CLERMONT
COAL OPERATIONS

GLENCORE

Progressive Rehabilitation and Closure Plan (PRC Plan)

December 2021

Project No: 0566938

ERM

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1. Cover Page

As required by the DES Application form ' Submission of a Progressive rehabilitation and closure plan' (ESR/2019/4957, Version 3.00, dates 4th February 2021), the following information is provided as a cover page to this PRC plan.

Title of the project	Clermont Coal Operations
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Acronyms and Abbreviations

Acronym	Meaning
AHD	Australian Height Datum
AMD	Acid Mine Drainage
ANZECC	Australian and New Zealand Environment and Conservation Council
ANZGV	Australian and New Zealand Guidelines for Fresh Water and Marine Water Quality
AQP	Appropriately Qualified Person
ARCP	Annual Rehabilitation and Closure Plan
ARI	Average Recurrence Interval
AWSA	Alternative Water Supply Agreement
BAC	Blair Athol Coal
BCP	Belyando Cobblers Peg
bgs	Below ground surface
BOD	Basis of Design
CCC	Community Consultative Committee
CCO	Clermont Coal Operations
CCP	Community Consultation Plan
CH	Cement Hill
CHCC	Cultural Heritage Coordinating Committee
CHPP	Coal Handling Preparation Plant
CM	Clermont Mine
CMLR	Centre of Mined Land Rehabilitation
DNRME	Department of Natural Resources, Mines and Energy
DRDMW	Department of Regional Development, Manufacturing and Water
EA	Environmental Authority

Acronym	Meaning
EIS	Environmental Impact Statement
EMOS	Environmental Management Overview Strategy
EP Act	*Environment Protection Act 1994*
EPBC Act	*Environmental Protection and Biodiversity Conservation Act 1999*
ERA	Environmentally Relevant Activities
GCAA	Glencore Coal Assets Australia
GERG	Groundwater and Environment Reference Group
GIS	Geographic Information System
ha	Hectare
LEM	Landform Evolution Modelling
LOD	Land Outcome Document
LOM	Life of Mine
LRA	Land Resource Area
MIA	Mine Industrial Area
ML	Mining Lease
NAF	Non-acid Forming
NC Act	*Nature Conservation Act 1992*
NEPC	National Environment Protection Council
NFNG	Near and Far Neighbours Group
NWRD	Northern Waste Rock Dump, including 360 Dump Top
OLC	Overland Conveyor
PAF	Potentially Acid Forming
PAF-LC	Potentially Acid Forming – Low Capacity
PMLU	Post Mining Land Use
PRC Plan	Progressive Rehabilitation and Closure Plan

Acronym	Meaning
RE	Regional Ecosystem
RL	Reduced Level
RMP	Rehabilitation Management Plan
ROM	Run of Mine
RRC	Rehabilitation Report Card
RTCA	Rio Tinto Coal Australia
SCL	Strategic Cropping Land
SEP	Stakeholder Engagement Plan
SEWRD	South East Waste Rock Dump
SIA	Social Impact Assessment
SPP	State Planning Policy
SWWRD	South West Waste Rock Dump
t	Tonnes
TEC	Threatened Ecological Community
TLO	Train Load Out
TSF	Tailing Storage Facilities
UQ	University of Queensland
VMA	*Vegetation Management Act 1999*
WRD	Waste Rock Dump
yr	Year

Introduction

Purpose

The *Mineral and Energy Resources (Financial Provisioning) Act 2018 (Qld)* (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 (PRC Plan), 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. The PRC Plan is comprised of two parts:

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

This document fulfils the requirements for the rehabilitation planning part for Clermont Coal Operations (CCO) (also referred to as the 'site'). The purpose of the rehabilitation planning part is to support and justify the development of the PRC Plan schedule (Appendix 4.1), and detail how progressive rehabilitation and closure will be carried out over the entire site and on a rehabilitation and improvement basis (DES, 2021).

The rehabilitation planning part is not approved by the administering authority, but must be submitted to support the PRC Plan schedule, which is approved by the administering authority and operates separately to the Environmental Authority (EA).

As stated in the PRC Plan statutory guideline (DES, 2021), "*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 PRC Plan schedule contains milestones and conditions that relate to the completion of progressive rehabilitation and mine closure. Both the EA and the PRC Plan 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 PRC Plan schedule the EA prevails to the extent of the inconsistency*".

The PRC Plan schedule (number 2. above) is provided separately to this document in the spreadsheet template provided by DES. Key elements of this schedule are included as Appendix 4.1 to this document.

Scope

This PRC Plan applies to CCO. CCO is an existing mine which operates under EA EPML00634113, the latest version of which came into effect 9 February 2021. This is a transitional PRC Plan submitted in response to the transition notice issued by DES, and transitional provisions under the MERFP Act apply. As a transitional site, existing rehabilitation and closure outcomes in the EA and other land outcome documents (LODs), as defined under section 750 of the EP Act, can be transitioned into the PRC Plan. CCO relies on two LODs under the EP Act as part of the transitionary process; these are listed below in hierarchical order, such that where there is an inconsistency between these documents the first document in the list prevails to the extent of the inconsistency (DES, 2021):

1. EA. Meets LOD definition under s750 of the EP Act: *a) an EA;* and

2. Rehabilitation Management Plan (RMP). Meets LOD definition under s750 of the EP Act: *c) a document made under a condition of an EA that:*

> *i) relates to the management or rehabilitation of land (e.g. rehabilitation and closure plan or residual void management plan)*

ii) was provided to the administering authority between 20 November 2019 and to 30 November 2021; and

iii) within 20 business days after receiving the document, the administering authority had not notified the EA holder that the document was insufficient.

CCO has pre- approved post mine land uses (PMLUs) and a non-use management area (NUMA). These are addressed within the above documents (discussed in Sections 3.3, 3.4 and 3.5), and they can be transitioned into the PRC Plan 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 PRC Plan 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 (3) (voids located within a floodplain having to be rehabilitated to a stable condition) of the EP Act.

For the purposes of the PRC Plan, CCO comprises the Clermont main (CM) deposit, Cement Hill (CH), Overland Conveyor (OLC), and Train Load-Out Facility (TLO) (Figure 1). This PRC Plan does not apply to other lands owned by CCO or offset properties which do not contain ERAs.

This PRC Plan has been prepared in accordance with the requirements of the statutory PRC Plan Guideline published by the Department of Environment and Science (2021). ***Table 1*** shows compliance with the requirements by listing the relevant sections in this PRC Plan where each requirement is addressed.

Site Description

CCO is a large scale open-cut operation, managed by Glencore on behalf of a joint venture between Glencore and Sumitomo Corporation (GS Coal Pty Ltd), J- Power Australia Pty Ltd and J.C.D. Australia Pty Ltd. CCO commenced operations in 2010, with Glencore commencing operational management of the site from June 2014 after GS Coal Pty Ltd acquired Rio Tinto Coal Australia's (RTCA) shareholding. The site is located approximately 12 kilometres from the Clermont township in Central Queensland (refer inset in Figure 1) and produces approximately 12 million tonnes (Mt) per annum of high energy thermal coal per year, using a truck and shovel method. The CM comprises the main operational area, including the open cut operations, workshops, administration buildings, site village, and associated infrastructure. The TLO is located north of the Blair Athol (BA) mine (operated by Terracom), and comprises the coal load-out facilities for CM, with coal transported from the CM to the TLO via the OLC. CH is an old alluvial gold mining lease, with a water filled void that is currently used for balancing water storage for the CCO water management system. The key features of each area, including detailed maps for each operational area, are provided in Section 3.1.2.2. The mining leases (MLs) associated with each of these operational components are described in Section 3.1.2.1.

Vision

The vision for the CCO project is to leave behind a predominant land use of woodland and grazing on the rehabilitated landforms, consistent with land uses in the surrounding area. This document describes the pathway to achieve this vision. The landforms corresponding with this vision are shown in Figures 2, 3 and 4.

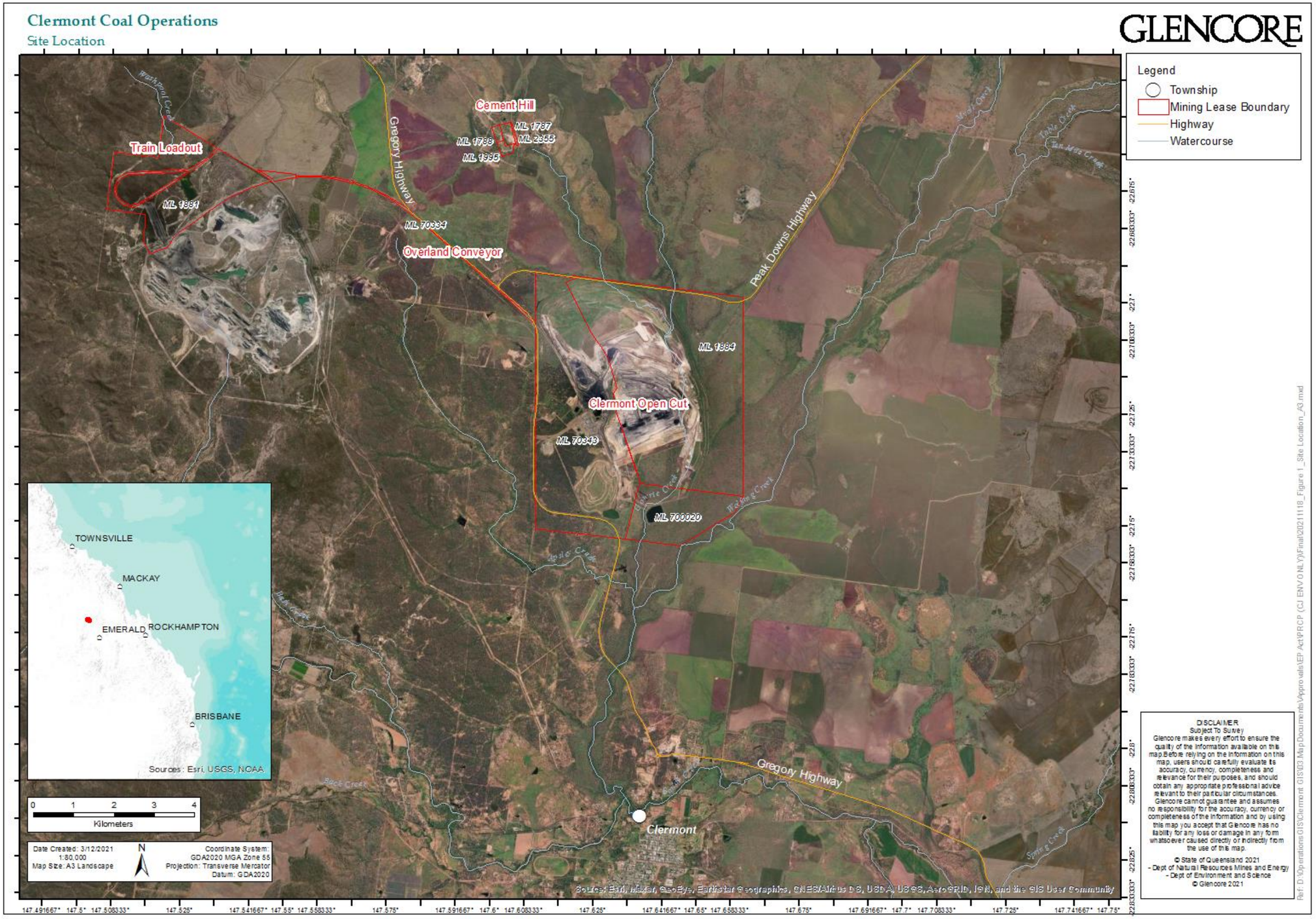


Figure 1 - Site Location

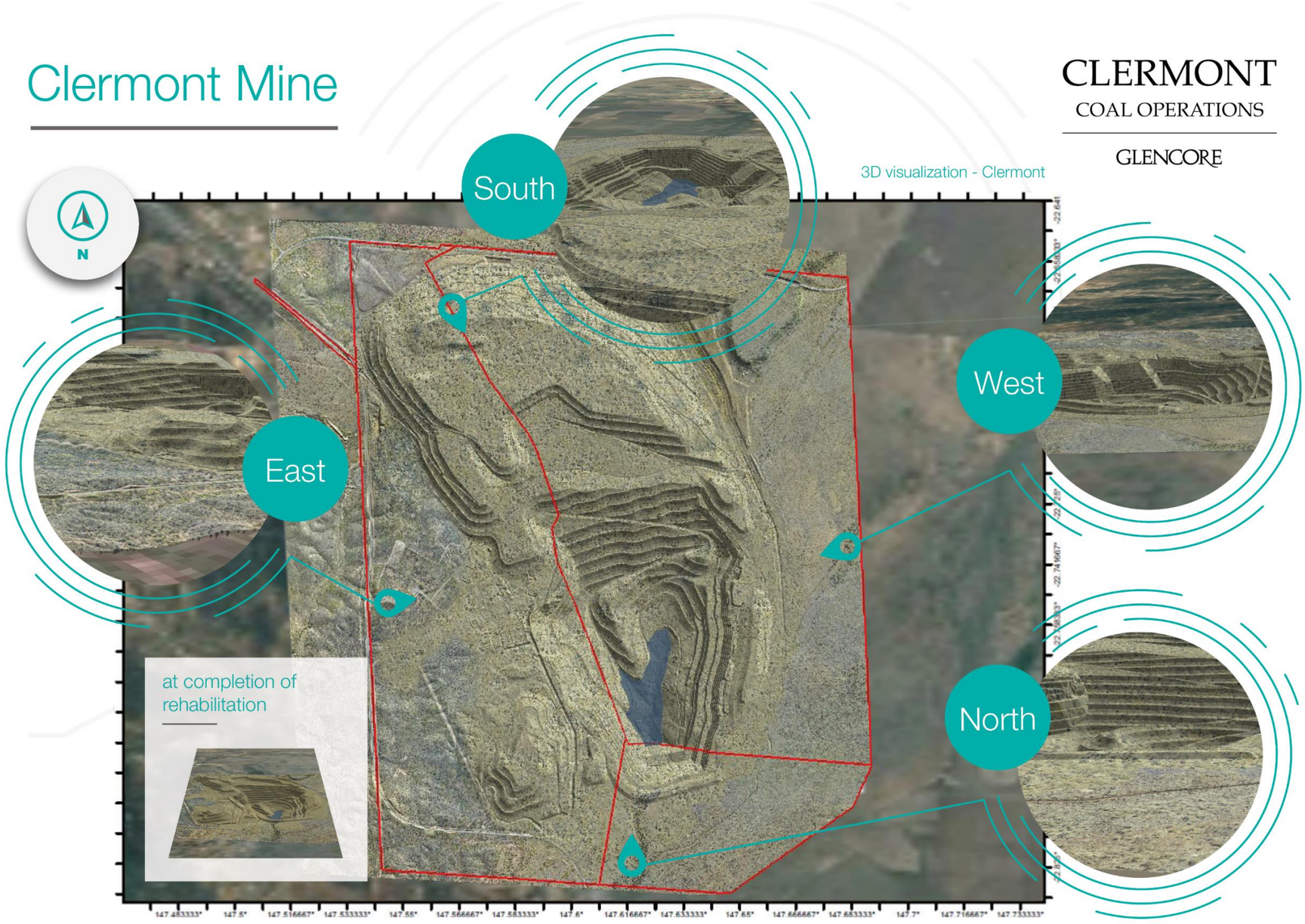


Figure 2 - CM visualisation at relinquishment (conceptual only)

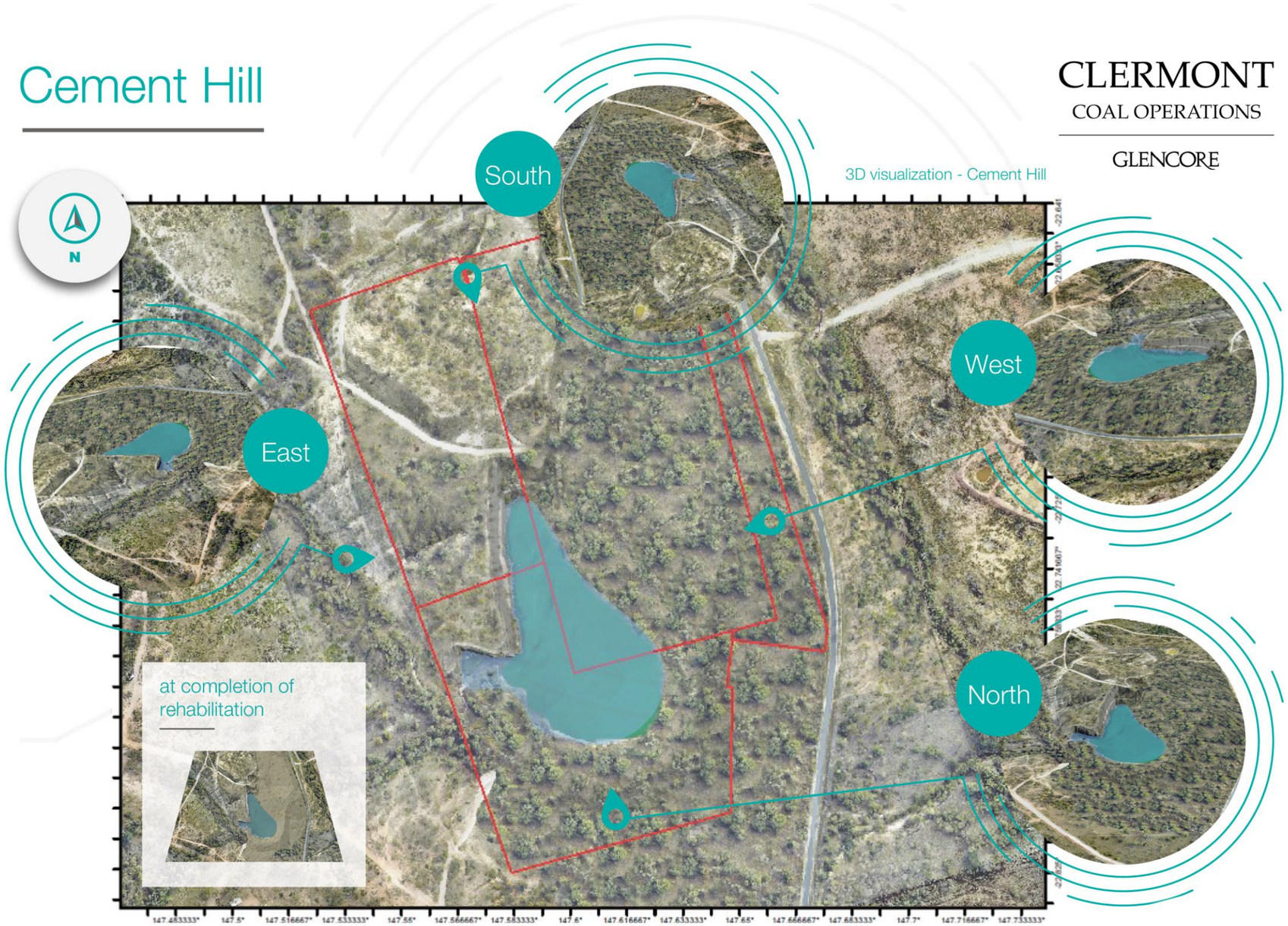


Figure 3 - CH visualisation at relinquishment (conceptual only)

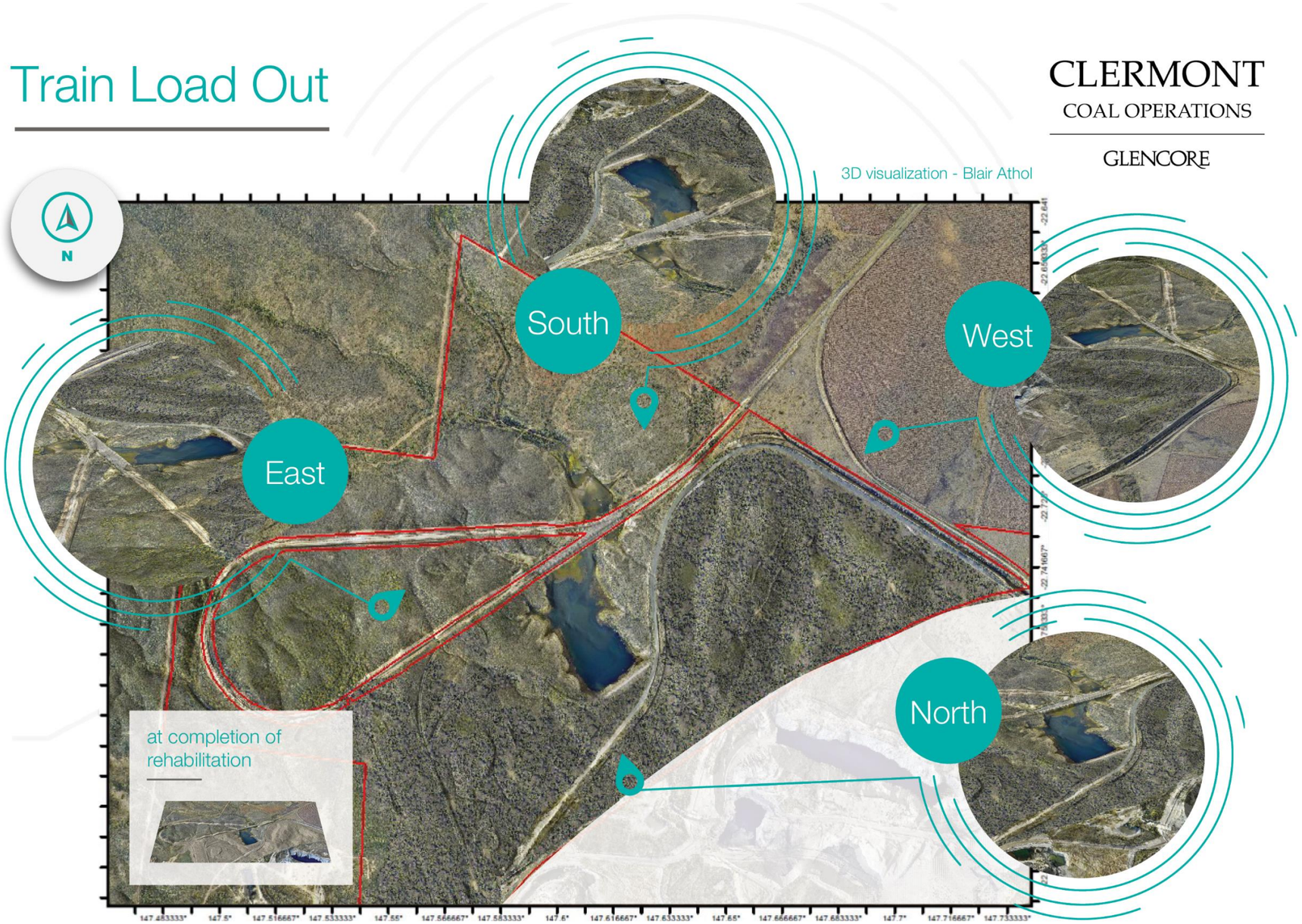


Figure 4 - TLO visualisation at relinquishment (conceptual only)

Table 1 - Compliance Table

PRC Plan Guideline Requirements	Section in Report
3.1 PROJECT PLANNING	3.1
Legislative Requirements *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 area of each tenure	1; 3.1.2.1
relevant activities to which the application relates	3.1.4
duration of relevant activities	3.1.2.3
how and where the relevant activities were carried out, including maps	3.1.4
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 PRC Plan schedule:	3.1.1
• site topography (locally and regionally)	3.1.1.1
• climate (general and specific (rain, evaporation, temperatures)) including long term projections	3.1.1.2
• geological setting	3.1.1.3
• site hydrology and fluvial networks	3.1.1.5
• groundwater levels and properties	3.1.1.4
• soil types, properties and productivity	3.1.1.6
• land stability (pre-existing land degradation/erosion and predisposition to ongoing stability issues)	3.1.1.7

PRC Plan Guideline Requirements	Section in Report
• vegetation communities and ecological data (including existing regional ecosystem mapping)	3.1.1.8
• fauna presence and populations	3.1.1.9
• pre-mining land use	3.1.1.10
• identification of underlying landholders	3.1.1.11
Project Description The project description must include the following details:	3.1.2
• mining tenements	3.1.2.1
• primary mine features/infrastructure on site (e.g. TSF, waste rock dump, etc.)	3.1.2.2
• type of mining operation	3.1.2.3
• proposed duration of operation as a whole	3.1.2.3
Design for Closure The rehabilitation planning part of the PRC plan for new or expanding sites must include a description of how the certain aspects have been designed for closure. *Note transitional PRC plans are not required to demonstrate design for closure for existing or approved disturbance, and as such this section is not applicable to CCO.*	3.1.3
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:	3.1.4
• 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	3.1.4.2

PRC Plan Guideline Requirements	Section in Report
• the size/extent of the relevant activities	3.1.2
• whether the different relevant activities can be progressively rehabilitated	3.1.4.2
Applicability to Transitional PRC Plans 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	3.1.4
• when the rehabilitation works commenced and were completed	3.1.4
• whether the rehabilitation has been applied for or approved as progressively certified under the EP Act	3.1.4
Spatial Information The following spatial information must be submitted as part of the PRC plan:	
• location and maximum extent of disturbance footprint for the mine life	3.8.2
• the PMLUs and NUMAs for the area within the resource tenures	3.8.2
• any sensitive receptors	3.8.2
• Spatial Information outlining the rehabilitation and improvement areas that correspond with the proposed PRC Plan schedule, for a 10-year period (minimum)	3.8.2
3.2 POST-MINING LAND USE	
Legislative Requirements	3.3

PRC Plan Guideline Requirements	Section in Report
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:	
a) the outcome of consultation with the community in developing the plan, and	3.3.4
b) any strategies or plans for the land of a local government, the State or the Commonwealth.	3.3.6
3.2 POST-MINING LAND USE	3.3
Legislative Requirements *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:*	
a) the outcome of consultation with the community in developing the plan, and	3.3.4
b) any strategies or plans for the land of a local government, the State or the Commonwealth.	3.3.6
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 PRC Plan 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.*	3.3.2
The description of proposed PMLUs must include (where relevant), but is not limited to:	
• a description of the use of the land	3.3.5
• if applicable, the specific vegetation types (e.g. RE 13.2.9) or land suitability classification (e.g. Class 4)	3.3.5
• identification of any permanent or essential management infrastructure to be included as part of the PMLU	3.3.5
• success criteria for measuring whether the PMLU has been achieved successfully.	Appendix 4.1
3.3 NON-USE MANAGEMENT AREAS	3.4

PRC Plan Guideline Requirements	Section in Report
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 PRC plan 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
• *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)*	3.4.1
• *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)*	3.4.1
Note where a NUMA has already been identified in a land outcome document and is able to be transitioned into the PRC Plan 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 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	3.4.2
• any relevant safety features	3.4.2
• success criteria for measuring whether the NUMA has achieved sufficient improvement (in which each of the following is minimised: a) the risk of the area collapsing, eroding or subsiding; b) the need to actively manage the area; and c) access to the area by an animal or person by, for example, fencing the boundary of the area)	3.4.3
3.4 VOIDS IN FLOOD PLAINS	

PRC Plan Guideline Requirements	Section in Report
Legislative requirement *In accordance with section 126D(3) of the EP Act, if land the subject of the proposed PRC Plan 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 where a land outcome document has a pre-approved land outcome for a void with a location specified, flood plain modelling is not required.	3.4.1
3.5 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*	3.2.3
• *details of how the applicant will undertake ongoing consultation in relation to the rehabilitation to be carried out under the plan.*	3.2.3
Note where there are land outcomes has 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 PRC plan. The community consultation register must include:	
• previous consultation (history of community engagement)	3.2.3.1
• consultation date(s)	Appendix 4.2
• identification of each community member	3.2.2; Appendix 4.2
• description of consultation type (workshop, quarterly meetings, etc.)	3.2.3; Appendix 4.2

PRC Plan Guideline Requirements	Section in Report
• information provided to the community	3.2.3; Appendix 4.2
• issues raised/discussed by the community	3.2.3; Appendix 4.2
• how issues have been considered	3.2.3; Appendix 4.2
• decisions/outcomes of engagement	3.2.3; Appendix 4.2
• commitments made by the applicant	3.2.3; Appendix 4.2
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 PRC plan. The community consultation plan must include details of:	
• the objectives for community consultation	3.2.1; Appendix 4.2
• how the community will be engaged	3.2.4; Appendix 4.2
• proposed consultation frequency	3.2.4; Appendix 4.2
• what information will be released for community consultation	3.2.4; Appendix 4.2
• how feedback/comments will be considered	3.2.4; Appendix 4.2

PRC Plan Guideline Requirements	Section in Report
3.6 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 PRC Plan 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 PRC Plan 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:	
• determining the groundwater occurrence including the existence of, and depth to, aquifers and aquitards	3.5.1.1
• locating groundwater recharge and discharge locations locally and regionally	3.5.1.3
• groundwater quality within each of the aquifers and from surface expressions (i.e. seeps and springs)	3.5.1.2
• current and potential future uses of groundwater including existing groundwater extraction bores	3.5.1.4
• groundwater flow direction and velocity, including field tests to determine hydraulic conductivity	3.5.1.2
• the development of potentiometric mapping and hydro stratigraphic cross sections	3.5.1.2; 3.5.1.5
• groundwater modelling to determine contaminant transport and potential changes to groundwater level from dewatering or waste storage	3.5.1.4
Flooding In addition to floodplain modelling, the applicant must also assess the flooding susceptibility and influence across the site	3.5.2

PRC Plan Guideline Requirements	Section in Report
If flooding is a consideration, develop a hydrologic model of the catchment and a hydraulic model of the proposed mining area.	3.5.2.3; Appendix 4.6
When assessing flooding, you must at least:	
• consider the location of domains in relation to potential flood levels	3.5.2.1
• consider alteration of flow upstream and downstream	3.5.2.2
• model flood levels (including probable maximum flood levels) for a range of design storm events	3.5.2.3
• develop a flooding risk profile	3.5.2.4
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	3.5.3.1; 3.5.3.2
• 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?)	3.5.3.3
• an assessment to determine the need for ameliorants and fertilisers	3.5.3.4
• the relationship between soils and vegetation ecosystems for the PMLU and rehabilitation methodology	3.5.3.5
Waste Characterisation	
• Describe contaminants that can pose a risk to the environment, such as contaminants associated with AMD, neutral mine drainage and saline mine drainage	3.5.4.1
• 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 representative of all lithologies	3.5.4.2

PRC Plan Guideline Requirements	Section in Report
• Landform design must include waste placement strategy	3.5.4.4, 3.5.5
• Describe how mine waste streams can be classified confidently based on environmental risk and managements requirements	3.5.4.3
• Describe the generation of block models and estimation of the volume of mine waste based on waste type (i.e. level of environmental risk)	3.5.4.3
• Provide recommendations for the management and mitigation of waste streams to manage environmental risk and achieve proposed rehabilitation methods and objectives.	3.5.4.4
• Maintain a database to store the characteristics of each rock type	3.5.4.3
• Characterise materials based on both static tests and kinetic tests	3.5.4.2
• 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	3.5.4.5
Landform Design The final landform design must include:	-
• 3D design plans of the final landform	3.5.5.3
• method of determining landform design	3.5.5.1
• modelling predicting the long-term stability of the final landform design	3.5.5.5
• method of construction	3.5.5.5
• Quality Assurance / Quality Control (QA/QC) requirements	3.5.5.5
• trial methodology to verify the predicted success of the final landform design	3.5.5.2; 3.5.5.4
• limitations and assumptions of the landform design	3.5.5.4

PRC Plan Guideline Requirements	Section in Report
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	3.5.5.3
• 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	3.5.5.2
• whether the landform is 'water-retaining' or 'water-shedding', considering rainfall patterns, and intensity, and the composition and texture of the waste	3.5.5.2; 3.5.5.3
• the identification of materials available for landform rehabilitation including their ability to achieve the required landform design outcomes	3.5.5.3
• erosion assessments to determine landform heights, gradients, profiles, and material placement	3.5.5.4
• 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	3.5.5.2
• settling and subsidence over time, which may impact the availability of areas for rehabilitation	3.5.5.5
• hydrological and hydrogeological assessments	3.5.5.2
• a waste placement strategy developed to mitigate environmental and rehabilitation risks during the construction and decommissioning phase	3.5.5.2
• 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	3.5.5.2
• monitoring to determine performance of control measures (i.e. liners or seepage collection systems)	3.5.5.5
Provide an analysis of future stability based on the factors described above (e.g. landform evolution modelling).	3.5.5.4

PRC Plan Guideline Requirements	Section in Report
Cover Design The cover design should include:	3.5.6
• identification and specification of the objectives of the cover system	3.5.6
• a detailed description of the design including the thickness of each layer	3.5.6
• a detailed description of construction methodology including any proposed staging of the cover system	3.5.6
• a quantitative assessment that identifies the location and quantity of proposed capping material available on site	3.5.6
• proposed QA/QC for the construction of the cover system including the timely implementation of corrective actions where deviations from the design are identified	3.5.6
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	3.5.7.1
• source, pathway and fate of contaminants that have the potential to impact environmental values	3.5.7.2
• infiltration and seepage intervention and collection controls	3.5.7.3
• surface water diversions and long-term management requirements	3.5.7.4
• dewatering requirements	3.5.7.4
• on-going water management and reduction requirements (i.e. treatment)	3.5.7.4
Revegetation	

PRC Plan Guideline Requirements	Section in Report
• Revegetation Plan must propose activities to establish self-sustaining vegetation communities appropriate for the intended PMLU	3.5.8; Appendix 4.12
• Revegetation Plan must:	
- Articulate revegetation objectives	3.5.8.1
- Identify key flora species appropriate for the PMLU	3.5.8.2
- Identify species of conservation significance	3.5.8.3
- Identify fauna habitat or use requirements, including monitoring and management plan	3.5.8.4
- Include evidence and justification for analogue sites of the monitoring plan	3.5.8.5
- Describe works for establishing and managing revegetation	3.5.8.6
- Identify appropriate plant/seed mixes and their source	3.5.8.6
- Identify seed density application rate and timing of seeding	3.5.8.6
- Identify proposed locations of any infrastructure required to protect revegetation	3.5.8.6
- Identify the growth media suitable to sustain the PMLU and its availability	3.5.8.6
- Identify topsoil depth requirements	3.5.8.6
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	3.5.8.6
• spreading of growth medium layer (topsoil, topsoil / rock mix, or suitable waste if appropriate) to a depth suitable for the target vegetation	3.5.8.6

PRC Plan Guideline Requirements	Section in Report
• the application of seed, fertiliser and, where applicable, irrigation.	3.5.8.6
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.	3.5.9.1, 3.5.9.2
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	3.5.9; Appendix 4.10
• Specific gravity testing. The specific gravity of tailings affects their hydraulic sorting down the tailings beach, and their settling and consolidation	3.5.9; Appendix 4.10
• Atterberg limit testing to determine the plasticity of the tailings, which affects their settling, consolidation and desiccation on atmospheric exposure	3.5.9; Appendix 4.10
• 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	3.5.9; Appendix 4.10
• Settling testing of the tailings used as an indicator of the settling density of the tailings	3.5.9; Appendix 4.10
• 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	3.5.9; Appendix 4.10
• Consolidation testing of the tailings to estimate their consolidated density and saturated hydraulic conductivity	3.5.9; Appendix 4.10
• Soil water characteristic curve testing to assess the unsaturated behaviour of the tailings on desiccation and calculate the unsaturated hydraulic conductivity function	3.5.9; Appendix 4.10

PRC Plan Guideline Requirements	Section in Report
• Instrumented column testing of the tailings to assess their settling, self-weight consolidation and desiccation	3.5.9; Appendix 4.10
• 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	3.5.9.3
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:	3.5.10
• options available for minimising final void area and volume (where a final void is proposed)	3.5.10.1
• proposed final dimensions of the void (i.e. depth, length and width)	3.5.10.2
• 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	3.5.10.3
• proposed final slope angles of high wall, low wall and end walls of each final void	3.5.10.2
• void hydrology, addressing the long-term water balance and water level in the voids, stratification connections to groundwater resources and potential for overflow	3.5.10.4
• groundwater modelling to determine whether the void is acting as a sink or a source for groundwater	3.5.10.5

PRC Plan Guideline Requirements	Section in Report
• a water balance study including an assessment of void surface and groundwater interactions such as:	
- groundwater lowering/reduction in hydraulic head (from new voids e.g. caves/karst systems)	3.5.10.6
- cones of depression and associated impacts	3.5.10.6
- the drainage and flooding behaviours of surface waters in the vicinity of the void	3.5.10.6
- the potential extent of flooding and implications of interactions with the void	3.5.10.6
- a conceptual model that incorporates all projected inflows, outflows, and recharge rates	3.5.10.6
- water storage and long-term water balance	3.5.10.6
- each of the major water fluxes into and out of the void	3.5.10.6
- the sources of surface water within the mine catchment that are likely to influence the water quality in the void	3.5.10.6
• predicted water quality in the long-term including potential stratification	3.5.10.7
• a 3D void design plan	3.5.10.2
• rehabilitation strategies	3.5.10.8
Underground mining	
Note that the CCO is an open-cut operation, without underground workings so that this section of the PRC Plan statutory guidelines is not relevant. A description of historic workings, their location, and implications for rehabilitation and closure is included in this PRC Plan	3.5.11
Built Infrastructure	
The rehabilitation planning part must include:	

PRC Plan Guideline Requirements	Section in Report
• Identification of infrastructure that will be decommissioned and the methods for decommissioning	3.5.12.1
• A description of infrastructure that will remain post rehabilitation and the identification of ongoing maintenance requirements	3.5.12.2
• Evidence of agreement for any infrastructure that will have ownership transferred	3.5.12.2
3.7 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.*	3.6
Identify sources of risk, areas of impacts, events and their causes and their potential consequences	3.6.1.1
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	3.6.1.1
Determine what risks need to be managed and prioritised.	3.6.1.2
Risk treatment must detail:	
• the reasons for selecting the treatment option	3.6.1.2
• those responsible for the approval and implementation of the plan	3.6.1.2
• proposed actions	3.6.1.2
• resource requirements	3.6.1.2
• performance measures and constraints	3.6.1.2
• reporting and monitoring requirements	3.6.1.2

PRC Plan Guideline Requirements	Section in Report
• timing and scheduling	3.6.1.2
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	3.7.3
- description of methodologies and standards, which could include field-based assessments and the application of new remote sensing, GIS and other relevant emerging technologies	3.7.1.2; Appendix 4.3
- monitoring that enables the repeatable collection of relevant statistically valid data	3.7.1.2; 3.7.1.3; Appendix 4.3
- monitoring using appropriate quality assurance and data management processes and systems	3.7.4
- regular analysis of site data including multi-year comparison trends and bench-marking against analogue/reference sites	3.7.5
- contingency strategies if monitoring data indicates milestone criteria are not being met	3.7.3
- post-closure monitoring to ensure milestone criteria has been demonstrated	3.7.2
- intent of monitoring reports, such as provision of results and key findings	3.7.6
• Describe the processes and activities that will be used to determine the biophysical state of rehabilitation and closure	3.7.1
• Standardised and repeatable approach to the measurement of certain biophysical attributes and processes must be identified that can be compared against the PRC Plan schedule	3.7.3

PRC Plan Guideline Requirements	Section in Report
• If there has/is any monitoring or maintenance of areas already rehabilitated, details must be included in the PRC plan	3.7.1; Appendix 4.3

3. Rehabilitation Planning Part

3.1 Project Planning

3.1.1 Baseline Information

Baseline information relating to the pre-mining environment for the CM and OLC operational areas is available within the EIS (RTCA, 2004). Documented baseline information for the TLO and CH operational areas is not readily available due to their longer operational histories. However, they are near the CM and OLC operational areas, and so baseline conditions at CM and OLC are representative of those at the TLO and CH areas. Where baseline information other than that from the EIS is referred to (including for TLO and CH), this is noted.

3.1.1.1 Site Topography

Prior to the mine development, the CM mining leases (MLs) contained a broad range of distinct topographic units, generally of low relief. Elevations ranged from RL 315m Australian Height Datum (AHD) to RL 260m AHD, with the relief typical of that of the wider Central Highlands region. The western side of the site contained rolling to undulating low hills with slopes from 20-25 percent, which merged into the low undulating rises (slopes <5 percent) and plains that dominated the western third of these MLs. Prospect Hill was a low conical hill that emerged from these rises west of Gowrie Creek.

Gowrie Creek drained most of the CM MLs, with gently sloping drainage lines, floodways and braided channel systems extending into basalt dominated areas to the north and sedimentary and metamorphic dominated areas to the west. A narrow, level to gently undulating alluvial plain is associated with Gowrie Creek.

A basaltic plateau was a prominent feature in the north-east of the CM. This plateau blended into undulating basaltic rises along the eastern boundary. These rises merge with level alluvium associated with the broad alluvial floodplains of Gowrie Creek and Wolfang Creek, draining to the south in the south-east of the CM.

The OLC ML is dominated by undulating rises and colluvial material derived from basalt, metamorphic and sedimentary geologies. The slopes are generally less than 5 percent although some section of the metamorphics may reach 10 percent.

Information on the topography of the TLO and CH prior to development is no longer available. Currently, the topography of the TLO consists of relatively flat to undulating land in the western parts, to undulating surfaces over the waste rock dumps towards the east with elevations up to RL 330m AHD. West Dam is located centrally within the TLO area.

CH is located on a slight elevation (RL 320m AHD) within an otherwise relatively flat landscape. A shallow void created by previous gold mining activities occupies the central southern part of the site, with a depth below water less than 10m. A steep rock wall of some 10m height rises from the western edge of the void. Waste dumps of previous workings occur south and east of the void, while three tailing cells in the north-east are separated from one another by cell walls of less than 2m height. A 10m high bund separates the site from Kenlogan Road east of the site.

3.1.1.2 Climate

The Clermont region has a sub-tropical continental climate, in which winter days are generally warm and sunny, whilst nights are cool. Summer days tend to be hot and nights warm. Summer weather is

influenced by a semi-permanent trough that lies roughly north-south through the interior of the state, and is normally the boundary between relatively moist air to the east and dry air to the west.

A summary of long-term (1870-2004) meteorological monitoring data (temperature, humidity, evaporation, wind speed, and rainfall) from the Bureau of Meteorology (BOM) weather station at Clermont Post Office (Station 035124) was completed for the EIS. Summary data were discontinued at this station in 2018, although calculation of more up to date data is possible from the raw data still produced by this station. Baseline data, updated with current data from Clermont Post Office (to August 2021, except for relative humidity at 9am and 3pm, which extend up to 2010) are presented in Table 2. The current monthly long-term rainfall averages are considerably less than they were during baseline in 2004, with likely repercussions for future vegetation growth.

Table 2 - Climatic Data - Baseline (Current)

Month	Ave. Maximum Temperature (°C)	Ave. Minimum Temperature (°C)	Median Rainfall (mm)	Ave. Evaporation (mm)	Ave. Relative Humidity (%) 9 am	Ave. Relative Humidity (%) 3 pm
January	34.4 (34.2)	21.5 (21.4)	93.3 (92.6)	235.6 (233.5)	65 (66)	40 (42)
February	33.0 (33.1)	21.0 (20.9)	85.1 (77.0)	190.4 (187.7)	70 (71)	45 (47)
March	32.0 (31.9)	19.4 (19.5)	47.6 (44.2)	198.4 (193.0)	69 (69)	42 (42)
April	29.5 (29.4)	15.7 (15.7)	30.0 (17.6)	150.0 (150.7)	66 (67)	40 (41)
May	26.0 (26.0)	11.5 (11.5)	23.1 (16.9)	111.6 (115.5)	68 (68)	43 (42)
June	23.1 (23.1)	8.1 (8.0)	20.5 (16.6)	90.0 (91.9)	68 (69)	40 (41)
July	23.0 (23.1)	6.7 (6.7)	10.3 (8.1)	99.2 (102.6)	65 (66)	36 (37)
August	25.2 (25.4)	8.2 (8.1)	8.7 (8.1)	127.1 (135.2)	60 (61)	32 (33)
September	28.7 (28.7)	12.0 (11.9)	6.5 (4.7)	171.0 (178.9)	54 (55)	28 (29)
October	31.9 (31.8)	16.2 (15.9)	27.3 (25.4)	207.7 (223.9)	54 (54)	29 (30)
November	34.0 (33.7)	19.0 (18.8)	44.0 (39.9)	219.0 (234.1)	55 (57)	32 (34)
December	34.9 (34.5)	20.8 (20.6)	71.1 (69.8)	254.2 (252.1)	60 (60)	36 (38)

Heavy rain and flooding associated with cyclonic low-pressure systems are a feature of the regional climate. Prior to the development of the CCO project, flooding caused major damage in the area downstream from the junction of Sandy Creek with Wolfang Creek, and, over December 2010 and January 2011, the town of Emerald was impacted by floodwaters when the Nogoa River catchment recorded rainfall in excess of 600 mm (BOM 2011).

Strong winds are rare in the Clermont area and are normally associated with thunderstorms during late spring or summer. During the summer months, night and early morning winds are predominantly from the north to north-northeast. Winds are predominantly from the east during the afternoon, when strongest wind speeds tend to occur. Lowest speeds generally occur at night. In the winter months, the predominant wind during the nocturnal hours is from the south-southeast. Winds during

the afternoon are predominantly from the south-east to east and highest speeds typically occur during the day with winds from the south-east.

Future climate reports of the Mackay region have provided indicative changes in temperature and rainfall for two future years, including 2030 and 2070 (Queensland Government 2019). The indicative changes are shown in ***Table 3***. While the temperatures are predicted to rise, rainfall is likely to reduce.

Table 3 - Mackay region temperature and rainfall climate change forecasts

Parameter		2030 RCP 4.5 emission scenario	2070 RCP 4.5 emission scenario
Temperature (°C)	Maximum	+1.4	+2.6
	Average	+1.0	+1.6
	Minimum	+0.5	+1.1
Rainfall (annual) (%)	Maximum	+9.0	+15
	Average	-8.0	-7.0
	Minimum	-21	-29

The RCP (representative concentration pathway) refers to a greenhouse gas concentration trajectory. The trajectory or pathway was labelled according to the potential radiative forcing (W/m^2) resulting from the representative greenhouse gas concentration.

Applying these forecast changes in temperature and rainfall to the baseline climate period used in the study for Clermont climate data (***Table 2***), Figure 5 and 6 provide an indication of future weather. The temperature results indicate the shift from baseline using monthly average maximum temperature for 2030 and 2070. The 2030 and 2070 rainfall scenarios are nearly identical to one another (***Figure 6***).

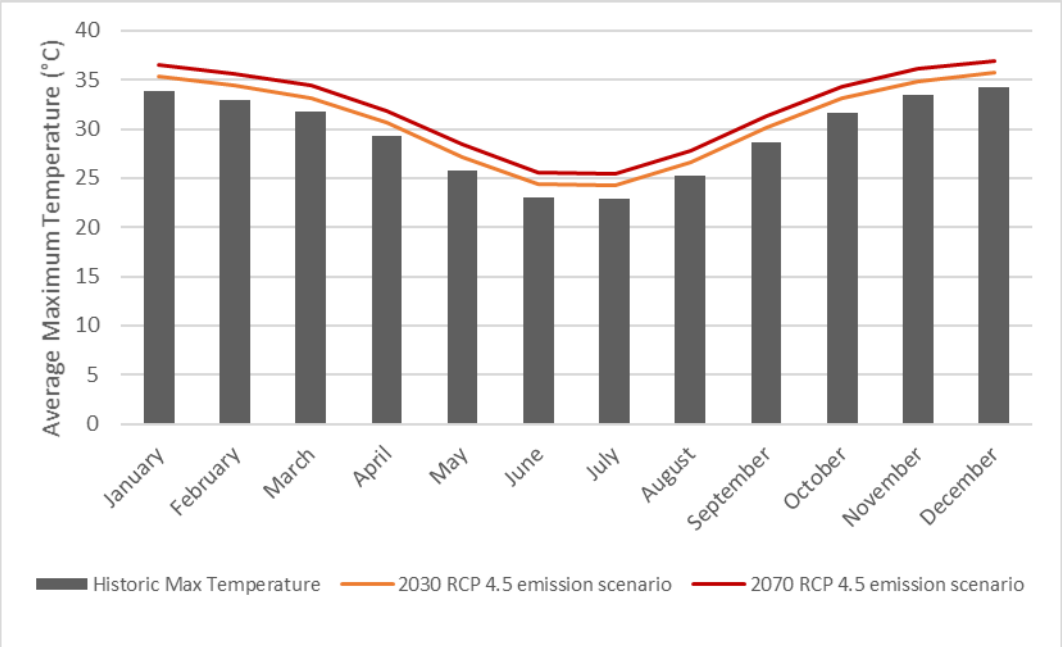


Figure 5 - Temperature baseline, 2030 and 2070 predictions

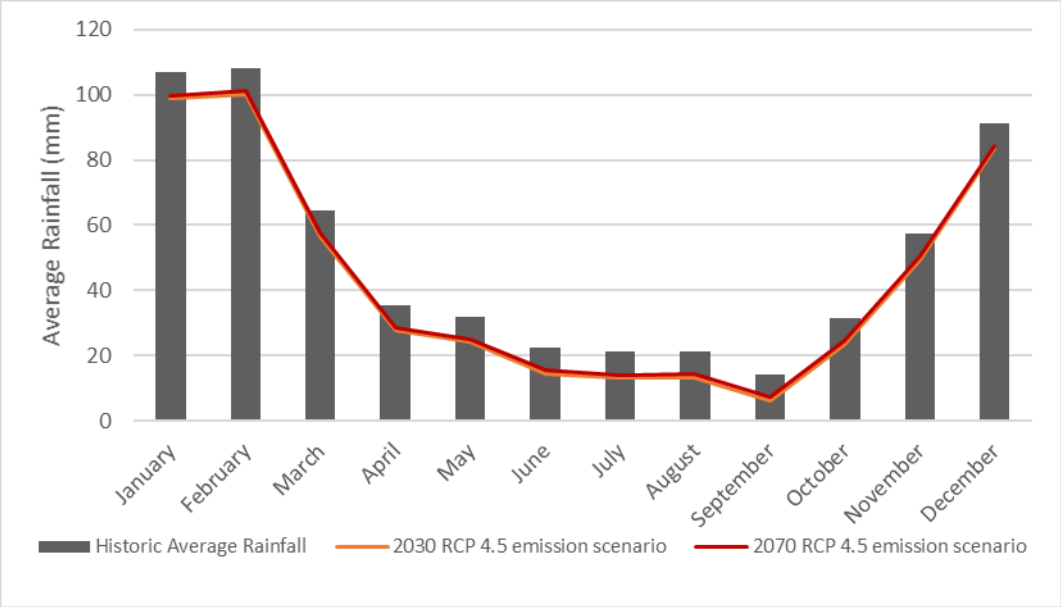


Figure 6 - Rainfall baseline, 2030 and 2070 predictions

3.1.1.3 Geological Setting

CCO is located within the Wolfang Basin, a geological map detailing the basin is shown in ***Figure 7***. The following geological units are typical of this Basin, listed in descending stratigraphic order (see also ***Figure 8***):

- Quaternary Alluvium;
- Tertiary Basalt;
- Undifferentiated Tertiary Sediments;
- Permian Sediments; and
- Pre-Devonian Anakie Metamorphics.

The coal seams occur within the Permian sediments unit. Four major coals seams have been identified within the coal sequence at CM, including Gowrie, Prospect, Wolfang Upper, and Wolfang, at depths ranging between 80 to 290m beneath the surface. The major coal resource is within the Wolfang seam, (35m - 40m thick). Another useful material is the Tertiary basalt, used as building material for roads and drain revetments. Cross sections of the key stratigraphic units at CCO are provided in ***Figure 9***. Further geological and hydrogeological information is presented in Appendices 4.4 and 4.5.

The CM and TLO area consists of a Permian sedimentary sequence deposited in a graben structure and hosts the Wolfang Coal Measures and a basal conglomerate. Cambrian-Ordovician basement rocks consist of the Hurley metamorphic formation. Tertiary sediments overlie the Permian Coal measures and include water bearing gravel. Tertiary basalts form a capping to the Tertiary sediments, having formed as a series of volcanic flows in a north-south oriented Tertiary trough. The Western Wall fault is a normal thrust faulted boundary to the Permian sedimentary trough. Quaternary sediments are developed along recent drainage features cut into the basalt.

The CH area lies within the northern extent of the Permian Blair Athol Coal Measures sedimentary package of rocks, where the basal conglomerate is observed in drill holes and the pit. Basalt overlies the Permian conglomerate sequence of greater than 50 m depth, across most of the site. The limited drilling data available in the area confirms the basement Hurleys Metamorphic unit below the conglomerate. A Tertiary clay unit between the basalt and conglomerate is evident in some areas but continuity is uncertain. The CH gold mining site was previously exploited for alluvial gold located within the gravel deposit, derived from the weathered Permian conglomerate.

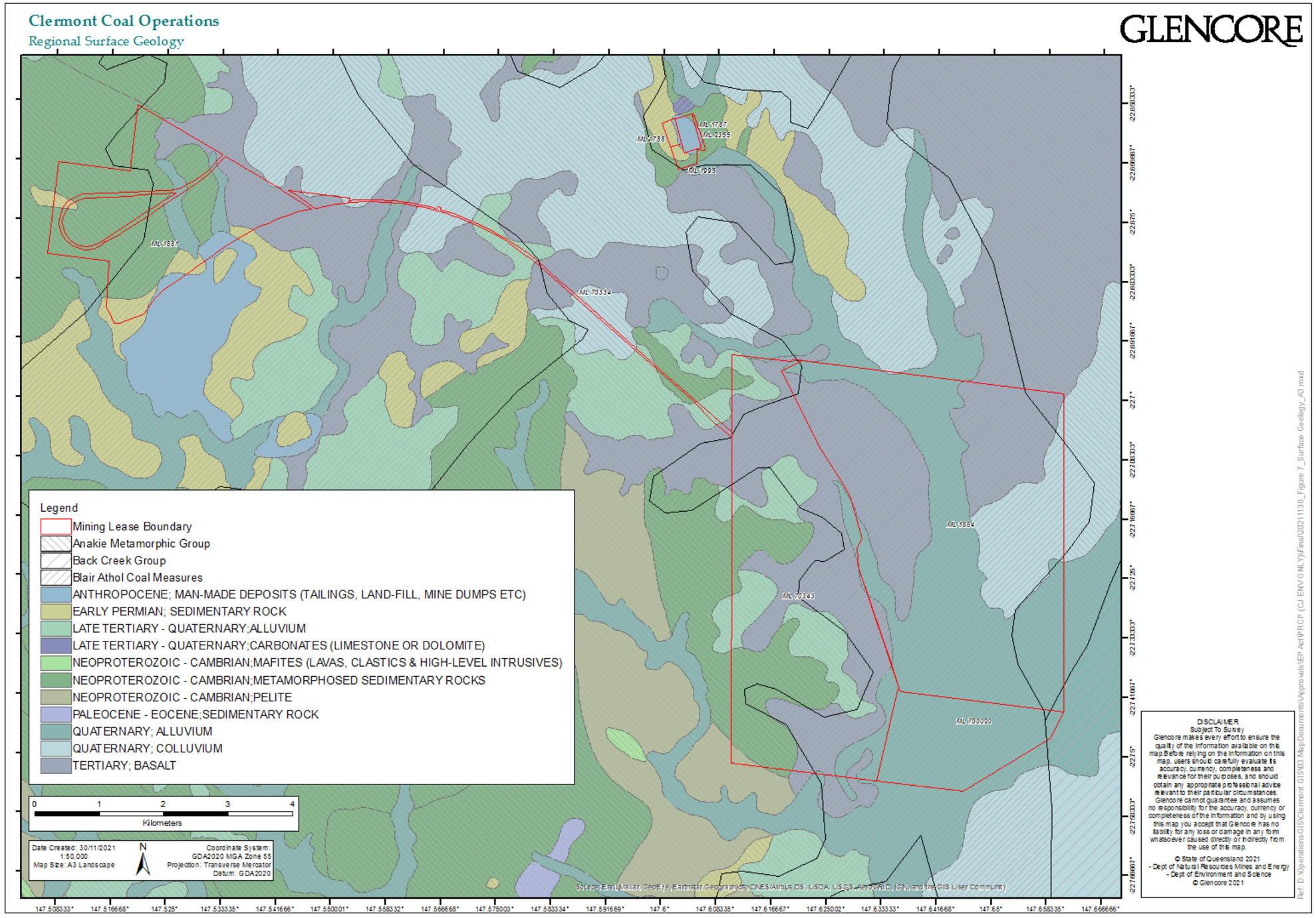
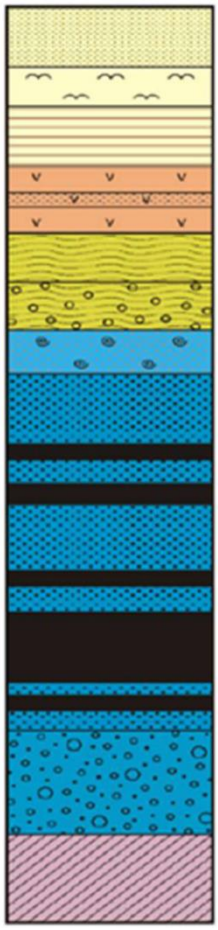


Figure 7 - Geology Units of the Region



Geological Period		*Formation*	*Description*
Quaternary		Soil	Dark grey clayey "blacksoil"; Red-yellow-brown silty to sandy soil.
		Alluvial Soils	Alluvial sandy loam with quartz lithic gravel.
		Clay	Dark brown clay with sand and gravel lenses (below blacksoil in east of lease).
Tertiary	Miocene	Basalt	Flow basalts with inter-flow sediments (clay, sand, peat). Vesicular in part with calcite veining.
	Undifferentiated	Sediments	Claystone, siltstone, quartzose and argillaceous sandstone
		Gravel	Gravelly sand to sandy quartzose gravel with cobbles and boulders
Permian	Upper	Marine	Fossiliferous micaceous claystone to fine grained sandstone. Limited extent.
	Lower	Wolfang Coal Measures	Laminated or massive sandstone and siltstone, coal seams, with minor conglomerate, carbonaceous siltstone and mudstone.
		Gowrie Seam	
		Prospect Seam	
		Wolfang Upper Seam	
		Wolfang Seam	
		Wolfang Lower Seam	
	Lower	Basal Conglomerate	Quartzose and lithic pebble to cobble conglomerate, fine-grained to granular sandstone. Minor variably carbonaceous and laminated siltstone, claystone and mudstone.
Cambrian - Ordovician		Hurleys Metamorphics	Tightly folded mica, quartz-mica and quartz-chlorite schist, with phyllite, slate and quartzite. Common quartz veining throughout.

Figure 8 - CCO Stratigraphy

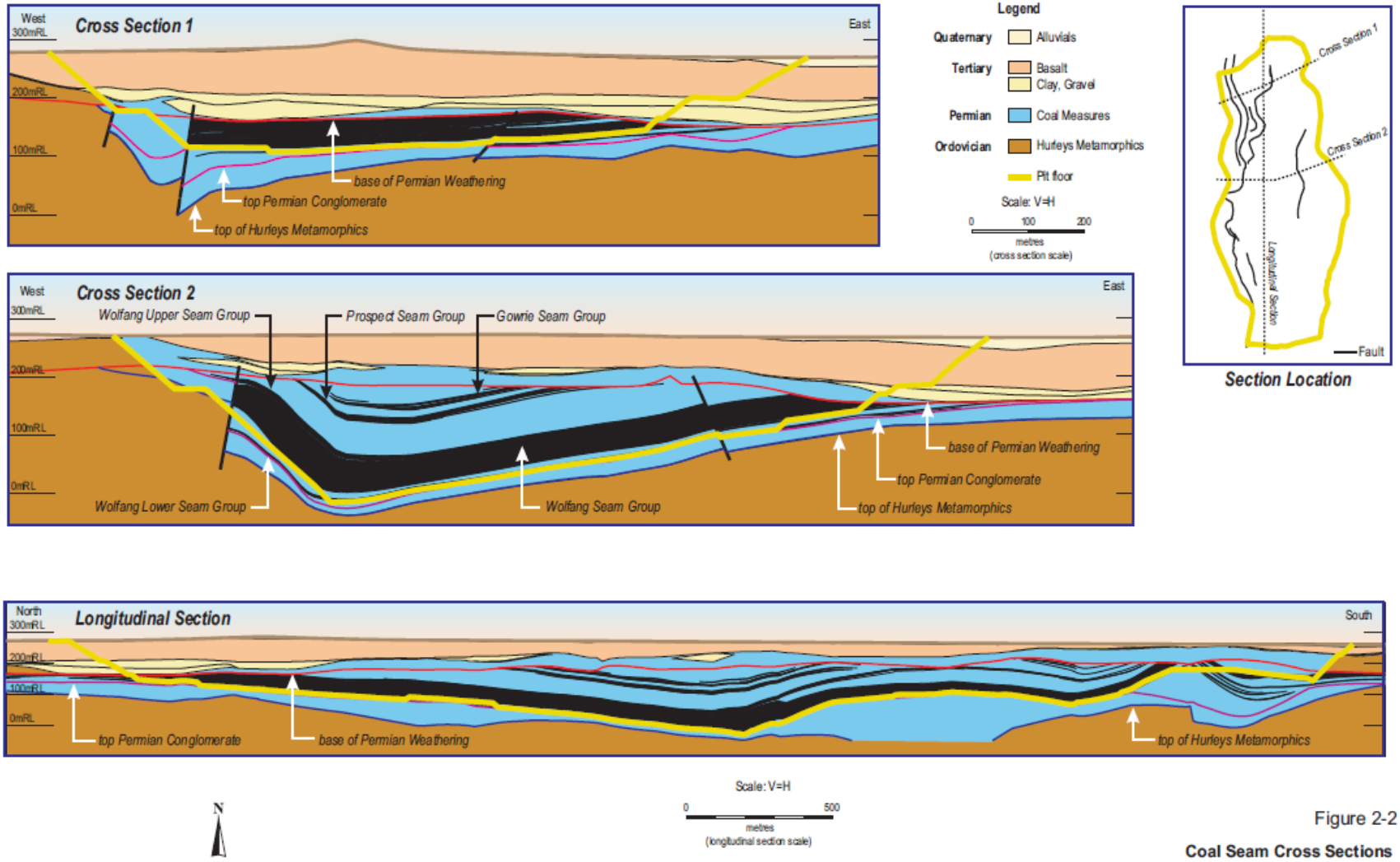


Figure 9 - Coal Seam Cross Sections at CM

3.1.1.4 Hydrogeology

Occurrence and Nature of Groundwater Systems

CCO is located within the Highlands Sub-artesian area, and groundwater investigations have been conducted at the CCO MLs and immediate surrounds dating back to the late 1970s. The underlying hydrogeology at CCO comprises the following aquifers:

- Alluvial aquifer. The Alluvial aquifer is limited spatially, with limited or no interaction with the CCO. It has some connection with the underlying basalt aquifer, is unconfined, and has a highly variable water level and water quality.
- Tertiary Basalt aquifer. The aquifer is semi-confined to confined, and consists of multiple individual basal layers separated by several metres of clay. Groundwater typically occurs within the fractured and vesicular horizons of the basalt. There is likely some recharge and discharge to the surrounding drainage system in limited areas of the local drainage system following rainfall and subsequent high stream flow event. The depth of the Basalt aquifer as a whole Tertiary volcanic package ranges from 50m in the CM area to 160m depth to the east of the CM where multiple flow basalt layers exist. The basalt aquifer is an extensive regional aquifer and the most significant aquifer in terms of water supply for landholders. It is the main aquifer at CH;
- Tertiary Sediment (gravel) aquifer. This is a confined aquifer, and consists of gravel, sand and clay layers. Groundwater typically occurs between 50m and 110m depth. This aquifer is of limited regional extent and occurs predominantly at and near the CM. The aquifer was and is significant in terms of water supply and mine dewatering during early mining but is now considered effectively dewatered at the CM with only small residual pockets of water remaining within the ML. There, however, are also Tertiary gravels east of the CM ML, at the Wolfang property also owned by CCO (***Figure 20***). These are proposed as an additional water supply;
- The Permian Sedimentary aquifers consist of the target coal seams, which contain fractures and jointing, sandstone and sandy clay interbeds. The Permian rock package is not high yielding and is essentially a confined aquifer system. Higher permeability occurs in the sandier interbeds and where fracturing of the Wolfang Seam is greater. The Permian conglomerate forms the base unit to the Permian sequence and is predominantly of low permeability; and
- Cambrian Metamorphic rock aquifer. This unit consists predominantly of schist and is regarded as the hydraulic basement, but contains water within secondary porosity in some areas (fractured and weathered zones). Interception of this aquifer is not expected.

Groundwater Flow Characteristics, Quality and Level

There are a large number (161) of groundwater bores within a 10km radius of the ML boundaries (Figure 10). Groundwater levels have been monitored within bores since 1983, and annually (at a minimum) since 2002. Bores include those near the mine site drilled in 1983 (WP-WC series), Near Field Bores (NF series), and regional bores (R series), as shown in Figure 10. Further detail on bores is provided in Appendix 4.5.

The water levels reflect the regional potentiometric surface, and in the Clermont area it is typically more than 10m above the top of the aquifer. Overall groundwater flow is from the north-east to south, in accordance with the topography of the regional terrain. Groundwater recharge occurs via surface water infiltration predominantly in topographically higher areas and along creek beds during and immediately following rainfall events. Water levels within bores installed in all units typically rise to within approximately 3m to 30m of the ground surface.

Typical groundwater piezometric levels are further shown for the CM as part of Section 3.5.1.2 which indicate that water levels generally correlate with broad rainfall trend, although some bores show

intermittent drawdown from pumping of landholder bores. Within the MLs, and also as a localised impact within the Tertiary Basalt aquifer, groundwater levels fluctuate in response to pumping from the aquifer and climatic influences. Water levels within bores in this unit rise to approximately 10m from the ground surface due to its confined nature. Within the Tertiary sediment (gravel) aquifer, groundwater levels respond immediately to pumping regardless of proximity to the bores installed in this unit, demonstrating the confined nature of the aquifer.

Water levels within bores installed in the Alluvial aquifer unit can rise to approximately 15 m of the ground surface, but this can take several years of no groundwater extraction and steady recharge.

The weathered coal measures underlie the gravel beds of the Tertiary sediment aquifer, and as such, respond in a similar way to groundwater extraction as the Tertiary sediment aquifer.

Outside the MLs, groundwater levels in the Tertiary and Permian aquifers have fluctuated up to 10m since 1983, regardless of the lithology of the screened interval. Monitoring bores within these units and within the MLs also display similar fluctuation, and correlate directly with periods of rainfall and drought. Under typical climatic conditions, water levels may fluctuate 1m to 3m in any single year.

Groundwater quality is similar for all aquifers and is suitable for irrigation and stock watering, with the exception of total phosphorous. The EC and pH data for the three main aquifers has been provided in ***Table 4***.

Table 4 - pH and EC of aquifers at CCO (2017-2020)

Aquifer	pH		EC (µS/cm)	
	Range	**Median**	**Range**	**Median**
Tertiary basalt	7.0 – 8.5	7.6	460-2,170	1,265
Tertiary sediments	7.1 – 8.3	8.0	583-2,770	757
Permian sedimentary	7.3 – 8.1	7.6	677-1,780	878

Groundwater Monitoring and Use

Of the 161 groundwater bores within a 10km radius of the ML boundary (Figure 10), 99 are neighbouring landholder bores and 62 were CCO bores. A total of 39 bores are not used, with the remainder used for stock water (43), domestic use (5), domestic and stock water (10), domestic and chemical mixing (1), chemical mixing (1), industrial (mining) (8), and CCO groundwater monitoring (54).

Many landholders rely on groundwater as the primary water source for stock water and domestic purposes, and neighbouring farm properties have groundwater extraction bores located on the property, with the majority likely extracting water from the Tertiary basalt aquifer.

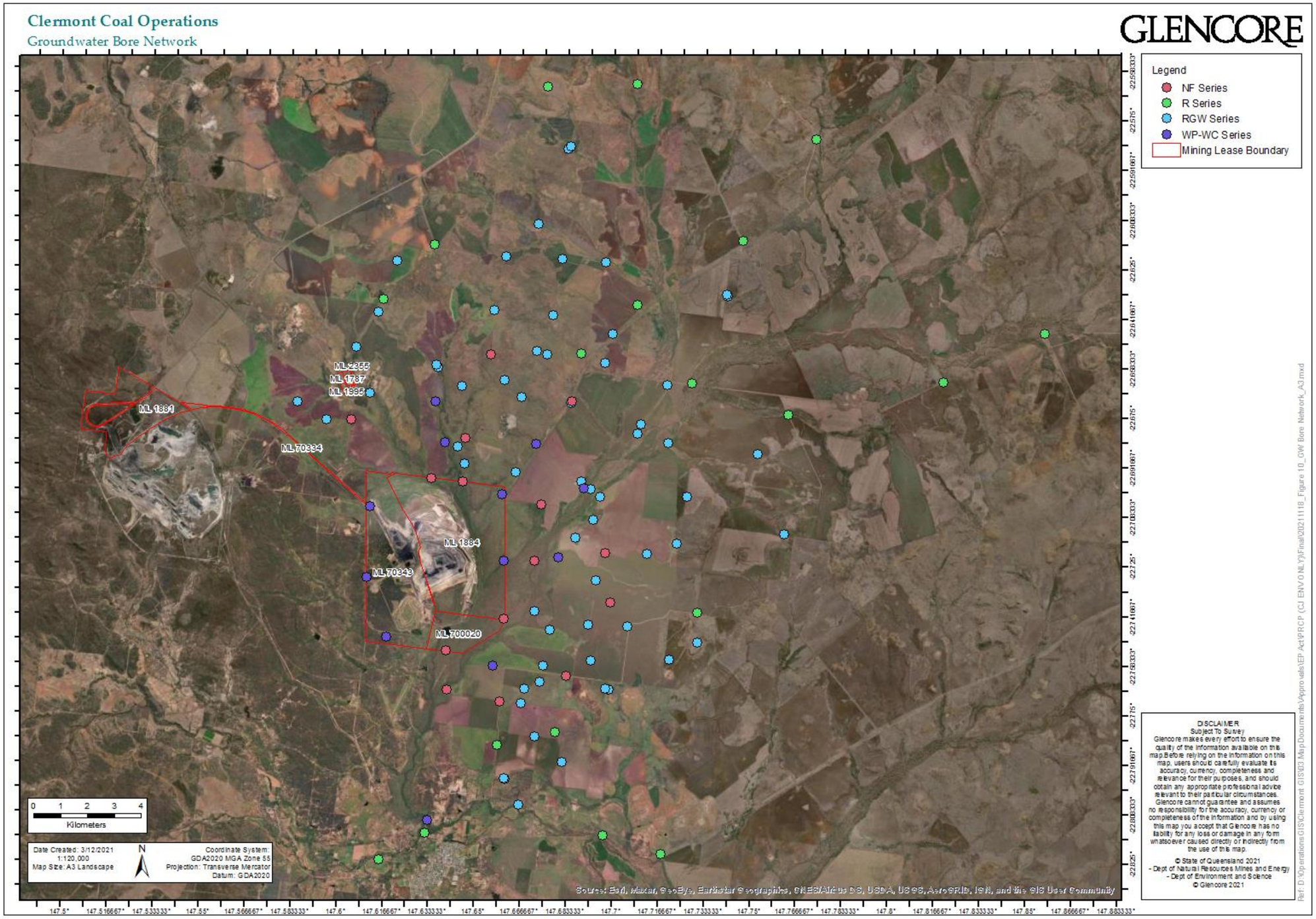


Figure 10 - Groundwater Bore Network

3.1.1.5 Hydrological and Fluvial Networks

Surface water hydrology in the region is dominated by Wolfang Creek, which ultimately drains into the Pacific Ocean via confluences with a number of creeks and rivers, including Sandy Creek, Theresa Creek, the Nogoa River, Mackenzie River, and the Fitzroy River.

CCO is located within the upper reaches of the Fitzroy River catchment, and may be divided into two distinct sub-catchments. The CM and CH sites are part of the Gowrie Creek sub-catchment and the TLO is part of the Washpool Creek and Bath Creek sub-catchment. Gowrie Creek feeds Wolfang Creek which in turn feeds Sandy Creek, whilst Bath Creek feeds directly into Sandy Creek.

The Wolfang Creek catchment has an area of approximately 830 km^2 and is bounded by Drummond Range to the north-west and Peak Range to the north-east. Land uses in the catchment include grazing and cropping. These have contributed to the degradation of waterways in the area and only limited stands of remnant vegetation exist in areas of steeper terrain and along some creek banks.

Both CH and the eastern parts of the CM are drained by Gowrie Creek, which flows into Wolfang Creek approximately 2 km to the south of the CM. Since development of the CM, the original flow path of Gowrie Creek has been diverted into an artificial drain along the eastern boundary of the CM. The western slopes of the CM and much of the OLC are drained by Aspley Creek, also a tributary of Wolfang Creek.

The structure of the Gowrie Creek system has four distinct reaches:

- Gowrie Creek Upper Reach – describes the creek from the headwaters to the confluence with Teatree Creek;
- Teatree Creek Upper Reach – typical of the creek from the headwaters to the confluence with Gowrie Creek;
- Gowrie Creek Mid Reach – describes the characteristics of the creek from the confluence to 1 km south of the Peak Downs Highway; and
- Gowrie Creek Lower Reach – typical of the section of the creek from south of the highway to the confluence with Wolfang Creek.

Within the four distinct reaches, the river types transition from a sinuous braided creek in the Gowrie Creek and Teatree Creek upper reaches to sinuous canal-form creek lines further to the south.

The TLO is drained by two branches of Washpool Creek, which flows via Bath Creek into Sandy Creek. The original flow path of the eastern branch (draining most of the TLO) was through the Blair Athol coal mine. Since the development of that mine (but before the development of the CM), its flow path was altered by the creation of West Dam, supplying water to the Blair Athol mine operation. A diversion was created along the northern and eastern boundary of the TLO to prevent the West Dam from overflowing into Blair Athol mine during flood periods. Therefore, current drainage of the TLO is towards West Dam and the downstream diversion. Smaller areas in the western part of the TLO drain into the western branch of Washpool Creek.

Figure 11 depicts the catchment extent associated with the major drainage systems associated with CM, CH and TLO, and also identifies gauging stations within those catchments.

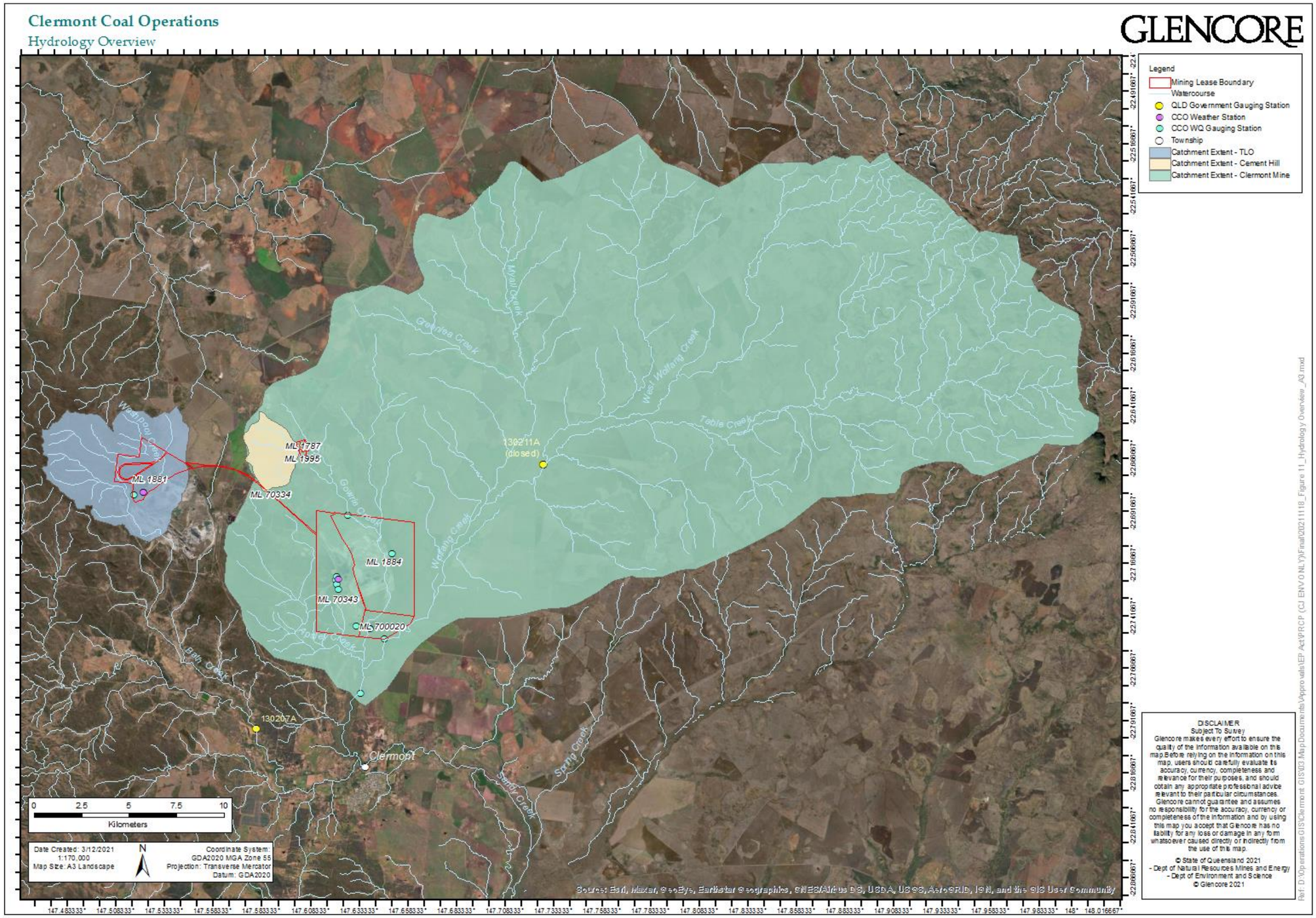


Figure 11 - Hydrological Overview

Gowrie Creek Catchment Hydrology

Hydrological characteristics (stream length and catchment area) of significant waterways in the vicinity of CCO are presented in ***Table 5***.

Table 5 - Hydrological Characteristics of Significant Waterways in the Vicinity of the CCO

Stream Name	Stream Length (km)	Catchment Area (km^2)
Sandy Creek	87	2,497
Wolfang Creek	53	866
Apsley Creek	14	53
Gowrie Creek	19	88
Teatree Creek (part of Gowrie Creek catchment)	12	36
Gowrie Creek (within Mining Leases)	8.5	19

The Department of Regional Development, Manufacturing and Water (DRDMW) have historical and existing monitoring for the hydrology of the region on Wolfang and Sandy Creeks, as further detailed in Appendix 4.6. The flow gauge on Sandy Creek remains active but the Wolfang Creek gauges ceased recording in 1988 and no historical monitoring exists for the Gowrie Creek catchment. Details of DRDMW Gauging Stations on Wolfang Creek and Sandy Creek are provided in ***Table 6***.

The total Gowrie Creek catchment is approximately 90 km^2, 11% of the Wolfang Creek catchment. Prior to mining, the CM mining leases were primarily used for grazing and cropping with some remnant vegetation in the western parts. The Peak Downs Highway forms a significant hydraulic control to flood flow. The natural surface of the CM mining leases slopes down to the south east to Gowrie Creek with terrain elevations ranging between 315 m AHD to 260 m AHD. The soils are dominated by dark, cracking clays with a high soil moisture storage capacity. Rainfall runoff modelling indicates that a very low proportion of rainfall results in runoff. On an annualised basis, only 3.5% of rainfall on the catchment becomes creek flow.

Table 6 - DRDMW Gauge station details

Parameter	DRDMW Station		
	130211A – Wolfang Creek at Innisfree	**Station 130211A – Wolfang Creek at Innisfree**	**Station 130211A – Wolfang Creek at Innisfree**
Site commenced	15/10/1971	01/10/1976	21/01/1965
Site ceased	01/10/1976	01/10/1988	Current
Grid reference	Zone – 55 E574593 N7492543	Zone – 55 E55414 N747589	Zone 55 E574593 N7492543
Max gauged stage in metres (m)	0.590 on 14/01/1974	0.260 on 09/08/1976	2.410 on 15/05/1977
Catchment area (km^2)	438	438	409

The flow record (17 years) for the Wolfang Creek gauge (approximately 15 km upstream of the confluence of Wolfang and Gowrie Creeks) shows a clear seasonal pattern. The average monthly flows in Wolfang Creek range from 8 ML in winter/spring to 3,508 ML in January, the wettest month.

Gowrie Creek dominates the local drainage regime of the 32 km² CM leases. Teatree Creek drains into Gowrie Creek at the upstream end of the CM and Apsley Creek drains into Gowrie Creek immediately downstream of the CM. The Wolfang Creek floodplain forms the downstream control to flows in Gowrie Creek ***(Figure 11***).

Water Quality

Agricultural development has resulted in highly disturbed waterways within the catchment. Water quality in the creeks is generally neutral to alkaline (pH ranging to 8.5) with high turbidity and variable electrical conductivity (EC), typically exceeding the ANZECC 2000 guideline criteria for aquatic ecosystems at the time of the EIS (now the Australian and New Zealand Guidelines for Fresh and Marine Water Quality, ANZGV, 2018), and background concentrations in the area.

In general, the surrounding creek watercourses are suitable for irrigation and stock water use, although phosphorous, iron, copper and aluminium concentrations is occasionally elevated beyond the relevant guideline levels, both before and since the development of the CCO.

Cement Hill void water quality is generally of better quality than the creeks and suitable for irrigation and stock water uses.

Existing agricultural users of Gowrie Creek and Wolfang Creek surface water resources are linked to seven surface water extractive licences on Sandy Creek, three of which are downstream of the Wolfang Creek confluence. Downstream water uses on Lots 5CLM403 and 2RP618200 are for domestic use and stock watering, whilst water use on Lot 2RP618200 is for irrigation. Gowrie and Wolfang Creeks have limited recreational value, as they do not contain any permanent water or water holes.

3.1.1.6 Soil Types, Properties and Productivity

Pre-Mining

Baseline sampling and soil profile inspection points to characterise all landform elements and geological units were conducted across the entire CM and OLC areas in 1983, 2002 and 2004. Ten soil types occurred at CM and OLC prior to mine development as summarised in ***Table 7***, and mapped in ***Figure 12***. Most of the area contained black cracking clays of varying depths which developed on basalt and alluvium. Duplex soils developed on older basalt in the western areas. Brown and red cracking clays, lithosols and duplex soils developed on various sedimentary and metamorphic geologies in the western half of the CM. Generally, duplex soils have the greatest erosion hazard due to the dispersion induced by sodium domination of the exchange complex. The TLO and CH areas mostly contain texture contrast soils.

Table 7 - Soil types

Landscape Element	Major Soil Characteristics	Australian Soil Classification**	Geotech. Classification+	Soil Area (ha)	Soil Types	Land suitability
Alluvial plains derived principally from basalt	Self-mulching alkaline clays over 2 m deep, high plant available water capacity (PAWC), may be saline and sodic	Black Vertosol	CH	954	Very deep cracking clays on alluvium	Suitable for dryland and irrigated crops outside of flood plains. Flood prone areas suitable for grazing
Undulating downs on Basalt	Self-mulching alkaline clays, 1.2-2 m deep, high PAWC, non-sodic and non-saline	Black Vertosol	CH	895	Deep cracking clays on basalt	Suitable for rain fed cropping
Undulating downs and lower slopes on basalt hills	Self-mulching alkaline clays, 0.6-1.2 m deep, high to moderate PAWC, non-sodic and non-saline	Black Vertosol	CH	279	Shallow cracking clays on basalt	Suitable for forage and grain cropping
Upper slopes and plateaus on basalt hills	Self-mulching clays <0.6 m deep, low PAWC, non-sodic and non-saline	Black Vertosol	CH	43	Very shallow cracking clays on basalt	Limited by steep slopes, rockiness, and low PAWC
Alluvium and colluvium on lower slopes and undulating plains	Cracking brown clays with low to moderate PAWC, may be sodic and saline, neutral to alkaline	Brown Vertosol	CH	74	Brown cracking clays and red cracking clays	Limited. Could cultivate improved pastures
Alluvium and colluvium on lower slopes and undulating plains	Clay loam to sandy clay loam over +/- sodic and saline medium clay	Brown Sodosol	SC-CL over CH	295	Duplex on clay sheets	Suitable for cleared and improved pasture
Colluvial lower slopes	Clay loam to sandy clay loan over medium clay over weathered basalt	Brown Chromosol	CL over CH	43	Duplex on basalt	Limited suitability for winter forage and crops
Crest and upper slopes on metamorphic	Lithosols and shallow duplex, low to very low PAWC, sodic or rocky subsoils	Rusosols and Brown Tenosols	GM-GC	428	Lithosols and sodic duplex	Suitable for grazing

Landscape Element	Major Soil Characteristics	Australian Soil Classification**	Geotech. Classification+	Soil Area (ha)	Soil Types	Land suitability
Crest and upper slopes	Gravel, very low PAWC	Rudosols	GM	42	Stripped Lithosols	Limited. Supports ironbark and rosewood
Undulating rises on conveyor and pipeline routes	Sodic duplex, low PAWC	Sodosol	SC over CL	NA	Duplex on Sedimentary rocks	Suitable for grazing

***Isbell (1996), +Hollingsworth (1983) PAWC – Plant Available Water Capacity. Note: Geotech Class – CH = Inorganic clays of high plasticity, SC = Clayey Sands, poorly graded sand-clay mixtures-inorganic clays of low to medium plasticity, GM = Silty gravels, poorly graded gravel-sand-silt mixtures, GC = Clayey gravels poorly graded gravel sand clay mixtures.*

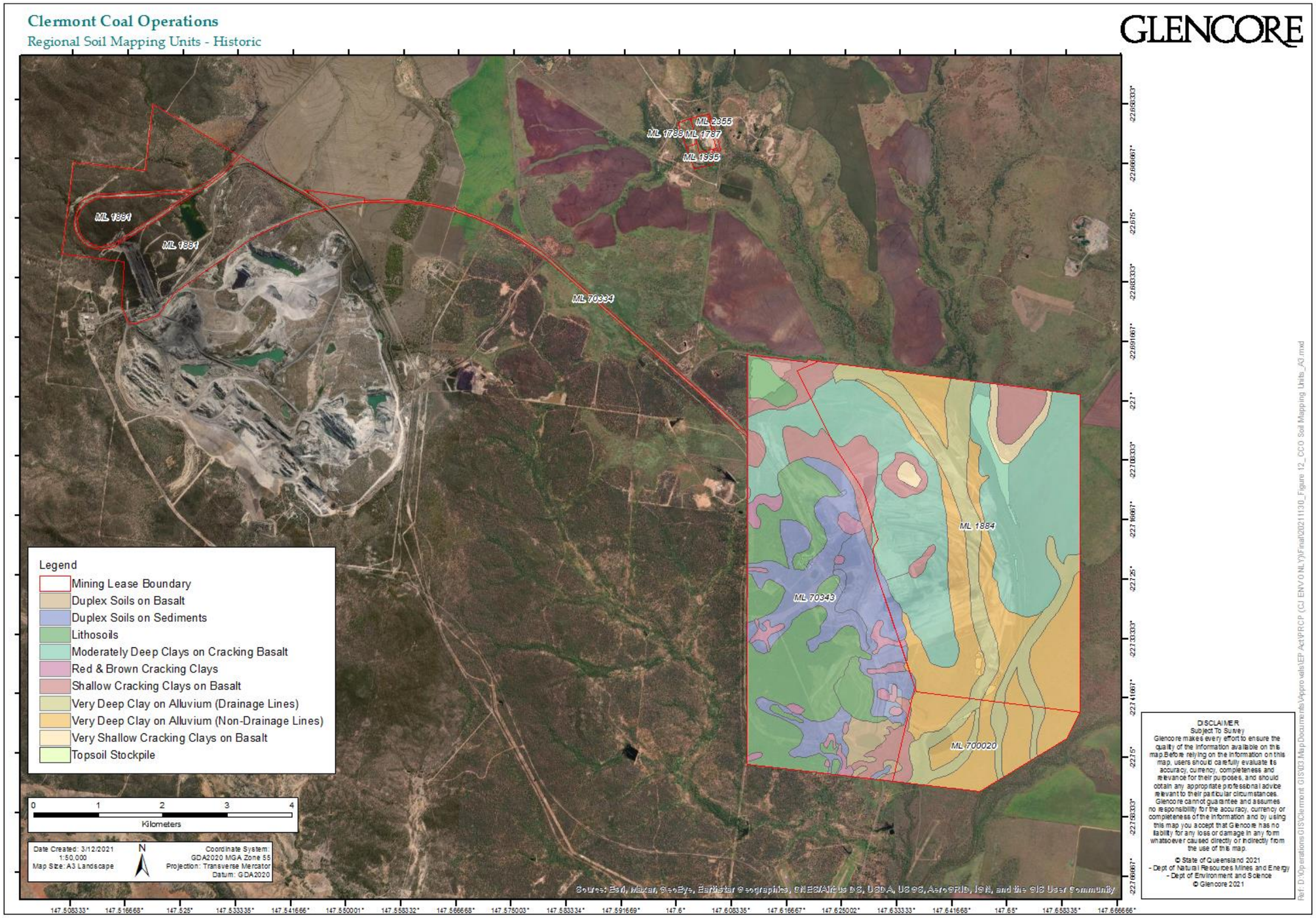


Figure 12 - CCO Soil Mapping Units

Good quality agricultural land was present at the CM prior to mining, including 648 ha of Class A crop land, 46 ha of marginal Class B crop land and 1260 ha of Class C1 land suitable for improved pasture.

For the TLO area, more fertile basalt derived soils are used for dryland farming to the east and north of the TLO. Sorghum and sunflowers are the major summer crops, with wheat and barley sown in the winter. These lands are predominantly Class C. The prominence of contour banks on the properties to the north are indicative of the need for intensive conservation practices on lands of this capability. Despite the use of contour banks, rill and gully erosion is still present throughout these lands.

Current State

Since the commencement of operations for the CM, further investigations of *in-situ* soil resources has occurred. The initial soils data associated with the EIS (RTCA 2004) were limited to a depth of 1.5 – 2.0m and were based on a relatively few soil analytical sites. Further work was completed between 2015 and 2017 to characterise deeper subsoil materials (down to a depth of 6m), in order to improve these into a primary growth medium if needed to supplement topsoil resources.

The soils of the study area appear similar from the surface, being dark clay materials. However, they originate from different parent materials and have very different soil properties. Basaltic soils (derived from basalt rocks), are typically low in salts and sodicity. Conversely, alluvial soils (formed by alluvial deposition) appear to have variable incidences of subsoil salinity and sodicity, though these remain largely unquantified. The basaltic soils are a much higher quality plant growth media than are the alluvial soils.

Figure 13 shows current soil resources within the CM area, classified according to basaltic and alluvium soil types. The latest soil characterisation work summarised the initial soil types as identified in ***Table 7***, and adopted Soil Recovery Classes to categorise plant growth media on the basis of their quality and suitability for use in rehabilitation. A total of five Soil Recovery Classes (I–V) have been classified for the CM area.

The primary constraint of concern for the CM area is subsoil salinity, which is difficult to ameliorate in clay soils. Also of concern is subsoil sodicity, which can be ameliorated but is likely to be impractical and costly due to the high volumes of ameliorant required. The aim is to salvage all materials suitable for use in rehabilitation, whilst avoiding those which have significant limitations as a growth media.

No further soil resources are anticipated to be disturbed for the CH or TLO areas. However, further investigations to characterise the soil and surface materials relevant to rehabilitation at these two locations has been conducted, as described below.

For CH, KBR (2019) found predominantly sands and gravels in the eastern section of the out of pit spoil dump, and a higher proportion of clay and silt at the southern spoil dumps. The alluvial tailings embankment contained a high percentage of fine material (silt and clay), with the base of the cells predominantly fine material. The mine infrastructure area was variable with sandy gravel, clay and loam texture classes observed.

All samples tested were below the Health Investigation Level and the Ecological Investigation Level included in National Environment Protection Council (NEPC) (2013).

For the TLO area, investigations into growth media materials used in historic rehabilitation areas indicated that surface soils were typically alkaline, non-saline and non-sodic (Highlands Environmental 2020). Cation exchange capacities were typically very high. Despite this capacity, surface soils were typically imbalanced with respect to relative proportions of Ca and Mg on exchange surfaces, indicating that soils were Ca deficient. All soils were deficient in macro-nutrient P and B, and were variably deficient in other macro-nutrients. Subsoils (sampled down to 90 cm depth) were typically alkaline, non-saline and non-sodic, though variability did exist.

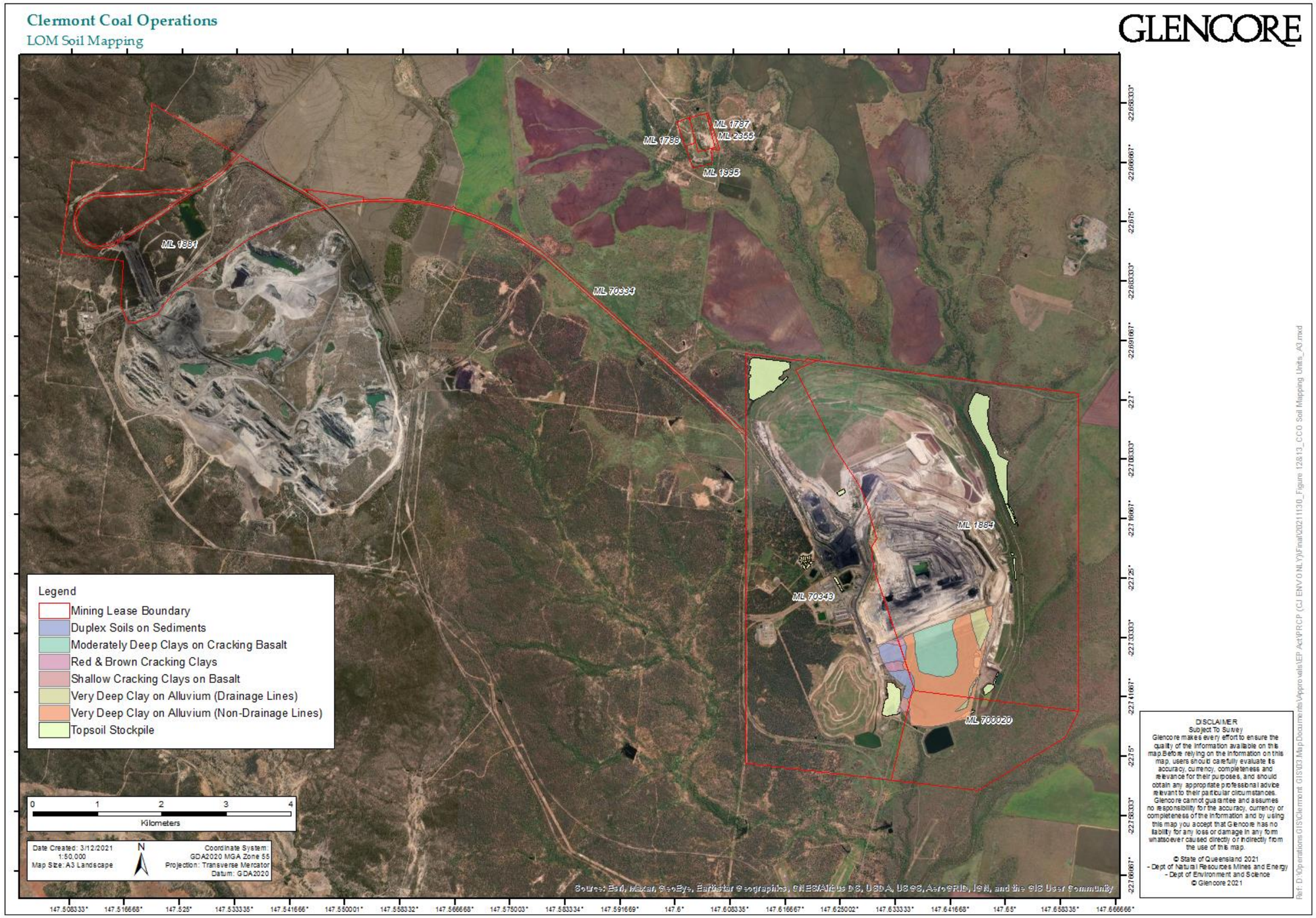


Figure 13 - Basaltic and alluvial soils for CCO LOM footprint

3.1.1.7 Land Stability

Pre-Mining

Baseline erosion hazard was assessed based on Exchangeable Sodium Percentage (ESP), Ca:Mg, Particle Size Distribution (PSD), Emerson aggregate stability index and observed erosion. The erosion susceptibility of the soil types found within CCO are presented in ***Table 8***.

Table 8 - Soil Erosion Susceptibility

Soil type	Sheet	Rill	Gully	Wind	Soil Erodibility Factor K#
Very Deep Cracking Clay	M	L	L	L	0.05
Deep Cracking Clay	M	M	L	L	0.05
Shallow Cracking Clay	M	M	M	L	0.05
Very Shallow Cracking Clay	M	H	H	L	0.05
Brown and red Cracking Clay	M	H	H	L	0.05
Duplex on Basalt	L	H	VH	L	0.02-0.03 A horizon 0.05 B horizon
Duplex on Clay	M	VH	VH	M	0.02-0.03 A horizon
Duplex on Metamorphics	H	VH	H	M	0.02-0.03 A horizon
Lithosols	H	H	H	M	0.025 – 0.03
Stripped Lithosols	VH	VH	H	M	0.02

Source: Bourne and Tuck (1993) Broadscale Tree Clearing Policy for State Lands 2000
* L = Low, M = Medium, H = High, VH = Very high
# assumes 60 percent surface cover and rainfall erosivity between 2000-3000

The soil erodibility factor, K, represents both the susceptibility of the soil type to erosion and the rate of runoff, under the standard unit plot condition. Soil types at CCO generally have low K values.

The duplex and lithosols are particularly prone to erosion and were actively gullying under the pre-mining grazing/ forestry land use. Generally, the duplex soils have the greatest erosion hazard due to dispersion resultant from sodium domination of the exchange complex. The deep cracking clays of the alluvial plains have the lowest erosion hazard under vegetation.

The Soil Recovery Classes now adopted for CM, incorporate land suitability and erodibility into a hierarchy for use. This has informed the topsoil stripping strategy for the site. For CH, soil textures with a higher proportion of finer sediment (clay and silt) represent a higher erosion risk based on Emerson Class testing. Areas of particular note are the out of pit dumps to the south of the void, the tailings area embankment and subsoil material associated with the elevated landform feature located in the central north of ML1788.

For the TLO area, investigations into existing areas of rehabilitation indicate that soils have an imbalance of cations on exchange surfaces. High proportions of Na and Mg indicate poor infiltration and hydraulic conductivity, leading to dispersion and excessive erosion, as reflected in tunnel and gully erosion observed in this area (Highlands Environmental, 2020).

3.1.1.8 Vegetation Communities and Ecological Data

Clermont Mine and Overland Conveyor – Pre-Mining

Various levels of disturbance were observed on the CM prior to mining. In the western parts of the CM, the greatest level of disturbance occurred in the understorey, while the over-storey remained relatively intact. Most of the eastern mining area was cleared previously for cropping and improved pastures for grazing with very little remnant vegetation in the area. Aspley State Forest, a high quality remnant habitat area, is located directly west of ML700020 (CM).

Nine regional ecosystems (REs) were identified within the CM and OLC during the 2004 EIS. Three of which were threatened ecological communities (TECs) under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and five of which were classified as Endangered or Of Concern under the Queensland *Vegetation Management Act 1999* (VMA), at the time of the EIS process (***Table 9***).

The most widespread REs were:

- RE 11.3.3, in the eastern part of the site between Gowrie Creek and Wolfang Creek;
- RE 11.11.1, RE 11.5.3, and RE 11.4.8 in a mosaic with one another in the western part of the CM;
- RE 11.8.11 along the stock route adjacent to Peak Down highway and a patch along the OLC; and
- RE 11.4.9 in a smaller patch along the OLC, between the TLO and CM.

A total of 241 flora species were recorded within the CM/OCL area in surveys up to and including the 2004 EIS. Two conservation significant flora species were also identified within CM, including the Belyando Cobblers Peg *(Trioncinia retroflexa)* and King Bluegrass *(Dichanthium queenslandicum)*. They are listed as Endangered and Vulnerable, respectively, under the Queensland Nature Conservation Act 1992 (NC Act), with King Bluegrass also listed as Endangered under the EPBC Act. Both these species occur within RE 11.8.11, on undulating downs country with cracking black clay soils.

Maps showing the spatial distribution of vegetation communities and protected species are retained at site as GIS layers. In accordance with the CCO Commonwealth and State approvals, a number of biodiversity offsets were required to be established. The offsets are designed to compensate for the unavoidable residual impacts caused by the CCO operations, and are located both on the mining lease and off-site, within dedicated offset properties. Two offsets are located within the CM, one for Belyando Cobblers Peg and one for Bluegrass, as discussed below. The remaining offsets, for Brigalow TECs, are located on non-operational land and are no longer discussed in this PRC Plan.

Clermont Mine and Overland Conveyor – Current

Currently, remnant vegetation and habitat at the CM and OLC as described in the previous section is restricted to the perimeter of the CM site, particularly in the south-west (open eucalypt forests), along Gowrie Creek diversion (Coolibah forest and woodland), and north-east (Bluegrass).

The remaining surfaces have largely been, or will be, mined or otherwise disturbed for mining or infrastructure purposes. Substantial areas have also been rehabilitated since mining.

Figure 14 shows the current distribution of REs at the CCO and surrounding areas.

Table 9 - Regional Ecosystems at CM and OLC

Regional Ecosystem	Description	Baseline Status*
11.11.1	Narrow leaved ironbark (*Eucalyptus crebra*) woodland with a moderate to dense understorey of rosewood (*Acacia rhodoxylon*)	NC
11.11.2	Lancewood (*Acacia shirleyi*) low open forest with narrow-leaved ironbark (*Eucalyptus crebra*) emergent	NC
11.5.3	Silver-leaved ironbark (*Eucalyptus melanophloia*) open woodland with scattered poplar box (*Eucalyptus populnea*)	NC
11.4.8	Dawson gum (*Eucalyptus cambageana*) woodland with brigalow (*Acacia harpophylla*)	E TEC
11.8.11	Grassland dominated by Queensland bluegrass (*Dicanthium sericeum*)	OC TEC
11.3.3	Coolibah (*Eucalyptus coolabah*) woodland with grassy understorey	OC
11.8.5	Mountain coolibah (*Eucalyptus orgadophila*) and gum-topped bloodwood (*Corymbia erythrophloia*) open woodland with a grassy understorey	NC
11.3.3a	Black tea-tree (*Melaleuca bracteata*) woodland with grassy understorey	OC
11.4.9	Brigalow (*Acacia harpophylla*) and yellowwood (*Terminalia oblongata*) woodland	E TEC

* E = Endangered, OC = Of Concern, NC = No Concern

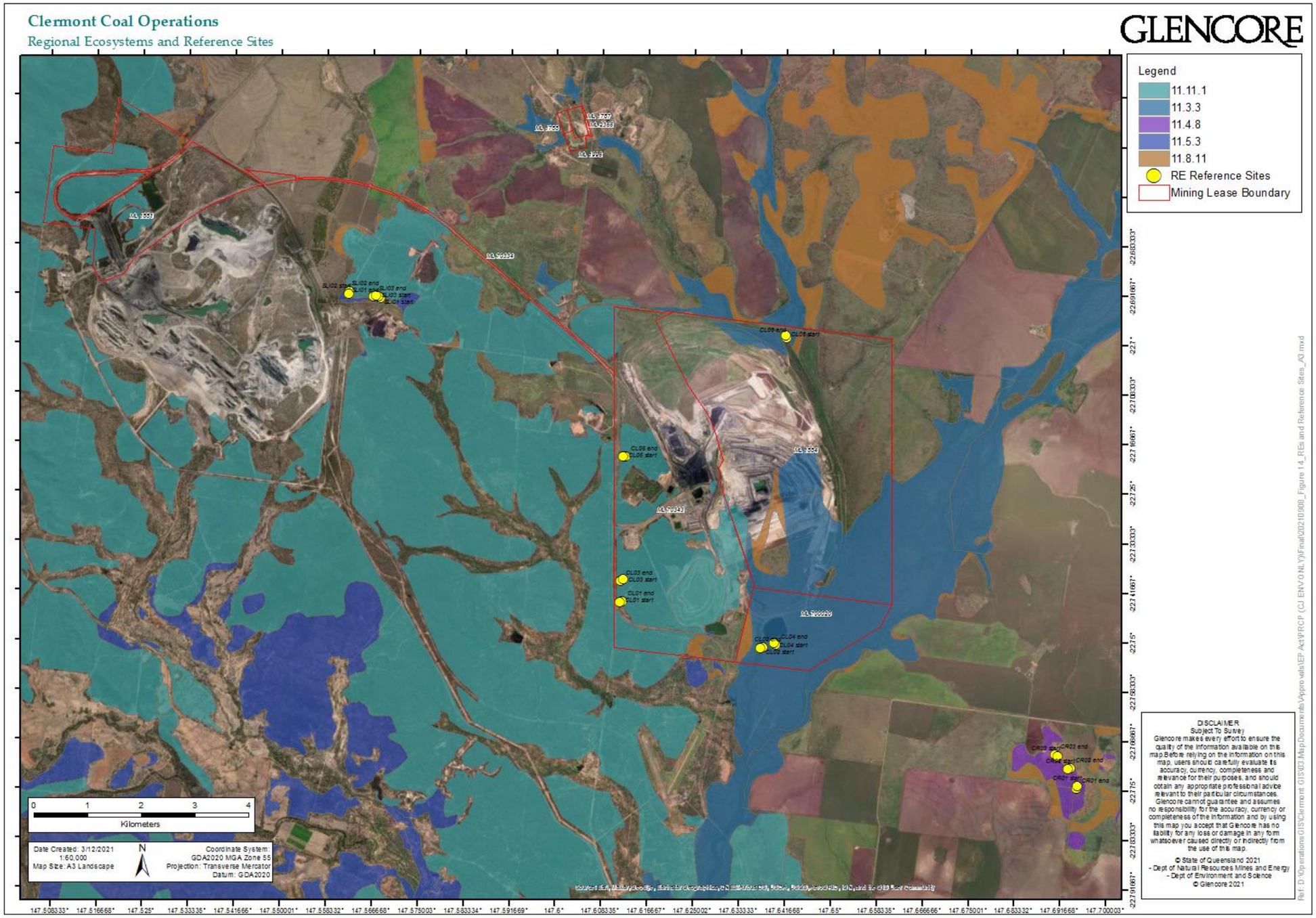


Figure 14 - Regional Ecosystems and Reference Site Locations

Cement Hill

The CH leases are a legacy asset, and no mining or other major activities have been undertaken at CH over the life of the CCO project. However, it was previously developed as an alluvial gold mine in the 1980s. No surviving documentation remains on the vegetation and habitats at CH prior to its development as a mine. However, pre-clearing mapping undertaken by the Queensland Herbarium indicates that the site was largely covered with RE 11.11.16/11.11.2/11.8.5/11.11.15 consisting of a variety of Eucalypts *(Eucalyptus spp.)* and Wattles *(Acacia spp.)*. The southern portion of the CH would have consisted of RE 11.3.3/11.4.9 (RE 11.3.3 - Coolabah woodland; RE 11.4.9 - Brigalow).

Field assessments for the 2004 EIS encountered an entirely disturbed site, except for a small remnant of RE 11.3.3a (see ***Table 9***). The remnant was highly disturbed, with a high incidence of weeds in the ground and mid strata of the vegetation. Apart from this remnant, the 2004 investigations encountered some regeneration within the remainder of CH. The dominant canopy species encountered was Sally Wattle *(Acacia salicina)*, with Poplar Box *(Eucalyptus populnea)* and Silver-leaved Ironbark *(E.melanophloia)* occurring as scattered individuals. Scattered shrubs included Mimosa, Water Bush, and Dogwood *(Eremophila bignoniiflora)*. The understorey of the regenerated areas was dominated by exotic grasses and daisies and saltbushes.

The current RE map for the site shows the presence of RE 11.3.3/11.4.9 (in respective proportions 80%/20%) along the creek flowing through the south-western corner of the site, and a small area of RE 11.11.16/11.11.2/11.8.5/11.11.15 (25% each) along the south-western boundary (***Figure 14***). Field observations undertaken for this PRC Plan indicate that the regenerating vegetation on the previously mined surfaces, spoil dumps, and tailings cells is relatively advanced compared to the 2004 EIS description, presently consisting of regenerating low open woodland and shrubland. There are no existing records of any threatened species on the CH site or in its immediate surroundings.

TLO

The Blair Athol area has a long mining history, dating back 150 years (Queensland Times 1873). Prior to the development of the CCO project, the TLO ML formed the northern part of the Blair Athol Mine. The area has been partly mined, and no documentation is available on the vegetation and habitats existing on the TLO site prior to this development within the site.

However, nearly half of the TLO continues to support remnant vegetation, as shown on the RE map for the site (***Figure 14***). The largest area of remnant vegetation consists of RE 11.11.1/11.11.2/11.5.3 (in respective proportions 75%/15%/10%), consisting of a variety of Eucalypts *(Eucalyptus spp.)* and Wattles *(Acacia spp.)*. This vegetation is similar to that occurring adjacent to the site. Most occurs along the northern and western boundary of the TLO, with additional areas within the rail loop, and areas west of West Dam. Smaller areas of RE 11.11.16 (*Eucalyptus cambageana* and Brigalow) occur in the north-western part of the TLO. The remainder of the site consists of infrastructure (TLO, access roads, OLC, etc.), clean water storages (West Dam), a number of creek diversions, and rehabilitated surfaces over previously mined land, spoil dumps, or otherwise disturbed land. The rail loop (not owned by CCO) crosses the site also. Most rehabilitation is located east of West Dam, dating from 1999 (i.e. well before the development of the CM), with smaller areas around the TLO, some of which date from 1984 (Landloch 2012). The vegetation on the rehabilitated land is represented by species from the surrounding native vegetation, including Rosewood *(Acacia spania)*, Lancewood *(Acacia shirleyi)*, and a variety of Eucalypts over sparse grasses including the exotic Buffel Grass *(Cenchrus ciliaris)* (Highlands Environmental 2020).

There are no existing records of any threatened species on the TLO site or in its immediate surroundings.

Vegetated Corridors

CCO is located in an area that has experienced wide scale vegetation clearing, even before the development of the CM. It has resulted in much of the vegetation becoming fragmented. Some vegetation corridors with biodiversity significance were identified during the preparation of the EIS (RTCA, 2004). These are:

- A corridor on the floodplain of Wolfang Creek and lower reaches of Gowrie Creek running through the southern part of the CM to Apsley State Forest, considered a sensitive environmental area as it contains high quality remnant habitat area;
- A short corridor including the lower reaches of Gowrie Creek (extension of Wolfang Creek to Apsley State Forest corridor), providing habitat for a range of amphibian species and fauna corridors (including for Koala) in a highly fragmented environment; and
- Areas of habitats and vegetation communities in road reserves and stock routes along Peak Downs Highway, Gregory Highway and Gregory Developmental Road.

These corridors largely remain in place currently, although the placement of the South-West Dump has impacted the connection within the CM between the Gowrie Creek/Wolfang Creek floodplain system with the forested vegetation to the west. Natural vegetation remains south of the CM ML to maintain this connection.

The western parts of CM provide relatively intact native forested vegetation, and it has an abundance of hollow bearing trees which provide habitat for a range of fauna species, particularly the arboreal mammals and bats recorded on the MLs. CCO's rehabilitation aims to incorporate connectivity between forested vegetation in the west of CM (and from there to Aspley State Forest) with both the floodplains and the native grasslands of the stock route in the east.

Weeds of Management Concern

Weeds of management concern observed in the CCO area during the EIS surveys include (RTCA, 2004):

- Weeds of National Significance (WoNS): Parkinsonia *(Parkinsonia aculeata)* and Parthenium *(Parthenium hysterophorus); and*
- Pest plants declared under the Queensland *Land Protection (Pest and Stock Route Management) Act 2002*: Fire Weed *(Senecio madagascariensis)* and Prickly Pear *(Opuntia species)*, as well as Parkinsonia and Parthenium.

Parthenium is the most prevalent weed species on CCO's MLs, commonly occurring in areas of high disturbance in the Coolabah open woodland, along roadsides, in cropping and grazing land, and in the Silver-leaved Ironbark Woodland.

Surveys conducted since the introduction of the Queensland *Biosecurity Act 2014* have encountered several additional species listed as restrictive invasive species under that Act, as shown in ***Table 10.*** These species are targeted for control.

Table 10 - Restricted invasive plant species currently identified on CCO lands

Scientific name	Common name	Status under the Biosecurity Act
Bryophyllum delagoense	Mother of Millions	Restricted invasive plant
Cryptostegia grandiflora	Rubber Vine	Restricted invasive plant
Lantana camara	Lantana	Restricted invasive plant
Opuntia spp.	Prickly Pear	Restricted invasive plant
Parkinsonia aculeata	Parkinsonia	Restricted invasive plant
Parthenium hysterophorus	Parthenium	Restricted invasive plant
Vachellia nilotica	Prickly Acacia	Restricted invasive plant
Ziziphus mauritiana	Chinee Apple	Restricted invasive plant

In addition to the above restricted invasive plant species, the environmental weeds Leucaena *(Leucaena leucocephala)* and Thatch Grass *(Hyparrhenia rufa)* have been detected on CM. Thatch Grass *(Hyparrhenia rufa)*, while not listed as a restrictive invasive plant or as a Weed of National Significance, is an exotic species that was previously targeted for control in areas of natural grassland and in the Belyando Cobblers Peg Nature Refuge within the CM to reduce competition with native species.

3.1.1.9 Fauna Presence and Populations

Native Species

A total of 170 fauna species were recorded on the CCO MLs during fauna surveys for the 2004 EIS, including 11 butterflies, 8 amphibians, 23 reptiles, 98 birds and 30 mammals. Fauna species of current conservation significance previously recorded within the CM area included:

- Northern Quoll *(Dasyurus hallucatus)* (listed as Endangered under the EPBC Act), recorded as roadkill by a landholder in 2001, but not recorded since, despite detailed surveys by URS (2006) and Ausecology (2014);
- Squatter Pigeon *(Geophaps scripta scripta)* (listed as Vulnerable under both NC Act and EPBC Act); and
- Koala (*Phascolarctos cinereus*) (listed as Vulnerable under both NC Act and EPBC Act).

Baseline surveys for the EIS indicated that macroinvertebrate communities of Gowrie, Apsley, Wolfang and Sandy Creeks were not very diverse or abundant, which is comparable to other ephemeral waterways in the region (RTCA, 2004). Aquatic fauna recorded included crustaceans, amphibians and turtles, none of which were of conservation significance.

Relatively few fish species were recorded in the creek systems, and those that were recorded are able to tolerate a range of physical conditions. No exotic or declared noxious fish species were recorded. The trophic structure of the creek systems indicated the waters are eutrophic and likely impacted by nutrient-rich agricultural runoff, with Chironomid larvae present at sites along Gowrie, Wolfang and

Aspley Creeks. Significantly, few filter feeders were represented in the surveys, indicative of the turbid conditions of the creeks.

Pests

Six species listed under the *Biodiversity Act 2004* were recorded on the CCO during the EIS assessment (RTCA, 2004). These included Cane Toad *(Rhinella marina)*, European Rabbit *(Oryctolagus cuniculus)*, House Mouse *(Mus musculus)*, Wild Dog *(Canis familiaris)*, and Cat *(Felis catus)* (***Table 11***). All species were observed in low abundance, excluding the Cane Toad which were common around all dams and were found under logs along some watercourses. No signs of Foxes were found and no anecdotal evidence of their presence was collected, and no previous studies identified Foxes on the CCO.

Table 11 - Restricted invasive animal species identified or considered likely to occur on the COC mine

Scientific name	Common name	Status under the Biosecurity Act	Confirmed / Likely to occur on site
Canis familiaris	Wild Dog	Restricted invasive animal	Likely
Canis familiaris dingo / Canis lupus dingo	Dingo	Restricted invasive animal	Likely
Felis catus	Feral Cat	Restricted invasive animal	Likely
Oryctolagus cuniculus	Rabbit	Restricted invasive animal	Likely
Sus scrofa	Feral Pig	Restricted invasive animal	Confirmed
Vulpes vulpes	Fox	Restricted invasive animal	Likely

3.1.1.10 Land Use

Pre-Mining Land Use

The CM and OLC areas were developed as greenfield sites, and pre-mining land uses included dry land cropping, grazing, and minor timber production, as described in the 2004 EIS. Land within CM was formerly trisected by the intersection of the original Gregory Highway, Gregory Development Road and Peak Downs Highway. Minor historical mining excavations are scattered in the western section of ML70343, to the south-west of the CM area. Although the ground disturbance footprint is small, the excavations have not been rehabilitated and contains some unfenced mining shafts between 1-3m in depth. Pre-mining land uses within the OLC included grain cropping, grazing and roadways (***Figure 15***).

The EIS noted that the development of CCO removed some areas of good quality agricultural land, however this was deemed acceptable under the State Planning Policy (SPP) at the time, as it represented an overriding benefit to the community (RTCA, 2004).

The CH area contains a former gold mining operation, and includes a final residual void and small areas used for occasional gravel extraction. Some limited rehabilitation has been completed at CH, but additional work is required. Small areas on the edges of CH were and are used for grazing by an

adjacent landholder, and there is an agreement in place to support this arrangement. Water in the final residual void is used by the same adjacent landholder for irrigation and by CCO as required.

The underlying land parcels relevant to the CH MLs are term leases for the purposes of "Grazing" and "Grazing - Reserve, Road and Stock Route", and the leases are held by a nearby neighbour (see also Section 3.2.2).

Prior to the TLO area becoming part of CCO, this facility and the surrounding land was owned and operated by Blair Athol Mine. Coal mining in various forms and intensities has occurred in and around this site for more than 100 years. Large scale open cut pit mining began in the early 1980s. Historical land use at the TLO is primarily a combination of state land, forest and mining infrastructure.

Current Surrounding Land Use

Surrounding land uses are primarily grazing enterprises, broad acre cropping (including on Strategic Cropping Land, see below), and forestry (including in State Forests, see below). Other uses include coal mining, domestic coal distribution, quarrying, an airport (south of the mining leases), and a rifle range (***Figure 16***).

Strategic Cropping Land

Strategic Cropping Land (SCL) is considered by the Queensland Government as the best cropping land and a finite resource that requires conservation and management for the long term.

SCL occurs within parts of the OLC, south and west of the CM, and adjacent to the northern, eastern and southern boundaries of CM (***Figure 17***). It is not feasible to return areas of SCL disturbed by mining to a cropping land use, due to the changed landforms, and changed site conditions in the post-mining landscape. It is also not contemplated in the LODs.

State Forests

Aspley State Forest is located directly west of CM and directly south of OLC (***Figure 17***). Aspley Forest hosts multiple REs and provides suitable habitat values for flora and fauna (RTCA, 2004). Given the proximity, ecosystems encountered within this forest form a suitable reference to understand environmental values in surrounding areas.

Blair Athol State Forest is located partly within and directly west of the TLO. Rehabilitation monitoring of the TLO has identified four REs as potential ecosystems/habitats that would also be consistent with a Woodland land use.

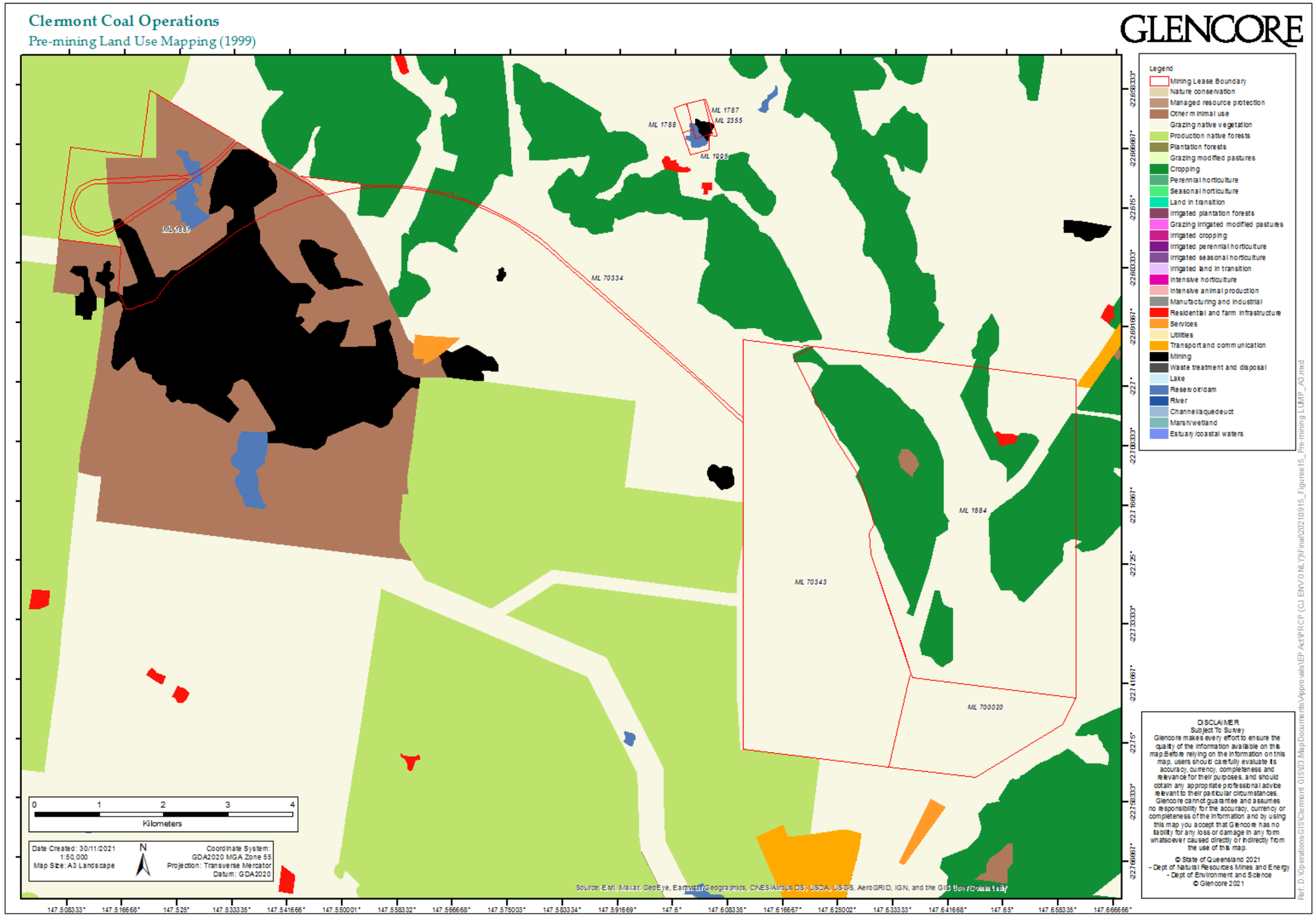


Figure 15 - Pre mining land use in the Clermont region

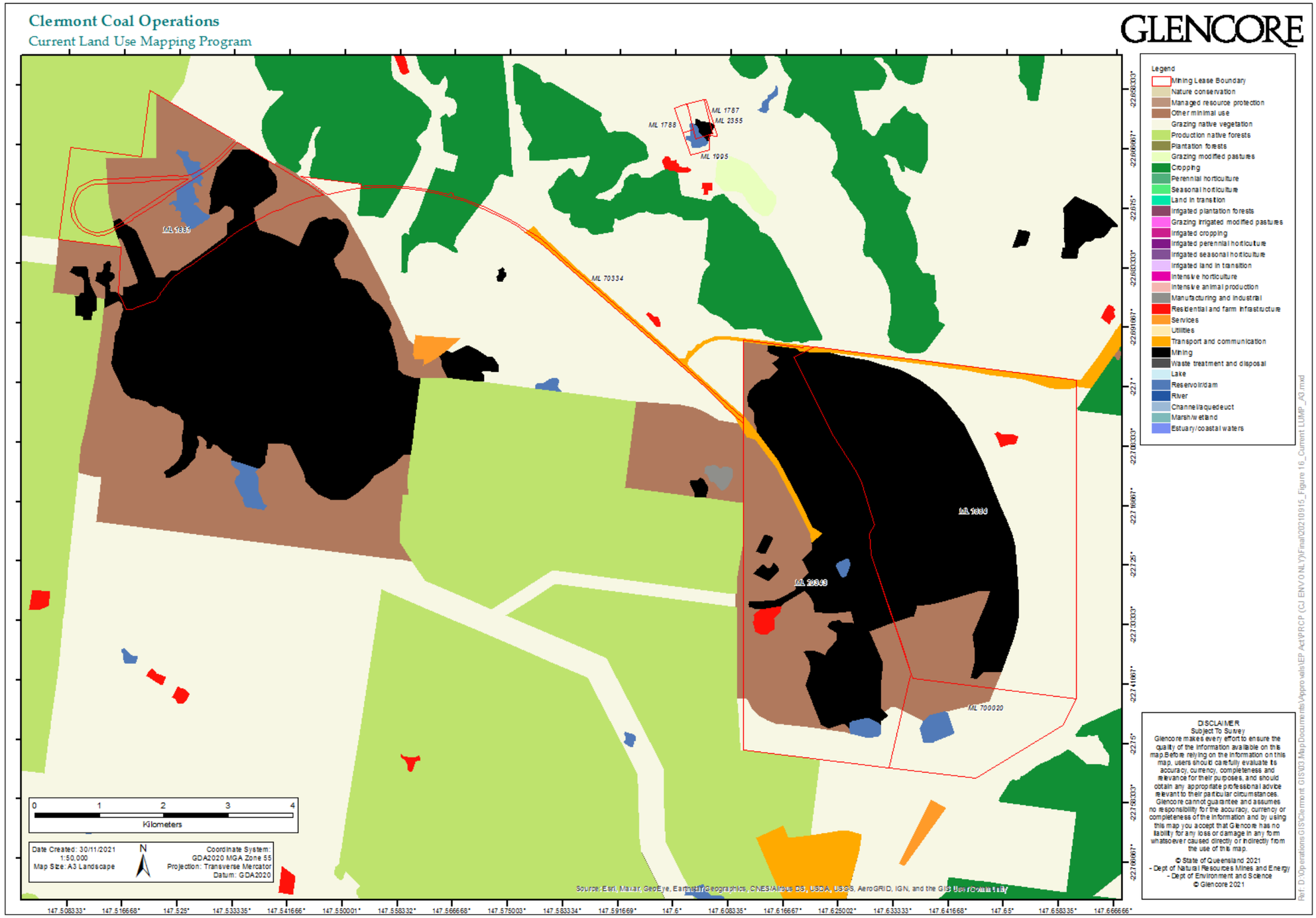


Figure 16 - Current Land Use in the Clermont region

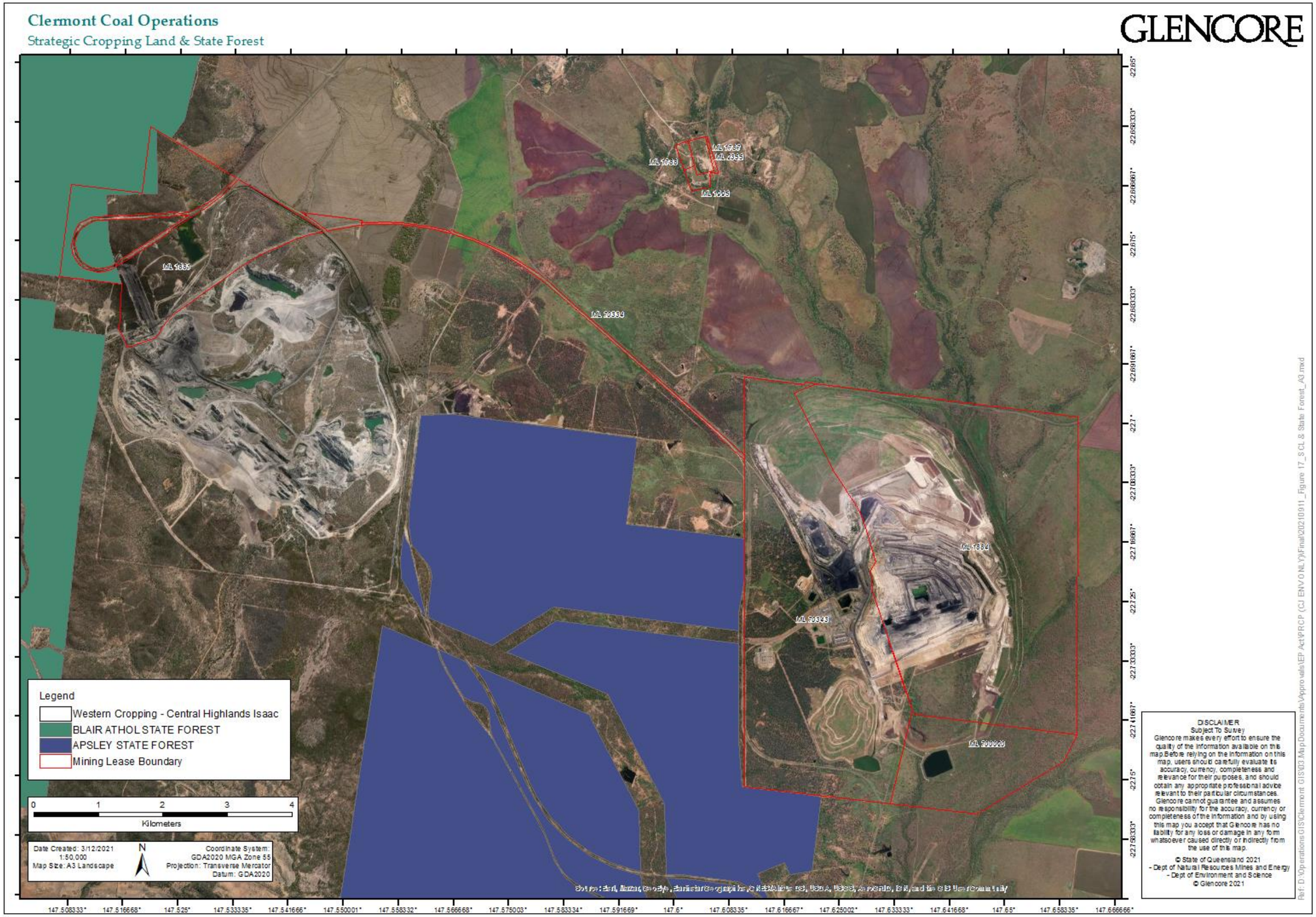


Figure 17 - Strategic Cropping Land and State Forest

3.1.1.11 Landholders

The CCO is located on a number of land parcels, held by different landholders. Current land parcels and landholders are as presented in ***Table 12*** and ***Figure 18***.

Table 12 - Real Property Descriptions

Lot/Plan	Tenure	Current Landholder
Clermont Mine (CM)		
33/SP244500	Freehold	Glencore, Sumitomo Corporation, J-Power Australia Pty Ltd, and JCD Australia Pty Ltd
1/SP237970	Freehold	Glencore, Sumitomo Corporation, J-Power Australia Pty Ltd, and JCD Australia Pty Ltd
24/L4113	Reserve	State of Queensland
82/SP237969	Lands Lease	Glencore, Sumitomo Corporation, J-Power Australia Pty Ltd, and JCD Australia Pty Ltd
Overland Conveyor Belt (OLC)		
117/SP232353	Freehold	J-Power Australia Pty Ltd, JCD Australia Pty Ltd, Mitsubishi Development Pty Ltd, Queensland Coal Pty Ltd.
18/SP285459	Freehold	J.N. Rawlins, I.R. McCauley, D.J. Mayes, D. Howard.
2/AP15616	State Land	State of Queensland
Cement Hill (CH)		
66/N25293	State Land	State of Queensland
25/L42327	Reserve	State of Queensland
23/CLM340	Reserve	W.E. Faint, R.W. Faint, J.S. Faint.
Train Load-out (TLO)		
2/USL43676	State Land	State of Queensland
3/USL43676	State Land	State of Queensland
5/USL43676	State Land	State of Queensland
635/MPH291	State Land	State of Queensland
13/AP5081	State Land	State of Queensland
40/USL43703	State Land	State of Queensland
127/FTY1849	State Forest	State of Queensland

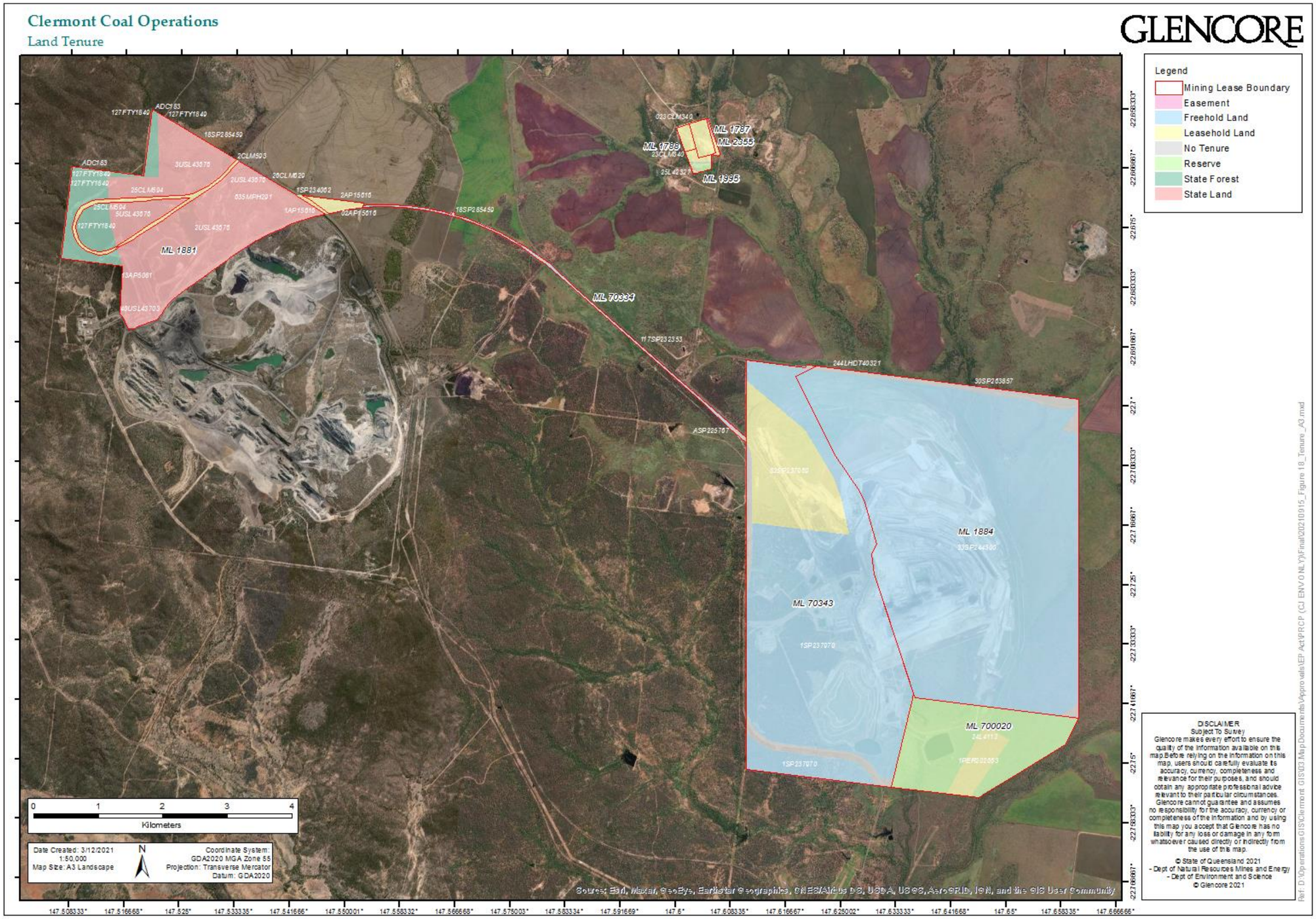


Figure 18 - Land Tenure

3.1.2 Project Description

3.1.2.1 Mining Tenements

CCO's EA (EPML00634113) encompasses nine mining leases, listed in ***Table 13*** and shown in ***Figure 19***. The mining leases are all held by the CCO JV. Land title is held to the majority of the land within the mining leases via a combination of freehold title and Term Lease (***Table 12***). Where land title does not exist (e.g. Reserves), valid compensation agreements are in place, as required under the *Mineral Resources Act 1989* (CCO 2018).

Table 13 - Mining Tenements

Mining Lease	Purpose	Operational Component	Background Tenure	Area (ha)
ML1884	Mining and related purposes	CM	• Freehold • Permit to Occupy over Unallocated State Land • State Controlled Road Reserve	1667
ML70343			• Freehold and Term Lease and Road Reserves for State Controlled Road • Permit to Occupy over Unallocated State Land	1234
ML700020			Stock Trucking Reserve	299
ML70334	Conveyor corridor	OLC	• Freehold • Grazing Homestead Perpetual Lease • Local Government Road Reserve	25.67
ML1787	Gold mining, water supply and related purposes	CH	• Term Lease (Grazing – Reserve, Road and Stock Route) Camping Reserve and Permit to Occupy (Grazing)	15.05
ML1788			• Term Lease (Grazing – Reserve, Road and Stock Route) Camping Reserve	7.6
ML1995			• Term Lease (Grazing) • Water Reserve, Unallocated State Land NRM Reserve R95 and Permit to Occupy (Grazing)	9.87
ML2355			• Term Lease (Grazing – Reserve, Road and Stock Route) • Camping Reserve and Permit to Occupy (Grazing)	2.85
ML1881	Mining infrastructure	TLO	• State Land • State Forest and Lands Lease (Queensland Rail)	656.2

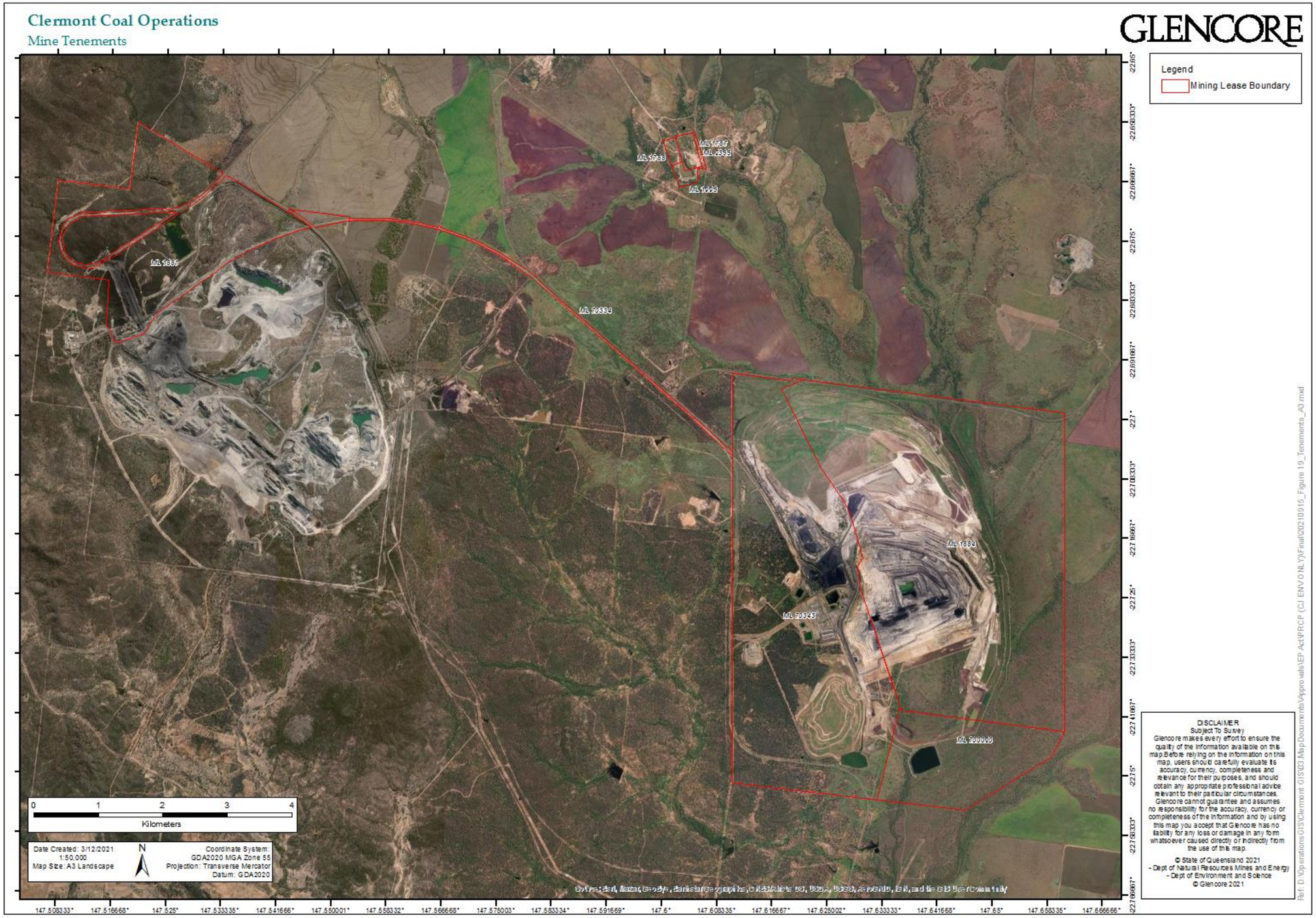


Figure 19 - Mine Tenements

3.1.2.2 Primary Mine Features/Infrastructure

The main features of the CM are as summarised below, and shown in ***Figure 20***.

