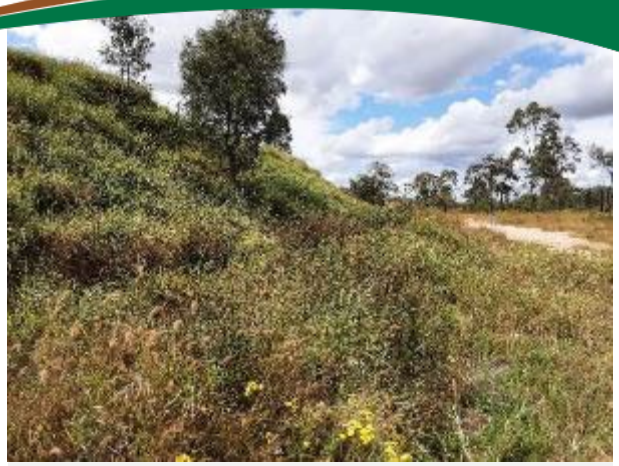
Figure A-10: Predicted erosion and deposition depths of the NCPP TSF rehabilitation landform after 100 years.



Figure A-11: Predicted erosion and deposition depths of the NCPP TSF rehabilitation landform after 200 years.



Figure A-12: Predicted erosion and deposition depths of the NCPP TSF rehabilitation landform after 300 years.



EROSION AND LANDFORM EVOLUTION SIMULATIONS TO SUPPORT WASTE LANDFORM DESIGN: BLACKWATER MINE

February 2024

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Project Number: 1447.21a8

Report Title: Erosion and landform evolution simulations to support waste landform design: Blackwater Mine

Client: BM Alliance Coal Operations Pty Ltd (BMA)

Review History

Version Number	Prepared by:	Reviewed by:	Date:
Rev 0 (draft)	E. Howard	BHP	07/02/2024
Rev 1 (final)	E. Howard		09/02/2024

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1 SUMMARY

For waste landforms at Blackwater Mine (BWM), Landloch Pty Ltd has completed:

a) Initial WEPP runoff/erosion model simulations;
b) Derivation of parameters for the SIBERIA landform evolution model; and
c) Landform evolution simulations for 3-D waste landforms provided by BMA.

Erodibility data for materials considered in WEPP simulations were sourced from previous erodibility studies that assessed BWM materials and from direct measurement of materials from BWM, and included:

- Heavy clay topsoil;
- Light clay topsoil; and
- Fresh Permian waste.

WEPP simulations were carried out for the following batter slope geometries:

- 500m long, at 30% gradient;
- 750m long at 20% gradient;
- 1,000m long, at 15% gradient; and
- 1,000m long, at 10% gradient.

Each of these batter slope geometries were sheeted with:

- Light clay soil with vegetation groundcover levels of 0–90%;
- Heavy clay soil with vegetation groundcover levels of 0–90%; and
- Fresh Permian waste with vegetation groundcover levels of 0–30%.

In deriving and applying SIBERIA parameters, it was assumed that the:

- Heavy clay topsoil with vegetation groundcover levels of 70% will be used for outward-facing batters with 15% gradient on:
  - R8N;
  - Boonie Doon;
  - Mimosa/Besgrove;
  - Deep Creek; and
  - Stewarton/Ballamoo.
- Light clay topsoil with vegetation groundcover levels of 50% will be used for outward-facing batters with 15% gradient on:
  - Kenmare;
  - Laleham;
  - Togara/North Marshmead;
  - South Marshmead;
  - Kennedy West; and
  - Comet Downs East.

- Fresh Permian waste with vegetation groundcover levels of 30% will be used for inward-facing (low wall) batters with 30% gradient on:
    - R8N;
    - Boonie Doon;
    - Mimosa/Besgrove;
    - Deep Creek;
    - Stewarton/Ballamoo;
    - Kenmare;
    - Laleham;
    - Togara/North Marshmead;
    - South Marshmead;
    - Kennedy West; and
    - Comet Downs East.

It is considered that these simulations address all options being considered for BWM.

SIBERIA model output showed batter slopes erode at rates below target levels in all cases except for the vegetated clay soil covered batters of Mimosa/Besgrove. The SIBERIA output for this landform predicts that despite the vegetated clay soils having slightly elevated erosion potential, the erosion is predicted to be well distributed and the risk of gully erosion is not increased.

Some gully erosion is predicted to occur for the topsoil and Permian waste covered slopes. For the clay topsoil covered areas, this is predicted to occur after 300 years for only the Mimosa/Besgrove, Deep Creek, Stewarton/Ballamoo, and Laleham landforms. For the fresh Permian waste covered slopes, this is predicted to occur after 200 years for the Mimosa/Besgrove, Deep Creek, Kenmare, Togara/North Marshmead, South Marshmead, Kennedy West, and Comet Downs East landforms.

In all these circumstances, given the planned post-mining land use for these areas is woodland habitat and the material underlying these surfaces is likely to be the more erosion-resistant fresh Permian waste, the risk of exposing problematic (more erodible) materials over the long-term via gully erosion and not achieving the post-mining land use is considered low. However, gully erosion should be monitored and assessed by an appropriately qualified person as part of the rehabilitation monitoring and maintenance process.

2 INTRODUCTION

2.1 Overview

Landloch has been engaged by BMA to carry out specific specialist studies for soils and capping, and landform design, to provide information for the subsequent compilation of transitional Progressive Rehabilitation and Closure Plans (PRC Plans) for its existing operational coal assets located within the Bowen Basin.

This report considers the design of stable waste landforms on the Blackwater Mine (BWM).

2.2 Objectives of landform design

A key requirement of landform design is to demonstrate that the rehabilitated landform shapes can confidently be expected to be erosionally stable over the long term, while also supporting the target Post Mining Land Use (PMLU). As part of that requirement, this landform study reports:

- Materials to be used in landform rehabilitation and their erodibility;
- Erosion assessments for a range of material and slope profile options, considering interactions between soil erodibility, rainfall erosivity, and landform height, gradient and vegetation groundcover. These assessments aim to identify options that will achieve acceptable erosion rates over a 100-year period; and
- Landform evolution simulations using the SIBERIA landform evolution model (LEM) to assess stability of 3-dimensional (3-D) rehabilitation landform designs over a period of 300 years.

3 LANDFORM STUDY METHODS

The landform study consisted of four stages:

a) Sourcing and review of erosion model and LEM input data and information;
b) Simulations of runoff and erosion for a range of landform batter options using the WEPP (Water Erosion Prediction Project) model (Flanagan and Livingston 1995);
c) Derivation of input parameters for the SIBERIA LEM (Willgoose *et al.* 1989); and
d) LEM simulations using SIBERIA for 3-D landform shapes provided by BMA.

3.1 Data sources

Information on the soil and waste types present at BWM were sourced from:

- Data collected as part of the development of this report;
- Landloch's BWM material characterisation study report (Landloch 2023a);
- Landloch's assessment of BWM's rocky Permian wastes (Landloch 2023b); and
- Historical erodibility testing of BWM's soils (Sheridan 2001).

3.2 Topsoils

The BWM material characterisation study report (Landloch 2023a) assessed the properties of 83 topsoil stockpiles.

Clay topsoils account for 75% of samples assessed across the BWM topsoil stockpiles and are evenly distributed across the mine. Generally, the clay soil samples have similar properties, but occasional minor inclusions of sands and loams were noted at some stockpiles. This is likely a result of topsoils from minor texture contrast soil units being stripped with the more dominant clays. Both light and heavy clay textured soils exist.

Gravelly clay topsoils account for 15% of samples assessed across BWM topsoil stockpiles and are located within the southern portion of the mine. These soils have similar properties to the clay topsoils except for their higher gravel content. The gravelly clay soils are likely to be more erosion resistant than the clay topsoils.

Loam topsoils account for 10% of samples assessed across the BWM topsoil stockpiles and are located the southern portion of the mine. These materials have a degree of variability, but due to the limited volumes present, have been grouped together to aid their management.

Given the dominance of the clay topsoil (and the similar gravelly clay topsoil) at BWM, only the clay topsoil was considered further for erodibility testing of the soils. Modelling of erosionally stable slopes sheeted with clay topsoils would also be erosionally stable for gravelly clay topsoils. Hence, gravelly clay topsoils were not considered separately from the clay topsoils.

A summary of the properties of the available soil types is given in Table 1. The table includes data from the assessment of a light clay topsoil from Stockpile 93 (R34) and a heavy clay topsoil from Stockpile 291b (R34) sourced for erodibility testing as part of this project. The data shows that the clay soils for which WEPP erodibility parameters are available are consistent with the properties of the stockpiled soils and hence can be used to model long-term erosion potential for BWM. Figure 1 shows the two clay topsoils tested immediately after exposure to high intensity simulated rain. Erodibility data for a clay soil was also available from Sheridan (2001). These data sources were incorporated to produce an aggregated erodibility parameter dataset for the light and heavy clay topsoils.

Table 1: Properties of soils at BWM as reported in Landloch (2023a).

Analysis	Clay Topsoil (Landloch 2023)	Gravelly Clay Topsoil (Landloch 2023)	Light Clay Topsoil Stockpile 93	Heavy Clay Topsoil Stockpile 291b
pH_w (pH Units)	8.0–9.0	8.1–9.0	8.0	8.6
$EC_{1:5}$ (dS/m)	<0.5	<0.7	0.4	0.7
ECEC (meg/100g)	14–27	12–28	23	23
Exchangeable sodium percentage (ESP) (%)	3.3–14	4.5–17	1.9	13
Clay content (%)	>35	>35	41	50
Rock content (%)	<20	20–50	10	10



Figure 1: Test plots immediately following application of simulated rain to a light clay topsoil from Stockpile 93 (left) and a heavy clay topsoil from Stockpile 291b (right).

3.3 Wastes

Waste materials at BWM include fresh Permian, weathered Permian, and Tertiary materials.

Fresh Permian materials are generally rocky and consist primarily of sandstone and siltstone. It is considered the most suitable waste for placement close to the final rehabilitated surface (Landloch 2023a). Weathered Permian materials have a lower abundance and smaller-sized rock content than fresh Permian. The rock consists primarily of low-durability mudstone and sandstone. It can be susceptible to capillary rise of salts if profile leaching is limited. Weathered Permian materials are considered suitable for use as a secondary growth material but should be capped with a primary growth material to prevent its exposure at the final rehabilitated surface (Landloch 2023a). Tertiary materials are weathered and often highly saline, strongly sodic, and prone to dispersion when compared to the fresh Permian. Placement of Tertiary materials close to the final rehabilitated surface is not recommended (Landloch 2023a).

Because the weathered Permian and Tertiary materials are not recommended to be placed close to the final rehabilitation surface, assessment of their erodibility and surface erosion potential was not included in this study. Assessment of only fresh Permian was considered.

A summary of the properties of the fresh Permian wastes are given in Table 2. Data from the BWM material characterisation study (Landloch 2023a) and an assessment of the erodibility of rocky Permian wastes at BWM (Landloch 2023b) are provided. The data shows that fresh Permian waste for which erodibility parameters are available are consistent with the properties reported more broadly for the same material (Landloch 2023a). Hence, they can be used to model long-term erosion potential for BWM. This data was aggregated to produce a single erodibility parameter dataset for the fresh Permian waste.

Table 2: Properties of Permian wastes at BWM as reported in Landloch (2023a; 2023b).

Analysis	Fresh Permian Waste (Landloch 2023a)	Fresh Permian Waste (This Study & Landloch 2023b)
pH_w (pH Units)	8.4–9.8	9.0–9.8
$EC_{1:5}$ (dS/m)	<2.3	<1.2
ECEC (meg/100g)	Low–adequate	12–16
ESP (%)	3–30	15–34
Clay content (%)	20–40	14–28
Rock content (%)	Up to 74	15–95

3.4 Summary

Soils available for use at the surface of rehabilitated waste landforms include light clay and heavy clay topsoils. Based on the geographical proximity of the stockpiled soils, erosion modelling of landforms assumed different soil materials as follows:

- Heavy clay topsoil will be used for outward-facing batters on:
  - R8N;
  - Boonie Doon;
  - Mimosa/Besgrove;
  - Deep Creek; and
  - Stewarton/Ballamoo.
- Light clay topsoil will be used for outward-facing batters on:
  - Kenmare;
  - Laleham;
  - Togara/North Marshmead;
  - South Marshmead;
  - Kennedy West; and
  - Comet Downs East.

Fresh Permian waste is also available for use at the surface of rehabilitated waste landforms and will be used for inward facing (low wall) batters on:

- R8M;
- Boonie Doon;
- Mimosa/Besgrove;
- Deep Creek;
- Stewart/Ballamoo;
- Kenmare;
- Laleham;
- Togara/North Marshmead;
- South Marshmead;
- Kennedy West; and
- Comet Downs East.

3.5 WEPP simulations

3.5.1 Parameters used

Erodibility parameters for WEPP runoff/erosion simulations have been determined experimentally for the light clay, heavy clay, and fresh Permian waste. These parameters include:

- Effective hydraulic conductivity;
- Interrill erodibility;
- Rill erodibility; and
- Critical flow shear stress for initiation of rilling.

3.5.2 Slope, materials, and vegetation groundcover options

Initial WEPP simulations were carried out for:

- Batter slopes 500m long, at 30% gradient, surfaced with:
  - Light clay soil with vegetation groundcover levels of 0–90%;
  - Heavy clay soil with vegetation groundcover levels of 0–90%; and
  - Fresh Permian waste with vegetation groundcover levels of 0–30%.
- Batter slopes 750m long, at 20% gradient, surfaced with:
  - Light clay soil with vegetation groundcover levels of 0–90%;
  - Heavy clay soil with vegetation groundcover levels of 0–90%; and
  - Fresh Permian waste with vegetation groundcover levels of 0–30%.
- Batter slopes 1,000m long, at 15% gradient, surfaced with:
  - Light clay soil with vegetation groundcover levels of 0–90%; and
  - Heavy clay soil with vegetation groundcover levels of 0–90%.
- Batter slopes 1,000m long, at 10% gradient, surfaced with:
  - Light clay soil with vegetation groundcover levels of 0–90%; and
  - Heavy clay soil with vegetation groundcover levels of 0–90%.

3.5.3 Vegetation groundcover impacts

Impacts of vegetation groundcover on infiltration rates were estimated using the relationship reported by Kato *et al.* (2009), and direct impacts of vegetation groundcover on erosion rates were estimated using Cover (C) factors for the Revised Universal Soil Loss Equation (RUSLE) (Renard *et al.* 1993) listed in Rosewell (1993).

Vegetation groundcover levels greater than 50–70% appear achievable on most rehabilitation carried out on BMA coal mines sites. As a conservative approach, vegetation groundcover levels of 30% for materials of relatively low fertility (fresh Permian waste) and 50% (light clay soil) and 70% (heavy clay soil) for the more fertile soils have been applied in erosion simulations.

3.5.4 Assumptions with respect to effects of cover on erosion

Two points should be noted:

a) In considering "vegetation groundcover" this report specifically considers contact cover of vegetation on the soil surface. Practically, this means a combination of grass cover and anchored (not readily moved) surface litter.
b) Considerations of vegetation groundcover do not include rock. Where rocky materials have had erodibility measured experimentally and those parameters are used in WEPP simulations, then effects of the rock are already accounted for within the parameters used.

3.5.5 Climate

All simulations used a synthetic 100-year climate file prepared to match all relevant characteristics of Blackwater climate.

3.5.6 Key assumptions – landforms and vegetation

The simulations are based on two key assumptions:

a) There will be no uncontrolled discharge of runoff from landform tops onto outer batter slopes; and
b) The assumed vegetation groundcover levels will be achieved sustainably, with those levels being set as triggers for investigation and remedial action should monitoring indicate that they are not being achieved.

It should be recognised there are also underlying assumptions of good rehabilitation practice such that:

- There will not be discharges of concentrated flows onto any batter slopes at any point of their rehabilitation;
- Batter slopes will not be formed with flow-concentrating profiles (e.g. variations in surface elevation such that there is cross-slope concentration of flow into consistent depressions running downslope);
- Any cross-slope ripping will be carried out strictly on the contour; and
- Soil management (including stripping, stockpiling, replacement, amendment, and fertilisation) will be carried out effectively to maximise early and continuing plant growth.

3.5.7 Soil loss targets

This study used runoff, and erosion modelling to identify landform options that would erode at rates low enough to provide long-term erosional stability. Effectively, the landforms are planned to be consistent with tolerable rates of soil loss. Wischmeier and Smith (1978) defined tolerable soil loss for cropland as, "the maximum rate of soil erosion that will permit a high level of crop productivity to be sustained economically and indefinitely."

A value of 11.2t/ha/y averaged over an area of interest is often cited as a tolerable soil loss rate, but that value was derived by US soil conservation agencies for deep, fertile cultivated soils, and has little relevance to most rehabilitated minesites. Using similar criteria to those applied for crop land, a lower soil loss tolerance value of 4.5t/ha/y was developed by US agencies for erosion of rangeland soils and shallow cultivated soils (Wight and Siddoway 1979).

Lower tolerance values are relevant to rangeland and minesite situations, as not only are the soils shallower and more susceptible to fertility decline, but the lack of regular tillage or disturbance means that any rills or points of scour that form are more likely to extend and develop into gullies over time. These are typically of concern for minesite landforms where there is no bedrock layer at depth to limit long-term depths of incision.

For that reason, a key priority in setting a tolerable erosion target is the prevention of significant rill or gully development. On that basis, for slopes where long-term erosion risk (for a range of reasons) is considered high, a maximum rate of erosion of 5t/ha/y at any point on the batter slopes being modelled has commonly been applied by Landloch on the basis that; at this rate rilling is largely if not completely absent.

Typically, the high risk category includes slopes where the overall landform height is greater than 50m, and situations where – due to either or both rainfall limitations or soil fertility concerns – vegetation growth is unlikely to rapidly colonise and stabilise any rills that form.

As the landforms at BWM are planned to be considerably higher than 50m, the adopted target erosion value for this assessment is a maximum at any point of the outer batter slopes of 5t/ha/y. However, for low wall slopes that drain to pits, there are no potential off-site impacts of erosion, and planned PMLU is typically native vegetation. For those situations, a slightly higher erosion target (a maximum of 10t/ha/y) has been adopted.

The elimination of rilling reduces the potential for channelised flow to form gullies, and experience to date with a large number of waste landforms designed by Landloch has shown that the target soil loss values adopted have achieved acceptable levels of stability to erosion.

3.6 Derivation of SIBERIA parameters

To run SIBERIA, the parameters β_1, m_1, n_1, β_3, and m_3 are usually needed. However, if the batter area to be modelled is identical to the batter for which erosion data are available for calibration, m_3 and β_3 can be taken as 1.0 and a value for n_1 of 1.5 can be adopted for situations where slope gradient does not affect slope erodibility (Willgoose, pers. comm.). Therefore, the two key parameters that require derivation are β_1 and m_1.

The β_1 parameter can be considered a "rate parameter", as it primarily controls the rate of sediment movement. The m_1 parameter can be considered as primarily controlling slope length responses. However, in practice, there is interaction between all the parameters with the result that a large number of parameter sets will all show the same rate of erosion though some aspects of the pattern of erosion that is predicted will vary. It is for this reason that, where possible, fixed values of n_1 and m_3 are adopted – thereby reducing the difficulty of deriving parameter values.

Input parameters for SIBERIA are typically derived by fitting the various model equations to time series data of runoff and erosion. To generate the necessary data, Landloch has developed method that involves:

a) Run the WEPP model to generate data sets of runoff and erosion for slopes consistent with the proposed landforms and for materials of interest using site specific climate data.
b) Analyse the WEPP output to derive the required SIBERIA input parameters.

This approach ensures that SIBERIA parameters are effectively benchmarked to the WEPP output, and thereby, effectively based on measured erodibility parameters for site materials and on site climate.

4 RESULTS OF WEPP SIMULATIONS

Simulations considered slope lengths of 500m and 1,000m. The target erosion rate for modelling outward-facing batters (light and heavy clay topsoil) is an average annual rate of 5t/ha/y. The target erosion rate for modelling inward-facing batters (low walls, fresh Permian waste) is an average annual rate of 10t/ha/y.

4.1 Outward-facing slopes surfaced with vegetated light clay topsoil

For the light clay topsoil, long-term WEPP erosion simulations indicate that gradients of 30% would require very high vegetation groundcover levels (>70%) (Figure 2). Slopes that are 1,000m long are predicted to be stable for a vegetation groundcover level of >50% for a 20% gradient slope (Figure 3), >50% for a 15% gradient slope (Figure 4), and >30% for a 10% gradient slope (Figure 5).

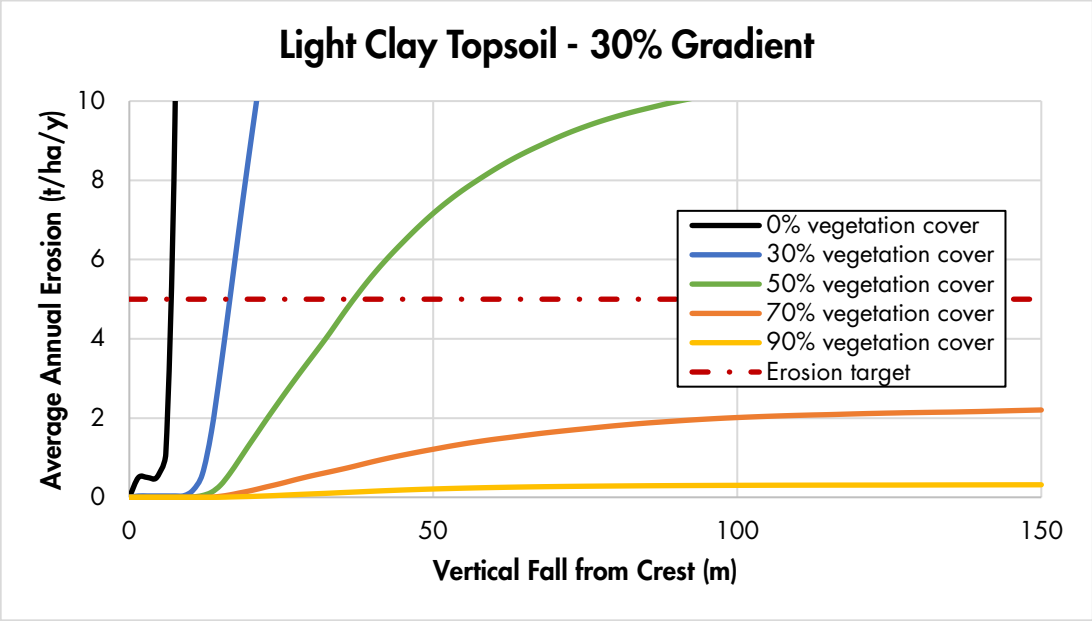

Figure 2: Predicted erosion rates on 30% gradient outward-facing slope sheeted with light clay topsoil.

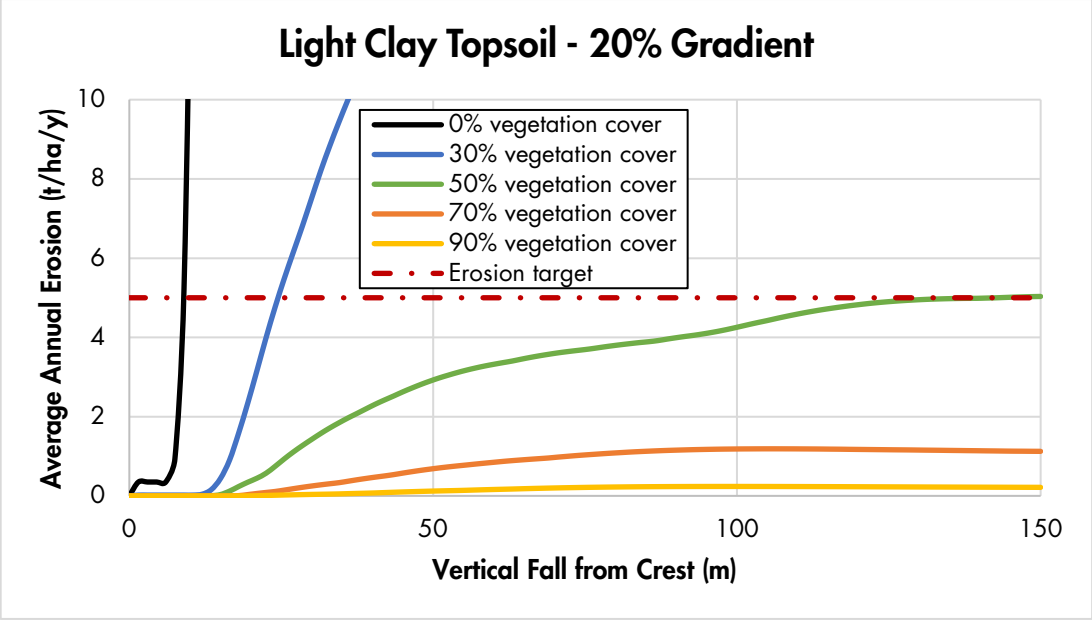

Figure 3: Predicted erosion rates on a 20% gradient outward-facing slope sheeted with light clay topsoil.

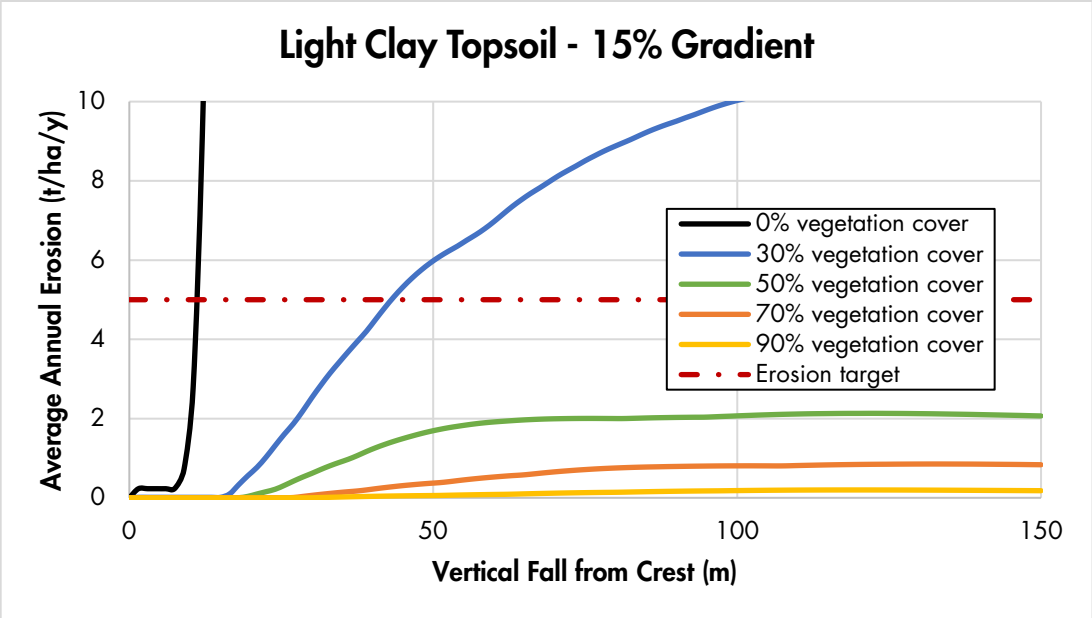

Figure 4: Predicted erosion rates on a 15% gradient outward-facing slope sheeted with light clay topsoil.

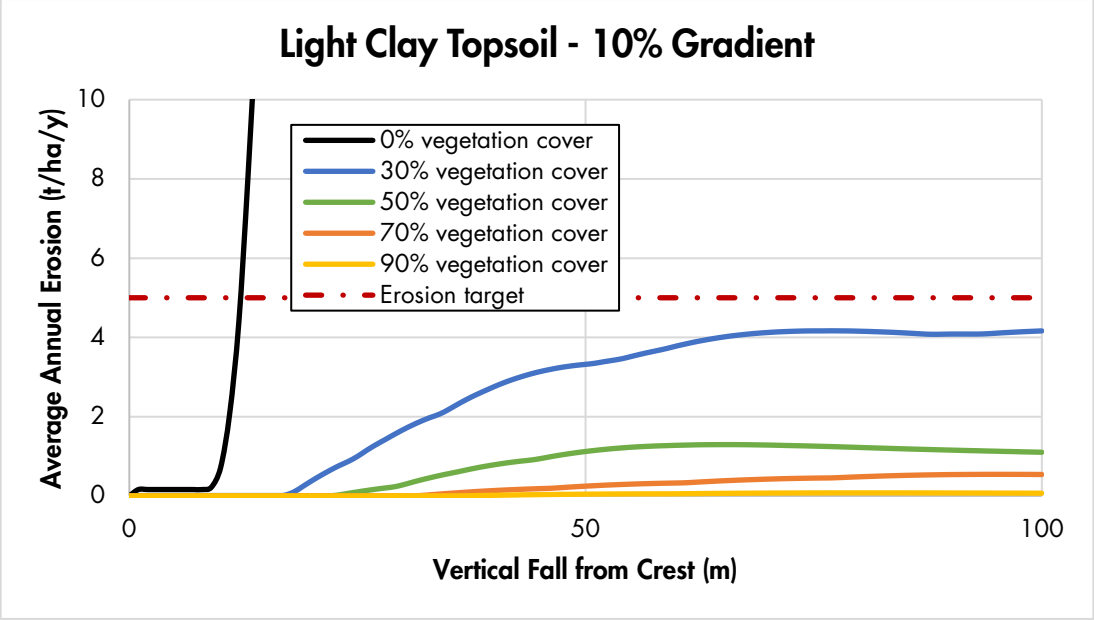

Figure 5: Predicted erosion rates on a 10% gradient outward-facing slope sheeted with light clay topsoil.

4.2 Outward-facing slopes surfaced with vegetated heavy clay topsoil

For the heavy clay topsoil, long-term WEPP erosion simulations indicate that gradients of 30% would require very high vegetation groundcover levels (>90%) (Figure 6). Slopes that are 1,000m long are predicted to be stable for a vegetation groundcover level of 90% for a 20% gradient slope (Figure 7), 70% for a 15% gradient slope (Figure 8), and 70% for a 10% gradient slope (Figure 9).

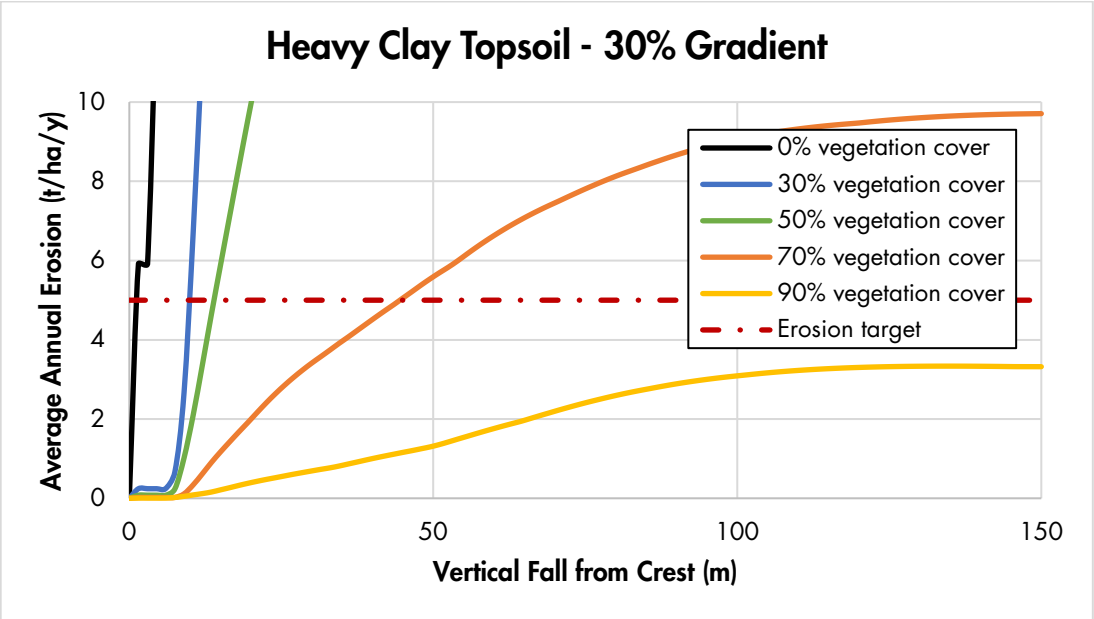

Figure 6: Predicted erosion rates on 30% gradient outward-facing slope sheeted with heavy clay topsoil.

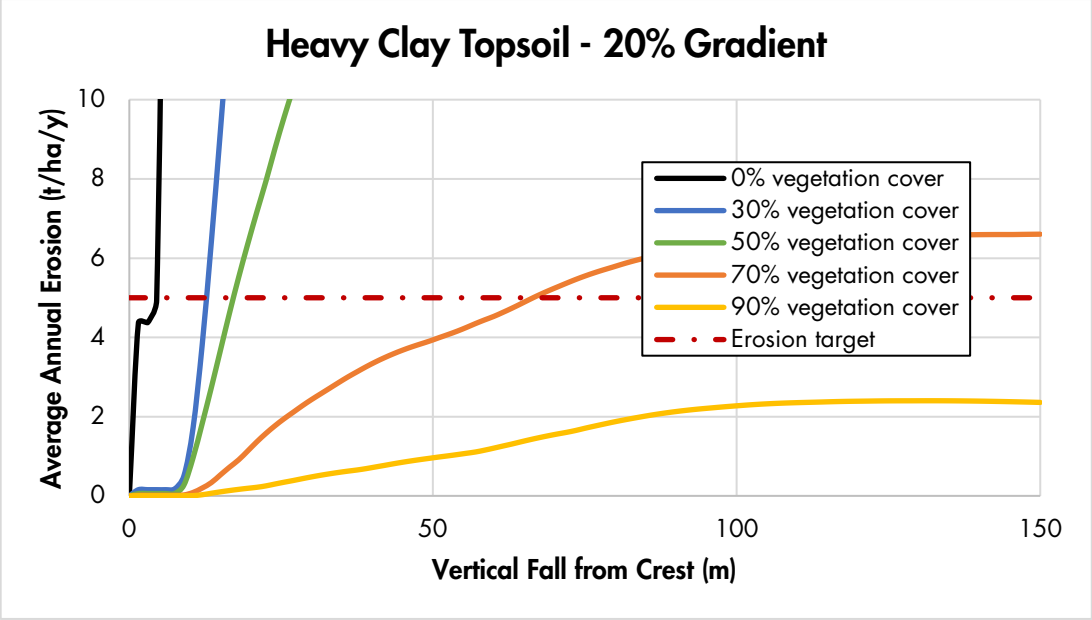

Figure 7: Predicted erosion rates on a 20% gradient outward-facing slope sheeted with heavy clay topsoil.

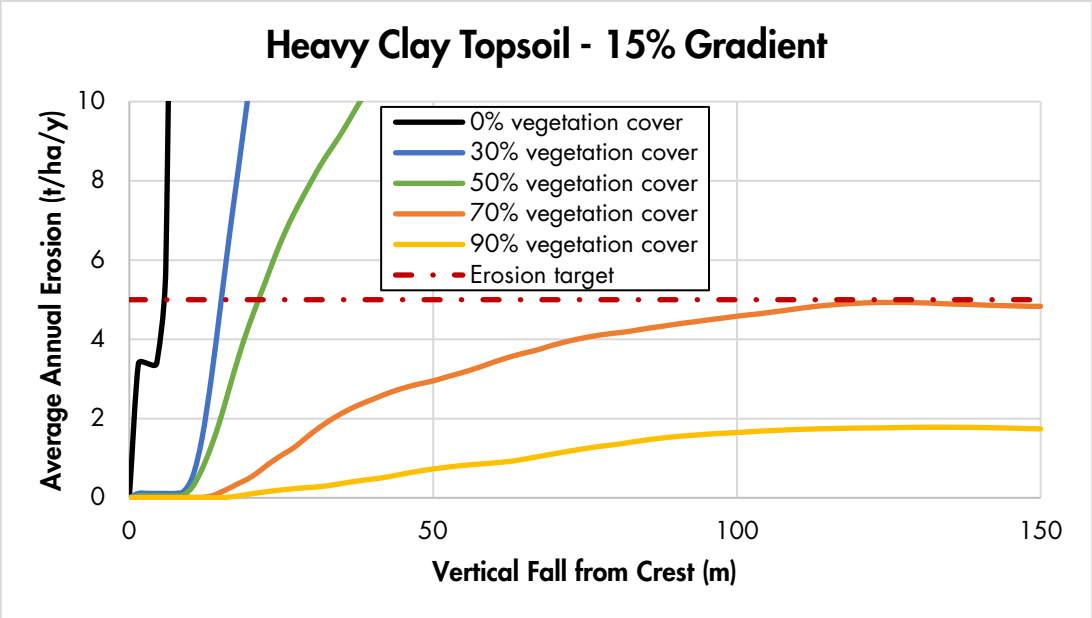

Figure 8: Predicted erosion rates on a 15% gradient outward-facing slope sheeted with heavy clay topsoil.

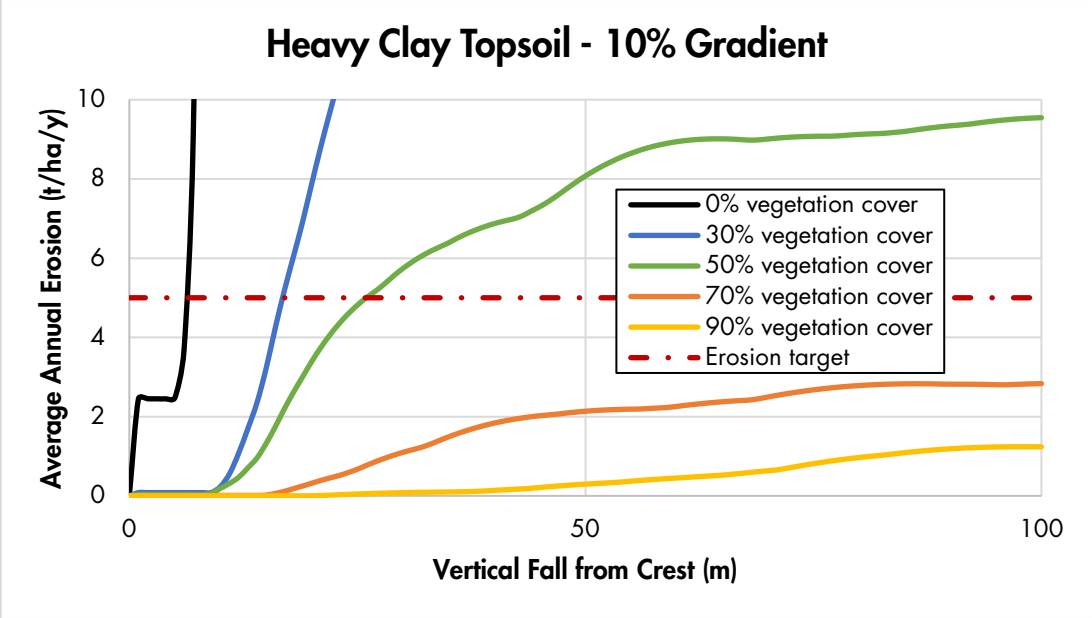

Figure 9: Predicted erosion rates on a 10% gradient outward-facing slope sheeted with heavy clay topsoil.

4.3 Inward-facing low walls sheeted with Permian waste

For the Permian waste, simulations indicate that 500m long slopes with gradients of 30% would require vegetation groundcover levels of >30% (Figure 10). Slopes with gradients of 20% are predicted to be stable for a vegetation groundcover level of >30% (Figure 11) and slopes with gradients of 15% are predicted to be stable for a vegetation groundcover level of 0% (bare) (Figure 12).

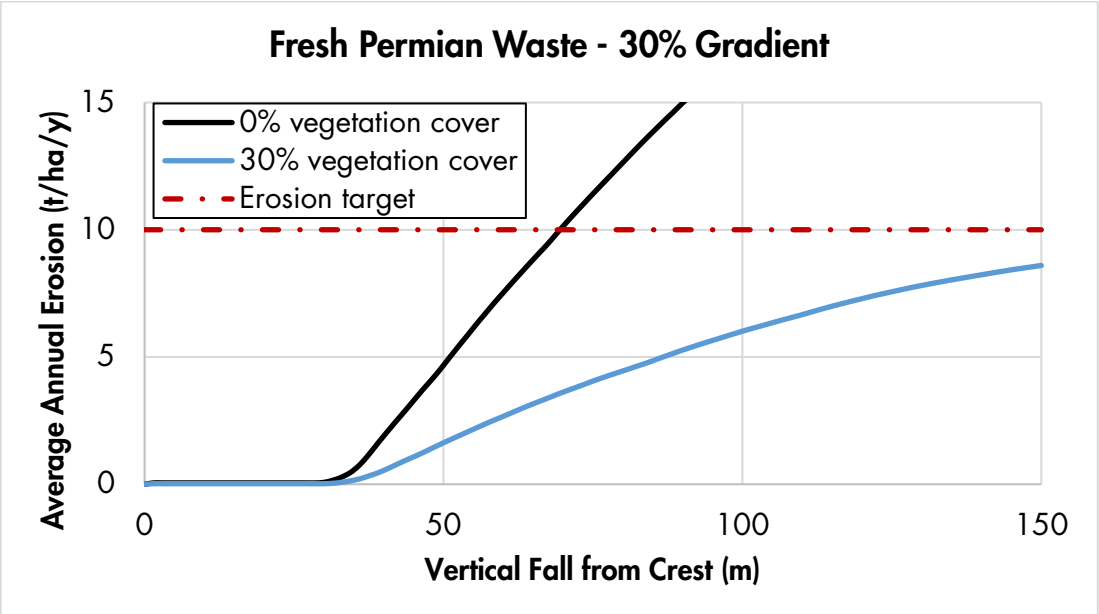

Figure 10: Predicted erosion rates on a 30% gradient inward-facing slope sheeted with Permian waste.

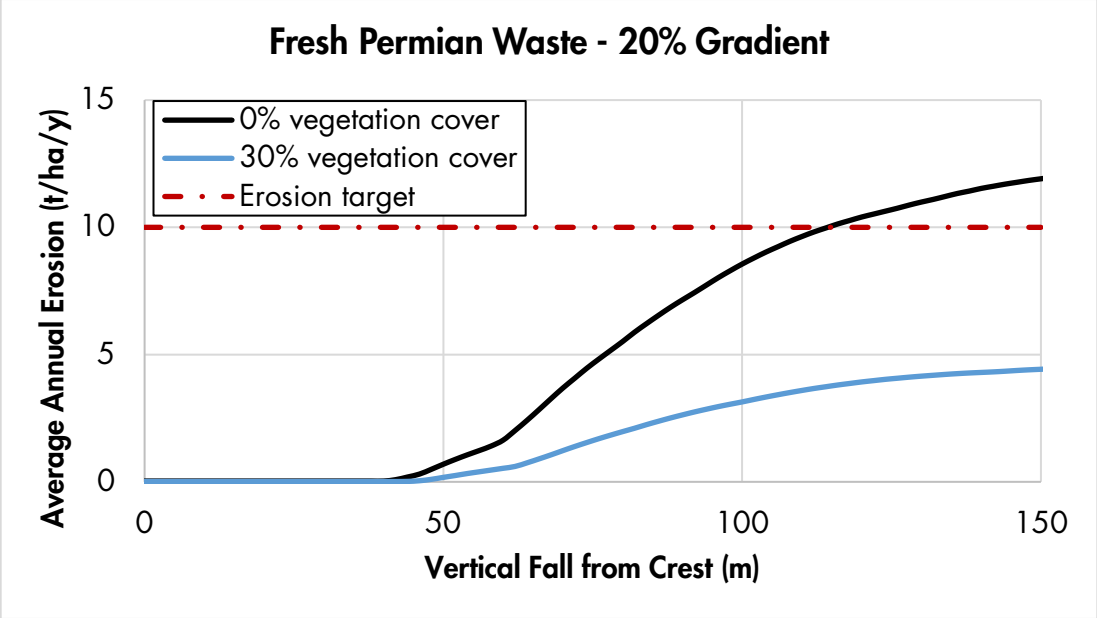

Figure 11: Predicted erosion rates on a 20% gradient inward-facing slope sheeted with Permian waste.

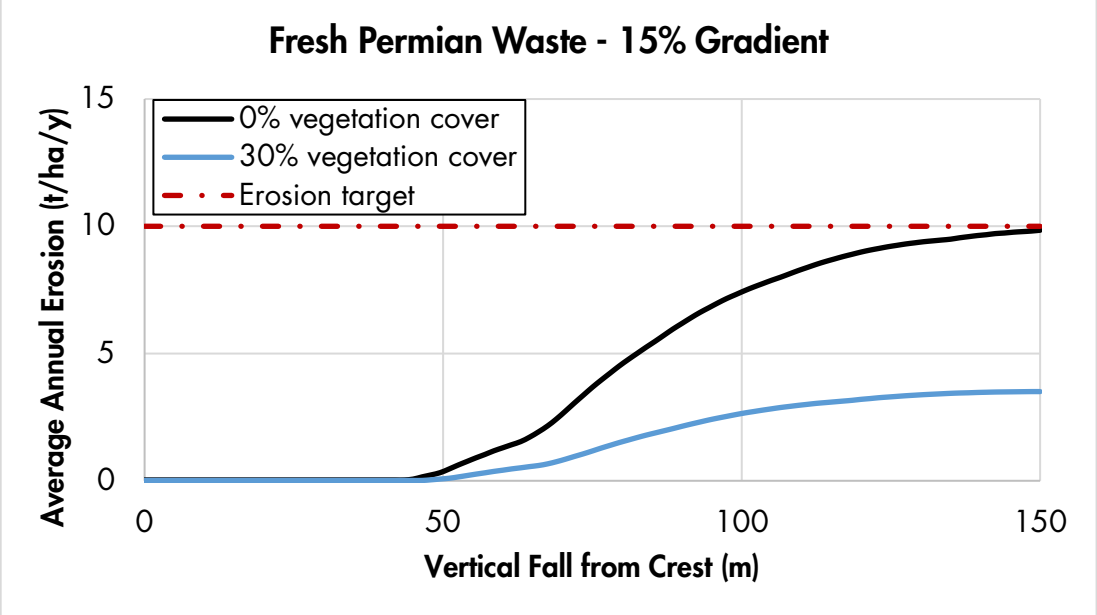

Figure 12: Predicted erosion rates on a 15% gradient inward-facing slope sheeted with Permian waste.

4.4 Summary

Based on the erosion modelling results, it was concluded that use of vegetated clay soil and fresh Permian waste surfaces can be erosionally stable. Given this finding and the spatial distribution of the stockpiled soils, SIBERIA landform evolution modelling used:

- Heavy clay topsoil with vegetation groundcover levels of 70% for outward-facing batters with 15% gradient on:
  - R8N;
  - Boonie Doon;
  - Mimosa/Besgrove;
  - Deep Creek; and
  - Stewarton/Ballamoo.
- Light clay topsoil with vegetation groundcover levels of 50% for outward-facing batters with 15% gradient on:
  - Kenmare;
  - Laleham;
  - Togara/North Marshmead;
  - South Marshmead;
  - Kennedy West; and
  - Comet Downs East.
- Fresh Permian waste with vegetation groundcover levels of 30% for inward-facing (low wall) batters with 30% gradient on:
  - R8N;
  - Boonie Doon;
  - Mimosa/Besgrove;
  - Deep Creek;
  - Stewarton/Ballamoo;
  - Kenmare;
  - Laleham;
  - Togara/North Marshmead;
  - South Marshmead;
  - Kennedy West; and
  - Comet Downs East.

5 SIBERIA MODEL SETUP

5.1 Parameters

SIBERIA model parameters derived from WEPP simulations are shown in Table 3. As noted previously (Section 3.5.3), the vegetation groundcover levels assumed are conservative, with some variation to account for lower fertility of the wastes.

It should be noted that the method of deriving parameters attempts to ensure that the m_1 parameter is optimised so that SIBERIA simulations show a similar impact of slope length to that predicted by WEPP. However, because the two models use different methods to consider impacts of slope length, it is not reasonable to expect complete agreement between the two models over the full range of slope lengths considered.

Table 3: Estimated SIBERIA parameters.

Material	Vegetation Groundcover (%)	m_1	β_1	n_1
Light clay topsoil	50	1.1127	0.00262	1.5
Heavy clay topsoil	70	1.2375	0.00360	1.5
Permian waste	30	1.5098	0.00009	1.5

5.2 Elevation models

Proposed 3-D final landform design files for BWM were provided by BMA. The landforms modelled included:

- R8N;
- Boonie Doon;
- Mimosa/Besgrove;
- Deep Creek;
- Stewarton/Ballamoo;
- Kenmare;
- Laleham;
- Togara/North Marshmead;
- South Marshmead;
- Kennedy West; and
- Comet Downs East.

These landforms were designed on the basis of WEPP model runoff/erosion results for potential surface materials to be applied (Figures 13–23). These figures also show the regions in which different surface materials and vegetation groundcover levels were applied.

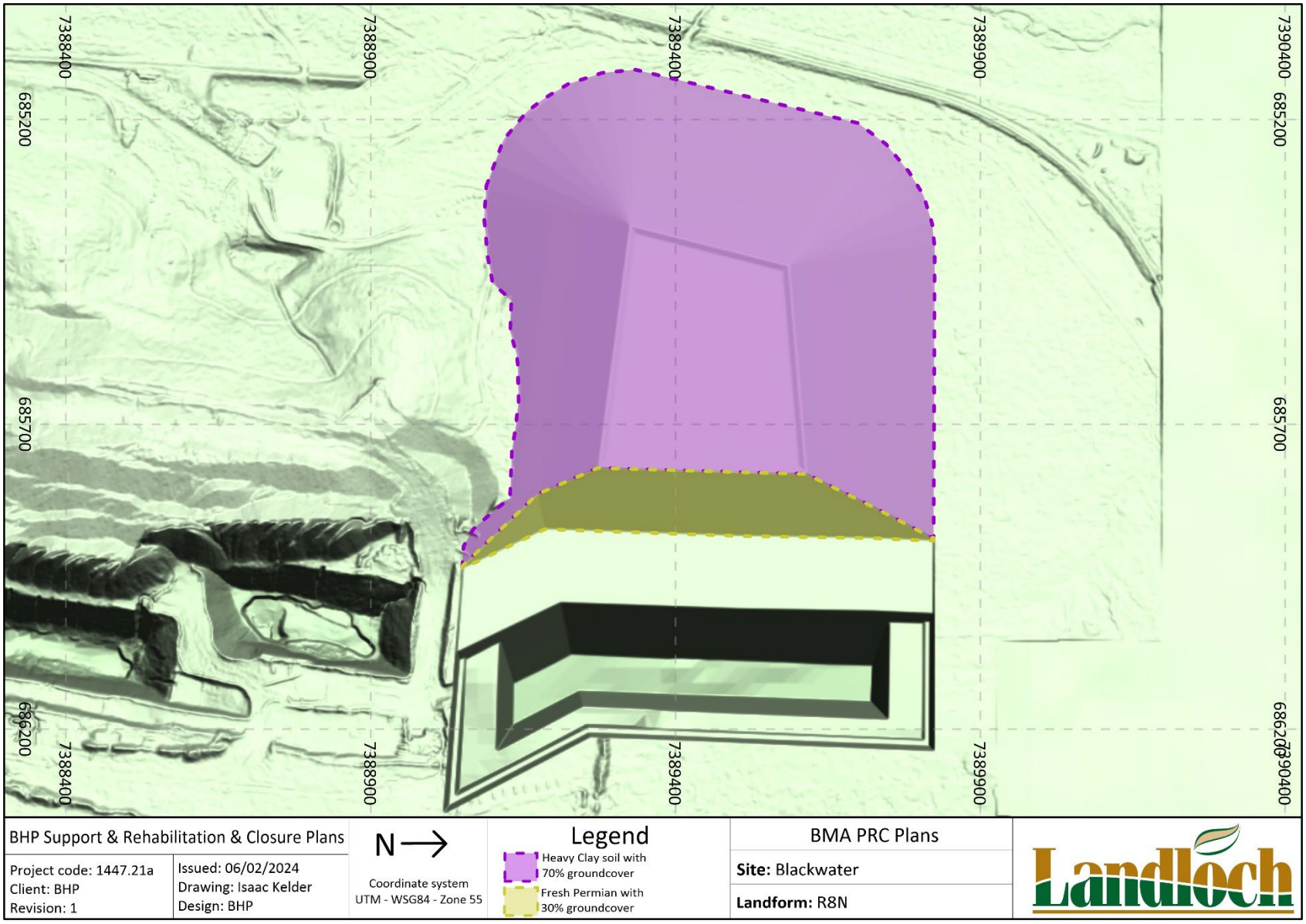

Figure 13: R8N rehabilitation landform.

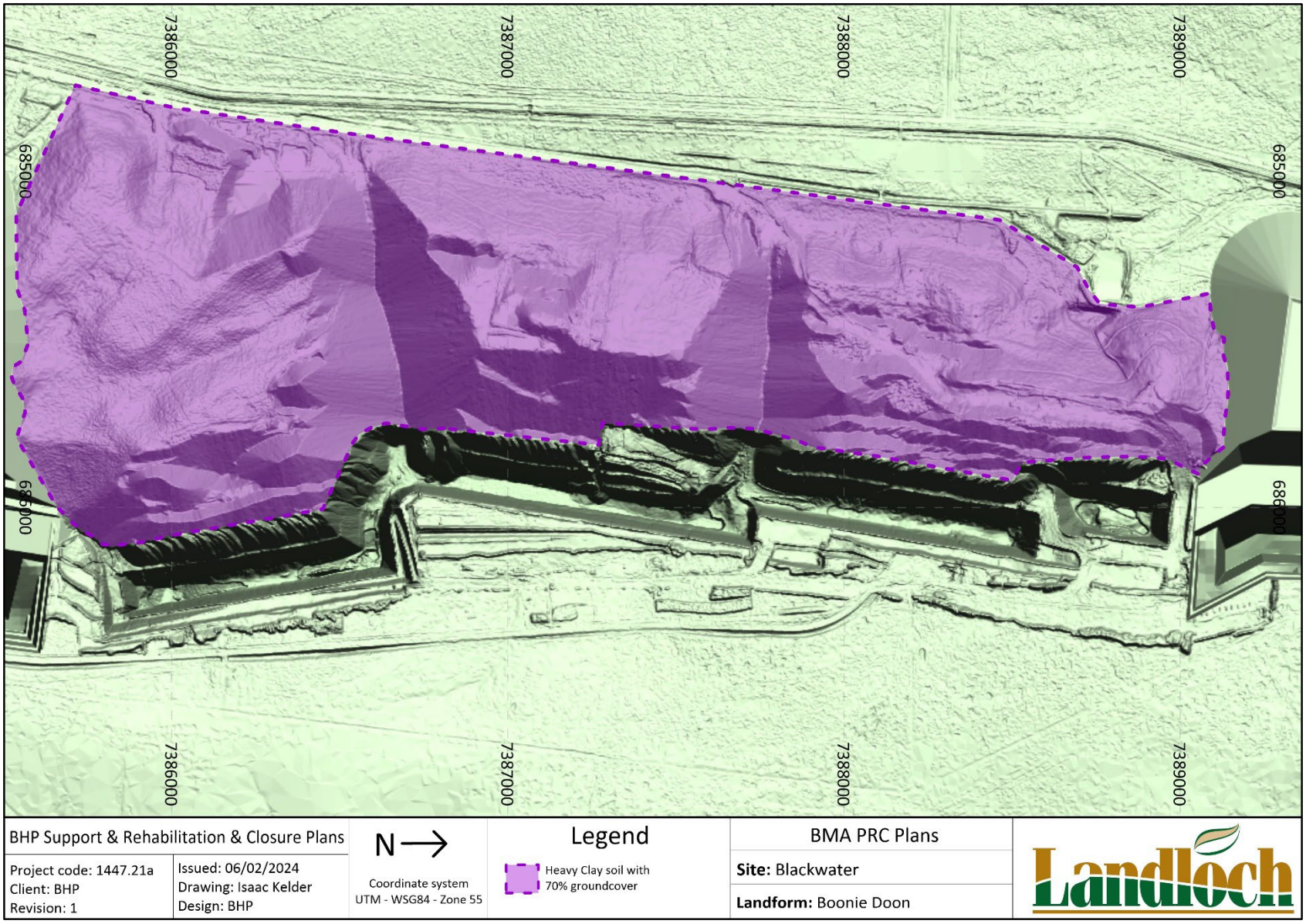

Figure 14: Boonie Doon rehabilitation landform.

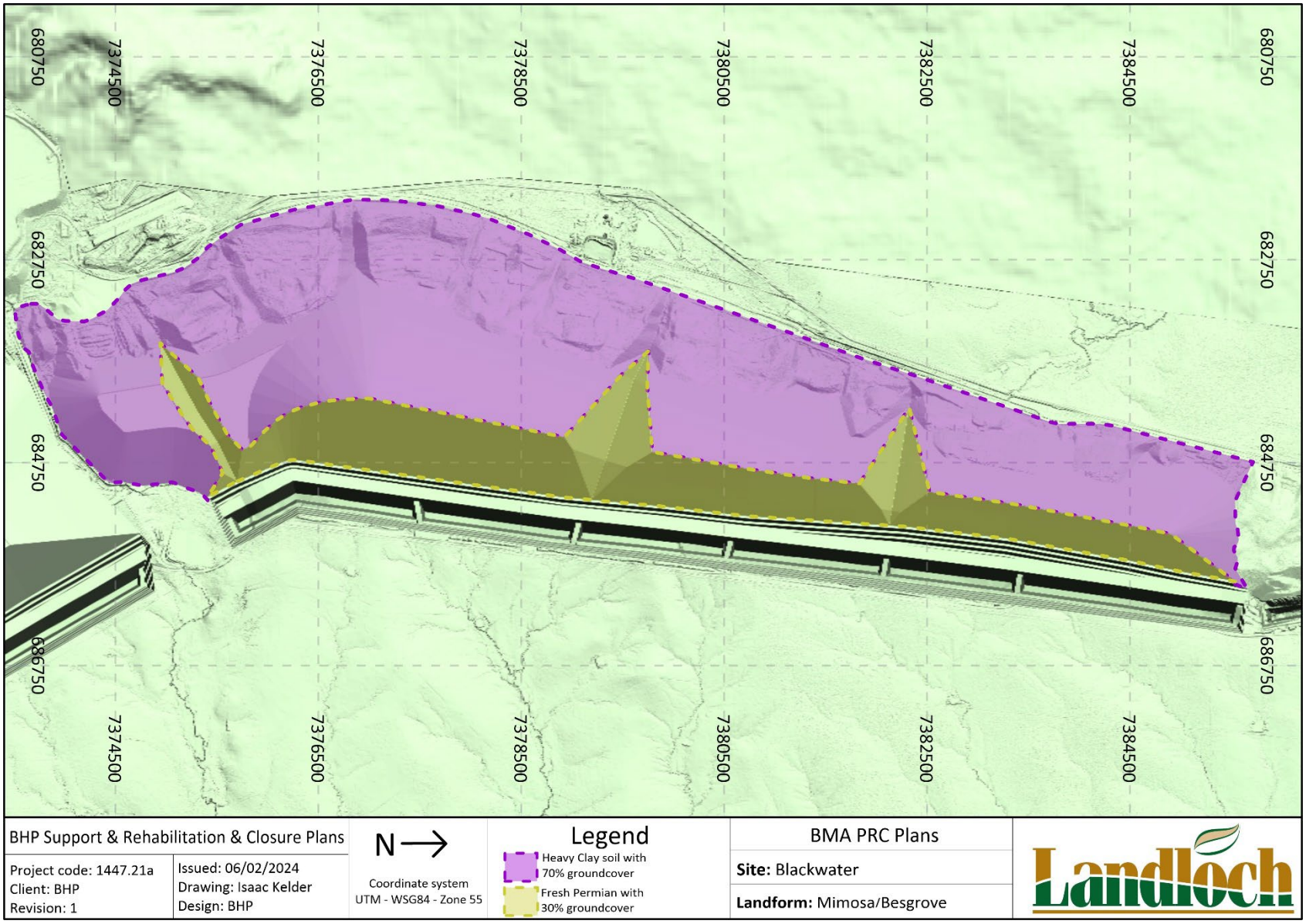

Figure 15: Mimosa/Besgrove rehabilitation landform.

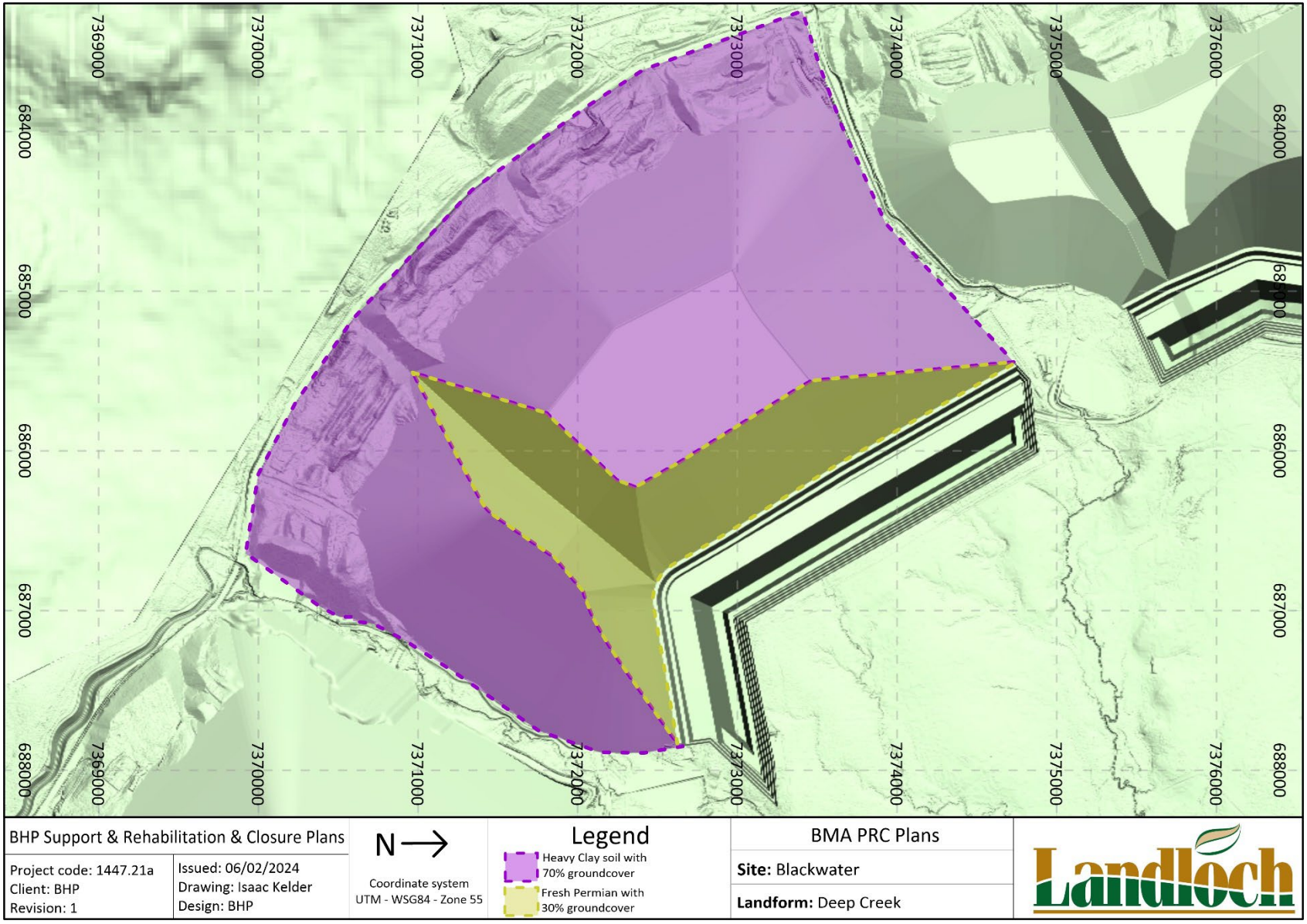

Figure 16: Deep Creek rehabilitation landform.

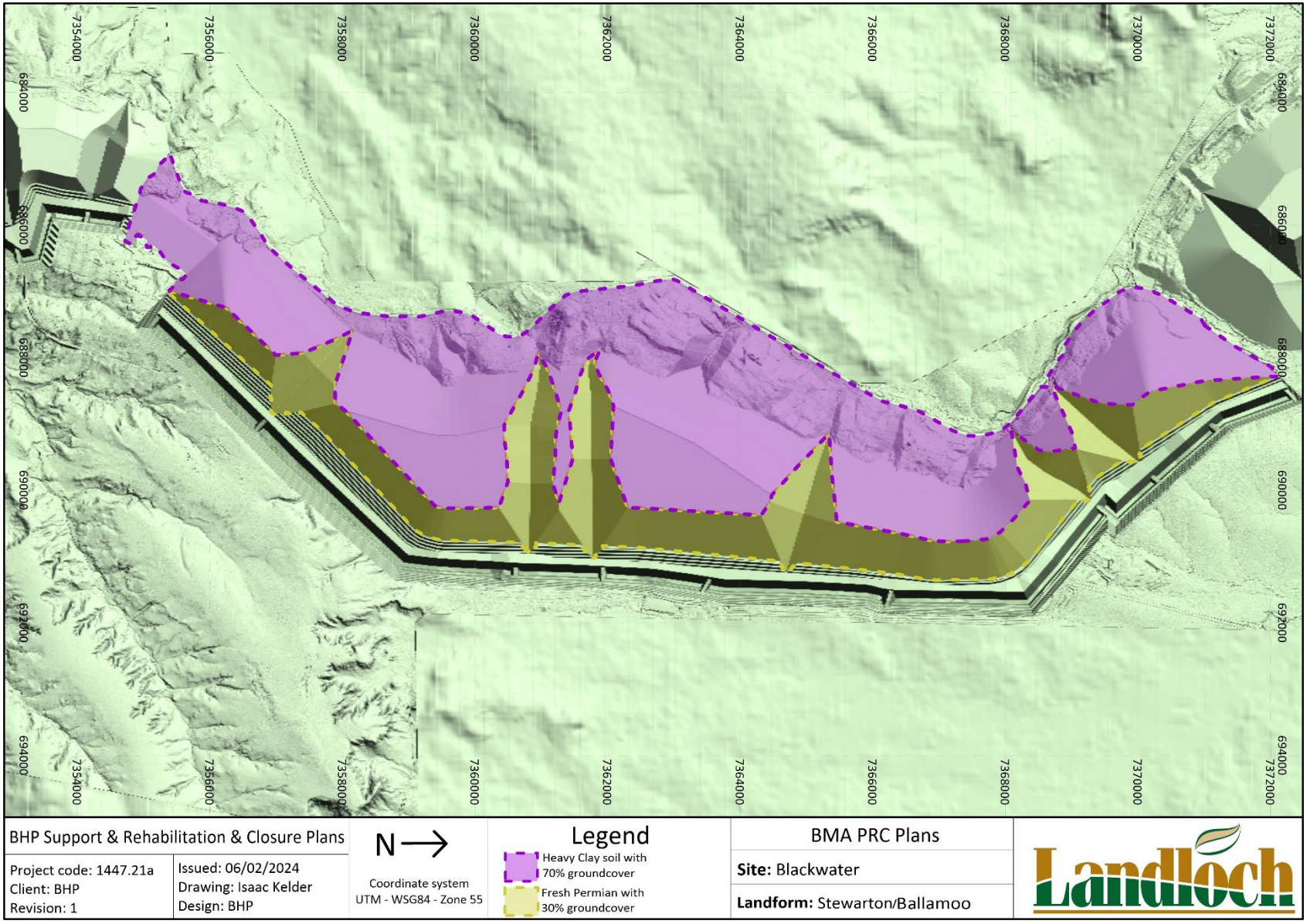

Figure 17: Stewarton/Ballamoo rehabilitation landform.

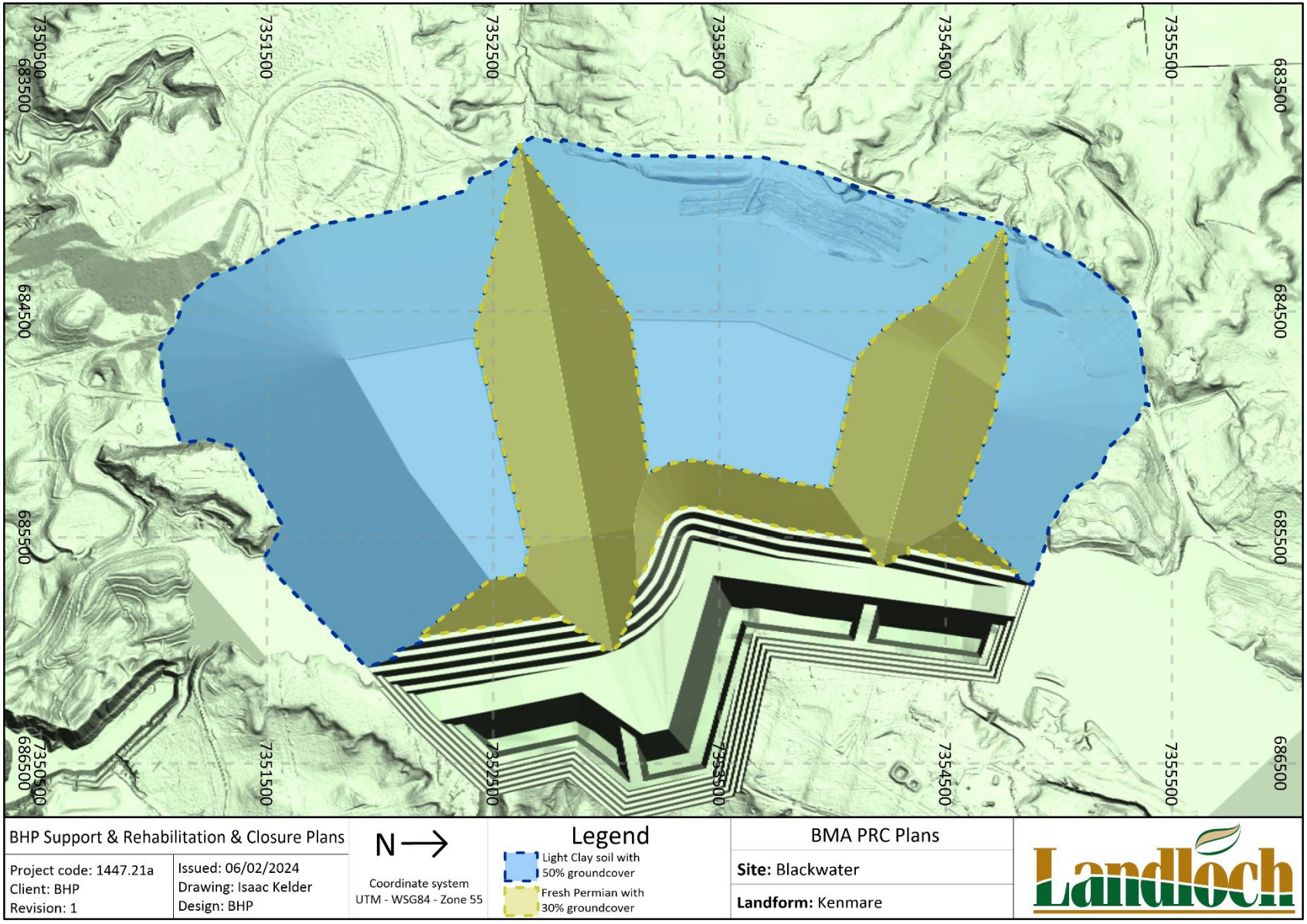

Figure 18: Kenmare rehabilitation landform.

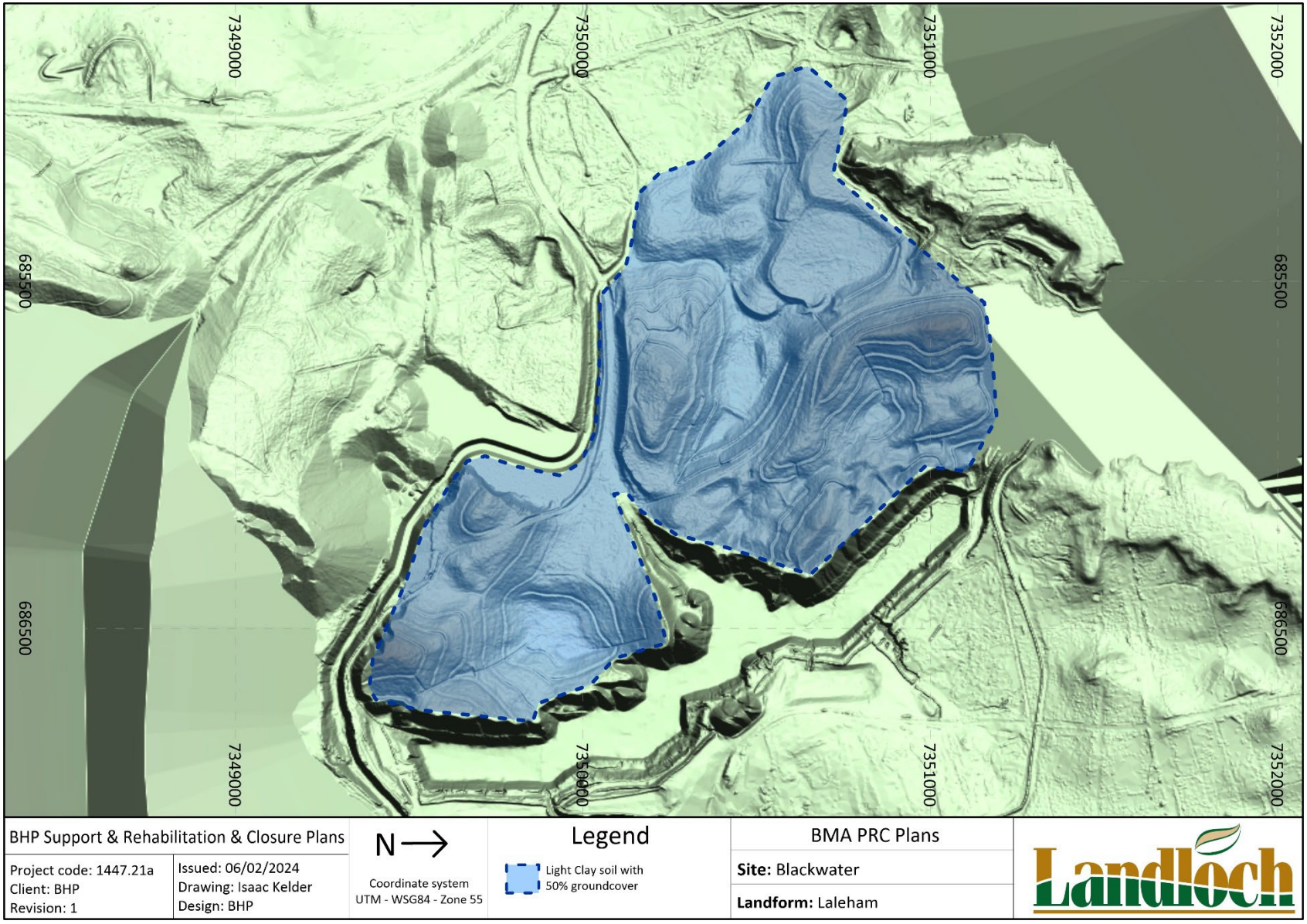

Figure 19: Laleham rehabilitation landform.

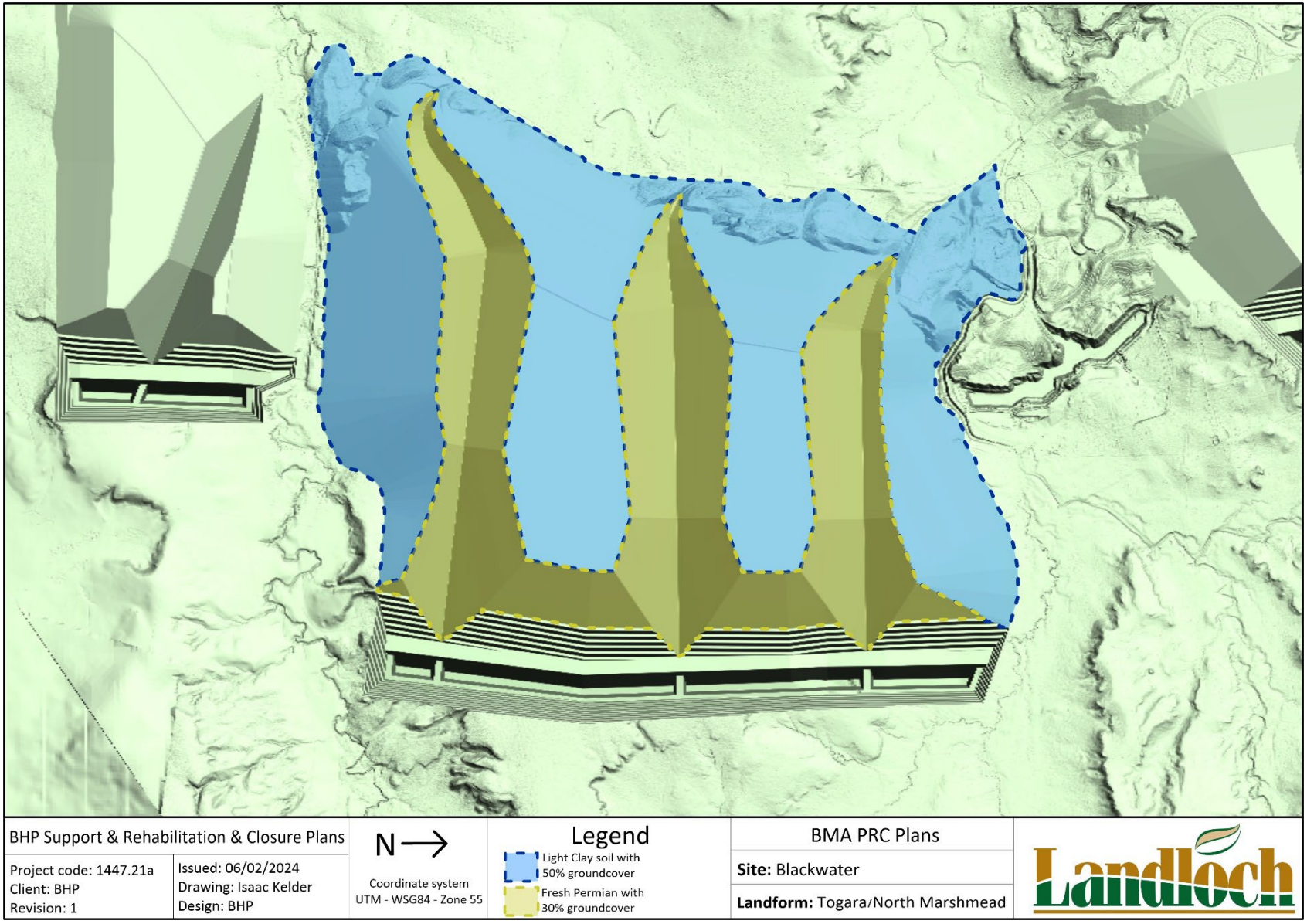

Figure 20: Togara/North Marshmead rehabilitation landform.

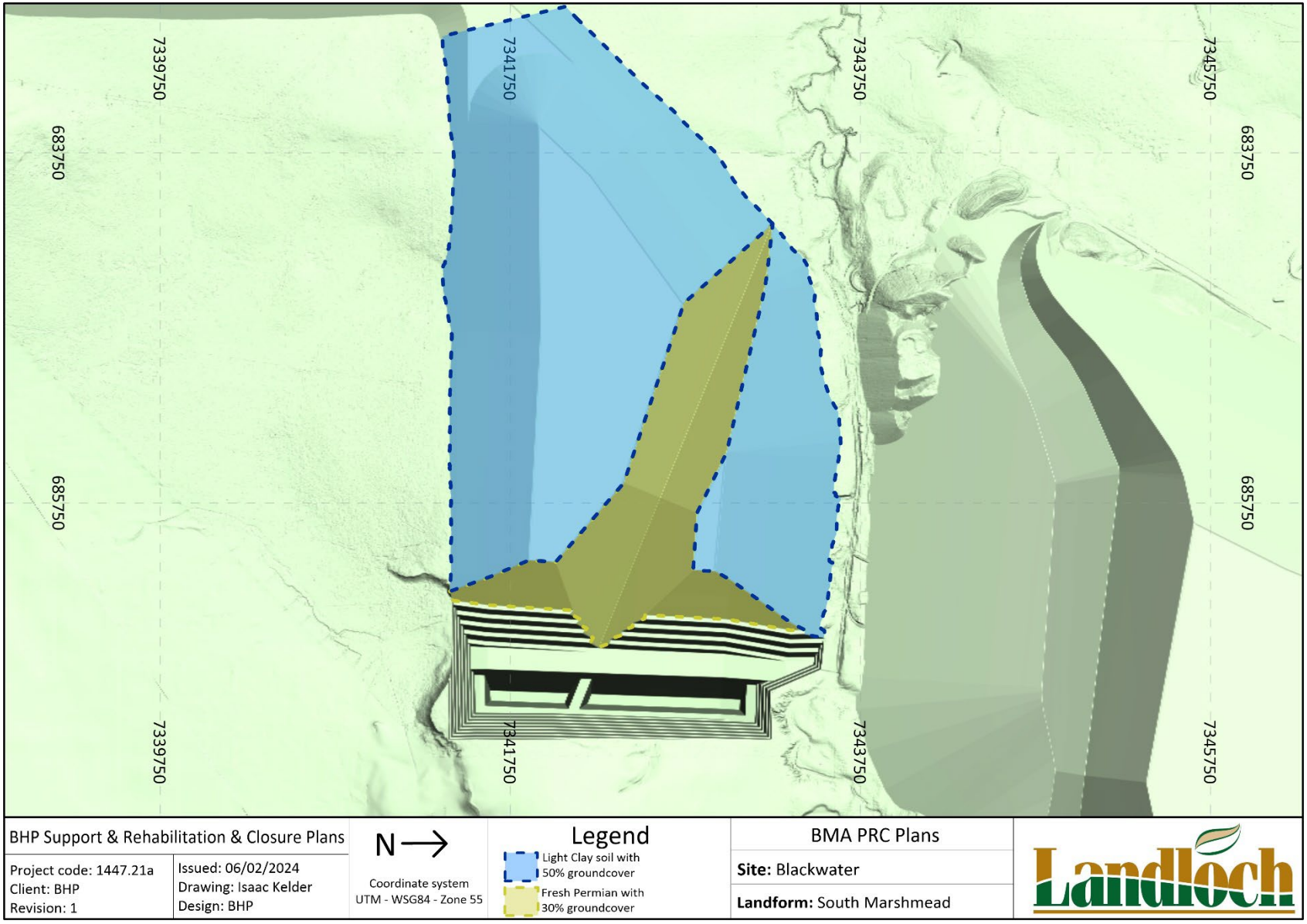

Figure 21: South Marshmead rehabilitation landform.

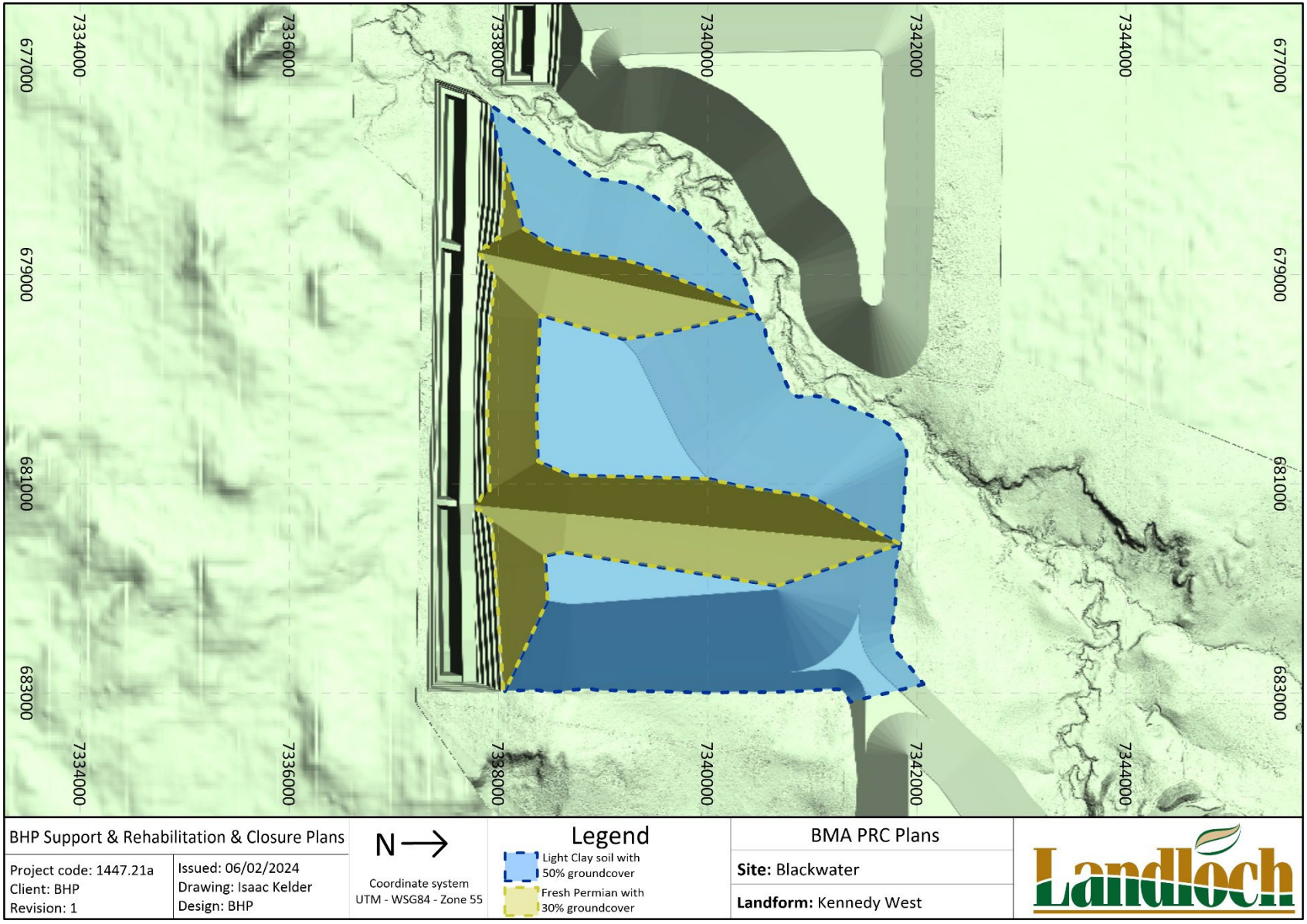

Figure 22: Kennedy West rehabilitation landform.

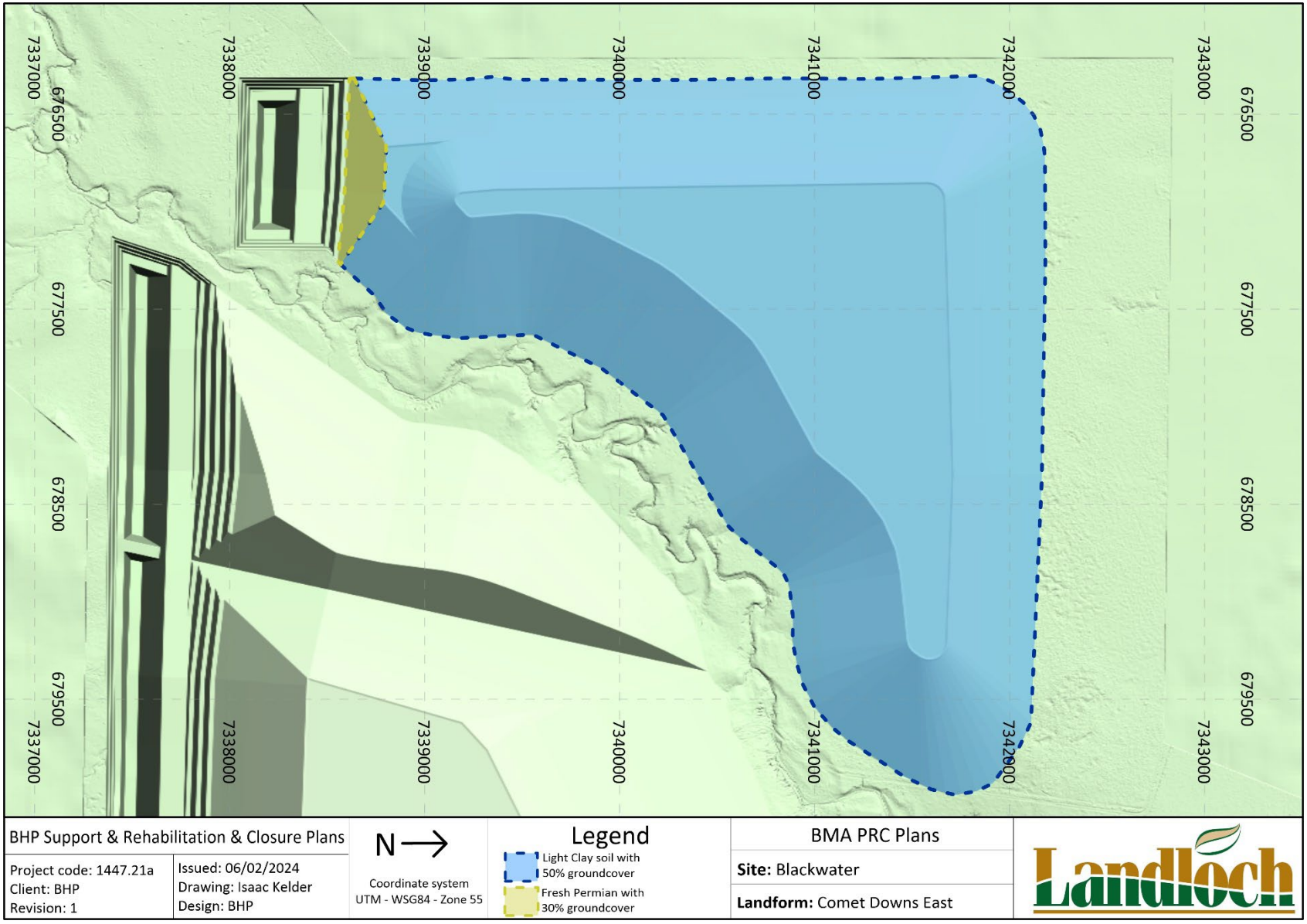

Figure 23: Comet Downs East rehabilitation landform.

6 LANDFORM EVOLUTION MODEL OUPUTS

Using input parameters derived for the materials to be used on the landforms, the SIBERIA model was run for 300 years, with outputs provided between 50 years and 300 years. At each output year, visualisations of the rate of erosion and gully development are provided, along with a table that includes rates for each material on the landform. Rates of gullying depth that exceeds 0.3m are highlighted in the visualisations. Visualisations for 300 years are shown below. However, all visualisations (50, 100, 200, and 300 years) are provided in Appendix A.

6.1 R8N landform

Rehabilitation of the R8N landform is planned to use vegetated heavy clay topsoil on the outward-facing slopes and vegetated Permian waste on the inward-facing (low wall) slopes (Figure 13). SIBERIA modelling has assumed a vegetation groundcover of 70% for the outward-facing heavy clay topsoil surfaces and 30% for the inward-facing Permian waste surfaces.

Predicted erosion rates shown in Table 4 indicate that at a vegetation groundcover level of 70%, predicted erosion rates of the outward-facing batter slopes are initially (after year 50) slightly above the target level of 5t/ha/y, but reduced to at or below the target level for the remainder of the simulation period. If vegetation groundcover of the inward-facing batters is >30%, then batter slope erosion rates are predicted to be below the target rate (10t/ha/y).

Table 4: Predicted erosion rates and gully depths for the R8M landform.

Simulation year	Maximum gully depth (m)	Average annual erosion (t/ha/y)	Cumulative erosion (mm)
Heavy clay topsoil with 70% vegetation groundcover			
50	-	5.1	26
100	-	5.0	51
200	-	4.8	75
300	0.4	4.7	98
Permian waste with 30% vegetation groundcover			
50	-	2.4	6
100	-	2.4	12
200	-	2.3	18
300	-	2.3	24

Figure 24 shows SIBERIA output after 300 years of simulation. The SIBERIA output indicates that the R8N landform is not prone to significant levels of gully erosion if the surface conditions (material type and vegetation groundcover levels) are achieved. Some gully erosion is predicted to occur after 300 years for the vegetated clay topsoil covered slopes. However, given the underlying secondary growth media material is likely to be the more erosion-resistant fresh Permian waste, the risk of exposing problematic (more

erodible) materials and for erosion to accelerate over the long-term is considered low. Gully erosion should be monitored as part of the rehabilitation monitoring process and remediated if assessed as required by an appropriately qualified person to achieve the post-mining land use. Gully erosion is not predicted to occur for the fresh Permian covered slopes, though some rilling may still occur.

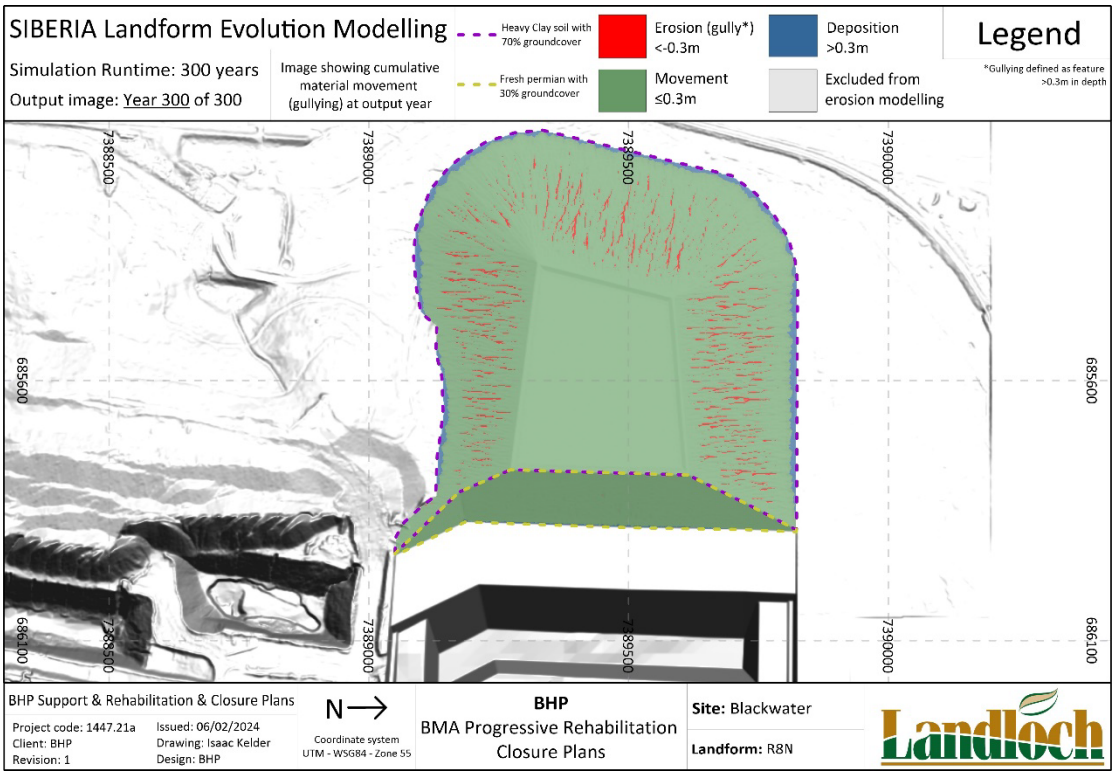

Figure 24: Predicted erosion and deposition depths of the R8N rehabilitation landform after 300 years.

6.2 Boonie Doon landform

Rehabilitation of the Boonie Doon landform has used vegetated heavy clay topsoil on all slopes (Figure 14). SIBERIA modelling has assumed a vegetation groundcover of 70% for the heavy clay topsoil surfaces.

Predicted erosion rates shown in Table 5 indicate that at a vegetation groundcover level of 70%, predicted erosion rates of the batter slopes will be below the target level of 5t/ha/y.

Table 5: Predicted erosion rates and gully depths for the Boonie Doon landform.

Simulation year	Maximum gully depth (m)	Average annual erosion (t/ha/y)	Cumulative erosion (mm)
Heavy clay topsoil with 70% vegetation groundcover			
50	-	1.5	5
100	-	1.1	9
200	-	0.9	12
300	-	0.8	14

Figure 25 shows SIBERIA output after 300 years of simulation. The SIBERIA output indicates that the Boonie Doon landform is not prone to significant levels of gully erosion if the surface conditions (material type and vegetation groundcover levels) are achieved. Some rill erosion is predicted to occur in areas where the slope shape is more complex and increased flow convergence is likely to occur.

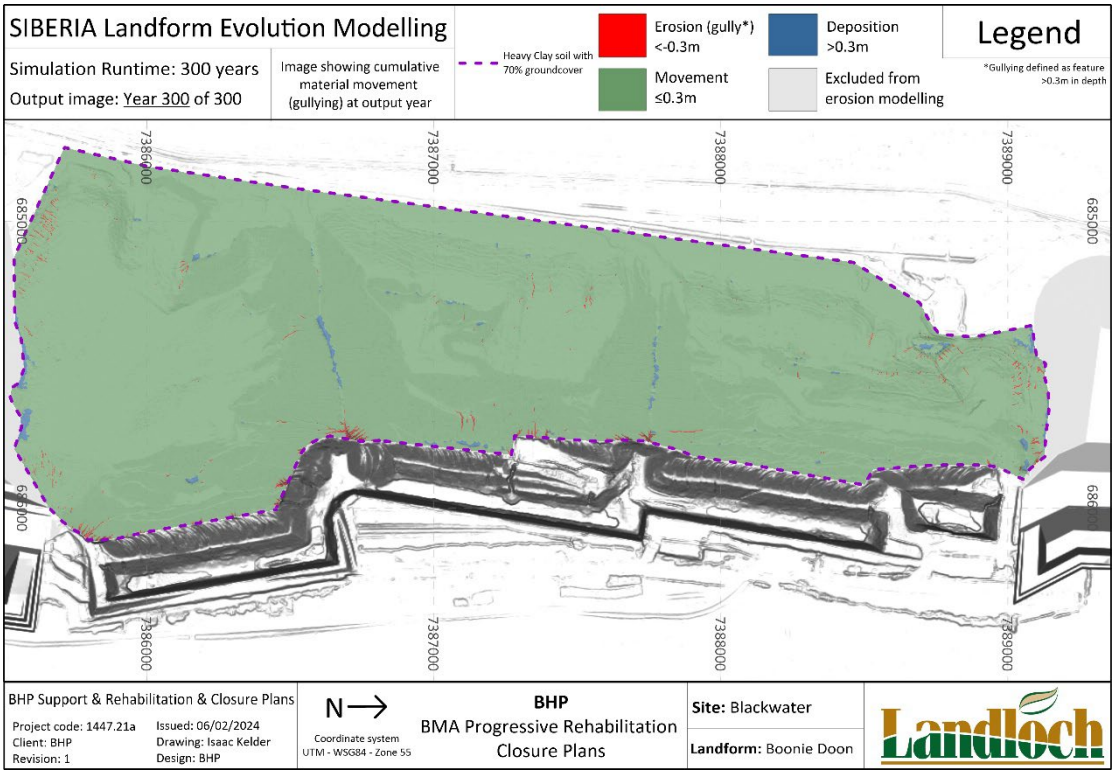

Figure 25: Predicted erosion and deposition depths of the Boonie Doon rehabilitation landform after 300 years.

6.3 Mimosa/Besgrove landform

Rehabilitation of the Mimosa/Besgrove landform is planned to use vegetated heavy clay topsoil on the outward-facing slopes and vegetated Permian waste on the inward-facing (low wall) slopes (Figure 15). SIBERIA modelling has assumed a vegetation groundcover of 70% for the outward-facing heavy clay topsoil surfaces and 30% for the inward-facing Permian waste surfaces.

Predicted erosion rates shown in Table 6 indicate that at a vegetation groundcover level of 70%, predicted erosion rates of the outward-facing batter slopes are slightly above (5.2t/ha/y) the target level (5t/ha/y). If vegetation groundcover of the inward-facing batters is >30%, batter slope erosion rates are predicted to be below the target rate.

Figure 26 shows SIBERIA output after 300 years of simulation. The SIBERIA output predicts that the Mimosa Besgrove landform is not prone to significant levels of gully erosion if the surface conditions (material type and vegetation groundcover levels) are achieved. This is despite the vegetated clay soils having slightly elevated erosion potential. This indicates that the erosion in the vegetated clay topsoil is predicted to be well distributed. Some gully erosion is predicted to occur after 300 years for the vegetated clay topsoil covered slopes. However, given the underlying secondary growth

media material is likely to be the more erosion-resistant fresh Permian waste, the risk of exposing problematic (more erodible) materials and for erosion to accelerate over the long-term is considered low.

Some gully erosion is also predicted to occur after 200 years for the fresh Permian covered slopes. However, given the underlying material is likely to be more erosion-resistant fresh Permian waste, the risk of exposing problematic (more erodible) materials over the long-term is considered low. Gully erosion should be monitored as part of the rehabilitation monitoring process and remediated if assessed as required by an appropriately qualified person to achieve the post-mining land use.

Table 6: Predicted erosion rates and gully depths for the Mimosa/Besgrove landform.

Simulation year	Maximum gully depth (m)	Average annual erosion (t/ha/y)	Cumulative erosion (mm)
Heavy clay topsoil with 70% vegetation groundcover			
50	-	5.2	26
100	-	5.2	52
200	-	5.2	78
300	0.3	5.2	104
Permian waste with 30% vegetation groundcover			
50	-	3.3	17
100	-	3.3	33
200	0.4	3.2	49
300	0.5	3.2	65

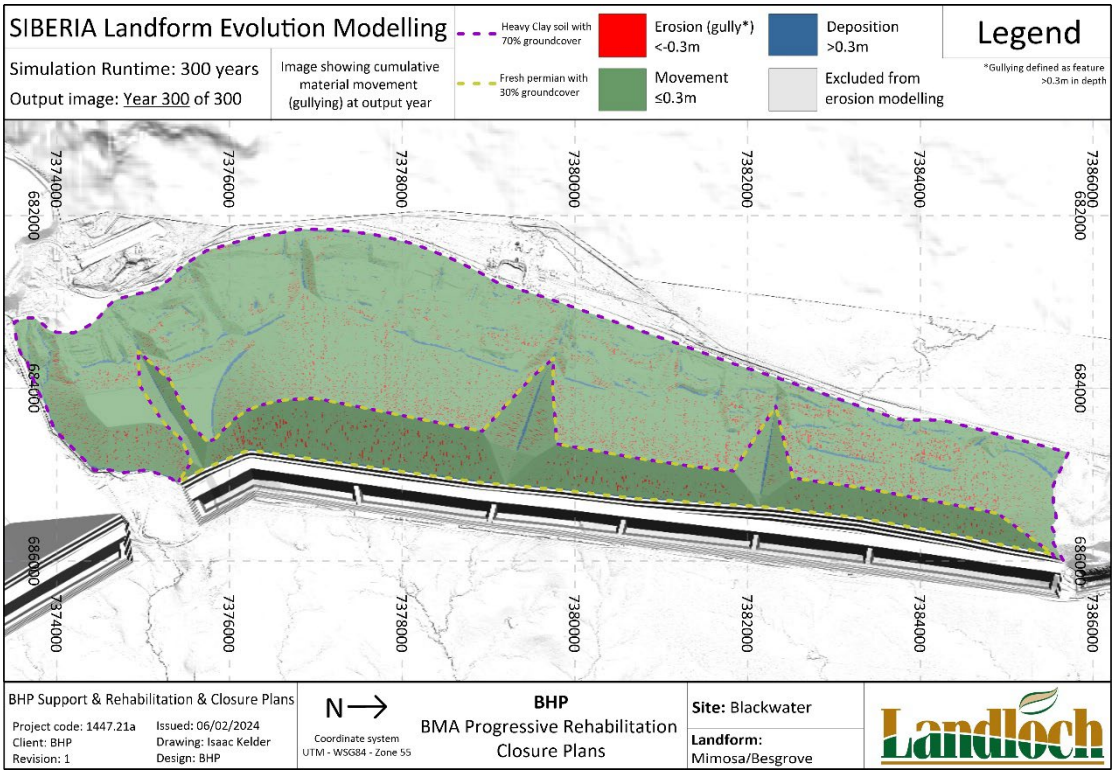

Figure 26: Predicted erosion and deposition depths of the Mimosa/Besgrove rehabilitation landform after 300 years.

6.4 Deep Creek landform

Rehabilitation of the Deep Creek landform is planned to use vegetated heavy clay topsoil on the outward-facing slopes and vegetated Permian waste on the inward-facing (low wall) slopes (Figure 16). SIBERIA modelling has assumed a vegetation groundcover of 70% for the outward-facing heavy clay topsoil surfaces and 30% for the inward-facing Permian waste surfaces.

Predicted erosion rates shown in Table 7 indicate that at a vegetation groundcover level of 70%, predicted erosion rates of the outward-facing batter slopes are initially (after year 50) slightly above the target level of 5t/ha/y, but reduced to at or below the target level for the remainder of the simulation period. If vegetation groundcover of the inward-facing batters is >30%, then batter slope erosion rates are predicted to be below the target rate (10t/ha/y).

Table 7: Predicted erosion rates and gully depths for the Deep Creek landform.

Simulation year	Maximum gully depth (m)	Average annual erosion (t/ha/y)	Cumulative erosion (mm)
Heavy clay topsoil with 70% vegetation groundcover			
50	-	5.6	35
100	-	5.0	66
200	-	4.7	95
300	0.3	4.6	124
Permian waste with 30% vegetation groundcover			
50	-	4.7	29
100	-	3.5	51
200	0.4	2.9	69
300	0.6	2.8	87

Figure 27 shows SIBERIA output after 300 years of simulation. The SIBERIA output indicates that the Deep Creek landform is not prone to significant levels of gully erosion if the surface conditions (material type and vegetation groundcover levels) are achieved. Some gully erosion is predicted to occur after 300 years for the vegetated clay topsoil covered slopes. However, given the underlying secondary growth media material is likely to be the more erosion-resistant fresh Permian waste, the risk of exposing problematic (more erodible) materials and for erosion to accelerate over the long-term is considered low. Some gully erosion is also predicted to occur after 200 years for the fresh Permian covered slopes. However, given the underlying material is likely to be more erosion-resistant fresh Permian waste, the risk of exposing problematic (more erodible) materials over the long-term is considered low. Gully erosion should be monitored as part of the rehabilitation monitoring process and remediated if assessed as required by an appropriately qualified person to achieve the post-mining land use.

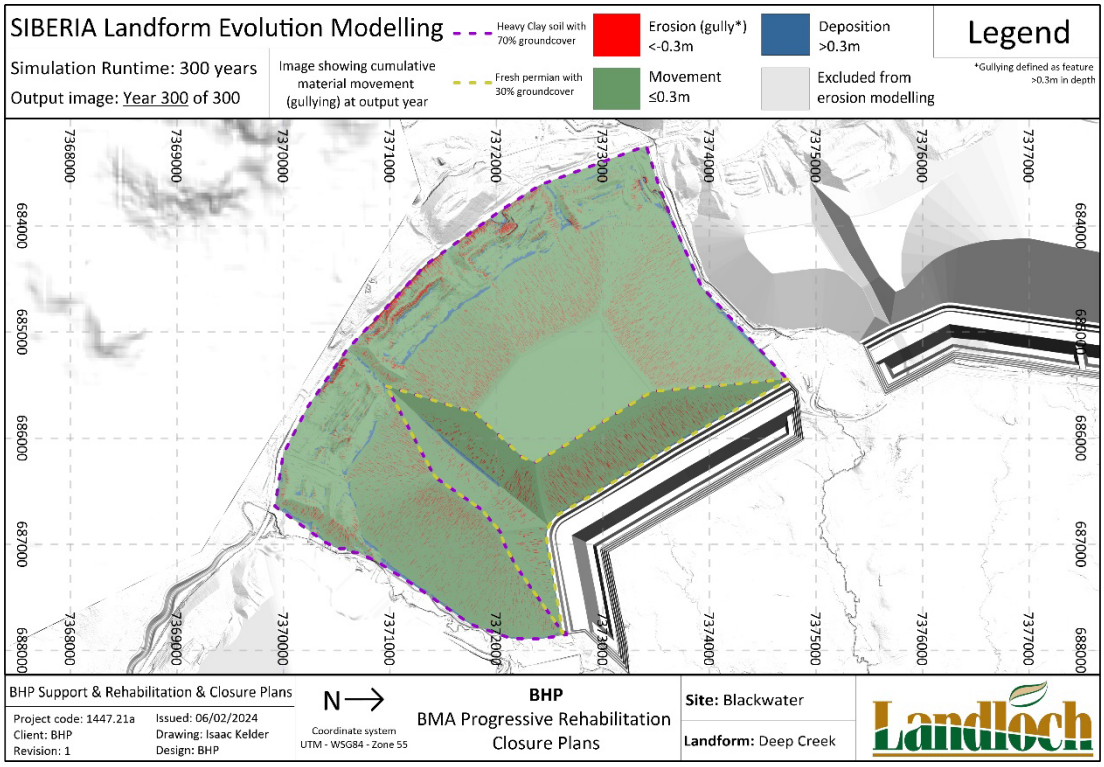

Figure 27: Predicted erosion and deposition depths of the Deep Creek rehabilitation landform after 300 years.

6.5 Stewarton/Ballamoo landform

Rehabilitation of the Stewarton/Ballamoo landform is planned to use vegetated heavy clay topsoil on the outward-facing slopes and vegetated Permian waste on the inward-facing (low wall) slopes (Figure 17). SIBERIA modelling has assumed a vegetation groundcover of 70% for the outward-facing heavy clay topsoil surfaces and 30% for the inward-facing Permian waste surfaces.

Predicted erosion rates shown in Table 8 indicate that at a vegetation groundcover level of 70%, predicted erosion rates of the outward-facing batter slopes are below the target level of 5t/ha/y for the simulation period. If vegetation groundcover of the inward-facing batters is >30%, batter erosion rates are also predicted to be below the target rate.

Figure 28 shows SIBERIA output after 300 years of simulation. The SIBERIA output indicates that the Stewarton/Ballamoo landform is not prone to significant levels of gully erosion if the surface conditions (material type and vegetation groundcover levels) are achieved. Some gully erosion is predicted to occur after 300 years for the vegetated clay topsoil covered slopes. However, given the underlying secondary growth media material is likely to be the more erosion-resistant fresh Permian waste, the risk of exposing problematic (more erodible) materials and for erosion to accelerate over the long-term is considered low. Gully erosion should be monitored as part of the rehabilitation monitoring process and remediated if assessed as required by an appropriately qualified person to achieve the post-mining land use. Gully erosion is not predicted to occur for the fresh Permian covered slopes, though some rilling may still occur.

Table 8: Predicted erosion rates and gully depths for the Stewarton/Ballamoo landform.

Simulation year	Maximum gully depth (m)	Average annual erosion (t/ha/y)	Cumulative erosion (mm)
Heavy clay topsoil with 70% vegetation groundcover			
50	-	4.9	29
100	-	4.8	57
200	-	4.7	84
300	0.4	4.7	112
Permian waste with 30% vegetation groundcover			
50	-	2.4	6
100	-	2.4	12
200	-	2.3	18
300	-	2.3	24

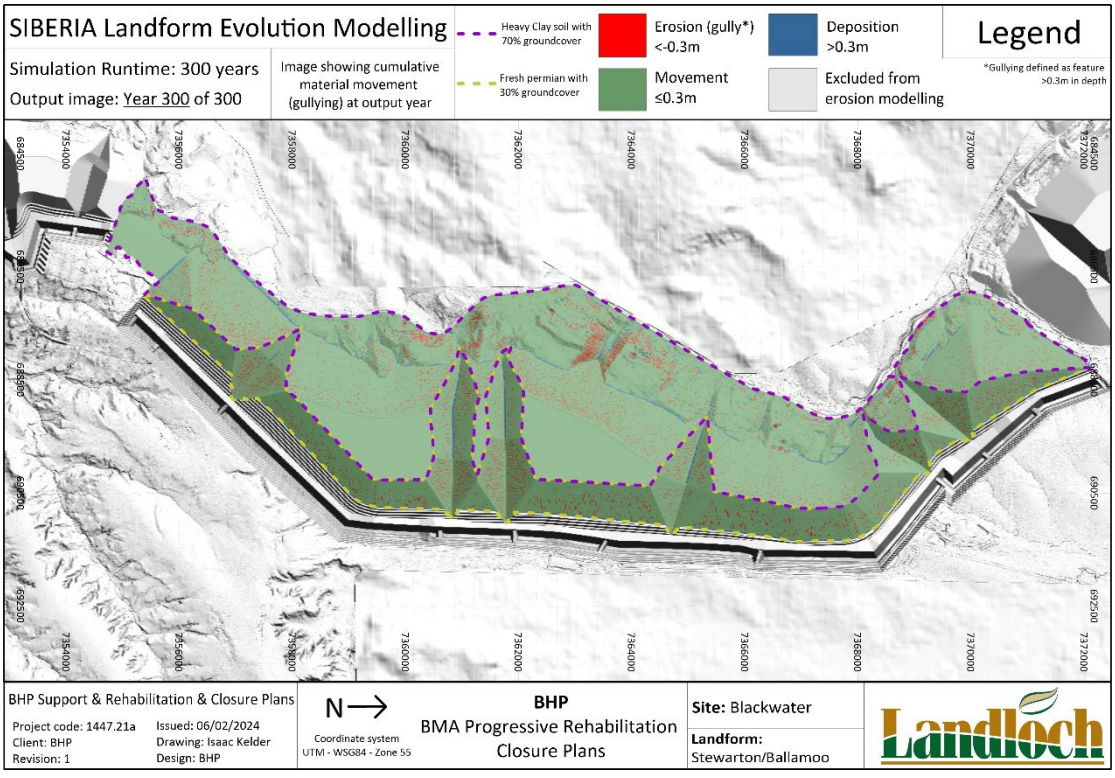

Figure 28: Predicted erosion and deposition depths of the Stewarton/Ballamoo rehabilitation landform after 300 years.

6.6 Kenmare landform

Rehabilitation of the Kenmare landform is planned to use vegetated light clay topsoil on the outward-facing slopes and vegetated Permian waste on the inward-facing (low wall) slopes (Figure 18). SIBERIA modelling has assumed a vegetation groundcover of 50% for the outward-facing light clay topsoil surfaces and 30% for the inward-facing Permian waste surfaces.

Predicted erosion rates shown in Table 9 indicate that at a vegetation groundcover level of 50%, predicted erosion rates of the outward-facing batter slopes are below the target level of 5t/ha/y for the simulation period. If vegetation groundcover of the inward-facing batters is >30%, then batter slope erosion rates are also predicted to be below the target rate (10t/ha/y).

Table 9: Predicted erosion rates and gully depths for the Kenmare landform.

Simulation year	Maximum gully depth (m)	Average annual erosion (t/ha/y)	Cumulative erosion (mm)
Light clay topsoil with 50% vegetation groundcover			
50	-	3.8	15
100	-	3.1	26
200	-	2.8	37
300	-	2.8	48
Permian waste with 30% vegetation groundcover			
50	-	3.5	16
100	-	3.5	32
200	0.5	3.4	47
300	0.7	3.4	63

Figure 29 shows SIBERIA output after 300 years of simulation. The SIBERIA output indicates that the Kenmare landform is not prone to significant levels of gully erosion if the surface conditions (material type and vegetation groundcover levels) are achieved. No gully erosion is predicted to occur within the simulation period for the vegetated clay topsoil covered slopes. Some gully erosion is predicted to occur after 200 years for the fresh Permian covered slopes. However, given the underlying material is likely to be more erosion-resistant fresh Permian waste, the risk of exposing problematic (more erodible) materials over the long-term is considered low. Gully erosion should be monitored as part of the rehabilitation monitoring process and remediated if assessed as required by an appropriately qualified person to achieve the post-mining land use.

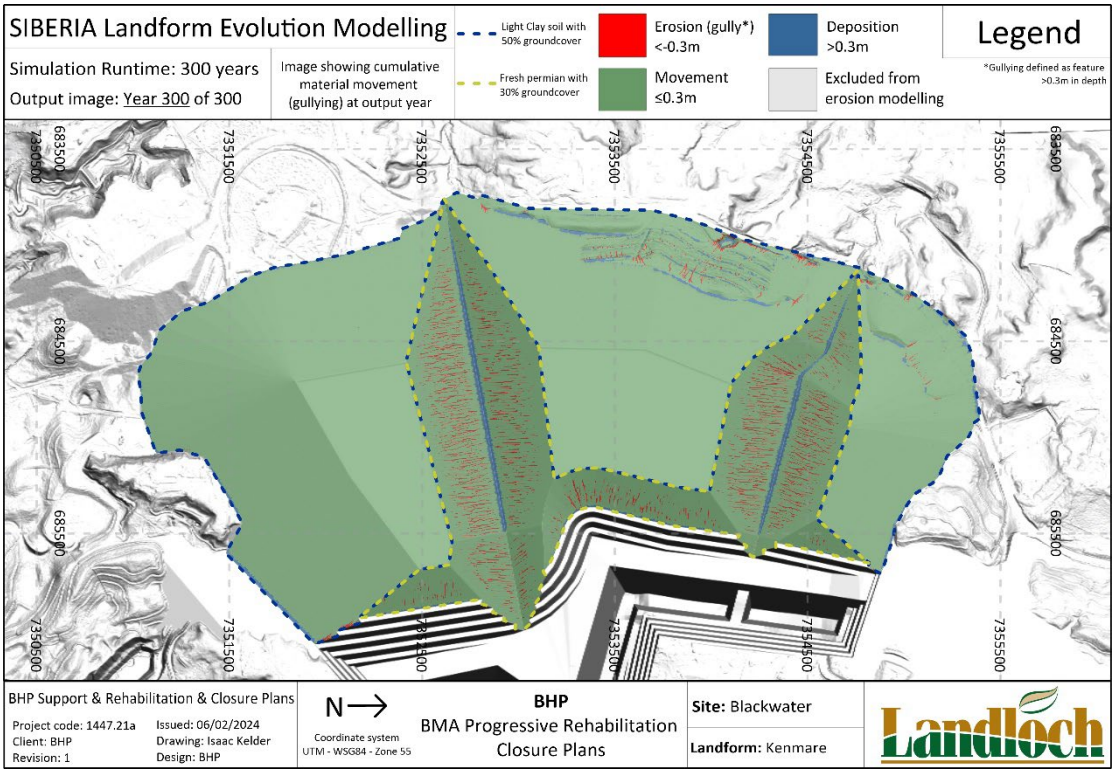

Figure 29: Predicted erosion and deposition depths of the Kenmare rehabilitation landform after 300 years.

6.7 Laleham landform

Rehabilitation of the Laleham landform has used vegetated light clay topsoil on all slopes (Figure 19). SIBERIA modelling has assumed a vegetation groundcover of 50% for the light clay topsoil surfaces.

Predicted erosion rates shown in Table 10 indicate that at a vegetation groundcover level of 50%, predicted erosion rates of the batter slopes will be below the target level of 5t/ha/y.

Table 10: Predicted erosion rates and gully depths for the Laleham landform.

Simulation year	Maximum gully depth (m)	Average annual erosion (t/ha/y)	Cumulative erosion (mm)
Light clay topsoil with 50% vegetation groundcover			
50	-	0.3	1
100	-	0.4	2
200	-	0.4	4
300	0.4	0.5	5

Figure 30 shows SIBERIA output after 300 years of simulation. The SIBERIA output indicates that the Laleham landform is not prone to significant levels of gully erosion if the surface conditions (material type and vegetation groundcover levels) are achieved. Some gully erosion is predicted to occur after 300 years in areas where the slope shape

is more complex and increased flow convergence is likely to occur. In reality reshaping of this area will be smoother than modelled in the 3-D surface provided, which would reduce the risk of erosion.

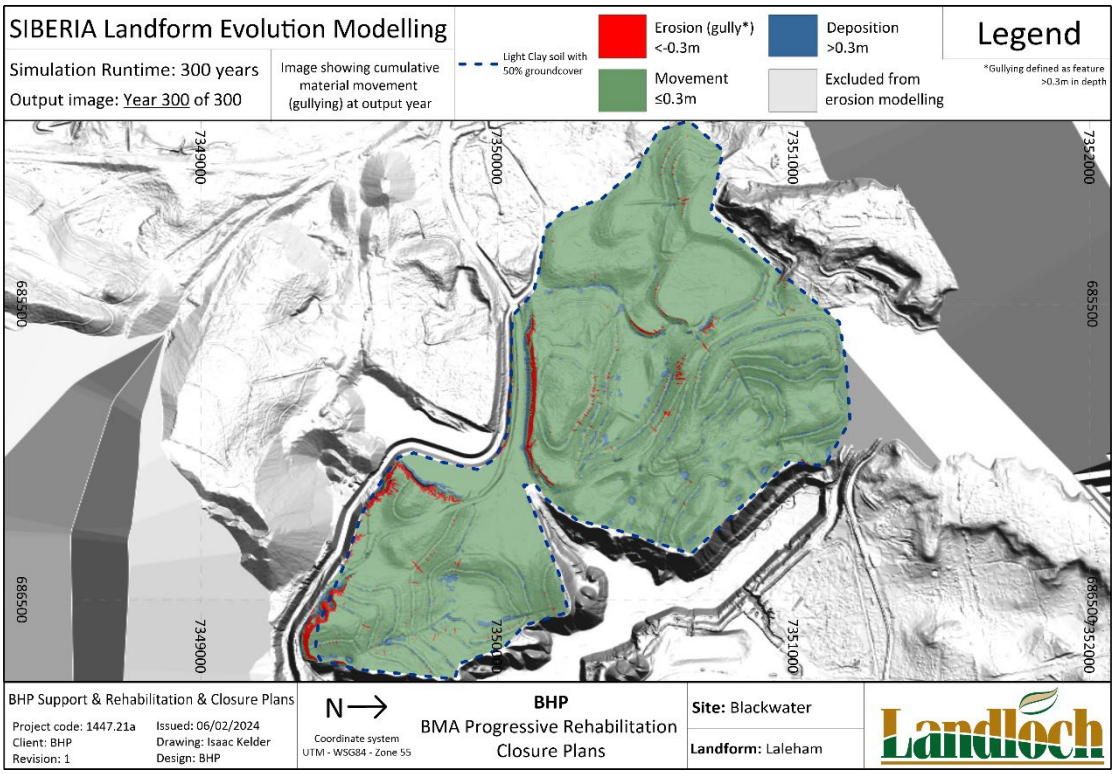

Figure 30: Predicted erosion and deposition depths of the Laleham rehabilitation landform after 300 years.

6.8 Togara/North Marshmead landform

Rehabilitation of the Togara/North Marshmead landform is planned to use vegetated light clay topsoil on the outward-facing slopes and vegetated Permian waste on the inward-facing (low wall) slopes (Figure 20). SIBERIA modelling has assumed a vegetation groundcover of 50% for the outward-facing light clay topsoil surfaces and 30% for the inward-facing Permian waste surfaces.

Predicted erosion rates shown in Table 11 indicate that at a vegetation groundcover level of 50%, predicted erosion rates of the outward-facing batter slopes are below the target level of 5t/ha/y for the simulation period. If vegetation groundcover of the inward-facing batters is >30%, then batter slope erosion rates are also predicted to be below the target rate (10t/ha/y).

Figure 31 shows SIBERIA output after 300 years of simulation. The SIBERIA output indicates that the Togara/North Marshmead landform is not prone to significant levels of gully erosion if the surface conditions (material type and vegetation groundcover levels) are achieved. No gully erosion is predicted to occur within the simulation period for the vegetated clay topsoil covered slopes. Some gully erosion is predicted to occur after 200 years for the fresh Permian covered slopes. However, given the underlying material is likely to be more erosion-resistant fresh Permian waste, the risk of exposing

problematic (more erodible) materials over the long-term is considered low. Gully erosion should be monitored as part of the rehabilitation monitoring process and remediated if assessed as required by an appropriately qualified person to achieve the post-mining land use.

Table 11: Predicted erosion rates and gully depths for the Togara/North Marshmead landform.

Simulation year	Maximum gully depth (m)	Average annual erosion (t/ha/y)	Cumulative erosion (mm)
Light clay topsoil with 50% vegetation groundcover			
50	-	3.3	16
100	-	2.5	29
200	-	2.2	40
300	-	2.1	50
Permian waste with 30% vegetation groundcover			
50	-	3.8	17
100	-	3.6	34
200	0.4	3.5	49
300	0.6	3.4	65

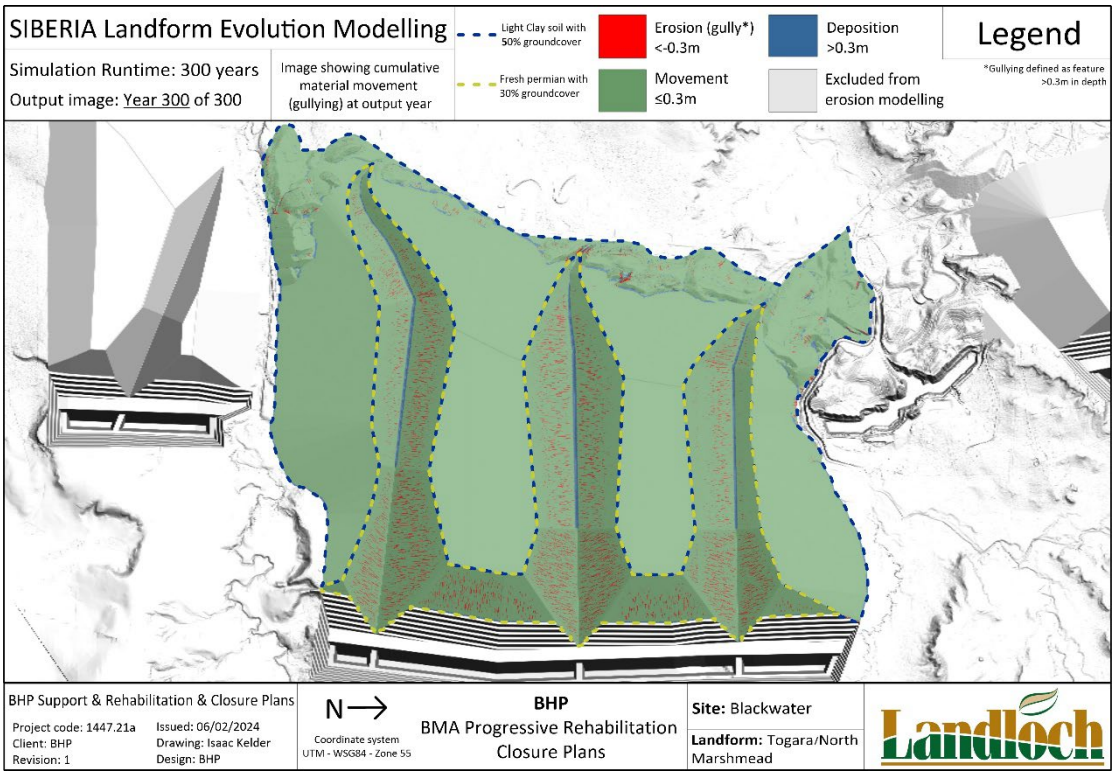

Figure 31: Predicted erosion and deposition depths of the Togara/North Marshmead rehabilitation landform after 300 years.

6.9 South Marshmead landform

Rehabilitation of the South Marshmead landform is planned to use vegetated light clay topsoil on the outward-facing slopes and vegetated Permian waste on the inward-facing (low wall) slopes (Figure 21). SIBERIA modelling has assumed a vegetation groundcover of 50% for the outward-facing light clay topsoil surfaces and 30% for the inward-facing Permian waste surfaces.

Predicted erosion rates shown in Table 12 indicate that at a vegetation groundcover level of 50%, predicted erosion rates of the outward-facing batter slopes are below the target level of 5t/ha/y for the simulation period. If vegetation groundcover of the inward-facing batters is >30%, then batter slope erosion rates are also predicted to be below the target rate (10t/ha/y).

Table 12: Predicted erosion rates and gully depths for the South Marshmead landform.

Simulation year	Maximum gully depth (m)	Average annual erosion (t/ha/y)	Cumulative erosion (mm)
Light clay topsoil with 50% vegetation groundcover			
50	-	3.4	15
100	-	2.7	28
200	-	2.4	39
300	-	2.4	50
Permian waste with 30% vegetation groundcover			
50	-	3.6	14
100	-	3.6	28
200	0.3	3.6	41
300	0.5	3.6	55

Figure 32 shows SIBERIA output after 300 years of simulation. The SIBERIA output indicates that the South Marshmead landform is not prone to significant levels of gully erosion if the surface conditions (material type and vegetation groundcover levels) are achieved. No gully erosion is predicted to occur within the simulation period for the vegetated clay topsoil covered slopes. Some gully erosion is predicted to occur after 200 years for the fresh Permian covered slopes. However, given the underlying material is likely to be more erosion-resistant fresh Permian waste, the risk of exposing problematic (more erodible) materials over the long-term is considered low. Gully erosion should be monitored as part of the rehabilitation monitoring process and remediated if assessed as required by an appropriately qualified person to achieve the post-mining land use.

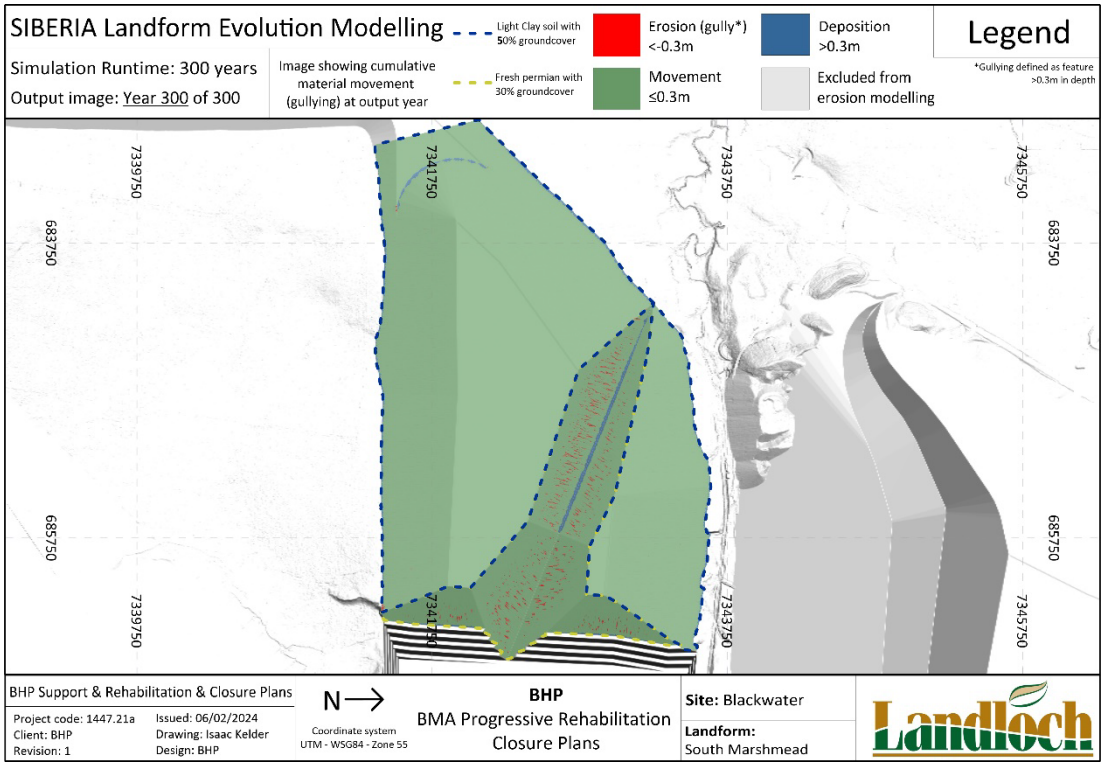

Figure 32: Predicted erosion and deposition depths of the South Marshmead rehabilitation landform after 300 years.

6.10 Kennedy West landform

Rehabilitation of the Kennedy West landform is planned to use vegetated light clay topsoil on the outward-facing slopes and vegetated Permian waste on the inward-facing (low wall) slopes (Figure 22). SIBERIA modelling has assumed a vegetation groundcover of 50% for the outward-facing light clay topsoil surfaces and 30% for the inward-facing Permian waste surfaces.

Predicted erosion rates shown in Table 13 indicate that at a vegetation groundcover level of 50%, predicted erosion rates of the outward-facing batter slopes are initially (after year 50) slightly above the target level (5t/ha/y) but reduced to below the target level for the rest of the simulation period. If vegetation groundcover of the inward-facing batters is >30%, batter erosion rates are predicted to be below the target rate.

Figure 33 shows SIBERIA output after 300 years of simulation. The SIBERIA output indicates that the Kennedy West landform is not prone to significant levels of gully erosion if the surface conditions (material type and vegetation groundcover levels) are achieved. No gully erosion is predicted to occur within the simulation period for the vegetated clay topsoil covered slopes. Some gully erosion is predicted to occur after 200 years for the fresh Permian covered slopes. However, given the underlying material is likely to be more erosion-resistant fresh Permian waste, the risk of exposing problematic (more erodible) materials over the long-term is considered low. Gully erosion should be monitored as part of the rehabilitation monitoring process and remediated if assessed as required by an appropriately qualified person to achieve the post-mining land use.

Table 13: Predicted erosion rates and gully depths for the Kennedy West landform.

Simulation year	Maximum gully depth (m)	Average annual erosion (t/ha/y)	Cumulative erosion (mm)
Light clay topsoil with 50% vegetation groundcover			
50	-	5.3	20
100	-	3.7	35
200	-	3.1	47
300	-	3.0	58
Permian waste with 30% vegetation groundcover			
50	-	5.8	24
100	-	4.7	44
200	0.5	4.3	61
300	0.6	4.2	79

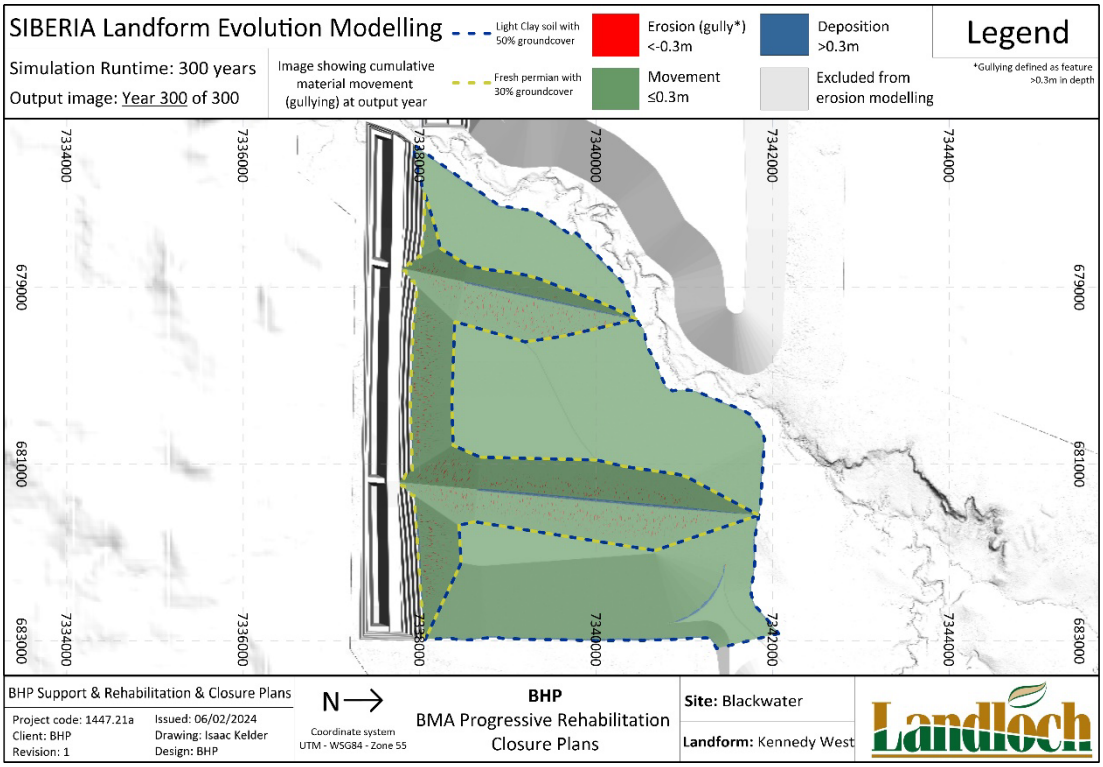

Figure 33: Predicted erosion and deposition depths of the Kennedy West rehabilitation landform after 300 years.

6.11 Comet Downs East landform

Rehabilitation of the Comet Downs East landform is planned to use vegetated light clay topsoil on the outward-facing slopes and vegetated Permian waste on the inward-facing (low wall) slopes (Figure 23). SIBERIA modelling has assumed a vegetation groundcover of 50% for the outward-facing light clay topsoil surfaces and 30% for the inward-facing Permian waste surfaces.

Predicted erosion rates shown in Table 14 indicate that at a vegetation groundcover level of 50%, predicted erosion rates of the outward-facing batter slopes are below the target level of 5t/ha/y for the simulation period. If vegetation groundcover of the inward-facing batters is >30%, then batter slope erosion rates are predicted to be below the target rate (10t/ha/y).

Table 14: Predicted erosion rates and gully depths for the Comet Downs East landform.

Simulation year	Maximum gully depth (m)	Average annual erosion (t/ha/y)	Cumulative erosion (mm)
Light clay topsoil with 50% vegetation groundcover			
50	-	4.2	16
100	-	3.3	29
200	-	2.9	40
300	-	2.8	51
Permian waste with 30% vegetation groundcover			
50	-	3.9	15
100	-	3.1	27
200	0.3	2.6	37
300	0.5	2.5	46

Figure 34 shows SIBERIA output after 300 years of simulation. The SIBERIA output indicates that the Comet Downs East landform is not prone to significant levels of gully erosion if the surface conditions (material type and vegetation groundcover levels) are achieved. No gully erosion is predicted to occur within the simulation period for the vegetated clay topsoil covered slopes. Some gully erosion is predicted to occur after 200 years for the fresh Permian covered slopes. However, given the underlying material is likely to be more erosion-resistant fresh Permian waste, the risk of exposing problematic (more erodible) materials over the long-term is considered low. Gully erosion should be monitored as part of the rehabilitation monitoring process and remediated if assessed as required by an appropriately qualified person to achieve the post-mining land use.

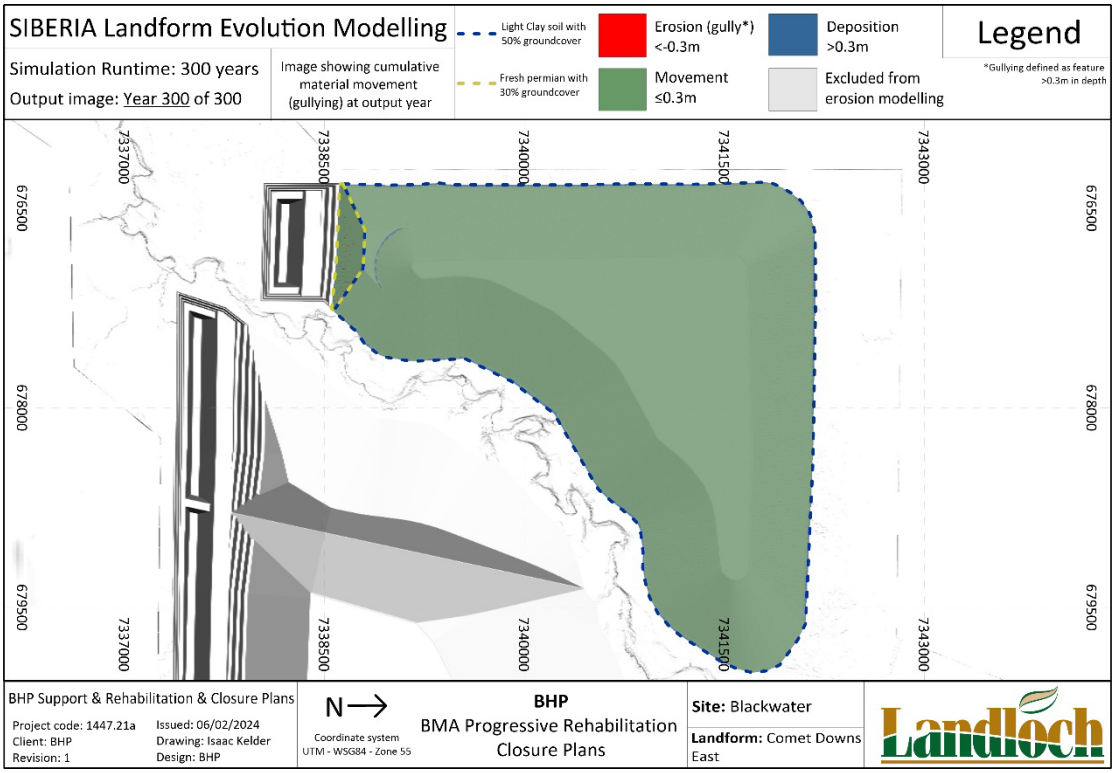

Figure 34: Predicted erosion and deposition depths of the Comet Downs East rehabilitation landform after 300 years.

7 WATER MANAGEMENT

Water management recommendations for waste landforms at BWM are summarised as:

- No construction of permanent berms or graded banks and rock chutes on batter slopes. Temporary berms are to be used only where considered absolutely essential.
- Prevention of discharge from the relatively small areas of level dump tops onto the dump slopes is critical.

Simulations of runoff and erosion indicate that – once vegetation is established – there is no requirement for installation of berms or graded banks to reduce slope length and erosion risk. It is anticipated that batter slope rehabilitation will be carried out progressively, working gradually up from the bottom of the slope, so that there will be increasing vegetation groundcover on lower sections of a slope as the works gradually (over a number of years) move towards the top of the landform.

It should be noted that – on well-vegetated surfaces – annual rainfall excess on average will be 2–5% of annual rainfall, so preventing water discharge onto the slopes results in only a very small increase in the amount of water retained on the land surface and made available for vegetation growth. It is also noted that the quite small increase in drainage to depth that will be caused by retention of runoff on the tops of the landforms will be insignificant.

8 CONCLUSIONS

Both runoff/erosion simulations using the WEPP model and landform evolution simulations using the SIBERIA model indicate that the proposed waste landforms at BWM can be expected to be stable over the long term (up to 300 years) provided the correct surface materials and the target levels of vegetation groundcover are achieved.

Water management recommendations for the site include the prevention of discharge from the small areas of level dump tops onto the slopes and avoidance of any permanent bunds or rock chutes on batter slopes.

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APPENDIX A: SIBERIA VISUALISATIONS

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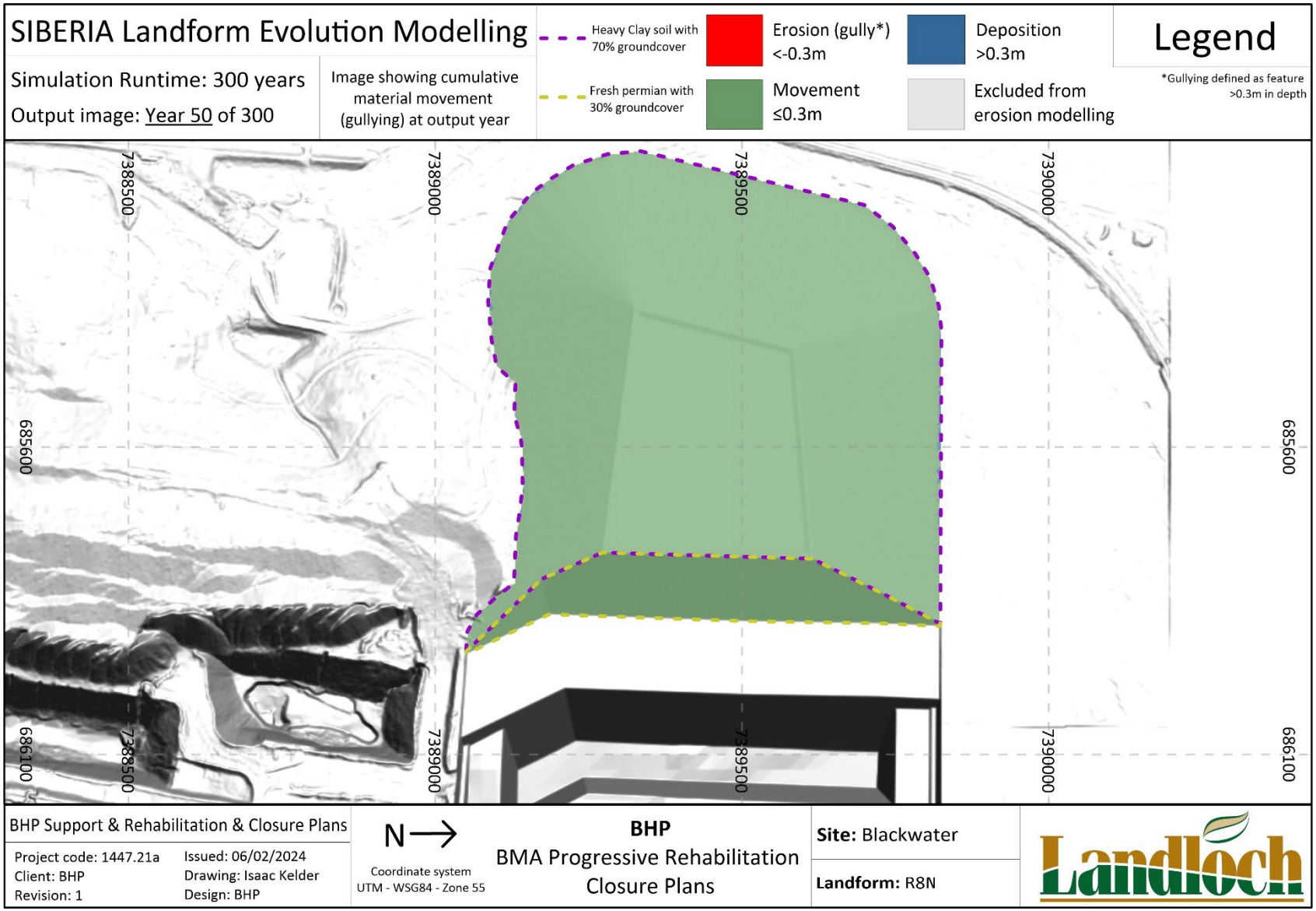

Figure A-1: Predicted erosion and deposition depths of the R8N rehabilitation landform after 50 years.

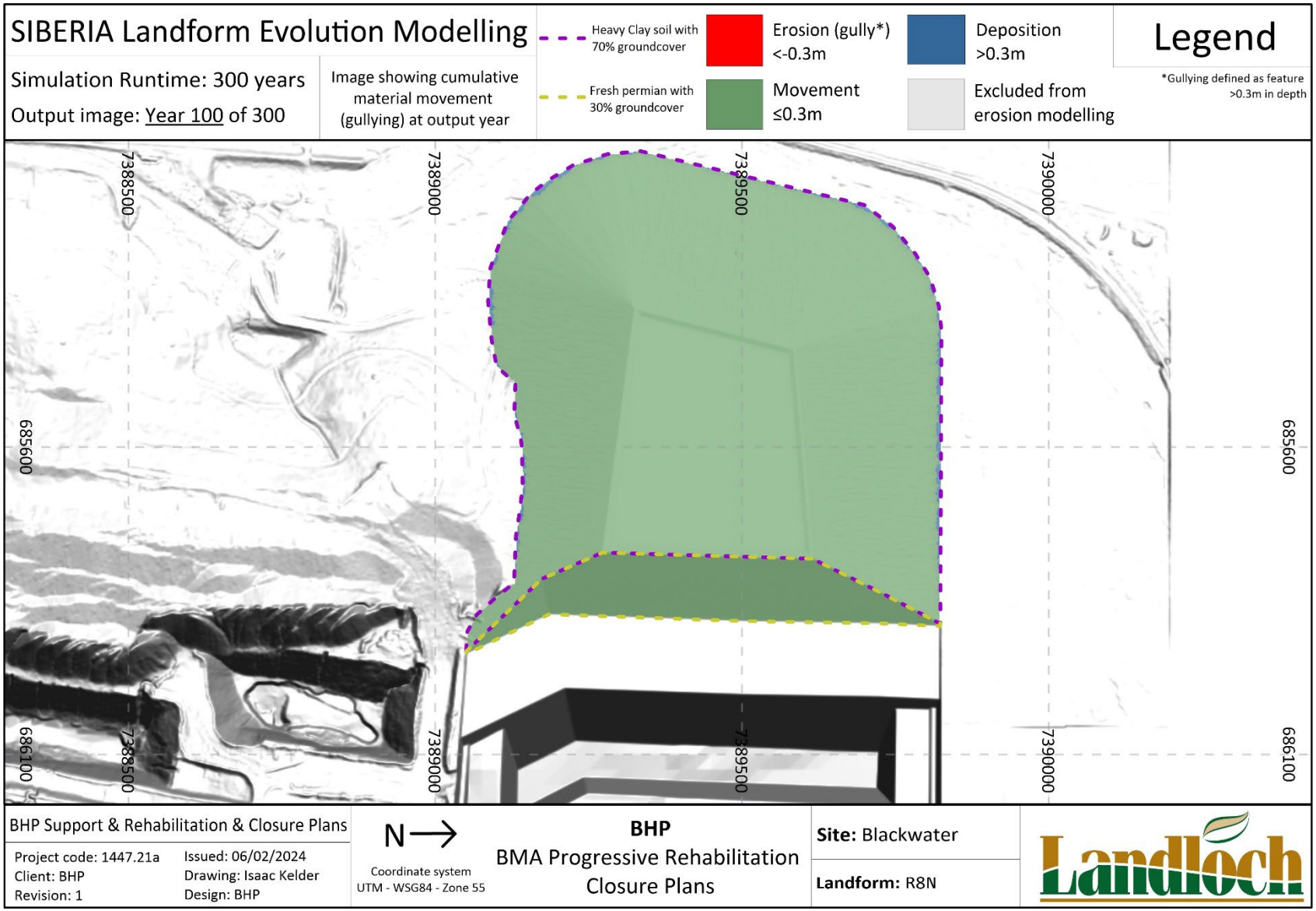

Figure A-2: Predicted erosion and deposition depths of the R8N rehabilitation landform after 100 years.

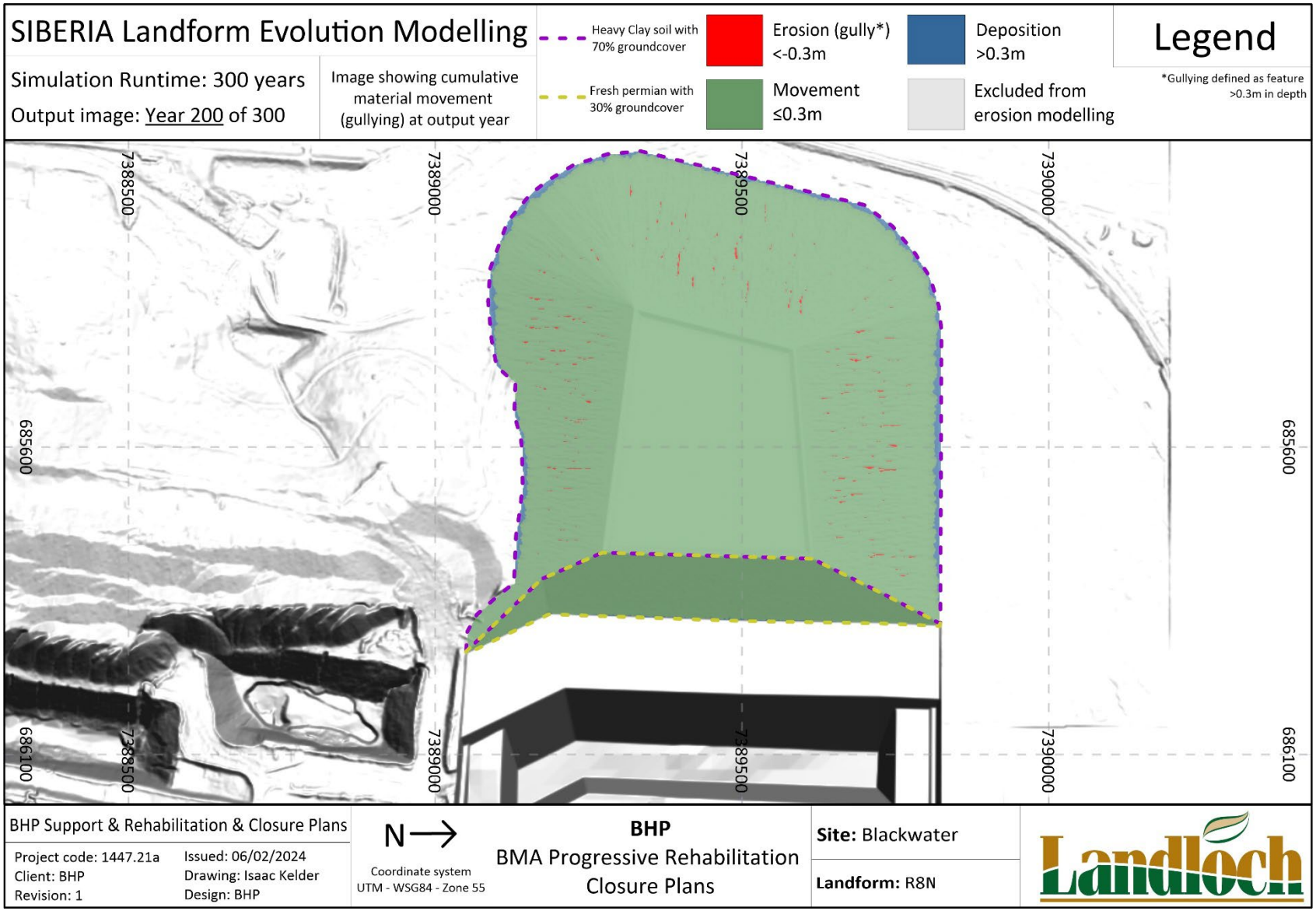

Figure A-3: Predicted erosion and deposition depths of the R8N rehabilitation landform after 200 years.

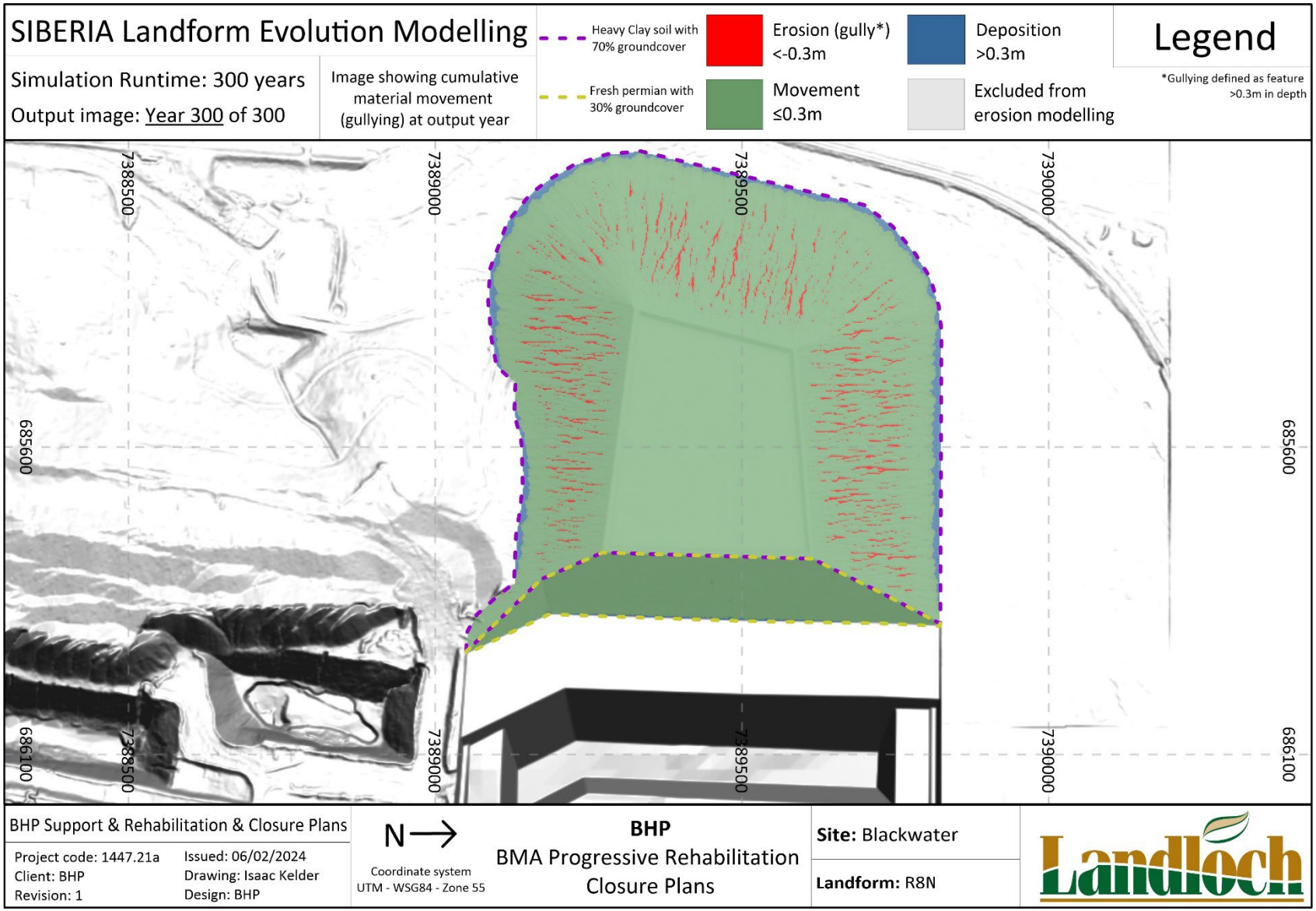

Figure A-4: Predicted erosion and deposition depths of the R8N rehabilitation landform after 300 years.

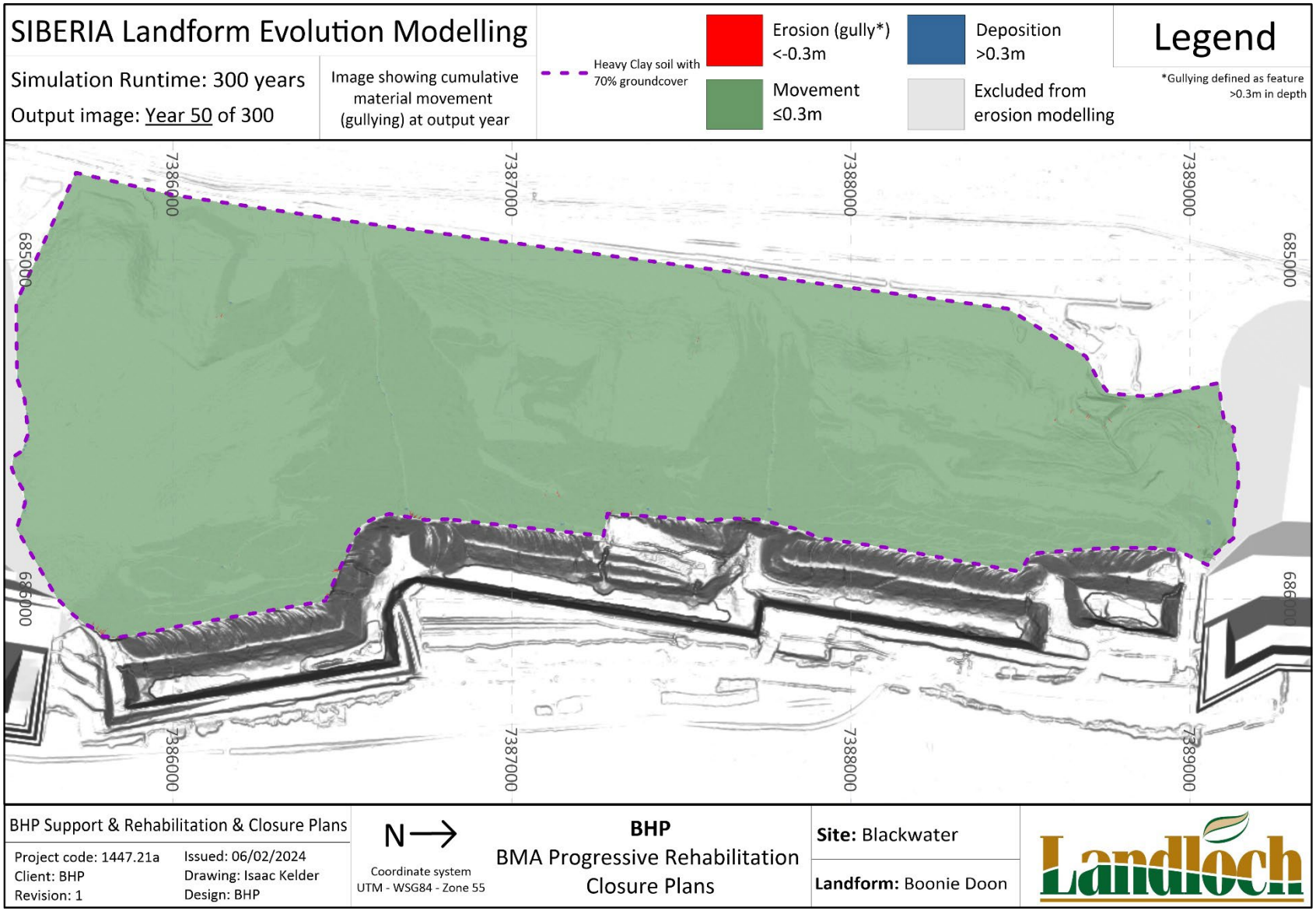

Figure A-5: Predicted erosion and deposition depths of the Boonie Doon rehabilitation landform after 50 years.

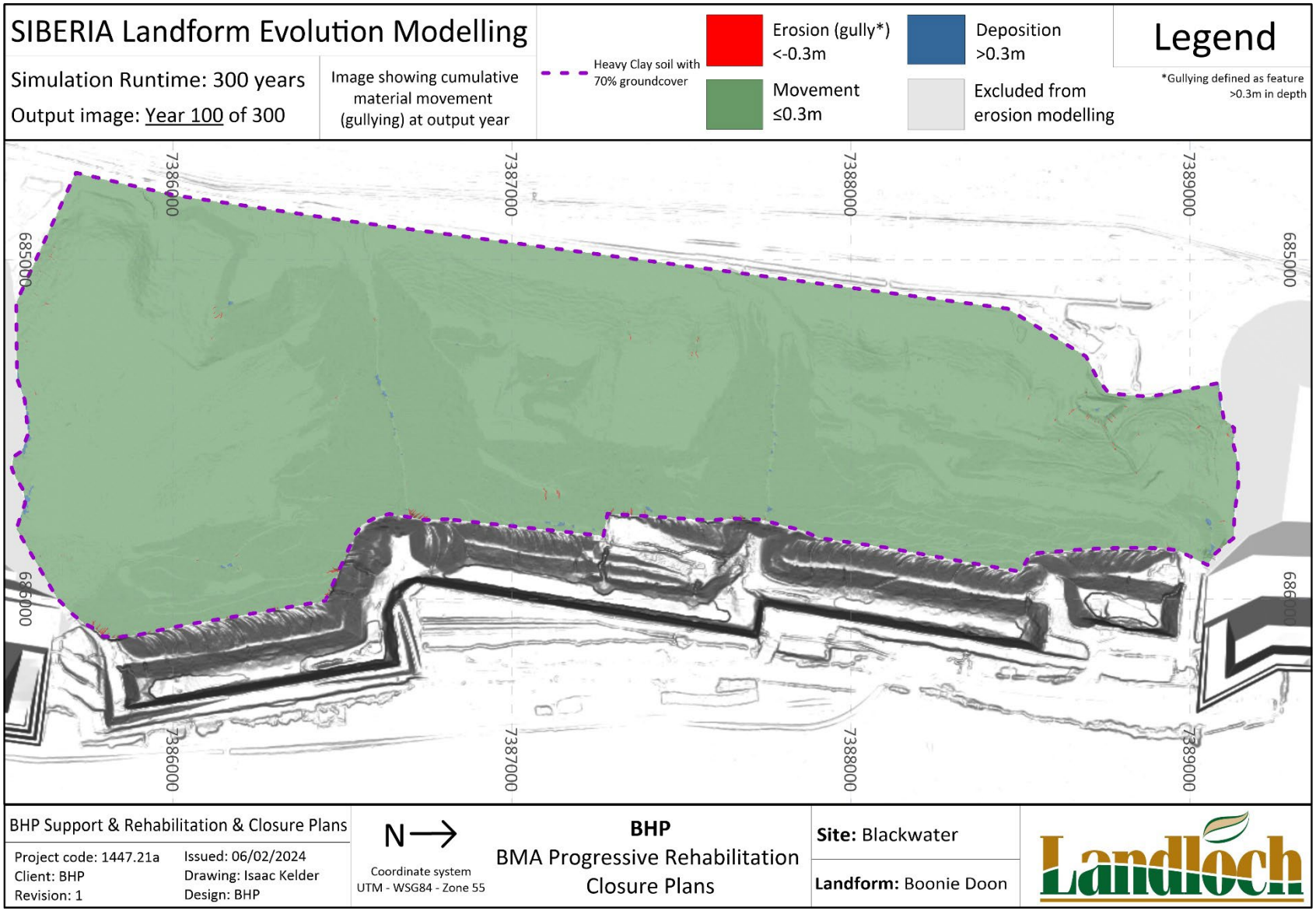

Figure A-6: Predicted erosion and deposition depths of the Boonie Doon rehabilitation landform after 100 years.

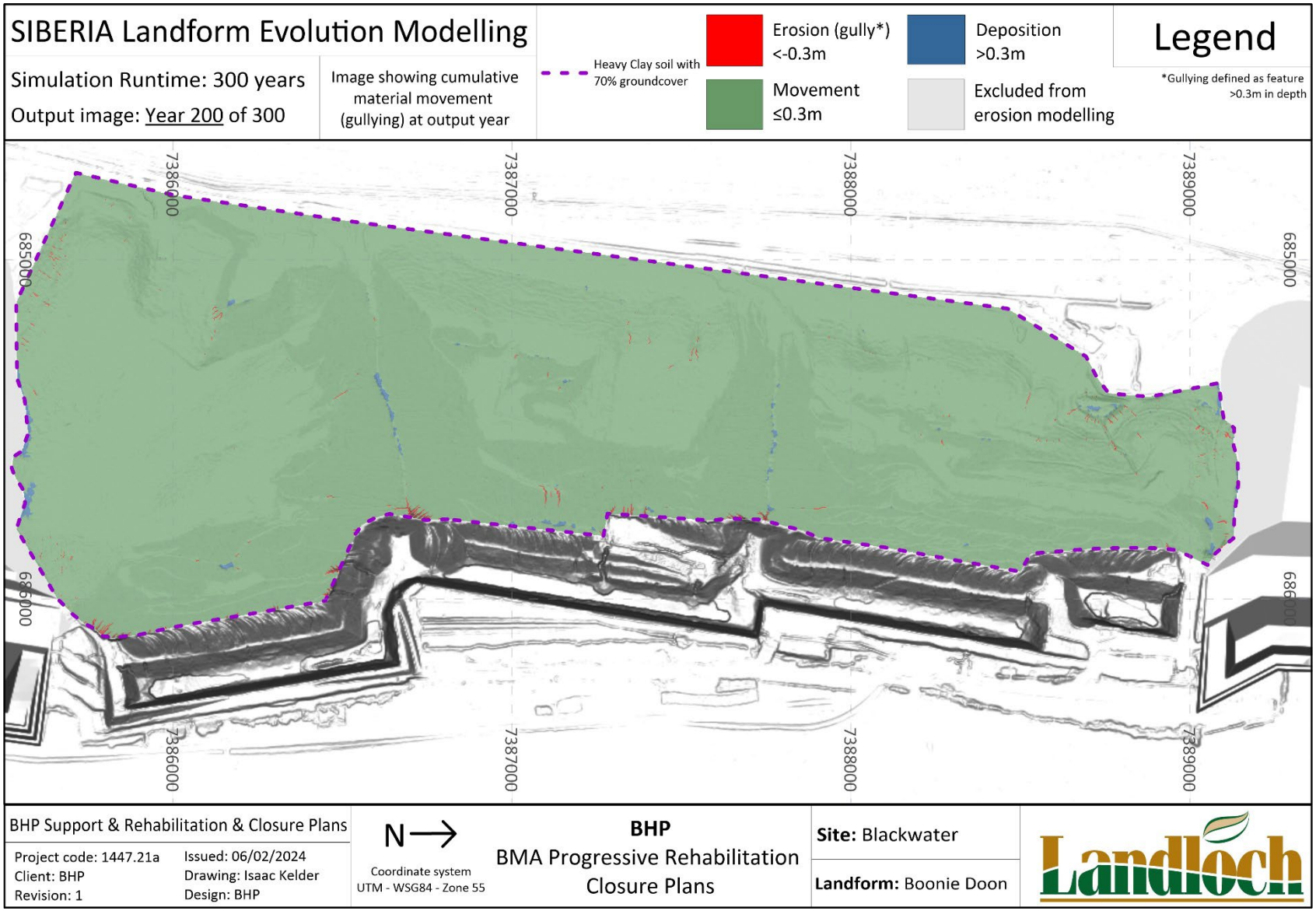

Figure A-7: Predicted erosion and deposition depths of the Boonie Doon rehabilitation landform after 200 years.

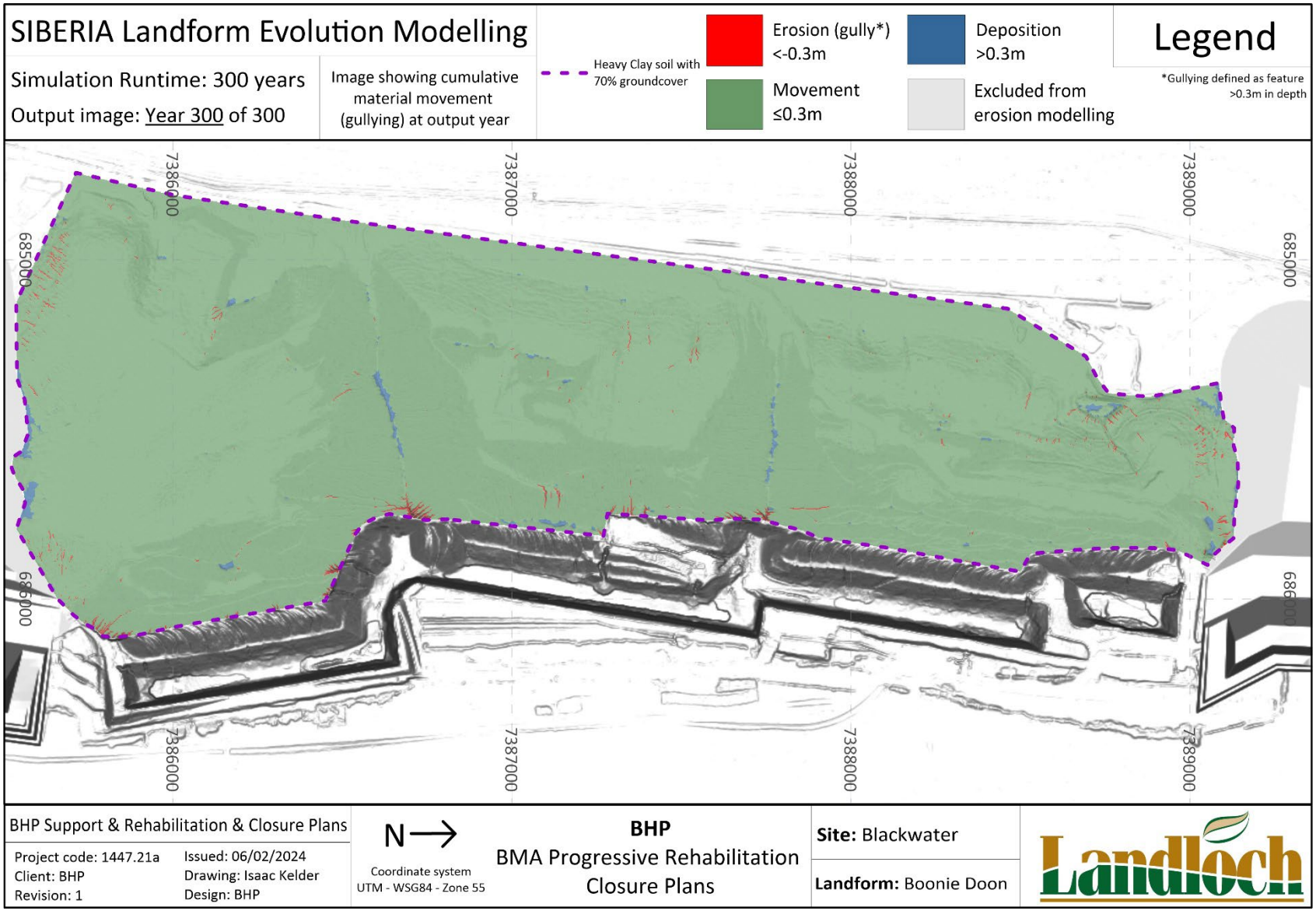

Figure A-8: Predicted erosion and deposition depths of the Boonie Doon rehabilitation landform after 300 years.

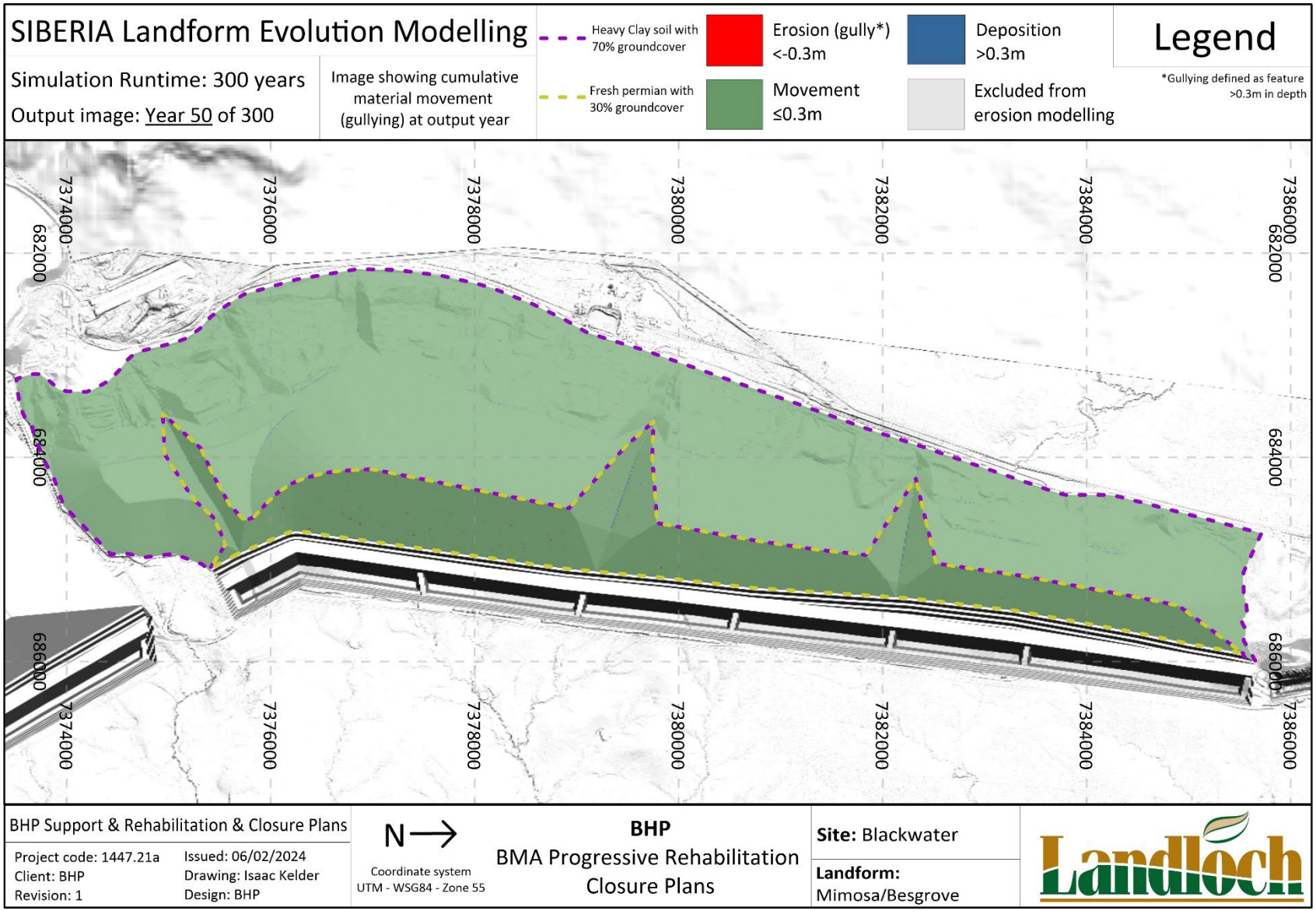

Figure A-9: Predicted erosion and deposition depths of the Mimosa/Besgrove rehabilitation landform after 50 years.

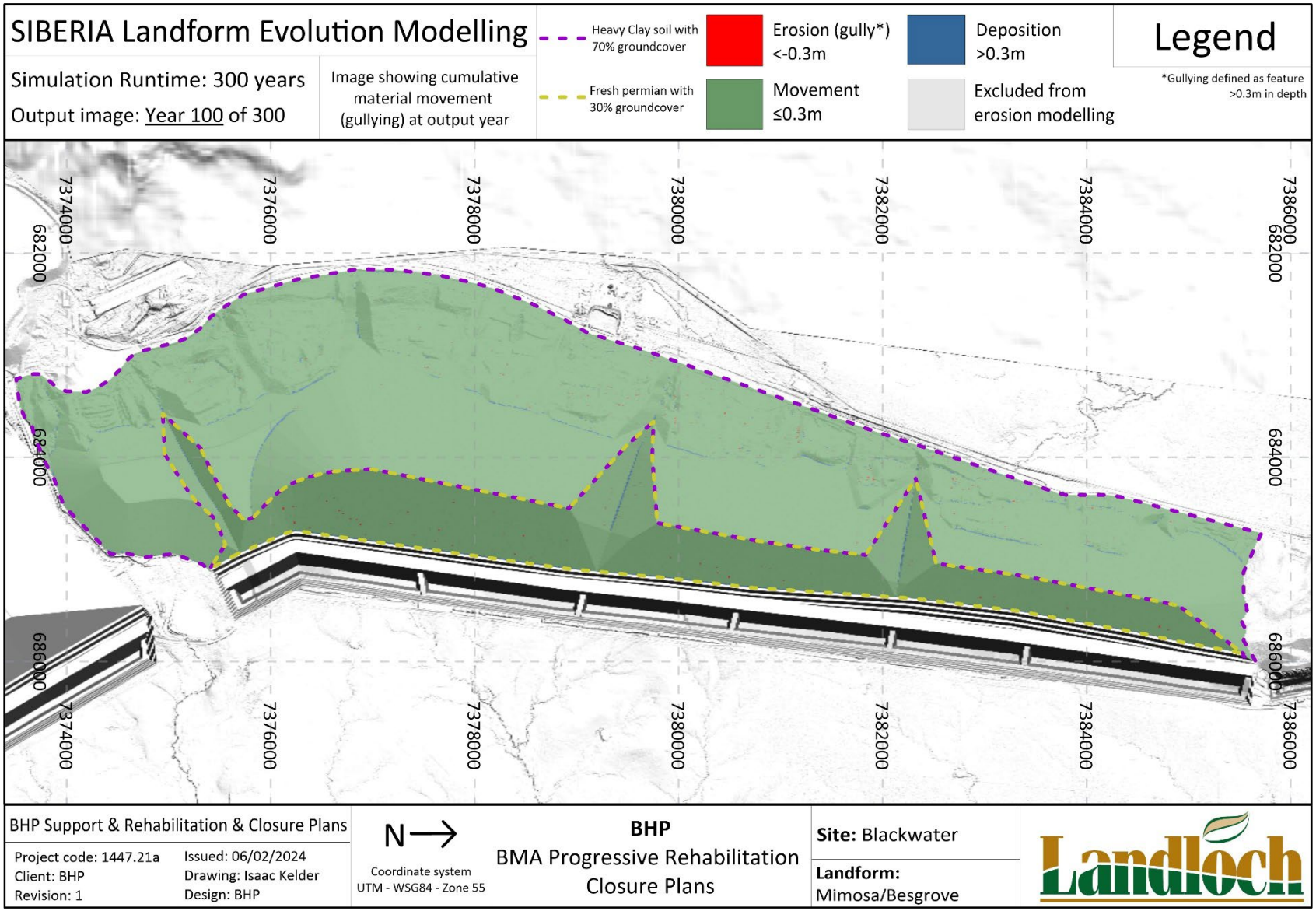

Figure A-10: Predicted erosion and deposition depths of the Mimosa/Besgrove rehabilitation landform after 100 years.

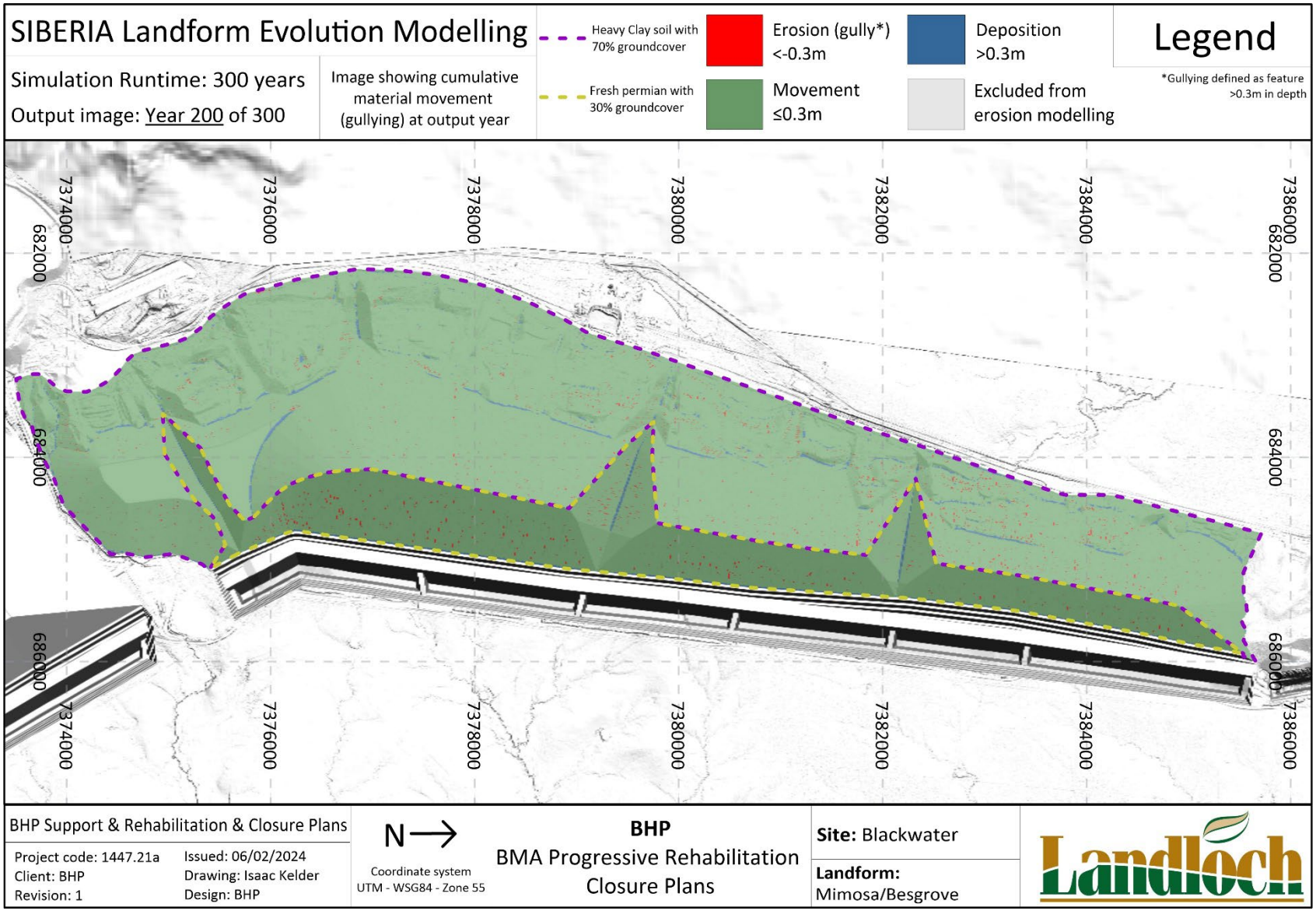

Figure A-11: Predicted erosion and deposition depths of the Mimosa/Besgrove rehabilitation landform after 200 years.

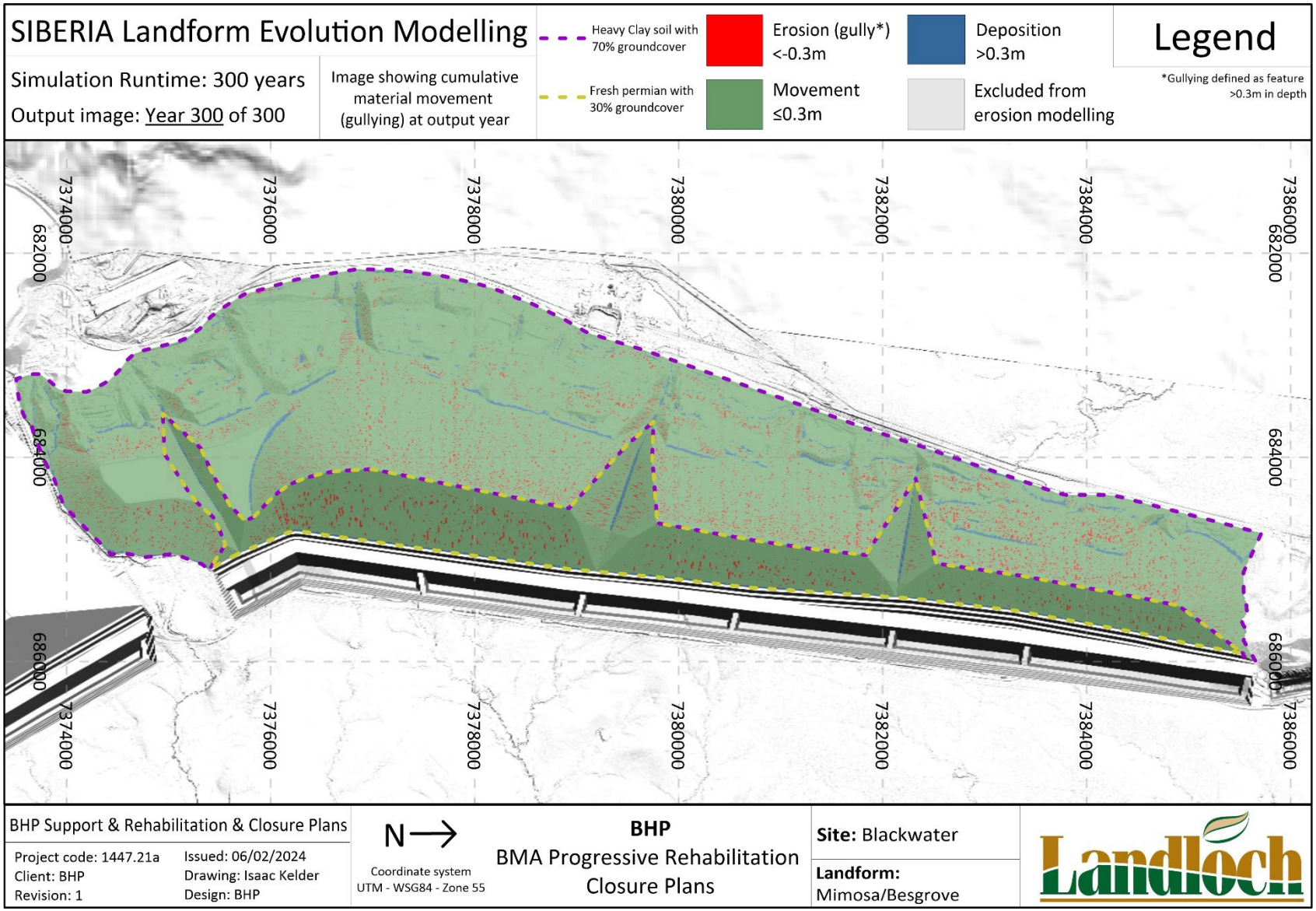

Figure A-12: Predicted erosion and deposition depths of the Mimosa/Besgrove rehabilitation landform after 300 years.

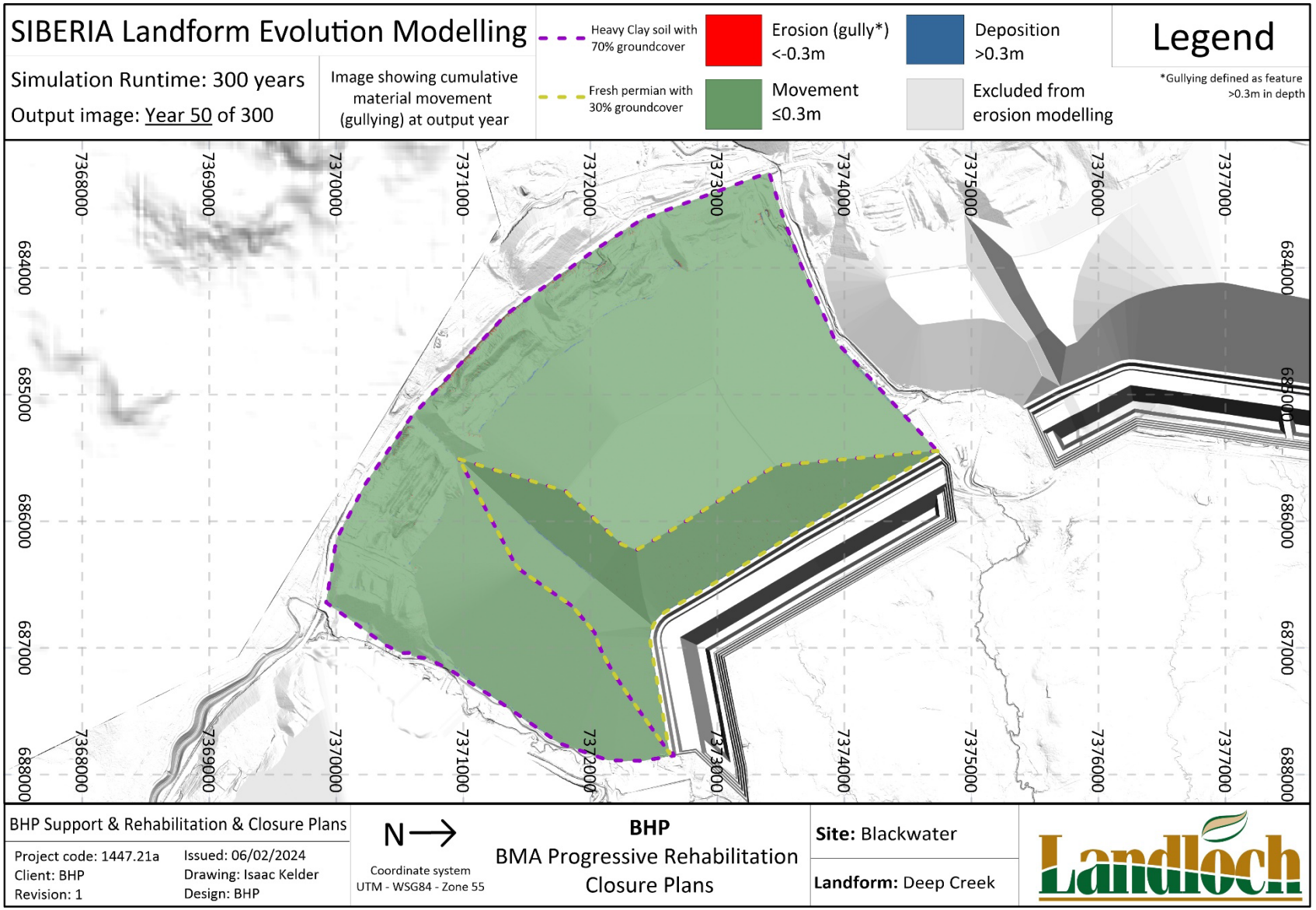

Figure A-13: Predicted erosion and deposition depths of the Deep Creek rehabilitation landform after 50 years.

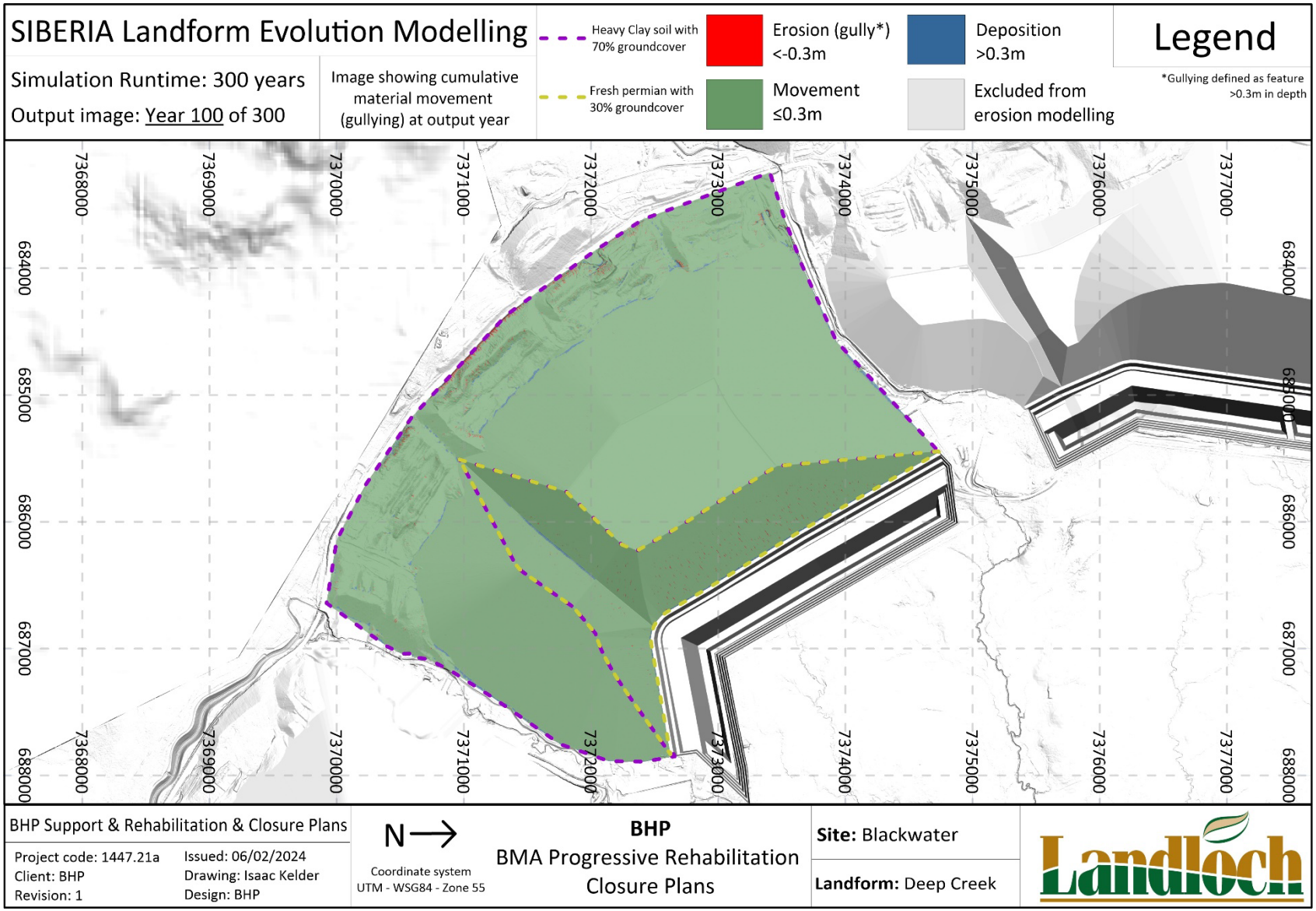

Figure A-14: Predicted erosion and deposition depths of the Deep Creek rehabilitation landform after 100 years.

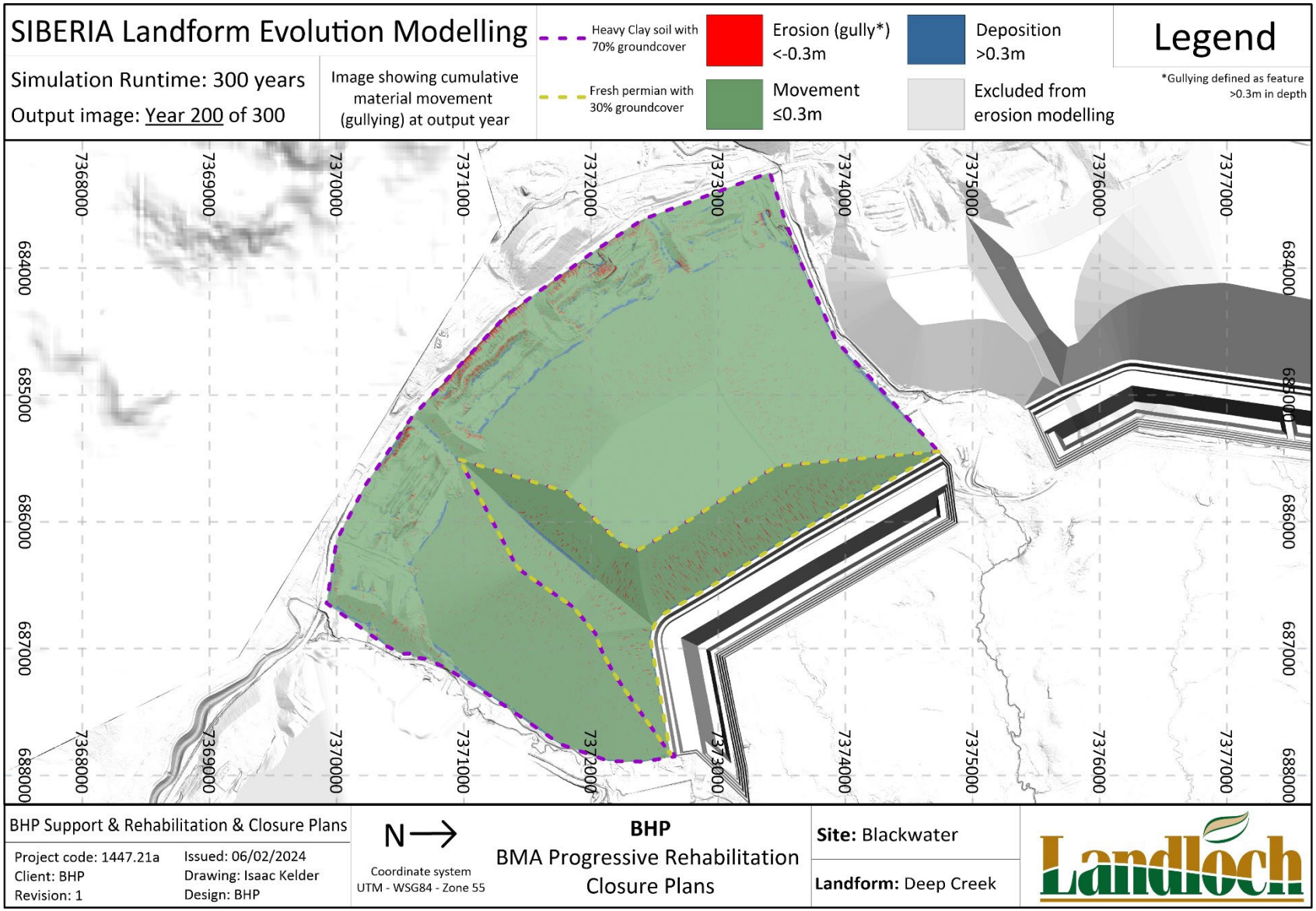

Figure A-15: Predicted erosion and deposition depths of the Deep Creek rehabilitation landform after 200 years.

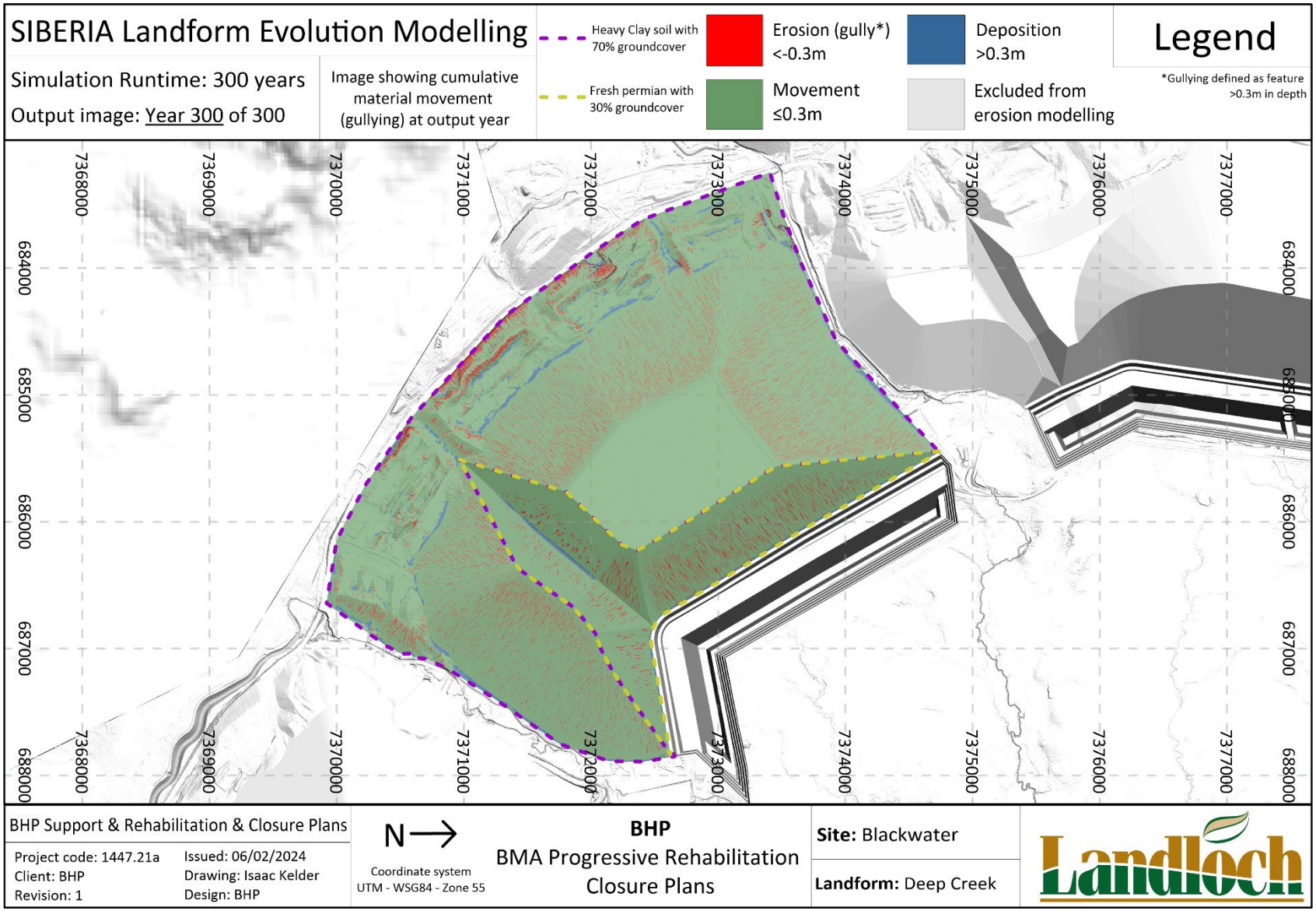

Figure A-16: Predicted erosion and deposition depths of the Deep Creek rehabilitation landform after 300 years.

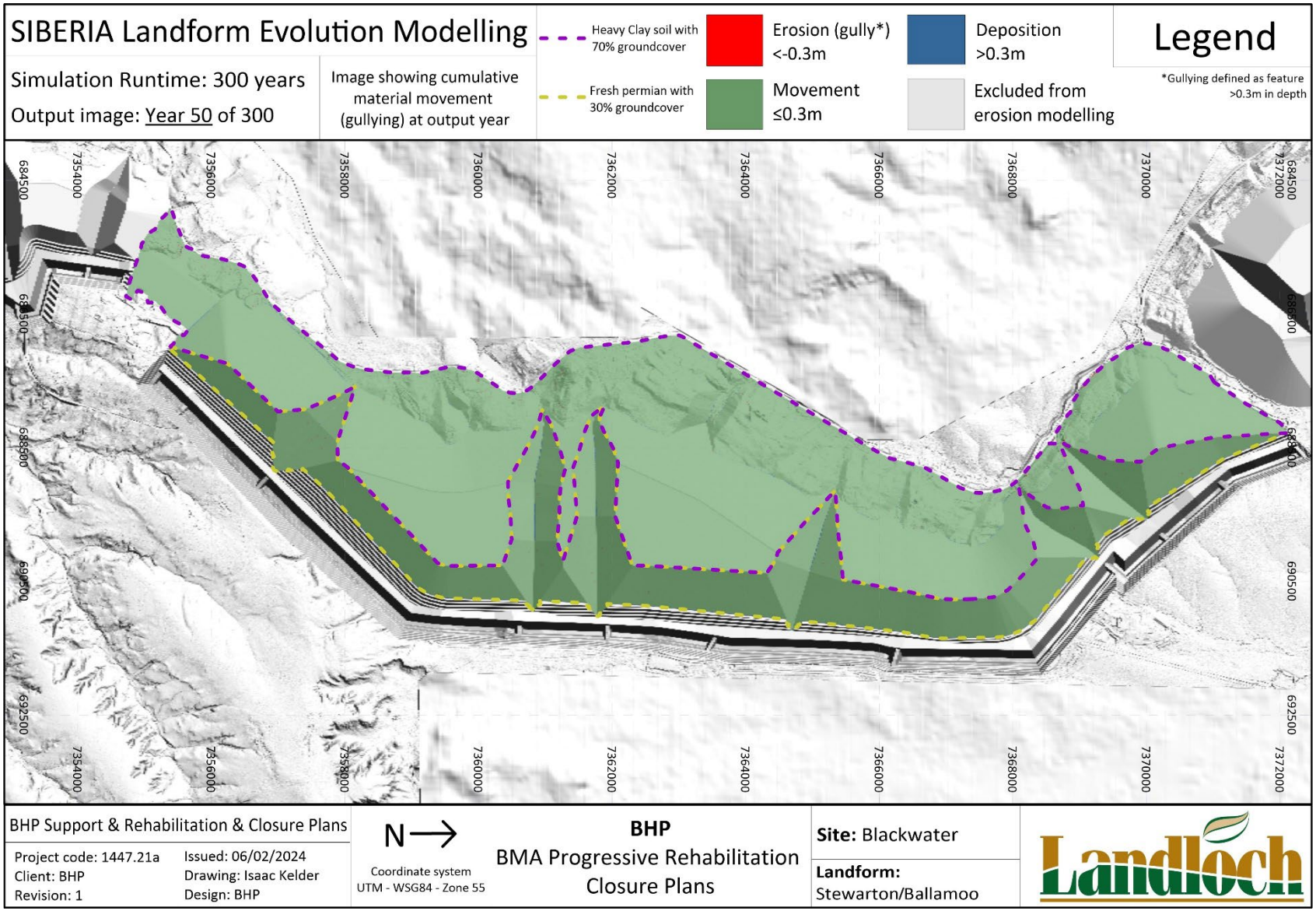

Figure A-17: Predicted erosion and deposition depths of the Stewarton/Ballamoo rehabilitation landform after 50 years.

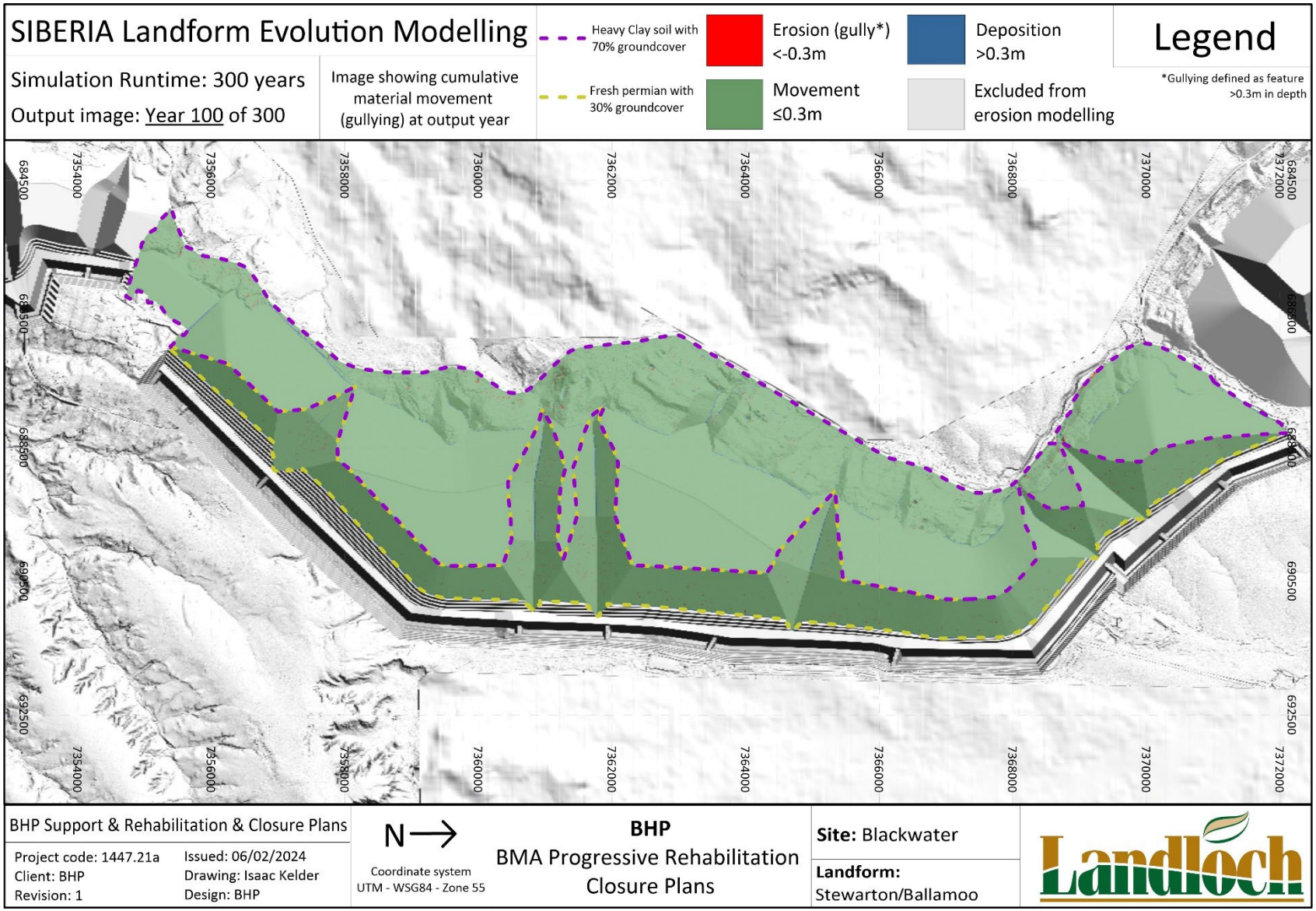

Figure A-18: Predicted erosion and deposition depths of the Stewarton/Ballamoo rehabilitation landform after 100 years.

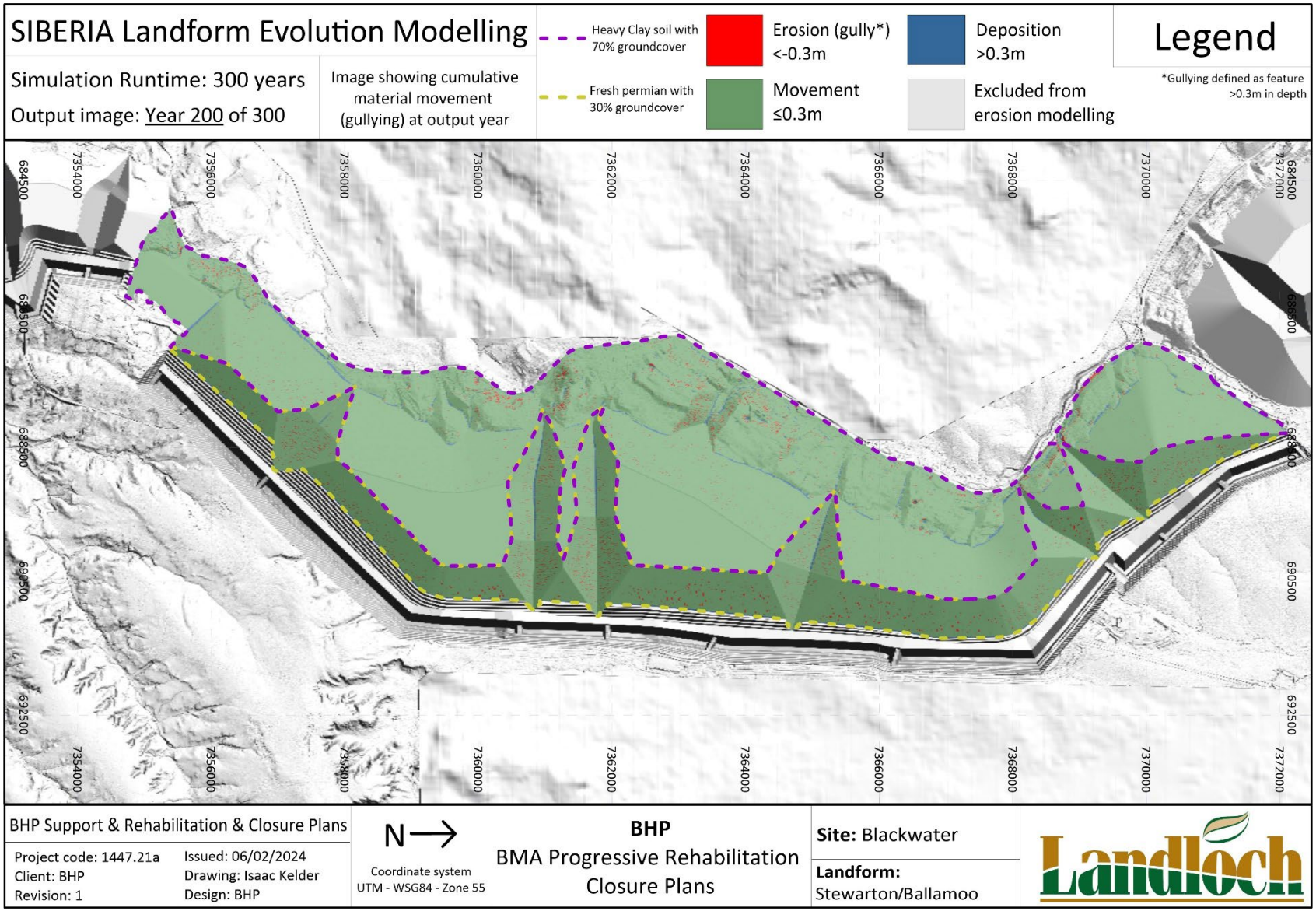

Figure A-19: Predicted erosion and deposition depths of the Stewarton/Ballamoo rehabilitation landform after 200 years.

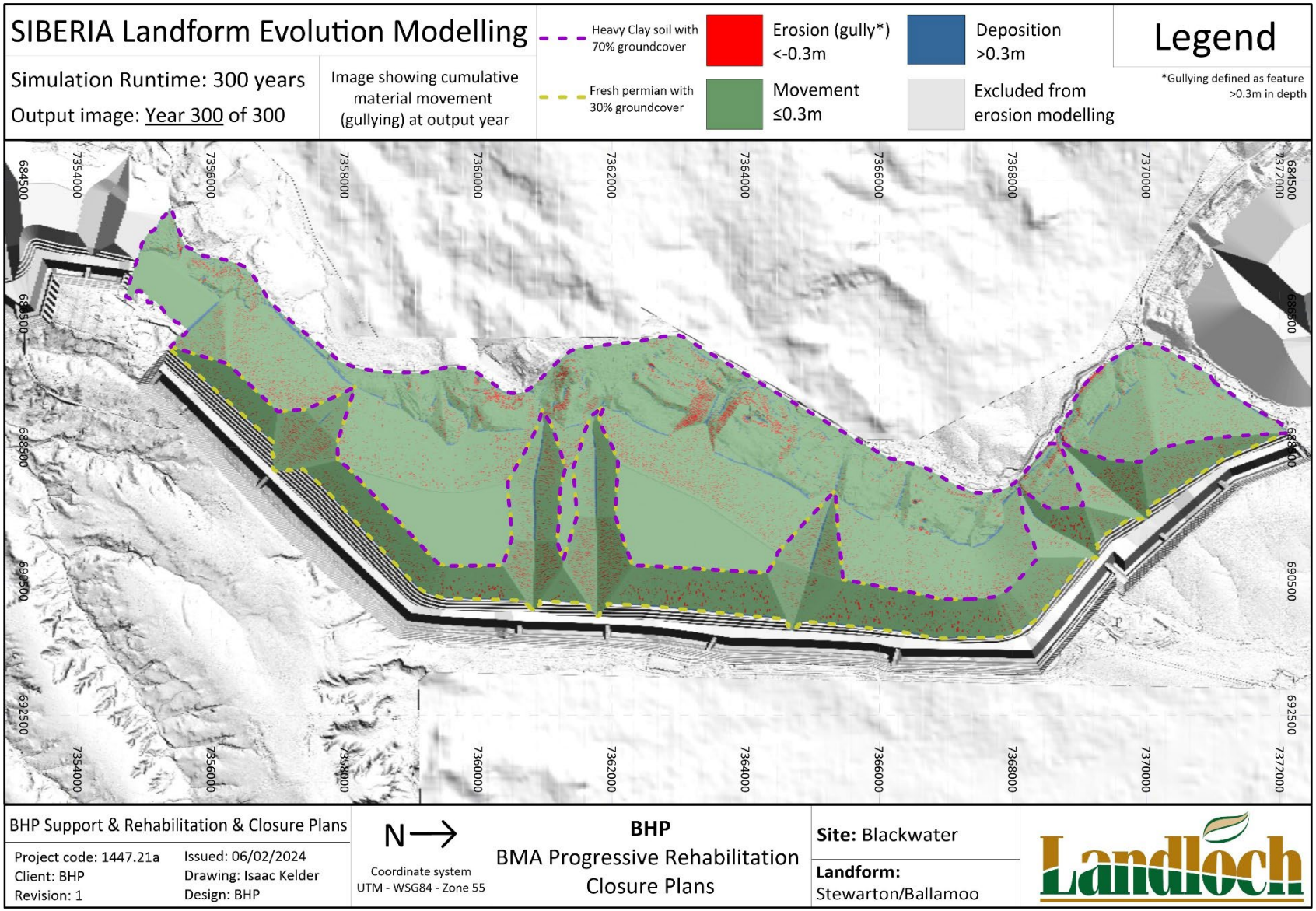

Figure A-20: Predicted erosion and deposition depths of the Stewarton/Ballamoo rehabilitation landform after 300 years.

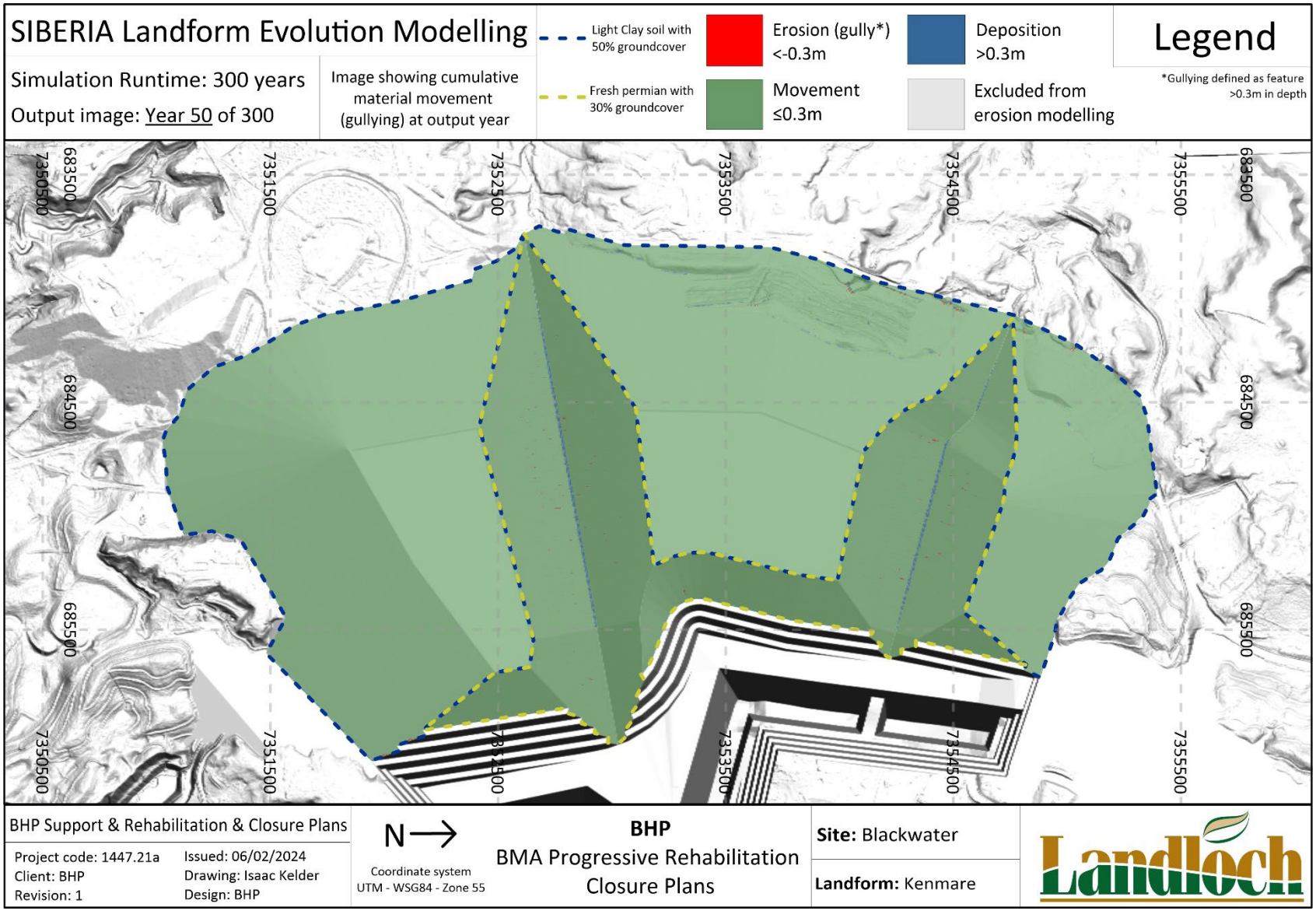

Figure A-21: Predicted erosion and deposition depths of the Kenmare rehabilitation landform after 50 years.

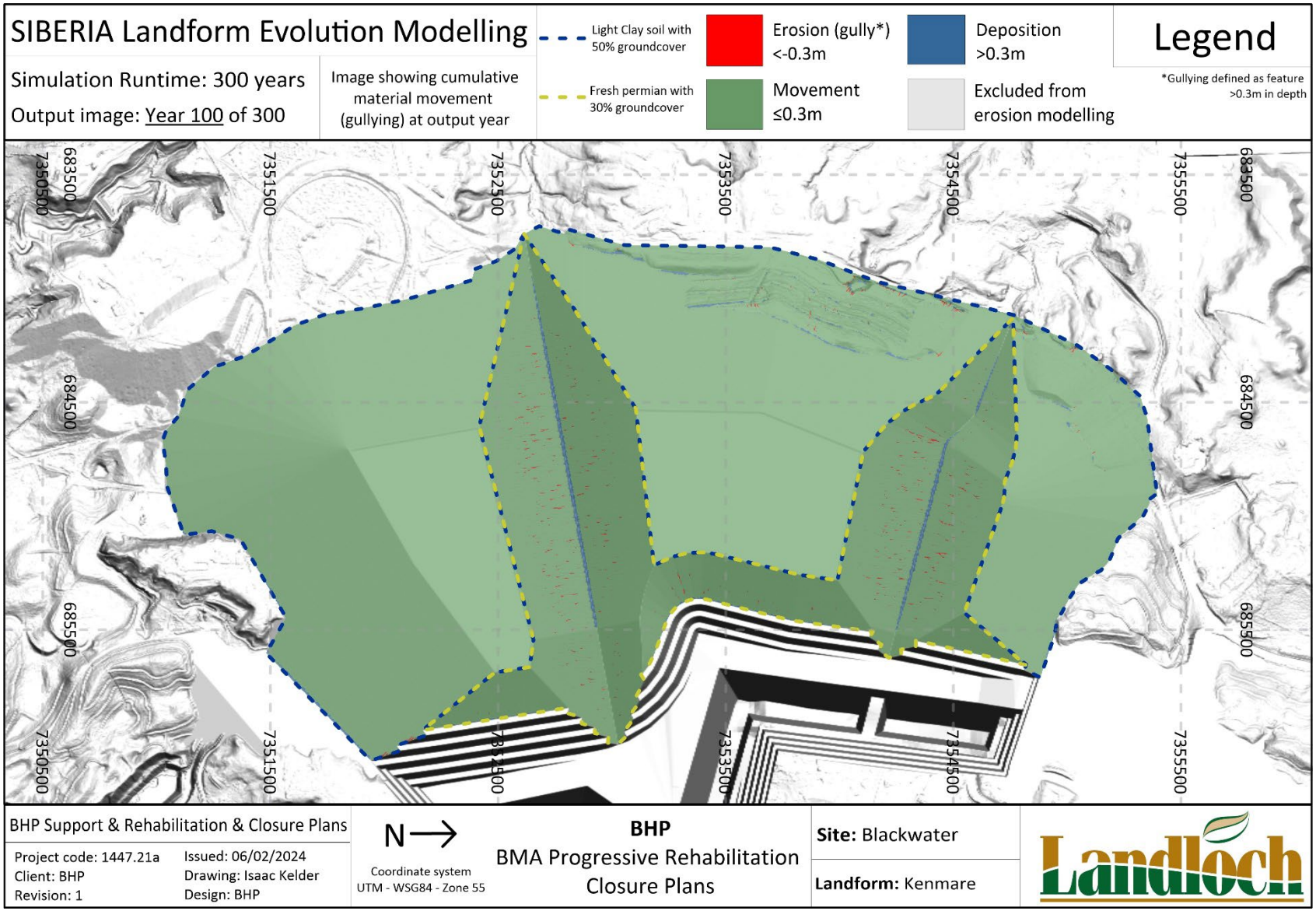

Figure A-22: Predicted erosion and deposition depths of the Kenmare rehabilitation landform after 100 years.

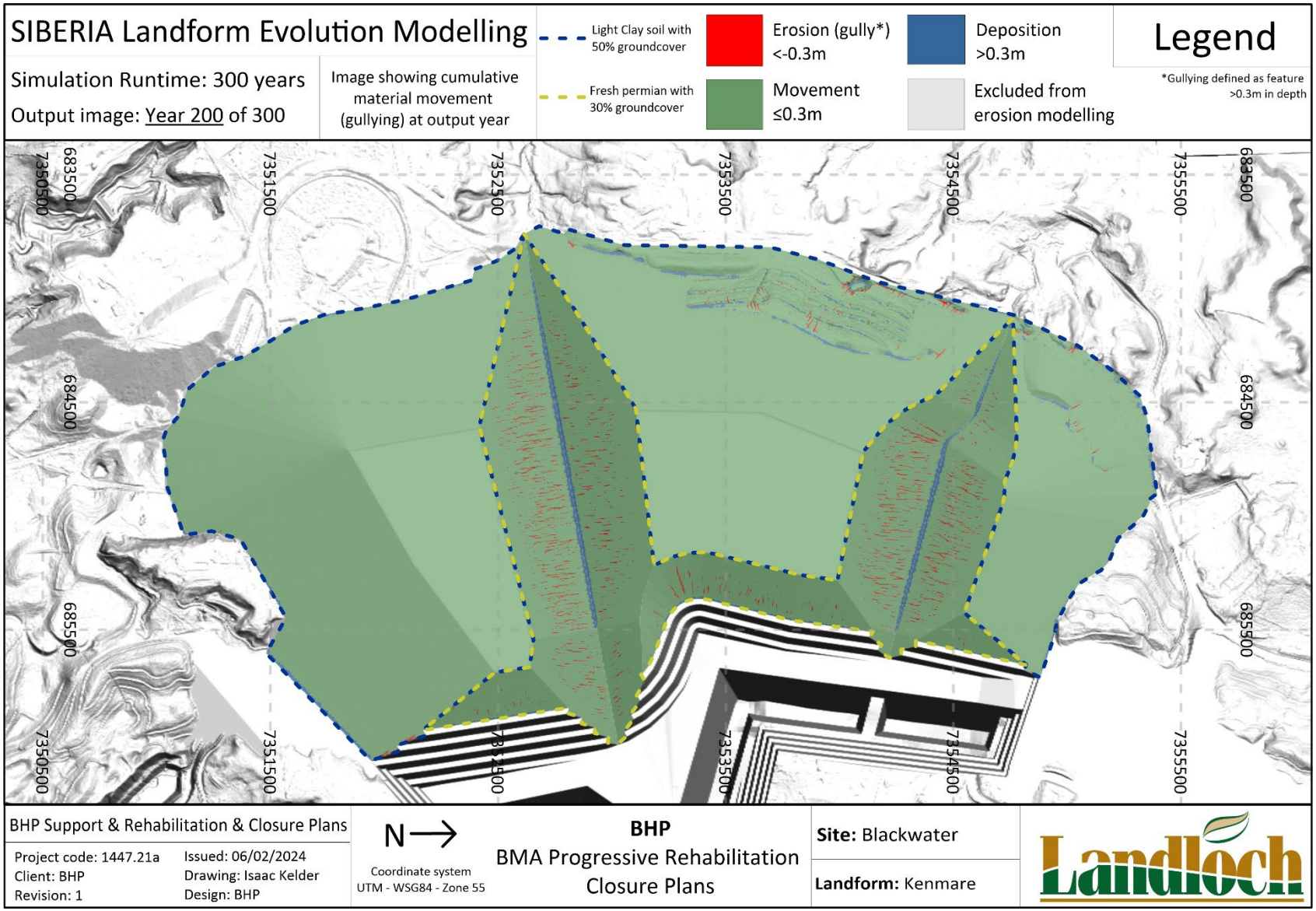

Figure A-23: Predicted erosion and deposition depths of the Kenmare rehabilitation landform after 200 years.

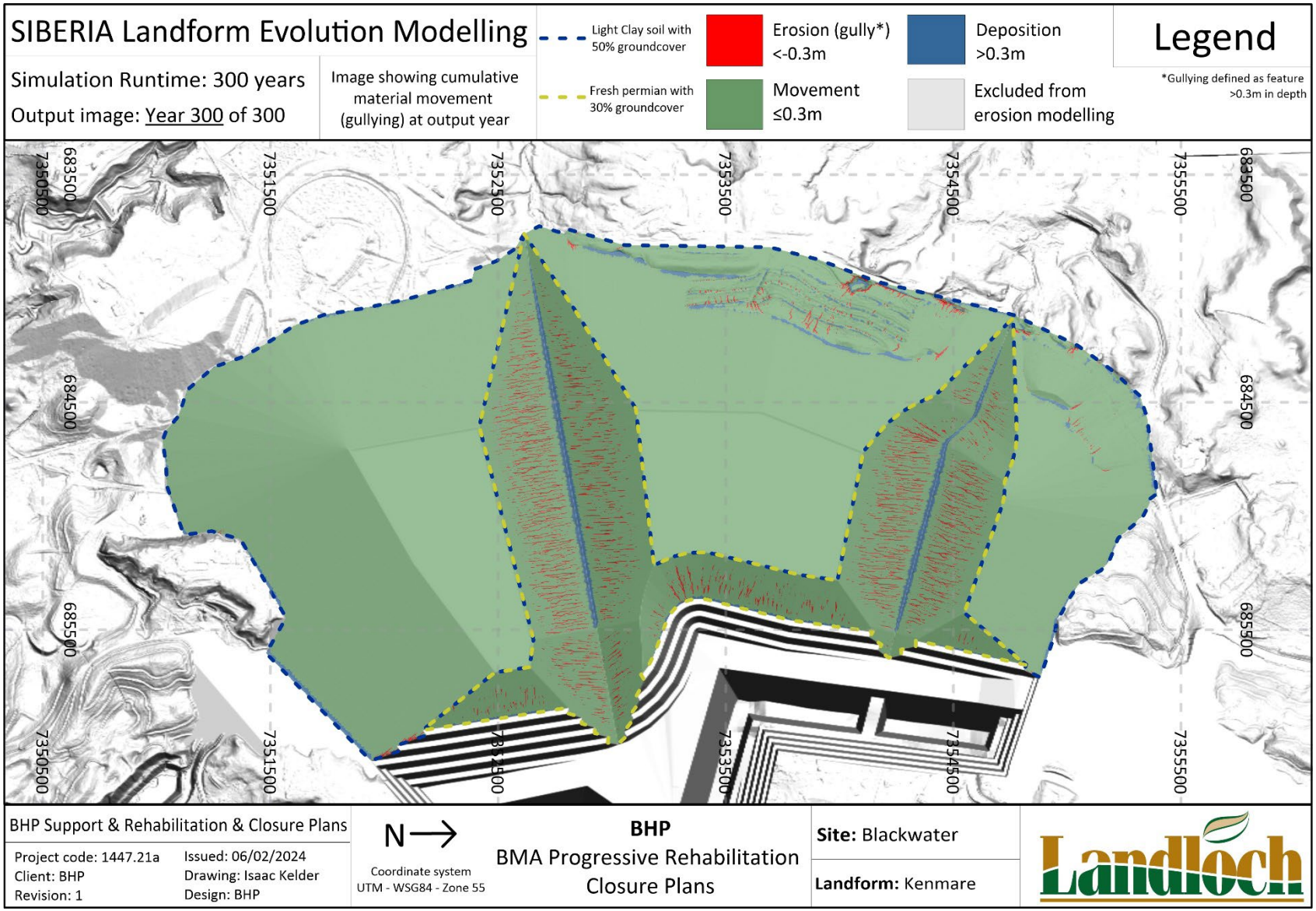

Figure A-24: Predicted erosion and deposition depths of the Kenmare rehabilitation landform after 300 years.

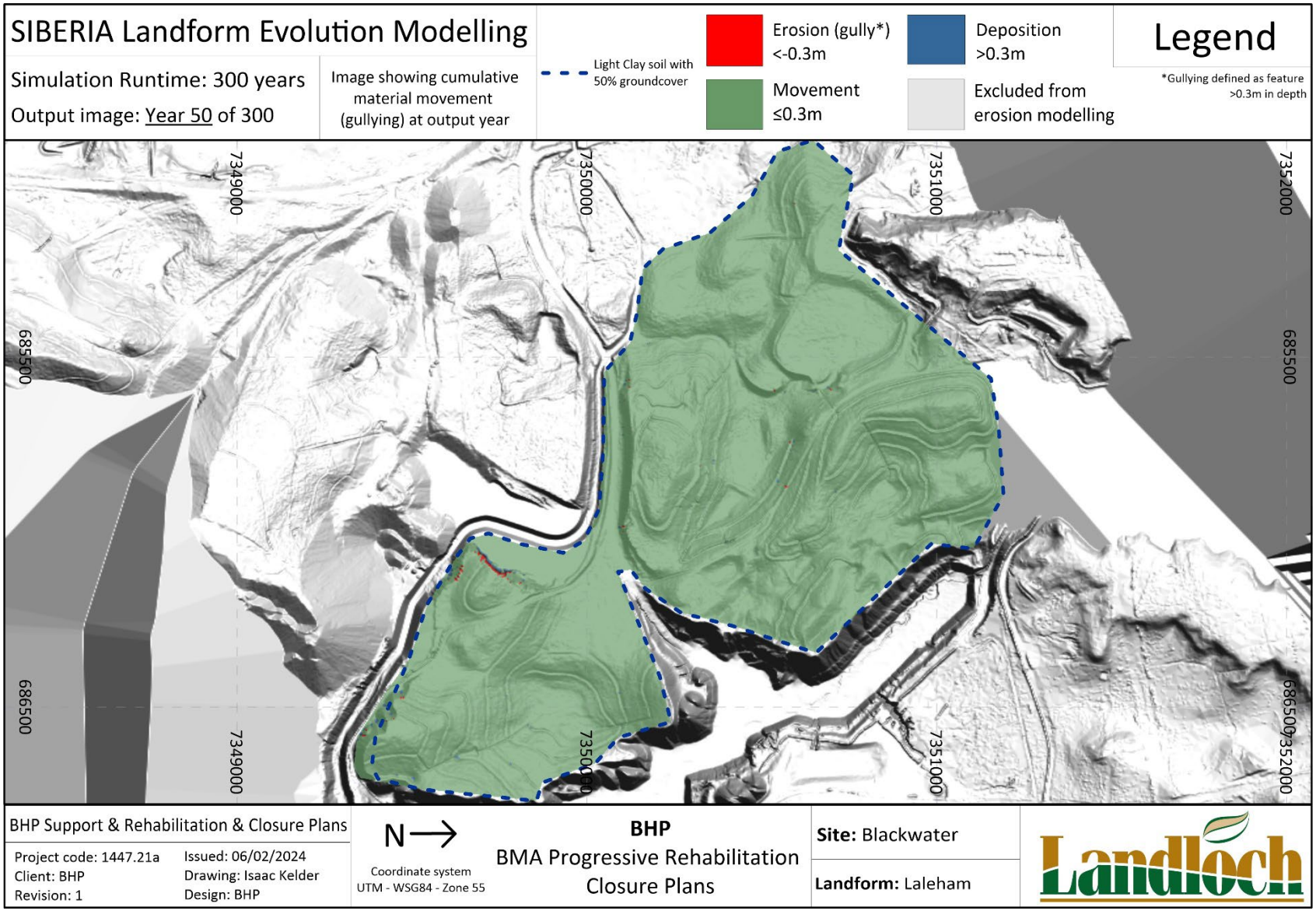

Figure A-25: Predicted erosion and deposition depths of the Laleham rehabilitation landform after 50 years.

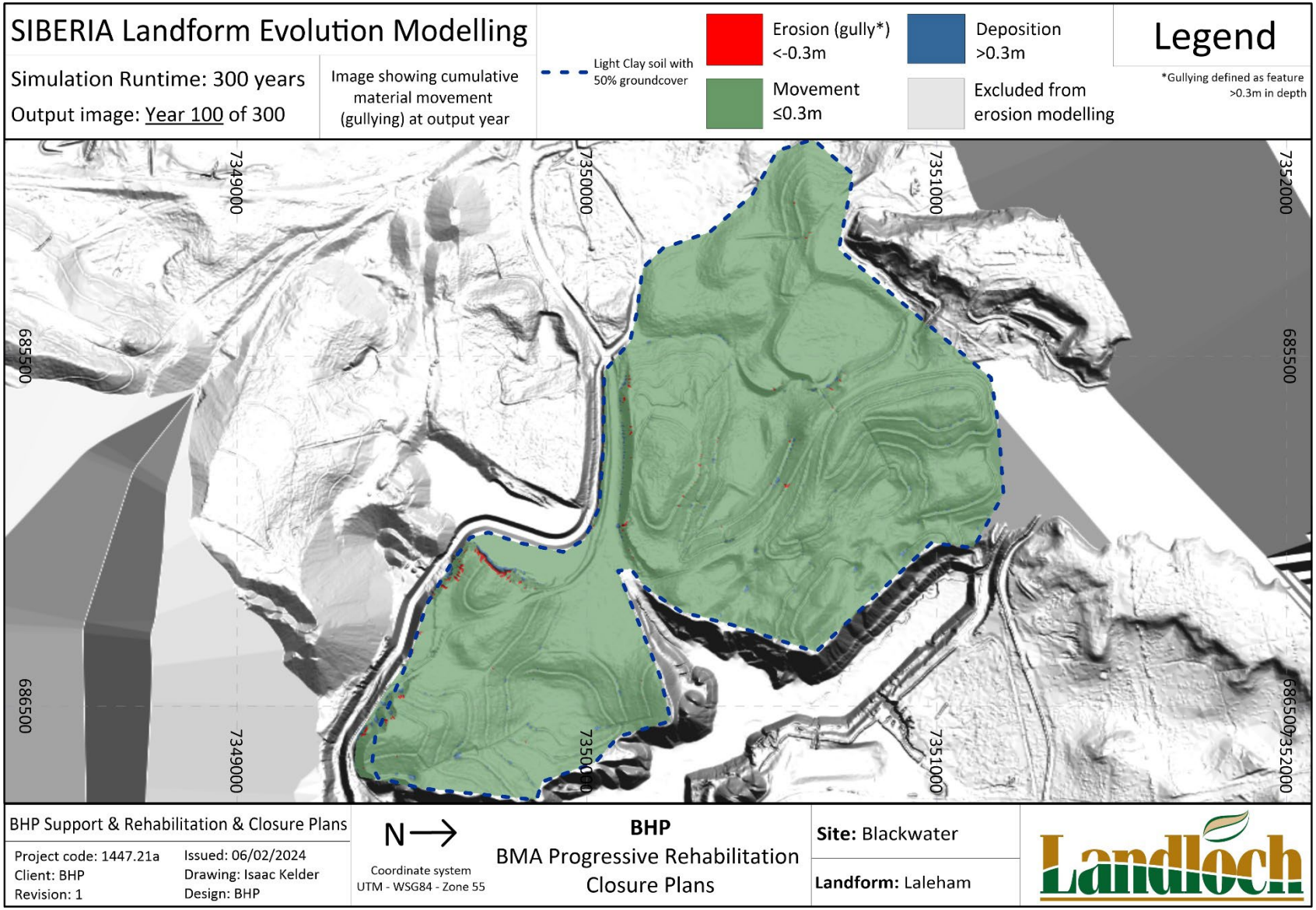

Figure A-26: Predicted erosion and deposition depths of the Laleham rehabilitation landform after 100 years.

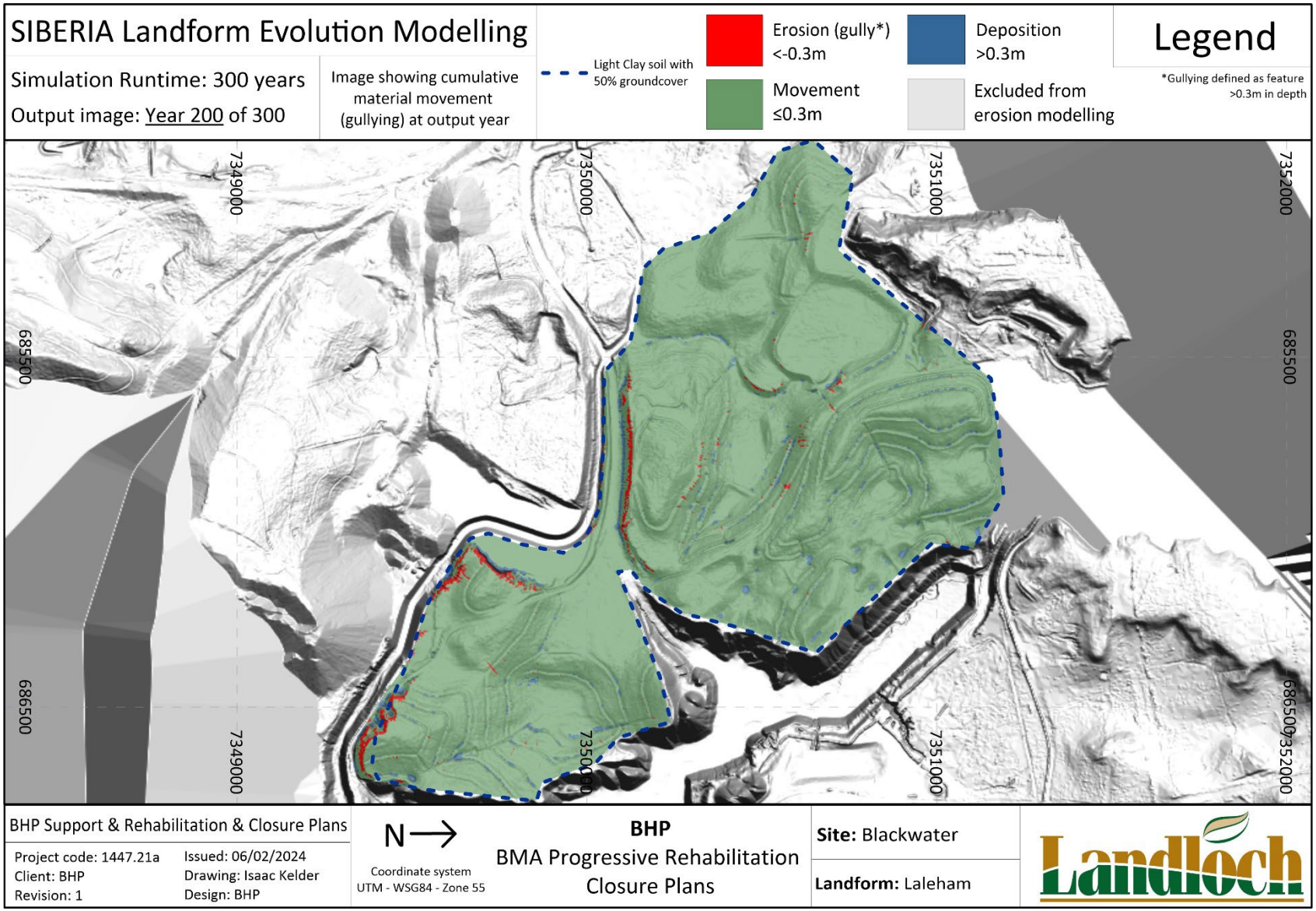

Figure A-27: Predicted erosion and deposition depths of the Laleham rehabilitation landform after 200 years.

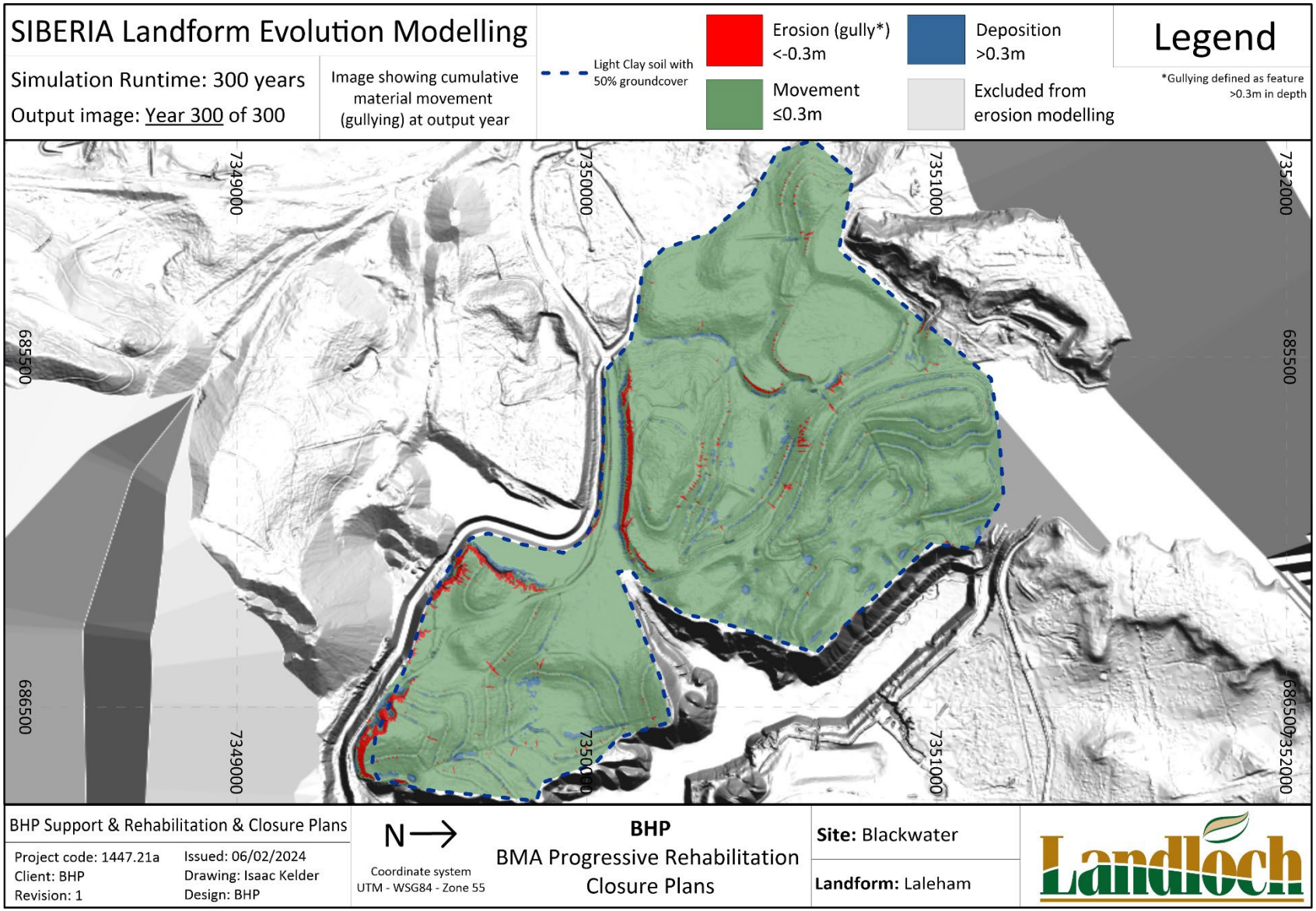

Figure A-28: Predicted erosion and deposition depths of the Laleham rehabilitation landform after 300 years.

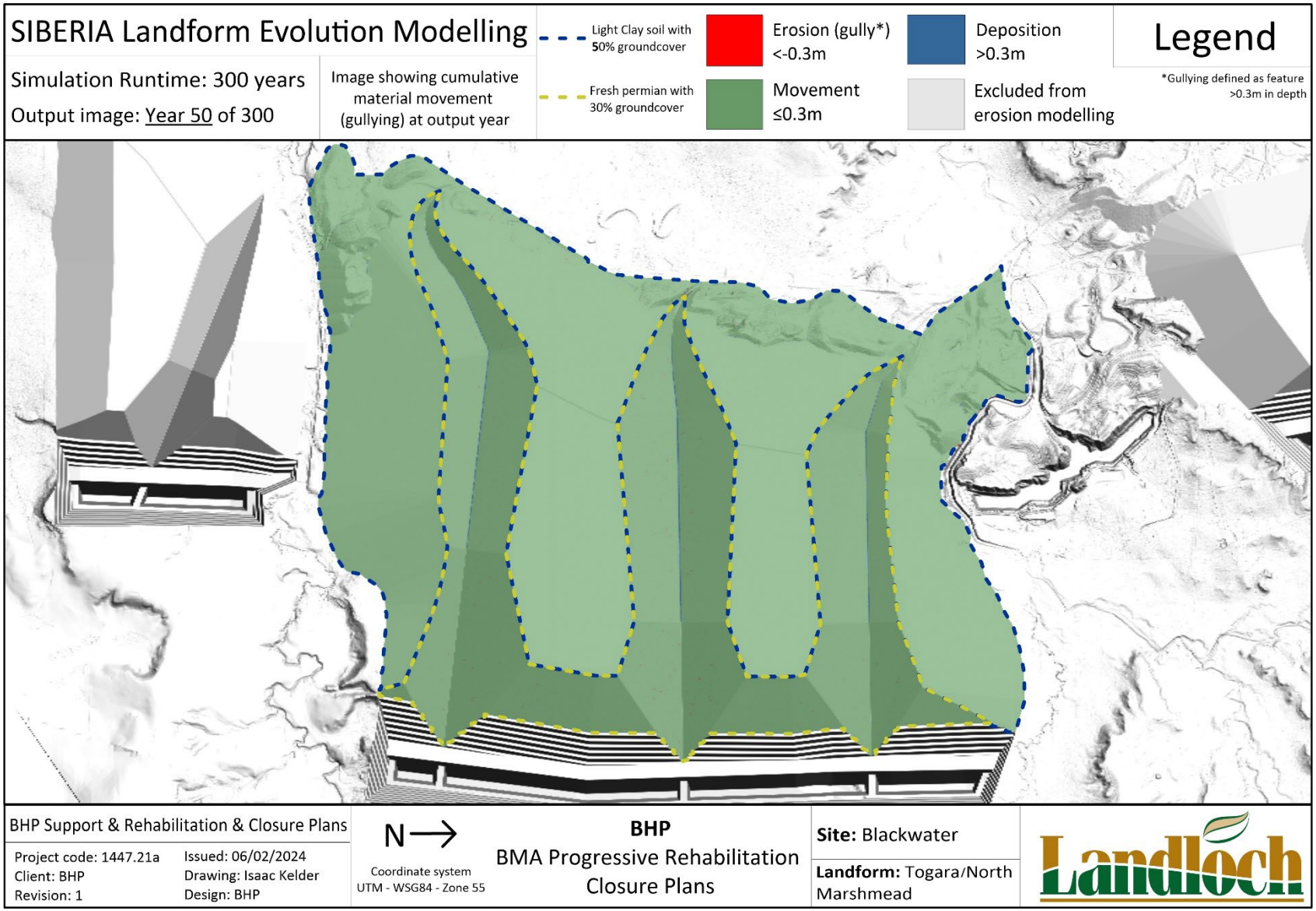

Figure A-29: Predicted erosion and deposition depths of the Togara/North Marshmead rehabilitation landform after 50 years.

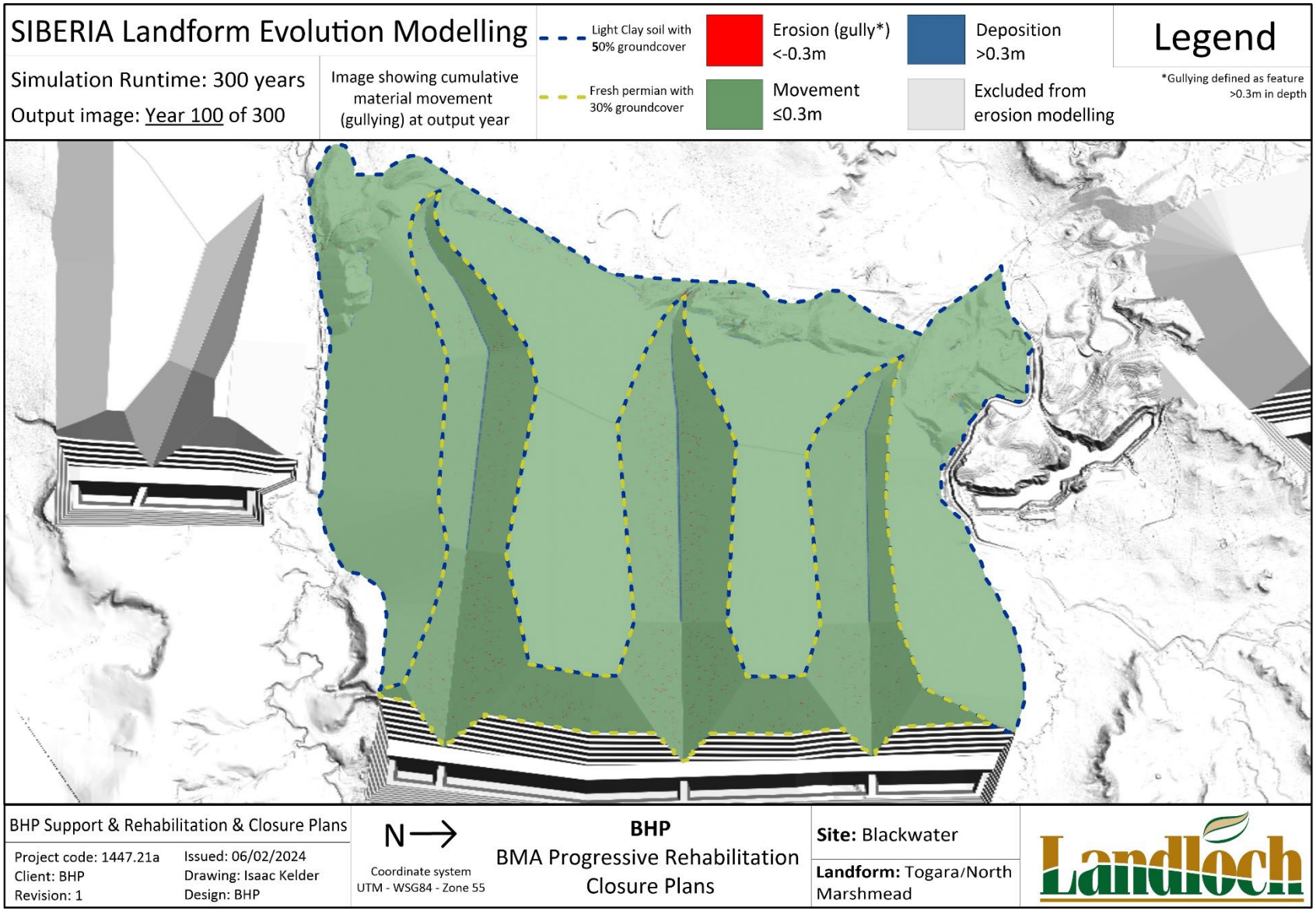

Figure A-30: Predicted erosion and deposition depths of the Togara/North Marshmead rehabilitation landform after 100 years.