- Open cut pit, up to approximately 290m deep and 2km wide, with production rates between 10 to 15 Million tonnes per annum (Mtpa). The current mine plan target production rate is approximately 12 Mtpa;
- Waste rock dumps (WRDs) to the north- west, south-west and south-east of the pit;
- Coal Handling and Preparation Plant (CHPP), for washing Run of Mine (ROM) coal with ash content higher than desired product ash levels;
- Settling cells to the west of the CHPP for drying out tailings before disposal in-pit;
- Megacell tailings storage facility for fine coal rejects from the CHPP;
- The Gowrie Creek Diversion, diverting Gowrie Creek to the east of the pit;
- Mine water management system, including various sediment dams;
- Heavy vehicle workshop and mine administration buildings;
- Site village and associated infrastructure;
- Electricity transmission line on an existing powerline easement to provide the site with power; and
- A proposed additional water supply borefield at the CCO owned Wolfang property (Lot Plan 33SP244500) east of the CM.

Coal is transported from the mine to the TLO previously on Blair Athol Mine land, but now part of the CCO, via a 13.3 km long OLC. The TLO contains (***Figure 21***):

- Coal handling facilities;
- Rail loop (outside the CCO ML, and owned by Aurizon);
- West Dam water supply;
- Creek diversions;
- Waste rock dumps in the eastern part of the TLO; and
- Access roads.

CH is a former alluvial gold mine, primarily containing a final residual void, tailings cells and spoil dumps (***Figure 22***).

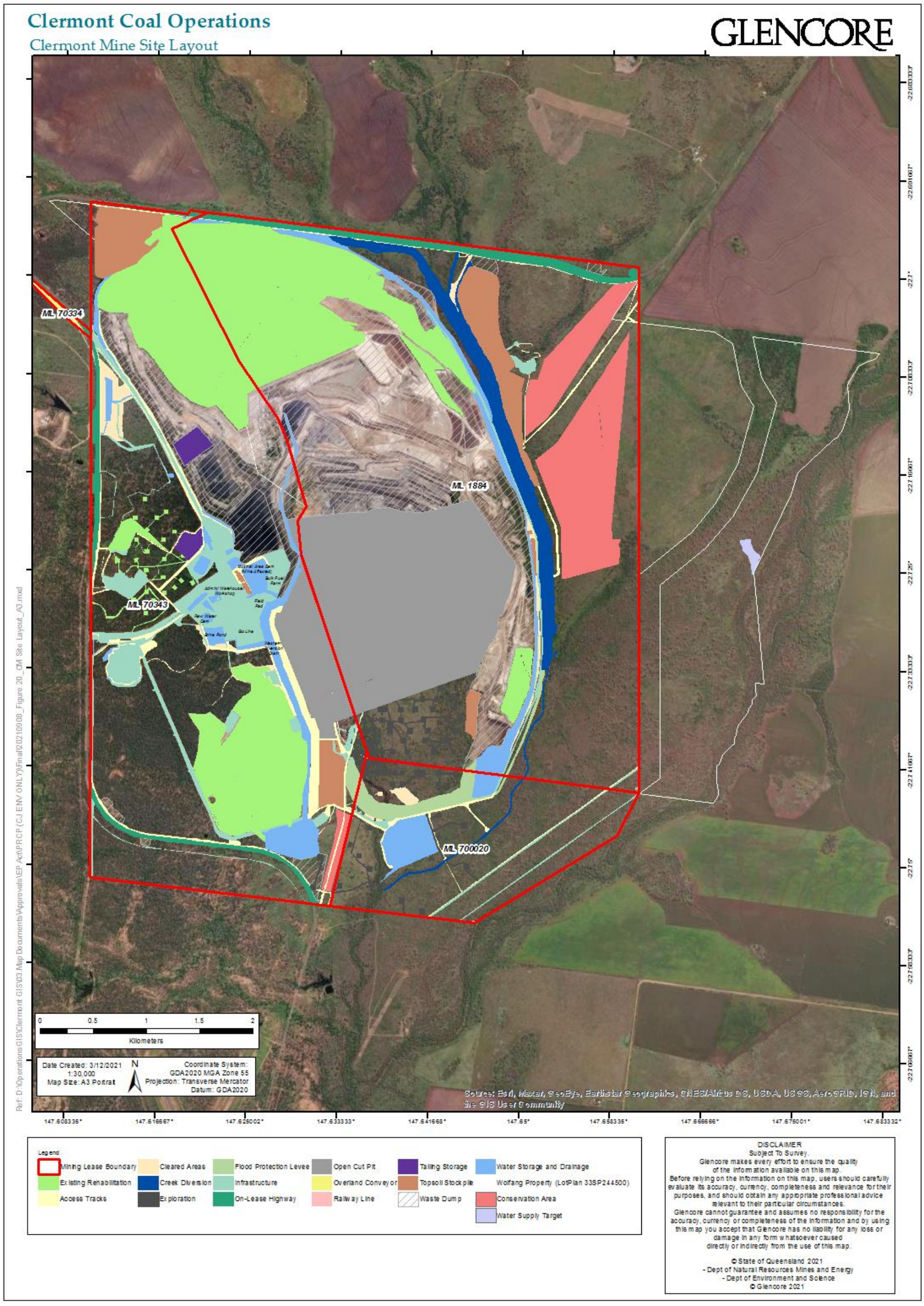


Figure 20 - Site Features - CM

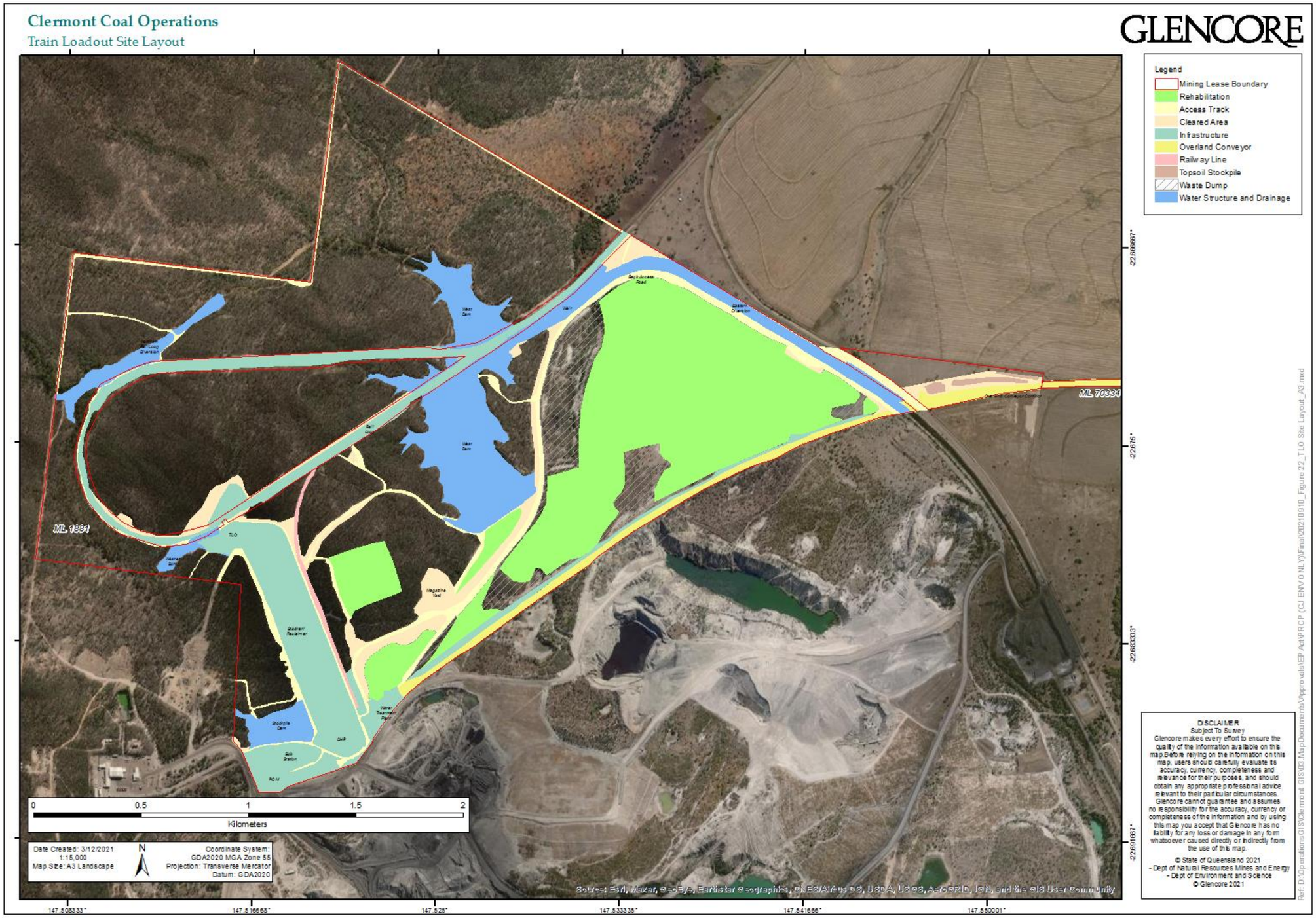


Figure 21 - Site Features – TLO

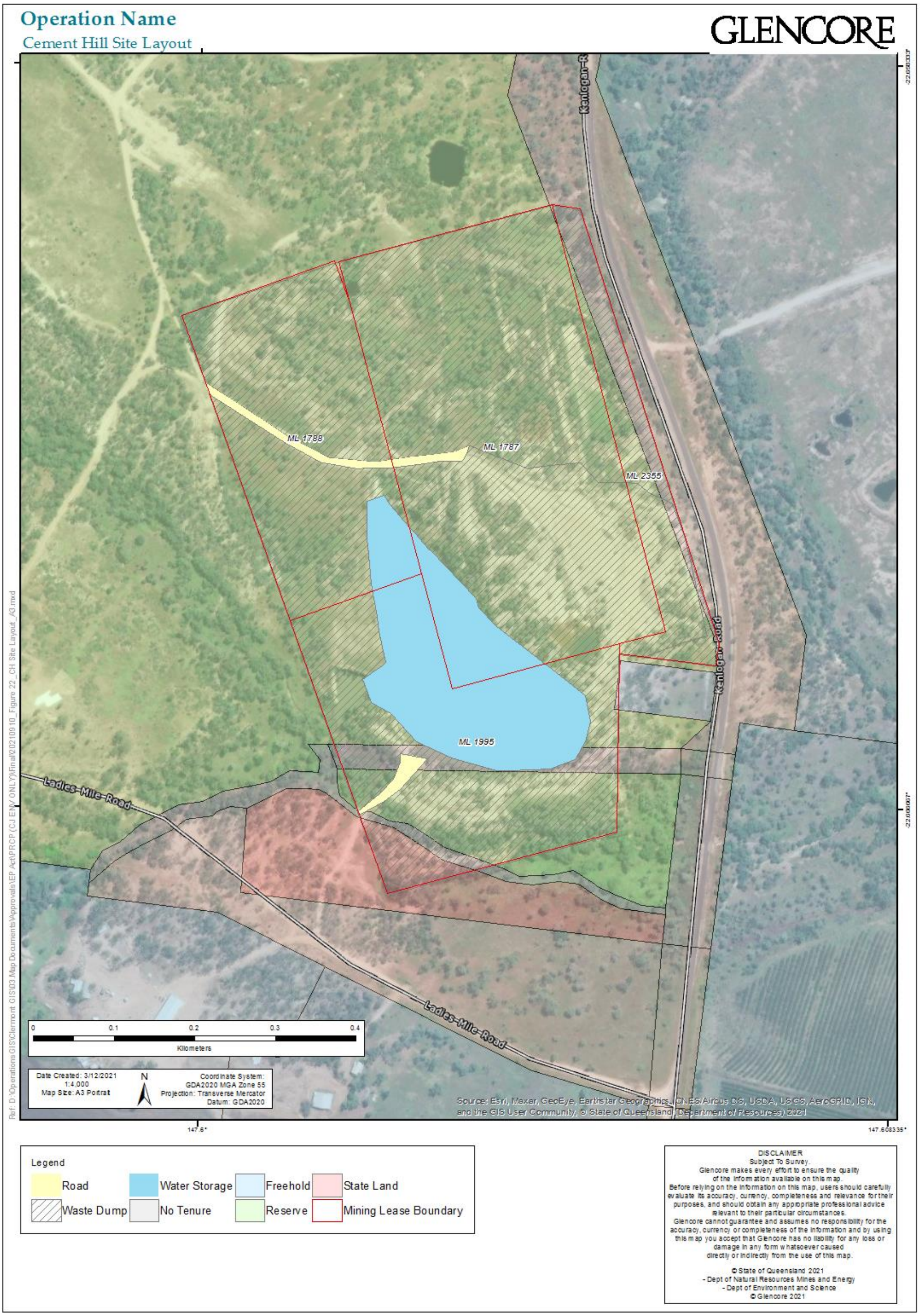


Figure 22 - Site Features – CH

3.1.2.3 Type of Mining Operation and Duration

The CM contains a high-quality measured coal resource of approximately 75 Mt (Glencore 2020). Mining operations involves the production of ROM coal from a single pit using the conventional open cut truck and shovel mining method. Typical depth to the top of the coal seam is approximately 150m, with the shallowest depth to coal being about 80m. The maximum depth of the pit will be approximately 290m.

Mining commenced with the box-cut (initial excavation) in the north of the resource, and continues to progress to the south. Waste rock and coal is stripped using a 65m^3 rope shovel and a fleet of 360 and 550 tonne (t) hydraulic excavators. A fleet of 290t and 220t rear dump trucks haul material either to the in-pit waste dumps, external outer pit waste dumps, or to the ROM pad for product. In-pit dumping will continue within the term of life of the mine, as areas of exhausted coal reserves are subsequently backfilled. A combination of in-pit and ex-pit dumping will continue with the north-west WRD eventually encroaching over the in-pit dump.

All coal mined at CM is crushed. ROM coal with ash levels exceeding target product ash levels is washed in the CHPP. Washed coal is then blended with unwashed crushed coal to produce a range of combined products.

The amount of coal washing has been less plan originally planned, with washing occurring typically 4 weeks per year, however fluctuates depending on a combination of mined coal quality and market conditions. The amount of washing has increased substantially since 2020 and is expected to stay at the higher rate for the remaining life of the operation. CHPP rejects (coarse and fine coal) are all deposited in pit. Until 2021 all tailings have been stored in “Megacells” within the dump. Two Megacells have been constructed, the first of which has been decommissioned and dumped over. The second one is partly filled. The main fine tailings disposal mechanism is currently via drying cells west of the CHPP. The dried material is transported from the cells to the pit for ultimate disposal. Coarse rejects are disposed of in pit directly.

Product coal is transported via the overland conveyor from the CM to the TLO for loading onto trains.

Mine site operations are planned to cease during 2027, with closure activities commencing immediately after.

3.1.3 Design for Closure

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.

CCO is under a transitional PRC Plan and has no expansions to the existing site, therefore this section is not applicable.

3.1.4 Rehabilitation/Improvement Planning

3.1.4.1 Identification of ERAs

Table 14 lists the ERAs, as defined under Schedules 2 and 3 of the *Environmental Protection Regulation 2019*, authorised by CCO’s EA (see also ***Figure 23***).

Table 14 - Environmentally Relevant Activities

Environmentally relevant activity/activities	Location(s)
Ancillary Activity, Schedule 2 – 8, Chemical storage, (3): storing more than 500m3 of chemicals of class C1 or C2 combustible liquids under AS 1940 or dangerous good class 3 under subsection (1)(c).	ML1787, ML1788, ML1881, ML1884, ML1995, ML2355, ML70334, ML70343, ML700020
Ancillary Activity, Schedule 2 – 31, Mineral processing, (2): processing, in a year, the following quantities of mineral products, other than coke—, (b): more than 100,000t.	ML1787, ML1788, ML1881, ML1884, ML1995, ML2355, ML70334, ML70343, ML700020
Ancillary Activity, Schedule 2 – 60, Waste disposal (1): operating a facility for disposing of, in a year, the following quantity of waste mentioned in subsection (1)(a)—, (d): more than 200,000t.	ML1787, ML1788, ML1881, ML1884, ML1995, ML2355, ML70334, ML70343, ML700020
Ancillary Activity, Schedule 2 – 63, Sewage treatment, (1): operating a sewage treatment works, other than norelease works, with a total daily peak design capacity of—, (b): more than 100 but not more than 1,500EP—, (i): if treated effluent is discharged from the works to an infiltration trench or through an irrigation scheme.	ML1787, ML1788, ML1881, ML1884, ML1995, ML2355, ML70334, ML70343, ML700020
Resource Activity, Schedule 3 – 13: Mining black coal	ML1787, ML1788, ML1881, ML1884, ML1995, ML2355, ML70334, ML70343, ML700020

Table 15 lists the notifiable activities, as defined under Schedule 3 of the EP Act, that can be undertaken as part of operations. Blasting activities undertaken in accordance with licensing requirements and explosives storage areas are licensed in accordance with the *Explosives Act 1999*.

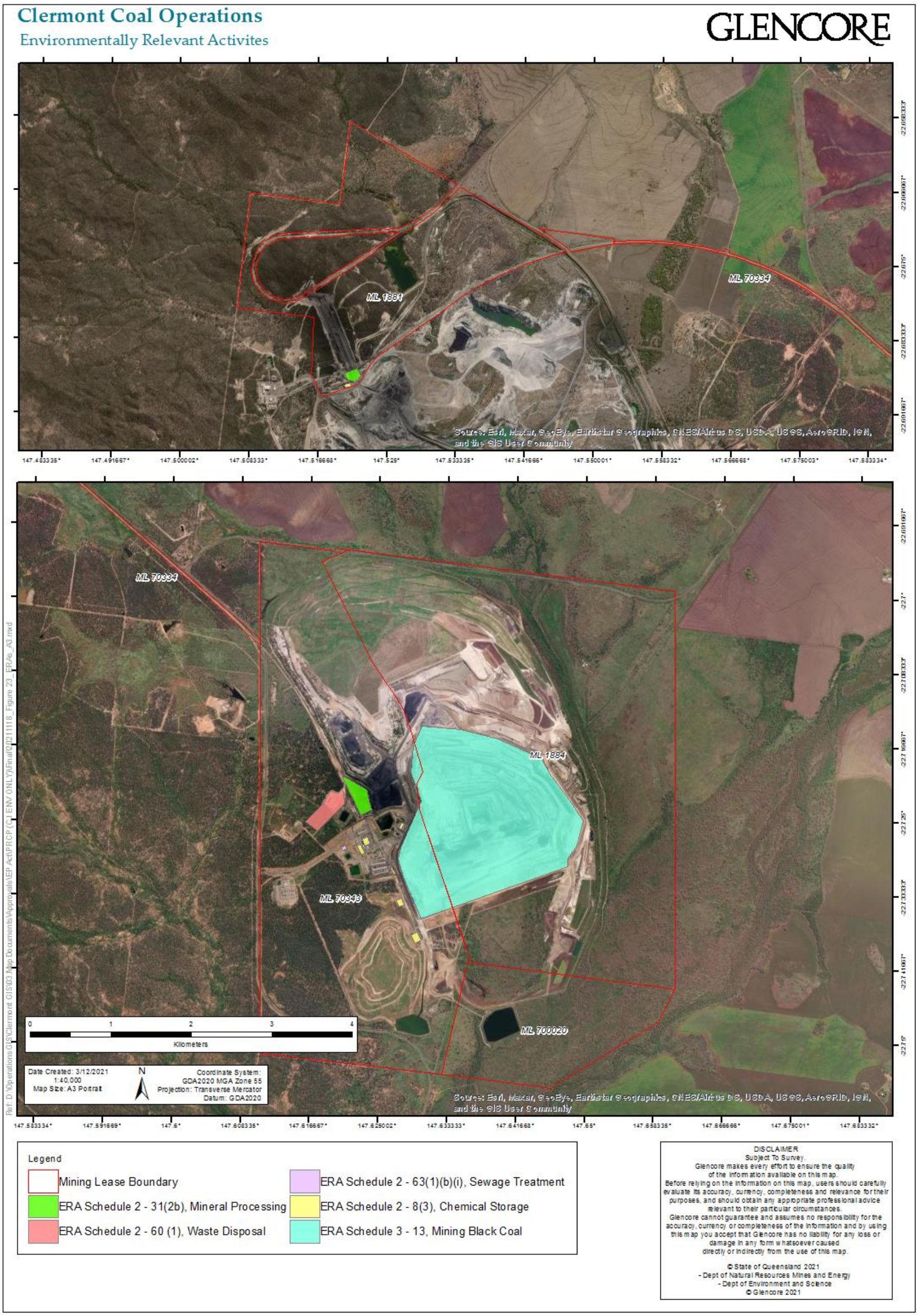


Figure 23 - Location of ERAs at CCO

Table 15 - Notifiable activities

Activity No.	Description
1	Abrasive blasting—carrying out abrasive blast cleaning (other than cleaning carried out in fully enclosed booths) or disposing of abrasive blasting material.
7	Chemical storage (other than petroleum products or oil under item 29)—storing more than 10t of chemicals (other than compressed or liquefied gases) that are dangerous goods under the dangerous goods code.
14	Engine reconditioning works—carrying out engine reconditioning work at a place where more than 500L of any of the following are stored— (a) halogenated and non-halogenated hydrocarbon solvents; (b) dangerous goods in class 6.1 under the dangerous goods code; (c) Industrial degreasing solutions.
15	Explosives production or storage—operating an explosives factory under the *Explosives Act 1999.*
24	Mine wastes— (a) storing hazardous mine or exploration wastes, including, for example, tailings dams, overburden or waste rock dumps containing hazardous contaminants; or (b) Exploring for, or mining or processing, minerals in a way that exposes faces, or releases groundwater, containing hazardous contaminants.
29	Petroleum product or oil storage—storing petroleum products or oil— (a) in underground tanks with more than 200L capacity; or (b) in above ground tanks with— (i) for petroleum products or oil in class 3 in packaging groups 1 and 2 of the dangerous goods code—more than 2500L capacity; or (ii) for petroleum products or oil in class 3 in packaging groups 3 of the dangerous goods code—more than 5000L capacity; or (iii) for petroleum products that are combustible liquids in class C1 or C2 in Australian Standard AS 1940, 'The storage and handling of flammable and combustible liquids' published by Standards Australia—more than 25000L capacity.
37	Waste storage, treatment or disposal—storing, treating, reprocessing or disposing of waste prescribed under a regulation to be regulated waste for this item (other than at the place it is generated), including operating a night soil disposal site or sewage treatment plant where the site or plant has a design capacity that is more than the equivalent of 50000 persons having sludge drying beds or on-site disposal facilities.

3.1.4.2 Predicted duration of ERAs and progressive rehabilitation

Mining across all the MLs is expected to be finished by the end of 2027. Rehabilitation of active mining out of pit dump areas and backfilling of a portion of the pit will occur progressively as part of mining operations, with the main rehabilitation activities (excluding monitoring and maintenance) anticipated to be completed by the end of 2035. The mid/long-term planning department for the site have developed an indicative LOM rehabilitation schedule, based on the long-term mining schedule (***Appendix 4.1***). LOM rehabilitation planning is an ongoing process which is updated at least annually following the overarching LOM planning process. Rehabilitation of infrastructure areas (including Chemical Storage, Minerals Processing and Sewage Treatment areas) will occur as soon as practical following decommissioning of infrastructure.

Therefore, all the ERAs and associated notifiable activities will be progressively rehabilitated or improved, with contaminated land investigations undertaken as part of the rehabilitation for chemical storage and minerals processing ERAs (under decommissioning infrastructure requirements).

3.1.4.3 Existing Rehabilitation

CCO commenced progressive rehabilitation of its waste rock dumps (WRDs) at the CM in 2015 (***Table 16***), and it is anticipated to continue through to end of LOM and beyond.

Legacy rehabilitation at the TLO was completed from 1984 to 2008, prior to Glencore management, and some limited rehabilitation at CH was completed at end of mining in the early 1990s. No part of the OLC has been rehabilitated at this time. To date, 595ha have been rehabilitated at CCO. No rehabilitation has yet been approved as progressively certified under the EP Act. However, application for certification of completed rehabilitation is anticipated from 2022 onwards.

Table 16 - Description of previous rehabilitation works

Rehabilitated Area	Year Rehabilitation Commenced	Year of Completion	PMLU Description
360 Dump – Plateau[(a)]	2017	2020	Woodland & Light Grazing[(b)]
South West Waste Rock Dump (SWWRD)	2015	2019	Woodland & Light Grazing
Northern Waste Rock Dump (NWRD)	2015	2020	Woodland & Light Grazing
Train Load Out	1984	2008	Woodland[(c)]

(a) Various sections have been progressively completed; there are still some plateau (or dump top) areas to be rehabilitated in the coming years
(b) Rehabilitation methodology used is described in detail in Section 3.5
(c) Rehabilitation methodology unknown as completed prior to current ownership

Methods

Rehabilitation methodology at CCO consists of the following components (see also Section 3.5):

- 1st Stage – Bulk push works to create a safe, structurally stable final landform that does not cause environmental harm, comprising:
  - Rehabilitation area design;

- Bulk push; and

- 2nd Stage – Detailed works to establish revegetation of shaped and disturbed areas, including area features such as water management and habitat structures, comprising:
  - Landform trim;
  - Detailed feature design and construction;
  - Topsoiling and amelioration;
  - Fertilising, seeding and mulching; and
  - Final rehabilitation survey.

Rehabilitation monitoring program and performance

A rehabilitation monitoring program has been developed by CCO (detail in Appendix 4.3). The monitoring process involves four key steps, as provided below:

- Pre- field monitoring works;
- Field monitoring;
- Data analysis; and
- Results and remedial actions.

The program assesses how progressive rehabilitation is tracking against agreed minimum (or critical) values for safe, structurally stable and sustainable outcomes that are aligned to this PRC Plan.

3.2 Community Consultation

3.2.1 Community Consultation Plan and Register

The objectives of CCO's community consultation process are to achieve the following:

- Identify, notify and engage the community regarding rehabilitation and closure of CCO;
- Provide ongoing community consultation throughout all stages of mining to communicate progressive rehabilitation, socio-economic and environmental impacts related to mine closure;
- Strengthen the relationship between CCO and stakeholders through effective partnerships;
- Collaborate with the community to identify rehabilitation and closure opportunities and constraints that could influence effectiveness of final land outcomes; and
- Provide a platform for comments and feedback.

CCO has a dynamic Stakeholder Engagement Plan (SEP) which provides a framework to achieve the above objectives. The SEP and a Social Impact Assessment (SIA), conducted with a focus on communicating closure outcomes (Wall Planning & Environmental Consulting, 2020), formed the basis of the Community Consultation Plan (CCP) prepared for this PRC Plan (and attached as Appendix 4.2). Relevant records of community engagement throughout operation have been summarised within Appendix 4.2, detailing consultation date and type, community members present, information provided, and issues discussed.

The CCP contains the following information:

- How the community will be engaged;
- Proposed consultation frequency;

- What information will be released for community consultation; and
- How feedback / comments will be considered.

3.2.2 Stakeholders

Key stakeholder groups for CCO are listed in ***Table 17***. Details of each community member within the landholder groups are provided in Appendix 4.2. Stakeholder groups have been further categorised into into three tiers according to their level of impact, influence or interest in site activities or decisions, including high/frequent, medium/semi frequent, and low/infrequent. Tier 1, Tier 2 and Tier 3 stakeholders are described in ***Table 18***.

The key focus of community engagement of relevance to this PRC Plan is the Tier 1 group, which includes affected landholders, traditional owners, local government, and local community groups. Engagement on rehabilitation, closure and post-mining land use(s) has been largely directed at these groups.

Table 17 - Stakeholders

Category	Description	Stakeholder
Direct landholders	Glencore is the direct landholder of the majority of the CCO sites	• Glencore and Sumitomo Corporation (GS Coal Pty Ltd) • J-Power Australia Pty Ltd • J.C.D. Australia Pty Ltd
Nearby Landowner	Residents located adjoining the CCO (mine lease neighbours)	• Landholders whose property is adjoining the Project site. There are five identified landholders. • Regional Local Landholders
Federal, Federal, State and Local Government Representatives	Government representatives at the Federal, State and Local level, including, local representatives and Government agencies. Police, emergency services, drug and alcohol services, housing, Aboriginal, employment and social services. The Isaac Regional Council play an important role in reviewing and providing feedback on potential project impacts on local government services.	**Federal** • Department of Agriculture, Water and Environment **State** • Department of Environment and Science • Department of Regional Development, Manufacturing and Water • Department of Resources • Department Seniors, Disability Services and Aboriginal and Torres Strait Islander Partnerships • Department of Children, Youth Justice and Multicultural Affairs • Department of State Development, Infrastructure, Local Government and Planning • Department of Transport and Main Roads **Local Government** • Isaac Regional Council

Category	Description	Stakeholder
		Government Service Representatives • Queensland Police • Queensland Ambulance Service • Queensland Fire and Emergency Services
Traditional Owner Stakeholders	Traditional owner groups, local land councils, other Aboriginal organisations, where these are related to the CCO lands	• Wangan People • Jagalingou People • Cultural Heritage Coordinating Committee (CHCC)
Business Operators and Representatives	Business operators and employees in the locality may experience indirect impacts on business operations. Agforce (local representative), local accommodation operators, local real-estate agents and local Chambers of Commerce.	• Various Clermont and regional businesses including accommodation providers, retail outlets, contractors, trades and services • Clermont Business Community representatives
Special Interest Groups	Community organisations and groups in the local community	• Industry Groups • Wolfang Landowners Reference Group • Clermont Community Consultative Committee • Groundwater and Environment Reference Group • Near and Far Neighbours Group • Clermont Coal Mine Employees • Residents of the Clermont Coal Mine workers camp • Local real-estate agents • Local community groups of Clermont • Educational and Training Organisations • Community Facilities
Local Community	Residents or visitors to the Isaac Region may have an interest in the project	• Other interested members of the Isaac Region and the surrounding area.

Table 18 - Stakeholder Tier Groups at CCO

Tier 1 Stakeholders	Tier 2 Stakeholders	Tier 3 Stakeholders
Employees	Regional Businesses	Shareholders
Contractors	Emergency Services	Federal Government
Suppliers and Contract Services	Support Services (i.e., Medical)	Industry Groups
JV Partners	State and Federal Government Agencies	Regional Tenement Holders
Adjoining Local Landholders	Regional Local Landholders	Neighbouring Communities
Traditional Owners	Neighbouring Tenement Holders	Media
Local Government	Local NGO's / Environmental Groups	Regional Industry
Local Community	Customers	National NGO's
Educational / Training Organisations		Research/Volunteer Groups
Transport & Infrastructure Providers		Conservation Groups
Community Facilities		Enterprise Groups

3.2.3 Engagement

3.2.3.1 History of community consultation

CCO has an established Community Consultative Committee (CCC), Groundwater and Environment Reference Group (GERG) and Near and Far Neighbours Groups (NFNGs) to discuss and address environmental, social and economic issues and challenges. These groups have provided a forum for open discussion between CCO representatives, the community, Isaac Regional Council (the Council) and other stakeholders for over a decade. Records of these engagements relating to rehabilitation and closure are provided in Appendix 4.2. Site also retains records of community engagement in a database.

3.2.3.2 Community consultation around the PRC Plan

The CCC, GERG and NFNGs are the key vehicles used to facilitate effective communication with stakeholder groups regarding rehabilitation and closure outcomes.

Consultation sessions are conducted in accordance with the CCP (attached as Appendix 4.2), which provides a clear framework to effectively engage stakeholder groups through regular meetings, forums and information sharing sessions, with the objective of strengthening relationships with key stakeholders. Ongoing consultation with these groups and future landholders will be undertaken to assist in balancing expectations and viewpoints for closure and providing a realistic and achievable closure outcome.

Building on the established community consultation processes at CCO, a SIA was conducted with consultation involving discussions and feedback sessions covering potential post-mining land use, final void options, rehabilitation performance and targeted vegetation, as well as alternative water supply arrangements and retained infrastructure for community benefit (Wall Planning and Environmental Consulting, 2020). Engagement with key stakeholders included one-on one meetings, workshops and focus groups between July 2020 and May 2021. Details of the engagement are provided in Appendix 4.2.

As part of the SIA, the following high level LOM plan and rehabilitation methodology was shared with the community:

a) LOM final coal date;

b) The active mine closure period ;

c) The post-closure period for activities;

d) The PMLU will be native vegetation in combination with low-intensity grazing pastures, gazetted vegetation areas, water management or undisturbed woodland, except for areas designated “no use” (NUMA) or where infrastructure is retained;

e) No long-term water treatment or management personnel will be required after the post-closure period;

f) Final landforms will meet design criteria (slopes, drainage, etc) and will be generally in accordance with the concept drainage and landform plans detailed in the RMP;

g) Any residual risks at the site will be managed appropriately;

h) All seepage, runoff, overflow and discharges will meet water quality objectives;

i) Progressive rehabilitation will occur;

j) Active decommissioning and demolition will meet CCO and regulatory environmental and safety standards;

k) The catchment reporting to the final void will be minimised, thereby promoting drainage above natural ground level to engineered surface water management features; and

l) The flood levee will be decommissioned and incorporated into the landform design.

The PMLU concept (which reflects the overarching approach adopted for this PRC Plan) was presented to external stakeholders for consideration and sourcing of alternatives which may provide value to the community post-mining. As communicated, the core PMLU adopted for the rehabilitated mining landforms is likely to be woodland and light grazing. Similarly to any central Queensland landholding, there will be areas with higher and lower productive capacity and this will constrain future use, with some areas likely to more reflect woodland and others light pasture. In addition to this predominant PMLU, there may be a range of additional uses and / or land use constraints, which include:

- Infrastructure (roads, services, firebreaks, buildings);
- Water management areas or systems such as dams, creek lines, diversions or similar; and
- Vegetation buffer areas and habitat corridors.

Additionally it was communciated that the final void would be left as a NUMA.

3.2.3.3 Key issues and commitments

Community consultation undertaken during the SIA raised a number of issues associated with the progressive rehabilitation and closure of the site, including the following which relate to the PRC Plan:

- The need for progressive rehabilitation;
- Utilisation of existing assets;
- The need for community representation; and
- The importance of a transparent stakeholder engagement program throughout the mine closure, decommissioning and rehabilitation phases.

The above concerns are addressed by ongoing consultation and the development of the CCP through the PRC Plan process. Input into PMLU for the site was also discussed and outcomes subsequently agreed upon, as outlined in ***Table 19***. A summary of key historic issues and commitments from previous consultation is provided in ***Table 20***.

Table 19 - Feedback incorporation to PRC Plan

Suggested Rehabilitation	Reflection in PRC Plan
Potential for industry reinvestment such as creating a workshop for servicing large mine vehicles	This was assessed and determined to have limited potential for future beneficial use of the CCO site, and therefore was not carried forward.
Potential tourism opportunities	This was assessed and determined to have limited potential for future beneficial use of the CCO site, and therefore was not carried forward.
Agriculture and farming opportunities including opportunities for an Agricultural College	A significant area of the mining lease is proposed to attain a PMLU of woodland and light grazing. In the long-term, this provides both habitat for native fauna and support for agriculture and farming opportunities.
Potential for community investment.	This was assessed and determined to have limited potential for future beneficial use of the CCO site, and therefore was not carried forward.

Table 20 - Summary of historical stakeholder issues in relation to closure

Date	Meeting	Issues/Concerns	Outcome
03 April 2007	Blair Athol Mine Closure Community Consultative Committee	Post mining water resource, both volume and quality.	Establish native vegetation as the primary end land use Surface water is to be diverted around the final void and off site to provide water of suitable quality to downstream users
17 March 2011	Clermont Community Consultative Committee	CCO final land use. Timeline for closure discussed.	Clermont community favour grazing, wildlife reserve, museum or bio fuel facility as PMLU.
03 June 2019	Clermont Mine Groundwater and Environment Reference Group	General discussion regarding targeted vegetation species.	The likely targeted vegetation species is native vegetation.
03 December 2019	Clermont Mine Groundwater and Environment Reference Group	Requested an approximate total rehabilitated area. Issues around the final void. Requested confirmation of final void size.	Total rehabilitated area will be approximately 2,200 ha at the end of the mining life. The final void (pit lake) area will be approximately 120 ha *

* This commitment is less than the approximately 400ha of final void that was envisaged within the Environmental Impact Statement (EIS) previously approved to be retained with non-beneficial land use. However it is understood that the context of the meeting was to confirm the area anticpated for the pit lake to remain/occupy after closure. The pit lake is part of the NUMA.

3.2.4 Ongoing Consultation

The community and stakeholder consultation measures undertaken to inform this PRC Plan are essential in achieving the project vision. To this end, the community consultation has:

- communicated the “Closure Project” to stakeholders and local community;
- obtained stakeholder input on the issues associated with the rehabilitation and closure of CCO (as applicable to the PRC Plan requirements) and also to inform the SIA; and
- established a stakeholder informed vision for the mine rehabilitation and closure.

The information shared with the community members was comprehensive, but understood to be dynamic and hence ongoing community consultation is required, which will continue throughout the life of mine. The various stakeholder committees (CCC, GERG, etc.) will be the main vehicles for engagment, largely through meetings, workshops and site tours. Frequency of engagement will vary, and a proposed schedule is provided in the CCP (Appendix 4.2).

Feedback and comments are received and logged in the database with timeframes to respond, if required. CCO will continue to undertake consultation in relation to the activities carried out under the PRC Plan, i.e. PMLUs/ NUMAs, rehabilitation methodology and LOM plan, amongst other routine mining operation issues. CCO will regularly review and revise the community consultation plan and community consultation register as necessary (as per the CCP, provided in Appendix 4.2).

3.3 Post Mining Land Use

3.3.1 Regulatory Context

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". Determining the appropriate PMLUs is a critical first step in mine rehabilitation planning. It supports and informs the remainder of the proposed PRC Plan, including rehabilitation and management strategies, and the PRC Plan schedule.

Mining is a temporary land use, and therefore it is important to consider a future land use that aligns with social, economic, environmental expectations for the site, as per Section 126C(1)(d) of the EP Act. Criteria for all PMLUs to be adopted for CCO will align to the requirements of the EP Act as described. The EP Act and 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

In order for a proposed PMLU to be accepted, the PRC Plan schedule 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 -

a) The land is safe and structurally stable, and

b) There is no environmental harm being caused by anything on or in the land, and

c) The land can sustain a PMLU.

This PRC Plan provides the pathway through which the above conditions can be achieved for the nominated PMLUs (addressed in CCO's LOD, the RMP).

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

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

3.3.2 Transitional PRC Plan Context

PMLUs have been previously addressed in an approved LOD, the RMP. These PMLUs, described in the following sections, can therefore be transitioned into the PRC Plan schedule.

The predominant PMLU for CCO as described in the RMP is native vegetation (open woodland/ bushland), providing a combination of native habitat and light grazing. In addition to this predominant PMLU, there are a range of additional uses described in the RMP as outlined below:

- Infrastructure (roads, dams, services, firebreaks, buildings);
- Water management areas or systems such as dams, creek lines, diversions or similar; and
- Nature refuge areas, habitat corridors.

The current post-mining land use concept for the CCO footprint is shown in ***Figure 24***. Results from the rehabilitation monitoring program (detailed in Appendix 4.3) undertaken at CCO to date, support the achievement of this predominant PMLU.

3.3.3 Land Use Context

Pre-mining land uses at the CM, CH, and the OLC included dry land cropping and grazing, whilst coal mining in various forms and intensities has occurred for more than 100 years at the TLO (RTCA, 2004). CCO is located within a predominantly rural landscape, with extensive agricultural and forested areas. Surrounding land uses are primarily grazing enterprises, broad acre cropping and forestry. The PMLUs developed for CCO aim to emulate general characteristics consistent with this wider landscape, within the constraints posed by historical and current mining related activities and consequent changes in land suitability resulting from changed physical, chemical and biological properties of soil, changes in slope and slope length, and changes in soil depth.

3.3.4 Community Consultation

As was previously discussed in Section 3.2, the PMLU concept was presented to external stakeholders for consideration and sourcing of alternatives which may provide value to the community post-mining. It was understood that the core PMLU adopted for the rehabilitated mining landforms is likely be woodland and light grazing, which is antipicated in the long-term to provide habitat for native wildlife and also allow for opportunities for pasture. Similarly to any central Queensland landholding, there will be areas with higher and lower productive capacity, with some areas more reflective of woodland and others of light grazing.

Consultation also indicated that the CCO site should incorporate other PMLUs, such as water management areas, infrastructure, and nature refuge areas/habitat corridors. It was communicated and accepted that the residual void will be retained without a productive PMLU (see Section 3.4). Water management and retained infrastructure areas may be able to service the current leaseholder or future landowner(s) for agricultural and grazing purposes.

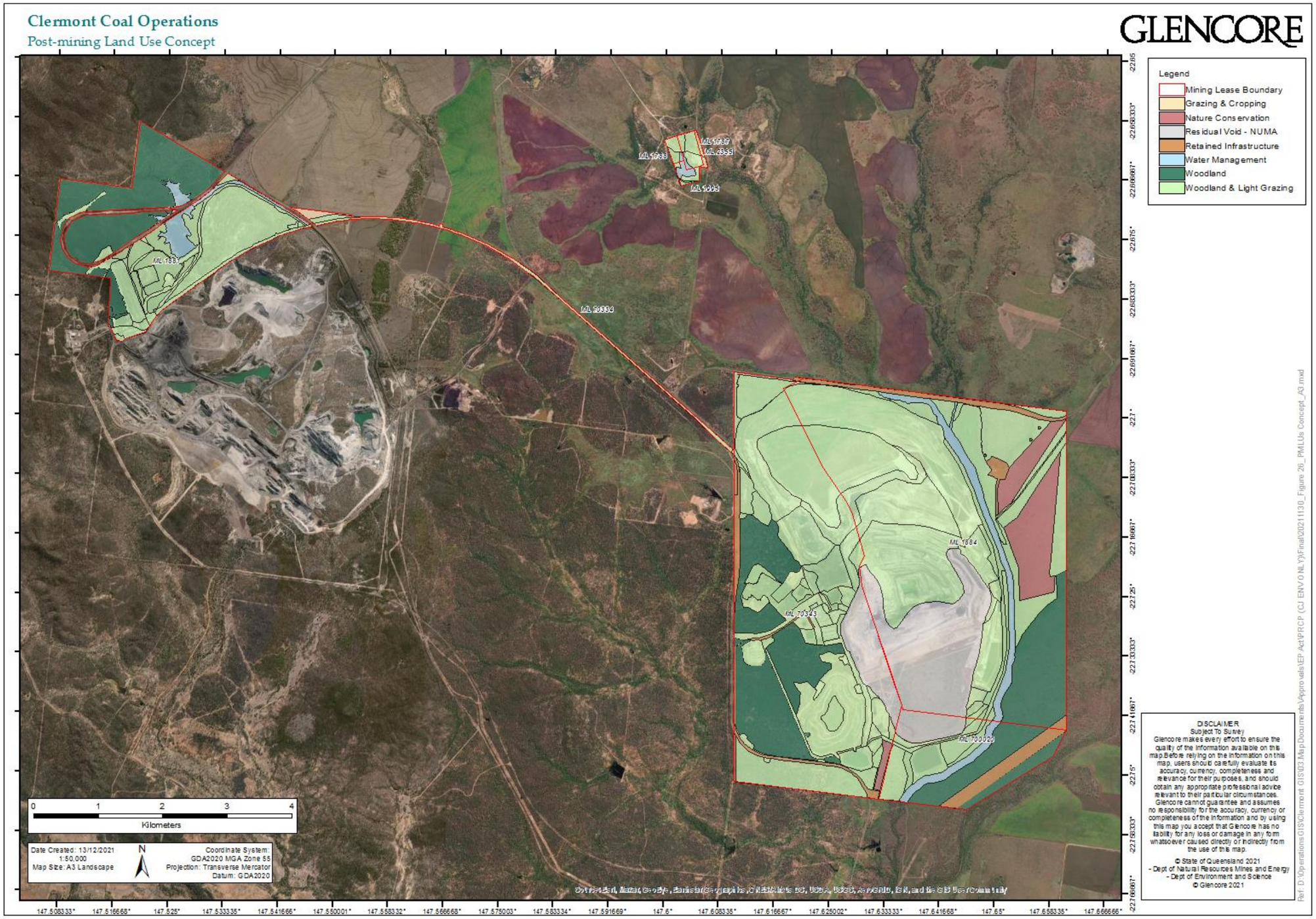


Figure 24 - Post Mining Land Use Concept

3.3.5 Description of each nominated PMLU

This Section describes each of the PMLUs proposed for the CCO. They are listed in ***Table 21*** along with their associated milestones**.** The rehabilitation methodologies to achieve the below PMLUs is provided in Section 5.3.

3.3.5.1 Woodland and Light Grazing

Areas with this PMLU will be rehabilitated to support woodland with opportunities for light grazing. When targeting vegetation communities for this PMLU, consideration is given to the regulatory constraints of the approvals, the surrounding land uses, and the quantity and quality of topsoil resources. CCO generally targets native vegetation in areas where attributes such as slope grade, access and water availability are not favourable for grazing, whilst light grazing is targeted in those areas with favourable grazing attributes and a potential for the land to become adequately productive. Native vegetation is also targeted to achieve:

- Connectivity with surrounding woodlands to the west of the CM and grasslands in the east; and
- Establishment of a koala corridor along the clean water Gowrie Creek Diversion.

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 a number of REs within the surrounding region, and native pasture grasses. Non-persistent cover crops may be used in areas where rapid stabilisation is required before colonisation by other species.

Ancillary infrastructure expected to remain, such as fencing and access roads, is consistent with this PMLU, as it can be used by the landholder and does not have a material impact on the PMLU. Therefore, ongoing management of fencing, access roads and weed populations is likely to be required.

3.3.5.2 Water Management

Areas with this PMLU will be rehabilitated to either provide a water storage area and/or riparian habitat. These areas will also contribute to the functioning of the predominant PMLU of woodland and light grazing by providing access to water for stock and/or irrigation.

The residual void at CH currently acts as a water storage feature and it is expected to continue to do so post-closure. Currently, void water is used for stock watering and irrigation, receiving inflows from surface water and groundwater. Based on investigations undertaken to date, the water within the void is of good quality, but the level varies based on climatic conditions (KBR, 2019). It is intended that the residual void at CH will remain in its current form as a water management area. The Gowrie Creek diversion will also be designated a water management area, to be rehabilitated using riparian native vegetation. At the TLO, West Dam will be largely retained as a water storage area, although the dam wall will be bulked out to create a stable landform. The Northern Boundary diversion receiving overflows from West Dam will also be retained and is a designated water management area.

Ongoing management of any remaining infrastructure and weeds is likely to be required. Again, this remaining infrastructure can be used by the landholder and does not have a material impact on the functioning of the PMLU.

3.3.5.3 Retained Infrastructure

Infrastructure will only be retained at CCO with a formal agreement with landholders. Retained inmfrastructure may include stock fencing, safety fencing, roads and any water and power infrastructure for landholders specified use. The historic Wolfang Homestead will also be retained.

Infrastructure retained at the TLO includes the rail loop which is owned by an external party, Aurizon, is outside the CCO ML. The Northern Boundary diversion that drains West Dam along the eastern boundary of the TLO will also remain.

Section 3.5 contains the full scope of retained infrastructure, including details of infrastructure agreements.

3.3.5.4 Nature Conservation

CCO has on-lease Nature Refuge and Voluntary Declaration areas to protect King Bluegrass (*Dicanthium queenslandicum*) and Beylando Cobbler's Peg (*Trioncinia retroflexa)*, each with their own management plans and monitoring requirements under approval conditions that do not form part of this PRC Plan. Ongoing management of fencing, access roads and weed populations is required under these management plans.

3.3.5.5 Cropping and Grazing

The majority of the land within CCO cannot be returned to a cropping use due to the reduced land suitability from mining activites (particularly slopes, soil properties, and resources). However, there is a small area at the TLO that is undisturbed and adjacent to cropping land. As no rehabilitation or particular management of this area is required, not specific milestones are associated with these areas.

3.3.5.6 Woodland

The woodland PMLU is applicable to the undisturbed native vegetation areas located at the CM and the TLO. They consist of woodlands dominated by Eucalypts (*Eucalyptus* spp.) and Wattles (*Acacia* spp.). As no rehabilitation or particular management of these areas is required, not specific milestones are associated with these areas.

Table 21 - PMLUs and their milestones

PMLU	Rehabilitation Area (RA)	Milestones	Progressively rehabilitated
Woodland and Light grazing	RA1 - WRDs	RM1 - Infrastructure decommissioning and removal RM3 - Identification and remediation of contaminated land RM4 - Bulk earthworks and general reshaping RM5 - Placement of topsoil/growth medium RM6 - Seeding RM7 - Water management in the final landform RM9 - Monitoring and verification of rehabilitation in final landform RM10 - Achievement of PMLU to a safe, stable, non-polluting and self-sustaining condition	Yes
	RA2 – CM Tailings		Yes (as Megacell 2 is decommissioned)
	RA3 – Infrastructure to be removed		No, rehabilitation completed upon closure once infrastructure no longer required
	RA5 – TLO historic rehabilitation		N/A, mining completed
	RA8 – West Dam landform		Yes
Water Management	RA4 – Water management areas	RM1 - Infrastructure decommissioning and removal RM4 - Bulk earthworks and general reshaping RM5 - Placement of topsoil/growth medium RM6 - Seeding RM9 - Monitoring and verification of rehabilitation in final landform RM10 - Achievement of PMLU to a safe, stable, non-polluting and self-sustaining condition	Yes
Retained infrastructure	RA6 – Retained infrastructure	RM2 - Infrastructure retention for handover	N/A – transfer of ownership
Nature conservation	RA7 – Nature conservation areas	RM10 - Achievement of PMLU to a safe, stable, non-polluting and self-sustaining condition	N/A – ongoing management area

3.3.6 Alignment with Relevant Strategies and Plans

3.3.6.1 Isaac Region Community Strategic Plan, Isaac 2035

The Isaac Region Community Strategic Plan, Isaac 2035, aims to provide clear goals and directions towards improving the future of the Isaac Region. Isaac 2035 presents a SWOT (Strength, Weakness, Opportunities and Threats) Analysis of four themes in the region – Communities, Economy, Infrastructure and Environment.

Goals for these themes are also presented within the plan, these goals are:

- Communities: In 2035 Isaac will have strong and diverse communities that support all to live, work and raise families;
- Economy: In 2035 Isaac will continue to be Queensland's number one performing regional economy, based upon a thriving, resilient and diverse mix of industry sectors;
- Infrastructure: In 2035 Isaac will have effective and sustainable infrastructure that supports the needs of the region's communities and its economic sectors; and
- Environment: In 2035 Isaac will have an appropriate and sustainable balance between environment, economy and community to ensure out natural resources are sustainably managed and protected.

The PRC Plan is in line with the environmental aims of the Isaac Region Community Strategic Plan. The PRC Plan also aims to deliver a beneficial environmental outcome to the land and soils of the area.

3.3.6.2 Isaac Regional Planning Scheme 2021

The Isaac Regional Council Planning Scheme 2021 (the Planning Scheme) has been prepared in accordance with the Planning Act 2016, and came into effect on 01 April 2021. The planning scheme applies over the entire Isaac Local Government Area, and sets out the intent for development to 2036. The policy intent for the planning scheme is represented in five themes:

- Liveable Communities: Seeks to ensure development provides high quality outcomes for communities, via building controls (e.g. zoning, built form, infrastructure, etc.).
- Diverse Economy: Recognises and seeks to capitalise on the many industries operating within the Isaac Region, including agriculture, tourism, industry and renewable energies.
- Protecting Natural Resources and the Environment: Recognises that mining and the resources sector has a strong historical, current and future role in the Isaac Region, together with agriculture. The planning scheme seeks to protect these industries, by requiring development for urban purposes be limited to urban areas. It also seeks to ensure all development minimises impact on the environment.
- Safety from Natural and Other Hazards: Identifies natural and other hazards that have the potential to occur within the Isaac Region and requires development to consider potential impacts of these hazards (e.g. bushfire, flood, etc.).
- Infrastructure for Communities: Seeks to ensure infrastructure provision is commensurate with proposed development, to support a high standard of living and is inextricably linked to the Liveable Communities theme. Infrastructure includes trunk, transport, social, and waste infrastructure.

The PRC Plan is aligned with the planning scheme, by rehabilitating the environment and maximising the potential for native woodland and light grazing to be supported through the identified PMLUs.

This supports both beneficial environmental outcomes and diversifying the local economy by providing grazing uses post-mining operations.

3.4 Non-Use Management Areas

3.4.1 Context

A NUMA and its location has already been identified in a LOD, the RMP. It can be transitioned into the PRC Plan schedule. The LOD details the following:

- The CM residual void contains a pre-approved NUMA; and
- The location of the CM residual void in relation to the Gowrie Creek/Wolfang Creek floodplain.

During the 2004 EIS process for the CM, it was recognised that the nature of the mining method employed necessitated the need to leave a 400 ha final residual void which will not be able to support a productive PMLU (RTCA, 2004). The final void was approved with expectations of deteriorating water quality and that no native vegetation is established.

Despite being a pre-approved NUMA and not being required to support a PMLU, CCO will endeavour to reduce the size of the NUMA, rehabilitate, minimise harm and achieve a safe, structurally stable and non-polluting condition.

3.4.2 Description of the NUMA at surrender

The NUMA is a subset of the final void and includes the western, eastern and southern highwall (with appropriate offsets), the pit lake and part of the low wall. The low wall will be reshaped using the trilinear slope profile successfully applied on existing spoil rehabilitation at CM, topsoiled and seeded. The upper weathered zone of the western wall of the void will be laid back, rock mulched in the lower segment and vegetated to stabilise the crest of the final void. The material generated from the layback will be pushed into the void.

A pit lake will develop within the void over time, and the quality of that water is expected to deteriorate over time. A model was developed to understand the future water level and quality under a number of scenarios relating to a flushing or non-flushing void configuration. The objective of the void configuration adopted as the base case (preferred option) was to minimise the interaction between pit water and the environment. It involves minimising catchment inflows and lowering the pit lake water surface elevation by:

- Contouring of the final landform to maximise external discharge to the surface water system; and
- Providing at least 0.1% Annual Exceedence Probability (AEP) flood immunity of the final residual void from Gowrie Creek and Wolfang Creek flood event through the design of the final landform.

3.4.2.1 Footprint

The EIS estimated that the final residual void would cover approximately 400ha. ***Figure 25*** shows the revised planned extent of the void (507.6ha), NUMA (400ha) and pit lake (50.4ha). The EIS assumed runoff from all inward facing dump slopes will be directed into the final residual void, however that approach has been revised to include only those areas below natural surface. A bund or fence was proposed to be erected around the final residual void to restrict public access to the area.

Key levels of interest are:

- The lowest point where the void will interact with the tertiary gravel aquifer (~200mAHD).
- The lowest point where the void will interact with the tertiary basalt, and most regionally significant, aquifer (~220mAHD).
- The point at which the void would spill to surface water systems (~260mAHD).

The void water level is projected to stabilise at 108 mAHD after a period of over 200 years. The 25th to 75th percentile ranges from approximately 104 mAHD to 113mAHD. This narrow range suggests a high confidence that the water level will stabilise well below both the pit rim (260mAHD) and the tertiary basalt aquifer (~220mAHD).

The approximate surface size of the pit lake once the water level has stabilised will be 50.4 ha.

3.4.2.2 Location in relation to floodplain

The CCO final void NUMA has very constrained location options due to the mining activities. The location of the pit lake in the NUMA is outlined in the RMP, and provided in ***Figure 25*** below. The final void NUMA will be outside the floodplain, separated from it by a permanently rehabilitated landform.

3.4.2.3 Safety Features

The following safety features will be present in relation to the proposed NUMA:

- Signage – Warning signage at regular intervals around the final void rim will be placed to warn of the void related risks and deter public access.
- Safety berm and/or fence – a safety berm and/or fence will be installed around the final void edge to prevent vehicular access and deter animal access.
- Safe egress – trilinear slopes on the low wall will allow for safe egress from the final void.

3.4.3 Milestones for NUMA

Milestones for the NUMA are outlined in ***Table 22***.

Table 22 - Milestones for NUMA

PMLU	Improvement Area (IA)	Milestone
NUMA (no-use)	IA1 – CM residual void	MM1 - Highwall treatment MM2 - Achievement of surface requirements MM3 - Achievement of sufficient improvement

Figure 25 - CM Conceptual Final Void

3.5 Rehabilitation Management Methodology

3.5.1 Hydrogeology

Detail on the hydrogeological systems of relevance to CCO is provided in Appendix 4.5 – Groundwater Assessment. Baseline conditions and the occurrence and nature of groundwater systems are described in Section 3.1.1.4. An overarching site conceptual model is provided in Section 3.5.7 of this PRC Plan that incorporates groundwater aspects and considerations relevant to the rehabilitation and management of the CCO areas.

3.5.1.1 Groundwater Flow Characteristics, Quality and Level

Water salinity of the CM Quaternary Alluvial aquifer is impacted by surface evaporation, resulting in a high variability, with electrical conductivity (EC) ranging from 615µS/cm to 10,000µS/cm with a mean of approximately 2,000µS/cm. Reported yields range from 0.5L/s to 10L/s. Reliable yields are difficult to predict due to the fractured nature of this aquifer. Initial drawdown is rapid as fractures are dewatered.

Quality in the Basalt aquifer is fresh to weakly brackish with a mean EC of 1,189µS/cm and water quality generally is within ANZECC guidelines for irrigation and stock purposes. Near field and regional groundwater samples from the basalt are similar. The salinity trend over time since 2008 has been relatively stable. pH ranges from 6.5 to 9.4 for Tertiary basalt monitored bores. Iron and manganese levels for some samples were above ANZECC guidelines for long term irrigation use. However, there is consistency in results for mine water production bores, near mine and regional bores.

Water yields for the Tertiary sediments aquifer were up to 20L/s with EC around 1190µS/cm and pH 9.15. This aquifer unit is now mostly mined out, with minor remnants on the eastern side of the pit.

Recorded yields within the Permian sediments aquifers have been estimated up to 5L/s. Water salinity of the Permian aquifer is of the order of 1160µS/cm for coal sediments and 800µS/cm for the non-coal sediments and a mean pH of 7.8.

The key groundwater flow for CM follows the broad topography and drainage, flowing north to south. In the area of TLO and the CM, the flow direction is toward the mine voids due to mine dewatering. Further south, the hydraulic gradient indicates flow in a southerly direction (as shown with the potentiometric mapping provided as ***Figure 26***). The bore network used to derive this mapping is extensive.

The main aquifer at CH is the Tertiary Basalt aquifer. Water levels in the area are approximately 10-15m below ground level (approximately 287mAHD). Groundwater sampling and analysis conducted by KBR (2019) from the limited number of bores in the area indicates low salinity in the ranges of 200µS/cm to 1,480µS/cm EC.

3.5.1.2 Groundwater Drawdown, Recharge and Discharge

Early groundwater modelling completed as part of the EIS predicted much greater drawdown impacts within the CM Basalt aquifer than what has subsequently been observed, and confirmed in a subsequently calibrated model. Modelling the highly fractured and compartmentalised basalt is of limited value as it does not behave as a regional system but as a series of localised storage zones. CCO has estimated a total water extraction of 5847ML through pumping and pit inflows since 2009.

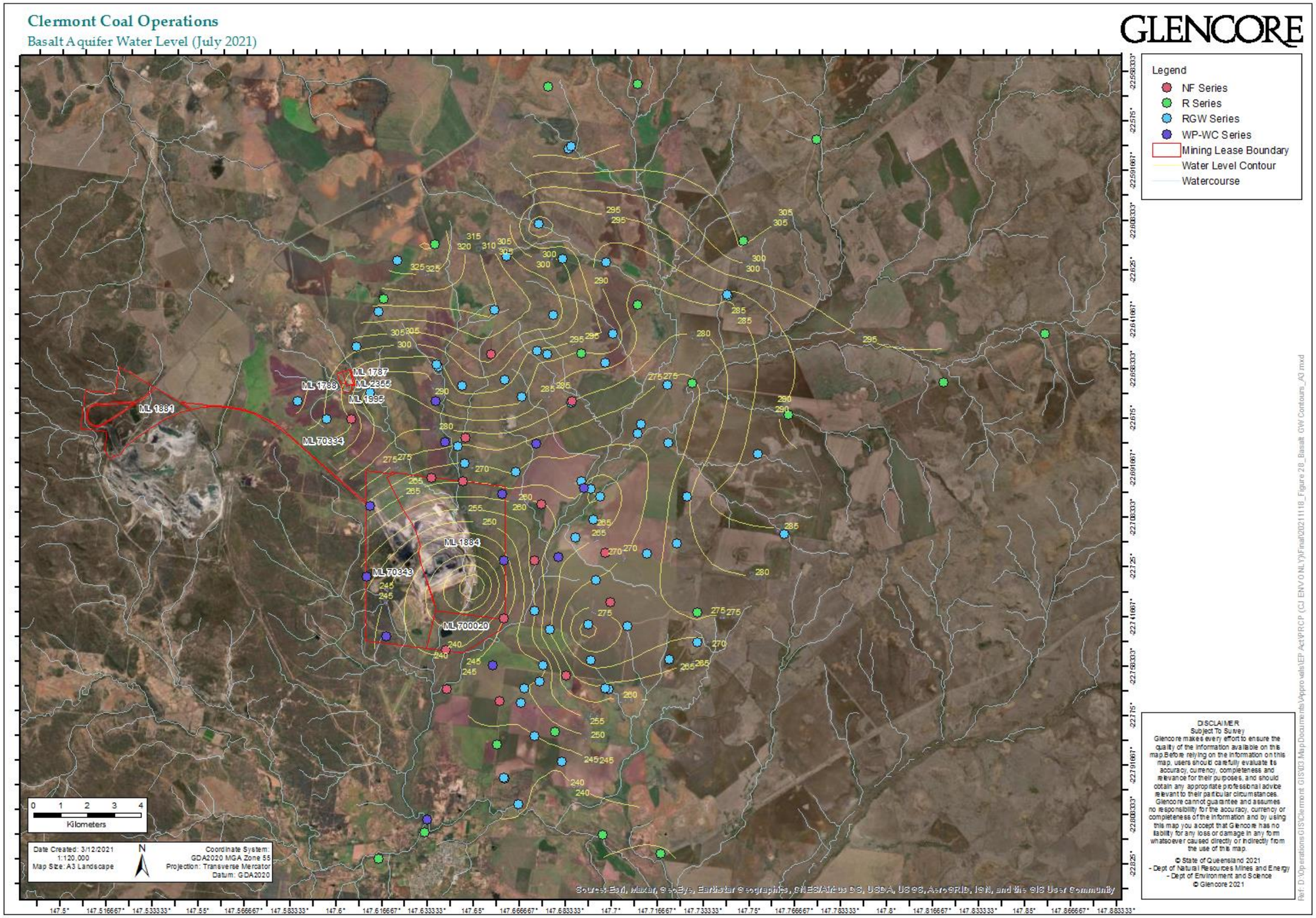


Figure 26 - Basalt Groundwater Contours and Inferred Flow direction

The Tertiary Sediments were dewatered during early mine development, and an estimated 3647ML has been extracted via pumping and pit inflows since 2009. The aquifer unit is mostly mined out with minor remnants on the eastern side of the pit.

The Permian Sedimentary Aquifers are not high yielding and are essentially a confined aquifer system. Higher permeability occurs in the sandier interbeds and where fracturing of Wolfang seam is greater. The Permian conglomerate forms the base unit to the Permian sequence, with low permeability.

At CH, groundwater flow in the Tertiary Basalt, the main aquifer at CH, is south-easterly following the topography and drainage direction (***Figure 27***). Seepage to the CH void is likely during wetter climatic periods and most likely from the fractured basalt.

3.5.1.3 Current and Potential Future Uses of Groundwater

Landholders of the region use the CM Basalt aquifer for stock and domestic purposes. Yields are variable, and in the order of 0.5L/s to 10L/s. Due to the fractured nature of this aquifer, yield and drawdown response is dependent on the connectivity of the fracture system, which is not easily predicted. There are a number of rural landowners around the CM and CH area with stock and domestic bore use with extraction from the basalt aquifer.

Groundwater seepage from the Permian aquifer into the existing CM pit area is used for CCO activities, and recycled where possible on site via internal transfers. Transfers to and from the neighbouring Blair Athol Coal Mine, currently operated by Terracom, also occurs as per a water sharing agreement.

3.5.1.4 Groundwater Modelling

The latest and most detailed groundwater model (JBT 2009) representing the active CM area, is a calibrated numerical model suitable for regional scale groundwater modelling. The model is adequate for monitoring operational scale impacts and for understanding potential changes to groundwater levels from dewatering and waste storage.

The model has also been used to develop longer-term predictions of the likely behaviour of the groundwater systems after mining. The basalt aquifer is the key system of relevance to rehabilitation and closure, as this is the regional groundwater system, which supports other uses.

The CM Basalt aquifer is predicted to continue to be drawn down locally both for the remainder duration of operations, but also after closure due to the presence of the residual void, which is predicted to act as a sink in perpetuity. Contaminant transport modelling in the groundwater is not considered relevant in the context and has not been presented, although detailed geochemical modelling has been performed for the predicted pit lake within the void that includes groundwater inputs.

At CH, mining operations for gold only involved wash and gravity separation, with a low risk of groundwater or surface water contamination from reagent spoils. There is no evidence of contamination in the groundwater, spoil or tailings samples analysed (KBR 2019).

No impacts to water quality are anticipated from CCO mining activities that would require containment and management of contaminants, or consideration of potential impacts on environmental values. The overarching 3-dimensional conceptual site model developed for CCO (as provided in Section 3.5.7) incorporates a schematic view of expected groundwater interactions for the site. Appendix 4.5 also contains a two-dimensional hydro-stratigraphic cross-section for CCO.

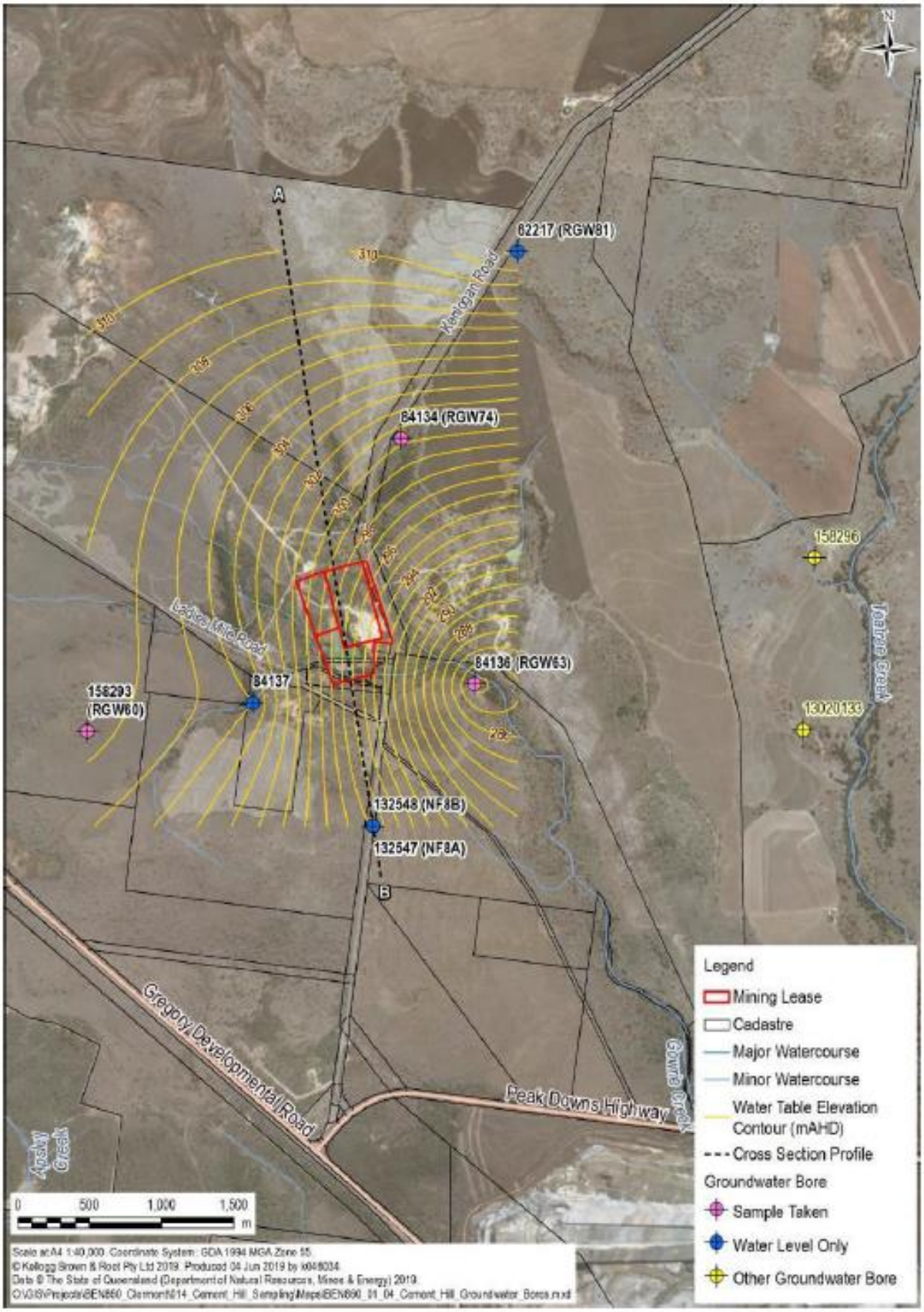


Figure 27 - Cement Hill groundwater contours as of July 2019

3.5.2 Flooding

Detail on the hydrology and flood interactions with the CCO is provided in Appendix 4.6 – Surface Water Assessment. Fluvial systems and baseline conditions are described in Section 3.1.1.5.

3.5.2.1 Location of Flood Interaction Areas

Flood interactions occur for most parts of the CCO footprint, but are particularly relevant to areas where voids will be retained, or where diversion structures have been installed for operational reasons. The CH void will remain as an off-line water storage facility, filled by overflow across a weir. The CM void will be separated from the floodplain by rehabilitated landforms.

A number of existing flood protection structures are in place, associated with licences for diverting the flow of water:

- Gowrie Creek Diversion (CM);
- Rail Loop Diversion (TLO); and
- Northern Boundary Diversion (TLO) - this is licenced as authorised interference associated with the West Dam licence (WL38931F) for Impounding Water.

3.5.2.2 Alteration of Catchment Flows

For all areas, the pre-mining catchment flows have been altered for the existing operations. Existing approvals are in place to licence all diversion structures as well as other features, which have resulted in alteration of flooding behaviour and catchment flows in particular. If information has been available to show pre-mining catchment flows, it has been included, however all flood modelling has considered the current operational context as a baseline.

Pre-Mining

The hydrology surrounding CM has been largely unchanged from the pre-mining regime, with contributing upstream catchments largely unaffected by mining and the resulting response to rainfall events similar. Flooding within the CM area is dominated by the local drainage of Gowrie Creek in conjunction with the floodplain flow of Wolfang Creek. The floodplains of the two creeks intersect at the southern end of the mining leases, where flood flows can inundate a large area.

Regional flooding characteristics were determined for the EIS using hydraulic modelling, showing that the existing flooding situation for CM was extensive, resulting in diversion of the watercourse to facilitate mining. The increase in flood depths beyond the mining leases was considered minimal and downstream impacts on flood depths did not extend past the confluence of Gowrie and Wolfang Creeks (RTCA, 2004).

The Gowrie Creek levee and diversion was initially installed to provide flood immunity for a 0.2% AEP design event, however the levee has been raised subsequently to provide immunity for a 0.1% AEP design event. Freeboard allowances have also been incorporated.

Historic gold mining activities have occurred at CH in the 1980s and into the early 1990s. Little historic information is available for the site. The current catchment in place promotes an externally draining system with ‘rehabilitation’ areas reporting to the drainage feature to the south of the site. The drainage feature interacts with the void during flow several times per year through the rehabilitated and permanent weir structure founded within in-situ rock.

The TLO also has a long operational history, and pre-mining flood information and interactions are not readily available. It is unclear whether flood modelling was conducted prior to the development of the mine, however it is considered unlikely given the long history of operations associated with the mine.

Breaker Creek catchment contains a number of open flood out areas to the west of the historic Blair Athol mine footprint which inhibits the number of flows (RTCA, 2010). Further, all creek diversions relevant to the TLO are licensed under the *Water Act 2000* and are designed to a minimum 1%AEP flood event (RTCA, 2010).

Current

The post-mining catchment flows reflects the current operational arrangement for all CCO area, as detailed in Section 3.5.2.1. The existing diversion structures have been installed to provide flood immunity for the mining operations. As described above, the flood protection structures include Gowrie Creek Diversion (CM), Rail Loop Diversion (TLO) and Northern Boundary Diversion (TLO).

Wolfang creek spills out of the primary channel very early in a flood event and both floodplains are broad relative to their primary channel. The floodplains of Gowrie and Wolfang Creek intersect approximately 2km from the southern end of the mining lease. The 1% AEP inundation in Gowrie Creek achieves approximately 276mAHD at the northern end of the ML and Wolfang Creek and Gowrie form a combined water surface at 263mAHD at the southern end of the ML. The design flood flows and flood interaction with the levees are shown in ***Table 23*** (RTCA 2004). Levee design updates were undertaken with a redesign of the southern levee to incorporate a haul road as the main flood protection and the existing levee converted to function as a spillway for larger events (KBR 2020).

Table 23 - Wolfang Creek and Gowrie Creek design flood flows

Location	1% AEP flood peak flow (m^3/s)	2% AEP flood peak flow (m^3/s)
Gowrie Creek at Teatree Creek confluence (upstream end of mining leases)	322	268
Gowrie Creek at Apsley Creek confluence (downstream end of mining leases)	378	315
Wolfang Creek at Gowrie Creek confluence	1645	1385

Post-mining

All levee structures will be incorporated into final landforms, providing long-term stability. The historic watercourse alignments will not be re-instated for any areas, and existing structures will be bulked out or incorporated into adjacent landforms. The following paragraphs provides a summary of implications for all CCO areas.

The hydrology surrounding the CM will be largely unchanged from the current active mining regime. Contributing upstream catchments will not be affected during closure and the resulting response to rainfall events will remain similar. The rehabilitation of the Northern WRD to a vegetated and outward draining surface is not expected to substantially alter the local hydrological response. Incorporation of Gowrie Creek levee into the final WRD landform is proposed. It will provide a robust and sustainable landform moving through closure and into the future.

The CH landform once rehabilitated will remain approximately consistent with the current catchment, resulting in little to no change in flow patterns from rainfall events.

The TLO Northern Boundary diversion will experience a decreased flow response due to the removal of the Breaker Creek (Rail Loop) diversion of the creek towards West Dam, returning to the original course. Additionally, the rock-filled spillway will be removed, lowering the spillway height from 321.2mAHD to 320.0mAHD and reducing the storage volume of West Dam.

The lowering of the West Dam spillway level that directs floodwater into the Northern Boundary diversion, and the associated decrease in storage within the dam, will result in a decrease in flood attenuation and an increase in the frequency of flows through the Northern Boundary diversion. Detailed flood modelling has been used to assess the combined interactions of the smaller contributing catchment to West Dam (due to removed of Rail Loop diversion) and the reduced storage capacity of West Dam (due to bulking out of the dam wall into a landform, and lowering of the spillway). Results of the impact to hydrology are shown in ***Table 24***.

Table 24 - TLO hydrological changes – peak flow entering Northern Boundary diversion (m^3/s)

AEP Event	Existing	Proposed Spillway lowered and bulked dam wall
50%	9.3	9.3
2%	54.5	51.3
1%	70.3	62.1
0.1%	146.9	126.7

The effect of the proposed hydrological changes is a reduction in peak flow through the Northern Boundary diversion. This will further improve the hydraulic performance of the diversion.

3.5.2.3 Modelled Flood Levels

Each of the CCO areas (CM, CH and TLO) contain locations where interactions with flood events are anticipated to occur. As such, significant past flood modelling work has occurred in order to address the interactions and enable operational activities. Much of the focus has been on the current open cut operational area at CM.

Wherever possible, past modelling work has been utilised for this PRC Plan, however some additional flood modelling has been required. Appendix 4.6 – Surface Water Assessment provides further detail of the methodologies employed for all modelling, as well as modelling results. Development of hydrologic modelling has occurred for all relevant catchments in all parts of the CCO site. All modelled outputs were reviewed and critiqued, and considered fit for purpose, utilising contemporary tools and techniques.

Modelling has considered likely flood extents for a range of design storm events, up to and including probable maximum flood levels. Typically, the 0.1% AEP has been adopted as the appropriate flood extent to apply for development of rehabilitation and management outcomes. Flood modelling indicates:

- Landform design ensures no interactions with CM void for flood events up to 0.1%AEP; and
- Long-term flood considerations and interactions have been incorporated into planning for rehabilitation and closure in several areas.

Where relevant, further detail has been provided in this PRC Plan as part of Section 3.5.5 on Landform Design, as well as Section 3.5.10 for Voids.

3.5.2.4 Flooding Risk Profile

A flood risk profile has been developed to identify and rank the risk of the key features and areas of concern to CCO. This has been completed to consider the susceptibility and likely influence of flooding on the areas and features of concern.

Mitigation measures to address any elevated level of flood risk are described in Appendix 4.6, and summarised as part of the proposed post-mining alterations of catchment flows (detailed within Section 3.5.2.2). The flood risk profile for CCO is as shown below in ***Table 25***.

Table 25 - CCO Flood Risk Profile

CCO Area	Feature	Risk rating
CM	Gowrie Creek diversion and levee	Low
	Southern extension of Gowrie Creek levee	Low
	Western diversion drain (mine drainage feature)	Low
CH	Void	Medium
TLO	West Dam	Low
	Northern Boundary diversion, downstream of West Dam	Low

The flood risk rating for CH is deemed medium risk because the void actively interacts with the floodplain, although this is mitigated by the interaction occurring over in-situ competent rock and evidence spanning almost 30 years that this has proven to be a stable connection.

3.5.3 Soil and Capping Material Assessment

Baseline soil assessments are presented in Section 3.1.1.6, with further detail in Appendix 4.8. The following sections summarise the quality and quantity of available resources for the CCO site. Topsoil assessments indicate that material of suitable quantity and quality is available to support the rehabilitation requirements for the operation. Additional sampling of stockpiled material is typically undertaken immediately prior to use, to guide selection and specification of ameliorants and fertilisers.

3.5.3.1 Quality of Available Resources

Topsoil resources have been characterised for the full CCO footprint, with the initial investigations of in-situ soil resources completed for the EIS subsequently refined for use during operations. A hierarchy of Soil Recovery Classes have been assigned to all in-situ topsoil resources, with material salvaged according to the quantities required as well as suitability for use in rehabilitation.

Soil Recovery Class I is considered the top priority material to salvage for rehabilitation, with each subsequent class less desirable but still suitable for use with amelioration and selective use. Class V materials are considered to be of marginal suitability, with restricted applicability (***Table 26***).

Table 26 - Soil Recovery Class: Rehabilitation Use Hierarchy

Rehabilitation Use Hierarchy (equivalent to Soil Recovery Class)	Description	Amelioration	Suitability	Use for Rehabilitation
I	Basaltic Topsoil materials	Fertiliser only.	Negligible quality limitations. Suitable for dump plateaux and batters.	Unrestricted use as primary growth media within Woodland and Light Grazing PMLU areas
II	Alluvial Topsoil materials	Fertiliser. Low rates of gypsum (2 – 5t/ 1000m^3).	Mild sodicity limitations. Suitable for dump plateaux and batters.	After amelioration, unrestricted use as primary growth media for batter slopes, natural surface or dump top areas within Woodland and Light Grazing PMLU areas
III	Basaltic Subsoil materials	Fertiliser only.	Negligible fertility and organic matter limitations. Better suited to dump tops than batters.	After amelioration, restrict materials to gentler slopes or use soil stability products for dump top and natural surfaces in any Woodland and Light Grazing PMLUs areas
IV	Basaltic Weathered Rock materials	Fertiliser only.	Negligible fertility and organic matter limitations. Potential to provide a rocky surface cover that resists erosion and supports vegetation (green rock mulch).	Use in areas at high risk of water erosion, including Water Management Area PMLUs and the Residual Void NUMA. Also suitable for batter slopes if required
V	Alluvial Subsoil materials	Fertiliser. Very high rates of gypsum (12 – 20t/ 1000m^3).	Appreciable salinity and sodicity limitations.	Marginal materials for plant growth. Not to be used.

For both the CH and TLO areas, there are no significant areas of future disturbance, and historic disturbance has occurred without stockpiling of significant topsoil materials. Thus, there are no additional topsoil resources available from these areas. The existing surface materials are suitable to use as a surrogate growth media when rehabilitation activities are completed for those areas, given that these media have supported historic revegetation. It is proposed that typical stripping depths be applied to salvage material at the commencement of reshaping activities for amelioration and use on the final rehabilitated surface.

3.5.3.2 Quantity of Available Resources

The total quantity of topsoil resources available and required at the CM each year is shown in ***Table 27***. As at 2021, a total topsoil volume of 3,955,500 m^3 is required, and a total volume of 4,378,943 m^3 is available. As such, the CM have sufficient topsoil resource to service the total rehabilitation requirements associated with the operation at the current application rate of between 100mm and 300mm.

Table 27 - Soil Material Balance

Year of Disturbance	Topsoil	
	Volume available (m^3)	Volume required (m^3)
2021	Classes I - III = 277,915	164,400
2022	Classes I - III = 323,632	198.900
2023	Classes I - III = 208,255	245,100
2024	Classes I - III = 51,180	265,500
2025	Classes I - III = 107,640	122,100
2026	Classes I - III = 69,428	654,600
2027	Material stockpiled before 2021: 3,340,893	654,600
2028	-	904,200
2029	-	746,100
Post-closure	-	-
TOTAL	4,378,943	3,955,500

The topsoil inventory and balance is reviewed annually to identify annual topsoil quantities required, volumes available for each Soil Recovery Class, and potential locations and access considerations for each material source. This supports selection of the most cost efficient growth media option for each year, while ensuring the quality and quantity of materials are assured for rehabilitation success. Where possible, direct placement of topsoil material will occur in areas of progressive rehabilitation, with existing stockpiled material to be used at the end of the mine life.

More accurate volumes of clay material and competent rock are also to be re-assessed as each rehabilitation area enters detailed design.

3.5.3.3 Location and Accessibility of Soil and Capping Materials

CCO have adopted a dynamic approach, with plans updated on an annual basis, to determine the best source, haulage routes and locations for stockpiling of topsoil materials as the operations progress, resulting in reduced transport and storage requirements.

3.5.3.4 Need for Ameliorants and Fertilisers

A constraint of concern for the CM area is salinity, which is difficult to ameliorate in clay soils. Also of concern is subsoil sodicity, which can be ameliorated but may be impractical and costly due to the high volumes of ameliorant required. Application of Soil Recovery Classes for topsoil aims to salvage those materials that are more suitable for use in rehabilitation, whilst avoiding those which have significant limitations as a growth media.

Past soil assessments for both *in-situ* topsoil resources as well as existing stockpiled material for the CM indicate that the need for ameliorants and fertiliser varies, depending on the Soil Recovery Class of the resource as well as localised physical and chemical characterisation. The classification has prioritised the salvage and use of material which requires less remediation and amelioration. An overview of the typical amelioration and fertiliser application that should be applied to each Soil Recovery Class is provided in Appendix 4.8.

Further investigations to characterise the soil and surface materials relevant to rehabilitation at the TLO and CH are likely to be conducted as rehabilitation activities commence. Soil sampling of stockpiled material is typically undertaken immediately prior to use in rehabilitation. Prescription of ameliorants and fertilisers for each area of rehabilitation are provided by a suitably qualified person.

3.5.3.5 Suitability of Soils to support PMLU Outcomes

The project area is included in four Land Resource Areas (LRAs) based on the pattern of soils, vegetation and geology (***Table 28***). The dominant LRA profiles are consistent with the most common soils found at CCO, indicating that the soil materials will be adequate for vegetation assemblages consistent with the proposed PMLUs.

Table 28 - Suitability of Soils to Support PMLUs.

Land Resource Area	Soils Recovery Class	Vegetation	Land Use	Adopted PMLU
Alluvial Plains	Alluvial Soils, Classes II	Eucalyptus woodlands with coolabah and poplar box	Rainfed and irrigated cropping; grazing on native and sown pastures	Woodland and Light Grazing
Undulating scrub plains	Basaltic Soils, Classes I & III	Brigalow and gidgee scrubs, minor communities of poplar box, belah and Dawson gum	Rainfed cropping, grazing on sown pastures, minor irrigated cropping	Woodland and Light Grazing
Undulating Downs	Basaltic Soils, Classes I, III & IV	Bluegrass, Mitchell grass, minor elements of mountain coolabah open woodland, bloodwoods and silver leaved ironbark	Rainfed cropping and grazing on native pastures: minor irrigated cropping	Woodland and Light Grazing
Ranges	Metamorphic Soils, Not available for recovery	Woodlands of narrow leaved ironbark, silver leaved ironbark, ghost gum, bendee, lancewood or cypress pine	Grazing on native pastures	Woodland and Light Grazing

3.5.4 Waste Characterisation

Detailed description of the likely physical behaviour and chemical reactivity characteristics of the waste materials relevant to the site is provided in Appendix 4.9. The following sections summarise the geochemical character of waste rock and tailings, highlighting contaminants that potentially pose a risk to the environment.

3.5.4.1 Description and Characterisation of Waste Contaminants of Concern

Sampling at CCO has considered the risk of saline drainage as well as the potential for both AMD and spontaneous combustion from all mined material. Three types of chemical interaction are relevant at CCO, including acidification of groundwater, spontaneous combustion of organic material, and leaching of soluble salts into the ground.

At the CM, the bulk of the overburden material (particularly the quaternary sediments) is non-acid forming (NAF). However, potentially acid forming (PAF) and PAF low capacity (PAF-LC) horizons were identified within Tertiary and Permian sediments. Coal materials tested are dominantly PAF, although some are classified as PAF-LC. In addition, the coal stockpiles, processing wastes, coal washery wastes and coal reject wastes are potential sources of AMD. Coal reject wastes are also susceptible to spontaneous combustion, in addition to being PAF. Saline drainage and erodibility of materials is not considered a major hazard at CM, since sampling has indicated a low potential for this to occur. This is also consistent with field observations of both disturbed areas and rehabilitation.

At CH, sampling indicates a low potential for acid generation across the site, with samples classified as NAF. Heavy metals testing also indicated levels similar to background levels, with minor exceptions within the spoil dump area and historic tailings area. Sampling at CH indicates that subsoils are extremely sodic but non-saline to slightly saline. Therefore saline drainage is not considered to be of concern for this location, but amelioration of materials is recommended during rehabilitation.

Historical data relevant to the TLO indicates that most of the overburden material is NAF and unlikely to be a concern with respect to AMD or element (neutral mineral) toxicity. Given the age of existing waste emplacements within this area, and that no seepage concerns have been observed, the risk of AMD, NMD or saline drainage is considered to be low. However, there are some historical rehabilitation areas at the TLO which exhibit significant erosion. It is likely that these areas are sodic and possibly saline, and, therefore, rehabilitation maintenance should consider amelioration requirements as part of planning.

For all CCO areas, the likelihood of significant metalliferous concentrations under neutral conditions (NMD) is moderate to low.

3.5.4.2 Review of Sampling Regime

Geochemical characterisation of waste materials commenced prior to the operation of CCO and during early exploration stages for the CM. KCB (2015) estimated that approximately 500 samples were necessary to characterise the total volume of waste material to be extracted at the CM, and these sampling numbers were achieved in 2018. Ongoing monitoring now focuses on the performance of waste placement practices and structures, as well as the continued verification of the different lithological units. The sampling regime includes collection of samples representative of all material being mined, lithologies, and waste rock structures created.

A range of both static and kinetic analytical techniques have been applied to the sampling of waste materials, meeting and exceeding the requirements of the PRC Plan guideline. This includes static tests, such as chemical composition (elemental analysis), mineralogical analysis, acid base accounting, net acid generation and water extraction tests. Kinetic testing has also been conducted on higher risk materials consisting of column leach testing. In addition a significant record of downstream and

surrounding surface water quality for the site exists, and no impacts have been recorded in the receiving environment monitoring to date (FRC 2020).

3.5.4.3 Classification of Mine Waste Streams

For simplicity, waste material at CCO is classified on its propensity to generate acid, and managed accordingly. Specifically, the waste characterisation is used to calculate Net Acid Generation (NAG) and Net Acid Producing Potential (NAPP) values, and then each type of waste material is classified according to these parameters. The following three categories of AMD-potential are recognized, and defined by the following criteria:

1. Non-Acid-Forming (NAF);
2. Potentially Acid Forming (PAF); and
3. Potentially Acid Forming-Low Capacity (PAF-LC).

At CCO, this classification is then further simplified for use by the active mining operation. All NAF material is termed “Clean”, while PAF and PAF-LC material is “Reactive”.

A geological block model has been developed for CCO as a database, to identify “Reactive” waste materials. This model forms the basis of current mine planning and operational mine waste placement. Waste that has not been classified is deemed as “Reactive” until confirmed otherwise.

Geochemical testing has shown that material that is subject to spontaneous combustion at the CM is also likely to be acid forming, and hence management measures to treat AMD are also directly applicable to managing spontaneous combustion.

An estimation of the historic and expected volume of mine wastes can be obtained from the block model, based on the level of environmental risk and aligned to the classification criteria, as shown in ***Table 29***. This indicates the ‘Reactive’ materials represent no more than 10% of the total wastes. Of the ‘Clean’ materials, the majority has considerable acid neutralising capacity and is used as part of the mine waste management strategy.

Table 29 - Breakdown of materials for CCO

Material	Volume 2008-2021 (bcm)	Volume Forecast 2022-2027 (bcm)
Clean waste	457,614,070 (92%)	177,999,803 (90%)
Reactive waste	41,415,593 (8%)	20,588,829 (10%)
Total waste (Clean + Reactive)	**499,029,664**	**198,588,632**

3.5.4.4 Management and Mitigation of Waste Streams

The management strategy for CCO outlines selective handling and placement of ‘Reactive’ waste, as well as providing guidelines for the placement of all waste material. Further management requirements are also outlined for the placement of materials with potential for spontaneous combustion, as well as coal reject and processing (Megacell) wastes.

Key management controls for reactive material is as detailed:

- all Reactive material is to be transported to its final destination within four weeks of generation;
- Reactive waste is to be placed preferentially in dumps located inside the pit, and ideally below an elevation of 90mAHD (or otherwise below the post-mining water table);

- All Reactive waste must be placed in adequately constructed waste rock dumps; and
- Dump areas containing Reactive waste are to be encapsulated as per the following design principles:
  - Reactive material is to be encapsulated using net-acid-consuming material;
  - A 2m thick basal layer of basalt (or some other net-acid-consuming material) must be placed on the original land surface/base of the area;
  - NAF/Clean material must be free dumped such that no reactive material is located within 10m of the final dump surface after the slope has been re-contoured at closure;
  - Where there is potential for spontaneous combustion, Clean material is required between lifts. Clean waste (or Basalt if available) may be mixed into Reactive waste if convenient to do so;
  - The final lift of the reactive waste rock dump must be a layer of Clean material. The thickness of this cover is to be informed by the specifics of each situation, or be no less than 10m in thickness as a default; and
  - The upper surface of the dump must be designed so that it only receives rainfall from the dump catchment itself, without run-on from adjacent areas.

Linkages have been made between the waste placement requirements specified here and the landform design detail outlined in Section 3.5.5 and Appendix 4.11 - Landform Design Report.

3.5.4.5 Conceptual Site Model for Waste

A conceptual site model for the CM waste streams comprises both a table detailing the potential for source-pathway-receptor interactions and a 2-dimensional schematic (in Appendix 4.9). This model contributes to the overarching conceptual site model for CCO that is provided as Section 3.5.7.2.

No further waste material will be moved at the TLO or CH, and the scope of future activities are restricted to rehabilitation and the continuation of infrastructure activities. Consideration of source-pathway-receptor interactions associated with tailings, and the development of a focused conceptual site model for Tailings Storage Facilities (TSFs), is provided within Appendix 4.10 – Tailings Characterisation and Design Report.

3.5.5 Landform Design

All landform designs have been guided by an objective to achieve long-term stability, and the performance of the design concept tested using appropriate analyses of long-term stability. As CCO 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 used to test the overall landform design concept. 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.

Considering operational areas, the CM is the key area where the landform requires reshaping and the design concept described below primarily applies to this location. The historic footprint at CH will be reshaped, and this will adopt the overall design principles with some modifications as required for the constraints at that site. The TLO primarily requires maintenance or small scale rehabilitation works.

3.5.5.1 Development of Design Concept

The CM design concept incorporates trilinear batters, which has been integrated into the overall design concept along with surface drainage features. This involved optimising landform height, slope gradient and vegetation covers to achieve acceptable erosion rates over the long-term. Community desires were kept in mind as the design was further developed. Appendix 4.11 details the process by which CCO has developed, enhanced and iterated the landform design concept.

3.5.5.2 Key Landform Design Principles

A summary of the key design principles for rehabilitated landforms overall at CCO are as detailed in ***Table 30*** below.

Table 30 - Summary of Design Principles at CCO

Summary of Design Principles

External dump slopes to use the approved tri-linear concave:
• Vertical elevation per section = 15m
• Horizontal slope length = 75m
  - Top slope = 25m @ 30%
  - Mid slope = 25m @ 20%
  - Lower slope = 25m @ 10%
• Invert of bench drain = toe of lower slope
• ~1% longitudinal grade – free draining, no pooling water
• Crest of bench drain = flow capacity + freeboard for a 1%AEP critical duration event @ 10% crossfall
Alternative slope designs:
• <17%
• Bench spacing as per IECA Best Practice Erosion and Sediment Control guidelines
Sediment dam designs:
• Containment of a 5%AEP, 24hr duration event; and
• No sedimentation volume required.
Stormwater chutes:
• Flow capacity + freeboard for a 5%AEP critical duration event
• ~5% – 6% longitudinal grade – free draining, no pooling
• Appropriate geofabric, rock armouring and scour protection must be provided

Landform Areas to be Rehabilitated

The location of each of the key landform structures to be rehabilitated are as shown in ***Figure 29***.

Environmental Factors

Key environmental factors of relevance considered in the landform design include the following:

- The majority of the waste material is clean and suitable for use across the site. A small proportion of materials require specific handling and placement strategies;
- The potential for floodplain interaction has required mitigation and protection through design;
- There are no hydrogeological factors of concern; and
- Community and stakeholder consultation has informed the landform design with consideration of all matters of relevance.

Earthworks Design

As explained previously, a trilinear or concave overall landform slope is to be adopted as standard. Figure 28 shows this concept for out of pit areas.

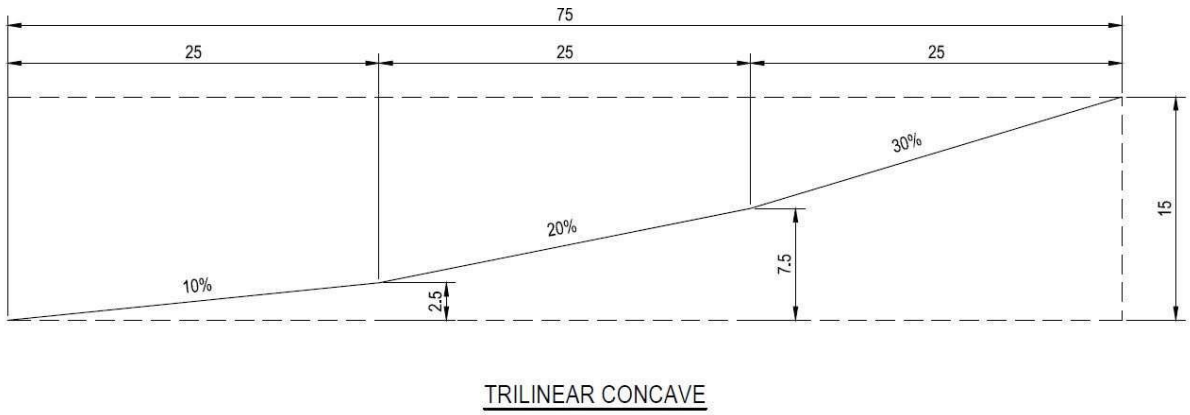


Figure 28 - Trilinear landform arrangement for earthworks at CCO

Water Management

Based on local climatic conditions, the landform design concept has adopted a water-shedding arrangement. Large ponding or standing water bodies are avoided on all rehabilitated landforms. It is expected that the primary contaminant from newly rehabilitated landforms will be sediment, and therefore all runoff from rehabilitation areas will have sediment controls in place for the initial period whilst vegetation is establishing. Details of the typical sizing and design criteria to adopt for bench drains and rock chutes is outlined in Appendix 4.11.

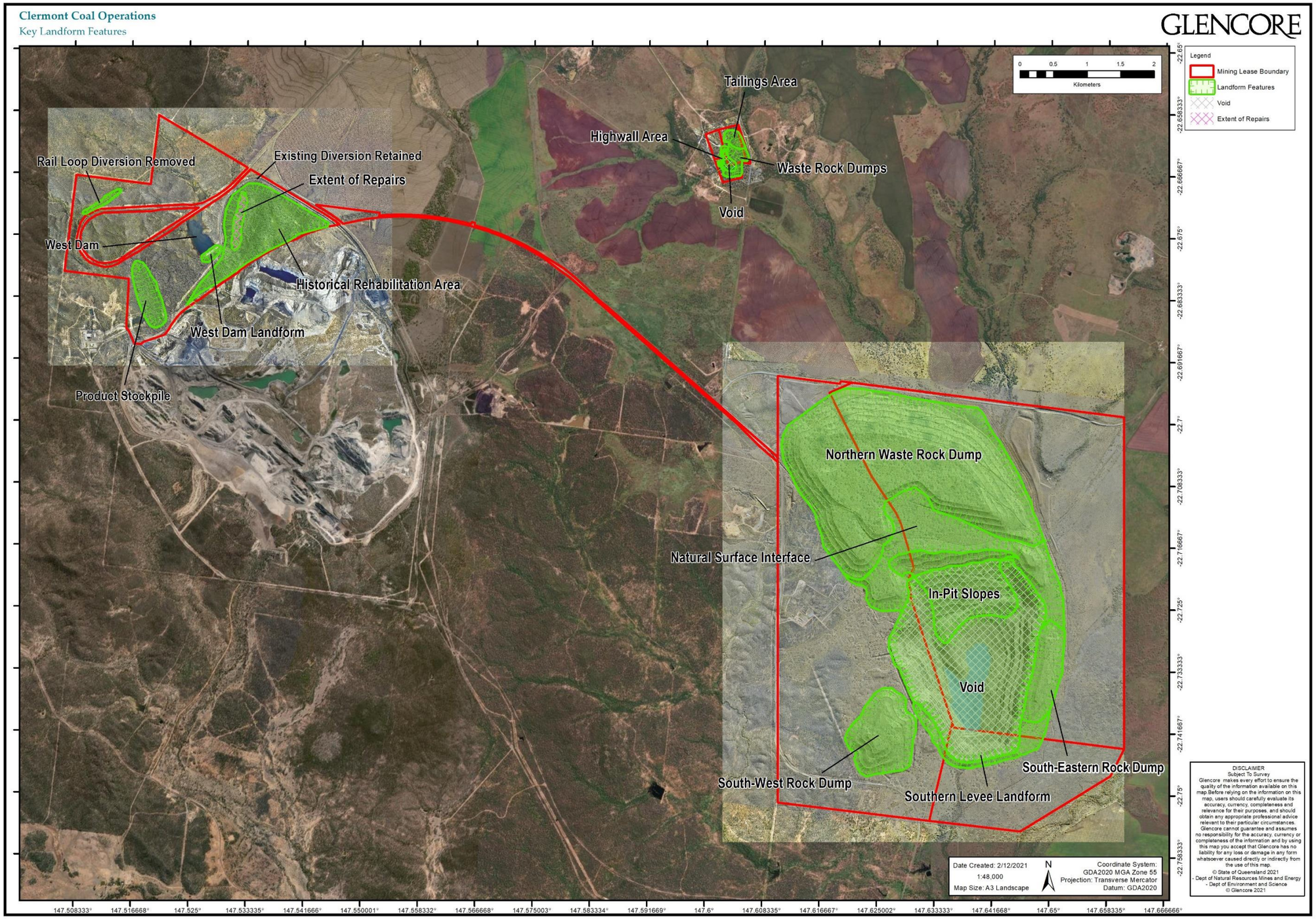


Figure 29 - Key landform areas to be rehabilitated at CCO

3.5.5.3 Final Rehabilitation Design Concept

Summary of Key Features

Table 31 summarises the landform design characteristics for each of the three CCO areas with landforms altered from the natural. For each location, the key features of the rehabilitated landform are identified.

3D Design Visualisation

3D design outputs have been developed for each of the CCO operational areas, using design tools that are complementary to that used by the mine planning function at CCO. This allows the designs to be further detailed as needed, then incorporated into mining schedules for the site. In this way, the site will be operating to achieve the final rehabilitated landform.

Rehabilitation and closure visualisations for each of the CCO locations (CM, CH and TLO) are shown in ***Figure 30*** to ***Figure 32***. These have taken the 3D landform design and used advanced spatial visualisations tools to overlay an aerial image over the landform. Additional visual detail is provided to show key features for each location. Further detail of all features for each area is provided as Appendix 4.11.

3.5.5.4 Landform Performance Assessment

Erosion and soil erodibility assessments were conducted using landform evolution modelling (LEM), using SIBERIA software. Multiple modelling runs were undertaken to account for design modifications required by the results of previous runs. Results of the final design indicate that the landform design concept performs well, achieving acceptable rates of erosion compared to a range of suitable benchmarks.

3.5.5.5 Landform Rehabilitation Process

Construction Methodology

Construction of the rehabilitated landforms includes the following key aspects:

- Completion of earthworks to achieve the required slope arrangement, with time allowance for settlement of waste rock prior to completion of rehabilitation activities;
- Installation of drainage structures to ensure the landforms will effectively shed surface water;
- Minor earthworks with smaller machinery to ensure improved tolerance to design and to complete works which cannot be established with larger equipment;
- Placement of growth media with deep ripping to incorporate into the underlying landform materials (Appendix 4.8); and
- Revegetation activities (Appendix 4.12).

CCO manages rehabilitation planning, design and execution using both internal and external resources.

Table 31 - Summary of Key Rehabilitation Landforms for CCO

Area	Landform Design Aspect	Dimensions
CM	Individual landform footprints =	60 - 654 ha
	Individual landform elevation =	295m AHD – 360m AHD
	Slope gradient =	Trilinear (30/20/10%)
	Lift height =	15m out-of-pit/ 20m in-pit
	Surface water philosophy =	Water-shedding
	Surface treatment =	Revegetated
	Landform PMLU =	Woodland & Light Grazing
	Key design constraints and considerations =	Restricted footprint, visual impact, significant interaction with mine planning, environmental factors - geotechnical (void), flooding, geochemical
CH	Individual landform footprints =	3 - 10 ha
	Individual landform elevation =	310 m AHD -320m AHD
	Slope gradient =	Linear
	Lift height =	N/A, optimised for cut/fill balance
	Surface water philosophy =	Water-shedding
	Surface treatment =	Revegetated
	Landform PMLU =	Woodland & Light Grazing
	Key design constraints and considerations =	Restricted footprint, historical disturbance, stakeholder expectations, environmental factors – geotechnical, flooding, water resource
TLO	Individual landform footprints =	4-10 ha
	Individual landform elevation =	320mAHD - 340 m AHD
	Slope gradient =	Linear (15% for West Dam), optimise cut/fill for rehabilitation maintenance
	Lift height =	N/A
	Surface water philosophy =	Water-shedding
	Surface treatment =	Revegetated
	Landform PMLU =	Woodland & Light Grazing
	Key design constraints and considerations =	Preservation of existing rehabilitation, historical disturbance, interaction with multiple stakeholders, environmental factors – revegetation, water management, infrastructure

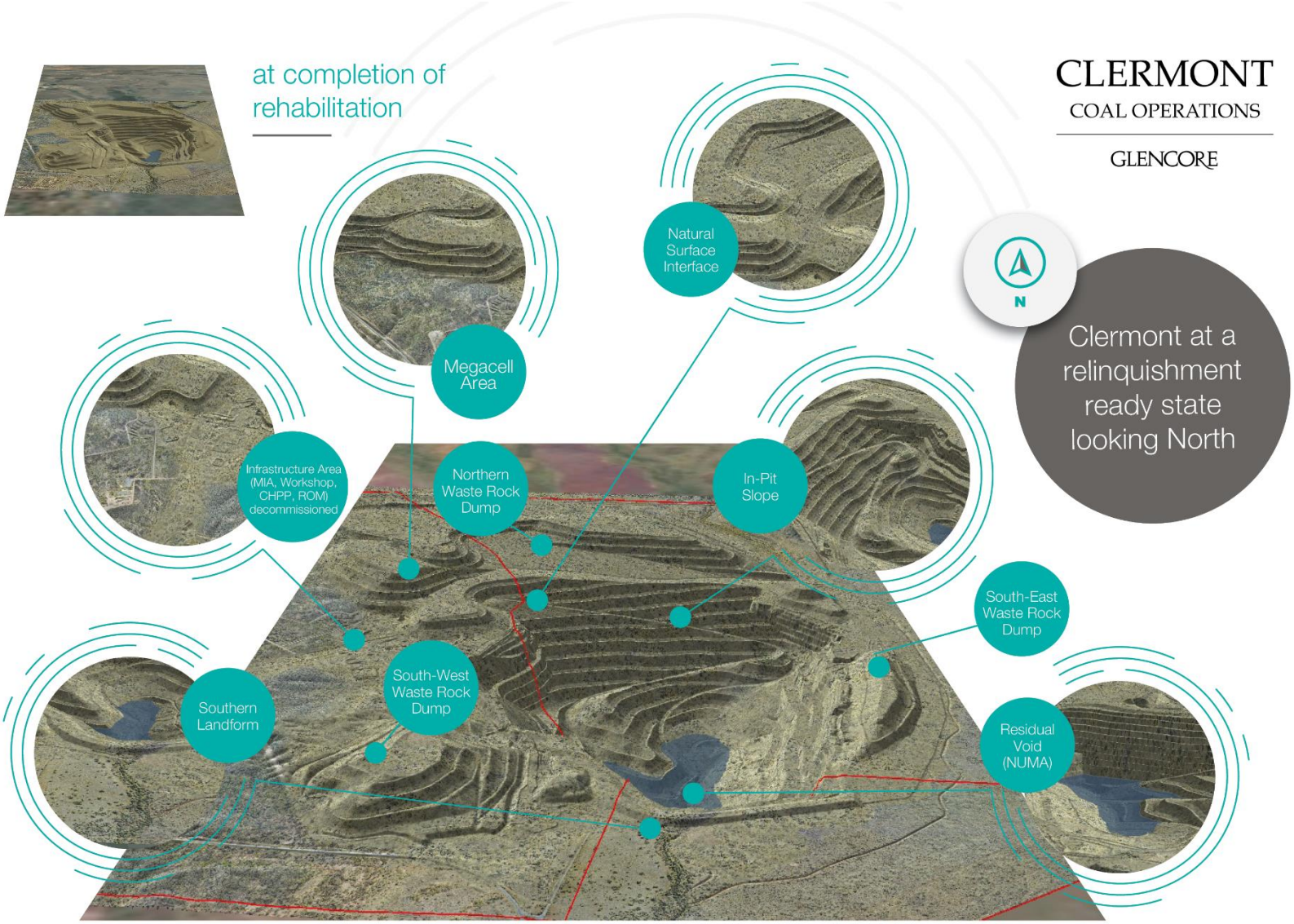


Figure 30 - Landform features at CM after rehabilitation and closure

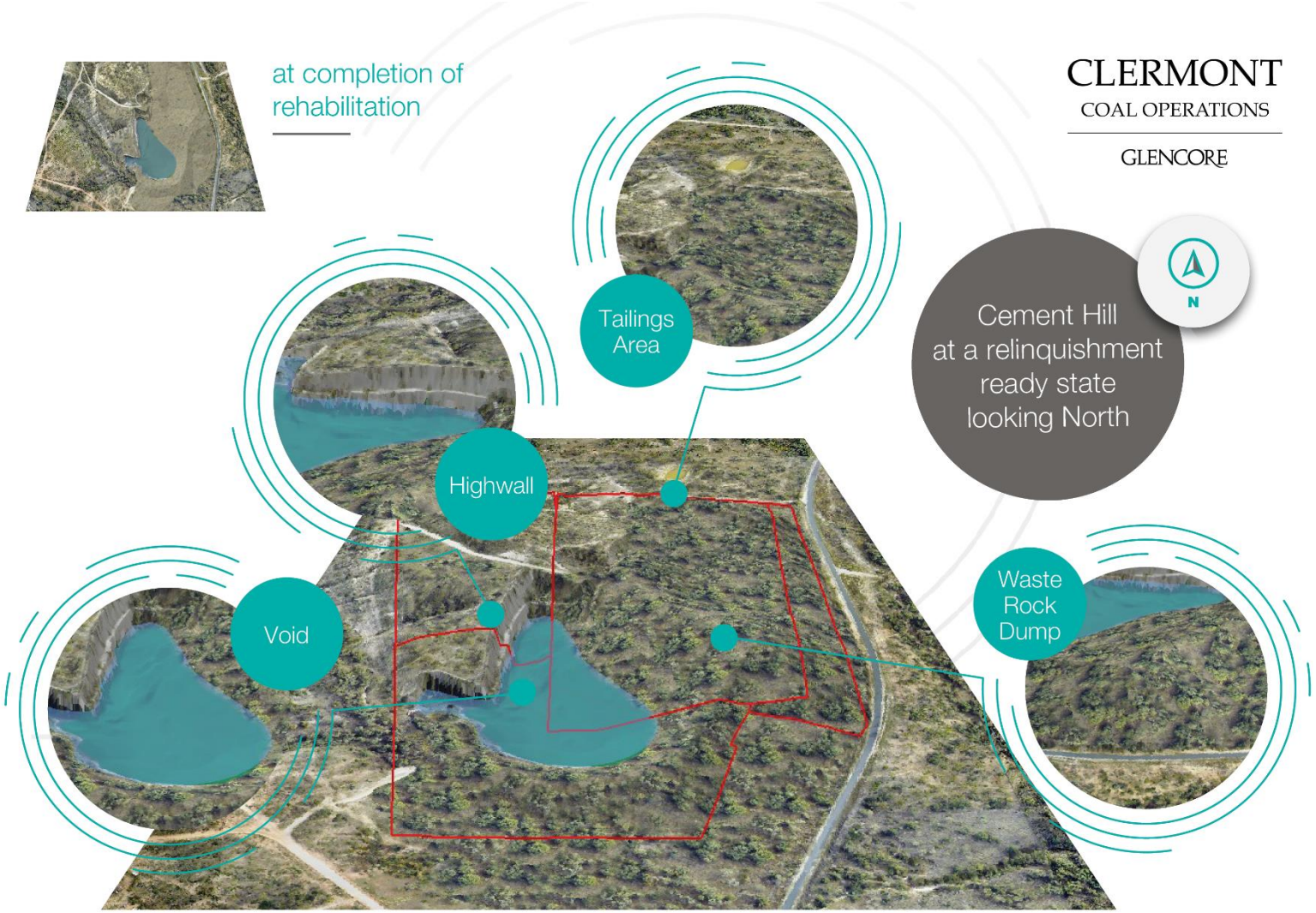


Figure 31 - Landform features at CH after rehabilitation and closure

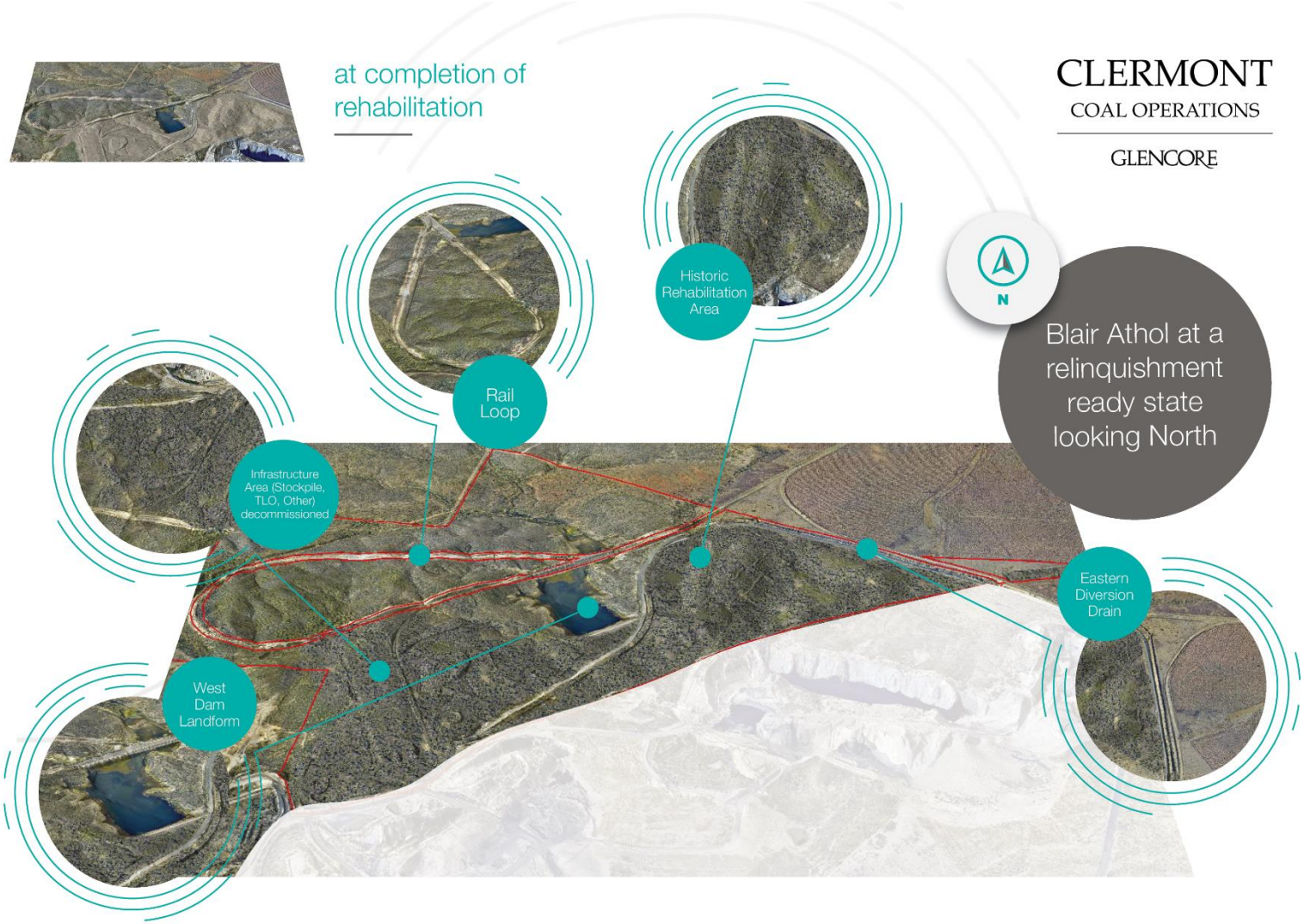


Figure 32 - Landform features at TLO after rehabilitation and closure

QA/QC Requirements

CCO has a number of quality assurance and quality control processes in place so that the rehabilitation landforms are constructed in accordance with the design concept and adheres to detailed design specification as established for each area of works. There are also a number of monitoring and reporting processes after the completion of rehabilitation activities, to verify that the key aspects of 'good' rehabilitation design have been considered, and that any aftercare and maintenance requirements are captured.

3.5.6 Cover Design

A cover system is required for circumstances where the surface treatment of a mine landform or other waste material is essential to manage the exposure of waste materials that are known or expected to result in AMD, NMD or saline drainage. Cover systems are required to prevent release to the receiving environment, legacy concerns, or direct impacts on rehabilitation success.

CCO does have waste materials that are likely to be of concern, deemed as 'Reactive' materials. The waste handling and placement strategy employed for the site is to encapsulate these materials within 'Clean' (or benign) materials. As a result, for all circumstances where 'Reactive' materials have been (or will be) encapsulated at CCO, the area will perform in line with the surrounding WRD characteristics. The design of the surrounding WRD areas is as described in Section 3.5.5 and Appendix 4.11.

As such, no engineered covers will be installed, and therefore, the remaining requirements for cover design are not relevant to CCO. The potential for seepage of contaminants from the encapsulated material through the surrounding WRD materials at the CM Megacells is discussed in Section 3.5.9 and Appendix 4.10.

3.5.7 Water Management

3.5.7.1 Description of Contaminants of Concern

The primary contaminant of concern relevant to the completion of rehabilitation and closure is expected to be sediment. The mobilisation of sediment indicates active erosion processes on the rehabilitated surface, including the removal of topsoil containing the majority of macro and micro-nutrients needed for revegetation. Deposition of sediment in low energy environments may alter the functioning of the landform design intention. Salinity, while currently not a major concern, may impact aquatic and land receptors if there is excessive leaching from the rehabilitated landform.

Appendix 4.6 – Surface Water Assessment provides a more detailed exploration of the contaminants of concern for each part of the CCO site. Specific contaminant sources of concern have also been explored within other technical appendices (Appendix 4.9 – Mine Waste Characterisation Report; Appendix 4.10 – Tailings Characterisation and Design Report).

3.5.7.2 Source, Pathway and Fate of Contaminants

Potential sources, pathways and receptor or fate of the contaminants are considered in the relevant Appendices, as noted in the previous Section. They are summarised in ***Table 32***. A 3-dimensional conceptual site model to illustrate potential contaminant interactions for CCO is shown in ***Figure 33***.

Table 32 - Overarching contaminants of concern by source-pathway-receptor

SPR	Issue	Potential for environmental harm	Key interventions and management strategies	Contaminant of concern	Rehabilitation Areas/ Improvement Areas
Source	PAF material encapsulated in WRD	Interaction of PAF material with water and oxygen resulting in mobilisation of AMD and other contaminants	Priority for PAF material to be placed below 90m RL Placement and encapsulation strategy for placement above this height	Sediment Salinity PAF/ Spontaneous combustion Other contaminants	RA1 – WRDs RA2 – CM Tailings Area RA5 – TLO Historic Rehabilitation Areas RA8 – West Dam Landform Earthworkds
	Point source contaminants from all other areas	Mobilisation of sediment, salinity or other contaminants	Records of contaminants placement on site		RA3 – Infrastructure to be removed RA6 – Retained Infrastructure
	Airborne dust and odour from WRD surface	Mobilisation of other contaminants and particulates	Dust control during operations Application of a dust suppression agent if a delay between cessation of production and rehabilitation occurs Rehabilitate as soon as available to stabilise surface		RA1 – WRDs RA2 – CM Tailings Area RA5 – TLO Historic Rehabilitation Areas RA8 – West Dam Landform Earthworkds
Pathway	Runoff into surface water drainage features	Mobilisation of sediment, salinity or other contaminants	Monitor WQ in receiving environment and manage if required	Sediment Salinity PAF/ Spontaneous combustion Other contaminants	RA3 – Infrastructure to be removed RA6 – Retained Infrastructure
	Seepage daylighting at WRD - natural surface interfaces	Interactions between daylighting locations and surrounding surface environment	Monitor for seepage locations and manage if required Monitor WQ in receiving environment		RA1 - WRDs RA2 – CM Tailings Area RA6 – Retained Infrastructure

SPR	Issue	Potential for environmental harm	Key interventions and management strategies	Contaminant of concern	Rehabilitation Areas/ Improvement Areas
	Runoff into surface water drainage into retention and sediment dams	Mobilisation of sediment, salinity or other contaminants	Monitor WQ in receiving environment and manage if required		RA1 - WRDs RA3 – Infrastructure to be removed RA4 – Water Management Areas RA6 – Retained Infrastructure
	Airborne particulates that are then deposited	Transport as airborne particulates	Dust control during operations. Rehabilitate as soon as available to stabilise surface		RA1 - WRDs RA3 – Infrastructure to be removed RA6 – Retained Infrastructure
Receptor	Residual void (NUMA)	N/A	N/A	Sediment Salinity PAF/ Spontaneous combustion Other contaminants	IA1 - Residual Void (NUMA)
	Receiving surface water environment	Impact to sensitive receptors – human or animal, or aquatic ecosystems Undesirable modification to WQ in downstream catchments	Monitor receiving environment and apply EA WQ criteria		RA3 – Infrastructure to be removed RA4 – Water Management Areas RA6 – Retained Infrastructure
	Surrounding groundwater system	N/A. The pit lake is modelled to be a permanent sink. No surrounding groundwater systems impacts will occur.	Monitor groundwater levels		N/A
	Surrounding surface areas and dwellings	Impacts to sensitive receptors – human or animal Undesirable modification to surface systems, e.g vegetation	Monitor sensitive receptors and dust deposition levels		RA7 – Nature Conservation areas Offsite Areas

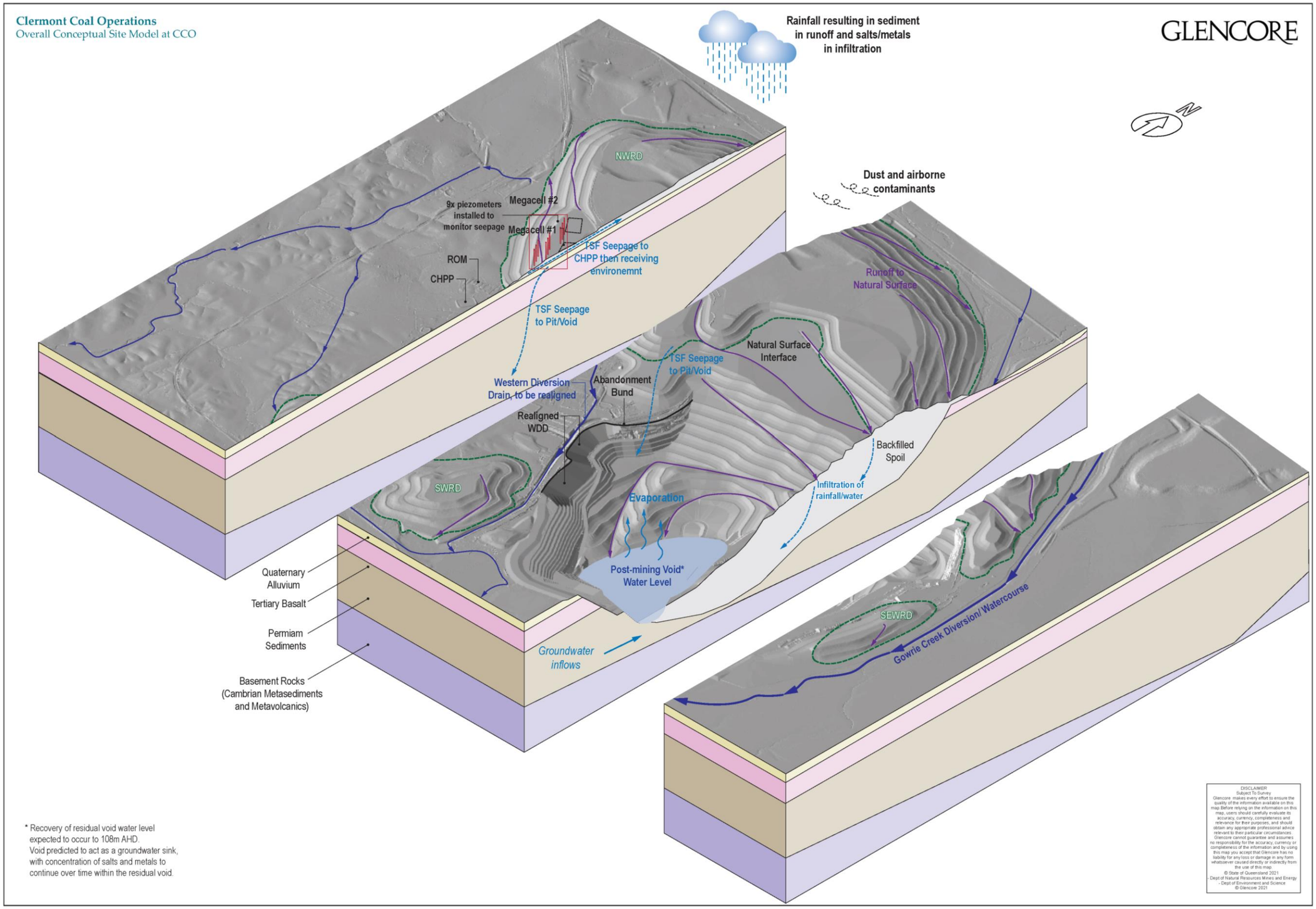


Figure 33 - Overarching 3-D Conceptual Site Model

3.5.7.3 Infiltration and Seepage Intervention and Collection Controls

For CCO, the tailings areas (Megacells) are the areas considered to be at risk of seepage into the future Seepage currently flows through the WRD to the east and is collected in the Western Diversion Drain (WDD), located along the mine haul road at the toe of the Northern WRD (Golder, 2021b). This is internal to the site, and no off-site drainage has been detected. Managing the water quality and release pathway of any seepage derived from the Megacells is further detailed in Appendix 4.10.

Key management activities required for rehabilitation and closure at CCO include monitoring of seepage via the installed piezometers, and responding to changes in seepage quantity in accordance with the TARP. It is unlikely that seepage will continue after closure, as the addition of tailings (and moisture) is discontinued. If seepage continues to occur via the eastern pathway observed, this will result in seepage collected under gravity and transported to the residual void NUMA. As such, irrespective of quality or quantity, any seepage will be entirely contained.

If any patterns of seepage change over time, additional seepage intervention and collection systems may be required. This is a relatively low contamination risk, given the moderate quality of apparent seepage as well as the distance between the source and any potential receptors. The contaminant pathways are also clearly defined and are likely to be diverted away easily from any potential offsite receptors, if required. This could be achieved by intercepting seepage and collecting and then redirecting the flow into the adjacent residual void (a NUMA) under gravity flow.

3.5.7.4 Long-term Water Management Requirements

Diversions

The two licensed diversions including the Gowrie Creek diversion and the Northern Boundary diversion downstream from West Dam will remain after closure and rehabilitation of CCO. Geotechnical results indicate that the Northern Boundary Diversion slopes are geotechnically safe and stable in their current condition, and with expected levels of ongoing degradation, weathering and erosion in future. Channel slope flattening in pursuit of erosion control criteria is likely to be counterproductive in terms of increased sediment loads generated by disturbance and challenges in sourcing and placing suitable armouring stone. Long-term slope safety will be provisional based on access to crest edges being adequately controlled to the standard that currently applies. The diversion has shown sufficiency in conveying the 0.1% AEP design event.

The Gowrie Creek diversion, currently featuring a levee on the western (mine) border, will remain as the flow path for Gowrie Creek into perpetuity. The levee will be incorporated into the final landform of the adjacent WRD, adding a degree of stability in the provision of an armoured toe on the Gowrie Creek side.

The Rail Loop Diversion will be decommissioned, returning the creek that feeds this diversion to its original course.

Dewatering

All existing dams on site, other than West Dam, will be decommissioned during rehabilitation activities. Dewatering activities will be required at the various sediment dams and the mine water dam prior to decommissioning and mine rehabilitation landform processes. Contributing catchment areas will decrease through successive and successful rehabilitation upstream of the various ponds and dams. Reduced water inflow may assist in the dewatering taking place through evaporation. Ponds and dams which have received water deemed to have been contact or mine affected water will require further rehabilitation prior to final landform operations.

Megacell 2 will require dewatering prior to encapsulation to ensure material compaction and prevent future slumping or subsidence following seepage of water entrained in slurry at the time of deposition.

On-going Water Management

On-going water management will focus on the landform drainage features employed during the final landform design process. Currently envisaged drainage features include chutes on the rehabilitated waste rock dumps, Gowrie Creek diversion, Northern Boundary diversion and the CH void in-situ rock weir feature.

The Gowrie Creek diversion and the Northern Boundary diversion downstream of West Dam will remain as watercourses bypassing the rehabilitated areas of CM and TLO respectively.

The weir feature at CH features a protrusion of conglomerate surrounded by geotechnically stable material. The addition or inclusion of an engineered structure is not required as history (supplemented by hydraulic modelling) indicates the stability of the current feature (as further detailed in Appendix 4.4).

3.5.8 Revegetation

Revegetation is an important step in achieving a sustainable cover on land surfaces disturbed during mining operations. The type of revegetation undertaken is intimately linked to the type of PMLU that can be achieved, and, hence, revegetation will need to be carefully planned to ensure that the PMLUs described in Section 3.2 can be realised post-closure.

This PRC Plan includes a Revegetation Methodology (or Revegetation Plan as required by the PRCP statutory guideline) as Appendix 4.12, and summarised in this section, outlining the activities to be undertaken to successfully establish self-sustaining vegetation suitable for the intended PMLU. Revegetation and rehabilitation activities are limited to those areas disturbed by CCO activities, all of which will be returned to a single PMLU outcome – that of woodland and light grazing. This is allocated to each rehabilitation area, as shown in ***Table 33***.

Table 33 - Revegetation Outcomes by PMLU and Rehabilitation Area

Rehabilitation Area	Description	Intended PMLU	Revegetation activities occurring?
RA1	All WRD areas	Woodland and Light Grazing	Yes
RA2	CM Tailings areas	Woodland and Light Grazing	Yes
RA3	All Infrastructure to be removed	Woodland and Light Grazing	Yes
RA4	Water Management Areas	Water Management	No – no revegetation required for PRC Plan
RA5	TLO Historic Rehabilitation Areas	Woodland and Light Grazing	Yes
RA6	All retained infrastructure	Retained Infrastructure	No – no revegetation required for PRC Plan
RA7	Nature conservation – Bluegrass and Belyando Cobbler's Peg (BCP) offset areas	Nature Conservation	No – no revegetation required for PRC Plan
RA8	West Dam landform	Woodland and Light Grazing	Yes

3.5.8.1 Revegetation Objectives

The objective of revegetation is to maximise the self-sustaining capacity of the vegetation through the use of plant species native to the region, occurring on similar landforms, and on similar soils, and are adapted to the conditions likely to be experienced within the nominated rehabilitation domains over the long term. Light grazing will be selectively promoted only in those areas with favourable grazing attributes and a potential for the land to become adequately productive.

Woodland and light grazing is the intended PMLU across most of CCO, and this PMLU is intended to contain vegetation consisting of both appropriate native and non-native cover species. The specific aims of revegetation for this PMLU are:

- rehabilitated areas are geotechnically safe and stable, and are non-polluting;
- rehabilitated areas are reshaped to support revegetation of plant species known to occur on similar landforms and on similar soils;
- vegetation is sustained after rehabilitation and closure activities are completed; and
- the grazing capacity of the post mining land areas is enhanced after rehabilitation and closure are completed, allowing for productive uses for future landowners.

3.5.8.2 Key Flora Species Selection

Appendix 4.12 presents a list of more than 120 suitable flora species for use in revegetation, including both pasture plant species and native tree, shrub and understory species that are considered appropriate for use by CCO.

The selection of suitable flora species has considered regulatory constraints relevant to CCO, the surrounding and post-mining land use concept, and the capacity of the available topsoil resources at the time of revegetation to support the selected species. It will allow for a resilient vegetation adapted to the conditions, while providing habitat and light grazing values.

When selecting species appropriate for use, consideration is given to the original vegetation communities that occurred prior to development, whilst recognising that re-creation of pre-mining vegetation on a newly created land surface would be impossible because of the transformations to hydrology, topography and geology due to the mining and rehabilitation process.

3.5.8.3 Species of Conservation Significance

Species (and communities) of conservation significance that are relevant to the approval of CCO include the Belyando Cobblers Peg (*Trioncinia retroflexa*) and Native Grassland dominated by Queensland Bluegrass (*Dichanthium sericeum*) within Brigalow Belt Bioregion – North (RE 11.8.11), Further, one constituent species of this community, King Bluegrass (*Dichanthum queenslandicum*), is also of conservation significance.

There are limited opportunities for the Belyando Cobblers Peg (BCP) to be incorporated into revegetation, and, as such, protection of the remnant populations recorded at the CM have been promoted. A Voluntary Declaration (VDec) is in place to protect the southern BCP population.

CCO has also entered into offsetting measures for Native Grassland dominated by Queensland Bluegrass (*Dichanthium sericeum*) within Brigalow Belt Bioregion – North (RE 11.8.11), to ensure ongoing protection to remnant population areas recorded on the CM MLs. This includes an area of 120ha conserved as a Nature Refuge, and further (offsite) offset measures under the EPBC approval required for development of the CM area. Where possible, the constituent species within this community have been incorporated into the flora species selection for revegetation.

3.5.8.4 Fauna Habitat or Use Requirements

The predominant PMLU of woodland and light grazing provides a combination of habitat and low-level grazing. In particular, revegetation with native species aims to connect habitat areas east of the CM (e.g. bluegrass) with the more extensive native habitat areas west of the CM, such as the Aspley State Forest.

3.5.8.5 Analogue Sites for Progressive Rehabilitation Monitoring

Revegetation efforts at CCO will be guided by the analogue vegetation that has established elsewhere in the region under conditions similar to those anticipated for the rehabilitation areas after closure.

Reference (or analogue) sites have been established across the dominant forested REs occurring in proximity to CCO with additional reference sites within grazed land and within Bluegrass dominant grasslands. The selection of the reference sites was aimed to enable sampling of the range of natural and grazed vegetation in surrounding areas, as well as to consider current and planned landforms, across a range of likely soil and geological formations. The reference sites are routinely monitored along with progressively rehabilitated areas.

3.5.8.6 Revegetation Process and Site Preparation Strategies

Appendix 4.12 describes the prescribed activities for establishing and managing revegetation at CCO. This includes an overview of the revegetation process, description of proposed site preparation strategies, with details of resources required. Site preparation strategies consider requirements for amelioration, considerations for the growth medium layer as well as the need for seed, fertiliser, ongoing infrastructure and other requirements.

Topsoil

All topsoil material is suitable for use as a revegetation growth media, and there is sufficient material available to support the revegetation of all CCO areas as required. The standard depth of topsoil placement at CM is between 100 and 300mm. The availability of topsoil resources for CH and TLO revegetation will be met through the salvage and reuse of in-situ growth media resources. Amelioration will be applied as advised by a suitably qualified person prior to use.

Topsoil is stripped and salvaged mainly using scrapers from all mine progression areas to ensure suitable high quality growth media is available for rehabilitation surfaces. Regular inventory reconciliations of topsoil stockpile locations and volumes are conducted for current and projected disturbed areas.

As part of planning activities for each annual rehabilitation (and revegetation) campaign, target seed mixes for trees and grasses/legumes are selected based on topsoil type and localised landform characteristics. Use of topsoil resources involves the spreading of the growth medium layer (whether this is topsoil, topsoil / rock mix, or salvaged resources as appropriate) to a depth within the range of placement identified, which achieves a local uniform coverage within the volumes of material available.

The application and incorporation of ameliorants (as required) also occurs as part of planning activities, with ameliorants added in the manner and at a point in time as required to ensure the product efficiency is optimised. This may be early for items such as gypsum and lime, or just prior to seeding for other ameliorants such as organic materials.

Seeding and Fertilizing

Prior to re-use for rehabilitation, topsoil samples are tested to determine their suitability as a growth medium. Where the soil samples indicate deficiencies, amelioration will be applied. Fertilisers or manures are spread prior to seeding to increase soil fertility and organic carbon characteristics.

The highest priority initially for rehabilitation is to establish a dense, vigorous and sustainable cover to stabilise the final landform. Annual seeding mixtures are developed from the target flora species identified within Section 3.5.8.2, with the overall tree or grass seed mix applied at a rate of 7-10kg/ha. Seed is sourced from reliable suppliers with evidence of appropriate seed analysis and quality control reports. In addition, a rapidly establishing cover crop species may also be added to the seed mix. The cover crop acts as an effective short term ground cover and a bulking agent for seed distribution.

Further mulching or straw blowing may also be undertaken following seeding to achieve surface protection prior to vegetation establishment, depending on prior performance in particular rehabilitation areas and based on weather forecasts. Timing of seeding works aims for completion by mid-September to early October to take advantage of potential early wet season rains, which tend to be of lower erosivity than storms in December and January.

Supporting Infrastructure

Given that light grazing forms a component of the PMLU, it is expected that fences will be required to manage livestock, in particular to exclude it from areas incompatible with grazing (such as the Nature Conservation PMLU areas). Such fencing will be installed on an 'as needed' basis in response to planned grazing activities.

It is likely that fencing for revegetation will consist of stock fences (i.e., standard stock fence or no-climb stock fence). Where stock fences are required to be constructed, the location and type of fence will be finalised with the relevant stakeholders of concern.

Access roads will generally be maintained for inspection and remediation (if required) until revegetation areas are compliant with closure criteria and certified. Access roads that will be handed over during relinquishment, and will be maintained until such time.

3.5.9 Tailings Storage Facilities

Appendix 4.10 – Tailings Characterisation and Design Report provides detail on the Tailings Storage Facilities (TSF) used at the CM. Coarse rejects from the CHPP are directly disposed of in pit at the CM. For fine tailings storage, CCO has utilised two Megacells during its existing operational life. Megacell 1 was commissioned in 2010, at the commencement of coal production, ceasing operation in July 2012 and was subsequently encapsulated by dump progression. Megacell 2 was commissioned for storage of fines in 2013 but ceased to be the main storage facility in 2021. Currently, fine tailings are temporarily stored in a series of cells constructed west of the CHPP plant. The cells are designed to allow for the drying out of the tailings after which they are disposed of in pit. Megacell 2 still serves as a back-up facility.

At CH, a historic gold mining operation has resulted in a small area containing three historic and decommissioned alluvial tailing cells. These will be rehabilitated. There are no TSFs located at the TLO.

3.5.9.1 Geochemical Characterisation of Tailings

Extensive characterisation work has occurred for CCO, so that the geochemical risks posed by the tailings material are well understood (Section 3.5.4, Appendix 4.9, Appendix 4.10): Tailings contact water (pore water) may have some potential to influence the quality of surface and groundwater resources, if left unmanaged (RGS 2021). On this basis, all tailings material at CM will be disposed in

pit or encapsulated entirely within the surrounding WRD storage facility, with NAF/net acid consuming Tertiary and Permian materials. The guiding principal for management is to limit oxidation.

Characterisation of the CH tailings has identified that they are benign, which is to be expected given the processing method involved only hydraulic separation of the alluvial sediments.

3.5.9.2 Geotechnical & Rheological Characterisation of Tailings

Geotechnical characterisation of tailings has included analysis of all relevant rheological and geotechnical parameters, as further detailed in Appendix 4.10. This includes all aspects considered to be relevant by the PRC Plan statutory guideline, including particle size distribution analysis, specific gravity testing, Atterberg limit testing, moisture content and dry density profiles, settling testing, and shear strength testing.

3.5.9.3 Design of Tailings Storage Facilities

The technical design specifications for tailings storage at CCO is contained within Appendix 4.10. It outlines the basis of design adopted, and justifies the need for design controls to address the material risk posed by each emplacement.

The general design philosophy adopted for CCO is one of integrated landform construction, whereby the tailings waste is disposed of and entirely encircled by a waste rock dump emplacement. Up until 2021 all tailings at the CM were stored in 'Megacells'. These comprise cells formed within spoil that encapsulate the tailings. They consist of a basal layer of basalt (or some other net-acid-consuming material), 'clean' material to form the sides of the Megacells and a minimum 10m layer of net acid consuming material above. The design concept is shown in Figure 34.

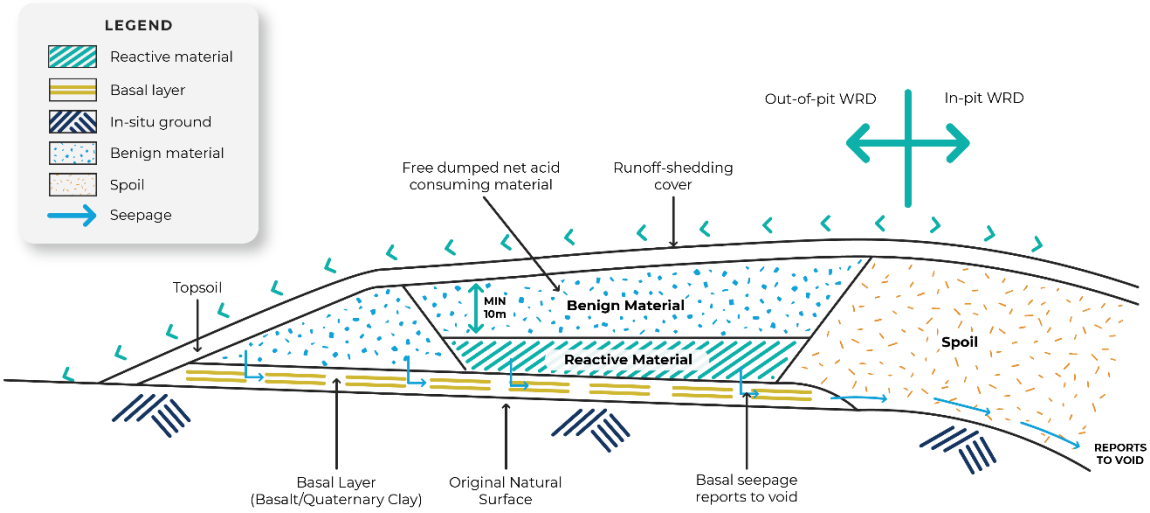


Figure 34 - Encapsulation Diagram for Reactive Tailings

In 2021, CCO constructed tailings settling cells that reduce the water content of the tailings. The cells consist of semi-permeable wall and are designed with a sufficient volume and area to promote evaporation and decant recovery. After sufficient drainage has occurred, the residual dry tailings are then disposed of in pit, in accordance with the Mineral Waste Management Plan. This requires the dried tailings to be placed low within the dump and not concentrated in any single location. The tailings are distributed amongst the spoil, which provides geotechnical stability and access to considerable acid neutralising capacity.

The tailings cells at CH consist of earthen embankments separating three cells. Current internal and external batter slopes are steep, ranging from 35% to 60%. No engineered liner or seepage collection

system has been identified, however tailings characterisation indicates they are benign and hence a collection system is not necessary.

3.5.10 Voids

A void closure methodology (or Void Closure Plan as required by the PRCP statutory guideline) has been developed for CCO and is provided as Appendix 4.7 of this PRC Plan, with a summary of the key considerations provided in the sections following. For CCO, there are two residual voids in the final landform:

1. The CM final void - to be retained as a NUMA; and
2. The CH final void - to be retained with a PMLU of Water Management.

As explained in Sections 3.3 and 3.4 these voids are pre-approved, and subject to transitional provisions.

3.5.10.1 Final Void Configuration and Options

Assessments of final void configurations were undertaken by KBR (2015; 2018), especially with respect to water management. The preferred and adopted option is to minimise the void catchment and void extent as much as practical within the constraints of the mining operation. To this end, drainage to the void will be minimised by building a bund around the rim of the pit, and a landform will be constructed around the southern and western end of the final void to provide flood immunity.

It has always been envisaged that the CH void in its current configuration would remain post closure in order to provide a water supply for local users. The long-term monitoring dataset, depth profiling and sediment sampling indicate that the void water quality meets the ANZGV (2018) for protection of aquatic ecosystems, and supports beneficial uses for livestock watering and irrigation (refer to Section 3.5.10.7 for further detail).

3.5.10.2 Void Design Details

Void design details at CM and CH are as follows:

- At CM, ground surface elevation at the top of the highwall is around 260m AHD and the base of the void will have an approximate elevation of around 66m AHD, resulting in a void depth of 194m below natural surface. The surface area (encompassing the full void crest perimeter) is 507.6 ha. The boundaries contain batter slopes with gradients ranging from around 60% in the north and south to round 35% along the eastern batter. ***Figure 25*** provides the 3D design plan for the CM final void.
- At CH, the ground surface elevation at the top of the western wall is around 310 mAHD and the floor of the void has an approximate elevation of around 291 mAHD, resulting in a void depth of 19m. The water surface area of the void is 4.7ha. The northern, eastern and southern boundaries contain batter slopes with gradients ranging from around 35 percent in the north and south to around 50-55 percent along the eastern batter.

3.5.10.3 Void Stability Considerations

Geotechnical

A geotechnical investigation was undertaken as part of PRC Plan development to update previous geotechnical closure assumptions. Appendix 4.4 contains the detail of this investigation including a geotechnical evaluation and modelling of the CM void and a review and assessment of the CH void. The outcomes of the assessment for the CM are:

- The West Wall geotechnical conditions vary greatly, and the thickness of spoil backfill buttressing is likely to range from significant to nil because of the mine development path. The part of the West Wall slope where weathered metamorphics are already and in future will be exposed requires flattening of the upper slope to improve long-term stability;
- The final South Wall slope profile is the closest part of the planned final void to the elevated post-mining landform that will provide flood exclusion to the nearby Gowrie Creek. The South Wall profile will require further design and stability analysis to achieve acceptable operational stability, and is likely to require additional spoil backfill buttressing to achieve stability acceptance criteria for post-mining landform conditions;
- The planned East Wall slope profile will also require further design and stability assessment to achieve acceptable operational stability, and it is anticipated that this will require progressive spoil backfill buttressing as the pushbacks advance southwards to expose further sections of the East Wall. Additional treatments may be required to achieve acceptable post-mining landform stability, including reducing the interramp angle above the 206 mRL haulroad bench and providing additional spoil backfill buttressing;
- The East Out-of-Pit Dump, and elevated earthworks between the South Wall and the Gowrie Creek floodplain, will provide flood exclusion for the final void following bulking out of the current levee into a permanent landform. There are not expected to be any significant impacts of a creek flood on the spoil dump or earthworks because the flood exposure time is short relative to the infiltration time of a flood wetting front; and
- The Lowwall Dump will be reshaped to a planned post-mining landform with a profile design based on erosion control considerations, with geotechnical safety and stability not likely to be significant concerns.

The Cement Hill landforms are geotechnically safe and stable in their current condition. Reshaping could be readily undertaken if considered necessary, and no formal geotechnical assessment would be required.

Erosion

Landform evolution modelling (LEM) conducted on both the CM void, and the CH overall landform, indicate that the landforms provide for acceptable long term erosional stability. The modelling outcome for the CM void shows improved erosional outcomes after redesign of the drainage concept. This is as detailed in Appendix 4.11.

3.5.10.4 Void Hydrology

The void hydrology has been conceptualised to develop water balance models for both final voids. This has drawn on site monitoring information, climate data, surface run-off and catchment hydrology. The overall catchment hydrology is detailed in Appendix 4.6.

3.5.10.5 Void Interactions with Groundwater

Appendix 4.5 provides a detailed assessment and investigation of the hydrogeological setting and interactions of relevance to CCO.

For CM, the key aquifers intersected by the void will either be removed during mining, or are isolated and discontinuous, so are not anticipated to provide any significant ongoing inflow or outflow from the final void. The main aquifer in the CH area is the Tertiary basalt which is recharged directly from rainfall. The underlying conglomerate is of low permeability. The geochemical signature of the void water is more consistent with surface runoff than the regional aquifer.

3.5.10.6 Void Water Balance

The CM model predicts that eventually (over many years) the water level in the pit void will reach a quasi-steady state condition. The water level in the pit is predicted to stabilise after approximately 300 years at 108 mAHD. There is a high confidence that the water level will stabilise well below the pit rim (260 mAHD). The formation of a pit lake is not expected until around 15 years post closure. Further detail is provided in Appendix 4.11. The model also predicts there is a permanent long-term drawdown of the regional groundwater, such that the final void will act as a sink.

The CH void has a weir that enables water exchange between the void and the adjacent external drainage feature. Flow events in the external drainage feature that exceed the elevation of the weir (300.5m AHD) causes water to enter into the void (demonstrated with flood modelling, provided in Appendix 4.13). The dominant recharge mechanism of the void is from the input of water from the drainage feature. The void has operated in its current configuration for over 20 years and has proven to be a viable water supply over this period.

3.5.10.7 Void Water Quality

A geochemical model and limnological model have been developed for the CM void to predict the long-term water quality. Details of the model are further discussed in the void closure methodology (Appendix 4.7). The modelling indicates that input waters are supersaturated with respect to various mineral phases, meaning they could precipitate and alter the quality of the water entering the pit lake.

The potential for wind to have an impact on the surface of the pit lake would likely be limited. It is expected that a thermocline could occur at some point in the water column during warmer seasons. Temperatures in the lake are consistently modelled to be 16°C at depth, and vary between 20°C and 30-35°C near the surface, with strong stratification in summer and weakening, but still persisting, in winter. The thermocline may extend from 10-30 m depth.

During the cooler months (winter plus the months either side), the variation in temperature between the upper and lower sections of the pit lake is expected to be much smaller. Evapo-concentration will occur, and as such, the pit lake is expected to become increasingly saline over time. This trend is expected to continue, with modelling indicating that a steady state will not be achieved in relation to salinity. The salinity is predicted to vary from 5,000 mg/L (25th percentile) to 10,000 mg/L (75th percentile) after 1,000 years.

Considering CH, water quality monitoring has been used in lieu of modelling. The long-term sampling dataset shows a slightly alkaline pH between 8-9 and a low electrical conductivity (EC) indicating fresh water and low turbidity. The EC trend shows the effect of significant recharge events and interspersed with slow evapo-concentration. The periodic connection to the external drainage feature prevents any long-term concentrating processes. Long term sampling also demonstrates that the void water has low metals concentrations. Depth profiling shows a consistent water chemistry throughout the profile, with some mild thermal stratification at depth.

3.5.10.8 Void Rehabilitation Strategies

The rehabilitation activities proposed for both the CM and CH voids have been summarised in Appendix 4.7. While the majority of the CM void footprint is a NUMA, the low wall will be rehabilitated in a manner that is consistent with the remainder of the out of pit WRDs. It may therefore also support a woodland and light grazing PMLU.

Since the CH void is long established and performing as intended, the majority of the proposed works are focused on stabilising the spoil batters on the northern, eastern and southern margins.

3.5.11 Underground

CM is a relatively recent open cut operation that was developed from a greenfield site, with no underground mining operations apart from some artisanal shafts west of the current void no more than 3 m deep. CH is a historic small-scale gold mining site. Historical records and aerial imagery have confirmed that this operation comprised only open cut mining methods.

As it is currently operated, the TLO area is primarily associated with infrastructure, which has been developed on the natural ground surface, as well as water management infrastructure and areas of historical rehabilitation. There is a long history of mining associated with Blair Athol Coal (BAC) Mine, of which the TLO footprint previously formed the northern part. It is known that both underground and open cut mining methods were used across the site during the BAC Mine's long history, and thus further investigation was made to confirm if historic underground workings has potential to underlie the TLO area, and what the implications may be for rehabilitation and closure now. There are no active underground operations associated with the TLO.

3.5.11.1 History and Location of Underground Workings at Blair Athol

Mining of coal at Blair Athol dates back to the 1890s, although it is understood that extraction from this period was nominal. The initial operations were all underground in nature, and small in scale, with open cut operations commencing from around 1920. Open cut operations continued sporadically, along with continued underground operations until 1946. After this time, all coal produced was from open cut operations (Dunne, 1950).

The extent of underground workings is as shown in ***Figure 35*** (BA EIS, 1976), with the TLO ML area highlighted in ***Figure 36***. As can be seen, a number of small shafts and the northern extent of one of the main collieries extend into the TLO area.

The mines were worked by hand-mining bord and pillar methods, with small shafts for ventilation and access purposes. Typically underground roadways were 5m wide by 3m high, with pillars approximately 20m thick. Support was by timber props, most of which were still in place as of 2000 (Prebble & Self, 2000).

As the Blair Athol Mine progressed, and open cut operations intersected with the historic underground workings around 1999, significant spontaneous combustion risks began to develop. This consisted of fires (resulting in dangerous CO concentrations) and the creation of explosive gases, and initially required evacuation of the mine, with subsequent development of a further management response to address the underlying issue (Prebble & Self, 2000). Key measures of relevance included the sealing of openings, and backfilling of underground workings (with a mixture of sandy loam overburden, water and cement). Backfilling continued until approximately 2009.

3.5.11.2 Implications for Rehabilitation and Closure

Although there have been historic underground workings underlying the TLO area, they are considered to be minor in scale, and developed utilising historic methods which are not anticipated to result in any geotechnical concerns or significant interactions with groundwater. Underground mining activities ceased 75 years ago, and have subsequently been backfilled to control spontaneous combustion. It is expected that any settlement or subsidence impacts, or indeed tunnelling or collapse related to ongoing spontaneous combustion, would have become apparent during this period. There are no remaining surface entries or shafts to the historic underground workings which require sealing. Rehabilitation monitoring within the historic rehabilitation areas that overlie the underground workings also do not show any signs of surface ponding and cracking that require mitigation.

As such, the historic workings at the TLO is not considered to warrant any further investigation, or require specific rehabilitation of management measures.

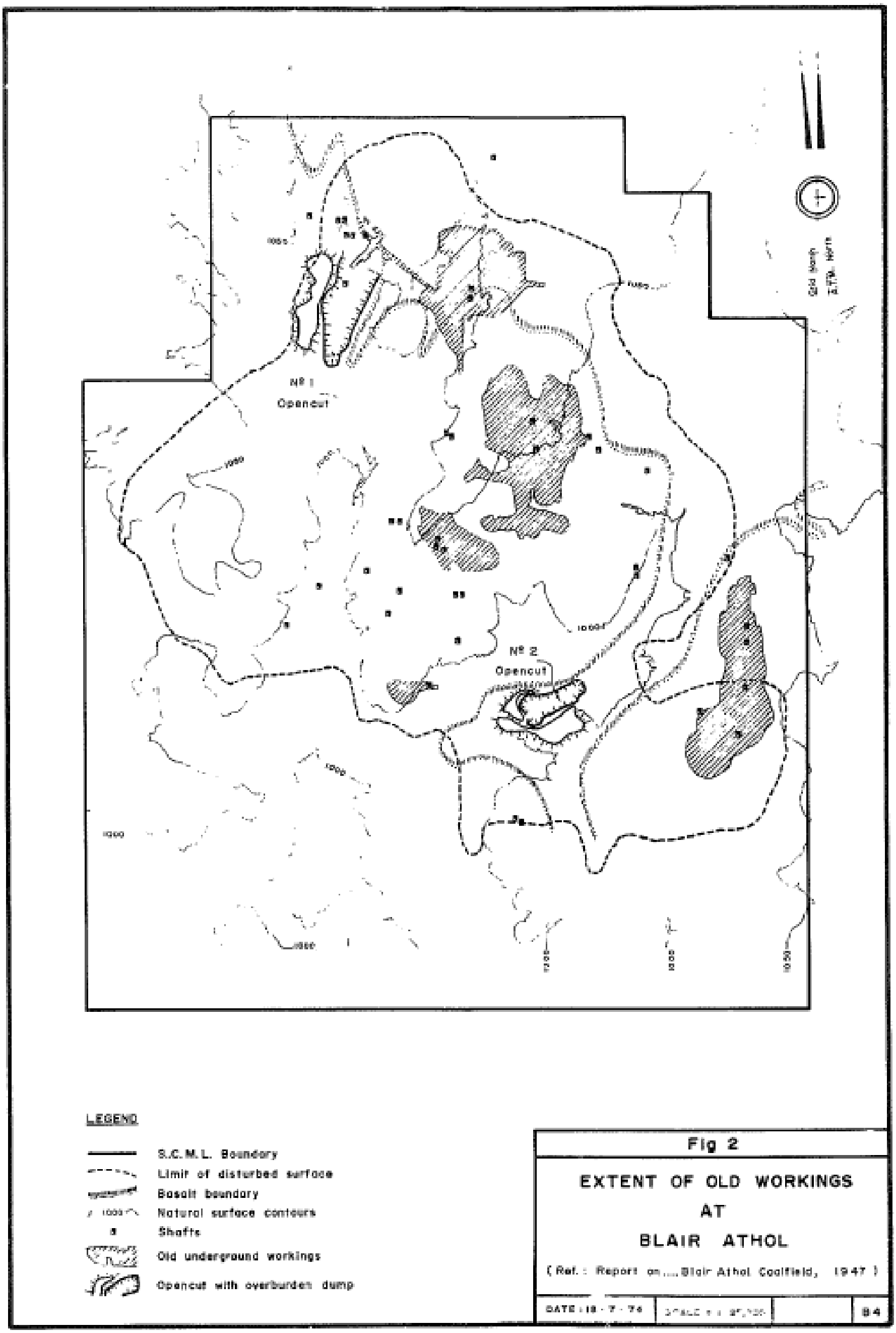


Figure 35 - Historic BAC underground workings

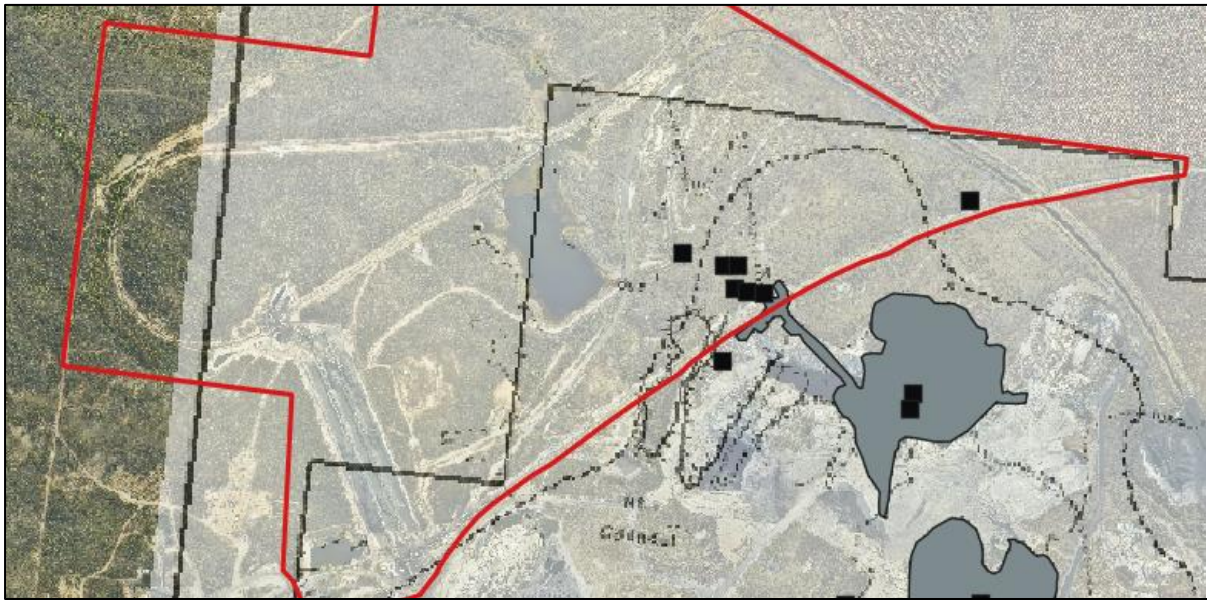


Figure 36 - Historic BAC underground workings (black squares) overlaid on current aerial photography and ML

3.5.12 Built Infrastructure

It is CCO's intention that built infrastructure will either be decommissioned, demolished, salvaged and/or disposed, except where formally retained by an appropriate stakeholder (e.g. roads, powerlines), where it is consistent with a PMLU after the completion of rehabilitation and closure, as described in Section 3.5.12.2.

Demolition planning and execution will be undertaken in accordance with relevant standards, policies and legislation requirements, and will include investigation of the site and surrounding aspects.

All decommissioned infrastructure has been compiled into a single rehabilitation area within the PRC Plan Schedule, area RA3.

3.5.12.1 Infrastructure to Be Decommissioned

Buildings, Infrastructure and Services

Following de-energising and decontamination, these key principles will apply during execution of the demolition program for all buildings, infrastructure and services:

- Stakeholder agreements and regulatory sign-off documentation and approval will be obtained for all services and infrastructure to be retained, to ensure CCO and GCAA assume no related liabilities;
- All sumps will be de-watered and de-silted prior to the commencement of demolition;
- All services, including power, water and communications, will be disconnected and terminated (or isolated as appropriate) to make them safe;
- Substations will be decommissioned, demolished and removed from the site;
- Where suitable, underground services will be made safe and left buried in the ground – the locations of these services will be recorded on the closed mine services register;

- Overhead power lines will be removed and the materials (i.e., poles and wire) recovered for potential resale or recycling, as identified during detailed closure planning;
- All buildings, sheds, tanks and fixed plant not retained for post-mining use will be demolished;
- Concrete footings and pads will be broken up at least 0.5 m below surface and removed. Options for the re-use of this material will be investigated as the mine approaches closure;
- Only pipelines and surfaces whose leachates will be inert and not have an adverse influence on water quality will remain buried in situ; and
- All salvageable equipment will be managed as assets and removed.

Conveyors, Transfer Stations and Gantries

All conveyors, transfer stations and gantries will be dismantled and removed from site. Opportunities for the reuse of assets and recycling of materials will be maximised to the extent practicable. Depending on available equipment, over-head conveyors will be cut up in situ or dismantled and lowered to the ground before being cut up. On ground conveyors will be cut up *in-situ*. All gearboxes and hydraulics will be drained of oil and depressurised to remove any potential for contamination prior to demolition. The carbonaceous material below and in the vicinity of the conveyors will be removed. Where possible, the material will be considered for reprocessing. If this is unsuitable, it will be disposed of in-pit.

Stockpile Areas

The carbonaceous material at ground level of the ROM and product stockpile areas will be stripped to a depth of at least 1.5 m. Where possible, the material will be considered for reprocessing prior to the decommissioning of CHPP operations, or on-sold. Alternatively, the carbonaceous material will be disposed of in-pit. Stockpile areas will be trimmed and reshaped, and, if required, rock raked and ripped to a depth of at least 1 m.

Water and Sewage Treatment Facilities

Once the site services and infrastructure are no longer required for the closure activities, the sewage and water treatment plants will be demolished and removed. These works will include:

- Flushing pipes and tanks;
- Disposal of any waste products (i.e. sewage sludge);
- Removal of and/or filling in any in-ground tanks;
- Underground pipes may be removed or made safe and left buried in-situ; and
- Removal of slabs, footings and concrete pads.

Once the infrastructure is removed, all areas will be reshaped, deep ripped, topsoiled and seeded as required to achieve the final land use.

Fuel Farm

The CCO fuel farm areas will likely be used for the duration of closure to facilitate the use of plant and equipment for closure works. Once the bulk of the works have been completed the following activities will be undertaken:

- Remove fuel inventories;
- Decontaminate and decommission equipment, structures, appurtenances e.g., storage tanks;

- Remove tanks for sale or salvage;
- Remove slabs, footings and concrete pads;
- Undertake a contaminated site assessment and if required develop a Sampling and Analysis Plan to identify any land and/or local groundwater contamination; and
- Where contamination is identified, prepare a Remediation Action Plan and undertake remediation works in-line with relevant legislative requirements and good industry practice.

Once the infrastructure is removed, all areas will be reshaped, deep ripped, topsoiled and seeded as required to achieve the final land use.

Roads, Tracks and Hardstands

All bitumen sealed surfaces, such as access roads, car parks and hardstands will be scalped to approximately 0.5 m below the surface to remove stabilised and compacted material. The inert waste will be disposed of in a suitable location on site, or crushed and re-used if required.

Haul roads, hardstands/laydown areas stabilised with road base (or similar) will have the top 0.5 m scalped to remove the surface, base and sub-base layers prior to being ripped, re- contoured, topsoiled and seeded as required to achieve the final land use.

Power Lines

All power lines established for the purposes of mining, and that are not part of the infrastructure handover (see Section 3.5.12.2), will be removed, unless an arrangement has been agreed in writing through consultation with relevant stakeholders during detailed closure planning. Overhead power lines will be removed and the materials, including poles and wire, recovered for potential re-sale or recycling where practicable.

Historical Mine Shafts

The scattered remains of artisanal mining in the south-western corner of the CM ML consist of small holes and shafts estimated to be up to 3m in depth. These will be bulldozed over and the ground surface reshaped to leave a stable surface. The earthworks will be topsoiled and seeded as required to achieve the final land use.

Boreholes

Exploration, groundwater monitoring and production wells will be decommissioned in accordance with relevant standards and guidelines, unless a groundwater well is a usable asset and an arrangement has been agreed in writing through consultation with relevant stakeholders during detailed closure planning. The outcomes for decommissioning of boreholes include removal of the well head and rehabilitation of any disturbance associated with historical drill pads, sumps or access roads to drill sites to be consistent with the surrounding land use.

3.5.12.2 Infrastructure to be Retained

A summary of infrastructure to be retained is listed in ***Table 34***. These features are compiled into a single PRC Plan Schedule, as RA6. The PMLU adopted is retained infrastructure, to recognise the prior and appropriate use of each area. These features will remain after rehabilitation activities have been completed, and will be subject to ongoing maintenance requirements. However, all retained infrastructure has a clear and existing purpose, and loss of the infrastructure would result in concern to a range of stakeholders. Detail of agreements to authorise and allow for the ongoing nature of the infrastructure is detailed below.

Table 34 - Infrastructure to be Retained

Infrastructure	Relevant agreements in place	Ongoing Maintenance Requirements
Highway	Note – easement over underlying land tenture	N/A – area is under DMR control
Rail Loop and associated rail areas	Area has been excised from the ML, but has been referenced for information only	N/A – area is under Aurizon control
Powerlines	Note – easement over underlying land tenture	N/A – area are under control of the state and relevant utilities
Wolfang Homestead	Nil, although community expectations around retention	Yes, as per CHMP

3.5.12.3 Infrastructure to Be Left In-Situ

Roads, Tracks and Hardstands associated with Highway

Roadways and/or tracks and culverts may temporarily be required to provide ongoing access for rehabilitation monitoring and maintenance activities. They may also be retained permanently on-site for use by the post-mining land user where agreed in writing (including as fire breaks).

Areas surrounding the Rail Loop at the Train Load Out

The rail loop located at the TLO is owned and operated by a third party (Aurizon) and will not be decommissioned within this PRC Plan framework. A contaminated site assessment will be undertaken for the surrounding areas including the development of a Sampling and Analysis Plan to identify any land and/or local groundwater contamination. If required, a Remediation Action Plan will be prepared and remediation works undertaken in-line with relevant legislative requirements and good industry practice.

Power Lines

Power lines may be kept where an arrangement has been agreed in writing through consultation with relevant stakeholders during detailed closure planning. Should no agreement be made, power lines will be taken down. Poles and lines would be sold or recycled, as determined during the closing stages of the project.

Stock Routes

Stock routes traversing along the edges of the CM ML have not been disturbed by the mine development. No rehabilitation is proposed within these areas.

Other

Should any other infrastructure be considered a usable asset, arrangements may be agreed in writing through consultation with relevant stakeholders during detailed closure planning in the future. This may including fencing. If no agreement can be made, any such infrastructure will be decommissioned as currently planned.

3.5.12.4 Maintenance Requirements

CCO utilises an annual rehabilitation review and assessment process to provide specific details of works required to actively manage progressively rehabilitated areas. This process allows adequate provisions and resources to be allocated annually. The care and maintenance works program is based on the outcomes and recommendations from the rehabilitation monitoring program, and any inspections or site observations. The program includes the requirement for weed control, pest control, fertiliser application, storm water management, re-seeding / planting, erosion control works, re-working of failed rehabilitation, fencing and controlled grazing of pasture areas.

3.5.12.5 Soil Contamination

Once all infrastructure and demolition materials are removed, the Contaminated Site Register for CCO will be updated following a contaminated site assessment. This information will be used to develop a Sampling and Analysis Plan to identify any land and/or local groundwater contamination. Where contamination is identified, a Remediation Action Plan will be prepared and remediation works undertaken in-line with relevant legislative requirements and good industry practice.

Information regarding the findings from the contaminated site assessment, and the activities completed as per the Remediation Action Plan, will be presented in the Final Rehabilitation Report to the Queensland Government for relinquishment.

3.6 Risk Assessment

This Section outlines the assessment undertaken to determine a range of risks potentially affecting the achievement of safe, stable, and sustainable PMLU conditions, as well as the controls in place or proposed to minimise these risks. The assessment also considers the risks to the safety and stability of the final void NUMA, and to the potential harm caused by it on the environment.

3.6.1 Risk Assessment Framework

CCO (as part of GCAA) considers a range of risks associated with rehabilitation, closure and post-closure phases. A closure risk assessment is maintained for CCO. This also aligns to the requirements of the ISO 31000:2018 Risk Management – Guidelines (Standards Australia 2018). The procedure describes risk assessment as the overall process of risk identification, risk analysis, risk evaluation and risk treatment, and the framework for each of these aspects is as described further below.

3.6.1.1 Risk Identification

As a first step, the assessment involves identification of the risks/unwanted event, cause(s) of the event, potential maximum consequences, current controls in place, and current risk control effectiveness. These were determined based on:

- Risks commonly encountered in mine rehabilitation as documented in the Guideline: Rehabilitation Risk Assessment (NSW Resources Regulator 2021);
- Site workshop on 26 July 2021, attended by corporate subject matter experts, site personnel from Technical Services, Environment and Community, Rehabilitation, and consultants with engineering and rehabilitation experience on the project; and
- Review of a range of management plans and risk control documentation produced for the CCO, including the Rehabilitation Management Plan.

3.6.1.2 Risk Analysis and Evaluation

The risk analysis step involves exploring the risks identified, determining risk causes and sources. The assessment is to consider the potential consequences and the likelihood that those consequences can occur. Consequence and likelihood of the unwanted event occurring were rated using the GCAA Risk Matrix (***Table 35***). This table contains five rating levels for consequence and likelihood each. The basis for likelihood used in the assessment is the remaining lifetime of the CCO until full relinquishment. This period includes remaining production, rehabilitation post-production, and a period of aftercare.

After completion of the previous steps, options for addressing the risks are selected for implementation. The most appropriate risk treatment options are selected after consideration of multiple factors including cost benefit, regulatory obligations, social responsibility and protection of the surrounding environment.

The risk treatment step details a justification for selecting the option, details proposed activities, identifies parties responsible for implementation as well as resources required. Performance measures and constraints are highlighted, reporting and monitoring requirements outlined and detail provided on timing and scheduling of each risk treatment option.

The results of the risk analysis are provided in ***Table 36***.

3.6.2 Rehabilitation Trials

CCO has undertaken rehabilitation and revegetation since 2016 at the CM, and hence considerable experience has been gained in ensuring waste rock dumps and other surfaces are adequately rehabilitated and revegetated. Nevertheless, improvements in rehabilitation processes are continuously trialled, including the use of surface protective materials such as rock mulching, and a variety of geotextiles and fibrous matting to ensure early retention of topsoil. Seed sources and mixes are also continuously adjusted as further experience is collected on previous trials, as documented in annual monitoring undertaken across the rehabilitation areas.

Table 35 - Risk Matrix adapted for rehabilitation

Likelihood		**Consequence**				
		1	**2**	**3**	**4**	**5**
		No lasting rehabilitation impact requiring no remediation	**• Minor / Short term rehabilitation impact requiring minor remediation, depending on failure consequence (<month)**	**• Moderate / Medium term rehabilitation impact requiring moderate remediation (<2 years)**	**• Major term rehabilitation impact (<10 years) requiring major remediation**	**• Long term or permanent (>10 years) rehabilitation impact requiring complete rework and may require re-assessment of design**
A - Almost Certain	May occur several times per year	11 High	16 High	20 Extreme	23 Extreme	25 Extreme
B - Likely	May occur once a year	7 Moderate	12 High	17 High	21 Extreme	24 Extreme
C - Possible	Could occur more than once during remaining lifetime	4 Low	8 Moderate	13 High	18 Extreme	22 Extreme
D - Unlikely	Could occur once during remaining lifetime	2 Low	5 Low	9 Moderate	14 High	19 Extreme
E - Rare	Unlikely to occur during remaining lifetime	1 Low	3 Low	6 Moderate	10 High	15 High

Table 36 - Risk Assessment

Step	Potential risk event / incident	Cause	Consequence	Likelihood	Current Level of Risk	Treatment Plan *(new or improved controls)*	Reasons for Selecting Treatment Plan	Responsibility	Proposed Actions	Resource Requirements	Performance Measures and Constraints	Reporting and Monitoring	Timing and Scheduling
MM1 **Void as NUMA (high wall treatment)**	Geotechnical failure Major structural slope failure causing impacts outside of predicted zone of influence (exclusion / safety fence) and impacting land use.	Safety exclusion zone insufficient Geotechnical model inadequate	3	D	9 Moderate	Obtain RPEQ signoff that design and rehabilitation treatment, including applied safety zone (fenced area), meets design intent Maintain geotechnical observation / monitoring until tenure relinquishment	Sign-off provides pathway for design intent (including consideration of slope failure) to be met	EC Department	Arrange annual (or at lower frequency as required by RPEQ) RPEQ sign-off of structural integrity rehabilitation construction	RPEQ As-constructed drawings	Full RPEQ sign-off	Maintain rehabilitation records	Annually or lower frequency as required, depending on failure consequence
RM1 **Infrastructure Decommissioning and Removal**	Infrastructure decommissioning removal not meeting standards	Not demolished to prescribed depth below ground, or waste not removed	2	C	8 Moderate	All buildings and infrastructure to be demolished to minimum of 0.5m below ground. Waste to be disposed using a legally acceptable option	Plan selected to facilitate comprehensive removal of infrastructure and appropriate waste disposal pathway	EC Department	Arrange inspection of areas once demolition has taken place to confirm treatment plan has been met	Company representative As-constructed drawings to determine extent of original construction	Sign-off by Company Representative	Maintain rehabilitation records	As required
RM2 **Infrastructure retention for handover**	Legal disagreements about whether infrastructure was to be retained or demolished	Differing interests	3	E	6 Moderate	Obtain formal legal signoff from landholder that infrastructure can be left and transferred to the landholder	Plan selected to avoid legal disputes	EC Department GCAA Legal Department	Commission and maintain a register of all legal agreements regarding infrastructure retention and transfer	Copy of legal agreement/s	Register in place and current	Maintain currency of legal register	As required
RM3 **Contaminated Land Remediation**	Contaminated area not meeting target remediation outcome	Inadequate land contamination clean up and inadequate decontamination program	4	D	14 High	Complete contaminated site investigation and signoff for all identified contaminated areas	Aim to prevent potential contamination liabilities	EC Department	Arrange inspection of areas once contaminated land clean-up has taken place to confirm treatment plan has been met	Registered QLD Contaminated Site Auditor Site remediation plan and monitoring records	Sign-off by Registered QLD Contaminated Site Auditor	Maintain Contaminated Land Register	As required
RM4 **Earthworks**	Landform not in accordance with design intent, resulting in major erosion and revegetation failure	Not constructing the landform as per design	3	D	9 Moderate	Staged approval allowing for internal approval of bulk constructed landform prior to topsoiling	Internal approval aims to have landform construction such that it is fit for purpose	EC Department Tech Services Department	Staged assessment and approval of construction activities to confirm construction is meeting the design intent	Company Representative As-constructed drawings	Sign-off by Company Representative	Maintain rehabilitation records	Annually or as required
RM4 **Earthworks**	Unsuitable material for landform / previously unknown geochemical/ materials hazard apparent	Insufficient materials characterisation PAF materials in top 5m of landform	3	D	9 Moderate	Maintain materials characterisation program during operations in accordance with the mineral waste management plan	Materials characterisation allows for separation of suitable from unsuitable materials	EC Department	Scope and arrange annual geochemistry characterisation campaign	Geochemist	Annual sampling and analysis as well as updating of geochemistry database	Maintain currency of geochemistry database Remediate any areas with unsuitable materials near surface	Annually
RM4 **Earthworks**	Not constructing the stormwater chutes as per design, resulting in increased erosion or chute failure	Not constructing the chute as per design	3	D	9 Moderate	RPEQ signoff that design intent is met	Sign-off ensures that design intent is met	EC Department	Arrange annual (or as required based on risk) inspection of rehabilitation construction	RPEQ As-constructed drawings Company representative	RPEQ initial sign-off Company representative	Maintain rehabilitation records	Initial signoff by RPEQ. Annually or at lower frequency as required, based on risk

Step	Potential risk event / incident	Cause	Consequence	Likelihood	Current Level of Risk	Treatment Plan *(new or improved controls)*	Reasons for Selecting Treatment Plan	Responsibility	Proposed Actions	Resource Requirements	Performance Measures and Constraints	Reporting and Monitoring	Timing and Scheduling
RM5 **Placement of topsoil/growth medium**	Top soil quality not suitable for vegetation establishment, revegetation failure or reduced growth	Insufficient/ incorrect amelioration applied	3	D	9 Moderate	Amelioration in accordance with laboratory testing	Laboratory testing determines amelioration required	EC Department	Scope and arrange topsoil characterisation campaign in failed areas prior to completion of the re- seeding process	Soil Scientist	Annual sampling and analysis as well as updating of database	Maintain currency of database Action any areas that indicate unsuitable amelioration has taken place	Annually
RM5 **Placement of topsoil/growth medium**	Inadequate top soil depth, resulting in revegetation failure or reduced growth not meeting the targeted PMLU	Top soil volume not available Erosion	3	D	9 Moderate	Place to thickness specification, or enhance / ameliorate spoil to achieve growth characteristics to support necessary vegetation growth	Topsoil of appropriate thickness promotes plant growth	EC Department	Arrange topsoil thickness to be confirmed prior to planting to confirm treatment plan has been met	Company representative	Topsoil thickness confirmed	Maintain rehabilitation records	As required
RM6 **Seeding**	Seed mix not meeting specification, resulting in increased erosion and inability to achieve PMLU	Incorrect seed mix, not containing minimum number of key species	3	D	9 Moderate	Seed mix to contain minimum seed specifications	Correct seed mix promotes maximum vegetative cover with appropriate species	E&C Department	Set up and undertake seed quality check process	Rehabilitation Specialist or Company representative	Percentage of visibly defect seed <95%	Report quality and conformity to specified seed mix in Supplier Register and back to supplier	Prior to each seeding campaign
RM6 **Seeding**	Required seed mix cannot be sourced, causing delay in rehabilitation schedule	Parent plants not seeding when required Parent plants cannot be accessed Seed collecting contractors not available	3	D	9 Moderate	Order seed well in advance to ensure high quality seed can be collected to accommodate rehabilitation schedule Request seed from preferred or alternative suitable species Applying additional follow-on seeding with species originally missed	Early notice and requests for preferred and alternative species seed provides seed collectors with options to ensure adequate supply on time	E&C Department	Provide seed suppliers well in advance with preferred and alternative lists of species	Rehabilitation Specialist or Company Representative	Delivery of adequate seed supplies on time	None	One year in advance of scheduled rehabilitation
RM7 **Water Management**	Flooding event resulting in entry of Gowrie Ck landform and spilling into void causing erosion of void wall during event in excess of 1000 year event or 0.1% ARI	Breach of Gowrie Creek landform, extreme high rainfall event over extended period of time	3	E	6 Moderate	RPEQ signoff that design intent is met	Sign-off provides pathway for design intent (including consideration of slope failure) has been met	E&C Department	Arrange RPEQ sign-off of construction	RPEQ As-constructed drawings	Full RPEQ sign-off	Maintain rehabilitation records	As required
RM7 **Water Management**	Surface runoff quality not meeting success / release criteria, potentially causing downstream impacts	Seepage or sediment yield impacting water quality exceedances	3	D	9 Moderate	Rehabilitation dumps to meet success criteria	Meeting success criteria appropriately manages surface run-off	EC Department Tech Services Department	Staged assessment and approval of construction activities to confirm construction of dumps meet design intent	Company representatives As-constructed drawings	Sign-off Company Representative Damage or failure of rehabilitation	Maintain rehabilitation records	Construction works are signed off once. Annual review of downstream water quality
RM7 **Water Management**	Long term stability and functioning of water management structures e.g. rock chutes/drop structures, causing erosion along flow paths	Inadequate armouring, excessive rainfall, unexpected settlement, sediment accumulation	3	D	9 Moderate	Approval by RPEQ that construction meets design intent, as required Apply maintenance and monitoring program until success criteria are met	Sign-off ensures that design intent is met Monitoring and maintenance allows for timely correction if required	E&C Department	Arrange annual (or as required based on risk) inspection of rehabilitation construction	RPEQ As-constructed drawings	RPEQ initial sign-off Company representative	Maintain rehabilitation records	Annually or as required

Step	Potential risk event / incident	Cause	Consequence	Likelihood	Current Level of Risk	Treatment Plan *(new or improved controls)*	Reasons for Selecting Treatment Plan	Responsibility	Proposed Actions	Resource Requirements	Performance Measures and Constraints	Reporting and Monitoring	Timing and Scheduling
RM8 **Encapsulation of tailings (incorporation of Megacell 2 into NWRD landform)**	Appropriate clean waste material unavailable Encapsulation ineffective, causing tailings seepage	Insufficient materials characterisation Incorrect installation of encapsulation cell	3	D	9 Moderate	Appropriate materials characterisation	Materials characterisation allows for separation of suitable from unsuitable materials. Sign-off facilitates that design intent is met	EC Department	Scope and arrange annual geochemistry characterisation campaign Arrange Appropriately Qualified Person inspection of encapsulation	Geochemist As construction drawings	Annual sampling and analysis as well as updating of geochemistry database Sign-off on encapsulation by Appropriately Qualified Person	Maintain currency of geochemistry database Action any areas that indicate unsuitable materials as near surface (<5m)	Annually or as required
RM9 **Monitoring and maintenance**	Rehabilitation maintenance and monitoring required beyond planned aftercare period (post-rehabilitation), resulting in financial outlays	Inadequate monitoring and maintenance causing inability to meet success criteria and delays with relinquishment	4	D	14 High	Maintain rehabilitation monitoring and maintenance program to achieve rehabilitation success criteria	Monitoring and maintenance allows for timely correction if required	EC Department	Scope and arrange annual rehabilitation monitoring Action all areas that require maintenance	Suitably qualified Company Representative	Rehabilitation Monitoring Scorecard	Rehabilitation Monitoring Report	Annually
RM10 **Achievement of PMLU**	Extreme rainfall event exceeding designs, causing rehabilitation failures	Climate change or natural variability	4	E	10 High	Maintain rehabilitation monitoring and maintenance program to achieve rehabilitation success criteria	Monitoring and maintenance allows for timely correction if required	EC Department	Scope and arrange annual rehabilitation monitoring Action all areas that require maintenance	Suitably qualified Company Representative	Rehabilitation Monitoring Scorecard	Rehabilitation Monitoring Report	Annually
RM10 **Achievement of PMLU**	Extended drought, causing revegetation failure, accelerated erosion, and /or wild fire	Climate change or natural variability	3	D	9 Moderate	Maintain bushfire management measures, use appropriate species mix	Plan provides for resilience of site rehabilitation in face of bushfire risk	E&C Department	Provide seed suppliers well in advance with preferred species mix for bushfire management	Suitably qualified Company Representative	Delivery of appropriate seed supplies on time	None	One year in advance of scheduled rehabilitation
RM10 **Achievement of PMLU**	Damage and competition to revegetation, resulting in revegetation not on schedule, increased erosion	Impact from stock, pests and weeds	3	E	6 Moderate	Maintain annual maintenance and monitoring program and implement maintenance as required	Apart from ongoing weed management, it is important to ensure that further weed species remain excluded or minimised from the site	E&C Department	Inspect machinery and vehicles prior to site entry	Personnel Budget	No new restricted or significant weed species on site	Annual rehabilitation Monitoring	Prior to each entry of vehicles, materials, and machinery

3.7 Monitoring and Maintenance

3.7.1 Monitoring Methodologies and Standards

Monitoring at CCO is undertaken for a range of environmental aspects, including for progressive rehabilitation, groundwater, surface water, and geotechnical aspects. Some of these are conducted separately under the EA and other regulatory requirements. This Section focuses on monitoring methods used during progressive rehabilitation monitoring at CCO (including erosion, soils, vegetation, analogue sites). Details and methods used for the other aspects can be found within the relevant sections of this PRC Plan and its Appendices:

- Groundwater – Section 3.5.1 and Appendix 4.5;
- Surface water – Section 3.5.7 and Appendix 4.6; and
- Geotechnical – Appendix 4.4.

Additional details of the progressive rehabilitation monitoring, as summarised in this Section, can be found in Appendix 4.3.

3.7.1.1 Overview and Purpose

Progressive rehabilitation monitoring at CCO is completed for the primary purpose of producing a concise and targeted rehabilitation dataset using scientifically robust and repeatable methods which demonstrate compliance with pre-determined success criteria and support relinquishment of all approvals. The outcomes of the monitoring are used to determine the performance of the rehabilitation, and to identify any areas that are at risk of failing from a stability, safety, and sustainability perspective.

CCO's rehabilitation monitoring program is summarised below.

3.7.1.2 Rehabilitation Monitoring Program

The development of the program is a scientifically robust process that supports GCAA in understanding how rehabilitation areas are progressing against proposed success criteria, and allows corrective actions to be undertaken when required.

The program was developed at CMLR in 2014 (Erskine and Fletcher 2014), and involves a combination of spatial and GIS-based planning processes, field monitoring techniques, and post-processing of field monitoring results for analysis and management decision-making.

The outcome of the annual program is the designation of one of four rehabilitation status categories to each discrete rehabilitation area, as described in ***Table 37***. CCO maintains a monitoring schedule based on the monitoring of representative transects when rehabilitation is at Year 1, Year 2, Year 5, Year 10 and five yearly thereafter until certified as complete by the regulatory agency. ***Table 38*** shows the frequency of monitoring for rehabilitation and other environmental aspects monitored at COO.

Table 37 - Rehabilitation status categories

Rehabilitation Status	Criteria
Rework	Does not meet rehabilitation success/completion criteria. Extensive rework required that would not typically form part of a rehabilitation maintenance program (e.g. slopes do not comply with approval requirements, bare areas >0.1ha, large erosion gullies).
Maintenance	Does not meet rehabilitation success/completion criteria. Routine rehabilitation maintenance works required (e.g. weed control, infill seeding/plantings, repair of minor erosion, fertiliser application).
Monitor	Progressing towards meeting relevant success criteria but does not meet all criteria. No intervention required but continue to monitor (e.g. ecologically young areas, variable results).
Acceptable	Meets all success criteria and ready for sign off by stakeholders. Continue to manage and monitor to maintain status until relinquishment is sought.

Table 38 - Details of PRC Plan Monitoring

Aspect	Operational Frequency	Post-Closure Duration
Rehabilitated surfaces	1, 2, 5, and 10 years after rehabilitation	10 years or until trends indicate no change as reported in annual reports
Reference Sites	Biannually	10 years or until trends indicate no change as reported in annual reports
Soils	1, 2, 5, and 10 years after rehabilitation	10 years or until trends indicate no change as reported in annual reports
Erosion	1, 2, 5, and 10 years after rehabilitation	10 years or until trends indicate no change as reported in annual reports
Groundwater	Bore standing water level: • Monthly at near-field bores • Quarterly at regional bores Bore pH and EC: Quarterly Bore field pH, EC, chemistry: Annual Licensed Dewatering Works: field pH, EC, chemistry: Six monthly	10 years at selected near-field and regional bores or until trends indicate no change, as reported in annual reports
Surface Water	Daily (automated water loggers for physical parameters), annually and during release events (physical and bio-chemical parameters)	10 years or until trends indicate no change, as reported in annual reports

In the event a rehabilitation area receives a "Rework" result, CCO completes a thorough investigation to establish the root cause of the poor result and identify appropriate adaptive management techniques to rectify the failure. Key issues that are considered during the investigation include, but are not limited to:

- Landform and drainage design aspects;
- Mine spoil geochemistry (propensity for acid, metalliferous and/or saline drainage);
- Growth medium physical and chemical properties;
- Suitability of rehabilitation methods used (e.g. site preparation, sowing methods and times);
- Suitability of the species mix and seed quality;
- Weed competition;
- Predation or excessive grazing by native herbivores or livestock; and
- Climatic conditions pre and post sowing, including effects of drought and frost.

Following the investigation, a rehabilitation methodology and/or design for the Rework area is developed and the proposed works are documented in the next annual plan for rehabilitation.

3.7.1.3 Annual Rehabilitation Inspection

The purpose of the annual inspection is to provide a "rapid" style assessment (via a walkover or flyover) of all existing rehabilitation areas, including recently completed areas, across CCO. The inspection aims to identify all rehabilitation failures or maintenance issues that if left unchecked could hinder rehabilitation progress or result in expensive remediation.

The inspection includes, but is not limited to, identification of:

- Erosion (rill, gully and tunnel);
- Stability and functioning of erosion and sediment control and water management structures;
- Visual assessment of vegetation cover, species diversity, vegetation health and growth rates;
- Identified contamination / nutrient deficiencies;
- Presence of weeds and pests;
- Areas of bare ground; and
- Mine rubbish and other waste (tyres, IBCs, etc.).

The annual rehabilitation inspection is completed by a suitably qualified and experienced specialist to provide independent appraisal of performance. An Aftercare and Maintenance Plan is then prepared.

3.7.1.4 Reference Sites

Reference sites have been established on and around CCO for the purpose of comparing with rehabilitated areas as per ***Figure 14***. Six reference transects have been established to monitor baseline bluegrass dominant grasslands and twelve reference transects established to monitor vegetation communities as similar as possible to those being targeted for native vegetation at CCO.

The selection of the reference sites aimed to sample a combination of (McCaffrey et al. 2015):

- The range of natural vegetation present in the CCO mining lease and surrounding areas;
- The current and planned landforms; and
- Likely soil and geological formations.

However, no reference sites are available that closely resemble CCO's batter slopes (I.e. black alluvial soils placed on slopes). Alluvial soils occur naturally in flat (alluvial) plains, unlike the batter slopes on the CCO landforms. As such, all reference sites are located on flat plains. These are still useful for comparative purposes but the targeted proportions (in comparison to the reference sites) have been reduced to reflect the expected reduced height, biomass and cover characteristics of vegetation communities on slopes (principally due to reduced water availability).

3.7.2 Schedules for Monitoring, Reporting and Review for Each Milestone

A schedule for monitoring, reporting and review for each of the milestones described in Appendix 4.1 is provided in ***Table 39***. Additional information on the treatment of contingencies is provided in the Risk Assessments in Section 3.6 of this PRC Plan.

3.7.3 Quality Assurance and Data Management

All monitoring will be undertaken by appropriately qualified personnel. Data will be collected for storage in a database. The data will be reviewed by appropriately qualified personnel and evaluated for the purpose of trending, reporting, and future reference.

3.7.4 Analysis and Interpretation

The monitoring methodology assesses the field recorded values against agreed minimum targets for safe, stable and sustainable values (critical criteria), creating a score for the rehabilitation. The normalised rehabilitation scores are then used to assess the status of the rehabilitation, using the following categories:

- Rework required (red);
- Maintenance required (yellow);
- Continue to monitor (light green); and
- Acceptable (dark green).

Appendix 4.3 provides a description of rehabilitation performance to date, based on trends in the data and benchmarking against critical values derived from reference sites.

Table 39 - Monitoring of Milestone Criteria

Criteria	Monitoring Methods	Frequency	Contingency/Maintenance	Reporting	Review
Milestone 1 Infrastructure decommissioning and removal					
Redundant services (water, electricity, gas, etc.) disconnected	Review services documentation, visual inspection	Once, upon closure	Arrange disconnection	Internally	Upon receipt of report
Asbestos and other hazardous materials to be removed	Review hazardous materials documentation, visual inspection	Once, upon closure	Arrange removal	Internally	Upon receipt of report
Redundant buildings demolished and removed	Review infrastructure documentation, visual inspection	Once, upon closure	Arrange removal	Internally	Upon receipt of report
Redundant pipelines decommissioned	Review infrastructure documentation, visual inspection	Once, upon closure	Arrange decommissioning	Internally	Upon receipt of report
Redundant fencing removed	Review infrastructure documentation, visual inspection	Once, upon closure	Arrange removal	Internally	Upon receipt of report
Redundant roads decommissioned	Review infrastructure documentation, visual inspection	Once, upon closure	Arrange decommissioning	Internally	Upon receipt of report
Redundant boreholes decommissioned	Review infrastructure documentation, visual inspection	Once, upon closure	Arrange decommissioning	Internally	Upon receipt of report

Criteria	Monitoring Methods	Frequency	Contingency/Maintenance	Reporting	Review
Milestone 2 Infrastructure retention for handover					
Transfer of ownership agreements in place where infrastructure to be retained	Review legal agreements for retention of infrastructure	Once, upon closure	Arrange transfer	Internally	Upon receipt of report
Milestone 3 Identification and remediation of contaminated land					
Preliminary site investigation (PSI) completed by an appropriately qualified person (AQP)	Review water and soil quality assessments and monitoring to identify contamination	Once, upon closure	Arrange PSI	Internally	Upon receipt of report
If required, detailed site investigation (DSI) completed by an AQP	Review PSI report	Upon receipt of PSI report	Arrange DSI	Internally	Upon receipt of report
If required, remediation or management of identified contaminated land	Review DSI report	Upon receipt of DSI report	Arrange remediation or management	Internally	Upon receipt of report
Auditor signoff as per Environmental Protection Act (EP Act) 1994 (Qld), to confirm all contaminated materials have been remediated, or removed and disposed of	Review Site Validation Report	Upon receipt of Site Validation Report	Arrange continued remediation if required	Internally	Upon receipt of report
Removal of land from Contaminated Land Register	Review Contaminated Land Register	Upon receipt of Site Validation Report showing full remediation	Arrange deregistration	Internally	Upon receipt of report
Removal of land from Environmental Management Land Register if feasible	Review Environmental Management Land Register	Upon receipt of Site Validation Report showing full remediation	Arrange deregistration	Internally	Upon receipt of report

Criteria	Monitoring Methods	Frequency	Contingency/Maintenance	Reporting	Review
Milestone 4 Bulk earthworks and general reshaping					
Construction of landforms completed to achieve design intent as described in the site's Rehabilitation Management Plan (RMP), created under the Environmental Authority (EA) (including encapsulation of hazardous material completed as per site's Mineral Waste Management Plan (MWMP), and slopes verified through survey by an AQP)	Review AQP report, LiDAR, Annual Rehabilitation Monitoring Reports	Upon receipt of AQP report, and annually for ongoing monitoring	Re-shape landform to design specifications prior to topsoiling	Internally	Upon completion of re-shaping
Erosion and sediment controls established	Visual inspection	Upon completion of establishment	Remediate (establish or re-establish controls)	Internally	Upon completion of remediation
Drainage features established	Visual inspection	Upon completion of establishment	Remediate (establish or re-establish drainage features)	Internally	Upon completion of remediation
Milestone 5 Placement of topsoil/growth medium					
Topsoil inventory completed	Review inventory	Annually	Arrange completion	Internally	Annually, upon completed inventory
Landform trim completed	Visual inspection	Upon completion of trim	Remediate (complete trim or re-trim)	Internally	Upon trim completion
Topsoil/ growth medium placed following the procedure outlined in the site's RMP	Visual inspection	Upon completion of placement	Re-place or place topsoil to specifications	Internally	Upon re-placement
Soil ameliorants and fertilisers applied as required to address soil limitations	Review soil laboratory documentation, rehabilitation records	Upon completion of amelioration, annually for ongoing monitoring	Re-ameliorate or ameliorate	Internally	Upon completion of re-amelioration

Criteria	Monitoring Methods	Frequency	Contingency/Maintenance	Reporting	Review
Milestone 6 Seeding					
Seeding sown at appropriate rates to align with PMLU: (i) Woodland and light grazing - seed mix containing at least two native Eucalypt/ Corymbia spp., two native Acacia spp., two native grass spp. and one legume sp.	Review seed mix specification, rehabilitation records, annual rehabilitation monitoring	Upon completion of seeding, and annually for ongoing monitoring	Re-seed or seed according to specifications	Internally	Upon completion of re-seeding
(ii) Water management area - seed mix containing native tree and shrub spp.	Review seed mix specification, rehabilitation records, annual rehabilitation monitoring	Upon completion of seeding, and annually for ongoing monitoring	Re-seed or seed according to specifications	Internally	Upon completion of re-seeding
Milestone 7 Water management in the final landform					
Construction of drainage features on landforms finalised	Visual inspection	Upon completion of establishment	Remediate (establish or re-establish drainage features)	Internally	Upon completion of remediation
Regulated structures decommissioned, or left in-situ for use by the landholder provided the structure: (i) no longer contains contaminants that will migrate into the environment; and (ii) it contains water of a quality that is demonstrated to be suitable for its intended use(s); and	Visual inspection, water and sediment monitoring records	Prior to decommissioning (water and sediment quality), upon completion of decommissioning (structures)	Update procedures and personnel training, arrange remediation of contaminated sediment, arrange decommissioning	Internally	Upon completion of sediment remediation
Regulated structures decommissioned, or left in-situ for use by the landholder provided the environmental authority holder and the landholder agree in writing that the: (i) dam will be used by the landholder following the cessation of the environmentally relevant activity; and	Review legal agreements, visual inspection	Prior to decommissioning	Arrange agreements or arrange decommissioning	Internally	Upon completion of agreement or decommissioning

Criteria	Monitoring Methods	Frequency	Contingency/Maintenance	Reporting	Review
(ii) the landholder is responsible for the dam, on and from an agreed date.					
Milestone 8 Encapsulation of tailings					
Geotechnical analysis completed by an AQP	Review AQP report	Upon completion of AQP report	Encapsulation design to be based on geotechnical analysis results	-	-
Design review of encapsulation concept completed by an AQP	Review AQP design	Upon completion of AQP design	Re-design encapsulation cell	Internally	Upon completion of re-design
Construction of encapsulation completed as per design intent	Visual inspection	Upon completion of construction	Review design, re-construct encapsulation cell	Internally	Upon design review, re-construction
Shaping of final landform completed	Visual inspection	Upon completion of shaping	Review design, re-shape landform	Internally	Upon design review, re-shaping
Milestone 9 Monitoring and verification of encapsulation and rehabilitation of final landform					
Seepage assessment completed	Visual inspection, seepage quality monitoring and analysis	Upon completion of assessment	Review encapsulation design and remediate	Internally	Upon completion of remediation
Rehabilitation monitoring completed, including remediation as required (aftercare and maintenance)	Annual rehabilitation monitoring	Annually	Remediation as required	Internally	Annually and upon completion of remediation
Surface water monitoring completed as per Receiving Environment Monitoring Program (REMP) and Surface Water Monitoring Procedure	Automated loggers (physical parameters), sampling and laboratory analysis (physical and bio-chemical parameters)	Daily with automated loggers, annually, and during release events	Update procedures and personnel training, arrange remediation	Internally	Annually and upon completion of remediation

Criteria	Monitoring Methods	Frequency	Contingency/Maintenance	Reporting	Review
Milestone 10 Achievement of PMLU to a safe, stable, non-polluting and self-sustaining condition					
Monitoring and maintenance program implemented as per GCAA Success/Completion Criteria and Rehabilitation Monitoring Procedure (the Procedure) with results meeting the success criteria outlined in the RMP	GCAA Success/Completion Criteria and Rehabilitation Monitoring Procedure	Annually	Arrange corrective actions, as required	Internally	Annually
Certification from an AQP that the area has achieved stable condition	Review AQP certification	Upon receipt of certification	Arrange corrective actions, as required	Internally	Upon completion of corrective actions
RPEQ geotechnical assessment completed for diversion (Water Management Area)	Review of RPEQ assessment	Upon receipt of assessment	Arrange remediation	Internally	Upon completion of remediation
Groundwater modelling completed by an AQP to ensure non-polluting to surrounding environment and understand steady state groundwater level rebound	Review AQP modelling	Upon receipt of modelling	Review water management arrangements and initiate remedial actions	Internally	Upon completion of remedial actions
Certification from an AQP that the groundwater quality will not overtop and spill into the environment and will not seep into and impact used aquifers	Review AQP certification	Upon receipt of certification	Arrange corrective actions, as required	Internally	Upon completion of corrective actions
Certification from an AQP that surface water quality will not cause environmental harm to the surrounding environment, using release contaminant trigger investigation levels outlined in the EA	Review AQP certification	Upon receipt of certification	Arrange corrective actions, as required	Internally	Upon completion of corrective actions
Improvement Area Milestone 1 Highwall Treatment					
RPEQ geotechnical assessment completed	Review of RPEQ assessment	Upon receipt of assessment	Arrange remediation	Internally	Upon completion of remediation
Upper weathered batter(s) of West Wall battered back to 1v:3h	Visual inspection, LiDAR	Upon completion of final West Wall	Re-batter	Internally	Upon completion of re-batter

Criteria	Monitoring Methods	Frequency	Contingency/Maintenance	Reporting	Review
Geotechnical controls must be installed as specified in the Geotechnical Assessment	Visual inspection	Upon completion of control	Re-assess and install control	Internally	Upon completion of control re-assessment
Remnant coal bench to be removed as part of mining (even if margin ranking is unfavourable)	Visual inspection	Upon removal of remnant coal bench	-	Internally	Upon completion of removal
Slope profile above 206mRL haulroad level on East Wall to be benched or flitch-benched softwalled to an inter-ramp angle of 33 degrees	Visual inspection, LiDAR	Upon completion of slope profile	Review profile design, re-profile	Internally	Upon completion of re-profile
Improvement Area Milestone 2 Achievement of surface requirements					
Signage – Warning signage around the final void rim will be placed to warn of the void related risks and deter public access	Visual inspection	Annually	Re-install fencing	Internally	Annually, and upon re-installation
An abandonment bund will be constructed around the final void rim, with the setback distance from the pit edge to be determined via the geotechnical assessment	Visual inspection	Annually	Re-construct	Internally	Annually, and upon re-construction
Safe egress via low wall	Visual inspection	Annually	Re-construct	Internally	Annually, and upon re-construction
Improvement Area Milestone 3 Achievement of sufficient improvement					
RPEQ geotechnical assessment to certify that the residual void is geotechnically stable	Review of RPEQ assessment	Upon receipt of assessment	Arrange remediation	Internally	Upon completion of remediation
Certification from an AQP that the residual void is safe to humans and livestock.	Review AQP certification	Upon receipt of certification	Install additional safety features	Internally	Upon installation of additional safety features

Criteria	Monitoring Methods	Frequency	Contingency/Maintenance	Reporting	Review
Groundwater and void pit lake modelling completed by an AQP to ensure non-polluting to surrounding environment	Review AQP modelling	Upon receipt of modelling	Review water management arrangements and initiate remedial actions	Internally	Upon completion of remedial actions
Certification from an AQP that the water level and quality in the void will not cause environmental harm to the surrounding environment	Review AQP certification	Upon receipt of certification	Review water management arrangements and initiate remedial actions	Internally	Upon completion of remedial actions

3.7.5 Reporting and Review

Within CCO's rehabilitation monitoring process there are three deliverables to be provided annually:

- The annual monitoring program results report;
- The annual Aftercare and Maintenance plan; and
- The annual rehabilitation implementation self- assessment forms.

These reports are prepared at the conclusion of each annual monitoring event. The purpose of the annual reports is to present an annual update of the rehabilitation progress towards the achievement of PMLU criteria. The results of each additional year of monitoring are compared to those of previous years by showing the trends towards the achievement of the safe, stable, non-polluting and self-sustaining PMLU criteria, and recommendations are provided to improve and further support the continued progression of the rehabilitation.

The reports may also describe corrective actions/contingency strategies, should these require implementation. These may include one or more of the following:

- Application of additional soil amelioration;
- Reshaping and stabilisation of erosion features;
- Reseeding and/or replanting;
- Review the seed mix, including species, supplier, viability, application method; and
- Weed and pest management.

The reports are reviewed by CCO, for implementation of contingency strategies, as appropriate.

3.8 Document Information

3.8.1 References

References used in the preparation of this document are listed below.

Reference	Title
Ausecology (2014)	Northern Quoll Detection Survey Report Clermont Open Cut, Clermont Queensland
BOM - Bureau of Meteorology (2011)	Flood summary for the Nogoa River at Emerald. Website: http://www.bom.gov.au/qld/flood/fld_reports/emerald_fact_sheet_2011.pdf. Accessed: 18/02/2021.
CCO - Clermont Coal Operation (2018)	Plan of Operations 2018-2020.
CCO - Clermont Coal Operation (2020)	Rehabilitation Management Plan
DES – Department of Environment and Science (2018)	Spatial Information Submission Guideline (ESR/2018/4337)
DES – Department of Environment and Science (2019)	Submission of a PRC Plan: Application Form (ESR/2019/4957)
DES – Department of Environment and Science (2021)	Progressive Rehabilitation and Closure Plans (PRC Plans) Guideline (ESR/2019/4964) – Version 2.00
E.F.Dunne (1950)	Brief History Of The Coal Mining Industry In Queensland. Published lecture at The Historical Society of Queensland, Inc., on 23rd November 1950.
Erskine PD and Fletcher AT (2014)	Rehabilitation monitoring manual for Glencore Coal operations, Queensland. Report by Centre for Mined Land Rehabilitation, The University of Queensland.
Erskine PD and Fletcher AT. (2015)	Rational assessment of Glencore Coal Australia's Queensland mines rehabilitation. Report by Centre for Mined Land Rehabilitation, The University of Queensland.
FRC (2020)	Clermont Coal Operations – Receiving Environment Monitoring Prgram 2020
Glencore (2020)	Resources and Reserves as at 31 December 2020
Highlands Environmental (2020)	Clermont mine: Blair Athol rehabilitation assessment and recommendations DRAFT report
Hollingsworth (1983)	Wolfang Mine (MLA 1874 and MLA 1980) Final Impact Assessment Study, Hollingsworth Consultants, Brisbane
Isbell (1996)	The Australian Soil Classification, CSIRO Publishing. Collingwood Victoria.

Reference	Title
KBR (2014)	Clermont Open Cut Final Void Assessment. Document number BEN462-TD-EV-REP-0001 Rev. C.
KBR (2019)	Clermont Coal Operations – Cement Hill Closure: Initial Data Collection
KBR (2020b)	Cement Hill Rehabilitation Final Landform Detailed Design- Design Basis Report (BEN951-010-TD-WR-DBA-0001 Rev. A)
KBR. (2020a)	Clermont Life of Mine (LOM) Concept Design Report (BEN951-001-TD-EV-REP-0001 Rev. A)
McDonald et al. (1998)	Australian Soil and Land Survey Handbook, Second Edition, Inkata Press, Melbourne.
NEPC - National Environment Protection Council (2013)	Schedule B1: Guideline on Investigation Levels for Soil and Groundwater
NSW Resources Regulator (2021)	Rehabilitation Risk Assessment
Prebble, S and A.Self (2000)	Spontaneous Combustion in Abandoned Coal Collieries at the Blair Athol Open Cut Mine/Development of an Explosibility Trending System, Blair Athol Coal, in Proc. Queensland Mining Industry Health and Safety Conference, Townsville, 269-280.
Queensland Government (2017)	Interpreting data: Map scales and site density. Retrieved from: https://www.qld.gov.au/environment/land/management/soil/soil-data/interpreting
Queensland Government (2019)	Climate Change in the Whitsunday, Hinterland and Mackay region. Version 1. Website: https://www.qld.gov.au/__data/assets/pdf_file/0026/68561/mackay-whitsunday-climate-change-impact-summary.pdf. Accessed: 18/02/2021.
Queensland Times (1873)	Peak Downs. Newspaper article published 11 March 1973
RTCA - Rio Tinto Coal Australia (2004)	Clermont Coal Mine Project - Environmental Impact Statement.
RTCA - Rio Tinto Coal Australia (2005)	Clermont Coal Mine Project - Supplementary Report
RTCA - Rio Tinto Coal Australia (2010)	Clermont Mine - Environmental Management Plan
SLR Consulting (2019)	Conceptual Mine Closure Plan
SLR Consulting (2019)	Clermont Open Cut Conceptual Mine Closure Plan
Wall Planning and Environmental Consulting (2020)	Clermont coal Mine – Social Impact Assessment (Mine Closure Planning)

Reference	Title
Blair Athol Coal (BAC) (1976)	BAC Environmental Impact Study for an expanded mining operation. Volumes 1 and 2

3.8.2 Spatial Information

The following spatial information has been prepared and submitted with this PRC Plan in accordance with the guideline 'Spatial Information Submission' (ESR/2018/4337):

- 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 a 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 PRC Plan 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" (DES 2018).

4. Appendices and Attachments

4.1 PRC Plan Schedule

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Appendix 4.1 – PRCP Schedule

Clermont Coal Operations

Site Design - Clermont Mine

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Legend

- Mining Lease Boundary
- Maximum Disturbance Footprint
- Flood Extent
- Grazing & Cropping
- Residual Void - NUMA
- Nature Conservation
- Retained Infrastructure
- Water Management
- Woodland
- Woodland & Light Grazing

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Clermont Coal Operations

Site Design - Train Loadout

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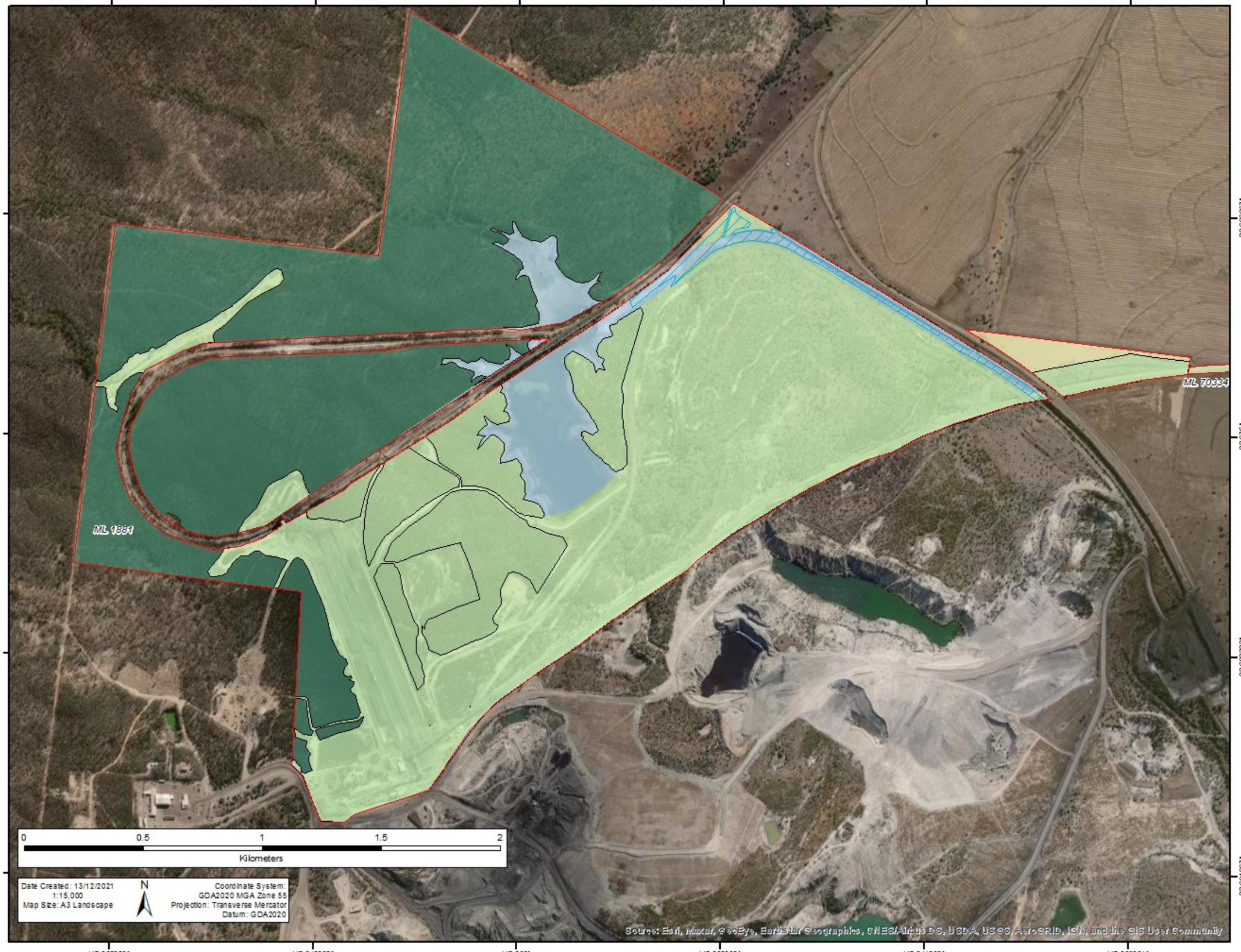

Legend

- Mining Lease Boundary
- Maximum Disturbance Footprint
- Flood Extent
- Grazing & Cropping
- Water Management
- Woodland
- Woodland & Light Grazing

Date Created: 13/12/2021
1:15,000
Map Size: A3 Landscape

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Coordinate System:
GDA2020 MGA Zone 55
Projection: Transverse Mercator
Datum: GDA2020

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-22675°
-22683333°
-22691667°

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Clermont Coal Operations

Site Design - Clermont Hill

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Legend

- Maximum Disturbance Footprint
- Mining Lease Boundary
- Flood Extentt
- Water Management
- Woodland & Light Grazing

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PRCP Schedule - Tab 1 Rehabilitation Area Milestones

Milestone reference	Rehabilitation milestone	Milestone criteria
RM1	Infrastructure decommissioning and removal	a) Redundant services (water, electricity, gas, etc.) disconnected b) Asbestos and other hazardous materials to be removed c) Redundant buildings demolished and removed d) Redundant pipelines decommissioned e) Redundant fencing removed f) Redundant roads decommissioned g) Redundant boreholes decommissioned
RM2	Infrastructure retention for handover	a) Transfer of ownership agreements in place where infrastructure to be retained
RM3	Identification and remediation of contaminated land	a) Preliminary site investigation (PSI) completed by an appropriately qualified person (AQP) b) If required, detailed site investigation (DSI) completed by an AQP c) If required, remediation or management of identified contaminated land d) Auditor signoff as per Environmental Protection Act (EP Act) 1994 (Qld), to confirm all contaminated materials have been remediated, or removed and disposed of. e) Removal of land from Contaminated Land Register f) Removal of land from Environmental Management Land Register if feasible
RM4	Bulk earthworks and general reshaping	a) Construction of landforms completed to achieve design intent as described in the site's Rehabilitation Management Plan (RMP), created under the Environmental Authority (EA) (including encapsulation of hazardous material completed as per site's Mineral Waste Management Plan (MWMP), and slopes verified through survey by an AQP) b) Erosion and sedimont controls established c) Drainage features established
RM5	Placement of topsoil/growth medium	a) Topsoil inventory completed b) Landform trim completed c) Topsoil/ growth medium placed following the procedure outlined in the site's RMP d) Soil ameliorants and fertilisers applied as required to address soil limitations
RM6	Seeding	a) Seeding sown at appropriate rates to align with PMLU: (i) Woodland and light grazing - seed mix containing at least two native Eucalypt/ Corymbia spp., two native Acacia spp., two native grass spp. and one legume sp. (ii) Water management area - seed mix containing native tree and shrub spp.
RM7	Water management in the final landform	a) Construction of drainage features on landforms finalised b) Regulated structures decommissioned, or left in-situ for use by the landholder provided the structure: (i) no longer contains contaminants that will migrate into the environment; and (ii) it contains water of a quality that is demonstrated to be suitable for its intended use(s); and the environmental authority holder and the landholder agree in writing that the: (i) dam will be used by the landholder following the cessation of the environmentally relevant activity; and (ii) the landholder is responsible for the dam, on and from an agreed date.
RM8	Encapsulation of tailings	a) Geotechical analysis completed by an AQP b) Design review of encapsulation concept completed by an AQP c) Construction of encapsulation completed as per design intent d) Shaping of final landform completed
RM9	Monitoring and verification of rehabilitation in final landform	b) Seepage assessment completed c) Rehabilitation monitoring completed, including remediation as required (aftercare and maintenance) d) Surface water monitoring completed
RM10	Achievement of PMLU to a safe, stable, non-polluting and self-sustaining condition	a) Monitoring and maintenace program implemented as per the Manual and GCAA Completion Criteria and Rehabilitation Monitoring Procedure (the Procedure) with results meeting the completion criteria outlined in the RMP b) Certification from an AQP that the area has achieved stable condition c) RPEQ geotechnical assessment completed for diversion (Water Management Area) d) Groundwater modelling completed by an AQP to ensure non-polluting to surrounding environment and understand steady state groundwater level rebound e) Certification from an AQP that the groundwater quality will not cause environmental harm to the surrounding environment f) Certification from an AQP that surface water quality will not cause environmental harm to the surrounding environment, using release contaminant trigger investigation levels outlined in the EA

1) Insert new rows below the table to record more Rehabilitation Area Milestones for the project
2) Ensure all Rehabiitation Milestones recorded in this table align with those included in the RA sheets in this form.
3) See the PRCP guideline before developing site-specific Rehabilitation Area Milestones

There's a SMART way to write management goals and objectives, and the criteria should reflect how the goals/ objectives are SMART. Importantly, it should be understood that not every objective writtten will

Specific	*What are you trying to do and why? Target a specific area for improvement*
Measurable	*How will you measure what you are doing? Quantify (or at least suggest) an indicator of progress*
Attainable	*With the tools/ resources you have can you reach the goal/ objective? Specify who will do it*
Realistic	*Can you actually meet the goals you are setting forth? State what results can be realistically achieved given available resources*
Timely	*What is the timeline to meet your goals. Specify when the result can be achieved*
Evaluated	*Appraisal of a goal to assess the extent to which it has been achieved*
Reviewed	*Reflection and adjustment of your approach or behaviour to reach a goal*

The last two items have been included in later years, and are addressed through the development and implementation of a monitoring and maintenance program for the Schedule

Clermont Coal Operations

Rehabilitation Area 1

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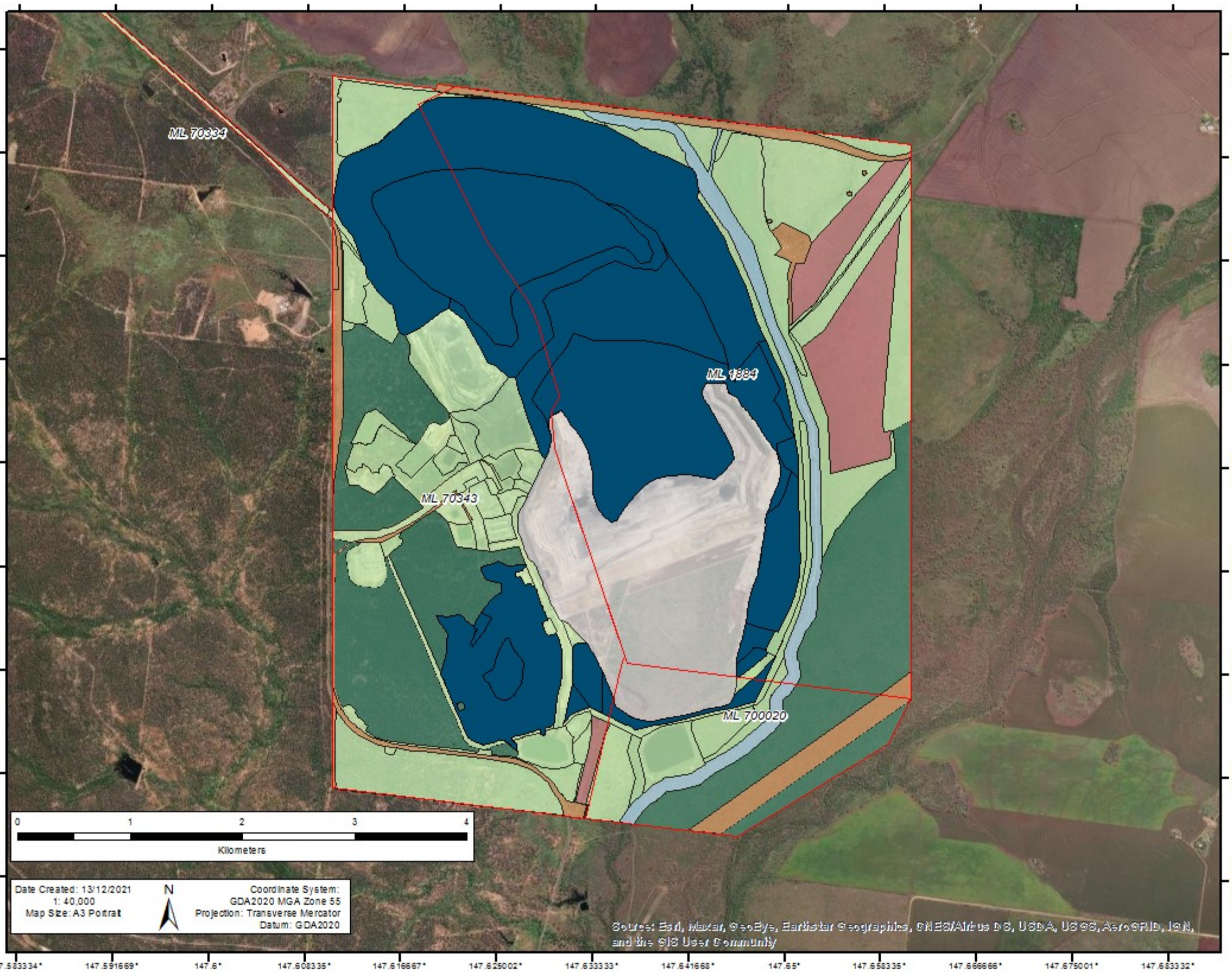

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Legend

- Mining Lease Boundary
- RA1
- Grazing & Cropping
- Residual Void - NUMA
- Nature Conservation
- Retained Infrastructure
- Water Management
- Woodland
- Woodland & Light Grazing

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Post-mining land uses (PMLU)

Rehabilitation area	RA1 - WRD This including all NWRD (360 dump areas) and southern face of NWRD, as well as SWRD and SEWRD. Also includes all WRD and tailings area requiring earthworks/rehabilitation at CH.
Relevant activities	Rehabilitation of out-of-pit waste rock dump areas.
Total rehabilitation area size (ha)	1094.53 (504.81 ha of existing rehabilitation)
Commencement of first milestone: RM4	31/12/2022
PMLU	Woodland and Light Grazing

Date area is available	31/12/21	31/12/22	31/12/23	31/12/24	31/12/25	31/12/26	31/12/27	31/12/28	31/12/29	31/12/30	31/12/31	31/12/32					
Cumulative area available (ha)	580.99	580.99	580.99	630.99	680.99	770.99	770.99	770.99	870.99	1035.99	1035.99	1094.53					
Milestone completed by	31/12/22	31/12/23	31/12/24	31/12/25	31/12/26	31/12/27	31/12/28	31/12/29	31/12/30	31/12/31	31/12/32	31/12/33	31/12/34	31/12/35	31/12/43		

Milestone Reference	**Cumulative area achieved (ha)**																
RM4	580.99	580.99	580.99	630.99	680.99	770.99	770.99	770.99	870.99	1035.99	1035.99	1094.53					
RM5	530.99	580.99	580.99	580.99	630.99	680.99	770.99	770.99	770.99	870.99	1035.99	1035.99	1094.53				
RM6	530.99	580.99	580.99	580.99	630.99	680.99	770.99	770.99	770.99	870.99	1035.99	1035.99	1094.53				
RM7	530.99	580.99	580.99	580.99	630.99	680.99	770.99	770.99	770.99	870.99	1035.99	1035.99	1094.53				
RM9	504.81	530.99	580.99	580.99	580.99	630.99	680.99	770.99	770.99	770.99	870.99	1035.99	1035.99	1094.53			
RM10															1094.53		

1) Insert new columns to the <u>yellow table</u> to include further rehabilitation milestone dates.
2) Insert new columns to the <u>blue table</u> to match rehabilitation milestone dates.
3) Insert new rows to the <u>blue table</u> to include additional rehabilitation milestone references.
4) Insert the relevant number in the "Milestone reference" column (i.e. RM1).

Clermont Coal Operations

Rehabilitation Area 2

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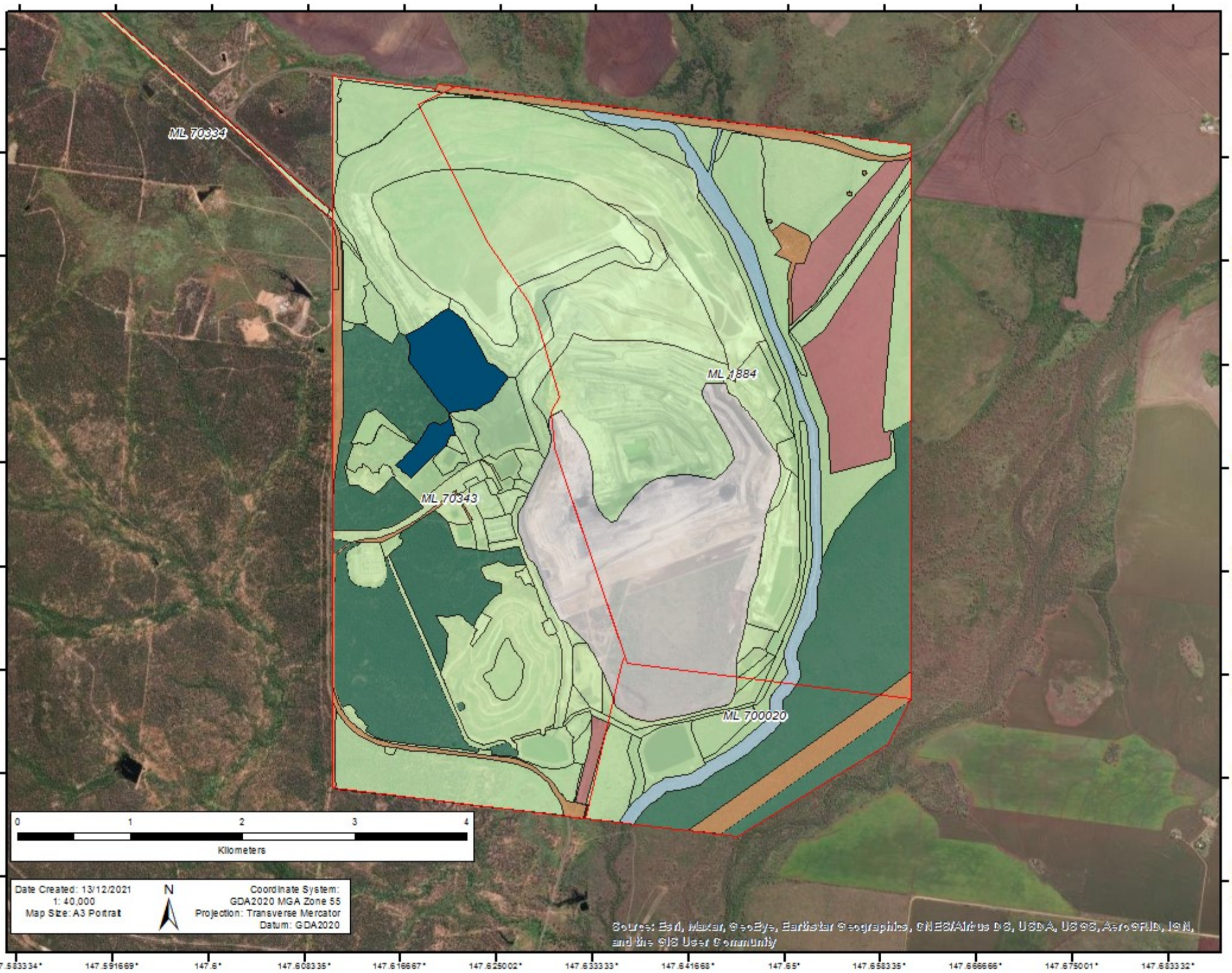

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Legend

- Mining Lease Boundary
- RA2
- Grazing & Cropping
- Residual Void - NUMA
- Nature Conservation
- Retained Infrastructure
- Water Management
- Woodland
- Woodland & Light Grazing

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Post-mining land uses (PMLU)										
Rehabilitation area				RA2 - CM Tailings						
Relevant activities				Rehabilitation of tailings areas including Megacell area and Settling Cells at CM						
Total rehabilitation area size (ha)				60.77						
Commencement of first milestone: RM3				31/12/2027						
PMLU				Woodland & Light Grazing						
Date area is available	31/12/27									
Cumulative area available (ha)	60.77									
Milestone completed by	31/12/28	31/12/29	31/12/43							
Milestone Reference	**Cumulative area achieved (ha)**									
RM8	60.77									
RM4	60.77									
RM5	60.77									
RM6	60.77									
RM8	60.77									
RM9		60.77								
RM10			60.77							

1) Insert new columns to the <u>yellow table</u> to include further rehabilitation milestone dates.
2) Insert new columns to the <u>blue table</u> to match rehabilitation milestone dates.
3) Insert new rows to the <u>blue table</u> to include additional rehabilitation milestone references.
4) Insert the relevant number in the "Milestone reference" column (i.e. RM1).

Clermont Coal Operations

Rehabilitation Area 3

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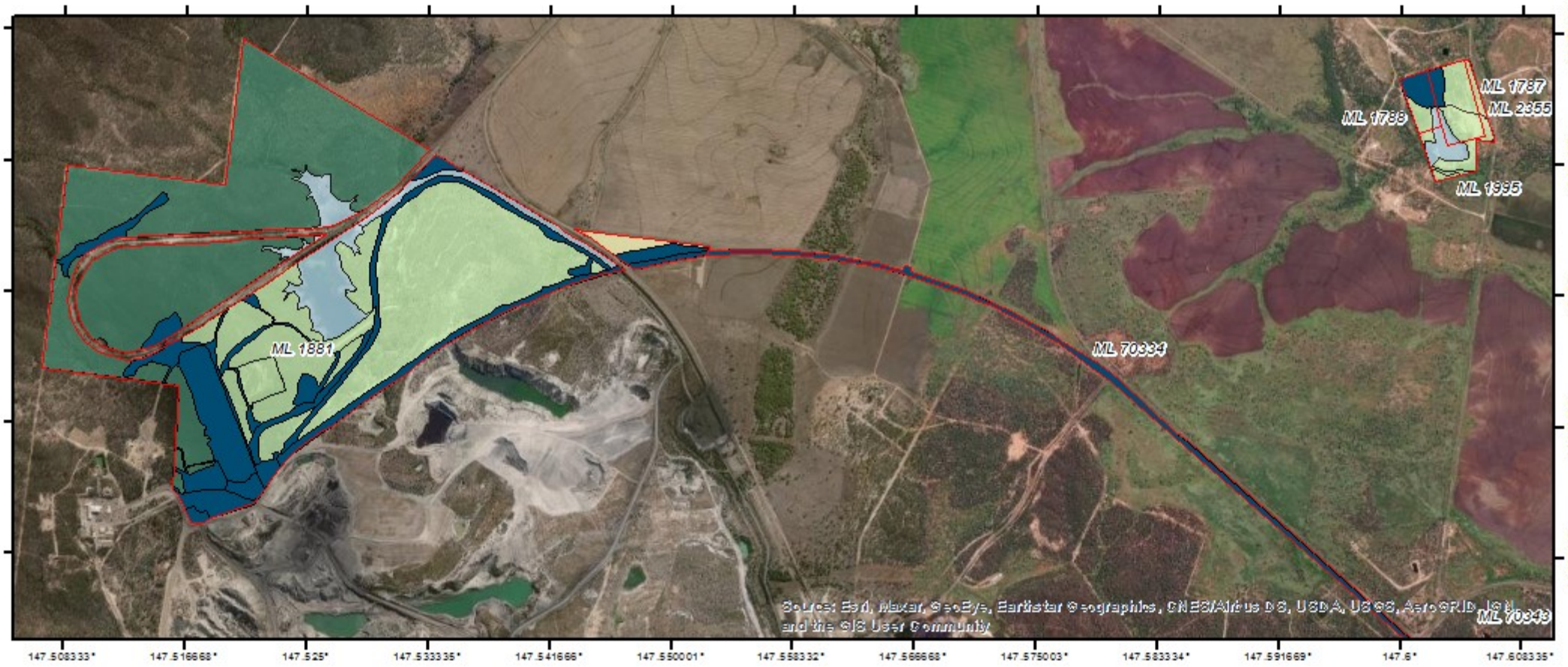

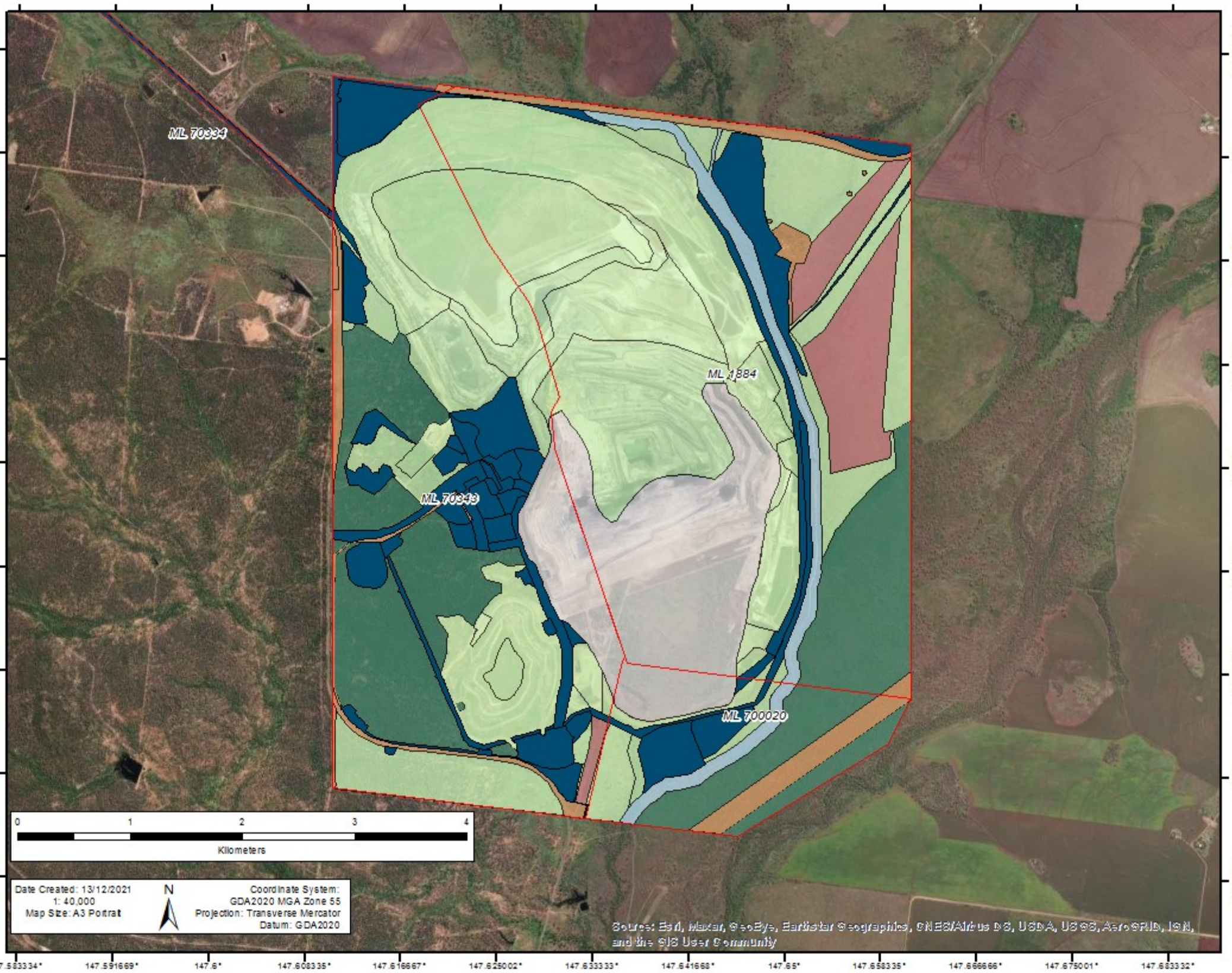

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Legend

- Mining Lease Boundary
- RA3
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- Residual Void - NUMA
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Post-mining land uses (PMLU)											
Rehabilitation area	RA3 - Infrastructure to be removed										
Relevant activities	All Infrastructure Removed										
Total rehabilitation area size (ha)	542.71 (32.15 ha of existing rehabilitation)										
Commencement of first milestone: RM1	46752										
PMLU	Woodland & Light Grazing										
Date area is available	31/12/21	31/12/22	31/12/23	31/12/24	31/12/30	31/12/31	31/12/32	31/12/33			
Cumulative area available (ha)	38.69	38.69	88.69	88.69	123.69	251.17	391.17	542.71			
Milestone completed by	31/12/22	31/12/23	31/12/24	31/12/25	31/12/31	31/12/32	31/12/33	31/12/34	31/12/35	31/12/36	31/12/1943
Milestone Reference	**Cumulative area achieved (ha)**										
RM1	38.69	38.69	88.69	88.69	123.69	251.17	391.17	542.71			
RM3	38.69	38.69	88.69	88.69	123.69	123.69	251.17	391.17	542.71		
RM4	38.69	38.69	88.69	88.69	88.69	123.69	251.17	391.17	542.71		
RM5	38.69	38.69	88.69	88.69	88.69	123.69	251.17	391.17	542.71		
RM6	38.69	38.69	88.69	88.69	88.69	123.69	251.17	391.17	542.71		
RM9	32.15	38.69	38.69	88.69	88.69	88.69	123.69	251.17	391.17	542.71	
RM10											542.71

1) Insert new columns to the <u>yellow table</u> to include further rehabilitation milestone dates.
2) Insert new columns to the <u>blue table</u> to match rehabilitation milestone dates.
3) Insert new rows to the <u>blue table</u> to include additional rehabilitation milestone references.
4) Insert the relevant number in the "Milestone reference" column (i.e. RM1).

Clermont Coal Operations

Rehabilitation Area 4

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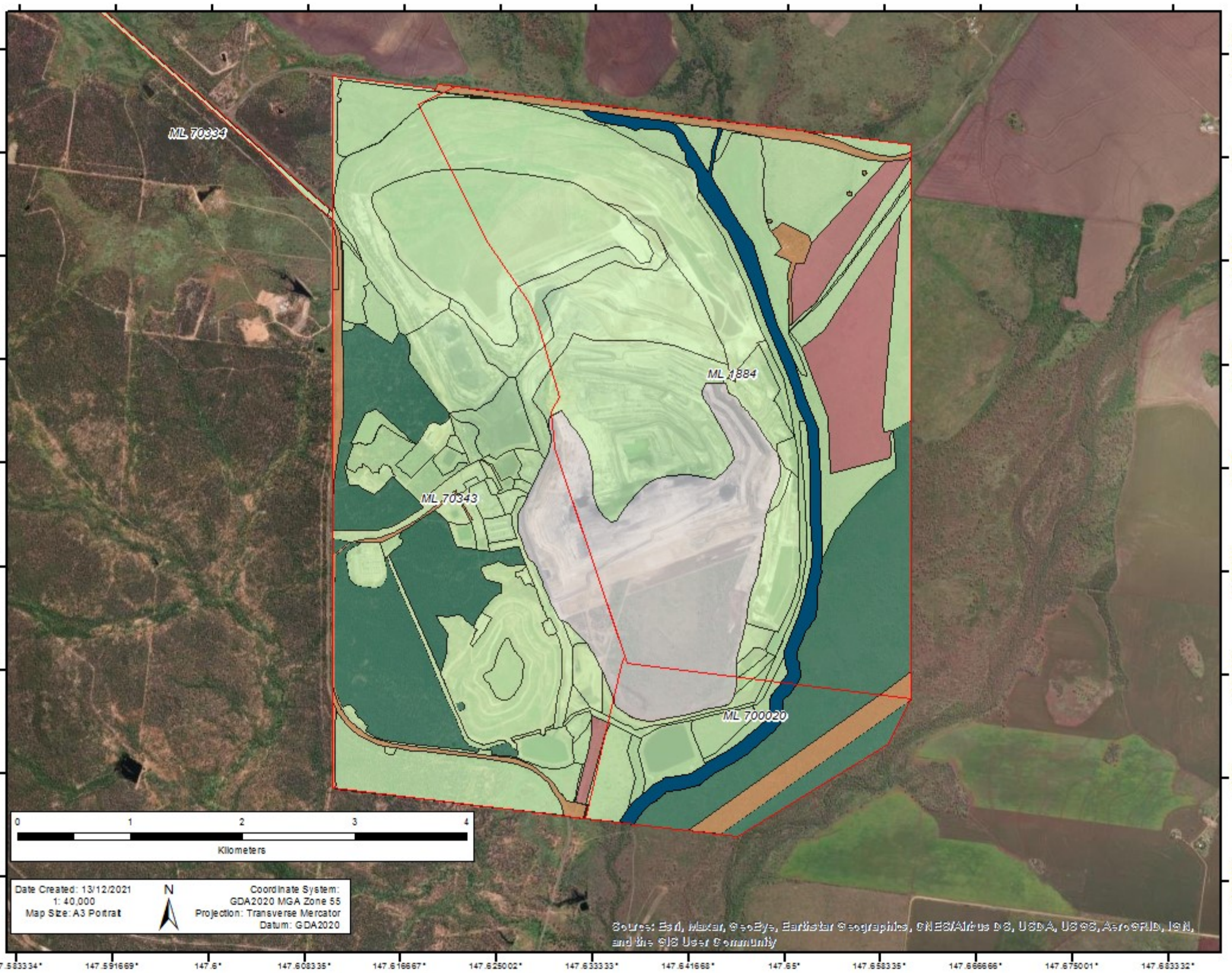

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Legend

- Mining Lease Boundary
- RA4
- Grazing & Cropping
- Residual Void - NUMA
- Nature Conservation
- Retained Infrastructure
- Water Management
- Woodland
- Woodland & Light Grazing

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Post-mining land uses (PMLU)										
Rehabilitation area				RA4 - Water Management Areas						
Relevant activities				Gowrie Creek diversion, Residual Void @ Cement Hill, West Dam @ TLO						
Total rehabilitation area size (ha)				143.66						
Commencement of first milestone: RM1				31/12/2022						
PMLU				Water Management						
Date area is available	31/12/21	31/12/24	31/12/32							
Cumulative area available (ha)	7.28	102.02	143.66							
Milestone completed by	31/12/24	31/12/25	31/12/33	31/12/43						
Milestone Reference	**Cumulative area achieved (ha)**									
RM1	7.28	102.02	143.66							
RM4	7.28	102.02	143.66							
RM5	7.28	102.02	143.66							
RM6	7.28	102.02	143.66							
RM10				143.66						
RM11				143.66						

1) Insert new columns to the yellow table to include further rehabilitation milestone dates.
2) Insert new columns to the blue table to match rehabilitation milestone dates.
3) Insert new rows to the blue table to include additional rehabilitation milestone references.
4) Insert the relevant number in the "Milestone reference" column (i.e. RM1).

Clermont Coal Operations

Rehabilitation Area 5

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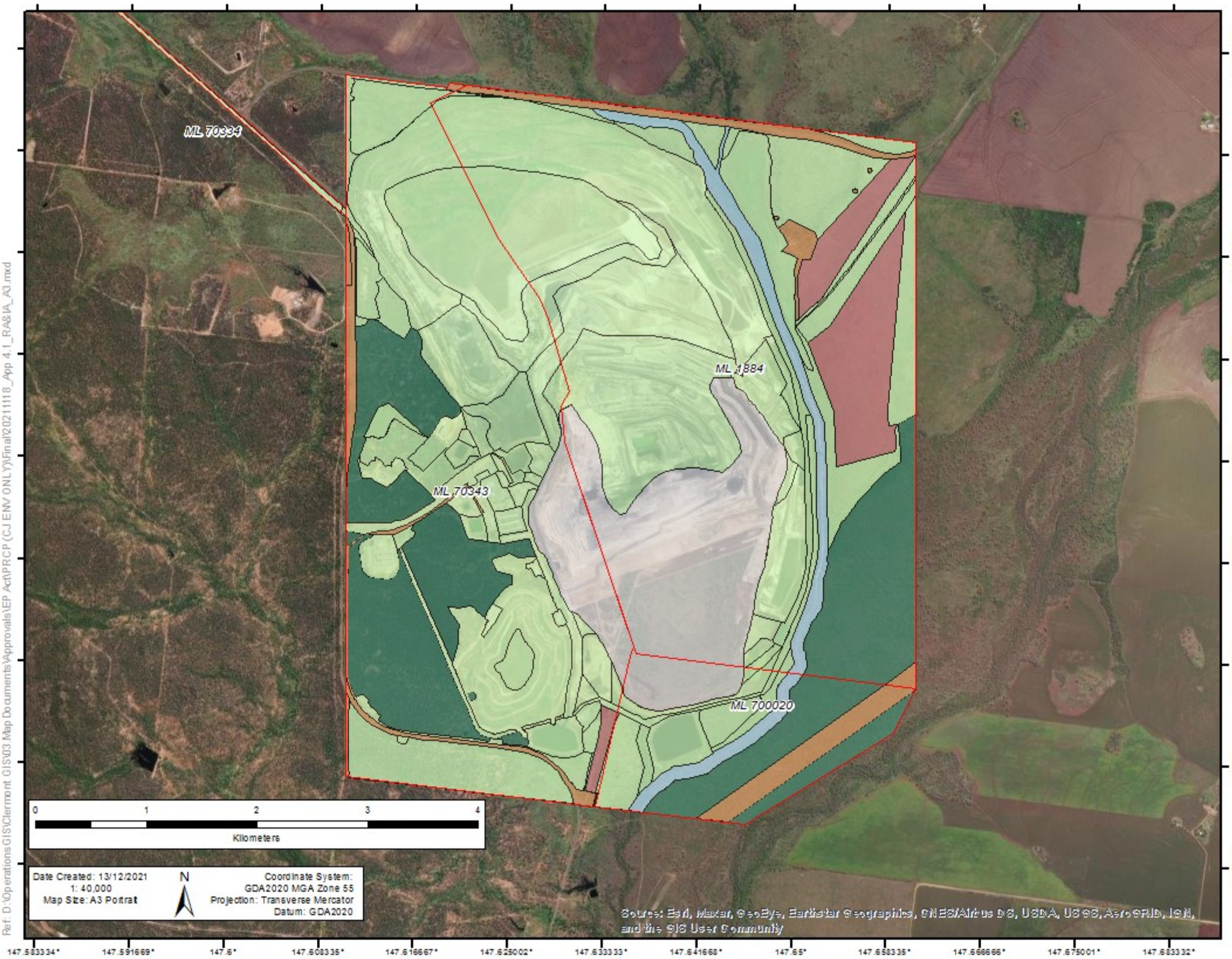

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Legend

- Mining Lease Boundary
- RA5
- Grazing & Cropping
- Residual Void - NUMA
- Nature Conservation
- Retained Infrastructure
- Water Management
- Woodland
- Woodland & Light Grazing

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Post-mining land uses (PMLU)										
Rehabilitation area	RA5 - TLO Historic Rehabilitation Areas									
Relevant activities	Historic BA/TLO - Rehabilitation completed from 1980S to 2000s									
Total rehabilitation area size (ha)	139.27 (112.34 ha of existing rehabilitation)									
Commencement of first milestone: RM1	31/12/2032									
PMLU	Woodland & Light Grazing									
Date area is available	31/12/32									
Cumulative area available (ha)	139.27									
Milestone completed by	31/12/33	31/12/34	31/12/43							
Milestone Reference	**Cumulative area achieved (ha)**									
RM1	139.27									
RM4	139.27									
RM5	139.27									
RM6	139.27									
RM7	139.27									
RM9	113.39	139.27								
RM10			139.27							

1) Insert new columns to the <u>yellow table</u> to include further rehabilitation milestone dates.
2) Insert new columns to the <u>blue table</u> to match rehabilitation milestone dates.
3) Insert new rows to the <u>blue table</u> to include additional rehabilitation milestone references.
4) Insert the relevant number in the "Milestone reference" column (i.e. RM1).

Clermont Coal Operations

Rehabilitation Area 6

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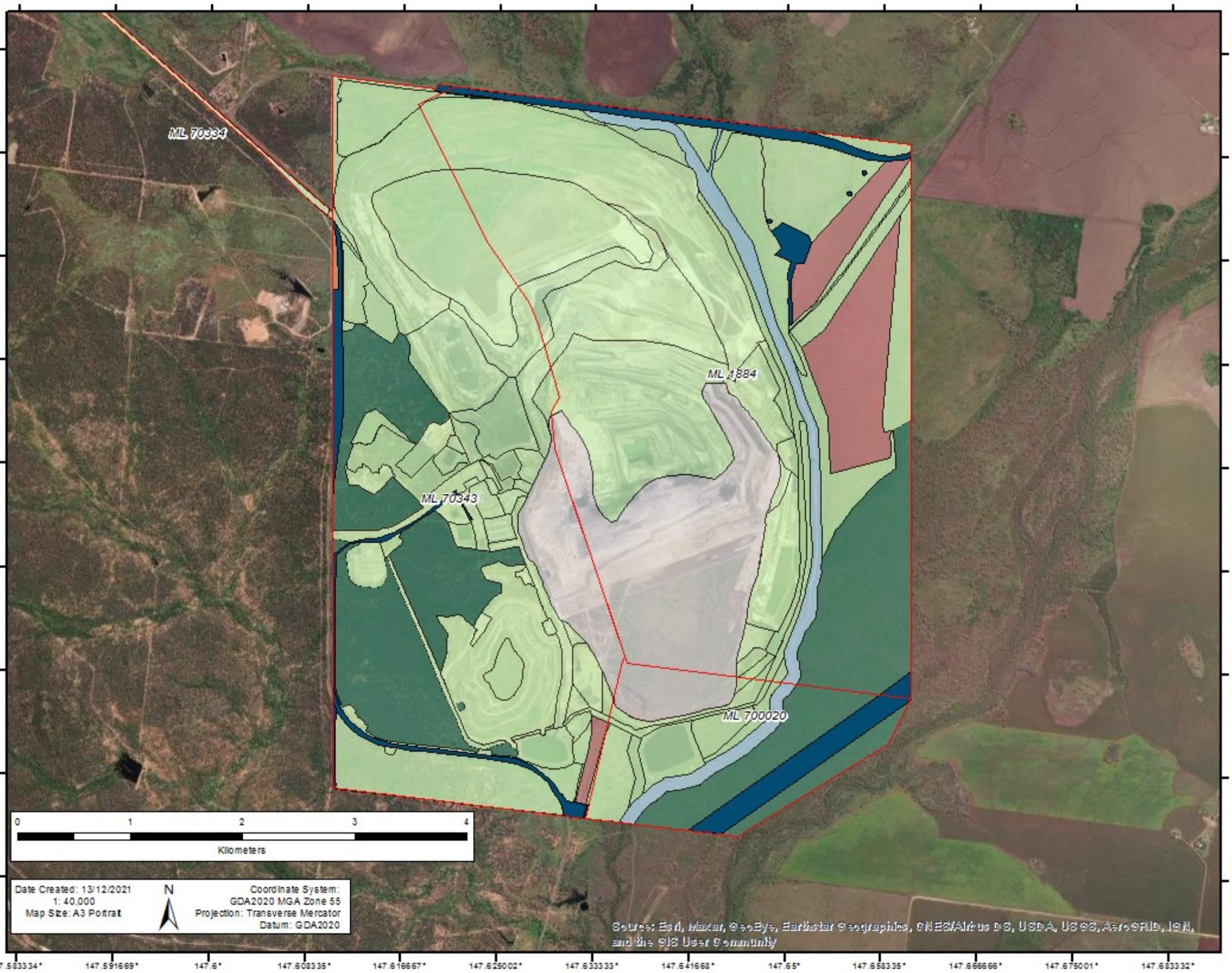

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Legend

- Mining Lease Boundary
- RA6
- Grazing & Cropping
- Residual Void - NUMA
- Nature Conservation
- Retained Infrastructure
- Water Management
- Woodland
- Woodland & Light Grazing

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Post-mining land uses (PMLU)										
Rehabilitation area	RA6 - Retained Infrastructure									
Relevant activities	Retained Infrastructure									
Total rehabilitation area size (ha)	123.89									
Commencement of first milestone: RM2	31/12/2028									
PMLU	Retained Infrastructure									
Date area is available	31/12/28									
Cumulative area available (ha)	123.89									
Milestone completed by	31/12/30									
Milestone Reference	**Cumulative area achieved (ha)**									
RM2	123.89									

1) Insert new columns to the yellow table to include further rehabilitation milestone dates.
2) Insert new columns to the blue table to match rehabilitation milestone dates.
3) Insert new rows to the blue table to include additional rehabilitation milestone references.
4) Insert the relevant number in the "Milestone reference" column (i.e. RM1).

Clermont Coal Operations

Rehabilitation Area 7

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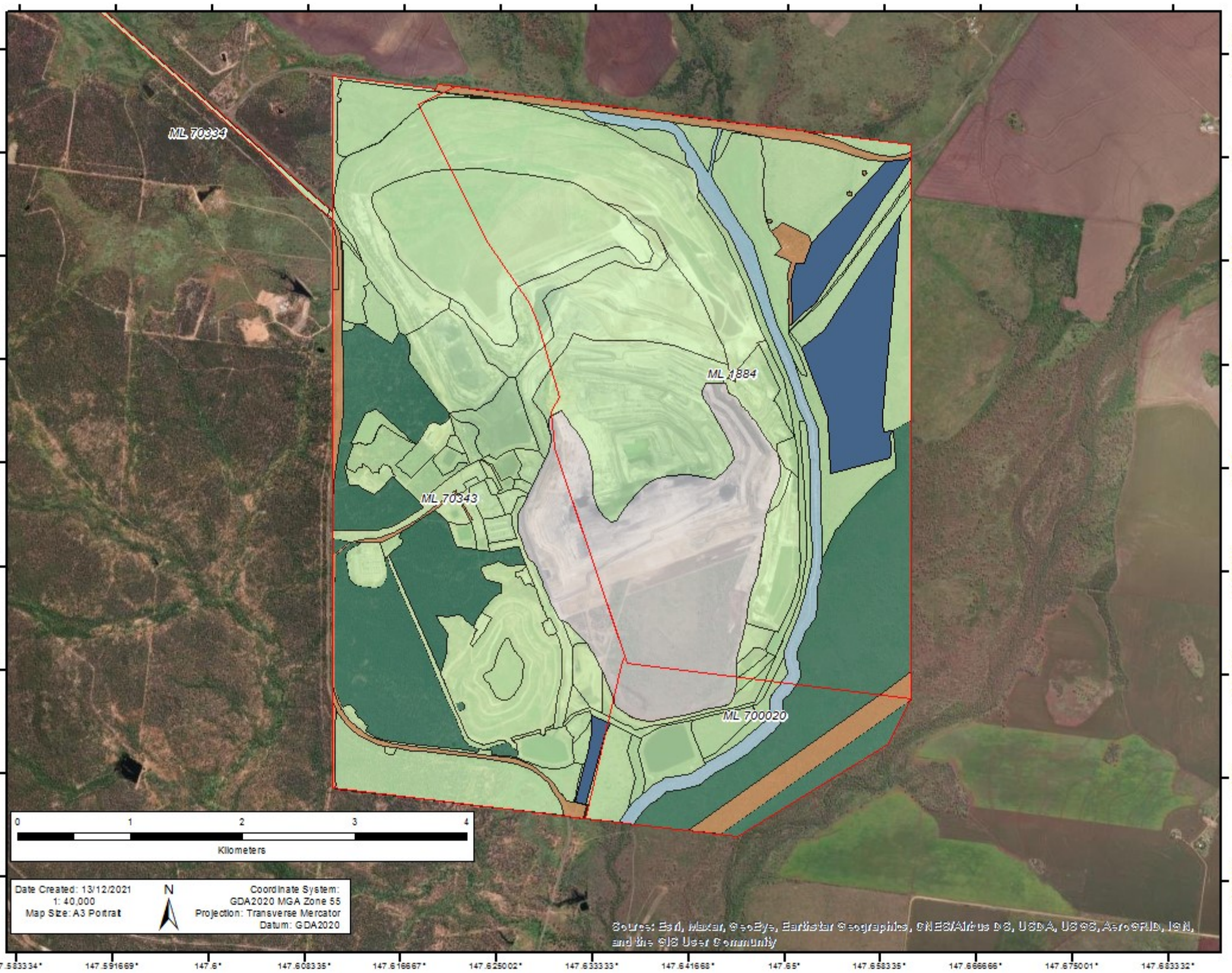

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Legend

- Mining Lease Boundary
- RA7
- Grazing & Cropping
- Residual Void - NUMA
- Nature Conservation
- Retained Infrastructure
- Water Management
- Woodland
- Woodland & Light Grazing

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Post-mining land uses (PMLU)										
Rehabilitation area	RA7 - Nature Conservation areas									
Relevant activities	Nature Conservation									
Total rehabilitation area size (ha)	153.27									
Commencement of first milestone: RM2	31/12/2021									
PMLU	Nature Conservation									
Date area is available	31/12/21	31/12/22	31/12/23	31/12/24	31/12/25	31/12/26				
Cumulative area available (ha)	153.27	153.27	153.27	153.27	153.27	153.27				
Milestone completed by	31/12/22	31/12/23	31/12/24	31/12/25	31/12/26	31/12/27				
Milestone Reference	**Cumulative area achieved (ha)**									
RM2	153.27									
RM10						153.27				

1) Insert new columns to the <u>yellow table</u> to include further rehabilitation milestone dates.
2) Insert new columns to the <u>blue table</u> to match rehabilitation milestone dates.
3) Insert new rows to the <u>blue table</u> to include additional rehabilitation milestone references.
4) Insert the relevant number in the "Milestone reference" column (i.e. RM1).

Clermont Coal Operations

Rehabilitation Area 8

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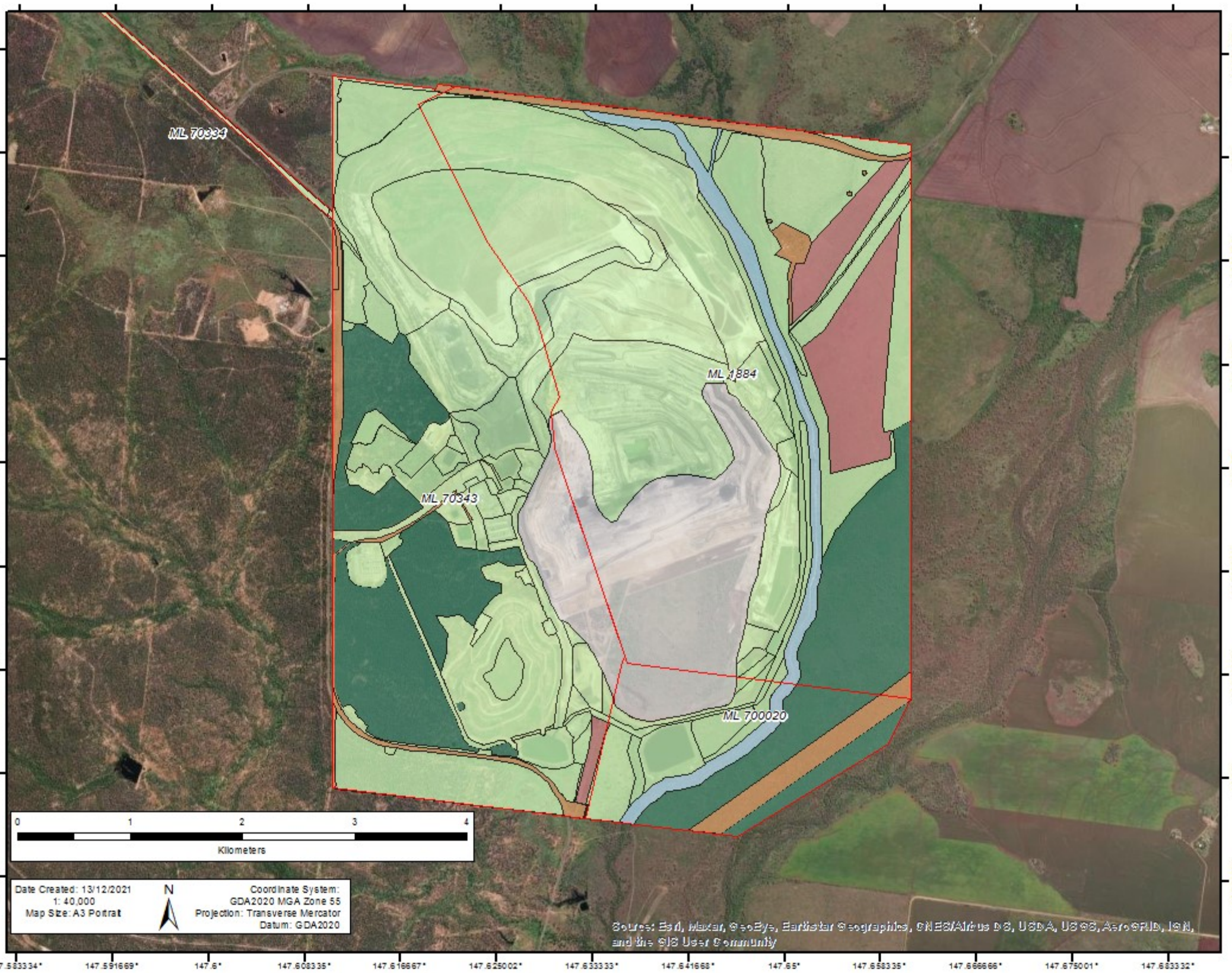

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Legend

- Mining Lease Boundary
- RA8
- Grazing & Cropping
- Residual Void - NUMA
- Nature Conservation
- Retained Infrastructure
- Water Management
- Woodland
- Woodland & Light Grazing

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Post-mining land uses (PMLU)										
Rehabilitation area	RA8 - West Dam Landform Earthworks									
Relevant activities	Rehabilitation (earthworks) of west dam wall to bulk out to a landform									
Total rehabilitation area size (ha)	3.95									
Commencement of first milestone: RM1	31/12/2032									
PMLU	Woodland & Light Grazing									
Date area is available	31/12/32									
Cumulative area available (ha)	3.95									
Milestone completed by	31/12/33	31/12/34	31/12/43							
Milestone Reference	**Cumulative area achieved (ha)**									
RM1	3.95									
RM4	3.95									
RM5	3.95									
RM6	3.95									
RM9		3.95								
RM10			3.95							

1) Insert new columns to the yellow table to include further rehabilitation milestone dates.
2) Insert new columns to the blue table to match rehabilitation milestone dates.
3) Insert new rows to the blue table to include additional rehabilitation milestone references.
4) Insert the relevant number in the "Milestone reference" column (i.e. RM1).

PRCP Schedule - Tab 2 Improvement Area Milestones

Milestone reference	Management milestone	Milestone criteria
MM1	Highwall treatment	a) RPEQ geotechnical assessment completed b) RPEQ geotechnical asssessment to certify that the residual void is geotechnically stable
MM2	Achievement of surface requirements	a) Warning signage around the final void rim will be placed to warn of the void related risks and deter public access b) An abandonment bund will be constructed at high risk locations c) Inclusion of flat batters to allow for safe egress from the final void
MM3	Achievement of sufficient improvement	a) Verification review completed to show that the residual void is safe to humans and livestock.

1) Insert new rows below the table to record more Improvement Area Milestones for the project
2) Ensure all Management Milestones recorded in this table align with those included in the IA sheets in this form.
3) See the PRCP guideline before developing site-specific Improvement Area Milestones

Clermont Coal Operations

Improvement Area 1

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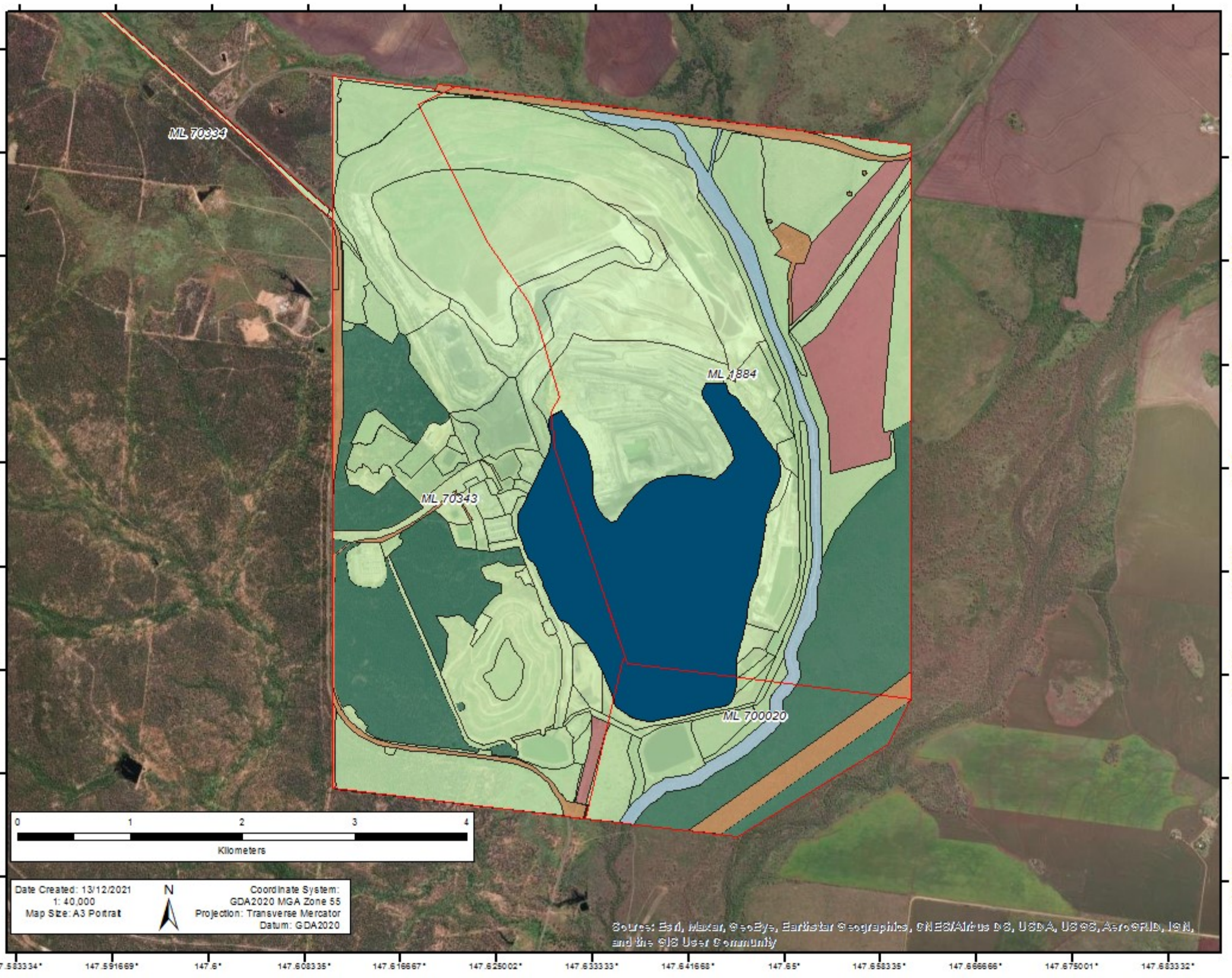

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Legend

- Mining Lease Boundary
- IA1
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Non-use management area (NUMA)						
Improvement area				IA1 - Residual Void NUMA		
Relevant activities				Open cut mining/ Void		
Total size (ha)				400 ha		
Commencement of first milestone: MM1				31/12/2026		
NUMA				Residual Void		
Date area is available	31/12/28	31/12/29	31/12/30			
Cumulative area available (ha)	150	300	400			
Milestone completed by	31/12/29	31/12/30	31/12/31	31/12/43		
Milestone Reference	**Cumulative area achieved (ha)**					
MM1	150	300	400			
MM2	150	300	400			
MM3				400		

1) Insert new columns to the <u>yellow table</u> to include further management milestone dates.
2) Insert new columns to the <u>blue table</u> to match management milestone dates.
3) Insert new rows to the blue table to include additional management milestone references.
4) Insert the relevant number in the "Milestone reference" column (i.e. MM1).

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Appendix 4.2 – Community Consultation Plan and Register

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1. Introduction

1.1 Purpose

This Community Consultation Plan and Register (CCPR) has been prepared to document CCO's strategy and process for engaging and collaborating with stakeholders on rehabilitation and closure aspects and outcomes, as well as detailing the consultation undertaken during the development and implementation of the Progressive Rehabilitation and Closure Plan (PRCP) as part of its requirements.

1.2 Scope

This document outlines the current community consultation process at CCO including stakeholder identification, stakeholder consultation type (details of how and when stakeholder will be engaged), engagement objectives, what information will be provided for community consultation as well as historical issues raised, and will document the process by which feedback will be considered by CCO.

It applies to all owned, leased or managed operational and non-mining landholdings under the CCO ownership or management. The CCPR is regularly reviewed to confirm its effectiveness.

1.3 Objectives for Community Consultation

Through the community consultation process, CCO will achieve the following objectives:

- Identify, notify and engage the community regarding rehabilitation and closure of the CCO;
- Provide ongoing community consultation throughout the stages of the mine to ensure progressive rehabilitation, socio-economic and environmental impacts related to mine closure are communicated and understood;
- Strengthen the relationship between CCO and stakeholders through effective partnerships;
- Collaborate with the community to identify rehabilitation and closure opportunities and constraints that could influence effectiveness of final land outcomes; and
- Provide a platform for comments and feedback mechanism to ensure closure and rehabilitation goals and expectations are effectively communicated and addressed.

2. Context to Community

Between July and November 2020, Wall Planning and Environmental Consulting (WPE) undertook a Stakeholder Engagement Strategy (SES) in order to develop a Social Impact Assessment (SIA) for the closure of CCO. This built on a strong history of engaging directly with the community and surrounding stakeholders.

2.1 Community Profile

The Project is located within Isaac Regional Council (hereafter referred to as "the region" unless otherwise stated), 12 km north of Clermont in Central Queensland. The region is strategically placed to capitalise on economic opportunities in Asia with world class export infrastructure.

On 30 June 2019, the estimated resident population of Isaac Regional Council area was 20,987, with an average annual growth rate of 0.6% (QGSO 2021). It is estimated that there are an additional 12,130 resource sector workers housed in temporary accommodation (non-resident population) (IRC 2021). The median age was 33.0 years in 2018.

Mining is the region's largest employer with 27 operating coal mines producing ~54% of Queensland's saleable coal (IRC 2021). According to the 2016 Census of Population and Housing data, the four main industry sectors for employment are mining (60.9% of workforce), agriculture, forestry & fishing (5.4% of workforce), accommodation and food services (4.4.%) and construction (4.0%). The regional unemployment rate in the March quarter 2020 was 2.1%, compared to 6.1% in Queensland.

Construction of the CCO project started in 2007, with mining operations commencing in late 2010, and closure scheduled for 2027, with all rehabilitation targeted for completion by end of 2035. Over this period, there have been direct and indirect employment opportunities through suppliers, contractors, service providers and local business.

2.2 Stakeholder Identification and Categorisation

The key focus of community engagement for the PRCP is the directly affected community in the vicinity of the mining operation, which includes affected landholders, traditional owners, local government and local community groups. Engagement on rehabilitation, closure and post-mining land use(s) will largely be directed at these groups.

For the purpose of consultation frequency, key stakeholder groups for CCO have been categorised into tiers according to their level of impact and engagement (***Table 2-1***):

- Tier 1 – High and/or frequent level of impact, influence or interest in site activities or decisions;
- Tier 2 – Medium/semi-frequent level of impact, influence or interest in site activities or decisions; and
- Tier 3 – Low or infrequent level of impact, influence or interest in site activities or decisions.

2.2.1 Stakeholders

Key stakeholders which may be impacted by the closure of CCO were identified. The stakeholder groups relevant to the mine closure are as follows (***Table 2-2***):

- Direct landholders;
- Adjoining neighbours;
- Local Government Officials;

- Traditional Owners; and
- Local Community & Groups.

Methods of engagement are detailed in ***Table 3-1***.

2.2.1.1 Affected Landholders and Sensitive Receptors

Affected landowners are the five landholders whose property is adjoining the CCO Project site. Engagement with these landowners has been ongoing since the commencement of the CCO project, however, closure specific consultation commenced early in the SIA process. The Near and Far Neighbours group play an important role in reviewing and providing feedback on potential project impacts on the region. Near and Far Neighbour dwelling locations (termed sensitive receptors) around the site are illustrated in ***Figure 2-1***.

Table 2-1 - Stakeholder Groups at CCO

Tier 1 Stakeholders	Tier 2 Stakeholders	Tier 3 Stakeholders
Employees	Regional Businesses	Shareholders
Contractors	Emergency Services	Federal Government
Suppliers and Contract Services	Support Services (i.e., Medical)	Industry Groups
JV Partners	State Government Agencies	Regional Tenement Holders
Adjoining Local Landholders	State Government	Neighbouring Communities
Traditional Owners	Regional Local Landholders	Media
Local Government	Neighbouring Tenement Holders	Regional Industry
Local Community	Local NGO's / Environmental Groups	National NGO's
Educational / Training Organisations	Customers	Research/Volunteer Groups
Community Facilities		Conservation Groups
Transport & Infrastructure Providers		Enterprise Groups

Table 2-2 - Key Stakeholders Identified as relevant to CCO

Category	Description	Stakeholder
Direct landholders	Glencore (and partners) are the direct landholder.	Glencore and Sumitomo Corporation (GS Coal Pty Ltd) J-Power Australia Pty Ltd J.C.D. Australia Pty Ltd
Adjoining neighbours	Residents located adjoining the Project site (mine lease neighbours)	Landholders whose property is adjoining the Project site. There are five identified landholders. Regional Local Landholders
Government Officials	Government representatives at the Federal, Federal, State and Local level, including, local representatives and Government agencies and services.	<u>Federal</u> Department of Agriculture, Water and Environment
		<u>State</u> Department of Environment and Science Department of Regional Development, Manufacturing and Water Department of Resources Department Seniors, Disability Services and Aboriginal and Torres Strait Islander Partnerships Department of Children, Youth Justice and Multicultural Affairs Department of State Development, Infrastructure, Local Government and Planning Department of Transport and Main Roads
		<u>Local Government</u> Minister for Capricornia Member of Burdekin Mayor of Isaac Regional Council Isaac Regional Council Representatives Clermont Mayor

Category	Description	Stakeholder
Traditional Owners	Traditional owner groups, local land councils, other Aboriginal organisations, where these are related to the project area.	Clermont-Belyando Area Native Title Applicant - Wangan and Jagalingou People
Business Operators and Representatives	Business operators and employees in the locality may experience indirect impacts on business operations. Agforce (local representative), local accommodation operators, local real-estate agents and local Chambers of Commerce.	Various Clermont and regional businesses including accommodation providers, retail outlets, contractors, trades and services Clermont Business Community representatives Local emergency services
Local Community & Groups	Residents or visitors to the Isaac Region may have an interest in the project. Community organisations and groups in the local community.	Clermont Coal Mine Employees Coal Mine workers camp Residents of the Clermont Community Facilities Clermont Other interested members of the Isaac Region and the surrounding area. Educational and Training Organisations Local community groups of Clermont Community Consultative Committee Clermont Mine - Groundwater and Environment Reference Group Wolfang Landowners Reference Group Local real-estate agents Industry Groups Near and Far Neighbours Group

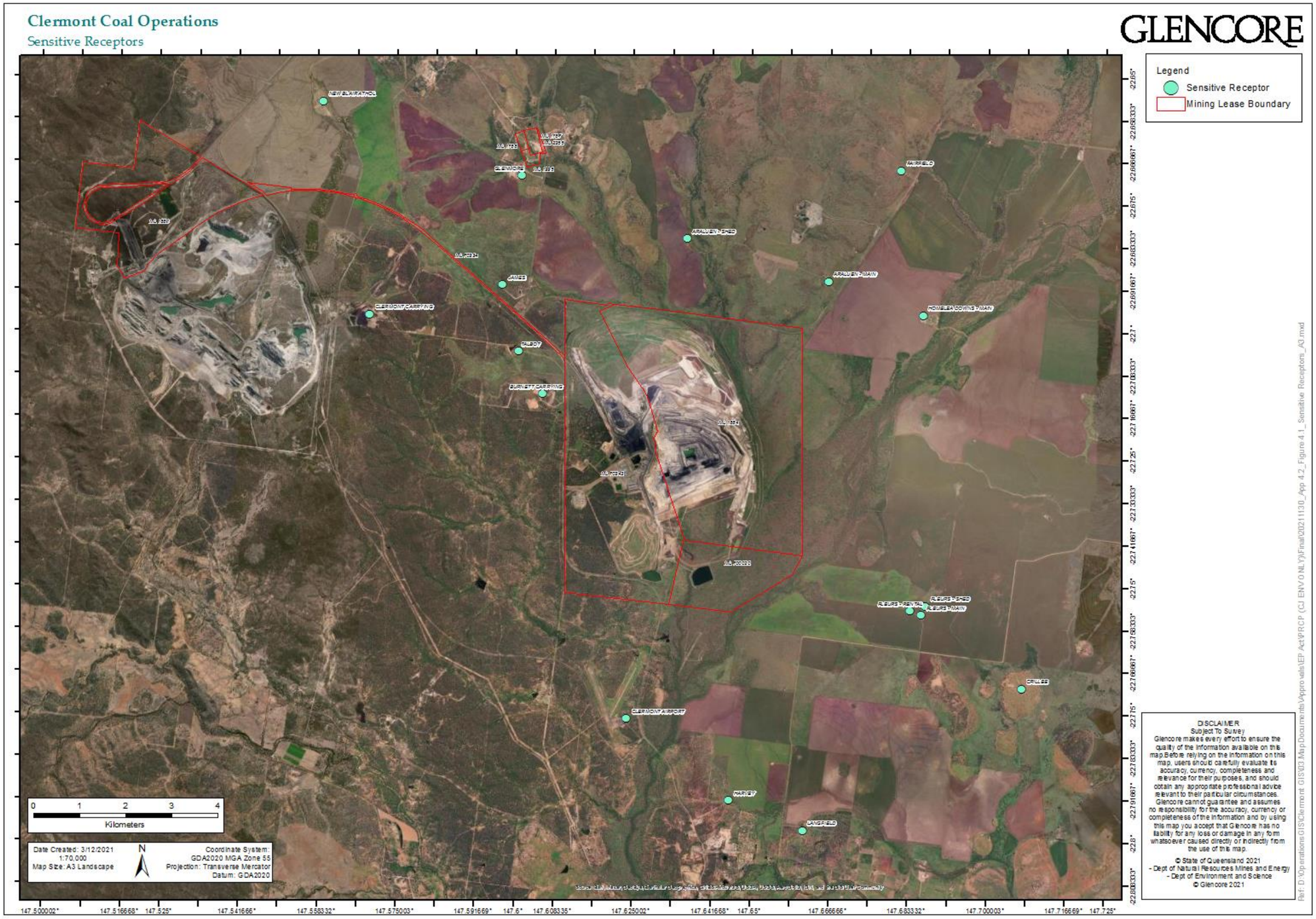

Figure 2-1 - Sensitive Receptors

2.2.1.2 Traditional Owners

In 2008, the Wangan and Jagalingou People and Rio Tinto Coal Australia (RTCA) as the then owner of Clermont Mine entered into a registered Cultural Heritage Management Plan (W&J, RTCA, 2004) which was approved under provisions of Part 7 of the Aboriginal Cultural Heritage Act, 2003 (ACHA).