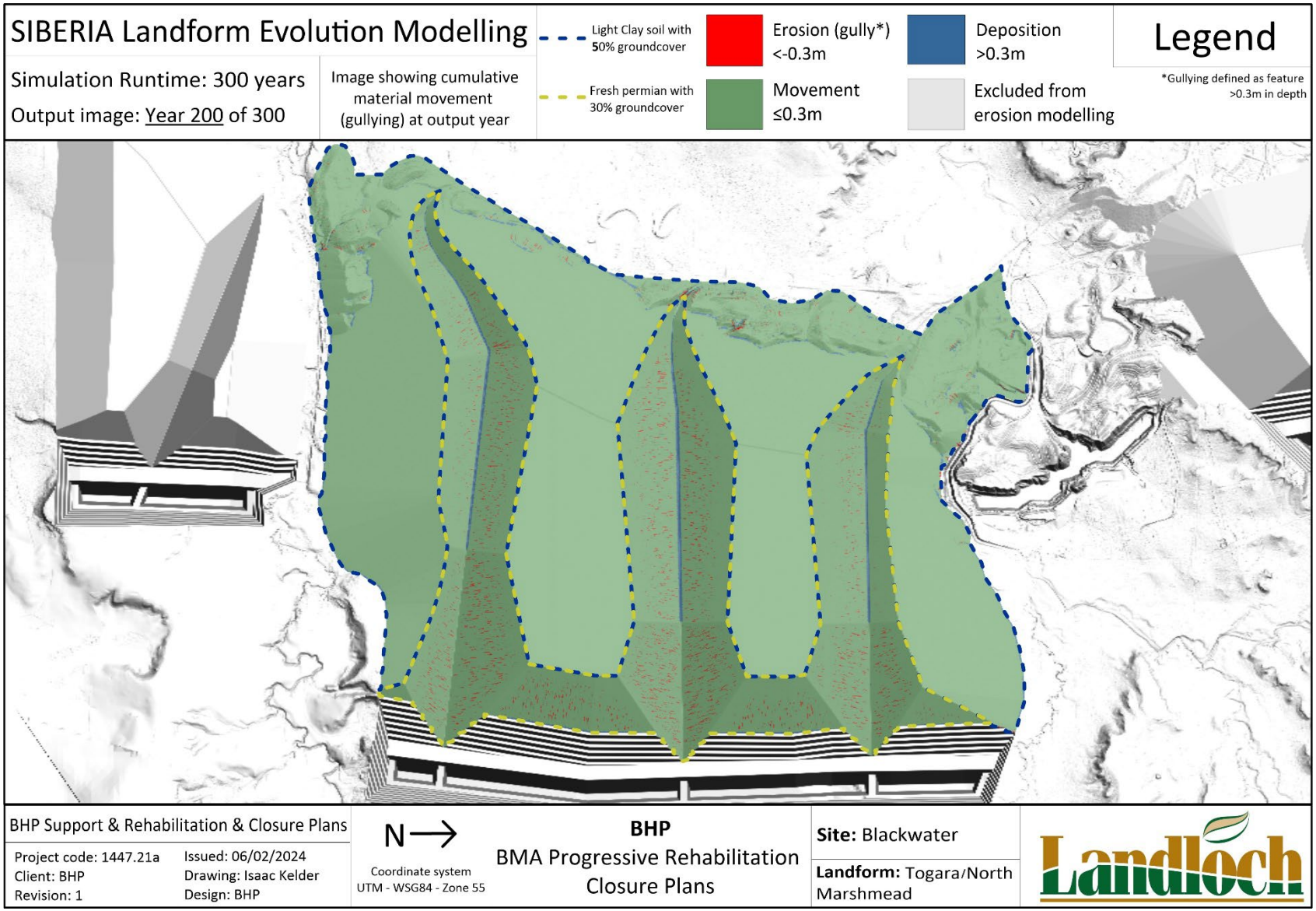

Figure A-31: Predicted erosion and deposition depths of the Togara/North Marshmead rehabilitation landform after 200 years.

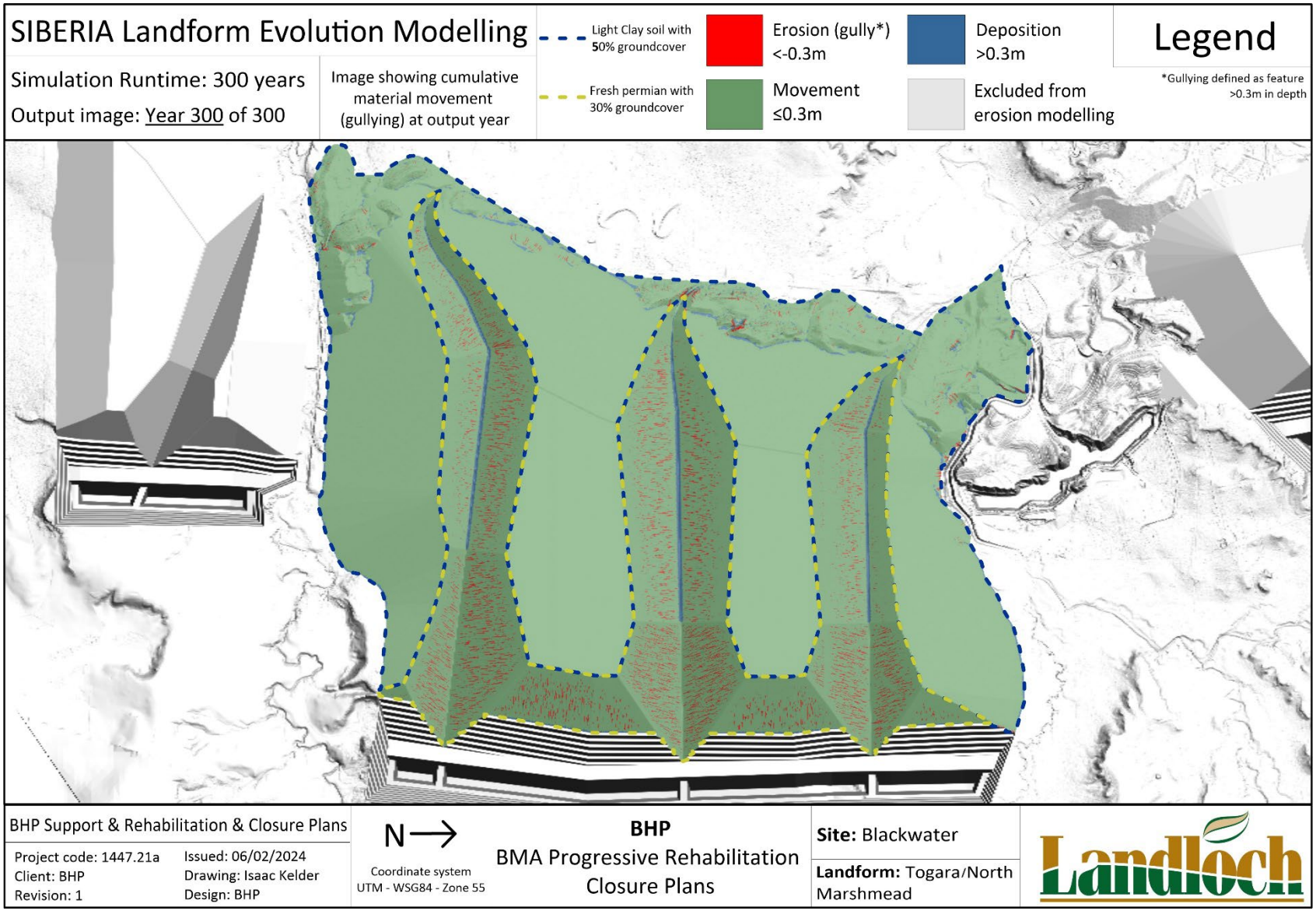

Figure A-32: Predicted erosion and deposition depths of the Togara/North Marshmead rehabilitation landform after 300 years.

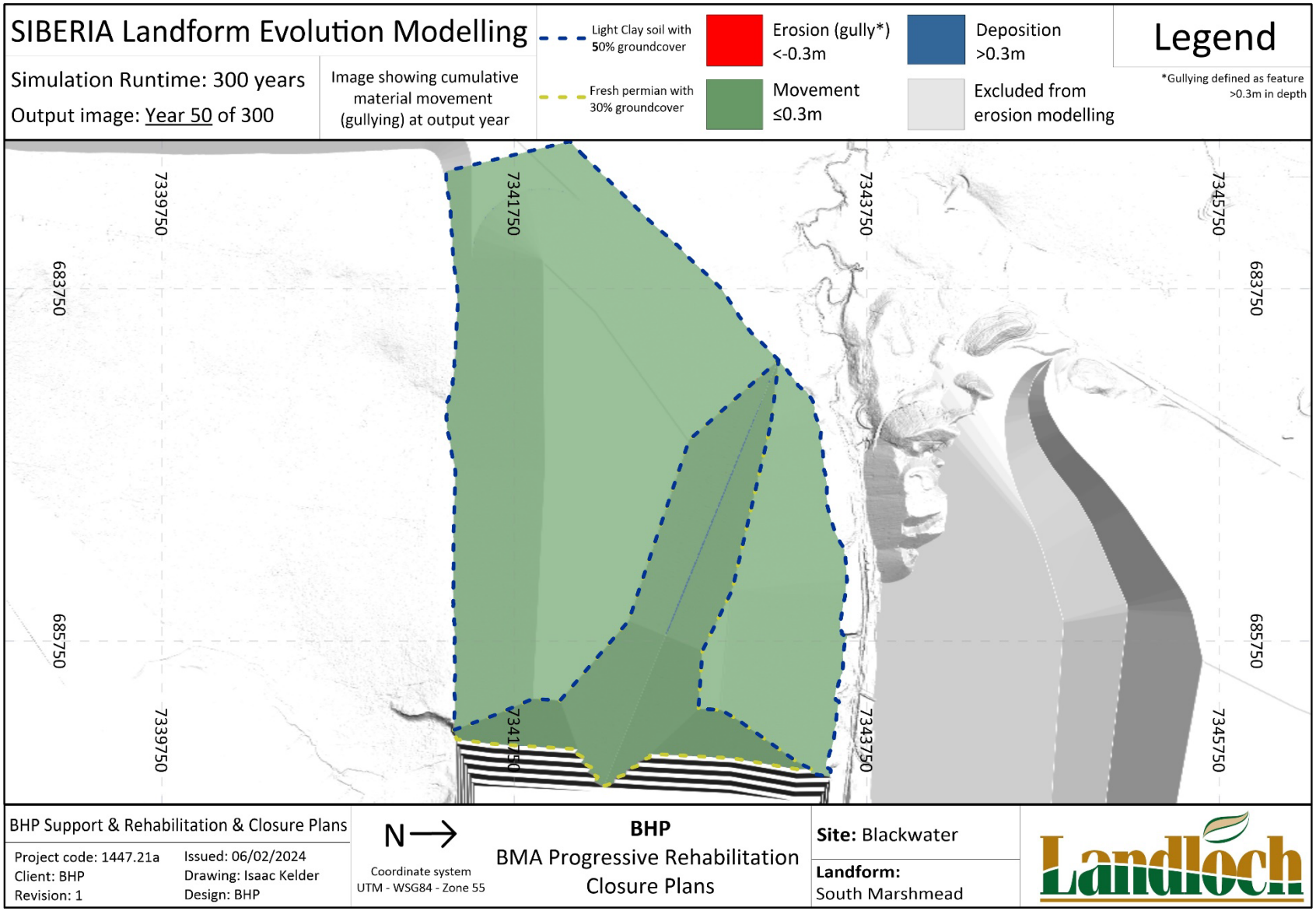

Figure A-33: Predicted erosion and deposition depths of the South Marshmead rehabilitation landform after 50 years.

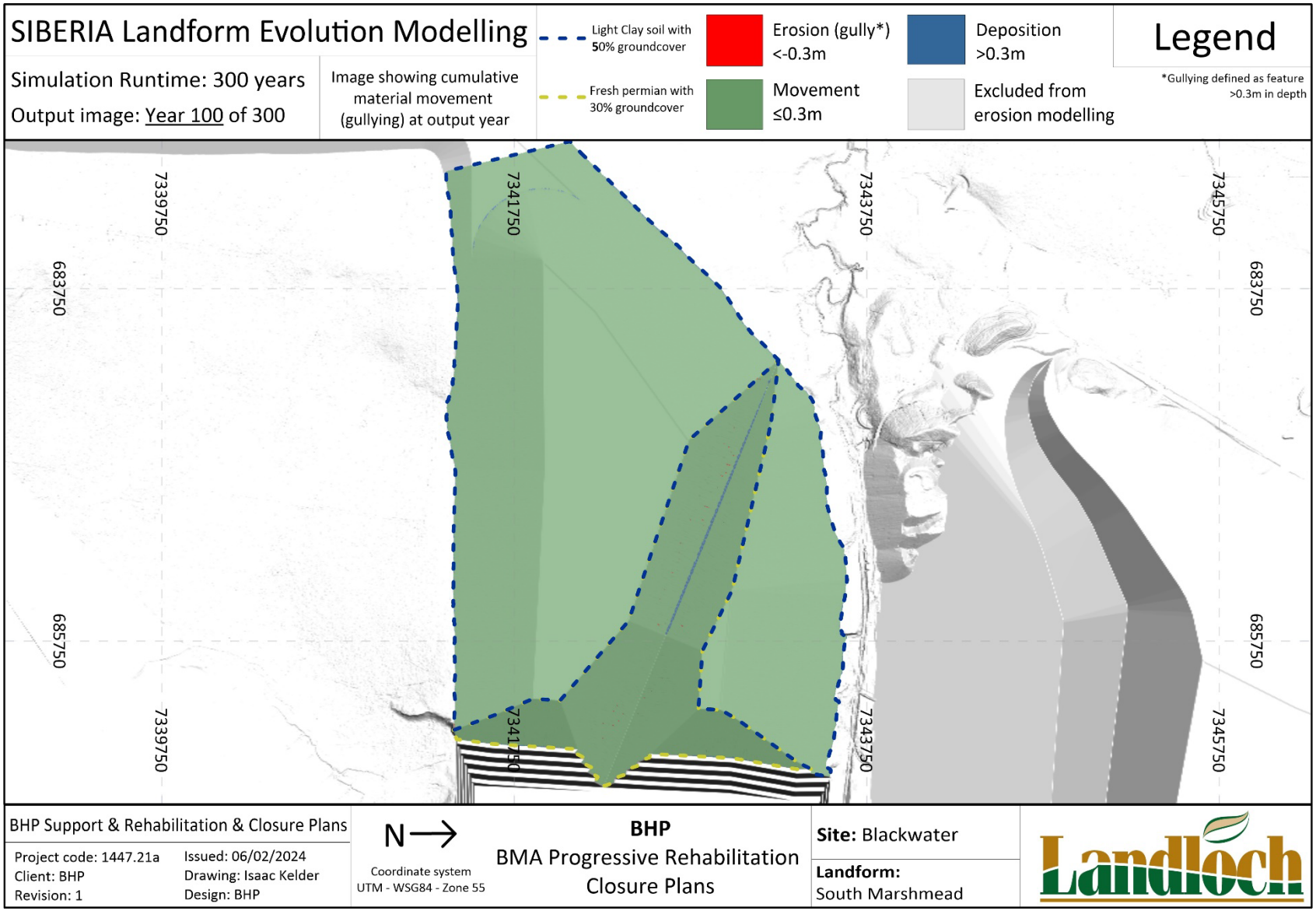

Figure A-34: Predicted erosion and deposition depths of the South Marshmead rehabilitation landform after 100 years.

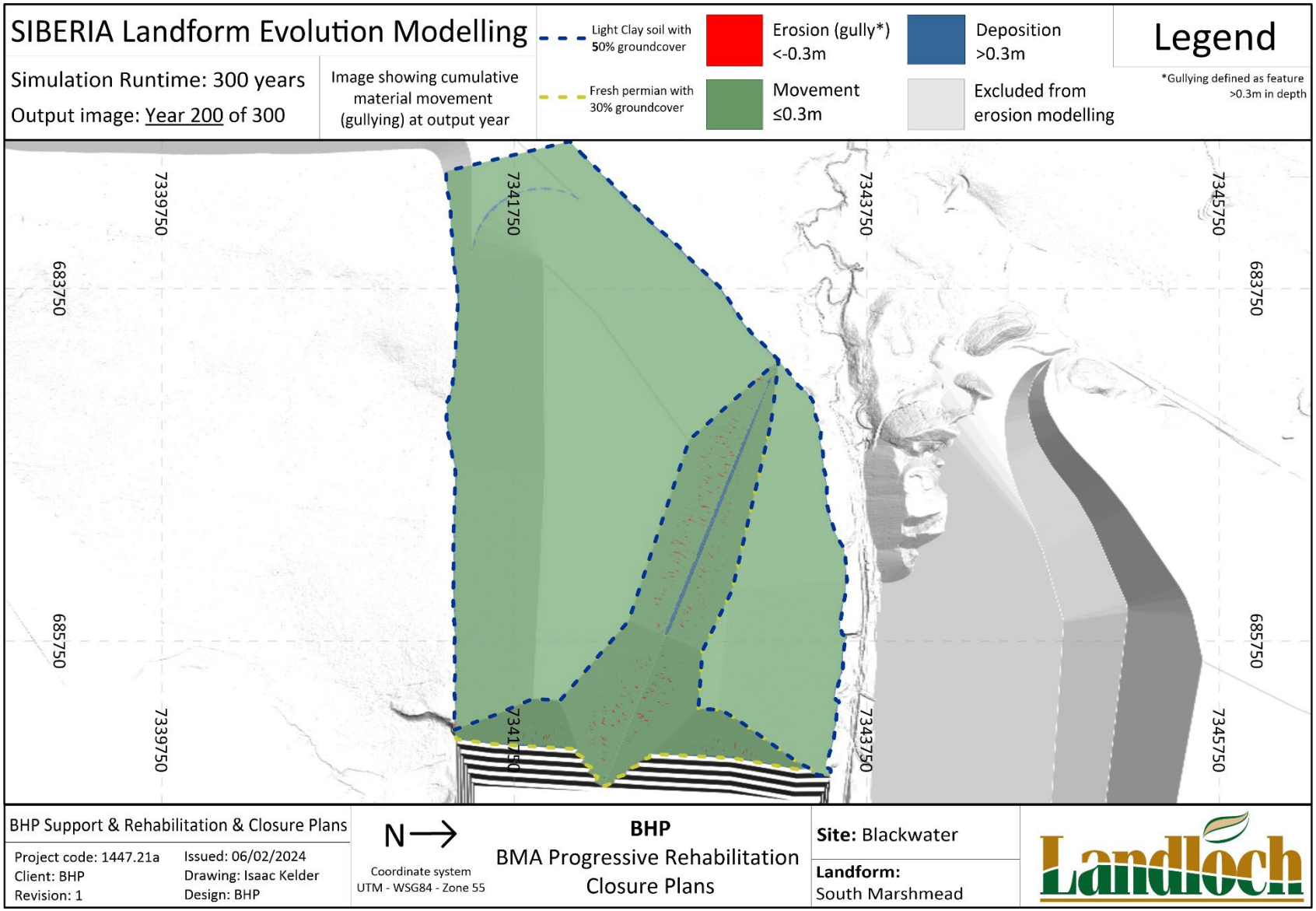

Figure A-35: Predicted erosion and deposition depths of the South Marshmead rehabilitation landform after 200 years.

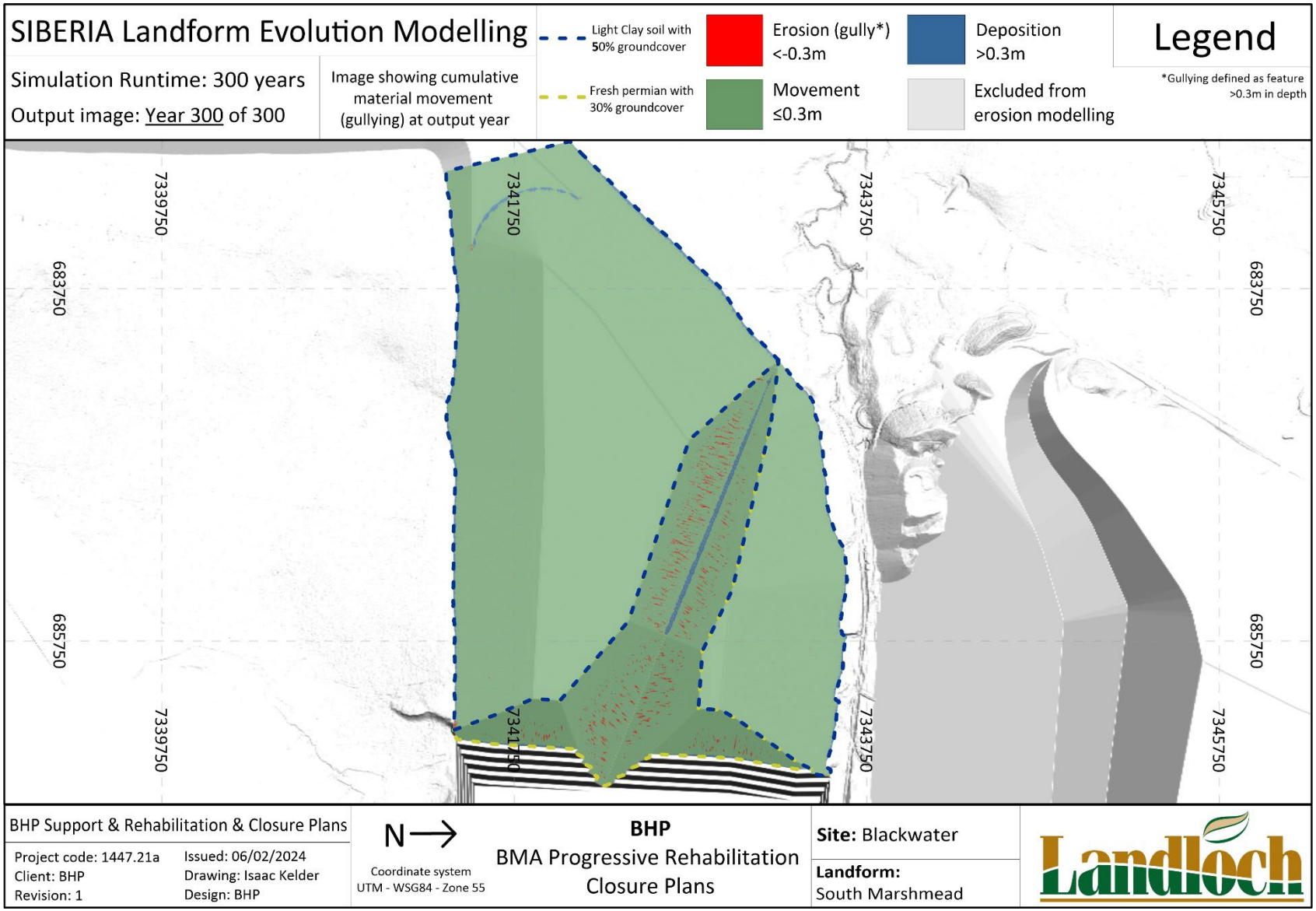

Figure A-36: Predicted erosion and deposition depths of the South Marshmead rehabilitation landform after 300 years.

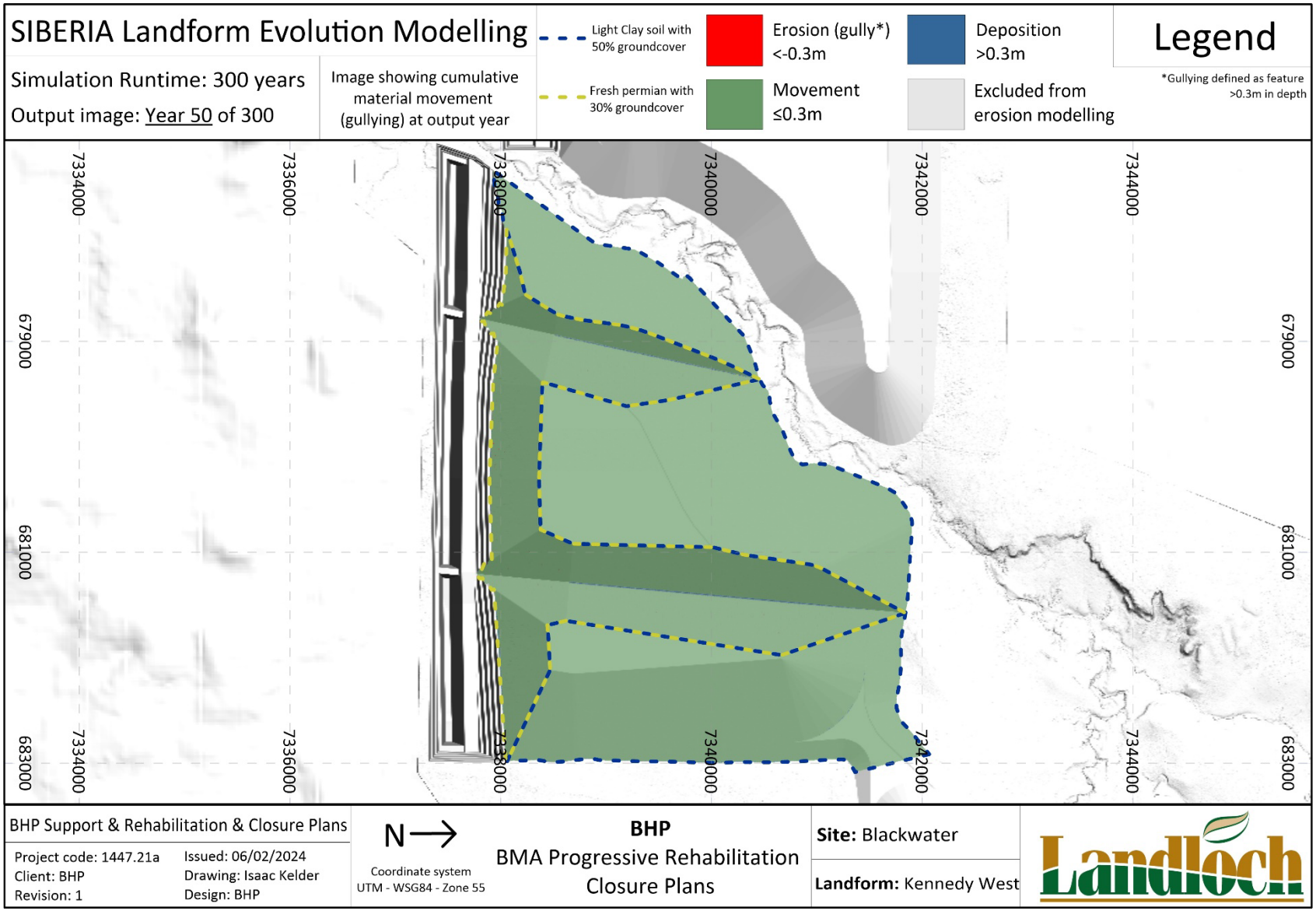

Figure A-37: Predicted erosion and deposition depths of the Kennedy West rehabilitation landform after 50 years.

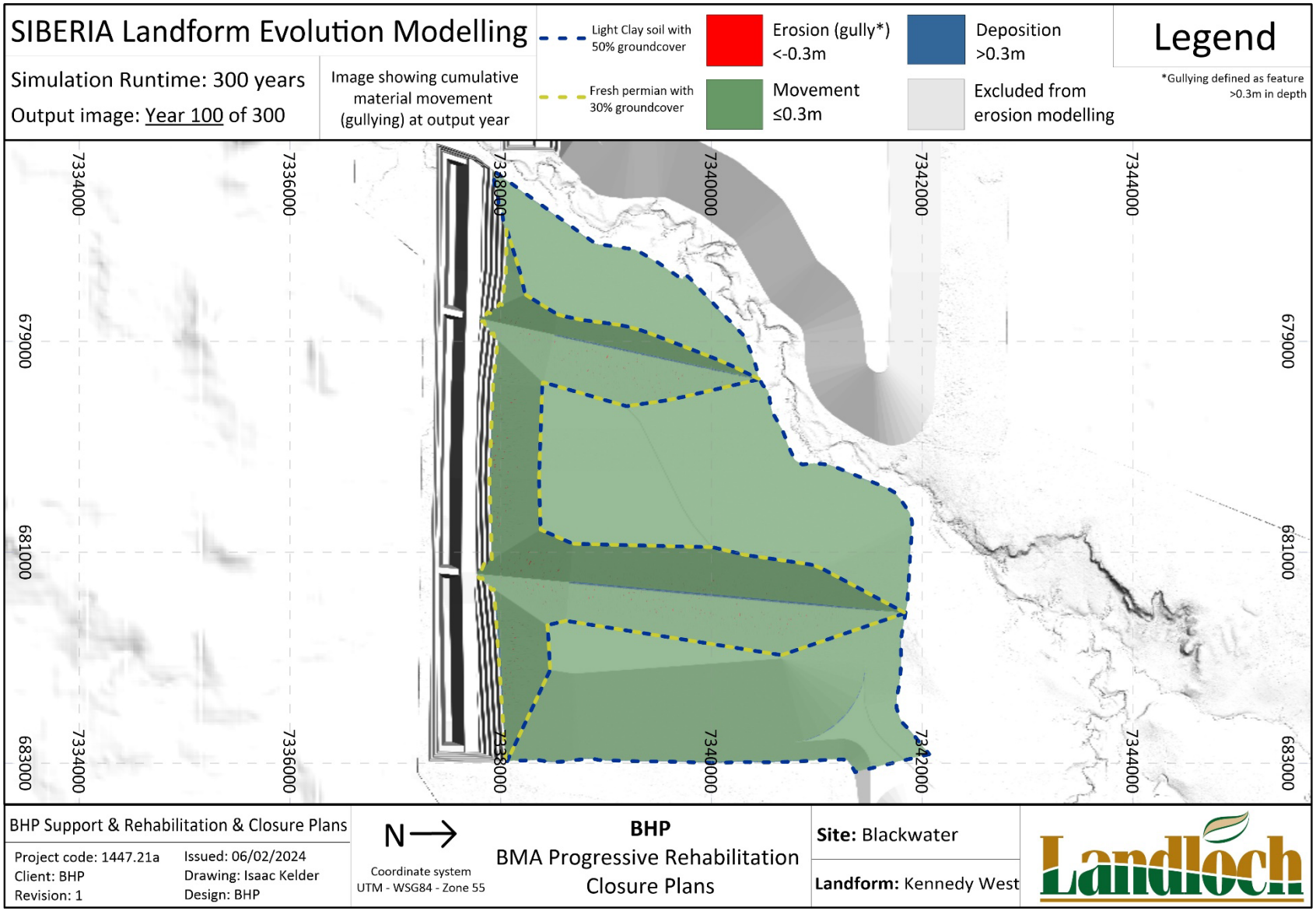

Figure A-38: Predicted erosion and deposition depths of the Kennedy West rehabilitation landform after 100 years.

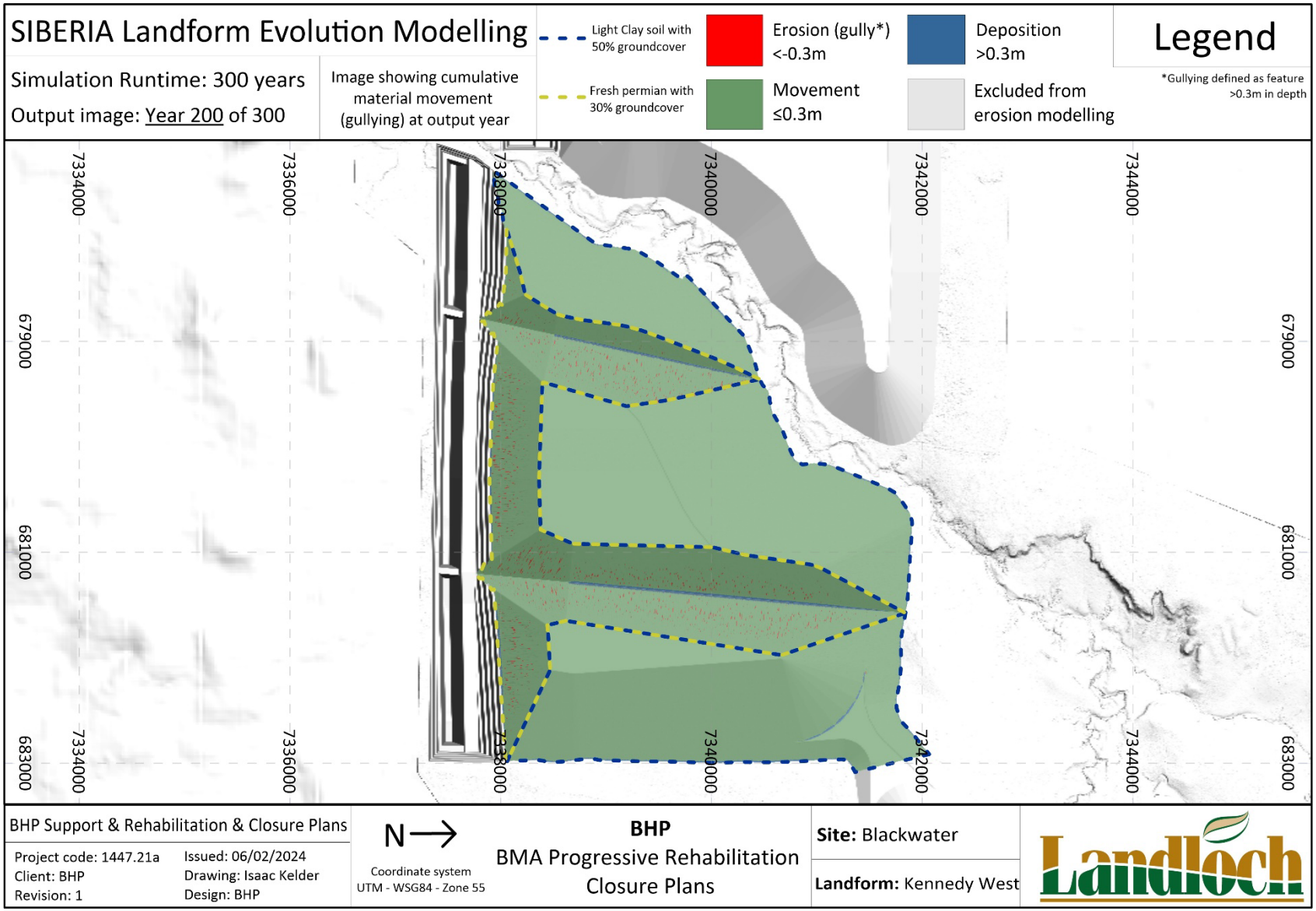

Figure A-39: Predicted erosion and deposition depths of the Kennedy West rehabilitation landform after 200 years.

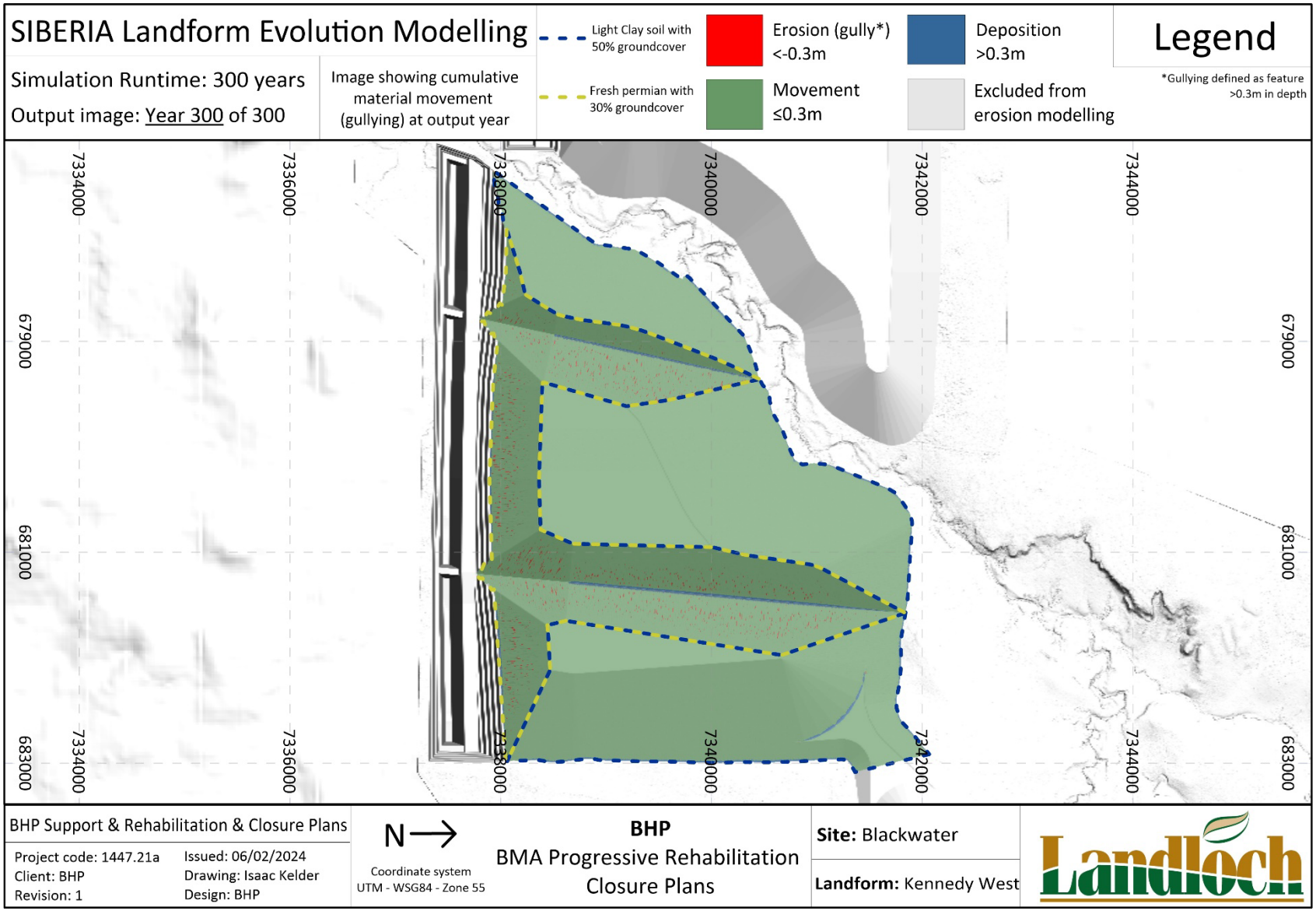

Figure A-40: Predicted erosion and deposition depths of the Kennedy West rehabilitation landform after 300 years.

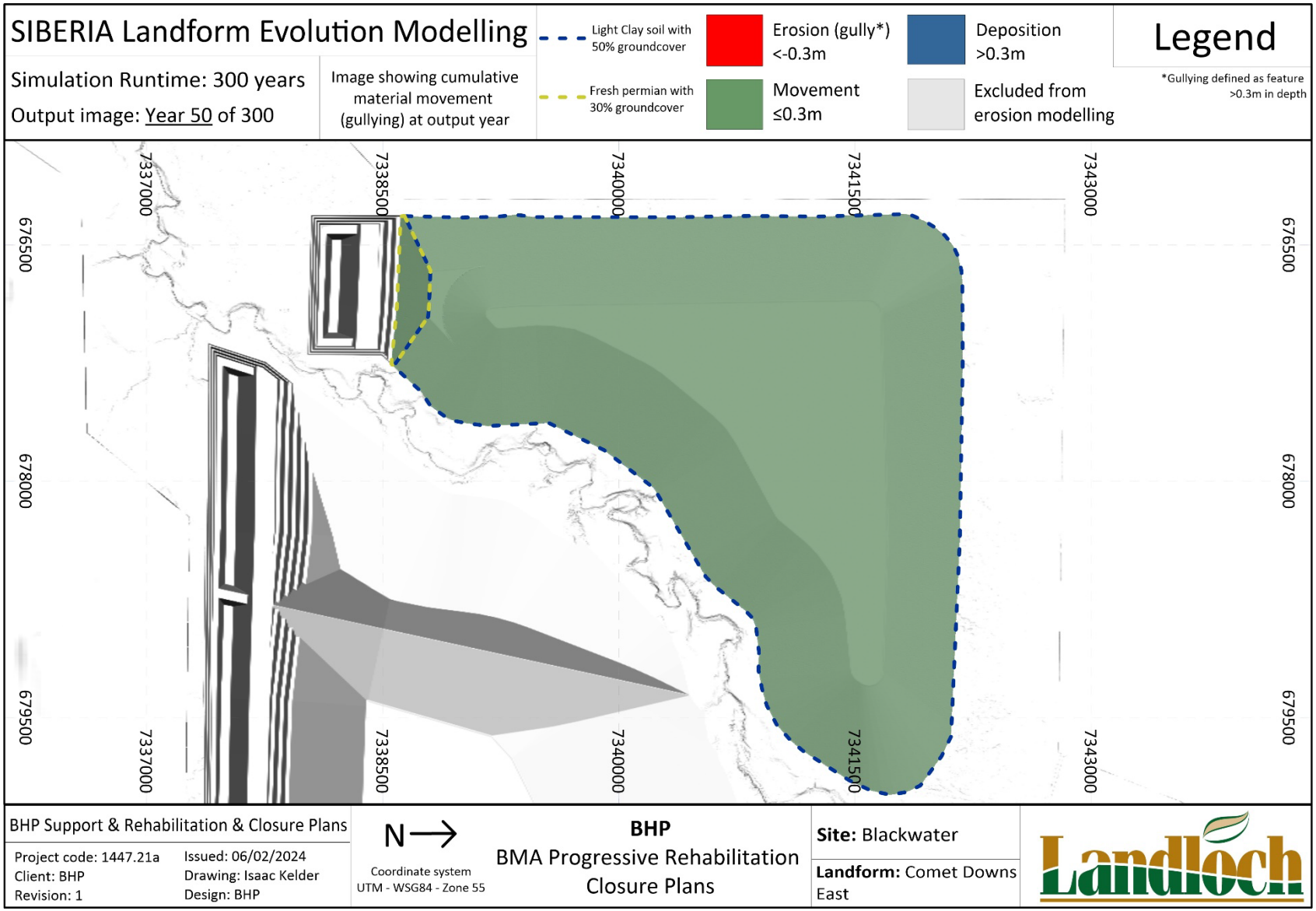

Figure A-41: Predicted erosion and deposition depths of the Comet Downs East rehabilitation landform after 50 years.

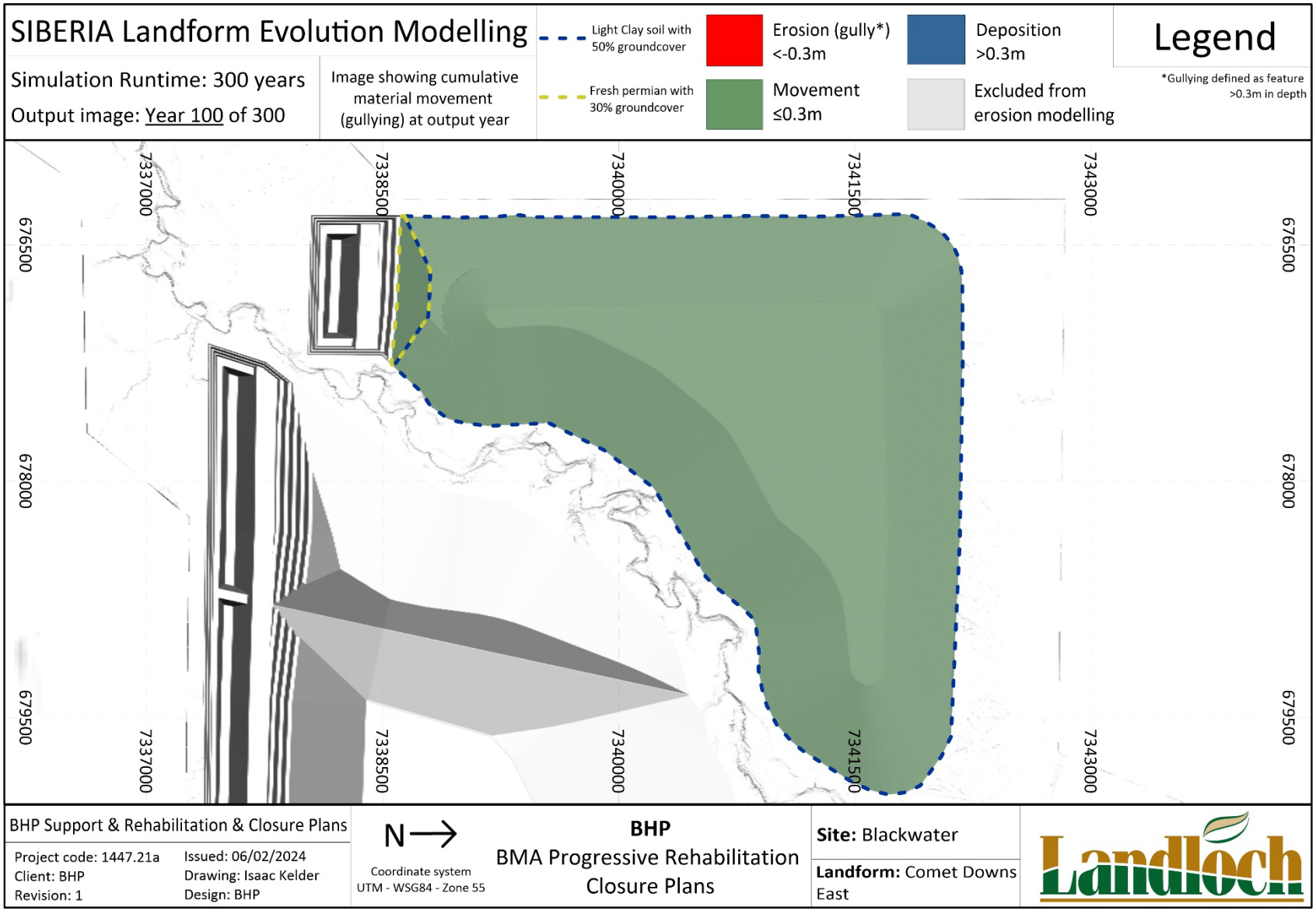

Figure A-42: Predicted erosion and deposition depths of the Comet Downs East rehabilitation landform after 100 years.

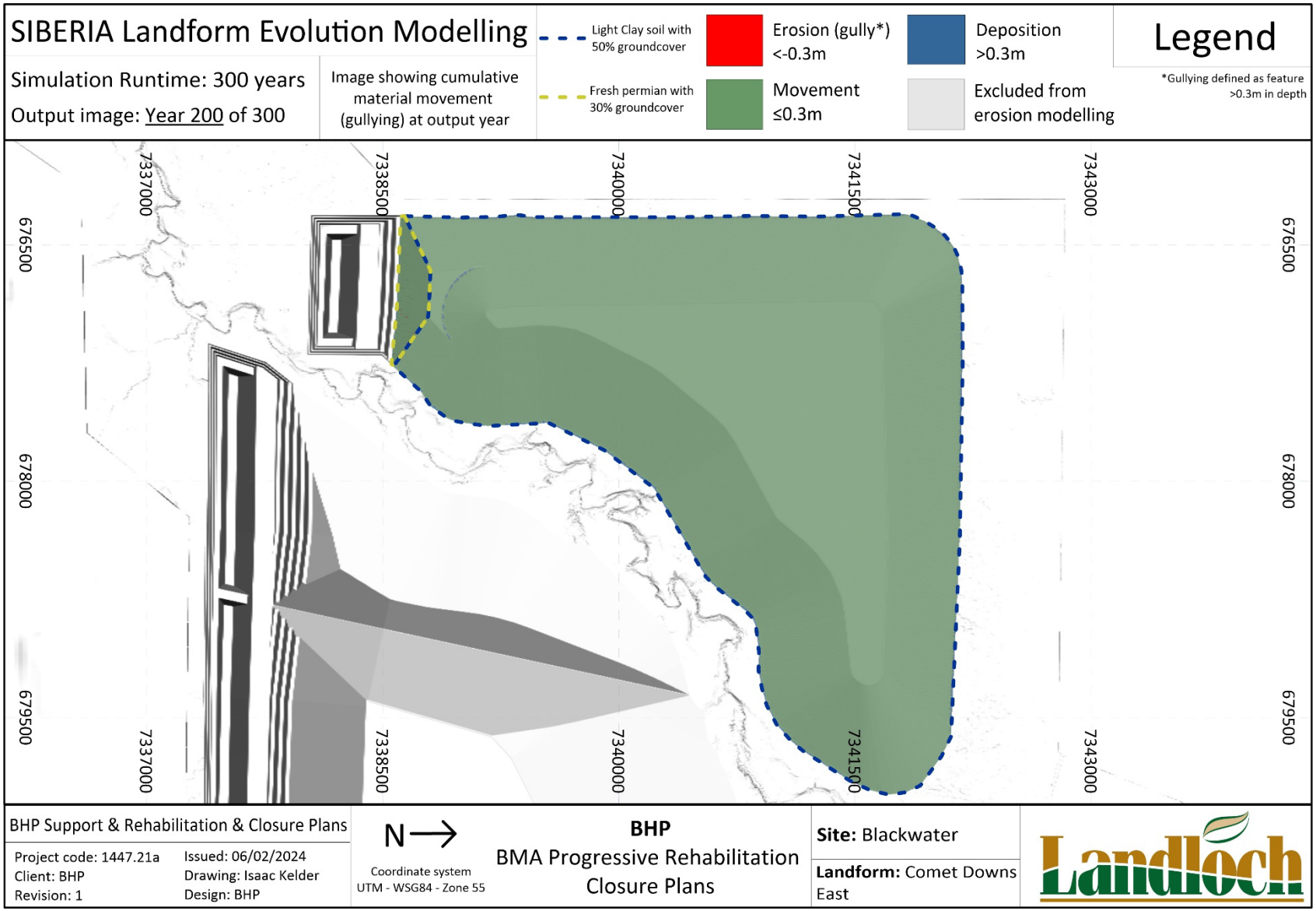

Figure A-43: Predicted erosion and deposition depths of the Comet Downs East rehabilitation landform after 200 years.

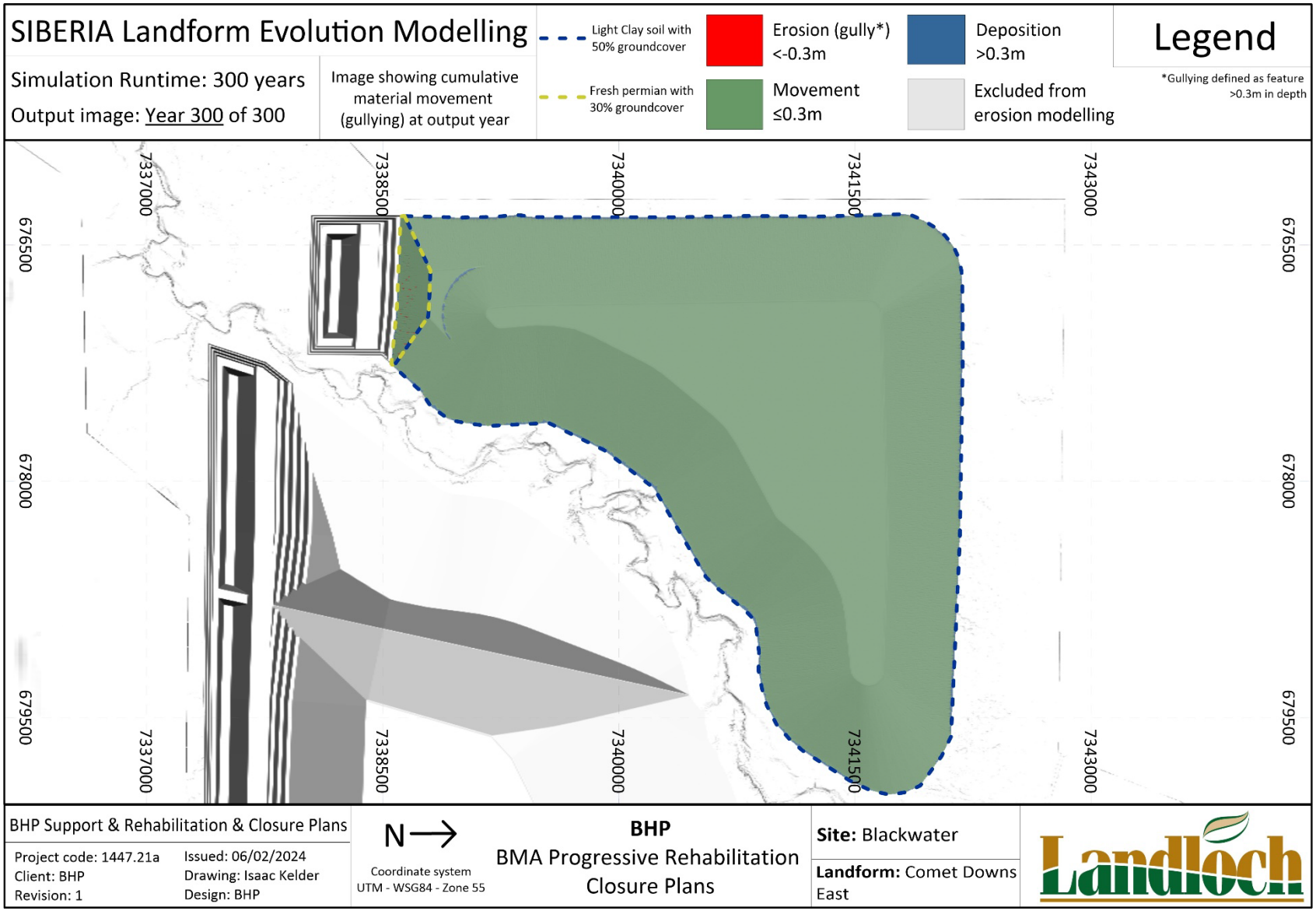

Figure A-44: Predicted erosion and deposition depths of the Comet Downs East rehabilitation landform after 300 years.

Whitehaven

Appendix 4.9 – Sirius Creek Diversion Concept Design

ENGENY
WATER MANAGEMENT

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PRCP Concept Design Report

Sirius Creek Diversion

28 March 2024

M11000_437-REP-002-2

Job no. and Project Name: M11000_437 PRCP Diversions FY21 (BWM)
Doc Path File: \\online.com\files\BNEManagement\Projects\QC1000 BHP (BMA)\QC1000_026 BHP Coal PRCP PD\07 Deliv\2. Report\BWM - Updates CH\Concept Design\Sirius Ck\M11000_437-REP-002-2 Sirius Creek Diversion Concept Design.docx

Rev	Date	Description	Author	Reviewer	Project Mgr.	Approver
1	18/05/2021	Final Issue	Julia Scholz	Ryan Kinnealy, Ben Kiernan	Ryan Kinnealy	Ben Kiernan
2	28/03/2024	Client Issue	Julia Scholz Christian Hansen	Whitney Claxton	Ryan Kinnealy	Ben Kiernan
Signatures						

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INTRODUCTION

1.1 CONTEXT

The Mineral and Energy Resources (Financial Provisioning) Act 2018 (MERFP Act) amended the Environmental Protection Act (EP Act) to introduce new requirements for the progressive rehabilitation and closure of mined land. These changes include the development of a Progressive Rehabilitation and Closure Plan (PRCP) for all existing and future site-specific Environmental Authority (EA) holders for mining activities relating to a mining lease.

The main purpose of the PRCP is to:

- Require the holder of an EA to plan for how and where activities will be carried out on land in a way that maximises the progressive rehabilitation of the land to a stable condition.
- Provide for the condition to which the holder must rehabilitate the land before the EA may be surrendered.

This report illustrates the concept design details for Sirius Creek and has been prepared in accordance with the requirements of the Department of Natural Resources, Mines and Energy (DNRME) Guideline: *Works that interfere with water in a watercourse for a resource activity – watercourse diversions authorised under the Water Act 2000* (DNRME, 2019). The objective of this report is to demonstrate the watercourse diversion concept design will satisfy the outcomes identified in the guideline for PRCP purposes.

1.2 PURPOSE AND SCOPE

The scope of work for each diversion is comprised of two stages:

- Stage 1: Options Assessment.
- Stage 2: Concept Design on the preferred option outcome from Stage 1.

The purpose of this document is to outline the concept design developed for the preferred diversion remediation option (outcome from Stage 1) to achieve a state of dynamic equilibrium to achieve a relinquishable state for the diversion. The following methodology approach was adopted:

- A desktop geomorphic assessment of the creek using historical aerial imagery and survey to inform the concept design of the options.
- Review of the existing flood studies and determine peak flow rates in the diversion for key design flow events for the purposes of and hydraulic analysis.
- Conduct a hydraulic assessment of the diversion option against the criteria in the DNRME 2019 Guideline: Works that interfere with water in a watercourse for a resource activity – watercourse diversions authorised under the Water Act 2000 (DNRME, 2019) (see Section 3.1).
- Develop concept design sketches and watercourse diversion spatial polygon for the diversion for presentation in the PRCP chapter and schedule.

1.3 LIMITATIONS

The concept design is developed exclusively for PRCP purposes and thereby is falling within the limitation of the PRCP as well. This means any concept design options considered for the diversion remediation only include permanent diversion remediation solutions. The design is considered to be concept only and not at a functional level which would be required to support an approval for the works.

2 OVERVIEW

2.1 LOCATION

Sirius Creek is an ephemeral tributary of the Comet River, situated within the Fitzroy River basin. The creek originates in a relatively low relief range to the east of Blackwater Mine. The creek flows from east to west through the southern part of Blackwater Mine operations and south of Laleham Pit and Ramp 74, eventually joining Comet River some 47 km west of Blackwater Mine. The catchment upstream of the diversion is approximately 100 km^2 and currently flows through “Old Cut 4” Dam. The diversion was likely constructed in 1977-1978 (Alluvium, 2010), at a length of approximately 2.7 km, to allow mining in Laleham Pit and form part of the flood mitigation for this pit. Refer to Figure 2.1 for the location of the Sirius Creek Diversion.

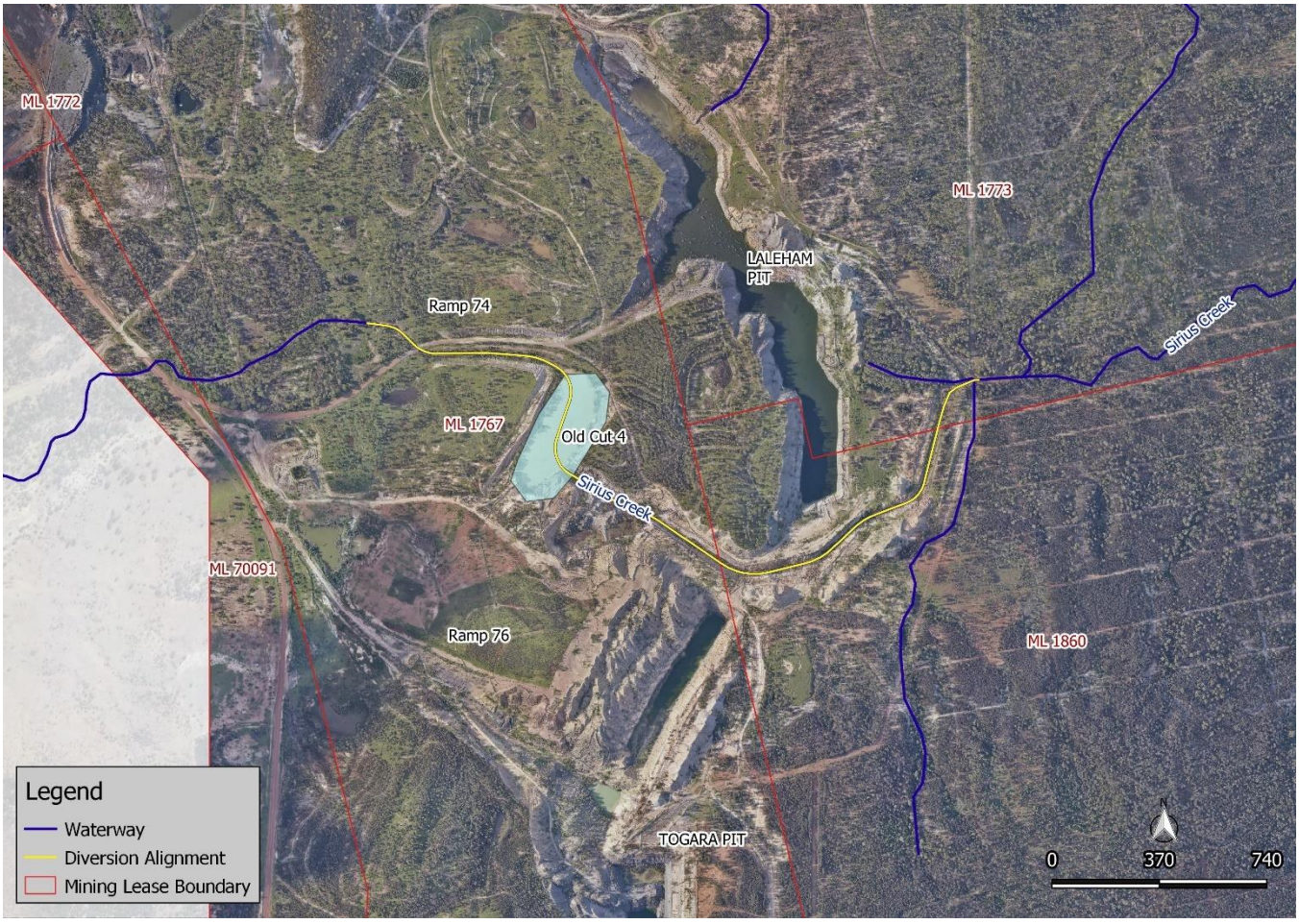

Figure 2.1: Location of the Sirius Creek Diversion at Blackwater Mine

2.2 NATURAL REACHES

The upstream, downstream and diversion reaches of Sirius Creek have been described as follows (Alluvium, 2010):

- **Upstream reach –** The upstream reach of the Sirius Creek diversion is a moderate sinuosity channel with low capacity, channel depths varying between 1-4 m and top width between 8-20 m. The channel does not have an excess supply of bedload sediment with native vegetation and habitat diversity enhanced due to woody debris. Some minor clearings have resulted in erosion heads along parts of the upstream channel. Generally, the upstream reach is representative of the natural environment of the surrounding land.

- **Downstream reach –** The downstream channel of the Sirius Creek diversion comprises of a moderate sinuosity low flow channel of low capacity, set within a broad floodplain. The riparian vegetation along the reach is subject to grazing and mining influences, with “Old Cut 4” dam impacting the sediment flow regime within the diversion. The dam is not allowing sediments to pass through the system freely and as a result sediment is accumulating within the diversion. The downstream reach is approximately 1-3 m deep with the low flow channel top width ranging from 10-20 m.
- **Diversion reach (pre-mining)** - The Sirius Creek diversion reach (pre-mining) was approximately 2.5 km long. It was gently meandering across the southern extent of what is now Laleham Pit.

The upstream, downstream and diversion reaches of the Sirius Creek diversion at Blackwater Mine are shown in Figure 2.2.

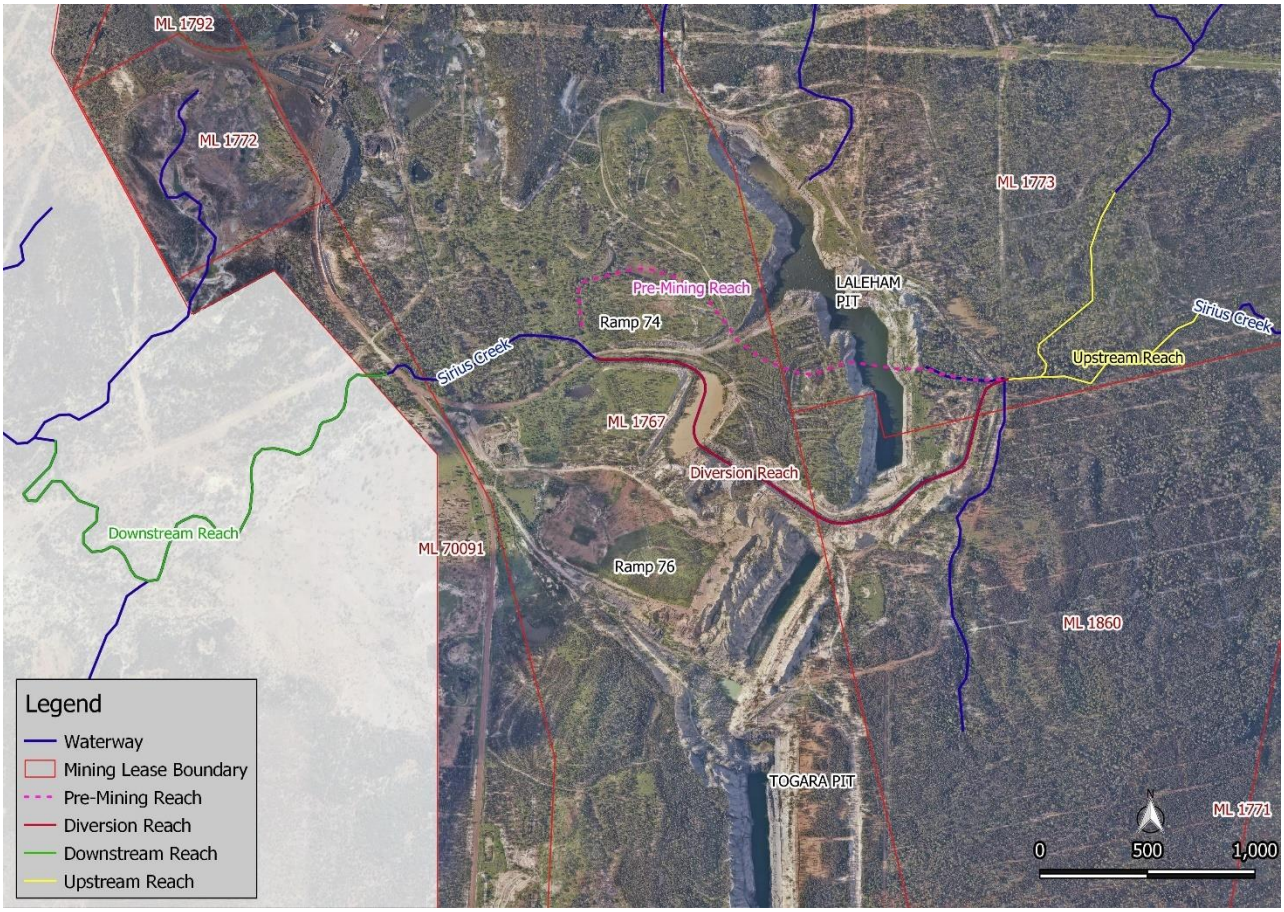

Figure 2.2: Upstream, Downstream and Diversion Reaches of the Sirius Creek Diversion

2.3 DIVERSION REACH

Monitoring of Sirius Creek diversion has been undertaken since 2010 and was last completed in 2017. As part of the major monitoring, the latest condition of the Sirius Creek diversion has been described as follows (Engeny, 2017):

- The upstream reach and downstream reach have remained relatively stable overall with a minor improvement in riparian vegetation condition. Prior to the last minoring assessment, the riparian condition was deteriorating steadily.
- There is an existing dam within the diversion reach, called “Old Cut 4” which is influencing the flow regime within the diversion as well as sediment supply of the reach.
- The diversion reach continues to remain in poor condition due to the nature of the diversion, the inability to function as a natural system and excess supply of sediment from spoil dumps and bank erosion.

Based on the current condition of the Sirius Creek diversion, it is highly unlikely that the diversion will achieve the water license relinquishment criteria prior to mine closure without intervention.

3 BASIS FOR CONCEPT DESIGN

There are currently two recognised guidelines for design of watercourse diversions within Queensland. These guidelines have been developed by DNRME and the Australian Coal Association Research Program (ACARP):

- Guideline: Works that interfere with water in a watercourse for a resource activity – watercourse diversions authorised under the Water Act 2000 (DNRME, 2019).
- Criteria for functioning river landscape units in mining and post mining landscapes (ACARP, 2014).

Both the DNRME and ACARP Guidelines were developed based on previous research completed by ACARP in the early 2000s which included assessment of existing diversion performance and the development of design and rehabilitation criteria for watercourse diversions. Details of the guidelines that have been used to design the Sirius Creek diversion are summarised below.

3.1 DNRME GUIDELINE

3.1.1 Diversion Design Outcome Requirements (Permanent Watercourse Diversions)

The diversion design outcome requirements are nominated by DNRME for permanent watercourse diversions and have been used to develop the design for Sirius Creek diversion:

- Outcome 1 - The permanent watercourse diversion incorporates natural features (including geomorphic and vegetation) present in the landscape and in local watercourses.
- Outcome 2 - The permanent watercourse diversion maintains the existing hydrologic characteristics of surface water and groundwater systems.
- Outcome 3 - The hydraulic characteristics of the permanent watercourse diversion are comparable with other local watercourses and suitable for the region in which the watercourse diversion is located.
- Outcome 4 - The permanent watercourse diversion maintains sediment transport and water quality regimes that allow the watercourse diversion to be self-sustaining, while minimising any impacts on upstream and downstream reaches.
- Outcome 5 - The permanent watercourse diversion and associated structures maintain equilibrium and functionality and are appropriate for all substrate conditions they encounter.

3.1.2 Design Criteria

DNRME recommend the following design criteria in development of permanent watercourse diversions and have been considered in development of the Sirius Creek diversion:

- The watercourse diversion should tie-in with the existing or receiving watercourse within the resource tenure boundary.
- The stability and performance of a watercourse diversion is assisted by vegetation within the watercourse diversion and adjoining floodplain and does not include artificial structures for grade control that requires ongoing maintenance.
- The channel capacity must be at least equivalent to the natural stream channel capacity existing in that vicinity.
- The length of the channel should be equivalent to the length of the watercourse it replaces.
- Bed grade/slope should be equivalent to the existing watercourse.
- Batter slopes should be designed to maintain stability through different substrates.

The DNRME Guideline also nominates a set of hydraulic design criteria which have been adapted from the original ACARP research. These hydraulic design criteria were developed based on assessment of existing Bowen Basin streams and watercourse diversions and are considered reflective of stable hydraulic conditions for ephemeral systems in central Queensland. The hydraulic design criteria are summarised in Table 3.1 and include the following:

- Shear stress which is a function of discharge, flow depth and hydraulic gradient and represents the tractive force acting on sediment particles and is used to determine the threshold of motion for sediment. High shear stress provides an indication of potential erosion in cohesive sediments or movement of non-cohesive sediments. It also provides a measure of the ability of vegetation to withstand flow.
- Stream power which is a function of hydraulic gradient, flow width and flow rate and represents the energy available to do work on the channel. High stream power values generally result in elevated erosion potential.
- Velocity which is a function of flow rate and cross-sectional area and is a simplified measure of erosion potential. Generally higher velocities result in higher erosion potential however stream power and shear stress are more reliable indicators of erosion and sediment transport potential.

Table 3.1: DNRME 2019 Hydraulic Design Criteria

Design Flow Event	Stream Power (W/m^2)	Velocity (m/s)	Shear Stress (N/m^2)
2-year ARI (no vegetation) (39% AEP)	<35	<1.0	<40
2-year ARI (vegetated) (39% AEP)	<60	<1.5	<40
50-year ARI (2% AEP)	<150	<2.5	<80[1]

1. DNRME values are taken from ACARP 2002 as the <50N/m^2 value in DNRME 2019 is incorrect.

3.2 ACARP GUIDELINES

ACARP (2014) outlined several approaches to the design of diversion channel dimensions, which included an analogous approach, where channel dimensions are selected from a reference reach; a hydraulic geometry approach where dimensions are determined from regression relationships; and an analytical approach, where equations are used to calculate continuity, hydraulic resistance, and sediment transport and channel characteristics are determined from field inspection of a reference reach.

In addition to the analogous approach, ACARP (2014) also provides guidance on alluvial channel design parameters which were adapted from ACARP (2002). These hydraulic parameters are intended to be represented of stable watercourses within the Bowen Basin and are summarised in Table 3.2.

Table 3.2: ACARP 2014 Alluvial Channel Design Parameters

Stream Type	Stream Power (W/m^2)	Stream Power 39% AEP (W/m^2)	Stream Power 2% AEP (W/m^2)
Alluvial	Supply limited	15-35	50-100
	Transport limited	35-60	80-150
Bedrock controlled	n/a	50-100	100-350

ACARP (2014) also provides recommendations on shear stress thresholds for vegetation used as part of rehabilitation activities. These thresholds are summarised in Table 3.3.

Table 3.3: ACARP 2014 Recommended Vegetation Shear Stress Thresholds

Vegetation Type	Design Shear Stress (N/m^2)
Buffel grass	40
Structurally diverse suite of established native vegetation	120

The long-term performance of the diversion under both operating and closure scenarios is assessed with the following objectives, based on industry standard closure objectives:

- The diversion demonstrates to be in a safe, stable, non-polluting, and self-sustaining state (as per PRCP Closure Criteria and Environmental Authority requirements as per Section 3.3).
- Reference rehabilitation requirements (acceptance criteria) include goals, objectives, and acceptance criteria for the post mining land use of the 'Watercourses' which is applicable for the watercourse diversion.
- Existing water licence diversion objectives generally align with the objectives under the DNRME Guidelines (2019).

3.3 ENVIRONMENTAL AUTHORITY EPML00717813

The land schedule within the Blackwater Mine EA (EPML00717813) requires that all areas significantly disturbed by mining activities must be rehabilitated in accordance with specified Rehabilitation Requirements. The EA provides the rehabilitation landform criteria for the post mining land use of watercourses (refer to Figure 3.1). Some indicators reference the Index of Diversion Condition (IDC) method, which is a component of ongoing diversion monitoring.

Table E1 (Rehabilitation Requirements)

Post Mining Land Use	Goal	Objective	Indicator	Acceptance Criteria
Watercourse	Safe to humans and wildlife	Safety hazards are not significantly different to surrounding unmined landscapes subject to the same land use	Hazard assessment	No significant difference
	Stable	Rehabilitation is erosionally stable	Geomorphic index (IDC method)	Greater or equal to upstream or downstream values.
	Non-polluting	Rainfall runoff from rehabilitation achieves relevant water quality objectives for receiving waters	pH EC Turbidity	Not significantly different to upstream values
	Able to sustain the agreed post-mining land use	Riparian vegetation	Riparian vegetation index (IDC method)	Greater or equal to upstream or downstream values.

Figure 3.1: Blackwater Mine EA EPML00717813 Rehabilitation Requirements for Watercourses

4 OPTIONS IDENTIFICATION

Engeny identified four potential remediation options for the Sirius Creek diversion based on the current alignment, final landform consideration and the future mine plan. To inform the remediation concept design, the geomorphic features of the pre mining drainage path were incorporated and utilised as well as the upstream and downstream channel geometry and grade.

The objective was to identify suitable options for the permanent remediation of the Sirius Creek diversion and identify a preferred option to carry though to concept design. The process to define the options includes a review of the natural waterway geometry, the existing creek diversion geometry, original design reports and current diversion design parameters.

Each option was defined with a concept cross section, longitudinal profile and meandering characteristics, if applicable. Civil earthworks modelling was undertaken to confirm the following:

- Alignment of the diversion options.
- The need for potential flood levees (during operations).
- Final landform reconfiguration.
- Reinstatement of floodplain.
- Proposed tie-in locations to the existing waterway.
- Development Class 5 capital cost estimate.

Where applicable, the earthworks quantities include the filling quantity for existing dams or depressions which would be ultimately remediated in closure.

The options identification also includes the assessment of key risks and opportunities regarding potential staging, possible impacts to downstream infrastructure, reinstating the flood plain and post mining land-use risks in the context of closure. The main focus for each option was to determine the impacts and interaction between the PRCP final landform and the proposed diversion. Refer to Figure 4.1 for the potential options identified and Table 4.1 for further details.

Table 4.1: Options Identification Details

Statistic	Option 1	Option 2	Option 3	Option 4
Description	Re-instating natural alignment of the creek	Remediation of existing diversion channel	Diverting channel south through spoil and final landform	Diverting channel north around final void
Likelihood that diversion will achieve state of dynamic equilibrium	High – stream length similar to natural	Low – stream length increased >10%	Medium – stream length increased <10%	Low- stream length increased >10%
Diversion constructed through spoil	No	Yes	Yes	No
Order of magnitude cost estimate*	$10.6 M	$19.2 M	$190 M	$40 M
Ability to isolate diversion from flows during establishment period	Yes	No	Yes	Yes

*Cost estimate based on average $10/m^3 and Option 2 including quantities to fill ‘Old Cut 4 Dam’

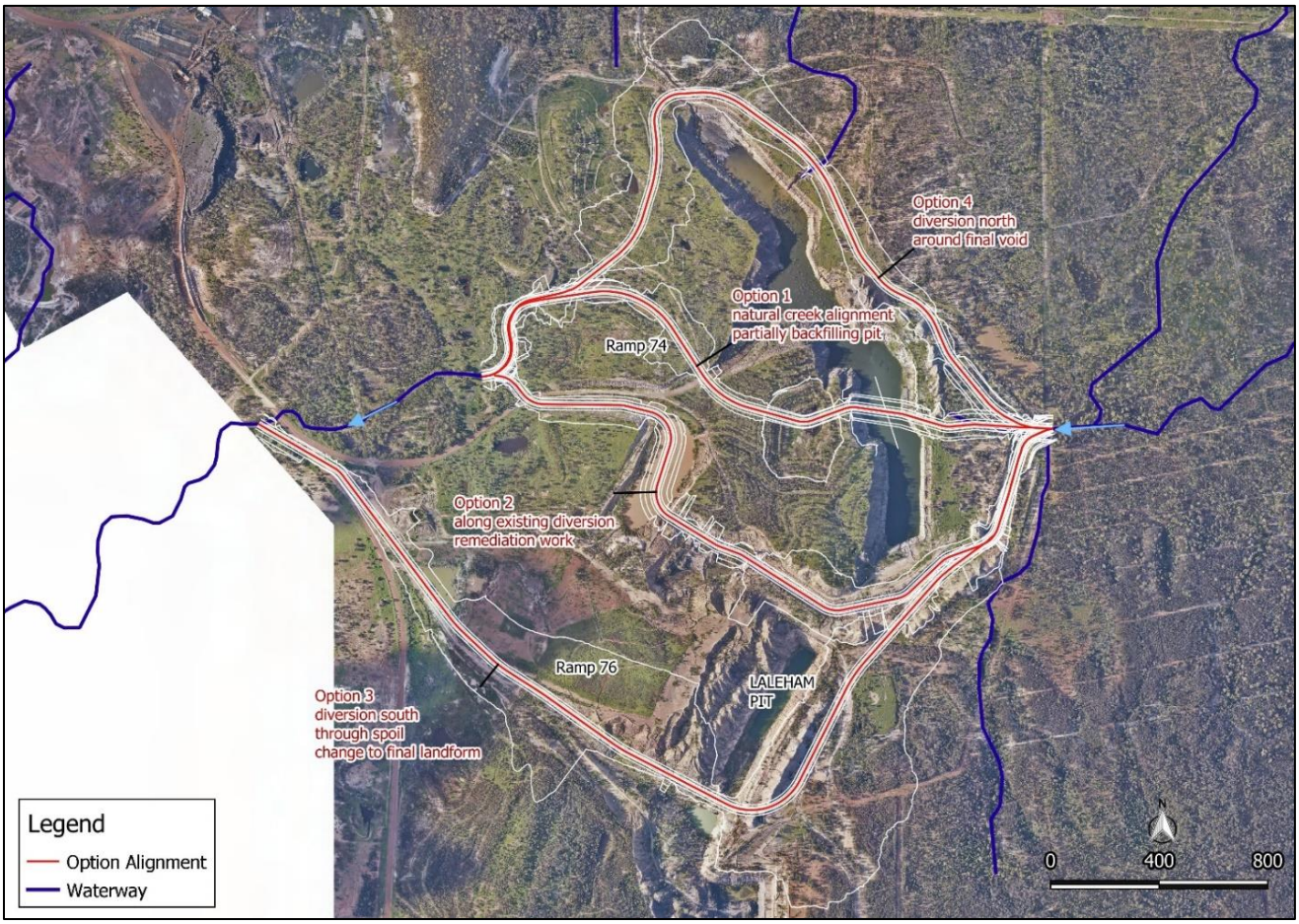

Figure 4.1: Sirius Creek Diversion Remediation Options

5 OPTIONS ANALYSIS

5.1 MULTI-CRITERIA ANALYSIS FRAMEWORK

A high-level multi-criteria analysis (MCA) was undertaken to rank the identified options for individual criteria as per Figure 5.1 below and determine a preferred option. The weighting of each criteria was determined and agreed upon with a BHP and Engeny collaborative decision group. The individual weightings are summarised in Table 5.1. Based on the score for each criteria against each option, a preferred option is identified.

-3	-2	-1	0	1	2
Fatal Flaw	Strongly Negative	Mildly Negative	Neutral	Mildly Positive	Strongly Positive

Figure 5.1: Ranking Scores for MCA

Table 5.1: Weighting for Individual Screening Criteria

Criteria	Weight
Likelihood that diversion will achieve state of dynamic equilibrium	40%
Diversion constructed through spoil	30%
Order of magnitude cost estimate	20%
Ability to isolate diversion from flows during establishment period	10%

5.2 MULTI-CRITERIA ANALYSIS

The MCA resulted in Option 2 to be carried forward into concept design as a preferred option, since it is without a fatal flaw and resulted in the lowest relative risk (see Table 5.2). Refer to Appendix A for the detailed MCA and scoring.

Table 5.2: Multi-Criteria Analysis Outcomes

Item	Option 1	Option 2	Option 3	Option 4
Overall Weighted Score	-0.6	-0.9	-1.0	-1.2
Relative Risk	Highest Risk	High Risk	Highest Risk	High Risk
Fatal Flaw	Yes	No	Yes	No

6 CONCEPT DESIGN

6.1 DESIGN PARAMETERS

Table 6.1 describes the parameters within each outcome which were applied to inform the concept design.

Table 6.1: DNRME and the Australian Coal Association Research Program (ACARP) Parameters Adopted

DNRME Parameters (DNRME, 2019)		Equivalent ACARP Parameters (ACARP, 2014)	
Outcome 1 – The design plan should include a detailed description of: a) the location, function and description of geomorphic features within the proposed watercourse diversion as well as a revegetation and vegetation management plan.	☐	*Outcome 1 –* Geomorphic and riparian vegetation features of the diverted watercourse and connecting reaches (minimum of 1 km upstream and downstream of proposed tie ins). Vegetation characteristics along the proposed optional watercourse diversions should also be noted.	☒
Outcome 2 – The design plan should include a detailed description of: a) the development and calibration, or sensitivity analysis, of the hydrologic model, including the referencing of methodologies used to generate flood frequency analysis[1] b) any design implications and construction processes that necessitate a lateral dysconnectivity of sub-surface flow between the watercourse and an adjacent final void (if proposed). [1] Hydrologic models were originally developed as part of the Saraji Mine Flood Study (Engeny, 2018).	☐ ☒	*Outcome 2 –* Summary of hydrological characteristics including surface water-groundwater interactions and water use. Flow changes along the reach should also be clearly noted.	☒
Outcome 3 – The design plan should include hydraulic modelling results (benchmarked against guideline values for stream power, shear stress and velocity adopted from ACARP, 2002) and analysis identifying depth of inundation. The design plan should include a floodplain of sufficient capacity.	☒	*Outcome 3 –* Summary of hydraulic characteristics along the waterway length. Longitudinal section of stream power with standard cross section increments. A higher frequency of cross sections is required at stream junctions and bifurcations. A table summarising stream powers (in channel and floodplain) at each cross section is also required, along with statistics for the reach. This specifically includes the reach minimum, low quartile, median, mean, upper quartile and maximum values[2]. [2] Only mean stream power values were calculated for comparison with the adopted criteria.	☒ ☐
Outcome 4 – The design plan should include a sediment transport analysis that identifies how the watercourse diversion will manage erosion or deposition events such that they are consistent with the existing sediment regime.	☒	*Outcome 4 –* Sedimentation characteristics. Where the existing reach is aggrading, degrading, or is in equilibrium. Note presence of sediment sources (e.g., main channel bed or bank instabilities, floodplain contributions) and sinks (e.g., flood outs or sediment splays along low gradient sections of the reach, and infilling pools).	☒
Outcome 5 – The design plan should include the specification of spoil placement and sequencing and the settlement process and timing of operation that will ensure the watercourse diversion, once constructed, operates in a stable manner.	☒	*Outcome 5 –* Interaction between watercourse diversion options and mine infrastructure (pipes, pits, culverts, access, etc.) and planning over the life of mine.	☒

It is important to note only benchmark values for shear stress and velocity were adopted from DNRME, 2019. Stream power benchmark values were adopted from ACARP, 2014 due to it being a more contemporary standard that considers impacts of sediment transport.

6.2 DIVERSION ALIGNMENT

Option 2 was identified to be the preferred option alignment using the MCA, retaining and remediating the diversion on its current alignment due to the voids north and south. The alignment was further refined to optimise quantities and is consistent with pre-mining stream length and grade. Figure 6.1 shows the proposed permanent diversion alignment design and general arrangement. The preferred option design is included in Appendix C.

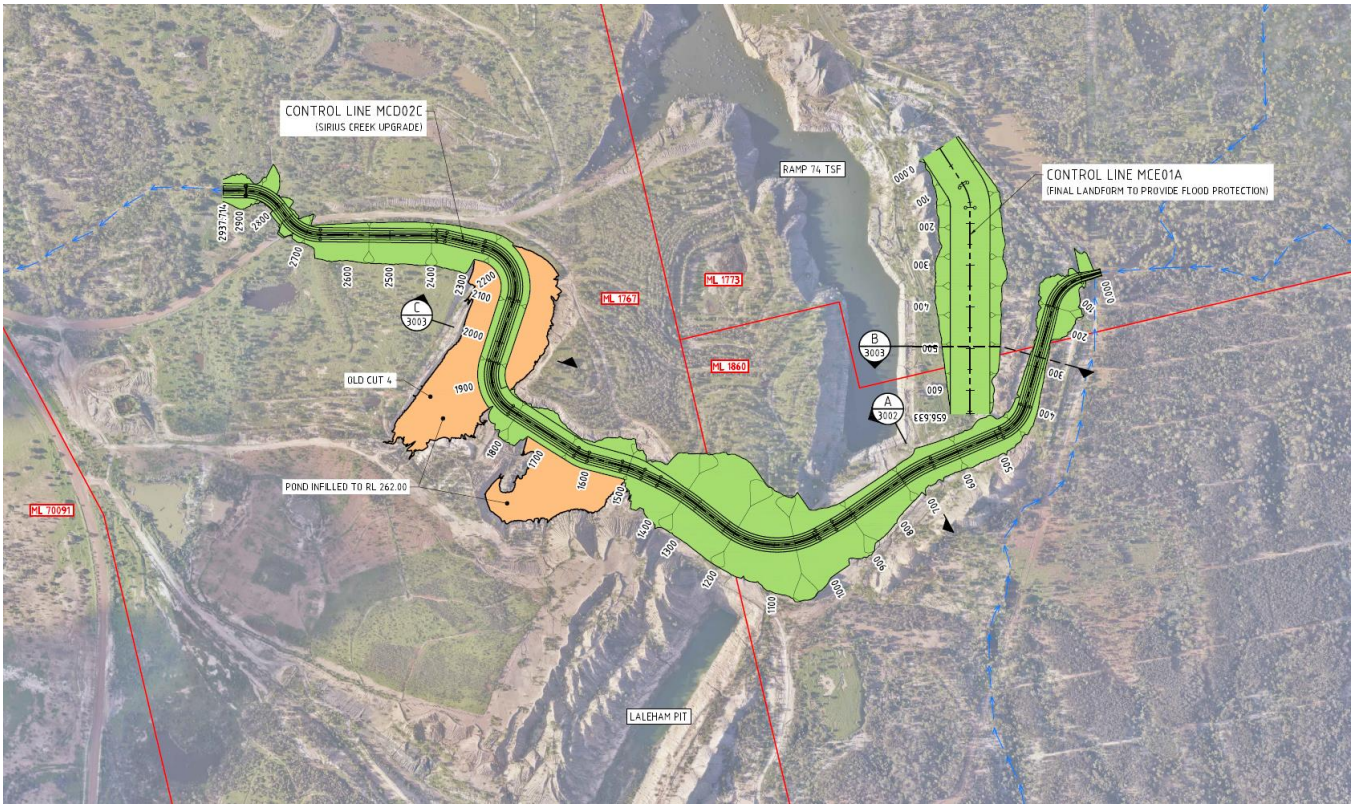

Figure 6.1: Option 2 General Arrangement

6.3 CHANNEL GEOMETRY AND GRADE

The typical upstream and downstream channel geometries are presented in Figure 6.3 and Figure 6.4 below. These dimensions were based on the average natural upstream and downstream channel geometry topographic data and aerial imagery were used to evaluate the planform and cross section parameters of multiple reference reaches of Sirius Creek. Cross-sectional dimensions were compared and evaluated for a total of 10 cross-section locations. The locations of the cross-sections taken for the analysis are provided in Figure 6.2. The accuracy of the survey used at the time of writing is defining the accuracy of the natural channel cross sections and the final cross section used for the concept design.Table 6.2 and Appendix C show the detailed geometry and typical cross section of the concept design with longitudinal profile, respectively.

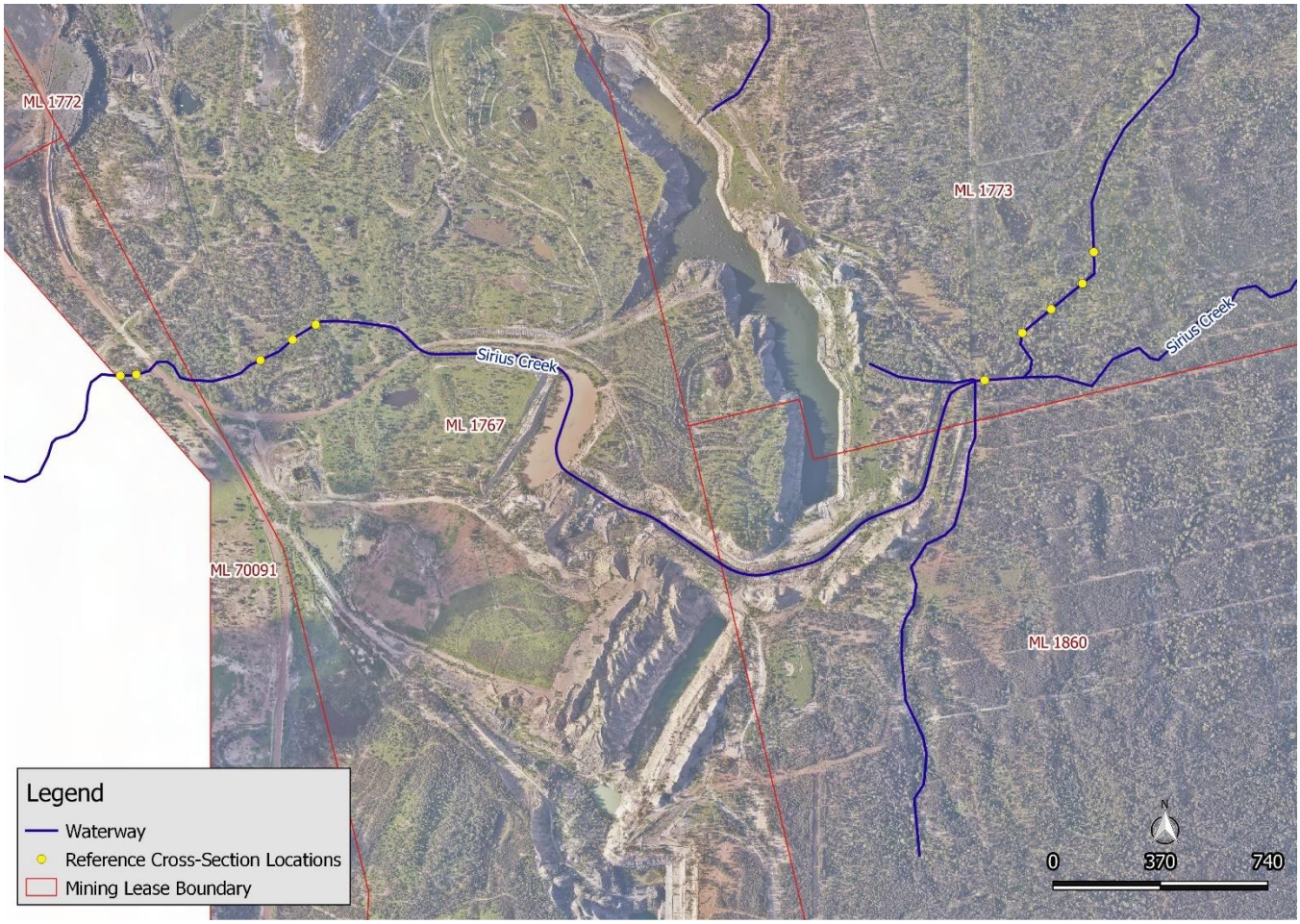

Figure 6.2: Locations of Reference Cross-Sectional Areas

Table 6.2: Concept Design Detailed Channel Cross Section Geometry

Channel Geometry	Quantity	Comments
Channel Bed Width	4 m	
Batter Slope	1V:4H	For both the low flow channel and high flow channel batters
Channel Depth	1 m	Consistent depth of low flow channel at 1m
Bench Width	5 m	

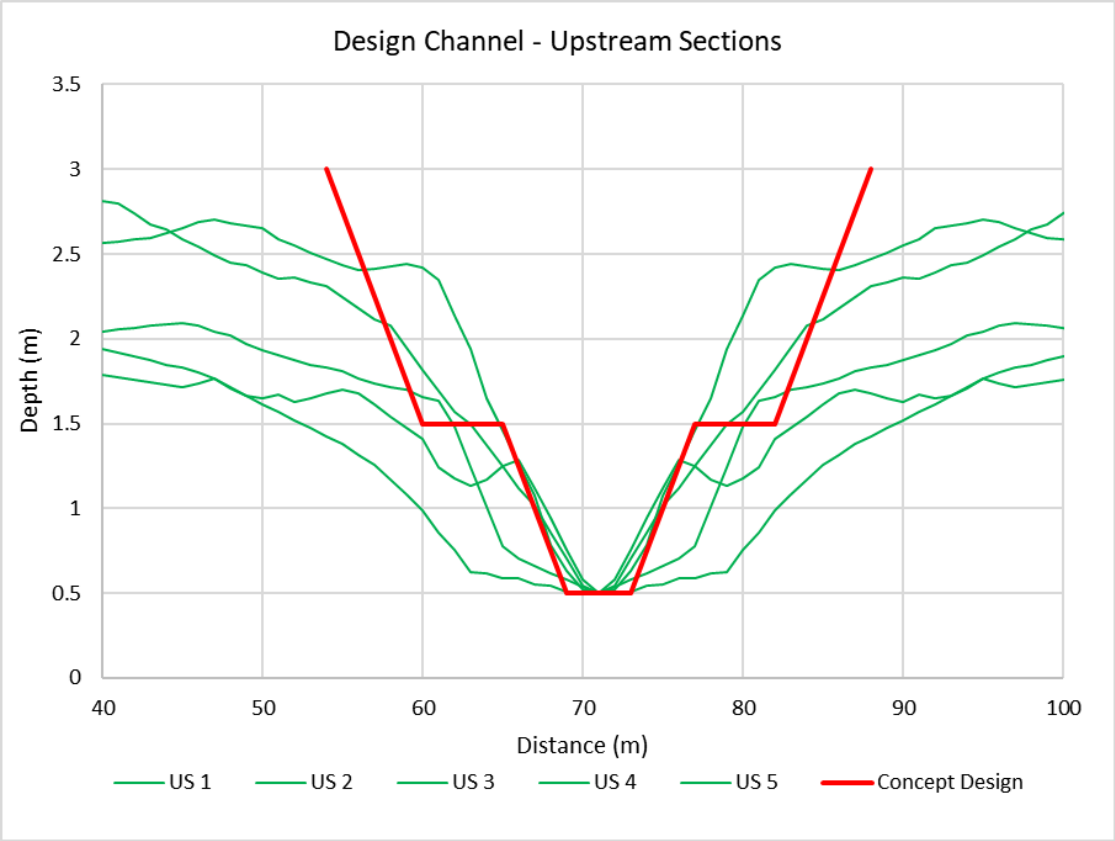

Figure 6.3: Typical Upstream Channel Cross Section

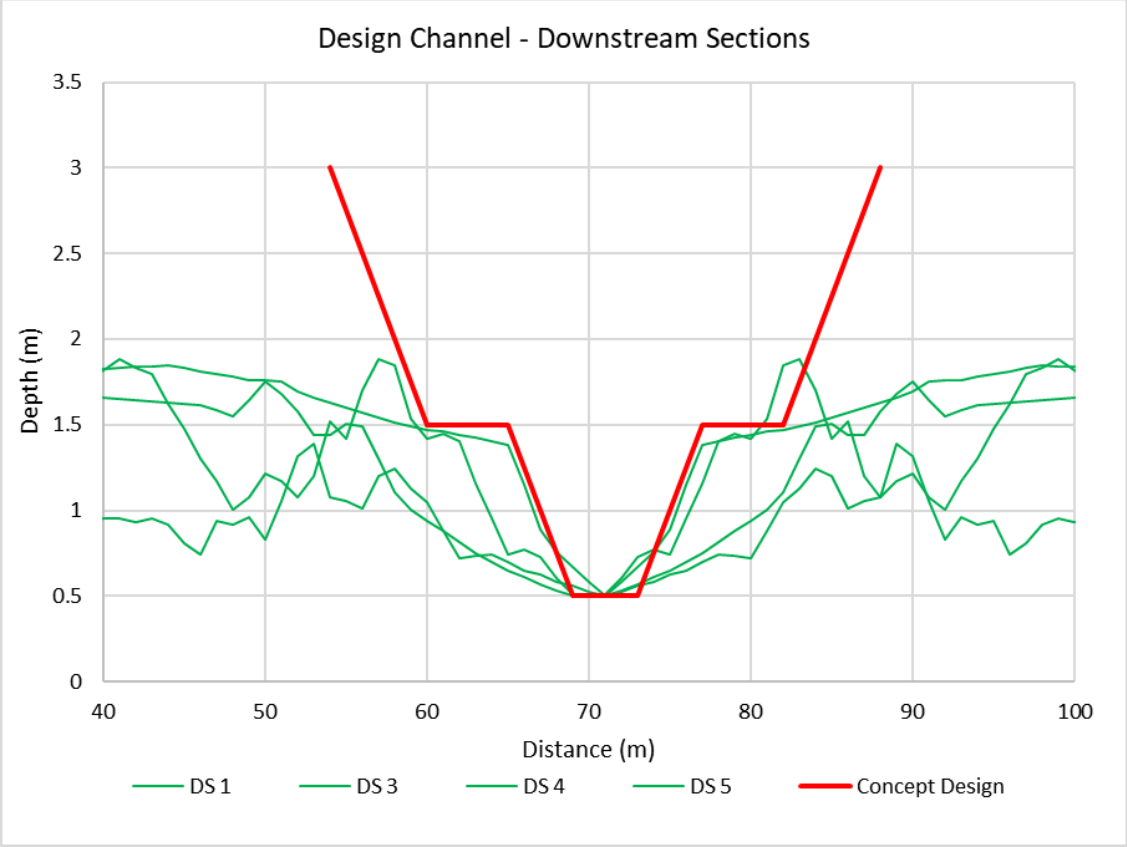

Figure 6.4: Typical Downstream Channel Cross Section

6.4 HYDROLOGY

A hydrologic model of Sirius Creek was developed as part of the Blackwater Mine Flood Model and Water Balance Update (Engeny, 2017) which estimated flows for 1% AEP and 0.1% AEP flood events. Peak flows for frequent events (39% AEP and 2% AEP) for the Sirius Creek diversion remediation were estimated using the ACARP (2002) methods and are presented in Table 6.3.

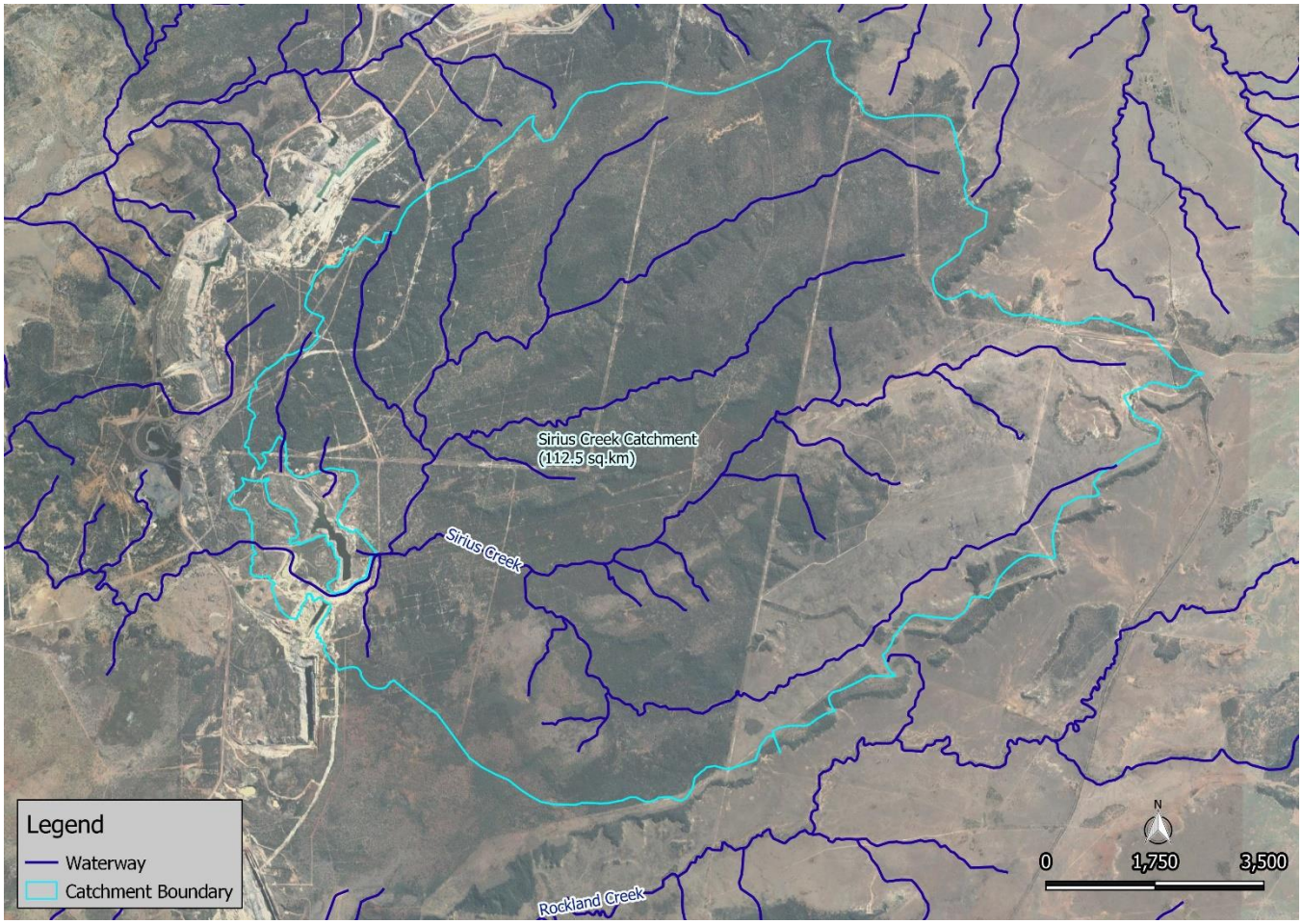

Figure 6.5: Map of Catchments

6.4.1 Frequent Events

The hydrologic model (Engeny, 2017) mentioned above was used to estimate flows through the diversion for the 39% AEP and 2% AEP flow events (refer to Table 6.3) in accordance with the ACARP (2002) method. The ACARP (2002) assessment included a regional flood frequency analysis for a selection of gauged catchments in the Bowen Basin region. From this, a method was developed to estimate flood magnitudes for ungauged catchments, based on catchment area and rainfall intensity. The calculated flood magnitudes for the 39% AEP and 2% AEP events were then used to determine diversion design limits for shear stress, stream power and velocity. This approach has been adopted to determine the flows within the proposed Sirius Creek diversion concept design and have been compared to the ACARP (2002) diversion channel design parameters.

Table 6.3: Sirius Creek Diversion Design Flows

Rainfall Event	Diversion Channel Design Flows (ACARP, 2002) m^3/s
39% AEP	59.7
2% AEP	146.8

6.5 HYDRAULICS

Stream power is the product of channel slope and discharge. It represents the excess energy available to do work in and on the channel. If there is too much excess energy, then channel erosion may occur. Stream velocity is calculated by dividing the flow by the cross-sectional area (based on flow depth in the channel). The higher the velocity, the greater the erosive force of a stream and therefore more sediment will be freed and move through the system. Shear stress is an indication of the size of granular material that will begin to move at a particular flow within the diversion reach.

Average values were derived from the TUFLOW model for the stream powers, stream velocity and shear stress in a 39% AEP and 2% AEP rainfall event (refer to Table 6.4). The proposed diversion values have been compared to the DNRME (2019) diversion channel design parameters for a transport limited system.

Table 6.4: Diversion design criteria compared to DNRME (2019) Guideline parameters

	39% AEP		2% AEP	
Design Criteria	Diversion	DNRME Design Parameter (2019)	Diversion	DNRME Design Parameter (2019)
Stream Power (W/m^2)	38	<60	67	<150
Stream Velocity (m/s)	1.0	<1.5	1.3	<2.5
Shear Stress (N/m^2)	33	<40	47	<80[1]

[1]DNRME values are taken from ACARP 2014 as the <50N/m^2 value in DNRME 2019 is incorrect.

All diversion concept design parameters for stream power, stream velocity and shear stress for both 29% AEP and 2% AEP storm events, are within acceptable limits and below DNRME (2019) guideline values.

Appendix B illustrates the variability along the diversion channel for each design parameter.

The PRCP final landform will need to be executed to provide flood protection for Ramp 74, ensuring the 0.1% AEP flood event does not contribute to additional external catchment inflows into the void. The final landform will need to be consolidated and designed according to specifications that will ensure flood protection of the void.

6.6 ADDITIONAL DESIGN AND CONSTRUCTION CONSIDERATIONS

6.6.1 Backfilling of Voids and Existing Dams

The concept design of the Sirius Creek diversion also includes backfilling of existing dams and voids located along the diversion alignment. The “Old Cut 4” dam will need to get backfilled completely, tying smoothly into the existing surrounding landforms. For concept design purposes, a maximum backfill level of 262 m AHD was chosen for the dam and the ponding area east of “Old Cut 4”. Backfill volumes and depths are summarized in Table 6.5 below and locations illustrated in Figure 6.6.

Table 6.5: Concept Design Fill Quantities for Voids and Dams

Void / Dam	Backfill Volume	Backfill Depth	Bottom of Dam/Void	Top of Fill (Concept Only)	Additional Detail
Old Cut 4	880000 m^3	20.6m	241.4m AHD	262m AHD	Backfill depth based on latest bathymetry levels with bottom of concept diversion channel at 255.3m AHD. The fill quantity is only including fill up to the diversion channel design.
Ponding Area	178000 m^3	6.6m	255.4m AHD	262m AHD	Bottom of concept diversion channel at 255.9. The fill quantity is only including fill up to the diversion channel design.

*Note: Old Cut 4 fill quantity includes filling of the dam to RL 255m AHD (as per bathymetry storage curve from July 2019) and filling up to RL 262 m AHD above storage curve to shape the diversion channel.

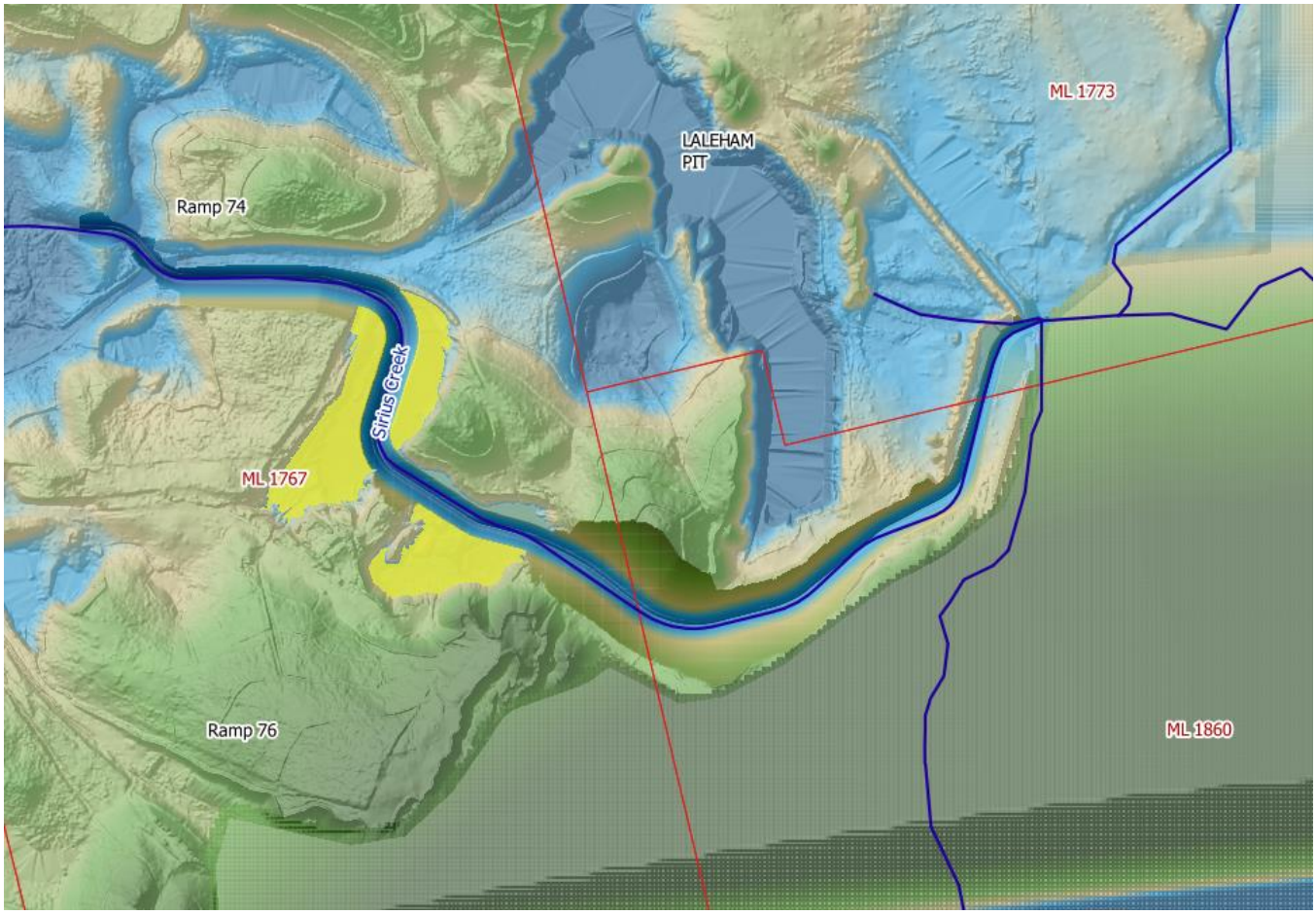

Figure 6.6: Backfilling Locations of Existing Dams and Voids (Yellow Areas)

6.6.2 Soils

The channel bed and banks are expected to comprise largely of the surrounding soils, consisting of potentially dispersive sandy to loamy duplex soils. Soils will be protected by emerging vegetation prior to major flows occurring. The final design of the diversion should include appropriate soils and vegetation management strategies. An assessment of soil and growth media characteristics will be completed by an appropriately qualified person, and amelioration and other treatments required identified and applied.

Excess supply of sediment from spoil dump in close proximity to the diversion can have potential impact on vegetation establishment within the new channel. It is suggested that measures are put in place to reduce the sediment influx from surrounding landforms during the establishment of the diversion channel. Further investigations and detail to soil suitability and erodibility will need to be gathered in a functional design stage. The concept design assumes that the topsoil application and treatment are assessed and allow for vegetation to successfully establish.

6.6.3 Revegetation

The revegetation for the Sirius Creek diversion is to incorporate species from the pre-clearing environment (as per Relevant Environment RE mapping) as they would naturally occur along Sirius Creek in the vicinity of Blackwater Mine. The revegetation should achieve the following:

- Geomorphic and vegetation features similar to those in the local landscape.
- Maintain a sediment transport regime that does not directly impact on upstream and downstream reaches.
- No ongoing maintenance is required.

Further, hydraulic modelling has demonstrated that the 39% AEP shear stress is within the ACARP (2014) guideline values for the vegetation establishment within a transport limited system. To ensure vegetation has sufficient time for establishment it is suggested to keep the diversion offline for 1 to 2 wet seasons. Revegetation will reflect the dominant ecosystem of *Eucalyptus populnea* (poplar box) and *Eucalyptus melanophloia* (silver-leaved ironbark) woodland on alluvial plains.

6.6.4 Monitoring and Maintenance

Ongoing monitoring and maintenance of the diversion during the operational phase of the mine is required and carried out as per BHPs monitoring program. The monitoring and maintenance of the diversion during the establishment phase has its main focus on the presence of introduced species, weeds and vegetation establishment.

6.6.5 Closure Landform and Considerations

Ramp 74 to the north of the diversion is an inactive Tailings Storage Facility (TSF) and at the time of completing this concept design the closure landform for the TSF is yet to be determined. If the proposed landform is to remain as a void flood protection from the 0.1% AEP design flood event will need to be provided. It is proposed this be achieved through the construction of a landform with crest level set with a 1.0m freeboard allowance to 0.1% AEP design flood event. For the purposes of the diversion concept design the landform has been designed with batter slopes of 1V:6H to manage long term stability (as shown in Appendix C, see Figure C.1). To manage a long-term piping risk a simplified approach has been adopted assuming a horizontal hydraulic gradient of 0.04 with the width of the landform provided to prevent piping at this gradient (USBR, 2014).

The overall intent will be to provide a landform in perpetuity that will not require ongoing maintenance to maintain function. The ultimate closure solution will be incorporated into the final landform provided in the PRC Plan.

6.7 RISKS AND MITIGATION MEASURES

The table below summarises the main risks for the diversion remediation design and construction. The risks were assessed in accordance with BHPs Risk Framework.

Table 6.6: Diversion Risks and Mitigation Measures

Risks	Likelihood	Consequences	Risk Rating and Score	Mitigation Measures	Residual Likelihood	Residual Consequences	Residual Risk Rating and Score
Damage to new diversion channel due to extreme flood event	Probable	2	9	Diversion channel constructed during dry season	Unlikely	1	1
Constructability of diversion channel – encountering bedrock, material availability and access	Probable	2	9	Geotechnical investigation as part of functional design, topsoil availability on site and construction during dry season (low chance of flood)	Unlikely	1	1
Significant erosion of channel due to extreme flood event	Probable	2	9	Construction of channel during dry season including a watering program for sufficient vegetation establishment prior to wet season	Unlikely	1	1
Vegetation establishment interrupted by extreme flow event (wash away of seeds and damage of plants)	Probable	2	9	Choosing a seed mix similar to the surrounding environment and apply topsoil treatment allowing for effective plant growth, construction during dry season with watering program	Unlikely	1	1

7 CONCLUSION

To develop a PRCP Chapter for the Sirius Creek diversion, a concept design for remediation of the Sirius Creek diversion will be developed. This report illustrates the concept design details and has been prepared in accordance with the requirements of the Department of Natural Resources, Mines and Energy (DNRME) Guideline: *Works that interfere with water in a watercourse for a resource activity – watercourse diversions authorised under the Water Act 2000* (DNRME,2019).

The concept design was developed based on three guidelines, two of which are currently recognised guidelines for design of watercourse diversions within Queensland. These guidelines have been developed by DNRME and the Australian Coal Association Research Program (ACARP):

- Guideline: Works that interfere with water in a watercourse for a resource activity – watercourse diversions authorised under the Water Act 2000 (DNRME, 2019).
- Criteria for functioning river landscape units in mining and post mining landscapes (ACARP, 2014).
- EA condition for specified rehabilitation requirements.

Four options for the remediation of Sirius Creek were identified and the second option was selected to be carried forward into concept design, utilising the Multi-Criteria Analysis outlined in Section 5. The final concept option design, typical cross sections and longitudinal section are presented in Section 6 and Appendix C. The main risks to the successful performance of the diversion are vegetation establishment and erosion which can be mitigated by construction timing, during dry season, the seed mix used and topsoil treatments to improve quality of the soil where necessary.

The concept design demonstrates that the watercourse diversion will satisfy the closure objectives identified in the guidelines, for PRCP purposes.

8 QUALIFICATIONS

a) In preparing this document, including all relevant calculation and modelling, Engeny Water Management (Engeny) has exercised the degree of skill, care and diligence normally exercised by members of the engineering profession and has acted in accordance with accepted practices of engineering principles.

b) Engeny has used reasonable endeavours to inform itself of the parameters and requirements of the project and has taken reasonable steps to ensure that the works and document is as accurate and comprehensive as possible given the information upon which it has been based including information that may have been provided or obtained by any third party or external sources which has not been independently verified.

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9 REFERENCES

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Appendix A:
Mulit-Criteria Analysis Details

Figure A.1: Multi-Criteria Analysis Details

Multi-Criteria Analysis - Sirius Creek Diversion

Project: PRCP Diversions FY21 (BWM)
Workshop Date: 11/2/2020

-3	-2	-1	0	1	2
Fatal Flaw	Strongly Negative	Mildly Negative	Neutral	Mildly Positive	Strongly Positive

Criteria	Assumptions/Considerations	Weight	Option 1	Option 2	Option 3	Option 4	Comments
Likelihood that diversion will achieve state of dynamic equilibrium	Considers the difference between diversion length and natural stream length. Ideally diversion length = natural stream length.	40%	1	-1	0	-1	Option 1 is the same length as natural stream. Other options are all longer by varying degrees.
Diversion constructed through spoil	For options that interact with the LoA mine plan, it is assumed that mining will occur (even if currently unapproved) then the diversion will be constructed through rehabilitated spoil. It is assumed that the PRCP final landform can be revised to achieve the required offset distances from rehabilitated spoil dumps (although the PRCP final landform would not show spoil dumps associated with currently unapproved mining).	25%	-1	-1	-1	-1	Options 1, 2 and 4 would be constructed through existing rehabilitated spoil. Option 3 would be constructed through a combination of existing and future rehabilitated spoil (associated with currently approved mining). For Options 2 and 3, the PRCP final landform would need to be revised to acheive the required offset distances from the future rehabilitated spoil dumps to the south.
Order of magnitude cost estimate	Assumes $10/m3 of cut. Includes cost to backfill voids as not proposing to backfill voids as part of the PRCP (so as not to lose grandfathering provisions under the EA).	25%	-3	0	-3	-2	Option 1 includes cost to backfill Ramp 74 TSF - fatal flaw. Option 3 excessive amount of earthworks due to topography - fatal flaw. Option 2 includes cost to backfill Old Cut 4 based on recent storage curve.
Ability to isolate diversion from flows during establishment period	Diversion can be isolated from flows if it is constructed offline of the existing diversion.	10%	0	-2	0	0	Not possible to isolate Option 2 as constructed on same alignment as the existing diversion. Risk of high flow events washing away topsoil during diversion establishment period.
	Overall Weighted Score		-0.6	-0.9	-1.0	-1.2	
	Is there a Fatal Flaw?		Fatal Flaw	No	Fatal Flaw	No	
	Relative Risk		Highest Risk	High Risk	Highest Risk	High Risk	

Appendix B:
Hydraulic Parameter Modelling Results

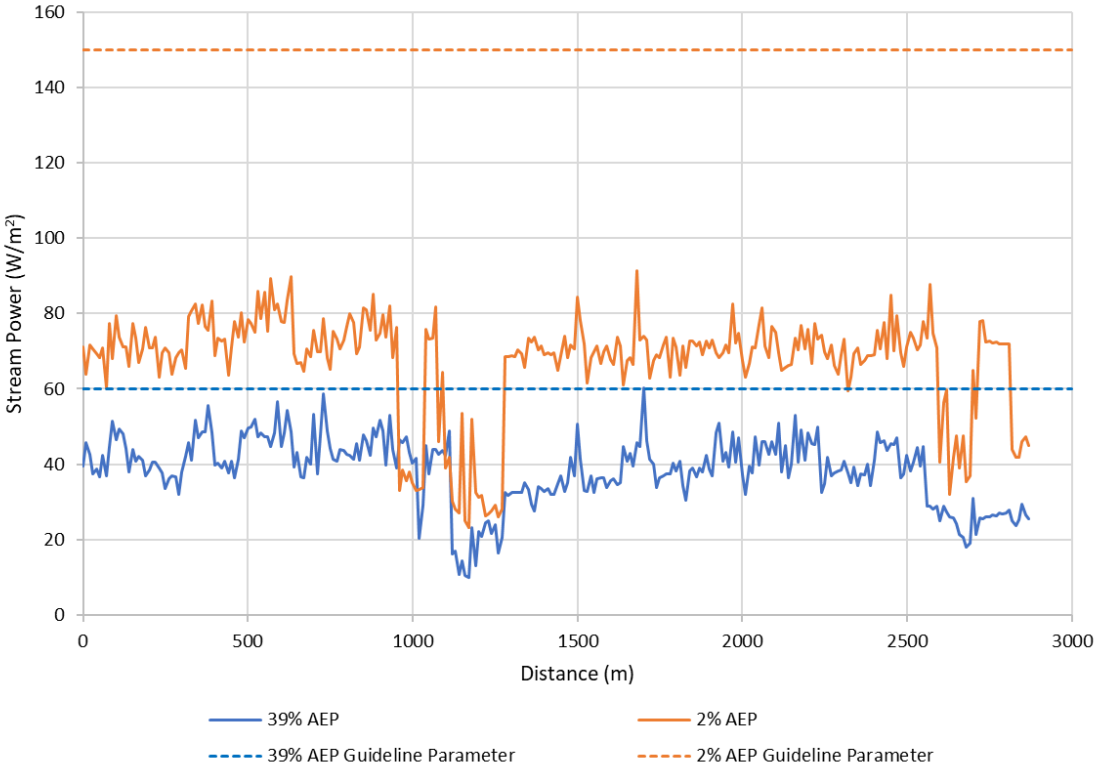


Figure B.1: Stream Power TUFLOW Model Results

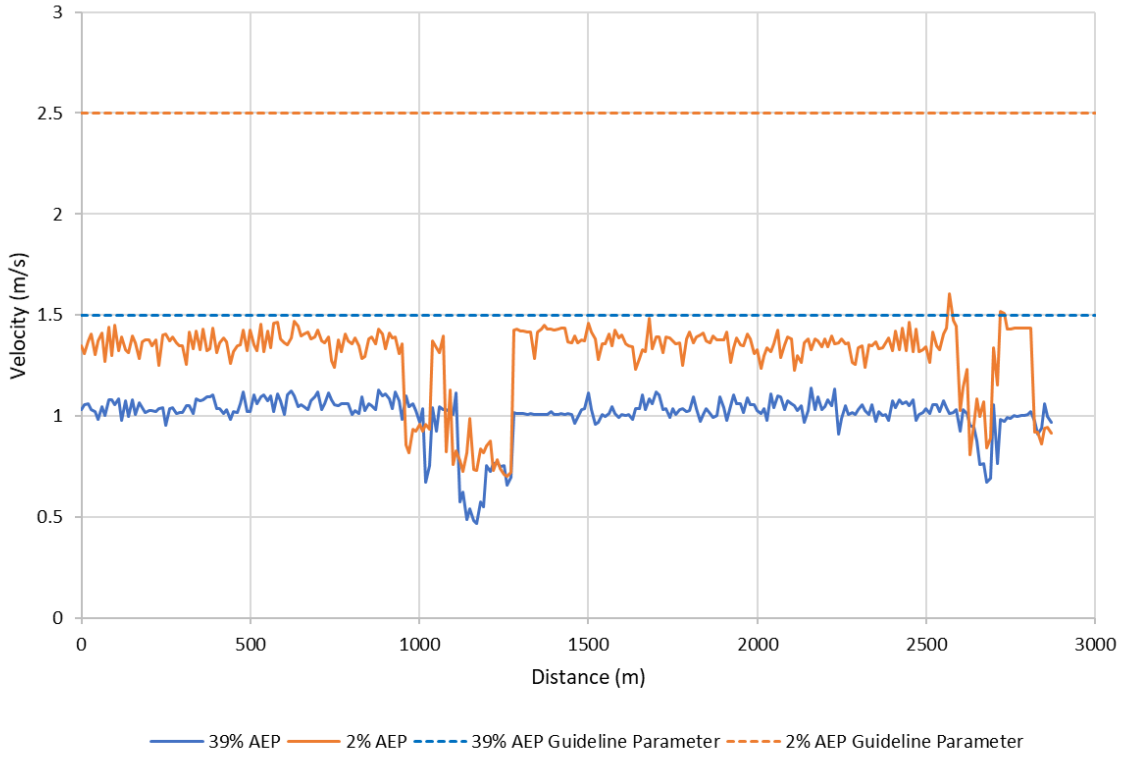


Figure B.2: Velocity TUFLOW Model Results

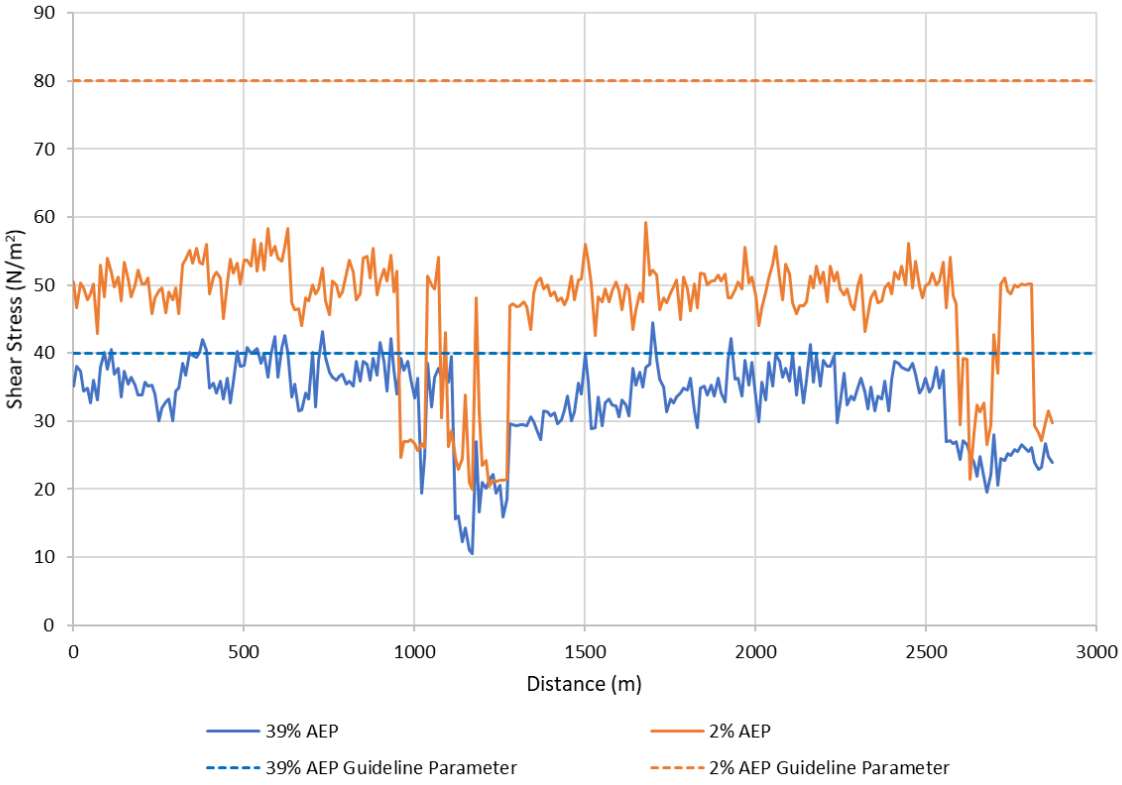
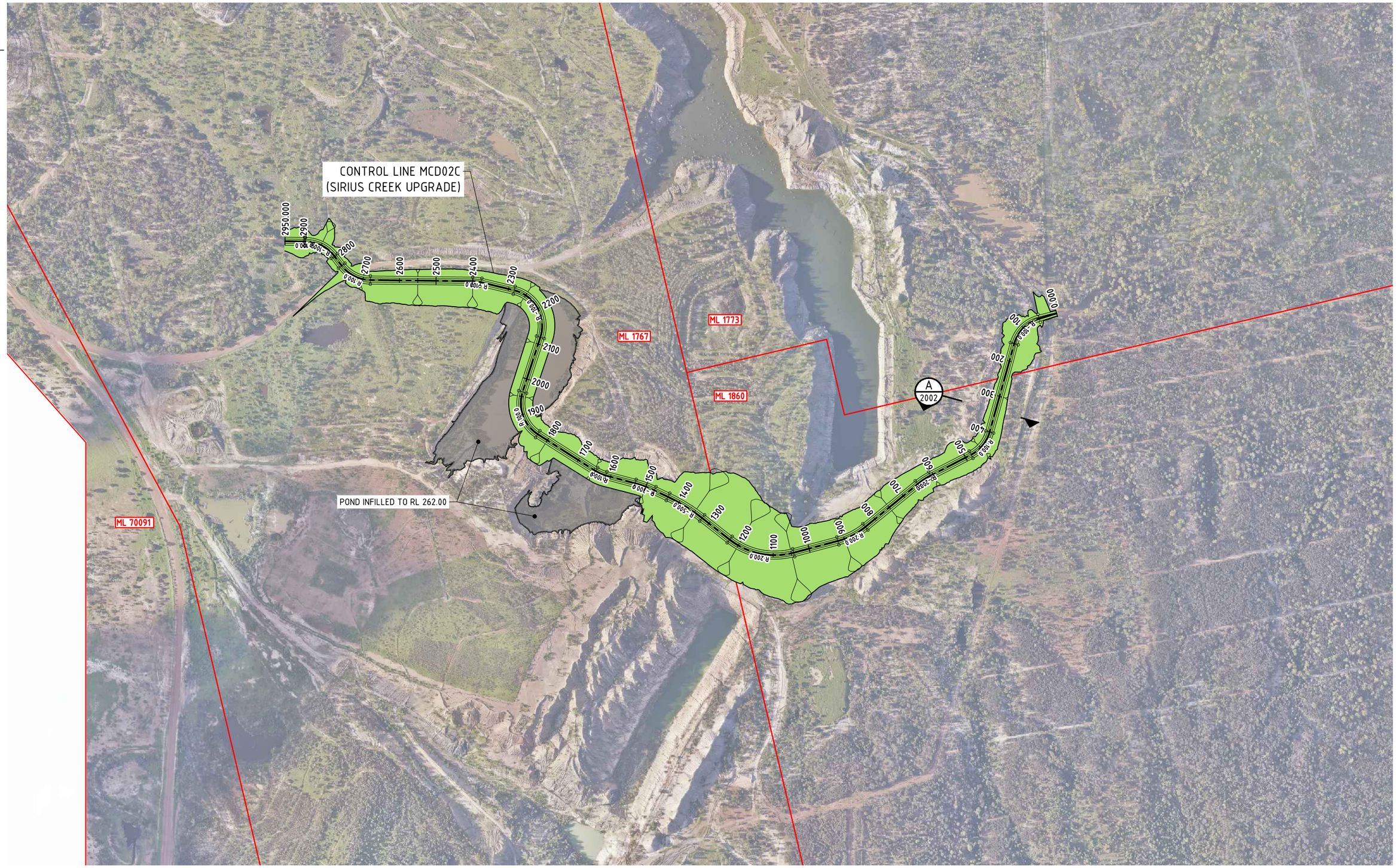


Figure B.3: Shear Stress TUFLOW Model Results

Appendix C:
Preferred Option Design Sketches



GENERAL ARRANGEMENT PLAN
SCALE 1:5000

LEGEND

MINE LEASE BOUNDARY

0 50 100 150 200 250m
SCALE 1:5000 (A1)
SCALE BEFORE REDUCTION

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NOT FOR CONSTRUCTION

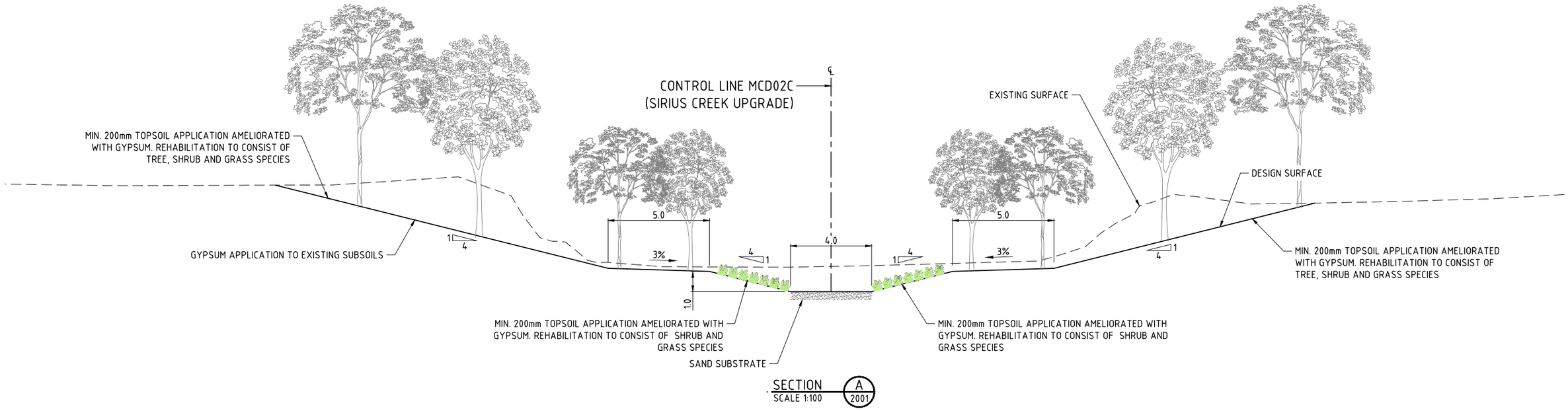
DATE	16.12.20
DRAWN BY	SB
JOB No.	M11000-437

BHP - BLACKWATER MINE

SIRIUS CREEK
GENERAL ARRANGEMENT PLAN

Original Size	Drg No.	Rev.
A1	M11000-437-SKE-2001	A

LAST MODIFIED:01/12/2020 10:28 AM CAD REF:M:\PROJECTS\M11000_BHP BILLITON\M11000_437 PRCP DIVERSIONS FY21\BHM\105 DESIGN\AUTOCAD\SKETCHES\M11000-437-SKE-2001.DWG



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2001

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SCALE BEFORE REDUCTION

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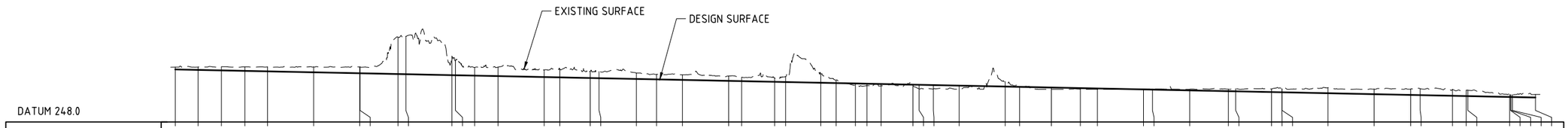
BHP - BLACKWATER MINE

SIRIUS CREEK
TYPICAL SECTION

Original Size A1
Drg No. M11000-437-SKE-2002
Rev. A


EXISTING SURFACE
DESIGN SURFACE
DATUM 248.0
-0.21%

| | | |

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Whitehaven

Appendix 4.10 – Taurus Creek Diversion Concept Design

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PRCP Concept Design Report

Taurus Creek

28 March 2024

M11000_437-REP-003-2

Job no. and Project Name: M11000_437 PRCP Diversions FY21 (BWM)
Doc Path File: \\online.com\files\BNEManagement\Projects\QC1000 BHP (BMA)\QC1000_026 BHP Coal PRCP PD\07 Deliv\2. Report\BWM - Updates CH\Concept Design\Taurus Ck\M11000_437-REP-003-2 Taurus Creek Diversion Concept Design.docx

Rev	Date	Description	Author	Reviewer	Project Mgr.	Approver
0	18/02/2021	DRAFT for Review	Julia Scholz	Ryan Kinnealy, Ben Kiernan	Ryan Kinnealy	Ben Kiernan
1	19/05/2021	Issue as Final	Julia Scholz	Ryan Kinnealy, Ben Kiernan	Ryan Kinnealy	Ben Kiernan
2	28/03/2024	Client Issue	Christian Hansen	Whitney Claxton	Ryan Kinnealy	Ben Kiernan
Signatures						

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1 INTRODUCTION

1.1 CONTEXT

The Mineral and Energy Resources (Financial Provisioning) Act 2018 (MERFP Act) amended the Environmental Protection Act (EP Act) to introduce new requirements for the progressive rehabilitation and closure of mined land. These changes include the development of a Progressive Rehabilitation and Closure Plan (PRCP) for all existing and future site-specific Environmental Authority (EA) holders for mining activities relating to a mining lease.

The main purpose of the PRCP is to:

- Require the holder of an EA to plan for how and where activities will be carried out on land in a way that maximises the progressive rehabilitation of the land to a stable condition.
- Provide for the condition to which the holder must rehabilitate the land before the EA may be surrendered.

This report illustrates the concept design details for Taurus Creek and has been prepared in accordance with the requirements of the Department of Natural Resources, Mines and Energy (DNRME) Guideline: *Works that interfere with water in a watercourse for a resource activity – watercourse diversions authorised under the Water Act 2000* (DNRME,2019). The objective of this report is to demonstrate the watercourse diversion concept design will satisfy the outcomes identified in the guideline for PRCP purposes.

1.2 PURPOSE AND SCOPE

The scope of work for each diversion is comprised of two stages:

- Stage 1: Options Assessment.
- Stage 2: Concept Design on the preferred option outcome from Stage 1.

The purpose of this document is to outline the concept design developed for the preferred diversion remediation option (outcome from Stage 1) to achieve a state of dynamic equilibrium to achieve a relinquishable state for the diversion. The following methodology was conducted:

- A desktop geomorphic assessment of the creek using historical aerial imagery and survey to inform the concept design of the options.
- Review of the existing flood studies and determine peak flow rates in the diversion for key design flow events for the purposes of hydraulic analysis.
- Conduct a hydraulic assessment of the diversion option against the criteria in the DNRME 2019 Guideline: Works that interfere with water in a watercourse for a resource activity – watercourse diversions authorised under the Water Act 2000 (DNRME, 2019) (see Section 3.1).
- Develop concept design sketches and watercourse diversion spatial polygon for the diversion for presentation in the PRCP chapter and schedule.

1.3 LIMITATIONS

The concept design is developed exclusively for PRCP purposes and thereby is falling within the limitation of the PRCP as well. This means any concept design options considered for the diversion remediation only include permanent diversion remediation solutions. The design is considered to be concept only and not at a functional level which would be required to support an approval for the works.

2 OVERVIEW

2.1 LOCATION

Taurus Creek is an ephemeral tributary of Blackwater Creek, which ultimately flows into the Mackenzie River, a major tributary in the Fitzroy River catchment. Taurus Creek flows north-east across the Blackwater Mine lease through a diversion within an access corridor between the Ramp 40 pit and the Ramp 42 pit and joins Two Mile Creek before continuing northwards to the confluence with Blackwater Creek. The diversion is thought to have been constructed in the late 1980s to early 1990s (Alluvium, 2010), at a length of approximately 2.7 km and diverted again in 2001 at a length of 2.2 km (Hatch, 2001) including a licensed diversion reach of approximately 470 m. The diversion was constructed to allow mining in Deep Creek Pit and Stewarton Pit. The catchment area for Taurus Creek upstream of the diversion channel is approximately 23.4 km^2 excluding the Emu Creek Diversion Catchment. Due to the Emu Creek diversion being constructed in early 2020 through to early 2021, the Emu Creek catchment contributes to the Taurus Creek catchment, increasing it to 42 km^2. Refer Figure 2.1 for the location of the Taurus Creek Diversion.

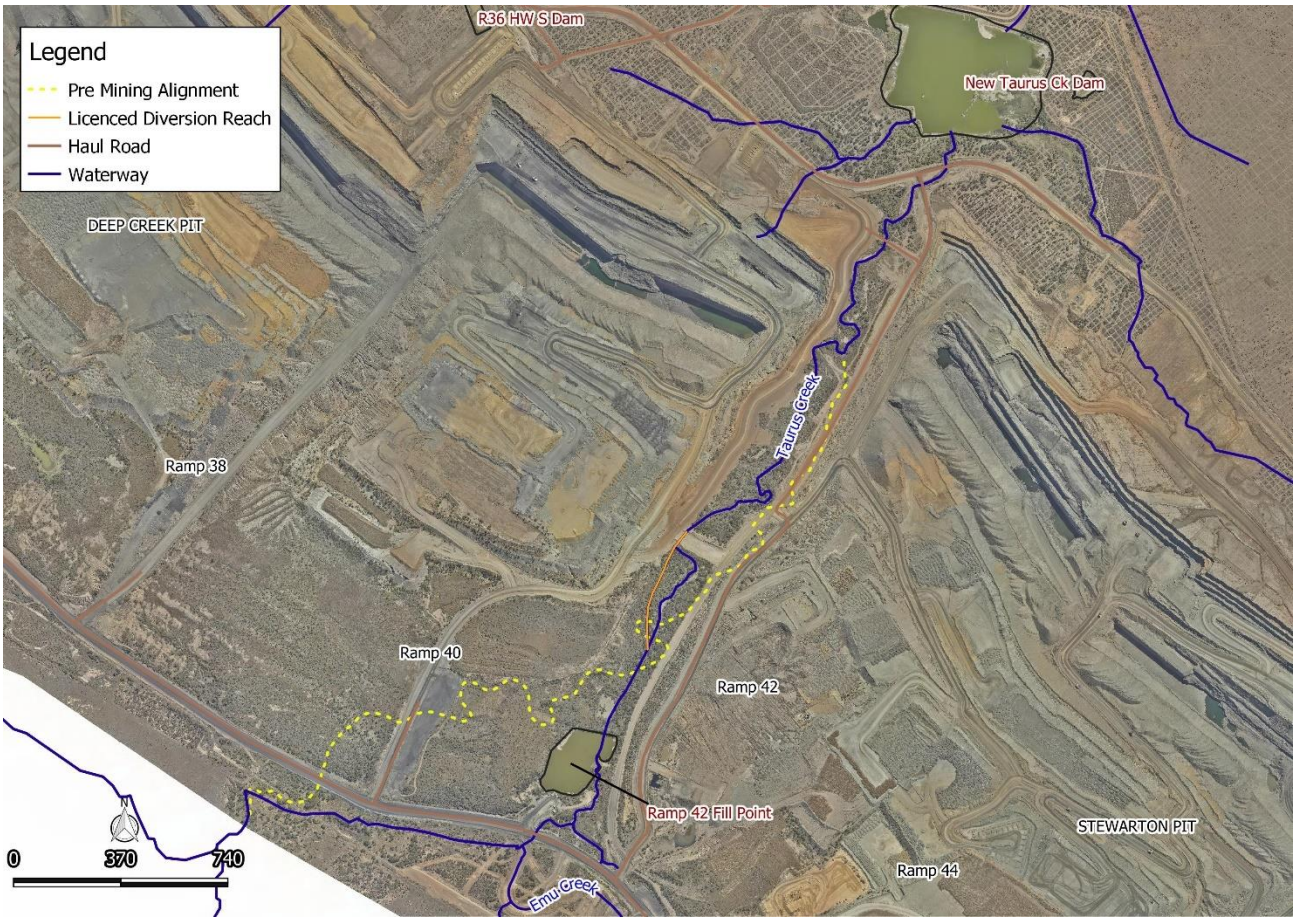

Figure 2.1: Location of the Taurus Creek Diversion at Blackwater Mine

2.2 NATURAL REACHES

The upstream, downstream and diversion reaches of Taurus Creek have been described as follows (Alluvium, 2010):

- **Upstream reach –** The majority of the upstream reach is located through grazing and some open woodland outside of the mine lease. It is generally of moderate sinuosity with low capacity of <1m depth and 5m top width. Sediment supply to the upstream reach is high due to clearing and grazing activities in the upstream catchment. The upstream channel consists of a single continuous alluvial channel within a broad floodplain (>100m). Riparian vegetation of the upstream channel consists of a continuous overstorey and poor groundcover due to grazing pressure.
- **Emu Creek Diversion Reach –** The Emu Creek diversion reach flows through catchments modified and impacted by vegetation clearing, grazing and mining activities. As described in the functional design report (Engeny, 2019) the Emu Creek diversion channel consists of a moderate sinuosity low flow channel with 2m base width and 2m depth, 1V:3H batter slopes and 0.44% channel bed slope designed to achieve a stable, non-polluting diversion channel in accordance with DNRM and ACARP guideline values.
- **Downstream reach –** The downstream channel of the Taurus Creek diversion comprises of a moderate sinuosity, low-capacity single alluvial channel (8-14m top width, 3m depth), set within a broad floodplain (>100m width). The downstream reach channel bed consists of exposed bedrock in several locations.
- **Diversion reach (pre-mining)** - The Taurus Creek diversion reach (pre-mining) was approximately 2.7 km long, meandering through what is now Ramp 38 and Ramp 40.

The upstream, downstream and diversion reaches of the Taurus Creek diversion at Blackwater Mine are shown in Figure 2.2.

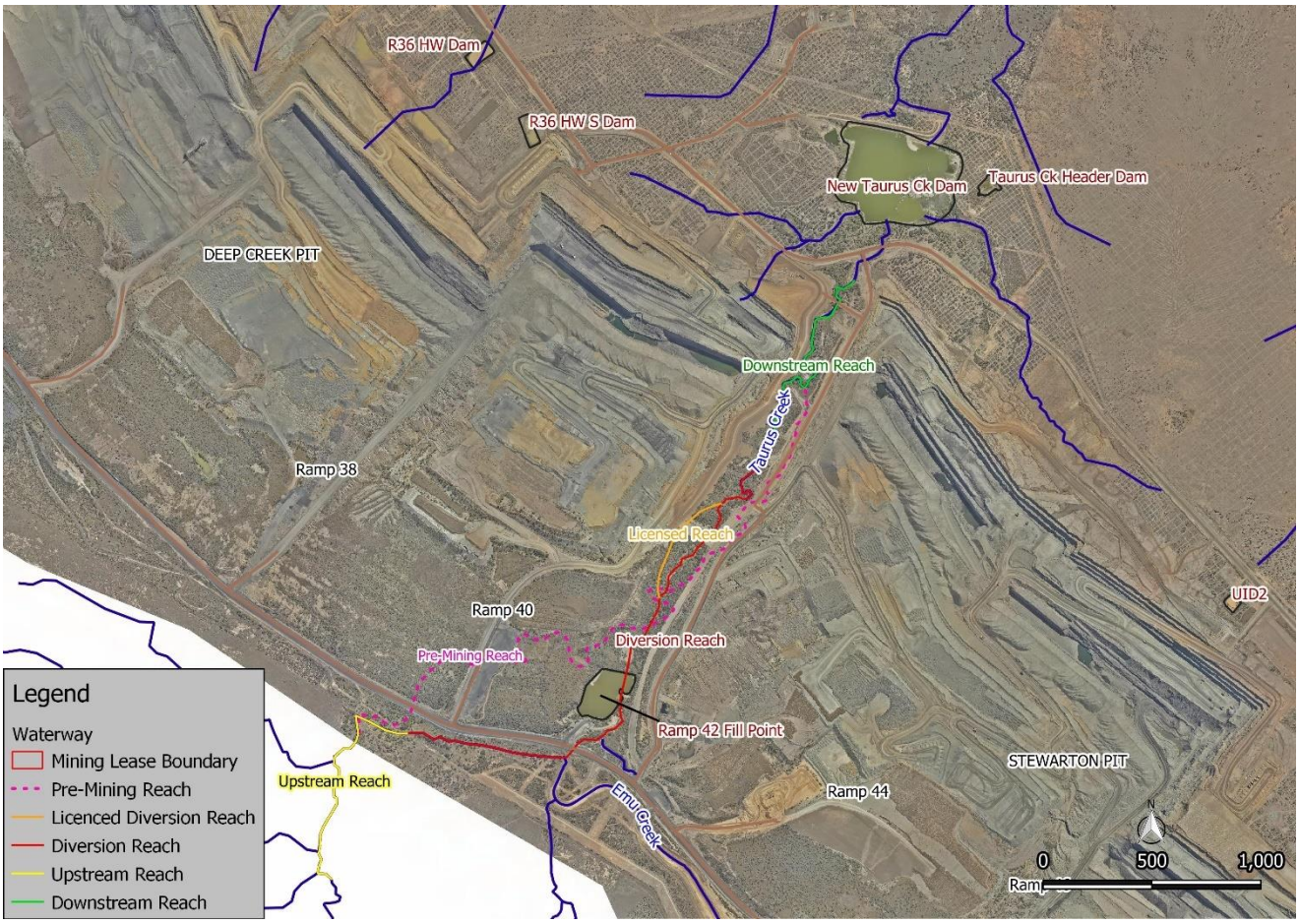

Figure 2.2: Upstream, Downstream and Diversion Reaches of the Taurus Creek Diversion

2.3 DIVERSION REACH

Monitoring of Taurus Creek diversion has been undertaken since 2010 and was last completed in 2018. As part of the major monitoring, the latest condition of the Taurus Creek diversion has been described as follows (Engeny, 2018):

- Clearing work, realignment of the creek, Ramp 42 Fillpoint Dam as well as spoil runoff are the main contributors to excess sediment supply and erosion within the creek. Culvert crossings under haul roads and dragline crossings as well as dams online of the diversion prohibit continuous sediment transport through the system and contribute to sediment build up within the diversion reach.

The above monitoring assessment outcomes have been addressed as part of the Ramp 47 Execution Support project (Engeny, 2020) which resulted in three distinct issues remaining with the diversion:

- Vertical grade of the diversion is much steeper than the pre-mining channel grade, resulting in erosion issues.
- A drop structure north of the haul road crossing which requires ongoing maintenance.
- Ramp 48 Fill Point dam located within Taurus Creek impeding sediment transport.

Based on the current condition of the Taurus Creek diversion, it is highly unlikely that the diversion will achieve the water license relinquishment criteria prior to mine closure without intervention.

3 BASIS FOR CONCEPT DESIGN

There are currently two recognised guidelines for design of watercourse diversions within Queensland. These guidelines have been developed by DNRME and the Australian Coal Association Research Program (ACARP):

- Guideline: Works that interfere with water in a watercourse for a resource activity – watercourse diversions authorised under the Water Act 2000 (DNRME, 2019)
- Criteria for functioning river landscape units in mining and post mining landscapes (ACARP, 2014)

Both the DNRME and ACARP Guidelines were developed based on previous research completed by ACARP in the early 2000s which included assessment of existing diversion performance and the development of design and rehabilitation criteria for watercourse diversions. Details of the guidelines that have been used to design the Taurus Creek diversion are summarised below.

3.1 DNRME GUIDELINES

3.1.1 Diversion Design Outcome Requirements (Permanent Watercourse Diversions)

The diversion design outcome requirements are nominated by DNRME for permanent watercourse diversions and have been used to develop the design for Taurus Creek diversion:

- Outcome 1 - The permanent watercourse diversion incorporates natural features (including geomorphic and vegetation) present in the landscape and in local watercourses.
- Outcome 2 - The permanent watercourse diversion maintains the existing hydrologic characteristics of surface water and groundwater systems.
- Outcome 3 - The hydraulic characteristics of the permanent watercourse diversion are comparable with other local watercourses and suitable for the region in which the watercourse diversion is located.
- Outcome 4 - The permanent watercourse diversion maintains sediment transport and water quality regimes that allow the watercourse diversion to be self-sustaining, while minimising any impacts on upstream and downstream reaches.
- Outcome 5 - The permanent watercourse diversion and associated structures maintain equilibrium and functionality and are appropriate for all substrate conditions they encounter.

3.1.2 Design Criteria

DNRME recommend the following design criteria in development of permanent watercourse diversions and have been considered in development of the Taurus Creek diversion:

- The watercourse diversion should tie-in with the existing or receiving watercourse within the resource tenure boundary.
- The stability and performance of a watercourse diversion is assisted by vegetation within the watercourse diversion and adjoining floodplain and does not include artificial structures for grade control that requires ongoing maintenance.
- The channel capacity must be at least equivalent to the natural stream channel capacity existing in that vicinity.
- The length of the channel should be equivalent to the length of the watercourse it replaces.
- Bed grade/slope should be equivalent to the existing watercourse.
- Batter slopes should be designed to maintain stability through different substrates.

The DNRME Guideline also nominates a set of hydraulic design criteria which have been adapted from the original ACARP research. These hydraulic design criteria were developed based on assessment of existing Bowen Basin streams and watercourse diversions and are considered reflective of stable hydraulic conditions for ephemeral systems in central Queensland. The hydraulic design criteria are summarised in Table 3.1 and include the following:

- Shear stress which is a function of discharge, flow depth and hydraulic gradient and represents the tractive force acting on sediment particles and is used to determine the threshold of motion for sediment. High shear stress provides an indication of potential erosion in cohesive sediments or movement of non-cohesive sediments. It also provides a measure of the ability of vegetation to withstand flow.
- Stream power which is a function of hydraulic gradient, flow width and flow rate and represents the energy available to do work on the channel. High stream power values generally result in elevated erosion potential.
- Velocity which is a function of flow rate and cross-sectional area and is a simplified measure of erosion potential. Generally higher velocities result in higher erosion potential however stream power and shear stress are more reliable indicators of erosion and sediment transport potential.

Table 3.1: DNRME 2019 Hydraulic Design Criteria

Design Flow Event	Stream Power (W/m^2)	Velocity (m/s)	Shear Stress (N/m^2)
2-year ARI (no vegetation) (39% AEP)	<35	<1.0	<40
2-year ARI (vegetated) (39% AEP)	<60	<1.5	<40
50-year ARI (2% AEP)	<150	<2.5	<80[1]

1. DNRME values are taken from ACARP 2002 as the <50N/m^2 value in DNRME 2019 is incorrect.

3.2 ACARP GUIDELINES

ACARP (2014) outlined several approaches to the design of diversion channel dimensions, which included an analogous approach, where channel dimensions are selected from a reference reach; a hydraulic geometry approach where dimensions are determined from regression relationships; and an analytical approach, where equations are used to calculate continuity, hydraulic resistance, and sediment transport and channel characteristics are determined from field inspection of a reference reach.

In addition to the analogous approach, ACARP (2014) also provides guidance on alluvial channel design parameters which were adapted from ACARP (2002). These hydraulic parameters are intended to be represented of stable watercourses within the Bowen Basin and are summarised in Table 3.2.

Table 3.2: ACARP 2014 Alluvial Channel Design Parameters

Stream Type	Stream Power (W/m^2)	Stream Power 39% AEP (W/m^2)	Stream Power 2% AEP (W/m^2)
Alluvial	Supply limited	15-35	50-100
	Transport limited	35-60	80-150
Bedrock controlled	n/a	50-100	100-350

ACARP (2014) also provides recommendations on shear stress thresholds for vegetation used as part of rehabilitation activities. These thresholds are summarised in Table 3.3.

Table 3.3: ACARP 2014 Recommended Vegetation Shear Stress Thresholds

Vegetation Type	Design Shear Stress (N/m^2)
Buffel grass	40
Structurally diverse suite of established native vegetation	120

The long-term performance of the diversion under both operating and closure scenarios is assessed with the following objectives, based on industry standard closure objectives:

- The diversion demonstrates to be in a safe, stable, non-polluting and self-sustaining state (as per PRCP Closure Criteria and Environmental Authority requirements as per Section 3.3).
- Reference rehabilitation requirements (acceptance criteria) include goals, objectives and acceptance criteria for the post mining landuse of the 'Watercourses' which is applicable for the watercourse diversion.
- Existing water licence diversion objectives generally align with the objectives under the DNRME Guidelines (2019).

3.3 ENVIRONMENTAL AUTHORITY EPML00717813

The land schedule within the Blackwater Mine EA (EPML00717813) requires that all areas significantly disturbed by mining activities must be rehabilitated in accordance with specified Rehabilitation Requirements. The EA provides the rehabilitation landform criteria for the post mining land use of watercourses (refer to Figure 3.1). Some indicators reference the Index of Diversion Condition (IDC) method, which is a component of ongoing diversion monitoring.

Table E1 (Rehabilitation Requirements)

Post Mining Land Use	Goal	Objective	Indicator	Acceptance Criteria
Watercourse	Safe to humans and wildlife	Safety hazards are not significantly different to surrounding unmined landscapes subject to the same land use	Hazard assessment	No significant difference
	Stable	Rehabilitation is erosionally stable	Geomorphic index (IDC method)	Greater or equal to upstream or downstream values.
	Non-polluting	Rainfall runoff from rehabilitation achieves relevant water quality objectives for receiving waters	pH EC Turbidity	Not significantly different to upstream values
	Able to sustain the agreed post-mining land use	Riparian vegetation	Riparian vegetation index (IDC method)	Greater or equal to upstream or downstream values.

Figure 3.1: Blackwater Mine EA EPML00717813 Rehabilitation Requirements for Watercourses

4 OPTIONS IDENTIFICATION

Engeny identified three potential remediation options for the Taurus Creek diversion based on the current alignment, final landform consideration and the future mine plan. To inform the remediation concept design, the geomorphic features of the pre mining drainage path were incorporated and utilised as well as the upstream and downstream channel geometry and grade.

The objective was to identify suitable options for the permanent remediation of the Taurus Creek diversion and identify a preferred option to carry though to concept design. The process to define the options includes a review of the natural waterway geometry, the existing creek diversion geometry, original design reports and current diversion design parameters.

Each option was defined with a concept cross section, longitudinal profile and meandering characteristics, if applicable. Civil earthworks modelling was undertaken to confirm the following:

- Alignment of the diversion options
- The need for potential flood levees (during operations)
- Final landform reconfiguration
- Reinstatement of floodplain
- Proposed tie-in locations to the existing waterway
- Development Class 5 capital cost estimate

Where applicable, the earthworks quantities include the filling quantity for existing dams or depressions which would be ultimately remediated in closure.

The options identification also includes the assessment of key risks and opportunities regarding potential staging, possible impacts to downstream infrastructure, reinstating the flood plain and post mining land-use risks in the context of closure. The main focus for each option was to determine the impacts and interaction between the PRCP final landform and the proposed diversion. Refer to Figure 4.1 for the potential options identified and Table 4.1 for further details.

Table 4.1: Options Identification Details

Statistic	Option 1	Option 2	Option 3
Description	Re-instating natural alignment and meander to tie into natural channel	Diversion north to Deep Creek	Removal of drop structure and meander in corridor
Likelihood that diversion will achieve state of dynamic equilibrium	Low- channel grade of 0.53% is steeper than natural at ~0.45%	Flawed- diversion flowing against grade	Medium – channel grade of 0.4% is similar to natural at ~0.45%
Diversion constructed through spoil	Yes	Yes	No
Order of magnitude cost estimate*	$27 M	N/A	$9.5 M
Ability to isolate diversion from flows during establishment period	No (only ~50% of diversion can be isolated)	Yes	No

*Cost estimate based on average $10/m^3 and Option 1 and 3 include quantities to fill ‘Ramp 42 Fill Point Dam’

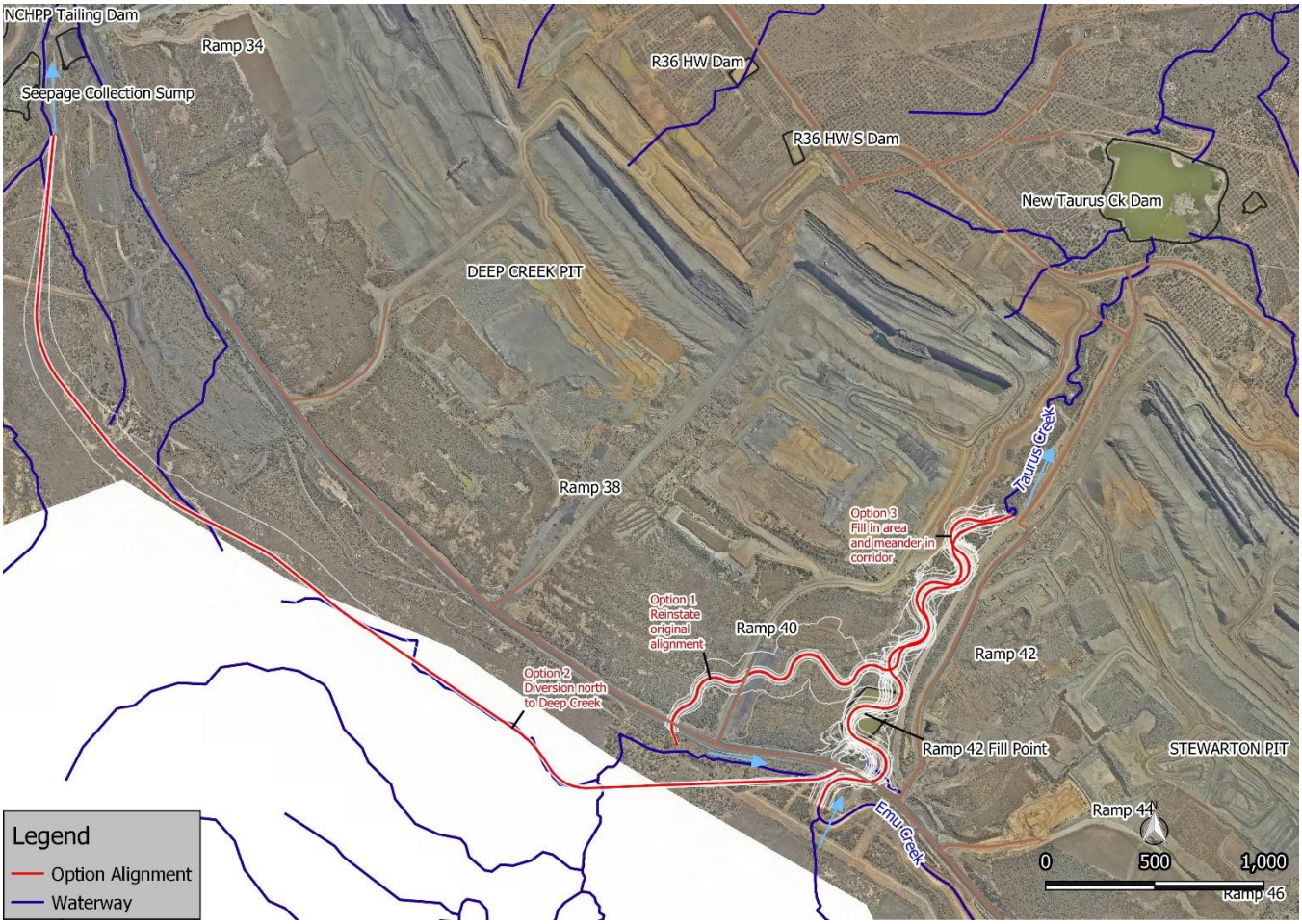

Figure 4.1: Taurus Creek Diversion Remediation Options

5 OPTIONS ANALYSIS

5.1 MULTI-CRITERIA ANALYSIS FRAMEWORK

A high level multi-criteria analysis (MCA) was undertaken to rank the identified options for individual criteria as per Figure 5.1 below and determine a preferred option. The weighting of each criteria was determined and agreed upon with a BHP and Engeny collaborative decision group. The individual weightings are summarised in Table 5.1. Based on the score for each criteria against each option, a preferred option is identified.

-3	-2	-1	0	1	2
Fatal Flaw	Strongly Negative	Mildly Negative	Neutral	Mildly Positive	Strongly Positive

Figure 5.1: Ranking Scores for MCA

Table 5.1: Weighting for Individual Screening Criteria

Criteria	Weight
Likelihood that diversion will achieve state of dynamic equilibrium	40%
Diversion constructed through spoil	30%
Order of magnitude cost estimate	20%
Ability to isolate diversion from flows during establishment period	10%

5.2 MULTI-CRITERIA ANALYSIS

The MCA resulted in Option 3 to be carried forward into concept design as a preferred option, since it scored highest out of all three options without a fatal flaw and resulted in the lowest relative risk (see Table 5.2). Refer to Appendix A for the detailed MCA and scoring.

Table 5.2: Multi-Criteria Analysis Outcomes

Item	Option 1	Option 2	Option 3
Overall Weighted Score	-0.8	-1.0	0.4
Relative Risk	High Risk	Highest Risk	Lowest Risk
Fatal Flaw	No	Yes	No

6 CONCEPT DESIGN

6.1 DESIGN PARAMETERS

Table 6.1 describes the parameters within each outcome described in Section 3 and which were applied to inform the concept design.

Table 6.1: DNRME and the Australian Coal Association Research Program (ACARP) Parameters Adopted

DNRME Parameters (DNRME, 2019)		Equivalent ACARP Parameters (ACARP, 2014)	
Outcome 1 – The design plan should include a detailed description of: a) the location, function and description of geomorphic features within the proposed watercourse diversion as well as a revegetation and vegetation management plan.	☒	*Outcome 1 –* Geomorphic and riparian vegetation features of the diverted watercourse and connecting reaches (minimum of 1 km upstream and downstream of proposed tie ins). Vegetation characteristics along the proposed optional watercourse diversions should also be noted.	☒
Outcome 2 – The design plan should include a detailed description of: a) the development and calibration, or sensitivity analysis, of the hydrologic model, including the referencing of methodologies used to generate flood frequency analysis[1] b) any design implications and construction processes that necessitate a lateral dysconnectivity of sub-surface flow between the watercourse and an adjacent final void (if proposed). [1] Hydrologic models were originally developed as part of the Saraji Mine Flood Study (Engeny, 2018).	☐ ☒	*Outcome 2 –* Summary of hydrological characteristics including surface water-groundwater interactions and water use. Flow changes along the reach should also be clearly noted.	☒
Outcome 3 – The design plan should include hydraulic modelling results (benchmarked against guideline values for stream power, shear stress and velocity adopted from ACARP, 2002) and analysis identifying depth of inundation. The design plan should include a floodplain of sufficient capacity.	☒	*Outcome 3 –* Summary of hydraulic characteristics along the waterway length. Longitudinal section of stream power with standard cross section increments. A higher frequency of cross sections is required at stream junctions and bifurcations. A table summarising stream powers (in channel and floodplain) at each cross section is also required, along with statistics for the reach. This specifically includes the reach minimum, low quartile, median, mean, upper quartile and maximum values[2]. [2] Only mean stream power values were calculated for comparison with the adopted criteria.	☒ ☐
Outcome 4 – The design plan should include a sediment transport analysis that identifies how the watercourse diversion will manage erosion or deposition events such that they are consistent with the existing sediment regime.	☒	*Outcome 4 –* Sedimentation characteristics. Where the existing reach is aggrading, degrading, or is in equilibrium. Note presence of sediment sources (e.g., main channel bed or bank instabilities, floodplain contributions) and sinks (e.g., flood outs or sediment splays along low gradient sections of the reach, and infilling pools).	☒
Outcome 5 – The design plan should include the specification of spoil placement and sequencing and the settlement process and timing of operation that will ensure the watercourse diversion, once constructed, operates in a stable manner.	☒	*Outcome 5 –* Interaction between watercourse diversion options and mine infrastructure (pipes, pits, culverts, access, etc.) and planning over the life of mine.	☒

It is important to note only benchmark values for shear stress and velocity were adopted from DNRME, 2019. Stream power benchmark values were adopted from ACARP, 2014 due to it being a more contemporary standard that considers impacts of sediment transport.

6.2 DIVERSION ALIGNMENT

Option 3 was identified to be the preferred option alignment using the MCA, removing the existing drop structure and meandering the diversion within the existing corridor to achieve a stable grade, filling in existing Ramp 42 Fill Point Dam. The alignment was further refined to optimise bill of quantities and meander of the channel. Figure 6.1 shows the permanent diversion alignment design and general arrangement of Option 3. Concept design drawings of the preferred option design is included in Appendix C.

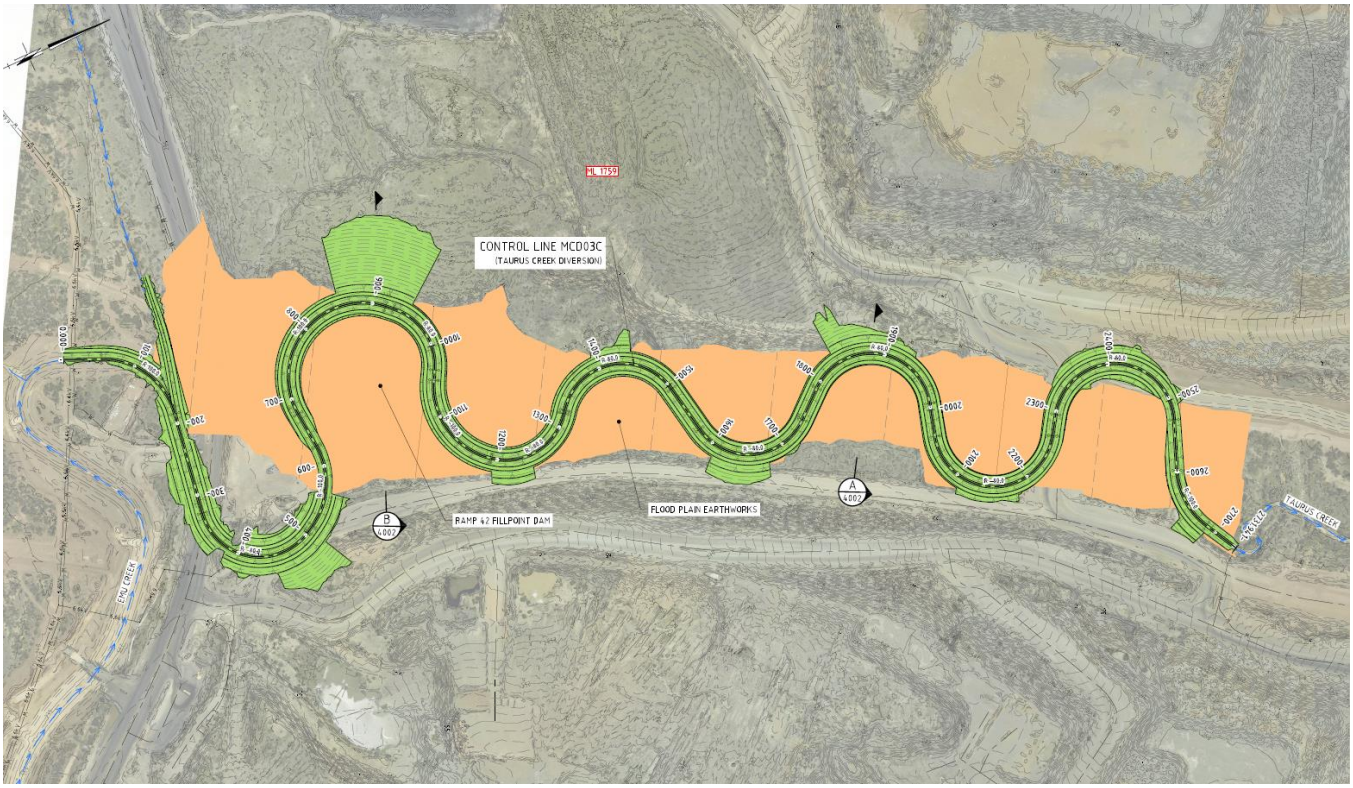

Figure 2.1: Option 3 General Arrangement

6.3 CHANNEL GEOMETRY AND GRADE

The typical upstream and downstream channel geometries are presented in Figure 6.5 and Figure 6.6. The concept diversion design dimensions were based on the average natural upstream and downstream channel geometry topographic data and aerial imagery were used to evaluate the planform and cross section parameters of multiple reference reaches of Taurus Creek. Cross-sectional dimensions were compared and evaluated for a total of 17 cross-section locations. The locations of the cross-sections taken for the analysis are provided in Figure 6.2. The upstream and downstream cross sections for the Taurus Creek diversion are presented in Figure 6.5 and Figure 6.6.

Due to the Emu Creek diversion, the Taurus Creek remediation channel needs to incorporate catchment flows from Emu Creek. The downstream reference reach located after the confluence of Taurus Creek and Deep Creek was found to be representative of the system with both catchments and therefore used to inform the channel dimensions for the Taurus Creek concept design. This was compared to sections of Taurus Creek, Emu Creek and Two Mile Creek locations presented in Figure 6.3 below and all of them were found to be of similar shape.

To achieve the desired longitudinal grade of 0.41% the haul road located at the confluence of Emu Creek diversion and Taurus Creek has been removed in the concept diversion design, which also satisfies the closure objective for the mine to remove all mine infrastructure, as further discussed in the PRCP chapter.

Table 6.2 and Appendix C show the detailed geometry and typical cross section of the concept design with longitudinal profile, respectively.

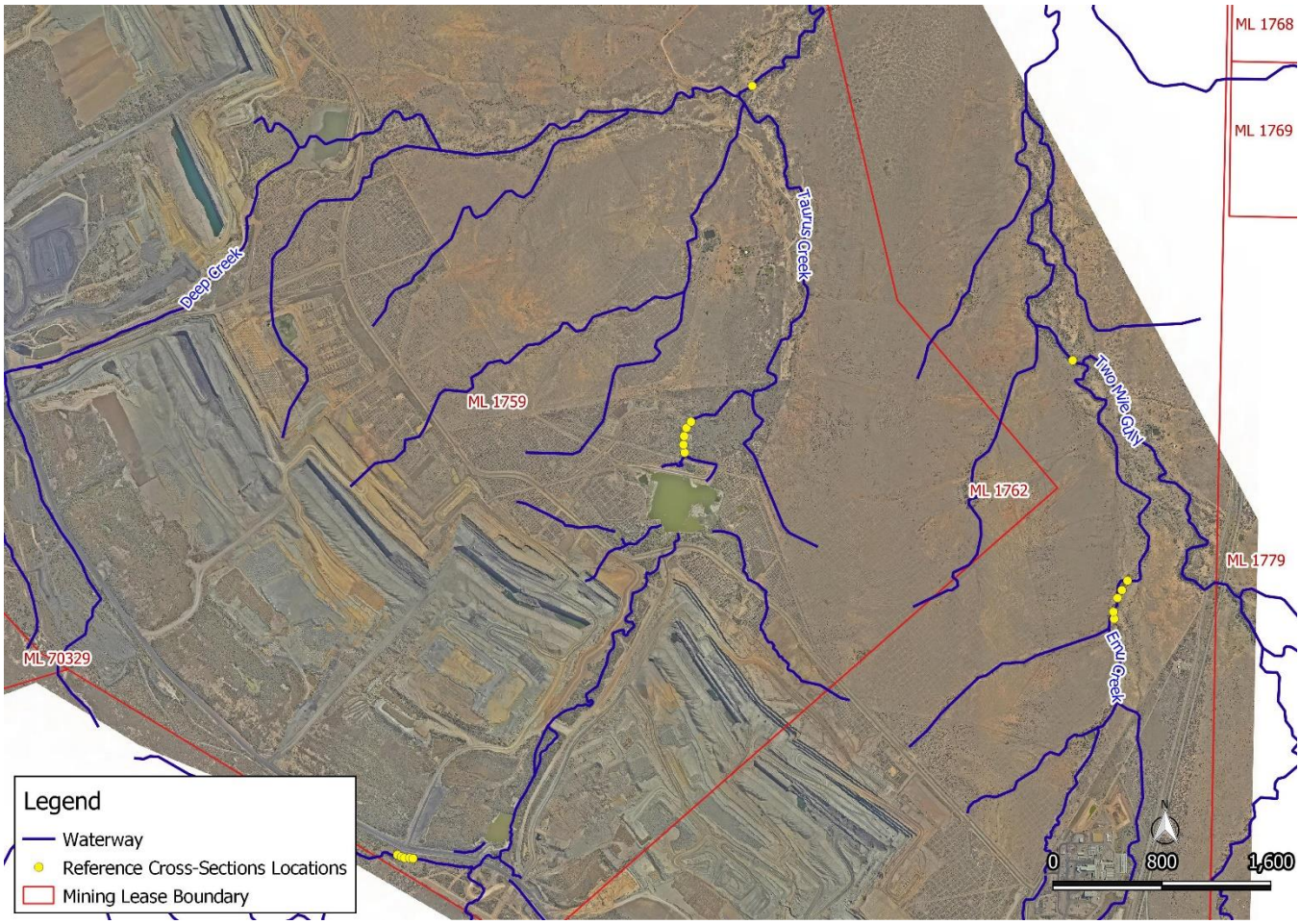

Figure 6.2: Locations of Reference Cross-Sectional Areas

Table 6.2: Concept Design Detailed Channel Cross Section Geometry

Channel Geometry	Quantity	Comments
Channel Bed Width	4 m	
Batter Slope	1V:4H	For both the low flow channel and high flow channel batters
Channel Depth	2 m	Consistent depth of low flow channel at 2 m
Bench Width	5 m	

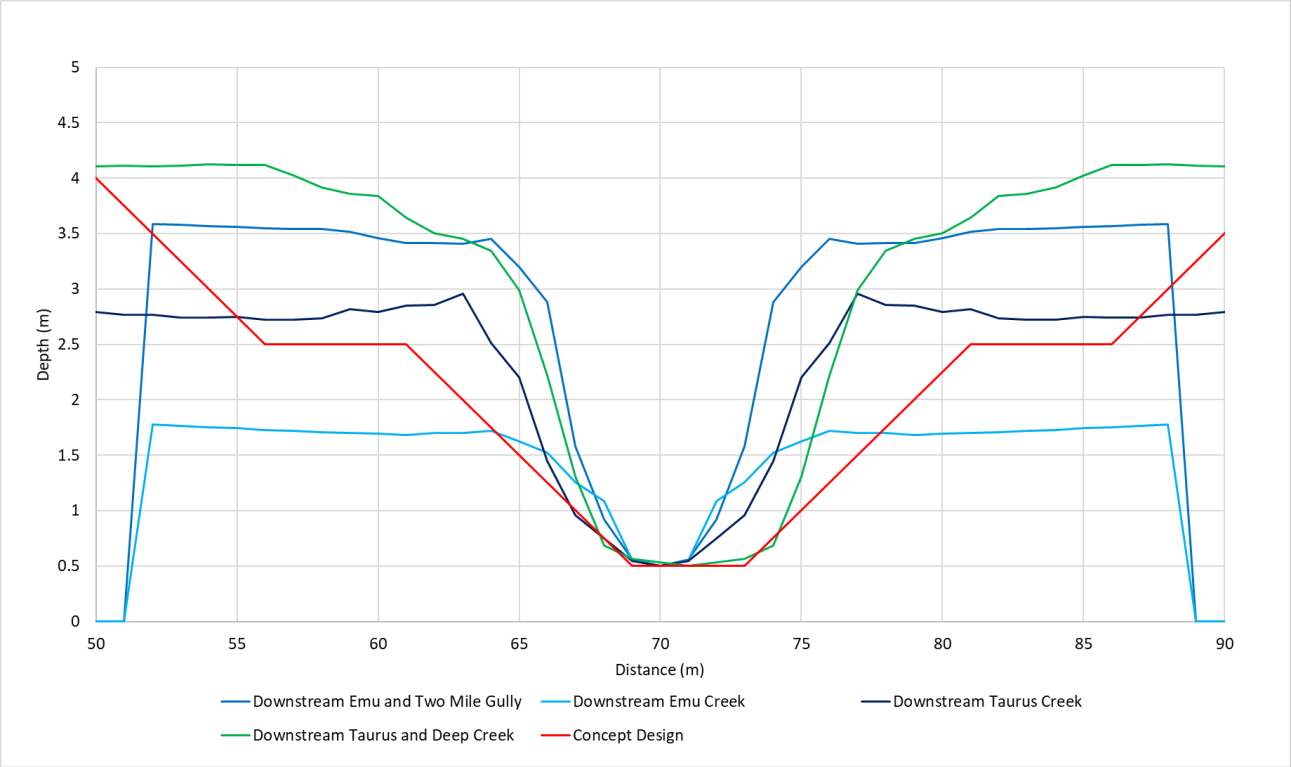

Figure 6.3: Downstream Sections Compared

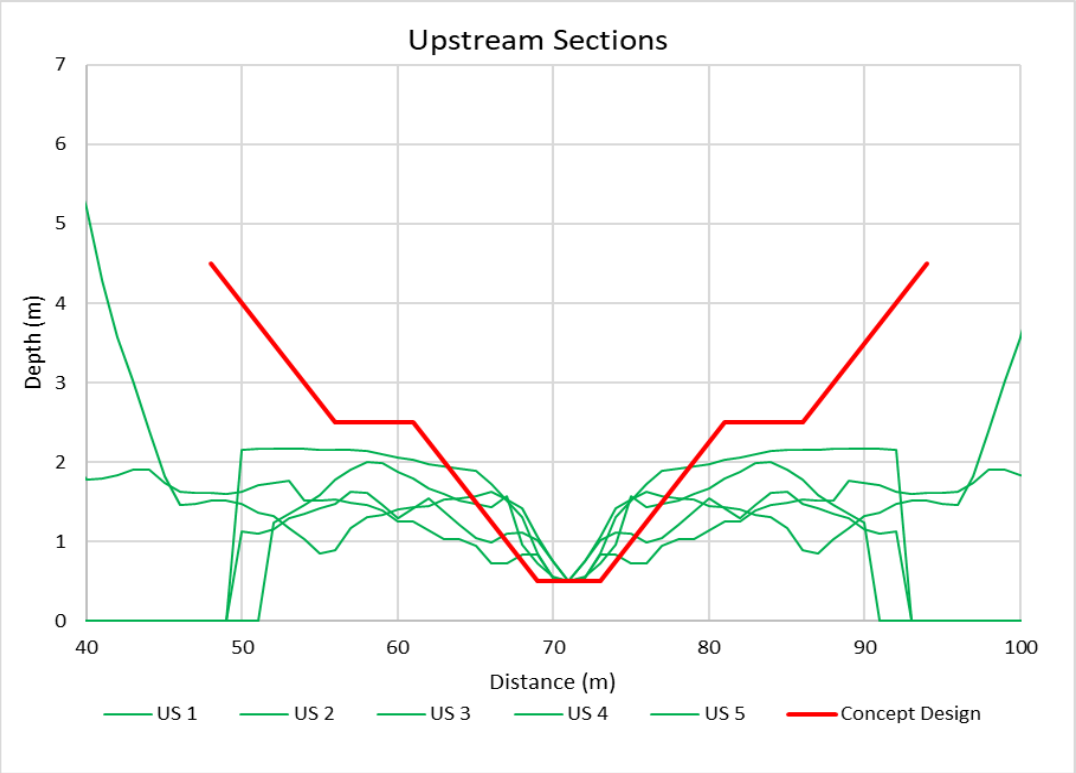

Figure 6.5: Typical Upstream Channel Cross Section of Taurus Creek

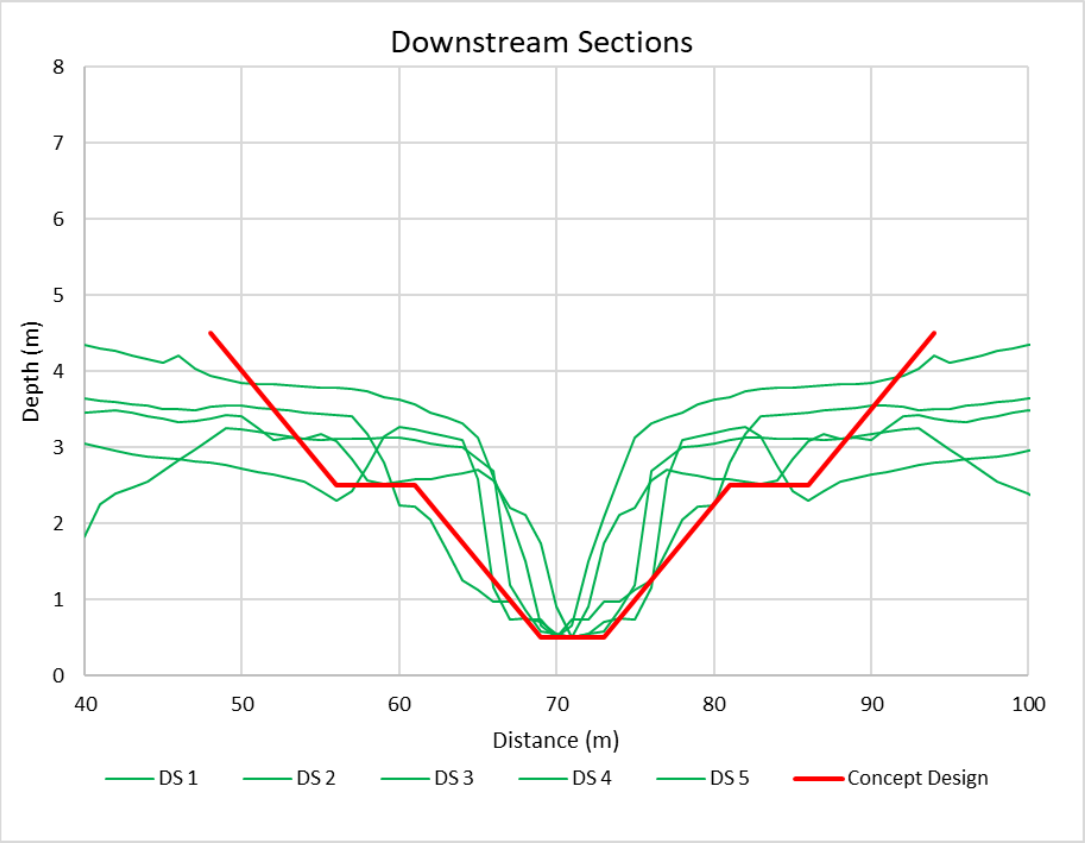

Figure 6.6: Typical Downstream Channel Cross Section of Taurus Creek

6.4 HYDROLOGY

A hydrologic model of Taurus Creek was originally developed as part of the Blackwater Mine Flood Model and Water Balance Update (Engeny, 2017b) and recently updated for the Ramp 47 project (Engeny, 2021) to include the Emu Creek Diversion and levee works, which estimated flows for the 1% AEP and 0.1% AEP flood events. Peak flows for frequent events (39% AEP and 2% AEP) for the Taurus Creek diversion remediation were estimated using the ACARP (2002) methods and are presented in Table 6.3. The Taurus Creek catchment has been updated to incorporate the Emu Creek catchment and is presented in Figure 6.6 below.

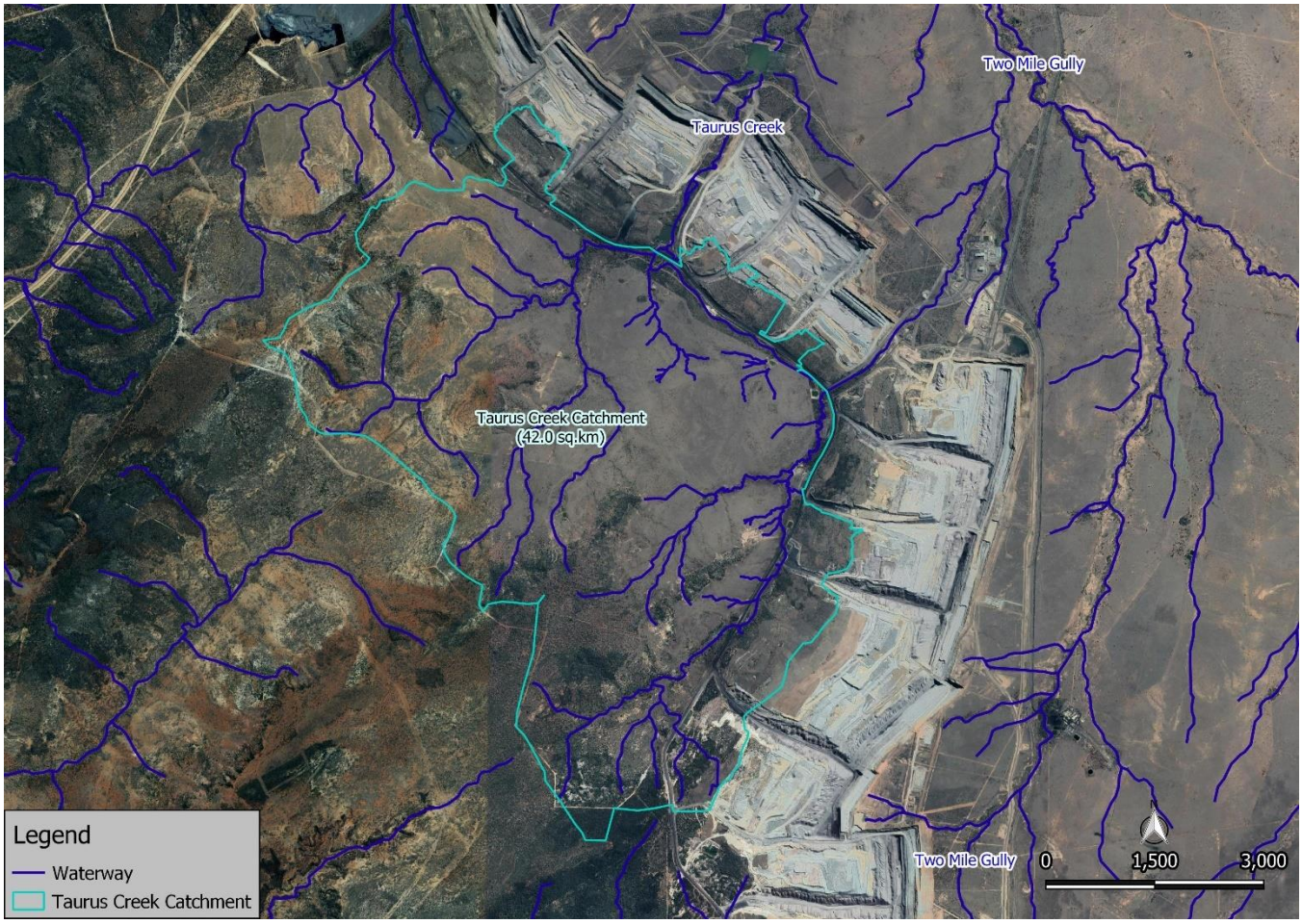

Figure 6.6: Map of Catchments (including Emu Creek Catchments)

6.4.1 Frequent Events

The hydrologic model (Engeny, 2021) mentioned above was used to estimate flows through the diversion for the 39% AEP and 2% AEP flow events (refer to Table 6.3) in accordance with the ACARP (2002) method. The ACARP (2002) assessment included a regional flood frequency analysis for a selection of gauged catchments in the Bowen Basin region. From this, a method was developed to estimate flood magnitudes for ungauged catchments, based on catchment area and rainfall intensity. The calculated flood magnitudes for the 39% AEP and 2% AEP events were then used to determine diversion design limits for shear stress, stream power and velocity. This approach has been adopted to determine the flows within the proposed Taurus Creek diversion concept design and have been compared to the ACARP (2002) diversion channel design parameters.

Table 6.3: Taurus Creek Diversion Design Flows

Rainfall Event	Diversion Channel Design Flows (ACARP, 2002) m^3/s
39% AEP	32.8
2% AEP	65.7

6.5 HYDRAULICS

Stream power is the product of channel slope and discharge. It represents the excess energy available to do work in and on the channel. If there is too much excess energy, then channel erosion may occur. Stream velocity is calculated by dividing the flow by the cross-sectional area (based on flow depth in the channel). The higher the velocity, the greater the erosive force of a stream and therefore more sediment will be freed and move through the system. Shear stress is an indication of the size of granular material that will begin to move at a particular flow within the diversion reach.

Average values were derived from the TUFLOW model for the stream powers, stream velocity and shear stress in a 39% AEP and 2% AEP rainfall event (refer to Table 6.4). The proposed diversion values have been compared to the DNRME (2019) diversion channel design parameters.

Table 6.4: Diversion Design Criteria Compared to DNRME (2019) Guideline Parameters

	39% AEP		2% AEP	
Design Criteria	Diversion	DNRME Design Parameter (2019)	Diversion	DNRME Design Parameter (2019)
Stream Power (W/m^2)	60	<60	119	<150
Stream Velocity (m/s)	1.29	<1.5	1.62	<2.5
Shear Stress (N/m^2)	44	<40	68	<80[1]

1. DNRME values are taken from ACARP 2014 as the <50N/m^2 value in DNRME 2019 is incorrect.

The shear stress for the 39% AEP exceeds the guideline value. All other parameters are within acceptable limits.

Even though the shear stress is exceeding guideline values, it still falls below the threshold of 120 N/m^2 at which a channel with established native vegetation is considered stable, as per Table 3.3. The design of the diversion will be able to be refined in future phases to ensure shear stresses are within guideline values.

Appendix B illustrates the variability for each design parameter along the diversion channel and shows overall lower values at the start of the diversion due to the open floodplain and multiple channels interacting with the Taurus Creek diversion.

The floodplain of the concept diversion design is confined by the PRCP final landform in a narrow corridor (100 – 300m) and the final landform will need to ensure the flood protection to final voids. The concept diversion design does interact with remediated mine areas (ie. haul roads) and final landform spoil dumps in the upstream reaches of the design. The flood assessment of the 0.1% AEP flood event shows flows within a wide floodplain within the upstream reaches, confined channel flows in the Emu Creek diversion and flows contained within the floodplain of the Taurus Creek concept diversion.

The floodplain of the downstream reaches and the last 100m of the concept diversion channel is confined by final voids on either side which poses potential risk for external catchment inflows to voids. The PRCP final landform will need to ensure the flood protection of final voids and include sufficient buffer of voids to the downstream reaches to mitigate this risk.

6.6 ADDITIONAL DESIGN AND CONSTRUCTION CONSIDERATIONS

6.6.1 Backfilling of Voids and Existing Dams

The concept design of the Taurus Creek diversion also includes backfilling of existing dams and voids located along the diversion alignment. The "Ramp 42 Fill Point Dam" will need to get backfilled completely integrating into the existing surrounding landforms. For concept design purposes, a maximum backfill level of 230.9m AHD was adopted for the dam and the surrounding area downstream of "Ramp 42 Fill Point Dam" (See Figure 6.7 "Minor fill area") is backfilled to match the grade of the diversion channel. This will ensure overland flow will not pond between channel meanders and contributes to diversion flows. The backfill volume of the corridor is approximately 600,000 m^3 with locations illustrated in Figure 6.7.

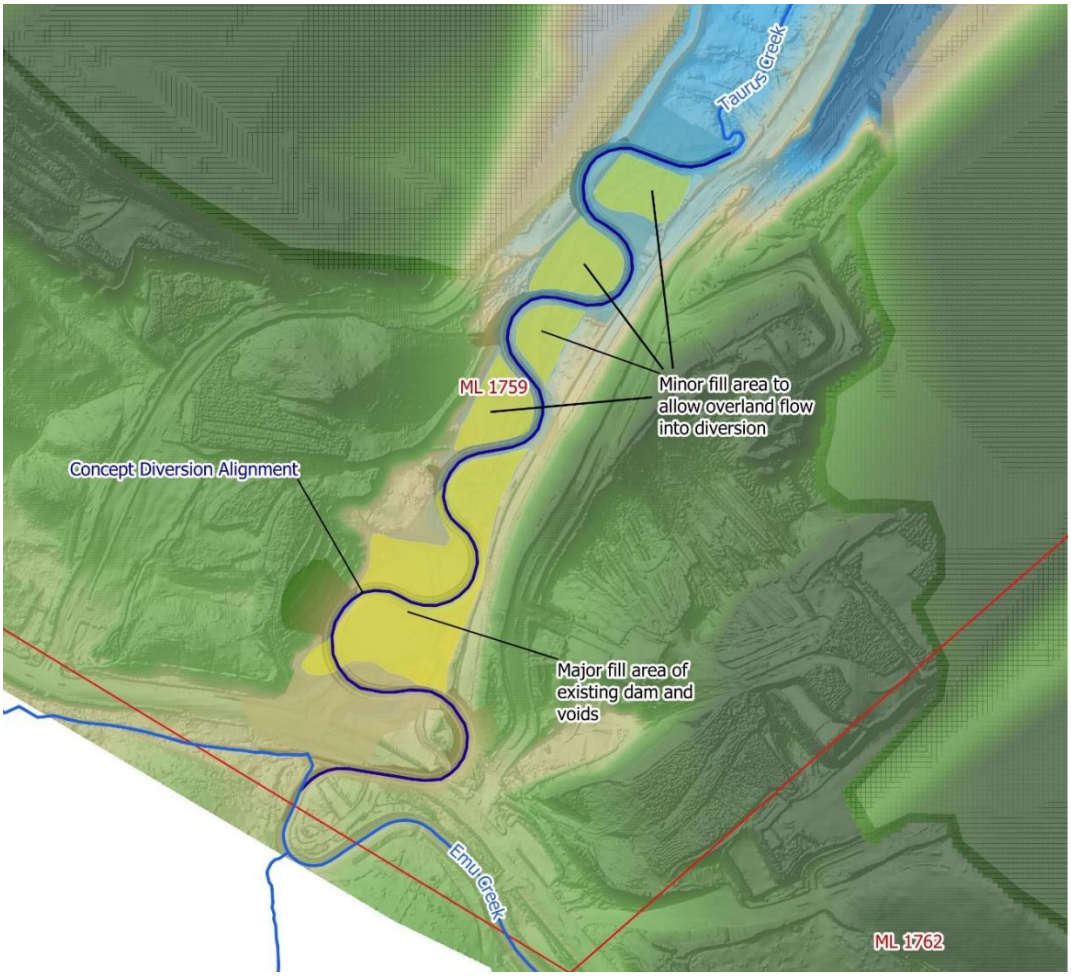

Figure 6.7: Backfilling Locations of Existing Dams and Voids (Yellow Areas)

6.6.2 Soils

The channel bed and banks are expected to comprise largely of the surrounding soils, consisting of potentially dispersive sandy to loamy duplex soils. Soils will be protected by emerging vegetation prior to major flows occurring. The final design of the diversion should include appropriate soils and vegetation management strategies. An assessment of soil and growth media characteristics will be completed by an appropriately qualified person, and amelioration and other treatments required identified and applied.

Excess supply of sediment from spoil dump in close proximity to the diversion can have potential impact on vegetation establishment within the new channel. It is suggested that measures are put in place to reduce the sediment influx from

surrounding landforms during the establishment of the diversion channel. Further investigations and detail to soil suitability and erodibility will need to be gathered in a functional design stage. The concept design assumes that the topsoil application and treatment are assessed and allow for vegetation to successfully establish.

6.6.3 Revegetation

The revegetation for the Taurus Creek diversion is to incorporate species from the pre-clearing environment (as per Relevant Environment RE mapping) as they would naturally occur along Taurus Creek in the vicinity of Blackwater Mine. The revegetation should achieve the following:

- Geomorphic and vegetation features similar to those in the local landscape.
- Maintain a sediment transport regime that does not directly impact on upstream and downstream reaches.
- No ongoing maintenance is required.

Further, hydraulic modelling has demonstrated that the 39% AEP shear stress is slightly above the ACARP (2014) guideline values for the vegetation establishment within a transport limited system and vegetation is required to ensure stability of the channel. To ensure vegetation has sufficient time for establishment it is suggested to keep the diversion offline for 1 to 2 wet seasons. Revegetation will reflect the keystone species Eucalyptus tereticornis (Queensland Blue Gum), Acacia harpophylla (Brigalow) and Eucalyptus spp. woodland ecosystem on alluvial plains.

6.6.4 Monitoring and Maintenance

Ongoing monitoring and maintenance of the diversion during the operational phase of the mine is required and carried out as per BHPs monitoring program. The monitoring and maintenance of the diversion during the establishment phase has its main focus on the presence of introduced species, weeds and vegetation establishment.

6.6.5 Closure Landform and Considerations

The PRCP landform will need to be executed to provide flood protection for the Deep Creek Pit and The Stewarton Pit, ensuring the 0.1% AEP flood event does not contribute to additional external inflows into the void. The overall intent for the flood protection landform will not require ongoing maintenance to maintain function.

6.7 RISKS AND MITIGATION MEASURES

The table below summarises the main risks for the diversion remediation design and construction. The risks were assessed in accordance with BHPs Risk Framework.

Table 6.5: Diversion Risks and Mitigation Measures

Risks	Likelihood	Consequences	Risk Rating and Score	Mitigation Measures	Residual Likelihood	Residual Consequences	Residual Risk Rating and Score
Damage to new diversion channel due to extreme flood event	Probable	2	9	Diversion channel constructed during dry season	Unlikely	1	1
Constructability of diversion channel – encountering bedrock, material availability and access	Probable	2	9	Geotechnical investigation as part of functional design, topsoil availability on site and construction during dry season (low chance of flood)	Unlikely	1	1
Significant erosion of channel due to extreme flood event	Probable	2	9	Construction of channel during dry season including a watering program for sufficient vegetation establishment prior to wet season	Unlikely	1	1

Risks	Likelihood	Consequences	Risk Rating and Score	Mitigation Measures	Residual Likelihood	Residual Consequences	Residual Risk Rating and Score
Vegetation establishment interrupted by extreme flow event (wash away of seed and damage to plants)	Probable	2	9	Choosing a seed mix similar to the surrounding environment and apply topsoil treatment allowing for effective plant growth, construction during dry season with watering program	Unlikely	1	1
Impact to natural downstream channel due to increased flow capacity in Taurus Creek (Emu Creek catchment now contributing to Taurus Creek catchment)	Probable	2	9	Concept design channel geometry chosen based on natural downstream cross section channel with comparable size catchments able to be conveyed.	Unlikely	1	1

7 CONCLUSION

This report illustrates the concept design details and has been prepared in accordance with the requirements of the Department of Natural Resources, Mines and Energy (DNRME) Guideline: *Works that interfere with water in a watercourse for a resource activity – watercourse diversions authorised under the Water Act 2000* (DNRME,2019).

Three options for the remediation of Taurus Creek were identified and the third option was selected to be carried forward into concept design, utilising the Multi-Criteria Analysis outlined in Section 5. The final concept option design, typical cross sections and longitudinal section are presented in Section 6 and Appendix C.

The main risks to the successful performance of the diversion are vegetation establishment and erosion which can be mitigated by construction timing, during dry season, the seed mix used and topsoil treatments to improve quality of the soil where necessary. The PRCP landform will also need to ensure the flood protection of final voids located on either side of the downstream sections of the concept design, including sufficient buffer between the downstream reaches and the final voids.

The concept design demonstrates that the watercourse diversion will satisfy the closure objectives identified in the guidelines, for PRCP purposes.

8 QUALIFICATIONS

a) In preparing this document, including all relevant calculation and modelling, Engeny Water Management (Engeny) has exercised the degree of skill, care and diligence normally exercised by members of the engineering profession and has acted in accordance with accepted practices of engineering principles.

b) Engeny has used reasonable endeavours to inform itself of the parameters and requirements of the project and has taken reasonable steps to ensure that the works and document is as accurate and comprehensive as possible given the information upon which it has been based including information that may have been provided or obtained by any third party or external sources which has not been independently verified.

c) Engeny reserves the right to review and amend any aspect of the works performed including any opinions and recommendations from the works included or referred to in the works if:

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   ii) Engeny considers it prudent to revise any aspect of the works in light of any information which becomes known to it after the date of submission.

d) Engeny does not give any warranty nor accept any liability in relation to the completeness or accuracy of the works, which may be inherently reliant upon the completeness and accuracy of the input data and the agreed scope of works. All limitations of liability shall apply for the benefit of the employees, agents and representatives of Engeny to the same extent that they apply for the benefit of Engeny.

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f) If any claim or demand is made by any person against Engeny on the basis of detriment sustained or alleged to have been sustained as a result of reliance upon the Report or information therein, Engeny will rely upon this provision as a defence to any such claim or demand.

g) This Report does not provide legal advice.

9 REFERENCES

ACARP (2014) ‘Criteria for functioning river landscape units in mining and post mining landscapes’.

Alluvium (2010) 'Taurus Creek Diversion Baseline Monitoring 2010, Blackwater Mine'.

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Engeny (2020) 'Ramp 47 Pit Development - Execution Support'.

Engeny (2021) 'Ramp 47 Pit Development - Ramp 40 Flood Modelling'.

Appendix A:
Mulit-Criteria Analysis Details

Multi-Criteria Analysis - Taurus Creek Diversion

Project: PRCP Diversions FY21 (BWM)
Workshop Date: NA

-3	-2	-1	0	1	2
Fatal Flaw	Strongly Negative	Mildly Negative	Neutral	Mildly Positive	Strongly Positive

Criteria	Assumptions/Considerations	Weight	Option 1	Option 2	Option 3	Comments
Likelihood that diversion will achieve state of dynamic equilibrium	Considers the difference between diversion length and grade to natural stream length and grade. Ideally diversion length/grade = natural stream length/grade.	40%	0	-3	1	Option 1 results in a steeper grade compared ot the natural environment. Option 3 achieves a similar grade ot the natural environment. Option 2 is flawed, since flows form Taurus to Deep Creek are not possible due to grade.
Diversion constructed through spoil	For options that interact with the LoA mine plan, it is assumed that mining will occur (even if currently unapproved) then the diversion will be constructed through rehabilitated spoil. It is assumed that the PRCP final landform can be revised to achieve the required offset distances from rehabilitated spoil dumps (although the PRCP final landform would not show spoil dumps associated with currently unapproved mining).	30%	-2	2	0	Options 1 would be constructed through rehabilitated spoil. Option 3 is confined to the corridor and only in parts will cut into lower reaches of existing spoil and haul road.
Order of magnitude cost estimate	Assumes $10/m3 of cut.	20%	-1	-3	1	Option 1 increased amount of earthworks due to topography. Option 2 fatal flaw due to diversion flowing against grade (no quantities done for this). Option 3 includes cost to backfill Ram 42 Fillpoint Dam and parts of the diversion corridor.
Ability to isolate diversion from flows during establishment period	Diversion can be isolated from flows if it is constructed offline of the existing diversion.	10%	0	2	-2	Not possible to isolate Option 3 as constructed on same alignment as the existing diversion. Risk of high flow events washing away topsoil during diversion establishment period. Option 1 can onlybe 50% isolated from flows.
	Overall Weighted Score		-0.8	-1.0	0.4	
	Is there a Fatal Flaw?		No	Fatal Flaw	No	
	Relative Risk		High Risk	Highest Risk	Lowest Risk	

Figure A.1: Multi-Criteria Analysis Details

Appendix B:
Hydraulic Parameter Modelling Results

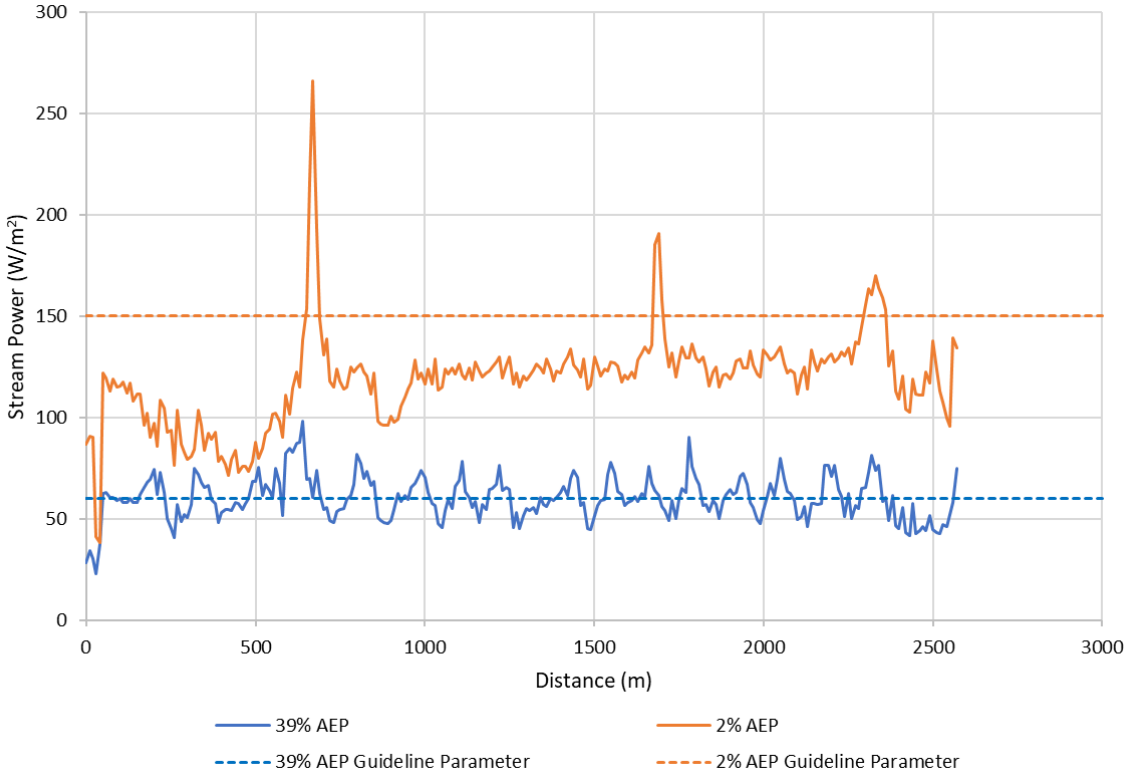


Figure B.1: Stream Power TUFLOW Model Results

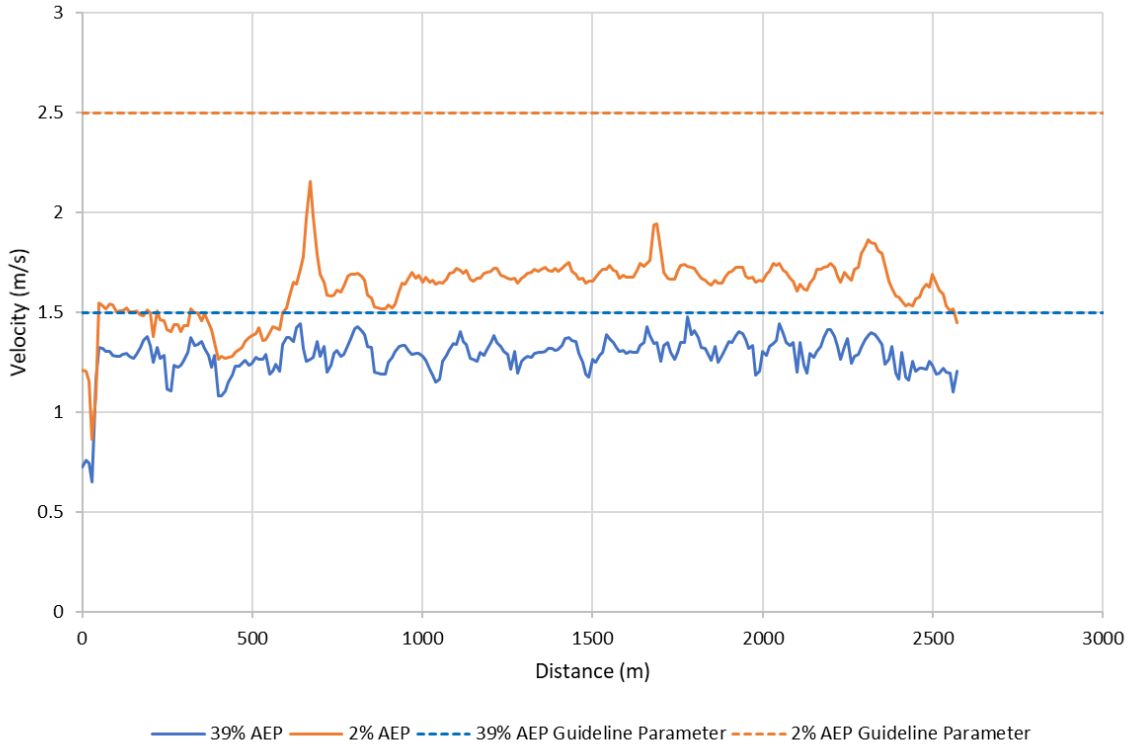


Figure B.2: Velocity TUFLOW Model Results

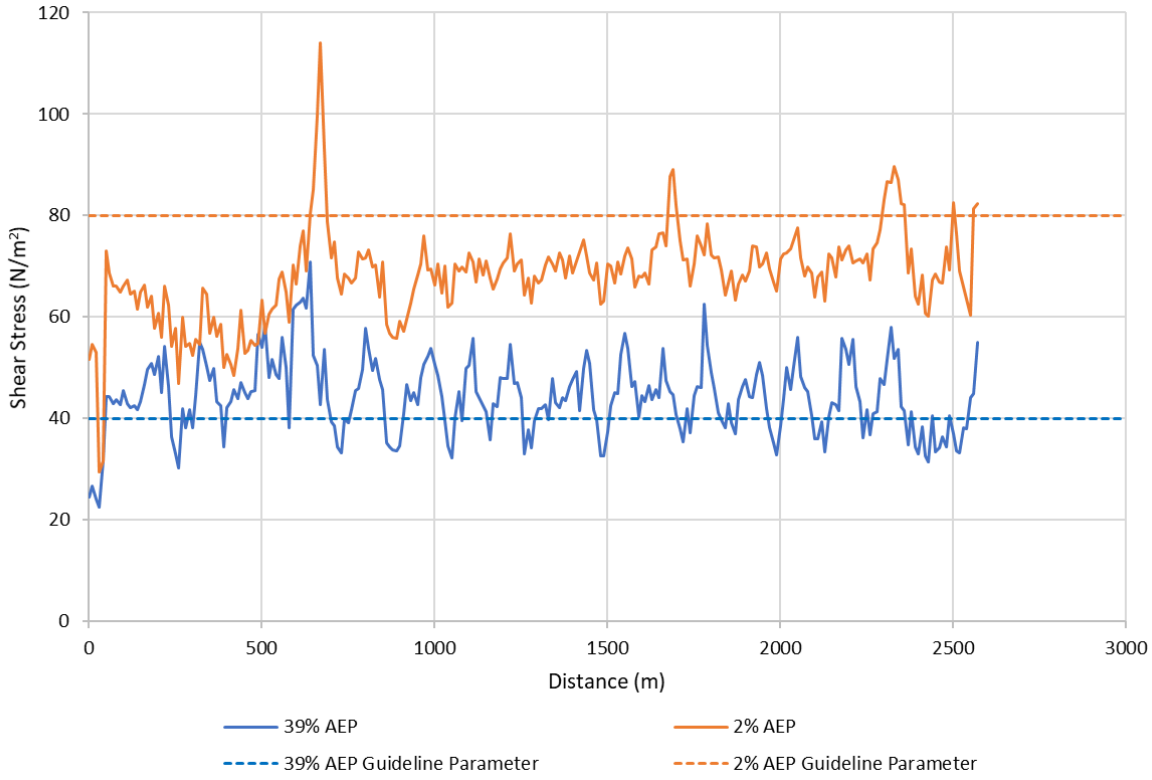
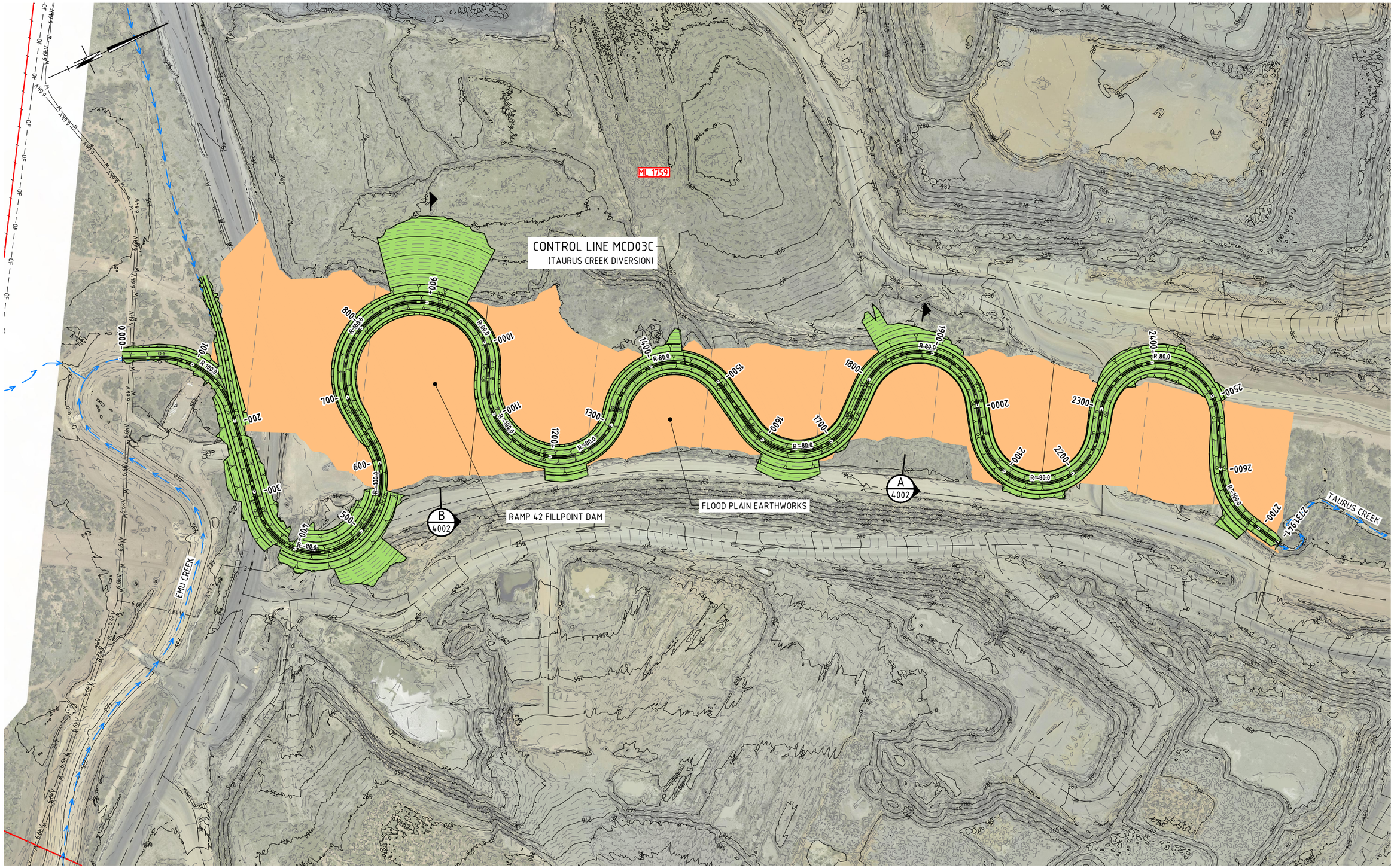


Figure B.3: Shear Stress TUFLOW Model Results

Appendix C:
Preferred Option



LEGEND

- MINE LEASE BOUNDARY
- EXISTING WATERWAY
- EXISTING ACCESS ROAD
- EXISTING OPTIC FIBRE (OF)
- EXISTING FENCE LINE
- EXISTING WATER PIPELINE (W)
- EXISTING OVERHEAD 6.6kV POWERLINE (6.6kV)
- EXISTING ELECTRICAL SERVICE (E)

GENERAL ARRANGEMENT PLAN

SCALE 1:2500

0 25 50 75 100 125m

SCALE 1:2500 (A1)
SCALE BEFORE REDUCTION

ENGENY WATER MANAGEMENT
Ph. 07 3221 7174
Level 2
500 Queen St
Brisbane QLD
www.engeny.com.au

NOT FOR CONSTRUCTION

DATE	05.02.21
DRAWN BY	SB
JOB No.	M11000-437

BHP - BLACKWATER MINE

TAURUS CREEK DIVERSION
GENERAL ARRANGEMENT PLAN

Original Size	Drg No.	Rev.
A1	M11000-437-SKE-4001	A

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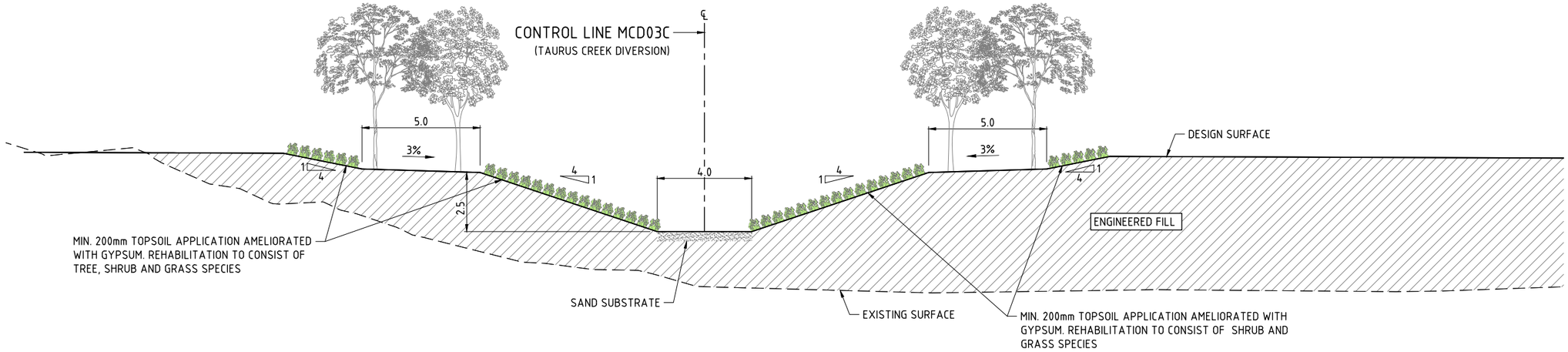

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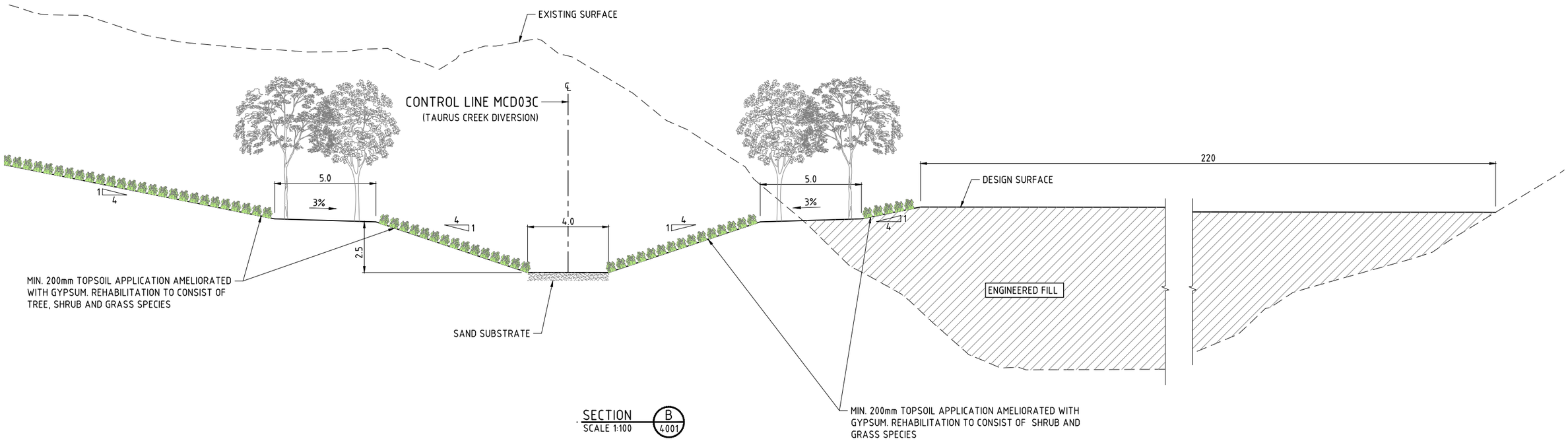

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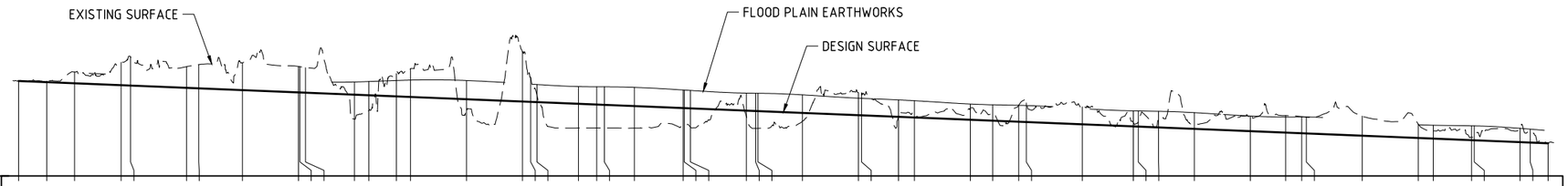

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Appendix 4.11 – Rockland Creek Diversion Concept Design

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PRCP Concept Design Report

Rockland Creek Diversion

28 March 2024

M11000_437-REP-001-2

Job no. and Project Name: M11000_437 PRCP Diversions FY21 (BWM)
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Rev	Date	Description	Author	Reviewer	Project Mgr.	Approver
0	4/12/2020	Client Issue	Julia Scholz	Ryan Kinnealy, Ben Kiernan	Ryan Kinnealy	Ben Kiernan
1	22/01/2021	Final Issue	Julia Scholz	Ryan Kinnealy, Ben Kiernan	Ryan Kinnealy	Ben Kiernan
2	28/03/2024	Client Issue	Christian Hansen	Whitney Claxton	Ryan Kinnealy	Ben Kiernan
Signatures						

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1 INTRODUCTION

1.1 CONTEXT

The Mineral and Energy Resources (Financial Provisioning) Act 2018 (MERFP Act) amended the Environmental Protection Act (EP Act) to introduce new requirements for the progressive rehabilitation and closure of mined land. These changes include the development of a Progressive Rehabilitation and Closure Plan (PRCP) for all existing and future site-specific Environmental Authority (EA) holders for mining activities relating to a mining lease.

The main purpose of the PRCP is to:

- Require the holder of an EA to plan for how and where activities will be carried out on land in a way that maximises the progressive rehabilitation of the land to a stable condition.
- Provide for the condition to which the holder must rehabilitate the land before the EA may be surrendered.

This report illustrates the concept design details for Rockland Creek and has been prepared in accordance with the requirements of the Department of Natural Resources, Mines and Energy (DNRME) Guideline: *Works that interfere with water in a watercourse for a resource activity – watercourse diversions authorised under the Water Act 2000* (DNRME,2019). The objective of this report is to demonstrate the watercourse diversion concept design will satisfy the outcomes identified in the guideline for PRCP purposes.

1.2 PURPOSE AND SCOPE

The scope of work for each diversion is comprised of two stages:

- Stage 1: Options Assessment
- Stage 2: Concept Design on the preferred option outcome from Stage 1

The purpose of this document is to outline the concept design developed for the preferred diversion remediation option (outcome from Stage 1) to achieve a state of dynamic equilibrium to achieve a relinquishable state for the diversion. The following methodology was conducted:

- A desktop geomorphic assessment of the creek using historical aerial imagery and survey to inform the concept design of the options.
- Review of the existing flood studies and determine peak flow rates in the diversion for key design flow events for the purposes of and hydraulic analysis.
- Conduct a hydraulic assessment of the diversion option against the DNRME 2019 Guideline criteria (see Section 3.1).
- Develop concept design sketches and watercourse diversion spatial polygon for the diversion for presentation in the PRCP chapter and schedule.

1.3 LIMITATIONS

The concept design is developed exclusively for PRCP purposes and thereby is falling within the limitation of the PRCP as well. This means any concept design options considered for the diversion remediation only include permanent diversion remediation solutions. The design is considered to be concept only and not at a functional level which would be required to support an approval for the works.

2 OVERVIEW

2.1 LOCATION

Rockland Creek is an ephemeral tributary of the Comet River, situated within the Fitzroy River basin. The creek originates in a relatively low relief range to the east of Blackwater Mine. The creek flows from east to west, through the south Blackwater Mine operations, the Rockland Creek Dam and eventually joining Humboldt Creek some 22 km west of Blackwater Mine. The diversion was likely constructed in 1993, at a length of approximately 1.5 km, to allow mining within Marshmead Pit. The diversion as well as the Rockland Dam, were constructed as part of the flood mitigation for this Pit. Refer to Figure 2.1 for the location of the Rockland Creek Diversion.

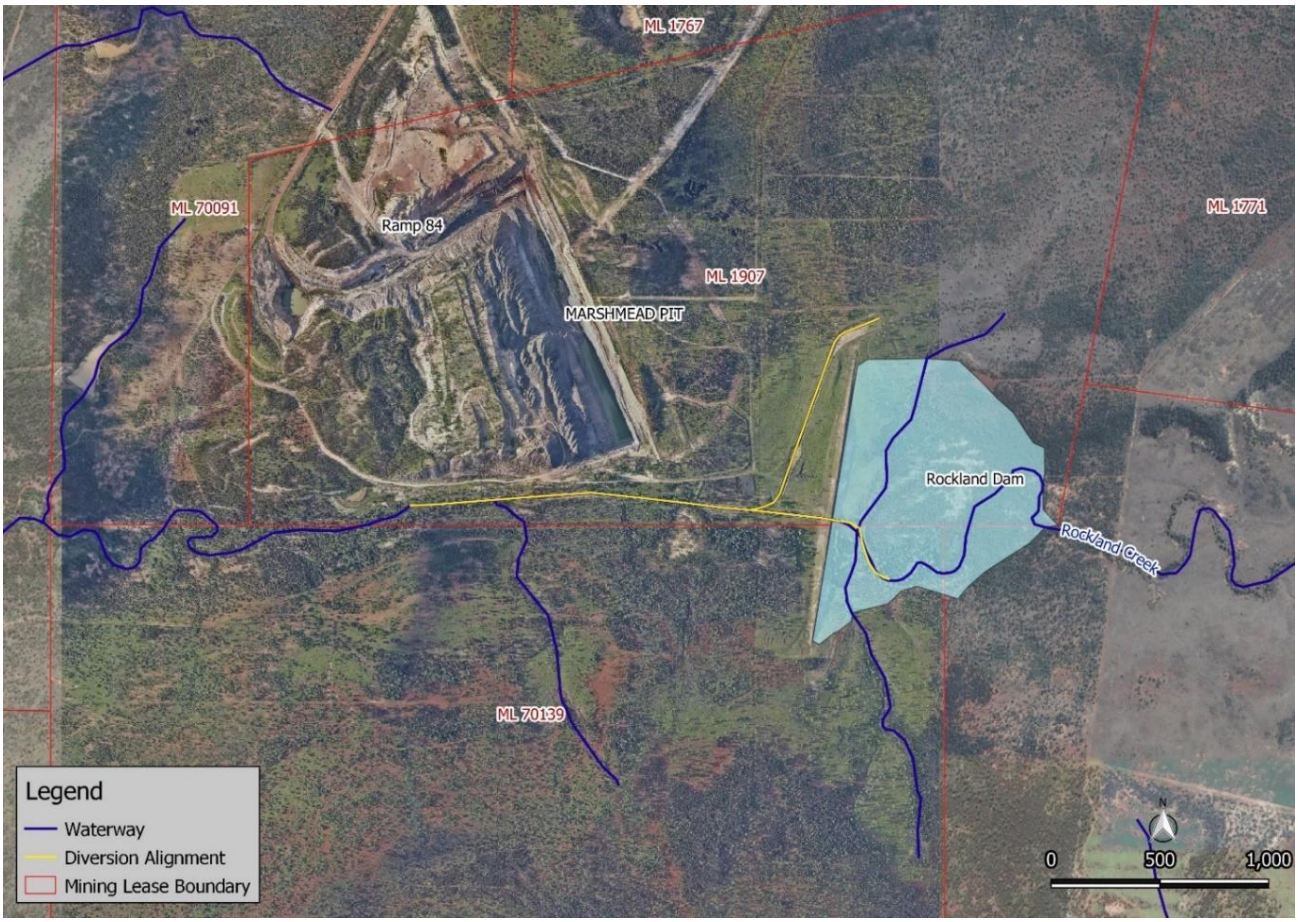

Figure 2.1: Location of the Rockland Creek Diversion at Blackwater Mine

2.2 NATURAL REACHES

The upstream, downstream and diversion reaches of Rockland Creek have been described as follows (Alluvium, 2010):

- **Upstream reach –** The upstream reach of the Rockland Creek diversion is within the mine lease and within the backwater influence of Rockland Dam. Much of the riparian, floodplain and hill slopes in the area are either uncleared or have well established regeneration. The upstream drainage network consists of moderate sinuosity channels with predominantly alluvial boundaries. The channel consists of a clear low flow channel within a high flow channel. The high flow channel varies in capacity with top width ranging from 30-60m and depth from 2 to 5m.
- **Downstream reach –** Downstream of the Rockland Creek diversion, the drainage network is comprised of a moderate sinuosity single low capacity low flow channel with predominantly clay boundaries. The floodplain has a moderate width of

40 to 60m with the low flow channel depths ranging from 0.5 to 2.5m. The downstream reach is mainly influenced by the Rockland Dam Embankment with notable aggradation within the channel bed due to excess sediment inputs from the eroding diversion and spillway channel.

- **Diversion reach (pre-mining)** - The Rockland Creek diversion reach (pre-mining) was approximately 3.1 km long. It was gently meandering across the southern extent of what is now Marshmead Pit.

The upstream, downstream and diversion reaches of the Rockland Creek diversion at Blackwater Mine are shown in Figure 2.2

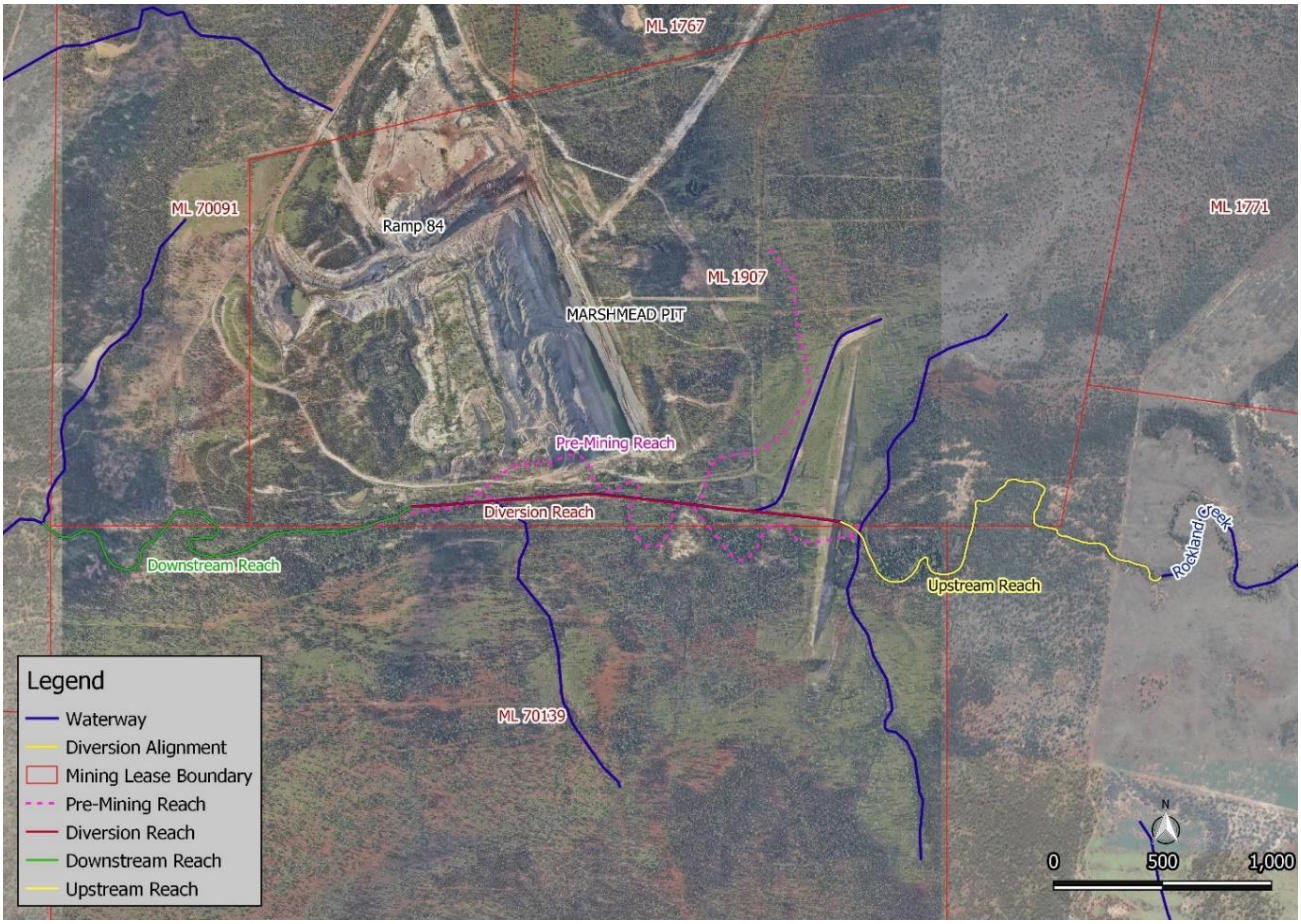

Figure 2.2: Upstream, Downstream and Diversion Reaches of the Rockland Creek Diversion

2.3 DIVERSION REACH

Monitoring of Rockland Creek diversion has been undertake since 2011 and was last completed in 2016. As part of the major monitoring, the latest condition of the Rockland Creek diversion has been described as follows (Engeny, 2016):

- The upstream reach is continuing to deteriorate due to the impacts of the Rockland Dam inhibiting sediment transport and long term ponding which has also resulted in a significant impact to vegetation, reducing the cover through all layers of the riparian vegetation.
- This is also artificially altering the upstream reach which as a result is no longer representative of the natural system.
- There is an existing drop structure within the diversion reach. The reach beyond this structure is showing signs of improvement in both geomorphic and riparian condition. Improvements in conditions prior to the drop structure are expected to be limited due to the impacts of Rockland Dam.
- The downstream reach geomorphic conditions remain relatively unchanged with a decrease in riparian condition attributed to drought stress and observed reduction in ground cover.

Based on the current condition of the Rockland Creek diversion, it is highly unlikely that the diversion will achieve the water license relinquishment criteria prior to mine closure without intervention.

3 BASIS FOR CONCEPT DESIGN

There are currently two recognised guidelines for design of watercourse diversions within Queensland. These guidelines have been developed by DNRME and the Australian Coal Association Research Program (ACARP):

- Guideline: Works that interfere with water in a watercourse for a resource activity – watercourse diversions authorised under the Water Act 2000 (DNRME, 2019)
- Criteria for functioning river landscape units in mining and post mining landscapes (ACARP, 2014)

Both the DNRME and ACARP Guidelines were developed based on previous research completed by ACARP in the early 2000s which included assessment of existing diversion performance and the development of design and rehabilitation criteria for watercourse diversions. Details of the guidelines that have been used to design the Rockland Creek diversion are summarised below.

3.1 DNRME GUIDELINE

3.1.1 Diversion Design Outcome Requirements (Permanent Watercourse Diversions)

The diversion design outcome requirements are nominated by DNRME for permanent watercourse diversions and have been used to develop the design for Deep Creek diversion:

- Outcome 1 - The permanent watercourse diversion incorporates natural features (including geomorphic and vegetation) present in the landscape and in local watercourses.
- Outcome 2 - The permanent watercourse diversion maintains the existing hydrologic characteristics of surface water and groundwater systems.
- Outcome 3 - The hydraulic characteristics of the permanent watercourse diversion are comparable with other local watercourses and suitable for the region in which the watercourse diversion is located.
- Outcome 4 - The permanent watercourse diversion maintains sediment transport and water quality regimes that allow the watercourse diversion to be self-sustaining, while minimising any impacts on upstream and downstream reaches.
- Outcome 5 - The permanent watercourse diversion and associated structures maintain equilibrium and functionality and are appropriate for all substrate conditions they encounter.

3.1.2 Design Criteria

DNRME recommend the following design criteria in development of permanent watercourse diversions and have been considered in development of the Rockland Creek diversion:

- The watercourse diversion should tie-in with the existing or receiving watercourse within the resource tenure boundary.
- The stability and performance of a watercourse diversion is assisted by vegetation within the watercourse diversion and adjoining floodplain and does not include artificial structures for grade control that requires ongoing maintenance.
- The channel capacity must be at least equivalent to the natural stream channel capacity existing in that vicinity.
- The length of the channel should be equivalent to the length of the watercourse it replaces.
- Bed grade/slope should be equivalent to the existing watercourse.
- Batter slopes should be designed to maintain stability through different substrates.

The DNRME Guideline also nominates a set of hydraulic design criteria which have been adapted from the original ACARP research. These hydraulic design criteria were developed based on assessment of existing Bowen Basin streams and watercourse diversions and are considered reflective of stable hydraulic conditions for ephemeral systems in central Queensland. The hydraulic design criteria are summarised in Table 3.1 and include the following:

- Shear stress which is a function of discharge, flow depth and hydraulic gradient and represents the tractive force acting on sediment particles and is used to determine the threshold of motion for sediment. High shear stress provides an indication of potential erosion in cohesive sediments or movement of non-cohesive sediments. It also provides a measure of the ability of vegetation to withstand flow.
- Stream power which is a function of hydraulic gradient, flow width and flow rate and represents the energy available to do work on the channel. High stream power values generally result in elevated erosion potential.
- Velocity which is a function of flow rate and cross-sectional area and is a simplified measure of erosion potential. Generally higher velocities result in higher erosion potential however stream power and shear stress are more reliable indicators of erosion and sediment transport potential.

Table 3.1: DNRME 2019 Hydraulic Design Criteria

Design Flow Event	Stream Power (W/m^2)	Velocity (m/s)	Shear Stress (N/m^2)
2-year ARI (no vegetation)	<35	<1.0	<40
2-year ARI (vegetated)	<60	<1.5	<40
50-year ARI	<150	<2.5	<50

3.2 ACARP GUIDELINES

ACARP (2014) outlined several approaches to the design of diversion channel dimensions, which included an analogous approach, where channel dimensions are selected from a reference reach; a hydraulic geometry approach where dimensions are determined from regression relationships; and an analytical approach, where equations are used to calculate continuity, hydraulic resistance, and sediment transport and channel characteristics are determined from field inspection of a reference reach.

In addition to the analogous approach, ACARP (2014) also provides guidance on alluvial channel design parameters which were adapted from ACARP (2002). These hydraulic parameters are intended to be represented of stable watercourses within the Bowen Basin and are summarised in Table 3.2.

Table 3.2: ACARP 2014 Alluvial Channel Design Parameters

Stream Type	Stream Power (W/m^2)	Stream Power 2-year ARI (W/m^2)	Stream Power 50-year ARI (W/m^2)
Alluvial	Supply limited	15-35	50-100
	Transport limited	35-60	80-150
Bedrock controlled	n/a	50-100	100-350

ACARP (2014) also provides recommendations on shear stress thresholds for vegetation used as part of rehabilitation activities. These thresholds are summarised in Table 3.3.

Table 3.3: ACARP 2014 Recommended Vegetation Shear Stress Thresholds

Vegetation Type	Design Shear Stress (N/m^2)
Buffel grass	40
Structurally diverse suite of established native vegetation	120

The long-term performance of the diversion under both operating and closure scenarios is assessed with the following objectives, based on industry standard closure objectives:

- The diversion demonstrates to be in a safe, stable, non-polluting, and self-sustaining state (as per PRCP Closure Criteria and Environmental Authority requirements as per Section 3.3).
- Reference rehabilitation requirements (acceptance criteria) include goals, objectives and acceptance criteria for the post mining land use of the 'Watercourses' which is applicable for the watercourse diversion.
- Existing water licence diversion objectives generally align with the objectives under the DNRME Guidelines (2019).

3.3 ENVIRONMENTAL AUTHORITY EPML00717813

The land schedule within the Blackwater Mine EA (EPML00717813) requires that all areas significantly disturbed by mining activities must be rehabilitated in accordance with specified Rehabilitation Requirements. The EA provides the rehabilitation landform criteria for the post mining land use of watercourses (refer to Figure 3.1). Some indicators reference the Index of Diversion Condition (IDC) method, which is a component of ongoing diversion monitoring.

Table E1 (Rehabilitation Requirements)

Post Mining Land Use	Goal	Objective	Indicator	Acceptance Criteria
Watercourse	Safe to humans and wildlife	Safety hazards are not significantly different to surrounding unmined landscapes subject to the same land use	Hazard assessment	No significant difference
	Stable	Rehabilitation is erosionally stable	Geomorphic index (IDC method)	Greater or equal to upstream or downstream values.
	Non-polluting	Rainfall runoff from rehabilitation achieves relevant water quality objectives for receiving waters	pH EC Turbidity	Not significantly different to upstream values
	Able to sustain the agreed post-mining land use	Riparian vegetation	Riparian vegetation index (IDC method)	Greater or equal to upstream or downstream values.

Figure 3.1: Blackwater Mine EA EPML00717813 Rehabilitation Requirements for Watercourses

4 OPTIONS IDENTIFICATION

Engeny identified three potential remediation options for the Rockland Creek diversion based on the current alignment, final landform consideration and the future mine plan. To inform the remediation concept design, the geomorphic features of the pre mining drainage path were incorporated and utilised as well as the upstream and downstream channel geometry and grade.

The objective was to identify suitable options for the permanent re-alignment of the Rockland diversion and identify a preferred option to carry though to concept design. The process to define the options includes a review of the natural waterway geometry, the existing creek diversion geometry, original design reports and current diversion design parameters.

Each option was defined with a concept cross section, longitudinal profile and meandering characteristics, if applicable. Civil earthworks modelling was undertaken to confirm the following:

- alignment of the diversion options
- the need for potential flood levees (during operations)
- final landform reconfiguration
- reinstatement of floodplain
- proposed tie-in locations to the existing waterway
- Development Class 5 capital cost estimate

The options identification also includes the assessment of key risks and opportunities regarding potential staging, possible impacts to downstream infrastructure, reinstating the flood plain and post mining land-use risks in the context of closure. The main focus for each option was to determine the impacts and interaction between the PRCP final landform and the proposed diversion. Refer to Figure 4.1 for the potential options identified and Table 4.1 for further details.

Table 4.1: Options Identification Details

Statistic	Option 1	Option 2	Option 3
Description	Meander channel along existing diversion	Take channel south and meander	Divert channel further south
Likelihood that diversion will achieve state of dynamic equilibrium	High – stream length similar to natural pre-mining state	High – stream length similar to natural pre-mining state	High – stream length similar to natural pre-mining state
Ability to integrate into and impacts on the PRCP final landform	Possible change to PRCP final landform	No Impact	No Impact
Diversion constructed through spoil	No	No	No
Order of magnitude cost estimate *	$ 6.9 M	$ 11.4 M	$ 131 M
Ability to isolate diversion from flows during establishment period	No	Yes	Yes
Impacts on coal reserves	No	Yes	Yes

*Cost estimate based on average $10/m^3 and including Rockland Dam embankment removal

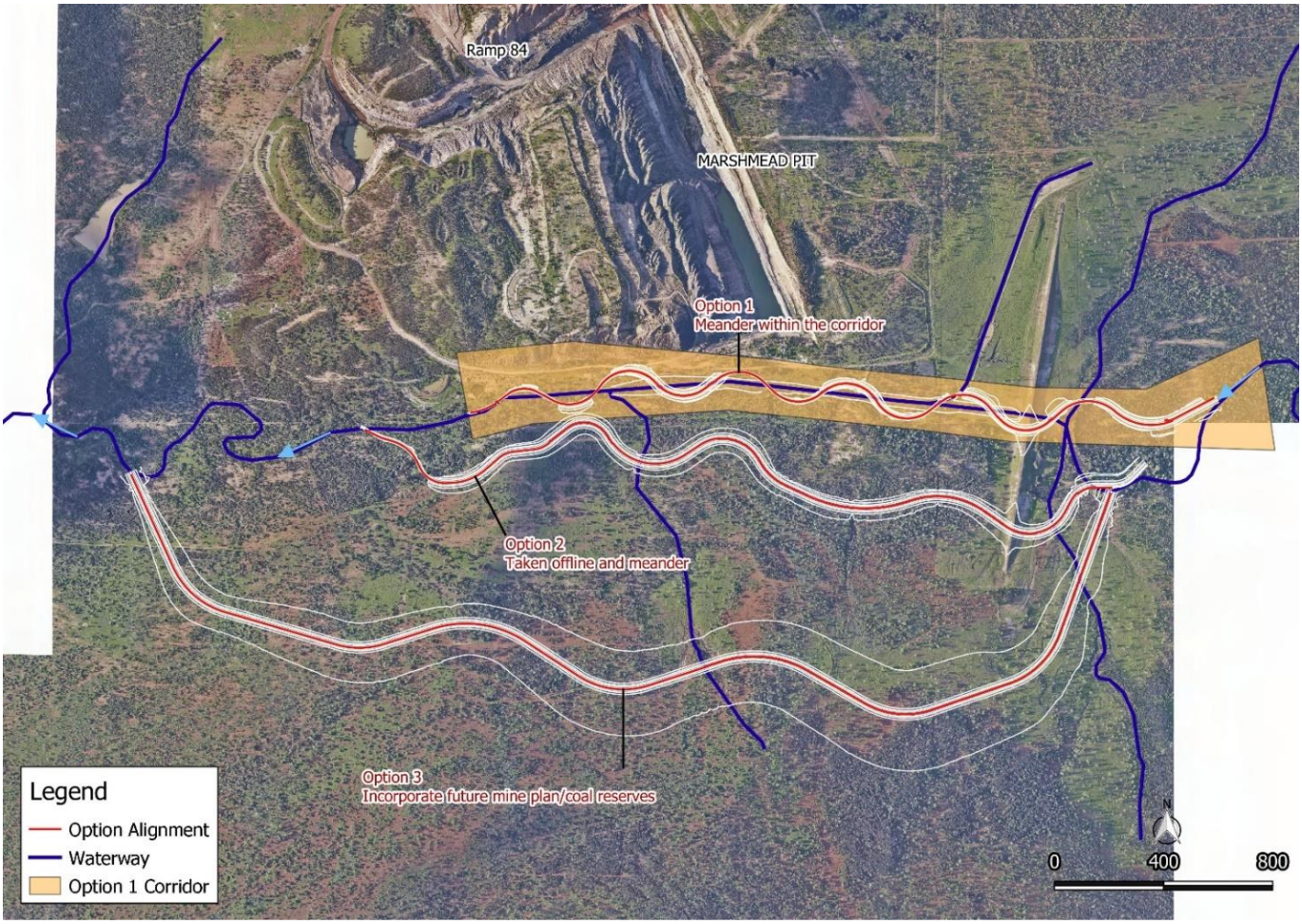

Figure 4.1: Rockland Creek Diversion Remediation Options

5 OPTIONS ANALYSIS

5.1 MULTI-CRITERIA ANALYSIS FRAMEWORK

A high-level multi-criteria analysis (MCA) was undertaken to rank the identified options for individual criteria as per Figure 5.1 below and determine a preferred option. The weighting of each criteria was determined and agreed upon with a BHP and Engeny collaborative decision group. The individual weightings are summarised in Table 5.1. Based on the score for each criteria against each option a preferred option is identified.

Figure 5.1: Ranking Scores for MCA

-3	-2	-1	0	1	2
Fatal Flaw	Strongly Negative	Mildly Negative	Neutral	Mildly Positive	Strongly Positive

Table 5.1: Weighting for Individual Screening Criteria

Criteria	Weight
Likelihood that diversion will achieve state of dynamic equilibrium	40%
Diversion constructed through spoil	30%
Order of magnitude cost estimate	20%
Ability to isolate diversion from flows during establishment period	10%

5.2 MULTI-CRITERIA ANALYSIS

The MCA resulted in Option 2 to be carried forward into concept design as a preferred option, since it scored highest out of all three options and resulted in the lowest relative risk (see Table 5.2). Refer to Appendix A for the detailed MCA and scoring.

Table 5.2: Multi-Criteria Analysis Outcomes

Item	Option 1	Option 2	Option 3
Overall Weighted Score	-0.4	0.1	-0.5
Relative Risk	Neutral Risk	Lowest Risk	Highest Risk

6 CONCEPT DESIGN

6.1 DIVERSION ALIGNMENT

Option 2 was identified to be the preferred option alignment using the MCA. The alignment was further refined to optimise bill of quantities and meander of the channel. Figure 6.1 shows the permanent diversion alignment design and general arrangement of Option 2. The preferred option design is included in Appendix C.

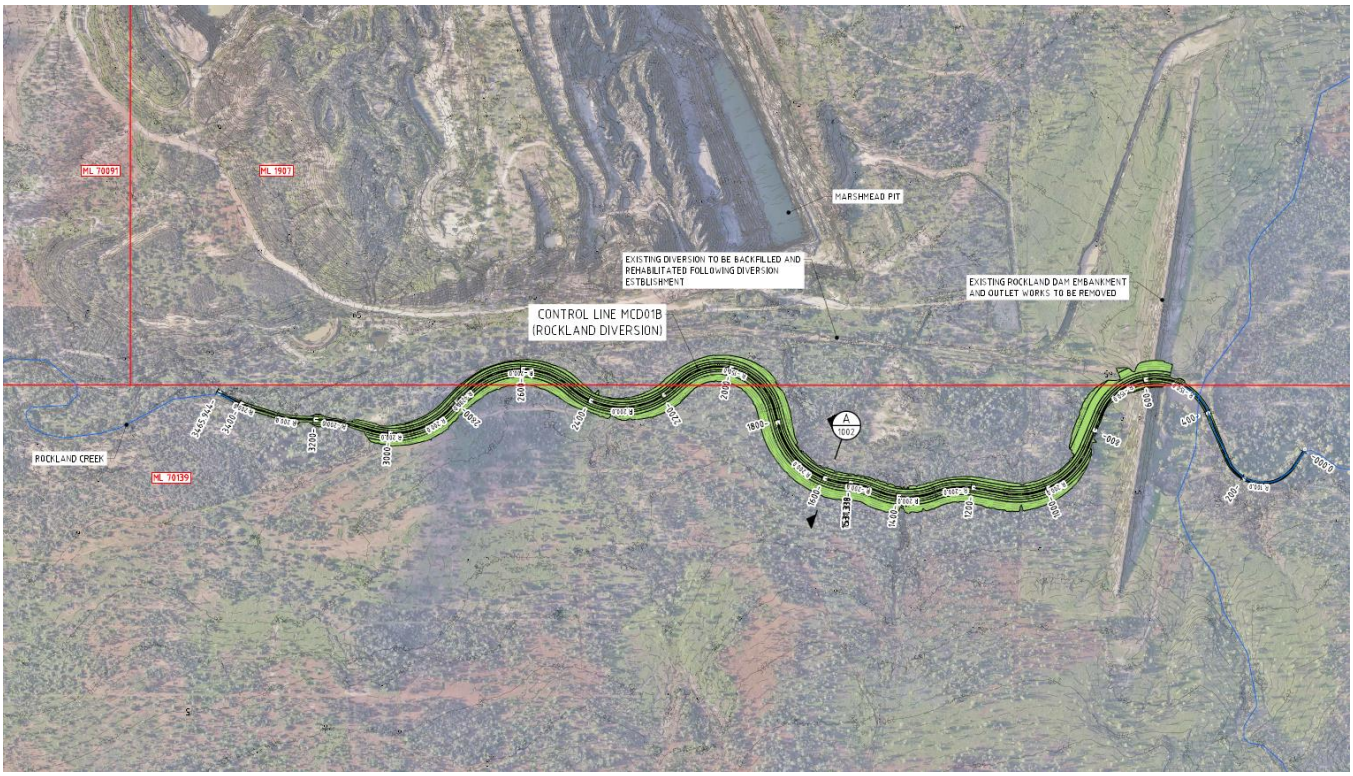

Figure 6.1: Option 2 General Arrangement

6.2 CHANNEL GEOMETRY AND GRADE

The typical upstream and downstream channel geometries are presented Figure 6.2 and Figure 6.3 below. These dimensions were based on the average natural upstream and downstream channel geometry and grade as assessed in the options identification phase.

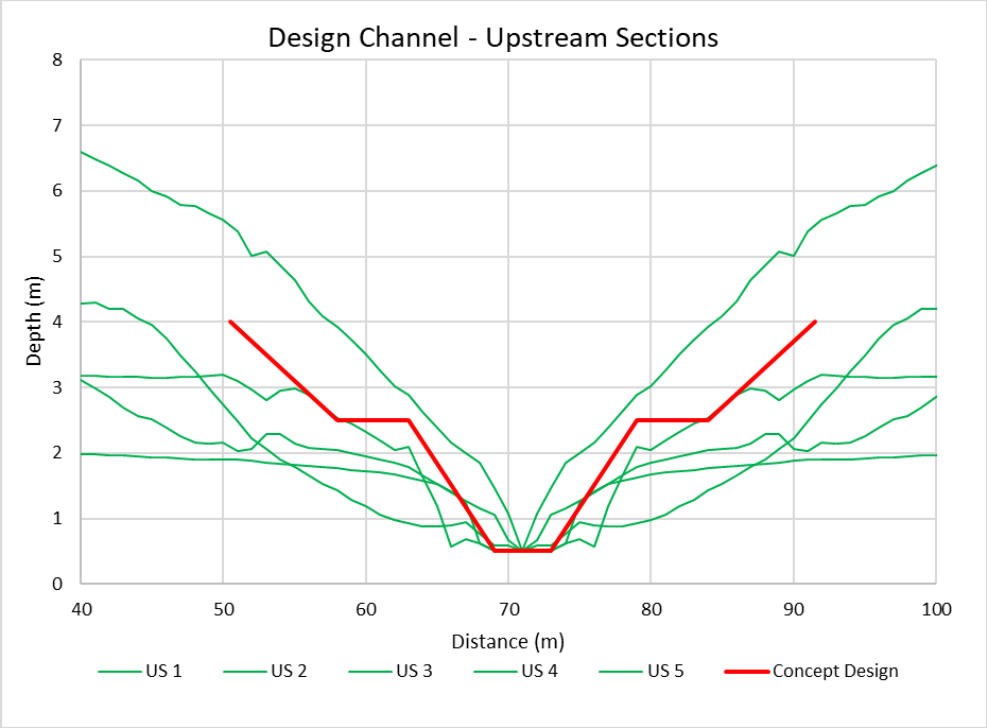

Figure 6.2: Typical Upstream Channel Cross Section

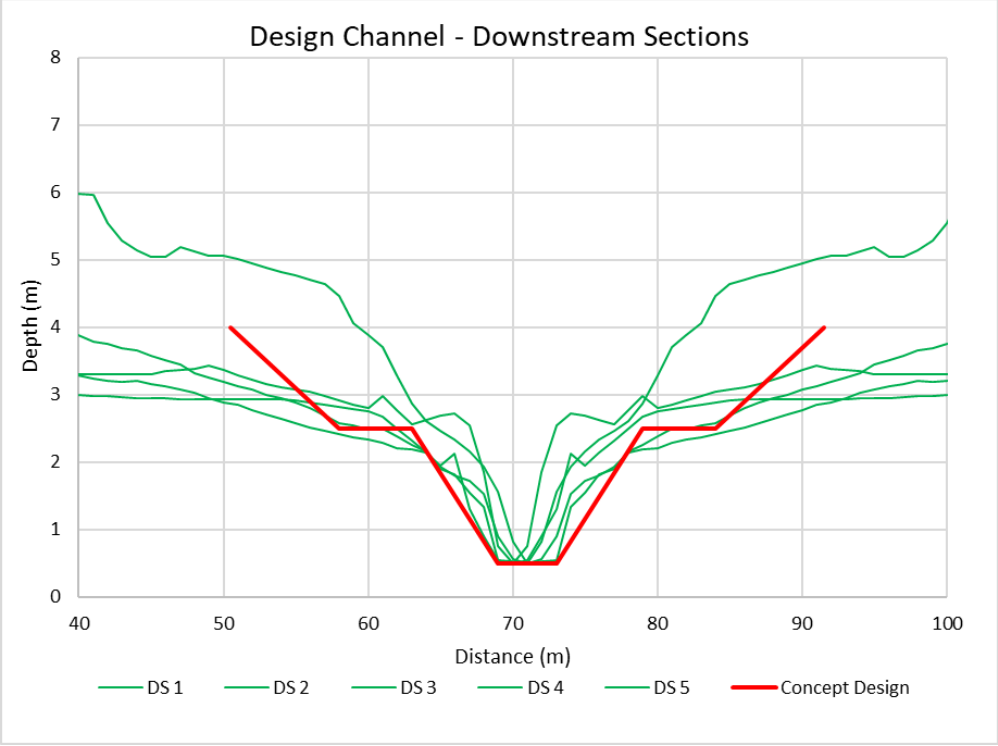

Figure 6.3: Typical Downstream Channel Cross Section

6.3 HYDROLOGY

A hydrologic model of Rockland Creek was developed as part of the Blackwater Mine Flood Model and Water Balance Update (Engeny, 2017). Peak flows for the Rockland Creek diversion remediation were estimated using the ACARP (2002) and are presented in Table 6.1.