In late May 2014, among a range of transfers/assignments associated with the sale (land, mining leases, statutory approvals, etc.) was the assignment of the native title agreement between RTCA and the Wangan and Jagalingou (W&J) People, in the form of an Indigenous Land Use Agreement (ILUA); and a Cultural Heritage Management Plan (CHMP).

The Cultural Heritage Coordinating Committee (CHCC) is the operational group responsible for communication, implementation, management and future conduct of all matters arising from the CHMP. The committee consists of three Wangan and Jagalingou representatives and three CCO representatives. Formal committee meetings predate the SIA process, beginning in 2017 and continue in an ad-hoc manner.

Two additional committees include the Agreement Impact Group (AIG) and the Aboriginal Community Development Fund Committee (ACDFC). Both of these are the executing groups of the requirements stipulated in the ILUA.

2.2.1.3 Federal, State and Local Government

Government representatives were included at the Federal, State and Local level, including local representatives and Government agencies. This specifically considered the involvement and consideration of issues of police, emergency services, drug and alcohol services, housing, Aboriginal, employment and social services.

Engagement with local government commenced early in the SIA process. The Isaac Regional Council play an important role in reviewing and providing feedback on potential project impacts on local government services.

2.2.1.4 Local Community & Groups

This included community organisations and groups in the local community, as well as residents or visitors to the Isaac Region that have a key interest or stake in the project, or a more general interest. Engagement with local and regional community groups has been ongoing since the commencement of the CCO project. Closure specific consultation commenced early in the SIA process.

3. Details of PRCP Consultation Process

3.1 How the Community will be Engaged

CCO has an established Community Consultative Committee (CCC), Groundwater and Environment Reference Group (GERG) and Near and Far Neighbours Groups (NFNGs) to discuss and address environmental, social and economic issues and challenges. As part of the ongoing community consultation at Clermont, CCO will engage with these stakeholders and potential future land holders to discuss rehabilitation and closure concerned, as required by the PRCP.

Discussions will include, but will not be limited to, potential post-mining land uses, rehabilitation performance, targeted vegetation and alternative water supply arrangements (AWSA's) based on groundwater and other monitoring results.

3.2 Consultation Type

As part of the Stakeholder Engagement Strategy, the relevant stakeholders were engaged to outline their concerns and views of the future of the CCO and the region. As such, a range of consultation methods and these are as follows:

- One-on-one meetings;
- Workshops;
- Site tours;
- Focus groups;
- Isaac Regional Council information session; and
- Youth engagement.

Table 3-1 summaries how the communities were consulted during the community consultation process for the SIA (WPE, 2020). The engagement strategies used are described below.

Table 3-1 - How the community was consulted

Consultation	Direct Landholders	Adjoining Landholders	Surrounding Region	Local Community	Government and Elected Representatives	Special Interest Groups
One-on-one meetings	✓	✓			✓	
Workshops	✓	✓	✓	✓	✓	✓
Site Tours	✓	✓	✓	✓	✓	✓
Focus Groups	✓	✓	✓	✓	✓	✓
Council Information Session					✓	✓

3.2.1 One-on-One Meetings

The one-on-one meetings were conducted with representatives of Glencore, nearby neighbours (to the mine lease) and the Isaac Regional Council representatives to confirm the stakeholder identification matrix and outline the stakeholder engagement activities. The one on one meetings also included discussions on possible reuse options for the site and what opportunities could be explored for the region.

3.2.2 Workshops

The workshops were conducted following the identification of stakeholder groups. Two workshops were held with 20 stakeholders (Workshop 1) and 8 stakeholders (Workshop 2) participating. These were formed so that the groups were representative of the demographic groups present in the Clermont area. The workshops were conducted to gather the community views on the potential vision for the site, community and economic objectives for the revitalised site, and further engagement strategies for future project phases.

3.2.3 Site Tours

Four site tours were completed specificially to inform the PRCP. The format of the site tours involved sign in, a safety induction, bus tour around the mine and trip to the viewing platform. A similar format was adapted for the Clermont State High School Youth, with further background information regarding the mining operation.

- Two site tours open to the public;
- One site tour for Isaac Regional Council; and
- One site tour for Clermont State High School Youth.

The site tours were designed to engage a broader cross section of the community including young people. The tours were valuable in providing stakeholders with a visual understanding of the site to be rehabilitated and to better inform their engagement in brainstorming potential redevelopment options for the site.

3.2.4 Focus Groups

The focus groups (3 open to the public and 1 with Clermont State High School) were the final component of the initial phase of engagement to support the SIA. From the focus groups, the stakeholders identified potential strategies to benefit the community, economy and environment of the Clermont area following the closure of the mine.

A separate focus group was held with the Clermont State High School Youth to gain their feedback and perspectives. The engagement activity informed the SIA document and the strategies recommended for implementation following the mine closure, as captured in this PRCP.

3.3 Proposed Consultation Frequency

Consultation should occur prior to any PRC plan schedule amendments that are likely to impact the community, with the register updated as consultation is completed.

Ongoing community consultation will 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. Unscheduled, less formal engagement may occur at any time via interaction with neighbours or when approached informally by relevant stakeholders.

Table 3-2 shows the planned frequency of engagement, as well as engagement type, per key-stakeholder (Glencore, 2019).

Table 3-2 - Annual Stakeholder Engagement Plan

Stakeholder (organisation, group or individual)	Engagement Technique	Engagement Deliverables	Engagement Timing												Resources/ Planning required	Engagement tracking/ progress
			J	F	M	A	M	J	J	A	S	O	N	D		
Department of Environment Science (DES)	Phone & Email	Meetings													Data and records requested Supporting Investigation reports	Approval notifications
Agreement Impact Group (AIG)	Email	Meetings													Independent Person Committee Members- Glencore and W&J	Meeting Minutes
Aboriginal Community Development Fund (ACDF)	Email	Meetings													Independent Person Committee Members- Glencore, W&J and Aboriginal Community Executive Officer	Meeting Minutes
Cultural Heritage Management Plan Coordinating Committee (CHCC)	Phone & Email	Meetings													Secretary Committee Members- Glencore and W&J Technical Advisor	Meeting Minutes
Clermont Community Consultative Committee (CCC)	Phone & Email	Meetings													Chairperson Committee Members- local government, business, NGOs, and community organisations.	Meeting Minutes

Stakeholder (organisation, group or individual)	Engagement Technique	Engagement Deliverables	Engagement Timing												Resources/ Planning required	Engagement tracking/ progress
			J	F	M	A	M	J	J	A	S	O	N	D		
Groundwater and Environment Reference Group (GERG) – formerly Community Reference Group (CRG)	Phone & Email	Meetings													Chairperson Committee Members Environment & Community Manager/ Advisor - provides supporting data and meeting arrangements.	Meeting Minutes
Community Development Fund (CDF)	Phone & Email	Meetings													Committee Members- Glencore Clermont Employees	Electronic – Smarty Grants
Near and Far Neighbour Groups	Phone & Email	Property access for environmental monitoring													One week notice prior to access required	Electronic - Consultation Manager

3.4 Consultation Dates

Details of the consultation sessions are included in the attachment. A summary of the consultation dates is provided below:

- One-on-one meetings
  - 13 July 2020
  - 26 August 2020
- Workshops
  - No. 1. – 6th August 2020 at 10:30am
  - No. 2. – 6th August 2020 at 5:30pm
- Site tours
  - 13 July 2020
  - 3 August 2020
- Focus Groups
  - 8 & 9 October 2020
- Council Information Session
  - 28 October 2020
- Youth Engagement - Site Visit & Focus Group
  - 11 November 2020
- Clermont Mine Cultural Heritage Coordinating Committee Meeting (outside of SIA)
  - 30 November 2020
  - 26 March 2021
  - 21 May 2021

4. Community Consultation Information

As part of the SES project, the following information below was shared with the community.

4.1 Plan for the Mine

A high level outline of the Life of Mine (LOM) plan was shared with the public throughout the community consultation. This covered:

- Life of Mine (LOM) is until 2027 (final coal);
- Duration of active rehabilitation works post production cessation;
- Expected duration of the post-closure period for maintenance and monitoring activities; and
- No long-term water treatment or management personnel will be required after relinquishment.

Due to the dynamic nature of the project, information of a similar nature will also be shared as part of the ongoing community consultation at Clermont.

4.2 Post Mining Land Use (PMLU)

Identifying the most appropriate post-mining land uses is a dynamic process open to new opportunities as they present themselves during the rehabilitation and closure planning process. The final landform and rehabilitation at CCO is designed to create a site that is safe, stable, does not cause environmental harm, and is able to sustain an agreed post-mining land use.

The PMLU concept (which reflects the overarching approach adopted for this PRCP) was presented to external stakeholders for consideration and sourcing of alternatives which may provide value to the community post-mining. As communicated, the core PMLU adopted for the rehabilitated mining landforms will likely be native vegetation (as a open woodland / bushland area), which is antipicated in the long-term to provide habitat to native wildlife and will also allow for opportunities for light grazing. Similarly to any central Queensland landholding, there will be areas with higher and lower productive capacity and resultant future use. In addition to these predominant uses, there may be a range of additional uses and / or land use constraints, which may include, but are not limited to:

- Infrastructure (roads, services, firebreaks, buildings);
- Water management areas or systems such as dams, creek lines, diversions or similar; and
- Vegetation buffer areas and habitat corridors.

In addition to discussing the Woodland and Light Grazing PMLU, consultation undertaken also indicated that the CCO site will incorporate other PMLUs, such as Water Management Areas and Infrastructure. Further, as discussed below, the residual void will be retained without a productive PMLU. Water Management and Infrastructure areas will be available to service the current leaseholder or future landowner(s) as a water body for agricultural and grazing purposes.

4.3 Non-Use Management Area (NUMA)

During the EIS process in 2004, it was recognised that due to the nature of the mining method, a 400ha final residual void would be left and would not be able to support a productive PMLU. Despite being a pre-approved NUMA and not being required to support a PMLU, CCO will endeavour to reduce the size of the NUMA, rehabilitate, minimise harm and achieve a safe, structurally stable and non-polluting condition.

The CCO final void NUMA has very constrained location options due to the mining activities. The location of the NUMA was communicated, as outlined in the Final Void Management Plan (Glencore, 2017), noting that the location of the NUMA was explained to differ slightly depending on future mining methodology changes.

During community consultation in December 2019, concerns over the size of the final void were communicated to CCO. As a result of this, a commitment was made to reduce the final pit lake to 120ha (to clarify, this is less than the 400ha final void envisaged within the EIS previously approved to be retained with non-beneficial land use. However it is understood that the context of the meeting was to confirm the area anticipated for the pit lake to remain/occupy after closure).

Changes to the final void footprint will be communicated with the community, so that the socio-economic and environmental impacts can be discussed.

4.4 Rehabilitation and Management Methods

A high level outline of the CCO rehabilitation and management methodology was shared with the public throughout the community consultation. It was recognised that this was not final, is dynamic in nature and that future Rehabilitation Management Plan methodologies would be shared as finalised, as part of the ongoing community consultation and engagement at Clermont.

However, the following key points were made:

- Final landforms will meet design criteria (slopes, drainage, etc), will be generally in accordance with the concept drainage and landform plans, and will be detailed in the Rehabilitation Management Plan;
- No significant residual risks will remain at the site including spontaneous combustion;
- All seepage, runoff, or overflow that discharges will meet water quality objectives;
- Progressive rehabilitation will occur;
- Active decommissioning and demolition will meet CCO's internal standards and regulatory environmental and safety standards;
- The catchment reporting to the final void will be minimised, thereby promoting drainage above natural ground level; and
- The flood levee will be decommissioned and incorporated into the landform design.

4.5 Progressive Rehabilitation and Closure Timeframe

While the area scheduled to be rehabilitated and to remain as disturbed over the life of the mine for each year was shared with the community, it was clear that it is subject to yearly change. Significant changes to the rehabilitation and closure schedule will be communicated to the community as part of the ongoing community consultation and engagement at Clermont.

4.6 PRCP Schedule Amendments

As per the SIA (WPE, 2020), CCO will update the community on the status of the closure process, through newsletters every 6 months and yearly drop in sessions.

5. Discussions Held With Stakeholders

5.1 Discussion Points

It was determined that across all stakeholder groups, the issues and opportunities of greatest significance were:

- The need for progressive rehabilitation;
- Utilisation of existing assets;
- Concerns regarding the changes in demographics and the flow-on effects to social services;
- The need for community representation;
- The importance of a transparent stakeholder engagement program throughout the mine closure, decommissioning and rehabilitation phases; and
- Concerns around employment and job loss.

The consultation also provided input to the vision for the site including:

- Potential for industry reinvestment such as creating a workshop for servicing large mine vehicles (local business and industry);
- Potential tourism opportunities (local business and industry);
- Agriculture and farming opportunities including opportunities for an Agricultural College (local business and industry); and
- Potential community investment (health and community wellbeing).

5.1.1 How Issues Have Been Considered

Participants strongly identify with the value of a country lifestyle, the strong sense of community spirit, the diversity of employment and sporting/recreational opportunities and the safety offered by the Clermont community.

5.1.2 Decisions/Outcomes of Engagement

Based on past community consultation undertaken, CCO has made some commitments listed in ***Table 5-1*** below to address community issues and concerns.

5.2 Historical Issues Raised and Commitments Made

CCO has been operating in close proximity to the Clermont township and a number of rural properties for more than 14 years. CCO has maintained a strong program of consultation with the community, prior to the SIA, through the Community Consultative Committee (CCC) and Groundwater and Environment Reference Group (GERG), among other formats and groups.

These groups have provided a forum for open discussion between Glencore representatives, the community, Isaac Regional Council (Council) and other stakeholders on issues directly relating to the mine's operations, environmental performance, rehabilitation and eventual closure.

Table 5-1 - Summary of Historical Stakeholder Issues

Date	Meeting	Issues/Concerns	Commitments
03 April 2007	Blair Athol Mine Closure Community Consultative Committee	• Concerns over the post mining water resource, both volume and quality.	• Establish native vegetation as the primary end land use • Surface water is to be diverted around the final void and off site to provide water of suitable quality to downstream users
17 March 2011	Clermont Community Consultative Committee	• CCO final land use. • Timeline for closure.	• Clermont community favour grazing, wildlife reserve, museum or bio fuel facility as PMLU.
03 June 2019	Clermont Mine Groundwater and Environment Reference Group	• General discussion regarding targeted vegetation species.	• The likely targeted vegetation species is native vegetation.
03 December 2019	Clermont Mine Groundwater and Environment Reference Group	• Requested an approximate total rehabilitated area. • Issues around the final void. Requested confirmation of final void size.	• Total rehabilitated area will be approximately 2,200 ha at the end of the mining life. • The final pit lake area will be approximately 120 ha*

* This commitment is less than the approximately 400ha of final void that was envisaged within the EIS previously approved to be retained with non-beneficial land use. However it is understood that the context of the meeting was to confirm the area anticpated for the pit lake to remain/occupy after closure.

5.3 Feedback and Comments

Feedback received from the community was used to gain an understanding of community desires and wishes following the closure of the mine. ***Table 5-2*** below details how this feedback has been reflected in the PRCP.

Table 5-2 - How community feedback corresponds to proposed PRCP outcomes

Suggested Rehabilitation	Reflection in PRCP
Potential for industry reinvestment such as creating a workshop for servicing large mine vehicles	This was assessed and determined to have limited potential for future beneficial use of the CCO site, and therefore was not carried forward.
Potential tourism opportunities	This was assessed and determined to have limited potential for future beneficial use of the CCO site, and therefore was not carried forward.
Agriculture and farming opportunities including opportunities for an Agricultural College	A significant area of the mining lease is proposed to attain a PMLU of native vegetation and light grazing. In the long-term,

Suggested Rehabilitation	Reflection in PRCP
	this provides both native habitat and support for agriculture and farming opportunities.
Potential for community investment.	This was assessed and determined to have limited potential for future beneficial use of the CCO site, and therefore was not carried forward.

CCO will continue to carry out consultation in relation to the activities carried out under the PRC plan. CCO will report back to community members on how feedback is received and addressed, as well as how they have been reflected in the PRCP, or otherwise considered as part of the rehabilitation and closure process. CCO will also continue to regularly review and revise the community consultation plan and register as needed.

6. Summary

The community and stakeholder consultation measures undertaken to inform this PRCP are essential in achieving the project vision. To this end, the community consultation has:

- Communicated the "Closure Project" to stakeholders and local community;
- Obtained stakeholder input on the issues associated with the rehabilitation and closure of CCO (as applicable to the PRCP requirements) and also to inform the Social Impact Assessment; and
- Established a stakeholder informed vision for the mine rehabilitation and closure.

The information shared with the community members was comprehensive, however due to the dynamic nature of the CCO project the exact details of the CCO site, at closure, are still to be finalised. Ongoing community consultation will 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 in detail.

Feedback/comments were received and logged, and CCO made an initial assessment to identify, classify and/or investigate any actions needed to address them (WPE, 2020). CCO will report back to community members on how feedback is received and addressed, including in the PRCP. CCO will continue to carry out consultation in relation to the activities carried out under the PRC plan, and will regularly review and revise the community consultation plan and community consultation register as required.

7. Document Information

Reference	Title
CCO (2019a)	Clermont Open Cut Strategy for Community and Stakeholder Engagement (CLEOC-520960306-2231).
CCO (2019b)	Clermont Open Cut Plan for Stakeholder Engagement (CLEOC-520960306-2230).
CCO (2020a)	Environment and Community Annual Plan (CLEOC-520960306-14116).
CCO (2020b)	Rehabilitation Management Plan (CLEOC-900537260-6).
CCO (2021)	Annual Rehabilitation and Closure Plan.
GCAA (2018)	10.0 Community and Stakeholder Engagement (GCAA-625378177-9977).
GCAA (2018)	10.01 Stakeholder Engagement Strategy (GCAA-625378177-15244).
ICMM (2006)	Community Development Toolkit, International Council on Mining & Metals.
IRC (2019)	Regional overview, Isaac Regional Council, retrieved 5 August 2020 from https://www.isaac.qld.gov.au/about-our-region/regional-overview
QGSO (2020)	Queensland Regional Profiles: Profile for Isaac (R) Local Government Area, Queensland Government Statistician's Office.
Wall Planning and Environmental Consulting (2020)	Clermont Coal Mine – Social Impact Assessment, Stakeholder Engagement Strategy (Mine Closure Planning).

Attachment - Records of Historical Engagement to Present

Organiser	Date & Time	Attendees	Location	Agenda
Rio Tinto	3 April 2007, 4:10 pm	• Blair Athol Mine Closure Community Consultative Committee Meeting	Guest House 3 Spring Street, Clermont	• BA Mine Closure Plan & Activities • Key aspects of the Mine Closure Plan • BA Mine Closure Plan Programme for 2007 • Community Consultative Committees
Rio Tinto	22 May 2007, 4:00pm	• Blair Athol Mine Closure Community Consultative Committee Meeting	Guest House 3 Spring Street, Clermont	• BA Closure

Rio Tinto	23 August 2010, 4:15pm	• Clermont Community Consultative Committee (CCC)	Guest House
			3 Spring Street, Clermont
				• Blair Athol Mine Closure
				  ○ A survey was conducted by Rio Tinto at the Isaac Regional Show in May regarding final land use of Blair Athol Mine post closure.
				  ○ The Clermont community favour grazing, wildlife reserve, museum or industrial development as final land use options which is consistent with planned final land use.
				• Environmental Issues
				  ○ Dust is a significant issue at Clermont Mine and actions have commenced to control dust, including OLC scrapers, sprays on IPCC, long string polymer on roads, water truck spray type and Dust Traka sampling.

Organiser	Date & Time	Attendees	Location	Agenda
				○ Lighting shields are being installed on lighting plants at Clermont Mine to alleviate lights shining into neighbouring homes and into oncoming highway traffic.
Rio Tinto	17 March 2011, 4:45pm	• Clermont Community Consultative Committee (CCC)	Clermont region meeting room (Old BA Gym) 38 Jellicoe Street, Clermont	• Blair Athol closure consultation Responses outlined from survey taken at the Clermont show – regarding final land use options. ○ Museum, grazing, wildlife reserve and bio fuel facility equally pitted as preferences. At this stage final land use design sits with the grazing and wildlife reserve option but can change to include industry/bio fuel options. ○ Indicates that BA's thinking is in line with what the community wants for the old site. ▪ CCC members raised concerns over the capacity of the existing infrastructure to deal with the industry/bio fuel option and existing community needs. ○ Timeline of closure discussed. Additional factors now to be included in plan due to change in mining. Decommissioning plan due 2011. CM Closure Plan update required 2011.
Rio Tinto	05 December 2012,	• Clermont Community Consultative Committee (CCC)	Guest House 3 Spring Street, Clermont	• Blair Athol Mine "Last Coal" and Rehabilitation ○ Current state at Blair Athol Mine ▪ Blair Athol ceased dragline and coal recovery during November 2012. ▪ Sedgmans Wash Plant has been decommissioned and demobilisation to occur Q1 2013. ▪ Infrastructure will remain in place until it is no longer required in rehabilitation or by Clermont Mine. ▪ Disposal of plant and equipment not required for rehabilitation is underway and will continue through 2013.

Organiser	Date & Time	Attendees	Location	Agenda
				▪ Coal plant and other infrastructure required by Clermont Mine will be run by Clermont Mine. ▪ Planning for the transition from mining aims to ensure continuity of Clermont operations and that Blair Athol is safe, compliant and functional during the gap to rehabilitation. ○ Rehabilitation ▪ Approximately 500ha of rehabilitation has been completed but is in varying condition. ▪ One third is on track for relinquishment, one third requires minor repair and the final third requires significant repair / rework. ▪ In addition there is approximately 1000ha of rehabilitation left to complete.
Glencore	15 June 2016, 4:20pm	• Clermont Community Consultative Committee (CCC)	Not listed	• Overview of the mines 2016 rehabilitation works. ○ The mine is aiming to rehabilitation 96ha during 2016. ○ To date approximately 70ha of shaping has been completed. ○ The Topsoiling and Water Management contract is currently being adjudicated.
Glencore	28 September 2016, 4:15pm	• Clermont Community Consultative Committee (CCC)	Not listed	• Overview of the mines 2016 rehabilitation works. ○ The mine is aiming to rehabilitation 96ha during 2016. ○ To date all of the shaping has been completed, with 20ha of topsoiling done.
Glencore	8 December 2016, 3:15pm	• Clermont Community Consultative Committee (CCC)	Clermont Open Cut and include a site tour.	• Overview of the mines 2016 rehabilitation works. ○ The mine has achieved its target of 96ha during 2016. ○ All shaping, topsoiling and revegetation works have been completed.

Organiser	Date & Time	Attendees	Location	Agenda
Glencore	15 March 2017, 4:00pm	• Clermont Community Consultative Committee (CCC)	Clermont Open Cut Town office	• Rehabilitation Update ○ 44 ha was rehabilitated in 2015 ○ 103 ha was rehabilitated in 2016 ○ The budget for 2017 is as follows: ○ Shaped: 155 ha ○ Topsoiled & Seeded: 74 ha
Glencore	7 June 2017, 4:15pm	• Clermont Community Consultative Committee (CCC)	Clermont Open Cut Town office	• Rehabilitation Update ○ 44 ha was rehabilitated in 2015 ○ 103 ha was rehabilitated in 2016 ○ The budget for 2017 is as follows: ○ Shaped: 155 ha ○ Topsoiled & Seeded: 74 ha • Progress to-date: ○ Shaped: 101 ha of 155 ha ○ Topsoiling and revegetation to commence during August 2017
Glencore	14 September 2017, 4:15pm	• Clermont Community Consultative Committee (CCC)	Clermont Open Cut Town office	• Rehabilitation Update ○ 44 ha was rehabilitated in 2015 ○ 103 ha was rehabilitated in 2016 ○ The budget for 2017 is as follows: ○ Shaped: 155 ha ○ Topsoiled & Seeded: 74 ha • Progress to-date: ○ Shaped: 134 ha of 155 ha ○ Topsoiling: 14 ha of 74 ha
Glencore	5 December 2017, 2:15pm	• Clermont Community Consultative Committee (CCC)	Clermont Open Cut, followed by a mine tour.	• Rehabilitation Update ○ 44 ha was rehabilitated in 2015 ○ 103 ha was rehabilitated in 2016 ○ The budget for 2017 is as follows: ○ Shaped: 155 ha ○ Topsoiled & Seeded: 74 h

Organiser	Date & Time	Attendees	Location	Agenda
				• Progress to-date: ○ Shaped: Completed ○ Topsoiling & Seeded: Completed
Glencore	8 March 2018, 2:06pm	• Clermont Community Consultative Committee (CCC)	Clermont Mine Town Office	• Rehabilitation Update
Glencore	26 March 2018, 7:00pm	• Groundwater and Environment Reference Group (GERG)	Clermont Open Cut Town Office	• Rehabilitation Update
Glencore	4 June 2018, 6:30pm	• Groundwater and Environment Reference Group (GERG)	Clermont Open Cut Town Office	• Safety Overview and Operational Update • Quarterly Environmental Update ○ Rehabilitation ▪ Presented summary of rehab completed YTD. ▪ Discussion around current/future dump footprints.
Glencore	12 June 2018, 3:25pm	• Clermont Community Consultative Committee (CCC)	Not listed	• Rehabilitation Update ○ On plan to meet end of year targets ○ Focusing on the areas closest to the highway/ visual areas.
Glencore	12 September 2018, 3:05pm	• Clermont Community Consultative Committee (CCC)	Not listed	• Environment and Community matters section. ○ Rehabilitation is on plan to meet end of year targets with areas for future rehabilitation identified ○ Schematic of LOM rehabilitation up until 2028 also shown along with images of works undertaken

Organiser	Date & Time	Attendees	Location	Agenda
Glencore	3 December 2018, 1:37pm	• Groundwater and Environment Reference Group (GERG)	Clermont Open Cut Administration Building and Site Tour	• Quarterly Environmental Update ○ Rehabilitation
Glencore	11 December 2018, 2:05pm	• Clermont Community Consultative Committee (CCC)	Village Training Room and Site Tour	• Environment and Community Update ○ Started rehabilitation on site during 2015 with 44ha achieved and have achieved approximately 100ha per year since. ○ Over LOM there will be between 2300 – 2500ha of total disturbance on site. ○ There are operational and infrastructure (diversions, highway etc.) constraints during the LOM which limit area available in some years and allow more significant areas to be rehabilitated as we progress toward closure. ○ Historically rehabilitation costs through contract arrangements were in the order of $100K/ha, whereas now with improved design and process in place and an in-house Rehab Crew we are achieving better results at $30K/ha over more recent years. ○ Rehabilitation design has 75m concave / tri-linear slope segments with cross bench drains and rock cutes to capture / divert water into sediment basins which are designed for peak velocity of 3-4m/second. ○ It is apparent from works done to date that steeper slopes are having plant establishment / erosion issues which we are looking into and endeavouring to trial different approaches such as rock mulching. ○ There are several different designs for rock chutes with the larger Type 5 form currently in place in the 2015/2016 N rehabilitation area. It is intended that there will be only a couple of these type structures implemented over LOM with the intent that they will become fully vegetated over time and will blend into the final landform.

Organiser	Date & Time	Attendees	Location	Agenda
Glencore	4 March 2019, 6:30pm	• Groundwater and Environment Reference Group (GERG)	Clermont Open Cut Town Office	• Quarterly Environmental Update ○ Dust Monitoring ▪ General discussion around the observed trends. A number of elevated readings were observed at all stations. These elevated results were attributed to regional dust events. ▪ Shane Lakmaker was engaged to investigate the elevated dust results. The upwind and downwind concentrations was used to calculate the site contribution. ▪ Discussion held around regulatory notification requirements for elevated results. ○ Rehabilitation ▪ A summary of the 2018 rehabilitation statistics were presented as well as the 2019 rehabilitation targets. ▪ A video of drone imagery was presented which showed images of recent rehabilitation work.
Glencore	3 June 2019, 6:30pm	• Groundwater and Environment Reference Group (GERG)	Clermont Open Cut Town Office	Quarterly Environmental Update ○ Rehabilitation ▪ General discussion shaping in the north-east and the possibility of bulk shaping encroaching on the existing Gowrie Creek Levee. Work on this is currently underway to understand what the designs may look like and the implications to the Levee and approval requirements. ▪ Recent photos of the northern and south-western rehabilitation areas were presented. ▪ The current Life-of Mine rehabilitation design was presented. This will continue to evolve over time but current designs are considered with the current mine plan. ▪ General discussion regarding targeted vegetation species – the mine is currently required to target native vegetation.

Organiser	Date & Time	Attendees	Location	Agenda
				▪ General discussion regarding the levee extension designs, which are required to protect the mine pit from flood inundation as the operation progresses south. Some concern raised regarding the impact of this change to southern properties in the event of flooding.
Glencore	9 September 2019, 12:35pm	• Groundwater and Environment Reference Group (GERG)	Clermont Open Cut Village Training Room & Site Tour	• Quarterly Environmental Update ○ Rehabilitation ▪ Progress to date – shaping approx. 12ha of 72ha and approximately 50ha of 76ha for topsoiling ▪ Brief discussion was held around black wattle in rehabilitated areas and if it was being controlled ▪ Drone footage was well received and team will endeavour to get more footage for future meetings ▪ The current Life-of Mine rehabilitation design was presented. This will continue to evolve over time but current designs are considered with the current mine plan ▪ General discussion regarding void area and water quality
Glencore	3 December 2019, 12:35pm	• Groundwater and Environment Reference Group (GERG)	Clermont Open Cut Town Office Meeting Room	• Quarterly Environmental Update ○ Rehabilitation ▪ Shaping target of 72ha vs actual of 46ha. This target will be challenging to meet by end of 2019, which has flow on effect on stage 2 of rehab (topsoil and seeding in 2020) ▪ Topsoil complete for year meeting target of 76ha. ▪ Seeding target of 76ha with actual of 65ha. Drone used for seeding was underway to meet the target this week but had a blade issue. Another method will be used to spread remaining seed.

Organiser	Date & Time	Attendees	Location	Agenda
Glencore	4 March 2020, 3:30pm	• Clermont Community Consultative Committee (CCC)	Glencore Town Office	• Environment Update ○ Update provided on rehabilitation progress, with a summary of areas now completed, as well as planned areas for 2020. Recent rainfall has assisted with the growth on the newer rehab areas. ○ Morné provided information on the rock mulching that took place on the South East Rock Dump. Rock mulch was used as a trial to achieve improved erosion control and assist to stabilise landform on steeper slopes.
Glencore	10 March 2020, 6:00pm	• Groundwater and Environment Reference Group (GERG)	Clermont Open Cut Town Office Meeting Room	• Quarterly Environmental Update ○ Rehabilitation ▪ A summary of rehabilitation achievements for 2019 was presented ○ Levee ▪ A plan displaying the levee realignment was presented. Levee works are proposed for this year. Consideration has been made on the potential impact this will have on the creek and water inundation, and studies have been completed. ○ Southern landform ▪ A plan displaying the proposed southern landform was presented, showing how this will incorporate the existing levee. It was highlighted that this is a concept only at this stage. This landform will function as a new haul road, with its main purpose long term to provide protection from water inundation into the pit. ○ Conceptual model video ▪ Video was shown to group. Member expressed concern again over 'blue water' in final void and raised concern over how this may be misleading.

Organiser	Date & Time	Attendees	Location	Agenda
Glencore	3 June 2020	• Clermont Community Consultative Committee (CCC)	Presentation sent via email as meeting was cancelled	• Rehabilitation ○ Progress to date: ▪ 2015: 44 ha ▪ 2016: 118 ha ▪ 2017: 82.6 ha ▪ 2018: 83.3 ha ▪ 2019: 76 ha ○ 2020 Actual vs Targets YTD: ▪ Shaping: 0 ha vs 55 ha ▪ Topsoiled: 29.15 ha vs 69 ha ▪ Seeded: 0 ha vs 69 ha
Glencore	14 September 2020, 4:00pm	• Groundwater and Environment Reference Group (GERG)	Penny's Plaza Coffee Shop Conference Room Capricorn Street, Clermont	• Rehabilitation Update ○ A summary of rehabilitation achievements for 2020 YTD was presented. • Other Business ○ Koala Corridor Update ▪ Created in 2011 and 2012 to help create a two-kilometre vegetation corridor that will provide habitat and support growth of koalas living on land owned by Clermont Mine. ○ LiDAR Update ▪ Active for 7 months – scans PM10 to provide imagery over the mine site. System does not provide concentrations nor hard data for dispatch. Not likely to provide a further beneficial use. Trial is to end at the end of September. Three additional E-Bams have been installed to provide more useful data and are located on the mining lease to predict elevated levels of dust before they reach the near neighbours so that operations can change in response to elevated dust levels.

Organiser	Date & Time	Attendees	Location	Agenda
Glencore	16 September 2020, 3:40pm	• Clermont Community Consultative Committee (CCC)	Penny's Conference Room (Cornett's IGA)	• Environment Update ○ Update provided on rehabilitation progress, with a summary of areas now completed, as well as planned areas for 2020.

Glencore	30 November 2020, 9:30am	• Summary of the Clermont-Belyando Area Native Title Applicant/ Clermont Coal Operations.	Empire Conference Centre, Rockhampton, QLD.	• Clermont Update
				  ○ An update on rehabilitation progress
				• Deed of Assignment and Assumption (change in joint venture ownership)
				  ○ The deed of assignment is required due to MDP selling its interest in Clermont Coal Operations therefore needing to transfer its rights and obligations under the ILUA. The deed of Assignment and Assumption was presented to the Applicants and they were requested to review the document with their own legal advice. The Applicants deemed to sign the document at the meeting.
				• Clermont Mine Closure Planning
				  ○ Closure and rehabilitation planning was presented to the Applicants. It was confirmed that mine closure is planned for 2026 / early 2027. The implications with respect to the Future Fund and how the fund will be administered upon cessation of mining was discussed.

Glencore	26 March 2021, 9:00am	• Cultural Heritage Coordinating Committee (CHCC)	Homelea Downs Meeting room, Clermont Coal and Site Tour	• Any other business ○ The W&J Applicants have requested a joint meeting with the CHCC and the AIG. W&J future aspirations and cultural heritage will be discussed.
Glencore	28 July 2021, 2:00pm	• Terracom	Clermont Open Cut Town Office Meeting Room	• West Dam and diversion. Discussed the rehabilitation and closure options that have been considered and assessed. Agreement that the best option is to retain West Dam, retain the existing diversion downstream of West Dam, and remove the Rail Loop diversion.

Organiser	Date & Time	Attendees	Location	Agenda
				• Acknowledged that removal of pumping infrastructure from West Dam may result in a period of approximately 4 years where Terracom will need to source an alternative supply for potable water (through trucking) • Discussed the need to remove the overland conveyor, access road and culvert.

Glencore	25 August 2021, 10:00am	• DES
		• RDMW
			Clermont Open Cut Town Office Meeting Room and Site Tour	• Presentation of rehabilitation activities and proposed solutions, followed by a site tour
				• RDMW agreed to:
				  • Confirm underlying tenure for all water authorisations on Blair Athol leases.
				  • Provide any relevant Glencore authorisations to ensure that all parties have the most up to date conditions.
				  • Provide pathway for obtaining any third-party authorisations.
				  • West Dam was highlighted as an issue to look into further regarding proposed rehabilitation option.
				  • Cement Hill undertake watercourse determination to confirm whether the water captured overland flow or water harvesting.
				• Glencore agreed to:
				  • Cement Hill – confirm date of construction of weir that facilitates the take of water from the feature into the void.
				  • Familiarise and summarise relinquishment requirements for all water authorisations and identify how they relate to proposed rehabilitation. Provide a summary of any discrepancies and work through a way forward.
				  • Review dewatering and make good requirements for the Clermont mine and commence pulling together relevant information, identify gaps in knowledge.
				  • Gowrie Ck – works to be completed prior to any relinquishment to bring it up to relevant standard.

Organiser	Date & Time	Attendees	Location	Agenda
				• Once all pulled together meet again to discuss way forward.

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Appendix 4.3 – Progressive Rehabilitation Monitoring Summary Report

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1. Introduction

1.1 Purpose

CCO commenced progressive rehabilitation of the CM WRDs in 2015, with approximately 593 ha rehabilitated at the time of this report. Areas at the TLO were rehabilitated prior to 2008 (before current CCO ownership), with some of the rehabilitation over 30 years old.

The purpose of this rehabilitation monitoring summary report is to:

- Outline of the methodology and process for undertaking monitoring at CCO; and
- Review past performance of the rehabilitation at the CCO.

1.2 Scope

This document applies to the rehabilitated areas at Clermont Mine (CM), Cement Hill (CH), and the Train Load-Out facility (TLO). Rehabilitation and subsequent monitoring will also need to be undertaken at the OLC post mine closure. It is anticipated that progressive rehabilitation of all areas will continue through to 2035.

1.3 Standards and Guidelines

CCO has a scientifically robust rehabilitation monitoring program in place that supports the site to understand the progression of rehabilitated areas through to a standard that meets regulatory rehabilitation success/completion criteria, and allows for corrective actions to be identified early and implemented when required. The methodologies used in this program are subject to change and improvement, as a result of monitoring learnings, technological advances, and scientific advances.

The rehabilitation goals for CCO are to:

- Create a site that is safe, geotechnically stable, does not cause environmental harm, and is able to sustain an agreed post-mining land use;
- Comply with all statutory requirements and attain regulatory consensus on the successful closure and rehabilitation of the site; and
- Develop a concise and targeted rehabilitation data set using scientifically robust and repeatable methods which demonstrate compliance with pre-determined success criteria and support relinquishment of all environmental and social approvals.

From these overarching goals, rehabilitation objectives and success criteria are developed to objectively and quantitatively demonstrate progress and ultimate success of rehabilitation, and to identify any areas that are at risk of failing from a stability, safety, and sustainability perspective.

In order to standardise the quality and success of rehabilitation across GCAA sites, a company-wide approach to monitoring and assessing rehabilitation performance was developed by Erskine and Fletcher (2014, 2015). Development of the CCO rehabilitation monitoring program has been guided by this methodology. The methodology stipulates annual monitoring of rehabilitated areas to assess the performance of the rehabilitation against proposed success criteria, and to identify areas requiring maintenance and aftercare.

2. Monitoring Program

2.1 Overview

The program involves a combination of spatial and GIS-based planning processes combined with field monitoring techniques, and post-processing of field monitoring results for analysis and management decision-making.

An overview of the four key steps is provided below:

- Pre- field monitoring works: office-based pre- planning using geographic information system (GIS) software, confirming site rehabilitation polygons and metadata are correct, slope assessments against stipulated criteria, persistent bare ground assessments, and random allocation of locations for new transects;
- Field monitoring: on the ground monitoring which involves transect based monitoring, habitat complexity assessments, slope assessments, soil sampling and rapid rehabilitation assessments;
- Analysis an devaluation to visualise and map the rankings; and
- Results and remedial actions.

2.2 Indicators and Criteria

A set of rehabilitation monitoring indicators that are utilised to assess against success criteria were selected by considering:

- Rehabilitation objectives at different Glencore mines;
- Previous work and historical rehabilitation results in the Bowen Basin and by other mines; and
- CSIRO (1999) defined ‘characteristics of a good indicator’.

As a result of this selection process, a variety of indicators were assessed and scored against the CSIRO (1999) guidelines before selecting the following:

- Slope;
- Erosion;
- Soils (pH, EC, CEC, chloride, sulphate, ESP, dispersion);
- Ground cover;
- Species richness;
- Structural composition;
- Native species recruitment;
- Weed species recruitment;
- Resilience to disturbance; and
- Fauna habitat complexity.

Success criteria were selected by considering:

- The proposed PMLU;

- The conditions of EA EPML00634113, approval conditions, EIS commitments and other regulatory requirements;
- Existing ecological and environmental monitoring data;
- Relevant government or industry guidelines, standards and scientific literature;
- Surrounding environment and land uses;
- Outcomes of stakeholder consultation and stakeholder expectations; and
- Any specific risks that may apply to the operation.

The monitoring program seeks to provide an age and land use normalised assessment of rehabilitation progress such that a single map is able to convey site compliance with fundamental rehabilitation requirements of safety, stability and sustainability (Erskine & Fletcher, 2015). Overall, mature rehabilitation critical values represent the minimum sustainable values for the monitored indicators under the agreed PMLU.

2.3 Reference Sites

Rehabilitation success can be assessed using comparative reference sites, or analogue sites. However, as Erskine & Fletcher (2014) note, it remains difficult to select appropriate reference communities to compare to rehabilitated mine-sites because of the changes to hydrology, topography and geology of an area from the mining process. Stripping and stockpiling soil for rehabilitation also negatively alters a range of soil properties (e.g. soil structure, nutrients, organic matter, permeability) and these changes affect both the establishment of vegetation communities and plant species composition over time. As a result, no analogue sites are available that closely resemble CM's batter slopes (i.e. black alluvial soils placed on slopes). However, reference sites are still useful for comparative purposes but the targeted proportions of the revegetation (in comparison to the reference sites) have been reduced in the success criteria to reflect the expected reduced height, biomass and cover characteristics of vegetation communities on slopes.

2.4 Field Assessment

Field assessment is undertaken as follows:

- Monitoring sites are located within appropriately placed locations (typically randomly generated) at a density suitable for mapping at the chosen scale. Monitoring sites are of a size that captures the majority of species presence and cover variation within the locale;
- In accordance with a previous EA, in 2014/2015, twelve reference sites were established within four REs previously (and still) occurring on the CM site (McCaffrey et al. 2015). Three reference sites within grazed land in the area (P01-P03), and six reference sites within bluegrass dominant grasslands (T1-T6) have since also been established. ***Table 4-1*** indicates how these reference sites will guide revegetation efforts. ***Figure 2-1*** shows the location of the reference sites. The methods for monitoring reference sites is the same as that used for the annual rehabilitation monitoring, facilitating meaningful comparisons with rehabilitated areas. Reference sites are initially monitored every two years. When clear trends have been established, monitoring frequency reduces to once per five years;
- Rehabilitation monitoring, reporting, and review occurs at CCO on an annual basis, ensuring that all completed rehabilitation is monitored 1, 2, 5 and 10+ years post rehabilitation. The early stages of monitoring (years 1 and 2) are primarily concerned with initial emergence and establishment of vegetation, and early signs of erosion. Monitoring at year 5 helps to assess the survival and establishment of tree seedlings and demonstrate sustainability for a light grazing.

Absence of critical species or levels of biodiversity at this time may trigger action including re-seeding, tube-stock plantings, soil sampling and perhaps addition of soil amendments. Sites that have reached the final age bracket (10+ years) are able to be directly assessed against the success criteria. Rehabilitation that is at this level of maturity and meets the success criteria should be of a standard that allows certification with regulators. The historic rehabilitation areas at TLO (legacy sites) have been subject to 5-yearly monitoring. These areas are covered in regenerating woodland vegetation;

- Monitoring is generally conducted between March and June (post wet season) to enable accurate identification of species, and to understand the impact of surface water movement across the rehabilitated landscapes following the wet season. This timing also allows for any required remedial actions to be completed before the following wet season; and
- Groundwater, surface water, contamination, and any other geotechnical monitoring and assessments have not been included in the rehabilitation monitoring program. These components are conducted separately under the EA and other regulatory requirements.

Table 2-1 - CCO Reference Transects and RE/TEC

Reference Site	RE/TEC	Description	Guidance for PMLU (Mine domain)
CL02, CL04, CL06	RE 11.3.3	*Eucalyptus coolabah* woodland on alluvial plains (Coolibah woodlands)	Water Management (Riparian)
CR1, CR2, CR3	RE 11.4.8	*Eucalyptus cambageana* woodland to open forest with *Acacia harpophylla* or *A. Argyrodendron* on Cainozoic clay plains (Dawson gum woodland)	Woodland and light grazing (Dump tops)
SLI01, SLI02, SLI03	RE 11.5.3	*Eucalyptus populnea* +/- *E. melanophloia* +/- *Corymbia clarksoniana* woodland on Cainozoic sand plains and/or remnant surfaces (Silver-leaved ironbark)	Woodland and light grazing (Dump tops)
CL01, CL03, CL05	RE 11.11.1	*Eucalyptus crebra* +/- *Acacia rhodoxylon* woodland on old sedimentary rocks with varying degrees of metamorphism and folding (Narrow-leaved ironbark)	Woodland and light grazing (Batter slopes)
T1-T6	RE 11.8.11 TEC	*Dichanthium and Astrebla* grasslands on igneous rocks (RE 11.8.11) and Natural Grasslands of the Central Queensland Highlands and the northern Fitzroy Basin TEC (Grassland dominated by *Dichanthium*)	Nature conservation (Bluegrass)
P01-P03	N/A	Actively grazed land	Woodland and light grazing

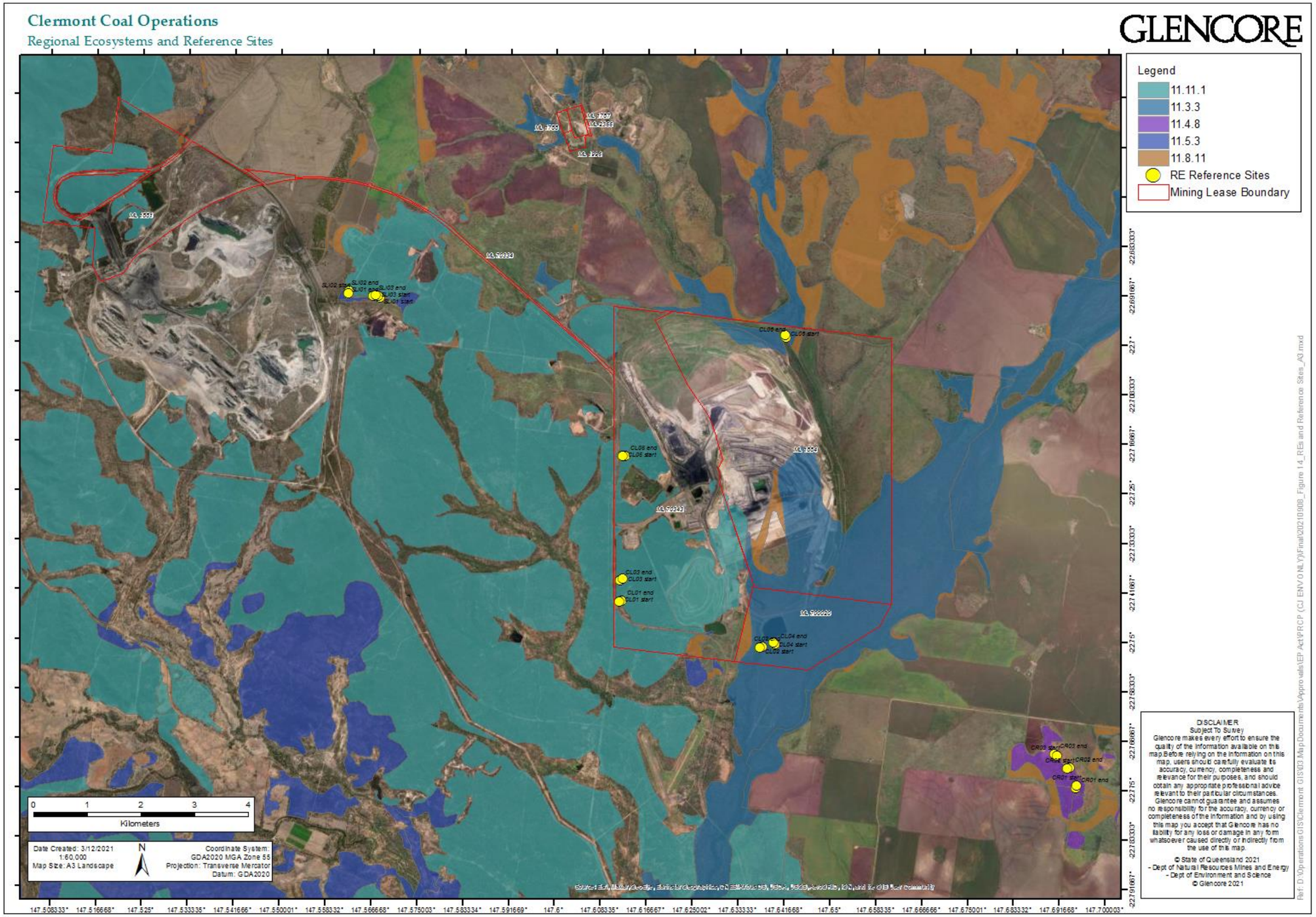

Figure 2-1 Regional Ecosystems and Reference Site Locations

2.5 Data Analysis

2.5.1 Field Data

The monitoring methodology assesses the field recorded values against agreed minimum targets for safe, geotechnically stable and sustainable values (critical criteria), creating a score for the rehabilitation. GIS figures are generated that visually demonstrate the status of the rehabilitation.

As listed previously, the key indicators assessed are as follows:

- Slope – assessed in the first two years following rehabilitation establishment and reported in percent against agreed construction values. This is one of the primary assessments for stability and safety;
- Erosion – scored as outlined in previous section. As for slope, this is a primary assessment for stability and safety;
- Cover - vegetation projected cover is a factor in suitability for light grazing;
- Biomass - productivity is critical in assessing the value of pasture for light grazing outcomes;
- Weeds – declared weeds only (presence/absence);
- Biodiversity (total, native) – total biodiversity represents the total number of native and exotic plant species present (but excluding declared weeds), whereas native biodiversity excludes all exotics;
- Tree height - mean tree height within transects compared against that of reference sites. Trees need to achieve sufficient size to withstand fire and drought; and
- Tree density - density of tree species compared against reference site values.

Using a scoring system, performance of each rehabilitation area is rated against critical values as one of the following:

- Exceeding or better than critical requirements;
- Within a margin of error of critical requirement and less than critical requirements; and
- Failing against minimum standards.

Taking PMLU and age of rehabilitation into account, rehabilitation scores are then used to assess the status of the rehabilitation, using the following categories:

- Rework required (red);
- Maintenance required (yellow);
- Continue to monitor (light green); and
- Acceptable (dark green).

LiDAR data and soil chemistry laboratory results are also analysed in concert with the field data.

2.5.2 Soils Data

The amount/presence, type and quality of growing medium used in rehabilitation has great influence on vegetation establishment, and therefore on rehabilitation success. In relation to soil chemical properties in rehabilitation areas, the ideal criteria to be achieved are listed in ***Table 2-2***.

Table 2-2 - Ideal Criteria for Key Soil Chemical Properties

Parameter	Land use – Grazing	Land use – Woodland
pH	5.5 – 7.5	5.0 – 8.5
EC (µS/cm)	< 700	< 700
Sulphates (mg/kg)	5 – 10	5 – 10
Nitrates (mg/kg)	> 12.5	> 12.5
Kjeldahl Nitrogen Total (mg/kg)	200-1000	200-1000
Phosphorus (mg/kg)	≥ 50	≥ 50
Chloride (mg/kg)	< 350	< 350
Cation Exchange Capacity (CEC) and Exchangeable cations (meq/100g)	>5	>5
Exchangeable Sodium Percentage (ESP) (%)	< 5	< 5
Organic Matter (mg/kg)	2-3	2-3

2.6 Reporting and Review

A report is prepared at the conclusion of each annual monitoring event. The purpose of the annual report is to present an annual update of the rehabilitation progress towards the achievement of PMLU criteria. The results of each additional year of monitoring are compared to those of previous years by showing the trends towards the achievement of the safe, geotechnically stable, non-polluting and self-sustaining PMLU criteria, and recommendations are provided to improve and further support the continued progression of the rehabilitation.

The report may also describe corrective actions/contingency strategies, should these require implementation. These may include one or more of, for example, the following:

- Application of additional soil amelioration;
- Reshaping and stabilisation of erosion features;
- Reseeding and/or replanting;
- Review the seed mix, including species, supplier, viability, application method; and
- Weed and pest management.

The report is reviewed by CCO, for implementation of contingency strategies, as appropriate.

3. Review of Performance

CCO has completed progressive rehabilitation followed by monitoring in the following areas of the CM:

- Northern waste rock dump (NWRD, including the 360 Dump – Plateau);
- Southern waste rock dump (SWRD); and
- South Eastern Waste Rock Dump (SEWRD).

The Train Load-Out (TLO) and Cement Hill (CH) are legacy areas. Of these, the TLO is currently monitored by CCO, based on rehabilitation undertaken prior to CCO ownership. The CH has not been rehabilitated, and no monitoring has been undertaken to date.

The following provides a brief overview of the rehabilitation performance at CM and TLO, based on the monitoring undertaken to date.

3.1 Clermont Mine

The first rehabilitation at CM occurred in 2015, followed by the first monitoring one year later, in 2016. All rehabilitation monitored to date has been assessed against criteria for a native woodland, but noting the following:

- The intention has always been to provide both native habitat and low-level grazing for the disturbed area; and
- Following best practice for revegetating rehabilitated areas (McCaffrey et al., 2015), seed mixes used at CCO comprise a combination of:
  - species characteristic of native vegetation found in surrounding REs; and
  - species typically available from commercial collectors with known success in rehabilitation.

Based on the latest monitoring report (ERM, 2021), within each of the areas monitored (SWRD, NWRD, etc.), there are areas with different stages of maturation. Thus, depending on the specific location monitored, scores will vary with age of rehabilitation. As monitoring locations vary within each area from year to year, comparability of the data for trending purposes is limited in the short term, though it can be expected to improve over time as the age differences between monitoring locations become smaller in proportion to the overall age of the area.

There have also been differences in the methodology applied each year, both with the field sampling and development of the report card itself, adding to this limitation.

Nevertheless, the results indicate that the SWRD, NWRD and 360 Dump – Plateau areas are on a positive trajectory overall, resulting in an ‘Acceptable’ rating for these areas. The SEWRD is tracking as ‘Maintenance’.

There was significant rainfall over the preceding wet season for the 2021 rehabilitation monitoring event compared to rainfall during previous monitoring events, resulting in positive outcomes in terms of cover, biomass and species diversity, and, therefore, in elevated scores for this year. It indicates the importance of rainfall for vegetation growth. It also indicates the importance of continued monitoring to put in perspective the year-on-year variability that may occur as a result of short-term changes in environmental conditions. It is suggested that no less than three consecutive monitoring events return an ‘Acceptable’ score prior to obtaining certification.

3.2 Legacy Areas

These are areas of CH and the TLO which are no longer active, or where rehabilitation has been carried out by previous owners. An assessment of these areas conducted in 2016 (AECOM, 2016b) concluded the following:

- No areas within CH were considered to be rehabilitated, with this entire area (approximately 36 ha) to be incorporated into the rehabilitation schedule; and
- A significant proportion of the areas within the TLO should continue to be considered as completed rehabilitation, and monitored accordingly under the annual monitoring process.

3.2.1 Cement Hill

The Historical Rehabilitation Assessment (AECOM, 2016b) found that no areas within the CH mining lease appear to have been intentionally rehabilitated, with the current vegetative cover likely to have resulted from natural recruitment of colonising plant species. Several landforms were found to contain some steep, eroding slopes that need to be reshaped to a geotechnically stable final landform. A full geotechnical assessment and LiDAR analysis of the landforms was recommended to determine the overall stability of the landforms, particularly adjacent to the gazetted road where the greatest risk to infrastructure and the public exists. Historical tailings dams and material handling areas were identified as having the potential to contain legacy contamination, and investigations were recommended to ensure that potential contamination risks are managed. Stabilisation, and establishment of an adequate native vegetative cover, was recommended for areas at the base of dams where soils are dispersive, and potentially subject to tunnelling.

Material and contaminated land investigations were undertaken to address the concerns around legacy contamination (RPS, 2014; SLR, 2017; and SLR, 2018), and no contaminants of concern (CoC) were identified at concentrations exceeding nominated investigation levels. However, soils were found to be alkaline and amelioration will be required.

A more detailed investigation of the area, undertaken in 2019 and involving the collection of groundwater and surface water samples, material from test pits, and general observations of site features (KBR, 2019), confirmed the findings of AECOM (2016b) around stability of landforms and stabilisation of soils.

Thus, while some areas of CH have adequate naturally established vegetation cover and stabilised landforms, there are some areas, particularly to the east and south of the void, and the eastern section of the tailings dams, that will require rework to stabilise the landforms, to ameliorate the soils, and to establish a suitable vegetative cover.

3.2.2 Train Load-Out

Rehabilitation occurred within part of the TLO prior to GCAA ownership, from 1984 to 2008, resulting in current rehabilitation ages ranging from 10 to 30+ years. Information on TLO rehabilitation monitoring prior to 2008 is no longer available. However, Landloch undertook monitoring until 2015, when the current monitoring process was developed and subsequently implemented.

Though AECOM (2016b) found that the rehabilitation at the TLO is established, some areas of erosion were identified. These problematic areas exist largely within the 1999, 2000 and 2001 rehabilitation, which contain black cracking soil placed over tunnel-prone white spoil, supporting limited vegetation diversity (predominantly *Acacia* spp.). Species diversity and abundance show little similarity to those observed at reference sites (AECOM, 2017). Additionally, despite the establishment of vegetation, limited litter is present, resulting in poor soil surface stability and nutrient cycling indices (Landloch, 2008; AECOM, 2017; and AECOM, 2019).

The latest monitoring at TLO occurred in the 1999 rehabilitation area (AECOM, 2019). Landforms appeared stable but significant tunnel erosion features were detected, though the extent of these erosion features was not quantified. Geotechnical assessment and LiDAR analysis have assisted in identifying the requirements for remediation and rehabilitation (AECOM, 2016b).

Scores from 2020 and 2021 monitoring resulted in a “continue to monitor” designation for most areas, with two areas requiring “maintenance” based on the erosion and biodiversity indicators. Whilst the TLO revegetation appears to be well established in general, the following is noted:

- These areas are unlikely to meet contemporary requirements for biodiversity. They were rehabilitated in accordance with success criteria/critical values existed prior to the ownership change to GCAA; and
- Tunnel erosion is evident in areas across the rehabilitation.

At a minimum, major gullies should be identified, repaired, revegetated and monitored to reduce the potential risk of increasing erosion and slope failure. Stabilising the soil and subsoil is critical to ensure these areas can be relinquished upon closure. This can be done through the application of gypsum to prevent clay dispersion and tunnelling, and of fertiliser to improve vegetation cover. Areas with cracking clay surfaces, such as those present in the rehabilitation, are dependent on vegetation establishment for erosion stability (Landloch, 2008).

A consideration of acceptable closure targets for historical rehabilitation is required, as further re-seeding/planting of desired native species may be required to achieve relinquishment.

3.3 Reference Sites

The reference site monitoring completed since 2015 indicates that average reference sites’ biodiversity composition is approximately 88 percent native species, and the habitat has 30-70 percent tree canopy as well as 30-70 percent shrub canopy, with varying levels of ground cover, litter/ rocks and free water availability.

To provide comparable data for a light grazing PMLU, grazing reference sites were established in 2021 (P01-03). Given the recent establishment of these reference sites, time-series analysis cannot be undertaken at this stage.

4. Summary

Identifying the most appropriate PMLUs is a dynamic process open to new opportunities as they present themselves during the rehabilitation and closure planning process. The final landform and rehabilitation at CCO is designed to create a site that is safe, geotechnically stable, does not cause environmental harm, and is able to sustain an agreed PMLU.

The current concept proposes a woodland and light grazing PMLU across most of the rehabilitated areas of the CCO. The rehabilitation monitoring methods as used by CCO, and the results obtained during rehabilitation monitoring undertaken at CCO to date, support the achievement of this PMLU.

5. Document Information

Reference	Title
AECOM (2016a)	Clermont Rehabilitation Monitoring 2016, Summary Report.
AECOM (2016b)	Clermont Historical Areas Rehabilitation Assessment Report, Blair Athol and Cement Hill.
AECOM (2017)	Clermont Open Cut Rehabilitation Monitoring 2017, Summary Report.
AECOM (2019a)	Clermont Coal Operations Monitoring Event Summary Report 2019, Summary Report.
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Rayment, G.E., and Higginson, F.R. (1992).	Australian Laboratory Handbook of Soil and Water Chemical Methods. Australian Soil and Land Survey Handbooks Vol. 3. Inkata Press, Sydney, NSW.
RPS (2014)	Clermont Coal Operations Phase 1 Contaminate Land Assessment, document number PR124013-1, October 2014.
SLR (2017)	Targeted Soil Sampling and Analysis Report, document reference 620.11234.00400, July 2017.
SLR (2018)	Contaminated Land Delineation Clermont Open Cut, document reference 626.10461-R02, May 2018.

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Appendix 4.4 - Geotechnical Assessment

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1. Executive Summary

Clermont Open Cut is preparing a Progressive Rehabilitation and Closure plan (PRCP) and this geotechnical report is required to address geotechnical safety and stability considerations for the PRCP. Clermont Open Cut is also required as a condition of its Environmental Authority to prepare a geotechnical report that describes the geotechnical conditions applying to the last five years of mining operations prior to closure.

This report provides a background to the Clermont Open Cut mining operation, and to two other mining lease areas that are also covered by the PRCP, at Cement Hill and at the Blair Athol Northern Diversion Drain (NDD). The context of the PRCP requirements is discussed. Requirements and constraints are outlined, including proposed slope criteria for final landform slopes, information regarding the final void surface area, and the specific circumstances applying to Cement Hill and the Blair Athol NDD.

Summary findings and recommendations are provided for all of the mining lease areas and are briefly described here as follows.

The West Wall geotechnical conditions vary greatly, and the thickness of spoil backfill buttressing is likely to range from significant to nil because of the mine development path. The part of the West Wall slope where weathered metamorphics are already and in future will be exposed requires flattening of the upper slope to improve long-term stability, but the extent of this treatment may have to be weighed against potential slope crest encroachment near the Western Drain.

The final South Wall slope profile is the closest part of the planned final void to the elevated post-mining landform that will provide flood exclusion to the nearby Gowrie Creek. The South Wall profile will require further design and stability analysis to achieve acceptable operational stability, and is likely to require additional spoil backfill buttressing to achieve stability acceptance criteria for post-mining landform conditions. For the final South Wall, piezometers will need to be installed to adequately understand the groundwater pressure regime and the changes that might occur in response to flooding in Gowrie Creek.

The planned East Wall slope profile will also require further design and stability assessment to achieve acceptable operational stability, and it is anticipated that this will require progressive spoil backfill buttressing as the pushbacks advance southwards to expose further sections of the East Wall. Additional treatments may be required to achieve acceptable post-mining landform stability, including reducing the inter-ramp angle above the 206 mRL haul road bench and providing additional spoil backfill buttressing. A significant uncertainty currently exists regarding the presence and influence of a weak shear at the WL ply level below the planned East Wall toe level. Additional exploration drilling is required to adequately identify and characterise this feature. The current level of uncertainty applies equally to the mining and post-mining slope conditions.

The East Out-of-Pit Dump, and elevated earthworks between the South Wall and the Gowrie Creek floodplain, will provide flood exclusion for the final void following decommissioning of the current levee. There are not expected to be any significant impacts of a creek flood on the spoil dump or earthworks because the flood exposure time is short relative to the infiltration time of a flood wetting front.

The low wall dump will be reshaped to a planned post-mining landform with a profile design based on erosion control considerations, with geotechnical safety and stability not likely to be significant concerns.

The Cement Hill landforms are geotechnically safe and stable in their current condition. Reshaping could be readily undertaken if considered necessary, and no formal geotechnical assessment would be required.

The Blair Athol NDD batters are geotechnically safe and stable in their current condition. Degradation, weathering, and erosion processes are likely to continue at currently low rates. Batter flattening to achieve erosion control criteria are likely to be counterproductive because of unavoidable disturbance and lack of suitable armour stone.

2. Introduction

Clermont Open Cut is operated by Clermont Coal Operations Pty Ltd (CCO) under the management of Glencore Coal Assets Australia (GCAA). Wherever relevant in this report, the acronym CCO will be used to reference the mining operation and its management structure as appropriate. Relevant details of the site facilities, history of development, geological, topographic, and mine operational conditions relevant to this geotechnical assessment, and life-of-mine plans are provided elsewhere in the PRC Plan.

The intended post-mining landform will comprise reshaped out-of-pit and in-pit dumps and remnant excavated slopes including a final void. Surface drainage features will be designed as fit-for-purpose for all slopes. A long-term water pond is expected to develop within the final void.

This geotechnical assessment report considers the geotechnical safety and stability of the pit slopes in the current life-of-mine plan and provides recommendations for slope treatments to achieve a range of acceptance criteria for post-mining landforms. This report is also intended to form the basis of the Final Void Geotechnical Report that is required under Condition H7 of the CCO Environmental Authority (Queensland Government, 2021).

Geotechnical considerations are also presented for two other post-mining landforms that form parts of the CCO mining leases outside of the Clermont Open Cut operational area:

- Cement Hill (ML 1787, ML 1788, ML 1995, ML 2355), a former gold mining area, that includes a final void with ponded water and adjacent wasted dumps, industrial areas, and former tailings ponds that are now normally dry; and
- Blair Athol Northern Diversion Drain (ML 1881), originally constructed to divert runoff around the Blair Athol Open Cut, and now forming a post-mining surface drainage feature.

3. Context

This report addresses the objectives of Condition H7 of the CCO Environmental Authority (Queensland Government, 2021). It also addresses relevant geotechnical aspects of the CCO PRC plan process as described in the regulatory guideline (Queensland Government, 2019), specifically:

- Waste Characterisation, Landform Design, Cover Design, and Water Management (Section 3.6.1);
- Tailings Storage Facilities (Section 3.6.2); and
- Voids (Section 3.6.3).

The regulatory guideline (Queensland Government, 2019) specifically mentions certification from an appropriately qualified person regarding the following:

- Landform development and re-shaping/re-profiling is stable (RM2);
- Post-mining land use (grazing and/or native ecosystem) has achieved stable condition (RM8, RM9); and

- Achievement of sufficient improvement that the residual void is safe to humans and livestock (MM3).

Such certification will rely upon compliance with recommended slope profile geometries determined from geotechnical stability and safety criteria. A range of slope profiles are set out in this report.

Geotechnical information for planning and development of CCO mining operations has been generated since well before commencement of mining. Additional geotechnical information has accumulated as mining has progressed. For mine operational planning and risk management purposes, the body of geotechnical knowledge is gathered into a Geotechnical Reference Report (GRR) and supplementary Geotechnical Design Reports (GDRs) that are issued from time to time as conditions or interpretations change. During 2020 a sequence of excavated wall instability incidents resulted in significant re-evaluation of geotechnical design for the South Wall in particular. From early 2021 this re-evaluation has been extended to the West Wall and East Wall geotechnical designs.

This geotechnical assessment is based on the CCO geological models and operational life-of-mine (LOM) plan current in effect from early- to mid-2021. Geotechnical shear strength and hydraulic conductivity parameters differ in minor respects from those recommended in the current GRR issued in October 2021 (Sherwood Geotechnical and Research Services, 2021). These differences are not significant to any of the safety and stability outcomes that are reported here.

In making this assessment, safety and stability acceptance criteria that are applicable to operational conditions differ in several respects from criteria to be applied to long-term post-mining landform conditions.

4. Requirements and Constraints

4.1 Proposed Acceptance Criteria for Clermont Open Cut Final Landform Slopes

4.1.1 Operational Safety and Stability Acceptance Criteria

Clermont Open Cut is a large-scale single pit operation comprising multiple areas of excavation and waste dumping. Acceptable operational slope safety includes consideration of both controlled and uncontrolled ground movements. This is achieved by development and application of a safety and health management system that is intended to satisfy relevant statutory and GCAA requirements.

The short-term nature of the operational pit slopes combined with the existing knowledge of material strengths and groundwater pressures means that acceptable slope stability is achieved by demonstrating a 2D limit equilibrium computed Factor of Safety (FOS) of 1.20 or greater (GCAA, 2018). Despite the general discussion and recommendations found in pit slope design texts (Read & Stacey, 2009; Beale & Read, 2013; Hawley & Cunning 2017; Martin & Stacey 2018), the general acceptance by open cut coal mine operators and regulatory authorities is that the FOS ≥ 1.20 criterion is acceptable for routine operational slopes, with higher FOS thresholds being required for specific circumstances involving consequences to external parties or to business budgets.

4.1.2 Post-Mining Safety and Stability Considerations

Achievement of acceptable slope safety and stability for post-mining landforms requires a different approach for several reasons, ranging from geotechnical considerations to perception limitations regarding future physical conditions and social attitudes. All landscapes are subject to

geomorphological processes (Schor & Gray, 2007) that act over timescales ranging from the short-term (erosion from a single rainfall event) to the very long-term ("geological time" over which mountain building and basin evolution occur). Geomorphological processes also act over a wide range of physical scales. Society currently places ranges of values on natural and constructed landscapes. These values have changed in the past and will change in the future.

Post-mining landform safety is not defined in statute but can be implied by applying the same risk management principles and meanings that are incorporated in current statute. Risk assessment may be applied to intended post-mining landscapes by identifying hazards and consequences and applying the same inferred likelihoods that are currently applied to landscapes surrounding proposed post-mining landforms. An acceptable level of safety would therefore correspond to likelihoods as low as reasonably achievable, based on observable conditions and reasonable predictions.

Post-mining landform stability can be difficult to define because it is technically meaningless unless the following geomorphological processes are both accepted and included:

- Material degradation resulting from physical and chemical changes (weathering);
- Erosion resulting from physical actions of wind, rainfall, and rainwater runoff and drainage; and
- Geotechnical slope instability resulting from actions of gravitational and other loadings for which the material strengths do not provide adequate resistance for a potential mechanism deforming under prevailing groundwater pressure conditions.

4.1.3 Post-Mining Landforms and Degradation and Erosion Processes

Degradation and erosion are inevitable over geomorphological timeframes, even where reasonable erosion protection can be provided. The easiest analogy is a river valley draining through hilly terrain, which may include cliff lines if suitable geological conditions and erosion rates are present. For such conditions, degradation and erosion processes are ongoing and accepted by the wider community as "normal" and reasonable. Degradation and erosion processes will impact post-mining landforms in ways that are predictable either in a qualitative or quantitative sense. The earliest stages of these impacts can be observed on pit slopes where no active mining activities have occurred for some time.

For the purposes of this report, it is proposed that statements regarding the impacts of degradation and weathering be provided in reasonable detail, and assessed using the same standards that the wider community currently applies to the landforms surrounding the subject post-mining landform.

4.1.4 Post-Mining Landforms and Geotechnical Instability Processes

Geotechnical slope instabilities are mass-wasting geomorphological process events that occur quickly relative to degradation and erosion timeframes. An instability event is a landform disturbance that will trigger accelerated erosion and contribute to ongoing degradation, erosion, or even future instability events. Slope stability assessment requires adequate knowledge of:

- Slope and material distribution geometries;
- Geotechnical strengths of all materials; and
- Groundwater pressure distributions.

For a defined post-mining landform, uncertainties in slope and material distribution geometries will exist within acceptable bounds that should not significantly impact the outcomes of stability calculations. In this respect, operational and post-mining conditions are similar, provided that the geomorphological evolution of the planned post-mining landform is reasonably understood.

Geotechnical strengths are accepted as being somewhat uncertain, arising from questions of representative sampling and testing, test result interpretation and application, and natural spatial

variability. Current stability analysis codes have the facility for specifying such variability in terms of mean and standard deviation values for strength parameters. In practical usage, this capability implies that material strength parameters are independent variables that are normally distributed. This is both technically incorrect and potentially misleading in application.

There is no convincing physical evidence or accepted theory that geotechnical strengths change with time. Within the open cut coal mining industry the overwhelming weight of observational evidence (in terms of areas of stable versus unstable slopes created) is for short-term operational slope stability to be followed by indefinite post-mining stability, subject to the impacts of degradation and erosion processes. This evidence means that observationally stable slopes that satisfy operational stability acceptance criteria will almost inevitable remain observationally stable in future. This evidence also implies that the actual inherent variability of geotechnical strengths is not likely to significantly influence the likelihood of future final landform stability.

Groundwater pressure distributions are also uncertain at the best of times, but are also subject to much less observational evaluation than slope deformation stability. Despite this, there is no convincing physical evidence or accepted theory that hydraulic conductivities change with time. It follows that the allowances for groundwater variability that are implied in operational slope stability assessment should be equally implied for post-mining stability assessment, subject to the impacts of degradation and erosion processes.

Greater uncertainty regarding post-mining landform geotechnical stability is therefore unavoidable to the extents that:

- Impacts of degradation and erosion can only be estimated over a future long time period based on limited experience over the cumulative operational time period; and
- Longer-term geotechnical strength and groundwater pressure conditions resulting from the impacts of degradation and erosion may vary more greatly than has been experienced within the timeframe applying to the open cut mining operation.

It is therefore reasonable to consider applying, as one component of a range of post-mining stability acceptance criteria, a requirement for FOS to be greater than 1.2 to cover the potential impacts of the greater uncertainty. Adoption of a single FOS acceptance threshold to represent all possible impacts on a wide range different slope conditions is unrealistic because the behaviours of some slopes and materials are better understood than for others, and the consequences of instability will also range widely. The consequences for a particular slope will be documented as part of the safety assessment. The likelihoods will depend on the certifying geotechnical specialist's understanding of the strength and groundwater pressure uncertainties.

It is proposed that the assessor be allowed the flexibility to assign an appropriate FOS acceptance criterion for each relevant slope situation. The adopted FOS acceptance criterion must be documented as part of the assessment process, together with a succinct summary of the justification for selection. For guidance, a FOS acceptance threshold ranging from 1.3 to 1.5 could be considered, depending on observations of slope performance over time and the assessed impact of uncertainties on identified instability consequences.

Irrespective of the adopted acceptance criterion, the assessment should also identify the distance behind proposed post-mining slope crest lines where a minimum FOS of 1.5 or greater would apply. This distance, corresponding to a widely-recognised long-term stability criterion applicable to non-mining projects, should be provided for guidance regarding any exclusion or notification measures to be applied to the post-mining landform crest line.

4.1.5 Proposed Post-Mining Landform Safety and Stability Acceptance Criteria

Post-mining landform safety will be assessed as the outcome of a risk assessment and management process applied to the intended post-mining landform(s) by identifying hazards and consequences and applying the same inferred likelihoods that are currently applied to existing landforms in similar geological conditions surrounding the intended post-mining landform(s). The acceptable level of safety will correspond to as low as reasonably achievable, based on observable conditions and reasonable predictions by credible persons. Risk management controls would be referenced in any certification as being reasonably achievable with identified resources.

Post-mining landform stability will be assessed based on determination of an appropriate FOS acceptance criterion for each relevant slope situation. The adopted FOS acceptance criteria must be documented as part of the certification, together with a succinct summary of the justification for selection, and might be somewhat higher than for the operational condition of FOS ≥ 1.20.

The certification statement should also identify the distance behind proposed post-mining slope crest lines where FOS ≥ 1.50 would apply, with this distance being provided for guidance regarding any exclusion or notification measures to be applied to the post-mining landform crest line.

4.2 Proposed Final Surface Area of Clermont Open Cut Void

Determination of the final surface area of the void requires certain assumptions to be made because the post-mining landform varies from the pre-mining landform. Further to this, continued mine planning iterations as the site approaches closure will result in modifications to the detailed landform design for the void. The effective boundary of the final void surface area was generated from the proposed post-mining landform as follows:

(1) Relevant information was reviewed to inform the 'pre-approved' location and extent of the residual void to be retained without a beneficial land use. This informed the maximum allowable final surface area of the NUMA;

(2) Geotechnical performance was considered to understand areas where geotechnical safety and stability considerations warranted inclusion in the final surface area;

(3) An understanding of final void behaviour and performance was considered to determine that the areas likely to form a pit lake in the future were captured within the final surface area of the residual void; and

(4) Other technical and environmental information was considered in determining the likelihood of the void area being unable to support a PMLU.

The extent and location of the residual void as shown in this PRCP should be treated as the approved NUMA, and any need for variation subject to change management to identify regulatory implications.

4.3 Cement Hill (ML 1787, ML 1788, ML 1995, ML 2355)

The Cement Hill leases consist of an undulating landform that includes an excavated void with ponded water, relatively flat former working platforms, and dried-out shallow flat cells containing fines from process screening and washing circuits.

Final landform safety for the Cement Hill leases will be assessed by identifying hazards and consequences and applying the same inferred likelihoods that are currently applied to landscapes surrounding proposed post-mining landforms. An acceptable level of safety would therefore

correspond to likelihoods as low as reasonably achievable, based on observable conditions and reasonable predictions.

All Cement Hill landforms were inspected on 25 November 2020 and assessed to be geotechnically stable as-is, based on physical and visual-tactile observations and further details are provided in Section 10. All surfaces will be subjected to ongoing weathering, degradation, and erosion. Any proposed final landform slopes are extremely unlikely to have significant geotechnical instability hazards. The proposed final landform geotechnical stability criterion is therefore based on experience and prior visual-tactile assessment.

4.4 Blair Athol Northern Diversion Drain (part of ML 1881)

The Blair Athol lease comprises an area of previously rehabilitated mine spoil, the overland conveyor and adjacent access road, landforms including the CHPP stockpile and rail load-out loop, and the Northern Diversion Drain (NDD) which effectively provides a spillway to the West Dam.

Final landform treatment of the NDD presents a geotechnical stability assessment dilemma because decommissioning of the West Dam will result in a significant change to the current channel design flow regime. The current condition of the channel was inspected on 25 November 2020 and assessed to be, for the most part, geotechnically stable as-is, based on physical and visual-tactile observations. Further details are provided in Section 10 below. All related surfaces will be subjected to ongoing weathering, degradation, and erosion. Any significant changes to the NDD and related landforms will disturb a potentially much larger surface area and require disproportionately large areas of reshaped slopes requiring extensive erosion protection treatments

Final landform safety for the NDD would be assessed by identifying hazards and consequences and applying the same inferred likelihoods that are currently applied to landscapes surrounding proposed post-mining landforms. An acceptable level of safety would therefore correspond to as low a likelihood of geotechnical instability as reasonably achievable, based on observable conditions and reasonable predictions.

The proposed final landform slopes for the NDD are extremely unlikely to have significant geotechnical instability hazards. The proposed final landform geotechnical stability criterion will therefore be based on experience and prior visual-tactile assessment.

5. Summary Findings and Recommendations

5.1 Clermont Open Cut Final Post-Mining Landform

The final landform will comprise post-mining treatments of the excavated West Wall, South Wall, and East Wall as well as final re-shaping of the low-wall Dump. For all excavated walls generally, the uppermost 25 m is planned to be chamfered at 45° and this will by default nominally contribute to achieving acceptable safety and stability.

For all excavated walls there will be continuing geomorphological processes of degradation, weathering, and erosion that will act on the slope profile and transport detrital material into the lower void. None of the exposed materials are known to be cliff-forming, therefore the geomorphological processes will, over a period of centuries, eventually result in a much flatter overall slope profile than the planned post-mining landforms slope profile.

During this period of geomorphological adjustment, excavated faces will remain steep enough to present the same safety considerations that currently apply to natural cliff lines on private and public

lands. Acceptable safety should therefore be considered in terms of limiting access to the final void excavated crest lines in the same manner and to a similar extent as currently applies to natural cliff lines.

For all landforms comprising earthworks, either backfill spoil buttresses or dozed blasted ground, the drainage and erosion control requirements will be achieved by a combination of slope profiling and channelised drainage. All slopes constructed in this manner will be subject to long-term settlements which can be empirically predicted. Stability considerations therefore extend to designing the drainage to be tolerant to potential long-term settlements and to remain functional according to the design intent. Settlement cracking can develop in circumstances where the thickness of the spoil varies significantly over a short lateral distance.

Backfill spoil is also subject to potential additional settlement resulting from saturation of the backfill when the water level within the residual void rises. Saturation settlement is a one-time phenomenon that is irreversible and can be empirically predicted. Under some circumstances the saturation settlement process may cause cracking at the ground surface.

Safety considerations for spoil backfill or dozed blasted ground include the likelihood and nature of settlement or saturation-settlement cracking, and also of the potential effects of sinkhole development as a result of concentrated runoff flows into cracked ground, or through dumped but otherwise uncompacted ground that is susceptible to internal piping erosion.

5.2 West Wall

The West Wall will be partly buttressed by spoil backfill during mining operations and will be acceptably safe provided that access to the slope crest edge is adequately controlled to the standards that currently apply in the wider community regarding access to rock cliff lines.

The West Wall will, at the completion of mining activity, be acceptably stable in a geotechnical stability sense consistent with safe mining standards (FOS of 1.20 or greater and/or acceptably managed slope instability risks). The nominal setback distance for FOS=1.5 encroaches on the current Western Diversion Drain for current operational slopes.

A FOS acceptance standard for the post-mining slope that is higher than for the operational slope would require additional batter-flattening treatment at locations where weathered Anakie Metamorphics rocks are exposed. An example batter reduction to 1v:3h that would achieve a FOS of 1.5 is discussed in ***Table 8-1***.

5.3 South Wall

Under current mining plans the final South Wall will require some combination of slope profile modification or buttressing to meet operational stability acceptance criteria. Potential modifications are discussed in Section 6.4 to achieve acceptable stability for operational and post-mining conditions. Post-mining safety will require that access to the slope crest edge is adequately controlled to the standards that currently apply in the wider community regarding access to rock cliff lines, and also provisional on the final landform to the south of the void crest line being elevated to provide acceptable freeboard against future flooding of Gowrie Creek.

The nominal setback distance for FOS=1.5 can readily be determined when the final South Wall profile is designed. For the post-mining slope to satisfy a criterion of FOS=1.5 or greater, additional South Wall treatment will be required, consisting of a minimum spoil backfill buttress bench width of 115 m at 150 mRL as described in Section 6.4.

There is currently uncertainty regarding the groundwater pressure response within the South Wall slope profile to a flood event in Gowrie Creek. It is recommended that one or more piezometers be

included in the mining schedule to be installed adjacent to the planned final South Wall so that this uncertainty is minimised prior to the final operational and post-mining slope profile designs being finalised.

5.4 East Wall

Modifications to the 2021 LOM mining plan are being implemented as outlined in Section 6.5 to achieve acceptably safe and stable East Wall operational slopes.

Operational slope safety is managed using existing site procedures. Post-mining slope safety will be provisional on access to the slope crest edge being adequately controlled to a standard that currently applies in the wider community regarding access to rock cliff lines.

The final East Wall will be acceptably stable based on operational acceptance criteria, expected to include spoil backfill buttressing and a suitable pushback mining sequence. Operational buttressing will be based on resolving uncertainties posed by possible shears within the Permian strata within the wall and below the mining floor horizons. Exploration drilling is being planned and scheduled for this purpose.

The post-mining slope crest setback distance corresponding to FOS=1.5 will be determined based on the actual post-mining slope profile, with additional slope treatment being required to achieve a higher post-mining FOS acceptance standard.

As guidance, to achieve a post-mining FOS=1.5 or greater will require a reduced inter-ramp angle of 33° above the 206 mRL haul road bench and also the provision of a minimum spoil backfill buttress bench width of 70 m at 190 mRL as described in Section 6.5. If future exploration identifies that subfloor shearing is present, the spoil backfill buttress would require a minimum bench width of 195 m at 158 mRL for the example section.

5.5 Low Wall Dump

The final low wall dump landform will be designed to achieve drainage and erosion control acceptance criteria. Geotechnical safety and stability will be acceptable by default, provided that runoff water flow is effectively managed. that consideration is given to the potential magnitudes of post-construction settlements, and that the likelihood of sinkhole formation is acceptably low based on assessment of near-surface materials and the as-constructed surface.

5.6 Cement Hill

The current landforms are geotechnically safe and stable and will continue to evolve under the influence of degradation and erosion processes. Long-term slope safety will be provisional based on access to crest edges being adequately controlled to the standard that currently applies. Recontouring of the site may be readily undertaken if required and no formal stability assessments are warranted.

5.7 Blair Athol Northern Diversion Drain

The NDD consists of excavated batters in weathered metamorphics, coal measures sedimentary rocks, and basalts. All slopes are geotechnically safe and stable in their current condition, with expected levels of ongoing degradation, weathering and erosion. Channel slope flattening in pursuit of erosion control criteria is likely to be counterproductive in terms of increased sediment loads generated by disturbance and challenges in sourcing and placing suitable armouring stone. Long-term slope safety will be provisional based on access to crest edges being adequately controlled to the standard that currently applies.

6. Clermont Open Cut Geotechnical Model

6.1 Geological Conditions and Geotechnical Domains

The CCO coal deposit formed in the localised Wolfang basin at the western margin of the Permian-Triassic Bowen Basin. The basin was subsequently uplifted and eroded until alluvial sediments accumulated in a localised Palaeogene basin that was subsequently overlain by Miocene basalts. ***Figure 6-1*** is a summary stratigraphic column from the GRR (Sherwood Geotechnical and Research Services, 2021).

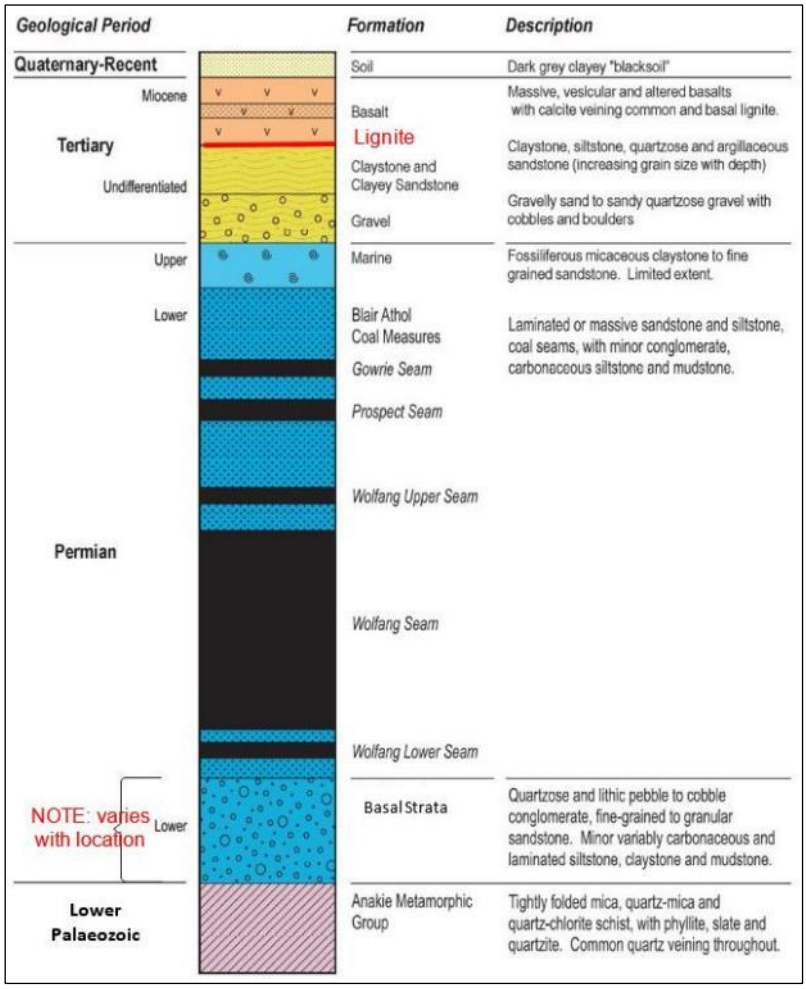

Figure 6-1 - Simplified stratigraphic column for Clermont Open Cut

Within the deposit the coal basin is limited to the north, south, and east by the weathering and erosion of the Palaeogene unconformity. The west margin is a complex zone where the coal basin sediments were originally interfingered with Permian alluvium, colluvium and outwash deposits and subsequently folded and overthrusted by basement metamorphics. The coal basin is completely covered by the Palaeogene-Neogene sequence, which is generally thicker to the east.

6.2 Slope Stability Assessment Methodology

CCO updates the LOM plan on a yearly basis. Slope designs are routinely assessed in accordance with operational acceptance criteria. Intended post-mining designs for excavated slope profiles are not significantly different from the operational LOM designs, with the additional treatment of a nominal

45° chamfer applied to the uppermost 25 m. The post-mining designs for dumped spoil slopes are based on the operational LOM designs but include nominal slope profiles that satisfy pre-determined erosion-control criteria.

2D limit equilibrium stability analyses were undertaken for representative section lines through the post-mining landform as described in detail in Section 5.5 below. The GLE/Morgenstern-Price method for vertical slices as implemented in the Slide2 code (RocScience, 2021) was used for all analyses. Groundwater pressures for stability analyses were modelled using 2D finite element analyses of groundwater flows. Potential circular arc mechanisms were evaluated for conditions where general rock mass or soil strength was judged to control strength mobilisation. Potential multiple-wedge block sliding mechanisms were evaluated for conditions where foliation or weak layer strength was judged to control strength mobilisation.

Stability analysis FOS outcomes were determined for representative sections. Treatments to achieve post-mining FOS ≥ 1.50 were evaluated as a basis for assessing options for acceptance as outlined in Section 3 above.

6.3 Methodology for Action of Ongoing Geomorphological Processes

Considerations for post-mining slope behaviour are outlined in Section 3.1. It is not possible to predict accurately how these considerations will play out over time in specific slope configurations, and therefore only broad generalisations can be made regarding geotechnical safety and stability. The factors that are likely to be manifested over the longer term under the actions of geomorphological processes were considered for each of the representative sections.

Separately, long-term post-mining landscape evolution under the action of geomorphological processes may be simulated using tools such as the Siberia code (Hancock et al, 2010). Any such simulation for CCO is outside the scope of geotechnical safety and stability assessment and is reported separately.

6.4 Information Sources

The geotechnical model for assessing stability for any landform requires relevant and adequate information on material strengths, groundwater pressure conditions, and landform geometry. Additional information regarding the impacts of time-dependent processes is required for a post-mining landform.

Material shear strength information for the Clermont Open Cut final landform was sourced from the available parameter set at the time of assessment, and was essentially the same as currently recommended (Sherwood Geotechnical and Research Services, 2021). Strictly, such information applies to the relatively short-term timeframes of operational mine slopes. There are no currently known time-dependent processes other than weathering, degradation and erosion which would lead to significant strength changes for materials. Some inferences regarding the effects of weathering, degradation and erosion can be made from mine slopes formed in similar materials that have remained exposed over timeframes of months to years.

Groundwater pressure conditions are interpreted using data from operational observation bores and piezometers. Hydraulic conductivity parameters were the most recent available at the time of assessment and essentially the same as the current parameter set (Sherwood Geotechnical and Research Services, 2021). Limited calibration of the hydraulic conductivity parameters against piezometer data was made by approximately matching piezometer data in response to the South Wall instability incident of mid-2020 (Sherwood Geotechnical and Research Services, 2020).

The groundwater level within the mining void during the operational phase will be controlled to a level required for efficient mining. Because the coal deposit geometry reached its deepest extent at P16 - P17, approximately the middle of the pit shell, and because of the ingress of water during the operational phase, the LOM sump water level will include a significant depth of saturated spoil in the middle of the pit shell. Following completion of mining and cessation of pumping from the void sump, the void water level is estimated to rebound to a long-term equilibrium level in the range of 90 mRL to 110 mRL. A level of 100 mRL was adopted for post-mining geotechnical stability assessment purposes. The potential range from 90 mRL to 110 mRL has no significant impact on stability analysis outcomes and acceptability for the 100 mRL level.

Post-mining landform geometry was adopted based on the CCO January 2021 LOM plan. The mid-January 2021 geological model surfaces were adopted, together with reasonable assumptions for surfaces not included in the geological model such as the strata on the west side of the West Wall thrust fault and all non-modelled horizons below the W2 seam floor. In April 2021 the operational geological model for the East Wall was updated to include the interpretations made for the post-mining assessments described in this report.

6.5 Representative Sections

Figure 6-2 is a plan showing the mine landform at completion of mining, as determined in January 2021 for budget and high-level equipment utilisation planning purposes. Also shown are locations of Section Lines 1 – 6, selected for stability assessment on the basis of known geological and geotechnical characteristics to be broadly representative of conditions to be considered for post-mining landform assessment purposes. The geometry of each section line is presented as part of the detailed discussion of stability assessment outcomes in Section 6 below.

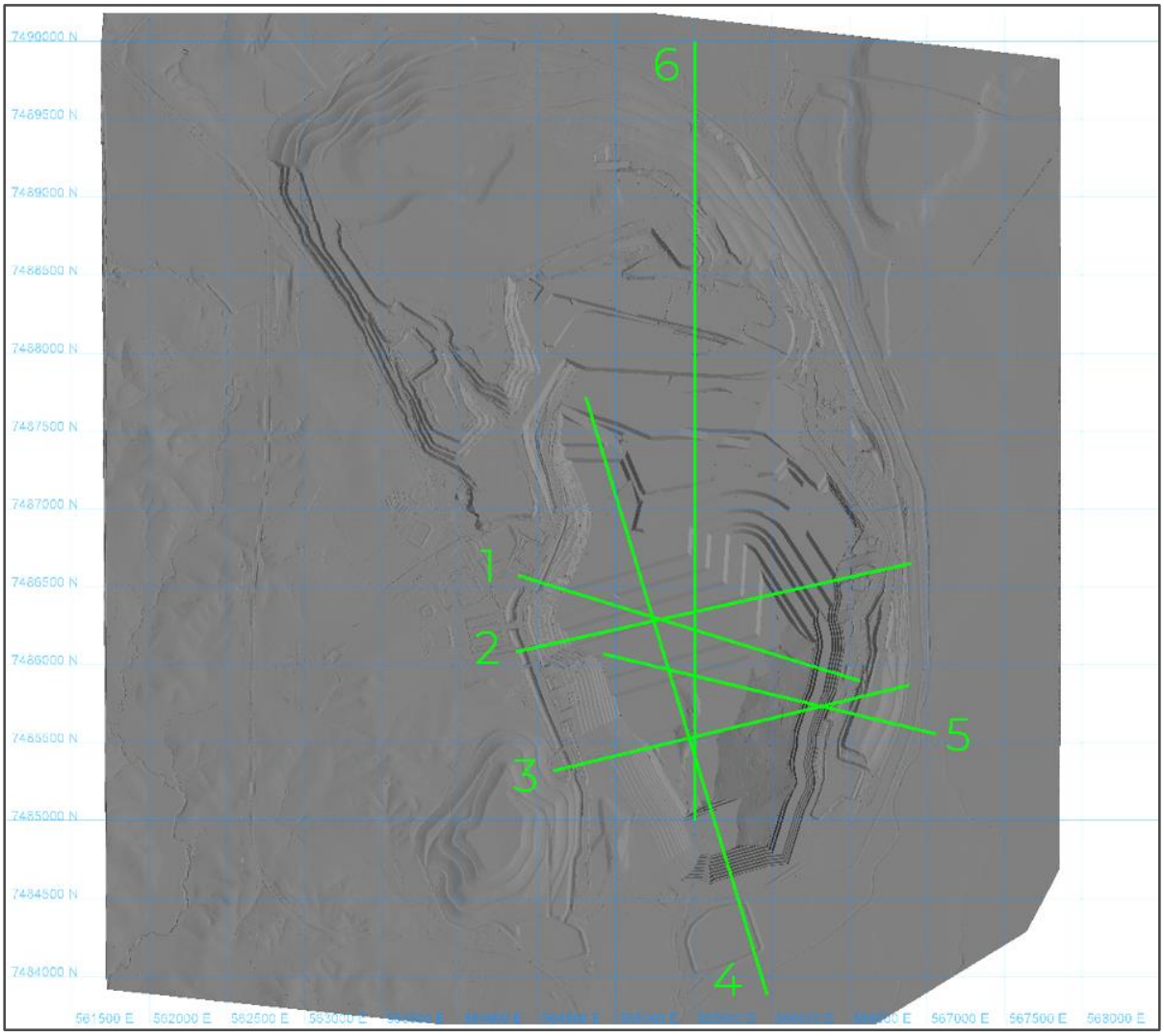

Figure 6-2 - Clermont Open Cut life-of-mine landform plan, January 2021, showing representative Sections 1-6

6.5.1 West Wall

The West Wall is represented by three section lines. Section 1 (***Figure 6-3***) corresponds to conditions where zones of face instability have been experienced during mining, including ongoing fretting of the upper weathered horizons. Risks from the fretting hazard were mitigating by reconfiguring of the Western Drain to minimise seepage inflows to the slope profile. Section 1 also extends to the East Wall.

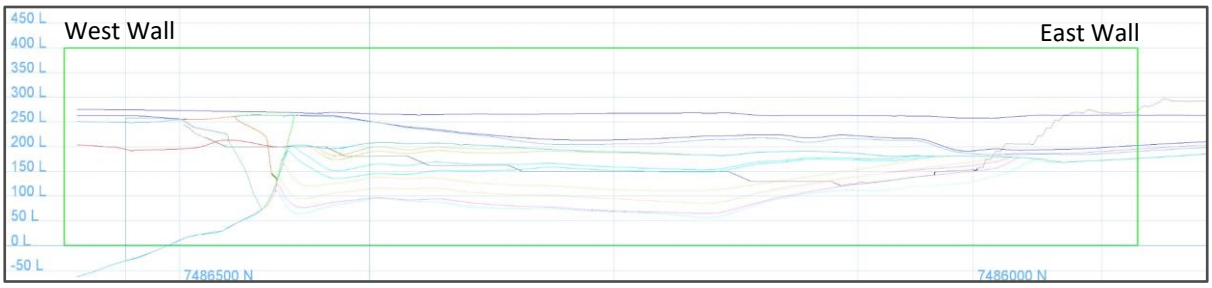

Figure 6-3 - Section 1 West Wall geological model viewed towards north-northeast

Section 2 (***Figure 6-4***) corresponds approximately to the location of the deepest pit profile, as well as being the focus of active mining activities in early-2021.

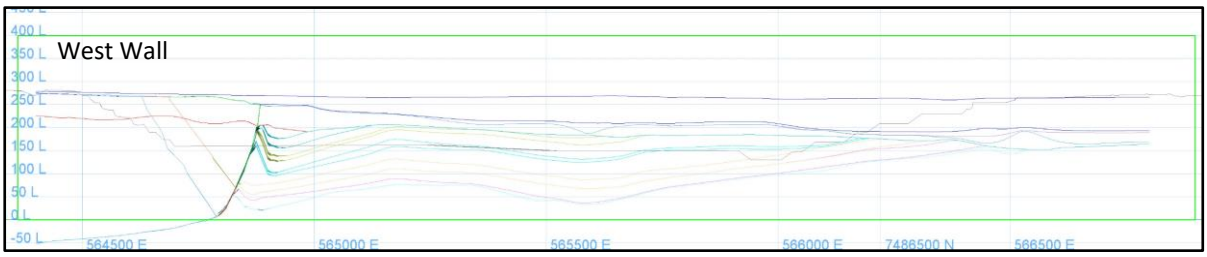

Figure 6-4 - Section 2 West Wall geological model viewed towards north-northwest

Both Section 1 and Section 2 are planned to be partially buttressed by the LOM in-pit dump. Section 3 (***Figure 6-5***), further to the south and not yet mined, corresponds approximately to where the planned West Wall would not be buttressed by the LOM in-pit dump.

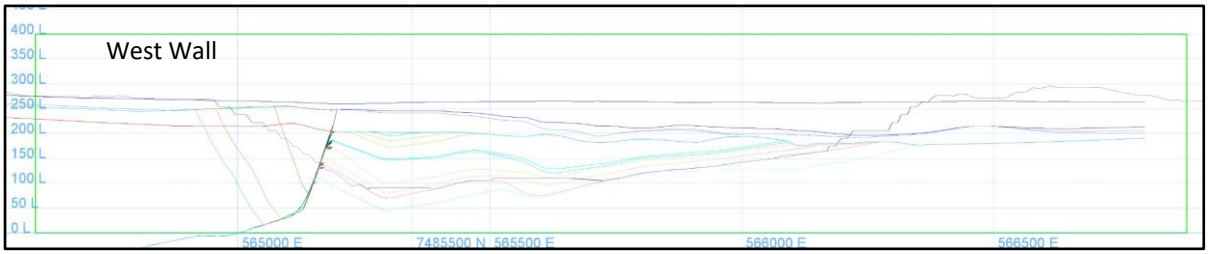

Figure 6-5 - Section 3 West Wall geological model viewed towards north-northwest

A common feature of Sections 1 – 3 is the thrust fault zone adjacent to the West Wall. The geological model is at best approximate for the fault zone, and particularly for the west side of the fault zone and the deeper strata below the target coal interval. While the model is updated regularly for short-term planning purposes, the approximate nature of the model available for this report means that there is a heightened element of geological uncertainty associated with the outcomes of the stability analyses.

Basal strata for the coal seams comprise a Permian conglomerate sequence which is thickest in three areas closer to the West Wall, and which is interfingered with and underlain by a Permian sediment package which is highly variable in thickness and character but typically modelled as a single unit. The basal strata are not fully represented in exploration borehole records but include a highly variable unconformable contact zone comprising the palaeosurface with the basement metamorphics. For groundwater pressure modelling of all sections the basal strata were generally not provided as model surfaces, and therefore the limited available information was used to recreate a geologically feasible basal set based on review of borehole logs.

Basement metamorphics and the basal coal measures strata are variably exposed in the West Wall. The metamorphics include zones of quartzites and phyllites with complex internal deformation. The phyllites exhibit a pronounced foliation which results in directionally anisotropic strength and this exerts a significant control on face stability within both weathered and fresh zones.

6.5.2 South Wall

Section 4 (***Figure 6-6***) corresponds to the deepest part of the planned final South Wall, which will potentially be impacted by seepage conditions for the final post-mining landform after decommissioning of the Gowrie Creek levee. The LOM plan does not include backfill buttressing of the South Wall.

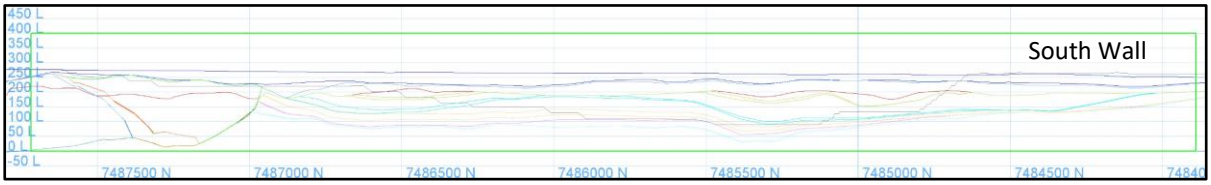

Figure 6-6 - Section 4 South Wall geological model viewed towards east

Basal geological model constraints apply equally to the South Wall model. The coal seams are significantly thinner and tend to be more split towards the south because of basin margin effects. A significant geotechnical uncertainty arises because there are known weak bedding-parallel surfaces within the currently mined coal sequence, but it is not clearly known whether the same weak horizons are present nearer the basin margins. For the purposes of the post-mining assessment, the weak surfaces were assumed to be equally present.

6.5.3 East Wall

Section 5 (***Figure 6-7***) corresponds to a representative location along the final East Wall where the east out-of-pit dump landform will remain in place, and where the LOM plan until recently did not include backfill buttressing of the East Wall.

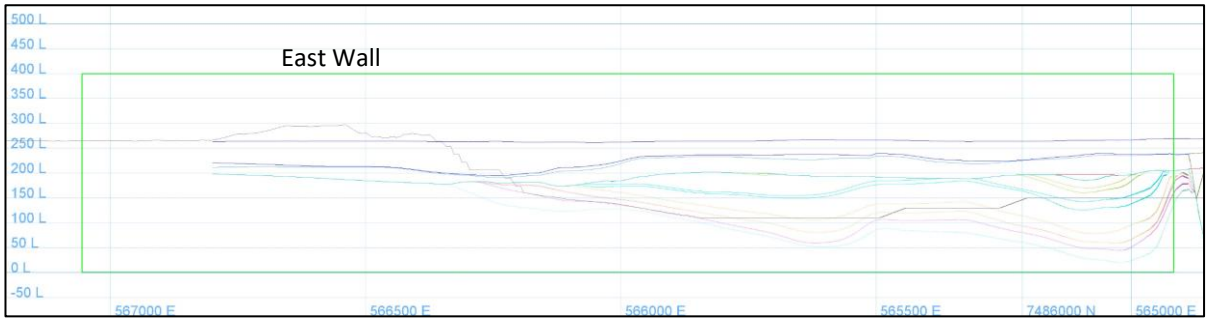

Figure 6-7 - Section 5 East Wall geological model viewed towards southwest

Basal geological model constraints apply equally to the East Wall model. The coal seams are thinner and tend to be more split towards the east because of basin margin effects. Significantly, there is a seam structure dip into the basin. There are known weak bedding-parallel surfaces within the currently mined East Wall coal sequence, but it is not clearly known whether these persist further south. For the purposes of the post-mining assessment, the weak surfaces were assumed to be equally present.

6.5.4 Lowwall Dump (North Wall)

Section 6 (***Figure 6-8***) is representative of the LOM lowwall dump, of which only a component would form part of the significant slopes of the planned LOM final void.

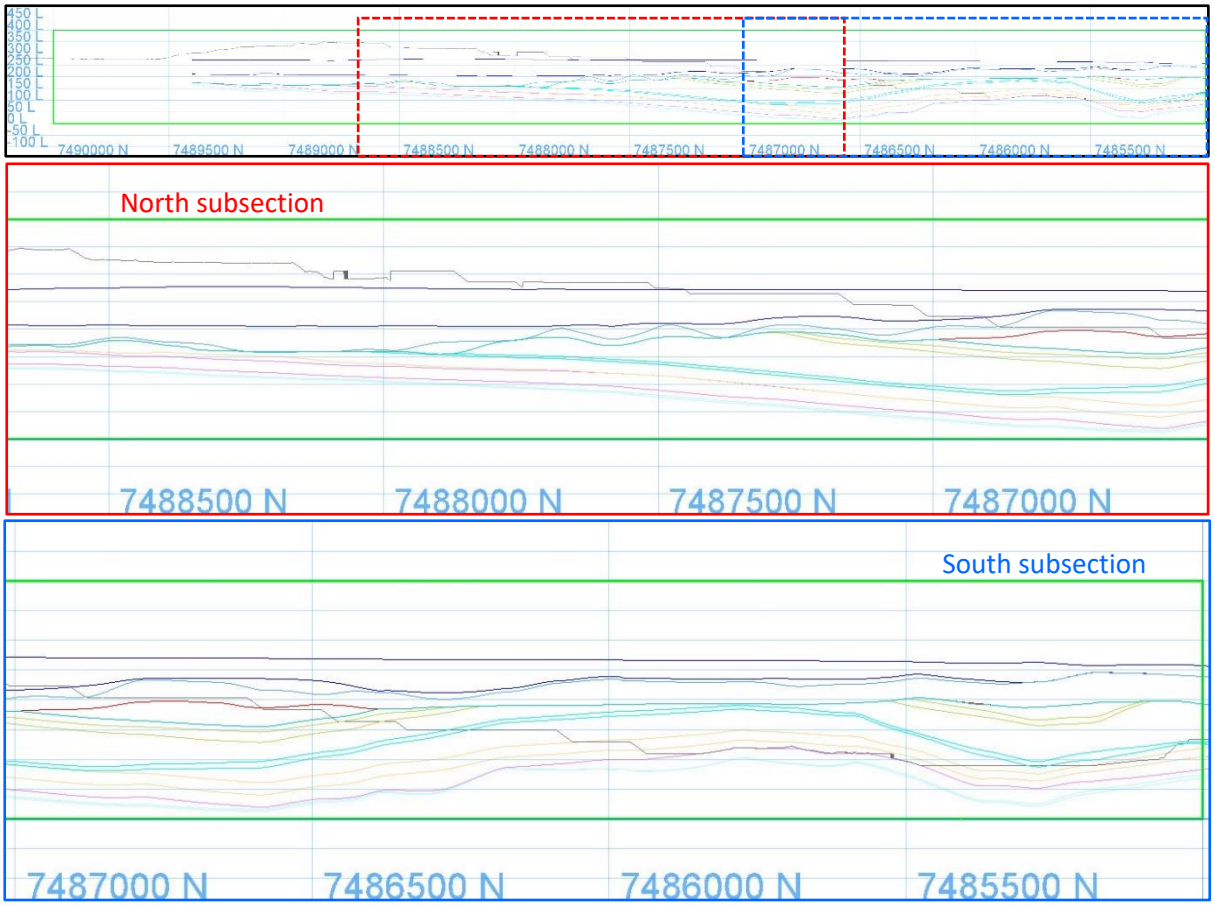

Figure 6-8 - Section 6 North Wall (low wall dump) geological model viewed towards east with subsections enlarged for clarity

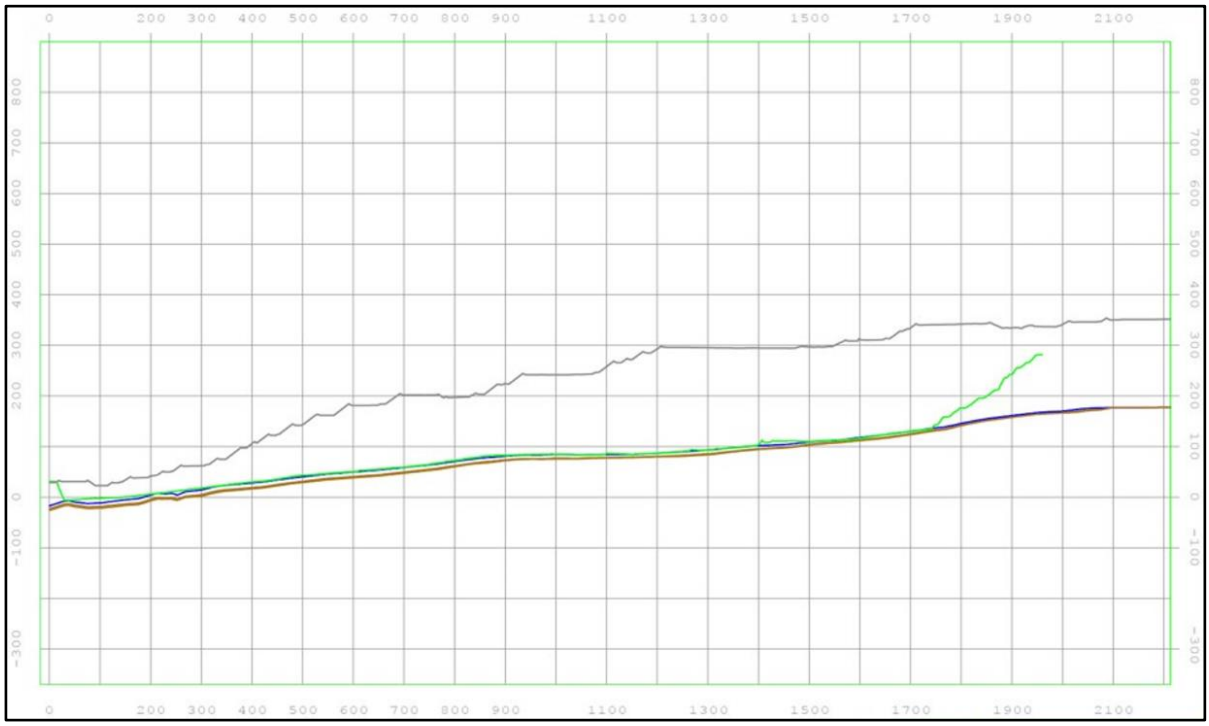

Figure 6-9 Low-wall dump profile as of June 2021 with mined-out surface (green) and WL seam (red/blue)

Mid-2021 corresponded approximately to the mine void reaching the lowest part of the deposit (***Figure 6-9***), resulting in the most critical condition for Section 6 stability. Low wall slope profile stability was assessed for the GRR (Sherwood Geotechnical and Research Services, 2021) to provide guidelines for dump slope profile stability. The governing condition for stability was the weak surface at the roof of the WL seam when located within several metres of the mined-out pit floor. Towards the south, the WL plies merge or truncate into the lower plies of the W2 seam sequence. It is assumed for the purpose of stability assessment that the W2 floor weakness will then be effectively removed with the mining of the W2 coal, and this is expected to remain the case for the last 5 years of the life of mine.

Based on the GRR low wall stability assessment, there is no formal requirement to undertake further stability analyse for the low wall dump provided that the dump's final post-mining landform complies with the angle-of-repose batter height limitations in the GRR. It is understood that the dump's final post-mining landform will comprise flatter batters to meet erosional risk control acceptance criteria.

7. Geotechnical Stability Assessment Outcomes

7.1 West Wall Section 1 Stability Assessment

Section 1 (***Figure 6-2***) corresponds approximately to the P17 West Wall which has been fully excavated and which has demonstrated acceptable geotechnical stability from an operational perspective. The planned southward progression of spoil dumping along the West Wall means that Section 1 will be partially backfilled to the approximate base of weathering within Anakie Metamorphics when mining is completed.

The groundwater flow model for Section 1, extending from the West Wall to the East Wall, is shown in ***Figure 7-1***. The boundary locations and specifications are intended so that the computed Phreatic Surface position and the groundwater pressure distributions are only minimally influenced by the modelling of boundaries.

Figure 7-2 shows the modelled groundwater pressure conditions for the long-term equilibrium void water level of 100 mRL, represented by the computed phreatic surface (pink line as marked) and contours of Total Head (Pressure Head + Elevation Head). Where the contour of Total Head lies above the phreatic surface level, the groundwater pressure is in a state of suction. The hydraulic conductivity material model is based on treating suction conditions so that they have negligible impacts on computing the groundwater phreatic surface location (RocScience, 2021).

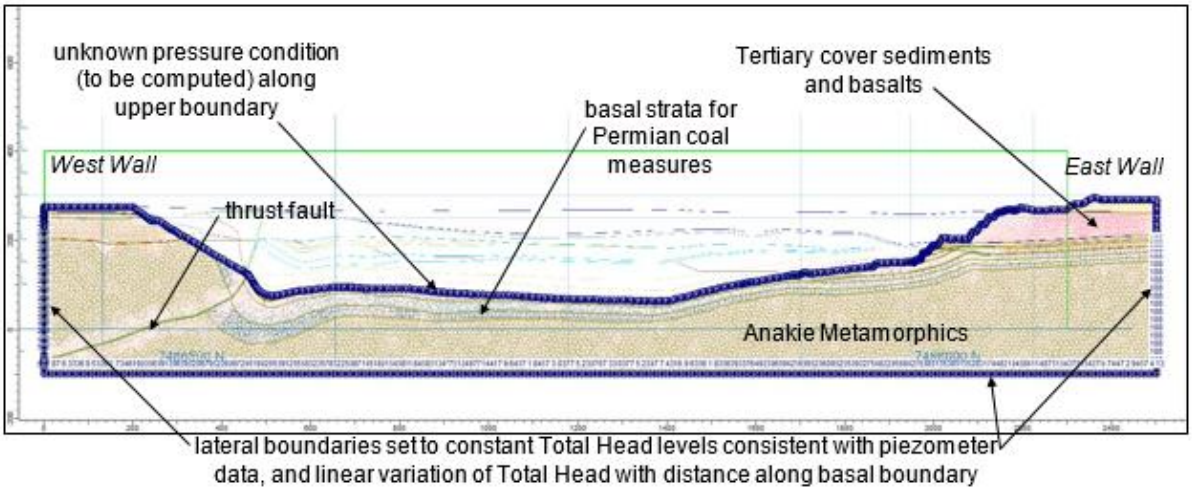

Figure 7-1 - Section 1 West Wall (unbuttressed) overall groundwater model showing region of analysis with fully specified flow boundary conditions

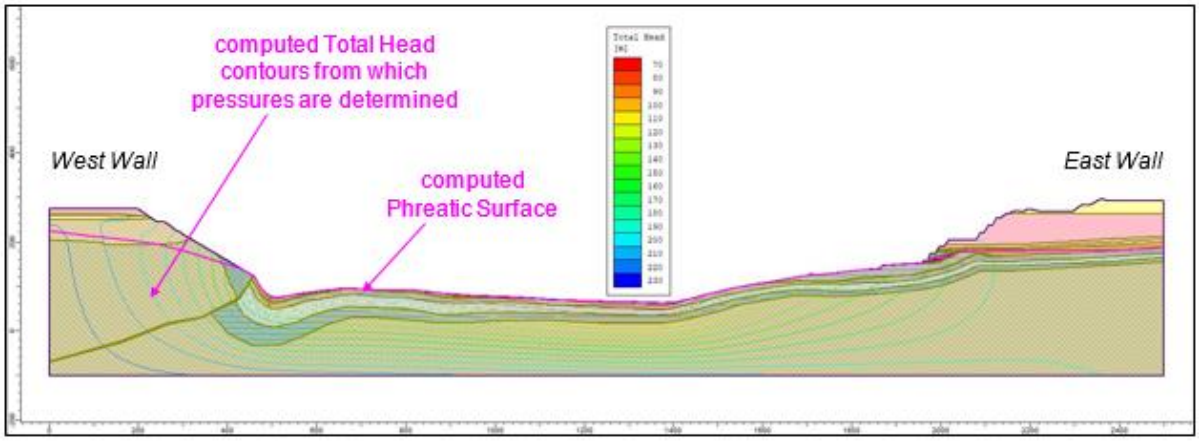

Figure 7-2 - Section 1 West Wall (unbuttressed) overall groundwater flow model outcome showing Total Head contours and location of Phreatic Surface

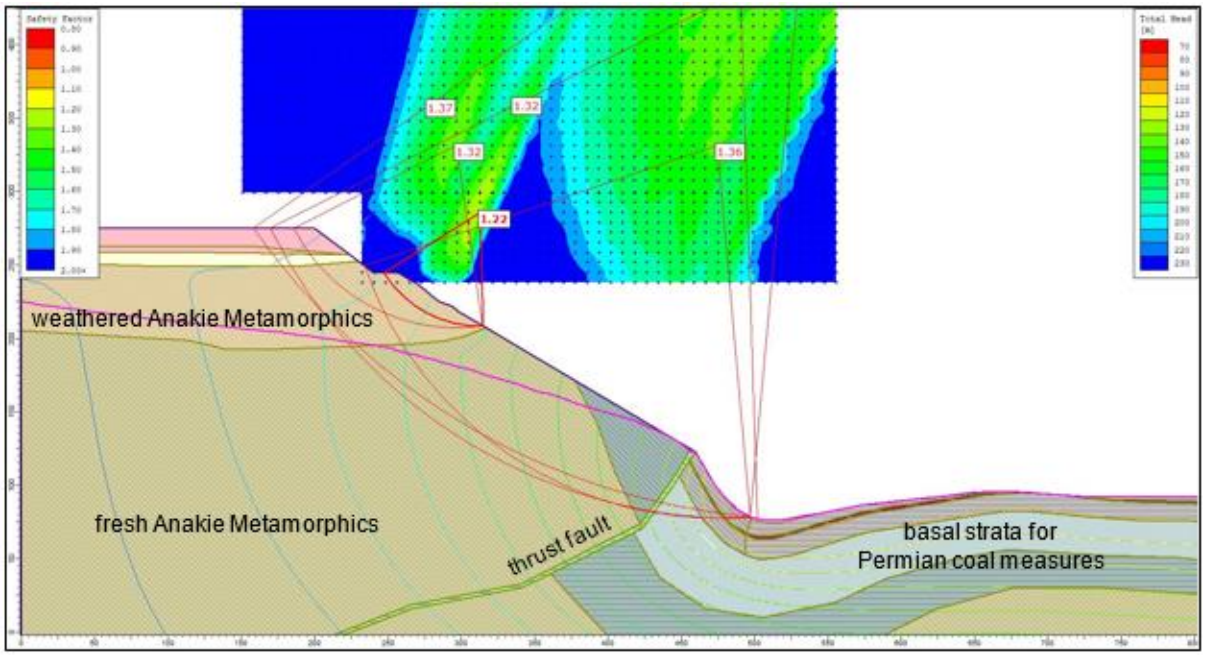

Figure 7-3 - Section 1 West Wall (worst-case, unbuttressed) critical stability conditions for potential rock mass strength-controlled circular arc mechanisms

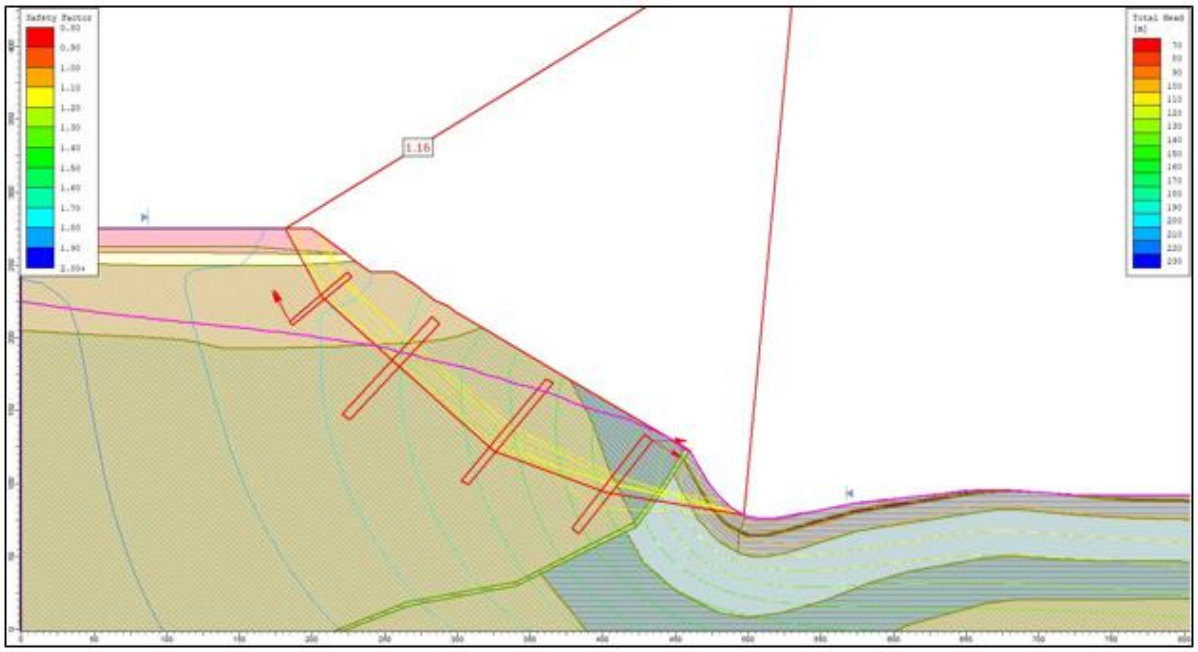

Figure 7-4 - Section 1 West Wall (worst-case, unbuttressed) critical stability condition for potential rock mass strength-controlled wedge mechanism exploiting weak foliation

The worst-case stability conditions for the Section 1 West Wall were determined by analysing for the unbuttressed case, which is approximately the situation at the time of reporting. ***Figure 7-3***, ***Figure 7-4*** and ***Figure 7-5*** respectively show critical strength-controlled circular arc and multi-wedge potential mechanisms respectively. For the full-slope profile, the multi-wedge mechanism exploiting the weak foliation of the metamorphics is more critical (FOS=1.16) than the circular arc (FOS=1.36). Most significantly, however, the critical stability condition for the slope is restricted to the weathered metamorphics zone where the multi-wedge mechanism exploiting the weak foliation is more critical (FOS=1.05, ***Figure 7-5***) than the circular arc (FOS=1.22, ***Figure 7-3***). These outcomes are consistent with the P17 operational mining experience for the Section 1 slope, where the weathered zone

required careful management because of fretting and marginal face instability. A localised zone of the lower P17 West Wall experience structure-controlled instability that was readily controlled.

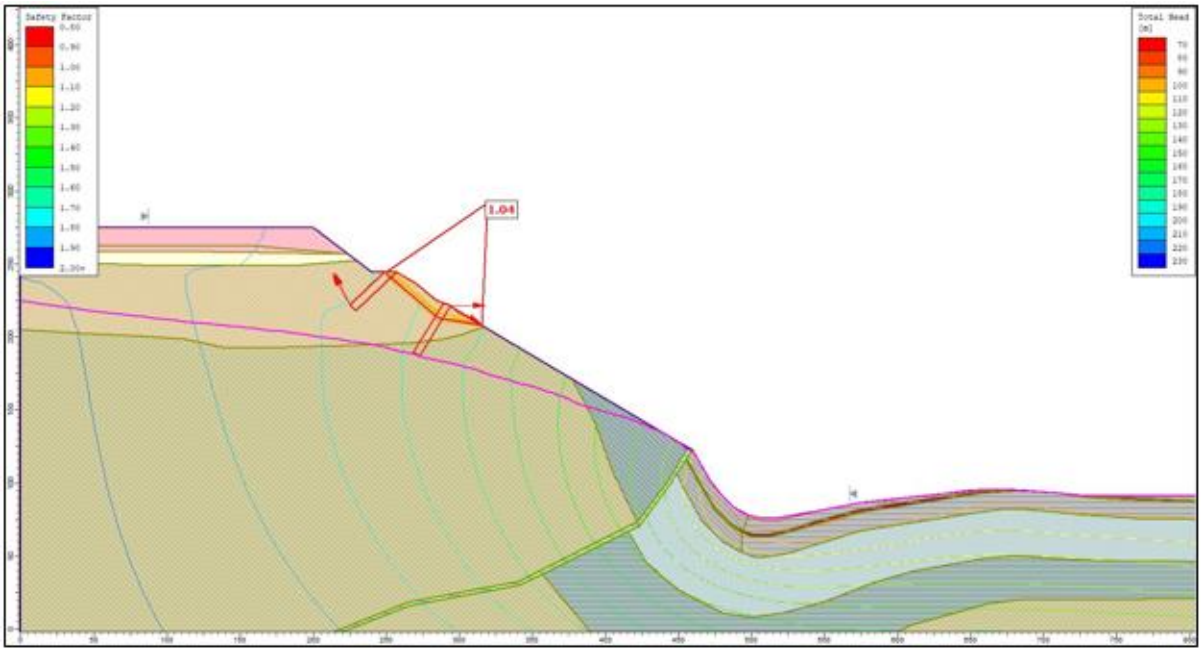

Figure 7-5 - Section 1 West Wall (worst-case, unbuttressed) critical stability condition for potential rock mass strength-controlled wedge mechanism exploiting weak foliation

The life-of-mine plan shows that Section 1 will be buttressed to approximately 200 mRL. There are two components to determining buttress requirements that would be consistent with a minimum computed FOS of at least 1.50 for the entire slope profile. ***Figure 7-6*** shows that a backfill buttress to 130 mRL would result in a critical potential arc mechanism for the lower slope with FOS=1.66 or greater. It can therefore be concluded that the planned backfill level will adequately provide acceptable stability for the full-slope profile. However, the weathered metamorphics would remain unsupported without a buttress to a level higher than the base of weathering. Additional buttressing, to a minimum width of 30 m and a minimum topo level of 222 mRL would be required to achieve a minimum computed FOS=1.52 (***Figure 7-7***) for the weathered zone. For this additionally buttressed slope, the setback from the crest to the FOS=1.5 limit is between 30 m and 60 m.

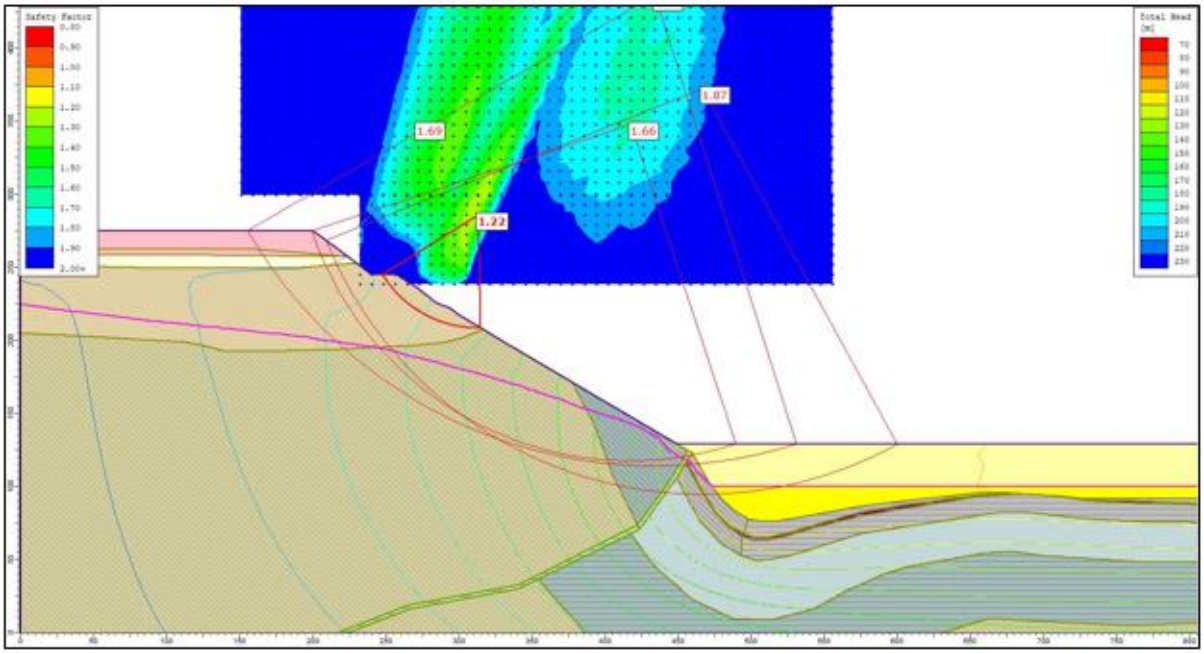

Figure 7-6 - Section 1 West Wall (buttressed to 130 mRL) critical stability condition for potential rock mass strength-controlled arc mechanism

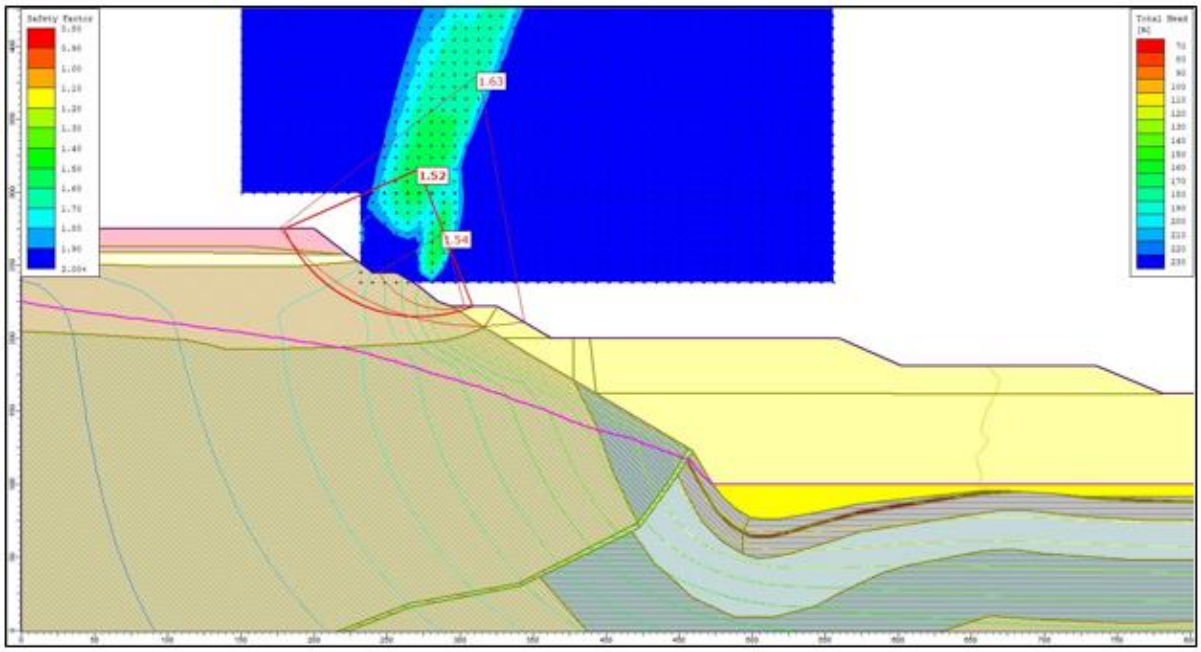

Figure 7-7 - Section 1 West Wall (buttressed to 222 mRL) critical stability condition for potential rock mass strength-controlled arc mechanism in weathered zone

Section 1 (P17) is the only example in this report where the entire slope has been mined, with the crest exposed for about 3 years and the toe for a few months at the time of reporting. Backfill buttressing had barely commenced at the time of reporting. The P17 slope has remained stable but has experienced localised face instability related to leakage from the Western Drain, which has now been mitigated. Some ongoing degradation and erosion have been noted in the upper weathered zone and in the exposed steeply-dipping basal sediments exposed near the slope toe. Post-mining performance of this slope will be observable and may be documented for the remaining mining operational life.

7.2 West Wall Section 2 Stability Assessment

Section 2 (***Figure 6-4***) corresponds approximately to the P18 West Wall where mining to the W1/W2 horizon was in progress during the preparation of this report. Significant changes to the short-term geological model were required and were based on infill blasthole drilling followed by additional exploration drilling. The short-term geological model changes could not be incorporated in this assessment report and are unlikely to make any significant difference as they affect only the lowest component of the slope where the planned southward progression of the spoil dump can only partially backfill Section 2. The LOM planned backfill level of about 160 mRL was adopted for all stability assessment.

There was almost no basal Permian or basement metamorphics geometry for Section 2, so the basal strata boundaries were based on the best information available from the GRR (Sherwood Geotechnical and Research Services, 2021). Groundwater pressure and stability analysis procedures for Section 2 were the same as for Section 1 and are therefore not described here. Section 2 corresponds to where the Western Drain was relocated away from the West Wall crest but is also adjacent to locations where the base of weathering within the metamorphics is much lower than the general case.

Figure 7-8 shows the stability analysis outcome for potential rock mass strength-controlled circular arc mechanisms, with the critical stability condition being FOS=1.32 for a single batter and FOS=1.65 for the entire weathered metamorphics interval of the slope profile. The most critical stability condition is for a multi-wedge mechanism exploiting the foliation within the weathered metamorphics (FOS=1.06, ***Figure 7-9***). Marginal stability of this form was experienced during mining, with localised face slumping triggered by rainfall and concentrated runoff.

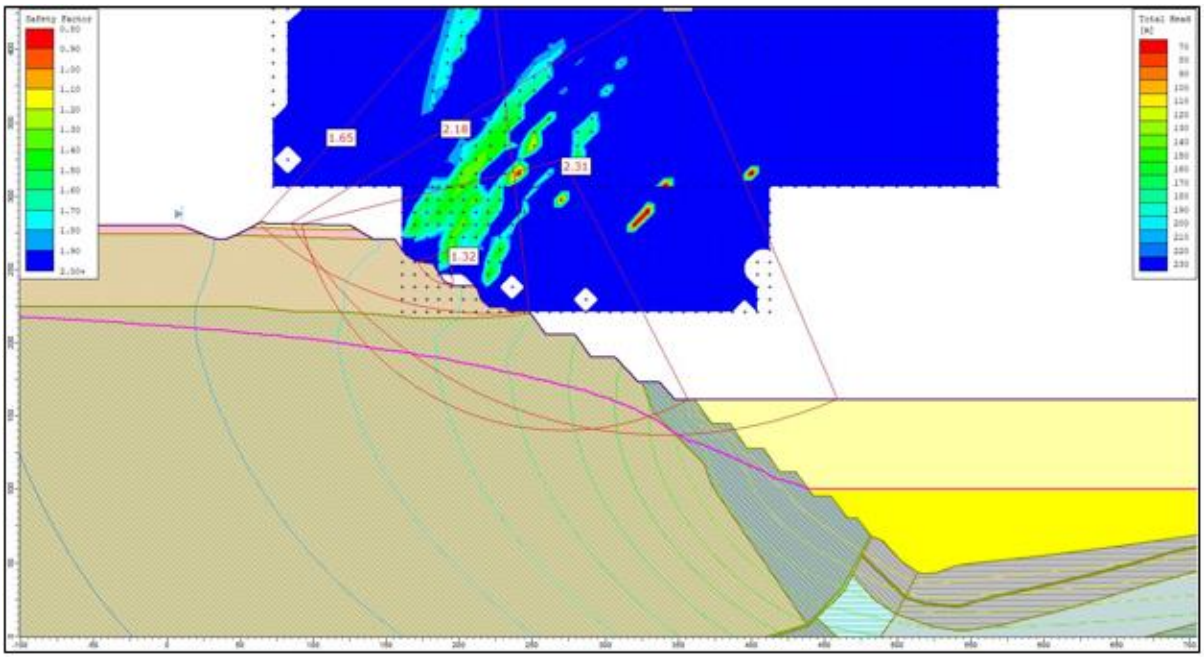

Figure 7-8 - Section 2 West Wall final buttress condition showing critical stability conditions for potential rock mass strength-controlled circular arc mechanisms

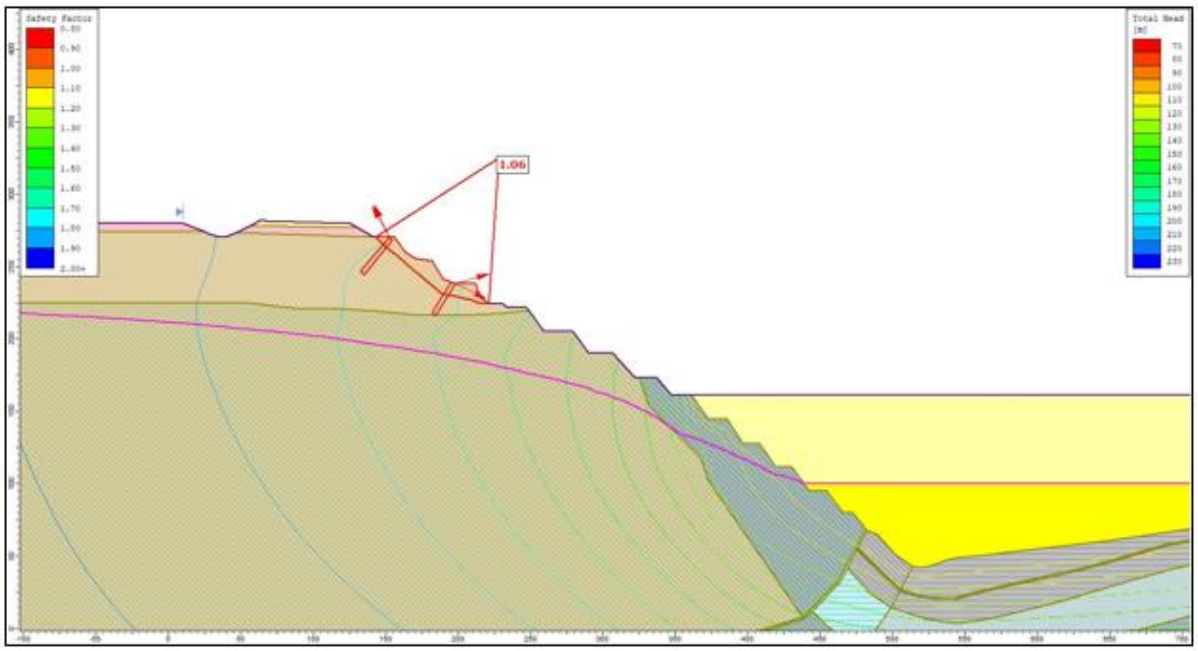

Figure 7-9 - Section 2 West Wall final buttress condition showing most critical stability condition for multi-wedge mechanism exploiting foliation in weathered metamorphics

Stability analysis adopts a stark transition from weathered to fresh, and this transition is observed to be more graduated in reality. In P18 the observed base of weathering also extended much lower that the modelled condition, and this was interpreted to be a result of deeper groundwater circulation through a zone of closely-fractured metamorphics.