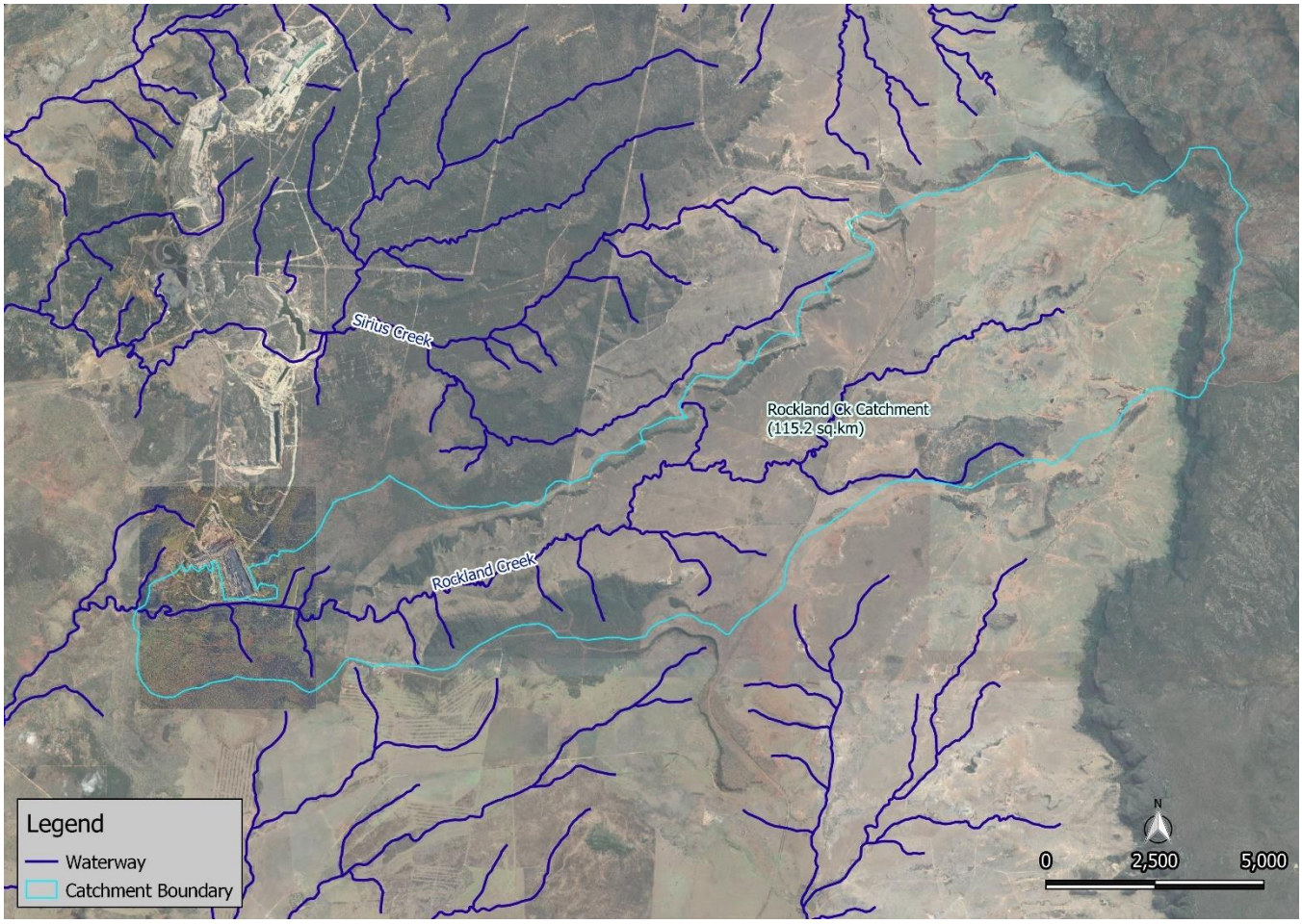

Figure 6.4: Map of Catchments

6.3.1 Frequent Events

The hydrologic model was used to estimate flows through the diversion for the 2-year ARI and 50-year ARI flow events (refer to Table 6.1). The flows have been compared to the ACARP (2014) diversion channel design parameters. A steady flow analysis was undertaken to assess the diversion design against guideline criteria.

Table 6.1: Rockland Creek Diversion Design Flows

Rainfall Event	Diversion Channel Design Flows (ACARP, 2002) m^3/s
2 year ARI	60.4
50 year ARI	148.7

6.4 HYDRAULICS

Stream power is the product of channel slope and discharge. It represents the excess energy available to do work in and on the channel. If there is too much excess energy, then channel erosion may occur. Stream velocity is calculated by dividing flow by cross-sectional area. The higher the velocity, the greater the erosive force of a stream. Shear stress is an indication of the size of granular material that will begin to move at a particular flow within the diversion reach.

Average values were derived from the TUFLOW model for the stream powers, stream velocity and shear stress in a 2-year ARI and 50-year ARI rainfall event (refer to Table 6.2). The proposed diversion values have been compared to the DNRME (2019) diversion channel design parameters.

Table 6.2: Diversion Design Criteria Compared to DNRME (2019) Guideline Parameters

	2-year ARI		50-year ARI	
Design Criteria	Diversion	DNRME Design Parameter (2019)	Diversion	DNRME Design Parameter (2019)
Stream Power (W/m^2)	51	<60	95	<150
Stream Velocity (m/s)	1.25	<1.5	1.54	<2.5
Shear Stress (N/m^2)	38	<40	57	<50

The shear stress for the 50-year ARI exceeds its guideline value. All other parameters are within acceptable limits.

The 2-year ARI shear stresses are below the threshold of 120 N/m^2 at which an established native vegetation is considered stable, as per Table 3.3. It is expected that the channel achieves stability during a flood of this magnitude when the vegetation is fully established.

Appendix B illustrates the variability along the diversion channel for each design parameter and shows a drop in values when the diversion channel opens up to a wider floodplain in the last 500m of the diversion.

6.5 ADDITIONAL DESIGN AND CONSTRUCTION CONSIDERATIONS

6.5.1 Soils

The channel bed and banks are expected to comprise largely of the surrounding spoils, consisting of potentially dispersive sandy to loamy duplex soils. Soils will be protected by emerging vegetation prior to opening the diversion to flow. The final design of the diversion should include appropriate soils and vegetation management strategies. An assessment of soil and growth media characteristics will be completed by an appropriately qualified person, and amelioration and other treatments required will be identified and applied.

Excess supply of sediment from spoil dump in close proximity to the diversion can have potential impact on vegetation establishment within the new channel. It is suggested that measures are put in place to reduce the sediment influx from surrounding landforms during the establishment of the diversion channel. Further investigations and detail to soil suitability and erodibility will need to be gathered in a functional design stage. The concept design assumes that the topsoil application and treatment are assessed and allow for vegetation to successfully establish.

6.5.2 Revegetation

The revegetation for the Rockland Creek diversion is to incorporate species from the pre-clearing environment (as per Relevant Environment RE mapping) as they would naturally occur along Rockland Creek in the vicinity of Blackwater Mine. The revegetation should achieve the following:

- Geomorphic and vegetation features similar to those in the local landscape.
- Maintain a sediment transport regime that does not directly impact on upstream and downstream reaches.
- No ongoing maintenance is required.

Further, hydraulic modelling has demonstrated that the 2-year ARI shear stress is slightly above the ACARP (2014) guideline values for the vegetation establishment within a transport limited system. To ensure vegetation has sufficient time for establishment it is suggested to keep the diversion offline for 1 to 2 wet seasons. Revegetation will reflect the dominant ecosystem of eucalyptus populnea woodland on alluvial plains.

6.5.3 Monitoring and Maintenance

Ongoing monitoring and maintenance of the diversion during the operational phase of the mine is required and carried out as per BHPs monitoring program. The monitoring and maintenance of the diversion during the establishment phase has its main focus on the presence of introduced species, weeds and vegetation establishment.

6.5.4 Closure Landform and Considerations

The PRCP landform can be reconfigured if the diversion is in close proximity to it and its alignment and re-instatement of the floodplain is inhibited by the closure landform. The concept design is required to inform the PRCP closure landform and will be offset to final voids by at least 100 m so seepage to or from voids is not expected.

6.6 RISKS AND MITIGATION MEASURES

The table below summarises the main risks for the diversion remediation design and construction.

Table 6.3: Diversion Risks and Mitigation Measures

Risks	Likelihood	Consequences	Risk Rating and Score	Mitigation Measures	Residual Likelihood	Residual Consequences	Residual Risk Rating and Score
Vegetation establishment and erosion potential	Probable	2	9	Channel taken offline during construction and vegetation establishment phase, vegetation type and seed-mix selected based on local environment	Unlikely	1	1
Damage to new diversion channel due to extreme flood event	Probable	2	9	Diversion channel constructed during dry season	Unlikely	1	1
Constructability of diversion channel – encountering bedrock, material availability and access	Probable	2	9	Geotechnical investigation as part of functional design, topsoil availability on site and construction during dry season (low chance of flood)	Unlikely	1	1

7 CONCLUSION

To develop a PRCP Chapter for the Rockland Creek diversion, a concept design for remediation of the Rockland Creek diversion will be developed. This report illustrates the concept design details and has been prepared in accordance with the requirements of the Department of Natural Resources, Mines and Energy (DNRME) Guideline: *Works that interfere with water in a watercourse for a resource activity – watercourse diversions authorised under the Water Act 2000* (DNRME,2019).

The concept design was developed based on three guidelines, two of which are currently recognised guidelines for design of watercourse diversions within Queensland. These guidelines have been developed by DNRME and the Australian Coal Association Research Program (ACARP):

- Guideline: Works that interfere with water in a watercourse for a resource activity – watercourse diversions authorised under the Water Act 2000 (DNRME, 2019).
- Criteria for functioning river landscape units in mining and post mining landscapes (ACARP, 2014).
- EA condition for specified rehabilitation requirements.

Three options for the remediation of Rockland Creek were identified and the second option was selected to be carried forward into concept design, utilising the Multi-Criteria Analysis outlined in Section 5. The final concept option design, typical cross sections and longitudinal section are presented in Section 6.

The concept design demonstrates that the watercourse diversion will satisfy the closure objectives identified in the guidelines, for PRCP purposes.

8 QUALIFICATIONS

a) In preparing this document, including all relevant calculation and modelling, Engeny Water Management (Engeny) has exercised the degree of skill, care and diligence normally exercised by members of the engineering profession and has acted in accordance with accepted practices of engineering principles.

b) Engeny has used reasonable endeavours to inform itself of the parameters and requirements of the project and has taken reasonable steps to ensure that the works and document is as accurate and comprehensive as possible given the information upon which it has been based including information that may have been provided or obtained by any third party or external sources which has not been independently verified.

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   ii) Engeny considers it prudent to revise any aspect of the works in light of any information which becomes known to it after the date of submission.

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g) This Report does not provide legal advice.

9 REFERENCES

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Appendix A:
Mulit-Criteria Analysis Details

Figure A.1: Multi-Criteria Analysis Details

Multi-Criteria Analysis - Rockland Creek Diversion

Project: PRCP Diversions FY21 (BWM)
Workshop Date: 11/2/2020

-3	-2	-1	0	1	2
Fatal Flaw	Strongly Negative	Mildly Negative	Neutral	Mildly Positive	Strongly Positive

Criteria	Assumptions/Considerations	Weight	Option 1	Option 2	Option 3	Comments
Likelihood that diversion will achieve state of dynamic equilibrium	Considers the difference between diversion length and natural stream length. Ideally diversion length = natural stream length.	40%	-1	1	1	All options are of a similar length to the natural stream length. Option 1 is rated as mildly negative due to the plugs across the natural alignment that would be required - risk of the plugs failing and the diversion reverting back to the current alignment.
Diversion constructed through spoil	For options that interact with the LoA mine plan, it is assumed that mining will occur (even if currently unapproved) then the diversion will be constructed through rehabilitated spoil. It is assumed that the PRCP final landform can be revised to achieve the required offset distances from rehabilitated spoil dumps (although the PRCP final landform would not show spoil dumps).	30%	0	-1	-1	Options 2 and 3 would be constructed through future rehabilitated spoil. Option 1 is confined to the corridor.
Order of magnitude cost estimate	Assumes $10/m3 of cut.	20%	1	0	-3	Option 3 excessive amount of earthworks due to topography - fatal flaw. Backfilling of voids/dams not required for any option.
Ability to isolate diversion from flows during establishment period	Diversion can be isolated from flows if it is constructed offline of the existing diversion.	10%	-2	0	0	Not possible to isolate Option 1 as constructed on same alignment as the existing diversion. Risk of high flow events washing away topsoil during diversion establishment period.
	Overall Weighted Score		-0.4	0.1	-0.5	

Is there a Fatal Flaw?	No	No	Fatal Flaw
Relative Risk	Neutral Risk	Lowest Risk	Highest Risk

Appendix B:
Hydraulic Parameter Modelling Results

Figure B.1: Stream Power TUFLOW Model Results

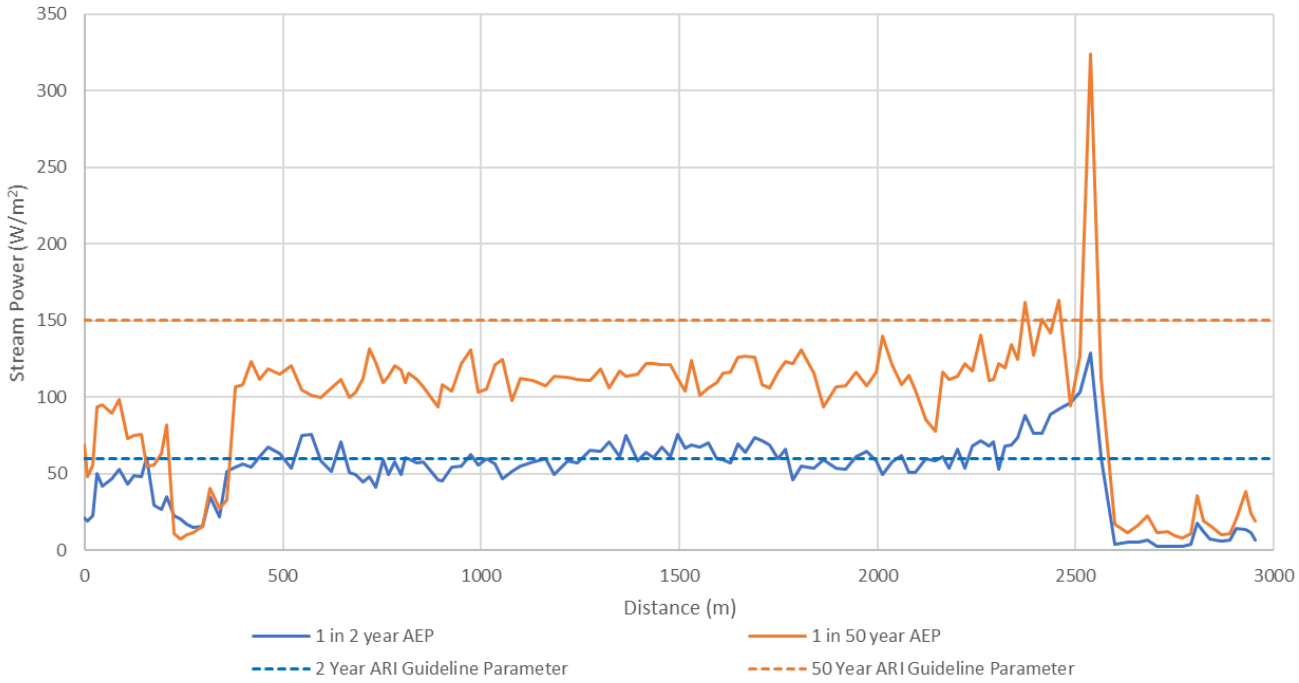


Figure B.2: Velocity TUFLOW Model Results

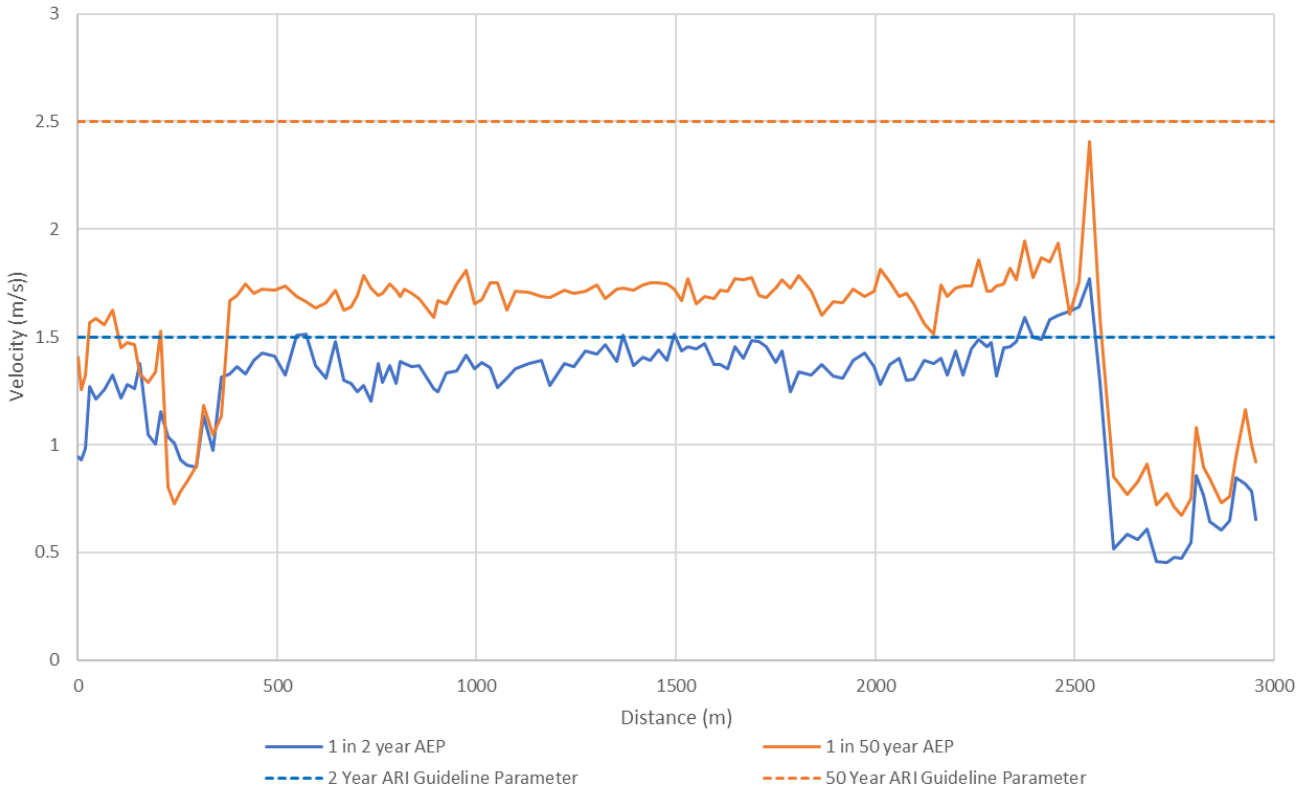
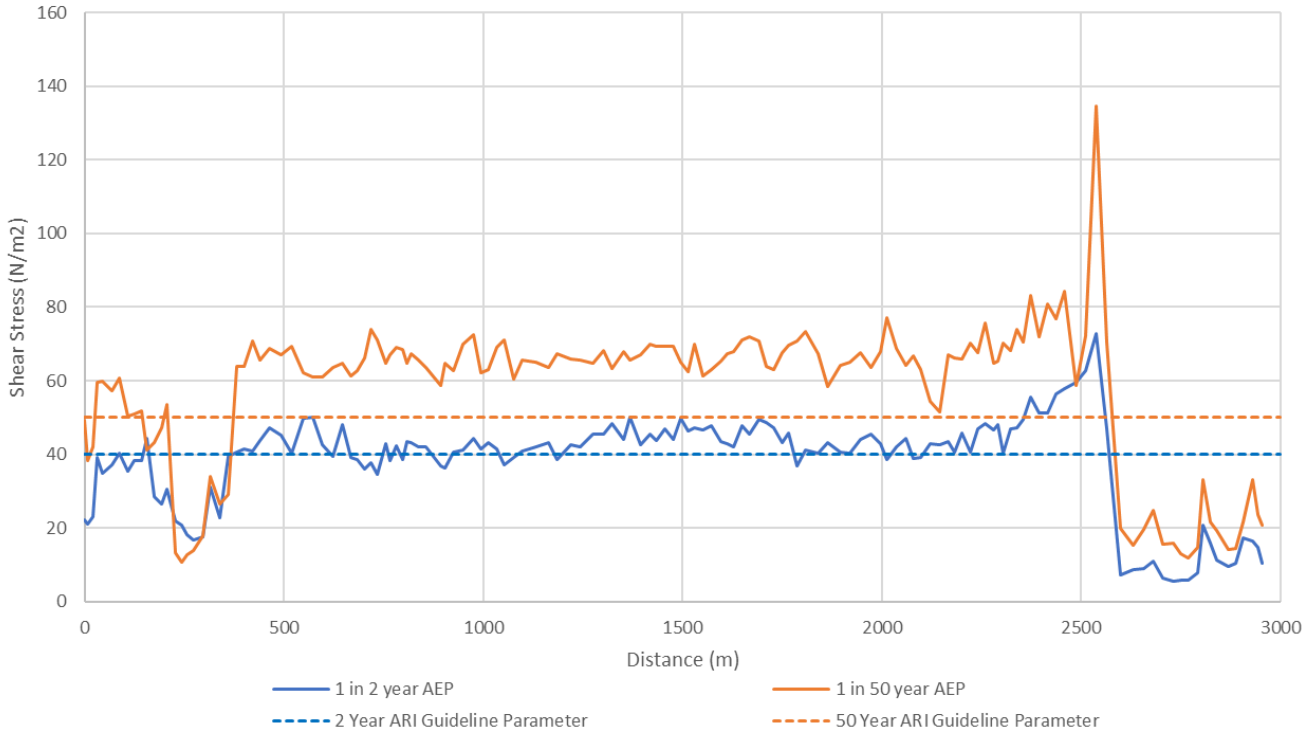
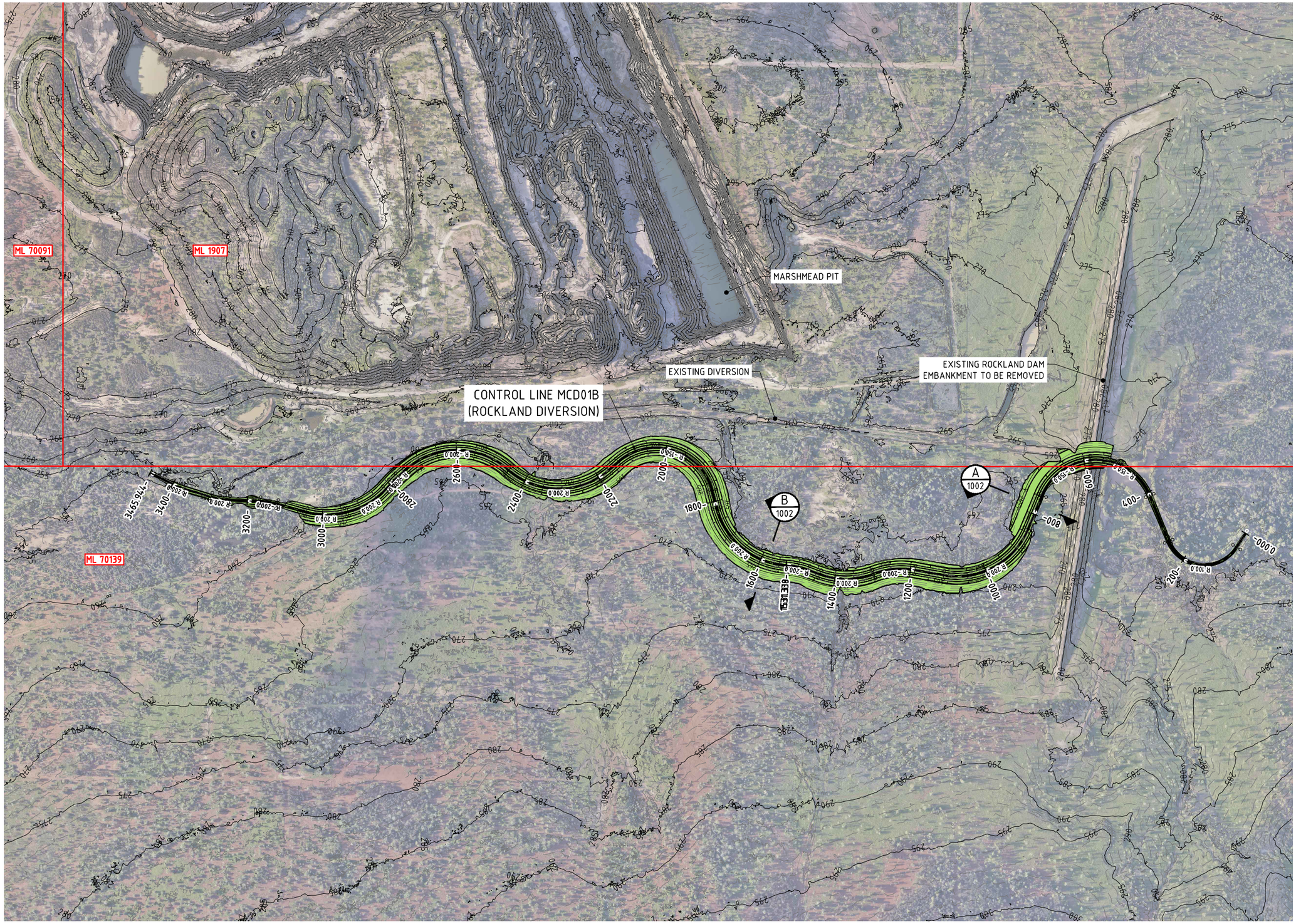


Figure B.3: Shear Stress TUFLOW Model Results



Appendix C:
Preferred Option



GENERAL ARRANGEMENT PLAN
SCALE 1:5000

LEGEND

MINE LEASE BOUNDARY

0 50 100 150 200 250m
SCALE 1:5000 (A1)
SCALE BEFORE REDUCTION

ENGENY WATER MANAGEMENT
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DATE	30.11.20
DRAWN BY	SB
JOB No.	M11000-437

BHP - BLACKWATER MINE

ROCKLAND DIVERSION - OPTION 2
GENERAL ARRANGEMENT PLAN

Original Size A1 | Drg No. M11000-437-SKE-1001 | Rev. A

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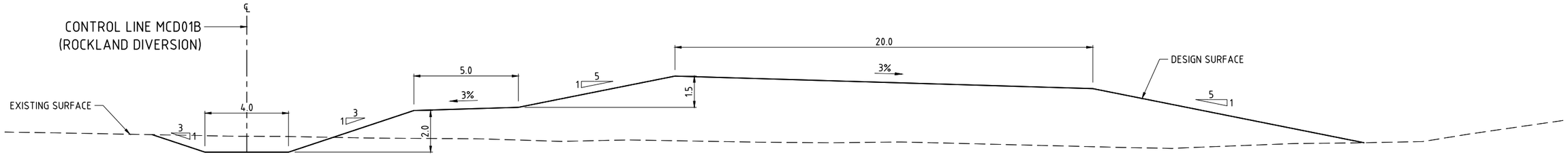

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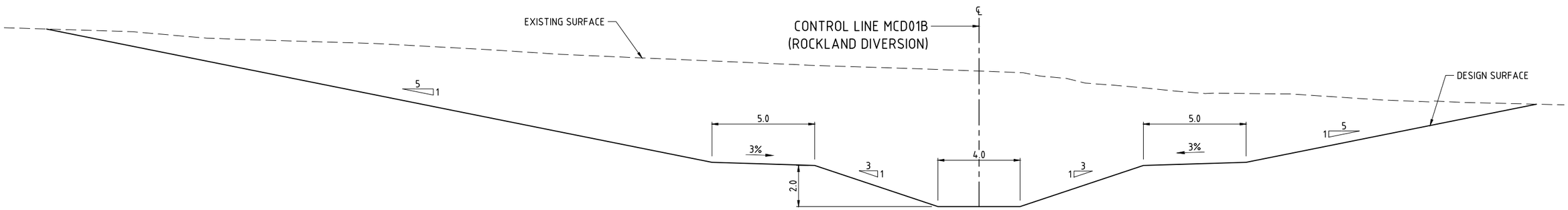

SECTION B
SCALE 1:100
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0 1 2 3 4 5m
SCALE 1:100 (A1)
SCALE BEFORE REDUCTION

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DATE	30.11.20
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BHP - BLACKWATER MINE

ROCKLAND DIVERSION - OPTION 2
TYPICAL SECTIONS & DETAILS

Original Size A1 | Drg No. M11000-437-SKE-1002 | Rev. A

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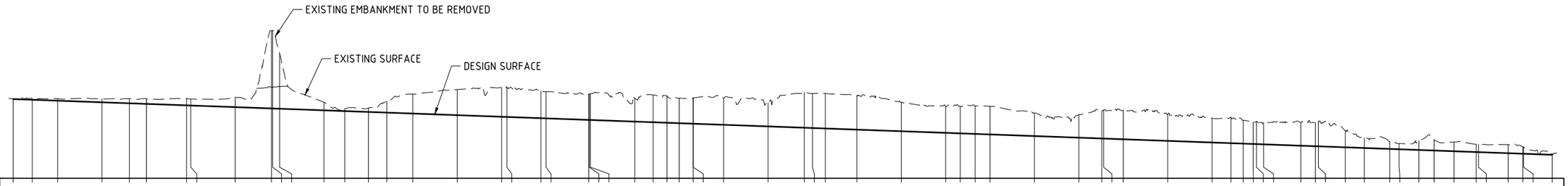
EXISTING EMBANKMENT TO BE REMOVED
EXISTING SURFACE
DESIGN SURFACE

DATUM 248.0

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Whitehaven

Appendix 4.12 – Concept Cover Design

WHITEHAVEN COAL

Concept Cover Designs for Waste Storage Facilities at Blackwater Mine

August 2024

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DOCUMENT AMENDMENT RECORD

Version	Date	Author	Reviewer
Draft	18/08/24	SJ Henderson, RPEQ 4952	M Gastaldon H Morgan
Rev 0, Final	30/08/2024	SJ Henderson	

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1. INTRODUCTION

Whitehaven Coal requested Henderson Geotech Pty Ltd to develop conceptual cover designs for Tailings Storage Facilities (TSFs) and coarse rejects areas at Blackwater Mine, in Central Queensland. The cover designs are intended to support preparation of the rehabilitation planning part of the progressive rehabilitation and closure plan (PRC Plan) for the mine.

This report provides an overview of relevant characteristics of potential cover materials (mining spoil) and waste materials (tailings and coarse rejects). It then describes the existing waste emplacements and potential hazards after mining, leading to objectives for earthen covers. Finally cover designs proposed to meet those rehabilitation objectives for the following facilities:

- NCPP TSF;
- Bonnie Doon TSF;
- Laleham TSF;
- Ramp 72 WSF (tailings and coarse rejects);
- Ramp 74 TSF;
- Bottom Dam TSF and ROM3 Rejects Area WSF; and
- Ramp 36 WSF.

Note that the cover designs have been developed based on material characteristics and accepted practice as understood at the time of preparing this report (August 2024). Before cover construction commences, detailed cover designs will be developed that will use the latest information and data available for each specific facility.

1.1 Limitation

This report has been prepared by Henderson Geotech Pty Ltd for Whitehaven (Client) for the purpose of supporting the Progressive Rehabilitation and Closure Plan for Blackwater Mine. No parties other than the Client and the Department of Environment, Science and Innovation are authorised to rely on this report without the prior written consent of Henderson Geotech Pty Ltd.

This report is, in part, based on information provided by the Client or by other parties on behalf of the Client (Client-supplied information) in addition to data collected by Henderson Geotech Pty Ltd from the public domain. Henderson Geotech Pty Ltd has not always verified the accuracy of such information and makes no representations regarding its accuracy. Henderson Geotech Pty Ltd is not responsible for the consequences of any error or omission in Client-supplied information.

Henderson Geotech Pty Ltd has prepared this report in a manner consistent with the level of care, skill and diligence ordinarily provided by members of the same specialist field for projects of a similar nature and at the time and in the jurisdiction where the services were rendered. Henderson Geotech Pty Ltd makes no warranty, express or implied.

The conceptual cover designs described in this report do not have the level of analysis required for detailed design and are applicable only to the scenarios and inputs also described herein. A new concept design will be required for the particular waste storage facility if there are changes to:

- Final landform geometry;
- Post-mining land use, especially a change requiring different vegetation;
- The approach to surface water management on the relevant final landforms (i.e. free-draining or ponding); or
- The understanding of end-of-mining and long-term groundwater levels in the vicinity of in-pit TSFs.

2. COVER MATERIALS

Spoil at Blackwater Mine is produced by the excavation of sedimentary strata overlying and between coal seams within the Rangal Coal Measures and broadly comprises:

- Unconsolidated and poorly consolidated sediments – small proportions of sandy Quaternary alluvium, usually mixed with Tertiary gravelly, sandy and silty clays.
- Weathered Permian –sand-silt clay mixtures with similar characteristics to Tertiary.
- Fresh Permian – spoil derived from predominantly fine to medium grained sandstone is typically clayey sandy gravel. Overburden/interburden with a higher proportion of siltstone/mudstone produces spoil trending toward gravelly clayey sand; some of the gravel fragments may break down over time.

2.1 Spoil Properties

2.1.1 Tertiary Spoil

Regionally, Quaternary alluvium is generally very shallow and limited to creek floodplains. Consequently, it is rarely excavated as a discrete stratum but is instead combined with Tertiary spoil. At pit and mine scale, the proportion of Quaternary alluvium is rarely sufficient to affect spoil properties.

Figure 2-1 summarises grading and index properties of Tertiary spoil from test results reported for Blackwater and various other mines across the Bowen Basin. It shows that the material is ‘typically’ sandy or silty clay with minor gravel; however, the size grading of individual samples varies over a wide range. The small number of Blackwater samples were typical of the norm and did not include any results with higher proportions of sand or gravel. Experience is that gravel fragments – being weathered rock – often break down with moisture and handling. Basic geochemical properties are summarised in Figure 2-2: using the categories in Hazelton & Murphy (2007), Tertiary spoil is typically moderately to strongly alkaline, moderately to highly saline, strongly sodic, and potentially dispersive. Once again, a proportion of results were well outside the main cluster. The samples from Blackwater Mine trended toward the high side of the distributions for alkalinity and salinity.

Physical and geochemical properties of weathered Permian spoil are usually similar to those of Tertiary spoil. Hence, the two materials are often not differentiated in spoil management practice.

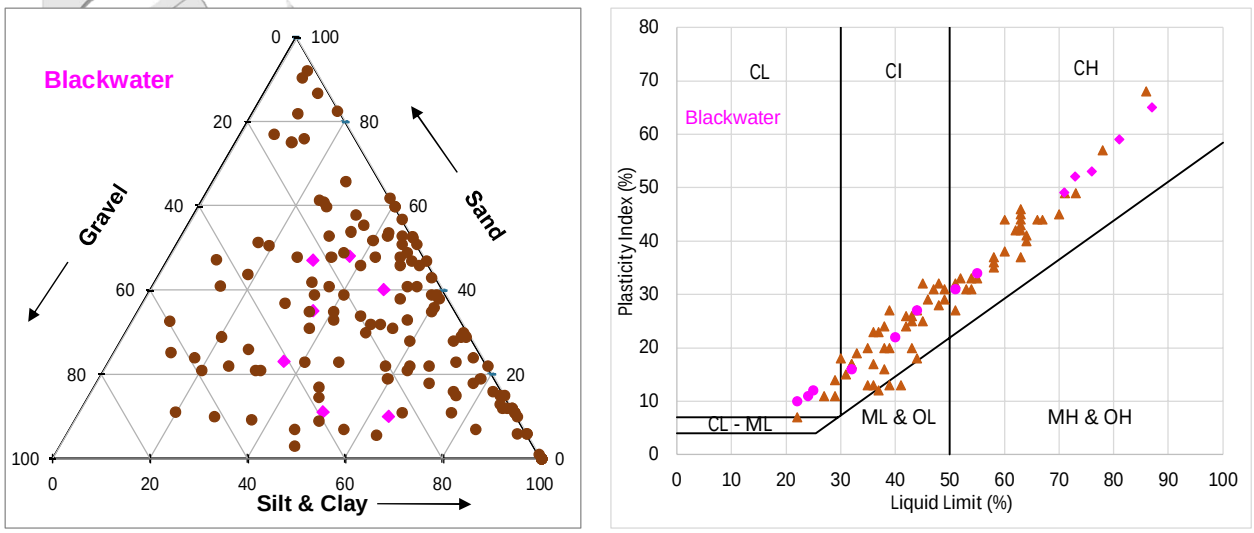

Figure 2-1: Physical Characteristics of Tertiary Spoil

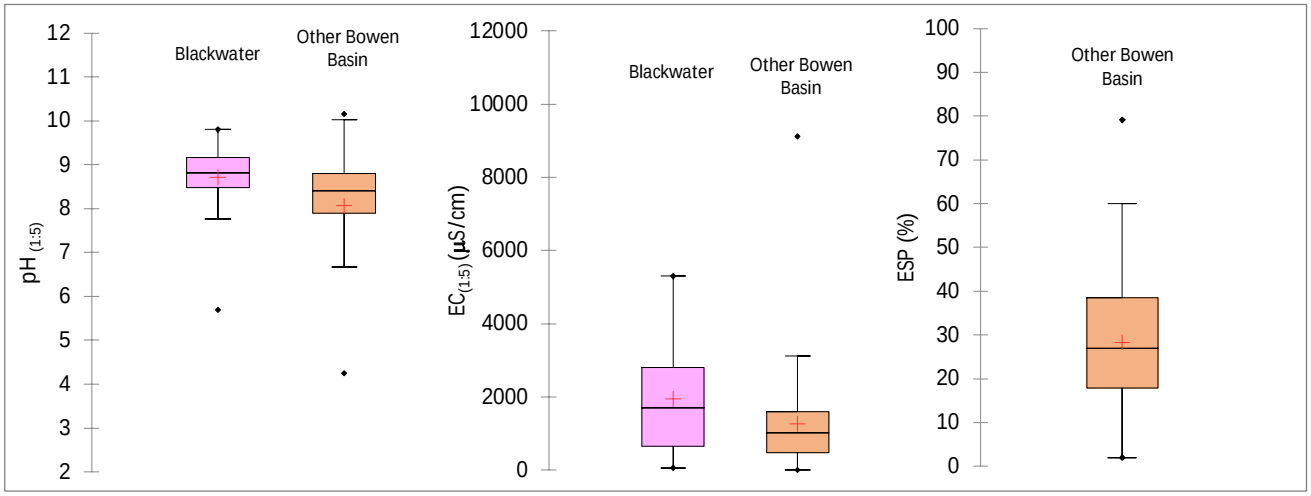

Figure 2-2: Geochemical Characteristics of Tertiary Spoil

2.1.2 Unweathered Permian Spoil

In a similar manner, Figure 2-3 summarises grading and index properties of spoil from fresh Permian overburden/interburden at Blackwater Mine and in the Bowen Basin generally. In contrast to Tertiary spoil, gravel is generally the major size fraction in fresh Permian spoil; however, the limited results available from Blackwater suggest a higher proportion of silt and clay than is typical of the Bowen Basin. Geotechnically, the spoil would be Category 2 (Simmons & McManus, 2004), that is, 'matrix supported'. Note also that the fines do not exhibit high plasticity, both at Blackwater Mine and throughout the Bowen Basin.

Geochemically, fresh Permian spoil ranges from mildly to-strongly alkaline, is variable with regard to salinity and sodicity, and is potentially dispersive (Figure 2-4). If the small number of Blackwater samples are typical of Permian spoil at the mine, it will tend toward the low end for salinity and sodicity.

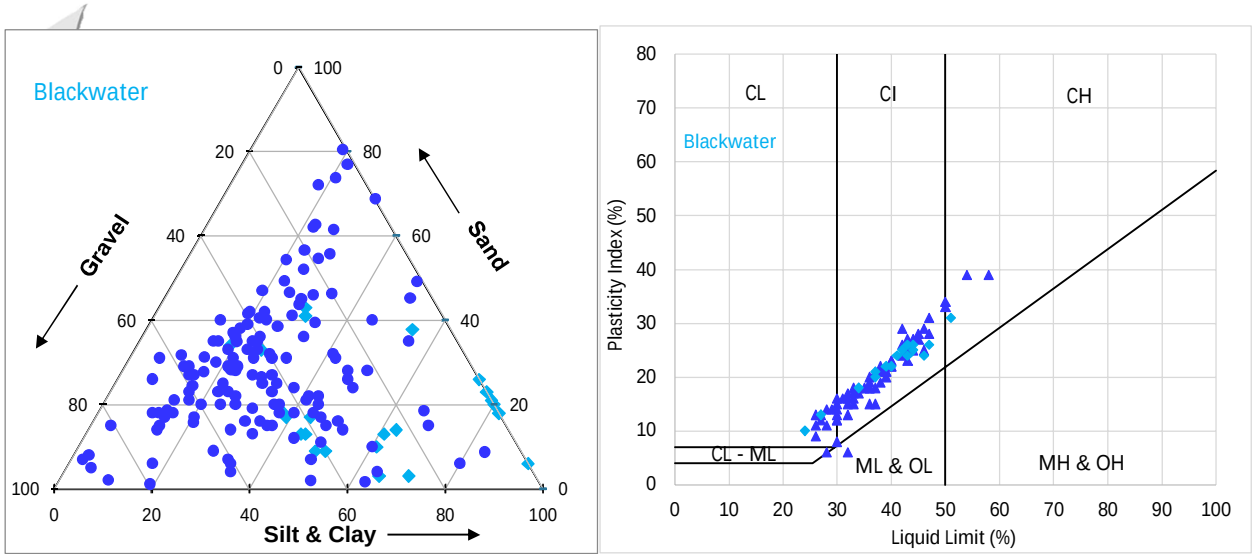

Figure 2-3: Physical Characteristics of Fresh Permian Spoil

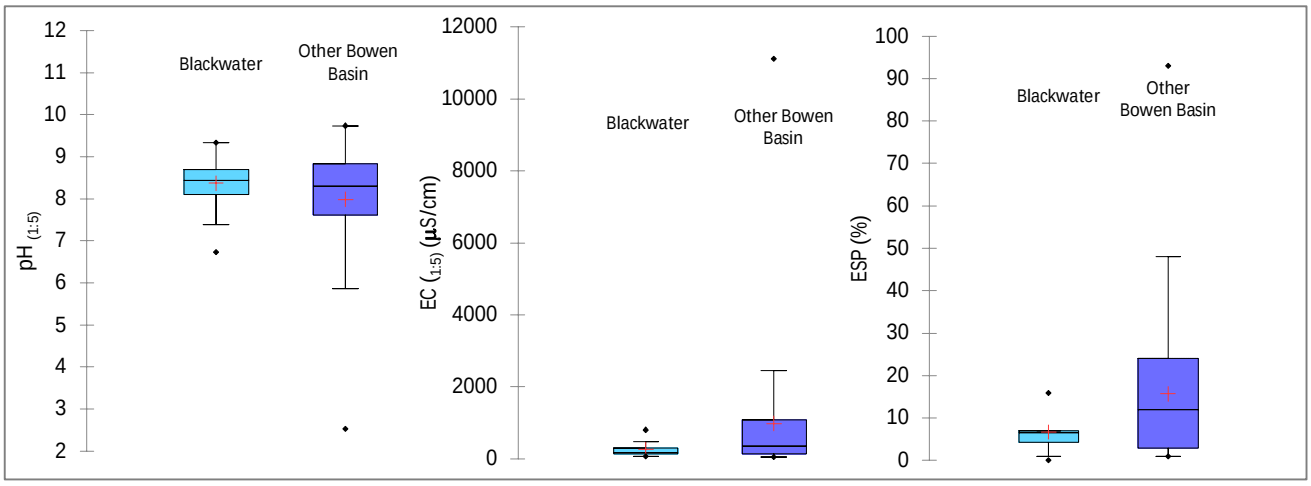

Figure 2-4: Geochemical Characteristics of Fresh Permian Spoil

2.2 Desirable Cover Material Properties

A cover system over chemically hostile material will ideally

- Allow shallow rainfall infiltration to support vegetation and reduce erosion from runoff;
- Not allow infiltration to seep down to the hostile material;
- Not allow solute from the hostile material to flow upward into the root zone or into surface waters;
- Decrease oxygen penetration to restrict acid generation reactions, if there is significant net Potential Acid Generation.

These criteria impose conflicting requirements on cover materials: high permeability allows initial infiltration but low permeability limits deeper seepage; greater clay content reduces permeability but lower clay content reduces matric (capillary) water suction potential. For example, clay-rich spoil from Tertiary and weathered Permian overburden/interburden could be placed to achieve

low permeability but doing so would increase its tendency to allow upward water movement due to capillary action (matric suction potential). Conversely, gravelly spoil would have less tendency to promote upward water movement but might be too permeable to prevent deep infiltration into the tailings.

Water is the most effective barrier to oxygen penetration – either as a permanent water cover or, more commonly, filling pore spaces in the cover material and in tailings themselves. This again presents a conflict in the tailings: maintaining saturation would decrease oxygen movement but dewatering promotes strength gain. In the cover, a higher clay content generally leads to greater water-holding capacity and therefore a higher degree of saturation (water in the pore spaces).

The outcome of this is that a multi-layer cover system is often required, with different spoil types placed to utilise the desirable properties of each and to balance the conflicting requirements. An alternative would be a thick cover of undifferentiated spoil, with the depth of material compensating for poorer cover properties.

Based on geologic boundaries along the planned final highwalls, the thickness of Tertiary/weathered overburden ranges from about 15m to 60m. The 40km of pit length in the middle of the mine will be more than 120m deep. On these bases, and allowing for bulking, future mining of a strip 60m wide will produce more than 1Mm^3 of Tertiary/weathered spoil and 10Mm^3 of fresh Permian spoil per kilometre of length. 1Mm^3 would provide 2m depth of cover over 50Ha of CHPP waste. Consequently, the quantities of both weathered and unweathered spoil available will be easily sufficient to allow selection of suitable materials.

3. WASTE MATERIALS

3.1 Tailings Characterisation

3.1.1 Physical Properties

WSP (2023) presents grading and plasticity index test results for tailings samples from Blackwater Mine. Based on those data, in accordance with AS 1726:2017 (Standards Australia Limited, 2017), the tailings are generally classified as low liquid limit Sandy SILT (ML) and intermediate plasticity Sandy CLAY (CI). A larger private database of results confirmed these descriptions and provided further information, specifically, tailings from NCPP TSF (the historic Blackwater operation) tended to contain more sand while tailings from the old South Blackwater operation contained more silt. However, both fall within the size range encountered across the Bowen Basin and are expected to behave cohesively (like intermediate plasticity clay).

Median solid particle density of samples from NCPP TSF was 1.7 t/m^3, with 80% of results falling tin the range from 1.5 t/m^3 to 2.4 t/m^3. By contrast the median for samples from the southern CHPP was 1.6 t/m^3 and the eighty percentile range was 1.4 t/m^3 to 1.7 t/m^3. Considering the different soil particle densities of coal (~1.4t/m^3) and general overburden (~2.6t/m^3), this suggests that the tailings vary from essentially all coal to no coal. The lower particle densities in the southern TSFs probably reflect the particular configuration of the CHPP that produced them.

Oedometer consolidation tests were reported for five samples, with the following median parameter values:

- Compression Index C_c = *0.14*

- Recompression Index C_r = *0.02*
- Coefficient of permeability k_{sat} = *2e-9 m/s*
- Coefficient of consolidation c_v = *60m²/yr*, but varied over a wide range

These values are close to the median of collated results measured for coal tailings in the Bowen Basin.

3.1.2 Chemical Properties

Geochemical characterisation studies for two TSFs and the NCPP at Blackwater Mine (Terrenus Earth Sciences, 2024) found that half of the tailings (current and historic) have moderate to high potential to generate AMD when they are able to oxidise. The other half of the samples analysed had relatively low potential to generate AMD. Historically, low pH in CHPP waters was an issue for the old South Blackwater Mine operations.

Fresh tailings were assessed as generally slightly saline, while aged tailings were generally slightly to moderately saline. The difference may be partly due to sulphide having oxidised to sulphate in the aged tailings, but might also reflect geochemical differences in the coal, roof and floor being mined at particular times.

3.1.3 In Situ Properties

In the context of rehabilitation, the most important physical properties of tailings are: strength profiles, which constrain safe placement of capping; and moisture-density profiles, which – in combination with consolidation properties - dictate how much water is squeezed out during consolidation, the consequent vertical settlement, and the timeframe over which that consolidation occurs (The Minserve Group et al, 2003).

Tailings has minimal shear strength when initially discharged (being fluid) and strength is only gained over time as the deposit dewaters, densifies, and develops a drier surface crust. WSP (2023) includes plots from a large number of Cone Penetrometer Tests (CPTs) on NCPP TSF that measure in situ strength based on the resistance to pushing a cone-tipped instrument vertically into the tailings. Only five of the tests were located more than 100m from the walls and many were pushed through a wall lift into the underlying tailings. Where the tailings surface was exposed, the drier (and stronger) crust was typically 1-2m thick, below which the tailings were variable but typically of soft or firm-stiff consistency.

The same report presents 16 CPT plots from Laleham TSF, again with most located close to the edge of the storage area. Existing spoil cover and crusted or consolidated tailings ranged from about 2-9m thick and there were thick layers of soft tailings at depth. Only three CPTs are included for R72 TSF. Two tests in the pit indicated a 3-4m thick desiccated crest with soft-firm tailings below, while the single test in the ramp section (the historic decant pond) showed <1m thick crust over very soft tailings. EDG (2024) presents 7 CPTs for Bottom Dam TSF. The crust depth in these ranged from 1-3m and the underlying tailings were generally of soft consistency but sometimes soft-firm.

It is understood that no strength profiling has yet been undertaken on R74 TSF. Bonnie Doon TSF is still active and profiling will be undertaken after tailings deposition has ceased and the fine waste has had some time to dewater and consolidate.

It is emphasised that strength in TSFs varies with location, depth, and time. As a consequence, testing carried out significantly in advance of cover construction may be useful for planning purposes, but detailed cover design should be based on testing undertaken closer to the start of cover construction. Even then, considering the inevitable variability throughout the emplaced tailings, the construction methodology and schedule should be adaptable to actual conditions encountered.

3.2 Coarse Rejects Characterisation

3.2.1 Physical Properties

Historic size grading data collated from mines in the Bowen Basin and summarised on Figure 3-1 indicates a composition ranging from *GRAVEL with sand* to *Sandy GRAVEL* (Standards Australia Limited, 2017). Current NCPP waste handled as rejects comprises about 80% from the Coarse Circuit that treats the 50mm to 1.4mm size range. The remainder is from the Fine Circuit and is in the 1.4mm to 0.25mm size range. Rejects comprise about 75% of waste produced by NCPP (tailings are produced from the ultra-fine circuit). Noting that gravel is >2.36mm and sand is 2.36mm to 0.075mm, these ranges confirm that coarse rejects currently produced are consistent with the collated historic data.

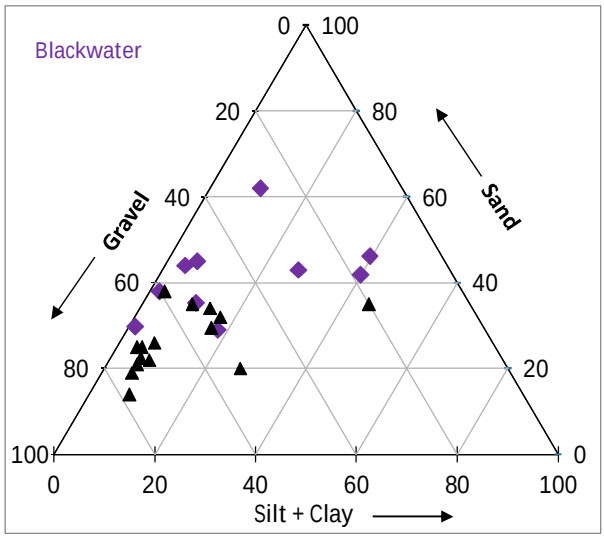

Figure 3-1: Particle Size Distribution of Coarse Rejects in the Bowen Basin

The classification of Sandy GRAVEL is also consistent with field observation that coarse rejects are a non-cohesive non-plastic material exhibiting frictional strength and high permeability.

In coarse rejects, solids particle density (specific gravity) varies with the ratio of fresh Permian spoil (from seam roof and floor) to coal. For example, 20% coal would produce an average solids particle density of about 2.4t/m^3 whereas 40% coal would produce an average of about 2.1t/m^3.

As an unsaturated non-cohesive material, coarse rejects will not experience consolidation settlement overtime. Some settlement is expected as the cover is constructed and imposes vertical load on the rejects and there may be further settlement due to moisture adjustment and particle breakage, but significant movement after the first few years is unlikely.

3.2.2 Chemical Properties

A geochemical characterisation study found that slightly less than half of the coarse rejects sampled at Blackwater Mine have moderate to high potential to generate AMD while the remainder had low to low-moderate potential to generate AMD (Terrenus Earth Sciences, 2024).

Samples of fresh coarse rejects were found to be generally non-saline, whereas aged rejects ranged from non-saline to moderately saline. Based on total sulphur concentration, the potential for saline drainage from sulphide oxidation was assessed as low to low-moderate.

3.2.3 In Situ Properties

The gravelly character of coarse rejects makes them difficult to test appropriately in situ. Five samples from the NCPP tested in 1974, gave a median dry density of 1.3t/m^3. Seventeen laboratory shear test results collated from mines in the Bowen Basin gave a median friction angle of 34° with three-quarters of the results within the range of 28° to 30°.

Because the waste is free draining (highly permeable) and not subject to consolidation settlement, density-moisture profiles are not important for rehabilitation design.

4. CONCEPTUAL COVER DESIGNS

4.1 Hazards at Closure

The Minserve Group (2003) identified potential hazards that may need to be addressed in tailings dam closure. The drivers and controls for these hazards are summarized in Table 4-1. Because Ramp 72, Ramp 36 WSF and ROM 3 Rejects Area also contain coarse rejects, the hazards have been re-phrased for ‘waste’ rather than only tailings, although the hazards relating to strength and consolidation will rarely apply to coarse rejects. As foreshadowed in Section 2.2, some hazard control objectives can impose conflicting requirements on cover systems, with complex interactions. These are discussed in the following paragraphs.

A cover constructed over the tailings at closure may have conflicting effects on seepage hazards (a & b): cessation of tailings discharge and removal of the decant pond both reduce seepage; but the weight of cover layers could temporarily increase pore water pressures in the tailings and consequently increase seepage; and rainfall infiltration through the landform into the tailings and coarse rejects could provide water to continue seepage. The weight effect will decrease over time as excess pore pressure equilibrates, but the cover system should aim to minimise recharge of tailings moisture from deep infiltration. Restricting recharge in this way will control seepage in the long term; however, measures separate from cover system design – for example, cut-off or collection trenches – may also be required over the initial period post-mining.

Acid drainage and/or neutral metalliferous drainage and moderate salinity are the geochemical hazards associated with tailings at Blackwater Mine (refer Section 3.1.2). Acidity and salinity can both have adverse effects on vegetation and consequent metal elevation might have impacts on the higher food chain. Oxygen is required for the chemical reactions that produce acid; to a large extent, oxygen cannot penetrate into water-saturated tailings and consequently, tailings with a degree of saturation greater than about 85% are not expected to produce acid drainage regardless of their acid generating capacity. The unsaturated surface layer of tailings already

contains oxygen for the reactions to proceed – in fact, those tailings have usually already oxidized to some extent before the cover is placed. A saturated layer within the cover system would limit ingress of further oxygen but in practice such a layer would be difficult to sustain in the drought-susceptible central Queensland climate. Furthermore, limiting oxygen penetration would not reduce the hazard from salinity. Given this context, adverse effects on vegetation could occur if water from the tailings flowed upward through the cover or seeped out of the walls or base.

The mechanisms that might drive upward flow against gravity are: soil suction (e.g. capillary action) drawing moisture from more saturated to less saturated layers; and consolidation settlement pushing water upwards out of the matrix of tailings solids. To mitigate the hazards to vegetation (d & e), the cover system should be designed to provide a barrier between solutes in the tailings and the topsoil and subsoil layers.

Consolidation settlement (hazard g) occurs when the loads on saturated tailings cause excess pore water pressures and water flows out of the material to reduce those pore pressures until equilibrium is achieved. The amount of settlement varies with depth and water content of the tailings and with height of overlying landform; consequently, settlement is unlikely to be constant over the TSF. All else being equal, a thinner cover would produce less settlement itself, but there is often a component of ongoing consolidation in the lower tailings due to the overlying tailings, and other hazard control objectives that are not served by minimising cover thickness. In addition, in the long term, greater consolidation has beneficial effects, including that it increases tailings strength to better support surface loads, it reduces the tendency to liquefaction, and it may cause upward flow of pore water that will re-saturate some of the near-surface tailings and thus limit future acid generation. In summary, the cover system needs to accommodate consolidation settlement but should not (and generally cannot) aim to avoid it.

Table 4-1: Potential Hazards at Closure

	Hazard	Source	Receptor	Cover System Controls
a	Contaminants seeping to groundwater	Waste has soluble contaminants that may leach at elevated concentrations AND TSF has permeable layers below base	There is a groundwater resource within the seepage path	Conflicting and complex effects, refer accompanying discussion
b	Contaminants seeping to surface water	Waste has soluble contaminants that may leach at elevated concentrations AND TSF has permeable layers in base	The seepage path daylights at ground surface	Conflicting and complex effects, refer accompanying discussion
c	Contaminants spilling to surface water	Waste has soluble contaminants that may leach at elevated concentrations AND Water can pond at surface	There is a watercourse within the overflow path	Shape landform to shed water OR Shape landform to maintain a permanent water cover without overflow
d	Contaminants affecting vegetation	Waste has soluble contaminants that may leach at elevated concentrations	Vegetation that is sensitive to the contaminants will grow on or near the facility	Complex effects, refer accompanying discussion
e	Contaminants entering food chain	Waste has soluble contaminants that bio-accumulate that may leach at elevated concentrations	Stock or native fauna will regularly eat affected vegetation	Complex effects, refer accompanying discussion
f	Interference with natural surface drainage	The facility significantly alters surface topography	There is a watercourse whose flow regime is significantly altered	Cover system cannot mitigate this; it must be addressed by landform/landscape design
g	Consolidation settlement affecting landform surface drainage	At least part of the waste is saturated and will compress under the weight of overlying tailings and cover	Surface drainage is sensitive to changes in ground slopes and gradients	Conflicting and complex effects, refer accompanying discussion
h	Minor release of waste solids due to erosion	Waste is erodible	Surrounding land or watercourses would be adversely affected by ongoing small amounts of waste	Any intact physical cover will prevent this
i	Major release of waste solids due to embankment failure	At least part of the waste has insufficient shear strength to hold a stable landform without embankment support	Surrounding land or watercourses would be adversely affected by a large amount of waste	Cover system cannot significantly mitigate this; it must be addressed by long-term embankment/ landform design
j	Combustion of waste	At least part of the waste is unsaturated and contains sufficient coal to burn	Surrounding vegetation could be ignited by burning waste OR Air quality is a significant value in the surrounding environment	Any intact physical cover thicker than about 0.1m will prevent this
k	Dust generation	Waste at the surface is unsaturated and includes fine particles	Air quality is a significant value in the surrounding environment	Any intact physical cover will prevent this
l	Equipment bogging in, or sinking into, waste[1]	Waste profile has low strength	Land use requires equipment or infrastructure to be on the landform	Design cover system to support and spread surface loads associated with land use

[11] This hazard was not identified in The Minserve Group (2003)

4.2 Objectives and Concepts

The hazard control measures arrived at in the preceding section essentially reflect the ideal cover material characteristics outlined in Section 2.2 with additional requirements related to load bearing capacity and consolidation. Paraphrasing those requirements, the key objectives of the covers for TSFs at Blackwater Mine are:

- To allow shallow infiltration but minimise recharge of tailings moisture from deep infiltration of rainfall;
- To avoid upward movement of solutes from tailings into the vegetation rooting zone;
- To support and spread pressures from anticipated surface loads enough that the bearing capacity of the tailings is not exceeded; and
- To accommodate long-term consolidation settlement in the tailings, such that the first two objectives and surface erosional stability are not compromised.

On mounded landforms that do not pond water, these objectives can potentially be achieved by two conceptual earth cover configurations, namely:

- A multi-layer cover comprising (from tailings to surface):
    - *Porous, low clay content material placed directly over the waste to limit upward flow;*
    - *A layer of lower permeability material finished with a mounded top surface so that any seepage that does reach it will tend to move laterally rather than downward; and*
    - *Uncompacted subsoil and topsoil shaped to a gently mounded surface, to allow shallow infiltration during rainfall but no surface ponding that would drive deeper seepage.*
- A single cover layer of Category 2 or Category 2-3 spoil (connected matrix of fine-grained material), loose placed but thick enough to perform the required functions without specifically differentiated permeability and matric suction properties.

In situations where it is not practical to construct a mounded cover that will not pond water, the cover will require a different design approach depending on whether the surface pond is ephemeral or permanent.

For ephemeral surface water:

- A multi-layer cover with an engineered very low permeability layer comprising (from base of cover to surface):
    - *Porous, low clay content material placed directly over the waste to limit upward flow;*
    - *A thin compacted clay layer to minimise downward flow;*
    - *A layer of medium- or coarse-grained spoil (*Simmons & McManus, 2004 Category 2-3, 3 or 4) to protect the clay layer from drying and physical damage, and to limit entrapment of fauna.

For permanent surface water:

- The water itself will be the cover, justified by the findings of Senes Consultants (2002) that shallow water covers are effective at greatly reducing the rates of sulphide oxidation, and therefore controlling the consequent production of mobile contaminants. In central Queensland, this type of cover may be appropriate for in-pit TSFs where a permanent pit lake can establish over the tailings, but several other specific constraints would also need to be met.

The choice of cover system for each TSF depends on the specific situation and hazards, availability of cover materials, and vision for landform and land use, as described in following reports sections.

5. NCPP TSF

5.1 Description

NCPP is an active aboveground (turkey's nest) TSF located at the west and south-west of the CHPP and rail loop, and bounded by a minor public road at the north-west.

The original tailings dam commenced in 1970 and comprised a single earthfill embankment across a northern tributary of Deep Creek. The facility has been raised and extended in various stages since then, with downstream and upstream wall lifts constructed of earthfill and, in recent decades, mainly coarse rejects. A final small raise was constructed in 2022 and routine tailings deposition ceased in 2023. There is a small emergency storage capacity remaining.

The TSF is 1.4km north-south and 1.7km east-west, with a footprint, of about 198Ha. Depth of tailings ranges up to 32m. The deposited tailings beach down to a decant pond inside the southern wall of the dam.

5.2 Surrounding Environment

At the northern side, the toe of the TSF is less than 40m from the rail loop. The CHPP is east of that, about 600m from the TSF, but part of the associated industrial area is closer. The north-western wall runs about 40m from a minor public road outside the lease boundary, with a rail line west of the road. Natural ground falls broadly from west to east, such that the TSF is upslope of the CHPP and associated buildings. The tributary of Deep Creek was diverted about 300m south of NCPP TSF, then the creek channel flows north to within about 60m of the eastern wall toe before flowing eastward through a culvert under the main mine haul road. Prior to mining and outside the area of mine disturbance, the dominant land use has been low intensity grazing, except in Amaroo State Forest more than 1.5km west and south-west of the TSF. Regulated vegetation (endangered regional ecosystem comprising acacia dominated open forest, woodland or shrublands) is mapped to the south-west of the TSF; regulated vegetation (riverine) is mapped along Deep Creek.

The final landform design for NCPP TSF is a stand-alone elevated landform surrounded by undisturbed and rehabilitated land at essentially pre-mining elevation. Deep Creek is a watercourse defined by the Water Act 2000.

In and around the mine area, groundwater occurs mainly in the coal seams in the Permian Rangal Coal Measures and potentially in poorly consolidated Tertiary sediments. Quaternary alluvium is limited to some current drainage features and watercourses and investigations to date suggest that any groundwater is ephemeral and associated with creek flows, rather than representing a sustained water table (SLR, 2024). That report also included flow path simulations to assess the movement of water particles within the groundwater system post-mining. However, the particles were positioned at mid-depth in the highest saturated aquifer at the start of the simulation. That is, the simulation indicated to fate of water from a surface storage, such as NCPP TSF, if it seeped downward into groundwater, but not the likelihood of such seepage occurring. Geology mapped for the footprint of NCPP TSF is regolith weathered from the Burngrove Formation that stratigraphically underlies the Rangal Coal Measures, with a small area of cemented Tertiary sediment along the western edge. Given this context, NCPP TSF is unlikely to be hydraulically connected to any significant aquifers.

5.3 Cover Design

5.3.1 Specific Hazards

The planned final landform is a mounded shape that will not pond water, so there is no risk of spill to surface water (hazard c in Table 4-1). The TSF altered natural surface drainage as it was constructed, mainly by changing where overland flow from the TSF area enters Deep Creek, but closure will not have significant additional impact (hazard f). Given the proximity, there is the possibility of shallow seepage out of the TSF and into Deep Creek. If seepage did occur, the rate would decrease over time since tailings deposition has ceased (hazard b). A cover system designed to minimize deep infiltration would also reduce long-term seepage. However, as noted in Section 4.1, direct control measures unrelated to cover design might also be required. Any deep seepage from the TSF would tend to follow the excavated ground surface into a final void and therefore would not measurably reach regional groundwaters (hazard a).

As an aboveground TSF, embankments are required to structurally contain low strength tailings, and so embankment failure is a credible scenario (hazard i). However, the cover can only influence embankment stability indirectly and in a limited way – by avoiding accumulation of water and consequent pore pressure increase – and so this hazard will be separately addressed through detailed design for overall decommissioning of the TSF.

Other relevant potential hazards will be addressed by the general controls outlined in Table 4-1.

5.3.2 Cover Concept Design

In the context of being rehabilitated to a separate elevated landform, the thick simple cover would generate a larger footprint because the higher surface elevation would involve longer slopes down to natural ground level. It might also be difficult to have a cover thick enough to meet infiltration objectives without it being so thick that its weight would cause excessive consolidation settlement. Consequently, the preferred cover for this TSF is the multi-layer system.

Gravelly fresh Permian spoil would be suitable for the base cover layer. Clay-rich spoil from Tertiary and weathered Permian overburden may be used for the lower permeability layer. Fresh Permian spoil is expected to have lower salinity and sodicity, which would make it also suitable for the subsoil layer, subject to chemical amelioration if testing suggest that is necessary.

Tailings consolidation settlement will vary with tailings depth and water content profile (or conversely, density profile) and with cover thickness, and is expected to occur over a long timeframe – potentially decades. Conceptually, this settlement can be accommodated by making the relevant layers of the cover thicker in the areas where greater settlement is predicted so that mounded interfaces and surfaces will remain mounded after the settlement has occurred.

5.3.3 Design Details

The over-arching objective for rehabilitation of NCPP TSF is to create a landform that permanently contains tailing solids, limits any release of solutes to levels that will not cause environmental harm, and can support managed grazing within a wider grazing enterprise. The following specify minimum layer thicknesses, but actual dimensions could be greater, either to create a landform that sheds rainfall runoff without ponding but also without causing excessive erosion, or from considerations of constructability:

- Bulk shaping fill comprising low clay content spoil and/or coarse rejects with low AMD potential will be spread over crusted tailings. Thickness will be as needed to provide a mounded, free-draining subsurface. The spoil/rejects will have minimal compaction to limit moisture suction potential;
- A 1m minimum thickness layer of selected weathered Permian and/or Tertiary spoil, will be spread and worked so as to be at least ten times less permeable than material above and below it. The surface will be shaped to shed any deep infiltration out of the landform when constructed and after consolidation settlement has occurred. This will require the surface of the layer to extend over the crests of the engineered embankments so that any such drainage would exit the landform;
- A 2m minimum thickness of more permeable material such as gravelly fresh Permian spoil will be placed over the low permeability layer. The thickness may be greater than 2m if needed to maintain separation between the vegetation rooting zone and the low permeability layer, and to allow a final ground surface that will shed rainfall without ponding with slopes not greater than those on rehabilitated spoil emplacement areas;
- Topsoil and erosion management practices consistent with those on rehabilitated spoil emplacement areas.

The magnitude and rate of consolidation settlement depend on composition (size grading), existing pre-consolidation, and the disposition of drainage paths, all of which vary within the three-dimensional tailings deposit. Consequently, estimates are not included in the conceptual cover design; instead, settlement will be assessed and allowed for as part of detailed design and especially by adaptive design revision during the construction phase.

5.3.4 Construction Methodology

The challenge in placing a first layer of cover material over soft fine waste is that the cover needs to be thick enough to spread the weight of the construction equipment (so that the resultant pressure is low enough to avoid bearing failure), without being so thick that the weight of the cover material itself causes bearing failure. The strength and thickness of the tailings surface crust is critical to being able to meet both constraints, but the in situ testing referred to in Section 3.1.3, was restricted to the edges of the tailings deposit. More testing will be required before cover works commence to understand strength conditions across the whole tailings surface and to accommodate those in the construction process.

That is, the construction sequence requires its own geomechanical design, separate from detailed design of the cover system. This will typically involve bearing capacity and/or stability analysis to determine combinations of thickness of the first layer of the bulk shaping and construction plant ground pressures that do not overload tailings strength profiles across the TSF. Even then, considering the inherent variability across the TSF, it should be expected that the cover design and the construction schedule will be further modified based on monitoring as the initial layers are placed.

Once the first layer has been placed, it may possible to proceed using normal spoil dumping practices up to the underside of the low permeability player. The actual dumping strategy should be confirmed by further geomechanical analysis, including estimation of consolidation settlement, after the first layer is completed. Topographic (survey) monitoring should continue until an appropriately qualified geotechnical engineer has reviewed the monitoring results and confirmed that predicted remaining differential settlement will not compromise the final mounded shape of the subsequent low permeability layer.

It is recommended that QC/QA for the low permeability layer be based on coefficient of permeability, which is the geomechanical property that most directly affects cover system performance. For QC, test areas could be prepared using the proposed spoil material and construction methodology for each cover layer. In situ infiltration tests would be undertaken to measure permeability, and the materials and/or methods modified as necessary, until the design coefficients of saturated permeability are consistently achieved. The resultant materials and methods can then be used to construct the whole layer, with further infiltration testing as appropriate to provide QA.

To ensure the desired contrast in permeability, spoil directly above the low permeability layer should be spread in thicker layers where practicable. As the constructed surface approaches the levels of the final landform, areas with the greatest predicted remaining consolidation settlement may be over-dumped to hasten and balance that settlement.

After completion of bulk earthworks, the landform may be left for a period while further consolidation settlement occurs. When topographic monitoring indicates that the remaining settlement is within a manageable range (nominally <0.3m), the surface may be trimmed to final design profile. The area would then be rehabilitated in accordance with normal site practices for spoil dumps, including topsoil placement and construction of erosion control measures. The vegetation species mix should be consistent with roots of mature plants not reaching the low permeability layer and with the post-mining land use of managed grazing.

6. LALEHAM TSF

6.1 Description

Laleham is an inactive TSF with in-pit and aboveground sections, the latter being formed by embankments across a hillslope, with the western end possibly founded in spoil. It is located about 1.2km south-east of the old South Blackwater Mine CHPP.

The in-pit section was present in 1984 and the embankment was under construction. The tailings surface was capped with clayey spoil by the end of 1994 but the exposed (downstream) embankment slope has not been structurally modified since original construction.

The TSF extends 0.4km north-south and 0.6km east-west, with a footprint of about 13 Ha. The depth of tailings in the in-pit section is not known but the main embankment is about 10m high. The capped surfaces are generally flat, except for a depression at the eastern side of the aboveground section that was probably caused by tailings consolidation.

6.2 Surrounding Environment

The in-pit area of the TSF wraps around the end of a laterised sandstone ridge to the north. Two small mine water dams, Duck Pond and Fish Bowl, are 100-200m to the west. The eastern side of the aboveground part of the TSF is bounded by a road around the western toe of the Ramp 74 northern in-pit spoil dump; Ramp 74 in-pit TSF is about 700m east of Laleham TSF. There are several vegetated spoil dumps around the southern side of the TSF, with Sirius Creek at the southern side of those, about 35m from Laleham TSF. Prior to mining, the dominant land use was low intensity grazing. Regulated vegetation is mapped on the sandstone ridge and an area to the south-west of the TSF, described as endangered acacia dominated open forest and of-concern eucalypt open forest respectively.

For the final landform, it is planned to re-handle spoil from some of the smaller nearby dumps to cover the TSF and create a broad mound abutting the natural sandstone ridge draining south to Sirius Creek.

In and around the mine area, groundwater occurs mainly in the coal seams in the Permian Rangal Coal Measures and potentially in poorly consolidated Tertiary sediments. Quaternary alluvium is limited to some current drainage features and watercourses and investigations to date suggest that any groundwater is ephemeral and associated with creek flows, rather than representing a sustained water table (SLR, 2024). Flow path simulation included in SLR (2024) may be relevant to the in-pit part of the TSF and indicated that if any seepage reached the groundwater system it would flow toward R74 void. Surface geology mapped for the footprint of Laleham TSF is Emerald Formation Tertiary sediment, with Rangal Formation sub-cropping south of Sirius Creek. Over the forty years since tailings were first deposited in-pit, there have been no reports of shallow seepage from the TSF being detected in Sirius Creek.

6.3 Cover Design

6.3.1 Specific Hazards

The planned final landform is a mounded shape that will not pond water, so there is no risk of spill to surface water (hazard c in Table 4-1). The TSF did not greatly alter natural surface drainage because it followed the pre-existing ground-slope direction (hazard f). As noted in the previous section, there is the possibility of shallow seepage out of the TSF and into Sirius Creek, although there is not a clear hydrogeologic connection. If seepage did occur, the rate would decrease over time since tailings deposition has ceased, and a cover system designed to minimize deep infiltration would also reduce long-term seepage. Any deep seepage from the TSF would follow the excavated ground surface into Ramp 74 void (another TSF) and therefore would not measurably reach regional groundwaters (hazard a).

As a TSF with some aboveground containment, embankments are required to structurally contain low strength tailings, and so embankment failure is a credible scenario (hazard i). However, the cover can only influence embankment stability indirectly and in a limited way – by avoiding

accumulation of water and consequent pore pressure increase – and so this hazard is separately addressed through detailed design for overall decommissioning of the TSF.

Other relevant potential hazards will be addressed by the general controls outlined in Table 4-1.

6.3.2 Concept Cover Design

The tailings surfaces (in-pit and out-of-pit) were covered with 1m minimum depth of spoil about thirty years ago. There are historically rehabilitated spoil dumps nearby and future mining is planned within that area of the minesite. Given this context, the preferred cover type is a thick layer of general spoil, including the material that is already in place. Final surface gradients, topsoil thickness and vegetation will be consistent with other spoil landforms rehabilitated to the same post-mining land use.

Tailings consolidation settlement varies with tailings depth and water content profile (or conversely, density profile) and with cover thickness. Considering that tailings deposition ceased so long ago, it is likely that a significant amount of settlement has already occurred. However, the additional weight of cover spoil will trigger a new stage of consolidation that theoretically might take decades to complete (although consolidation follows a logarithmic timeframe which means that most of the settlement happens in the early years). For detailed cover design, the rate of consolidation and total and differential settlement will need to be estimated and allowed for, typically by adjusting the cover thickness to compensate.

6.3.3 Design Details

The high level design objective for rehabilitation of Laleham TSF is to create a landform that permanently contains tailing solids, limits any release of solutes to levels that will not cause environmental harm, and can support managed grazing within a wider grazing enterprise. In addition to providing a cover function, the spoil also needs to create the required landform topography. Consequently, the following specifies a minimum spoil thickness, but in some areas the actual thickness will be greater, to create a surface that sheds rainfall runoff without ponding but also without causing excessive erosion.

- 5m thickness of spoil (including that already placed), dumped and spread in such a way that dispersive spoil with high fines content is not placed in the outer 1m of the landform. This may be achieved by selective placement or by chemically treating the top metre of spoil to reduce sodicity;
- Topsoil and erosion management practices consistent with those on other rehabilitated spoil areas.

Tailings consolidation settlement will vary with tailings depth and water content profile (or conversely, density profile) and with spoil thickness, and is expected to occur over a long timeframe – potentially decades. Conceptually, this settlement can be accommodated by making the relevant layers of the cover thicker in the areas where greater settlement is predicted so that mounded interfaces and surfaces will remain mounded after the settlement has occurred.

6.3.4 Construction Methodology

The greatest challenge in constructing a cover over soft fine waste is usually in placing an initial layer that can support construction equipment without breaking through the crusted surface itself. In the case of Laleham TSF, that first layer is already in place; however, its thickness and condition is not known in detail. Consequently, further strength profiling is recommended to support detailed design of the cover system and selection of construction equipment with appropriate ground pressure configurations.

All vegetation and the topsoil/root matter should be removed before fresh spoil placement commences. Spoil placement may then proceed as determined to suit strength conditions; however, considering the inherent variability across the TSF, the construction methodology may be further modified based on monitoring as work proceeds.

Because the proposed cover system is essentially simple bulk spoil fill, no specific testing is required for QC/QA during construction except to confirm minimum cover thickness. After completion of bulk earthworks, the landform may be left for a period while further consolidation settlement occurs. When topographic monitoring indicates that the remaining settlement is within a manageable range (nominally <0.3m), the surface may be trimmed to final design profile. The area would then be rehabilitated in accordance with normal site practices for spoil dumps, including topsoil placement and construction of erosion control measures.

7. R72 WSF

7.1 Description

R72 is an inactive tailings and coarse rejects storage facility with the waste mainly below ground, but rainfall and runoff are intermittently stored over tailings behind an aboveground embankment. It is located just north of the loadout rail line into South Blackwater.

Ramp 72 was mined sometime before 1985. Tailings were discharged to the pit from the early 1990's until December 2001; at some stage during that period, a 4m high embankment was constructed at the top (western end) of the ramp to contain the decant pond as the tailings level rose slightly above natural ground level and decant drained to that end of the ramp. Mixed CHPP waste was dumped into the southern end of the pit, over the tailings, from about 2005 until it reached a couple of metres below pre-mining ground level. In 2010, the embankment was raised 6m to better contain rainfall runoff from the pit and surrounding catchment.

The pit section of the WSF is about 950m long and 150m wide, while the ramp section is about 650m long with a width opening from 50m at the top of the ramp to 160m where it joins the pit. Depth of tailings ranges from a couple of metres at the top of the ramp to about 40m in-pit, and the mixed rejects in the southern end are about 16m thick over the tailings.

7.2 Surrounding Environment

The WSF is bound by the rail line at the south, a mine access/haul road at the west, other mine voids at the north and presently, highwall spoil at the east. As noted, at closure there will be a new residual void further east, with an in-pit spoil dump in between. The southern rail loop is about 1km to the south-west with old mine building and the SCPP at the eastern side of the loop. It is

understood that most of that infrastructure will be removed prior to closure. In this part of the mine, the pre-mining ground surface and its watercourses drained from east to west, and a natural drainage line flows from the top of the ramp into Sirius Creek about 4km downstream to the south-west. That drainage line is mapped as regulated vegetation (endangered regional ecosystem comprising remnant acacia dominated woodland to open forest on gilgai clay plains). Prior to mining, the land use was mainly low intensity grazing, and this continues in areas outside the area of mine disturbance.

The final landform for the mine involves burying R72 under a new spoil dump generated from mining down-dip (east) of the previous pit. The depth of spoil over CHPP waste will range from at least 5m at the top of the ramp to more than 100m at the current highwall. The final void from new mining will be about 1.2km east of R72 WSF.

In and around the mine area, groundwater occurs mainly in the coal seams in the Permian Rangal Coal Measures and potentially in poorly consolidated Tertiary sediments. Quaternary alluvium is limited to some current drainage features and watercourses and investigations to date suggest that any groundwater is ephemeral and associated with creek flows, rather than representing a sustained water table (SLR, 2024). Flow path simulation included in that report indicated that the TSF would remain a groundwater sink, and therefore tailings-contacted water would not flow out into the broader groundwater system. Surface geology mapped for the footprint of R72 WSF is cemented Tertiary sediment (duricrust) on deeply weathered regolith. The planned future mining will remove Tertiary and Permian overburden down to coal floor; consequently, any seepage from R72 would be eastward through in-pit spoil to that subsequent final void.

7.3 Cover Design

7.3.1 Specific Hazards

The proposed final landform over R72 WSF is sloping ground that will not pond water, so there is no risk of spill to surface water (hazard c in Table 4-1). No watercourse or defined drainage feature is directly impacted by the WSF; the rehabilitated landform will locally increase the catchment draining to a gully that flows into Sirius Creek but it will not interfere with the watercourse alignment (hazard f). There is a slight possibility of seepage through the western embankment and into the gully, however this (hazard b) was addressed in the embankment design. If seepage has occurred, the rate will decrease after the decant pond is removed. A cover system designed to minimize deep infiltration would also reduce long-term seepage. As was also noted in the preceding report section, any deep seepage from the WSF would likely follow the excavated ground surface into a final void and therefore would not measurably reach regional groundwaters (hazard a).

As the WSF contains tailings stored aboveground, the embankment is required to structurally contain low strength tailings in the long-term, and so embankment failure is a credible scenario (hazard i). However, the hazard of embankment failure will be separately addressed through detailed design for decommissioning of the overall TSF structure.

Other relevant potential hazards will be addressed by the general controls outlined in Table 4-1.

7.3.2 Concept Cover Design

Given the location of R72 WSF within a large spoil landform, a thick cover of general spoil material is proposed to achieve cover performance objectives. At concept design level, gravelly spoil or coarse rejects will be spread over the exposed tailings surface to provide an initial support layer, then a thicker layer of general spoil will be placed over that. Final surface gradients, topsoil thickness and vegetation will be consistent with other spoil landforms rehabilitated to the same post-mining land use.

Tailings consolidation settlement varies with tailings depth and water content profile (or conversely, density profile) and with cover thickness. Consolidation actually occurs throughout the life of the facility and beyond, and it is likely that a significant amount of settlement has already occurred. However, the additional weight of spoil will trigger a new stage of consolidation. Consolidation theory indicates that the process might take decades to complete (although consolidation follows a logarithmic timeframe which means that most of the settlement happens in the early years). For detailed cover design, the rate of consolidation and total and differential settlement will need to be estimated and allowed for, typically by adjusting the spoil thickness to compensate.

7.3.3 Design Details

The high-level objective for rehabilitation of R72 WSF is to incorporate it in a larger spoil landform such that the whole area has consistent topography and land use capabilities. The thickness of spoil required to achieve this varies markedly across the facility, as described in Section **Error! Reference source not found.**. The following, therefore, are proposed minimum layer thicknesses, to be refined in the detailed design:

- 1.5m thickness of coarse rejects or gravelly spoil – for example, spoil from fresh non-carbonaceous sandstone-siltstone overburden and/or interburden - over the exposed tailings;
- Spoil, 3.5m thick at the top of the ramp, 5m thick over coarse rejects and as required over the remainder of the WSF, dumped and spread in such a way that dispersive spoil with high fines content is not placed in the outer 1m of the landform (spoil may be chemically ameliorated to achieve this); and
- Topsoil and erosion management practices consistent with those on the adjoining rehabilitated spoil areas.

The magnitude and rate of consolidation settlement depend on composition (size grading), existing pre-consolidation, and the disposition of drainage paths, all of which will vary throughout the tailings deposit. Consequently, estimates are not included in the conceptual cover design; instead, settlement will be assessed and allowed for as part of detailed design and especially by adaptive design revision during the construction phase.

7.3.4 Construction Methodology

As described in Section 5.3.4, the first layer over tailings is the most difficult to construct because it needs to balance the conflicting effects of supporting construction equipment and loading the tailings. The strength and thickness of the tailings surface crust is critical to being able to meet both constraints. For this reason, the ramp section must be dewatered continuously and allowed to desiccate for several years before in situ strength profiles are measured and used to undertake

geomechanical design of the construction sequence. This will typically involve bearing capacity and/or stability analysis to determine combinations of thickness of the first layer of cover material and construction plant ground pressures that do not overload tailings strength profiles across the WSF. Even then, considering the inherent variability in tailings due to changes in CHPP feed and product targets, and the effects of beaching and sorting at discharge, it should be expected that the cover design and the construction schedule will be further modified based on monitoring as the initial layer is placed. If the surface cannot be strengthened sufficiently within an acceptable timeframe, special construction support such as geogrid may be required.

Once the first layer has been placed, it may be possible to proceed using normal spoil dumping practices to complete the bulk shape of the final landform. The actual dumping strategy should be confirmed by further geomechanical analysis, including estimation of consolidation settlement, after the first layer is completed. Topographic (survey) monitoring should continue until an appropriately qualified geotechnical engineer has reviewed the monitoring results and confirmed that predicted remaining differential settlement will not compromise the final surface drainage plan.

Because the proposed cover system is essentially simple bulk spoil fill, no specific testing is required for QC/QA during construction, except to confirm minimum cover thickness. After completion of bulk earthworks, the landform may be left for a period while further consolidation settlement occurs. When topographic monitoring indicates that the remaining settlement is within a manageable range (nominally <0.3m), the surface may be trimmed to final design profile. The area would then be rehabilitated in accordance with normal site practices for spoil dumps, including topsoil placement and construction of erosion control measures.

8. R74 TSF

8.1 Description

R74 is an inactive in-pit tailings storage facility with no aboveground storage. The pit was mined sometime before 2001. The northern half of the pit is aligned roughly north-west to south-east while the southern part is nearly north to south. The northern endwall is about 1.8km south-west of the SCPP, with various mine small mine-affected water dams and Laleham TSF in between.

From December 2001 until 2008, tailings were discharged from the northern endwall and allowed to beach down toward the southern end. Based on the site geological model, the tailings surface is below the base of weathering except at the location of the pre-mining alignment of Sirius Creek, and it is more than 10m below spill level. Since tailings deposition ceased, the pit has at times been used to store excess mine-affected water, apparently without infrastructure to recover the water.

R74 TSF is about 1.9km long from northern to southern endwall and has a footprint of about 41Ha. Based on limited historic survey, it is estimated that the depth of tailings varies from about 24m in the south to 32m in the north. The beach angle of the tailings is about 0.6%.

8.2 Surrounding Environment

R74 TSF is not close to any third party infrastructure. A power line easement to the SCPP passes about 0.4km north of the northern endwall, but the only other nearby infrastructure are mine access roads. Prior to mining, Sirius Creek flowed east-to-west across the southern area of the

pit, and a diversion was constructed around the southern endwall. An upgraded creek diversion and associated flood protection structures have been designed but the alignment near R74 will not change greatly. In keeping with creek-flow direction, unmined ground east of the highwall slopes gently toward the pit. Spoil west of the pit lowwall has undergone rehabilitation. Prior to mining, the dominant regional land use was low intensity grazing but a significant area of land east of the highwall is uncleared woodland mapped as MSES regulated vegetation (Category B – endangered) comprising sub-dominant shrubby open forest. A smaller area about 1km south of the TSF (on the other side of Sirius Creek is mapped as high ecological significance wetlands comprising dominant endangered open forest.

In and around the mine area, groundwater occurs mainly in the coal seams in the Permian coal measures and potentially in poorly consolidated Tertiary sediments. Quaternary alluvium is limited to some current drainage features and watercourses and investigations to date suggest that any groundwater is ephemeral and associated with creek flows, rather than representing a sustained water table (SLR, 2024). Flow path simulation included in that report indicated that the TSF would remain a groundwater sink, and therefore tailings-contacted water would not flow out into the broader groundwater system. The site geological model shows typically 10-20m depth of Tertiary/ Quaternary soil and rock overlying weathered Permian rock with unweathered Permian Rangal Coal Measures generally 20-25m below pre-mining ground level. The exception is at the original channel of Sirius Creek, where the depth of weathering increases to about 35m.

As noted in Section 10.1, the tailings surface is more that 10m below surrounding ground level and more than 5 million cubic metres of spoil would be required to completely backfill the void. Considering geological changes, proximity to Sirius Creek and the presence of regulated endangered vegetation about a kilometre east of the current highwall, no further mining is planned in the vicinity. The spoil that was produced from R74 pit has been rehabilitated up to the lowwall and so re-handling from that source would have a negative environmental outcome. Consequently, the final landform design for R74 TSF is a residual void that is a NUMA approved under existing Land Outcome Documents. This imposes different requirements on cover design, as discussed in the following sections.

8.3 Cover Design

8.3.1 Specific Hazards and Concept Cover Design

As an in-pit TSF with no aboveground storage, there is no mechanism for embankment failure (hazard i). In addition, because the void will be a NUMA, hazards d and e, regarding uptake of contaminants by vegetation, are not relevant. Consequently, the most important specific hazards relate to seepage or spill of tailings-contacted water (hazards a, b, and c). Iterative final landform design, hydrogeological modelling and void water balance modelling (SLR, 2024 and WSP, 2024) have shown that by constructing a thick single-layer spoil cover from the northern end down to about 650m from the southern endwall, a water cover always at least 1m deep will establish over the remaining (southern) section and the void will remain a long-term groundwater sink with no risk of overflow to surface waters.

Tailings consolidation settlement (hazard g) will vary with tailings depth and water content profile (or conversely, density profile) and with spoil cover thickness, and is expected to occur over a long timeframe – potentially decades. Conceptually, this settlement can be accommodated by making the cover thicker in the areas where greater settlement is predicted so that surface drainage is maintained after the settlement has occurred. Settlement under the permanent water cover will not affect cover performance.

Other relevant potential hazards will be addressed by the general controls outlined in Table 4-1.

8.3.2 Design Details

As a NUMA, the over-arching objective for closure of R74 TSF is to create a stable landform that permanently contains tailing solids and limits any release of solutes to levels that will not cause environmental harm. The following are preliminary specifications for the combined spoil and water covers:

- 5m minimum thickness of spoil will be placed over the tailings, from the northern end of the TSF to nominally 650m north of the southern endwall. The spoil layer will be battered down at an angle assumed to be 1:3 for planning purposes but to be determined by stability analyses at detailed design;

- A pit lake will be established south from the spoil batter to act as a permanent water cover with a minimum depth of 1m over the tailings that are not covered by spoil.

The magnitude and rate of consolidation settlement depend on composition (size grading), existing pre-consolidation, and the disposition of drainage paths, all of which vary within the three-dimensional tailings deposit. Consequently, estimates are not included in the conceptual cover design; instead, settlement will be assessed and allowed for as part of detailed design and especially by adaptive design revision during the construction phase.

8.3.3 Construction Methodology

As described in Section 5.3.4, the first layer over tailings is the most difficult to construct because it needs to balance the conflicting effects of supporting construction equipment and loading the tailings. The strength and thickness of the tailings surface crust is critical to being able to meet both constraints. For this reason, mine-affected water stored in the void must be pumped down to allow the tailings north of about 600m from the southern endwall to desiccate for several years before in situ strength profiles are measured and used to undertake geomechanical design of the construction sequence. This will typically involve bearing capacity and/or stability analysis to determine combinations of thickness of the first layer of cover material and construction plant ground pressures that do not overload tailings strength profiles across the TSF. Even then, considering the inherent variability in tailings due historic to changes in CHPP feed and product targets, and the effects of beaching and sorting at discharge, it should be expected that the cover design and the construction schedule will be further modified based on monitoring as an initial layer of spoil is placed.

Once a first layer has been placed, it may be possible to place the remaining thickness of spoil cover in one pass. The actual dumping strategy should be confirmed by further geomechanical analysis, including estimation of consolidation settlement, after the first layer is completed. Topographic (survey) monitoring should continue until an appropriately qualified geotechnical engineer has reviewed the monitoring results and confirmed that predicted remaining differential settlement will not prevent the final surface from draining freely to the water cover at the northern end.

Because the proposed northern cover is essentially simple bulk spoil fill, no specific testing is required for QC/QA during construction, except to confirm minimum cover thickness. After completion of bulk earthworks, the landform may be left for a period while further consolidation

settlement occurs. When topographic monitoring indicates that the remaining settlement is within a manageable range (nominally <0.3m), the surface may be trimmed to final design profile.

The water cover at the southern end is expected to establish readily once dewatering ceases. If this does not occur within a desired timeframe, for example if closure occurred during drought conditions, water could be pumped onto the tailings until conditions equilibrated.

9. BOTTOM DAM TSF & ROM3 AREA WSF

9.1 Description

The ROM3 Area coarse rejects dump is located against an east-facing natural slope about 0.7k south of the SCPP. The dump batter is at angle of repose and about 38m high; the flat top ranges up to 120m wide and the total footprint is 5.5Ha.

Bottom Dam abuts the eastern toe of the dump, about half-way along. It is bound by sloping ground at the north, a 6m high earthfill embankment at the east, and a spoil dump at the south. The footprint of Bottom Dam TSF is 3.2Ha Geotechnical drilling suggests that the storage is up to 15m deep and founded within the regolith, that is, above fresh Permian coal measures.

Bottom Dam was originally a process water storage forming part of the SCPP water management system. It received overflow from No.1 Dam (upslope to the north) and into flowed though a culvert to Duck Pond at the east, on the other side of a mine road. The dam also incidentally received coal fines and other sediment washed in from No.1 Dam and the rejects dump but it was not designated as a TSF until sometime after 2012.

The tailings surface is close to the embankment crest level and is fairly flat except for a small sump around the culvert to Duck Pond. Scrubby mid-storey has established over more than half of the tailings surface. Recent geotechnical investigation showed a desiccated surface crust typically 1-2m thick.

9.2 Surrounding Environment

The combined WSF is in the middle of the old South Blackwater Mine industrial area, with ROM3 Area and the CHPP on natural high ground to the west and north respectively, other mine dams immediately east and Laleham TSF further east again, a spoil dump immediately to the south and natural ground draining to Sirius Creek about to the south-east. Prior to mining the dominant land use on the mining lease was low intensity grazing, with significant areas of uncleared woodland. Some of the latter remain in the vicinity of ROM3 Area/Bottom Dam and are mapped as Category B regulated vegetation (endangered and of-concern eucalyptus woodland to open forest).

In and around the mine area, groundwater occurs mainly in the coal seams in the Permian Rangal Coal Measures and potentially in poorly consolidated Tertiary sediments. Quaternary alluvium is limited to some current drainage features and watercourses and investigations to date suggest that any groundwater is ephemeral and associated with creek flows, rather than representing a sustained water table (SLR, 2024). Similar to NCPP TSF, flow path simulation included in SLR (2024) does not reflect the risk of seepage to the groundwater system. Surface geology mapped for the footprint of the combined WSF is Emerald Formation Tertiary weathered siltstone and claystone; the ridge to the west and north has Tertiary duricrust, and Sirius Creek runs through

regolith of Permian Burngrove formation. That is, the WSF is unlikely to have direct hydrogeologic connection with Sirius Creek.

For the final landform, it is planned to push the rejects down over the tailings to create a slope abutting the Tertiary ridge with runoff draining freely to the south and south-east.

9.3 Cover Design

9.3.1 Specific Hazards

The planned final landform is a sloping shape that will not pond water, so there is no risk of spill to surface water (hazard c in Table 4-1). The rejects dump and TSF did not greatly alter natural surface drainage because they broadly followed the pre-existing ground-slope direction (hazard f). As noted in the previous section, shallow seepage out of the TSF and into Sirius Creek is unlikely because there is not a clear hydrogeologic connection. Deep seepage from the TSF might flow toward Sirius Creek as indicated by the flow path simulations (SLR, 2024), however it is unlikely (hazard a).

As a TSF with some aboveground containment, embankments are required to structurally contain low strength tailings, and so embankment failure is a credible scenario (hazard i). However, the cover can only influence embankment stability indirectly and in a limited way – by avoiding accumulation of water and consequent pore pressure increase – and so this hazard will be separately addressed through detailed design for overall decommissioning of the TSF.

Other relevant potential hazards will be addressed by the general controls outlined in Table 4-1.

9.3.2 Concept Cover Design

The present batter of the rejects dump is steep and eroded and requires significant re-shaping to create an acceptable final landform. Bottom Dam TSF has been colonised by shrubby vegetation but has formed a shallow surface depression that would intermittently pond and potentially overflow. Hence, it is planned to push the rejects down over the TSF to flatten the slope and fill the depression. There is a spoil dump immediately south of Bottom Dam but the spoil characteristics are unknown; the same applies to the next closest potential sources of cover material. Given this context, the preferred cover type is a thick layer of general spoil. Final surface gradients, topsoil thickness and vegetation will be consistent with other spoil landforms rehabilitated to the same post-mining land use.

Tailings consolidation settlement varies with tailings depth and water content profile (or conversely, density profile) and with cover thickness. Considering that tailings deposition ceased so long ago, it is likely that a significant amount of settlement has already occurred. However, the additional weight of cover spoil will trigger a new stage of consolidation that theoretically might take decades to complete (although consolidation follows a logarithmic timeframe which means that most of the settlement happens in the early years). For detailed cover design, the rate of consolidation and total and differential settlement will need to be estimated and allowed for, typically by adjusting the cover thickness to compensate.

9.3.3 Design Details

The high level design objective for rehabilitation of Bottom Dam TSF and ROM3 Area WSF is to create a landform that permanently contains tailing solids, limits any release of solutes to levels that will not cause environmental harm, and can support managed grazing within a wider grazing enterprise. The coarse rejects will be pushed over Bottom Dam to create the bulk landform topography, so in this case the spoil will only be required to provide cover function – limiting the movement of solutes both downward and upward. The following specifies a minimum spoil thickness, but in some areas the actual thickness may be greater, to create a surface that sheds rainfall runoff causing excessive erosion.

- 5m thickness of spoil, dumped and spread in such a way that dispersive spoil with high fines content is not placed in the outer 1m of the landform. This may be achieved by selective placement or by chemically treating the top metre of spoil to reduce sodicity;
- Topsoil and erosion management practices consistent with those on other rehabilitated spoil areas.

Tailings consolidation settlement will vary with tailings depth and water content profile (or conversely, density profile) and with spoil thickness, and is expected to occur over a long timeframe – potentially decades. Conceptually, this settlement can be accommodated by making the relevant layers of the cover thicker in the areas where greater settlement is predicted so that mounded interfaces and surfaces will remain mounded after the settlement has occurred.

9.3.4 Construction Methodology

As described in Section 5.3.4, the first layer over tailings is the most difficult to construct because it needs to balance the conflicting effects of supporting construction equipment and loading the tailings. On Bottom Dam TSF, that first layer will be coarse rejects rather than spoil; this is an advantage because the rejects are both lighter and stronger. However, the strength and thickness of the tailings surface crust will still be critical to being able to meet both construction constraints. The in situ strength profiles recently measured may be sufficient to undertake geomechanical design of the construction sequence. This will typically involve bearing capacity and/or stability analysis to determine combinations of thickness of the first layer of rejects and construction plant ground pressures that do not overload tailings strength profiles across the TSF. Even then, considering the inherent variability in tailings due to changes in CHPP feed and product targets, and the effects of beaching and sorting at discharge, it should be expected that the cover design and the construction schedule will be further modified based on monitoring as the initial layer is placed. If the surface cannot be strengthened sufficiently within an acceptable timeframe, special construction support such as geogrid may be required.

Once the first layer has been placed, it may be possible to complete the coarse rejects re-handling and subsequent spoil cover placement using normal earthworks practices. However, the actual dumping strategy should be confirmed by further geomechanical analysis, including estimation of consolidation settlement, after the first layer is completed. Topographic (survey) monitoring should continue until an appropriately qualified geotechnical engineer has reviewed the monitoring results and confirmed that predicted remaining differential settlement will not compromise the final surface drainage plan.

Because the proposed cover system is essentially simple bulk spoil fill, no specific testing is required for QC/QA during construction except to confirm minimum cover thickness. After completion of bulk earthworks, the landform may be left for a period while further consolidation

settlement occurs. When topographic monitoring indicates that the remaining settlement is within a manageable range (nominally <0.3m), the surface may be trimmed to final design profile. The area would then be rehabilitated in accordance with normal site practices for spoil dumps, including topsoil placement and construction of erosion control measures.

10. BONNIE DOON TSF

10.1 Description

Boonie Doon is an active in-pit TSF located at the northern end of current mining. It comprises four straight pit sections connected by two ramps (R10 and R12).

The lowest part of the mined pit floor was RL 119m. Tailings deposition commenced in December 2023 and will continue until the tailings reach RL 160m just north of R10, beaching down from about RL 179m at the southern end. The maximum tailings elevation was reduced from the level specified in the design plan, both to keep the operating tailings and decant pond levels below the base of weathering exposed in the highwall (ranging from RL 172m to RL 185m), and to ensure that the storage facility remains a sink relative to possible groundwater aquifers in the Tertiary and Quaternary sediments.

The TSF is 2.7km north-south and has a footprint of about 42Ha. When filled, the depth of tailings will range from about 25m in the north to 60m at the southern end. The location of tailings discharge and the decant pond may change throughout the operational life but by closure, the tailings surface will drain toward the north with beach slope in the order of 1-1.5%.

10.2 Surrounding Environment

The northern end of the TSF is about 1.5km south of the Capricorn Highway and 5km south-west of the town of Blackwater. The two pit ramps run about 1km down from the main mine access road at the west and the mine's rail line is at the western side of the road. Sagittarius Creek is located about 3.7km east of the TSF highwalls and flows northward. Several unnamed gullies (that are defined drainage features under the Water Act 2000) collect overland flow from the area east the TSF and feed it into the creek. Prior to mining the dominant land use was low intensity grazing and this continues outside the area of mine disturbance. Regulated vegetation (Category R – GBR riverine) is mapped along the upslope ends of some of those drainage features but there are no other Matters of State Environmental Significance near the TSF.

In and around the mine area, groundwater occurs mainly in the coal seams in the Permian Rangal Coal Measures and potentially in poorly consolidated Tertiary sediments. Quaternary alluvium is limited to some current drainage features and watercourses and investigations to date suggest that any groundwater is ephemeral and associated with creek flows, rather than representing a sustained water table (SLR, 2024). Surface geology mapped for the footprint of Boonie Doon shows most of the highwall edging into Triassic Rewan Formation overburden that overlies the mined Permian Rangal Formation. The exception is at the northern end, where Quaternary alluvium comprising sheetwash and flood-out sheets is mapped. Hence Bonnie Doon TSF, like all pits mined at Blackwater, intersects the unmined portions of coal seam aquifers; however, this TSF could also contact shallow local aquifer(s) in the surface alluvium, if the tailings and decant pond level were not restricted to avoid it.

Because of the constraints on maximum tailings level described in Section 10.1, the final tailings surface will be 20-40m below surrounding ground level. Within the current life-of-mine plan, there will not be mining close to Bonnie Doon when the TSF is undergoing closure so no close-haul spoil will be produced at the time. Much of the spoil that was produced by mining Bonnie Doon is already under rehabilitation, so re-handling enough of that spoil to fill the TSF to ground level would be high cost and have negative environmental impact. Consequently, the final landform design for Bonnie Doon TSF is a residual void that is a NUMA approved under existing Land Outcome Documents. This imposes different requirements on cover design, as discussed in the following sections.

10.3 Cover Design

10.3.1 Specific Hazards and Concept Cover Design

As an in-pit TSF with no aboveground storage, there is no mechanism for embankment failure (hazard i in Table 4-1). In addition, because the void will be a NUMA, hazards d and e, regarding uptake of contaminants by vegetation, are not relevant. Consequently, the most important specific hazards relate to seepage or spill of tailings-contacted water (hazards a, b, and c). Iterative final landform design, hydrogeological modelling and void water balance modelling (SLR, 2024 and WSP, 2024) have shown limiting the tailings level to RL 160m at the end of R10, and constructing a thick single-layer spoil cover south of R10 will maintain the void as a long-term groundwater sink, avoid seepage into any shallow alluvial aquifers, and avoid overflow to surface waters. This configuration will also provide a permanent water cover, at least 1m deep, over tailings north of R10.

Tailings consolidation settlement (hazard g) will vary with tailings depth and water content profile (or conversely, density profile) and with spoil cover thickness, and is expected to occur over a long timeframe – potentially decades. Conceptually, this settlement can be accommodated by making the cover thicker in the areas where greater settlement is predicted so that surface drainage is maintained after the settlement has occurred. Settlement under the permanent water cover will not affect cover performance.

Other relevant potential hazards will be addressed by the general controls outlined in Table 4-1.

10.3.2 Design Details

As a NUMA, the over-arching objective for closure of Bonnie Doon TSF is to create a stable landform that permanently contains tailing solids and limits any release of solutes to levels that will not cause environmental harm. The following are preliminary specifications for the combined spoil and water covers:

- The final tailings elevations in the TSF will be RL 160m at the end of R10, with the surface sloping down to the north and up to the south;

- 5m minimum thickness of spoil will be placed over the tailings, from the southern end of the TSF to nominally 150m south of the endwall at R10. The spoil layer will be battered down at an angle assumed to be 1:3 for planning purposes but to be determined by stability analyses at detailed design;

- A pit lake will be established north from the spoil batter to act as a permanent water cover with a minimum depth of 1m over the tailings that are not covered by spoil.

The magnitude and rate of consolidation settlement depend on composition (size grading), existing pre-consolidation, and the disposition of drainage paths, all of which vary within the three-dimensional tailings deposit. Consequently, estimates are not included in the conceptual cover design; instead, settlement will be assessed and allowed for as part of detailed design and especially by adaptive design revision during the construction phase.

10.3.3 Construction Methodology

As described in Section 5.3.4, the first layer over tailings is the most difficult to construct because it needs to balance the conflicting effects of supporting construction equipment and loading the tailings. The strength and thickness of the tailings surface crust is critical to being able to meet both constraints. For this reason, after the tailings reach final design level, the decant pond must be pumped down continuously to allow the tailings south of the endwall at R10 to desiccate for several years before in situ strength profiles are measured and used to undertake geomechanical design of the construction sequence. This will typically involve bearing capacity and/or stability analysis to determine combinations of thickness of the first layer of cover material and construction plant ground pressures that do not overload tailings strength profiles across the TSF. Even then, considering the inherent variability in tailings due to changes in CHPP feed and product targets, and the effects of beaching and sorting at discharge, it should be expected that the cover design and the construction schedule will be further modified based on monitoring as an initial layer of spoil is placed.

Once a first layer has been placed, it may be possible to place the remaining thickness of spoil cover in one pass. The actual dumping strategy should be confirmed by further geomechanical analysis, including estimation of consolidation settlement, after the first layer is completed. Topographic (survey) monitoring should continue until an appropriately qualified geotechnical engineer has reviewed the monitoring results and confirmed that predicted remaining differential settlement will not prevent the final surface from draining freely to the water cover at the northern end.

Because the proposed southern cover is essentially simple bulk spoil fill, no specific testing is required for QC/QA during construction, except to confirm minimum cover thickness. After completion of bulk earthworks, the landform may be left for a period while further consolidation settlement occurs. When topographic monitoring indicates that the remaining settlement is within a manageable range (nominally <0.3m), the surface may be trimmed to final design profile.

The water cover at the northern end is expected to establish readily once dewatering ceases. If this does not occur within a desired timeframe, for example if closure occurred during drought conditions, water could be pumped onto the tailings until conditions equilibrated.

11. RAMP 36 REJECTS DUMP

11.1 Description

Ramp 36 Rejects Dump is a long narrow WSF located south-east of the NCPP TSF, on the southern side of Deep Creek and the western side of the main haul road. It has a footprint of

72Ha, with a high mound at the southern end reaching about 30m above surrounding ground levels. The batters in that area are at angle-of-repose.

It is understood that the WSF received coarse rejects over the period from 1967 to 2007 and that rejects were also removed from the WSF at times, to use in construction of wall lifts on the NCPP TSF.

11.2 Surrounding Environment

The is a small sediment pond at the northern end of the WSF, about 30m from the culvert where Deep Creek flows under the haul Road. At the east and south, it appears that runoff is directed into the haul road side drains. Taurus Creek flows under the haul road about 2km to the south.

Current mining pits are about 1.6km east of the haul road; partly rehabilitated spoil dumps at the back of the pits drain west toward the haul road. Under the Life-of-Mine Plan, the final Deep Creek Void will be about 0.9km further east from the present location.

Prior to mining and outside the area of mine disturbance, the dominant land use has been low intensity grazing, except in Amaroo State Forest more than 3km west and up-slope of the WSF. An are of regulated vegetation (sub-dominant of-concern regional ecosystem comprising remnant acacia dominated open forest, woodland and shrublands) is mapped south-east of the WSF; regulated vegetation (riverine) is mapped along Deep Creek and Taurus Creek and their tributaries. Deep Creek and Taurus Creek are watercourses defined by the Water Act 2000.

The final landform design for Ramp 36 is a stand-alone elevated landform with about the same footprint as the current facility. Some coarse rejects will be moved within that area to flatten slopes down to the same gradients being applied to spoil dumps.

11.3 Cover Design

11.3.1 Specific Hazards

Coarse rejects are geotechnically competent and do not need physical containment, so hazards g, i, and l in Table 4-1 are not relevant. In addition, the waste was dry-placed and contains much less water than tailings, so the risk of deep seepage to groundwater is much reduced (hazard a).

The proposed final landform is a mounded shape that will not pond water, so there is no risk of spill to surface water (hazard c). The WSF did not alter surface drainage except in its immediate vicinity - runoff draining east and west is presently captured but after rehabilitation it will follow normal drainage paths north and south to Deep Creek and Taurus Creek respectively (hazard f). Shallow seepage out of the WSF, in particular to Deep Creek, is feasible (hazard b) so minimising infiltration below the rooting zone will be a focus of detailed cover design.

Other relevant potential hazards will be addressed by the general controls outlined in Table 4-1.

11.3.2 Concept Cover Design

Because coarse rejects do not require containing embankments, Ramp 36 WSF can be re-shaped and covered essentially within its existing footprint (unlike NCPP TSF). In this context, a thick layer of general spoil is proposed for rehabilitation, with spoil sourced from future mining of the Deep Creek Pits. Final surface gradients, topsoil thickness and vegetation will be consistent with other spoil landforms rehabilitated to the same post-mining land use.

11.3.3 Design Details

The high level design objective for rehabilitation of Ramp 36 WSF is to create a landform that limits any release of solutes to levels that will not cause environmental harm, and can support managed grazing within a wider grazing enterprise. Coarse rejects presently in the emplacement will be re-handled to create a rough landform shape such that the required cover layer thickness will be fairly uniform, with details as follow:

- 5m thickness of spoil, dumped and spread in such a way that dispersive spoil with high fines content is not placed in the outer 1m of the landform. This may be achieved by selective placement or by chemically treating the top metre of spoil to reduce sodicity;
- Topsoil and erosion management practices consistent with those on other rehabilitated spoil areas.

Coarse rejects do not experience consolidation settlement. Due to the uncompacted nature of the waste, there may be some settlement due to the weight of the cover layer but most of this will occur as the cover is constructed and does not need to be specifically addressed in design.

11.3.4 Construction Methodology

Given the geotechnical competence of coarse rejects, construction of the thick spoil cover will be straight forward, typically comprising a simple dump and spread operation. Because the thick spoil is essentially simple bulk fill, no specific testing is required for QC/QA during construction except to confirm minimum cover thickness.

After completion of bulk earthworks, it would be advisable to leave the landform for a period to allow any residual settlement to occur. When topographic monitoring suggests that minimal further movement is likely, the area would then be rehabilitated in accordance with normal site practices for spoil dumps, including topsoil placement and construction of erosion control measures. The vegetation species mix should be consistent with the post-mining land use of managed grazing.

12. FUTURE WORK

The cover systems described herein are conceptual designs based on information available at August 2024.

As emphasised in the sections discussing construction methodology, construction design for the TSF covers cannot be finalised until in situ strength profiles are measured and this should be done as short a time as possible before cover works commence.

Spoil that may be suitable for the various cover layers should be identified as mined and/or in spoil dumps close to each TSF. Ideally, spoil should have been aged in dump for at least a couple of years to observe slaking and other degradation before samples for classification testing including silt/clay fraction and plasticity. In situ infiltration tests to confirm construction materials and methodology may be undertaken after suitable spoils have been identified and must be completed before the design is finalised.

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Whitehaven

Appendix 4.13 – Void Closure Plan

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Rev	Date	Details
A	2 September 2024	Draft for client review
0	15 October 2024	Final report issued

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Approved by:	Gareth Simpson	15 October 2024	

WSP acknowledges that every project we work on takes place on First Peoples lands.
We recognise Aboriginal and Torres Strait Islander Peoples as the first scientists and engineers and pay our respects to Elders past and present.

This document may contain confidential and legally privileged information, neither of which are intended to be waived, and must be used only for its intended purpose.

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Abbreviations

Abbreviation/Term	Description
AEP	Annual Exceedance Probability
AHD	Australian Height Datum
AWBM	Australian Water Balance Model
BHWE	Below High-wall Weathered Extent
BMA	BHP Mitsubishi (BM) Alliance Coal Operations Pty Ltd (former owner of Blackwater Mine)
BWM	Blackwater Mine
BWM residual voids	Ramp 8, Boonie Doon, Mimosa/Besgrove, Deep Creek, Stewarton/Ballamoo, Kenmare, Laleham, Togara/North Marshmead, South Marshmead, Comet Downs East, and Kennedy West
CHPP	Coal Handling and Processing Plant
CHM	Conceptual Hydrogeological Model
DESI	Department of Environment, Science and Innovation (formerly DES)
EA	Environmental Authority
EP Act	*Environmental Protection Act 1994*
FoS	Factor of Safety
FRP	Flood Risk Profile
GDE	Groundwater Dependent Ecosystems
LOD	Land Outcome Document
LOR	Limit of Reporting
PCM	Permian Coal Measures
ML	Megalitres
ML	Mining Lease
NUMA	Non-use Management Area
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation
PMLU	Post-mining Land Use
PRC Plan	Progressive Rehabilitation and Closure Plan
PRCP Guideline	*Progressive rehabilitation and closure plan (PRC plans) Guideline (version 3.0)*, dated 4 April 2023 (Department of Environment, Science)
RCM	Rangal Coal Measure
RCP	Representative Concentration Pathway

Abbreviation/Term	Description
ROM	Run-of-Mine
TDS	Total Dissolved Solids
TSF	Tailings Storage Facility
VCP	Void Closure Plan
WBM	Water Balance Model
Whitehaven	Whitehaven Coal Ltd.

1 Introduction

Blackwater Mine (BWM) is an open-cut metallurgical coal mine with historical underground workings, owned and operated by Whitehaven Coal Ltd (Whitehaven), approximately 4.5 kilometres (km) southwest of Blackwater in the Bowen Basin, Queensland. The site operates across various mining leases (MLs), namely: ML1959 (part), ML1760, ML1761 (part), ML1762 (part), ML1767, ML1771 (part), ML1772, ML1773, ML1792, ML1800, ML1812, ML1929, ML1860, ML1962, ML1907, ML70091, ML70103, ML70104, ML70139, ML70167, and ML70329.

BWM was formerly owned and operated by BHP Mitsubishi (BM) Alliance Coal Operations Pty Ltd (BMA) until Whitehaven took ownership on 2 April 2024. The operations at BWM are authorised under Environment Authority (EA) EPML00717813. Holders of an EA are required to submit a progressive rehabilitation and closure plan (PRC Plan) that meets requirements under the *Environmental Protection Act (1994) (EP Act)*. A Transition Notice has been issued to BMA (as the previous owners of BWM) by the Department of Environment, Science and Innovation[1] (DESI) for BWM, requiring a PRC Plan to be submitted to the administering authority by 15 November 2024.

This void closure plan (VCP) presents outcomes of technical studies completed to support closure planning and achieving safe residual voids that do not cause environmental harm at BWM. This VCP is an appendix to the BWM PRC Plan and is required by the DESI *Progressive rehabilitation and closure plan (PRC plans) Guideline (version 3.0)*, referred to as the *PRCP Guideline*, dated 4 April 2023.

Technical studies, including hydrogeology and rehabilitation flood modelling, have been undertaken through an iterative approach to the development of the closure landform design. These iterations have resulted in a closure landform design that includes refinements comprising residual void partial backfill, increased set-back distances, removal of culverts and other infrastructure from watercourses and floodplains, and changes to flood protection landforms to provide increased protection from flood water. This VCP documents how these refinements contribute to minimising environmental harm related to the final voids at BWM.

1.1 Scope and objectives

The BWM mining pits will be transitioned as pre-approved non-use management areas (NUMAs) and will be combined in the closure landform design as eleven residual voids with two in-pit tailings emplacements at Bonnie Doon and Laleham. The eleven residual voids are: Ramp 8, Boonie Doon, Mimosa/Besgrove, Deep Creek, Stewarton/Ballamoo, Kenmare, Laleham, Togara/North Marshmead, South Marshmead, Comet Downs East, and Kennedy West (herein referred to as the BWM residual voids).

The objective of this VCP is to document the rehabilitation and management approach, capturing how Whitehaven will aim to achieve safe residual voids that do not cause environmental harm at closure. This void closure plan will also assist to:

- minimise risks of the residual voids and surrounding areas within the Non-Use Management Area (NUMA) extents
- minimise active management of the residual voids post-closure
- avoid unmitigated access to the NUMA by humans and livestock.

The following sections present information as required by sections 3.4 and 3.6.3 of the *PRCP Guideline*, specifically:

- Section 3 – Proposed residual voids
- Section 4 – Groundwater
- Section 5 – Flooding assessment
- Section 6 – Void water balance
- Section 7 – Geotechnical stability

[1] Previously referred to as Department of Environment and Science (DES)

- Section 8 – Geochemical stability
- Section 9 – Residual void management.

1.2 Applicable legislation and guidelines

The following applicable legislation and guidelines have informed the development of this VCP:

- *Environmental Protection Act* (1994)
- Environmental Authority EPML00717813 dated 18 March 2024
- *Progressive rehabilitation and closure plan (PRC plans) Guideline (version 3.0)*, dated 4 April 2023 (Department of Environment, Science).

2 Site overview

BWM is a conventional open-cut metallurgical coal mine with historical underground workings located approximately 4.5 km southwest of Blackwater in the Bowen Basin in Central Queensland. The Bowen Basin is a major coal producing region, and as such BWM is in close proximity to a number of other operational open-cut coal mines.

Mining at BWM involves the removal and stockpiling of topsoil, drilling and blasting of overburden and interburden, removal of overburden and interburden by draglines and truck and shovel fleets, and mining of the coal by truck and shovel fleets. As mining progresses, overburden and interburden are placed in spoil dumps within the void of the previous strips. As pits get deeper, the in-pit spoil placement increases to reduce out-of-pit dumping.

Coal is hauled from the pits to the run-of-mine (ROM) area or to designated stockpiles. Coal is processed at the coal handling and preparation plant (CHPP), which generates coal waste fines that are disposed of in dedicated tailings storage facilities (TSFs), and coarse rejects that are disposed of within the spoil dumps. Product coal is loaded on to coal trains via an existing train load-out facility located adjacent to the CHPP and product stockpiles.

Operations at BWM commenced in 1967. Current life-of-mine planning project mining of the EA approved extent until 2113. This timeline assumes mining continues at current mining rates.

An overview of the existing environment within and surrounding BWM is provided in the PRC Plan and, therefore, is not repeated in this VCP.

3 Proposed residual voids

Residual voids are identified and authorised under Schedule E (Condition E10 and E11) of the EA (BWM's Land Outcome Document (LOD)). Therefore, the eleven proposed BWM residual voids are being transitioned as pre-approved NUMAs in the BWM PRC Plan.

The residual voids will be partially backfilled with spoil to reduce the void extents and assist with flood protection to mitigate the risk of inundation from floodwater (refer to Section 5). The NUMAs extent is designed to achieve an area that is safe and therefore includes the residual void below natural ground level (high-wall, end-walls, low-wall and floor); the associated set-back distances from the crest to achieve a factor of safety (FoS) of greater than or equal to (≥) 1.5; and a safety bund and fence.

The total proposed NUMA area is 3,960 ha. This NUMA area has been minimised by reducing the number of ramp voids through backfilling during the mining operations and by backfilling sections of the final voids at the end of mining. Indicative final dimensions of the residual voids are presented in Table 3.1. A three-dimensional (3D) depiction of the BWM residual voids, including the void lakes, is presented in Figure 3.1.

Table 3.1 Indicative BWM residual void dimensions

Residual void	Indicative maximum width (m)	Indicative maximum length (m)	Indicative maximum depth (m)
Ramp 8	220	800	34
Bonnie Doon	220	3,460	9
Mimosa/Besgrove	480	10,250	53
Deep Creek	540	3,590	54
Stewarton/Ballamoo	320	19,700	84
Kenmare	420	3,290	62
Laleham	190	1,940	2
Togara/North Marshmead	610	5,340	88
South Marshmead	640	1,780	77
Comet Downs East	270	5,630	43
Kennedy West	564	734	93

Note: Dimensions are indicative of measurements at void crests and do not represent full NUMA extents.

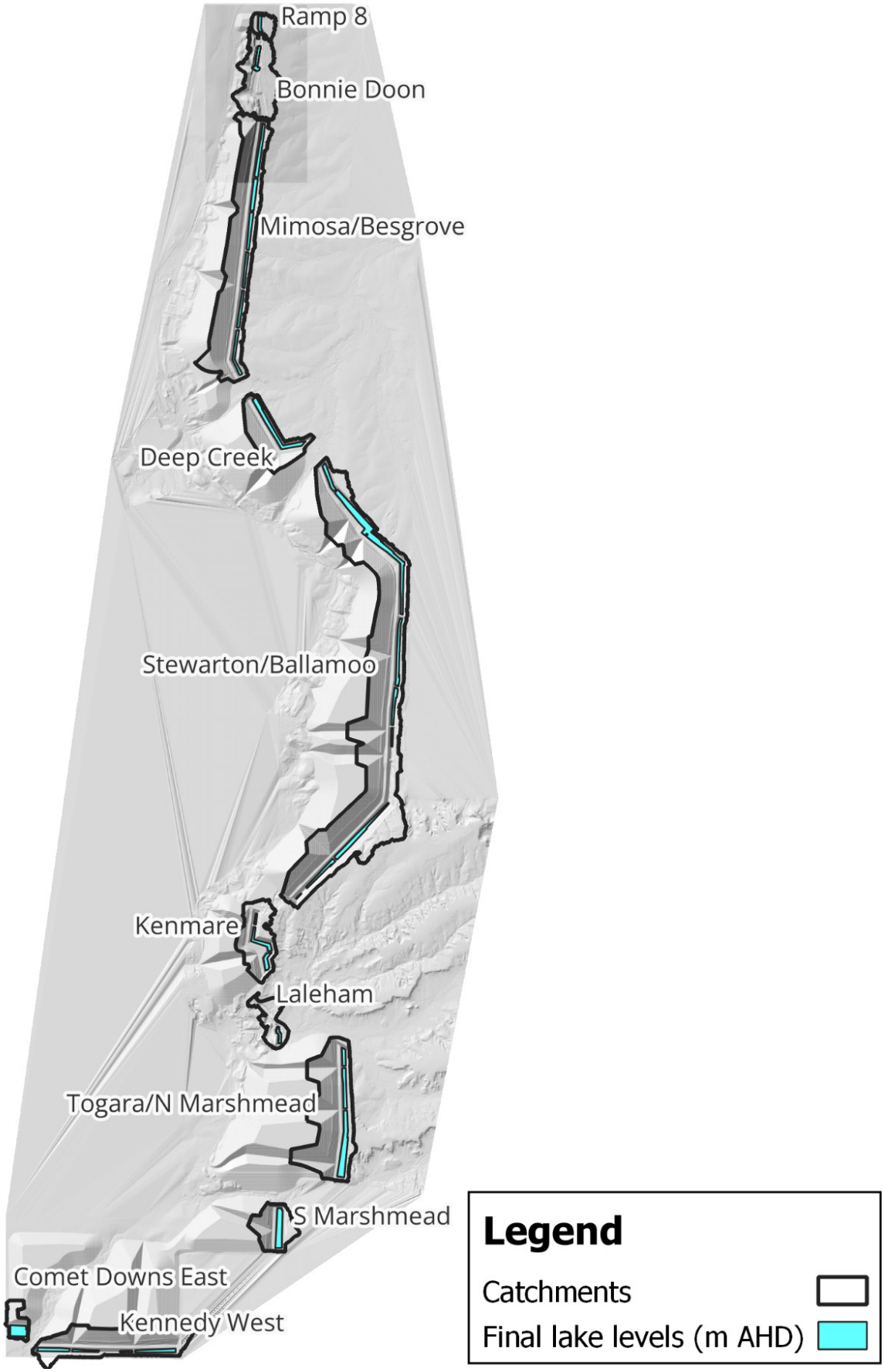


Figure 3.1 3D depiction of BWM residual voids and void lakes (mean lake level in final 20 years of modelled period) (WSP, 2024)

4 Groundwater

The hydrogeological assessment completed included conceptual and numerical modelling to determine groundwater interactions with the potential for contaminant transport from BWM residual voids (SLR Consulting, 2024). The complete hydrogeological assessment, including details of the model set-up, calibration, and discussion of the results, is provided as an attachment to the PRC Plan, and, therefore, is not repeated in this void closure plan. This section presents a summary of the hydrogeological assessment of the BWM residual voids, as it relates to the rehabilitation and management approach to achieve safe residual voids that do not cause environmental harm at closure.

A post-mining conceptual hydrogeological model (CHM) was developed to depict groundwater interactions with residual voids. A visual representation is presented for the northern area in Figure 4.1 and the southern area in Figure 4.2. The CHM's key findings, relevant to post-mining groundwater impacts from the closure landform design, are as follows (SLR Consulting, 2024):

- Residual void lake formation, with lake levels stabilising significantly below any shallow post-Permian strata, including the base of surficial weathering and shallow hydrostratigraphic units (i.e., alluvium and Tertiary strata).
- Partial groundwater system recovery outside the residual voids, primarily in the Rangal Coal Measures.
- Continued groundwater drawdown within the Rangal Coal Measures, associated with evaporative discharge from the void lakes, resulting in continued inwards hydraulic flow gradients in the coal measures and ongoing groundwater discharge to the residual voids.
- Potential for ongoing salinization of the residual void lakes associated with evaporative discharge from the lakes.
- Reflooding of historical underground workings.
- No potential for groundwater quality impacts outside of the BWM area associated with residual voids or spoil emplacements, due to the inward groundwater flow gradients towards the residual voids continuing to capture all potential seepage.
- No potential for groundwater quality impacts outside of the BWM area associated with in-pit tailings emplacements at Bonnie Doon and Laleham, due to the inward groundwater flow gradients towards the residual voids continuing to capture all potential seepage.
- Some potential for groundwater movement from the mine areas west of Laleham residual void towards Sirius Creek outside of the BWM area, with this area subject to specific risk mitigation planning under the PRC Plan.

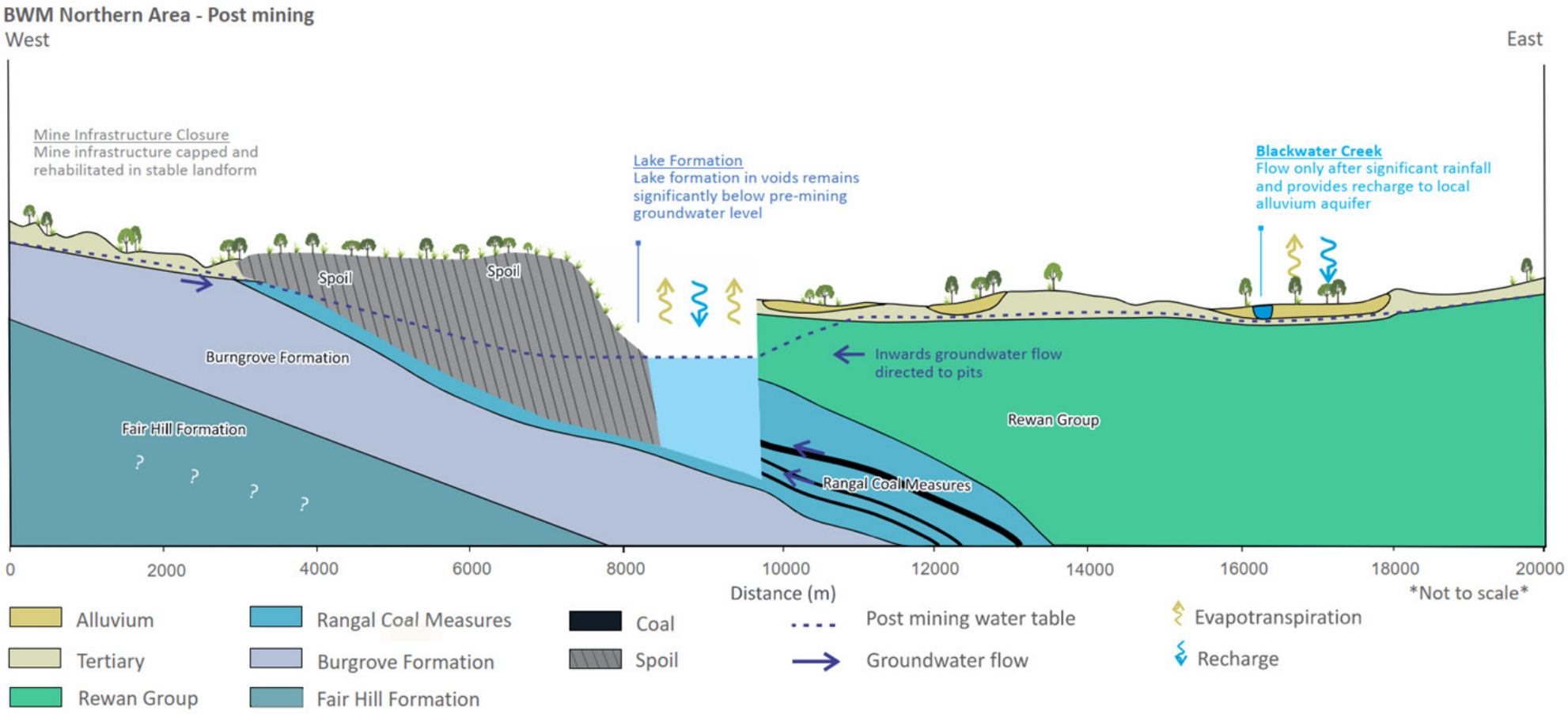


Figure 4.1 Depiction of the conceptual model of BWM groundwater system – BWM Northern area (post-mining) (SLR Consulting, 2024)

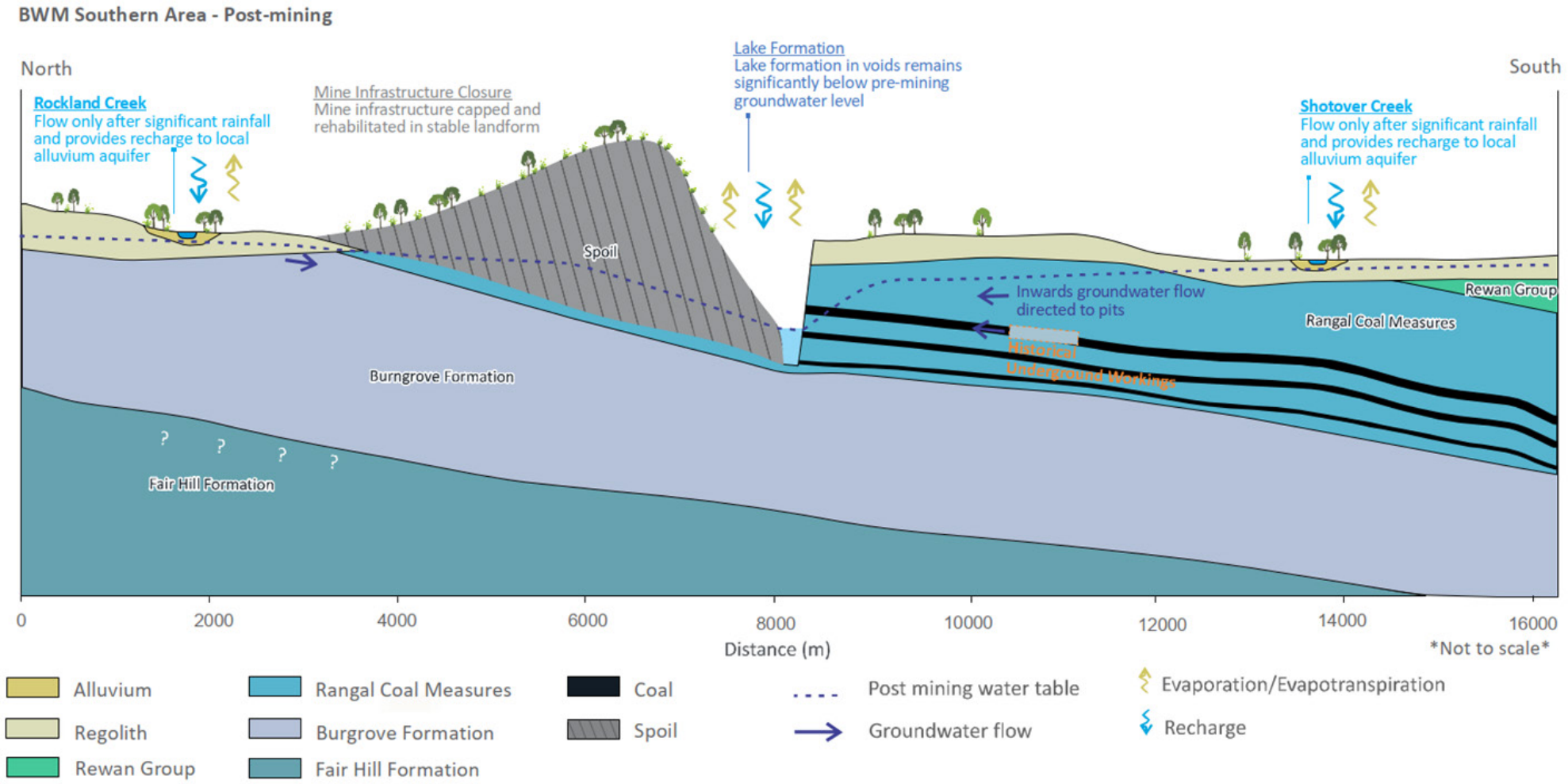


Figure 4.2 Depiction of the conceptual model of BWM groundwater system – BWM Southern area (post-mining) (SLR Consulting, 2024)

Calibrated numerical modelling was undertaken to evaluate the potential impacts of the closure landform design for the BWM residual voids on the groundwater regime (SLR Consulting, 2024). The objectives of the predictive modelling were to:

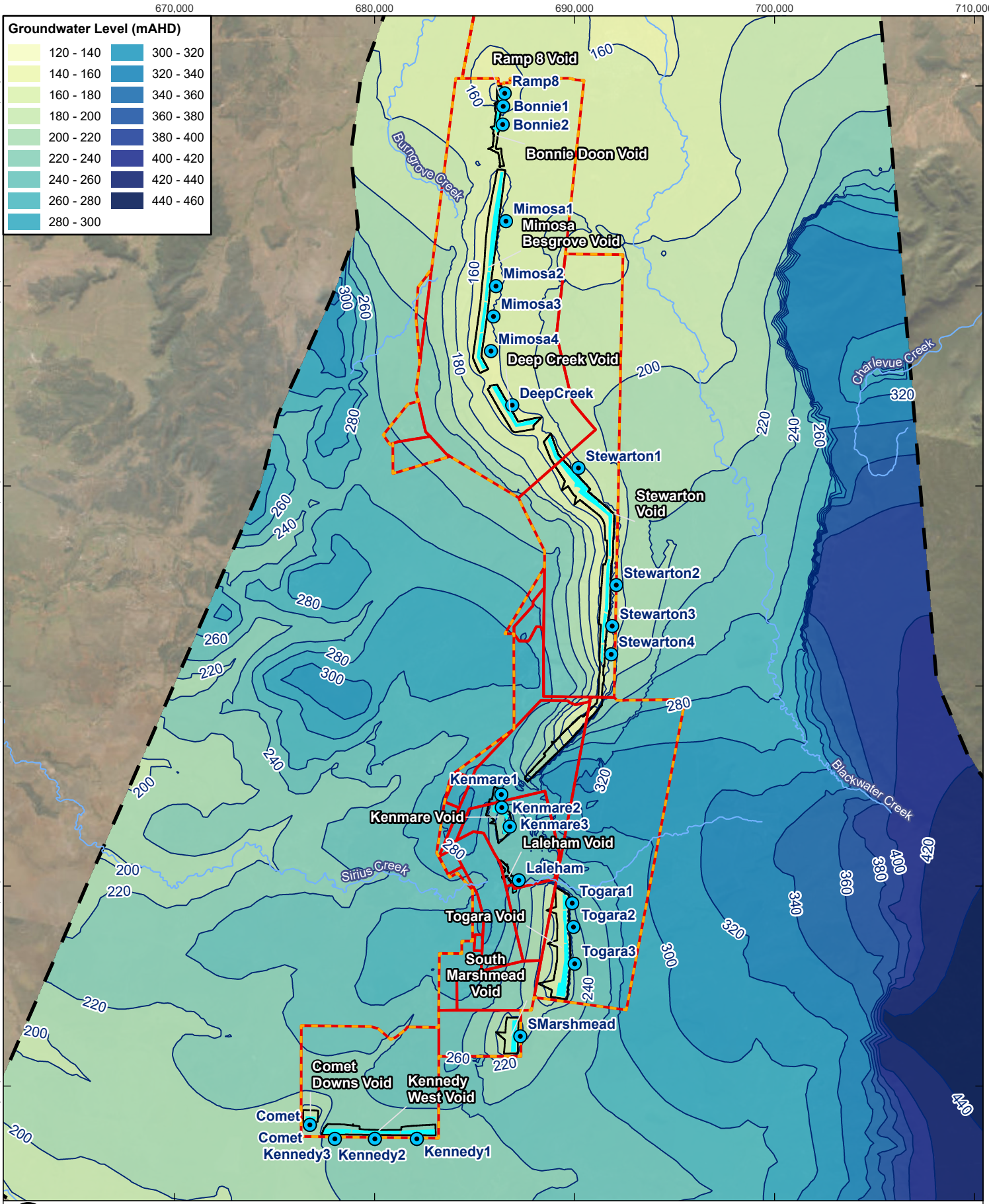
- Simulate the water level and rate of recovery of the residual void lakes, and the water level and rate of recovery from mining-related groundwater drawdown in the groundwater system surrounding the voids.
- Simulate the groundwater level and rate of recovery within historic underground mine workings relevant to the PRC Plan.
- Assess groundwater inflow to the final residual voids.
- Identify areas of potential environmental or anthropogenic risk, such as impacts to private water supply bores or GDEs, where groundwater impact mitigation/control measures may be necessary post-closure.

The closure landform design, including the eleven residual voids and in-pit tailings emplacement at Laleham and Bonnie Doon was incorporated into the model. The model timeframe was developed to commence at the end of mining (end of the year 2113) and cover a period of 500 years over eight model stress periods. The predicted end of mining groundwater level was used as the starting heads for the post-closure simulation (SLR Consulting, 2024).

To reasonably represent future climate conditions, three climate scenarios (wetter-R1, mid-R4, and drier-R6) from the water balance model (WBM) (refer to Section 6) that provides a reasonable potential range of climate impacts, were adopted to generate three sets of groundwater model predictions to account for climate sensitivity. Groundwater level predictions and the associated discussion herein focus primarily on the mid-climate scenario (R4) with the drier (R6) and wetter (R1) scenarios reported as sensitivities (where relevant). The predicted equilibrium (long-term steady state) of the water table elevation adjacent to the final voids is shown in Figure 4.3 for the mid-climate scenario.

Post mining the residual voids will accumulate water over time due to direct rainfall, surface water runoff and groundwater inflow from both spoil and natural rock as groundwater levels recover. The groundwater levels proximal to the residual voids are predicted to remain below pre-mining groundwater levels in the long-term, driven by ongoing groundwater discharge to the residual void lakes and governed by the lake elevations themselves (Figure 4.3) Long-term inwards groundwater flow gradients are maintained post-mining.

Hydraulic gradients to the residual voids are steepest along the eastern sides of the Stewarton/Ballamoo and Togara residual voids and on the southeast corner of the South Marshmead residual void. Relatively steep hydraulic gradients also occur within the spoil emplacements to the west of the Ramp 8, Bonnie Doon, Mimosa/Besgrove, Deep Creek, Stewarton/Ballamoo, Kenmare, Laleham, Togara/North Marshmead and South Marshmead residual voids, and to the north of the Kennedy West and Comet Downs East residual voids. Flatter hydraulic gradients are modelled in the natural rock away from the mining area and away from the residual voids outside the BWM area (with the exception of the steeper gradient observed distant to the east that occurs due to the Clematis Group escarpment) (SLR Consulting, 2024).



0 2.5 5 km

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Scale:	1:250,000 at A4
Project Number:	620.040199
Date Drawn:	09-Aug-2024
Drawn by:	AS

LEGEND

- Hydrograph Location
- Watercourse
- Groundwater Level (mAHD)
- BWM Mining Lease
- Project Area (Environmental Authorities boundary)
- Study Area
- Void Extent
- Void Lake

BLACKWATER MINE - TRANSITIONAL PRCP HYDROGEOLOGY ASSESSMENT

PREDICTED WATER TABLE ELEVATION – POST-MINING EQUILIBRIUM (MID CLIMATE SCENARIO)

SLR

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FIGURE 4.3

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040199.00001 BWM PRCP – GW\03 SLR Data\01 CADGIS\GIS\ArcPro\BWM PRCP – GW\BWM PRCP – GW.aprx\620040199_F08_25_Predicted Water Table Elevation – PME (Mid Climate Scenario)

Whilst the residual voids remain net groundwater sinks, temporally variable fluxes of water between the voids and adjacent spoil and bedrock formations occur in the beginning of the post-closure simulation. During these initial periods, groundwater levels in the spoil and natural geological formations are recovering from mine dewatering activities and groundwater fluxes are largely controlled by the difference between predicted groundwater levels in the spoil and the periodic rise and fall of the residual void lake level. The residual void lake levels rise and fall according to the climatic simulation applied to the WBM, as well as how the daily timestep water balance results are translated to the comparatively simplified stress periods set up in the groundwater model. For Deep Creek residual void outward fluxes to the surrounding natural geology are predicted to extend through the initial 100 years post-closure. As the groundwater levels in the surrounding in-pit spoil landform and natural geology recover to elevations above the void lakes and lake levels stabilise, the direction of flow out of the void lakes is reversed and long-term net groundwater inflow to the residual voids is established.

Following this initial period of groundwater flux, groundwater inflows prevail for the duration of the simulation for all voids except Kennedy West (SLR Consulting, 2024). Minor outflows of water to the surrounding natural geology (107 m^3/day) from Kennedy West residual void persists at equilibrium. This outward flux is predicted to be captured by the adjacent Comet Downs East residual void driven by the hydraulic gradient that establishes between the two voids. This hydraulic gradient develops from the predicted lake elevation in the Comet Downs residual void being much lower than the Kennedy West residual void (SLR Consulting, 2024).

The predicted lake levels in the Kenmare and Laleham residual voids remain above the elevation of the historic underground workings that would be exposed in the void high-wall. This indicates that the Kenmare and Laleham Underground workings remain permanently flooded and there is no potential for oxidisation of the workings (SLR Consulting, 2024).

It should be noted that it is the network of residual voids in the closure state landform that are providing long-term management of groundwater from the mining areas. The network of residual voids establishes a hydraulic control (sink) through relatively deep void lakes in which the long-term lake levels are maintained by evaporation. Any form of further backfilling of residual voids to attempt to limit any modelled outflows, particularly to above the coal seams or above surrounding groundwater levels, is likely to result in removal of this hydraulic control and less beneficial environmental outcomes. Additional backfilling other than to a free draining landform would likely result in an increase in the void lake level elevation and therefore potentially creating a hydraulic head gradient toward the surrounding groundwater system, increasing the potential for outflow.

Predicted groundwater inflows for the mid-climate scenario for BWM residual voids are shown on Figure 4.4 to Figure 4.14.

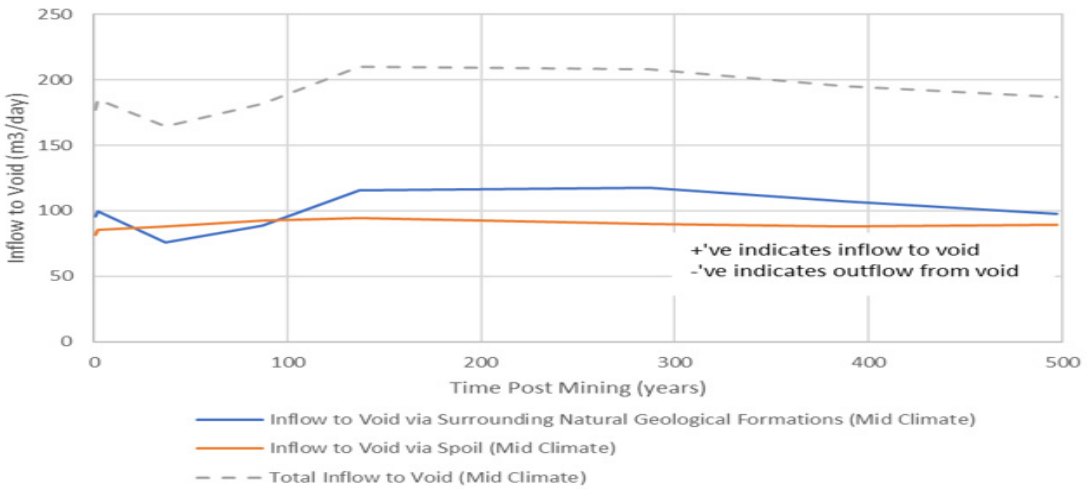


Figure 4.4 Predicted groundwater inflows for the mid-climate scenario for Ramp 8 residual void (SLR Consulting, 2024)

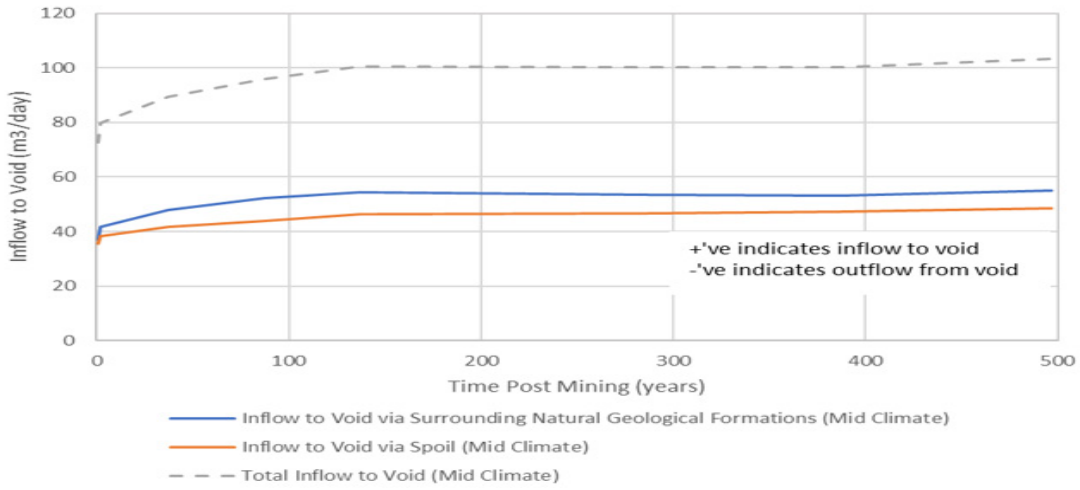


Figure 4.5 Predicted groundwater inflows for the mid-climate scenario for Bonnie Doon residual void (SLR Consulting, 2024)

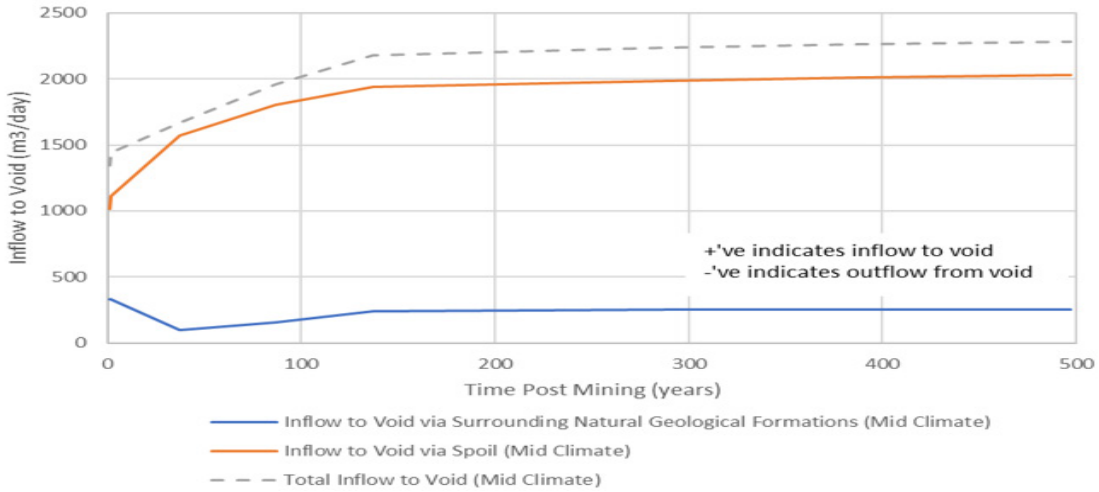


Figure 4.6 Predicted groundwater inflows for the mid-climate scenario for Mimosa/Besgrove residual void (SLR Consulting, 2024)

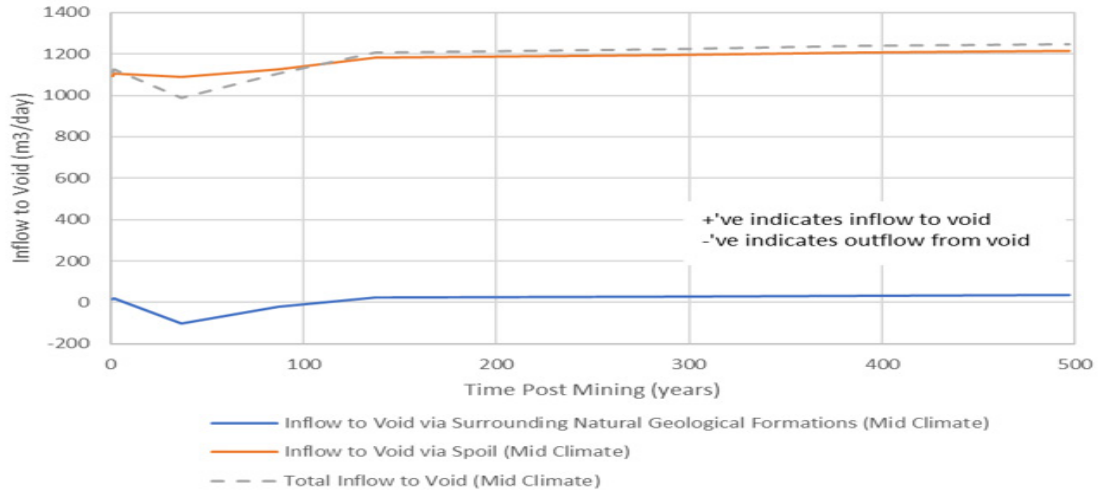


Figure 4.7 Predicted groundwater inflows for the mid-climate scenario for Deep Creek residual void (SLR Consulting, 2024)

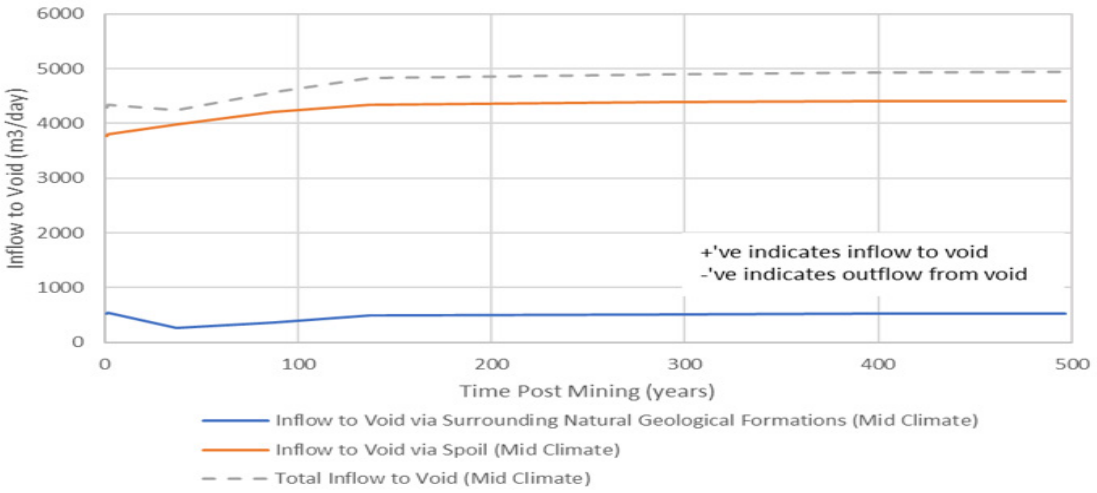


Figure 4.8 Predicted groundwater inflows for the mid-climate scenario for Stewarton/Ballamoo residual void (SLR Consulting, 2024)

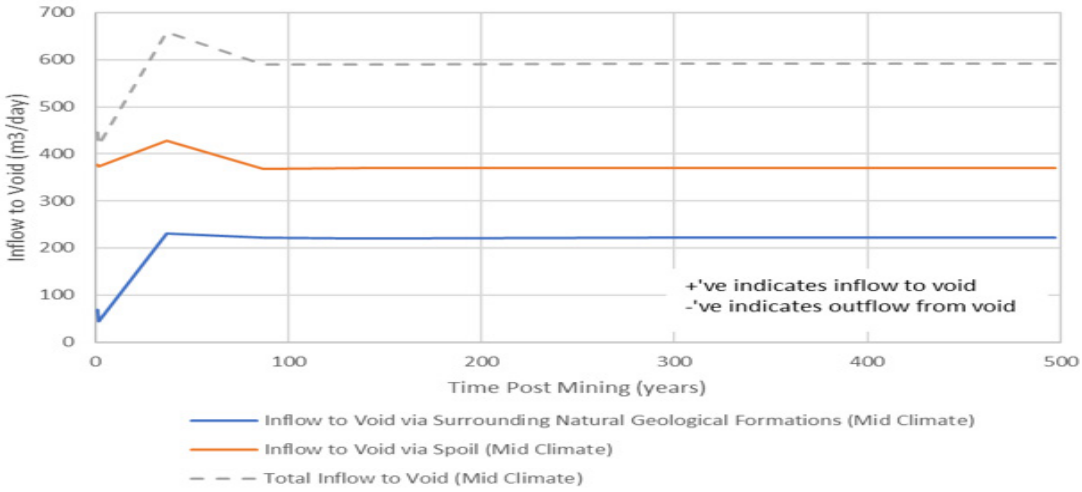


Figure 4.9 Predicted groundwater inflows for the mid-climate scenario for Kenmare residual void (SLR Consulting, 2024)

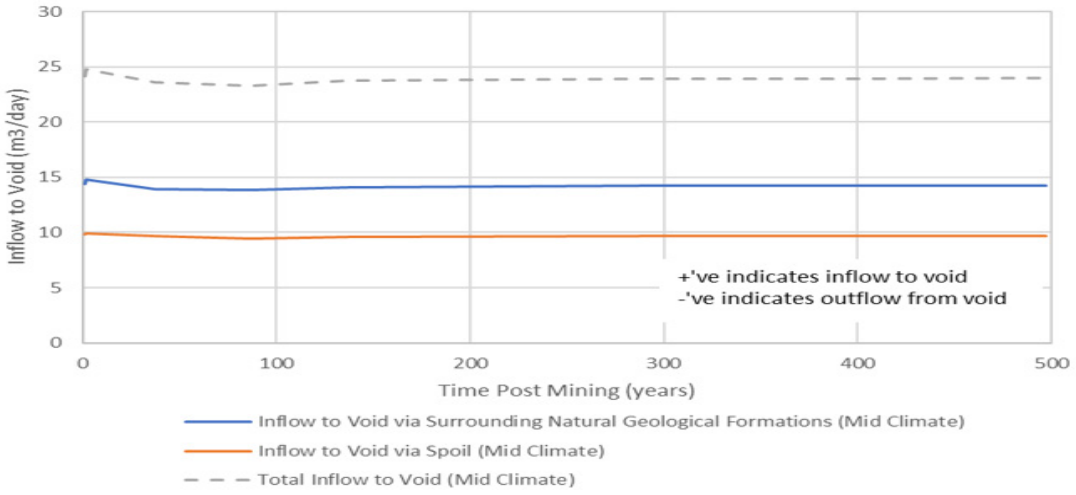


Figure 4.10 Predicted groundwater inflows for the mid-climate scenario for Laleham residual void (SLR Consulting, 2024)

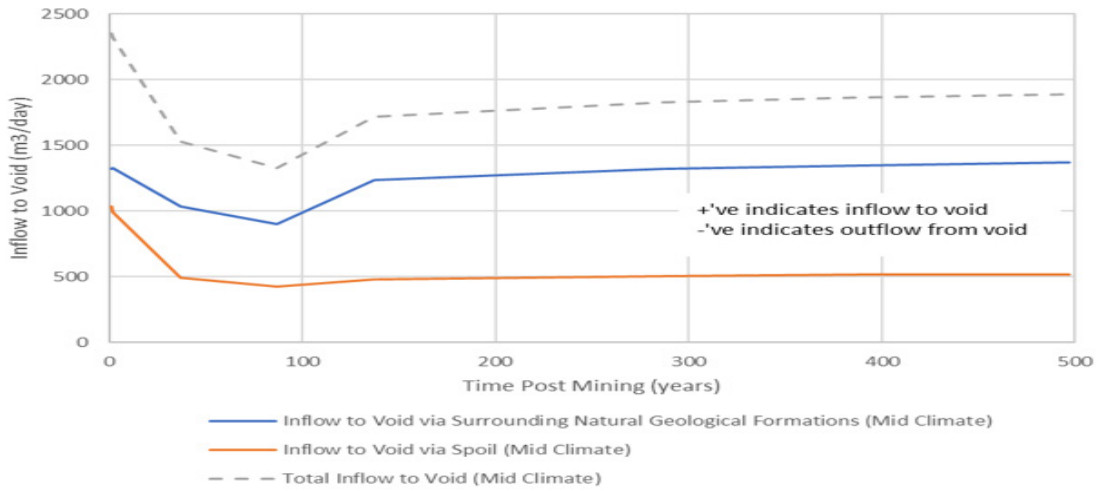


Figure 4.11 Predicted groundwater inflows for the mid-climate scenario for Togara/North Marshmead residual void (SLR Consulting, 2024)

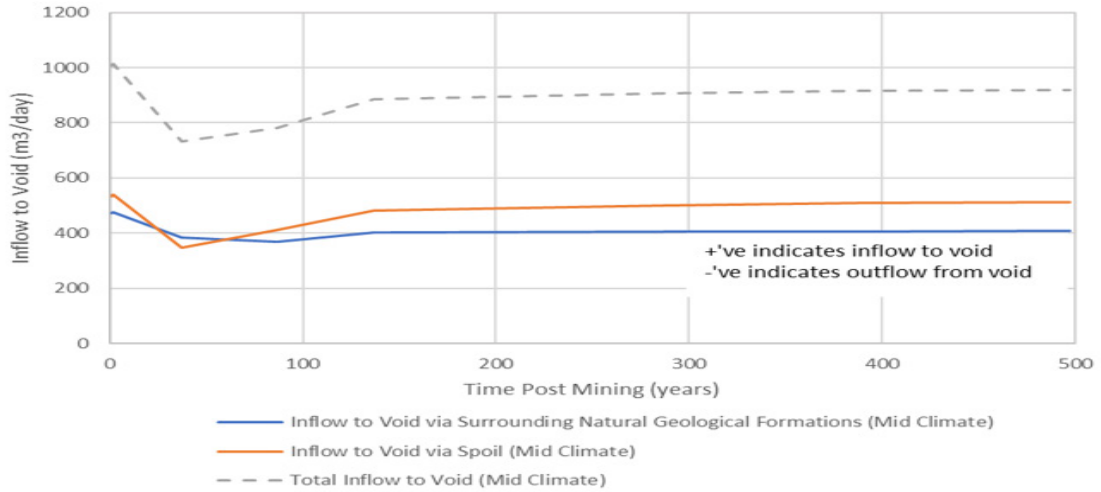


Figure 4.12 Predicted groundwater inflows for the mid-climate scenario for South Marshmead residual void (SLR Consulting, 2024)

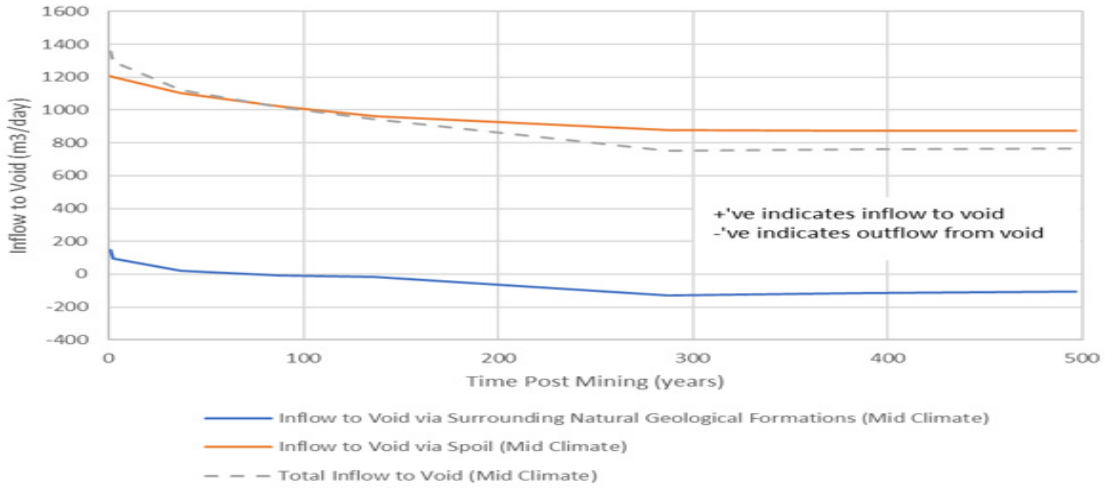


Figure 4.13 Predicted groundwater inflows for the mid-climate scenario for Kennedy West residual void (SLR Consulting, 2024)

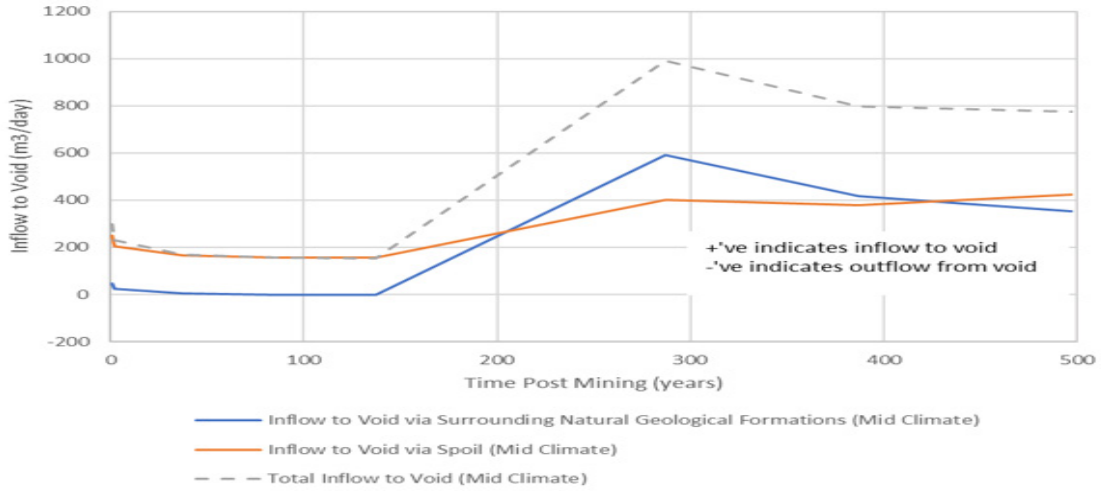


Figure 4.14 Predicted groundwater inflows for the mid-climate scenario for Comet Downs East residual void (SLR Consulting, 2024)

Predictive hydrographs generated during the groundwater modelling show that groundwater levels in the BWM area are predicted to remain below pre-mining conditions in the long-term; however, the majority of the post-mining drawdown is expected to be less than during the operational mining period. Groundwater levels surrounding the residual voids are controlled by the residual void lake levels, which in turn are controlled by the rate of evaporation from the void lakes balancing mostly surface inflows and some groundwater inflows to the lakes (SLR Consulting, 2024).

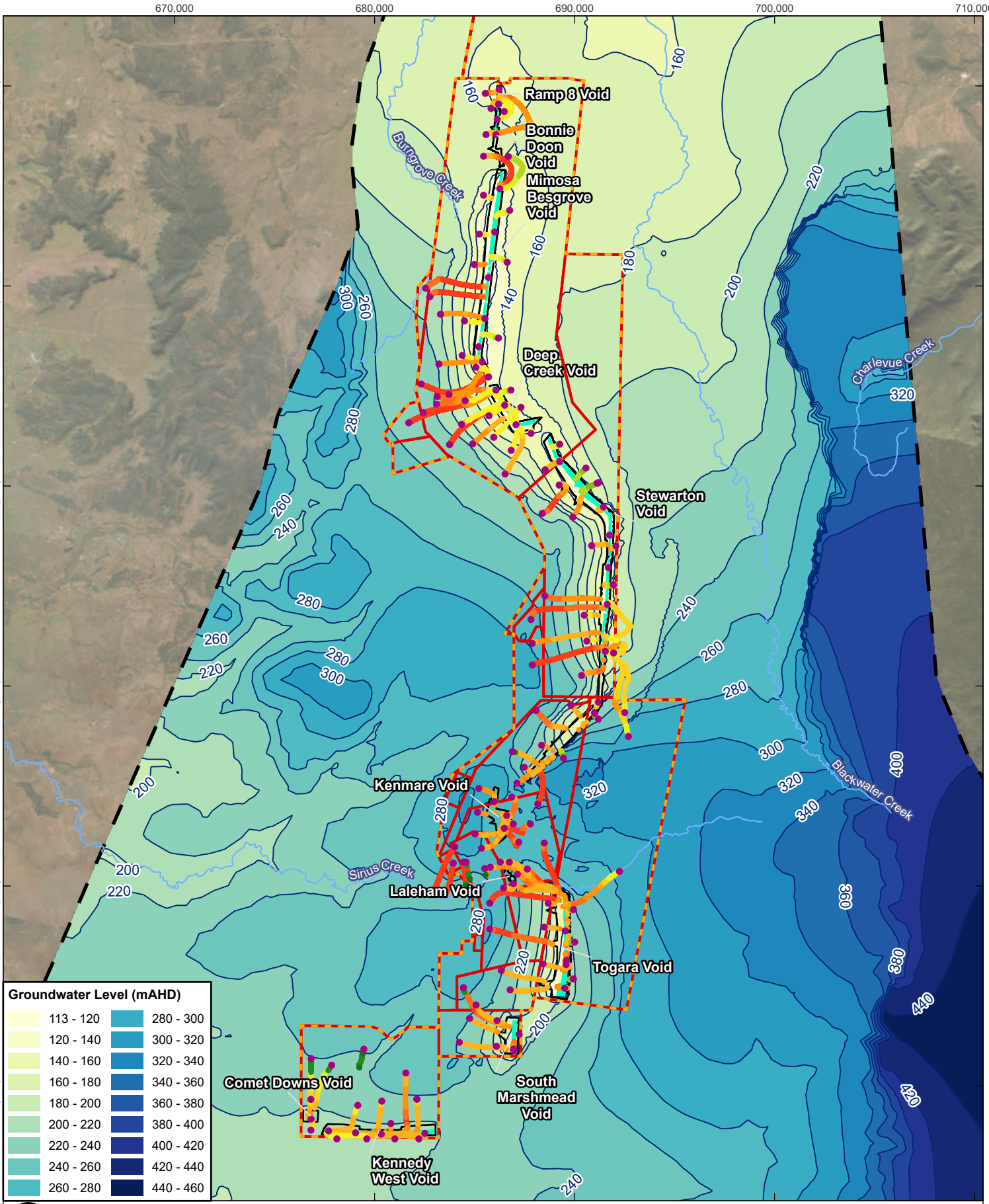
The hydrographs (SLR Consulting, 2024) show that predicted groundwater levels just outside the residual voids are approximately similar, or below the predicted void lake levels however only a few hundred metres further from the residual voids, groundwater levels will be higher than the void lake levels. This will hydraulicly prevent any void lake from travelling outward from the void for any distance. Short term outward flux from areas with flatter gradients, such as near Bonnie Doon and Kennedy West is recaptured by the voids in the long-term post-mining due to the hydraulic gradient between adjacent voids (SLR Consulting, 2024).

Although the groundwater chemistry data set for BWM is limited, the available data suggests salinity is the key constraint to future use of groundwater (SLR Consulting, 2024). Groundwater monitoring for total dissolved solid (TDS) in the various stratigraphic units for BWM returned TDS ranges of moderately saline to saline for all stratigraphic units, with the exception of the Tertiary strata which ranged from fresh to saline. Water quality within the RCM coal seams bores range from brackish to highly saline (503 to 28,900 mg/L) (SLR Consulting, 2024).

The pH of the groundwater at BWM ranges from 5.8 to 8.2 however the median is generally neutral, as such, any potential outflows are considered to pose minimal risk to the environment if they were to occur (SLR Consulting, 2024).

Using the numerical groundwater model and the 'mod-PATH3DU' code, an analysis of the water movement within the final closure state landform was completed to simulate and assess the movement and fate of water particles through the groundwater system post-mining. The particle movement simulation for particles placed within the residual voids (Figure 4.15) indicated that groundwater at BWM will remain within the final closure state landform (i.e., rehabilitated in-pit spoil and residual voids) in the long-term (SLR Consulting, 2024). Modelled particles which begin their simulation within the residual voids, in the spoil adjacent to the voids or in the historic underground mines near Laleham migrate towards or are captured by the residual voids within the recovery simulation and are therefore not predicted to leave the BWM area (SLR Consulting, 2024). The flow path analysis indicates that the particles generally move toward the void lakes, with most of the particles captured in the voids. The exception to this is an area not associated with residual voids (Bottom Dam) that is addressed within the PRC Plan (SLR Consulting, 2024).

In summary, water associated with in-pit spoil and tailings deposition, historic underground mine workings or open cut residual void lakes is not predicted to migrate away from the BWM area, with the residual voids acting as passive containment for groundwater which has passed through the mine workings (SLR Consulting, 2024).



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Project Number:	620.040199
Date Drawn:	02-Aug-2024
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BLACKWATER MINE - TRANSITIONAL PRCP HYDROGEOLOGY ASSESSMENT

PREDICTED MOVEMENT OF PARTICLES (MID CLIMATE SCENARIO)

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FIGURE 4.15

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040199.00001 BWM PRCP – GW\03 SLR Data\01 CADGIS\GIS\ArcPro\BWM PRCP – GW\BWM PRCP – GW.aprx\620040199_F08_XX_Predicted Movement of Particles (Mid Climate Scenario)

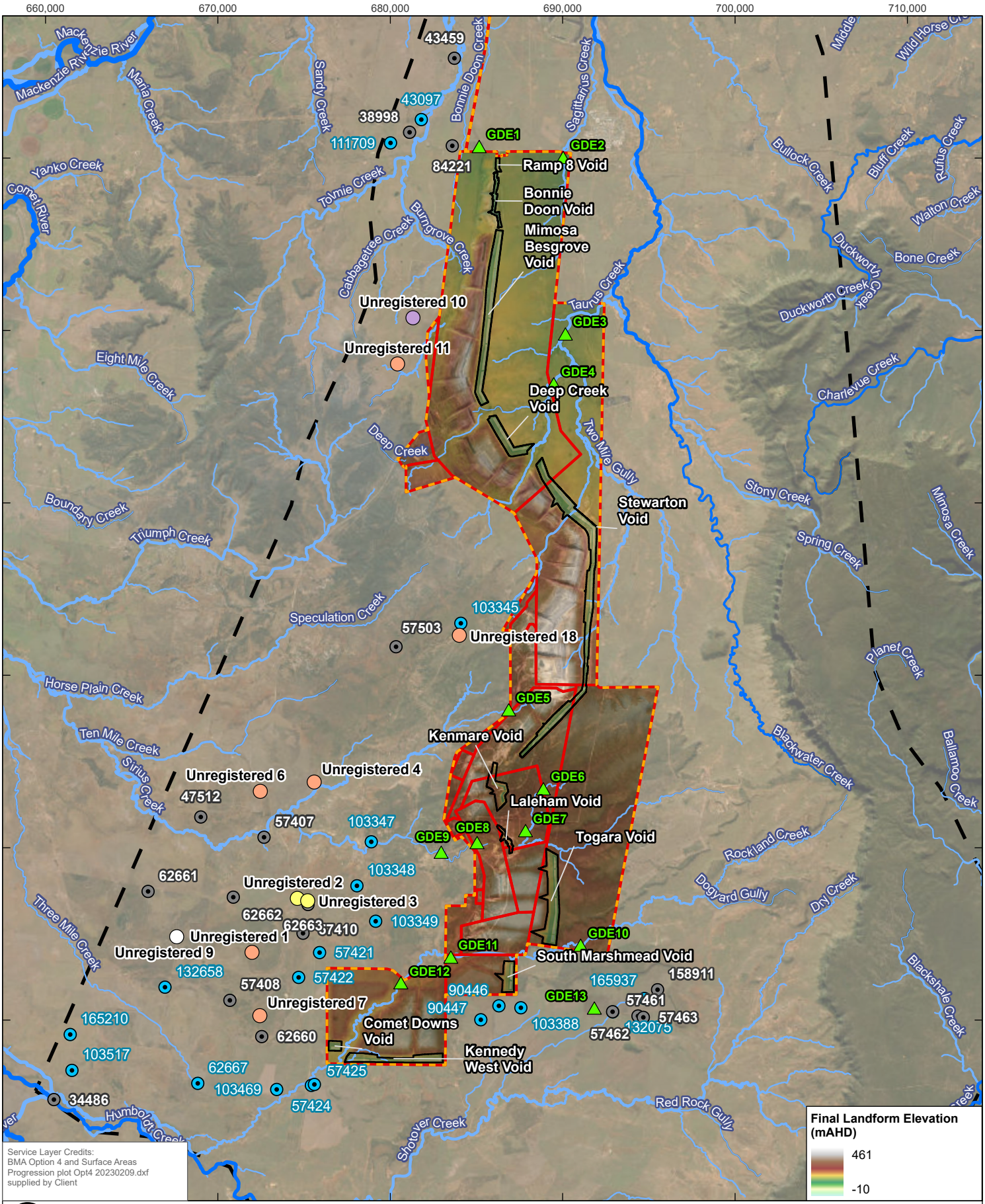
Initially, rainfall derived water captured in the residual voids is expected to move into the in-pit spoil. Following stabilisation of groundwater and lake levels, these initial outflows to the in-pit spoil, are expected to return to the residual voids, thereby maintaining a closed-loop system with low potential for environmental harm.

This absence of environmental harm is supported by the groundwater modelling, particle tracking simulation, and assessment of potential impact on identified third-party bores or groundwater-dependent ecosystems (GDEs) in the vicinity of BWM.

Predictive hydrographs were derived from the groundwater model to understand the potential impact of groundwater level change for identified potential natural and anthropogenic groundwater receptors in the vicinity of BWM.

The location of potential GDEs in the vicinity of BWM were identified through the BoM's National Atlas of Groundwater Dependent Ecosystems (SLR Consulting, 2024). Predictive hydrographs were derived from the groundwater model at the potential GDE and third-party water supply groundwater bore sites identified within and adjacent to the BWM mining leases (Figure 4.16).

Given that the initial predicted depth to the water table exceeds 10 m – a depth that indicates the total plant groundwater use would be negligible, a number of these GDEs are not likely to be present. Other identified potential GDE sites are associated with anthropogenic sources such as dams and therefore interpretation of potential impacts must consider the limitations of the GDE Atlas mapping. The hydrographs (Figure 4.17 to Figure 4.20) indicate that most water table drawdown in the vicinity of the potential GDEs is predicted to occur prior to the end of mining (i.e., associated with approved BWM mining operations). Any additional drawdown occurring over the post-mining period is predicted to be a result of continuing operational drawdown trends (i.e., a time lag from active BWM mining) and regional scale influences, rather than new impacts caused by the final closure state landform design. It is also noted that there was no difference in the hydrographs for the drier or wetter climate scenarios, suggesting that the final landform is not contributing significantly to additional impacts at the potential GDE locations (SLR Consulting, 2024).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Mackenzie River
Maria Creek
Sandy Creek
Bonnie Doon Creek
Sagittarius Creek
Middle
Wild Horse Creek
Yanko Creek
Comet River
Tolmie Creek
Cabbagetree Creek
Burngrove Creek
Bullock Creek
Bluff Creek
Rufus Creek
Walton Creek
Duckworth Creek
Bone Creek
Taurus Creek
Eight Mile Creek
Deep Creek
Two Mile Gully
Charlevue Creek
Stony Creek
Mimosa Creek
Spring Creek
Boundary Creek
Triumph Creek
Speculation Creek
Planet Creek
Horse Plain Creek
Ten Mile Creek
Sirius Creek
Blackwater Creek
Ballamoo Creek
Rockland Creek
Dogyard Gully
Dry Creek
Three Mile Creek
Blackshale Creek
Red Rock Gully
Shotover Creek
Humboldt Creek
43459
43097
38998
111709
84221
GDE1
GDE2
Ramp 8 Void
Bonnie Doon Void
Mimosa Besgrove Void
Unregistered 10
Unregistered 11
GDE3
GDE4
Deep Creek Void
Stewarton Void
103345
57503
Unregistered 18
GDE5
Kenmare Void
Unregistered 6
47512
Unregistered 4
GDE6
Laleham Void
57407
103347
GDE7
GDE8
GDE9
Togara Void
103348
62661
Unregistered 2
Unregistered 3
62662
62663
57410
103349
Unregistered 1
Unregistered 9
57421
GDE10
GDE11
South Marshmead Void
132658
57408
57422
GDE12
90446
165937
158911
GDE13
57461
57463
Unregistered 7
90447
103388
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57462
165210
62660
Comet Downs Void
Kennedy West Void
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62667
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103469
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Service Layer Credits:
BMA Option 4 and Surface Areas Progression plot Opt4 20230209.dxf supplied by Client
Final Landform Elevation (mAHD)
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2.5
5
km
LEGEND
Major Watercourse
Minor Watercourse
Project Area (Environmental Authorities boundary)
BWM Mining Lease
Study Area
Void Extent
Potential GDE – Hydrograph Location
Groundwater Database Bore
Water Supply
Unknown
Bore Census Unregistered Bores EMM (2019)
Stock
Stock and Domestic
Not in Use
Unknown
Coordinate System: GDA2020 MGA Zone 55
Scale: 1:290,000 at A4
Project Number: 620.040199
Date Drawn: 06-Aug-2024
Drawn by: RB
BLACKWATER MINE - TRANSITIONAL PRCP HYDROGEOLOGY ASSESSMENT
POTENTIAL RECEPTOR PREDICTIVE HYDROGRAPH LOCATIONS
SLR
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FIGURE 4.16
Path: H:\Projects-SLR\620-BNE\620-BNE\620.040199.00001 BWM PRCP – GW\03 SLR Data\01 CADGIS\GIS\ArcPro\BWM PRCP – GW\BWM PRCP – GW.aprx\620040199_F08_30_Potential Receptor Predictive Hydrograph Locations

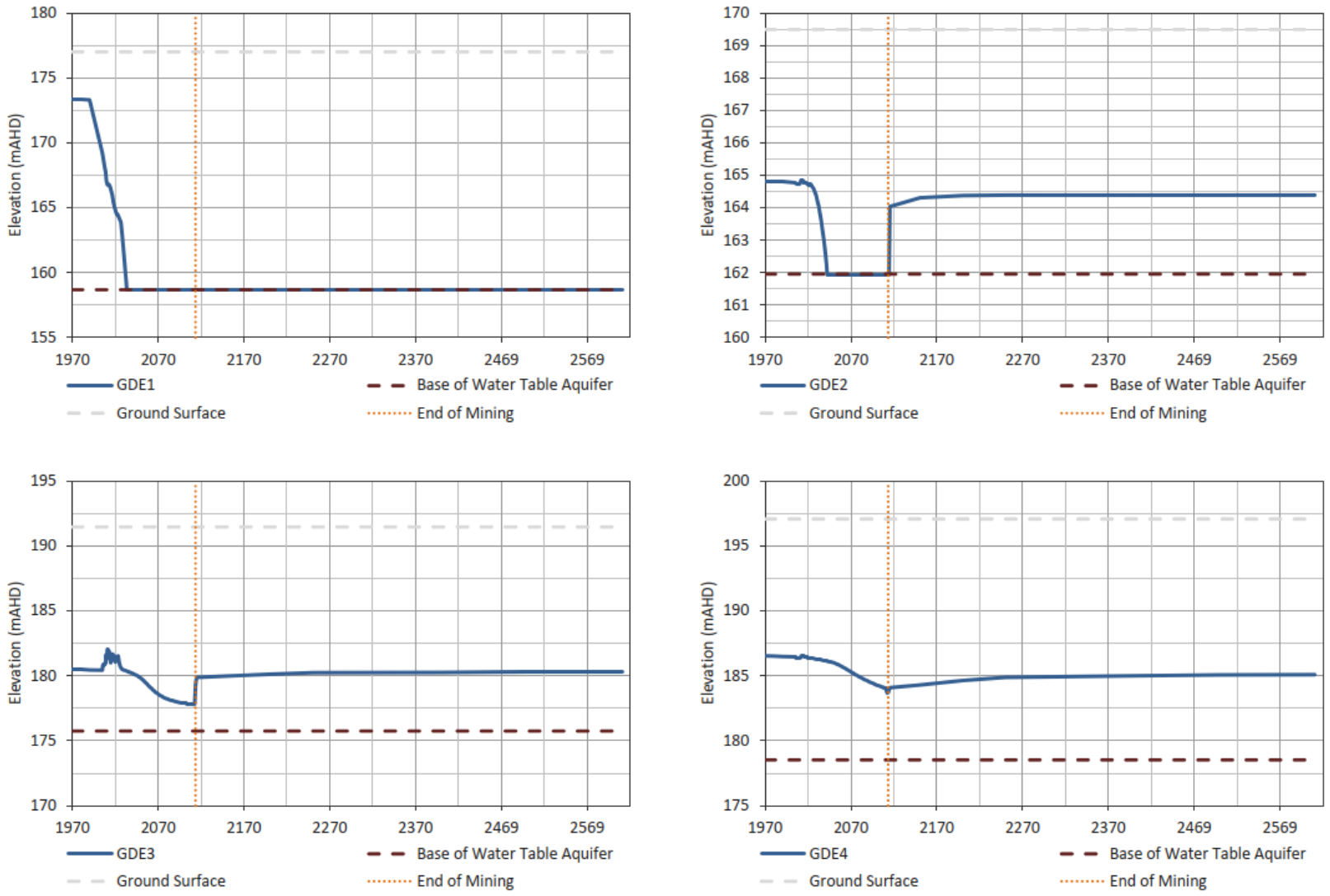


Figure 4.17 Water table hydrographs at potential GDEs (GDE1 to GDE4) (SLR Consulting, 2024)

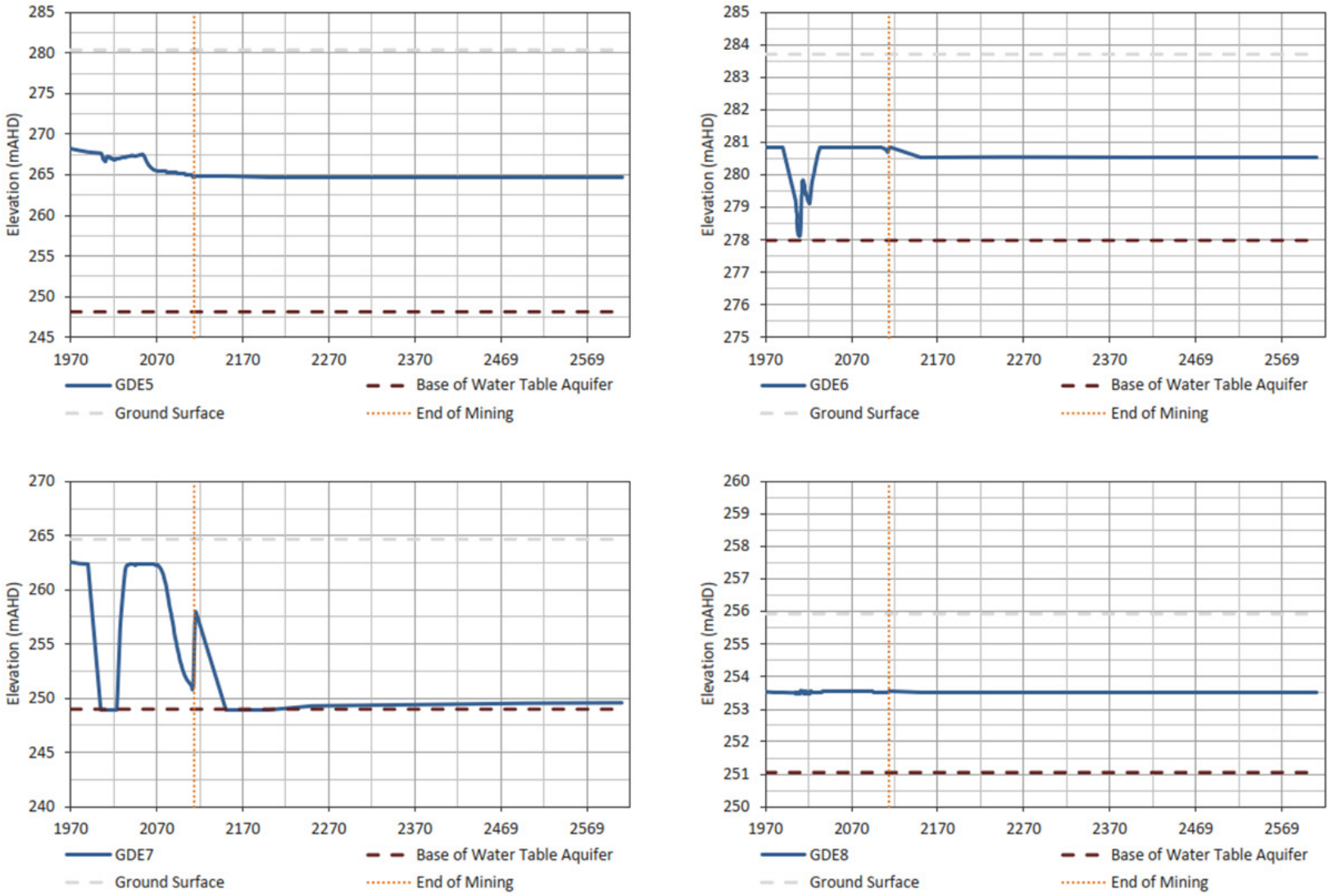


Figure 4.18 Water table hydrographs at potential GDEs (GDE5 to GDE8) (SLR Consulting, 2024)

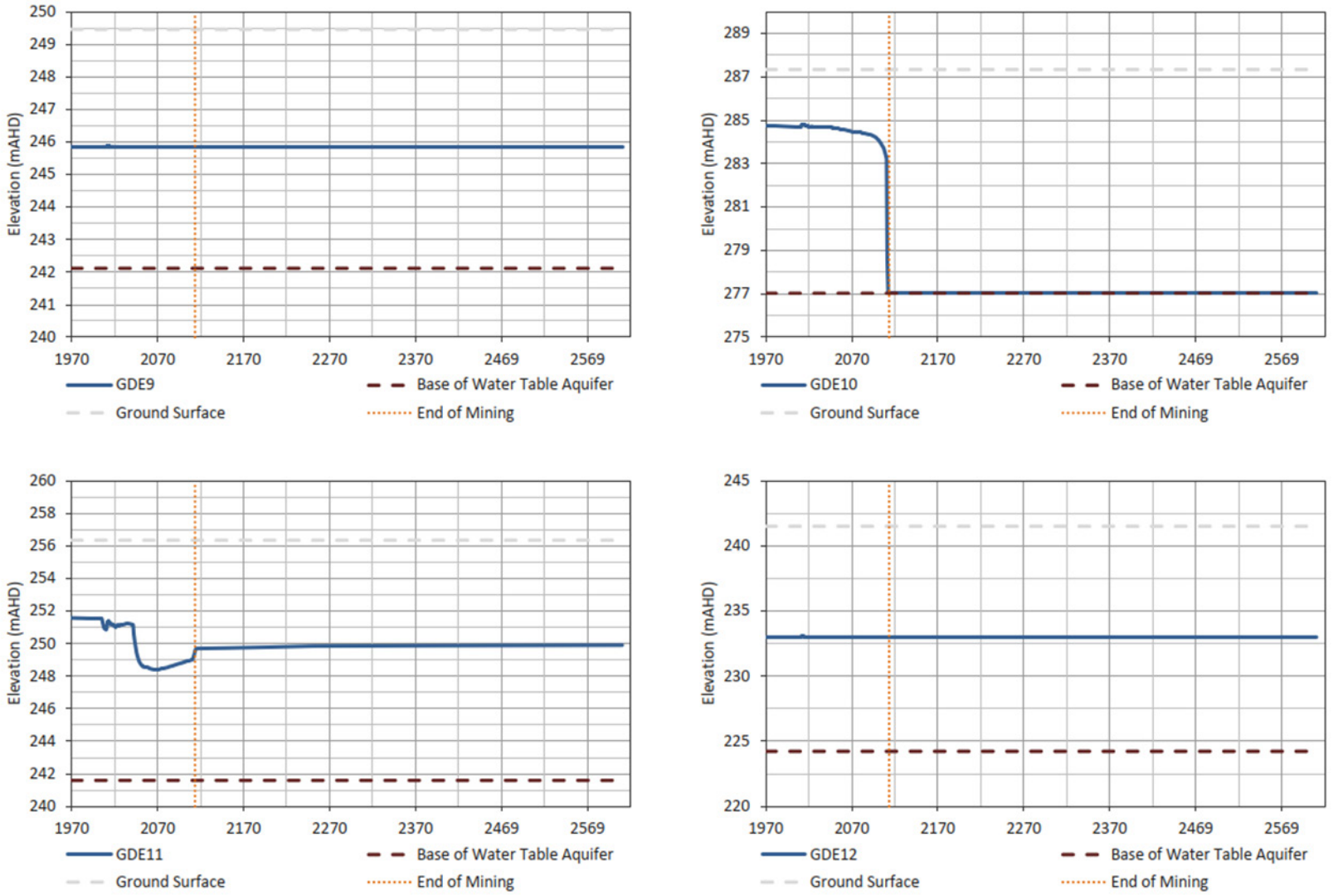


Figure 4.19 Water table hydrographs at potential GDEs (GDE9 to GDE12) (SLR Consulting, 2024)

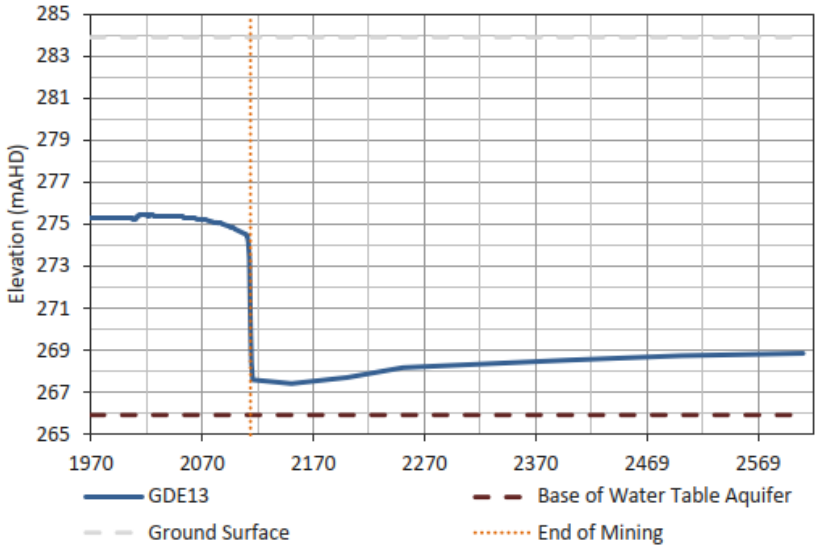


Figure 4.20 Water table hydrographs at potential GDEs (GDE13) (SLR Consulting, 2024)

Predictive hydrographs presented in SLR Consulting (2024) were derived from the groundwater model for the 48 identified third-party water supply bores with sufficient information to attribute a source aquifer. Bores interpreted to be screened in formations below the base of the groundwater model are not considered as they are therefore interpreted to be below the base of the groundwater system that could be affected by BWM. The aim of the hydrographs was to assess the potential for additional impacts at these bores in the post-mining period, beyond those that have occurred during active mining operations through to closure in 2113 (SLR Consulting, 2024).

The predictive hydrographs identified where groundwater level is predicted to experience greater drawdown are shown in Table 4.1.

Table 4.1 Output of the predictive hydrographs for third-party water supply bores in the vicinity of BWM (SLR Consulting, 2024)

Lithology	Bore ID	Maximum drawdown (m)
Weathered zone/regolith	132075	2.7
Rewan Formation	158911	2.4
	165937	2.6
	57461	2.7
	57462	2.5
	57463	2.3
Rangal Coal Measures	57425	7.0
	57424	5.8
Burngrove Formation	103469	4.1

Evaluation of the predicted drawdown of the third-party groundwater bores shown in Table 4.1 shows that the maximum drawdown occurs over hundreds of years and is considered to be related to continuing operational drawdown trends (i.e., a time lag from active mining) and regional scale influences represented in the model.

5 Flooding assessment

Residual void flooding assessments were completed to determine surface water interactions, and the drainage and flooding behaviour of surface water in the vicinity of the BWM residual voids. This section presents the assessment findings, as relevant to void closure at BWM.

5.1 Voids in floodplains

The specific locations of the pre-approved NUMAs which are the eleven BWM residual voids are not identified in the LOD (EA EPML00717813) and, therefore, in accordance with the *PRCP Guideline* transitional provisions, an assessment of voids in flood plains was undertaken (SLR Consulting, 2024b). As a conservative approach, the final void extents used for the voids in floodplain assessment were the preliminary extents of the final voids – prior to any final landform design considerations and/or final void partial backfill that provides for flood protection.

The flood plain assessment of the pre-mining landform identified that the Laleham Pit would be located within the flood plain of Sirius Creek in the 0.1% annual exceedance probability (AEP) event. The remaining pits are located outside the flood plain, except for fringe encroachments at the extents of the Togara/North Marshmead Pit. This pit encroaches into the modelled flood plain for Sirius Creek, noting that the area of flood plain encroachment relates to a watercourse stream order less than 4 (SLR Consulting, 2024b).

For the final closure state landforms, the extents of the residual voids modelled in the voids in floodplain assessment have been reduced and refined following the relevant studies to reduce the environmental impact through full and partial backfill, placement of landforms and increasing residual void set-backs.

5.2 Closure state landform flooding

Final closure state landform rehabilitation flood modelling was undertaken (SLR Consulting, 2024d) for a range of design storm events, including Probable Maximum Flood (PMF), 0.1% AEP, and smaller events in accordance with the PRCP Guideline to predict the flood event inundation extent and depths for post-mining conditions.

Previously developed hydrologic modelling undertaken for each of the watercourses at BWM was adapted for this assessment (SLR Consulting, 2024d). The hydrologic modelling adopted to estimate runoff hydrographs through the BWM area included the following catchments:

- Sagittarius Creek;
- Bonnie Doon Creek;
- Burngrove Creek;
- Blackwater Creek
- Taurus Creek
- Two Mile Gully;
- Speculation Creek;
- Sirius Creek; and
- Rockland Creek.

To incorporate the final closure state landform, the hydrological model catchment configuration, reach lengths and storm definitions were updated.

Effects of climate change through the increase in rainfall intensity were considered in the hydrological analysis. The upper climate change Representative Concentration Pathway (RCP) 4.5 at or above the 90th percentile scenario (RCP 4.5 P90) was modelled as the upper rainfall for a 20% rainfall intensity increase.

RCPs are projections of greenhouse gas and aerosol concentrations (pathways) and, together with land use change, are consistent with a set of broad climate outcomes adopted by the Intergovernmental Panel on Climate Change and used by the climate modelling community (SLR Consulting, 2024b).

For the closure state landform, the pits will be fully or partially backfilled with spoil to reduce the extent of the BWM residual voids. Spoil dumping will be conducted to reduce the risk of inundation on the residual voids from floodwaters up to and including the 0.1% AEP under the climate change scenario with 20% increase in rainfall intensity.

There are several locations across BWM where floodwaters come in contact with the final closure state landforms; however, as these locations are at the edge of the floodplain, the velocities and stream power are generally low and are considered to be low risk (SLR Consulting, 2024b).

A flood risk profile (FRP) was developed for the BWM post-closure conditions based on the hydrologic and hydraulic model results. The FRP outcome applied to the *Whitehaven Coal HSE Risk Management Procedure* and *Risk assessment matrix* resulted in the residual risk (risk after controls) to be rated as 'Low' for all identified risks and therefore no additional control measures are required (SLR Consulting, 2024d).

Figure 5.1 to Figure 5.7 show modelled peak flow depths for Sagittarius Creek, Bonnie Doon Creek, Burngrove Creek, Blackwater Creek, Speculation Creek, Sirius Creek, and Rockland Creek respectively, for the 0.1% AEP under the climate change 20% increase in rainfall intensity scenario.

685000 686000 687000 688000 689000 690000 691000 692000 693000

7390000 7389000 7388000 7387000 7386000 7385000 7384000 7383000 7382000 7381000

Depth (m)
- Below 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 2
- Above 2

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

0 400 800 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:30,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Sagittarius Creek PRCP Conditions Peak Depths - 0.1% AEP 20p CC

SLR

FIGURE 5.1

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CAD\GIS\Output\Map setup\Sagittarius\MXDs\620.040134_APPENDIX C\1-7-3_N004_1in1000CC20p_d.mxd

682000 683000 684000 685000 686000 687000

7390000 7389000 7388000 7387000 7386000 7385000 7384000

Depth (m)
- Below 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 2
- Above 2

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

0 250 500 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:20,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Bonnie Doon Creek PRCP Conditions Peak Depths - 0.1% AEP 20p CC

SLR

FIGURE 5.2

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Bonnie Doon\MXDs\620.040134_APPENDIX C2-7-3_N006_1in1000CC20p_d.mxd

677000 678000 679000 680000 681000 682000 683000 684000 685000 686000 687000 688000

7388000 7387000 7386000 7385000 7384000 7383000 7382000 7381000 7380000 7379000 7378000 7377000 7376000 7375000 7374000 7373000 7372000

Depth (m)
- Below 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 2
- Above 2

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

0 500 1,000 Meters

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:45,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

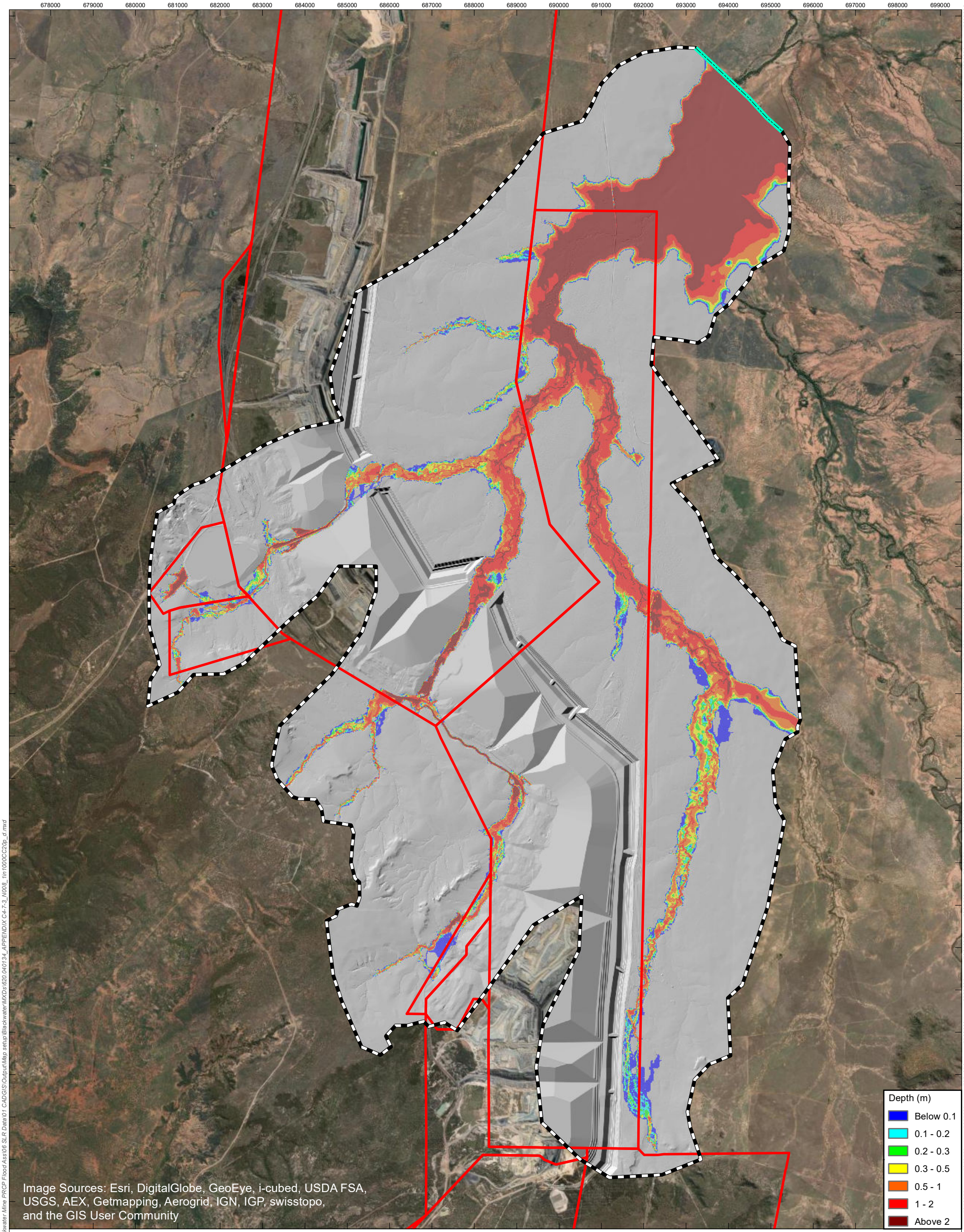
Blackwater Mine PRCP Flood Assessment

Burngrove Creek PRCP Conditions Peak Depths - 0.1% AEP 20p CC

SLR

FIGURE 5.3

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Burngrove\MXDs\620.040134_APPENDIX C3-7-3_N006_1in1000CC20p_d.mxd



0 1,000 2,000 Meters

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:80,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

LEGEND

- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Blackwater Mine PRCP Flood Assessment

Blackwater Creek PRCP Conditions Peak Depths - 0.1% AEP 20p CC

SLR

APPENDIX C4-7-3

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\Blackwater\MXDs\620.040134_APPENDIX C4-7-3_N008_1in1000CC20p_d.mxd

679000 680000 681000 682000 683000 684000 685000 686000 687000 688000 689000 690000 691000

7364000 7363000 7362000 7361000 7360000 7359000 7358000 7357000 7356000 7355000 7354000 7353000 7352000 7351000 7350000 7349000

Depth (m)
- Below 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 2
- Above 2

Image Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

0 500 1,000 Meters

LEGEND
- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:45,000 at A3
Project Number:	620.040134
Date:	4/07/2024
Drawn by:	OA

Blackwater Mine PRCP Flood Assessment

Speculation Creek PRCP Conditions Peak Depths - 0.1% AEP 20p CC

SLR

FIGURE 5.5

H:\Projects-SLR\620-BNE\620.040134.00001 Blackwater Mine PRCP Flood Ass\06 SLR Data\01 CADGIS\Output\Map setup\SpeculationMXDs\620.040134_APPENDIX C5-7-3_W004_1in1000CC20p_d.mxd

683000 684000 685000 686000 687000 688000 689000 690000 691000 692000

7353000 7352000 7351000 7350000 7349000 7348000 7347000 7346000

Blackwater Mine PRCP Flood Assessment

Sirius Creek PRCP Conditions Peak Depths - 0.1% AEP 20p CC

FIGURE 5.6

LEGEND

- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Depth (m)

- Below 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 2
- Above 2

N

0 200 400 800 Meters

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:30,000 at A3
Project Number:	620.014601
Date:	4/07/2024
Drawn by:	SM

SLR

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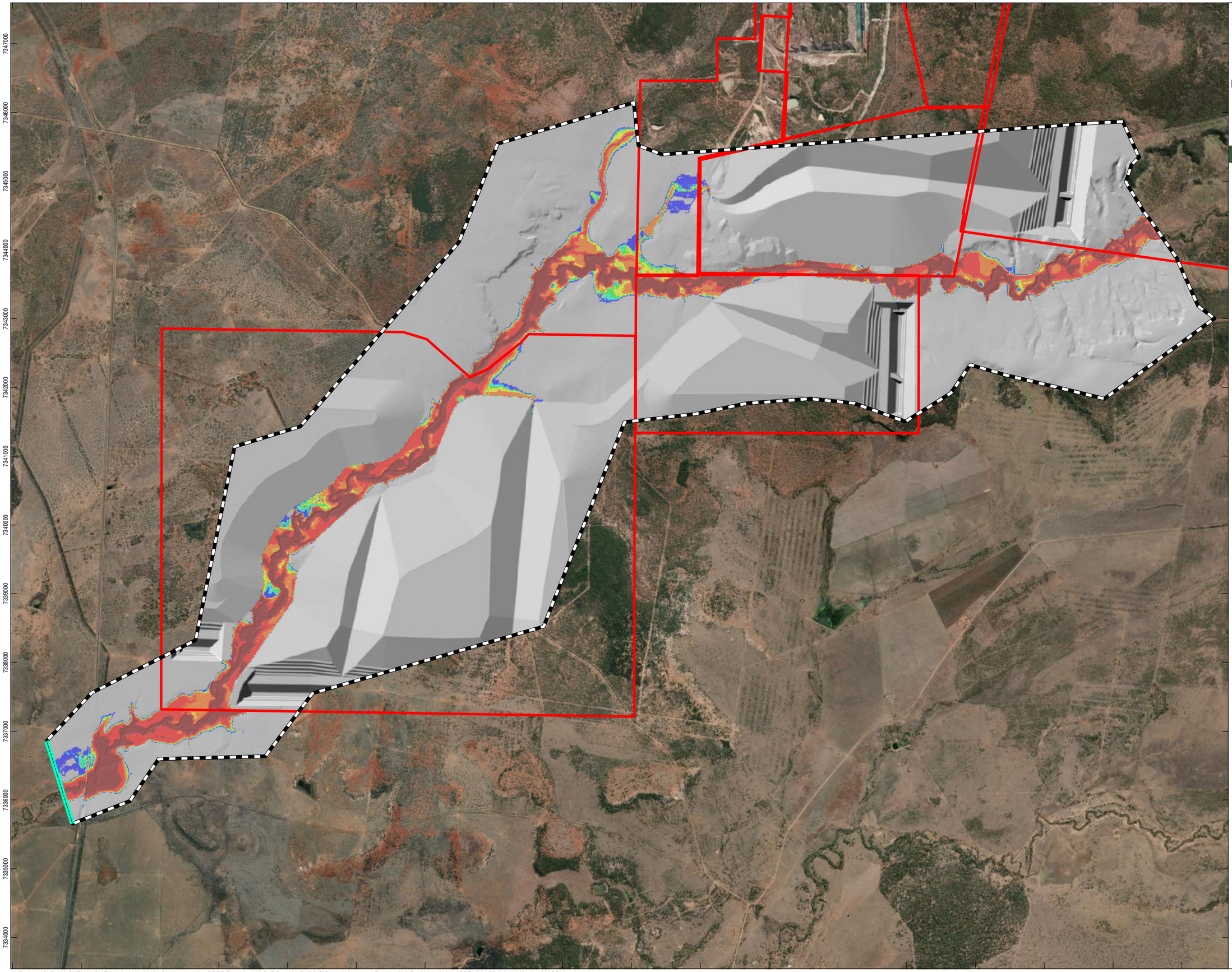
Blackwater Mine PRCP Flood Assessment

Rockland Creek PRCP Conditions Peak Depths - 0.1% AEP 20p CC

FIGURE 5.7



LEGEND

- Downstream Boundary
- TUFLOW Model Extent
- Mining Leases

Depth (m)

- Below 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 2
- Above 2

0 300 600 1,200 Meters

Coordinate System:	AGD 1966 AMG Zone 55
Scale:	1:50,000 at A3
Project Number:	620.014601
Date:	4/07/2024
Drawn by:	SM

SLR

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6 Void water balance

A void water balance assessment was completed to determine the behaviour of the BWM residual voids in their closure state (WSP, 2024). The assessment also sought to understand the inherent hydrological closure risks and to inform separate assessments relating to geotechnical and geochemical stability of the voids over time (findings from these separate assessments are presented in Sections 7 and 8, respectively). Findings from the void water balance assessment, where relevant to void closure at BWM, are presented below.

6.1 Water balance model

A WBM was developed using the software program GoldSim to estimate the changes in the volume of water in the final closure state landforms over time in response to water inflows and outflows. The WBM adds the possible inflows and calculates the possible outflows for every step of the duration over the modelled period. The WBM for the BWM residual voids incorporated direct rainfall, surface water runoff, groundwater interactions, and evaporation.

It is acknowledged that these final closure state landforms may not be realised for years (or decades). A model period of 564 years – from the year 2035 (the final mining year of the first void) to 2599, with a daily time-step was selected using available final closure state landforms to estimate the water balance behaviour within the void. No operational processes (i.e., pumping or transfers to/from the assessed structures) were considered active for the period modelled.

Each void has a different final year of mining based on the current projected mine plan. Table 6.1 shows the projected final mining year for each BWM void.

Table 6.1 Final mining year for each BWM void

Final mining year	Residual void
2035	Ramp 8
2040	Bonnie Doon
2049	Deep Creek
2088	Mimosa/Besgrove
2090	Laleham
2094	Stewarton/Ballamoo, Kenmare and Kennedy West
2100	South Marshmead
2102	Comet Downs East
2109	Togara/North Marshmead

6.1.1 Catchment areas

The conceptual final closure state landform for the BWM residual voids was used to generate contour lines and calculate the drainage network of the area. The catchment subdivision of each void was estimated by analysing a slope map, generated using the software, QGIS. This slope map recognises zones with ‘flat’ slopes and zones with downward slopes. This information was then used to delimitate the void catchment areas into three areas: natural, void, and rehabilitated. The ‘natural’ area was assigned as the area that will remain undisturbed, while comparing the proposed residual voids’ landform and the current topography of the area. The ‘void’ area was assigned as the area of the residual void itself at the spill level. Finally, the ‘rehabilitated’ area represents the remaining catchment area of each residual void. The delimitation of each of the areas is presented in Figure 6.1 and Table 6.2.

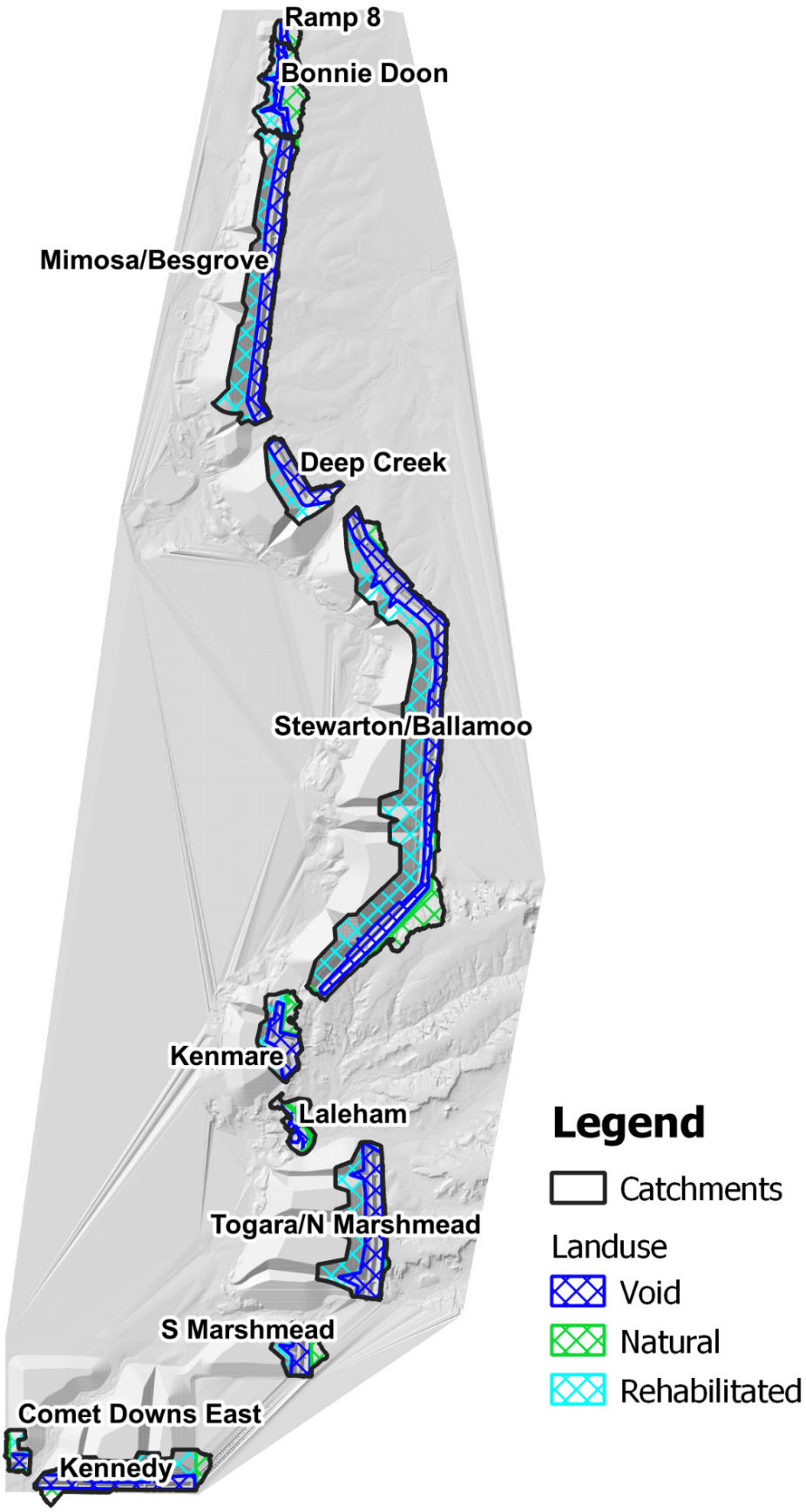

Figure 6.1 Catchment delimitation for each catchment area zone land use applied to the WBM for the BWM residual voids (WSP, 2024)

Table 6.2 Catchment areas for each zone land use applied to the WBM for the BWM residual voids (WSP, 2024)

Residual void	Land use (ha)			Total (ha)
	Rehabilitated	Natural	Void	
Ramp 8	16	40	18	**74**
Bonnie Doon	146	186	82	**414**
Mimosa/Besgrove	651	41	472	**1,164**
Deep Creek	172	15	175	**362**
Stewarton/Ballamoo	1,738	258	826	**2,822**
Kenmare	136	62	150	**348**
Laleham	46	55	61	**162**
Togara/North Marshmead	451	6	399	**856**
South Marshmead	77	42	123	**242**
Kennedy West	400	94	209	**703**
Comet Downs East	45	15	42	**102**

The final closure state landform was analysed to determine the spill elevation of each of the voids, which is presented in Table 6.3.

Table 6.3 Spill elevation for the BWM residual voids (WSP, 2024)

Void	Spill elevation (m AHD)
Ramp 8	189
Bonnie Doon	190
Mimosa/Besgrove	199
Deep Creek	212
Stewarton/Ballamoo	216
Kenmare	300
Laleham	262
Togara/North Marshmead	270
South Marshmead	267
Kennedy West	218
Comet Downs East	222

Stage-storage relationships were derived from the closure state landform to obtain the relationship between lake elevation and volume/surface of the lake, as shown in These relationships were used in the WBM to estimate the lake surface area and elevation based on the lake volume for each modelled time-step (WSP, 2024).

The residual voids were initially assumed to begin at a zero level, implying that they were considered empty at the cessation of mining and hence the start of the simulations.

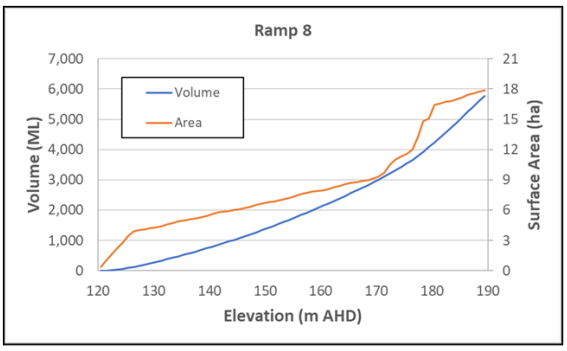

Figure 6.2 Ramp 8 residual void stage-storage relationship

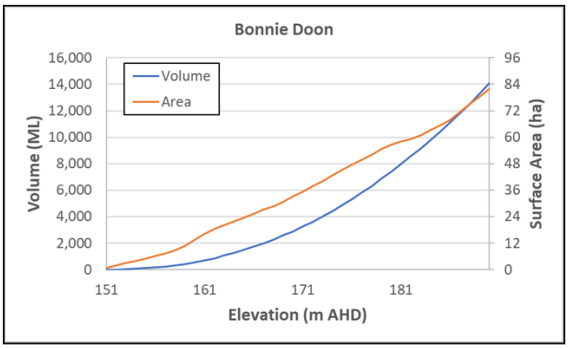

Figure 6.3 Bonnie Doon residual void stage-storage relationship

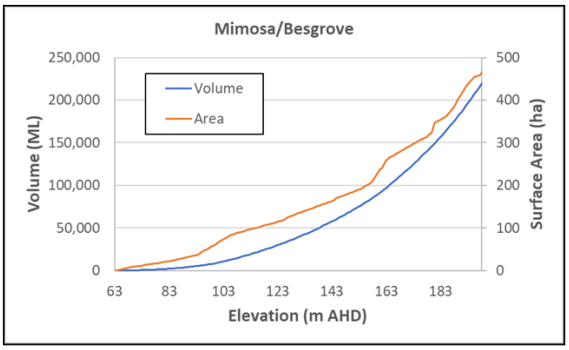

Figure 6.4 Mimosa/Besgrove residual void stage-storage relationship

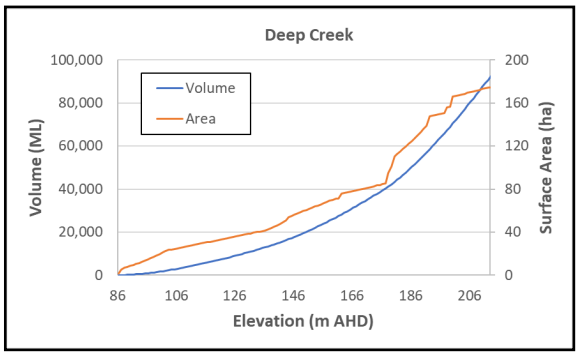

Figure 6.5 Deep Creek residual void stage-storage relationship

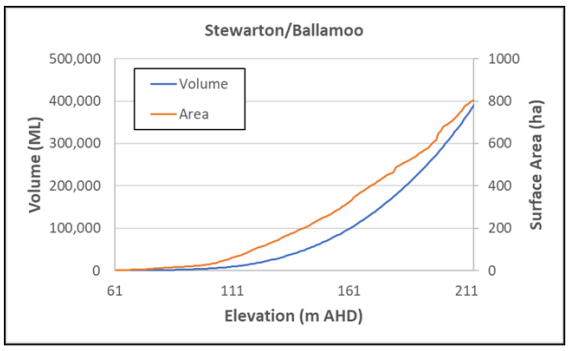

Figure 6.6 Stewarton/Ballamoo residual void stage-storage relationship

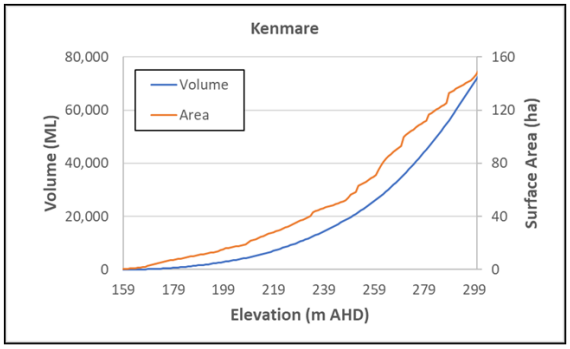

Figure 6.7 Kenmare residual void stage-storage relationship

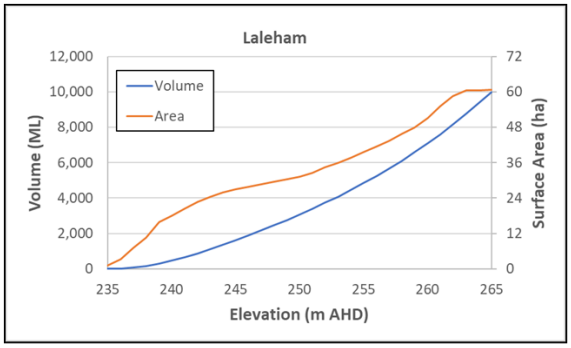

Figure 6.8 Laleham residual void stage-storage relationship

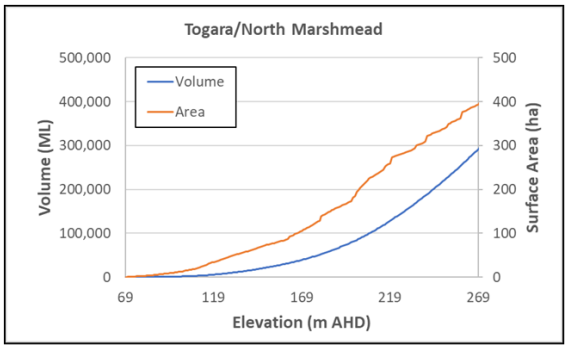

Figure 6.9 Togara/North Marshmead residual void stage-storage relationship

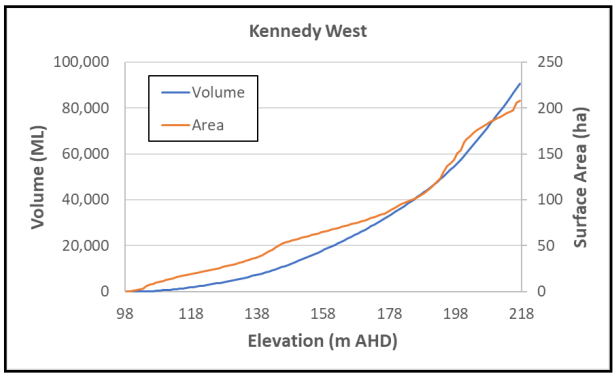

Figure 6.10 Kennedy West residual void stage-storage relationship

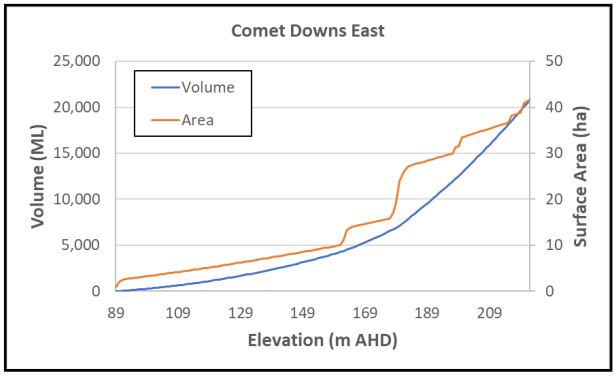

Figure 6.11 Comet Downs East residual void stage-storage relationship

6.1.2 *Rainfall, evaporation, and surface runoff*

The amount of surface water runoff resulting from rainfall is calculated using the Australian Water Balance Model (AWBM). The AWBM is a catchment WBM that relates daily rainfall and evapotranspiration to runoff and calculates losses from rainfall for flood hydrograph modelling.

The projected evaporation and rainfall data (BMA, 2023) was applied to the AWBM to determine the surface runoff that should be input into the WBM. The AWBM contained five storages:

- three surface storages to simulate partial areas of runoff
- one baseflow storage
- one surface runoff routing storage.

The three surface storages have differing capacities (small, medium, and large) for each catchment area, as shown in Figure 6.12 and presented in Table 6.4. Each capacity is added together with fractional areas for weights, which are summarised in Table 6.5.

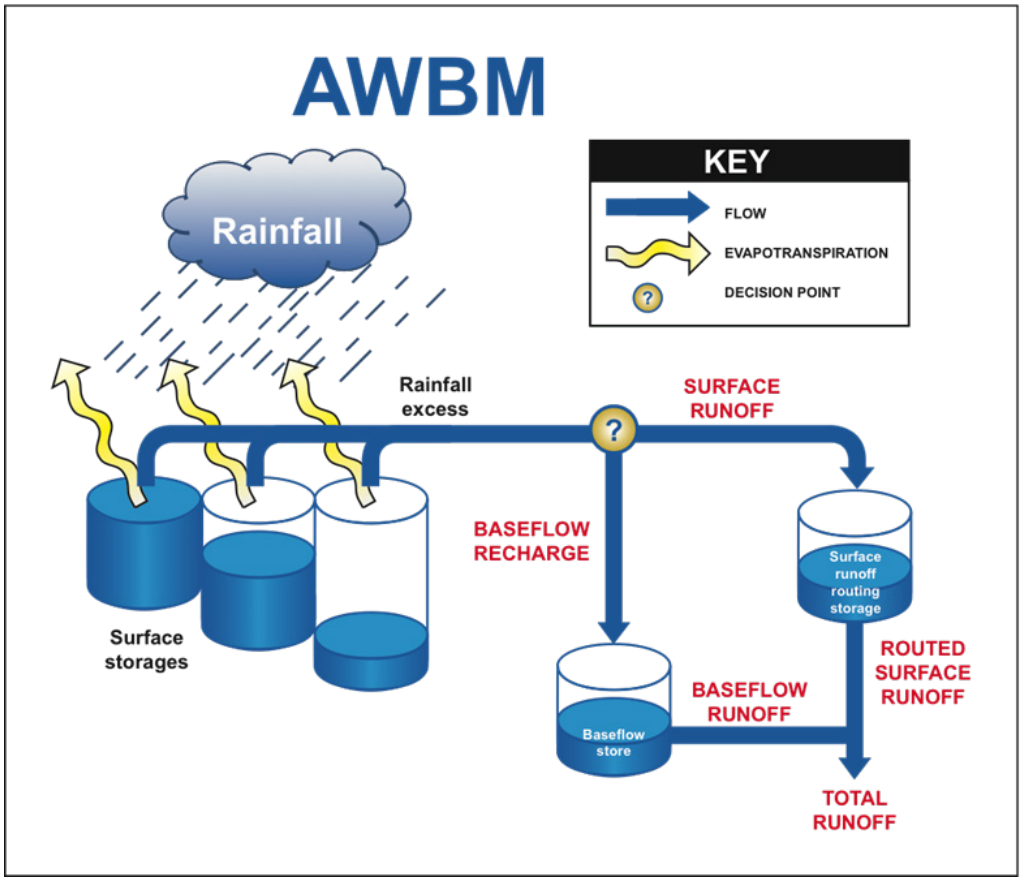

Figure 6.12 Structure of AWBM rainfall-runoff model including small, medium, and large surface storage

Table 6.4 Surface storage capacities (BMA, 2023) applied to the WBM for BWM

Land use	Storage capacity (mm)		
	Small	Medium	Large
Natural	20	90	200
Void	7	27	37
Rehabilitated	20	90	200

Table 6.5 Surface storage proportions (BMA, 2023a) applied to the WBM for BWM

Land use	Small	Medium	Large
Natural	0.134	0.433	0.433
Void	0.134	0.433	0.433
Rehabilitated	0.134	0.433	0.433

Table 6.6 presents the remaining AWBM parameters (baseflow index, channel coefficient, and baseflow coefficient). Surface water runoff considers flows as daily averages and do not include effects of high intensity and short duration events.

Table 6.6 Baseflow and channel parameters (BMA, 2023) applied to the WBM for BWM

Land use	Baseflow index	Channel coefficient (1/day)	Baseflow coefficient
Natural	0.35	0.1	0.7
Void	0.1	0.1	0.7
Rehabilitated	0.35	0.1	0.7

6.1.3 *Climate change considerations*

To reasonably represent future climate conditions in the WBM assessment, climate change data was used from the projections of three different climate models (ACCESS1-0Q, GFDL-CM3Q and MPI-ESM-LRQ). These climate models were evaluated under two RCP's (4.5 and 8.5), giving six climate projections.

Simulations were completed for all climate realisations. These realisations represent a reasonable range of probable climate scenarios and provide a reasonable range of potential climate impacts for each residual void. Based on the climate models, the range of probable climate scenarios include the wetter (R6), middle (R4) and the drier (R1) climate ranges. Table 6.7 presents a summary of the combined pathways and models considered in each WBM realisation.

Table 6.7 Climate change scenarios selected for BWM WBM

Realisation	Climate model	RCP
R1	ACCESS1-0Q	4.5
R2	GFDL-CM3Q	4.5
R3	MPI-ESM-LRQ	4.5
R4	ACCESS1-0Q	8.5
R5	GFDL-CM3Q	8.5
R6	MPI-ESM-LRQ	8.5

To cover the WBM simulation period of 565 years, the climate projections were applied from 2035 until 31 December 2599. As the climate projections data only cover the interval from 2020 to 2099, the period between January 2080 and December 2099 was repeated to act as the projected rainfall conditions beyond 2099 (WSP, 2024).

The annual rainfall for each year in a pivotal year period was calculated from daily rainfall projections from each of the climate change scenarios. For each pivotal year period, the annual rainfall was averaged over this period. A pivotal year period represents the future average climate of a decade centred on the pivotal year: for example, the pivotal year of 2070 projects the climate from 2060 to 2079 (CSIRO, 2022). The pivotal years relevant to the WBM simulation period are 2030 (projections from 2035 to 2039) and 2050 (projections from 2040 to 2059), 2070 (projections from 2060 to 2079) and 2090 (projections from 2080 to 2099).

As the data does not extend past 2099, the projections from the pivotal year 2090 were applied for the period beyond 2100. The annual mean rainfall calculated for each climate realisation applied to the WBM for each simulated period via this methodology is summarised in Table 6.8.

Table 6.8 Rainfall data used for each simulated period (WSP, 2024)

Simulation period	Data used	
	From	To
01-01-2100 to 31-12-2119	01-01-2080	31-12-2099
01-01-2120 to 31-12-2139	01-01-2080	31-12-2099
01-01-2140 to 31-12-2159	01-01-2080	31-12-2099
01-01-2160 to 31-12-2179	01-01-2080	31-12-2099
01-01-2180 to 31-12-2199	01-01-2080	31-12-2099
01-01-2200 to 31-12-2219	01-01-2080	31-12-2099
01-01-2220 to 31-12-2239	01-01-2080	31-12-2099
01-01-2240 to 31-12-2259	01-01-2080	31-12-2099
01-01-2260 to 31-12-2279	01-01-2080	31-12-2099
01-01-2280 to 31-12-2299	01-01-2080	31-12-2099
01-01-2300 to 31-12-2319	01-01-2080	31-12-2099
01-01-2320 to 31-12-2339	01-01-2080	31-12-2099
01-01-2340 to 31-12-2359	01-01-2080	31-12-2099
01-01-2360 to 31-12-2379	01-01-2080	31-12-2099
01-01-2380 to 31-12-2399	01-01-2080	31-12-2099
01-01-2400 to 31-12-2419	01-01-2080	31-12-2099
01-01-2420 to 31-12-2439	01-01-2080	31-12-2099
01-01-2440 to 31-12-2459	01-01-2080	31-12-2099
01-01-2460 to 31-12-2479	01-01-2080	31-12-2099
01-01-2480 to 31-12-2499	01-01-2080	31-12-2099
01-01-2500 to 31-12-2519	01-01-2080	31-12-2099
01-01-2520 to 31-12-2539	01-01-2080	31-12-2099
01-01-2540 to 31-12-2559	01-01-2080	31-12-2099
01-01-2560 to 31-12-2579	01-01-2080	31-12-2099
01-01-2580 to 31-12-2599	01-01-2080	31-12-2099

The future increase in evaporation was estimated considering:

- reference period (1986 to 2005)
- projected period between 2035 and 2099.

The result is a value showing the annual increase in evaporation for each climate change scenario. This factor was applied to the monthly values for evaporation. These factors are presented in Table 6.9.

Table 6.9 Percentage increase of evaporation considered for each realisation from 2035–2099

	R1	R2	R3	R4	R5	R6
1986–2005						
Mean evaporation (mm/yr)	1,727	1,765	1,752	1,735	1,761	1,763
2035–2039						
Mean evaporation (mm/yr)	1,939	1,967	1,826	1,885	2,131	1,881
Increase in average evaporation (%)	12.2	11.5	4.2	8.6	21.0	6.7
2040-2059						
Mean evaporation (mm/yr)	1,938	1,970	1,927	2,000	2,003	2,003
Increase in average evaporation (%)	12.2	11.7	10.0	15.3	13.8	13.6
2060–2079						
Mean evaporation (mm/yr)	1,910	2,026	1,960	2,054	2,268	2,135
Increase in average evaporation (%)	10.5	14.8	11.9	18.4	28.8	21.1
2080–2099						
Mean evaporation (mm/yr)	1,995	2,132	1,896	2,149	2,375	2,295
Increase in average evaporation (%)	15.5	20.8	8.3	23.9	34.9	30.2

6.1.4 Groundwater inflows

Groundwater inflows to each of the residual voids post-closure, as discussed in Section 4, were simulated using the numerical groundwater model and time-series data. The modelled groundwater inflow rates applied as inputs to the WBM for the post-closure period are discussed in Section 4 and presented in Figure 4.4 to Figure 4.14. Groundwater inflows to the residual voids are predicted to equate to between approximately 7% to 60% of the total volumetric inflow to the voids, and therefore, certain void lake levels are influenced more by surface water fluxes than groundwater inflow volumes, and vice versa (SLR Consulting, 2024).

6.2 Residual void water balance outcomes

The average annual inflows and outflows were calculated for the final 20 years of the simulation period from 2580 to 2599 for each residual void, as presented in Table 6.10 and illustrated in Figure 6.13 to Figure 6.23.

By 2599, at the end of the simulation period, the difference between mean inflows and mean outflows indicates the void water levels stabilise in all voids as discussed in Table 6.10 and establish the long-term sink behaviour for all residual voids.

Table 6.10 Water balance model average inflows/outflows and behaviour simulated for each residual void for the period from 2580 to 2599

Residual void	Stabilisation (after 2599)	Long-term behaviour (groundwater)
Ramp 8	After 2599 mean water levels start to stabilise, with simulated mean inflows of 140 ML/year being similar to outflows of 141 ML/year. Although a steady state is not achieved by the end of the simulation, mean inflow and outflow are close enough to represent achievement of equilibrium.	Sink
Bonnie Doon	After 2599 mean water levels reaches equilibrium, with simulated mean inflows of 283 ML/year being the same as mean outflows of 283 ML/year. Mean water balance has reached an equilibrium.	Sink
Mimosa/Besgrove	After 2599 mean water levels start to stabilise, with simulated mean inflows of 2,035 ML/year being the same as mean outflows of 2,035 ML/year. Mean water balance has reached an equilibrium.	Sink
Deep Creek	After 2599 mean water levels start to stabilise, with simulated mean inflows of 931 ML/year being the same as mean outflows of 931 ML/year. Mean water balance has reached an equilibrium.	Sink
Stewarton/ Ballamoo	After 2599 mean water levels start to stabilise, with simulated mean inflows of 4,321 ML/year being the similar to the mean outflows of 4,323 ML/year. Although a steady state is not achieved by the end of the simulation, mean inflow and outflow are close enough to represent achievement of equilibrium.	Sink
Kenmare	After 2599 mean water levels start to stabilise, with simulated mean inflows of 573 ML/year being the same as mean outflows of 573 ML/year. Mean water balance has reached an equilibrium.	Sink
Laleham	After 2599 mean water levels start to stabilise, with simulated mean inflows of 131 ML/year being the same as mean outflows of 131 ML/year. Mean water balance has reached an equilibrium. Potential for this residual void to interact with shallow geological formation (base of weathering). However, groundwater flows and the WBM results do not indicate this is occurring (WSP, 2024).	Sink
Tongara/ North Marshmead	After 2599 mean water levels start to stabilise, with simulated mean inflows of 1,652 ML/year being similar to the mean outflows of 1,649 ML/year. Although a steady state is not achieved by the end of the simulation, mean inflow and outflow are close enough to represent achievement of equilibrium.	Sink
South Marshmead	After 2599 mean water levels start to stabilise, with simulated mean inflows of 672 ML/year being similar to the mean outflows of 671 ML/year. Although a steady state is not achieved by the end of the simulation, mean inflow and outflow are close enough to represent achievement of equilibrium.	Sink

Residual void	Stabilisation (after 2599)	Long-term behaviour (groundwater)
Kennedy West	After 2599 mean water levels start to stabilise, with simulated mean inflows of 846 ML/year being the same as mean outflows of 846 ML/year. Mean water balance has reached an equilibrium.	Sink
Comet Downs East	After 2599 mean water levels start to stabilise, with simulated mean inflows of 471 ML/year being similar to the mean outflows of 475 ML/year. Although a steady state is not achieved by the end of the simulation, mean inflow and outflow are close enough to represent achievement of equilibrium.	Sink

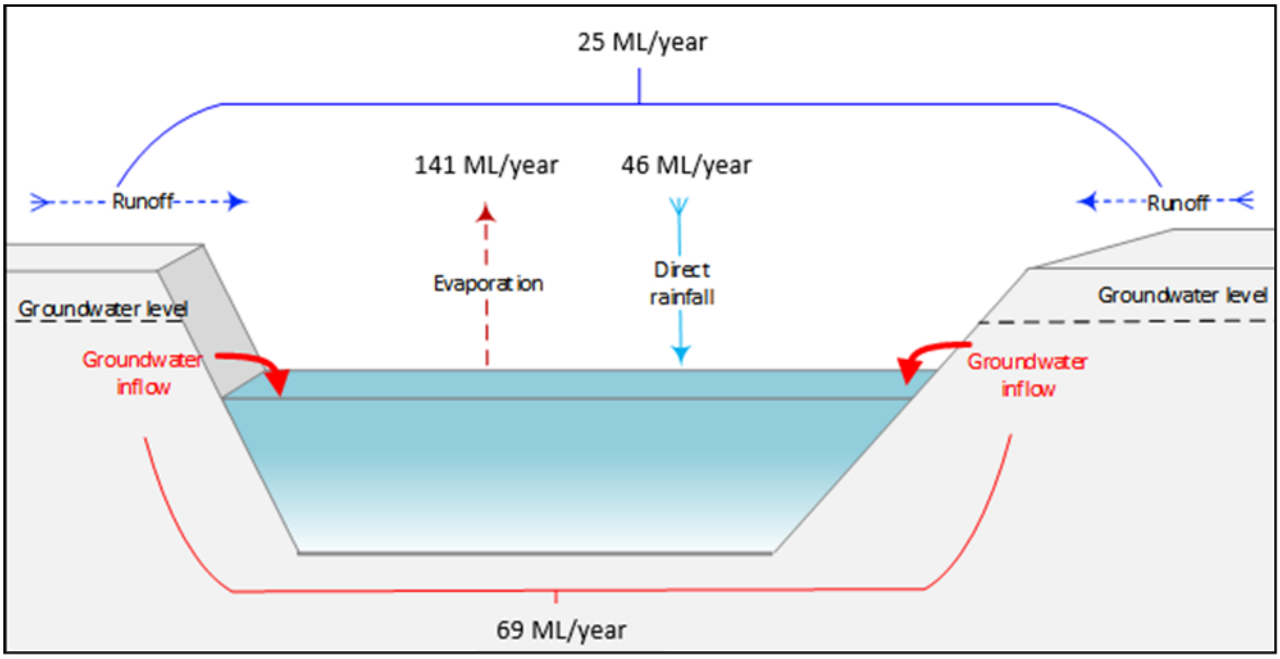

Figure 6.13 Schematic representation of average inflows/outflows simulated for period from 2580 to 2599 – Ramp 8 residual void (realisations 1 to 6)

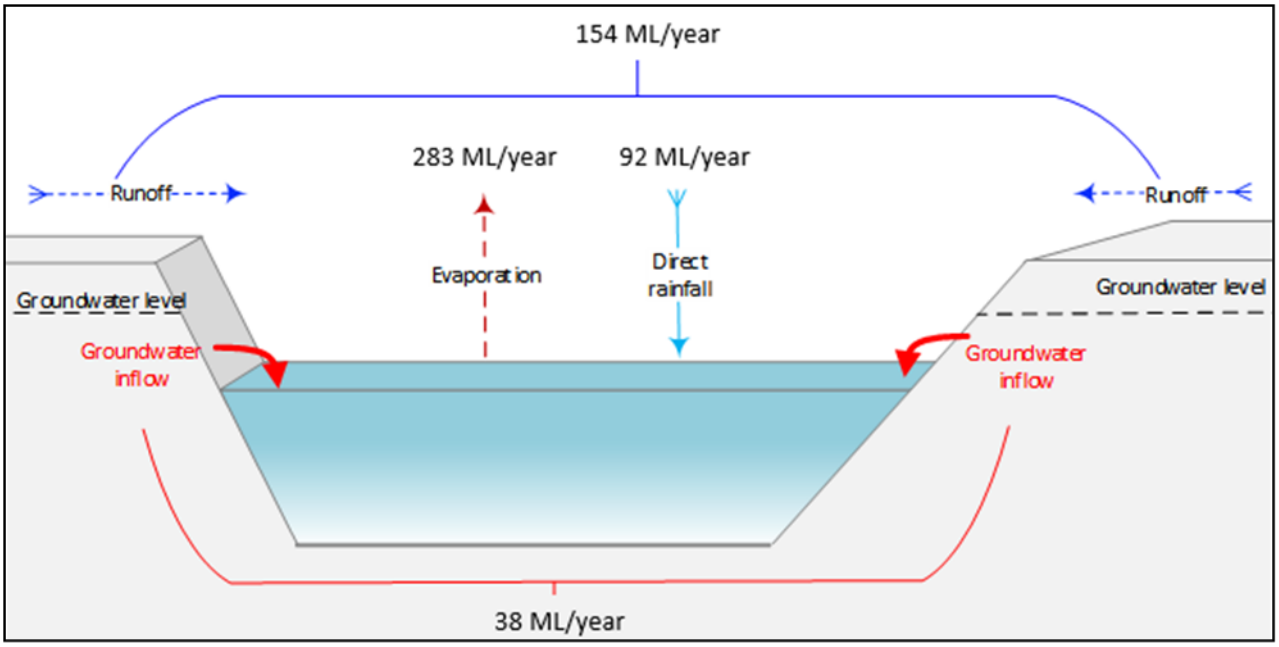

Figure 6.14 Schematic representation of average inflows/outflows simulated for period from 2580 to 2599 – Bonnie Doon residual void (realisations 1 to 6)

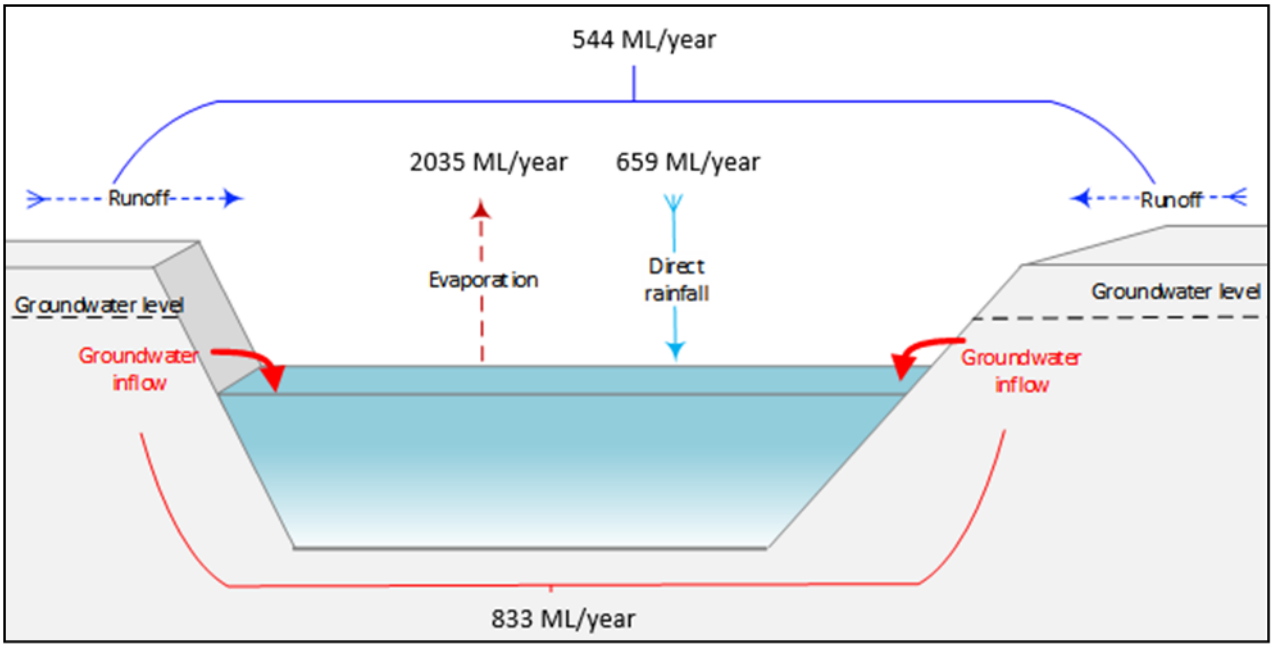

Figure 6.15 Schematic representation of average inflows/outflows simulated for period from 2580 to 2599 – Mimosa/Besgrove residual void (realisations 1 to 6)

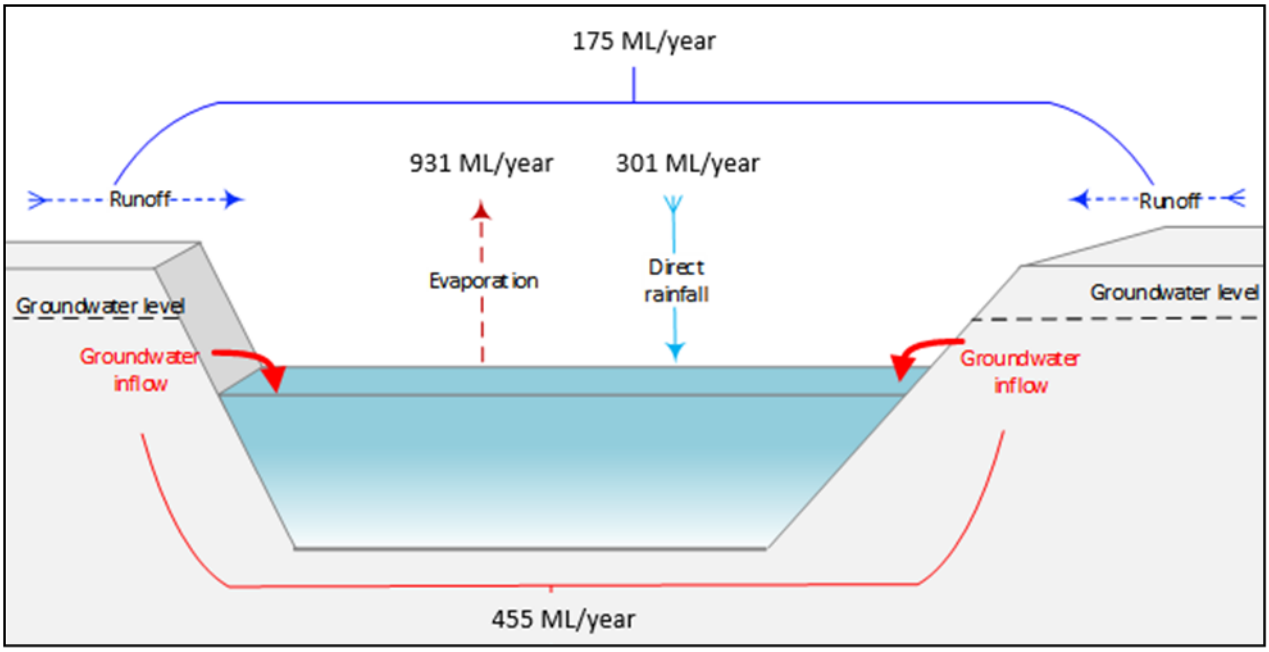

Figure 6.16 Schematic representation of average inflows/outflows simulated for period from 2580 to 2599 – Deep Creek residual void (realisations 1 to 6)

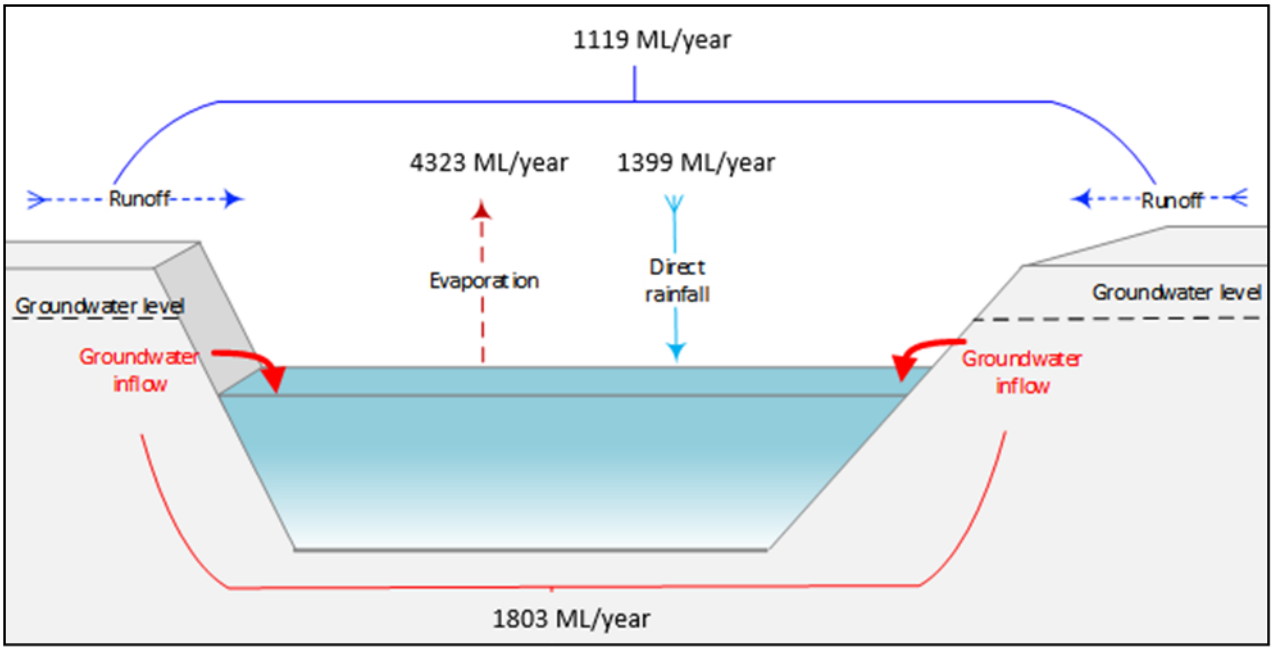

Figure 6.17 Schematic representation of average inflows/outflows simulated for period from 2580 to 2599 – Stewarton/Ballamoo residual void (realisations 1 to 6)

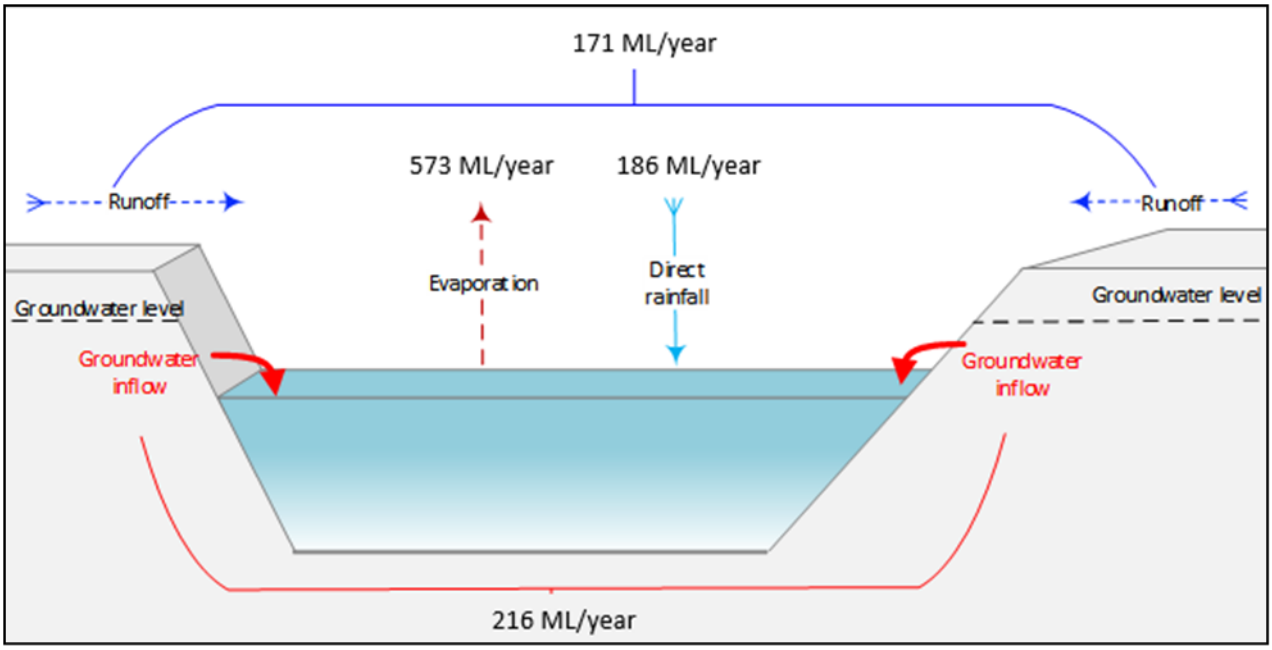

Figure 6.18 Schematic representation of average inflows/outflows simulated for period from 2580 to 2599 – Kenmare residual void (realisations 1 to 6)

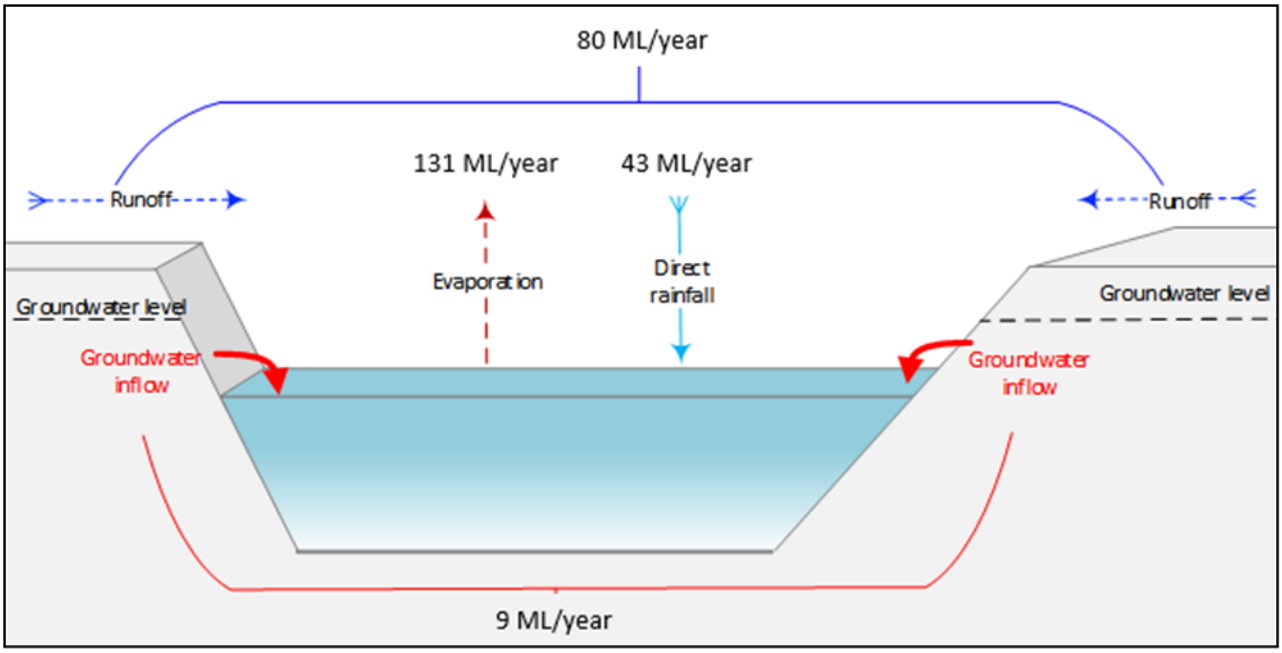

Figure 6.19 Schematic representation of average inflows/outflows simulated for period from 2580 to 2599 – Laleham residual void (realisations 1 to 6)

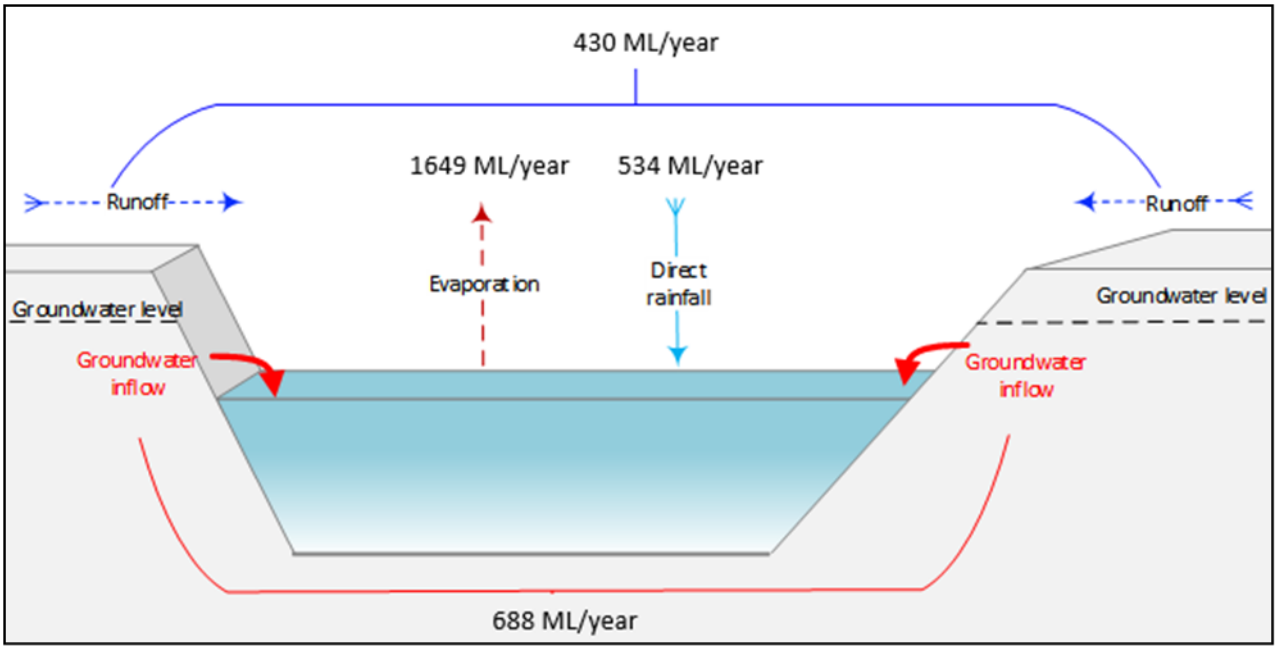

Figure 6.20 Schematic representation of average inflows/outflows simulated for period from 2580 to 2599 – Togara/North Marshmead residual void (realisations 1 to 6)

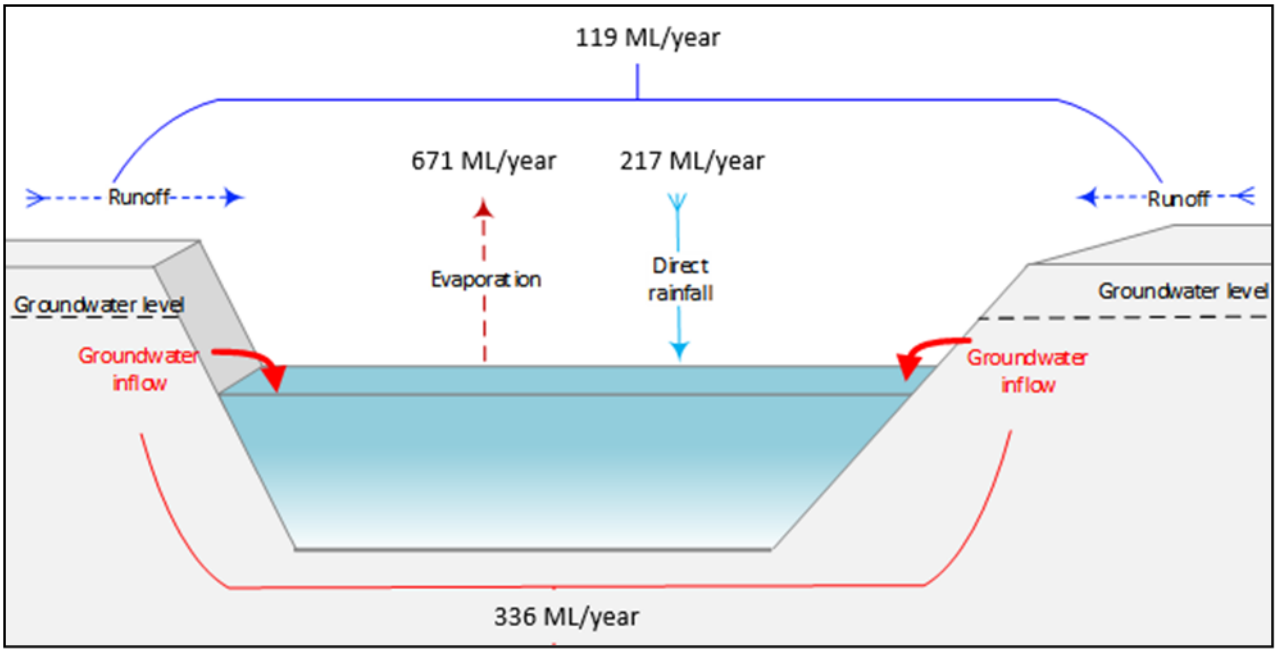

Figure 6.21 Schematic representation of average inflows/outflows simulated for period from 2580 to 2599 – South Marshmead residual void (realisations 1 to 6)

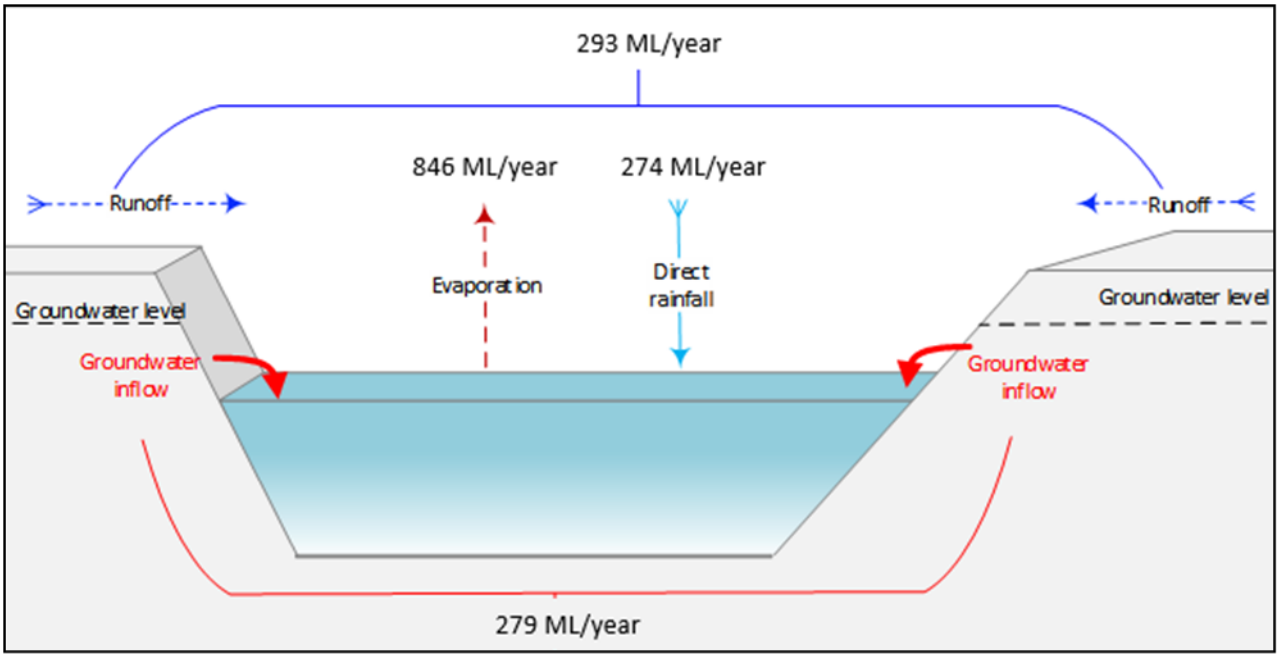

Figure 6.22 Schematic representation of average inflows/outflows simulated for period from 2580 to 2599 – Kennedy West residual void (realisations 1 to 6)

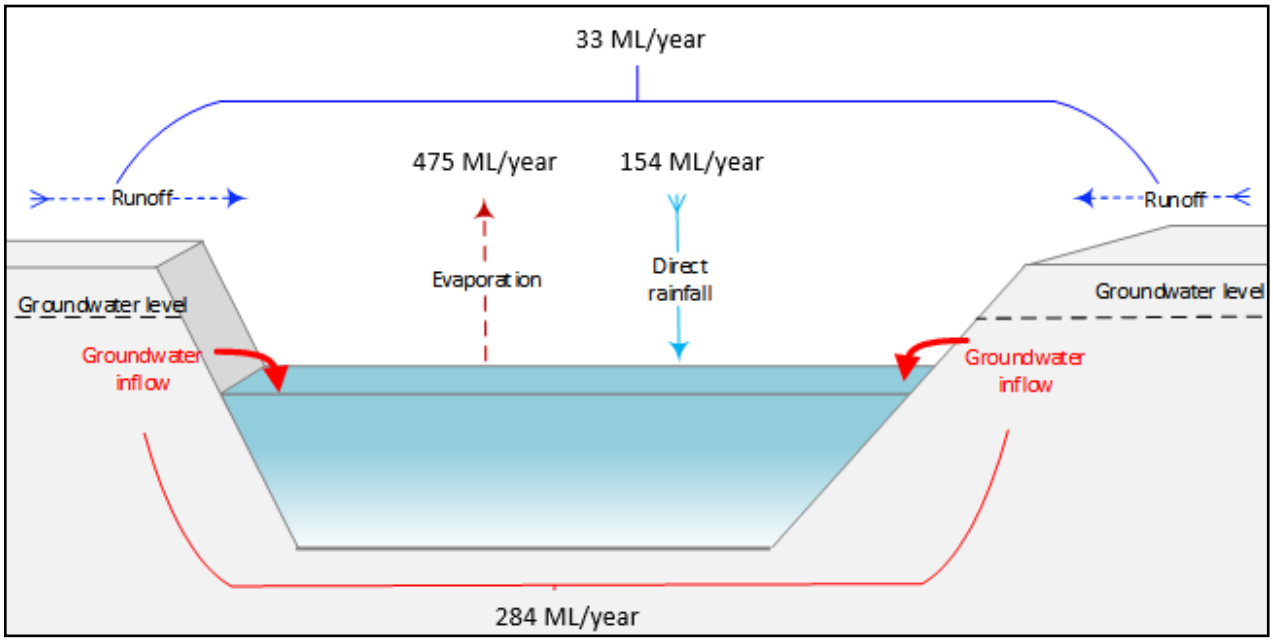

Figure 6.23 Schematic representation of average inflows/outflows simulated for period from 2580 to 2599 – Comet Downs East residual void (realisations 1 to 6)

The results from the WBM indicate that, after an initial increase in void volumes and water level observed from the beginning of the simulation until the year 2599, the mean void water levels start to stabilise at the end of the simulation Table 6.11 (Figure 6. to Figure 6.).