Foliation-controlled potential instability is less of a concern within the fresh metamorphics because of the increased substance strength of the fresh rock material. This is demonstrated in ***Figure 7-10*** with a minimum computed FOS=2.06 for the fresh metamorphics alone, and ***Figure 7-11*** having a minimum computed FOS=1.78 for the full height of the exposed slope above the final buttress level.

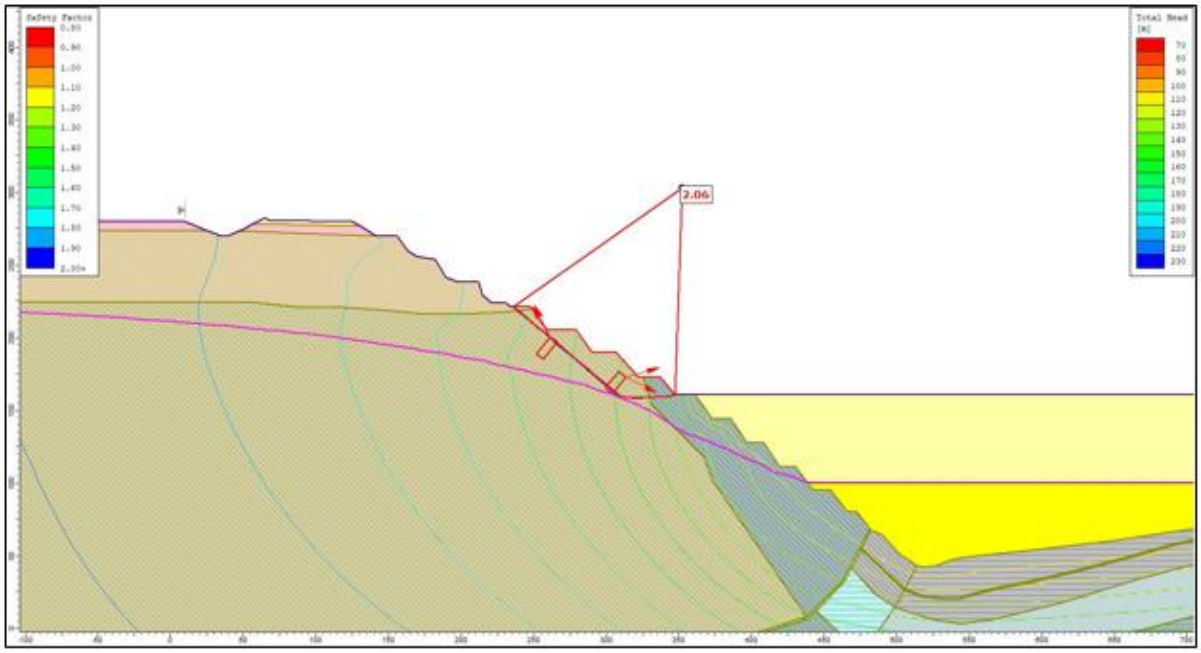

Figure 7-10 - Section 2 West Wall final buttress condition showing adequate stability condition for multi-wedge mechanism exploiting foliation in fresh metamorphics

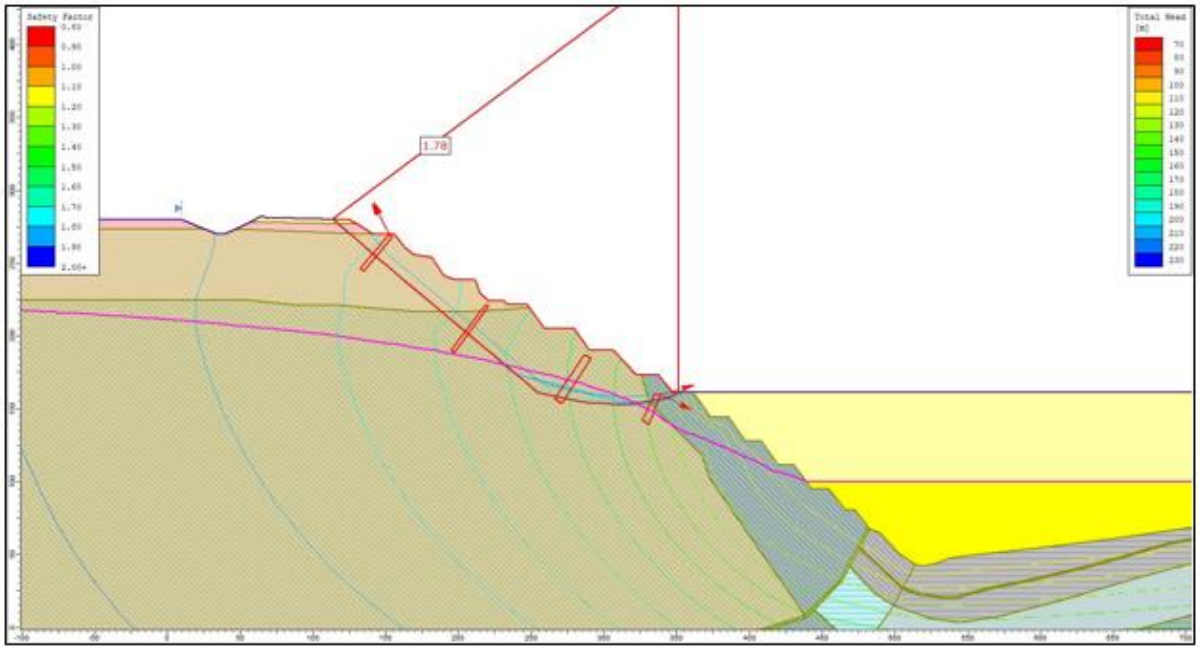

Figure 7-11 - Section 2 West Wall final buttress condition showing adequate stability condition for multi-wedge mechanism exploiting foliation for full exposed slope height

Marginal stability of the weathered metamorphics interval in Section 2 presents a significant issue for the post-mining landform. Increased stability will require treatment to achieve a reduction in destabilising forces, an increase in resisting forces, or some combination of these. The only plausible option, in the absence of buttressing with backfill spoil to within 15 m of the slope crest, was to identify the stabilising effect of unloading by reducing the effective slope angle within the weathered metamorphics interval.

The mean foliation dip is approximately eastwards at about 45° which means that any flattening of the upper slope will potentially expose a greater extent of foliated weathered rock to weathering and degradation. Presence of the Western Drain to the west also means that any flattening of the upper slope will reduce the seepage distance from the channel to the slope batter, potentially increasing the negative impacts of enhanced seepage on degradation rate and potential face instability.

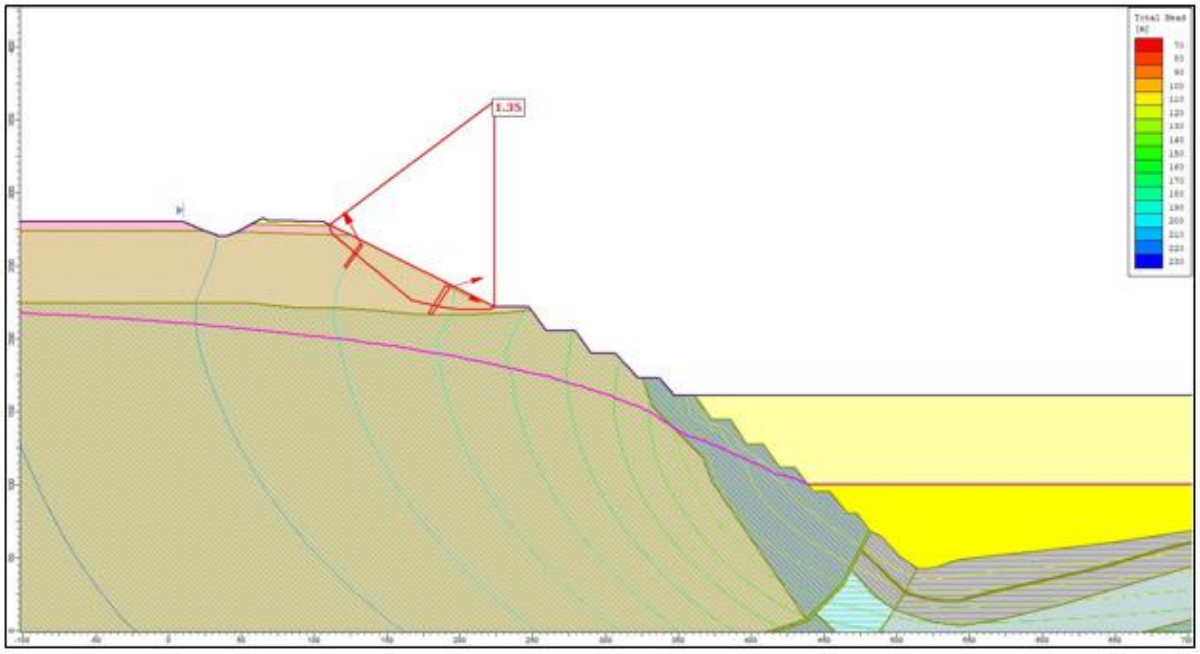

Figure 7-12 - Section 2 West Wall weathered metamorphics treatment with 1v:2h (26.6°) cutback stability condition for multi-wedge mechanism exploiting foliation

Cutback of the weathered metamorphics slope to 1v:2h (26.6°) increased the minimum computed FOS from 1.06 to 1.35 (***Figure 7-12***), which is less than the guidance upper bound of 1.50 but a 30% improvement from the untreated condition. A minimum computed FOS greater than 1.5 (***Figure 7-13***) could be achieved by 1v:2.66h (20.6°) slope reduction but this would be unacceptably close to the drain.

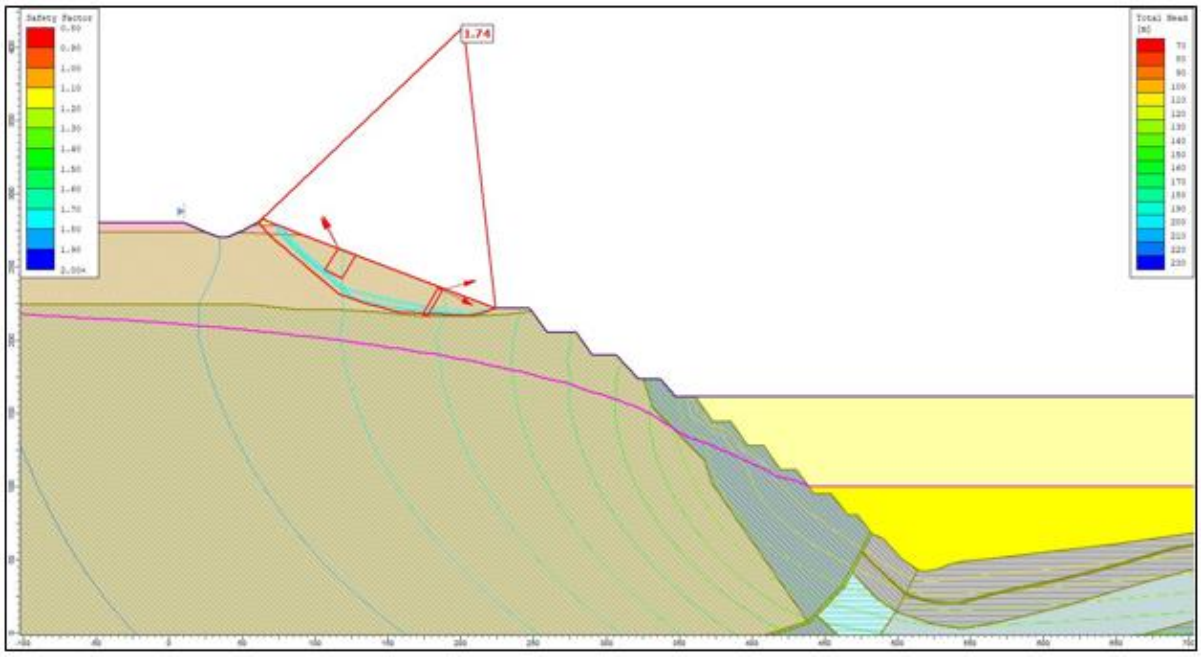

Figure 7-13 - Section 2 West Wall weathered metamorphics treatment with 1v:2.66h (20.6°) cutback stability condition for multi-wedge mechanism exploiting foliation

7.3 West Wall Section 3 Stability Analyses

Section 3 (***Figure 6-5***) corresponds approximately to the future West Wall where the planned LOM spoil backfill will be virtually absent due to the location of the thrust fault zone, and where the seam structure includes two synclines.

Checking of potential rock mass strength-controlled arc mechanisms resulted in minimum computed FOS outcomes ranging from 1.68 upwards (***Figure 7-14***). In the absence of any identified weak surfaces that might control potential instability mechanisms, it was concluded that Section 3, and by association the West Wall extent where metamorphics are not exposed satisfies the preferred stability acceptance criterion for the post-mining landform without treatment.

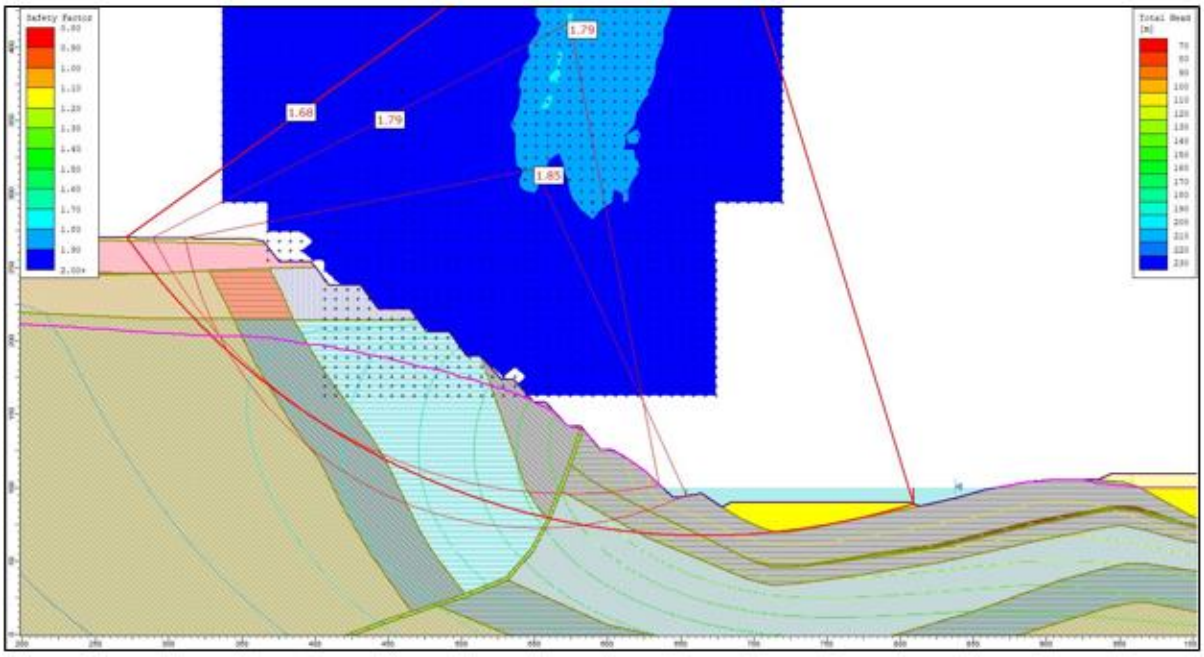

Figure 7-14 Section 3 West Wall final slope profile with no exposed metamorphics, showing critical stability conditions for potential rock mass strength-controlled circular arc mechanisms

7.4 South Wall Section 4 Stability Analyses

The final South Wall (Section 4, ***Figure 6-6***) has a limited east-west extent where potential 3D lateral constraining effects might enhance the FOS outcomes from 2D stability analyses. Because of the discrete nature of the Wolfang coal basin, the final South Wall has a component of seam structure dip towards the north, which has an adverse effect on north-facing slope stability.

The 2021 LOM slope profile for Section 4 includes a low-level bench which was presumably planned based on resource constraints. This was initially included for stability analysis purposes but, as explained below, will be mined-out to achieve adequate stability for mining operations. The Section 4 geological model surfaces show the Prospect seam at the base of weathering, but not projected upwards within the weathered Permian interval. Because of the spacing of exploration boreholes at this limit of the models, the full extent of the weak surface in the Prospect seam could not be represented in the stability analyses.

Stability analyses were carried out using the same principles for modelling groundwater pressure conditions, and also on the assumption that weak bedding-parallel surfaces were fully present just as they are for current mining operations. There is currently insufficient exploration data to be able to conclusively prove or disprove the question of whether or not the weak bedding-parallel surfaces are fully mobilised nearer to the basin margins.

Figure 7-15 shows the outcome for the planned LOM final slope profile and potential rock-mass strength-controlled arc mechanisms, with minimum computed FOS outcomes ranging from 1.53 to 2.80. These outcomes do not take into account the influence of multiple horizons of weak bedding-parallel surfaces.

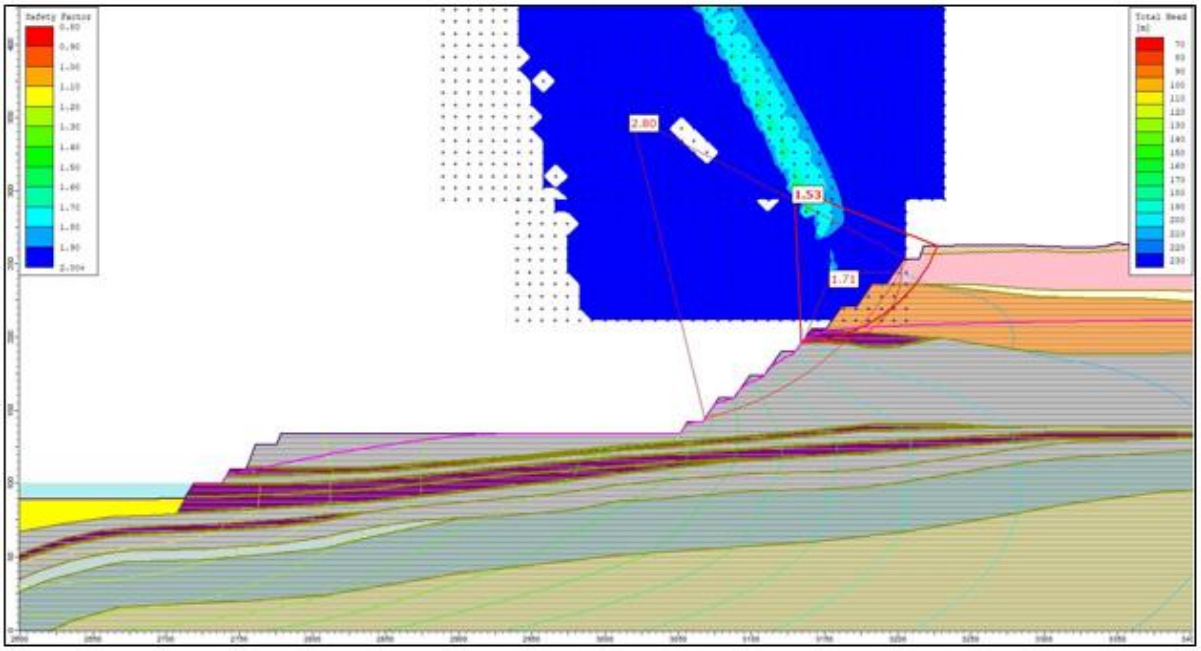

Figure 7-15 - Section 4 South Wall LOM final slope profile showing critical stability conditions for potential rock mass strength-controlled circular arc mechanisms

The strike length of the final South Wall crest is sufficient to allow a full-height instability mechanism to mobilise with minimal restraining influence of 3D geometry. ***Figure 7-16*** shows the critical potential mechanism with FOS=1.18 for sliding on the Prospect seam weak surface.

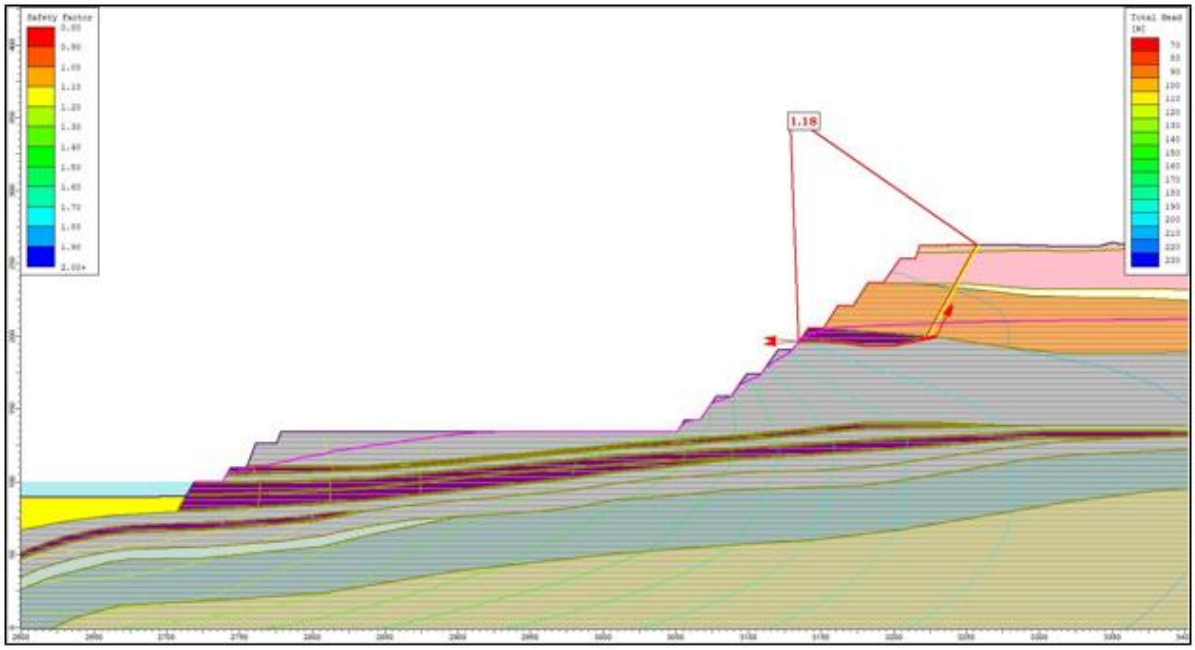

Figure 7-16 Section 4 South Wall LOM final slope profile showing critical stability conditions for potential sliding on weak surface in Prospect seam

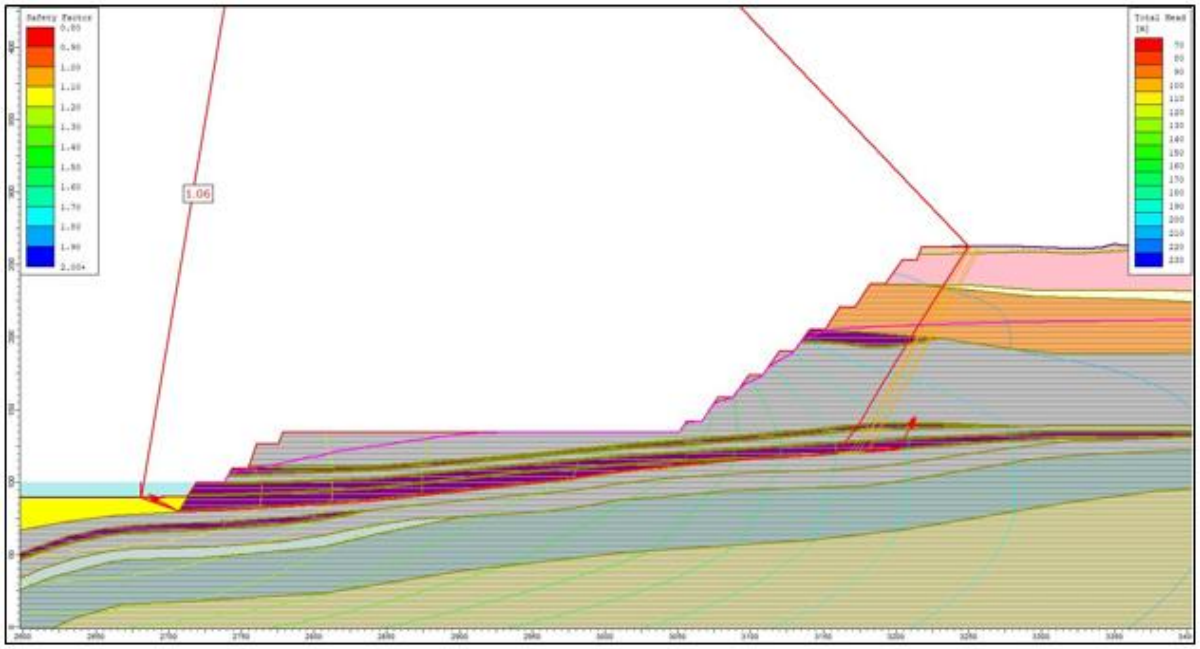

Figure 7-17 - Section 4 South Wall LOM final slope profile showing critical stability conditions for potential sliding on weak surface at W2 floor level with FOS=1.06

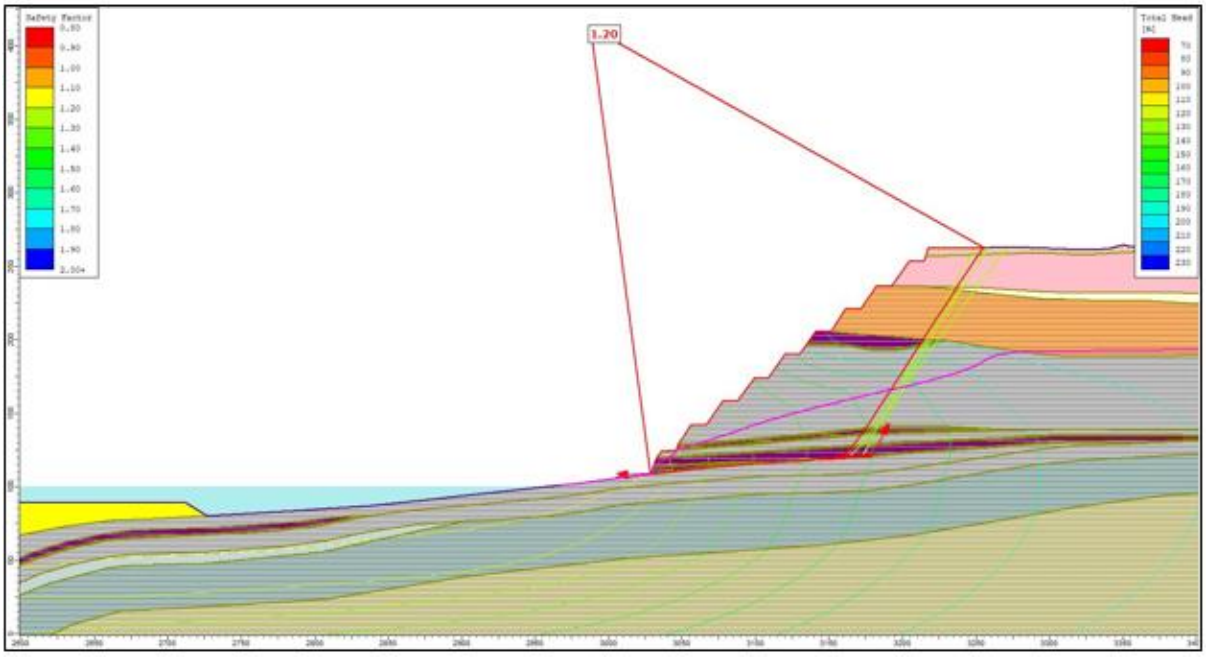

Figure 7-18 - Section 4 South Wall revised final slope profile showing critical stability conditions for potential sliding on weak surface at W2 floor level with FOS=1.20

Stability of the 2021 LOM slope profile is therefore not satisfactory because of the broad bench left above the Wolfang seam, with minimum computed FOS outcomes of 1.12 for potential sliding on the weak W1 roof and 1.06 for potential sliding on the weak W2 floor (***Figure 7-17***). Redesign involving removal of this broad bench will result in significant groundwater pressure drawdown and improved stability conditions that are acceptable for operational mine design, with a minimum computed FOS = 1.20 (***Figure 7-18***).

While the revised final South Wall stability is acceptable for mining operations purposes, other considerations will be required for post-mining landform stability acceptance purposes. The existing levee structure will be decommissioned and replaced with a final landform including an elevated haul

road embankment and sedimentation ponds spilling into Gowrie Creek. There are additional uncertainties associated with long-term performance of a slope condition challenged by long-term flood events, a target minimum computed FOS greater than 1.2 is appropriate and is likely to require provision of a spoil backfill buttress.

Dimensioning of such a buttress required consideration of potential sliding mechanisms at WU, W1 roof, and W2 floor levels. Other potential sliding surfaces at Prospect and W1/W2 parting levels were judged to be less critical based on experience to date. While the WL horizon is geologically modelled below the final South Wall area, there was judged to be insufficient carbonaceous material present to warrant development of the weak sheared surface that is typically present at WL roof level where coal is fully developed.

Two different buttress levels were considered. For a buttress level at 134 mRL and a bench width of 100 m, minimum computed FOS outcomes of 1.29 to 1.42 were obtained (***Figure 7-19***).

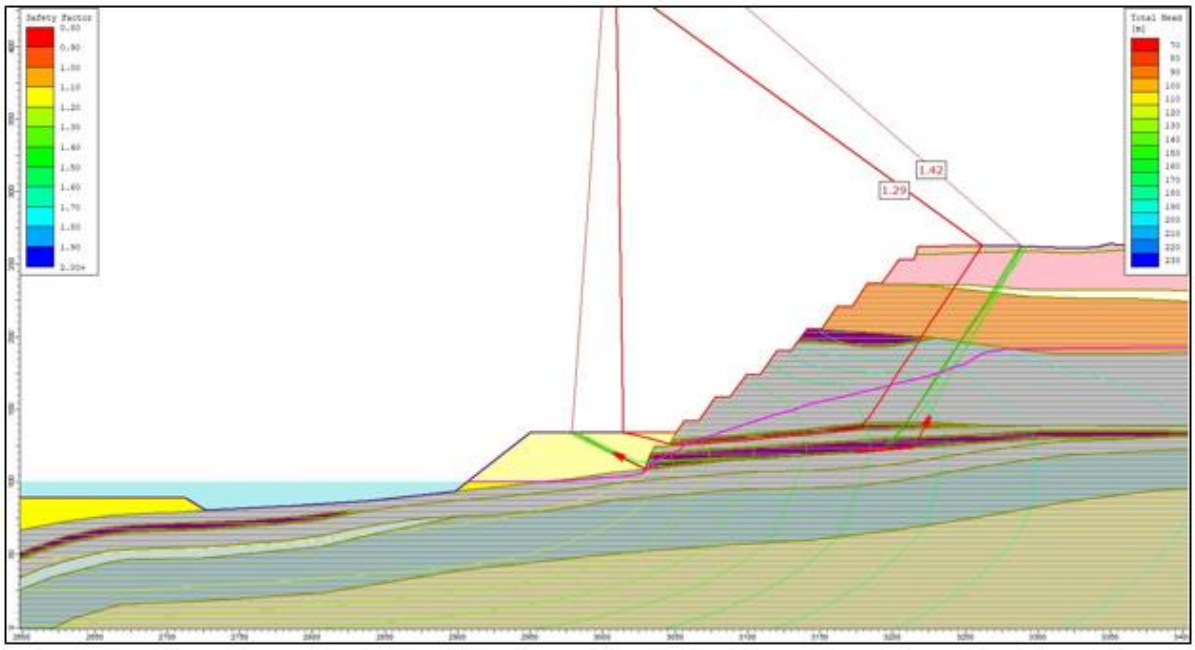

Figure 7-19 - Section 4 South Wall revised final slope profile buttress to 134 mRL with 100 m width with FOS ranging from 1.29 (WU) to 1.42 (W2 floor)

To achieve a FOS of 1.5 or greater, the buttress level was then raised to 150 mRL with the bench width increased to 115 m to provide adequate width against toe breakout. For potential sliding at WU level the minimum computed FOS was 1.58 (***Figure 7-20***) and for potential sliding at W2 floor level the minimum computed FOS was 1.75 (***Figure 7-21***). Based on these outcomes, this buttress dimension would be acceptable for a final post-mining landform condition based on a FOS acceptance criterion of at least 1.5.

Reconfiguration of the Gowrie Creek levee and flood exclusion system (KBR 2019; KBR 2020) is not likely to have a significant impact on stability considerations for the South Wall post-mining landform slope profile because of the limited duration of a flood event. Given the location of the Gowrie Creek channel and the adjacent final flood exclusion earthworks, and assuming that maximum flood events are likely to last for a period of 1 to 2 weeks, there is likely to be insufficient time for a wetting front to significantly change to the groundwater pressures in the vicinity of the South Wall slope.

Currently there is no specific information adjacent to the final South Wall location regarding groundwater pressure conditions or possible changes caused by flooding events. It is recommended that one or more piezometers be planned in this location to provide specific data to confirm groundwater pressure conditions associated with Gowrie Creek flooding events.

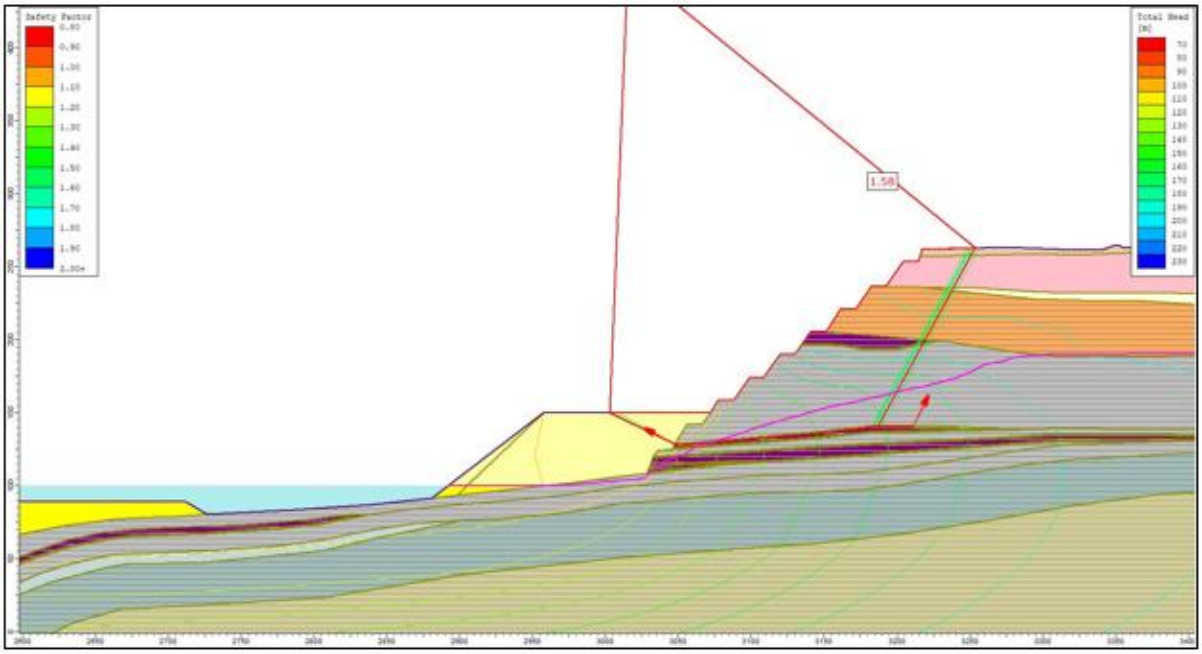

Figure 7-20 - Section 4 South Wall revised final slope profile buttress to 150 mRL with 115 m width and FOS=1.58 for potential sliding on weak WU shear

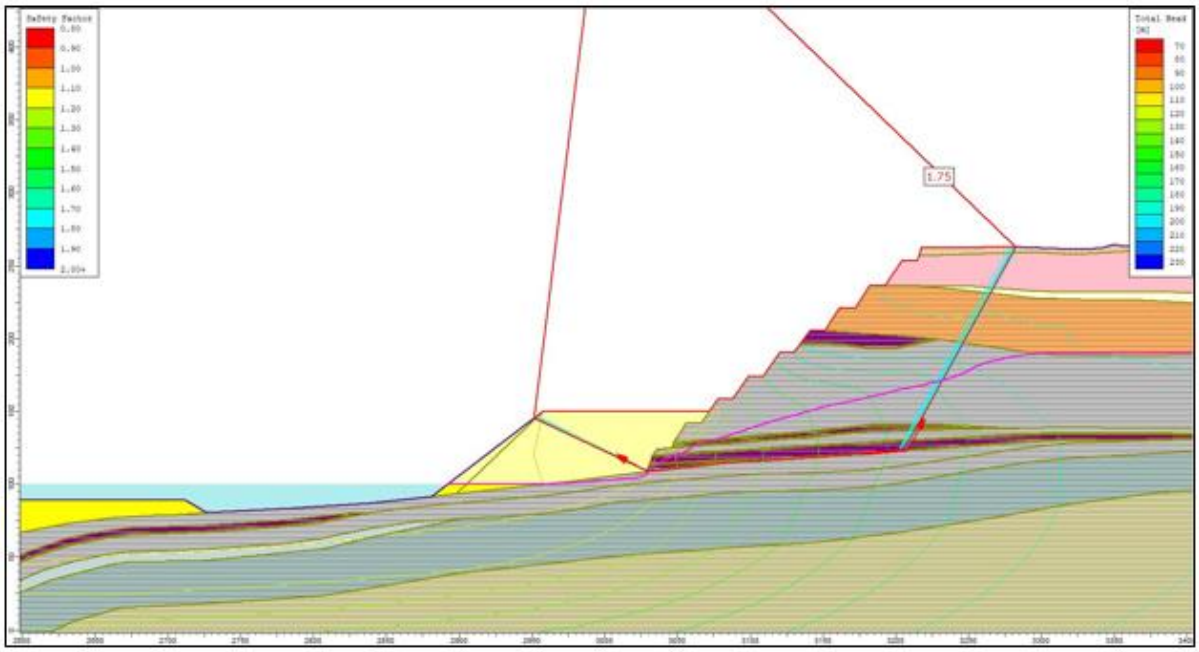

Figure 7-21 - Section 4 South Wall revised final slope profile buttress to 150 mRL with 115 m width and FOS=1.75 for potential sliding on weak W2 floor shear

7.5 East Wall Section 5 Stability Analyses

The East Wall for the remaining life of mine is effectively an extending box-cut end-wall for the southward-advancing pushbacks. While the 2021 LOM plan did not include backfill spoil buttressing of the excavated end-wall slope profile, buttressing to satisfy operational stability acceptance criteria is now implemented in design. A representative 2021 LOM East Wall model (Section 5, ***Figure 6-7***) was chosen where the seam structure conditions were as typical as possible. Because of the discrete structure of the basin and the truncation of coal by the Tertiary unconformity, the East Wall pit shell

toe line includes Permian seam structure with identified weak bedding-parallel surfaces dipping outwards into the void.

Stability outcomes for potential rock mass strength-controlled arc mechanisms are shown in ***Figure 7-22***, with minimum computed FOS of 1.11 (full slope), 1.31 (Tertiary slope above 206 mRL haul road bench), and 1.45 (full slope excluding effects of weak surfaces). Without the buttressing now being incorporated in operational designs, the full slope profile would not satisfy the mine operational FOS acceptance criterion.

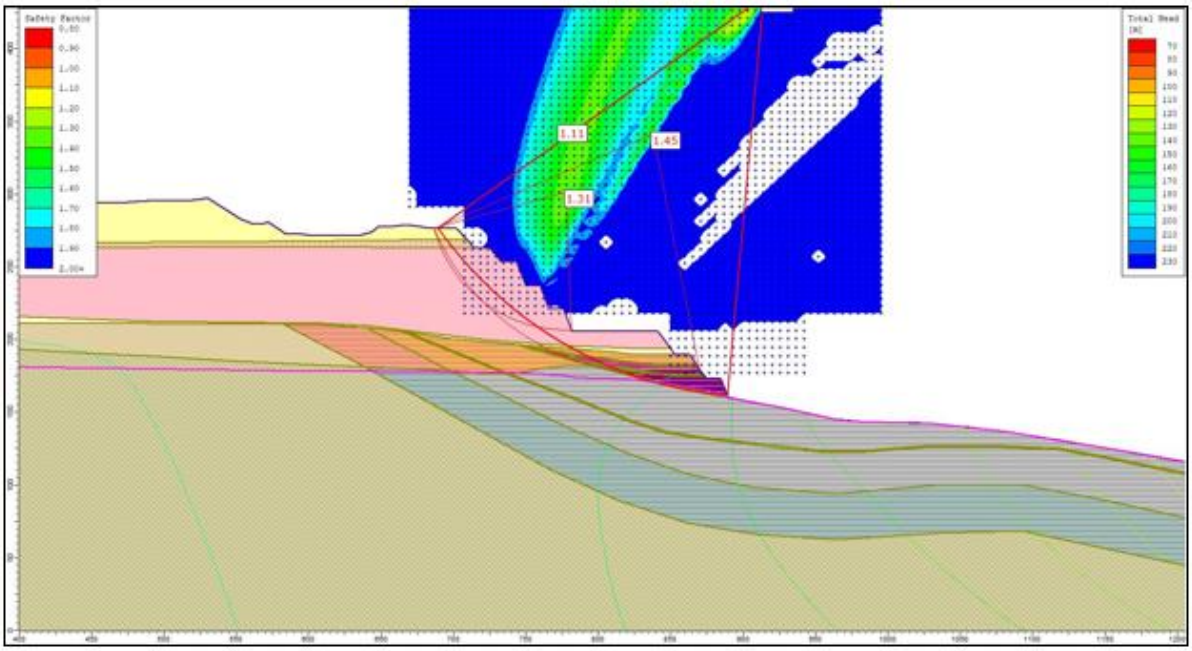

Figure 7-22 - Section 5 East Wall LOM final slope profile showing critical stability conditions for potential rock mass strength-controlled circular arc mechanisms, FOS=1.11

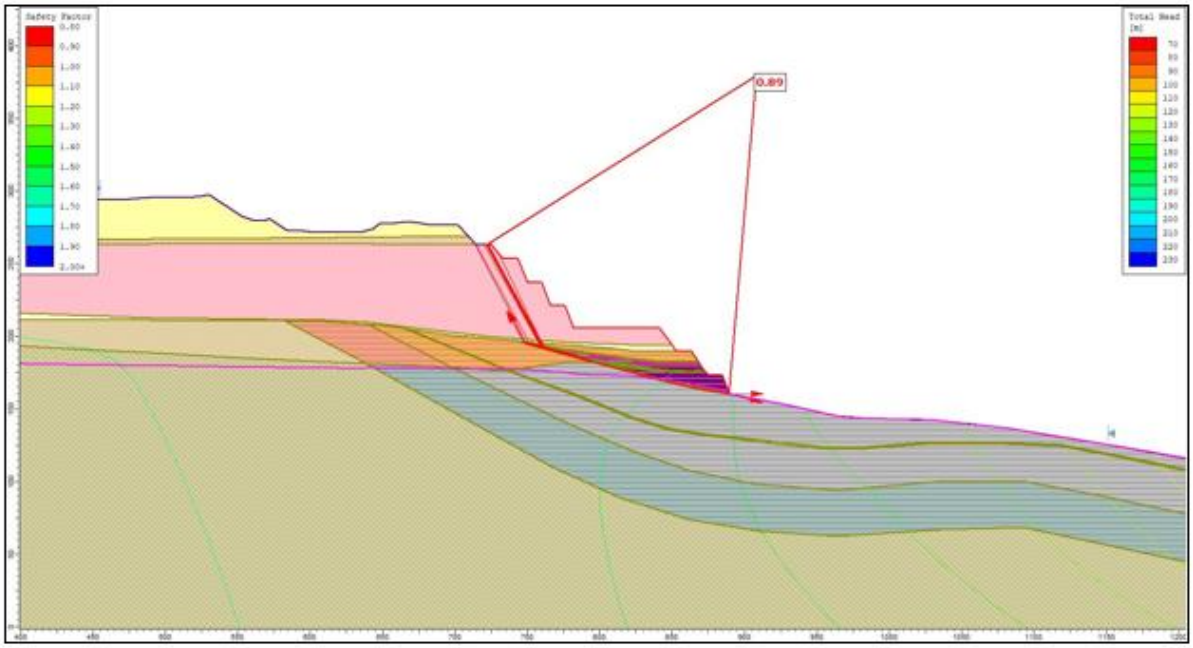

Figure 7-23 - Section 5 East Wall LOM final slope profile showing critical stability conditions for potential sliding mechanism on W2 floor shear, FOS=0.89

The stability situation for the most critical (W2 floor, FOS=0.89) of the potential sliding mechanisms along weak bedding-parallel surfaces is shown in ***Figure 7-23***. This mechanism is currently the focus for buttress designs to achieve operational acceptance criteria.

Also shown on this figure is the WL ply sequence at some distance below the W2 floor. Very little is known about the WL in this area and it is uncertain whether or not the weakness at the WL roof contact is present within this sector of the deposit. The influence of potential WL weakness, if present, is discussed further below.

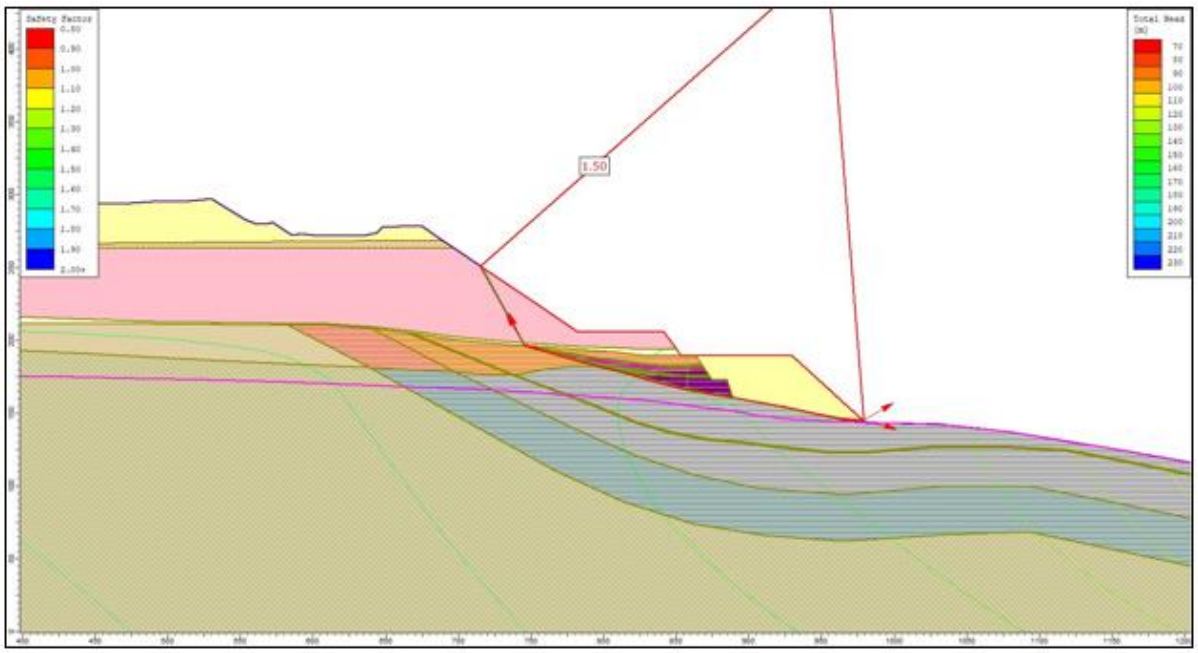

Figure 7-24 - Section 5 East Wall modified final slope profile with 33° interramp angle above 206 mRL haulroad and 70 m wide buttress at 190 mRL showing critical stability conditions for potential sliding mechanism on W2 floor shear, FOS=1.50

Combined effects of two East Wall treatments are shown on ***Figure 7-24***, which illustrates a minimum computed FOS=1.5 that could be achieved by the following:

- Reduction of the interramp angle to 33° above the 206 mRL haul road bench level; and
- Provision of a spoil backfill buttress to a minimum level of 190 mRL with a bench width of 70 m.

Some form of operational 3D buttressing technique will probably be required in order to construct such a modified slope profile. The upper inter-ramp angle is shown as a single batter for ease of modelling for stability analysis but could be constructed as a benched profile.

The potential role of a weak surface at the roof of the WL ply sequence within the subfloor of the East Wall is quite uncertain due to a lack of geotechnical data. Towards the centre of the basin the WL roof shear is well understood. Analyses were carried out to evaluate the effect of the presence of the WL roof shear. ***Figure 7-25*** shows the critical stability outcome of the WL roof shear on the modified slope profile, with a minimum computed FOS=1.04.

Further large-scale buttressing would be required to achieve acceptable stability for the post-mining landform condition if the WL roof shear was present, with ***Figure 7-26*** showing the outcome of FOS=1.47 for an additional spoil backfill buttress to 158 mRL with a bench width of 195 m. It is emphasised that this requirement is provisional, due to the current uncertainty regarding the presence of the WL roof shear within the East Wall subfloor.

Based on this assessment, it is recommended that exploration drilling be planned with the objective of minimising uncertainty regarding the presence of a weak bedding-parallel surface associated with the WL seam.

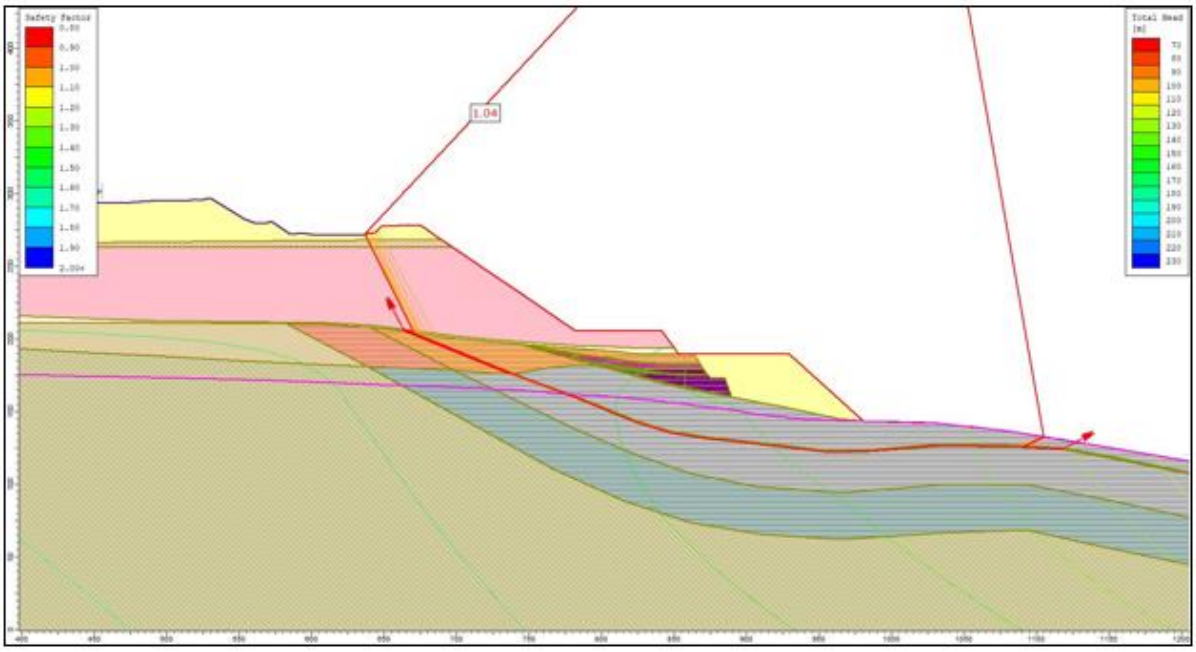

Figure 7-25 - Section 5 East Wall modified final slope profile with 33° interramp angle above 206 mRL haulroad and 70 m wide buttress at 190 mRL showing critical stability conditions for potential sliding mechanism on possible WL shear, FOS=1.04

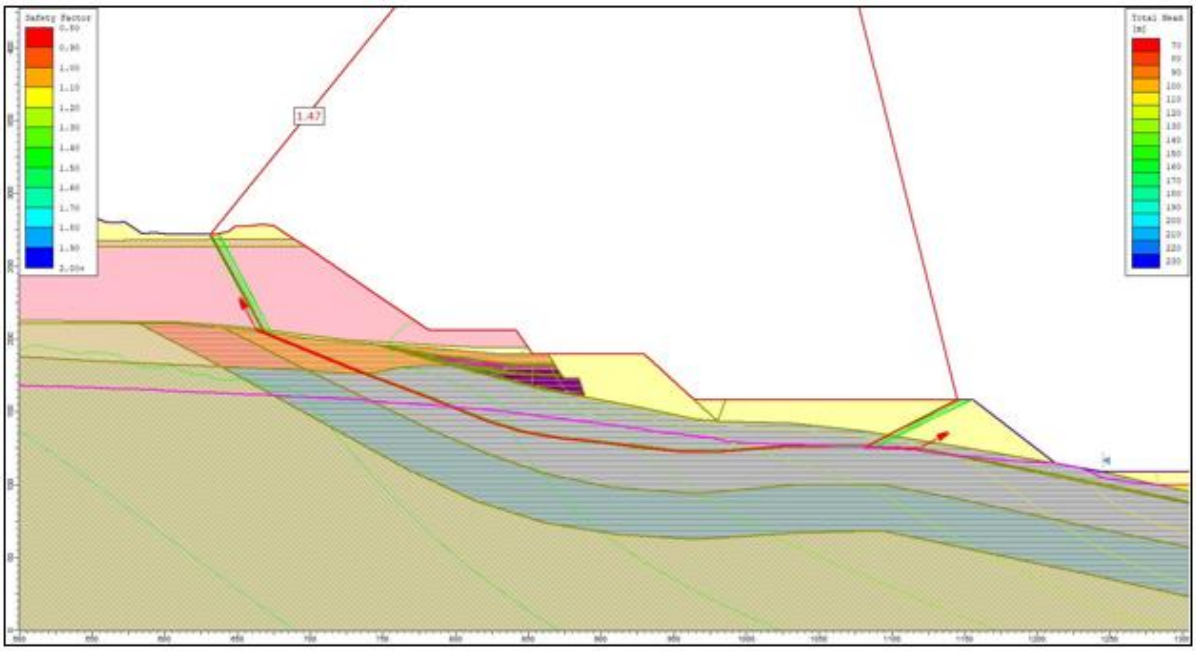

Figure 7-26 - Section 5 East Wall modified final slope profile with 33° inter-ramp angle above 206 mRL haul road, 70 m wide buttress at 190 mRL, and 195m wide buttress at 158 mRL showing critical stability conditions for potential sliding mechanism on possible WL shear, FOS=1.47

The East Wall is generally separated from the Gowrie creek floodplain by the East Out-of-Pit Dump and levee. Decommissioning of the current levee structure at conclusion of mining operations will potentially result in this dumped spoil providing flood exclusion for the East Wall component of the final void. Based on the understanding that a major Gowrie Creek flood event will have a duration of

a few weeks at most, significant transient seepage flow through the dump materials and underlying alluvium is extremely unlikely to create adverse groundwater pressure conditions for the East Wall.

7.6 Low Wall Dump Section 6 Stability Analyses

The LOM plan for the low wall dump (***Figure 6-8***) will be regraded to a trilinear landform slope concept where geotechnical slope stability is not physically possible, and where the post-mining landform performance will be governed by erosion considerations.

Currently the dump toe-line has reached the lowest part of the mined-out void, so that the remaining life of mine will be characterised by flattened foundations with enhanced stability. During the remaining life of mine a sump will be provided to manage ponded water levels. Following completion of mining, the water level within the void is expected to rise in response to future water input and output processes, with a predicted long-term equilibrium water level range of 90 mRL to 100 mRL.

Water-saturated spoil has a lower shear strength than unsaturated spoil, and the contrast in strengths is taken into account in geotechnical stability assessments and is not of concern for the conditions expected within the CCO final void. Climate conditions are likely to cause fluctuations in pond water level, but the rate of change will be too slow for any water pressure drainage lag to trigger localised instability. What is expected to occur are localised erosion features triggered by wavelet erosion at the water edge. Such features are commonly observed near the water margins of any ponded water body contained by soil and rock materials.

The current GRR (Sherwood Geotechnical and Research Services, 2021) provides adequate evidence for stability of the dump slope profile under current and planned future dump development. No further analyses are necessary to demonstrate acceptable post-mining dump landform stability.

8. Functional Synthesis

8.1 West Wall Excavated Slope Post-Mining Stability Treatment

Operational stability of the West Wall, based on stability design targeting a FOS of 1.20 or greater, has been successfully managed to date by a combination of profile design, monitoring, groundwater depressurisation, and progressive backfill dumping that has provided buttress support. A default consideration for the post-mining excavated landform will be the providing of a nominal 45° chamfer to be applied to the uppermost 25 m of the slope. Such a chamfer has no significant impact on slope profile stability.

Operational experience to date and the analyses presented in Sections 6.1, 6.2, and 6.3 show that exposures of unbuttressed weathered Anakie Metamorphics will result in slopes where additional mitigation treatments would be required to achieve a higher FOS for post-mining slopes.

For the current and remaining parts of the West Wall there is limited scope to raise the level of the spoil backfill buttress because of dump volume constraints, so the option of cutting-back was examined. ***Figure 8-1*** shows the West Wall condition in March 2021. The current geological model for this area only approximately matches observed locations of weathered metamorphics. with the base of weathering observed to be much lower within a zone of sheared metamorphics below Location 3 on the figure. The March 2021 face conditions shown on ***Figure 8-1*** were observed a few days after a significant rainfall event that resulted in face fretting and multi-batter scale slumping within the weathered metamorphics zone.

Geological modelling for the West Wall will continue to be revised and updated as mining operations progress southwards. To provide details for the extent of potential cutback requirements, a series of sections (***Figure 8-2***) were prepared along the West Wall, and for each section the lithological data from closest available exploration boreholes was examined in order to estimate the base of exposed weathered metamorphics. ***Table 8-1*** provides a summary of the interpreted crest, slope toeline level for Anakie Metamorphics, slope level of the base of weathering, and recommended toe level for cutting-back at 1v:3h to be confident of achieving, as an example, a minimum FOS=1.5 outcome. Recommendations are summarised in Section 4.

Cutting-back the West Wall for this purpose would be constrained by the location of the Western Drain and also by the enhanced erosional potential that would result from the increased surface area of weak foliated weathered metamorphics. Experience to date with exposure of weathered metamorphics on the West Wall is that cycles of wetting and drying cause fracturing and fissuring that enables runoff from a rainfall event to pressurise the near surface and thereby create shallow fretting and erosional debris flows. Consideration of enhanced stability represented by a higher calculated FOS outcome for a cutback exercise would have to be weighed against the potential downside of significantly increased erosion rates.

8.2 South Wall Excavated Slope Post-Mining Stability Treatment

Stability analyses described in Section 6.4 demonstrates that the LOM final slope design will be modified to achieve acceptable operational stability, and with additional spoil backfill buttressing to achieve a condition of FOS ≥ 1.5. Buttress design requirements for this purpose are identified in Section 6.4 and summarised in Section 4. Uncertainties in groundwater pressure conditions will have to be minimised so that stability of the operational and post-mining slope will not be compromised by the flood exclusion landform for the Gowrie Creek floodplain.

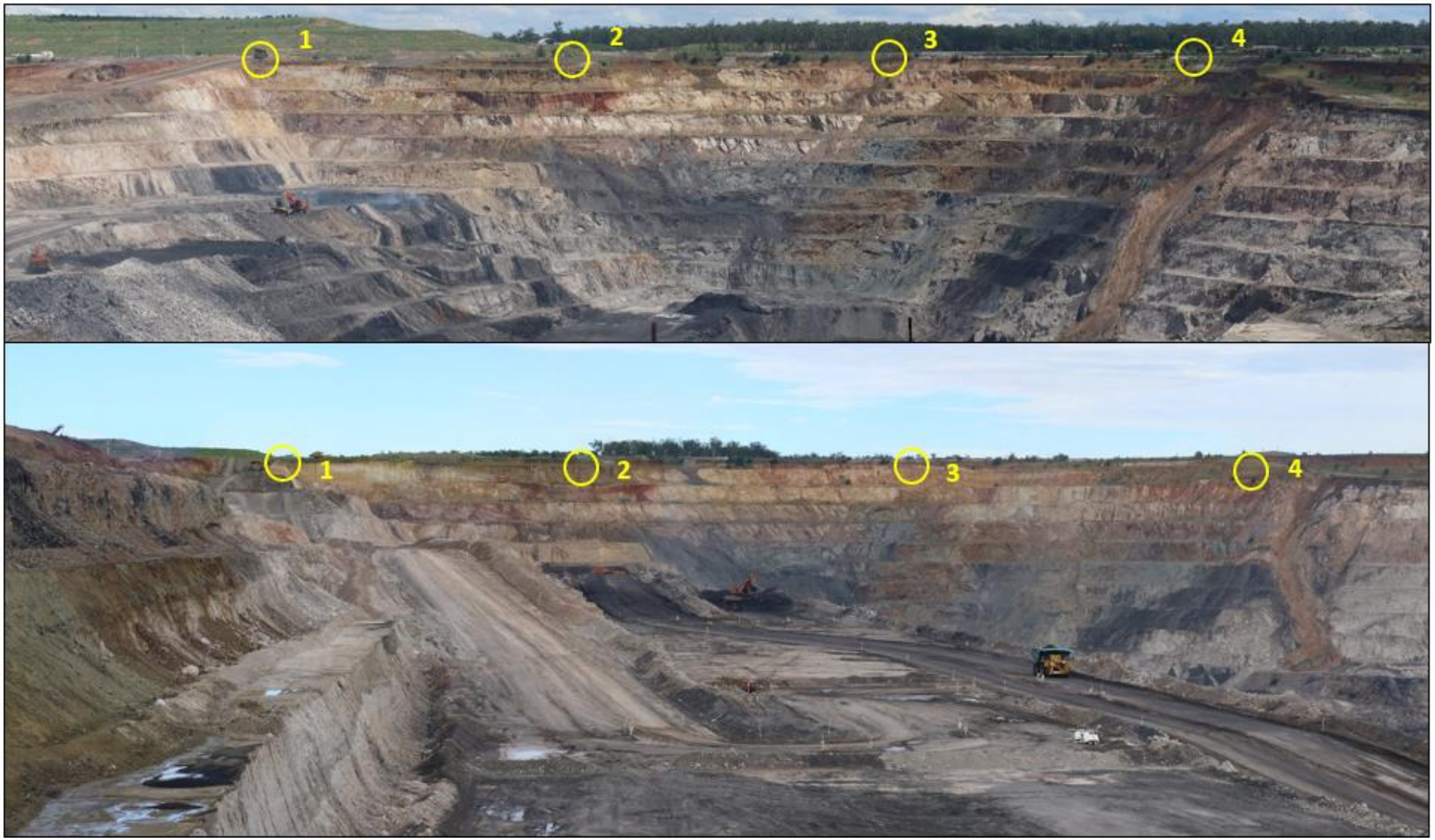

Figure 8-1 - West Wall March 2021 marked-up locations of weathered Anakie Metamorphics recommended for 1v:3h cutback treatment

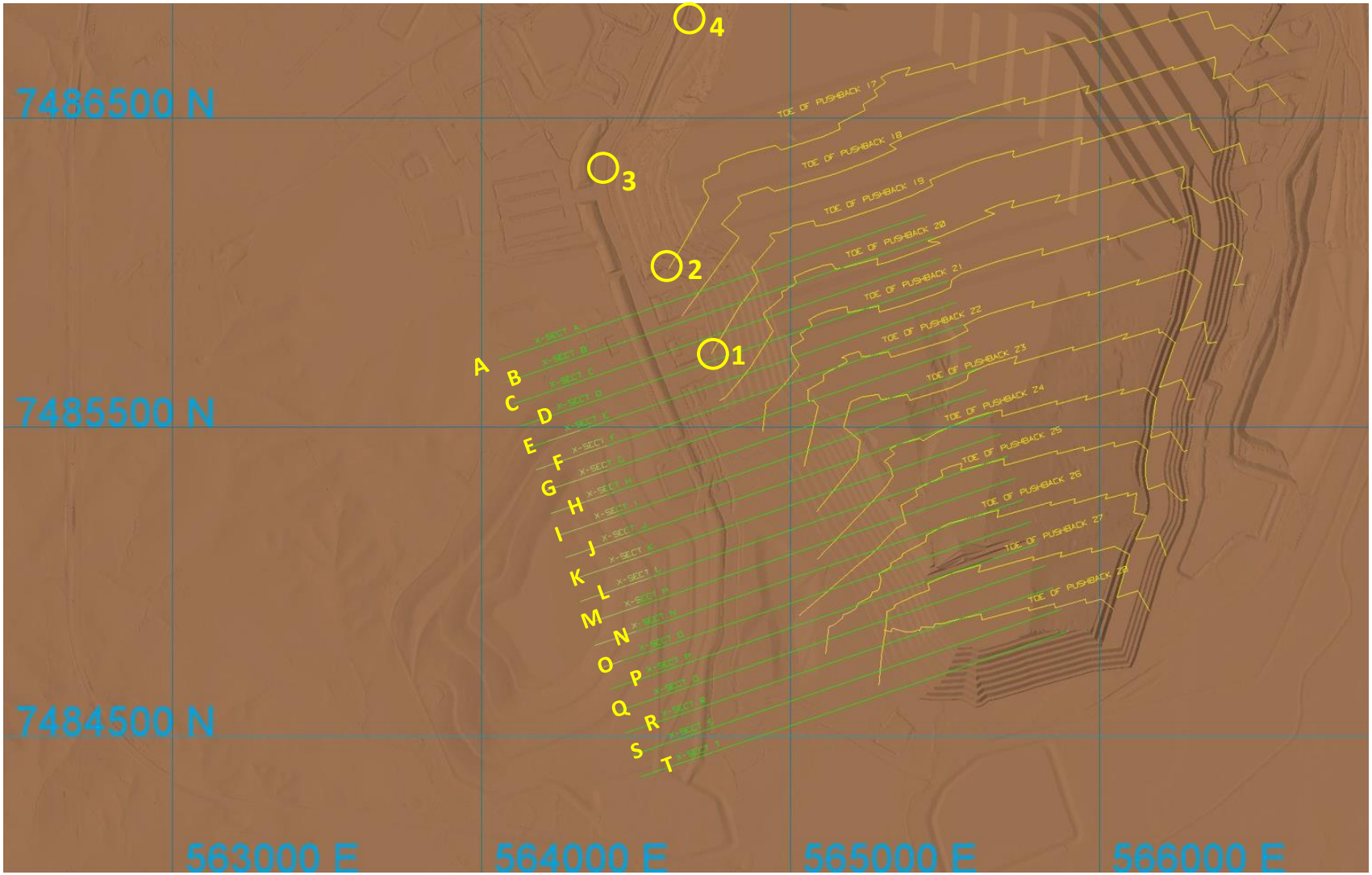

Figure 8-2 - West Wall section locations (75 m spacings) with marked-up locations of weathered Anakie Metamorphics treatment zone

Table 8-1 - West Wall Recommended Depth of 1v:3h Batter Treatment for Weathered Anakie Metamorphics*

Section Location	Crest RL	RL_ANMM_Toe	RL_BHOX	RL_Toe_1v:3h_Batter*
4	285	np	200	25m @ 1v:1h
3	283	230	200	230
2	280	225	205	225
1	275	180	210	210
A	275	170	206	210
B	270	230	200	230
C	275	270	210	230
D	275	220	210	220
E	275	214	200	210
F	272	186	200	200
G	270	220	200	200
H	268	np	210	25m @ 1v:1h
I	266	np	216	25m @ 1v:1h
J	264	np	226	25m @ 1v:1h
K	263	np	196	25m @ 1v:1h
L	263	np	190	25m @ 1v:1h
M	262	np	174	25m @ 1v:1h
N	262	np	180	25m @ 1v:1h
O	262	np	184	25m @ 1v:1h
P	262	np	190	25m @ 1v:1h
Q	262	np	196	25m @ 1v:1h
R	261	np	194	25m @ 1v:1h
S	261	np	200	25m @ 1v:1h
T	261	np	206	25m @ 1v:1h

**NOTES: np denotes section locations where ANMM not identified on slope face, BHOX denotes base of weathering*

25 m @ 1v:1h denotes section locations where the nominal 25 m deep chamfer with 1v:1h batter would apply

8.3 East Wall Excavated Slope Post-Mining Stability Treatment

The 2021 LOM design for the remaining East Wall is being modified to achieve acceptable operational stability. This will be detailed sequentially during the remaining operating mining life by the routine mining design process.

East Wall subfloor conditions are relatively close to the basin margins and currently include a modelled WL ply interval for which there is no information on geotechnical characteristics. Elsewhere in the main part of the basin the WL ply interval typically includes a weak sheared condition at the roof contact. There are geological arguments both for and against the weak shear being present towards the basin margins. Treatment of the East Wall to achieve acceptable post-mining landform stability conditions will require further exploration to reduce uncertainties relating to the WL weak shear.

The 206 mRL haul road bench is a critical part of mining infrastructure for which the current inter-ramp angle above that bench provides acceptable stability for mining operations. However, this slope would not meet an FOS acceptance criterion of 1.5 for the post-mining landform and a revised maximum inter-ramp angle of 33° would be required.

Mine operational stability will be provided by spoil backfill buttressing. Indicative minimum buttress dimensions were identified in Section 6.5 and are summarised in Section 4.

The uncertainty posed by the presence or absence of the WL weak shear in the East Wall subfloor requires further investigation. If the WL weak shear is absent then the stability treatments for the inter-ramp angle above the 206 mRL haul road bench and the buttressing of the W1/W2 slope interval will be sufficient to achieve a nominated post-mining slope stability acceptance criterion. If the WL weak shear is present then additional stability treatment involving spoil backfill buttressing will be required to provide acceptable stability for mining operations and post-mining landform conditions. Possible additional treatments are provided in Section 7.5 and are summarised in Section 4.

8.4 Low Wall Dump and Backfill Spoil Buttress Post-Mining Stability Treatment

For the remaining life of mine the low wall spoil dump will be constructed to satisfy a combination of operational haulage cost constraints and provision of a profile that most closely matches the post-mining landform shaping criteria. For mine operational requirements the low wall design will satisfy stability acceptance criteria. For the reasons outlined in Section 6.6, it is extremely unlikely that geotechnical stability considerations will be relevant for the post-mining landform shape. Potential changes in void water level following construction of the post-mining dump landform are unlikely to have any significant impact on geotechnical stability.

Spoil dumps and backfill spoil buttresses are constructed incrementally but will undergo post-construction settlement. Because of the wide range of materials, variable placement techniques, and scale effects, it is impractical to base settlement predictions on laboratory testing of samples. There is a generally accepted civil engineering rule of thumb that backfill spoil may settle by as perhaps 1% of thickness per log cycle of time. For the low wall dump profile the incremental nature of construction means that the thickness subjected to this “settlement clock” will be a fraction of the overall thickness. It is recommended that the post-construction settlement be estimated as 150 mm in the first year, another 150 mm after 10 years, another 150 mm after 100 years, and so on. The uncertainty in this prediction magnitude is about ± 30%.

Saturation settlement is not straightforward to predict because it depends on the pre-saturation density, which varies with the self-compaction effect of the thickness of the total spoil column, and also on the thickness of the spoil which becomes saturated. Based on industry-wide visual

observations but almost no actual survey data, it is recommended that saturation settlement of dumped spoil be estimated as 2% on average for the spoil thickness that becomes saturated.

9. Clermont Open Cut Void Evaluation

The PRCP process has occurred somewhat separately to the mine operational slope design process, and during a period when the mining operations geotechnical reference report, geotechnical design parameters, and geotechnical design recommendations were being revised. This has now been recognised in operational slope designs, and additional post-mining landform stability treatment requirements that have been identified in this report may also be introduced in stages during mining operations.

Current uncertainties that most directly affect the recommended post-mining landform treatments are:

- The actual depth of exposure of weathered metamorphics along the West Wall;
- The current conditions and duration of potential groundwater pressure changes in South Wall strata resulting from proximity to Gowrie Creek and flood events; and
- The presence or absence of weak surfaces associated with the WU, W1, W2, and WL ply intervals, for the South Wall and East Wall.

These uncertainties will be progressively addressed as part of the mining operations design process. This may lead to modification, clarification, or adaptation of the conditions identified in this report.

10. Cement Hill Evaluation

Following site inspection on 26 November 2020 a PowerPoint® summary of ground conditions and findings was prepared in early December 2020. The contents of that summary are provided here for the record.

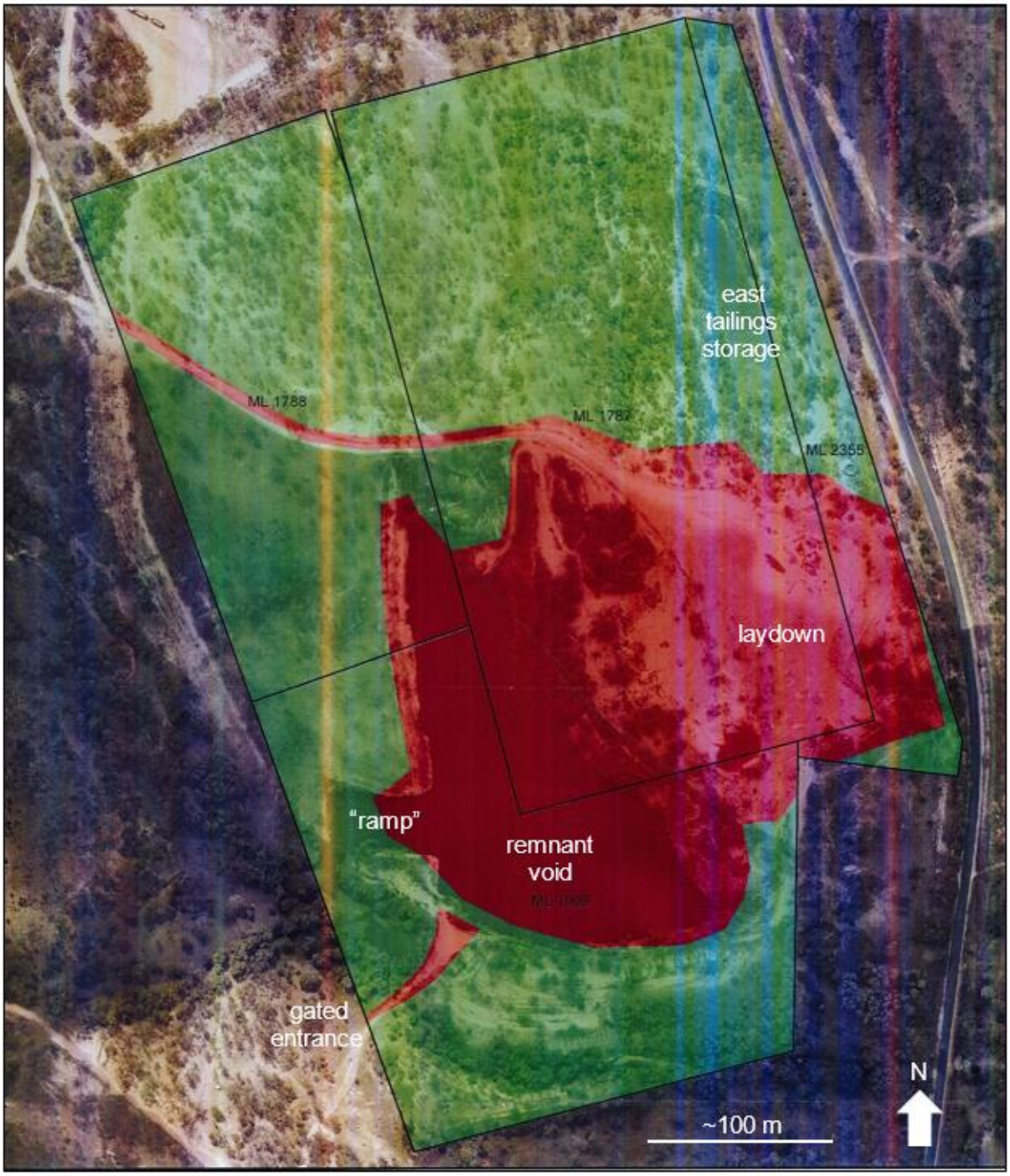

Figure 10-1 - Cement Hill plan marked with disturbed (red) and seeded (green) areas showing described features (map provided by CCO)

The Cement Hill mining lease area (***Figure 10-1***) is located within an outcrop of reworked pebbly conglomerate. Geologically, it is probably alluvial fan outwash conglomerate of the mid-Permian basal sequence of the Blair Athol and Wolfang basins, subsequently elevated by the fault structures that separate the Blair Athol and Clermont mine sites. The intact conglomerate has been weathered and subsequently laterised with low-level patchy silcrete cementation.

Alluvial gold within the conglomerate was the target for the mining operation at Cement Hill, resulting in the current void layout with semi-vertical cut walls. Gold would have been separated and recovered by washing and gravity screening. The tailings would have been the fines from the washing process, essentially clays with a component of sand and silt.

The current disturbed area consists of:

(1) Waste dumps of clayey and silty sands and pebbly gravels;

(2) The main pit, partially water-filled with excavated faces on the southwest-west sector and waste dumps on the east sector;

(3) Tailings cells formed of waste to contain initially ponded clays and silts; and

(4) Roads and processing/laydown areas.

Figure 10-2 is a general view of the current condition of the waste dumps on the southwest margin of the remnant void. The gravelly nature of the conglomerate waste, and essentially angle-of-repose dump slopes, is clearly evident.

Figure 10-2 - Cement Hill view to northeast from gated entrance looking towards waste dumps and remnant void

The remnant void has an unknown depth of water contained by excavated faces (batter angle typically 75°) on the west and south margins and dumped spoil backfill elsewhere (***Figure 10-3***).

The in-situ materials forming the west and south sides are low strength conglomerate with a capping layer about 1 m thick comprising extremely weathered conglomerate and residual soil (***Figure 10-4***). Along the west side is an excavated "ramp" (***Figure 10-5***) which provides a flow path for flood overflow into the residual void from a tributary ephemeral creek channel. In-situ material is amenable to ripping and dozing, but light blasting may be required for reshaping the deeper conglomerate.

Dumped waste slopes along the north and east margins of the void comprise gravel with sand and silt (***Figure 10-6***) that may be reshaped readily by dozing.

Figure 10-3 - Cement Hill remnant void viewed from southwest corner to north

Figure 10-4 - Cement Hill void crest of south margin viewed to east with weathered gravelly soil capping layer

Figure 10-5 - Cement Hill "ramp" at west void margin provides flow path for flood overflow into void from tributary creek

Figure 10-6 - Cement Hill gravelly waste and compacted laydown surface at process area to east of remnant void, with opportunistic revegetation

Shallow tailings cells were excavated in the northeast sector of the site. Remnant tailings is dry clay and silt that has been somewhat eroded by runoff but is otherwise contained by the existing margins. ***Figure 10-7*** is a general view of the eastern tailings cell, while ***Figure 10-8*** shows the waste forming the upper south margin. Occasional remnant boulders are contained within the waste, some of which were loosened by erosion and have rolled to the base of the slope.

Figure 10-7 - Cement Hill eastern tailings cell viewed towards north showing northeast perimeter exclusion bund

In summary, the Cement Hill site is geotechnically stable as-is but can be readily reshaped to the desired extent to a final long-term landform. From a geotechnical perspective, the excavated faces on the West and south margins of the remnant void will continue to weather and erode, and if necessary, could be battered down to a landform that would eliminate any residual water storage. The current residual void has possible environmental values that may be worth retaining, and current

land use has obviously been interpreted by the users involved as acceptably safe for the intended purposes of water storage and stock watering.

Figure 10-8 - Cement Hill dumped waste overlying southeast containment wall of tailings cell and remnant concrete tank (circled)

11. Blair Athol Northern Diversion Drain Evaluation

Following site inspection on 26 November 2020 a PowerPoint® summary of ground conditions and findings was prepared in early December 2020. The contents of that summary are provided here for the record.

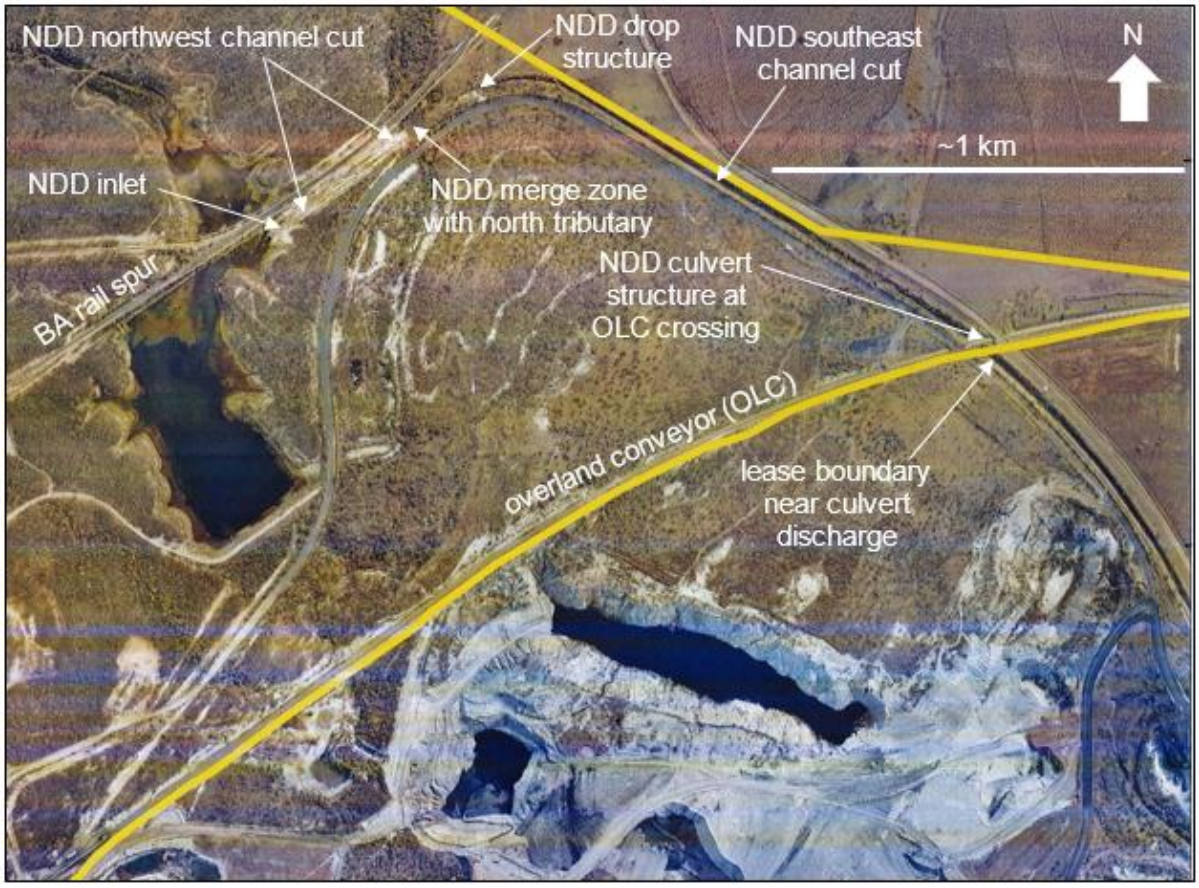

Figure 11-1 - Blair Athol Northern Diversion Drain (NDD) plan showing described features (lease boundary is yellow line, map provided by CCO)

The Northern Diversion Drain (NDD, ***Figure 11-1***) can be subdivided into sectors:

(1) Northwest channel cut in Anakie Metamorphics and Blair Athol Coal Measures conglomerates and sandstones;

(2) Merge zone with north tributary and discharge from rail culvert, transitions into shallow channel;

(3) Gabion and reno mattress drop structure;

(4) Southeast channel cut in Neogene basalts; and

(5) OLC and access road culvert discharging into basalt channel that continues into the neighbouring lease.

The NDD inlet is at the west part of the northwest channel cut (***Figure 11-2***) which is excavated in weathered Anakie Metamorphics having a thin soil capping layer of silty clayey gravel. Batters at 2v:1h have been weathered and superficially eroded, but with only minor build-up of weathered material at the batter toe-lines. The thrust faulted transition from weathered metamorphics to weathered Blair Athol coal measures conglomerates and sandstones in the central area of the northwest channel cut (***Figure 11-3***) has similarly well-preserved batters and channel floor.

Figure 11-2 - West part of northwest channel cut viewed towards northwest showing erosion of batters in weathered Anakie Metamorphics and soil capping

Figure 11-3 - Central part of northwest channel cut viewed towards northeast showing faulted transition from Anakie Metamorphics to Blair Athol coal measures rocks and erosion of batters

The east part of the northwest channel cut (***Figure 11-4***) exposes weathered sandstones and includes a batter transition to 1v:1h on the south (right) bank at the discharge end where weathered basalt outcrops.

Immediately downstream (east) of the northwest channel cut discharge is the merge point with a tributary ephemeral channel on the north side which discharges into the NDD through a culvert under

the Blair Athol rail spur line. The merge point area is broad (***Figure 11-5***) with no evidence of side slope erosion cause by channel flow.

Figure 11-4 - East part of northwest channel cut viewed towards west showing batter and floor condition in weathered coal measures rocks

Figure 11-5 - Northwest channel cut merge zone with north tributary and transition to flatter batter in weathered basalt on south (right) bank

At the east end of the merge point is a drop structure where the channel narrows and transitions into a cut through weathered basalts. The structure is constructed of gabions and reno mattresses, and founded at the transition from weathered sandstone to weathered basalt (***Figure 11-6***).

The mattress on the northeast discharge batter had slumped as a result of inadequate anchorage and will require repair to restore hydraulic effectiveness. There were no other indications of damage or loss of hydraulic effectiveness.

Figure 11-6 - Gabion and reno mattress drop structure at transition from merge zone into southeast channel cut and transition from sandstone to basalt materials

Downstream from the drop structure the NDD becomes a narrow trapezoidal channel excavated in weathered basalts with batters of nominally 2v:1h. The basalt materials range from hard residual soils to distinctly weathered blocky rock and have experienced degradation and superficial erosion since excavation. ***Figure 11-7*** and ***Figure 11-8*** show two typical areas of the channel adjacent to cleared farmland (to the east) and the access road (to the west).

Figure 11-7 - Southeast (trapezoidal) channel cut in weathered basalt with nominal 2v:1h batters, local gullying, and opportunistic revegetation (view upstream towards north)

The southeast channel cut is characterised by localised, generally minor sheet and gully erosion and there were no indications of significant build-up of erosion products at the channel floor that could compromise hydraulic effectiveness. The current vegetation growth was providing some reinforcement of the more soil-like materials within the upper slope adjacent to the channel bank crest lines.

Figure 11-8 - Southeast channel cut in weathered basalt with nominal 2v:1h batters (view downstream towards southeast)

A culvert structure (***Figure 11-9***) carries the overland conveyor (OLC) and maintenance access road across the southeast channel cut at the immediate north side of the lease boundary. The culvert consists of twin corrugated metal pipes (CMPs) contained within an embankment having relatively steep lower side slopes, protected by shotcrete covers with drain holes, and gently sloping upper side slopes protected by basalt rock fill.

Figure 11-9 - Culvert crossing of southeast channel cut by overland conveyor (OLC) and access road, with upper side slopes protected by basalt rock fill

Figure 11-10 and ***Figure 11-11*** respectively show the north and south lower side slopes of the culvert crossing. There were no indications of significant erosion of the culvert structure or of the flow transition zones at each side slope. There was also no evidence of a flood debris "tideline" on the north side that would be indicative of partial CMP intake blockage during a significant flow event.

Figure 11-10 - Upstream (north) side of access road culvert with twin CMPs and lower side slope protected by shotcrete cover

Figure 11-11 - Downstream (south) side of access road culvert with twin CMPs and lower side slope protected by shotcrete cover

In summary, the NDD slopes were observed to be geotechnically stable with no evidence of wall deformation, cracking, or accelerated degradation that could compromise continuing safe and stable performance for a time period of potentially several decades.

The NDD is required to continue in service following mine and rail load-out closure. Further reinforcement of the current channel batters would create disturbance with temporarily accelerated erosion, and batter flattening would expose greater side slope areas to degradation and erosion. Because of the current stability condition, it was recommended that the final landform works for the NDD be minimised, with the exception of adequate repair of the northeast bank reno mattress at the drop structure shown in ***Figure 11-6***.

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Glencore Coal Assets Australia (GCAA) (2018)	Geotechnical Design Standard – Open Cut. Document OC_GCAA-625378177-15117, V.1, effective 10 April 2018.
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Reference	Title
Sherwood Geotechnical and Research Services (2020)	Clermont Open Cut Pushback 17 South Wall Failure 21 May 2020 Independent Geotechnical Review. Report to Clermont Coal Operations Pty Ltd, Ref. 40030-2-1, 9 July 2020.
Sherwood Geotechnical and Research Services (2021)	Clermont Open Cut Geotechnical Reference Report Update V3 – 2021. Report to Clermont Coal Operations Pty Ltd, Ref. 42030-1-1, 20 October 2021.

CLERMONT
COAL OPERATIONS

GLENCORE

Appendix 4.5 – Groundwater Summary Report

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1. Introduction

1.1 Purpose

The purpose of this document is to address the hydrogeological requirements of the PRCP by reviewing and assessing existing hydrogeological knowledge and data for Clermont Coal Operations (CCO). It was prepared by:

- Reviewing groundwater modelling reports, groundwater monitoring data and reports and other relevant literature available; and
- Evaluating the groundwater modelling work to date, historical, present and predicted groundwater response from the modelling. Assessment of the data including groundwater levels, groundwater quality and water use.

1.2 Scope

This document covers all areas of CCO and applies to the Clermont main (CM) deposit, Cement Hill (CH) void and the train load-out facility (TLO).

This document focuses on the hydrogeology of the CCO area, with the understanding that the final void at CM acts as a permanent sink upon closure. Details on final void interactions are discussed further in Appendix 4.7 –Void Closure Methodology.

1.3 Standards and Guidelines

CCO's groundwater management is conducted in accordance with the Environmental Authority (EA) EPML00634113, Groundwater Licenses, and landowner Alternative Water Supply Agreements (AWSAs). Groundwater monitoring and analysis is conducted by a suitably qualified independent third party, and is undertaken in accordance with:

- Department of Environment and Science (DES) Monitoring and Sampling Manual 2018, under the Environmental Protection (Water and Wetland Biodiversity) Policy 2019; and
- Australian/ New Zealand Standard (AS/NZS) 5667.11.1998: Water Quality - Sampling Part 11: Guidance on sampling of groundwaters.

2. Historical Groundwater Characterisation

2.1 Basis of Findings

A number of hydrogeological studies have been completed for CCO including the 2004 EIS and 2009 regional groundwater model update (JBT consulting, 2009), and the following hydrogeological monitoring and reporting has been conducted since 2008:

- Quarterly groundwater reports under the AWSAs (groundwater level focus);
- Quarterly mine compliance reports (groundwater extraction focus);
- Aquifer performance review reports; and
- Annual groundwater quality review reports.

Information on aquifer hydraulic properties is available from several phases of pumping tests which have been conducted in the Clermont area by various consultants including Coffey Partners (1981), Golder Associates (2006), ERM (2002) and Matrix (2008), and falling head (slug) tests conducted by Golder Associates (1982).

2.2 Overview of Monitoring

2.2.1 Clermont Mine

Monitoring of groundwater has been undertaken for the CM since June 2007. Groundwater modelling undertaken for the Environmental Impact Statement (EIS) for Clermont Mine (RTCA 2014) predicted that mining would result in groundwater level impacts within the Tertiary basalt aquifer. Based on these modelling predictions, Alternative Water Supply Agreements (AWSA) were developed with neighbouring landholders (CCO, 2018). Landholders within the zone of predicted impact are subject to “Inner” AWSA’s, while landholders outside the zone of predicted impact are subject to “Outer” AWSA’s. Correspondingly, groundwater monitoring bores within the zone of predicted impact are defined as “Near Field” bores, while bores outside the zone of predicted impact are defined as “Regional” bores (CCO, 2018).

The groundwater monitoring network for CCO (***Figure 2-1***) includes several sub-programs including:

- Near Field (NF) Monitoring Bores:
  - NF monitoring bores are used to monitor groundwater levels and groundwater quality within the zone of predicted impact from mining as determined from the 2004 EIS. A total of 28 NF bores were installed at 16 sites prior to mining during the period 2006-2007 and target the various main aquifers identified. Water levels are taken monthly;
- WP-WC Monitoring Bores:
  - An additional 11 monitoring bores were drilled dating back to 1983 in the vicinity of the mine site that are referred to as WP-WC bores (WP1-7, WP10-11, WC1, and WC6). These bores were drilled by a previous lease-holder and have longer duration water level records. WP-WC bore water levels are taken monthly;
  - Regional bores (R series) are intended to monitor groundwater levels and groundwater quality outside the zone of predicted impact from mining. These bores were constructed at the same time as the NF bores. There are 29 bores at 19 sites (R1 to R19);

- RGW Monitoring bore network consists of a mixture of exploration bores and landholder bores, some of which are equipped with wind mills. A number of bores over the years have been removed from the list because they no longer exist or other bore access reasons. As of 2018, the number of RGW bores monitored regularly totalled 70 and when conditions and access allow, groundwater data is collected quarterly; and
- Bores within the CM lease area – licensed production bores and standpipe piezometer bores.

A Groundwater Environment Reference Group (GERG) was also established to allow landowners, mine personnel and regulators to meet on a regular basis with the aim of sharing information from ongoing reviews of groundwater data and to provide a forum for airing and discussion of any groundwater concerns (CCO, 2018).

Routine monitoring includes the preparation of quarterly data review reports as well as aquifer performance reports that are completed at defined intervals; these reports and data are provided to landholders and the regulating authority as a condition of the project's water licenses and the AWSA's.

Alternative Water Supply Agreements (AWSA) obligations were established as part of the Groundwater Management Plan. The monitoring requirements of the CCO bore network are listed in ***Table 2-1, Table 2-2*** and ***Table 2-3***. CCO has adequate spatial (both in terms of area and aquifers) and temporal coverage of the groundwater system.

2.2.2 Cement Hill

Near field and RGW bores in the CH area are routinely monitored as part of CCO's groundwater monitoring program (***Section 2.2.1***).

2.2.3 Train Load-Out

Limited groundwater monitoring data exists in the TLO area. Four groundwater monitoring bores lie within the TLO area, including GW02A, GW02B, GW06 and RN89427 (old name 1277R) (***Figure 2-2***). The bores are no longer active. Bores GW02A, GW02B and RN89427 are located within the present rehabilitation area and GW06 is located in the Ramp 2a waste dump area.

The available data for bores GW02A, GW02B and GW06 extends from 2007 to 2011 and includes water level and water quality data. There is no data available on bore depth or aquifer screen details for the GW bores. A bore report on Queensland Globe for bore RN89427 indicates an open exploration hole to 97m depth with no screened casing. Water level and water chemistry data is available for one period in 1993.

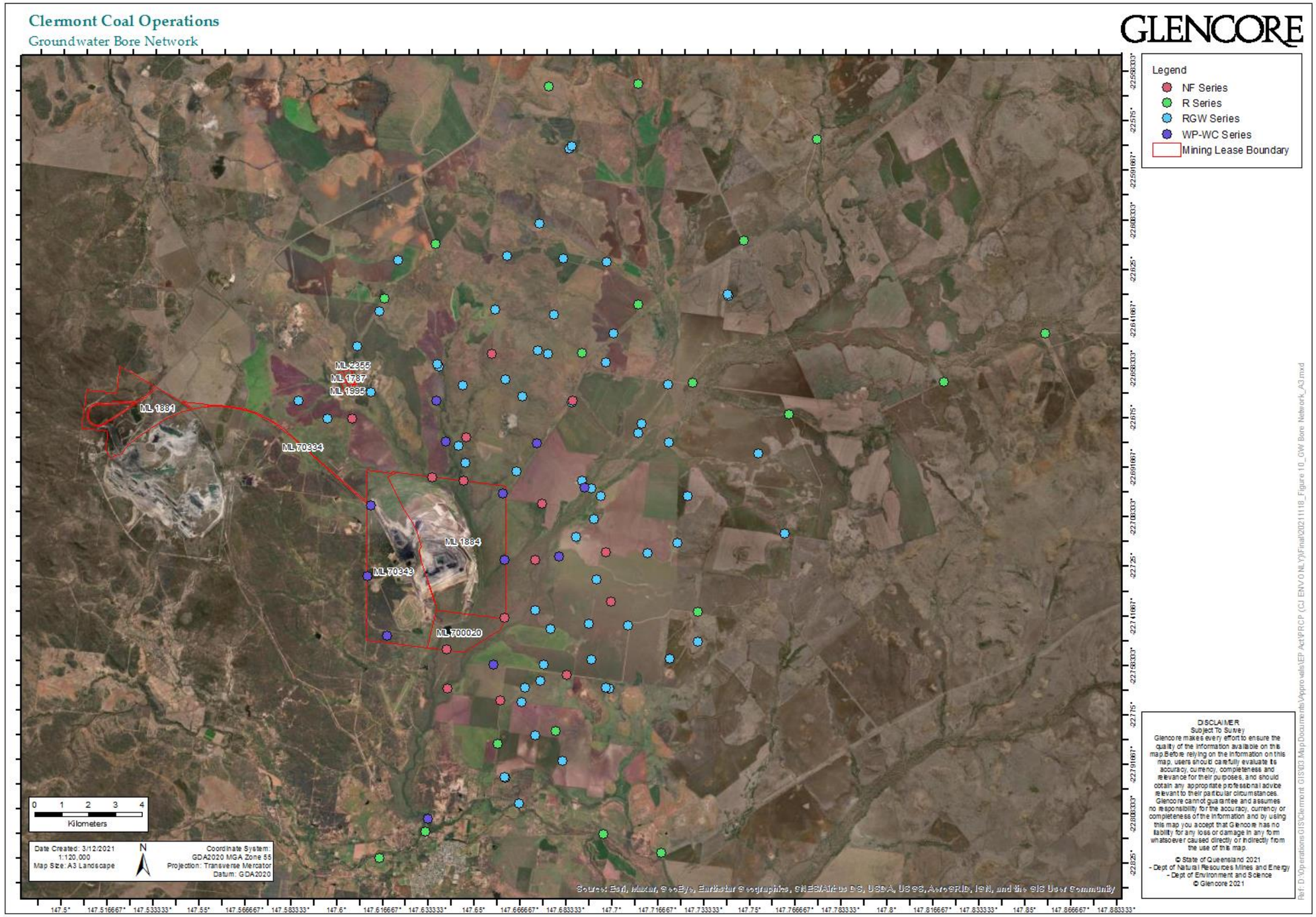

Figure 2-1 - Regional Groundwater Monitoring Bore Network

Table 2-1 - AWSA Monitoring Obligations as per Groundwater Monitoring Plan

Item No.	Bore	Frequency	Parameters
1	Near field 1-14, WC6, WP1-7, WP9-11	Monthly	Standing water level
2	Regional 1-18, WC1, RGW1-99	Quarterly	Standing water level
3	Near field 1, 4, 6, 9, 10, 11 and 12 Regional 1, 3, 5, 7, 10, 11 and 12	Quarterly	pH and electrical conductivity
4	Near field 1, 4, 6, 9, 10, 11 and 12 Regional 1, 3, 5, 7, 10, 11 and 12	Annual	Field pH & EC TDS, major and minor ions (Ca, Mg, K, Na, SO4, Cl, Alkalinity (hydroxide, carbonate, bicarbonate, total), F Dissolved and Total metals/metalloids (Al, As, B, Cd, Cr, Co, Cu, Fe, Pb, Hg, Mn, Mo, Ni, Se, Ag, U, V, Zn)**
5	RGW1-99	Quarterly	Standing water level
6	Licensed Dewatering Works (groundwater production bores)	Six Monthly	Field pH & EC TDS, major and minor ions (Ca, Mg, K, Na, SO4, Cl, Alkalinity (hydroxide, carbonate, bicarbonate, total), F Dissolved and Total metals/metalloids (Al, As, B, Cd, Cr, Co, Cu, Fe, Pb, Hg, Mn, Mo, Ni, Se, Ag, U, V, Zn)**
		Monthly	Monthly and cumulative abstraction volumes, pumping schedule, operational pumping rate

Table 2-2 - Groundwater monitoring plan for CCO

Frequency	No. Bores	Requirements
Monthly (Jan – Dec)	44 bores	Standing Water Level Only (Measured to nearest cm)
	6 bores (Megacell)	Standing Water Level Only (Measured to nearest cm)
Quarterly **(Mar, Jun, Sep, Dec)**	97 bores	Standing Water Level Only (Measured to nearest cm) (this excludes bores that are already monitored monthly for SWL)
	24 bores	Field Water Quality (in situ pH and EC) (These bores are also visited as part of the monthly and quarterly SWL monitoring)
Annual (Dec)	25 bores	Field and Lab Water Quality Field pH & EC TDS, major and minor ions (Ca, Mg, K, Na, sulphate as SO42-, Cl, Alkalinity (hydroxide, carbonate, bicarbonate, total as CaCO3), F Dissolved and Total metals/metalloids by ICPMS/FIMS (Al, As, B, Cd, Cr, Co, Cu, Fe, Pb, Hg, Mn, Mo, Ni, Se, Ag, U, V, Zn)

Table 2-3 - Bore details for water quality monitoring bores

Bore ID	Aquifer	Easting (AGD84)	Northing (AGD84)	RL TOC* (mAHD)	Depth (m)	Gravel Pack Interval (mbgl)*		Slotted Interval (mbgl)*	
						Top	Base	Top	Base
Near Field Bores									
NF1A	Cambrian Metamorphics	565029	7489799	278.60	198	46	198	192	198
NF3A	Tertiary Basalt	569118	7488792	273.84	61	47	61	54	60
NF4A	Tertiary Basalt	568867	7486725	268.08	58	44	58	46	58
NF4B	Tertiary Sediments	568862	7486722	268.13	110	90	110	92	104
NF5C	Tertiary Basalt	567723	7484553	265.08	48	40	48	42	48
NF6A	Permian Sediments	565542	7483390	262.90	155	148	155	150	153
NF6E	Tertiary Sediments	565555	7483391	262.70	36	18.6	36	21	35
NF7B	Tertiary Basalt	567311	7482815	265.28	29	23	31	25	28
NF9A	Tertiary Basalt	567248	7494377	320.50	62	51.5	62	55	61
NF9C	Tertiary Sediments	567250	7494391	320.53	143	132	143	138	141
NF10A	Tertiary Basalt	570251	7492637	289.46	61	52	61	54	60
NF11A	Permian Sediments	571496	7486992	276.87	61	49	61	51	60

Bore ID	Aquifer	Easting (AGD84)	Northing (AGD84)	RL TOC* (mAHD)	Depth (m)	Gravel Pack Interval (mbgl)*		Slotted Interval (mbgl)*	
						Top	Base	Top	Base
NF11B	Tertiary Basalt	571494	7486986	276.89	39	27	39	32	38
NF12A	Tertiary Basalt	570050	7482431	277.07	61	45	61	51	60
NF16B	Tertiary Basalt	566200	7489653	278.95	29	22	29	22	28
Regional Bores									
R1A	Permian Sediments	563239	7496465	331.94	78.5	70.5	78.5	71.5	77.5
R1B	Tertiary Basalt	563243	7496470	332.04	52	36	52	42	51
R3B	Tertiary Basalt	572710	7496232	293.08	46	36	54	39	45
R3C	Tertiary Sediments	572718	7496226	293.12	141	133	151	134	140
R5A	Tertiary Basalt	578310	7492137	294.90	94	86	96	87	93
R7A	Permian Sediments	569637	7480338	258.93	97	81.3	97	84	96
R7B	Tertiary Basalt	569637	7480345	258.97	37	58	37	30	36
R10A	Alluvial Sediments	564756	7476596	258.33	9	4	12.3	5	8
R11B	Alluvial Sediments	563062	7475596	260.64	23	3	23.7	13	22
R12A	Permian Sediments	571404	7476481	249.26	73	60.5	73	66	72

Bore ID	Aquifer	Easting (AGD84)	Northing (AGD84)	RL TOC* (mAHD)	Depth (m)	Gravel Pack Interval (mbgl)*		Slotted Interval (mbgl)*	
						Top	Base	Top	Base
R12B	Alluvial Sediments	571418	7476483	249.11	15	6	17	8	14
R12C	Tertiary Basalt	571408	7476480	249.08	35	24	36	28	34
	Bore monitored in addition to Water Licence commitments								

* *RL TOC = the reduced level (RL), i.e. the elevation, of the top of bore casing (TOC), relative to the Australian Height Datum (AHD)*
mbgl = metres below ground level

Figure 2-2 - Location of Groundwater Bores in the TLO area

2.3 Summary of Results

2.3.1 Groundwater Levels

2.3.1.1 Clermont Mine

Tertiary Basalt Aquifer

Groundwater level trend data (standing water levels, SWL) has been reviewed and reported as part of the triannual reporting requirements. The following observations are made from the 2020 Aquifer Performance report (JBT Consulting Pty Ltd, 2020):

- Water level trend data as compiled 2008 to June 2020 for near mine bores (***Figure 2-3***) regional (***Figure 2-4***) and show a general correlation with the cumulative residual rainfall trend; and
- Basalt groundwater levels close to the mine, for example NF4A (***Figure 2-3***), have higher groundwater levels as of Dec 2020 compared to early 2008 despite a protracted dry climate period since mid-2012. This demonstrates the ability of the basalt aquifer to recharge.

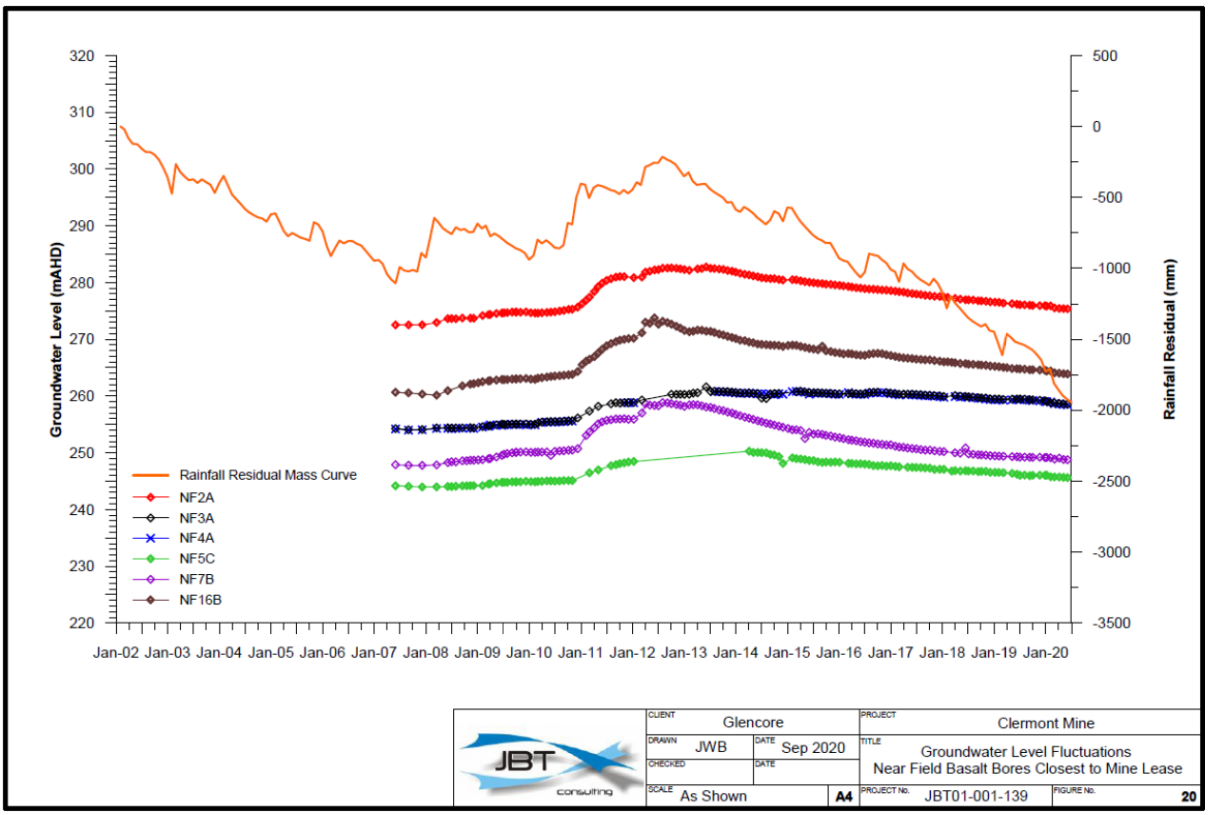

Figure 2-3 - Near Mine Basalt Groundwater Level trends

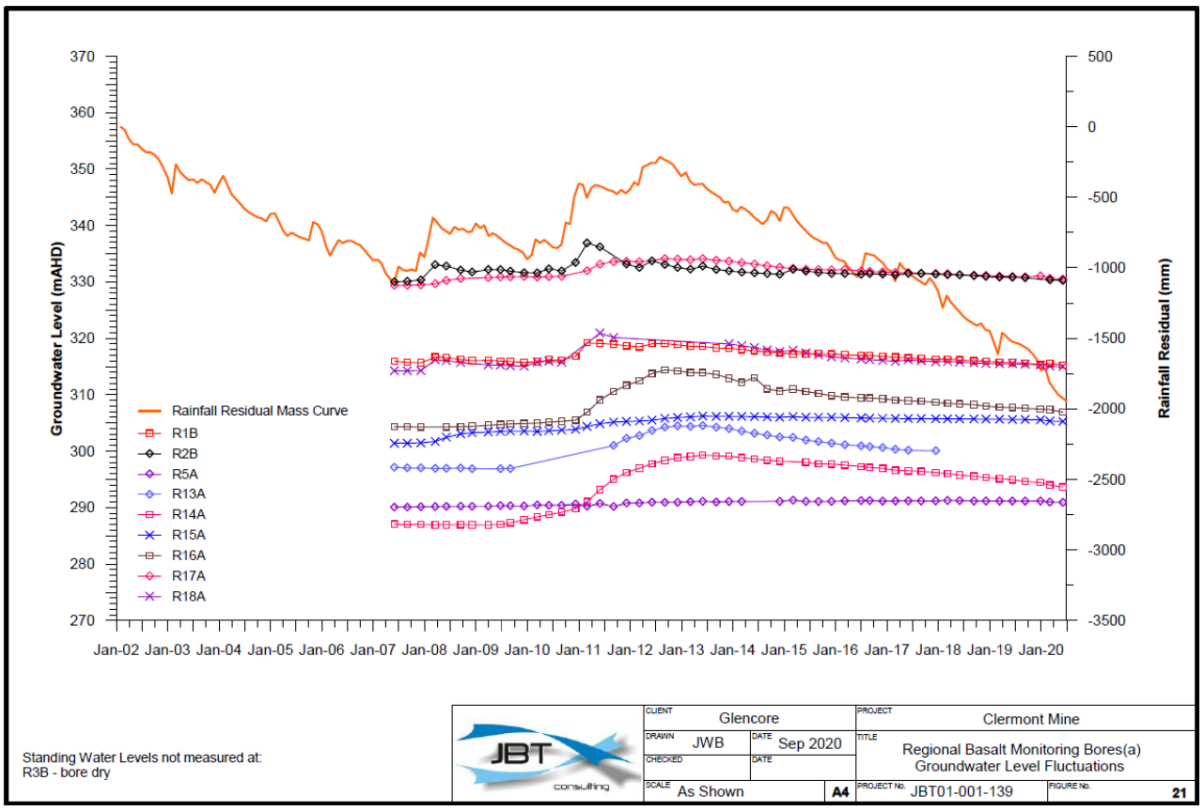

Figure 2-4 - Regional Bore Basalt Groundwater Level trends

A plot of the groundwater level contours of the regional groundwater bore network for the Tertiary Basalt (***Figure 2-5***) shows a southerly groundwater flow direction, generally following topography. A groundwater sink is observed at the mine pit area.

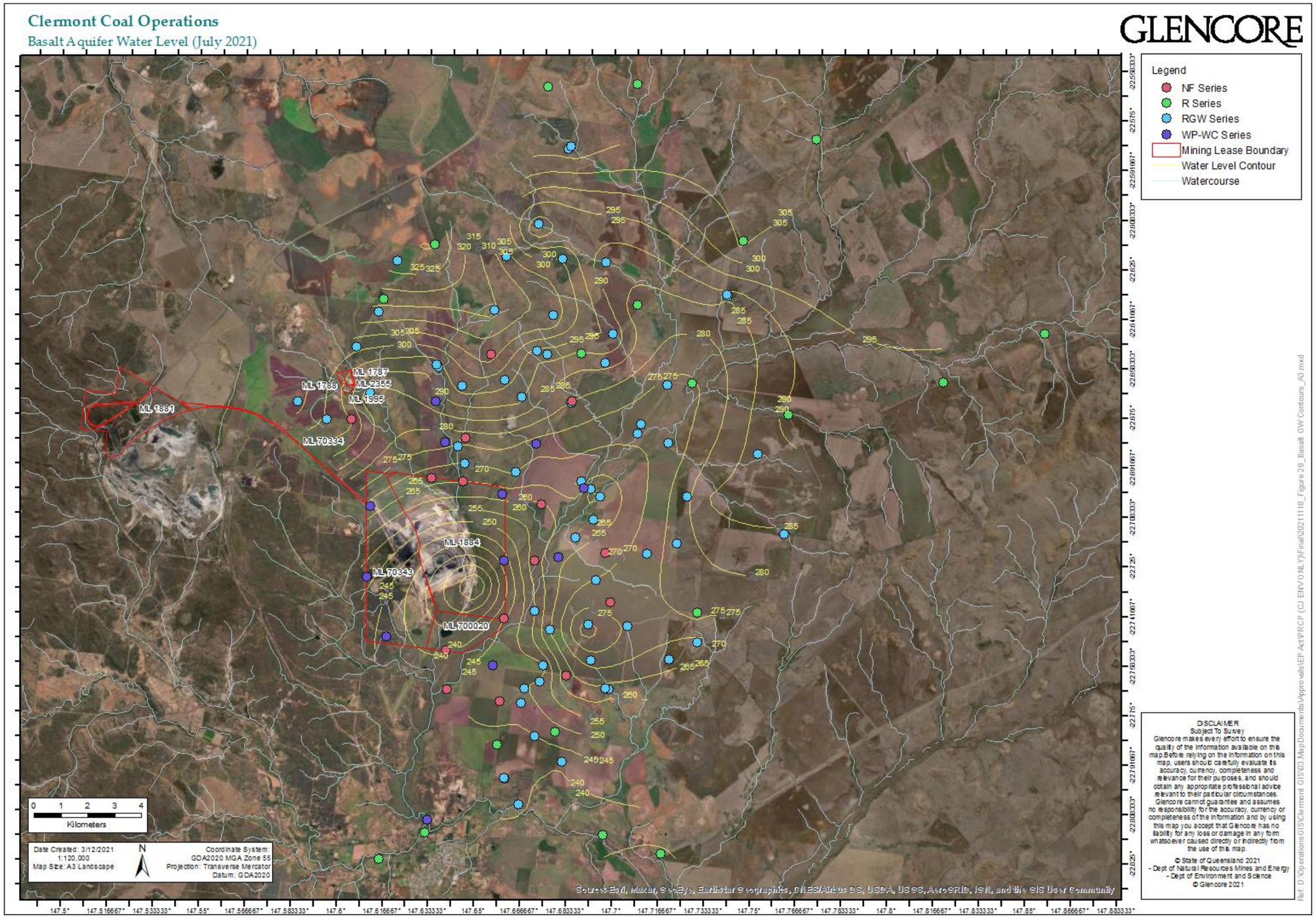

Figure 2-5 - June 2020 Groundwater Level Contour (mAHD) Plot for the Basalt regional Groundwater Monitoring Bores

Permian Aquifer

The Permian groundwater piezometric levels for June 2020 area presented in ***Figure 2-6*** below.

Groundwater flow direction can be inferred from the hydraulic gradient, being north to south across the site. A weak cone of depression around groundwater monitoring bore NF6A, which is located near Tertiary Basalt pumping bore BDB13. Bore BDB13 is the only groundwater pumping bore extracting water during 2019-2020.

2.3.1.2 Cement Hill

A south-easterly groundwater gradient has been shown from groundwater level monitoring data (***Figure 2-7***) which corresponds with the topographic / drainage system.

The groundwater level data is presented in ***Figure 2-8***, along with monthly residual rainfall data. This plot shows a period typified by low rainfall from the early 2000's to around 2007. From around 2008 to 2013, monthly residual rainfall increased to positive values (i.e. above average rainfall conditions) before returning to persistent below average conditions from 2013 (KBR, 2019).

2.3.1.3 Train Load-Out

The available groundwater level data does not have a surveyed reference point for any of the bores listed below that would permit accurate levels recorded in mAHD.

Bore GW02A

The depth to groundwater for the period 2008 to 2011 was reported in the range of 11.5 m depth to 13.7 m depth, presumably depth below ground level.

Bore GW02B

The depth to groundwater for the period 2008 to 2011 was in the range of 25 m depth to 32.7 m depth, presumably depth below ground level.

Bore GW06

The depth to groundwater for the period 2008 to 2011 was in the range of 17 m depth to 19 m depth, presumably depth below ground level.

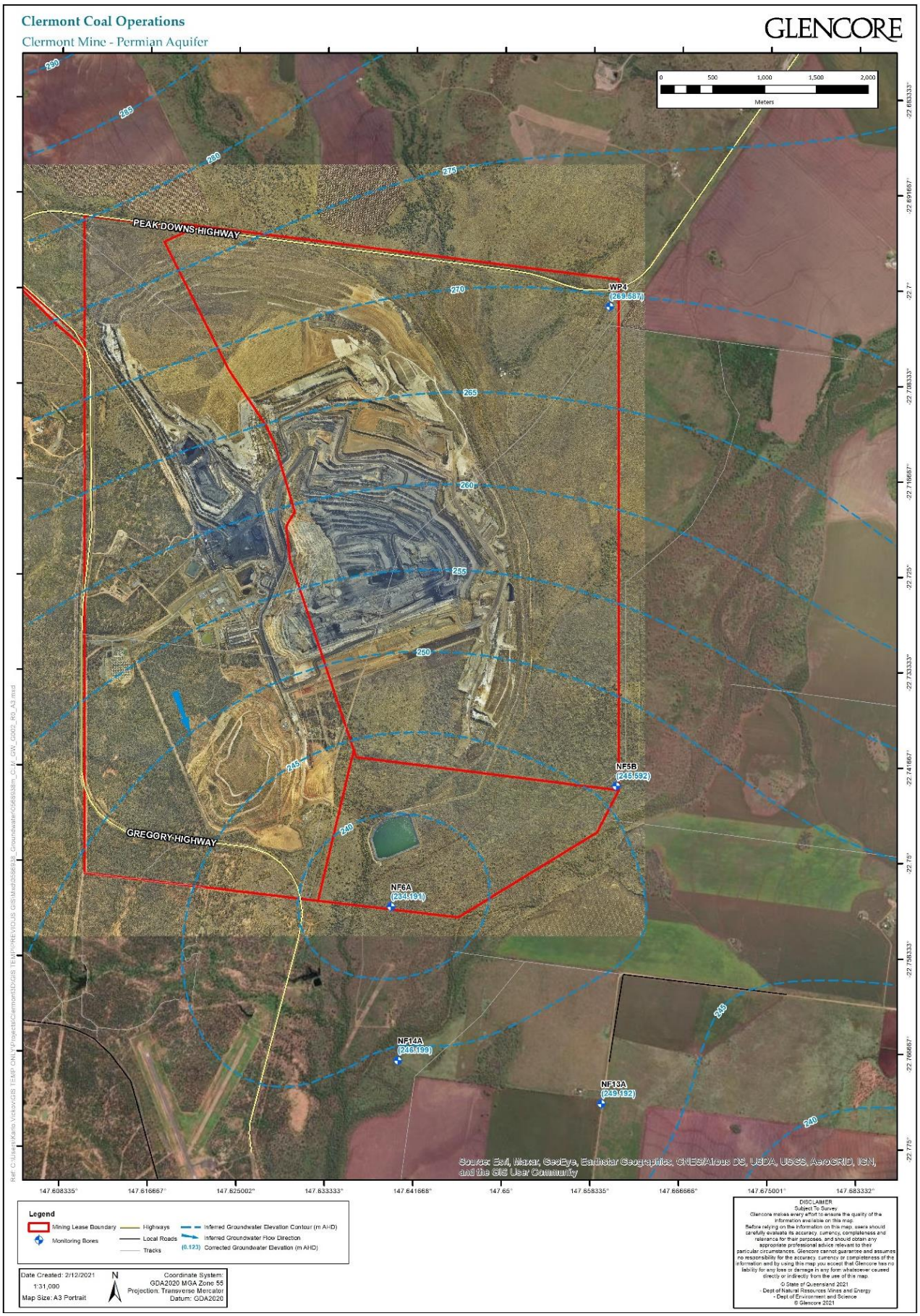

Figure 2-6- June 2020 Permian Aquifer Groundwater Piezometric Contours

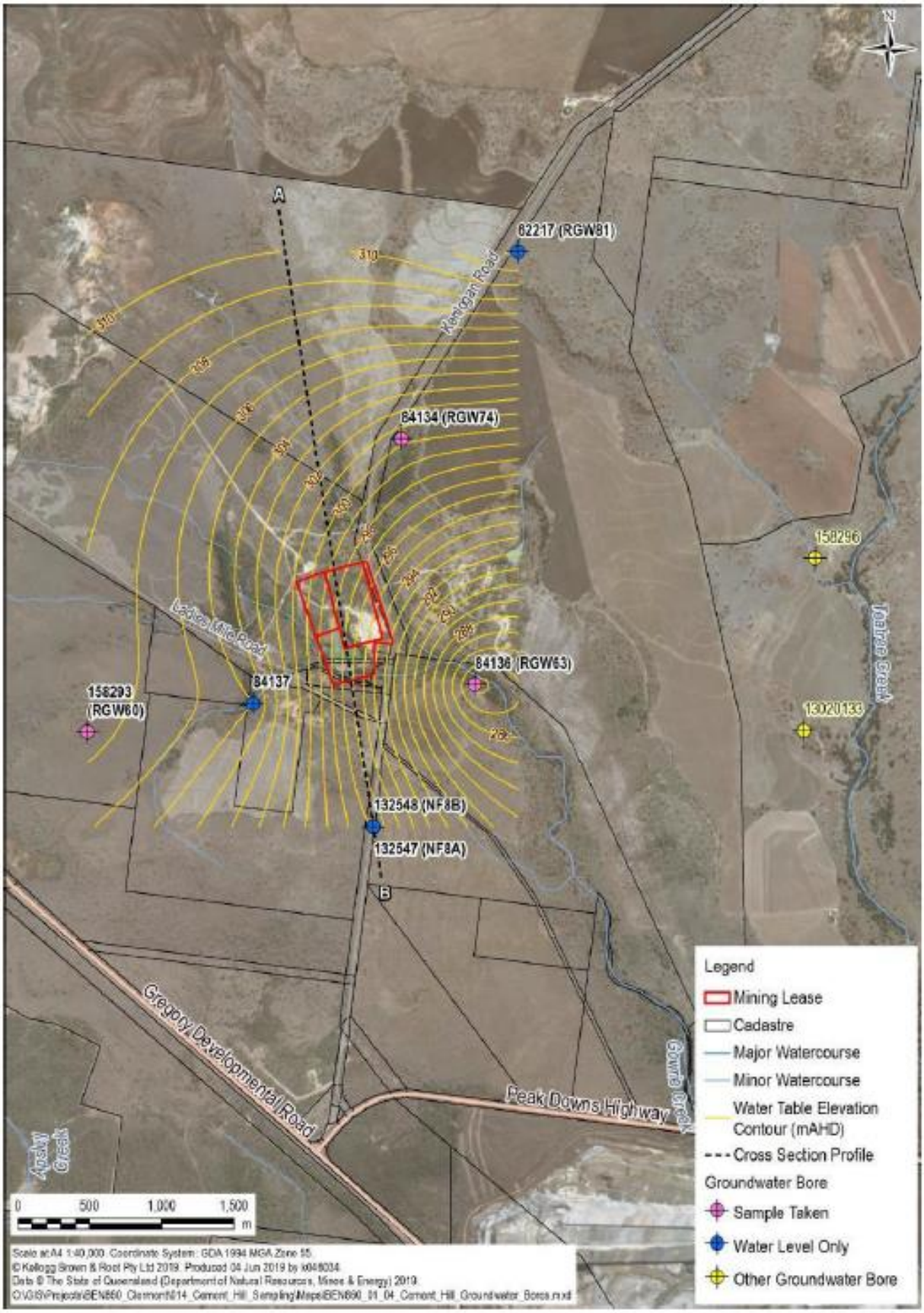

Figure 2-7 - Basalt aquifer groundwater contours for 2019

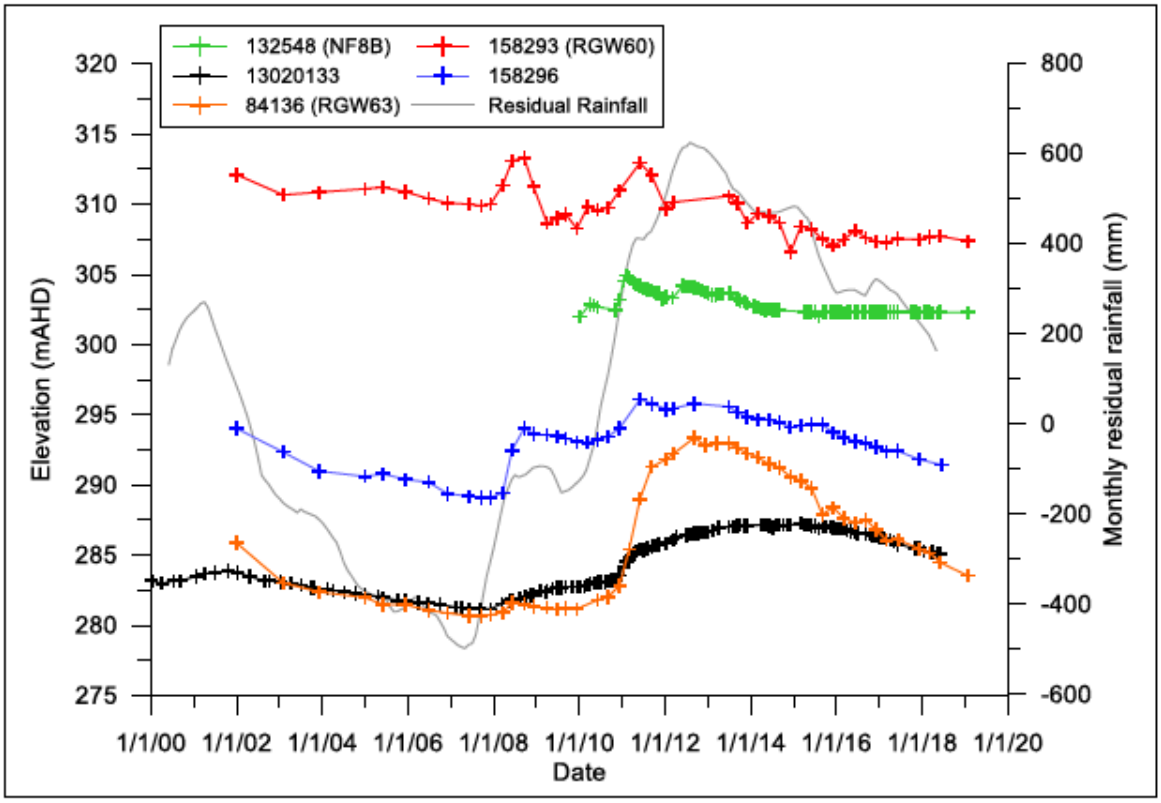

Figure 2-8 - Long term water table elevation records with monthly residual rainfall

2.3.2 Groundwater Quality

2.3.2.1 Clermont Mine

The groundwater quality data available is provided in a comprehensive data set that allows for a statistical characterisation of the various aquifers. No significant detrimental chemical trends have been identified.

The Environmental Authority for CCO does not prescribe an upper trigger limit for groundwater quality. Past assessments of water quality has been compared against ANZECC 2000 water quality guidelines (now ANZG 2018) for stock water use, and against Australian Drinking Water Guidelines (ADWG, 2011) for health and aesthetic considerations.

The available groundwater salinity data of the main aquifers is summarised in the following ***Table 2-4***.

Attachments A to E provides a summary of groundwater chemistry for dissolved and total metals/ metalloids for all samples to date. The data was extracted from JBT Consulting Pty Ltd (2020), appendices B-9 and B-10.

No significant detrimental chemical trends have been identified. Recent water quality results are interpreted to be representative of background groundwater quality, that is, groundwater quality has not been impacted by operations at CCO (JBT Consulting, 2020).

Table 2-4 - Groundwater salinity statistics

Statistic (Unit)	Minimum (µS/cm)	Maximum (µS/cm)	Mean EC (µS/cm)	Median EC (µS/cm)	80th percentile (µS/cm)	Std Dev (µS/cm)	No.of Samples
Alluvium	615	10000	2030	1175	2370	2222	18
Basalt	460	2170	1218	1265	1560	429	202
Tertiary Sediments	583	2770	1189	757	1864	780	50
Permian (Non- Coal)	732	1780	1167	949	1660	380	53
Permian (Coal Seams)	677	985	985	807	835	71	17

2.3.2.2 Cement Hill

A recent groundwater quality investigation (KBR, 2019) found that the groundwater in proximity to the site is typically neutral to alkaline, and fresh water. The groundwater contains low concentrations of nutrients and concentrations of dissolved metals below the high reliability (95th percentile) ANZG (2018) guideline values, except for zinc.

Groundwater quality sample results for bores in the Cement Hill area are presented in ***Table 2-5***.

Table 2-5 - Groundwater field water quality measurements

Groundwater bore	pH	EC (µS/cm)	TDS (mg/L)	ORP (mV)	DO (mg/L)	Turbidity (NTU)	Temperature (deg C)
84134 (RGW74)	7.5	913	600	-7.6	3.08	12.2	24.4
84136 (RGW63)	7.7	813	508	82.3	2.54	60.8	27.2
84137	7.7	2.1	1.3	18.5	7.87	4.7	25.6
158293 (RGW60)	9.2	441	271	32.8	4.07	<1	28.1
132547 (NF8A)	7.2	1486	972	-46.6	3.54	1250	24.7

Groundwater analysis for samples taken in 2019 for dissolved metals showed all values were below ANZECC freshwater guideline 95 percentile protection values for all metals except zinc, where all bores except of bore 158293 was above the 0.008 mg/L guideline level. Bore 132547 (NF8A) sample for cobalt of 0.002 was marginally higher than guideline value of 0.0014.

Interaction of Void with Aquifer System

It is unlikely that the limited interaction of the aquifer system with void will have lasting significant impact to the regional aquifer system.

Physico-chemical profiling of the void water body was undertaken in 2019 by KBR with the following conclusions:

- Void chemistry both spatially and throughout the upper and mid water column is generally consistent; and
- The deeper layers within the void contains different chemistry (anoxic conditions with marginal thermal and salinity stratification).

The profiling was conducted at 4 locations within the water body down to a depth of 4.75 m. A transition zone at around the 4 m to 4.5m depth is evident where;

- dissolved oxygen saturation is reduced from around 90% to 15%;
- a significant decrease in oxidation-reduction potential (ORP) from around 100 mV to -50 mV;
- reduction in pH from 8.6 to 7.5;
- A slight increase in the total dissolved solids (TDS increase from 260 to 300 mg/L) and salinity (from 460 EC to 485 EC (unknown if units are ppm or µS/cm));
- Temperature reduction (from 28.5 deg C to 27 deg C);
- Turbidity increase from around 12 FNU to 30 FNU; and
- It is possible the transition zone is related to the location of groundwater inflow or it could be a seasonal occurrence typical of non-flowing water bodies.

2.3.2.3 Train Load-Out

Limited groundwater monitoring data exists in the TLO area.

Bore GW02A

Groundwater salinity was recorded in the range of 1030 to 1368 EC (unknown if units are ppm or µS/cm) and pH in the range of 7.1 to 7.7.

Bore GW02B

Groundwater salinity was recorded in the range of 720 to 1219 EC (unknown if units are ppm or µS/cm) and pH in the range of 7.1 to 8.0.

Bore GW06

Groundwater salinity was recorded in the range of 10,000 to 12,000 EC (unknown if units are ppm or µS/cm) and pH in the range of 6.27 to 6.67.

3. Summary of Groundwater Conceptualisation

3.1 Climate

Groundwater in the CCO area is interpreted to be largely fed by diffuse groundwater recharge and is therefore largely dependent on annual rainfall and its seasonal distribution. As such, rainfall data has been obtained from the Queensland Government Longpaddock website (SILO database) and is shown on ***Figure 3-1***. The three month-moving average rainfall provides clarity on seasonality and local recharge for the shallow aquifers, with the cumulative residual rainfall mass (RRM) useful for interpreting longer term response in the aquifers.

Key observations made with respect to rainfall data over the past ten years:

- The period from 2006 to mid-2012 shows a general wetter climate trend as demonstrated from the rising cumulative residual rainfall mass curve with the September 2010-March 2011. The early onset of the wet season in September provided enhanced conditions for groundwater recharge, as the ground was already saturated from the rain in September when the wet season rainfall began;
- The 2011-2012 wet season was also above average, due mainly to high rainfall recorded during January and March 2012; and
- The rainfall trend has essentially been in a dry climate trend since mid-2012. This falling trend over the past eight years indicates a potential for longer-term falling groundwater levels, especially for shallow aquifers (such as the Tertiary basalt aquifer) where water levels are, in some cases, strongly influenced by rainfall.

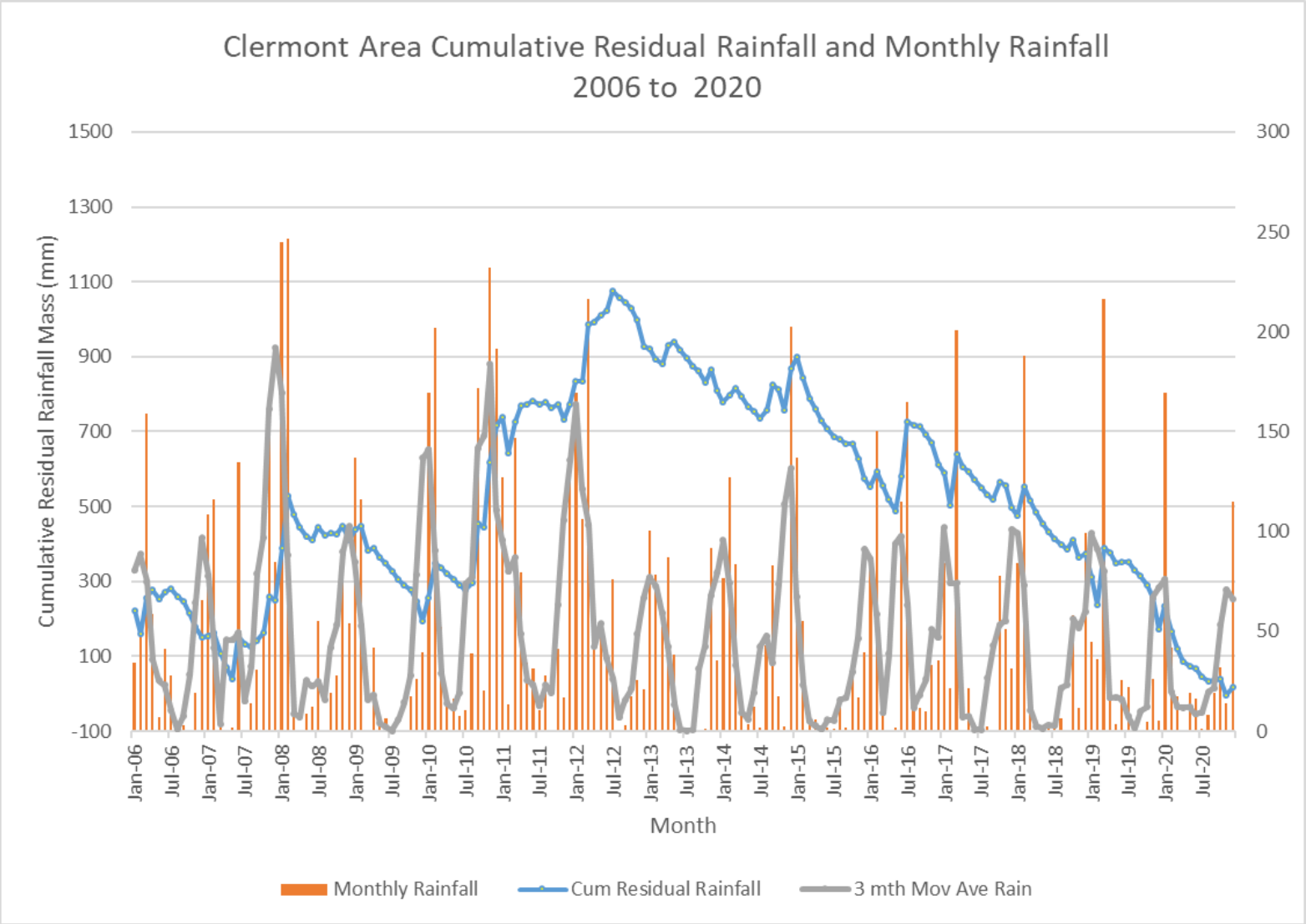

Figure 3-1 - Monthly rainfall from SILO database (Lat -22.7, Long 147.6) 2006-2020

3.2 Site Topography

Topography across CCO areas has been significantly modified by mining operations. However, northeast of CM the Tertiary landforms are illustrated by low, undulating hills, which are dissected and eroded basalt with Quaternary colluvial and alluvial sediments occupying the gullies, shallow valleys and drainage lines. Tertiary basalt flows form the upper creek catchment areas north of the site, with Gowrie and Teatree Creeks cutting into these formations to the east of the mine site, joining to the confluence of Wolfgang Creek 5 km south of the CM site. At the TLO, a significant portion of the area remains as low undulating open woodland / bushland. West of the area, the terrain is dominated by undulating hills and southeast trending drainage lines cut into the Hurley metamorphic rocks. The main topographic features of the CH site are the final void and the out of pit dumps. The void currently acts as a water storage feature, receiving inflows from both surface water and groundwater. The water level within the void varies based on climatic variability, however typically contains water (KBR, 2019).

It is generally observed that the water table is a subdued reflection of the topography (JBT Consulting, 2020). This is evident from the water level contours (refer to ***Figure 2-5***), which dip towards major drainage features such as Wolfang Creek.

3.3 Site Geology

3.3.1 Clermont Mine

Permian sediments lie under the surface geology of Quaternary sediments, Tertiary sediments and Tertiary basalt (***Figure 3-2*** and ***Figure 3-3***), formed in a graben basin during the Early Permian following a tectonic extension episode. The western margin of the Clermont main deposit represents the up-thrust side of the graben and is locally referred to as the 'Western Wall Fault'. Glacial sediments form the lower basal conglomerate of the Permian sequence in the graben structure, with subsequent sedimentation of finer sediments forming the coal and interburden layers of the Wolfgang coal measures in the Clermont main deposit area. The Permian sediments in the Clermont main deposit area and east of the active mine area can range in thickness from 80 m to 290 m.