For the duration of the simulation, the water levels remain below the void spill point as shown in Table 6.11 therefore there is a low risk of the void overtopping.

The residual void lake water levels also remain below the lowest elevation of the base of the shallow geologic formations (Tertiary sediments and weathered regolith) for the duration of the simulation for all residual voids except Laleham residual void (WSP, 2024).

The Laleham residual void lake water levels remain around the base of the shallow geologic formations (Tertiary sediments and weathered regolith) (around 237 m AHD) for the duration of the simulation (SLR, 2024) (Figure 6.36). This means there is potential for this residual void to interact with shallow geological formation (base of weathering), however groundwater flows and the WBM results do not indicate this is occurring.

Table 6.11 Water balance results for the BWM residual voids water balance modelling

Residual void	Spill level (m AHD)	Void lake levels (range) (m AHD)	Base elevation of shallow geologic formation (m AHD)
Ramp 8	189	153–154	174.5
Bonnie Doon	190	159–162	171
Mimosa/Besgrove	199	116–118	179
Deep Creek	212	140–141	203.5
Stewarton/Ballamoo	216	144–146	203
Kenmare	300	220–221	261
Laleham	262	236–238	237
Tongara/North Marshmead	270	156–157	232
South Marshmead	267	180–182	189
Kennedy West	218	141–143	181
Comet Downs East	222	182–183	192

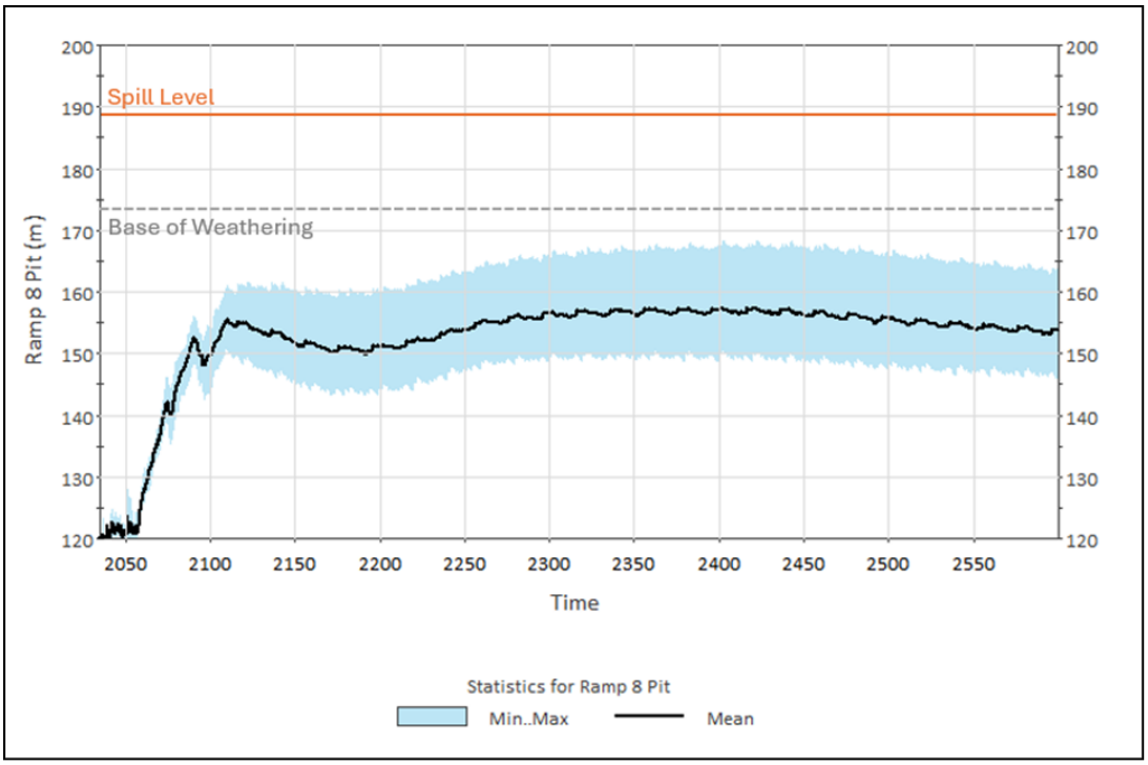

Figure 6.24 Modelled water levels in Ramp 8 residual void compared to spill level and the base of the shallow geological formation

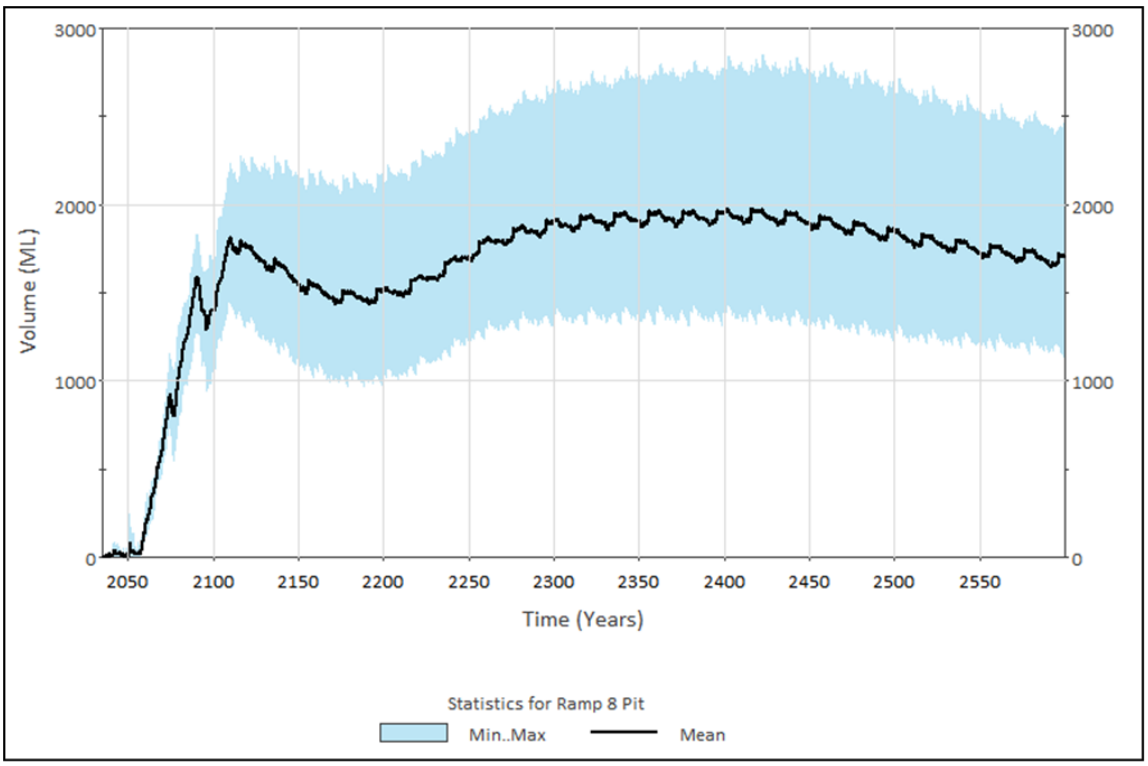

Figure 6.25 Modelled water volumes in Ramp 8 residual void

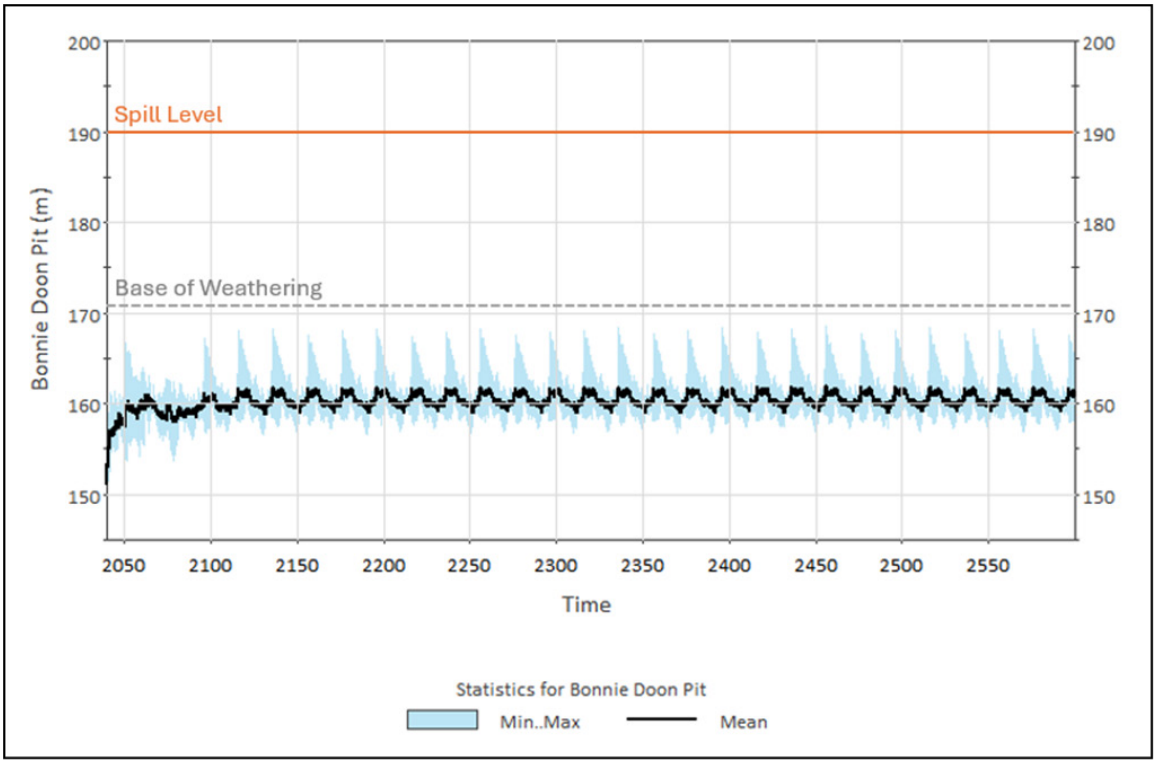

Figure 6.26 Modelled water levels in Bonnie Doon residual void compared to spill level and the base of the shallow geological formation

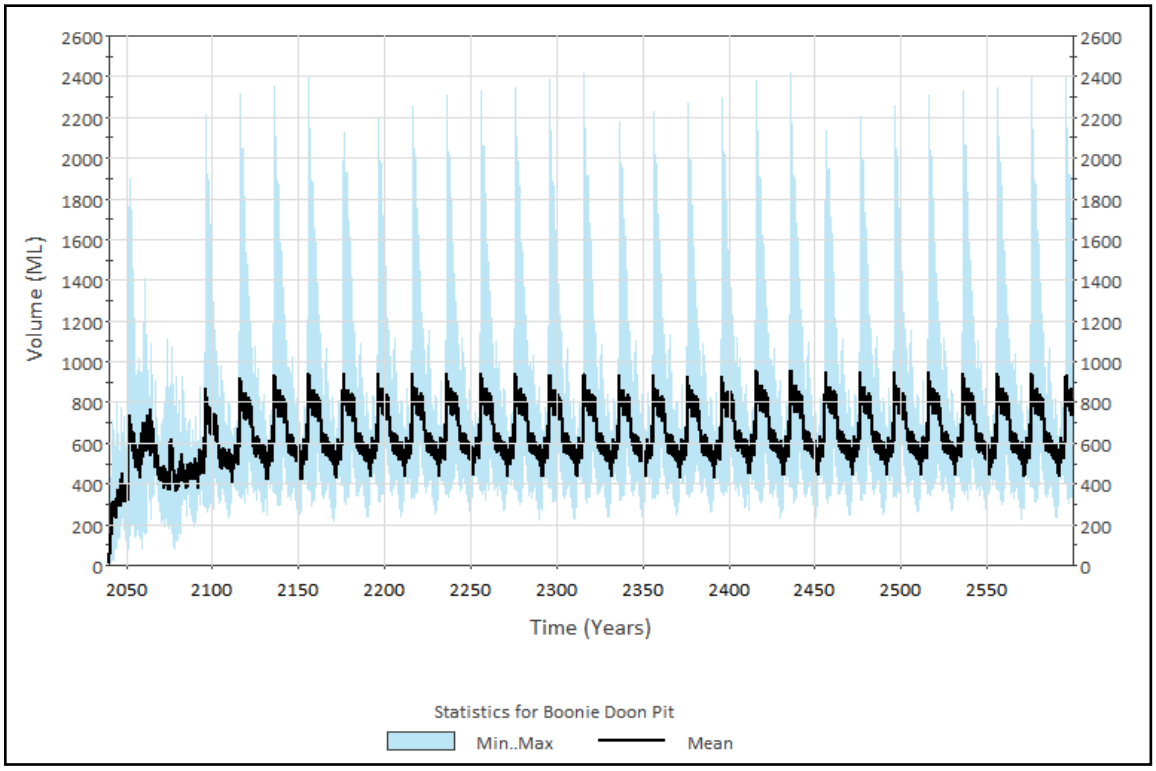

Figure 6.27 Modelled water volumes in Bonnie Doon residual void

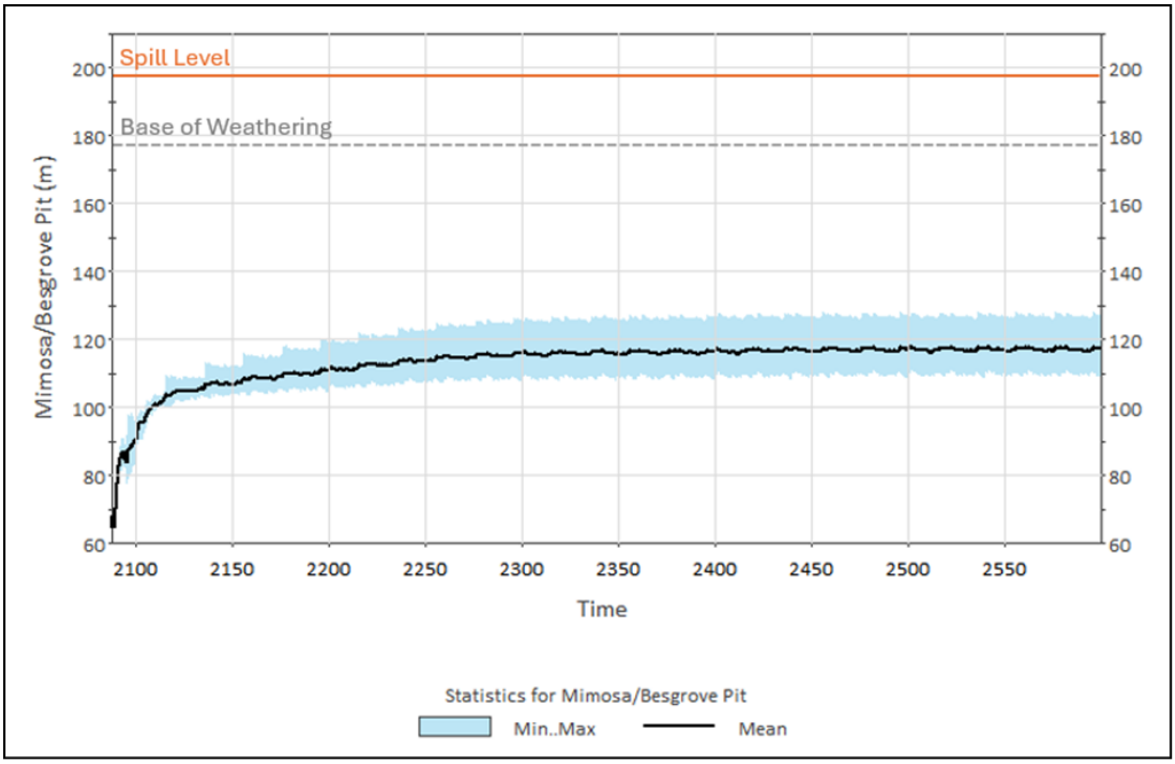

Figure 6.28 Modelled water levels in Mimosa/Besgrove residual void compared to spill level and the base of the shallow geological formation

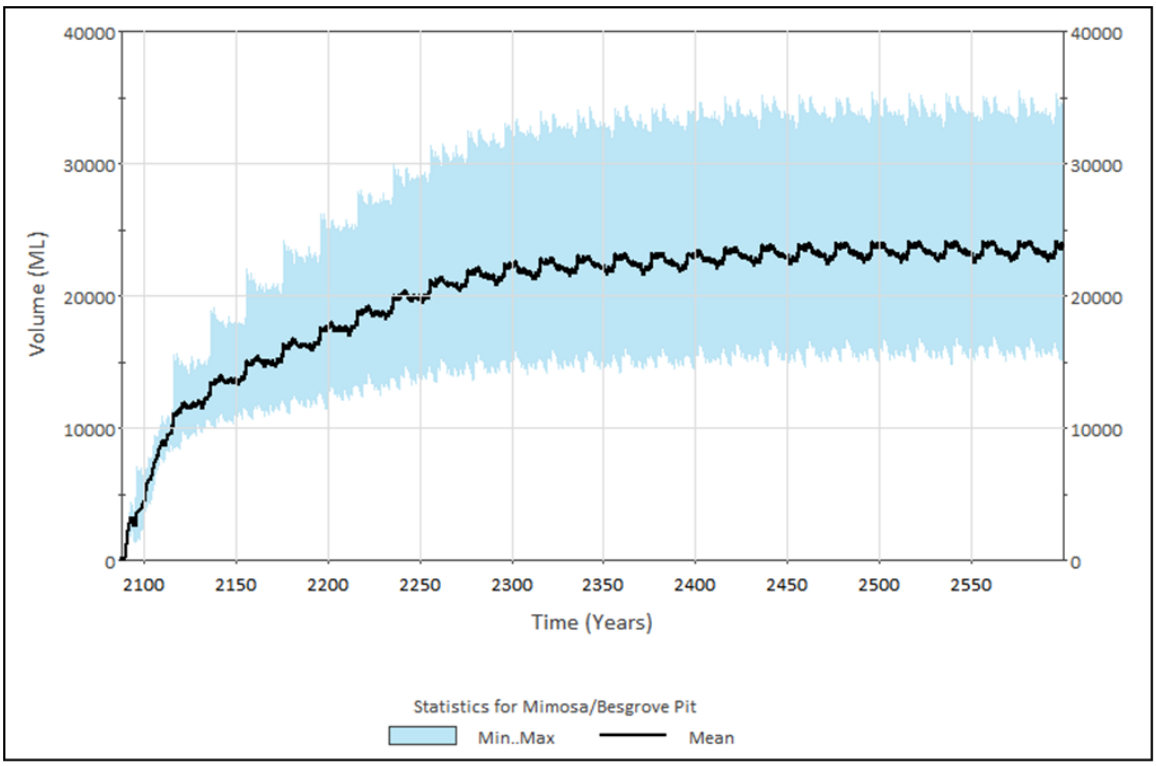

Figure 6.29 Modelled water volumes in Mimosa/Besgrove residual void

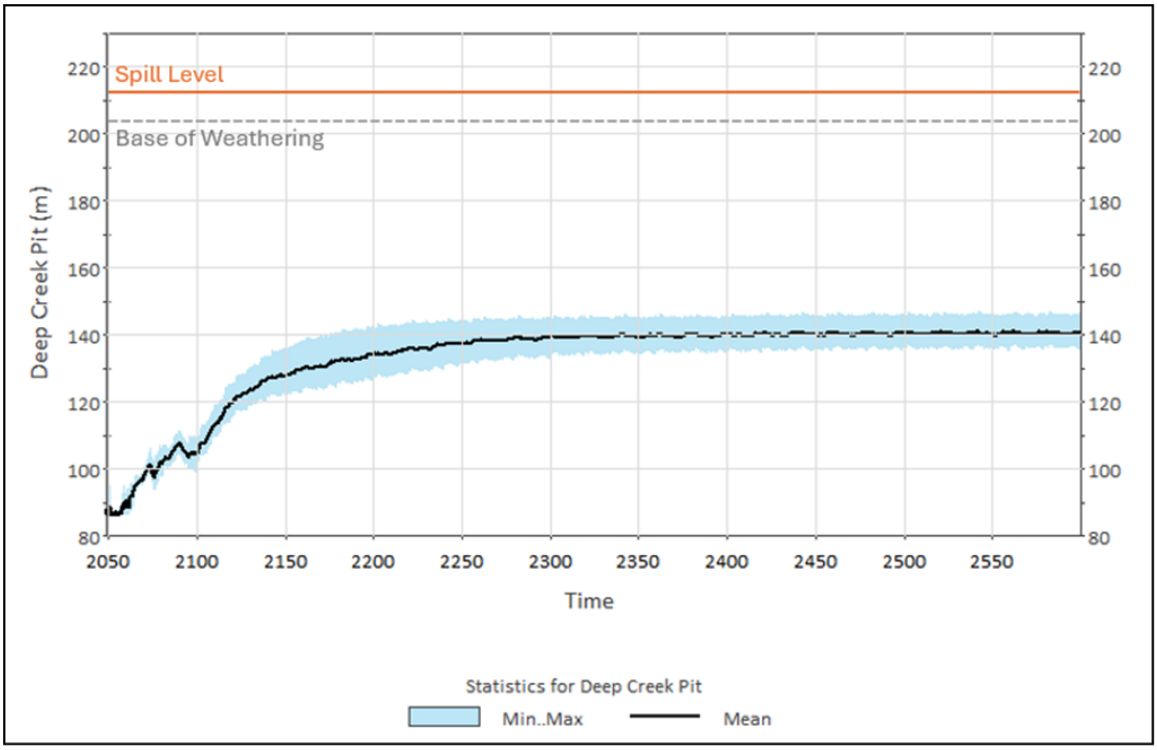

Figure 6.30 Modelled water levels in Deep Creek residual void compared to spill level and the base of the shallow geological formation

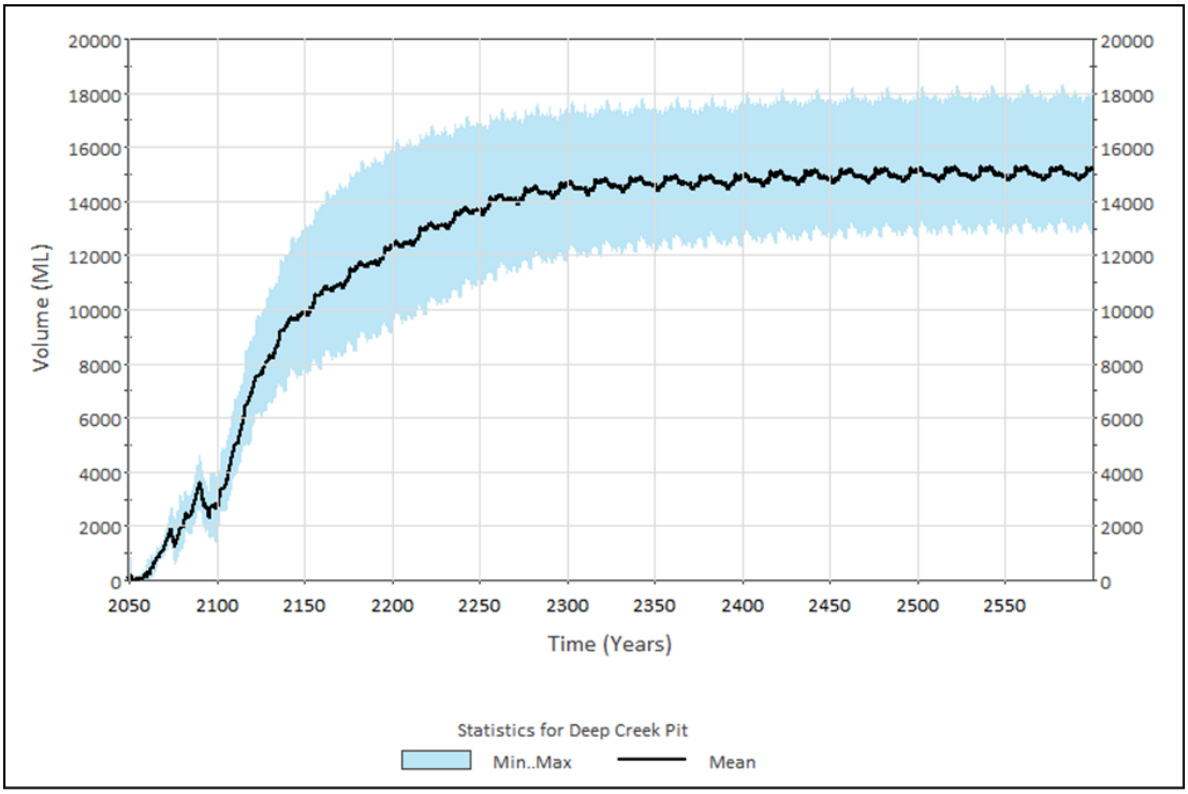

Figure 6.31 Modelled water volumes in Deep Creek residual void

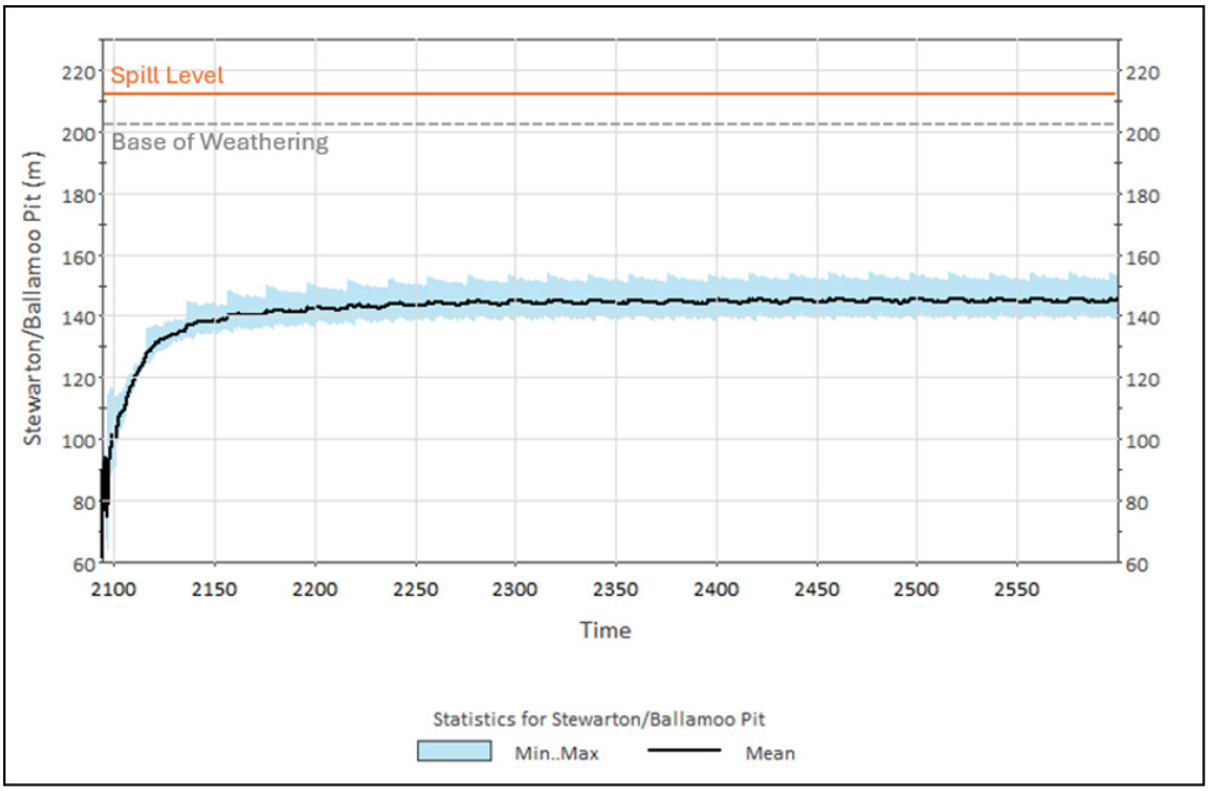

Figure 6.32 Modelled water levels in Stewarton/Ballamoo residual void compared to spill level and the base of the shallow geological formation

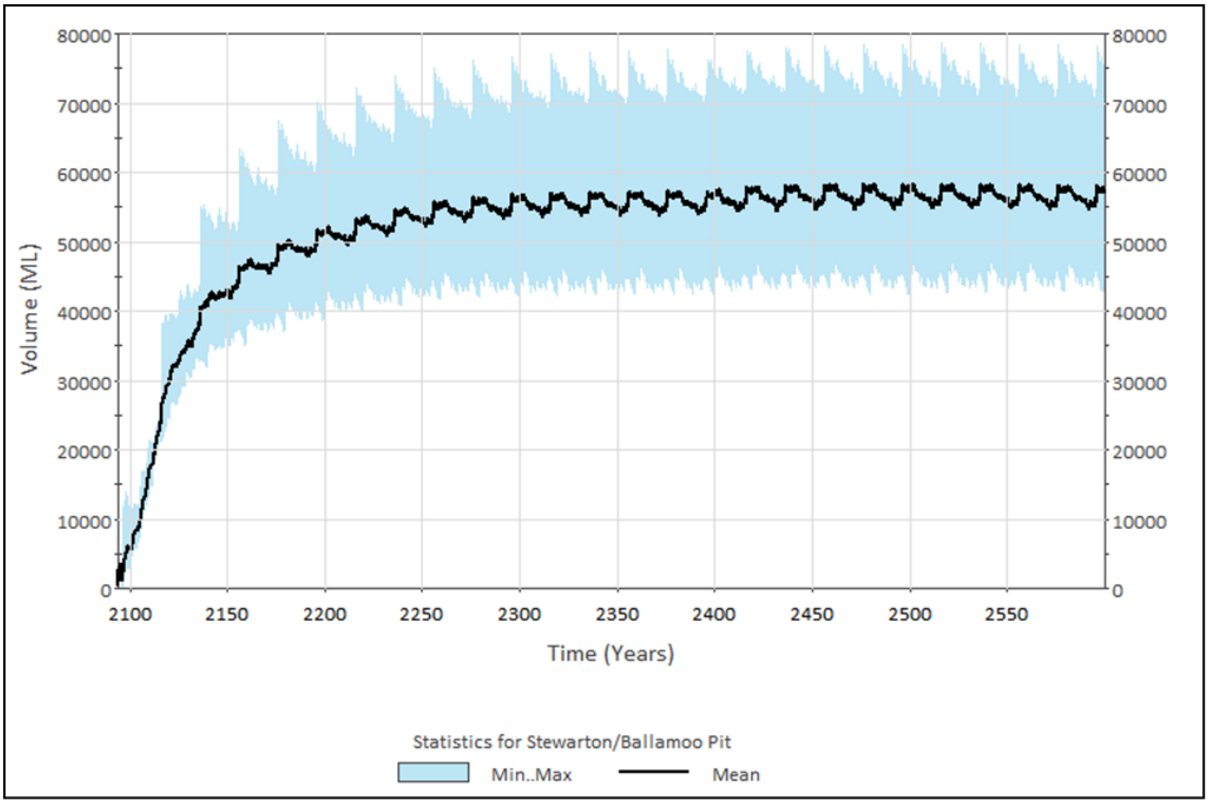

Figure 6.33 Modelled water volumes in Stewarton/Ballamoo residual void

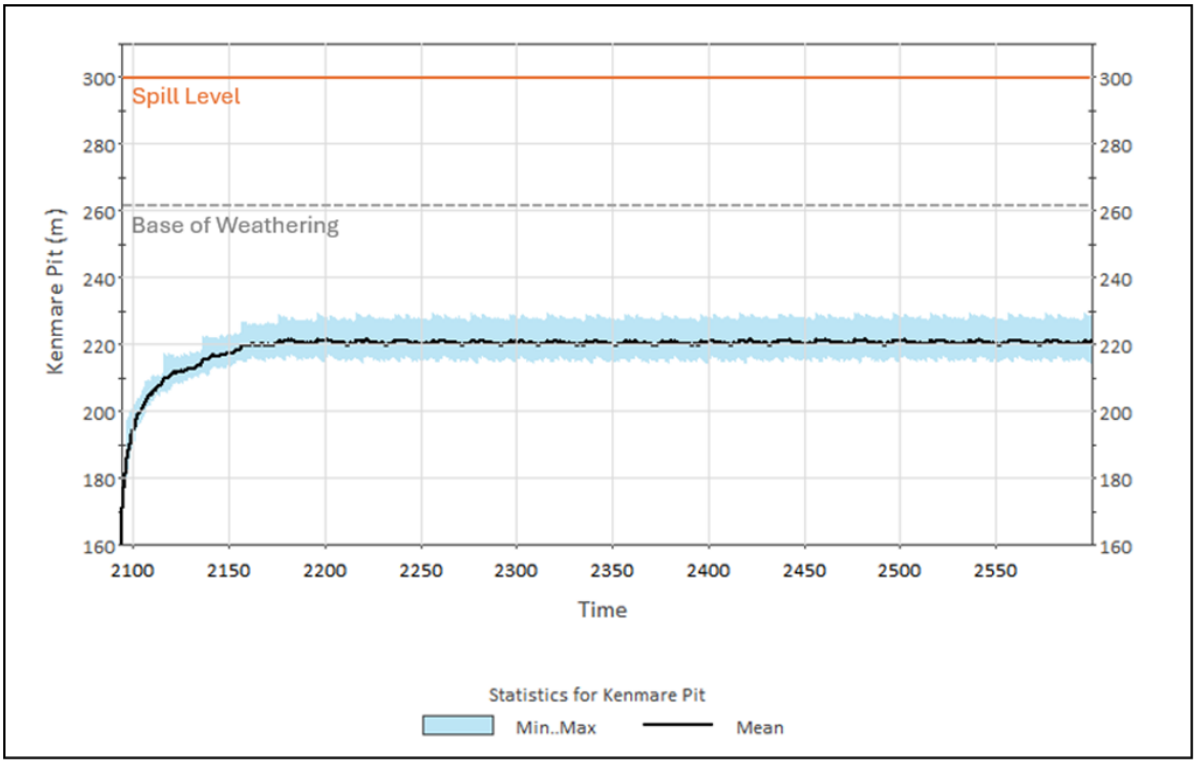

Figure 6.34 Modelled water levels in Kenmare residual void compared to spill level and the base of the shallow geological formation

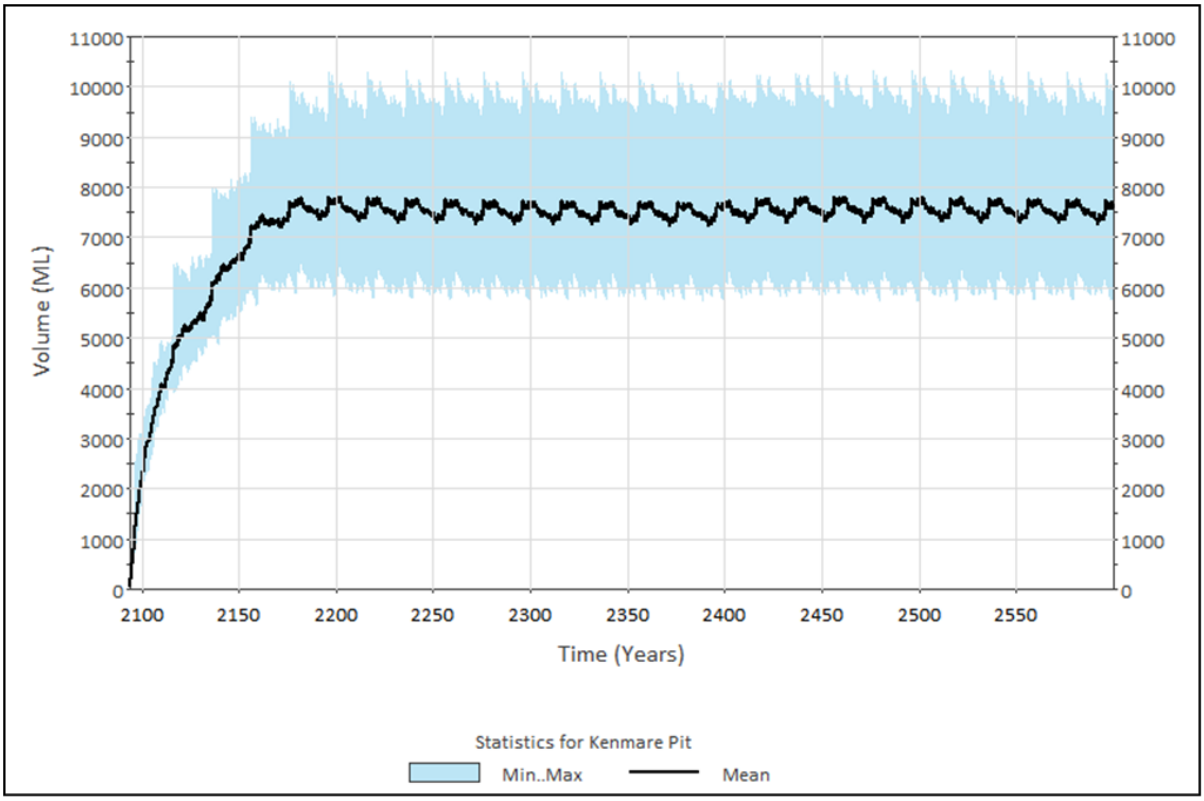

Figure 6.35 Modelled water volumes in Kenmare residual void

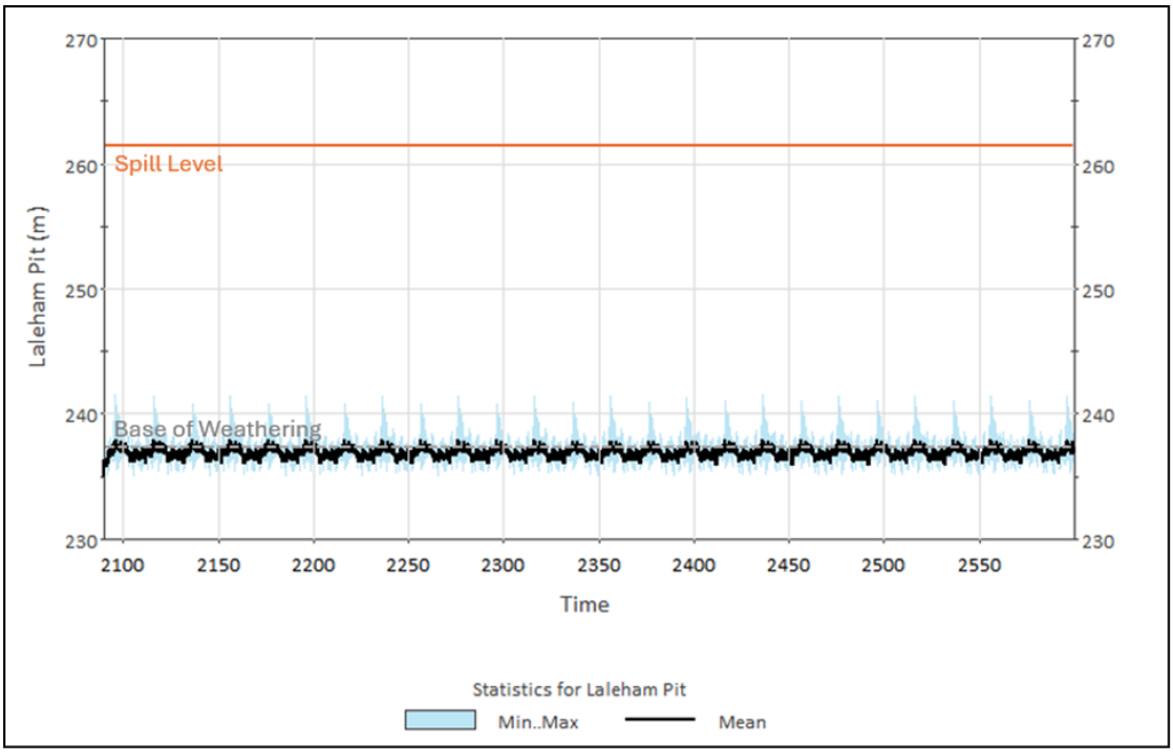

Figure 6.36 Modelled water levels in Laleham residual void compared to spill level and the base of the shallow geological formation

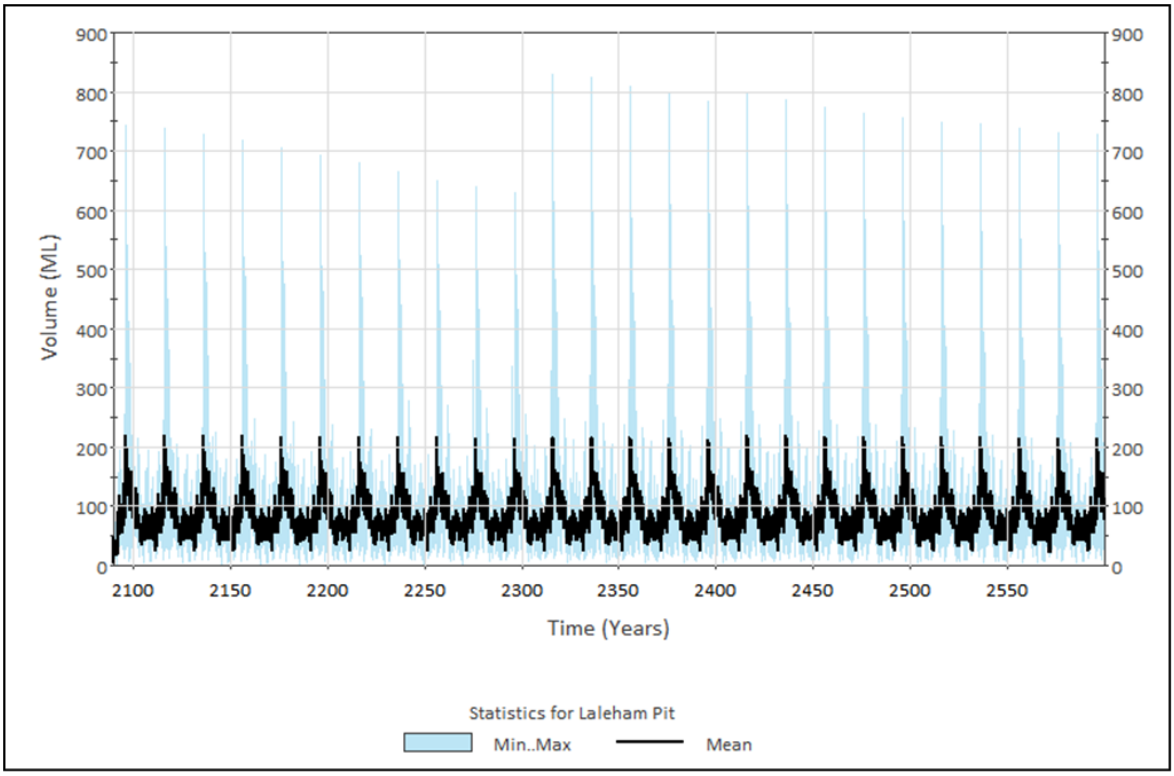

Figure 6.37 Modelled water volumes in Laleham residual void

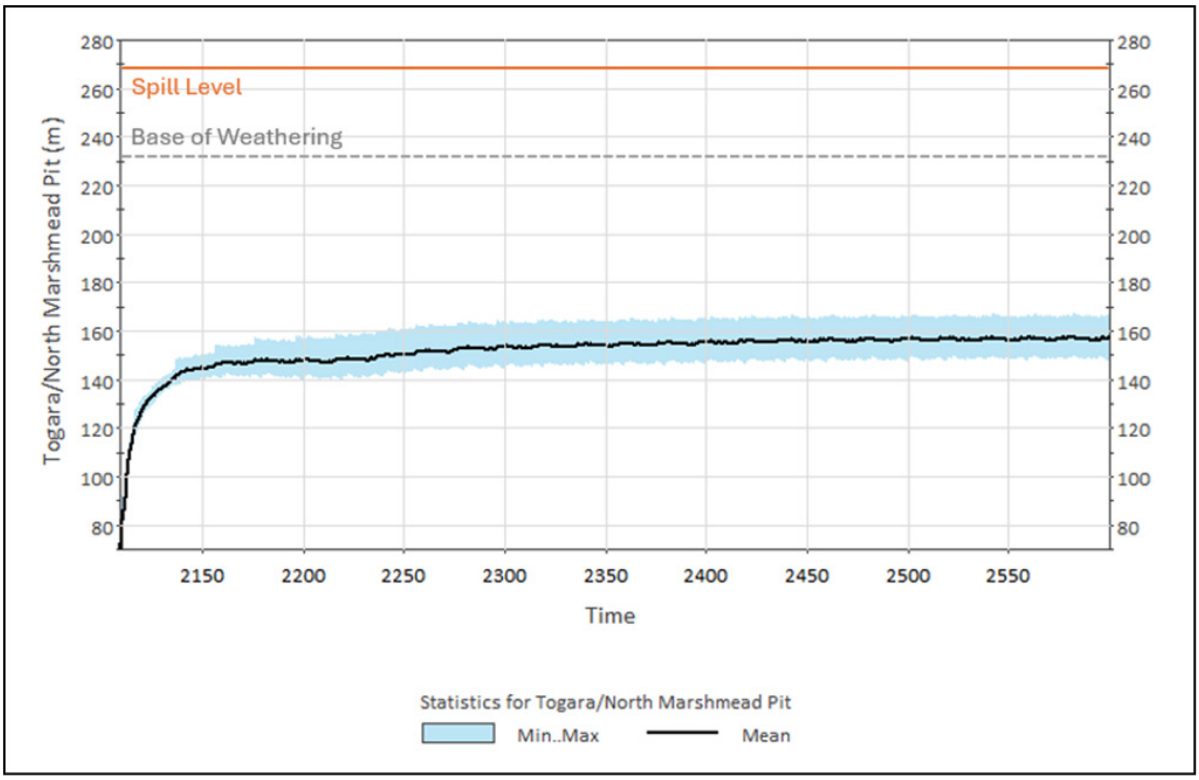

Figure 6.38 Modelled water levels in Togara/North Marshmead residual void compared to spill level and the base of the shallow geological formation

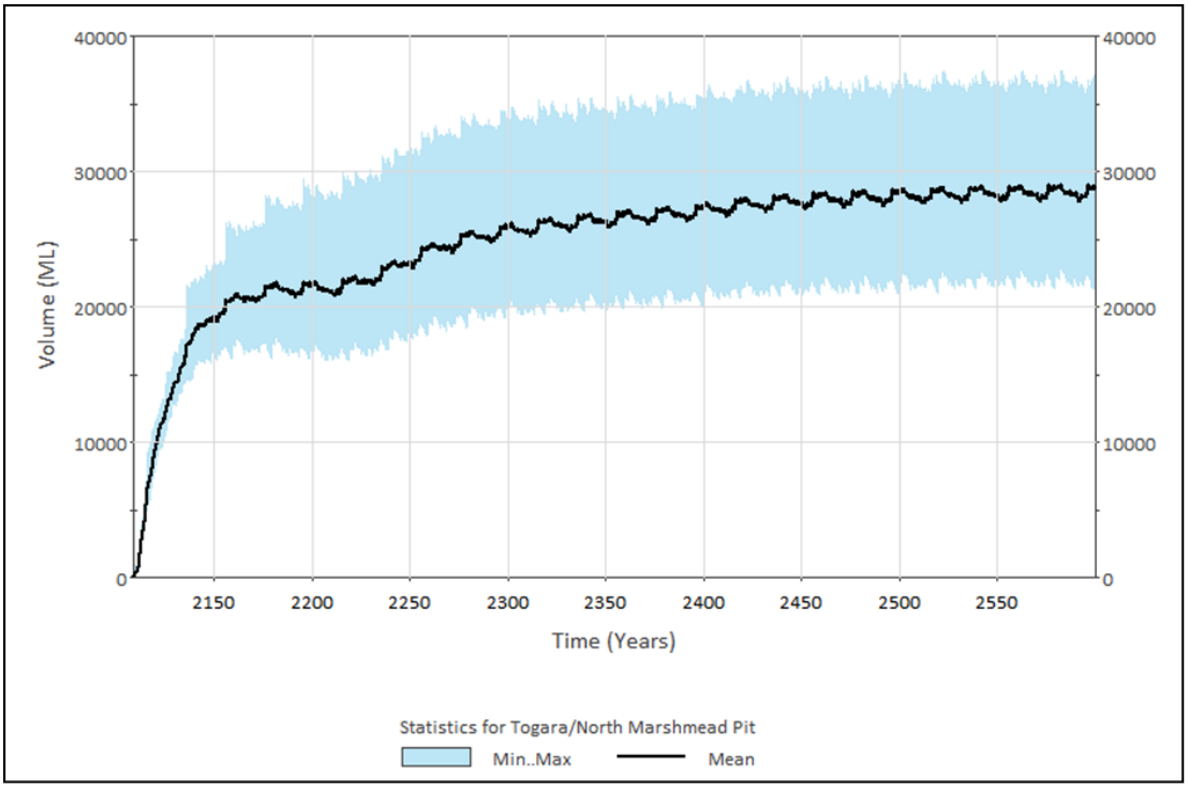

Figure 6.39 Modelled water volumes in Togara/North Marshmead residual void

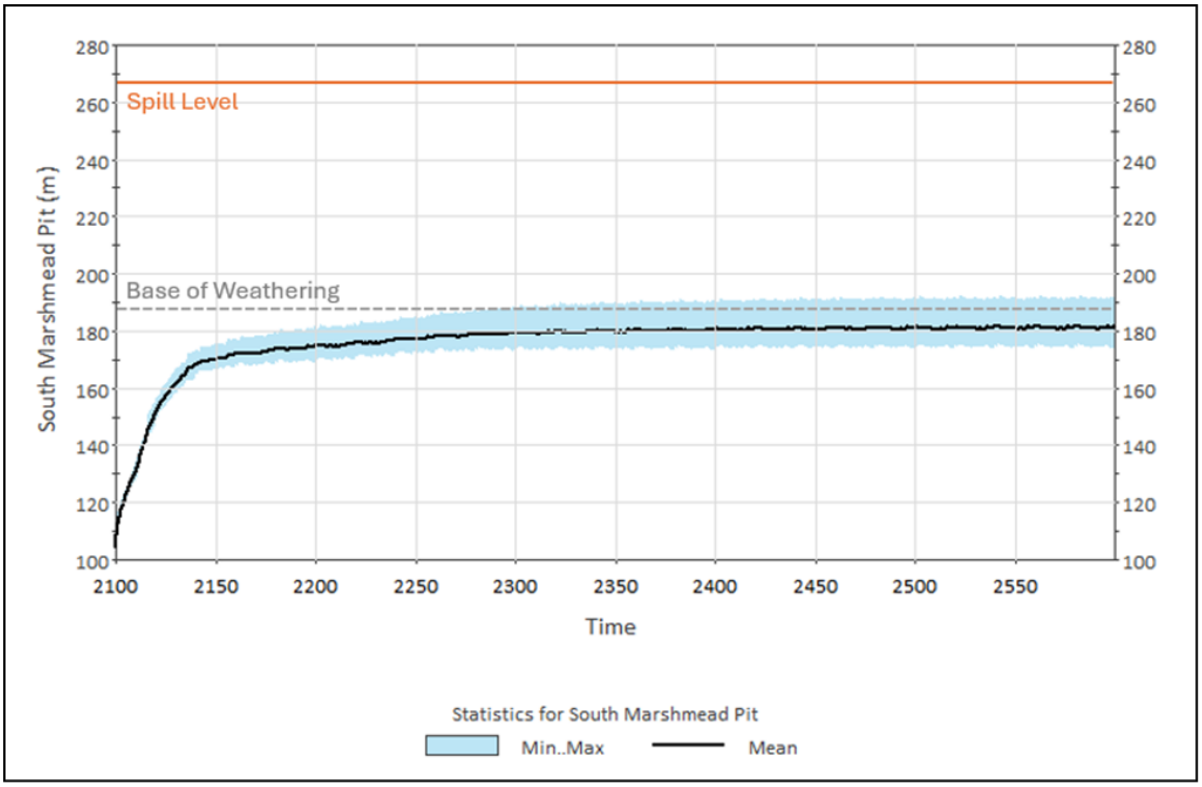

Figure 6.40 Modelled water levels in South Marshmead residual void compared to spill level and the base of the shallow geological formation

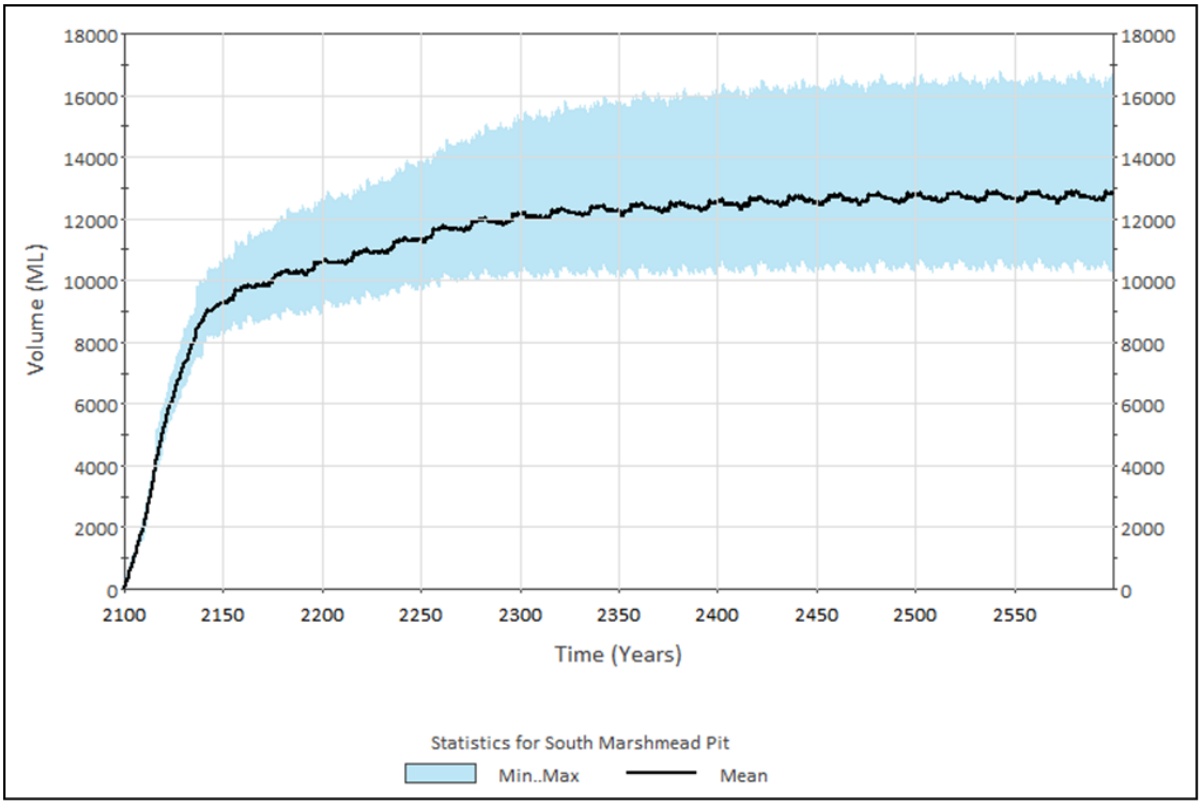

Figure 6.41 Modelled water volumes in South Marshmead residual void

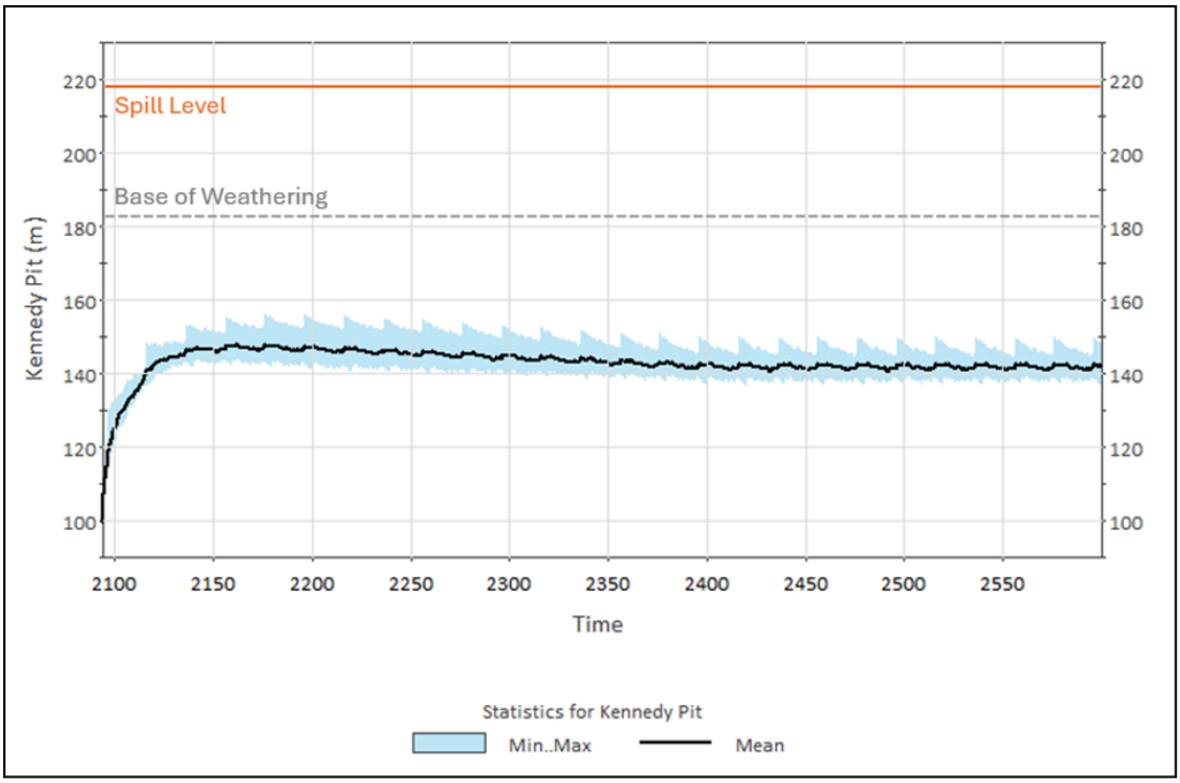

Figure 6.42 Modelled water levels in Kennedy West residual void compared to spill level and the base of the shallow geological formation

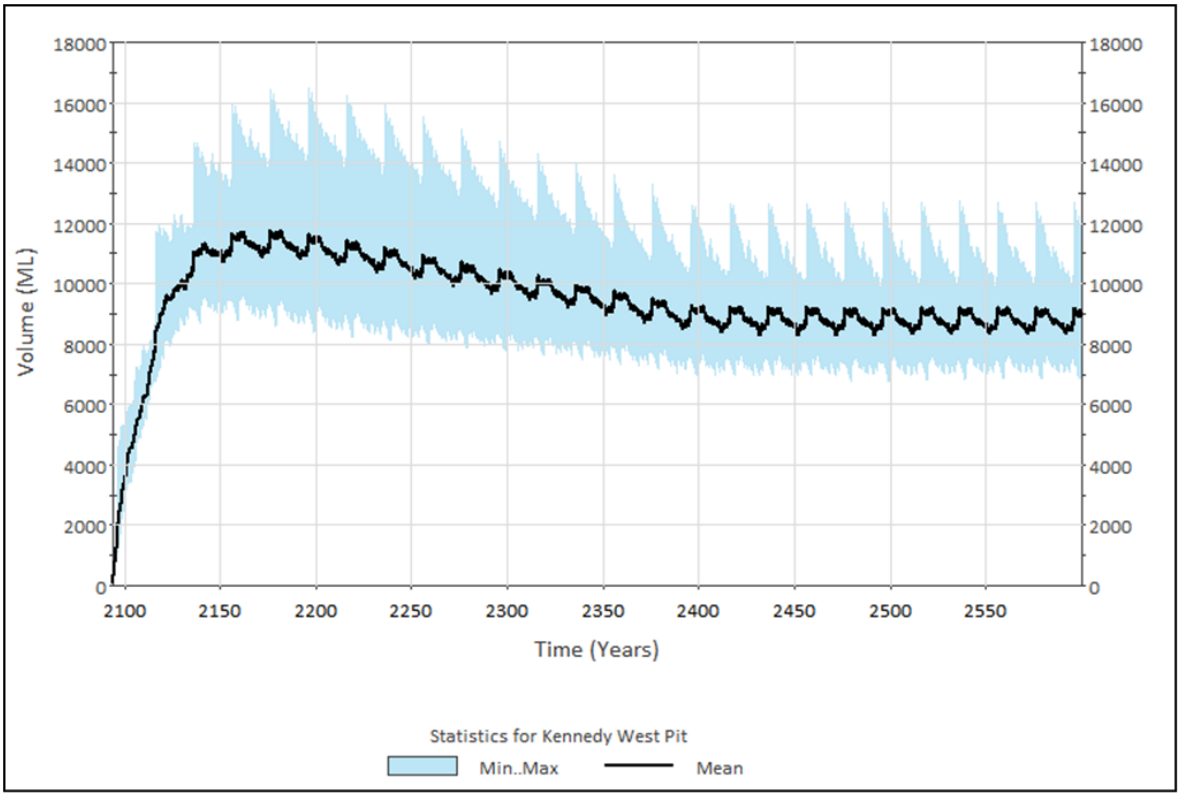

Figure 6.43 Modelled water volumes in Kennedy West residual void

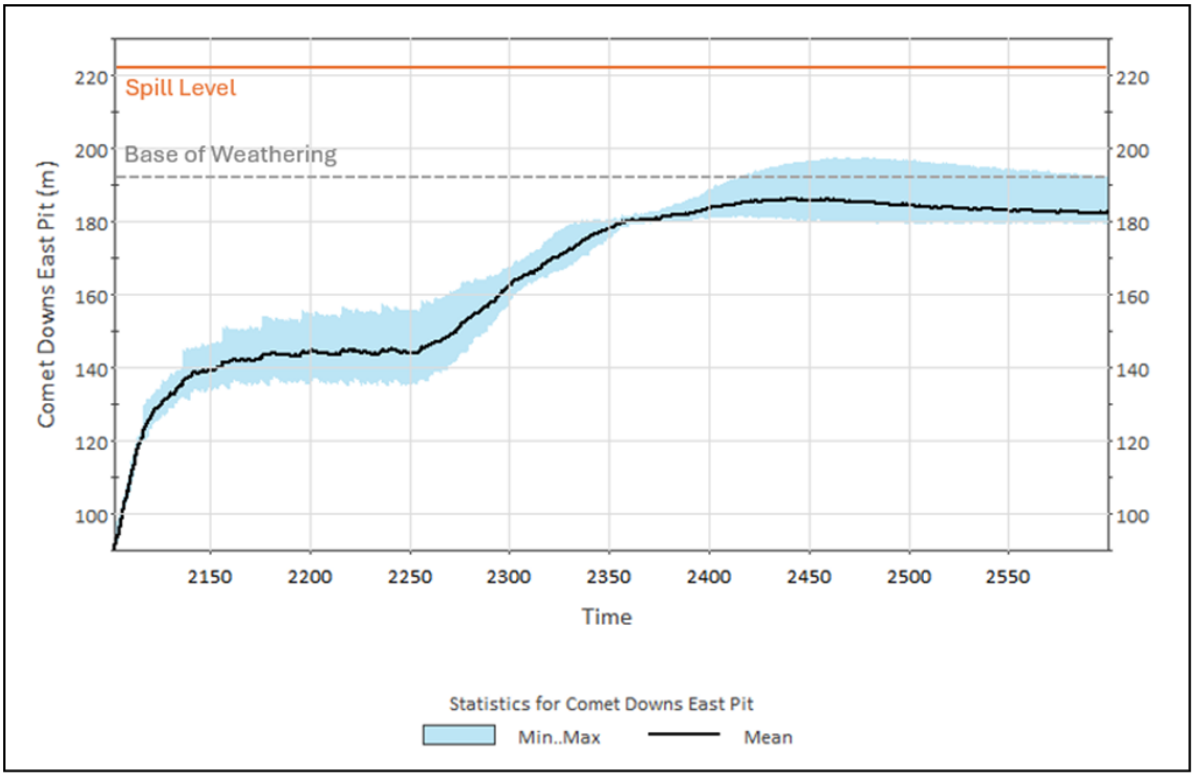

Figure 6.44 Modelled water levels in Comet Downs East residual void compared to spill level and the base of the shallow geological formation

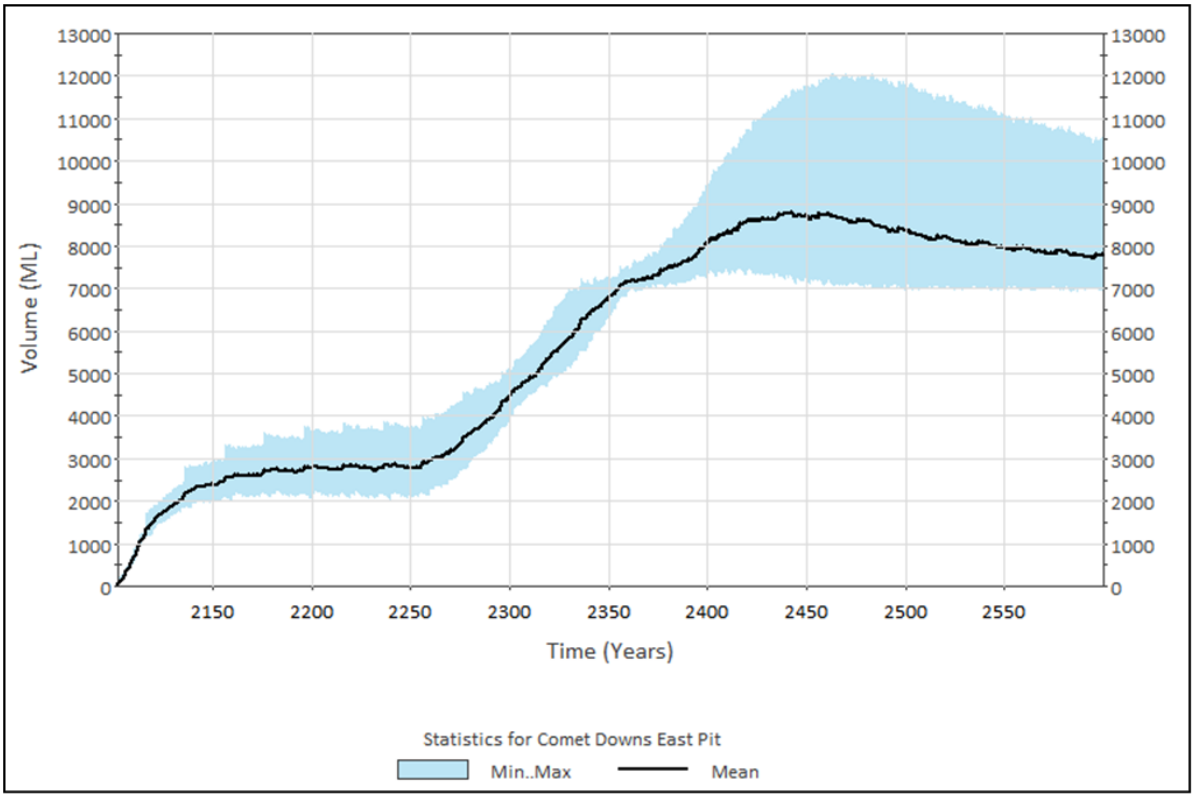

Figure 6.45 Modelled water volumes in Comet Downs East residual void

7 Geotechnical stability

Geotechnical stability assessments have been completed to demonstrate that post-closure, the conceptual void high-wall, end-wall and low-wall slopes will all exhibit long-term geotechnical stability for the BWM residual voids (BHP, 2024). This section presents the assessment findings relevant to void closure at BWM.

7.1 High-wall and end-wall stability assessment

The method of limit equilibrium was selected to geotechnically assess and quantify the risk of instability for BWM residual voids' high-walls and end-walls. Limit equilibrium compares forces on a surface with (limiting) strength if the high-wall/end-wall were at the point of failing. Defects may be included explicitly as discrete strata when known, but more often they are implicit within the strengths of broader material layers. The main disadvantage of this method is that it assumes all material along the surface can realise its peak strength at the same time; the significance of any subsequent inaccuracy depends on the load-deformation behaviour of the particular materials. However, the method is generally accepted by industry as a practical industry method and has therefore been adopted for the BWM PRC Plan.

FoS computed by limit equilibrium is essentially a ratio of the strength available to hold a slope in place divided by the loads tending to move, or destabilise, material behind the slope face. Thus, a FoS less than one (1) indicates instability, and a value greater than 1 implies that the slope is stable because the capacity to resist slipping is greater than the forces promoting slipping. A FoS is a relatively coarse and simplified measure of stability that was devised to use as a design methodology. In this context, a minimum value somewhat greater than one is specified to allow for inaccuracies and uncertainties in both the method and the input data.

As a design or performance criterion, the selected minimum FoS should be appropriate to the consequences if instability did occur, which in the closure context in turn relates to land use (Martin & Stacey, 2018) in (BHP, 2024). A minimum FoS of 1.5 is often adopted for long-term stability of civil engineering features such as road cuttings and dam walls, that is, features with broad public access. By contrast, a FoS of 1.2 is typically applied to operational design for coal mine pit walls, where stability is required for a shorter time and with limited human exposure.

Pending industry research to develop observational methods and consequence assessment for long-term pit wall stability, a minimum FoS of 1.5 has been adopted for BWM closure planning. However, a too conservative approach could lead to an unnecessary increase in void area and additional land disturbance at the potential expense of adjoining higher value land uses. Hence, BWM is applying the minimum FoS, not to the physical crest of the pit wall but instead:

- To a distance set back behind the crest, such that there are no environmental or third-party assets of significant value within that set-back; or
- To the final void walls, which have been located such that their computed set-back does not include any valuable assets.

This approach allows for flexibility to apply improvements in stability practice in the future and translates to both the high-walls and end-walls. At closure, all third-party assets will remain outside any identified zones of instability (i.e., a FoS equal to or less than 1.5). This constraint is illustrated in Figure 7.1. The NUMA extent will include the required set-back to achieve the minimum FoS.

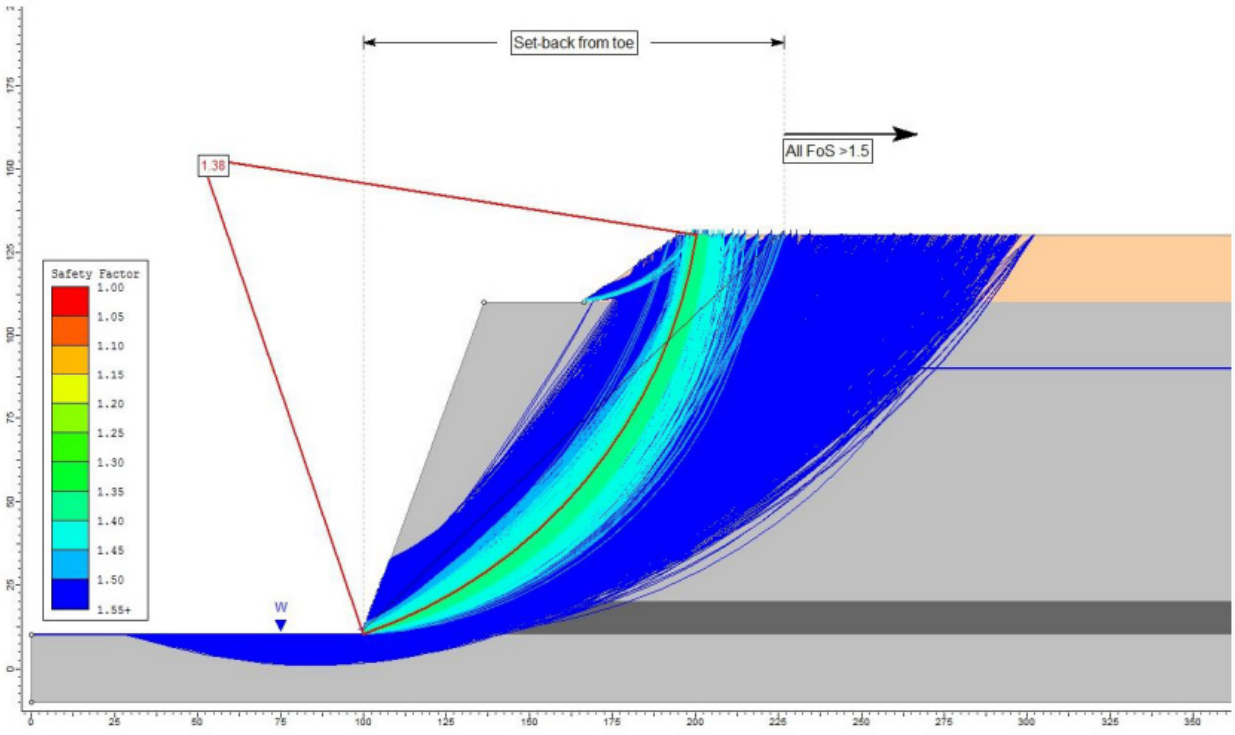

Figure 7.1 Example illustration of set-back to FoS of ≥1.5

A common engineering approach, when it is anticipated that designs will be required for a large number of similar scenarios, is to undertake upfront a large number of analyses to cover the range of expected scenarios and collate the results into a design tool, for example design charts or empirical formulae or lookup tables. It is important to appreciate that such tools do not omit design analyses, it is simply that all the analyses are carried out first so that when a particular scenario is considered, the result is already available. Set-backs for long-term pit wall stability for BWM residual voids clearly lend themselves to this approach – the regional geology is broadly consistent; mining methods constrain the range of efficient wall geometries; and given the number of pits and different planning horizons, there will be a large number of specific scenarios to address over time.

A pit wall stability design tool for determining set-backs for long-term coal mine pit wall stability is applicable for BWM, however is not applicable for all parts of the residual voids at BWM, (namely Laleham, part of Togara/North Marshmead and part of South Marshmead). Consequently, modified geotechnical stability analyses were undertaken for those segments using the same general approach and material properties as the design tool (BHP, 2024).

The key features of this design process are summarised at the start of Section 7.1. The design tool is used for initial planning and individual assessment of each high-wall and end-wall will be undertaken as part of the final pit detailed designs as mining approaches the final pit extents.

7.1.1 Inputs to assessment – regional

7.1.1.1 Regional geology and geotechnical (strength) properties

In the context of wall stability, the important geological boundaries are base of Tertiary and base of weathering; however, for simplicity in the design tool, Tertiary and weathered Permian rocks were treated as one material, which is a conservative approach. Stability analyses (forming the basis of the design tool) used the wall geometry and assumed strength properties summarised in Table 7.1 and Table 7.2 respectively.

Table 7.1 Wall geometry covered by the stability design tool (BHP, 2024)

Aspect	Value range
Average wall angle in Tertiary overburden	35° (constant)
Depth of Tertiary/weathered overburden	1 m to 100 m
Bench width at base of Tertiary overburden	30 m (constant)
Average wall angle in Permian overburden	40° to 70°
Depth of Permian overburden incl. 10 m coal	50 m to 400 m

Table 7.2 Strength properties applied in the stability design tool (BHP, 2024)

Material	Cohesion (kPa)	Friction angle (°)	Unit weight (kN/m^3)
Tertiary/weathered	50	30	22
Fresh Permian	450	42	24
Coal	30	35	15

7.1.1.2 Effect of weathering

The effects of weathering on the character and strength of rocks and hence the long-term stability of pit walls only relates to weathering that might occur after cessation of mining, being physical degradation and chemical decomposition. Degradation depends heavily on water ingress and is largely restricted to the surface of pit walls and does not penetrate far enough to cause geotechnical instability. An exception may be when particularly moisture-sensitive rock is below the long-term void water level that is addressed by adopting saturated strength properties.

Chemical decomposition involves reactions of the actual rock minerals to form different minerals (ultimately, clay minerals) and occurs at the crystalline/molecular level at a very slow rate relative to other processes. Chemical weathering only occurs where water and other reactants can reach and therefore occurs mainly at the rock surface and along joints and bedding planes.

Both phases of weathering occur fastest in hot, wet climates – rainfall providing the necessary moisture, and high temperature promoting chemical reactions. The climate at BWM is hot but not wet and as such only “very slight” ongoing weathering is expected. Very specific situations where even a very small amount of additional weathering might affect pit wall stability are generally localised that may only be apparent when the pit wall is excavated. Generally, these situations cannot be planned for and will be assessed and managed at the end of coal extraction at the detailed design stage for closure (BHP, 2024).

7.1.1.3 Effect of long-term erosion

Erosion is the detachment of solid particles from the soil or rock mass and the subsequent transport of those particles away from their initial location.

On high-walls and end-walls in the Bowen Basin, erosion in fresh rock is mainly limited to material that has already slaked because the intact rock is too strongly bound for particles to be readily detached. Above the base of weathering, particles are more easily detached. As particles are transported in water flow, erosion develops and progresses over time along flow lines. These are mainly perpendicular to the line of the wall. By contrast, slip failures involve surfaces that are at least sub-parallel to the line of the wall. Consequently, erosion rarely causes geomechanical instability and generally has little impact on geomechanical stability in in-situ pit wall geotechnical stability. Erosion is generally addressed through surface water and erosion control measures rather than by slope stability design. Therefore, it has not been considered further in this assessment (BHP, 2024).

7.1.1.4 Effect of significant hydrological events

In Bowen Basin coal mines, weathered overburden is generally susceptible to softening when saturated, especially materials containing significant clay. Water balance modelling for the proposed residual voids at BWM predicts average and long-term void water levels many metres below the base of weathering.

Unweathered (fresh) coal measure rocks generally do not show significant strength loss on wetting. Particular claystones and mudstones may be more sensitive to moisture, but these tend to start slaking soon after exposure to humid air, and so are apparent during mining when wall designs can be amended to mitigate any impact on wall stability. Residual void water is only expected to contact fresh rock, and so will not affect geotechnical stability of excavated pit walls (BHP, 2024).

The most serious potential impact of severe rainfall events would be the inrush of floodwaters to the void. For the final closure state landform, spoil placement will be undertaken to reduce the risk to the final residual voids for the NUMA from inundation by floodwaters as discussed in Section 5.2.

A final mode of instability related to water storage is drawdown failure. This can occur when pore water pressures in the containing earth and rock have equilibrated with the water level in the storage and that water level is then lowered quicker than the containing materials can drain, causing imbalance in the pore pressures. This will not be an issue for voids that contain water passively because evaporation will not lower the water level at a rate to establish this imbalance (BHP, 2024).

7.1.2 Inputs to assessment – local

Long sections extracted from the current BWM geological model provided void wall profile data as summarised in Table 7.3.

Table 7.3 Geotechnical profiles for the residual void walls at BWM (BHP, 2024)

Geotechnical profile parameters		Ramp 8	Boonie Doon	Mimosa/ Besgrove	Deep Creek	South Marshmead	Kennedy West	Comet Down East	Stewarton/ Ballamoo	Kenmare	Laleham	Togara/ North Marshmead
Depth of Tertiary/ weathered overburden (m)	Average Range 90% less than	15 13–17 16	16 7–21 20	18 7–28 25	76 46–113 112	38 22–49 45	27 27–28 28	13 6–21 18	31 7–78 69	59 45–68 68	20 14–28 23	70 21–108 103
Thickness of base coal seam (m)	Average Range 90% less than	1.0 1.0–1.0 1.0	5.1 3.8–6.1 6.0	5.5 1.1–9.2 7.4	5.3 5.1–5.4 5.4	2.4 1.8–4.5 2.8	0.7 0.7–0.7 0.7	5.6 2.7–9.3 9.0	3.3 0.6–5.4 4.4	3.7 3.4–4.0 3.9	2.9 1.1–3.3 3.3	4.0 3.0–5.1 4.9
Depth of fresh overburden (m)	Average Range 90% less than	57 56–58 58	56 45–68 64	118 82–136 132	110 94–128 124	79 43–121 104	105 102–107 107	120 108–132 130	127 91–166 158	87 62–118 110	6 0–11 9	143 127–167 157
Total Wall depth (m)	Average Range 90% less than	72 70–73 73	73 52–87 82	137 109–158 155	186 155–212 209	117 189–170 147	133 131–134 134	133 129–140 137	158 110–237 219	146 115–164 163	26 22–30 30	213 165–247 243

The depth ranges for Tertiary/weathered and fresh Permian overburdens are within the application limits for the design tool. Computations were made with an assumed wall angle of 60°. Computed set-back from wall toe is not very sensitive to that parameter but steeper angles are slightly more conservative because they impose greater overburden weight on the potential slip surface. The thickness of the coal seam at the pit floor ranged up to 10 m, which is the assumed thickness in the design tool (10 m) (BHP, 2024).

The design tool is used for initial planning only. Individual assessment of each high-wall and end-wall will be undertaken as part of the final pit detailed design stage required as part of closure works as mining approaches the final pit extents and as additional geological and geotechnical data becomes available.

The procedure for estimation of set-back developed in the design tool is:

1. If D_{TW} = <47m, FoS_{TW} =1.5 and $S_{TW} = D_{TW}/\tan(35°)$
2. Otherwise $S_{TW} = 2.58*D_{TW} – 41.5$
3. $S1 = S_{TW} + 30 + D_P/\tan(A_P)$
4. $FoS_P = 1.208 + 0.0655/\sqrt{D_{TW}} + 13.87/\sqrt{D_P} – 0.0168A_P$; if $FoS_P >= 1.5$ then $S_P = D_P/\tan(A_P) + 30 + D_{TW}/\tan(35°)$
5. Otherwise, $S_P = 0.856*D_{TW}^{1.15} + 3.727*D_P^{0.94} + 39.35\tan(A_P)^{1.09} + 35.01\ FoS_P^{2.49}$ -389
6. Required set-back from the wall toe = $\max(S_1, S_P)$

Where:

- D_{TW} = depth of Tertiary/weathered overburden (m) 0
- D_P = depth of fresh Permian overburden (m)
- A_P = average wall angle in fresh Permian overburden (degrees)
- S_{TW} = set-back for stability in Tertiary/weathered overburden (m), measured from the toe of the weathered overburden batter
- S_1 = set-back for the whole operational wall design (m), measured from the toe of the whole wall
- S_P = set-back for stability of whole wall (m), at FoS = 1.5.

7.1.3 High-wall and end-wall stability assessment results

The results for the BWM high-walls are summarised in Table 7.4. Set-backs for end-walls will range from the value at the end of each high-wall down to the value coinciding with the excavated wall crest as the exposed wall height reduces.

Table 7.4 Setbacks for long-term high-wall stability at BWM at 60° wall angle (using the standard design tool) (BHP, 2024)

Geotechnical stability parameters		**Ramp 8**	**Boonie Doon**	**Mimosa/ Besgrove**	**Deep Creek**	**Stewarton/ Ballamoo**	**Kenmare**	**Togara/North Marshmead**	**South Marshmead**	**Kennedy West**	**Comet Down East**
D_{TW} (m)	Average Range 90% less than	15 13–17 16	16 7–21 20	18 7–28 25	13 6–21 18	59 45–68 68	64 21–99 92	52 46–68 62	38 22–49 45	27 27–28 28	31 7–78 69
D_P (m)	Average Range 90% less than	57 56–58 58	56 45–68 64	118 82–136 132	120 108–132 130	87 62–118 110	144 127–167 158	119 108–128 126	79 43–121 104	105 102–107 107	127 91–166 158
A_P (°)**60**											
S_1 (m)	Average Range 90% less than	42 40–42 42	42 30–50 47	79 63–91 90	77 74–81 79	156 94–186 178	204 95–296 280	122 89–204 173	72 51–155 90	77 75–77 77	117 63–240 225
FoS_P	Average Range 90% more than	2.06 2.04–2.07 2.04	2.08 1.90–2.28 1.95	1.50 1.40–1.75 1.42	1.49 1.43–1.55 1.44	1.72 1.48–1.97 1.53	1.37 1.28–1.44 1.31	1.48 1.44–1.54 1.45	1.83 1.47–2.33 1.57	1.57 1.55–1.58 1.55	1.46 1.28–1.67 1.32
S_p (m)	Average Range 90% less than	84 82–86 86	86 66–97 94	135 109–170 167	129 117–145 140	165 141- 179 178	262 186–325 317	189 159–222 214	131 111–187 151	130 130–131 130	174 105–319 284
Set-back from toe of wall (m)	**Average Range 90% less than**	**84 82–86 86**	**86 66–97 94**	**135 109–170 167**	**129 117–145 140**	**167 141–186 178**	**262 186–325 317**	**189 159–222 214**	**131 111–187 151**	**130 130–131 130**	**174 105–319 284**

As discussed in Section 7.1, the standard stability design tool is not applicable for all parts of the BWM residual voids. As such, the setbacks for long-term stability for Laleham, part of Togara/North Marshmead and part of South Marshmead were determined using modified geotechnical stability analyses (BHP, 2024). Analysis of the Laleham void resulted in a minimum FoS greater than 1.5, meaning no additional set-back is imposed as the void wall is considered geomechanically stable at the crest.

The cross-sections for the parts of Togara/North Marshmead and South Marshmead voids had minimum FoS less than 1.0 for slip surfaces daylighting behind the pit wall. For planning purposes, the set-backs from the wall toe at which FoS ≥1.5 were measured; however, it is expected that as the final mining strip is approached, the wall design will also be refined to improve the FoS at the wall face. The setbacks for long-term wall stability derived using the modified geotechnical stability analyses are shown in Table 7.5 (BHP, 2024).

Table 7.5 Setbacks for long-term high-wall stability at BWM at (using the bespoke design tool) (BHP, 2024)

Void section	Exposed depth of Tertiary/weathered (m)	Exposed depth of fresh Permian (m)	Void water level (m) (below high-wall weathered extent)	Factor of Safety at crest	Set-back from toe (m)
Laleham Ch 500	22	0	4	2.83	0
Laleham Ch 500	22	0	-2 (above HWE)*	2.81	0
Laleham Ch 1500	25	1	1	2.74	0
Togara/North Marshmead Ch 3750	103	139	84	0.96	366
South Marshmead Ch 1500	106	102	32	0.98	328

*High-wall weathered extent

This set-back approach to long-term geotechnical stability offers several options to meet the requirements for mine closure including:

- Stop mining within the pit when the toe of each pit wall reaches at least the set-back distance away from significant permanent assets including lease boundaries, third-party infrastructure, and Matters of State Environmental Significance.
- Move the asset in question (e.g., relocate a public road).
- Undertake a more detailed geotechnical investigation and wall stability analysis to remove some of the conservatism imposed by the design tool.
- Plan to partially backfill of the residual void. In simple terms, this would reduce the (exposed) wall depth and depth of fresh Permian overburden, which would in turn reduce the required set-back.

For BWM, the conceptual voids have been designed with the toes or crest (where relevant) of each void wall at least the set-back distance away from significant permanent third-party assets. The design will be refined with detailed individual geotechnical assessment as mining of the pits approaches the final extents. The NUMA extents include the calculated set-back distance to achieve geotechnical stability within the NUMA.

7.2 Low-wall stability assessment

The geotechnical stability of low-walls has been assessed for the BWM residual voids with the purpose of demonstrating that, post-closure, void low-wall slopes will exhibit long-term geotechnical stability (WSP, 2024c).

A stability analyses of the low-wall final closure state landform for the BWM residual voids was undertaken using the 2-dimensional (2D) limit equilibrium analysis software Slide2 (version 9.010). Twelve (12) cross-sections were selected that represented the interpreted critical (worst case) low-wall conditions from a stability point of view, targeting areas of greatest spoil height and steepest floor dip. The section locations for the analysis are identified as shown in Table 7.6 and presented in Figure 7.2.

Table 7.6 Low wall analysis cross sections for BWM

Analysis section	Pit name
Section 1	Ramp 8
Section 2	Bonnie Doon
Section 3	Mimosa/Besgrove
Section 4	Deep Creek
Section 5	Stewarton/Ballamoo
Section 6	
Section 7	Kenmare
Section 8	Laleham
Section 9	Togara/North Marshmead
Section 10	South Marshmead
Section 11	Kennedy West
Section 12	Comet Downs East

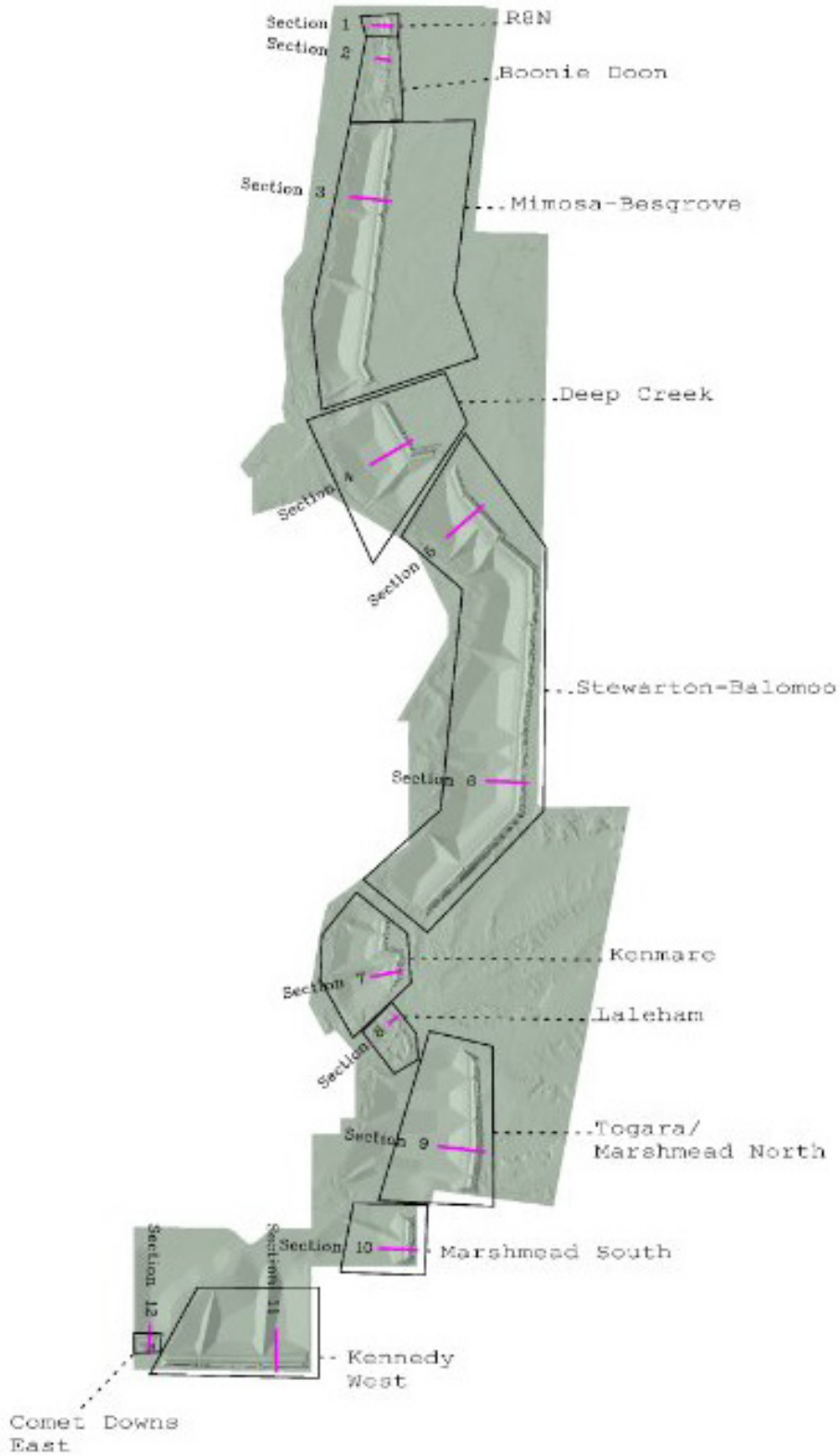

Figure 7.2 Low-wall cross-section locations analysed at BWM (WSP, 2024c)

For each of the twelve cross-sections, the following analysis cases were considered:

- Slope configuration based on the 3D final closure state landform and 3D final pit floor profile.
- Two alternative failure mechanisms include:
  - **a** Circular analyses using *Morgenstern-Price*.

b Non-circular using *Sarma* and *Morgenstern-Price*, non-vertical slices.

- Two alternative cases of failure extents, including:

a Global stability: Slip surfaces extending from the upper post-mining land use (PMLU) area of the low-wall slope to the spoil toe level.

b PMLU local stability: Slip surfaces constrained to within the PMLU low-wall slope.

The geotechnical stability assessment for all BWM residual voids indicate that, for the closure state landform:

- The minimum FoS for all potential slip surfaces affecting the low-wall slope outside the NUMA was > 1.5.
- The stability requirements of a FoS ≥1.5 for the overall slope and for slopes outside the NUMA are met.

A summary of the analysis results for the BWM residual voids are presented in Table 7.7, and depicted in Figure 7.3 to Figure 7.27.

Table 7.7 Summary of low-wall stability analysis results for the BWM closure state landform

Section number	Pit	Low-wall spoil height (m)	Low-wall floor dip (°)	Minimum Factor of Safety	
				Overall slope (global stability)	Slope outside NUMA (local stability)
1	Ramp 8	94	2.7	2.08	3.38
2	Bonnie Doon	90	5.2	2.50	3.62
3	Mimosa/Besgrove	261	3.8	1.68	2.35
4	Deep Creek	280	1.1	1.93	2.58
5	Stewarton/Balomoo (north)	322	3.0	1.85	2.62
6	Stewarton/Balomoo (south)	300	4.6	1.99	2.26
7	Kenmare	233	2.1	1.58	2.43
8	Laleham	40	4.8	1.67	2.99
9	Togara/Marshmead North	351	2.2	1.56	2.93
10	Marshmead South	253	1.2	1.55	4.03
11	Kennedy West	305	1.5	1.76	2.22
12	Comet Downs East	191	0.1	1.60	2.74

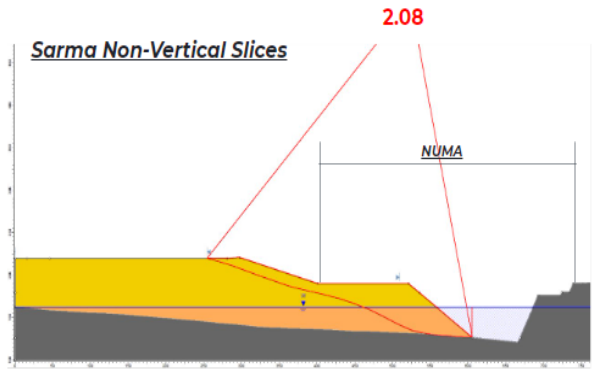

Figure 7.3 Ramp 8 residual void (cross-section 1) – global stability

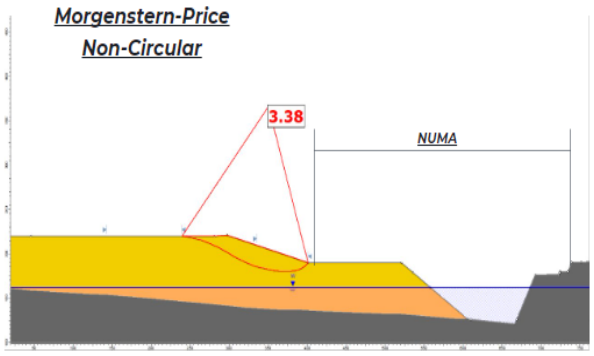

Figure 7.4 Ramp 8 residual void (cross-section 1) – local stability, slope outside the NUMA

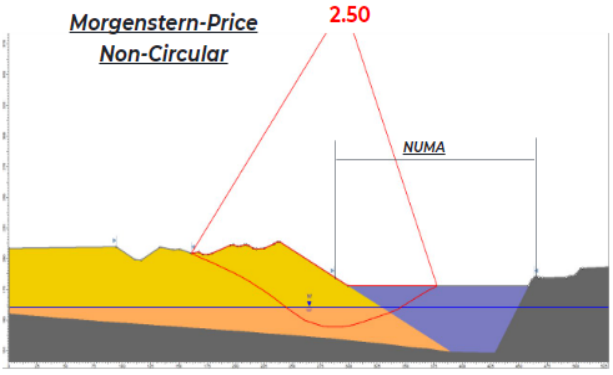

Figure 7.5 Bonnie Doon residual void (cross-section 2) – global stability

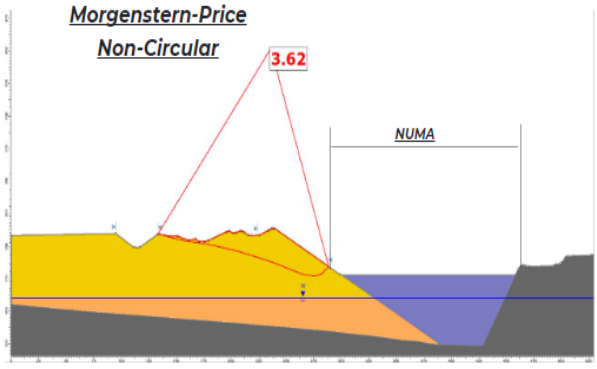

Figure 7.6 Bonnie Doon residual void (cross-section 2) – local stability

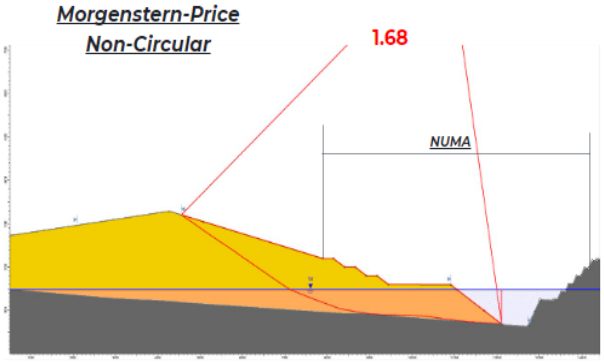

Figure 7.7 Mimosa/Besgrove residual void (section 3) – global stability

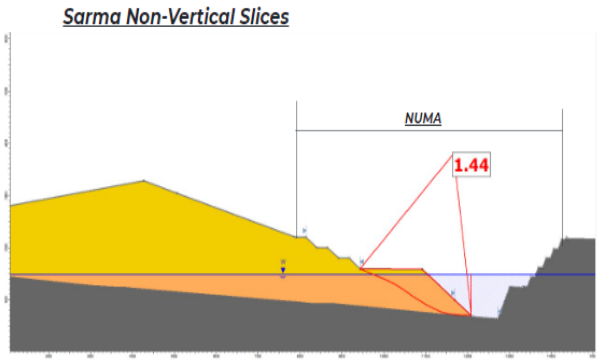

Figure 7.8 Mimosa/Besgrove residual void (section 3) – local stability

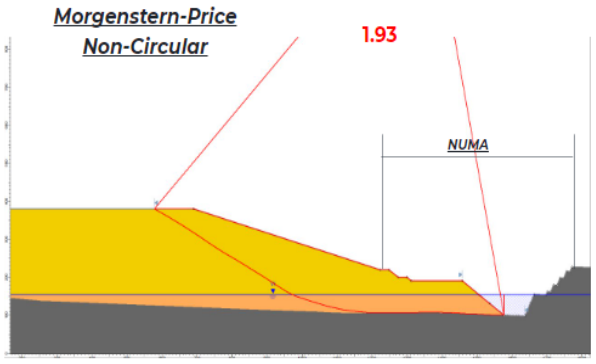

Figure 7.9 Deep Creek residual void (cross-section 4) – global stability

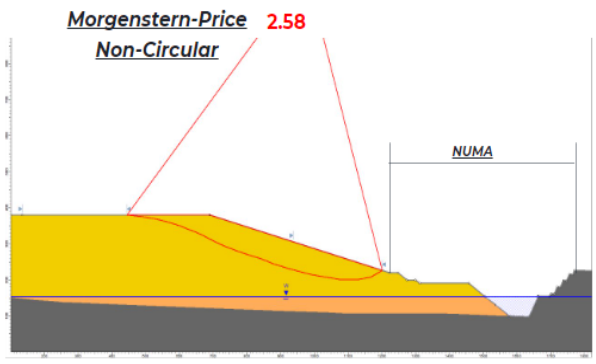

Figure 7.10 Deep Creek residual void (cross-section 4) – local stability

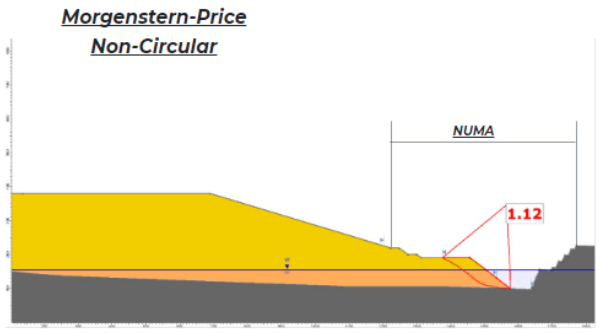

Figure 7.11 Deep Creek residual void (cross-section 4) – local stability

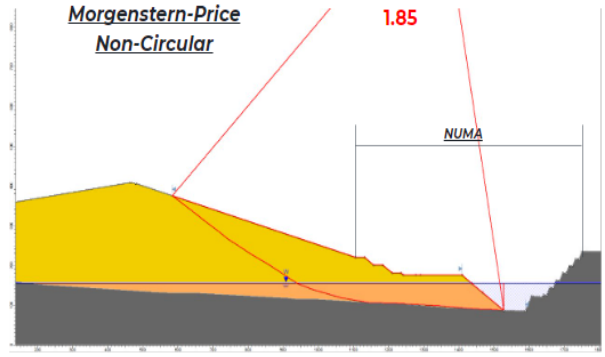

Figure 7.12 Stewarton/Balomoo (North) residual void (cross-section 5) – global stability

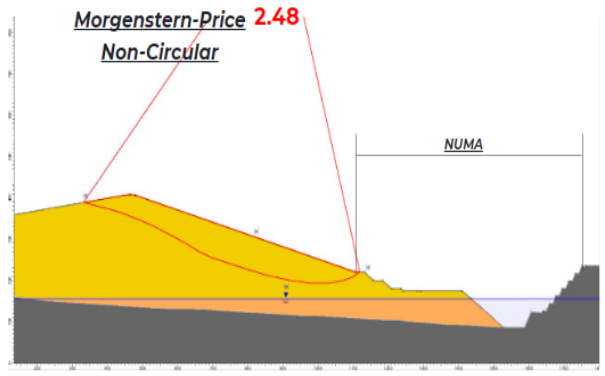

Figure 7.13 Stewarton/Balomoo (North) residual void (cross-section 5) – local stability

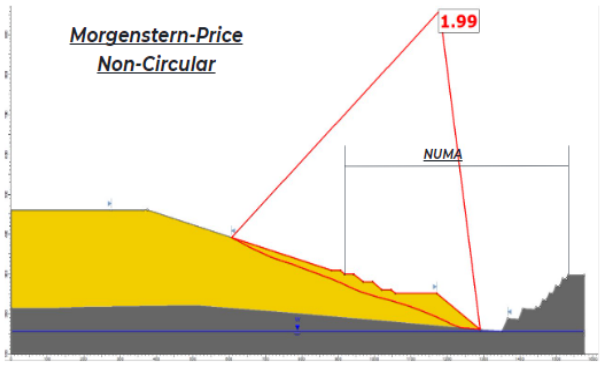

Figure 7.14 Stewarton/Balomoo (South) residual void (cross-section 6) – global stability

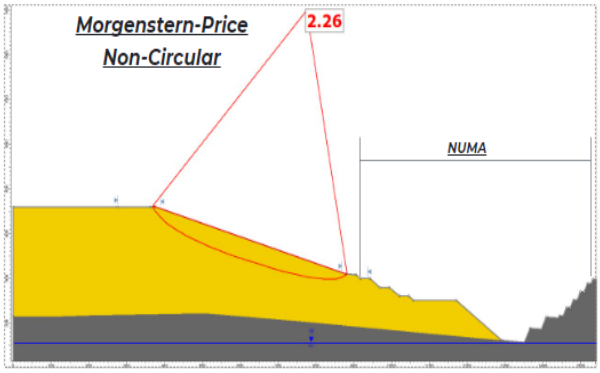

Figure 7.15 Stewarton/Balomoo (South) residual void (cross-section 6) – local stability

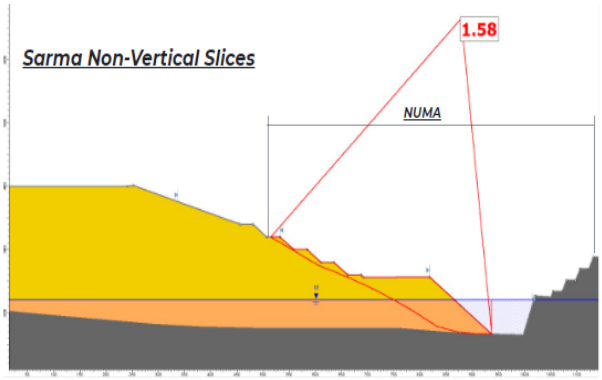

Figure 7.16 Kenmare residual void (cross-section 7) – global stability

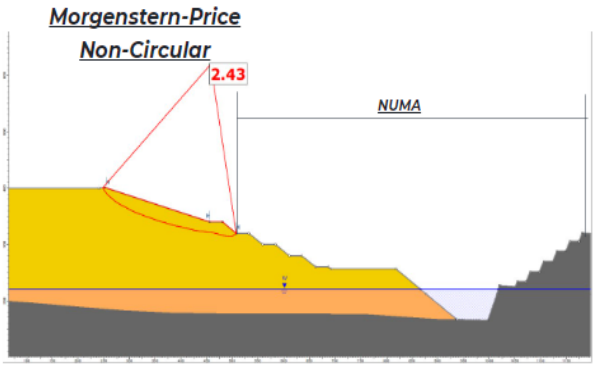

Figure 7.17 Kenmare residual void (cross-section 7) – local stability

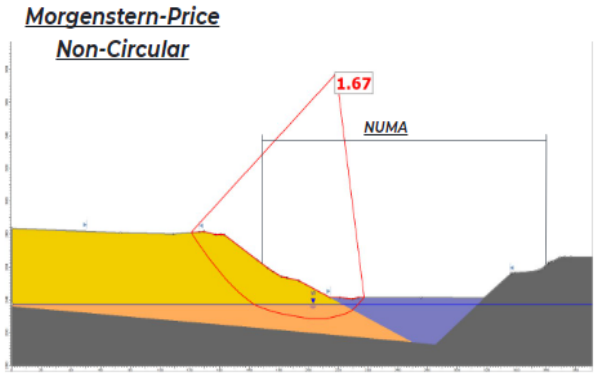

Figure 7.18 Laleham residual void (cross-section 8) – global stability

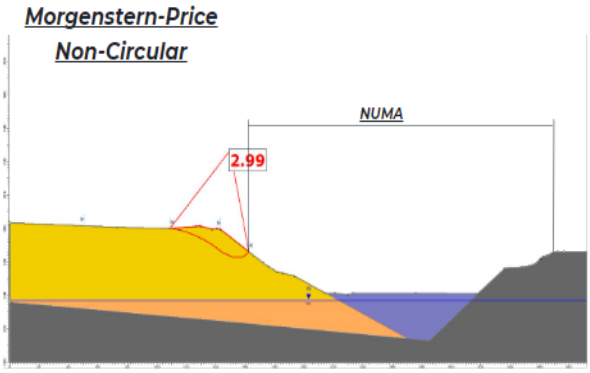

Figure 7.19 Laleham residual void (cross-section 8)) – local stability

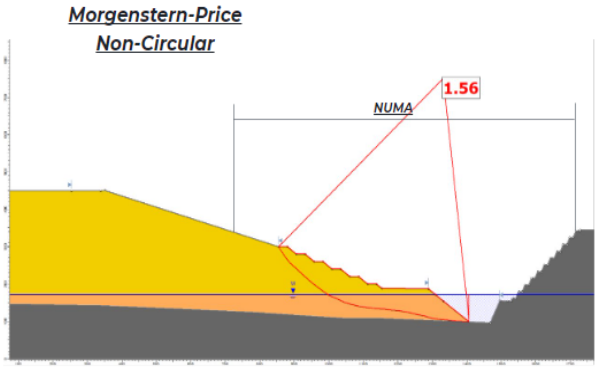

Figure 7.20 Togara/Marshmead North residual void (section 9) – global stability

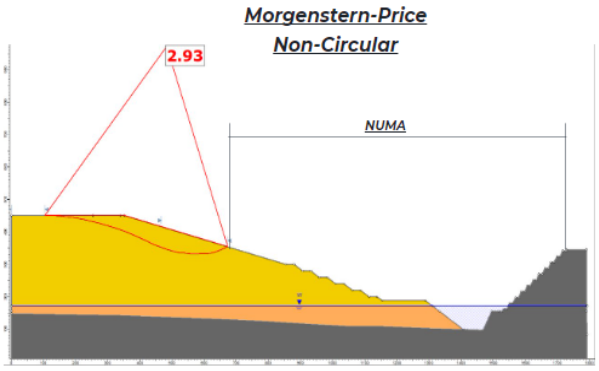

Figure 7.21 Togara/Marshmead North residual void (section 9) – local stability

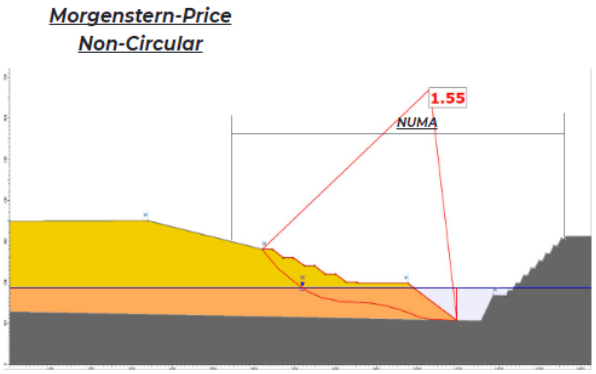

Figure 7.22 South Marshmead residual void (cross-section 10) – global stability

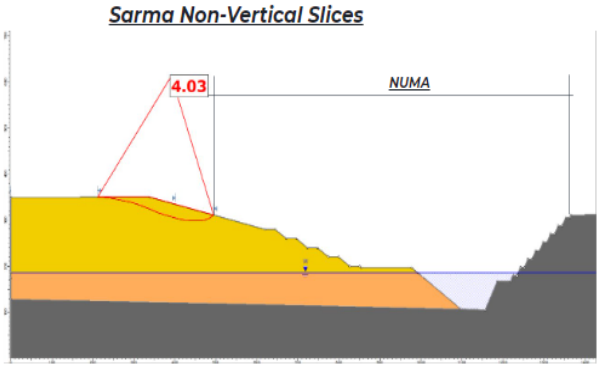

Figure 7.23 South Marshmead residual void (cross-section 10) – local stability

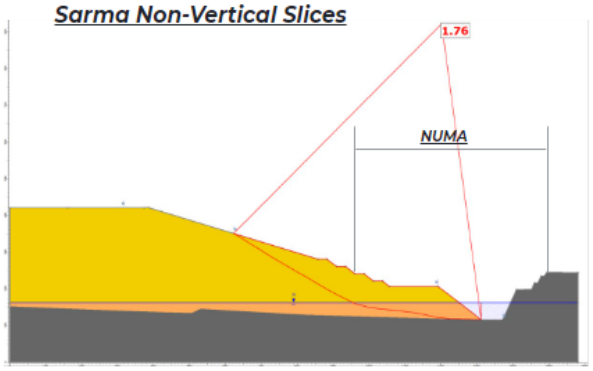

Figure 7.24 Kennedy West residual void (cross-section 11) – global stability

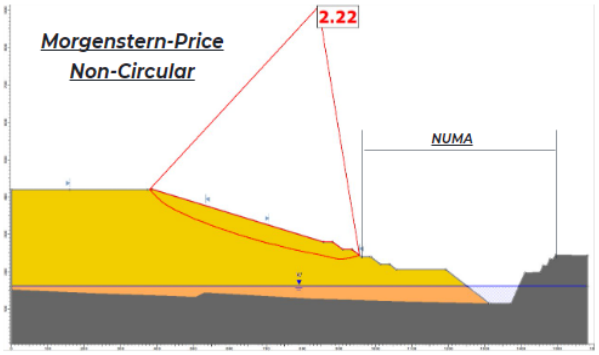

Figure 7.25 Kennedy West residual void (cross-section 11) – local stability

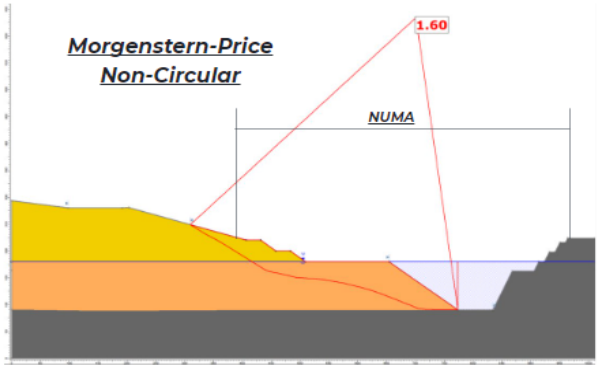

Figure 7.26 Comet Downs East residual void (cross-section 12) – global stability

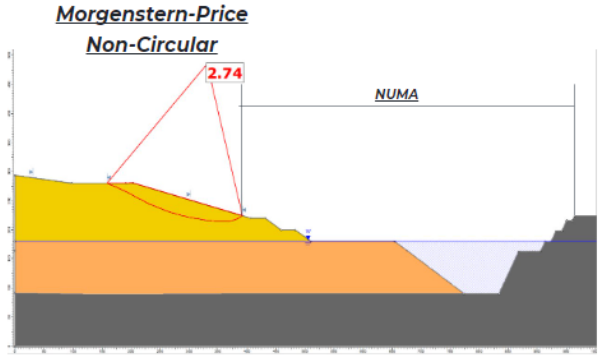

Figure 7.27 Comet Downs East residual void (cross-section 12) – local stability

7.2.1 Assumptions

The following assumptions were made and used to inform the low-wall geotechnical stability assessments:

- The current assessment of stability of the low-wall final closure state landform at BWM is preliminary in nature. It has been based on inputs and assumptions that will be reviewed and verified as mining approaches the final void limits.
- This assessment has not considered any effects of surface erosion on the stability of the low-wall spoil slopes.
- The agreed minimum FoS for any potential slip surfaces affecting low-wall slopes outside the NUMA was assigned a FoS ≥1.5 (in accordance with EA condition E3 and Table E1).
- The equilibrium residual void lake levels assumed for the low-wall stability analyses were based on the results of the WBM (Section 6).
- Material parameters were provided by Whitehaven and are presented below in Table 7.8 .

Table 7.8 Material strength parameters adopted for BWM low-wall geotechnical assessment.

Material	Bulk unit weight of intact rock (kN/m^3)	Cohesion (kPa)	Angle of friction (°)
Spoil (down dip, unsaturated)	18	40	30
Spoil (down dip, saturated)	20	23	25
Fresh Permian rock	24	450	42

- The spoil material is assumed to be homogeneous throughout, with all spoil above the void water equilibrium level assigned the same material parameters (spoil down dip, unsaturated), and all spoil below the void water equilibrium level assigned the same material parameters (spoil down dip, saturated).
- Any weak seams that might have been present within the sub-floor strata were assumed to have been treated by disrupting them with floor ripping or blasting. Therefore, no such structures have been considered present in the current preliminary stability assessment of the conceptual low-wall slopes.
- No clay-rich spoil or mud will be present on the pit floor at the time when spoil is dumped there. Appropriate floor preparation is assumed to have been completed prior to placing the spoil on the pit floor. Therefore no ‘weak layer’ is assumed to be present at pit floor level.
- The final pit floor surface considered in the analyses was based on the basal coal seam model files provided by Whitehaven.
- The analyses were based on the closure state landform model files provided by Whitehaven.

8 Geochemical stability

A geochemical assessment has been undertaken to determine the post-closure water quality for the eleven BWM residual voids within the final closure state landform (WSP, 2024b).

The objectives of the geochemical assessment were to:

- Predict the evolution of water quality of each void lake in a long-term closure scenario.
- Determine, at a conceptual level (by comparison to EA groundwater trigger values), whether the predicted void lake water quality has the potential to impact the receiving environment in a closure setting.
- Determine, at a conceptual level, if stratified conditions may develop within the voids.

The geochemical assessment builds directly on the void WBM undertaken for the BWM residual voids (see Section 6). Noting that the final mining year varies between the residual voids, the geochemical assessment covers the same timeframe as the WBM: a period of 564 years (2035 through 2599).

8.1 Water quality model

8.1.1 Geochemical materials

According to their geochemical characteristics, the geologic materials and associated mine waste materials (spoil and rejects) may react with water and release or immobilise solutes. Material interactions considered in the water quality model include:

- High-wall lithologies interacting with rainfall/runoff.
- In-pit and out-of-pit spoil, rejects, and tailings covered with non-carbonaceous interburden interacting with rainfall/runoff (infiltration of rainfall through the spoil, rejects and tailings was not included).
- Natural catchment interacting with rainfall/runoff. The natural catchment is assumed to be composed of weathered materials.

For the purposes of the geochemical assessment, the lithological materials present in the excavated walls of the BWM residual voids, and their distribution were classified into five lithological domain groupings (Table 8.1). The relative proportions of each lithological group on current and future post-closure high-walls were derived from the stratigraphic distribution (meterage) of each material within selected drill holes. Material that had no lithological classification (classified as unknown) was reallocated to carbonaceous and non-carbonaceous domains using the carbonaceous percentage in Table 8.1.

Table 8.1 Proportions of lithologies in the BWM void walls (WSP, 2024b)

Void	Weathered, non-carbonaceous	Weathered, carbonaceous/coal	Fresh, non-carbonaceous	Fresh, carbonaceous	Coal	Unknown
Ramp 8	3%	0%	89%	2%	6%	0%
Bonnie Doon*	2%	0%	87%	4%	7%	0%
Mimosa/Besgrove	1%	0%	89% (92%)	1%	6%	2%
Deep Creek*	1%	0%	89%	1%	8%	1%
Stewarton/Ballamoo	5%	0%	83% (85%)	1%	8%	2%
Kenmare*	19%	0%	70% (74%)	1%	5%	4%

Void	Weathered, non-carbonaceous	Weathered, carbonaceous/coal	Fresh, non-carbonaceous	Fresh, carbonaceous	Coal	Unknown
Laleham*	5%	0%	88%	1%	6%	0%
Togara/N Marshmead	6%	0%	60% (85%)	1%	7%	26%
South Marshmead	0%	0%	54% (92%)	1%	7%	38%
Kennedy West	6%	0%	60% (85%)	1%	7%	26%
Comet Downs East	0%	0%	54% (92%)	1%	7%	38%

Carbonaceous % was used to distribute 'unknown' to carbonaceous and non-carbonaceous. Rescaled results are indicated in parentheses.
* indicates pits where mapped high wall exposures were provided by Whitehaven (WHC, 2023)

8.1.2 Geochemical source terms

The geochemical source terms were derived from the groundwater and environmental geochemistry databases provided by Whitehaven, summarised in Table 8.2 and Table 8.3.

Table 8.2 Summary of data used to derive geochemical source terms for the BWM residual voids (WSP, 2024b)

Water inflow	Comment	Data source
Natural catchment runoff	Represented by leachate data from weathered non-carbonaceous drill core samples.	BWM drill core database
Rehabilitated catchment/in-pit spoil runoff	Represented by leachate data from fresh non-carbonaceous drill core samples.	BWM drill core database
High-wall runoff	Based on exposed lithological domains on the high-wall – the BWM drill core databases were used to derive source terms for each lithological domain/grouping.	BWM drill core database
Groundwater inflow	Median water quality from BWM groundwater database.	BWM groundwater database
Direct rainfall	Pure water equilibrated with atmospheric CO_2.	-

Notes: '-' indicates not available/not required

Table 8.3 Summary of geochemical source terms for BWM (WSP, 2024b)

Parameter	Unit	Groundwater	Fresh carbonaceous	Fresh coal	Weathered non-carbonaceous	Fresh non-carbonaceous
pH	pH Units	7.53	9.2	8.5	7.7	9.4
Log of electron activity (pe)	pe units	4	8	8	8	8
Alkalinity	mg/L as $CaCO_3$	368	66	40	7	93
Calcium (Ca)	mg/L	121	0.5	10.5	0.5	1
Magnesium (Mg)	mg/L	232	0.5	3	0.75	1
Potassium (K)	mg/L	10	3	2	2	6
Sodium (Na)	mg/L	1815	66.5	17	53	67
Chlorine (Cl)	mg/L	3095	8	6	35	11
Fluorine (F)	mg/L	0.4	0.3	0.05	0.4	0.3
Sulphate (SO_4)	mg/L	85	58	22	9.5	17
Nitrate (NO_3)	mgN/L	0.005	0.005	0.005	0.02	0.005
Aluminium (Al)	mg/L	0.01	0.09	0.06	0.05	0.15
Silver (Ag)	mg/L	*0.0005*	*0.0005*	*0.0005*	*0.0005*	*0.0005*
Arsenic (As)	mg/L	0.0025	0.018	0.0005	0.0005	0.042
Boron (B)	mg/L	0.51	0.05	0.05	0.05	0.1
Barium (Ba)	mg/L	0.5075	0.02	0.036	0.018	0.012
Beryllium (Be)	mg/L	0.0005	0.0005	0.0005	0.0005	0.001
Cadmium (Cd)	mg/L	0.00005	0.00005	0.00005	0.00005	0.001
Cobalt (Co)	mg/L	0.0025	0.0005	0.0005	0.0005	0.001

Parameter	Unit	Groundwater	Fresh carbonaceous	Fresh coal	Weathered non-carbonaceous	Fresh non-carbonaceous
Copper (Cu)	mg/L	0.002	0.0005	0.0005	0.0005	0.001
Chromium (Cr)	mg/L	0.0005	0.0005	0.0005	0.0005	0.001
Iron (Fe)	mg/L	0.64	0.025	0.025	0.025	0.1
Mercury (Hg)	mg/L	*0.00005*	*0.00005*	*0.00005*	*0.00005*	*0.00005*
Manganese (Mn)	mg/L	0.171	0.0005	0.0145	0.003	0.001
Molybdenum (Mo)	mg/L	0.002	0.044	0.003	0.001	0.017
Nickel (Ni)	mg/L	0.007	0.0005	0.002	0.0005	0.001
Lead (Pb)	mg/L	0.0005	0.0005	0.0005	0.0005	0.001
Antimony (Sb)	mg/L	0.0005	0.002	0.0005	0.0005	0.002
Selenium (Se)	mg/L	*0.005*	0.03	*0.005*	*0.005*	0.01
Silicon (Si)	mg/L	17.4	-	-	-	-
Strontium (Sr)	mg/L	4.04	0.029	0.2275	0.0055	0.1
Uranium (U)	mg/L	0.0025	0.0005	0.0005	0.0005	0.001
Vanadium (V)	mg/L	0.005	0.005	0.005	0.005	0.01
Zinc (Zn)	mg/L	0.025	0.0025	0.0025	0.00375	0.005

Notes: '-' indicates not measured; treated as a concentration of zero.

8.1.3 *Water quality model approach and development*

The water quality model was run for major cations, anions, and selected metal(loid)s per the availability of data.

The results for each timestep were calculated using the geochemical modelling code PHREEQC (Parkhurst, 2013) with the Minteq.v4 thermodynamic database, derived from the MINTEQA2 version 4 database (US EPA, 1998).

The water quality model contained the following features (WSP, 2024b):

- Source terms were mixed for monthly timesteps, with inflow/outflow proportions calculated from the GoldSim water balance.
- Modelling was incremental, with the output for the void lake from the previous timestep being used as the input for the next time step.
- Geochemical reactions, such as mineral precipitation/dissolution, gas exchange, and sorption.

The following assumptions apply to the water quality model:

- At all times, the void lake is fully mixed, geochemical reactions occur within the modelled timestep and are not kinetically controlled. Mineral precipitates are retained within the void lake.
- Solute release from highwall rock and spoil does not occur below the lake water level. Mineral solids initially present in the void lake are not accounted for in the current model.
- The release of coal bed methane is not a significant process and does not drive groundwater or lake chemistry towards more reducing conditions.
- Seepage from the void to the groundwater system has the same composition as the void lake[2].
- There is no infiltration of rainfall or groundwater through the in-pit waste to the void lake.
- Stratification is assessed at a conceptual level based on TDS threshold. Seasonal temperature, wind patterns and other impacts on mixing are not considered.
- The geochemical model does not account for biological processes.

A model sensitivity test was performed to highlight the role of geochemical controls on predicted water quality. The two simulations are summarised in Table 8.4 and were performed for the mean water balance scenario.

Table 8.4 Model sensitivity simulations

Simulation	Atmospheric CO_2 equilibrium	Mineral precipitation	Surface adsorption
Base case	Equilibrium at $10^{-3.38}$ (~420 ppm)*	Equilibrium	Adsorption onto precipitated ferrihydrite surfaces
No geochemical controls (NC)	No equilibrium	No equilibrium	No sorption

Notes *420 ppm is representative of 2024 atmospheric CO_2 concentrations. Variation with time (i.e., geochemical climate change scenarios) is not included in current model scenarios.

A conceptual level assessment of potential chemical stratification was conducted based on the evolution of TDS, which can be used to approximate the fluid density of the fully mixed void lake. Stratification assessment is provided in Section 8.2.

[2] Seepage from the void to the groundwater system is negligible as the pits act as a groundwater sinks once equilibrium lake level is achieved.

8.2 Residual void water quality outcomes

Water quality modelling results were compared against groundwater trigger values specified in Table I2 of the BWM EA. It should be noted that Table I2 relates to trigger values for groundwater (Table 8.5). The WBM and groundwater model outcomes indicate that the BWM residual voids are predicted to behave as post-closure groundwater sinks. Therefore, comparison of the water quality model outcomes against the range of values from Table I2 of the EA are for interpretive purposes only, as no modelled groundwater outflows from the residual void lakes are expected.

Further discussion is focused on the available modelled results of the major cations, anions, and selected metal(loid)s where there is a corresponding groundwater trigger value.

Table 8.5 Trigger value screening thresholds applied to BWM residual void lake water quality

Parameter	Units	Groundwater trigger levels	
		Lower value	Upper value
pH	pH units	6.0	8.5
EC	µS/cm	7,260	39,560
TDS*	mg/L	4,864	26,505
Sulfate (SO^4)	mg/L	210	1,510
Aluminium (Al)	mg/L	0.055	0.055
Arsenic (As)	mg/L	0.013	0.019
Iron (Fe)	mg/L	1.4	6.3
Mercury (Hg)	mg/L	0.0006	0.0006
Molybdenum (Mo)	mg/L	0.034	0.034
Antimony (Sb)	mg/L	0.009	0.009
Selenium (Se)	mg/L	0.011	0.011

Notes: * TDS calculated from EC assuming a conversion factor of 0.67 (ANZECC & ARMCANZ, 2000).

The following sections present the results of the water quality modelling for the eleven void lakes at BWM for pH, TDS, and selected metal(loid)s, based on EA trigger values. The results are presented for scenarios with and without geochemical controls (i.e., mineral precipitation, sorption, and gas exchange).

pH

Acidic conditions are unlikely to develop in any of the BWM residual void lakes assessed. Neutral to mildly alkaline conditions are predicted to develop within all void lakes, remaining within the pH trigger value range by the end of the simulation, regardless of whether geochemical controls are applied or not.

The simulation with geochemical controls results in a higher pH by the end of the simulation than without geochemical controls. The main geochemical control is CO_2 degassing, which raises pH, resulting in calcite/magnesite precipitation and dissolution that reduces and raises pH, respectively.

The modelled outputs of the simulations for pH for all residual voids are presented in Figure 8.1.

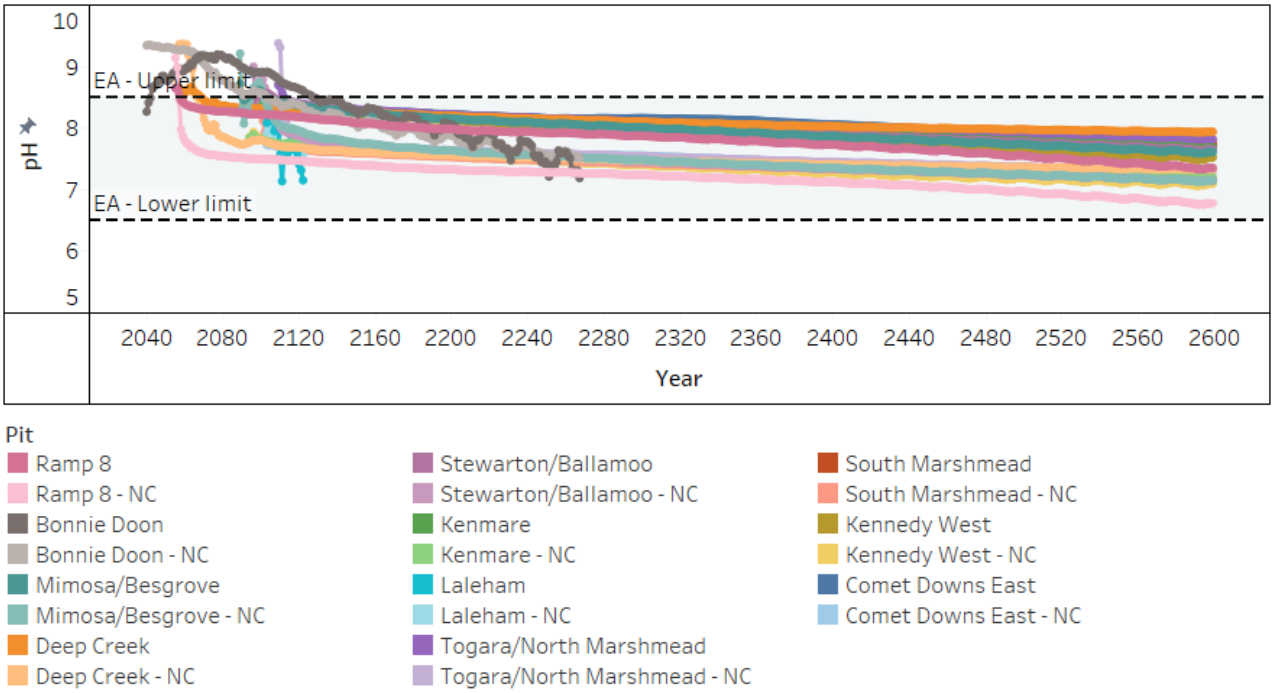

Figure 8.1 Summary of predicted pH conditions at BWM residual void lakes (NC represents no geochemical controls)

TDS

Based on the outcomes of this assessment, the void water quality in the BWM residual voids is predicted to evolve through time, with TDS simulated to increase steadily following closure, which is primarily driven by evapo-concentration.

Predicted TDS concentrations are elevated above the trigger value (26,505 mg/L) for all BWM residual voids by the end of the simulation period. The rate of TDS increase is the largest at Bonnie Doon.

Lower TDS concentrations are predicted in simulations with geochemical controls due to the removal of barium, calcium, iron, magnesium, manganese and dissolved inorganic carbon through barite ($BaSO_4$), calcite ($CaCO_3$), ferrihydrite (FeOOH), magnesite ($MgCO_3$) precipitation. Geochemical controls do not lead to an 'equilibrium' state for water quality (i.e., constant TDS).

The modelled outputs of the simulations for TDS for all residual voids are presented in Figure 8.2.

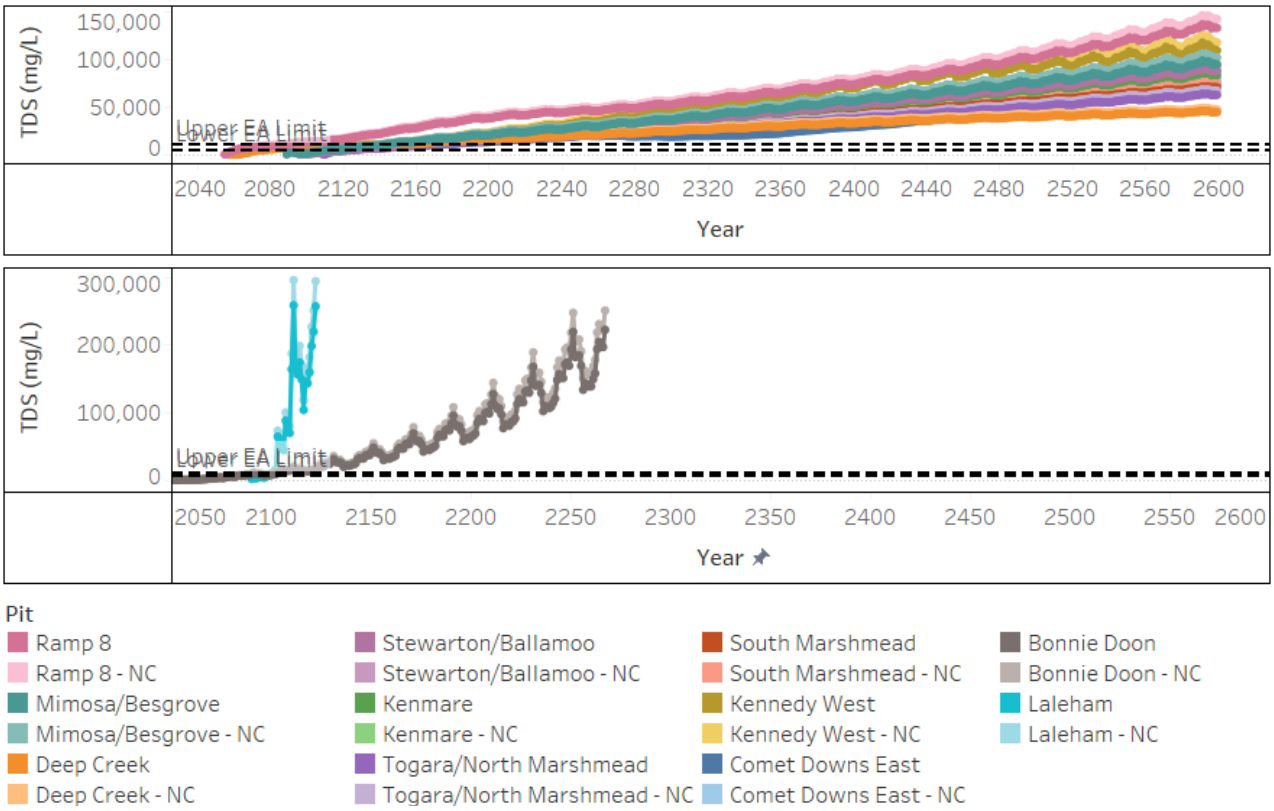

Figure 8.2 Summary of predicted TDS conditions at BWM residual void lakes

Stratification

The steep sides of the voids, high TDS, and the maximum water depth present favourable conditions for stratification in all BWM residual voids. The water of higher density (cooler or more saline) has the potential to become isolated at depth. Hydrodynamic/limnological analysis is required to assess the potential for onset of thermal/chemical stratification, and the importance of seasonal mixing processes and groundwater mixing inputs. However, as the residual voids are considered NUMAs and modelled as groundwater sinks, further stratification assessment is not warranted.

Metal(loid)s

For all BWM residual voids, the predicted aluminium, antimony, arsenic, mercury, molybdenum, silver, sulfate, and selenium concentrations are elevated above the corresponding trigger values in simulations with and without geochemical controls, while only the predicted iron concentrations are elevated above the corresponding trigger values in simulations without geochemical controls.

Predicted selenium and mercury concentrations consider results below the limit of reporting (LOR) by representing these as half the LOR for model input, and therefore, may not be representative as this results in an artificial increase by evapo-concentration.

8.2.1 Qualifications

The following caveats and limitations apply to the water quality model:

- Available data at the time of modelling was used to represent the relevant geochemical interactions. Availability of additional data in future may result in different model outputs.
- Water movements are based on complementary studies (groundwater and water balance). These studies constrain the model duration and the water sources. Most notably, it is currently not possible in the water quality model to quantify in-pit seepage through spoil.
- Screening was performed against EA criteria for groundwater contaminant trigger values. The criteria for TDS were derived from the EA EC value using a 0.67 factor that is considered acceptable for freshwater.

9 Residual void management

A summary of the key findings from the technical studies (presented in Sections 4 to 8) used to inform the development of residual void management measures are presented below:

- Groundwater modelling and WBM results indicate the formation of void lakes in all eleven residual voids. Residual voids are modelled to behave as a network of terminal groundwater sinks driven by the continued evaporation for the residual void lakes.
- No potential for causing harm to the environment outside of the BWM tenure area associated with the residual voids, spoil emplacements or in-pit tailing emplacements, due to the inward groundwater flow gradients towards the residual voids continuing to capture all potential seepage (sink for groundwater)
- Minimal additional impact beyond that which already exists at the end of mining is expected on environmental (e.g., potential GDEs) or anthropogenic receptors (e.g., water extraction bores) post-closure is expected.
- WBM results predict that the voids are at low risk of overtopping, with the residual voids achieving the mean void water levels and volumes in Table 9.1 at the end of the simulation; these are well below the spill elevations for the respective voids.

Table 9.1 Mean void water levels and volumes for the BWM residual voids

Residual void	Mean void water elevation (m AHD)	Mean void water volume (ML)
Ramp 8	154	1,693
Bonnie Doon	161	660
Mimosa/Besgrove	117	23,426
Deep Creek	140	15,054
Stewarton/Ballamoo	145	56,518
Kenmare	221	7,531
Laleham	237	86
Togara/North Marshmead	157	28,469
South Marshmead	181	12,736
Kennedy West	142	8,782
Comet Downs East	182	7,786

- The final closure state landforms have been designed such that the geotechnical stability for the low-walls achieved a FoS ≥1.5. Therefore, the low-walls of the final closure state landforms can be considered stable for all BWM residual voids.
- With regards to high-walls and end-walls, at closure the NUMA extents include identified set-back zones to achieve a FoS ≥1.5. All third-party assets will remain outside of these extents.
- All BWM final residual voids in the final closure state landform are not subject to inundation from floodwaters up to and including the 0.1% AEP event under the upper climate change rainfall intensity scenario.
- At closure, the BWM residual voids will be bunded and fenced, with appropriate signage – where restricting access to the residual voids is required, to maintain safety for humans and livestock.

- Monitoring and maintenance of the residual voids in accordance with the relevant section of the PRC Plan is expected to be restricted to the following:
  - Monitoring and maintenance of exclusion fences/bunds to ensure these remain effective.
  - Groundwater and residual void lake level monitoring to confirm the voids are progressing towards acting as sinks and whether groundwater moves from the Kennedy West to the Comet Downs East residual void.
- All eleven BWM residual voids will be retained as NUMAs. To support attainment of NUMA voids that are safe and do not present an unacceptable risk of off-tenure environmental harm, the management strategies presented in Table 9.2 will be implemented.

Table 9.2 BWM residual void closure context (safe, stable, non-polluting) and management considerations

Residual void closure aspect	Closure objective			Residual void closure context	Management consideration
	Safety	Stability	Non-polluting		
Geotechnical stability	✓	✓	-	— Stability outside of the NUMA extents = FoS ≥1.5 — Set-back distances for long-term pit wall stability have been defined by geotechnical analysis for all residual voids for high-walls, end-walls and low-walls. — Setbacks are included within the NUMA extent to ensure stability and that no assets (Whitehaven, third-party, or of significant environmental value) are retained within this boundary at closure.	— As mining approaches the final limits, re-assess the geotechnical wall designs and set-back distances based on the latest available data. — Review and adjust the mine plan and final closure state landform, if needed, to account for any revised set-back requirements. — Use a minimum FoS ≥1.5 as a guidance for ongoing void closure planning. (This may be refined over the mine life should industry research provide optimised guidance on observational methods and consequence assessment).
Void hydrology	✓	✓	✓	— All BWM residual voids in the final closure state landform are not modelled to be subject to inundation from floodwaters up to and including the 0.1% AEP event under the upper climate change rainfall intensity scenario based on rehabilitation flood modelling completed. — All void water levels are modelled to remain below the spill elevations, the voids are not predicted to overtop and environmental harm beyond that of the void itself is not expected. Therefore, no management activities required. — The long-term mean void lake levels for all BWM residual voids remain below modelled recovered groundwater levels. This provides an available storage capacity for these voids to keep acting as long-term groundwater sinks (based on average gradients).	— Residual void catchments are minimised as far as practicable and predominantly include only the low-wall areas. — At cessation of mining activities, review and update the void water balance modelling, incorporating identified changes to the voids' final closure state landforms and spill point elevations, any stored water, rainfall and evaporation, surface water runoff and groundwater inflows, and climate projections. — Although not identified in current modelling, if future modelling identifies an unacceptable risk of environmental harm outside the tenure boundary, then management strategies to be implemented.

<table>
<tr><th rowspan="2">Residual void closure aspect</th><th colspan="3">Closure objective</th><th rowspan="2">Residual void closure context</th><th rowspan="2">Management consideration</th></tr>
<tr><th>Safety</th><th>Stability</th><th>Non-polluting</th></tr>
<tr><td>Void hydrology (continued)</td><td>✓</td><td>✓</td><td>✓</td><td>After 2599, mean water level in all residual voids start to stabilise, with simulated mean inflows being similar to outflows and can be considered at or approaching equilibrium as per below table.
<table>
<tr><th>Residual void</th><th>Mean inflows (ML/year)</th><th>Mean outflows (ML/year)</th></tr>
<tr><td>Ramp 8</td><td>140</td><td>141</td></tr>
<tr><td>Bonnie Doon</td><td>283</td><td>283</td></tr>
<tr><td>Mimosa/Besgrove</td><td>2,035</td><td>2,035</td></tr>
<tr><td>Deep Creek</td><td>931</td><td>931</td></tr>
<tr><td>Stewarton/Ballamoo</td><td>4,321</td><td>4,323</td></tr>
<tr><td>Kenmare</td><td>573</td><td>573</td></tr>
<tr><td>Laleham</td><td>131</td><td>131</td></tr>
<tr><td>Togara/North Marshmead</td><td>1,652</td><td>1,649</td></tr>
<tr><td>South Marshmead</td><td>672</td><td>671</td></tr>
<tr><td>Kennedy West</td><td>846</td><td>846</td></tr>
<tr><td>Comet Downs East</td><td>471</td><td>475</td></tr>
</table></td><td>— Obtain certification from an appropriately qualified person that the residual voids will not cause environmental harm beyond the tenure boundary.
— If necessary, identify and implement mitigation measures for appropriate protection works of landforms where floodwaters from watercourses interact with final closure state landforms.</td></tr>
</table>

Residual void closure aspect	Closure objective			Residual void closure context	Management consideration
	Safety	Stability	Non-polluting		
Void hydrogeology	-	-	✓	— Mining-related dewatering activities have lowered groundwater levels which will result in suppression of the water table centred on the BWM residual voids. — Void lakes are predicted to form in residual voids post-mining. Water levels in these void lakes are modelled to remain below the recovered groundwater levels for all residual voids, driven by evaporative effects on the void lakes. — The BWM residual voids are modelled to behave as a network of groundwater sinks post-closure. — Modelling, including particle tracking, indicates that infiltration of rainfall from the spoil and most of the other disturbed areas within the tenure will migrate towards and be captured within the residual voids. Groundwater flow is not expected to flow off-tenure toward the receiving environment, except for an area not associated with the residual void management (Bottom Dam) that is addressed within the PRC Plan.	— At cessation of mining activities, review and update the groundwater modelling, incorporating updated void WBM outputs and in-field groundwater sampling data, as required. — Although not identified in current modelling, if future modelling identifies an unacceptable risk of environmental harm outside the tenure boundary from the residual voids, management strategies are to be developed and implemented to minimise the harm. — Obtain certification from an appropriately qualified person that, upon completion of mining, residual voids do not present an unacceptable risk of environmental harm beyond the tenure boundary.

Residual void closure aspect	Closure objective			Residual void closure context	Management consideration
	Safety	Stability	Non-polluting		
Void water quality	-	-	✓	— Acidic conditions are unlikely to develop in lakes that are predicted to establish in the residual voids. — TDS in all BWM residual voids is modelled to continue to increase over time. — Preliminary, high-level screening base on predicted TDS levels suggest that all BWM residual voids may become chemically stratified. — All BWM residual voids do not present an unacceptable risk of environmental harm beyond that of the void itself as they stabilise as net groundwater sinks over time. Note: As all residual voids are classified as NUMAs and are predicted to behave as a network of terminal sinks, void water quality should be interpreted in this context.	— At cessation of mining activities, review and update the void geochemical assessment including additional or refined data from in-pit surface water samples, surface- and groundwater samples, and biochemical modelling. — Although not identified in current modelling, if future modelling identifies an unacceptable risk of environmental harm outside the tenure boundary, then management strategies to be developed and implemented. — Obtain certification from an appropriately qualified person that the residual voids will not present an unacceptable risk of environmental harm beyond the tenure boundary.
Void access control	✓	-	-	— Access to the residual void will be restricted for humans and livestock.	On cessation of mining activities: — Construct a safety bund at the geotechnical set-back distance. — Erect fencing and signage (where required) around the perimeter of the safety bund. — Obtain certification from an appropriately qualified person that the residual void is safe to humans and livestock.

Monitoring of the residual voids will be undertaken as part of monitoring of the NUMA extents (see Monitoring Section in the PRC Plan). This monitoring will aim to demonstrate the achievement of sufficient improvement (final NUMA management milestone) that enables certification from an appropriately qualified person that all residual voids:

- will not present an unacceptable risk of environmental harm outside of the tenure boundary
- are safe to humans and livestock.

10 Conclusion

This void closure plan provides outcomes of technical studies completed to support closure planning and achievement of residual voids at BWM that are safe and do not cause environmental harm. This void closure plan is an appendix to the BWM PRC Plan and has been compiled in terms of the requirements of the *PRCP Guideline*.

The documented technical studies – including water balance, hydrogeological, rehabilitation flooding, geochemical and geotechnical stability modelling, have been undertaken through an iterative approach with the development of the closure state landform design. These iterations have resulted in a closure landform design that minimises the area of the voids, provides protection from flood water, and contributes to minimising environmental harm as it relates to the final residual voids.

This plan (and associated supporting technical studies) may be required to be updated should amendments to the site PRC Plan be required.

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Appendix 4.14 – Geochemical Void Water Quality

Design
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Whitehaven Coal LimitedGeochemical Void Water Quality Report – Blackwater Mine

PRCP Technical Studies for Void Closure Planning

wsp

September 2024

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Geochemical Void Water Quality Report – Blackwater Mine
PRCP Technical Studies for Void Closure Planning

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A	27 August 2024	Draft for client comment
0	13 September 2024	Final report

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WSP acknowledges that every project we work on takes place on First Peoples lands.
We recognise Aboriginal and Torres Strait Islander Peoples as the first scientists and engineers and pay our respects to Elders past and present.

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Abbreviations and glossary

Acronym/abbreviation/term	Definition
AHD	Australian Height Datum
AMD	Acid and Metalliferous Drainage. Includes acid/acidic drainage (AD), pH-neutral metalliferous drainage (NMD) and sulfide-derived saline drainage (SD) – and/or any combination of these.
BWM	Blackwater Mine
BMC	BHP Mitsui Coal
CCS	Climate Change Scenario
CHPP	Coal Handling and Processing Plant
Closure state landform	Integrated rehabilitated surface landform within the mining lease area, including the residual voids
DES	Department of Environment and Science
EA	Environmental Authority (in terms of the *Environmental Protection Act 1994*, Queensland)
EC	Electrical Conductivity
Interburden	Non-carbonaceous or carbonaceous mine waste located between coal seams
LoR	Limit of Reporting
Mine waste	Material comprising interburden, overburden, ± coarse/fine reject (dewatered), ± waste coal. Sometimes called ‘mineral waste’ or ‘mining waste’
NC	No geochemical controls (with respect to PHREEQC modelling)
NUMA	Non-use management area
Overburden	Non-carbonaceous or carbonaceous mineral waste located above (overburden proper) or between (interburden) coal seams. Carbonaceous overburden is generated during mining of non-ore material and may be represented by sedimentary units (non-coal) rich in organic carbon. Carbonaceous overburden does not include coarse reject, seam floor, seam roof or coal partings. Overburden reports to spoils dumps.
PHREEQC	A geochemical modelling package developed by the United States Geological Survey used to simulate low temperature thermodynamic reactions (i.e., mineral dissolution/precipitation, metal(loid) ad/desorption, and gas exchange) in natural waters.
PRCP	Progressive Rehabilitation and Closure Plan
QLD	Queensland
Reject	Waste material produced during coal washing, separated from run-of-mine (ROM) coal in the coal handling and preparation plant (CHPP). Can be separated and disposed as fine rejects (tailings) and coarse reject, or co-disposed as mixed plant reject which is a mixture of coarse reject and ‘dewatered’ fine reject.

Acronym/abbreviation/term	Definition
RCM	Rangal Coal Measures
RCP	Representative Concentration Pathway
Remnant coal	In-situ coal that remains exposed on the pit walls (highwall) and/or pit floor. Remnant coal can be ore grade or waste coal. Remnant coal can be fresh, oxidised or coked (heat affected).
Residual void	Residual void means a void in place at the end of mining that has been delineated as per the WSP water balance modelling report (WSP, 2024) and that will be retained and form part of the final mine closure landform.
ROM	Run of Mine
Spoil	Mine waste comprising non-ore (non-ROM) material such as overburden and waste coal. Within this report, unless stated otherwise, spoil is assessed as a whole (bulk material) with no distinction made between carbonaceous and non-carbonaceous overburden.
TDS	Total Dissolved Solids
Void	Void means an area of land to be excavated in the carrying out of a mining activity (Section 126D of *the Environmental Protection Act 1994*).
Waste coal	Sub-economical coal that reports to the spoil dumps as waste. Waste coal can be fresh or oxidised. All oxidised and coked (cindered) coal is waste.
WHC	Whitehaven Coal Pty Ltd

Executive summary

Whitehaven Coal Limited (WHC) has engaged WSP Australia Pty Ltd (WSP) to undertake technical studies for void closure planning to assist in the compilation of the transitional Progressive Rehabilitation and Closure Plans (PRCPs) for WHC's coal asset, Blackwater Mine (BWM), located in Queensland (QLD), Australia.

This report presents the findings of the geochemical void water quality assessment completed for eleven residual voids at BWM, namely Ramp 8, Bonnie Doon, Mimosa/Besgrove, Deep Creek, Stewarton/Ballamoo, Kenmare, Laleham, Togara/North Marshmead, South Marshmead, Kennedy West and Comet Downs East (herein referred collectively as the BWM residual voids). This reporting is aligned to DES *Progressive rehabilitation and closure plan (PRC plans) Guideline (version 3.0)* (PRCP guideline), dated 04 April 2023 (DES, 2023).

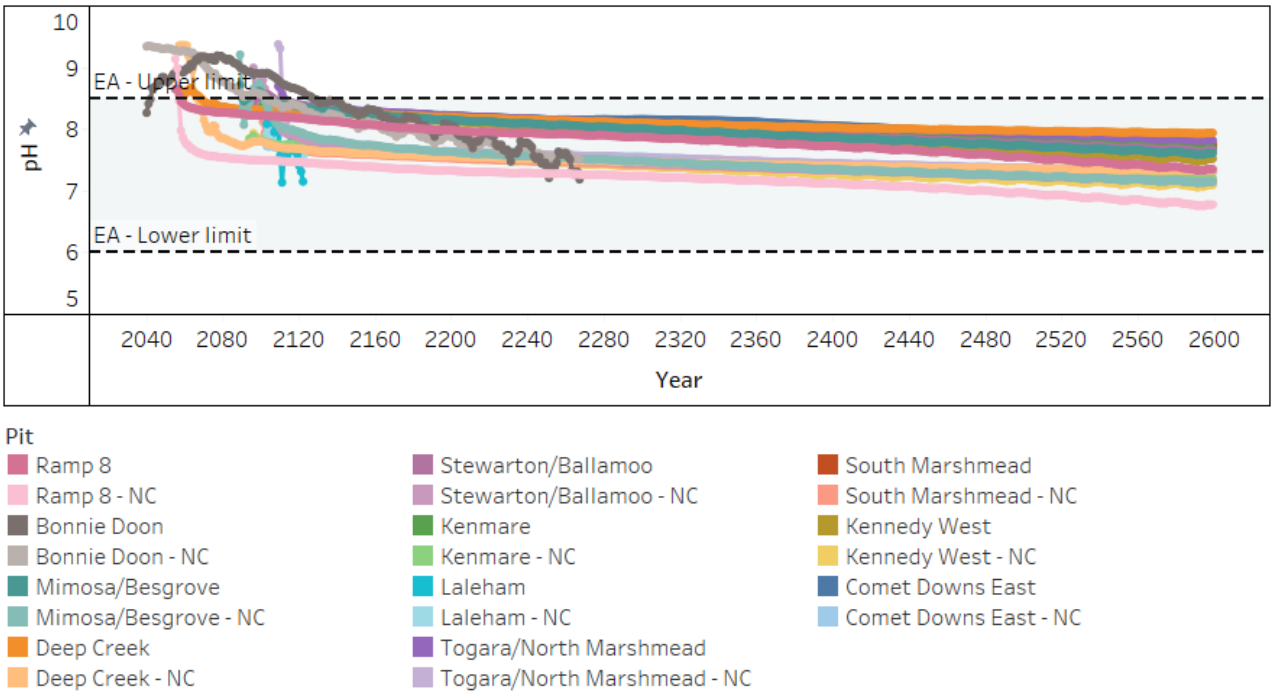
The objective of this study is to assess the evolution of the water quality within the eleven BWM residual void lakes within the closure landform following the cessation of mining. The assessment considers the geochemical characteristics of residual highwall material and deposited mine waste materials (spoil and rejects), and the interactions with residual void water inflows and established lakes.

Based on the outcomes of this assessment, the water qualities of the BWM residual void lakes are predicted to evolve through time, primarily affected by evapo-concentration. The resulting concentrations of some analytes are simulated to exceed their respective groundwater Environmental Authority (EA) trigger values. All eleven voids are classified as Non-use Management Areas (NUMAs) and predicted to behave as terminal/hydraulic sinks. Exceedances should, therefore, be considered in this context.

The findings of the geochemical water quality model are summarised as follows:

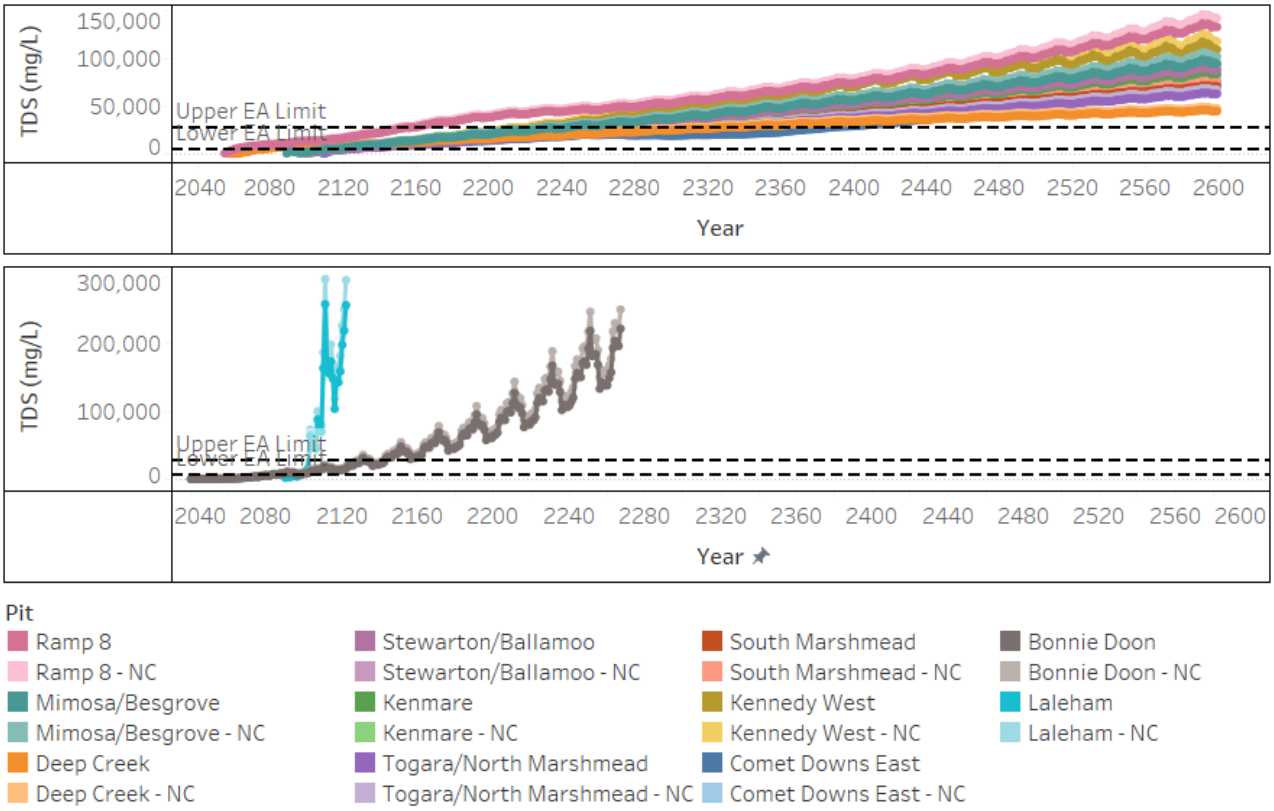
- **Void lake pH:** Acidic conditions are unlikely to develop in all of the BWM closure residual void lakes assessed as there are no significant sources of acid generating materials associated with the surface water hydrology mine closure landforms. Geochemical models predict lake pH to remain within the EA-specified upper and lower limits for the modelled period at all residual void lakes (Figure ES.1).
- **Geochemical controls:** Relative to simulations without geochemical controls, the simulations with geochemical controls generally result in lower TDS, barium, calcium, iron, magnesium, manganese and alkalinity concentrations due to the precipitation of barite ($BaSO_4$), calcite ($CaCO_3$), ferrihydrite (FeOOH), magnesite ($MgCO_3$). The groundwater input composition is the main source of dissolved inorganic carbon, calcium, magnesium, and iron to the void lakes. The decrease in iron concentration occurs through ferrihydrite (FeOOH) precipitation and drives the reduction in concentrations of other metals (arsenic, beryllium, copper, nickel, lead, vanadium, and zinc) through surface adsorption processes.
- **Void lake salinity:** The modelled TDS concentration in all voids generally increases through the full period of simulation, resulting in predicted hypersaline conditions (Figure ES.2). It is anticipated that the TDS concentration in all void lakes will continue to increase further, if models were to be extended. Further modelling for time scales beyond the current water balance is required to determine if or when a TDS concentration plateau is reached.
- **Dissolved metal(loid)s:** Predicted aluminium, antimony, arsenic, mercury, molybdenum, sulfate, and selenium concentrations exceed the EA trigger values for all void lakes in simulations with and without geochemical controls. Selenium, silver and mercury concentration exceedances likely result from the substitution of results below limit of reporting (LOR) with half the LOR, and therefore, may not be relevant.
- **Stratification:** Most voids have deep estimated maximum water depths (~34 to 93 m), except for Bonnie Doon (~10 m) and Laleham (~2 m). Lake depth coupled with predicted hypersaline conditions render the likely probability for stratification to develop during a post-closure period. Lake TDS is shown to be directly related to evapo-concentration of lake water.

- **Density-driven saline seepage:** predicted residual void lake water quality is predicted to have higher TDS concentrations than the median inflowing groundwater and may potentially seep beyond the residual void walls through density-driven seepage.



(NC: no geochemical controls)

Figure ES.1 Summary of predicted lake pH at BWM residual void lakes



(NC: no geochemical controls)

Figure ES.2 Summary of predicted TDS concentrations at BWM residual void lakes

1 Introduction

Whitehaven Coal Limited (WHC) has engaged WSP Australia Pty Ltd (WSP) to undertake technical studies for void closure planning to assist in the compilation of the transitional Progressive Rehabilitation and Closure Plans (PRCPs) for WHC's coal asset, Blackwater Mine (BWM), located in Queensland (QLD), Australia.

BWM is an open-cut coal mine situated approximately 25 km south-west of the township of Blackwater. Operations at BWM are authorised under Environmental Authority (EA) No. EPML00865013. Holders of an EA are required to submit a PRCP that meets requirements under the *Environmental Protection Act 1994* (*EP Act*). A Transition Notice was issued to BMA Mitsubishi Alliance (BMA) (as the previous owner of BWM) by the Department of Environment and Science (DES[1]*)*, requiring Whitehaven (as the current owner of BWM) to submit a transitional PRCP for BWM by 15 November 2024.

This report presents the findings of the geochemical void water quality assessment completed for eleven residual voids[2] at BWM, namely Ramp 8, Bonnie Doon, Mimosa/Besgrove, Deep Creek, Stewarton/Ballamoo, Kenmare, Laleham, Togara/North Marshmead, South Marshmead, Kennedy West and Comet Downs East (herein referred collectively as the BWM residual voids). This reporting is aligned to DES *Progressive rehabilitation and closure plan (PRC plans) Guideline (version 3.0)* (PRCP guideline)*,* dated 04 April 2023 (DES, 2023).

This report is an initial deliverable for the PRCP technical studies for void closure planning; the relevant contents of this report will inform the development of the BWM Void Closure Plan. As supporting information is expected to change over time, the currency and validity of this report should be confirmed with relevant WSP or WHC personnel before use. This report is based on the BWM Void Water Balance Report (WSP, 2024), which used the most current mine closure landform extents (WHC, 2023a) and outputs from the post-closure groundwater modelling undertaken by SLR (SLR, 2024).

1.1 Study limitations

At the time of undertaking the void water quality modelling for BWM, the EA groundwater trigger values were applied as comparison criteria for this assessment. The EA groundwater trigger values are relevant to BWM's operational compliance management; and the electrical conductivity (EC) groundwater trigger value also reflect the rehabilitation acceptance criteria for the objective '*Deep drainage from rehabilitation achieves relevant water quality objectives for groundwater*' in Schedule E, Table E1 of the EA. These comparison criteria may not be relevant to final site relinquishment for a non-use management area (NUMA) but provides an initial comparison. Any updates to the management (or rehabilitation) milestone criteria for the voids should be used as the basis for future rehabilitation-related water quality assessments going forward.

1 Now known as the Department of Environment, Science and Innovation (DESI)

2 Residual void means a void in place at the end of mining that has been delineated as per the WSP water balance modelling report (WSP, 2024) and that will be retained and form part of the final mine closure landform.

2 Scope and objectives

The Airstrip, Besgrove, Blackdown, Bonnie Doon, Comet Downs, Deep Creek, Kenmare, Kennedy, Laleham, Marshmead, South Marshmead, Mimosa, Sagittarius, South Ballamoo, Stewarton, Tannyfoil, Togara and Wilpeen Pits are consolidated as part of BWM's closure state into the remaining Ramp 8, Bonnie Doon, Mimosa/Besgrove, Deep Creek, Stewarton/Ballamoo, Kenmare, Laleham, Togara/North Marshmead, South Marshmead, Kennedy West and Comet Downs East residual voids, which is based on the final closure state topography (Figure 2.1) (hereafter referred to as final closure state landform[3]) (WHC, 2023a).

The objective of this study is to assess the evolution of the water quality within the eleven BWM residual voids[4] lakes within the closure landform following cessation of mining. The assessment considers the geochemical characteristics of residual highwall material and deposited mine waste materials (spoil and rejects), and the interactions with residual void water inflows and established lakes.

This assessment will be used to understand the inherent hydrological, hydrogeological and geochemical water quality closure risks of the residual voids in the mine closure landform.

The scope of work includes the following:

- Review information provided by WHC as provided in the request for information (RFI), including previous geochemical material characterisation studies, acid, and metalliferous drainage (AMD) assessments, and laboratory leachate data from environmental geochemistry sampling programs.
- Conceptualise the geochemical model and align with the void water balance model (WBM) for each void for the period of 2035 to 2599 (up to 564 years).
- Derive geochemical source terms applicable to the site with reference to previous geochemical characterisation reports and geochemical databases.
- Develop geochemical water quality models for each of the eleven void lakes.
- Present sensitivity scenarios for different geochemical controls, such as mineral precipitation, sorption, and atmospheric CO_2 exchange.

The objectives of the geochemical water quality model are to:

- Predict the evolution of water quality of each void lake in a long-term closure scenario.
- Determine, at a conceptual level (by comparison to EA groundwater trigger values), whether the predicted void lake water quality has the potential to impact the receiving environment in a closure setting.
- Determine, at a conceptual level, if stratified conditions may develop within the voids.

This study builds directly on the outputs of the void WBM undertaken by WSP (WSP, 2024). Studies relating to void water balance modelling are presented in separate reports (WSP, 2024).

[3] Voids at BWM are progressively backfilled with overburden and mine waste as mining advances during the operational stage. At closure, only the location of final cuts will remain, which in this document is referred to as the residual voids. In this report, the **closure state landform** refers to the entire integrated rehabilitated surface landform within the mining lease area, including the residual voids.

[4] ***Void*** means *an area of land to be excavated in the carrying out of a mining activity* (Section 126D of the EP Act). For the purpose of this reporting, the actual void names will be referenced as Ramp 8 Pit, Bonnie Doon Pit, Mimosa/Besgrove Pit, Deep Creek Pit, Stewarton/Ballamoo Pit, Kenmare Pit, Laleham Pit, Togara/North Marshmead Pit, South Marshmead Pit, Kennedy West Pit and Comet Downs East Pit.

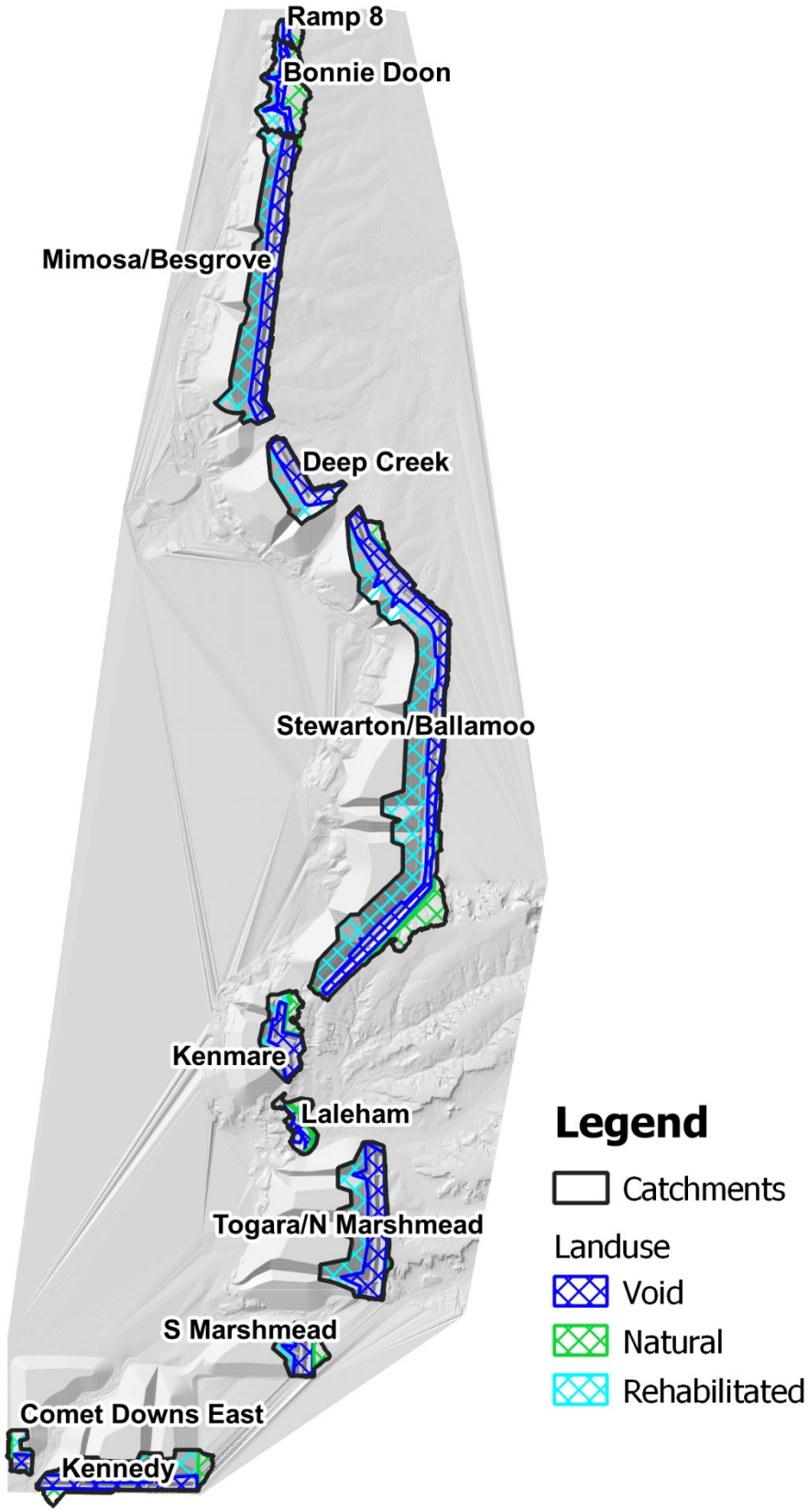


Figure 2.1 Residual void locations for BWM closure state landform

3 Water quality modelling concept

The conceptual site model for a typical coal mine void at closure is presented in Figure 3.1, which illustrates the inputs and outputs of water (in blue), and the geochemical interactions (in red) that may occur in a generic open pit coal mine void. The water quality modelling concept is tailored for each site based on the WBM and water quality data. For BWM, the following are considered:

- Water balance developed in GoldSim (WSP, 2024).
- Water movements determined from current groundwater models (SLR, 2024).
- The chemical composition of each surface and groundwater source is derived from water quality data provided by WHC (Section 4.2) and considers the geochemical interaction of solid-water phases and water-gas phases.
- The residual void floors at each residual void are below the interpreted groundwater table, hence, void lakes are predicted to develop in a closure setting.

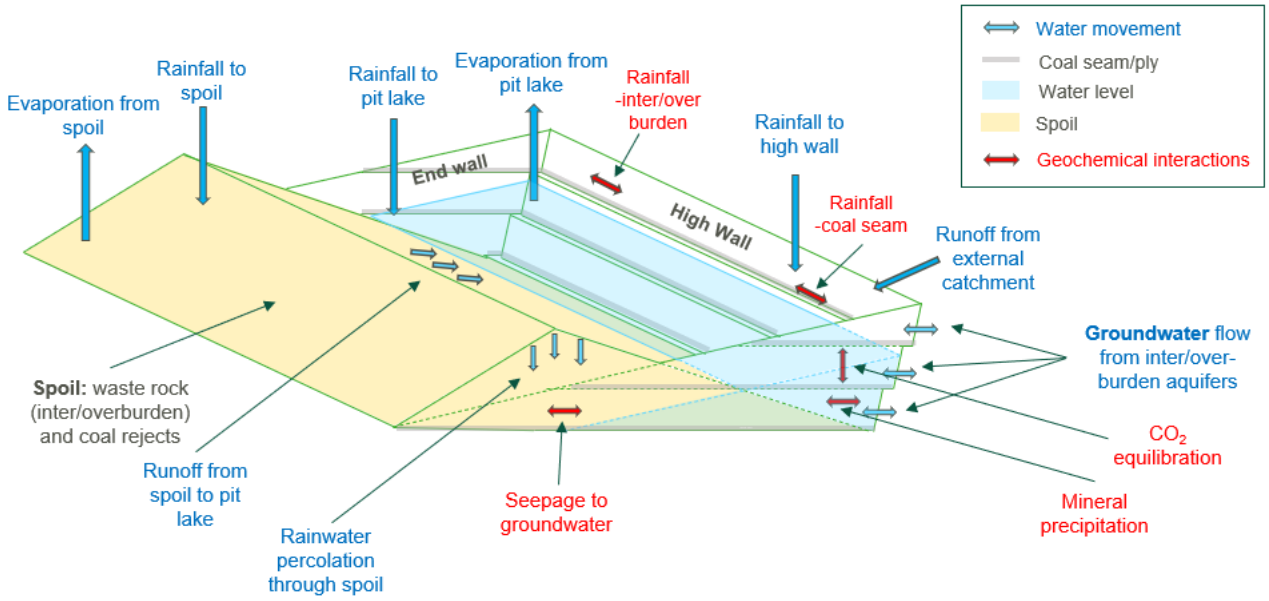


Figure 3.1 Generic conceptual model of a void lake and associated source terms

4 Information review

4.1 Legislation and guidance

The Queensland Government legislation and guidance documents relevant to void water quality include:

- EP Act 1994 (QLD)
- PRCP guideline (DES, 2023)
- EA (EPML00717813), dated 29 March 2023 (Queensland Government, 2023).

4.2 Whitehaven guidance documents and data reviewed

The relevant documents provided by WHC include:

- Blackwater Mine: Environmental Geochemical Characterisation and Risk Assessment of Mineral Waste (Draft) (Terrenus Earth Sciences, 2024). This assessment includes details regarding the AMD classification and lithological domain proportions for materials exposed on low walls and highwalls of each residual void. It should be noted that data were not available for all voids, hence, analogue sites were used as required. Further information is presented in Section 5.2.
- Relevant databases provided by WHC with site-specific data for BWM, including:
  - BWM drill core database: *"BWM_Drillhole Results – 27 March 2024_WORKING.xlsx"*
  - BWM high wall lithological proportion database: *"BWM all pits_Golder_05102023.xlsx"*
  - BWM Groundwater quality database: "*BWM_Export_2018.xlsx"*.

5 Water quality model inputs

The geochemical water quality model adopts the same timeframe as the corresponding WBM: a period of up to 564 years post-closure (2035 through 2599). Within this timeframe, the water levels each of the void lakes reach equilibrium (i.e., steady-state lake levels). The following sections outline the key features of the geochemical models, including summaries of:

- Void water balance results (Section 5.1).
- Pit wall exposure and in-pit waste disposal (Section 5.2).
- Development of geochemical source terms (Section 5.3).
- Development of the geochemical models and underlying key assumptions (Section 5.3.3).

The geochemical models are limited by the corresponding WBM assumptions and by the availability and quality of geochemical characterisation data. As additional or revised information is made available, the water quality models should be reviewed and refined, as necessary.

5.1 Water balance modelling results

The WBM for each void were developed for the overall closure period 2035 to 2599 (WSP, 2024), noting that the closure period varied between the residual voids. The modelled period is from January 2035 to December 2599, modelling a period of up to 564 years. Closure commencement and model durations are summarised for each void in Table 5.1.

Table 5.1 Modelled void closure periods and durations

Void	Closure from	Closure to	Model duration (years)
Ramp 8	2035	2599	564
Bonnie Doon	2040	2599	559
Mimosa/Besgrove	2088	2599	511
Deep Creek	2049	2599	550
Stewarton/Ballamoo	2094	2599	505
Kenmare	2094	2599	505
Laleham	2090	2599	509
Togara/North Marshmead	2109	2599	490
South Marshmead	2100	2599	499
Kennedy West	2094	2599	505
Comet Downs East	2102	2599	497

The main considerations of the water balance are summarised as follows:

- All residual voids are assumed to dry/devoid of water at the start of the modelled period (WSP, 2024). Inflows and outflows for each void are listed in Table 5.2.
- Groundwater flows to/from each void are represented by time series data extracted from groundwater modelling of the closure scenario (SLR, 2024).
- A single climate change scenario (CCS) was adopted to simplify the WBM analytical process. The Representative Concentration Pathway (RCP) 8.5_M_HI5 CCS was identified as the most representative of the 24 considered

scenarios. Precipitation and evaporation rates change at pivotal years centred on 2030 (projected from 2020 to 2039), 2050 (projected from 2040 to 2059), and 2070 (projected from 2060 to 2079) (CSIRO, 2022). As the climate data does not extend past the 2070 pivotal year for the years from 2080 to 2599, the projections from the pivotal year 2070 were applied for the subsequent modelled period to 2599.

- Runoff and/or seepage from in-pit or out-of-pit tailings or reject facilities were not considered in the WBM but is covered in the hydrogeological study as part of defined particle tracking analysis. It is assumed that in-pit tailings will be managed as part of the NUMAs, and out-of-pit tailings facilities will be appropriately rehabilitated and closed thereby limiting potential source generation and pathway movement over time.

The results of the WBM are summarised as follows:

- BWM experiences high summer temperatures, dry winters and wet summers. Maximum precipitation and evaporation occur during summer months, with a slight offset in timing and duration. Maximum evaporation occurs from October through March, while maximum precipitation occurs for a shorter period in December through February. Seasonality is not captured in the water quality model, as results are integrated into annual time-steps.
- Pit wall runoff, direct void lake rainfall, and evaporation follow this pattern of seasonality. Groundwater inputs are consistent and do not display any seasonality pattern (WSP, 2024).
- The water inflow and outflow proportions for the individual water sources to/from each residual void are presented in Table 5.3. The volumes of water accumulated in each void up to December 2599 are presented in Figure 5.1. The proportions of water volumes from each source for the BWM residual voids are represented in Figure 5.2 and Figure 5.3.
- Evaporation is the major output of water from all voids. Evapo-concentration thus may be significant in regulating void water quality.
- Whilst long-term groundwater inflows to the voids are modelled to occur, there are initial fluctuations of inflows and outflows from some of the BWM residual voids. This behaviour is transient and occurs over approximately the following initial timescale post closure for each residual void: Ramp 8 (~23 years), Bonnie Doon (~26 years), Mimosa/Besgrove (~9 years), Deep Creek (~27 years), Stewarton/Ballamoo (~8 years) and Togara/North Marshmead (~1 year). These modelled outflow results reflect the groundwater level recovery following the cessation of dewatering activities as groundwater levels in the surrounding in-pit spoil (and natural geological formations) slowly recover from mining activities. Following this initial period of groundwater fluxes, groundwater inflows prevail for the duration of the WBM simulation.
- For all voids, the differences between mean inflows and mean outflows reduce, and the mean equilibrium is reached by the end of the simulation period (December 2599). Water level/storage volumes stabilise with a minor seasonal, cyclical pattern (Figure 5.1) with water levels equilibrating around 7 to 64 m below interpreted groundwater levels at the end of the simulation period:
  - **Ramp 8:** The long-term, mean storage levels (last 20 years) range between 153 and 154 m AHD. This is approximately 20.5 to 21.5 m below the base elevation of shallow geologic formation[5] (174.5 m AHD).
  - **Bonnie Doon:** The long-term, mean storage levels (last 20 years) range between 159 and 162 m AHD. This is approximately 9 to 12 m below the base elevation of shallow geologic formation (171 m AHD).
  - **Mimosa/Besgrove:** The long-term, mean storage levels (last 20 years) range between 116 and 118 m AHD. This is approximately 61 to 63 m below the base elevation of shallow geologic formation (179 m AHD).
  - **Deep Creek:** The long-term, mean storage levels (last 20 years) range between 140 and 141 m AHD. This is approximately 62.5 to 63.5 m below the base elevation of shallow geologic formation (203.5 m AHD).

[5] This is interpreted to infer 'below the pre-mining groundwater level'.

- **Stewarton/Ballamoo:** The long-term, mean storage levels (last 20 years) range between 144 and 146 m AHD. This is approximately 57 to 59 m below the base elevation of shallow geologic formation (203 m AHD).
- **Kenmare:** The long-term, mean storage levels (last 20 years) range between 220 and 221 m AHD. This is approximately 41 to 42 m below the base elevation of shallow geologic formation (261 m AHD).
- **Laleham:** The long-term, mean storage levels (last 20 years) range between 236 and 238 m AHD.
- **Togara/North Marshmead:** The long-term, mean storage levels (last 20 years) range between 156 and 157 m AHD. This is approximately 59 to 60 m below the base elevation of shallow geologic formation (232 m AHD).
- **South Marshmead:** The long-term, mean storage levels (last 20 years) range between 180 and 182 m AHD. This is approximately 7 to 9 m below the base elevation of shallow geologic formation (189 m AHD).
- **Kennedy West:** The long-term, mean storage levels (last 20 years) range between 141 and 143 m AHD. This is approximately 38 to 40 m below the base elevation of shallow geologic formation (181 m AHD).
- **Comet Downs East:** The long-term, mean storage levels (last 20 years) range between 182 and 183 m AHD. This is approximately 9 to 10 m below the base elevation of shallow geologic formation (192 m AHD).

- All voids are modelled as groundwater and are predicted to pose a very low risk of overtopping.

For the purposes of geochemical modelling, the mean daily water volumes from the WBM were integrated into annual intervals.

Table 5.2 Summary of inflow and outflow source terms for modelled BWM residual voids

Type	Inflow/outflow source term	Residual voids										
		Ramp 8	Bonnie Doon	Mimosa/ Besgrove	Deep Creek	Stewarton/ Ballamoo	Kenmare	Laleham	Togara/North Marshmead	South Marshmead	Kennedy West	Comet Downs East
Inflows	Direct rainfall	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Highwall runoff	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	External catchment runoff	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	In-pit spoil runoff	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	In-pit spoil seepage	×	×	×	×	×	×	×	×	×	×	×
	Groundwater inflow	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Outflows	Evaporation	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Groundwater outflow*	✓	✓	✓	✓	✓	×	×	✓	×	×	×

Notes *minor groundwater outflows from Ramp 8, Bonnie Doon, Mimosa/Besgrove, Deep Creek, Stewarton/Ballamoo and Togara/ North Marshmead are indicated in numerical groundwater time series data (SLR, 2024).

Table 5.3 Water inflow and outflow proportions for each water source to BWM residual voids

Residual Void	Inflows						Outflows	
	Direct lake rainfall	Groundwater inflow	Highwall runoff	Rehabilitated catchment runoff	Natural catchment runoff	In-pit spoil runoff	Evaporation	Groundwater Seepage
Ramp 8	31%	50%	1%	3%	8%	6%	99%	1%
Bonnie Doon	32%	12%	2%	14%	18%	22%	99.8%	0.2%
Mimosa/Besgrove	31%	39%	6%	9%	1%	13%	99.7%	0.3%
Deep Creek	30%	45%	4%	5%	5%	11%	99%	1%
Stewarton/Ballamoo	31%	41%	9%	11%	2%	5%	99.7%	0.3%
Kenmare	31%	38%	7%	6%	3%	15%	100%	0%
Laleham	33%	7%	11%	9%	11%	29%	100%	0%
Togara/N Marshmead	31%	41%	7%	8%	0%	14%	99.95%	0.05%
South Marshmead	31%	50%	5%	3%	2%	10%	100%	0%
Kennedy West	32%	36%	9%	12%	3%	9%	100%	0%
Comet Downs East	31%	58%	1%	3%	1%	6%	100%	0%

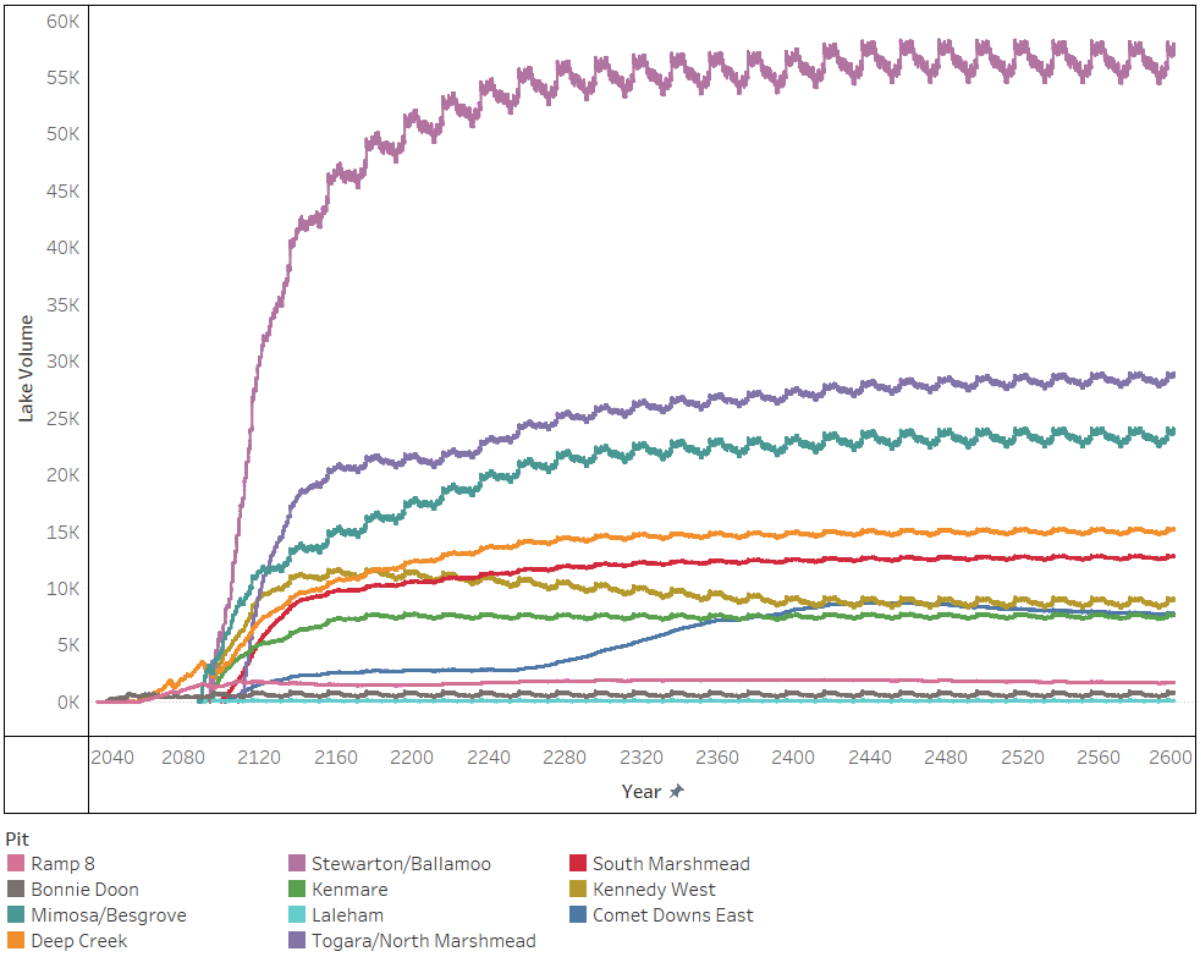


Figure 5.1 BWM mean void lake volume (WSP, 2024)

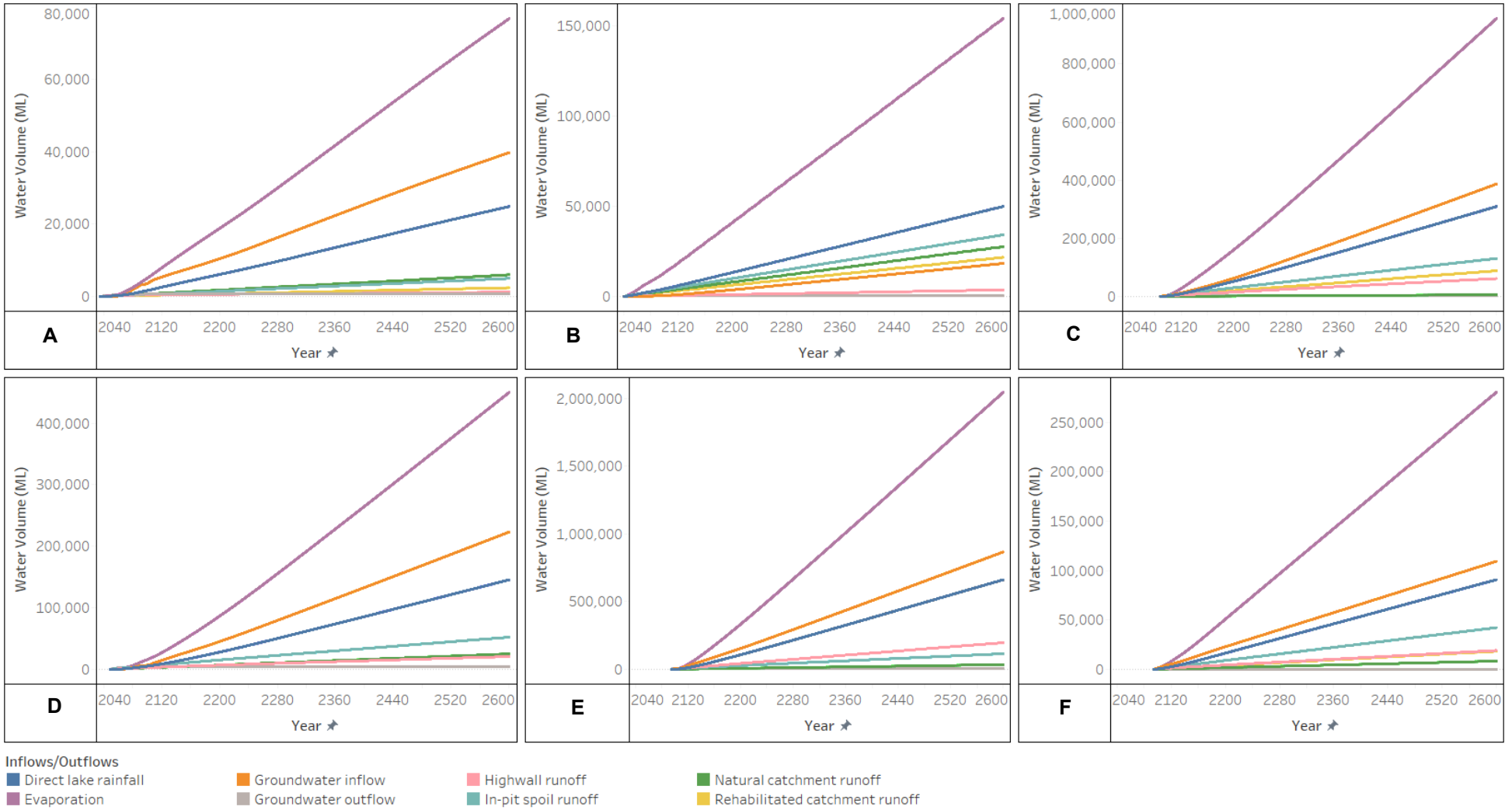


Figure 5.2 Ramp 8 (A), Bonnie Doon (B), Mimosa/Besgrove (C), Deep Creek (D), Stewarton/Ballamoo (E), Kenmare (F) residual voids – cumulative inflow/outflow volumes for each source

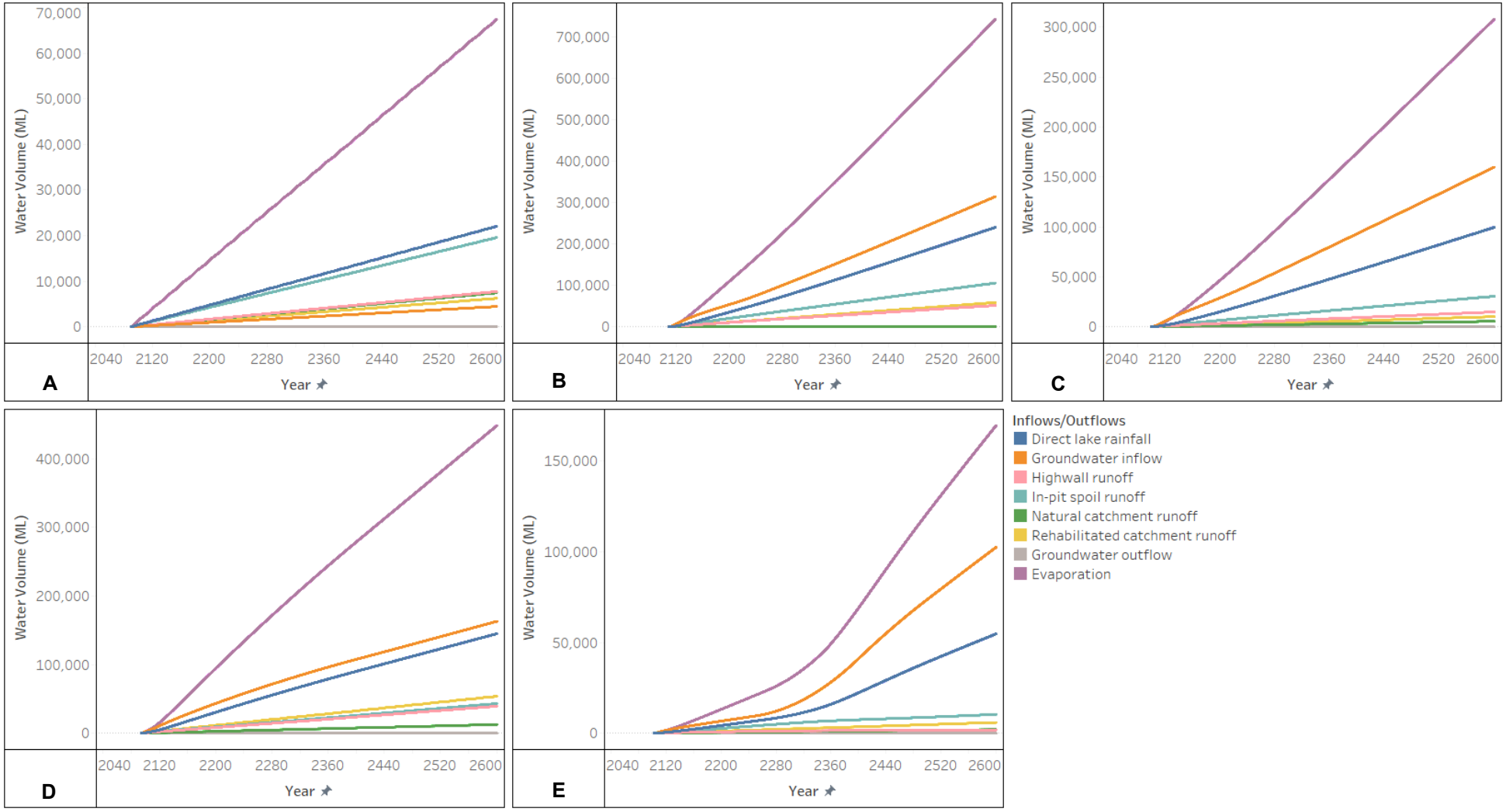


Figure 5.3 Laleham (A), Togara/Marshmead (B), South Marshmead (C), Kennedy West (D), Comet Downs East (E) residual voids – cumulative inflow/outflow volumes for each source

5.2 Geologic materials

5.2.1 Material types and reactions

The geologic materials and associated mine waste materials (spoil and rejects) may react with water and release or immobilise solutes, depending on their geochemical characteristics. Materials considered in the current model include:

- Highwall lithologies interacting with rainfall/runoff. The lithological distributions of the highwalls are outlined in Section 5.2.2 and the geochemical properties are outlined in Section 5.3.1.
- In-pit spoil capped with non-carbonaceous interburden interacting with rainfall/runoff.
- Natural catchment interacting with rainfall/runoff. The natural catchment is assumed to be composed of weathered materials.

The current model excludes:

- In-pit and out-of-pit mine waste (i.e., spoil, rejects and/or tailings) interacting with infiltrating water (Sections 5.2.3 and 5.2.4). This material is not exposed at the landform surface as it will be capped and, therefore, it does not interact with rainfall/runoff.
- Seepage through in-pit spoil is not quantified in the current water balance or groundwater models – refer to Section 5.1 for further details.

5.2.2 Highwall exposures

For the current assessment, geologic materials have been classified into lithological domain groups. The classification, shown in Table 5.4, is based on the distinction of wall rock lithologies in the overburden/interburden (coal, carbonaceous and non-carbonaceous materials) and their weathering condition (weathered or fresh). The classification used for this assessment does not consider potential differences between Permian and Tertiary age materials. However, this simplification is necessary based upon available water quality data (Section 5.3.1).

Table 5.4 Spoil and highwall material lithological classification

Spoil type	
Weathering condition	**Lithology**
Weathered	Non-carbonaceous
	Carbonaceous and coaly
Fresh	Non-carbonaceous
	Carbonaceous
	Coal

Notes Weathering condition is defined based upon logged lithology (i.e. if samples are above/below the base of weathering; BHWE).

The relative proportions of each lithological group exposed on current and future post-closure highwalls were estimated for BWM based on the stratigraphic logging (meterage) in drill holes (Terrenus Earth Sciences, 2024). This is considered across the full BWM site and does not consider localised differences which may exist between the voids. Material with no lithological classification (classified as ‘unknown’) was reallocated to carbonaceous and non-carbonaceous domains using the ratio of carbonaceous to non-carbonaceous materials, assuming coal is likely to be properly logged in the field. The resulting simplification provided three main lithological groupings: coal, carbonaceous overburden and non-carbonaceous overburden. The subdivision of coal materials into specific seams was not considered given the low proportional area of remnant coal exposed on the highwall compared to the overburden.

Highwall proportions were provided by WHC for Airstrip Pit, Besgrove Pit, Blackdown Pit, Bonnie Doon Pit, Deep Creek Pit, Kenmare Pit, Laleham Pit, Marshmead Pit, Sagittarius Pit, Stewarton Pit, Tannyfoil Pit, Togara Pit and Wilpeena Pit. Highwall proportions for some pits were unavailable, hence, proportions from analogue pits with similar elevation were used, as follows:

- Ramp 8: used Mimosa proportions as analogue.
- Mimosa/Besgrove: combined proportions from Mimosa, Sagittarius, Airstrip and Besgrove.
- Togara/North Marshmead: combined Togara and Marshmead proportions.
- South Marshmead: used Marshmead proportions as analogue.
- Kennedy West: used Togara/North Marshmead proportions as analogue.
- Comet Downs East: used South Marshmead proportions as analogue.
- Ballamoo: used Besgrove proportions as analogue.
- Stewarton/Ballamoo: combined Tannyfoil, Stewarton, Wilpeena, Blackdown and Ballamoo (Besgrove) proportions.

The calculated lithological proportions are presented in Table 5.5. The derivation of corresponding geochemical source terms for the highwall in this model is discussed in Section 5.3.

Table 5.5 Proportions of exposed lithologies in BWM highwalls

Void	Weathered, non-carbonaceous	Weathered, carbonaceous/coal	Fresh, non-carbonaceous	Fresh, carbonaceous	Coal	Unknown
Ramp 8	3%	0%	89%	2%	6%	0%
Bonnie Doon*	2%	0%	87%	4%	7%	0%
Mimosa/Besgrove	1%	0%	89% (92%)	1%	6%	2%
Deep Creek*	1%	0%	89%	1%	8%	1%
Stewarton/Ballamoo	5%	0%	83% (85%)	1%	8%	2%
Kenmare*	19%	0%	70% (74%)	1%	5%	4%
Laleham*	5%	0%	88%	1%	6%	0%
Togara/N Marshmead	6%	0%	60% (85%)	1%	7%	26%
South Marshmead	0%	0%	54% (92%)	1%	7%	38%
Kennedy West	6%	0%	60% (85%)	1%	7%	26%
Comet Downs East	0%	0%	54% (92%)	1%	7%	38%

Notes Carbonaceous % was used to distribute 'unknown' to carbonaceous and non-carbonaceous. Rescaled results are indicated in parentheses.
* indicates pits where mapped high wall exposures were provided by WHC (WHC, 2023)

5.2.3 *In-pit mine waste*

In-pit mine waste will be composed of backfilled spoil and will not include co-mingled coal waste materials. It is assumed that the closure in-pit waste landform is to be capped and rehabilitated with non-carbonaceous Permian interburden material (Terrenus Earth Sciences, 2024). Seepage and rainwater infiltration through backfilled spoil is not considered in the geochemical model as the WBM does not distinguish this as a unique water source.

5.2.4 Out-of-pit mine waste

There are three above ground tailings facilities at BWM: north coal processing plant (NCPP) TSF, Laleham TSF, Bottom Dam TSF (Terrenus Earth Sciences, 2024). Interactions between rejects and tailings in these facilities with surface or groundwater water were not considered in the current model bases on the following:

- The residual void catchments for the closure landform do not include surface water runoff from the tailings storage facilities.
- These facilities are assumed to be capped and rehabilitated with non-carbonaceous Permian interburden material. Tailings is not expected to be exposed to surface runoff.
- Although groundwater inflows to the residual voids are included in the WBM, specific infiltration of rainfall through the closed tailings facilities has not been quantified. It is assumed that these facilities will be appropriately closed prior to the start of the modelling period.

5.3 Geochemical source terms

The following subsections describe the derivation and assignment of model source terms used to represent inflowing waters to the residual voids. The geochemical source terms were derived from the groundwater and environmental geochemistry databases provided by WHC, as summarised in Table 5.6. The source term compositions are presented in Table A.1 of Appendix A.

Table 5.6 Summary of data sources used to derive geochemical source terms

Water inflow	Data source	Report section	Comment
Initial void lake	-	-	It is assumed that no water is currently accumulated in the BWM voids or will accumulate prior to closure.
Natural catchment runoff	BWM Drill-core database	5.3.1	Represented by leachate data from weathered non-carbonaceous drill core samples.
Rehabilitated catchment/In-pit spoil runoff	BWM Drill-core database	5.3.1	It is assumed that non-carbonaceous interburden will be specified as capping material for final landform. Spoil runoff is, therefore, represented by leachate data from fresh non-carbonaceous drill core samples.
Highwall runoff	BWM Drill-core database	5.2.2, 5.3.1	Exposed lithological domains on the highwall are described in Section 5.2.2. The BWM drill core databases were used to derive source terms for each lithological domain/grouping.
Groundwater inflow	BWM Ground-water database	5.3.2	Median water quality from BWM groundwater database.
In-pit spoil seepage	-	-	Not included in the current water balance.
Direct Rainfall	-	-	Pure water equilibrated with atmospheric CO_2.

Notes '-' indicates not required/available

5.3.1 Runoff

The environmental geochemistry database (*"BWM_Drillhole Results_WORKING.xlsx"*) was used to derive source terms for solute inputs from highwall runoff, natural catchment runoff, and in-pit spoil/rehabilitated catchment runoff. The database includes the results of analyses undertaken on drill core material collected at BWM. Leachate data represented a 1:5 solid to liquid ratio, and were filtered based upon lithology, with available sample numbers by parameter class indicated in Table 5.7. The median of compiled data for each lithological grouping was used as the source term for the respective group. Where analytical results were below the limit of reporting (<LoR), the entry was substituted with half the LoR. Detailed source term compositions are presented in Table A.1 of Appendix A.

Table 5.7 Summary of BWM drill core database leachate data by lithological grouping

Lithology group	Drillhole database sample numbers			
	Laboratory pH	Major cations and anions	Metal(loid)s	Nutrients
Coal	387	24 – 70	24 – 70	24
Non-carbonaceous, Fresh	2,861	141 – 319	141 – 319	141
Non-carbonaceous, Weathered	678	63 – 131	61 – 131	61 – 63
Carbonaceous, Fresh	261	25 – 54	25 – 54	25
Carbonaceous, Weathered	9	1 – 3	1 – 3	1

5.3.2 Groundwater

The groundwater source term was derived using the groundwater database provided by WHC (median values selected as the source term). The database includes monitoring information for 106 monitoring bores and contains data from January 2018. No distinction is currently made between bores when deriving the groundwater source term, and a median of all available data was taken. The available data is summarised in Table 5.8.

The groundwater source terms derived by this approach may be biased as the water samples in this database may not be representative of the water volumes/aquifers that would flow into the residual voids within the final mine closure landform following cessation of mining.

Table 5.8 Summary of BWM groundwater database

Groundwater database sample numbers			
Field pH (Laboratory pH)	Major cations and anions	Metal(loid)s	Nutrients
959 (1,086)	669 – 1,174	143 – 1,153	713 – 840

5.3.3 Potential limitations

The following geochemical limitations apply to the water quality model for the eleven BWM residual voids:

- Analyte suites varied between datasets:
  - All datasets for leachate and groundwater included data for metal(loid)s with defined groundwater EA criteria (Section 5.4.5). The metal(loid)s with values included: silver (Ag), aluminium (Al), arsenic (As), iron (Fe), mercury (Hg), molybdenum (Mo), antimony (Sb), and selenium (Se).
  - Dissolved silicon (Si) concentrations were not analysed in the leachate dataset; therefore, silicate minerals were not considered in the equilibrium phases selected for the geochemical model (Section 5.4.2).
  - Source terms have been defined using static data and do not necessarily represent long term leaching behaviour of the lithologies.

- Quality control of derived source terms indicates:
  - The derived source terms from the leachate database (Table A.1 of Appendix A) show positive charge imbalance (+4.8 to +29.5) suggesting an overestimation of cations. Charge balance on these source terms was achieved with the addition of chloride.
  - None of the source terms included in the model are acid-generating. Minor acid generation is anticipated from some of the mine waste materials – for example oxidation of residual coal on the highwalls (Terrenus Earth Sciences, 2024). Static leach testing on fresh materials do not show acidic conditions; however, kinetic testing results for acid generating material may demonstrate acidic drainage over time and will be more representative for model input than static results.

5.4 Geochemical model development

5.4.1 Overarching approach and assumptions

The geochemical model was run for major cations, anions, and metal(loid)s for which data was available and for parameters with EA-specified groundwater trigger values, such as pH. If the input concentrations were below the limit of reporting (<LOR), these were substituted with half the limit of reporting. Nutrients (i.e., nitrate, phosphate, etc.) were modelled, noting that limited data were available for source term definition.

The results for each timestep were calculated using the geochemical modelling code PHREEQC (Parkhurst, 2013) with the Minteq.v4 thermodynamic database, derived from the MINTEQA2 version 4 database (US EPA, 1998). The geochemical model was run as follows:

- Source terms were mixed for annual timesteps, according to the inflow and outflow proportions that were calculated from the GoldSim water balance output volumes.
- Modelling was incremental, with the output for the void lake from the previous timestep being used as the input for the next time step before mixing the subsequent inflows and outflows.
- Geochemical reactions were possible, such as mineral precipitation/dissolution, gas exchange and sorption.

In addition to the key assumptions inherent to the groundwater and the WBM, the following assumptions apply to the geochemical model:

- At all times, the void lake is fully mixed, geochemical reactions occur to equilibrium within the modelled timestep and are not kinetically controlled. Mineral precipitates are retained within the void lake.
- Solute release from highwall rock and spoil does not occur below the lake water level. Mineral solids initially present in the void lake are not accounted for in the current model (i.e., submerged highwall, spoil, regolith, and talus).
- The release of coal bed methane caused during the dewatering of coal seams does not drive groundwater or lake chemistry towards more reducing conditions. Hence, oxygenated lake conditions were assumed.
- Seepage from the void to the groundwater system has the same composition as the void lake[6].
- There is no seepage of infiltrated rainfall or groundwater through the in-pit waste to the void lake.
- Stratification is assessed at a conceptual level based on a salinity (as total dissolved solids (TDS)) threshold. Seasonal temperature, wind patterns and other impacts on mixing are not considered.
- The geochemical model does not account for biological processes.

[6] Seepage from the void to the groundwater system is negligible as the pits act as a groundwater sinks once equilibrium lake level is achieved.

5.4.2 Geochemical controls, solid, and gas phases

The geochemical controls considered in the model include mineral precipitation, gas exchange with the atmosphere and sorption (onto precipitated ferrihydrite surfaces). The leaching of pre-existing solid phases (talus or regolith) in the void lake was not included. Geochemical equilibrium phases are presented in Table 5.9 and include a range of carbonate, sulfate, oxide, fluoride and hydroxide minerals, and gaseous CO_2.

Results from mineralogical analysis by quantitative x-ray diffraction (QXRD) from the drill core database[7,8] were used for guidance in the selection of mineral phases allowed to form in the model. Sorption onto any precipitated ferrihydrite surfaces was also allowed, provided that ferrihydrite precipitated in the model. The redox conditions of all source terms are set to represent oxygenated surface waters (pe = 8; Eh = 472 mV), whilst groundwater inputs represent moderately oxygenated conditions (pe = 4; Eh = 236 mV).

Table 5.9 Equilibrium phase assemblage for the water quality models

Mineral phase	Formula	Mineral phase	Formula
Carbonate/hydroxy-carbonate minerals			
Azurite	$Cu_3(OH)_2(CO_3)_2$	Rhodochrosite	$MnCO_3$
Calcite	$CaCO_3$	Siderite	$FeCO_3$
Malachite	$Cu_2(OH)_2CO_3$	Witherite	$BaCO_3$
Otavite	$CdCO_3$	Magnesite	$MgCO_3$
$CoCO_3$	$CoCO_3$		
Sulfate/hydroxy-sulfate minerals			
Barite	$BaSO_4$	Epsomite	$MgSO_4•7H_2O$
Basaluminite	$Al_4(OH)_{10}SO_4$	Gypsum	$CaSO_4•2H_2O$
Brochantite	$Cu_4(OH)_6SO_4$	Melanterite	$FeSO_4•7H_2O$
Chalcanthite	$CuSO_4•5H_2O$	Celestite	$SrSO_4$
K-jarosite	$KFe_3(SO_4)_2(OH)_6$	Na-jarosite	$NaFe_3(SO_4)_2(OH)_6$
Oxide minerals			
Birnessite	MnO_2	Tenorite	CuO
Scorodite	$FeAsO_4•2H_2O$		
Fluoride minerals			
Fluorite	CaF_2		
Hydroxide/oxyhydroxide minerals			
Ferrihydrite	$Fe(OH)_3$	Gibbsite (amorphous)	$Al(OH)_3$
$Cu(OH)_2$	$Cu(OH)_2$	Manganite	MnO(OH)
$Ni(OH)_2$	$Ni(OH)_2$		

[7] The current highwalls/spoil mineralogy may not cover all mineral phases that may precipitate in a future void-lake.

[8] Mineral phases identified in QXRD results for BWM include pyrite, marcasite, jarosite, calcite, ankerite-dolomite, siderite, rhodochrosite, illite-smectite, mixed-layer illite, illite, kaolinite, montmorillonite, muscovite, quartz, albite, microcline, apatite, chlorite, anatase, goethite, rutile, and amorphous phases (inc. coal).

Mineral phase	Formula	Mineral phase	Formula
Gas			
CO_2 (g)	CO_2		

5.4.3 Model scaling and sensitivity

Scaling factors are frequently used to account for the variations between laboratory and field-scale conditions. These variations relate mostly to the different contact surface areas for the same mass of material that are due to the state of the material: crushed in the laboratory vs testing blasted and fractured material in the field. Different contact surface areas affect the degree of water-rock interaction.

Application of scaling factors was not considered meaningful due to the nature of available water quality data for the derivation of the source terms (i.e., results for short-term leach test on crushed material which do not reflect long-term reactions/behaviour). As scaling factors generally account for the reduced available surface area in the field, the current models are considered conservative in regard to dissolved concentrations of metal(loid)s.

A sensitivity test was performed to assess the role of geochemical controls on predicted void lake water quality. The two simulations are summarised in Table 5.10 and were performed for the mean result on the base case water balance result for each void. These simulations are considered to represent upper and lower bound predicted compositions, with actual pit lake compositions anticipated to fall within the predicted ranges.

Table 5.10 Model sensitivity simulations

Simulation	Atmospheric CO_2 equilibrium	Mineral precipitation	Surface adsorption
Base case	Equilibrium at $10^{-3.38}$ (~420 ppm)*	Equilibrium	Adsorption onto precipitated ferrihydrite surfaces
No geochemical controls (NC)	No equilibrium	No equilibrium	No sorption

Notes *420 ppm is representative of current (2024) atmospheric CO_2 concentrations. Variation with time (i.e., geochemical climate change scenarios) is not included in current model scenarios.

5.4.4 Stratification

A conceptual-level assessment of potential chemical stratification was conducted based on the predicted TDS, which can be used to approximate the fluid density of the mixed void lake. It is assumed that when the fluid density exceeds a TDS of approximately 10,000 mg/L (ρ is approximately 1,005 kg/m^3), fresh rainfall and/or runoff (ρ is approximately 998 kg/m^3) may begin to form a freshwater 'cap' on top of a salty underlayer. This is a similar density contrast to that observed in seasonally stratified lakes based upon typical temperature differences (approximately 10 to 15°C) (Boehrer & Schultze, 2008; Jewell, 2009). As such, a high-level discussion of potential chemical stratification is included alongside the discussion of the TDS results. Thermal stratification should be considered in future hydrodynamical assessment(s).

5.4.5 Water quality screening thresholds

Water quality modelling results were compared against groundwater trigger values specified in the EA. These values relate to operational compliance, not residual void-lake closure objectives, and therefore, should be treated as reference values only. WHC should consider the derivation of rehabilitation-specific closure water quality criteria for future PRCP studies.

The water quality comparison values used in this study are summarised in Table 5.11. The thresholds for each parameter were extracted from Table I2 of the EA, which provides trigger levels for four bores (RN43060, P6R, RN38547 and RN43062). Monitoring at one other bore (P3) is undertaken for interpretive purposes only, and therefore, has no applied trigger values.

The TDS thresholds were derived using a conversion factor of 0.67 following Section 4.3.3.5 of the Australian and New Zealand Guidelines for fresh and marine water quality (ANZECC & ARMCANZ, 2000). This value is only applicable to freshwater, and the factor will differ for waters of higher salinity.

Table 5.11 Trigger value screening thresholds (Table I2 of the EA)

Parameter	Units	Groundwater trigger levels										
		MB1	MB18	MB21	MB19BW M2A	MB19BW M01P	MB19BW M08P	MB19BW M27P	MB20BW M03P2	BG-1	BG-2	Other bores[c]
pH	pH units	6.3 – 7.4	6.5 – 8.5	6.1 – 7.1	6.0 – 6.3	6.5 – 8.5	6.5 – 8.5	6.5 – 8.5	6.5 – 8.5	6.5 – 8.5	6.5 – 8.5	6.5 – 8.5
EC	µS/cm	39,560	18,610	15,890	37,860	26,430	7,260	15,190	20,180	15,780	18,170	TBC[b]
TDS[a]	mg/L	26,505	12,469	10,646	25,366	17,708	4,864	10,177	13,520	10,572	12,174	TBC[b]
Sulfate (SO_4)	mg/L	426	210	600	515	210	210	210	210	210	1,510	TBC[b]
Aluminium (Al)	mg/L	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055
Arsenic (As)	mg/L	0.019	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	TBC[b]
Iron (Fe)	mg/L	6.3	2.7	4.7	1.4	2.1	1.4	1.9	1.6	1.4	1.4	TBC[b]
Mercury (Hg)	mg/L	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006
Molybdenum (Mo)	mg/L	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034
Antimony (Sb)	mg/L	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009
Selenium (Se)	mg/L	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011

Notes *TDS calculated from EC assuming conversion factor of 0.67 (ANZECC & ARMCANZ, 2000). # Contaminant limits have not yet been developed. + includes BWM_MB02_01, BWM_MB02_02, BWM_MB03_01, BWM_MB03_02, BWM_MB12_01, BWM_MB12_02, BWM_MB14_01, BWM_MB14_02, BWM_MB15_01, BWM_MB17_01 and BWM_MB17_02. Cells shaded in blue denote lower limit EA trigger values and cells shaded in grey denote upper limit EA trigger values.

6 Water quality model results

The following sections present the results of the geochemical modelling for the eleven void lakes at BWM. The results are presented for scenarios with and without geochemical controls (i.e., mineral precipitation, sorption, and atmospheric CO_2 exchange), followed by an inter-comparison of all simulations between the void lakes. The discussion is limited to pH, TDS and selected metal(loid)s of interest, based on EA trigger value exceedances. Exceedances should be considered in the context of all voids being classified as NUMAs for the PRCPs and are predicted to behave as terminal sinks. Tabulated results for each decade are presented in Appendix B and figures for all other parameters are presented in Appendix C.

The modelled period for each void lake geochemical model is presented in Table 6.1, including the proportion of the water quality model period in comparison to the WBM period for each lake. Due to model convergence issues, the modelled periods for some void lakes do not align with the total duration of the WBM. For the majority of void lakes (9 of 11 lakes), this difference is marginal (i.e., similar modelling periods). However, the model periods for Bonnie Doon and Laleham void lakes were significantly lower in comparison to the WBM (52% and 6%, respectively). The reason for model convergence issues is likely to be related to the upper TDS threshold (ionic strength) that the PHREEQC thermodynamic database can accommodate (i.e., Minteq V4 database selected as default).

Table 6.1 Geochemical model simulation periods for BWM voids

Pit	Model Start Year	Model End Year	Modelled period (years)	Proportion of years modelled versus WBM
Ramp 8	2055	2599	544	96%
Bonnie Doon	2040	2267	227	41%
Mimosa/Besgrove	2089	2599	510	99%
Deep Creek	2057	2599	542	98%
Stewarton/Ballamoo	2096	2599	503	99%
Kenmare	2094	2599	505	100%
Laleham	2090	2122	32	6%
Togara/North Marshmead	2109	2599	490	100%
South Marshmead	2100	2599	499	100%
Kennedy West	2094	2599	505	100%
Comet Downs East	2102	2599	497	100%

6.1 Ramp 8

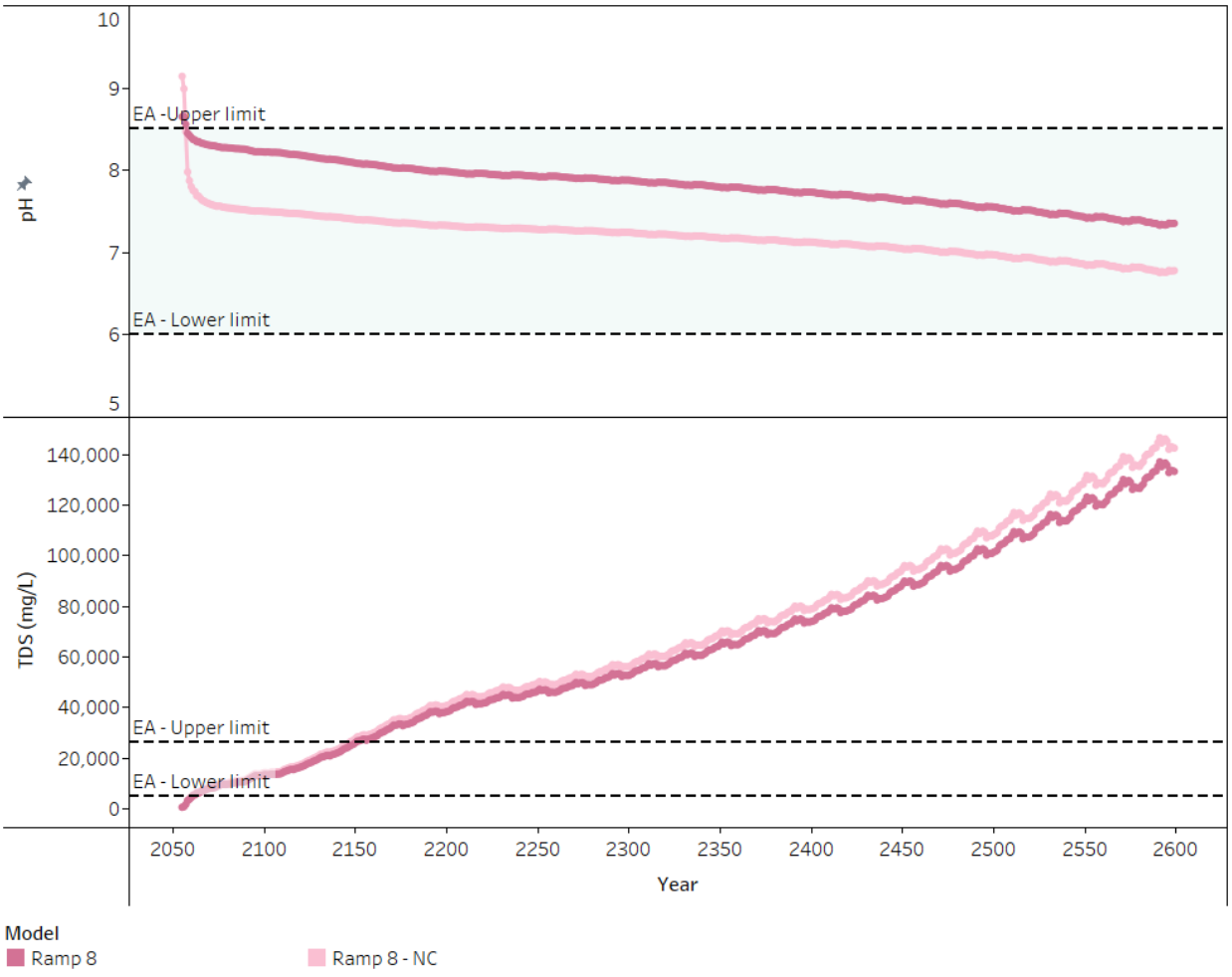
The model for the Ramp 8 residual void is based on a closure year of 2035, however, results are presented from 2055 as the void lake is not established until 2055. Modelled results for pH and TDS are presented in Figure 6.1. The indicative timing by decade of when modelling results trigger the EA values for each of the parameters is summarised in Table 6.2. The model results are summarised as follows:

- **pH:**
  - Acidic conditions are unlikely to develop in the Ramp 8 residual void lake, with neutral to mildly alkaline conditions predicted, which are within the EA trigger value range for the modelled period. A decreasing pH trend is observed for both simulations (i.e., with and without application of geochemical controls).
  - The simulation with geochemical controls results in a higher predicted pH compared with the simulation without geochemical controls. The main geochemical control is CO_2 degassing which raises pH, resulting in carbonate mineral precipitation that reduces pH, such as calcite ($CaCO_3$), magnesite ($MgCO_3$) and manganite (MnO(OH)).These geochemical processes are driven by the input of dissolved inorganic carbon, from runoff and groundwater inflow to the void lake.
- **TDS:**
  - TDS concentrations increase with time, indicating the development of hypersaline conditions. TDS concentrations exceed the EA-derived trigger value (26,505 mg/L) by the year 2070 in both simulations.
  - The increase in TDS concentration is primarily driven by evapo-concentration.
  - TDS concentrations are lower in simulations with geochemical controls due to the removal of barium, calcium, iron, magnesium, manganese and dissolved inorganic carbon through barite ($BaSO_4$), calcite ($CaCO_3$), ferrihydrite (FeOOH), magnesite ($MgCO_3$), manganite (MnO(OH)) precipitation. Geochemical controls do not lead to an 'equilibrium' state for water quality (i.e., constant TDS).
- **Metal(loid)s:**
  - Predicted concentrations of aluminium, antimony, arsenic, mercury, molybdenum, sulfate, and selenium exceed EA criteria in simulations with and without geochemical controls.
  - Predicted iron concentrations exceed EA criteria in simulations without geochemical controls.
  - The exceedances of selenium, and mercury to the criteria are due to expressing results below LOR as half the LOR, and therefore, may not be representative.
  - The indicative timing of the onset of parameter exceedances is summarised in Table 6.2, noting that the Ramp 8 residual void is classified as a NUMA, is at very low risk of overtopping, has net inflows of groundwater, and is predicted to behave as a terminal sink. Exceedances of predicted parameter concentrations to EA criteria should, therefore, be interpreted in this context.
  - The decrease in iron concentration occurs through ferrihydrite (FeOOH) precipitation and drives the reduction in concentrations of other metal(loid)s (arsenic, beryllium, copper, nickel, lead, vanadium, and zinc) through adsorption processes.
- **Stratification:** The steep sides of the void and the high TDS present favourable conditions for stratification, with a maximum estimated water depth of ~34 m. The water of higher density (cooler or more saline) has the potential to become isolated at depth. Hydrodynamic/limnological analysis is required to assess the importance of seasonal mixing processes and groundwater mixing inputs, to confirm if thermal/chemical stratification is likely to occur.
- **Model QA/QC:** pe and water mass conservation stay within a suitable range throughout the model duration.

Table 6.2 Ramp 8 EA first exceedance occurrence by decade

Parameter	Exceedance occurrence	
	Geochemical controls	No geochemical controls
pH	2055 only	2055 only
TDS	2070	2070
Sulfate (SO_4)	2100	2100
Aluminium (Al)	2055	2055
Arsenic (As)	2055 only, then 2140 onwards	2055
Iron (Fe)	n/a	2100
Mercury (Hg)	2310	2250
Molybdenum (Mo)	2180	2190
Antimony (Sb)	2310	2280
Selenium (Se)	2055	2055

Notes n/a = not applicable



(NC: no geochemical controls)

Figure 6.1 Ramp 8 pH and TDS evolution

6.2 Bonnie Doon

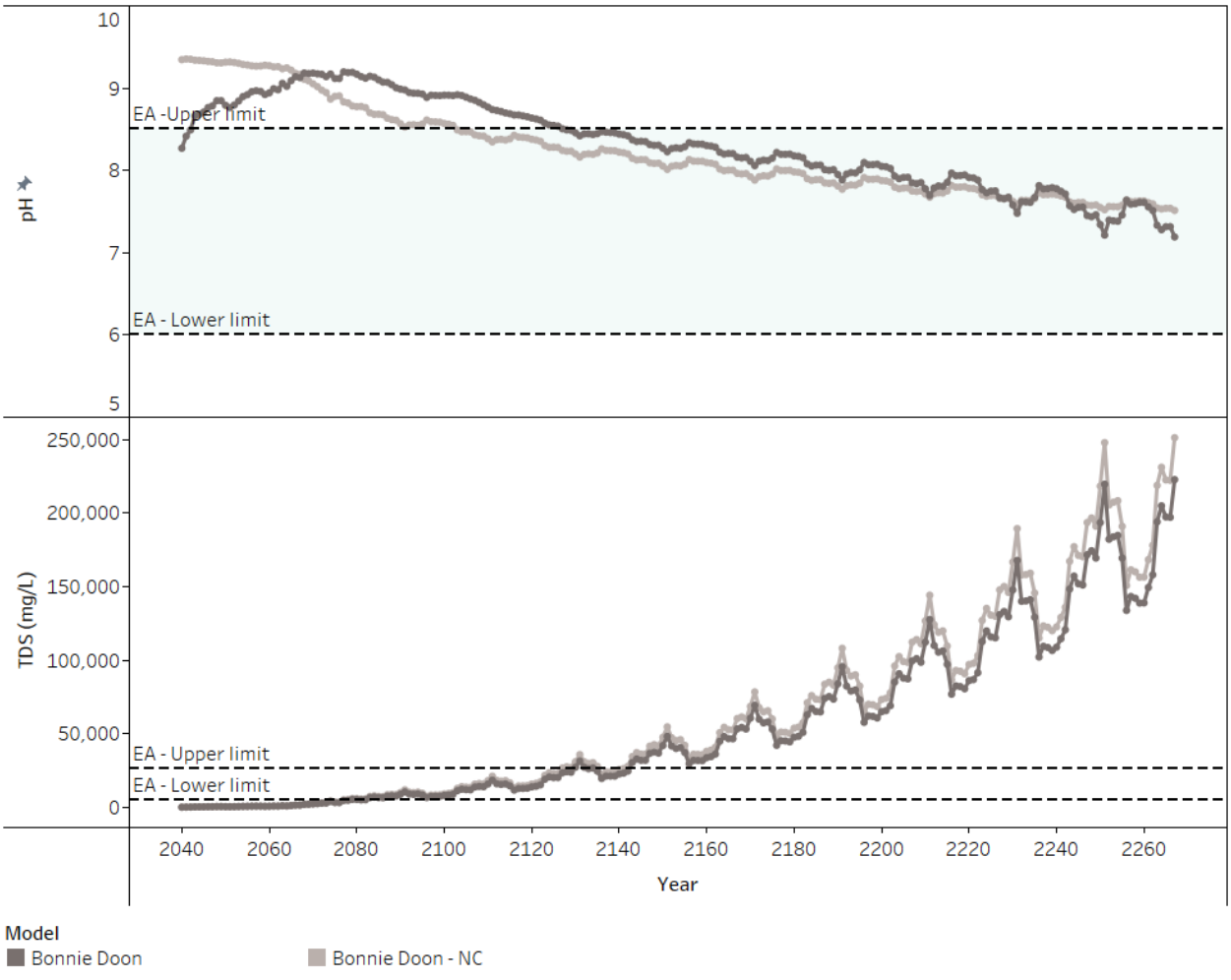
The model for the Bonnie Doon residual void is based on a closure year of 2040 and results are provided from that date until 2267 as the model convergence issues were encountered, likely caused by low lake volume and extremely high predicted salinity (ionic strength surpassing the threshold capability of the thermodynamic database used in the model). Due to this, model results were not shown beyond the TDS value of 200,000 mg/L to prevent the prediction of unrealistic TDS values. Modelled results for pH and TDS are presented in Figure 6.2, with tabulated results at the start of each decade provided in Appendix B; figures of all parameters provided in Appendix C. The Bonnie Doon residual void is classified as a NUMA and is predicted to behave as a terminal sink. Exceedances should, therefore, be considered in this context. The indicative timing by decade of when modelling results trigger the EA values for each of the parameters is summarised in Table 6.3. Model results are summarised as follows:

- **pH:**
  - Acidic conditions are unlikely to develop in the Bonnie Doon residual void lake, with simulations indicating neutral to mildly alkaline pH values predicted, which are within the EA trigger value range for the modelled period. In the simulation without geochemical controls, the predicted pH remains within the lower and upper EA limits and begins to decrease from around 2090. However, acidic conditions may develop considering the decreasing pH trend beyond the modelled period.
  - The simulation with geochemical controls results in a higher pH than the simulation without geochemical controls. The main geochemical control is CO_2 degassing which raises pH, resulting in carbonate mineral precipitation that reduces pH, such as calcite ($CaCO_3$), magnesite ($MgCO_3$), and manganite (MnO(OH)). These geochemical processes are driven by the input of dissolved inorganic carbon, from runoff and groundwater inflow to the void lake.
- **TDS:**
  - TDS concentrations increase with time, indicating the development of hypersaline conditions. TDS concentrations exceed the EA-derived trigger value (26,505 mg/L) by the year 2080 in both simulations.
  - The increase in TDS concentration is primarily driven by evapo-concentration.
  - TDS concentrations are lower in simulations with geochemical controls due to the removal of barium, calcium, iron, magnesium, manganese and dissolved inorganic carbon through barite ($BaSO_4$), calcite ($CaCO_3$), ferrihydrite (FeOOH), magnesite ($MgCO_3$) and manganite (MnO(OH)) precipitation. Geochemical controls do not lead to an 'equilibrium' state for water quality (i.e., constant TDS).
- **Metal(loid)s:**
  - Predicted aluminium, antimony, arsenic, iron, mercury, molybdenum, sulfate, and selenium concentrations exceed the EA criteria in simulations with and without geochemical controls.
  - Predicted selenium and mercury concentrations exceed the EA criteria due to expressing results below the LOR by half the LOR, and therefore, may not be representative.
  - The decrease in iron concentration occurs through ferrihydrite (FeOOH) precipitation and drives the reduction in concentrations of other metal(loid)s (arsenic, beryllium, copper, nickel, lead, vanadium, and zinc) through adsorption processes.
- **Stratification:** The steep sides of the void and the high TDS present favourable conditions for stratification, noting that the permanent void lake is predicted to be shallow (maximum estimated water depth of ~10 m). The water of higher density (cooler or more saline) has the potential to become isolated at depth. Hydrodynamic/limnological analysis is required to assess the importance of seasonal mixing processes and groundwater mixing inputs, to confirm if thermal/chemical stratification is likely to occur.
- **Model QA/QC:** pe and water mass conservation stay within a suitable range throughout the model duration.

Table 6.3 Bonnie Doon EA first exceedance occurrence by decade

Parameter	Exceedance occurrence	
	Geochemical controls	No geochemical controls
pH	2050 to 2130, then 2330 onwards	2040 to 2100
TDS	2080	2080
Sulfate (SO_4)	2080	2080
Aluminium (Al)	2040	2040
Arsenic (As)	2040	2040
Iron (Fe)	2330	2080
Mercury (Hg)	2070	2070
Molybdenum (Mo)	2060	2060
Antimony (Sb)	2070	2070
Selenium (Se)	2050	2050

Notes n/a = not applicable



(NC: no geochemical controls)

Figure 6.2 Bonnie Doon pH and TDS evolution

6.3 Mimosa/Besgrove

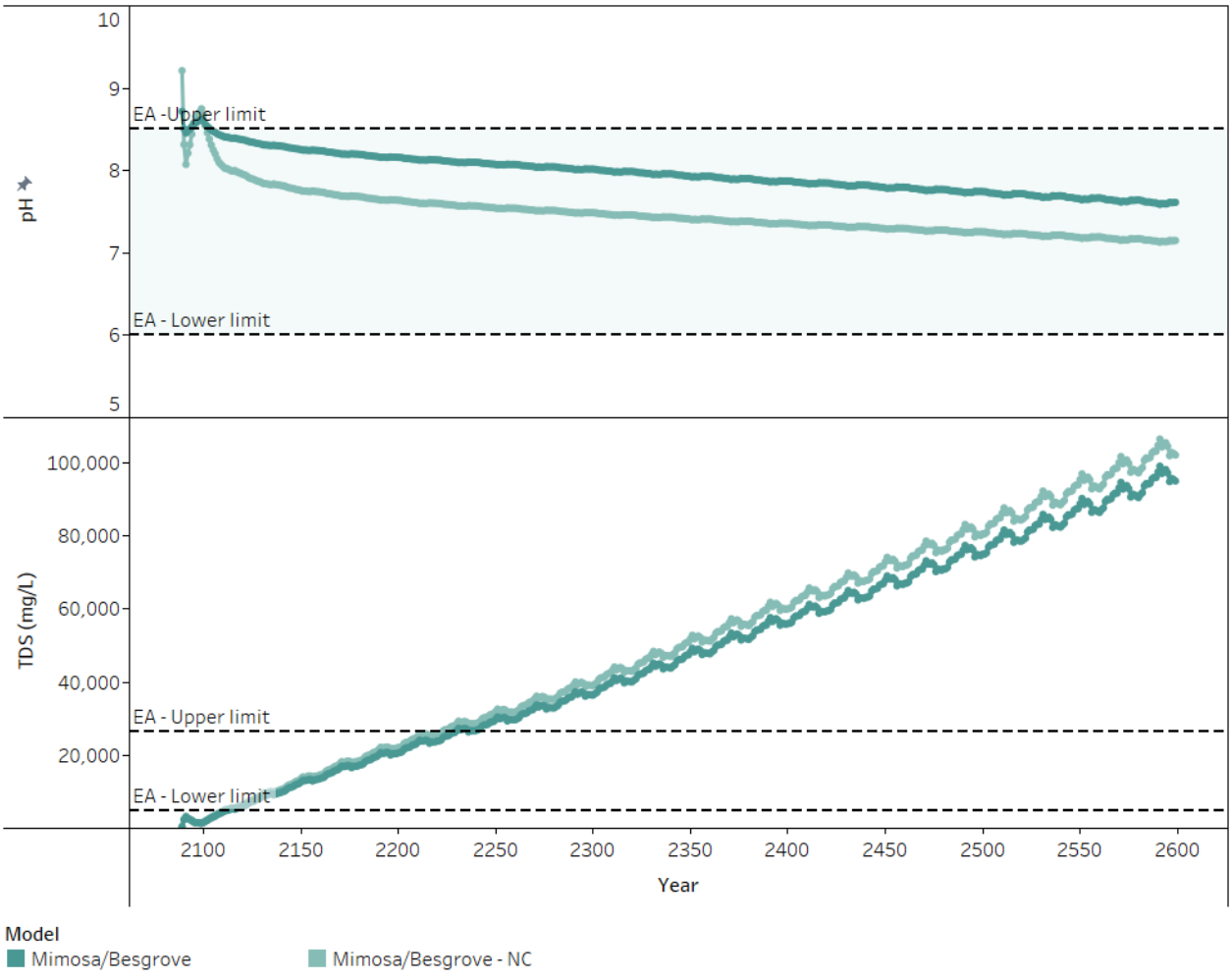
The model for the Mimosa/Besgrove residual void is based on a closure year of 2088; however, results are provided from 2089 as the void lake is not established until 2089. Modelled results for pH and TDS are presented in Figure 6.3, with tabulated results at the start of each decade provided in Appendix B; figures of all parameters provided in Appendix C. The Mimosa/Besgrove residual void is classified as a NUMA and predicted to behave as a terminal sink. Exceedances should, therefore, be considered in this context. The indicative timing by decade of when modelling results trigger the EA values for each of the parameters is summarised in Table 6.4. Model results are summarised as follows:

- **pH:**
  - Acidic conditions are unlikely to develop in the Mimosa/Besgrove residual void lake, with simulations indicating neutral to mildly alkaline pH values predicted, which are within the EA trigger value range for the modelled period. A decreasing pH trend is observed for both simulations.
  - The simulation with geochemical controls results in a higher pH than the simulation without geochemical controls. The main geochemical control is CO_2 degassing which raises pH, resulting in carbonate mineral precipitation that reduces pH, such as calcite ($CaCO_3$), and magnesite ($MgCO_3$). These geochemical processes are driven by the input of dissolved inorganic carbon, from runoff and groundwater inflow to the void lake.
- **TDS:**
  - TDS concentrations increase with time, indicating the development of hypersaline conditions. TDS concentrations exceed the EA-derived trigger value (26,505 mg/L) by the year 2120 in both simulations.
  - The increase in TDS concentration is primarily driven by evapo-concentration.
  - TDS concentrations are lower in simulations with geochemical controls due to the removal of barium, calcium, iron, magnesium, manganese and dissolved inorganic carbon through barite ($BaSO_4$), calcite ($CaCO_3$), ferrihydrite (FeOOH) and magnesite ($MgCO_3$) precipitation. Geochemical controls do not lead to an 'equilibrium' state for water quality (i.e., constant TDS).
- **Metal(loid)s:**
  - Predicted aluminium, antimony, arsenic, mercury, molybdenum, sulfate, and selenium concentrations exceed the EA criteria in simulations with and without geochemical controls.
  - Predicted iron concentrations exceed the EA criteria in simulations without geochemical controls.
  - Predicted selenium, and mercury concentrations exceed the EA criteria due to expressing results below LOR by half the LOR, and therefore, may not be representative.
  - The decrease in iron concentration occurs through ferrihydrite (FeOOH) precipitation and drives the reduction in concentrations of other metal(loid)s (arsenic, beryllium, copper, nickel, lead, vanadium, and zinc) through adsorption processes.
- **Stratification:** The steep sides of the void and the high TDS present favourable conditions for stratification, with a maximum estimated water depth of ~53 m. The water of higher density (cooler or more saline) has the potential to become isolated at depth. Hydrodynamic/limnological analysis is required to assess the importance of seasonal mixing processes and groundwater mixing inputs, to confirm if thermal/chemical stratification is likely to occur.
- **Model QA/QC:** pe and water mass conservation stay within a suitable range throughout the model duration.

Table 6.4 Mimosa/Besgrove EA first exceedance occurrence by decade

Parameter	Exceedance occurrence	
	Geochemical controls	No geochemical controls
pH	2089 to 2100	2089 to 2100
TDS	2120	2120
Sulfate (SO4)	2150	2150
Aluminium (Al)	2089	2089
Arsenic (As)	2089	2089
Iron (Fe)	n/a	2150
Mercury (Hg)	2290	2290
Molybdenum (Mo)	2130	2130
Antimony (Sb)	2190	2210
Selenium (Se)	2089	2089

Notes n/a = not applicable



(NC: no geochemical controls)

Figure 6.3 Mimosa/Besgrove pH and TDS evolution

6.4 Deep Creek

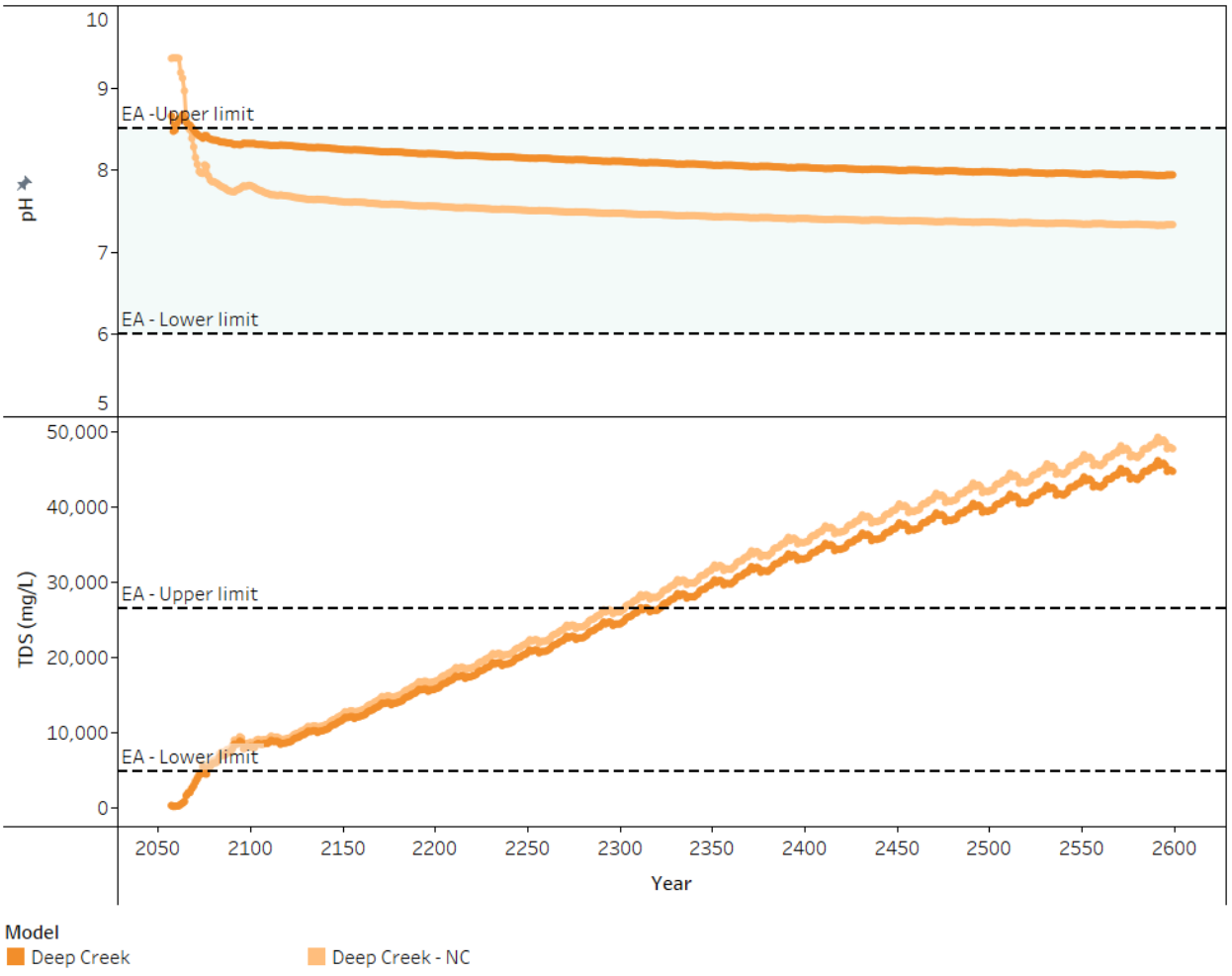
The model for the Deep Creek residual void is based on a closure year of 2049; however, results are provided from 2057 as the void lake is not established until 2057. Modelled results for pH and TDS are presented in Figure 6.4, with tabulated results at the start of each decade provided in Appendix B; and figures of all parameters provided in Appendix C. The Deep Creek residual void is classified as a NUMA and predicted to behave as a terminal sink. Exceedances should, therefore, be considered in this context. The indicative timing by decade of when modelling results trigger the EA values for each of the parameters is summarised in Table 6.5. Model results are summarised as follows:

- **pH:**
  - Acidic conditions are unlikely to develop in the Deep Creek residual void lake, with simulations indicating neutral to mildly alkaline pH values predicted, which are within the EA trigger value range for the modelled period. A relatively stable pH is predicted for both simulations.
  - The simulation with geochemical controls results in higher (more alkaline) predicted pH compared with the simulation without geochemical controls. The main geochemical control is CO_2 degassing which raises pH, resulting in carbonate mineral precipitation that reduces pH, such as calcite ($CaCO_3$) and magnesite ($MgCO_3$). These geochemical processes are driven by the input of dissolved inorganic carbon, from runoff and groundwater inflow to the void lake.
- **TDS:**
  - TDS concentrations increase with time, indicating the development of hypersaline conditions. TDS concentrations exceed the EA-derived trigger value (26,505 mg/L) by the year 2080 in both simulations.
  - The increase in TDS concentration is primarily driven by evapo-concentration.
  - TDS concentrations are lower in simulations with geochemical controls due to the removal of barium, calcium, iron, magnesium, manganese and dissolved inorganic carbon through barite ($BaSO_4$), calcite ($CaCO_3$), ferrihydrite (FeOOH) and magnesite ($MgCO_3$) precipitation. Geochemical controls do not lead to an 'equilibrium' state for water quality (i.e., constant TDS).
- **Metal(loid)s:**
  - Predicted aluminium, antimony, arsenic, mercury, molybdenum, sulfate, and selenium concentrations exceed the EA criteria in simulations with and without geochemical controls.
  - Predicted iron concentrations exceed the EA criteria in simulations without geochemical controls.
  - Predicted selenium and mercury concentrations exceed the EA criteria due to expressing results below LOR by half the LOR, and therefore, may not be representative.
  - The decrease in iron concentration occurs through ferrihydrite (FeOOH) precipitation and drives the reduction in concentrations of other metal(loid)s (arsenic, beryllium, copper, nickel, lead, vanadium, and zinc) through adsorption processes.
- **Stratification:** The steep sides of the void and the high TDS present favourable conditions for stratification, with a maximum estimated water depth of ~54 m. The water of higher density (cooler or more saline) has the potential to become isolated at depth. Hydrodynamic/limnological analysis is required to assess the importance of seasonal mixing processes and groundwater mixing inputs, to confirm if thermal/chemical stratification is likely to occur.
- **Model QA/QC:** pe and water mass conservation stay within a suitable range throughout the model duration.

Table 6.5 Deep Creek EA first exceedance occurrence by decade

Parameter	Exceedance occurrence	
	Geochemical controls	No geochemical controls
pH	2057 to 20700	2057 to 2060
TDS	2080	2080
Sulfate (SO_4)	2170	2170
Aluminium (Al)	2057	2057
Arsenic (As)	2057	2057
Iron (Fe)	n/a	2160
Mercury (Hg)	n/a	2530
Molybdenum (Mo)	2250	2250
Antimony (Sb)	2470	2450 only, then 2470 onwards
Selenium (Se)	2057	2057

Notes n/a = not applicable



(NC: no geochemical controls)

Figure 6.4 Deep Creek pH and TDS evolution

6.5 Stewarton/Ballamoo

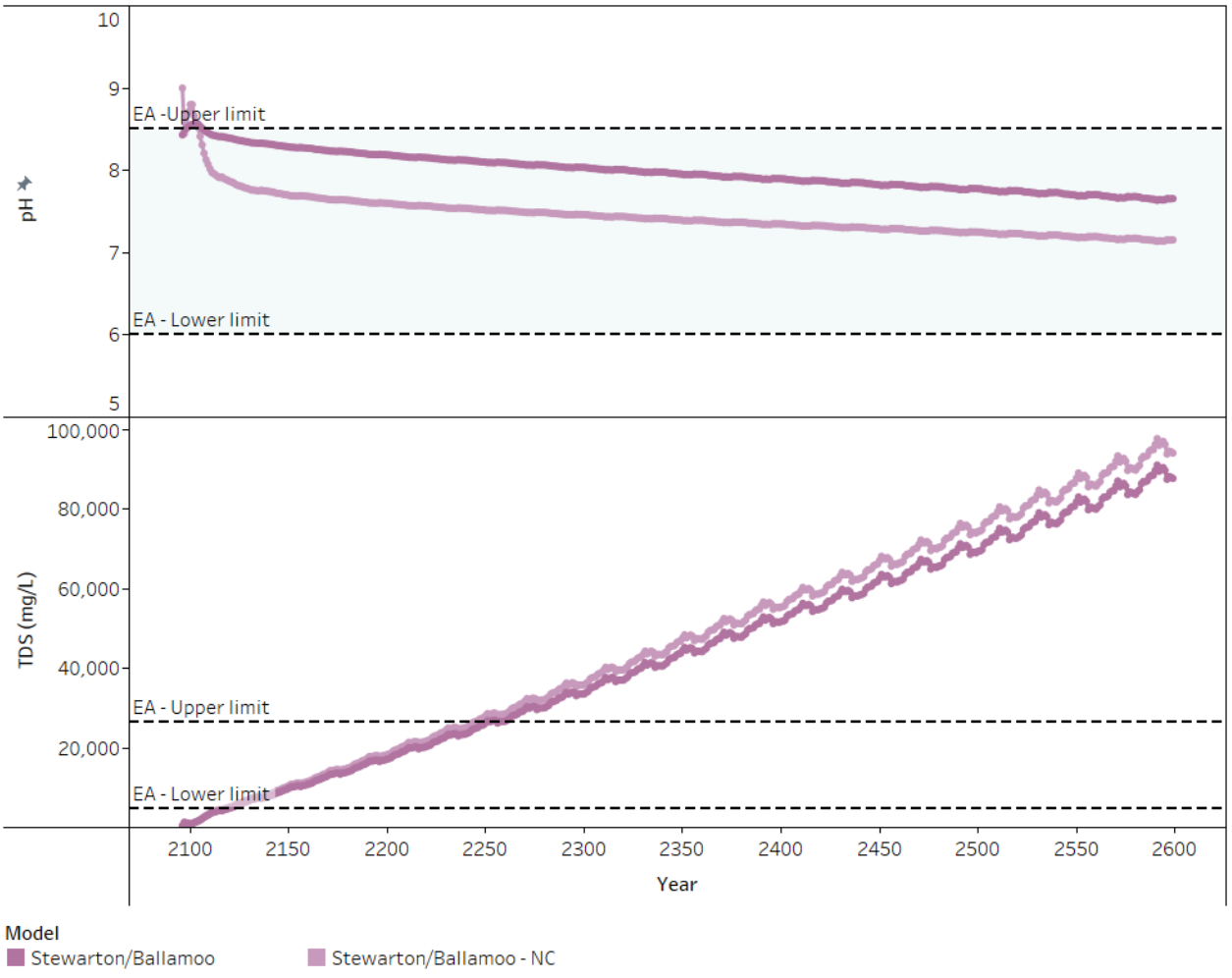
The model for the Stewarton/Ballamoo residual void is based on a closure year of 2094; however, results are provided from 2096 as the void lake is not established until 2096. Modelled results for pH and TDS are presented in Figure 6.5, with tabulated results at the start of each decade provided in Appendix B; figures of all parameters provided in Appendix C. The Stewarton/Ballamoo residual void is classified as a NUMA and predicted to behave as a terminal sink. Exceedances should, therefore, be considered in this context. The indicative timing by decade of when modelling results trigger EA values for each of the parameters is summarised in Table 6.6. Model results are summarised as follows:

- **pH:**
  - Acidic conditions are unlikely to develop in the Stewarton/Ballamoo residual void lake, with simulations indicating neutral to mildly alkaline pH values predicted, which are within the EA trigger value range for the modelled period. A decreasing pH trend is observed for both simulations.
  - The simulation with geochemical controls results in a higher pH than the simulation without geochemical controls. The main geochemical control is CO_2 degassing which raises pH, resulting in carbonate mineral precipitation that reduces pH, such as calcite ($CaCO_3$), and magnesite ($MgCO_3$). These geochemical processes are driven by the input of dissolved inorganic carbon, from runoff and groundwater inflow to the void lake.
- **TDS:**
  - TDS concentrations increase with time, indicating the development of hypersaline conditions. TDS concentrations exceed the EA-derived trigger value (26,505 mg/L) by the year 2120 in both simulations The increase in TDS concentration is primarily driven by evapo-concentration.
  - TDS concentrations are lower in simulations with geochemical controls due to the removal of barium, calcium, iron, magnesium, manganese and dissolved inorganic carbon through barite ($BaSO_4$), calcite ($CaCO_3$), ferrihydrite (FeOOH) and magnesite ($MgCO_3$) precipitation. Geochemical controls do not lead to an 'equilibrium' state for water quality (i.e., constant TDS).
- **Metal(loid)s:**
  - Predicted aluminium, antimony, arsenic, mercury, molybdenum, sulfate, and selenium concentrations exceed the EA criteria in simulations with and without geochemical controls.
  - Predicted iron concentrations exceed the EA criteria in simulations without geochemical controls.
  - Predicted selenium and mercury concentrations exceed the EA criteria due to expressing results below LOR by half the LOR, and therefore, may not be representative.
  - The decrease in iron concentration occurs through ferrihydrite (FeOOH) precipitation and drives the reduction in concentrations of other metal(loid)s (arsenic, beryllium, copper, nickel, lead, vanadium, and zinc) through adsorption processes.
- **Stratification:** The steep sides of the void and the high TDS present favourable conditions for stratification, with a maximum estimated water depth of ~84 m. The water of higher density (cooler or more saline) has the potential to become isolated at depth. Hydrodynamic/limnological analysis is required to assess the importance of seasonal mixing processes and groundwater mixing inputs, to confirm if thermal/chemical stratification is likely to occur.
- **Model QA/QC:** pe and water mass conservation stay within a suitable range throughout the model duration.