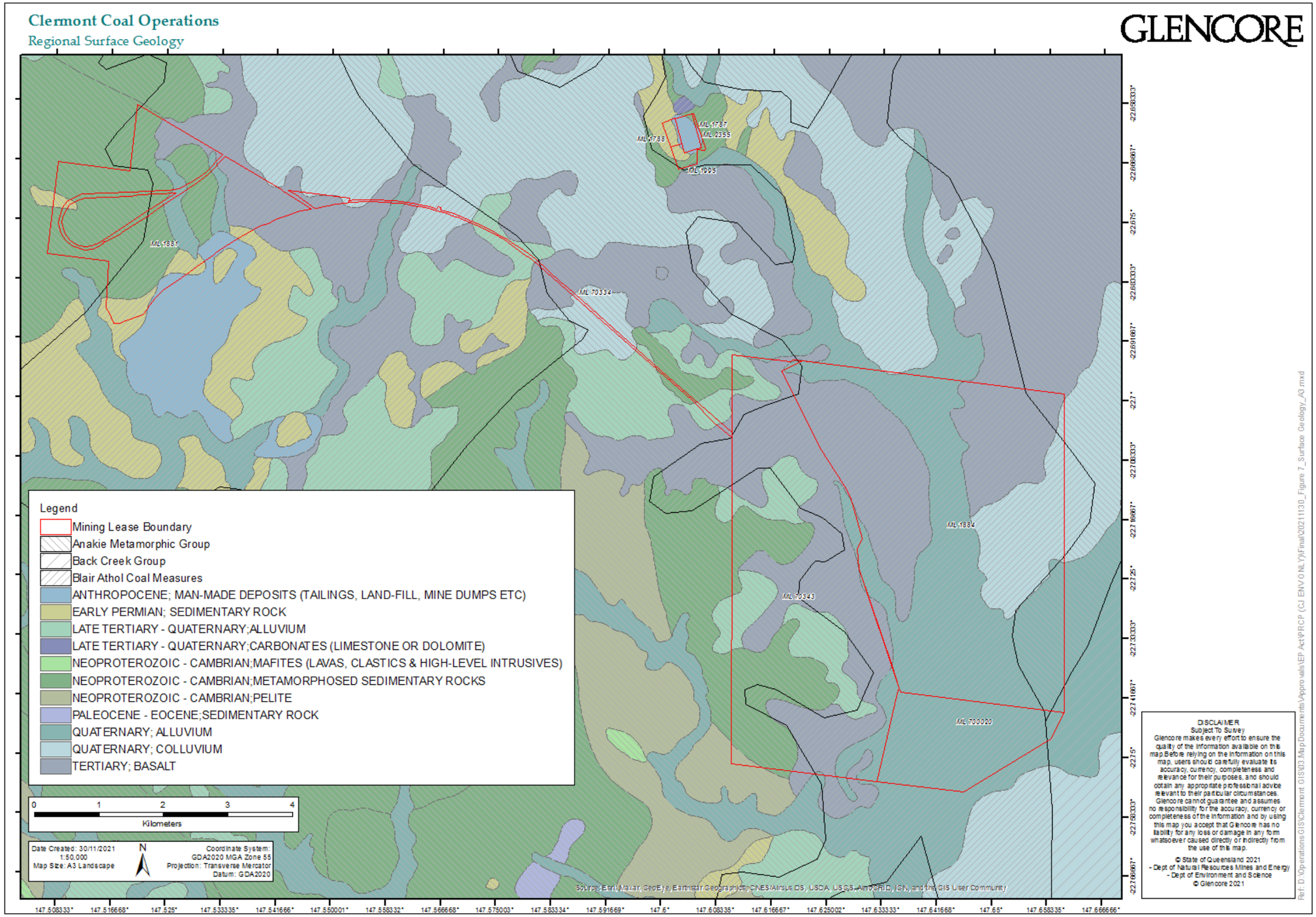

Figure 3-2 - Regional Surface Geology of the Clermont Area

Tertiary sediments overlie the Permian sequence, and consist variable sediment grainsize from fine sand and clay to gravel and is variable in thickness. Tertiary basalt flows overlying the Tertiary sediments, include multiple basalt layers interbedded with clay lenses separating volcanic flow events.

A north-south oriented trough of basalt up to 160 m thick is located east of the CM. A secondary, thinner package of basalt up to 60 m thick trend northwest-southeast was located within the CM area (prior to open cut mining), and has been mined out as part of pre-stripping to access the coal deposits below.

The more recent Quaternary sediments are eroded remnants of the underlying geology, consisting of clays, sands, gravel and weathered basalt. These alluvial deposits are clay rich and do not yield significant quantities of water.

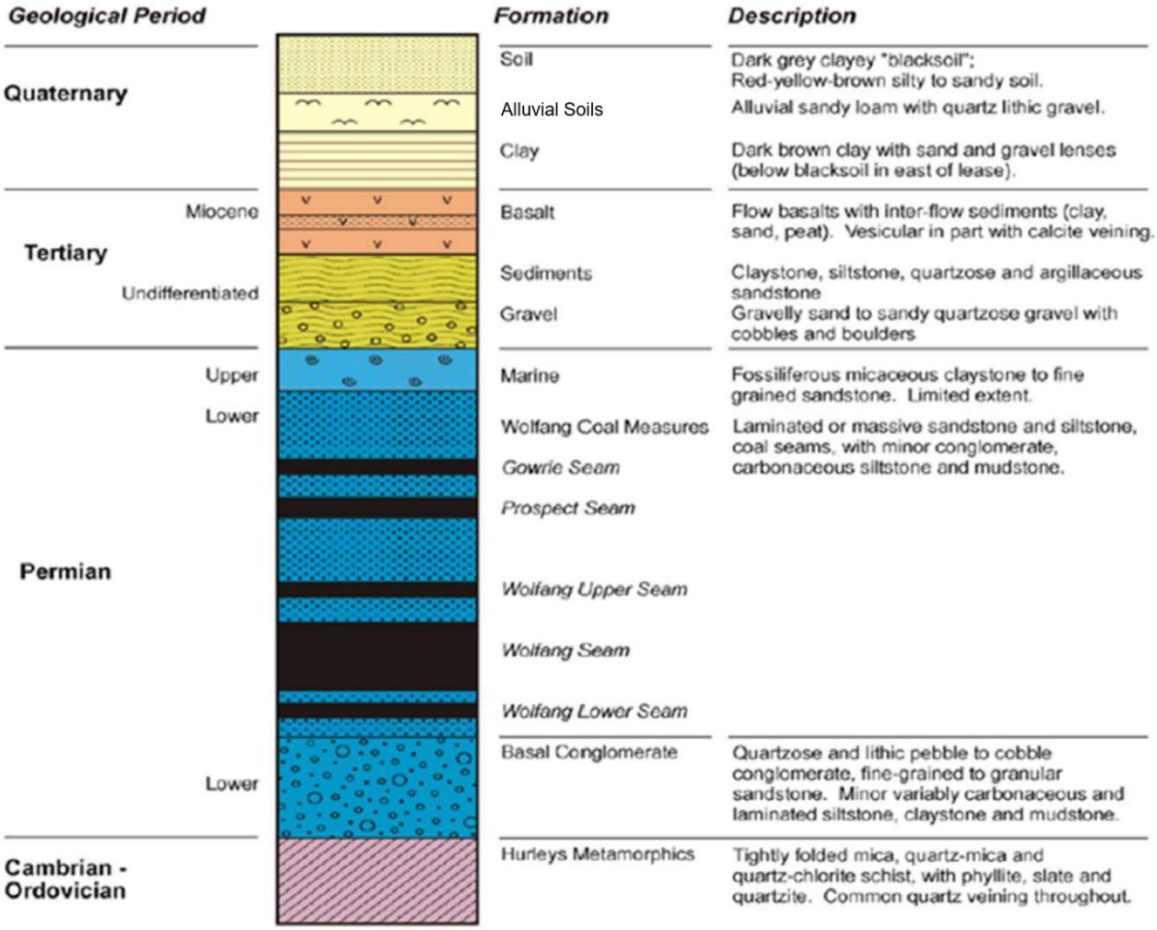

Figure 3-3 - Typical Stratigraphic Sequence at the CCO site

3.3.2 Cement Hill

The regional geology mapping data from the Queensland Globe database (***Figure 3-2***, ***Section 3.3.1***), shows the existence of the Blair Athol Coal measures overlying the basement Hurley metamorphic rocks with recent tailings sediments occupying much of the ML1787. A small block of Late Tertiary limestone has been mapped immediately north in ML100160. Basalt is mapped northwest of the Cement Hill area.

Local drill hole data suggests that in the local area, a 10-20 m thick layer of basalt overlies a conglomerate sequence of greater than 50 m depth, across most of the site, except in the south, where a 10 m thick layer of clay occurs between the conglomerate and the basalt (refer to ***Figure 3-4*** below).

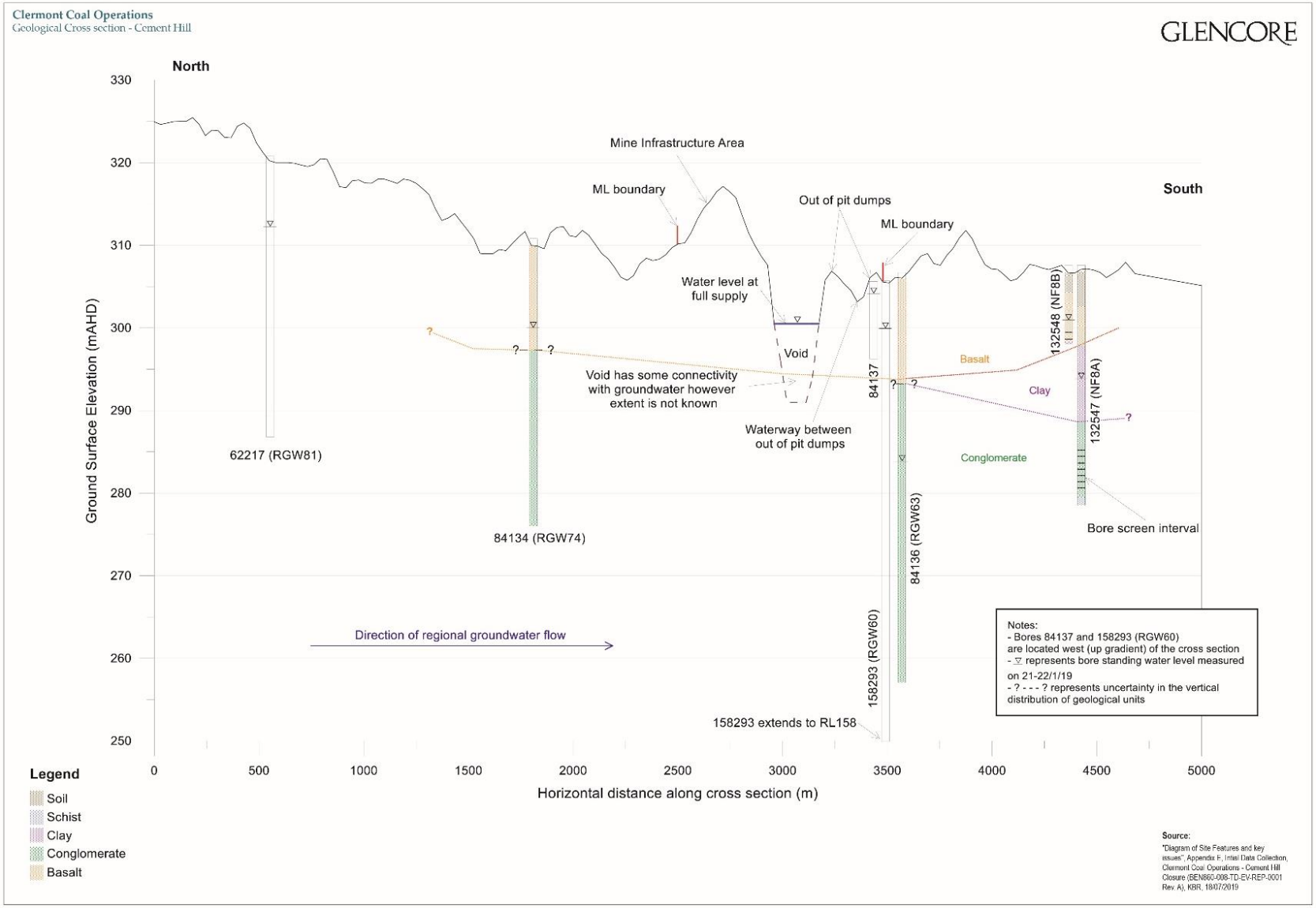

Figure 3-4 Geology Cross Cement Hill Area

Test pits across the Cement Hill lease area show that surface layers tested (1.6 – 4 m depth) consist of clays, silts, sands, and gravels. The current final void floor is 291mAHD, and the top of the void is 310mAHD.

3.3.3 Train Load-Out

The geology of the area is dominated by the Hurley metamorphics (***Figure 3-2***) with a portion of the Blair Athol Coal measures in the southern portion of lease area. Recent Quaternary alluvium flanks the existing drainage lines into West Dam area and the eastern portion of the lease. Prior to earlier open cut mining, Tertiary basalts and shallow alluvial sediments existed in the eastern extremity of the lease area and have since been removed by mining.

The Blair Athol Coal measures in the Blair Athol area consist of sandstone, siltstone, mudstone, conglomerate and four significant coal seams (Seams No. 1, 2, 3 and 4). The basement metamorphic rocks consist of coarse sandstone, conglomerate and minor carbonaceous shales. The coal seams deposited above the metamorphic rocks are generally flat lying (up to 6 to 8 degrees dip) and lenticular in nature (Rio Tinto, 2010).

3.4 Site Hydrogeology

The conceptual groundwater model for the site (with the expected footprint to be mined highlighted) is provided in ***Figure 3-5***, and this will be discussed in the following sections. Note that a post mining conceptual model is provided in ***Figure 3-10*** which highlights where backfilled material will replace original hydrogeological strata.

3.4.1 Clermont Mine

Within the stratigraphic sequence described above in ***Section 3.3***, the three main water bearing aquifers, from top to bottom, include the Tertiary basalt, Tertiary gravels and the Permian sedimentary formation, which contain economic coal deposits and interburden of sandstone, siltstone and shale. The Cambrian metamorphics are considered to be the hydraulic basement, but contain water within secondary porosity (fractures, weathered horizons) in some areas.

The Tertiary basalt aquifer is the most extensive aquifer in the Clermont area, and is the most significant aquifer in terms of groundwater supply for landholders (refer to ***Section 5.2***). The Tertiary gravel aquifer is separated from the overlying basalt by a clay unit up to 25 m thick (referred to as the Tertiary claystone). This clay unit acts as a confining unit for the Tertiary gravel aquifer and hydraulically separates the gravel aquifer from the overlying basalt aquifer at the mine site. The gravel aquifer is interpreted to be the equivalent of a colluvial fan, and is not part of an extensive regional prior channel system. It is up to 30 m thick beneath the mine site, but is not regarded to be an extensive regional aquifer as the distribution of coarse sediments appears to be limited to the Clermont mining lease area. The Permian sediments are the host to the coal measures. Groundwater occurs in Permian non-coal sediments, (conglomerates and sandstones) as well as the coal seams.

Considering surface water/ groundwater interactions, conceptually, the streams in the area are regarded as being gaining streams, i.e. they receive water from the groundwater system (JBT Consulting, 2009). It is possible in some stream reaches, under certain conditions, that streams are losing, i.e. they provide recharge to the groundwater system. However, this has not been observed in field measurements (JBT Consulting, 2009) and is not considered significant.

Figure 3-6 provides a schematic hydro stratigraphic cross section through the mine area, which identifies the units described above and their associated depths.

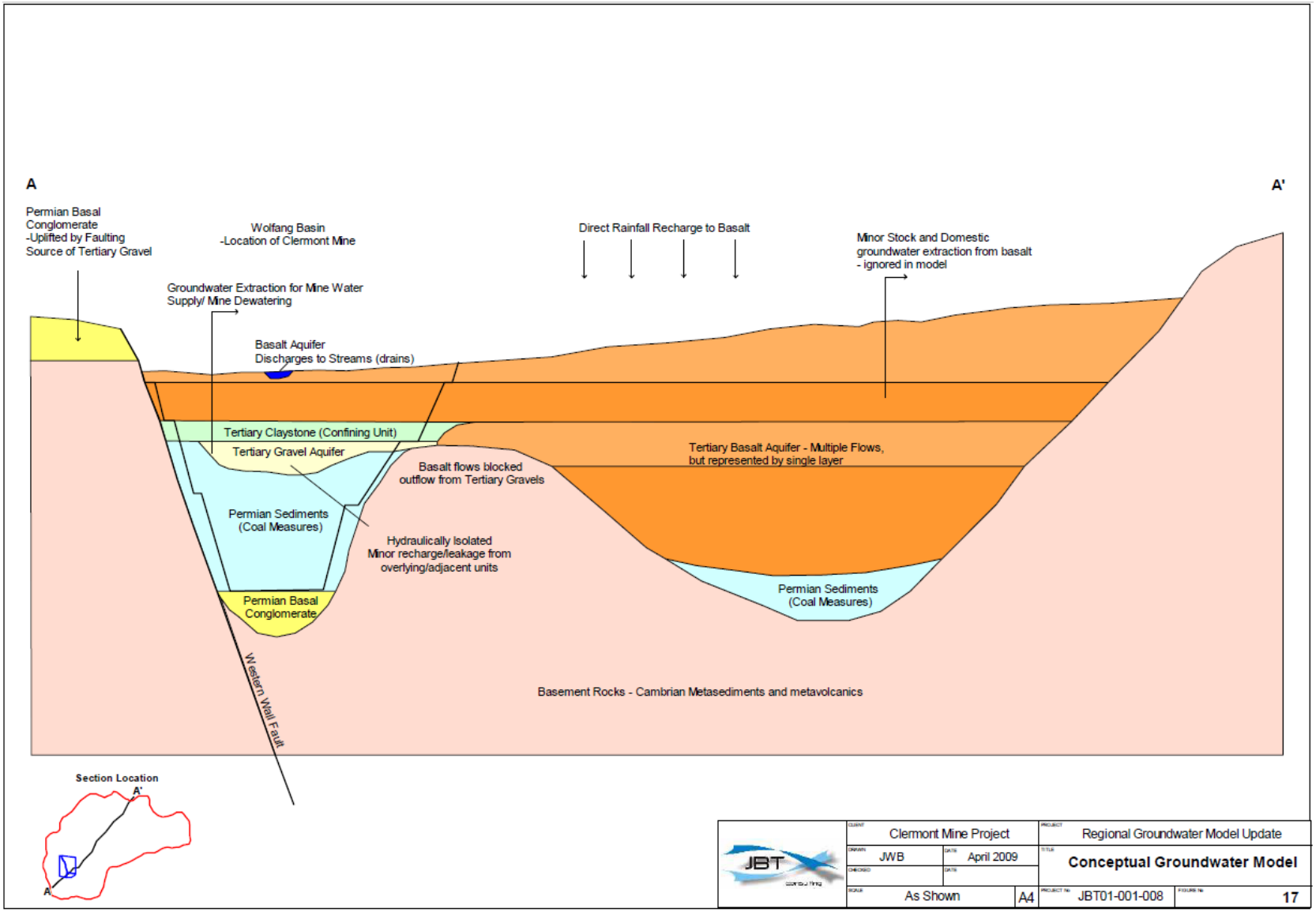

Figure 3-5 - Conceptual Groundwater Model

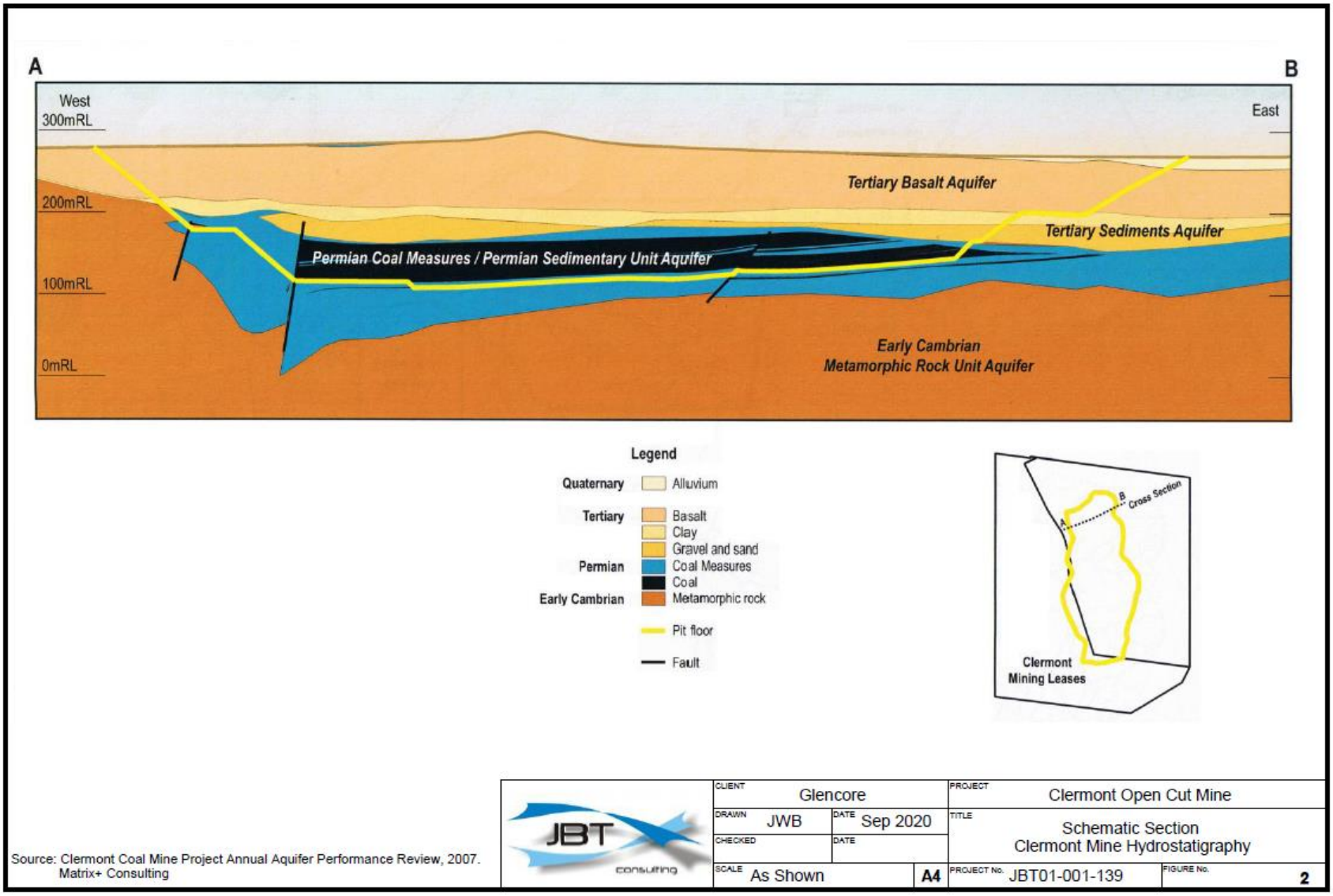

Figure 3-6 - Hydro stratigraphic cross section of Clermont

3.4.1.1 Tertiary Basalt (unconfined aquifer)

The Tertiary basalt is typical of fractured rock aquifers and has a high degree of heterogeneity in terms of potential groundwater yield since fracturing is generally not uniform. Bores located on a favourable fracture system may yield up to 5 to 10 litres/second (L/s) with drawdown in the aquifer skewed strongly in the direction of fracturing. Bores located away from fracture zones are more likely to have much lower yields. More typically, bore yields in the basalt aquifer range from 0.5 to 10 L/s.

Groundwater quality is generally fresh (mean of approximately 1,200 µS/cm), and moderately alkaline with a mean pH of 8 (data from JBT Consulting, 2020, Appendix B-8).

Locally within the mine area, the Tertiary basalt and underlying Tertiary gravel aquifer may have some connectivity depending on the thickness and extent of the intervening confining clay layer and sand content if that intervening clay layer. Where the confining clay layer is thinner and a higher sand content, a greater hydraulic connection may exist between the basalt and the underlying gravel aquifer. However, the basalt is generally considered hydraulically separate to the Tertiary gravel due to the Tertiary claystone.

On the regional scale, the basalt is recharged directly by rainfall where it is exposed to the surface or below thin Quaternary sediments. Some lateral recharge may occur from Tertiary gravels. Groundwater discharge from the basalt will occur at shallow levels where it is eroded and in connection with surface water drainage system. Downward leakage will occur via fracturing in the basalt, however vertical leakage is limited through several clay lenses within the basalt flows.

Groundwater pressure levels in the basalt aquifer are influenced by the local topography, fracturing in the bedrock, connectivity to the surface drainage system, groundwater pumping and drainage to the mine void. To the northeast of the mining lease, interpreted flow direction is toward Wolfang Creek flowing southwest, then more southerly flow in the area of Sandy Creek, south of the CCO.

Groundwater levels shown in ***Figure 3-7*** below, demonstrate a general north to south flow towards the cone of depression from the mine void area. Early groundwater contours from 2004 show the impact of groundwater pumping for water supply to Blair Athol mine. This trend is deepened with CM progression of the open cut and subsequent aquifer dewatering. Groundwater drawdown influences from the mine are localised with no evidence of impact outside the lease area (JBT Consulting, 2020).

South of CCO, groundwater contours indicate flow in a southerly direction.

3.4.1.2 Tertiary Gravel (confined aquifer)

Recharge to the gravel aquifer is interpreted to be limited to minor downward leakage from the Tertiary basalt. It is limited due to a claystone aquitard layer separating the Tertiary gravel from the overlying basalt. As mentioned above, leakage can occur where the confining claystone is thin and/ or where higher sand content exists within the claystone. Leakage also occurs laterally from adjacent units including the basalt layers.

Considerable water has been extracted from the Tertiary gravel aquifer as part of the dewatering process to access the coal reserves. The aquifer is for the most part, a confined aquifer. The gravel aquifer has limited aerial extent as outlined in blue in ***Figure 3-8***, having deposited in eroded valleys within the top of the Permian sedimentary package. The lateral extent of the gravel aquifer in the CCO area is approximately 4 km in strike length by 250 m wide and up to 30 m thick in the deeper section. The aquifer has been drained by the earlier advanced dewatering and subsequent in pit seepage to the mine void. The impact of mine dewatering is shown in ***Figure 3-9***, where the groundwater levels rapidly drawdown over an initial 12 month period followed by steady decline.

The gravel unit can yield up to 20 L/s with water quality (salinity) around 1190 µS/cm and pH of 9.15.

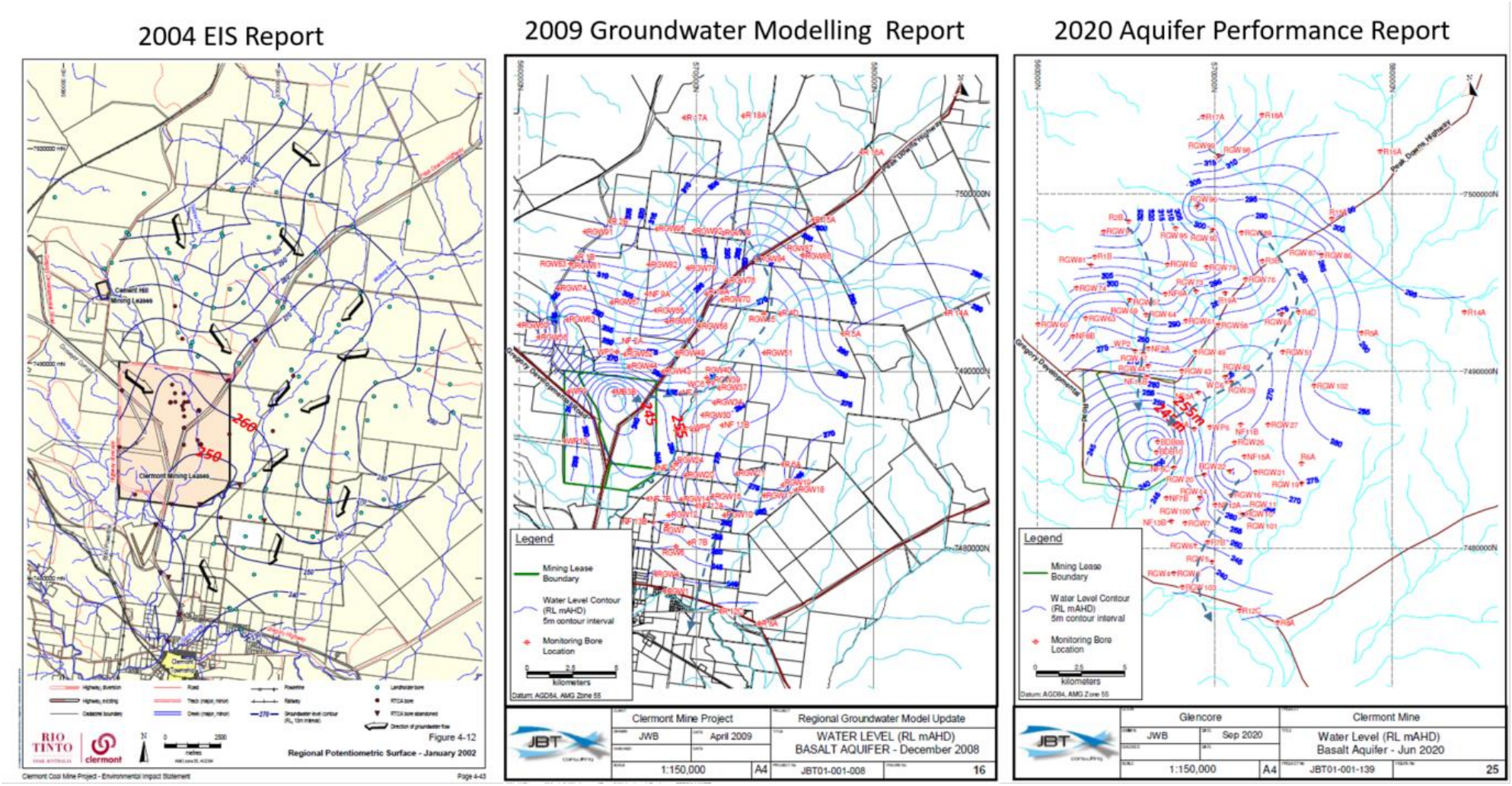

Figure 3-7 - Basalt Aquifer Groundwater Contours for periods 2004, 2008 and 2020

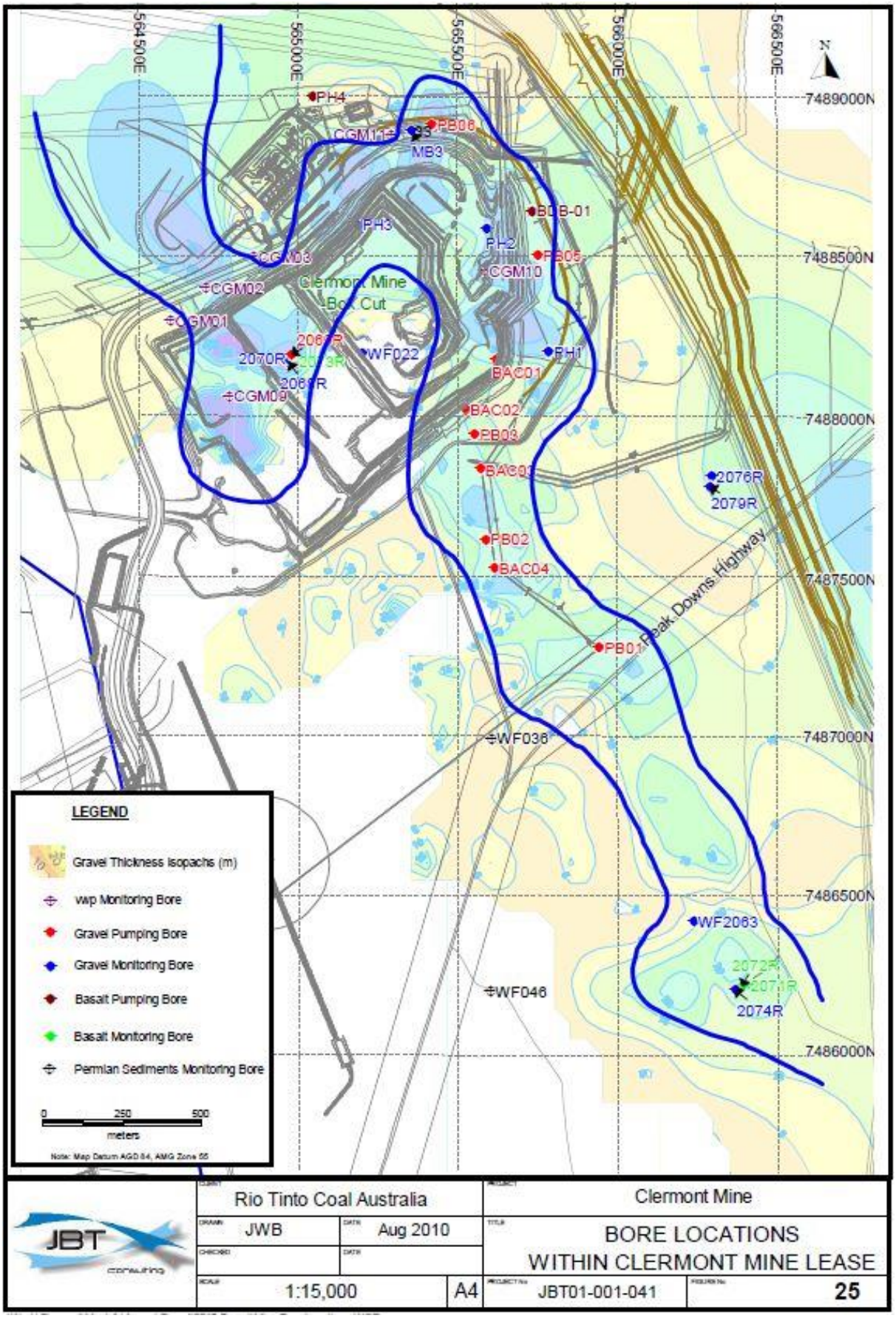

Figure 3-8 - Tertiary Gravel Aquifer Thickness map

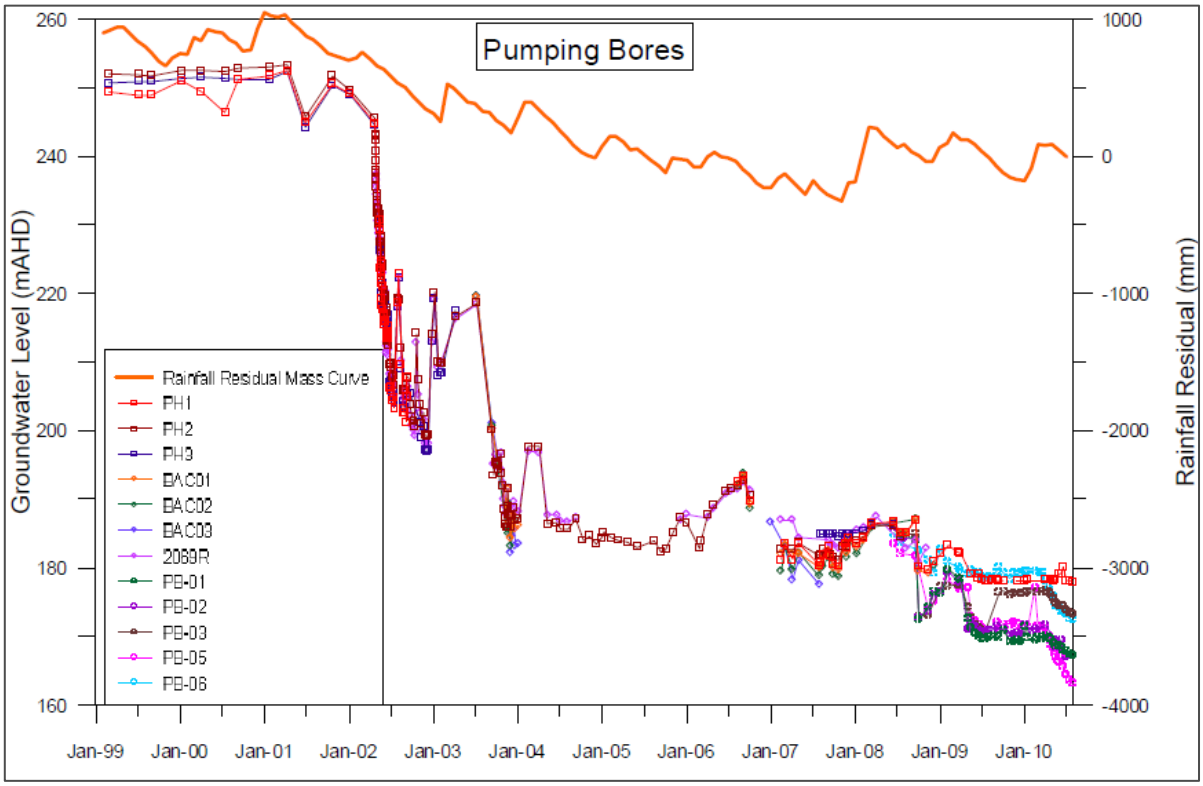

Figure 3-9 - Groundwater drawdown of Tertiary Gravel Aquifer

3.4.1.3 Permian Sediments (confined aquifer)

The Permian aquifers consist of coal seams which contain fractures and jointing, sandstone and sandy clay interburden. The Permian rock package is not high yielding and is essentially a confined aquifer system. Higher permeability occurs in the sandier interburden layers and where fracturing of the Wolfang coal seam is greater. The Permian conglomerate forms the base unit to the Permian sequence and is predominantly low permeability. The higher yields of up to 5 L/s have been estimated however more recent pit inflow estimates from pit mapping is of the order of 2 L/s. Overall, in comparison to the overlying gravel aquifer, groundwater yields from the Permian sediments in the Clermont area are relatively low (JBT Consulting 2020).

The weathered upper part of the Permian sediments are reportedly higher permeability than un-weathered Permian sediments and are likely hydraulically connected to some degree to the Tertiary gravel above which has relatively high hydraulic conductivity.

3.4.2 Cement Hill

The main aquifer in the Cement Hill Mine area is the Tertiary basalt which is recharged directly from rainfall. The underlying conglomerate is considered low permeability. Groundwater level data is consistent with the findings presented in JBT Consulting (2016) where the direction of groundwater flow in the basalt aquifer in this area generally follows the Gowrie Creek system (i.e. from north west to south east) (KBR, 2019).

3.4.3 Train Load-Out

The main aquifer in the Blair Athol Lease area is the Hurley Metamorphics basement, which by its geological nature, is not very permeable and hence not strictly considered an aquifer. The Tertiary

basalts and sediments are no longer present due to historical mining. The remaining coal measures in the south end of the lease constitute the main groundwater aquifer and is part of Blair Athol Coal Measures currently mined by Terracom's Blair Athol Coal Mine operation (Rio Tinto, 2010).

Early conceptual groundwater models for the Blair Athol Mine predicted an overall groundwater sink scenario with the final void in the neighbouring Blair Athol mine, with limited impact on the basalt aquifer and neighbouring bores (Rio Tinto, 2010).

3.4.4 Post Mining Update

At CM, as the mine progresses, the pit will be successively backfilled with spoil (waste) until a final void is left in the southern end of the lease (refer to ***Figure 3-10***) (the post mining landscape is discussed further in the PMLU and NUMA sections of the PRCP Report). The mine waste component and associated risks of this are discussed in detail in Appendix 4.9 – Mine Waste Characterisation Report, and the detailed final void assessment is provided in Appendix 4.7 –Void Closure Methodology.

However, the implications for groundwater are summarised below (JBT Consulting, 2009; KBR, 2015):

- The final void acts as a permanent sink;
- A pit lake will develop within the final void, going through a number of development stages until a quasi-steady state is reached in which the water level is relatively stable, and salinity may reach a concentration such that density stratification is permanent;
- Very limited groundwater interaction is expected, with no long term yielding aquifers intersected by the final void. The aquifers intersected by the open cut operations are either removed during mining or those that remain are isolated and discontinuous. The Tertiary aquifers that do remain (gravels and basalt) are isolated, so short term loss from the void may occur as the aquifers are recharged during pit lake recovery but this is unlikely to persist in the long-term. The exposed Permian sediments in the final void are relatively tight and are unlikely to interact with the pit lake (loss or recharge); and
- The backfilled pit will create an aquifer within the spoil material, with the spoil providing considerable water storage (being recharged by water from seepage through the rehabilitated spoil, inflow from the tertiary basalt aquifer to the spoil and inflow from the pit lake) and this has implications for water quality. However, due to the limited groundwater interactions, it is not anticipated to impact on groundwater. As mentioned previously, mine waste risks are addressed in Appendix 4.9.

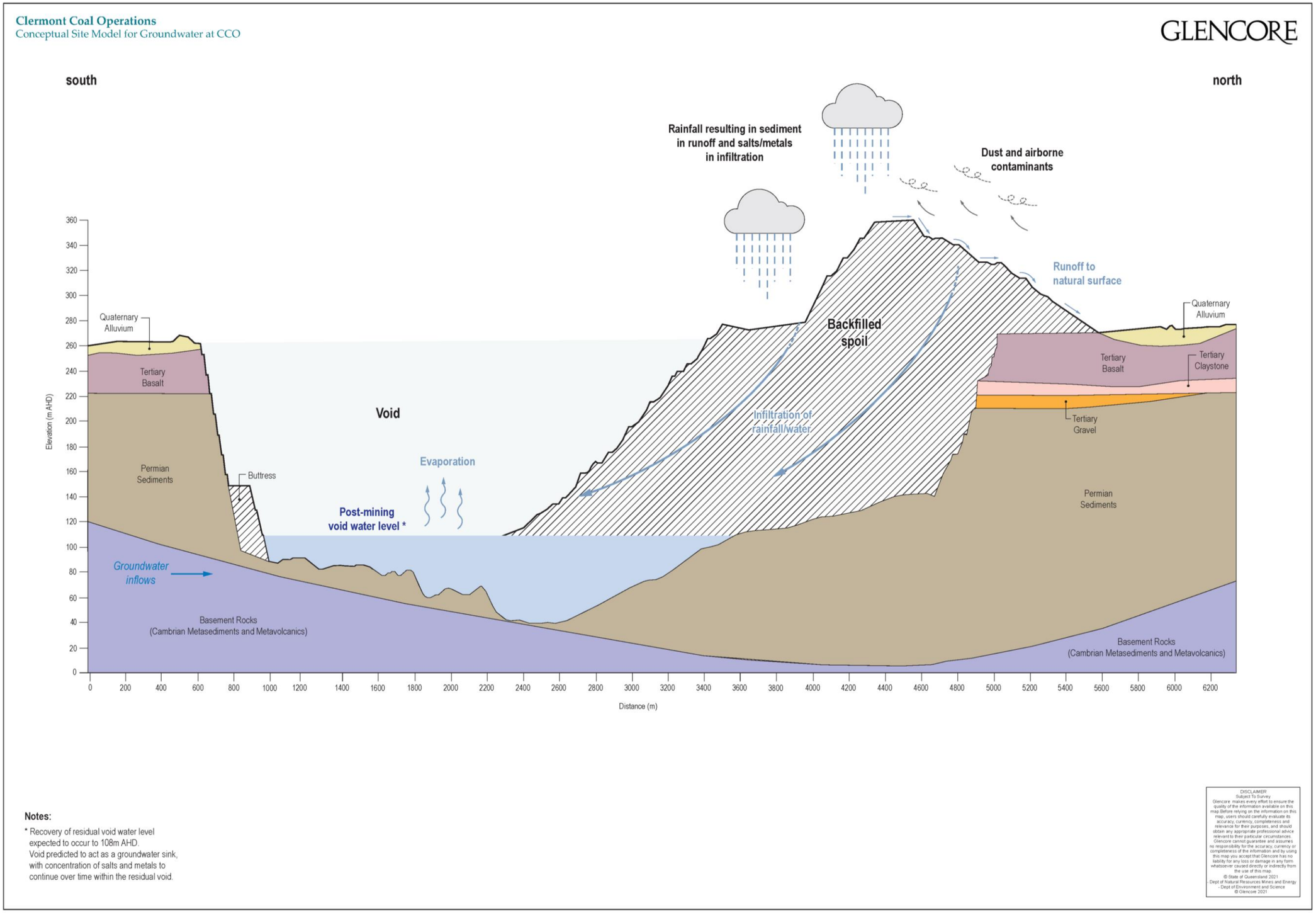

Figure 3-10 - Post-mine hydrostratigraphy and conceptual groundwater model

4. Groundwater Modelling

Groundwater modelling for CCO has been an evolutionary process with a groundwater model completed by Golder Associates (2001) and ERM (2002). A revised model by Matrix in 2004 as part of the EIS work was undertaken after additional drilling information led to a revision of the hydrogeological conceptual understanding.

The most recent groundwater modelling was undertaken by JBT Consulting in June 2009 using a numerical modelling software FEFLOW V5.3, an industry standard finite element model for simulating groundwater flow, and mass and contaminant transport. The model covers a regional area of approximately 110,000 ha with model boundaries being catchment topographic highs representing groundwater divides which were modelled as no-flow boundaries, except the southern boundary classified as fixed head boundary for the model (JBT Consulting, 2009).

The model was developed with 5 hydro-stratigraphic layers in a 7 layer model.

The model layers and parameters adopted in the 2009 model are included in ***Table 4-1*** below.

Table 4-1 - Summary of aquifer parameter ranges for various aquifers

Unit	Horizontal Hydraulic Conductivity Kh (m/s)	Vertical Hydraulic Conductivity Kv (m/s)	Specific Yield
Tertiary Basalt (Layer 1)	0.1 to 75 m/d	0.01 to 7.5 m/d (est 10% of Kh)[#2]	0.007 to 0.08
Tertiary Upper Claystone (Layer 2)	8.6×10^{-5} m/d	8.6×10^{-6} m/d	0.001
Tertiary Lower Claystone (Layer 3)	8.6×10^{-5} m/d	8.6×10^{-5} m/d	0.001
Tertiary Gravel (Layer 4)	2.2 to 2.5 m/d	0.22 to 0.25 m/d (est 10% of Kh)[#2]	0.08
Permian Upper (Layer 2,3)	0.009 m/d	8.6×10^{-3} m/d	0.002
Permian Upper (Layer 4,5)	0.004	0.004	0.002
Permian Lower (Layer 6)	8.6×10^{-4} m/d	8.6×10^{-4} m/d	0.002
Basement (Layer 7)	8.6×10^{-4} m/d	8.6×10^{-4} m/d	0.003

#1 Specific storage set for all units as 8.8 x 10-6
#2 John Bradley (JBT Consulting), pers comm

The hydraulic conductivity parameters were within the range of those obtained from the pumping tests (discussed below), with the high values found in areas of the model in which there were no calibration points, and were an artefact of the krigging method (JBT Consulting, 2009).

Several phases of pumping tests have been conducted in the Clermont area, by various consultants including Coffey Partners (1981), Golder Associates (2006), ERM (2002) and Matrix (2008), and falling head (slug) tests were conducted by Golder Associates (1982). This investigation was not repeated as parameters derived from slug tests are not as well regarded as those derived from pumping tests, as slug tests can be strongly influenced by near-bore effects (JBT Consulting, 2009).

Hydraulic parameters compiled from historical pump and slug test data ranges are presented in ***Table 4-2*** below.

Table 4-2 - Summary of historically reported aquifer hydraulic parameter ranges Tertiary Basalt

Aquifer	Range of Hydraulic Conductivity (m/d)	Range of Storativity
Basalt	0.3 to 48.8	$1x10^{-4}$ to 0.06
Gravel	0.5 to 20	$6x10^{-6}$ to 0.01
Wolfang Seam	0.1 to 1.0	0.0015 to 0.005
Permian sandstone	$5x10^{-5}$ to 0.15	No data

Modelling was run in steady state and transient calibration modes. Sensitivity modelling determined that recharge rate and hydraulic conductivity were the most significant variables. Predictive analysis was undertaken to compare the calibrated results to the predictive response. Transient calibration was achieved using the approach called “Pilot Pont” in the model program PEST. Hydraulic conductivity values are geo-statistically estimated between pilot points.

Calibration for the basalt aquifer was reasonable and should be considered as such in the context that the scale of the model is regional scale. Correlation of model hydrograph to actual hydrograph response within the mine area was not ideal due to uncertainty in leakage potential to the underlying gravel aquifer from variable geology, however the model was considered adequate for prediction of regional long term impacts.

The more recent groundwater model estimates for drawdown of the Tertiary basalt aquifer show the earlier modelling by Matrix consulting (Clermont Coal Project, 2005) may have been overly conservative indicating much greater drawdown than the 2009 model prediction, and as shown by recent groundwater level data (refer to ***Figure 4-1*** below).

The 2004 modelling for end of mine life period, showed up to 20 m drawdown was likely at the lease boundary on the eastern side, and later modelling 2009 showed drawdown up to 10 m for the same period. Although the groundwater modelling that was undertaken for the EIS (and subsequent model revisions) predicted drawdown in the basalt aquifer within the “Inner” area (the area monitored by Near Field bores) within the first 10 years of mining, there has been no evidence to date of groundwater level impacts beyond the area of the mining leases. It is noted that groundwater within the Tertiary basalt aquifer occurs within hydraulically isolated fractures, and that the modelling prediction of groundwater level impacts may not occur if regional water-bearing fractures are not intercepted and drained by mining operations (JBT Consulting, 2009).

The main potential impacts from mining is the local drawdown of groundwater levels in the basalt aquifer, which the has been shown to be limited in extent with groundwater monitoring data providing

further evidence of the responsive nature of the basalt to recharge after wetter climate. Further modelling would not provide any greater understanding or accuracy in prediction. Contaminant transport is not considered a concern as the final void is anticipated to act like a sink so contaminants will not be released into the receiving environment. Further detail is provided on the void behaviour and modelling completed, as Appendix 4.7 – Void Closure Methodology. Additionally, groundwater quality monitoring data does not highlight any contaminants of concern.

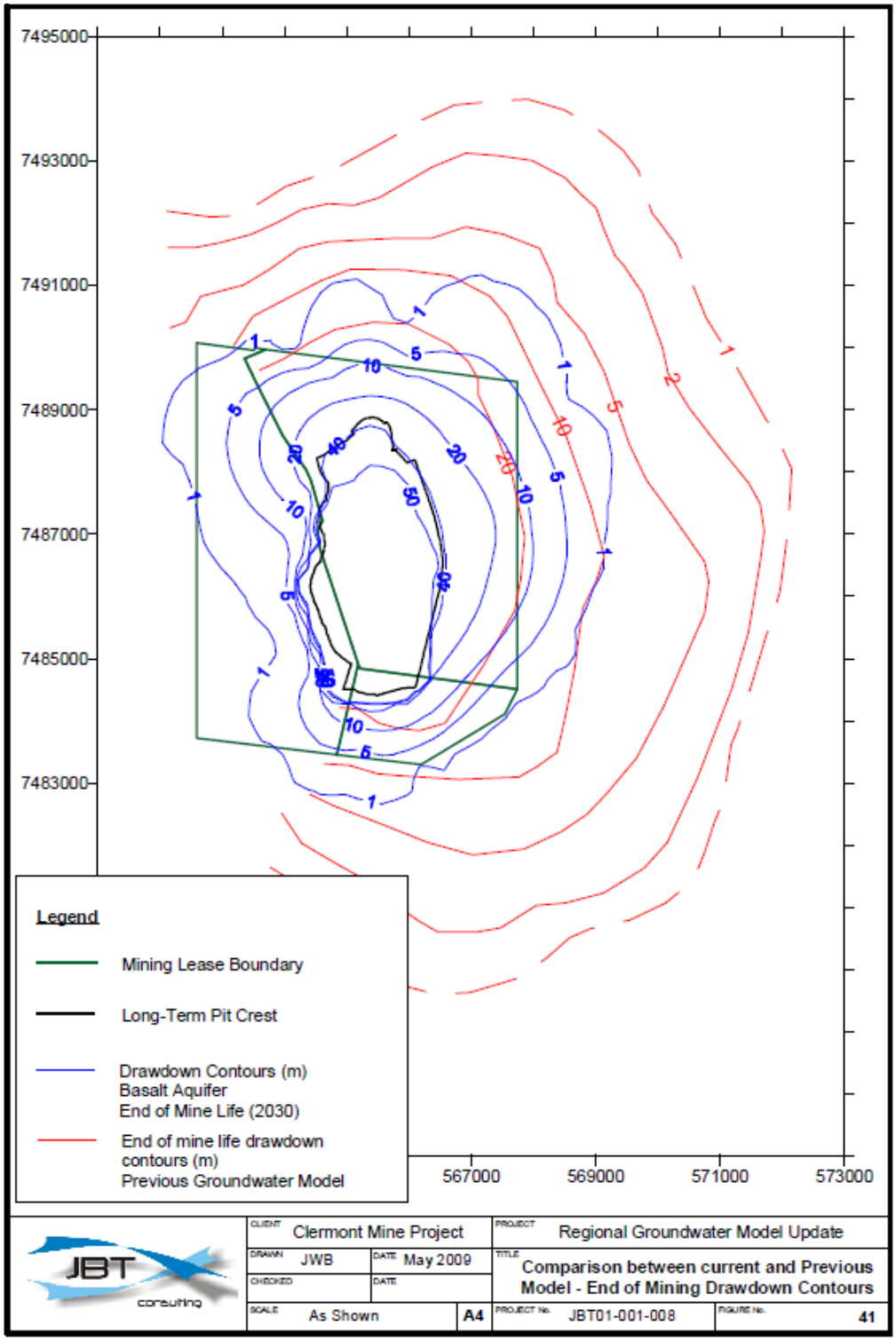

Figure 4-1 - 2009 Basalt groundwater drawdown prediction versus 2004 model prediction

5. Groundwater Users

5.1 Groundwater Take

The groundwater licenses for the CCO site were granted by DNRME for advanced dewatering of the aquifers to allow mining to operate safely. The Groundwater Management Plan (CCO, 2018) outlines the requirement for CCO ensure monitoring of groundwater use as per Water Licence conditions for the various licences held including:

- 188235 (700 ML/year, dewatering and industrial uses, Coal measures on ML70343, ML1884 and ML1904);
- 188236 (1100 ML/year, dewatering and industrial uses, Basalt on ML70343, ML1884 and ML1904);
- 188007 (2800 ML/year, dewatering and industrial uses, Tertiary undefined on ML70343, ML1884 and ML1904);
- 84530F (Blair Athol licence, industrial use, Basalt on ML1884); and
- 84527F (Blair Athol licence, industrial use, Tertiary gravel on ML 1884).

Water use data is monitored and reported annually and compiled every 3 years. The Aquifer Performance Report (JBT Consulting, 2020) has compiled and assessed groundwater data for the period July 2017 to Jun 2020. The report provides analysis of groundwater levels, groundwater quality and water pumped from licensed extraction bores for CCO.

Groundwater extraction at CCO has primarily occurred from bores constructed within the Tertiary basalt and Tertiary gravel aquifers, which overlay the Permian Coal Measures. However due to the unreliability and limited supply of these aquifers, it has been determined that they have no on-going water supply potential other than as a mine water supply through discharge/ seepage into the mining pit (JBT Consulting, 2020). The historical groundwater extraction data from Years 3 to 13 is summarised in ***Table 5-1*** below.

Table 5-1 - Reported groundwater extraction volumes (ML)

		Basalt			Gravel Aquifer			Permian Aquifer		
Mining Year	Water Year	Bores	Pit inflow	Total	Bores	Pit inflow	Total	Bores	Pit inflow	Total
Year 3	2009-2010	20.6	0	20.6	824.7	614.3	1439	0	0	0
Year 4	2010-2011	11.3	63	74.3	397.4	1160	1557.4	0	0	0
Year 5	2011-2012	141	366	507	63.2	119	182.2	0	63	63
Year 6	2012-2013	166.4	1151	1317.4	0	274	274	0	163	163
Year 7	2013-2014	99.2	1346	1445.2	0	37	37	0	386	386
Year 8	2014-2015	98.4	607.7	706.1	0	41.9	41.9	0	329.6	329.6
Year 9	2015-2016	12.9	487	499.9	0	64.6	64.6	58.2	348.1	406.3
Year 10	2016-2017	0	484.3	484.3	0	10.5	10.5	66.6	141.3	207.9
Year 11	2017-2018	0	523.5	523.5	0	0	0	60	366.6	426.6
Year 12	2018-2019	49.1	110	159.1	0	33.9	33.9	17.6	140.1	157.7
Year 13	2019-2020	18.7	91.4	110.1	0	6.7	6.7	0	130.9	130.9

Groundwater extraction monitoring has been measured via metered groundwater bore use, and in-pit pumping where practical. Pit seepage has at times, included visual estimation from pit mapping observations where no accurate pit pumping data has been available.

The historical mine water use shows the high volumes initially extracted from the Tertiary basalt and underlying gravel aquifers during the dewatering period of the mining operation. The gravel aquifer is effectively completely dewatered due to the confined nature and limited lateral extent. The basalt aquifer continued to dewater albeit at a much lower rate than in the initial mine history as pressure levels dropped due to dewatering and drier climate conditions from 2012 onwards.

5.2 Landholder Groundwater Use

The Tertiary basalt aquifer is the main water source for surrounding properties for stock and domestic uses. The fractured rocky nature of the soil means that farm dams do not hold water well. Groundwater pumping rates range from 0.5 litres per second to 9 litres per second (EIS, 2004). Groundwater usage from private bores is not readily available. Regular groundwater pumping can be inferred from groundwater level drawdown in nearby groundwater monitoring bores.

Several bores are used for stock watering purposes around the Cement Hill void including 62217 (RGW81), 84134 (RGW74 and 84136 (RGW63). Groundwater use volumes are unavailable. Grazing access rights and access to stock water from the void is available to Glenmore property as a part of the Clermont Coal Joint Venture agreement (Nov 2014).

6. Ongoing and Post-Mining Monitoring

6.1 Clermont Mine

It is expected that a reduced bore network will be maintained on-going monitoring of groundwater in the Tertiary basalt, Tertiary sediments and Permian aquifer bores after closure of the site is completed. This will continue until relinquishment of the mining leases associated with CCO.

Tertiary basalt areas of focus should be those areas close to landholder bores, and with proximity to the final void (both near and far to check on groundwater recharge), surrounding tailings and waste dump areas for monitoring of potential contaminants, particularly down-gradient locations.

Monitoring of shallow aquifers, Tertiary basalt and Tertiary sediments close to waterways down-stream of the void is also expected to monitor impacts on aquifer levels and chemistry, particularly during latter stages of void water recharge.

6.2 Cement Hill

It is noted that the current monitoring network is limited, with respect to groundwater level and quality monitoring, and further monitoring may provide greater clarity over the salinity and water levels of the void. However this would only provide incremental confidence to a low risk scenario. Therefore, no further groundwater monitoring is proposed post closure, given the low risk to surrounding users and the environment.

6.3 Train Load-Out

For post-mining monitoring, continued water level and quality monitoring is proposed, to confirm and validate historical groundwater data. It is proposed to maintain the current/historical bores still in service. There is limited risk to environmental and other groundwater users in this area.

7. Summary

Extensive hydrogeology data and information has been analysed and reported over many years including aquifer hydraulic parameter estimation, groundwater monitoring and groundwater modelling. This has occurred to different levels for each of the operational areas, but it is considered that the groundwater concerns for the CCO site are well understood.

The main impact of the CM mine void is the dewatering of the Tertiary basalt aquifer. Early groundwater modelling predicted a significant groundwater drawdown, but subsequent monitoring data has shown early predictions to be well in excess of actual drawdown. The nature of the fractured bedrock being 'compartmentalised' and responsive to recharge from rainfall, has limited the extent to which the aquifer dewatering has occurred surrounding the mine. Groundwater chemistry in all aquifers monitored have been extensively analysed and statistically assessed. No significant chemical contaminants have been identified that are of threat to existing groundwater users, and no significant detrimental trends have been highlighted.

Although there is no evidence to date of impacts from mining on groundwater levels or groundwater quality, the commitment remains for existing monitoring, assessment and reporting mechanisms to remain in place. Following mine cessation, a reduced groundwater monitoring network for future on-going monitoring of any potential impacts will target areas of higher potential contamination, such as around the void where water level rebound will occur, tailings and waste storage areas and a small number of regional Tertiary aquifer bores near existing groundwater users.

8. Document Information

Reference	Title
CCO (2018)	Groundwater Management Plan 2018-2021.
Clermont Coal Project (2004)	Environmental Impact Statement, Volume 1, August 2004.
Clermont Coal Project (2004)	Environmental Impact Statement, Volume 2 - Appendices, August 2004.
Clermont Coal Project (2005)	Environmental Impact Statement Supplementary Report, January 2005.
Coffey & Partners (1981)	Wolfang Coal Deposit Clermont, Qld. Geotechnical and Hydrogeological Studies. Volumes 1 and 2. Report No. S6539/2-AR. Report prepared for White Industries (Qld) Pty Ltd.
ERM (2002)	Clermont Coal Groundwater Investigations. Report No. 8010667, to Pacific Coal Pty Ltd.
Golder Associates (1982)	Wolfang Coal Project Hydrogeological Investigations. Report to White Industries (Qld) Pty Ltd, March 1982.
Golder Associates (2006)	Report on Pumping Test – TPB2, BAC02. Golder Associates Report No. 015-05631016.
JBT Consulting Pty Ltd (2009)	Clermont Mine Project Regional Groundwater Model Update.
JBT Consulting (2016)	Groundwater Monitoring Data – Near Field and Regional Monitoring Bores – Q3 2016. Document reference JBT01-001-100.
JBT Consulting Pty Ltd (2020)	Glencore Clermont Open Cut Mine, Aquifer Performance Report, Water years 11, 12 & 13, (July 2017 – June 2020), JBT01-001-013, September 2020.
KBR (2015)	Clermont Open Cut Final Void Assessment, Prepared for: Clermont Coal Operations, February 2015.
KBR (2019)	Clermont Coal Operations – Cement Hill Closure, Initial Data Collection, Prepared for: Clermont Coal Operations, July 2019.
KBR (2019)	Groundwater Assessment, Clermont Mining Leases. Final Report for Pacific Coal Pty Limited, November 2003.
Matrix Consulting (2005)	Clermont Coal Mine Project, Groundwater Monitoring Program, Report produced for Rio Tinto Coal Australia, RTC509, December 2005.
Rio Tinto (2010)	Blair Athol Coal Project Mine Closure Plan.

Attachment A - Groundwater metals/ metalloids statistics – Alluvial Aquifer

Unit (mg/L)		Total Count	Count (> LOR)	% >LOR	Minimum	Maximum	20th Percentile	Mean	Median	80th Percentile	95th Percentile	Std Dev
Aluminium	dissolved	21	2	9.5%	0.005	0.011						
	total	21	19	90.5%	0.01	6.0	0.02	0.491	0.04	0.198	2.387	1.393
Arsenic	dissolved	21	16	76.2%	0.001	0.027	0.001	0.007	0.005	0.011	0.02	0.007
	total	21	20	95.2%	0.001	0.03	0.002	0.007	0.005	0.009	0.019	0.007
Boron	dissolved	20	14	70.0%	0.04	0.27	0.06	0.089	0.065	0.096	0.18	0.063
	total	20	13	65%	0.04	0.29	0.54	0.107	0.07	0.14	0.274	0.081
Cadmium	dissolved	21	3	14.3%	0	0						
	total	21	3	14.3%	0	0						
Chromium	dissolved	20	0	0.0%	0	0						
	total	20	7	35%	0.002	0.03	0.002	0.007	0.003	0.006	0.024	0.01
Cobalt	dissolved	20	11	55.0%	0.001	0.001	0.003	0.004	0.004	0.004	0.007	0.002
	total	20	13	65%	0.002	0.01	0.003	0.005	0.004	0.006	0.009	0.002
Copper	dissolved	21	10	47.6%	0.001	0.001	0.001	0.002	0.002	0.002	0.004	0.001
	total	21	12	57.1%	0.001	0.012	0.002	0.004	0.003	0.006	0.011	0.003

Unit (mg/L)		Total Count	Count (> LOR)	% >LOR	Minimum	Maximum	20th Percentile	Mean	Median	80th Percentile	95th Percentile	Std Dev
Iron	dissolved	20	10	50.0%	0.36	0.36	0.508	0.736	0.625	0.946	1.312	0.335
	total	20	20	100%	0.12	9.4	0.518	1.472	0.83	1.526	5.008	2.107
Lead	dissolved	21	3	14.3%	0.007	0.007						
	total	21	7	33.3%	0.002	0.134	0	0	0	0	0	0
Manganese	dissolved	20	19	95.0%	0.002	0.002	0.015	0.279	0.178	0.489	0.885	0.308
	total											
Mercury	dissolved	21	0	0.0%	0	0						
	total	21	0	0%	0	0						
Molybdenum	dissolved	20	9	45.0%	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.001
	total	20	8	40.0%	0.001	0.004	0.001	0.002	0.002	0.002	0.003	0.001
Nickel	dissolved	20	14	70.0%	0.001	0.001	0.002	0.004	0.003	0.004	0.009	0.004
	total	20	17	85.0%	0.001	0.026	0.002	0.006	0.003	0.005	0.022	0.007
Selenium	dissolved	21	2	9.5%	0.005	0.005						
	total	21	0	0%	0	0						
Silver	dissolved	11	0	0.0%	0	0						
	total	11	0	0%	0	0						
Vanadium	dissolved	20	3	15.0%	0.01	0.01						

Unit (mg/L)		Total Count	Count (> LOR)	% >LOR	Minimum	Maximum	20th Percentile	Mean	Median	80th Percentile	95th Percentile	Std Dev
	total	20	3	15%	0.01	0.04						
Zinc	dissolved	21	20	95.2%	0.009	0.712	0.017	0.115	0.035	0.088	0.66	0.203
	total	21	21	100%	0.006	0.771	0.026	0.148	0.057	0.122	0.706	0.231

Attachment B - Groundwater metals/ metalloids statistics – Basalt Aquifer

Unit (mg/L)		Total Count	Count (> LOR)	% >LOR	Minimum	Maximum	20th Percentile	Mean	Median	80th Percentile	95th Percentile	Std Dev
Aluminium	dissolved	224	56	25.0%	0.005	0.28	0.008	0.034	0.02	0.04	0.123	0.05
	total	224	204	91.1	0.006	32.4	0.04	0.843	0.14	0.528	1.831	3.494
Arsenic	dissolved	224	138	61.6%	0.001	0.108	0.002	0.01	0.006	0.015	0.028	0.013
	total	224	150	67	0.001	0.104	0.002	0.01	0.007	0.015	0.031	0.013
Boron	dissolved	211	163	77.3%	0.01	0.27	0.061	0.107	0.1	0.15	0.2	0.048
	total	206	155	75.2	0.02	0.24	0.07	0.105	0.09	0.15	0.184	0.045
Cadmium	dissolved	219	12	5.5%	0	0	0	0	0	0	0	0
	total	219	34	15.5	0	0.002	0	0	0	0	0	0
Chromium	dissolved	206	3	1.5%	0.001	0.002						
	total	206	83	40.3	0.001	0.083	0.001	0.005	0.002	0.004	0.022	0.012
Cobalt	dissolved	206	6	2.9%	0.001	0.002	0	0	0	0	0	0
	total	206	33	16	0.001	0.018	0.001	0.003	0.001	0.004	0.008	0.003
Copper	dissolved	219	55	25.1%	0.001	0.014	0.001	0.002	0.002	0.003	0.006	0.002
	total	219	143	65.3	0.001	0.034	0.001	0.004	0.002	0.005	0.01	0.005

Unit (mg/L)		Total Count	Count (> LOR)	% >LOR	Minimum	Maximum	20th Percentile	Mean	Median	80th Percentile	95th Percentile	Std Dev
Iron	dissolved	206	109	52.9%	0.017	5.17	0.13	0.793	0.23	1.776	1.553	0.97
	total	211	198	93.8	0.01	108	0.17	2.78	0.64	2.52	9.082	9.205
Lead	dissolved	219	25	11.4%	0.001	0.022	0.002	0.007	0.003	0.012	0.021	0.007
	total	219	126	57.5	0.001	0.168	0.002	0.014	0.004	0.017	0.065	0.026
Manganese	dissolved	211	189	89.6%	0.001	0.32	0.005	0.041	0.024	0.061	0.161	0.054
	total	202	200	99	0.001	0.54	0.01	0.05	0.029	0.061	0.202	0.068
Mercury	dissolved	219	0	0.0%	0	0						
	total	219	3	1.4	0	0						
Molybdenum	dissolved	206	168	81.6%	0.001	0.214	0.002	0.011	0.003	0.012	0.066	0.023
	total	206	166	80.6	0.001	0.225	0.002	0.012	0.004	0.013	0.073	0.025
Nickel	dissolved	206	76	36.9%	0.001	0.007	0.001	0.002	0.002	0.003	0.005	0.001
	total	206	152	73.8	0.001	0.064	0.002	0.004	0.003	0.005	0.01	0.007
Selenium	dissolved	219	1	0.5%	0.004	0.004						
	total	219	0	0	0	0						
Silver	dissolved	154	3	1.9%	0.001	0.001						
	total	154	0	0	0	0						
Vanadium	dissolved	206	3	1.5%	0.01	0.02						

Unit (mg/L)		Total Count	Count (> LOR)	% >LOR	Minimum	Maximum	20th Percentile	Mean	Median	80th Percentile	95th Percentile	Std Dev
	total	206	10	4.9	0.01	0.13						
Zinc	dissolved	219	159	72.6%	0.005	0.111	0.007	0.018	0.013	0.026	0.048	0.016
	total	219	199	90.9	0.005	0.244	0.01	0.026	0.017	0.037	0.064	0.026

Attachment C - Groundwater metals/ metalloids statistics – Tertiary Sediments Aquifer

Unit (mg/L)		Total Count	Count (> LOR)	% >LOR	Minimum	Maximum	20th Percentile	Mean	Median	80th Percentile	95th Percentile	Std Dev
Aluminium	dissolved	64	41	64.1	0.007	3.24	0.02	0.683	0.17	1.37	2.74	0.948
	total	64	61	95.3	0.01	17.9	0.09	1.124	0.51	1.77	2.8	2.367
Arsenic	dissolved	64	56	87.5	0.001	0.687	0.004	0.029	0.01	0.027	0.058	0.092
	total	64	62	96.9	0.001	0.633	0.003	0.028	0.009	0.028	0.069	0.081
Boron	dissolved	54	32	59.3	0.04	0.23	0.07	0.094	0.08	0.1	0.2	0.043
	total	54	31	57.4	0.01	0.2	0.06	0.086	0.08	0.1	0.16	0.037
Cadmium	dissolved	64	12	18.8	0	0	0	0	0	0	0	0
	total	64	16	25	0	0.001	0	0	0	0	0.001	0
Chromium	dissolved	54	2	3.7	0.001	0.004	0.002	0.003	0.003	0.003	0.004	0.002
	total	54	28	51.9	0.001	0.046	0.001	0.005	0.002	0.004	0.014	0.009
Cobalt	dissolved	54	7	13	0.001	0.005	0.001	0.002	0.002	0.002	0.004	0.001
	total	54	9	16.7	0.002	0.072	0.002	0.012	0.002	0.009	0.049	0.023
Copper	dissolved	64	20	31.3	0.001	0.007	0.001	0.002	0.002	0.004	0.004	0.002
	total	64	55	85.9	0.001	0.21	0.002	0.012	0.004	0.008	0.033	0.035

Unit (mg/L)		Total Count	Count (> LOR)	% >LOR	Minimum	Maximum	20th Percentile	Mean	Median	80th Percentile	95th Percentile	Std Dev
Iron	dissolved	54	23	42.6	0.007	3.71	0.086	0.963	0.16	2.512	2.836	1.229
	total	54	51	94.4	0.05	260	0.16	6.674	0.52	3.92	6.875	36.258
Lead	dissolved	64	14	21.9	0.001	0.023	0.001	0.003	0.002	0.003	0.011	0.006
	total	64	49	76.6	0.001	0.201	0.002	0.011	0.003	0.013	0.028	0.03
Manganese	dissolved	54	31	57.4	0.003	0.198	0.006	0.049	0.021	0.075	0.188	0.06
	total	50	46	92	0.001	1.5	0.003	0.072	0.017	0.049	0.245	0.228
Mercury	dissolved	64	1	1.6	0	0						
	total	64	1	1.6	0	0						
Molybdenum	dissolved	54	53	98.1	0.002	0.494	0.007	0.109	0.032	0.233	0.443	0.139
	total	54	53	98.1	0.002	0.542	0.008	0.12	0.035	0.254	0.505	0.155
Nickel	dissolved	54	28	51.9	0.001	0.016	0.001	0.003	0.002	0.003	0.006	0.003
	total	54	45	83.3	0.001	0.036	0.002	0.005	0.003	0.006	0.013	0.007
Selenium	dissolved	64	0	0	0	0						
	total	64	2	3.1	0.004	0.004						
Silver	dissolved	33	0	0	0	0						
	total	33	0	0	0	0						
Vanadium	dissolved	54	12	22.2	0.01	0.09	0.01	0.032	0.02	0.06	0.079	0.028

Unit (mg/L)		Total Count	Count (> LOR)	% >LOR	Minimum	Maximum	20th Percentile	Mean	Median	80th Percentile	95th Percentile	Std Dev
	total	54	15	27.8	0.01	0.49	0.01	0.057	0.02	0.054	0.196	0.121
Zinc	dissolved	64	32	50	0.005	0.154	0.008	0.03	0.017	0.046	0.08	0.032
	total	64	57	89.1	0.007	5.95	0.012	0.16	0.03	0.067	0.25	0.786

Attachment D - Groundwater metals/ metalloids statistics – Permian Sediments Aquifer

Unit (mg/L)		Total Count	Count (> LOR)	% >LOR	Minimum	Maximum	20th Percentile	Mean	Median	80th Percentile	95th Percentile	Std Dev
Aluminium	dissolved	63	20	31.7	0.005	0.28	0.01	0.042	0.02	0.052	0.119	0.062
	total	63	60	95.2	0.012	3.1	0.059	0.304	0.14	0.334	1.022	0.491
Arsenic	dissolved	63	50	79.4	0.001	0.657	0.004	0.064	0.012	0.037	0.297	0.137
	total	63	55	87.3	0.001	0.802	0.002	0.064	0.013	0.038	0.304	0.149
Boron	dissolved	58	52	89.7	0.05	0.78	0.062	0.126	0.105	0.168	0.195	0.104
	total	58	51	87.9	0.05	0.36	0.06	0.12	0.13	0.16	0.19	0.058
Cadmium	dissolved	63	7	11.1	0	0.001	0	0	0	0	0	0
	total	63	9	14.3	0	0.009	0	0.001	0	0	0.006	0.003
Chromium	dissolved	58	6	10.3	0.001	0.002	0.001	0.002	0.002	0.002	0.002	0
	total	58	27	46.6	0.001	0.007	0.001	0.003	0.002	0.004	0.007	0.002
Cobalt	dissolved	58	2	3.4	0.002	0.003	0.002	0.003	0.003	0.003	0.003	0.001
	total	58	9	15.5	0.001	0.004	0.001	0.002	0.002	0.003	0.004	0.001
Copper	dissolved	63	26	41.3	0.001	0.007	0.002	0.003	0.003	0.003	0.005	0.001
	total	63	52	82.5	0.001	0.037	0.002	0.005	0.004	0.006	0.013	0.006

Unit (mg/L)		Total Count	Count (> LOR)	% >LOR	Minimum	Maximum	20th Percentile	Mean	Median	80th Percentile	95th Percentile	Std Dev
Iron	dissolved	58	26	44.8	0.005	5.79	0.098	1.468	0.31	3.31	5.7	2.006
	total	58	51	87.9	0.085	7.33	0.38	1.691	0.73	3.22	5.835	1.867
Lead	dissolved	63	17	27	0.001	0.033	0.001	0.005	0.002	0.007	0.018	0.008
	total	63	46	73	0.001	0.172	0.003	0.025	0.01	0.038	0.123	0.038
Manganese	dissolved	58	53	91.4	0.001	0.208	0.005	0.043	0.022	0.079	0.143	0.05
	total	53	50	94.3	0.003	0.725	0.009	0.073	0.038	0.09	0.253	0.116
Mercury	dissolved	63	0	0	0	0						
	total	63	0	0	0	0						
Molybdenum	dissolved	58	49	84.5	0.001	0.851	0.002	0.042	0.004	0.034	0.144	0.134
	total	58	49	84.5	0.001	1	0.002	0.047	0.003	0.039	0.165	0.155
Nickel	dissolved	58	34	58.6	0.001	0.018	0.002	0.005	0.003	0.008	0.013	0.004
	total	58	51	87.9	0.001	0.094	0.002	0.007	0.004	0.009	0.022	0.014
Selenium	dissolved	63	1	1.6	0.003	0.003						
	total	63	1	1.6	0.003	0.003						
Silver	dissolved	38	1	2.6	0.002	0.002						
	total	38	0	0	0	0						
Vanadium	dissolved	58	0	0	0	0						

Unit (mg/L)		Total Count	Count (> LOR)	% >LOR	Minimum	Maximum	20th Percentile	Mean	Median	80th Percentile	95th Percentile	Std Dev
	total	58	2	3.4	0.02	0.02						
Zinc	dissolved	63	55	87.3	0.005	0.19	0.012	0.036	0.024	0.052	0.102	0.036
	total	63	62	98.4	0.006	0.445	0.018	0.055	0.033	0.079	0.134	0.064

Attachment E - Groundwater metals/ metalloids statistics – Permian Coal Aquifer

Unit (mg/L)		Total Count	Count (> LOR)	% >LOR	Minimum	Maximum	20th Percentile	Mean	Median	80th Percentile	95th Percentile	Std Dev
Aluminium	dissolved	17	2	11.8	0.005	0.02	0.008	0.013	0.013	0.017	0.02	0.011
	total	17	8	47.1	0.01	1.4	0.024	0.305	0.046	0.508	1.208	0.509
Arsenic	dissolved	17	11	64.7	0.001	0.01	0.001	0.002	0.002	0.002	0.007	0.003
	total	17	13	76.5	0.002	0.041	0.002	0.005	0.002	0.003	0.018	0.011
Boron	dissolved	17	11	64.7	0.05	0.14	0.05	0.065	0.054	0.07	0.07	0.026
	total	14	9	64.3	0.05	0.07	0.05	0.056	0.05	0.06	0.066	0.007
Cadmium	dissolved	14	0	0	0	0						
	total	14	4	28.6	0	0	0	0	0	0	0	0
Chromium	dissolved	14	0	0	0	0						
	total	14	2	14.3	0.002	0.002						
Cobalt	dissolved	14	0	0	0	0						
	total	14	0	0	0	0						
Copper	dissolved	14	0	0	0	0						
	total	14	8	57.1	0.002	0.043	0.003	0.011	0.004	0.018	0.036	0.015

Unit (mg/L)		Total Count	Count (> LOR)	% >LOR	Minimum	Maximum	20th Percentile	Mean	Median	80th Percentile	95th Percentile	Std Dev
Iron	dissolved	14	2	14.3	0.09	0.1	0.092	0.095	0.095	0.098	0.1	0.007
	total	17	17	100	0.05	24	0.072	2.246	0.55	1.122	7.853	5.816
Lead	dissolved	14	0	0	0	0						
	total	14	2	14.3	0.001	0.002	0.001	0.002	0.002	0.002	0.002	0.001
Manganese	dissolved	17	17	100	0.004	0.12	0.009	0.023	0.01	0.029	0.059	0.027
	total	17	17	100	0.007	0.24	0.009	0.045	0.012	0.039	0.173	0.067
Mercury	dissolved	14	0	0	0	0						
	total	14	0	0	0	0						
Molybdenum	dissolved	14	5	35.7	0.006	0.009	0.007	0.007	0.007	0.008	0.009	0.001
	total	14	5	35.7	0.007	0.009	0.008	0.008	0.009	0.009	0.009	0.001
Nickel	dissolved	14	0	0	0	0						
	total	14	7	50	0.001	0.006	0	0	0	0	0	0
Selenium	dissolved	14	0	0	0	0						
	total	14	0	0	0	0						
Silver	dissolved	14	3	21.4	0.002	0.005						
	total	14	0	0	0	0						
Vanadium	dissolved	14	0	0	0	0						

Unit (mg/L)		Total Count	Count (> LOR)	% >LOR	Minimum	Maximum	20th Percentile	Mean	Median	80th Percentile	95th Percentile	Std Dev
	total	14	0	0	0	0						
Zinc	dissolved	14	4	28.6	0.005	0.011	0	0	0	0	0	0
	total	14	10	71.4	0.008	0.032	0.011	0.018	0.018	0.022	0.029	0.008

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Appendix 4.6 – Surface Water Assessment

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1. Introduction

1.1 Purpose

The purpose of this technical appendix is to detail surface water management in relation to mine domains and final landforms. It explores flooding susceptibility and influence across the site as well as the relationship between voids and the flood plain. This appendix satisfies the requirements of the PRCP Guidelines in relation to voids of flood plains and flooding.

1.2 Scope

This appendix outlines the hydrology of the Clermont Mine, Train Load-out and Cement Hill domains. Selected design events and the resulting design floods are also provided.

Aspects of hydrology and flooding covered in the appendix involve the identification of the mining domains in relation to potential flood levels, potential impact to the hydrology regime upstream and downstream of the identified domains, flood levels for a range of design storm events with a focus on water level relative to landform and the associated flood risk.

It applies to all owned, leased or managed operational and non-mining landholdings under the Clermont Coal Operations (CCO) ownership or management.

2. Surface Water Context

2.1 Watercourses and Flow Characteristics

CCO is located within the upper reaches of the Fitzroy River catchment. Surface water hydrology in the region is dominated by Wolfang Creek, which ultimately drains into the Pacific Ocean via confluences with a number of creeks and rivers, including Sandy Creek, Theresa Creek, the Nogoa River, Mackenzie River, and the Fitzroy River.

The site may be divided into two distinct sub-catchments. The CM and CH sites are part of the Gowrie Creek sub-catchment and TLO is part of the Washpool Creek and Bath Creek sub-catchment. Bath Creek feeds Sandy Creek which in turn receives flow from Wolfang Creek. Wolfang Creek in turn is fed by Gowrie Creek. The named creeks within the project area are shown in ***Figure 2-1***. Agricultural development in the catchment has resulted in a disturbed aquatic ecosystem within these waterways. All of these creeks are ephemeral waterways.

2.2 Regulated Structures and Licensed Activities

As part of the need to manage water across the site in order to undertake mining activities, regulated infrastructure is required in places. A list of regulated structures and licensed activities are provided below and in ***Table 2-1***. A summary of revisions and updates to structures in shown in ***Table 2-2***. The location of the structures is show in ***Figure 2-2***.

Table 2-1 - Details of regulated structures and licensed activities

Item	Authorised purpose	Reference	Date given	Consequence Category
Gowrie Creek Levee and Diversion (CM)	Diverting the flow of water	EPML00634115 WL189400	06/05/2016	NA NA
Mine Water Dam (CM)	Water storage	EPML00634113		Significant
Stockpile Dam (TLO)	Water storage	EPML00634114		Significant
Rail loop Diversion (TLO)	Diverting the flow of water	WL48368F	03/02/2016	NA
West Dam (TLO)	Impounding water Permit to take	WL38931F WL608383	03/02/2016 19/10/2018	NA NA
Northern Boundary Diversion (TLO)	Interference authorised by WL38931F	WL48361F	03/02/2016	NA

Note: NA – not applicable

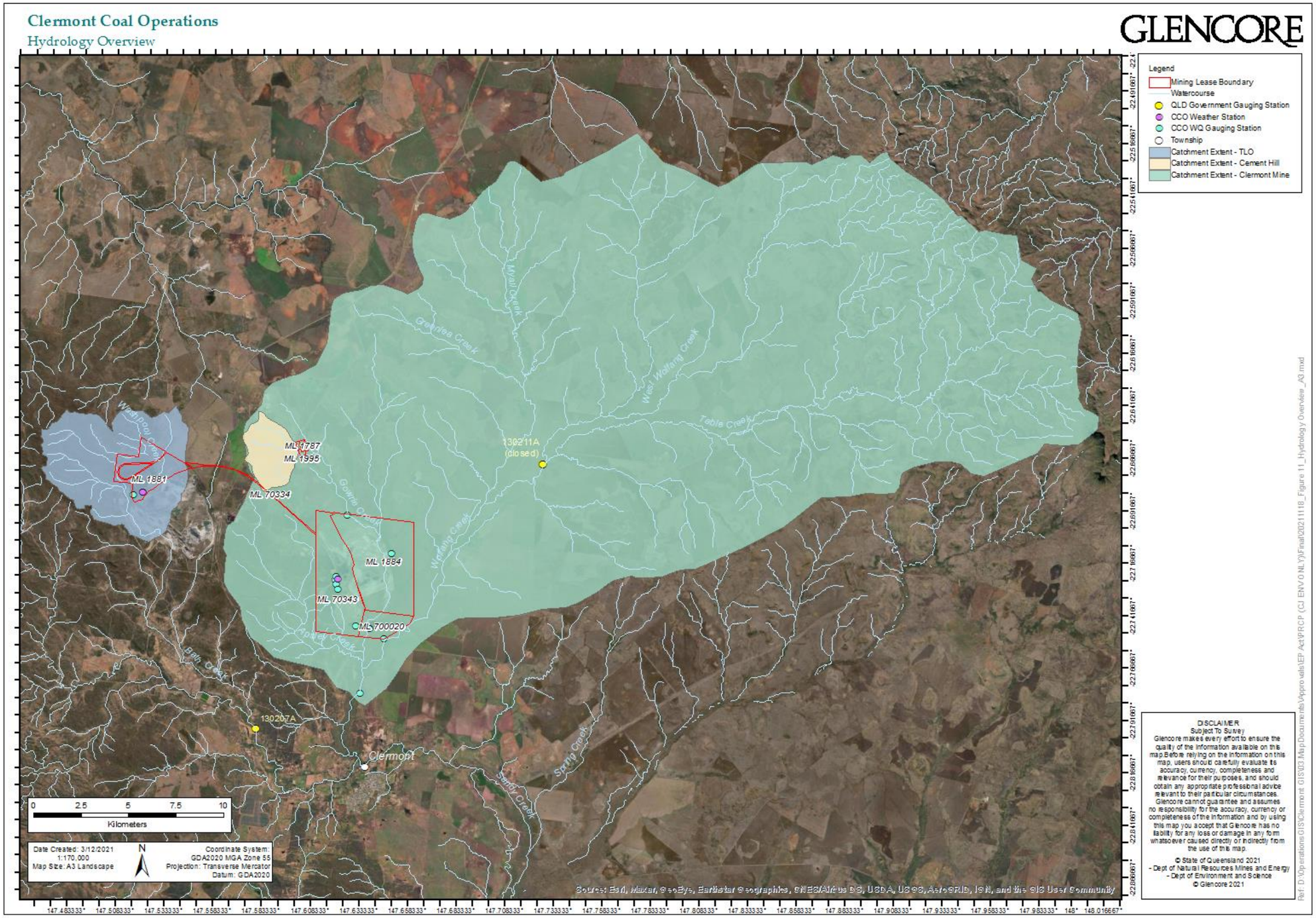

Figure 2-1 - Project site watercourses

Table 2-2 - Structures revision and update history

Structure	Original design date	Subsequent design revisions	Details
Gowrie Creek Levee and Diversion	2004	2008 (construction)	0.2% AEP flood immunity + 500 mm freeboard
		2012	0.1% AEP flood immunity + 500 mm freeboard
		2020	Southern flood levee design - 0.1% AEP flood immunity + 500 mm freeboard
Western Diversion Drain			0.2% AEP flood immunity

2.3 Diversions

As detailed in ***Table 2-1*** and ***Table 2-2***, there are multiple structures and diversions that influence flow. These are (***Figure 2-2***):

- Clermont Mine:
  - Gowrie Creek diversion and levee – permanent diversion of Gowrie Creek to the east of Clermont void;
  - Western diversion drain – drainage feature immediately west of Clermont void;
- Train Load Out:
  - Rail loop diversion – temporary diversion away from the rail loop and towards West Dam; and
  - West Dam and diversion – storage and diversion around the eastern side of Blair Athol. Consists of a number of segments of which the Northern Boundary Diversion is located within the TLO, with segments further downstream (on Terracom land) including the Eastern Diversion and the South Eastern Diversion.

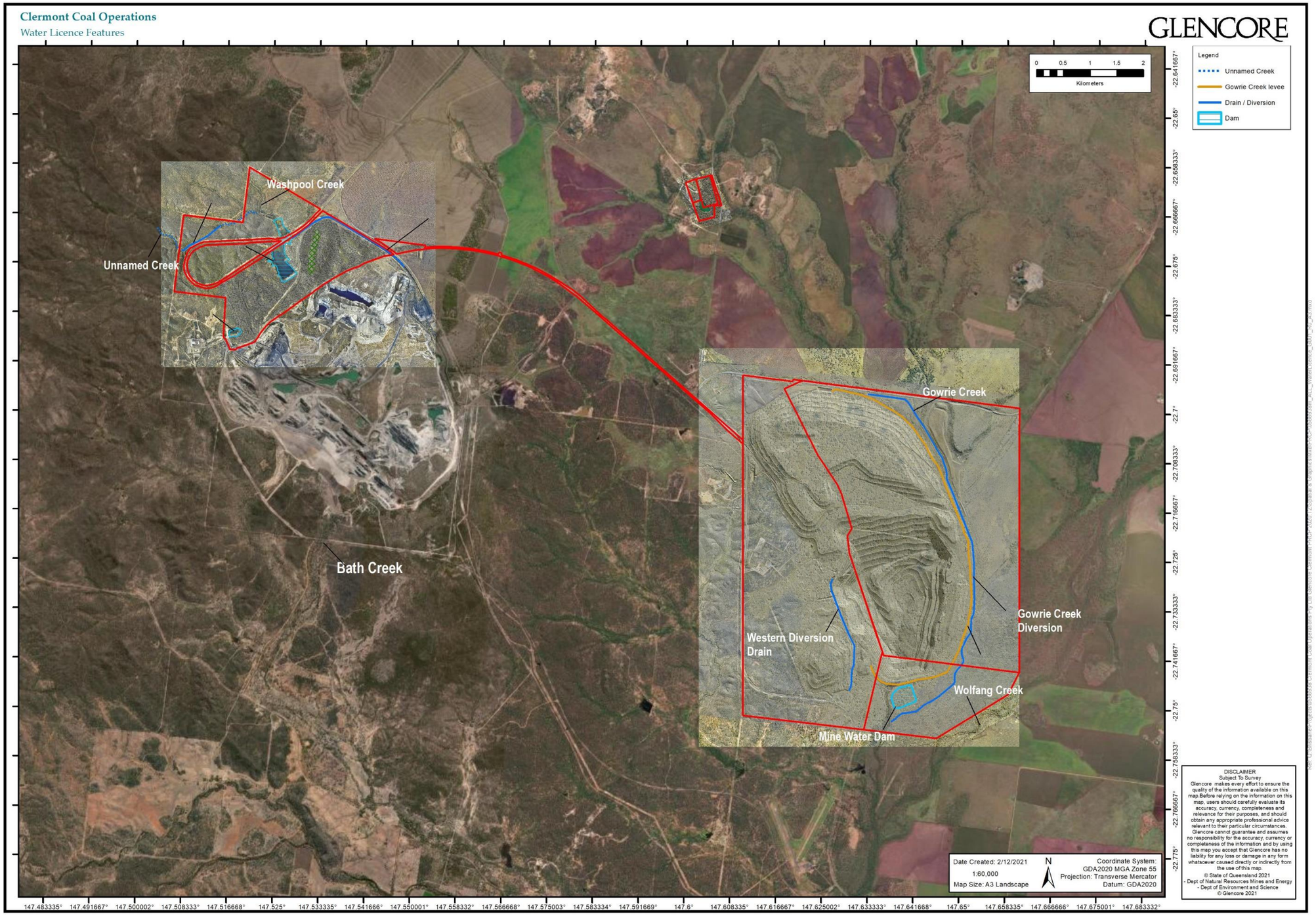

Figure 2-2 - Water Licence Features

3. Catchment Hydrology

3.1 Methodology

The methodology to determine the associated hydrology (design flow) for CM, TLO and CH sites follow the recommended guidelines under ARR 2019. The process involves:

- Catchment delineation;
- Runoff generation;
- Baseflow;
- Losses; and
- Flow routing.

Dependent on the scale of topographical data available, an automated or manual approach was adopted to identify and delineate the catchments contributing to a pre-selected point of interest. The most frequently used catchment delineation software used was CatchmentSIM for large areas. Smaller areas were completed by-hand as the time penalty when compared to using software was negligible.

Runoff generation takes place by converting rainfall to primarily quickflow, in the case of floods. The rainfall input was obtained from the Bureau of Meteorology (BOM) in the format of an intensity-frequency-duration (IFD) data table. The simulation process of applying rainfall spatially over the catchment using a temporal pattern was carried out using an initial/continual loss infiltration model. Pre-burst rainfall data obtained from the ARR Data Hub was applied for the study area. Two pieces of software were used in simulating the routing and design flows across the three areas; XP-RAFTS and RORB. The simulation modelling was completed a per ARR 2019 procedures.

The probable maximum precipitation (PMP) was determined using the Generalised Short Duration Method (GSDM) and the Generalised Tropical Storm Method-Revised (GTSMR). The GSDM parameters used in the determination of the PMP estimate are shown in ***Table 3-1*** and the GTSMR parameters are shown in ***Table 3-2***.

The design flood investigation considered topographic data and infrastructure data include characteristics of the catchment (shape, slope), drainage topology and structures and infrastructure in accordance with ARR (2019).

Model validation was carried out using flow calibration in the case of CM, and using Regional Flood Frequency Estimation Model (RFFEM) for CH and TLO. The RFFEM approach is data-driven which attempts to transfer flood characteristics from a group of gauged catchments to ungauged locations of interest. The RFFEM is a web application which estimates the required discharge calculations based on the geo-spatial information: catchment area (in km^2) and the locations of catchment outlet and centroid (Latitude, Longitude). The RFFEM provides design flood quantiles and associated uncertainty estimates with 90% confidence limits. RFFEM estimated peak discharges were compared to modelled peak discharge at the catchment outlet. Flow records from contributing gauging stations were also investigated to inspect location, catchment characteristics, area and shape.

Table 3-1 - GSDM local information

Location Information				
Catchment Name	Clermont		*Reference:* *Generalised Short Duration Method (BOM, 2003)*	
Catchment Area	As required			
State	QLD			
Latitude	Longitude	Duration Limit	Prop Smooth	Prop Rough
-22.66	147.6	6	1	0
Elevation Adjustment Factor (EAF)				
Mean Elevation at Site Location:		310 m	EAF	1
Moisture Adjustment Factor (MAF)				
			MAF	0.85

Table 3-2 - GTSMR local information

Location Information			
Catchment Name	Clermont	State	QLD
GTSMR zone	GTSMR Coastal	Catchment Area	As required
Catchment Information			
Topographical Adjustment Factor		TAF	1.0000
Decay Amplitude Factor		DAF	1.00
Annual Moisture Adjustment Factor		MAF_a	88.9 / 120.0
Extreme Precipitable Water ($EPW_{Catchment}$)	88.94	MAF_a	0.74
Winter Moisture Adjustment Factor		MAF_w	62.8 / 82.3
Winter EPW ($EPW_{catchment_winter}$)	62.82	MAF_w	0.76

3.2 Catchments and Design Flow

Applying the methodology described above, design flood/flows were determined for each of the study areas. The catchments were delineated based on the point for which a design flow was required. In addition to the delineation of the catchments, basic hydrological characteristics (stream length and catchment area) were determined. Details for the significant catchments and watercourses for the area is shown in ***Table 3-3***. The CM and CH associated creeks and the greater Wolfang catchment area is shown in ***Figure 2-1***.

Table 3-3 - Hydrological Characteristics of Significant Waterways in the Vicinity of the Project

Stream Name	Stream Length (km)	Catchment Area (km^2)
Sandy Creek	87	2497
Wolfang Creek	53	866
Aspley Creek	14	53
Gowrie Creek	19	88
Teatree Creek (part of Gowrie Creek catchment)	12	36
Gowrie Creek (within Mining Leases)	8.5	19

No major hydrological changes are planned for the CM and CH area. However, additional modelling was undertaken for the TLO due to rehabilitation work required which is likely to impact the hydrology in sub-catchments. These include the removal of the Rail Loop diversion and the reduction in West Dam capacity (and associated attenuation).

3.2.1 Clermont Mine

The total Gowrie Creek catchment is approximately 90 km^2, comprising 11% of the much larger Wolfang Creek catchment. The mining leases are generally cleared for grazing and cropping and has stands of remnant vegetation. The majority of remnant vegetation is along the western side of the mining lease. The Peak Downs Highway forms a significant hydraulic control to flood flow. The mining leases generally slope to the south east to Gowrie Creek with terrain elevations ranging between 315 m AHD to 260 m AHD. The soils are dominated by dark, cracking clays that have a high soil moisture storage capacity. Rainfall runoff modelling undertaken showed that a very low proportion of rainfall results in runoff. On an annualised basis, only 3.5% of rainfall on the catchment becomes creek flow. Details of Department of Regional Development, Manufacturing and Water's (DRDMW) Gauging Stations on Wolfang Creek and Sandy Creek are provided in ***Table 3-4***.

The hydrology surrounding CM will be largely unchanged from the current regime after completion of mining. Contributing catchments upstream of the mine are unaffected by mining and closure activities and the resulting response to rainfall events are to remain similar. The rehabilitation of the northern WRD to a vegetated and outward draining surface is not expected to substantially alter the local hydrological response. Incorporation of the eastern levee into the final landform provides a robust and sustainable landform moving through closure and into the future.

Design inputs include:

- June 2019 LiDAR;
- July 2017, July 2018 and June 2019 aerial images of mine;
- Proposed mine landform and drainage plans to inform delineation of mine catchments; and
- Mine infrastructure and services information.

Table 3-4 - DRDMW gauge station details

DRDMW Station 130211A – Wolfang Creek at Innisfree	
Site commenced	15/10/1971
Site ceased	01/10/1976
Grid reference	Zone – 55 E574593 N7492543
Max gauged stage in metres (m)	0.590 on 14/01/1974
Catchment area (km^2)	438
DRDMW Station 130211A – Wolfang Creek at Innisfree	
Site commenced	01/10/1976
Site ceased	01/10/1988
Grid reference	Zone – 55 E55414 N747589
Max gauged stage in metres (m)	0.260 on 09/08/1976
Catchment area (km2)	438
DRDMW Station 130211A – Wolfang Creek at Innisfree	
Site commenced	21/01/1965
Site ceased	Current
Grid reference	Zone 55 E574593 N7492543
Max gauged stage in metres (m)	2.410 on 15/05/1977
Catchment area (km2)	409

3.2.1.1 Clermont pre-mining

Prior to mining Gowrie Creek flowed through the current mining footprint. The Gowrie Creek channel was poorly defined with evidence of significant lateral migration. Gowrie Creek was generally 1 m deep, more deeply incised on the outside bend of meanders and shallower in the flatter reaches near the Peak Downs Highway. In these sections there was significant deposition of alluvial sediments within the channel bed.

3.2.1.2 Clermont post-mining

The Gowrie Creek diversion and surrounding creeks are shown in ***Figure 3-1***. The hydrology surrounding CM will be largely unchanged from the current regime under active mining. The rehabilitation of the northern WRD to a vegetated and outward draining surface is not expected to substantially alter the local hydrological response. Incorporation of the eastern levee into the final landform provides a robust and sustainable landform moving through closure and into the future.

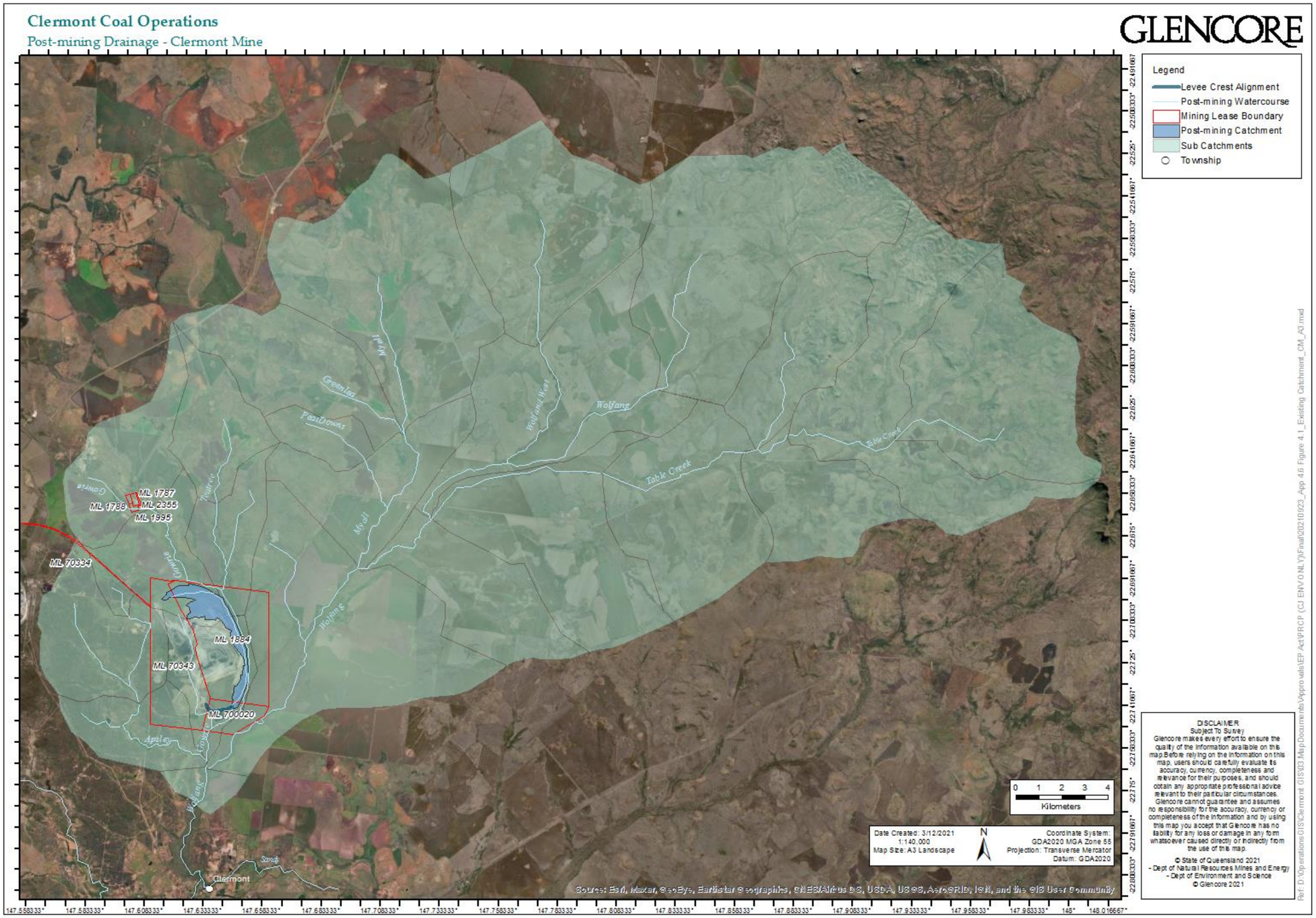

Figure 3-1 - Existing mine catchments delineation

3.2.1.3 Clermont design flows

The following hydrological parameters were used in the determination of the design flows (***Table 3-5***).

Table 3-5 - Hydrological parameters

Hydrological parameter	Value
Rainfall intensity	Sourced from AR&R 2016/2019
Temporal patterns	Sourced from AR&R 2016/2019
Area reduction factor (ARF)	1.0 for mine catchments/small creek catchments, as per AR&R 2016/2019 for Wolfang Creek
Fraction impervious	2.5% for mine area
Hydrological roughness	As required for calibration, within reasonable values (reference industry guidelines)
Lag time	Bransby Williams
1% and 0.1% AEP initial loss/continuing loss	To be calibrated to RFFE/FFA

An analysis of available gauges from Water Monitoring Queensland, Bureau of Meteorology and Clermont Mine privately owned gauges was carried out. The analysis included:

- Obtaining rainfall and stream gauges near the catchment;
- Reviewing the gauge data for rare events to calibrate to;
- Reviewing the gauge data to validate 'quality' data for use; and
- Exclude data of 'poor' quality.

Data obtained for the gauges is shown in ***Table 3-6*** and spatially ***Figure 2-1***.

Table 3-6 - Gauges available for calibration

Gauge name	Lat	Long	Type	Comment	Date available	Maximum event
35267	-22.43	147.55	Rain (daily)	Coovin	1983-2020	Not known
35124	-22.78	147.62	Rain (daily)	Clermont Airport	2010-2020	Not known
35199	-22.28	147.44	Rain (daily)	Mount Wilkin	1923-2020	Not known
35094	-22.48	147.52	Rain (daily)	Winvic	1962-2020	Not known
35121	-22.96	147.8	Rain (daily)	Valencia	2009-2020	Not known
34078	-22.52	147.69	Rain (daily)	Greenmantle	1968-2020	Not known
35019	-22.83	147.64	Rain (daily)	Clermont Post Office	1870-2018	Not known
130211B	-22.67	147.7247	Stream	Wolfang Creek at Innisfree	1976-1988	1983
1304P002	-22.82	148.6898	Rainfall	Middlemount Standalone Pluvio	2007-2020	2014 (1hr burst)
130210A	-23.19	147.8948	Stream	Theresa Creek at Valencia	1971-2020	1975
130211A	-22.7	147.7261	Stream	Wolfang Creek at Innisfree	1971-1976	19741977
130207A	-22.8	147.5803	Stream	Sandy Creek at Clermont	1963-2020	1978
130208A	-22.98	147.5839	Stream	Theresa Creek at Ellendale	1964-2005	2014/2016
Clermont AWS	-22.73	147.6228	Rainfall	Wolfang Creek upstream @ Glencore Clermont Mine	2014-2020	Not known
330753	-22.72	147.6483	Stream	Gowrie Creek diversion @ Glencore Clermont Mine	2011-2020	2019
330752	-22.73	147.6323	Stream	Wolfang Creek downstream @ Glencore Clermont Mine	2014-2020	2016
36084	-22.81	147.13	Rain (daily)	Banchory	1962-2020	Not known
35211	-22.62	147.66	Rain (daily)	Kurrajong	1961-2020	Not known

The calibration parameters taken forward to design event modelling were as follows:

- IL = 43 mm;
- CL = 1.5 mm/h;
- Manning's 'n' (pervious) = 0.05; and
- Bx = 0.9.

The summary of the calibration results is as follows:

- Difference in flow peak = 1.5 m^3/s or 0.75%.

Results from the calibrated hydrological model are summarised in ***Table 3-7*** and ***Table 3-8***. It is noted that the flows at Gowrie Creek for the Wolfang Creek scenario (i.e. 24-hour critical duration) were simulated higher than for the Gowrie Creek scenario (i.e. 12-hour critical duration). This difference can be attributed to the adopted ARR 2019 temporal pattern selected through the ensemble temporal pattern approach (i.e. the adopted 24-hour temporal pattern for Wolfgang Creek scenario would be above the median temporal pattern in Gowrie Creek).

Table 3-7 - Gowrie Creek scenario results

AEP Event	Duration	Temporal Pattern	Flow (Gowrie, m^3/s)	Flow (Wolfang, m^3/s)
1%	12	6	324	1586
0.2%	12	6	448	2564
0.1%	12	6	523	3191

Table 3-8 - Wolfang Creek scenario results

AEP Event	Duration	Temporal Pattern	Flow (Gowrie, m^3/s)	Flow (Wolfang, m^3/s)
1%	24	5	304	1811
0.2%	24	1	537	2713
0.1%	24	1	621	3198

3.2.2 Cement Hill

The CH area is a historical mining area with no mining activity undertaken on site since the early 1990s. The current landform is largely externally draining. Two areas drain internally; the historical tailings areas and the portions of the waste dumps located to the east of the void. The historical tailings area drains to the lowest cell while the waste dump area drains to the void, with the potential to discharge to Spring Creek under higher rainfall events.

The hydrology assessment considered topographic and infrastructure data including:

- Drainage topology;
- Waterway structures (void);
- Infrastructure (inlet/outlet weir, Kenlogan Road culvert); and
- Topography data obtained from November 2020 aerial survey.

3.2.2.1 Cement Hill Pre-Mining

Pre-mining topography was inferred by inspection of historical aerial photography. The key drainage features of Spring Creek and Gowrie Creek remain in their present day position with the same contributing catchment.

3.2.2.2 Cement Hill Post-Mining

The hydrology surrounding the Cement Hill mining site is largely dominated by Spring Creek in the post-mining scenario. Spring Creek is able to interact with the void created as a result of the mining process. The interaction takes place to the south of the void, over a hard rock interface. The weir has an invert level of RL 300.52 m AHD. Spring Creek interacts with the void, replenishing the stored water, typically several times per year.

The post-mining hydrology for CH was determined after delineating the catchment, which would naturally provide surface water runoff to Spring Creek. The major catchment boundary exit point was positioned a few metres upstream of the creek and void interaction point. The delineated catchment is shown in ***Figure 3-2***. The CH site is located in the upper reaches of the greater Gowrie Creek catchment. Spring Creek which flows to the south of CH and the void in particular joins the Gowrie Creek a few kilometres to the south-east of the CH site. The location of CH relative to the Gowrie Creek catchment results in a smaller catchment area for generating surface flows.

3.2.2.3 Cement Hill design flows

The hydrology of the delineated catchment was modelled to determine the surface water flows from each of the delineated sub-catchments. The hydrological models were prepared adopting 0% impervious cover and using an initial/continuing loss infiltration model. The loss infiltration model utilised 28 mm initial loss and 1.8 mm/hr continuing loss with pre-burst rainfall data that was taken from ARR Data Hub for the Study Area. The following hydrological parameters were used in the determination of the design flows (***Table 3-9***). The estimated design flows are shown in ***Table 3-10***.

Table 3-9 - Hydrological parameters

Hydrological parameter	Value
Rainfall intensity	Sourced from AR&R 2016/2019
Temporal patterns	Sourced from AR&R 2016/2019
Area reduction factor (ARF)	1.0 for mine catchments/small creek catchments, as per AR&R 2016/2019 for Wolfang Creek
Fraction impervious	0
Hydrological roughness	As required for calibration, within reasonable values (reference industry guidelines)
Lag time	Bransby Williams
Design initial loss/continuing loss	28 mm/1.8 mm/hr

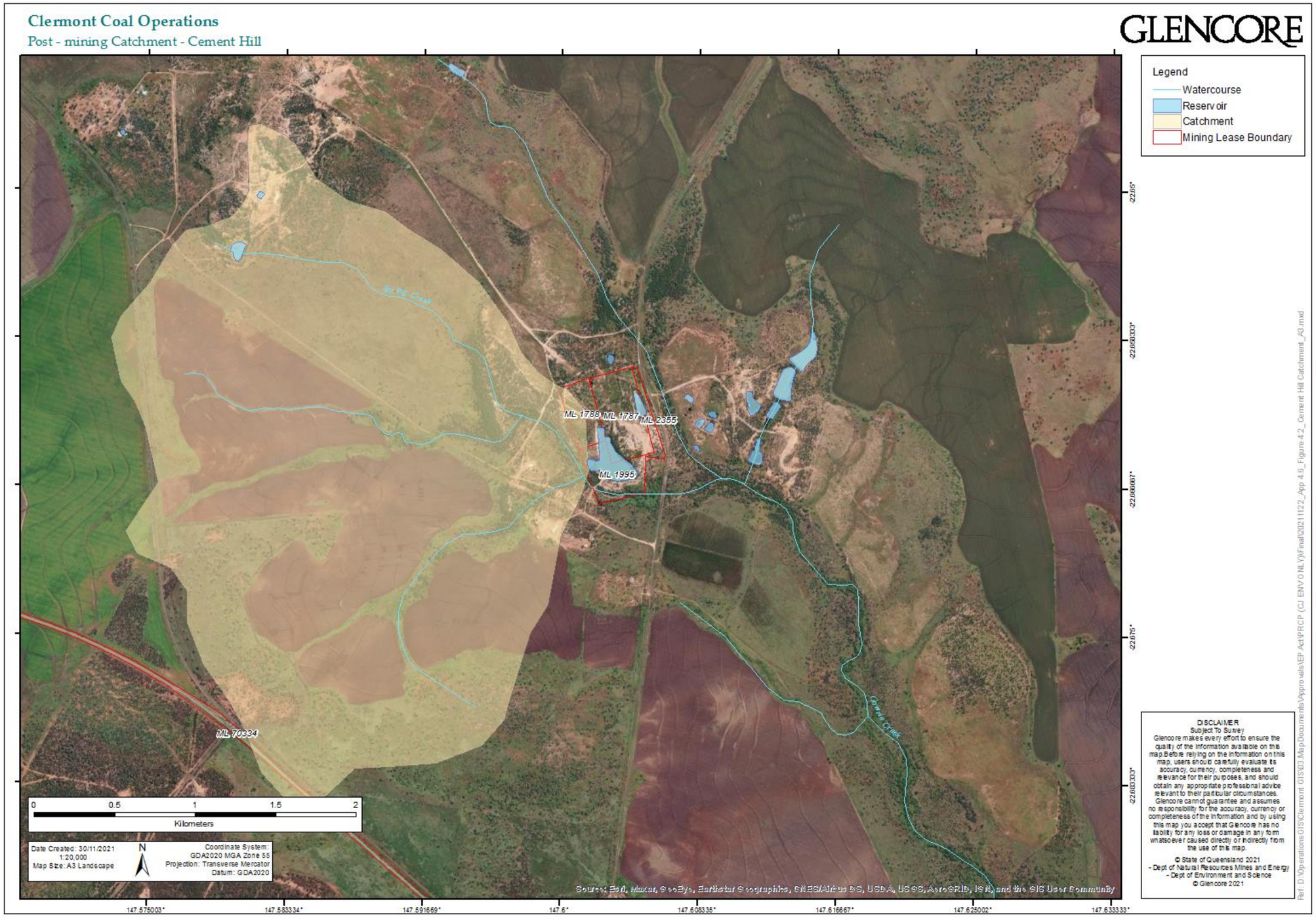

Figure 3-2 - Cement Hill catchment delineation

Table 3-10 - Cement Hill (Spring Creek) scenario results

AEP Event	Critical Duration	Temporal Pattern	Peak Flow (cumecs)
1%	6	2	41.9
0.2%	6	2	59.0
0.1%	6	2	69.9

3.2.3 Train Load-Out

The key hydrological feature within the TLO area is West Dam. It is fed by parts of the upper Bath Creek catchment and Washpool Creek catchment. Part of the Bath Creek catchment was diverted from its original flow path via the Breaker Creek (Rail Loop) diversion to drain into Washpool Creek upstream of West Dam.

The hydrology assessment considered topographic and infrastructure data including:

- Drainage topology;
- Waterway structures (West Dam);
- Infrastructure (culverts/bridges); and
- Topography data obtained from November 2020 aerial survey.

3.2.3.1 TLO pre-mining

Pre-mining topography comprising the Study Area was obtained from the Queensland Spatial Catalogue - QSpatial. ***Figure 3-3*** shows the delineated pre-mining flow path mapping and catchment boundaries based on available topographical data. The original flow path of the Western Creek is to the south, just west of the rail loop before it enters the Blair Athol (BA) mine lease, owned and operated by Terracom.

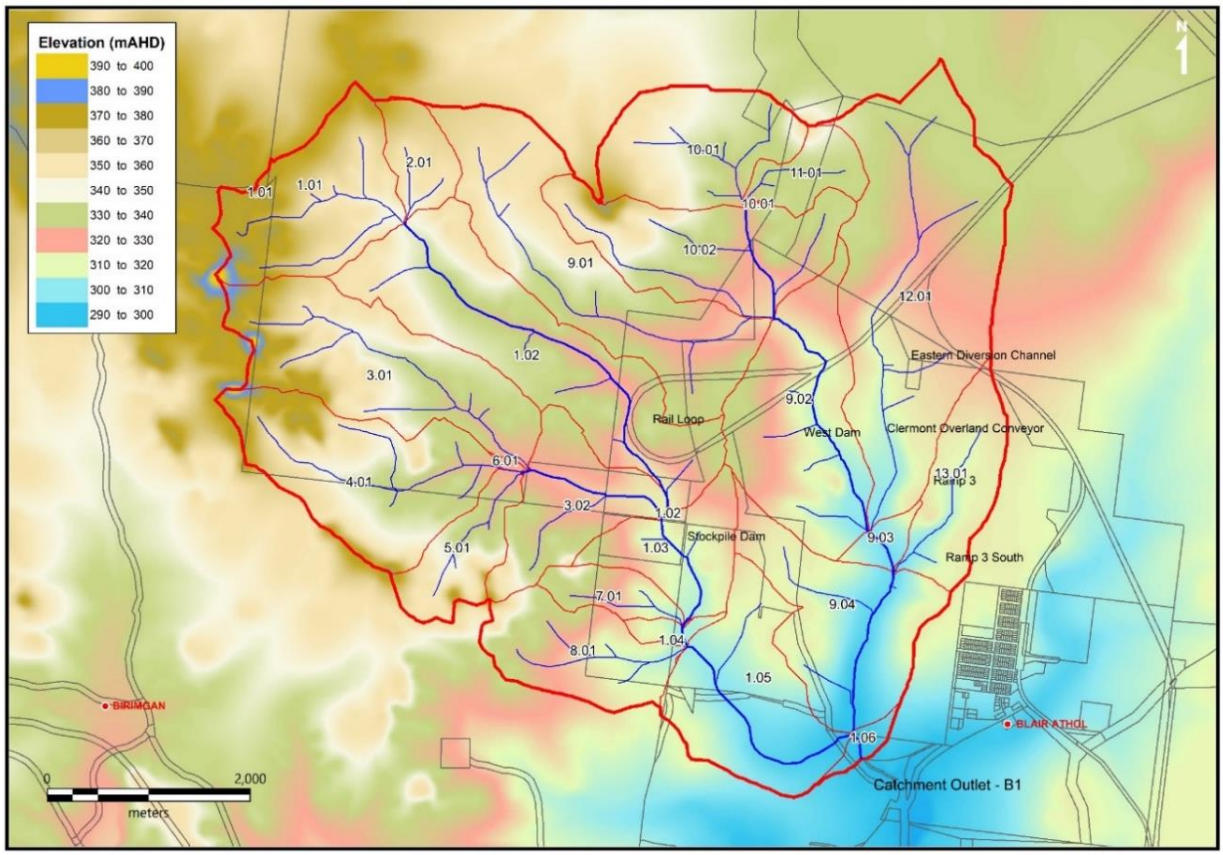

Figure 3-3 - Delineated pre-mining flow path and catchment boundaries

3.2.3.2 TLO post-mining

The current topography dataset was derived by stamping the Study Area LiDAR data on the pre-mining topography on ***Figure 3-3***. Flow path mapping and catchment delineation was undertaken using the derived topography. The delineation of the hydrologic sub-catchment boundaries was important for simulating appropriate routing, especially given the location of West Dam for the estimation of flow entering via the Rail Loop diversion. The Rail Loop diversion contribution to West Dam was implemented with a hydraulic control feature. ***Figure 3-4*** shows the delineated catchment boundaries to West Dam and the downstream Northern Boundary diversion.

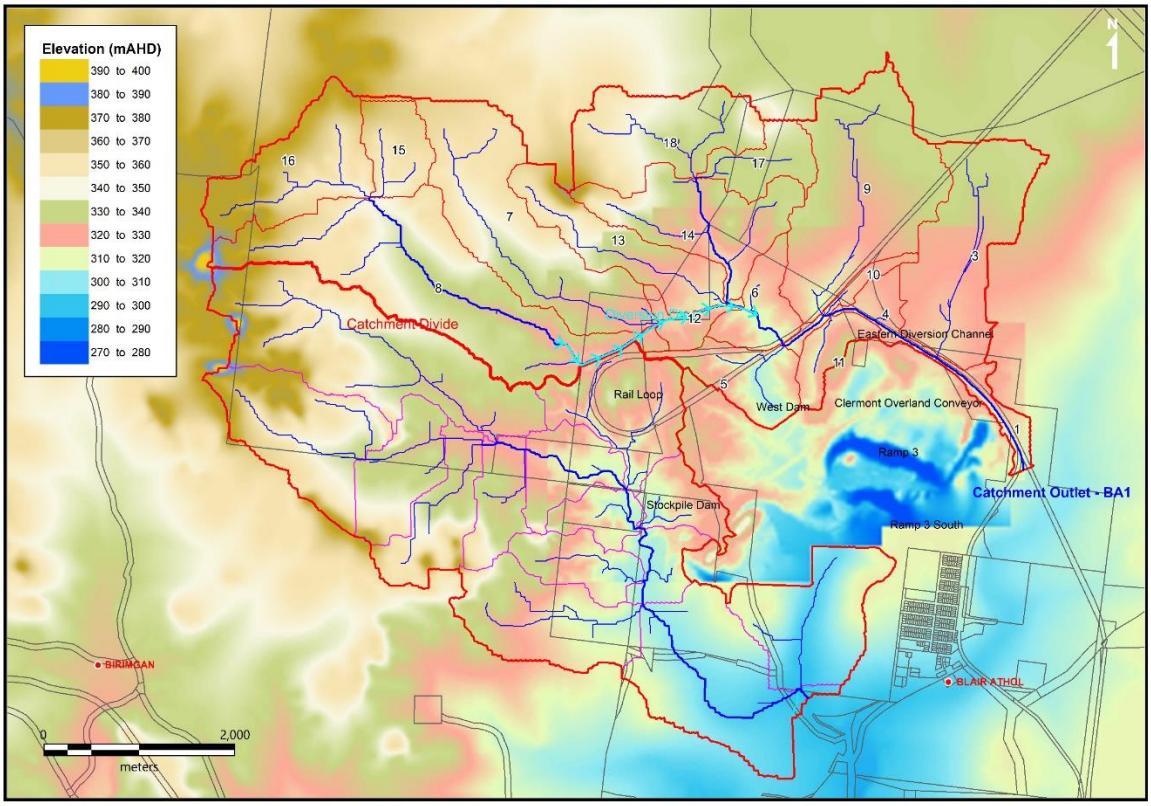

Figure 3-4 - Delineated post mining flow path and catchment boundaries

Various hydrological scenarios were assessed in order to identify an appropriate closure scenario. The following scenarios were investigated:

- Rail Loop diversion:
  - Retain diversion to West Dam;
  - Remove diversion to reinstate original flow path;
- West Dam:
  - Unchanged;
  - Lowered crest with upstream bulking;
  - Removal;
- Northern Boundary diversion downstream of West Dam:
  - Retain diversion. The existing diversion was found to be geotechnically stable, being cut into competent basalt material;
  - Reinstate original flow path. This option was eliminated due to consultation with Terracom and practicality constraints of reinstating a flow path from the Blair Athol mining pits; and
  - Divert to the west. This option was eliminated based on excessive cut depths.

There are many combinations of the above scenarios, so an initial screening process was used to rationalise to the most feasible combinations. The scenarios carried forward for detailed modelling and evaluation are summarised in ***Table 3-11***.

Table 3-11 - TLO hydrology scenarios

Scenario	Rail Loop diversion	West Dam	Northern Boundary diversion	Original flow path (into Terracom)
1	✓	✓	✓	×
2	✓	×	✓	×
3	×	✓	✓	×
4	×	×	✓	×

3.2.3.3 TLO design flows

The hydrology of the delineated catchments were modelled to determine the surface water flows from each of the delineated catchments. The hydrological models were prepared adopting 0% impervious cover and using an initial/continuing loss infiltration model. The loss infiltration model utilised 28 mm initial loss and 1.8 mm/hr continuing loss with pre-burst rainfall data that was taken from ARR Data Hub for the Study Area.

The estimated pre-mining design flows are shown in ***Table 3-12***. This relates to the catchment exit point as indicated in ***Figure 2-1***.

Table 3-12 - Pre-mining peak discharges for 5%, 2% and 1% AEP events

AEP Event	Peak Flows (m^3/s)
5%	171.3
2%	224.4
1%	261.1

The results for the various scenarios encompassing the options of including or excluding the Rail Loop diversion and the West Dam is shown in ***Table 3-13***. The lowest flow through the Northern Boundary diversion downstream of West Dam occurs when West Dam is retained and the Rail Loop diversion is removed. The largest flows occur with the retention of the Rail Loop diversion but the removal of the West Dam. West Dam provides an important attenuation role that throttles the flow rate through the diversion. The selected scenario includes removal of the Rail Loop diversion and the retention of West Dam (scenario 3).

Table 3-13 - Post mining peak discharges for 1% and 0.1% AEP events

Scenario	Rail Loop diversion	West Dam	Design flows (m^3/s)	
			1%	**0.1%**
1 (existing)	✓	✓	70.3	146.9
2	✓	×	139.5	225.8
3	×	✓	55.1	90.9
4	×	×	106.5	173.6

The hydraulic assessment of the Northern Boundary diversion identified the need for some localised channel rectification works to address hydraulic constraints. One key component of these works is a reduction in the elevation of the bywash of West Dam and removal of the gabion basket spillway. The reduction in crest height reduces the storage capacity of the West Dam, reducing the detention storage capacity and resulting in a potentially more frequent overflow/discharge to the downstream Northern Boundary diversion. The spillway elevation will be lowered from 321.2 mAHD to 320.0 mAHD. The dam wall will also be bulked out to create a mined landform, further consuming airspace within the dam. Results of the impact to hydrology following the bulking of the dam wall and change to spillway elevation are shown in ***Table 3-14***.

Table 3-14 - TLO hydrological changes

AEP Event	Existing (Scenario 1)	Proposed (Scenario 3) with spillway lowered (320.0 mRL) and bulked dam wall
50%	9.3	9.3
2%	54.5	51.3
1%	70.3	62.1
0.1%	**146.9**	**126.7**

The hydrology assessment concludes that the proposed changes to TLO will result in a reduction of peak flow down the diversion. This, coupled with hydraulic rectification works, will result in a long term stable diversion and retention of West Dam which provides habitat value and a viable water resource.

4. Floodplain Hydraulics

4.1 Methodology

Flood modelling for CM, TLO and CH were carried out using 2D modelling software. The software used in the determination of design flood extents were TUFLOW HPC (2020-01-AB release) and HEC-RAS (6.0). The process involved demarcating the model boundaries, defining the area (mesh) for the model to performing the 2D modelling. An appropriate cell size was selected for the area involved in the modelling. The cell size is dependent on the intended area included under the mesh and the level of detail of the digital elevation model (DEM) available for the simulation.

Surface roughness needs to be considered as part of the modelling process. The surface roughness informs the model the ease with which water would move over the surface. The surface roughness coefficient (Mannings 'n') was derived from interpretation of aerial photography and ground truthing.

Additional infrastructure and surface features were included in the model where required in order to present a representation of the potential flow paths and limitations available to surface water during a design flood event. The additional features include bridges, culverts and weirs to name only a few examples.

The CM void is a pre-approved NUMA with the location identified in LODs. While certain components of the flood plain modelling requirements of the PRCP Guidelines are not required for pre-approved NUMAs with their locations identified, a substantial body of hydrology and hydraulic assessment exists and is provided for context of the proposed rehabilitation activities.

4.2 Flood Modelling

4.2.1 Clermont Mine

Flooding on the mining lease is dominated by the local drainage of Gowrie Creek in conjunction with the floodplain flow of Wolfang Creek. The floodplains of the two creeks intersect at the southern end of the mining leases, where flood flows inundate a large area. The Wolfang Creek floodplain forms the downstream control to flows in Gowrie Creek.

Initial flood plain modelling was performed for the EIS (RTCA 2004). These early models comprised a two-dimensional MIKE21 hydraulic model. At the time no historical flood level data were available for calibration of the model, so conservative parameters were adopted. Freeboards were applied to design levels to account for lack of calibration. Hydraulic modelling showed that the existing flooding situation of the site is extensive. Gowrie Creek diversion channel has limited capacity and the 1% AEP event quickly spills into the floodplain (***Figure 4-1***). The levee designs as part of diversion channel are shown in ***Table 4-1***.

Table 4-1 – CM levee designs

	Length (km)	Typical height (m)	Maximum height (m)	Top width (m)	Levee batter slopes (v:h)	Fill volume (m^3)
Western levee	8.0	2.0	4.0	3.0	4:1	170000
Eastern levee	1.5	1.7	3.0	3.0	4:1	30000

Wolfang Creek also spills out of the primary channel very early in a flood event and both floodplains are broad relative to their primary channel. The floodplains of Gowrie and Wolfang Creek intersect approximately 2 km from the southern end of the mining lease. The 1% AEP inundation in Gowrie Creek achieves approximately 276 m AHD at the northern end of the ML and Wolfang Creek and Gowrie form a combined water surface at 263 m AHD at the southern end of the ML. The design flood flows are shown in Figure 4-1.

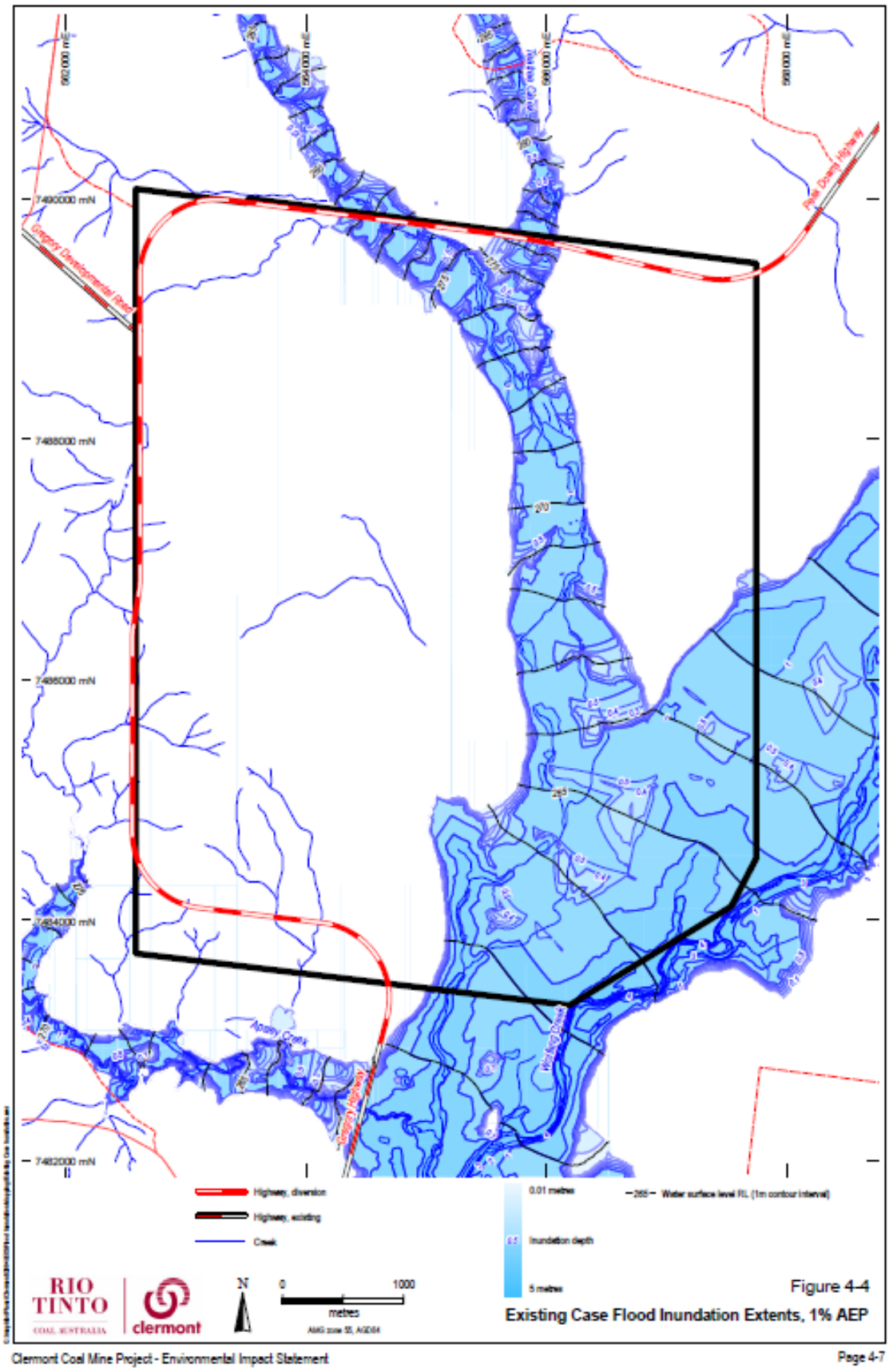

Figure 4-1 - 1% AEP flood inundation extents (pre-mining)

Flood modelling has been regularly revised throughout the life of the mine. A major update was completed in 2020 as part of a levee extension to the south and west to provide flood protection as the pit progresses further to the south. The hydraulic model was developed using TUFLOW HPC (2020-01-AB release) to simulate site orientated flood behaviour. The model extents were defined as north of Peak Downs Highway to south of the Gowrie-Wolfang Creek confluence. A cell size of 5 m was adopted for the 2D model domain. The CM levees were reinforced in the model. The adopted Manning's "n" values are presented in ***Table 4-2***. The Manning's "n" for active channels was calibrated to the Gowrie Creek gauge.

Table 4-2 - Adopted Manning's 'n'

Land Use/Material Type	Manning's 'n'
Vegetation (non-mine affected)	0.045
Active channel	0.05
Riparian zone/bush	0.05
Mining areas/roads	0.03
Cleared areas/roads	0.025
Ponded water	0.01

Two scenarios were run per design event scenario. These were the critical duration events for Gowrie and Wolfang Creek catchments (i.e. 12-hour and 24-hour events respectively). The defined design event result was taken as the maximum flood level of the two scenarios. The Wolfgang Creek critical duration scenario generally produced the critical conditions at the levees in the southern of the mining lease, with the critical conditions for the north of mining lease generally dictated by the critical event at Gowrie Creek.

The levees protecting the pit were upgraded from the original design standard of 0.2% AEP to 0.1% AEP flood immunity. A freeboard of 500 mm was incorporated to account for model uncertainty, construction tolerances and settlement. As detailed previously, the rehabilitation approach for these levees will be to incorporate them into a final landform with a minimum top width of 50 m. This will ensure long term 0.1% AEP flood immunity of the Clermont void.

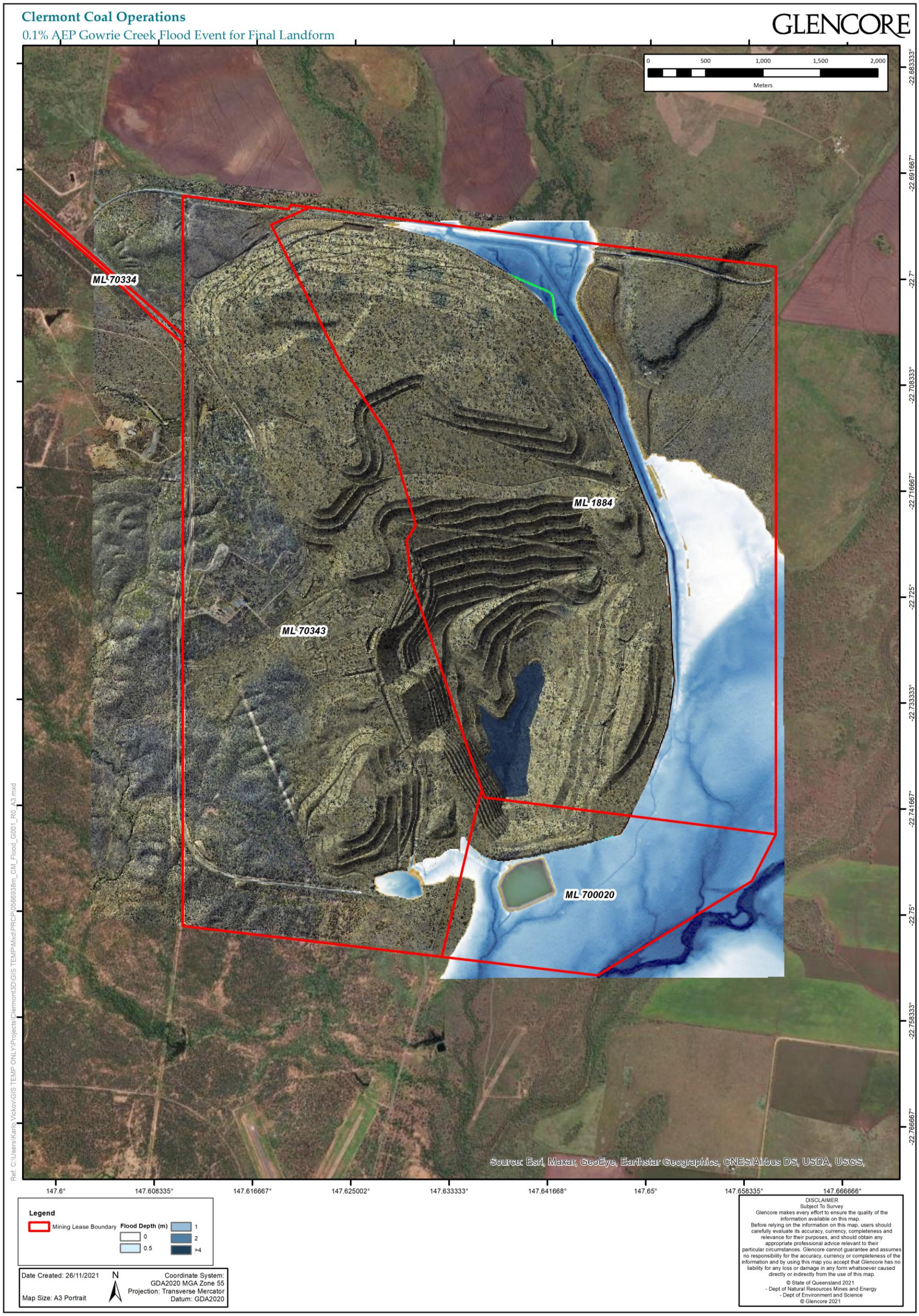

Figure 4-2 - 0.1% AEP Gowrie Creek flood event for final landform

4.2.2 Cement Hill

The hydraulic model for Cement Hill was developed using HEC-RAS 6.0.0 Beta 3 to simulate the hydraulic routing of a design event hydrograph. The flood model adopted a 2-dimensional approach. Kenlogan Road was adopted as the downstream control and the model domain was extended to approximately 400 m upstream of the void. A 3 m mesh cell size was adopted for the 2D model domain.

The void is linked to the creek via a weir excavated into the insitu conglomerate rock, set at an elevation of RL 300.5 mAHD. During high flows, water enters the void via this weir. Should the void water level reach and exceed the RL 300.5 m AHD, a floodplain storage and attenuation effect takes place. Once the flood water level recedes below the void water level, water flow direction reverses and the void will decant to the external drainage feature. This phenomenon results in the flood hydrograph being attenuated (peak reduced) before it reaches the Peak Downs highway. The hydrograph flow duration is extended due to the potential temporary storage taking place in the void, before decant back to the creek.

The hydraulic model was used to explore the exchange of water volume from the flood event and the inflow characteristics (e.g. hydrograph, velocity, shear stress) as water enters the void. ***Figure 4-3*** provides a summary of the water level in the drainage feature and void throughout a 5% AEP design storm event. In this case the void was assumed to be empty at the commencement of the storm event. The modelling shows:

- No entry of floodwater into the void until floodwater reaches the weir elevation of 300.5 mAHD;
- Differential water elevations between the drainage feature and the void during the filling phase, caused by the constriction of the weir that throttles the flow rate of water entering the void;
- Equilibration between the flood level and the void water level after approximately 5 hours of first water entry into the void; and
- Retention of water in the void following the flow event.