Table 6.6 Stewarton/Ballamoo EA first exceedance occurrence by decade

Parameter	Exceedance occurrence	
	Geochemical controls	No geochemical controls
pH	n/a	2096 to 2100
TDS	2120	2120
Sulfate (SO_4)	2170	2170
Aluminium (Al)	2096	2096
Arsenic (As)	2096	2096
Iron (Fe)	n/a	2170
Mercury (Hg)	2350	2350
Molybdenum (Mo)	2180	2180
Antimony (Sb)	2270	2270
Selenium (Se)	2110	2110

Notes n/a = not applicable



(NC: no geochemical controls)

Figure 6.5 Stewarton/Ballamoo pH and TDS evolution

6.6 Kenmare

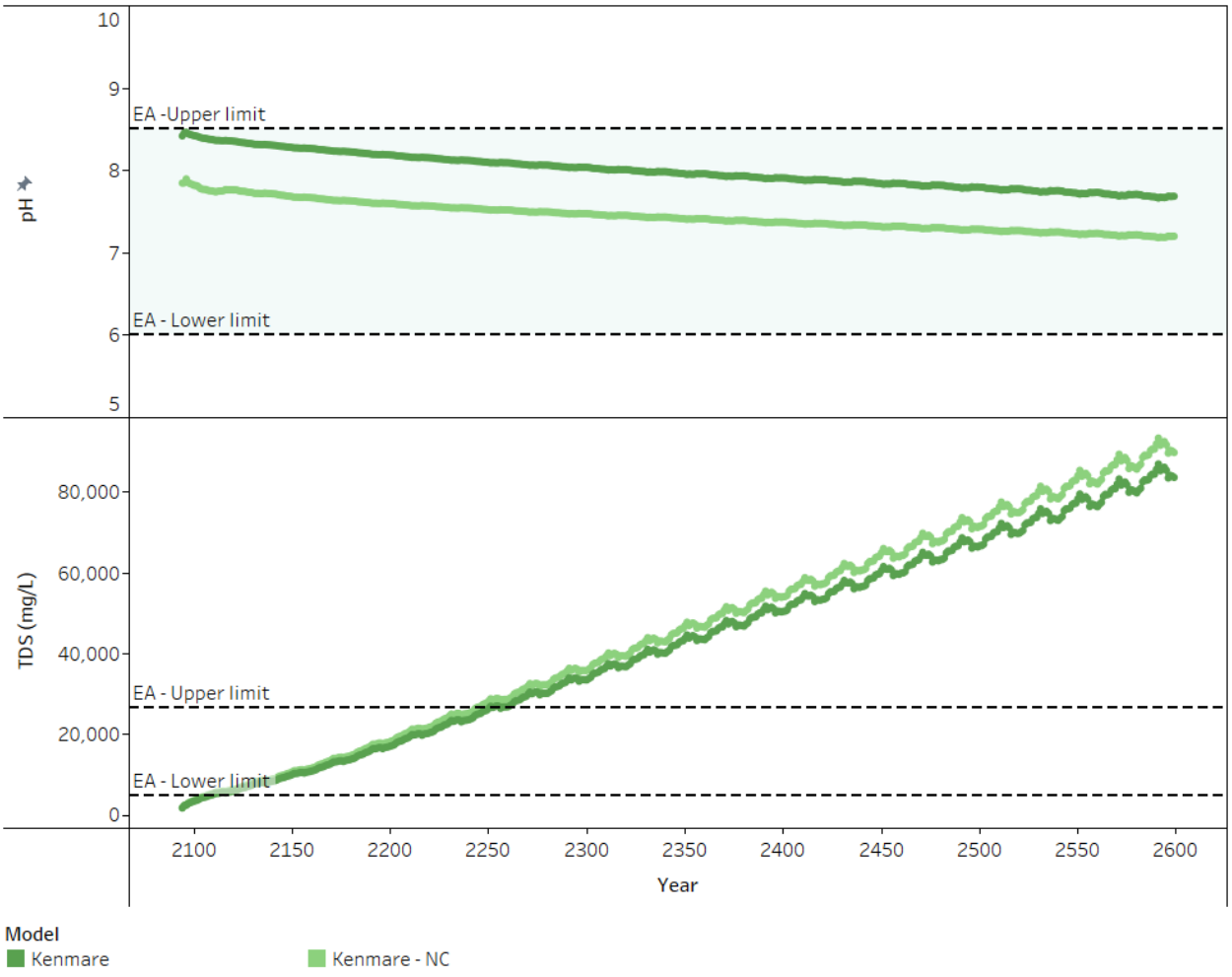
The model for the Kenmare residual void is based on a closure year of 2094 and results are provided from that date onward. Modelled results for pH and TDS are presented in Figure 6.6, with tabulated results at the start of each decade provided in Appendix B; figures of all parameters provided in Appendix C. The Kenmare residual void is classified as a NUMA and predicted to behave as a terminal sink. Exceedances should, therefore, be considered in this context. The indicative timing by decade of when modelling results trigger EA values for each of the parameters is summarised in Table 6.7. Model results are summarised as follows:

- **pH:**
  - Acidic conditions are unlikely to develop in the Kenmare residual void lake, with simulations indicating neutral to mildly alkaline pH values predicted, which are within the EA trigger value range for the modelled period. A decreasing pH trend is observed for both simulations.
  - The simulation with geochemical controls results in a higher pH than the simulation without geochemical controls. The main geochemical control is CO_2 degassing which raises pH, resulting in carbonate mineral precipitation that reduces pH, such as calcite ($CaCO_3$), and magnesite ($MgCO_3$). These geochemical processes are driven by the input of dissolved inorganic carbon, from runoff and groundwater inflow to the void lake.
- **TDS:**
  - TDS concentrations increase with time, indicating the development of hypersaline conditions. TDS concentrations exceed the EA-derived trigger value (26,505 mg/L) by the year 2110 in both simulations.
  - The increase in TDS concentration is primarily driven by evapo-concentration.
  - TDS concentrations are lower in simulations with geochemical controls due to the removal of barium, calcium, iron, magnesium, manganese and dissolved inorganic carbon through barite ($BaSO_4$), calcite ($CaCO_3$), ferrihydrite (FeOOH) and magnesite ($MgCO_3$) precipitation. Geochemical controls do not lead to an 'equilibrium' state for water quality (i.e., constant TDS).
- **Metal(loid)s:**
  - Predicted aluminium, antimony, arsenic, mercury, molybdenum, sulfate, and selenium concentrations exceed the EA criteria in simulations with and without geochemical controls.
  - Predicted iron concentrations exceed the EA criteria in simulations without geochemical controls.
  - Predicted selenium and mercury concentrations exceed the EA criteria due to expressing results below LOR by half the LOR, and therefore, may not be representative.
  - The decrease in iron concentration occurs through ferrihydrite (FeOOH) precipitation and drives the reduction in concentrations of other metal(loid)s (arsenic, beryllium, copper, nickel, lead, vanadium, and zinc) through adsorption processes.
- **Stratification:** The steep sides of the void and the high TDS present favourable conditions for stratification, with a maximum estimated water depth of ~62 m. The water of higher density (cooler or more saline) has the potential to become isolated at depth. Hydrodynamic/limnological analysis is required to assess the importance of seasonal mixing processes and groundwater mixing inputs, to confirm if thermal/chemical stratification is likely to occur.
- **Model QA/QC:** pe and water mass conservation stay within a suitable range throughout the model duration.

Table 6.7 Kenmare EA first exceedance occurrence by decade

Parameter	Exceedance occurrence	
	Geochemical controls	No geochemical controls
pH	n/a	n/a
TDS	2110	2110
Sulfate (SO_4)	2170	2170
Aluminium (Al)	2100	2100
Arsenic (As)	2120	2100
Iron (Fe)	n/a	2170
Mercury (Hg)	2350	2350
Molybdenum (Mo)	2190	2190
Antimony (Sb)	2260	2260
Selenium (Se)	2120	2110

Notes n/a = not applicable



(NC: no geochemical controls)

Figure 6.6 Kenmare pH and TDS evolution

6.7 Laleham

The model for the Laleham residual void is based on a closure year of 2090; however, results are provided until 2122 as the model convergence issues were encountered, likely caused by low lake volume and extremely high predicted salinity (ionic strength surpassing the threshold capability of the thermodynamic database used in the model). Modelled results for pH and TDS are presented in Figure 6.7, with tabulated results at the start of each decade provided in Appendix B; figures of all parameters provided in Appendix C. The Kenmare residual void is classified as a NUMA and predicted to behave as a terminal sink. Exceedances should, therefore, be considered in this context. The indicative timing by decade of when modelling results trigger EA values for each of the parameters is summarised in Table 6.8. Model results are summarised as follows:

- **pH:**
  - Acidic conditions are unlikely to develop in the Laleham residual void lake, with simulations indicating neutral to mildly alkaline pH values predicted, which are within the EA trigger value range for the modelled period. The pH trend for both simulations is variable and decreasing.
  - The simulation with geochemical controls results in a higher pH than the simulation without geochemical controls. The main geochemical control is CO_2 degassing which raises pH, resulting in carbonate mineral precipitation that reduces pH, such as calcite ($CaCO_3$), and magnesite ($MgCO_3$). These geochemical processes are driven by the input of dissolved inorganic carbon, from runoff and groundwater inflow to the void lake.
- **TDS:**
  - TDS concentrations increase with time, indicating the development of hypersaline conditions. TDS concentrations exceed the EA-derived trigger value (26,505 mg/L) by the year 2100 in both simulations. The distinctive TDS peaks predicted ~2103, ~2107, and ~2110 corresponds with higher influx of direct rainfall (and rehabilitation runoff), in combination with high evaporation for the same periods. During these periods, the inflow proportions of other inflows are comparatively lower.
  - The increase in TDS concentration is primarily driven by evapo-concentration.
  - TDS concentrations are lower in simulations with geochemical controls due to the removal of barium, calcium, iron, magnesium, manganese and dissolved inorganic carbon through barite ($BaSO_4$), calcite ($CaCO_3$), ferrihydrite (FeOOH) and magnesite ($MgCO_3$) precipitation. Geochemical controls do not lead to an 'equilibrium' state for water quality (i.e., constant TDS).
- **Metal(loid)s:**
  - Predicted aluminium, antimony, arsenic, mercury, molybdenum, sulfate, and selenium concentrations exceed the EA criteria in simulations with and without geochemical controls.
  - Predicted iron concentrations exceed the EA criteria in simulations without geochemical controls.
  - Predicted selenium and mercury concentrations exceed the EA criteria due to expressing results below LOR by half the LOR, and therefore, may not be representative.
  - The decrease in iron concentration occurs through ferrihydrite (FeOOH) precipitation and drives the reduction in concentrations of other metal(loid)s (arsenic, beryllium, copper, nickel, lead, vanadium, and zinc) through adsorption processes.
- **Stratification:** The steep sides of the void and the high TDS present favourable conditions for stratification, noting that the permanent lake is predicted to be small (maximum estimated water depth of ~2 m). The water of higher density (cooler or more saline) has the potential to become isolated at depth. Hydrodynamic/limnological analysis is required to assess the importance of seasonal mixing processes and groundwater mixing inputs, to confirm if thermal/chemical stratification is likely to occur.
- **Model QA/QC:** pe and water mass conservation stay within a suitable range throughout the model duration.

Table 6.8 Laleham EA first exceedance occurrence by decade

Parameter	Exceedance occurrence	
	Geochemical controls	No geochemical controls
pH	2090 only	2090
TDS	2100	2100
Sulfate (SO_4)	2100	2100
Aluminium (Al)	2090	2090
Arsenic (As)	2090	2090
Iron (Fe)	n/a	2100
Mercury (Hg)	2100	2100
Molybdenum (Mo)	2100	2100
Antimony (Sb)	2100	2100
Selenium (Se)	2100	2090

Notes n/a = not applicable



(NC: no geochemical controls)

Figure 6.7 Laleham pH and TDS evolution

6.8 Togara/North Marshmead

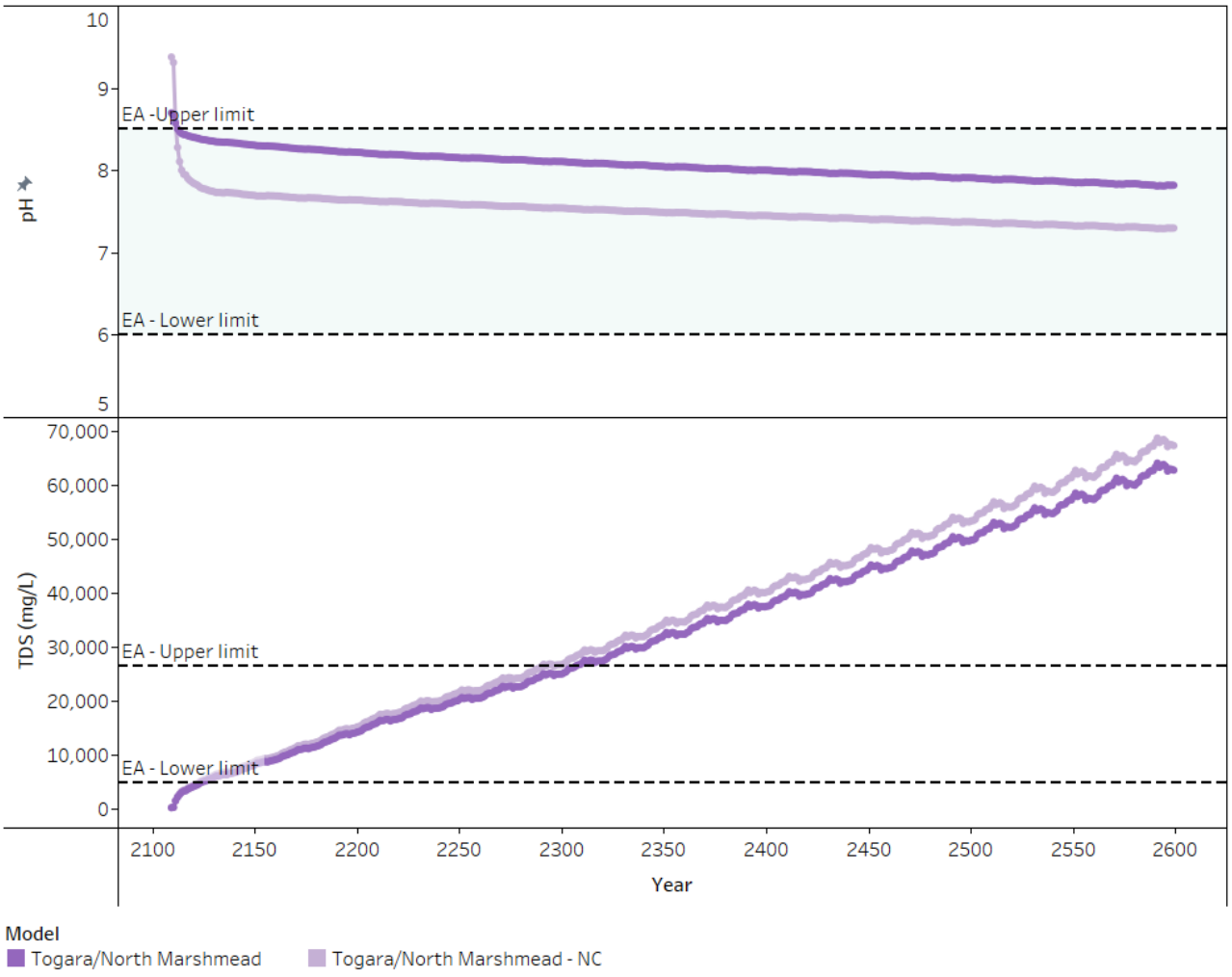
The model for the Togara/North Marshmead residual void is based on a closure year of 2109 and results are provided from that date onward. Modelled results for pH and TDS are presented in Figure 6.8, with tabulated results at the start of each decade provided in Appendix B; figures of all parameters provided in Appendix C. The Kenmare residual void is classified as a NUMA and predicted to behave as a terminal sink. Exceedances should, therefore, be considered in this context. The indicative timing by decade of when modelling results trigger EA values for each of the parameters is summarised in Table 6.9. Model results are summarised as follows:

- **pH:**
  - Acidic conditions are unlikely to develop in the Togara/North Marshmead residual void lake, with simulations indicating neutral to mildly alkaline pH values predicted, which are within the EA trigger value range for the modelled period. A stable pH trend is observed for both simulations.
  - The simulation with geochemical controls results in a higher pH than the simulation without geochemical controls. The main geochemical control is CO_2 degassing which raises pH, resulting in carbonate mineral precipitation that reduces pH, such as calcite ($CaCO_3$), and magnesite ($MgCO_3$). These geochemical processes are driven by the input of dissolved inorganic carbon, from runoff and groundwater inflow to the void lake.
- **TDS:**
  - TDS concentrations increase with time, indicating the development of hypersaline conditions. TDS concentrations exceed the EA-derived trigger value (26,505 mg/L) by the year 2130 in both simulations.
  - The increase in TDS concentration is primarily driven by evapo-concentration.
  - TDS concentrations are lower in simulations with geochemical controls due to the removal of barium, calcium, iron, magnesium, manganese and dissolved inorganic carbon through barite ($BaSO_4$), calcite ($CaCO_3$), ferrihydrite (FeOOH) and magnesite ($MgCO_3$) precipitation. Geochemical controls do not lead to an 'equilibrium' state for water quality (i.e., constant TDS).
- **Metal(loid)s:**
  - Predicted aluminium, antimony, arsenic, mercury, molybdenum, sulfate, and selenium concentrations exceed the EA criteria in simulations with and without geochemical controls.
  - Predicted iron concentrations exceed the EA criteria in simulations without geochemical controls.
  - Predicted selenium and mercury concentrations exceed the EA criteria due to expressing results below LOR by half the LOR, and therefore, may not be representative.
  - The decrease in iron concentration occurs through ferrihydrite (FeOOH) precipitation and drives the reduction in concentrations of other metal(loid)s (arsenic, beryllium, copper, nickel, lead, vanadium, and zinc) through adsorption processes.
- **Stratification:** The steep sides of the void and the high TDS present favourable conditions for stratification, with a maximum estimated water depth of ~88 m. The water of higher density (cooler or more saline) has the potential to become isolated at depth. Hydrodynamic/limnological analysis is required to assess the importance of seasonal mixing processes and groundwater mixing inputs, to confirm if thermal/chemical stratification is likely to occur.
- **Model QA/QC:** pe and water mass conservation stay within a suitable range throughout the model duration.

Table 6.9 Togara/North Marshmead EA first exceedance occurrence by decade

Parameter	Exceedance occurrence	
	Geochemical controls	No geochemical controls
pH	2109 to 2110	2109 to 2110
TDS	2130	2130
Sulfate (SO^4)	2190	2190
Aluminium (Al)	2109	2109
Arsenic (As)	2109 to 2110, 2140 onwards	2109
Iron (Fe)	n/a	2180
Mercury (Hg)	2430	2430
Molybdenum (Mo)	2200	2190
Antimony (Sb)	2310	2310
Selenium (Se)	2109	2109

Notes n/a = not applicable



(NC: no geochemical controls)

Figure 6.8 Togara/North Marshmead pH and TDS evolution

6.9 South Marshmead

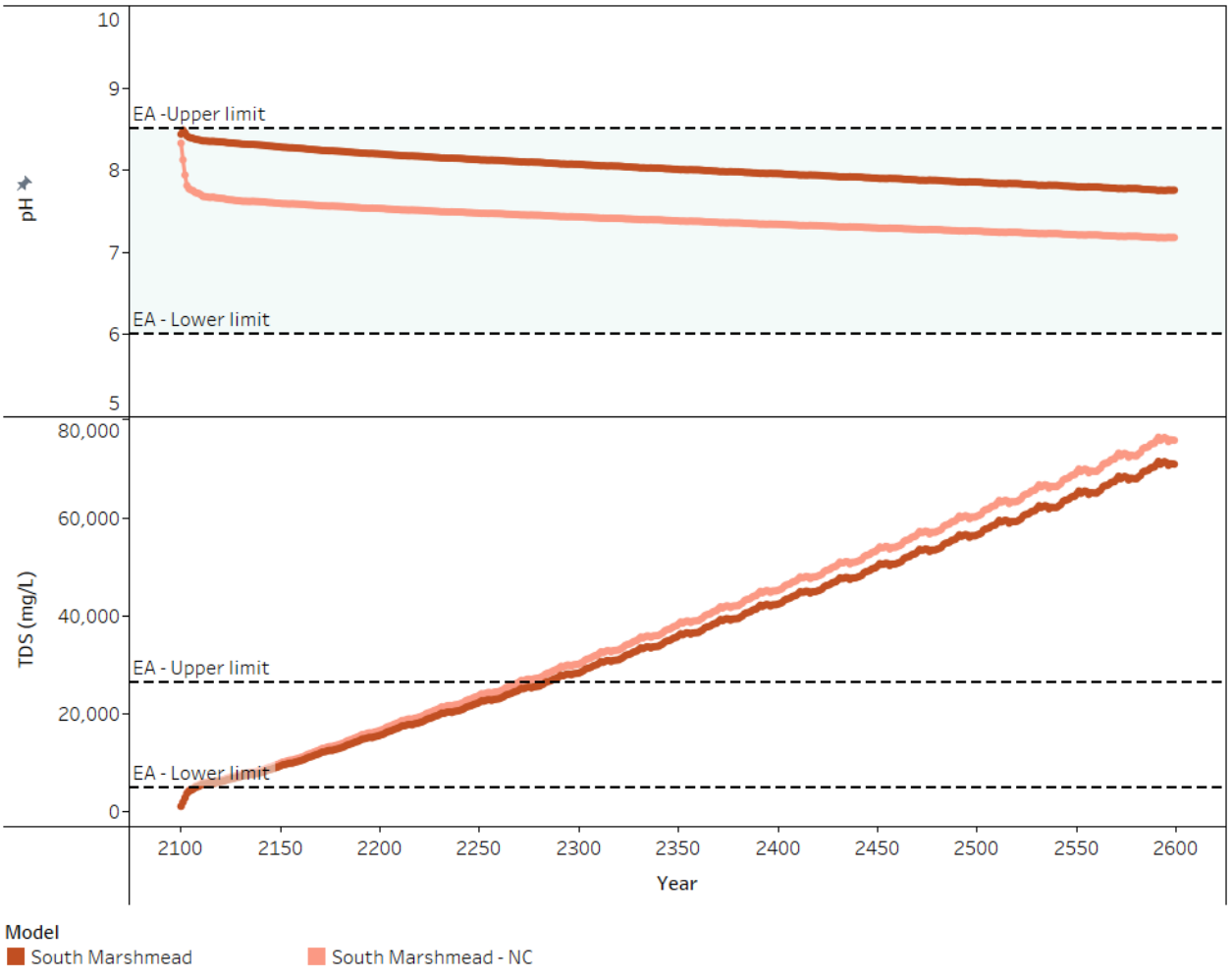
The model for the South Marshmead residual void is based on a closure year of 2100 and results are provided from that date onward. Modelled results for pH and TDS are presented in Figure 6.9, with tabulated results at the start of each decade provided in Appendix B; figures of all parameters provided in Appendix C. The South Marshmead residual void is classified as a NUMA and predicted to behave as a terminal sink. Exceedances should, therefore, be considered in this context. The indicative timing by decade of when modelling results trigger EA values for each of the parameters is summarised in Table 6.10. Model results are summarised as follows:

- **pH:**
  - Acidic conditions are unlikely to develop in the South Marshmead residual void lake, with simulations indicating neutral to mildly alkaline pH values predicted, which are within the EA trigger value range for the modelled period. A stable pH trend is observed for both simulations.
  - The simulation with geochemical controls results in a higher pH than the simulation without geochemical controls. The main geochemical control is CO_2 degassing which raises pH, resulting in carbonate mineral precipitation that reduces pH, such as calcite ($CaCO_3$), and magnesite ($MgCO_3$). These geochemical processes are driven by the input of dissolved inorganic carbon, from runoff and groundwater inflow to the void lake.
- **TDS:**
  - TDS concentrations increase with time, indicating the development of hypersaline conditions. TDS concentrations exceed the EA-derived trigger value (26,505 mg/L) by the year 2110 in both simulations.
  - The increase in TDS concentration is primarily driven by evapo-concentration.
  - TDS concentrations are lower in simulations with geochemical controls due to the removal of barium, calcium, iron, magnesium, manganese and dissolved inorganic carbon through barite ($BaSO_4$), calcite ($CaCO_3$), ferrihydrite (FeOOH) and magnesite ($MgCO_3$) precipitation. Geochemical controls do not lead to an 'equilibrium' state for water quality (i.e., constant TDS).
- **Metal(loid)s:**
  - Predicted aluminium, antimony, arsenic, mercury, molybdenum, sulfate, and selenium concentrations exceed the EA criteria in simulations with and without geochemical controls.
  - Predicted iron concentrations exceed the EA criteria in simulations without geochemical controls.
  - Predicted selenium and mercury concentrations exceed the EA criteria due to expressing results below LOR by half the LOR, and therefore, may not be representative.
  - The decrease in iron concentration occurs through ferrihydrite (FeOOH) precipitation and drives the reduction in concentrations of other metal(loid)s (arsenic, beryllium, copper, nickel, lead, vanadium, and zinc) through adsorption processes.
- **Stratification:** The steep sides of the void and the high TDS present favourable conditions for stratification, with a maximum estimated water depth of ~77 m. The water of higher density (cooler or more saline) has the potential to become isolated at depth. Hydrodynamic/limnological analysis is required to assess the importance of seasonal mixing processes and groundwater mixing inputs, to confirm if thermal/chemical stratification is likely to occur.
- **Model QA/QC:** pe and water mass conservation stay within a suitable range throughout the model duration.

Table 6.10 South Marshmead EA first exceedance occurrence by decade

Parameter	Exceedance occurrence	
	Geochemical controls	No geochemical controls
pH	n/a	n/a
TDS	2110	2110
Sulfate (SO^4)	2180	2180
Aluminium (Al)	2100	2100
Arsenic (As)	2170	2100
Iron (Fe)	n/a	2180
Mercury (Hg)	2470	2450
Molybdenum (Mo)	2260	2260
Antimony (Sb)	2390	2390
Selenium (Se)	2130	2130

Notes n/a = not applicable



(NC: no geochemical controls)

Figure 6.9 South Marshmead pH and TDS evolution

6.10 Kennedy West

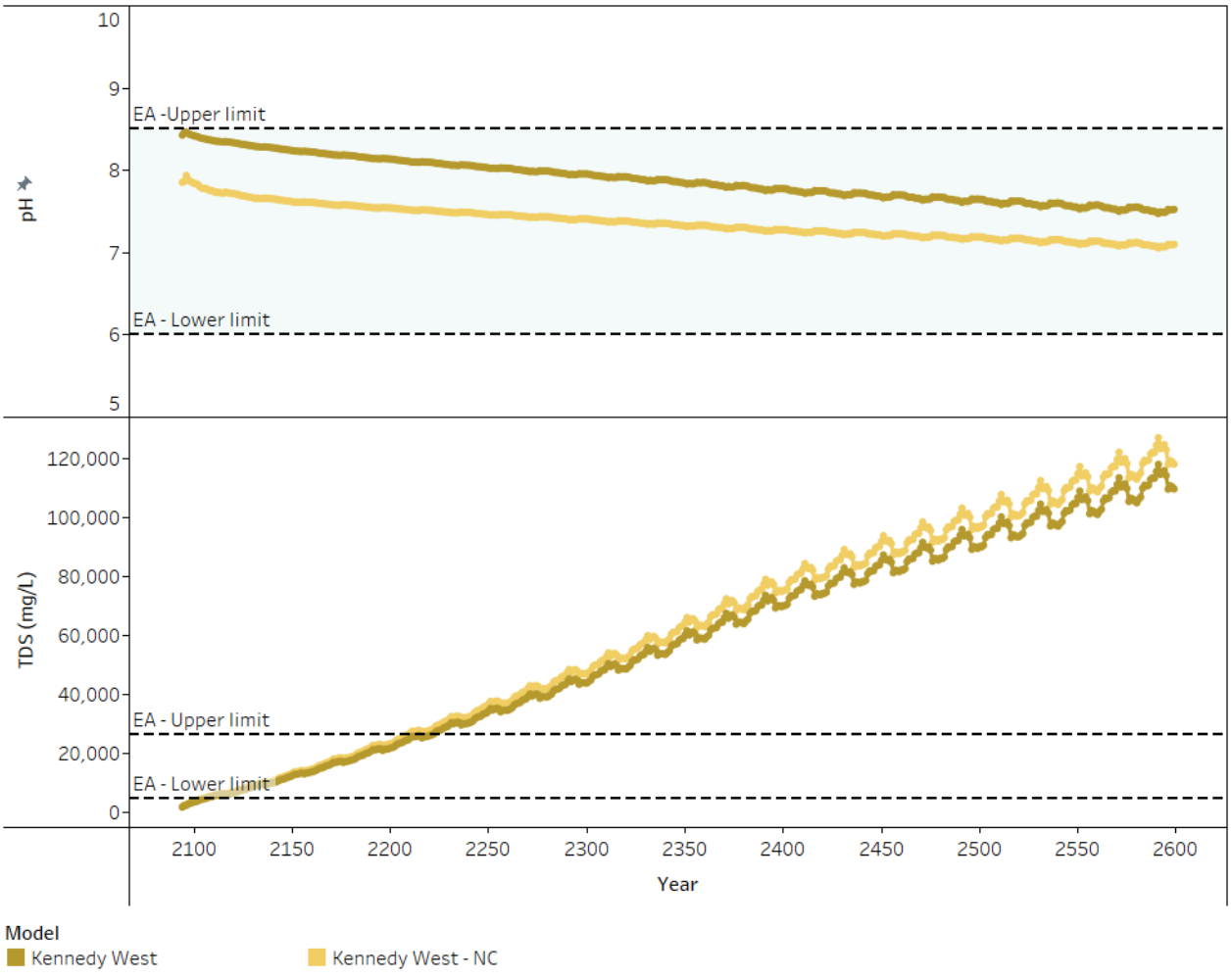
The model for the Kennedy West residual void is based on a closure year of 2094 and results are provided from that date onward. Modelled results for pH and TDS are presented in Figure 6.10, with tabulated results at the start of each decade provided in Appendix B; figures of all parameters provided in Appendix C. The Kennedy West residual void is classified as a NUMA and predicted to behave as a terminal sink. Exceedances should, therefore, be considered in this context. The indicative timing by decade of when modelling results trigger EA values for each of the parameters is summarised in Table 6.11. Model results are summarised as follows:

- **pH:**
  - Acidic conditions are unlikely to develop in the Kennedy West residual void lake, with simulations indicating neutral to mildly alkaline pH values predicted, which are within the EA trigger value range for the modelled period. A stable pH trend is observed for both simulations.
  - The simulation with geochemical controls results in a higher pH than the simulation without geochemical controls. The main geochemical control is CO_2 degassing which raises pH, resulting in carbonate mineral precipitation that reduces pH, such as calcite ($CaCO_3$), and magnesite ($MgCO_3$). These geochemical processes are driven by the input of dissolved inorganic carbon, from runoff and groundwater inflow to the void lake.
- **TDS:**
  - TDS concentrations increase with time, indicating the development of hypersaline conditions. TDS concentrations exceed the upper EA-derived trigger value (26,505mg/L) by the year 2110 in both simulations.
  - The increase in TDS concentration is primarily driven by evapo-concentration.
  - TDS concentrations are lower in simulations with geochemical controls due to the removal of barium, calcium, iron, magnesium, manganese and dissolved inorganic carbon through barite ($BaSO_4$), calcite ($CaCO_3$), ferrihydrite (FeOOH) and magnesite ($MgCO_3$) precipitation. Geochemical controls do not lead to an 'equilibrium' state for water quality (i.e., constant TDS).
- **Metal(loid)s:**
  - Predicted aluminium, antimony, arsenic, mercury, molybdenum, sulfate, and selenium concentrations exceed the EA criteria in simulations with and without geochemical controls.
  - Predicted iron concentrations exceed the EA criteria in simulations without geochemical controls.
  - Predicted selenium and mercury concentrations exceed the EA criteria due to expressing results below LOR by half the LOR, and therefore, may not be representative.
  - The decrease in iron concentration occurs through ferrihydrite (FeOOH) precipitation and drives the reduction in concentrations of other metal(loid)s (arsenic, beryllium, copper, nickel, lead, vanadium, and zinc) through adsorption processes.
- **Stratification:** The steep sides of the void and the high TDS present favourable conditions for stratification, with a maximum estimated water depth of ~43 m. The water of higher density (cooler or more saline) has the potential to become isolated at depth. Hydrodynamic/limnological analysis is required to assess the importance of seasonal mixing processes and groundwater mixing inputs, to confirm if thermal/chemical stratification is likely to occur.
- **Model QA/QC:** pe and water mass conservation stay within a suitable range throughout the model duration.

Table 6.11 Kennedy West EA first exceedance occurrence by decade

Parameter	Exceedance occurrence	
	Geochemical controls	No geochemical controls
pH	n/a	n/a
TDS	2110	2110
Sulfate (SO^4)	2150	2150
Aluminium (Al)	2100	2100
Arsenic (As)	2120	2100
Iron (Fe)	n/a	2150
Mercury (Hg)	2290	2290
Molybdenum (Mo)	2170	2170
Antimony (Sb)	2230	2230
Selenium (Se)	2110	2110

Notes n/a = not applicable



(NC: no geochemical controls)

Figure 6.10 Kennedy West pH and TDS evolution

6.11 Comet Downs East

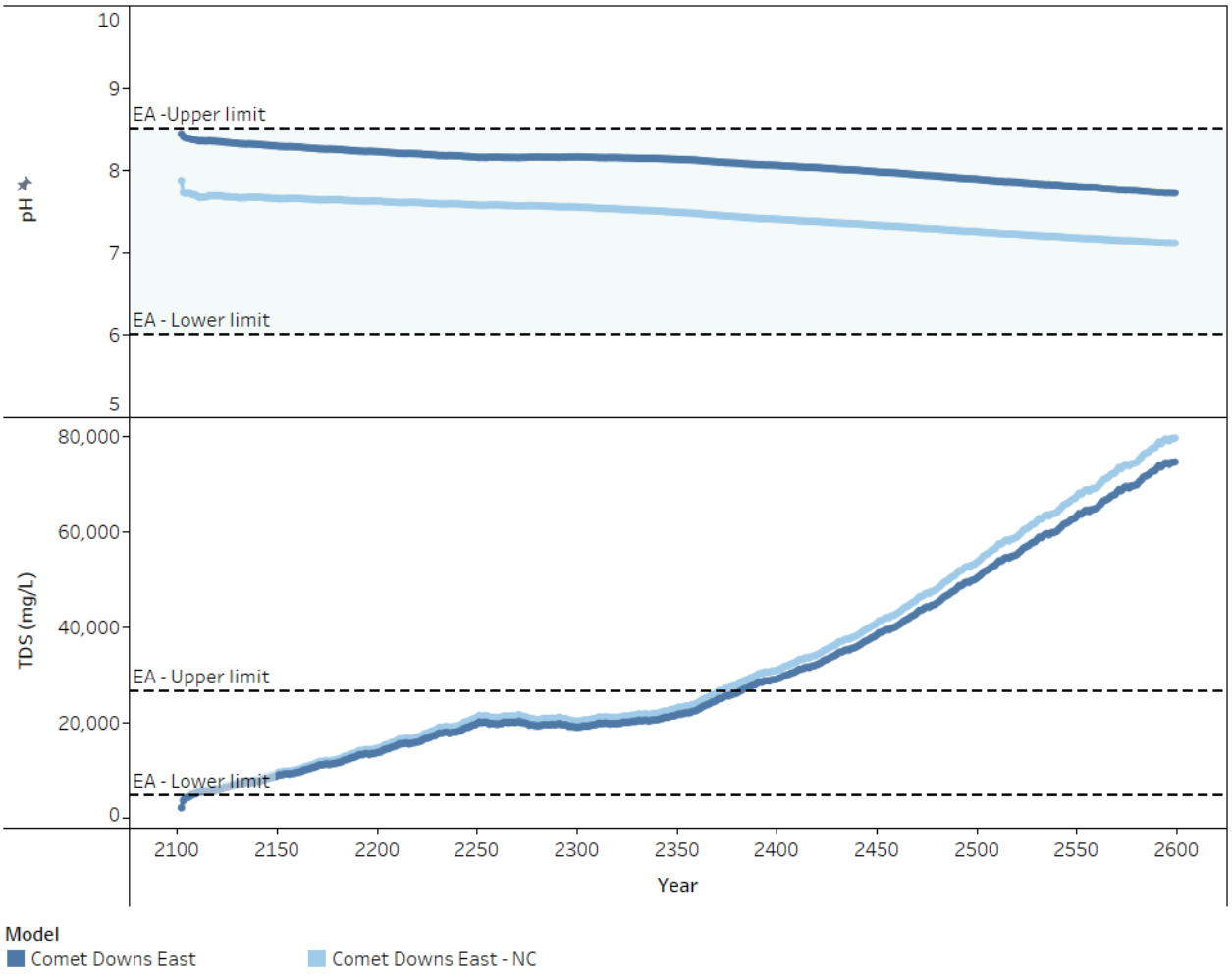
The model for the Comet Downs East residual void is based on a closure year of 2102 and results are provided from that date onward. Modelled results for pH and TDS are presented in Figure 6.11, with tabulated results at the start of each decade provided in Appendix B; figures of all parameters provided in Appendix C. The Comet Downs East residual void is classified as a NUMA and predicted to behave as a terminal sink. Exceedances should, therefore, be considered in this context. The indicative timing by decade of when modelling results trigger EA values for each of the parameters is summarised in Table 6.12. Model results are summarised as follows:

- **pH:**
  - Acidic conditions are unlikely to develop in the Comet Downs East residual void lake, with simulations indicating neutral to mildly alkaline pH values predicted, which are within the EA trigger value range for the modelled period. A decreasing pH trend is observed for both simulations.
  - The simulation with geochemical controls results in a higher pH than the simulation without geochemical controls. The main geochemical control is CO_2 degassing which raises pH, resulting in carbonate mineral precipitation that reduces pH, such as calcite ($CaCO_3$), and magnesite ($MgCO_3$). These geochemical processes are driven by the input of dissolved inorganic carbon, from runoff and groundwater inflow to the void lake.
- **TDS:**
  - TDS concentrations increase with time, indicating the development of hypersaline conditions. TDS concentrations exceed the EA-derived trigger value (26,505 mg/L) by the year 2110 in both simulations.
  - The increase in TDS concentration is primarily driven by evapo-concentration. Following an initial increase in the predicted TDS concentrations, it achieves a brief plateau period between ~2250 to 2350 in response to an increase in the groundwater inflow. At ~2350, the predicted TDS increases again in response to increasing evaporation and reduction in all inflows, except groundwater and direct rainfall (which remain constant).
  - TDS concentrations are lower in simulations with geochemical controls due to the removal of barium, calcium, iron, magnesium, manganese and dissolved inorganic carbon through barite ($BaSO_4$), calcite ($CaCO_3$), ferrihydrite (FeOOH) and magnesite ($MgCO_3$) precipitation. Geochemical controls do not lead to an 'equilibrium' state for water quality (i.e., constant TDS).
- **Metal(loid)s:**
  - Predicted aluminium, antimony, arsenic, mercury, molybdenum, sulfate, and selenium concentrations exceed the EA criteria in simulations with and without geochemical controls.
  - Predicted iron concentrations exceed the EA criteria in simulations without geochemical controls.
  - Predicted selenium and mercury concentrations exceed the EA criteria due to expressing results below LOR by half the LOR, and therefore, may not be representative.
  - The decrease in iron concentration occurs through ferrihydrite (FeOOH) precipitation and drives the reduction in concentrations of other metal(loid)s (arsenic, beryllium, copper, nickel, lead, vanadium, and zinc) through adsorption processes.
- **Stratification:** The steep sides of the void and the high TDS present favourable conditions for stratification, with a maximum estimated water depth of ~93 m. The water of higher density (cooler or more saline) has the potential to become isolated at depth. Hydrodynamic/limnological analysis is required to assess the importance of seasonal mixing processes and groundwater mixing inputs, to confirm if thermal/chemical stratification is likely to occur.
- **Model QA/QC:** pe and water mass conservation stay within a suitable range throughout the model duration.

Table 6.12 Comet Downs East South EA first exceedance occurrence by decade

Parameter	Exceedance occurrence	
	Geochemical controls	No geochemical controls
pH	n/a	n/a
TDS	2110	2110
Sulfate (SO^4)	2190	2190
Aluminium (Al)	2110	2110
Arsenic (As)	2140	2110
Iron (Fe)	n/a	2190
Mercury (Hg)	2550	2550
Molybdenum (Mo)	2210 to 2350, 2370 onwards	2210 to 2350, 2370 onwards
Antimony (Sb)	2550	2550
Selenium (Se)	2150	2140

Notes n/a = not applicable



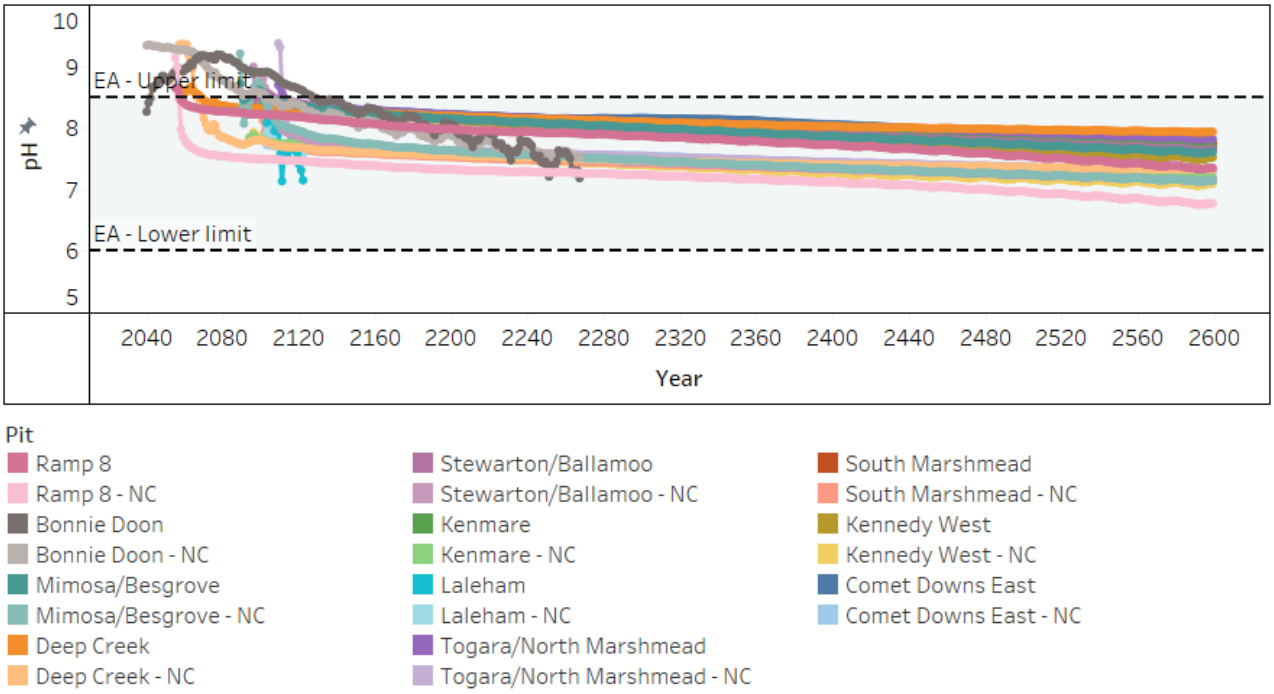
(NC: no geochemical controls)

Figure 6.11 Comet Downs East South pH and TDS evolution

6.12 Void comparison

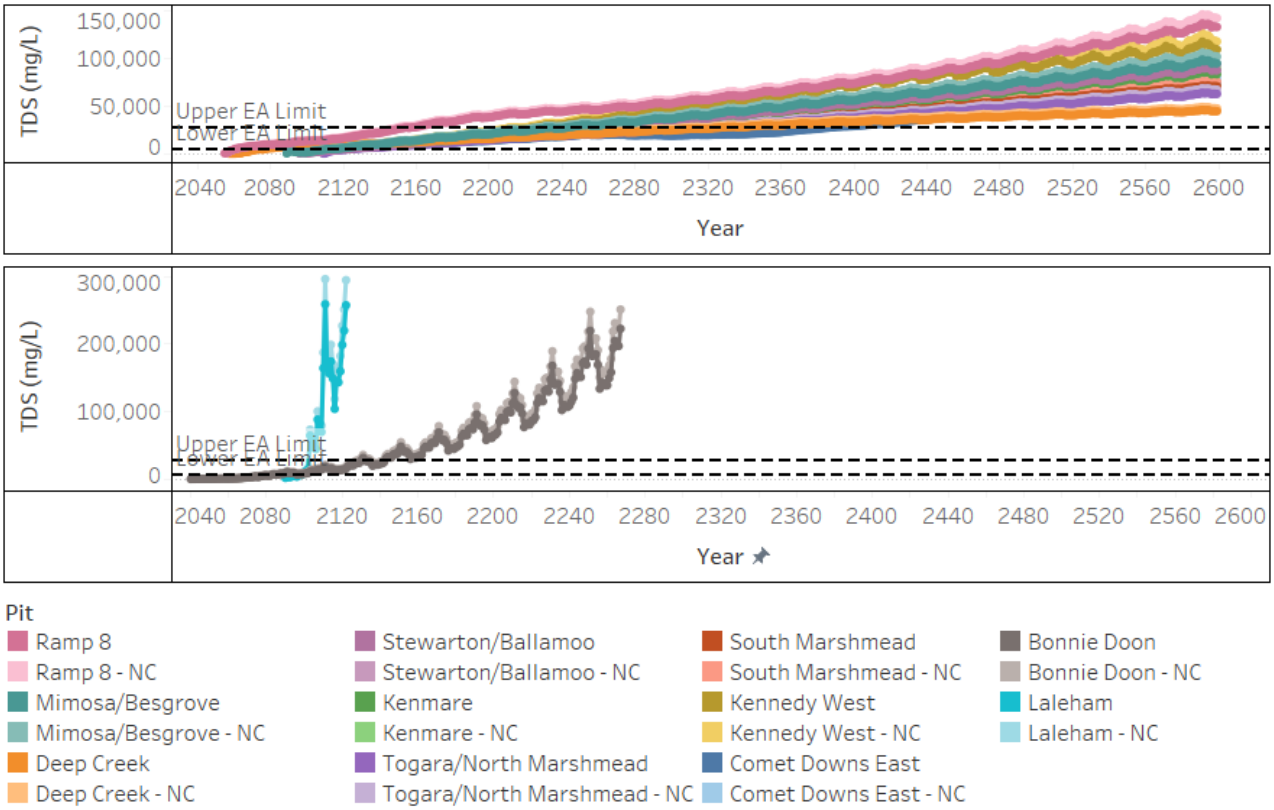
The modelled outputs of the simulations for all residual voids are presented in Figure 6.12 and Figure 6.13 for predicted pH and TDS, respectively. The outcomes of the void lake comparison for pH and TDS are summarised as follows:

- **pH:**
  - Acidic conditions are unlikely to develop in any of the BWM closure void lakes assessed. Neutral to mildly alkaline conditions are predicted to develop at all void lakes, remaining within the EA trigger value limits.
  - Geochemical controls do not significantly vary between the BWM voids. The key geochemical controls regulating pH are CO_2 degassing, which increases pH resulting in calcite ($CaCO_3$)/magnesite ($MgCO_3$) precipitation, which decreases pH.
- **TDS:**
  - Predicted TDS concentrations exceed the upper EA trigger value (26,505 mg/L) for all BWM residual voids by the end of the modelled period.
  - The increase of TDS at all voids is likely driven by evapo-concentration. The rate of TDS increase is largest at Bonnie Doon.
  - Lower TDS concentrations are predicted in simulations with geochemical controls due to the removal of barium, calcium, iron, magnesium, manganese and dissolved inorganic carbon through barite ($BaSO_4$), calcite ($CaCO_3$), ferrihydrite (FeOOH), magnesite ($MgCO_3$) precipitation. Geochemical controls do not lead to an 'equilibrium' state for water quality (i.e., constant TDS).
- **Metal(loid)s:**
  - For all BWM residual voids, the predicted aluminium, antimony, arsenic, mercury, molybdenum, sulfate, and selenium concentrations exceed the EA criteria in simulations with and without geochemical controls, while predicted iron concentrations only exceed the EA criteria in simulations without geochemical controls.
  - Predicted selenium, and mercury concentrations exceed the EA criteria due to expressing results below the LOR by half the LOR for model input, and therefore, may not be representative.
- **Stratification:**
  - All BWM voids present steep sides and high depths which together with high TDS are favourable conditions for stratification. The water of higher density (cooler or more saline) has the potential to become isolated at depth. Hydrodynamic/limnological analysis is required to assess the importance of seasonal mixing processes and groundwater mixing inputs, to confirm if thermal/chemical stratification is likely to occur. Additionally, if stratification occurs the higher TDS concentration may potentially seep beyond the residual void walls through density-driven seepage. There may be an opportunity to mitigate risks associated with stratification and density driven saline seepage for two voids (i.e., Bonnie Doon and Laleham). The permanent void lake is predicted to be shallow (10 m and 2 m, respectively, and backfilling may be achievable to prevent void lake formation. These void lakes have the highest predicted TDS.



(NC: no geochemical controls)

Figure 6.12 Summary of predicted pH conditions at BWM residual void lakes



(NC: no geochemical controls)

Figure 6.13 Summary of predicted TDS conditions at BWM residual void lakes

7 Conclusions and recommendations

7.1 Conclusions

Based on the outcomes of this assessment, the water qualities of the BWM residual void lakes are predicted to evolve through time, primarily affected by evapo-concentration. The resulting concentrations of some analytes are simulated to exceed their respective groundwater EA trigger values. All eleven voids are classified as NUMAs and predicted to behave as terminal sinks. Exceedances should, therefore, be considered in this context.

The findings of the geochemical water quality model are summarised as follows:

- **Void lake pH:** Acidic conditions are unlikely to develop in all of the BWM closure residual void lakes assessed as there are no significant sources of acid generating materials associated with the surface water hydrology mine closure landforms. Geochemical models predict pH conditions within the EA-specified upper and lower limits for the modelled period at all residual void lakes.
- **Geochemical controls:** Simulations including geochemical controls generally result in lower TDS, barium, calcium, iron, magnesium, manganese and alkalinity concentrations due to the precipitation of barite ($BaSO_4$), calcite ($CaCO_3$), ferrihydrite (FeOOH), magnesite ($MgCO_3$). The groundwater input composition is the main source of dissolved inorganic carbon, calcium, magnesium, and iron to the void lakes. The decrease in iron concentration occurs through ferrihydrite (FeOOH) precipitation and drives the reduction in concentrations of other metals (arsenic, beryllium, copper, nickel, lead, vanadium, and zinc) through surface adsorption processes.
- **Void lake salinity:** The modelled TDS concentration in all voids generally increases through the full period of simulation, resulting in predicted hypersaline conditions. It is anticipated that the TDS concentration in all void lakes will continue to increase further, if models were to be extended. Further modelling for time scales beyond the current water balance is required to determine if or when a TDS concentration plateau is reached.
- **Dissolved metal(loid)s:** Predicted aluminium, antimony, arsenic, mercury, molybdenum, sulfate, and selenium concentrations exceed the EA trigger values for all void lakes in simulations with and without geochemical controls. Selenium and mercury concentration exceedances are likely result from the substitution of results below LOR with half the LOR, and therefore, may not be relevant. All BWM voids are classified as NUMAs and predicted to behave as terminal sinks. Exceedances of predicted parameter concentrations to EA criteria should, therefore, be interpreted in this context.
- **Stratification:** Most voids have deep estimated maximum water depths (~34 to 93 m), except for Bonnie Doon (~10 m) and Laleham (~2 m). Lake depth coupled with predicted hypersaline conditions render the likely probability for stratification to develop during a post-closure period. It should be noted that there may be opportunity to mitigate risks associated with stratification or density driven saline seepage for Bonnie Doon and Laleham through backfilling the voids. Lake TDS is shown to be directly related to evapo-concentration of lake water.
- **Density-driven saline seepage:** predicted residual void lake water quality is predicted to have higher TDS concentrations than the median inflowing groundwater and may potentially seep beyond the residual void walls through density-driven seepage.

7.2 Caveats and limitations

The following caveats and limitations apply to the water quality model:

- Available groundwater and static leachate data were used to represent the relevant geochemical interactions.

- Water movements are based on complementary studies (groundwater and water balance). These studies constrain the model duration and the water sources. Most notably, it is currently not possible to quantify in-pit seepage through spoil.
- Assessment for some metal(loid)s (selenium and silver) are likely to be biased high as the analytical data recorded was below the LOR at the start of the modelling period (i.e., input source terms). The replacement of the LOR by half its value results in an artificial increase by evapo-concentration.
- There are no defined EA criteria for void lake water quality and, thus, screening was performed against EA criteria for groundwater contaminant trigger values.
- The criteria for TDS were derived from EC using a 0.67 factor that is considered acceptable for freshwater. No criteria for TDS was available and since the water quality modelling predicts TDS, a conversion of EC to TDS was required. Future groundwater sampling should include gravimetric analysis of TDS and criteria developed. This should be compared to the calculated TDS criteria used in the current assessment for verification purposes.

7.3 Recommendations

The geochemical assessment is limited in several ways, due to the availability of data or the current progress of other related studies. The following activities are recommended before closure to facilitate future geochemical modelling studies, and to refine and improve upon key assumptions made in this study:

- Measure elements, especially selenium, silver and mercury, by methods with lower detection limits (i.e., ORC ICP-MS and low-level/ultra-trace FIMS, respectively) to reduce the bias that may have occurred due to half LOR values used in the modelling. In addition, include silicon in the analysis suite.
- Further screening could supplement the study, such as the Australian and New Zealand Environment Conservation Council and Agriculture and Resource Management Council of Australia (ANZECC & ARMCANZ) guidelines and/or derivation of site-specific trigger values for the void lakes.
- Undertake a hydrodynamic/limnological assessment for lake stratification and potential density-driven seepage, including predictions of mixed layer depth and seasonality based upon local/regional wind patterns and solar insolation patterns and the role of groundwater mixing. Comparison to appropriate regional lakes and void lakes should be conducted.
- Define seepage through the spoil to the void lake in future water balance modelling, once appropriate groundwater models are available.
- At the time of undertaking the void water quality modelling, the EA trigger values were the criteria applied for comparison to modelled water quality. However, as these values may not be specific to NUMAs, future water quality assessments should consider criteria specific to the residual voids and NUMAs.
- Run kinetic tests (and static oxidation texts) on representative wall-rock coal samples to better understand long term behaviour and account for potential AMD from oxidation of *in situ* coal seams exposed on the pit highwalls. Leachate data available for coal seam materials exposed on highwalls were considered unrepresentative.
- Account for potential release of coal bed methane caused during the dewatering of coal seams which can drive groundwater or lake chemistry towards more reducing conditions.
- Map highwall exposures for pits that have no available data (Ramp 8, Ballamoo, Comet Downs East, Kennedy West, etc) as analogue data was used as a substitute.
- If residual void lakes have already developed, the lake water should be sampled and analysed to assist in the calibration of the water quality models and for comparison against modelled water quality. It can also be used in the water balance models to consider pit lakes already present (i.e., water balance to start with a lake instead of a dry void assumption).
- Consider possible hydraulic inter-connectivity between void lakes (i.e., seepage from one void migrating to another void).

8 Next steps

Outcomes from this assessment will guide the development of, or form an input into, the following PRCP technical studies for void closure planning deliverables:

- BWM Void Closure Plan – to be developed by WSP.
- Inputs required for relevant sections of the BWM PRCP (third party).

The geochemical models and their results presented in this study represent the first of several iterations of this study for BWM. As new and improved data becomes available, this model will be re-run, and results should improve in accuracy, robustness, and defensibility.

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10 Closure

We trust that this technical report meets WHC's needs. If you have any queries, please do not hesitate to contact Bob Boshrouyeh.

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Appendix A

Model source terms



Table A.1 Water quality model source term compositions

Parameter	Unit	Metal(loid) LOR	Lower EA TV	Upper EA TV	Groundwater	Fresh carbonaceous	Fresh coal	Weathered non-carbonaceous	Fresh non-carbonaceous
pH	pH Units	-	6.5 to 8.5	6.5 to 8.5	7.53	9.2	8.5	7.7	9.4
pe	pe units	-	-	-	4	8	8	8	8
TDS	mg/L	-	4,992	10,599	-	-	-	-	-
Alkalinity	mg/L as $CaCO_3$	-	-	-	368	66	40	7	93
Ca	mg/L	-	-	-	121	0.5	10.5	0.5	1
Mg	mg/L	-	-	-	232	0.5	3	0.75	1
K	mg/L	-	-	-	10	3	2	2	6
Na	mg/L	-	-	-	1815	66.5	17	53	67
Cl	mg/L	-	-	-	3095	8	6	35	11
F	mg/L	-	-	-	0.4	0.3	0.05	0.4	0.3
SO_4	mg/L	-	318	520	85	58	22	9.5	17
NO_3	mgN/L	-	-	-	0.005	0.005	0.005	0.02	0.005
Al	mg/L	0.01	0.055	0.48	0.01	0.09	0.06	0.05	0.15
Ag	mg/L	0.001	0.001	0.39	*0.0005*	*0.0005*	*0.0005*	*0.0005*	*0.0005*
As	mg/L	0.001	0.013	0.013	0.0025	0.018	0.0005	0.0005	0.042
B	mg/L	0.005	-	-	0.51	0.05	0.05	0.05	0.1
Ba	mg/L	0.002	-	-	0.5075	0.02	0.036	0.018	0.012
Be	mg/L	0.002 (GW: 0.001)	-	-	0.0005	0.0005	0.0005	0.0005	0.001
Cd	mg/L	0.0001	-	-	0.00005	0.00005	0.00005	0.00005	0.001
Co	mg/L	0.001	-	-	0.0025	0.0005	0.0005	0.0005	0.001
Cu	mg/L	0.001	-	-	0.002	0.0005	0.0005	0.0005	0.001
Cr	mg/L	0.001	-	-	0.0005	0.0005	0.0005	0.0005	0.001
Fe	mg/L	0.2 (GW: 0.05)	0.7	7.2	0.64	0.025	0.025	0.025	0.1
Hg	mg/L	0.0001	0.0006	0.0006	*0.00005*	*0.00005*	*0.00005*	*0.00005*	*0.00005*

Parameter	Unit	Metal(loid) LOR	Lower EA TV	Upper EA TV	Groundwater	Fresh carbonaceous	Fresh coal	Weathered non-carbonaceous	Fresh non-carbonaceous
Mn	mg/L	0.002 (GW: 0.001)	-	-	0.171	0.0005	0.0145	0.003	0.001
Mo	mg/L	0.001	0.034	0.034	0.002	0.044	0.003	0.001	0.017
Ni	mg/L	0.002 (GW: 0.001)	-	-	0.007	0.0005	0.002	0.0005	0.001
Pb	mg/L	0.002 (GW: 0.001)	-	-	0.0005	0.0005	0.0005	0.0005	0.001
Sb	mg/L	0.001	0.009	0.009	0.0005	0.002	0.0005	0.0005	0.002
Se	mg/L	0.02 (GW: 0.01)	0.011	0.011	*0.005*	0.03	*0.005*	*0.005*	0.01
Si	mg/L	0.001	-	-	17.4	-	-	-	-
Sr	mg/L	0.2 (GW: 0.001)	-	-	4.04	0.029	0.2275	0.0055	0.1
U	mg/L	0.001	-	-	0.0025	0.0005	0.0005	0.0005	0.001
V	mg/L	0.02 (GW: 0.01)	-	-	0.005	0.005	0.005	0.005	0.01
Zn	mg/L	0.01 (GW: 0.005)	-	-	0.025	0.0025	0.0025	0.00375	0.005

Notes TV = trigger value
"-" denotes no unit or no guideline
GW = Groundwater LOR
Highlighted cells denote exceedance to EA TVs

Appendix B

Geochemical modelling results tables

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Table B.1 Ramp 8 residual void lake water quality – with geochemical controls (Part 1 of 2)

Parameter	Unit	Lower TV	Upper TV	2055	2060	2070	2080	2090	2100	2110	2120	2130	2140	2150	2160	2170	2180	2190	2200	2210	2220	2230	2240	2250	2260	2270	2280	2290	2300	2310	2320
pH	pH Units	6.5	8.5	8.7	8.4	8.3	8.3	8.3	8.2	8.2	8.2	8.1	8.1	8.1	8.1	8	8	8	8	8	8	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9
pe	pe units	NG	NG	6.4	5.9	5.7	5.6	5.4	5.6	5.5	5.6	5.7	5.7	5.8	5.8	5.9	5.9	6	6	6	6	6	6	6	6	6.1	6.1	6.1	6.1	6.1	6.1
TDS	mg/L	4992	10599	583	4424	8017	9731	10866	13471	14172	16478	19846	22047	26097	28259	32387	33810	37648	38383	41771	41747	44572	43980	46665	46044	49297	49068	52748	52661	56611	56510
Alkalinity	mg $CaCO_3$/L	NG	NG	130	92	82	79	77	75	75	74	72	72	71	71	70	70	70	70	70	70	70	70	70	70	70	70	71	71	71	71
Ca	mg/L	NG	NG	5.1	25	45	55	61	75	79	92	110	120	144	155	178	185	206	210	229	229	244	241	256	252	270	269	289	289	310	310
Mg	mg/L	NG	NG	11	157	285	346	387	474	499	577	692	767	905	978	1119	1167	1298	1323	1439	1438	1535	1515	1607	1586	1698	1690	1817	1813	1950	1946
K	mg/L	NG	NG	9.4	12	17	20	22	27	28	33	40	45	53	58	66	69	77	79	86	86	91	90	96	94	101	100	108	108	116	115
Na	mg/L	NG	NG	195	1430	2592	3146	3513	4363	4589	5341	6437	7154	8472	9177	10523	10989	12244	12485	13592	13585	14508	14315	15191	14989	16051	15976	17178	17150	18440	18408
Cl	mg/L	NG	NG	247	2650	4868	5924	6623	8220	8652	10070	12130	13480	15970	17290	19825	20701	23065	23517	25604	25589	27330	26965	28619	28237	30241	30099	32366	32313	34746	34684
F	mg/L	NG	NG	0.7	0.6	0.8	0.9	1	1.2	1.3	1.5	1.8	2	2.4	2.6	3	3.1	3.5	3.6	3.9	3.9	4.1	4.1	4.3	4.3	4.6	4.5	4.9	4.9	5.2	5.2
SO_4	mg/L	318	520	33	78	130	154	170	213	222	259	313	348	412	447	513	536	597	609	663	663	707	698	740	730	782	778	836	835	897.3	895.8
N	mg N/L	NG	NG	0.02	0.01	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.04	0.04	0.05	0.05	0.06	0.06	0.07	0.07	0.07	0.07	0.07	0.07	0.08	0.08	0.08	0.08	0.09	0.09
Al	mg/L	0.055	0.48	0.23	0.12	0.098	0.09	0.085	0.12	0.11	0.14	0.16	0.19	0.22	0.25	0.28	0.3	0.33	0.34	0.37	0.37	0.39	0.39	0.41	0.4	0.43	0.43	0.45	0.46	0.48	0.49
Ag	mg/L	0.001	0.39	0.001	0.0009	0.0011	0.0012	0.0013	0.0016	0.0016	0.0019	0.0023	0.0026	0.0031	0.0034	0.0039	0.0041	0.0045	0.0046	0.005	0.0051	0.0054	0.0053	0.0056	0.0056	0.0059	0.0059	0.0063	0.0063	0.0068	0.0068
As	mg/L	0.013	0.013	0.048	0.013	0.005	0.004	0.004	0.007	0.006	0.009	0.012	0.015	0.018	0.022	0.026	0.029	0.033	0.036	0.039	0.041	0.044	0.045	0.047	0.048	0.051	0.052	0.056	0.057	0.061	0.062
B	mg/L	NG	NG	0.2	0.5	0.8	0.9	1	1	1.3	1.6	1.9	2.1	2.5	2.7	3.1	3.2	3.6	3.7	4	4	4.2	4.2	4.4	4.4	4.7	4.7	5	5	5.4	5.4
Ba	mg/L	NG	NG	0.05	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.09	0.09	0.08	0.08	0.07	0.07	0.07	0.07	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.05	0.05
Be	mg/L	NG	NG	2E-04	0.00005	0.00004	0.00004	0.00004	0.00005	0.00004	0.00006	0.00005	0.00006	0.00006	0.00007	0.00006	0.00007	0.00006	0.00007	0.00007	0.00007	0.00007	0.00007	0.00007	0.00007	0.00007	0.00008	0.00007	0.00008	0.00007	0.00008
Cd	mg/L	NG	NG	0.001	0.0007	0.0005	0.0005	0.0005	0.0006	0.0006	0.0007	0.0009	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.003	0.003
Co	mg/L	NG	NG	0.002	0.003	0.004	0.005	0.005	0.007	0.007	0.008	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03
Cu	mg/L	NG	NG	0.001	0.001	0.002	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.004	0.004	0.005	0.005	0.006	0.006	0.007	0.007	0.008	0.008	0.009	0.009	0.009	0.009	0.01	0.01	0.01	0.01
Cr	mg/L	NG	NG	0.002	0.0006	0.00009	0.00006	0.00005	0.0001	0.00006	0.0001	0.00009	0.0001	0.0001	0.0001	0.0001	0.0002	0.0001	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
Fe	mg/L	0.7	16	4E-05	0.00004	0.00004	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006	0.00007	0.00007	0.00007	0.00007	0.00007	0.00007	0.00007	0.00007	0.00008	0.00008
Hg	mg/L	0.0006	0.0006	1E-04	0.00009	0.0001	0.0001	0.0001	0.0002	0.0002	0.0002	0.0002	0.0003	0.0003	0.0003	0.0004	0.0004	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0007	0.0007
Li	mg/L	NG	NG	0.009	0.2	0.3	0.4	0.4	0.5	0.5	0.6	0.7	0.8	1	1	1	1.3	1.4	1.4	1.6	1.6	1.7	1.7	1.8	1.7	1.9	1.9	2	2	2.1	2.1
Mn	mg/L	NG	NG	0.009	0.1	0.2	0.3	0.3	0.4	0.4	0.5	0.6	0.7	0.8	0.9	1	1	1.1	1.2	1.3	1.3	1.4	1.3	1.4	1.4	1.5	1.5	1.6	1.6	1.7	1.7
Mo	mg/L	0.034	0.034	0.023	0.013	0.011	0.011	0.01	0.014	0.013	0.016	0.019	0.022	0.026	0.029	0.033	0.035	0.039	0.04	0.043	0.043	0.046	0.046	0.048	0.047	0.05	0.05	0.053	0.053	0.057	0.057
Ni	mg/L	NG	NG	0.002	0.006	0.01	0.01	0.013	0.02	0.02	0.02	0.02	0.03	0.03	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.06	0.07	0.07	0.07	0.07
P	mg/L	NG	NG	1.6	1.2	1.3	1.4	1.4	1.8	1.8	2.2	2.6	3	3.5	3.8	4.4	4.6	5.1	5.3	5.7	5.7	6.1	6	6.4	6.3	6.7	6.7	7.1	7.1	7.6	7.6
Pb	mg/L	NG	NG	5E-04	0.00007	0.00004	0.00005	0.00004	0.00009	0.00006	0.0001	0.0001	0.0002	0.0002	0.0003	0.0003	0.0004	0.0005	0.0006	0.0008	0.0009	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.002
Sb	mg/L	0.009	0.009	0.003	0.002	0.002	0.002	0.002	0.002	0.002	0.003	0.003	0.004	0.005	0.005	0.006	0.006	0.007	0.007	0.007	0.007	0.008	0.008	0.008	0.008	0.009	0.009	0.009	0.009	0.01	0.01
Se	mg/L	0.011	0.02	0.017	0.012	0.013	0.014	0.014	0.019	0.019	0.022	0.027	0.03	0.036	0.039	0.045	0.047	0.052	0.054	0.058	0.058	0.062	0.061	0.065	0.064	0.068	0.068	0.073	0.073	0.078	0.078
Si	mg/L	NG	NG	0.3	6.1	11	14	16	19	20	24	28	32	37	41	44	44	43	43	42	42	41	41	41	40	40	40	39	39	38	38
Sn	mg/L	NG	NG	0.01	0.007	0.005	0.005	0.005	0.006	0.006	0.007	0.009	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03
Sr	mg/L	NG	NG	0.3	3.1	5.7	6.9	7.8	9.6	10	12	14	16	19	20	23	24	27	28	30	30	32	32	34	33	35	35	38	38	41	41
Tl	mg/L	NG	NG	0.001	0.0009	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.004	0.004	0.005	0.005	0.005	0.005	0.005	0.005	0.006	0.006	0.006	0.006	0.006	0.006	0.007	0.007
U	mg/L	NG	NG	0.002	0.003	0.004	0.005	0.005	0.007	0.007	0.008	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03
V	mg/L	NG	NG	0.01	0.006	0.003	0.003	0.003	0.005	0.005	0.006	0.008	0.009	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04
Zn	mg/L	NG	NG	0.009	0.02	0.04	0.04	0.05	0.06	0.06	0.07	0.09	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3

Table B.2 Ramp 8 residual void lake water quality – with geochemical controls (Part 2 of 2)

Parameter	Unit	Lower TV	Upper TV	2330	2340	2350	2360	2370	2380	2390	2400	2410	2420	2430	2440	2450	2460	2470	2480	2490	2500	2510	2520	2530	2540	2550	2560	2570	2580	2590	2599
pH	pH Units	6.5	8.5	7.8	7.8	7.8	7.8	7.8	7.8	7.7	7.7	7.7	7.7	7.7	7.7	7.6	7.6	7.6	7.6	7.6	7.6	7.5	7.5	7.5	7.5	7.4	7.4	7.4	7.4	7.3	7.4
pe	pe units	NG	NG	6.1	6.1	6.2	6.2	6.2	6.2	6.2	6.2	6.3	6.3	6.3	6.3	6.4	6.4	6.4	6.4	6.4	6.4	6.5	6.5	6.5	6.5	6.6	6.6	6.6	6.6	6.6	6.6
TDS	mg/L	4992	10599	60732	60600	65061	64857	69552	69244	74179	74035	78448	78424	83343	83483	88875	89071	94918	95105	101390	101520	108130	107570	114860	113770	121630	120140	128450	126580	135320	133320
Alkalinity	mg $CaCO_3$/L	NG	NG	72	72	73	73	74	74	76	76	78	78	80	80	83	83	86	86	89	89	93	92	97	96	102	101	108	107	115	113
Ca	mg/L	NG	NG	333	332	357	356	382	380	408	407	431	431	458	459	489	490	523	524	559	559	596	593	634	628	671	663	710	699	748	737
Mg	mg/L	NG	NG	2091	2087	2240	2233	2395	2384	2554	2549	2701	2700	2869	2874	3059	3066	3267	3274	3490	3494	3722	3702	3954	3916	4187	4135	4422	4357	4658	4589
K	mg/L	NG	NG	124	124	133	132	142	141	151	151	160	160	170	170	181	181	193	194	206	207	220	219	234	232	248	245	262	258	276	272
Na	mg/L	NG	NG	19787	19744	21201	21134	22668	22567	24179	24132	25574	25566	27172	27219	28980	29045	30957	31019	33074	33116	35278	35095	37478	37121	39691	39206	41920	41310	44166	43512
Cl	mg/L	NG	NG	37284	37202	39950	39825	42716	42526	45565	45477	48194	48179	51208	51294	54616	54736	58340	58455	62330	62407	66484	66137	70629	69955	74799	73883	79000	77847	83231	81997
F	mg/L	NG	NG	5.6	5.6	6	6	6.4	6.4	6.8	6.8	7.2	7.2	7.6	7.7	8.1	8.2	8.7	8.7	9.3	9.3	9.9	9.9	11	10	11	11	12	12	12	12
SO_4	mg/L	318	520	962.4	960.5	1031	1028	1102	1097	1175	1173	1243	1243	1320	1323	1405	1407	1494	1496	1589	1590	1689	1679	1788	1771	1889	1866	1990	1962	2093	2062
N	mg N/L	NG	NG	0.1	0.1	0.1	0.1	0.11	0.11	0.12	0.12	0.12	0.12	0.13	0.13	0.14	0.14	0.15	0.15	0.16	0.16	0.17	0.17	0.18	0.18	0.19	0.19	0.2	0.2	0.21	0.21
Al	mg/L	0.055	0.48	0.52	0.52	0.55	0.55	0.59	0.59	0.62	0.62	0.66	0.66	0.7	0.7	0.74	0.75	0.7	0.68	0.63	0.61	0.55	0.54	0.49	0.48	0.44	0.43	0.39	0.38	0.35	0.34
Ag	mg/L	0.001	0.39	0.0073	0.0073	0.0078	0.0078	0.0083	0.0083	0.0088	0.0088	0.0093	0.0094	0.0099	0.01	0.011	0.011	0.011	0.011	0.012	0.012	0.013	0.013	0.014	0.014	0.015	0.014	0.015	0.015	0.016	0.016
As	mg/L	0.013	0.013	0.067	0.068	0.073	0.074	0.079	0.08	0.086	0.087	0.093	0.094	0.1	0.1	0.11	0.11	0.12	0.12	0.13	0.13	0.14	0.14	0.15	0.15	0.16	0.16	0.17	0.17	0.19	0.18
B	mg/L	NG	NG	5.8	5.8	6.2	6.2	6.6	6.6	7.1	7	7.5	7.5	7.9	7.9	8.5	8.5	9	9.1	9.7	9.7	10	10	11	11	12	11	12	12	13	13
Ba	mg/L	NG	NG	0.05	0.05	0.05	0.05	0.05	0.05	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Be	mg/L	NG	NG	0.00007	0.00008	0.00007	0.00009	0.00008	0.00009	0.00008	0.00009	0.00009	0.0001	0.00009	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0002	0.0001	0.0002	0.0002	0.0002
Cd	mg/L	NG	NG	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.005	0.005	0.005	0.005	0.005	0.005	0.006	0.005	0.006	0.006	0.006	0.006
Co	mg/L	NG	NG	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.06	0.07	0.07
Cu	mg/L	NG	NG	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04
Cr	mg/L	NG	NG	0.0002	0.0002	0.0002	0.0002	0.0002	0.0003	0.0003	0.0003	0.0003	0.0004	0.0004	0.0004	0.0005	0.0005	0.0006	0.0007	0.0008	0.0009	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.002	0.003	0.003
Fe	mg/L	0.7	16	0.00008	0.00008	0.00008	0.00008	0.00009	0.00009	0.00009	0.00009	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
Hg	mg/L	0.0006	0.0006	0.0007	0.0007	0.0008	0.0008	0.0008	0.0008	0.0009	0.0009	0.0009	0.0009	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.002
Li	mg/L	NG	NG	2.3	2.3	2.5	2.5	2.6	2.6	2.8	2.8	3	3	3.2	3.2	3.4	3.4	3.6	3.6	3.8	3.8	4.1	4.1	4.4	4.3	4.6	4.6	4.9	4.8	5.1	5.1
Mn	mg/L	NG	NG	1.8	1.8	2	2	2.1	2.1	2.3	2.2	2.4	2.4	2.5	2.5	2.7	2.7	2.9	2.9	3.1	3.1	3.3	3.3	3.5	3.5	3.7	3.7	3.9	3.9	4.1	4.1
Mo	mg/L	0.034	0.034	0.061	0.061	0.065	0.065	0.069	0.069	0.073	0.073	0.077	0.078	0.082	0.082	0.088	0.088	0.094	0.094	0.1	0.1	0.11	0.11	0.11	0.11	0.12	0.12	0.13	0.13	0.13	0.13
Ni	mg/L	NG	NG	0.08	0.08	0.08	0.08	0.09	0.09	0.09	0.09	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2
P	mg/L	NG	NG	8.2	8.2	8.7	8.7	9.3	9.3	9.9	9.9	10	11	11	11	12	12	13	13	14	14	14	14	15	15	16	16	17	17	18	18
Pb	mg/L	NG	NG	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.005	0.005	0.005	0.006	0.006	0.006	0.007	0.007	0.008	0.008	0.008	0.008	0.009	0.009	0.01	0.01	0.01	0.01	0.01	0.01
Sb	mg/L	0.009	0.009	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Se	mg/L	0.011	0.02	0.083	0.083	0.089	0.089	0.095	0.095	0.1	0.1	0.11	0.11	0.11	0.11	0.12	0.12	0.13	0.13	0.14	0.14	0.15	0.15	0.16	0.16	0.17	0.16	0.18	0.17	0.19	0.18
Si	mg/L	NG	NG	37	37	37	37	36	36	35	35	34	34	33	33	32	32	31	31	30	30	29	29	28	28	27	27	26	26	25	25
Sn	mg/L	NG	NG	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.05	0.06	0.06	0.06	0.06
Sr	mg/L	NG	NG	44	44	47	47	50	50	53	53	56	56	60	60	61	60	59	58	57	56	55	54	53	52	52	51	50	49	49	48
Tl	mg/L	NG	NG	0.007	0.007	0.008	0.008	0.008	0.008	0.009	0.009	0.009	0.009	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02
U	mg/L	NG	NG	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.06	0.07	0.07
V	mg/L	NG	NG	0.04	0.04	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.07	0.07	0.07	0.07	0.08	0.08	0.09	0.09	0.09	0.09	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Zn	mg/L	NG	NG	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.5	0.6	0.6	0.6	0.6

Table B.3 Ramp 8 residual void lake water quality – without geochemical controls (Part 1 of 2)

Parameter	Unit	Lower TV	Upper TV	2055	2060	2070	2080	2090	2100	2110	2120	2130	2140	2150	2160	2170	2180	2190	2200	2210	2220	2230	2240	2250	2260	2270	2280	2290	2300	2310	2320
pH	pH Units	6.5	8.5	9.1	7.8	7.6	7.5	7.5	7.5	7.5	7.5	7.4	7.4	7.4	7.4	7.4	7.4	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.2	7.2	7.2	7.2
pe	pe units	NG	NG	6	6.6	6.5	6.4	6.2	6.4	6.3	6.4	6.4	6.5	6.5	6.6	6.6	6.7	6.7	6.7	6.7	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.9	6.9	6.9	6.9
TDS	mg/L	4992	10599	588	4657	8470	10288	11492	14270	15013	17470	21056	23403	27715	30020	34425	35949	40056	40845	44470	44445	47468	46836	49707	49044	52523	52278	56216	56123	60350	60243
Alkalinity	mg $CaCO_3$/L	NG	NG	139	337	560	667	738	921	964	1124	1355	1508	1786	1937	2221	2322	2587	2639	2872	2872	3066	3025	3209	3166	3389	3373	3625	3620	3890	3884
Ca	mg/L	NG	NG	6.9	92	170	207	232	287	303	352	424	471	558	605	693	724	807	822	895	895	956	943	1000	988	1058	1053	1132	1130	1216	1213
Mg	mg/L	NG	NG	11	175	325	397	444	551	580	674	813	903	1070	1158	1328	1387	1545	1575	1715	1714	1831	1806	1917	1892	2026	2017	2169	2165	2329	2324
K	mg/L	NG	NG	9.4	12	17	20	22	27	28	33	40	45	53	58	66	69	77	79	86	86	91	90	96	94	101	100	108	108	116	115
Na	mg/L	NG	NG	195	1430	2592	3146	3513	4364	4590	5342	6438	7156	8475	9180	10527	10994	12250	12491	13599	13592	14517	14323	15201	14998	16062	15987	17191	17163	18455	18422
Cl	mg/L	NG	NG	247	2650	4868	5924	6624	8221	8654	10068	12135	13485	15970	17296	19833	20710	23076	23529	25618	25603	27346	26981	28637	28254	30261	30119	32390	32336	34773	34711
F	mg/L	NG	NG	0.7	0.6	0.8	0.9	1	1.2	1.3	1.5	1.8	2	2.4	2.6	3	3.1	3.5	3.6	3.9	3.9	4.1	4.1	4.3	4.3	4.6	4.5	4.9	4.9	5.2	5.2
SO_4	mg/L	318	520	33	79	130	155	171	213	223	260	314	349	414	449	515	538	599	612	666	666	710	701	744	734	785	782	840	839	902	900
N	mg N/L	NG	NG	0.02	0.01	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.04	0.04	0.05	0.05	0.06	0.06	0.07	0.07	0.07	0.07	0.07	0.07	0.08	0.08	0.08	0.08	0.09	0.09
Al	mg/L	0.055	0.48	0.2	0.1	0.1	0.09	0.08	0.12	0.11	0.14	0.16	0.19	0.22	0.25	0.28	0.3	0.33	0.34	0.37	0.37	0.39	0.39	0.41	0.4	0.43	0.43	0.46	0.46	0.49	0.49
Ag	mg/L	0.001	0.39	0.001	0.0009	0.0011	0.0012	0.0013	0.0016	0.0016	0.0019	0.0023	0.0026	0.0031	0.0034	0.0039	0.0041	0.0045	0.0046	0.005	0.0051	0.0054	0.0053	0.0056	0.0056	0.0059	0.0059	0.0063	0.0063	0.0068	0.0068
As	mg/L	0.013	0.013	0.054	0.028	0.023	0.021	0.02	0.027	0.026	0.032	0.038	0.043	0.052	0.057	0.065	0.069	0.077	0.079	0.086	0.086	0.092	0.091	0.095	0.094	0.1	0.099	0.11	0.11	0.11	0.11
B	mg/L	NG	NG	0.2	0.5	0.8	0.9	1	1	1.3	1.6	1.9	2.1	2.5	2.7	3.1	3.2	3.6	3.7	4	4	4.2	4.2	4.4	4.4	4.7	4.7	5	5	5.4	5.4
Ba	mg/L	NG	NG	0.05	0.4	0.7	0.9	1	1.2	1.3	1.5	1.8	2	2.4	2.6	2.9	3.1	3.4	3.5	3.8	3.8	4	4	4.2	4.2	4.5	4.5	4.8	4.8	5.1	5.1
Be	mg/L	NG	NG	0.002	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.003	0.003	0.004	0.004	0.004	0.005	0.005	0.005	0.006	0.006	0.006	0.006	0.007	0.006	0.007	0.007	0.007	0.007	0.008	0.008
Cd	mg/L	NG	NG	0.001	0.0007	0.0005	0.0005	0.0005	0.0006	0.0006	0.0007	0.0009	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.003	0.003
Co	mg/L	NG	NG	0.002	0.003	0.004	0.005	0.005	0.007	0.007	0.008	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03
Cu	mg/L	NG	NG	0.002	0.002	0.003	0.004	0.004	0.005	0.006	0.007	0.008	0.009	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Cr	mg/L	NG	NG	0.002	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.003	0.003	0.004	0.004	0.004	0.005	0.005	0.005	0.006	0.006	0.006	0.006	0.007	0.006	0.007	0.007	0.007	0.007	0.008	0.008
Fe	mg/L	0.7	16	0.2	0.6	0.9	1.1	1.3	1.6	1.7	1.9	2.3	2.6	3.1	3.3	3.8	4	4.4	4.5	4.9	4.9	5.2	5.2	5.5	5.4	5.8	5.8	6.2	6.2	6.7	6.6
Hg	mg/L	0.0006	0.0006	1E-04	0.00009	0.0001	0.0001	0.0001	0.0002	0.0002	0.0002	0.0002	0.0003	0.0003	0.0003	0.0004	0.0004	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0007	0.0007
Li	mg/L	NG	NG	0.009	0.2	0.3	0.4	0.4	0.5	0.5	0.6	0.7	0.8	1	1	1	1.3	1.4	1.5	1.6	1.6	1.7	1.7	1.8	1.7	1.9	1.9	2	2	2.1	2.1
Mn	mg/L	NG	NG	0.01	0.1	0.2	0.3	0.3	0.4	0.4	0.5	0.6	0.7	0.8	0.9	1	1	1.1	1.2	1.3	1.3	1.4	1.3	1.4	1.4	1.5	1.5	1.6	1.6	1.7	1.7
Mo	mg/L	0.034	0.034	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.06
Ni	mg/L	NG	NG	0.002	0.006	0.01	0.01	0.01	0.02	0.02	0.02	0.03	0.03	0.03	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.06	0.07	0.07	0.07	0.07
P	mg/L	NG	NG	2	1	1.3	1.4	1.4	1.9	1.9	2.2	2.7	3	3.6	3.9	4.5	4.7	5.3	5.4	5.8	5.9	6.2	6.2	6.5	6.4	6.8	6.8	7.3	7.3	7.8	7.8
Pb	mg/L	NG	NG	0.002	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.003	0.003	0.004	0.004	0.004	0.005	0.005	0.005	0.006	0.006	0.006	0.006	0.007	0.006	0.007	0.007	0.007	0.007	0.008	0.008
Sb	mg/L	0.009	0.009	0.003	0.002	0.002	0.002	0.002	0.002	0.002	0.003	0.003	0.004	0.005	0.005	0.006	0.006	0.007	0.007	0.007	0.007	0.008	0.008	0.008	0.008	0.009	0.009	0.009	0.009	0.01	0.01
Se	mg/L	0.011	0.02	0.017	0.012	0.013	0.014	0.014	0.019	0.019	0.022	0.027	0.03	0.036	0.039	0.045	0.047	0.053	0.054	0.059	0.059	0.062	0.062	0.065	0.064	0.069	0.068	0.073	0.073	0.078	0.078
Si	mg/L	NG	NG	0.3	6.1	11	14	16	19	20	24	28	32	37	41	46	49	54	55	60	60	64	63	67	66	71	71	76	76	82	81
Sn	mg/L	NG	NG	0.01	0.007	0.005	0.005	0.005	0.006	0.006	0.007	0.009	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03
Sr	mg/L	NG	NG	0.3	3.1	5.7	6.9	7.8	9.6	10	12	14	16	19	20	23	24	27	28	30	30	32	32	34	33	35	35	38	38	41	41
Tl	mg/L	NG	NG	0.001	0.0009	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.004	0.004	0.005	0.005	0.005	0.005	0.005	0.005	0.006	0.006	0.006	0.006	0.006	0.006	0.007	0.007
U	mg/L	NG	NG	0.002	0.003	0.004	0.005	0.005	0.007	0.007	0.008	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03
V	mg/L	NG	NG	0.02	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.03	0.03	0.04	0.04	0.04	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.07	0.06	0.07	0.07	0.07	0.07	0.08	0.08
Zn	mg/L	NG	NG	0.01	0.02	0.04	0.05	0.05	0.06	0.07	0.08	0.09	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3

Table B.4 Ramp 8 residual void lake water quality – without geochemical controls (Part 2 of 2)

Parameter	Unit	Lower TV	Upper TV	2330	2340	2350	2360	2370	2380	2390	2400	2410	2420	2430	2440	2450	2460	2470	2480	2490	2500	2510	2520	2530	2540	2550	2560	2570	2580	2590	2599
pH	pH Units	6.5	8.5	7.2	7.2	7.2	7.2	7.2	7.2	7.1	7.1	7.1	7.1	7.1	7.1	7	7	7	7	7	7	6.9	6.9	6.9	6.9	6.9	6.9	6.8	6.8	6.8	6.8
pe	pe units	NG	NG	7	7	7	7	7	7	7	7	7	7	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.2	7.2	7.2	7.2
TDS	mg/L	4992	10599	64760	64619	69394	69176	74202	73872	79154	79001	83725	83700	88967	89117	94894	95106	101370	101580	108320	108450	115550	114950	122770	121590	130030	128440	137350	135340	144720	142570
Alkalinity	mg $CaCO_3$/L	NG	NG	4173	4165	4471	4457	4779	4758	5097	5087	5390	5389	5727	5738	6108	6123	6525	6539	6972	6982	7438	7400	7903	7829	8371	8269	8842	8715	9317	9180
Ca	mg/L	NG	NG	1305	1302	1398	1394	1495	1488	1595	1592	1687	1686	1792	1795	1912	1916	2042	2046	2182	2185	2328	2316	2473	2450	2620	2587	2767	2726	2915	2872
Mg	mg/L	NG	NG	2499	2493	2678	2669	2864	2851	3055	3049	3231	3230	3434	3439	3662	3670	3912	3920	4180	4186	4460	4436	4738	4693	5018	4957	5301	5223	5585	5502
K	mg/L	NG	NG	124	124	133	132	142	141	151	151	160	160	170	170	181	182	193	194	207	207	221	219	234	232	248	245	262	259	276	272
Na	mg/L	NG	NG	19803	19760	21220	21154	22690	22589	24204	24158	25602	25595	27205	27251	29017	29082	30999	31061	33122	33164	35334	35150	37541	37182	39761	39275	41999	41386	44253	43597
Cl	mg/L	NG	NG	37315	37234	39987	39861	42758	42567	45613	45524	48248	48233	51269	51355	54685	54806	58420	58536	62422	62499	66589	66240	70747	70070	74932	74012	79148	77991	83396	82157
F	mg/L	NG	NG	5.6	5.6	6	6	6.4	6.4	6.8	6.8	7.2	7.2	7.6	7.7	8.2	8.2	8.7	8.7	9.3	9.3	9.9	9.9	11	10	11	11	12	12	12	12
SO_4	mg/L	318	520	967	965	1036	1033	1108	1103	1181	1179	1249	1249	1327	1330	1416	1419	1512	1516	1616	1618	1724	1715	1832	1814	1940	1917	2049	2020	2159	2128
N	mg N/L	NG	NG	0.1	0.1	0.1	0.1	0.11	0.11	0.12	0.12	0.12	0.12	0.13	0.13	0.14	0.14	0.15	0.15	0.16	0.16	0.17	0.17	0.18	0.18	0.19	0.19	0.2	0.2	0.21	0.21
Al	mg/L	0.055	0.48	0.52	0.52	0.55	0.55	0.59	0.59	0.62	0.62	0.66	0.66	0.7	0.7	0.74	0.75	0.8	0.8	0.85	0.85	0.91	0.91	0.96	0.96	1	1	1.1	1.1	1.1	1.1
Ag	mg/L	0.001	0.39	0.0073	0.0073	0.0078	0.0078	0.0083	0.0083	0.0089	0.0088	0.0094	0.0094	0.0099	0.01	0.011	0.011	0.011	0.011	0.012	0.012	0.013	0.013	0.014	0.014	0.015	0.014	0.015	0.015	0.016	0.016
As	mg/L	0.013	0.013	0.12	0.12	0.13	0.13	0.14	0.14	0.15	0.14	0.15	0.15	0.16	0.16	0.17	0.17	0.18	0.19	0.2	0.2	0.21	0.21	0.22	0.22	0.24	0.24	0.25	0.25	0.26	0.26
B	mg/L	NG	NG	5.8	5.8	6.2	6.2	6.6	6.6	7.1	7.1	7.5	7.5	7.9	8	8.5	8.5	9	9.1	9.7	9.7	10	10	11	11	12	11	12	12	13	13
Ba	mg/L	NG	NG	5.5	5.5	5.9	5.9	6.3	6.3	6.7	6.7	7.1	7.1	7.6	7.6	8.1	8.1	8.6	8.7	9.2	9.2	9.8	9.8	10	10	11	11	12	12	12	12
Be	mg/L	NG	NG	0.008	0.008	0.009	0.009	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Cd	mg/L	NG	NG	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.005	0.005	0.005	0.005	0.005	0.005	0.006	0.006	0.006	0.006	0.006	0.006
Co	mg/L	NG	NG	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.06	0.07	0.07
Cu	mg/L	NG	NG	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Cr	mg/L	NG	NG	0.008	0.008	0.009	0.009	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Fe	mg/L	0.7	16	7.1	7.1	7.7	7.6	8.2	8.1	8.7	8.7	9.2	9.2	9.8	9.8	10	10	11	11	12	12	13	13	14	13	14	14	15	15	16	16
Hg	mg/L	0.0006	0.0006	0.0007	0.0007	0.0008	0.0008	0.0008	0.0008	0.0009	0.0009	0.0009	0.0009	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.002
Li	mg/L	NG	NG	2.3	2.3	2.5	2.5	2.6	2.6	2.8	2.8	3	3	3.2	3.2	3.4	3.4	3.6	3.6	3.8	3.9	4.1	4.1	4.4	4.3	4.6	4.6	4.9	4.8	5.1	5.1
Mn	mg/L	NG	NG	1.8	1.8	2	2	2.1	2.1	2.3	2.3	2.4	2.4	2.5	2.5	2.7	2.7	2.9	2.9	3.1	3.1	3.3	3.3	3.5	3.5	3.7	3.7	3.9	3.9	4.1	4.1
Mo	mg/L	0.034	0.034	0.06	0.06	0.06	0.06	0.07	0.07	0.07	0.07	0.08	0.08	0.08	0.08	0.09	0.09	0.09	0.09	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Ni	mg/L	NG	NG	0.08	0.08	0.08	0.08	0.09	0.09	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2
P	mg/L	NG	NG	8.4	8.4	9	8.9	9.6	9.5	10	10	11	11	11	11	12	12	13	13	14	14	15	15	16	16	17	17	18	17	19	18
Pb	mg/L	NG	NG	0.008	0.008	0.009	0.009	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Sb	mg/L	0.009	0.009	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Se	mg/L	0.011	0.02	0.084	0.084	0.09	0.09	0.096	0.095	0.1	0.1	0.11	0.11	0.11	0.11	0.12	0.12	0.13	0.13	0.14	0.14	0.15	0.15	0.16	0.16	0.17	0.17	0.18	0.17	0.19	0.18
Si	mg/L	NG	NG	87	87	94	93	100	100	107	107	113	113	120	120	128	129	137	137	146	147	156	155	166	164	176	174	186	183	196	193
Sn	mg/L	NG	NG	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.06
Sr	mg/L	NG	NG	44	44	47	47	50	50	53	53	56	56	60	60	64	64	68	69	73	73	78	78	83	82	88	87	93	91	98	96
Tl	mg/L	NG	NG	0.007	0.007	0.008	0.008	0.008	0.008	0.009	0.009	0.009	0.009	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02
U	mg/L	NG	NG	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.06	0.07	0.07
V	mg/L	NG	NG	0.08	0.08	0.09	0.09	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Zn	mg/L	NG	NG	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.6

Table B.5 Boonie Doon residual void lake water quality – with geochemical controls

Parameter	Unit	Lower TV	Upper TV	2040	2050	2060	2070	2080	2090	2100	2110	2120	2130	2140	2150	2160	2170	2180	2190	2200	2210	2220	2230	2240	2250	2260	2270	2280	2290	2300	2310	2320	2330
pH	pH Units	6.5	8.5	8.3	8.8	8.9	9.2	9.2	9	8.9	8.8	8.6	8.5	8.4	8.3	8.3	8.1	8.2	8	8	7.8	7.9	7.6	7.8	7.3	7.6	7	7.4	6.6	7.1	6.1	6.8	5.2
pe	pe units	NG	NG	8.3	6.5	6.2	5.8	5.6	5.7	5.8	5.9	6	6.2	6.3	6.5	6.4	6.7	6.6	7	6.8	7.3	7	7.6	7.3	8.1	7.6	8.9	8	10	8.7	11	9.7	12
TDS	mg/L	4992	10599	133	501	779	2372	5401	8918	8110	15901	13920	27257	22717	42055	33796	60685	47694	83968	65022	112300	86215	147820	108890	193580	138970	252780	180420	330240	234600	426970	300730	552360
Alkalinity	mg $CaCO_3$/L	NG	NG	50	187	283	622	720	503	404	363	255	258	221	241	204	240	204	263	219	306	248	375	285	482	344	642	440	866	583	1200	771	1826
Ca	mg/L	NG	NG	0.7	2	1.7	0.9	1.1	2.5	3.3	7.1	12	30	31	64	58	111	92	170	136	246	192	343	254	474	337	647	452	752	538	866	633	1088
Mg	mg/L	NG	NG	0.7	2.6	4.1	4.7	5.9	14	19	43	75	184	194	400	358	684	571	1047	843	1499	1181	2068	1551	2802	2038	3751	2695	4977	3522	6458	4525	8420
K	mg/L	NG	NG	3.6	13	21	54	91	117	102	178	144	260	206	363	283	493	380	653	499	847	643	1089	796	1401	1000	1805	1283	2338	1657	3005	2113	3868
Na	mg/L	NG	NG	46	176	275	856	1973	3270	2967	5822	5049	9844	8150	15049	12050	21609	16944	29798	23036	39747	30478	52210	38429	68258	48976	89012	63526	116360	82691	150620	106110	194890
Cl	mg/L	NG	NG	40	153	241	903	2571	4762	4378	8910	7889	15673	13107	24449	19689	35530	27959	49374	38262	66213	50860	87315	64346	114480	82217	149610	106850	195900	139280	253880	178920	328800
F	mg/L	NG	NG	0.2	0.9	1.5	3.8	6.3	7.8	6.8	12	9.5	15	10	13	8.9	12	9.1	14	11	18	14	24	18	32	23	42	31	57	41	75	53	98
SO_4	mg/L	318	520	11	42	65	173	309	418	369	665	546	1011	813	1453	1142	1993	1539	2656	2033	3461	2636	4472	3276	5776	4131	7466	5283	9303	6488	11299	7887	14060
N	mg N/L	NG	NG	0.007	0.03	0.04	0.1	0.2	0.2	0.2	0.3	0.3	0.5	0.4	0.6	0.5	0.9	0.7	1.1	0.9	1.5	1.1	1.9	1.4	2.4	1.7	3.1	2.2	4	2.8	5.1	3.6	6.6
Al	mg/L	0.055	0.48	0.09	0.34	0.52	1.3	2.2	2.7	2.3	4	3.1	5.6	4.4	4.8	2.9	2.8	1.8	1.7	1.1	0.98	0.76	0.54	0.51	0.28	0.37	0.13	0.27	0.06	0.16	0.08	0.07	0.22
Ag	mg/L	0.001	0.39	4E-04	0.001	0.002	0.006	0.009	0.012	0.01	0.018	0.014	0.025	0.02	0.035	0.027	0.047	0.036	0.062	0.047	0.08	0.061	0.1	0.075	0.13	0.094	0.17	0.12	0.22	0.15	0.28	0.2	0.36
As	mg/L	0.013	0.013	0.02	0.08	0.1	0.3	0.5	0.6	0.5	0.8	0.7	1	0.9	1.6	1.2	2.2	1.7	2.8	2.2	3.7	2.8	4.7	3.4	6	4.3	7.7	5.5	10	7.1	13	9	17
B	mg/L	NG	NG	0.06	0.2	0.4	1	1.8	2.4	2.1	3.9	3.2	5.9	4.7	8.5	6.7	12	9.1	16	12	21	16	27	20	35	25	45	32	58	41	75	53	97
Ba	mg/L	NG	NG	0.01	0.04	0.06	0.05	0.04	0.04	0.04	0.04	0.04	0.03	0.04	0.02	0.03	0.02	0.02	0.01	0.02	0.01	0.01	0.008	0.01	0.006	0.009	0.004	0.007	0.004	0.005	0.004	0.004	0.004
Be	mg/L	NG	NG	2E-05	0.0001	0.0003	0.0005	0.0004	0.0002	0.0004	0.0002	0.0002	0.0002	0.0003	0.0003	0.0003	0.0003	0.0003	0.0004	0.0004	0.0005	0.0005	0.0007	0.0007	0.001	0.0009	0.002	0.001	0.004	0.002	0.006	0.007	0.01
Cd	mg/L	NG	NG	5E-04	0.002	0.003	0.007	0.01	0.01	0.01	0.02	0.02	0.03	0.02	0.04	0.03	0.05	0.04	0.07	0.05	0.09	0.07	0.1	0.08	0.1	0.1	0.2	0.1	0.2	0.2	0.3	0.2	0.4
Co	mg/L	NG	NG	6E-04	0.002	0.004	0.009	0.02	0.02	0.02	0.03	0.03	0.05	0.04	0.07	0.05	0.09	0.07	0.1	0.09	0.2	0.1	0.2	0.1	0.3	0.2	0.3	0.2	0.4	0.3	0.6	0.4	0.7
Cu	mg/L	NG	NG	2E-04	0.001	0.002	0.007	0.01	0.01	0.01	0.01	0.009	0.01	0.007	0.01	0.009	0.02	0.01	0.02	0.02	0.03	0.02	0.04	0.03	0.06	0.04	0.08	0.06	0.1	0.08	0.2	0.1	0.2
Cr	mg/L	NG	NG	6E-04	0.002	0.004	0.01	0.02	0.02	0.02	0.03	0.02	0.04	0.03	0.06	0.04	0.07	0.06	0.09	0.07	0.1	0.09	0.1	0.1	0.2	0.1	0.2	0.2	0.3	0.2	0.4	0.3	0.5
Fe	mg/L	0.7	16	4E-05	0.00004	0.00005	0.00007	0.00007	0.00006	0.00005	0.00005	0.00004	0.00004	0.00004	0.00005	0.00005	0.00006	0.00005	0.00007	0.00006	0.00009	0.00007	0.0001	0.00009	0.0002	0.0001	0.08	0.0002	0.6	0.04	0.8	1	2.6
Hg	mg/L	0.0006	0.0006	4E-05	0.0001	0.0002	0.0006	0.0009	0.001	0.001	0.002	0.001	0.003	0.002	0.003	0.003	0.005	0.004	0.006	0.005	0.008	0.006	0.01	0.007	0.01	0.009	0.02	0.01	0.02	0.02	0.03	0.02	0.04
Li	mg/L	NG	NG	0	0	0	0.02	0.1	0.2	0.2	0.4	0.4	0.8	0.7	1	1	1.9	1.5	2.7	2.1	3.6	2.8	4.8	3.5	6.3	4.5	8.3	5.9	11	7.7	14	9.9	18
Mn	mg/L	NG	NG	0.001	0.003	0.002	0.002	0.004	0.02	0.02	0.09	0.1	0.4	0.3	0.7	0.6	1.1	0.9	1.6	1.3	2.3	1.8	3.1	2.3	4.1	3	5.5	3.9	7.3	5.2	9.5	6.7	12
Mo	mg/L	0.034	0.034	0.009	0.03	0.05	0.1	0.2	0.3	0.2	0.4	0.3	0.6	0.4	0.8	0.6	1	0.8	1.4	1	1.8	1.3	2.2	1.6	2.9	2	3.7	2.6	4.7	3.4	6.1	4.3	7.8
Ni	mg/L	NG	NG	6E-04	0.002	0.003	0.009	0.02	0.02	0.02	0.04	0.03	0.06	0.05	0.08	0.07	0.1	0.09	0.2	0.1	0.2	0.2	0.3	0.2	0.4	0.3	0.5	0.3	0.6	0.4	0.8	0.6	1
P	mg/L	NG	NG	0.6	2.4	3.7	9.5	16	19	17	29	23	41	32	57	44	76	58	100	76	128	97	164	120	211	150	270	192	350	248	449	315	577
Pb	mg/L	NG	NG	9E-05	0.0007	0.001	0.004	0.006	0.006	0.005	0.006	0.003	0.003	0.002	0.003	0.003	0.007	0.006	0.01	0.01	0.02	0.02	0.03	0.03	0.05	0.04	0.07	0.05	0.09	0.07	0.1	0.09	0.2
Sb	mg/L	0.009	0.009	0.001	0.004	0.007	0.02	0.03	0.03	0.03	0.05	0.04	0.07	0.06	0.1	0.08	0.1	0.1	0.2	0.1	0.2	0.2	0.3	0.2	0.4	0.3	0.5	0.3	0.6	0.4	0.8	0.6	1
Se	mg/L	0.011	0.02	0.006	0.02	0.04	0.1	0.2	0.2	0.2	0.3	0.2	0.4	0.3	0.6	0.4	0.8	0.6	1	0.8	1.3	0.98	1.7	1.2	2.1	1.5	2.7	1.9	3.5	2.5	4.5	3.2	5.8
Si	mg/L	NG	NG	0	0	0	0.7	3.7	8.3	7.8	17	15	31	26	43	30	39	28	34	24	30	21	25	17	19	14	14	11	9.5	7.9	5.7	5.8	2.9
Sn	mg/L	NG	NG	0.005	0.02	0.03	0.08	0.1	0.2	0.1	0.2	0.2	0.3	0.3	0.4	0.3	0.6	0.5	0.8	0.6	1	0.8	1.3	0.9	1.6	1.2	2.1	1.5	2.7	1.9	3.5	2.5	4.5
Sr	mg/L	NG	NG	0.05	0.2	0.3	1.1	3.1	5.7	5.3	11	9.4	19	16	29	23	31	20	25	16	20	13	16	11	13	9	11	8.1	10	7.9	10	8.3	11
Tl	mg/L	NG	NG	4E-04	0.001	0.002	0.006	0.009	0.01	0.01	0.02	0.01	0.03	0.02	0.03	0.03	0.05	0.04	0.06	0.05	0.08	0.06	0.1	0.07	0.1	0.09	0.2	0.1	0.2	0.2	0.3	0.2	0.4
U	mg/L	NG	NG	6E-04	0.002	0.004	0.01	0.02	0.02	0.02	0.03	0.03	0.05	0.04	0.07	0.05	0.09	0.07	0.1	0.1	0.2	0.1	0.2	0.2	0.3	0.2	0.3	0.2	0.5	0.3	0.6	0.4	0.7
V	mg/L	NG	NG	0.006	0.02	0.03	0.09	0.1	0.2	0.1	0.2	0.2	0.3	0.3	0.5	0.4	0.6	0.5	0.8	0.6	1	0.8	1	1	2	1	2	2	3	2	4	3	5
Zn	mg/L	NG	NG	0.003	0.01	0.02	0.05	0.08	0.1	0.09	0.2	0.1	0.2	0.2	0.3	0.3	0.5	0.4	0.7	0.5	0.9	0.7	1	0.8	1	1	2	1	3	2	3	2	4

Table B.6 Boonie Doon residual void lake water quality – without geochemical controls

Parameter	Unit	Lower TV	Upper TV	2040	2050	2060	2070	2080	2090	2100	2110	2120	2130	2140	2150	2160	2170	2180	2190	2200	2210	2220	2230	2240	2250	2260	2270	2280	2290	2300	2310	2320	2330
pH	pH Units	6.5	8.5	9.3	9.3	9.3	9.1	8.8	8.6	8.6	8.4	8.4	8.2	8.2	8.1	8.1	7.9	8	7.8	7.9	7.7	7.8	7.6	7.7	7.5	7.6	7.5	7.6	7.4	7.5	7.4	7.5	7.4
pe	pe units	NG	NG	7.8	7.9	7.9	6.3	6.3	6.4	6.4	6.6	6.5	6.7	6.7	6.9	6.8	7.1	7	7.4	7.2	7.6	7.4	8	7.6	8.4	7.9	9	8.3	9.7	8.8	11	9.4	11
TDS	mg/L	4992	10599	133	502	785	2507	5981	10122	9206	18200	15849	31031	25741	47655	38197	68634	53840	94849	73330	126740	97163	166760	122660	218380	156520	285280	203290	373650	264990	484670	340560	628700
Alkalinity	mg $CaCO_3$/L	NG	NG	50	188	289	773	1376	1864	1643	2957	2427	4490	3606	6456	5074	8920	6908	11988	9185	15702	11958	20357	14902	26363	18829	34152	24274	44452	31464	57388	40265	74176
Ca	mg/L	NG	NG	0.7	2.5	3.8	20	71	144	133	278	249	501	421	791	639	1159	913	1618	1255	2178	1674	2881	2123	3787	2718	4962	3539	6513	4622	8462	5949	10990
Mg	mg/L	NG	NG	0.7	2.6	4.1	30	122	259	241	508	458	926	781	1470	1189	2159	1703	3020	2344	4071	3129	5389	3971	7089	5088	9292	6628	12201	8659	15856	11147	20597
K	mg/L	NG	NG	3.6	13	21	54	91	117	102	178	144	260	206	364	283	493	380	655	499	849	645	1093	798	1407	1003	1815	1288	2355	1665	3033	2126	3912
Na	mg/L	NG	NG	46	176	275	856	1974	3271	2968	5824	5051	9850	8154	15063	12060	21640	16963	29856	23071	39849	30538	52386	38524	68559	49130	89522	63785	117210	83118	152000	106790	197130
Cl	mg/L	NG	NG	40	153	241	903	2571	4763	4378	8913	7892	15683	13114	24473	19704	35580	27989	49470	38319	66384	50960	87609	64505	114990	82476	150470	107280	197330	140000	256200	180070	332570
F	mg/L	NG	NG	0.2	0.9	1.5	3.8	6.3	7.8	6.8	12	9.5	17	13	24	18	32	24	42	32	54	41	70	51	89	64	115	82	149	106	192	135	248
SO_4	mg/L	318	520	11	42	65	173	310	420	370	670	550	1014	810	1459	1148	2018	1564	2714	2080	3556	2709	4612	3377	5974	4267	7741	5502	10077	7133	13011	9129	16818
N	mg N/L	NG	NG	0.007	0.03	0.04	0.1	0.2	0.2	0.2	0.3	0.3	0.5	0.4	0.6	0.5	0.9	0.7	1.1	0.9	1.5	1.1	1.9	1.4	2.4	1.7	3.1	2.2	4	2.8	5.2	3.6	6.7
Al	mg/L	0.055	0.48	0.09	0.3	0.5	1.3	2.2	2.7	2.3	4	3.1	5.6	4.4	7.6	5.9	10	7.8	13	10	17	13	22	16	28	20	36	26	47	33	60	42	77
Ag	mg/L	0.001	0.39	4E-04	0.001	0.002	0.006	0.009	0.012	0.01	0.02	0.01	0.03	0.02	0.04	0.03	0.05	0.04	0.06	0.05	0.08	0.06	0.1	0.08	0.1	0.09	0.2	0.1	0.2	0.2	0.3	0.2	0.4
As	mg/L	0.013	0.013	0.022	0.082	0.13	0.33	0.53	0.65	0.57	0.97	0.77	1.4	1.1	1.9	1.4	2.5	1.9	3.3	2.5	4.2	3.2	5.3	3.9	6.9	4.9	8.8	6.2	11	8	15	10	19
B	mg/L	NG	NG	0.06	0.2	0.4	1	1.8	2.4	2.1	3.9	3.2	5.9	4.7	8.5	6.7	12	9.1	16	12	21	16	27	20	35	25	45	32	59	42	76	53	98
Ba	mg/L	NG	NG	0.01	0.04	0.06	0.2	0.5	0.8	0.8	1.5	1.3	2.6	2.1	4	3.2	5.7	4.5	7.9	6.1	11	8.1	14	10	18	13	24	17	31	22	41	29	53
Be	mg/L	NG	NG	6E-04	0.002	0.004	0.01	0.02	0.02	0.02	0.03	0.02	0.04	0.03	0.06	0.04	0.08	0.06	0.1	0.08	0.1	0.1	0.2	0.1	0.2	0.2	0.3	0.2	0.4	0.2	0.5	0.3	0.6
Cd	mg/L	NG	NG	5E-04	0.002	0.003	0.008	0.01	0.02	0.01	0.02	0.02	0.03	0.03	0.05	0.03	0.06	0.05	0.08	0.06	0.1	0.08	0.1	0.09	0.2	0.1	0.2	0.2	0.3	0.2	0.4	0.2	0.5
Co	mg/L	NG	NG	6E-04	0.002	0.004	0.01	0.02	0.02	0.02	0.03	0.03	0.05	0.04	0.07	0.05	0.09	0.07	0.1	0.1	0.2	0.1	0.2	0.2	0.3	0.2	0.4	0.2	0.5	0.3	0.6	0.4	0.8
Cu	mg/L	NG	NG	6E-04	0.002	0.004	0.01	0.02	0.02	0.02	0.03	0.03	0.05	0.04	0.07	0.05	0.09	0.07	0.1	0.09	0.2	0.1	0.2	0.1	0.3	0.2	0.3	0.2	0.4	0.3	0.6	0.4	0.7
Cr	mg/L	NG	NG	6E-04	0.002	0.004	0.01	0.02	0.02	0.02	0.03	0.02	0.04	0.03	0.06	0.04	0.08	0.06	0.1	0.08	0.1	0.1	0.2	0.1	0.2	0.2	0.3	0.2	0.4	0.2	0.5	0.3	0.6
Fe	mg/L	0.7	16	0.06	0.2	0.3	0.9	1.7	2.4	2.1	3.9	3.2	6	4.9	8.8	6.9	12	9.5	17	13	22	17	28	21	37	26	48	34	62	44	81	57	104
Hg	mg/L	0.0006	0.0006	4E-05	0.0001	0.0002	0.0006	0.0009	0.001	0.001	0.002	0.001	0.003	0.002	0.004	0.003	0.005	0.004	0.006	0.005	0.008	0.006	0.01	0.008	0.01	0.009	0.02	0.01	0.02	0.02	0.03	0.02	0.04
Li	mg/L	NG	NG	0	0	0	0.02	0.1	0.2	0.2	0.4	0.4	0.8	0.7	1.3	1.1	1.9	1.5	2.7	2.1	3.6	2.8	4.8	3.5	6.3	4.5	8.3	5.9	11	7.7	14	10	18
Mn	mg/L	NG	NG	0.001	0.005	0.007	0.03	0.1	0.2	0.2	0.4	0.4	0.7	0.6	1.1	0.9	1.7	1.3	2.3	1.8	3.1	2.4	4.2	3.1	5.5	3.9	7.1	5.1	9.4	6.7	12	8.6	16
Mo	mg/L	0.034	0.034	0.009	0.03	0.05	0.1	0.2	0.3	0.2	0.4	0.3	0.6	0.4	0.8	0.6	1	0.8	1.4	1	1.8	1.3	2.2	1.6	2.9	2	3.7	2.6	4.8	3.4	6.1	4.3	7.9
Ni	mg/L	NG	NG	6E-04	0.002	0.004	0.01	0.02	0.03	0.02	0.04	0.04	0.07	0.05	0.1	0.08	0.1	0.1	0.2	0.1	0.2	0.2	0.3	0.2	0.4	0.3	0.5	0.4	0.7	0.5	0.9	0.6	1
P	mg/L	NG	NG	0.6	2.4	3.7	9.5	16	19	17	29	23	41	33	57	44	76	58	100	76	129	97.9	166	121	212	151	273	194	353	250	454	318	585
Pb	mg/L	NG	NG	6E-04	0.002	0.004	0.01	0.02	0.02	0.02	0.03	0.02	0.04	0.03	0.06	0.04	0.08	0.06	0.1	0.08	0.1	0.1	0.2	0.1	0.2	0.2	0.3	0.2	0.4	0.2	0.5	0.3	0.6
Sb	mg/L	0.009	0.009	0.001	0.004	0.007	0.02	0.03	0.03	0.03	0.05	0.04	0.07	0.06	0.1	0.08	0.1	0.1	0.2	0.1	0.2	0.2	0.3	0.2	0.4	0.3	0.5	0.3	0.6	0.4	0.8	0.6	1
Se	mg/L	0.011	0.02	0.006	0.02	0.04	0.1	0.2	0.2	0.2	0.3	0.2	0.4	0.3	0.6	0.4	0.8	0.6	1	0.8	1.3	1	1.7	1.2	2.1	1.5	2.7	1.9	3.5	2.5	4.6	3.2	5.9
Si	mg/L	NG	NG	0	0	0	0.7	3.7	8.3	7.8	17	15	31	26	49	40	73	58	100	79	138	106	183	135	241	173	316	225	415	295	540	379	701
Sn	mg/L	NG	NG	0.005	0.02	0.03	0.08	0.1	0.2	0.1	0.2	0.2	0.3	0.3	0.5	0.3	0.6	0.5	0.8	0.6	1	0.8	1.3	0.9	1.7	1.2	2.1	1.5	2.7	1.9	3.5	2.5	4.5
Sr	mg/L	NG	NG	0.05	0.2	0.3	1.1	3.1	5.7	5.3	11	9.4	19	16	29	23	42	33	59	45	79	60	104	76	136	98	178	127	234	166	303	213	394
Tl	mg/L	NG	NG	4E-04	0.001	0.002	0.006	0.009	0.01	0.01	0.02	0.01	0.03	0.02	0.04	0.03	0.05	0.04	0.06	0.05	0.08	0.06	0.1	0.08	0.1	0.09	0.2	0.1	0.2	0.2	0.3	0.2	0.4
U	mg/L	NG	NG	6E-04	0.002	0.004	0.01	0.02	0.02	0.02	0.03	0.03	0.05	0.04	0.07	0.05	0.09	0.07	0.1	0.1	0.2	0.1	0.2	0.2	0.3	0.2	0.4	0.2	0.5	0.3	0.6	0.4	0.8
V	mg/L	NG	NG	0.006	0.02	0.04	0.1	0.2	0.2	0.2	0.3	0.2	0.4	0.3	0.6	0.4	0.8	0.6	1	0.8	1	1	2	1	2	2	3	2	4	2	5	3	6
Zn	mg/L	NG	NG	0.003	0.01	0.02	0.05	0.1	0.1	0.1	0.2	0.2	0.3	0.2	0.4	0.4	0.6	0.5	0.8	0.6	1	0.8	1	1	2	1	2	2	3	2	4	3	5

Table B.7 Mimosa/Besgrove residual void lake water quality – with geochemical controls (Part 1 of 2)

Parameter	Unit	Lower TV	Upper TV	2089	2090	2100	2110	2120	2130	2140	2150	2160	2170	2180	2190	2200	2210	2220	2230	2240	2250	2260	2270	2280	2290	2300	2310	2320
pH	pH Units	6.5	8.5	8.7	8.5	8.6	8.4	8.4	8.3	8.3	8.3	8.2	8.2	8.2	8.2	8.2	8.1	8.1	8.1	8.1	8.1	8.1	8	8	8	8	8	8
pe	pe units	NG	NG	6.2	5.9	6	5.9	5.9	5.9	5.9	5.9	5.9	6	6	6	6	6	6	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.2	6.2
TDS	mg/L	4992	10599	543	2385	1625	4526	6056	8677	9958	12703	13718	16558	17319	20197	20715	23585	23919	26813	26819	29872	29716	33116	32975	36678	36489	40433	40115
Alkalinity	mg $CaCO_3$/L	NG	NG	160	110	130	98	93	89	87	85	85	84	83	83	82	82	82	82	81	82	81	82	81	82	82	82	82
Ca	mg/L	NG	NG	3.8	13	7.8	23	31	44	50	64	69	83	87	100	105	120	121	136	136	152	152	169	169	188	187	207	206
Mg	mg/L	NG	NG	11	80.6	48.4	146	193	275	315	402	435	525	550	642	660	752	764	858	859	958	954	1065	1061	1181	1176	1304	1294
K	mg/L	NG	NG	10	10	11	16	20	27	30	38	40	47	49	57	58	65	65	73	72	80	79	87	87	96	96	105	104
Na	mg/L	NG	NG	181	774	534	1481	1986	2848	3269	4171	4505	5437	5687	6630	6799	7740	7849	8797	8798	9798	9745	10862	10815	12033	11971	13268	13163
Cl	mg/L	NG	NG	210	1381	892	2694	3630	5233	6016	7694	8314	10049	10516	12275	12592	14347	14552	16321	16326	18193	18098	20183	20098	22371	22257	24677	24484
F	mg/L	NG	NG	0.5	0.5	0.5	0.7	0.9	1	1	1.7	1.8	2.1	2.2	2.5	2.6	2.9	2.9	3.2	3.2	3.5	3.5	3.8	3.8	4.2	4.2	4.6	4.6
SO_4	mg/L	318	520	33	52	47	90	117	163	185	233	250	300	312	362	370	419	424	473	473	524	521	579	576	639	635	703	697
N	mg N/L	NG	NG	0.009	0.008	0.009	0.01	0.01	0.02	0.02	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.07	0.07
Al	mg/L	0.055	0.48	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.5	0.5	0.6	0.6	0.6	0.6	0.7	0.7	0.7	0.7	0.8	0.8	0.9	0.9	0.9	0.9
Ag	mg/L	0.001	0.39	0.0009	0.0007	0.0009	0.0011	0.0014	0.0018	0.002	0.0024	0.0026	0.003	0.0032	0.0036	0.0037	0.0041	0.0041	0.0046	0.0045	0.005	0.0049	0.0054	0.0054	0.006	0.0059	0.0065	0.0064
As	mg/L	0.013	0.013	0.06	0.03	0.05	0.04	0.04	0.05	0.06	0.06	0.07	0.08	0.08	0.09	0.09	0.1	0.1	0.11	0.11	0.12	0.12	0.13	0.13	0.14	0.14	0.16	0.16
B	mg/L	NG	NG	0.2	0.3	0.3	0.5	0.7	1	1.1	1.4	1.5	1.8	1.9	2.1	2.2	2.5	2.5	2.8	2.8	3.1	3.1	3.4	3.4	3.8	3.8	4.2	4.2
Ba	mg/L	NG	NG	0.04	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.09	0.09	0.09	0.08	0.08	0.08	0.08	0.07	0.07	0.07	0.07	0.06	0.06	0.06	0.06
Be	mg/L	NG	NG	0.0002	0.00005	0.0002	0.00007	0.00008	0.00008	0.00009	0.00008	0.00009	0.00008	0.00009	0.00008	0.0001	0.00008	0.0001	0.00009	0.0001	0.00009	0.0001	0.00009	0.0001	0.00009	0.0001	0.0001	0.0001
Cd	mg/L	NG	NG	0.002	0.001	0.001	0.001	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.004	0.004	0.005	0.005	0.005	0.005	0.006	0.006	0.006	0.006
Co	mg/L	NG	NG	0.002	0.002	0.002	0.003	0.004	0.006	0.006	0.008	0.009	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Cu	mg/L	NG	NG	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.005	0.005	0.005	0.005	0.006	0.006	0.007	0.007
Cr	mg/L	NG	NG	0.002	0.0009	0.001	0.001	0.001	0.0009	0.0008	0.0007	0.0007	0.0006	0.0006	0.0005	0.0005	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004
Fe	mg/L	0.7	16	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006
Hg	mg/L	0.0006	0.0006	0.00009	0.00007	0.00009	0.0001	0.0001	0.0002	0.0002	0.0002	0.0003	0.0003	0.0003	0.0004	0.0004	0.0004	0.0004	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0006	0.0006	0.0007	0.0006
Li	mg/L	NG	NG	0.008	0.08	0.05	0.2	0.2	0.3	0.4	0.5	0.5	0.6	0.6	0.8	0.8	0.9	0.9	1	1	1.1	1.1	1.2	1.2	1.4	1.4	1.5	1.5
Mn	mg/L	NG	NG	0.008	0.07	0.04	0.1	0.2	0.3	0.3	0.4	0.4	0.5	0.5	0.6	0.6	0.7	0.7	0.8	0.8	0.9	0.9	1	1	1.1	1.1	1.2	1.2
Mo	mg/L	0.034	0.034	0.03	0.02	0.03	0.03	0.03	0.04	0.04	0.05	0.05	0.06	0.06	0.07	0.07	0.08	0.08	0.08	0.08	0.09	0.09	0.1	0.1	0.1	0.1	0.1	0.1
Ni	mg/L	NG	NG	0.002	0.004	0.003	0.007	0.009	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05
P	mg/L	NG	NG	2	1	1.6	1.8	2.1	2.8	3.1	3.7	3.9	4.5	4.7	5.3	5.4	6	6	6.6	6.6	7.2	7.1	7.8	7.7	8.5	8.4	9.2	9.1
Pb	mg/L	NG	NG	0.0006	0.0001	0.0005	0.0001	0.0002	0.0002	0.0002	0.0002	0.0003	0.0003	0.0003	0.0003	0.0004	0.0004	0.0004	0.0004	0.0005	0.0005	0.0006	0.0007	0.0008	0.0009	0.001	0.001	0.001
Sb	mg/L	0.009	0.009	0.003	0.002	0.003	0.003	0.004	0.005	0.005	0.006	0.007	0.008	0.008	0.009	0.009	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01
Se	mg/L	0.011	0.02	0.017	0.013	0.016	0.018	0.022	0.028	0.032	0.038	0.04	0.047	0.048	0.055	0.056	0.062	0.062	0.068	0.068	0.074	0.073	0.08	0.08	0.088	0.087	0.095	0.094
Si	mg/L	NG	NG	0.3	3.1	1.9	6.2	8.4	12	14	18	19	23	24	29	29	33	34	38	38	42	42	44	43	43	42	42	41
Sn	mg/L	NG	NG	0.02	0.01	0.01	0.01	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06
Sr	mg/L	NG	NG	0.3	1.7	1.1	3.2	4.3	6.2	7.1	9.1	9.9	12	12	15	15	17	17	19	19	22	21	24	24	26	26	29	29
Tl	mg/L	NG	NG	0.0009	0.0007	0.0009	0.001	0.001	0.002	0.002	0.002	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.005	0.005	0.005	0.005	0.005	0.005	0.006	0.006	0.007	0.006
U	mg/L	NG	NG	0.002	0.002	0.002	0.003	0.004	0.006	0.007	0.008	0.009	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
V	mg/L	NG	NG	0.01	0.009	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.05
Zn	mg/L	NG	NG	0.008	0.01	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.08	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2

DRAFT

Table B.8 Mimosa/Besgrove residual void lake water quality – with geochemical controls (Part 2 of 2)

Parameter	Unit	Lower TV	Upper TV	2330	2340	2350	2360	2370	2380	2390	2400	2410	2420	2430	2440	2450	2460	2470	2480	2490	2500	2510	2520	2530	2540	2550	2560	2570	2580	2590	2599
pH	pH Units	6.5	8.5	8	8	7.9	7.9	7.9	7.9	7.9	7.9	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.6	7.6	7.6	7.6
pe	pe units	NG	NG	6.2	6.2	6.2	6.2	6.3	6.2	6.3	6.3	6.3	6.3	6.3	6.3	6.4	6.4	6.4	6.4	6.4	6.4	6.5	6.4	6.5	6.5	6.5	6.5	6.5	6.5	6.6	6.6
TDS	mg/L	4992	10599	44342	43901	48383	47785	52511	51725	56699	56076	60261	59532	63991	63243	67940	67096	72011	71046	76160	75063	80326	78635	84534	82429	88818	86457	93158	90523	97510	95050
Alkalinity	mg $CaCO_3$/L	NG	NG	83	83	84	83	85	84	86	86	88	87	89	88	89	88	90	89	91	90	92	91	94	92	96	94	98	96	100	98
Ca	mg/L	NG	NG	228	226	249	246	271	267	293	289	311	308	331	327	352	347	373	368	395	389	417	408	439	428	462	450	485	471	508	495
Mg	mg/L	NG	NG	1432	1418	1564	1545	1699	1674	1836	1816	1953	1929	2075	2050	2204	2176	2337	2305	2472	2437	2609	2554	2746	2678	2887	2810	3029	2944	3172	3092
K	mg/L	NG	NG	115	114	125	123	135	133	145	143	154	152	163	161	172	170	182	180	193	190	203	198	213	208	223	218	234	227	245	239
Na	mg/L	NG	NG	14554	14409	15883	15686	17240	16982	18617	18412	19789	19549	21015	20769	22314	22036	23653	23335	25018	24656	26387	25831	27772	27081	29183	28406	30611	29745	32043	31234
Cl	mg/L	NG	NG	27078	26809	29560	29195	32095	31614	34667	34285	36854	36408	39145	38686	41570	41053	44070	43478	46618	45945	49176	48139	51762	50472	54396	52948	57063	55447	59738	58230
F	mg/L	NG	NG	5	5	5.4	5.4	5.9	5.8	6.3	6.2	6.7	6.6	7.1	7	7.5	7.4	7.9	7.8	8.4	8.2	8.8	8.6	9.3	9	9.7	9.4	10	9.9	11	10
SO_4	mg/L	318	520	769	761	838	827	908	894	979	968	1039	1026	1102	1089	1169	1155	1238	1221	1308	1290	1379	1349	1446	1408	1513	1472	1582	1536	1650	1608
N	mg N/L	NG	NG	0.07	0.07	0.08	0.08	0.09	0.08	0.09	0.09	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1
Al	mg/L	0.055	0.48	1	1	1.1	1.1	1.2	1.1	1.2	1.2	1.3	1.3	1.3	1.3	1.2	1.2	1.1	1.1	1	1	1	0.9	0.9	0.8	0.8	0.8	0.7	0.7	0.7	0.7
Ag	mg/L	0.001	0.39	0.0071	0.007	0.0077	0.0076	0.0083	0.0081	0.0089	0.0088	0.0094	0.0093	0.0099	0.0098	0.011	0.01	0.011	0.011	0.012	0.012	0.012	0.012	0.013	0.013	0.014	0.013	0.014	0.014	0.015	0.014
As	mg/L	0.013	0.013	0.17	0.17	0.19	0.19	0.21	0.2	0.22	0.22	0.24	0.24	0.25	0.25	0.27	0.27	0.29	0.29	0.31	0.31	0.33	0.32	0.35	0.34	0.36	0.36	0.38	0.38	0.4	0.4
B	mg/L	NG	NG	4.6	4.5	5	4.9	5.4	5.3	5.8	5.8	6.2	6.1	6.6	6.5	7	6.9	7.4	7.3	7.8	7.7	8.2	8.1	8.7	8.4	9.1	8.9	9.5	9.3	10	9.7
Ba	mg/L	NG	NG	0.06	0.06	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.03	0.04	0.03	0.03	0.03	0.03
Be	mg/L	NG	NG	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0002	0.0001	0.0002	0.0001	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
Cd	mg/L	NG	NG	0.006	0.006	0.007	0.007	0.007	0.007	0.008	0.008	0.008	0.008	0.009	0.009	0.009	0.009	0.01	0.01	0.01	0.01	0.011	0.011	0.011	0.011	0.012	0.011	0.012	0.012	0.013	0.013
Co	mg/L	NG	NG	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.05
Cu	mg/L	NG	NG	0.008	0.008	0.009	0.009	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03
Cr	mg/L	NG	NG	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0005	0.0005	0.0005	0.0005	0.0006	0.0006	0.0006	0.0006	0.0007	0.0007	0.0007	0.0008	0.0008	0.0009	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Fe	mg/L	0.7	16	0.00006	0.00006	0.00007	0.00007	0.00007	0.00007	0.00007	0.00007	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00009	0.00009	0.00009	0.00009	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Hg	mg/L	0.0006	0.0006	0.0007	0.0007	0.0008	0.0008	0.0008	0.0008	0.0009	0.0009	0.0009	0.0009	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Li	mg/L	NG	NG	1.7	1.6	1.8	1.8	2	1.9	2.1	2.1	2.3	2.2	2.4	2.4	2.6	2.5	2.7	2.7	2.9	2.8	3	3	3.2	3.1	3.3	3.3	3.5	3.4	3.7	3.6
Mn	mg/L	NG	NG	1.3	1.3	1.5	1.4	1.6	1.6	1.7	1.7	1.8	1.8	1.9	1.9	2.1	2	2.2	2.1	2.3	2.3	2.4	2.4	2.6	2.5	2.7	2.6	2.8	2.7	2.9	2.9
Mo	mg/L	0.034	0.034	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Ni	mg/L	NG	NG	0.06	0.06	0.06	0.06	0.07	0.07	0.08	0.07	0.08	0.08	0.09	0.08	0.09	0.09	0.1	0.09	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
P	mg/L	NG	NG	10	9.9	11	11	12	11	12	12	13	13	14	14	15	14	15	15	16	16	17	17	18	18	19	18	20	19	21	20
Pb	mg/L	NG	NG	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.004	0.004	0.005	0.005	0.005	0.006	0.006	0.006	0.007	0.007	0.008	0.008	0.009	0.009	0.009	0.009	0.01	0.01	0.01	0.01
Sb	mg/L	0.009	0.009	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Se	mg/L	0.011	0.02	0.1	0.1	0.11	0.11	0.12	0.12	0.13	0.13	0.14	0.13	0.14	0.14	0.15	0.15	0.16	0.16	0.17	0.17	0.18	0.17	0.19	0.18	0.19	0.19	0.2	0.2	0.21	0.21
Si	mg/L	NG	NG	41	41	40	40	39	39	38	38	38	38	37	37	36	36	35	35	34	35	34	34	33	33	32	32	31	31	31	31
Sn	mg/L	NG	NG	0.06	0.06	0.07	0.07	0.07	0.07	0.08	0.08	0.08	0.08	0.09	0.09	0.09	0.09	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Sr	mg/L	NG	NG	32	32	35	34	38	37	41	40	44	43	46	46	49	48	52	51	55	54	58	56	57	54	55	53	54	51	52	50
Tl	mg/L	NG	NG	0.007	0.007	0.008	0.008	0.008	0.008	0.009	0.009	0.009	0.009	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
U	mg/L	NG	NG	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.05
V	mg/L	NG	NG	0.06	0.06	0.07	0.07	0.07	0.07	0.08	0.08	0.08	0.08	0.09	0.09	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1
Zn	mg/L	NG	NG	0.2	0.2	0.2	0.2	0.3	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.4	0.5	0.5

Table B.9 Mimosa/Besgrove residual void lake water quality – without geochemical controls (Part 1 of 2)

Parameter	Unit	Lower TV	Upper TV	2089	2090	2100	2110	2120	2130	2140	2150	2160	2170	2180	2190	2200	2210	2220	2230	2240	2250	2260	2270	2280	2290	2300	2310	2320
pH	pH Units	6.5	8.5	9.2	8.3	8.7	8.1	8	7.9	7.8	7.8	7.7	7.7	7.7	7.6	7.6	7.6	7.6	7.6	7.6	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
pe	pe units	NG	NG	5.8	6.1	5.9	6.2	6.3	6.4	6.4	6.5	6.5	6.5	6.5	6.5	6.5	6.6	6.6	6.6	6.6	6.6	6.6	6.7	6.7	6.7	6.7	6.7	6.7
TDS	mg/L	4992	10599	551	2508	1711	4817	6462	9277	10653	13599	14687	17732	18547	21631	22184	25259	25614	28712	28716	31985	31814	35465	35314	39295	39093	43334	42993
Alkalinity	mg $CaCO_3$/L	NG	NG	165	239	223	409	530	735	836	1049	1127	1347	1404	1624	1661	1879	1901	2120	2116	2346	2331	2588	2575	2856	2839	3139	3113
Ca	mg/L	NG	NG	6.6	48	30.6	93.8	127	183	210	269	290	351	367	429	440	501	509	570	571	636	633	706	703	782	778	863	856
Mg	mg/L	NG	NG	10.7	90.7	56.9	178	241	348	400	512	554	669	701	818	840	957	971	1089	1090	1214	1208	1348	1342	1494	1487	1649	1636
K	mg/L	NG	NG	10	10	11	16	20	27	30	38	40	47	49	57	58	65	65	73	72	80	79	88	87	96	96	105	104
Na	mg/L	NG	NG	181	774	534	1481	1986	2848	3270	4172	4506	5438	5688	6632	6801	7743	7851	8800	8801	9802	9749	10867	10820	12039	11977	13276	13171
Cl	mg/L	NG	NG	210	1381	892	2694	3630	5233	6017	7695	8316	10052	10518	12278	12595	14351	14556	16327	16332	18200	18106	20192	20108	22382	22269	24692	24498
F	mg/L	NG	NG	0.5	0.5	0.5	0.7	0.9	1.2	1.4	1.7	1.8	2.1	2.2	2.5	2.6	2.9	2.9	3.2	3.2	3.5	3.5	3.8	3.8	4.2	4.2	4.6	4.6
SO_4	mg/L	318	520	33	52	47	90	117	163	186	234	251	301	313	363	371	421	426	475	475	526	523	581	578	642	638	706	700
N	mg N/L	NG	NG	0.009	0.008	0.009	0.01	0.01	0.02	0.02	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.07	0.07
Al	mg/L	0.055	0.48	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.5	0.5	0.6	0.6	0.6	0.6	0.7	0.7	0.7	0.7	0.8	0.8	0.9	0.9	0.9	0.9
Ag	mg/L	0.001	0.39	9E-04	0.0007	0.0009	0.001	0.001	0.002	0.002	0.002	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.005	0.005	0.005	0.005	0.005	0.005	0.006	0.006	0.007	0.006
As	mg/L	0.013	0.013	0.07	0.04	0.06	0.06	0.07	0.09	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3
B	mg/L	NG	NG	0.2	0.3	0.3	0.5	0.7	1	1.1	1.4	1.5	1.8	1.9	2.2	2.2	2.5	2.5	2.8	2.8	3.1	3.1	3.4	3.4	3.8	3.8	4.2	4.2
Ba	mg/L	NG	NG	0.04	0.2	0.1	0.4	0.5	0.78	0.9	1.1	1.2	1.5	1.6	1.8	1.9	2.1	2.2	2.4	2.4	2.7	2.7	3	3	3.3	3.3	3.7	3.6
Be	mg/L	NG	NG	0.002	0.001	0.002	0.002	0.002	0.003	0.003	0.004	0.004	0.005	0.005	0.005	0.005	0.006	0.006	0.007	0.007	0.007	0.007	0.008	0.008	0.009	0.009	0.009	0.009
Cd	mg/L	NG	NG	0.002	0.001	0.001	0.001	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.004	0.004	0.005	0.005	0.005	0.005	0.006	0.006	0.006	0.006
Co	mg/L	NG	NG	0.002	0.002	0.002	0.003	0.004	0.006	0.007	0.008	0.009	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Cu	mg/L	NG	NG	0.002	0.002	0.002	0.003	0.004	0.005	0.006	0.007	0.008	0.009	0.009	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.02	0.02	0.02	0.02	0.02	0.02
Cr	mg/L	NG	NG	0.002	0.001	0.002	0.002	0.002	0.003	0.003	0.004	0.004	0.005	0.005	0.005	0.005	0.006	0.006	0.007	0.007	0.007	0.007	0.008	0.008	0.009	0.009	0.009	0.009
Fe	mg/L	0.7	16	0.2	0.4	0.3	0.6	0.8	1.2	1.3	1.7	1.8	2.1	2.2	2.6	2.7	3	3.1	3.4	3.4	3.8	3.8	4.2	4.2	4.6	4.6	5.1	5.1
Hg	mg/L	0.0006	0.0006	9E-05	0.00007	0.00009	0.0001	0.0001	0.0002	0.0002	0.0002	0.0003	0.0003	0.0003	0.0004	0.0004	0.0004	0.0004	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0006	0.0006	0.0007	0.0006
Li	mg/L	NG	NG	0.008	0.08	0.05	0.2	0.2	0.3	0.4	0.5	0.5	0.6	0.6	0.8	0.8	0.9	0.9	1	1	1.1	1.1	1.2	1.2	1.4	1.4	1.5	1.5
Mn	mg/L	NG	NG	0.009	0.07	0.04	0.1	0.2	0.3	0.3	0.4	0.4	0.5	0.5	0.6	0.6	0.7	0.7	0.8	0.8	0.9	0.9	1	1	1.1	1.1	1.2	1.2
Mo	mg/L	0.034	0.034	0.03	0.02	0.03	0.03	0.03	0.04	0.04	0.05	0.05	0.06	0.06	0.07	0.07	0.08	0.08	0.08	0.08	0.09	0.09	0.1	0.1	0.1	0.1	0.1	0.1
Ni	mg/L	NG	NG	0.002	0.004	0.003	0.007	0.0089	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.06	0.06
P	mg/L	NG	NG	1.6	1.2	1.6	1.8	2.2	2.8	3.1	3.7	3.9	4.6	4.7	5.4	5.4	6	6.1	6.7	6.6	7.2	7.2	7.9	7.8	8.6	8.5	9.3	9.2
Pb	mg/L	NG	NG	0.002	0.001	0.0016	0.002	0.002	0.003	0.003	0.004	0.004	0.005	0.005	0.005	0.005	0.006	0.006	0.007	0.007	0.007	0.007	0.008	0.008	0.009	0.009	0.009	0.009
Sb	mg/L	0.009	0.009	0.003	0.002	0.003	0.003	0.004	0.005	0.005	0.006	0.007	0.008	0.008	0.009	0.009	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01
Se	mg/L	0.011	0.02	0.017	0.013	0.016	0.018	0.022	0.029	0.032	0.038	0.041	0.047	0.049	0.055	0.056	0.062	0.062	0.068	0.068	0.074	0.073	0.081	0.08	0.088	0.087	0.096	0.095
Si	mg/L	NG	NG	0.3	3.1	1.9	6.2	8.4	12	14	18	19	23	24	29	29	33	34	38	38	42	42	47	47	52	52	58	57
Sn	mg/L	NG	NG	0.02	0.01	0.01	0.01	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06
Sr	mg/L	NG	NG	0.3	1.7	1.1	3.2	4.3	6.2	7.1	9.1	9.9	12	12	15	15	17	17	19	19	22	21	24	24	26	26	29	29
Tl	mg/L	NG	NG	9E-04	0.0007	0.0009	0.001	0.001	0.002	0.002	0.002	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.005	0.005	0.005	0.005	0.005	0.005	0.006	0.006	0.007	0.006
U	mg/L	NG	NG	0.002	0.002	0.002	0.003	0.004	0.006	0.007	0.008	0.009	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
V	mg/L	NG	NG	0.02	0.01	0.02	0.02	0.02	0.03	0.03	0.04	0.04	0.05	0.05	0.05	0.05	0.06	0.06	0.07	0.07	0.07	0.07	0.08	0.08	0.09	0.09	0.09	0.09
Zn	mg/L	NG	NG	0.009	0.01	0.01	0.03	0.03	0.05	0.05	0.07	0.07	0.09	0.09	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Table B.10 Mimosa/Besgrove residual void lake water quality – without geochemical controls (Part 2 of 2)

Parameter	Unit	Lower TV	Upper TV	2330	2340	2350	2360	2370	2380	2390	2400	2410	2420	2430	2440	2450	2460	2470	2480	2490	2500	2510	2520	2530	2540	2550	2560	2570	2580	2590	2599
pH	pH Units	6.5	8.5	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.1	7.2
pe	pe units	NG	NG	6.8	6.7	6.8	6.8	6.8	6.8	6.9	6.9	6.9	6.9	6.9	6.9	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
TDS	mg/L	4992	10599	47539	47066	51887	51244	56329	55483	60834	60163	64667	63882	68682	67876	72933	72024	77316	76276	81783	80601	86268	84449	90804	88539	95423	92882	100100	97265	104790	102150
Alkalinity	mg $CaCO_3$/L	NG	NG	3434	3399	3739	3692	4051	3990	4367	4318	4636	4579	4917	4860	5216	5151	5524	5450	5838	5753	6153	6023	6471	6310	6795	6615	7123	6922	7452	7264
Ca	mg/L	NG	NG	947	938	1034	1021	1123	1106	1213	1200	1290	1274	1370	1354	1455	1437	1543	1522	1632	1608	1722	1685	1812	1767	1905	1854	1998	1942	2092	2039
Mg	mg/L	NG	NG	1809	1791	1976	1951	2145	2113	2318	2292	2464	2434	2618	2587	2780	2746	2948	2908	3119	3073	3290	3221	3463	3377	3640	3543	3819	3711	3998	3897
K	mg/L	NG	NG	115	114	125	123	135	133	145	143	154	152	163	161	173	170	183	180	193	190	203	199	213	208	224	218	234	228	245	239
Na	mg/L	NG	NG	14563	14418	15894	15697	17254	16995	18633	18427	19806	19566	21035	20789	22337	22059	23679	23360	25046	24684	26419	25862	27808	27115	29222	28444	30655	29786	32091	31280
Cl	mg/L	NG	NG	27096	26826	29581	29215	32120	31638	34696	34314	36888	36440	39183	38723	41613	41094	44118	43525	46672	45997	49236	48197	51829	50536	54470	53018	57145	55524	59827	58315
F	mg/L	NG	NG	5	5	5.4	5.4	5.9	5.8	6.3	6.3	6.7	6.6	7.1	7	7.5	7.4	7.9	7.8	8.4	8.3	8.8	8.6	9.3	9	9.7	9.5	10	9.9	11	10
SO_4	mg/L	318	520	772	764	841	831	912	898	983	972	1044	1031	1107	1094	1175	1160	1244	1228	1315	1296	1386	1357	1458	1422	1532	1491	1606	1560	1680	1638
N	mg N/L	NG	NG	0.07	0.07	0.08	0.08	0.09	0.08	0.09	0.09	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1
Al	mg/L	0.055	0.48	1	1	1.1	1.1	1.2	1.1	1.2	1.2	1.3	1.3	1.4	1.4	1.5	1.4	1.5	1.5	1.6	1.6	1.7	1.7	1.8	1.7	1.8	1.8	1.9	1.9	2	2
Ag	mg/L	0.001	0.39	0.007	0.007	0.008	0.008	0.008	0.008	0.009	0.009	0.009	0.009	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
As	mg/L	0.013	0.013	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
B	mg/L	NG	NG	4.6	4.5	5	4.9	5.4	5.3	5.8	5.8	6.2	6.1	6.6	6.5	7	6.9	7.4	7.3	7.8	7.7	8.2	8.1	8.7	8.5	9.1	8.9	9.5	9.3	10	9.7
Ba	mg/L	NG	NG	4	4	4.4	4.3	4.8	4.7	5.2	5.1	5.5	5.4	5.8	5.8	6.2	6.1	6.6	6.5	6.9	6.8	7.3	7.2	7.7	7.5	8.1	7.9	8.5	8.2	8.9	8.7
Be	mg/L	NG	NG	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Cd	mg/L	NG	NG	0.006	0.006	0.007	0.007	0.007	0.007	0.008	0.008	0.008	0.008	0.009	0.009	0.009	0.009	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Co	mg/L	NG	NG	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.05
Cu	mg/L	NG	NG	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05
Cr	mg/L	NG	NG	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Fe	mg/L	0.7	16	5.6	5.5	6.1	6	6.6	6.5	7.1	7	7.6	7.5	8	7.9	8.5	8.4	9	8.9	9.5	9.4	10	9.9	11	10	11	11	12	11	12	12
Hg	mg/L	0.0006	0.0006	0.0007	0.0007	0.0008	0.0008	0.0008	0.0008	0.0009	0.0009	0.0009	0.0009	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Li	mg/L	NG	NG	1.7	1.6	1.8	1.8	2	1.9	2.1	2.1	2.3	2.2	2.4	2.4	2.6	2.5	2.7	2.7	2.9	2.8	3	3	3.2	3.1	3.3	3.3	3.5	3.4	3.7	3.6
Mn	mg/L	NG	NG	1.3	1.3	1.5	1.4	1.6	1.6	1.7	1.7	1.8	1.8	1.9	1.9	2.1	2	2.2	2.1	2.3	2.3	2.4	2.4	2.6	2.5	2.7	2.6	2.8	2.7	3	2.9
Mo	mg/L	0.034	0.034	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Ni	mg/L	NG	NG	0.06	0.06	0.07	0.07	0.07	0.07	0.08	0.08	0.08	0.08	0.09	0.09	0.09	0.09	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
P	mg/L	NG	NG	10	10	11	11	12	12	13	12	13	13	14	14	15	15	16	15	17	16	17	17	18	18	19	19	20	19	21	20
Pb	mg/L	NG	NG	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Sb	mg/L	0.009	0.009	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Se	mg/L	0.011	0.02	0.1	0.1	0.11	0.11	0.12	0.12	0.13	0.13	0.14	0.13	0.14	0.14	0.15	0.15	0.16	0.16	0.17	0.17	0.18	0.17	0.19	0.18	0.2	0.19	0.2	0.2	0.21	0.21
Si	mg/L	NG	NG	63	63	69	68	75	74	81	80	86	85	91	90	97	96	103	102	109	107	115	113	121	118	127	124	133	130	140	136
Sn	mg/L	NG	NG	0.06	0.06	0.07	0.07	0.07	0.07	0.08	0.08	0.08	0.08	0.09	0.09	0.09	0.09	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Sr	mg/L	NG	NG	32	32	35	35	38	37	41	41	44	43	46	46	49	49	52	51	55	54	58	57	61	60	64	63	67	66	71	69
Tl	mg/L	NG	NG	0.007	0.007	0.008	0.008	0.008	0.008	0.009	0.009	0.009	0.009	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
U	mg/L	NG	NG	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.05
V	mg/L	NG	NG	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Zn	mg/L	NG	NG	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5

Table B.11 Deep Creek residual void lake water quality – with geochemical controls (Part 1 of 2)

Parameter	Unit	Lower TV	Upper TV	2057	2060	2070	2080	2090	2100	2110	2120	2130	2140	2150	2160	2170	2180	2190	2200	2210	2220	2230	2240	2250	2260	2270	2280	2290	2300	2310	2320
pH	pH Units	6.5	8.5	8.7	8.6	8.5	8.4	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.2	8.2	8.2	8.2	8.2	8.2	8.2	8.2	8.2	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1
pe	pe units	NG	NG	6.9	7.2	6	5.9	5.9	6	5.9	5.9	5.8	5.8	5.8	5.8	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9
TDS	mg/L	4992	10599	316	247	3423	5984	7813	8179	8755	8725	9976	10376	11791	12257	13676	14080	15509	15857	17277	17567	19014	19206	20728	20855	22525	22639	24410	24476	26298	26278
Alkalinity	mg $CaCO_3$/L	NG	NG	132	103	103	91	86	88	84	84	82	81	80	80	79	79	78	78	77	77	76	76	76	76	75	75	75	75	74	74
Ca	mg/L	NG	NG	1.9	1.5	18	32	42	42	47	47	54	56	64	66	74	76	83	85	93	94	102	103	111	112	121	121	131	131	141	141
Mg	mg/L	NG	NG	1.7	1.3	111	199	264	265	295	297	340	354	401	416	464	477	525	537	584	594	643	649	701	705	761	765	825	827	889	888
K	mg/L	NG	NG	9	7	13	18	21	24	23	22	24	25	28	29	32	33	36	37	40	41	44	44	47	48	51	52	55	55	59	59
Na	mg/L	NG	NG	110	86	1118	1952	2544	2677	2851	2838	3244	3375	3837	3989	4452	4584	5050	5164	5627	5721	6193	6256	6752	6793	7337	7375	7952	7973	8567	8561
Cl	mg/L	NG	NG	87	68	2016	3596	4724	4934	5302	5287	6057	6302	7170	7455	8325	8572	9448	9661	10532	10710	11597	11715	12648	12725	13749	13819	14904	14945	16061	16049
F	mg/L	NG	NG	0.5	0.4	0.7	0.9	1	1.2	1.1	1	1.1	1.2	1.3	1.3	1.5	1.5	1.6	1.7	1.8	1.8	2	2	2.1	2.2	2.3	2.3	2.5	2.5	2.7	2.7
SO_4	mg/L	318	520	27	21	71	110	136	150	152	149	168	174	197	205	228	235	258	263	286	291	314	317	342	344	370	372	401	402	431	431
N	mg N/L	NG	NG	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Al	mg/L	0.055	0.48	0.2	0.2	0.2	0.2	0.2	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4
Ag	mg/L	0.001	0.39	9E-04	7E-04	0.001	0.001	0.001	0.002	0.001	0.001	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.004	0.004
As	mg/L	0.013	0.013	0.05	0.04	0.04	0.03	0.02	0.04	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05
B	mg/L	NG	NG	0.2	0.1	0.4	0.7	0.8	0.9	0.9	0.9	1	1	1.2	1.2	1.4	1.4	1.5	1.6	1.7	1.7	1.9	1.9	2	2.1	2.2	2.2	2.4	2.4	2.6	2.6
Ba	mg/L	NG	NG	0.02	0.02	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.09	0.09	0.09	0.09	0.09	0.09
Be	mg/L	NG	NG	6E-05	4E-05	0.00006	0.00008	0.00007	0.0001	0.00005	0.00006	0.00005	0.00006	0.00006	0.00007	0.00006	0.00007	0.00006	0.00007	0.00006	0.00007	0.00006	0.00007	0.00006	0.00007	0.00006	0.00007	0.00006	0.00008	0.00007	0.00008
Cd	mg/L	NG	NG	0.001	0.001	0.001	0.001	0.001	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Co	mg/L	NG	NG	0.001	0.001	0.003	0.004	0.005	0.005	0.005	0.005	0.006	0.006	0.006	0.007	0.007	0.008	0.008	0.009	0.009	0.009	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Cu	mg/L	NG	NG	8E-04	5E-04	0.001	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.004
Cr	mg/L	NG	NG	0.002	0.001	0.001	0.0008	0.0004	0.0009	0.0003	0.0003	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
Fe	mg/L	0.7	16	4E-05	4E-05	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005
Hg	mg/L	0.0006	0.0006	9E-05	7E-05	0.0001	0.0001	0.0001	0.0002	0.0001	0.0001	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0004	0.0004
Li	mg/L	NG	NG	0	0	0.12	0.22	0.29	0.3	0.32	0.32	0.37	0.39	0.44	0.46	0.51	0.53	0.58	0.59	0.65	0.66	0.71	0.72	0.78	0.78	0.85	0.85	0.92	0.92	0.99	0.99
Mn	mg/L	NG	NG	0.002	0.002	0.1	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.7	0.7	0.7	0.7	0.8	0.8
Mo	mg/L	0.034	0.034	0.02	0.02	0.02	0.02	0.02	0.03	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Ni	mg/L	NG	NG	0.001	0.001	0.005	0.008	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
P	mg/L	NG	NG	1.5	1.2	1.6	1.8	1.9	2.5	2.1	1.9	2	2.1	2.3	2.4	2.6	2.7	2.9	3	3.2	3.2	3.4	3.5	3.7	3.7	4	4	4.2	4.3	4.5	4.5
Pb	mg/L	NG	NG	3E-04	2E-04	0.000096	0.0001	0.0001	0.0003	0.00009	0.0001	0.00009	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0002	0.0001	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0003	0.0003	0.0003
Sb	mg/L	0.009	0.009	0.0029	0.0023	0.0028	0.003	0.003	0.0041	0.0033	0.003	0.0031	0.0032	0.0035	0.0036	0.0039	0.0041	0.0044	0.0044	0.0047	0.0048	0.0051	0.0051	0.0054	0.0055	0.0058	0.0058	0.0062	0.0062	0.0066	0.0066
Se	mg/L	0.011	0.02	0.016	0.012	0.016	0.019	0.019	0.025	0.021	0.019	0.021	0.021	0.023	0.024	0.027	0.027	0.03	0.03	0.032	0.033	0.035	0.035	0.037	0.038	0.04	0.04	0.043	0.043	0.046	0.046
Si	mg/L	NG	NG	0	0	4.6	8.3	11	11	12	12	14	15	17	17	19	20	22	23	25	25	27	27	30	30	32	32	35	35	38	38
Sn	mg/L	NG	NG	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Sr	mg/L	NG	NG	0.1	0.1	2.4	4.2	5.6	5.8	6.2	6.2	7.1	7.4	8.4	8.8	9.8	10	11	11	12	13	14	14	15	15	16	16	18	18	19	19
Tl	mg/L	NG	NG	9E-04	7E-04	0.001	0.001	0.001	0.002	0.001	0.001	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.004	0.004
U	mg/L	NG	NG	0.002	0.001	0.003	0.004	0.005	0.005	0.005	0.005	0.006	0.006	0.006	0.007	0.007	0.008	0.008	0.009	0.009	0.009	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
V	mg/L	NG	NG	0.01	0.01	0.01	0.01	0.009	0.01	0.01	0.009	0.009	0.009	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Zn	mg/L	NG	NG	0.007	0.005	0.02	0.03	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.06	0.06	0.06	0.07	0.07	0.08	0.08	0.09	0.09	0.09	0.09	0.1	0.1	0.1	0.1	0.1	0.1

DRAFT

Table B.12 Deep Creek residual void lake water quality – with geochemical controls (Part 2 of 2)

Parameter	Unit	Lower TV	Upper TV	2330	2340	2350	2360	2370	2380	2390	2400	2410	2420	2430	2440	2450	2460	2470	2480	2490	2500	2510	2520	2530	2540	2550	2560	2570	2580	2590	2599
pH	pH Units	6.5	8.5	8.1	8.1	8.1	8.1	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	7.9	8	7.9	7.9
pe	pe units	NG	NG	5.9	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1
TDS	mg/L	4992	10599	28157	28057	29976	29786	31732	31444	33417	33172	34803	34487	36163	35809	37512	37102	38824	38355	40089	39564	41294	40567	42459	41597	43592	42650	44686	43662	45731	44764
Alkalinity	mg $CaCO_3$/L	NG	NG	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74
Ca	mg/L	NG	NG	151	150	161	160	170	169	179	178	187	185	194	192	201	199	208	206	215	212	222	218	228	223	234	229	240	235	246	241
Mg	mg/L	NG	NG	951	948	1012	1006	1072	1062	1129	1120	1176	1165	1222	1210	1267	1253	1312	1296	1354	1337	1395	1371	1435	1405	1473	1441	1510	1475	1546	1513
K	mg/L	NG	NG	63	63	67	67	71	70	75	74	78	77	81	80	83	83	86	85	89	88	92	90	94	92	97	95	99	97	101	99
Na	mg/L	NG	NG	9173	9141	9766	9704	10340	10246	10892	10812	11346	11243	11791	11676	12233	12099	12662	12509	13076	12905	13471	13234	13853	13571	14224	13916	14582	14247	14924	14608
Cl	mg/L	NG	NG	17201	17139	18315	18199	19393	19218	20431	20281	21284	21090	22121	21904	22951	22700	23759	23471	24538	24215	25280	24833	25997	25468	26694	26115	27367	26739	28011	27417
F	mg/L	NG	NG	2.8	2.8	3	3	3.2	3.1	3.3	3.3	3.5	3.4	3.6	3.6	3.7	3.7	3.8	3.8	4	3.9	4.1	4	4.2	4.1	4.3	4.2	4.4	4.3	4.5	4.4
SO_4	mg/L	318	520	461	459	490	487	518	514	546	542	568	563	590	585	612	605	633	626	654	645	673	661	692	678	710	695	728	711	745	729
N	mg N/L	NG	NG	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
Al	mg/L	0.055	0.48	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.5	0.6	0.6	0.6	0.6	0.6	0.6
Ag	mg/L	0.001	0.39	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006
As	mg/L	0.013	0.013	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.06	0.07	0.07	0.07	0.07	0.07	0.07	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.09	0.09	0.09	0.09
B	mg/L	NG	NG	2.8	2.8	2.9	2.9	3.1	3.1	3.3	3.2	3.4	3.4	3.5	3.5	3.7	3.6	3.8	3.8	3.9	3.9	4	4	4.2	4.1	4.3	4.2	4.4	4.3	4.5	4.4
Ba	mg/L	NG	NG	0.08	0.08	0.08	0.08	0.08	0.08	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
Be	mg/L	NG	NG	0.00007	0.00008	0.00007	0.00008	0.00007	0.00008	0.00007	0.00008	0.00007	0.00008	0.00007	0.00008	0.00008	0.00008	0.00008	0.00009	0.00008	0.00009	0.00008	0.00009	0.00008	0.00009	0.00008	0.00009	0.00008	0.00009	0.00008	0.00009
Cd	mg/L	NG	NG	0.002	0.002	0.003	0.002	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.004	0.003
Co	mg/L	NG	NG	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Cu	mg/L	NG	NG	0.004	0.004	0.004	0.004	0.005	0.005	0.005	0.005	0.005	0.006	0.006	0.006	0.006	0.006	0.007	0.007	0.007	0.007	0.007	0.007	0.008	0.008	0.008	0.008	0.008	0.008	0.009	0.009
Cr	mg/L	NG	NG	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
Fe	mg/L	0.7	16	0.00006	0.00005	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006	0.00007	0.00006	0.00007	0.00007
Hg	mg/L	0.0006	0.0006	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006
Li	mg/L	NG	NG	1.1	1.1	1.1	1.1	1.2	1.2	1.3	1.2	1.3	1.3	1.4	1.3	1.4	1.4	1.5	1.4	1.5	1.5	1.6	1.5	1.6	1.6	1.6	1.6	1.7	1.6	1.7	1.7
Mn	mg/L	NG	NG	0.9	0.8	0.9	0.9	1	0.9	1	1	1.1	1	1.1	1.1	1.1	1.1	1.2	1.2	1.2	1.2	1.2	1.2	1.3	1.3	1.3	1.3	1.4	1.3	1.4	1.4
Mo	mg/L	0.034	0.034	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.07	0.06	0.07	0.07	0.07	0.07	0.07	0.07
Ni	mg/L	NG	NG	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.05	0.06	0.06	0.06	0.06
P	mg/L	NG	NG	4.8	4.8	5.1	5.1	5.3	5.3	5.6	5.6	5.8	5.8	6	6	6.2	6.2	6.4	6.4	6.6	6.5	6.8	6.7	7	6.8	7.1	7	7.3	7.2	7.5	7.3
Pb	mg/L	NG	NG	0.0003	0.0003	0.0004	0.0004	0.0004	0.0005	0.0005	0.0005	0.0006	0.0006	0.0007	0.0007	0.0007	0.0008	0.0008	0.0009	0.0009	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.002
Sb	mg/L	0.009	0.009	0.007	0.007	0.0074	0.0073	0.0078	0.0077	0.0081	0.0081	0.0084	0.0083	0.0087	0.0086	0.009	0.0089	0.0093	0.0092	0.0095	0.0094	0.0098	0.0096	0.01	0.0099	0.01	0.01	0.011	0.01	0.011	0.011
Se	mg/L	0.011	0.02	0.049	0.049	0.052	0.051	0.054	0.054	0.057	0.056	0.059	0.059	0.061	0.061	0.063	0.063	0.065	0.065	0.067	0.066	0.069	0.068	0.071	0.07	0.073	0.071	0.074	0.073	0.076	0.074
Si	mg/L	NG	NG	40	40	43	43	44	43	44	43	43	43	43	42	43	42	42	42	42	42	42	41	42	41	41	41	41	40	41	40
Sn	mg/L	NG	NG	0.02	0.02	0.03	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.03
Sr	mg/L	NG	NG	20	20	22	21	23	23	24	24	25	25	26	26	27	27	28	28	29	28	30	29	31	30	31	31	32	31	33	32
Tl	mg/L	NG	NG	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006
U	mg/L	NG	NG	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
V	mg/L	NG	NG	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Zn	mg/L	NG	NG	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Table B.13 Deep Creek residual void lake water quality – without geochemical controls (Part 1 of 2)

Parameter	Unit	Lower TV	Upper TV	2057	2060	2070	2080	2090	2100	2110	2120	2130	2140	2150	2160	2170	2180	2190	2200	2210	2220	2230	2240	2250	2260	2270	2280	2290
pH	pH Units	6.5	8.5	9.4	9.4	8.2	7.9	7.7	7.8	7.7	7.7	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
pe	pe units	NG	NG	7.9	7.9	6.3	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.6	6.6	6.6	6.6	6.6	6.6	6.6
TDS	mg/L	4992	10599	316	247	3626	6356	8298	8719	9303	9262	10594	11021	12531	13029	14543	14974	16499	16870	18385	18694	20237	20442	22065	22200	23981	24103	25991
Alkalinity	mg $CaCO_3$/L	NG	NG	132	104	321	489	603	668	669	656	740	767	868	902	1002	1031	1132	1157	1257	1278	1379	1393	1499	1508	1625	1633	1758
Ca	mg/L	NG	NG	1.9	1.5	70	125	165	172	185	185	212	220	250	260	291	299	330	338	368	374	405	409	442	445	481	483	520
Mg	mg/L	NG	NG	1.7	1.3	132	238	314	327	353	353	404	421	479	498	556	573	631	646	704	716	775	783	846	851	919	924	997
K	mg/L	NG	NG	9	7	13	18	21	24	23	22	24	25	28	29	32	33	36	37	40	41	44	44	47	48	51	52	55
Na	mg/L	NG	NG	110	86	1118	1952	2544	2678	2852	2838	3245	3375	3837	3990	4453	4585	5051	5165	5628	5723	6195	6257	6754	6795	7340	7377	7954
Cl	mg/L	NG	NG	87	68	2016	3596	4725	4935	5303	5288	6057	6303	7171	7456	8327	8574	9450	9663	10534	10712	11600	11718	12651	12729	13753	13823	14909
F	mg/L	NG	NG	0.5	0.4	0.7	0.9	1	1.2	1.1	1	1.1	1.2	1.3	1.3	1.5	1.5	1.7	1.7	1.8	1.8	2	2	2.1	2.2	2.3	2.3	2.5
SO_4	mg/L	318	520	27	21	71	110	137	151	152	149	169	175	198	206	229	236	259	264	287	292	315	318	343	345	372	374	402
N	mg N/L	NG	NG	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04
Al	mg/L	0.055	0.48	0.2	0.2	0.2	0.2	0.2	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4
Ag	mg/L	0.001	0.39	9E-04	7E-04	0.001	0.001	0.001	0.002	0.001	0.001	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
As	mg/L	0.013	0.013	0.06	0.05	0.05	0.05	0.05	0.07	0.05	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.07	0.07	0.07	0.07	0.08	0.08	0.08	0.08	0.09	0.09	0.09
B	mg/L	NG	NG	0.2	0.1	0.4	0.7	0.8	0.9	0.9	0.9	1	1	1.2	1.2	1.4	1.4	1.5	1.6	1.7	1.7	1.9	1.9	2	2.1	2.2	2.2	2.4
Ba	mg/L	NG	NG	0.02	0.02	0.3	0.5	0.7	0.7	0.8	0.8	0.9	0.9	1.1	1.1	1.2	1.3	1.4	1.4	1.6	1.6	1.7	1.7	1.9	1.9	2	2	2.2
Be	mg/L	NG	NG	0.002	0.001	0.002	0.002	0.002	0.003	0.002	0.002	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.004	0.004
Cd	mg/L	NG	NG	0.001	0.001	0.001	0.001	0.001	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Co	mg/L	NG	NG	0.002	0.001	0.003	0.004	0.005	0.005	0.005	0.005	0.006	0.006	0.006	0.007	0.007	0.008	0.008	0.009	0.009	0.009	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Cu	mg/L	NG	NG	0.002	0.001	0.002	0.003	0.004	0.005	0.004	0.004	0.005	0.005	0.005	0.006	0.006	0.006	0.007	0.007	0.008	0.008	0.008	0.009	0.009	0.009	0.01	0.01	0.01
Cr	mg/L	NG	NG	0.002	0.001	0.002	0.002	0.002	0.003	0.002	0.002	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.004	0.004
Fe	mg/L	0.7	16	0.1	0.1	0.5	0.8	1	1.1	1.1	1.1	1.2	1.3	1.4	1.5	1.7	1.7	1.9	1.9	2.1	2.1	2.3	2.3	2.5	2.5	2.7	2.7	2.9
Hg	mg/L	0.0006	0.0006	9E-05	7E-05	0.0001	0.0001	0.0001	0.0002	0.0001	0.0001	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003
Li	mg/L	NG	NG	0	0	0.12	0.22	0.29	0.3	0.32	0.32	0.37	0.39	0.44	0.46	0.51	0.53	0.58	0.59	0.65	0.66	0.71	0.72	0.78	0.78	0.85	0.85	0.92
Mn	mg/L	NG	NG	0.003	0.002	0.1	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.7	0.7	0.7
Mo	mg/L	0.034	0.034	0.02	0.02	0.02	0.02	0.02	0.03	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04
Ni	mg/L	NG	NG	0.002	0.001	0.005	0.009	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03
P	mg/L	NG	NG	1.6	1.2	1.6	1.8	1.9	2.5	2.1	1.9	2.1	2.1	2.3	2.4	2.7	2.7	3	3	3.2	3.3	3.5	3.5	3.7	3.8	4	4	4.3
Pb	mg/L	NG	NG	0.002	0.001	0.0016	0.002	0.002	0.003	0.002	0.002	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.004	0.004
Sb	mg/L	0.009	0.009	0.0029	0.0023	0.0028	0.003	0.003	0.0041	0.0033	0.003	0.0031	0.0032	0.0035	0.0036	0.0039	0.0041	0.0044	0.0044	0.0047	0.0048	0.0051	0.0051	0.0054	0.0055	0.0058	0.0058	0.0062
Se	mg/L	0.011	0.02	0.016	0.012	0.016	0.019	0.019	0.025	0.021	0.019	0.021	0.021	0.024	0.024	0.027	0.027	0.03	0.03	0.032	0.033	0.035	0.035	0.038	0.038	0.04	0.04	0.043
Si	mg/L	NG	NG	0	0	4.6	8.3	11	11	12	12	14	15	17	17	19	20	22	23	25	25	27	27	30	30	32	32	35
Sn	mg/L	NG	NG	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Sr	mg/L	NG	NG	0.1	0.1	2.4	4.2	5.6	5.8	6.2	6.2	7.1	7.4	8.43	8.8	9.8	10	11	11	12	13	14	14	15	15	16	16	18
Tl	mg/L	NG	NG	9E-04	7E-04	0.001	0.001	0.001	0.002	0.001	0.001	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
U	mg/L	NG	NG	0.002	0.001	0.003	0.004	0.005	0.005	0.005	0.005	0.006	0.006	0.006	0.007	0.007	0.008	0.008	0.009	0.009	0.009	0.01	0.01	0.01	0.01	0.01	0.01	0.01
V	mg/L	NG	NG	0.02	0.01	0.02	0.02	0.02	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04
Zn	mg/L	NG	NG	0.008	0.006	0.02	0.03	0.04	0.04	0.04	0.04	0.05	0.05	0.06	0.06	0.07	0.07	0.08	0.08	0.08	0.09	0.09	0.09	0.1	0.1	0.1	0.1	0.1

Table B.14 Deep Creek residual void lake water quality – without geochemical controls (Part 2 of 2)

Parameter	Unit	Lower TV	Upper TV	2300	2310	2320	2330	2340	2350	2360	2370	2380	2390	2400	2410	2420	2430	2440	2450	2460	2470	2480	2490	2500	2510	2520	2530	2540
pH	pH Units	6.5	8.5	7.5	7.5	7.5	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4
pe	pe units	NG	NG	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7
TDS	mg/L	4992	10599	26062	28004	27983	29988	29881	31927	31725	33804	33499	35610	35350	37096	36759	38553	38176	39999	39562	41405	40905	42761	42200	44053	43276	45301	44380
Alkalinity	mg $CaCO_3$/L	NG	NG	1763	1891	1890	2022	2015	2150	2137	2274	2254	2394	2376	2492	2470	2588	2564	2684	2655	2777	2744	2866	2829	2952	2901	3034	2973
Ca	mg/L	NG	NG	520	560	560	600	600	640	640	680	670	710	710	740	740	770	770	800	790	830	820	860	850	880	870	910	890
Mg	mg/L	NG	NG	1000	1074	1074	1151	1147	1225	1218	1298	1286	1367	1357	1424	1411	1481	1466	1536	1519	1590	1571	1643	1621	1692	1662	1740	1705
K	mg/L	NG	NG	55	59	59	63	63	67	67	71	70	75	74	78	77	81	80	83	83	86	85	89	88	92	90	94	92
Na	mg/L	NG	NG	7976	8570	8564	9177	9144	9770	9708	10344	10251	10896	10817	11351	11248	11797	11681	12239	12105	12669	12516	13084	12912	13479	13241	13861	13579
Cl	mg/L	NG	NG	14950	16067	16055	17207	17146	18322	18206	19401	19226	20440	20290	21294	21100	22132	21915	22963	22712	23771	23484	24551	24228	25294	24847	26012	25482
F	mg/L	NG	NG	2.5	2.7	2.7	2.8	2.8	3	3	3.2	3.1	3.3	3.3	3.5	3.4	3.6	3.6	3.7	3.7	3.8	3.8	4	3.9	4.1	4	4.2	4.1
SO_4	mg/L	318	520	403	433	432	463	461	492	489	521	516	548	544.1	570.6	565.5	592.7	587.1	614.7	608.1	636	628.4	656.5	648.1	676.1	664.4	695	681.1
N	mg N/L	NG	NG	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.07	0.07	0.07	0.07
Al	mg/L	0.055	0.48	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.5
Ag	mg/L	0.001	0.39	0.003	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.006	0.006
As	mg/L	0.013	0.013	0.09	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
B	mg/L	NG	NG	2.4	2.6	2.6	2.8	2.8	2.9	2.9	3.1	3.1	3.3	3.3	3.4	3.4	3.5	3.5	3.7	3.6	3.8	3.8	3.9	3.9	4	4	4.2	4.1
Ba	mg/L	NG	NG	2.2	2.4	2.4	2.6	2.5	2.7	2.7	2.9	2.8	3	3	3.2	3.1	3.3	3.2	3.4	3.4	3.5	3.5	3.6	3.6	3.7	3.7	3.9	3.8
Be	mg/L	NG	NG	0.004	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.007	0.006	0.007	0.007	0.007	0.007	0.007	0.007
Cd	mg/L	NG	NG	0.002	0.002	0.002	0.002	0.002	0.003	0.002	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
Co	mg/L	NG	NG	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Cu	mg/L	NG	NG	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Cr	mg/L	NG	NG	0.004	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.007	0.006	0.007	0.007	0.007	0.007	0.007	0.007
Fe	mg/L	0.7	16	3	3.2	3.2	3.4	3.4	3.6	3.6	3.8	3.8	4	4	4.2	4.1	4.4	4.3	4.5	4.5	4.7	4.6	4.8	4.8	5	4.9	5.1	5
Hg	mg/L	0.0006	0.0006	0.0003	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0006	0.0006
Li	mg/L	NG	NG	0.92	0.99	0.99	1.1	1.1	1.1	1.1	1.2	1.2	1.3	1.2	1.3	1.3	1.4	1.3	1.4	1.4	1.5	1.4	1.5	1.5	1.6	1.5	1.6	1.6
Mn	mg/L	NG	NG	0.7	0.8	0.8	0.9	0.8	0.9	0.9	1	1	1	1	1.1	1	1.1	1.1	1.1	1.1	1.2	1.2	1.2	1.2	1.3	1.2	1.3	1.3
Mo	mg/L	0.034	0.034	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.07	0.06
Ni	mg/L	NG	NG	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.05
P	mg/L	NG	NG	4.3	4.6	4.6	4.9	4.9	5.2	5.1	5.4	5.4	5.7	5.7	5.9	5.9	6.1	6.1	6.3	6.3	6.5	6.5	6.7	6.7	6.9	6.8	7.1	7
Pb	mg/L	NG	NG	0.004	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.007	0.006	0.007	0.007	0.007	0.007	0.007	0.007
Sb	mg/L	0.009	0.009	0.0062	0.0066	0.0066	0.007	0.007	0.0074	0.0074	0.0078	0.0077	0.0081	0.0081	0.0084	0.0083	0.0087	0.0086	0.009	0.0089	0.0093	0.0092	0.0095	0.0094	0.0098	0.0096	0.01	0.0099
Se	mg/L	0.011	0.02	0.043	0.046	0.046	0.049	0.049	0.052	0.052	0.054	0.054	0.057	0.057	0.059	0.059	0.061	0.061	0.064	0.063	0.066	0.065	0.068	0.067	0.069	0.068	0.071	0.07
Si	mg/L	NG	NG	35	38	38	40	40	43	43	45	45	48	47	50	49	52	51	54	53	56	55	57	57	59	58	61	60
Sn	mg/L	NG	NG	0.02	0.02	0.02	0.02	0.02	0.03	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Sr	mg/L	NG	NG	18	19	19	20	20	22	21	23	23	24	24	25	25	26	26	27	27	28	28	29	28	30	29	31	30
Tl	mg/L	NG	NG	0.003	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.006	0.006
U	mg/L	NG	NG	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
V	mg/L	NG	NG	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.07	0.06	0.07	0.07	0.07	0.07	0.07	0.07
Zn	mg/L	NG	NG	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2

DRAFT

Table B.15 Stewarton/Ballamoo residual void lake water quality – with geochemical controls (Part 1 of 2)

Parameter	Unit	Lower TV	Upper TV	2096	2100	2110	2120	2130	2140	2150	2160	2170	2180	2190	2200	2210	2220	2230	2240	2250	2260	2270	2280	2290	2300	2310	2320	2330	2340
pH	pH Units	6.5	8.5	8.4	8.5	8.4	8.4	8.3	8.3	8.3	8.3	8.2	8.2	8.2	8.2	8.2	8.2	8.1	8.1	8.1	8.1	8.1	8.1	8	8	8	8	8	8
pe	pe units	NG	NG	6.3	6.1	5.8	5.8	5.8	5.8	5.8	5.8	5.9	5.9	5.9	5.9	5.9	5.9	6	6	6	6	6	6	6.1	6.1	6.1	6.1	6.1	6.1
TDS	mg/L	4992	10599	461	913	3425	4872	6788	7890	9866	10912	13062	14033	16328	17204	19629	20405	22963	23522	26308	26699	29768	30065	33365	33540	37021	37026	40728	40584
Alkalinity	mg $CaCO_3$/L	NG	NG	78	108	99	92	87	86	83	82	81	80	79	79	79	78	78	78	78	78	78	78	78	78	78	78	78	78
Ca	mg/L	NG	NG	7.6	8.3	19	27	37	42	53	58	69	74	86	90	103	107	120	123	138	140	156	157	175	176	194	194	214	213
Mg	mg/L	NG	NG	14	30	119	167	231	266	331	364	434	465	541	569	649	674	758	776	868	880	981	991	1100	1105	1220	1220	1343	1338
K	mg/L	NG	NG	4.3	6.7	11	14	18	21	26	28	33	36	41	43	49	51	57	58	65	66	73	74	82	82	90	90	99	99
Na	mg/L	NG	NG	146	292	1109	1581	2208	2569	3216	3559	4263	4581	5332	5619	6413	6667	7503	7687	8597	8726	9729	9827	10909	10967	12110	12112	13328	13281
Cl	mg/L	NG	NG	225	481	2030	2921	4097	4772	5982	6622	7938	8531	9936	10472	11955	12430	13995	14337	16042	16281	18159	18340	20366	20474	22613	22616	24891	24803
F	mg/L	NG	NG	0.2	0.3	0.5	0.6	0.8	0.9	1.1	1.3	1.5	1.6	1.8	1.9	2.2	2.3	2.5	2.6	2.9	2.9	3.2	3.3	3.6	3.6	4	4	4.4	4.3
SO_4	mg/L	318	520	16	27	65	88	119	138	171	189	225	242	280	295	335	349	391	401	447	454	505	510	565	569	627	627	689	687
N	mg N/L	NG	NG	0.005	0.007	0.009	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.07	0.07
Al	mg/L	0.055	0.48	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.7	0.7	0.8	0.8
Ag	mg/L	0.001	0.39	4E-04	0.0006	0.0008	0.0009	0.001	0.001	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.005	0.005	0.005	0.005	0.006	0.006	0.006	0.006
As	mg/L	0.013	0.013	0.02	0.03	0.02	0.02	0.02	0.02	0.03	0.03	0.04	0.04	0.04	0.05	0.05	0.06	0.06	0.06	0.07	0.07	0.08	0.08	0.09	0.09	0.1	0.1	0.1	0.1
B	mg/L	NG	NG	0.09	0.2	0.4	0.5	0.7	0.8	1	1	1	1	2	2	2	2	2	2	3	3	3	3	3	3	4	4	4	4
Ba	mg/L	NG	NG	0.04	0.08	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.09	0.09	0.09	0.08	0.08	0.08	0.08	0.07	0.07	0.07	0.07	0.06	0.06
Be	mg/L	NG	NG	6E-05	0.0002	0.00005	0.00006	0.00006	0.00007	0.00006	0.00008	0.00007	0.00008	0.00007	0.00008	0.00007	0.00008	0.00007	0.00009	0.00008	0.00009	0.00008	0.0001	0.00008	0.0001	0.00009	0.0001	0.00009	0.0001
Cd	mg/L	NG	NG	6E-04	0.0009	0.0009	0.0009	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.004	0.004	0.005	0.005
Co	mg/L	NG	NG	8E-04	0.001	0.002	0.003	0.004	0.005	0.006	0.006	0.007	0.008	0.009	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Cu	mg/L	NG	NG	5E-04	0.0009	0.001	0.001	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.005	0.005	0.005	0.005	0.006	0.006	0.007	0.007
Cr	mg/L	NG	NG	7E-04	0.0009	0.0007	0.0005	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003
Fe	mg/L	0.7	16	4E-05	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006
Hg	mg/L	0.0006	0.0006	4E-05	0.00006	0.00008	0.00009	0.0001	0.0001	0.0002	0.0002	0.0002	0.0002	0.0003	0.0003	0.0003	0.0003	0.0004	0.0004	0.0004	0.0004	0.0005	0.0005	0.0005	0.0005	0.0006	0.0006	0.0006	0.0006
Li	mg/L	NG	NG	0.01	0.03	0.1	0.2	0.3	0.3	0.4	0.4	0.5	0.5	0.6	0.6	0.7	0.8	0.9	0.9	1	1	1.1	1.1	1.3	1.3	1.4	1.4	1.5	1.5
Mn	mg/L	NG	NG	0.01	0.02	0.1	0.1	0.2	0.2	0.3	0.3	0.4	0.4	0.5	0.5	0.6	0.6	0.7	0.7	0.8	0.8	0.9	0.9	1	1	1.1	1.1	1.2	1.2
Mo	mg/L	0.034	0.034	0.01	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.04	0.04	0.04	0.05	0.05	0.05	0.06	0.06	0.06	0.07	0.07	0.08	0.08	0.08	0.08	0.09	0.09
Ni	mg/L	NG	NG	0.001	0.002	0.005	0.007	0.009	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05
P	mg/L	NG	NG	0.7	1	1.2	1.4	1.7	1.9	2.3	2.5	2.9	3.1	3.6	3.7	4.2	4.4	4.8	4.9	5.5	5.5	6.1	6.2	6.8	6.8	7.5	7.5	8.2	8.2
Pb	mg/L	NG	NG	1E-04	0.0004	0.00008	0.0001	0.0001	0.0001	0.0001	0.0002	0.0001	0.0002	0.0002	0.0002	0.0002	0.0003	0.0003	0.0003	0.0004	0.0004	0.0005	0.0005	0.0006	0.0007	0.0008	0.0009	0.001	0.001
Sb	mg/L	0.009	0.009	0.0013	0.0019	0.0021	0.0023	0.0027	0.0031	0.0036	0.004	0.0046	0.005	0.0056	0.0059	0.0066	0.0068	0.0076	0.0078	0.0085	0.0087	0.0095	0.0096	0.011	0.011	0.012	0.012	0.013	0.013
Se	mg/L	0.011	0.02	0.0068	0.01	0.012	0.014	0.017	0.019	0.023	0.025	0.029	0.032	0.036	0.038	0.043	0.044	0.049	0.05	0.055	0.056	0.062	0.063	0.069	0.069	0.076	0.076	0.083	0.083
Si	mg/L	NG	NG	0.5	1	4.7	6.8	9.5	11	14	15	19	20	23	24	28	29	33	33	37	38	42	43	44	43	43	42	42	41
Sn	mg/L	NG	NG	0.006	0.009	0.009	0.009	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05
Sr	mg/L	NG	NG	0.29	0.6	2.4	3.5	4.8	5.6	7.1	7.8	9.4	10	12	12	14	15	17	17	19	19	21	22	24	24	27	27	29	29
Tl	mg/L	NG	NG	4E-04	0.0006	0.0008	0.0009	0.001	0.001	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.005	0.005	0.005	0.005	0.006	0.006	0.006	0.006
U	mg/L	NG	NG	8E-04	0.001	0.002	0.003	0.004	0.005	0.006	0.006	0.007	0.008	0.009	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
V	mg/L	NG	NG	0.006	0.008	0.007	0.007	0.008	0.009	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04
Zn	mg/L	NG	NG	0.004	0.007	0.02	0.02	0.03	0.04	0.05	0.05	0.06	0.07	0.08	0.08	0.09	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2

DRAFT

Table B.16 Stewarton/Ballamoo residual void lake water quality – with geochemical controls (Part 2 of 2)

Parameter	Unit	Lower TV	Upper TV	2350	2360	2370	2380	2390	2400	2410	2420	2430	2440	2450	2460	2470	2480	2490	2500	2510	2520	2530	2540	2550	2560	2570	2580	2590	2599
pH	pH Units	6.5	8.5	8	8	7.9	7.9	7.9	7.9	7.9	7.9	7.8	7.9	7.8	7.8	7.8	7.8	7.8	7.8	7.7	7.8	7.7	7.7	7.7	7.7	7.7	7.7	7.6	7.7
pe	pe units	NG	NG	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.3	6.3	6.3	6.3	6.3	6.3	6.4	6.4	6.4	6.4	6.4	6.4	6.5	6.4	6.5	6.5	6.5	6.5
TDS	mg/L	4992	10599	44488	44184	48284	47807	52112	51754	55451	54991	58938	58454	62610	62038	66382	65698	70215	69410	74055	72756	77920	76276	81838	79968	85788	83680	89744	87685
Alkalinity	mg $CaCO_3$/L	NG	NG	79	79	80	80	81	81	82	82	83	83	84	84	86	86	87	86	88	87	89	88	90	89	91	90	93	92
Ca	mg/L	NG	NG	233	232	253	251	274	272	291	289	310	307	329	326	349	346	370	365	390	383	411	402	432	422	453	442	474	463
Mg	mg/L	NG	NG	1467	1457	1592	1576	1719	1707	1829	1814	1944	1928	2065	2046	2190	2167	2317	2290	2443	2400	2571	2517	2701	2639	2831	2762	2962	2894
K	mg/L	NG	NG	108	107	117	116	126	125	134	133	142	141	151	150	160	158	169	167	178	175	187	183	196	192	206	201	215	210
Na	mg/L	NG	NG	14563	14464	15810	15654	17066	16949	18163	18013	19308	19150	20515	20327	21753	21529	23012	22748	24273	23847	25542	25003	26829	26216	28127	27436	29428	28753
Cl	mg/L	NG	NG	27201	27015	29534	29242	31886	31666	33937	33655	36080	35783	38336	37984	40652	40232	43007	42513	45367	44569	47741	46732	50148	49001	52577	51284	55011	53748
F	mg/L	NG	NG	4.7	4.7	5.1	5.1	5.5	5.5	5.9	5.8	6.2	6.2	6.6	6.6	7	6.9	7.4	7.3	7.8	7.7	8.2	8	8.6	8.4	9	8.8	9.4	9.2
SO_4	mg/L	318	520	752	747	816	808	880	874	936	929	995	987	1057	1047	1120	1109	1184	1171	1249	1227	1313	1286	1379	1346	1440	1404	1502	1467
N	mg N/L	NG	NG	0.07	0.07	0.08	0.08	0.09	0.08	0.09	0.09	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Al	mg/L	0.055	0.48	0.8	0.8	0.9	0.9	1	0.9	1	1	1.1	1.1	1.1	1.1	1.2	1.2	1.2	1.1	1.1	1	1	0.9	0.9	0.9	0.9	0.8	0.8	0.8
Ag	mg/L	0.001	0.39	0.007	0.007	0.007	0.007	0.008	0.008	0.008	0.008	0.009	0.009	0.009	0.009	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
As	mg/L	0.013	0.013	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3
B	mg/L	NG	NG	4	4	5	5	5	5	6	6	6	6	6	6	7	7	7	7	7	7	8	8	8	8	9	8	9	9
Ba	mg/L	NG	NG	0.06	0.06	0.05	0.06	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Be	mg/L	NG	NG	0.00009	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0002	0.0001	0.0002	0.0001	0.0002	0.0001	0.0002
Cd	mg/L	NG	NG	0.005	0.005	0.006	0.005	0.006	0.006	0.006	0.006	0.007	0.007	0.007	0.007	0.007	0.007	0.008	0.008	0.008	0.008	0.009	0.008	0.009	0.009	0.009	0.009	0.01	0.01
Co	mg/L	NG	NG	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05
Cu	mg/L	NG	NG	0.008	0.008	0.009	0.009	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Cr	mg/L	NG	NG	0.0003	0.0003	0.0003	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0005	0.0005	0.0005	0.0005	0.0006	0.0006	0.0006	0.0007	0.0007	0.0007	0.0008	0.0008	0.0009	0.001	0.001
Fe	mg/L	0.7	16	0.00006	0.00006	0.00007	0.00007	0.00007	0.00007	0.00007	0.00007	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00009	0.00009	0.00009	0.00009	0.0001	0.00009	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Hg	mg/L	0.0006	0.0006	0.0007	0.0007	0.0007	0.0007	0.0008	0.0008	0.0008	0.0008	0.0009	0.0009	0.0009	0.0009	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Li	mg/L	NG	NG	1.7	1.7	1.8	1.8	2	1.9	2.1	2.1	2.2	2.2	2.4	2.3	2.5	2.5	2.6	2.6	2.8	2.7	2.9	2.9	3.1	3	3.2	3.2	3.4	3.3
Mn	mg/L	NG	NG	1.3	1.3	1.5	1.4	1.6	1.6	1.7	1.7	1.8	1.8	1.9	1.9	2	2	2.1	2.1	2.2	2.2	2.4	2.3	2.5	2.4	2.6	2.5	2.7	2.7
Mo	mg/L	0.034	0.034	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Ni	mg/L	NG	NG	0.06	0.06	0.06	0.06	0.07	0.07	0.07	0.07	0.08	0.08	0.08	0.08	0.09	0.09	0.09	0.09	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
P	mg/L	NG	NG	8.9	8.8	9.6	9.5	10	10	11	11	12	12	12	12	13	13	14	14	14	14	15	15	16	16	17	16	17	17
Pb	mg/L	NG	NG	0.001	0.002	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.004	0.004	0.004	0.005	0.005	0.005	0.005	0.006	0.006	0.007	0.007	0.007	0.007	0.008	0.008	0.009	0.009
Sb	mg/L	0.009	0.009	0.014	0.014	0.015	0.015	0.016	0.016	0.017	0.017	0.018	0.018	0.019	0.019	0.02	0.02	0.021	0.021	0.022	0.022	0.023	0.023	0.024	0.024	0.026	0.025	0.027	0.026
Se	mg/L	0.011	0.02	0.09	0.09	0.097	0.097	0.1	0.1	0.11	0.11	0.12	0.12	0.12	0.12	0.13	0.13	0.14	0.14	0.15	0.14	0.15	0.15	0.16	0.16	0.17	0.17	0.18	0.17
Si	mg/L	NG	NG	41	41	40	40	39	39	39	39	38	38	37	37	36	36	36	36	35	35	34	34	33	33	33	33	32	32
Sn	mg/L	NG	NG	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.06	0.07	0.07	0.07	0.07	0.07	0.07	0.08	0.08	0.08	0.08	0.09	0.08	0.09	0.09	0.09	0.09	0.1	0.1
Sr	mg/L	NG	NG	32	32	35	34	38	37	40	40	43	42	45	45	48	47	51	50	53	53	56	55	59	57	58	55	56	54
Tl	mg/L	NG	NG	0.007	0.007	0.007	0.007	0.008	0.008	0.008	0.008	0.009	0.009	0.009	0.009	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
U	mg/L	NG	NG	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05
V	mg/L	NG	NG	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.07	0.07	0.07	0.07	0.08	0.08	0.09	0.09	0.09	0.09	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Zn	mg/L	NG	NG	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4

Table B.17 Stewarton/Ballamoo residual void lake water quality – without geochemical controls (Part 1 of 2)

Parameter	Unit	Lower TV	Upper TV	2096	2100	2110	2120	2130	2140	2150	2160	2170	2180	2190	2200	2210	2220	2230	2240	2250	2260	2270	2280	2290	2300	2310	2320	2330	2340
pH	pH Units	6.5	8.5	9	8.8	8	7.9	7.8	7.7	7.7	7.7	7.6	7.6	7.6	7.6	7.6	7.6	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.4	7.4	7.4	7.4
pe	pe units	NG	NG	5.7	5.8	6.3	6.3	6.4	6.4	6.4	6.4	6.5	6.5	6.5	6.5	6.5	6.5	6.6	6.6	6.6	6.6	6.6	6.6	6.7	6.7	6.7	6.7	6.7	6.7
TDS	mg/L	4992	10599	461	934	3610	5155	7204	8385	10499	11620	13920	14960	17415	18353	20946	21777	24512	25111	28090	28508	31790	32108	35648	35838	39577	39585	43560	43408
Alkalinity	mg $CaCO_3$/L	NG	NG	78	129	293	392	530	613	759	839	998	1072	1241	1308	1487	1545	1734	1776	1981	2011	2237	2260	2503	2517	2775	2776	3050	3040
Ca	mg/L	NG	NG	7.6	17	71	102	143	167	209	232	278	299	348	367	419	435	490	502	562	570	636	643	714	717	792	792	872	869
Mg	mg/L	NG	NG	14	30	135	194	273	318	399	442	530	570	664	699	799	830	935	958	1072	1088	1214	1226	1362	1369	1512	1512	1665	1659
K	mg/L	NG	NG	4.3	6.7	11	14	18	21	26	28	33	36	41	43	49	51	57	58	65	66	73	74	82	82	90	90	99	99
Na	mg/L	NG	NG	146	292	1109	1581	2208	2569	3216	3560	4263	4582	5333	5621	6414	6669	7506	7689	8601	8729	9733	9831	10914	10972	12116	12119	13335	13289
Cl	mg/L	NG	NG	225	481	2030	2921	4098	4772	5983	6622	7939	8533	9938	10474	11959	12433	13999	14341	16048	16286	18166	18348	20375	20483	22625	22628	24905	24817
F	mg/L	NG	NG	0.2	0.3	0.5	0.6	0.8	0.9	1.1	1.3	1.5	1.6	1.8	1.9	2.2	2.3	2.5	2.6	2.9	2.9	3.2	3.3	3.6	3.6	4	4	4.4	4.3
SO_4	mg/L	318	520	16	27	65	88	119	138	171	189	226	242	281	296	337	350	393	402	449	456	507	512	568	571	630	630	692	690
N	mg N/L	NG	NG	0.005	0.007	0.009	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.07	0.07
Al	mg/L	0.055	0.48	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.7	0.7	0.8	0.8
Ag	mg/L	0.001	0.39	4E-04	0.0006	0.0008	0.0009	0.001	0.001	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.005	0.005	0.005	0.005	0.006	0.006	0.006	0.006
As	mg/L	0.013	0.013	0.025	0.037	0.037	0.04	0.046	0.052	0.061	0.067	0.076	0.082	0.092	0.097	0.11	0.11	0.12	0.13	0.14	0.14	0.15	0.15	0.17	0.17	0.19	0.19	0.2	0.2
B	mg/L	NG	NG	0.09	0.2	0.4	0.5	0.7	0.8	1	1.1	1.3	1.4	1.7	1.8	2	2.1	2.3	2.4	2.7	2.7	3	3	3.4	3.4	3.7	3.7	4.1	4.1
Ba	mg/L	NG	NG	0.04	0.08	0.3	0.4	0.6	0.7	0.9	1	1.2	1.3	1.5	1.6	1.8	1.8	2.1	2.1	2.4	2.4	2.7	2.7	3	3	3.4	3.4	3.7	3.7
Be	mg/L	NG	NG	7E-04	0.001	0.001	0.001	0.002	0.002	0.002	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.005	0.005	0.006	0.006	0.006	0.006	0.007	0.007	0.008	0.008	0.008	0.008
Cd	mg/L	NG	NG	6E-04	0.0009	0.0009	0.0009	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.004	0.004	0.005	0.005
Co	mg/L	NG	NG	8E-04	0.001	0.002	0.003	0.004	0.005	0.006	0.006	0.007	0.008	0.009	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Cu	mg/L	NG	NG	8E-04	0.001	0.002	0.003	0.003	0.004	0.005	0.005	0.006	0.007	0.008	0.008	0.009	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02
Cr	mg/L	NG	NG	7E-04	0.001	0.001	0.001	0.002	0.002	0.002	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.005	0.005	0.006	0.006	0.006	0.006	0.007	0.007	0.008	0.008	0.008	0.008
Fe	mg/L	0.7	16	0.1	0.2	0.5	0.6	0.86	0.99	1.2	1.4	1.6	1.8	2	2.1	2.4	2.5	2.8	2.9	3.3	3.3	3.7	3.7	4.1	4.1	4.6	4.6	5	5
Hg	mg/L	0.0006	0.0006	4E-05	0.00006	0.00008	0.00009	0.0001	0.0001	0.0002	0.0002	0.0002	0.0002	0.0003	0.0003	0.0003	0.0003	0.0004	0.0004	0.0004	0.0004	0.0005	0.0005	0.0005	0.0005	0.0006	0.0006	0.0006	0.0006
Li	mg/L	NG	NG	0.01	0.03	0.1	0.2	0.3	0.3	0.4	0.4	0.5	0.5	0.6	0.6	0.7	0.8	0.9	0.9	1	1	1.1	1.1	1.3	1.3	1.4	1.4	1.5	1.5
Mn	mg/L	NG	NG	0.01	0.02	0.1	0.1	0.2	0.2	0.3	0.3	0.4	0.4	0.5	0.5	0.6	0.6	0.7	0.7	0.8	0.8	0.9	0.9	1	1	1.1	1.1	1.2	1.2
Mo	mg/L	0.034	0.034	0.01	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.04	0.04	0.04	0.05	0.05	0.05	0.06	0.06	0.06	0.07	0.07	0.08	0.08	0.08	0.08	0.09	0.09
Ni	mg/L	NG	NG	0.001	0.002	0.005	0.007	0.009	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.06	0.05
P	mg/L	NG	NG	0.7	1	1.2	1.4	1.7	1.9	2.3	2.5	2.9	3.2	3.6	3.8	4.2	4.4	4.9	5	5.5	5.6	6.2	6.2	6.9	6.9	7.6	7.6	8.3	8.3
Pb	mg/L	NG	NG	7E-04	0.001	0.001	0.001	0.002	0.002	0.002	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.005	0.005	0.006	0.006	0.006	0.006	0.007	0.007	0.008	0.008	0.008	0.008
Sb	mg/L	0.009	0.009	0.0013	0.0019	0.0021	0.0023	0.0027	0.0031	0.0036	0.004	0.0046	0.005	0.0056	0.0059	0.0066	0.0069	0.0076	0.0078	0.0085	0.0087	0.0095	0.0096	0.011	0.011	0.012	0.012	0.013	0.013
Se	mg/L	0.011	0.02	0.0068	0.01	0.012	0.014	0.017	0.019	0.023	0.025	0.03	0.032	0.036	0.038	0.043	0.044	0.049	0.05	0.056	0.056	0.062	0.063	0.069	0.07	0.076	0.076	0.083	0.083
Si	mg/L	NG	NG	0.5	1	4.7	6.8	9.5	11	14	15	19	20	23	24	28	29	33	33	37	38	42	43	48	48	53	53	58	58
Sn	mg/L	NG	NG	0.006	0.009	0.009	0.009	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05
Sr	mg/L	NG	NG	0.3	0.6	2.4	3.5	4.8	5.6	7.1	7.8	9.4	10	12	12	14	15	17	17	19	19	21	22	24	24	27	27	29	29
Tl	mg/L	NG	NG	4E-04	0.0006	0.0008	0.0009	0.001	0.001	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.005	0.005	0.005	0.005	0.006	0.006	0.006	0.006
U	mg/L	NG	NG	8E-04	0.001	0.002	0.003	0.004	0.005	0.006	0.006	0.007	0.008	0.009	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
V	mg/L	NG	NG	0.007	0.01	0.01	0.01	0.02	0.02	0.02	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.05	0.05	0.06	0.06	0.06	0.06	0.07	0.07	0.08	0.08	0.08	0.08
Zn	mg/L	NG	NG	0.005	0.008	0.02	0.03	0.03	0.04	0.05	0.06	0.07	0.07	0.08	0.09	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Table B.18 Stewarton/Ballamoo residual void lake water quality – without geochemical controls (Part 2 of 2)

Parameter	Unit	Lower TV	Upper TV	2350	2360	2370	2380	2390	2400	2410	2420	2430	2440	2450	2460	2470	2480	2490	2500	2510	2520	2530	2540	2550	2560	2570	2580	2590	2599
pH	pH Units	6.5	8.5	7.4	7.4	7.4	7.4	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.2	7.3	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.1	7.2
pe	pe units	NG	NG	6.8	6.8	6.8	6.8	6.8	6.8	6.9	6.9	6.9	6.9	6.9	6.9	7	7	7	7	7	7	7	7	7	7	7	7	7.1	7.1
TDS	mg/L	4992	10599	47601	47277	51681	51171	55795	55411	59384	58891	63133	62614	67081	66467	71136	70402	75257	74393	79388	77992	83545	81779	87759	85751	92013	89749	96273	94062
Alkalinity	mg $CaCO_3$/L	NG	NG	3329	3307	3611	3576	3895	3869	4142	4109	4402	4367	4675	4633	4955	4905	5240	5181	5525	5429	5812	5691	6103	5965	6397	6241	6691	6538
Ca	mg/L	NG	NG	953	947	1035	1025	1118	1110	1190	1180	1265	1254	1344	1332	1425	1411	1508	1491	1591	1563	1674	1639	1759	1718	1844	1799	1929	1885
Mg	mg/L	NG	NG	1820	1807	1976	1956	2133	2119	2271	2252	2414	2394	2566	2542	2721	2693	2879	2845	3037	2983	3196	3128	3357	3280	3520	3434	3684	3599
K	mg/L	NG	NG	108	107	117	116	126	125	134	133	142	141	151	150	160	158	169	167	178	175	187	183	197	192	206	201	215	211
Na	mg/L	NG	NG	14572	14473	15820	15664	17079	16962	18178	18027	19325	19166	20533	20346	21774	21550	23036	22771	24300	23873	25572	25032	26862	26247	28164	27471	29468	28791
Cl	mg/L	NG	NG	27218	27032	29555	29262	31910	31690	33965	33682	36111	35813	38371	38019	40692	40272	43052	42557	45417	44617	47797	46786	50210	49059	52645	51349	55085	53819
F	mg/L	NG	NG	4.7	4.7	5.1	5.1	5.5	5.5	5.9	5.8	6.2	6.2	6.6	6.6	7	6.9	7.4	7.3	7.8	7.7	8.2	8	8.6	8.4	9	8.8	9.4	9.2
SO_4	mg/L	318	520	756	751	820	812	884	878	940	933	999	991	1061	1052	1125	1114	1190	1176	1255	1233	1320	1292	1386	1355	1453	1418	1520	1485
N	mg N/L	NG	NG	0.07	0.07	0.08	0.08	0.09	0.08	0.09	0.09	0.1	0.1	0.1	0.1	0.11	0.11	0.11	0.11	0.12	0.12	0.13	0.12	0.13	0.13	0.14	0.14	0.14	0.14
Al	mg/L	0.055	0.48	0.8	0.8	0.9	0.9	1	0.9	1	1	1.1	1.1	1.1	1.1	1.2	1.2	1.3	1.2	1.3	1.3	1.4	1.4	1.5	1.4	1.5	1.5	1.6	1.6
Ag	mg/L	0.001	0.39	0.007	0.007	0.007	0.007	0.008	0.008	0.008	0.008	0.009	0.009	0.009	0.009	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
As	mg/L	0.013	0.013	0.22	0.22	0.24	0.23	0.25	0.25	0.27	0.27	0.28	0.28	0.3	0.3	0.32	0.31	0.33	0.33	0.35	0.35	0.37	0.36	0.39	0.38	0.4	0.39	0.42	0.41
B	mg/L	NG	NG	4.5	4.5	4.9	4.8	5.3	5.2	5.6	5.6	5.9	5.9	6.3	6.3	6.7	6.6	7.1	7	7.5	7.3	7.9	7.7	8.3	8.1	8.6	8.4	9	8.8
Ba	mg/L	NG	NG	4	4	4.4	4.3	4.7	4.7	5	5	5.4	5.3	5.7	5.6	6	6	6.4	6.3	6.7	6.6	7.1	7	7.5	7.3	7.8	7.6	8.2	8
Be	mg/L	NG	NG	0.009	0.009	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Cd	mg/L	NG	NG	0.005	0.005	0.006	0.006	0.006	0.006	0.006	0.006	0.007	0.007	0.007	0.007	0.007	0.007	0.008	0.008	0.008	0.008	0.009	0.009	0.009	0.009	0.009	0.009	0.01	0.01
Co	mg/L	NG	NG	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05
Cu	mg/L	NG	NG	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Cr	mg/L	NG	NG	0.009	0.009	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Fe	mg/L	0.7	16	5.5	5.5	6	5.9	6.4	6.4	6.8	6.8	7.3	7.2	7.7	7.7	8.2	8.1	8.7	8.6	9.1	9	9.6	9.4	10	10	10	10	10	10
Hg	mg/L	0.0006	0.0006	0.0007	0.0007	0.0007	0.0007	0.0008	0.0008	0.0008	0.0008	0.0009	0.0009	0.0009	0.0009	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Li	mg/L	NG	NG	1.7	1.7	1.8	1.8	2	1.9	2.1	2.1	2.2	2.2	2.4	2.3	2.5	2.5	2.6	2.6	2.8	2.7	2.9	2.9	3.1	3	3.2	3.2	3.4	3.3
Mn	mg/L	NG	NG	1.3	1.3	1.5	1.4	1.6	1.6	1.7	1.7	1.8	1.8	1.9	1.9	2	2	2.1	2.1	2.2	2.2	2.4	2.3	2.5	2.4	2.6	2.5	2.7	2.7
Mo	mg/L	0.034	0.034	0.1	0.1	0.11	0.1	0.11	0.11	0.12	0.12	0.13	0.13	0.13	0.13	0.14	0.14	0.15	0.15	0.16	0.16	0.17	0.16	0.17	0.17	0.18	0.18	0.19	0.19
Ni	mg/L	NG	NG	0.06	0.06	0.07	0.06	0.07	0.07	0.07	0.07	0.08	0.08	0.08	0.08	0.09	0.09	0.09	0.09	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
P	mg/L	NG	NG	9	8.9	9.7	9.6	10	10	11	11	12	12	12	12	13	13	14	14	15	14	15	15	16	16	17	17	18	17
Pb	mg/L	NG	NG	0.009	0.009	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Sb	mg/L	0.009	0.009	0.014	0.014	0.015	0.015	0.016	0.016	0.017	0.017	0.018	0.018	0.019	0.019	0.02	0.02	0.021	0.021	0.022	0.022	0.023	0.023	0.025	0.024	0.026	0.025	0.027	0.026
Se	mg/L	0.011	0.02	0.09	0.09	0.098	0.097	0.11	0.1	0.11	0.11	0.12	0.12	0.13	0.12	0.13	0.13	0.14	0.14	0.15	0.15	0.15	0.15	0.16	0.16	0.17	0.17	0.18	0.17
Si	mg/L	NG	NG	64	63	69	68	75	74	79	79	84	84	90	89	95	94	100	99	106	104	112	109	117	115	123	120	129	126
Sn	mg/L	NG	NG	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.06	0.07	0.07	0.07	0.07	0.07	0.07	0.08	0.08	0.08	0.08	0.09	0.09	0.09	0.09	0.09	0.09	0.1	0.1
Sr	mg/L	NG	NG	32	32	35	35	38	37	40	40	43	42	45	45	48	47	51	50	54	53	56	55	59	58	62	61	65	63
Tl	mg/L	NG	NG	0.007	0.007	0.007	0.007	0.008	0.008	0.008	0.008	0.009	0.009	0.009	0.009	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
U	mg/L	NG	NG	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.04	0.05	0.05	0.05	0.05
V	mg/L	NG	NG	0.09	0.09	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Zn	mg/L	NG	NG	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4

Table B.19 Kenmare residual void lake water quality – with geochemical controls (Part 1 of 2)

Parameter	Unit	Lower TV	Upper TV	2094	2100	2110	2120	2130	2140	2150	2160	2170	2180	2190	2200	2210	2220	2230	2240	2250	2260	2270	2280	2290	2300	2310	2320	2330	2340
pH	pH Units	6.5	8.5	8.4	8.4	8.4	8.4	8.3	8.3	8.3	8.3	8.2	8.2	8.2	8.2	8.2	8.2	8.1	8.1	8.1	8.1	8.1	8.1	8	8	8	8	8	8
pe	pe units	NG	NG	5.6	5.7	5.7	5.8	5.8	5.8	5.9	5.9	5.9	5.9	5.9	6	6	6	6	6	6.1	6.1	6.1	6.1	6.1	6.1	6.2	6.2	6.2	6.2
TDS	mg/L	4992	10599	1888	3582	5288	6060	7669	8524	10167	11046	12966	13965	16170	17200	19609	20509	23053	23703	26509	26932	29980	30222	33457	33532	36920	36802	40392	40119
Alkalinity	mg $CaCO_3$/L	NG	NG	85	94	89	88	85	85	83	82	81	80	79	79	79	79	78	79	79	79	79	79	79	79	80	80	80	80
Ca	mg/L	NG	NG	18	21	30	33	41	46	54	59	69	74	85	90	103	107	120	124	138	140	156	157	174	174	192	191	210	208
Mg	mg/L	NG	NG	74	132	187	209	261	287	341	370	432	464	536	568	647	675	758	778	869	882	981	989	1094	1096	1206	1202	1319	1310
K	mg/L	NG	NG	4.5	9.2	13	16	20	22	26	28	33	35	41	43	49	52	58	60	67	68	75	76	84	84	93	93	101	101
Na	mg/L	NG	NG	594	1150	1709	1966	2494	2776	3313	3602	4230	4558	5281	5619	6408	6704	7537	7751	8670	8810	9808	9888	10951	10977	12091	12054	13234	13146
Cl	mg/L	NG	NG	1108	2138	3185	3654	4639	5162	6168	6705	7881	8491	9840	10469	11942	12492	14048	14444	16160	16418	18281	18429	20413	20459	22539	22467	24671	24503
F	mg/L	NG	NG	0.2	0.4	0.6	0.7	0.9	1	1.2	1.3	1.5	1.6	1.8	2	2.2	2.3	2.6	2.7	3	3.1	3.4	3.4	3.8	3.8	4.2	4.2	4.6	4.6
SO_4	mg/L	318	520	31	61	89	105	132	147	174	189	222	239	276	294	335	351	394	405	453	460	512	516	571	573	631	629	690	686
N	mg N/L	NG	NG	0.003	0.007	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.05	0.05	0.06	0.06	0.06	0.06	0.07	0.07	0.08	0.08
Al	mg/L	0.055	0.48	0.04	0.08	0.1	0.1	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.4	0.5	0.5	0.6	0.6	0.6	0.6	0.7	0.7	0.8	0.8	0.8	0.8
Ag	mg/L	0.001	0.39	0.0003	0.0006	0.0008	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.005	0.005	0.005	0.005	0.006	0.006	0.006	0.006
As	mg/L	0.013	0.013	0.004	0.01	0.01	0.02	0.02	0.03	0.03	0.03	0.03	0.04	0.04	0.05	0.05	0.06	0.07	0.07	0.08	0.08	0.09	0.09	0.1	0.11	0.12	0.12	0.13	0.13
B	mg/L	NG	NG	0.2	0.4	0.5	0.6	0.8	0.9	1	1.1	1.3	1.4	1.7	1.8	2	2.1	2.4	2.4	2.7	2.8	3.1	3.1	3.4	3.4	3.8	3.8	4.1	4.1
Ba	mg/L	NG	NG	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.09	0.09	0.09	0.08	0.08	0.08	0.07	0.07	0.07	0.07	0.07	0.06	0.06
Be	mg/L	NG	NG	0.00004	0.00006	0.00006	0.00008	0.00007	0.00007	0.00006	0.00008	0.00007	0.00008	0.00008	0.00009	0.00008	0.00009	0.00009	0.0001	0.00009	0.0001	0.00009	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Cd	mg/L	NG	NG	0.0002	0.0005	0.0007	0.0009	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.004	0.005	0.005	0.005	0.005
Co	mg/L	NG	NG	0.001	0.002	0.003	0.004	0.004	0.005	0.006	0.006	0.007	0.008	0.009	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Cu	mg/L	NG	NG	0.0006	0.001	0.001	0.002	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.005	0.005	0.005	0.005	0.006	0.006	0.007	0.007
Cr	mg/L	NG	NG	0.00009	0.0002	0.0002	0.0003	0.0004	0.0004	0.0003	0.0003	0.0003	0.0003	0.0003	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0005	0.0005	0.0005	0.0005	0.0005
Fe	mg/L	0.7	16	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006
Hg	mg/L	0.0006	0.0006	0.00003	0.00006	0.00008	0.0001	0.0001	0.0001	0.0002	0.0002	0.0002	0.0002	0.0003	0.0003	0.0003	0.0003	0.0004	0.0004	0.0004	0.0004	0.0005	0.0005	0.0005	0.0005	0.0006	0.0006	0.0006	0.0006
Li	mg/L	NG	NG	0.07	0.1	0.2	0.2	0.3	0.3	0.4	0.4	0.5	0.5	0.6	0.6	0.7	0.8	0.9	0.9	1	1	1.1	1.1	1.3	1.3	1.4	1.4	1.5	1.5
Mn	mg/L	NG	NG	0.05	0.1	0.2	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.5	0.5	0.6	0.6	0.7	0.7	0.8	0.8	0.9	0.9	1	1	1.1	1.1	1.2	1.2
Mo	mg/L	0.034	0.034	0.004	0.01	0.01	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.04	0.04	0.05	0.05	0.06	0.06	0.06	0.07	0.07	0.07	0.08	0.08	0.09	0.09	0.1	0.1
Ni	mg/L	NG	NG	0.002	0.005	0.007	0.008	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05
P	mg/L	NG	NG	0.4	0.8	1.1	1.4	1.8	2	2.3	2.5	2.8	3.1	3.5	3.8	4.3	4.5	5	5.2	5.7	5.8	6.5	6.5	7.2	7.3	7.9	7.9	8.7	8.7
Pb	mg/L	NG	NG	0.00004	0.00008	0.00009	0.0001	0.0001	0.0001	0.0001	0.0002	0.0002	0.0002	0.0002	0.0002	0.0003	0.0003	0.0003	0.0004	0.0004	0.0005	0.0006	0.0007	0.0008	0.0009	0.001	0.001	0.001	0.001
Sb	mg/L	0.009	0.009	0.00061	0.0013	0.0018	0.0023	0.0028	0.0032	0.0036	0.0039	0.0045	0.0048	0.0055	0.0059	0.0067	0.007	0.0078	0.0081	0.009	0.0092	0.01	0.01	0.011	0.011	0.012	0.012	0.014	0.014
Se	mg/L	0.011	0.02	0.004	0.0084	0.011	0.014	0.018	0.02	0.023	0.025	0.029	0.031	0.036	0.038	0.043	0.045	0.05	0.052	0.058	0.059	0.065	0.066	0.073	0.073	0.08	0.081	0.088	0.088
Si	mg/L	NG	NG	3	5	7.4	8.5	11	12	14.4	15.6	18.4	19.8	22.9	24.4	27.8	29.1	32.7	33.7	37.7	38.3	42.6	43	43.8	43.1	43	42.3	42.1	41.5
Sn	mg/L	NG	NG	0.002	0.005	0.007	0.009	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05
Sr	mg/L	NG	NG	1.3	2.5	3.8	4.3	5.5	6.1	7.3	7.9	9.3	10	12	12	14	15	17	17	19	19	22	22	24	24	27	26	29	29
Tl	mg/L	NG	NG	0.0003	0.0006	0.0008	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.005	0.005	0.005	0.005	0.006	0.006	0.006	0.006
U	mg/L	NG	NG	0.001	0.002	0.003	0.004	0.004	0.005	0.006	0.006	0.007	0.008	0.009	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
V	mg/L	NG	NG	0.002	0.004	0.005	0.007	0.008	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.05	0.05
Zn	mg/L	NG	NG	0.009	0.02	0.02	0.03	0.04	0.04	0.05	0.05	0.06	0.07	0.08	0.08	0.09	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2

DRAFT

Table B.20 Kenmare residual void lake water quality – with geochemical controls (Part 2 of 2)

Parameter	Unit	Lower TV	Upper TV	2350	2360	2370	2380	2390	2400	2410	2420	2430	2440	2450	2460	2470	2480	2490	2500	2510	2520	2530	2540	2550	2560	2570	2580	2590	2599
pH	pH Units	6.5	8.5	8	8	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.7	7.8	7.7	7.7	7.7	7.7	7.7	7.7
pe	pe units	NG	NG	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.4	6.4	6.4	6.4	6.4	6.4	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.6	6.6	6.6	6.6
TDS	mg/L	4992	10599	43896	43461	47424	46818	50976	50503	54015	53463	57219	56647	60602	59943	64075	63311	67604	66727	71138	69755	74693	72957	78299	76347	81942	79761	85588	83568
Alkalinity	mg $CaCO_3$/L	NG	NG	81	81	82	82	83	83	84	84	85	85	87	86	88	88	89	88	90	89	90	89	92	90	93	92	94	93
Ca	mg/L	NG	NG	228	226	246	243	265	262	281	278	297	294	315	311	333	329	351	347	370	363	389	379	407	397	427	415	446	435
Mg	mg/L	NG	NG	1433	1418	1548	1527	1663	1647	1762	1743	1866	1846	1975	1953	2088	2063	2203	2174	2317	2272	2433	2376	2550	2486	2668	2597	2787	2721
K	mg/L	NG	NG	110	109	119	118	128	127	136	134	144	142	152	151	161	159	170	168	179	175	187	183	197	192	206	200	215	210
Na	mg/L	NG	NG	14388	14246	15549	15351	16718	16563	17719	17538	18773	18586	19887	19671	21030	20779	22192	21904	23355	22901	24525	23956	25712	25071	26912	26196	28113	27450
Cl	mg/L	NG	NG	26822	26555	28987	28616	31168	30878	33033	32694	35000	34648	37075	36671	39207	38738	41373	40834	43542	42694	45724	44659	47938	46740	50174	48837	52414	51176
F	mg/L	NG	NG	5	5	5.4	5.3	5.8	5.7	6.1	6.1	6.5	6.4	6.9	6.8	7.3	7.2	7.7	7.6	8.1	7.9	8.5	8.3	8.9	8.7	9.3	9.1	9.7	9.5
SO_4	mg/L	318	520	750	743	810	801	871	863	923	914	978	969	1036	1025	1096	1083	1156	1142	1217	1193	1277	1248	1339	1306	1400	1362	1458	1423
N	mg N/L	NG	NG	0.08	0.08	0.09	0.09	0.09	0.09	0.1	0.1	0.11	0.11	0.11	0.11	0.12	0.12	0.13	0.12	0.13	0.13	0.14	0.14	0.15	0.14	0.15	0.15	0.16	0.16
Al	mg/L	0.055	0.48	0.9	0.9	1	1	1.1	1	1.1	1.1	1.2	1.2	1.3	1.2	1.3	1.3	1.2	1.2	1.1	1.1	1.1	1	1	0.9	0.9	0.9	0.9	0.8
Ag	mg/L	0.001	0.39	0.007	0.007	0.007	0.007	0.008	0.008	0.009	0.008	0.009	0.009	0.01	0.009	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
As	mg/L	0.013	0.013	0.15	0.15	0.16	0.16	0.17	0.18	0.19	0.19	0.2	0.2	0.22	0.22	0.23	0.23	0.25	0.25	0.27	0.26	0.28	0.28	0.3	0.3	0.32	0.31	0.34	0.33
B	mg/L	NG	NG	4.5	4.4	4.9	4.8	5.2	5.2	5.5	5.5	5.9	5.8	6.2	6.1	6.6	6.5	6.9	6.8	7.3	7.1	7.6	7.5	8	7.8	8.4	8.2	8.8	8.6
Ba	mg/L	NG	NG	0.06	0.06	0.05	0.06	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Be	mg/L	NG	NG	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0002	0.0001	0.0002	0.0001	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
Cd	mg/L	NG	NG	0.006	0.006	0.006	0.006	0.007	0.007	0.007	0.007	0.007	0.007	0.008	0.008	0.008	0.008	0.009	0.009	0.009	0.009	0.01	0.009	0.01	0.01	0.01	0.01	0.01	0.01
Co	mg/L	NG	NG	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05
Cu	mg/L	NG	NG	0.007	0.007	0.008	0.008	0.009	0.009	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Cr	mg/L	NG	NG	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0006	0.0006	0.0006	0.0006	0.0006	0.0007	0.0007	0.0007	0.0007	0.0008	0.0008	0.0008	0.0009	0.0009	0.0009	0.001	0.001	0.001	0.001
Fe	mg/L	0.7	16	0.00006	0.00006	0.00007	0.00007	0.00007	0.00007	0.00007	0.00007	0.00007	0.00007	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00009	0.00009	0.00009	0.00009	0.0001	0.00009	0.0001	0.0001	0.0001	0.0001
Hg	mg/L	0.0006	0.0006	0.0007	0.0007	0.0007	0.0007	0.0008	0.0008	0.0009	0.0008	0.0009	0.0009	0.001	0.0009	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Li	mg/L	NG	NG	1.6	1.6	1.8	1.8	1.9	1.9	2	2	2.1	2.1	2.3	2.2	2.4	2.4	2.5	2.5	2.7	2.6	2.8	2.7	2.9	2.9	3.1	3	3.2	3.1
Mn	mg/L	NG	NG	1.3	1.3	1.4	1.4	1.5	1.5	1.6	1.6	1.7	1.7	1.8	1.8	1.9	1.9	2	2	2.1	2.1	2.3	2.2	2.4	2.3	2.5	2.4	2.6	2.5
Mo	mg/L	0.034	0.034	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Ni	mg/L	NG	NG	0.06	0.06	0.06	0.06	0.07	0.07	0.07	0.07	0.08	0.08	0.08	0.08	0.09	0.08	0.09	0.09	0.09	0.09	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
P	mg/L	NG	NG	9.4	9.4	10	10	11	11	12	11	12	12	13	13	14	14	14	14	15	15	16	16	17	16	18	17	18	18
Pb	mg/L	NG	NG	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.005	0.005	0.006	0.006	0.006	0.006	0.007	0.007	0.008	0.008	0.008	0.008	0.009	0.009
Sb	mg/L	0.009	0.009	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.02	0.03	0.03	0.03	0.03	0.03	0.03
Se	mg/L	0.011	0.02	0.1	0.09	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Si	mg/L	NG	NG	41.3	40.7	40.5	39.9	39.7	39.4	39	38.8	38.3	38.2	37.6	37.5	36.8	36.8	36.1	36.1	35.4	35.3	34.7	34.5	34	33.8	33.3	33.1	32.7	32.5
Sn	mg/L	NG	NG	0.06	0.06	0.06	0.06	0.07	0.07	0.07	0.07	0.07	0.07	0.08	0.08	0.08	0.08	0.09	0.09	0.09	0.09	0.1	0.09	0.1	0.1	0.1	0.1	0.1	0.1
Sr	mg/L	NG	NG	32	31	34	34	37	36	39	39	41	41	44	43	46	46	49	48	51	50	54	53	56	55	58	55	57	54
Tl	mg/L	NG	NG	0.007	0.007	0.007	0.007	0.008	0.008	0.009	0.008	0.009	0.009	0.01	0.009	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
U	mg/L	NG	NG	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05
V	mg/L	NG	NG	0.05	0.05	0.06	0.06	0.06	0.07	0.07	0.07	0.08	0.08	0.08	0.08	0.09	0.09	0.09	0.09	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Zn	mg/L	NG	NG	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4

Table B.21 Kenmare residual void lake water quality – without geochemical controls (Part 1 of 2)

Parameter	Unit	Lower TV	Upper TV	2094	2100	2110	2120	2130	2140	2150	2160	2170	2180	2190	2200	2210	2220	2230	2240	2250	2260	2270	2280	2290	2300	2310	2320	2330	2340
pH	pH Units	6.5	8.5	7.9	7.8	7.8	7.8	7.7	7.7	7.7	7.7	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.4	7.4
pe	pe units	NG	NG	6.2	6.3	6.4	6.4	6.4	6.5	6.5	6.5	6.5	6.5	6.5	6.6	6.6	6.6	6.6	6.6	6.7	6.7	6.7	6.7	6.7	6.7	6.8	6.8	6.8	6.8
TDS	mg/L	4992	10599	1940	3750	5580	6420	8140	9060	10800	11800	13800	14900	17200	18300	20900	21900	24600	25300	28300	28800	32000	32300	35800	35800	39500	39400	43200	42900
Alkalinity	mg $CaCO_3$/L	NG	NG	137	271	396	465	587	654	774	840	982	1060	1220	1300	1480	1550	1740	1800	2010	2040	2270	2290	2530	2540	2800	2790	3060	3040
Ca	mg/L	NG	NG	39	75	111	128	162	180	215	234	275	297	344	366	417	436	491	504	564	573	639	644	713	715	787	785	862	856
Mg	mg/L	NG	NG	74	142	213	243	309	344	411	447	526	567	657	699	797	834	938	964	1080	1100	1220	1230	1360	1370	1500	1500	1650	1640
K	mg/L	NG	NG	4.6	9.2	13	16	20	22	26	28	33	35	41	43	49	52	58	60	67	68	75	76	84	84	93	93	101	101
Na	mg/L	NG	NG	594	1150	1710	1970	2490	2780	3310	3600	4230	4560	5280	5620	6410	6710	7540	7750	8670	8810	9810	9890	11000	11000	12100	12100	13200	13200
Cl	mg/L	NG	NG	1110	2140	3190	3650	4640	5160	6170	6710	7880	8490	9840	10500	11900	12500	14100	14400	16200	16400	18300	18400	20400	20500	22600	22500	24700	24500
F	mg/L	NG	NG	0.2	0.4	0.6	0.7	0.9	1	1.2	1.3	1.5	1.6	1.9	2	2.2	2.4	2.6	2.7	3	3.1	3.4	3.5	3.8	3.8	4.2	4.2	4.6	4.6
SO_4	mg/L	318	520	31	61	90	105	133	148	175	190	222	240	277	295	336	352	395	407	454	462	514	518	574	575	633	632	693	689
N	mg N/L	NG	NG	0.003	0.007	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.05	0.05	0.06	0.06	0.06	0.06	0.07	0.07	0.08	0.08
Al	mg/L	0.055	0.48	0.04	0.08	0.1	0.1	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.4	0.5	0.5	0.6	0.6	0.6	0.6	0.7	0.7	0.8	0.8	0.8	0.8
Ag	mg/L	0.001	0.39	0.0003	0.0006	0.0008	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.005	0.005	0.005	0.005	0.006	0.006	0.006	0.006
As	mg/L	0.013	0.013	0.01	0.02	0.03	0.04	0.05	0.05	0.06	0.06	0.07	0.08	0.09	0.1	0.11	0.11	0.13	0.13	0.15	0.15	0.17	0.17	0.18	0.19	0.2	0.2	0.22	0.22
B	mg/L	NG	NG	0.2	0.4	0.5	0.6	0.8	0.9	1	1.1	1.3	1.4	1.7	1.8	2	2.1	2.4	2.4	2.7	2.8	3.1	3.1	3.4	3.4	3.8	3.8	4.1	4.1
Ba	mg/L	NG	NG	0.2	0.3	0.5	0.5	0.7	0.8	0.9	1	1.2	1.3	1.5	1.6	1.8	1.9	2.1	2.2	2.4	2.4	2.7	2.7	3	3	3.4	3.3	3.7	3.6
Be	mg/L	NG	NG	0.0004	0.0008	0.001	0.001	0.002	0.002	0.002	0.003	0.003	0.003	0.004	0.004	0.004	0.005	0.005	0.005	0.006	0.006	0.007	0.007	0.007	0.007	0.008	0.008	0.009	0.009
Cd	mg/L	NG	NG	0.0002	0.0005	0.0007	0.0009	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.004	0.005	0.005	0.005	0.005
Co	mg/L	NG	NG	0.001	0.002	0.003	0.004	0.004	0.005	0.006	0.006	0.007	0.008	0.009	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Cu	mg/L	NG	NG	0.0009	0.002	0.003	0.003	0.004	0.004	0.005	0.005	0.006	0.007	0.008	0.008	0.009	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02
Cr	mg/L	NG	NG	0.0004	0.0008	0.001	0.001	0.002	0.002	0.002	0.003	0.003	0.003	0.004	0.004	0.004	0.005	0.005	0.005	0.006	0.006	0.007	0.007	0.007	0.007	0.008	0.008	0.009	0.009
Fe	mg/L	0.7	16	0.2	0.4	0.7	0.8	1	1.1	1.3	1.4	1.6	1.7	2	2.1	2.4	2.6	2.9	3	3.3	3.4	3.7	3.8	4.2	4.2	4.6	4.6	5	5
Hg	mg/L	0.0006	0.0006	0.00003	0.00006	0.00008	0.0001	0.0001	0.0001	0.0002	0.0002	0.0002	0.0002	0.0003	0.0003	0.0003	0.0003	0.0004	0.0004	0.0004	0.0004	0.0005	0.0005	0.0005	0.0005	0.0006	0.0006	0.0006	0.0006
Li	mg/L	NG	NG	0.07	0.1	0.2	0.2	0.3	0.3	0.4	0.4	0.5	0.5	0.6	0.6	0.7	0.8	0.9	0.9	1	1	1.1	1.1	1.3	1.3	1.4	1.4	1.5	1.5
Mn	mg/L	NG	NG	0.05	0.1	0.2	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.5	0.5	0.6	0.6	0.7	0.7	0.8	0.8	0.9	0.9	1	1	1.1	1.1	1.2	1.2
Mo	mg/L	0.034	0.034	0.004	0.01	0.01	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.04	0.04	0.05	0.05	0.06	0.06	0.06	0.07	0.07	0.07	0.08	0.08	0.09	0.09	0.1	0.1
Ni	mg/L	NG	NG	0.002	0.005	0.007	0.008	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.05
P	mg/L	NG	NG	0.4	0.8	1.1	1.4	1.8	2	2.3	2.5	2.9	3.1	3.6	3.8	4.3	4.5	5	5.2	5.8	5.9	6.5	6.6	7.3	7.3	8	8	8.8	8.8
Pb	mg/L	NG	NG	0.0004	0.0008	0.001	0.001	0.002	0.002	0.002	0.003	0.003	0.003	0.004	0.004	0.004	0.005	0.005	0.005	0.006	0.006	0.007	0.007	0.007	0.007	0.008	0.008	0.009	0.009
Sb	mg/L	0.009	0.009	0.00061	0.0013	0.0018	0.0023	0.0028	0.0032	0.0036	0.0039	0.0045	0.0048	0.0055	0.0059	0.0067	0.007	0.0078	0.0081	0.009	0.0092	0.01	0.01	0.011	0.011	0.013	0.013	0.014	0.014
Se	mg/L	0.011	0.02	0.004	0.0084	0.012	0.015	0.018	0.02	0.023	0.025	0.029	0.031	0.036	0.038	0.043	0.045	0.051	0.052	0.058	0.059	0.066	0.067	0.073	0.074	0.081	0.081	0.088	0.088
Si	mg/L	NG	NG	2.6	5	7.4	8.5	11	12	14	16	18	20	23	24	28	29	33	34	38	38	43	43	48	48	53	52	58	57
Sn	mg/L	NG	NG	0.002	0.005	0.007	0.009	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05
Sr	mg/L	NG	NG	1.3	2.5	3.8	4.3	5.5	6.1	7.3	7.9	9.3	10	12	12	14	15	17	17	19	19	22	22	24	24	27	27	29	29
Tl	mg/L	NG	NG	0.0003	0.0006	0.0008	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.005	0.005	0.005	0.005	0.006	0.006	0.006	0.006
U	mg/L	NG	NG	0.001	0.002	0.003	0.004	0.004	0.005	0.006	0.006	0.007	0.008	0.009	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
V	mg/L	NG	NG	0.004	0.008	0.01	0.01	0.02	0.02	0.02	0.03	0.03	0.03	0.04	0.04	0.04	0.05	0.05	0.05	0.06	0.06	0.07	0.07	0.07	0.07	0.08	0.08	0.09	0.09
Zn	mg/L	NG	NG	0.009	0.02	0.03	0.03	0.04	0.04	0.05	0.06	0.07	0.07	0.08	0.09	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Table B.22 Kenmare residual void lake water quality – without geochemical controls (Part 2 of 2)

Parameter	Unit	Lower TV	Upper TV	2350	2360	2370	2380	2390	2400	2410	2420	2430	2440	2450	2460	2470	2480	2490	2500	2510	2520	2530	2540	2550	2560	2570	2580	2590	2599
pH	pH Units	6.5	8.5	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.2	7.2	7.2	7.2	7.2	7.2
pe	pe units	NG	NG	6.8	6.8	6.9	6.9	6.9	6.9	6.9	6.9	7	6.9	7	7	7	7	7	7	7.1	7	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1
TDS	mg/L	4992	10599	47000	46500	50800	50100	54600	54100	57900	57300	61300	60700	65000	64300	68700	67900	72500	71600	76300	74800	80200	78300	84000	81900	88000	85600	91900	89700
Alkalinity	mg $CaCO_3$/L	NG	NG	3330	3300	3590	3550	3860	3830	4100	4060	4340	4300	4600	4550	4860	4810	5130	5070	5400	5300	5670	5540	5940	5800	6220	6060	6500	6350
Ca	mg/L	NG	NG	937	928	1010	1000	1090	1080	1150	1140	1220	1210	1300	1280	1370	1350	1450	1430	1520	1490	1600	1560	1680	1630	1750	1710	1830	1790
Mg	mg/L	NG	NG	1790	1770	1940	1910	2080	2060	2210	2180	2340	2310	2480	2450	2620	2590	2760	2730	2910	2850	3050	2980	3200	3120	3350	3260	3500	3420
K	mg/L	NG	NG	110	109	119	118	128	127	136	134	144	142	152	151	161	159	170	168	179	175	188	183	197	192	206	201	215	210
Na	mg/L	NG	NG	14400	14300	15600	15400	16700	16600	17700	17600	18800	18600	19900	19700	21100	20800	22200	21900	23400	22900	24600	24000	25700	25100	26900	26200	28100	27500
Cl	mg/L	NG	NG	26800	26600	29000	28600	31200	30900	33100	32700	35000	34700	37100	36700	39200	38800	41400	40900	43600	42700	45800	44700	48000	46800	50200	48900	52500	51200
F	mg/L	NG	NG	5	5	5.4	5.3	5.8	5.8	6.1	6.1	6.5	6.5	6.9	6.8	7.3	7.2	7.7	7.6	8.1	8	8.5	8.3	8.9	8.7	9.3	9.1	9.7	9.5
SO_4	mg/L	318	520	753	746	814	804	875	867	927	918	983	973	1040	1030	1100	1090	1160	1150	1220	1200	1280	1250	1350	1310	1410	1370	1470	1440
N	mg N/L	NG	NG	0.08	0.08	0.09	0.09	0.1	0.09	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.2	0.2
Al	mg/L	0.055	0.48	0.9	0.9	1	1	1.1	1.1	1.1	1.1	1.2	1.2	1.3	1.2	1.3	1.3	1.4	1.4	1.5	1.5	1.5	1.5	1.6	1.6	1.7	1.7	1.8	1.7
Ag	mg/L	0.001	0.39	0.007	0.007	0.007	0.007	0.008	0.008	0.009	0.008	0.009	0.009	0.01	0.009	0.01	0.01	0.011	0.011	0.011	0.011	0.012	0.012	0.012	0.012	0.013	0.013	0.014	0.013
As	mg/L	0.013	0.013	0.24	0.24	0.26	0.26	0.28	0.28	0.3	0.29	0.31	0.31	0.33	0.33	0.35	0.35	0.37	0.37	0.39	0.38	0.41	0.4	0.43	0.42	0.45	0.44	0.47	0.46
B	mg/L	NG	NG	4.5	4.5	4.9	4.8	5.2	5.2	5.5	5.5	5.9	5.8	6.2	6.1	6.6	6.5	6.9	6.8	7.3	7.2	7.7	7.5	8	7.8	8.4	8.2	8.8	8.6
Ba	mg/L	NG	NG	4	4	4.3	4.3	4.6	4.6	4.9	4.9	5.2	5.2	5.5	5.5	5.8	5.8	6.2	6.1	6.5	6.4	6.8	6.6	7.1	7	7.5	7.3	7.8	7.6
Be	mg/L	NG	NG	0.01	0.009	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Cd	mg/L	NG	NG	0.006	0.006	0.006	0.006	0.007	0.007	0.007	0.007	0.007	0.007	0.008	0.008	0.008	0.008	0.009	0.009	0.009	0.009	0.01	0.009	0.01	0.01	0.01	0.01	0.01	0.01
Co	mg/L	NG	NG	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05
Cu	mg/L	NG	NG	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Cr	mg/L	NG	NG	0.01	0.009	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Fe	mg/L	0.7	16	5.5	5.4	5.9	5.8	6.4	6.3	6.7	6.7	7.1	7.1	7.6	7.5	8	7.9	8.4	8.3	8.9	8.7	9.3	9.1	9.8	9.5	10	10	11	10
Hg	mg/L	0.0006	0.0006	0.0007	0.0007	0.0007	0.0007	0.0008	0.0008	0.0009	0.0008	0.0009	0.0009	0.001	0.0009	0.001	0.001	0.0011	0.0011	0.0011	0.0011	0.0012	0.0012	0.0012	0.0012	0.0013	0.0013	0.0014	0.0013
Li	mg/L	NG	NG	1.7	1.6	1.8	1.8	1.9	1.9	2	2	2.2	2.1	2.3	2.3	2.4	2.4	2.5	2.5	2.7	2.6	2.8	2.7	2.9	2.9	3.1	3	3.2	3.1
Mn	mg/L	NG	NG	1.3	1.3	1.4	1.4	1.5	1.5	1.6	1.6	1.7	1.7	1.8	1.8	1.9	1.9	2	2	2.2	2.1	2.3	2.2	2.4	2.3	2.5	2.4	2.6	2.5
Mo	mg/L	0.034	0.034	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Ni	mg/L	NG	NG	0.06	0.06	0.06	0.06	0.07	0.07	0.07	0.07	0.08	0.08	0.08	0.08	0.09	0.09	0.09	0.09	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
P	mg/L	NG	NG	9.5	9.5	10	10	11	11	12	12	12	12	13	13	14	14	15	15	16	15	16	16	17	17	18	17	19	18
Pb	mg/L	NG	NG	0.01	0.009	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Sb	mg/L	0.009	0.009	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.02	0.03	0.03	0.03	0.03	0.03	0.03
Se	mg/L	0.011	0.02	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Si	mg/L	NG	NG	63	62	68	67	73	72	77	76	82	81	87	86	92	90	97	95	100	100	107	104	112	109	117	114	122	119
Sn	mg/L	NG	NG	0.06	0.06	0.06	0.06	0.07	0.07	0.07	0.07	0.07	0.07	0.08	0.08	0.08	0.08	0.09	0.09	0.09	0.09	0.1	0.09	0.1	0.1	0.1	0.1	0.1	0.1
Sr	mg/L	NG	NG	32	31	34	34	37	36	39	39	41	41	44	43	46	46	49	48	51	50	54	53	57	55	59	58	62	60
Tl	mg/L	NG	NG	0.007	0.007	0.007	0.007	0.008	0.008	0.009	0.008	0.009	0.009	0.01	0.009	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
U	mg/L	NG	NG	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05
V	mg/L	NG	NG	0.1	0.09	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Zn	mg/L	NG	NG	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4

Table B.23 Laleham residual void lake water quality – with geochemical controls

Parameter	Unit	Lower TV	Upper TV	2090	2100	2110	2120	2122
pH	pH Units	6.5	8.5	8.6	8.5	7.6	7.4	7.2
pe	pe units	NG	NG	6	6.1	7.9	8.4	9.2
TDS	mg/L	4992	10599	1845	9871	164330	198810	257580
Alkalinity	mg $CaCO_3$/L	NG	NG	122	160	445	539	713
Ca	mg/L	NG	NG	9.4	20	309	377	500
Mg	mg/L	NG	NG	58	127	1838	2199	2840
K	mg/L	NG	NG	11	81	1322	1604	2080
Na	mg/L	NG	NG	603	3482	58620	70954	91943
Cl	mg/L	NG	NG	1037	5702	96667	116940	151510
F	mg/L	NG	NG	0.6	5	30	30	40
SO_4	mg/L	318	520	47	325	5213	6316	8182
N	mg N/L	NG	NG	0.01	0.1	1.7	2.1	2.7
Al	mg/L	0.055	0.48	0.2	2	0.5	0.3	0.2
Ag	mg/L	0.001	0.39	9E-04	0.007	0.1	0.14	0.18
As	mg/L	0.013	0.013	0.04	0.37	6.1	7.4	9.6
B	mg/L	NG	NG	0.3	1.9	31	38	49
Ba	mg/L	NG	NG	0.1	0.06	0.006	0.004	0.003
Be	mg/L	NG	NG	2E-04	0.0003	0.001	0.002	0.004
Cd	mg/L	NG	NG	0.001	0.01	0.2	0.2	0.3
Co	mg/L	NG	NG	0.002	0.02	0.2	0.3	0.4
Cu	mg/L	NG	NG	0.001	0.006	0.05	0.07	0.09
Cr	mg/L	NG	NG	0.001	0.01	0.2	0.2	0.3
Fe	mg/L	0.7	16	4E-05	0.00004	0.0001	0.0002	0.2
Hg	mg/L	0.0006	0.0006	9E-05	0.0007	0.01	0.01	0.02
Li	mg/L	NG	NG	0.06	0.3	5.3	6.5	8.4
Mn	mg/L	NG	NG	0.05	0.2	3.8	4.7	6.1
Mo	mg/L	0.034	0.034	0.02	0.2	2.9	3.5	4.6
Ni	mg/L	NG	NG	0.003	0.02	0.3	0.4	0.6
P	mg/L	NG	NG	1.5	12	197	240	311
Pb	mg/L	NG	NG	3E-04	0.002	0.04	0.06	0.08
Sb	mg/L	0.009	0.009	0.003	0.02	0.4	0.4	0.6
Se	mg/L	0.011	0.02	0.014	0.12	2.0	2.4	3.1
Si	mg/L	NG	NG	2.3	12	23	19	14
Sn	mg/L	NG	NG	0.01	0.1	1.7	2	2.6
Sr	mg/L	NG	NG	1.3	7	13	11	8.5
Tl	mg/L	NG	NG	9E-04	0.007	0.1	0.1	0.2
U	mg/L	NG	NG	0.002	0.02	0.2	0.3	0.4
V	mg/L	NG	NG	0.01	0.1	2	2	3
Zn	mg/L	NG	NG	0.01	0.09	1	2	2

DRAFT

Table B.24 Laleham residual void lake water quality – without geochemical controls

Parameter	Unit	Lower TV	Upper TV	2090	2100	2110	2120	2122
pH	pH Units	6.5	8.5	8.5	8.4	7.7	7.6	7.6
pe	pe units	NG	NG	6	6.4	8.1	8.5	9.1
TDS	mg/L	4992	10599	1938	11081	187520	227150	294780
Alkalinity	mg $CaCO_3$/L	NG	NG	220	1513	24990	30333	39382
Ca	mg/L	NG	NG	35	190	3245	3927	5096
Mg	mg/L	NG	NG	66	352	6021	7288	9455
K	mg/L	NG	NG	11	81	1327	1612	2094
Na	mg/L	NG	NG	603	3483	58858	71304	92534
Cl	mg/L	NG	NG	1037	5703	97060	117520	152490
F	mg/L	NG	NG	0.6	4.7	76	92	119
SO_4	mg/L	318	520	47	326	5384	6535	8485
N	mg N/L	NG	NG	0.01	0.1	1.7	2.1	2.8
Al	mg/L	0.055	0.48	0.2	1.7	27	33	43
Ag	mg/L	0.001	0.39	9E-04	0.007	0.1	0.1	0.2
As	mg/L	0.013	0.013	0.05	0.4	7	8.6	11
B	mg/L	NG	NG	0.3	1.9	31	38	50
Ba	mg/L	NG	NG	0.2	0.9	16	19	24
Be	mg/L	NG	NG	0.001	0.01	0.2	0.2	0.3
Cd	mg/L	NG	NG	0.001	0.01	0.2	0.2	0.3
Co	mg/L	NG	NG	0.002	0.02	0.2	0.3	0.4
Cu	mg/L	NG	NG	0.002	0.014	0.2	0.3	0.4
Cr	mg/L	NG	NG	0.001	0.01	0.2	0.2	0.3
Fe	mg/L	0.7	16	0.3	2	34	41	53
Hg	mg/L	0.0006	0.0006	9E-05	0.0007	0.01	0.01	0.02
Li	mg/L	NG	NG	0.06	0.3	5.4	6.5	8.4
Mn	mg/L	NG	NG	0.05	0.3	4.6	5.6	7.2
Mo	mg/L	0.034	0.034	0.02	0.2	2.9	3.6	4.6
Ni	mg/L	NG	NG	0.003	0.02	0.4	0.4	0.6
P	mg/L	NG	NG	1.5	12	199	242	314
Pb	mg/L	NG	NG	0.001	0.01	0.2	0.2	0.3
Sb	mg/L	0.009	0.009	0.003	0.02	0.4	0.4	0.6
Se	mg/L	0.011	0.02	0.014	0.12	2	2	3
Si	mg/L	NG	NG	2	12	204	247	320
Sn	mg/L	NG	NG	0.01	0.1	1.7	2.1	2.7
Sr	mg/L	NG	NG	1.3	7	119	144	186
Tl	mg/L	NG	NG	9E-04	0.007	0.1	0.1	0.2
U	mg/L	NG	NG	0.002	0.02	0.2	0.3	0.4
V	mg/L	NG	NG	0.01	0.1	2	2	3
Zn	mg/L	NG	NG	0.01	0.1	2	2	3

DRAFT

Table B.25 Togara/North Marshmead residual void lake water quality – with geochemical controls (Part 1 of 2)

Parameter	Unit	Lower TV	Upper TV	2109	2110	2120	2130	2140	2150	2160	2170	2180	2190	2200	2210	2220	2230	2240	2250	2260	2270	2280	2290	2300	2310	2320	2330	2340	2350
pH	pH Units	6.5	8.5	8.7	8.7	8.4	8.4	8.3	8.3	8.3	8.3	8.3	8.2	8.2	8.2	8.2	8.2	8.2	8.2	8.2	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8
pe	pe units	NG	NG	6.9	6.5	5.7	5.6	5.6	5.6	5.7	5.7	5.7	5.8	5.8	5.8	5.8	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	6	6	6	6	6
TDS	mg/L	4992	10599	308	359	4271	5968	6861	8347	9243	10842	11719	13475	14352	16198	16821	18500	18801	20429	20622	22472	22769	24817	25107	27279	27511	29805	29982	32371
Alkalinity	mg $CaCO_3$/L	NG	NG	145	136	92	87	86	84	83	82	81	81	80	80	80	79	80	79	79	79	79	79	79	79	79	79	79	79
Ca	mg/L	NG	NG	1.9	3.4	24	33	38	45	50	58	62	71	75	85	88	96	98	106	107	117	118	129	130	142	143	155	156	168
Mg	mg/L	NG	NG	1.7	4.7	152	209	237	285	313	364	391	448	474	534	553	607	616	669	675	736	745	812	821	892	899.3	974.2	979.7	1058
K	mg/L	NG	NG	9.4	8.6	11	15	17	21	23	27	30	34	37	41	43	47	48	52	53	57	58	63	64	69	70	75	76	81
Na	mg/L	NG	NG	106	120	1379	1932	2226	2713	3008	3533	3822	4398	4688	5293	5499	6049	6149	6682	6745	7351	7448	8119	8214	8925	9001	9752	9810	10594
Cl	mg/L	NG	NG	74	114	2558	3602	4148	5058	5605	6583	7118	8192	8726	9855	10235	11261	11445	12441	12559	13691	13872	15125	15302	16630	16772	18175	18283	19748
F	mg/L	NG	NG	0.5	0.4	0.5	0.6	0.7	0.9	1	1.2	1.3	1.5	1.6	1.8	1.9	2.1	2.1	2.3	2.3	2.5	2.5	2.7	2.8	3	3	3.2	3.3	3.5
SO_4	mg/L	318	520	28	26	74	101	116	141	157	184	200	230	246	278	289	318	323	350	354	385	390	424	429	466	470	508	511	551
N	mg N/L	NG	NG	0.009	0.008	0.007	0.009	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05
Al	mg/L	0.055	0.48	0.2	0.2	0.1	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.7
Ag	mg/L	0.001	0.39	0.0008	0.0007	0.0007	0.0009	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.004	0.005	0.005	0.005
As	mg/L	0.013	0.013	0.06	0.05	0.01	0.01	0.02	0.02	0.02	0.03	0.03	0.04	0.04	0.05	0.05	0.06	0.06	0.07	0.07	0.07	0.07	0.08	0.08	0.09	0.09	0.1	0.1	0.1
B	mg/L	NG	NG	0.2	0.1	0.4	0.6	0.7	0.8	0.9	1.1	1.2	1.4	1.5	1.7	1.7	1.9	1.9	2.1	2.1	2.3	2.3	2.5	2.6	2.8	2.8	3	3.1	3.3
Ba	mg/L	NG	NG	0.02	0.03	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.09	0.09	0.09	0.09	0.08	0.08	0.08	0.08	0.08	0.08	0.07
Be	mg/L	NG	NG	0.00006	0.00008	0.00005	0.00005	0.00007	0.00006	0.00008	0.00007	0.00009	0.00008	0.0001	0.00008	0.00009	0.00008	0.00009	0.00008	0.00009	0.00008	0.00009	0.00008	0.0001	0.00008	0.0001	0.00009	0.0001	0.00009
Cd	mg/L	NG	NG	0.001	0.001	0.0007	0.0008	0.0009	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.004
Co	mg/L	NG	NG	0.002	0.001	0.003	0.003	0.004	0.005	0.005	0.006	0.007	0.008	0.008	0.009	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02
Cu	mg/L	NG	NG	0.0008	0.0008	0.001	0.001	0.002	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.005	0.005	0.005	0.005
Cr	mg/L	NG	NG	0.002	0.001	0.0002	0.0001	0.0002	0.0002	0.0002	0.0002	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003
Fe	mg/L	0.7	16	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00006	0.00006	0.00006
Hg	mg/L	0.0006	0.0006	0.00008	0.00007	0.00007	0.00009	0.0001	0.0001	0.0001	0.0002	0.0002	0.0002	0.0002	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0004	0.0004	0.0004	0.0004	0.0004	0.0005	0.0005	0.0005
Li	mg/L	NG	NG	0.000009	0.003	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.5	0.5	0.6	0.6	0.7	0.7	0.8	0.8	0.8	0.9	0.9	0.9	1	1	1.1	1.1	1.2
Mn	mg/L	NG	NG	0.002	0.004	0.1	0.2	0.2	0.2	0.3	0.3	0.4	0.4	0.4	0.5	0.5	0.6	0.6	0.6	0.6	0.7	0.7	0.7	0.8	0.8	0.8	0.9	0.9	1
Mo	mg/L	0.034	0.034	0.03	0.02	0.01	0.01	0.02	0.02	0.02	0.03	0.03	0.03	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.07	0.07	0.08	0.08	0.08
Ni	mg/L	NG	NG	0.001	0.001	0.006	0.008	0.009	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04
P	mg/L	NG	NG	1.6	1.4	1.1	1.3	1.5	1.8	2	2.3	2.6	2.9	3.2	3.6	3.8	4.1	4.2	4.5	4.6	4.9	5	5.4	5.5	5.9	5.9	6.4	6.4	6.9
Pb	mg/L	NG	NG	0.0003	0.0003	0.00008	0.00008	0.0001	0.0001	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0004	0.0004	0.0004	0.0005	0.0005	0.0006	0.0006
Sb	mg/L	0.009	0.009	0.0031	0.0028	0.0017	0.002	0.0023	0.0028	0.0032	0.0037	0.0041	0.0047	0.0052	0.0058	0.0061	0.0067	0.0068	0.0073	0.0074	0.0079	0.008	0.0087	0.0088	0.0094	0.0095	0.01	0.01	0.011
Se	mg/L	0.011	0.02	0.016	0.014	0.011	0.013	0.015	0.018	0.02	0.023	0.026	0.03	0.032	0.036	0.038	0.042	0.042	0.046	0.046	0.05	0.05	0.054	0.055	0.059	0.06	0.064	0.065	0.07
Si	mg/L	NG	NG	0.0003	0.1	6	8.4	9.7	12	13	15	17	19	20	23	24	26	27	29	29	32	32	35	36	39	39	42	43	44
Sn	mg/L	NG	NG	0.02	0.01	0.007	0.008	0.009	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04
Sr	mg/L	NG	NG	0.2	0.2	3	4.3	4.9	6	6.6	7.8	8.4	9.7	10	12	12	13	14	15	15	16	16	18	18	20	20	21	22	23
Tl	mg/L	NG	NG	0.0008	0.0007	0.0007	0.0009	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.004	0.005	0.005	0.005
U	mg/L	NG	NG	0.002	0.001	0.003	0.003	0.004	0.005	0.005	0.006	0.007	0.008	0.008	0.009	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02
V	mg/L	NG	NG	0.01	0.01	0.005	0.005	0.006	0.007	0.009	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04
Zn	mg/L	NG	NG	0.006	0.006	0.02	0.03	0.03	0.04	0.04	0.05	0.05	0.06	0.07	0.08	0.08	0.09	0.09	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2

Table B.26 Togara/North Marshmead residual void lake water quality – with geochemical controls (Part 2 of 2)

Parameter	Unit	Lower TV	Upper TV	2360	2370	2380	2390	2400	2410	2420	2430	2440	2450	2460	2470	2480	2490	2500	2510	2520	2530	2540	2550	2560	2570	2580	2590	2599
pH	pH Units	6.5	8.5	8	8	8	8	8	8	8	8	8	8	8	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.8	7.8	7.8	7.8
pe	pe units	NG	NG	6	6	6	6	6	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.3	6.3
TDS	mg/L	4992	10599	32480	34957	34990	37559	37670	39874	39954	42276	42364	44789	44849	47366	47387	49988	49961	52623	52351	55291	54851	58003	57465	60748	60103	63503	62914
Alkalinity	mg $CaCO_3$/L	NG	NG	79	79	79	79	79	79	79	80	80	80	80	81	81	82	82	82	82	83	83	84	84	85	85	86	86
Ca	mg/L	NG	NG	169	182	182	195	196	207	208	220	220	233	233	247	247	260	260	274	273	288	286	303	300	317	314	332	328
Mg	mg/L	NG	NG	1061	1143	1144	1228	1231	1304	1306	1382	1385	1465	1467	1549	1550	1635	1634	1722	1713	1809	1795	1898	1881	1988	1967	2079	2060
K	mg/L	NG	NG	82	88	88	94	94	99	100	105	106	111	112	118	118	124	124	130	130	137	136	143	142	150	148	157	155
Na	mg/L	NG	NG	10630	11444	11456	12300	12337	13061	13088	13851	13880	14677	14697	15525	15531	16386	16378	17253	17164	18130	17985	19021	18845	19923	19711	20829	20635
Cl	mg/L	NG	NG	19815	21337	21358	22935	23004	24358	24407	25834	25887	27377	27414	28960	28973	30571	30554	32189	32023	33828	33559	35494	35164	37180	36784	38872	38511
F	mg/L	NG	NG	3.5	3.8	3.8	4.1	4.1	4.3	4.3	4.5	4.6	4.8	4.8	5.1	5.1	5.4	5.4	5.6	5.6	5.9	5.9	6.2	6.1	6.5	6.4	6.8	6.7
SO_4	mg/L	318	520	553	595	596	639	641	678	679	719	720	761	762	804	805	849	848	893	888	938	931	984	975	1030	1019	1076	1066
N	mg N/L	NG	NG	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.07	0.07	0.07	0.07	0.07	0.07	0.08	0.08	0.08	0.08	0.08	0.08	0.09	0.09	0.09	0.09	0.1	0.1
Al	mg/L	0.055	0.48	0.7	0.7	0.7	0.8	0.8	0.8	0.8	0.9	0.9	0.9	0.9	0.9	0.9	1	1	1	1	1.1	1.1	1.1	1.1	1.2	1.2	1.2	1.2
Ag	mg/L	0.001	0.39	0.005	0.005	0.005	0.006	0.006	0.006	0.006	0.006	0.006	0.007	0.007	0.007	0.007	0.007	0.007	0.008	0.008	0.008	0.008	0.009	0.009	0.009	0.009	0.009	0.009
As	mg/L	0.013	0.013	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
B	mg/L	NG	NG	3.3	3.6	3.6	3.8	3.8	4.1	4.1	4.3	4.3	4.6	4.6	4.8	4.8	5.1	5.1	5.4	5.3	5.6	5.6	5.9	5.8	6.2	6.1	6.4	6.4
Ba	mg/L	NG	NG	0.07	0.07	0.07	0.07	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.04	0.04
Be	mg/L	NG	NG	0.0001	0.00009	0.0001	0.00009	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Cd	mg/L	NG	NG	0.004	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.006	0.006	0.006	0.006	0.006	0.006	0.007	0.007	0.007	0.007	0.007	0.007	0.008	0.008	0.008	0.008
Co	mg/L	NG	NG	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04
Cu	mg/L	NG	NG	0.005	0.006	0.006	0.006	0.007	0.007	0.007	0.008	0.008	0.008	0.008	0.009	0.009	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Cr	mg/L	NG	NG	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0005	0.0005	0.0005
Fe	mg/L	0.7	16	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006	0.00007	0.00007	0.00007	0.00007	0.00007	0.00007	0.00007	0.00007	0.00007	0.00007	0.00008	0.00007	0.00008	0.00008	0.00008	0.00008
Hg	mg/L	0.0006	0.0006	0.0005	0.0005	0.0005	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007	0.0008	0.0008	0.0008	0.0008	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009
Li	mg/L	NG	NG	1.2	1.3	1.3	1.4	1.4	1.5	1.5	1.6	1.6	1.7	1.7	1.8	1.8	1.9	1.9	2	2	2.1	2.1	2.2	2.2	2.3	2.3	2.4	2.4
Mn	mg/L	NG	NG	1	1.1	1.1	1.1	1.1	1.2	1.2	1.3	1.3	1.4	1.4	1.4	1.4	1.5	1.5	1.6	1.6	1.7	1.7	1.8	1.7	1.8	1.8	1.9	1.9
Mo	mg/L	0.034	0.034	0.08	0.09	0.09	0.09	0.09	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Ni	mg/L	NG	NG	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.06	0.07	0.07	0.07	0.07	0.07	0.07	0.08	0.08	0.08	0.08	0.08	0.08
P	mg/L	NG	NG	6.9	7.4	7.4	7.9	7.9	8.3	8.4	8.8	8.8	9.3	9.3	9.8	9.8	10	10	11	11	11	11	12	12	12	12	13	13
Pb	mg/L	NG	NG	0.0007	0.0008	0.0008	0.0009	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.004
Sb	mg/L	0.009	0.009	0.011	0.012	0.012	0.013	0.013	0.013	0.013	0.014	0.014	0.015	0.015	0.016	0.016	0.016	0.016	0.017	0.017	0.018	0.018	0.019	0.019	0.02	0.02	0.021	0.02
Se	mg/L	0.011	0.02	0.07	0.075	0.075	0.08	0.08	0.085	0.085	0.089	0.09	0.094	0.094	0.099	0.099	0.1	0.1	0.11	0.11	0.12	0.11	0.12	0.12	0.13	0.12	0.13	0.13
Si	mg/L	NG	NG	44	43	43	43	43	42	42	42	42	41	41	40	40	40	40	39	39	39	39	38	38	38	37	37	37
Sn	mg/L	NG	NG	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.07	0.07	0.07	0.07	0.07	0.07	0.08	0.08	0.08	0.08
Sr	mg/L	NG	NG	23	25	25	27	27	29	29	31	31	32	32	34	34	36	36	38	38	40	40	42	42	44	43	46	45
Tl	mg/L	NG	NG	0.005	0.005	0.005	0.006	0.006	0.006	0.006	0.006	0.006	0.007	0.007	0.007	0.007	0.007	0.007	0.008	0.008	0.008	0.008	0.009	0.009	0.009	0.009	0.009	0.009
U	mg/L	NG	NG	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04
V	mg/L	NG	NG	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.07	0.07	0.07	0.07	0.07	0.07	0.08	0.08	0.08	0.08
Zn	mg/L	NG	NG	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3

DRAFT

Table B.27 Togara/North Marshmead residual void lake water quality – without geochemical controls (Part 1 of 2)

Parameter	Unit	Lower TV	Upper TV	2109	2110	2120	2130	2140	2150	2160	2170	2180	2190	2200	2210	2220	2230	2240	2250	2260	2270	2280	2290	2300	2310	2320	2330	2340	2350
pH	pH Units	6.5	8.5	9.4	9.3	7.8	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.5	7.5	7.5	7.5	7.5
pe	pe units	NG	NG	8	5.9	6.2	6.2	6.3	6.3	6.3	6.3	6.4	6.4	6.4	6.4	6.4	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.6	6.6	6.6
TDS	mg/L	4992	10599	308	359	4500	6310	7270	8860	9820	11500	12500	14400	15300	17300	18000	19800	20100	21800	22000	24000	24300	26500	26800	29200	29400	31900	32000	34600
Alkalinity	mg $CaCO_3$/L	NG	NG	145	136	333	450	519	630	703	824	896	1030	1100	1240	1300	1420	1450	1570	1580	1720	1750	1900	1920	2080	2100	2270	2290	2470
Ca	mg/L	NG	NG	1.9	3.4	89	126	145	177	196	230	249	287	305	345	358	394	400	435	439	479	485	529	535	582	587	636	640	691
Mg	mg/L	NG	NG	1.7	4.7	171	241	277	338	375	440	476	547	583	658	684	752	765	831	839	915	927	1010	1020	1110	1120	1220	1220	1320
K	mg/L	NG	NG	9.4	8.6	12	15	17	21	23	27	30	34	37	42	43	48	48	52	53	57	58	63	64	69	70	75	76	81
Na	mg/L	NG	NG	106	120	1380	1930	2230	2710	3010	3530	3820	4400	4690	5290	5500	6050	6150	6680	6750	7350	7450	8120	8220	8930	9000	9760	9810	10600
Cl	mg/L	NG	NG	74	114	2560	3600	4150	5060	5610	6580	7120	8190	8730	9860	10200	11300	11400	12400	12600	13700	13900	15100	15300	16600	16800	18200	18300	19800
F	mg/L	NG	NG	0.5	0.4	0.5	0.6	0.7	0.9	1	1.2	1.3	1.5	1.6	1.8	1.9	2.1	2.1	2.3	2.3	2.5	2.5	2.7	2.8	3	3	3.3	3.3	3.5
SO_4	mg/L	318	520	28	26	74	101	116	142	158	185	201	231	247	279	290	319	324	352	355	386	391	426	431	468	472	510	513	554
N	mg N/L	NG	NG	0.009	0.008	0.007	0.009	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05
Al	mg/L	0.055	0.48	0.2	0.2	0.1	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.7
Ag	mg/L	0.001	0.39	0.0008	0.0007	0.0007	0.0009	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.004	0.004	0.005	0.005	0.005
As	mg/L	0.013	0.013	0.06	0.06	0.03	0.03	0.04	0.05	0.05	0.06	0.07	0.08	0.09	0.1	0.1	0.11	0.12	0.12	0.13	0.13	0.14	0.15	0.15	0.16	0.16	0.17	0.17	0.18
B	mg/L	NG	NG	0.2	0.1	0.4	0.6	0.7	0.8	0.9	1.1	1.2	1.4	1.5	1.7	1.7	1.9	1.9	2.1	2.1	2.3	2.3	2.5	2.6	2.8	2.8	3	3.1	3.3
Ba	mg/L	NG	NG	0.02	0.03	0.4	0.5	0.6	0.8	0.8	1	1.1	1.2	1.3	1.5	1.5	1.7	1.7	1.9	1.9	2	2.1	2.3	2.3	2.5	2.5	2.7	2.7	2.9
Be	mg/L	NG	NG	0.002	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.005	0.005	0.005	0.005	0.005	0.006	0.006	0.006	0.006	0.006	0.007
Cd	mg/L	NG	NG	0.002	0.001	0.0007	0.0008	0.0009	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.004
Co	mg/L	NG	NG	0.002	0.001	0.003	0.003	0.004	0.005	0.005	0.006	0.007	0.008	0.008	0.009	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02
Cu	mg/L	NG	NG	0.002	0.001	0.002	0.003	0.003	0.004	0.004	0.005	0.006	0.007	0.007	0.008	0.008	0.009	0.009	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02
Cr	mg/L	NG	NG	0.002	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.005	0.005	0.005	0.005	0.005	0.006	0.006	0.006	0.006	0.006	0.007
Fe	mg/L	0.7	16	0.2	0.1	0.5	0.7	0.8	1	1.2	1.4	1.5	1.7	1.8	2	2.1	2.3	2.4	2.6	2.6	2.8	2.9	3.1	3.1	3.4	3.4	3.7	3.7	4
Hg	mg/L	0.0006	0.0006	0.00008	0.00007	0.00007	0.00009	0.0001	0.0001	0.0001	0.0002	0.0002	0.0002	0.0002	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0005	0.0005	0.0005
Li	mg/L	NG	NG	0.000009	0.003	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.5	0.5	0.6	0.6	0.7	0.7	0.8	0.8	0.8	0.9	0.9	0.9	1	1	1.1	1.1	1.2
Mn	mg/L	NG	NG	0.002	0.004	0.1	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.4	0.5	0.5	0.6	0.6	0.6	0.6	0.7	0.7	0.7	0.8	0.8	0.8	0.9	0.9	1
Mo	mg/L	0.034	0.034	0.03	0.02	0.01	0.01	0.02	0.02	0.02	0.03	0.03	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.07	0.07	0.08	0.08	0.08
Ni	mg/L	NG	NG	0.002	0.002	0.006	0.008	0.009	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04
P	mg/L	NG	NG	1.6	1.4	1.1	1.3	1.5	1.8	2	2.4	2.6	3	3.2	3.6	3.8	4.2	4.2	4.6	4.6	5	5	5.4	5.5	5.9	6	6.4	6.5	7
Pb	mg/L	NG	NG	0.002	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.005	0.005	0.005	0.005	0.005	0.006	0.006	0.006	0.006	0.006	0.007
Sb	mg/L	0.009	0.009	0.0031	0.0028	0.0017	0.002	0.0023	0.0028	0.0032	0.0037	0.0041	0.0047	0.0052	0.0058	0.0061	0.0067	0.0068	0.0073	0.0074	0.0079	0.008	0.0087	0.0088	0.0094	0.0095	0.01	0.01	0.011
Se	mg/L	0.011	0.02	0.016	0.014	0.011	0.013	0.015	0.018	0.02	0.024	0.026	0.03	0.032	0.037	0.038	0.042	0.043	0.046	0.046	0.05	0.051	0.055	0.055	0.06	0.06	0.065	0.065	0.07
Si	mg/L	NG	NG	0.0003	0.1	6	8.4	9.7	12	13	15	17	19	20	23	24	26	27	29	29	32	32	35	36	39	39	43	43	46
Sn	mg/L	NG	NG	0.02	0.01	0.007	0.008	0.009	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04
Sr	mg/L	NG	NG	0.16	0.2	3	4.3	4.9	6	6.6	7.8	8.4	9.7	10	12	12	13	14	15	15	16	16	18	18	20	20	22	22	23
Tl	mg/L	NG	NG	0.0008	0.0007	0.0007	0.0009	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.004	0.004	0.005	0.005	0.005
U	mg/L	NG	NG	0.002	0.001	0.003	0.003	0.004	0.005	0.005	0.006	0.007	0.008	0.008	0.009	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02
V	mg/L	NG	NG	0.02	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.07
Zn	mg/L	NG	NG	0.008	0.007	0.02	0.03	0.03	0.04	0.05	0.05	0.06	0.07	0.07	0.08	0.09	0.09	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2

Table B.28 Togara/North Marshmead residual void lake water quality – without geochemical controls (Part 2 of 2)

Parameter	Unit	Lower TV	Upper TV	2360	2370	2380	2390	2400	2410	2420	2430	2440	2450	2460	2470	2480	2490	2500	2510	2520	2530	2540	2550	2560	2570	2580	2590	2599
pH	pH Units	6.5	8.5	7.5	7.5	7.5	7.5	7.5	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.3	7.3	7.3	7.3	7.3	7.3
pe	pe units	NG	NG	6.6	6.6	6.6	6.6	6.6	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.8	6.8	6.8	6.8	6.8	6.8	6.9	6.8	6.9	6.9	6.9	6.9
TDS	mg/L	4992	10599	34700	37400	37400	40200	40300	42700	42800	45300	45400	48000	48000	50700	50800	53600	53500	56400	56100	59300	58800	62200	61600	65100	64400	68100	67500
Alkalinity	mg $CaCO_3$/L	NG	NG	2480	2660	2660	2860	2870	3030	3040	3210	3220	3400	3410	3590	3600	3790	3790	3990	3970	4190	4160	4390	4350	4600	4550	4810	4760
Ca	mg/L	NG	NG	693	747	747	803	805	853	854	904	906	958	960	1010	1010	1070	1070	1130	1120	1180	1180	1240	1230	1300	1290	1360	1350
Mg	mg/L	NG	NG	1320	1430	1430	1530	1540	1630	1630	1730	1730	1830	1830	1940	1940	2050	2040	2150	2140	2260	2250	2380	2350	2490	2460	2600	2580
K	mg/L	NG	NG	82	88	88	94	94	100	100	105	106	111	112	118	118	124	124	130	130	137	136	143	142	150	149	157	155
Na	mg/L	NG	NG	10600	11500	11500	12300	12300	13100	13100	13900	13900	14700	14700	15500	15500	16400	16400	17300	17200	18100	18000	19000	18900	19900	19700	20800	20700
Cl	mg/L	NG	NG	19800	21300	21400	22900	23000	24400	24400	25800	25900	27400	27400	29000	29000	30600	30600	32200	32000	33900	33600	35500	35200	37200	36800	38900	38500
F	mg/L	NG	NG	3.5	3.8	3.8	4.1	4.1	4.3	4.3	4.6	4.6	4.8	4.8	5.1	5.1	5.4	5.4	5.6	5.6	5.9	5.9	6.2	6.1	6.5	6.4	6.8	6.7
SO_4	mg/L	318	520	556	598	598	642	644	681	682	722	723	764	765	808	808	852	852	897	892	942	935	988	979	1030	1020	1080	1070
N	mg N/L	NG	NG	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.07	0.07	0.07	0.07	0.07	0.07	0.08	0.08	0.08	0.08	0.08	0.08	0.09	0.09	0.09	0.09	0.1	0.1
Al	mg/L	0.055	0.48	0.7	0.7	0.7	0.8	0.8	0.8	0.8	0.9	0.9	0.9	0.9	0.9	0.9	1	1	1	1	1.1	1.1	1.1	1.1	1.2	1.2	1.2	1.2
Ag	mg/L	0.001	0.39	0.005	0.005	0.005	0.006	0.006	0.006	0.006	0.006	0.006	0.007	0.007	0.007	0.007	0.007	0.007	0.008	0.008	0.008	0.008	0.009	0.009	0.009	0.009	0.009	0.009
As	mg/L	0.013	0.013	0.19	0.2	0.2	0.21	0.21	0.22	0.22	0.23	0.23	0.25	0.25	0.26	0.26	0.27	0.27	0.29	0.28	0.3	0.3	0.31	0.31	0.33	0.32	0.34	0.34
B	mg/L	NG	NG	3.3	3.6	3.6	3.8	3.8	4.1	4.1	4.3	4.3	4.6	4.6	4.8	4.8	5.1	5.1	5.4	5.3	5.6	5.6	5.9	5.8	6.2	6.1	6.5	6.4
Ba	mg/L	NG	NG	2.9	3.2	3.2	3.4	3.4	3.6	3.6	3.8	3.9	4.1	4.1	4.3	4.3	4.5	4.5	4.8	4.8	5	5	5.3	5.2	5.5	5.5	5.8	5.7
Be	mg/L	NG	NG	0.007	0.007	0.007	0.008	0.008	0.008	0.008	0.009	0.009	0.009	0.009	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Cd	mg/L	NG	NG	0.004	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.007	0.007	0.007	0.007	0.007	0.007	0.008	0.008	0.008	0.008
Co	mg/L	NG	NG	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04
Cu	mg/L	NG	NG	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Cr	mg/L	NG	NG	0.007	0.007	0.007	0.008	0.008	0.008	0.008	0.009	0.009	0.009	0.009	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Fe	mg/L	0.7	16	4.1	4.4	4.4	4.7	4.7	5	5	5.3	5.3	5.6	5.6	5.9	5.9	6.2	6.2	6.6	6.5	6.9	6.8	7.2	7.2	7.6	7.5	7.9	7.8
Hg	mg/L	0.0006	0.0006	0.0005	0.0005	0.0005	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007	0.0008	0.0008	0.0008	0.0008	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009
Li	mg/L	NG	NG	1.2	1.3	1.3	1.4	1.4	1.5	1.5	1.6	1.6	1.7	1.7	1.8	1.8	1.9	1.9	2	2	2.1	2.1	2.2	2.2	2.3	2.3	2.4	2.4
Mn	mg/L	NG	NG	1	1.1	1.1	1.1	1.1	1.2	1.2	1.3	1.3	1.4	1.4	1.4	1.4	1.5	1.5	1.6	1.6	1.7	1.7	1.8	1.7	1.8	1.8	1.9	1.9
Mo	mg/L	0.034	0.034	0.08	0.09	0.09	0.09	0.09	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Ni	mg/L	NG	NG	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.06	0.07	0.07	0.07	0.07	0.07	0.07	0.08	0.08	0.08	0.08	0.09	0.09
P	mg/L	NG	NG	7	7.5	7.5	8	8	8.5	8.5	8.9	9	9.4	9.5	9.9	10	11	11	11	11	12	11	12	12	13	13	13	13
Pb	mg/L	NG	NG	0.007	0.007	0.007	0.008	0.008	0.008	0.008	0.009	0.009	0.009	0.009	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Sb	mg/L	0.009	0.009	0.011	0.012	0.012	0.013	0.013	0.013	0.013	0.014	0.014	0.015	0.015	0.016	0.016	0.016	0.016	0.017	0.017	0.018	0.018	0.019	0.019	0.02	0.02	0.021	0.02
Se	mg/L	0.011	0.02	0.07	0.075	0.075	0.08	0.081	0.085	0.085	0.09	0.09	0.095	0.095	0.1	0.1	0.11	0.11	0.11	0.11	0.12	0.12	0.12	0.12	0.13	0.13	0.13	0.13
Si	mg/L	NG	NG	46	50	50	54	54	57	57	60	61	64	64	68	68	72	71	75	75	79	79	83	82	87	86	91	90
Sn	mg/L	NG	NG	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.07	0.07	0.07	0.07	0.07	0.07	0.08	0.08	0.08	0.08
Sr	mg/L	NG	NG	23	25	25	27	27	29	29	31	31	32	32	34	34	36	36	38	38	40	40	42	42	44	44	46	46
Tl	mg/L	NG	NG	0.005	0.005	0.005	0.006	0.006	0.006	0.006	0.006	0.006	0.007	0.007	0.007	0.007	0.007	0.007	0.008	0.008	0.008	0.008	0.009	0.009	0.009	0.009	0.009	0.009
U	mg/L	NG	NG	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04
V	mg/L	NG	NG	0.07	0.07	0.07	0.08	0.08	0.08	0.08	0.09	0.09	0.09	0.09	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Zn	mg/L	NG	NG	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3

Table B.29 South Marshmead residual void lake water quality – with geochemical controls (Part 1 of 2)

Parameter	Unit	Lower TV	Upper TV	2100	2110	2120	2130	2140	2150	2160	2170	2180	2190	2200	2210	2220	2230	2240	2250	2260	2270	2280	2290	2300	2310	2320	2330	2340	2350
pH	pH Units	6.5	8.5	8.4	8.4	8.3	8.3	8.3	8.3	8.3	8.2	8.2	8.2	8.2	8.2	8.2	8.2	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8	8	8	8
pe	pe units	NG	NG	5.9	5.5	5.3	5.1	5.2	5.2	5.3	5.3	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.3	5.4	5.3	5.4	5.3
TDS	mg/L	4992	10599	1150	5463	6177	7237	8007	9404	10470	12017	13047	14651	15662	17319	18265	19934	20709	22418	23121	24959	25681	27634	28342	30377	31052	33170	33818	36020
Alkalinity	mg $CaCO_3$/L	NG	NG	85	87	85	83	82	80	79	78	77	76	76	75	75	74	74	74	74	73	73	73	73	73	73	72	72	72
Ca	mg/L	NG	NG	15	31	35	41	45	52	58	66	72	80	85	94	99	108	112	122	125	135	139	149	153	164	168	179	183	195
Mg	mg/L	NG	NG	42.8	196	222	258	283	330	365	417	451	505	538	594	626	682	708	765	789	851	875	942	965	1034	1057	1129	1151	1225
K	mg/L	NG	NG	4.3	13	14	16	18	21	23	26	29	32	34	38	40	44	45	49	50	54	56	60	62	66	67	72	73	78
Na	mg/L	NG	NG	360	1762	1993	2338	2590	3046	3394	3899	4236	4759	5089	5630	5939	6482	6736	7292	7522	8120	8356	8992	9223	9886	10106	10799	11012	11732
Cl	mg/L	NG	NG	650.1	3297	3738	4390	4861	5719	6370	7320	7951	8934	9553	10569	11149	12171	12647	13695	14125	15252	15694	16892	17326	18573	18987	20291	20690	22046
F	mg/L	NG	NG	0.2	0.6	0.6	0.7	0.8	0.9	1	1.1	1.2	1.4	1.5	1.6	1.7	1.9	1.9	2.1	2.2	2.3	2.4	2.6	2.6	2.8	2.9	3.1	3.1	3.3
SO_4	mg/L	318	520	23	90	100	116	129	152	169	194	211	237	254	280	296	322	335	362	374	403	415	446	457	490	501	534	545	580
N	mg N/L	NG	NG	0.003	0.008	0.009	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.05	0.05
Al	mg/L	0.055	0.48	0.06	0.09	0.09	0.09	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4
Ag	mg/L	0.001	0.39	0.0003	0.0008	0.0008	0.0009	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.004	0.004
As	mg/L	0.013	0.013	0.012	0.0078	0.0068	0.0066	0.0083	0.0097	0.012	0.014	0.016	0.018	0.02	0.022	0.024	0.026	0.028	0.029	0.031	0.033	0.035	0.037	0.039	0.042	0.044	0.047	0.049	0.052
B	mg/L	NG	NG	0.1	0.5	0.6	0.7	0.8	0.9	1	1.2	1.3	1.4	1.5	1.7	1.8	1.9	2	2.2	2.2	2.4	2.5	2.7	2.7	2.9	3	3.2	3.3	3.5
Ba	mg/L	NG	NG	0.1	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.09	0.09	0.09	0.09	0.08	0.08	0.08	0.08	0.08	0.07	0.07
Be	mg/L	NG	NG	0.00005	0.00004	0.00005	0.00004	0.00005	0.00005	0.00006	0.00005	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006	0.00007	0.00006	0.00007	0.00006	0.00007	0.00006	0.00007	0.00006	0.00007	0.00007
Cd	mg/L	NG	NG	0.0004	0.0006	0.0005	0.0006	0.0006	0.0007	0.0008	0.0009	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.003
Co	mg/L	NG	NG	0.0009	0.003	0.003	0.004	0.004	0.005	0.005	0.006	0.007	0.007	0.008	0.009	0.009	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02
Cu	mg/L	NG	NG	0.0005	0.001	0.001	0.002	0.002	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.005	0.005	0.005	0.006	0.006	0.006	0.007	0.007	0.008
Cr	mg/L	NG	NG	0.0003	0.00008	0.00007	0.00006	0.00008	0.00008	0.0001	0.00009	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Fe	mg/L	0.7	16	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006
Hg	mg/L	0.0006	0.0006	0.00003	0.00008	0.00008	0.00009	0.0001	0.0001	0.0001	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004
Li	mg/L	NG	NG	0.04	0.2	0.2	0.3	0.3	0.4	0.4	0.5	0.5	0.6	0.6	0.7	0.7	0.8	0.8	0.8	0.9	0.9	1	1	1.1	1.1	1.2	1.3	1.3	1.4
Mn	mg/L	NG	NG	0.03	0.2	0.2	0.2	0.2	0.3	0.3	0.4	0.4	0.4	0.5	0.5	0.6	0.6	0.6	0.7	0.7	0.8	0.8	0.8	0.9	0.9	0.9	1	1	1.1
Mo	mg/L	0.034	0.034	0.007	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05
Ni	mg/L	NG	NG	0.002	0.007	0.008	0.009	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.05
P	mg/L	NG	NG	0.5	1	1	1.1	1.3	1.5	1.7	1.9	2.1	2.3	2.5	2.8	2.9	3.2	3.3	3.5	3.6	3.9	4	4.3	4.4	4.7	4.8	5.1	5.2	5.5
Pb	mg/L	NG	NG	0.00009	0.00006	0.000057	0.00005	0.00007	0.00007	0.00009	0.00009	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0003	0.0003	0.0003	0.0004	0.0004	0.0005
Sb	mg/L	0.009	0.009	0.0009	0.0015	0.0015	0.0017	0.0019	0.0022	0.0025	0.0028	0.0031	0.0034	0.0037	0.004	0.0042	0.0046	0.0048	0.0051	0.0053	0.0056	0.0058	0.0062	0.0063	0.0067	0.0069	0.0073	0.0075	0.0079
Se	mg/L	0.011	0.02	0.0051	0.01	0.01	0.012	0.013	0.015	0.017	0.019	0.021	0.024	0.025	0.028	0.03	0.032	0.033	0.036	0.037	0.039	0.041	0.043	0.045	0.047	0.049	0.052	0.053	0.056
Si	mg/L	NG	NG	1	7.7	8.8	10	11	13	15	17	19	21	22	25	26	29	30	32	33	36	37	40	41	44	44	44	44	43
Sn	mg/L	NG	NG	0.004	0.006	0.005	0.006	0.0064	0.0073	0.0084	0.0095	0.01	0.012	0.013	0.014	0.014	0.016	0.016	0.017	0.018	0.019	0.019	0.021	0.021	0.022	0.023	0.024	0.025	0.026
Sr	mg/L	NG	NG	0.78	3.9	4.4	5.2	5.7	6.7	7.5	8.6	9.4	11	11	12	13	14	15	16	17	18	18	20	20	22	22	24	24	26
Tl	mg/L	NG	NG	0.0003	0.0008	0.0008	0.0009	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.004	0.004
U	mg/L	NG	NG	0.0009	0.003	0.003	0.004	0.004	0.005	0.005	0.006	0.007	0.008	0.008	0.009	0.009	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02
V	mg/L	NG	NG	0.004	0.004	0.003	0.003	0.004	0.005	0.005	0.006	0.007	0.008	0.009	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Zn	mg/L	NG	NG	0.006	0.02	0.03	0.03	0.04	0.04	0.05	0.05	0.06	0.06	0.07	0.08	0.08	0.09	0.09	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2

Table B.30 South Marshmead residual void lake water quality – with geochemical controls (Part 2 of 2)

Parameter	Unit	Lower TV	Upper TV	2360	2370	2380	2390	2400	2410	2420	2430	2440	2450	2460	2470	2480	2490	2500	2510	2520	2530	2540	2550	2560	2570	2580	2590	2599
pH	pH Units	6.5	8.5	8	8	8	8	8	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8
pe	pe units	NG	NG	5.3	5.2	5.3	5.2	5.2	5.1	5.2	5.1	5.2	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.2	5.2	5.2	5.2	5.2
TDS	mg/L	4992	10599	36632	38910	39471	41825	42438	44547	45156	47357	47958	50234	50804	53147	53678	56080	56570	59017	59318	61976	62146	64961	65055	67964	67977	70969	70972
Alkalinity	mg $CaCO_3$/L	NG	NG	72	72	72	72	72	72	72	72	73	73	73	73	73	74	74	75	75	75	75	76	76	77	77	78	78
Ca	mg/L	NG	NG	198	210	213	226	229	241	244	256	259	272	275	288	291	304	306	320	321	336	337	352	353	368	369	385	385
Mg	mg/L	NG	NG	1246	1323	1342	1422	1443	1515	1535	1610	1630	1708	1727	1807	1824	1906	1923	2006	2016	2106	2112	2208	2211	2310	2310	2412	2412
K	mg/L	NG	NG	79	84	85	90	91	96	97	102	103	108	109	114	115	121	122	127	127	133	133	139	140	146	146	152	152
Na	mg/L	NG	NG	11933	12679	12862	13633	13833	14524	14723	15443	15640	16385	16572	17338	17512	18298	18459	19259	19358	20228	20283	21204	21235	22187	22191	23170	23171
Cl	mg/L	NG	NG	22422	23825	24170	25620	25997	27296	27671	29025	29395	30797	31147	32589	32916	34395	34697	36203	36388	38024	38128	39861	39919	41710	41717	43559	43561
F	mg/L	NG	NG	3.4	3.6	3.6	3.8	3.9	4.1	4.1	4.3	4.4	4.6	4.7	4.9	4.9	5.1	5.2	5.4	5.4	5.7	5.7	5.9	5.9	6.2	6.2	6.5	6.5
SO_4	mg/L	318	520	590	627	636	674	683	717	727	762	772	809	818	856	864	903	911	950	955	997	1000	1045	1047	1094	1094	1142	1142
N	mg N/L	NG	NG	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.06	0.07	0.07	0.07	0.07	0.07	0.07	0.08	0.08	0.08	0.08	0.09	0.09	0.09	0.09	0.09	0.09
Al	mg/L	0.055	0.48	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.6	0.7	0.7	0.7	0.7	0.7	0.7	0.8	0.8	0.8	0.8
Ag	mg/L	0.001	0.39	0.005	0.005	0.005	0.005	0.005	0.005	0.006	0.006	0.006	0.006	0.006	0.007	0.007	0.007	0.007	0.007	0.007	0.008	0.008	0.008	0.008	0.008	0.008	0.009	0.009
As	mg/L	0.013	0.013	0.054	0.057	0.059	0.062	0.064	0.068	0.07	0.073	0.076	0.079	0.082	0.086	0.088	0.092	0.094	0.098	0.1	0.1	0.11	0.11	0.11	0.12	0.12	0.12	0.13
B	mg/L	NG	NG	3.5	3.8	3.8	4	4.1	4.3	4.4	4.6	4.6	4.9	4.9	5.1	5.2	5.4	5.5	5.7	5.7	6	6	6.3	6.3	6.6	6.6	6.9	6.9
Ba	mg/L	NG	NG	0.07	0.07	0.07	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.04	0.04
Be	mg/L	NG	NG	0.00007	0.00007	0.00008	0.00007	0.00008	0.00007	0.00008	0.00007	0.00008	0.00007	0.00008	0.00008	0.00008	0.00008	0.00009	0.00008	0.00009	0.00008	0.00009	0.00008	0.00009	0.00009	0.0001	0.00009	0.0001
Cd	mg/L	NG	NG	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.005	0.005	0.005	0.005	0.005	0.005
Co	mg/L	NG	NG	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04
Cu	mg/L	NG	NG	0.008	0.009	0.009	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Cr	mg/L	NG	NG	0.0001	0.0001	0.0002	0.0001	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0003	0.0003	0.0003	0.0003	0.0003
Fe	mg/L	0.7	16	0.00006	0.00006	0.00006	0.00006	0.00006	0.00007	0.00007	0.00007	0.00007	0.00007	0.00007	0.00007	0.00007	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00009	0.00009	0.00009	0.00009	0.0001	0.0001
Hg	mg/L	0.0006	0.0006	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0006	0.0006	0.0006	0.0006	0.0006	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0009	0.0009
Li	mg/L	NG	NG	1.4	1.5	1.5	1.6	1.6	1.7	1.7	1.8	1.8	1.9	1.9	2	2	2.1	2.1	2.2	2.2	2.3	2.4	2.5	2.5	2.6	2.6	2.7	2.7
Mn	mg/L	NG	NG	1.1	1.2	1.2	1.3	1.3	1.4	1.4	1.4	1.5	1.5	1.5	1.6	1.6	1.7	1.7	1.8	1.8	1.9	1.9	2	2	2.1	2.1	2.2	2.2
Mo	mg/L	0.034	0.034	0.05	0.06	0.06	0.06	0.06	0.06	0.06	0.07	0.07	0.07	0.07	0.07	0.08	0.08	0.08	0.08	0.08	0.09	0.09	0.09	0.09	0.09	0.09	0.1	0.1
Ni	mg/L	NG	NG	0.05	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.06	0.07	0.07	0.07	0.07	0.08	0.08	0.08	0.08	0.08	0.08	0.09	0.09	0.09	0.09
P	mg/L	NG	NG	5.6	5.9	6	6.4	6.4	6.7	6.8	7.2	7.3	7.6	7.7	8	8.1	8.4	8.5	8.9	8.9	9.3	9.3	9.7	9.7	10	10	11	11
Pb	mg/L	NG	NG	0.0005	0.0006	0.0007	0.0008	0.0009	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.004
Sb	mg/L	0.009	0.009	0.008	0.0085	0.0086	0.0091	0.0092	0.0096	0.0098	0.01	0.01	0.011	0.011	0.011	0.012	0.012	0.012	0.013	0.013	0.013	0.013	0.014	0.014	0.014	0.014	0.015	0.015
Se	mg/L	0.011	0.02	0.057	0.06	0.061	0.064	0.065	0.068	0.069	0.073	0.074	0.077	0.078	0.081	0.082	0.086	0.086	0.09	0.09	0.094	0.095	0.099	0.099	0.1	0.1	0.11	0.11
Si	mg/L	NG	NG	43	42	42	42	42	41	41	40	40	40	40	39	39	38	38	38	38	37	37	37	37	36	36	35	35
Sn	mg/L	NG	NG	0.027	0.028	0.028	0.03	0.03	0.032	0.032	0.034	0.034	0.035	0.036	0.037	0.038	0.039	0.04	0.041	0.041	0.043	0.043	0.045	0.045	0.047	0.047	0.049	0.049
Sr	mg/L	NG	NG	26	28	28	30	31	32	33	34	35	36	37	38	39	40	41	43	43	45	45	47	47	49	49	51	51
Tl	mg/L	NG	NG	0.005	0.005	0.005	0.005	0.005	0.005	0.006	0.006	0.006	0.006	0.006	0.007	0.007	0.007	0.007	0.007	0.007	0.008	0.008	0.008	0.008	0.008	0.008	0.009	0.009
U	mg/L	NG	NG	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04
V	mg/L	NG	NG	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06
Zn	mg/L	NG	NG	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3

DRAFT

Table B.31 South Marshmead residual void lake water quality – without geochemical controls (Part 1 of 2)

Parameter	Unit	Lower TV	Upper TV	2100	2110	2120	2130	2140	2150	2160	2170	2180	2190	2200	2210	2220	2230	2240	2250	2260	2270	2280	2290	2300	2310	2320	2330	2340	2350
pH	pH Units	6.5	8.5	8.3	7.7	7.7	7.6	7.6	7.6	7.6	7.6	7.6	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.4	7.4	7.4	7.4	7.4	7.4	7.4
pe	pe units	NG	NG	6	6.2	6.1	5.9	6	6	6.1	6.1	6.1	6.1	6.2	6.2	6.2	6.2	6.2	6.2	6.3	6.3	6.3	6.3	6.3	6.3	6.4	6.4	6.4	6.4
TDS	mg/L	4992	10599	1170	5760	6520	7640	8470	9960	11100	12800	13900	15600	16600	18400	19400	21200	22000	23800	24600	26600	27300	29400	30200	32300	33100	35300	36000	38400
Alkalinity	mg $CaCO_3$/L	NG	NG	105	398	441	513	569	668	746	856	931	1040	1120	1230	1300	1420	1480	1600	1650	1770	1830	1960	2010	2160	2200	2350	2400	2560
Ca	mg/L	NG	NG	23	115	131	154	170	200	223	256	278	313	335	370	390	426	443	480	495	534	550	592	607	651	665	711	725	772
Mg	mg/L	NG	NG	43	221	250	294	326	383	427	490	533	599	640	708	747	816	847	918	947	1020	1050	1130	1160	1250	1270	1360	1390	1480
K	mg/L	NG	NG	4.3	13	14	16	18	21	23	26	29	32	34	38	40	44	45	49	51	54	56	60	62	66	67	72	73	78
Na	mg/L	NG	NG	360	1760	1990	2340	2590	3050	3390	3900	4240	4760	5090	5630	5940	6480	6740	7290	7520	8120	8360	9000	9230	9890	10100	10800	11000	11700
Cl	mg/L	NG	NG	650	3300	3740	4390	4860	5720	6370	7320	7950	8940	9550	10600	11200	12200	12700	13700	14100	15300	15700	16900	17300	18600	19000	20300	20700	22100
F	mg/L	NG	NG	0.2	0.6	0.6	0.7	0.8	0.9	1	1.1	1.2	1.4	1.5	1.6	1.7	1.9	1.9	2.1	2.2	2.3	2.4	2.6	2.6	2.8	2.9	3.1	3.1	3.3
SO_4	mg/L	318	520	23	90	100	117	129	152	170	195	212	238	255	281	297	324	336	364	375	404	416	447	459	492	503	537	547	583
N	mg N/L	NG	NG	0.003	0.008	0.009	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.05	0.05
Al	mg/L	0.055	0.48	0.06	0.09	0.09	0.09	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4
Ag	mg/L	0.001	0.39	0.0003	0.0008	0.0008	0.0009	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.004	0.004
As	mg/L	0.013	0.013	0.017	0.024	0.023	0.024	0.027	0.031	0.036	0.041	0.045	0.05	0.054	0.058	0.062	0.067	0.069	0.074	0.076	0.081	0.083	0.088	0.091	0.096	0.098	0.1	0.11	0.11
B	mg/L	NG	NG	0.1	0.5	0.6	0.7	0.8	0.9	1	1.2	1.3	1.4	1.5	1.7	1.8	1.9	2	2.2	2.2	2.4	2.5	2.7	2.7	2.9	3	3.2	3.3	3.5
Ba	mg/L	NG	NG	0.1	0.5	0.6	0.7	0.7	0.8	0.9	1.1	1.2	1.3	1.4	1.6	1.7	1.8	1.9	2	2.1	2.3	2.3	2.5	2.6	2.8	2.8	3	3.1	3.3
Be	mg/L	NG	NG	0.0005	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.004	0.004	0.005	0.005	0.005	0.005	0.006
Cd	mg/L	NG	NG	0.0004	0.0006	0.0005	0.0006	0.0006	0.0007	0.0008	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.003
Co	mg/L	NG	NG	0.0009	0.003	0.003	0.004	0.004	0.005	0.005	0.006	0.007	0.008	0.008	0.009	0.009	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02
Cu	mg/L	NG	NG	0.0008	0.002	0.003	0.003	0.003	0.004	0.004	0.005	0.006	0.006	0.007	0.007	0.008	0.008	0.009	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02
Cr	mg/L	NG	NG	0.0005	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.004	0.004	0.005	0.005	0.005	0.005	0.006
Fe	mg/L	0.7	16	0.2	0.7	0.7	0.9	0.95	1.1	1.3	1.4	1.6	1.8	1.9	2.1	2.2	2.4	2.5	2.7	2.8	3	3.1	3.3	3.4	3.6	3.7	4	4	4.3
Hg	mg/L	0.0006	0.0006	0.00003	0.00008	0.00008	0.00009	0.0001	0.0001	0.0001	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004
Li	mg/L	NG	NG	0.04	0.2	0.2	0.3	0.3	0.4	0.4	0.5	0.5	0.6	0.6	0.7	0.7	0.8	0.8	0.8	0.9	0.9	1	1	1.1	1.2	1.2	1.3	1.3	1.4
Mn	mg/L	NG	NG	0.03	0.2	0.2	0.2	0.2	0.3	0.3	0.4	0.4	0.4	0.5	0.5	0.6	0.6	0.6	0.7	0.7	0.8	0.8	0.8	0.9	0.9	0.9	1	1	1.1
Mo	mg/L	0.034	0.034	0.007	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05
Ni	mg/L	NG	NG	0.002	0.007	0.008	0.009	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.05
P	mg/L	NG	NG	0.5	1	1	1.2	1.3	1.5	1.7	2	2.1	2.4	2.6	2.8	3	3.2	3.3	3.6	3.7	4	4.1	4.4	4.5	4.8	4.9	5.2	5.3	5.6
Pb	mg/L	NG	NG	0.0005	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.004	0.004	0.005	0.005	0.005	0.005	0.006
Sb	mg/L	0.009	0.009	0.0009	0.0015	0.0015	0.0017	0.0019	0.0022	0.0025	0.0028	0.0031	0.0034	0.0037	0.004	0.0042	0.0046	0.0048	0.0051	0.0053	0.0056	0.0058	0.0062	0.0063	0.0067	0.0069	0.0073	0.0075	0.0079
Se	mg/L	0.011	0.02	0.0051	0.01	0.011	0.012	0.013	0.015	0.017	0.02	0.021	0.024	0.026	0.028	0.03	0.032	0.033	0.036	0.037	0.04	0.041	0.044	0.045	0.048	0.049	0.052	0.053	0.056
Si	mg/L	NG	NG	1	7.7	8.8	10	11	13	15	17	19	21	22	25	26	29	30	32	33	36	37	40	41	44	45	48	49	52
Sn	mg/L	NG	NG	0.004	0.006	0.005	0.006	0.006	0.007	0.008	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03
Sr	mg/L	NG	NG	0.78	3.9	4.4	5.2	5.7	6.7	7.5	8.6	9.4	11	11	12	13	14	15	16	17	18	19	20	20	22	22	24	24	26
Tl	mg/L	NG	NG	0.0003	0.0008	0.0008	0.0009	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.004	0.004
U	mg/L	NG	NG	0.0009	0.003	0.003	0.004	0.004	0.005	0.005	0.006	0.007	0.008	0.008	0.009	0.009	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02
V	mg/L	NG	NG	0.005	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.06
Zn	mg/L	NG	NG	0.007	0.03	0.03	0.03	0.04	0.04	0.05	0.06	0.06	0.07	0.07	0.08	0.09	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2

Table B.32 South Marshmead residual void lake water quality – without geochemical controls (Part 2 of 2)

Parameter	Unit	Lower TV	Upper TV	2360	2370	2380	2390	2400	2410	2420	2430	2440	2450	2460	2470	2480	2490	2500	2510	2520	2530	2540	2550	2560	2570	2580	2590	2599
pH	pH Units	6.5	8.5	7.4	7.4	7.4	7.4	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2
pe	pe units	NG	NG	6.5	6.5	6.5	6.5	6.5	6.6	6.6	6.6	6.6	6.7	6.7	6.7	6.7	6.8	6.8	6.8	6.8	6.8	6.8	6.9	6.9	6.9	6.9	6.9	6.9
TDS	mg/L	4992	10599	39000	41500	42100	44600	45300	47500	48200	50500	51200	53600	54200	56700	57300	59900	60400	63000	63400	66200	66400	69400	69500	72600	72600	75800	75900
Alkalinity	mg $CaCO_3$/L	NG	NG	2600	2760	2800	2970	3010	3160	3200	3360	3400	3560	3600	3770	3810	3970	4010	4180	4200	4390	4400	4600	4610	4820	4820	5030	5030
Ca	mg/L	NG	NG	785	835	847	898	911	956	969	1020	1030	1080	1090	1140	1150	1210	1220	1270	1280	1330	1340	1400	1400	1460	1460	1530	1530
Mg	mg/L	NG	NG	1500	1600	1620	1720	1740	1830	1860	1950	1970	2070	2090	2190	2210	2310	2330	2430	2440	2550	2560	2670	2680	2800	2800	2920	2920
K	mg/L	NG	NG	79	84	85	90	92	96	97	102	103	108	109	114	116	121	122	127	128	133	134	140	140	146	146	152	152
Na	mg/L	NG	NG	11900	12700	12900	13600	13800	14500	14700	15500	15700	16400	16600	17400	17500	18300	18500	19300	19400	20200	20300	21200	21300	22200	22200	23200	23200
Cl	mg/L	NG	NG	22400	23800	24200	25600	26000	27300	27700	29000	29400	30800	31200	32600	32900	34400	34700	36200	36400	38100	38200	39900	40000	41800	41800	43600	43600
F	mg/L	NG	NG	3.4	3.6	3.6	3.9	3.9	4.1	4.2	4.4	4.4	4.6	4.7	4.9	4.9	5.1	5.2	5.4	5.4	5.7	5.7	5.9	6	6.2	6.2	6.5	6.5
SO_4	mg/L	318	520	593	629	639	677	687	721	731	766	776	812	822	860	868	907	915	954	959	1000	1010	1050	1050	1100	1100	1150	1150
N	mg N/L	NG	NG	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.06	0.07	0.07	0.07	0.07	0.07	0.07	0.08	0.08	0.08	0.08	0.09	0.09	0.09	0.09	0.09	0.09
Al	mg/L	0.055	0.48	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.6	0.7	0.7	0.7	0.7	0.7	0.7	0.8	0.8	0.8	0.8
Ag	mg/L	0.001	0.39	0.005	0.005	0.005	0.005	0.005	0.005	0.006	0.006	0.006	0.006	0.006	0.007	0.007	0.007	0.007	0.007	0.007	0.008	0.008	0.008	0.008	0.008	0.008	0.009	0.009
As	mg/L	0.013	0.013	0.11	0.12	0.12	0.13	0.13	0.14	0.14	0.14	0.15	0.15	0.15	0.16	0.16	0.17	0.17	0.18	0.18	0.19	0.19	0.19	0.19	0.2	0.2	0.21	0.21
B	mg/L	NG	NG	3.5	3.8	3.8	4.1	4.1	4.3	4.4	4.6	4.6	4.9	4.9	5.1	5.2	5.4	5.5	5.7	5.7	6	6	6.3	6.3	6.6	6.6	6.9	6.9
Ba	mg/L	NG	NG	3.3	3.5	3.6	3.8	3.9	4	4.1	4.3	4.4	4.6	4.6	4.8	4.9	5.1	5.1	5.4	5.4	5.6	5.7	5.9	5.9	6.2	6.2	6.5	6.5
Be	mg/L	NG	NG	0.006	0.006	0.006	0.006	0.007	0.007	0.007	0.007	0.007	0.008	0.008	0.008	0.008	0.009	0.009	0.009	0.009	0.009	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Cd	mg/L	NG	NG	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.005	0.005	0.005	0.005	0.005	0.005
Co	mg/L	NG	NG	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04
Cu	mg/L	NG	NG	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Cr	mg/L	NG	NG	0.006	0.006	0.006	0.006	0.007	0.007	0.007	0.007	0.007	0.008	0.008	0.008	0.008	0.009	0.009	0.009	0.009	0.009	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Fe	mg/L	0.7	16	4.4	4.7	4.7	5	5.1	5.3	5.4	5.7	5.7	6	6.1	6.4	6.4	6.7	6.8	7.1	7.1	7.4	7.4	7.8	7.8	8.1	8.1	8.5	8.5
Hg	mg/L	0.0006	0.0006	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0006	0.0006	0.0006	0.0006	0.0006	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0009	0.0009
Li	mg/L	NG	NG	1.4	1.5	1.5	1.6	1.6	1.7	1.7	1.8	1.8	1.9	1.9	2	2	2.1	2.1	2.2	2.3	2.4	2.4	2.5	2.5	2.6	2.6	2.7	2.7
Mn	mg/L	NG	NG	1.1	1.2	1.2	1.3	1.3	1.4	1.4	1.4	1.5	1.5	1.5	1.6	1.6	1.7	1.7	1.8	1.8	1.9	1.9	2	2	2.1	2.1	2.2	2.2
Mo	mg/L	0.034	0.034	0.05	0.06	0.06	0.06	0.06	0.06	0.06	0.07	0.07	0.07	0.07	0.08	0.08	0.08	0.08	0.08	0.08	0.09	0.09	0.09	0.09	0.09	0.09	0.1	0.1
Ni	mg/L	NG	NG	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.07	0.07	0.07	0.07	0.07	0.07	0.08	0.08	0.08	0.08	0.08	0.09	0.09	0.09	0.09	0.09
P	mg/L	NG	NG	5.7	6	6.1	6.5	6.6	6.9	7	7.3	7.4	7.7	7.8	8.2	8.2	8.6	8.7	9	9.1	9.5	9.5	9.9	9.9	10	10	11	11
Pb	mg/L	NG	NG	0.006	0.006	0.006	0.006	0.007	0.007	0.007	0.007	0.007	0.008	0.008	0.008	0.008	0.009	0.009	0.009	0.009	0.009	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Sb	mg/L	0.009	0.009	0.008	0.0085	0.0086	0.0091	0.0092	0.0096	0.0098	0.01	0.01	0.011	0.011	0.011	0.012	0.012	0.012	0.013	0.013	0.013	0.013	0.014	0.014	0.014	0.015	0.015	0.015
Se	mg/L	0.011	0.02	0.057	0.061	0.061	0.065	0.066	0.069	0.07	0.073	0.074	0.077	0.078	0.082	0.083	0.086	0.087	0.091	0.091	0.095	0.095	0.099	0.1	0.1	0.1	0.11	0.11
Si	mg/L	NG	NG	53	56	57	60	61	64	65	68	69	72	73	77	77	81	81	85	85	89	90	94	94	98	98	102	102
Sn	mg/L	NG	NG	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.05
Sr	mg/L	NG	NG	26	28	28	30	31	32	33	34	35	36	37	38	39	41	41	43	43	45	45	47	47	49	49	51	51
Tl	mg/L	NG	NG	0.005	0.005	0.005	0.005	0.005	0.005	0.006	0.006	0.006	0.006	0.006	0.007	0.007	0.007	0.007	0.007	0.007	0.008	0.008	0.008	0.008	0.008	0.008	0.009	0.009
U	mg/L	NG	NG	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04
V	mg/L	NG	NG	0.06	0.06	0.06	0.06	0.07	0.07	0.07	0.07	0.07	0.08	0.08	0.08	0.08	0.09	0.09	0.09	0.09	0.09	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Zn	mg/L	NG	NG	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3

DRAFT

Table B.33 Kennedy West residual void lake water quality – with geochemical controls (Part 1 of 2)

Parameter	Unit	Lower TV	Upper TV	2094	2100	2110	2120	2130	2140	2150	2160	2170	2180	2190	2200	2210	2220	2230	2240	2250	2260	2270	2280	2290	2300	2310	2320	2330	2340
pH	pH Units	6.5	8.5	8.4	8.4	8.4	8.3	8.3	8.3	8.2	8.2	8.2	8.2	8.1	8.1	8.1	8.1	8.1	8.1	8	8	8	8	8	8	7.9	7.9	7.9	7.9
pe	pe units	NG	NG	5.6	5.7	5.7	5.7	5.7	5.7	5.8	5.8	5.8	5.9	5.9	5.9	6	6	6	6.1	6.1	6.1	6.2	6.2	6.2	6.2	6.3	6.3	6.3	6.3
TDS	mg/L	4992	10599	1990	3743	5773	6810	8916	10210	12660	13960	16689	17890	20913	22009	25325	26252	29870	30439	34563	34771	39391	39279	44362	43948	49462	48680	54751	53629
Alkalinity	mg $CaCO_3$/L	NG	NG	87	94	88	86	83	82	80	79	78	78	77	78	77	78	78	78	78	79	79	79	80	81	82	82	84	84
Ca	mg/L	NG	NG	17	22	32	38	49	55	68	74	89	95	110	116	133	138	156	159	180	181	205	204	231	228	257	253	284	278
Mg	mg/L	NG	NG	78	136	203	236	306	347	428	469	558	596	695	729	837	866	984	1001	1136	1141	1291	1286	1451	1436	1615	1588	1785	1747
K	mg/L	NG	NG	4.9	9.9	14	17	22	25	31	34	40	44	51	54	62	65	73	75	85	86	98	98	110	110	124	122	137	135
Na	mg/L	NG	NG	628	1204	1869	2209	2897	3323	4124	4550	5443	5838	6828	7188	8274	8579	9764	9952	11310	11380	12900	12860	14536	14403	16217	15963	17961	17595
Cl	mg/L	NG	NG	1171	2236	3482	4118	5409	6202	7702	8495	10160	10900	12750	13416	15444	16010	18222	18568	21099	21226	24062	23993	27112	26858	30241	29760	33485	32796
F	mg/L	NG	NG	0.2	0.4	0.6	0.8	1	1.1	1.4	1.5	1.8	1.9	2.3	2.4	2.7	2.9	3.3	3.3	3.8	3.8	4.3	4.4	4.9	4.9	5.5	5.5	6.1	6
SO_4	mg/L	318	520	33	65	98	115	150	172	213	235	281	302	353	372	428	444	505	516	586	591	670	669	756	750	844	832	936	919
N	mg N/L	NG	NG	0.003	0.007	0.01	0.01	0.01	0.02	0.02	0.02	0.03	0.03	0.04	0.04	0.04	0.04	0.05	0.05	0.06	0.06	0.07	0.07	0.08	0.08	0.09	0.09	0.1	0.1
Al	mg/L	0.055	0.48	0.04	0.09	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.5	0.5	0.6	0.6	0.7	0.7	0.8	0.8	0.9	0.9	1	1	1.1	1.1
Ag	mg/L	0.001	0.39	0.0003	0.0006	0.0009	0.001	0.001	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.004	0.004	0.005	0.005	0.005	0.005	0.006	0.006	0.007	0.007	0.008	0.008	0.009	0.008
As	mg/L	0.013	0.013	0.0046	0.012	0.013	0.016	0.018	0.022	0.027	0.032	0.038	0.043	0.051	0.057	0.066	0.072	0.082	0.088	0.1	0.11	0.12	0.13	0.14	0.15	0.17	0.17	0.19	0.19
B	mg/L	NG	NG	0.2	0.4	0.6	0.7	0.9	1	1.3	1.4	1.7	1.8	2.1	2.2	2.6	2.7	3	3.1	3.5	3.5	4	4	4.5	4.5	5.1	5	5.6	5.5
Ba	mg/L	NG	NG	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.09	0.09	0.08	0.08	0.08	0.08	0.07	0.07	0.06	0.06	0.06	0.06	0.05	0.05	0.05	0.05
Be	mg/L	NG	NG	0.00004	0.00006	0.00006	0.00006	0.00006	0.00007	0.00006	0.00008	0.00007	0.00009	0.00008	0.0001	0.00009	0.0001	0.00009	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0002	0.0001	0.0002
Cd	mg/L	NG	NG	0.0003	0.0006	0.0008	0.0009	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.005	0.005	0.006	0.006	0.006	0.006	0.007	0.007
Co	mg/L	NG	NG	0.001	0.002	0.003	0.004	0.005	0.006	0.007	0.008	0.009	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03
Cu	mg/L	NG	NG	0.0006	0.001	0.002	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.005	0.005	0.006	0.006	0.007	0.007	0.008	0.008	0.009	0.009	0.01	0.01
Cr	mg/L	NG	NG	0.00009	0.0003	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0003	0.0003	0.0003	0.0003	0.0004	0.0004	0.0004	0.0004	0.0004	0.0005	0.0005	0.0005	0.0005	0.0006	0.0006	0.0006	0.0007
Fe	mg/L	0.7	16	0.00004	0.00004	0.00004	0.00004	0.00004	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006	0.00007	0.00007	0.00007	0.00007
Hg	mg/L	0.0006	0.0006	0.00003	0.00006	0.00009	0.0001	0.0001	0.0002	0.0002	0.0002	0.0002	0.0003	0.0003	0.0003	0.0004	0.0004	0.0005	0.0005	0.0005	0.0005	0.0006	0.0006	0.0007	0.0007	0.0008	0.0008	0.0009	0.0008
Li	mg/L	NG	NG	0.07	0.1	0.2	0.3	0.3	0.4	0.5	0.5	0.6	0.7	0.8	0.8	0.9	1	1.1	1.1	1.3	1.3	1.5	1.5	1.7	1.6	1.9	1.8	2.1	2
Mn	mg/L	NG	NG	0.06	0.1	0.2	0.2	0.3	0.3	0.4	0.4	0.5	0.5	0.6	0.7	0.8	0.8	0.9	0.9	1	1	1	1	1.3	1.3	1.5	1.5	1.7	1.6
Mo	mg/L	0.034	0.034	0.005	0.01	0.01	0.02	0.02	0.02	0.03	0.03	0.04	0.04	0.05	0.05	0.06	0.06	0.07	0.07	0.08	0.08	0.09	0.09	0.1	0.1	0.1	0.1	0.1	0.1
Ni	mg/L	NG	NG	0.003	0.005	0.008	0.009	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.04	0.04	0.05	0.05	0.05	0.05	0.06	0.06	0.07	0.06	0.07	0.07
P	mg/L	NG	NG	0.4	0.9	1.2	1.4	1.8	2.1	2.5	2.8	3.4	3.6	4.2	4.5	5.2	5.4	6.1	6.3	7.2	7.3	8.2	8.3	9.3	9.3	10	10	12	12
Pb	mg/L	NG	NG	0.00005	0.00009	0.00009	0.0001	0.00009	0.0001	0.0001	0.0002	0.0002	0.0002	0.0003	0.0003	0.0004	0.0005	0.0006	0.0007	0.0008	0.001	0.001	0.001	0.002	0.002	0.002	0.003	0.003	0.003
Sb	mg/L	0.009	0.009	0.00066	0.0015	0.002	0.0023	0.0028	0.0032	0.0039	0.0044	0.0052	0.0057	0.0066	0.007	0.008	0.0084	0.0096	0.0099	0.011	0.011	0.013	0.013	0.015	0.015	0.017	0.016	0.018	0.018
Se	mg/L	0.011	0.02	0.0042	0.0092	0.013	0.015	0.018	0.021	0.026	0.029	0.034	0.037	0.043	0.046	0.052	0.055	0.062	0.064	0.072	0.074	0.083	0.084	0.095	0.095	0.11	0.11	0.12	0.12
Si	mg/L	NG	NG	3	5.2	8.1	9.6	13	14	18	20	24	25	30	31	36	37	43	43	44	43	42	41	41	40	40	39	39	38
Sn	mg/L	NG	NG	0.003	0.006	0.008	0.009	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.05	0.05	0.06	0.06	0.06	0.06	0.07	0.07
Sr	mg/L	NG	NG	1.4	2.6	4.1	4.9	6.4	7.3	9.1	10	12	13	15	16	18	19	21	22	25	25	28	28	32	32	36	35	39	39
Tl	mg/L	NG	NG	0.0003	0.0006	0.0009	0.001	0.001	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.004	0.004	0.005	0.005	0.005	0.005	0.006	0.006	0.007	0.007	0.008	0.008	0.009	0.008
U	mg/L	NG	NG	0.001	0.002	0.003	0.004	0.005	0.006	0.007	0.008	0.009	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03
V	mg/L	NG	NG	0.002	0.004	0.005	0.006	0.007	0.009	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.04	0.04	0.04	0.05	0.05	0.05	0.06	0.06	0.07	0.07
Zn	mg/L	NG	NG	0.009	0.02	0.03	0.03	0.04	0.05	0.06	0.06	0.08	0.08	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3

Table B.34 Kennedy West residual void lake water quality – with geochemical controls (Part 2 of 2)

Parameter	Unit	Lower TV	Upper TV	2350	2360	2370	2380	2390	2400	2410	2420	2430	2440	2450	2460	2470	2480	2490	2500	2510	2520	2530	2540	2550	2560	2570	2580	2590	2599
pH	pH Units	6.5	8.5	7.8	7.9	7.8	7.8	7.8	7.8	7.7	7.8	7.7	7.7	7.7	7.7	7.7	7.7	7.6	7.6	7.6	7.6	7.6	7.6	7.5	7.6	7.5	7.6	7.5	7.5
pe	pe units	NG	NG	6.4	6.4	6.4	6.4	6.5	6.5	6.5	6.5	6.6	6.6	6.6	6.6	6.6	6.6	6.7	6.7	6.7	6.7	6.7	6.7	6.8	6.7	6.8	6.8	6.8	6.8
TDS	mg/L	4992	10599	60285	58766	66053	64068	72043	70153	76871	74270	81204	78276	85455	82231	89678	86195	93914	90191	98109	93425	102350	97017	106700	100950	111110	104920	115530	109620
Alkalinity	mg $CaCO_3$/L	NG	NG	87	86	89	88	90	89	92	91	94	92	96	94	98	96	101	98	103	100	106	102	110	105	113	108	117	112
Ca	mg/L	NG	NG	313	305	343	332	373	363	398	384	420	404	442	425	463	445	485	465	506	482	528	500	551	520	573	541	596	565
Mg	mg/L	NG	NG	1962	1911	2147	2080	2338	2274	2491	2404	2627	2531	2762	2655	2895	2781	3029	2907	3162	3009	3296	3122	3434	3247	3573	3372	3714	3522
K	mg/L	NG	NG	152	149	167	163	183	179	196	190	208	201	220	212	232	223	243	234	255	243	266	253	278	264	290	275	303	288
Na	mg/L	NG	NG	19785	19289	21688	21038	23664	23046	25258	24406	26690	25730	28096	27039	29493	28350	30893	29671	32280	30741	33683	31929	35120	33229	36578	34542	38039	36095
Cl	mg/L	NG	NG	36878	35946	40415	39197	44088	42927	47047	45450	49702	47906	52309	50332	54899	52763	57496	55214	60069	57197	62671	59400	65336	61810	68041	64246	70752	67129
F	mg/L	NG	NG	6.8	6.7	7.5	7.3	8.2	8	8.8	8.5	9.3	9	9.9	9.5	10	10	11	11	11	11	12	11	13	12	13	12	14	13
SO_4	mg/L	318	520	1033	1008	1134	1101	1239	1208	1324	1281	1400	1349	1470	1415	1540	1480	1611	1547	1680	1600	1751	1660	1823	1725	1897	1792	1971	1870
N	mg N/L	NG	NG	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Al	mg/L	0.055	0.48	1.3	1.2	1.3	1.2	1.1	1.1	1	1	0.9	0.9	0.9	0.8	0.8	0.8	0.7	0.7	0.7	0.7	0.6	0.6	0.6	0.6	0.5	0.5	0.5	0.5
Ag	mg/L	0.001	0.39	0.009	0.009	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
As	mg/L	0.013	0.013	0.22	0.22	0.25	0.25	0.28	0.28	0.31	0.31	0.34	0.33	0.36	0.36	0.39	0.38	0.42	0.41	0.45	0.43	0.48	0.46	0.5	0.48	0.53	0.51	0.56	0.54
B	mg/L	NG	NG	6.2	6	6.8	6.6	7.4	7.2	7.9	7.7	8.4	8.1	8.8	8.5	9.3	8.9	9.7	9.4	10	9.7	11	10	11	11	12	11	12	11
Ba	mg/L	NG	NG	0.05	0.05	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.03	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Be	mg/L	NG	NG	0.0001	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0003	0.0002	0.0003	0.0002	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003
Cd	mg/L	NG	NG	0.008	0.008	0.009	0.009	0.01	0.01	0.01	0.01	0.011	0.011	0.012	0.012	0.013	0.012	0.013	0.013	0.014	0.014	0.015	0.014	0.016	0.015	0.016	0.015	0.017	0.016
Co	mg/L	NG	NG	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.05	0.06	0.06	0.06	0.06	0.06	0.06	0.07	0.06
Cu	mg/L	NG	NG	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Cr	mg/L	NG	NG	0.0007	0.0008	0.0008	0.0009	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.003	0.003	0.004	0.004
Fe	mg/L	0.7	16	0.00008	0.00008	0.00008	0.00008	0.00009	0.00009	0.00009	0.00009	0.0001	0.00009	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0002	0.0001
Hg	mg/L	0.0006	0.0006	0.0009	0.0009	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.0015	0.0014	0.0015	0.0015	0.0016	0.0015	0.0017	0.0016	0.0018	0.0017	0.0018	0.0017	0.0019	0.0018
Li	mg/L	NG	NG	2.3	2.2	2.5	2.4	2.7	2.6	2.9	2.8	3	2.9	3.2	3.1	3.4	3.2	3.5	3.4	3.7	3.5	3.8	3.6	4	3.8	4.2	3.9	4.3	4.1
Mn	mg/L	NG	NG	1.8	1.8	2	1.9	2.2	2.1	2.3	2.2	2.5	2.4	2.6	2.5	2.7	2.6	2.8	2.7	3	2.8	3.1	2.9	3.2	3	3.4	3.2	3.5	3.3
Mo	mg/L	0.034	0.034	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Ni	mg/L	NG	NG	0.08	0.08	0.09	0.09	0.1	0.09	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.2	0.1
P	mg/L	NG	NG	13	13	14	14	16	15	17	17	18	18	19	19	20	20	21	21	22	21	23	22	25	23	26	24	27	25
Pb	mg/L	NG	NG	0.004	0.004	0.005	0.005	0.006	0.006	0.007	0.007	0.008	0.008	0.009	0.009	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.02	0.02
Sb	mg/L	0.009	0.009	0.021	0.02	0.023	0.022	0.025	0.025	0.027	0.026	0.029	0.028	0.031	0.03	0.032	0.031	0.034	0.033	0.036	0.034	0.038	0.036	0.039	0.038	0.041	0.039	0.043	0.041
Se	mg/L	0.011	0.02	0.13	0.13	0.15	0.14	0.16	0.16	0.17	0.17	0.18	0.18	0.19	0.19	0.21	0.2	0.22	0.21	0.23	0.22	0.24	0.23	0.25	0.24	0.26	0.25	0.27	0.26
Si	mg/L	NG	NG	38	37	36	36	35	35	34	34	33	33	33	32	32	31	31	31	30	30	30	29	29	28	28	28	28	27
Sn	mg/L	NG	NG	0.08	0.08	0.09	0.09	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.2	0.2	0.2	0.2
Sr	mg/L	NG	NG	43	42	48	46	52	51	56	54	58	54	56	52	54	51	53	49	51	48	50	46	49	45	48	44	47	43
Tl	mg/L	NG	NG	0.009	0.009	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
U	mg/L	NG	NG	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.05	0.06	0.06	0.06	0.06	0.06	0.06	0.07	0.06
V	mg/L	NG	NG	0.08	0.08	0.09	0.09	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Zn	mg/L	NG	NG	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.5	0.6	0.5

Table B.35 Kennedy West residual void lake water quality – without geochemical controls (Part 1 of 2)

Parameter	Unit	Lower TV	Upper TV	2094	2100	2110	2120	2130	2140	2150	2160	2170	2180	2190	2200	2210	2220	2230	2240	2250	2260	2270	2280	2290	2300	2310	2320	2330	2340
pH	pH Units	6.5	8.5	7.9	7.8	7.7	7.7	7.7	7.7	7.6	7.6	7.6	7.6	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4
pe	pe units	NG	NG	6.2	6.3	6.3	6.4	6.4	6.4	6.4	6.5	6.5	6.5	6.5	6.6	6.6	6.6	6.6	6.7	6.7	6.7	6.7	6.7	6.8	6.8	6.9	6.8	6.9	6.9
TDS	mg/L	4992	10599	2050	3929	6102	7212	9462	10853	13471	14863	17781	19069	22304	23480	27028	28025	31897	32510	36942	37173	42140	42028	47494	47058	52988	52156	58688	57490
Alkalinity	mg $CaCO_3$/L	NG	NG	146	288	435	511	663	762	942	1043	1245	1338	1563	1649	1897	1971	2242	2290	2601	2623	2972	2970	3355	3331	3750	3698	4160	4083
Ca	mg/L	NG	NG	41	78	122	144	189	217	269	297	355	381	446	469	540	560	637	649	738	742	842	839	948	939	1058	1041	1171	1147
Mg	mg/L	NG	NG	78	149	232	275	361	414	515	568	679	728	852	896	1032	1070	1218	1241	1410	1418	1608	1603	1812	1795	2021	1988	2238	2191
K	mg/L	NG	NG	4.9	9.9	14	17	22	25	31	34	41	44	51	54	62	65	73	75	85	86	98	98	110	110	124	122	137	135
Na	mg/L	NG	NG	628	1204	1869	2209	2897	3323	4125	4551	5444	5839	6829	7190	8276	8582	9768	9956	11310	11380	12910	12870	14545	14412	16229	15975	17975	17609
Cl	mg/L	NG	NG	1171	2236	3482	4118	5409	6203	7703	8496	10170	10900	12750	13420	15450	16015	18229	18576	21109	21237	24075	24006	27129	26875	30263	29782	33512	32822
F	mg/L	NG	NG	0.2	0.4	0.6	0.8	1	1.1	1.4	1.5	1.8	1.9	2.3	2.4	2.7	2.9	3.3	3.3	3.8	3.8	4.3	4.4	4.9	4.9	5.5	5.5	6.1	6
SO_4	mg/L	318	520	33	65	98	116	150	173	213	236	282	303	354	373	429	446	507	518	589	593	672	672	759	753	848	836	940	923
N	mg N/L	NG	NG	0.003	0.007	0.01	0.01	0.01	0.02	0.02	0.02	0.03	0.03	0.04	0.04	0.04	0.05	0.05	0.05	0.06	0.06	0.07	0.07	0.08	0.08	0.09	0.09	0.1	0.1
Al	mg/L	0.055	0.48	0.04	0.09	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.5	0.5	0.6	0.6	0.7	0.7	0.8	0.8	0.9	0.9	1	1	1.1	1.1
Ag	mg/L	0.001	0.39	0.0003	0.0006	0.0009	0.001	0.001	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.004	0.004	0.005	0.005	0.005	0.005	0.006	0.006	0.007	0.007	0.008	0.008	0.009	0.008
As	mg/L	0.013	0.013	0.01	0.03	0.03	0.04	0.04	0.05	0.06	0.07	0.08	0.09	0.11	0.11	0.13	0.14	0.15	0.16	0.18	0.18	0.21	0.21	0.24	0.24	0.27	0.27	0.3	0.3
B	mg/L	NG	NG	0.2	0.4	0.6	0.7	0.9	1	1.3	1.4	1.7	1.8	2.1	2.2	2.6	2.7	3	3.1	3.5	3.5	4	4	4.5	4.5	5.1	5	5.6	5.5
Ba	mg/L	NG	NG	0.2	0.3	0.5	0.6	0.8	0.9	1.1	1.3	1.5	1.6	1.9	2	2.3	2.4	2.7	2.8	3.1	3.2	3.6	3.6	4	4	4.5	4.4	5	4.9
Be	mg/L	NG	NG	0.0004	0.0009	0.001	0.001	0.002	0.002	0.003	0.003	0.003	0.004	0.004	0.005	0.005	0.005	0.006	0.006	0.007	0.007	0.008	0.008	0.009	0.009	0.01	0.01	0.01	0.01
Cd	mg/L	NG	NG	0.0003	0.0006	0.0008	0.0009	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.005	0.005	0.006	0.006	0.006	0.006	0.007	0.007
Co	mg/L	NG	NG	0.001	0.002	0.003	0.004	0.005	0.006	0.007	0.008	0.009	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.02	0.03	0.03	0.03	0.03
Cu	mg/L	NG	NG	0.0009	0.002	0.003	0.003	0.004	0.005	0.006	0.007	0.008	0.008	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03
Cr	mg/L	NG	NG	0.0004	0.0009	0.001	0.001	0.002	0.002	0.003	0.003	0.003	0.004	0.004	0.005	0.005	0.005	0.006	0.006	0.007	0.007	0.008	0.008	0.009	0.009	0.01	0.01	0.01	0.01
Fe	mg/L	0.7	16	0.2	0.5	0.7	0.8	1.1	1.3	1.6	1.7	2.1	2.2	2.6	2.7	3.1	3.2	3.7	3.8	4.3	4.3	4.9	4.9	5.5	5.5	6.2	6.1	6.8	6.7
Hg	mg/L	0.0006	0.0006	0.00003	0.00006	0.00009	0.0001	0.0001	0.0002	0.0002	0.0002	0.0002	0.0003	0.0003	0.0003	0.0004	0.0004	0.0005	0.0005	0.0005	0.0005	0.0006	0.0006	0.0007	0.0007	0.0008	0.0008	0.0009	0.0008
Li	mg/L	NG	NG	0.07	0.1	0.2	0.3	0.3	0.4	0.5	0.5	0.6	0.7	0.8	0.8	0.9	1	1.1	1.1	1.3	1.3	1.5	1.5	1.7	1.6	1.9	1.8	2.1	2
Mn	mg/L	NG	NG	0.06	0.1	0.2	0.2	0.3	0.3	0.4	0.4	0.5	0.5	0.6	0.7	0.8	0.8	0.9	0.9	1	1	1	1	1.3	1.3	1.5	1.5	1.7	1.6
Mo	mg/L	0.034	0.034	0.005	0.01	0.01	0.02	0.02	0.02	0.03	0.03	0.04	0.04	0.05	0.05	0.06	0.06	0.07	0.07	0.08	0.08	0.09	0.09	0.1	0.1	0.1	0.1	0.1	0.1
Ni	mg/L	NG	NG	0.003	0.005	0.008	0.009	0.012	0.01	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.06	0.06	0.07	0.07	0.07	0.07
P	mg/L	NG	NG	0.4	0.9	1.3	1.5	1.8	2.1	2.6	2.9	3.4	3.7	4.3	4.5	5.2	5.5	6.2	6.4	7.2	7.4	8.3	8.4	9.4	9.4	11	11	12	12
Pb	mg/L	NG	NG	0.0004	0.0009	0.001	0.001	0.002	0.002	0.003	0.003	0.003	0.004	0.004	0.005	0.005	0.005	0.006	0.006	0.007	0.007	0.008	0.008	0.009	0.009	0.01	0.01	0.01	0.01
Sb	mg/L	0.009	0.009	0.00066	0.0015	0.002	0.0023	0.0028	0.0032	0.0039	0.0044	0.0052	0.0057	0.0066	0.007	0.008	0.0084	0.0096	0.0099	0.011	0.011	0.013	0.013	0.015	0.015	0.017	0.016	0.018	0.018
Se	mg/L	0.011	0.02	0.0042	0.0092	0.013	0.015	0.018	0.021	0.026	0.029	0.034	0.037	0.043	0.046	0.052	0.055	0.062	0.064	0.073	0.074	0.084	0.084	0.095	0.095	0.11	0.11	0.12	0.12
Si	mg/L	NG	NG	3	5.2	8.1	9.6	13	14	18	20	24	25	30	31	36	37	43	43	49	50	56	56	63	63	71	69	78	77
Sn	mg/L	NG	NG	0.003	0.006	0.008	0.009	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.05	0.05	0.06	0.06	0.06	0.06	0.07	0.07
Sr	mg/L	NG	NG	1.4	2.6	4.1	4.9	6.4	7.3	9.1	10	12	13	15	16	18	19	21	22	25	25	28	28	32	32	36	35	40	39
Tl	mg/L	NG	NG	0.0003	0.0006	0.0009	0.001	0.001	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.004	0.004	0.005	0.005	0.005	0.005	0.006	0.006	0.007	0.007	0.008	0.008	0.009	0.008
U	mg/L	NG	NG	0.001	0.002	0.003	0.004	0.005	0.006	0.007	0.008	0.009	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.02	0.03	0.03	0.03	0.03
V	mg/L	NG	NG	0.004	0.009	0.01	0.01	0.02	0.02	0.03	0.03	0.03	0.04	0.04	0.05	0.05	0.05	0.06	0.06	0.07	0.07	0.08	0.08	0.09	0.09	0.1	0.1	0.1	0.1
Zn	mg/L	NG	NG	0.01	0.02	0.03	0.03	0.04	0.05	0.06	0.07	0.08	0.09	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3

Table B.36 Kennedy West residual void lake water quality – without geochemical controls (Part 2 of 2)

Parameter	Unit	Lower TV	Upper TV	2350	2360	2370	2380	2390	2400	2410	2420	2430	2440	2450	2460	2470	2480	2490	2500	2510	2520	2530	2540	2550	2560	2570	2580	2590	2599
pH	pH Units	6.5	8.5	7.3	7.3	7.3	7.3	7.3	7.3	7.2	7.3	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.1	7.2	7.1	7.1	7.1	7.1	7.1	7.1
pe	pe units	NG	NG	7	6.9	7	7	7	7	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.2	7.1	7.2	7.2	7.2	7.2	7.2	7.2
TDS	mg/L	4992	10599	64653	63029	70873	68747	77336	75310	82549	79757	87230	84087	91829	88365	96396	92653	100980	96975	105520	100480	110110	104360	114810	108610	119580	112910	124370	117990
Alkalinity	mg $CaCO_3$/L	NG	NG	4591	4483	5041	4899	5511	5375	5894	5703	6239	6023	6579	6339	6916	6655	7254	6974	7589	7234	7927	7522	8274	7835	8625	8151	8977	8524
Ca	mg/L	NG	NG	1290	1257	1414	1371	1542	1502	1646	1590	1739	1676	1830	1761	1921	1846	2012	1932	2102	2001	2193	2078	2286	2163	2381	2248	2476	2349
Mg	mg/L	NG	NG	2464	2402	2701	2619	2946	2868	3144	3036	3321	3200	3495	3362	3668	3525	3841	3688	4013	3821	4187	3968	4365	4129	4546	4292	4727	4485
K	mg/L	NG	NG	152	149	167	163	183	179	196	190	208	202	220	212	232	223	244	234	255	244	267	253	279	264	291	275	303	288
Na	mg/L	NG	NG	19803	19306	21709	21059	23690	23070	25288	24434	26723	25761	28133	27073	29533	28387	30938	29712	32329	30786	33737	31977	35178	33281	36641	34598	38108	36156
Cl	mg/L	NG	NG	36912	35977	40455	39234	44136	42973	47102	45501	49763	47963	52378	50395	54974	52833	57580	55290	60160	57279	62770	59489	65444	61907	68159	64351	70879	67243
F	mg/L	NG	NG	6.8	6.7	7.5	7.3	8.2	8	8.8	8.5	9.4	9.1	9.9	9.6	10	10	11	11	11	11	12	11	13	12	13	12	14	13
SO_4	mg/L	318	520	1038	1013	1139	1107	1245	1214	1331	1288	1409	1359	1485	1430	1561	1502	1637	1573	1712	1632	1788	1696	1866	1767	1945	1838	2024	1921
N	mg N/L	NG	NG	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Al	mg/L	0.055	0.48	1.3	1.2	1.4	1.4	1.5	1.5	1.7	1.6	1.8	1.7	1.9	1.9	2	2	2.1	2.1	2.2	2.2	2.4	2.3	2.5	2.4	2.6	2.5	2.7	2.6
Ag	mg/L	0.001	0.39	0.009	0.009	0.01	0.01	0.011	0.011	0.012	0.012	0.013	0.013	0.014	0.013	0.015	0.014	0.015	0.015	0.016	0.015	0.017	0.016	0.018	0.017	0.018	0.017	0.019	0.018
As	mg/L	0.013	0.013	0.34	0.33	0.37	0.37	0.41	0.41	0.45	0.44	0.48	0.46	0.51	0.49	0.54	0.52	0.57	0.55	0.6	0.57	0.63	0.6	0.66	0.63	0.69	0.66	0.72	0.69
B	mg/L	NG	NG	6.2	6	6.8	6.6	7.4	7.2	7.9	7.7	8.4	8.1	8.8	8.5	9.3	8.9	9.7	9.4	10	9.7	11	10	11	11	12	11	12	11
Ba	mg/L	NG	NG	5.5	5.3	6	5.8	6.6	6.4	7	6.8	7.4	7.1	7.8	7.5	8.2	7.9	8.6	8.2	8.9	8.5	9.3	8.9	9.7	9.2	10	9.6	11	10
Be	mg/L	NG	NG	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.02	0.03	0.03
Cd	mg/L	NG	NG	0.008	0.008	0.009	0.009	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.02	0.02	0.02	0.02
Co	mg/L	NG	NG	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.05	0.06	0.06	0.06	0.06	0.07	0.06	0.07	0.06
Cu	mg/L	NG	NG	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.05	0.06	0.05
Cr	mg/L	NG	NG	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.02	0.03	0.03
Fe	mg/L	0.7	16	7.5	7.4	8.3	8	9	8.8	9.7	9.3	10	9.9	11	10	11	11	12	11	12	12	13	12	13	13	14	13	15	14
Hg	mg/L	0.0006	0.0006	0.0009	0.0009	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.001	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Li	mg/L	NG	NG	2.3	2.2	2.5	2.4	2.7	2.6	2.9	2.8	3.1	2.9	3.2	3.1	3.4	3.2	3.5	3.4	3.7	3.5	3.8	3.6	4	3.8	4.2	3.9	4.3	4.1
Mn	mg/L	NG	NG	1.8	1.8	2	1.9	2.2	2.1	2.3	2.2	2.5	2.4	2.6	2.5	2.7	2.6	2.8	2.7	3	2.8	3.1	2.9	3.2	3.1	3.4	3.2	3.5	3.3
Mo	mg/L	0.034	0.034	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Ni	mg/L	NG	NG	0.08	0.08	0.09	0.09	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.2	0.2
P	mg/L	NG	NG	13	13	15	14	16	16	17	17	18	18	19	19	21	20	22	21	23	22	24	23	25	24	26	25	27	26
Pb	mg/L	NG	NG	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.02	0.03	0.03
Sb	mg/L	0.009	0.009	0.021	0.02	0.023	0.022	0.025	0.025	0.027	0.026	0.029	0.028	0.031	0.03	0.032	0.031	0.034	0.033	0.036	0.034	0.038	0.036	0.04	0.038	0.041	0.039	0.043	0.041
Se	mg/L	0.011	0.02	0.13	0.13	0.15	0.14	0.16	0.16	0.17	0.17	0.18	0.18	0.2	0.19	0.21	0.2	0.22	0.21	0.23	0.22	0.24	0.23	0.25	0.24	0.26	0.25	0.27	0.26
Si	mg/L	NG	NG	86	84	94	91	103	100	110	106	116	112	122	117	128	123	134	129	140	133	146	139	152	144	159	150	165	157
Sn	mg/L	NG	NG	0.08	0.08	0.09	0.09	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.2	0.2	0.2	0.2
Sr	mg/L	NG	NG	44	42	48	46	52	51	56	54	59	57	62	59	65	62	68	65	71	68	74	70	77	73	80	76	84	79
Tl	mg/L	NG	NG	0.009	0.009	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
U	mg/L	NG	NG	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.05	0.06	0.06	0.06	0.06	0.07	0.06	0.07	0.06
V	mg/L	NG	NG	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.2	0.3	0.3
Zn	mg/L	NG	NG	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.5	0.6	0.6

Table B.37 Comet Downs East residual void lake water quality – with geochemical controls (Part 1 of 2)

Parameter	Unit	Lower TV	Upper TV	2102	2110	2120	2130	2140	2150	2160	2170	2180	2190	2200	2210	2220	2230	2240	2250	2260	2270	2280	2290	2300	2310	2320	2330	2340	2350
pH	pH Units	6.5	8.5	8.4	8.4	8.4	8.3	8.3	8.3	8.3	8.3	8.3	8.2	8.2	8.2	8.2	8.2	8.2	8.2	8.2	8.2	8.2	8.2	8.2	8.2	8.2	8.1	8.1	8.1
pe	pe units	NG	NG	5.6	5.4	5.5	5.5	5.6	5.6	5.7	5.7	5.8	5.8	5.8	5.8	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.8	5.8	5.8	5.7	5.6	5.5
TDS	mg/L	4992	10599	2190	5333	5922	7107	7711	8956	9622	10960	11632	13081	13761	15316	15955	17596	18120	19902	19714	20200	19380	19735	19090	19780	19797	20439	20644	21703
Alkalinity	mg $CaCO_3$/L	NG	NG	93	87	86	84	84	82	82	81	81	80	80	79	79	79	79	79	79	78	78	78	77	77	76	75	75	74
Ca	mg/L	NG	NG	16	31	34	40	43	49	52	59	62	70	73	81	84	92	95	104	103	106	102	104	101	105	106	110	111	117
Mg	mg/L	NG	NG	86	193	211	250	268	308	329	372	392	439	460	510	530	583	598	656	650	667	642	657	638	664	667	691	700	739
K	mg/L	NG	NG	5.6	12	14	17	18	21	23	27	29	32	34	38	40	44	46	50	50	50	48	48	46	47	46	47	46	48
Na	mg/L	NG	NG	693	1718	1913	2301	2500	2908	3128	3567	3789	4264	4488	4998	5209	5747	5920	6504	6443	6600	6329	6441	6227	6449	6451	6657	6721	7063
Cl	mg/L	NG	NG	1289	3219	3578	4305	4673	5435	5841	6660	7069	7956	8371	9322	9711	10714	11033	12123	12008	12307	11807	12028	11637	12063	12076	12473	12601	13253
F	mg/L	NG	NG	0.25	0.52	0.6	0.72	0.8	0.93	1	1.2	1.3	1.4	1.5	1.7	1.8	1.9	2	2.2	2.2	2.2	2.1	2.1	2	2	2	2	2	2.1
SO_4	mg/L	318	520	37	87	97	117	128	149	161	184	196	221	233	259	271	299	309	339	336	343	328	332	319	328	327	335	337	352
N	mg N/L	NG	NG	0.004	0.008	0.009	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Al	mg/L	0.055	0.48	0.05	0.08	0.1	0.12	0.14	0.16	0.18	0.21	0.23	0.26	0.28	0.31	0.33	0.36	0.38	0.42	0.41	0.41	0.38	0.37	0.34	0.33	0.32	0.31	0.29	0.29
Ag	mg/L	0.001	0.39	0.0004	0.0007	0.0008	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
As	mg/L	0.013	0.013	0.0061	0.0067	0.01	0.012	0.015	0.018	0.022	0.025	0.029	0.033	0.037	0.042	0.045	0.05	0.054	0.06	0.06	0.059	0.054	0.051	0.046	0.042	0.039	0.036	0.033	0.03
B	mg/L	NG	NG	0.2	0.5	0.6	0.7	0.8	0.9	1	1.1	1.2	1.3	1.4	1.6	1.6	1.8	1.8	2	2	2.1	2	2	1.9	2	2	2	2	2.1
Ba	mg/L	NG	NG	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.09	0.1	0.09	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Be	mg/L	NG	NG	0.00005	0.00004	0.00006	0.00006	0.00007	0.00007	0.00008	0.00007	0.00008	0.00008	0.00009	0.00008	0.00009	0.00009	0.0001	0.00009	0.00009	0.00007	0.00007	0.00005	0.00006	0.00005	0.00005	0.00004	0.00005	0.00004
Cd	mg/L	NG	NG	0.0003	0.0005	0.0006	0.0007	0.0009	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Co	mg/L	NG	NG	0.001	0.003	0.003	0.004	0.004	0.005	0.005	0.006	0.006	0.007	0.008	0.009	0.009	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Cu	mg/L	NG	NG	0.0007	0.001	0.001	0.002	0.002	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.003	0.003	0.004	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
Cr	mg/L	NG	NG	0.0001	0.00007	0.0001	0.0001	0.0002	0.0002	0.0002	0.0002	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0004	0.0004	0.0003	0.0003	0.0002	0.0001	0.0001	0.0001	0.0001	0.00008	0.00008	0.00007
Fe	mg/L	0.7	16	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005
Hg	mg/L	0.0006	0.0006	0.00004	0.00007	0.00008	0.0001	0.0001	0.0001	0.0001	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003
Li	mg/L	NG	NG	0.08	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.4	0.5	0.5	0.6	0.6	0.7	0.7	0.7	0.7	0.8	0.7	0.7	0.7	0.7	0.7	0.8	0.8	0.8
Mn	mg/L	NG	NG	0.06	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.4	0.4	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.7
Mo	mg/L	0.034	0.034	0.006	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Ni	mg/L	NG	NG	0.003	0.007	0.008	0.009	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.02	0.03	0.03	0.03	0.03	0.03
P	mg/L	NG	NG	0.5	0.93	1.1	1.3	1.5	1.7	1.9	2.2	2.4	2.7	2.9	3.2	3.4	3.7	3.9	4.3	4.2	4.3	4	4	3.7	3.7	3.6	3.6	3.5	3.5
Pb	mg/L	NG	NG	0.00006	0.00005	0.00009	0.00008	0.0001	0.0001	0.0002	0.0001	0.0002	0.0002	0.0002	0.0002	0.0003	0.0003	0.0003	0.0003	0.0003	0.0002	0.0002	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Sb	mg/L	0.009	0.009	0.0008	0.001	0.002	0.002	0.002	0.003	0.003	0.003	0.004	0.004	0.005	0.005	0.005	0.006	0.006	0.007	0.007	0.007	0.006	0.006	0.006	0.006	0.005	0.005	0.005	0.005
Se	mg/L	0.011	0.02	0.005	0.009	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Si	mg/L	NG	NG	3	7.5	8.4	10	11	13	14	16	17	19	20	22	23	25	26	28	28	29	28	28	27	28	28	29	30	31
Sn	mg/L	NG	NG	0.003	0.005	0.006	0.007	0.009	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Sr	mg/L	NG	NG	1.5	3.8	4.2	5.1	5.5	6.4	6.9	7.9	8.3	9.4	9.9	11	11	13	13	14	14	15	14	14	14	14	14	15	15	16
Tl	mg/L	NG	NG	0.0004	0.0007	0.0008	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
U	mg/L	NG	NG	0.001	0.003	0.003	0.004	0.004	0.005	0.005	0.006	0.006	0.007	0.008	0.009	0.009	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
V	mg/L	NG	NG	0.002	0.003	0.004	0.005	0.006	0.007	0.008	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.01
Zn	mg/L	NG	NG	0.01	0.02	0.03	0.03	0.04	0.04	0.04	0.05	0.05	0.06	0.06	0.07	0.07	0.08	0.08	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.1

Table B.38 Comet Downs East residual void lake water quality – with geochemical controls (Part 2 of 2)

Parameter	Unit	Lower TV	Upper TV	2360	2370	2380	2390	2400	2410	2420	2430	2440	2450	2460	2470	2480	2490	2500	2510	2520	2530	2540	2550	2560	2570	2580	2590	2599
pH	pH Units	6.5	8.5	8.1	8.1	8.1	8.1	8.1	8	8	8	8	8	8	8	7.9	7.9	7.9	7.9	7.9	7.8	7.8	7.8	7.8	7.8	7.8	7.7	7.7
pe	pe units	NG	NG	5.4	4.8	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.7	4.7	4.7	4.7	4.8	4.8	4.8	4.8	4.8	4.9	4.9	4.9	4.9	5	5
TDS	mg/L	4992	10599	22658	24833	26233	28260	29158	30925	32199	34388	35961	38476	40272	43091	45095	48190	50310	53436	55255	58386	60066	63315	64936	68294	69844	73290	74569
Alkalinity	mg $CaCO_3$/L	NG	NG	74	73	72	72	71	71	70	70	70	69	69	69	69	69	69	69	69	69	70	70	71	71	72	73	73
Ca	mg/L	NG	NG	123	135	143	154	159	169	176	188	197	211	221	237	248	265	277	294	304	322	331	349	359	377	386	405	412
Mg	mg/L	NG	NG	773	848	898	969	1000	1060	1109	1185	1241	1328	1391	1489	1559	1666	1740	1848	1912	2021	2079	2192	2249	2365	2419	2539	2584
K	mg/L	NG	NG	50	54	56	60	61	64	66	70	73	78	81	87	91	96	101	107	110	116	119	125	129	135	138	145	147
Na	mg/L	NG	NG	7372	8078	8531	9188	9478	10051	10465	11179	11691	12512	13097	14017	14670	15680	16372	17392	17985	19006	19554	20614	21142	22238	22743	23867	24284
Cl	mg/L	NG	NG	13841	15177	16037	17283	17837	18923	19709	21060	22031	23582	24690	26428	27664	29572	30879	32807	33928	35858	36894	38897	39896	41966	42922	45046	45834
F	mg/L	NG	NG	2.1	2.3	2.4	2.5	2.6	2.7	2.8	3	3.1	3.3	3.4	3.6	3.8	4	4.2	4.4	4.6	4.8	5	5.2	5.3	5.6	5.7	6	6.1
SO_4	mg/L	318	520	366	399	420	451	463	490	509	543	567	605	633	677	707	755	788	837	865	913	939	990	1010	1070	1091	1144	1164
N	mg N/L	NG	NG	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.07	0.07	0.07	0.07	0.08	0.08	0.08	0.08
Al	mg/L	0.055	0.48	0.28	0.29	0.29	0.3	0.29	0.29	0.29	0.3	0.3	0.31	0.32	0.34	0.34	0.36	0.37	0.39	0.4	0.41	0.42	0.44	0.45	0.46	0.47	0.49	0.49
Ag	mg/L	0.001	0.39	0.003	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.004	0.004	0.005	0.005	0.005	0.005	0.006	0.006	0.006	0.006	0.007	0.007	0.007	0.007	0.008	0.008
As	mg/L	0.013	0.013	0.029	0.028	0.027	0.027	0.026	0.025	0.025	0.025	0.026	0.027	0.028	0.029	0.031	0.032	0.034	0.036	0.038	0.04	0.042	0.044	0.046	0.048	0.05	0.053	0.055
B	mg/L	NG	NG	2.2	2.4	2.5	2.7	2.8	2.9	3.1	3.3	3.4	3.6	3.8	4.1	4.3	4.5	4.7	5	5.2	5.5	5.7	6	6.1	6.4	6.6	6.9	7
Ba	mg/L	NG	NG	0.09	0.09	0.09	0.08	0.08	0.08	0.08	0.08	0.07	0.07	0.07	0.07	0.06	0.06	0.06	0.06	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.04	0.04
Be	mg/L	NG	NG	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004	0.00005	0.00004	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00006	0.00005	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006
Cd	mg/L	NG	NG	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
Co	mg/L	NG	NG	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04
Cu	mg/L	NG	NG	0.003	0.004	0.005	0.005	0.006	0.007	0.007	0.008	0.009	0.009	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Cr	mg/L	NG	NG	0.00007	0.00006	0.00006	0.00006	0.00006	0.00006	0.00007	0.00007	0.00007	0.00007	0.00008	0.00008	0.00009	0.00009	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0002	0.0002	0.0002
Fe	mg/L	0.7	16	0.00005	0.00005	0.00005	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006	0.00007	0.00007	0.00007	0.00007	0.00008	0.00008	0.00008	0.00009	0.00009	0.00009	0.0001	0.0001	0.0001	0.0001
Hg	mg/L	0.0006	0.0006	0.0003	0.0003	0.0003	0.0003	0.0003	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0005	0.0005	0.0005	0.0005	0.0006	0.0006	0.0006	0.0006	0.0007	0.0007	0.0007	0.0007	0.0008	0.0008
Li	mg/L	NG	NG	0.9	0.9	1	1.1	1.1	1.2	1.2	1.3	1.4	1.5	1.5	1.6	1.7	1.8	1.9	2	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.8
Mn	mg/L	NG	NG	0.7	0.8	0.8	0.9	0.9	0.9	1	1	1	1.2	1.2	1.3	1.4	1.5	1.5	1.6	1.7	1.8	1.8	1.9	2	2.1	2.1	2.2	2.3
Mo	mg/L	0.034	0.034	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.07	0.07
Ni	mg/L	NG	NG	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.06	0.06	0.06	0.07	0.07	0.07	0.07	0.08	0.08	0.09	0.09	0.09	0.09
P	mg/L	NG	NG	3.6	3.8	3.9	4.1	4.1	4.3	4.4	4.6	4.7	5	5.2	5.5	5.7	6	6.2	6.6	6.8	7.1	7.3	7.6	7.8	8.2	8.3	8.7	8.9
Pb	mg/L	NG	NG	0.0001	0.0001	0.0001	0.0001	0.0002	0.0002	0.0002	0.0002	0.0003	0.0003	0.0004	0.0005	0.0006	0.0007	0.0008	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.002	0.003	0.003
Sb	mg/L	0.009	0.009	0.005	0.005	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.007	0.007	0.007	0.007	0.008	0.008	0.009	0.009	0.009	0.009	0.01	0.01	0.01	0.01	0.01	0.01
Se	mg/L	0.011	0.02	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.07	0.07	0.07	0.07	0.08	0.08	0.08	0.09	0.09	0.09
Si	mg/L	NG	NG	32	36	38	41	42	44	44	44	43	42	42	41	41	40	40	39	39	38	38	37	37	36	36	35	35
Sn	mg/L	NG	NG	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Sr	mg/L	NG	NG	16	18	19	20	21	22	23	25	26	28	29	31	32	35	36	38	40	42	43	46	47	49	50	53	54
Tl	mg/L	NG	NG	0.003	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.004	0.004	0.005	0.005	0.005	0.005	0.006	0.006	0.006	0.006	0.007	0.007	0.007	0.007	0.008	0.008
U	mg/L	NG	NG	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04
V	mg/L	NG	NG	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04
Zn	mg/L	NG	NG	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3

DRAFT

Table B.39 Comet Downs East residual void lake water quality – without geochemical controls (Part 1 of 2)

Parameter	Unit	Lower TV	Upper TV	2102	2110	2120	2130	2140	2150	2160	2170	2180	2190	2200	2210	2220	2230	2240	2250	2260	2270	2280	2290	2300	2310	2320	2330	2340	2350
pH	pH Units	6.5	8.5	7.9	7.7	7.7	7.7	7.7	7.7	7.7	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.5	7.5	7.5	7.5	7.5
pe	pe units	NG	NG	6.2	6.1	6.2	6.2	6.3	6.3	6.3	6.4	6.4	6.4	6.4	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.4	6.4	6.4	6.3	6.3
TDS	mg/L	4992	10599	2262	5616	6249	7518	8168	9501	10218	11651	12373	13926	14657	16323	17011	18768	19332	21241	21040	21555	20671	21042	20346	21074	21084	21761	21973	23095
Alkalinity	mg $CaCO_3$/L	NG	NG	164	384	431	518	568	662	716	817	872	982	1037	1155	1207	1332	1376	1511	1497	1527	1459	1475	1418	1457	1449	1484	1490	1556
Ca	mg/L	NG	NG	45	113	125	151	163	190	204	233	247	278	293	326	339	374	386	424	420	430	413	421	407	422	422	436	441	464
Mg	mg/L	NG	NG	86	215	239	288	312	363	390	445	472	532	559	623	649	716	737	810	802	822	789	804	778	807	808	835	844	888
K	mg/L	NG	NG	5.6	12	14	17	18	21	23	27	29	32	34	38	40	44	46	50	50	50	48	48	46	47	46	47	47	48
Na	mg/L	NG	NG	693	1718	1913	2301	2500	2909	3129	3568	3789	4265	4489	4999	5210	5748	5921	6506	6445	6602	6330	6443	6229	6451	6453	6659	6723	7065
Cl	mg/L	NG	NG	1289	3219	3579	4305	4673	5436	5842	6661	7070	7957	8372	9323	9713	10716	11036	12126	12011	12310	11810	12031	11640	12066	12079	12476	12605	13257
F	mg/L	NG	NG	0.2	0.5	0.6	0.7	0.8	0.9	1	1.2	1.3	1.4	1.5	1.7	1.8	1.9	2	2.2	2.2	2.2	2.1	2.1	2	2	2	2	2	2.1
SO_4	mg/L	318	520	37	87	98	117	129	150	162	185	197	221	234	260	272	300	310	340	337	344	329	333	320	330	328	337	338	354
N	mg N/L	NG	NG	0.004	0.008	0.009	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Al	mg/L	0.055	0.48	0.05	0.08	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.3
Ag	mg/L	0.001	0.39	0.0004	0.0007	0.0008	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
As	mg/L	0.013	0.013	0.01	0.02	0.03	0.03	0.04	0.04	0.05	0.06	0.06	0.07	0.07	0.08	0.09	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.09	0.09	0.09	0.08	0.08	0.08
B	mg/L	NG	NG	0.2	0.5	0.6	0.7	0.8	0.9	1	1.1	1.2	1.3	1.4	1.6	1.6	1.8	1.8	2	2	2.1	2	2	1.9	2	2	2	2	2.1
Ba	mg/L	NG	NG	0.2	0.5	0.5	0.6	0.7	0.8	0.9	1	1	1.2	1.2	1.4	1.4	1.6	1.6	1.8	1.8	1.8	1.8	1.8	1.7	1.8	1.8	1.8	1.9	2
Be	mg/L	NG	NG	0.0005	0.0009	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
Cd	mg/L	NG	NG	0.0003	0.0005	0.0006	0.0007	0.0009	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Co	mg/L	NG	NG	0.001	0.003	0.003	0.004	0.004	0.005	0.005	0.006	0.006	0.007	0.008	0.009	0.009	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Cu	mg/L	NG	NG	0.001	0.002	0.003	0.003	0.004	0.004	0.004	0.005	0.005	0.006	0.007	0.007	0.008	0.008	0.009	0.01	0.009	0.01	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009
Cr	mg/L	NG	NG	0.0005	0.0009	0.001	0.001	0.002	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
Fe	mg/L	0.7	16	0.3	0.6	0.7	0.9	0.9	1.1	1.2	1.3	1.4	1.6	1.7	1.9	2	2.2	2.3	2.5	2.5	2.5	2.4	2.4	2.3	2.4	2.4	2.5	2.5	2.6
Hg	mg/L	0.0006	0.0006	0.00004	0.00007	0.00008	0.0001	0.0001	0.0001	0.0001	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003
Li	mg/L	NG	NG	0.08	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.4	0.5	0.5	0.6	0.6	0.7	0.7	0.7	0.7	0.8	0.7	0.7	0.7	0.7	0.7	0.8	0.8	0.8
Mn	mg/L	NG	NG	0.06	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.4	0.4	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.7
Mo	mg/L	0.034	0.034	0.006	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Ni	mg/L	NG	NG	0.003	0.007	0.008	0.009	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
P	mg/L	NG	NG	0.5	0.9	1.1	1.3	1.5	1.8	1.9	2.2	2.4	2.7	2.9	3.2	3.4	3.8	3.9	4.3	4.3	4.3	4.1	4	3.8	3.8	3.6	3.6	3.5	3.6
Pb	mg/L	NG	NG	0.0005	0.0009	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
Sb	mg/L	0.009	0.009	0.0008	0.001	0.002	0.002	0.002	0.003	0.003	0.003	0.004	0.004	0.005	0.005	0.005	0.006	0.006	0.007	0.007	0.007	0.006	0.006	0.006	0.006	0.005	0.005	0.005	0.005
Se	mg/L	0.011	0.02	0.005	0.009	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Si	mg/L	NG	NG	3	7.5	8.4	10	11	13	14	16	17	19	20	22	23	25	26	28	28	29	28	28	27	28	28	29	30	31
Sn	mg/L	NG	NG	0.003	0.005	0.006	0.007	0.009	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Sr	mg/L	NG	NG	1.5	3.8	4.2	5.1	5.5	6.4	6.9	7.9	8.3	9.4	9.9	11	11	13	13	14	14	15	14	14	14	14	14	15	15	16
Th	mg/L	NG	NG	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tl	mg/L	NG	NG	0.0004	0.0007	0.0008	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
U	mg/L	NG	NG	0.001	0.003	0.003	0.004	0.004	0.005	0.005	0.006	0.006	0.007	0.008	0.009	0.009	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
V	mg/L	NG	NG	0.005	0.009	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Zn	mg/L	NG	NG	0.01	0.03	0.03	0.03	0.04	0.04	0.05	0.05	0.06	0.07	0.07	0.08	0.08	0.09	0.09	0.1	0.1	0.1	0.1	0.1	0.09	0.1	0.1	0.1	0.1	0.1

Table B.40 Comet Downs East residual void lake water quality – without geochemical controls (Part 2 of 2)

Parameter	Unit	Lower TV	Upper TV	2360	2370	2380	2390	2400	2410	2420	2430	2440	2450	2460	2470	2480	2490	2500	2510	2520	2530	2540	2550	2560	2570	2580	2590	2599
pH	pH Units	6.5	8.5	7.5	7.5	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.3	7.3	7.3	7.3	7.3	7.3	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.1	7.1	7.1
pe	pe units	NG	NG	6.2	6.2	6.2	6.2	6.1	6.1	6.1	6.2	6.2	6.3	6.3	6.4	6.4	6.5	6.5	6.6	6.6	6.7	6.7	6.8	6.8	6.8	6.8	6.8	6.8
TDS	mg/L	4992	10599	24107	26420	27906	30061	31011	32888	34248	36586	38267	40955	42874	45888	48030	51340	53608	56951	58896	62244	64041	67516	69250	72842	74500	78186	79554
Alkalinity	mg $CaCO_3$/L	NG	NG	1615	1760	1850	1983	2038	2153	2236	2382	2487	2656	2776	2967	3102	3312	3456	3668	3790	4003	4116	4336	4446	4673	4778	5011	5097
Ca	mg/L	NG	NG	485	531	562	605	625	663	691	738	772	826	865	926	970	1037	1083	1150	1190	1257	1294	1364	1399	1472	1505	1580	1608
Mg	mg/L	NG	NG	927	1017	1075	1159	1196	1270	1323	1413	1479	1583	1658	1775	1858	1986	2074	2204	2279	2409	2479	2614	2681	2820	2884	3027	3080
K	mg/L	NG	NG	50	54	56	60	61	64	66	70	73	78	81	87	91	97	100	110	110	116	119	126	129	135	138	145	147
Na	mg/L	NG	NG	7374	8080	8534	9192	9482	10060	10470	11184	11697	12518	13104	14025	14679	15690	16383	17405	17999	19022	19571	20632	21162	22259	22766	23892	24310
Cl	mg/L	NG	NG	13845	15182	16043	17290	17843	18930	19718	21069	22041	23594	24703	26443	27681	29592	30901	32831	33954	35887	36925	38931	39932	42006	42964	45093	45882
F	mg/L	NG	NG	2.1	2.3	2.4	2.5	2.6	2.7	2.8	3	3.1	3.3	3.4	3.6	3.8	4	4.2	4.4	4.6	4.8	5	5.2	5.3	5.6	5.7	6	6.1
SO_4	mg/L	318	520	368	401	422	453	465	492	511	545	569	608	636	680	711	759	792	841	869	918	944	994	1020	1072	1096	1150	1170
N	mg N/L	NG	NG	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.07	0.07	0.07	0.07	0.08	0.08	0.08	0.08
Al	mg/L	0.055	0.48	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5
Ag	mg/L	0.001	0.39	0.003	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.004	0.004	0.005	0.005	0.005	0.005	0.006	0.006	0.006	0.006	0.007	0.007	0.007	0.007	0.008	0.008
As	mg/L	0.013	0.013	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.09	0.09	0.09	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
B	mg/L	NG	NG	2.2	2.4	2.5	2.7	2.8	2.9	3.1	3.3	3.4	3.6	3.8	4.1	4.3	4.5	4.7	5	5.2	5.5	5.7	6	6.1	6.4	6.6	6.9	7
Ba	mg/L	NG	NG	2	2.2	2.4	2.6	2.6	2.8	2.9	3.1	3.3	3.5	3.6	3.9	4.1	4.4	4.6	4.8	5	5.3	5.5	5.7	5.9	6.2	6.3	6.7	6.8
Be	mg/L	NG	NG	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.005	0.005	0.005	0.005	0.006	0.006	0.006	0.006	0.007	0.007	0.007	0.007	0.008	0.008	0.008	0.009	0.009	0.009
Cd	mg/L	NG	NG	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
Co	mg/L	NG	NG	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04
Cu	mg/L	NG	NG	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03
Cr	mg/L	NG	NG	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.005	0.005	0.005	0.005	0.006	0.006	0.006	0.006	0.007	0.007	0.007	0.007	0.008	0.008	0.008	0.009	0.009	0.009
Fe	mg/L	0.7	16	2.7	3	3.1	3.4	3.5	3.7	3.8	4.1	4.2	4.5	4.7	5.1	5.3	5.7	5.9	6.3	6.5	6.8	7	7.4	7.6	8	8.2	8.6	8.7
Hg	mg/L	0.0006	0.0006	0.0003	0.0003	0.0003	0.0003	0.0003	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0005	0.0005	0.0005	0.0005	0.0006	0.0006	0.0006	0.0006	0.0007	0.0007	0.0007	0.0007	0.0008	0.0008
Li	mg/L	NG	NG	0.9	0.9	1	1.1	1.1	1.2	1.2	1.3	1.4	1.5	1.5	1.6	1.7	1.8	1.9	2	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.8
Mn	mg/L	NG	NG	0.7	0.8	0.8	0.9	0.9	0.9	1	1	1	1.2	1.2	1.3	1.4	1.5	1.5	1.6	1.7	1.8	1.8	1.9	2	2.1	2.1	2.2	2.3
Mo	mg/L	0.034	0.034	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.07	0.07
Ni	mg/L	NG	NG	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.07	0.07	0.07	0.08	0.08	0.08	0.09	0.09	0.09	0.1
P	mg/L	NG	NG	3.6	3.9	4	4.2	4.2	4.3	4.4	4.7	4.8	5.1	5.3	5.6	5.8	6.1	6.4	6.7	6.9	7.3	7.5	7.8	8	8.4	8.6	8.9	9.1
Pb	mg/L	NG	NG	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.005	0.005	0.005	0.005	0.006	0.006	0.006	0.006	0.007	0.007	0.007	0.007	0.008	0.008	0.008	0.009	0.009	0.009
Sb	mg/L	0.009	0.009	0.005	0.005	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.007	0.007	0.007	0.007	0.008	0.008	0.009	0.009	0.009	0.009	0.01	0.01	0.01	0.01	0.01	0.01
Se	mg/L	0.011	0.02	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.07	0.07	0.07	0.07	0.08	0.08	0.08	0.09	0.09	0.09
Si	mg/L	NG	NG	32	36	38	41	42	44	46	49	52	55	58	62	65	70	73	77	80	84	87	92	94	99	101	106	108
Sn	mg/L	NG	NG	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Sr	mg/L	NG	NG	16	18	19	20	21	22	23	25	26	28	29	31	32	35	36	39	40	42	43	46	47	49	50	53	54
Th	mg/L	NG	NG	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tl	mg/L	NG	NG	0.003	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.004	0.004	0.005	0.005	0.005	0.005	0.006	0.006	0.006	0.006	0.007	0.007	0.007	0.007	0.008	0.008
U	mg/L	NG	NG	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04
V	mg/L	NG	NG	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.07	0.07	0.07	0.07	0.08	0.08	0.08	0.09	0.09	0.09
Zn	mg/L	NG	NG	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3

Appendix C

Geochemical modelling results figures

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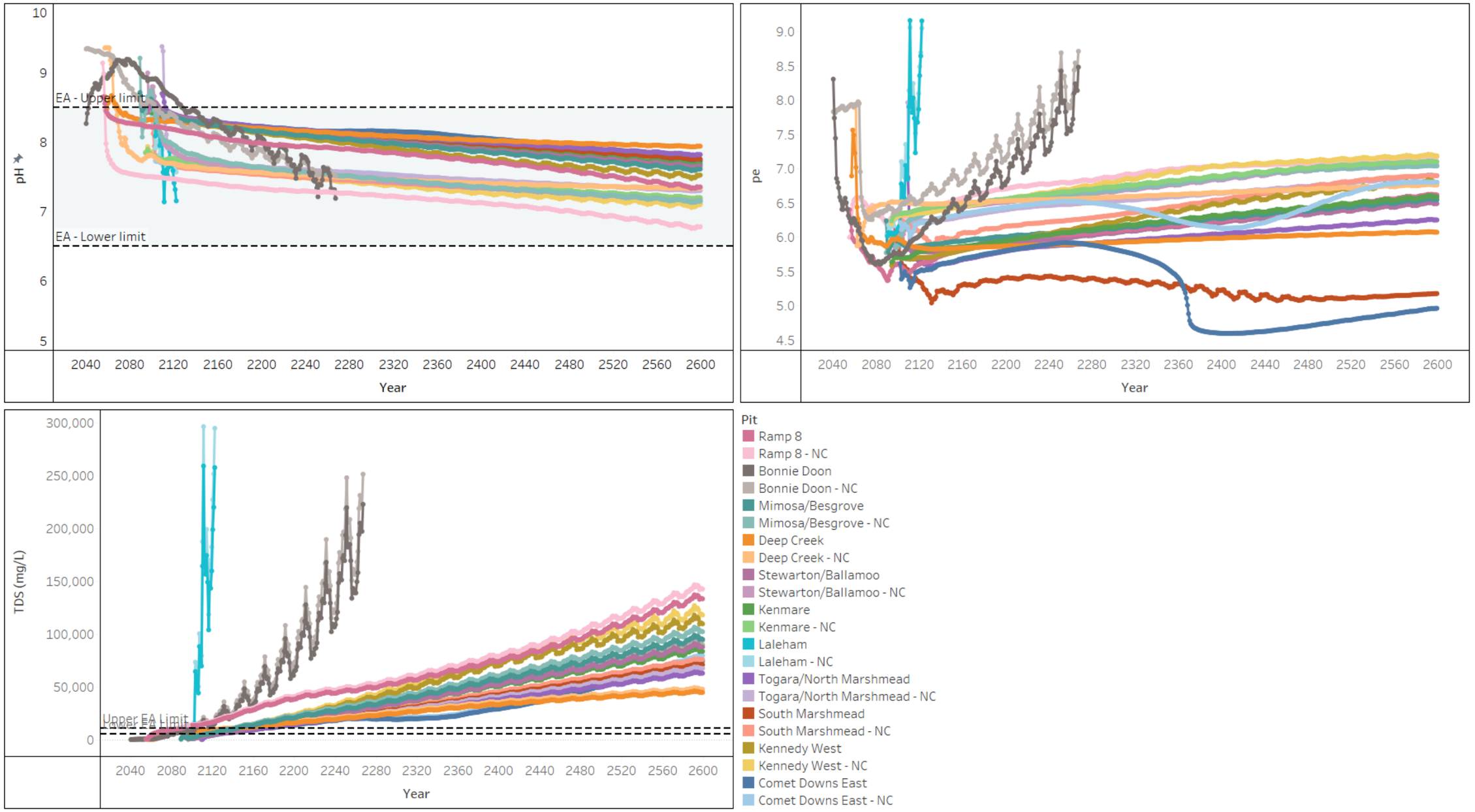

Figure C.1 BWM residual void lake water quality evolution – pH, pe and TDS

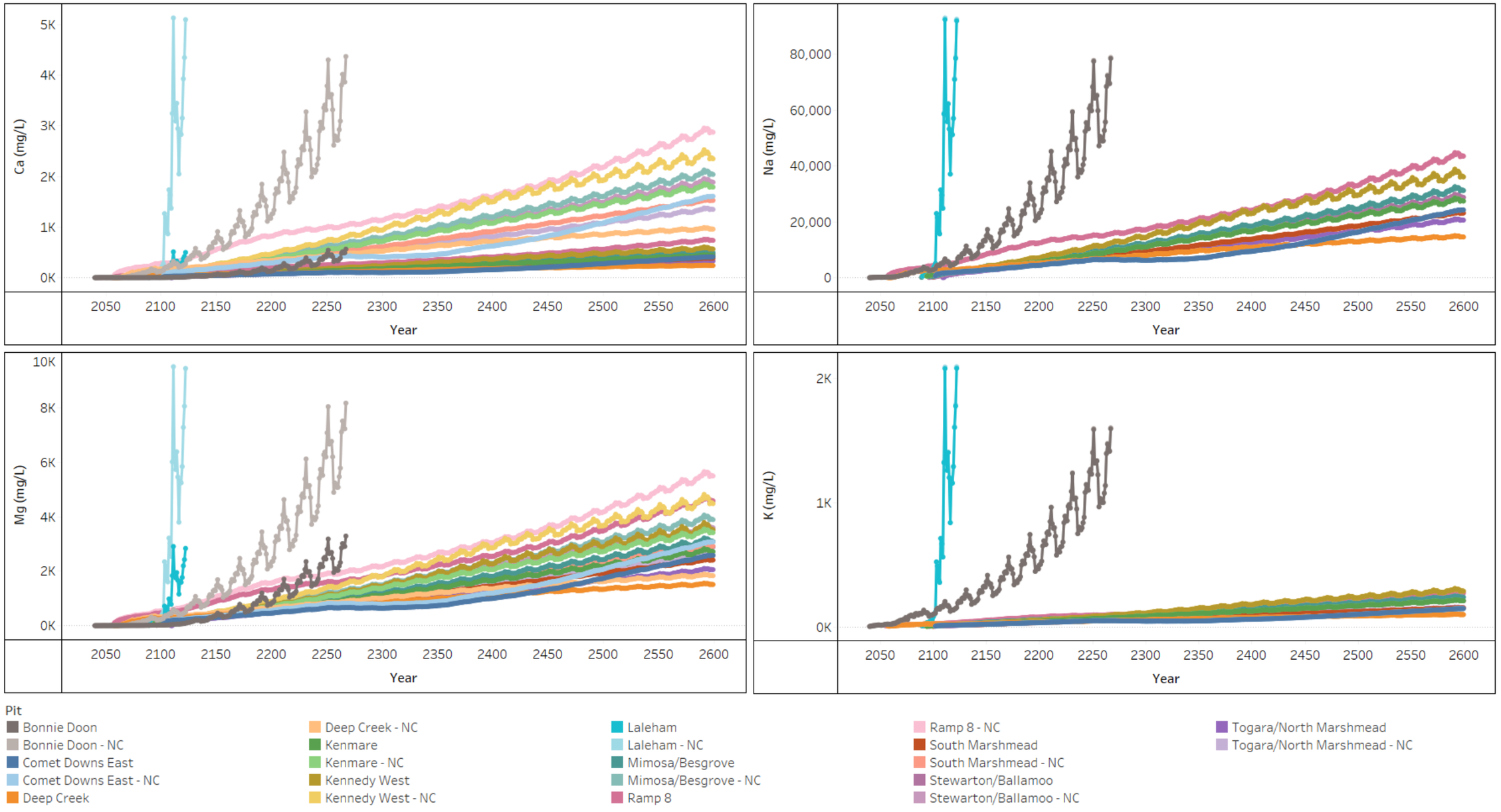

Figure C.2 BWM residual void lake water quality evolution – major cations (Ca, Na, Mg and K)

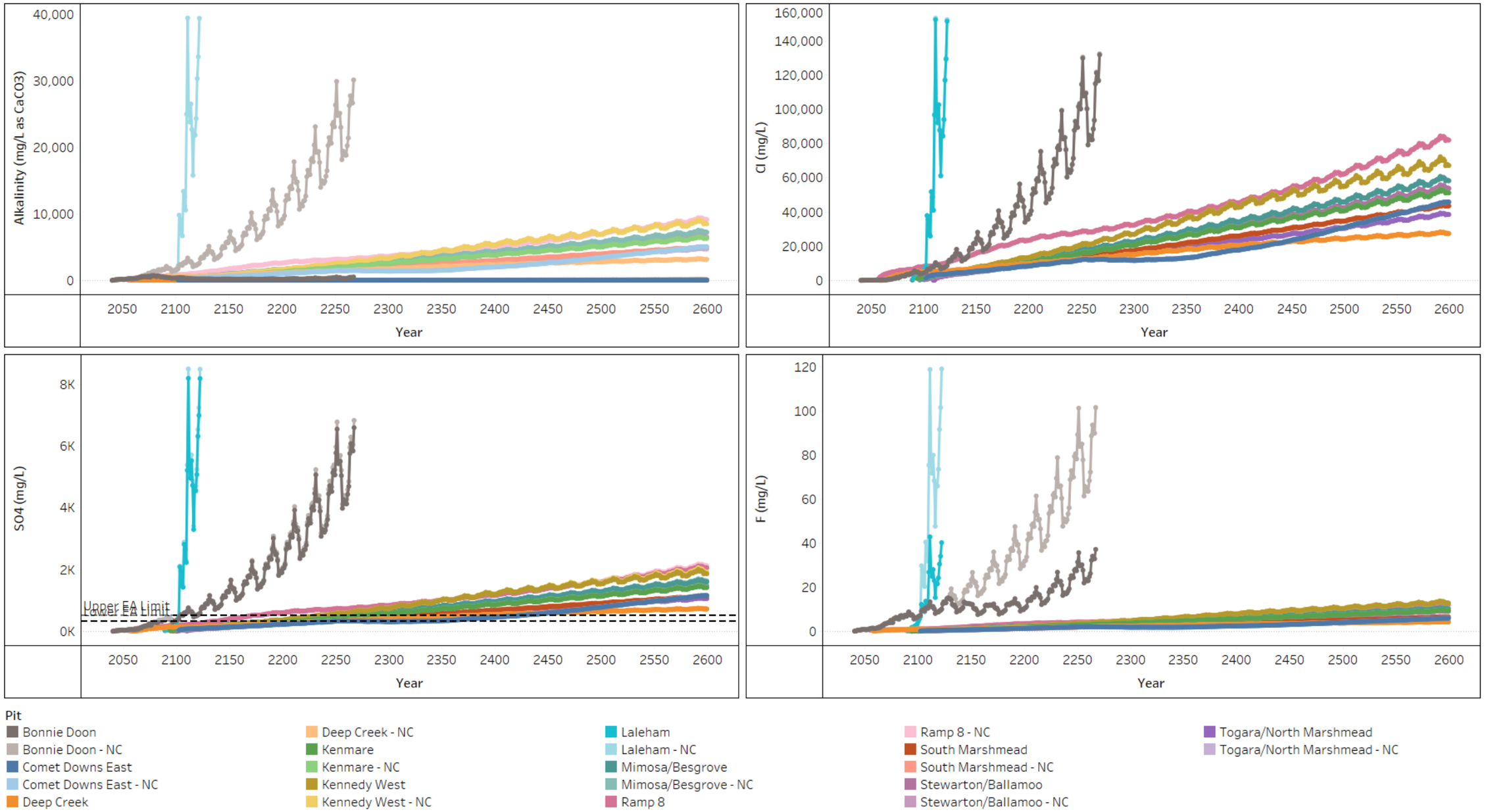

Figure C.3 BWM residual void lake water quality evolution – major anions (alkalinity, Cl, SO_4, F)

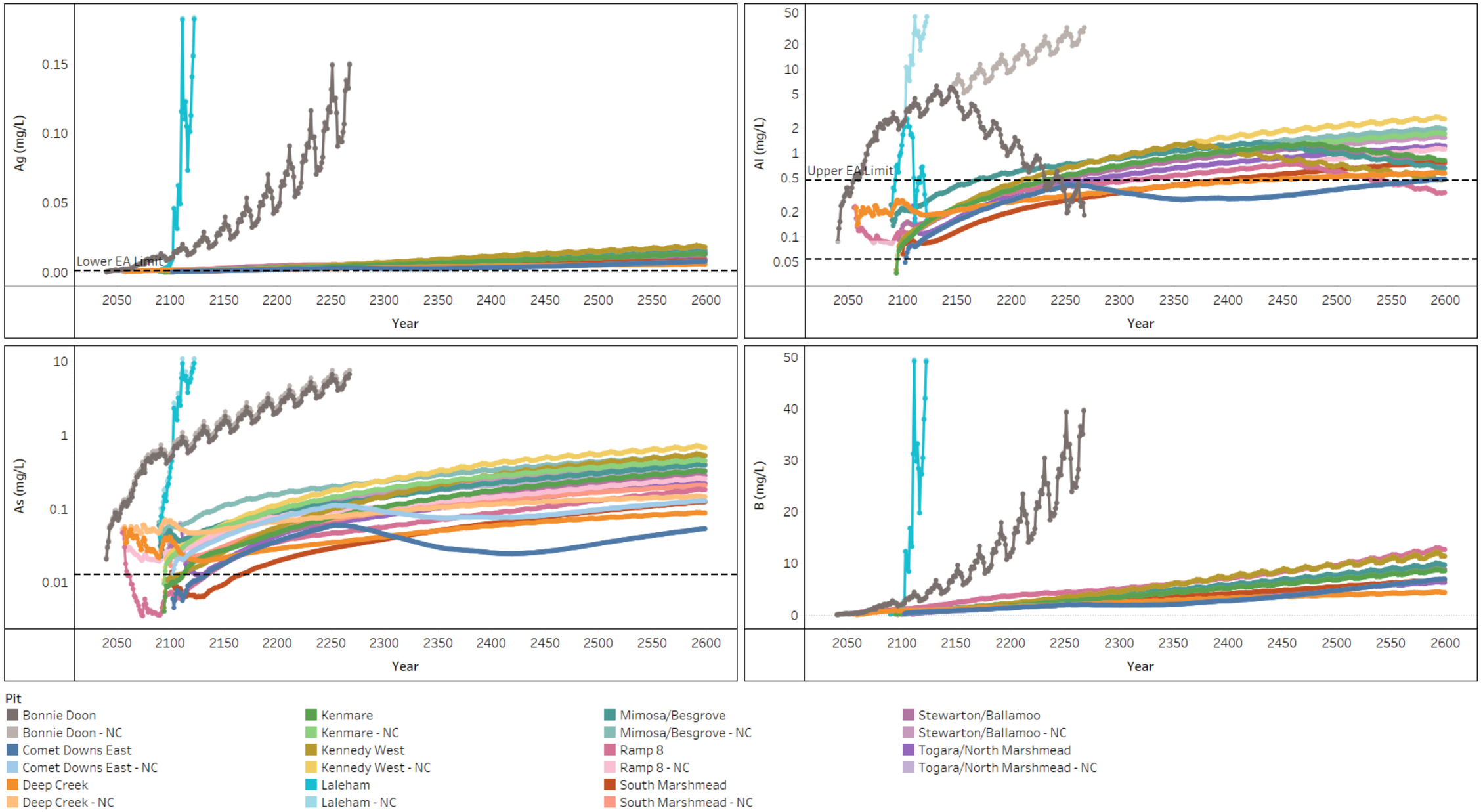

Figure C.4 BWM residual void lake water quality evolution – minor/trace elements (Ag, Al, As and B)

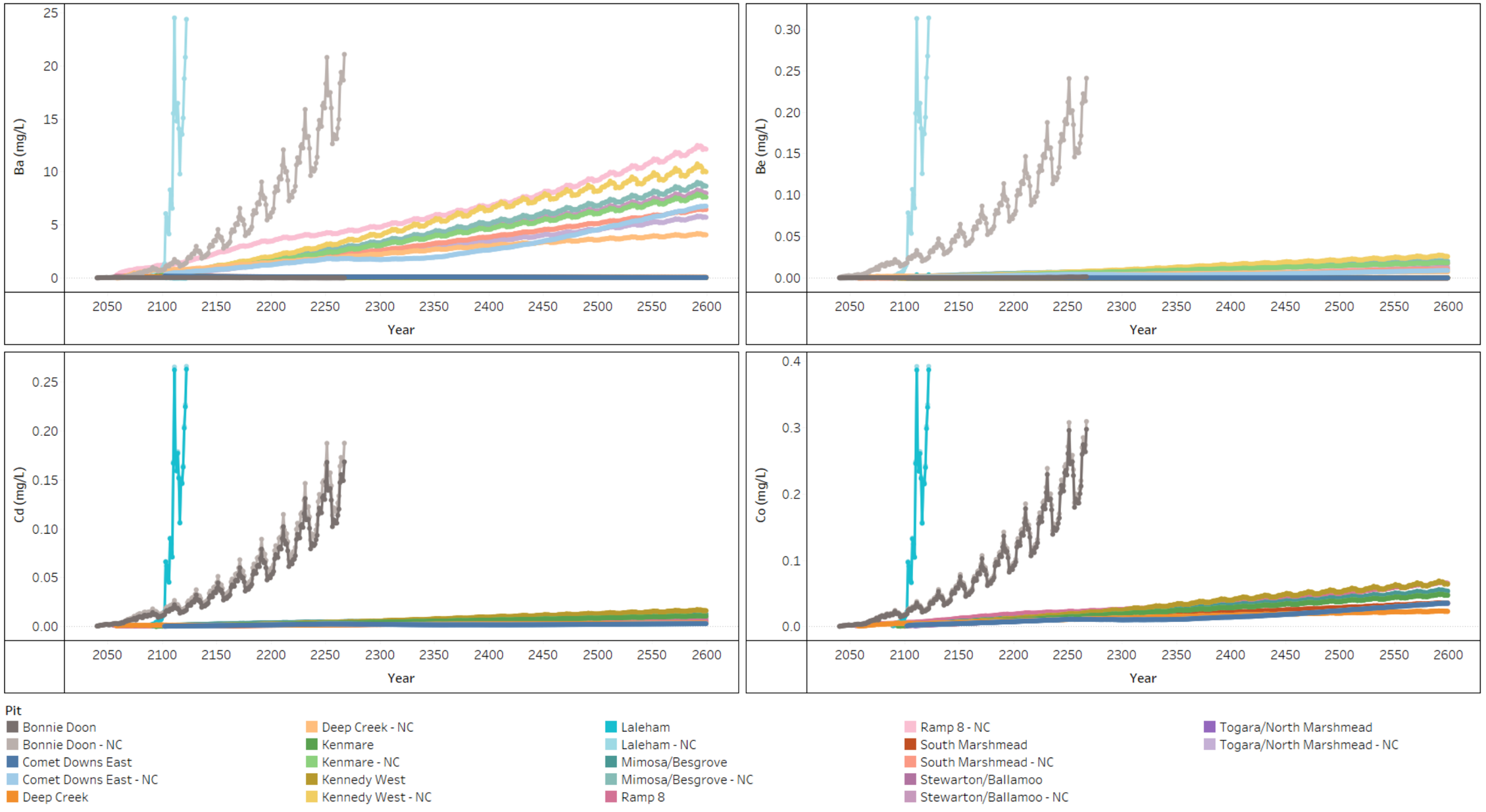

Figure C.5 BWM residual void lake water quality evolution – minor/trace elements (Ba, Be, Cd and Co)

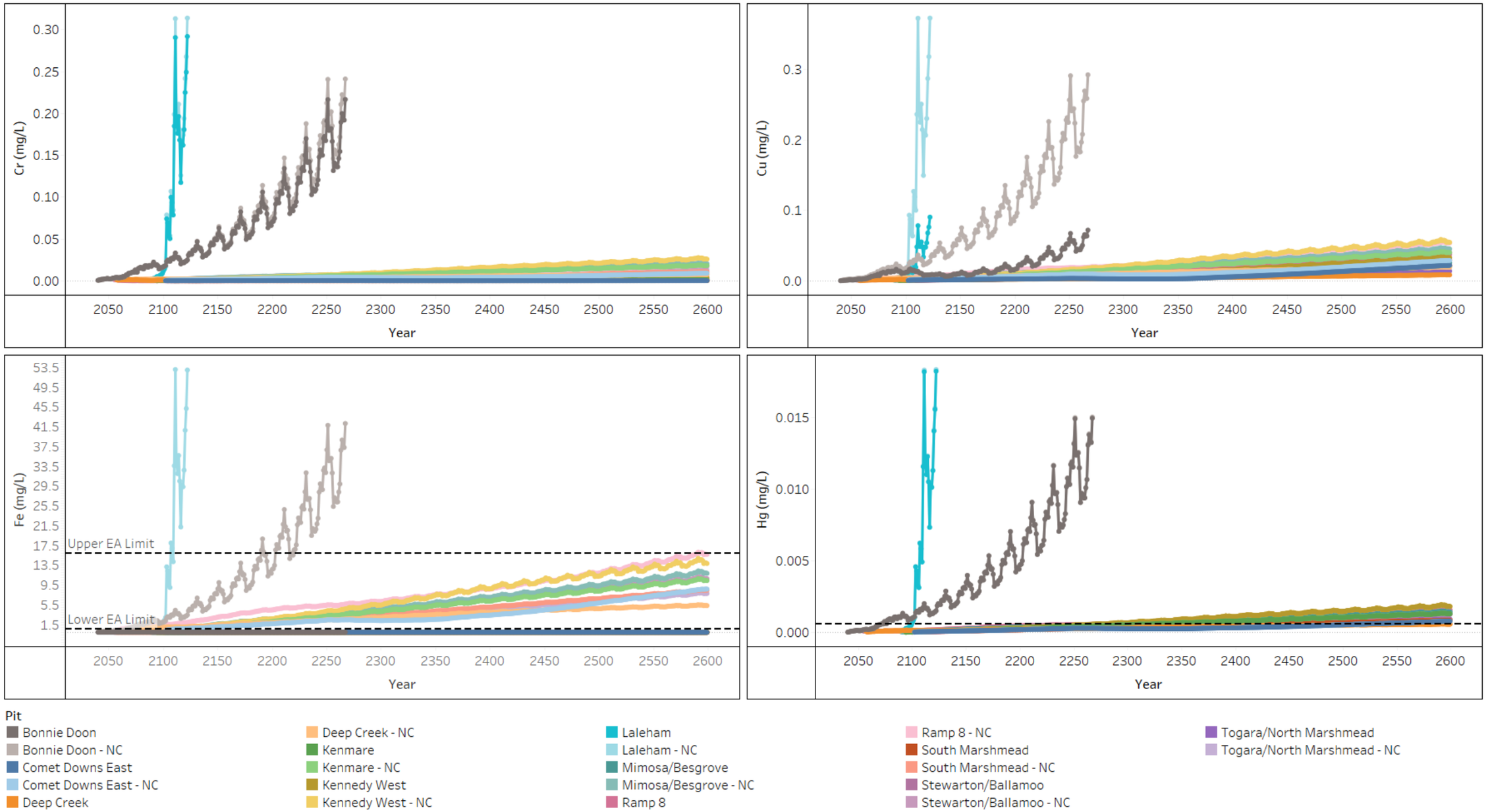

Figure C.6 BWM residual void lake water quality evolution – minor/trace elements (Cr, Cu, Fe and Hg)

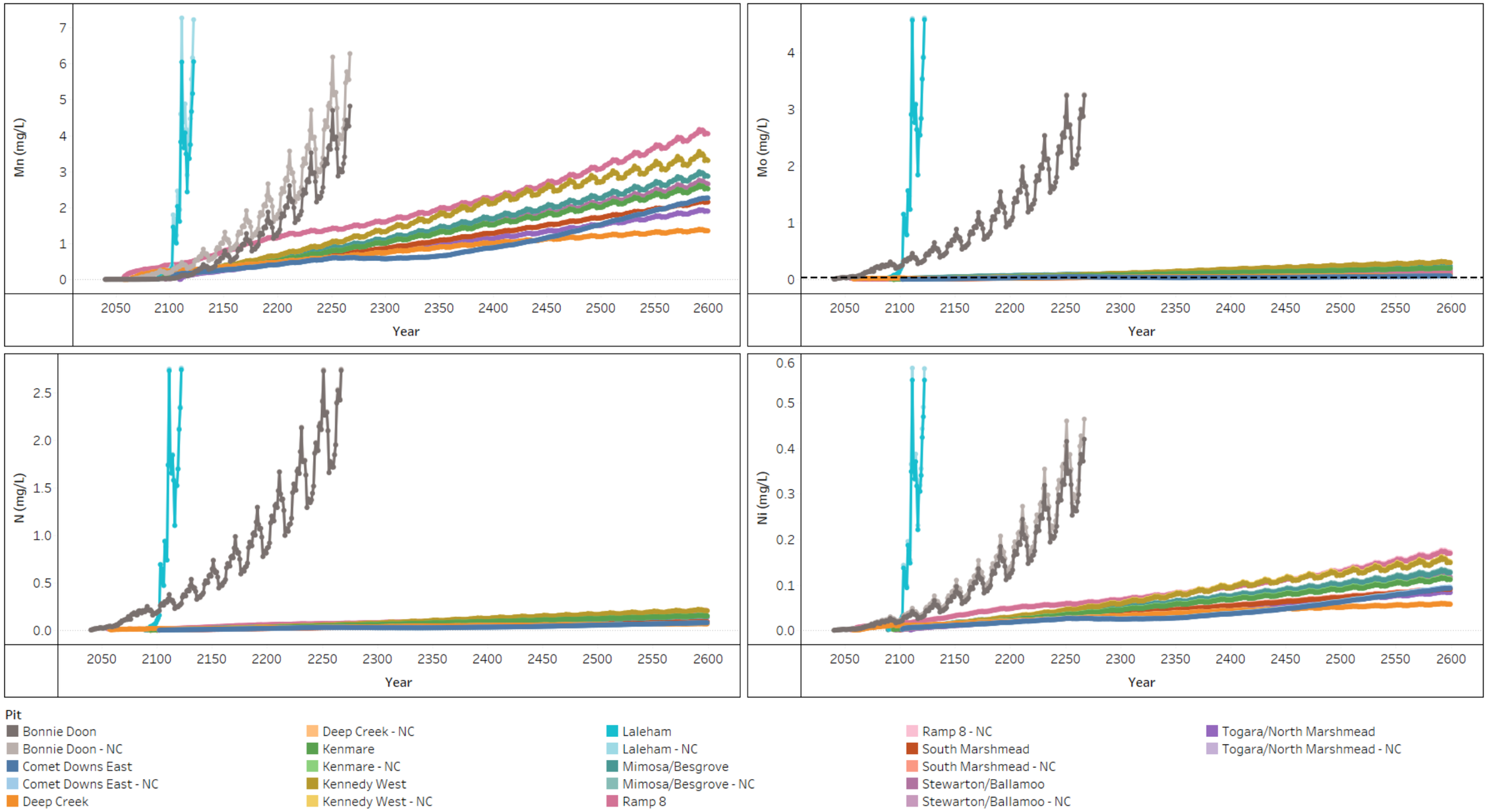

Figure C.7 BWM residual void lake water quality evolution – minor/trace elements (Mn, Mo, N and Ni)

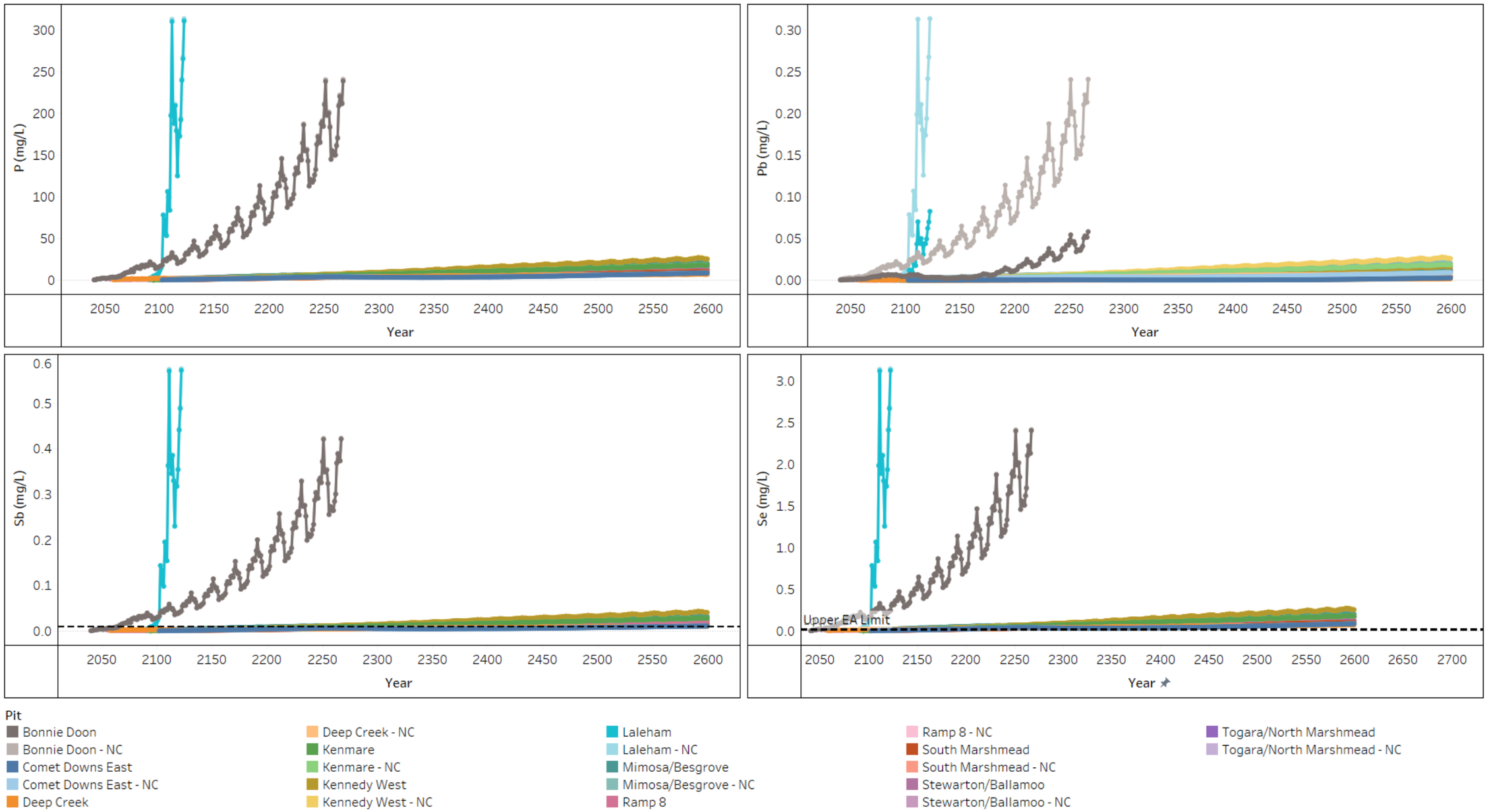

Figure C.8 BWM residual void lake water quality evolution – minor/trace elements (P, Pb, Sb and Se)

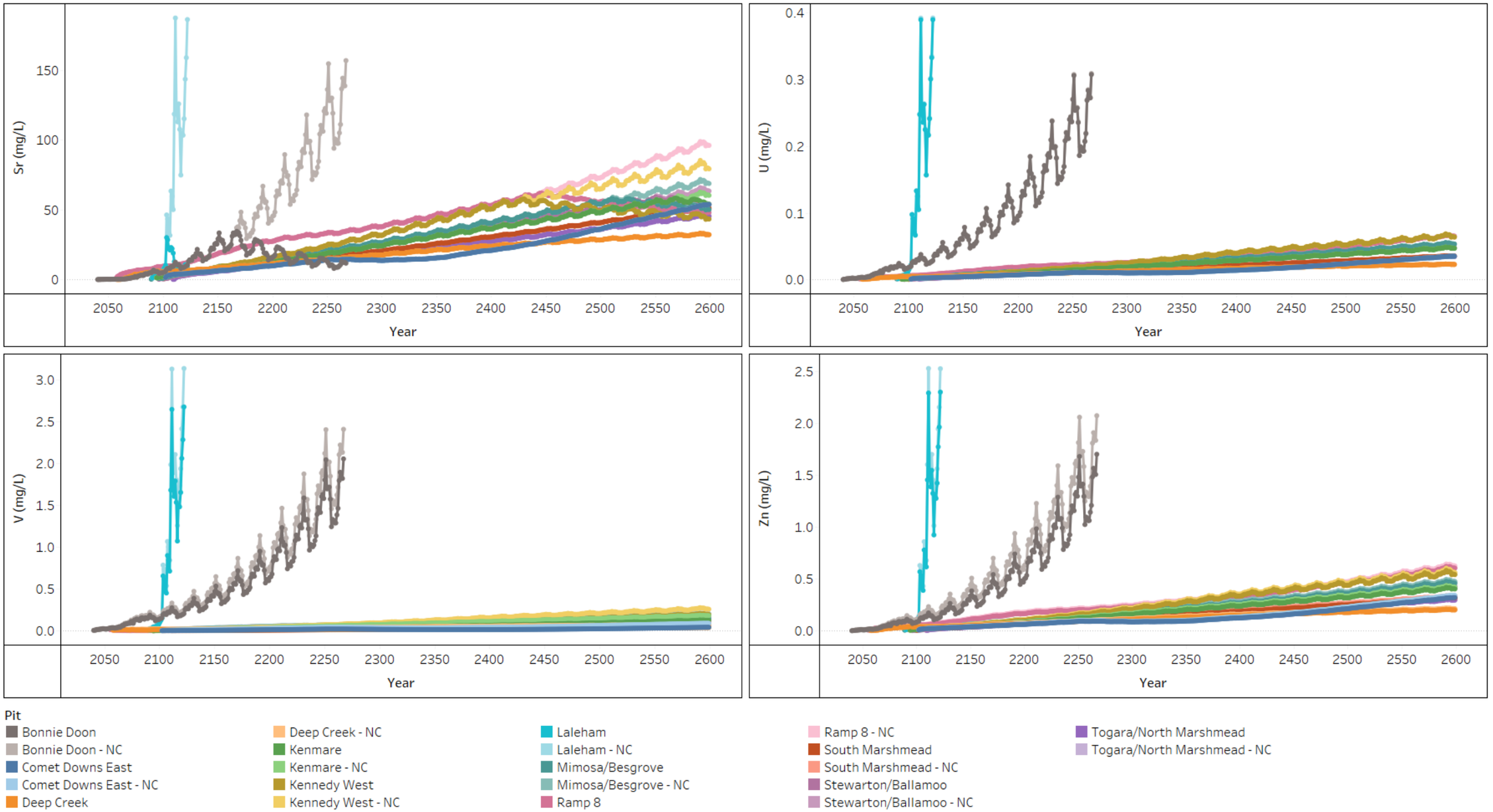

Figure C.9 BWM residual void lake water quality evolution – minor/trace elements (Sr, U, V and Zn)

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Appendix 4.15 – Risk Assessment

Risk ID	RISK	Risk Scenario	CAUSE (How could it happen?)	IMPACT (What could happen?)	Inherent LIKELIHOOD	Inherent CONSEQUENCE	Inherent RISK ASSESSMENT (without controls)	CONTROL	Residual Consequence	Residual Likelihood	Current Risk Assessment	Proposed ACTION and RESOURCES REQUIREMENTS (RISK TREATMENT)	Performance measures and Constraints	Reporting and monitoring requirements
PMLU 1	Stable condition (safe, stable, non-polluting and sustainable) for land described as a PMLU (cattle grazing, woodland habitat, watercourse) is not achieved.	Landform failure	1. Erosional instability 2. Geotechnical instability 3. Incorrect geotechnical assessment 4. Differential settlement (spoil and backfilled dams) 5. Insufficient materials to achieve design (rock, growth media) 6. Unsuitable materials used on final landform surface 7. Flooding 8. Not achieving design 9. Inappropriate modelling and design 10. Selection of inappropriate PMLU 11. Fire	- Erosion - Growth media loss - Failure of vegetation (vegetated cover) - Slumping and settlement - Mass movement of landform - Inability to meet surface water quality criteria	Almost Certain	Medium	H15	Preventative Controls: - Landform design appropriate for PMLU - Ongoing materials characterisation - Selective handling of materials for placement - Review the topsoil and rock material balance periodically during operations to ensure sufficient volumes for the rehabilitation needs - No permanent berms or water management on slopes - Landform surrounding the spoil dumps and voids to be reshaped to be free-draining where required to prevent impacts - Groundcover including vegetation to provide erosion resistance - Compliance to plan - Closure landform design, growth media and spoil assessment by Appropriately Qualified Person (APQ) to determine ameliorant and fertiliser requirements. - Duration of monitoring, over extended timeline to demonstrate success Mitigating Controls: - Monitoring of landform stability and rehabilitation success to be undertaken post-rehabilitation - Identify requirements for rectification works - Complete maintenance - Verified rehabilitation performance that already demonstrates criteria achievement (over time)	Minor	Possible	M6	- Growth media assessment by an AQP to determine ameliorant and physical treatment requirements - Landform designed for materials available onsite and what can be achieved based on their properties - PMLU selected based on what is most appropriate for landform and materials - Groundcover of vegetation and rock to provide erosion resistance - Rehabilitation monitoring and maintenance **Requires** '- Rehabilitation monitoring data - Materials inventory - AQP to undertake growth media assessment - Rehabilitation program - Rehabilitation monitoring and maintenance program	- Comparison against design - Tracking against milestone criteria	- Rehabilitation Monitoring
PMLU 2	Stable condition (safe, stable, non-polluting and sustainable) for land described as a PMLU (cattle grazing, woodland habitat, watercourse) is not achieved.	Altered hydrogeological conditions (to modelled/assumed conditions), based on interaction of groundwater with spoil dumps. (For all areas, excluding TSFs (PMLU12))	1. Release of contaminants to groundwater (percolation through spoil, or toe seepage interacting with shallow aquifer) 2. Change in groundwater flow, recharge and/or discharge characteristics resulting in changes to the hydrogeological system 3. Drawdown of groundwater due to void lakes acting as a sink due to losses associated with evaporation 4. Hydrogeologic conditions that are different to groundwater modelling outcomes	- Groundwater chemistry altered rendering it not suitable for extraction and/or to support PMLU - Groundwater quality not supporting the establishment/maintenance of Environmental Values and Water Quality Objectives for the basins in which the site is located - AMD reporting to shallow and deep groundwater systems - Reduction of groundwater height within surrounding extraction bores - Degradation of terrestrial and aquatic groundwater dependant ecosystems (GDEs)	Possible	Medium	M9	Note: All residual voids are sinks; would require a significant change to alter this to a source. Preventative Controls: - Regular, ongoing monitoring (re-assessing and calibration of groundwater model, resulting in refined design, as needed) (accounting for climate predictability) - Pre-defined backfill planning aligned to site-wide source-sink retention - Groundwater-related rehabilitation requirements and/or modelling to be aligned to site-wide mine planning - Mine-affected water dams to be decommissioned (including investigation for potential contamination and groundwater impacts). - Groundwater monitoring to be undertaken in accordance with EA conditions - Residual void catchments to be designed and created to establish sinks that provide for the collection of seepage from former operational areas and spoil dumps (maintenance of the void as a sink in perpetuity) - Appropriate management, placement, and monitoring of waste (spoil, tailings, rejects) during operations - Landforms constructed to minimise the potential for flooding of the residual voids - Groundwater condition assessment integrated into mine planning constraints Mitigating Controls: - Assessment and remediation of impacted material, where appropriate - Development and approval of a Site Management Plan to assist with ongoing management and restriction to future land use activities where appropriate - Implementation of management controls and monitoring programs outlined in an approved Site Management Plan - Re-establishment of impacted ecosystems - Decommissioning of impacted supply bores and re-instatement in suitable location	Minor	Unlikely	L4	- All imported hazardous materials are to be stored and used in accordance with relevant standards and removed from site on completion of mining - At the completion of operations, all stored hazardous materials and infrastructure within the MIA and CHPP, that have the potential to release contaminants to groundwater, will be appropriately recycled or disposed of - Contaminated land investigation to be undertaken at the completion of operations to identify contamination that has the potential to cause impacts to groundwater - Implementation of remediation and/or management plans as required to reduce potential groundwater impact risks - Mine affected water dams to be decommissioned (including investigation for potential contamination and groundwater impacts). - Groundwater monitoring to be undertaken in accordance with EA conditions - Appropriate management, placement, and monitoring of waste (spoil, tailings, rejects) during operations - Landforms constructed to minimise the potential for flooding of the residual voids **Requires** - Refined flood modelling - Waste characterisation data - Contaminated land investigation report - Remediation program (as required) - Groundwater monitoring program - Survey - Equipment capabilities - Stockpile managment during operations	- Operational EA condition for groundwater contaminant trigger levels	- Monitoring at defined frequency - Reporting under existing EA requirements
PMLU 3	Stable condition (safe, stable, non-polluting and sustainable) for land described as a PMLU (cattle grazing, woodland habitat, watercourse) is not achieved.	Alteration of surface water systems	1. Release of contaminants to surface water resources 2. Changes to alignments and ecosystems of drainage lines and creek 3. Changes to hydraulic flows 4. Changes to flood patterns/distribution 5. Alteration of surface water infiltration rates 6. Surface water flows over unvegetated/disturbed soils where revegetation has not re-established 7. Overland discharges from neighbouring landforms and rehabilitated areas 8. Creeks and drainage lines not attaining successful rehabilitated state	- Surface water chemistry altered rendering it not suitable for PMLU - AMD reporting to surface water - Degradation of ecosystems and land uses connected to surface water flows and floodplains on and down gradient of the mine - Sedimentation of downstream surface water drainage lines resulting in changes to their hydraulic properties and impacting ecosystems - Surface water quality not supporting the establishment/maintenance of Environmental Values and Water Quality Objectives for the basins in which the mine is located - Accelerated erosion rates from surface water flows in disturbed areas and degraded ecosystems - Reduction in rehabilitation success rates due to reduced surface water quality - Alteration of soil properties associated with contaminants carried by surface waters, including erodibility and geotechnical qualities	Likely	Medium	H12	Preventative Controls: '- All imported hazardous materials to be stored and used in accordance with relevant standards and removed from site on completion of operations - Mine affected water dams to be decommissioned and areas rehabilitated - Surface water monitoring to be undertaken in accordance with EA conditions - Monitoring of surrounding ecosystems will be undertaken in accordance with EA conditions - A contaminated land investigation will be undertaken at the completion of operations and remediation works undertaken as appropriate - Rehabilitation of disturbed areas will be undertaken as soon as possible after land becomes available - Rehabilitation and monitoring of disturbed reaches of creeks undertaken - Appropriate management, placement, and monitoring of waste (spoil, tailings, rejects) during operations - Landforms and creek diversions designed and constructed (AQP) to minimise the potential for flooding of the residual voids Mitigating Controls: '- Surface water monitoring data to be collected in accordance with the EA. If impacts are identified, further investigations will be undertaken to determine appropriate remedial measures - Any loss of hazardous contaminants that cause contaminated land/environmental harm will be reported and investigated/remediated as appropriate - Remedial works will be undertaken where releases from site result in impacts to surface waters, which may include alteration of the landforms, implementation of a Site Management Plan, implementation of additional controls/measures that reduce the potential for surface water impacts and/or re-establishment of impacted ecosystems where appropriate - Rehabilitated landforms and creek diversions/watercourses that do not attain a stable state to be repaired and revegetated	Medium	Unlikely	M6	- All imported hazardous materials to be stored and used in accordance with relevant standards and removed from site on completion of operations - Mine affected water dams to be decommissioned and areas rehabilitated - Surface water monitoring to be undertaken in accordance with EA conditions - A contaminated land investigation will be undertaken at the completion of operations and remediation works undertaken as appropriate - Rehabilitation of disturbed areas will be undertaken as soon as possible after land become available - Rehabilitation and monitoring of disturbed reaches of creeks undertaken - Appropriate management, placement, and monitoring of waste (spoil, tailings, rejects) during operations - Landforms constructed to minimise the potential for flooding of the residual voids **Requires** - Refined flood modelling - Remediation program (as required) - Groundwater and surface monitoring programs - Survey - Equipment capabilities - Stockpile managment during operations - Progressive rehabilitation program	Surface water milestone criteria and WQO	- Monitoring when surface water flows are available - Reporting under existing EA requirements

PMLU 4	Stable condition (safe, stable, non-polluting and sustainable) for land described as a PMLU (cattle grazing, woodland habitat, watercourse) is not achieved.	Creek diversion not achieving closure objectives	1. Hydrologic characteristics of surface water and groundwater systems not representative of natural reaches 2. Hydraulic characteristics not representative of natural reaches 3. Geomorphic instability (bank erosion) 4. Seepage to/from residual voids impacting on stability 5. Sediment transport regime is not in equilibrium with and/or representative of the natural reaches 6. Poor riparian vegetation diversity and cover 7. High percentage of weeds/ invasive species 8. Poor water quality from runoff from surrounding landforms and rehabilitated areas 9. Failure of landforms impacting the performance of the diversion 10. Failure of rehabilitation along creek diversion	- Sediment regime impacts within diversion and downstream reaches resulting in changes to hydraulic properties - Surface water chemistry altered rendering it not suitable for PMLU - Degradation of downstream ecosystems and land uses connected to surface water flows and floodplains - Surface water quality not supporting the establishment/maintenance of Environmental Values and Water Quality Objectives for the basins in which the mine is located - accelerated rates of erosion and instability within diversion embankments and surrounding the diversion causing landform instability, damage to rehabilitation areas and alteration of diversion hydraulics - changes to environmental flows and flood regimes impacting on surrounding land users and environmental receptors - Rehabilitation failure along length of creek diversion	Almost Certain	Medium	H15	Preventative Controls: '- Creek diversion monitoring to relevant IDC standard and maintenance during the operational phase - Diversion remediation designs in accordance with the DNRME 2019 hydraulic design criteria for permanent diversions - Growth media and spoil assessment by AQP to determine ameliorant and fertiliser requirements - Revegetation species aligned to growth media, landforms and PMLU - Mine infrastructure that interacts with the creek diversions during operations will be removed prior to closure (e.g. culverts) - Rehabilitation of surrounding landforms Mitigating Controls: - Rehab undertaken during dry season - Surface water monitoring data to be collected. If impacts are identified, further investigations will be undertaken to determine appropriate remedial measures - Rehabilitated landforms that do not attain a stable state to be investigated, repaired, revegetated and/or redesigned	Medium	Unlikely	M6	- Creek diversion remediation concept designs to be progressed to functional designs when rehabilitation of surrounding areas commences. - Construction of any remediation diversion channels in line with the final functional designs - Removal and remediation of any mine infrastructure that presents an unacceptable risk to the diversion attaining a relinquishable state (i.e. culverts and dams) - Rehabilitation of surrounding landforms - Surface water monitoring to be undertaken - Creek diversion monitoring to relevant IDC standard and maintenance to be undertaken **Requires** - Refined flood modelling - Rehabilitation program - Decomissioning plan - Surface monitoring programs - Survey - Landform design for creek diversion	- Watercourse geomorphic index and riparian vegetation index milestone criteria - Surface water (rainfall runoff) milestone criteria and WQO	- Creek diversion monitoring - Surface water quality data
PMLU 5	Stable condition (safe, stable, non-polluting and sustainable) for land described as a PMLU (cattle grazing, woodland habitat, watercourse) is not achieved.	Contaminated land impacting on environmental receptors, rehabilitation and attainment of PMLUs	1. Discharges and accumulation of hazardous contaminants (including emerging contaminants) from operational activities.	- Contaminants present within soil or water that present an unacceptable risk to the receiving environment or PMLU - Alteration of soil chemistry that impacts on structural characteristics - Contaminants reducing the soil suitability for rehabilitation species	Likely	Major	H16	Preventative Controls: '- Cleaning up of spills upon identification - Remediation or management of residual risk - Contaminated land investigation to be undertaken during operations and at closure and areas of contamination remediated and/or managed as appropriate - Ongoing surface water and groundwater monitoring providing an earlier indication of contamination - Management of operational activities to limit any potential contamination Mitigating Controls: '- Investigate and remediate contamination incidents - Implement a Site Management Plan to manage impacts, where required - Removal of primary or secondary sources - Restrict site usage - Undertake ongoing monitoring to manage contaminated land risks	Medium	Unlikely	M6	- Environmental monitoring and reporting as per the EP Act 1994 and existing EA requirements. - Contaminated land investigation at time of closure **Requires** - Contaminated land investigation report - Remediation program (as required) - Groundwater and surface water monitoring program	Attainment of surface water and groundwater milestone criteria and a site suitability statement	Contaminated land investigation report and reporting of water quality as per EA.
PMLU 6	Stable condition (safe, stable, non-polluting and sustainable) for land described as a PMLU (cattle grazing, woodland habitat, watercourse) is not achieved.	Flooding influences on rehabilitation of final landforms	1. Water inundation of landforms 2. Saturation of materials within landforms 3. Velocities of floodwaters on rehabilitated landforms 4. Inaccurate modelling 5. Fire	- Reduction in geotechnical stability of landforms causing failure of the landforms - Activation of dispersive materials resulting in accelerated erosion and sedimentation - Mobilisation of any contaminants contained within the landforms and impacts to downstream water and groundwater quality - Alteration of terrestrial ecology through introduction of weeds, sedimentation, or damage to rehabilitation species not able to withstand flooding - Erosion of landforms due to increased velocities of flood waters - Introduction of weeds and impacts to rehabilitation vegetation establishment	Possible	Major	H12	Preventative Controls: '- Removal of infrastructure from watercourses, decommissioning of dams and remediation of contaminated material where required - Design of landforms within flood extents that are stable and able to withstand flooding and water velocities - Establishment of vegetation suitable for the environment and reduces erosion risks - Flood modelling for 0.01% AEP informing landform design Mitigating Controls: '- Assessment of landform failure and required rectification works upon safe access to site immediately after the flood event. Assessment to include identification of measures that would limit potential for ongoing impacts. - Re-engineering of landforms to mitigate future failures followed by re-construction of landforms, and rehabilitation works. - Assessment of downstream impacts and undertake remediation/rehabilitation as required to re-establish drainage line hydraulics and ecosystems in liaison with the administering authority. - Monitoring of landform stability and rehabilitation success to be undertaken	Medium	Unlikely	M6	- Removal of infrastructure from watercourses, decommissioning of dams and remediation/management of contaminated material where required - Design of landforms informed by flood modelling, within flood extents that are safe and stable - Establishment of vegetation suitable for the environment and reduces erosion risks - Undertake monitoring for potential landform risks and undertake rectification works to attain PRC plan milestone criteria **Requires** - Refined flood modelling - Rehabilitation program - Decomissioning plan - Surface monitoring programs - Survey - Landform design - Rehabilitation monitoring and maintenance program	No flooding damage to landforms up to a 0.1% AEP event	Rehabilitation monitoring
PMLU 7	Stable condition (safe, stable, non-polluting and sustainable) for land described as a PMLU (cattle grazing, woodland habitat, watercourse) is not achieved.	Rehabilitated landforms result in alteration of flood hydrology upstream and downstream	1. Changes to drainage network hydraulics. 2. Artificial landforms reducing or increasing flood extent and changing velocities/flows. 3. Changes to vegetation cover and soil type which alter runoff and infiltration rates. 4. Environmental flows impacted due to incorrect runoff coefficients	- Increasing/decreasing of flood extents, frequency and severity - Degradation of ecosystems due to altered flows, flood extent, duration or frequency - Health and safety risks to on-site and off-site land users associated with increased flood heights, velocities and frequency	Rare	Medium	L3	Preventative Controls: '- Removal of infrastructure that would adversely interfere with stream hydraulics (culverts) and decommissioning of dams - Establishment of landforms that are stable and provide appropriate level of flood protection to the residual voids (0.1% AEP flood event (extremely conservative) - Undertake monitoring and maintenance works where required to maintain landforms - Landform design with consideration of water balance and catchment size - Reduction of catchment with landform and rehabilitation - Flood modelling for 0.01% AEP informing landform design Mitigating Controls: 'Due to the off-site nature of the impacts, which occur during significant flood events, available mitigating controls at the time of the impact are limited due to safety and accessibility restrictions. After flooding has receded, landform design and alteration could be undertaken to reduce possible future events.	Minor	Possible	M6	- Removal of infrastructure within watercourse alignments (e.g. culverts) that could adversely impact flows and decommissioning of dams - Landform design informed by flood modelling and establishment of landforms that are stable - Undertake monitoring and maintenance works where required to maintain landforms - Provide appropriate level of flood protection through landforms for the residual voids **Requires** - Refined flood modelling - Rehabilitation program - Decomissioning plan - Surface monitoring programs - Survey - Landform design - Rehabilitation monitoring and maintenance program	No unacceptable damage to infrastructure or ecosystems as a result of final landform.	No reporting or monitoring requirement
PMLU 8	Stable condition (safe, stable, non-polluting and sustainable) for land described as a PMLU (cattle grazing, woodland habitat, watercourse) is not achieved.	Insufficient or inappropriate growth media and rock resources required for rehabilitation activities	1. Insufficient growth media and rock quantities of suitable quality 2. Unstable material (erosive, dispersive, saline materials) 3. Weed infestation (soil is already infested with weed seeds) 4. Insufficient placement depth and surface treatment 5. Incorrect soil and rock characterisation and amelioration 6. Inappropriate topsoil and rock stockpiling and management	- Erosion - Growth media loss - Topsoil deficit - Failure of vegetation (poor vegetation growth or incorrect vegetation affecting PMLU)	Likely	Catastrophic	C20	Controls: '- Topsoil surveys and mapping - Review the topsoil, growth media and rock resource quantities periodically during operations to ensure sufficient volumes for the rehabilitation needs. - Undertake rehabilitation planning and preparation in accordance with the requirements for growth media, rock, seed and management for the PMLU - Management of topsoil and rock stockpiles and application during rehabilitation. - Growth media assessment by suitably qualified person to determine use of ameliorant and fertiliser requirements. - Amelioration and fertiliser applied as per assessment - Selective handling of materials for placement - Compliance to plan Mitigating Controls: '- Monitoring of growth media and landform stability and rehabilitation success to be undertaken post rehabilitation to confirm stability and identify requirements for rectification works. - Repair erosion areas, retest growth media and revegetate.	Medium	Unlikely	M6	- Management of topsoil and rock stockpiling - Management of rehabilitation material application - Review of the growth media and rock resource quantities periodically during operations - Growth media assessment by suitably qualified person to determine ameliorant and fertiliser requirements - Application of ameliorants and fertilisers as per assessment - Rehabilitation monitoring and maintenance **Requires:** '- Topsoil inventory - Burden model - Survey - Equipment capabilities - Rehabilitation monitoring data - AQP to undertake growth media assessment	Tracking against milestone criteria	Rehabilitation monitoring

PMLU 9	Stable condition (safe, stable, non-polluting and sustainable) for land described as a PMLU (cattle grazing, woodland habitat, watercourse) is not achieved.	Inadequate and/or inappropriate management of mineral waste	1. Inadequate or incorrect geochemical characterisation and assessment of landform materials. 2. Management strategy adopted was inadequate or inappropriate to manage the AMD hazards of the waste materials. 3. Incorrect or inappropriate placement of adverse material in landform. 4. Poor final landform execution (e.g. poor/incorrect landform reshaping, resulting in exposure of adverse material)	- Contamination of surface water and/or groundwater by AMD or other contaminants. - Impact to flora (vegetation failure) - Impact to fauna (aquatic)	Possible	Catastrophic	H15	Mitigating Controls: '- Monitoring of growth media and spoil to be undertaken post rehabilitation to confirm stability and identify requirements for rectification works. - Rehabilitation maintenance and/or corrective actions - NUMAs are acting as sinks for groundwater - Spoil materials have buffering capacity (high neutralising ANC) - Post-capping QA/QC Preventative Controls: '- Material characterisation (outcomes to be stored into GeoBank) in line with Whitehaven Materials Standards - Remove and / or cover undesirable materials - Sampling of course and fine rejects from processing plant - Sampling of overburden / Interburden - Appropriate material placement and selective handling during operations - Management of operational activities to limit any potential contamination - Appropriate water quality monitoring for surface and groundwater to enable tracking of processes affecting water quality during operation and into closure - Undertaking appropriate fate and transport modelling during operations	Major	Unlikely	M8	- Waste characterisation during operations - Surface and groundwater monitoring during operation - Ongoing sampling during operations - Reject material appropriately placed in spoil dumps. - In-situ geochemical monitoring of landforms - Rehabilitation monitoring and maintenance **Requires** '- Data from waste characterisation - Mineral waste sampling data - Rehabilitation monitoring data - Surface and groundwater monitoring data - In-situ geochemical monitoring data	- Rehabilitation monitoring - Waste characterisation sampling and analysis - Surface and groundwater monitoring	- Throughout operations to final achievement of PMLU
PMLU 1	Stable condition (safe, stable, non-polluting and sustainable) for land described as a PMLU (cattle grazing, woodland habitat, watercourse) is not achieved.	Inadequate and/or inappropriate revegetation	1. Unfavourable climatic conditions and/or weather events 2. Incorrect species mix 3. Poor seed quality 4. Weed contaminated seed 5. Poor quality growth media or seed bed preparation 6. Erosion 7. Land contaminants	- Exposed soils due to poor vegetation establishment and growth, resulting in enhanced erosion rates. - Increased weed establishment and growth. - Reduction in land capability of PMLU (woodland habitat and/or grazing) - Need for ongoing corrective action - soil sampling and analysis, amelioration and re-vegetation.	Possible	Medium	M9	Preventative Controls: '- Growth media and spoil assessment by AQP to determine ameliorant and fertiliser requirements. - Management of seed selection, provenance and quality. - Plant at optimal time of year. - Revegetation species aligned to growth media, landforms and PMLU Mitigating Controls: '- Monitoring of landform stability and rehabilitation success to be undertaken post operations to confirm stability and identify requirements for rectification works. - Repair erosion areas, retest materials, review seed mix and revegetate.	Medium	Unlikely	M6	- Growth media assessment by suitably qualified person to determine ameliorant and fertiliser requirements for the PMLU - Management of seed selection, provenance and quality - Rehabilitation monitoring and maintenance **Requires** '- Rehabilitation monitoring data - Seed - AQP to undertake growth media assessment	Tracking against milestone criteria	Rehabilitation and reference site monitoring
PMLU 1	Stable condition (safe, stable, non-polluting and sustainable) for land described as a PMLU (cattle grazing, woodland habitat, watercourse) is not achieved.	Failure of TSF rehabilitation	1. Geotechnical instability including foundation failure and slope failure 2. Geochemical instability including AMD affected seepage to surface and groundwater, ineffective cap or cover and recharge from surrounding landform 3. Erosional instability including surface water quality to receiving environment not meeting target criteria, failure of vegetative cover and ineffective erosion protection elements	- Contamination of surface and groundwater sources - Failure of achievement of PMLU - Loss of containment causing potential Injury to people in the failure impact zone - Contamination of surface and groundwater sources - Financial cost of rectification and remediation	Likely	Major	H16	Controls: '- Ongoing periodic monitoring by suitably qualified persons to ensure alignment with rehabilitation milestones and PMLU requirements - Remediation works where evidence through ongoing monitoring suggests that PMLU requirements may not be achieved - Surface and groundwater monitoring - In situ geochemical monitoring Mitigating Controls: '- Response (maintenance, remediation, increased monitoring, notification to any affected stakeholders) to performance indicators not being met.	Major	Unlikely	M8	- Rehabilitation monitoring and maintenance - Corrective actions, if identified as being needed **Requires** '- Monitoring program - Maintenance and remediation where rehabilitation outcomes do not meet planned performance criteria	- Comparison against design - Tracking against milestone criteria	As per the PRCP schedule
PMLU 1	Stable condition (safe, stable, non-polluting and sustainable) for land described as a PMLU (cattle grazing, woodland habitat, watercourse) is not achieved.	Failure of TSF cover (NCPP TSF)	1. Inadequate cover placement 2. Inappropriate cover material 3. Inadequate cover design 4. Cover doesn't function as designed 5. Cover deterioration over time	- AMD seepage impact on surrounding water values - AMD seepage resulting in vegetation dieback	Likely	Medium	H12	Preventative Controls: '- Cover design based on trials - Material characterisation - Water balance and groundwater modelling - Seepage containment system as required - Monitoring of the cover after significant rainfall during operation of the mine Mitigating Controls: '- Groundwater monitoring with TARP '- Surface water monitoring with TARP -	Medium	Unlikely	M6	- Undertake a preliminary contaminated land assessment prior to the completion of the approved activities, conduct a detailed site investigation and develop remediation plan if required - Rehabilitation monitoring and maintenance **Requires** '- Rehabilitation monitoring data - SQP to undertake contaminated land investigations and oversee on-going monitoring requirements	- Tracking against remediation and management of contaminated land milestone criteria	Rehabilitation monitoring
PMLU 1	Stable condition (safe, stable, non-polluting and sustainable) for land described as a PMLU (cattle grazing, woodland habitat, watercourse) is not achieved.	Deterioration of built infrastructure conditions	1. Potential soil contamination around mine industrial areas	- Reduced soil fertility to support PMLU land capability - Potential contamination of surface water runoff affecting integrity of local catchments	Possible	Medium	M9	Preventative Controls: '- Clean up and remediate contamination during operational period. - Undertake contaminated land assessment and remediation/management where required post mining Mitigating Controls: '- Undertake a preliminary contaminated land assessment prior to the completion of the approved activities, identify if any areas require a further Detailed Site Investigation and remediation plan developed if required. - Conduct ongoing maintenance	Medium	Unlikely	M6	- Undertake a preliminary contaminated land assessment prior to the completion of the approved activities, conduct a detailed site investigation and develop remediation plan if required - Rehabilitation monitoring and maintenance **Requires** '- Rehabilitation monitoring data - SQP to undertake contaminated land investigations and oversee on-going monitoring requirements	- Tracking against remediation and management of contaminated land milestone criteria	Rehabilitation monitoring
NUMA 1	NUMA does not achieve safe, structurally stable condition or causes environmental harm	Void walls do not achieve geotechnical stability	1. Geotechnical instability 2. Increase/decrease in predicted void water levels 3. Use of inaccurate geological model (geotechnical parameters) 4. Poor low-wall and high-wall design (compliance to plan) 5. Erosional instability 6. Not dug to design	- Failure of void walls leads to instability beyond NUMA extent	Unlikely	Major	M8	Preventative Controls: '- Geotechnical assessment to be completed by AQP - Wall designs based on geotechnical assessment. - Pit floor treatments as required during operations to improve low-wall stability. - Geotechnical monitoring during operations. - Updated geotechnical assessment to be completed as mining approaches final limits and wall design and NUMA extent adjusted if required. - NUMA extents designed to include the required factor of safety (FoS) limit. - Bunding, fencing and signage placed at FoS limit. Mitigating Controls: '- Geotechnical monitoring - Identify requirements for rectification works.	Medium	Unlikely	M6	- Geotechnical assessment to be completed by an appropriately qualified person - Wall designs based on geotechnical assessment. - Pit floor treatments as required during operations to improve low-wall stability. - Geotechnical monitoring during operations. - Updated geotechnical assessment to be completed as mining approaches final limits and wall design and NUMA extent adjusted if required. - NUMA extents designed to include the required FoS limit. - Bunding, fencing and signage placed at FoS limit. **Requires** - Geotechnical assessment	Tracking against milestone criteria	Geotechnical Monitoring
NUMA 2	NUMA does not achieve safe, structurally stable condition or causes environmental harm	Uncontrolled access to NUMA	1. Inappropriate design, management and construction of safety bund 2. Inadequate/poorly maintained fencing and signage	- Unmanaged access to NUMA by people or livestock	Possible	Major	H12	Preventative Controls: '- Safety bund, fencing and signage placed at FoS limit, where required. Mitigating Controls: '- Compliance checks as part of monitoring	Negligeable	Unlikely	L2	- Safety bund, fencing and signage placed at FoS limit where required to restrict access **Requires** - Monitoring and maintenance	Tracking against milestone criteria	Document visual inspection

NUMA 3	NUMA does not achieve safe, structurally stable condition or causes environmental harm	Uncontrolled flooding into residual voids	1. Flood mitigation (backfill and/or landforms) is not constructed or installed correctly, or included as part of future mine planning 2. Inaccurate flood modelling	- Uncontrolled capture of flood waters - Altered/changed alignment of creeks and drainage lines - Removal of downstream environmental flows - Filling of residual void with water and interconnecting groundwater units - Geotechnical instability of residual void - Contamination of clean surface water flows, within residual void - Contamination of groundwater resources	Rare	Major	L4	Preventative Controls: '- Flood modelling completed by AQP - Flood mitigation designed to correct flood event and outside of the predicted failure slope assessed with a suitable factor of safety - Regular, ongoing monitoring (re-assessing and calibration of groundwater model, resulting in refined design, as needed, accounting for climate - Flood mitigation (partial backfill and/or landforms) Mitigating Controls: '- Compliance checks as part of monitoring - Review flood modelling following flood events to refine model	Minor	Unlikely	L4	- Flood modelling completed by an AQP - Flood mitigation (partial backfill and/or landforms) designed to correct flood event - Flood mitigation installed **Requires** - Flood modelling	Tracking against milestone criteria	Document visual inspection
NUMA 4	NUMA does not achieve safe, structurally stable condition or causes environmental harm	Water in the void causes environmental harm outside of the mining tenure (due to pit lake)	1. Groundwater outflow seepage not identified by groundwater modelling 2. Poor water quality 3. Overtopping or interconnection of the void lake with shallow groundwater water units	- Reduction in surface and/or groundwater quality down gradient of the site - Degradation of ecosystems interacting with impacted water - Changes to the chemistry of shallow groundwater units - Groundwater extraction/use off site impacted	Likely	Minor	M8	Controls: '- Modelling completed by AQP - Catchment area minimised where possible and practical to do so - Flood mitigation (partial backfill and/or landforms) designed to provide protection for a 0.1% AEP event - Groundwater quality and level monitoring - Water quality monitoring - Containment of potential sediment as a result of erosion from the low-wall within the residual void Mitigating Controls: '- Rectification works on impacted ecosystems or bores - Installation of engineering controls to limit potential for ongoing impacts	Medium	Unlikely	M6	- Modelling completed by an AQP - Flood mitigation designed to provide protection for a 0.1% AEP event - Groundwater quality and level monitoring until relinquishment - Water quality monitoring **Requires** - Groundwater and void lake water balance modelling	Tracking against milestone criteria	Groundwater level and quality monitoring Water quality monitoring

Whitehaven

Appendix 4.16 – Underground Geotechnical Considerations

BYRNES GEOTECHNICAL

BMA

Geotechnical considerations for closure of underground mines at BMA Blackwater.

REPORT: BMA-10 BLACKWATER PRCP

Date: 11/03/2024

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Executive Summary

The purpose of this report is to fulfill the requirements of the PRCP guideline pertaining to UG mines and identifies geo-technical hazards and provides recommendations which are secondary to any requirements under Queensland mining legislation.

Most of the workings in Laleham and Kenmare should now be in a stable condition given that the end of underground mining was more than 20 years ago. There is a negligible hazard of pot-hole subsidence in the future.

Surface damage in the form of rib parallel tensile cracking is present above both Laleham and Kenmare. The cracks are typically 200 mm wide and several metres deep. Where Quaternary sediments are present at the surface, the cracking that developed during pillar extraction at Laleham has been naturally remediated by slumping associated with rainfall.

The portal entries for Sirius Creek No 2 and Clutha should be rehabilitated by removing the existing steel sets and lagging boards and then backfilling. No earth works are recommended for Sirius Creek No 1.

These recommendations are provided for the purpose of planning closure and rehabilitation of Blackwater mines and further and more specific guidance is to be obtained to the specific areas/mines before conducting any operational activities which may be required as a part of these closure recommendations.

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1 Introduction

The guidelines for Progressive Rehabilitation and Closure Plans (PRCP) as they relate to underground mining require a geotechnical study that must include:

- an assessment of post closure stability of the workings
- proposed methods for sealing-off of surface access to the workings
- the extent of post-closure subsidence
- subsidence modelling to inform rehabilitation strategies and milestones.

The long-term closure impacts are primarily changes in surface topography. Most of these will develop within 1-2 years after mining and need to be considered for progressive rehabilitation.

After mining there will be recovery of the groundwater levels as the ground water stabilises back into the underground voids and reaches equilibrium. This will then represent a significant change in the geotechnical environment within the underground workings and may lead to additional deformations at the surface.

This report has been compiled for the use within the PRCP and presents the underground related geotechnical issues that require consideration for the legacy and abandoned underground mines within the Blackwater Mine operations.

There are multiple underground mines located within the Blackwater mining leases, all of which were never operated by BMA (Figure 1). They are located within the area known as “South Blackwater” and include:

- Kenmare 1 & 2.
- Laleham Mine.
- Sirius Creek No 1 & No 2.
- Ballamoo Mine.
- Clutha Trial Mine.

The area known as the Clutha trial mine in this report has been known under many names in the history of the site. For all purposes in this document, it will be maintained as Clutha Trial mine.

The operations that resulted in surface subsidence are Kenmare (longwall) and Laleham (bord and pillar and pillar extraction). Both mines extracted coal from the Aries Seam and the underlying Pollux Seam (Figure 2).

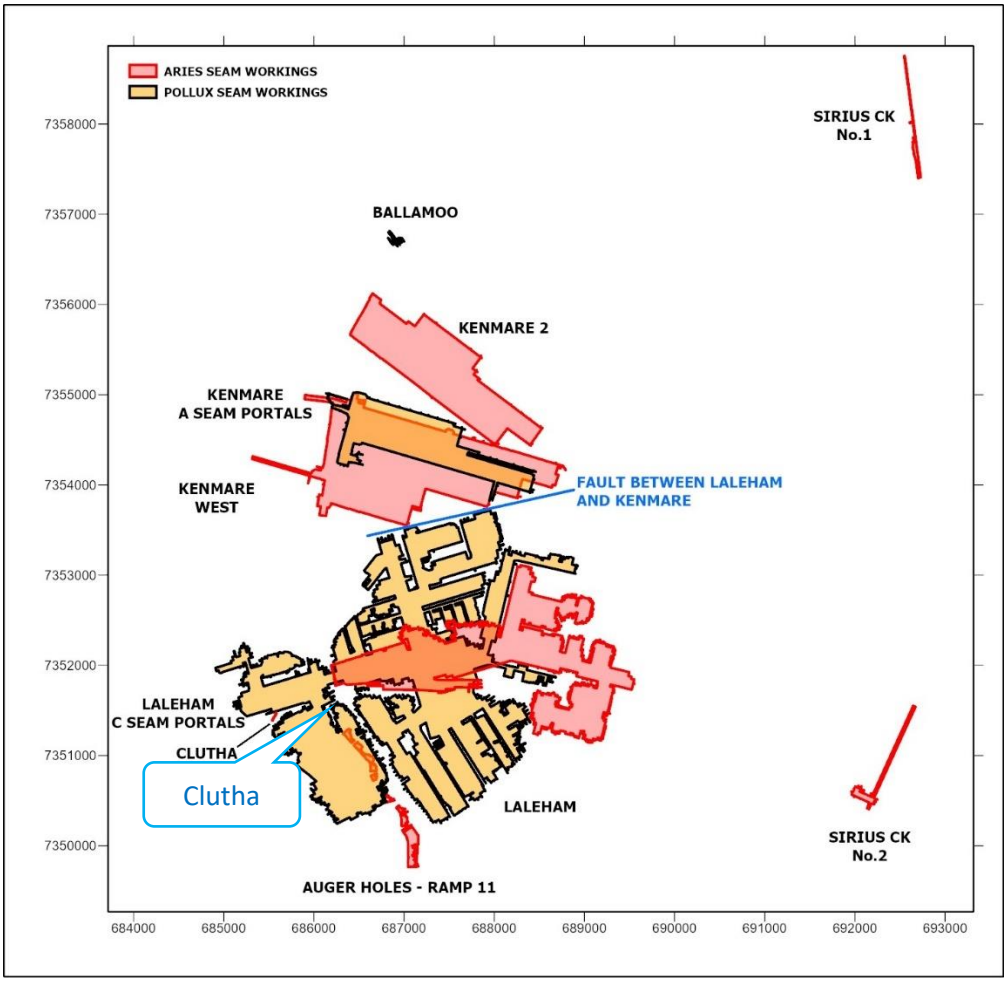


Figure 1 Mine plans for Laleham and Kenmare undergrounds.

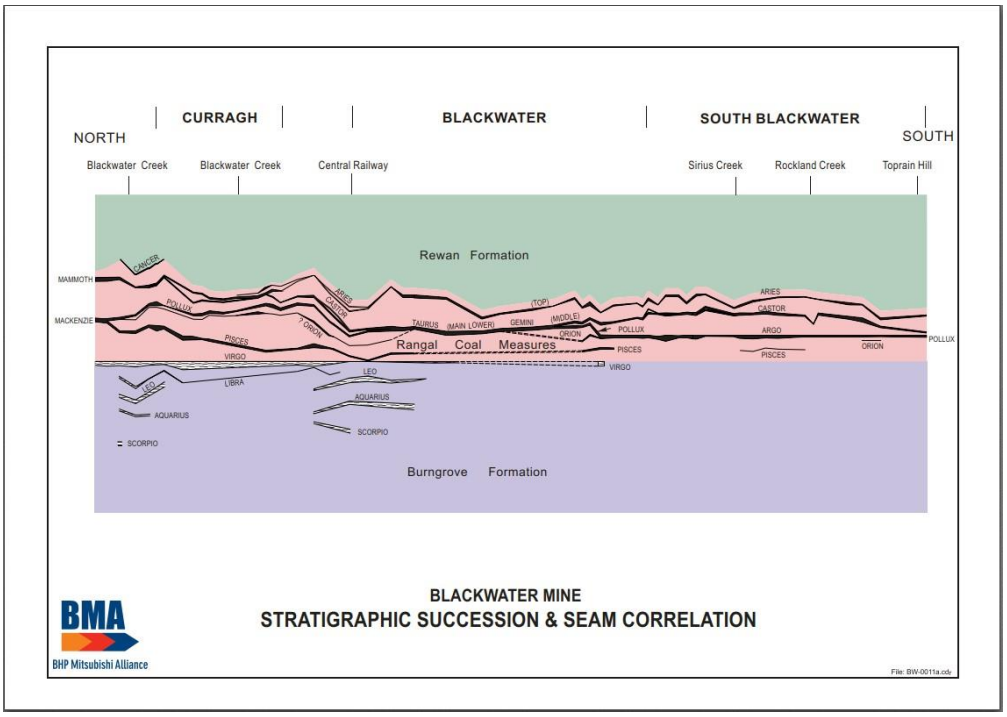


Figure 2 Seam Correlation Diagram of Blackwater Area.

2 Surficial geology

The impact of mine subsidence deformations on post-mining land use depends in part on the nature of the geological materials at the surface. Maps of the surface geology/soils (Figure 3 and Figure 4) indicate the presence of 5 different units.

- Qrc – Quaternary, colluvium and or residual deposits, talus, scree, sheet wash, boulder, gravel, sand.
- Czl – Cainozoic, Ferruginous duricrust, laterite, may include massive to pisolitic subsoil, mottled clays.
- Czoem – Eocene, Emerald Formation – fluviatile and lacustrine claystone and siltstone, quartzose sandstone, pebbly sandstone, gravel, lignite, oil shale, interbedded basalt, all deeply weathered.
- Rsr – Triassic Rewan Group, Lithic sandstones, green to reddish brown mudstone.
- Pok – Permian Blackwater Group, coal measures.

The ability for subsidence cracks to "self-heal" after rainfall depends on the surface geology and topography. It has been observed throughout BMA sites that where there is a loose surface soil, it becomes more easily rehabilitated and soil can settle into the cracks naturally during rain events. However, where there is a duricrust or rock at the surface (for example Czl), it is less likely that natural self-healing will occur over time, and the rain may increase the erosion risks in these areas.

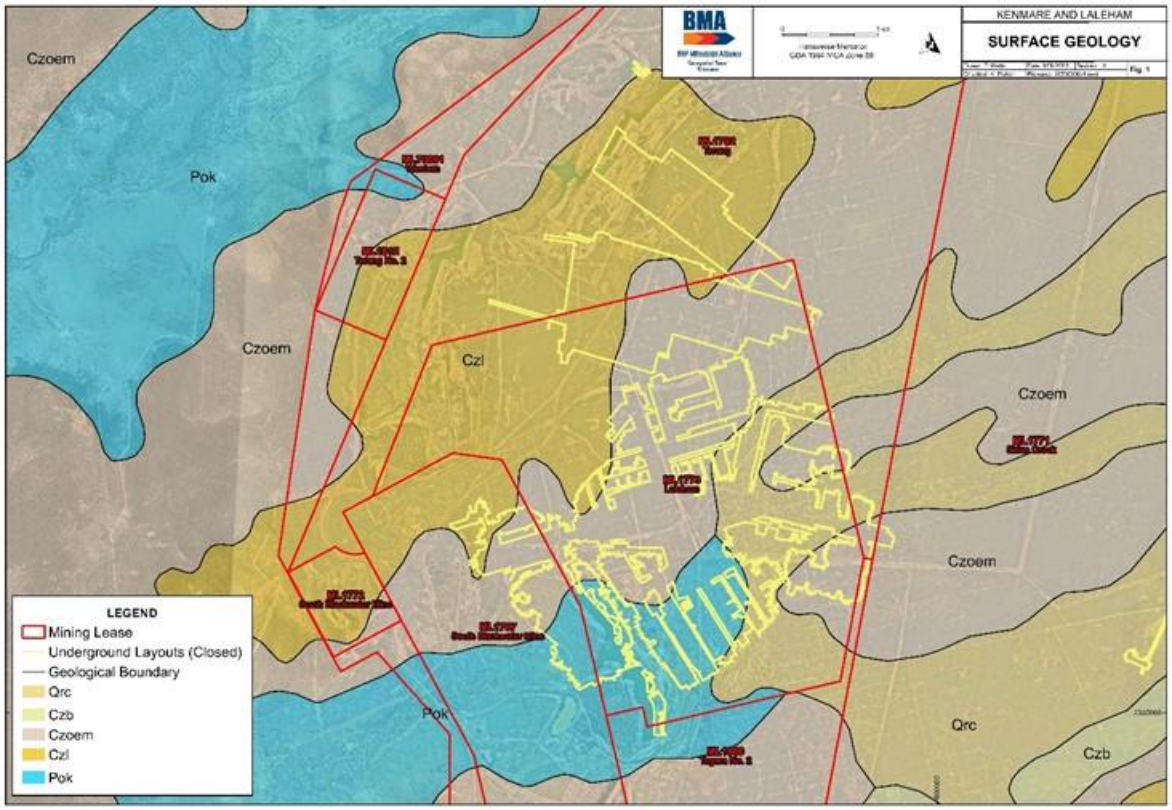


Figure 3 Surface geology – Laleham and Kenmare.



Figure 4 Surficial geology - Sirius Creek No 1 No 2.

3 Underground Mining Operations

A number of different underground mining methods were utilised at BWM:

- Kenmare 1 & 2 – Longwall
- Laleham Mine – Pillar extraction and bord and pillar
- Sirius Creek No 1 & No 2 – Bord and pillar
- Ballamoo – Bord and pillar (headings only)
- Clutha Trial Mine – (single 80m heading in Laleham area)

3.1 Longwalls

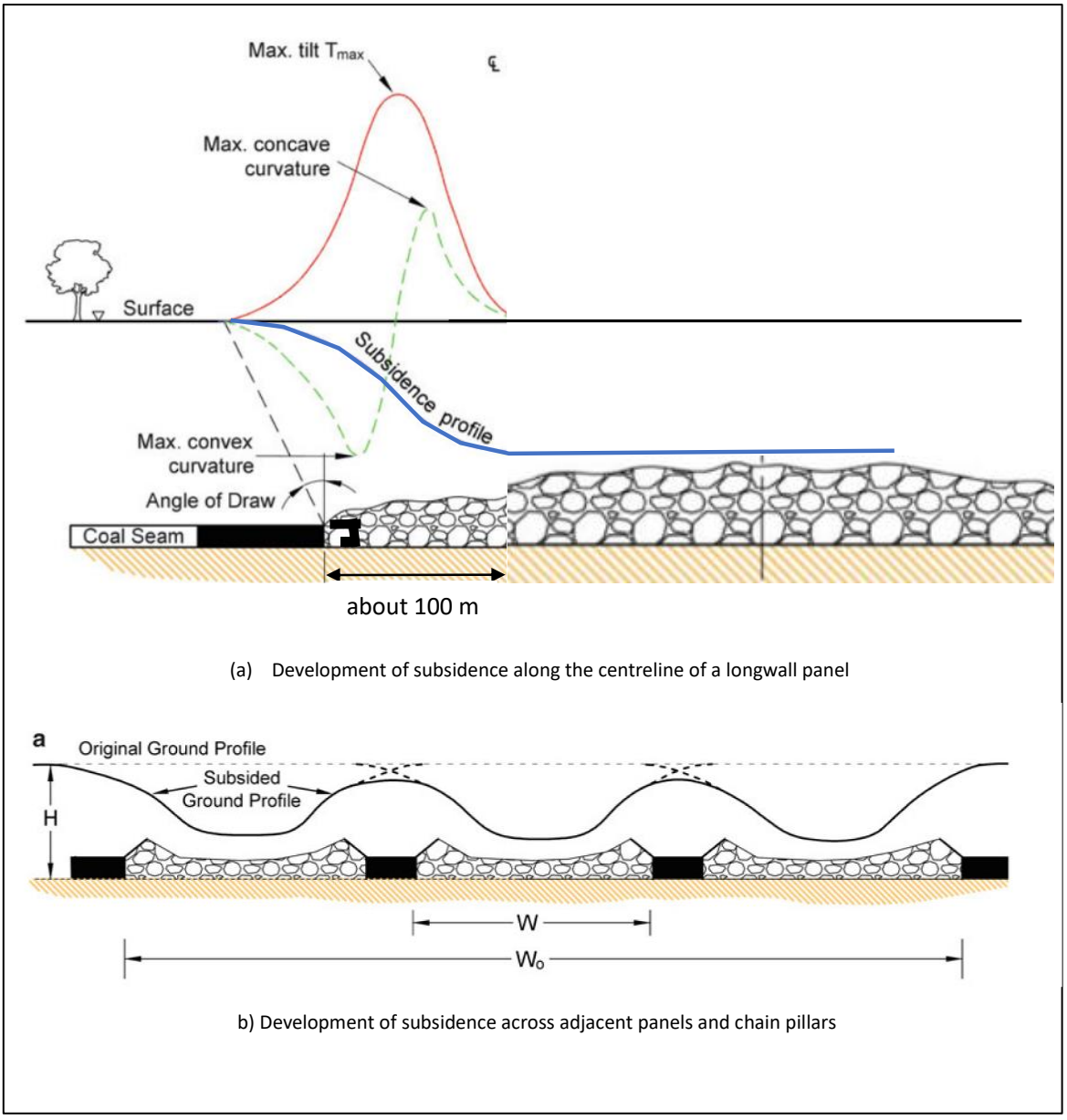
3.1.1 General comments

Inherent in safe and productive longwall mining is the collapse of the rock mass above the extracted coal. This collapse may extend to the surface if the width of the extraction relative to the depth of mining exceeds about 0.5. The width:depth ratio for the Kenmare longwall mine means that substantial vertical subsidence developed progressively as the longwall retreated. Maximum subsidence likely developed above the extraction within about 100 m of the retreating face, there would also have been a lesser amount of vertical subsidence above the chain pillars that developed independently of that above the extraction (Figure 5).

When the underground workings are flooded there may be a small amount of additional vertical subsidence related to the softening of the caved rock above the extracted coal in the presence of water. This flooding can occur as a direct result of the mine being purposefully flooded, or over time as the ground water recovers from dewatering. The subsidence above the chain pillars is unlikely to increase when the groundwater recovers.

The situation with the mains pillars and roadways is different. These are designed to be stable during the operations – both in terms of roof collapse in the roadways and stability of the pillars. Over time, the roof will likely collapse as the support/reinforcement steel members degrade either in the humid mine air or as the mine floods. The possibility that such collapses could extend to the surface at

shallow depths of cover needs to be considered. The mains pillars are typically designed with high stability factors such that failure over the long term is unlikely. Flooding of the mine may temporarily reduce the stability of the pillars, but eventually their stability will be increased due to a buoyancy effect reducing the loads on the pillars.



(a) Development of subsidence along the centreline of a longwall panel

b) Development of subsidence across adjacent panels and chain pillars

Figure 5 General nature of longwall subsidence[1].

3.1.2 Kenmare

Underground drivEage at Kenmare, accessing the Aries Seam from South Blackwater Ramp 66 South, began in November 1994 and the first longwall panel was extracted between November 1996 and April 1997. Longwall panels were about 203 m wide (Figure 6).

Based on discussions with previous mining and geotechnical engineers based at the underground mines prior to abandonment, there was a large amount of historical monitoring information regarding subsidence above both Laleham and Kenmare. However, it is unable to be located, and

[1] Galvin JM 2016. Ground Engineering: Principles and Practices for Underground Coal Mining. Springer.

hence no subsidence information can be used to validate subsidence predictions. This is not seen as a limitation to a Blackwater PRCP as the major identified hazard is subsidence cracking and the predictions are adequate to locate areas of interest. Some information on rock strengths from the Kenmare operation is available for use[2], but it is minimal.

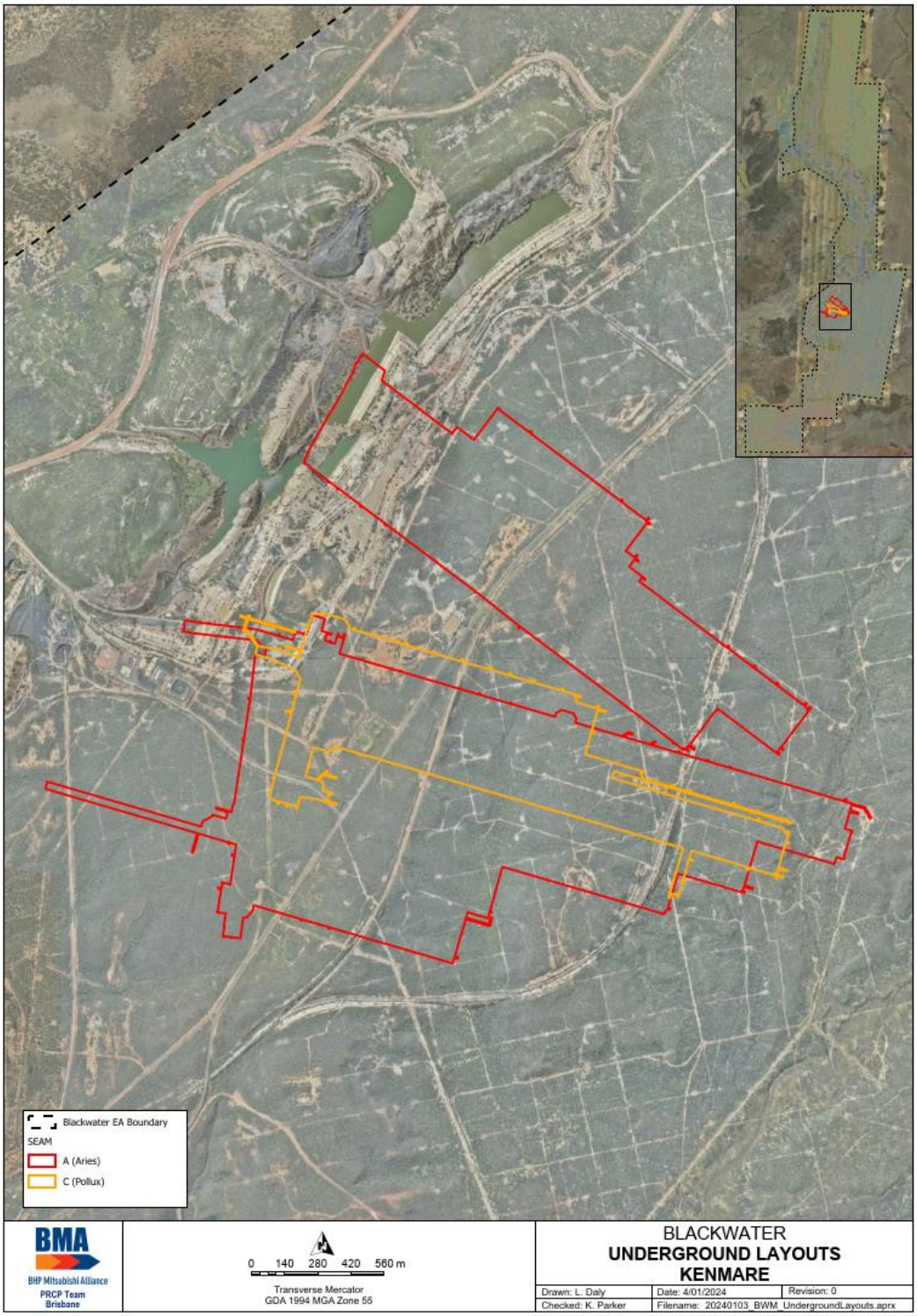


Figure 6 Layouts of longwall extraction by mined seam (insert shows location relative to lease boundary).

[2] Coutts, R. 2001. Kenmare2 - Longwall2, Hazard management exploration programme, Results of Phase 1 & 2

3.2 Pillar extraction mines

3.2.1 General comments

Legacy pillar extraction mines have mains pillars designed similarly to those for longwalls and also have some areas where pillars may have lesser stability and some areas where the pillars have been extracted. Where the pillars have been extracted surface subsidence may have developed in the same way as for longwalls. There is a possibility that in some areas where the pillars have been extracted the extracted width was insufficient to cause complete subsidence to the surface – such areas may collapse over time.

There may be cases where very high/narrow pillars were formed during the extraction operation resulting in pillars with low stability and the possibility of collapse within a 100-year time frame. Whether such a collapse could extend to the surface needs to be examined.

3.2.2 Laleham

At Laleham, pillar extraction was conducted in the Pollux Seam and only bord and pillar operations were conducted in the Aries Seam (Figure 7).

The Laleham underground bord and pillar mine began in the Pollux Seam in 1969 and was accessed by two drifts, approximately 150 m long. Various methods of pillar extraction were carried out, mostly using timber as ground support, but towards the completion of mining in the Pollux Seam, breaker line supports (BLS) were utilised in a Wongawilli layout (Figure 8) which results in a layout somewhat analogous to a longwall.

At around the same time that Kenmare began operations, Laleham accessed the Aries Seam with an interseam drift from the Pollux Seam and successfully mined several bord and pillar panels using place-change development systems with no pillar extraction.

3.3 Bord and pillar mines

Legacy bord and pillar mines such as the Sirius Creek operations (Figure 9) can be considered in the same context as mains pillars in the longwall mines with regards to stability.

Flooding of the bord and pillar workings will have the same effects as for longwalls.

3.3.1 Sirius Creek Mines

Sirius Creek No 1 (Figure 10a) was a 900 m single entry until it intersected the Aries Seam at about 300 m depth where a line of 18 m wide pillars were formed. Being a single row of pillars, their stability is very high – it is assessed that these will never collapse and there will be no associated surface subsidence.

Sirius Creek No 2 (Figure 10b) utilised 2 of 6 m wide roadways with a 15.2 m wide pillar until it intersected pit bottom at about 200 m depth, at which point pillars were formed on 30 m centres (24 m solids). The limited lateral extent of the pillars, together with their width means that they have high levels of stability – it is assessed that these will never collapse and there will be no associated surface subsidence. The site inspection revealed a pothole has developed through the fill material placed above the original portal canopy.



Figure 7 Underground mining by seam at Laleham.

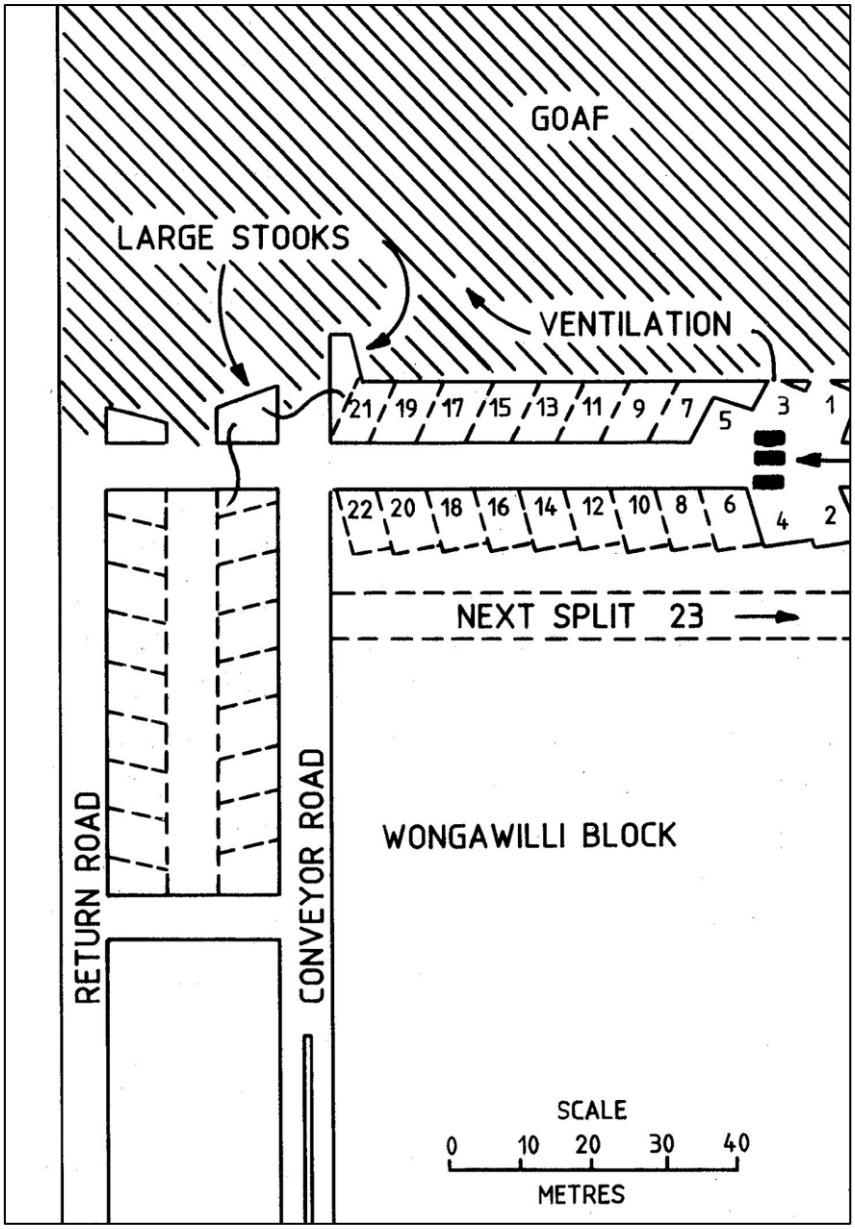
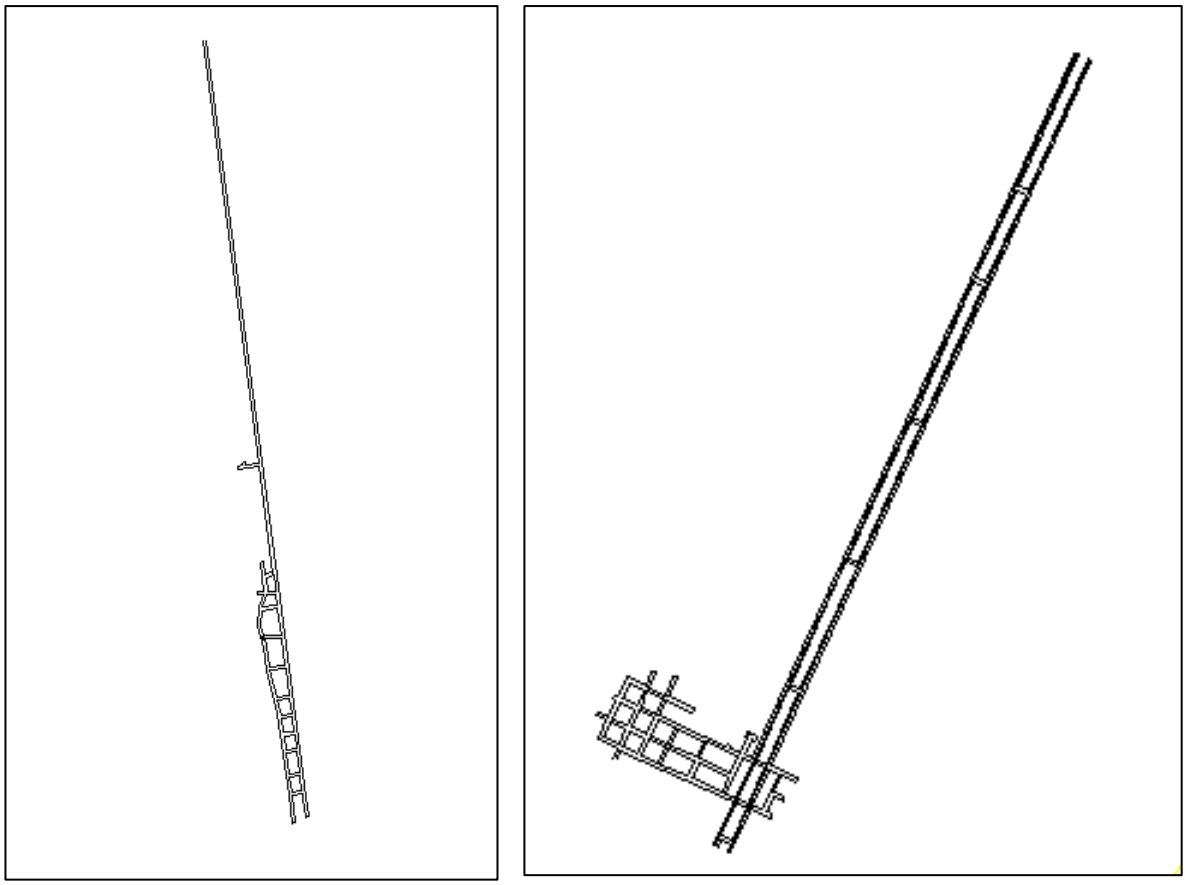


Figure 8 Plan view image of a Wongawilli pillar extraction layout with double sided lifting and BLS units (source Galvin: op. cit.).



Figure 9 Underground layouts by seam for Sirius Creek Undergrounds.



Sirius Creek No 1 Sirius Creek No 2

Figure 10 a) Layouts for Sirius Creek No 1 (pit bottom at 320 m depth) and b) No 2 (pit bottom at 200 m depth).

3.3.2 Ballamoo Mine

The Ballamoo mine extended about 190 m from the Ballamoo highwall and involved 5 headings: no pillars were formed (Figure 11). The headings were located on 30 m centres with 7 m wide roads. The current closure plan is that they will be buried with backfill. The maximum mining depths were in the order of 50 m, no pillar instability is anticipated even when they are buried by backfill.

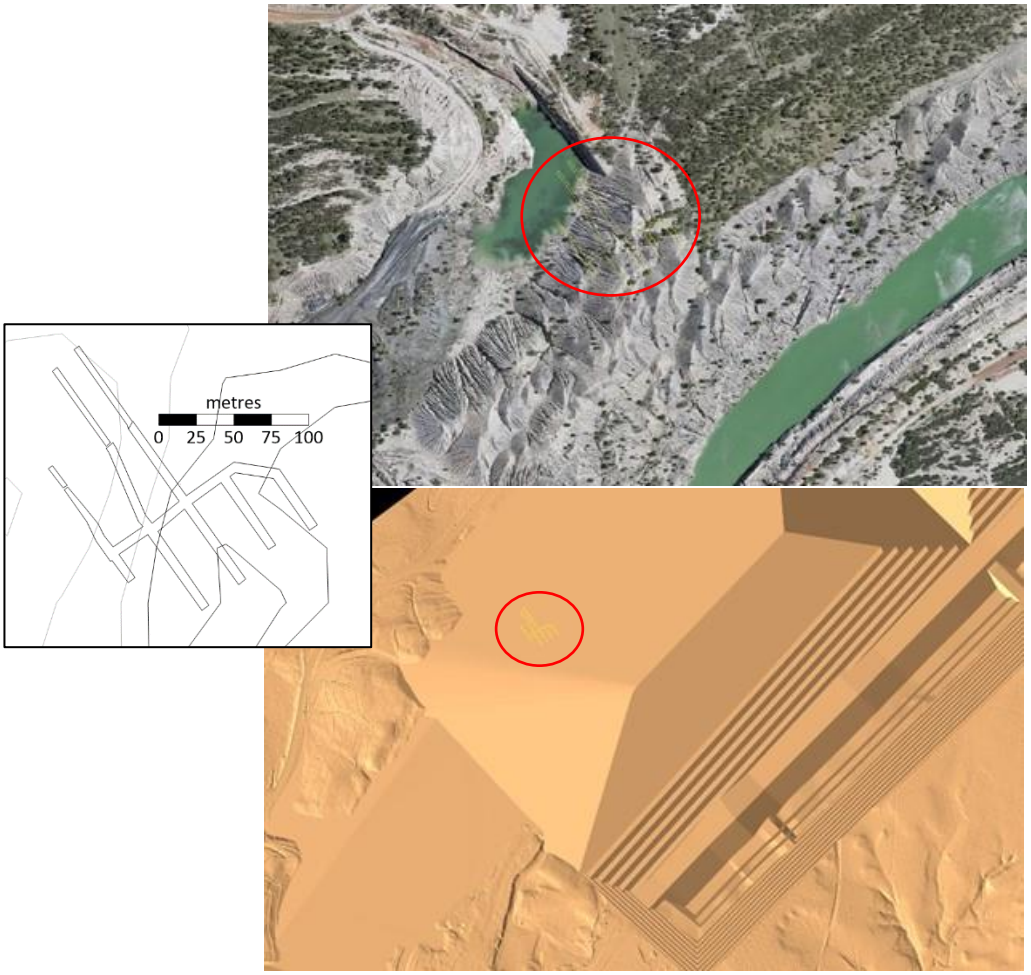


Figure 11 Ballamoo pit and underground workings will be buried by backfill.

4 Stability assessment

An assessment of the current and ongoing stability of the underground workings is critical to understanding the subsidence risk at closure. Specifically, there is a need to consider possible impacts on the post mining land use related to further pillar collapse or further roof collapse.

For operational reasons the pillars in the main access roadways (Mains pillars) were designed with high levels of stability and a design life in excess of 50 years. Typically, Mains pillars are dimensioned with a factor of safety in excess of 2.0 and there is an industry conjecture that the probability of failure is better than 1:1 000 000. It is valid to conclude that these Mains pillars have not and will not collapse.

In both legacy pillar mines and the longwall mines there are pillars that were designed to collapse as an integral part of the mining system, for example longwall chain pillars and some pillars in pillar extraction mines. These will have already collapsed and any associated surface subsidence developed.

There are also pillars that have intermediate levels of stability. Typically, during mining operations the heuristics applied to pillar stability relate to a ratio of pillar strength: pillar load. Typical thresholds used for mine design are presented in Table 1:

Table 1 Pillar stability thresholds

Stability	Factor of Safety	Implied probability of collapse within a nominal 50-year periods
Immediate collapse	<1.0	1:1
Short term	>1.2	1:10
Pillar formed on advance	>1.6	1:1 000
Long term	>2.11	1:1 000 000

It is important to emphasise that these factors of safety are derived from a statistical analysis of small databases (n<100) in which there are no collapse cases with a pillar width to height ratio greater than 5.0.

From a rock mechanics perspective, the ultimate strength of a pillar relates to the frictional restraint that can be developed once any cohesive strength is lost (for example by overstressing or weathering). If a very much lower-bound frictional strength of 12° is adopted for coal it would follow that the width to height ratio of a coal pillar would need to be 4.7 for the pillar to completely collapse (by lateral displacement) assuming that the loading is purely vertical; this is similar to the upper bound in the database of failed pillars. From this discussion, our assessment is that for the for bord and pillar workings at Laleham and Kenmare long term stability will be present if the Factor of Safety is greater than 1.6 and/or the aspect ratio of the pillars is in excess of 4.7.

4.1 Laleham pillars

There are pillars at Laleham with stability factors less than 2.0, therefore based on the previous discussion there could be a risk of further collapse. These pillars are located in production panels where only first workings development (beyond the Mains) or pillar splitting was undertaken (Figure 1213). A series of pillar stability analyses have been conducted on these pillars. The pillars examined in the stability analysis, are located in either the Aries or Pollux seams with their specific locations shown in Figure 12. Seam thickness in both the Aries and Pollux Seams ranged from 3.4 m – 3.8 m. A roadway height of 3.6 m has been assumed for this analysis.

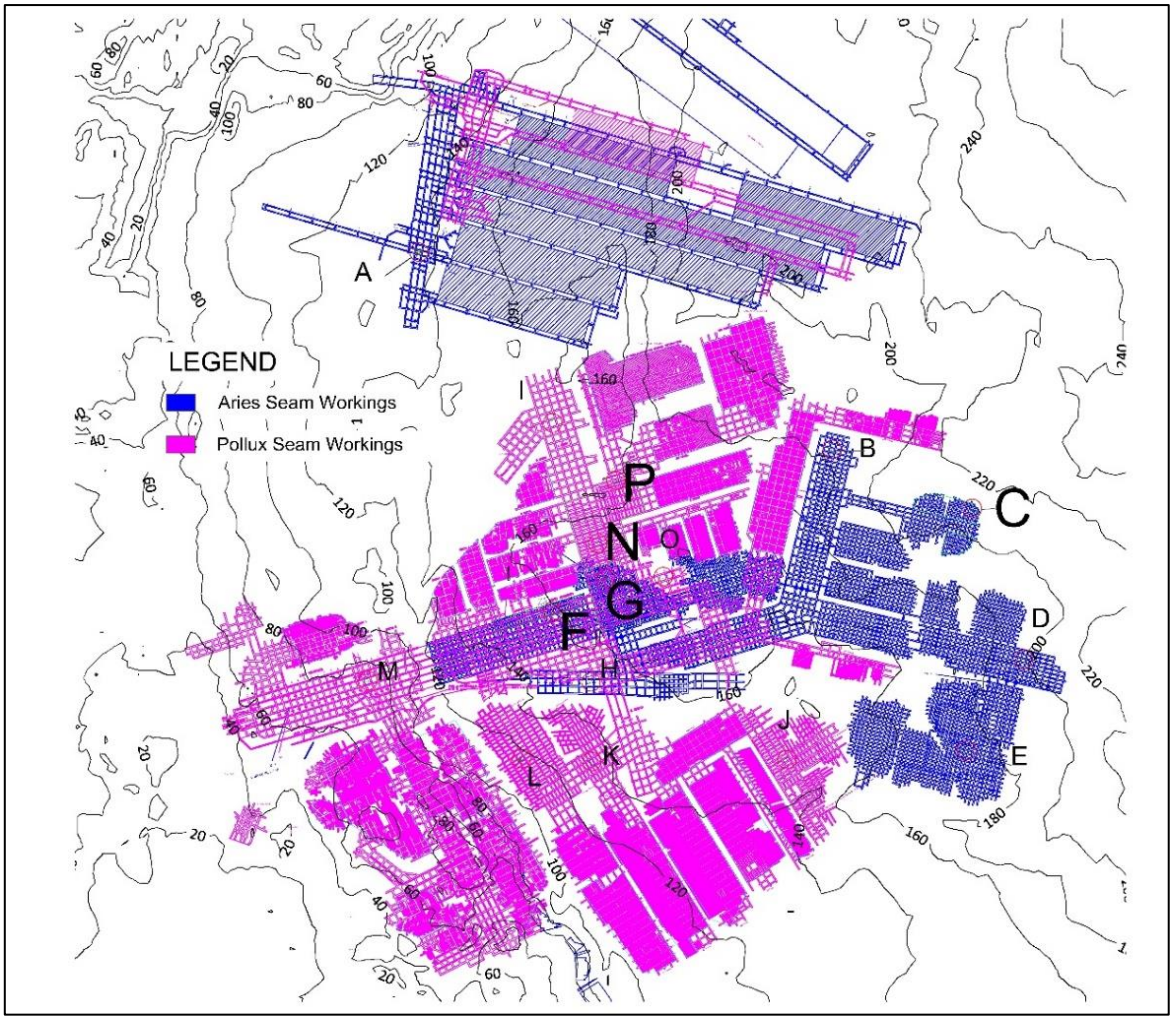


Figure 12 Depth to Pollux Seam and location of pillar stability analyses (larger fonts indicate pillars of marginal stability).

The stability of these pillars has been assessed using either the UNSW power (width to height ratio <5) or UNSW squat (width to height ratio >5) pillar formulae (Table 2). Pillar's C, F, G, N, and P have marginal long-term stability as indicated by low factors of safety results as shown in Table 2. These results indicate that there may be a hazard of further subsidence in these areas within a nominal time frame of 100 years (Section 5.4).

Table 2 Kenmare and Laleham Pillar Stability Analyses

Location	Depth (m)	Width to Height Ratio	Factor of Safety
Pillar A Kenmare Mains	110	5.5	3.58
Pillar B Laleham Aries First Workings 1	150	5.0	2.19
Pillar C Laleham Aries First Workings 2	**170**	**3.1**	**1.14**
Pillar D Laleham Aries First Workings 3	160	4.4	1.70
Pillar E Laleham Aries First Workings 4	140	3.9	1.69
Pillar F Laleham Aries First Workings 5	**120**	**2.8**	**1.58**
Pillar G Laleham Aries First Workings 6	**130**	**2.5**	**1.27**
Pillar H Laleham Aries Mains	130	9.2	5.08
Pillar I Laleham Pollux 1 North Mains	170	9.0	3.48
Pillar J Laleham Pollux 303 Panel Split Pillars	150	3.8	1.69
Pillar K Laleham Pollux 3 South Panel Split Pillars	140	3.8	1.99
Pillar L Laleham Pollux 4 South Panel	120	3.8	2.30
Pillar M Laleham Pollux East Headings	80	8.1	6.13
Pillar N Laleham Pollux 111 Panel Split Pillars	**165**	**3.5**	**1.39**
Pillar O Laleham Pollux 1 East	170	8.1	3.03
Pillar P Laleham Pollux 100 Panel Split Pillars	**160**	**2.8**	**1.16**

Due to the depths of cover being mostly in excess of 30 m for both the Laleham and Kenmare 2 portal areas, pot-hole risk is highly unlikely to occur. There is only a small section of Kenmare 1 that has a lower depth of cover than this (Figure 13) which means that there is a hazard of pot holing occurring near the mine's entrance and this should be addressed in the plans for the surface mine void.

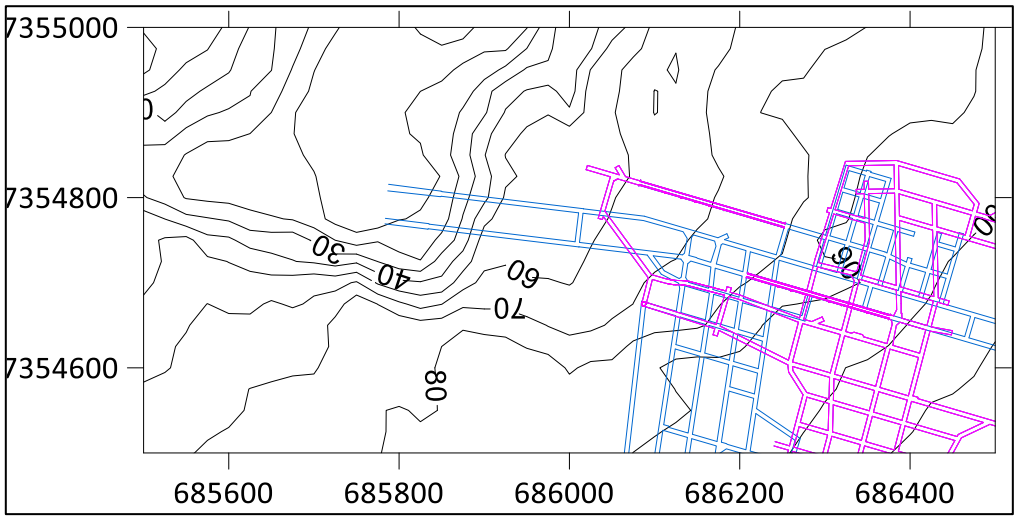


Figure 13 Depth to Aries Seam roadways near the entry to Kenmare 1.

4.2 Flooding Impacts on pillar stability

In the laboratory there is a measurable decrease in uniaxial compressive strength on saturation of coal measure rocks (about 20%). The impact of this on the stability of narrow pillars is in the order of 11% for pillars with width to height ratios of less than four but has not been studied for wider pillars. It is assessed that this strength loss will not add materially to the consideration for the stability of the pillars in Laleham.

There is a possibility of reduction in the floor strength of the roadways which would result in a reduction in the bearing strength of the pillar floor system (Figure 16). The reduction in roadway floor strength may be relatively small so the impact on pillar stability will be minor unless the impacted layer is very thick and initial floor stability was low. The available information on the Aries and Pollux seams[3] suggests that the floor strengths are well in excess of those that could be associated with this type of failure mechanism.

In contrast to these reductions in strength, there will be an overall trend for an increase in stability related to a buoyancy effect as the water level rises above the coal seam. The result is that any decrease in stability will be temporary while the material at or below seam level softens and the water level is such that there is no buoyancy effect. Over time as the water level rises above the coal seam level, buoyancy will dominate and stability will increase beyond that at mine closure. It is valid to include consideration of buoyancy when using the available method to estimate pillar loading.

5 Surface deformations

Mining subsidence results in the following deformation and associated impacts at the surface:

- Downward vertical movements.
- Change in surface slope angles.
- Vertical steps and compression humps.
- Surface cracking.

It is noted that the remediation of vertical steps, humps, and cracking is addressed as part of progressive rehabilitation and forms a part of the operational mining activities.

5.1 Subsidence prediction and visualisation

There are many tools for visualising the distribution of vertical subsidence, tilt, and curvature, all require a prediction of the maximum vertical subsidence which can only be derived from surveys of mines in the same geological regime. In this report the SDPS influence function method[4] has been used.

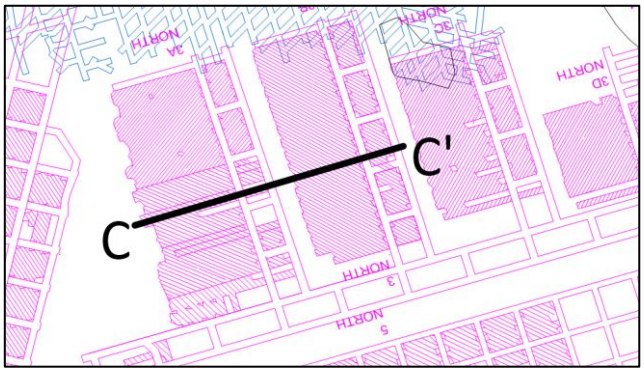
Documented subsidence information has been located, related to a 110-125 m wide pillar extraction panel at Laleham mine at a nominal 150 m depth[5]. This survey was conducted before Panel B was fully extracted; the information from Panel A is consistent with other subsidence results in the

[3] Gordon N. Optimisation of strata reinforcement at Kenmare Colliry. Coutts R 2001. Kenmare 2 – Longwall 2. Hazard Management Exploration Programme, Results of Phase 1 & 2.

[4] Surface Deformation Prediction System (SDPS) Software | Office of Surface Mining Reclamation and Enforcement (osmre.gov)

[5] Wardle, LJ. 1993. The use of numerical modelling for underground coal mine design. Chapter 28 in Volume 2, Analysis and Design Methods, Comprehensive Rock Engineering, pp 733-948

Bowen Basin allowing more recently derived generic parameters to be applied when predicting these values.



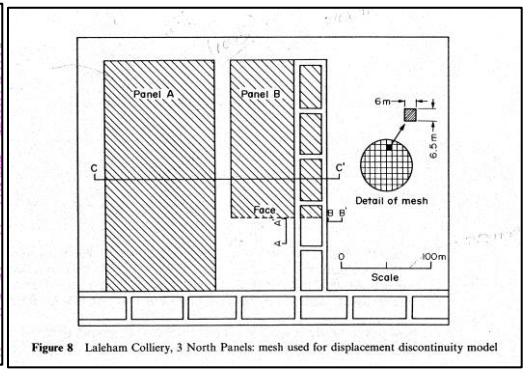


Figure 8 Laleham Colliery, 3 North Panels: mesh used for displacement discontinuity model

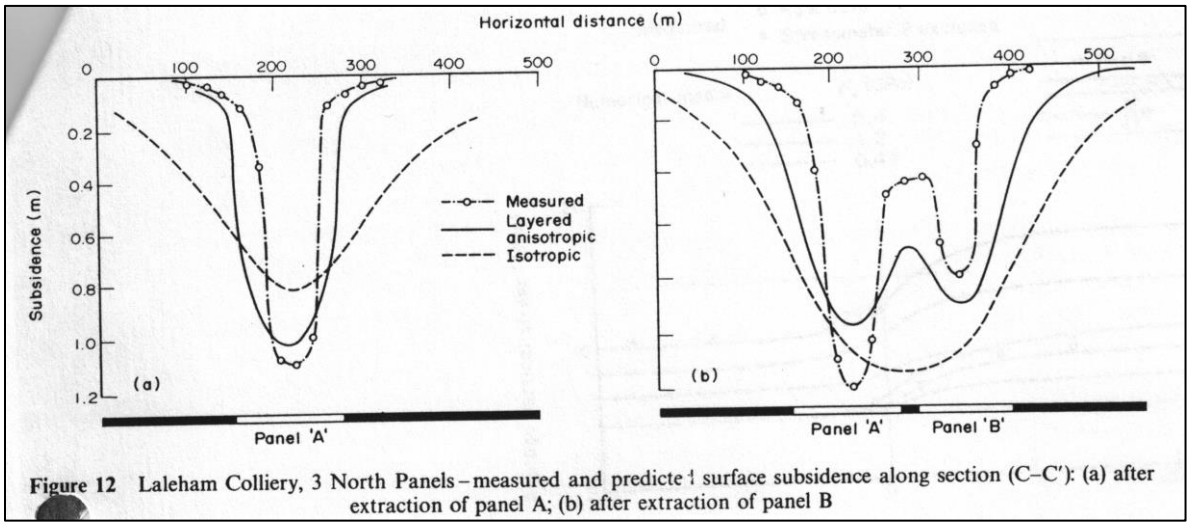


Figure 12 Laleham Colliery, 3 North Panels – measured and predicted surface subsidence along section (C–C'): (a) after extraction of panel A; (b) after extraction of panel B

Figure 14 Subsidence information from a pillar extraction panel at Laleham Colliery (from Wardle 1993).

5.2 Mining subsidence

The modelled distribution of vertical subsidence is shown in Figure 15 and the horizontal strains shown in Figure 16. For the Laleham Pollux Seam workings it was necessary to make assumptions on the collapse of some of the shallower (early) panels where extensive extraction of bord and pillars workings was completed and likely to have been sufficient to cause surface subsidence.

The maximum vertical subsidence is 2.5 m for single seam extraction and 3.5m for dual seam extraction. The 3.5 m applies only to a small area of Kenmare 1 where mining of both the Aries and Pollux seam was undertaken.

For the vertical subsidence, a cut-off deformation of 20 mm was adopted to define the onset of displacement. Using this definition, there is an estimated area of 3.2 km^2 subsided ground above Laleham and 2.9 km^2 above Kenmare.

For horizontal strain (Figure 16), the presented contours are those in excess of 5 mm/m in either tension or compression to give an insight into areas where visible localised surface deformations may be seen (cracking).

Figure 17 presents frequency plots of the level of vertical subsidence, change in slope, and tensile/compressive strains expressed relative to the area defined by the 20 mm vertical subsidence level. The maximum change in slope is 4.8° (8%). It is anticipated that 20% of the subsided area may

have tensile strains in excess of 5 mm/m and a similar percentage will have compressive strains in excess of 5 mm/m.

The modelling of horizontal strain and inferences on surface deformations was validated by the observed cracking during the May 2023 site inspection.

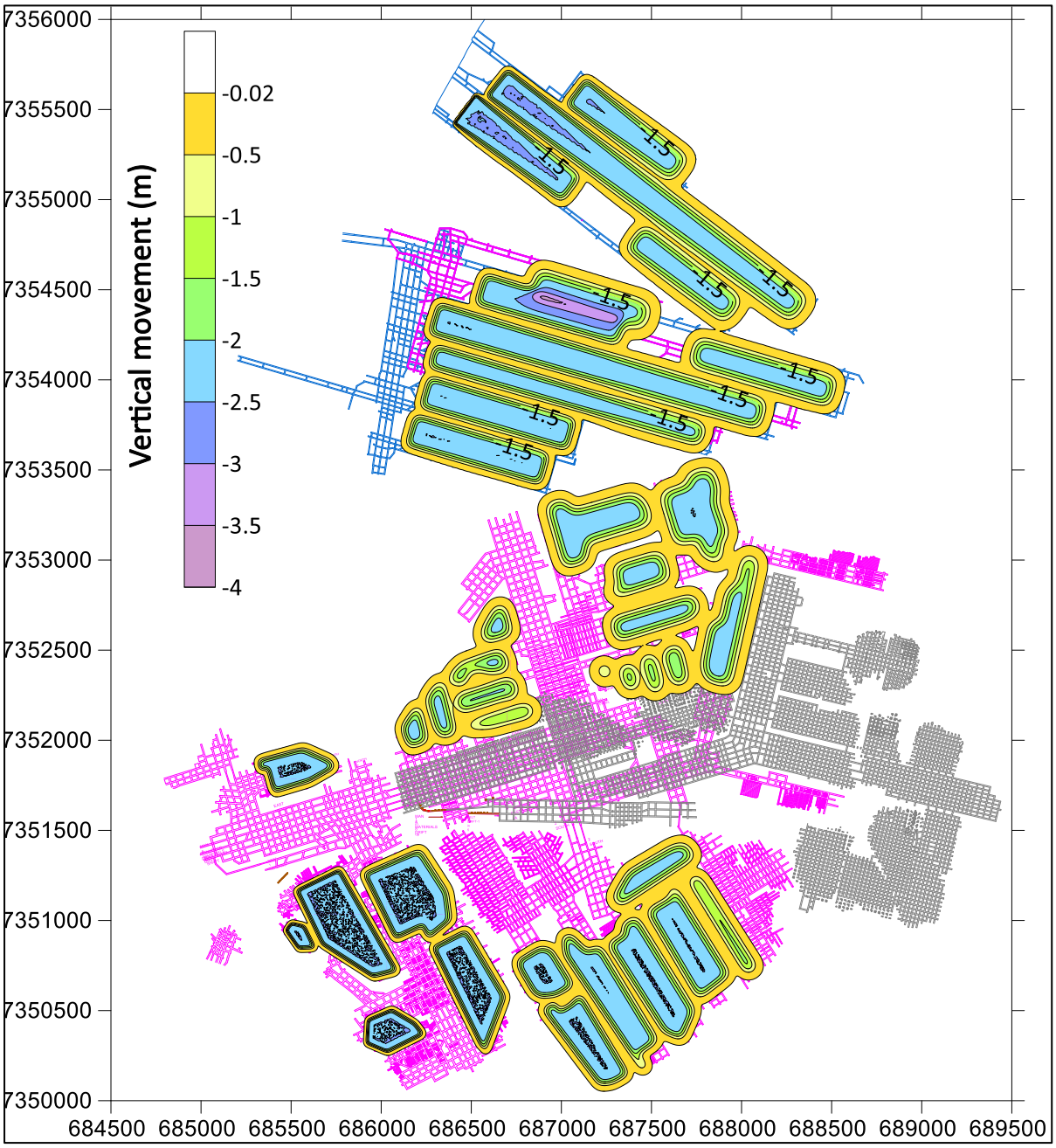


Figure 15 Visualisation of vertical subsidence at Laleham and Kenmare.

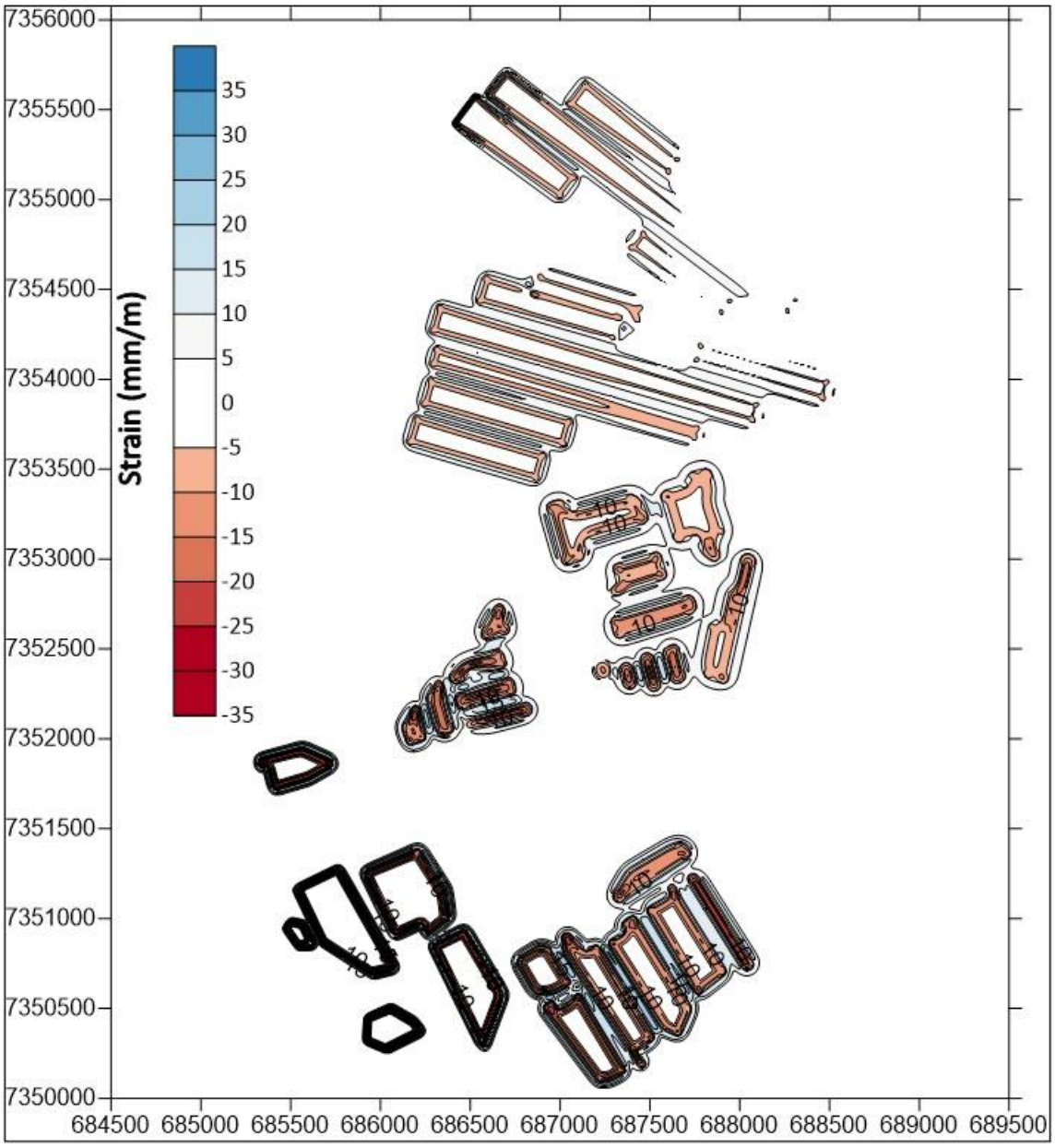


Figure 16 Visualisation of likely horizontal strain at Laleham and Kenmare..

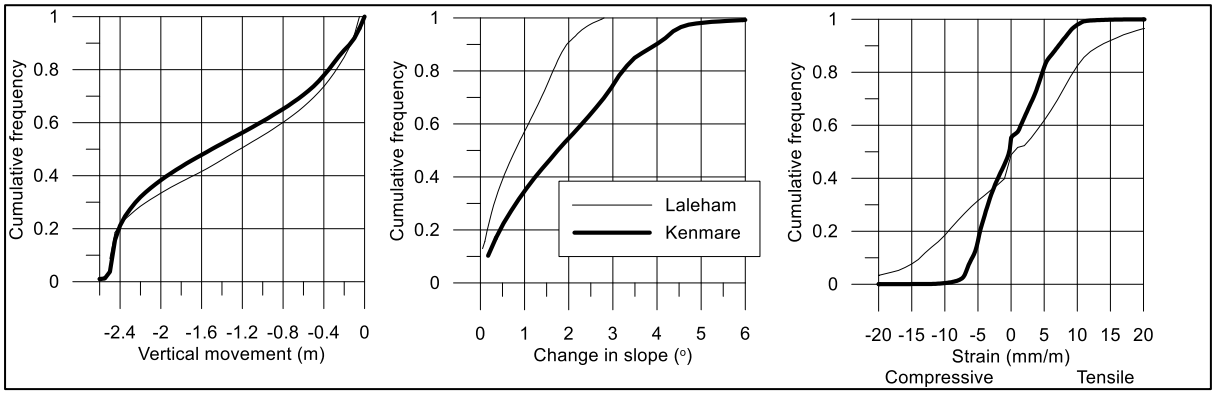


Figure 17 Frequency statistics on total area exposed to mine subsidence as defined by a prediction of vertical subsidence in excess of 20 mm..

5.3 Surface cracking

High levels of tensile strain can lead to the onset of cracking at the surface. There are two end members of cracking – ribs-parallel tensile cracking and face-parallel/arcuate steps (Figure 19).

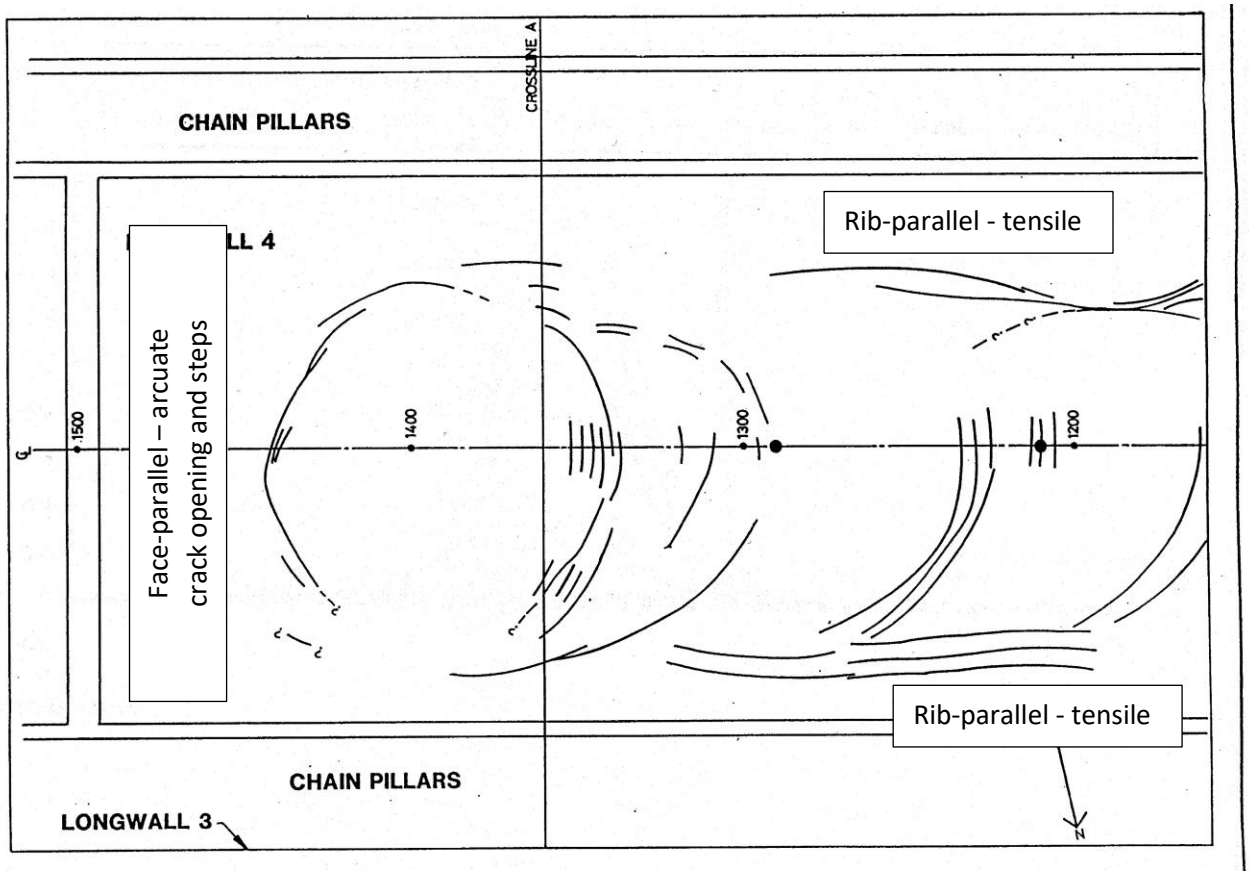


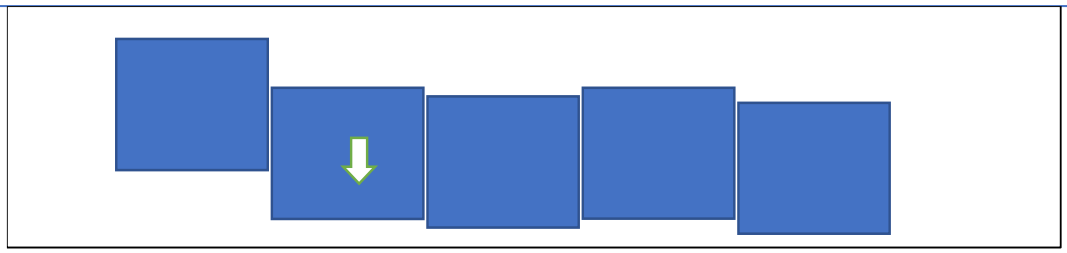
Figure 18 Typical areal distribution of surface cracking, dots indicate noticeable compressive humps (LW4 Cook Colliery ACARP C1311).

The rib-side cracking is perhaps the most obvious and is typically the focus of progressive rehabilitation regimes on most mine sites. Rib cracking is the result of overburden blocks' rotation at the edge of the extraction panel (Figure 19). Both a tensile opening and a compression strain associated with block rotation is experienced. The tensile opening (crack) becomes easily visible at the surface, where the compression strain is usually not clearly discernible.



Figure 19 Mechanism and examples of rib parallel cracks.

The face-parallel deformations are related to periodic vertical collapse (Figure 20) with the collapse somewhat akin to the periodic weighting events experienced at the longwall mining face but at a much smaller scale. As the longwall face retreats the rocks near the surface may temporarily "hang up" but then collapse vertically. The roughness of the interface between the blocks will mean that the blocks will not match perfectly - hence the steps and some opening. As for the rib-parallel cracks, the face-parallel deformations will be apparent through the soil cover but may be ameliorated by rainfall.



Longwall centreline – blocks move downwards (and to a lesser degree sideways) at discrete intervals



Figure 20 Mechanism and examples of face parallel cracking.

Rehabilitation of rib-parallel cracks and face-parallel cracks near the longwall end lines is standard practice at mines in the Bowen Basin.

A reconnaissance survey of subsidence cracking was conducted in May 2023 by inspecting areas of predicted high visualised tensile strain that could be readily accessed on foot. Figure 21 shows the location of observed cracking relative to the visualised tensile strain and the surface geology.

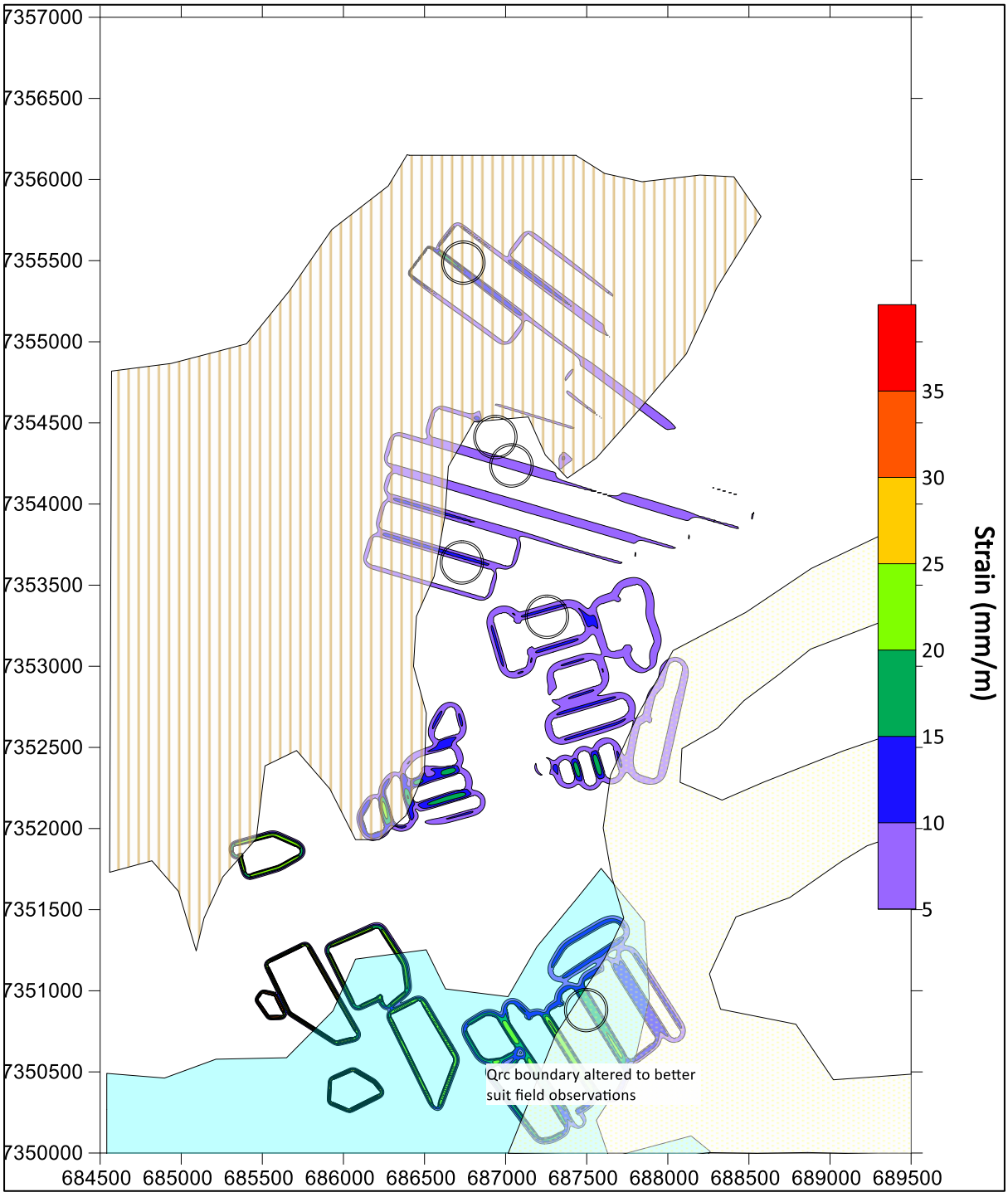


Figure 21 Location of sites inspected in May 2023 relative to the prediction of tensile strain and the surface geology (Qrc boundary moved to better represent observations).

The nature of the rib parallel cracking associated with both, longwall and pillar extraction show cracks up to 200 mm – 250 mm wide with depths sometimes in excess of 2 m.

It was observed during the inspection that the cracking does not appear to have adversely impacted vegetation growth. The mining was concluded in excess of 20 years ago but there is no obvious natural remediation of the cracking; this is attributed to the surface geology – duricrust (Czl) or sandstone/mudstones of the Emerald Formation (Czoem).

The surface above Laleham extraction panels where the surface geology appears to be Quaternary (Qrc) are shallow linear "trenches" which are interpreted to have been large tensile cracks that have "self-healed" over the years through rainfall and sediment migration. Note that the Qrc boundary presented in Figure 21 has been moved to reflect the observations made in May 2023.

5.4 Possibility of post-closure subsidence

Most of the workings in Laleham and Kenmare should now be in a stable condition given that the end of underground mining was more than 20 years ago. Figure 22 indicates the potential for additional vertical subsidence that may develop if additional pillars within the Laleham Aries seam workings collapse (Section 4.1).

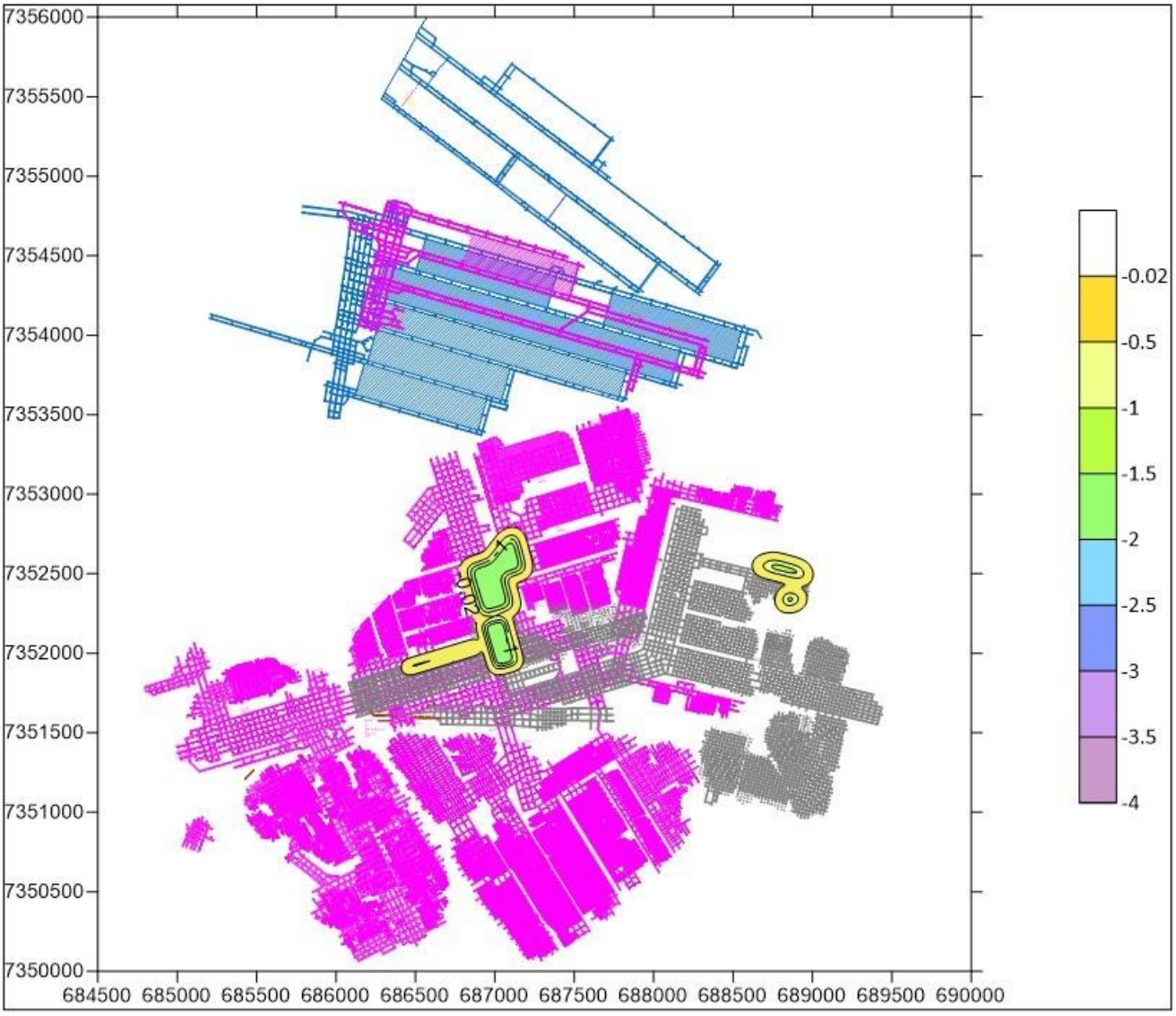


Figure 22 Possible additional subsidence if pillars collapse.

6 Groundwater

6.1 Current water level

In the first week of September 2023, the water level recorded in the pump hole at the inbye end of Kenmare 1 Aries Seam workings (Figure 23) was 21 m below the top of the casing and at an RL of 277.5 m. Assuming that the standing water level is horizontal and that the two seams are interconnected either by longwall caving or cross measure drifts, the standing water level is 3 m below and 37 m east of the Kenmare 1 portal. MB16 is located above the Laleham workings and the water level in this hole is 37.76m below the top of the casing indicating that these working are flooded. From a geotechnical perspective this means that any strength losses due to inundation have already developed and hence no hazard off additional collapses.

Kenmare K2 retreated into an existing surface mine void and there was no attempt to create a hydraulic seal between the surface and underground voids. The minimum separation between K1 and K2 is in the order of 18 m (at E687878, N7354266). It is assessed that K2 can be considered to be flooded.

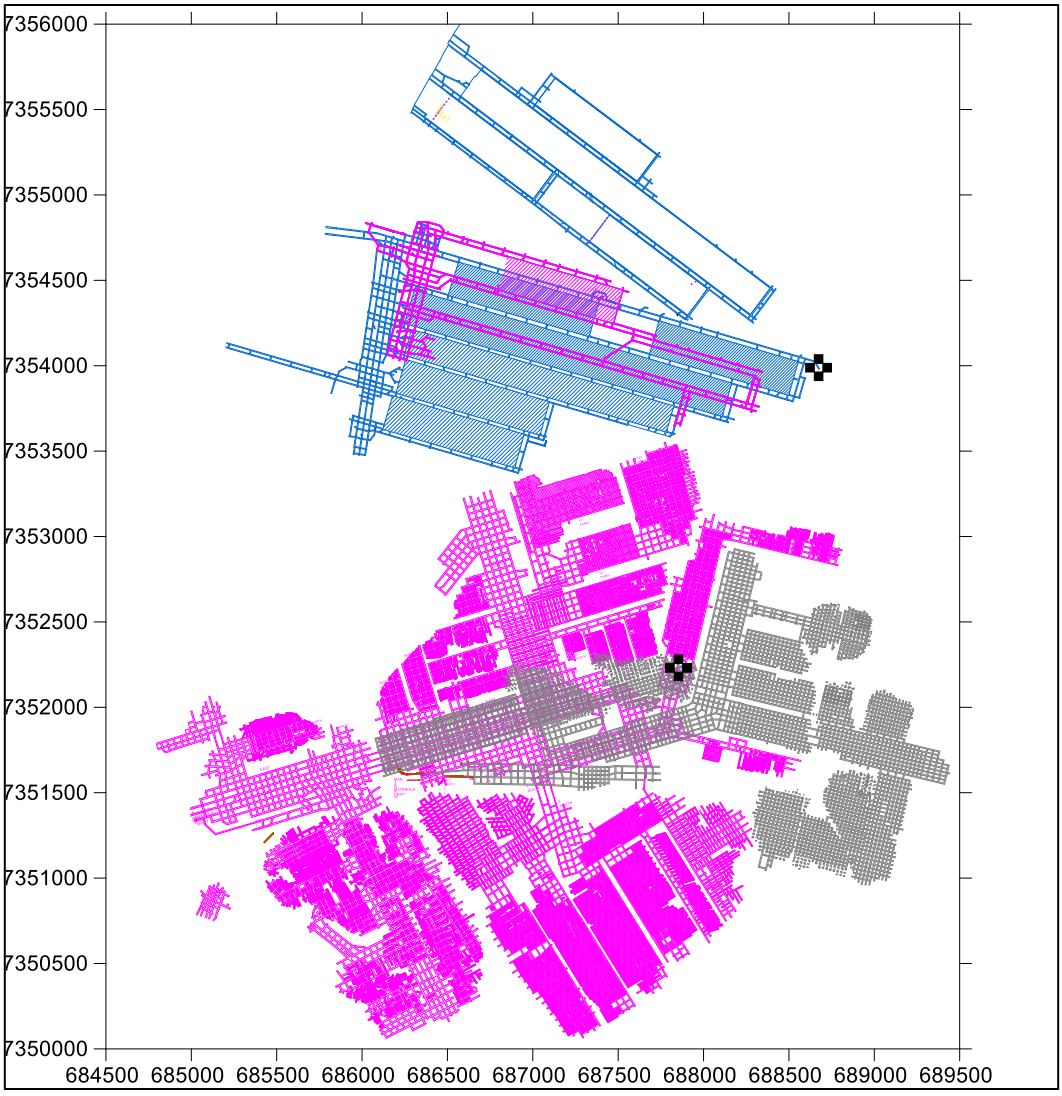


Figure 23 Location of holes monitoring groundwater in Laleham and Kenmare 1.

No standing water data is available for the Sirius Creek, Clutha or Ballamoo mines but it is assessed that they are now flooded to the regional groundwater level. It is noted that there is no pillar collapse hazard in these mines as they had no or very few pillars.

6.2 Flooding of undergrounds

Flooding an underground mine will result in the saturation of the bottom of the goaf (the Potential Consolidation or Caved Zone in Figure 24) and this will cause a softening of the fragmented immediate roof with consequent consolidation. This consolidation may be reflected in additional surface subsidence. Based on the discussion above, it is assessed that this softening and consolidation has already developed.

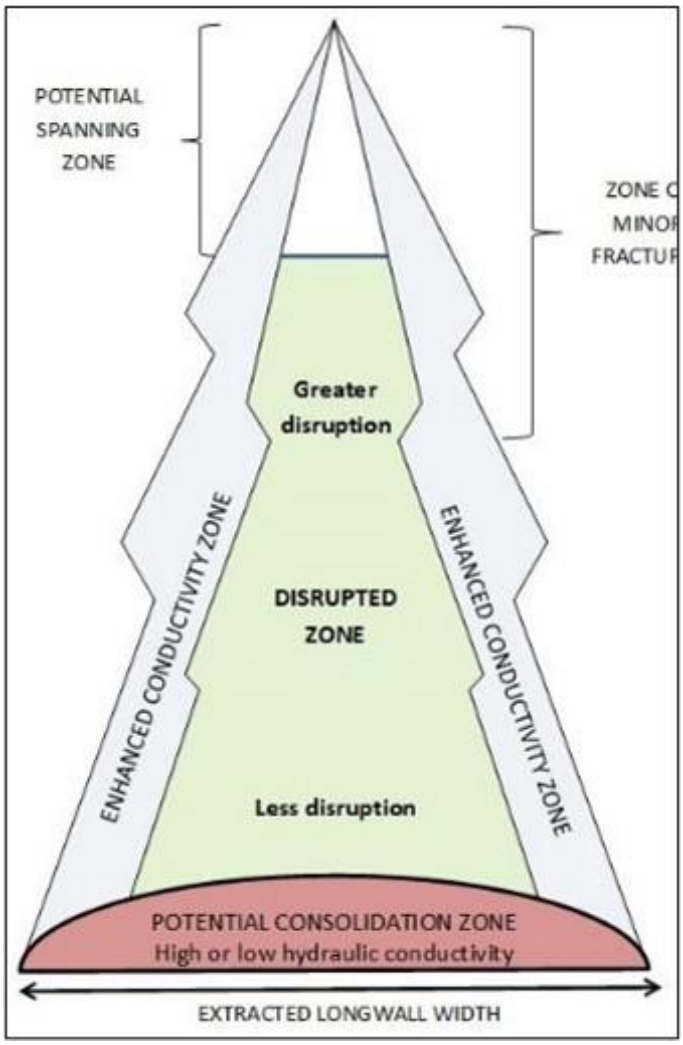


Figure 24 Framework of the geotechnical model for fracturing.