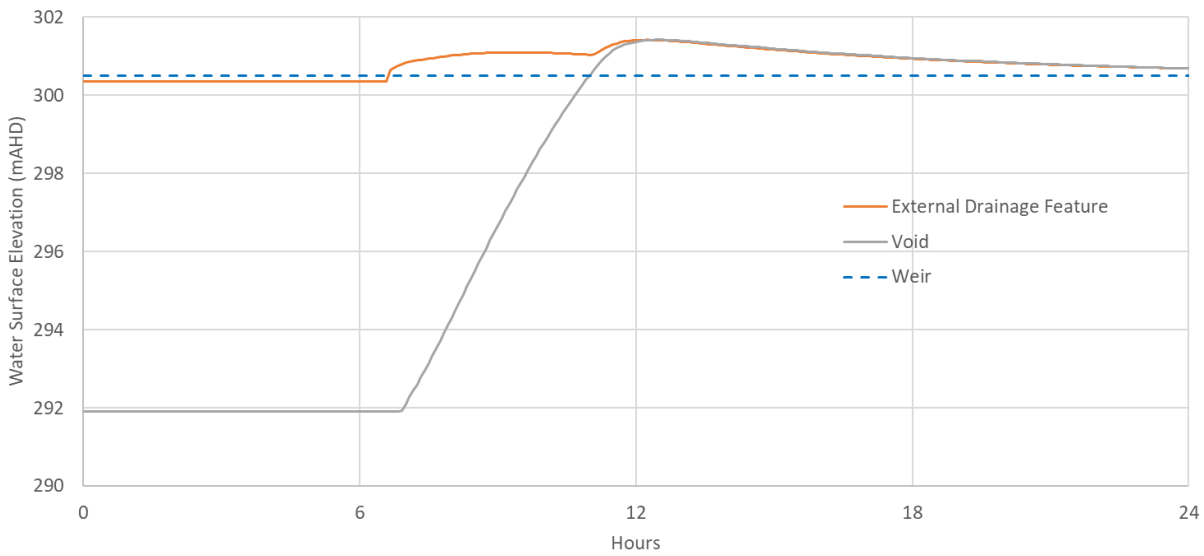

Figure 4-3 - 5%AEP floodplain/void interaction

A range of design storm events were assessed using the 2D hydraulic model, including the 2EY, 1EY, 1% AEP and 0.1% AEP design events. PMF was also modelled, with the critical duration being 3 hours and resulting in a peak flow of 286 m^3/s. The void was simulated as empty, RL 291 m AHD at the

beginning of the simulation, as this results in the greatest movement of water into the void and allows for assessment of the hydraulic performance of the weir structure.

The water surface elevation in the main channel adjacent to the void for the 1% AEP, 0.1% AEP and PMF flood events is shown in ***Figure 4-4***.

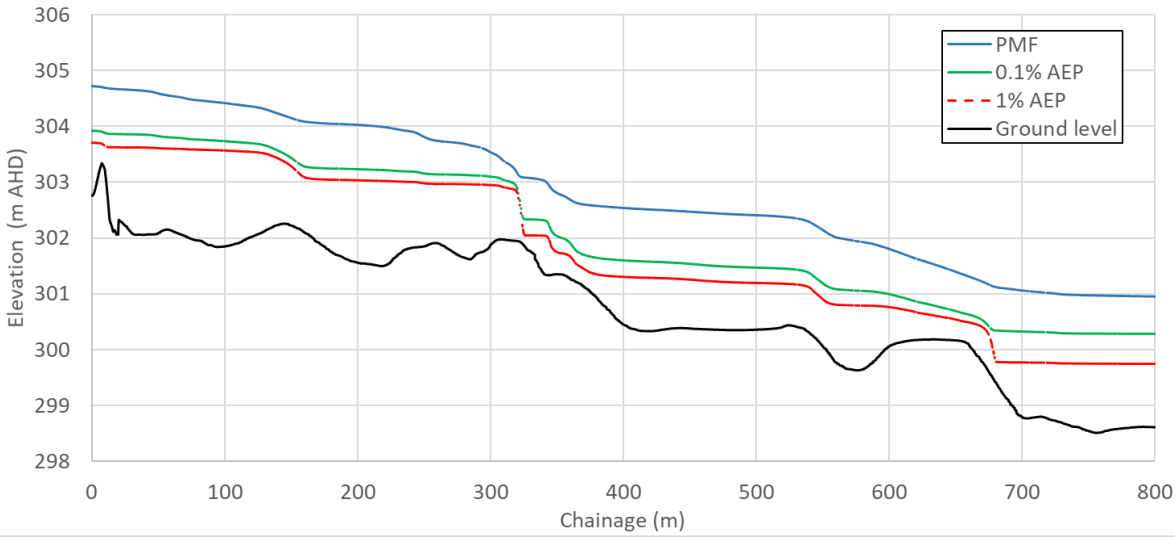

Figure 4-4 - Design flood events at Cement Hill

Given that the CH void is connected to the flood plain via a weir, void flood immunity is not relevant and therefore the effect of extreme flood events such as 0.1% AEP and PMF is less significant at this location. The 1% AEP event is presented in ***Figure 4-5*** as this is the event of most relevance from an erosion perspective associated with a major flood event. The flood extent and velocity profile of the current situation shows a constriction to flow between the southern WRD and a satellite WRD placed in stream. Peak velocity in the location reaches 6 m/s and is likely to result in bed erosion and scour of the waste rock margins.

To address this scour risk, Glencore have committed to relocating the satellite WRD, thereby reinstating a flood plain to the south of the southern WRD. The effect of these proposed works within the floodplain was assessed in the hydraulic model and the results are shown in the post-rehabilitation scenario depicted on ***Figure 4-5***. The peak velocity is reduced substantially to less than 2 m/s, which adequately addresses the toe scour risk and is equivalent to other sections of the floodplain upstream of the ML.

Figure 4-5 - 1% AEP velocity prior to and after final landform

4.2.3 Train Load-Out

The hydraulic modelling for the TLO region focussed on assessment of the Northern Boundary diversion downstream of West Dam. Key features that were assessed included the West Dam bywash, diversion stability, flood containment, culvert performance and tailwater conditions from the downstream diversion within the Terracom mining lease. The model was prepared in HECRAS using a 1D methodology with high resolution cross sections derived from LiDAR. The model extent and stations are shown in ***Figure 4-6***.

Figure 4-6 - TLO 1D model domain

Velocity, shear stress and stream power were investigated for the 2% AEP and 50% AEP design storm events. Flood containment was investigated for the 1% AEP and 0.1% AEP design storm events.

The hydraulic investigation identified:

- The existing bywash is causing a hydraulic constraint and localised high velocity, shear stress and stream power. This is confirmed by field observations revealing scour of the gabion baskets, as shown in ***Figure 4-7***;
- The culverts under the overland conveyor and access road is causing a hydraulic constraint, leading to backwater effects propagating up the majority of the diversion. This is exacerbated by the very low gradient on the diversion channel; and
- The diversion does not cater for 0.1% AEP flooding containment in two locations: immediately upstream of the culvert and adjacent to West Dam bywash.

Figure 4-7 - Scour and instability at the diversion bywash

These hydraulic constraints can be addressed through the following rectification works:

- Lowering of West Dam bywash and removal of the gabion basket spillway. The spillway elevation will be lowered from 321.2 mAHD to 320.0 mAHD;
- Removal of the culverts and waterway cross at the existing conveyor and access road corridor; and
- Minor landform reshaping in the vicinity of the bywash to provide 0.1% AEP flood containment.

The proposed works result in the desired 0.1% AEP flood containment, as well as stability indicators falling within the guidance ranges provided within ACARP 8030 – Maintenance of Geomorphic Processes in Bowen Basin River Diversions. It is noted that because the diversion is cut into in-situ competent basalt the stability indicators detailed in ACARP 8030 are not likely to be applicable and much higher velocity, shear stress and stream power could be tolerated in this diversion. A comparison between the existing and proposed channel elevation and water surface profile is provided in ***Figure 4-8*** and ***Figure 4-9*** respectively.

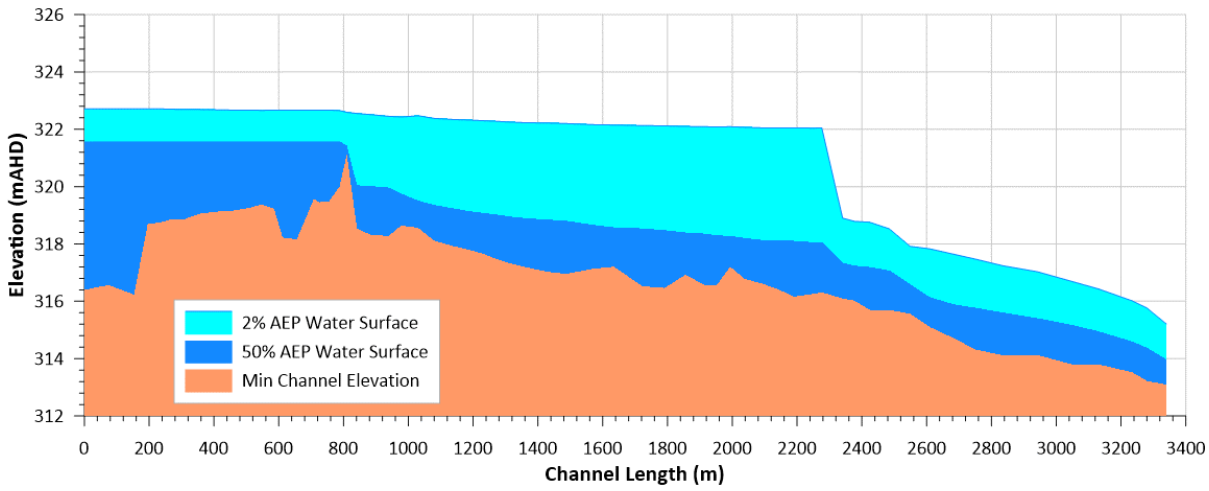

Figure 4-8 - Water surface elevation - existing

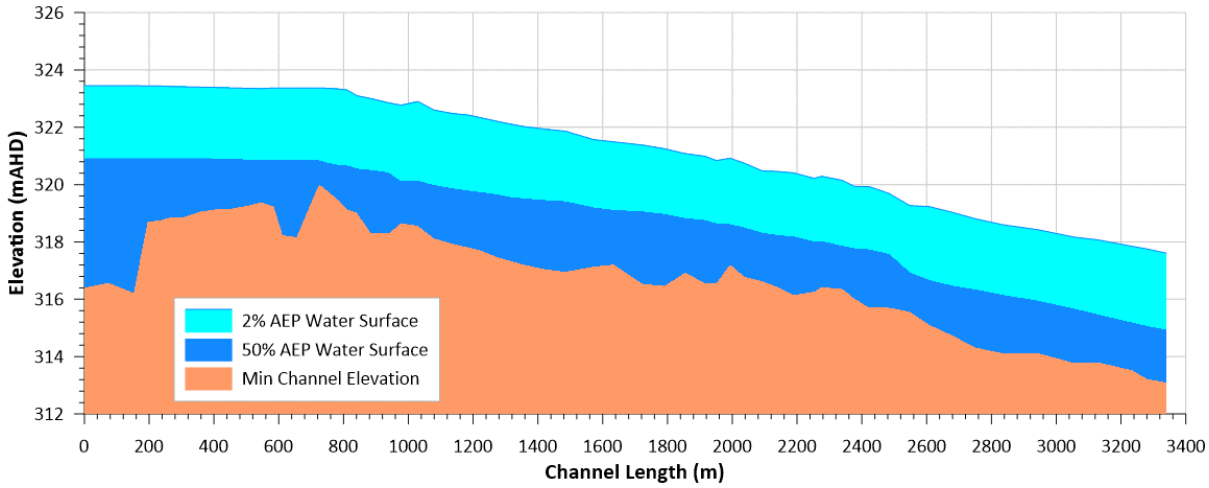

Figure 4-9 - Water surface elevation - proposed

4.3 Flood Risk Profile

A flood risk profile has been developed to identify and rank the risk of the key features and areas of concern to CCO. This has been completed to consider the susceptibility and likely influence of flooding on the areas and features of concern and focuses on the flood risk posed to each area for the rehabilitation and closure of the CCO site. Planned mitigation measures to be adopted to ensure that the risk of rehabilitation not meeting a stable condition has also been incorporated.

The risk ranking applied herein has been aligned to the methodology and matrix applied for the overarching Risk Assessment for the PRCP, as detailed in Section 3.6 of the main PRCP document.

The outcome of the flood risk profile for CM, TLO and CH is indicated below in ***Table 4-3***.

Table 4-3 - Flood risk profile at CM, TLO and CH

Area	Risk rating	Comment
CH Void	Medium	Few engineered surfaces fall within the flood inundation boundary of the creek. The CH void provides a means of attenuating the peak flows, reducing potential impact downstream. It is deemed medium risk because the void actively interacts with the floodplain, although this is mitigated by the interaction occurring over in-situ competent rock and evidence spanning almost 30 years that this has proven to be a stable connection.
TLO West Dam	Low	Dam located upstream of recently mined open pits in neighbouring mining lease. Upstream spillway design provides more direct routing of rare (large) design flows once dam is above full supply capacity. Dam wall bulked out to form a landform. Attenuation of peak flows significantly reduces the flood risk profile.
TLO Northern Boundary diversion downstream of West Dam	Low	Diversion cut in competent material showing few signs of erosion after many years of use. Diversion designed to contain 0.1% AEP without spilling and features few engineered or compacted soil sections providing a robust structure.
CM Gowrie Creek diversion	Low	Gowrie Creek levee incorporated into final CM landform. Incorporation prevents ability of flood water to undermine and erode levee by access to unprotected faces. Protected faces for the 0.1 AEP depth + 500 mm freeboard provides long-term protection and a sustainable feature allowing rehabilitation to establish.
CM Southern levee	Low	Wolfang Creek and Gowrie Creek backwater intersection point features low velocity flow. Levee designed for 0.1% AEP + 500 mm freeboard.
CM Western diversion (mine drainage feature)	Low	No interaction with Gowrie Creek or Wolfang Creek flooding. Limit of function set to draining western portion of the CM site. Diversion designed for 0.1% AEP flood event.

5. Climate Change Assessment

5.1 Climate Change Scenarios

Short duration (daily and sub-daily) rainfall in Australia has experienced a statistically significant increase in intensity across Australia. These are likely to become more evident towards the end of the 21st century (ARR, 2019). Changes in long duration events are expected to be smaller and more difficult to detect but projections indicate that an increase in daily rainfall is likely under climate change (ARR, 2019).

The impact of climate change on storm frequency, mechanisms, spatial and temporal behaviour is less understood. Area with strong orographic enhancement are more likely to see increases in rainfall (ARR, 2019). However, regardless of climate region or season, work done by Wasco and Sharma (2015) indicates that temperature increases are associated with patterns becoming less uniform.

Northern and central Australia, areas associated with summer rainfall, has seen an increase, most apparent from the early 1970's, large enough to increase total Australian rainfall (over the entire continent) by about 50 mm when comparing the 1900 – 1960 period to 1970 – 2013 (CSIRO and Bureau of Meteorology, 2015). Recent evidence indicates that extremes of intense precipitation, over various time intervals are increasing. The fraction of Australia receiving a high proportion (greater than the 90th percentile) of annual rainfall from extreme rain days (greater than the 90th percentile for 24 hour rainfall) has been increasing since the 1970s (CSIRO and Bureau of Meteorology, 2015).

Rainfall strongly influences runoff across Australia with the percentage change in annual rainfall generally amplified 2 – 3 times in percentage change in annual runoff (CSIRO and Bureau of Meteorology, 2015). Changes in temperature are also shown in impact runoff with a 1 °C increase in temperature will reduce annual runoff by 2 – 5 % (CSIRO and Bureau of Meteorology, 2015). An increase in higher/extreme intense rainfall has the ability to result in greater surface runoff due to the potential infiltration of the soil being exceeded by the rainfall intensity/rate. This is further impacted by antecedent soil conditions resulting from historical rainfall. Should the extreme rainfall occur following spells of longer duration rainfall (filling the soil profile with water) surface runoff might increase as soil infiltration rate and soil storage are exceeded.

A six-step process is used to incorporate climate change risks into decisions involving the estimation of design flood characteristics. The process uses a decision tree approach that enables the practitioner to define the nature of the information needed for a particular problem and to reach an appropriate course of action. The decision process is shown in ***Figure 5-1***.

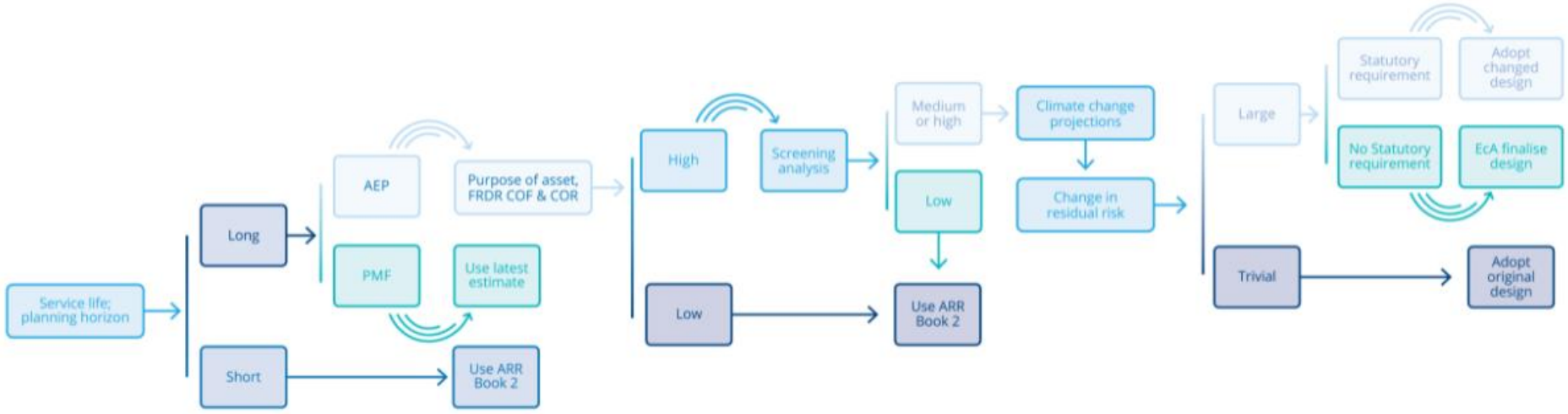

Figure 5-1 - AR&R 2019 climate change incorporation decision tree

The service life, planning horizon, screening and scaling process was undertaken for CCO to test the sensitivity of the design against possible climate change impacts. Rather than conducting an extensive exercise of assessing these impacts in every waterway within the mining leases, a detailed analysis was conducted for one location and then those outcomes used to infer potential impacts in other areas of the footprint. The detailed analysis was conducted for Cement Hill, given this has a higher flood risk profile than other areas.
The service life was considered 'long' as per the decision trees detailed in ARR. The requirement to consider a range of design events necessitated the use of both the PMF and AEP decision tree pathways.

The AEP pathway requires an understanding and an assessment of the purpose of the asset; flood-related design requirements, consequence of failure, cost of retrofitting if IFD change with time. The assessment should provide a better understanding of the consequences of failure of the structure. The CH site was judged to fall under a medium consequence rating. A screening analysis was required based on the potential impacts.

The screening analysis provides the question of the significance of climate change for the facility of interest. Should the opinion be that climate change poses a risk to the functioning of the facility, steps may be taken to consider a rarer design event and the potential impacts to the facility. If the design AEP corresponds to the ith row in ***Table 5-1***, consider the impact of the AEP events corresponding to the $(i+1)^{th}$ and $(i+2)^{th}$ rows on the facility of interest and the associated consequences. For example, for the 1% AEP the practitioner could consider the impact of the 0.5% and 0.2% AEP events.

Table 5-1 - Design flood annual exceedance probabilities

AEP (%)	AEP (1 in *x*)
5	20
2	50
1	100
0.5	200
0.2	500

The impact to rainfall intensity may be determined using the Climate Change in Australia, Climate Futures Tool (Bates, 2015). Using the East Coast climate futures data (CSIRO, 2015) obtained for the three areas for the project, the following potential to rainfall at Clermont was identified (***Table 5-2***).

Table 5-2 - Range of predictions on future climate associated with RCP4.5 scenario

		Annual Mean Surface Temperature (C)			
		Slightly Warmer < 0.50	**Warmer 0.50 to 1.50**	**Hotter 1.50 to 3.00**	**Much Hotter > 3.00**
Annual Rainfall (%)	Much Wetter > 15.00	0%	0%	0%	0%
	Wetter 5.00 to 15.00	0%	*7%*	*13%*	0%
	Little Change -5.00 to 5.00	0%	*9%*	*22%*	0%
	Drier -15.00 to -5.00	0%	*13%*	*20%*	0%
	Much Drier < -15.00	0%	0%	*17%*	0%

The RCP 4.5 scenario is most heavily represented by the "hotter" class interval. This is indicated by the percent of models, out of the total of 46, indicating the potential change regarding temperature and rainfall. The highest consensus on a single outcome is for a 'hotter' and 'little change' scenario (10/46 (22%). The model potential climate outcomes are confined to a narrow range of warmer to hotter and wetter to drier. The impact of the RCP 4.5 scenario on rainfall intensity is presented in ***Table 5 3*** below. The resulting rainfall scaling factor is applied to the design rainfall intensity obtained from BOM.

Table 5-3 - RCP 4.5 impact to rainfall intensity

Variable	Value
Temperature/humidity scaling factor	1.05
Surface temperature midpoint	(1.5 + 3.0)/2 = 2.25
Rainfall scaling factor	RCP 4.5: $1.05^{2.25} = 1.12$

After applying the scaling factors calculated in ***Table 5-3*** and confirmed using AR&R data hub, the design flow at CH was determined. The results are shown in ***Table 5-4***.

Table 5-4 - CH current and scaled design flows

AEP (%)	Current (m^3/s)	Scaled (m^3/s)
50	8	10
20	15	18
10	21	25
5	27	32
2	34	41
1	41	50
0.5	59	57
0.2	68	70
0.1	78	81

5.2 Impact Assessment

The climate change impact assessment was conducted for the Cement Hill mining lease, being the area with the highest flood risk profiles identified in Section 5.3. The findings and implications of the impact assessment were extrapolated to the nearby CM and TLO areas. The final landform design was assessed featuring the removal of the satellite WRD. The 1% AEP design flood event was considered, being a major flood event that has the potential to result in high velocities leading to scour.

The approach of considering the design AEP $(i)^{th}$ AEP and then applying the AEP event corresponding to the $(i + 2)^{th}$ was applied. This resulted in the comparison of the 1% and the 0.2% AEP for the potential change in flood characteristics for the CH site. The corresponding design flows were 41 m^3/s and 68 m^3/s. This approach results in a peak flow considerably greater than the alternative scaled analysis and is therefore a conservative approach to assessing climate change impacts.

The change in the inundation boundary and velocity from the 1% to climate change screening scenario (0.2% AEP) is shown in ***Figure 5-2***. The flood plain upstream from the void shows little change other than an area of surface flow developing in the upper portion. The section downstream of the remaining WRD on the perimeter of the void shows an increase in the breadth of flow in the flatter portions. The additional area inundated under the climate change scenario is small; vertical height increase of approximately 15 cm taken on a cross section through the area where the southern WRD had been.

The velocity through the same cross section was reviewed and the results tabulated in ***Table 5-5***. The increase in the peak flow from 41 m^3/s to 68 m^3/s (***Table 5-5***) results in an increase in average flow velocity of approximately 0.2 m/s and the maximum velocity increasing by approximately 0.3 m/s. The increase is not expected to be a significant departure from the current flow conditions for the 1% AEP.

Table 5-5 - Climate change screening - velocity

Parameter	1% AEP	1% AEP climate change screening (0.2% AEP)
Average velocity (m/s)	0.87	1.16
Maximum velocity (m/s)	1.2	1.48

Based on this analysis the effect of climate change on the CH closure design from a flooding perspective is considered negligible. Similar results are expected for other areas of the mining operation. The Northern Boundary diversion at TLO is considerably incised into the landscape and therefore has the ability to contain an increased peak flow. West Dam will continue to be present and provide a flood detention function. The dryer climate is also likely to result in a reduction in the average water level in the dam, improving the attenuation affects of the dam.

The Gowrie Creek and Wolfang Creek floodplains are isolated from the Clermont void by a landform. The landform provides 0.1 AEP flood immunity and includes a considerable freeboard at least 500mm.

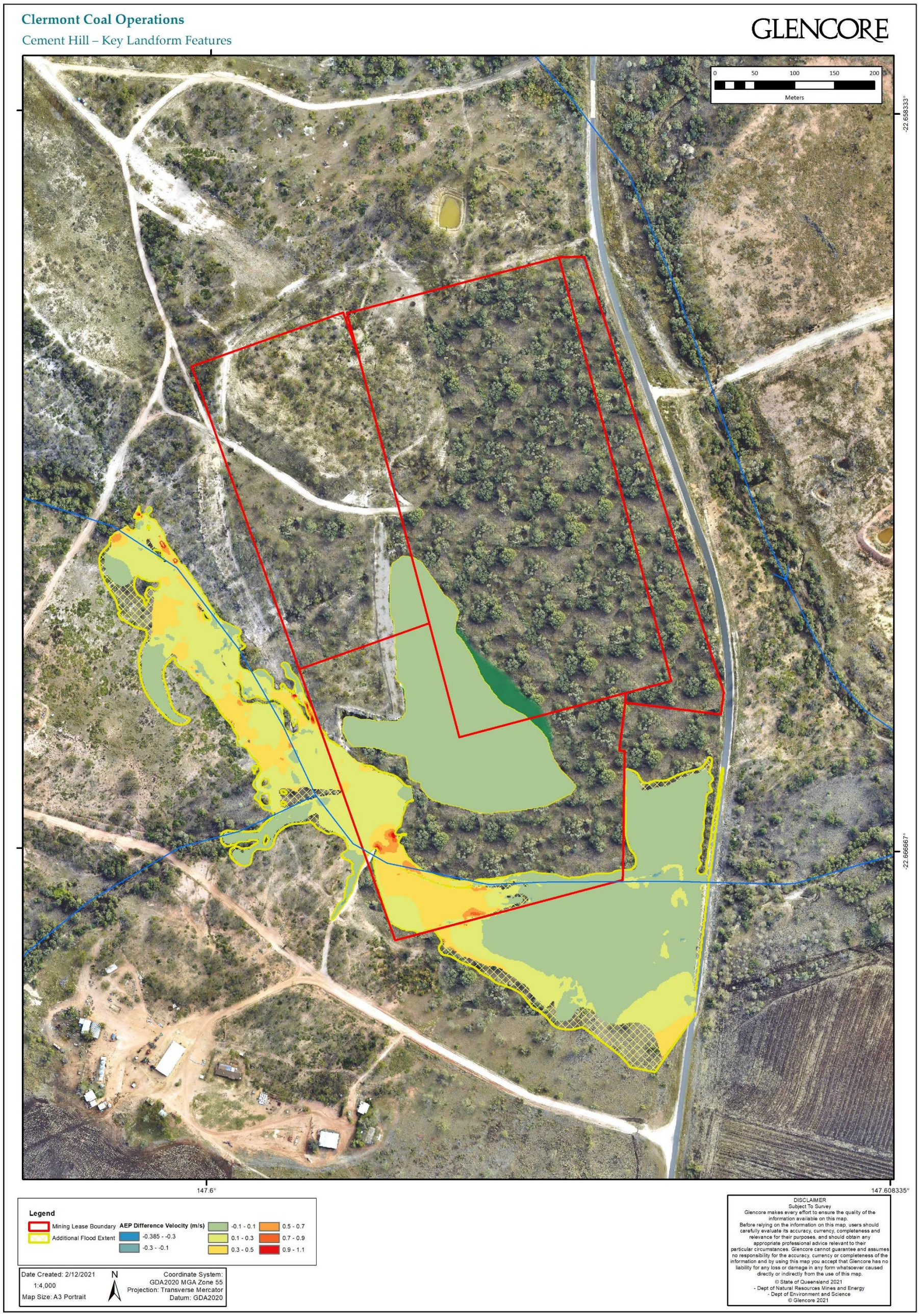

Figure 5-2 - 1% AEP climate change screening – velocity change

6. Surface Water Quality

Surface water monitoring has been undertaken at CCO since 2010, as part of the Receiving Environment Monitoring Program (REMP) to identify and describe any adverse impacts to surface water environmental values, quality, and flows from mining activities. The outcomes of this program are described in this section.

Whilst no specific surface water monitoring under the REMP has been completed at CH, the long-term CH void water quality data indicates a slightly alkaline pH ranging 8-9, low electrical conductivity (EC) indicating fresh water and low turbidity, with periodic connection to the external drainage feature (a weir) preventing any long-term concentrating processes. The waterbody appears to function as any natural water storage would. The long-term sampling also demonstrates that the void water has low metals concentrations, consistently below the ANZGV aquatic ecosystems trigger values. This information is provided in Appendix 4.7.

6.1 Environmental Values

Water can be released from CCO to surrounding waterways (the receiving environment) in accordance with the conditions in Environmental Authority EPML006341131 (the EA), and from two authorised release points (RP1 and RP2, refer to ***Figure 6-1***). The receiving environment for the purposes of the environmental values (EVs) and water quality objectives (WQOs) is the water of the Wolfang Creek, Bath Creek and connected waterways within 15 km downstream of the release points (FRC, 2020).

The release of mine affected water may:

- Directly influence some water quality parameters within the receiving environment:
  - High risk water quality parameters are electrical conductivity, sulphate, arsenic, copper, nickel, zinc, molybdenum, selenium, uranium, boron and nitrate;
  - Moderate risk water quality parameters are aluminium, chromium, iron and vanadium;
- Directly influence some sediment quality parameters within the receiving environment;
- Directly influence flow within the receiving environment;
- Directly influence aquatic habitat, including bank stability, presence of benthic or filamentous algae, and suitability of habitat for aquatic fauna, and
- Indirectly influence biological communities within the receiving environment (FRC, 2020).

The primary contaminants of concern identified at the completion of closure and rehabilitation are linked to sedimentation and salinity. Transport of sediment identifies active erosion processes taking place over the rehabilitated surface. Loss of sediment identifies the removal of topsoil, which contains the majority of macro- and micronutrients needed for revegetation. Further, sediment is deposited in low energy environments and may alter the functioning of landform closure design intentions. Salinity represents a contaminant of concern due to potential impacts to water and land receptors. Excessive leaching of salinity from the rehabilitated landform identifies as an impact to local watercourses and drainage lines as well as land receptors of the high salinity water.

EVs of waterways are protected under the Environmental Protection (Water) Policy 2009 (EPP Water). They describe the specific values of each waterway as determined by physical, biological, social, economic and historical features of the waterway. EVs applicable to waterways within the CCO and receiving environment are scheduled in the Environmental Protection (Water and Wetland Biodiversity) Policy 2019 Nogoa River Sub-basin Environmental Values and Water Quality Objectives

Basin No. 130 (part), including all waters of the Nogoa River Sub-basin September 2011 (DES 2013). The relevant water type for the CCO is 'Lower Nogoa / Theresa Creek tributaries – developed areas', with the identified EVs being:

- Aquatic ecosystem protection – slightly to moderately disturbed;
- Primary industries – the suitability of the water for:
  - Stock watering – use of water for drinking by livestock;
  - Irrigation – of crops such as sugar cane, lucerne etc.;
  - Farm water supply – uses other than drinking water;
- Industrial use of water; and
- Cultural and spiritual values – indigenous and non-indigenous cultural values.

While surrounding land-uses have impacted the waterways of the receiving environment they are not considered to be of lower ecological value than similar streams in the region. Therefore, the aquatic ecosystem environmental values are considered slightly to moderately disturbed, based on the classifications presented in the EPP Water and QWQG (DES 2013).

Gowrie, Wolfang and Bath Creeks are considered to have very limited recreational values as they do not have any permanent water holes (RTCA 2004). Consequently, human consumers, and primary, secondary and visual recreation have not been included as EVs for the receiving waters. The suitability of water for industrial use has also not been considered for the receiving environment.

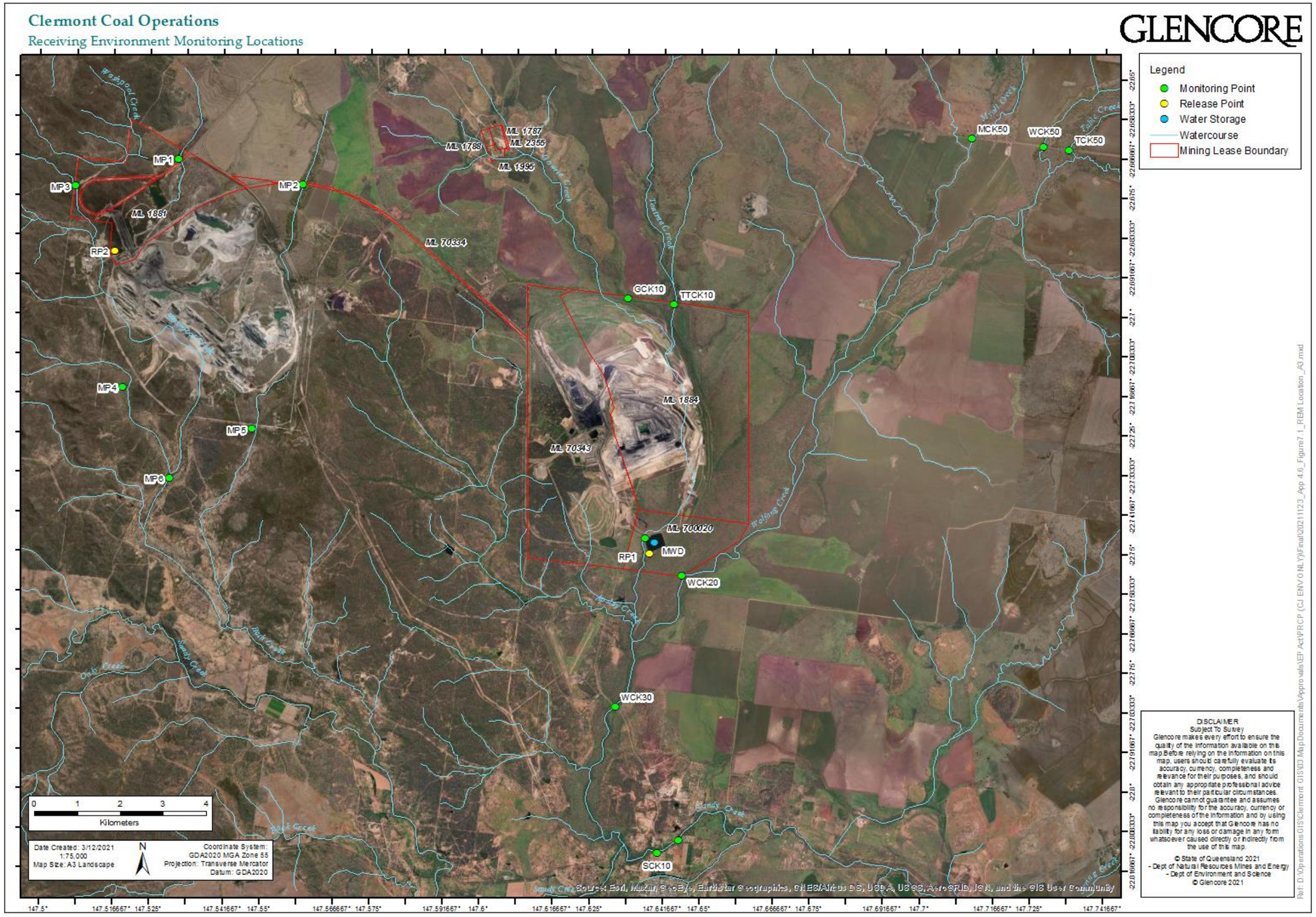

Figure 6-1 - Receiving environment monitoring locations

6.2 Water Quality Objectives

WQOs are pre-defined levels for water quality indicators (including physical-chemical water quality, nutrient concentrations, contaminant concentrations in water and sediment, and biological indicators) that protect a stated EV. Published WQOs for waters applicable to the CCO and receiving environment are presented in Environmental Protection (Water and Wetland Biodiversity) Policy 2019 Nogoa River Sub-basin Environmental Values and Water Quality Objectives Basin No. 130 (part), including all waters of the Nogoa River Sub-basin (DES 2013).

Local water quality guidelines (WQGs) can be developed using water quality data from unimpacted reference sites (the 'acceptable departure from reference condition' approach), or from background conditions at background sites, that may be impacted by other activities (the 'no change from existing condition' approach; DES 2009). As there are few suitable un-impacted reference sites, the 'no change from existing condition' approach is most appropriate for the development of local WQGs, with sites upstream of the release locations considered representative of 'existing condition'.

Interim water quality guidelines (WQGs) have been adopted based on the default WQGs of the EA. These are presented in ***Table 6-1*** (FRC, 2020).

Table 6-1 - Interim water quality guidelines for CCO receiving environment

Parameter	Units	RP1 WQG	RP2 WQG	Source
Physico-chemical				
pH	-	6.5 – 8.0	6.5 – 8.0	EA Table F5
Turbidity	NTU	315	315	EA Table F2
Total suspended solids (TSS)	mg/L	700	1000	EA Table F5
Conductivity		1000	1000	EA Table F5
Dissolved oxygen		85 – 110	85 – 110	EHP 2013
Nutrients				
Ammonia	mg/L	0.9	0.9	EA Table F3
Nitrate	mg/L	1.1	1.1	EA Table F3
Major ions				
Fluoride	mg/L	2	2	EA Table F3
Sulphate	mg/L	1000	1000	EA Table F5
Metals and metalloids				
Aluminium	mg/L	0.100	0.100	EA Table F3
Arsenic	mg/L	0.013	0.013	EA Table F3
Boron	mg/L	0.370	0.370	EA Table F3
Cadmium	mg/L	0.0002	0.0002	EA Table F3

Parameter	Units	RP1 WQG	RP2 WQG	Source
Chromium	mg/L	0.001	0.001	EA Table F3
Cobalt	mg/L	0.090	0.090	EA Table F3
Copper	mg/L	0.002	0.002	EA Table F3
Iron	mg/L	0.300	0.300	EA Table F3
Lead	mg/L	0.01	0.01	EA Table F3
Manganese	mg/L	1.9	1.9	EA Table F3
Mercury (inorganic)	mg/L	0.0002	0.0002	EA Table F3
Molybdenum	mg/L	0.034	0.034	EA Table F3
Nickel	mg/L	0.011	0.011	EA Table F3
Selenium	mg/L	0.010	0.010	EA Table F3
Silver	mg/L	0.001	0.001	EA Table F3
Zinc	mg/L	0.008	0.008	EA Table F3
Uranium	mg/L	0.001	0.001	EA Table F3
Vanadium	mg/L	0.010	0.010	EA Table F3
Total petroleum hydrocarbons (TPH)				
C6 – C9 fraction		20	20	EA Table F3
C10 – C36 fraction		100	100	EA Table F3

6.3 Water Quality Results

Water quality data available in CCO's Environmental Monitoring Database (EMD) was compiled for key locations upstream and downstream of the mine (***Table 6-2***). In general, the surface water systems around CCO meet the WQOs, with the notable exception of pH. The pH results are slightly alkaline both upstream and downstream of the MLs, suggesting the WQO is not aligned to local conditions rather than any anthropogenic influences. It is noted that the groundwater in the region is alkaline, so the geological setting is likely contributing to the pH conditions in the region.

Table 6-2 – Water quality records 2014-2021 (median)

Analyte	Unit	WQO	Gowrie Upstream (GCK10)	Gowrie Downstream (GCK20)	Wolfang Upstream (WCK20)	Wolfang Downstream (WCK30)	Sandy Creek Downstream (SCK10)	Sandy Creek Downstream (SCK20)
Electrical Conductivity	µS/cm	1,000	760	**1,010**	440	748.5	766	328
pH		6.5-8	**8.5**	**8.04**	**8.42**	**8.015**	**8.32**	7.79
Suspended Solids	mg/L	1,000	17.5	22	25	965	361.5	19
TDS	mg/L		-	703	234	440	243	184
Turbidity	NTU	315	30	22	37.6	**1,605**	917	19
Ammonia	mg/L	0.9	0.08	0.17	0.04	<LOR	<LOR	0.05
Nitrate as N	mg/L	1.1	0.05	<LOR	<LOR	0.15	<LOR	<LOR
Nitrite as N	mg/L		<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
TN as N	mg/L		-	-	-	-	-	-
TP as P	mg/L		0.03	0.07	0.04	0.02	0.04	0.05
Reactive P	mg/L		-	-	-	-	-	-
Calcium	mg/L		32.5	82	27	55	30	21
Chloride	mg/L		171	-	-	-	-	-
Magnesium^	mg/L		41.5	45	16	30	16	12
Potassium	mg/L			5	3	4	4	4
Sodium	mg/L		75	76	48	58	38	28
Sulphate	mg/L	1000	12	187	5	20	18	13
Total Alkalinity	mg/L		279	243	190	172	156	120
Aluminium^	mg/L	0.1	<LOR	<0.01	0.005	<LOR	<LOR	0.005

Analyte	Unit	WQO	Gowrie Upstream (GCK10)	Gowrie Downstream (GCK20)	Wolfang Upstream (WCK20)	Wolfang Downstream (WCK30)	Sandy Creek Downstream (SCK10)	Sandy Creek Downstream (SCK20)
Arsenic^	mg/L	0.013	0.001	0.002	0.0005	<LOR	0.001	**0.5**
Boron^	mg/L	0.37	0.08	0.06	0.05	0.0001	0.0001	0.03
Cadmium^	mg/L	0.0002	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Chromium^	mg/L	0.001	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Cobalt^	mg/L	0.09	0.001	0.002	0.0005	<LOR	<LOR	0.0005
Copper^	mg/L	0.002	0.002	0.002	0.0015	0.0015	0.001	0.001
Iron^	mg/L	0.3	<LOR	<LOR	0.025	<LOR	<LOR	0.25
Lead^	mg/L	0.01	<LOR	<LOR	0.0005	<LOR	<LOR	0.0005
Manganese^	mg/L	1.9	0.002	0.249	0.001	<LOR	<LOR	<LOR
Mercury^	mg/L	0.0002	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Molybdenum^	mg/L	0.034	0.001	0.003	0.0005	<LOR	0.001	0.0005
Nickel^	mg/L	0.011	0.004	0.007	0.0015	0.0025	0.002	0.0015
Selenium^	mg/L	0.01	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Zinc^	mg/L	0.008	0.006	**0.015**	0.0025	<LOR	<LOR	0.0025

^ filtered

6.4 Contaminants of Potential Concern

The primary contaminants of concern relevant to the completion of rehabilitation and closure are expected to be related to sedimentation and salinity, although it is noted that there are other contaminants of concern. Transport of sediment identifies active erosion processes taking place on the rehabilitated surface. Loss of sediment identifies the removal of topsoil, which contains the majority of macro and micro-nutrients needed for revegetation. Further, sediment is deposited in low energy environments and may alter the functioning of landform design intention.

Salinity also represents a contaminant of concern due to potential impacts to water and land receptors. Excessive leaching of salinity from the rehabilitated landform identifies as an impact to local watercourses and drainage lines as well as land receptors of the high salinity water. A summary of the key risks from a surface water perspective is summarised in ***Table 6-3***.

Table 6-3 – Contaminants of Concern

Area	Sediment	Salinity	Sediment and salinity	Other
Infrastructure – Natural Surface	✓			✓
Infrastructure – Decommission	✓			✓
Active Mining Area – Batter Slopes	✓			
Cement Hill Void – Batter Slopes			✓	
Active Mining Area – Mega Cell			✓	✓
Active Mining Area – Dump Tops			✓	✓
Cement Hill Void – Dump Tops			✓	
Active Mining Area – Residual Void	✓			
Cement Hill Void – Residual Void	✓			
Active Mining Area – Natural Surface	✓			
Water Management – Decommission		✓		
Water Management – Riparian			✓	
Overland Conveyor (OLC)			✓	
Train Load-out Facility – Infrastructure			✓	✓

7. Long-term Water Management Requirements

7.1 Diversions

The two licensed diversions Gowrie Creek and Northern Boundary diversion will remain after closure and rehabilitation of the mine. Geotechnical results indicate that the Northern Boundary diversion at the TLO into and from West Dam is geotechnically stable having been created in basalts. No additional layback of the batters is required. The diversion has shown sufficiency in conveying the 0.1% AEP design event after proposed works to lower the bywash and remove the culverts at the southern extent of the mining lease.

The Gowrie Creek diversion on the western edge of the CM will remain as the flow path for Gowrie Creek into perpetuity. The levee will be incorporated into the final landform around the full extent exposed to flood flow. The eastern diversion drain that currently exists between the levee and the northern and eastern WRDs will be in-filled with material during final landform bulk push operations.

The water licences for the diversions contain conditions that must be satisfied prior to relinquishment. These conditions have been reviewed and incorporated into the PRCP milestones where relevant.

7.2 Dewatering

All sediment dams and water dams will be removed prior to lease relinquishment. Dewatering activities will be required at the various sediment dams and the mine water dam prior to decommissioning and mine rehabilitation landform processes. Contributing catchment areas will decrease through successive and successful rehabilitation upstream of the various ponds and dams. Reduced water inflow may assist in the dewatering taking place through evaporation. Ponds and dams which have received water deemed to have been contact or mine affected water will require further and specific rehabilitation prior to final landform operations.

7.3 On-going Water Management

On-going water management will focus on the in-landform drainage features employed during the final landform design process. Currently envisaged features include chutes on the NWRD, Gowrie Creek and Northern Boundary diversion and the CH void natural weir feature.

The majority of the chutes have been designed in a way that minimises the need for engineered structures. Rock armouring was preferred at locations of higher velocity and energy.

Gowrie Creek and Northern Boundary diversion structures will remain as watercourses bypassing the rehabilitated areas of CM and TLO respectively.

The natural weir feature at CH features a protrusion of conglomerate surrounded by geotechnically stable material. The addition or inclusion of an engineered structure is not required as history indicates the stability of the current feature.

8. Summary

A wide range of hydrology and hydraulic data and information has been analysed, prepared and updated over the current life of the mine. These parameters include rainfall with the establishment of on-site weather monitoring, hydrologic flows for a mix of design events, hydraulic responses to creek diversions and for risk reduction for mining activities. The three sites of CM, TLO and CH have had considerable flooding assessment performed and the overall knowledge base with respect to surface water is well understood.

The main surface water consideration at CM is the Gowrie Creek diversion. The Gowrie Creek was diverted in order for the development of the open pit and mining activities to be conducted. Subsequently on closure, the void will remain necessitating the continued permanent diversion of Gowrie Creek. The diversion levee was upgraded in 2018 to provide 0.1% AEP + 500 mm freeboard from inundating the pit from the eastern, southern and western aspects. The major factor in the flood depth surrounding CM is the degree of backwater created by the confluence of Wolfang Creek and Gowrie Creek; Gowrie Creek flooding is downstream controlled. The subsequent final landform design incorporates the levee into the final landform, and retains at least 0.1% AEP + 500 mm freeboard flood immunity.

The surface water feature in the TLO area is West Dam and the downstream Northern Boundary diversion. After proposed rehabilitation activities are complete, hydraulic modelling indicates the diversion has sufficient capacity to contain and route the 0.1% AEP design event following attenuation of the peak in West Dam. The Rail Loop diversion will be removed and the original flow path reinstated, decreasing the area contributing to the generation of the peak design event entering West Dam.

The interaction between the CH void and external drainage feature has been assessed in detail. Dependent on the design event, the flow is either one-way (filling) or two-way (temporary storage and release). The storage of water and the attenuation of larger design event flows provide a positive impact on the immediate surrounding area, either through reduction in flood depth due to the partial rerouting of flow to the void and water storage.

Aspects of climate change were reviewed and considered in the determination of applicable design flood events. These included the more conservative RCP8.5 emissions pathway. A screening and scaling exercise was performed including a sensitivity analysis were performed for the RCP8.5 pathway. It has been determined that the surface water systems will continue to perform as intended.

9. Document Information

Reference	Title
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Department of Environment and Science (DES) (2021)	Queensland Government. 2021. Website: https://www.longpaddock.qld.gov.au/silo/about/. Accessed: 16/02/2021
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KBR (2020)	Southern Flood Levee, Sediment Dam and Pivot Point Realignment Extensions – Detailed Design Report

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Appendix 4.7 - Void Closure Methodology

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1. Introduction

1.1 Purpose

The purpose of this void closure methodology (or Void Closure Plan as required by the PRCP statutory guideline) is to detail how the final voids that will remain at the completion of mining operations will be designed in such a way as to realise value and minimise environmental risk. Two final voids are proposed as part of CCO, namely:

- Cement Hill void (PMLU - Water Management Area); and
- Clermont void (PMLU – No Use (NUMA)).

Final void assessments are a key component of the rehabilitation planning process. This assessment is intended to:

- Provide strategic direction to the life of mine (LOM) plan;
- Align rehabilitation objectives;
- Predict final void behaviour; and
- Meet requirements to have investigated final void options and environmental risks.

1.2 Scope

Appendix 4.7 – Void Closure Methodology summarises rehabilitation and closure regulatory requirements around final voids, discusses final void design as well as its hydrology, and the rehabilitation and management strategies in place for the final void.

This appendix provides cross references to the following related technical studies included in the PRCP:

- Appendix 4.4 – Geotechnical Assessment;
- Appendix 4.5 – Groundwater Assessment; and
- Appendix 4.6 – Surface Water Assessment.

1.3 Regulatory Context

The Void Closure Methodology has been developed in accordance with the Department of Environment and Science (DES) *2019 Guideline for Progressive Rehabilitation and Closure Plans (PRC plans)*. The scope of the assessments that feed into the Void Closure Methodology is dependent on the transitionary provisions applicable to the site. The Rehabilitation Management Plan (GCAA, 2020) is a Land Outcome Document (LOD) and states:

- The Clermont final void does not have a use (i.e. is a NUMA);
- Identifies the location of the Clermont final void in relation to the Gowrie Creek/Wolfang Creek floodplain; and
- The post mining land use for the Cement Hill void is for water management.

The location of the Cement Hill void is not detailed in a LOD and is therefore subject to additional requirements for Final Voids in Floodplains, in Section 3.4 of the PRCP Guidelines and further detailed in Voids in Flood Plans information sheet ESR/2019/4966 (DES, 2020).

2. Design Development

2.1 Clermont Void

The Clermont final void design has been evolving since the Environmental Impact Statement (EIS) conceptual designs were produced in 2004. Given the localised basin within which the coal has formed, the location and extent of the final void has remained largely unchanged from the early assessments, however the water balance, pit geometry and water quality predictions have evolved.

A major final void study was undertaken in 2014, subsequently updated in 2017 and then revised again as part of the PRCP to reflect the current pit design and rehabilitation plan.

A range of models have been developed as part of these final void studies to predict the pit lake formation, water balance and water quality evolution in the void. These include:

- Generation of long-term stochastic climate data;
- Generation of a long-term daily run-off model (AWBM);
- Water balance model (GOLDSIM);
- Geochemical model (PHREEQC); and
- Stratification model (DYRESM).

2.2 Cement Hill Void

The Cement Hill void has been in its current configuration since mining ceased in the area in the early 1990s. It has operated as an off-stream storage since that time, with water entering the void periodically during flood flow. In recent years, Glencore has permitted livestock grazing within the site and non-routine water take from the void by the local lease-holder.

Vegetation has established (primarily in the form of trees with limited groundcover vegetation observed) on the batters along the northern, eastern, and southern boundaries of the void however significant erosion features (rills) were observed. It is likely that these rills were formed in the years following closure of the mining operation at a time when these batters were bare and susceptible to erosive processes. It is estimated that the rate of erosion on these slopes has reduced commensurate with the establishment of vegetation over the approximately 25 years since operations ceased.

In terms of physical infrastructure, there is a partially submerged pump located in the south western portion of the void. This pump feeds an above ground pipeline which has been used on occasion by the lease holder.

It has always been envisaged that the void would remain post closure to provide a water supply for local users. The low point in the void that provides for a connection between the void and the floodplain was specifically excavated for that purpose at completion of mining.

Glencore have been monitoring water level and water quality in the void on a regular basis since 2014. The long-term observations and monitoring record provide a good understanding of how the void and floodplain interaction have performed over time.

3. Design Details

3.1 Clermont Void

3.1.1 Void Location, Extent and Area

The final void is located in the southern part of the mining lease and lies immediately west of the Gowrie Creek diversion. Gowrie Creek joins Wolfang Creek approximately 2 km downstream of the final void.

A final void will remain in the southern extent of the deposit, as it was originally depicted in the 2004 EIS and subsequent Plan of Operations throughout the mine life. The location of the proposed final void is shown in ***Figure 5-1***.

The extent of the Clermont final void for the purposes of this Void closure Methodology has been defined as the landform below the natural surface.

The ground surface elevation at the top of the high wall sits at around 260 mAHD and the base of the void will have an elevation of around 66 mAHD. The boundaries around the western, eastern and southern walls may contain buttresses and high wall batters slopes with gradients around 1V:2H. The total area of the void is 507.6 ha.

The extent of the void has been minimised to the maximum extent possible within the constraints of the mine plan. A key focus for the landform design was to maximise the usable area at natural surface, and this has resulted in a substantial shift of the northern extent of the void to the south.

The LODs identify that the void will have no use (NUMA), GCAA have committed to an extensive rehabilitation program within the void, which will aim to minimise the extent of the no use area (NUMA). This involves re-contouring, topsoiling and seeding the entire low wall down to the pit floor.

Figure 3-1 - Clermont void location and extent

3.1.2 Void Geometry and Storage Characteristics

The final void geometry determines the ponded surface area and volume of water at different water levels. The geometry affects evaporation, incident rainfall and surface water inflow and therefore the steady state water level that will eventually occur in the final void is determined predominately by the geometry.

The stage-storage curve (i.e. relationship between water level and volume and water level and surface area) of the rehabilitated void design is presented in ***Figure 3-2***.

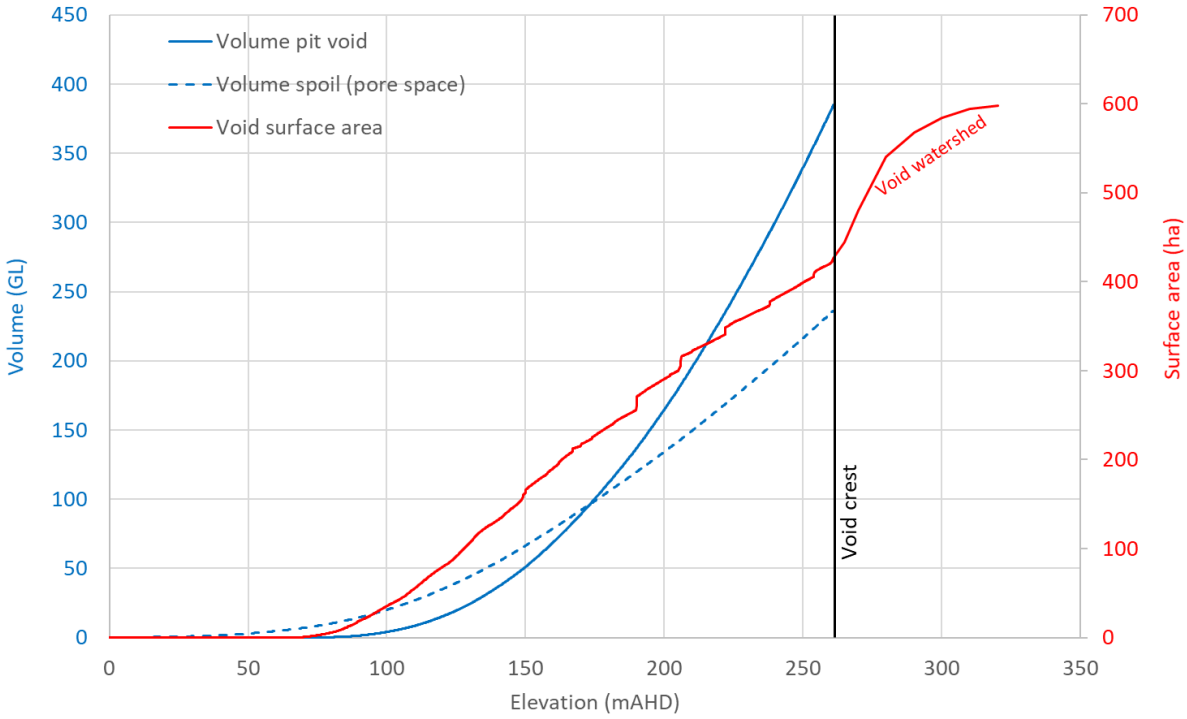


Figure 3-2 - Stage Storage relationship - Clermont void

Given that the coal deposit has a dipping floor, a considerable volume of backfill exists below the final pit floor. The pit floor (excluding spoil) is shown in ***Figure 3-3***. This will have an important influence on the water level recovery immediately following mining, as water will initially accumulate in the spoil rather than the final void. The spoil storage relationship has been estimated based on the pit shell (floor levels prior to backfill). The porosity was estimated using the site-derived swell factor of 16%, which is regularly tested and verified by site. The effective porosity at some other Glencore coal mines has been measured at less than 16%, as low as 6% at one site. In the event that the porosity is lower than expected at Clermont, this would increase the rate of water level rise in the final void, but would not alter the elevation of the predicted steady state water level.

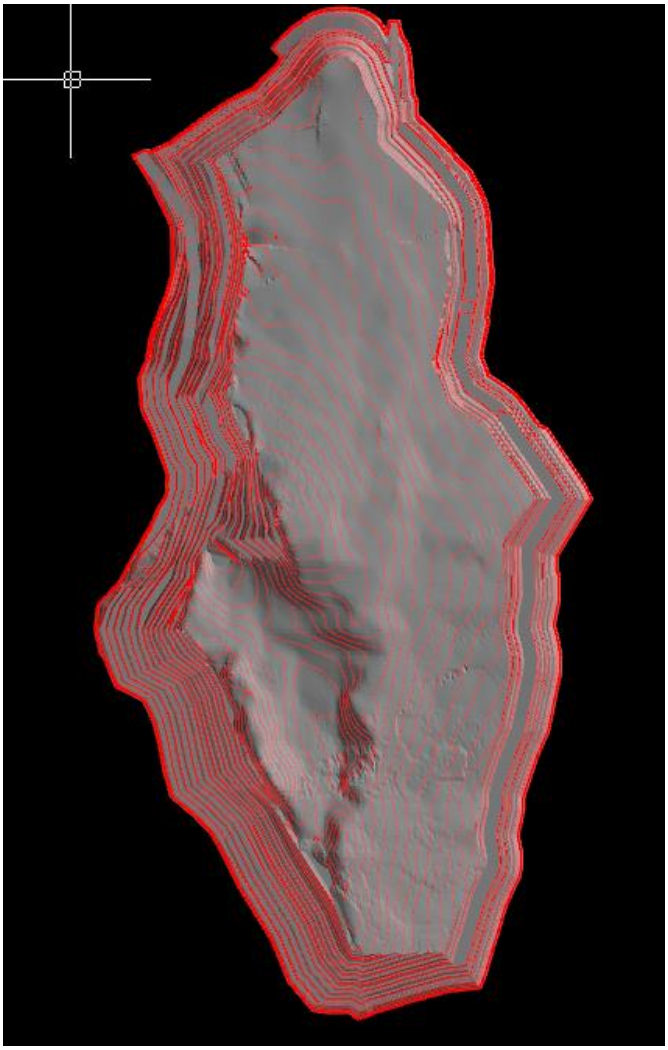


Figure 3-3 - Pit shell (i.e. mined extent excluding in pit spoil)

3.1.3 Assessment of Alternatives

Given the nature of the resource and the mining methodology, there is no alternative other than having a final void. A final void has been proposed at all stages of the mine planning and approval process and throughout the operational phase of the mine.

There has been considerable assessment of alternative final void configurations, especially with respect to water management. The contributing catchment to the void is a major variable and three options were explored as follows:

- Minimise local catchments by constructing a perimeter bund around the pit rim and excluding surface water;
- Maximise local catchments by directing run-off from the mine area into the final void; and
- Maximise local and regional catchments by directing run-off from the mine area and diverting a portion of Gowrie Creek into the final void.

Water harvesting and storage was explored however was discounted on the predicted effects on downstream users and ecosystems, and the licencing implications for harvesting surface water. Water quality was also predicted to deteriorate over time due to evapo-concentration effects. On this basis the preferred option, which has since been adopted, is to minimise the void catchment and void extent as much as practical within the constraints of the mining operation.

3.2 Cement Hill Void

3.2.1 Void Location, Extent and Area

The final void is located in the Cement Hill alluvial gold mining leases, north of the Clermont operational area. The gold resource has been exhausted and the void is in now its final configuration.

The extent of the Cement Hill final void for the purposes of this Void Closure Methodology been defined as the maximum water level that exists at full supply level, plus the western wall. The post mining land use of the void has been identified in the LOD as 'Water Management Area'. The external spoil mounds that drain towards the void have an alternative PMLU.

The void as shown in ***Figure 3-4*** covers an area of approximately 4.7 ha. The ground surface elevation at the top of the western wall sits at around 310 mAHD and the floor has an approximate elevation of around 291 mAHD. The northern, eastern and southern boundaries contain batter slopes with gradients ranging from around 35% in the north and south to around 50-55% along the eastern batter.

3.2.2 Storage Characteristics

The void currently acts as a water storage feature, receiving inflows from surface water and groundwater. Surface water inflows originate from immediate runoff from the spoil reporting to the void and from periodic inflows during flow events in the adjacent drainage feature. The water level within the void varies based on climatic sequence however typically contains water. The inlet in the south western corner of the void controls the void maximum water level which is around 300.5 mAHD. At maximum water level, surface water runoff collected in the tributary which drains towards the inlet bypasses the void via the drainage feature to the south of the void (located between the two out of pit dumps). The ponded area of the void at full supply level (at the elevation of 300.5 mAHD) is around 4.7 ha and occupies a volume of approximately 228 ML. The stage-storage relationship is shown in ***Figure 3-4***.

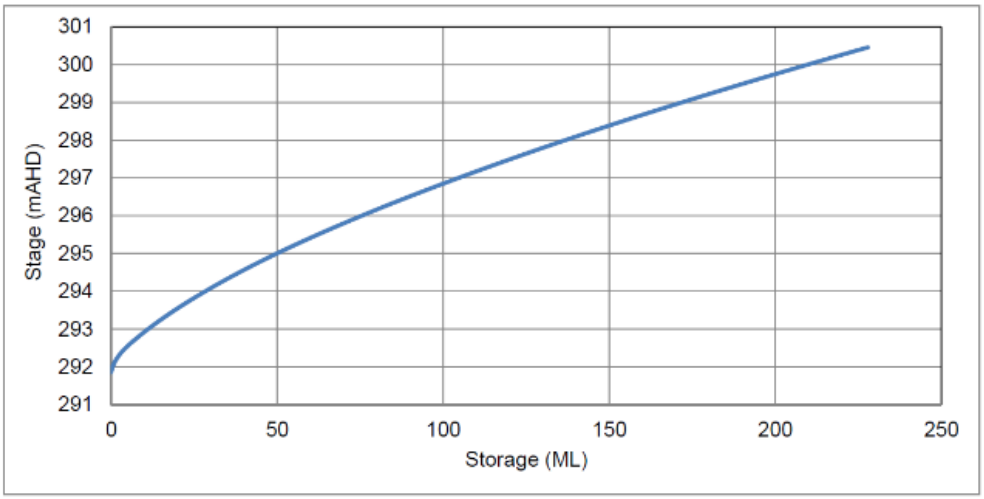


Figure 3-4 - Storage stage relationship – Cement Hill void

3.2.3 Assessment of Alternatives

The Cement Hill void in its current configuration provides a reliable water supply for use by surrounding landowners. It is proposed that the rehabilitation activities preserve the beneficial use.

Alternatives considered include:

- Battering back the western wall – not pursued on the basis that it reduces water storage volume, and increases susceptibility to erosion due to the longer exposure of the batter;
- Backfilling the void – not pursued on the basis that it completely removes the ability for water storage. Despite this option being lower cost that the proposed spoil reshaping works, Glencore chose not to pursue this option on the basis of community consultation and desire to leave a positive legacy; and
- Blocking the connection between the external drainage feature and the void – not pursued on the basis that the void would cease to function in its current (proven) configuration. Blocking the connection reduces water availability for future usage, creates uncertainty in the water balance and water quality.

4. Geotechnical stability

4.1 Clermont Void

Detailed geotechnical evaluation and modelling of the Clermont void is provided in Appendix 4.4 – Geotechnical Assessment.

The geotechnical investigation revised previous geotechnical assumptions that had been made with respect to closure. The outcomes of the assessment are:

- Buttressing may be required along the western, southern and eastern walls of the void; and
- The Anakie Metamorphics in the upper weathered zone of the western wall needs to be laid back to a batter of 1V:3H to provide geotechnical and erosional stability.

Post-mining landform stability will be certified based on assignment of an appropriate FOS acceptance criterion for each relevant slope situation. The adopted FOS acceptance criterion must be documented as part of the certification, together with a succinct summary of the justification for selection, and would normally be somewhat higher than for the operational condition of FOS ≥ 1.20.

The certification statement will also identify the distance behind proposed post-mining slope crest lines where FOS ≥ 1.50 would apply. This distance will be provided for guidance regarding any exclusion or notification measures to be applied to the post-mining landform crest line.

4.2 Cement Hill Void

Detailed geotechnical assessment of the Cement Hill void is provided in Appendix 4.4 – Geotechnical Assessment. The assessment concludes that the void is geotechnically stable in its current form. The excavated faces on the west and south margins of the void will continue to weather, but will not comprise its long term geotechnical integrity.

While layback of the wall was considered as an option to address erosion, this was not adopted on the basis that it would significantly reduce the ability to store water in the void, and it would increase the slope length vulnerable to erosion.

5. Erosional Stability

5.1 Clermont Void

Detailed geotechnical evaluation and modelling of the Clermont void is provided in Appendix 4.11 – Landform Design. The outcomes of the assessment are:

- The proposed low wall will be reshaped to incorporate trilinear slopes that have been proven to be erosionally stable;
- Drainage features in the void will be installed to safely convey surface runoff to the floor of the void; and
- The high wall layback will have a long slope length, and erosion will be controlled using vegetation in the upper segment and rock mulching in the lower segment.

Landform evolution modelling of the Clermont void demonstrates that the design is erosionally stable.

5.2 Cement Hill Void

Detailed geotechnical evaluation and modelling of the Clermont void is provided in Appendix 4.11 – Landform Design. The outcomes of the assessment are:

- Spoil batter slopes will be re-profiled to 15% batter angles; and
- The western wall will be retained in its current configuration, as this has been shown to be geotechnically stable and this approach will minimise the flow length.

Landform evolution modelling of the Cement Hill void demonstrates that the design is erosionally stable.

6. Water Balance and Floodplain Interaction

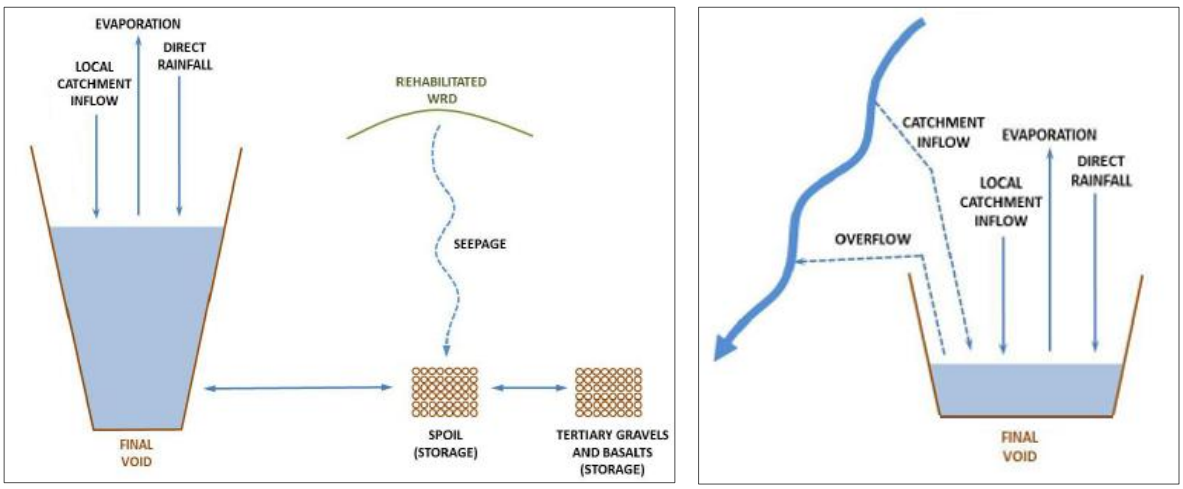
6.1 Approach

6.1.1 Conceptualisation

Water balance models were developed for Clermont void and Cement Hill void to predict the long-term water level recovery, and relationship to aquifers intersected by the voids. The models were developed in Goldsim, and included the key hydrological processes the affect the water balance including:

- Inflows:
  - Local surface water catchments (pit wall, rehabilitated spoil);
  - External catchment inputs (Cement Hill only);
  - Seepage through rehabilitated spoil;
  - Direct rainfall; and
  - Groundwater inflows;
- Storage:
  - Void storage; and
  - Spoil storage;
- Outflows:
  - Evaporation;
  - Groundwater outflows; and
  - Overflows to external catchments.

The conceptual model for both voids is shown in ***Figure 6-1***.



(a) Clermont void *(b) Cement Hill void*

Figure 6-1 - Hydrological Conceptual Model

6.1.2 Stochastic Climate Data

To model the voids long periods of climate data are required to enable the water in the voids to reach equilibrium. Five hundred years of stochastic climate data was generated using the Stochastic Climate Library (SCL). SCL generates synthetic, random data that is modified so that they have the same characteristics in terms of mean, variance, skew and long-term persistency as the historical input data. Stochastic pan evaporation and rainfall datasets were generated from the Datadrill record.

Figure 6-2 presents a comparison between the input historical data (Datadrill) and the output stochastic data from SCL. The results show a good comparison, with the resulting monthly averages of the datasets mostly within 0.1 mm of each other.

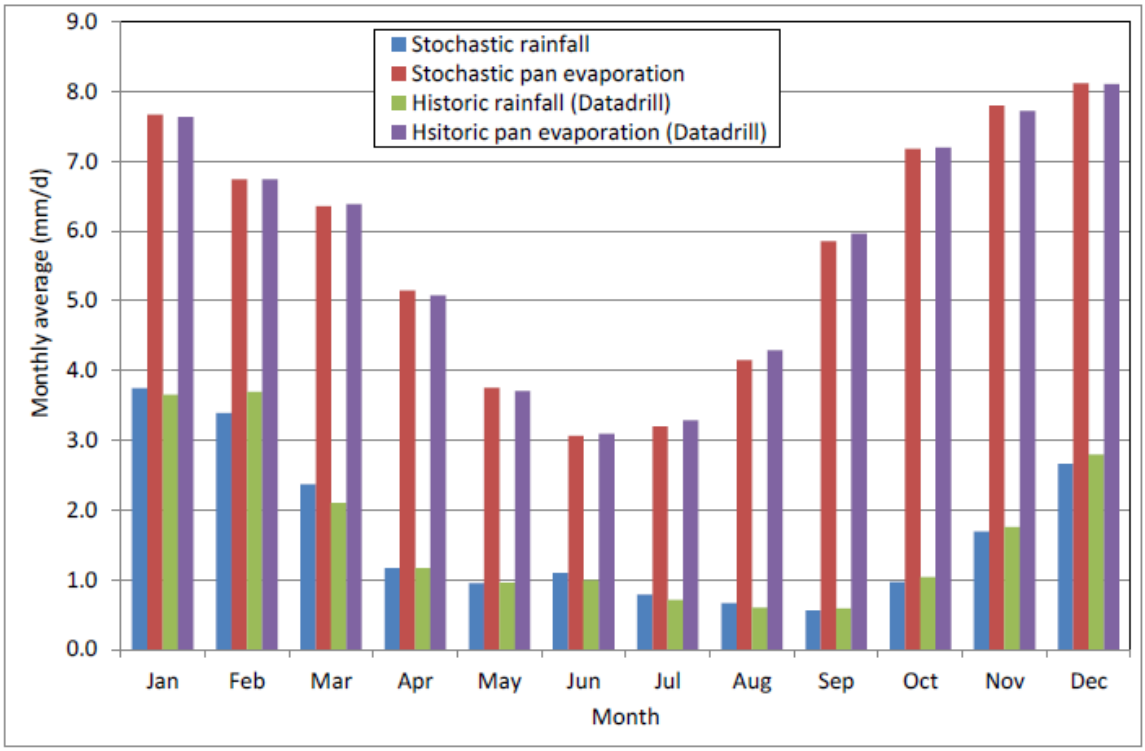


Figure 6-2 - Stochastic and Historic Data Comparison

6.1.3 Surface Run-off

Surface run-off is required to estimate volumes of water entering the void from a range of different catchment types. Surface run-off was estimated using a catchment hydrology model that uses the stochastic climate data as input. The resulting surface run-off time series therefore is continuous (no missing data) and matches the climate data in length and timing.

Catchment hydrology was modelled using the Australian Water Balance Model (AWBM) (Boughton, 1993). AWBM is a partial area saturation overland flow model. The partial area method separates the catchments into regions that produce run-off (contributing areas) during a rainfall-runoff event and those that do not. These contributing areas can be modelled to vary within a catchment according to predefined catchment conditions, allowing for the spatial variability of surface storage in a catchment. The use of partial area saturation overland flow approach is simple and provides a good representation of the physical processes occurring in most Australian catchments (Boughton, 1993).

AWBM parameters for natural undisturbed areas were obtained from the operational water balance model that has been developed for the site and calibrated over a period of more than a decade.

6.1.4 Groundwater Interaction

Appendix 4.5 – Groundwater Assessment provides details of the hydrogeological setting, and a summary is provided below with specific emphasis on the relationship to the Cement Hill void and Clermont void.

6.1.4.1 Clermont Void

The hydrostratigraphy in the vicinity of the Clermont void, and an interpretation of how the final void would interact with aquifers present is provided in ***Table 6-1***. The stratigraphy is described from top to bottom.

Table 6-1 - Clermont hydrostratigraphy

Unit	Implication for void hydrology
Quaternary alluvial deposits	In the vicinity of the final void the alluvial deposits are clay rich and do not yield significant quantities of water. Quaternary alluvial deposits within the Mining Leases do not constitute an aquifer (Rio Tinto, 2004). Even if the void filled to overflow point, loss via the alluvium will be minor. However, the modelled pit lake water level will never reach the quaternary alluvial deposits, with the surface pit water level stabilized some 150m below the void rim, well below these deposits.
Tertiary basalt aquifer (unconfined aquifer)	The tertiary basalt is an unconfined system that is fractured and discontinuous. Water within the basalt aquifer occurs preferentially within fractures, and the strike of the major sub-vertical joint sets. It is expected that its discontinuity will mean it does not significantly influence final void behaviour. It may provide water storage during the recovery phase which slows the rate of water level rise, but is unlikely to offer any lasting water inflow or outflow. The extent of connected fractures is only expected to extend to a maximum of several hundred metres beyond the final void and is more associated with surface water recharge than a groundwater aquifer. There is strong evidence the fractures do not extend beyond the mining lease.
Tertiary claystone (aquitard)	The Tertiary claystone forms a confining unit to the Tertiary gravel aquifer, and is interpreted to have been deposited in a lower energy environment that resulted from progressive damming of the stream outflow by basalt flows. Basalt flows initially filled a north-south trending valley to the east of the mine area, and extended further west as the valley was progressively filled by subsequent flows. Eventually, all flow to the east was blocked by basalt flows, resulting in development of a lake system in which the upper part of the claystone was deposited. Subsequent basalt flows covered the lake system with a further 70 m of basalt, effectively encapsulating and hydraulically isolating the underlying gravel aquifer.
Tertiary gravel (confined aquifer)	The Tertiary gravel aquifer has been interpreted to have been derived from remobilisation of the Permian basalt conglomerate, which was brought to the surface to the west of the mine area by the western wall fault. The Tertiary gravel aquifer is interpreted geologically to be more a fan deposit than a sequence of alluvium deposited by stream action, and therefore has limited regional extent. The tertiary gravel is isolated, depressurised (at end of mining) and will have little bearing on pit lake behaviour (inflow or outflow will be constrained in long term). It may provide short term loss from the void as the aquifer is

Unit	Implication for void hydrology
	recharged during pit lake recovery, but since this is an isolated and limited aquifer, this not likely to persist in the long term.
Permian sedimentary deposits (confined aquifer)	The Permian sediments host the coal measures that will be extracted by Clermont mine. The Permian sediments are expected to be of low yield relative to overlying aquifers. Permian sediments are exposed in the southern face of the final void with a thickness of around 100 m. However, they are relatively tight, so likely to provide little interaction with the pit lake (loss or recharge).
Cambrian metamorphic	This unit is regarded as the hydraulic basement, but contains water within secondary porosity (fractures, weathered horizons) in some areas. However, there are no beneficial uses of this water.

The aquifers intersected by the void will either be removed during mining, or are isolated and discontinuous, so will not provide any ongoing inflow or outflow from the final void. As highlighted above, there may be connected fractures immediately around the mined extent that could contribute additional water to the final void beyond the physical surface water catchment extent (via seepage). The volume of water entering the final void in this manner was estimated by applying the calibrated groundwater model recharge rate (8% annual rainfall) over the area where connected fractures could extend from the pit rim. It has been estimated that the connected fractures extend 200 m from the pit rim around the perimeter of the mined extent. The pit lake is situated well below this fracture zone.

6.1.4.2 Cement Hill Void

Local drill hole data suggests that in the local area, a 10-20 m thick layer of basalt overlies a conglomerate sequence of greater than 50 m depth, across most of the site, except in the south, where a 10m thick layer of clay occurs between the conglomerate and the basalt. However, the pit wall exposure at the mine reveals conglomerate only.

The main aquifer in the Cement Hill Mine area is the Tertiary basalt which is recharged directly from rainfall. The underlying conglomerate is considered low permeability. Groundwater level data indicates the direction of groundwater flow in the basalt aquifer generally follows the Gowrie Creek system (i.e. from north west to south east).

Water level observations over the last 10 years, in addition to water balance modelling, suggest a limited connection between the void and the basalt aquifer. The geochemical signature of the void water is more consistent with surface runoff than the regional aquifer.

While the base case model scenario was negligible groundwater input, sensitivity analysis was conducted on groundwater inflows as part of the water balance model.

6.1.5 Spoil Seepage

Seepage through the rehabilitated spoil was estimated using the calibrated AWBM model, where seepage is considered to be the visible base flow component. The area of the rehabilitated spoil that drains towards the final void was estimated by review of pre-mining topography. All of the in-pit dump footprint was assumed to report to the voids.

6.1.6 Uncertainty Analysis

Not all variables of the Goldsim model are measured values. As such there is some inherent uncertainty in the selection of appropriate values for certain variables. The water balance was constructed using probabilistic simulation, which involves explicitly representing this uncertainty by specifying inputs as probability distribution functions and specifying random events that could affect the system. The probability distributions are either assumed based on the range of expected values, or derived based on analysis of available datasets.

Goldsim uses advanced Monte Carlo techniques to propagate the uncertainty in model inputs to model outputs. Since the inputs describing the water balance are uncertain, the water level predictions in the voids are also approximations. That is, the result of any analysis based on inputs represented by probability distributions is itself a probability distribution. This type of result is typically more useful for understanding risks than avoiding traditional deterministic simulation, which provides a single result based on ‘the best guess’ or ‘worst case’ values, without providing context of the likelihood of this scenario actually occurring.

The model was run 100 times (realisations) for each void in order to generate water level probability distributions.

6.2 Clermont Void

The Clermont void model predicts that eventually (over many years) the water level in the pit void will reach a quasi-steady state condition as shown in ***Figure 6-3***. This occurs when the inflows from rainfall, run-off and groundwater balance the outflows, mainly evaporation. As these fluxes are climate dependent, there will be some small variability in water level each year.

The water level in the pit stabilises after approximately 300 years at 108 mAHD. The 25th to 75th percentile ranges from approximately 104 mAHD to 113 mAHD. This relatively narrow band suggests there is a very high confidence that the water level will stabilise well below the pit rim (260 mAHD).

The lake will result in a depth of approximately 40-50 m. Once steady state is achieved, the water level typically varies around 2.5 m in elevation as a result of climatic variation.

Another important observation is that the formation of a pit lake is not expected to form until around 15-20 years post closure. The final void is not located in the lowest part of the pit shell and therefore water entering the final void can transfer through the permeable spoil and accumulate at the lowest point (in the spoil). A shallow lake (several metres deep) may form during the wet season due to blinding of the bed and sides of the final void by fine particles.

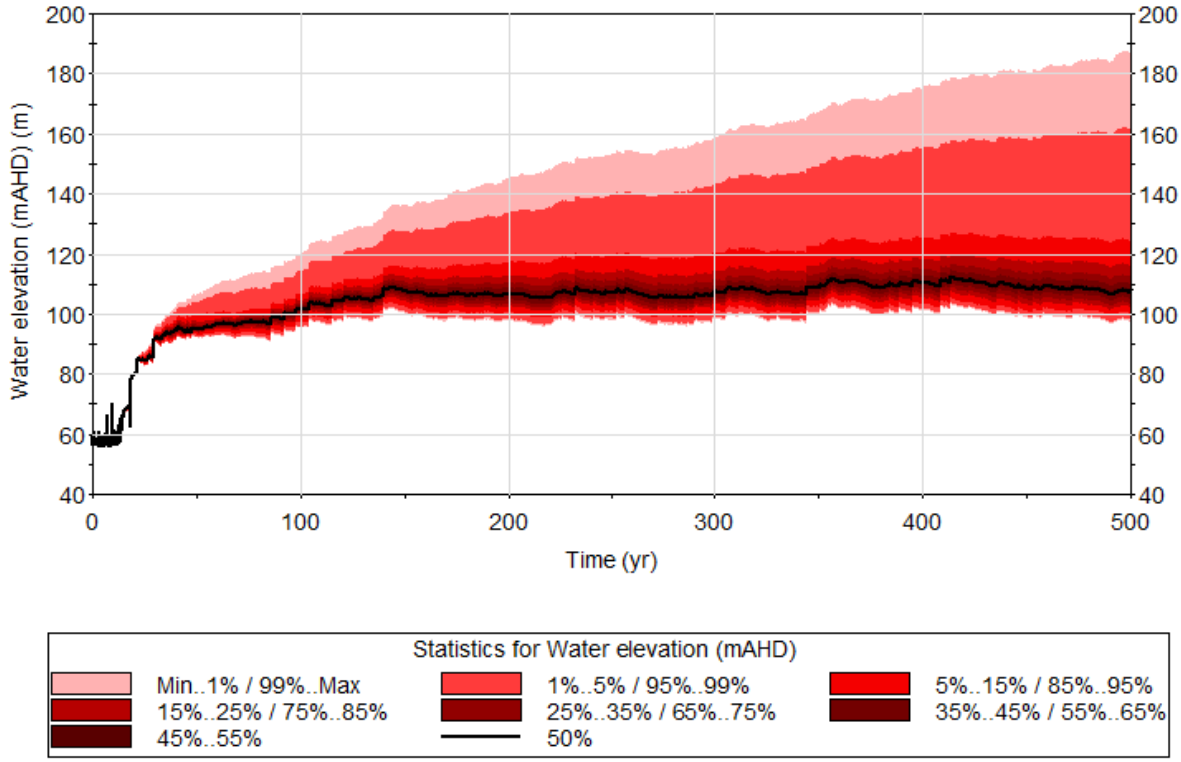


Figure 6-3 - Predicted final void level

The model predicts that there is a permanent long-term drawdown of the regional groundwater, which aligns with the original long term impacts predicted by the EIS, such that the final void will act as a sink and groundwater will flow from the Tertiary basalt aquifer into the void. Inflow into the void may diminish over time, however it is expected that inflow and losses (through evaporation) will result in an RL equilibrium.

6.3 Cement Hill Void

The Cement Hill void has a weir that enables water exchange between the void and the adjacent external drainage feature. Flow events in the external drainage feature that exceed the elevation of the weir (300.5 mAHD) causes water to enter into the void. The dominant recharge mechanism of the void is from the input of water from the drainage feature. The void has operated in its current configuration for over 20 years and has proven to be a viable water supply over this period.

Spot observations of water level in the void have been collected since 2014, and continuous water level monitoring was performed in 2019 for water balance model calibration. Continuous monitoring of the void water level in 2019 captured a significant rainfall event that resulted in recharge of the void from the external drainage feature. The water level record shows the recharge event, followed by a steady decline caused by evaporative losses and withdrawal. The effect of smaller runoff events from the immediate void catchment are also visible in the dataset. The data is presented in ***Figure 6-4***.

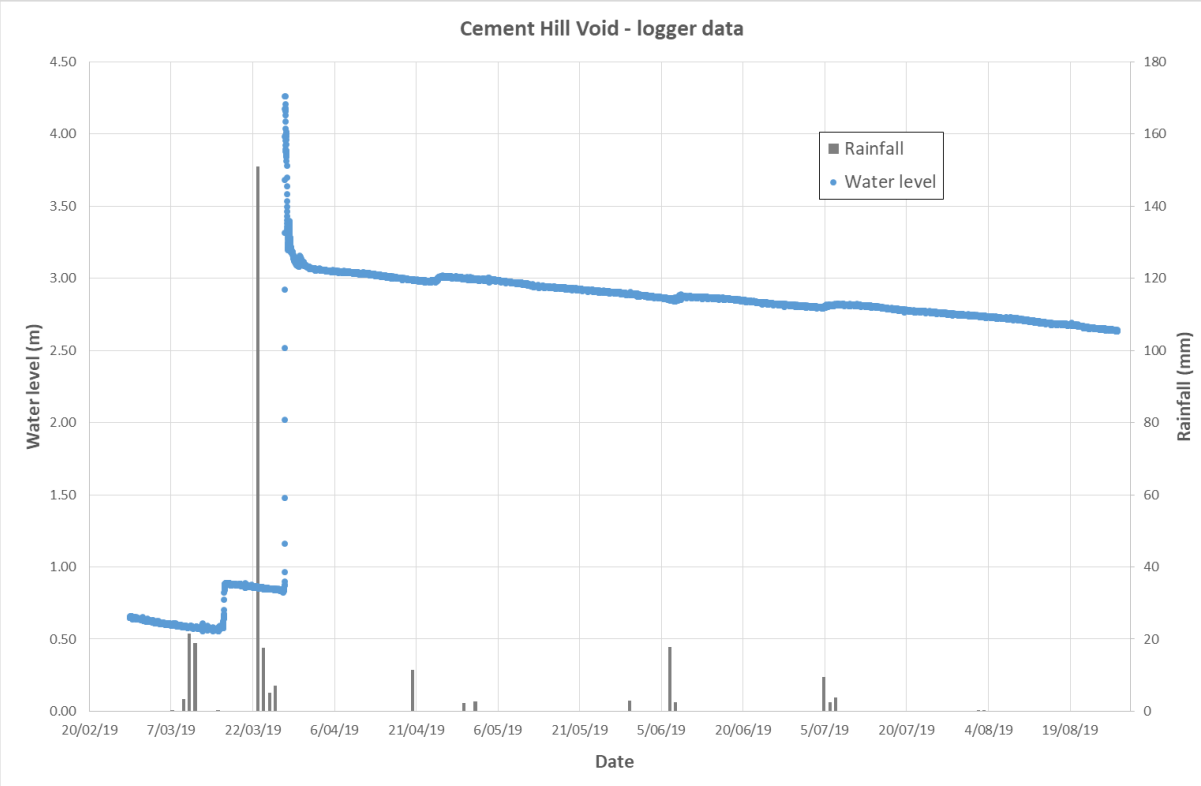


Figure 6-4 - Cement Hill continuous water level observations

Detailed flood modelling has been performed for the drainage feature, with particular focus on its relationship with the void. The hydrology and hydraulic model setup is detailed in Appendix 4.6 - Surface Water Assessment.

The flood assessment reviewed a wide range of design storm events and identified that the void is recharged by flow from the external drainage feature typically twice per year (2EY). The relationship between flood depth in the drainage feature and AEP is shown in ***Table 6-2***.

Table 6-2 - Flood depth relative to weir (300.5 mAHD)

Return Period	Flood elevation at weir (mAHD)
2EY	300.64
1EY (63% AEP)	300.72
20% AEP	300.97
1% AEP	301.86

The hydraulic model was also used to explore the exchange of water volume from the flood event and the inflow characteristics (e.g. hydrograph, velocity, shear stress) as water enters the void. ***Figure 6-5*** provides a summary of the water level in the drainage feature and void throughout a 5% AEP design storm event. In the case the void was assumed to be empty at the commencement of the storm event. The modelling shows:

- No entry of floodwater into the void until floodwater reaches the weir elevation of 300.5 mAHD;
- Differential water elevations between the drainage feature and the void during the filling phase, caused by the constriction of the weir that throttles the flow rate of water entering the void;
- Equilibration between the flood level and the void water level after approximately 5 hours of first water entry into the void; and
- Retention of water in the void following the flow event.

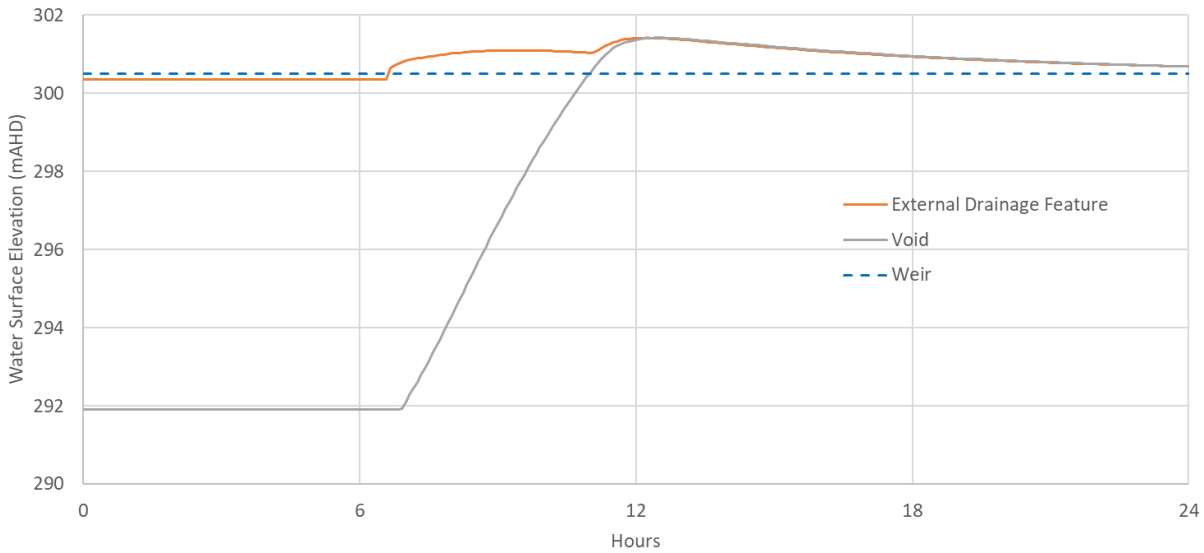


Figure 6-5 - 5% AEP floodplain/void interaction

A long-term water balance model was developed to represent the inflows and outflows as detailed earlier, with periodic recharge from the external drainage feature. The water balance predictions are shown in ***Table 6-3*** for various extraction scenarios.

Table 6-3 - Water level predictions (mAHD (% full supply volume))

Percentile	No withdrawal	1 L/s withdrawal	5 L/s withdrawal
20th	299.6 (85%)	297.2 (48%)	292.4 (1%)
50th	300.1 (93%)	299.2 (78%)	297.7 (55%)
80th	300.3 (96%)	300.1 (93%)	299.6 (85%)

The water balance modelling confirms the anecdotal evidence that the void provides a reliable water storage that is periodically recharged by local runoff (minor contribution) and external catchment inflows (major contribution).

7. Water Quality

7.1 Clermont Void

7.1.1 Approach

A geochemical model and limnological model has been developed of the Clermont void to predict the long term water quality evolution in the void.

The geochemical model is built in the PHREEQC platform, a widely applied equilibrium geochemical model produced by USGS. The model considers speciation and assesses the saturation state of mineral phases within input waters. The structure of the model is shown in ***Figure 7-1***.

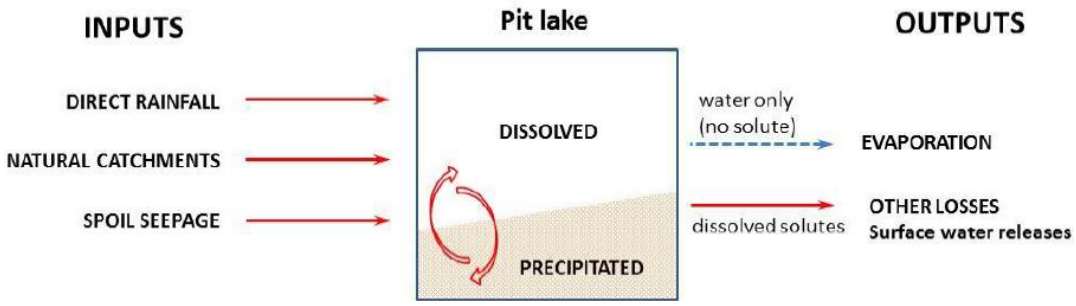


Figure 7-1 - Geochemical Model Structure

The geochemical model was set up to permit secondary minerals to form when the saturation index (SI) is positive. In addition mineral phases are permitted to redissolve (if present) to the extent necessary to obtain equilibrium (SI=0). A list of possible secondary mineral phases has been developed based principally on reaction kinetics. Nordstrom and Alpers (1999) identify common minerals that can be used for geochemical modelling and the selection of secondary mineral phases was compared with their study. The potential precipitates (minerals) are discussed later in ***Table 7-2***, and the implications of formation on other solutes present in the water is also presented.

The geochemical model includes the following geochemical processes:

- Aqueous speciation;
- Precipitation of secondary minerals; and
- Adsorption of metals onto iron oxy-hydroxides (surface complexation).

Secondary minerals may form when a solution becomes supersaturated with respect to the mineral phase being considered; although precipitation may not actually occur until moderate degrees of super saturation are achieved. The factors that affect the saturation state include pH, redox, ion activity and the assemblage of other species.

7.1.1.1 Geochemical Controls

Minerals are chemical precipitates generated when constituent ions jointly exceed the 'solubility product' for that mineral. Waters where this occurs are described as 'saturated' with respect to that mineral.

Characterisation of waters by the minerals with which each is saturated (in relation to a solid phase) provides a system for classifying waters in terms of potential mineral formation. This classification can be quantified by calculation of a 'saturation index' (SI). Minerals that have SI values that equal or

exceed zero are saturated and if environmental conditions are suitable and kinetics favourable, the supersaturated mineral phases may begin to precipitate.

A summary of the saturation state of major mineral phases for input waters to the pit lake is presented in ***Table 7-1***. The table indicates whether a mineral phase is either supersaturated (✓) or under-saturated (×). The saturation state of minerals is often sensitive to the redox conditions. Redox conditions have been assumed based on the likely exposure of water to oxygen prior to entering the pit lake.

Table 7-1 - Saturation State of Mineral Phases for Input Waters

Mineral phase	Seepage and surface run-off from spoil	Seepage vis fractured rock
Apatite phases	✓	✓
Barite	✓	
Ferrihydrite	✓	✓
Aluminium oxyhydroxides	✓	✓
Calcite	✓	✓
Gypsum	×	×
Magnesite	✓	✓
Malachite	×	×
Manganese oxides	✓	×
Manganese carbonates	×	×
Halite	×	×

✓ supersaturated × under-saturated ID – insufficient data

Table 7-1 indicates that input waters are supersaturated with respect to various mineral phases, meaning they could precipitate and alter the quality of the water entering the pit lake. Ferrihydrite and aluminium oxy hydroxides are likely to play a key role in the geochemistry of the pit lake. These minerals adsorb a range of anions and cations onto their surface and cause a reduction in their concentration in the water column.

Other phases that are likely to have an important role in pit lake chemistry include calcite and gypsum, which are likely to compete for the available calcium. In this case the input waters appear to be limited in sulfate, and therefore calcite is likely to be the dominant control on calcium.

Redox sensitive minerals such as copper and iron are likely to undergo cyclical precipitation in the upper oxygenated zone of the pit lakes, and dissolution at depth under anoxic conditions. In the event that desertification occurs during winter, copper and iron concentrations are likely to remain low throughout the water column.

The precipitation of mineral phases identified in ***Table 7-2*** can also influence a range of other metals and ions in the water column through adsorption and co-precipitation. A summary of the likely changes caused by these minerals is summarised below.

Table 7-2 - Mineral Precipitation and Geochemical Consequences

Mineral	Influences
Apatite phases	Aluminium, Fluorine, Calcium, Carbonate, Phosphorus, Lead (a)
Ferrihydrite	Iron, Lead (b), Zinc (b), Copper (b), Calcium (b), Nickel (b), Manganese (b), Barium (b), Magnesium (b), Sulfate (b), Fluorine (b), Phosphorus (b), Arsenic (b)
Aluminium oxyhydroxides	Aluminium
Calcite	Calcium, Carbonate, Manganese (a), Zinc (a), Nickel (a), Magnesium (a)
Gypsum	Calcium, Sulfate, Barium (a)
Magnesite	Magnesium, Carbonate
Malachite	Copper, Carbonate
Manganese oxides	Manganese
Manganese carbonates	Manganese, Carbonate
Halite	Sodium, Chloride, Lead (a)

(a) co-precipitation

(b) adsorption

The available data suggests that metal concentrations will be low in the near surface layers (the epilimnion). This is attributed to the alkaline conditions and the oxidising conditions in this zone, which will promote precipitation of mineral phases, many of which incorporate, co-precipitate or adsorb metals during the process.

7.1.1.2 pH

pH of the pit lake was estimated from the mixing ratios of inputs waters. The pH is principally a function of the input water pH, but also affected by redox potential and carbon dioxide partial pressure assumptions.

7.1.1.3 Redox

A range of redox conditions are anticipated within the pit lake. It is expected that near surface layers in contact with atmosphere would be relatively well mixed and remain oxygenated, primarily as a result of wind induced turbulence. The extent to which the oxygen is distributed vertically within the water column is dependent on whether stratification occurs, and the strength and duration of the stratification. Deeper layers are more likely to be oxygen depleted, especially during stratification events. ***Figure 7-2*** shows the relationship between pH and Eh for various environments.

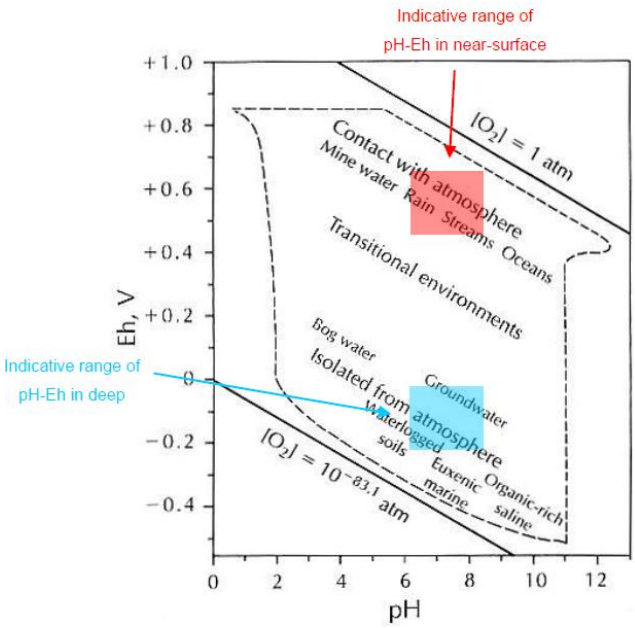


Figure 7-2 - Range of Eh-pH Conditions in Natural Environments

Based on ***Figure 7-2***, Eh is expected to lie in the range +400 to +600 mV within the near-surface horizons of the pit lake. Based on Manahan (2005) Eh (mV) = 59.2pe (at 25°C), a pe range of +6.8 to +10.1 is expected. pe is the logarithm of electron concentration in a solution, as opposed to pH which is the logarithm of hydrogen ion concentration in a solution. pe is directly proportional to the redox potential.

Less oxidised conditions would be anticipated at depth within the pit lake. A range of precipitation and dissolution reactions would occur at various levels within the water column due to the variation of redox potential with depth. The processes are not considered in this study because this study is concerned with near-surface water chemistry. The near-surface waters would be accessible to humans and terrestrial fauna and salt precipitation (due to evapo-concentration) would also occur in this region.

7.1.1.4 Carbon Dioxide

Carbon dioxide is an important gas in lakes. As carbon dioxide dissolves in water, it forms a series of compounds, including carbonic acid, bicarbonate, and carbonate that effect pH. The equilibrium condition that is established with CO2 (gas) varies with temperature, biological activity and mixing processes. A review of various mine voids around the world was completed by Eary (1999) and the relationship between pH and carbon dioxide shown in ***Figure 7-3*** was derived. This indicates that the likely range of CO_2 (g) partial pressures varies from 10^{-2} atm to $10^{-3.5}$ atm (atmospheric carbon dioxide partial pressure). A sensitivity analysis was conducted over this range to assess the effect of this variable.

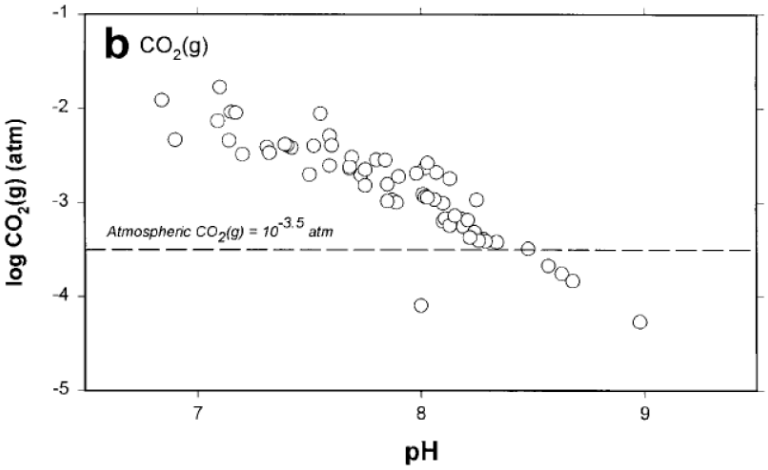


Figure 7-3 - Saturation Indices in Hard Rock Pit Lakes for Equilibrium Partial Pressures of CO2 (Gas)

7.1.2 Meteorological Drivers

Wind, temperature and rainfall are the dominant meteorological drivers which have the greatest effect on the stratification potential. These factors are seasonally variable and have varying degrees of influence throughout the year.

Wind

Wind through shearing forces on the water's surface can increase the mixing potential of the water within the pit lake. The effect of this would likely be limited to the upper layer of the water column. The average 9 am and 3 pm wind speeds are generally consistent throughout the seasons, however, slightly higher wind speeds are observed during Spring than during the other seasons.

Due to the geometry of the voids whereby the water is confined within an excavation with generally steep side slopes and at a considerable distance from the surface, the potential for the wind to have an impact on the surface of the pit lake would likely be limited.

Temperature

During the warmer seasons (summer, autumn and spring) the upper layers of the pit lake water column are expected to be warmer than the water in the lower section of the void water column as a result of direct radiation from the sun. This would produce a thermocline at a point in the water column. During the cooler months (winter plus the months either side), the variation in temperature between the upper and lower sections of the pit lake is expected to be much smaller. A typical thermocline may not be developed during this period. It is noted that from the effect of shading from the void walls and other features surrounding the voids, heating of the surface waters from direct radiation is expected to occur at a lower rate than what would normally be observed in natural lakes with minimal shading.

Rainfall

Rainfall is an important input which can have a bearing on the stratification dynamics of the pit lake. Direct rainfall onto the lake surface would bring about an injection of freshwater into the upper section of the water column. Higher rainfall is more common during the warmer seasons at a time when the temperature differences are expected to produce a thermocline. This influx of freshwater is expected to occupy the top layer of the water column due to the lower densities in comparison to the more dense deeper waters. Evaporation rates (which are greater than double that of rainfall for each season) will have an effect on increasing the concentration of constituents within the pit lake through evapo-concentration.

7.1.3 Salinity

The pit lake within the final void is expected to become increasingly saline over time. Average evaporation in the region is approximately three times the average annual rainfall. This trend is expected to continue over time, with modelling indicating that no steady state will be achieved in relation to salinity.

Quantitative water quality predictions were made for the final void using the contaminant transport module of GoldSim to track salt movement and accumulation, and a geochemical model ***Figure 6-1*** to review other solutes and non-conservative species.

The predicted salinity in the pit lake is expected to slowly increase due to evapoconcentration processes, from around 1,000 mg/L (median) 50 years post closure to 3000 mg/L (median) after 300 years. In the very long term (1,000 years) the water is expected to be brackish to saline, but remain below seawater salinity. The salinity varies from 5,000 mg/L (25th percentile) to 10,000 mg/L (75th percentile) after 1,000 years.

The salinity of water in the spoil is predicted to increase more slowly. Since there is no evaporation the salinity rises only when seepage from the pit into the spoil occurs. After 1,000 years the salinity in the spoil is expected to be around 3,500 mg/L.

7.1.4 Stratification and Mixing

Stratification refers to the separation of a water body into multiple layers. This separation is brought about by the different properties of the water body which occur through the water profile. Mixing throughout the profile is another important factor which can impact on pit lake water quality. Mixing and stratification are related factors as the potential for and degree of mixing and stratification is primarily driven by meteorological conditions.

Stratification can occur in relatively shallow water bodies such as lakes and reservoirs (typically <10 m in depth) but is more likely to occur in deeper water bodies such as the Clermont final void. In addition to the physical characteristics of the void, other factors such as meteorological conditions can influence the likelihood of the voids developing either a thermocline (temperature separation between layers) or a chemocline (salinity, oxygen or other chemical separation between layers).

Limnological modelling was undertaken using the one-dimensional hydraulic model DYRESM developed by the Centre for Water Research, University of Western Australia. DYRESM simulates the one-dimensional thermal structure of a lake over time. The model uses a range of environmental variables affecting the stability of the water column and acting to influence seasonal stratification and mixing.

DYRESM was used to evaluate the stratification potential under the quasi-steady state condition (300 years post closure). The model results are presented in ***Figure 7-4***. These results show the vertical distribution of the pit lake over the simulation period for temperature, salinity and density. The dates on the x-axis refer to the calendar year in which the meteorological data was collected (1979-1991), but should be interpreted as a 13 year period around 300 years post closure.

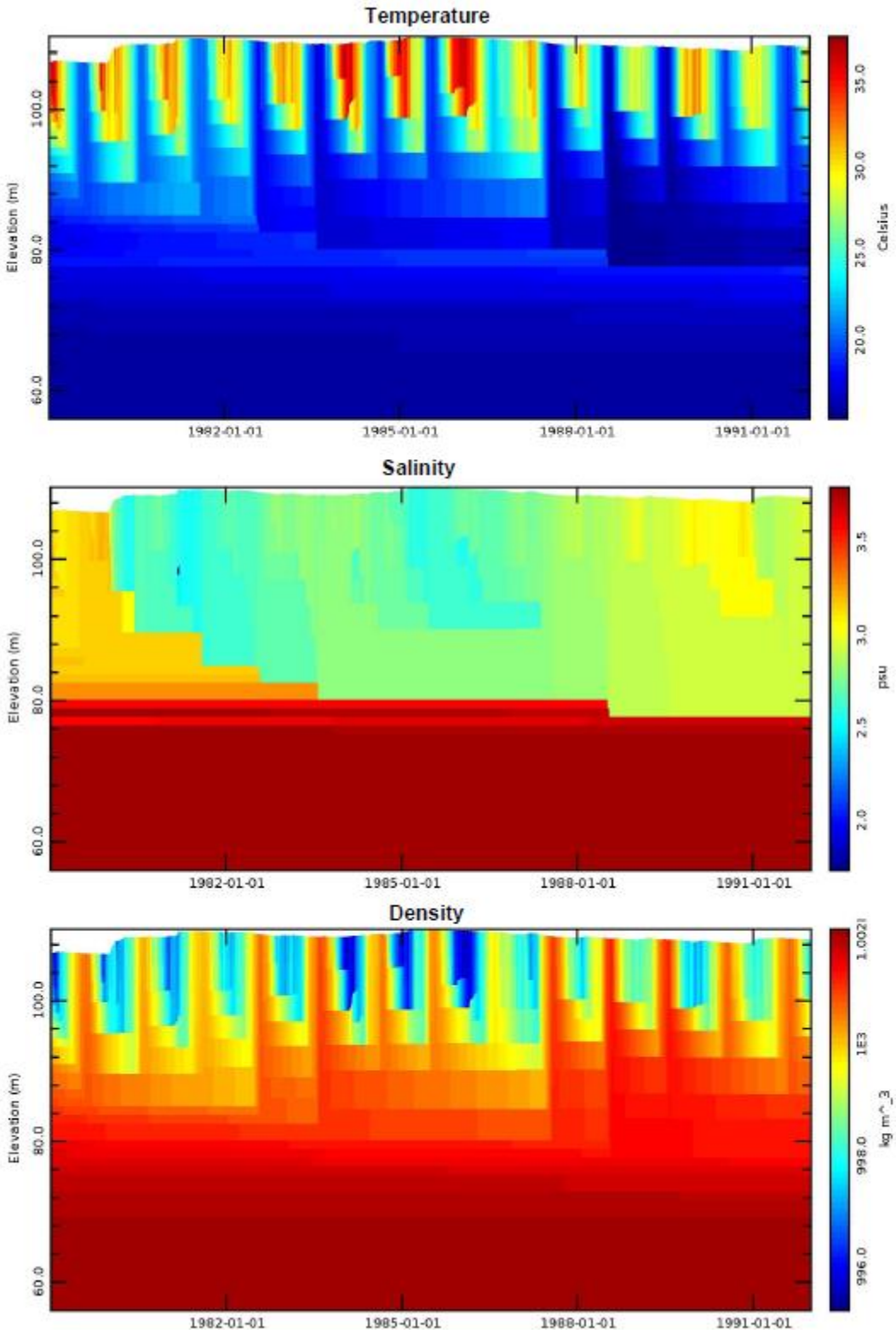


Figure 7-4 - DYRESM Results for Steady Condition 300 Years Post Closure

The model results identify the following processes occurring:

- Temperatures in the lake are consistently 16°C at depth, and vary between 20°C and 30-35°C near the surface;
- Strong stratification occurs in summer and weakens, but normally persists, in winter. The stratification is caused by surface heating and is therefore more pronounced during summer;
- Thermal effects have more influence on water density than salinity at the TDS concentrations expected in the final void. The thermal heating is causing more saline water to overlie less saline water for most of the time;
- The thermocline may extend from 10-30 m depth, depending on the turbidity of the water and climatic conditions;
- Evaporation is causing salinity to increase near the surface, despite the regular inputs of fresh water from rainfall and groundwater. Thermal stratification is preventing mixing of this more saline water with the deeper waters in the lake; and
- Every few years during winter, there is a prolonged cold period (usually occurring in July) that cools the surface layers of the lake. The density of the surface waters approaches that of the deeper waters and full mixing occurs. It is during this full mixing period that aquatic flora and fauna will be most vulnerable.

This pattern is likely to persistent for thousands of years due to the slow rate of evapo-concentration expected in the pit lake. If the pit lake were to become considerably more saline, then the salinity gradient would eventually become more dominant than the thermal gradient. At that stage, the water column as a whole is expected to approach near homogeneity with respect to salinity. Water chemistry would still vary with depth, primarily due to a reduction in redox potential.

Thermal stratification occurs on a seasonal basis in water-bodies due to the warming of the surface waters (concurrent with the onset of summer) and the development of a warmer, less-dense surface layer overlying a cooler, denser layer. The resultant stratification is due to the logarithmic absorption of incident energy (insolation) in the water column. The depth of the resultant thermocline (where there is a relatively rapid decrease in temperature) is dependent on the limit of energy penetration (extinction depth) which in turn depends on the optical density of the water-body as influenced by turbidity, algal density and true colour.

The stability (strength) of stratification may vary diurnally due to the short-term warming and cooling at the surface of a lake, although the high latent heat of water means that it tends to change temperature relatively slowly in response to short-term environmental fluctuations. Since the pit lake is expected to be deep, its capacity to store heat over time is relatively large. As a result, water temperature at depth is not expected to fluctuate significantly through a given year.

The pit lake will have a much smaller surface area to depth ratio than natural lakes. Thus the susceptibility of the deeper regions to wind driven mixing is comparatively low since there is less surface exposure to the forcing energy of the given wind.

Seasonal (winter) mixing in such water bodies is dominated by the loss of energy from the surface layer. This is caused by seasonal cooling with the onset of winter such that the surface layer approaches the same temperature as the deeper layer and hence the same density. Under such circumstances these layers would usually merge to become a single homogenous unit.

Additionally, unusual seasonal cooling (and to a lesser degree, wind energy) may cause partial or complete mixing at any time during the seasonal cycle. Wind-driven mixing results from turbulent transport through the water column due to the effect of shear created at the water surface. In shallow lakes this is often the dominant mixing mechanism and results in a source of energy sufficient to

prevent persistent stratification even during warm summer months. As described above; however, this is unlikely to occur at COC.

7.1.5 Biological Succession

Primary production in the context of this final void assessment is the growth of phytoplankton (i.e. algae) within the pit lake. Algal growth in the broad sense is typically controlled by the availability of bioavailable forms of nutrients (typically nitrogen, phosphorus as well as other elements).

Water bodies with low concentrations of nutrients are classed as oligotrophic systems with limited biological production. A eutrophic system contains high concentrations of nutrients and is a system with a high level of biological production. Mesotrophic systems are intermediate systems between the eutrophic and oligotrophic states.

The water quality modelling suggests low phosphorus concentrations and higher nitrogen concentrations. Algae growth is optimised when there is high concentration of both nutrients. In the case of the Clermont final void where phosphorus is limited the extent to which algae growth occurs is quite uncertain. In the formative years the surface of the pit lake will be depressed well below the pit rim and is likely to receive considerable shading. As photosynthetic algae require sunlight to grow, these shaded conditions are not optimal for algae production. As the water level increases, shading will decrease and conditions will begin to promote algae growth.

Nutrient species are expected to undergo transformations when transitioning between different lake zones (anoxic and oxic). This can bring about nutrient reactions which can be particularly significant under strong stratifying conditions. The pathways and the reactions involved in the nitrogen cycle are complicated due to the many different forms that may exist. Major pathways can include:

- N_2 → organic-N (fixation);
- Organic-N → NH_4^+ (mineralisation);
- NH_4^+ → NO_3^- (nitrification);
- NO_3^- → N_2 (denitrification); and
- NO_3^- and NH_4^+ → organic-N (photosynthesis).

7.1.6 Geochemical Behaviour and Trace Metals

There are three main inflow sources to the final void: direct rainfall, seepage and void run-off. Direct rainfall typically has very low solutes and the main influence on water geochemistry is to lower the ionic strength of the water through dilution. This can be significant in the near surface layers of the lake, causing density differences.

Water that enters spoil may eventually report to the pit lake, and carry solutes derived from the waste rock. Acid rock drainage (ARD) assessments have been completed and found that majority of the overburden/interburden material is Non-Acid Forming (NAF). ARD testing has identified some Potential Acid Forming (PAF) and Potential Acid Forming Low Capacity (PAF-LC) rock types within the Tertiary sediments, Permian overburden/interburden and Cambrian-Ordovician metamorphics (EGI, 2011).

The ARD assessments have found that PAF materials are likely to be fast reacting, with little or no lag time (days to weeks) once exposed to atmospheric conditions. This is reportedly due to a combination of fast reacting pyrite forms and poorly reactive carbonate minerals.

There is considerable uncertainty around the extent to which ARD reactions have occurred or will occur in the future, and the effectiveness of mitigation strategies employed at the site.

A reasonable approximation of water emanating from the spoil can be obtained from monitoring records from the current mine workings. The Process Water Dam and Mine Water Dam both can receive water from the active pit area and therefore provide an indication of its likely chemistry. It is noted that there may also be substantial groundwater inputs that influence water samples collected from these locations, and more targeted sampling of spoil seepage water quality in future would provide greater confidence in the assessment.

The other potential water source to the lake is incident rainfall. A summary of the water chemistry is presented in ***Table 7-3***.

Table 7-3 - Typical (average) values of key water quality parameters of waters (mg/l, unless noted otherwise)

Analytes	Pit Lake Inputs		
	Incident rainfall	Seepage and run-off from spoil (a)	Seepage via fractured rock (b)
TDS	30	900	765
pH (pH units)	5	8.7	7.8
HCO3	-	145	435
Al	<0.001	0.021	0.022
As	<0.001	0.015	0.006
B	<0.001	0.066	0.084
Ba	<0.001	0.054	0.032
Ca	3.0	47.8	29.7
Cd	<0.001	<0.001	<0.001
Cl	8.6	148.1	70.9
Cu	<0.001	0.001	0.002
F	<0.001	0.280	0.088
Fe	<0.001	0.048	0.117
Mg	<0.001	34.053	26.627
Mn	<0.001	0.05	0.017
N	2.0	3.222	0.625
Na	9.0	197.9	170.8
Ni	<0.001	0.006	0.001
P	<0.001	0.068	0.075

Analytes	Pit Lake Inputs		
	Incident rainfall	Seepage and run-off from spoil (a)	Seepage via fractured rock (b)
K	<0.001	4.83	4.31
Pb	<0.001	0.001	0.002
SO_4	8.0	317.9	26.8
Sr	<0.001	0.394	0.271
Zn	<0.001	0.011	0.022

Notes:
(a) Spoil chemistry is based on MWD01 - Mine water dam, being the most representative dataset available of spoil seepage
(b) Tertiary basalt chemistry is based on 10 representative bores from JBT (2014) as follows: NF10A; NF11B; NF12A; NF4A; NF9A; R12C; R1B; R3B; R5A; R7B

7.1.7 Dissolved Oxygen

In natural open water bodies such as in lakes, dams and reservoirs, the surface area to depth ratio is generally quite large. For mine voids, this ratio is usually a lot lower due to the abnormal shape of the mine void (deep with a small surface area). Given this, the meteorological effects on the void water are expected to be limited when compared with a natural system. This will reduce the potential for dissolved oxygen to mix throughout the void water profile.

The oxic zone of the pit lake is expected to be limited to the upper layers of the water column, whereas the anoxic zone will comprise the deeper more stable saline section of the water column. A typical chemocline that reflects a distinct change in dissolved oxygen concentration between the epilimnion and the hypolimnion is expected to develop.

7.1.8 Turbidity

Turbidity is a measure of the finer particles within a water body and is measured in Nephelometric Turbidity Units (NTU). A low turbidity relates to a water body with a low fraction of suspended particulates and in-turn high clarity, whereas a high turbidity relates to a water body with a high fraction of suspended particles. Turbidity is an important indicator of the health of an aquatic system as light penetration (and the subsequent processes which require light) can be reduced due to even moderate levels of turbidity.

During the early filling of the void when the surface area of the pit wall is greatest, turbidity within the pit lake is expected to be higher than the average turbidity levels under quasi steady state water level conditions. In the Base Case external surface water run-off is excluded from the void and the source of turbidity is likely limited to run-off from the pit wall. The characteristics of the particulates within the pit lake will have a bearing on the settling rates of these particles and as such the turbidity profile throughout the water column.

7.1.9 Pit Lake Evolution

The quality of water and mixing processes within the lake will change over time as a result of solute input, evapo-concentration, biological activity and climatic conditions.

The geochemical model was used to quantitatively predict the water quality evolution of the pit lake over time. The rate of evapoconcentration was determined from the water balance model and then input into the geochemical model. Evaporation was modelled by the extraction of water (not solute) from the geochemical model, again using the losses derived from the water balance model. The predictions at 50 years (early stages of forming) and 300 years (post closure are presented in ***Table 7-4***. While the void is a NUMA, the ANZG for Protection of Aquatic Ecosystems is also provided for comparison.

Table 7-4 - Comparison between pit lake surface waters (0-20m deep) and WQO (mg/L, unless noted otherwise)

Analyte	ANZG Protection of Aquatic Ecosystems	Pit Lake Water Quality	
		50 years post closure	300 years post closure
TDS		1,070	2,910
pH (pH units)		8.5	8.6
Pe (pe units)		+6.9	+6.8
HCO_3		90.5	108
Al	0.0550	0.002	0.002
As	0.0130	**0.021**	**0.081**
B	0.3700	0.114	**0.444**
Ba		0.019	0.013
Ca		12.6	17.4
Cd	0.0002	0.0001	**0.0004**
Cl		213	838
Cu	0.0014	**0.002**	**0.007**
F		0.340	1.29
Fe		0.002	0.007
Mg		22.1	30.8
Mn	1.9000	0.013	0.022
N		5.40	26.0
Na		314	1240
Ni	0.011	0.008	**0.029**
P		<0.001	<0.001
K		7.59	29.3

Analyte	ANZG Protection of Aquatic Ecosystems	Pit Lake Water Quality	
		50 years post closure	300 years post closure
Pb	0.0034	0.002	**0.006**
SO_4		402	1530
Sr		0.587	2.25
Zn	0.008	**0.022**	**0.088**

Notes:
Assumes oxic conditions, $10^{-3.5}$ $CO_2(g)$ partial pressure
Charge balance achieved using chloride
***Bold** values indicate exceedance of WQOs*

The key findings from the water quality model are:

- The input water sources are slightly alkaline and provide some buffering capacity against acidification arising from AMD reactions;
- The rate of evapo-concentration is slowed due to the presence of the in-pit spoil. The spoil offers a large reservoir of relatively fresh water that buffers the rate of salinity increase in the pit lake;
- Evapoconcentration will result in the concentration of some metals that over time are expected to exceed WQOs for protection of aquatic ecosystems. However, this may be reduced through sorption or co-precipitation processes;
- Cycling of metals between the oxic (surface) and anoxic (deep) zones is likely to occur. Ferrihydrite plays an important role, precipitating in the oxic zone and carrying trace metals (via sorption) to the deeper zones of the lake as the precipitated mineral falls under gravity. It then dissolves in anoxic conditions, releasing the iron and other metals back into solution which are likely to stay in this zone under stratified conditions. If a desertification event occurs they can be brought to the surface and the process begins again;
- There is a limited iron supply, and therefore ferrihydrite cycling which is common in pit lakes is not exerting as strong an influence on metal concentrations as in other coal mine pit lakes; and
- The water chemistry of the primary input sources is fairly similar. This results in only minor geochemical transformation upon mixing of the waters in the pit lake.

The major stages of pit lake evolution are predicted to be as follows:

- Lake formation stage:
  - After an initial period of approximately 15-20 years a lake will begin to form in the base of the void. Prior to this water accumulating in the void will be lost into the spoil via seepage;
  - Metal concentrations are expected to be relatively low, but increase over time due to ongoing inputs and evapo-concentration;
  - Ferrihydrite is predicted to readily precipitate and form a coating over the bed of the pit lake, and may also influence (reduce) the concentration of a range of metals through adsorption; and
  - The lake is expected to generally be stratified, causing anoxic zones to form at depth. The surface water inflows and increasing water levels should cause periodic mixing during the cooler months;

- Lake maturing stage:
  - After 150 years the water level increases would begin to slow as surface area increases and evaporative losses begin to approach inflows; and
  - Stratification is likely to be pronounced during summer, with mixed conditions during winter;
- Quasi-steady state:
  - After 300 years the water level would reach a quasi-steady state, with water levels around 108 mAHD. The depth of water in the void would be around 40-50 m;
  - Inflows and losses are expected to be similar and the water level is relative stable;
  - Water level fluctuations are expected to occur in response to climatic variation, but changes will not be significant;
  - Stratification is likely to be pronounced during summer, with mixed conditions during winter; and
  - Eventually salinity may increase to such a concentration that density stratification is permanent provided there are no discharges to groundwater or surface water (as expected).

7.2 Cement Hill Void

Glencore have been monitoring water quality in the Cement Hill void since 2014. This has involved monthly surface sampling for a range of physicochemical parameters, including total and dissolved metals. Water surface elevations are routinely surveyed, and a continuous monitor has been installed to calibrate a water balance model. Several additional targeted campaigns have also been commissioned to review sediment accumulated in the void and the hydrochemical changes in the water column.

The long term physicochemical parameters are shown in ***Figure 7-5***. This reveals a slightly alkaline pH ranging 8-9, low electrical conductivity indicating fresh water and low turbidity routinely less than 20 NTU. The EC trend shows the effect of some significant recharge events and interspersed with slow evapoconcentration. The periodic connection to the external drainage feature prevents any long term concentrating processes. The waterbody appears to function as any natural water storage would.

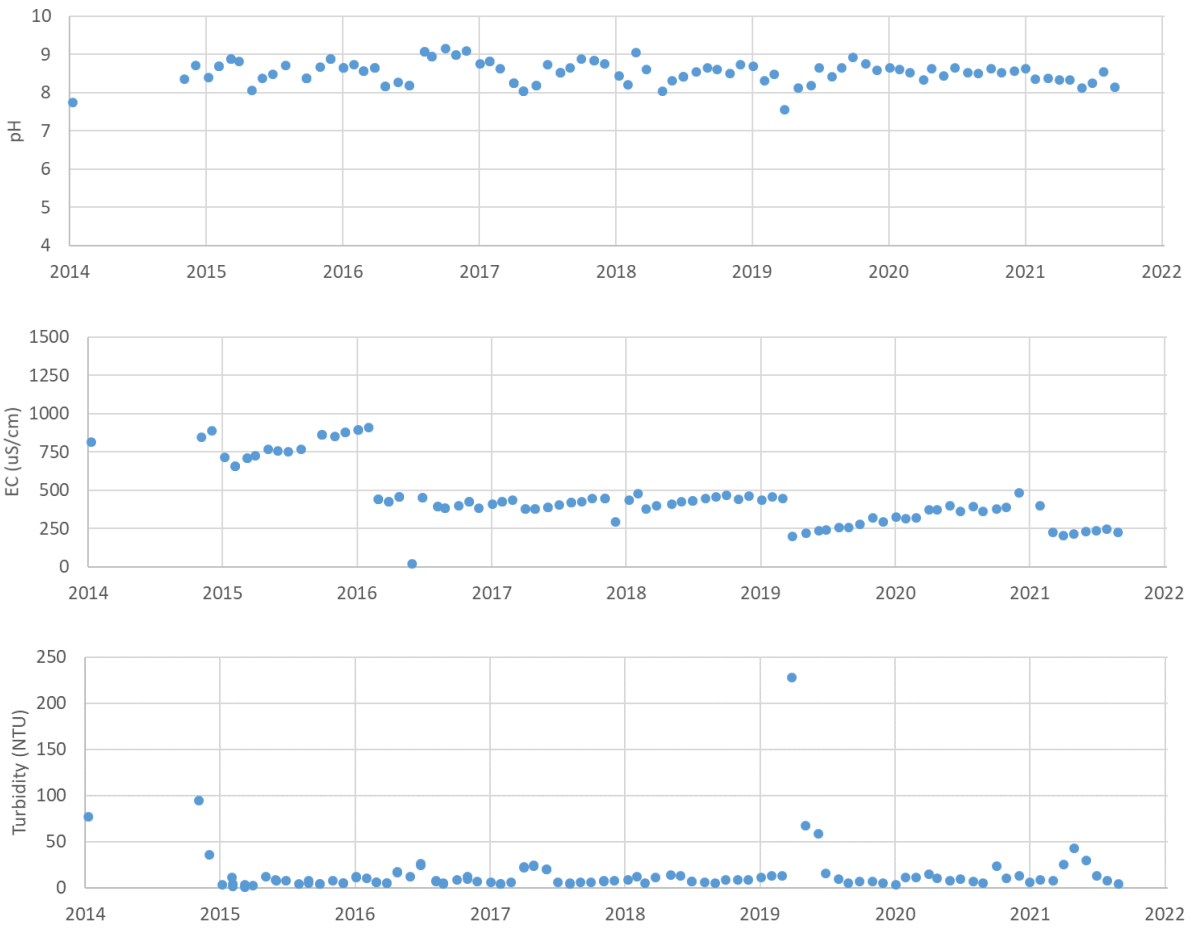


Figure 7-5 - Cement Hill void water quality observations

Long term sampling demonstrates that the void water has low metals concentrations, consistently below the ANZGV aquatic ecosystems trigger values (with the exception of copper on a couple of occasions) as shown in ***Table 7-5***.

Table 7-5 - Cement Hill void – dissolved metal concentrations (µg/L) 2015-2021

	Trigger value	n	%<LOR	Min	P-20	P-50	P-80	Max
Aluminium	55	99	93%	<LOR	<LOR	<LOR	<LOR	30
Arsenic	13	99	82%	<LOR	<LOR	<LOR	<LOR	2
Boron	370	99	62%	<LOR	<LOR	<LOR	70	120
Cadmium	0.2	99	100%	<LOR	<LOR	<LOR	<LOR	<LOR
Chromium	1	99	100%	<LOR	<LOR	<LOR	<LOR	<LOR
Copper	1.4	99	49%	<LOR	<LOR	1	1	3
Cobalt	NA	99	100%	<LOR	<LOR	<LOR	<LOR	<LOR

	Trigger value	n	%<LOR	Min	P-20	P-50	P-80	Max
Iron	NA	99	100%	<LOR	<LOR	<LOR	<LOR	<LOR
Lead	3.4	99	99%	<LOR	<LOR	<LOR	<LOR	1
Manganese	1,900	99	42%	<LOR	<LOR	1	2	10
Molybdenum	NA	99	61%	<LOR	<LOR	<LOR	2	7
Nickel	11	99	2%	<LOR	2	2	3	4
Selenium	NA	99	100%	<LOR	<LOR	<LOR	<LOR	<LOR
Silver	0.05	99	100%	<LOR	<LOR	<LOR	<LOR	<LOR
Uranium	NA	99	99%	<LOR	<LOR	<LOR	<LOR	1
Vanadium	NA	99	78%	<LOR	<LOR	<LOR	10	20
Zinc	8	99	88%	<LOR	<LOR	<LOR	<LOR	34

Depth profiling undertaken in summer of 2019 (***Figure 7-6***) shows a consistent water chemistry throughout the profile, with some mild stratification in the deeper parts of the waterbody. pH values are in the alkaline range throughout the water column (around pH 8.5), with lower pH values (pH 7.5-8.0) recorded at depth (from 4 m). ORP values were positive throughout much of the water column at all locations, with negative values (representing an anoxic zone) recorded in the deeper zone (at around 4.8 m depth) at one location only

EC and TDS values were low (freshwater) however slightly higher values were recorded at depth (from 4 m) indicating very minor salinity stratification. DO values in the upper approximately 3 m of the water column were in the range generally acceptable for aquatic ecosystems (DO >80%) with much lower values (<20%) recorded in deeper sections of the void (from 4 m), confirming stratification below 3 m.

Temperature was consistent throughout much of the water column (values around 28.5ºC), with slightly lower temperatures (between 27 and 28ºC) recorded in deeper sections of the void, representing a slight thermal stratification at depth

Turbidity values were low (<10 FNU) throughout much of the water column, with these values in the range generally acceptable for aquatic ecosystems. Higher values were recorded at depth which is likely a function of where the water quality instrument disturbed the fine sediment on the base of the void.

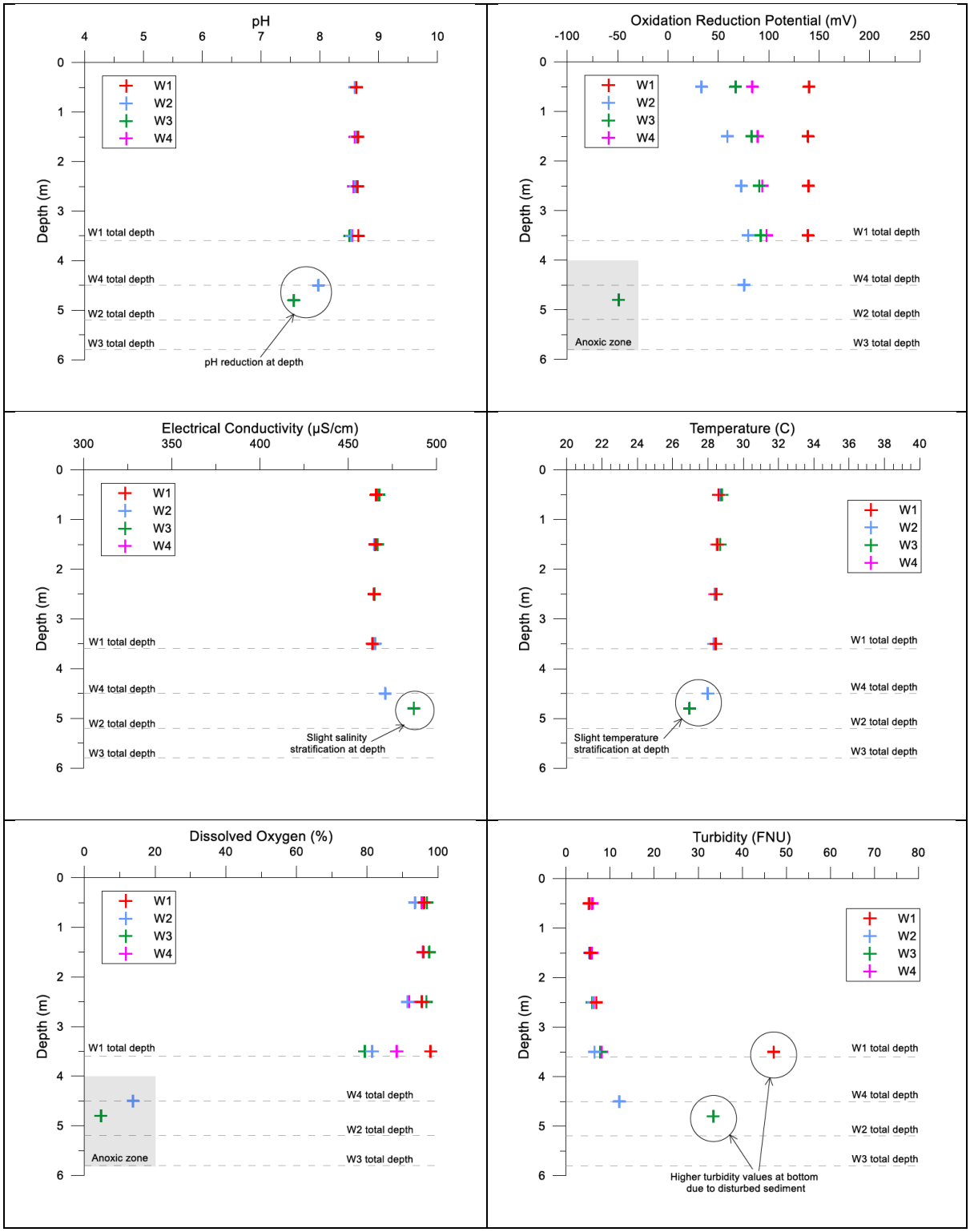


Figure 7-6 - Cement Hill void – depth profile (January 2019)

Sediment sampling was also conducted in the void during 2019. The void sediment consists of dark grey / black sediment of fine consistency, thought to be representative of the black soil (clays and silts) located in the larger catchment (to the west of the site) which flows into the main void inflow point. No FPAS or cyanide was detected in all 12 samples collected from within the void.

The long term monitoring dataset, depth profiling and sediment sampling indicate that the void water quality meet ANZECC guidelines for protection of aquatic ecosystems, and also supports beneficial uses for livestock watering and irrigation.

8. Rehabilitation strategies

8.1 Clermont Void

8.1.1 Proposed Rehabilitation Activities

The rehabilitation activities proposed for the Clermont void are summarised in ***Table 8-1***. While the majority of the Clermont void footprint is a NUMA, the low wall will be rehabilitated in a manner that is consistent with the remainder of the out of pit WRDs, and may therefore also support a potential native woodland and light grazing PMLU. In addition, because the pit lake may take many years to develop and equilibrate at the long term steady state level, all drainage features will be constructed to the floor of the void and therefore not rely on future filling to be stable.

Table 8-1 - Clermont void rehabilitation activities

Feature	Scope	Purpose
Reshaping	Provide 20 m height trilinear slopes on the low wall	Erosional stability
Buttressing	Provision of rock buttresses may be required on the eastern, southern and western walls	Geotechnical stability of the high wall and management of spontaneous combustion risks
Layback	Lay back western wall	Geotechnical stability of the high wall (Anakie Metamorphics)
	Rock mulching on lower half of lay back	Erosion protection
	Topsoil and seed upper half of lay back	Erosion protection
Drainage	Bench drains between trilinear slopes on the low wall	Drainage and erosion protection
	Rock lined chutes directing flow from bench drains to the floor of the void	Drainage and erosion protection
Revegetation	Topsoil and seed the rehabilitated low wall	Erosion control and potential future grazing activity
Abandonment bund	Construct abandonment bund on the western wall to tie into the southern landform	Deter access of people, vehicles and animals to the high wall
Southern landform	Bulk out the Gowrie Creek levee to create a permanent landform	Final void flood immunity for events up to 0.1% AEP

8.1.2 Risks and Management Measures

While the final void water quality is expected to concentrate over time, it is not likely to interact with the environment and therefore presents a low risk profile. Proposed management measures are therefore focussed on periodic assessment of the risk profile and seeking optimal outcomes. Specific measures are detailed in ***Table 8-2***.

Table 8-2 - Risks and Management Measures

Risk	Measure	Description
Basis of model predictions incorrect	Continue data collection program	Continue surface water (flow and quality) and groundwater (level and quality) monitoring programs.
	Final void model refinement	Review final void models annually
LOMP changes result in different final void location/configuration	Regular review of LOMP implications for the final void	Modifications to the LOMP should be made with due regard to the implications for final void management.
Public access into the final void	Signage	Install warning signage at regular intervals around the final void rim to warn of the dangers and deter public access
	Abandonment bund	Install abandonment bund around the western pit rim to prevent vehicular access and deter animal access
No egress from the void in the event of access by animals or people	Provide safe egress	Provide batter angle that enable egress at long-term steady state water level

8.1.3 Monitoring Program

Monitoring is required prior to mine closure to confirm the basis for final void planning, and then post closure monitoring is required to ensure that the final void does not cause serious environmental harm to land, surface waters or any recognised groundwater aquifer. A summary of the proposed monitoring program is provided in ***Table 8-3***. Details of operational phase monitoring programs covering analytical suites, monitoring locations, frequencies are provided in separate monitoring plans and align with DES and EA requirements and obligations.

Table 8-3 - Summary Environmental Monitoring Program

Aspect	Monitoring	Phase	
		Prior to mine closure	Post closure
Tertiary basalt aquifer	Groundwater level	✓	✓
	Water quality	✓	✓
Gowrie Creek (Upstream/Downstream)	Flow record	✓	✓
	Water quality	✓	✓
Pit dewatering	Volume	✓	×
	Water quality	✓	×

8.2 Cement Hill void

8.2.1 Proposed Rehabilitation Activities

The rehabilitation activities proposed for the Cement Hill void are summarised in ***Table 8-4***. Since the void is established and performing as intended, the majority of the proposed works are focused on stabilising the spoil batters on the northern, eastern and southern margins.

Table 8-4 - Cement Hill rehabilitation activities

Feature	Scope	Purpose
Reshaping	Covering of saline and dispersive spoil	Erosional stability
	Reshape external batters to 15% gradient	Erosional stability
Flood interaction	Repairing erosion of the weir between the void and the drainage feature.	Erosional stability
	Extending the southern WRD to cover the secondary low point connecting the void and the drainage feature.	Floodplain interaction
Revegetation	Topsoil and seed the rehabilitated low wall	Erosion control and potential future grazing activity

8.2.2 Risks and Management Measures

Since the Cement Hill void has been operating for over 20 years it is considered that there are relatively few unknowns and the risk profile is low. Proposed management measures are therefore focussed on assessing the performance of the rehabilitation activities detailed above. Specific measures are detailed in ***Table 8-5***.

Table 8-5 - Risks and Management Measures

Risk	Measure	Description
Flood related erosion and scour	Stabilise the weir	Stabilise the weir structure and remove the secondary flow path
Public access into the final void	Signage	Install warning signage at regular intervals around the final void rim to warn of the dangers and deter public access
No egress from the void in the event of access by animals or people	Provide safe egress	Provide batter angles that enable egress from the final void at the water level margins

8.2.3 Monitoring Program

A summary of the proposed monitoring program is provided in ***Table 8-6***.