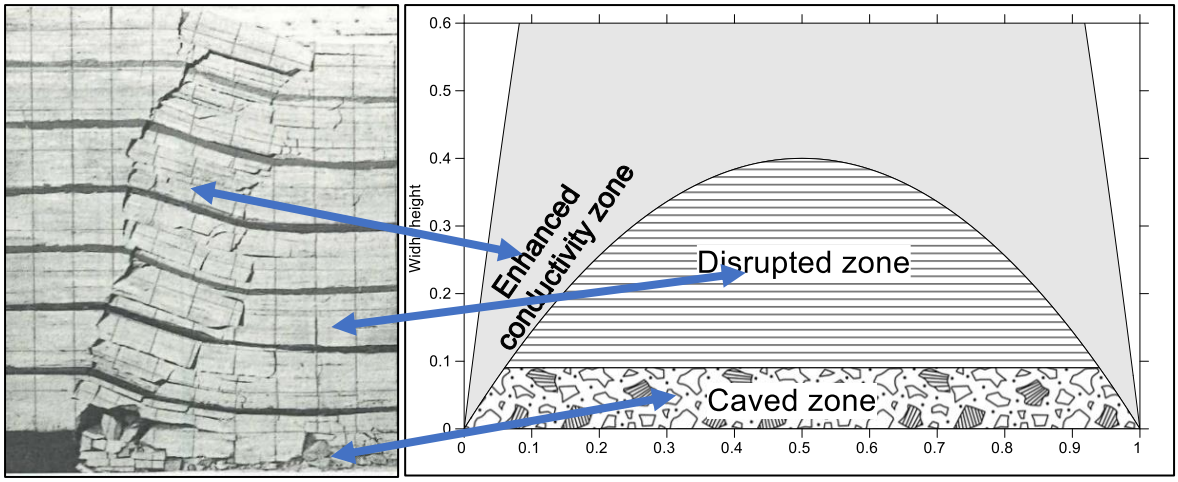


Figure 25 Physical and conceptual models for fracturing between seam and surface.

6.3 Hydraulic conductivity

Collapse or fracturing of the rock mass above the extracted coal is an intrinsic feature of extraction or longwall mining, except in some specific geological environments. Subsidence results in large scale fracturing of the overburden and subsequently, disruption to the overburden above the mined seam. This means that groundwater systems are unlikely to be returned to pre-mining condition. Importantly, if the differential surface subsidence above any extraction panel is in excess of about 500 mm there will be fracturing through to the surface.

Following work done at Crinum Mine, then owned by BMA in 2014, there has been a revision in the model for longwall fracturing and hydraulic conductivity. The largest changes in hydraulic conductivity are now recognised to be in the "Enhanced Conductivity Zones" (Figure 24 and Figure 25).The Impact on the overburden above the extracted area is not homogenous in its extents. An estimate of the resulting hydraulic conductivity (based on one scenario of how cracking develops in the overburden) is presented in Figure 26.

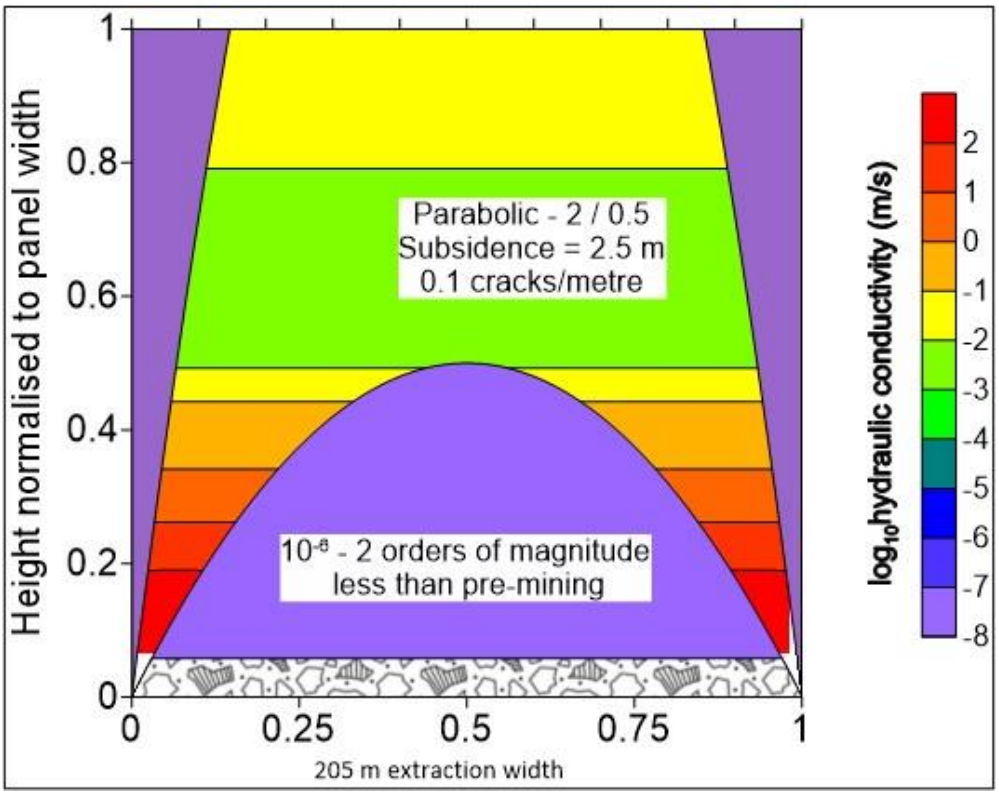


Figure 26 Hydrogeology model – fracturing.

7 Rehabilitation strategies

7.1 Rib parallel cracks

Up to 20 % of the subsided ground may be exposed to rib parallel cracks. Areas of high predicted tensile strain (Figure 21) indicate likely locations. Any cracking that has occurred in the Qrc surface geological will show evidence of self-healing, and no further subsidence or cracking is expected.

If rehabilitation is considered for the cracking in the non Qrc area, then earthworks to flatten the sides will be required or material will need to be imported. The general strategy of rehabilitation for this type of movement should be based on removing the slip/trip hazard at the surface by ripping/breaking the vertical faces to a 1 m depth and then compacting/grading (Figure 27). A nominal 3 m wide rounded gutter shape will result.

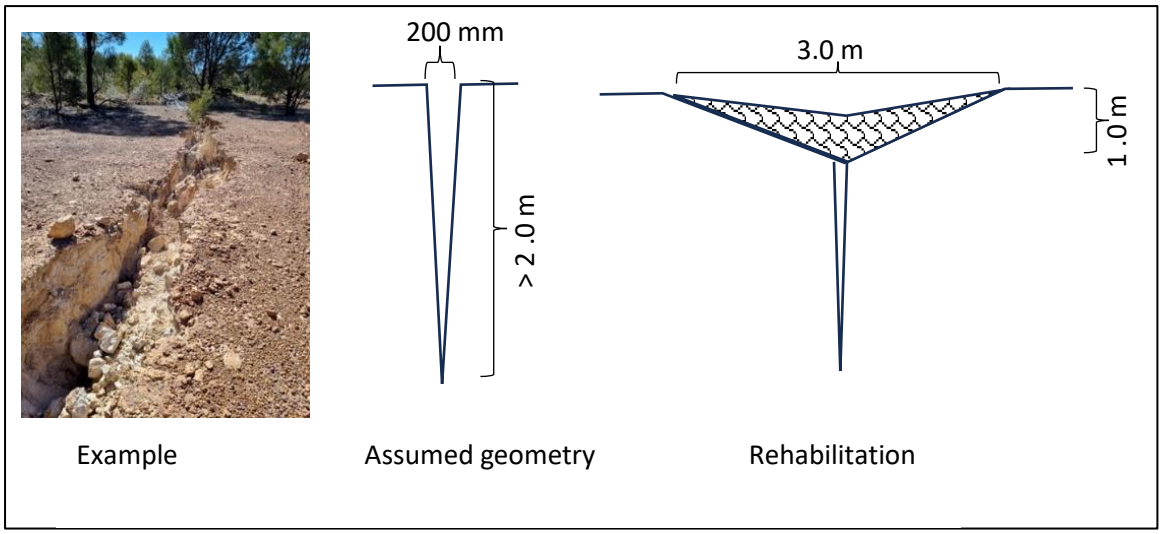


Figure 27 Schematic of general strategy to remove safety hazard associated with subsidence cracks in duricrust.

7.2 Face parallel or arcuate cracking

Face parallel cracking was not observed during the site reconnaissance. It should be assumed that these cracks may be present where the surface subsidence is greater than 2.0 m (Figure 28).

Rehabilitation would be to remove the edge with a grader or similar.

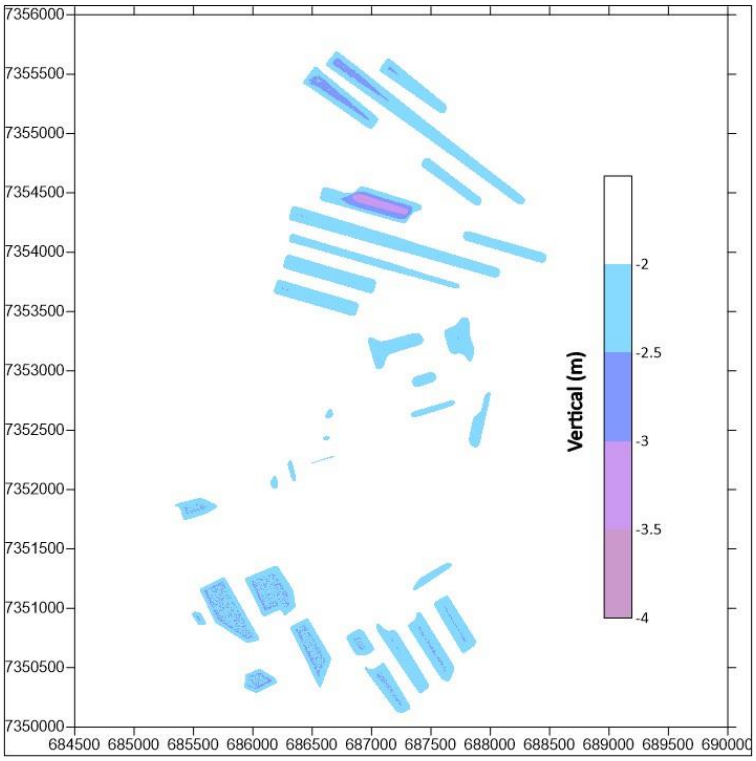


Figure 28 Possible areas of face parallel subsidence fractures in the Kenmare and Laleham areas as defined by subsidence greater than 2.0m.

7.3 Seals and Bulkheads

Mine seals are used to manage or limit water and gas flows as well as to control physical access to parts of the mine.

7.3.1 Kenmare 1

The Statutory Mine Plan (Plan of Abandonment) submitted to the Mines Department in 2001 shows seals at about 142 m from the portal entrance in both the "Man & Materials" & "Conveyor" drifts. A survey of the "Man & Materials" drift that was conducted on 19th of October 2023 showed that the drift has filled (floor to roof) with silt to a distance of about 70m from the entrance (Figure 29).

The current landform designs for closure of the surface mine has the Kenmare pit backfilled to surface.

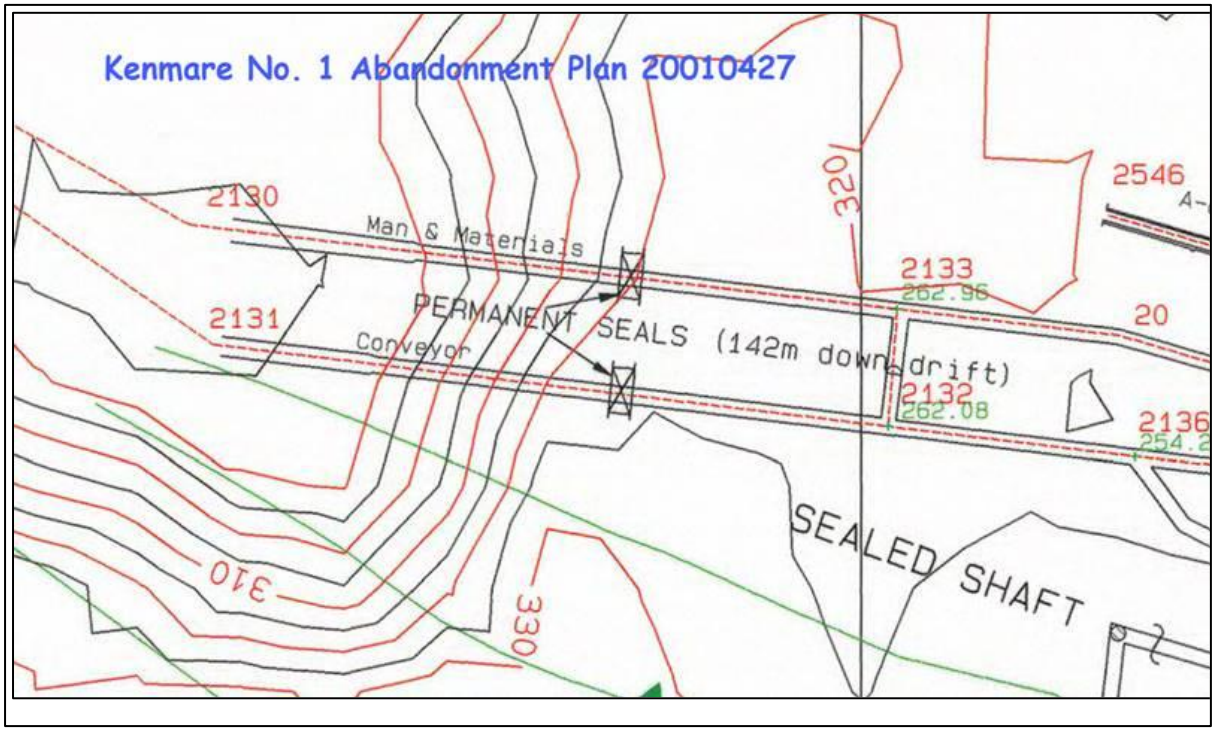


Figure 29 Kenmare Aries portal.

7.3.2 Kenmare 2

Kenmare 2 retreated the longwall face into an existing surface excavation which has since been incorporated into the surface operation.

7.3.3 Laleham

The Laleham portals have been either dozed-in or dumped-over.

7.3.4 Sirius Creek No 1

Sirius Creek No 1 was closed soon after opening and the portal entries are not visible. Re-excavation is not recommended. The current surface should be regraded and revegetated.

7.3.5 Sirius Creek No 2

Permanent seals appear to have been installed at about 1150m from portal entrance in both the Man & Materials and Conveyor drifts. The symbols appear to indicate an "Explosion Proof Stopping" on the statutory mine plans submitted to the Mines Department in 1976.

There has been a recent collapse at the Sirius Creek # 2 portal. It is assessed that timber lagging bords and/or the steel arches have deteriorated over time and a pothole has developed

A solution for closure would be to excavate the steel arches and lagging bords and backfill with a coarse-grained fill. An indicative specification would be:

- UCS>30 MPa
- 150 mm topsize
- 20 mm minimum size
- free draining
- not acid forming.

It is noted that a potential for remote installation of a grout seal may be required. This is also relevant for Clutha below.

7.3.6 Clutha

The Clutha portal is located at the outcrop of the Aries Seam. It was a single entry only, approximately 80 m long. Recommendations for closure include removal of the arches and lagging bords and then backfill using fill sourced from the immediate area.

7.4 Shafts

The main ventilation shaft for Kenmare 1 is annotated as sealed on the statutory mine abandonment plan and there is a plaque glued to the concrete plug on top of the shaft (Figure 30).



Figure 30 Kenmare 1 ventilation shaft.

Shafts should be fully backfilled with any locally sourced material. The shaft collar should be removed to allow removal of weathered/soil like material and then backfilled and compacted.

7.5 Exploration Holes

All open exploration holes previously completed as part of the exploration works of the mine development will require, as per legislation, the hole to be located, the casing to be removed and the hole to be cleaned out and grouted to surface.

7.6 Underground service holes (drop holes, pump holes)

Open holes to surface that are not defined as geological in nature will also need to be grouted to surface and sealed. All mine plans should be reviewed for these holes to ensure that no open access to the underground workings is maintained at closure.

8 Mine Closure Requirements

Mine subsidence results in permanent changes in the relative level of the surface and the generation of small-scale disruptions to the surface (cracks, steps, and humps).

The tensile cracks and steps discussed in Section 8 present a hazard to fast moving vehicles and possibly to wildlife. Over time there would be a lesser hazard if the surficial geology allows “self-healing” during rainfall events but where there are duricrusts or rock exposures the hazards will continue to exist for an unspecified duration.

Specific rehabilitation strategies should only be developed after an appropriate risk assessment is conducted based on the final land use and its impacts.

9 Monitoring

No further monitoring of the undergrounds at Blackwater Mine is recommended once it is established that the mines are flooded.

Where flooding has not occurred, there is potential for an additional subsidence of up to 250 mm; this is unlikely to change the current surface conditions.

Whitehaven

Appendix 4.17 – Rehabilitation Monitoring RFI Response

Blackwater Coal Mine Rehabilitation Monitoring RFI Response

To: Sahar Donner (Superintendent – Group Approvals)

From: Steve Lyngcoln (Principal Ecologist)

cc: Mark Gastaldon (Superintendent Environment), Brendon Dillon (Group Manager Approvals – Queensland)

Date: 2/03/2025

Re: Blackwater Coal Mine Rehabilitation Monitoring RFI Response

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Dear Sahar

This Blackwater Mine (BWM) rehabilitation monitoring request for information (RFI) memorandum has been prepared in response to the following RFI's on the BWM Progressive Rehabilitation and Closure Plan (PRCP) from the Department of the Environment, Tourism, Science and Innovation (DETSI):

- *"Details of previous monitoring or maintenance of areas already rehabilitated has not been provided to satisfy the requirements of s126C(1)(j) of the EP Act and Section 3.8 of the PRCP Guideline.*
- *No supporting reports or data for previous monitoring or maintenance of areas already rehabilitated has been presented with the PRC Plan for an area of 1,929ha which the PRC Plan cites as 'existing rehabilitation'. The Rehabilitation Planning Part (Whitehaven 2024, p. 73) states:*
    - *Over time, BWM has progressively advanced 1,929ha of existing rehabilitation towards the achievement of the nominated PMLUs and rehabilitation milestones outlined in the PRCP Schedule (see Appendix 4.1). The existing rehabilitation areas completed for the cattle grazing and woodland habitat PMLUs are summarised as follows*
        - *1,200 ha of cattle grazing*
        - *729 ha of woodland habitat*
    - *As part of FY24 rehabilitation monitoring, some of these areas have been identified as being suitable for progressive rehabilitation certification under the EP Act. However, at the time of submission of this transitional PRCP, no applications have been submitted to the administrating authority. The existing rehabilitation progressing towards the achievement of the PMLU is outlined in the PRCP Schedule provided in Appendix 4.1 (see RA6 and RA7). Routine rehabilitation monitoring will continue to be implemented to identify any maintenance/corrective actions required to enable the rehabilitated areas to achieve the milestone criteria.*
    - *Upon review of the submitted materials, details of the rehabilitation monitoring and maintenance described above do not appear to have been provided in the Rehabilitation Planning Part or appendices.*
- *(Action 4):*
    - *The Rehabilitation Planning Part indicates that rehabilitation monitoring has been completed and is ongoing for the 1,929ha of existing rehabilitation. As detailed in Section 3.8 of the PRCP Guideline, if there are any monitoring or maintenance of areas already rehabilitated, details must be included in the PRC plan. Accordingly, as per the*

requirements of s126C(1)(j) of the EP Act and Section 3.8 of the PRCP Guideline, provide a PRC Plan that includes details of previous monitoring or maintenance of areas already rehabilitated.

- *In responding to this item, please also ensure that all areas of existing rehabilitation are presented it the spatial data submission with the correct 'Feature' description of 'EX_REH' as required by Attachment 1 of the approved form 'Submission of a progressive rehabilitation and closure plan' (ESR/2019/4957).*

Previous monitoring or maintenance and supporting reports or data for previous monitoring or maintenance

On April 2nd 2024, BWM was transferred to Whitehaven Coal (WHC). In 2018 the previous owner, BHP Mitsubishi Alliance (BMA) negotiated revised final post mining land uses (PMLU) completion criteria for cattle grazing and woodland habitat land uses under Table E1 of the BWM Environmental Authority (EA) Permit EPML00717813 (refer Attachment One).

Rehabilitation monitoring on BWM has been undertaken since 2018 in accordance with the *BWM Rehabilitation Monitoring Methodology (RMM)* and associated subsequent versions to determine the performance of rehabilitation against the updated EA completion criteria for a cattle grazing and woodland habitat PMLU. Prior to 2018, monitoring was undertaken under a different methodology and compared to different completion criteria and has therefore not been summarised in this response.

Since 2018 the following rehabilitation monitoring programs have been completed in accordance with the RMM:

- Initial Rehabilitation Monitoring Report Blackwater Mine 2018 (ELA, 2018)
- Initial Rehabilitation Monitoring Report Blackwater Mine 2019 (ELA, 2020)
- Blackwater Mine Major Rehabilitation Monitoring Report 2022 (ELA, 2023)
- BMA Blackwater Coal Mine Rehabilitation Monitoring Report FY24 (BMA, 2024a).
- Blackwater Coal Mine Woodland Habitat Rehabilitation Monitoring Report 2024 (BMA, 2024b).
- Blackwater Coal Mine Rehabilitation Monitoring Report 2024 (LEC, 2024a).
- Blackwater Coal Mine Woodland Habitat Rehabilitation Technical Report BWM25, BWM33 and BWM180 (LEC, 2024b)

The following summarises the results rehabilitation monitoring undertaken on BWM between 2022 – 2024 which includes all sites ever monitored at Blackwater. Sites monitored prior to 2022 have since been reassessed and therefore the later results have been summarised in this response.

The existing rehabilitation areas on BWM and associated monitoring sites are illustrated in Figure 1. Table 1 lists the rehabilitation monitoring sites that have been monitored during each monitoring program between 2018-2024. A total of 1497 ha of the existing 1929 ha listed as existing rehabilitation in the BWM PRCP has been monitored between 2022-2024.

The remaining area of rehabilitation on BWM that has not yet been monitored includes:

- Approximately 30 ha of small areas <5 ha adjacent to existing rehabilitation required to be merged into surrounding areas.

- Approximately 43 ha of cattle grazing PMLU under dense *Leucaena leucocephala* (Leucaena) >50% canopy cover under planned maintenance requiring ‘surface preparation (cattle grazing) (PRCP RM4).’
- Approximately 195 ha of existing rehabilitation requiring ‘landform development and reshaping (PRCP Rehabilitation Milestone (RM) 3).’
- Approximately 81 ha of existing rehabilitation requiring surface treatment (PRCP RM4).’
- Approximately 30 ha of cattle grazing rehabilitation requiring reseeding (PRCP RM5).
- Approximately 48 ha of existing cattle grazing and 5 ha of woodland habitat to be monitored in 2025.

It is understood that the 2025 rehabilitation monitoring program will focus on assessing areas not yet monitored and developing and associated maintenance program.

Table 1 BWM Rehabilitation Monitoring Summary 2022-2024

Rehabilitation Area/ Site ID	Area (ha)	Post Mining Land Use (PMLU)	Blackwater Coal Mine Rehabilitation Monitoring Report (LEC, 2024a).	Blackwater Coal Mine Woodland Habitat Rehabilitation Monitoring Report 2024 (BMA 2024a)	BMA Blackwater Coal Mine Rehabilitation Monitoring Report FY24 (BMA 2024b)	BWM Major Rehabilitation Monitoring 2022 (ELA, 2023)	Initial Rehabilitation Monitoring Report Blackwater Mine 2019 (ELA, 2020)	Initial Rehabilitation Monitoring Report Blackwater Mine 2018 (ELA, 2018)
			Rehabilitation Area (ha) monitored per year.					
	Area (ha)	**PMLU**	**2024**	**2024**	**2023**	**2022**	**2019**	**2018**
BWM_R28_01	18.1	Cattle Grazing			18.1			
BWM_R44_01	2.8	Cattle Grazing	2.8			2.8		
BWM_R50_01	6.5	Cattle Grazing	6.5			6.5	6.5	
BWM_R54_01	33.4	Cattle Grazing			33.4	33.4	33.4	
BWM_R54_02	17.8					17.8	17.8	
BWM_R54N	55.6	Cattle Grazing	55.6					55.6
BWM_R56S	16.5	Woodland Habitat	16.5					16.5
BWM_REF01	NA	Cattle Grazing			Yes			
BWM_REF02	NA	Woodland Habitat			Yes			
BWM_REF03	NA	Cattle Grazing			Yes			

Rehabilitation Area/ Site ID	Area (ha)	Post Mining Land Use (PMLU)	Blackwater Coal Mine Rehabilitation Monitoring Report (LEC, 2024a).	Blackwater Coal Mine Woodland Habitat Rehabilitation Monitoring Report 2024 (BMA 2024a)	BMA Blackwater Coal Mine Rehabilitation Monitoring Report FY24 (BMA 2024b)	BWM Major Rehabilitation Monitoring 2022 (ELA, 2023)	Initial Rehabilitation Monitoring Report Blackwater Mine 2019 (ELA, 2020)	Initial Rehabilitation Monitoring Report Blackwater Mine 2018 (ELA, 2018)
			Rehabilitation Area (ha) monitored per year.					
BWM_REF04	NA	Woodland Habitat			Yes			
BWM_REF05	NA	Woodland Habitat		Yes				
BWM_REF06	NA	Woodland Habitat		Yes				
BWM000	26.9	Cattle Grazing	26.9					
BWM01	3.8	Cattle Grazing	3.8			3.8		
BWM02	6.4	Cattle Grazing				6.4		
BWM03	33.1	Cattle Grazing			33.1	33.1		
BWM05_A	53.3	Cattle Grazing	53.3			53.3		
BWM102	1.7	Woodland Habitat	1.7					
BWM103, BWM103A	35.0	Cattle Grazing	35.0					
BWM104	2.1	Cattle Grazing	2.1					
BWM105A	6.2	Cattle Grazing	6.2					

Rehabilitation Area/ Site ID	Area (ha)	Post Mining Land Use (PMLU)	Blackwater Coal Mine Rehabilitation Monitoring Report (LEC, 2024a).	Blackwater Coal Mine Woodland Habitat Rehabilitation Monitoring Report 2024 (BMA 2024a)	BMA Blackwater Coal Mine Rehabilitation Monitoring Report FY24 (BMA 2024b)	BWM Major Rehabilitation Monitoring 2022 (ELA, 2023)	Initial Rehabilitation Monitoring Report Blackwater Mine 2019 (ELA, 2020)	Initial Rehabilitation Monitoring Report Blackwater Mine 2018 (ELA, 2018)
			Rehabilitation Area (ha) monitored per year.					
BWM105B	15.3	Cattle Grazing	15.3					
BWM106	3.3	Cattle Grazing	3.3					
BWM107	40.8	Cattle Grazing	40.8					
BWM108	24.8	Cattle Grazing	24.8					
BWM11	14.2	Cattle Grazing				14.2		
BWM116A	3.5	Woodland Habitat	3.5					
BWM116B	2.0	Cattle Grazing			2.0			
BWM118	1.5	Cattle Grazing	1.5					
BWM119	11.3	Woodland Habitat			11.3			
BWM12	13.0	Cattle Grazing				13.0		
BWM120	14.9	Cattle Grazing	14.9					
BWM124	5.9	Cattle Grazing	5.9					
BWM128	59.9	Cattle Grazing	59.9					

Rehabilitation Area/ Site ID	Area (ha)	Post Mining Land Use (PMLU)	Blackwater Coal Mine Rehabilitation Monitoring Report (LEC, 2024a).	Blackwater Coal Mine Woodland Habitat Rehabilitation Monitoring Report 2024 (BMA 2024a)	BMA Blackwater Coal Mine Rehabilitation Monitoring Report FY24 (BMA 2024b)	BWM Major Rehabilitation Monitoring 2022 (ELA, 2023)	Initial Rehabilitation Monitoring Report Blackwater Mine 2019 (ELA, 2020)	Initial Rehabilitation Monitoring Report Blackwater Mine 2018 (ELA, 2018)
			Rehabilitation Area (ha) monitored per year.					
BWM130A	46.7	Cattle Grazing	46.7					
BWM130B	35.1	Cattle Grazing			35.1			
BWM147A	19.1	Cattle Grazing	19.1					
BWM148	7.3	Cattle Grazing	7.3					
BWM149B	9.8	Cattle Grazing	9.8					
BWM152	35.2	Woodland Habitat	35.2					
BWM153	25.4	Woodland Habitat	25.4					
BWM155	1.5	Woodland Habitat	1.5					
BWM156	7.4	Cattle Grazing	7.4					
BWM157	10.5	Cattle Grazing	10.5					
BWM157A	12.1	Cattle Grazing	12.1					
BWM161	57.3	Cattle Grazing	57.3					
BWM162A	67.1	Cattle Grazing	67.1					

Rehabilitation Area/ Site ID	Area (ha)	Post Mining Land Use (PMLU)	Blackwater Coal Mine Rehabilitation Monitoring Report (LEC, 2024a).	Blackwater Coal Mine Woodland Habitat Rehabilitation Monitoring Report 2024 (BMA 2024a)	BMA Blackwater Coal Mine Rehabilitation Monitoring Report FY24 (BMA 2024b)	BWM Major Rehabilitation Monitoring 2022 (ELA, 2023)	Initial Rehabilitation Monitoring Report Blackwater Mine 2019 (ELA, 2020)	Initial Rehabilitation Monitoring Report Blackwater Mine 2018 (ELA, 2018)
			Rehabilitation Area (ha) monitored per year.					
BWM164A	21.7	Cattle Grazing	21.7					
BWM166	8.4	Cattle Grazing	8.4					
BWM167B	3.9	Cattle Grazing	3.9					
BWM168, BWM168A	16.0	Woodland Habitat		16.0	16.0			
BWM169	7.6	Cattle Grazing	7.6					
BWM170, BWM170A	20.9	Woodland Habitat		20.9	20.9			
BWM173	8.4	Cattle Grazing	8.4					
BWM18	26.9	Woodland Habitat	26.9			26.9		
BWM180, BWM180A	12.8	Woodland Habitat		12.8	12.8			
BWM185	47.5	Woodland Habitat	47.5					
BWM185A	3.1	Woodland Habitat	3.1					

Rehabilitation Area/ Site ID	Area (ha)	Post Mining Land Use (PMLU)	Blackwater Coal Mine Rehabilitation Monitoring Report (LEC, 2024a).	Blackwater Coal Mine Woodland Habitat Rehabilitation Monitoring Report 2024 (BMA 2024a)	BMA Blackwater Coal Mine Rehabilitation Monitoring Report FY24 (BMA 2024b)	BWM Major Rehabilitation Monitoring 2022 (ELA, 2023)	Initial Rehabilitation Monitoring Report Blackwater Mine 2019 (ELA, 2020)	Initial Rehabilitation Monitoring Report Blackwater Mine 2018 (ELA, 2018)
			Rehabilitation Area (ha) monitored per year.					
BWM188A	15.8	Woodland Habitat	15.8					
BWM189, BWM189A	50.8	Woodland Habitat		50.8	50.8			
BWM193	7.6	Woodland Habitat	7.6					
BWM199	2.1	Woodland Habitat		2.1	2.1			
BWM200	5.9	Woodland Habitat	5.9					
BWM202	8.6	Woodland Habitat	8.6					
BWM203A	23.9	Woodland Habitat	23.9					
BWM204A	8.9	Woodland Habitat	8.9					
BWM205	16.4	Woodland Habitat			16.4			
BWM208A	4.9	Woodland Habitat	4.9					

Rehabilitation Area/ Site ID	Area (ha)	Post Mining Land Use (PMLU)	Blackwater Coal Mine Rehabilitation Monitoring Report (LEC, 2024a).	Blackwater Coal Mine Woodland Habitat Rehabilitation Monitoring Report 2024 (BMA 2024a)	BMA Blackwater Coal Mine Rehabilitation Monitoring Report FY24 (BMA 2024b)	BWM Major Rehabilitation Monitoring 2022 (ELA, 2023)	Initial Rehabilitation Monitoring Report Blackwater Mine 2019 (ELA, 2020)	Initial Rehabilitation Monitoring Report Blackwater Mine 2018 (ELA, 2018)
			Rehabilitation Area (ha) monitored per year.					
BWM208B	6.1	Cattle Grazing	6.1					
BWM22	10.3	Woodland Habitat	10.3			10.3		
BWM23	18.8	Woodland Habitat	18.8			18.8		
BWM25, BWM25A	24.2	Woodland Habitat		24.2		24.2		
BWM26	4.1	Woodland Habitat	4.1					
BWM28	16.1	Woodland Habitat	16.1			16.1		
BWM29	19.1	Woodland Habitat	19.1			19.1		
BWM32	40.4	Woodland Habitat	40.4					
BWM33, BWM33A, BWM33B	35.6	Woodland Habitat		35.6	35.6	16.4		
BWM35A, BWM35B	48.3	Cattle Grazing	48.3			48.3		

Rehabilitation Area/ Site ID	Area (ha)	Post Mining Land Use (PMLU)	Blackwater Coal Mine Rehabilitation Monitoring Report (LEC, 2024a).	Blackwater Coal Mine Woodland Habitat Rehabilitation Monitoring Report 2024 (BMA 2024a)	BMA Blackwater Coal Mine Rehabilitation Monitoring Report FY24 (BMA 2024b)	BWM Major Rehabilitation Monitoring 2022 (ELA, 2023)	Initial Rehabilitation Monitoring Report Blackwater Mine 2019 (ELA, 2020)	Initial Rehabilitation Monitoring Report Blackwater Mine 2018 (ELA, 2018)
			Rehabilitation Area (ha) monitored per year.					
BWM37A	3.9	Cattle Grazing				3.9		
BWM38A	7.3	Cattle Grazing				7.3		
BWM38B	18.2	Cattle Grazing				18.2		
BWM40	16.4	Cattle Grazing			16.4	16.4		
BWM42	27.5	Cattle Grazing			27.5			
BWM43	9.6	Cattle Grazing			9.6			
BWM44	1.3	Cattle Grazing			1.3			
BWM58	3.5	Cattle Grazing			3.5			
Total	**1497**		**1046.4**	**162.3**	**346**	**410.4**	**57.7**	**72.1**

680000
682500
685000
687500
690000
7387500
7385000
7382500
7380000
7377500
7375000

BWM102
BWM104
BWM103
BWM105A
BWM106
BWM105B
BWM209
BWM108
BWM107
BWM210
BWM35A
BWM01
BWM112
BWM40
BWM37A
BWM11
BWM116A
BWM116B
BWM208B
BWM118
BWM121
BWM120
BWM208A
BWM38A
BWM208C
BWM38B
BWM122
BWM12
BWM44
BWM124
BWM119
BWM02
BWM43
BWM03
BWM211
BWM42
BWM128
BWM129
BWM130A
BWM130B
BWM_R28_01
BWM212
BWM05
BWM132
BWM213

ML 1759
ML 1762

GDA2020, MGA Zone 55

BLACKWATER MINE REHABILITATION
FY2024 Rehabilitation Monitoring

0 0.25 0.5 0.75 1 1.25
km

BWM Mining Lease
Existing Rehab Area (PRCP 2024)
Existing Rehabilitation Monitoring Site
RehabilitationMonitoring Site Completed 2024

Image: Blackwater Mine 2024-02-07

LYNGCO ENVIRONMENTAL CONSULTING

Drawn By: C Schlebusch
Requested by: S Lyngcoln
Date: 30/01/2025

BWM PRCP Rehab Areas and FY25 Rehabilitation Monitoring Sites Page 1 of 3

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ML 759

ML 1762

ML 1800

ML 1862

ML 70091

ML 1792

ML 1771

BWM147B
BWM147A
BWM148
BWM149A
BWM149B
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BWM153
BWM157B
BWM157A
BWM158
BWM155
BWM156
BWM_R50_01
BWM159
BWM157A
BWM161
BWM215
BWM162B
BWM162A
BWM216
BWM_R54_N
BWM217
BWM_R54_01
BWM218
BWM_R54_02
BWM164A
BWM219
BWM166
BWM167B
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BWM221
BWM222
BWM173
BWM58
BWM223
BWM28
BWM180
BWM29
BWM26

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692500
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7367500
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7357500

GDA2020, MGA Zone 55

BLACKWATER MINE REHABILITATION

FY2024 Rehabilitation Monitoring

0 0.25 0.5 0.75 1 1.25
km

BWM Mining Lease
Existing Rehab Area (PRCP 2024)
Existing Rehabilitation Monitoring Site
Rehabilitation Monitoring Site Completed 2024

Image: Blackwater Mine 2024-02-07

LYNGCO ENVIRONMENTAL CONSULTING

Drawn By: C Schlebusch
Requested by: S Lyngcoln
Date: 30/01/2025

BWM PRCP Rehab Areas and FY25 Rehabilitation Monitoring Sites
Page 2 of 3

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7345000
7342500
7340000

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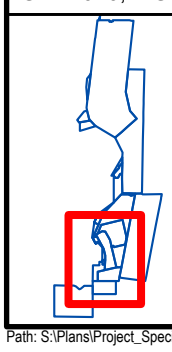
ML 1792
ML 1773
ML 1772
ML 1771
ML 1860
ML 1767
ML 1907
ML 70091
ML 70139
ML 70167

BWM25
BWM23
BWM224
BWM22
BWM225
BWM32
BWM185
BWM185
BWM18
BWM33
BWM188B
BWM187
BWM188A
BWM226
BWM189
BWM227
BWM193
BWM228
BWM199
BWM200
BWM201
BWM202
BWM204A
BWM203B
BWM204A
BWM204B
BWM203A
BWM205

GDA2020, MGA Zone 55

BLACKWATER MINE REHABILITATION
FY2024 Rehabilitation Monitoring

0 0.25 0.5 0.75 1 1.25
km



- BWM Mining Lease
- Existing Rehab Area (PRCP 2024)
- Existing Rehabilitation Monitoring Site
- Rehabilitation Monitoring Site Completed 2024

Image: Blackwater Mine 2024-02-07

LYNGCO ENVIRONMENTAL CONSULTING

Drawn By: C Schlebusch
Requested by: S Lyngcoln
Date: 30/01/2025

BWM PRCP Rehab Areas and FY25 Rehabilitation Monitoring Sites
Page 3 of 3

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Rehabilitation Monitoring Results Summary

Cattle Grazing PMLU Results

The results of monitoring of cattle grazing PMLU areas have been summarised below as it relates to the following criteria:

- land suitability class ≤3 (Short, 2023)
- land condition Good (A) or Fair (B) (DES, 2022a)

The land suitability class raw data has been provided for all cattle grazing sites assessed between 2022 and 2024 in Attachment Two and Three. The land suitability class results are summarised in Figure 2 with the results of rehabilitation monitoring sites represented in the blue bars and the cattle grazing reference sites in purple bars. The results indicate that the majority of the existing cattle grazing is classed between LSC 4 and 5. It is important to note that in accordance with (Short, 2023) land suitability is scored on the most limiting factor. The results of a review of the raw data (refer Attachment Two and Three) indicate that many sites are limited by low available Phosphorus (P) in 0.1m of the rehabilitated soil profile as well as moderate to higher pH in 0.1m of the rehabilitated soil profile. Other limiting factors include percent slope and exchangeable sodium percent (ESP) in 0.1 and/or subsoil erosion associated with high >23% ESP at 0.5m depth. Whilst available Phosphorus (P) can be ameliorated through application of fertiliser, it is important to note that both cattle grazing reference sites are also limited by low available P which can therefore be considered evidence of a pre-mining limitation. Furthermore, both reference sites are also limited by high moderate to higher pH in 0.1m which can also be considered a pre-mining condition.

Whilst not a current completion criterion in the BWM EA, areas of cattle grazing have also been assessed against 'land condition' criteria based on the *Queensland Reef Quality Program Reef Protection Regulations Farming in Reef Catchments Grazing Guide Version 2* (DES, 2022a). The results of the grazing land condition monitoring are provided in attachment four and five and have been summarised in Figure 3 with the results of rehabilitation monitoring sites represented in the blue bars and the cattle grazing reference sites in purple bars. Whilst land condition is not a completion criterion in the BWM EA, it is an important criterion for monitoring the condition of grazing lands in Central Queensland (DES, 2022a). The results indicate the majority of the cattle grazing is in Good (A) or Fair (B) land condition.

It is however important to note that the majority of cattle grazing in Good (A) or Fair (B) land condition only supports one preferred, perennial and palatable (3P) grass species predominantly buffel grass (*Cenchrus ciliaris*). The BWM PRCP addresses this issue for all future cattle grazing requiring at least four 3P species of pasture grass to be sown.

It is understood that BWM are undertaking ongoing maintenance of rehabilitation areas based on prioritised works recommended from annual monitoring. From a maintenance perspective, BWM is currently undertaking a Leucaena management program targeting areas of high density Leucaena identified during the 2022-2024 monitoring program. It is expected ongoing maintenance including control of outliers of Leucaena, erosion control and reseeding will follow on from the weed management programs in cattle grazing PMLU areas returned from monitoring with rehabilitated land in Poor (C) or Degraded (D) condition based on the results of annual monitoring.

BWM is also currently undertaking further monitoring in areas of cattle grazing rehabilitation identified during the 2024 monitoring program likely to be able to progress towards progressive certification against the BWM EA with LSC ≤3, or not different from pre-mining class if ≥4. BWM will prepare a progressive certification application for areas of cattle grazing rehabilitation returned compliant with current EA completion criteria as listed in Attachment One.

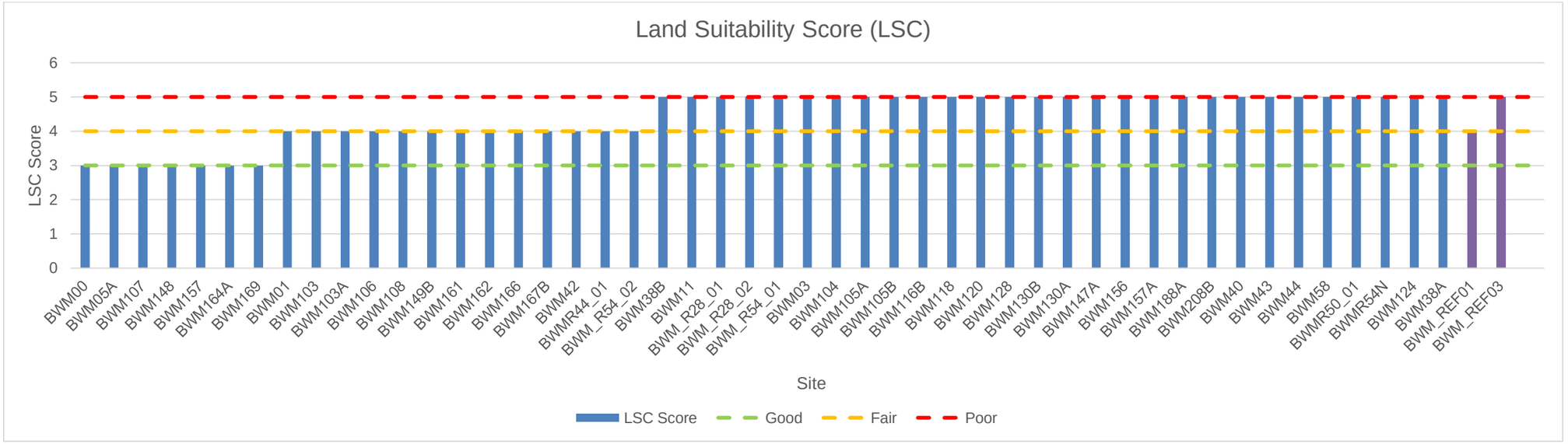

Figure 2 Land Suitability Class Results 2022-2024



Figure 3 Land Condition Monitoring Results 2022-2024

Woodland Habitat PMLU Results

The results of the woodland habitat monitoring between 2022-2024 have been provided in Attachment Six and Attachment Seven.

Table E1 of the BWM EA requires all woodland areas to meet 'native bushland habitat characteristics' including ≥2 tree, ≥3 shrub and ≥4 grass species richness as well as ≥16% canopy cover. A summary of the overall results for all woodland habitat sites have been presented for each of the native bushland habitat characteristics with the rehabilitation site results represented by the blue bars and the woodland habitat reference sites represented by the purple bass as follows:

- Species richness:
    - Trees ≥2 (Figure 4)
    - Shrubs ≥3 (Figure 5)
    - Grasses ≥4 (Figure 6)
- Tree canopy cover ≥16% (Figure 7)

A summary of erosional stability of woodland habitat has also been provided in Figure 8 based on the following EA criteria:

- Groundcover (steep slopes, >15%) ≥80%
- Groundcover (lesser slopes, ≤15%) ≥50%

The results of the woodland habitat monitoring indicate that the majority of woodland habitat sites are performing well with ≥2 tree species, ≥3 shrub species, ≥16% tree canopy cover and total ground cover (%) over slope consistent with the EA requirements. It is however important to note grass species' richness is quite low across many of the woodland sites. Mine soils and spoils are often contaminated with exotic pasture grasses and historically rehabilitation focused primarily on trees and shrubs with exotic pasture species. Native grasses have only become available in commercial quantities over the last ten or so years. For this reason, both exotic and native grasses are considered justified for older areas of rehabilitation >10 years.

The woodland habitat analysis also considers invasive plant species cover and recruitment of the canopy species, as summarised in Attachment Six and Seven. The majority of the woodland rehabilitation is low in invasive plant cover and has evidence of recruitment of canopy species. Despite the low presence of invasive plans BWM is conducting weed control in woodland areas and is also focusing on a control program of Leucaena.

In December 2024 BWM lodged a woodland habitat progressive certification application for 65.6 ha of historic woodland habitat rehabilitation associated with rehabilitation areas BWM25, BWM33 and BWM180 (LEC, 2024b). The application demonstrated the conditions of the environmental authority have been complied and the land has been satisfactory rehabilitated. Satisfactory rehabilitation is safe, stable, non-polluting and able to sustain the agreed post-mining land use. In addition to demonstrating compliance with the rehabilitation success criteria, the application also described the ongoing environmental management requirements and presented a detailed assessment of environmental risks associated with the rehabilitation.

BWM intend to continue to maintain woodland habitat and pursue further progressive certification application for woodland habitat that complies with the BWM EA.

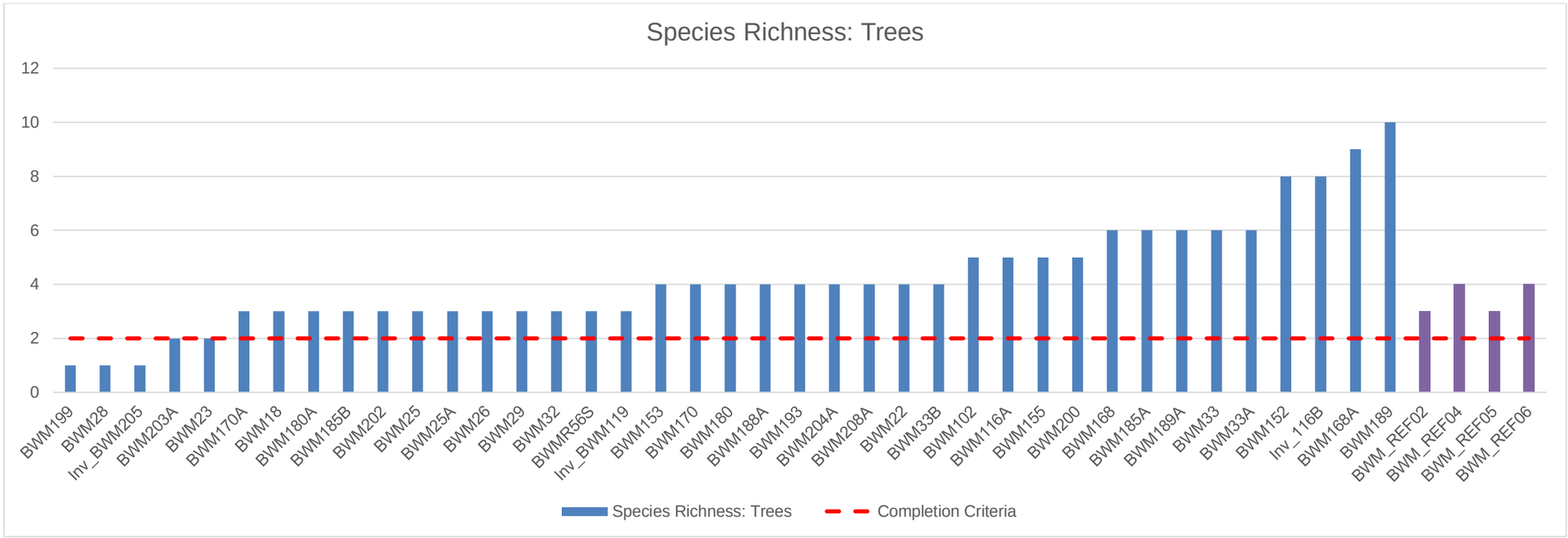

Figure 4 BWM woodland habitat rehabiliaition tree species richness 2022-2024

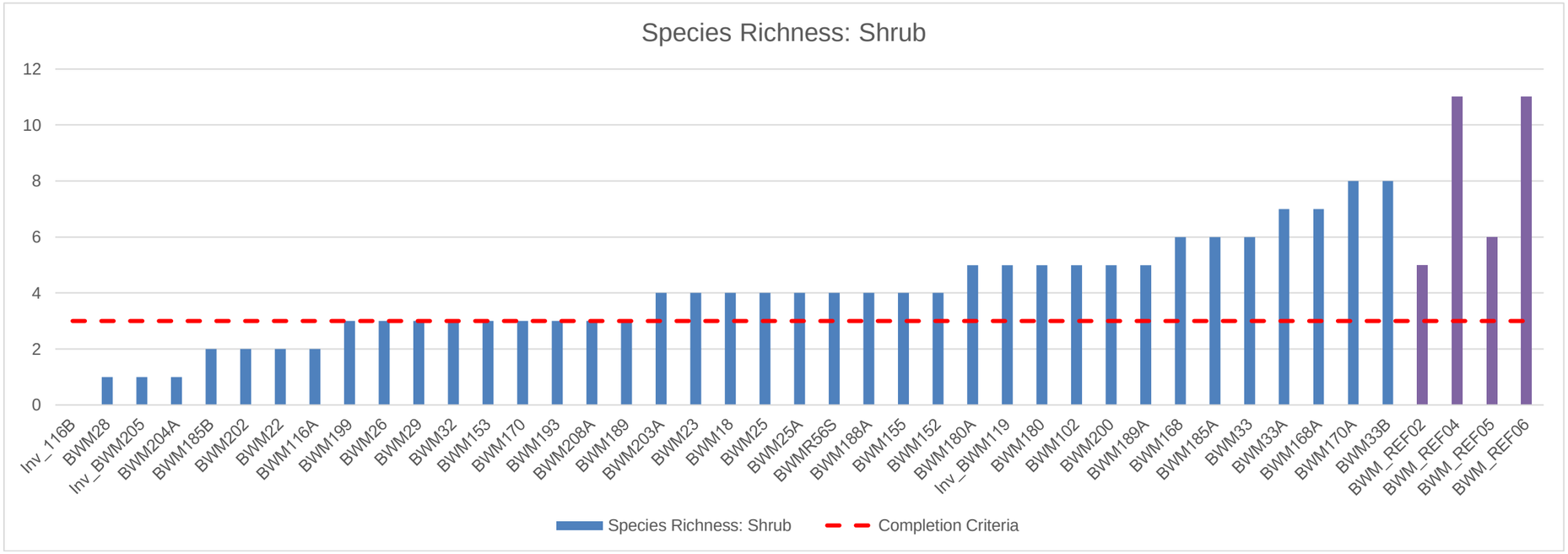

Figure 5 BWM woodland habitat rehabilitation shrub species richness 2022-2024

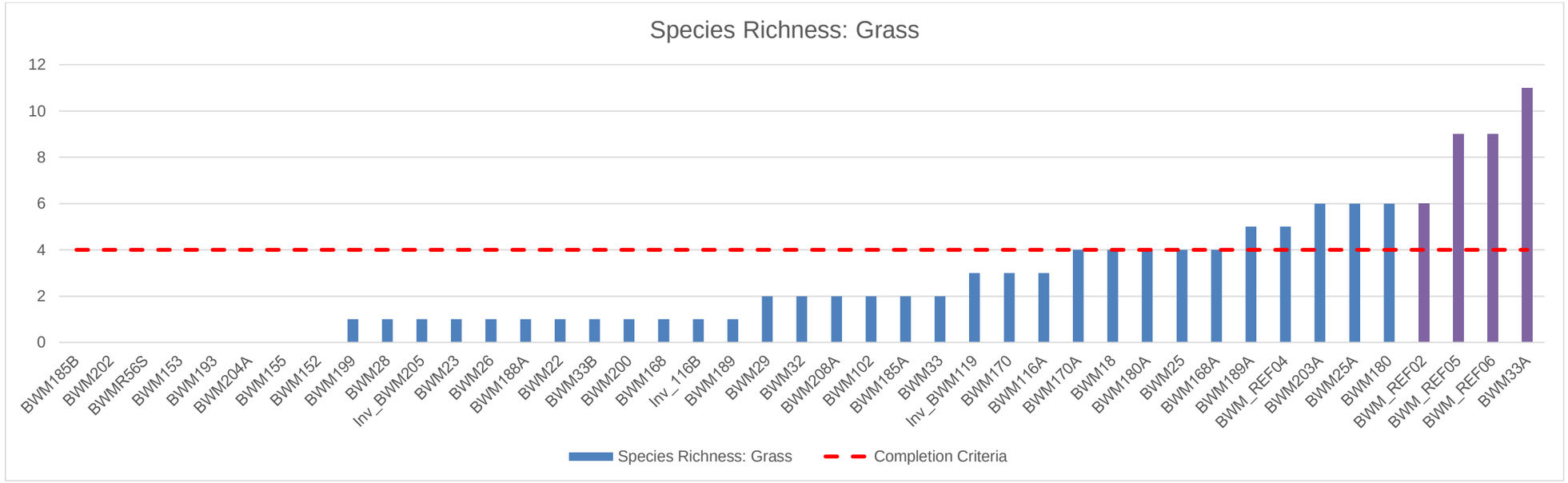

Figure 6 BWM woodland habitat rehabilitation grass species richness 2022-2024

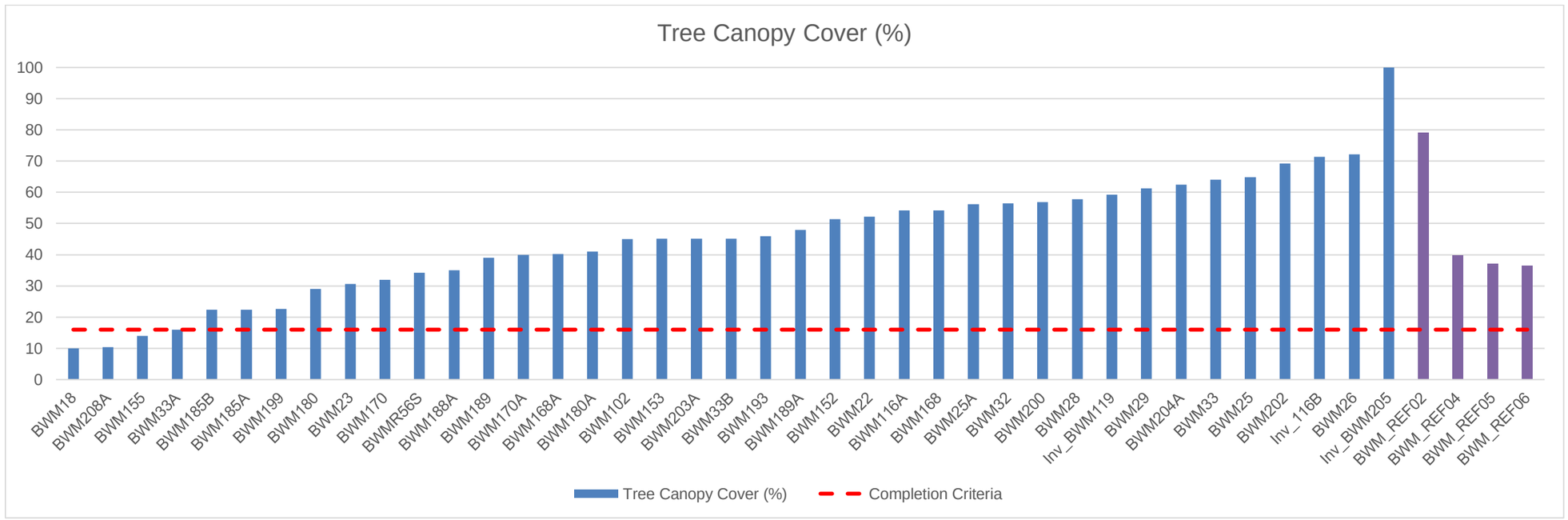

Figure 7 BWM woodland habitat rehabilitation tree canopy cover percent (%) 2022-2024

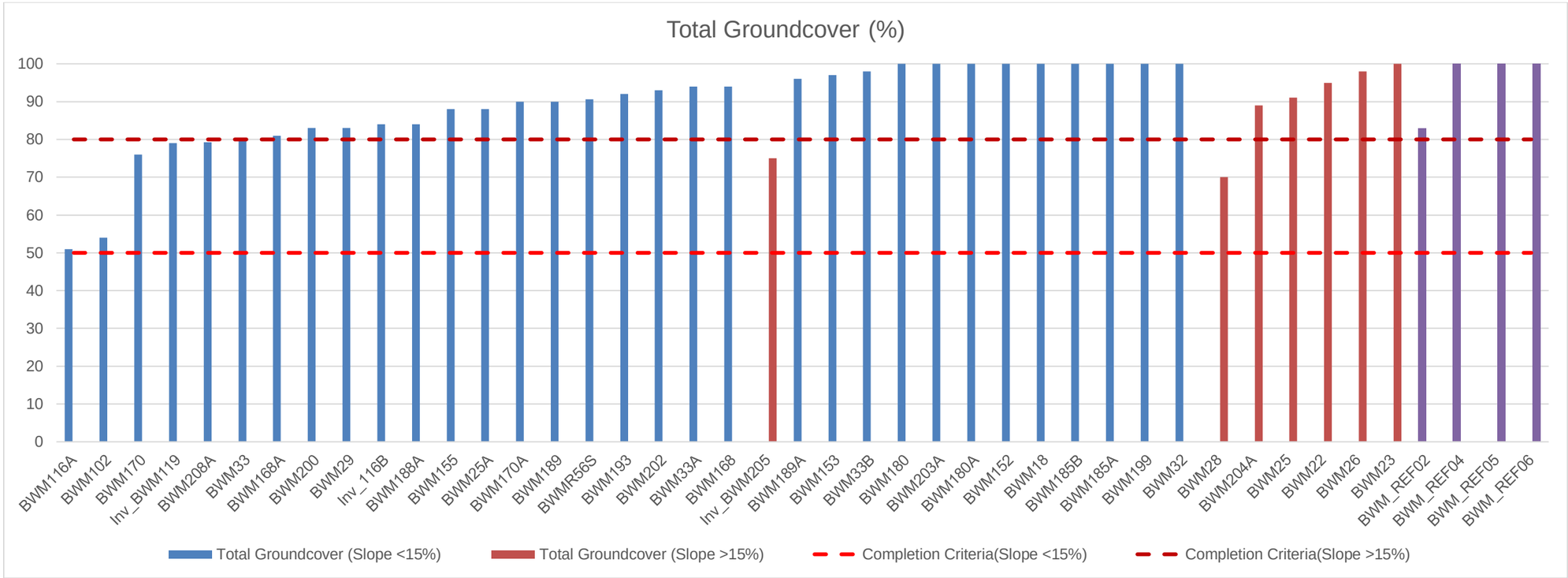

Figure 8 BWM woodland habitat rehabilitation total ground cover (%) over slope 2022-2024

Summary and Conclusions

On April 2nd, 2024, BWM was transferred to Whitehaven Coal (WHC). In 2018 the previous owner BHP Mitsubishi Alliance (BMA) negotiated revised final post mining land uses (PMLU) completion criteria for cattle grazing and woodland habitat land uses under Table E1 of the BWM Environmental Authority (EA) Permit EPML00717813 (refer Attachment One).

Rehabilitation monitoring on BWM has been undertaken since 2018 in accordance with the BWM Rehabilitation Monitoring Methodology (RMM) and associated subsequent versions to determine the performance of rehabilitation against the updated EA completion criteria for cattle grazing, and woodland habitat PMLU.

The existing rehabilitation areas on BWM and associated monitoring sites are illustrated in Figure 1. Table 1 lists the associated rehabilitation monitoring sites that have been monitored as a result of each monitoring program between 2018-2024. A total of 1497 ha of the existing 1929 ha listed as existing rehabilitation in the BWM PRCP has been monitored between 2022-2024 which includes all sites ever monitored on BWM.

It is understood that the 2025 rehabilitation monitoring program will focus on assessing areas not yet monitored and developing and an associated maintenance program.

Cattle grazing monitoring results between 2022-2024 are summarised as they relate to BWM EA land suitability class completion criteria in Attachment Two and Three. The results indicate that the majority of the existing cattle grazing is classed between LSC 4 and 5. It is important to note that in accordance with Short (2023) land suitability is scored on the most limiting factor. The results indicate that many sites are limited by low available Phosphorus (P) in 0.1m of the rehabilitated soil profile as well as moderate to higher pH in 0.1m of the rehabilitated soil profile. Other limiting factors include percent slope and exchangeable sodium percent (ESP) in 0.1 and/or subsoil erosion associated with high >23% ESP at 0.5m depth. Whilst available Phosphorus (P) can be ameliorated through application of fertiliser, it is important to note that both cattle grazing reference sites are also limited by low available P which can therefore be considered evidence of a pre-mining limitation. Furthermore, both reference sites are also limited by high moderate to higher pH in 0.1m of the rehabilitated soil profile which can also be considered a pre-mining condition.

Whilst not a current completion criterion in the BWM EA, areas of cattle grazing have also been assessed against 'land condition' criteria based on the *Queensland Reef Quality Program Reef Protection Regulations Farming in Reef Catchments Grazing Guide Version 2* (DES, 2022a). The results of the grazing land condition monitoring are provided in Attachments Four and Five and have been summarised in Figure 3. Whilst land condition is not a completion criterion in the BWM EA, it is an important criterion for monitoring the condition of grazing lands in Central Queensland (DES, 2022a).

It is understood that BWM are undertaking ongoing maintenance of rehabilitation areas based on prioritised works recommended from annual monitoring. From a maintenance perspective, BWM is currently undertaking a Leucaena management program targeting areas of high density Leucaena identified during the 2022-2024 monitoring program. It is expected ongoing maintenance including control of outliers of Leucaena, erosion control and reseeding will follow on from the weed management programs in cattle grazing PMLU areas returned from monitoring with rehabilitated land in Poor (C) or Degraded (D) condition based on the results of annual monitoring.

BWM is also currently undertaking further monitoring in areas of cattle grazing rehabilitation identified during the 2024 monitoring program likely to be able to progress towards progressive certification against the BWM EA with LSC ≤3 or not different from pre-mining class if ≥4. BWM will prepare a progressive certification application for areas of cattle grazing rehabilitation returned compliant with current EA completion criteria as listed in Attachment One.

The results of the woodland habitat monitoring between 2022-2024 indicate that the majority of woodland habitat sites are performing well with ≥2 tree species, ≥3 shrub species, ≥16% tree canopy cover and total ground cover (%) over slope consistent with the EA requirements. It is however important to note grass species' richness is quite low across much of the woodland sites. Mine soils

and spoils are often contaminated with exotic pasture grasses and historically rehabilitation focused primarily on trees and shrubs with exotic pasture species. Native grasses have only become available in commercial quantities over the last ten or so years. For this reason, both exotic and native grasses are considered justified for older areas of rehabilitation >10 years.

In December 2024 BWM lodged a woodland habitat progressive certification application for 65.6 ha of historic woodland habitat rehabilitation associated with rehabilitation areas BWM25, BWM33 and BWM180. The application demonstrated the conditions of the environmental authority have been complied with and the land has been satisfactory rehabilitated. Satisfactory rehabilitation is safe, stable, non-polluting and able to sustain the agreed post-mining land use. In addition to demonstrating compliance and rehabilitation success, the application also described the ongoing environmental management requirements and presented a detailed assessment of environmental risks associated with the rehabilitation.

BWM intends to continue to maintain woodland habitat and pursue further progressive certification application for woodland habitat that complies with the BWM EA.

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Attachment One – Post Mining Land Use Completion Criteria

Table 2: BWM EA PMLU objectives, indicators and acceptance criteria: cattle grazing.

Goal	Objective	Indicator	Acceptance criteria
Safe to humans and wildlife	Safety hazards in rehabilitation are not significantly different to surrounding unmined landscapes subject to the same land use	Hazard assessment	No significant difference
Stable	Rehabilitation is geotechnically stable	Factor of Safety	≥1.5
	Rehabilitation is erosionally stable	Extent, slope gradient and groundcover	Groundcover >50%, and 70% of slopes ≤20%
Non-polluting	Rainfall runoff from rehabilitation achieves relevant water quality objectives for receiving waters	pH EC Turbidity	Not significantly different to upstream values
	Deep drainage from rehabilitation achieves relevant water quality objectives for groundwater	EC	Not significantly different to: The EPP (Water) schedule documents water quality objectives for relevant groundwater chemistry zones; or, Local water quality objectives developed in accordance with the Queensland Water Quality Guidelines.
Able to sustain the agreed post-mining land use	Rehabilitation is suitable for sustainable cattle grazing	Land suitability assessment for cattle grazing	Land suitability class ≤3 or not different from pre-mining class if ≥4. Assessment completed in accordance with *LSA Framework for Open-Cut Coal Mine Rehabilitation 2018 (A rule-set for land suitability assessment of sustainable beef cattle grazing on land rehabilitated after open-cut coal mining in the Bowen Basin Queensland* (Short, Land Suitability Assessment (LSA) Framework for Open-Cut Coal Mine Rehabilitation 2018 (A rule-set for land suitability assessment of sustainable beef cattle grazing on land rehabilitated after open-cut coal mining in the Bowen Basin Queensland), 2018)*)* Unless otherwise agreed in writing between the administering authority and the environmental authority holder.

Goal	Objective	Indicator	Acceptance criteria
		Leucaena stem density	<250 stems >2 m height per ha (1 per 40 m^2), mean total area

Table 3: BWM EA PMLU objectives, indicators and acceptance criteria: woodland habitat.

Goal	Objective	Indicator	Acceptance criteria
Safe to humans and wildlife	Safety hazards in rehabilitation are not significantly different to surrounding unmined landscapes subject to the same land use	Hazard assessment	No significant difference
Stable	Rehabilitation is geotechnically stable	Factor of safety	≥1.5 unless an alternative is justified by an appropriately qualified engineer
	Rehabilitation is erosionally stable	Groundcover (steep slopes, >15%)	80%
		Groundcover (lesser slopes, ≤15%)	50%
Non-polluting	Rainfall runoff from rehabilitation achieves relevant water quality objectives for receiving waters	pH EC Turbidity	Not significantly different to upstream values
	Deep drainage from rehabilitation achieves relevant water quality objectives for groundwater	EC	Not significantly different to: the EPP (Water) schedule documents water quality objectives for relevant groundwater chemistry zones; or local water quality objectives developed in accordance with the Queensland Water Quality Guidelines.
Able to sustain an agreed post-mining land use	Native bushland habitat characteristics	Species richness: Trees Shrubs Grasses	 ≥2 ≥3 ≥4
		Tree canopy cover	≥16

Table 4: ABCD Land Condition Framework (DES, 2022a)**.**

Land Condition	Land Condition Features
Good – A	A condition land has all the following features: • most land types in good condition will typically have at least 50% and often above 70% ground cover at the end of the dry season • good density of perennial grasses dominated by those species considered to be 3P grasses for that land type, little bare ground (less than 30 % in most years) • few weeds and no significant infestations • good soil condition: no erosion, good surface condition
Fair – B	B condition land has at least one or more of the following features, but otherwise is similar to A condition land: • land types will typically have at least 50% ground cover and less than 70% in most years at the end of the dry season • some decline of grasses that are 3P grasses, increase in other species (less favoured grasses, weeds) and/or bare ground (more than 30% but less than 50% in most years) • some decline in soil condition, some signs of previous erosion and current susceptibility to erosion
Poor – C	C condition land has one or more of the following features, but otherwise is similar to B condition land: • land with poor or degraded condition will typically have less than 50% ground cover at the end of the dry season • general decline of grasses that are 3P grasses, large amounts of less favoured species and/or bare ground (greater than 50% in most years) • obvious signs of past erosion and/or current susceptibility to erosion is high
Degraded – D	D condition land has one or more of the following features: • generally, less than 20% ground cover • general lack of any perennial grasses or forbs • severe erosion or scalding, resulting in hostile environment for plant growth • often no long-term ability to carry stock

Attachment Two – Land Suitability Class Monitoring Results (BMA, 2024a)

Limitation		Water availability			Nutrient supply				Soil physical factors		Salinity		Rockiness		Topography (slope)				Water, erosion, surface soil		Subsoil erosion		Potential acid forming materials		
Site ID	Soil Core ID	PAWC in ERD			Colwell P to 0.1m		pH in 0.1m		Surface soil structure		EC in ERD dS/m		Fragments on surface		Gradient, surface		Vertical interval, surface		Slope % (ESP in 0.1m)		Subsoil erosion		pH <4.5		
Notes: Good, Fair, Poor		From soil texture lab results 0-10cm, 10-30cm, 30-60cm	Total Core PAWC	LSC Score	Phosphorus (Colwell)	LSC Score	pH (1:5 Water)	LSC Factor Score	Use pedality in surface sample and/or surface condition from erosion.	LSC Factor Score	Electrical Conductivity (Sat. Ext.) dS/m to 0.1m (10cm)	LSC Factor Score	Percent rock groundcover	LSC Factor Score	Mean Slope %	LSC Factor Score	Topography (slope and microrelief) (m) Soils	LSC Factor Score	Median Slope % and Sodium % of Cations (ESP) 0.1m	LSC Factor Score	Sodium % of Cations (ESP) >0.5m	LSC Factor Score	Depth to pH 4.5	LSC Factor Score	Grazing Land Suitability Class
BWM 37B-1A	1																				2.9	-	No	1	
BWM 37B-1B	1																				6.2	-	No	1	
BWM 37B-1C	1	64			<5.0	5	8.6	4	2-5	1	1.2	1	0	1			Nil	1	2.9	1	8.1	2	No	1	
BWM 37B-2A	2																				1.9	-	No	1	
BWM 37B-2B	2																				4.3	-	No	1	
BWM 37B-2C	2	66	64	2	<5.0	5	8.6	4	2-5	1	1.2	1	0	1	5	2	Nil	1	1.9	1	8.1	2	No	1	5
BWM42_1A	1																				5.9	-	No	1	
BWM42_1B	1																				8.0	-	No	1	
BWM42_1C	1																				9.9	2	No	1	
BWM42_1D	1	60			6.5	4	8.9	4	2-5	1	1.3	1	0	1			0.2 - 0.4	3	5.9	2	13	3	No	1	
BWM42_2A	2																				6.7	-	No	1	
BWM42_2B	2																				8.7	-	No	1	
BWM42_2C	2	54	54	3	<5.0	5	9.0	4	2-5	1	1.5	1	0	1	8	2	0.2 - 0.4	3	6.7	3	11	2	No	1	5
BWM43_1A	1																				6.8	-	No	1	
BWM43_1B	1																				11	-	No	1	
BWM43_1C	1	50	50	3	<5.0	5	9.1	5	Surface Crusting	3	1.2	1	0	1	2	1	0.4 - 0.6	4	6.8	2	14	2	No	1	5

Limitation		Water availability			Nutrient supply				Soil physical factors		Salinity		Rockiness		Topography (slope)				Water, erosion, surface soil		Subsoil erosion		Potential acid forming materials		
Site ID	Soil Core ID	PAWC in ERD			Colwell P to 0.1m		pH in 0.1m		Surface soil structure		EC in ERD dS/m		Fragments on surface		Gradient, surface		Vertical interval, surface		Slope % (ESP in 0.1m)		Subsoil erosion		pH <4.5		
Notes: Good, Fair, Poor		From soil texture lab results 0-10cm, 10-30cm, 30-60cm	Total Core PAWC	LSC Score	Phosphorus (Colwell)	LSC Score	pH (1:5 Water)	LSC Factor Score	Use pedality in surface sample and/or surface condition from erosion.	LSC Factor Score	Electrical Conductivity (Sat. Ext.) dS/m to 0.1m (10cm)	LSC Factor Score	Percent rock groundcover	LSC Factor Score	Mean Slope %	LSC Factor Score	Topography (slope and microrelief) (m) Soils	LSC Factor Score	Median Slope % and Sodium % of Cations (ESP) 0.1m	LSC Factor Score	Sodium % of Cations (ESP) >0.5m	LSC Factor Score	Depth to pH 4.5	LSC Factor Score	Grazing Land Suitability Class
BWM43_2A	2																				7.5	-	No	1	
BWM43_2B	2	50			<5.0	5	9.2	5	Surface Crusting	3	1.2	1	0	1			0.4 - 0.6	4	7.5	2	9.6	-	No	1	
BWM44_1A	1																				5.4	-	No	1	
BWM44_1B	1																				6.9	-	No	1	
BWM44_1C	1	60			<5.0	5	9.0	4	Surface Crusting	3	1.3	1	0	1			0.4 - 0.6	4	5.4	2	15	3	No	1	
BWM44_2A	2																				4.8	-	No	1	
BWM44_2B	2	72	60	2	<5.0	5	9.0	4	Surface Crusting	3	1.2	1	0	1	2	1	0.4 - 0.6	4	4.8	1	7.2	-	No	1	5
BWM54_TS	1	30	30	4	<5.0	5	5.6	3	10-20	2	0.2	1	0	1	5	2	Nil	1	2.0	1	2.0	-	No	1	5
BWM58-1A	1																				2.3	-	No	1	
BWM58-1B	1																				2.0	-	No	1	
BWM58-1C	1	30			5.9	5	6.1	2	5-10	1	1.1	1	0	1			Nil	1	2.3		3.6	2	No	1	
BWM58-2A	2																				3.4	-	No	1	
BWM58-2B	2																				24	-	No	1	
BWM58-2C	2	30	30	4	7.9	4	5.9	3	5-10	1	0.5	1	0	1			Nil	1	3.4		17	3	No	1	5
INVOI_1A	1																				3.9	-	No	1	
INVOI_1B	1	30	30	4	<5.0	5	7.9	2	10-20	2	0.3	1	0	1	1	1	Nil	1	3.9	1	7.5	-	No	1	5

Limitation		Water availability			Nutrient supply				Soil physical factors		Salinity		Rockiness		Topography (slope)				Water, erosion, surface soil		Subsoil erosion		Potential acid forming materials		
Site ID	Soil Core ID	PAWC in ERD			Colwell P to 0.1m		pH in 0.1m		Surface soil structure		EC in ERD dS/m		Fragments on surface		Gradient, surface		Vertical interval, surface		Slope % (ESP in 0.1m)		Subsoil erosion		pH <4.5		
Notes: Good, Fair, Poor		From soil texture lab results 0-10cm, 10-30cm, 30-60cm	Total Core PAWC	LSC Score	Phosphorus (Colwell)	LSC Score	pH (1:5 Water)	LSC Factor Score	Use pedality in surface sample and/or surface condition from erosion.	LSC Factor Score	Electrical Conductivity (Sat. Ext.) dS/m to 0.1m (10cm)	LSC Factor Score	Percent rock groundcover	LSC Factor Score	Mean Slope %	LSC Factor Score	Topography (slope and microrelief) (m) Soils	LSC Factor Score	Median Slope % and Sodium % of Cations (ESP) 0.1m	LSC Factor Score	Sodium % of Cations (ESP) >0.5m	LSC Factor Score	Depth to pH 4.5	LSC Factor Score	Grazing Land Suitability Class
INVOI_1C	1																				15	3	No	1	
R28 01-1A	1																				5.8	-	No	1	
R28 01-1B	1																				8.9	-	No	1	
R28 01-1C	1																				12	2	No	1	
R28 01-1D	1	66			<5.0	5	8.9	4	2-5	1	1.4	1	0	1			0.4 - 0.6	4	5.8	2	10	2	No	1	
R28 01-2A	2																				6.0	-	No	1	
R28 01-2B	2																				8.6	-	No	1	
R28 01-2C	2	72	66	2	<5.0	5	9.1	5	2-5	1	1.4	1	0	1	8	2	0.4 - 0.6	4	6.0	2	8.7	2	No	1	5
REF 03-1A	1																				0.90	-	No	1	
REF 03-1B	1																				3.6	-	No	1	
REF 03-1C	1																				12	2	No	1	
REF 03-1D	1	70			<5.0	5	8.3	3	5-10	1	1.1	1	0	1			Nil	1	0.90	1	19	3	No	1	
REF 03-2A	2																				1.4	-	No	1	
REF 03-2B	2																				1.3	-	No	1	
REF 03-2C	2	64	64	2	<5.0	5	7.5	2	5-10	1	0.3	1	0	1	2	1	Nil	1	1.4	1	1.4	1	No	1	5
R28 02-1A	1																				1.9	-	No	1	
R28 02-1B	1																				3.6	-	No	1	
R28 02-1C	1	54	54	3	<5.0	5	8.7	4	5-10	1	0.9	1	0	1	8	2	0.4 - 0.6	4	1.9	1	9.6	2	No	1	5

Limitation		Water availability			Nutrient supply				Soil physical factors		Salinity		Rockiness		Topography (slope)				Water, erosion, surface soil		Subsoil erosion		Potential acid forming materials		
Site ID	Soil Core ID	PAWC in ERD			Colwell P to 0.1m		pH in 0.1m		Surface soil structure		EC in ERD dS/m		Fragments on surface		Gradient, surface		Vertical interval, surface		Slope % (ESP in 0.1m)		Subsoil erosion		pH <4.5		
Notes: Good, Fair, Poor		From soil texture lab results 0-10cm, 10-30cm, 30-60cm	Total Core PAWC	LSC Score	Phosphorus (Colwell)	LSC Score	pH (1:5 Water)	LSC Factor Score	Use pedality in surface sample and/or surface condition from erosion.	LSC Factor Score	Electrical Conductivity (Sat. Ext.) dS/m to 0.1m (10cm)	LSC Factor Score	Percent rock groundcover	LSC Factor Score	Mean Slope %	LSC Factor Score	Topography (slope and microrelief) (m) Soils	LSC Factor Score	Median Slope % and Sodium % of Cations (ESP) 0.1m	LSC Factor Score	Sodium % of Cations (ESP) >0.5m	LSC Factor Score	Depth to pH 4.5	LSC Factor Score	Grazing Land Suitability Class
R28 02-2A	2																				2.8	-	No	1	
R28 02-2B	2																				4.6	-	No	1	
R28 02-2C	2	62			<5.0	5	8.7	4	5-10	1	1.2	1	0	1			0.4 - 0.6	4	2.8	1	5.9	1	No	1	
R54_01_1A	1																				17	-	No	1	
R54_01_1B	1																				36	-	No	1	
R54_01_1C	1	60			<5.0	5	9.1	5	Surface Crusting	3	3.4	2	0	1			0.4 - 0.6	4	17	5	36	5	No	1	
R54_01_2A	2																				2.7	-	No	1	
R54_01_2B	2																				9.3	-	No	1	
R54_01_2C	2	58	58	3	53	1	8.5	3	Surface Crusting	3	0.9	1	0	1	1	1	0.4 - 0.6	4	2.7	1	17	3	No	1	5
BWM 116B-01A	1																				6.5	-	No	1	
BWM 116B-01B	1																				12	-	No	1	
BWM 116B-01C	1	48			<5.1	5	9.3	5	10-20	2	1.1	1	0	1			<0.2	2	6.5	2	22	3	No	1	
BWM 116B-02A	2																				0.76	-	No	1	
BWM 116B-02B	2																				0.70	-	No	1	
BWM 116B-02C	2	38	38	4	-	-	5.6	3	10-20	2	0.4	1	0	1	5	2	<0.2	2	0.76	1	0.43	1	No	1	5
BWM 40-1A	1																				3.8	-	No	1	
BWM 40-1B	1																				7.2	-	No	1	
BWM 40-1C	1	60	60	2	<5.0	5	8.6	4	2-5	1	1.6	1	0	1	10	2	0.2 - 0.4	3	3.8	2	7.7	2	No	1	5

Limitation		Water availability			Nutrient supply				Soil physical factors		Salinity		Rockiness		Topography (slope)				Water, erosion, surface soil		Subsoil erosion		Potential acid forming materials		
Site ID	Soil Core ID	PAWC in ERD			Colwell P to 0.1m		pH in 0.1m		Surface soil structure		EC in ERD dS/m		Fragments on surface		Gradient, surface		Vertical interval, surface		Slope % (ESP in 0.1m)		Subsoil erosion		pH <4.5		
Notes: Good, Fair, Poor		From soil texture lab results 0-10cm, 10-30cm, 30-60cm	Total Core PAWC	LSC Score	Phosphorus (Colwell)	LSC Score	pH (1:5 Water)	LSC Factor Score	Use pedality in surface sample and/or surface condition from erosion.	LSC Factor Score	Electrical Conductivity (Sat. Ext.) dS/m to 0.1m (10cm)	LSC Factor Score	Percent rock groundcover	LSC Factor Score	Mean Slope %	LSC Factor Score	Topography (slope and microrelief) (m) Soils	LSC Factor Score	Median Slope % and Sodium % of Cations (ESP) 0.1m	LSC Factor Score	Sodium % of Cations (ESP) >0.5m	LSC Factor Score	Depth to pH 4.5	LSC Factor Score	Grazing Land Suitability Class
BWM 40-2A	2																				6.1	-	No	1	
BWM 40-2B	2																				9.6	-	No	1	
BWM 40-2C	2	60			<5.0	5	8.9	4	2-5	1	1.7	1	0	1			0.2 - 0.4	3	6.1	3	13	2	No	1	
BWM REF01-1A	1																				0.61	-	No	1	
BWM REF01-1B	1																				1.7	-	No	1	
BWM REF01-1C	1	60			5.5	4	8.4	4	Surface Crusting	3	0.9	1	0	1			Nil	1	0.61	1	7.9	2	No	1	
BWM REF01-2A	2																				2.1	-	No	1	
BWM REF01-2B	2																				0.74	-	No	1	
BWM REF01-2C	2	66	60	2	7.2	4	8.7	4	Surface Crusting	3	1.1	1	0	1	1	1	Nil	1	2.1	1	14	2	No	1	4
BWM03-1A	1																				0.13	-	No	1	
BWM03_1B	1																				0.20	-	No	1	
BWM03_1C	1																				0.42	1	No	1	
BWM03_1D	1	52			<5.0	5	8.7	4	5-10	1	0.8	1	0	1			0.2 - 0.4	3	0.13	1	1.3	1	No	1	
BWM03_2A	2																				0.097	-	No	1	
BWM03_2B	2																				0.40	-	No	1	
BWM03_2C	2	52	52	3	6.1	4	8.3	3	5-10	1	0.9	1	0	1	9	2	0.2 - 0.4	3	0.097	1	1.0	1	No	1	5

Attachment Three – Land Suitability Class Monitoring Results (BMA, 2024b)

Limitation			Water availability		Nutrient supply				Soil physical factors		Salinity		Rockiness		Topography (slope)				Water, erosion, surface soil		Subsoil erosion		Potential acid forming materials		Grazing Land Suitability Class
Site ID	Soil Core ID	PAWC in ERD			Colwell P to 0.1m		pH in 0.1m		Surface soil structure		EC in ERD dS/m		Fragments on surface		Gradient, surface		Vertical interval, surface		Slope % (ESP in 0.1m)		Subsoil erosion		pH <4.5		
Notes: Good, Fair, Poor		From soil texture lab results 0-10cm, 10-30cm, 30-60cm	Total Core PAWC	LSC Score	Phosphorus (Colwell)	LSC Score	pH (1:5 Water)	LSC Factor Score	Use pedality in surface sample and/or surface condition from erosion.	LSC Factor Score	Electrical Conductivity (Sat. Ext.) dS/m to 0.1m (10cm)	LSC Factor Score	Percent rock groundcover	LSC Factor Score	Mean Slope %	LSC Factor Score	Topography (slope and microrelief) (m) Soils	LSC Factor Score	Median Slope % and Sodium % of Cations (ESP) 0.1m	LSC Factor Score	Sodium % of Cations (ESP) >0.5m	LSC Factor Score	Depth to pH 4.5	LSC Factor Score	
BWM 01-1A	2	10	60	**2**	9.6	**3**	8.4	**3**	>10mm	**2**	1.3	**1**	0	**1**	8	**2**	<0.4m	**3**	2	**1**	2	-	8.4	**1**	**4**
BWM 01-1B	2	20			6		9.3				3.2								17		17		9.3	**1**	
BWM 01-1C	2	30			6.6		9.4				5.3								26		26	**4**	9.4	**1**	
	2	-					-												-		-	**-**	-	**1**	
BWM 01-2A		10	60	**2**	10	**3**	8.2	**3**	>10mm	**2**	1.4	**1**	0	**1**	8	**2**	<0.4m	**3**	1.2	**1**	1.2	-	8.2	**1**	**3**
BWM 01-2B		20			<5.0		9.1				1.6								7.3		7.3		9.1	**1**	
BWM 01-2C		30			<5.0		9.5				3								17		17	**3**	9.5	**1**	
		-					-												-		-	**-**	-	**1**	
BWM 104-1A		12	72	**2**	<5.0	**5**	8.7	**4**	>10mm	**2**	0.9	**1**	0	**1**	6	**2**	<0.4m	**3**	2	**1**	2	-	8.7	**1**	**5**
BWM 104-1B		24			<5.0		9.2				1.7								8.4		8.4		9.2	**1**	
BWM 104-1C		36			<5.0		9.1				3.8								26		26	**4**	9.1	**1**	
		-					-												-		-	**-**	-	**1**	
BWM 104-2A		12	72	**2**	<5.0	**5**	8.6	**4**	>10mm	**2**	1.2	**1**	0	**1**	6	**2**	<0.4m	**3**	4.2	**2**	4.2	-	8.6	**1**	**5**
BWM 104-2B		24			<5.0		8.9				3.1								13		13		8.9	**1**	
BWM 104-2C		36			<5.0		8.9				4.5								24		24	**4**	8.9	**1**	
		-					-												-		-	**-**	-	**1**	
BWM 105A-1A		12	72	**2**	<5.0	**5**	8.5	**3**	>10mm	**2**	1	**1**	0	**1**	11.5	**3**	<0.4m	**3**	1.4	**1**	1.4	-	8.5	**1**	**5**

Limitation			Water availability	Nutrient supply				Soil physical factors		Salinity		Rockiness		Topography (slope)				Water, erosion, surface soil		Subsoil erosion		Potential acid forming materials		Grazing Land Suitability Class
Site ID	Soil Core ID	PAWC in ERD			Colwell P to 0.1m		pH in 0.1m	Surface soil structure		EC in ERD dS/m		Fragments on surface		Gradient, surface		Vertical interval, surface		Slope % (ESP in 0.1m)		Subsoil erosion		pH <4.5		
Notes: Good, Fair, Poor		From soil texture lab results 0-10cm, 10-30cm, 30-60cm	Total Core PAWC	LSC Score	Phosphorus (Colwell)	LSC Score	pH (1:5 Water)	LSC Factor Score	Use pedality in surface sample and/or surface condition from erosion.	LSC Factor Score	Electrical Conductivity (Sat. Ext.) dS/m to 0.1m (10cm)	LSC Factor Score	Percent rock groundcover	LSC Factor Score	Mean Slope %	LSC Factor Score	Topography (slope and microrelief) (m) Soils	LSC Factor Score	Median Slope % and Sodium % of Cations (ESP) 0.1m	LSC Factor Score	Sodium % of Cations (ESP) >0.5m	LSC Factor Score	Depth to pH 4.5	LSC Factor Score	
BWM 105A-1B		24			9.4		8.7				1.5								5.4		5.4		8.7	**1**	
BWM 105A-1C		36			6.1		9.1				2.2								12		12	**2**	9.1	**1**	
		-					-												-		-	**-**	-	**1**	
BWM 105A-2A		12			<5.0		8.4				1.2								1.5		1.5		8.4	**1**	
BWM 105A-2B		24			<5.0		8.6				1.4								3.9		3.9	**-**	8.6	**1**	
BWM 105A-2C		36	72	**2**	5.1	**5**	9.2	**3**	>10mm	**2**	1.6	**1**	0	**1**	11.5	**3**	<0.4m	**3**	8.8	**1**	8.8	**2**	9.2	**1**	**5**
		-					-												-		-	**-**	-	**1**	
BWM107-1A		12			12		8.4				1.5								2.5		2.5		8.4	**1**	
BWM107-1B		24			12		8.7				1.7								5.7		5.7	**-**	8.7	**1**	
BWM107-1C		36	72	**2**	13	**3**	8.4	**3**	>10mm	**2**	2.8	**1**	0	**1**	7.6	**2**	<0.4m	**3**	6	**1**	6	**1**	8.4	**1**	**3**
BWM107-1D		-			<5.0		8.8				5.5								15		15	**3**	8.8	**1**	
BWM107 2A		12			23		8.4				1.6								2.2		2.2		8.4	**1**	
BWM107 2B		24			5.2		8.6				1.4								2.6		2.6	**-**	8.6	**1**	
BWM107 2C		36	72	**2**	7.2	**1**	8.8	**3**	>10mm	**2**	1.5	**1**	0	**1**	7.6	**2**	<0.4m	**3**	4.7	**1**	4.7	**1**	8.8	**1**	**3**
		-					-												-		-	**-**	-	**1**	
BWM 120-1A		10			<5.0		8.3				1								0.42		0.42		8.3	**1**	
BWM 120-1B		24			<5.0		8.7				1.5								4.7		4.7	**-**	8.7	**1**	
BWM 120-1C		30	64	**2**	<5.0	**5**	9.7	**3**	>10mm	**2**	1.9	**1**	0	**1**	8.5	**3**	<0.4m	**3**	12	**1**	12	**2**	9.7	**1**	**5**
		-					-												-		-	**-**	-	**1**	

Limitation			Water availability		Nutrient supply				Soil physical factors		Salinity		Rockiness		Topography (slope)				Water, erosion, surface soil		Subsoil erosion		Potential acid forming materials		Grazing Land Suitability Class
Site ID	Soil Core ID	PAWC in ERD			Colwell P to 0.1m		pH in 0.1m		Surface soil structure		EC in ERD dS/m		Fragments on surface		Gradient, surface		Vertical interval, surface		Slope % (ESP in 0.1m)		Subsoil erosion		pH <4.5		
Notes: Good, Fair, Poor		From soil texture lab results 0-10cm, 10-30cm, 30-60cm	Total Core PAWC	LSC Score	Phosphorus (Colwell)	LSC Score	pH (1:5 Water)	LSC Factor Score	Use pedality in surface sample and/or surface condition from erosion.	LSC Factor Score	Electrical Conductivity (Sat. Ext.) dS/m to 0.1m (10cm)	LSC Factor Score	Percent rock groundcover	LSC Factor Score	Mean Slope %	LSC Factor Score	Topography (slope and microrelief) (m) Soils	LSC Factor Score	Median Slope % and Sodium % of Cations (ESP) 0.1m	LSC Factor Score	Sodium % of Cations (ESP) >0.5m	LSC Factor Score	Depth to pH 4.5	LSC Factor Score	
BWM 120-2A		12	72	**2**	7	**4**	8.1	**3**	>10mm	**2**	1.1	**1**	0	**1**	8.5	**3**	<0.4m	**3**	0.66	**1**	0.66	-	8.1	**1**	**4**
BWM 120-2B		24			<5.0		8.9				1.8								8.2		8.2		8.9	**1**	
		36					-												-		-	-	-	**1**	
		-					-												-		-	-	-	**1**	
BWM 147A-1A		8	58	**3**	20	**2**	6.7	**2**	>10mm	**2**	2.2	**2**	0	**1**	10.3	**3**	<0.4m	**3**	3.5	**2**	3.5	-	6.7	**1**	**5**
BWM 147A-1B		20			9		7.1				1.9								11		11		7.1	**1**	
BWM 147A-1C		30			13		7.1				4.7								33		33	**4**	7.1	**1**	
BWM 147A-1D		-			13		6.6				16.5								37		37	**5**	6.6	**1**	
BWM 147A-2A		10	60	**2**	<5.0	**5**	7.3	**1**	>10mm	**2**	0.6	**1**	0	**1**	10.3	**3**	<0.4m	**3**	1.8	**1**	1.8	-	7.3	**1**	**5**
BWM 147A-2B		20			<5.0		7.9				0.9								7.4		7.4		7.9	**1**	
BWM 147A-2C		30			6.6		8.4				11.4								30		30	**4**	8.4	**1**	
		-					-												-		-	-	-	**1**	
BWM148-1A		10	60	**2**	14	**2**	7.4	**2**	>10mm	**2**	0.9	**1**	0	**1**	12.3	**3**	<0.4m	**3**	0.3	**1**	0.3	-	7.4	**1**	**3**
BWM148-1B		20			11		7.9				0.8								0.57		0.57		7.9	**1**	
BWM148-1C		30			<5.0		8.8				1								2.3		2.3	**1**	8.8	**1**	
BWM148-1D		-			<5.0		9.3				1.1								4.4		4.4	**1**	9.3	**1**	
BWM 148-2A		10	60	**2**	12	**3**	7.7	**2**	>10mm	**2**	0.6	**1**	0	**1**	12.3	**3**	<0.4m	**3**	0.42	**1**	0.42	-	7.7	**1**	**3**
BWM 148-2B		20			7.9		7.8				0.5								0.9		0.9		7.8	**1**	
		30					-												-		-	-	-	**1**	

Limitation			Water availability		Nutrient supply				Soil physical factors		Salinity		Rockiness		Topography (slope)				Water, erosion, surface soil		Subsoil erosion		Potential acid forming materials		Grazing Land Suitability Class
Site ID	Soil Core ID	PAWC in ERD			Colwell P to 0.1m		pH in 0.1m		Surface soil structure		EC in ERD dS/m		Fragments on surface		Gradient, surface		Vertical interval, surface		Slope % (ESP in 0.1m)		Subsoil erosion		pH <4.5		
Notes: Good, Fair, Poor		From soil texture lab results 0-10cm, 10-30cm, 30-60cm	Total Core PAWC	LSC Score	Phosphorus (Colwell)	LSC Score	pH (1:5 Water)	LSC Factor Score	Use pedality in surface sample and/or surface condition from erosion.	LSC Factor Score	Electrical Conductivity (Sat. Ext.) dS/m to 0.1m (10cm)	LSC Factor Score	Percent rock groundcover	LSC Factor Score	Mean Slope %	LSC Factor Score	Topography (slope and microrelief) (m) Soils	LSC Factor Score	Median Slope % and Sodium % of Cations (ESP) 0.1m	LSC Factor Score	Sodium % of Cations (ESP) >0.5m	LSC Factor Score	Depth to pH 4.5	LSC Factor Score	
		-					-												-		-	-	-	1	
BWM35B 1A		10	60	2	6.2	4	8.3	3	>10mm	2	1.1	1	0	1	9.5	3	<0.4m	3	0.43	1	0.43	-	8.3	1	4
BWM35B 1B		20			<5.0		8.5				1								0.86		0.86		8.5	1	
BWM35B 1C		30			<5.0		9.5				1.8								11		11	2	9.5	1	
BWM35B 1D		-			<5.0		9.3				4.4								18		18	3	9.3	1	
BWM 35B-2A		10	64	2	9.1	3	7.8	2	>10mm	2	1.7	1	0	1	9.5	3	<0.4m	3	0.3	1	0.3	-	7.8	1	3
BWM 35B-2B		24			9.3		8.4				1.1								0.72		0.72		8.4	1	
BWM 35B-2C		30			<5.0		8.8				1.2								3.9		3.9	1	8.8	1	
		-					-												-		-	-	-	1	
BWM00_1A		10	54	3	19	2	7.8	2	>10mm	2	0.8	1	0	1	14.6	3	<0.4m	3	0.33	1	0.33	-	7.8	1	3
BWM00_1B		20			13		7.9				0.9								0.63		0.63		7.9	1	
BWM00_1C		24			<5.0		8.6				1.4								4		4	1	8.6	1	
BWM00_1D		-			<5.0		8.2				4.2								7.4		7.4	2	8.2	1	
BWM00_2A		10	60	2	32	1	8.5	3	>10mm	2	1.4	1	0	1	14.6	3	<0.4m	3	0.25	1	0.25	-	8.5	1	3
BWM00_2B		20			14		8.6				1.3								0.24		0.24		8.6	1	
BWM00_2C		30			7.8		8.8				1.2								1.1		1.1	1	8.8	1	
		-					-												-		-	-	-	1	
BWM05A 1A		10	60	2	19	2	7.3	2	>10mm	2	1.9	1	0	1	9.2	3	<0.4m	3	0.21	1	0.21	-	7.3	1	3
BWM05A 1B		20			20		7.8				1.8								0.26		0.26		7.8	1	

Limitation			Water availability	Nutrient supply				Soil physical factors		Salinity		Rockiness		Topography (slope)				Water, erosion, surface soil		Subsoil erosion		Potential acid forming materials		Grazing Land Suitability Class
Site ID	Soil Core ID	PAWC in ERD			Colwell P to 0.1m		pH in 0.1m		Surface soil structure		EC in ERD dS/m		Fragments on surface		Gradient, surface		Vertical interval, surface		Slope % (ESP in 0.1m)		Subsoil erosion		pH <4.5		
Notes: Good, Fair, Poor		From soil texture lab results 0-10cm, 10-30cm, 30-60cm	Total Core PAWC	LSC Score	Phosphorus (Colwell)	LSC Score	pH (1:5 Water)	LSC Factor Score	Use pedality in surface sample and/or surface condition from erosion.	LSC Factor Score	Electrical Conductivity (Sat. Ext.) dS/m to 0.1m (10cm)	LSC Factor Score	Percent rock groundcover	LSC Factor Score	Mean Slope %	LSC Factor Score	Topography (slope and microrelief) (m) Soils	LSC Factor Score	Median Slope % and Sodium % of Cations (ESP) 0.1m	LSC Factor Score	Sodium % of Cations (ESP) >0.5m	LSC Factor Score	Depth to pH 4.5	LSC Factor Score	
BWM05A 1C		30			15		8.7				1.1								0.42		0.42	1	8.7	1	
		-					-												-		-	-	-	1	
BWM05A 2A		10			45		7.1				1.4								0.27		0.27		7.1	1	
BWM05A 2B		20			20		7.8				1.2								0.24		0.24	-	7.8	1	
		30	60	2		1	-	1	>10mm	2		1	0	1	9.2	3	<0.4m	3	-	1	-	-	-	1	3
		-					-												-		-	-	-	1	
BWM103 1A		10			15		8.1				1.2								0.52		0.52		8.1	1	
BWM103 1B		24			6.6		8.9				1.5								6.4		6.4	-	8.9	1	
BWM103 1C		36	70	2	<5.0	2	9.6	3	>10mm	2	2.2	1	0	1	11.4	3	<0.4m	3	17	1	17	3	9.6	1	3
BWM103 1D		-			<5.0		9.9				2								17		17	3	9.9	1	
BWM103 2A		12			6.5		8.5				1.1								1.3		1.3		8.5	1	
BWM103 2B		24			<5.0		8.6				1.2								3.3		3.3	-	8.6	1	
BWM103 2C		36	72	2	<5.0	4	9.5	3	>10mm	2	1.8	1	0	1	11.4	3	<0.4m	3	12	1	12	2	9.5	1	4
		-					-												-		-	-	-	1	
BWM103A 1A		10			5.8		8.3				0.9								0.6		0.6		8.3	1	
BWM103A 1B		20			<5.0		8.6				1.1								1.5		1.5	-	8.6	1	
BWM103A 1C		30	60	2	<5.0	4	9.9	3	>10mm	2	1.7	1	0	1	11.4	3	<0.4m	3	13	1	13	2	9.9	1	4
		-					-												-		-	-	-	1	
BWM103A 2A		10	64	2	25	1	8.4	3	>10mm	2	1	1	0	1	11.4	3	<0.4m	3	0.38	1	0.38	-	8.4	1	3

Limitation			Water availability	Nutrient supply				Soil physical factors		Salinity		Rockiness		Topography (slope)				Water, erosion, surface soil		Subsoil erosion		Potential acid forming materials		Grazing Land Suitability Class
Site ID	Soil Core ID	PAWC in ERD			Colwell P to 0.1m		pH in 0.1m	Surface soil structure		EC in ERD dS/m		Fragments on surface		Gradient, surface		Vertical interval, surface		Slope % (ESP in 0.1m)		Subsoil erosion		pH <4.5		
Notes: Good, Fair, Poor		From soil texture lab results 0-10cm, 10-30cm, 30-60cm	Total Core PAWC	LSC Score	Phosphorus (Colwell)	LSC Score	pH (1:5 Water)	LSC Factor Score	Use pedality in surface sample and/or surface condition from erosion.	LSC Factor Score	Electrical Conductivity (Sat. Ext.) dS/m to 0.1m (10cm)	LSC Factor Score	Percent rock groundcover	LSC Factor Score	Mean Slope %	LSC Factor Score	Topography (slope and microrelief) (m) Soils	LSC Factor Score	Median Slope % and Sodium % of Cations (ESP) 0.1m	LSC Factor Score	Sodium % of Cations (ESP) >0.5m	LSC Factor Score	Depth to pH 4.5	LSC Factor Score	
BWM103A 2B		24			<5.0		8.9				1.2								4.6		4.6		8.9	1	
BWM103A 2C		30			<5.0		9.6				1.7								12		12	2	9.6	1	
		-					-												-		-	-	-	1	
BWM105B 1A		10			<5.0		8.5				0.9								1.7		1.7	-	8.5	1	
BWM105B 1B		24			<5.0		9				1.6								6.4		6.4		9	1	
BWM105B 1C		36	70	2	5.9	5	9.7	3	>10mm	2	2.5	1	0	1	10.8	3	<0.4m	3	18	1	18	3	9.7	1	5
BWM105B 1D		-			12		8.8				7.2								24		24	4	8.8	1	
BWM105B 2A		10			<5.0		8.5				1								1.3		1.3	-	8.5	1	
BWM105B 2B		24			<5.0		8.7				1.1								3		3		8.7	1	
BWM105B 2C		36	70	2	5.4	5	9.5	3	>10mm	2	2.3	1	0	1	10.8	3	<0.4m	3	15	1	15	3	9.5	1	5
		-					-												-		-	-	-	1	
BWM106 1A		12			7.9		8.3				1.3								0.53		0.53	-	8.3	1	
BWM106 1B		24			<5.0		8.8				1.4								4		4		8.8	1	
BWM106 1C		36	72	2	<5.0	4	9.3	3	>10mm	2	3.1	1	0	1	6	2	<0.4m	3	15	1	15	3	9.3	1	4
		-					-												-		-	-	-	1	
BWM106 2A		12			7.6		8				1.4								0.31		0.31	-	8	1	
BWM106 2B		24			<5.0		8.9				1.6								5.5		5.5		8.9	1	
BWM106 2C		30	66	2	<5.0	4	9.5	2	>10mm	2	2.4	1	0	1	6	2	<0.4m	3	15	1	15	3	9.5	1	4
BWM106 2D		-			<5.0		8.9				7								19		19	3	8.9	1	

Limitation			Water availability		Nutrient supply				Soil physical factors		Salinity		Rockiness		Topography (slope)				Water, erosion, surface soil		Subsoil erosion		Potential acid forming materials		Grazing Land Suitability Class
Site ID	Soil Core ID	PAWC in ERD			Colwell P to 0.1m		pH in 0.1m		Surface soil structure		EC in ERD dS/m		Fragments on surface		Gradient, surface		Vertical interval, surface		Slope % (ESP in 0.1m)		Subsoil erosion		pH <4.5		
Notes: Good, Fair, Poor		From soil texture lab results 0-10cm, 10-30cm, 30-60cm	Total Core PAWC	LSC Score	Phosphorus (Colwell)	LSC Score	pH (1:5 Water)	LSC Factor Score	Use pedality in surface sample and/or surface condition from erosion.	LSC Factor Score	Electrical Conductivity (Sat. Ext.) dS/m to 0.1m (10cm)	LSC Factor Score	Percent rock groundcover	LSC Factor Score	Mean Slope %	LSC Factor Score	Topography (slope and microrelief) (m) Soils	LSC Factor Score	Median Slope % and Sodium % of Cations (ESP) 0.1m	LSC Factor Score	Sodium % of Cations (ESP) >0.5m	LSC Factor Score	Depth to pH 4.5	LSC Factor Score	
BWM108 1A		12	72	2	10	3	8.3	3	>10mm	2	1	1	0	1	8.1	3	<0.4m	3	0.15	1	0.15	-	8.3	1	3
BWM108 1B		24			<5.0		8.4				1.1								0.5		0.5		8.4	1	
		36					-												-		-	-	-	1	
		-					-												-		-	-	-	1	
BWM108 2A		10	60	2	7.9	4	8.1	3	>10mm	2	1.3	1	0	1	8.1	3	<0.4m	3	0.17	1	0.17	-	8.1	1	4
BWM108 2B		20			<5.0		8.4				1.1								0.44		0.44		8.4	1	
BWM108 2C		30			<5.0		8.7				0.9								0.84		0.84	1	8.7	1	
		-					-												-		-	-	-	1	
BWM118 1A		10	70	2	5.9	4	8.7	4	>10mm	2	1.1	1	0	1	6.2	2	<0.4m	3	2.9	1	2.9	-	8.7	1	4
BWM118 1B		24			<5.0		8.9				2.1								9.5		9.5		8.9	1	
		36					-												-		-	-	-	1	
		-					-												-		-	-	-	1	
BWM118 2A		12	72	2	<5.0	5	8.8	4	>10mm	2	1.2	1	0	1	6.2	2	<0.4m	3	3.3	2	3.3	-	8.8	1	5
BWM118 2B		24			5.5		9				1.6								6.9		6.9		9	1	
		36					-												-		-	-	-	1	
		-					-												-		-	-	-	1	
BWM128 1A		10	60	2	<5.0	5	8.7	4	>10mm	2	1	1	0	1	7.8	2	<0.4m	3	0.61	1	0.61	-	8.7	1	5
BWM128 1B		20			<5.0		9				2.2								7.2		7.2		9	1	
BWM128 1C		30			<5.0		9.5				8.6								33		33	4	9.5	1	

Limitation			Water availability		Nutrient supply				Soil physical factors		Salinity		Rockiness		Topography (slope)				Water, erosion, surface soil		Subsoil erosion		Potential acid forming materials		Grazing Land Suitability Class
Site ID	Soil Core ID	PAWC in ERD			Colwell P to 0.1m		pH in 0.1m		Surface soil structure		EC in ERD dS/m		Fragments on surface		Gradient, surface		Vertical interval, surface		Slope % (ESP in 0.1m)		Subsoil erosion		pH <4.5		
Notes: Good, Fair, Poor		From soil texture lab results 0-10cm, 10-30cm, 30-60cm	Total Core PAWC	LSC Score	Phosphorus (Colwell)	LSC Score	pH (1:5 Water)	LSC Factor Score	Use pedality in surface sample and/or surface condition from erosion.	LSC Factor Score	Electrical Conductivity (Sat. Ext.) dS/m to 0.1m (10cm)	LSC Factor Score	Percent rock groundcover	LSC Factor Score	Mean Slope %	LSC Factor Score	Topography (slope and microrelief) (m) Soils	LSC Factor Score	Median Slope % and Sodium % of Cations (ESP) 0.1m	LSC Factor Score	Sodium % of Cations (ESP) >0.5m	LSC Factor Score	Depth to pH 4.5	LSC Factor Score	
		-					-												-		-	-	-	1	
BWM128 2A		10	60	2	<5.0	5	8.9	4	>10mm	2	20	5	0	1	7.8	2	<0.4m	3	44	5	44	-	8.9	1	5
BWM128 2B		20			<5.0		9.1				15.1								40		40		9.1	1	
BWM128 2C		30			<5.0		9.1				16.1								44		44	5	9.1	1	
		-					-												-		-	-	-	1	
BWM130A 1A		12	66	2	5.3	4	8	2	>10mm	2	2.2	2	0	1	7.8	2	<0.4m	3	0.3	1	0.3	-	8	1	4
BWM130A 1B		24			10		7.9				2.2								0.2		0.2		7.9	1	
BWM130A 1C		30			<5.0		8.8				1.1								1.1		1.1	1	8.8	1	
		-					-												-		-	-	-	1	
BWM130A 2A		12	72	2	<5.0	5	8.2	3	>10mm	2	1.8	1	0	1	7.8	2	<0.4m	3	0.78	1	0.78	-	8.2	1	5
BWM130A 2B		24			<5.0		8.2				1.7								0.35		0.35		8.2	1	
BWM130A 2C		36			<5.0		8.4				2.2								3.3		3.3	1	8.4	1	
		-					-												-		-	-	-	1	
BWM149B-1A		10	60	2	5.6	4	8.4	3	>10mm	2	1.5	1	0	1	13.3	3	<0.4m	3	0.35	1	0.35	-	8.4	1	4
BWM149B-1B		20			6.2		8.7				1.5								1.3		1.3		8.7	1	
BWM149B-1C		30			<5.0		8.3				8.5								8.8		8.8	2	8.3	1	
		-					-												-		-	-	-	1	
BWM149B-2A		10	60	2	6.8	4	8.1	3	>10mm	2	1.5	1	0	1	13.3	3	<0.4m	3	0.55	1	0.55	-	8.1	1	4
BWM149B-2B		20			6.5		8.4				1.4								0.55		0.55		8.4	1	

Limitation			Water availability	Nutrient supply				Soil physical factors		Salinity		Rockiness		Topography (slope)				Water, erosion, surface soil		Subsoil erosion		Potential acid forming materials		Grazing Land Suitability Class
Site ID	Soil Core ID	PAWC in ERD			Colwell P to 0.1m		pH in 0.1m			EC in ERD dS/m		Fragments on surface		Gradient, surface		Vertical interval, surface		Slope % (ESP in 0.1m)		Subsoil erosion		pH <4.5		
Notes: Good, Fair, Poor		From soil texture lab results 0-10cm, 10-30cm, 30-60cm	Total Core PAWC	LSC Score	Phosphorus (Colwell)	LSC Score	pH (1:5 Water)	LSC Factor Score	Use pedality in surface sample and/or surface condition from erosion.	LSC Factor Score	Electrical Conductivity (Sat. Ext.) dS/m to 0.1m (10cm)	LSC Factor Score	Percent rock groundcover	LSC Factor Score	Mean Slope %	LSC Factor Score	Topography (slope and microrelief) (m) Soils	LSC Factor Score	Median Slope % and Sodium % of Cations (ESP) 0.1m	LSC Factor Score	Sodium % of Cations (ESP) >0.5m	LSC Factor Score	Depth to pH 4.5	LSC Factor Score	
BWM149B-2C		30			5.1		8.7				1.6								0.57		0.57	1	8.7	1	
		-					-												-		-	-	-	1	
BWM153-1A		12			9.5		8.4				1.7								0.48		0.48		8.4	1	
BWM153-1B		20			6.6		8.6				1.6								1.6		1.6	-	8.6	1	
BWM153-1C		30	62	2	6	3	9.5	3	>10mm	2	2.5	1	0	1	12.3	3	<0.4m	3	9.6	1	9.6	2	9.5	1	3
		-					-												-		-	-	-	1	
BWM153-2A		10			<5.0		8.5				1.5								1.3		1.3		8.5	1	
BWM153-2B		20			<5.0		9.4				1.9								7.7		7.7	-	9.4	1	
		30	60	2		5	-	3	>10mm	2		1	0	1	12.3	3	<0.4m	3	-	2	-	-	-	1	5
		-					-												-		-	-	-	1	
BWM155-1A		12			5.4		8.4				1.3								0.79		0.79		8.4	1	
BWM155-1B		24			<5.0		8.5				1.6								2.1		2.1	-	8.5	1	
BWM155-1C		30	66	2	6.1	4	9.8	3	>10mm	2	2	1	0	1	6.4	2	<0.4m	3	17	1	17	3	9.8	1	4
		-					-												-		-	-	-	1	
BWM155-2A		10			5.5		8.7				0.9								0.31		0.31		8.7	1	
BWM155-2B		20			6.1		8.7				1.1								1.3		1.3	-	8.7	1	
BWM155-2C		30	60	2	<5.0	4	9.6	4	>10mm	2	1.2	1	0	1	6.4	2	<0.4m	3	9.6	1	9.6	2	9.6	1	4
		-					-												-		-	-	-	1	
BWM156-1A		12	66	2	<5.0	5	8.4	3	>10mm	2	0.9	1	0	1	9.7	3	<0.4m	3	0.28	1	0.28	-	8.4	1	5

Limitation			Water availability	Nutrient supply				Soil physical factors		Salinity		Rockiness		Topography (slope)				Water, erosion, surface soil		Subsoil erosion		Potential acid forming materials		Grazing Land Suitability Class
Site ID	Soil Core ID	PAWC in ERD		Colwell P to 0.1m		pH in 0.1m		Surface soil structure		EC in ERD dS/m		Fragments on surface		Gradient, surface		Vertical interval, surface		Slope % (ESP in 0.1m)		Subsoil erosion		pH <4.5		
Notes: Good, Fair, Poor		From soil texture lab results 0-10cm, 10-30cm, 30-60cm	Total Core PAWC	Phosphorus (Colwell)	LSC Score	pH (1:5 Water)	LSC Factor Score	Use pedality in surface sample and/or surface condition from erosion.	LSC Factor Score	Electrical Conductivity (Sat. Ext.) dS/m to 0.1m (10cm)	LSC Factor Score	Percent rock groundcover	LSC Factor Score	Mean Slope %	LSC Factor Score	Topography (slope and microrelief) (m) Soils	LSC Factor Score	Median Slope % and Sodium % of Cations (ESP) 0.1m	LSC Factor Score	Sodium % of Cations (ESP) >0.5m	LSC Factor Score	Depth to pH 4.5	LSC Factor Score	
BWM156-1B		24		5.9		8.6				1.1								1		1		8.6	**1**	
BWM156-1C		30		<5.0		9.6				1.6								8.3		8.3	**2**	9.6	**1**	
		-				-												-		-	**-**	-	**1**	
BWM156-2A		12		<5.0		8.6				0.9								0.65		0.65		8.6	**1**	
BWM156-2B		24		6.1		8.7				1.2								2.1		2.1	**-**	8.7	**1**	
BWM156-2C		30	66	<5.0	**5**	9.2	**4**	>10mm	**2**	1.9	**1**	0	**1**	9.7	**3**	<0.4m	**3**	6.7	**1**	6.7	**1**	9.2	**1**	**5**
		-				-												-		-	**-**	-	**1**	
BWM157-1A		10		8.5		8.3				1.2								0.23		0.23		8.3	**1**	
BWM157-1B		20		6.7		8.6				0.9								0.33		0.33	**-**	8.6	**1**	
BWM157-1C		30	60	<5.0	**3**	9.2	**3**	>10mm	**2**	0.7	**1**	0	**1**	9	**3**	<0.4m	**3**	1	**1**	1	**1**	9.2	**1**	**3**
		-				-												-		-	**-**	-	**1**	
BWM157-2A		10		10		8.4				1								0.17		0.17		8.4	**1**	
BWM157-2B		20		10		8.3				0.9								0.21		0.21	**-**	8.3	**1**	
BWM157-2C		24	54	5.9	**3**	9.1	**3**	>10mm	**2**	0.6	**1**	0	**1**	9	**3**	<0.4m	**3**	0.41	**1**	0.41	**1**	9.1	**1**	**3**
		-				-												-		-	**-**	-	**1**	
BWM157A_1A		10		7.4		8.5				1.4								0.19		0.19		8.5	**1**	
BWM157A_1B		24		<5.0		8.5				1.3								<1		<1	**-**	8.5	**1**	
BWM157A_1C		30	64	<5.0	**4**	9.2	**3**	>10mm	**2**	1.2	**1**	0	**1**	10.3	**3**	<0.4m	**3**	2.2	**1**	2.2	**1**	9.2	**1**	**4**
		-				-												-		-	**-**	-	**1**	

Limitation			Water availability		Nutrient supply				Soil physical factors		Salinity		Rockiness		Topography (slope)				Water, erosion, surface soil		Subsoil erosion		Potential acid forming materials		Grazing Land Suitability Class
Site ID	Soil Core ID	PAWC in ERD			Colwell P to 0.1m		pH in 0.1m		Surface soil structure		EC in ERD dS/m		Fragments on surface		Gradient, surface		Vertical interval, surface		Slope % (ESP in 0.1m)		Subsoil erosion		pH <4.5		
Notes: Good, Fair, Poor		From soil texture lab results 0-10cm, 10-30cm, 30-60cm	Total Core PAWC	LSC Score	Phosphorus (Colwell)	LSC Score	pH (1:5 Water)	LSC Factor Score	Use pedality in surface sample and/or surface condition from erosion.	LSC Factor Score	Electrical Conductivity (Sat. Ext.) dS/m to 0.1m (10cm)	LSC Factor Score	Percent rock groundcover	LSC Factor Score	Mean Slope %	LSC Factor Score	Topography (slope and microrelief) (m) Soils	LSC Factor Score	Median Slope % and Sodium % of Cations (ESP) 0.1m	LSC Factor Score	Sodium % of Cations (ESP) >0.5m	LSC Factor Score	Depth to pH 4.5	LSC Factor Score	
BWM157A-2A		10	60	2	<5.0	5	8.2	3	>10mm	2	2.1	2	0	1	10.3	3	<0.4m	3	0.31	1	0.31	-	8.2	1	5
BWM157A-2B		20			7.9		8.1				1.9								0.27		0.27		8.1	1	
BWM157A-2C		30			5.3		8.9				1.1								0.58		0.58	1	8.9	1	
		-					-												-		-	-	-	1	
BWM161_1A		10	60	2	7.4	4	8.5	3	>10mm	2	1.5	1	0	1	7.5	2	<0.4m	3	0.23	1	0.23	-	8.5	1	4
BWM161_1B		20			<5.0		8.6				1.4								0.26		0.26		8.6	1	
BWM161_1C		30			<5.0		9.1				1.6								2.3		2.3	1	9.1	1	
		-					-												-		-	-	-	1	
BWM161_2A		10	60	2	15	2	8.3	3	>10mm	2	1.8	1	0	1	7.5	2	<0.4m	3	0.18	1	0.18	-	8.3	1	3
BWM161_2B		20			<5.0		8.6				1.4								0.19		0.19		8.6	1	
BWM161_2C		30			<5.0		8.8				1.4								0.78		0.78	1	8.8	1	
		-					-												-		-	-	-	1	
BWM162_1A		12	66	2	7.9	4	8.4	3	>10mm	2	1.6	1	0	1	11.5	3	<0.4m	3	0.33	1	0.33	-	8.4	1	4
BWM162_1B		24			6.8		8.6				0.9								1.1		1.1		8.6	1	
BWM162_1C		30			<5.0		9.7				2								12		12	2	9.7	1	
BWM162_1D		-			<5.0		9.8				2.6								17		17	3	9.8	1	
BWM162_2A		10	60	2	6.2	4	8.3	3	>10mm	2	1.2	1	0	1	11.5	3	<0.4m	3	0.43	1	0.43	-	8.3	1	4
BWM162_2B		20			7.2		7.9				1.1								1.1		1.1		7.9	1	
BWM162_2C		30			21		9				3								17		17	3	9	1	

Limitation			Water availability	Nutrient supply				Soil physical factors		Salinity		Rockiness		Topography (slope)				Water, erosion, surface soil		Subsoil erosion		Potential acid forming materials		Grazing Land Suitability Class
Site ID	Soil Core ID	PAWC in ERD			Colwell P to 0.1m		pH in 0.1m		Surface soil structure		EC in ERD dS/m		Fragments on surface		Gradient, surface		Vertical interval, surface		Slope % (ESP in 0.1m)		Subsoil erosion		pH <4.5		
Notes: Good, Fair, Poor		From soil texture lab results 0-10cm, 10-30cm, 30-60cm	Total Core PAWC	LSC Score	Phosphorus (Colwell)	LSC Score	pH (1:5 Water)	LSC Factor Score	Use pedality in surface sample and/or surface condition from erosion.	LSC Factor Score	Electrical Conductivity (Sat. Ext.) dS/m to 0.1m (10cm)	LSC Factor Score	Percent rock groundcover	LSC Factor Score	Mean Slope %	LSC Factor Score	Topography (slope and microrelief) (m) Soils	LSC Factor Score	Median Slope % and Sodium % of Cations (ESP) 0.1m	LSC Factor Score	Sodium % of Cations (ESP) >0.5m	LSC Factor Score	Depth to pH 4.5	LSC Factor Score	
		-					-												-		-	-	-	1	
BWM164A_1A		10	60	2	23	1	8.5	3	>10mm	2	1.2	1	0	1	7	2	<0.4m	3	0.55	1	0.55	-	8.5	1	3
BWM164A_1B		20			6.8		8.7				1.2								1.8		1.8		8.7	1	
BWM164A_1C		30			5.9		9.4				1.6								7.8		7.8	2	9.4	1	
		-					-												-		-	-	-	1	
BWM164A_2A		10	60	2	21	1	7.6	2	>10mm	2	1	1	0	1	7	2	<0.4m	3	0.37	1	0.37	-	7.6	1	3
BWM164A_2B		20			11		7.5				0.8								0.57		0.57		7.5	1	
		30					-												-		-	-	-	1	
		-					-												-		-	-	-	1	
BWM166_1A		10	60	2	15	2	8.4	3	>10mm	2	3	2	0	1	6	2	<0.4m	3	3.6	2	3.6	-	8.4	1	3
BWM166_1B		20			12		8.3				2.2								4.2		4.2		8.3	1	
		30					-												-		-	-	-	1	
		-					-												-		-	-	-	1	
BWM166_2A		12	72	2	6.5	4	8.6	4	>10mm	2	1.7	1	0	1	6	2	<0.4m	3	2.3	1	2.3	-	8.6	1	4
BWM166_2B		24			<5.0		8.8				2								5.2		5.2		8.8	1	
BWM166_2C		36			<5.0		8.8				2.3								6.2		6.2	1	8.8	1	
		-					-												-		-	-	-	1	
BWM167B_1A		10	66	2	21	1	7.8	2	>10mm	2	1.9	1	0	1	12	3	<0.4m	3	4.7	2	4.7	-	7.8	1	4
BWM167B_1B		20			29		7.3				3.3								6.7		6.7		7.3	1	

Limitation			Water availability	Nutrient supply				Soil physical factors		Salinity		Rockiness		Topography (slope)				Water, erosion, surface soil		Subsoil erosion		Potential acid forming materials		Grazing Land Suitability Class
Site ID	Soil Core ID	PAWC in ERD			Colwell P to 0.1m		pH in 0.1m			EC in ERD dS/m		Fragments on surface		Gradient, surface		Vertical interval, surface		Slope % (ESP in 0.1m)		Subsoil erosion		pH <4.5		
Notes: Good, Fair, Poor		From soil texture lab results 0-10cm, 10-30cm, 30-60cm	Total Core PAWC	LSC Score	Phosphorus (Colwell)	LSC Score	pH (1:5 Water)	LSC Factor Score	Use pedality in surface sample and/or surface condition from erosion.	LSC Factor Score	Electrical Conductivity (Sat. Ext.) dS/m to 0.1m (10cm)	LSC Factor Score	Percent rock groundcover	LSC Factor Score	Mean Slope %	LSC Factor Score	Topography (slope and microrelief) (m) Soils	LSC Factor Score	Median Slope % and Sodium % of Cations (ESP) 0.1m	LSC Factor Score	Sodium % of Cations (ESP) >0.5m	LSC Factor Score	Depth to pH 4.5	LSC Factor Score	
BWM167B_1C		36			9.4		6.2				4.9								24		24	**4**	6.2	**1**	
BWM167B_1D		-			14		5.3				4.8								26		26	**4**	5.3	**1**	
BWM167B_2A		10			39		7.7				1								0.66		0.66		7.7	**1**	
BWM167B_2B		20			31		8.1				1.1								1.8		1.8	-	8.1	**1**	
BWM167B_2C		36	66	**2**	20	**1**	8.2	**2**	>10mm	**2**	1.7	**1**	0	**1**	12	**3**	<0.4m	**3**	7.6	**1**	7.6	**2**	8.2	**1**	**3**
		-					-												-		-	**-**	-	**1**	
BWM169_1A		10			29		8.3				2								8		8		8.3	**1**	
BWM169_1B		20			17		8.3				2.2								8.5		8.5	-	8.3	**1**	
BWM169_1C		30	60	**2**	15	**1**	8.4	**3**	>10mm	**2**	2.4	**2**	0	**1**	6	**2**	<0.4m	**3**	7.9	**3**	7.9	**2**	8.4	**1**	**3**
BWM169_1D		-			<5.0		9.5				2.7								13		13	**2**	9.5	**1**	
BWM169_2A		10			14		7.2				1.1								5.4		5.4		7.2	**1**	
BWM169_2B		20			<5.0		8.8				2.6								12		12	-	8.8	**1**	
BWM169_2C		30	60	**2**	7.9	**2**	7	**1**	>10mm	**2**	0.9	**1**	0	**1**	6	**2**	<0.4m	**3**	8.5	**2**	8.5	**2**	7	**1**	**3**
		-					-												-		-	**-**	-	**1**	
BWM173_1A		10			24		7.1				0.9								0.53		0.53		7.1	**1**	
BWM173_1B		20			11		6.9				0.9								0.67		0.67	-	6.9	**1**	
BWM173_1C		30	60	**2**	5.4	**1**	6.2	**1**	>10mm	**2**	2.3	**1**	0	**1**	13.8	**3**	<0.4m	**3**	8.1	**1**	8.1	**2**	6.2	**1**	**3**
BWM173_1D		-			6.4		6				5.8								14		14	**2**	6	**1**	
BWM173_2A		10	60	**2**	7.4	**4**	6.6	**1**	>10mm	**2**	1.1	**1**	0	**1**	13.8	**3**	<0.4m	**3**	3.1	**2**	3.1	-	6.6	**1**	**4**

Limitation			Water availability		Nutrient supply				Soil physical factors		Salinity		Rockiness		Topography (slope)				Water, erosion, surface soil		Subsoil erosion		Potential acid forming materials		Grazing Land Suitability Class
Site ID	Soil Core ID	PAWC in ERD			Colwell P to 0.1m		pH in 0.1m		Surface soil structure		EC in ERD dS/m		Fragments on surface		Gradient, surface		Vertical interval, surface		Slope % (ESP in 0.1m)		Subsoil erosion		pH <4.5		
Notes: Good, Fair, Poor		From soil texture lab results 0-10cm, 10-30cm, 30-60cm	Total Core PAWC	LSC Score	Phosphorus (Colwell)	LSC Score	pH (1:5 Water)	LSC Factor Score	Use pedality in surface sample and/or surface condition from erosion.	LSC Factor Score	Electrical Conductivity (Sat. Ext.) dS/m to 0.1m (10cm)	LSC Factor Score	Percent rock groundcover	LSC Factor Score	Mean Slope %	LSC Factor Score	Topography (slope and microrelief) (m) Soils	LSC Factor Score	Median Slope % and Sodium % of Cations (ESP) 0.1m	LSC Factor Score	Sodium % of Cations (ESP) >0.5m	LSC Factor Score	Depth to pH 4.5	LSC Factor Score	
BWM173_2B		20			7.8		6.1				1								2.5		2.5		6.1	1	
		30					-												-		-	-	-	1	
		-					-												-		-	-	-	1	
BWM208B 1A		10			7.1		7.9				1.8								0.17		0.17		7.9	1	
BWM208B 1B		24			<5.0		8.3				1.4								0.87		0.87	-	8.3	1	
BWM208B 1C		36	70	2	<5.0	4	9.1	2	>10mm	2	2.9	1	0	1	10.4	3	<0.4m	3	11	1	11	2	9.1	1	4
		-					-												-		-	-	-	1	
BWM208B 2A		10			<5.0		8.5				1								0.46		0.46		8.5	1	
BWM208B 2B		20			<5.0		8.6				1.2								2.8		2.8	-	8.6	1	
BWM208B 2C		30	60	2	<5.0	5	9.7	3	>10mm	2	3	1	0	1	10.4	3	<0.4m	3	20	1	20	3	9.7	1	5
		-					-												-		-	-	-	1	
BWM188A_1A		12			<5.0		6.1				1.7								9.2		9.2		6.1	1	
BWM188A_1B		20			<5.0		6.1				2.4								12		12	-	6.1	1	
BWM188A_1C		30	62	2	<5.0	5	6.7	2	>10mm	2	3	1	0	1	11.6	3	<0.4m	3	16	3	16	3	6.7	1	5
		-					-												-		-	-	-	1	
BWM32_1A		10			<5.0		6.7				0.4								2.3		2.3		6.7	1	
BWM32_1B		20			<5.0		6.8				0.6								7.3		7.3	-	6.8	1	
BWM32_1C		36	66	2	9.3	5	5.9	1	>10mm	2	4	1	0	1	13.1	3	<0.4m	3	28	1	28	4	5.9	1	5
		-					-												-		-	-	-	1	

Limitation			Water availability	Nutrient supply				Soil physical factors		Salinity		Rockiness		Topography (slope)				Water, erosion, surface soil		Subsoil erosion		Potential acid forming materials		Grazing Land Suitability Class
Site ID	Soil Core ID	PAWC in ERD		Colwell P to 0.1m		pH in 0.1m		Surface soil structure		EC in ERD dS/m		Fragments on surface		Gradient, surface		Vertical interval, surface		Slope % (ESP in 0.1m)		Subsoil erosion		pH <4.5		
Notes: Good, Fair, Poor		From soil texture lab results 0-10cm, 10-30cm, 30-60cm	Total Core PAWC	Phosphorus (Colwell)	LSC Score	pH (1:5 Water)	LSC Factor Score	Use pedality in surface sample and/or surface condition from erosion.	LSC Factor Score	Electrical Conductivity (Sat. Ext.) dS/m to 0.1m (10cm)	LSC Factor Score	Percent rock groundcover	LSC Factor Score	Mean Slope %	LSC Factor Score	Topography (slope and microrelief) (m) Soils	LSC Factor Score	Median Slope % and Sodium % of Cations (ESP) 0.1m	LSC Factor Score	Sodium % of Cations (ESP) >0.5m	LSC Factor Score	Depth to pH 4.5	LSC Factor Score	
BWM35A 1A		12	66	<5.0	5	8.5	3	>10mm	2	0.9	1	0	1	12	3	<0.4m	3	0.49	1	0.49	-	8.5	1	5
BWM35A 1B		24		<5.0		9				1.6								7		7		9	1	
BWM35A 1C		30		<5.0		9.3				2.6								13		13	2	9.3	1	
		-				-												-		-	-	-	1	
BWM42_1A		12	62	6.3	4	8.7	4	>10mm	2	3.7	2	0	1	8.6	3	<0.4m	3	9.7	3	9.7	-	8.7	1	4
BWM42_1B		20		5.3		8.1				14.4								6.2		6.2		8.1	1	
		30				-												-		-	-	-	1	
		-				-												-		-	-	-	1	
BWM42_2A		10	60	5.6	4	8.4	3	>10mm	2	4	3	0	1	8.6	3	<0.4m	3	3.9	2	3.9	-	8.4	1	4
BWM42_2B		20		5.5		8.7				2.4								5.3		5.3		8.7	1	
BWM42_2C		30		<5.0		8.7				2.9								6.3		6.3	1	8.7	1	
		-				-												-		-	-	-	1	
BWMR44-01-1A		12	66	5.5	4	9	4	>10mm	2	2.2	2	0	1	9.3	3	<0.4m	3	6.8	3	6.8	-	9	1	4
BWMR44-01-1B		24		6.4		8.8				3.5								8		8		8.8	1	
BWMR44-01-1C		30		6.3		9.3				2.3								9		9	2	9.3	1	
		-				-												-		-	-	-	1	
BWMR44-01-2A		12	72	6.3	4	9	4	>10mm	2	2.2	2	0	1	9.3	3	<0.4m	3	6.8	3	6.8	-	9	1	4
BWMR44-01-2B		24		9		9.2				2.7								10		10		9.2	1	
		36				-												-		-	-	-	1	

Limitation			Water availability		Nutrient supply				Soil physical factors		Salinity		Rockiness		Topography (slope)				Water, erosion, surface soil		Subsoil erosion		Potential acid forming materials		Grazing Land Suitability Class
Site ID	Soil Core ID	PAWC in ERD			Colwell P to 0.1m		pH in 0.1m		Surface soil structure		EC in ERD dS/m		Fragments on surface		Gradient, surface		Vertical interval, surface		Slope % (ESP in 0.1m)		Subsoil erosion		pH <4.5		
Notes: Good, Fair, Poor		From soil texture lab results 0-10cm, 10-30cm, 30-60cm	Total Core PAWC	LSC Score	Phosphorus (Colwell)	LSC Score	pH (1:5 Water)	LSC Factor Score	Use pedality in surface sample and/or surface condition from erosion.	LSC Factor Score	Electrical Conductivity (Sat. Ext.) dS/m to 0.1m (10cm)	LSC Factor Score	Percent rock groundcover	LSC Factor Score	Mean Slope %	LSC Factor Score	Topography (slope and microrelief) (m) Soils	LSC Factor Score	Median Slope % and Sodium % of Cations (ESP) 0.1m	LSC Factor Score	Sodium % of Cations (ESP) >0.5m	LSC Factor Score	Depth to pH 4.5	LSC Factor Score	
		-					-												-		-	-	-	1	
BWMR50-01-1A		10	60	2	10	3	9.5	5	>10mm	2	1.6	1	0	1	8.3	3	<0.4m	3	11	4	11	-	9.5	1	5
BWMR50-01-1B		20			10		9.4				2.8								21		21		9.4	1	
BWMR50-01-1C		30			7.1		9.5				5								27		27	4	9.5	1	
		-					-												-		-	-	-	1	
BWMR50-01-2A		10	60	2	27	1	8.9	4	>10mm	2	0.7	1	0	1	8.3	3	<0.4m	3	2.2	1	2.2	-	8.9	1	4
BWMR50-01-2B		20			22		9.1				0.8								4.6		4.6		9.1	1	
BWMR50-01-2C		30			10		9.8				1.7								17		17	3	9.8	1	
		-					-												-		-	-	-	1	
BWMR54N_1A		10	60	2	<5.0	5	8.8	4	>10mm	2	1.5	1	0	1	6.6	2	<0.4m	3	3.2	2	3.2	-	8.8	1	5
BWMR54N_1B		20			5.4		8.8				1.6								3.8		3.8		8.8	1	
BWMR54N_1C		30			<5.0		9.7				2.1								12		12	2	9.7	1	
		-					-												-		-	-	-	1	
BWMR54N_2A		10	60	2	<5.0	5	8.9	4	>10mm	2	1.5	1	0	1	6.6	2	<0.4m	3	3.9	2	3.9	-	8.9	1	5
BWMR54N_2B		20			5.1		9				1.5								4.7		4.7		9	1	
BWMR54N_2C		30			<5.0		9.9				2.7								19		19	3	9.9	1	
		-					-												-		-	-	-	1	
BWMR56S_1A		8	54	3	11	3	7.3	2	>10mm	2	1	1	0	1	5.7	2	<0.4m	3	1.6	1	1.6	-	7.3	1	3
BWMR56S_1B		16			6.2		7.3				0.9								0.97		0.97		7.3	1	

Limitation			Water availability	Nutrient supply				Soil physical factors		Salinity		Rockiness		Topography (slope)				Water, erosion, surface soil		Subsoil erosion		Potential acid forming materials		Grazing Land Suitability Class
Site ID	Soil Core ID	PAWC in ERD			Colwell P to 0.1m		pH in 0.1m			EC in ERD dS/m		Fragments on surface		Gradient, surface		Vertical interval, surface		Slope % (ESP in 0.1m)		Subsoil erosion		pH <4.5		
Notes: Good, Fair, Poor		From soil texture lab results 0-10cm, 10-30cm, 30-60cm	Total Core PAWC	LSC Score	Phosphorus (Colwell)	LSC Score	pH (1:5 Water)	LSC Factor Score	Use pedality in surface sample and/or surface condition from erosion.	LSC Factor Score	Electrical Conductivity (Sat. Ext.) dS/m to 0.1m (10cm)	LSC Factor Score	Percent rock groundcover	LSC Factor Score	Mean Slope %	LSC Factor Score	Topography (slope and microrelief) (m) Soils	LSC Factor Score	Median Slope % and Sodium % of Cations (ESP) 0.1m	LSC Factor Score	Sodium % of Cations (ESP) >0.5m	LSC Factor Score	Depth to pH 4.5	LSC Factor Score	
BWMR56S_1C		30			<5.0		8.7				3.3								4.8		4.8	1	8.7	1	
BWMR56S_1D		-			<5.0		8.5				4.4								6.9		6.9	1	8.5	1	
BWMR56S_2A		5			5.9		7.1				1.5								0.91		0.91	-	7.1	1	
BWMR56S_2B		10			<5.0		7.3				0.3								1.6		1.6		7.3	1	
BWMR56S_2C		30	45	3	<5.0	4	8.5	1	>10mm	2	1.1	1	0	1	5.7	2	<0.4m	3	2.1	1	2.1	1	8.5	1	4
		-					-												-		-	-	-	1	
BWMR80A-1A		10			<5.0		5.9				0.5								2.1		2.1	-	5.9	1	
BWMR80A-1B		10			6.1		5.8				1.1								4.4		4.4		5.8	1	
		15	35	4		5	-	3	>10mm	2		1	0	1	10	1	<0.4m	3	-	1	-	-	-	1	5
		-					-												-		-	-	-	1	
BWMR80B-1A		5			6.7		6.2				0.6								4.7		4.7	-	6.2	1	
BWMR80B-1B		10			7.1		6.2				0.3								2.9		2.9		6.2	1	
BWMR80B-1C		15	30	4	<5.0	4	6.6	2	>10mm	2	0.3	1	0	1	10	1	<0.4m	3	13	2	13	2	6.6	1	4
		-					-												-		-	-	-	1	
BWMR80C-1A		5			18		5.6				0.3								0.9		<1	-	5.6	1	
BWMR80C-1B		10			10		5.8				0.3								1.5		1.5		5.8	1	
BWMR80C-1C		30	45	3	6.1	2	4.5	3	>10mm	2	1	1	0	1	10	1	<0.4m	3	10	1	10	2	4.5	5	5
		-					-												-		-	-	-	1	
BWMR44-TS1		12	72	2	8.6	3	8.7	4	>10mm	2	3.4	2	0	1	1	1	<0.4m	3	12	3	12	-	8.7	1	4

Limitation			Water availability	Nutrient supply				Soil physical factors		Salinity		Rockiness		Topography (slope)				Water, erosion, surface soil		Subsoil erosion		Potential acid forming materials		Grazing Land Suitability Class
Site ID	Soil Core ID	PAWC in ERD		Colwell P to 0.1m		pH in 0.1m		Surface soil structure		EC in ERD dS/m		Fragments on surface		Gradient, surface		Vertical interval, surface		Slope % (ESP in 0.1m)		Subsoil erosion		pH <4.5		
Notes: Good, Fair, Poor		From soil texture lab results 0-10cm, 10-30cm, 30-60cm	Total Core PAWC	Phosphorus (Colwell)	LSC Score	pH (1:5 Water)	LSC Factor Score	Use pedality in surface sample and/or surface condition from erosion.	LSC Factor Score	Electrical Conductivity (Sat. Ext.) dS/m to 0.1m (10cm)	LSC Factor Score	Percent rock groundcover	LSC Factor Score	Mean Slope %	LSC Factor Score	Topography (slope and microrelief) (m) Soils	LSC Factor Score	Median Slope % and Sodium % of Cations (ESP) 0.1m	LSC Factor Score	Sodium % of Cations (ESP) >0.5m	LSC Factor Score	Depth to pH 4.5	LSC Factor Score	
		24				-												-		-		-	1	
		36				-												-		-	-	-	1	
		-				-												-		-	-	-	1	
BWMR44-TS2		12		<5.0		9.1		>10mm		2.7		0		1		<0.4m		9		9		9.1	1	
		24				-												-		-	-	-	1	
		36	72			-												-		-	-	-	1	
		-				-												-		-	-	-	1	
BWMR44-TS3		12		<5.0		9		>10mm		2.7		0		1		<0.4m		8.7		8.7		9	1	
		24				-												-		-	-	-	1	
		36	72			-												-		-	-	-	1	
		-				-												-		-	-	-	1	
BWMR44-TS4		12		<5.0		9		>10mm		3		0		1		<0.4m		10		10		9	1	
		24				-												-		-	-	-	1	
		36	72			-												-		-	-	-	1	
		-				-												-		-	-	-	1	
R80HWTS1A		10		<5.0		6.2		>10mm		0.1		0		1		<0.4m		1.2		1.2		6.2	1	
R80HWTS1B		20		6.1		5.4				0.7								3.8		3.8		5.4	1	
R80HWTS1C		30	60	<5.0		5.3				0.6								4.7		4.7	1	5.3	1	
		-				-												-		-	-	-	1	

Limitation			Water availability		Nutrient supply				Soil physical factors		Salinity		Rockiness		Topography (slope)				Water, erosion, surface soil		Subsoil erosion		Potential acid forming materials		Grazing Land Suitability Class
Site ID	Soil Core ID	PAWC in ERD			Colwell P to 0.1m		pH in 0.1m		Surface soil structure		EC in ERD dS/m		Fragments on surface		Gradient, surface		Vertical interval, surface		Slope % (ESP in 0.1m)		Subsoil erosion		pH <4.5		
Notes: Good, Fair, Poor		From soil texture lab results 0-10cm, 10-30cm, 30-60cm	Total Core PAWC	LSC Score	Phosphorus (Colwell)	LSC Score	pH (1:5 Water)	LSC Factor Score	Use pedality in surface sample and/or surface condition from erosion.	LSC Factor Score	Electrical Conductivity (Sat. Ext.) dS/m to 0.1m (10cm)	LSC Factor Score	Percent rock groundcover	LSC Factor Score	Mean Slope %	LSC Factor Score	Topography (slope and microrelief) (m) Soils	LSC Factor Score	Median Slope % and Sodium % of Cations (ESP) 0.1m	LSC Factor Score	Sodium % of Cations (ESP) >0.5m	LSC Factor Score	Depth to pH 4.5	LSC Factor Score	
R80HWTS2A		10	60	2	<5.0	5	6.9	1	>10mm	2	0.4	1	0	1	1	1	<0.4m	3	1	1	1	-	6.9	1	5
R80HWTS2B		20			<5.0		6.5				0.2								2		2		6.5	1	
R80HWTS2C		30			<5.0		6.9				0.2								2.3		2.3	1	6.9	1	
R80HWTS2D		-			<5.0		7.2				0.2								2.9		2.9	1	7.2	1	

Attachment Four – Cattle Grazing land Condition FY24 (BMA, 2024a)

Site	Estimated DM Yield and % of Preferred Pasture Species			Crown Cover		Annual Grass % DM Yield		Undesirable Grasses and Other Weeds % DM Yield		Pasture Condition Score	Soil condition/ erosion rating	Land condition rating
	Value (kg/ha)	Value (%)	Score	Value	Score	Value	Score	Value	Score			
BWM_R28_01	2666	6	4	moderate density and some plants dead	3	0	1	1	1	3	no erosion	Poor (C)
BWM_R54_01	436	70	2	sparse and many plants dead	4	0	1	0	1	4	no erosion	Degraded (D)
BWM_REF01	2833	100	1	dense and some plants unhealthy	2	0	1	0	1	2	no erosion	Fair (B)
BWM_REF03	3000	100	1	dense and some plants unhealthy	2	0	1	0	1	2	no erosion	Fair (B)
BWM40	2500	100	1	dense and some plants unhealthy	2	0	1	0	1	2	minor	Fair (B)
BWM41	3833	100	1	dense and some plants unhealthy	2	0	1	0	1	2	minor	Fair (B)
Inv_BWM116B	500	100	1	sparse and many plants dead	2	0	1	0	1	4	no erosion	Degraded (D)
Inv_BWM130	1000	100	1	sparse and many plants dead	2	0	1	0	1	4	no erosion	Degraded (D)
BWM03	3000	100	1	sparse and many plants dead	2	0	1	0	1	2	no erosion	Fair (B)

Attachment Five – Cattle Grazing land Condition FY24 (LEC, 2024a)

Site	Estimated DM Yield and % of Preferred Pasture Species			Crown Cover		Annual Grass % DM Yield		Undesirable Grasses and Other Weeds % DM Yield	Pasture Yield and Condition Score		Number of 3P Grasses	Soil Condition	Land Condition Score ABCD
	Value (kg/ha)	Value (%)	Score	Value	Score	Value	Score	Value	Score		Value		
BWM00	2667	100	1	High to moderate density and some plants unhealthy	2	0	1	0	1	Good (B=2)	2	Moderate Erosion	Poor (C)
BWM01	2833	100	2	Dense and plants healthy	1	0	1	0	1	Good (B=2)	1	Stable	Good (A)
BWM05A	3167	77	2	High to moderate density and some plants unhealthy	2	0	1	20	2	Good (B=2)	1	Stable	Fair (B)
BWM103	3333	100	1	Dense and plants healthy	1	0	1	0	1	Good (B=2)	1	Stable	Good (A)
BWM103A	4000	100	1	Dense and plants healthy	1	0	1	0	1	Good (B=2)	1	Stable	Good (A)
BWM104	3667	100	1	Dense and plants healthy	1	0	1	0	1	Good (B=2)	1	Stable	Good (A)
BWM105A	3000	100	1	Dense and plants healthy	1	0	1	0	1	Good (B=2)	1	Stable	Good (A)
BWM105B	3000	100	1	Dense and plants healthy	1	0	1	0	1	Good (B=2)	1	Stable	Fair (B)
BWM106	3167	83	1	High to moderate density and some plants unhealthy	2	0	1	13	1	Good (B=2)	1	Stable	Fair (B)
BWM107	3000	100	1	Dense and plants healthy	1	0	1	0	1	Good (B=2)	2	Stable	Good (A)
BWM108	3500	100	1	Dense and plants healthy	1	0	1	0	1	Good (B=2)	1	Stable	Good (A)
BWM118	4333	100	2	Dense and plants healthy	1	0	1	0	1	Good (B=2)	1	Stable	Good (A)
BWM120	3000	100	2	Dense and plants healthy	1	0	1	0	1	Good (B=2)	1	Stable	Good (A)
BWM124	3333	100	2	High to moderate density and some plants unhealthy	2	0	1	0	1	Good (B=2)	2	Stable	Good (A)
BWM128	3000	100	2	High to moderate density and some plants unhealthy	2	0	1	0	1	Good (B=2)	1	Stable	Fair (B)
BWM130A	2833	100	2	High to moderate density and some plants unhealthy	2	0	1	0	1	Good (B=2)	1	Stable	Fair (B)
BWM147A	3000	100	1	Dense and plants healthy	1	0	1	0	1	Good (B=2)	1	Stable	Good (A)

Site	Estimated DM Yield and % of Preferred Pasture Species			Crown Cover		Annual Grass % DM Yield		Undesirable Grasses and Other Weeds % DM Yield	Pasture Yield and Condition Score		Number of 3P Grasses	Soil Condition	Land Condition Score ABCD
	Value (kg/ha)	Value (%)	Score	Value	Score	Value	Score	Value	Score		Value		
BWM148	3000	100	1	Dense and plants healthy	1	0	1	0	1	Good (B=2)	1	Stable	Good (A)
BWM149B	1667	100	1	Moderate to low density and some plants dead	3	0	1	22	2	Poor (C=3)	1	Stable	Poor (C)
BWM153	3000	100	1	High to moderate density and some plants unhealthy	2	0	1	0	1	Good (B=2)	1	Stable	Fair (B)
BWM155	3000	100	1	High to moderate density and some plants unhealthy	2	0	1	0	1	Good (B=2)	1	Stable	Fair (B)
BWM156	2833	100	1	High to moderate density and some plants unhealthy	2	0	1	0	1	Good (B=2)	1	Stable	Fair (B)
BWM157	2500	100	1	High to moderate density and some plants unhealthy	2	0	1	0	1	Good (B=2)	1	Stable	Fair (B)
BWM157A	3500	100	1	High to moderate density and some plants unhealthy	2	0	1	0	1	Good (B=2)	1	Stable	Fair (B)
BWM161	2500	93	1	High to moderate density and some plants unhealthy	2	0	1	20	2	Good (B=2)	1	Stable	Fair (B)
BWM162	2833	100	1	High to moderate density and some plants unhealthy	2	0	1	0	1	Good (B=2)	1	Stable	Fair (B)
BWM164A	2833	80	1	High to moderate density and some plants unhealthy	2	0	1	20	2	Good (B=2)	2	Stable	Fair (B)
BWM166	3667	100	1	High to moderate density and some plants unhealthy	2	0	1	0	1	Good (B=2)	3	Stable	Fair (B)
BWM167B	2167	100	1	High to moderate density and some plants unhealthy	2	0	1	0	1	Good (B=2)	1	Slight Erosion	Fair (B)
BWM169	2333	68	2	Moderate to low density and some plants dead	3	0	1	35	3	Poor (C=3)	4	Stable	Poor (C)
BWM173	3000	100	1	High to moderate density and some plants unhealthy	2	0	1	0	1	Good (B=2)	1	Stable	Fair (B)
BWM188A	3000	100	1	High to moderate density and some plants unhealthy	2	0	1	0	1	Good (B=2)	2	Stable	Fair (B)
BWM208B	2667	100	2	High to moderate density and some plants unhealthy	2	0	1	0	1	Good (B=2)	1	Stable	Fair (B)

Site	Estimated DM Yield and % of Preferred Pasture Species			Crown Cover		Annual Grass % DM Yield		Undesirable Grasses and Other Weeds % DM Yield	Pasture Yield and Condition Score		Number of 3P Grasses	Soil Condition	Land Condition Score ABCD
	Value (kg/ha)	Value (%)	Score	Value	Score	Value	Score	Value	Score		Value		
BWM35B	3000	73	2	High to moderate density and some plants unhealthy	2	0	1	27	2	Good (B=2)	1	Moderate Erosion	Poor (C)
BWM38A	2500	100	2	High to moderate density and some plants unhealthy	2	0	1	0	1	Good (B=2)	1	Stable	Fair (B)
BWM42	3500	100	1	Moderate to low density and some plants dead	3	0	1	0	1	Poor (C=3)	2	Stable	Poor (C)
BWMR44_01	1000	0	4	Moderate to low density and some plants dead	3	0	1	0	1	Very poor (D=4)	0	Stable	Very Poor (D)
BWMR50_01	2167	100	1	High to moderate density and some plants unhealthy	2	0	1	0	1	Good (B=2)	3	Stable	Fair (B)
BWMR54N	3000	100	1	Dense and plants healthy	1	0	1	0	1	Good (B=2)	1	Stable	Fair (B)
BWMR56S	2667	100	1	High to moderate density and some plants unhealthy	2	0	1	0	1	Good (B=2)	2	Stable	Fair (B)

Attachment Six – Woodland Habitat Results FY24 (BMA, 2024a)

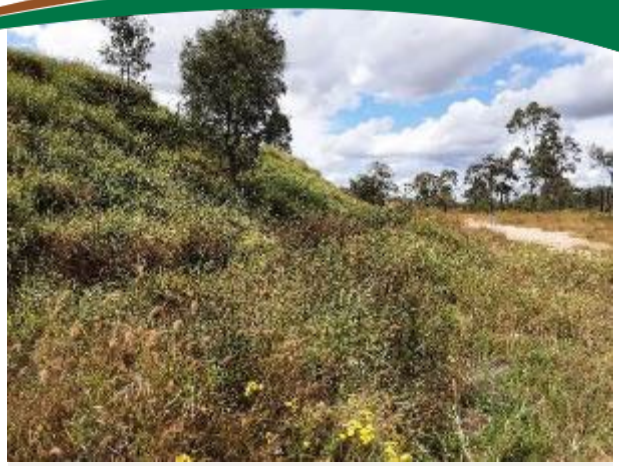
Site	Species Richness: Trees			Species Richness: Shrub			Species Richness: Grass			Tree Canopy Cover (%)			Total Groundcover (%)			Invasive Species Cover (%)			Recruitment			Woodland Score
	Value	Score	Weighted Score	Value	Score	Weighted Score	Value	Score	Weighted Score	Value	Score	Weighted Score	Value	Score	Weighted Score	Value	Score	Weighted Score	Value	Score	Weighted Score	
BWM_REF02	3	3	6	5	3	3	6	3	3	69.2	3	6	93	3	6	0	3	3	33	1	1	**28**
BWM_REF04	4	3	6	11	3	3	5	3	3	45.2	3	6	100	3	6	1	3	3	50	2	2	**29**
BWM168	6	3	6	6	3	3	1	1	1	48	3	6	96	3	6	0	3	3	0	1	1	**26**
BWM170	4	3	6	3	3	3	3	2	2	64.8	3	6	91	3	6	1	3	3	25	1	1	**27**
BWM180	4	3	6	5	3	3	6	3	3	56.2	3	6	88	3	6	1	3	3	50	2	2	**29**
BWM189	10	3	6	3	3	3	1	1	1	39.8	3	6	100	3	6	1	3	3	10	1	1	**26**
BWM199	1	2	4	3	3	3	1	1	1	71.4	3	6	84	3	6	1	3	3	100	3	3	**26**
BWM33	6	3	6	6	3	3	2	2	2	54.2	3	6	94	3	6	4	3	3	83	3	3	**29**
Inv_BWM119	3	3	6	5	3	3	3	2	2	39	3	6	90	3	6	5	3	3	66	2	2	**28**
Inv_BWM205	1	2	4	1	1	1	1	1	1	100	3	6	75	3	6	0	3	3	100	3	3	**24**
Inv_116B	8	3	6	0	0	0	1	1	1	40	3	6	90	3	6	0	3	3	100	3	3	**25**

Attachment Seven – Woodland Habitat Results 2024 (LEC, 2024a)

Monitoring Site	Species Richness: Trees			Species Richness: Shrub			Species Richness: Grass*			Tree Canopy Cover			Total Groundcover			Invasive Species Cover (%)			Recruitment			Woodland Score
	Value	Score	Weighted Score	Value	Score	Weighted Score	Value	Score	Weighted Score	Value	Score	Weighted Score	Value	Score	Weighted Score	Value	Score	Weighted Score	Value	Score	Weighted Score	
BWM102	5	3	6	5	3	3	5	3	3	41	3	6	100	3	6	<5	3	3	Yes	3	3	**30**
BWM204A	4	3	6	1	1	1	1	1	1	14	2	4	88	3	6	0	3	3	Yes	3	3	**24**
BWM202	3	3	6	2	2	2	1	1	1	61.2	3	6	83	3	6	0	3	3	Yes	3	3	**27**
BWM200	5	3	6	5	3	3	2	2	2	45	3	6	54	3	6	0	3	3	Yes	3	3	**29**
BWM193	4	3	6	3	3	3	1	1	1	35	3	6	84	3	6	0	3	3	Yes	3	3	**28**
BWM35A	10	3	6	5	3	3	4	3	3	36.4	3	6	100	3	6	10	2	2	Yes	3	3	**29**
BWM208A	4	3	6	3	3	3	6	3	3	20	3	6	83.4	3	6	25	1	1	Yes	3	3	**28**
BWM116A	5	3	6	2	2	2	7	3	3	59.2	3	6	79	3	6	25	1	1	Yes	3	3	**27**
BWM185A	6	3	6	6	3	3	5	3	3	65	3	6	93.4	3	6	0	3	3	No	1	1	**28**
BWM32	3	3	6	3	3	3	4	3	3	10.4	1	2	79.2	3	6	0	3	3	Yes	3	3	**26**
BWM185B	3	3	6	2	2	2	1	1	1	0	1	2	29.4	1	2	0	3	3	Yes	3	3	**19**
BWM188A	4	3	6	4	3	3	3	2	2	34.2	3	6	90.6	3	6	0	3	3	Yes	3	3	**29**
BWM203A	2	3	6	4	3	3	7	3	3	22	3	6	19.6	1	2	0	3	3	Yes	3	3	**26**
BWM18	3	3	6	4	3	3	7	3	3	13.2	2	4	95.4	3	6	0	3	3	Yes	3	3	**28**
BWM22	4	3	6	2	2	2	4	3	3	51.4	3	6	100	3	6	0	3	3	Yes	3	3	**29**
BWM23	2	3	6	4	3	3	2	2	2	22.4	3	6	100	3	6	0	3	3	Yes	3	3	**29**
BWM29	3	3	6	3	3	3	4	3	3	46	3	6	92	3	6	0	3	3	Yes	3	3	**30**
BWM26	3	3	6	3	3	3	5	3	3	32	3	6	76	2	4	<5	3	3	Yes	3	3	**28**
BWM28	1	1	2	1	1	1	3	2	2	57.8	3	6	70	2	4	5	2	2	Yes	3	3	**20**
BWMR56S	3	3	6	4	3	3	2	1	1	10.6	1	2	95	3	6	5	2	2	Yes	3	3	**23**

Monitoring Site	Species Richness: Trees			Species Richness: Shrub			Species Richness: Grass*			Tree Canopy Cover			Total Groundcover			Invasive Species Cover (%)			Recruitment			Woodland Score
	Value	Score	Weighted Score	Value	Score	Weighted Score	Value	Score	Weighted Score	Value	Score	Weighted Score	Value	Score	Weighted Score	Value	Score	Weighted Score	Value	Score	Weighted Score	
BWM155	5	3	6	4	3	3	1	1	1	29	3	6	100	3	6	<5	3	3	Yes	3	3	**28**
BWM153	4	3	6	3	3	3	1	1	1	10	1	2	100	3	6	0	3	3	Yes	3	3	**24**
BWM152	8	3	6	4	3	3	2	2	2	16	3	6	94	3	6	0	3	3	Yes	3	3	**29**
BWMR80A	5	3	6	2	2	2	2	2	2	56.8	3	6	83	3	6	0	3	3	Yes	3	3	**28**
BWMR80B	6	3	6	3	3	3	1	1	1	64	3	6	80	3	6	0	3	3	Yes	3	3	**28**
BWMR80C	4	3	6	1	1	1	1	1	1	79.2	3	6	83	3	6	0	3	3	Yes	3	3	**26**

** Note grass species richness includes both native and exotic species*



LANDFORM EVOLUTION MODELLING SIMULATIONS TO SUPPORT TAILINGS STORAGE FACILITY DESIGN: BLACKWATER MINE

March 2025

Whitehaven Coal Limited

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Project Number: 1035.24d

Report Title: Landform evolution modelling simulations to support Tailings Storage Facility design: Blackwater mine

Client: Whitehaven Coal Limited

Review History

Version Number	Prepared by:	Reviewed by:	Date:
Rev 0 (draft)	E. Howard	I. Kelder	23/02/2025
Rev 1 (final)	E. Howard		04/03/2025

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EXECUTIVE SUMMARY

Landloch has been engaged by Whitehaven Coal Limited (Whitehaven) to carry out SIBERIA landform evolution modelling for three (3) Tailings Storage Facilities (TSFs) at the Blackwater Coal Mine (Blackwater). The 3 TSFs that have been modelled are named Bottom Dam, Laleham, and NCPP.

SIBERIA LEM input parameters were previously derived for two soils present at Blackwater, heavy clay topsoil and light clay topsoil. SIBERIA LEM input parameters were derived through a process of laboratory-based erodibility testing, long-term WEPP (Water Erosion Prediction Project) runoff/erosion modelling, and analysis of 100 years of WEPP model output of daily runoff and erosion. This process is detailed as part of previous landform evolution modelling undertaken for waste landforms at Blackwater (Landloch 2024). In assigning SIBERIA parameters for each TSF, it was assumed that the topsoils and vegetation groundcover levels applied are spatially consistent with those applied in the previous landform evolution modelling work (Landloch 2024). As such, the following topsoils and vegetation groundcover levels were applied:

- Bottom Dam – Light clay topsoil with 50% vegetation cover;
- Laleham – Light clay topsoil with 50% vegetation cover; and
- NCPP – Heavy clay topsoil with vegetation groundcover levels of 70%.

SIBERIA LEM simulations indicate that the 3 proposed TSFs modelled (Bottom Dam, Laleham, and NCPP) have a low tendency for gully erosion (up to 300 years) provided the correct soils and the target levels of vegetation groundcover are achieved.

An area of increased gully erosion potential was identified in the southern section of the proposed Bottom Dam design. This increased risk is due to a steepening of the gradient in that area. This could be mitigated by further refinement of the design in this zone so that a fixed gradient is used, and a steepening gradient is avoided. Another area of increased erosion risk was identified in the northern portion of the design. However, these were model artefacts caused by imperfections in the DEM supplied. These erosion areas could be mitigated by refinement of the design input file in this zone to remove these artefacts. Once removed, the gully erosion modelled in this zone is likely to be reduced.

Some gully erosion was identified in isolated zones of the Laleham TSF. However, these were model artefacts caused by imperfections in the DEM supplied. These erosion areas could be mitigated by refinement of the design input file in these zones to remove these artefacts. Once removed, the gully erosion modelled in this zone is likely to be reduced.

The NCPP TSF design is predicted to erode at rates with a low tendency for gully erosion. However, it does erode at higher rates than either the Bottom Dam or Laleham TSFs. The increased gully erosion risk of the NCPP TSF design (relative to Bottom Dam and Laleham) is due to the use of the heavy clay topsoils and the presence of steeper-gradient outer slopes (20% rather than 15%) on some sections of the eastern side of the TSF. The increased gully erosion risk caused by the presence of steeper-gradient outer could be mitigated by further refinement of the design to lower the gradient of the outer slopes in that zone.

1 INTRODUCTION

Landloch has been engaged by Whitehaven Coal Limited (Whitehaven) to carry out SIBERIA landform evolution modelling for three (3) Tailings Storage Facilities (TSFs) at the Blackwater Coal Mine (Blackwater). The 3 TSFs that have been modelled are named:

1. Bottom Dam;
2. Laleham; and
3. NCPP.

This report briefly outlines the SIBERIA landform evolution modelling methods and provides the modelling results, including erosion statistics and visualisations.

2 MODELLING METHODS

2.1 The SIBERIA model

The SIBERIA landform evolution model predicts the long-term, 3D development of channels and hillslopes (e.g. landform batters) in a catchment based on runoff, erosion, and deposition.

SIBERIA has been successfully applied to explain aspects of the geomorphology of natural landforms (Willgoose 1994) and has been widely used to assess the evolution of constructed waste dumps on mine sites across Australia and overseas (Willgoose 1995; Willgoose and Riley 1993; Boggs *et al.* 2000; Hancock *et al.* 2003; Hancock and Willgoose 2004; Hancock 2004; Mengler *et al.* 2004; Hancock and Turley 2006). It has also been subjected to numerous validation studies. In general, the validation studies indicate that SIBERIA's predictions of landform evolution are reasonable provided the model is suitably parameterised (Hancock *et al.* 2000; Hancock *et al.* 2003). In one validation study (Hancock 2004) it was noted that erosion rates predicted by SIBERIA for a catchment in the Northern Territory compared favourably to erosion estimates derived using the caesium-137 method. As the two erosion assessment methods use independent input information, the reported agreement is particularly significant.

SIBERIA solves for two variables: elevation, from which slope geometries are determined, and an indicator function that determines where erosion features (channels) exist.

Changes to the predicted erosion features is governed by an activation threshold that is dependent on the runoff discharge and gradient of the slope. When the activation threshold is exceeded, an erosion feature is predicted to develop. In this way, it is possible for a modelled surface to initially have no erosion features and for rills/gullies to develop where the activation threshold is exceeded.

The rate at which rills and gullies develop is controlled by a channelisation function. SIBERIA does not directly input rainfall or material erodibility parameters. Rather, the SIBERIA input parameters define the channelisation function that is a function of both runoff and erosion (Willgoose *et al.* 1989). As a result, SIBERIA parameters are specific to both the climatic regime and the material being considered and must be derived for each specific material located within each specific climatic regime.

2.2 SIBERIA input parameters

SIBERIA predicts the long-term average change in elevation of a node (i.e. a point in the landscape) by predicting the volume of sediment lost from that node. The rate of sediment transport through a node (q_s in units of m^3/y) is determined by the equation:

$$q_s = \beta_1 \times q^{m_1} \times S^{n_1} \quad 1)$$

where β_1 is the sediment transport rate coefficient (unitless), q is discharge (m^3/y), m_1 is the discharge exponent (unitless), S is the slope (m/m), and n_1 is the slope exponent (unitless).

SIBERIA does not directly model discharge, but uses sub-grid effective parameterisation which relates discharge to the area draining through a node as:

$$q = \beta_3 \times A^{m_3} \quad 2)$$

where β_3 is the coefficient between discharge and area (unitless), A is area (m^2), and m_3 is the exponent of the area in discharge (unitless).

To run SIBERIA, the parameters β_1, m_1, n_1, β_3, and m_3 are needed. There is interaction between all 5 parameters, with the result that an almost infinite number of parameter sets will all show the same rate of erosion, though some aspects of the pattern of erosion that is predicted will vary. Fixed values for β_3, n_1, and m_3 are adopted where possible, reducing the difficulty of deriving parameter values. If the batter to be modelled is identical to the batter for which erosion data are available for calibration, m_3 and β_3 can be taken as 1.0, and for situations where slope gradient does not affect slope erodibility, n_1 can be taken as 1.5 (Willgoose pers. comm.). This is consistent with Kirkby (1971) who suggests values ranging from 1.3–2.0 are reasonable for soils.

Therefore, two key parameters require fitting against runoff and erosion data: β_1 and m_1. Effectively, the β_1 parameter could be described as an erosion rate parameter, as it primarily controls the rate of sediment movement. The m_1 parameter could be described as primarily controlling slope length responses of erosion.

2.3 Derivation of parameters

The β_1 and m_1 input parameters for SIBERIA are derived by fitting the SIBERIA model equations to time series data of runoff and erosion. However, in most instances, sufficient record lengths of these time series data are not available for the landforms being considered. This is particularly true for landform design planning where the landforms do not yet exist. Therefore, Landloch has developed an alternative approach for deriving the β_1 and m_1 SIBERIA input parameters:

a) Use measurements of material runoff and erosion from laboratory-based flume and rainfall simulations to derive calibrated WEPP model parameters.
b) Generate daily time-series data of runoff and erosion using WEPP set up with:
    a. Batter geometries consistent with the geometries of the landform being considered (allowing values for β_3, n_1, and m_3 to be fixed).
    b. A long-term climate sequence (100-years) that is site specific and that contains a frequent, infrequent, rare and very rare events.
c) Fit WEPP runoff and erosion output data to the SIBERIA model equations to derive values for β_1 and m_1 that are both material and site specific.

2.4 Surface soils and vegetation groundcover

SIBERIA LEM input parameters were previously derived for two soils present at Blackwater:

1. Heavy clay topsoil; and
2. Light clay topsoil.

SIBERIA LEM input parameters were derived through a process of laboratory-based erodibility testing, long-term WEPP (Water Erosion Prediction Project) runoff/erosion modelling, and analysis of 100 years of WEPP model output of daily runoff and erosion. This process is detailed as part of previous landform evolution modelling undertaken for waste landforms at Blackwater (Landloch 2024).

In assigning SIBERIA parameters for each TSF, it was assumed that the topsoils and vegetation groundcover levels applied be spatially consistent with those applied in the previous landform evolution modelling work (Landloch 2024). As such, the following topsoils and vegetation groundcover levels were applied:

- Bottom Dam – Light clay topsoil with 50% vegetation cover;
- Laleham – Light clay topsoil with 50% vegetation cover; and
- NCPP – Heavy clay topsoil with vegetation groundcover levels of 70%.

2.5 Model settings

The Digital Elevation Models (DEMs) modelled by SIBERIA included the landform surface meshed into the surrounding landscape. A random roughness (±10cm) was added to the DEMs prior to modelling. This was done to reduce triangulation gridding artefacts from the surface of the DEMs and to provide a more realistic surface for modelling (landform surfaces are not perfectly smooth).

The following SIBERIA outputs were produced for each landform modelled at years 50, 100, 150, 200, 250, and 300:

- Maximum depth of gullies at each output year with gullies defined as having a minimum depth of 0.3m;
- Average erosion (t/ha/y);
- Cumulative erosion (mm) for each output year
- Visual outputs showing the evolved DEM over which is draped the predicted material movement (erosion and deposition).

2.6 Modelling assumptions

The following assumptions apply to the SIBERIA modelling:

- The DEMs of the existing land surface and design files for the rehabilitation TSFs provided by Whitehaven are assumed to be accurate.
- Input parameters are based on a single material being present on the outer surface of the modelled landform. Light clay topsoil was applied to the surface

of the Bottom Dam and Laleham TSFs. Heavy clay topsoil was applied to the NCPP TSF.

- In considering vegetation groundcover this report specifically considers contact cover of vegetation on the soil surface. Practically, this means a combination of grass cover and anchored (not readily moved) surface litter.
- Vegetation groundcover levels for the light clay topsoil was 50%. Vegetation groundcover levels for the heavy clay topsoil was 70%.
- These vegetation groundcover levels are rapidly achieved and maintained in the long-term. It is assumed that soil management (including stripping, stockpiling, replacement, amendment, and fertilisation) will be carried out effectively to maximise early and continuing plant growth.
- During construction:
    - Batter slopes will not be formed with flow-concentrating profiles (e.g. variations in surface elevation such that there is cross-slope concentration of flow into consistent depressions running downslope).
    - Any cross-slope ripping will be carried out strictly on the contour.

3 SIBERIA MODEL SETUP

3.1 SIBERIA parameters

The SIBERIA model parameters used are shown in Table 1. These parameters were originally reported by Landloch (2024).

Table 1: Estimated SIBERIA parameters.

Material	Vegetation Groundcover (%)	m_1	β_1	n_1
Light clay topsoil	50	1.1127	0.00262	1.5
Heavy clay topsoil	70	1.2375	0.00360	1.5

3.2 Digital elevation models

Proposed 3D rehabilitation design files for the Bottom Dam, Laleham, and NCPP TSFs were provided to Landloch by Whitehaven (Figures 1–3). These rehabilitation landforms were designed based on WEPP model runoff/erosion results for the soils and vegetation groundcover levels that are to be applied.

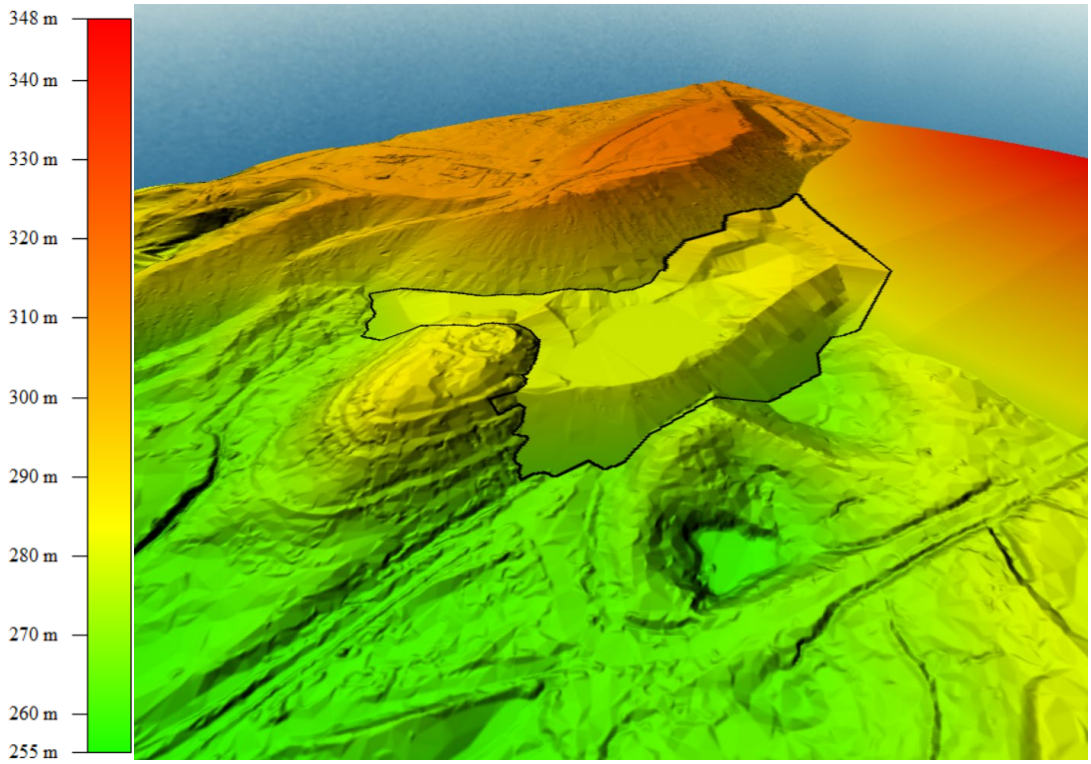

Figure 1: Digital elevation model of the Bottom Dam TSF. The black line shows the modelling domain considered within the SIBERIA LEM.

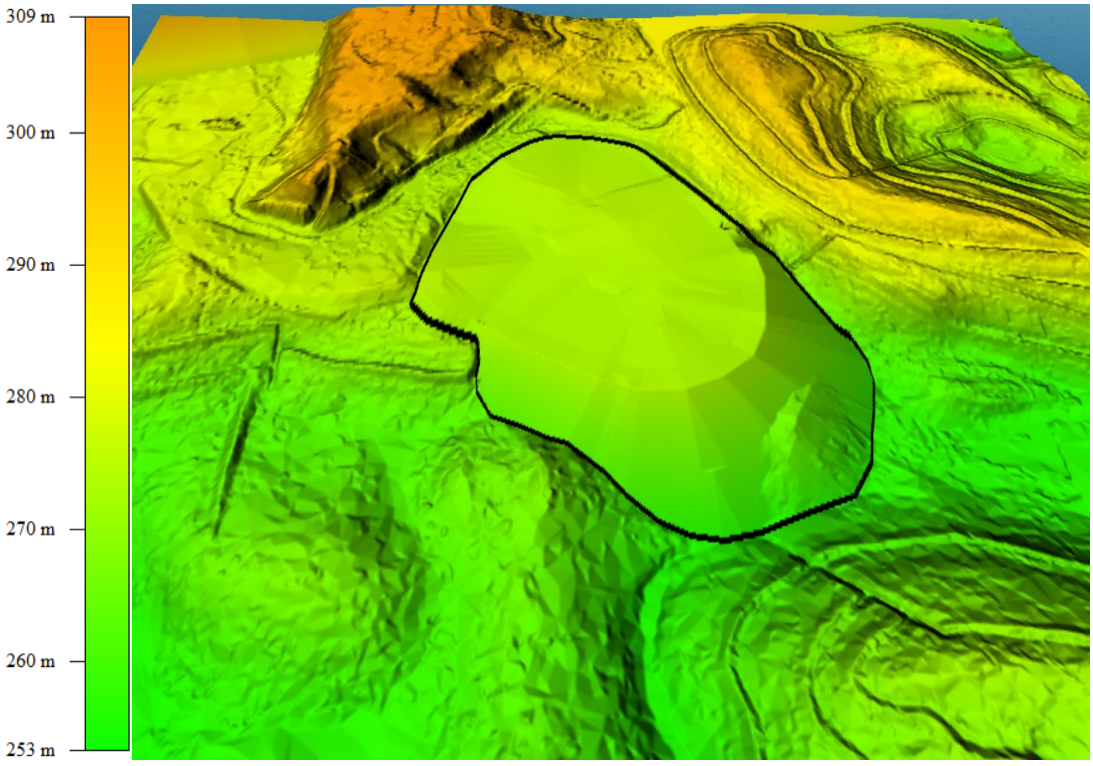

Figure 2: Digital elevation model of the Laleham TSF. The black line shows the modelling domain considered within the SIBERIA LEM.

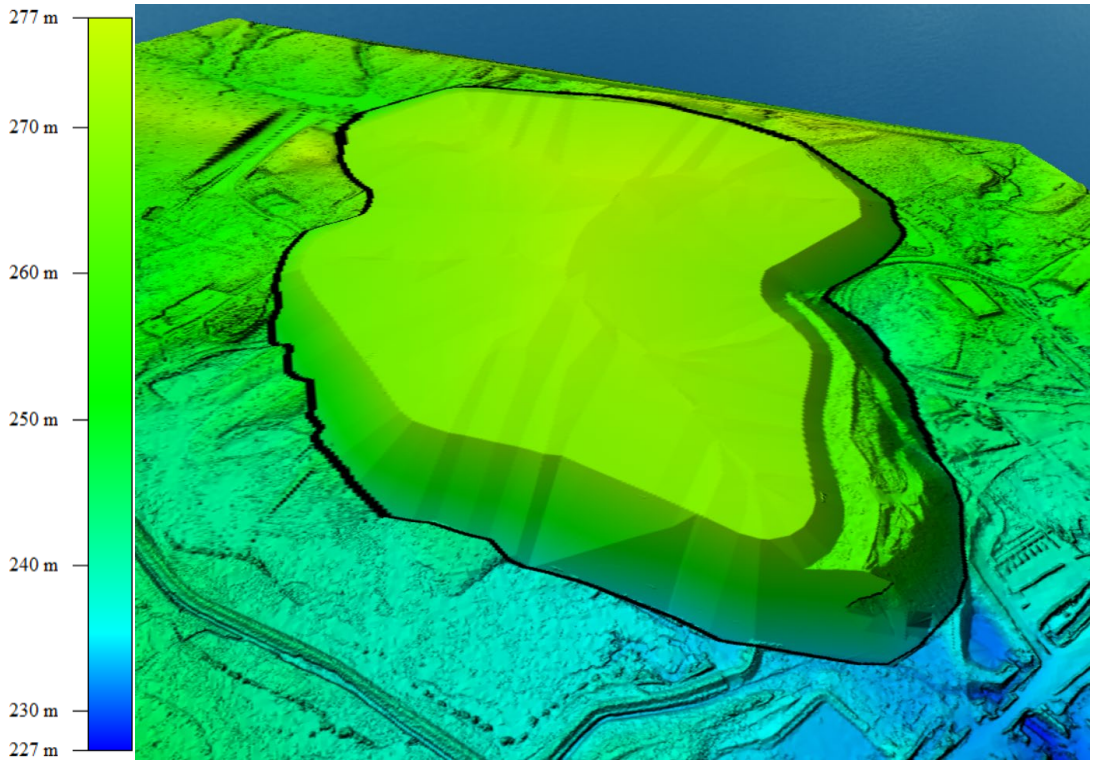

Figure 3: Digital elevation model of the NCPP TSF. The black line shows the modelling domain considered within the SIBERIA LEM.

4 SIBERIA LEM OUPUTS

Using input parameters derived for the soils and vegetation groundcover to be applied to the landforms, the SIBERIA LEM was run for a period of 300 years, with outputs being generated at 50, 100, 200, and 300 years within the simulation period.

At each output year, visualisations of rill/gully development were produced along with a table of maximum gully depths, average annual erosion rates, and cumulative average erosion depths. These rates and depths are calculated for the steep-gradient outer slopes within the modelling domain and exclude the low gradient landform top or berm areas (if they exist).

Negative material movements (i.e. erosion) that exceed 0.3m are considered gully erosion and are reported in the tables. The reported maximum gully depth is calculated as the average of the largest 1% of material movements.

Visualisations for 300 years are shown in the sections below. However, all visualisations (50, 100, 200, and 300 years) are provided in Appendix A.

4.1 Bottom Dam

Rehabilitation of the Bottom Dam TSF is planned to use light clay topsoil with 50% vegetation groundcover. The results shown in Table 2 indicate that at a vegetation groundcover level of 50%, predicted erosion rates of the steep-gradient outer slopes are low. The maximum gully depth after 300 years is predicted to be 0.4m (that is gullying is largely absent). The SIBERIA output indicates that the Bottom Dam rehabilitation design is not prone to significant levels of gully erosion if the surface conditions (material type and vegetation groundcover levels) are achieved.

Figure 4 shows SIBERIA output after 300 years of simulation. Some gully erosion is predicted to occur in the southern section of the TSF (circled in yellow). This is due to a steepening of the gradient in that area. This could be mitigated by further refinement of the design input file in this zone so that a fixed gradient is used, and a steepening gradient is avoided.

The gully erosion predicted to occur in the north (circled in purple) are model artefacts caused by imperfections in the DEM supplied (i.e. artificial elevation differences resulting from triangulation and/or gridding of the data). These erosion areas could be mitigated by refinement of the design input file in this zone to remove these artefacts. Once removed, the gully erosion modelled in this zone is likely to be reduced.

Table 2: Predicted erosion rates and gully depths for the Bottom Dam TSF.

Simulation year	Maximum gully depth (m)	Average annual erosion (t/ha/y)	Cumulative average erosion (mm)
Light clay topsoil with 50% vegetation groundcover			
50	-	0.5	3
100	-	0.4	5
200	0.3	0.4	10
300	0.4	0.3	14

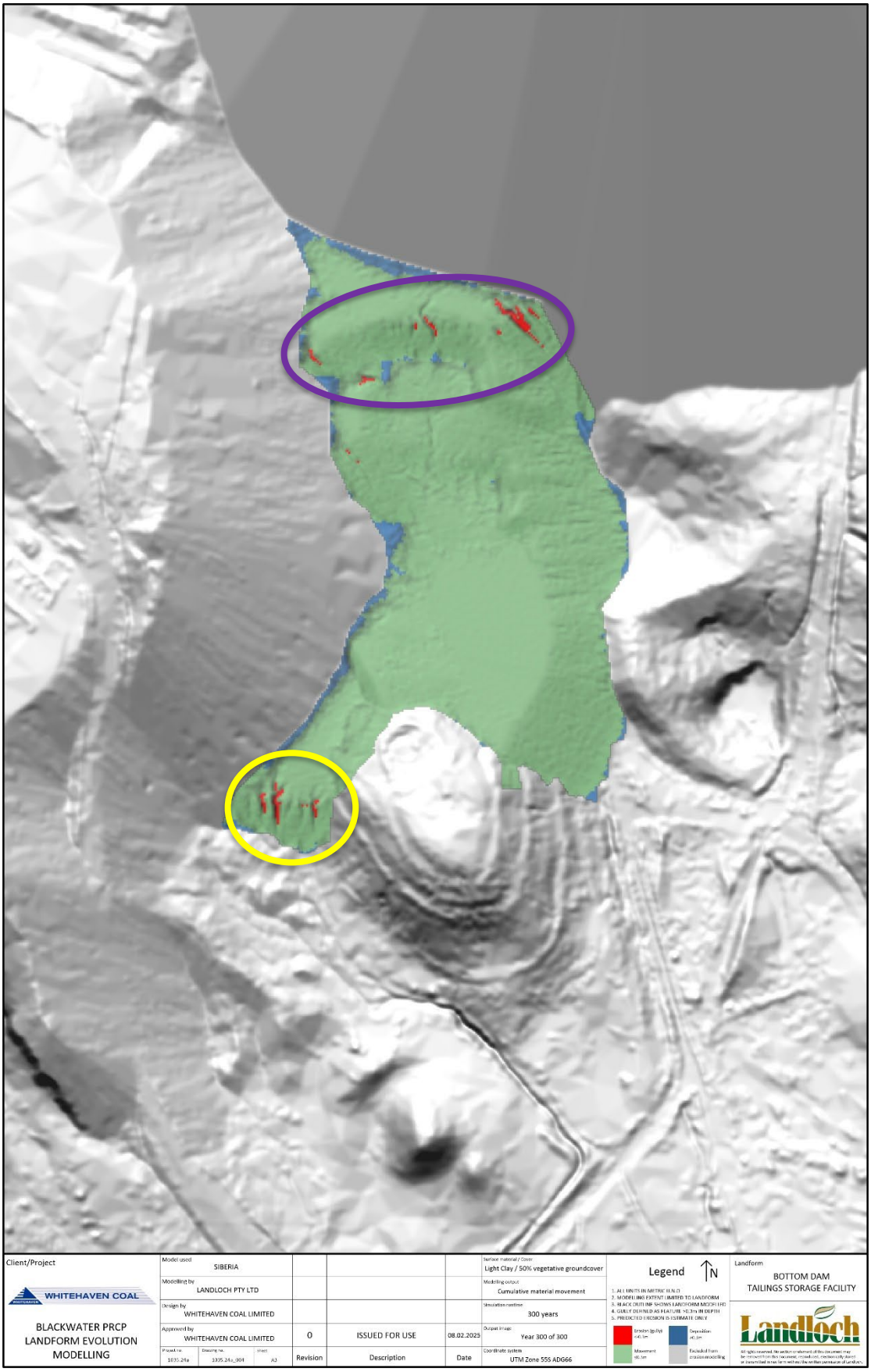

Figure 4: Predicted erosion and deposition depths of the Bottom Dam TSF rehabilitation landform after 300 years.

4.2 Laleham

Rehabilitation of the Laleham TSF is planned to use light clay topsoil with 50% vegetation groundcover. The results shown in Table 3 indicate that at a vegetation groundcover level of 50%, predicted erosion rates of the steep-gradient outer slopes are low. The maximum gully depth after 300 years is predicted to be <0.3m (that is gullying is absent). The SIBERIA output indicates that the Laleham rehabilitation design is not prone to significant levels of gully erosion if the surface conditions (material type and vegetation groundcover levels) are achieved.

Figure 5 shows SIBERIA output after 300 years of simulation. Some gully erosion is predicted to occur in isolated zones of the TSF (circled in yellow). These are model artefacts caused by imperfections in the DEM supplied (i.e. artificial elevation differences resulting from triangulation and/or gridding of the data). These erosion areas could be mitigated by refinement of the design input file in these zones to remove these artefacts. Once removed, the gully erosion modelled in this zone is likely to be reduced.

Table 3: Predicted erosion rates and gully depths for the Laleham TSF.

Simulation year	Maximum gully depth (m)	Average annual erosion (t/ha/y)	Cumulative average erosion (mm)
Light clay topsoil with 50% vegetation groundcover			
50	-	1.4	9
100	-	1.4	18
200	-	1.4	34
300	-	1.3	51



Figure 5: Predicted erosion and deposition depths of the Laleham TSF rehabilitation landform after 300 years.

4.3 NCPP

Rehabilitation of the NCPP TSF is planned to use heavy clay topsoil with 70% vegetation groundcover. The results shown in Table 4 indicate that at a vegetation groundcover level of 50%, predicted erosion rates of the steep-gradient outer slopes are low. The maximum gully depth after 300 years is predicted to be 0.6m.

The SIBERIA output indicates that the NCPP rehabilitation design is not prone to significant levels of gully erosion if the surface conditions (material type and vegetation groundcover levels) are achieved. However, it is more prone to erosion than either the Laleham or Bottom Dam TSF designs.

Figure 6 shows SIBERIA output after 300 years of simulation. The increased gully erosion risk of the NCPP TSF design (relative to Bottom Dam and Laleham) is due to:

1. The heavy clay topsoil being more erodible than the light clay topsoil, with gullies being triggered by the discharge of runoff generated on the lower-gradient TSF upper surface onto the steeper-gradient outer slopes; and
2. The presence of steeper-gradient outer slopes (20% rather than 15%) on sections of the eastern side of the TSF circled in yellow.

The increased gully erosion risk caused by the presence of steeper-gradient outer slopes (20% rather than 15%) on sections of the eastern side of the TSF could be mitigated by refinement of the design input file to lower the gradient of the outer slopes in that zone.

Table 4: Predicted erosion rates and gully depths for the NCPP TSF.

Simulation year	Maximum gully depth (m)	Average annual erosion (t/ha/y)	Cumulative average erosion (mm)
Heavy clay topsoil with 70% vegetation groundcover			
50	-	4.4	27
100	0.3	4.2	54
200	0.4	4.1	105
300	0.6	4.0	154

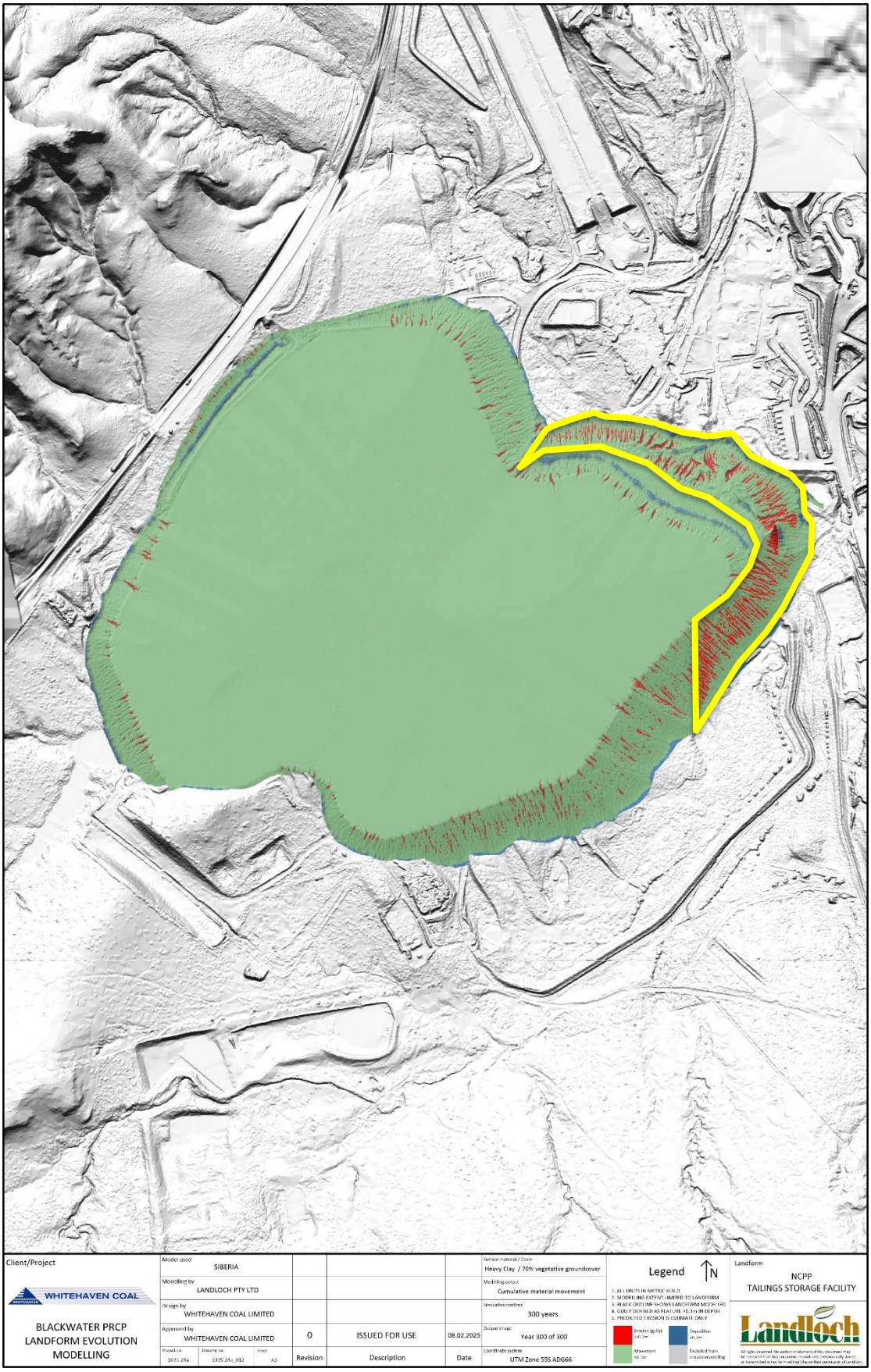

Figure 6: Predicted erosion and deposition depths of the NCPP TSF rehabilitation landform after 300 years.

5 CONCLUSIONS

SIBERIA LEM simulations indicate that the 3 proposed TSFs modelled (Bottom Dam, Laleham, and NCPP) have a low tendency for gully erosion (up to 300 years) provided the correct soils and the target levels of vegetation groundcover are achieved.

An area of increased gully erosion potential was identified in the southern section of the proposed Bottom Dam design. This increased risk is due to a steepening of the gradient in that area. This could be mitigated by refinement of the design input file in this zone so that a fixed gradient is used, and a steepening gradient is avoided. Another area of increased erosion risk was identified in the northern portion of the design. However, these were model artefacts caused by imperfections in the DEM supplied. These erosion areas could be mitigated by refinement of the design input file in this zone to remove these artefacts. Once removed, the gully erosion modelled in this zone is likely to be reduced.

Some gully erosion was identified in isolated zones of the Laleham TSF. However, these were model artefacts caused by imperfections in the DEM supplied. These erosion areas could be mitigated by refinement of the design input file in these zones to remove these artefacts. Once removed, the gully erosion modelled in this zone is likely to be reduced.

The NCPP TSF design is predicted to erode at rates with a low tendency for gully erosion. However, it does erode at higher rates than either the Bottom Dam or Laleham TSFs. The increased gully erosion risk of the NCPP TSF design (relative to Bottom Dam and Laleham) is due to the use of the heavy clay topsoils and the presence of steeper-gradient outer slopes (20% rather than 15%) on some sections of the eastern side of the TSF. The increased gully erosion risk caused by the presence of steeper-gradient outer could be mitigated by refinement of the design to lower the gradient of the outer slopes in that zone.

The model output has assumed the use of either a vegetated light clay or vegetated heavy clay soils as the surface material. These soils were found to be the dominant soils across Blackwater mine. However, if alternative growth media (e.g. different soil types, ameliorated subsoils, or manufactured growth media, etc.) are identified in the future and are to be used as part of rehabilitation, this modelling should be performed again using these alternatives.

The modelling has been completed to assess the performance of the rehabilitated TSFs with respect to erosional stability. While the landforms are predicted to have a low tendency for gully erosion, there is insufficient data to set site-specific erosion criteria. Whitehaven have committed to the establishment of site-specific erosion criteria that will be informed by site measurements of erosion from rehabilitated landforms.

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APPENDIX A: SIBERIA VISUALISATIONS

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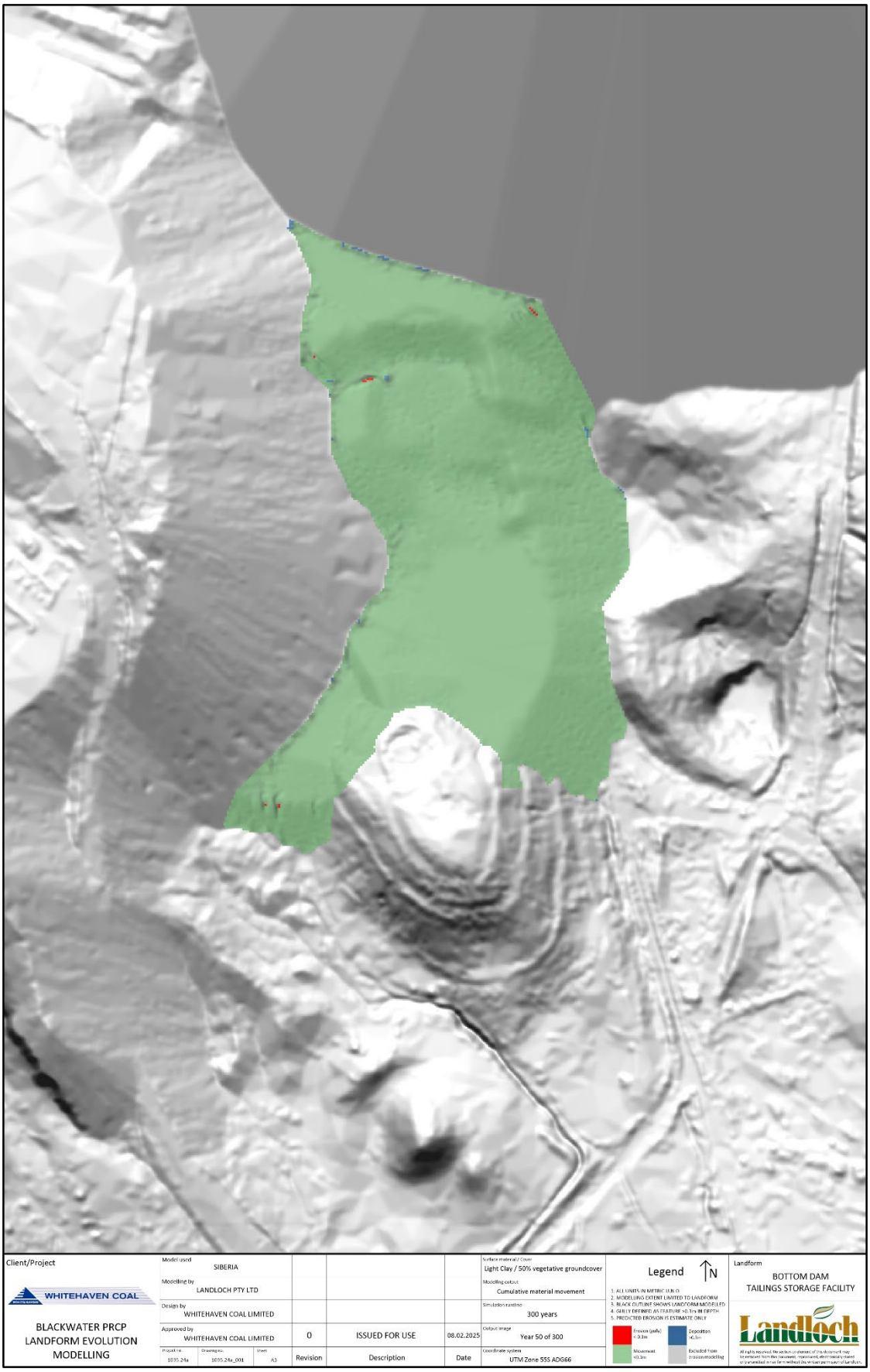

Figure A-1: Predicted erosion and deposition depths of the Bottom Dam TSF rehabilitation landform after 50 years.

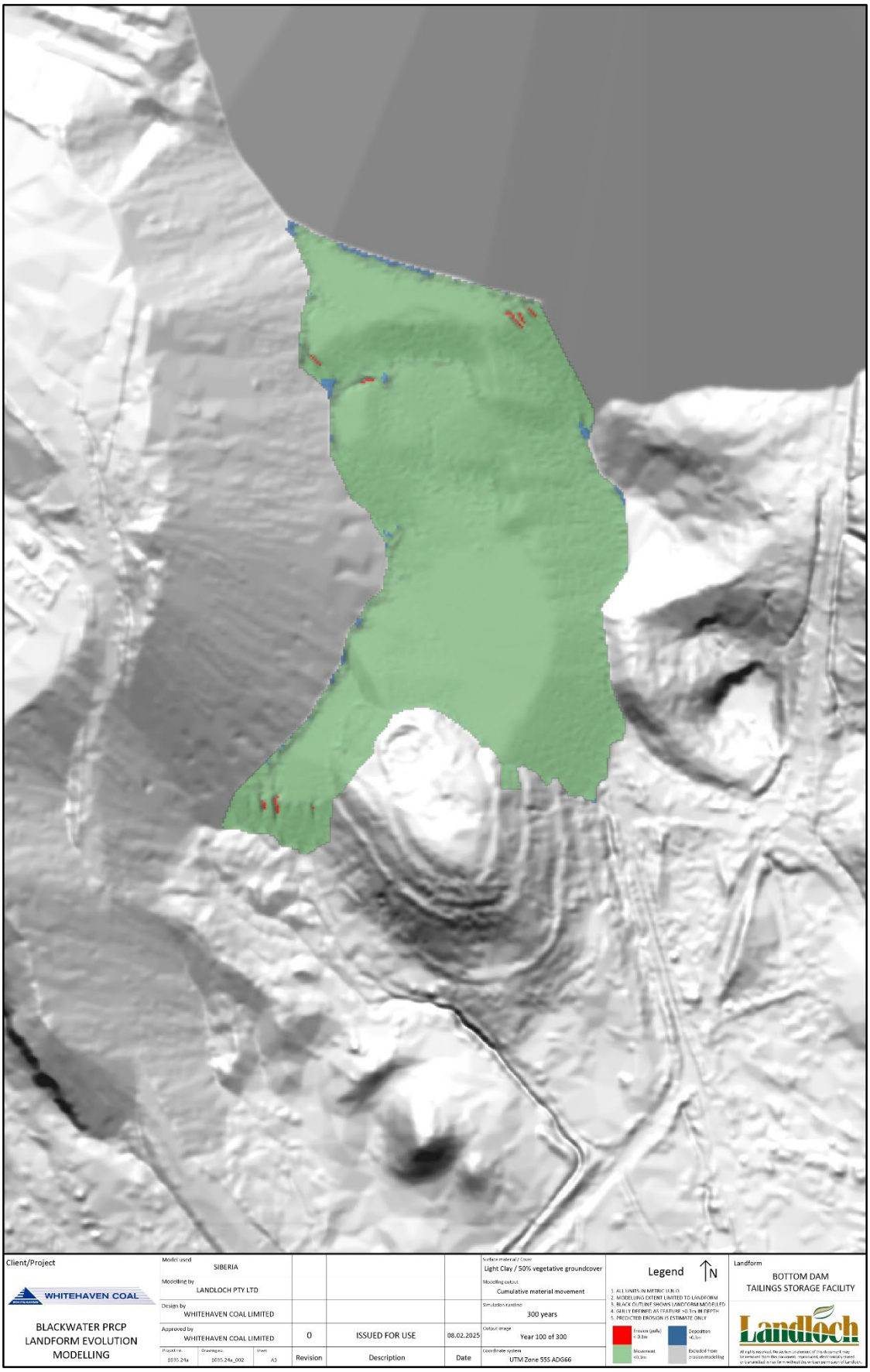

Figure A-2: Predicted erosion and deposition depths of the Bottom Dam TSF rehabilitation landform after 100 years.

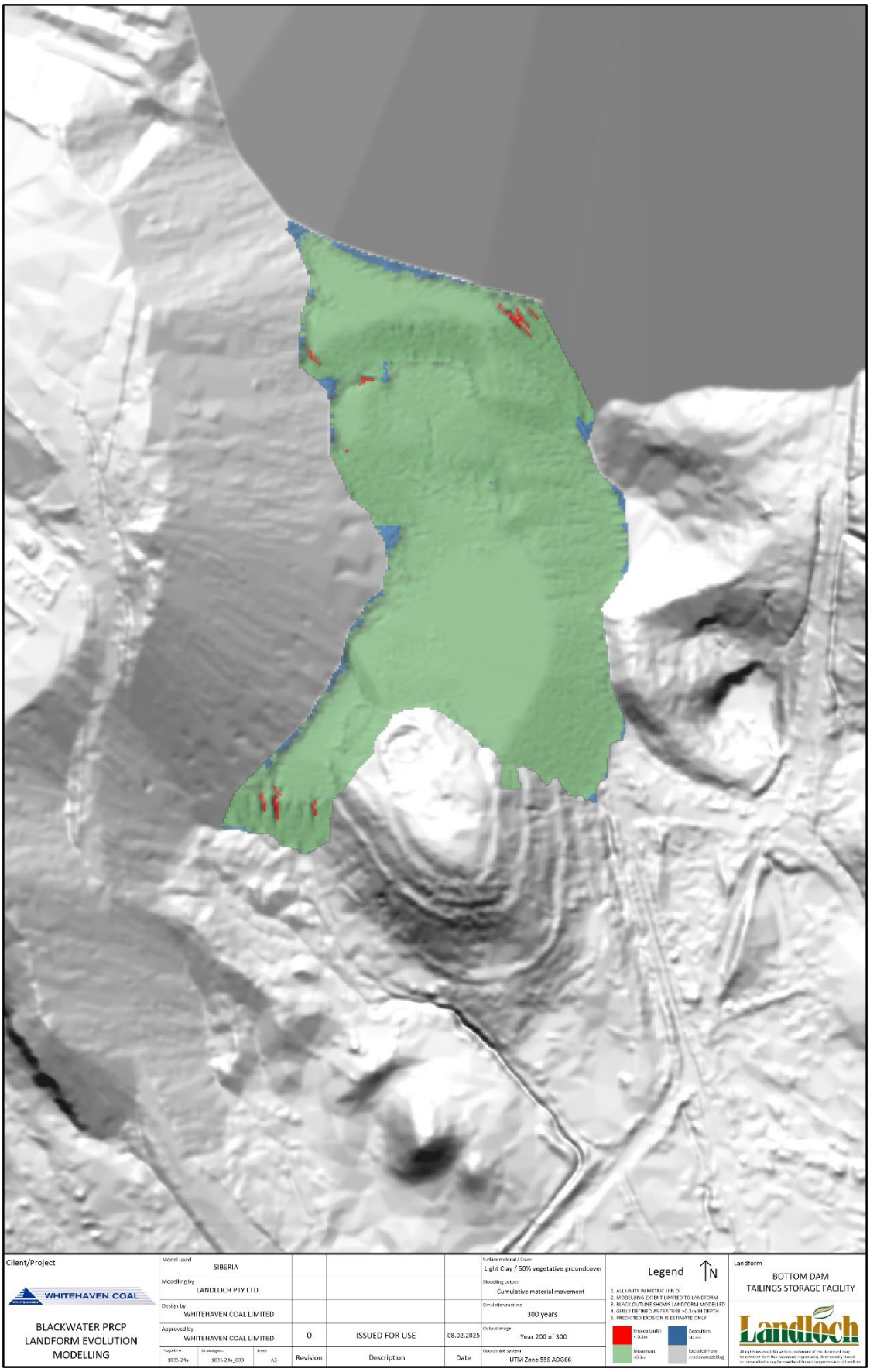

Figure A-3: Predicted erosion and deposition depths of the Bottom Dam TSF rehabilitation landform after 200 years.

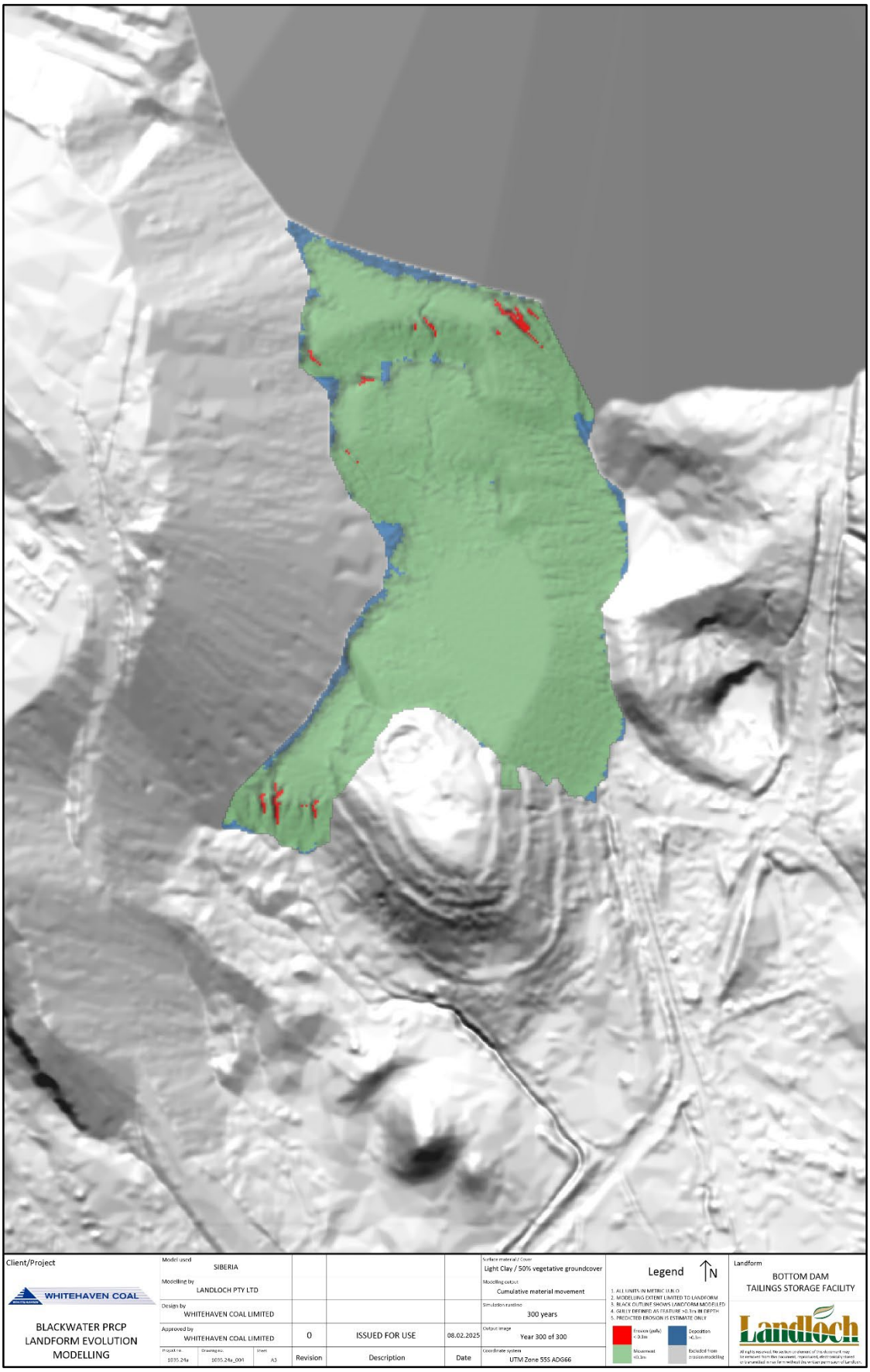

Figure A-4: Predicted erosion and deposition depths of the Bottom Dam TSF rehabilitation landform after 300 years.

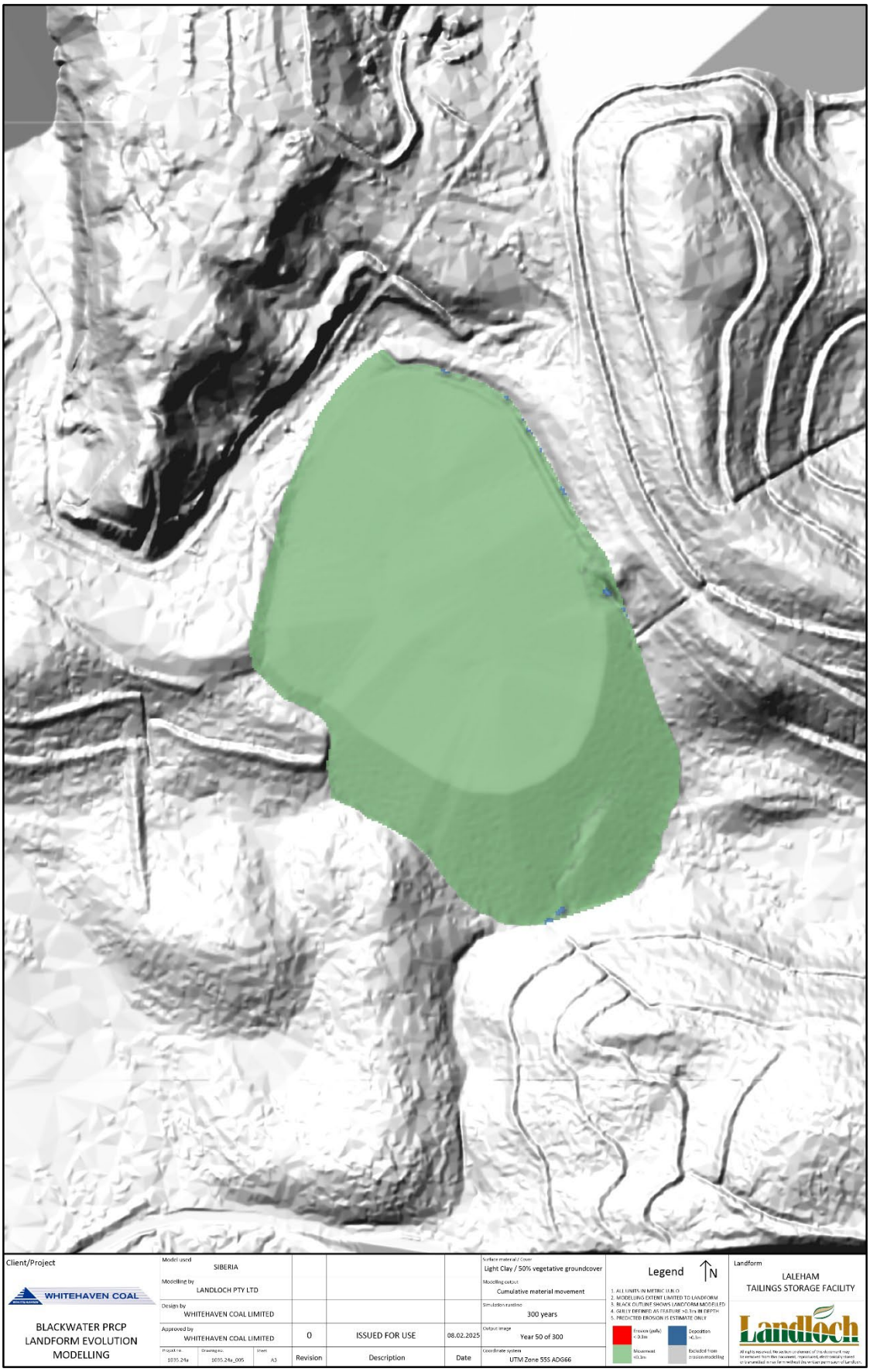

Figure A-5: Predicted erosion and deposition depths of the Laleham TSF rehabilitation landform after 50 years.

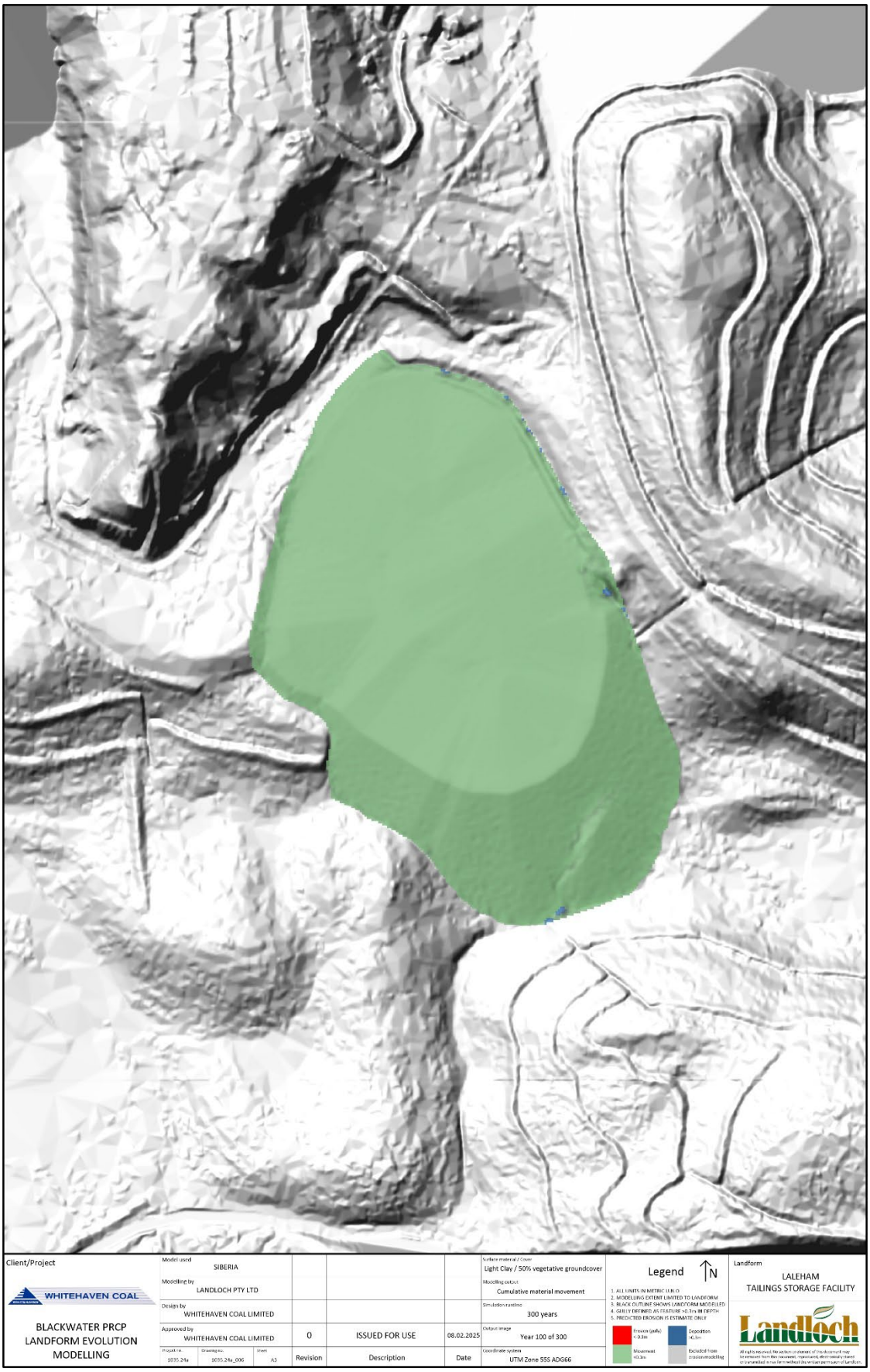

Figure A-6: Predicted erosion and deposition depths of the Laleham TSF rehabilitation landform after 100 years.

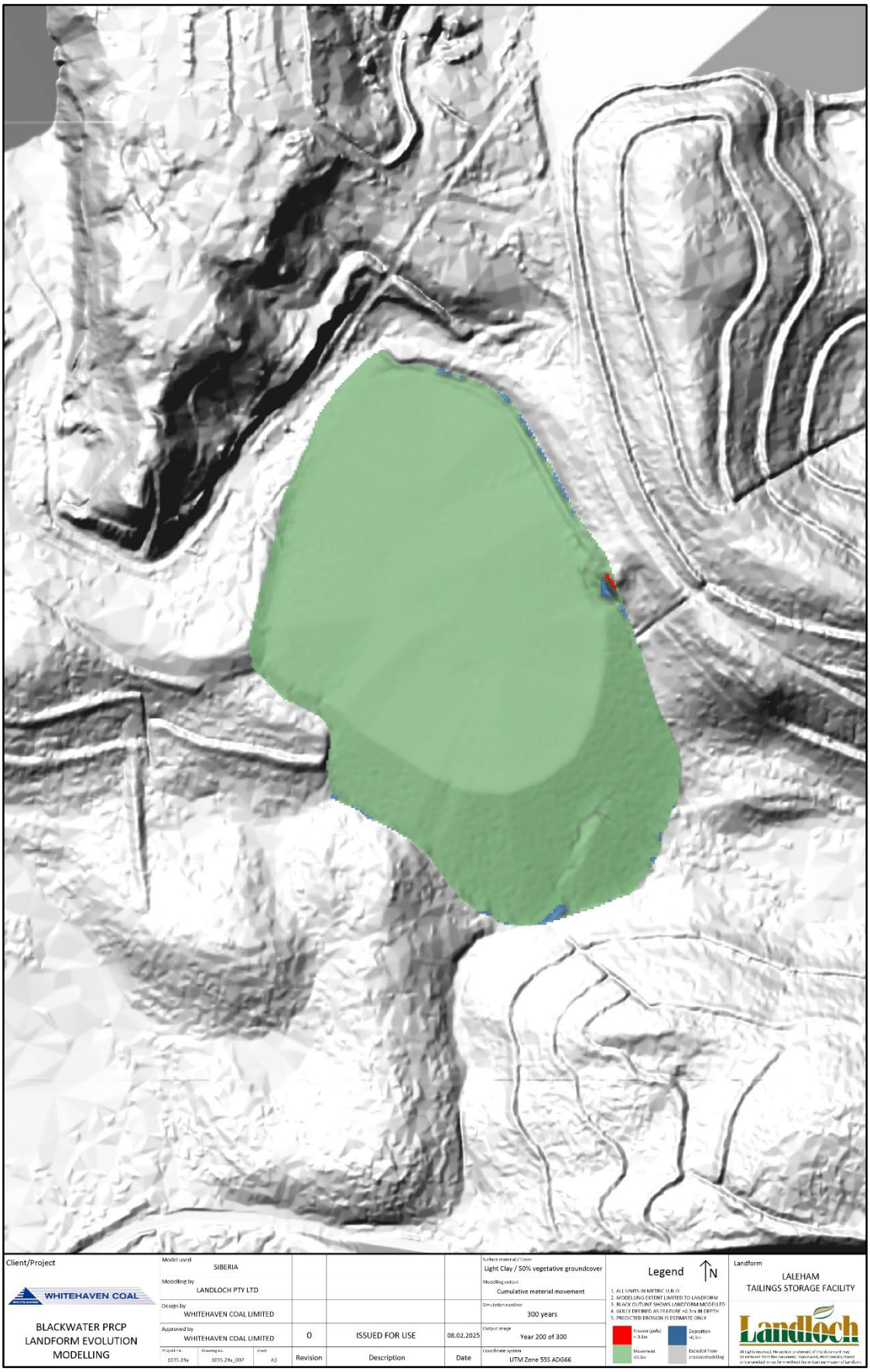

Figure A-7: Predicted erosion and deposition depths of the Laleham TSF rehabilitation landform after 200 years.

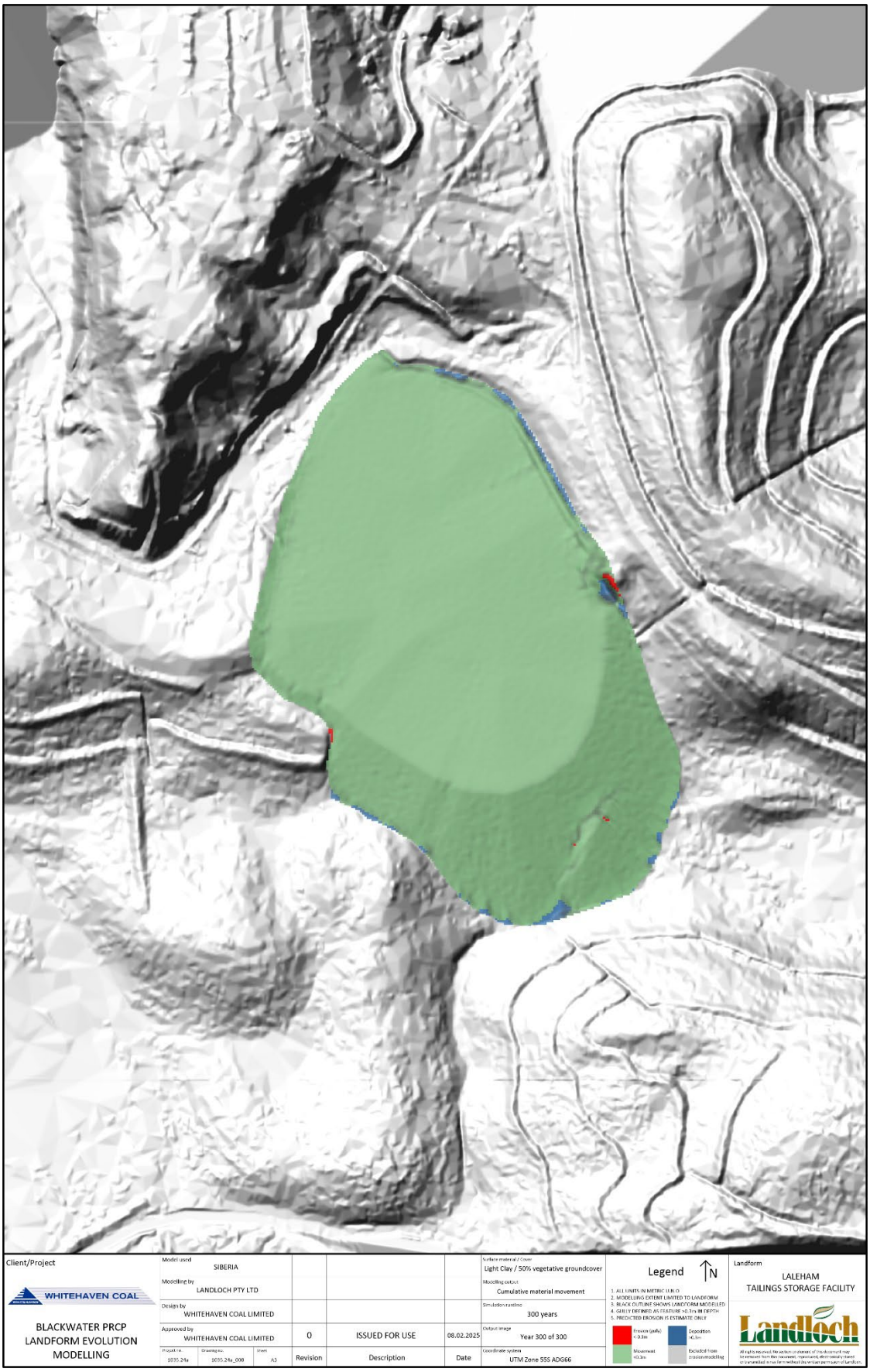

Figure A-8: Predicted erosion and deposition depths of the Laleham TSF rehabilitation landform after 300 years.



Figure A-9: Predicted erosion and deposition depths of the NCPP TSF rehabilitation landform after 50 years.



Figure A-10: Predicted erosion and deposition depths of the NCPP TSF rehabilitation landform after 100 years.



Figure A-11: Predicted erosion and deposition depths of the NCPP TSF rehabilitation landform after 200 years.



Figure A-12: Predicted erosion and deposition depths of the NCPP TSF rehabilitation landform after 300 years.

Bottom Dam Tailings Storage Facility & Sirius Creek

Preliminary Hydrogeological Review and Investigation

Whitehaven Coal Limited

Blackwater Mine
Blackwater, QLD, 4717

Prepared by:

SLR Consulting Australia

SLR Project No.: 620.010199.00013

15 May 2025

Revision: 3.0

Revision Record

Revision	Date	Prepared By	Checked By	Authorised By
1.0	12 March 2025	K. Gibson, S. Hulbert	D Lyons	D Lyons
2.0	7 April 2025	K. Gibson, S. Hulbert	D Lyons	D Lyons
3.0	15 May 2025	S. Hulbert	D Lyons	D Lyons

Basis of Report

This report has been prepared by SLR Consulting Australia (SLR) with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with Whitehaven Coal Limited (the Client). Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

This report is for the exclusive use of the Client. No warranties or guarantees are expressed or should be inferred by any third parties. This report may not be relied upon by other parties without written consent from SLR.

SLR disclaims any responsibility to the Client and others in respect of any matters outside the agreed scope of the work.

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Appendices

Appendix A Bore Logs

1.0 Introduction

1.1 Background

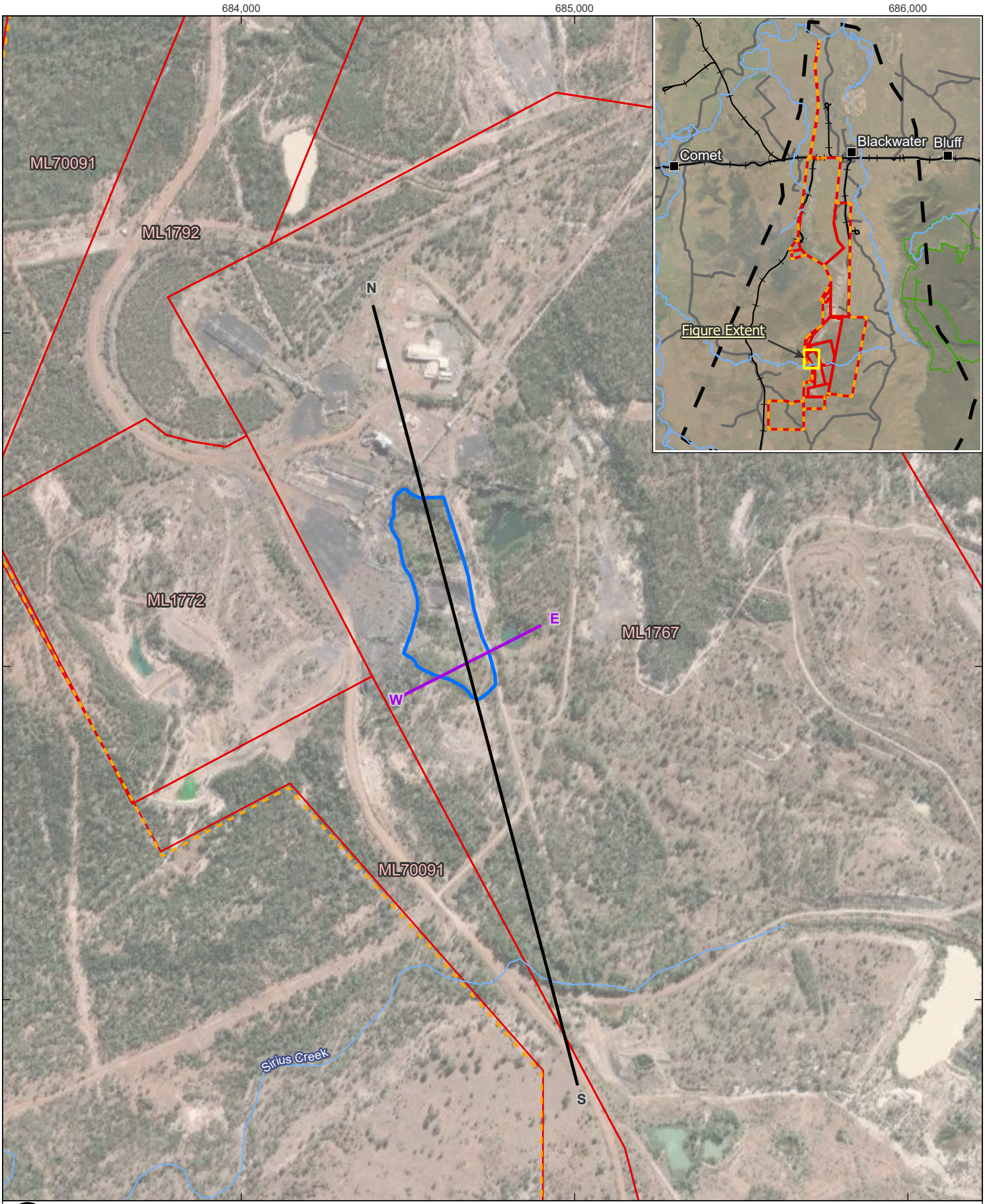
SLR Consulting Australia Pty Ltd (SLR) has been engaged by Whitehaven Blackwater Pty Ltd a subsidiary of Whitehaven Coal Limited (WHC) to undertake a preliminary hydrogeological assessment of the conceptual relationship between the historical Bottom Dam Tailings Storage Facility (TSF) and Sirius creek at Blackwater Mine (BWM). The intent of this investigation is to provide input into a response to an Information Request (IR) related to the BWM Transitional Progressive Rehabilitation and Closure Plan (PRC Plan).

Groundwater modelling and particle tracking carried out in support of the Transitional PRC Plan Hydrogeology Assessment (SLR, 2024) identified that residual voids in the post-mining landform across the BWM will generally act as groundwater "sinks," except in the vicinity of the historic Bottom Dam TSF. Modelling suggests that some groundwater may migrate from the Bottom Dam TSF area towards Sirius Creek located 750 m southeast of Bottom Dam (SLR, 2024).

The initial objective of the works presented herein is to conceptually assess current hydrogeological conditions at a local scale not possible in the site-wide Transitional PRC Plan Hydrogeology Assessment and identify if there a plausible potential pathway for subsurface hydraulic connection between the Bottom Dam TSF and Sirius Creek as predicted by the model. The scope of this work involves a focussed desktop review of the data available at the time of the investigation, to explore local information to conceptualise the system and identify the likely groundwater – surface water interaction at Sirius Creek, and thus the possible flow pathways from the TSF.

Subsequently, the findings of the SLR (2024) model will be reviewed in consideration of the local conceptualisation presented herein, and a discussion presented.

The location of Bottom Dam TSF and Sirius Creek in relation to BWM as well as bores installed in the vicinity of Bottom Dam and Sirius Creek, relevant to this review, are shown in Figure 1-1.



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Scale:	1:15,000 at A4
Project Number:	620.040199
Date Drawn:	07-Apr-2025
Drawn by:	AS

LEGEND

- Section (W-E)
- Section (N-S)
- Watercourse
- Bottom Dam Tailings Storage Facility (TSF)
- BWM Mining Lease
- Project Area (Environmental Authorities boundary)

BLACKWATER MINE - BOTTOM DAM TSF AND SIRIUS CREEK INVESTIGATION

LOCATION AND SECTIONS OF BOTTOM DAM TAILINGS STORAGE FACILITY

SLR

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FIGURE 1-1

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040199.00001 BWM PRCP – GW\03 SLR Data\01 CADGIS\GIS\ArcPro\BWM PRCP – GW\BWM PRCP – GW.aprx\620040199_F01_01 Location Plan Bottom Dam

1.2 Information Request

The specific IR commentary that this investigation is responding to is replicated here for completeness:

Tailings Storage Facility

(Reason 2):

Section 3.6.2 of the PRCP Guideline requires that 'proposed tailings management options must minimise interactions between the tailings and the surrounding environment to prevent the release of contaminants to the receiving environment '.

Flow path simulations presented in the *Transitional PRC Plan Hydrogeology Assessment* (SLR 2024a) (Appendix 4.2 of the Rehabilitation Planning Part) conclude that:

'water associated with spoil and tailings deposition, underground mine workings or open cut residual void lakes is not predicted migrate away from the BWM Area, with the residual voids acting as passive containment for groundwater which has passed through the mine workings. The ***exception to this is the specific location of Bottom Dam, west of Laleham residual void, with groundwater predicted to migrate towards Sirius Creek outside of the BWM Area****. The environmental risk associated with this prediction is addressed within the PRC Plan's tailings cover design and geochemistry assessments (Henderson Geotech, 2024, and Terrenus Earth Sciences, 2024)'* (SLR 2024a, p. 128)

Terrenus Earth Science (2024) reiterate that 'there are plausible surface water receptors; and the run-off and seepage pathways linking the source (Bottom Dam TSF/rejects final landform) to these receptors (Sirius Creek) have been identified' (p. xvii) and state:

'Environmental and engineering investigations of this area are underway to support rehabilitation and closure planning and, as such, no geochemical data specifically from Bottom Dam was available for this waste characterisation assessment. The final landform of the greater Bottom Dam area is also to be determined, subject to the outcome of the engineering and environmental investigation programs' (p. xiv).

Terrenus Earth (2024, p. 80) state:

'..until a detailed geochemical assessment is undertaken, Bottom Dam area (comprising TSF and rejects) is conservatively assumed to pose a ***Moderate-High AMD [Acid Mine Drainage] hazard, with AMD generation rated as Probable/Likely****.*

The Concept Cover Design (Henderson Geotech, 2024, p. 16) states:

'…there is the ***possibility of shallow seepage out of the TSF and into Sirius Creek****, although there is not a clear hydrogeologic connection. If seepage did occur, the rate would decrease over time since tailings deposition has ceased, and a cover system designed to minimize deep infiltration would also reduce long-term seepage.*

The statement that 'a clear hydrogeologic connection' contradicts the flow path modelling presented by SLR in the Hydrogeology Assessment (2024a).

(Action 2):

Provide a Rehabilitation Planning Part in accordance with Section 3.6.2 of the PRCP Guideline which details tailings management options which minimise interactions between the tailings and the surrounding environment to prevent the release of contaminants to the receiving environment.

2.0 Local Site Background

2.1 Surface Features

2.1.1 Sirius Creek

Sirius Creek is the primary surface drainage feature within the southern BWM area, situated in the Comet River sub-catchment of the Mackenzie River catchment. Sirius Creek is located approximately 750 m south of Bottom Dam at an elevation of ~255 mAHD (Figure 1-1). The creek flows from east to west across the southern portion of the Blackwater Mine Project Area. It is classified as an ephemeral watercourse, exhibiting intermittent flow that occurs predominantly in response to high-intensity rainfall events (AGE, 2003). Under dry conditions, the creek bed remains dry, with surface water present only for limited durations following significant precipitation. It is noted that Schedule F of the BWM Environmental Authority (EA) permits the release of mine affected water to Sirius Creek.

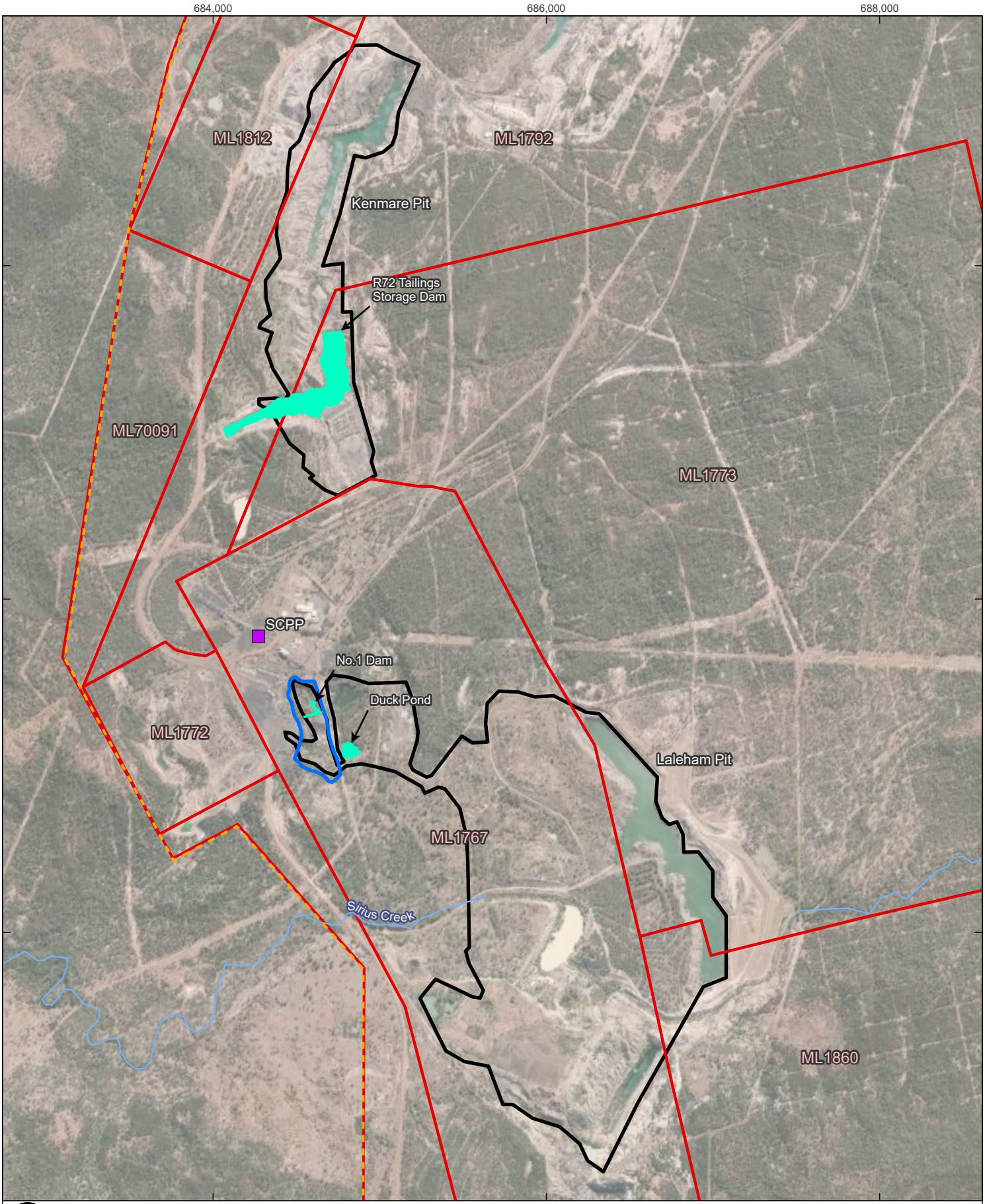
2.1.2 Bottom Dam

The Bottom Dam TSF is a historic tailings storage facility situated in the southern area of the Blackwater Mine (BWM), south of ROM 3 and near the southern coal handling and preparation plant (SCPP) (Figure 2-1). Covering approximately 1.6 ha, the Bottom Dam TSF has an estimated total storage volume of 0.2 Mm^3, while the broader Bottom Dam TSF area spans approximately 10 ha with a total reject volume estimated at less than 1 Mm^3 (Terrenus Earth Sciences, 2024). Geotechnical drilling indicates that the storage depth reaches up to 15 m.

The Bottom Dam TSF is bordered by sloping ground to the north, a 6-m-high earthfill embankment to the east, and a spoil dump to the south. It is located at an elevation of approximately 270 mAHD (estimated from 1 m digital elevation model (DEM)), and lies 37 m below the elevated natural ground of ROM 3, situated to the northwest. Duck Pond is positioned immediately to the east. The tailings surface is relatively flat, except for a small sump near the culvert that connects to Duck Pond. Vegetation, primarily scrubby mid-storey species, has naturally established across more than half of the tailings surface, which is underlain by a desiccated surface crust approximately 1–2 m thick.

The Bottom Dam TSF was originally constructed as a process water storage facility within the SCPP water management system, the Bottom Dam TSF received overflow from No. 1 Dam (located upslope to the north) and drained via a culvert into Duck Pond, east of the mine road. Over time, coal fines and sediment washed from No. 1 Dam and the rejects dump also accumulated at Bottom Dam. It was formally designated as a TSF after 2012 and subsequently received a mixture of tailings and coal rejects, estimated in equal proportions. These materials, generated at the SCPP, are assumed to have environmental geochemical characteristics similar to those observed in other storage facilities, such as Ramp 72 TSF, Kenmore Pit, and Laleham Pit. It is unknown when the TSF was decommissioned from use.

Pre-mining land use in the area primarily consisted of low-intensity grazing, with significant portions of uncleared woodland.



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Date Drawn:	12-Mar-2025
Drawn by:	AS

LEGEND

- SCPP
- Water Storage Area
- Bottom Dam Tailings Storage Facility (TSF)
- Pit Extent
- Watercourse
- Project Area (Environmental Authorities boundary)
- BWM Mining Lease

BLACKWATER MINE - BOTTOM DAM TSF AND SIRIUS CREEK INVESTIGATION

SURFACE FEATURES

SLR

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FIGURE 2-1

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040199.00001 BWM PRCP – GW\03 SLR Data\01 CADGIS\GIS\ArcPro\BWM PRCP – GW\BWM PRCP – GW.aprx\620040199_F02_01 Surface Features

2.2 Hydrogeology

The surficial hydrostratigraphic units underlying the Bottom Dam TSF and relevant to this investigation include Alluvium, Tertiary deposits, and the underlying Permian Burngrove Formation. Bore details and location of the bores targeting these units are provided in Table 2-1, Table 2-2 and Figure 2-3. Bore logs are provided in Appendix A.

Alluvium:

- Alluvium, where sporadically present, forms a relatively thin, porous aquifer system with variable permeability. Drilling investigations indicate that the spatial extent of alluvial deposits is more limited than suggested by regional surface geology maps, with thicknesses ranging from 0 to 12 m. These deposits are primarily associated with local creeks and, when saturated, form a localised unconfined aquifer. However, recent observations indicate that where present, the alluvium within the BWM area is dry and of limited extent.
- There is no evidence of Alluvium present at Bottom Dam.
- Only one bore, BWM_MB136_01, has encountered Alluvium along Sirius Creek. The geological log indicates alluvium at 0 – 0.2 metres, overlying predominantly clayey sand interpreted as Tertiary sediments. The bore screens the Permian Burngrove Formation, logged from 6 – 8.3 metres beneath the Tertiary sediments. The bore is screened at 4 – 7 m below ground level (mBGL). This bore was recorded as dry at the time of installation (late 2024) and again more recently at the end of January 2025.
- As discussed, the alluvium is often found to be limited in extent and thickness, and predominantly unsaturated. It may become temporarily saturated following rainfall recharge and occasional seepage from ephemeral creek streamflow.
- Where the alluvium is saturated it is expected to potentially facilitate recharge to the underlying geological units. Discharge is generally considered to be via evapotranspiration and leakage to underlying aquifers.

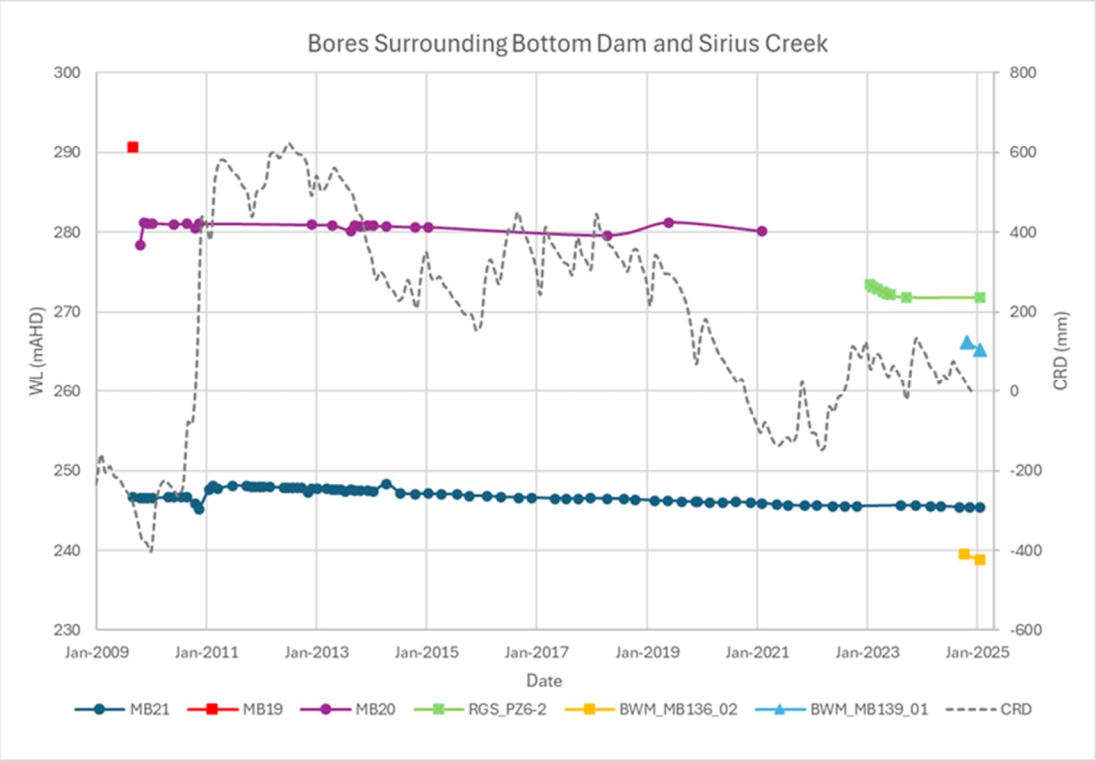
Tertiary:

- Tertiary deposits regionally at BWM consist dominantly of claystones and mudstones, typically ranging from 5 to 50 m in thickness. The unconsolidated surface layer, which includes weathered Tertiary strata and some basalt flows, may provide preferential flow pathways for groundwater if the water table rises above the base of weathering. When saturated, this unit functions as an unconfined aquifer, though its permeability is generally low.
- Bores screening the Tertiary sediments within the local study area are generally dry. This indicates that although the Tertiary deposits are persistent across the region, they do not form a saturated continuous aquifer. Rather, there are potentially isolated areas where saturation occurs.
- Given the discontinuous nature of the saturated Tertiary, it is not reasonable to define groundwater flow regimes, specifically at the local study scale.
- The longest recorded Tertiary groundwater level time series is available for bores MB20 (located 850 m upgradient/northwest of the Dam) and MB21 (350 m downgradient/southeast of Bottom Dam). Neither of these bores have available logs to confirm the screened unit, and more recent co-located drilling indicate these bores may be mis-attributed to this aquifer. However, temporal data from these bores is

presented for completeness and indicate relatively stable groundwater levels since 2009, with a gradual background decline of approximately 1 m over this period (Figure 2-2). This decline is likely attributable to below-average rainfall conditions observed during 2013–2016 and 2018–2022. Notably, no significant changes in these groundwater levels were observed following conversion of Bottom Dam to a TSF in 2012 or its subsequent decommissioning (date unknown, however at some point between commencement in 2012 and current status).

- Seven bores are recorded as “dry”, indicating that the Tertiary sediments are not continuously saturated across the study area (see Table 2-1).

Figure 2-2 Hydrograph of Tertiary bores around Bottom Dam and Sirius Creek



Permian:

- Permian deposits regionally at BWM underly the Tertiary sediments and form a continuous hydrostratigraphic unit. The Permian is typically saturated, hosting the regional water table. Groundwater flow in the Permian strata is expected to be consistent with the regional topographic gradient and follow a south-southeasterly directions.

Table 2-1 Details of Bores surrounding Bottom Dam and Sirius Creek and applicable to the investigation

Bore ID	Easting1	Northing1	Ground level (mAHD)	Log?	Depth (m)	Screened Interval	Screened unit	Water Level (mTOC)	Used in N-S Cross Section
BWM_MB119_01	684198	7350590	281	yes	19	15.5 - 18.5	Tertiary	Dry[2]	no
BWM_MB121_01	684202	7350959	306	yes	18.5	10.5 - 16.5	Tertiary	Dry[2]	no
BWM_MB123_01	683965	7351157	306	yes	8.8	5.2 - 8.2	Tertiary	Dry[2]	no
BWM_MB132_01	684573	7351281	288	yes	19	12.5-18.5	Tertiary	Dry[2]	yes
BWM_MB132_02	684591	7351283	288	yes	29.5	22-29	Permian (Burngrove formation, overburden)	19.93	yes
BWM_MB133_00	684655	7351045	275	yes	12	5.2-11.2	Spoil (coal tailings)	5.22	yes
BWM_MB133_01	684651	7351045	275	yes	18	14.5-17.5	Spoil (mine rejects)	5.47	yes
BWM_MB133_02	684648	7351044	275	yes	28.5	22-28	Permian (underburden, below Rangal Coal Measures)	20.13	yes
BWM_MB135_01	684895	7350808	264	yes	12	6.5-9.5	Tertiary	Dry	yes
BWM_MB136_01	684837	7350128	255	yes	8.3	4.0-7.0	Permian (Burngrove Formation, overburden)	Dry	yes
BWM_MB136_02	684603	7350311	255	yes	21.5	15.0-21.0	Permian (Burngrove Formation, overburden)	15.8	yes
BWM_MB138_01	684738	7350977	275	yes	14	10.5-13.5	Spoil (mine rejects)	13.61	yes
MB19	684418	7351975	311	no	19.7	13.7-19.7	NO LOG	Dry[3]	yes
MB20	684428	7351856	312	no	31.6	25.6-31.6	NO LOG	Dry[3]	yes
MB21	684905	7350813	264	no	30.69	25-31	NO LOG	18.38	no
BWM_MB135_02	684899	7350805	279	yes	24	17-23	Permian	20.1	yes

[1] Coordinates GDA 2020 Zone 55 [2]Bore recorded as “Dry” since installation [3]Bore Recorded as “Dry” in January 2025
*Ground Level

Table 2-2 Geological interpretations of bores surrounding Bottom Dam TSF and Sirius Creek

Bore ID	Easting1	Northing1	Interpreted Geological Unit Intersection (mBGL)					Screened Interval	Screened unit
			Alluvial	Spoil (coal tailings)	Spoil (mine rejects)	Tertiary	Permian		
BWM_MB119_01	684198	7350590				0-19		15.5 - 18.5	Tertiary
BWM_MB121_01	684202	7350959				0-18.5		10.5 - 16.5	Tertiary
BWM_MB123_01	683965	7351157				0-8.8		5.2 - 8.2	Tertiary
BWM_MB132_01	684573	7351281				0-19		12.5-18.5	Tertiary
BWM_MB132_02	684591	7351283				0-19	19 - 29.50	22-29	Permian (Burngrove Formation, overburden)
BWM_MB133_00	684655	7351045		0-12				5.2-11.2	Spoil (coal tailings)
BWM_MB133_01	684651	7351045		0-13	13-18			14.5-17.5	Spoil (mine rejects)
BWM_MB133_02	684648	7351044		0-13	13-20		20-28.5	22-28	Permian (underburden, below Rangal Coal Measures)
BWM_MB135_01	684895	7350808			0-4	4-10		6.5-9.5	Tertiary
BWM_MB136_01	684837	7350128	0-0.2			0.2-6	6-8.3	4.0-7.0	Permian (Burngrove Formation, overburden)
BWM_MB136_02	684603	7350311				0-8	8-21.5	15.0-21.0	Permian (Burngrove Formation, overburden)
BWM_MB138_01	684738	7350977		0-8.3	8.3-14			10.5-13.5	Spoil (mine rejects)
MB19	684418	7351975						13.7-19.7	NO LOG
MB20	684428	7351856						25.6-31.6	NO LOG
MB21	684905	7350813						25-31	NO LOG
BWM_MB135_02	684899	7350805			0-5.5	5.5-10	10-24	17-23	Permian

[1] Coordinates GDA 2020 Zone 55



0 250 500 m

Coordinate System:	GDA2020 MGA Zone 55
Scale:	1:15,000 at A4
Project Number:	620.040199
Date Drawn:	04-Apr-2025
Drawn by:	AS

LEGEND

Groundwater Monitoring Bore

- Spoil (mine rejects)
- Spoil (coal tailings)
- Tertiary
- Permian

- Watercourse
- Bottom Dam Tailings Storage Facility (TSF)
- BWM Mining Lease
- Project Area (Environmental Authorities boundary)

BLACKWATER MINE - BOTTOM DAM TSF AND SIRIUS CREEK INVESTIGATION

GROUNDWATER MONITORING BORE AND SCREENED UNIT

SLR

DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.

FIGURE 2-3

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040199.00001 BWM PRCP – GW\03 SLR Data\01 CADGIS\GIS\ArcPro\BWM PRCP – GW\BWM PRCP – GW.aprx\620040199_F02_02 GW Monitoring Bottom Dam

3.0 Conceptualisation

A hydrogeological conceptual model for the area surrounding Bottom Dam and Sirius Creek is illustrated in Figure 3-1. This conceptualisation integrates monitoring data with an understanding of local hydrogeological conditions presented in Section 2.0.

3.1 Alluvium

The alluvial deposits in the area are very localised and limited in extent, and predominantly unsaturated. Any localised saturation which may occur within the alluvium is transient, occurring only in response to recharge from rainfall and surface water drainage lines, with saturation persisting for short periods. Discharge from the alluvial deposits, when temporarily saturated, is expected to be via evaporation or leakage downwards to the underlying aquifers.

3.2 Tertiary

Similarly, the Tertiary sediments in the study area is largely unsaturated, with bore monitoring data indicating dry conditions at most local bore locations.

Where saturated Tertiary exists, groundwater have shown minimal fluctuation over time, with no significant rises in response to rainfall events, further supporting limited connectivity between surface water and groundwater.

3.3 Permian

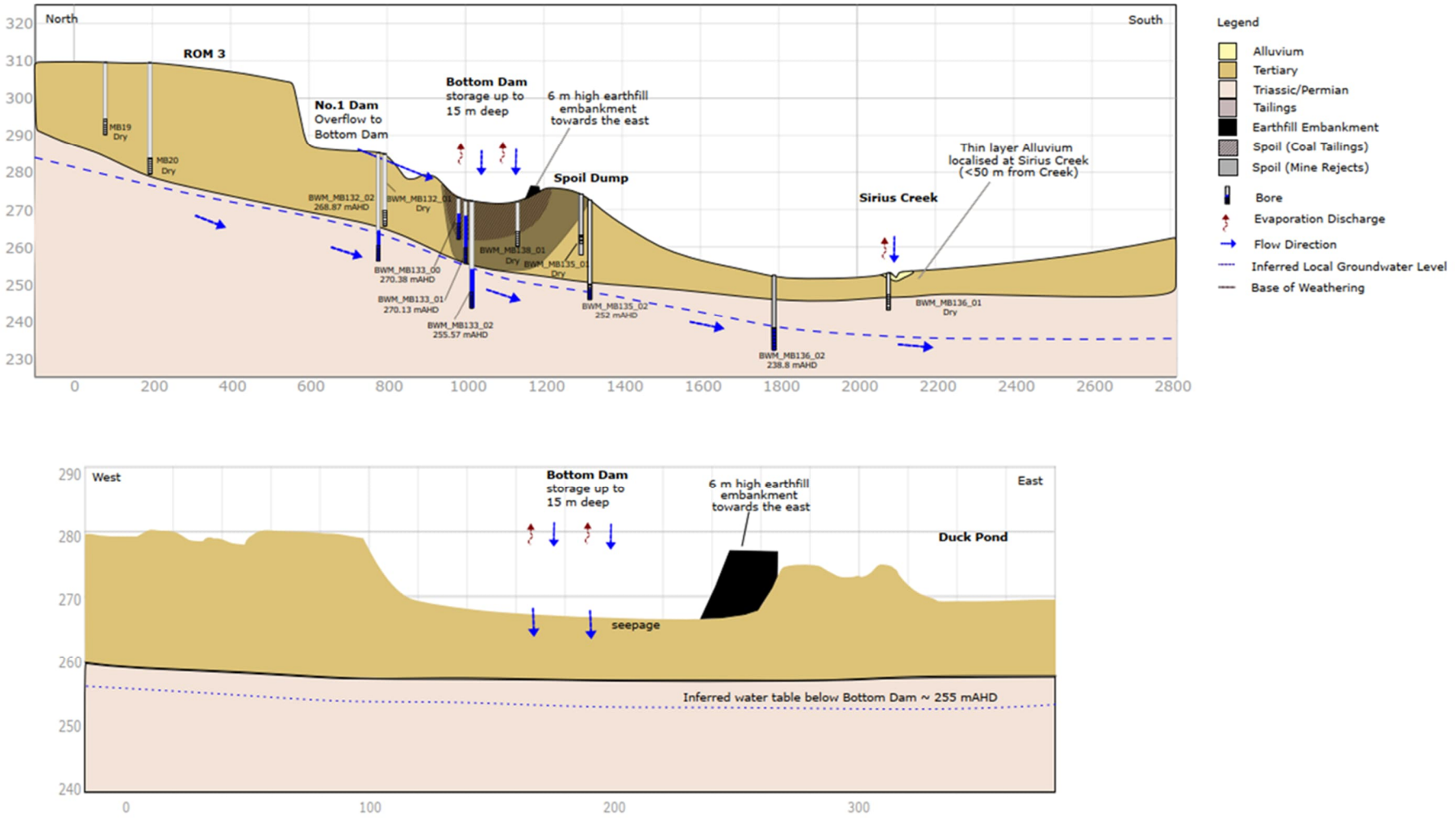
The Permian aquifer locally forms the water table aquifer. The water table below Bottom Dam is approximately 270 mAHD, which is below the creek's elevation of approximately 255 mAHD. As such, groundwater beneath Bottom Dam cannot physically discharge to Sirius Creek as hydraulic gradients do not allow this to occur.

3.4 Summary

Overall, surface water-groundwater interactions in this area are assessed to be minimal. The ephemeral nature of the creek, combined with its elevation above the groundwater table, reduces the likelihood of groundwater discharge into Sirius creek from the Permian (via the Tertiary) aquifer. Instead, recharge processes are primarily driven by surface water inputs, such as streamflow and flooding, rather than contributions from groundwater.

Consequently, local scale conceptualisation does not support the potential movement of groundwater from Bottom Dam TSF to Sirius Creek as the key factors such as groundwater levels, aquifer properties, and recharge mechanisms indicate no potential pathway for connectivity between these features.

Figure 3-1 North-South and West-East cross sections through Bottom Dam



4.0 Flow Path Simulation Modelling

4.1 Overview

Flow path simulation modelling presented by SLR (2024) is a numerical predictive analysis used to assess the movement water through the groundwater system post-mining, at a scale appropriate to the PRC Plan (i.e. site-wide). In this modelling, a number of water 'particles' were placed on the BWM final landform and residual voids in the model and the mod-PATH3DU code (S.S. Papadopulos & Associates, Inc., 2018) was used to simulate particle pathways along the groundwater flow field during the simulated post-mining period (i.e. 500 years). The numerical groundwater model and subsequent particle tracking presented in the PRC Plan did not incorporate the closure strategy outlined in the PRC Plan for Bottom Dam TSF.

The particles were placed at the surface of the model and released at the start of the post-mining simulation, with the movement recorded during the post-mining simulation. Although it is stated that the particles are placed "at the surface", the modelling code automatically moves the particles to the shallowest saturated layer at the commencement of the simulation. MOD-PATH3DU was configured to release the particles at the midpoint between the base of the first saturated layer and the water table.

4.2 Predicted Movement

Overall, the PRC Plan's groundwater modelling indicated that the particles generally move toward the void lakes across the BWM final landform, with the majority of particles captured by the voids (see Figure 4-1).

The variation to this were the simulated particles placed at or near Bottom Dam TSF west of the Laleham residual void, which appeared to migrate out of the BWM Area towards Sirius Creek, with these particles commencing the simulation too far from the residual void lakes to be captured by their associated hydraulic gradients.

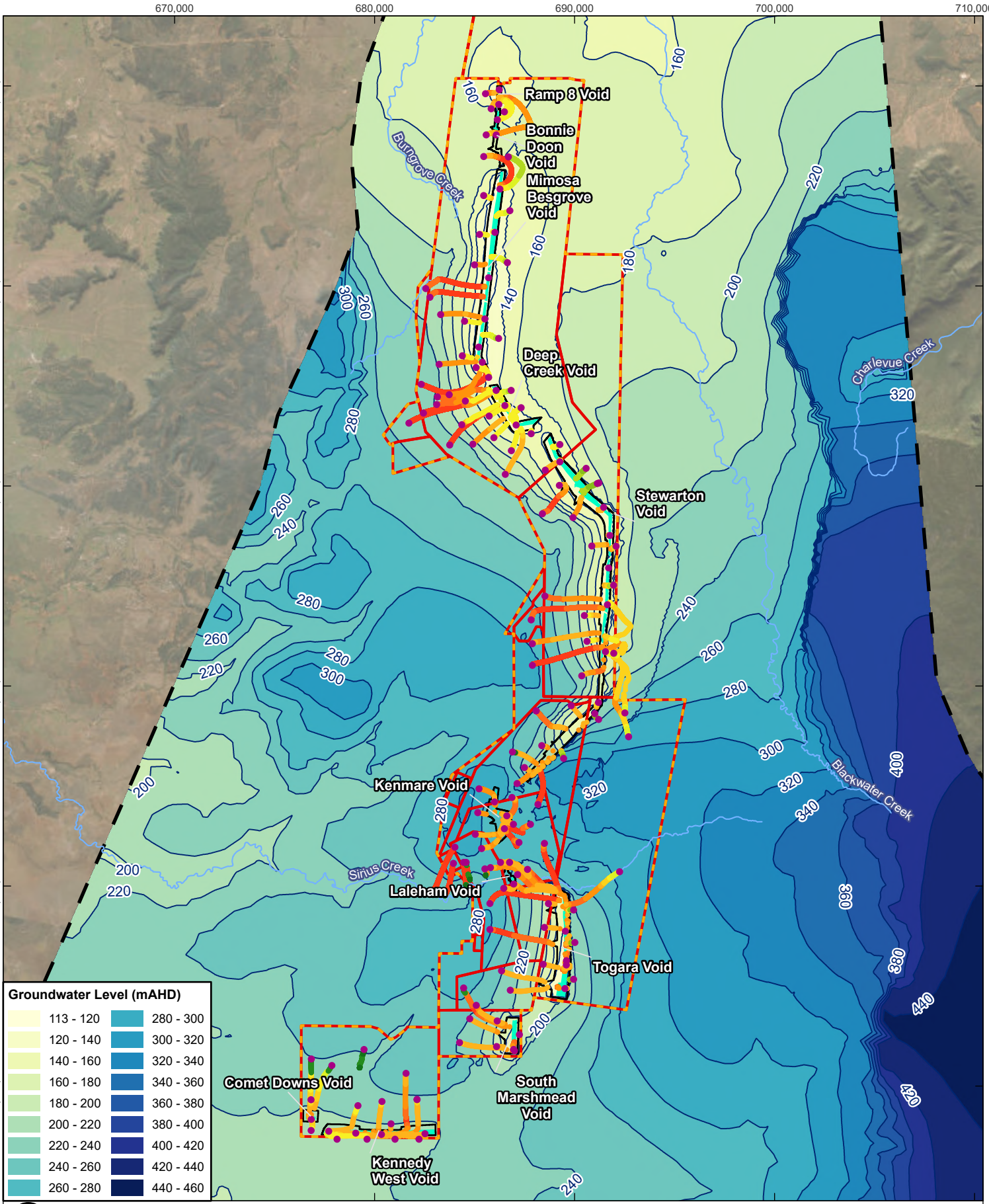
Figure 4-2 shows the particles in question near to Bottom Dam TSF, the path of movement and layer in which they are travelling. Table 4-1 provides the model layering set-up.

It is important to note that the model layer in which the particles commenced their migration from is Layer 14 (Burngrove Formation), i.e. below the Tertiary sediments (Layer 2). Particle movement continued within Layer 14 for approximately 80 years, before an emergence into Layer 2 prior to cessation of the post-mining simulation.

Table 4-1 Model Layering Details (SLR, 2024)

Model Layer	Geologic Formation	Hydrogeologic Unit	Present in the BWM Area
1	Alluvium/Tertiary	Surface cover and Tertiary	Yes
2	Alluvium/ Weathered zone	Weathered zone / Regolith	Yes
3	Clematis Group	Triassic	No
4	Rewan Group (Upper)	Triassic	No
5	Rewan Group (Middle)	Triassic	Yes (in part)
6	Rewan Group (Lower)	Triassic	Yes (in part)
7	Rangal Coal Measures	Overburden	Yes (in part)

Model Layer	Geologic Formation	Hydrogeologic Unit	Present in the BWM Area
8		Aries seam	Yes (in part)
9		Interburden	Yes (in part)
10		Castor seam	Yes (in part)
11		Interburden	Yes (in part)
12		Pollux seam	Yes (in part)
13		Underburden	Yes (in part)
14	Burngrove Formation	Permian	Yes



Coordinate System:	GDA2020 MGA Zone 55
Scale:	1:250,000 at A4
Project Number:	620.040199
Date Drawn:	12-Mar-2025
Drawn by:	AS

BLACKWATER MINE - BOTTOM DAM TSF AND SIRIUS CREEK INVESTIGATION

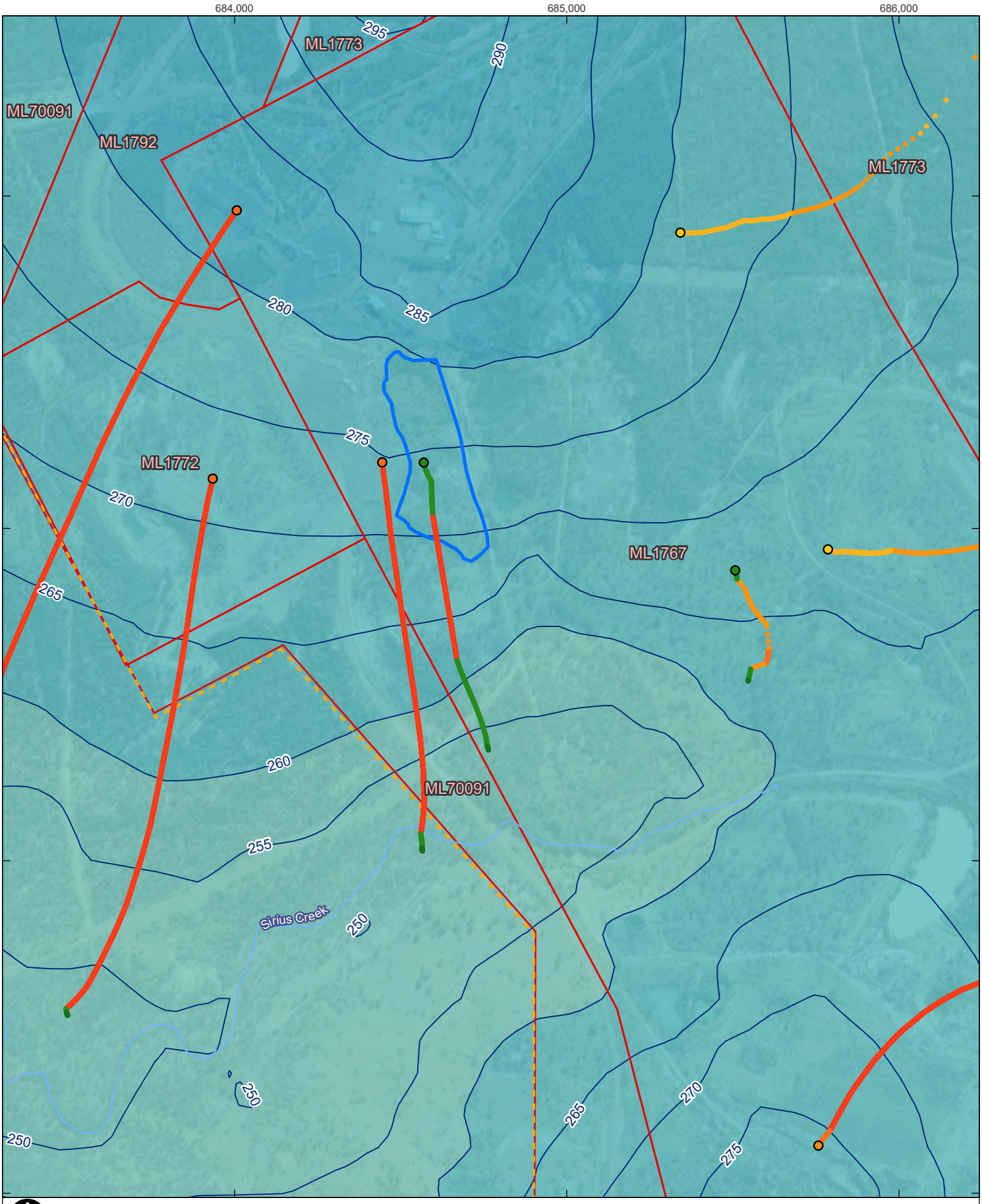
PREDICTED MOVEMENT OF PARTICLES (MID CLIMATE SCENARIO)

SLR

DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.

FIGURE 4-1

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040199.00001 BWM PRCP – GW\03 SLR Data\01 CADGIS\GIS\ArcPro\BWM PRCP – GW\BWM PRCP – GW.aprx\620040199_F0X_04_Predicted Movement of Particles (Mid Climate Scenario) Bottom



0 250 500 m

Coordinate System:	GDA2020 MGA Zone 55
Scale:	1:15,000 at A4
Project Number:	620.040199
Date Drawn:	06-Mar-2025
Drawn by:	AS

LEGEND

- Watercourse
- Bottom Dam Tailings Storage Facility (TSF)
- BWM Mining Lease
- Project Area (Environmental Authorities boundary)

Model Layer

- 1
- 2
- 11
- 12
- 13
- 14

Groundwater Level (mAHD)

- 240 - 260
- 260 - 280
- 280 - 300

BLACKWATER MINE - BOTTOM DAM TSF AND SIRIUS CREEK INVESTIGATION

PREDICTED MOVEMENT OF PARTICLES BOTTOM DAM TAILINGS STORAGE FACILITY

SLR

DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.

FIGURE 4-2

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040199.00001 BWM PRCP – GW\03 SLR Data\01 CADGIS\GIS\ArcPro\BWM PRCP – GW\BWM PRCP – GW.aprx\620040199_F0X Particle Tracks for Bottom TSF

It can be seen the particle migration follows the groundwater flow gradients as indicated by the groundwater elevation contours. As the groundwater flow gradient steadies progressively over the post-mining period as it approaches equilibrium, the model naturally has to find a progression pathway for the particle. Towards the equilibrium point, the vertical flux in the model becomes preferential to horizontal flux, and the particle appears to migrate upwards to Layer 2 (representing the Tertiary weathered zone), around Sirius Creek.

It is clear from the conceptualisation that this upward vertical flux is not realistic of the system, and the groundwater system is highly unlikely to behave in this manner. At the termination point of the particle tracking, it is expected that Layer 2 would likely be dry. The upwards flux is therefore potentially driven by a simulation nuance in the change to unsaturated flow that the model adopts.

4.3 Comparison of Site-Wide Model Results with Local Conceptualisation

It can be concluded that the predicted movement of particles from Bottom Dam TSF to Sirius Creek as predicted by the model is not supported by the conceptual model for the system. The reasoning for this disconnect is multi-faceted, and includes the following factors:

- Scale of both conceptualisation and of the model in relation to specific features:
  - Scale of hydrogeological investigations and modelling is highly variable dependent upon the intent of the study. The boundary of the numerical groundwater model, utilised for the particle flow path simulation modelling in discussion here, was fit for purpose for its original intent, being BWM site to regional scale groundwater flow modelling. However, the groundwater model is not scaled to the specific level of local detail developed within this study, that is, refined sufficiently to represent small local scale features such as Bottom Dam TSF. It becomes necessary in developing a regional groundwater model that the nuances of small localised conceptualisation may not be captured in the broader site conceptualisation and model build.
- Data availability:
  - The local bore data used to develop the conceptualisation for this study was not available at the time of the initial model construction. Consequently, the model is not specifically calibrated to this information and therefore the model is reflective of the broader site to regional scale dataset and generalised hydrogeological principals rather than the local site-specific information.
- Intent of particle pathway modelling:
  - It is important to note, ‘particles’ are simply a marker for tracking groundwater flow patterns and potential flow pathways, and do not represent an actual contaminant or specific parameter. The ‘particle’ commencing flow in Layer 14 (Burngrove Formation) is unlikely to be representative of any contaminated water from the Bottom Dam TSF, as this layer is well below the base of the TSF and hydraulically disconnected from the upper shallow layers.

5.0 Conclusion

Historically, the hydrogeological conditions around Bottom Dam TSF and Sirius Creek have been characterised by limited connectivity between surface water and groundwater systems. Monitoring data from the one bore in Sirius Creek near to Bottom Dam TSF has consistently shown dry conditions, indicating that the alluvial deposits and underlying Tertiary here have remained predominantly unsaturated i.e. there is no alluvial aquifer associated with Sirius Creek. Locally, and of importance, beneath Sirius Creek the Tertiary sediments are unsaturated. The water table in the Permian aquifer indicates groundwater levels occur well below the Sirius Creek bed elevation.

Minimal fluctuations in groundwater levels over time suggest that the Tertiary sediments are not significantly influenced by surface water inputs, rainfall events, or other external recharge mechanisms. These observations highlight that the ephemeral nature of Sirius Creek and its elevation above the water table have historically prevented groundwater discharge to the creek.

Under current conditions, surface water-groundwater interactions remain limited. Groundwater flow in the area is southward, however the water table continues to lie well below the creek's elevation preventing discharge of groundwater to the creek. The alluvial deposits remain predominantly unsaturated, with any localised saturation being highly transient and reliant on surface water inputs during flow events or flooding. Similarly, the Tertiary sediments, where saturated, shows consistent, stable groundwater levels with no significant response to rainfall, confirming a lack of hydraulic connection to surface water systems. Further, the Tertiary sediments appears to be unsaturated in the area around Sirius Creek. The ephemeral nature of the creek further reinforces its role as a temporary recharge source during flow events rather than a discharge point for groundwater.

Overall, both historical and current data suggest that surface water recharge processes in this area are dominated by episodic inputs from streamflow and flooding, with minimal contributions from groundwater. The hydrogeological setting supports limited connectivity between Bottom Dam TSF, Sirius Creek, and the regional groundwater system.

The numerical groundwater model and subsequent particle tracking presented in the PRC Plan:

- Was based on a groundwater model designed for site to regional scale flow modelling, rather than local scale modelling at specific BWM features such that the model sufficiently represents the localised interaction of groundwater around Bottom Dam TSF and Sirius Creek specifically.
- did not incorporate the closure strategy outlined in the PRC Plan for Bottom Dam TSF.

As such the model results near Bottom Dam TSF are considered a conservative first pass assessment of risk prior to any local scale remedial measures.

The conceptual understanding presented herein, based on a review of local data, provides the most accurate representation of the relationship between Bottom Dam TSF and Sirius Creek and a better basis for understanding the local groundwater dynamics than the numerical groundwater model. Based on this, in conjunction with a review of the modelling processes and intent, it is concluded that there is highly limited potential for hydraulic connection between the Bottom Dam TSF and Sirius Creek.

6.0 References

Australasian Groundwater and Environmental (AGE) Consultants, 2003. Report on CBM Extraction – South Blackwater Area, Prepared for BMA. Project No. G1187

Henderson Geotech Pty Ltd, 2024. Concept Cover Designs for Waste Storage Facilities at Blackwater Mine

SLR, 2023b. Blackwater Mine – North Extension Project Groundwater Modelling Technical Report. Prepared for BMA. Report reference: 620.014301.00006-R02-v4.0_20231211.docx, December 2023.

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S.S. Papadopulos & Associates, Inc., 2018. mod-PATH3DU, version 2.1.2. Rockville, Maryland

Terrenus Earth Sciences, 2024, Environmental Geochemical Characterisation and Risk Management of Mineral Waste, Blackwater Mine, prepared for Whitehaven Blackwater Pty Ltd, report ref: 24-063-178/R001

Appendix A Bore Logs

Bottom Dam Tailings Storage Facility & Sirius Creek

Preliminary Hydrogeological Review and Investigation

Whitehaven Coal Limited

SLR Project No.: 620.010199.00013

15 May 2025

REPORT OF STANDPIPE INSTALLATION: BWM_MB119_01

SHEET: 1 OF 1

CLIENT:	WHC	COORDS:	684084.8 m 7350413.1 m	DRILL RIG:	Geoprobe 8140LS sonic rig
PROJECT:	Blackwater South Site Investigation	SURFACE RL:	280.55 m DATUM: AHD	CONTRACTOR:	Legion Drilling
LOCATION:	Blackwater Mine	INCLINATION:	-90°	LOGGED: CS	DATE: 25/5/24
JOB NO:	PS213941	HOLE DEPTH:	19.00 m	CHECKED: BD	DATE: 2/10/24

Drilling				Field Material Description		Instrumentation Details
METHOD	WATER	DEPTH (metres)	DEPTH RL	GRAPHIC LOG	SOIL/ROCK MATERIAL DESCRIPTION	
SONIC		0	280.55		Topsoil/Fill - Silty SAND	0.00, RL280.55 — PVC stick up (0.75 m aGL) with well plug, encased in protective steel monument
			0.60			
			1.00		Sandy SILT	
					Tertiary Sediments - Silty SAND	
			1.60			
			278.95			
		2	2.10			
			278.45		Clayey SAND	
			3.10			
			277.45		Silty SAND	
		4	4.20			
			276.15		SANDSTONE	
			5.00			
			275.55		Clayey SANDSTONE	
		6				80/20 Cement/bentonite mix
			6.70			
			273.85			50 mm internal diameter class 12 uPVC solid casing
		8	8.00			
			272.55		SANDSTONE	
			9.00			
			9.30			
			271.25		Clayey SANDSTONE	
		10				
			10.50			
			270.05		SANDSTONE	
			11.80			
		12	268.75		Clayey SAND	
			12.50			
			268.05		SANDSTONE	
			13.50			
			267.05			
		14	14.00			14.00, RL266.55
			266.55		Silty SAND	Bentonite plug
			14.80			15.00, RL265.55
					Clayey SANDSTONE	
			15.30			
			265.25		SANDSTONE	
		16				Filter Pack - 2-3 mm washed graded gravel
			16.40			
			264.15			0.8 mm aperture, 5 mm spacing, factory slotted class 12 uPVC
			16.90			
			263.65		Clayey SANDSTONE	
		18				18.50, RL262.05
			19.00			19.00, RL261.55 — Sump - Class 12 uPVC solid casing, with endcap
			261.55		END OF BOREHOLE @ 19.00 m	

This report of standpipe installation must be read in conjunction with accompanying notes and abbreviations. It has been prepared for hydrogeological purposes only, without attempt to assess geotechnical properties or possible contamination. Any reference to geotechnical properties or potential contamination are for information only and do not necessarily indicate the presence or absence of the properties stated.

GAP gINT FN. F17
RL1

GAP 10.0.6 LIB.GLB Log GAP WELL 3 PS137749 BLACKWATER SOUTH SITE INVESTIGATION-OCT2-WELL INSTALL.GPJ <<DrawingFile>> 04/10/2024 10:21 10.03.00.09 Datgel Tools

REPORT OF STANDPIPE INSTALLATION: BWM_MB121_01

SHEET: 1 OF 1

CLIENT:	WHC	COORDS:	684088.4 m 7350782.4 m	DRILL RIG:	Geoprobe 8140LS sonic rig
PROJECT:	Blackwater South Site Investigation	SURFACE RL:	306.42 m DATUM: AHD	CONTRACTOR:	Legion Drilling
LOCATION:	Blackwater Mine	INCLINATION:	-90°	LOGGED: SK	DATE: 17/4/24
JOB NO:	PS213941	HOLE DEPTH:	18.50 m	CHECKED: BD	DATE: 2/10/24

Drilling				Field Material Description		Instrumentation Details
METHOD	WATER	DEPTH (metres)	DEPTH RL	GRAPHIC LOG	SOIL/ROCK MATERIAL DESCRIPTION	
SONIC		0	306.42		Topsoil - Silty CLAY	0.00, RL306.42 — PVC stick up (0.62 m aGL) with well plug, encased in protective monument
			1.00			
			305.42		Tertiary Sediments - SANDSTONE	
		2				
		4				80/20 Cement/bentonite mix
			5.00			
			301.42		CLAY	
			6.00			50 mm internal diameter class 12 uPVC solid casing
		6	300.42		SANDSTONE	
			7.50			
			298.92		SANDSTONE	
		8				9.00, RL297.42 — Bentonite plug
						10.00, RL296.42
		10				
		12				0.8 mm aperture, 5 mm spacing, factory slotted class 12 uPVC Filter Pack - 2-3 mm washed graded gravel
		14				
		16				16.50, RL289.92
						Sump - Class 12 uPVC solid casing, with endcap
						17.50, RL288.92
		18				Backfill - Natural backfill
			18.50			18.50, RL287.92
			287.92		END OF BOREHOLE @ 18.50 m	

This report of standpipe installation must be read in conjunction with accompanying notes and abbreviations. It has been prepared for hydrogeological purposes only, without attempt to assess geotechnical properties or possible contamination. Any reference to geotechnical properties or potential contamination are for information only and do not necessarily indicate the presence or absence of the properties stated.

GAP gINT FN. F17
RL1

GAP 10.0.6 LIB.GLB Log GAP WELL 3 PS137749 BLACKWATER SOUTH SITE INVESTIGATION-OCT2-WELL INSTALL.GPJ <<DrawingFile>> 04/10/2024 10:19 10.03.00.09 Datgel Tools

REPORT OF STANDPIPE INSTALLATION: BWM_MB123_01

SHEET: 1 OF 1

CLIENT:	WHC	COORDS: 683851.6 m 7350980.2 m	DRILL RIG: Comacchio GEO 900 sonic rig
PROJECT:	Blackwater South Site Investigation	SURFACE RL: 306.27 m DATUM: AHD	CONTRACTOR: Legion Drilling
LOCATION:	Blackwater Mine	INCLINATION: -90°	LOGGED: SK DATE: 20/4/24
JOB NO:	PS213941	HOLE DEPTH: 8.80 m	CHECKED: BD DATE: 2/10/24

Drilling				Field Material Description		Instrumentation Details
METHOD	WATER	DEPTH (metres)	DEPTH RL	GRAPHIC LOG	SOIL/ROCK MATERIAL DESCRIPTION	
SONIC		0	306.27		Fill	PVC stick up (0.73 m aGL) with well plug, encased in protective monument
			0.50			0.00, RL306.27
			305.77		Fill	80/20 Cement/bentonite mix
		3	3.50			50 mm internal diameter class 12 uPVC solid casing
			302.77		Tertiary Formation - SILCRETE	3.00, RL303.27
						Bentonite plug
		4				4.00, RL302.27
		5	5.50			Filter Pack - 2-3 mm washed graded gravel
			300.77		SILTSTONE	
		6				
		7				
		8				0.8 mm aperture, 5 mm spacing, factory slotted class 12 uPVC
						8.20, RL298.07
			8.80			Sump - Class 12 uPVC solid casing, with endcap
		9	297.47		END OF BOREHOLE @ 8.80 m	8.80, RL297.47

This report of standpipe installation must be read in conjunction with accompanying notes and abbreviations. It has been prepared for hydrogeological purposes only, without attempt to assess geotechnical properties or possible contamination. Any reference to geotechnical properties or potential contamination are for information only and do not necessarily indicate the presence or absence of the properties stated.

GAP 10.0.6 LIB.GLB Log GAP WELL 3 PS137749 BLACKWATER SOUTH SITE INVESTIGATION-OCT2-WELL INSTALL.GPJ <<DrawingFile>> 04/10/2024 10:12 10.03.00.09 Datgel Tools

REPORT OF STANDPIPE INSTALLATION: BWM_MB132_01

SHEET: 1 OF 1

CLIENT:	WHC	COORDS: 684460.4 m 7351104.4 m	DRILL RIG: Comacchio GEO 900 sonic rig
PROJECT:	Blackwater South Site Investigation	SURFACE RL: 287.65 m DATUM: AHD	CONTRACTOR: Legion Drilling
LOCATION:	Blackwater Mine	INCLINATION: -90°	LOGGED: SK DATE: 6/3/24
JOB NO:	PS213941	HOLE DEPTH: 19.00 m	CHECKED: BD DATE: 2/10/24

Drilling				Field Material Description		Instrumentation Details
METHOD	WATER	DEPTH (metres)	DEPTH RL	GRAPHIC LOG	SOIL/ROCK MATERIAL DESCRIPTION	
SONIC		0	287.65		Topsoil / Fill - Sandy GRAVEL	0.00, RL287.65 PVC stick up (0.97 m aGL) with well plug, encased in protective steel monument
		2	2.50 285.15		Tertiary Sediments - Sandy CLAY	
		4				80/20 Cement/bentonite mix
		6				50 mm internal diameter class 12 uPVC solid casing
		8				
		10	10.00 277.65		CLAYSTONE	10.50, RL277.15 Bentonite plug
		12				11.50, RL276.15
		14				Filter Pack - 2-3 mm washed graded gravel
	▽		15.00 272.65		SANDSTONE	
		16				0.8 mm aperture, 5 mm spacing, factory slotted class 12 uPVC
		18				18.50, RL269.15
			19.00 268.65		END OF BOREHOLE @ 19.00 m	19.00, RL268.65 Sump - Class 12 uPVC solid casing, with endcap

This report of standpipe installation must be read in conjunction with accompanying notes and abbreviations. It has been prepared for hydrogeological purposes only, without attempt to assess geotechnical properties or possible contamination. Any reference to geotechnical properties or potential contamination are for information only and do not necessarily indicate the presence or absence of the properties stated.

GAP gINT FN. F17
RL1

GAP 10.0.6 LIB.GLB Log GAP WELL 3 PS137749 BLACKWATER SOUTH SITE INVESTIGATION-OCT2-WELL INSTALL.GPJ <<DrawingFile>> 04/10/2024 10:21 10.03.00.09 Datgel Tools

REPORT OF STANDPIPE INSTALLATION: BWM_MB132_02

SHEET: 1 OF 1

CLIENT:	WHC	COORDS: 684477.8 m 7351106.0 m	DRILL RIG: Comacchio GEO 900 sonic rig
PROJECT:	Blackwater South Site Investigation	SURFACE RL: 287.88 m DATUM: AHD	CONTRACTOR: Legion Drilling
LOCATION:	Blackwater Mine	INCLINATION: -90°	LOGGED: SK DATE: 6/3/24
JOB NO:	PS213941	HOLE DEPTH: 29.50 m	CHECKED: BD DATE: 2/10/24

Drilling				Field Material Description		Instrumentation Details
METHOD	WATER	DEPTH (metres)	DEPTH RL	GRAPHIC LOG	SOIL/ROCK MATERIAL DESCRIPTION	
SONIC		0	287.88		Topsoil / Fill - Sandy GRAVEL	0.00, RL287.88 — PVC stick up (0.90 m aGL) with well plug, encased in protective steel monument
			2.50 285.38		Tertiary Sediments - Sandy CLAY medium plasticity	
		5				
		10	10.00 277.88		CLAYSTONE	80/20 Cement/bentonite mix; 50 mm internal diameter class 12 uPVC solid casing
		15	15.00 272.88		SANDSTONE	
			19.00 268.88		Permian (Burngrove Formation) - SANDSTONE	
		20	21.00 266.88		SILTSTONE	21.00, RL266.88; 22.00, RL265.88 — Bentonite plug
		25				Filter Pack - 2-3 mm washed graded gravel; 0.8 mm aperture, 5 mm spacing, factory slotted class 12 uPVC
			29.50 258.38		END OF BOREHOLE @ 29.50 m	29.00, RL258.88; 29.50, RL258.38 — Sump - Class 12 uPVC solid casing, with endcap
		30				

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GAP gINT FN. F17
RL1

GAP 10.0.6 LIB.GLB Log GAP WELL 3 PS137749 BLACKWATER SOUTH SITE INVESTIGATION-OCT2-WELL INSTALL.GPJ <<DrawingFile>> 04/10/2024 10:29 10.03.00.09 Datgel Tools

REPORT OF STANDPIPE INSTALLATION: BWM_MB133_00

SHEET: 1 OF 1

CLIENT: WHC
PROJECT: Blackwater South Site Investigation
LOCATION: Blackwater Mine
JOB NO: PS213941

COORDS: 684541.9 m 7350868.4 m
SURFACE RL: 274.64 m DATUM: AHD
INCLINATION: -90°
HOLE DEPTH: 12.00 m

DRILL RIG: Geoprobe 8140LS sonic rig
CONTRACTOR: Legion Drilling
LOGGED: AL DATE: 8/5/24
CHECKED: BD DATE: 2/10/24

Drilling				Field Material Description		Instrumentation Details
METHOD	WATER	DEPTH (metres)	DEPTH RL	GRAPHIC LOG	SOIL/ROCK MATERIAL DESCRIPTION	
SONIC		0	274.64		Topsoil / Fill - Silty SAND	PVC stick up (0.86 m aGL) with well plug, encased in protective steel monument
			0.80 273.84		Mine Spoil - Coal TAILINGS	0.00, RL274.64
		2				80/20 Cement/bentonite mix
						50 mm internal diameter class 12 uPVC solid casing
		4				4.00, RL270.64
						Bentonite plug
		6				5.00, RL269.64
		8				Filter Pack - 2-3 mm washed graded gravel
		10				0.8 mm aperture, 5 mm spacing, factory slotted class 12 uPVC
						11.20, RL263.44
						Sump - Class 12 uPVC solid casing, with endcap
						11.70, RL262.94
		12	12.00 262.64		END OF BOREHOLE @ 12.00 m	12.00, RL262.64 Hole Collapse
		14				

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GAP gINT FN. F17
RL1

GAP 10.0.6 LIB.GLB Log GAP WELL 3 PS137749 BLACKWATER SOUTH SITE INVESTIGATION-OCT2-WELL INSTALL.GPJ <<DrawingFile>> 04/10/2024 10:17 10.03.00.09 Datgel Tools

REPORT OF STANDPIPE INSTALLATION: BWM_MB133_01

SHEET: 1 OF 1

CLIENT: WHC
PROJECT: Blackwater South Site Investigation
LOCATION: Blackwater Mine
JOB NO: PS213941

COORDS: 684538.1 m 7350867.8 m
SURFACE RL: 274.68 m DATUM: AHD
INCLINATION: -90°
HOLE DEPTH: 18.00 m

DRILL RIG: Geoprobe 8140LS sonic rig
CONTRACTOR: Legion Drilling
LOGGED: AL DATE: 8/5/24
CHECKED: BD DATE: 2/10/24

Drilling				Field Material Description		Instrumentation Details
METHOD	WATER	DEPTH (metres)	DEPTH RL	GRAPHIC LOG	SOIL/ROCK MATERIAL DESCRIPTION	
SONIC		0	274.68		Topsoil / Fill - Silty SAND	PVC stick up (0.90 m aGL) with well plug, encased in protective steel monument
			0.80			
			273.88		Mine Spoil - Coal TAILINGS	
		2				
		4				
		6				
		8				
		10				
		12				
			13.00			
			261.68		Mine Spoil - Rejects	
		14				
			15.00			
			259.68			
			16.00			
		16	258.68			
			18.00			
		18	256.68		END OF BOREHOLE @ 18.00 m	

0.00, RL274.68

80/20 Cement/bentonite mix

50 mm internal diameter class 12 uPVC solid casing

13.00, RL261.68

Bentonite plug

14.00, RL260.68

Filter Pack - 2-3 mm washed graded gravel

0.8 mm aperture, 5 mm spacing, factory slotted class 12 uPVC

17.50, RL257.18

Sump - Class 12 uPVC solid casing, with endcap

18.00, RL256.68

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GAP gINT FN. F17
RL1

GAP 10.0.6 LIB.GLB Log GAP WELL 3 PS137749 BLACKWATER SOUTH SITE INVESTIGATION-OCT2-WELL INSTALL.GPJ <<DrawingFile>> 04/10/2024 10:19 10.03.00.09 Datgel Tools

REPORT OF STANDPIPE INSTALLATION: BWM_MB133_02

SHEET: 1 OF 1

CLIENT:	WHC	COORDS: 684534.4 m 7350867.1 m	DRILL RIG: Geoprobe 8140LS sonic rig
PROJECT:	Blackwater South Site Investigation	SURFACE RL: 274.68 m DATUM: AHD	CONTRACTOR: Legion Drilling
LOCATION:	Blackwater Mine	INCLINATION: -90°	LOGGED: AL DATE: 7/5/24
JOB NO:	PS213941	HOLE DEPTH: 28.50 m	CHECKED: BD DATE: 2/10/24

Drilling				Field Material Description		Instrumentation Details
METHOD	WATER	DEPTH (metres)	DEPTH RL	GRAPHIC LOG	SOIL/ROCK MATERIAL DESCRIPTION	
SONIC		0	274.68		Topsoil / Fill - Silty SAND	0.00, RL274.68: PVC stick up (0.92 m aGL) with well plug, encased in protective steel monument
			0.80			
			273.88		Mine Spoil - Coal TAILINGS	
		5				
		10				80/20 Cement/bentonite mix; 50 mm internal diameter class 12 uPVC solid casing
			13.00			
			261.68		Mine Spoil - Rejects	
		15	15.00			
			259.68			
			16.00			
			258.68			
		20	20.00			
			254.68		Permian (Rangal Coal Measures) - Mudstone	20.50, RL254.18
			21.00			
			21.50		SILTSTONE	21.50, RL253.18: Bentonite plug
			253.18		SANDSTONE	
			22.50			
			252.18		Clayey SANDSTONE	
			24.00			
			250.68		Silty SANDSTONE	Filter Pack - 2-3 mm washed graded gravel
		25				0.8 mm aperture, 5 mm spacing, factory slotted class 12 uPVC
						28.00, RL246.68
			28.50			28.50, RL246.18: Sump - Class 12 uPVC solid casing, with endcap
			246.18		END OF BOREHOLE @ 28.50 m	

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GAP gINT FN. F17
RL1

GAP 10.0.6 LIB.GLB Log GAP WELL 3 PS137749 BLACKWATER SOUTH SITE INVESTIGATION-OCT2-WELL INSTALL.GPJ <<DrawingFile>> 04/10/2024 10:28 10.03.00.09 Datgel Tools

REPORT OF STANDPIPE INSTALLATION: BWM_MB135_01

SHEET: 1 OF 1

CLIENT:	WHC	COORDS: 684781.9 m 7350631.2 m	DRILL RIG: Comacchio GEO 900 sonic rig
PROJECT:	Blackwater South Site Investigation	SURFACE RL: 262.87 m DATUM: AHD	CONTRACTOR: Legion Drilling
LOCATION:	Blackwater Mine	INCLINATION: -90°	LOGGED: SK DATE: 15/12/23
JOB NO:	PS213941	HOLE DEPTH: 10.00 m	CHECKED: BD DATE: 2/10/24

Drilling				Field Material Description		Instrumentation Details
METHOD	WATER	DEPTH (metres)	DEPTH RL	GRAPHIC LOG	SOIL/ROCK MATERIAL DESCRIPTION	
SONIC		0	262.87		Mine Spoil (Rejects) - Clayey SAND	PVC stick up (0.78 m aGL) with well plug, encased in protective steel monument
						0.00, RL262.87
		2				80/20 Cement/bentonite mix
						50 mm internal diameter class 12 uPVC solid casing
		4	4.00 258.87		Tertiary Sediments - Sandy CLAY	Bentonite plug
						5.50, RL257.37
		6				Filter Pack - 2-3 mm washed graded gravel
		8				0.8 mm aperture, 5 mm spacing, factory slotted class 12 uPVC
						9.50, RL253.37
		10	10.00 252.87		END OF BOREHOLE @ 10.00 m	Sump - Class 12 uPVC solid casing, with endcap
						10.00, RL252.87

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GAP gINT FN. F17 RL1

GAP 10.0.6 LIB.GLB Log GAP WELL 3 PS137749 BLACKWATER SOUTH SITE INVESTIGATION-OCT2-WELL INSTALL.GPJ <<DrawingFile>> 04/10/2024 10:14 10.03.00.09 Datgel Tools

REPORT OF STANDPIPE INSTALLATION: BWM_MB136_01

SHEET: 1 OF 1

CLIENT:	WHC	COORDS: 684490.1 m 7350133.8 m	DRILL RIG: Geoprobe 8140LS sonic rig
PROJECT:	Blackwater South Site Investigation	SURFACE RL: 255.41 m DATUM: AHD	CONTRACTOR: Legion Drilling
LOCATION:	Blackwater Mine	INCLINATION: -90°	LOGGED: BD DATE: 21/7/24
JOB NO:	PS213941	HOLE DEPTH: 8.30 m	CHECKED: BD DATE: 2/10/24

Drilling				Field Material Description		Instrumentation Details
METHOD	WATER	DEPTH (metres)	DEPTH RL	GRAPHIC LOG	SOIL/ROCK MATERIAL DESCRIPTION	
SONIC		0	255.41		Alluvium - Silty SAND	0.00, RL255.41
			0.20 255.21		Clayey SAND	PVC stick up (0.85 m aGL) with well plug, encased in protective steel monument 80/20 Cement/bentonite mix
		1	1.30 254.11		Sandy CLAY	1.00, RL254.41 Bentonite plug
		2	2.00 253.41		Clayey SAND	2.00, RL253.41 50 mm internal diameter class 12 uPVC solid casing
		3				
		4				Filter Pack - 2-3 mm washed graded gravel
		5	4.80 250.61		SAND	
		6	6.00 249.41		Permian (Burngrove Formation) - SANDSTONE	0.8 mm aperture, 5 mm spacing, factory slotted class 12 uPVC
		7	7.00 248.41		Clayey SANDSTONE	7.00, RL248.41
		8				Sump - Class 12 uPVC solid casing, with endcap
			8.30 247.11		END OF BOREHOLE @ 8.30 m	8.00, RL247.41 Backfill - 2-3 mm washed graded gravel 8.30, RL247.11
		9				

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GAP gINT FN. F17
RL1

GAP 10.0.6 LIB.GLB Log GAP WELL 3 PS137749 BLACKWATER SOUTH SITE INVESTIGATION-OCT2-WELL INSTALL.GPJ <<DrawingFile>> 04/10/2024 10:12 10.03.00.09 Datgel Tools

REPORT OF STANDPIPE INSTALLATION: BWM_MB136_02

SHEET: 1 OF 1

CLIENT:	WHC	COORDS:	684490.1 m 7350133.8 m	DRILL RIG:	Geoprobe 8140LS sonic rig
PROJECT:	Blackwater South Site Investigation	SURFACE RL:	254.65 m DATUM: AHD	CONTRACTOR:	Legion Drilling
LOCATION:	Blackwater Mine	INCLINATION:	-90°	LOGGED: BD	DATE: 27/4/24
JOB NO:	PS213941	HOLE DEPTH:	21.50 m	CHECKED: BD	DATE: 2/10/24

Drilling				Field Material Description		Instrumentation Details
METHOD	WATER	DEPTH (metres)	DEPTH RL	GRAPHIC LOG	SOIL/ROCK MATERIAL DESCRIPTION	
SONIC		0	254.65		Topsoil - Silty SAND	PVC stick up (0.66 m aGL) with well plug, encased in protective steel monument
			0.50			
			254.15		Tertiary - Sandy CLAY	
			1.60			
			253.05			
			3.00			
			251.65		Clayey SAND	
			4.90			
		5	249.75		Sandy CLAY	
			5.40			
			249.25		Clayey SAND	
			6.60			
			248.05		SAND	
			7.40			
			247.25		CLAY	
			8.00			
			246.65		Permian (Burngrove Formation) - Clayey SANDSTONE	
			8.50			
			246.15			
		10				
			12.60			
			242.05		SANDSTONE	
		15				
			17.50			
			237.15		SILTSTONE	
			18.60			
			236.05			
		20	20.00			
			234.65			
			21.50			
			233.15		END OF BOREHOLE @ 21.50 m	

0.00, RL254.65

80/20 Cement/bentonite mix

50 mm internal diameter class 12 uPVC solid casing

12.00, RL242.65

Bentonite plug

14.00, RL240.65

Filter Pack - 2-3 mm washed graded gravel

0.8 mm aperture, 5 mm spacing, factory slotted class 12 uPVC

21.00, RL233.65

21.50, RL233.15

Sump - Class 12 uPVC solid casing, with endcap

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GAP gINT FN. F17
RL1

GAP 10.0.6 LIB.GLB Log GAP WELL 3 PS137749 BLACKWATER SOUTH SITE INVESTIGATION-OCT2-WELL INSTALL.GPJ <<DrawingFile>> 04/10/2024 10:23 10.03.00.09 Datgel Tools

REPORT OF STANDPIPE INSTALLATION: BWM_MB138_01

SHEET: 1 OF 1

CLIENT: WHC
PROJECT: Blackwater South Site Investigation
LOCATION: Blackwater Mine
JOB NO: PS213941

COORDS: 684625.2 m 7350799.7 m
SURFACE RL: 275.23 m DATUM: AHD
INCLINATION: -90°
HOLE DEPTH: 14.00 m

DRILL RIG: Geoprobe 8140LS sonic rig
CONTRACTOR: Legion Drilling
LOGGED: CS DATE: 9/5/24
CHECKED: BD DATE: 2/10/24

Drilling				Field Material Description		Instrumentation Details
METHOD	WATER	DEPTH (metres)	DEPTH RL	GRAPHIC LOG	SOIL/ROCK MATERIAL DESCRIPTION	
SONIC		0	275.23		FILL - Sandy CLAY	PVC stick up (0.93 m aGL) with well plug, encased in protective steel monument
			1.00			
			274.23		Mine Spoil - Coal tailings	
		2				
		4				80/20 Cement/bentonite mix
			5.50			50 mm internal diameter class 12 uPVC solid casing
			269.73			
		6				
			7.00			
			268.23			
		8				Bentonite plug
			8.30			
			266.93		Mine spoil (rejects) - Gravelly CLAY	
		10				
			10.40			
			264.83			
			11.50			Filter Pack - 2-3 mm washed graded gravel
			263.73			
		12				0.8 mm aperture, 5 mm spacing, factory slotted class 12 uPVC
			12.50			
			262.73			
						13.50, RL261.73
		14	14.00			Sump - Class 12 uPVC solid casing, with endcap
			261.23		END OF BOREHOLE @ 14.00 m	14.00, RL261.23

0.00, RL275.23
7.50, RL267.73
8.50, RL266.73

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GAP gINT FN. F17
RL1

GAP 10.0.6 LIB.GLB Log GAP WELL 3 PS137749 BLACKWATER SOUTH SITE INVESTIGATION-OCT2-WELL INSTALL.GPJ <<DrawingFile>> 04/10/2024 10:18 10.03.00.09 Datgel Tools

REPORT OF STANDPIPE INSTALLATION: BWM_MB135_02

SHEET: 1 OF 1

CLIENT:	WHC	COORDS: 684785.6 m 7350627.7 m	DRILL RIG: Comacchio GEO 900 sonic rig
PROJECT:	Blackwater South Site Investigation	SURFACE RL: 262.88 m DATUM: AHD	CONTRACTOR: Legion Drilling
LOCATION:	Blackwater Mine	INCLINATION: -90°	LOGGED: SK DATE: 15/12/23
JOB NO:	PS213941	HOLE DEPTH: 24.00 m	CHECKED: BD DATE: 2/10/24

Drilling				Field Material Description		Instrumentation Details
METHOD	WATER	DEPTH (metres)	DEPTH RL	GRAPHIC LOG	SOIL/ROCK MATERIAL DESCRIPTION	
SONIC		0	262.88		Mine Spoil (Rejects) - Clayey SAND	0.00, RL262.88 PVC stick up (0.93 m aGL) with well plug, encased in protective steel monument
		5	5.50 257.38		Tertiary Sediments - Sandy CLAY	80/20 Cement/bentonite mix; 50 mm internal diameter class 12 uPVC solid casing
		10	10.00 252.88		Permian (Rangal Coal Measures) - Carbonaceous MUDSTONE	
		15	17.00			15.00, RL247.88 Bentonite plug; 16.00, RL246.88
			17.50 245.38		COAL SILTSTONE	Filter Pack - 2-3 mm washed graded gravel
		20	20.50 242.38		Carbonaceous SILTSTONE increased organic content, trace clay, moderaetly weathered	0.8 mm aperture, 5 mm spacing, factory slotted class 12 uPVC
			24.00 238.88		END OF BOREHOLE @ 24.00 m	23.00, RL239.88; 23.50, RL239.38 Sump - Class 12 uPVC solid casing, with endcap; 24.00, RL238.88 Backfill - 2-3 mm washed graded gravel
		25				

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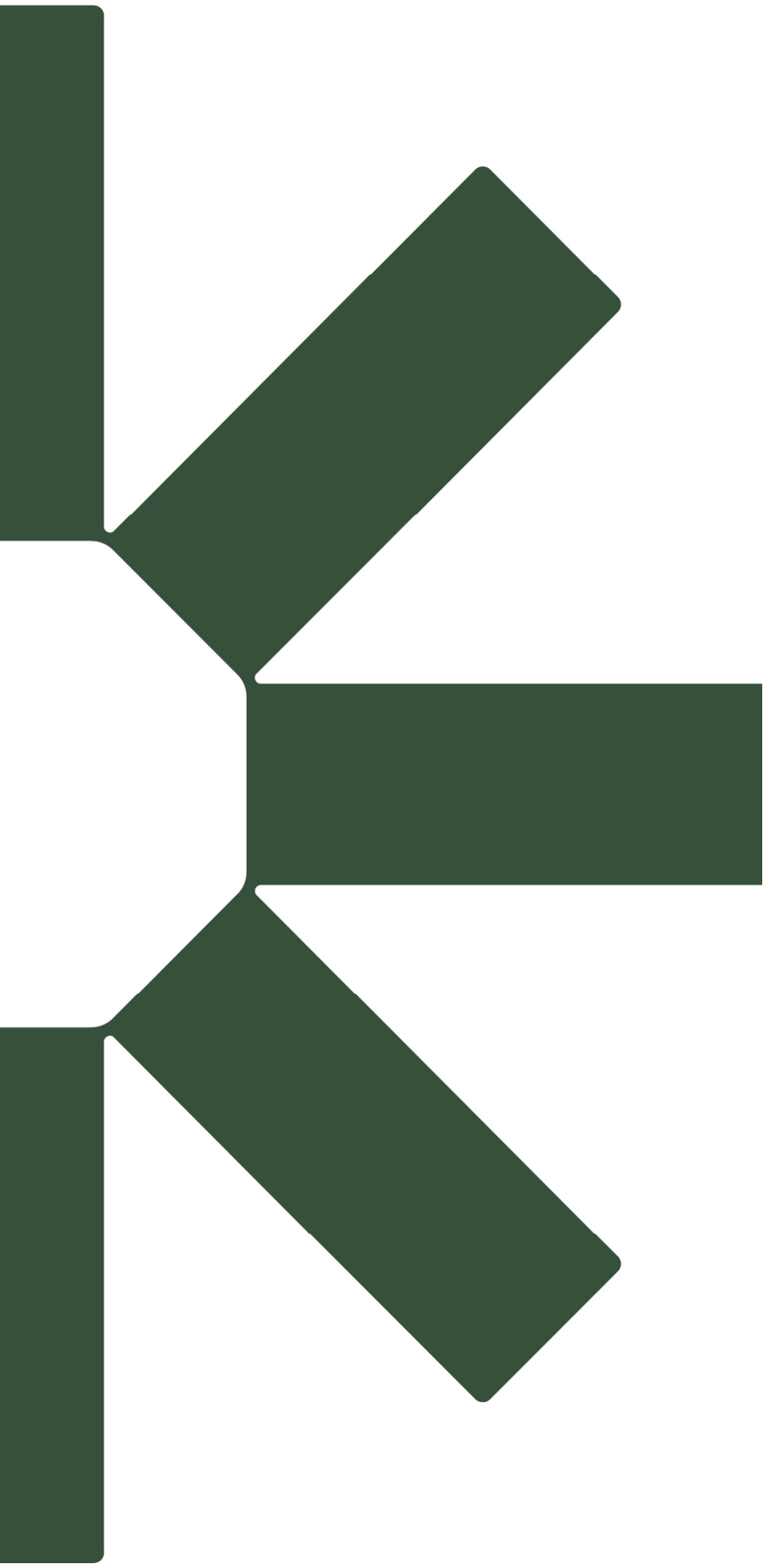
GAP 10.0.6 LIB.GLB Log GAP WELL 3 PS137749 BLACKWATER SOUTH SITE INVESTIGATION-OCT2-WELL INSTALL.GPJ <<DrawingFile>> 04/10/2024 10:25 10.03.00.09 Datgel Tools



Making Sustainability Happen

Technical Memorandum

To:	Sahar Donner	**From:**	Sharon Hulbert
Company:	Whitehaven Coal		**SLR Consulting Australia**
cc:		**Date:**	15 May 2025
		Project No.	620.040199.00014

RE: Bottom Dam TSF Study
Further Response to DETSI Observations - DRAFT

Confidentiality
This document is confidential and may contain legally privileged information. If you are not a named or authorised recipient, you must not read, copy, distribute or act in reliance on it. If you have received this document in error, please notify us immediately and return the document by mail.

1.0 Introduction

Please see responses to request for additional information required to address NPM Notice matter #2 in line with the observations (a) to (g) outlined in the emailed dated 28 March 2025.

Three observations have been provided for response.

2.0 Response to Comments

Each DETSI observation comment has been reproduced here for completeness, with the response provided directly following.

2.1 Observation (a)

There is still concern about the wording of a paragraph in Attachment 1 and similar wording in the updated Attachment 2. Attachment 1 states '*Where the aquifer is saturated, groundwater levels remain well below the creek's elevation; the water table below bottom dam is approximately 270 m AHD, which is significantly below the creek's elevation of 255 m AHD'.* 270 m AHD is not significantly below 255 m AHD. Please review the attachments and reword as required.

Response:

The word significant has been removed from the reporting – noting it does not change the outcome that there is no hydraulic connection between the Sirius Creek and the water table. The water table is expected to be 15 metres below the base of the creek and situated in the Permian sediments, with the minor alluvial sediments and Tertiary deposits dry between.

2.2 Observation (b)

i. The considerations made by SLR and the reasons for excluding the water quality analysis have been noted.

ii. The Technical Memorandum includes the statement '*There are no distinguishable trends or indications of specific relationships between different hydrostratigraphic unit chemistry*'. Further information is required to be provided to support this statement.

iii. It is also acknowledged there may be limited data. However any available water quality data is required to be provided along with an analysis of water level for those bores utilised in the 'TSF/Creek assessment', where water samples can be obtained

.

Response:

i. Noted.

ii. Statement should be amended to state that '*there is insufficient data to define distinguishable trends or indicate specific relationships between different hydrostratigraphic unit chemistry*'. No required changes to the Bottom Dam TSF Study report.

iii. The available water quality data at site is provided routinely *the administering authority via WaTERs*, in the *annual compliance database as required per condition I11 of the EA*.

2.3 Observation (c) – (g)

In consideration of the additional information provided, these matters are considered resolved for the purpose of the NPM response. Further information may be sought during the information stage if deemed necessary

Response:

Noted.

LEGEND

...Blackwater Mine EA boundary
.....Lessee or Agistee boundary
.....WHC leasehold land
.....WHC freehold land
.....Property boundary

Third-party Infrastructure

.....Homestead
.....Powerline
.....Rail line
.....Pipeline
.....Road

Location Map

Blackwater
Bluff
Comet

675000 680000 685000 690000 695000

7395000 7390000 7385000 7380000 7375000 7370000 7365000 7360000

The Curragh
Cardona
Columba
Tannyfoil
Maryvale
Bestgrove
Tantallon
Taurus
Tolmie Creek
Mountain View & Stewarton
Yarrawonga
Ardurad
Terang
Monash

Ergon Overhead Power 22kV
Powerlink Overhead Power 132kV
Ergon Overhead Power 132kV
Ergon Overhead Power 66kV
Ergon Overhead Power 22kV
Bauhinia Railway
South Blackwater Rail
Mountain View Homestead
Yarrawonga Road
Ergon Overhead Power Thermal Coal Plant 22kV Feeder
Taurus Road
Sunwater Blackwater Pump Station to Cook
Cook Colliery Rail Loop
Blackwater Mine Railway
Taurus Homestead
Ergon Overhead Power 22kV
Cook CHPP Access Rd
Ardurad Road
Cook CHPP Access Rd
Blackwater Rolleston Road
Blackwater Rolleston Road

Whitehaven

GIS Team - Brisbane

0 1 2 3 4 5 km

Transverse Mercator Projection

N

BLACKWATER PRCP
LAND OWNERSHIP

Date: 13/03/2025

Filename: Figure20_A3_20240703-1_LandOwner.aprx

670000 675000 680000 685000 690000 695000

7365000 7360000 7355000 7350000 7345000 7340000 7335000 7330000 7325000

Monash
Tannyfoil
Ardurad
Terang
Cluthua
Togara
Penrose
Kulla
Kullanda
Struan
Memooloo
Red Rock
Coorumbene
Bottle Tree Camp

CAPRICORN HIGHWAY
Blackwater Rolleston Road
Comet River Road
Humboldt Comet Road

Ergon Overhead Power 66kV
Ergon Overhead Power 22kV
Ergon Overhead Power 22kV
Ergon Overhead Power 22kV

LEGEND

...Blackwater Mine EA boundary
.....Lessee or Agistee boundary
.....WHC leasehold land
.....WHC freehold land
.....Property boundary

Third-party Infrastructure

.....Homestead
.....Powerline
.....Rail line
.....Pipeline
.....Road

Location Map
Blackwater
Comet
Bluff

Whitehaven

GIS Team - Brisbane

0 1 2 3 4 5 km

Transverse Mercator Projection

GDA 1994, MGA Zone 55

N

BLACKWATER PRCP
LAND OWNERSHIP

Date: 13/03/2025

Filename: Figure20_A3_20240703-1_LandOwner.aprx

Blackwater Coal Mine Rehabilitation Monitoring RFI Response

To: Sahar Donner (Superintendent – Group Approvals)

From: Steve Lyngcoln (Principal Ecologist)

cc: Mark Gastaldon (Superintendent Environment), Brendon Dillon (Group Manager Approvals – Queensland)

Date: 2/03/2025

Re: Blackwater Coal Mine Rehabilitation Monitoring RFI Response

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Dear Sahar

This Blackwater Mine (BWM) rehabilitation monitoring request for information (RFI) memorandum has been prepared in response to the following RFI's on the BWM Progressive Rehabilitation and Closure Plan (PRCP) from the Department of the Environment, Tourism, Science and Innovation (DETSI):

- *"Details of previous monitoring or maintenance of areas already rehabilitated has not been provided to satisfy the requirements of s126C(1)(j) of the EP Act and Section 3.8 of the PRCP Guideline.*
- *No supporting reports or data for previous monitoring or maintenance of areas already rehabilitated has been presented with the PRC Plan for an area of 1,929ha which the PRC Plan cites as 'existing rehabilitation'. The Rehabilitation Planning Part (Whitehaven 2024, p. 73) states:*
    - *Over time, BWM has progressively advanced 1,929ha of existing rehabilitation towards the achievement of the nominated PMLUs and rehabilitation milestones outlined in the PRCP Schedule (see Appendix 4.1). The existing rehabilitation areas completed for the cattle grazing and woodland habitat PMLUs are summarised as follows*
        - *1,200 ha of cattle grazing*
        - *729 ha of woodland habitat*
    - *As part of FY24 rehabilitation monitoring, some of these areas have been identified as being suitable for progressive rehabilitation certification under the EP Act. However, at the time of submission of this transitional PRCP, no applications have been submitted to the administrating authority. The existing rehabilitation progressing towards the achievement of the PMLU is outlined in the PRCP Schedule provided in Appendix 4.1 (see RA6 and RA7). Routine rehabilitation monitoring will continue to be implemented to identify any maintenance/corrective actions required to enable the rehabilitated areas to achieve the milestone criteria.*
    - *Upon review of the submitted materials, details of the rehabilitation monitoring and maintenance described above do not appear to have been provided in the Rehabilitation Planning Part or appendices.*
- *(Action 4):*
    - *The Rehabilitation Planning Part indicates that rehabilitation monitoring has been completed and is ongoing for the 1,929ha of existing rehabilitation. As detailed in Section 3.8 of the PRCP Guideline, if there are any monitoring or maintenance of areas already rehabilitated, details must be included in the PRC plan. Accordingly, as per the*

requirements of s126C(1)(j) of the EP Act and Section 3.8 of the PRCP Guideline, provide a PRC Plan that includes details of previous monitoring or maintenance of areas already rehabilitated.

- *In responding to this item, please also ensure that all areas of existing rehabilitation are presented it the spatial data submission with the correct 'Feature' description of 'EX_REH' as required by Attachment 1 of the approved form 'Submission of a progressive rehabilitation and closure plan' (ESR/2019/4957).*

Previous monitoring or maintenance and supporting reports or data for previous monitoring or maintenance

On April 2nd 2024, BWM was transferred to Whitehaven Coal (WHC). In 2018 the previous owner, BHP Mitsubishi Alliance (BMA) negotiated revised final post mining land uses (PMLU) completion criteria for cattle grazing and woodland habitat land uses under Table E1 of the BWM Environmental Authority (EA) Permit EPML00717813 (refer Attachment One).

Rehabilitation monitoring on BWM has been undertaken since 2018 in accordance with the *BWM Rehabilitation Monitoring Methodology (RMM)* and associated subsequent versions to determine the performance of rehabilitation against the updated EA completion criteria for a cattle grazing and woodland habitat PMLU. Prior to 2018, monitoring was undertaken under a different methodology and compared to different completion criteria and has therefore not been summarised in this response.

Since 2018 the following rehabilitation monitoring programs have been completed in accordance with the RMM:

- Initial Rehabilitation Monitoring Report Blackwater Mine 2018 (ELA, 2018)
- Initial Rehabilitation Monitoring Report Blackwater Mine 2019 (ELA, 2020)
- Blackwater Mine Major Rehabilitation Monitoring Report 2022 (ELA, 2023)
- BMA Blackwater Coal Mine Rehabilitation Monitoring Report FY24 (BMA, 2024a).
- Blackwater Coal Mine Woodland Habitat Rehabilitation Monitoring Report 2024 (BMA, 2024b).
- Blackwater Coal Mine Rehabilitation Monitoring Report 2024 (LEC, 2024a).
- Blackwater Coal Mine Woodland Habitat Rehabilitation Technical Report BWM25, BWM33 and BWM180 (LEC, 2024b)

The following summarises the results rehabilitation monitoring undertaken on BWM between 2022 – 2024 which includes all sites ever monitored at Blackwater. Sites monitored prior to 2022 have since been reassessed and therefore the later results have been summarised in this response.

The existing rehabilitation areas on BWM and associated monitoring sites are illustrated in Figure 1. Table 1 lists the rehabilitation monitoring sites that have been monitored during each monitoring program between 2018-2024. A total of 1497 ha of the existing 1929 ha listed as existing rehabilitation in the BWM PRCP has been monitored between 2022-2024.

The remaining area of rehabilitation on BWM that has not yet been monitored includes:

- Approximately 30 ha of small areas <5 ha adjacent to existing rehabilitation required to be merged into surrounding areas.

- Approximately 43 ha of cattle grazing PMLU under dense *Leucaena leucocephala* (Leucaena) >50% canopy cover under planned maintenance requiring ‘surface preparation (cattle grazing) (PRCP RM4).’
- Approximately 195 ha of existing rehabilitation requiring ‘landform development and reshaping (PRCP Rehabilitation Milestone (RM) 3).’
- Approximately 81 ha of existing rehabilitation requiring surface treatment (PRCP RM4).’
- Approximately 30 ha of cattle grazing rehabilitation requiring reseeding (PRCP RM5).
- Approximately 48 ha of existing cattle grazing and 5 ha of woodland habitat to be monitored in 2025.

It is understood that the 2025 rehabilitation monitoring program will focus on assessing areas not yet monitored and developing and associated maintenance program.

Table 1 BWM Rehabilitation Monitoring Summary 2022-2024

Rehabilitation Area/ Site ID	Area (ha)	Post Mining Land Use (PMLU)	Blackwater Coal Mine Rehabilitation Monitoring Report (LEC, 2024a).	Blackwater Coal Mine Woodland Habitat Rehabilitation Monitoring Report 2024 (BMA 2024a)	BMA Blackwater Coal Mine Rehabilitation Monitoring Report FY24 (BMA 2024b)	BWM Major Rehabilitation Monitoring 2022 (ELA, 2023)	Initial Rehabilitation Monitoring Report Blackwater Mine 2019 (ELA, 2020)	Initial Rehabilitation Monitoring Report Blackwater Mine 2018 (ELA, 2018)
			Rehabilitation Area (ha) monitored per year.					
	Area (ha)	**PMLU**	**2024**	**2024**	**2023**	**2022**	**2019**	**2018**
BWM_R28_01	18.1	Cattle Grazing			18.1			
BWM_R44_01	2.8	Cattle Grazing	2.8			2.8		
BWM_R50_01	6.5	Cattle Grazing	6.5			6.5	6.5	
BWM_R54_01	33.4	Cattle Grazing			33.4	33.4	33.4	
BWM_R54_02	17.8					17.8	17.8	
BWM_R54N	55.6	Cattle Grazing	55.6					55.6
BWM_R56S	16.5	Woodland Habitat	16.5					16.5
BWM_REF01	NA	Cattle Grazing			Yes			
BWM_REF02	NA	Woodland Habitat			Yes			
BWM_REF03	NA	Cattle Grazing			Yes			

Rehabilitation Area/ Site ID	Area (ha)	Post Mining Land Use (PMLU)	Blackwater Coal Mine Rehabilitation Monitoring Report (LEC, 2024a).	Blackwater Coal Mine Woodland Habitat Rehabilitation Monitoring Report 2024 (BMA 2024a)	BMA Blackwater Coal Mine Rehabilitation Monitoring Report FY24 (BMA 2024b)	BWM Major Rehabilitation Monitoring 2022 (ELA, 2023)	Initial Rehabilitation Monitoring Report Blackwater Mine 2019 (ELA, 2020)	Initial Rehabilitation Monitoring Report Blackwater Mine 2018 (ELA, 2018)
			Rehabilitation Area (ha) monitored per year.					
BWM_REF04	NA	Woodland Habitat			Yes			
BWM_REF05	NA	Woodland Habitat		Yes				
BWM_REF06	NA	Woodland Habitat		Yes				
BWM000	26.9	Cattle Grazing	26.9					
BWM01	3.8	Cattle Grazing	3.8			3.8		
BWM02	6.4	Cattle Grazing				6.4		
BWM03	33.1	Cattle Grazing			33.1	33.1		
BWM05_A	53.3	Cattle Grazing	53.3			53.3		
BWM102	1.7	Woodland Habitat	1.7					
BWM103, BWM103A	35.0	Cattle Grazing	35.0					
BWM104	2.1	Cattle Grazing	2.1					
BWM105A	6.2	Cattle Grazing	6.2					

Rehabilitation Area/ Site ID	Area (ha)	Post Mining Land Use (PMLU)	Blackwater Coal Mine Rehabilitation Monitoring Report (LEC, 2024a).	Blackwater Coal Mine Woodland Habitat Rehabilitation Monitoring Report 2024 (BMA 2024a)	BMA Blackwater Coal Mine Rehabilitation Monitoring Report FY24 (BMA 2024b)	BWM Major Rehabilitation Monitoring 2022 (ELA, 2023)	Initial Rehabilitation Monitoring Report Blackwater Mine 2019 (ELA, 2020)	Initial Rehabilitation Monitoring Report Blackwater Mine 2018 (ELA, 2018)
			Rehabilitation Area (ha) monitored per year.					
BWM105B	15.3	Cattle Grazing	15.3					
BWM106	3.3	Cattle Grazing	3.3					
BWM107	40.8	Cattle Grazing	40.8					
BWM108	24.8	Cattle Grazing	24.8					
BWM11	14.2	Cattle Grazing				14.2		
BWM116A	3.5	Woodland Habitat	3.5					
BWM116B	2.0	Cattle Grazing			2.0			
BWM118	1.5	Cattle Grazing	1.5					
BWM119	11.3	Woodland Habitat			11.3			
BWM12	13.0	Cattle Grazing				13.0		
BWM120	14.9	Cattle Grazing	14.9					
BWM124	5.9	Cattle Grazing	5.9					
BWM128	59.9	Cattle Grazing	59.9					

Rehabilitation Area/ Site ID	Area (ha)	Post Mining Land Use (PMLU)	Blackwater Coal Mine Rehabilitation Monitoring Report (LEC, 2024a).	Blackwater Coal Mine Woodland Habitat Rehabilitation Monitoring Report 2024 (BMA 2024a)	BMA Blackwater Coal Mine Rehabilitation Monitoring Report FY24 (BMA 2024b)	BWM Major Rehabilitation Monitoring 2022 (ELA, 2023)	Initial Rehabilitation Monitoring Report Blackwater Mine 2019 (ELA, 2020)	Initial Rehabilitation Monitoring Report Blackwater Mine 2018 (ELA, 2018)
			Rehabilitation Area (ha) monitored per year.					
BWM130A	46.7	Cattle Grazing	46.7					
BWM130B	35.1	Cattle Grazing			35.1			
BWM147A	19.1	Cattle Grazing	19.1					
BWM148	7.3	Cattle Grazing	7.3					
BWM149B	9.8	Cattle Grazing	9.8					
BWM152	35.2	Woodland Habitat	35.2					
BWM153	25.4	Woodland Habitat	25.4					
BWM155	1.5	Woodland Habitat	1.5					
BWM156	7.4	Cattle Grazing	7.4					
BWM157	10.5	Cattle Grazing	10.5					
BWM157A	12.1	Cattle Grazing	12.1					
BWM161	57.3	Cattle Grazing	57.3					
BWM162A	67.1	Cattle Grazing	67.1					

Rehabilitation Area/ Site ID	Area (ha)	Post Mining Land Use (PMLU)	Blackwater Coal Mine Rehabilitation Monitoring Report (LEC, 2024a).	Blackwater Coal Mine Woodland Habitat Rehabilitation Monitoring Report 2024 (BMA 2024a)	BMA Blackwater Coal Mine Rehabilitation Monitoring Report FY24 (BMA 2024b)	BWM Major Rehabilitation Monitoring 2022 (ELA, 2023)	Initial Rehabilitation Monitoring Report Blackwater Mine 2019 (ELA, 2020)	Initial Rehabilitation Monitoring Report Blackwater Mine 2018 (ELA, 2018)
			Rehabilitation Area (ha) monitored per year.					
BWM164A	21.7	Cattle Grazing	21.7					
BWM166	8.4	Cattle Grazing	8.4					
BWM167B	3.9	Cattle Grazing	3.9					
BWM168, BWM168A	16.0	Woodland Habitat		16.0	16.0			
BWM169	7.6	Cattle Grazing	7.6					
BWM170, BWM170A	20.9	Woodland Habitat		20.9	20.9			
BWM173	8.4	Cattle Grazing	8.4					
BWM18	26.9	Woodland Habitat	26.9			26.9		
BWM180, BWM180A	12.8	Woodland Habitat		12.8	12.8			
BWM185	47.5	Woodland Habitat	47.5					
BWM185A	3.1	Woodland Habitat	3.1					

Rehabilitation Area/ Site ID	Area (ha)	Post Mining Land Use (PMLU)	Blackwater Coal Mine Rehabilitation Monitoring Report (LEC, 2024a).	Blackwater Coal Mine Woodland Habitat Rehabilitation Monitoring Report 2024 (BMA 2024a)	BMA Blackwater Coal Mine Rehabilitation Monitoring Report FY24 (BMA 2024b)	BWM Major Rehabilitation Monitoring 2022 (ELA, 2023)	Initial Rehabilitation Monitoring Report Blackwater Mine 2019 (ELA, 2020)	Initial Rehabilitation Monitoring Report Blackwater Mine 2018 (ELA, 2018)
			Rehabilitation Area (ha) monitored per year.					
BWM188A	15.8	Woodland Habitat	15.8					
BWM189, BWM189A	50.8	Woodland Habitat		50.8	50.8			
BWM193	7.6	Woodland Habitat	7.6					
BWM199	2.1	Woodland Habitat		2.1	2.1			
BWM200	5.9	Woodland Habitat	5.9					
BWM202	8.6	Woodland Habitat	8.6					
BWM203A	23.9	Woodland Habitat	23.9					
BWM204A	8.9	Woodland Habitat	8.9					
BWM205	16.4	Woodland Habitat			16.4			
BWM208A	4.9	Woodland Habitat	4.9					

Rehabilitation Area/ Site ID	Area (ha)	Post Mining Land Use (PMLU)	Blackwater Coal Mine Rehabilitation Monitoring Report (LEC, 2024a).	Blackwater Coal Mine Woodland Habitat Rehabilitation Monitoring Report 2024 (BMA 2024a)	BMA Blackwater Coal Mine Rehabilitation Monitoring Report FY24 (BMA 2024b)	BWM Major Rehabilitation Monitoring 2022 (ELA, 2023)	Initial Rehabilitation Monitoring Report Blackwater Mine 2019 (ELA, 2020)	Initial Rehabilitation Monitoring Report Blackwater Mine 2018 (ELA, 2018)
			Rehabilitation Area (ha) monitored per year.					
BWM208B	6.1	Cattle Grazing	6.1					
BWM22	10.3	Woodland Habitat	10.3			10.3		
BWM23	18.8	Woodland Habitat	18.8			18.8		
BWM25, BWM25A	24.2	Woodland Habitat		24.2		24.2		
BWM26	4.1	Woodland Habitat	4.1					
BWM28	16.1	Woodland Habitat	16.1			16.1		
BWM29	19.1	Woodland Habitat	19.1			19.1		
BWM32	40.4	Woodland Habitat	40.4					
BWM33, BWM33A, BWM33B	35.6	Woodland Habitat		35.6	35.6	16.4		
BWM35A, BWM35B	48.3	Cattle Grazing	48.3			48.3		

Rehabilitation Area/ Site ID	Area (ha)	Post Mining Land Use (PMLU)	Blackwater Coal Mine Rehabilitation Monitoring Report (LEC, 2024a).	Blackwater Coal Mine Woodland Habitat Rehabilitation Monitoring Report 2024 (BMA 2024a)	BMA Blackwater Coal Mine Rehabilitation Monitoring Report FY24 (BMA 2024b)	BWM Major Rehabilitation Monitoring 2022 (ELA, 2023)	Initial Rehabilitation Monitoring Report Blackwater Mine 2019 (ELA, 2020)	Initial Rehabilitation Monitoring Report Blackwater Mine 2018 (ELA, 2018)
			Rehabilitation Area (ha) monitored per year.					
BWM37A	3.9	Cattle Grazing				3.9		
BWM38A	7.3	Cattle Grazing				7.3		
BWM38B	18.2	Cattle Grazing				18.2		
BWM40	16.4	Cattle Grazing			16.4	16.4		
BWM42	27.5	Cattle Grazing			27.5			
BWM43	9.6	Cattle Grazing			9.6			
BWM44	1.3	Cattle Grazing			1.3			
BWM58	3.5	Cattle Grazing			3.5			
Total	**1497**		**1046.4**	**162.3**	**346**	**410.4**	**57.7**	**72.1**

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685000
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7387500
7385000
7382500
7380000
7377500
7375000

BWM102
BWM104
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BWM105B
BWM209
BWM108
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BWM210
BWM35A
BWM01
BWM112
BWM40
BWM37A
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BWM116B
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BWM208C
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BWM129
BWM130A
BWM130B
BWM_R28_01
BWM212
BWM05
BWM132
BWM213

ML 1759
ML 1762

GDA2020, MGA Zone 55

BLACKWATER MINE REHABILITATION
FY2024 Rehabilitation Monitoring

0 0.25 0.5 0.75 1 1.25
km

BWM Mining Lease
Existing Rehab Area (PRCP 2024)
Existing Rehabilitation Monitoring Site
RehabilitationMonitoring Site Completed 2024

Image: Blackwater Mine 2024-02-07

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Requested by: S Lyngcoln
Date: 30/01/2025

BWM PRCP Rehab Areas and FY25 Rehabilitation Monitoring Sites Page 1 of 3

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ML 759

ML 1762

ML 1800

ML 1862

ML 70091

ML 1792

ML 1771

BWM147B
BWM147A
BWM148
BWM149A
BWM149B
BWM214
BWM_R44_01
BWM152
BWM153
BWM157B
BWM157A
BWM158
BWM155
BWM156
BWM_R50_01
BWM159
BWM157A
BWM161
BWM215
BWM162B
BWM162A
BWM216
BWM_R54_N
BWM217
BWM_R54_01
BWM218
BWM_R54_02
BWM164A
BWM219
BWM166
BWM167B
BWM168
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BWM170
BWM_R56_S
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BWM222
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BWM58
BWM223
BWM28
BWM180
BWM29
BWM26

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7357500

GDA2020, MGA Zone 55

BLACKWATER MINE REHABILITATION

FY2024 Rehabilitation Monitoring

0 0.25 0.5 0.75 1 1.25
km

BWM Mining Lease
Existing Rehab Area (PRCP 2024)
Existing Rehabilitation Monitoring Site
Rehabilitation Monitoring Site Completed 2024

Image: Blackwater Mine 2024-02-07

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Requested by: S Lyngcoln
Date: 30/01/2025

BWM PRCP Rehab Areas and FY25 Rehabilitation Monitoring Sites
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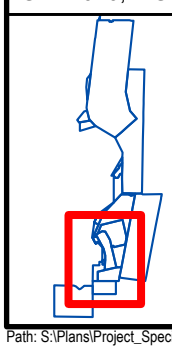
ML 1792
ML 1773
ML 1772
ML 1771
ML 1860
ML 1767
ML 1907
ML 70091
ML 70139
ML 70167

BWM25
BWM23
BWM224
BWM22
BWM225
BWM32
BWM185
BWM185
BWM18
BWM33
BWM188B
BWM187
BWM188A
BWM226
BWM189
BWM227
BWM193
BWM228
BWM199
BWM200
BWM201
BWM202
BWM204A
BWM203B
BWM204A
BWM204B
BWM203A
BWM205

GDA2020, MGA Zone 55

BLACKWATER MINE REHABILITATION
FY2024 Rehabilitation Monitoring

0 0.25 0.5 0.75 1 1.25
km



- BWM Mining Lease
- Existing Rehab Area (PRCP 2024)
- Existing Rehabilitation Monitoring Site
- Rehabilitation Monitoring Site Completed 2024

Image: Blackwater Mine 2024-02-07

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Requested by: S Lyngcoln
Date: 30/01/2025

BWM PRCP Rehab Areas and FY25 Rehabilitation Monitoring Sites
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Rehabilitation Monitoring Results Summary

Cattle Grazing PMLU Results

The results of monitoring of cattle grazing PMLU areas have been summarised below as it relates to the following criteria:

- land suitability class ≤3 (Short, 2023)
- land condition Good (A) or Fair (B) (DES, 2022a)

The land suitability class raw data has been provided for all cattle grazing sites assessed between 2022 and 2024 in Attachment Two and Three. The land suitability class results are summarised in Figure 2 with the results of rehabilitation monitoring sites represented in the blue bars and the cattle grazing reference sites in purple bars. The results indicate that the majority of the existing cattle grazing is classed between LSC 4 and 5. It is important to note that in accordance with (Short, 2023) land suitability is scored on the most limiting factor. The results of a review of the raw data (refer Attachment Two and Three) indicate that many sites are limited by low available Phosphorus (P) in 0.1m of the rehabilitated soil profile as well as moderate to higher pH in 0.1m of the rehabilitated soil profile. Other limiting factors include percent slope and exchangeable sodium percent (ESP) in 0.1 and/or subsoil erosion associated with high >23% ESP at 0.5m depth. Whilst available Phosphorus (P) can be ameliorated through application of fertiliser, it is important to note that both cattle grazing reference sites are also limited by low available P which can therefore be considered evidence of a pre-mining limitation. Furthermore, both reference sites are also limited by high moderate to higher pH in 0.1m which can also be considered a pre-mining condition.

Whilst not a current completion criterion in the BWM EA, areas of cattle grazing have also been assessed against 'land condition' criteria based on the *Queensland Reef Quality Program Reef Protection Regulations Farming in Reef Catchments Grazing Guide Version 2* (DES, 2022a). The results of the grazing land condition monitoring are provided in attachment four and five and have been summarised in Figure 3 with the results of rehabilitation monitoring sites represented in the blue bars and the cattle grazing reference sites in purple bars. Whilst land condition is not a completion criterion in the BWM EA, it is an important criterion for monitoring the condition of grazing lands in Central Queensland (DES, 2022a). The results indicate the majority of the cattle grazing is in Good (A) or Fair (B) land condition.

It is however important to note that the majority of cattle grazing in Good (A) or Fair (B) land condition only supports one preferred, perennial and palatable (3P) grass species predominantly buffel grass (*Cenchrus ciliaris*). The BWM PRCP addresses this issue for all future cattle grazing requiring at least four 3P species of pasture grass to be sown.

It is understood that BWM are undertaking ongoing maintenance of rehabilitation areas based on prioritised works recommended from annual monitoring. From a maintenance perspective, BWM is currently undertaking a Leucaena management program targeting areas of high density Leucaena identified during the 2022-2024 monitoring program. It is expected ongoing maintenance including control of outliers of Leucaena, erosion control and reseeding will follow on from the weed management programs in cattle grazing PMLU areas returned from monitoring with rehabilitated land in Poor (C) or Degraded (D) condition based on the results of annual monitoring.

BWM is also currently undertaking further monitoring in areas of cattle grazing rehabilitation identified during the 2024 monitoring program likely to be able to progress towards progressive certification against the BWM EA with LSC ≤3, or not different from pre-mining class if ≥4. BWM will prepare a progressive certification application for areas of cattle grazing rehabilitation returned compliant with current EA completion criteria as listed in Attachment One.

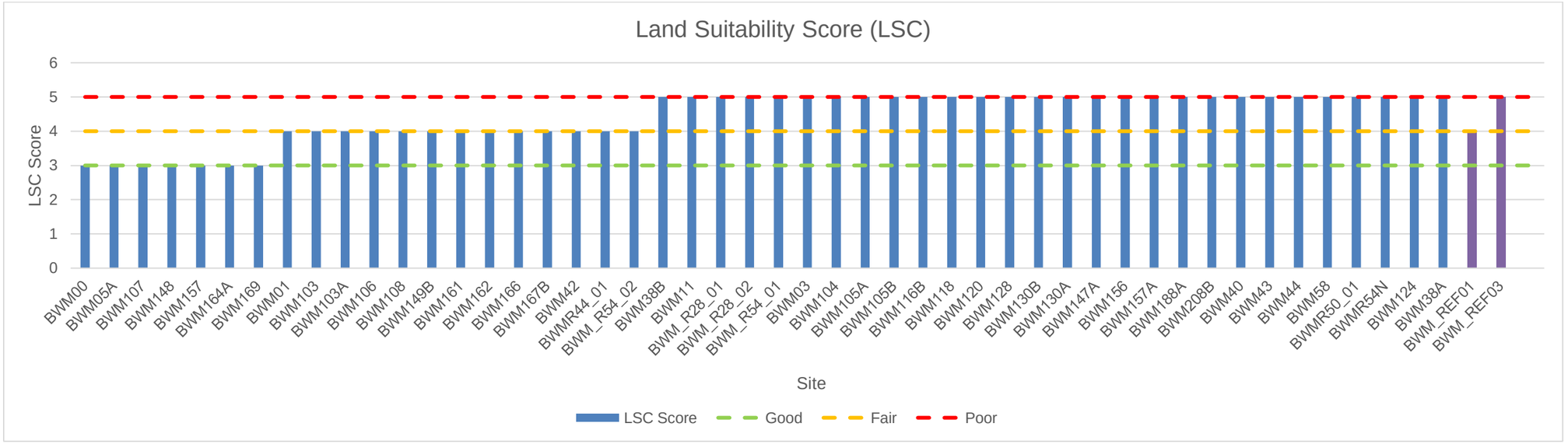

Figure 2 Land Suitability Class Results 2022-2024



Figure 3 Land Condition Monitoring Results 2022-2024

Woodland Habitat PMLU Results

The results of the woodland habitat monitoring between 2022-2024 have been provided in Attachment Six and Attachment Seven.

Table E1 of the BWM EA requires all woodland areas to meet 'native bushland habitat characteristics' including ≥2 tree, ≥3 shrub and ≥4 grass species richness as well as ≥16% canopy cover. A summary of the overall results for all woodland habitat sites have been presented for each of the native bushland habitat characteristics with the rehabilitation site results represented by the blue bars and the woodland habitat reference sites represented by the purple bass as follows:

- Species richness:
    - Trees ≥2 (Figure 4)
    - Shrubs ≥3 (Figure 5)
    - Grasses ≥4 (Figure 6)
- Tree canopy cover ≥16% (Figure 7)

A summary of erosional stability of woodland habitat has also been provided in Figure 8 based on the following EA criteria:

- Groundcover (steep slopes, >15%) ≥80%
- Groundcover (lesser slopes, ≤15%) ≥50%

The results of the woodland habitat monitoring indicate that the majority of woodland habitat sites are performing well with ≥2 tree species, ≥3 shrub species, ≥16% tree canopy cover and total ground cover (%) over slope consistent with the EA requirements. It is however important to note grass species' richness is quite low across many of the woodland sites. Mine soils and spoils are often contaminated with exotic pasture grasses and historically rehabilitation focused primarily on trees and shrubs with exotic pasture species. Native grasses have only become available in commercial quantities over the last ten or so years. For this reason, both exotic and native grasses are considered justified for older areas of rehabilitation >10 years.

The woodland habitat analysis also considers invasive plant species cover and recruitment of the canopy species, as summarised in Attachment Six and Seven. The majority of the woodland rehabilitation is low in invasive plant cover and has evidence of recruitment of canopy species. Despite the low presence of invasive plans BWM is conducting weed control in woodland areas and is also focusing on a control program of Leucaena.

In December 2024 BWM lodged a woodland habitat progressive certification application for 65.6 ha of historic woodland habitat rehabilitation associated with rehabilitation areas BWM25, BWM33 and BWM180 (LEC, 2024b). The application demonstrated the conditions of the environmental authority have been complied and the land has been satisfactory rehabilitated. Satisfactory rehabilitation is safe, stable, non-polluting and able to sustain the agreed post-mining land use. In addition to demonstrating compliance with the rehabilitation success criteria, the application also described the ongoing environmental management requirements and presented a detailed assessment of environmental risks associated with the rehabilitation.

BWM intend to continue to maintain woodland habitat and pursue further progressive certification application for woodland habitat that complies with the BWM EA.

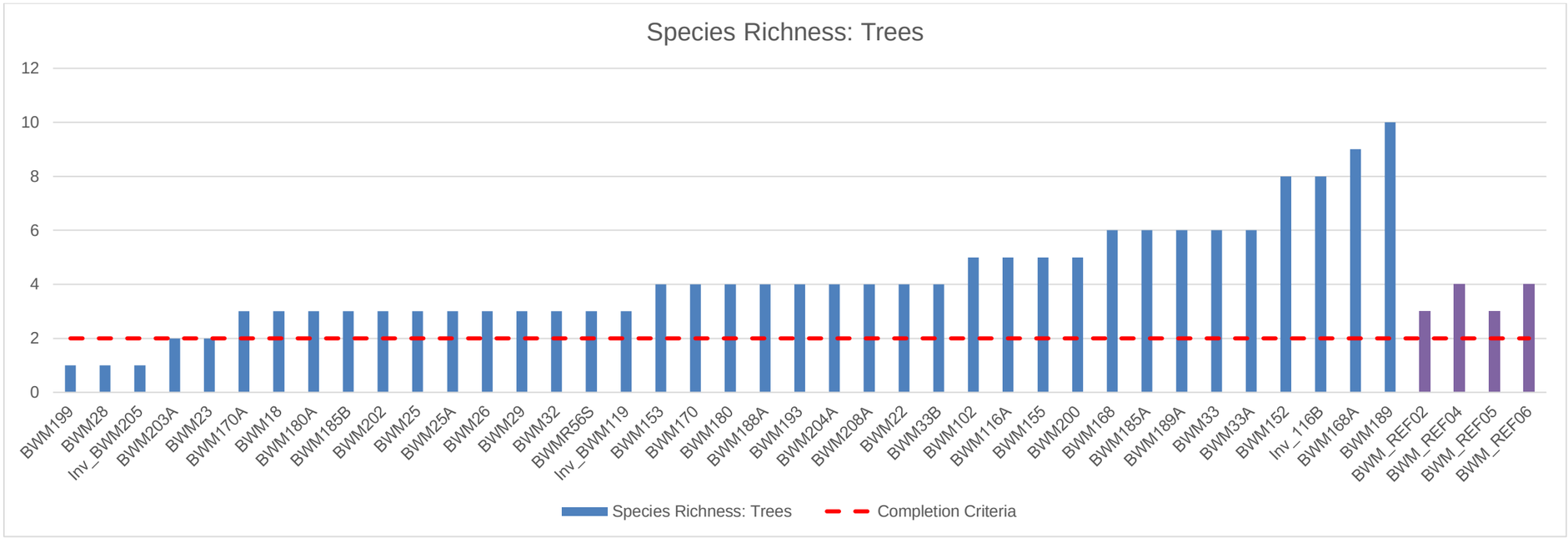

Figure 4 BWM woodland habitat rehabiliaition tree species richness 2022-2024

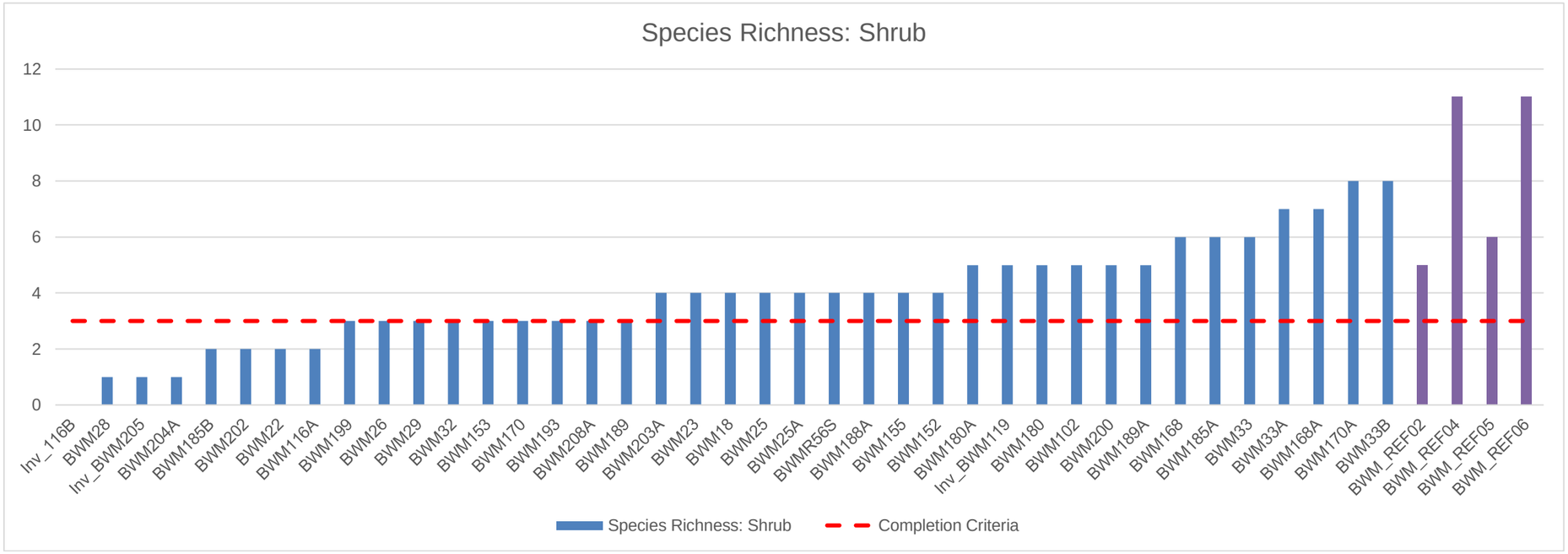

Figure 5 BWM woodland habitat rehabilitation shrub species richness 2022-2024

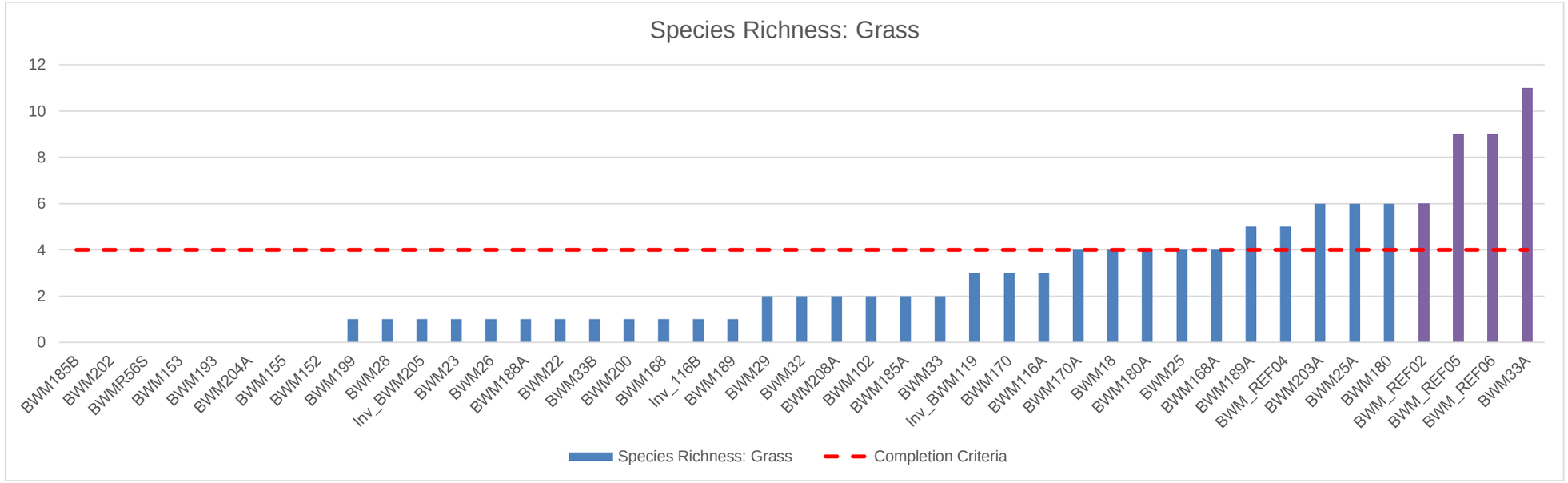

Figure 6 BWM woodland habitat rehabilitation grass species richness 2022-2024

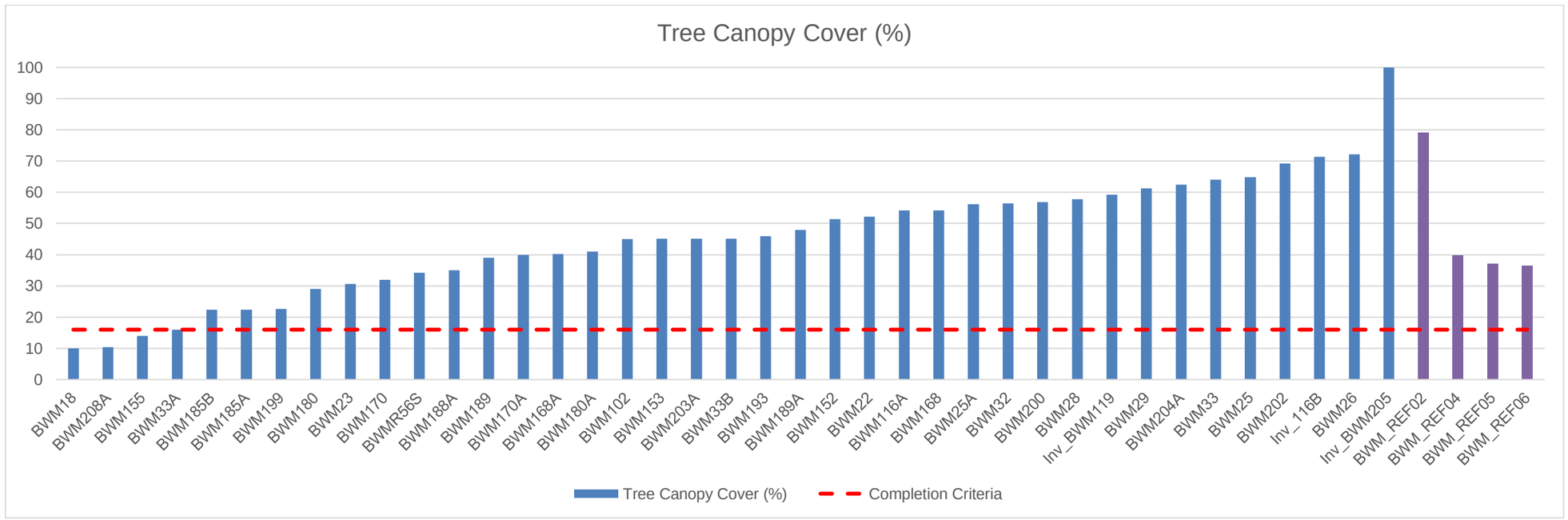

Figure 7 BWM woodland habitat rehabilitation tree canopy cover percent (%) 2022-2024

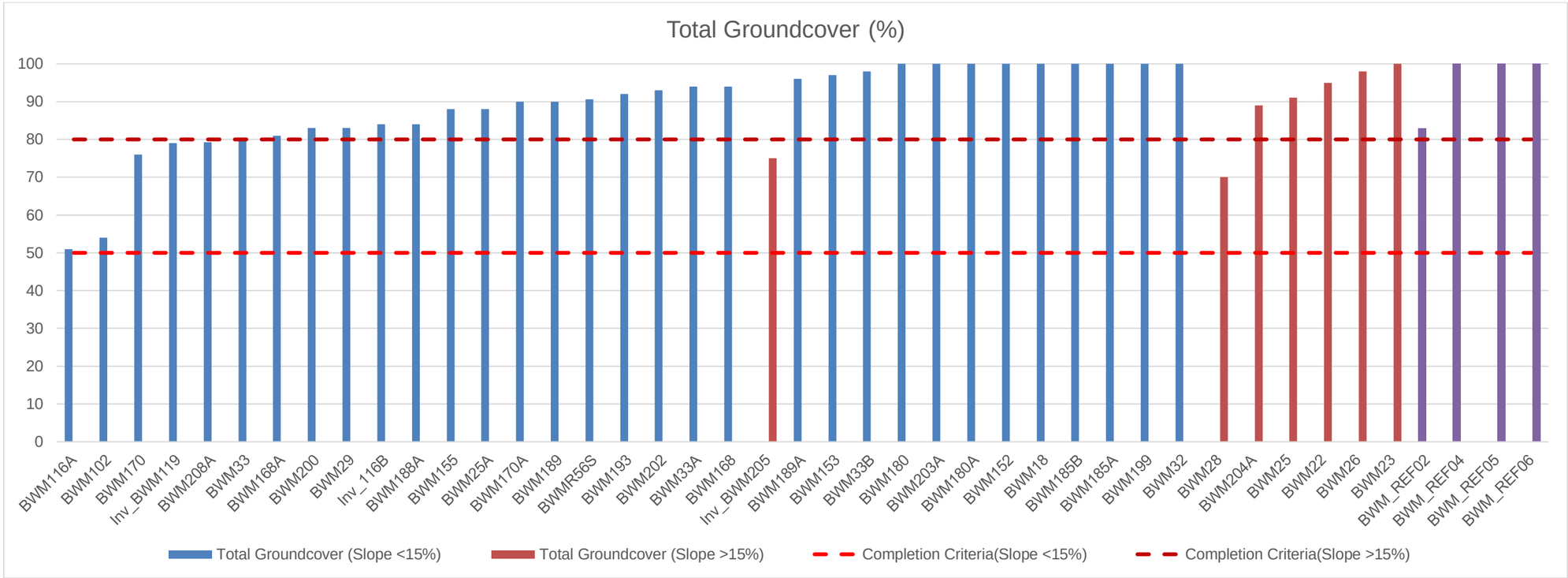

Figure 8 BWM woodland habitat rehabilitation total ground cover (%) over slope 2022-2024

Summary and Conclusions

On April 2nd, 2024, BWM was transferred to Whitehaven Coal (WHC). In 2018 the previous owner BHP Mitsubishi Alliance (BMA) negotiated revised final post mining land uses (PMLU) completion criteria for cattle grazing and woodland habitat land uses under Table E1 of the BWM Environmental Authority (EA) Permit EPML00717813 (refer Attachment One).

Rehabilitation monitoring on BWM has been undertaken since 2018 in accordance with the BWM Rehabilitation Monitoring Methodology (RMM) and associated subsequent versions to determine the performance of rehabilitation against the updated EA completion criteria for cattle grazing, and woodland habitat PMLU.

The existing rehabilitation areas on BWM and associated monitoring sites are illustrated in Figure 1. Table 1 lists the associated rehabilitation monitoring sites that have been monitored as a result of each monitoring program between 2018-2024. A total of 1497 ha of the existing 1929 ha listed as existing rehabilitation in the BWM PRCP has been monitored between 2022-2024 which includes all sites ever monitored on BWM.

It is understood that the 2025 rehabilitation monitoring program will focus on assessing areas not yet monitored and developing and an associated maintenance program.

Cattle grazing monitoring results between 2022-2024 are summarised as they relate to BWM EA land suitability class completion criteria in Attachment Two and Three. The results indicate that the majority of the existing cattle grazing is classed between LSC 4 and 5. It is important to note that in accordance with Short (2023) land suitability is scored on the most limiting factor. The results indicate that many sites are limited by low available Phosphorus (P) in 0.1m of the rehabilitated soil profile as well as moderate to higher pH in 0.1m of the rehabilitated soil profile. Other limiting factors include percent slope and exchangeable sodium percent (ESP) in 0.1 and/or subsoil erosion associated with high >23% ESP at 0.5m depth. Whilst available Phosphorus (P) can be ameliorated through application of fertiliser, it is important to note that both cattle grazing reference sites are also limited by low available P which can therefore be considered evidence of a pre-mining limitation. Furthermore, both reference sites are also limited by high moderate to higher pH in 0.1m of the rehabilitated soil profile which can also be considered a pre-mining condition.

Whilst not a current completion criterion in the BWM EA, areas of cattle grazing have also been assessed against 'land condition' criteria based on the *Queensland Reef Quality Program Reef Protection Regulations Farming in Reef Catchments Grazing Guide Version 2* (DES, 2022a). The results of the grazing land condition monitoring are provided in Attachments Four and Five and have been summarised in Figure 3. Whilst land condition is not a completion criterion in the BWM EA, it is an important criterion for monitoring the condition of grazing lands in Central Queensland (DES, 2022a).

It is understood that BWM are undertaking ongoing maintenance of rehabilitation areas based on prioritised works recommended from annual monitoring. From a maintenance perspective, BWM is currently undertaking a Leucaena management program targeting areas of high density Leucaena identified during the 2022-2024 monitoring program. It is expected ongoing maintenance including control of outliers of Leucaena, erosion control and reseeding will follow on from the weed management programs in cattle grazing PMLU areas returned from monitoring with rehabilitated land in Poor (C) or Degraded (D) condition based on the results of annual monitoring.

BWM is also currently undertaking further monitoring in areas of cattle grazing rehabilitation identified during the 2024 monitoring program likely to be able to progress towards progressive certification against the BWM EA with LSC ≤3 or not different from pre-mining class if ≥4. BWM will prepare a progressive certification application for areas of cattle grazing rehabilitation returned compliant with current EA completion criteria as listed in Attachment One.

The results of the woodland habitat monitoring between 2022-2024 indicate that the majority of woodland habitat sites are performing well with ≥2 tree species, ≥3 shrub species, ≥16% tree canopy cover and total ground cover (%) over slope consistent with the EA requirements. It is however important to note grass species' richness is quite low across much of the woodland sites. Mine soils

and spoils are often contaminated with exotic pasture grasses and historically rehabilitation focused primarily on trees and shrubs with exotic pasture species. Native grasses have only become available in commercial quantities over the last ten or so years. For this reason, both exotic and native grasses are considered justified for older areas of rehabilitation >10 years.

In December 2024 BWM lodged a woodland habitat progressive certification application for 65.6 ha of historic woodland habitat rehabilitation associated with rehabilitation areas BWM25, BWM33 and BWM180. The application demonstrated the conditions of the environmental authority have been complied with and the land has been satisfactory rehabilitated. Satisfactory rehabilitation is safe, stable, non-polluting and able to sustain the agreed post-mining land use. In addition to demonstrating compliance and rehabilitation success, the application also described the ongoing environmental management requirements and presented a detailed assessment of environmental risks associated with the rehabilitation.

BWM intends to continue to maintain woodland habitat and pursue further progressive certification application for woodland habitat that complies with the BWM EA.

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Attachment One – Post Mining Land Use Completion Criteria

Table 2: BWM EA PMLU objectives, indicators and acceptance criteria: cattle grazing.

Goal	Objective	Indicator	Acceptance criteria
Safe to humans and wildlife	Safety hazards in rehabilitation are not significantly different to surrounding unmined landscapes subject to the same land use	Hazard assessment	No significant difference
Stable	Rehabilitation is geotechnically stable	Factor of Safety	≥1.5
	Rehabilitation is erosionally stable	Extent, slope gradient and groundcover	Groundcover >50%, and 70% of slopes ≤20%
Non-polluting	Rainfall runoff from rehabilitation achieves relevant water quality objectives for receiving waters	pH EC Turbidity	Not significantly different to upstream values
	Deep drainage from rehabilitation achieves relevant water quality objectives for groundwater	EC	Not significantly different to: The EPP (Water) schedule documents water quality objectives for relevant groundwater chemistry zones; or, Local water quality objectives developed in accordance with the Queensland Water Quality Guidelines.
Able to sustain the agreed post-mining land use	Rehabilitation is suitable for sustainable cattle grazing	Land suitability assessment for cattle grazing	Land suitability class ≤3 or not different from pre-mining class if ≥4. Assessment completed in accordance with *LSA Framework for Open-Cut Coal Mine Rehabilitation 2018 (A rule-set for land suitability assessment of sustainable beef cattle grazing on land rehabilitated after open-cut coal mining in the Bowen Basin Queensland* (Short, Land Suitability Assessment (LSA) Framework for Open-Cut Coal Mine Rehabilitation 2018 (A rule-set for land suitability assessment of sustainable beef cattle grazing on land rehabilitated after open-cut coal mining in the Bowen Basin Queensland), 2018)*)* Unless otherwise agreed in writing between the administering authority and the environmental authority holder.

Goal	Objective	Indicator	Acceptance criteria
		Leucaena stem density	<250 stems >2 m height per ha (1 per 40 m^2), mean total area

Table 3: BWM EA PMLU objectives, indicators and acceptance criteria: woodland habitat.

Goal	Objective	Indicator	Acceptance criteria
Safe to humans and wildlife	Safety hazards in rehabilitation are not significantly different to surrounding unmined landscapes subject to the same land use	Hazard assessment	No significant difference
Stable	Rehabilitation is geotechnically stable	Factor of safety	≥1.5 unless an alternative is justified by an appropriately qualified engineer
	Rehabilitation is erosionally stable	Groundcover (steep slopes, >15%)	80%
		Groundcover (lesser slopes, ≤15%)	50%
Non-polluting	Rainfall runoff from rehabilitation achieves relevant water quality objectives for receiving waters	pH EC Turbidity	Not significantly different to upstream values
	Deep drainage from rehabilitation achieves relevant water quality objectives for groundwater	EC	Not significantly different to: the EPP (Water) schedule documents water quality objectives for relevant groundwater chemistry zones; or local water quality objectives developed in accordance with the Queensland Water Quality Guidelines.
Able to sustain an agreed post-mining land use	Native bushland habitat characteristics	Species richness: Trees Shrubs Grasses	 ≥2 ≥3 ≥4
		Tree canopy cover	≥16

Table 4: ABCD Land Condition Framework (DES, 2022a)**.**

Land Condition	Land Condition Features
Good – A	A condition land has all the following features: • most land types in good condition will typically have at least 50% and often above 70% ground cover at the end of the dry season • good density of perennial grasses dominated by those species considered to be 3P grasses for that land type, little bare ground (less than 30 % in most years) • few weeds and no significant infestations • good soil condition: no erosion, good surface condition
Fair – B	B condition land has at least one or more of the following features, but otherwise is similar to A condition land: • land types will typically have at least 50% ground cover and less than 70% in most years at the end of the dry season • some decline of grasses that are 3P grasses, increase in other species (less favoured grasses, weeds) and/or bare ground (more than 30% but less than 50% in most years) • some decline in soil condition, some signs of previous erosion and current susceptibility to erosion
Poor – C	C condition land has one or more of the following features, but otherwise is similar to B condition land: • land with poor or degraded condition will typically have less than 50% ground cover at the end of the dry season • general decline of grasses that are 3P grasses, large amounts of less favoured species and/or bare ground (greater than 50% in most years) • obvious signs of past erosion and/or current susceptibility to erosion is high
Degraded – D	D condition land has one or more of the following features: • generally, less than 20% ground cover • general lack of any perennial grasses or forbs • severe erosion or scalding, resulting in hostile environment for plant growth • often no long-term ability to carry stock

Attachment Two – Land Suitability Class Monitoring Results (BMA, 2024a)

Limitation		Water availability			Nutrient supply				Soil physical factors		Salinity		Rockiness		Topography (slope)				Water, erosion, surface soil		Subsoil erosion		Potential acid forming materials		
Site ID	Soil Core ID	PAWC in ERD			Colwell P to 0.1m		pH in 0.1m		Surface soil structure		EC in ERD dS/m		Fragments on surface		Gradient, surface		Vertical interval, surface		Slope % (ESP in 0.1m)		Subsoil erosion		pH <4.5		
Notes: Good, Fair, Poor		From soil texture lab results 0-10cm, 10-30cm, 30-60cm	Total Core PAWC	LSC Score	Phosphorus (Colwell)	LSC Score	pH (1:5 Water)	LSC Factor Score	Use pedality in surface sample and/or surface condition from erosion.	LSC Factor Score	Electrical Conductivity (Sat. Ext.) dS/m to 0.1m (10cm)	LSC Factor Score	Percent rock groundcover	LSC Factor Score	Mean Slope %	LSC Factor Score	Topography (slope and microrelief) (m) Soils	LSC Factor Score	Median Slope % and Sodium % of Cations (ESP) 0.1m	LSC Factor Score	Sodium % of Cations (ESP) >0.5m	LSC Factor Score	Depth to pH 4.5	LSC Factor Score	Grazing Land Suitability Class
BWM 37B-1A	1																				2.9	-	No	1	
BWM 37B-1B	1																				6.2	-	No	1	
BWM 37B-1C	1	64			<5.0	5	8.6	4	2-5	1	1.2	1	0	1			Nil	1	2.9	1	8.1	2	No	1	
BWM 37B-2A	2																				1.9	-	No	1	
BWM 37B-2B	2																				4.3	-	No	1	
BWM 37B-2C	2	66	64	2	<5.0	5	8.6	4	2-5	1	1.2	1	0	1	5	2	Nil	1	1.9	1	8.1	2	No	1	5
BWM42_1A	1																				5.9	-	No	1	
BWM42_1B	1																				8.0	-	No	1	
BWM42_1C	1																				9.9	2	No	1	
BWM42_1D	1	60			6.5	4	8.9	4	2-5	1	1.3	1	0	1			0.2 - 0.4	3	5.9	2	13	3	No	1	
BWM42_2A	2																				6.7	-	No	1	
BWM42_2B	2																				8.7	-	No	1	
BWM42_2C	2	54	54	3	<5.0	5	9.0	4	2-5	1	1.5	1	0	1	8	2	0.2 - 0.4	3	6.7	3	11	2	No	1	5
BWM43_1A	1																				6.8	-	No	1	
BWM43_1B	1																				11	-	No	1	
BWM43_1C	1	50	50	3	<5.0	5	9.1	5	Surface Crusting	3	1.2	1	0	1	2	1	0.4 - 0.6	4	6.8	2	14	2	No	1	5

Limitation		Water availability			Nutrient supply				Soil physical factors		Salinity		Rockiness		Topography (slope)				Water, erosion, surface soil		Subsoil erosion		Potential acid forming materials		
Site ID	Soil Core ID	PAWC in ERD			Colwell P to 0.1m		pH in 0.1m		Surface soil structure		EC in ERD dS/m		Fragments on surface		Gradient, surface		Vertical interval, surface		Slope % (ESP in 0.1m)		Subsoil erosion		pH <4.5		
Notes: Good, Fair, Poor		From soil texture lab results 0-10cm, 10-30cm, 30-60cm	Total Core PAWC	LSC Score	Phosphorus (Colwell)	LSC Score	pH (1:5 Water)	LSC Factor Score	Use pedality in surface sample and/or surface condition from erosion.	LSC Factor Score	Electrical Conductivity (Sat. Ext.) dS/m to 0.1m (10cm)	LSC Factor Score	Percent rock groundcover	LSC Factor Score	Mean Slope %	LSC Factor Score	Topography (slope and microrelief) (m) Soils	LSC Factor Score	Median Slope % and Sodium % of Cations (ESP) 0.1m	LSC Factor Score	Sodium % of Cations (ESP) >0.5m	LSC Factor Score	Depth to pH 4.5	LSC Factor Score	Grazing Land Suitability Class
BWM43_2A	2																				7.5	-	No	1	
BWM43_2B	2	50			<5.0	5	9.2	5	Surface Crusting	3	1.2	1	0	1			0.4 - 0.6	4	7.5	2	9.6	-	No	1	
BWM44_1A	1																				5.4	-	No	1	
BWM44_1B	1																				6.9	-	No	1	
BWM44_1C	1	60			<5.0	5	9.0	4	Surface Crusting	3	1.3	1	0	1			0.4 - 0.6	4	5.4	2	15	3	No	1	
BWM44_2A	2																				4.8	-	No	1	
BWM44_2B	2	72	60	2	<5.0	5	9.0	4	Surface Crusting	3	1.2	1	0	1	2	1	0.4 - 0.6	4	4.8	1	7.2	-	No	1	5
BWM54_TS	1	30	30	4	<5.0	5	5.6	3	10-20	2	0.2	1	0	1	5	2	Nil	1	2.0	1	2.0	-	No	1	5
BWM58-1A	1																				2.3	-	No	1	
BWM58-1B	1																				2.0	-	No	1	
BWM58-1C	1	30			5.9	5	6.1	2	5-10	1	1.1	1	0	1			Nil	1	2.3		3.6	2	No	1	
BWM58-2A	2																				3.4	-	No	1	
BWM58-2B	2																				24	-	No	1	
BWM58-2C	2	30	30	4	7.9	4	5.9	3	5-10	1	0.5	1	0	1			Nil	1	3.4		17	3	No	1	5
INVOI_1A	1																				3.9	-	No	1	
INVOI_1B	1	30	30	4	<5.0	5	7.9	2	10-20	2	0.3	1	0	1	1	1	Nil	1	3.9	1	7.5	-	No	1	5

Limitation		Water availability			Nutrient supply				Soil physical factors		Salinity		Rockiness		Topography (slope)				Water, erosion, surface soil		Subsoil erosion		Potential acid forming materials		
Site ID	Soil Core ID	PAWC in ERD			Colwell P to 0.1m		pH in 0.1m		Surface soil structure		EC in ERD dS/m		Fragments on surface		Gradient, surface		Vertical interval, surface		Slope % (ESP in 0.1m)		Subsoil erosion		pH <4.5		
Notes: Good, Fair, Poor		From soil texture lab results 0-10cm, 10-30cm, 30-60cm	Total Core PAWC	LSC Score	Phosphorus (Colwell)	LSC Score	pH (1:5 Water)	LSC Factor Score	Use pedality in surface sample and/or surface condition from erosion.	LSC Factor Score	Electrical Conductivity (Sat. Ext.) dS/m to 0.1m (10cm)	LSC Factor Score	Percent rock groundcover	LSC Factor Score	Mean Slope %	LSC Factor Score	Topography (slope and microrelief) (m) Soils	LSC Factor Score	Median Slope % and Sodium % of Cations (ESP) 0.1m	LSC Factor Score	Sodium % of Cations (ESP) >0.5m	LSC Factor Score	Depth to pH 4.5	LSC Factor Score	Grazing Land Suitability Class
INVOI_1C	1																				15	3	No	1	
R28 01-1A	1																				5.8	-	No	1	
R28 01-1B	1																				8.9	-	No	1	
R28 01-1C	1																				12	2	No	1	
R28 01-1D	1	66			<5.0	5	8.9	4	2-5	1	1.4	1	0	1			0.4 - 0.6	4	5.8	2	10	2	No	1	
R28 01-2A	2																				6.0	-	No	1	
R28 01-2B	2																				8.6	-	No	1	
R28 01-2C	2	72	66	2	<5.0	5	9.1	5	2-5	1	1.4	1	0	1	8	2	0.4 - 0.6	4	6.0	2	8.7	2	No	1	5
REF 03-1A	1																				0.90	-	No	1	
REF 03-1B	1																				3.6	-	No	1	
REF 03-1C	1																				12	2	No	1	
REF 03-1D	1	70			<5.0	5	8.3	3	5-10	1	1.1	1	0	1			Nil	1	0.90	1	19	3	No	1	
REF 03-2A	2																				1.4	-	No	1	
REF 03-2B	2																				1.3	-	No	1	
REF 03-2C	2	64	64	2	<5.0	5	7.5	2	5-10	1	0.3	1	0	1	2	1	Nil	1	1.4	1	1.4	1	No	1	5
R28 02-1A	1																				1.9	-	No	1	
R28 02-1B	1																				3.6	-	No	1	
R28 02-1C	1	54	54	3	<5.0	5	8.7	4	5-10	1	0.9	1	0	1	8	2	0.4 - 0.6	4	1.9	1	9.6	2	No	1	5

Limitation		Water availability			Nutrient supply				Soil physical factors		Salinity		Rockiness		Topography (slope)				Water, erosion, surface soil		Subsoil erosion		Potential acid forming materials		
Site ID	Soil Core ID	PAWC in ERD			Colwell P to 0.1m		pH in 0.1m		Surface soil structure		EC in ERD dS/m		Fragments on surface		Gradient, surface		Vertical interval, surface		Slope % (ESP in 0.1m)		Subsoil erosion		pH <4.5		
Notes: Good, Fair, Poor		From soil texture lab results 0-10cm, 10-30cm, 30-60cm	Total Core PAWC	LSC Score	Phosphorus (Colwell)	LSC Score	pH (1:5 Water)	LSC Factor Score	Use pedality in surface sample and/or surface condition from erosion.	LSC Factor Score	Electrical Conductivity (Sat. Ext.) dS/m to 0.1m (10cm)	LSC Factor Score	Percent rock groundcover	LSC Factor Score	Mean Slope %	LSC Factor Score	Topography (slope and microrelief) (m) Soils	LSC Factor Score	Median Slope % and Sodium % of Cations (ESP) 0.1m	LSC Factor Score	Sodium % of Cations (ESP) >0.5m	LSC Factor Score	Depth to pH 4.5	LSC Factor Score	Grazing Land Suitability Class
R28 02-2A	2																				2.8	-	No	1	
R28 02-2B	2																				4.6	-	No	1	
R28 02-2C	2	62			<5.0	5	8.7	4	5-10	1	1.2	1	0	1			0.4 - 0.6	4	2.8	1	5.9	1	No	1	
R54_01_1A	1																				17	-	No	1	
R54_01_1B	1																				36	-	No	1	
R54_01_1C	1	60			<5.0	5	9.1	5	Surface Crusting	3	3.4	2	0	1			0.4 - 0.6	4	17	5	36	5	No	1	
R54_01_2A	2																				2.7	-	No	1	
R54_01_2B	2																				9.3	-	No	1	
R54_01_2C	2	58	58	3	53	1	8.5	3	Surface Crusting	3	0.9	1	0	1	1	1	0.4 - 0.6	4	2.7	1	17	3	No	1	5
BWM 116B-01A	1																				6.5	-	No	1	
BWM 116B-01B	1																				12	-	No	1	
BWM 116B-01C	1	48			<5.1	5	9.3	5	10-20	2	1.1	1	0	1			<0.2	2	6.5	2	22	3	No	1	
BWM 116B-02A	2																				0.76	-	No	1	
BWM 116B-02B	2																				0.70	-	No	1	
BWM 116B-02C	2	38	38	4	-	-	5.6	3	10-20	2	0.4	1	0	1	5	2	<0.2	2	0.76	1	0.43	1	No	1	5
BWM 40-1A	1																				3.8	-	No	1	
BWM 40-1B	1																				7.2	-	No	1	
BWM 40-1C	1	60	60	2	<5.0	5	8.6	4	2-5	1	1.6	1	0	1	10	2	0.2 - 0.4	3	3.8	2	7.7	2	No	1	5

Limitation		Water availability			Nutrient supply				Soil physical factors		Salinity		Rockiness		Topography (slope)				Water, erosion, surface soil		Subsoil erosion		Potential acid forming materials		
Site ID	Soil Core ID	PAWC in ERD			Colwell P to 0.1m		pH in 0.1m		Surface soil structure		EC in ERD dS/m		Fragments on surface		Gradient, surface		Vertical interval, surface		Slope % (ESP in 0.1m)		Subsoil erosion		pH <4.5		
Notes: Good, Fair, Poor		From soil texture lab results 0-10cm, 10-30cm, 30-60cm	Total Core PAWC	LSC Score	Phosphorus (Colwell)	LSC Score	pH (1:5 Water)	LSC Factor Score	Use pedality in surface sample and/or surface condition from erosion.	LSC Factor Score	Electrical Conductivity (Sat. Ext.) dS/m to 0.1m (10cm)	LSC Factor Score	Percent rock groundcover	LSC Factor Score	Mean Slope %	LSC Factor Score	Topography (slope and microrelief) (m) Soils	LSC Factor Score	Median Slope % and Sodium % of Cations (ESP) 0.1m	LSC Factor Score	Sodium % of Cations (ESP) >0.5m	LSC Factor Score	Depth to pH 4.5	LSC Factor Score	Grazing Land Suitability Class
BWM 40-2A	2																				6.1	-	No	1	
BWM 40-2B	2																				9.6	-	No	1	
BWM 40-2C	2	60			<5.0	5	8.9	4	2-5	1	1.7	1	0	1			0.2 - 0.4	3	6.1	3	13	2	No	1	
BWM REF01-1A	1																				0.61	-	No	1	
BWM REF01-1B	1																				1.7	-	No	1	
BWM REF01-1C	1	60			5.5	4	8.4	4	Surface Crusting	3	0.9	1	0	1			Nil	1	0.61	1	7.9	2	No	1	
BWM REF01-2A	2																				2.1	-	No	1	
BWM REF01-2B	2																				0.74	-	No	1	
BWM REF01-2C	2	66	60	2	7.2	4	8.7	4	Surface Crusting	3	1.1	1	0	1	1	1	Nil	1	2.1	1	14	2	No	1	4
BWM03-1A	1																				0.13	-	No	1	
BWM03_1B	1																				0.20	-	No	1	
BWM03_1C	1																				0.42	1	No	1	
BWM03_1D	1	52			<5.0	5	8.7	4	5-10	1	0.8	1	0	1			0.2 - 0.4	3	0.13	1	1.3	1	No	1	
BWM03_2A	2																				0.097	-	No	1	
BWM03_2B	2																				0.40	-	No	1	
BWM03_2C	2	52	52	3	6.1	4	8.3	3	5-10	1	0.9	1	0	1	9	2	0.2 - 0.4	3	0.097	1	1.0	1	No	1	5

Attachment Three – Land Suitability Class Monitoring Results (BMA, 2024b)

Limitation			Water availability		Nutrient supply				Soil physical factors		Salinity		Rockiness		Topography (slope)				Water, erosion, surface soil		Subsoil erosion		Potential acid forming materials		Grazing Land Suitability Class
Site ID	Soil Core ID	PAWC in ERD			Colwell P to 0.1m		pH in 0.1m		Surface soil structure		EC in ERD dS/m		Fragments on surface		Gradient, surface		Vertical interval, surface		Slope % (ESP in 0.1m)		Subsoil erosion		pH <4.5		
Notes: Good, Fair, Poor		From soil texture lab results 0-10cm, 10-30cm, 30-60cm	Total Core PAWC	LSC Score	Phosphorus (Colwell)	LSC Score	pH (1:5 Water)	LSC Factor Score	Use pedality in surface sample and/or surface condition from erosion.	LSC Factor Score	Electrical Conductivity (Sat. Ext.) dS/m to 0.1m (10cm)	LSC Factor Score	Percent rock groundcover	LSC Factor Score	Mean Slope %	LSC Factor Score	Topography (slope and microrelief) (m) Soils	LSC Factor Score	Median Slope % and Sodium % of Cations (ESP) 0.1m	LSC Factor Score	Sodium % of Cations (ESP) >0.5m	LSC Factor Score	Depth to pH 4.5	LSC Factor Score	
BWM 01-1A	2	10	60	**2**	9.6	**3**	8.4	**3**	>10mm	**2**	1.3	**1**	0	**1**	8	**2**	<0.4m	**3**	2	**1**	2	-	8.4	**1**	**4**
BWM 01-1B	2	20			6		9.3				3.2								17		17		9.3	**1**	
BWM 01-1C	2	30			6.6		9.4				5.3								26		26	**4**	9.4	**1**	
	2	-					-												-		-	**-**	-	**1**	
BWM 01-2A		10	60	**2**	10	**3**	8.2	**3**	>10mm	**2**	1.4	**1**	0	**1**	8	**2**	<0.4m	**3**	1.2	**1**	1.2	-	8.2	**1**	**3**
BWM 01-2B		20			<5.0		9.1				1.6								7.3		7.3		9.1	**1**	
BWM 01-2C		30			<5.0		9.5				3								17		17	**3**	9.5	**1**	
		-					-												-		-	**-**	-	**1**	
BWM 104-1A		12	72	**2**	<5.0	**5**	8.7	**4**	>10mm	**2**	0.9	**1**	0	**1**	6	**2**	<0.4m	**3**	2	**1**	2	-	8.7	**1**	**5**
BWM 104-1B		24			<5.0		9.2				1.7								8.4		8.4		9.2	**1**	
BWM 104-1C		36			<5.0		9.1				3.8								26		26	**4**	9.1	**1**	
		-					-												-		-	**-**	-	**1**	
BWM 104-2A		12	72	**2**	<5.0	**5**	8.6	**4**	>10mm	**2**	1.2	**1**	0	**1**	6	**2**	<0.4m	**3**	4.2	**2**	4.2	-	8.6	**1**	**5**
BWM 104-2B		24			<5.0		8.9				3.1								13		13		8.9	**1**	
BWM 104-2C		36			<5.0		8.9				4.5								24		24	**4**	8.9	**1**	
		-					-												-		-	**-**	-	**1**	
BWM 105A-1A		12	72	**2**	<5.0	**5**	8.5	**3**	>10mm	**2**	1	**1**	0	**1**	11.5	**3**	<0.4m	**3**	1.4	**1**	1.4	-	8.5	**1**	**5**

Limitation			Water availability	Nutrient supply				Soil physical factors		Salinity		Rockiness		Topography (slope)				Water, erosion, surface soil		Subsoil erosion		Potential acid forming materials		Grazing Land Suitability Class
Site ID	Soil Core ID	PAWC in ERD			Colwell P to 0.1m		pH in 0.1m	Surface soil structure		EC in ERD dS/m		Fragments on surface		Gradient, surface		Vertical interval, surface		Slope % (ESP in 0.1m)		Subsoil erosion		pH <4.5		
Notes: Good, Fair, Poor		From soil texture lab results 0-10cm, 10-30cm, 30-60cm	Total Core PAWC	LSC Score	Phosphorus (Colwell)	LSC Score	pH (1:5 Water)	LSC Factor Score	Use pedality in surface sample and/or surface condition from erosion.	LSC Factor Score	Electrical Conductivity (Sat. Ext.) dS/m to 0.1m (10cm)	LSC Factor Score	Percent rock groundcover	LSC Factor Score	Mean Slope %	LSC Factor Score	Topography (slope and microrelief) (m) Soils	LSC Factor Score	Median Slope % and Sodium % of Cations (ESP) 0.1m	LSC Factor Score	Sodium % of Cations (ESP) >0.5m	LSC Factor Score	Depth to pH 4.5	LSC Factor Score	
BWM 105A-1B		24			9.4		8.7				1.5								5.4		5.4		8.7	**1**	
BWM 105A-1C		36			6.1		9.1				2.2								12		12	**2**	9.1	**1**	
		-					-												-		-	**-**	-	**1**	
BWM 105A-2A		12			<5.0		8.4				1.2								1.5		1.5		8.4	**1**	
BWM 105A-2B		24			<5.0		8.6				1.4								3.9		3.9	**-**	8.6	**1**	
BWM 105A-2C		36	72	**2**	5.1	**5**	9.2	**3**	>10mm	**2**	1.6	**1**	0	**1**	11.5	**3**	<0.4m	**3**	8.8	**1**	8.8	**2**	9.2	**1**	**5**
		-					-												-		-	**-**	-	**1**	
BWM107-1A		12			12		8.4				1.5								2.5		2.5		8.4	**1**	
BWM107-1B		24			12		8.7				1.7								5.7		5.7	**-**	8.7	**1**	
BWM107-1C		36	72	**2**	13	**3**	8.4	**3**	>10mm	**2**	2.8	**1**	0	**1**	7.6	**2**	<0.4m	**3**	6	**1**	6	**1**	8.4	**1**	**3**
BWM107-1D		-			<5.0		8.8				5.5								15		15	**3**	8.8	**1**	
BWM107 2A		12			23		8.4				1.6								2.2		2.2		8.4	**1**	
BWM107 2B		24			5.2		8.6				1.4								2.6		2.6	**-**	8.6	**1**	
BWM107 2C		36	72	**2**	7.2	**1**	8.8	**3**	>10mm	**2**	1.5	**1**	0	**1**	7.6	**2**	<0.4m	**3**	4.7	**1**	4.7	**1**	8.8	**1**	**3**
		-					-												-		-	**-**	-	**1**	
BWM 120-1A		10			<5.0		8.3				1								0.42		0.42		8.3	**1**	
BWM 120-1B		24			<5.0		8.7				1.5								4.7		4.7	**-**	8.7	**1**	
BWM 120-1C		30	64	**2**	<5.0	**5**	9.7	**3**	>10mm	**2**	1.9	**1**	0	**1**	8.5	**3**	<0.4m	**3**	12	**1**	12	**2**	9.7	**1**	**5**
		-					-												-		-	**-**	-	**1**	

Limitation			Water availability		Nutrient supply				Soil physical factors		Salinity		Rockiness		Topography (slope)				Water, erosion, surface soil		Subsoil erosion		Potential acid forming materials		Grazing Land Suitability Class
Site ID	Soil Core ID	PAWC in ERD			Colwell P to 0.1m		pH in 0.1m		Surface soil structure		EC in ERD dS/m		Fragments on surface		Gradient, surface		Vertical interval, surface		Slope % (ESP in 0.1m)		Subsoil erosion		pH <4.5		
Notes: Good, Fair, Poor		From soil texture lab results 0-10cm, 10-30cm, 30-60cm	Total Core PAWC	LSC Score	Phosphorus (Colwell)	LSC Score	pH (1:5 Water)	LSC Factor Score	Use pedality in surface sample and/or surface condition from erosion.	LSC Factor Score	Electrical Conductivity (Sat. Ext.) dS/m to 0.1m (10cm)	LSC Factor Score	Percent rock groundcover	LSC Factor Score	Mean Slope %	LSC Factor Score	Topography (slope and microrelief) (m) Soils	LSC Factor Score	Median Slope % and Sodium % of Cations (ESP) 0.1m	LSC Factor Score	Sodium % of Cations (ESP) >0.5m	LSC Factor Score	Depth to pH 4.5	LSC Factor Score	
BWM 120-2A		12	72	**2**	7	**4**	8.1	**3**	>10mm	**2**	1.1	**1**	0	**1**	8.5	**3**	<0.4m	**3**	0.66	**1**	0.66	-	8.1	**1**	**4**
BWM 120-2B		24			<5.0		8.9				1.8								8.2		8.2		8.9	**1**	
		36					-												-		-	-	-	**1**	
		-					-												-		-	-	-	**1**	
BWM 147A-1A		8	58	**3**	20	**2**	6.7	**2**	>10mm	**2**	2.2	**2**	0	**1**	10.3	**3**	<0.4m	**3**	3.5	**2**	3.5	-	6.7	**1**	**5**
BWM 147A-1B		20			9		7.1				1.9								11		11		7.1	**1**	
BWM 147A-1C		30			13		7.1				4.7								33		33	**4**	7.1	**1**	
BWM 147A-1D		-			13		6.6				16.5								37		37	**5**	6.6	**1**	
BWM 147A-2A		10	60	**2**	<5.0	**5**	7.3	**1**	>10mm	**2**	0.6	**1**	0	**1**	10.3	**3**	<0.4m	**3**	1.8	**1**	1.8	-	7.3	**1**	**5**
BWM 147A-2B		20			<5.0		7.9				0.9								7.4		7.4		7.9	**1**	
BWM 147A-2C		30			6.6		8.4				11.4								30		30	**4**	8.4	**1**	
		-					-												-		-	-	-	**1**	
BWM148-1A		10	60	**2**	14	**2**	7.4	**2**	>10mm	**2**	0.9	**1**	0	**1**	12.3	**3**	<0.4m	**3**	0.3	**1**	0.3	-	7.4	**1**	**3**
BWM148-1B		20			11		7.9				0.8								0.57		0.57		7.9	**1**	
BWM148-1C		30			<5.0		8.8				1								2.3		2.3	**1**	8.8	**1**	
BWM148-1D		-			<5.0		9.3				1.1								4.4		4.4	**1**	9.3	**1**	
BWM 148-2A		10	60	**2**	12	**3**	7.7	**2**	>10mm	**2**	0.6	**1**	0	**1**	12.3	**3**	<0.4m	**3**	0.42	**1**	0.42	-	7.7	**1**	**3**
BWM 148-2B		20			7.9		7.8				0.5								0.9		0.9		7.8	**1**	
		30					-												-		-	-	-	**1**	

Limitation			Water availability		Nutrient supply				Soil physical factors		Salinity		Rockiness		Topography (slope)				Water, erosion, surface soil		Subsoil erosion		Potential acid forming materials		Grazing Land Suitability Class
Site ID	Soil Core ID	PAWC in ERD			Colwell P to 0.1m		pH in 0.1m		Surface soil structure		EC in ERD dS/m		Fragments on surface		Gradient, surface		Vertical interval, surface		Slope % (ESP in 0.1m)		Subsoil erosion		pH <4.5		
Notes: Good, Fair, Poor		From soil texture lab results 0-10cm, 10-30cm, 30-60cm	Total Core PAWC	LSC Score	Phosphorus (Colwell)	LSC Score	pH (1:5 Water)	LSC Factor Score	Use pedality in surface sample and/or surface condition from erosion.	LSC Factor Score	Electrical Conductivity (Sat. Ext.) dS/m to 0.1m (10cm)	LSC Factor Score	Percent rock groundcover	LSC Factor Score	Mean Slope %	LSC Factor Score	Topography (slope and microrelief) (m) Soils	LSC Factor Score	Median Slope % and Sodium % of Cations (ESP) 0.1m	LSC Factor Score	Sodium % of Cations (ESP) >0.5m	LSC Factor Score	Depth to pH 4.5	LSC Factor Score	
		-					-												-		-	-	-	1	
BWM35B 1A		10	60	2	6.2	4	8.3	3	>10mm	2	1.1	1	0	1	9.5	3	<0.4m	3	0.43	1	0.43	-	8.3	1	4
BWM35B 1B		20			<5.0		8.5				1								0.86		0.86		8.5	1	
BWM35B 1C		30			<5.0		9.5				1.8								11		11	2	9.5	1	
BWM35B 1D		-			<5.0		9.3				4.4								18		18	3	9.3	1	
BWM 35B-2A		10	64	2	9.1	3	7.8	2	>10mm	2	1.7	1	0	1	9.5	3	<0.4m	3	0.3	1	0.3	-	7.8	1	3
BWM 35B-2B		24			9.3		8.4				1.1								0.72		0.72		8.4	1	
BWM 35B-2C		30			<5.0		8.8				1.2								3.9		3.9	1	8.8	1	
		-					-												-		-	-	-	1	
BWM00_1A		10	54	3	19	2	7.8	2	>10mm	2	0.8	1	0	1	14.6	3	<0.4m	3	0.33	1	0.33	-	7.8	1	3
BWM00_1B		20			13		7.9				0.9								0.63		0.63		7.9	1	
BWM00_1C		24			<5.0		8.6				1.4								4		4	1	8.6	1	
BWM00_1D		-			<5.0		8.2				4.2								7.4		7.4	2	8.2	1	
BWM00_2A		10	60	2	32	1	8.5	3	>10mm	2	1.4	1	0	1	14.6	3	<0.4m	3	0.25	1	0.25	-	8.5	1	3
BWM00_2B		20			14		8.6				1.3								0.24		0.24		8.6	1	
BWM00_2C		30			7.8		8.8				1.2								1.1		1.1	1	8.8	1	
		-					-												-		-	-	-	1	
BWM05A 1A		10	60	2	19	2	7.3	2	>10mm	2	1.9	1	0	1	9.2	3	<0.4m	3	0.21	1	0.21	-	7.3	1	3
BWM05A 1B		20			20		7.8				1.8								0.26		0.26		7.8	1	

Limitation			Water availability	Nutrient supply				Soil physical factors		Salinity		Rockiness		Topography (slope)				Water, erosion, surface soil		Subsoil erosion		Potential acid forming materials		Grazing Land Suitability Class
Site ID	Soil Core ID	PAWC in ERD			Colwell P to 0.1m		pH in 0.1m		Surface soil structure		EC in ERD dS/m		Fragments on surface		Gradient, surface		Vertical interval, surface		Slope % (ESP in 0.1m)		Subsoil erosion		pH <4.5		
Notes: Good, Fair, Poor		From soil texture lab results 0-10cm, 10-30cm, 30-60cm	Total Core PAWC	LSC Score	Phosphorus (Colwell)	LSC Score	pH (1:5 Water)	LSC Factor Score	Use pedality in surface sample and/or surface condition from erosion.	LSC Factor Score	Electrical Conductivity (Sat. Ext.) dS/m to 0.1m (10cm)	LSC Factor Score	Percent rock groundcover	LSC Factor Score	Mean Slope %	LSC Factor Score	Topography (slope and microrelief) (m) Soils	LSC Factor Score	Median Slope % and Sodium % of Cations (ESP) 0.1m	LSC Factor Score	Sodium % of Cations (ESP) >0.5m	LSC Factor Score	Depth to pH 4.5	LSC Factor Score	
BWM05A 1C		30			15		8.7				1.1								0.42		0.42	1	8.7	1	
		-					-												-		-	-	-	1	
BWM05A 2A		10			45		7.1				1.4								0.27		0.27		7.1	1	
BWM05A 2B		20			20		7.8				1.2								0.24		0.24	-	7.8	1	
		30	60	2		1	-	1	>10mm	2		1	0	1	9.2	3	<0.4m	3	-	1	-	-	-	1	3
		-					-												-		-	-	-	1	
BWM103 1A		10			15		8.1				1.2								0.52		0.52		8.1	1	
BWM103 1B		24			6.6		8.9				1.5								6.4		6.4	-	8.9	1	
BWM103 1C		36	70	2	<5.0	2	9.6	3	>10mm	2	2.2	1	0	1	11.4	3	<0.4m	3	17	1	17	3	9.6	1	3
BWM103 1D		-			<5.0		9.9				2								17		17	3	9.9	1	
BWM103 2A		12			6.5		8.5				1.1								1.3		1.3		8.5	1	
BWM103 2B		24			<5.0		8.6				1.2								3.3		3.3	-	8.6	1	
BWM103 2C		36	72	2	<5.0	4	9.5	3	>10mm	2	1.8	1	0	1	11.4	3	<0.4m	3	12	1	12	2	9.5	1	4
		-					-												-		-	-	-	1	
BWM103A 1A		10			5.8		8.3				0.9								0.6		0.6		8.3	1	
BWM103A 1B		20			<5.0		8.6				1.1								1.5		1.5	-	8.6	1	
BWM103A 1C		30	60	2	<5.0	4	9.9	3	>10mm	2	1.7	1	0	1	11.4	3	<0.4m	3	13	1	13	2	9.9	1	4
		-					-												-		-	-	-	1	
BWM103A 2A		10	64	2	25	1	8.4	3	>10mm	2	1	1	0	1	11.4	3	<0.4m	3	0.38	1	0.38	-	8.4	1	3

Limitation			Water availability	Nutrient supply				Soil physical factors		Salinity		Rockiness		Topography (slope)				Water, erosion, surface soil		Subsoil erosion		Potential acid forming materials		Grazing Land Suitability Class
Site ID	Soil Core ID	PAWC in ERD			Colwell P to 0.1m		pH in 0.1m	Surface soil structure		EC in ERD dS/m		Fragments on surface		Gradient, surface		Vertical interval, surface		Slope % (ESP in 0.1m)		Subsoil erosion		pH <4.5		
Notes: Good, Fair, Poor		From soil texture lab results 0-10cm, 10-30cm, 30-60cm	Total Core PAWC	LSC Score	Phosphorus (Colwell)	LSC Score	pH (1:5 Water)	LSC Factor Score	Use pedality in surface sample and/or surface condition from erosion.	LSC Factor Score	Electrical Conductivity (Sat. Ext.) dS/m to 0.1m (10cm)	LSC Factor Score	Percent rock groundcover	LSC Factor Score	Mean Slope %	LSC Factor Score	Topography (slope and microrelief) (m) Soils	LSC Factor Score	Median Slope % and Sodium % of Cations (ESP) 0.1m	LSC Factor Score	Sodium % of Cations (ESP) >0.5m	LSC Factor Score	Depth to pH 4.5	LSC Factor Score	
BWM103A 2B		24			<5.0		8.9				1.2								4.6		4.6		8.9	1	
BWM103A 2C		30			<5.0		9.6				1.7								12		12	2	9.6	1	
		-					-												-		-	-	-	1	
BWM105B 1A		10			<5.0		8.5				0.9								1.7		1.7	-	8.5	1	
BWM105B 1B		24			<5.0		9				1.6								6.4		6.4		9	1	
BWM105B 1C		36	70	2	5.9	5	9.7	3	>10mm	2	2.5	1	0	1	10.8	3	<0.4m	3	18	1	18	3	9.7	1	5
BWM105B 1D		-			12		8.8				7.2								24		24	4	8.8	1	
BWM105B 2A		10			<5.0		8.5				1								1.3		1.3	-	8.5	1	
BWM105B 2B		24			<5.0		8.7				1.1								3		3		8.7	1	
BWM105B 2C		36	70	2	5.4	5	9.5	3	>10mm	2	2.3	1	0	1	10.8	3	<0.4m	3	15	1	15	3	9.5	1	5
		-					-												-		-	-	-	1	
BWM106 1A		12			7.9		8.3				1.3								0.53		0.53	-	8.3	1	
BWM106 1B		24			<5.0		8.8				1.4								4		4		8.8	1	
BWM106 1C		36	72	2	<5.0	4	9.3	3	>10mm	2	3.1	1	0	1	6	2	<0.4m	3	15	1	15	3	9.3	1	4
		-					-												-		-	-	-	1	
BWM106 2A		12			7.6		8				1.4								0.31		0.31	-	8	1	
BWM106 2B		24			<5.0		8.9				1.6								5.5		5.5		8.9	1	
BWM106 2C		30	66	2	<5.0	4	9.5	2	>10mm	2	2.4	1	0	1	6	2	<0.4m	3	15	1	15	3	9.5	1	4
BWM106 2D		-			<5.0		8.9				7								19		19	3	8.9	1	

Limitation			Water availability		Nutrient supply				Soil physical factors		Salinity		Rockiness		Topography (slope)				Water, erosion, surface soil		Subsoil erosion		Potential acid forming materials		Grazing Land Suitability Class
Site ID	Soil Core ID	PAWC in ERD			Colwell P to 0.1m		pH in 0.1m		Surface soil structure		EC in ERD dS/m		Fragments on surface		Gradient, surface		Vertical interval, surface		Slope % (ESP in 0.1m)		Subsoil erosion		pH <4.5		
Notes: Good, Fair, Poor		From soil texture lab results 0-10cm, 10-30cm, 30-60cm	Total Core PAWC	LSC Score	Phosphorus (Colwell)	LSC Score	pH (1:5 Water)	LSC Factor Score	Use pedality in surface sample and/or surface condition from erosion.	LSC Factor Score	Electrical Conductivity (Sat. Ext.) dS/m to 0.1m (10cm)	LSC Factor Score	Percent rock groundcover	LSC Factor Score	Mean Slope %	LSC Factor Score	Topography (slope and microrelief) (m) Soils	LSC Factor Score	Median Slope % and Sodium % of Cations (ESP) 0.1m	LSC Factor Score	Sodium % of Cations (ESP) >0.5m	LSC Factor Score	Depth to pH 4.5	LSC Factor Score	
BWM108 1A		12	72	2	10	3	8.3	3	>10mm	2	1	1	0	1	8.1	3	<0.4m	3	0.15	1	0.15	-	8.3	1	3
BWM108 1B		24			<5.0		8.4				1.1								0.5		0.5		8.4	1	
		36					-												-		-	-	-	1	
		-					-												-		-	-	-	1	
BWM108 2A		10	60	2	7.9	4	8.1	3	>10mm	2	1.3	1	0	1	8.1	3	<0.4m	3	0.17	1	0.17	-	8.1	1	4
BWM108 2B		20			<5.0		8.4				1.1								0.44		0.44		8.4	1	
BWM108 2C		30			<5.0		8.7				0.9								0.84		0.84	1	8.7	1	
		-					-												-		-	-	-	1	
BWM118 1A		10	70	2	5.9	4	8.7	4	>10mm	2	1.1	1	0	1	6.2	2	<0.4m	3	2.9	1	2.9	-	8.7	1	4
BWM118 1B		24			<5.0		8.9				2.1								9.5		9.5		8.9	1	
		36					-												-		-	-	-	1	
		-					-												-		-	-	-	1	
BWM118 2A		12	72	2	<5.0	5	8.8	4	>10mm	2	1.2	1	0	1	6.2	2	<0.4m	3	3.3	2	3.3	-	8.8	1	5
BWM118 2B		24			5.5		9				1.6								6.9		6.9		9	1	
		36					-												-		-	-	-	1	
		-					-												-		-	-	-	1	
BWM128 1A		10	60	2	<5.0	5	8.7	4	>10mm	2	1	1	0	1	7.8	2	<0.4m	3	0.61	1	0.61	-	8.7	1	5
BWM128 1B		20			<5.0		9				2.2								7.2		7.2		9	1	
BWM128 1C		30			<5.0		9.5				8.6								33		33	4	9.5	1	

Limitation			Water availability		Nutrient supply				Soil physical factors		Salinity		Rockiness		Topography (slope)				Water, erosion, surface soil		Subsoil erosion		Potential acid forming materials		Grazing Land Suitability Class
Site ID	Soil Core ID	PAWC in ERD			Colwell P to 0.1m		pH in 0.1m		Surface soil structure		EC in ERD dS/m		Fragments on surface		Gradient, surface		Vertical interval, surface		Slope % (ESP in 0.1m)		Subsoil erosion		pH <4.5		
Notes: Good, Fair, Poor		From soil texture lab results 0-10cm, 10-30cm, 30-60cm	Total Core PAWC	LSC Score	Phosphorus (Colwell)	LSC Score	pH (1:5 Water)	LSC Factor Score	Use pedality in surface sample and/or surface condition from erosion.	LSC Factor Score	Electrical Conductivity (Sat. Ext.) dS/m to 0.1m (10cm)	LSC Factor Score	Percent rock groundcover	LSC Factor Score	Mean Slope %	LSC Factor Score	Topography (slope and microrelief) (m) Soils	LSC Factor Score	Median Slope % and Sodium % of Cations (ESP) 0.1m	LSC Factor Score	Sodium % of Cations (ESP) >0.5m	LSC Factor Score	Depth to pH 4.5	LSC Factor Score	
		-					-												-		-	-	-	1	
BWM128 2A		10	60	2	<5.0	5	8.9	4	>10mm	2	20	5	0	1	7.8	2	<0.4m	3	44	5	44	-	8.9	1	5
BWM128 2B		20			<5.0		9.1				15.1								40		40		9.1	1	
BWM128 2C		30			<5.0		9.1				16.1								44		44	5	9.1	1	
		-					-												-		-	-	-	1	
BWM130A 1A		12	66	2	5.3	4	8	2	>10mm	2	2.2	2	0	1	7.8	2	<0.4m	3	0.3	1	0.3	-	8	1	4
BWM130A 1B		24			10		7.9				2.2								0.2		0.2		7.9	1	
BWM130A 1C		30			<5.0		8.8				1.1								1.1		1.1	1	8.8	1	
		-					-												-		-	-	-	1	
BWM130A 2A		12	72	2	<5.0	5	8.2	3	>10mm	2	1.8	1	0	1	7.8	2	<0.4m	3	0.78	1	0.78	-	8.2	1	5
BWM130A 2B		24			<5.0		8.2				1.7								0.35		0.35		8.2	1	
BWM130A 2C		36			<5.0		8.4				2.2								3.3		3.3	1	8.4	1	
		-					-												-		-	-	-	1	
BWM149B-1A		10	60	2	5.6	4	8.4	3	>10mm	2	1.5	1	0	1	13.3	3	<0.4m	3	0.35	1	0.35	-	8.4	1	4
BWM149B-1B		20			6.2		8.7				1.5								1.3		1.3		8.7	1	
BWM149B-1C		30			<5.0		8.3				8.5								8.8		8.8	2	8.3	1	
		-					-												-		-	-	-	1	
BWM149B-2A		10	60	2	6.8	4	8.1	3	>10mm	2	1.5	1	0	1	13.3	3	<0.4m	3	0.55	1	0.55	-	8.1	1	4
BWM149B-2B		20			6.5		8.4				1.4								0.55		0.55		8.4	1	

Limitation			Water availability	Nutrient supply				Soil physical factors		Salinity		Rockiness		Topography (slope)				Water, erosion, surface soil		Subsoil erosion		Potential acid forming materials		Grazing Land Suitability Class
Site ID	Soil Core ID	PAWC in ERD			Colwell P to 0.1m		pH in 0.1m			EC in ERD dS/m		Fragments on surface		Gradient, surface		Vertical interval, surface		Slope % (ESP in 0.1m)		Subsoil erosion		pH <4.5		
Notes: Good, Fair, Poor		From soil texture lab results 0-10cm, 10-30cm, 30-60cm	Total Core PAWC	LSC Score	Phosphorus (Colwell)	LSC Score	pH (1:5 Water)	LSC Factor Score	Use pedality in surface sample and/or surface condition from erosion.	LSC Factor Score	Electrical Conductivity (Sat. Ext.) dS/m to 0.1m (10cm)	LSC Factor Score	Percent rock groundcover	LSC Factor Score	Mean Slope %	LSC Factor Score	Topography (slope and microrelief) (m) Soils	LSC Factor Score	Median Slope % and Sodium % of Cations (ESP) 0.1m	LSC Factor Score	Sodium % of Cations (ESP) >0.5m	LSC Factor Score	Depth to pH 4.5	LSC Factor Score	
BWM149B-2C		30			5.1		8.7				1.6								0.57		0.57	1	8.7	1	
		-					-												-		-	-	-	1	
BWM153-1A		12			9.5		8.4				1.7								0.48		0.48		8.4	1	
BWM153-1B		20			6.6		8.6				1.6								1.6		1.6	-	8.6	1	
BWM153-1C		30	62	2	6	3	9.5	3	>10mm	2	2.5	1	0	1	12.3	3	<0.4m	3	9.6	1	9.6	2	9.5	1	3
		-					-												-		-	-	-	1	
BWM153-2A		10			<5.0		8.5				1.5								1.3		1.3		8.5	1	
BWM153-2B		20			<5.0		9.4				1.9								7.7		7.7	-	9.4	1	
		30	60	2		5	-	3	>10mm	2		1	0	1	12.3	3	<0.4m	3	-	2	-	-	-	1	5
		-					-												-		-	-	-	1	
BWM155-1A		12			5.4		8.4				1.3								0.79		0.79		8.4	1	
BWM155-1B		24			<5.0		8.5				1.6								2.1		2.1	-	8.5	1	
BWM155-1C		30	66	2	6.1	4	9.8	3	>10mm	2	2	1	0	1	6.4	2	<0.4m	3	17	1	17	3	9.8	1	4
		-					-												-		-	-	-	1	
BWM155-2A		10			5.5		8.7				0.9								0.31		0.31		8.7	1	
BWM155-2B		20			6.1		8.7				1.1								1.3		1.3	-	8.7	1	
BWM155-2C		30	60	2	<5.0	4	9.6	4	>10mm	2	1.2	1	0	1	6.4	2	<0.4m	3	9.6	1	9.6	2	9.6	1	4
		-					-												-		-	-	-	1	
BWM156-1A		12	66	2	<5.0	5	8.4	3	>10mm	2	0.9	1	0	1	9.7	3	<0.4m	3	0.28	1	0.28	-	8.4	1	5

Limitation			Water availability	Nutrient supply				Soil physical factors		Salinity		Rockiness		Topography (slope)				Water, erosion, surface soil		Subsoil erosion		Potential acid forming materials		Grazing Land Suitability Class
Site ID	Soil Core ID	PAWC in ERD		Colwell P to 0.1m		pH in 0.1m		Surface soil structure		EC in ERD dS/m		Fragments on surface		Gradient, surface		Vertical interval, surface		Slope % (ESP in 0.1m)		Subsoil erosion		pH <4.5		
Notes: Good, Fair, Poor		From soil texture lab results 0-10cm, 10-30cm, 30-60cm	Total Core PAWC	Phosphorus (Colwell)	LSC Score	pH (1:5 Water)	LSC Factor Score	Use pedality in surface sample and/or surface condition from erosion.	LSC Factor Score	Electrical Conductivity (Sat. Ext.) dS/m to 0.1m (10cm)	LSC Factor Score	Percent rock groundcover	LSC Factor Score	Mean Slope %	LSC Factor Score	Topography (slope and microrelief) (m) Soils	LSC Factor Score	Median Slope % and Sodium % of Cations (ESP) 0.1m	LSC Factor Score	Sodium % of Cations (ESP) >0.5m	LSC Factor Score	Depth to pH 4.5	LSC Factor Score	
BWM156-1B		24		5.9		8.6				1.1								1		1		8.6	**1**	
BWM156-1C		30		<5.0		9.6				1.6								8.3		8.3	**2**	9.6	**1**	
		-				-												-		-	**-**	-	**1**	
BWM156-2A		12		<5.0		8.6				0.9								0.65		0.65		8.6	**1**	
BWM156-2B		24		6.1		8.7				1.2								2.1		2.1	**-**	8.7	**1**	
BWM156-2C		30	66	<5.0	**5**	9.2	**4**	>10mm	**2**	1.9	**1**	0	**1**	9.7	**3**	<0.4m	**3**	6.7	**1**	6.7	**1**	9.2	**1**	**5**
		-				-												-		-	**-**	-	**1**	
BWM157-1A		10		8.5		8.3				1.2								0.23		0.23		8.3	**1**	
BWM157-1B		20		6.7		8.6				0.9								0.33		0.33	**-**	8.6	**1**	
BWM157-1C		30	60	<5.0	**3**	9.2	**3**	>10mm	**2**	0.7	**1**	0	**1**	9	**3**	<0.4m	**3**	1	**1**	1	**1**	9.2	**1**	**3**
		-				-												-		-	**-**	-	**1**	
BWM157-2A		10		10		8.4				1								0.17		0.17		8.4	**1**	
BWM157-2B		20		10		8.3				0.9								0.21		0.21	**-**	8.3	**1**	
BWM157-2C		24	54	5.9	**3**	9.1	**3**	>10mm	**2**	0.6	**1**	0	**1**	9	**3**	<0.4m	**3**	0.41	**1**	0.41	**1**	9.1	**1**	**3**
		-				-												-		-	**-**	-	**1**	
BWM157A_1A		10		7.4		8.5				1.4								0.19		0.19		8.5	**1**	
BWM157A_1B		24		<5.0		8.5				1.3								<1		<1	**-**	8.5	**1**	
BWM157A_1C		30	64	<5.0	**4**	9.2	**3**	>10mm	**2**	1.2	**1**	0	**1**	10.3	**3**	<0.4m	**3**	2.2	**1**	2.2	**1**	9.2	**1**	**4**
		-				-												-		-	**-**	-	**1**	

Limitation			Water availability		Nutrient supply				Soil physical factors		Salinity		Rockiness		Topography (slope)				Water, erosion, surface soil		Subsoil erosion		Potential acid forming materials		Grazing Land Suitability Class
Site ID	Soil Core ID	PAWC in ERD			Colwell P to 0.1m		pH in 0.1m		Surface soil structure		EC in ERD dS/m		Fragments on surface		Gradient, surface		Vertical interval, surface		Slope % (ESP in 0.1m)		Subsoil erosion		pH <4.5		
Notes: Good, Fair, Poor		From soil texture lab results 0-10cm, 10-30cm, 30-60cm	Total Core PAWC	LSC Score	Phosphorus (Colwell)	LSC Score	pH (1:5 Water)	LSC Factor Score	Use pedality in surface sample and/or surface condition from erosion.	LSC Factor Score	Electrical Conductivity (Sat. Ext.) dS/m to 0.1m (10cm)	LSC Factor Score	Percent rock groundcover	LSC Factor Score	Mean Slope %	LSC Factor Score	Topography (slope and microrelief) (m) Soils	LSC Factor Score	Median Slope % and Sodium % of Cations (ESP) 0.1m	LSC Factor Score	Sodium % of Cations (ESP) >0.5m	LSC Factor Score	Depth to pH 4.5	LSC Factor Score	
BWM157A-2A		10	60	2	<5.0	5	8.2	3	>10mm	2	2.1	2	0	1	10.3	3	<0.4m	3	0.31	1	0.31	-	8.2	1	5
BWM157A-2B		20			7.9		8.1				1.9								0.27		0.27		8.1	1	
BWM157A-2C		30			5.3		8.9				1.1								0.58		0.58	1	8.9	1	
		-					-												-		-	-	-	1	
BWM161_1A		10	60	2	7.4	4	8.5	3	>10mm	2	1.5	1	0	1	7.5	2	<0.4m	3	0.23	1	0.23	-	8.5	1	4
BWM161_1B		20			<5.0		8.6				1.4								0.26		0.26		8.6	1	
BWM161_1C		30			<5.0		9.1				1.6								2.3		2.3	1	9.1	1	
		-					-												-		-	-	-	1	
BWM161_2A		10	60	2	15	2	8.3	3	>10mm	2	1.8	1	0	1	7.5	2	<0.4m	3	0.18	1	0.18	-	8.3	1	3
BWM161_2B		20			<5.0		8.6				1.4								0.19		0.19		8.6	1	
BWM161_2C		30			<5.0		8.8				1.4								0.78		0.78	1	8.8	1	
		-					-												-		-	-	-	1	
BWM162_1A		12	66	2	7.9	4	8.4	3	>10mm	2	1.6	1	0	1	11.5	3	<0.4m	3	0.33	1	0.33	-	8.4	1	4
BWM162_1B		24			6.8		8.6				0.9								1.1		1.1		8.6	1	
BWM162_1C		30			<5.0		9.7				2								12		12	2	9.7	1	
BWM162_1D		-			<5.0		9.8				2.6								17		17	3	9.8	1	
BWM162_2A		10	60	2	6.2	4	8.3	3	>10mm	2	1.2	1	0	1	11.5	3	<0.4m	3	0.43	1	0.43	-	8.3	1	4
BWM162_2B		20			7.2		7.9				1.1								1.1		1.1		7.9	1	
BWM162_2C		30			21		9				3								17		17	3	9	1	

Limitation			Water availability	Nutrient supply				Soil physical factors		Salinity		Rockiness		Topography (slope)				Water, erosion, surface soil		Subsoil erosion		Potential acid forming materials		Grazing Land Suitability Class
Site ID	Soil Core ID	PAWC in ERD			Colwell P to 0.1m		pH in 0.1m		Surface soil structure		EC in ERD dS/m		Fragments on surface		Gradient, surface		Vertical interval, surface		Slope % (ESP in 0.1m)		Subsoil erosion		pH <4.5		
Notes: Good, Fair, Poor		From soil texture lab results 0-10cm, 10-30cm, 30-60cm	Total Core PAWC	LSC Score	Phosphorus (Colwell)	LSC Score	pH (1:5 Water)	LSC Factor Score	Use pedality in surface sample and/or surface condition from erosion.	LSC Factor Score	Electrical Conductivity (Sat. Ext.) dS/m to 0.1m (10cm)	LSC Factor Score	Percent rock groundcover	LSC Factor Score	Mean Slope %	LSC Factor Score	Topography (slope and microrelief) (m) Soils	LSC Factor Score	Median Slope % and Sodium % of Cations (ESP) 0.1m	LSC Factor Score	Sodium % of Cations (ESP) >0.5m	LSC Factor Score	Depth to pH 4.5	LSC Factor Score	
		-					-												-		-	-	-	1	
BWM164A_1A		10	60	2	23	1	8.5	3	>10mm	2	1.2	1	0	1	7	2	<0.4m	3	0.55	1	0.55	-	8.5	1	3
BWM164A_1B		20			6.8		8.7				1.2								1.8		1.8		8.7	1	
BWM164A_1C		30			5.9		9.4				1.6								7.8		7.8	2	9.4	1	
		-					-												-		-	-	-	1	
BWM164A_2A		10	60	2	21	1	7.6	2	>10mm	2	1	1	0	1	7	2	<0.4m	3	0.37	1	0.37	-	7.6	1	3
BWM164A_2B		20			11		7.5				0.8								0.57		0.57		7.5	1	
		30					-												-		-	-	-	1	
		-					-												-		-	-	-	1	
BWM166_1A		10	60	2	15	2	8.4	3	>10mm	2	3	2	0	1	6	2	<0.4m	3	3.6	2	3.6	-	8.4	1	3
BWM166_1B		20			12		8.3				2.2								4.2		4.2		8.3	1	
		30					-												-		-	-	-	1	
		-					-												-		-	-	-	1	
BWM166_2A		12	72	2	6.5	4	8.6	4	>10mm	2	1.7	1	0	1	6	2	<0.4m	3	2.3	1	2.3	-	8.6	1	4
BWM166_2B		24			<5.0		8.8				2								5.2		5.2		8.8	1	
BWM166_2C		36			<5.0		8.8				2.3								6.2		6.2	1	8.8	1	
		-					-												-		-	-	-	1	
BWM167B_1A		10	66	2	21	1	7.8	2	>10mm	2	1.9	1	0	1	12	3	<0.4m	3	4.7	2	4.7	-	7.8	1	4
BWM167B_1B		20			29		7.3				3.3								6.7		6.7		7.3	1	

Limitation			Water availability	Nutrient supply				Soil physical factors		Salinity		Rockiness		Topography (slope)				Water, erosion, surface soil		Subsoil erosion		Potential acid forming materials		Grazing Land Suitability Class
Site ID	Soil Core ID	PAWC in ERD			Colwell P to 0.1m		pH in 0.1m			EC in ERD dS/m		Fragments on surface		Gradient, surface		Vertical interval, surface		Slope % (ESP in 0.1m)		Subsoil erosion		pH <4.5		
Notes: Good, Fair, Poor		From soil texture lab results 0-10cm, 10-30cm, 30-60cm	Total Core PAWC	LSC Score	Phosphorus (Colwell)	LSC Score	pH (1:5 Water)	LSC Factor Score	Use pedality in surface sample and/or surface condition from erosion.	LSC Factor Score	Electrical Conductivity (Sat. Ext.) dS/m to 0.1m (10cm)	LSC Factor Score	Percent rock groundcover	LSC Factor Score	Mean Slope %	LSC Factor Score	Topography (slope and microrelief) (m) Soils	LSC Factor Score	Median Slope % and Sodium % of Cations (ESP) 0.1m	LSC Factor Score	Sodium % of Cations (ESP) >0.5m	LSC Factor Score	Depth to pH 4.5	LSC Factor Score	
BWM167B_1C		36			9.4		6.2				4.9								24		24	**4**	6.2	**1**	
BWM167B_1D		-			14		5.3				4.8								26		26	**4**	5.3	**1**	
BWM167B_2A		10			39		7.7				1								0.66		0.66		7.7	**1**	
BWM167B_2B		20			31		8.1				1.1								1.8		1.8	-	8.1	**1**	
BWM167B_2C		36	66	**2**	20	**1**	8.2	**2**	>10mm	**2**	1.7	**1**	0	**1**	12	**3**	<0.4m	**3**	7.6	**1**	7.6	**2**	8.2	**1**	**3**
		-					-												-		-	**-**	-	**1**	
BWM169_1A		10			29		8.3				2								8		8		8.3	**1**	
BWM169_1B		20			17		8.3				2.2								8.5		8.5	-	8.3	**1**	
BWM169_1C		30	60	**2**	15	**1**	8.4	**3**	>10mm	**2**	2.4	**2**	0	**1**	6	**2**	<0.4m	**3**	7.9	**3**	7.9	**2**	8.4	**1**	**3**
BWM169_1D		-			<5.0		9.5				2.7								13		13	**2**	9.5	**1**	
BWM169_2A		10			14		7.2				1.1								5.4		5.4		7.2	**1**	
BWM169_2B		20			<5.0		8.8				2.6								12		12	-	8.8	**1**	
BWM169_2C		30	60	**2**	7.9	**2**	7	**1**	>10mm	**2**	0.9	**1**	0	**1**	6	**2**	<0.4m	**3**	8.5	**2**	8.5	**2**	7	**1**	**3**
		-					-												-		-	**-**	-	**1**	
BWM173_1A		10			24		7.1				0.9								0.53		0.53		7.1	**1**	
BWM173_1B		20			11		6.9				0.9								0.67		0.67	-	6.9	**1**	
BWM173_1C		30	60	**2**	5.4	**1**	6.2	**1**	>10mm	**2**	2.3	**1**	0	**1**	13.8	**3**	<0.4m	**3**	8.1	**1**	8.1	**2**	6.2	**1**	**3**
BWM173_1D		-			6.4		6				5.8								14		14	**2**	6	**1**	
BWM173_2A		10	60	**2**	7.4	**4**	6.6	**1**	>10mm	**2**	1.1	**1**	0	**1**	13.8	**3**	<0.4m	**3**	3.1	**2**	3.1	-	6.6	**1**	**4**

Limitation			Water availability		Nutrient supply				Soil physical factors		Salinity		Rockiness		Topography (slope)				Water, erosion, surface soil		Subsoil erosion		Potential acid forming materials		Grazing Land Suitability Class
Site ID	Soil Core ID	PAWC in ERD			Colwell P to 0.1m		pH in 0.1m		Surface soil structure		EC in ERD dS/m		Fragments on surface		Gradient, surface		Vertical interval, surface		Slope % (ESP in 0.1m)		Subsoil erosion		pH <4.5		
Notes: Good, Fair, Poor		From soil texture lab results 0-10cm, 10-30cm, 30-60cm	Total Core PAWC	LSC Score	Phosphorus (Colwell)	LSC Score	pH (1:5 Water)	LSC Factor Score	Use pedality in surface sample and/or surface condition from erosion.	LSC Factor Score	Electrical Conductivity (Sat. Ext.) dS/m to 0.1m (10cm)	LSC Factor Score	Percent rock groundcover	LSC Factor Score	Mean Slope %	LSC Factor Score	Topography (slope and microrelief) (m) Soils	LSC Factor Score	Median Slope % and Sodium % of Cations (ESP) 0.1m	LSC Factor Score	Sodium % of Cations (ESP) >0.5m	LSC Factor Score	Depth to pH 4.5	LSC Factor Score	
BWM173_2B		20			7.8		6.1				1								2.5		2.5		6.1	1	
		30					-												-		-	-	-	1	
		-					-												-		-	-	-	1	
BWM208B 1A		10			7.1		7.9				1.8								0.17		0.17		7.9	1	
BWM208B 1B		24			<5.0		8.3				1.4								0.87		0.87	-	8.3	1	
BWM208B 1C		36	70	2	<5.0	4	9.1	2	>10mm	2	2.9	1	0	1	10.4	3	<0.4m	3	11	1	11	2	9.1	1	4
		-					-												-		-	-	-	1	
BWM208B 2A		10			<5.0		8.5				1								0.46		0.46		8.5	1	
BWM208B 2B		20			<5.0		8.6				1.2								2.8		2.8	-	8.6	1	
BWM208B 2C		30	60	2	<5.0	5	9.7	3	>10mm	2	3	1	0	1	10.4	3	<0.4m	3	20	1	20	3	9.7	1	5
		-					-												-		-	-	-	1	
BWM188A_1A		12			<5.0		6.1				1.7								9.2		9.2		6.1	1	
BWM188A_1B		20			<5.0		6.1				2.4								12		12	-	6.1	1	
BWM188A_1C		30	62	2	<5.0	5	6.7	2	>10mm	2	3	1	0	1	11.6	3	<0.4m	3	16	3	16	3	6.7	1	5
		-					-												-		-	-	-	1	
BWM32_1A		10			<5.0		6.7				0.4								2.3		2.3		6.7	1	
BWM32_1B		20			<5.0		6.8				0.6								7.3		7.3	-	6.8	1	
BWM32_1C		36	66	2	9.3	5	5.9	1	>10mm	2	4	1	0	1	13.1	3	<0.4m	3	28	1	28	4	5.9	1	5
		-					-												-		-	-	-	1	

Limitation			Water availability	Nutrient supply				Soil physical factors		Salinity		Rockiness		Topography (slope)				Water, erosion, surface soil		Subsoil erosion		Potential acid forming materials		Grazing Land Suitability Class
Site ID	Soil Core ID	PAWC in ERD		Colwell P to 0.1m		pH in 0.1m		Surface soil structure		EC in ERD dS/m		Fragments on surface		Gradient, surface		Vertical interval, surface		Slope % (ESP in 0.1m)		Subsoil erosion		pH <4.5		
Notes: Good, Fair, Poor		From soil texture lab results 0-10cm, 10-30cm, 30-60cm	Total Core PAWC	Phosphorus (Colwell)	LSC Score	pH (1:5 Water)	LSC Factor Score	Use pedality in surface sample and/or surface condition from erosion.	LSC Factor Score	Electrical Conductivity (Sat. Ext.) dS/m to 0.1m (10cm)	LSC Factor Score	Percent rock groundcover	LSC Factor Score	Mean Slope %	LSC Factor Score	Topography (slope and microrelief) (m) Soils	LSC Factor Score	Median Slope % and Sodium % of Cations (ESP) 0.1m	LSC Factor Score	Sodium % of Cations (ESP) >0.5m	LSC Factor Score	Depth to pH 4.5	LSC Factor Score	
BWM35A 1A		12	66	<5.0	5	8.5	3	>10mm	2	0.9	1	0	1	12	3	<0.4m	3	0.49	1	0.49	-	8.5	1	5
BWM35A 1B		24		<5.0		9				1.6								7		7		9	1	
BWM35A 1C		30		<5.0		9.3				2.6								13		13	2	9.3	1	
		-				-												-		-	-	-	1	
BWM42_1A		12	62	6.3	4	8.7	4	>10mm	2	3.7	2	0	1	8.6	3	<0.4m	3	9.7	3	9.7	-	8.7	1	4
BWM42_1B		20		5.3		8.1				14.4								6.2		6.2		8.1	1	
		30				-												-		-	-	-	1	
		-				-												-		-	-	-	1	
BWM42_2A		10	60	5.6	4	8.4	3	>10mm	2	4	3	0	1	8.6	3	<0.4m	3	3.9	2	3.9	-	8.4	1	4
BWM42_2B		20		5.5		8.7				2.4								5.3		5.3		8.7	1	
BWM42_2C		30		<5.0		8.7				2.9								6.3		6.3	1	8.7	1	
		-				-												-		-	-	-	1	
BWMR44-01-1A		12	66	5.5	4	9	4	>10mm	2	2.2	2	0	1	9.3	3	<0.4m	3	6.8	3	6.8	-	9	1	4
BWMR44-01-1B		24		6.4		8.8				3.5								8		8		8.8	1	
BWMR44-01-1C		30		6.3		9.3				2.3								9		9	2	9.3	1	
		-				-												-		-	-	-	1	
BWMR44-01-2A		12	72	6.3	4	9	4	>10mm	2	2.2	2	0	1	9.3	3	<0.4m	3	6.8	3	6.8	-	9	1	4
BWMR44-01-2B		24		9		9.2				2.7								10		10		9.2	1	
		36				-												-		-	-	-	1	

Limitation			Water availability		Nutrient supply				Soil physical factors		Salinity		Rockiness		Topography (slope)				Water, erosion, surface soil		Subsoil erosion		Potential acid forming materials		Grazing Land Suitability Class
Site ID	Soil Core ID	PAWC in ERD			Colwell P to 0.1m		pH in 0.1m		Surface soil structure		EC in ERD dS/m		Fragments on surface		Gradient, surface		Vertical interval, surface		Slope % (ESP in 0.1m)		Subsoil erosion		pH <4.5		
Notes: Good, Fair, Poor		From soil texture lab results 0-10cm, 10-30cm, 30-60cm	Total Core PAWC	LSC Score	Phosphorus (Colwell)	LSC Score	pH (1:5 Water)	LSC Factor Score	Use pedality in surface sample and/or surface condition from erosion.	LSC Factor Score	Electrical Conductivity (Sat. Ext.) dS/m to 0.1m (10cm)	LSC Factor Score	Percent rock groundcover	LSC Factor Score	Mean Slope %	LSC Factor Score	Topography (slope and microrelief) (m) Soils	LSC Factor Score	Median Slope % and Sodium % of Cations (ESP) 0.1m	LSC Factor Score	Sodium % of Cations (ESP) >0.5m	LSC Factor Score	Depth to pH 4.5	LSC Factor Score	
		-					-												-		-	-	-	1	
BWMR50-01-1A		10	60	2	10	3	9.5	5	>10mm	2	1.6	1	0	1	8.3	3	<0.4m	3	11	4	11	-	9.5	1	5
BWMR50-01-1B		20			10		9.4				2.8								21		21		9.4	1	
BWMR50-01-1C		30			7.1		9.5				5								27		27	4	9.5	1	
		-					-												-		-	-	-	1	
BWMR50-01-2A		10	60	2	27	1	8.9	4	>10mm	2	0.7	1	0	1	8.3	3	<0.4m	3	2.2	1	2.2	-	8.9	1	4
BWMR50-01-2B		20			22		9.1				0.8								4.6		4.6		9.1	1	
BWMR50-01-2C		30			10		9.8				1.7								17		17	3	9.8	1	
		-					-												-		-	-	-	1	
BWMR54N_1A		10	60	2	<5.0	5	8.8	4	>10mm	2	1.5	1	0	1	6.6	2	<0.4m	3	3.2	2	3.2	-	8.8	1	5
BWMR54N_1B		20			5.4		8.8				1.6								3.8		3.8		8.8	1	
BWMR54N_1C		30			<5.0		9.7				2.1								12		12	2	9.7	1	
		-					-												-		-	-	-	1	
BWMR54N_2A		10	60	2	<5.0	5	8.9	4	>10mm	2	1.5	1	0	1	6.6	2	<0.4m	3	3.9	2	3.9	-	8.9	1	5
BWMR54N_2B		20			5.1		9				1.5								4.7		4.7		9	1	
BWMR54N_2C		30			<5.0		9.9				2.7								19		19	3	9.9	1	
		-					-												-		-	-	-	1	
BWMR56S_1A		8	54	3	11	3	7.3	2	>10mm	2	1	1	0	1	5.7	2	<0.4m	3	1.6	1	1.6	-	7.3	1	3
BWMR56S_1B		16			6.2		7.3				0.9								0.97		0.97		7.3	1	

Limitation			Water availability	Nutrient supply				Soil physical factors		Salinity		Rockiness		Topography (slope)				Water, erosion, surface soil		Subsoil erosion		Potential acid forming materials		Grazing Land Suitability Class
Site ID	Soil Core ID	PAWC in ERD			Colwell P to 0.1m		pH in 0.1m			EC in ERD dS/m		Fragments on surface		Gradient, surface		Vertical interval, surface		Slope % (ESP in 0.1m)		Subsoil erosion		pH <4.5		
Notes: Good, Fair, Poor		From soil texture lab results 0-10cm, 10-30cm, 30-60cm	Total Core PAWC	LSC Score	Phosphorus (Colwell)	LSC Score	pH (1:5 Water)	LSC Factor Score	Use pedality in surface sample and/or surface condition from erosion.	LSC Factor Score	Electrical Conductivity (Sat. Ext.) dS/m to 0.1m (10cm)	LSC Factor Score	Percent rock groundcover	LSC Factor Score	Mean Slope %	LSC Factor Score	Topography (slope and microrelief) (m) Soils	LSC Factor Score	Median Slope % and Sodium % of Cations (ESP) 0.1m	LSC Factor Score	Sodium % of Cations (ESP) >0.5m	LSC Factor Score	Depth to pH 4.5	LSC Factor Score	
BWMR56S_1C		30			<5.0		8.7				3.3								4.8		4.8	1	8.7	1	
BWMR56S_1D		-			<5.0		8.5				4.4								6.9		6.9	1	8.5	1	
BWMR56S_2A		5			5.9		7.1				1.5								0.91		0.91	-	7.1	1	
BWMR56S_2B		10			<5.0		7.3				0.3								1.6		1.6		7.3	1	
BWMR56S_2C		30	45	3	<5.0	4	8.5	1	>10mm	2	1.1	1	0	1	5.7	2	<0.4m	3	2.1	1	2.1	1	8.5	1	4
		-					-												-		-	-	-	1	
BWMR80A-1A		10			<5.0		5.9				0.5								2.1		2.1	-	5.9	1	
BWMR80A-1B		10			6.1		5.8				1.1								4.4		4.4		5.8	1	
		15	35	4		5	-	3	>10mm	2		1	0	1	10	1	<0.4m	3	-	1	-	-	-	1	5
		-					-												-		-	-	-	1	
BWMR80B-1A		5			6.7		6.2				0.6								4.7		4.7	-	6.2	1	
BWMR80B-1B		10			7.1		6.2				0.3								2.9		2.9		6.2	1	
BWMR80B-1C		15	30	4	<5.0	4	6.6	2	>10mm	2	0.3	1	0	1	10	1	<0.4m	3	13	2	13	2	6.6	1	4
		-					-												-		-	-	-	1	
BWMR80C-1A		5			18		5.6				0.3								0.9		<1	-	5.6	1	
BWMR80C-1B		10			10		5.8				0.3								1.5		1.5		5.8	1	
BWMR80C-1C		30	45	3	6.1	2	4.5	3	>10mm	2	1	1	0	1	10	1	<0.4m	3	10	1	10	2	4.5	5	5
		-					-												-		-	-	-	1	
BWMR44-TS1		12	72	2	8.6	3	8.7	4	>10mm	2	3.4	2	0	1	1	1	<0.4m	3	12	3	12	-	8.7	1	4

Limitation			Water availability	Nutrient supply				Soil physical factors		Salinity		Rockiness		Topography (slope)				Water, erosion, surface soil		Subsoil erosion		Potential acid forming materials		Grazing Land Suitability Class
Site ID	Soil Core ID	PAWC in ERD		Colwell P to 0.1m		pH in 0.1m		Surface soil structure		EC in ERD dS/m		Fragments on surface		Gradient, surface		Vertical interval, surface		Slope % (ESP in 0.1m)		Subsoil erosion		pH <4.5		
Notes: Good, Fair, Poor		From soil texture lab results 0-10cm, 10-30cm, 30-60cm	Total Core PAWC	Phosphorus (Colwell)	LSC Score	pH (1:5 Water)	LSC Factor Score	Use pedality in surface sample and/or surface condition from erosion.	LSC Factor Score	Electrical Conductivity (Sat. Ext.) dS/m to 0.1m (10cm)	LSC Factor Score	Percent rock groundcover	LSC Factor Score	Mean Slope %	LSC Factor Score	Topography (slope and microrelief) (m) Soils	LSC Factor Score	Median Slope % and Sodium % of Cations (ESP) 0.1m	LSC Factor Score	Sodium % of Cations (ESP) >0.5m	LSC Factor Score	Depth to pH 4.5	LSC Factor Score	
		24				-												-		-		-	1	
		36				-												-		-	-	-	1	
		-				-												-		-	-	-	1	
BWMR44-TS2		12		<5.0		9.1		>10mm		2.7		0		1		<0.4m		9		9		9.1	1	
		24				-												-		-	-	-	1	
		36	72			-												-		-	-	-	1	
		-				-												-		-	-	-	1	
BWMR44-TS3		12		<5.0		9		>10mm		2.7		0		1		<0.4m		8.7		8.7		9	1	
		24				-												-		-	-	-	1	
		36	72			-												-		-	-	-	1	
		-				-												-		-	-	-	1	
BWMR44-TS4		12		<5.0		9		>10mm		3		0		1		<0.4m		10		10		9	1	
		24				-												-		-	-	-	1	
		36	72			-												-		-	-	-	1	
		-				-												-		-	-	-	1	
R80HWTS1A		10		<5.0		6.2		>10mm		0.1		0		1		<0.4m		1.2		1.2		6.2	1	
R80HWTS1B		20		6.1		5.4				0.7								3.8		3.8		5.4	1	
R80HWTS1C		30	60	<5.0		5.3				0.6								4.7		4.7	1	5.3	1	
		-				-												-		-	-	-	1	

Limitation			Water availability		Nutrient supply				Soil physical factors		Salinity		Rockiness		Topography (slope)				Water, erosion, surface soil		Subsoil erosion		Potential acid forming materials		Grazing Land Suitability Class
Site ID	Soil Core ID	PAWC in ERD			Colwell P to 0.1m		pH in 0.1m		Surface soil structure		EC in ERD dS/m		Fragments on surface		Gradient, surface		Vertical interval, surface		Slope % (ESP in 0.1m)		Subsoil erosion		pH <4.5		
Notes: Good, Fair, Poor		From soil texture lab results 0-10cm, 10-30cm, 30-60cm	Total Core PAWC	LSC Score	Phosphorus (Colwell)	LSC Score	pH (1:5 Water)	LSC Factor Score	Use pedality in surface sample and/or surface condition from erosion.	LSC Factor Score	Electrical Conductivity (Sat. Ext.) dS/m to 0.1m (10cm)	LSC Factor Score	Percent rock groundcover	LSC Factor Score	Mean Slope %	LSC Factor Score	Topography (slope and microrelief) (m) Soils	LSC Factor Score	Median Slope % and Sodium % of Cations (ESP) 0.1m	LSC Factor Score	Sodium % of Cations (ESP) >0.5m	LSC Factor Score	Depth to pH 4.5	LSC Factor Score	
R80HWTS2A		10	60	2	<5.0	5	6.9	1	>10mm	2	0.4	1	0	1	1	1	<0.4m	3	1	1	1	-	6.9	1	5
R80HWTS2B		20			<5.0		6.5				0.2								2		2		6.5	1	
R80HWTS2C		30			<5.0		6.9				0.2								2.3		2.3	1	6.9	1	
R80HWTS2D		-			<5.0		7.2				0.2								2.9		2.9	1	7.2	1	

Attachment Four – Cattle Grazing land Condition FY24 (BMA, 2024a)

Site	Estimated DM Yield and % of Preferred Pasture Species			Crown Cover		Annual Grass % DM Yield		Undesirable Grasses and Other Weeds % DM Yield		Pasture Condition Score	Soil condition/ erosion rating	Land condition rating
	Value (kg/ha)	Value (%)	Score	Value	Score	Value	Score	Value	Score			
BWM_R28_01	2666	6	4	moderate density and some plants dead	3	0	1	1	1	3	no erosion	Poor (C)
BWM_R54_01	436	70	2	sparse and many plants dead	4	0	1	0	1	4	no erosion	Degraded (D)
BWM_REF01	2833	100	1	dense and some plants unhealthy	2	0	1	0	1	2	no erosion	Fair (B)
BWM_REF03	3000	100	1	dense and some plants unhealthy	2	0	1	0	1	2	no erosion	Fair (B)
BWM40	2500	100	1	dense and some plants unhealthy	2	0	1	0	1	2	minor	Fair (B)
BWM41	3833	100	1	dense and some plants unhealthy	2	0	1	0	1	2	minor	Fair (B)
Inv_BWM116B	500	100	1	sparse and many plants dead	2	0	1	0	1	4	no erosion	Degraded (D)
Inv_BWM130	1000	100	1	sparse and many plants dead	2	0	1	0	1	4	no erosion	Degraded (D)
BWM03	3000	100	1	sparse and many plants dead	2	0	1	0	1	2	no erosion	Fair (B)

Attachment Five – Cattle Grazing land Condition FY24 (LEC, 2024a)

Site	Estimated DM Yield and % of Preferred Pasture Species			Crown Cover		Annual Grass % DM Yield		Undesirable Grasses and Other Weeds % DM Yield	Pasture Yield and Condition Score		Number of 3P Grasses	Soil Condition	Land Condition Score ABCD
	Value (kg/ha)	Value (%)	Score	Value	Score	Value	Score	Value	Score		Value		
BWM00	2667	100	1	High to moderate density and some plants unhealthy	2	0	1	0	1	Good (B=2)	2	Moderate Erosion	Poor (C)
BWM01	2833	100	2	Dense and plants healthy	1	0	1	0	1	Good (B=2)	1	Stable	Good (A)
BWM05A	3167	77	2	High to moderate density and some plants unhealthy	2	0	1	20	2	Good (B=2)	1	Stable	Fair (B)
BWM103	3333	100	1	Dense and plants healthy	1	0	1	0	1	Good (B=2)	1	Stable	Good (A)
BWM103A	4000	100	1	Dense and plants healthy	1	0	1	0	1	Good (B=2)	1	Stable	Good (A)
BWM104	3667	100	1	Dense and plants healthy	1	0	1	0	1	Good (B=2)	1	Stable	Good (A)
BWM105A	3000	100	1	Dense and plants healthy	1	0	1	0	1	Good (B=2)	1	Stable	Good (A)
BWM105B	3000	100	1	Dense and plants healthy	1	0	1	0	1	Good (B=2)	1	Stable	Fair (B)
BWM106	3167	83	1	High to moderate density and some plants unhealthy	2	0	1	13	1	Good (B=2)	1	Stable	Fair (B)
BWM107	3000	100	1	Dense and plants healthy	1	0	1	0	1	Good (B=2)	2	Stable	Good (A)
BWM108	3500	100	1	Dense and plants healthy	1	0	1	0	1	Good (B=2)	1	Stable	Good (A)
BWM118	4333	100	2	Dense and plants healthy	1	0	1	0	1	Good (B=2)	1	Stable	Good (A)
BWM120	3000	100	2	Dense and plants healthy	1	0	1	0	1	Good (B=2)	1	Stable	Good (A)
BWM124	3333	100	2	High to moderate density and some plants unhealthy	2	0	1	0	1	Good (B=2)	2	Stable	Good (A)
BWM128	3000	100	2	High to moderate density and some plants unhealthy	2	0	1	0	1	Good (B=2)	1	Stable	Fair (B)
BWM130A	2833	100	2	High to moderate density and some plants unhealthy	2	0	1	0	1	Good (B=2)	1	Stable	Fair (B)
BWM147A	3000	100	1	Dense and plants healthy	1	0	1	0	1	Good (B=2)	1	Stable	Good (A)

Site	Estimated DM Yield and % of Preferred Pasture Species			Crown Cover		Annual Grass % DM Yield		Undesirable Grasses and Other Weeds % DM Yield	Pasture Yield and Condition Score		Number of 3P Grasses	Soil Condition	Land Condition Score ABCD
	Value (kg/ha)	Value (%)	Score	Value	Score	Value	Score	Value	Score		Value		
BWM148	3000	100	1	Dense and plants healthy	1	0	1	0	1	Good (B=2)	1	Stable	Good (A)
BWM149B	1667	100	1	Moderate to low density and some plants dead	3	0	1	22	2	Poor (C=3)	1	Stable	Poor (C)
BWM153	3000	100	1	High to moderate density and some plants unhealthy	2	0	1	0	1	Good (B=2)	1	Stable	Fair (B)
BWM155	3000	100	1	High to moderate density and some plants unhealthy	2	0	1	0	1	Good (B=2)	1	Stable	Fair (B)
BWM156	2833	100	1	High to moderate density and some plants unhealthy	2	0	1	0	1	Good (B=2)	1	Stable	Fair (B)
BWM157	2500	100	1	High to moderate density and some plants unhealthy	2	0	1	0	1	Good (B=2)	1	Stable	Fair (B)
BWM157A	3500	100	1	High to moderate density and some plants unhealthy	2	0	1	0	1	Good (B=2)	1	Stable	Fair (B)
BWM161	2500	93	1	High to moderate density and some plants unhealthy	2	0	1	20	2	Good (B=2)	1	Stable	Fair (B)
BWM162	2833	100	1	High to moderate density and some plants unhealthy	2	0	1	0	1	Good (B=2)	1	Stable	Fair (B)
BWM164A	2833	80	1	High to moderate density and some plants unhealthy	2	0	1	20	2	Good (B=2)	2	Stable	Fair (B)
BWM166	3667	100	1	High to moderate density and some plants unhealthy	2	0	1	0	1	Good (B=2)	3	Stable	Fair (B)
BWM167B	2167	100	1	High to moderate density and some plants unhealthy	2	0	1	0	1	Good (B=2)	1	Slight Erosion	Fair (B)
BWM169	2333	68	2	Moderate to low density and some plants dead	3	0	1	35	3	Poor (C=3)	4	Stable	Poor (C)
BWM173	3000	100	1	High to moderate density and some plants unhealthy	2	0	1	0	1	Good (B=2)	1	Stable	Fair (B)
BWM188A	3000	100	1	High to moderate density and some plants unhealthy	2	0	1	0	1	Good (B=2)	2	Stable	Fair (B)
BWM208B	2667	100	2	High to moderate density and some plants unhealthy	2	0	1	0	1	Good (B=2)	1	Stable	Fair (B)

Site	Estimated DM Yield and % of Preferred Pasture Species			Crown Cover		Annual Grass % DM Yield		Undesirable Grasses and Other Weeds % DM Yield	Pasture Yield and Condition Score		Number of 3P Grasses	Soil Condition	Land Condition Score ABCD
	Value (kg/ha)	Value (%)	Score	Value	Score	Value	Score	Value	Score		Value		
BWM35B	3000	73	2	High to moderate density and some plants unhealthy	2	0	1	27	2	Good (B=2)	1	Moderate Erosion	Poor (C)
BWM38A	2500	100	2	High to moderate density and some plants unhealthy	2	0	1	0	1	Good (B=2)	1	Stable	Fair (B)
BWM42	3500	100	1	Moderate to low density and some plants dead	3	0	1	0	1	Poor (C=3)	2	Stable	Poor (C)
BWMR44_01	1000	0	4	Moderate to low density and some plants dead	3	0	1	0	1	Very poor (D=4)	0	Stable	Very Poor (D)
BWMR50_01	2167	100	1	High to moderate density and some plants unhealthy	2	0	1	0	1	Good (B=2)	3	Stable	Fair (B)
BWMR54N	3000	100	1	Dense and plants healthy	1	0	1	0	1	Good (B=2)	1	Stable	Fair (B)
BWMR56S	2667	100	1	High to moderate density and some plants unhealthy	2	0	1	0	1	Good (B=2)	2	Stable	Fair (B)

Attachment Six – Woodland Habitat Results FY24 (BMA, 2024a)

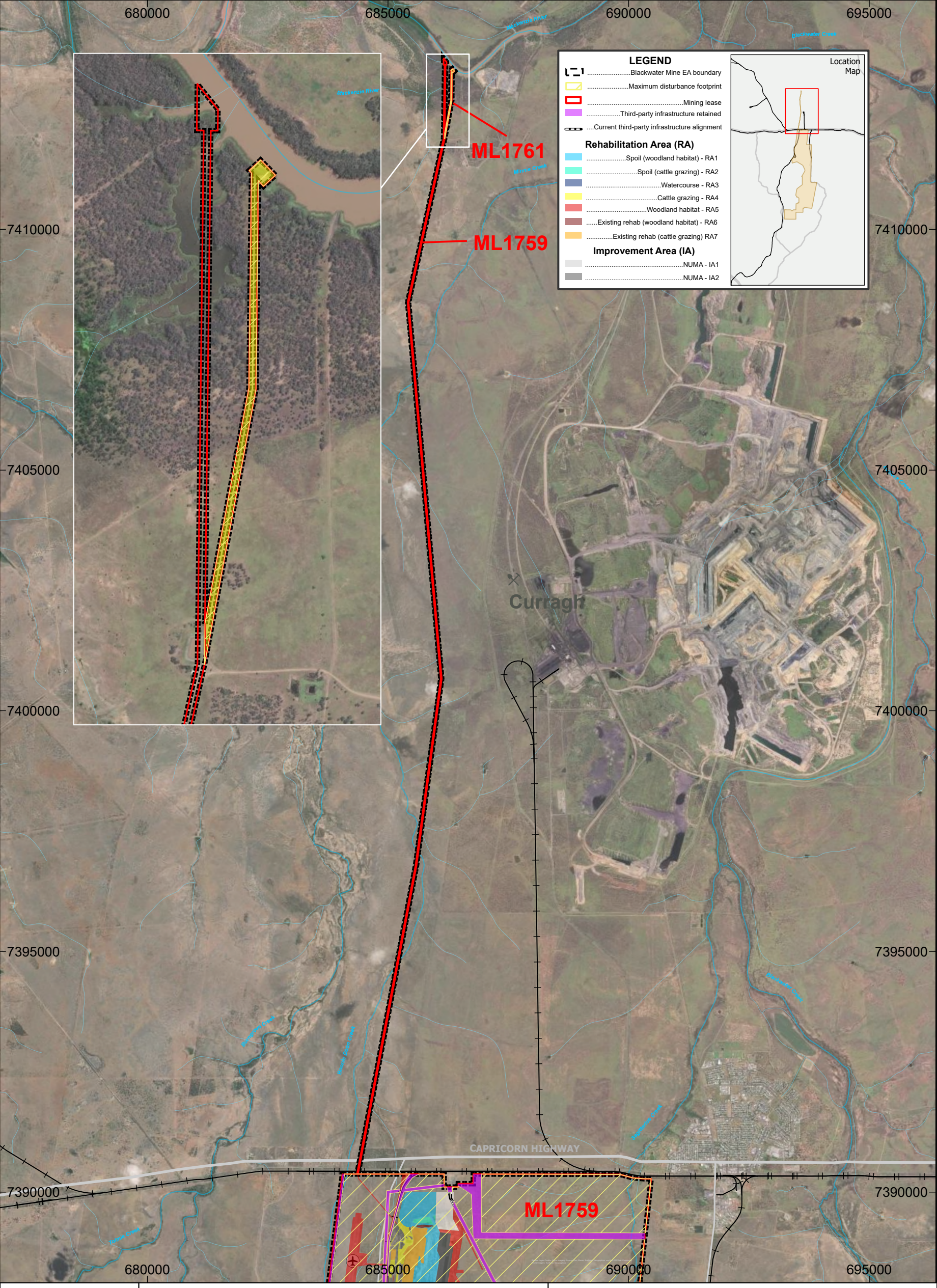
Site	Species Richness: Trees			Species Richness: Shrub			Species Richness: Grass			Tree Canopy Cover (%)			Total Groundcover (%)			Invasive Species Cover (%)			Recruitment			Woodland Score
	Value	Score	Weighted Score	Value	Score	Weighted Score	Value	Score	Weighted Score	Value	Score	Weighted Score	Value	Score	Weighted Score	Value	Score	Weighted Score	Value	Score	Weighted Score	
BWM_REF02	3	3	6	5	3	3	6	3	3	69.2	3	6	93	3	6	0	3	3	33	1	1	**28**
BWM_REF04	4	3	6	11	3	3	5	3	3	45.2	3	6	100	3	6	1	3	3	50	2	2	**29**
BWM168	6	3	6	6	3	3	1	1	1	48	3	6	96	3	6	0	3	3	0	1	1	**26**
BWM170	4	3	6	3	3	3	3	2	2	64.8	3	6	91	3	6	1	3	3	25	1	1	**27**
BWM180	4	3	6	5	3	3	6	3	3	56.2	3	6	88	3	6	1	3	3	50	2	2	**29**
BWM189	10	3	6	3	3	3	1	1	1	39.8	3	6	100	3	6	1	3	3	10	1	1	**26**
BWM199	1	2	4	3	3	3	1	1	1	71.4	3	6	84	3	6	1	3	3	100	3	3	**26**
BWM33	6	3	6	6	3	3	2	2	2	54.2	3	6	94	3	6	4	3	3	83	3	3	**29**
Inv_BWM119	3	3	6	5	3	3	3	2	2	39	3	6	90	3	6	5	3	3	66	2	2	**28**
Inv_BWM205	1	2	4	1	1	1	1	1	1	100	3	6	75	3	6	0	3	3	100	3	3	**24**
Inv_116B	8	3	6	0	0	0	1	1	1	40	3	6	90	3	6	0	3	3	100	3	3	**25**

Attachment Seven – Woodland Habitat Results 2024 (LEC, 2024a)

Monitoring Site	Species Richness: Trees			Species Richness: Shrub			Species Richness: Grass*			Tree Canopy Cover			Total Groundcover			Invasive Species Cover (%)			Recruitment			Woodland Score
	Value	Score	Weighted Score	Value	Score	Weighted Score	Value	Score	Weighted Score	Value	Score	Weighted Score	Value	Score	Weighted Score	Value	Score	Weighted Score	Value	Score	Weighted Score	
BWM102	5	3	6	5	3	3	5	3	3	41	3	6	100	3	6	<5	3	3	Yes	3	3	**30**
BWM204A	4	3	6	1	1	1	1	1	1	14	2	4	88	3	6	0	3	3	Yes	3	3	**24**
BWM202	3	3	6	2	2	2	1	1	1	61.2	3	6	83	3	6	0	3	3	Yes	3	3	**27**
BWM200	5	3	6	5	3	3	2	2	2	45	3	6	54	3	6	0	3	3	Yes	3	3	**29**
BWM193	4	3	6	3	3	3	1	1	1	35	3	6	84	3	6	0	3	3	Yes	3	3	**28**
BWM35A	10	3	6	5	3	3	4	3	3	36.4	3	6	100	3	6	10	2	2	Yes	3	3	**29**
BWM208A	4	3	6	3	3	3	6	3	3	20	3	6	83.4	3	6	25	1	1	Yes	3	3	**28**
BWM116A	5	3	6	2	2	2	7	3	3	59.2	3	6	79	3	6	25	1	1	Yes	3	3	**27**
BWM185A	6	3	6	6	3	3	5	3	3	65	3	6	93.4	3	6	0	3	3	No	1	1	**28**
BWM32	3	3	6	3	3	3	4	3	3	10.4	1	2	79.2	3	6	0	3	3	Yes	3	3	**26**
BWM185B	3	3	6	2	2	2	1	1	1	0	1	2	29.4	1	2	0	3	3	Yes	3	3	**19**
BWM188A	4	3	6	4	3	3	3	2	2	34.2	3	6	90.6	3	6	0	3	3	Yes	3	3	**29**
BWM203A	2	3	6	4	3	3	7	3	3	22	3	6	19.6	1	2	0	3	3	Yes	3	3	**26**
BWM18	3	3	6	4	3	3	7	3	3	13.2	2	4	95.4	3	6	0	3	3	Yes	3	3	**28**
BWM22	4	3	6	2	2	2	4	3	3	51.4	3	6	100	3	6	0	3	3	Yes	3	3	**29**
BWM23	2	3	6	4	3	3	2	2	2	22.4	3	6	100	3	6	0	3	3	Yes	3	3	**29**
BWM29	3	3	6	3	3	3	4	3	3	46	3	6	92	3	6	0	3	3	Yes	3	3	**30**
BWM26	3	3	6	3	3	3	5	3	3	32	3	6	76	2	4	<5	3	3	Yes	3	3	**28**
BWM28	1	1	2	1	1	1	3	2	2	57.8	3	6	70	2	4	5	2	2	Yes	3	3	**20**
BWMR56S	3	3	6	4	3	3	2	1	1	10.6	1	2	95	3	6	5	2	2	Yes	3	3	**23**

Monitoring Site	Species Richness: Trees			Species Richness: Shrub			Species Richness: Grass*			Tree Canopy Cover			Total Groundcover			Invasive Species Cover (%)			Recruitment			Woodland Score
	Value	Score	Weighted Score	Value	Score	Weighted Score	Value	Score	Weighted Score	Value	Score	Weighted Score	Value	Score	Weighted Score	Value	Score	Weighted Score	Value	Score	Weighted Score	
BWM155	5	3	6	4	3	3	1	1	1	29	3	6	100	3	6	<5	3	3	Yes	3	3	**28**
BWM153	4	3	6	3	3	3	1	1	1	10	1	2	100	3	6	0	3	3	Yes	3	3	**24**
BWM152	8	3	6	4	3	3	2	2	2	16	3	6	94	3	6	0	3	3	Yes	3	3	**29**
BWMR80A	5	3	6	2	2	2	2	2	2	56.8	3	6	83	3	6	0	3	3	Yes	3	3	**28**
BWMR80B	6	3	6	3	3	3	1	1	1	64	3	6	80	3	6	0	3	3	Yes	3	3	**28**
BWMR80C	4	3	6	1	1	1	1	1	1	79.2	3	6	83	3	6	0	3	3	Yes	3	3	**26**

** Note grass species richness includes both native and exotic species*



Whitehaven

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0 1 2 3 4 5 km

Transverse Mercator Projection

MGA Zone 55 of the GDA 1994

N

BLACKWATER PRCP

REFERENCE MAP (MAP 1 of 2)

Drawn: GOtter	Date: 30/04/2025
Checked: S.Donner	Filename: Figure22_23_A3_20240703-1_RA.aprx

LEGEND

- Blackwater Mine EA boundary
- Maximum disturbance footprint
- Mining lease
- Third-party infrastructure retained
- Current third-party infrastructure alignment

Rehabilitation Area (RA)

- Spoil (woodland habitat) - RA1
- Spoil (cattle grazing) - RA2
- Watercourse - RA3
- Cattle grazing - RA4
- Woodland habitat - RA5
- Existing rehab (woodland habitat) - RA6
- Existing rehab (cattle grazing) RA7

Improvement Area (IA)

- NUMA - IA1
- NUMA - IA2

Location Map

CAPRICORN HIGHWAY

Blackwater Rolleston Road

ML1759
ML1760
ML1759
ML70104
ML70329
ML1762
ML70103
ML1800
ML1862
ML70091
ML1811
ML1792
ML1773
ML1771
ML1829
ML1860
ML1767
ML1907
ML70139
ML70167

665000 670000 675000 680000 685000 690000 695000 700000

7390000 7385000 7380000 7375000 7370000 7365000 7360000 7355000 7350000 7345000 7340000

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0 1 2 3 4 5 km

Transverse Mercator Projection

GDA 1994, MGA Zone 55

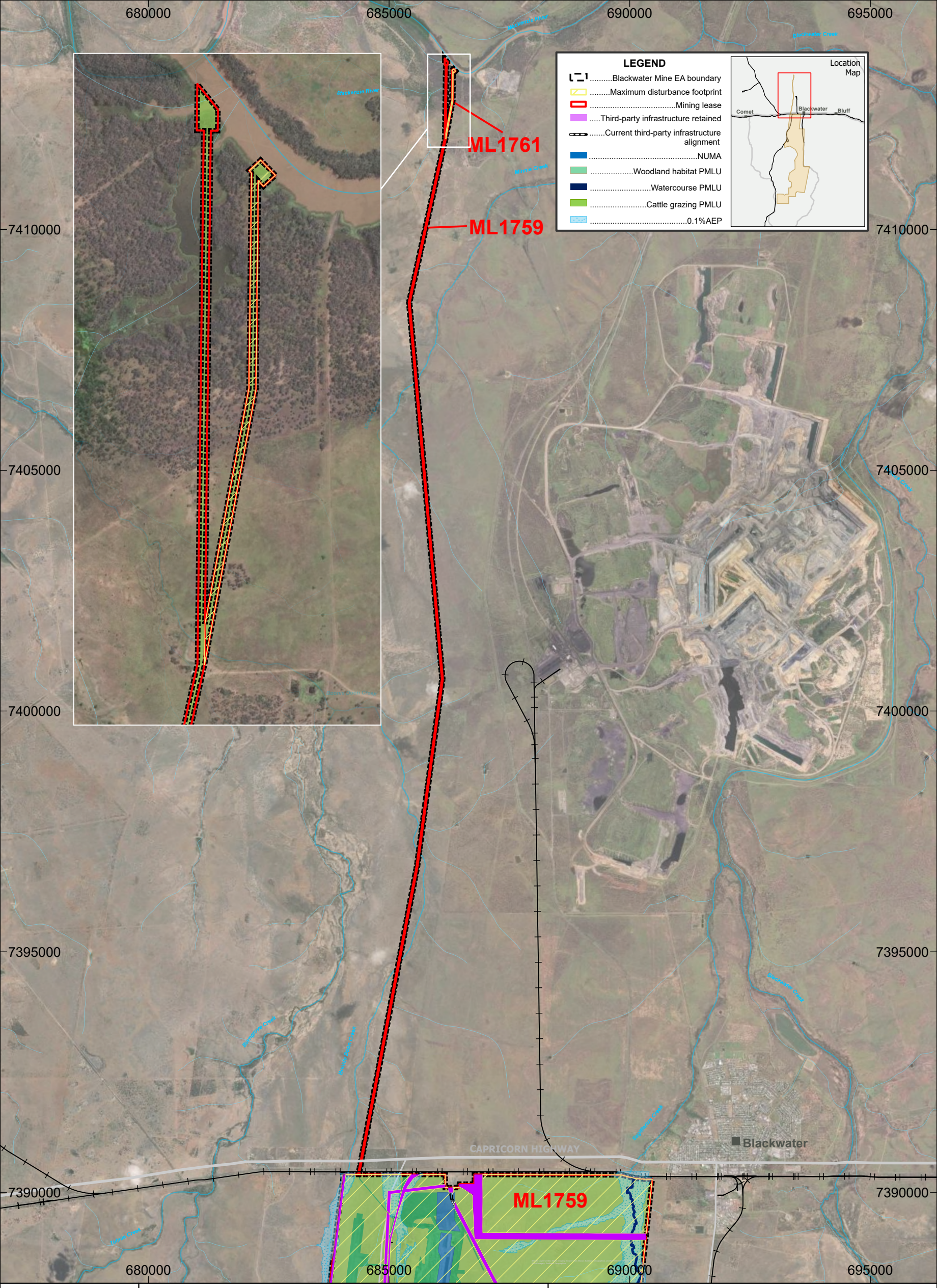
N

BLACKWATER PRCP

REFERENCE MAP (MAP 2 of 2)

Date: 30/04/2025

Filename: Figure22_23_A3_20240703-1_RA.aprx



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Transverse Mercator Projection

MGA Zone 55 of the GDA 1994

BLACKWATER PRCP

FINAL SITE DESIGN (MAP 1 of 2)

Drawn: GOtter	Date: 30/04/2025
Checked: S.Donner	Filename: Figure3-1_A3_20240703-1_FinalSiteDesign.aprx

LEGEND

- Blackwater Mine EA boundary
- Maximum disturbance footprint
- Mining lease
- Third-party infrastructure retained
- Current third-party infrastructure alignment
- NUMA
- Woodland habitat PMLU
- Watercourse PMLU
- Cattle grazing PMLU
- 0.1%AEP

Location Map

Comet Blackwater Bluff

Blackwater

CAPRICORN HIGHWAY

Blackwater Rolleston Road

ML1759

ML1760

ML1759

ML70104

ML70329

ML1762

ML70103

ML1800

ML1862

ML1792

ML70091

ML1812

ML1771

ML1829

ML1767

ML1907

ML70139

665000 670000 675000 680000 685000 690000 695000 700000

7390000 7385000 7380000 7375000 7370000 7365000 7360000 7355000 7350000 7345000 7340000

0 1 2 3 4 5 km

Transverse Mercator Projection

GDA 1994, MGA Zone 55

N

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BLACKWATER PRCP

FINAL SITE DESIGN (MAP 2 of 2)

Date: 30/04/2025

Filename: Figure3-1_A3_20240703-1_FinalSiteDesign.aprx

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Summary of Third-Party Owned Land / Assets within Blackwater Mining Leases

Infrastructure Item	Owner/Operator	Relevant Land Tenure/Rights	Within Surface Area Rights?	Authorised under BWM EA (as ERA)?
Bauhinia Railway	Crown lease held by Department of Transport and Main Roads. Subleased to Aurizon Network Pty Ltd.	Aligns with area of Easement KSP257940 held by Aurizon for railway and also Lot 76 HT561, being a Crown lease held by Department of Transport and Main Roads and subleased to Aurizon Network Pty Ltd.	Part	No – railway constructed and used in accordance with Crown lease and sublease held by Aurizon Network Pty Ltd.
	Freehold title owned by Department of Transport and Main Roads. Subleased to Aurizon Network Pty Ltd.	Aligns with Lot 1SP185514 held by the Department of Transport and Main Roads and subleased to Aurizon Network Pty Ltd.	No	No – surface not included in ML over the subject area.
Ergon overhead power 132kV	Ergon Energy Corporation Ltd	Aligns with area of Easement CSP173050 (EMT 708522588) held by Ergon Energy Corporation Ltd for power supply	Yes	No – powerline constructed under authority of registered easement.
Ergon overhead power Thermal Coal Plant 22kV Feeder	Ergon Energy Corporation Ltd	Aligns with Lot 22HT600, which is subject to Lands Lease TL0/231769 held by WHC. Certificate of title for Lot 22HT600 records easement in gross No 708522588 to Ergon Energy burdening Lot 22 on HT600 over easements A and C on SP173050 and easements U AND UU on SP173047. Certificate of title for Lot 22HT600 also records easement in gross No 714916062 to Ergon Energy burdening the land over easements AR and AT on SP255267.	No	No – powerline constructed under authority of registered easement.
Ergon overhead power 66kV	Ergon Energy Corporation Ltd	Aligns with Easement BH456 (EMT 601358555) held by Ergon Energy Corporation Ltd for power supply	Yes	No – powerline constructed under authority of registered easement.
South Blackwater Rail	Crown lease held by Department of Transport and Main Roads. Subleased to QR Network Pty Ltd.	Aligns with Lands Leases 35HT240, 36HT243, 7HT243 held by Department of Transport and Main Roads and subleased to QR Network Pty Ltd.	No	No – railway constructed and used in accordance with Crown lease and sublease held by QR Network Pty Ltd.
Ardurad Road	Central Highlands Regional Council	Public road corridor. Aligns with Compensation Agreement between WHC (subject to assignment from BMA) and Central Highlands Regional Council.	Yes	No – public road subject to road reserve and managed by Council
Sunwater Blackwater pump station to Cook	Sunwater Ltd	Aligns with Lands Lease VAP17084 (PO241302) held by Sunwater Ltd	Yes	No – pump station is subject to terms of lands lease
Yarrawonga Road	Central Highlands Regional Council	Public road corridor. Aligns with Compensation Agreement between WHC (subject to assignment from BMA) and Central Highlands Regional Council	Part	No – public road subject to road reserve and managed by Council
Cook Colliery Rail Loop	Constellation Mining Pty Ltd	Aligns with Lands Lease TL 0/233298 (Lot 30HT640) held by Constellation Mining Pty Ltd	No	No – activities subject to Lands Lease TL 0/233298 (Lot 30HT640) held by Constellation Mining Pty Ltd
Cook Colliery CHPP Access Road	Constellation Mining Pty Ltd	Aligns with Lands Lease TL 0/233298 (Lot 25HT635) held by Constellation Mining Pty Ltd	No	No – activities subject to Lands Lease TL 0/233298 (Lot 25HT635) held by Constellation Mining Pty Ltd
South Blackwater Rail	South Blackwater Coal Pty Ltd, Constellation Mining Pty Ltd	Aligns with Lands Lease TL 0/234784 (Lot 9HT545) held by South Blackwater Coal Pty Ltd, road reserve for Blackwater Rolleston Road, Lands Lease TL 0/233298 (Lot 27HT637) held by Constellation Mining Pty Ltd, Lands Lease TL 0/233298 (Lot 6SP179577) held by Constellation Mining Pty Ltd	No	No – rail activities carried out under authority of lands lease.
Blackwater-Rolleston Road	Central Highlands Regional Council	Aligns with the road reserve for Blackwater Rolleston Road and Lands Lease TL 0/233298 (Lot 6/SP179577) held by Constellation Mining Pty Ltd	No	No – public road subject to road reserve and managed by Council
Blackwater Mine Railway	Freehold title owned by Department of Transport and Main Roads. Subleased to QR Network Pty Ltd.	Aligns with Lot 22HT562 held by the Department of Transport and Main Roads and subleased to QR Network Pty Ltd.	No	No – surface not included in ML over the subject area.
PowerLink Overhead Power 132kV	Powerlink / Ergon Energy Corporation Ltd	Infrastructure located within easements EMT 602656588 and EMT 602656587 held by Ergon Energy Corporation Ltd for power supply.	Yes	No – existing infrastructure for power supply unrelated to mining activities.
Ergon Overhead Power 22kV	Ergon Energy Corporation Ltd	Does not fall within any easements shown in existing spatial data.	Yes, in parts	No – where powerlines do not link to mine infrastructure
Ergon Overhead Power 66kV	Ergon Energy Corporation Ltd	Aligns with easement EMT602811179 held by Ergon and does not appear to relate to mining operations or infrastructure.	Yes, in parts	No – existing infrastructure for power supply unrelated to mining activities.
Ergon Overhead Power 66kV	Ergon Energy Corporation Ltd	Do not fall within any easements shown in existing spatial data but do not appear to relate to mining operations or infrastructure.	Yes, in parts	No – existing infrastructure for power supply unrelated to mining activities.
Taurus Road	Central Highlands Regional Council	Subject to compensation agreement with Council for works within road corridor.	Yes	No – public road subject to road reserve and managed by Council
MountainView Homestead access Road	Whitehaven Blackwater Pty Ltd	Private access road to homestead owned by WHC	Yes	No – road is for access to homestead and not associated with mining activities.
Humboldt Comet Road	Central Highlands Regional Council	Subject to compensation agreement with Council for works within road corridor.	Yes	No – public road subject to road reserve and managed by Council
Taurus Homestead	Third party	Privately owned by third party and subject to compensation agreement.	Yes	No – Existing homestead not affected by mining operations
MountainView Homestead	Whitehaven Blackwater Pty Ltd	Privately owned by WHC	Yes	No – Existing homestead not affected by mining operations

LEGEND

- Blackwater Mine EA boundary
- Mining lease
- Rehabilitation area
- Improvement area

Third-party Infrastructure

- Homestead
- Powerline
- Rail line
- Pipeline
- Road

Location Map

Ergon Overhead Power 22kV
Powerlink Overhead Power 132kV
Ergon Overhead Power 132kV
Ergon Overhead Power 66kV
Ergon Overhead Power 22kV
Bauhinia Railway
South Blackwater Rail
Mountain View Homestead
ML1760
Ergon Overhead Power Thermal Coal Plant 22kV Feeder
Yarrawonga Road
Sunwater Blackwater Pump Station to Cook
Taurus Road
Cook Colliery Rail Loop
ML1759
Blackwater Mine Railway
Taurus Homestead
Ergon Overhead Power 22kV
Cook CHPP Access Rd
Ardurad Road
ML70104
ML70329
ML1762
Cook CHPP Access Rd
Blackwater Rolleston Road
ML70103
ML1800

680000 685000 690000 695000
7390000 7385000 7380000 7375000 7370000 7365000

Whitehaven
GIS Team - Brisbane

0 1 2 3 4 5 km

Transverse Mercator Projection
GDA 1994, MGA Zone 55

N

BLACKWATER PRCP
THIRD-PARTY INFRASTRUCTURE TO BE RETAINED

Date: 13/03/2025

Filename: Figure25_A3_20240703-1_3rdPartyInfrastructure.ap

LEGEND

- Blackwater Mine EA boundary
- Mining lease
- Rehabilitation area
- Improvement area

Third-party Infrastructure

- Homestead
- Powerline
- Rail line
- Pipeline
- Road

Location Map

ML1800
ML1862
ML1792
ML70091
ML1812
ML1773
ML1771
ML1829
ML1860
ML1767
ML1907
ML70139
ML70167

Blackwater Rolleston Road
Ergon Overhead Power 66kV
Ergon Overhead Power 22kV
Humboldt Comet Road
Ergon Overhead Power 22kV

680000 685000 690000 695000
7360000 7355000 7350000 7345000 7340000

Whitehaven

GIS Team - Brisbane

0 1 2 3 4 5 km

Transverse Mercator Projection

GDA 1994, MGA Zone 55

N

BLACKWATER PRCP

THIRD-PARTY INFRASTRUCTURE TO BE RETAINED

Date: 13/03/2025

Filename: Figure25_A3_20240703-1_3rdPartyInfrastructure.ap

Whitehaven

Ashleigh Lynch
Department of Environment, Tourism, Science and Innovation
Delegate of the Administering Authority
Environmental Protection Act 1994
Email: Ashleigh.Lynch@des.qld.gov.au, CRMining@des.qld.gov.au

Reference: A-PRCP-NEW-100758431, C-PRCP-100758454, EPML00717813 (Blackwater Mine)

16 May 2025

Dear Ashleigh,

Subject: Response to Not Properly Made (NPM) Notice – Blackwater Mine PRCP Application

This letter provides a formal response to the Department of Environment, Tourism, Science and Innovation (DETSI) regarding the *Not Properly Made (NPM) Application Notice* dated 25 November 2024 (NPM Notice). The NPM Notice pertains to the Blackwater Mine Progressive Rehabilitation and Closure Plan (PRCP) application submitted 11 November 2024.

Following receipt of the NPM Notice, Whitehaven engaged with DETSI on a number of occasions to discuss, clarify and seek feedback as to how Whitehaven could appropriately address the matters raised in the NPM Notice. This included by way of Teams meetings, emails and letters.

A summary of this engagement and the relevant outcomes as they related to each matter raised in the NPM Notice is summarised in Appendix 1 to this letter. We have also included a statement as to how each NPM Notice matter has been addressed in this formal submission.

In accordance with the requirements of the NPM Notice, an updated PRC Planning Part, PRCP Schedule and spatial files which addresses each of the NPM Notice matters is provided (see electronic folder titled “PRCP Submission 16.05.25”). For ease of reference, we have also included all finalised documentation related to each NPM Notice matter in the electronic folder provided with this submission (see folder titled “NPM Documentation 16.05.25”).

Should you have any questions regarding this correspondence, please do not hesitate to contact me.

Yours sincerely

Brendan Dillon
Manager – Approvals
0436 648 938

Whitehaven

Appendix 1: Summary of Correspondence between DETSI and Whitehaven following issue of the NPM Notice provided by DETSI on 25 November 2024

NPM Reason #	Aspect	Correspondence Forum and Date	Correspondence
1	Final Landform Design	**DETSI NPM Notice issued to Whitehaven 25/11/25**	**DETSI Reason Commentary** As per subheading 'landform design', Section 3.6.1 of the department's guideline *Progressive rehabilitation and closure plans (PRC plans)*' (ESR2019/4964, Version 3.01) ('the PRCP Guideline'), final landform design must be based on the proposed PMLUs and NUMAs and demonstrate that the land will be safe and structurally stable, inclusive of modelling predicting the long-term stability of the final landform design. Section 3.5.1.5.5 Long-term landform stability of the Rehabilitation Planning Part states that 'material testing, erosion modelling and landform evolution modelling of the spoil dumps have been completed by Landloch to establish the slope profiles for the materials at BWM to ensure long-term landform stability (Appendix 4.8). Upon review of Appendix 4.8, the landforms modelled are limited to the 11 residual voids described as: • R8M; • Boonie Doon; • Mimosa/Besgrove; • Deep Creek; • Stewart/Ballamoo; • Kenmare; • Laleham; • Togara/North Marshmead; • South Marshmead; • Kennedy West; and • Comet Downs East Appendix 4.8 does not appear to consider all proposed PMLUs not limited to higher-risk structures such as the NCPP Tailings Storage Facility (TSF), Laleham TSF, or Bottom Dam TSF. Section 3.5.1.5.6 Method of construction of the Rehabilitation Planning Part provides discussion limited to spoil dumps only. **DETSI Action** Provide a final landform design which addresses all requirements of subheading 'landform design', Section 3.6.1 of the PRCP Guideline, inclusive of modelling predicting the long-term stability of the final landform design based on all proposed PMLUs and NUMAs.
		Whitehaven and DETSI meeting 04/12/24	**Meeting Minutes Key Points and Actions** 1. Scope of Landform Evolution Modelling (LEM) Requirements: ○ DETSI confirmed that to address the Not Properly Made Notice (NPMN), LEM is only required for NCPP Tailings Storage Facility (TSF), Laleham TSF and Bottom Dam TSF. ○ WHC discussed that LEM is unnecessary at the conceptual design stage being that the simulations undertaken by Landloch were considerate of all representative options for BWM at the time, inclusive of TSFs. It was further discussed that Appendix 4.10 mentions that the TSFs identified in the NPMN will be subjected to further detailed cover designs in future using the latest information and data available for each facility. WHC questioned the practicality of doing LEM modelling now, being that detailed design information is not readily available for these facilities. In response, DETSI discussed that they consider TSFs as "high-risk" and therefore require sufficient documentation for PRCP approval, noting that they are aware that designs change iterations may occur over time. DETSI also noted that creek diversions (e.g., Sirius Creek) may require LEM in future, but that they needed to engage with other government departments in relation to interrelated works and how to approach this. WHC indicated that this will be addressed separately under a permanent license application to be submitted as part of the permanent licence approval. DETSI agreed that this will not be required as part of addressing the NPMN. 2. Next Steps: ○ To address the NPMN, WHC will undertake LEM for the NCPP TSF, Laleham TSF and Bottom Dam TSF facilities. In relation to confirmation on future creek diversion LEM requirements, DETSI have indicated they will coordinate with other government departments post-Christmas and will provide guidance to WHC as part of RFI stage.
		Whitehaven letter response issued to DETSI 24/03/25	**Whitehaven Response – NPM Item #1** During the NPM Notice meeting on 4 December 2024, Whitehaven and DETSI agreed that for Whitehaven to satisfy this action, Landform Evolution Modelling (LEM) was required to be completed for the NCPP TSF, Laleham TSF and Bottom Dam TSF. Landloch was engaged to undertake the required assessment and their report is provided in Appendix 1. The report concludes that the three (3) TSFs modelled have a low tendency for gully erosion (up to 300 years) provided the correct soils and the target levels of vegetation groundcover are achieved. The report also discussed areas of each TSF which may be prone to areas of increased localised erosion risk in the future, and it suggested mitigations to reduce these risks. Since report issue, Whitehaven has reviewed these areas and the suggested mitigations and have since updated the TSF landform surfaces to reduce the potential for future erosion risk in these areas. The PRC Plan has been updated to include information provided in the Landloch report. The report has also been addended to Appendix 4.8 of the PRC Plan.
		Whitehaven and DETSI meeting 25/03/25	In this meeting the Whitehaven letter responses issued to DETSI on 24/03/25 were discussed.
		DETSI email response issued to Whitehaven 28/03/25	No further mention of NPM Reason #1.
		NPM Reason #1 Item Close-Out: The Landloch report which has been referenced above (see Whitehaven letter response issued to DETSI 24/03/25), is provided with this correspondence in the electronic folder titled "NPM Documentation 16.05.25". Further note, the PRC Plan also resubmitted today 16 May 2025, has been updated to include information provided in the Landloch report. The report has also been addended to Appendix 4.8 of the PRC Plan.	

NPM Reason #	Aspect	Correspondence Forum and Date	Correspondence
2	Tailings Storage Facility	**DETSI NPM Notice issued to Whitehaven 25/11/25**	**DETSI Reason Commentary** Section 3.6.2 of the PRCP Guideline requires that 'proposed tailings management options must minimise interactions between the tailings and the surrounding environment to prevent the release of contaminants to the receiving environment. Flow path simulations presented in the *Transitional PRC Plan Hydrogeology Assessment* (SLR 2024a) (Appendix 4.2 of the Rehabilitation Planning Part) conclude that: '*water associated with spoil and tailings deposition, underground mine workings or open cut residual void lakes is not predicted migrate away from the BWM Area, with the residual voids acting as passive containment for groundwater which has passed through the mine workings. The exception to this is the specific location of Bottom Dam, west of Laleham residual void, with groundwater predicted to migrate towards Sirius Creek outside of the BWM Area. The environmental risk associated with this prediction is addressed within the PRC Plan's tailings cover design and geochemistry assessments (Henderson Geotech, 2024, and Terrenus Earth Sciences, 2024)'* (SLR 2024a, p. 128) Terrenus Earth Science (2024) reiterate that 'there are plausible surface water receptors; and the run-off and seepage pathways linking the source (Bottom Dam TSF/rejects final landform) to these receptors (Sirius Creek) have been identified' (p. xvii) and state: *'Environmental and engineering investigations of this area are underway to support rehabilitation and closure planning and, as such, no geochemical data specifically from Bottom Dam was available for this waste characterisation assessment. The final landform of the greater Bottom Dam area is also to be determined, subject to the outcome of the engineering and environmental investigation programs'* (p. xiv). Terrenus Earth (2024, p. 80) state: *'..until a detailed geochemical assessment is undertaken, Bottom Dam area (comprising TSF and rejects) is conservatively assumed to pose a Moderate-High AMD [Acid Mine Drainage] hazard, with AMD generation rated as Probable/Likely.* The Concept Cover Design (Henderson Geotech, 2024, p. 16) states: *'…there is the possibility of shallow seepage out of the TSF and into Sirius Creek, although there is not a clear hydrogeologic connection. If seepage did occur, the rate would decrease over time since tailings deposition has ceased, and a cover system designed to minimize deep infiltration would also reduce long-term seepage.* The statement that 'a clear hydrogeologic connection' contradicts the flow path modelling presented by SLR in the Hydrogeology Assessment (2024a). **DETSI Action** Provide a Rehabilitation Planning Part in accordance with Section 3.6.2 of the PRCP Guideline which details tailings management options which minimise interactions between the tailings and the surrounding environment to prevent the release of contaminants to the receiving environment.
		Whitehaven and DETSI meeting 04/12/24	**Meeting Minutes Key Points and Actions** • WHC understands the NPMN matter as explained in the correspondence and will provide information as necessary to address the NPMN.
		Whitehaven letter response to DETSI 24/03/25	**Whitehaven Response – NPM Item #2** To address this NPM Notice item, Whitehaven engaged SLR Consulting Australia Pty Ltd (SLR) to undertake a preliminary hydrogeological assessment of the conceptual relationship between the historical Bottom Dam Tailings Storage Facility (TSF) and Sirius Creek. The report is provided in Appendix 2. By way of summary, the report concluded that surface water-groundwater interactions in this area are assessed to be minimal. The ephemeral nature of the creek, combined with its elevation above the groundwater table, reduces the likelihood of groundwater discharge into Sirius creek from the Tertiary aquifer. Instead, recharge processes are primarily driven by surface water inputs, such as streamflow and flooding, rather than contributions from groundwater. Consequently, local scale conceptualisation does not support the potential movement of groundwater from Bottom Dam TSF to Sirius Creek as the key factors such as groundwater levels, aquifer properties, and recharge mechanisms indicate no potential pathway for connectivity between these features. The objective of the work was to conceptually assess current hydrogeological conditions at a local scale which was not possible in the site-wide Transitional PRC Plan Hydrogeology Assessment, and to identify if there was a plausible potential pathway for subsurface hydraulic connection between the Bottom Dam TSF and Sirius Creek as predicted by the model. The report indicates that overall, both historical and current data suggests that surface water recharge processes in the area are dominated by episodic inputs from streamflow and flooding, with minimal contributions from groundwater, and that the hydrogeological setting supports limited connectivity between Bottom Dam TSF, Sirius Creek, and the regional groundwater system. The results modelled near Bottom Dam TSF are considered by SLR as a conservative first pass assessment of risk prior to any local scale remedial measures, and that this work provides the most accurate representation of the relationship between Bottom Dam TSF and Sirius Creek, forming a better basis for understanding the local groundwater dynamics than the numerical groundwater model. The SLR report concludes that there is a highly limited potential for hydraulic connection between the Bottom Dam TSF and Sirius Creek. The PRC Plan has been updated to include information provided in the SLR report. The report has also been addended to Appendix 4.2 of the PRC Plan.
		Whitehaven and DETSI meeting 25/03/25	In this meeting the Whitehaven letter responses issued to DETSI on 24/03/25 were discussed.
		DETSI email response issued to Whitehaven 28/03/25	***Tailings Storage Facility (NPM Reason #2)*** The following observations and requests for clarification are made regarding the *Bottom Dam Tailings Storage Facility & Sirius Creek: Preliminary Hydrogeological Review and Investigation* (SLR 2025) (the 'TSF/Creek assessment'): (a) The assessment inconsistently reports on the bed level elevation of Sirius Creek. For example, s 2.1.1 states Sirius Creek is at approx. 255 mAHD; however, s 3.2 states that the Creek's elevation is approx. 270 mAHD. Provide a revised 'TSF/Creek assessment' which uses consistent information and associated analysis in relation to the bed level elevation at Sirius Creek south of the TSF area.

NPM Reason #	Aspect	Correspondence Forum and Date	Correspondence
			(b) The 'TSF/Creek assessment' indicates that there is a saturated Tertiary sediments aquifer in bore MB21 immediately south of the TSF and in MB136_02, between MB21 and Sirius Creek. There also appears to be a gradient south from MB21 towards MB136_02. No water quality analysis has been presented for samples from these bores or any other saturated Tertiary sediments bores to compare with potential contaminants from the TSF. Provide water quality data along with an analysis of water level for those bores utilised in the 'TSF/Creek assessment', where water samples can be obtained. (c) A review of Queensland Globe and the groundwater database indicates that logs are not available for many of the bores listed in Table 2-1; however, these logs are necessary to enable a thorough review of the data presented in 'the TSF/Creek assessment'. Provide copies of available drill logs for bores referenced in Table 2-1. (d) It is noted that there is a bore (RN208334), located near MB136_02 and Sirius Creek which is plotted in Queensland Globe and strikes water in the sand between 7 and 10 m. This bore appears not to have been used in the 'TSF/Creek assessment'. Provide advice as to why RN208334 was excluded from the 'TSF/Creek assessment'. (e) The department does not consider that the cross sections illustrated in Figure 3-1 are reflective of the data presented. The following observations were made: ○ North-south cross section: ▪ MB136_01, adjacent to Sirius Creek, is identified in Table 2-1 as a 7 m deep alluvial bore which is dry. Based on the scale on the y-axis in the cross section, this appears to be a 17 m bore going down into the base of the Tertiary. ▪ The alluvium is illustrated in the cross section as ~ 1 m deep; however, MB136_01 is 7 m deep, which is therefore understood to be representative of the alluvium depth and should be illustrated on the cross section accordingly. ▪ Adjacent to MB136_01 is MB136_02 which is a Tertiary bore 21 m deep with a water level of ~ 16 m below ground level. This bore is not shown on the cross section. ▪ MB21 is shown on the cross section as being drilled through the Tertiary down into the Triassic/Permian; however, Table 2-1 indicates that it is screened between 25 and 31 m in Tertiary with a water level of ~ 18 m below ground level. This is not represented in the cross section. ▪ The cross section indicates that there is no groundwater in the Tertiary; however, based on the data presented, this does not appear to be the case. The cross section indicates that water is in the Triassic/ Permian only, although no bores in these formations were presented in the assessment. ○ West – east cross section: ▪ The cross section infers that the water table is in the Triassic/ Permian when bore MB21, located south of this cross section, has 12 m of saturated aquifer in the Tertiary. Accordingly, provide updated cross sections which accurately reflect the data provided. (f) The 'TSF/Creek assessment' appears to indicate that the particles commenced their migration from layer 14 and that the numerical model predicted upward vertical flux is highly unlikely as layer 2 (Tertiary) would be dry. However, the 'TSF/Creek assessment' identified saturated Tertiary at MB21 immediately south of the TSF and at MB136_02, towards Sirius Creek from MB21. Based on this, there appears to be saturation in the Tertiary where the particle tracking was providing predictions. The department recommends a review of the findings in Section 4.2 in relation to saturation of layer 2 in the numerical model and how this compares to the information provided for monitoring bores MB21 and MB136_02. (g) Section 5 of the 'TSF/Creek assessment' concludes that '*In areas where the Tertiary aquifer is saturated, groundwater levels occur well below the Sirius Creek bed elevation*'. It further concludes that '*The conceptual understanding presented herein, based on a review of local data, provides the most accurate representation of the relationship between Bottom Dam TSF and Sirius Creek and a better basis for understanding the local groundwater dynamics than the numerical groundwater model*'. Noting the uncertainty regarding the bed level elevation of Sirius Creek (see item (a)) and matters outlined above, it is considered that the concluding statements are not proven. Provide consistent information regarding the bed level elevation in Sirius Creek in comparison to the Tertiary groundwater elevation at that location leading to a more accurate conceptualisation of the groundwater system between the TSF and Sirius Creek.
		Whitehaven letter response to DETSI 30/04/25	**Whitehaven Response to Item 1 - Tailings Storage Facility (NPM Reason #2)** SLR Consulting Australia Pty Ltd (SLR) have prepared a summary response technical memorandum to address the observations and requests for clarification outlined in DETSI's on 28 March 2025 (see Attachment 1). The Preliminary Hydrogeological Review and Investigation report was also updated to reflect the information provided in the technical memo (see Attachment 2).
		DETSI email response issued to Whitehaven 09/05/25	**Tailings Storage Facility (NPM Reason #2)** Additional information is required to address NPM Notice matter #2 in line with the observations (a) to (g) outlined in the emailed dated 28 March 2025 as follows: a) Observation (a) – i. There is still concern about the wording of a paragraph in Attachment 1 and similar wording in the updated Attachment 2. Attachment 1 states '*Where the aquifer is saturated, groundwater levels remain well below the creek's elevation; the water table below bottom dam is approximately 270 m AHD, which is significantly below the creek's elevation of 255 m AHD'.* 270 m AHD is not significantly below 255 m AHD. Please review the attachments and reword as required. b) Observation (b) i. The considerations made by SLR and the reasons for excluding the water quality analysis have been noted. ii. The Technical Memorandum includes the statement '*There are no distinguishable trends or indications of specific relationships between different hydrostratigraphic unit chemistry*'. Further information is required to be provided to support this statement. iii. It is also acknowledged there may be limited data. However any available water quality data is required to be provided along with an analysis of water level for those bores utilised in the 'TSF/Creek assessment', where water samples can be obtained c) Observation (c) – (g) – in consideration of the additional information provided, these matters are considered resolved for the purpose of the NPM response. Further information may be sought during the information stage if deemed necessary.
		Whitehaven letter response to DETSI 16/05/25 (this letter)	SLR Consulting Australia Pty Ltd (SLR) has prepared a technical memorandum responding to the observations outlined in DETSI's email dated 09 May 2025. This memorandum is provided in the electronic folder titled "NPM Documentation 16.05.25". In addition, the *Preliminary Hydrogeological Review and Investigation Report* has been updated to align with the information provided in the technical memorandum. The updated report is also enclosed in the "NPM Documentation 16.05.25" folder.
			NPM Reason #2 Item Close-Out: The PRC Plan resubmitted today 16 May 2025, has been updated to include information provided in the SLR report. The report has been addended to Appendix 4.2 of the PRC Plan.

NPM Reason #	Aspect	Correspondence Forum and Date	Correspondence
3	**Built Infrastructure**	**DETSI NPM Notice issued to Whitehaven 25/11/25**	**DETSI Reason Commentary** The description of infrastructure to be retained is limited to a general description only, and it does not include information on ongoing maintenance requirements, with the exception of discussion regarding contaminated land obligations. Furthermore, no evidence of agreement has been provided for infrastructure that will have ownership transferred. The Rehabilitation Planning Part therefore does not satisfy the requirements of s126C(1)(e) and (i) and (j) of the *Environmental Protection Act 1994* (EP Act) and Section 3.6.5 of the departmental guideline '*Progressive rehabilitation and closure plans (PRC plans)*' (ESR2019/4964, Version 3.01). Whilst it is noted that EA condition E21 states '*NOTE: This is not applicable where the landowner/ landholder is also the environmental authority holder'*, Section 3.5.5.1 of the Rehabilitation Planning Part states that this applies to '*parts of BWM'* only. Section 3.1.2.12 describes several third-party underlying landholders in addition to the current EA holder (BMA) as well as utilities and service asset owners. *Figure 16 BWM land ownership* of the Rehabilitation Planning Part is not of a scale that enables the department to determine where third-party landholders apply. It is noted that the Community Consultation Plan states 'CHRC owns land within the EA and is a party to agreements relating to roads and road reserves'. This agreement has not been provided. No figures are provided to illustrate the location of infrastructure proposed to be retained to enable the department to determine whether retained infrastructure is situated on land held by third parties which would otherwise require a written agreement as per Section 3.2 of the PRCP Guideline. If the underlying landholder is also the EA holder, justification on how the infrastructure will provide a benefit or improvement to the use of the land and/or community once mining has ceased must be provided. Furthermore, Section 3.2 of the PRCP Guideline requires that all infrastructure to be retained onsite is safe, stable and not cause environmental harm. This information has not been included in Section 3.5.5 of the Rehabilitation Planning Part, with the exception of discussion regarding contaminated land obligations. **DETSI Action** Provide evidence of agreement for any infrastructure that will have ownership transferred in accordance with s754(4) of the EP Act and Section 3.6.5 of the PRCP Guideline. In addition, as required by Sections 3.2 and 3.6.5 of the PRCP Guideline, provide a revised Rehabilitation Planning Part which describes: • the specific infrastructure that will remain post rehabilitation and the identification of ongoing maintenance requirements. • information on how the infrastructure will be safe, stable and not cause environmental harm. In providing a response to this item, consider providing maps to illustrate the location of infrastructure to be retained in relation to third-party landholders and ensure that ongoing maintenance for all retained infrastructure is outlined in the Rehabilitation Planning Part.
		Whitehaven and DETSI meeting 04/12/24	**Meeting Minutes Key Points and Actions** 1. Post-Rehabilitation Infrastructure: ○ DETSI requires clarity on infrastructure designated to remain post-rehabilitation completion and if agreements exist, WHC must provide evidence. In the absence of agreements, a plan for obtaining agreements is required. ○ WHC clarified if a map with an associated table explaining infrastructure that will or may be retained post rehabilitation and closure would be sufficient to address the NPMN. DETSI agreed with this approach. ○ Excised areas were also discussed – see NPMN Reason #7. 2. Next Steps: ○ WHC will produce a map and associated table including information on what infrastructure will or may be retained post rehabilitation and closure. Where agreements exist, information will be provided on these. Information on excised areas will also be provided to address NPMN Reason #7.
		Whitehaven letter response to DETSI 24/03/25	**Whitehaven Response – NPM Item #3** Whitehaven acknowledges that it is the DETSI's expectation that built infrastructure is required to be decommissioned, demolished and salvaged or disputed unless it is being formally retained by the landholder to achieve an appropriate PMLU. In practical terms, due to the long life of the operation, Blackwater Mine does not have any agreements in place for the ownership of mining related infrastructure to be transferred in the future. Formal agreements for the transfer of mining related infrastructure ownership will be developed and secured over time as the mine progresses through the rehabilitation milestones associated with the PRCP Schedule. In the event that there is no agreement for transfer of ownership of one or more item of mining related infrastructure, Whitehaven intends to carry out rehabilitation as defined in the PRC Plan and PRCP Schedule, and in support of the proposed PMLU for the relevant area. Third-party infrastructure located within the Blackwater Mine Mining Leases are shown in the figures provided in Appendix 3. This infrastructure will not be impacted by Blackwater mining activities, other than in accordance with an agreement with the relevant owner. In the event that the land which is subject to third-party infrastructure is to be impacted by mining operations beyond what is currently set out under the PRC Plan and PRCP Schedule, the PRC Plan and PRCP Schedule will be updated accordingly. The PRC Plan has been updated to include the above information and related figures.
		Whitehaven and DETSI meeting 25/03/25	In this meeting the Whitehaven letter responses issued to DETSI on 24/03/25 were discussed.
		DETSI email response issued to Whitehaven 28/03/25	***Built Infrastructure (NPM Reason #3)*** During consultation on 25/3/25, Whitehaven advised that the intention was to remove all items of infrastructure prior to closure, therefore no landowner agreements would be provided at this stage. However, the revised PRCP Planning Part provided on 24/3/25 states *'Surface infrastructure that may be retained includes: fencing, access tracks, services-related infrastructure, sheds and buildings, hardstand areas/transport logistics areas, and water-related infrastructure'* (Whitehaven 2025, p. 186). The department requests that all references in the Planning Part reflect the outlined intent not to retain infrastructure.

NPM Reason #	Aspect	Correspondence Forum and Date	Correspondence
		Whitehaven letter response to DETSI 30/04/25	**Whitehaven Response to Item 2 - Built Infrastructure (NPM Reason #3)** The PRC Plan will be updated to remove the following statement '*Surface infrastructure that may be retained includes: fencing, access tracks, services-related infrastructure, sheds and buildings, hardstand areas/transport logistics areas, and water-related infrastructure*' (Whitehaven 2025, p. 186). This statement does not reflect the current approach at Blackwater Mine which is to remove all infrastructure prior to closure unless otherwise shown in the retained infrastructure map or utilised for access or associated with a PMLU.
		DETSI email response issued to Whitehaven 09/05/25	**Built Infrastructure (NPM Reason #3) -** a) The department is satisfied the information provided addresses the NPM Notice matter #3 b) Whilst it is noted the intention is to remove all infrastructure prior to closure unless otherwise shown in the retained infrastructure map or utilised for access or associated with a PMLU, ensure that specific figures or attachments are referenced rather than using general terminology such as 'retained infrastructure map' and ensure this terminology is used consistently throughout the PRCP schedule and planning part
		Whitehaven letter response to DETSI 16/05/25 (this letter)	We acknowledge DETSI's confirmation that the information provided in our previous letter dated 30 April 2025 adequately addresses NPM Reason #3. Further, we confirm that the updated PRC Plan and PRCP Schedule do not contain any general references to 'retained infrastructure maps/mapping' or similar.
		NPM Reason #3 Item Close-Out: The third-party infrastructure and land ownership figures referenced above (see Whitehaven letter response issued to DETSI 24/03/25), are provided with this correspondence in the electronic folder titled "NPM Documentation 16.05.25". These figures are also included in the PRC Plan resubmitted today 16 May 2025 (see Figures 16 and 17).	
4	**Previous monitoring or maintenance of areas already rehabilitated**	**DETSI NPM Notice issued to Whitehaven 25/11/25**	**DETSI Reason Commentary** Details of previous monitoring or maintenance of areas already rehabilitated has not been provided to satisfy the requirements of s126C(1)(j) of the EP Act and Section 3.8 of the PRCP Guideline. No supporting reports or data for previous monitoring or maintenance of areas already rehabilitated has been presented with the PRC Plan for an area of 1,929ha which the PRC Plan cites as 'existing rehabilitation'. The Rehabilitation Planning Part (Whitehaven 2024, p. 73) states: *Over time, BWM has progressively advanced 1,929ha of existing rehabilitation towards the achievement of the nominated PMLUs and rehabilitation milestones outlined in the PRCP Schedule (see Appendix 4.1). The existing rehabilitation areas completed for the cattle grazing and woodland habitat PMLUs are summarised as follows* • 1,200 ha of cattle grazing • 729 ha of woodland habitat *As part of FY24 rehabilitation monitoring, some of these areas have been identified as being suitable for progressive rehabilitation certification under the EP Act. However, at the time of submission of this transitional PRCP, no applications have been submitted to the administrating authority. The existing rehabilitation progressing towards the achievement of the PMLU is outlined in the PRCP Schedule provided in Appendix 4.1 (see RA6 and RA7). Routine rehabilitation monitoring will continue to be implemented to identify any maintenance/corrective actions required to enable the rehabilitated areas to achieve the milestone criteria.* Upon review of the submitted materials, details of the rehabilitation monitoring and maintenance described above do not appear to have been provided in the Rehabilitation Planning Part or appendices. **DETSI Action** The Rehabilitation Planning Part indicates that rehabilitation monitoring has been completed and is ongoing for the 1,929ha of existing rehabilitation. As detailed in Section 3.8 of the PRCP Guideline, if there are any monitoring or maintenance of areas already rehabilitated, details must be included in the PRC plan. Accordingly, as per the requirements of s126C(1)(j) of the EP Act and Section 3.8 of the PRCP Guideline, provide a PRC Plan that includes details of previous monitoring or maintenance of areas already rehabilitated. In responding to this item, please also ensure that all areas of existing rehabilitation are presented it the spatial data submission with the correct 'Feature' description of 'EX_REH' as required by Attachment 1 of the approved form '*Submission of a progressive rehabilitation and closure plan*' (ESR/2019/4957).
		Whitehaven and DETSI meeting 04/12/24	**Meeting Minutes Key Points and Actions** • WHC understands the NPMN matter as explained in the correspondence and will provide information as necessary to address the NPMN.
		Whitehaven letter response to DETSI 24/03/25	**Whitehaven Response – NPM Item #4** To address this NPM Notice item, Whitehaven engaged Steve Lyngcoln (Principal Ecologist) from Lyngco Environmental Consulting to provide a report outlining the rehabilitation monitoring and maintenance activities which have been undertaken within the existing rehabilitation areas at Blackwater. The report is provided in Appendix 4 of this NPM Notice response. The PRC Plan has also been updated to include this information, and the report provided as Appendix 4.17 of the PRC Plan. Spatial data has also been updated to correct the 'Feature' description of 'EX_REH' for all areas of existing rehabilitation. The spatial data has been provided as a separate attachment to this NPM Notice response.
		Whitehaven and DETSI meeting 25/03/25	In this meeting the Whitehaven letter responses issued to DETSI on 24/03/25 were discussed.
		DETSI email response issued to Whitehaven 28/03/25	Please see the correspondence detailed in the letter response provided above – Item closed.
		NPM Reason #4 Item Close-Out: The report from Lyngco Environmental Consulting referenced above (see Whitehaven letter response issued to DETSI 24/03/25), is provided with this correspondence in the electronic folder titled "NPM Documentation 16.05.25". Note, the PRC Plan also resubmitted today 16 May 2025, has been updated to include information provided in the report. The report is also provided as Appendix 4.17 of the PRC Plan. Further note, as communicated in the Whitehaven letter response issued to DETSI 24/03/25, spatial data was also updated to correct the 'Feature' description of 'EX_REH' for all areas of existing rehabilitation. The updated spatial data is provided in the electronic folder titled "PRCP Submission 16.05.25".	

NPM Reason #	Aspect	Correspondence Forum and Date	Correspondence
5	Reference Map	**DETSI NPM Notice issued to Whitehaven 25/11/24**	**DETSI Reason Commentary** A reference map that meets the requirements of s126D(1)(d) of the EP Act and Section 4.1 of the PRCP Guideline has not been provided. The reference map (*Figure 17 Indicative areas available for rehabilitation* of the Rehabilitation Planning Part titled 'Reference Map) does not illustrate the location of all Rehabilitation Areas (RAs) for all land which has been disturbed by the mining activities. This is most evident in disturbed areas adjacent to Terang Pit, Laleham Pit, Kenmare Pit, Ramp 72 and Ramp 74 Tailings Storage Facilities (TSFs), NCPP TSF and some sections underlying Watercourse PMLUs; however, note that this is not an exhaustive list. In accordance with Section 4.1, Step 2 of the PRCP Guideline the PMLUs identified in the final site design, where disturbance has occurred or will occur, must be broken down into RAs. Section 4.1, Step 2 of the PRCP Guideline further states that RAs must be based on the proposed rehabilitation or management methodology applicable to the PMLU. **DETSI Action** Provide a reference map and spatial data that meet the requirements of s126D(1)(d) of the EP Act and Section 4.1 of the PRCP Guideline.
		Whitehaven and DETSI meeting 04/12/24	**Meeting Minutes Key Points and Actions** 1. Additional Areas Identified: o DETSI explained in the meeting via screenshare of GIS information, areas which appeared to be disturbed by mining, including watercourse reaches which did not have an overlying Rehabilitation Area (RA) associated. o Historical seismic areas which do not have overlying RAs were also discussed. DETSI confirmed no rehabilitation plans are required for these areas being that they were previously associated with exploration and subject to rehabilitation requirements as associated with those permits. 2. Next Steps: o WHC will update reference mapping and spatial data to ensure the NPMN matter is addressed.
		Whitehaven letter response to DETSI 24/03/25	**Whitehaven Response – NPM Item #5** Whitehaven has updated the reference map and associated spatial data files, to correct the issues identified in the NPM Notice and as discussed in the meeting between Whitehaven and DETSI on 4 December 2024. The updated figure is provided in Appendix 5, and the spatial data is provided as a separate attachment to this NPM Notice response. The PRC Plan has also been updated to include the new figure (see *Figure 18 Reference map - indicative areas available for rehabilitation*). Within the updated figure, the mapping insets show areas which are defined by the legend as *"Existing retained third-party infrastructure subject to potential future re-alignment".* This information is shown to denote areas where the potential future realignment of third-party infrastructure may be required to enable mining activities in accordance with the PRC Plan. Any future realignment of these areas, and also potentially other areas not currently defined, would be subject to future agreement between Whitehaven and the relevant owner. For clarity, should future mining activities not progress in these areas, the infrastructure will remain in place and any future decisions, including for decommissioning and rehabilitation will be at the discretion of the owner. In addition, Whitehaven would also like to acknowledge the feedback provided by the Department following the NPM notice meeting held between Whitehaven and DETSI on 4 December 2024. The feedback provided indicated that the rehabilitation of exploration disturbance must be undertaken in accordance with condition E22 of the environmental authority, however a specific 'exploration' Rehabilitation Area and corresponding spatial data to accompany the PRCP schedule is not required. The feedback also stated conditions will be prescribed in the PRCP schedule that require rehabilitation outcomes to align to the relevant PMLU for the area disturbed by exploration activities. Whitehaven acknowledge the feedback provided and have updated the PRC Plan to reflect this approach. We consider that the exploration areas not planned to be mined and within designated Rehabilitation Areas, will be rehabilitated in accordance with the *Eligibility criteria and standard conditions for exploration and mineral development projects'* or its successor.
		Whitehaven and DETSI meeting 25/03/25	In this meeting the Whitehaven letter responses issued to DETSI on 24/03/25 were discussed.
		DETSI email response issued to Whitehaven 28/03/25	***Reference Map, Final Site Design and Spatial Data (NPM Reason # 5 to 7)*** Please find attached screen captures which illustrate some of the errors including: • disturbance areas not being subject to rehabilitation area (RA) mapping. • mapped RAs over some portions of land which Whitehaven do not currently have ML surface area granted. • ML surface area with no RA or PMLU mapping. • RA mapping and 'maximum disturbance footprint' in some locations that do not align. The screen captures are a selection of issues identified by DETSI to assist, as requested by Whitehaven; however, this is not intended to be an exhaustive assessment. It is the responsibility of Whitehaven to conduct a review of imagery and ML surface areas to ensure that all land the subject of the PRCP is accurately mapped.
		Whitehaven letter response to DETSI 30/04/25	**Whitehaven Response to Item 3 - Reference Map, Final Site Design and Spatial Data (NPM Reason # 5 to 7)** Whitehaven has conducted a thorough review of the spatial data, imagery and Mining Lease (ML) surface areas associated with the PRCP application. This was inclusive of the screen capture error information highlighted by DETSI. As part of the review the following was identified and addressed: • Further refinement of disturbance areas; • Addressed areas highlighted by DETSI in email on 28 March 2025 (see Attachment 3 and 4) ;and

NPM Reason #	Aspect	Correspondence Forum and Date	Correspondence
			• Updated PRCP Schedule to align with the above changes (see Attachment 5).
		DETSI email response issued to Whitehaven 09/05/25	**Reference Map, Final Site Design and Spatial Data (NPM Reason # 5 to 7)** a) The department is satisfied the information provided is sufficient to address NPM Notice matter #5- 7 b) Please note, through further assessment during the information stage, additional information may be requested through a formal information request
		Whitehaven letter response to DETSI 16/05/25 (this letter)	We also acknowledge DETSI's confirmation that our response dated 30 April 2025 adequately addresses NPM Reasons #5-7.
		NPM Reason #5 Item Close-Out: The updated reference map is provided with this correspondence in the electronic folder titled "NPM Documentation 16.05.25". This figure has also been included in the PRC Plan resubmitted today 16 May 2025 (see Figure 18). In addition, the updated spatial data files mentioned above (see Whitehaven letter response issued to DETSI 30/04/25), are provided in the electronic folder titled "PRCP Submission 16.05.25".	
6	**Final Site Design**	**DETSI NPM Notice issued to Whitehaven 25/11/24**	**DETSI Reason Commentary** A final site design that meets the requirements of s126D(1)(d) of the EP Act and Section 4.1 of the PRCP Guideline has not been provided. The final site design (*Figure 19 Locations of BWM PMLUs and NUMAs* titled 'Final Site Design' of the Rehabilitation Planning Part) does not illustrate the 'maximum disturbance footprint' as required by the PRCP Guideline. It is noted that a 'Reference Map' (provided in Appendix 4.1 of the Rehabilitation Planning Part) illustrates the RAs / IAs and maximum disturbance boundary; however, this is separate and distinct from the 'Final Site Design' map required by the PRCP Guideline. **DETSI Action** Provide a final site design and spatial data that meets the requirements of s126D(1)(d) of the EP Act and Section 4.1 of the PRCP Guideline inclusive of the 'maximum disturbance footprint' as per the EP Act and PRCP Guideline requirements.
		Whitehaven and DETSI meeting 04/12/24	Meeting Minutes Key Points and Actions
		Whitehaven letter response to DETSI 24/03/25	**Whitehaven Response – NPM Item #6** Whitehaven has updated the final site design map which now includes the 'maximum disturbance footprint' as required. The updated figure is provided in Appendix 6, and the spatial data is provided as a separate attachment to this NPM Notice response. The PRC Plan has also been updated to include the new figure (see *Figure 27 Final site design - locations of BWM PMLUs and NUMAs*).
		Whitehaven and DETSI meeting 25/03/25	In this meeting the Whitehaven letter responses issued to DETSI on 24/03/25 were discussed.
		DETSI email response issued to Whitehaven 28/03/25	***Reference Map, Final Site Design and Spatial Data (NPM Reason # 5 to 7)*** Please find attached screen captures which illustrate some of the errors including: • disturbance areas not being subject to rehabilitation area (RA) mapping. • mapped RAs over some portions of land which Whitehaven do not currently have ML surface area granted. • ML surface area with no RA or PMLU mapping. • RA mapping and 'maximum disturbance footprint' in some locations that do not align. The screen captures are a selection of issues identified by DETSI to assist, as requested by Whitehaven; however, this is not intended to be an exhaustive assessment. It is the responsibility of Whitehaven to conduct a review of imagery and ML surface areas to ensure that all land the subject of the PRCP is accurately mapped.
		Whitehaven letter response to DETSI 30/04/25	**Whitehaven Response to Item 3 - Reference Map, Final Site Design and Spatial Data (NPM Reason # 5 to 7)** Whitehaven has conducted a thorough review of the spatial data, imagery and Mining Lease (ML) surface areas associated with the PRCP application. This was inclusive of the screen capture error information highlighted by DETSI. As part of the review the following was identified and addressed: • Further refinement of disturbance areas; • Addressed areas highlighted by DETSI in email on 28 March 2025 (see Attachment 3 and 4) ;and • Updated PRCP Schedule to align with the above changes (see Attachment 5).
		DETSI email response issued to Whitehaven 09/05/25	**Reference Map, Final Site Design and Spatial Data (NPM Reason # 5 to 7)** a) The department is satisfied the information provided is sufficient to address NPM Notice matter #5- 7 b) Please note, through further assessment during the information stage, additional information may be requested through a formal information request

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		Whitehaven letter response to DETSI 16/05/25 (this letter)	We also acknowledge DETSI's confirmation that our response dated 30 April 2025 adequately addresses NPM Reasons #5-7.
		NPM Reason #6 Item Close-Out: The updated final site design map is provided with this correspondence in the electronic folder titled "NPM Documentation 16.05.25". These figures have also been included in the PRC Plan resubmitted today 16 May 2025 (see Figures 29 and 30). In addition, the updated spatial data files mentioned above (see Whitehaven letter response issued to DETSI 30/04/25), are provided in the electronic folder titled "PRCP Submission 16.05.25".	
7	**Post-mining land use (PMLU) for all land in the area of each resource tenure**	**DETSI NPM Notice issued to Whitehaven 25/11/24**	**DETSI Reason Commentary** The PRC Plan does not provide a post-mining land use (PMLU) for all land in the area of each resource tenure and therefore does not meet the requirements of s126D(1) of the EP Act and Section 4.1 of the PRCP Guideline. The mapping and spatial data provided illustrate several polygons labelled '*Excised*'. No information or justification is provided in the PRC Plan as to why this land has been excised and it has not been assigned a PMLU as per the EP Act and PRCP Guideline requirements. Furthermore, *Figure 19 Locations of BWM PMLUs and NUMAs* also includes polygons labelled 'Excised land'. **DETSI Action** Provide a PRC Plan that provides a PMLU for all land in the area of each resource tenure to meet the requirements of s126D(1) of the EP Act and Section 4.1 of the PRCP Guideline. Where land is to be excised and not assigned a PMLU, adequate justification supported by evidence for this exclusion from PMLU mapping must be provided with the PRC Plan.
		Whitehaven and DETSI meeting 04/12/24	Meeting Minutes Key Points and Actions
		Whitehaven letter response to DETSI 24/03/25	**Whitehaven Response – NPM Item #7** Whitehaven has identified that the term *'excised'* has caused confusion with regard to the PRCP application (predominately the maps and spatial datasets submitted), and we qualify in replacement of this term that *'Third-party owned infrastructure* is more appropriate. Under section 112 of the EP Act 'post-mining land use' (PMLU) is defined as *"the purpose for which the land will be used after all relevant activities for the PRC Plan carried out on the land have ended"*. It is our interpretation that the definition is not intended to include third-party activities or assets which are undisturbed by mining activities which may continue to exist once mining activities have ceased. In this regard we do not believe these areas require assignment of a PMLU. As discussed in our response for Reason #3 (above), in the event land subject to third-party infrastructure is to be impacted by mining operations beyond what is currently set out under the PRC Plan and PRCP Schedule, the PRC Plan and PRCP Schedule will be updated accordingly. This may for example include the realignment of third-party owned areas and infrastructure to allow for continued mining activity progression, as outlined in the PRC Plan and PRCP Schedule. The table provided in Appendix 7 provides information regarding the third-party owned infrastructure, which is not to be assigned a PMLU, and are therefore excluded from PMLU mapping and spatial data. The figures presented in Appendix 7 provide the locality of the infrastructure which is identified in this table. As mentioned in our response provided for Reason #5 (above), within the legend and mapping insets provided within these maps, certain areas are defined as *"Existing retained third-party infrastructure subject to potential future re-alignment"*. This information is shown to denote areas where the potential future realignment of third-party infrastructure may be required to enable mining activities in accordance with the PRC Plan. Any future realignment of these areas, and also potentially other areas not currently defined, would be subject to future agreement between Whitehaven and the relevant owner. For clarity, should future mining activities not progress in these areas, the infrastructure will remain in place and any future decisions, including for decommissioning and rehabilitation, will be at the discretion of the owner.
		Whitehaven and DETSI meeting 25/03/25	In this meeting the Whitehaven letter responses issued to DETSI on 24/03/25 were discussed.
		DETSI email response issued to Whitehaven 28/03/25	***Reference Map, Final Site Design and Spatial Data (NPM Reason # 5 to 7)*** Please find attached screen captures which illustrate some of the errors including: • disturbance areas not being subject to rehabilitation area (RA) mapping. • mapped RAs over some portions of land which Whitehaven do not currently have ML surface area granted. • ML surface area with no RA or PMLU mapping. • RA mapping and 'maximum disturbance footprint' in some locations that do not align. The screen captures are a selection of issues identified by DETSI to assist, as requested by Whitehaven; however, this is not intended to be an exhaustive assessment. It is the responsibility of Whitehaven to conduct a review of imagery and ML surface areas to ensure that all land the subject of the PRCP is accurately mapped.
		Whitehaven letter response to DETSI 30/04/25	**Whitehaven Response to Item 3 - Reference Map, Final Site Design and Spatial Data (NPM Reason # 5 to 7)** Whitehaven has conducted a thorough review of the spatial data, imagery and Mining Lease (ML) surface areas associated with the PRCP application. This was inclusive of the screen capture error information highlighted by DETSI. As part of the review the following was identified and addressed: • Further refinement of disturbance areas;

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			• Addressed areas highlighted by DETSI in email on 28 March 2025 (see Attachment 3 and 4) ;and • Updated PRCP Schedule to align with the above changes (see Attachment 5).
		DETSI email response issued to Whitehaven 09/05/25	**Reference Map, Final Site Design and Spatial Data (NPM Reason # 5 to 7)** a) The department is satisfied the information provided is sufficient to address NPM Notice matter #5- 7 b) Please note, through further assessment during the information stage, additional information may be requested through a formal information request
		Whitehaven letter response to DETSI 16/05/25 (this letter)	We also acknowledge DETSI's confirmation that our response dated 30 April 2025 adequately addresses NPM Reasons #5-7.
		NPM Reason #7 Item Close-Out: The table and figures referred to above (see Whitehaven letter response issued to DETSI 24/03/25), are provided with this correspondence in the electronic folder titled "NPM Documentation 16.05.25". The table and figures have also been included in the PRC Plan resubmitted today 16 May 2025 (see Table 49 and Figures 55 and 56). In addition, the updated spatial data files mentioned above (see Whitehaven letter response issued to DETSI 30/04/25), are provided in the electronic folder titled "PRCP Submission 16.05.25".	

Spatial information

GIS data associated with this application is available upon request to the Department of Environment and Science.

Information on how to make a request is available at:
https://www.qld.gov.au/environment/pollution/licences-permits/public-register