Table 8-6 - Summary Environmental Monitoring Program

Aspect	Monitoring	Phase
		Post closure
Pit lake	Water level	✓
	Water quality above thermocline	✓
	Water quality below thermocline	✓

9. Document Information

Number	Title
Department of Industry, Science, Energy and Resources (DISER) (2011)	Leading Practice Handbooks for sustainable mining: Guide to Leading Practice Sustainable Development in Mining.
Clermont Open Cut (COC) (2019)	Final Void Management Plan.
EGI (2011)	ARD Assessment of Overburden and Coal from the Clermont Mine, Document No. 8151/986.
JBT (2009)	Regional Groundwater Model Update, JBT01-001-008.
Nordstrom, D.K. and Alpers, C.N. (1999)	Geochemistry of Acid Mine Waters, In Plumlee, G.S., and Logsdon, M.J., Eds., the Environmental Geochemistry of Mineral Deposits: Processes, Methods and Health Issues: Reviews In Economic Geology, v. 6A, p. 133-160.
KBR (2015)	Clermont Coal Operations – Final Void Assessment [PDF].
KBR (2018)	Clermont Coal Operations – Final Void Planning – Workshop 2 [PDF].
KBR (2019)	Clermont Coal Operations – Cement Hill Closure [PDF].
Rio Tinto (2004)	Clermont Coal Mine Project – Environmental Impact Statement.
SKM (2005)	Gowrie Creek Diversion Channel and Levee Design Report (Document number: CCM02-5410-RE-CC-0002).

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Appendix 4.8 - Soil and Capping Material Assessment

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1. Introduction

1.1 Purpose

The purpose of this Appendix is to describe soil and capping resources and their management at the CCO, particularly with respect to topsoil. Topsoil management is often the most crucial factor in successful rehabilitation.

1.2 Scope

This appendix outlines the pre-mining soil and current resources available at CCO. It describes the need for amelioration or fertiliser, and the locations of the materials as well as their suitability to support and sustain the proposed PMLUs.

1.3 Standards and Guidelines

As per Condition H6 of the EA granted 9th February 2021, topsoil will be stripped ahead of mining and stockpiled if not used via direct placement on areas that have been prepared to final contour in preparation for vegetation establishment. Prior to using a topsoil resource, whether it be an existing stockpile or stripped topsoil that is direct placed at its final location, the resource will be subjected to a growth medium suitability assessment to determine amelioration and fertiliser requirements. Classification of the soil type and profile will be used to inform stripping depth. This process is particularly important if the topsoil overlies subsoil material that may not support plant growth or which may be susceptible to erosion. Dilution of the valuable topsoil resource via stripping and amalgamation with the underlying hostile material should be avoided via prescription of an appropriate harvesting depth.

All topsoiled areas are to be deep ripped on contour to a depth of not less than 0.5 m to relieve compaction, create a suitable surface for seed lodgement and moisture harvesting, and to key the topsoil into the underlying spoil or subsoil material.

2. Pre-mining Soil Resources

Soil mapping units and their description as provided in the Clermont Coal Mine EIS (RTCA 2004a) are listed in ***Table 2-1*** and shown in ***Figure 2-1***. Regional ecosystems associated with each Soil mapping unit are shown in ***Figure 2-2***.

Table 2-1 - Soil Mapping Units and their associated REs at CCO

Soil Mapping Unit	Soil Description	Associated REs
BCC – Brown Clays	Clay soils derived from unconsolidated sediments, usually on lower slopes and drainage lines. Supports brigalow, Dawson River blackbutt and bauhinia. Neutral to mildly alkaline surfaces to strongly alkaline subsoil, +/- salinity, subsoil sodic. Linear gilgai to 30 cm deep may occur with mounds covered in white quartz pebbles. Profile may be over 2 m deep. **Physical characteristics** – Plant available water capacity is low to moderate depending on the depth to saline or highly sodic layers. **Management** – Erosion hazard in these soils is high due to the high clay content and high sodium levels. Soils are susceptible to compaction when moist and have low ability to repair structure through cracking. The top 20 cm can be stripped for topsoil. **Distinguishing features** – The clay content of surface soils, cracking and colour distinguish these soils from the duplex soils they are associated with. Very low potassium, moderately phosphorus, and moderate organic matter. High to very high levels of salt may occur at approximately 60 cm – 2 m. Erosion hazard in these soils is high due to the high clay content.	11.4.8a, 11.11.1, 11.5.3
DCB – Deep Clays on Basalt	Formed from basalt and occur on gently undulating lower slopes and raised areas surrounded by flat alluvium. They are alkaline to strongly alkaline and are generally non-saline and non-sodic. This soil unit represents the majority of the area to be disturbed by the mine pit. Most of the area has been cleared for rain fed cropping. Shallow linear gilgai (corrugations) of 30 cm depth may occur on lower slopes. **Physical characteristics** – These soils have high to very high plant available water capacity. The surface structure is fine and granular, typically <1 cm diameter. The high clay content allows it to retain water, making it susceptible to compaction. The soil cracks as it dries so it can repair compaction. It is very soft when wet but dries to very strong material. **Management** – Soil will remain wet for long periods if plants are not present to extract water. Moisture content critical for effective stripping and spreading. Nitrogen phosphorus and potassium required to accelerate establishment of vegetation, The top 30 cm can be stockpiled for use as topsoil. These soils can be used for broad-based contour banks, diversion banks and grassed waterways. **Distinguishing features** – These cracking clays occur over basalt on lower slopes, are non-sodic or slightly sodic and free of significant salt.	-
LITH – Lithosols	Lithosols cover a large area of the waste rock dump areas as shallow soils o crests and ridgelines on metamorphic rocks. Poorly developed profiles consisting of clay loam over weathered and unweathered rock. Support ironbark and rosewood. Very low nutrient levels.	11.11.1, 11.4.8a,

Soil Mapping Unit	Soil Description	Associated REs
	Physical characteristics – Very low plant available water capacity. The A horizon has weak structure that will be lost following stripping and spreading. **Management** – Retain vegetative cover. Areas of previously stripped lithosol may be rehabilitated using bunds and diversion banks. They offer no significant topsoil but may be used for gravel extraction. Regeneration of acacia and eucalypt species is occurring on these gravel areas. Areas that have been previously stripped may yield useful, soft weathered rock. The top 20 cm or soft material can be taken for topsoil. **Distinguishing features** – Occur on crests and upper slopes as shallow profiles (lithosols) or areas of bare gravel (stripped lithosols).	11.4.8b, 11.5.3, 11.8.5
ROC – Red Clays	Clay soils derived from unconsolidated sediments, usually on lower slopes and drainage lines. Supports brigalow, Dawson River blackbutt and bauhinia. Neutral to mildly alkaline surfaces to strongly alkaline subsoil, +/- salinity, subsoil sodic. Linear gilgai to 30 cm deep may occur with mounds covered in white quartz pebbles. Profile may be over 2 m deep. **Physical characteristics** – Plant available water capacity is low to moderate depending on the depth to saline or highly sodic layers. **Management** – Erosion hazard in these soils is high due to the high clay content and high sodium levels. Soils are susceptible to compaction when moist and have low ability to repair structure through cracking. The top 20 cm can be stripped for topsoil. **Distinguishing features** – The clay content of surface soils, cracking and colour distinguish these soils from the duplex soils they are associated with. Very low potassium, moderately phosphorus, and moderate organic matter. High to very high levels of salt may occur at approximately 60 cm – 2 m. Erosion hazard in these soils is high due to the high clay content.	11.11.1, 11.5.3
RDB – Red Duplex on Basalt	Non-saline, non-sodic duplex soil formed on basalt and colluvium on lower slopes in undulating rises. Silver leaved ironbark, Dawson River blackbutt, beefwood and brigalow predominant. **Physical characteristics** – This soil has a medium erosion hazard. Bourne and Tuck (1993) consider it had limited suitability for winter forage and crops and that long-term suitability for cropping was doubtful. It supports low productivity pasture uncleared but highly productive pasture when cleared and sown with buffel grass, Rhodes grass, stylo and green panic. Surface susceptible to wind erosion when disturbed. Plant available water capacity is low to medium. **Management** – Nitrogen levels are very low. Avoid stripping topsoil too dry, as this will pulverize structure and generate dust. If large quantities of dust are being generated the soil is too dry. This soil is suitable for dams diversion banks, waterways, narrow based contour banks. The top 20 cm can be stripped and retained as topsoil. The surface soil is a useful source of loam.	11.4.8a, 11.5.3

Soil Mapping Unit	Soil Description	Associated REs
	Distinguishing features – Neutral clay loam surface over strongly structured reddish brown subsoil.	
RDC – Red Duplex on Clay Sheet	Sandy loam surfaced duplex soils on undulating rises. These soils support brigalow, silver leaved ironbark and Dawson River blackbutt. They are weathered from clay sheets and are mixed with brown and red clay units. **Physical characteristics** – Surface soil is very prone to wind erosion and dust generation. Subsoil is highly dispersive and should not be left bare or have run-off concentrated on it. Drains should be pushed up from down slope to avoid exposing subsoil in drain bottoms. This soil has low to very low PAWC. It is suitable for cleared and improved pasture. **Management** – These soils are highly susceptible to gully and rill erosion. Tunnel erosion is common in gully lines indicating the subsoils are highly dispersive. The top 20 cm can be stripped for topsoil. **Distinguishing features** – Lighter surface texture and no subsoil red hues compared with duplexes.	11.4.8a, 11.4.8b, 11.5.3
ROM – Red Duplex on Metamorphics	A widespread duplex soil on moderate to steep slopes on rolling hills in the western third of the lease. Surface is hard-setting. Vegetation includes ironbark, rosewood and Dawson River blackbutt. **Physical characteristics** – The soil has very low plant available water capacity and is suitable for grazing with careful thinning of native vegetation. Gully erosion was observed in disturbed areas. Surface soil is very prone to wind erosion and dust generation. Subsoil is highly dispersive and should not be left bare or have run-off concentrated on it. Drains should be pushed up from down slope to avoid exposing subsoil in drain bottoms. **Management** – Retain vegetative cover. The top 20 cm can be retained for topsoil. **Distinguishing features** – Soil occurs throughout moderate to steep slopes on metamorphic rocks.	11.11.1, 11.4.8a, 11.4.8b
SCB – Shallow Clay on Basalt	These soils occupy the midslopes and undulating areas overlying basalt with mountain coolabah and bloodwood. Some areas have been cleared for forage and grain cropping. They are non-sodic and non-saline. Structure is strong and a granular surface mulch is present. Some basalt cobbles may be present on the surface and in the profile. **Physical characteristics** – Plant available water capacity is medium to high. Depth to weathered basalt ranges from 0.4 – 1.2 m. Plant available water capacity is limited by depth to weathered basalt and horizons containing over 30% gravel. **Management** – High clay content makes this soil difficult to work as it has high strength when dry and is easily compacted when moist. Only strip, cultivate and traffic soil when it is drier than the plastic limit. Erosion hazard in these soils is high due to the high clay content and moderate slopes. These soils have a midly alkaline surface over strongly alkaline subsoil. The upper 20 cm can be stripped. **Distinguishing features** – Lower slope position, cobbles, depth of profile.	11.4.8a, 11.8.5, 11.8.11, 11.5.3

Soil Mapping Unit	Soil Description	Associated REs
SL – Stripped Lithosol	Lithosols cover a large area of the waste rock dump areas as shallow soils o crests and ridgelines on metamorphic rocks. Poorly developed profiles consisting of clay loam over weathered and unweathered rock. Support ironbark and rosewood. Very low nutrient levels. **Physical characteristics** – Very low plant available water capacity. The A horizon has weak structure that will be lost following stripping and spreading. **Management** – Retain vegetative cover. Areas of previously stripped lithosol may be rehabilitated using bunds and diversion banks. They offer no significant topsoil but may be used for gravel extraction. Regeneration of acacia and eucalypt species is occurring on these gravel areas. Areas that have been previously stripped may yield useful, soft weathered rock. The top 20 cm or soft material can be taken for topsoil. **Distinguishing features** – Occur on crests and upper slopes as shallow profiles (lithosols) or areas of bare gravel (stripped lithosols).	11.11.1, 11.4.8b, 11.5.3
VDCA – Very Deep Clay on Alluvium	This soil type occupied a large proportion of the mining lease. It occurs on 1-2% slopes, is susceptible to flooding and supports coolabah woodland, black tea-tree and pasture on the mining lease. Black tea-tree areas commonly have rotting depth restricted by salinity within 1m of the surface. Phosphorus levels are high, nitrogen levels are low. Surface pH is typically >8, subsoils commonly have pH over 9. This soil type is suitable for dryland and irrigated crops where it is not inundated by flooding. Flood prone areas are suitable to grazing. **Physical characteristics** – The surface structure is fine and granular, typically <1 cm diameter. The high clay content allows it to retain water making it susceptible to compaction. It dries to very strong material, making moisture content a critical aspect for operational works. Trafficability is poor when wet. Cracking during dry periods can relieve compaction. It is imperfectly drained and may waterlog after rain and flooding. **Management** – Moderate water erosion hazard, suitable for broad contour banks. Reactive, so requires geotechnical analysis for foundations and large earth structures. Suitable for use in dams, diversion banks, contour banks, and waterways at low slopes. Sown pastures needed if fresh topsoil is not used as native pastures are slow to regenerate unassisted on cultivated land. Nitrogen required to accelerate vegetation establishment. Only strip, cultivate or traffic topsoil when it is drier than the plastic limit. The top 30 cm should be stripped for topsoil. **Distinguishing features** – Occupies low landscape positions, very low slopes, fine surface structure, greater than 2 m soil depth, supports coolabah/black tea-tree on current floodplain. Large, shiny surfaces develop in subsoils. These slickensides or “slippery backs” are generated by rubbing during swelling and shrinking.	11.3.3

Soil Mapping Unit	Soil Description	Associated REs
VSC – Very Shallow Clay on Basalt	These soils occupy the scree slopes and crests of basalt hills and plateau. They are alkaline to strongly alkaline. Land suitability is limited by steep slopes, rockiness and low plant available water capacity. **Physical characteristics** – Erosion hazard in these soils is high due to the high clay content and steep slopes. These soils have a mildly alkaline surface over strongly alkaline subsoil. **Management** – High clay content makes this soil difficult to work as it has high strength when dry and is easily compacted when moist. Only strip, cultivate and traffic soil when it is drier than the plastic limit. These soils are generally unsuitable as topsoil due to large amounts of surface stone. **Distinguishing features** – Occur on crest, have abundant surface stone, shallow soil profile.	-

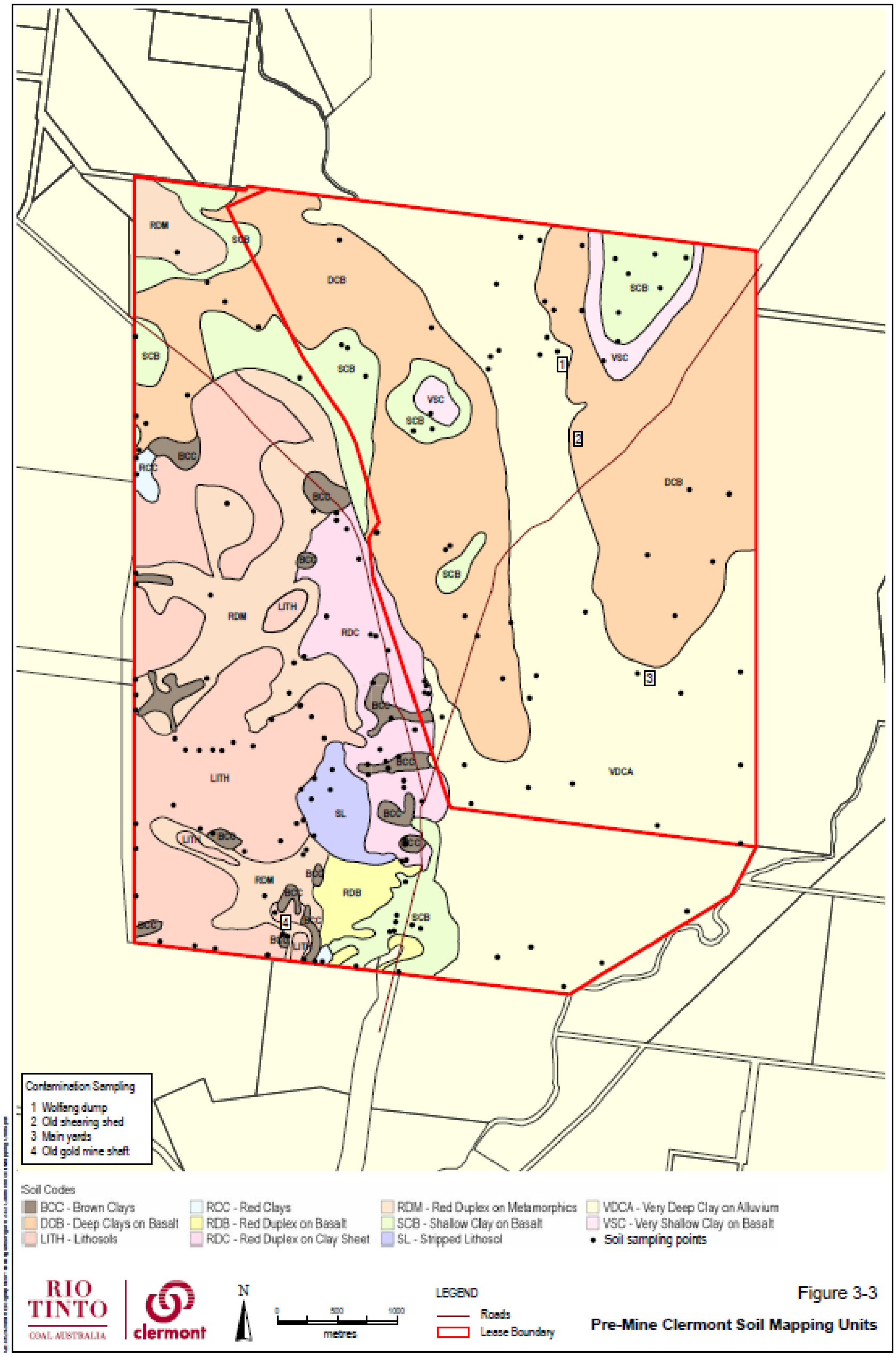

Figure 2-1 - Pre-Mine Clermont Soil Mapping Units

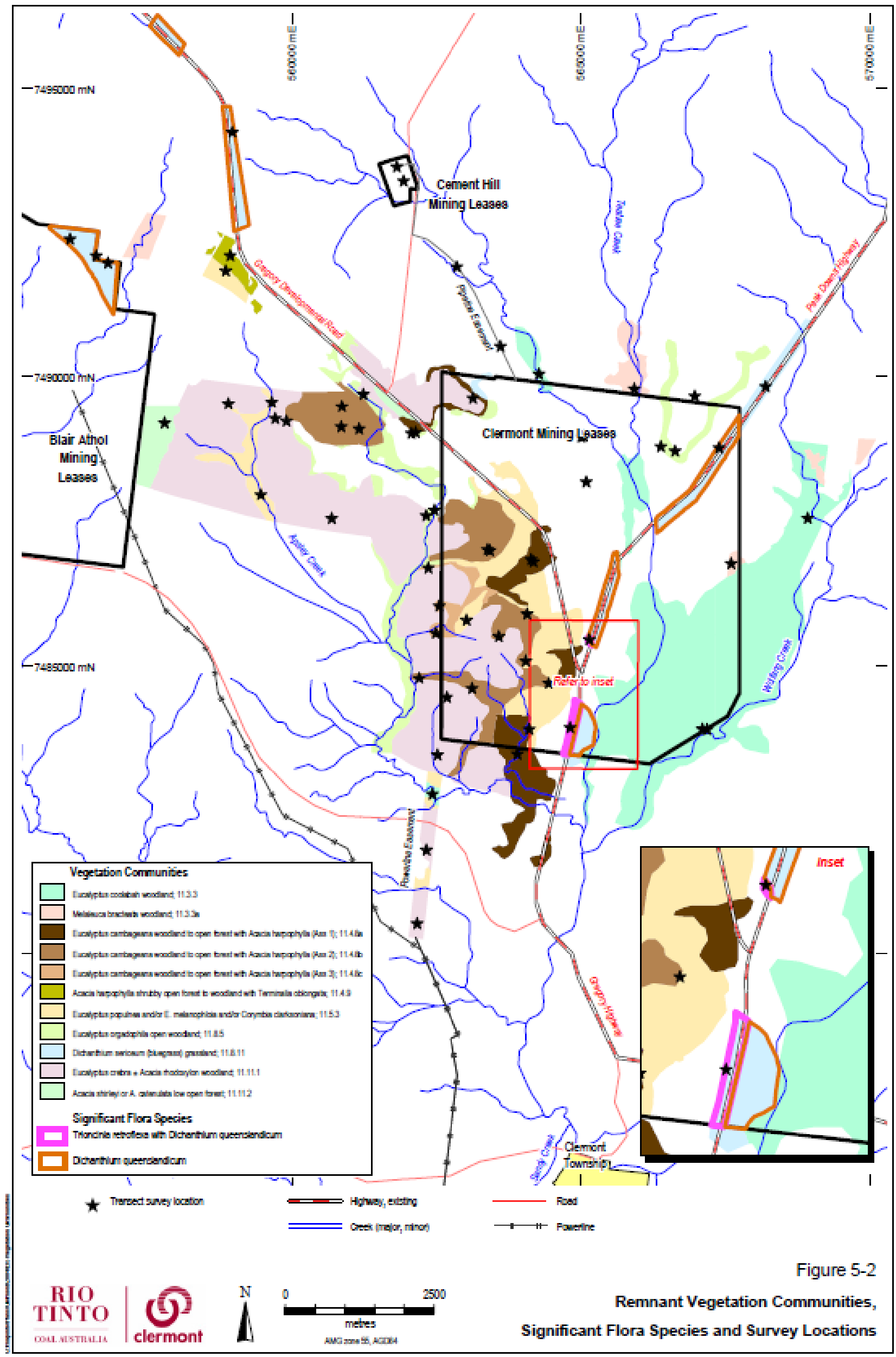

Figure 2-2 - Location of regional ecosystems and significant flora species

3. Current Soil Resources

3.1 Soil Resources

3.1.1 Clermont Mine (CM)

The soil resources at CM can be broken down into three categories each with a number of sub-categories based on studies for the EIS, Soil Mapping and Monitoring campaigns undertaken in 2010, 2011, 2012, and Landloch (2016) (***Table 3-1***).

Table 3-1 - Various Topsoil Characterisation Studies Completed at CM

Soil Mapping (2010 – 2012)		EIS	Topsoil Management Strategy
Alluvial Soils			
A1	Very deep clay on alluvium (drainage lines)	Very deep clay on alluvium	Very deep clay on alluvium (drainage lines)
A2	Very deep clay on alluvium (non-drainage lines)		Very deep clay on alluvium (non-drainage lines)
A3	Gravelly black cracking clay		
Basaltic Soils			
B1	Deep cracking clays on basalt	Moderately deep cracking clays on basalt	Moderately deep cracking clays on basalt
B2	Moderately deep cracking clays on basalt		
B3	Shallow cracking clays on basalt	Shallow cracking clays on basalt	Shallow cracking clays on basalt
Metamorphic Soils			
C2	Gravelly red loam / non cracking clay	Duplex soils on clay sediments	Duplex soils on clay sediments
C4	Gravelly black, grey, brown cracking clays	Brown cracking clay or brown and red cracking clays	Brown and red cracking clays

3.1.2 Cement Hill

Limited soil assessments have been completed at Cement Hill. A material characterisation study was undertaken in 2019 at fifteen tests pits across the site (KBR, 2019) ***(Figure 3-1)***. The soils encountered during excavation of the test pits was variable across the areas sampled. Classification of soil texture in the field is described in ***Table 3-2*** below.

Table 3-2 - Soil Texture Classification

Locations (refer to *Figure 3-1*)	Soil texture
D1, D2 and D3	Predominantly sands and gravels in the eastern section of the out of pit spoil dump.
D5, D6 and D7	Material with a higher proportion of clay and silt was encountered at the southern spoil dumps.
E1	The samples collected from the tailings embankment contained a high percentage of fine material (silt and clay).
Tail1, Tail2 and Tail3	The samples collected from the base of the tailings cells were comprised of predominantly fine material.
MIA	The material encountered within the mine infrastructure area was variable with sandy gravel, clay and loam texture classes observed.

Soil textures with a higher proportion of finer sediment (clay and silt) represent a higher erosion risk based on the results of Emerson Class testing. If these materials are encountered during re-profiling works, they will be placed under a material with non-erosive properties.

3.1.3 Train Load Out

The TLO is located in a landscape which consists of gently sloping country derived from metamorphosed sedimentary rocks intersected by volcanic intrusions mostly to the north of the mining leases. Soil sampling in this area has generally been conducted as a component of CCO's rehabilitation monitoring, and so is viewed in the context of supporting vegetation. Highlands Environmental (2020) collected 63 samples from 31 sites across all the rehabilitation areas in TLO. Soil profiles were excavated by hand auger to a total depth of 90 cm or refusal on rock or gravel. Depending on excavation depth, soil samples were taken from up to five depth increments (0 to 10 cm, 20 to 30 cm, 40 to 50 cm, 60 to 70 cm and 80 to 90 cm depth).

The assessment found that soils in rehabilitation completed prior to 1987 is deficient in macro-nutrients P, Ca, K and S, and micro-nutrient B. Later rehabilitation is deficient in P, Ca, and B only. This likely reflects a change in rehabilitation practices, specifically the type and amount of fertiliser supplied. Laboratory results also showed an imbalance of cations on exchange surfaces. High relative proportions of Na and Mg indicate that soil will have low infiltration and hydraulic conductivity and be prone to dispersion and excessive erosion. This is reflected in field observations of tunnel and gully erosion in rehabilitation, particularly in the 1999 and 2000 rehabilitation (RTCA, 2010).

Figure 3-1 - Location of soil test pits

3.2 Availability of Soil Materials

3.2.1 Quality

Topsoil resources have been characterised for the full CCO footprint, with the initial investigations of in-situ soil resources completed for the EIS subsequently refined for use in an operational context. A hierarchy of Soil Recovery Classes have been assigned to all in-situ topsoil resources, with material salvaged according to the quantities required as well as suitability for use in rehabilitation.

Soil Recovery Class I is considered the top priority material to salvage for rehabilitation, with each subsequent class less desirable but still suitable for use with amelioration and selective use. Class V materials are considered to be of marginal suitability, with restricted applicability (***Table 3-3***).

For both the CH and TLO areas, there are no significant areas of future disturbance, and historic disturbance has occurred without stockpiling of significant topsoil materials. Thus, there are no additional topsoil resources available from these areas. The existing surface materials are suitable to use as a surrogate growth media when rehabilitation activities are completed for those areas, given that these media have supported historic revegetation. It is proposed that typical stripping depths be applied to salvage material at the commencement of reshaping activities for amelioration and use on the final rehabilitated surface.

3.2.1.1 I - Basaltic Topsoil Materials

These topsoil materials (0-0.2 m) are the highest quality growth media materials available. This layer also contains valuable seed, propagules, organic matter and nutrients. They are expected to have negligible limitations to plant growth and will not require soil amelioration other than fertiliser addition. The Basaltic topsoil materials are fit for unrestricted use as primary growth media. They are suitable for use in rehabilitation of the dump tops and batters, and other disturbance categories where sufficient material is available.

The biotic activity of topsoil materials is also a property that is beneficial to preserve. Soil flora and fauna are key to the biological process that lead to the physical breakdown and biochemical transformation of organic matter into simpler organic and inorganic molecules for plant uptake and soil health. These topsoil materials could be used to 'inoculate' other less biologically active materials, such as subsoil and weathered rock, to stimulate biological processes.

In order to preserve the biological activity of topsoil materials, they should either be recovered and placed directly, or stockpiled at heights no greater than 1.5–2.0 m and maintained in a vegetated condition with a mixture of sterile leguminous and non-leguminous species. Use of exotic pasture species as a temporary cover should be avoided unless the soil will be utilised in an area where grazing is the intended PMLU.

3.2.1.2 II - Alluvial Topsoil Materials

The Alluvial soils are derived from deposited materials from fluvial processes along watercourses, paleo-channels, and flood plains. They are also predominantly clay textured; but are relatively heterogeneous in nature and vary widely in salt content and sodicity.

These materials are expected to have a moderate fertility but with regular incidences of appreciable salts and sodicity. Once the sodicity of these materials is addressed, they should be suitable for use and management in the same manner and situations as the Basaltic Topsoil materials.

Table 3-3 - Soil Recovery Class: Rehabilitation Use Hierarchy

Rehabilitation Use Hierarchy (equivalent to Soil Recovery Class)	Description	Amelioration	Suitability	Use for Rehabilitation
I	Basaltic Topsoil materials	Fertiliser only.	Negligible quality limitations. Suitable for dump plateaux and batters.	Unrestricted use as primary growth media within Woodland and Light Grazing PMLU areas
II	Alluvial Topsoil materials	Fertiliser. Low rates of gypsum (2 – 5t/ 1000m^3).	Mild sodicity limitations. Suitable for dump plateaux and batters.	After amelioration, unrestricted use as primary growth media for batter slopes, natural surface or dump top areas within Woodland and Light Grazing PMLU areas
III	Basaltic Subsoil materials	Fertiliser only.	Negligible fertility and organic matter limitations. Better suited to dump tops than batters.	After amelioration, restrict materials to gentler slopes or use soil stability products for dump top and natural surfaces in any Woodland and Light Grazing PMLUs areas
IV	Basaltic Weathered Rock materials	Fertiliser only.	Negligible fertility and organic matter limitations. Potential to provide a rocky surface cover that resists erosion and supports vegetation (green rock mulch).	Use in areas at high risk of water erosion, including Water Management Area PMLUs and the Residual Void NUMA. Also suitable for batter slopes if required
V	Alluvial Subsoil materials	Fertiliser. Very high rates of gypsum (12 – 20t/ 1000m^3).	Appreciable salinity and sodicity limitations.	Marginal materials for plant growth. Not to be used.

3.2.1.3 III - Basaltic Subsoil Materials

The depths of Basaltic soils are expected to vary from 0.5 to 2 m. The subsoil materials (0.2 m to weathered rock) have negligible limitations to plant growth, but are expected to be lower in organic matter and perhaps fertility. A lower organic matter content will result in these materials being more prone to erosion than the topsoil materials; resulting in the materials being more suitable to dump tops than batters. However, the erodibility of these materials could be reduced by the addition of organic materials, application of binders/hydromulch, or with time as vegetation grows and soil organic carbon levels increase. Use of this material under a thin layer of upper horizon topsoil

containing seed, organic matter and nutrients may be advantageous where topsoil resources are insufficient to meet rehabilitation objectives.

3.2.1.4 IV - Basaltic Weathered Rock and Fines from Materials

Below the soil layers there is a zone of weathered rock (C Horizon) that has potential to be used as a plant growth medium and for development of a 'green armour'. Test pits into the weathered rock were able to progress to 5–6 m below ground surface. Morphologic data is not available for these materials; but it is expected that they will include a mixture of gravel to cobble sized rock (~ 50 %), and soil-like materials (although strictly speaking these are not soils because they are largely devoid of biological life or evidence of biological soil forming processes).

These rocky/fines materials are suitable for use as growth media in situations of high erosion hazard. This may include steep slopes, long batters, or channel linings where vegetation is desired together with a degree of rock armouring.

Basalt rock/soil mixtures have been used to good effect in several Central and North Queensland mine sites, with slopes surfaces (on a gradient of approximately 25% to angle of repose) with these materials found to be highly resistant to erosion with satisfactory vegetation growth.

3.2.1.5 V - Alluvial Subsoil Materials

The Alluvial soils are derived from deposited materials from fluvial processes along watercourses, paleo-channels, and flood plains. They are also predominantly clay textured; but are relatively heterogeneous in nature and vary widely in salt content and sodicity.

Recovery and reuse of Alluvial Subsoil materials for rehabilitation will need to allow for management of the saline and sodic properties of the soils. The salt content is generally low–moderately saline; but there are common incidences of localised areas of high salinity. Using these materials in rehabilitation is possible provided the species mix includes salt-tolerant species. It should also be expected that there will be will be areas of 'hot spots' of high salinity where vegetation establishment and growth may be limited by the presence of salts.

Alluvial subsoil identified to be in high salinity zones should be excluded from the soil recovery program. Although stripping and mixing will dilute the highly saline materials such that they should average out to a moderately saline growth media; it would likely result in incidences of saline hot spots due to improper mixing, in which it would be difficult to establish vegetation.

3.2.2 Quantity

The topsoil and other material inventory and balance is reviewed annually to identify annual topsoil quantities required, volumes available for each Soil Recovery Class, and potential locations and access considerations for each material source.

This supports the site in selecting the most cost efficient growth media option for each year, whilst ensuring the quality and quantity of materials are assured for rehabilitation success. Where possible, efforts are made to allow for direct placement of topsoil material into areas of progressive rehabilitation, with existing stockpiled material to be used at the end of the mine life.

Volumes of suitable clay material and competent rock are to be confirmed as each rehabilitation area enters detailed design. If quantities of materials are available from the site footprint, they will be utilised. Alternatively, externally sourced material will be utilised to complete the target rehabilitation methodology.

As of 2021, a total topsoil volume of 4,378,943 m^3 is available. This includes all stockpiled material, and all Clas I-III in-situ topsoil resources that will be salvaged for the remainder of the operation. The current 3,955,500 m^3 application requirements will therefore be covered by the available materials. Application of 100 mm of topsoil is adequate for the lower slope, void, and infrastructure areas. As

such, CCO will continue to optimise the required placement depth according to the quality and quantity of materials available on a year by year basis so as to ensure rehabilitation success whilst also planning to have adequate topsoil materials for the full rehabilitation footprint. Topsoil depth will range from 100 mm to 300 mm according to the rehabilitation methodology to be applied to each area.

3.2.3 Management

Topsoils are stripped from all mine progression areas and are subsequently stockpiled until later reuse for rehabilitation if they are unable to be immediately applied. As freshly stripped and placed topsoil retains more viable seed, micro-organisms, and nutrients than stockpiled soil, direct placement will be applied where practicable. Vegetation establishment is generally improved by using fresh topsoil. Topsoil will be managed so that suitable high-quality growth media is available for all rehabilitation surfaces. This will be achieved by:

- Soil types with significantly different properties will be stockpiled separately and in accordance with contemporary stockpile construction and management practices;
- Locations are recorded using GPS and data recorded relating to the soil type and volume;
- Conducting regular inventory reconciliations of topsoil stockpile locations and volumes to current and projected disturbed areas; and
- Stockpile surfaces are ripped and seeded (if natural revegetation does not provide adequate cover).

Topsoil stripping requirements are considered for any ground disturbance for the mining operation, so that any clearing activities require the identification of topsoil management requirements as appropriate. Refer to Appendix 4.12 – Revegetation Methodology for further details on the revegetation process around topsoil application.

3.3 Availability of Capping Materials

Capping material at CCO largely consists of “clean” waste and basalt materials, which are then used to blend with and encapsulate “reactive” material that has been placed ex-pit; “reactive” material is that which is identified to have acid forming potential and/ or risk of spontaneous combustion (discussed fully in Appendix 4.9 – Mine Waste Characterisation Report). Generally, “reactive” material is placed in-pit, and ideally below the post mining water table RL where it can become permanently submerged (and oxidation therefore inhibited). However, when it cannot be placed in-pit, this reactive material is encapsulated by net – acid consuming material with a basalt base layer. This process is explained in detail in Appendix 4.9.

Capping is not generally required for erosion control purposes at CCO. As is discussed in Appendix 4.11 – Landform Design Report, CCO has adopted an atypical rehabilitation landform design, the tri-linear concave landform, due to space constraints for out of pit (ex-pit) dumps (as a significant volume of material is required to be dumped out of pit prior to space becoming available in pit).

This was based on many natural landforms within the region. These develop a concave slope which tends to reduce erosion potential downslope. Site specific erosivity assessment concluded that the tri-linear profile has improved erosion performance compared to the standard 17 % linear profile (CCO, 2015). Minimal erosion issues have been observed across CCO through the rehabilitation monitoring program.

3.4 Location of Soil and Capping Materials

A survey of all topsoil stockpiles is conducted annually to reconcile the topsoil inventory (***Figure 3-2***). From this updated inventory, decisions are made on the optimal source of topsoil material to support that year's rehabilitation requirements (i.e. directly placed from in situ topsoil resources or from stockpiles). In turn, this informs the preferred location and haul routes for the growth media material to be used. Should there be an excess of material stripped during the year, decisions are also made on the manner and location of stockpiling.

3.5 Amelioration and Fertiliser Assessment

Soil testing is undertaken immediately prior to use in rehabilitation, and the advice of an Appropriately Qualified Person (AQP) sought to ensure accurate prescription of ameliorants and fertilisers for each area of rehabilitation to understand the nature of the growth media being rehabilitated.

Optimum or reference values for a number of key soil properties are listed in ***Table 3-4***. However, where the soil samples indicate deficiencies, amelioration will be undertaken. Fertilisers or manures are spread prior to seeding to increase soil fertility and organic carbon characteristics, or to adjust soil pH or sodicity if required.

Table 3-4 - Optimum Criteria for Key Soil Properties

Parameter	Land use – Pasture	Land use – Woodland
pH	5.5 – 7.5	5.0 – 8.5
EC (µS/cm)	< 700	< 700
Sulphates (mg/kg)	5 – 10	5 – 10
Nitrates (mg/kg)	> 12.5	> 12.5
Kjeldahl Nitrogen Total (mg/kg)	200-1000	200-1000
Phosphorus (mg/kg)	≥ 50	≥ 50
Chloride (mg/kg)	< 350	< 350
Cation Exchange Capacity (CEC) and Exchangeable cations (m_{eq}/100g)	>5	>5
Exchangeable Sodium Percentage (ESP) (%)	< 5	< 5
Organic Matter (mg/kg)	2-3	2-3

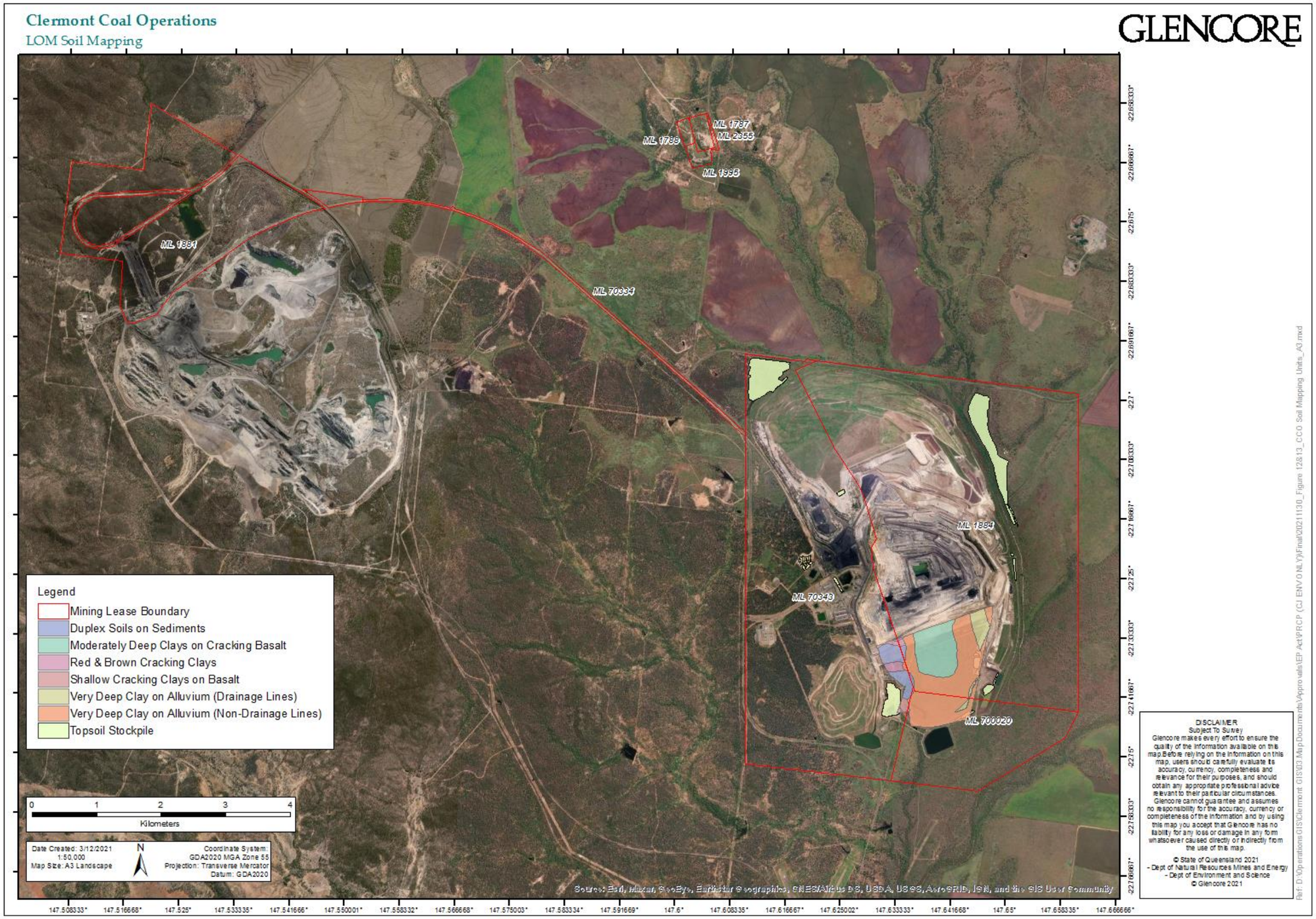

Figure 3-2 – Current Topsoil Mapping Units

A constraint of concern to topsoil resources for the CM area is salinity, which is difficult to ameliorate in clay soils. Also of concern is subsoil sodicity, which can be ameliorated but may be impractical and costly due to the high volumes of ameliorant required. Below are estimated rates for alluvial materials (Landloch, 2017):

- For Soil Recovery Class II - Alluvial Topsoil Materials, gypsum amelioration rates are estimated at a rate of 2–5 t/1000 m^3; and
- For Soil Recovery Class V – Alluvial Subsoil Materials, amelioration of the sodic properties can be done by the thorough incorporation of gypsum. The default rate should be 12.5 t/1000 m^3 (i.e. 37.5 t/ha for a 0.3 m thickness application of soil) if materials are to be used on dump tops. Where materials are used on batters then an additional 6 t/1000 m^3 should be applied when the soil is being prepared for sowing.

Where gypsum or lime is required, the recommended rates should be spread prior to soil stripping to ensure:

- Thorough mixing; and
- Maximum time for dissolution and greater improvement in soil properties.

Additional treatments may include rock armouring of washouts/gullies and supplementary application of gypsum or other fertilisers. Past soil assessments for CM indicate that the need for ameliorants and fertiliser varies, depending on the Soil Recovery Class of the resource as well as localised physical and chemical characterisation. The classification has prioritised the salvage and use of material which requires less remediation and amelioration.

Fertiliser application broadly aims to return the rehabilitated soil profile's fertility to that of equivalent undisturbed soil profiles in good condition supporting similar vegetation to that targeted in rehabilitation. Challenges for fertiliser application include:

- Difficulties with highly infertile soils, where it is not possible to add the large quantities required without damaging plant growth in the short term;
- Achieving effective placement, as some fertilisers (particularly K and P) can be relatively immobile in soils, and are most effective if incorporated; and
- Possible impacts of fertiliser types and rates on establishment of some specific plant groups.

No further soil resources are anticipated to be disturbed for the CH or TLO areas, however, further investigations to characterise the soil and surface materials relevant to rehabilitation at these two locations is likely to be conducted as rehabilitation activities commence within these areas.

Clay and rock materials do not require amelioration, however all available quantities will be retained as they represent useful resources to support WRD encapsulation, ameliorate Reactive materials through chemical neutralisation, and may also be used to cap other materials that require treatment.

3.6 Suitability of Materials to Support PMLU Outcomes

The project area is included in four Land Resource Areas (LRAs) by Bourne and Tuck (1993) (***Table 3-5***). These LRAs represent a repeated pattern of soils, vegetation and geology. The dominant profiles listed for the LRAs are consistent with the most common soils found at CCO, indicating that the soil materials available will be adequate to support the desired PMLU outcomes. Vegetation types are strongly influenced by land systems and soil types. Appendix 4.12 provides further detail on plant species selection with considerations given to the regulatory constraints of the approvals, the surrounding and post-mining land use concept, and the capacity of the available topsoil resources at the time of revegetation to support the selected species.

Table 3-5 - Land Resource Areas of Bourne and Tuck (1993) contained in the Project Area

Land Resource Area	Landform	Soils	Soils Recovery Class	Vegetation	Land Use	Adopted PMLU
Alluvial Plains	Level plains on Quaternary alluvium	Cracking clays, non-cracking clays and solodics	Alluvial Soils, Classes II	Eucalyptus woodlands with coolabah and poplar box	Rain fed and irrigated cropping; grazing on native and sown pastures	Woodland and Light Grazing
Undulating scrub plains	Undulating plains and rises developed on sedimentary rocks, tertiary basalts and unconsolidated sediments	Cracking clays, solodics, redbrown earths, non-cracking clays and structured earths	Basaltic Soils, Classes I & III	Brigalow and gidgee scrubs, minor communities of poplar box, belah and Dawson gum	Rain fed cropping, grazing on sown pastures, minor irrigated cropping	Woodland and Light Grazing
Undulating Downs	Gently undulating plains formed on basalts, Permian shales sandstone and unconsolidated sediments	Black, brown and grey cracking clays; frequent stony phases	Basaltic Soils, Classes I, III & IV	Bluegrass, Mitchell grass, minor elements of mountain coolabah open woodland, bloodwoods and silver leaved ironbark	Rain fed cropping and grazing on native pastures: minor irrigated cropping	Woodland and Light Grazing
Ranges	Undulating to very steep hills formed on sedimentary rocks, metamorphics	Stony lithosols, hallow loams, minor red and yellow earths, non-calcic brown s soils and solodic soils	Metamorphic Soils, Not available for recovery	Woodlands of narrow leaved ironbark, silver leaved ironbark, ghost gum, bendee, lancewood or cypress pine	Grazing on native pastures	Woodland and Light Grazing

4. Summary

This appendix covers pre-mining soil resources available at CCO and how the current available resources correlate. It also discusses the current known availability and quality of soil and capping materials, whether they require amelioration or fertiliser, as well as their suitability to support and sustain the desired PMLU planned for the CCO areas.

5. Document Information

Reference	Title
CCO (2015)	Clermont Rehabilitation landform design and erosivity assessment.
CCO (2016)	Clermont Coal Operations – Annual Rehabilitation and Land Management: 2017 Update.
CCO (2018)	Clermont Coal Operations – Topsoil Management Strategy for 2020.
CCO (2020)	Clermont Coal Operations – Rehabilitation Management Plan (CLEOC-900537260-6).
Dames and Moore (1983)	Waste management and rehabilitation programme – soil and overburden characterisation
Department of Environment and Science (DES) (2019)	Guideline for Progressive Rehabilitation and Closure Plans (PRC plans). ESR/2019/4964, Version 1.00, Effective: 01 NOV 2019.
Department of Environment, Climate Change and Water NSW (DECCW) (2009)	Protocols for soil condition and land capability monitoring.
Department of Industry, Science, Energy and Resources (DISER) (2016)	Leading Practice Handbook for sustainable mining: Mine Rehabilitation.
International Council on Mining & Metals (ICMM) (2019)	Integrated Mine Closure: Good practice guide, 2nd edition.
Isbell, R & National Committee on Soil and Terrain (2016)	The Australian Soil Classification, Australian Soil and Land Survey Handbooks Series - Third Edition.
Kellogg, Brown & Root (KBR) (2019)	Clermont Coal Operations – Cement Hill Closure: Initial Data Collection
Landloch (2012)	Rehabilitation Monitoring on Blair Athol Coal Mine, Queensland. Draft Report prepared for Rio Tinto.
Landloch (2016)	Discussion of the potential to recover topsoil from deeper in the soil profile to assist operational efficiencies and address possible inventory shortfalls (1218 16b COC Growth Media Suitability_Rev1_17Aug2016.docx).
Landloch (2017)	Soil Assessment for the 2017- 2018 Pushback Program, Clermont Open Cut Coal Mine, 1218.17a.

Reference	Title
McKenzie, N, Grundy, M, Webster R & Ringrose-Voase, A (2008)	Guidelines for surveying soil and land resources, Second Edition.
Munsell Colour (2009)	Munsell Soil Colour Chart.
National Committee on Soil and Terrain (NCST) (2009)	Australian Soil and Land Survey Handbooks Series, Third Edition.
Rayment, G & Lyon, D (2011)	Soil Chemical Methods Australasia.
Rio Tinto Coal Australia (RTCA) (2004a, 2004b)	Clermont Coal Mine Project Environmental Impact Statement (EIS).
Rio Tinto Coal Australia (RTCA) (2010)	Blair Athol Coal Project – Mine Closure Plan, Version 3.2, September 2011.
Soil Mapping and Monitoring (2010)	Soil mapping and topsoil stripping recommendations for FY10/11 disturbance areas, Clermont Coal Project.
Soil Mapping and Monitoring (2011)	Soil mapping and stripping recommendations for Clermont Coal Mine, Stage 2 – disturbance areas for 2011.
Soil Mapping and Monitoring (2012)	Soil mapping and stripping recommendations for Clermont Coal Mine, Stage 3 – Pre-mining disturbance areas for 2012.

CLERMONT
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Appendix 4.9 - Mine Waste Characterisation

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1. Introduction

1.1 Purpose

This mine waste characterisation report summarises the relevant plans and studies undertaken to date, and aims to achieve the following outcomes:

- Demonstrate that the sampling regime meets leading practice standards, is spatially representative of all material being mined (i.e. the ore body, exposed pit walls and overburden etc.) and representative of all lithologies;
- Be capable of confidently classifying mine waste streams based on environmental risk and managements requirements;
- Be capable of generating block models and estimating the volume of mine waste based on waste type (i.e. level of environmental risk);
- That the developed waste block model can be used to generate the waste mining schedule for selective placement of different waste types during the life of the mine;
- The waste block can be used to develop the materials balance for design and construction of the mine waste storages; and
- Provide recommendations for the management and mitigation of waste streams to manage environmental risk and achieve proposed rehabilitation methods and objectives.

1.2 Scope

This document, Appendix 4.9 – Mine Waste Characterisation Report focuses on the geochemical characteristics of waste and their relationship with environmental factors. Geotechnical characteristics and hazards of waste material are described elsewhere within this PRCP, primarily within Appendix 4.4 and Appendix 4.11 of the PRCP. Appendix 4.10 of the PRCP contains information specifically relating to the TSF facilities, including geochemical risks.

1.3 Standards and Guidelines

The regulatory framework for geochemical characterisation of sulfidic geologic materials to assess their AMD potential is diverse in Australia, but is generally based on the following sources:

- AMIRA (2002) ARD Test Handbook - Prediction and Kinetic Control of Acid Mine Drainage; AMIRA International. Project P387A Prediction & Kinetic Control of Acid Mine Drainage, Ian Wark Research Institute and Environmental Geochemistry International Pty Ltd;
- List of Potential Information Requirements in Metal Leaching/Acid Rock Drainage Assessment and Mitigation, MEND Report 5.10E, January 2005;
- Prediction Manual for Drainage Chemistry from Sulfidic Geologic Materials, MEND Report 1.20.1, December 2009;
- The Global Acid Rock Drainage Guide, International Network for Acid Prevention INAP, 2014; and
- Leading Practice Handbook - Sustainable Development Program for the Mining Industry. Preventing Acid and Metalliferous Drainage, DFAT, 2016.

2. Geology

Waste characteristics of concern in rehabilitation and closure are primarily related to their geological origin, and associated geochemical properties.

At CM, five distinct coal seams are mined. These are located within Permian deposits at depths ranging from 80 m to 290 m, as illustrated in ***Figure 2-1***. The overburden consists of Quaternary soils and subsoils overlying Tertiary basalts, sedimentary rock, and loose sedimentary deposits. The Permian coal seams include fossiliferous micaceous claystone and sandstone of marine origin at the upper part of the Permian sequence, over sandstone and siltstone bands with minor conglomerate and mudstone interbedded with the coal seams.

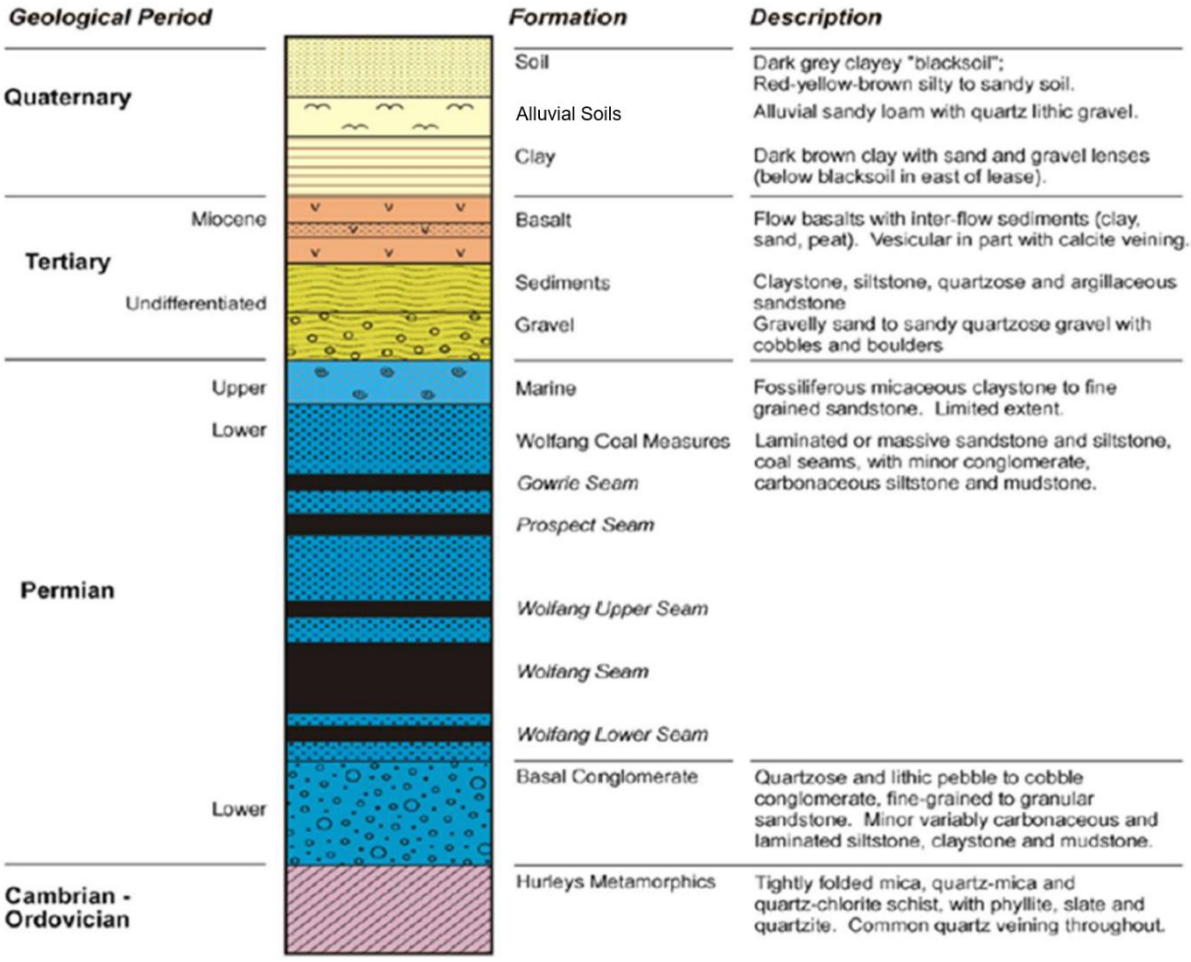

Figure 2-1 - Typical Stratigraphic Sequence at CCO

At CH, substrate characterisation of groundwater bores extending to depths of over 50 m below the surface within the general area of the mine indicate that the deepest layers here consist of conglomerate (Basal Conglomerate). A 10-20 m thick layer of basalt overlies the conglomerate, across most of the area, except in the south, where a 10 m thick layer of clay occurs between the conglomerate and the basalt. Test pits across the CH lease area show that surface layers tested (1.6 – 4 m depth) consist of clays, silts, sands, and gravels.

At Blair Athol (BA) mine (where the TLO is located), the coal bearing sequence consists of sandstone, siltstone, mudstone, conglomerate and four significant coal seams (identified as Seams No. 1, 2, 3 and 4) (refer ***Figure 2-2***). The sequence overlies a basement of Anakie Metamorphics and a basal conglomerate consisting of coarse sandstone and minor carbonaceous shales with stony coal seams.

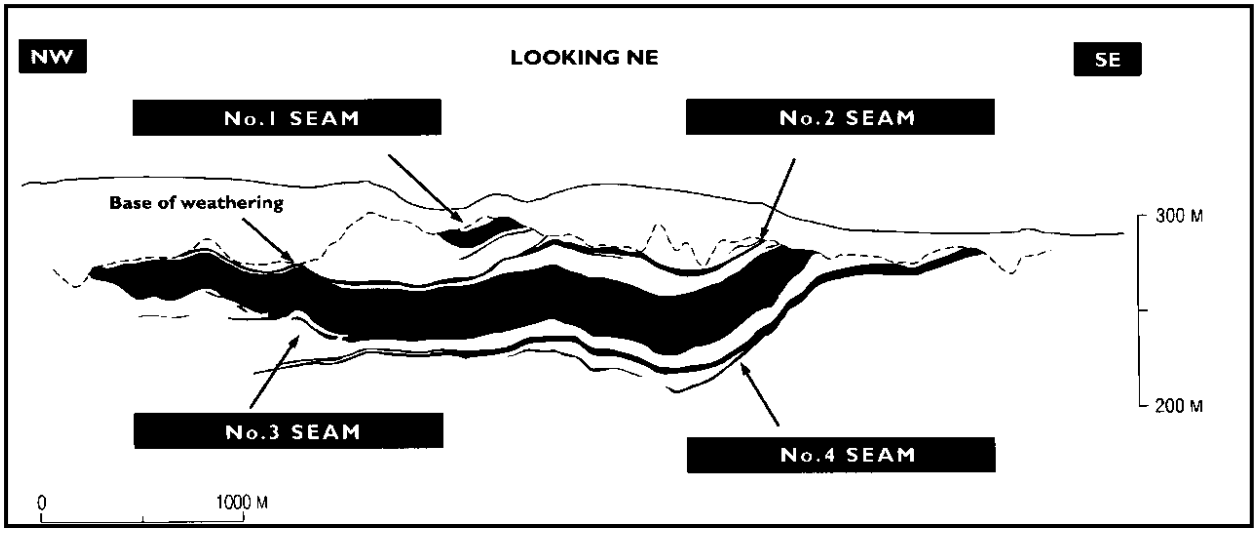

Figure 2-2 - Typical Stratigraphic Sequence at BA

Overburden material is primarily made up of white sandstone with minor silty bands ranging from 25-55 m in thickness above Seam No. 3. Overlying the coal measures are tertiary flow basalts and quaternary alluvial deposits. The basalts occur in the north and north-east of the coalfield and average between 18 m and 22 m in thickness.

3. Previous Geochemical Characterisation

Extensive geochemical characterisation of waste material from CCO has been undertaken between 1997 (RTTS, 1997) and 2011 (EGi, 2004, 2008, 2011). In 2012, 2014, 2017, 2018 and 2019 further sampling and geochemical characterisation was completed (KCB, 2015, KCB, 2017, and KCB, 2020), with sampling and testing now incorporated into site operations as an ongoing task. The earlier results were included in the Clermont Coal Mine Project Environmental Impact Statement (EIS) (RTCA, 2004) and included characterisation of a large number of samples of all lithologies, as well as coal rejects. Each subsequent characterisation program has involved analysis of additional samples from the expected disturbance area using drill holes undertaken for both exploration and resource development.

KCB (2015) estimated that approximately 500 samples are necessary to characterise the volume of material at CCO. This total was achieved in June 2018, and the subsequent geochemical AMD characterisation has built on a substantial dataset of more than 850 samples (KCB, 2017). ***Figure 3-1*** shows that the spatial distribution of this sampling has covered the entire mine footprint, and all lithologies. Ongoing AMD monitoring programs will focus on the performance of waste placement practices and structures, as well as the continued verification of the different lithological units as they are mined and placed into WRD structures.

No waste characterisation details are available dating from when CH or the TLO part of the lease were operational (pre-mid-1990s and from the 1980s to mid-2010s, respectively). However, KBR (2019) provides data and findings on a number of investigations at CH, including on material characterisation from test pit samples and soil chemistry.

Characterisation of mineral waste from the Blair Athol operation (the wider operation on which the TLO section of the lease sits) has been undertaken through various geochemical assessments over the life of the operation, and categorised in accordance with its acid mine drainage (AMD) potential, in line with the current classification for CCO. A range of overburden and interburden types were tested by Dames and Moore (1983), with further AMD analysis of waste material performed as part of exploration drilling as well as operational sampling campaigns between 2006 and 2016.

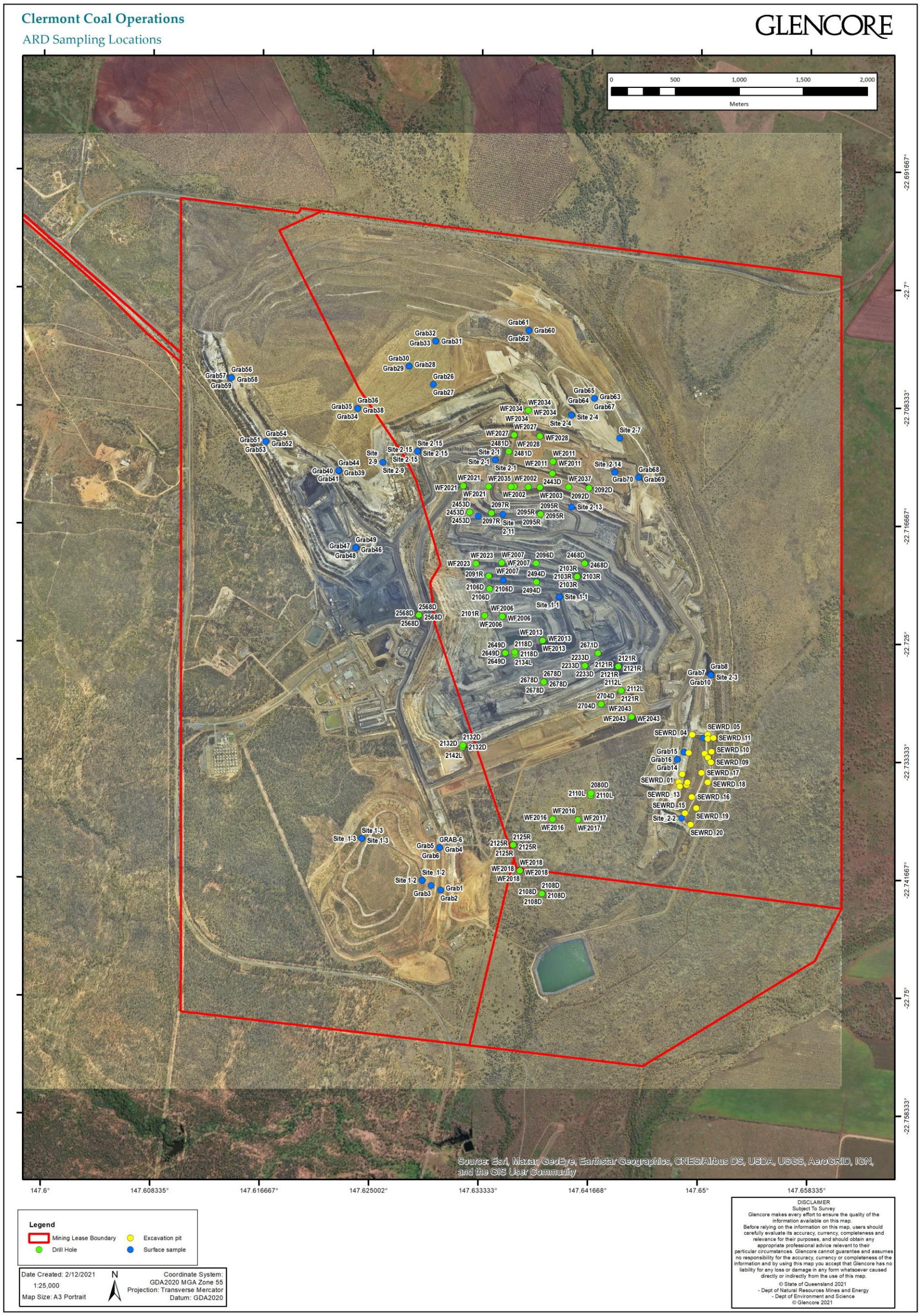

Figure 3-1 - Distribution of previous geochemistry samples at CM

4. Summary of Geochemical Hazards

Interaction between mineral wastes and groundwater can be detrimental to the environment and must therefore be carefully managed. Three types of chemical interaction are especially relevant at CCO:

- Acidification of groundwater (also due to sulfide oxidation);
- Spontaneous combustion of organic material (due to sulfide oxidation); and
- Leaching of soluble salts, salinity and metals and discharge to surface water and groundwater.

4.1 Potential for Acid Metalliferous Drainage

4.1.1 Clermont

The prevalence of acid drainage potential, classed into NAF, PAF-LC and PAF materials for the various rock types at CCO was most recently reviewed by KCB (2018), as summarised in ***Table 4-1***. Methods included field testing (portable X-ray fluorescence spectroscopy, field pH, and pH_{FOX}) and laboratory testing of 198 samples (X-ray fluorescence spectroscopy, static acid-base accounting, acid buffering characteristic curves, sequential NAG testing).

The results confirm previous geochemical characterisation programs, indicating that the bulk of the overburden material (particularly the quaternary sediments) is non-acid forming (NAF). However, potentially acid forming (PAF) and PAF low capacity (PAF-LC) horizons were identified within Tertiary and Permian sediments. Coal materials tested are dominantly PAF, although some are classified as PAF-LC. In addition, the coal stockpiles, processing wastes, coal washery wastes and coal reject wastes are potential sources of acid drainage. Coal rejects waste material are also susceptible to self-heating and generating spontaneous combustion, in addition to being potentially acid forming.

Table 4-1 - Relative proportions of different AMD classes by rock type at CCO

Geology		NAF	PAF-LC	PAF
Quaternary Sediments		100%	0%	0%
Tertiary Overburden	Basalts	80%	16%	4%
	Sedimentary	61%	27%	12%
	Combined	70%	22%	8%
Permian Overburden		65%	18%	17%
Permian Coal		15%	27%	58%

From the site characterisation, the following units are most likely to be classified as PAF:

- Carbonaceous/coal Tertiary sediment material within 5 m of the lower basalt boundary;
- Overburden within 5 m of the Wolfang Upper (WU) seam roof;

- Interburden between Wolfang and Wolfang Lower seams;
- Wolfang Lower seam splits;
- Wolfang Lower seam floor; and
- Possibly Gowrie seam floor and roof pendants.

Based on testing, units from the roof and floor within 2 m of coal seams, and interburden and partings between seam splits, should be treated as PAF unless confidently characterised as NAF. All of the Permian Coal samples tested to date are PAF, but most had only a low acid potential (PAF-LC). The AMD potential of interburden and overburden material is higher immediately above and below the coal seams (particularly the Gowrie and Prospect seams). ***Table 4-2*** shows the current distribution of geochemical acid forming propensities with respect to major lithological units intersected by the mining operation.

Table 4-2 - Distribution of geochemical acid forming propensities for major lithological units

Lithological Unit	Distribution of geochemical acid forming abilities (%)			Volume of each lithological unit (Mbcm)	Volume of geochemical acid forming abilities (Mbcm)		
Classification	NAF	PAF-LC	PAF		NAF	PAF-LC	PAF
Quaternary clay / weathered basalt	100%	0%	0%	123 (17%)	123	0	0
Tertiary basalt	80%	16%	4%	189 (27%)	151	30	8
Tertiary sediments	61%	27%	12%	62 (9%)	38	17	7
Permian sediments	65%	18%	17%	334 (47%)	217	60	57

Of particular importance to the management of mineral waste at CCO is that the PAF materials have very short lag times to acidity (i.e. rapidly acidify). This has been confirmed by testing completed by CCO in 2014 (KCB, 2018). The 2014 testing indicated a large proportion of the samples show potential for acidification if allowed to oxidise. Ex-pit material (i.e. above RL of 222 m) was confirmed as generally NAF or low reactivity.

As was mentioned in ***Section 3***, testing of placed mineral waste within the ex-pit dumps (NWRD, SWRD and SEWRD) and the pit was undertaken during 2018-2019 (KCB, 2020). Field testing was by hand held pH (pH_F) instrument. Laboratory testing (n=340) included Phase 1 (n=340, X-ray fluorescence spectroscopy, pH_F, and pH_{FOX}), Phase 2 (n=70, TS, ANC, NAPP, NAG), and Phase 3 (n=20, leach tests for major cations, anions, and trace metals).

These tests indicated that, while the proportion of PAF samples is higher in in-pit samples than ex-pit samples, 3 percent of the ex-pit samples are acidic by their pH_F results, and 9 percent are PAF by their pH_{FOX} results. PAF samples were collected from across the ex-pit areas, but were most prevalent in the SEWRD.

These areas do not exhibit any signs of AMD, indicating there may be adequate buffering capacity within the WRD. The externally draining portion of the site has also been rehabilitated, with the vegetation cover starting to stabilise the area. Continued inspection and monitoring for reactivity,

which will occur as part of rehabilitation monitoring and normal site operations, is likely to be appropriate to highlight AMD concerns if apparent in the future.

Results from the 2018-2019 leach tests showed that sulfate (SO_4^{2-}) was the dominant anion, being 10-100 times more abundant than Cl^- (the next most abundant anion). As there were no dominant cation species, it suggests that acid neutralisation is provided by both the alkalinity in the water and by more than one mineral at CCO. Trace metals tested were low or essentially absent.

4.1.2 Cement Hill

At Cement Hill, test pit samples indicate a low potential for acid generation across the site, while the net neutralisation potential was higher than the potential acidity values. All samples taken from the site would be classified as NAF (and as described in KBR, 2019). Heavy metals testing indicated levels similar to background levels, except for arsenic (As), which was slightly elevated in the spoil dumps and tailings area.

4.1.3 TLO

Historical data on AMD potential for the Blair Athol area has considered the former operational footprint, of which the current TLO is the northern portion only. EGi (2006) identified that most of the overburden material was NAF and unlikely to be a concern with respect to AMD or element (neutral mineral - NMD) toxicity.

The highest AMD risk related to historic BA materials are the coal washery wastes, and as a result, associated tailings storage facilities. There are no historical TSF structures, or coal washery wastes which have been placed within the current BA footprint for CCO (associated with the TLO). There is also no evidence of apparent AMD from the existing rehabilitated areas, comprising old overburden materials from the former site. Given these rehabilitated areas were constructed between the 1980s and early 2000s, it is considered that if any AMD materials were going to be of concern, they would have become apparent by now.

4.2 Potential for Neutral Metalliferous Drainage

Neutral metalliferous drainage (NMD) is characterised by drainage with a neutral pH but elevated sulfate and dissolved metals concentrations. If these consitituents are present at high concentrations in soils or mineral wastes, they may directly inhibit plant growth or may pose an exposure risk to terrestrial or aquatic fauna.

The current characterisation of waste suggests that the likelihood of significant metalliferous concentrations under neutral conditions is moderate to low at CCO, with toxic metal concentrations in leachates generally low (KCB, 2020).

4.3 Potential for Spontaneous Combustion

For CCO, the primary lithologies of concern for spontaneous combustion are the coal seams themselves, especially the Wolfang and Gowrie Seams. These two seams represent different risks for spontaneous combustion, since the underlying mechanisms leading to combustion differ. The reactivity of the Gowrie Seam is an inherent characteristic of the rock; a result of the fine-grained pyritic materials present in the lens. In contrast, the Wolfang Seam is reactive largely due to interactions with external factors, such as moisture and weather conditions.

CCO has experienced incidents of spontaneous combustion in the coal and associated mineral waste, and has several methods of identifying spontaneous combustion. These include geological modelling, mine planning, visual inspections and temperature and gas monitoring.

Experience at CCO has shown that coal and units that contain coal are most susceptible to spontaneous combustion. These units are also those most likely to be PAF (***Table 4-1***), and hence management for AMD also includes management of spontaneous combustion and *vice versa*. Therefore, a common placement approach has been developed and is discussed in ***Section 8***. This document will refer to AMD management as the primary control to also prevent spontaneous combustion in the dumps.

Operationally, CCO uses the terms "reactive" and "clean" to differentiate between materials at risk of spontaneous combustion; and only material with no spontaneous combustion risk or PAF risk is regarded as "clean" and therefore suitable for direct ex-pit disposal.

4.4 Potential for Saline Drainage

4.4.1 Clermont

Measurements of sodicity have been undertaken in CCO's characterisation programs. The exchangeable sodium percentage (ESP), exchangeable sodium as a percentage of the total effective cation exchange capacity (ECEC), is used as a measure of sodicity. A summary of the results classified by ESP is provided below in ***Table 4-3*** (Rio Tinto, 2005).

Table 4-3 - Sodicity of overburden and interburden samples from CCO

Exchangeable Sodium %	Number Samples	Proportion of total samples
< 6% (non-sodic)	163	86.2%
6-10% (sodic – low)	22	11.6%
10-15% (sodic – medium)	3	1.6%
15-30% (highly sodic)	1	0.5%
> 30% (very highly sodic)	0	0.0%

Of the low to highly sodic samples listed in ***Table 4-3***, the vast majority (85%) are associated with, or in very close proximity to, three main lithologies – clay, coal (or other carbonaceous material), and conglomerate. However, carbonaceous materials and conglomerate have relatively low total effective cation exchange capacities (ECEC) (< 10 meq/100 g), resulting in a low potential for sodium to be released from these materials.

Only clay samples were found to have both elevated ESP values (> 10% ESP) and relatively high ECEC values (> 20 meq/100 g). Clay should not be used for near-surface rehabilitation activities, as high sodicity in these materials has the potential to inhibit plant growth.

Therefore, leaching of soluble salts is not considered a major hazard at CCO, since measurements of sodicity in waste materials indicate a low potential for release of sodium. However, the quaternary clay returned elevated sodicity, and therefore should not be used for near-surface rehabilitation activities.

4.4.2 Cement Hill

KBR (2019) completed sampling of 15 test pits (1.5-4 m depth) across the Cement Hill site. This indicated that the subsoils are extremely sodic (based on ESP) but non-saline to slightly saline (based on EC), except for samples from the waste dumps, which were extremely sodic as well as moderately to extremely saline.

4.4.3 TLO

No direct geochemical or physical data are available for Blair Athol, although a number of characterisation studies have occurred over the history of the site, and also further described in the Blair Athol Coal Project – Mine Closure Plan (2010). Direct review of these historic characterisation studies has not been possible, thus adequacy of sampling in terms of scope of analysis as well as representativeness cannot be completed.

However, considering the nature of the TLO area, the disturbance footprint comprises primarily infrastructure such as stockpiles, train load-out, roads and tracks, water management structures and historic rehabilitation areas. Given the age of existing waste emplacements within this area, and that no seepage concerns have been observed, the risk of saline drainage is considered to be low.

There are also historical rehabilitation areas at the TLO, some parts of which exhibit significant erosion. It is likely that these areas are sodic, and may also be saline.

5. Waste Classification Criteria

In order to store mineral waste appropriately with respect to the previously discussed hazards, produced waste must be classified. The criteria used for classification are discussed below, and are sourced from the site's Mineral Waste Management Plan (MWMP, 2020). These criteria have been adapted from those specified in the AMIRA (2002) ARD test handbook. They are relevant to CM only and not to the TLO and CH, where waste is no longer produced.

Geochemical testing has shown that sodicity is generally not an issue at CCO, except in the Quaternary clay materials of the overburden (***Section 4.4***), which should therefore not be used for near-surface remediation activities. Further, geochemical testing has shown that material that is subject to spontaneous combustion is also likely to be acid forming and hence management measures to treat AMD are also applicable to managing spontaneous combustion (***Section 4.3***). On that basis, waste material at CCO is classified on its propensity to generate acid, and managed accordingly.

Specifically, geochemical analysis of waste material is used to calculate its Net Acid Generation (NAG) and Net Acid Producing Potential (NAPP), and the material is then classified according to whether these parameters exceed particular thresholds.

The following three categories of AMD-potential are recognized, and defined by the following criteria:

1. Non-Acid-Forming (NAF)
    - Total S $\leq$ 0.05%; or
    - 0.05% < Total S $\leq$ 0.5% and NAG pH $\geq$ 4.5, and NAPP < 0 kg/t H_2SO_4
2. Potentially Acid Forming (PAF)
    - Total S > 0.5%, NAPP > 10 kg/t H_2SO_4
3. Potentially Acid Forming-Low Capacity (PAF-LC)
    - Total S > 0.05%, 0 < NAPP < 10 kg/t H_2SO_4 and NAG pH < 4.5

In general, 0.5% S is defined as a cut-off limit, above which material should be segregated and encapsulated or effectively blended to have an overall Acid Neutralising Capacity to Maximum Potential Acidity ratio of more than three (ANC:MPA>3).

Materials that contain an excess of acid-consuming minerals are net-acid-consuming. At CCO, these include Basalt and Quaternary Sediment (***Section 4.1***). However, CCO's MWMP (2020) does not rely on the availability of excess acid consuming materials and instead is focussed on early identification, appropriate segregation and placement of potentially acid-forming waste.

At the operational level at CCO, NAF material is termed "clean", while PAF and PAF-LC material is "reactive". The definitions of the above parameters (e.g. NAPP, ANC, etc.) are in GCAA's *Protocol 11.26 Managing Geochemical Risks*, and explained in detail in the GARD Guide (INAP, 2014).

A geological block model has been developed that is used to identify "reactive" waste, and this model forms the basis of current mine planning and operational mine waste placement. Within the geological model, blocks of material with potential for AMD have been developed using the geochemical criteria outlined above. The site also uses machine guidance for operators, to ensure dumping of 'Reactive" wastes is in accordance with the placement strategy.

5.1 Verification

Appropriate classification, handling and long-term storage of PAF waste forms the basis for the MWMP (2020), and therefore a key component is to confirm that NAF material (assigned as "clean" waste) has been placed appropriately (KCB, 2020). Ongoing testing is occurring to confirm that the NAF / "clean" and PAF / "reactive" terms are analogous.

As part of this program, in 2019, CCO commissioned an initial appraisal of the implementation of the site's MWMP (2020) and concluded the following (KCB, 2019):

- CCO has advanced the understanding of mineral waste and mineral waste management significantly over the past four to five years;
- The additional testing, the creation of Trigger-Action-Response Plans (TARPs) for mineral waste, and several updates of the MWMP have provided CCO with a sound level of understanding of the potential for AMD, the units that are more susceptible to containing elevated sulfides, and methods to manage mineral waste;
- The appraisal showed that CCO has well-established processes to plan for, identify, implement, and check mineral waste properties and to place these in the designated areas;
- Interviews and site observations indicate that in broad terms the intent of the MWMP is being followed on site. With the associated occurrence of spontaneous combustion from units that contain elevated sulfide, the site has developed consistent and appropriate methods to handle, place and limit the reactivity of the waste. Since many of the concepts for preventing spontaneous combustion and AMD are similar, the site follows many practices which collectively limit the reactivity of much of the mine waste. This includes:
    - Planning processes which are based on geological identification and differentiation of waste types;
    - Planning which considers the potential for reactivity based on the geological information;
    - Placement criteria that define where different classes of waste can be placed (both spatially, in terms of placement elevations (RLs) and whether the waste is suitable for ex-pit storage);
    - Limiting exposure times before waste is covered or encapsulated with less reactive material;
    - Identification of units that would pose a higher risk (especially of spontaneous combustion);
    - Consistent use of terminology between Geology, Mid-Term Planning, Short Term Planning, Production through to supervisors and mine equipment operators;
    - Consistent understanding (refined through site observations) of the requirements to identify and separate waste classes;
    - Consistency of concepts and implementation of waste separation and waste placement. This provides the ability to have good control on mineral waste identification, placement and management throughout the operation; and
    - Many of the CCO processes have been developed to consider both operational constraints and the potential closure/post-closure implication of the mineral waste placement/management;
- The occurrence of units that are susceptible to spontaneous combustion has allowed the site to establish a system that is based on "Reactive" and "Clean" waste. In broad terms, the geological units that produce "Reactive" waste correspond with the geological units that have been identified in the environmental geochemical classification as posing an enhanced risk of generating AMD or spontaneous combustion; and

- Visual observations and the results from site water quality monitoring suggest that currently there is no evidence to indicate that significant proportions of PAF material have been placed/classified as “clean” material (previous investigations have indicated that the PAF materials are able to generate acid drainage within less than six-to-twelve months).

6. Continued Sampling & Analysis Regime

This section discusses the sampling and analysis regime that apply to mineral waste that is produced for CCO. It is directly relevant to CM only, but not to TLO and CH, as waste is no longer produced in these locations, although this section should be considered for these locations when rehabilitation works are occurring.

6.1 Sampling

6.1.1 Material Selection

Previous geochemical characterisations have indicated an uneven distribution of sulfide (and consequently AMD potential) among the various geologic units. For example, the coal seams and Tertiary and Permian sediments (particularly those in close proximity to the coal seams) pose the greatest AMD risk, while the Quaternary clay/weathered basalt lithologies are strongly net acid consuming. Sampling density should therefore be weighted such that the highest-risk materials are more extensively studied into the future.

Continued sampling is to be proportioned to consist of 70% from the Permian sediments, 20% from the Tertiary sediments, 5% from the basalt and 5% from the Tertiary/Quaternary overburden.

Samples that are required to support the current and future understanding of mine waste at CCO are to be randomly selected from all material collected and include:

- Exploration samples - sampling of new exploration bores (both core and chips) is to be completed as part of exploration programs;
- Waste rock facilities and coal waste - verification sampling is to monitor the nature of the waste after it has been placed as a dumped surface/structure; and
- Pit wall sampling – samples are to be collected within the final three years of operation to confirm the AMD properties of entire sequence of wall rock lithologies.

Once collected, samples will be stored in a covered location until analysis can be conducted. This is particularly important in light of the tendency of reactive waste at CCO to acidify rapidly (KCB, 2020).

6.1.2 Water Sampling

Water sampling is completed for the CCO site according to the details of the Surface Water Monitoring Procedure and Groundwater Management Plan and Groundwater Monitoring Instruction.

6.2 Analysis

6.2.1 Laboratory Testing

Laboratory testing at CCO will include:

- pH/EC of waste samples;
- Acid Base Accounting (including TOS, ANC, NAPP, TS and MPA);
- Chromium reducible sulfur (CRS);
- NAG testing (including analysis of supernatant);

- Total Elemental composition of whole rock; and
- Shake Flask Extraction tests (SFE) (30 metals, pH, EC, major cations/anions) (selected samples).

Of the samples collected for laboratory testing, a portion (~15%, with the majority (80%) from the Permian sediments) may be subject to the following further testing:

- Kinetic NAG;
- Reactivity of Carbonates (ABCC); or
- Quantitative Mineralogy by XRD.

6.2.2 Field Verification

To confirm the findings of the laboratory analysis, and to provide timely information on AMD risk and actual impact, field testing may also be undertaken for:

- Field pH;
- Rapid indication of potential acidification; and
- Handheld X-ray Fluorescence to identify PAF and metalliferous samples (Zinc (Zn), Lead (Pb), Copper (Cu), Magnesium (Mg), Aluminium (Al), Silicon (Si), Phosphorous (P), Chlorine (Cl), Potassium (K), Calcium (Ca), Scandium (Sc), Titanium (Ti), Vanadium (V), Chromium (Cr), Manganese (Mn), Iron (Fe), Cobalt (Co), Nickel (Ni), Arsenic (As), Selenium (Se), Rubidium (Rb), Strontium (Sr), Zirconium (Zr), Niobium (Nb), Molybdenum (Mo), Palladium (Pd), Silver (Ag), Cadmium (Cd), Tin (Sn), Antimony (Sb), Tellurium (Te), Caesium (Cs), Barium (Ba), Hafnium (Hf), Tantalum (Ta), Tungsten (W), Rhenium (Re), Gold (Au), Mercury (Hg), Bismuth (Bi), Thorium (Th) and Uranium (U)).

6.3 Interpretation of Results

Samples are be interpreted in accordance with the classification criteria outlined in ***Section 5***. To ensure standardised data interpretation at CCO, the CCO AMD rules have been incorporated into a tool previously developed to provide consistent classification of materials, graphical presentation, and automated classification of samples and, where appropriate, facility or mine-scale integration of Acid Base Accounting results (KCB, 2020).

All material which has not been classified as “clean” will be considered to be reactive until further analysis has been completed and shown it to be otherwise. All test results will be stored in Glencore’s Environmental Monitoring Database (EMD).

7. Material Balance and Conceptual Site Model

A material balance has been developed to show the source and nature of material for CCO, applying the classification system described in ***Section 5***. This provides content to the proportion of each waste type (clean and reactive) that has been disturbed for mining, and where the material has been placed. Further to this, a conceptual site model has been developed to show the environmental risk posed by geochemical material at CCO, as well as to indicate the source-pathway-receptor connections to the surrounding environment.

At CCO, a geological block model is maintained to adequately highlight the mineral waste risks for the site. The block model describes each mineable coal block and is used to identify areas which require selective mining and placement management, and based on this visibility within the model, short and medium-term planning personnel then indicate when handling and placement controls are required by the operational teams. The block model and associated material tracking systems can be used to initially understand the material balance, but also verify placement of materials.

7.1 Material Balance

The block model is used to estimate the volume of mine wastes based on the level of environmental risk, as aligned to the classification criteria outlined in ***Section 5*** (***Table 7-1***).

Table 7-1 - Breakdown of materials for CCO

Material	Volume 2008-2021 (bcm)	Volume Forecast 2022-2027 (bcm)
Tertiary basalt	8,811,561	4,112,100*
Clean waste	457,614,070 (92%)	177,999,803 (90%)
Reactive waste	41,415,593 (8%)	20,588,829 (10%)
Total waste (clean + reactive)	**499,029,664**	**198,588,632**

*Competent basalt will be depleted by the end of 2024, and approximately 200,000bcm is used per year (total 1,200,000bcm) for road base and stemming

This summary of materials has been further organised to provide input to the conceptual site model for waste materials (including waste rock dumps and stockpiles - ***Figure 7-1***). A separate conceptual site model has been developed for TSFs, in order to provide sufficient detail to clearly show the source-pathway-receptor interactions, contained within Appendix 4.10 – Tailings Characterisation and Design Report.

The table above provides a snapshot in time only, and the dynamic block model should be considered to be the best and latest understanding of mineral waste risk for the site, as well as the latest understanding of the material balance for the site. CCO classifies individual batches of waste rock as “reactive” (PAF, PAF-LC) or “clean” (NAF) and to incorporate these into long-term and short-term planning schedules, according to their stratigraphic position (as indicated by the block model). This classification is supported by in-field observations. Batches of waste that have not been classified are deemed as “reactive” until confirmed otherwise.

This classification underpins the associated handling/placement requirements for geochemically distinct materials. Further management requirements are outlined in Section 8 of this document.

7.2 Conceptual Site Model

CCO have developed a conceptual site model to consider the waste rock dumps, that identifies site-specific factors that may result in geochemical risks, including consideration of the interaction of natural and anthropogenic processes that may influence management controls. A separate conceptual site model for the TSF has been provided in Appendix 4.10 of the PRCP, in order to provide sufficient detail to clearly show the source-pathway-receptor interactions.

The conceptual model provided below forms both a summary table (***Table 7-2***) and a schematic diagram to show key interactions between the WRD and surrounding environment. The summary table considers the source-pathway-receptor linkages and highlights key geochemical risks as well as management controls and interventions required. Further, the schematic (***Figure 9-2***) presents the boundary conditions, site topography and climate, the in situ distribution and location of reactive materials and illustrates key hydrological and hydrogeological pathways.

This summary of materials has been organised to provide input to the visual conceptual site model for waste materials (for waste rock dumps).

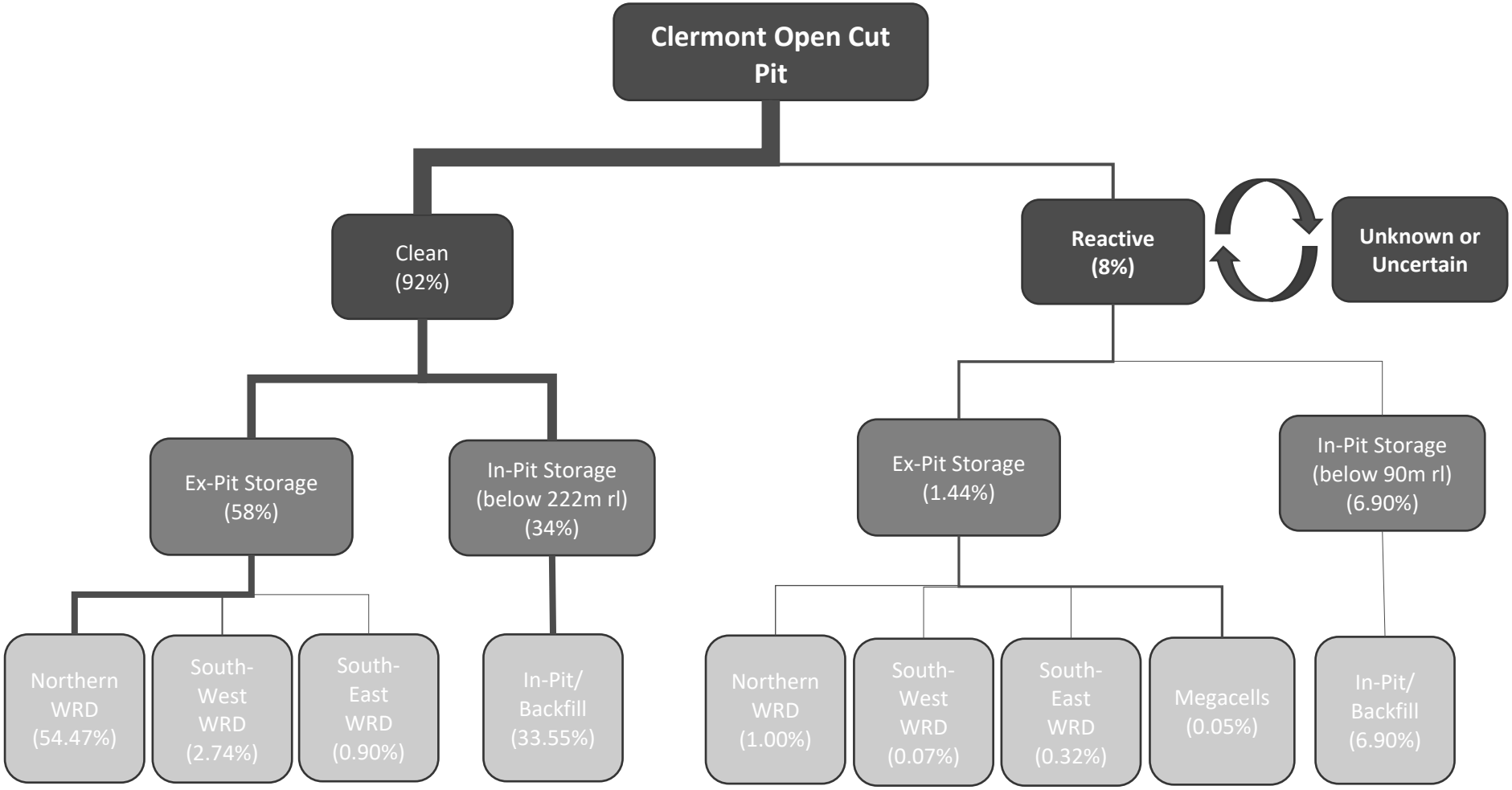

Figure 7-1 - Conceptual material balance for waste rock dumps at CCO

Table 7-2 - Source-pathway-receptor model for waste rock dumps at CCO

Domain	Occurrence	Potential for environmental harm	Key interventions and management strategies
Source	• PAF material encapsulated in WRD	Interaction of PAF material with water and oxygen resulting in mobilisation of AMD and other contaminants	Priority for PAF material to be placed below 90 m RL Placement and encapsulation strategy for placement above this height
	• Potential point sources within WRD footprint (i.e. tyres)	Mobilisation of other contaminants	Records of contaminants placed within WRD
	• Airborne dust and odour from WRD surface	Mobilisation of other contaminants and particulates	Dust control during operations Application of a dust suppression agent if a delay between cessation of production and capping is anticipated Rehabilitate as soon as available to stabilise surface
Pathway	• Seepage daylighting at WRD - natural surface interfaces	Interactions between daylighting locations and surrounding surface environment	Monitor seepage locations and manage if required
	• Runoff into surface water drainage	Instability and interactions to surface water drainage as a result of seepage	Monitor seepage locations for WQ, and ensure adequate mixing in receiving environment
	• Airborne particulates that are then deposited	Transport as airborne particulates	Dust control during operations. Rehabilitate as soon as available to stabilise surface

Domain	Occurrence	Potential for environmental harm	Key interventions and management strategies
Receptor	• Residual void (NUMA)	N/A	N/A
	• Receiving surface water environment	Impact to sensitive receptors – human or animal, or aquatic ecosystems Undesirable modification to WQ within downstream surface water catchments	Monitor receiving environment and apply EA WQ criteria
	• Surrounding groundwater system	Impacts to sensitive receptors – human or animal Undesirable modification to WQ within groundwater systems	Monitor receiving groundwater systems and apply EA groundwater quality criteria
	• Surrounding surface areas and dwellings	Impacts to sensitive receptors – human or animal Undesirable modification to surface systems, such as vegetation	Monitor sensitive receptors and dust deposition levels

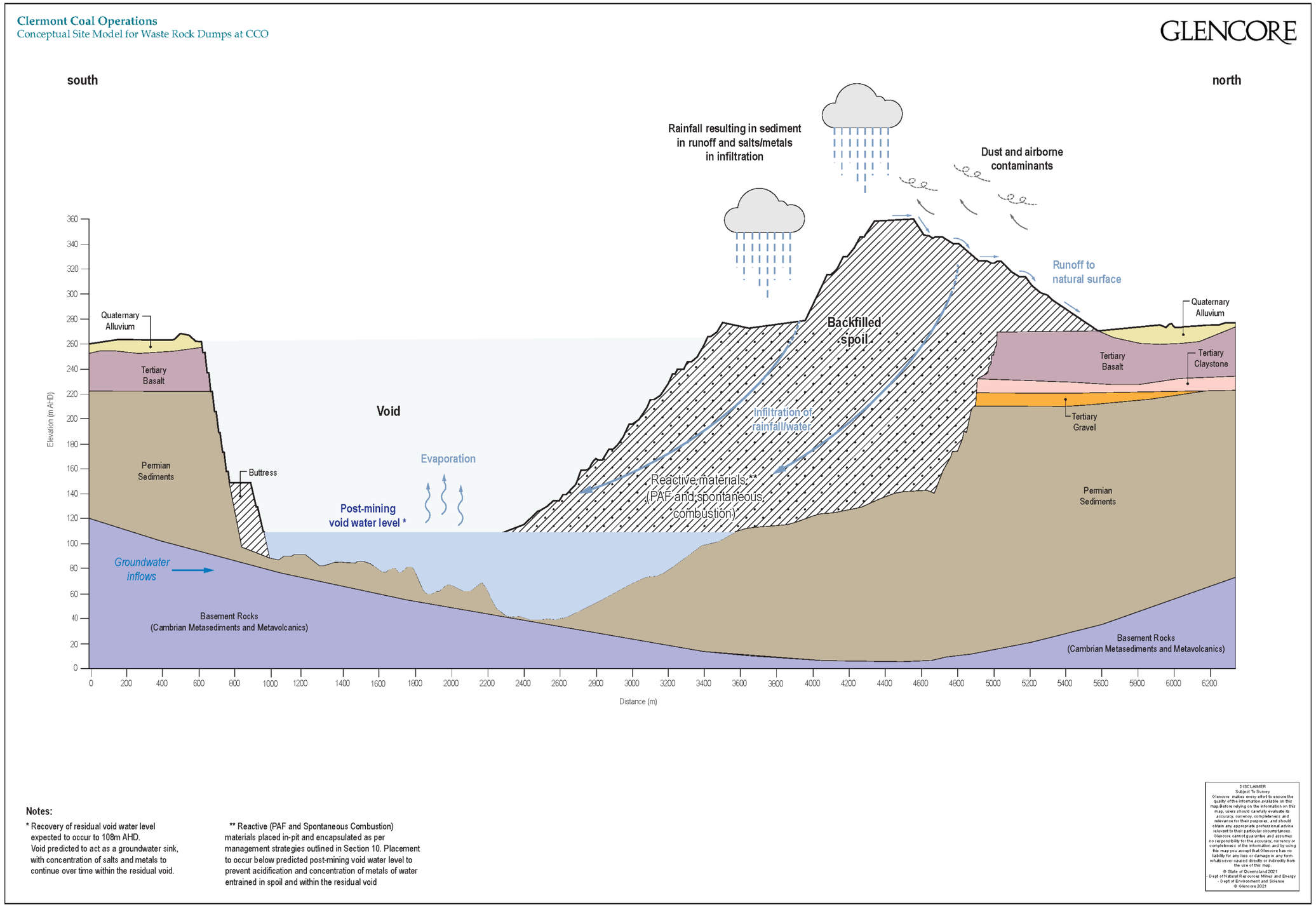

Figure 7-2 - Conceptual site model for waste rock dumps at CCO

8. Waste Handling and Placement Management

8.1 Waste Handling

All PAF / PAF-LC / "reactive" material is transported to its final destination within four weeks of generation of the waste wherever possible. Should this not be feasible, operations should place the material in temporary stockpiles with temporary encapsulation with "clean" material to reduce the rate of oxidation.

When handling reject coal waste, monitoring and data investigation must be in place to provide an early warning system, and to further the understanding of its AMD and spontaneous combustion risks. Any additional information sourced from monitoring must be used to update existing control measures.

There are no special control measures required for handling NAF / "clean" materials.

8.2 Waste Placement

Different placement procedures have been developed for NAF / "clean" and PAF / PAF-LC / "reactive" waste. These procedures specify the placement location and the dump construction (specifically, how reactive waste is to be encapsulated).

8.2.1 Placement of "Reactive" Waste

Reactive waste is to preferentially be placed in dumps located inside the pit. The intent of this control is to place reactive waste within the contained environment of the void. Reactive wastes should ideally be placed below an elevation of 90 mAHD below the post-mining water table where possible, as this area will become permanently submerged (and its oxidation will thereby be inhibited).

If reactive material cannot be placed below 90 mAHD, the final void closure plan should take the presence of this waste (and the deterioration in water quality) into consideration. Measures will be put in place to monitor the water quality, and if necessary, treat the pit lake water for acidification/ AMD risk.

All reactive waste must be placed in adequately-constructed waste rock dumps. These waste rock dumps must not contain more than 10% of reactive material. Should the mining sequence result in a dump that contains more than 10% of reactive material, the dump must be encapsulated as per the design criteria outlined in the CCO MWMP (2020).

If reactive material cannot be placed in-pit, it must be encapsulated using net-acid-consuming material. In addition, the procedures outlined in the Acid Rock Drainage TARP should be followed. All reactive waste placed external to the pit must be encapsulated.

The following criteria must be applied to ex-pit dumps encapsulating reactive materials:

- A 2 m thick basal layer of basalt (or some other net-acid-consuming material) must be placed on the original land surface/base of the area. If available, Quaternary clay should be incorporated into the basal layer to reduce basal and toe seepage;
- Net-acid-consuming material must be free dumped such that no reactive material is located within 10 m of the final dump surface after the slope has been re-contoured at closure. For design purposes it should be assumed that all outer dumps slopes will be reduced as per the CCO closure criteria;

- Ex-pit dumps should preferably contain only clean waste. Where reactive material must be placed ex-pit for Operational or Health and Safety reasons, the ex-pit waste dump should contain less than 5% reactive material within its total footprint;
- If there is potential for spontaneous combustion, clean / NAF material is required between lifts. Clean waste or basalt should be mixed into reactive waste if convenient to do so;
- The final lift of the reactive waste rock dump must be a layer of clean material. The thickness of this cover is to be informed by the specifics of each situation, or be no less than 10m in thickness as a default;
- The upper surface of the dump must be designed so that it only receives rainfall from the dump catchment itself, without run-on from adjacent areas;
- The dump must be constructed such that the encapsulated (reactive) material is not exposed during outer slope re-profiling and rehabilitation; and
- Records must be maintained of the placement of reactive material in ex-pit dumps. These should indicate the masses of reactive material placed in each dump.

The above controls are incorporated into normal site review and quality assurance processes, which will assure compliance with the required design standard.

8.3 Placement of Potentially Spontaneous Combustion Materials

All carbonaceous materials with total sulfur content greater than 0.5% must be managed as reactive, and classified as potentially self heating leading to spontaneous combustible. The geological model for the site will incorporate a tag on each block to identify areas which will require selective management.

Management controls must focus on minimising the time period during which these rock types are allowed to oxidize. Investigations into the self-heating behaviour of coal at CCO indicate that the time window for ignition of these materials is between two and seven days as a conservative worst-case scenario (for the Gowrie Seam).

Controls in place for managing acid drainage risk can be adapted to minimise the risk of spontaneous combustion. Alternatively, controls may be applied to address the risk to human health, and the risk to the environment where exposure time cannot be minimised. In the event that spontaneous combustion does occur, CCO has standard operating procedures that detail the appropriate response.

8.4 Placement of Coal Rejects / Processing Wastes

Management of coal rejects is detailed in Appendix 4.10. Monitoring bores are located along the western side of the Megacells, are placed down to the pre-mine natural surface, and are checked for seepage and leachate on a monthly basis. CCO also has an extensive groundwater monitoring network which can be used to identify impacts to groundwater from mining operations. Seepage into the active mine pit in the short-term, or void in the long-term, has been considered as part of the Void Closure Methodology (refer Appendix 4.7).

8.5 Placement of “Clean” Waste

Clean waste rock may be placed anywhere onsite. Although there are no restrictions on its placement, clean waste may be required for blending/capping of reactive material. For example, basaltic waste rock will be used to form basal layers beneath dumps of reactive material, and Tertiary and Permian sediments will be used to encapsulate these dumps.

9. Document Information

Reference	Title
AMIRA (2002)	ARD Test Handbook. Project P387A. Prediction and Kinetic Control of Acid Mine Drainage, AMIRA International Limited, Melbourne, Australia.
Dames and Moore (1983)	Waste management and rehabilitation programme – soil and overburden characterisation.
Department of Environment and Science (DES) (2019)	Guideline for Progressive Rehabilitation and Closure Plans (PRC plans). ESR/2019/4964, Version 1.00, Effective: 01 NOV 2019.
EGi - Environmental Geochemistry International (2004)	Geochemistry and ARD Characterisation of Clermont Coal Waste Materials. Report 8151/606, May 2004.
EGi (2006)	Geochemical Assessment of Overburden from Blair Athol Mine.
EGi (2008)	Column Leach Test Results for Reject and Tailings from the Blair Athol Coal Washery Plant.
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Geo-Environmental Management (GEM) (2005)	Acid Rock Drainage Prediction and Control Strategy Review, Blair Athol Mine.
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INAP (2014)	The Global Acid Rock Drainage (GARD) Guide, accessed here: <http://www.gardguide.com/index.php?title=Main_Page>
KBR – Kellogg, Brown & Root (2019)	Clermont Coal Operations – Cement Hill Closure: Initial Data Collection.
KCB – Klohn Krippen Berger (2018)	ARD Field Sampling August 2016 – November 2017 Summary Report. Report prepared for Glencore Clermont Coal Operations.
KCB (2019)	Clermont Open Cut 2019 ARD Assessment. Findings from the appraisal of the MWMP Implementation draft. Report prepared for Glencore Clermont Coal Operations.
KCB (2020)	Clermont Open Cut 2019/20 ARD Assessment. 2018/2019 Geochemical Testing of Mine Waste. Draft Summary Report. Report prepared for Glencore Clermont Coal Operations.

Reference	Title
Landloch (2012)	Rehabilitation Monitoring on Blair Athol Coal Mine, Queensland. Draft Report prepared for Rio Tinto.
Munns, R. (2002)	Comparative physiology of salts and water stress. Plant, Cell and Environment 25, pp 239-250.
Rangasamy, P., North, S. and Smith A. (2010)	Diagnosis and management of sodicity and salinity in soil and water in the Murray Irrigation region, The University of Adelaide, SA.
Rio Tinto (2005)	Appendix C Additional Geochemistry Results. In: Clermont Coal Mine Project: Environmental Impact Statement, Supplementary Report.
Rio Tinto (2010)	Blair Athol Coal Project – Mine Closure Plan, Version 3.2, September 2011.
RTCA (2004)	Clermont Coal Mine Project Environmental Impact Statement (EIS).
RTTS (1997)	Clermont Coal Project Overburden Characterisation Report. Rio Tinto Technical Services Report, June 1997.

Attachment - Mineral Waste Trigger Action Response Plan (TARP)

Normal States	**ARD Sampling, Water Quality Sampling, Field Tests and Chemical Analysis** – Complete as per schedule, check-in every six-months		
	Block Model Criteria and Planning – Block model and mine plans/schedules up-to-date with latest ARD criteria		
	Waste Source and Placement – Mine waste is placed in areas according to the Mineral Waste Management Plan		
Trigger Action Response Plan	Level 1 Trigger – Alert / Investigate	Level 2 Trigger – High Alert / Rectify	Level 3 Triggers – Stop – Withdrawal / Removal
	Sampling • Drilling and ARD sampling and laboratory testing program is not complete (no campaigns in the year); • Water quality monitoring is not completed (quarterly). Block Model Criteria & Planning • Interpretation criteria for ARD not included in Block Model and planning strategy (PAF & NAF) – checked six-monthly); • Expected ARD properties are inconclusive or not confirmed through drilling and ARD sampling and laboratory testing program e.g. No ex-pit	Sampling • Drilling and ARD sampling and laboratory testing program verifies material more reactive – increase in average %S by more than 10%, or significantly more PAF tonnage (PAF increases by more than 15% than expected. Monitor quarterly • Evidence of ARD in water monitoring results (pH drops and changes in SO4-Cl and alkalinity ratio or metal concentrations increase. Monitor quarterly. Block Model Criteria & Planning • Multiple planning requests for material below 222RL be placed ex-pit. Waste Source & Placement	Sampling • Drilling and ARD sampling and laboratory testing program shows significant sulfides in waste material - >10% increase above 75th percentile for lithological units; • Water quality monitoring results show rapidly increasing sulfate/chloride ratio and pH dropping below 6 for three successive quarters. Monitor within 1 week of completing sampling in the third quarter. Block Model Criteria & Planning • Acid-base accounting suggests that long-term and/or post-closure ARD is likely – reviewed annually. Waste Source & Placement

Normal States	**ARD Sampling, Water Quality Sampling, Field Tests and Chemical Analysis** – Complete as per schedule, check-in every six-months		
	Block Model Criteria and Planning – Block model and mine plans/schedules up-to-date with latest ARD criteria		
	Waste Source and Placement – Mine waste is placed in areas according to the Mineral Waste Management Plan		
	waste dump will contain more than 5% PAF material unless blended with NAF material. No in-pit material has an overall NAPP >50kg/t H2SO4; • Planning request that material below 222RL is placed ex-pit. Waste Source & Placement • Waste sourced below RL222 placed ex-pit; • Material placed ex-pit is not confirmed NAF; • Waste placed incorrectly – Management plan for high PAF lithology not followed	• Multiple events of PAF material placed ex-pit.	• No consideration of PAF material characteristics during waste placement

Persons affected	Action / Response	Action / Response	Action / Response
Environment & Community Manager	1. Implement field and laboratory sampling programs; 2. Assess most recent data, confirm laboratory data; 3. If PAF identified, ensure rehandle back to pit; 4. Review obligations contained in the Mineral Waste Management Plan annually; 5. Review the Mineral Waste management plan bi-annually.	1. Stop placement of material immediately until confirmed as NAF; 2. Incident investigation triggered to identify if Mineral Waste Management Plan is being followed; 3. Implement monitoring plan; 4. Review ARD and water quality monitoring program 5. Increase frequency of field testing and monitoring points (including first flush events); 6. Undertake sampling and testing of nearest waste source (including first flush events); 7. Move to a more conservative waste management schedule.	1. Implement high PAF waste disposal strategy. Confirm with further testing; 2. Independent review of data and management plan; 3. Confirm ARD criteria in Block model and planning (quarterly).

Persons affected	Action / Response	Action / Response	Action / Response
Geologist	1. Implement drilling and sampling programs; 2. Assess most recent data, confirm laboratory data; 3. Geology to assess lithology and likelihood of sulfides; 4. Regard unidentified material as PAF until confirmed; 5. Update/Review ARD criteria in Block Model; 6. Evaluate the requirement for a Hazard Alert.	1. PAF material to be included in geological description – geology logs and updates; 2. Confirm ARD criteria in Block Model; 3. Visually inspect affected areas; 4. Create Hazard Alert for geochemical hazard and communicate to all coal mine workers; 5. Consult with OCE if additional controls are required	1. Implement high PAF waste disposal strategy. Confirm with further testing; 2. Confirm ARD criteria in Block model and planning (quarterly).
Medium & Long-term Planning	1. Consider Block Model ARD criteria in mine planning; 2. Waste sourced below RL222 placed in-pit; 3. If PAF identified, rehandle back to pit in accordance with the Mineral Waste Management Plan	1. Stop placement of material immediately until confirmed as NAF; 2. Move to a more conservative waste management schedule	1. Implement high PAF waste disposal measures as detailed in the strategy.
References	Contact Phone Numbers		
Mineral Waste Management Plan	**Dispatch – 0477 307 530** **OCE – 0467 725 738** **Superintendent Geology – 0467 782 024** **Environment & Community Manager – 0449 059 293**		

CLERMONT
COAL OPERATIONS

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Appendix 4.10 - Tailings Characterisation & Design Report

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1. Introduction

1.1 Purpose

This document summarises the tailings characterisation and design undertaken to date, and aims to achieve the following outcomes:

- Describe the geochemistry, rheology and geotechnical parameters as relevant to detail the materials within the TSFs at CCO, and the level of long-term risk posed to environmental values; and
- Present the type and nature of facilities used at CCO, and detail how their design features allows for the safe management of tailings given the site-specific constraints.

1.2 Scope

This document applies to the Clermont Main (CM) deposit and Cement Hill (CH). It summarises the relevant plans and studies undertaken to date that outline the characterisation of tailings. Subsequent criteria and parameters are outlined for tailings storage facility design, with linkages made to progressive rehabilitation and closure strategies as required.

1.3 Standards and Guidelines

Tailings management options must adhere to the following (but not limited to) acts, by-laws, and regulations, both state and federal:

- Water Act 2000;
- Coal Mining Safety and Health Act 1999;
- Environment Protection and Biodiversity Conservation Act 1994;
- Work Health and Safety Regulation 2011;
- Coal Mining Safety and Health Regulation 2017;
- AS/NZS 4360 2004, Risk management, Standards Australia; and
- Environmental Protection Act 1994.

2. Reject Management at CCO

2.1 Processing Waste Stream

Historically, only a small portion (5-10%) of the run of mine (ROM) coal has been washed in the Coal Handling and Processing Plant (CHPP). Recent market influences since 2020 have resulted in an increase in the predicted volume of coal washing at CM over its remaining life. Current ROM throughput is about 16,000 tpm, and this may rise to 90,000 tpm and possibly further to 160,000 tpm, with a yield of 78%. The corresponding tailings production will be from 1,760 tpm currently to about 12,000 tpm or possibly 19,000 tpm (Golder Associates, 2021b).

2.2 Reject Management

2.2.1 Early Planning

The initial reject management solution proposed for CM was for coarse coal rejects to be wet co-disposed with tailings in a 'Coal Washery Waste Disposal Area'. This was initially to be located to the west of the CHPP, located within in a designated ex-pit facility, as shown in ***Figure 2-1*** below. A total footprint of ~60 ha was expected to be required to contain the waste generated for the life of the operation. The liquid portion was to be disposed to a series of cells, which would result in the materials in each cell being stable and able to be trafficked after a 'relatively short period of time' (RTCA, 2004a).

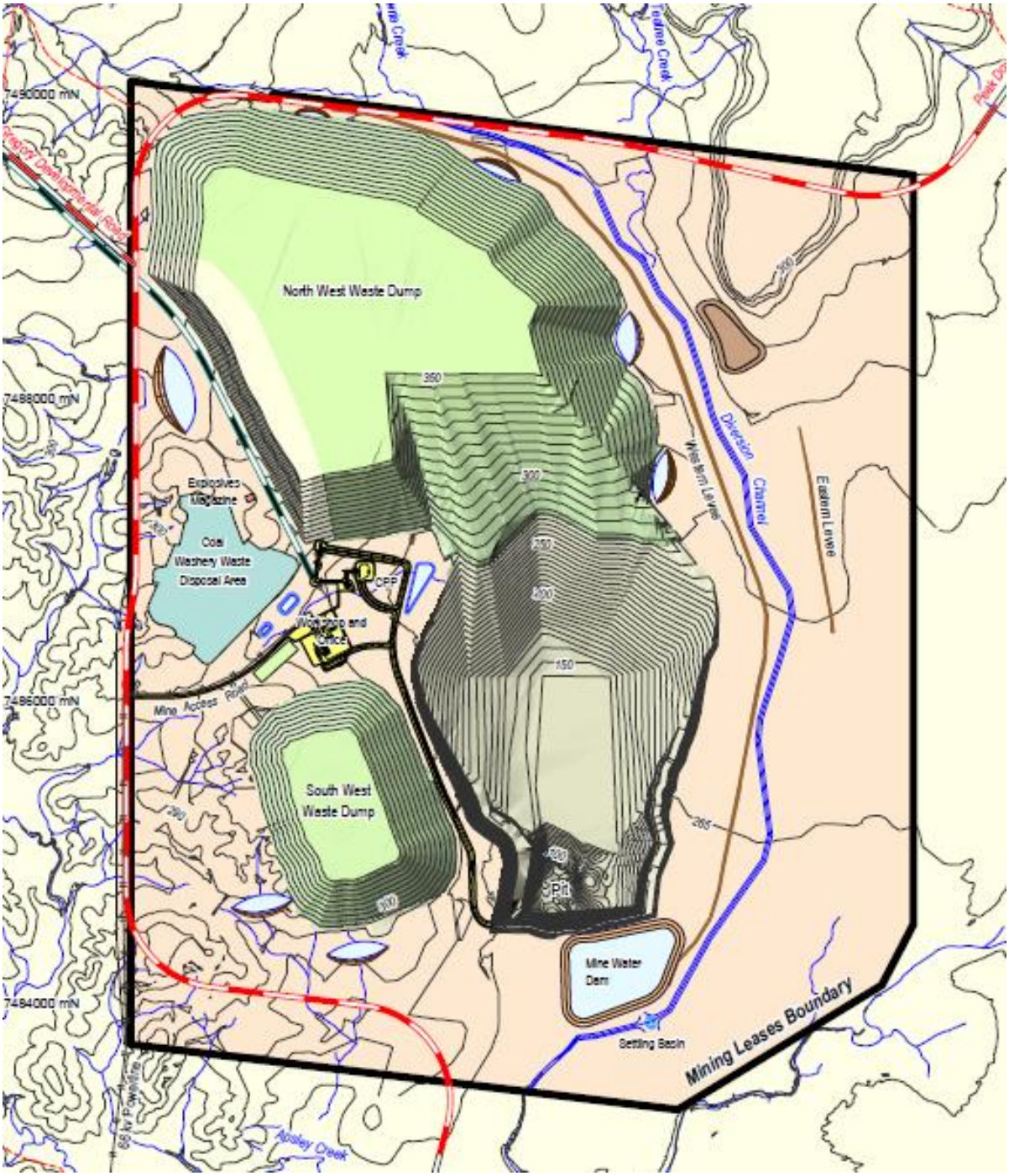

Figure 2-1 - Initial proposed Coal Washery Waste Disposal Area (RTCA, 2004a)

As initial construction commenced for CM in 2009, an alternate tailings management solution was sought for placement of tailings that was safe, stable and non-polluting.

This resulted in the wet co-disposal system being modified to a dry co-disposal system, whereby the fine tailings would be pumped to a placement location as a thickened slurry. This thickened slurry was expected to have very little free moisture at emplacement, and thus was planned to be dry co-disposed with the coarse rejects within designated "cells" constructed from overburden dump material (CCMP, 2009).

The method of reject placement was to initially create cells within constructed overburden bunding (termed Megacells), then co-dispose coarse rejects and tailings within the emplacement area, allowing

for the tailings fraction to settle in the hollows and be absorbed due to the porosity of the co-disposed coarse rejects material, and thus not displace when overburden is subsequently dumped on top.

2.2.2 Megacells (2010-2022)

CCO has utilised two Megacells during its existing operational life, which represent an approximate combined area of less than 10 ha. Both Megacells are located to the north of the Processing Plant and ROM coal stockpiles, adjacent to the Secondary ROM Stockpile, as shown in ***Figure 2-2***. The Megacells contain all of the CCO tailings generated up to 2021. They are surrounded on all sides by spoil dumps, with an embankment to the west also constructed utilising mine spoil.

Figure 2-2 – Megacell 1 at completion and prior to encapsulation (circa 2013)

Megacell 1 was commissioned in 2010 at the commencement of coal production and Megacell 2 was commissioned in 2012 as the washing needs of the operation continued. During the initial period of operation Megacell 1 received co-disposed tailings and coarse rejects, however due to the low proportion of washing at CM (5-10%) the operation of the Megacells changed from that initially planned. The proportion of coarse rejects co-disposed with the tailings declined and the extended periods between washing allowed strong desiccation of tailings as the layers were placed. Washing

occurred on average only 4 weeks per year. This has both increased the lifespan of the Megacells beyond that initially planned, and resulted in a low water content of the placed tailings.

Megacell 1 ceased operation in July 2012, and was subsequently encapsulated by dump progression. The total volume of tailings material deposited was approximately 70,000 m^3. Megacell 1 was constructed with an area of 180 m x 150 m (or 2.7 ha), and at the end of its life, had an average depth of 15 m.

Megacell 2 was brought into service in 2012 and remains in service, although its operation has recently been modified as a consequence of the introduction of drying cells in 2021. As of 2021, the deposited tailings is estimated to have a volume of approximately 130,000 m^3 covering an area of 206 m x 140 m (or 2.9 ha). Megacell 2 has an average depth of approximately 32 m. Megacell 2 is expected to be taken out of service in 2022, contingent on the Tailings Drying Cells performing as planned. In the intervening period Megacell 2 is used for occasionally for disposal of tailings when the tailings settling cells have reached their capacity. It is expected that Megacell 2 will be activated a few times per month for a period of 2-5 days until additional Tailings Drying Cells are installed (expected in 2022).

Coarse rejects are trucked and placed within the in-pit WRD emplacements as road base and for stemming of blast holes within the advancing face.

2.2.3 Tailings Settling Cells (2021-2027)

In late 2020, CCO undertook a life of mine study for future tailings disposal options, triggered by significantly increased demand for washing, and resulting in a greater rate of tailings production causing Megacell 2 to approach its maximum capacity (Golder Associates, 2021d).

Various options for continued tailings disposal were considered. The preferred option that has since been implemented is the installation of tailings settling cells. Tailings are pumped to a number of settling cells to reduce the water content through by passing through a semi-permeable wall, evaporation and decant recovery. After sufficient drainage has occurred (25-35% total moisture content) the residual dry tailings are then disposed of in pit, in accordance with the Mineral Waste Management Plan. This requires the dried tailings to be placed low within the dump and not concentrated in any single location. The tailings are distributed amongst the spoil, which provides geotechnical stability and access to considerable acid neutralising capacity. The location for these settling cells is to the west of the CHPP, as shown in ***Figure 2-3***.

The typical dimensions of the settling cells are summarised in ***Table 2-1***.

Table 2-1 – Typical dimension for Tailings Settling Cells

THREE SETTLING CELLS	DIMENSIONS
Length	150 m x 250 m
Width (Top)	30 m
Width (Base)	8 m
Depth (Max)	5.5 m

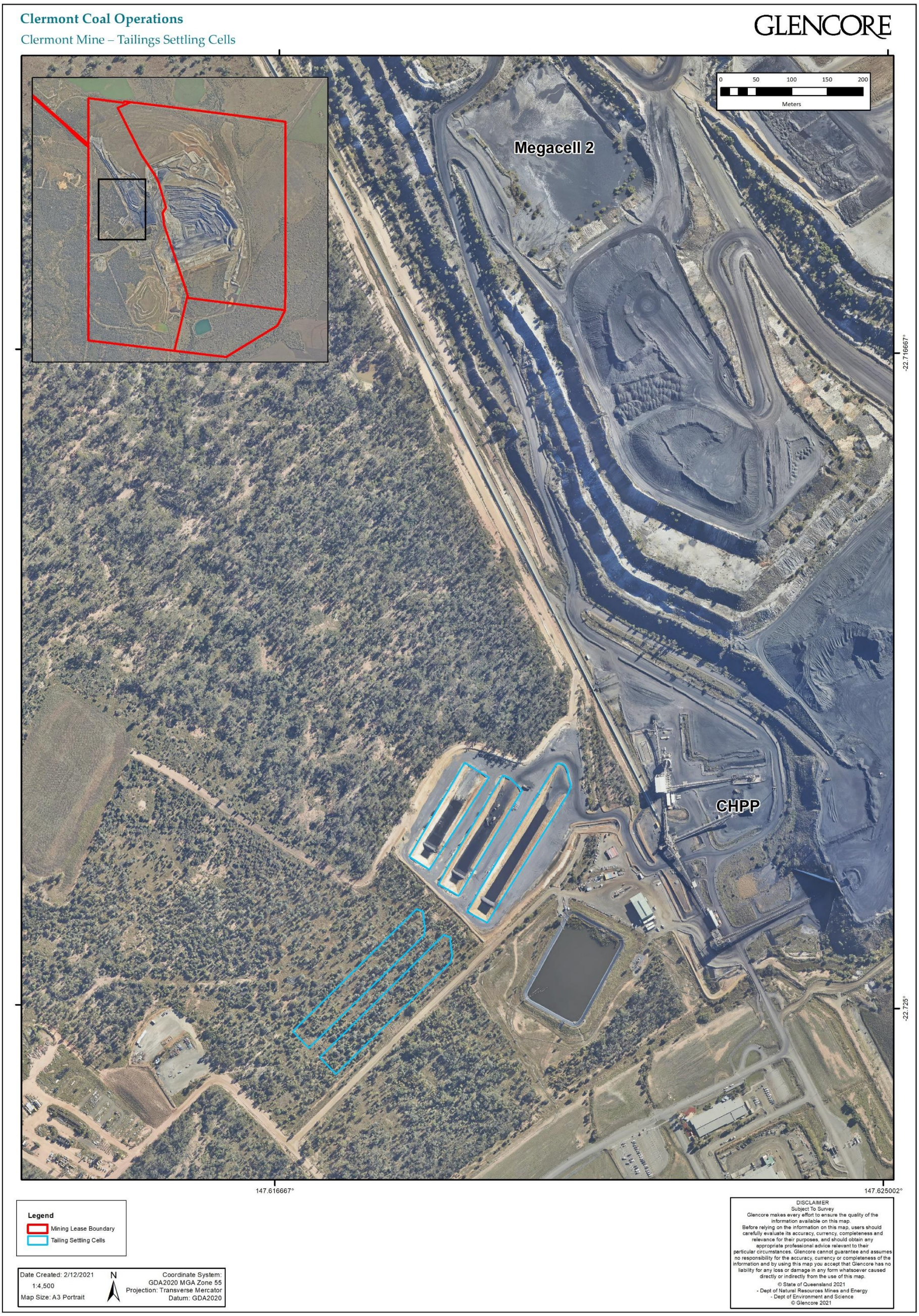

Figure 2-3 – Location of Drying Cells, Megacell 2, and CHPP

2.3 CH Tailings Area

At CH, a historic tailings area is located in the north-eastern portion of the site (as per ***Figure 2-4***) and occupies an area of approximately 6.6 ha, and consists of three main cells. It is known that the previous operation was an alluvial gold mine, whereby the tailings process was limited to washing. No evidence of metal or contaminant concentration is present, with material sampling indicating a high percentage of fine material (silt and clay) from the base of the tailings cells (KBR, 2019).

The primary cell (located closest to Ken Logan Road and to the eastern extent of the ML) is depressed in the landscape, with an earthen embankment between 9 m and 12 m high. Current internal and external batter slopes are steep, ranging from 35% to 60%. Vegetation on the batter slopes has established since mining operations ceased in the 1980s, and groundcover vegetation occurs on the base of each of the three cells.

The secondary cell (in the centre) is elevated approximately 4 m higher than the primary cell, and contains reasonably dense vegetation with established trees and groundcover). The grade of the internal batters are also steep, at to 35%.

The third cell (at the western extent of the area) is generally flat, and around 4 m higher again in elevation from the secondary cell. This area is also reasonably well vegetated, with evidence of grazing activity.

There is an above ground circular concrete tank located in the south-eastern corner of the primary tailings cell. Apart from that, no other physical infrastructure of remains from the former mining operation (KBR, 2019).

Figure 2-4 - Location of historic TSFs at CH

3. Tailings Characterisation

3.1 Geochemical Characterisation

The expected geochemistry of the tailings (in particular, the potential for AMD, salinity and other contaminants to be generated by the tailings) influences how they need to be contained and subsequently rehabilitated.

As further detailed in Appendix 4.9 of the PRCP, extensive geochemical characterisation of waste material from CCO has been undertaken. Each characterisation program has involved analysis of coal rejects material.

3.1.1 Megacells

3.1.1.1 Basis of Findings

Appendix 4.9 of the PRCP details the overarching geochemical characterisation completed for CCO, and concludes that the characterisation is based on a more than adequate number of samples, with spatial distribution covering the entire mine footprint, and all lithologies.

From this characterisation, it is clear that whilst the rejects material is a small portion of the total volume of waste to be generated, it represent some of the highest risk material for the site from the perspective of AMD risk. Coal and surrounding lithologies tested were dominantly PAF and PAF-LC and also susceptible to spontaneous combustion. In addition, coal stockpile materials, processing wastes, coal washery wastes and coal reject wastes were all potential sources of AMD. On the other hand, spoils surrounding the tailings are acid buffering materials, and all seepage to the Western Diversion Drain has been neutral to slightly alkaline, indicating that the risk is low.

CCO have completed geochemical characterisation of placed materials, as well as the tailings materials produced after processing, to understand how mining and washing processes have modified the risk of the material and to verify the expected potential for AMD and other geochemical concerns (KCB, 2019; RGS, 2021).

3.1.1.2 Sampling Methodology

Appendix 4.9 of the PRCP outlines the regular sampling and analysis program for geochemical samples collected for CCO, and will continue to be applied for all tailings geochemical characterisation undertaken. However, for completeness, a summary of sampling methodology used for tailings materials has been provided herein.

Past samples collected have been subject to static geochemical testing consisting of:

- pH/EC of waste samples;
- Acid Base Accounting (including TOS, ANC, NAPP, TS and MPA);
- Chromium reducible sulphur (CRS);
- NAG testing (including analysis of supernatant);
- Total Elemental composition of whole rock; and
- Shake Flask Extraction tests (SFE) (30 metals, pH, EC, major cations/anions) (selected samples).

A further portion of coal material sampled have also been subject to Kinetic NAG, Reactivity of Carbonates (ABCC) and Quantitative Mineralogy by XRD as part of extended laboratory analysis.

Field testing has also included of Field pH, Rapid indication of potential acidification and Handheld X-ray Fluorescence to identify PAF and metalliferous samples.

Kinetic testing has also been completed with Kinetic Leach Column (KLC) testing to simulate weathering that can lead to AMD under laboratory-controlled conditions. For this test, samples were composited as per AMIRA (2002) and the leachate analysed for pH and EC, alkalinity and acidity, major cations, major anions and soluble metals/metalloids.

Quality control and assurance processes have been applied to all samples, as is standard practice for NATA accredited laboratories, to verify internal quality control and quality assurance of samples.

3.1.1.3 Summary of Inherent Geochemical Risks

Acid Mine Drainage

Data from the geochemical characterisation programs indicate that coal materials tested are dominantly PAF, although some are classified as PAF-LC. In addition, the coal stockpiles, processing wastes, coal washery wastes and coal reject wastes are potential sources of AMD. From the site characterisation, the following coal reject materials are most likely to be classified as PAF:

- Carbonaceous/coal Tertiary sediment material within 5 m of the lower basalt boundary;
- Wolfang Lower seam splits;
- Wolfang Lower seam floor; and
- Possibly Gowrie seam floor and roof.

All of the Permian Coal materials samples tested to date have been PAF, but most had only a low acid potential (PAF-LC). All sampled tailings material were classified as PAF-LC. Analysis did note there is also a short lag time for the production of acid from exposed tailings material.

Further, where residual process reagents add alkalinity, and due to the near-saturated state, tailings may experience a lag of up to several years before acid drainage commences, and oxidation may occur slowly, since it is driven by the slow diffusion of oxygen from the desiccating tailings surface.

AMD from oxidising tailings may occur through surface run-off or seepage. Contaminated run-off can leave the facility via the spillway or seepage can emerge at the toe of the embankment and/or into the foundation beneath the TSF, possibly re-emerging at the surface.

Total sulfur for the tailings indicated concentrations of 0.33% to 0.45%, with sulfide sulfur reported as Chromium reducible sulfur (CRS) concentration ranging from 0.12% to 0.27%. Sulfate sulfur reported as SO_4^{2-} in water extracts for tailings samples ranged from 322 mg/L to 406 mg/L (RGS, 2021).

Carbonate alkalinity as measured in mg/L of $CaCO_3$ was found to be low in all samples (<1 mg/L).

Tailings that contain sulfides and insufficient acid neutralising/buffering minerals are particularly susceptible to oxidation and acid generation and sulfate and metal release on exposure to the atmosphere by mining and processing activities. This is because the finely ground tailings have a large available reactive surface area.

Neutral Drainage

The current characterisation of waste (as per Appendix 4.9 of the PRCP) suggests that the likelihood of significant metal ion concentrations under neutral conditions is moderate to low at CCO, with toxic metal concentrations in leachates generally low. Recently, additional tailings material has been sampled and tested for metals/metalloids.

Most metals analysed were below the limit of reporting, with only two elements exceeding the ANZECC aquatic ecosystems (freshwater) guideline values. These were Nickel and Zinc. No elements

exceeded the livestock drinking water guideline values. It is noted that the tailings contain elevated sulfides and such tailings are also susceptible to acid base reactions leading to neutral to alkaline drainage with elevated dissolved sulphates and metals.

Spontaneous Combustion

For CCO, the primary lithologies of concern for spontaneous combustion are the coal seams themselves, especially the Wolfang and Gowrie Seams (as noted in Appendix 4.9 of the PRCP). These two seams represent different risks for spontaneous combustion, since the underlying mechanisms leading to combustion differ. The reactivity of the Gowrie Seam is an inherent characteristic of the rock; a result of the fine-grained pyritic materials present in the lens. In contrast, the Wolfang Seam is reactive largely due to interactions with external factors, such as moisture and weather conditions.

Experience at CCO has shown that coal and units that contain residual coal (such as the tailings) are most susceptible to spontaneous combustion. These units are also those most likely to be PAF or PAF-LC), and hence management for AMD will also manage the spontaneous combustion risk.

Saline Drainage

As detailed in Appendix 4.9 of the PRCP, the majority of material considered sodic is associated with coal or other carbonaceous materials (along with clay and conglomerate lithologies). However, it is noted that carbonaceous materials have relatively low total effective cation exchange capacities (ECEC) which means a low potential for sodium to be released. Therefore, leaching of soluble salts is not considered a major hazard for the tailings at CM.

Trace Elements

The geochemical abundance of heavy metals in the tailings samples was evaluated, with only three metals indicating levels elevated above background concentrations. This was Cobalt (Co), Mercury (Hg) and Selenium (Se), however overall the tailings do not contain any significantly enriched total metal/metalloid concentrations compared to un-mineralised soils. It is also noted that the tailings material at CM will be encapsulated within benign/clean overburden material, and is therefore unlikely to be in contact with the surface.

3.1.1.4 Summary of Potential for Leaching

Leach testing was carried out over six months, with the resulting leachate collected at multiple dates over this period, and subsequently submitted for laboratory analysis. The reports indicated that rapid (but low) acidification occurs with the oxidation of tailing material. Salinity was also found to rise over time. The major ion concentrations in leachate were dominated by Sodium (Na), Magnesium (Mg) and Sulfate (SO_2^{-4}) and generally increased over the test period. Acidity increased as alkalinity, measured as $CaCO_3$, decreased. The increasing sulfate trend could potentially exceed livestock drinking water values over time (RGS, 2021).

The dynamic concentration of metals/metalloids was typically below the limit of reporting, with the exception of Cobalt (Co), Manganese (Mn), Nickel (Ni) and Zinc (Zn). These metals were all below the livestock drinking water guideline values.

On the basis of these results, tailings contact water (pore water) may have some potential to influence the quality of surface and groundwater resources at the tailings storage area, if left unmanaged (RGS, 2021).

3.1.1.5 Impact of Tailings on Water Quality

RGS (2021) reported that the tailings as sampled present a risk to contact water (surface water, pore water, and groundwater) if left untreated or un-encapsulated. Tailings materials have the potential to

contribute some acidity, sulfate and relatively low concentrations of some dissolved elements to contact water. Management requirements for both encapsulation leachate management of the Megacells is contained as ***Sections 4.3 to 4.5*** of this report.

3.1.1.6 Implications for Management

Previous characterisation work has recommended that all tailings material be encapsulated in a suitable storage facility. At Clermont, tailings are ultimately disposed within the Megacell, which, upon closure, will be encapsulated within the landform and surrounded by NAF/net acid consuming Tertiary and Permian materials. The guiding principle for management of reactive waste rock is to limit oxidation.

3.1.2 Cement Hill Tailings Area

3.1.2.1 Basis of Findings

CH is an old gold mine site, which was developed and closed prior to CM being developed, however is considered to be part of CCO. Samples have been collected for testing to inform the rehabilitation and closure process (KBR, 2019). No waste characterisation is available dating from when CH was operational (pre mid-1990s).

3.1.2.2 Sampling Methodology

KBR (2019) have completed a number of investigations, including material characterisation from test pit samples to inform geochemical risks associated with the tailings area. Previously collected samples have been tested for static geochemistry parameters, including pH/EC of waste samples, and Acid Base Accounting (including TOS, ANC, NAPP, TS and MPA).

Quality control and assurance processes have been applied to all samples, as is standard practice for NATA accredited laboratories, to verify internal quality control and quality assurance of samples.

3.1.2.3 Summary of Inherent Geochemical Risks

Acid Mine Drainage

Acid base accounting testing was undertaken on the sampled material. The neutralisation potential in the samples tested was higher than the potential acidity values, which indicates that there is a net neutralisation potential (negative NAPP). Previous geochemical characterisation programs indicating the residual material within the Tailings Area is considered to be NAF. Total Sulphur for the material collected from the tailings area indicated concentrations from <0.01% to 0.02%, which is considered to be low (KBR, 2019).

Neutral Drainage

Heavy metals testing indicated levels similar to background levels, except for Arsenic (As), which was slightly elevated for the tailings area. (KBR, 2019). However, it was noted that all samples tested were below the Health Investigation Level and the Ecological Investigation Level included in NEPC (2013). No elements exceeded the livestock drinking water guideline values (ANZECC, 2000). The results show that there is no specific enrichment of metals across the site of concern.

Spontaneous Combustion

At CH, there is no evidence of pyritic materials present, which could result in spontaneous combustion, and the material has long ago been disturbed and placed. There is no observation or evidence of

spontaneous combustion or surface heating still occurring. Further, as the tailings area was considered to be NAF, it is unlikely to pose a self-heating risk leading to a spontaneous combustion risk.

Saline Drainage

KBR (2019) sampling indicates that the subsoils are extremely sodic but non-saline to slightly saline (based on EC), for the tailings area.

Trace Elements

Heavy metals testing indicated concentrations similar to background concentrations, except for Arsenic (As), which was slightly elevated for the tailings area. (KBR, 2019). However, it was noted that all samples tested were below the Health Investigation Level and the Ecological Investigation Level included in NEPC (2013). The results show that there is no specific enrichment of metals of concern across the site of concern.

3.1.2.4 Summary of Potential for Leaching

Given the low risk of long-term geochemical concerns for the CH tailings area, an approach of reviewing water quality information has been adopted to understand potential for long-term leaching (KBR, 2019). This investigation considered water quality within the void as well as a surrounding water body, and found that the surface water:

- Is slightly to moderately alkaline, and is considered to be fresh in nature (with a near neutral pH);
- Contains low concentrations of suspended particulates and acceptable concentrations of dissolved oxygen to support aquatic ecosystems;
- Contains concentrations of dissolved metals below the ANZECC guideline values, with the exception being for Zinc (Zn);
- Did not contain PFAS or Cyanide, with all samples returning values at or below the limit of reporting; and
- Dissolved metals were below the ANZECC guidelines with the exception of Aluminium (Al), Copper (Cu), and Zinc (Zn).

On the basis of this investigation, it is considered highly unlikely for the Cement Hill tailings area to result in any leaching of concern.

3.1.2.5 Implications for Management

Overall, the geochemistry at the Cement Hill Tailings area indicates that the area is benign, and does not require any specialised management, capping or encapsulation. This is supported by the fact that the area has not been operational for some time, and has been allowed to naturally revegetate. There have been no observations of inability for vegetation to establish, or any undesired seepage or runoff, which indicates that there are unlikely to be any geochemistry limitations or concerns.

The tailings are dry, so that there is no risk of tailings spillage due to failure of the containment walls.

3.2 Rheological Characterisation

Rheology is the science of deformation of material, and is concerned with how a material responds to a force. It is notable that virtually all materials deform in response to an imposed stress and rheological characterisation will assist in understanding the nature of the material and understand how it flows, or why it does not flow as normal.

In the context of tailings materials, rheology is a function of their expected solids concentration, particle size distribution, specific gravity, and mineralogy and geochemistry, and is the key determinant in assessing and understanding the ability to pump tailings slurry and thickened tailings and flow characteristics. It is notable that many of these considerations are addressed for the geochemical or geotechnical characterisation.

However, rheology is particularly relevant to the optimisation of the tailings disposal system and for understanding the feasibility of dewatering of the tailings to the required solids concentration before transport and disposal. It can also specify optimal conditions for tailings pumping and pipeline transport as well as provide an understanding of solids concentration required to achieve the optimal management of the tailings on disposal (Boger et al., 2002). Therefore, the rheological characterisation predicts operational and rehabilitation response of the tailings, both in shear and in compression. This can then inform how and when a tailings surface will be trafficable and then solid enough to allow for rehabilitation and closure activities to safely commence.

Slurried tailings of low solids concentration exhibit Newtonian behaviour (Boger et al., 2002), in which the shear stress of the tailings is a linear function of the shear rate applied. However, once tailings are thickened above a certain consistency, they exhibit non-Newtonian behaviour in which the tailings possess a yield stress beyond which the shear stress increases with increasing shear rate in some fashion, with the possibility of time-dependent behaviour.

For CM, the rejects solution that has been employed consists of thickened tailings material, which is co-disposed with coarse rejects material in Megacells. These cells are then located within a WRD emplacement. These factors mean that the Megacells are not anticipated to act as typical tailings storage facilities, but actually contain a significant proportion of solid materials, which means that the areas will act in line with the surrounding WRD at rehabilitation. An understanding of the post-mining WRD landform is provided as Appendix 4.11 - Landform Design Report.

Further, for CH, the historical tailings area has been decommissioned for approximately 40 years now, and no longer consists of any residual tailings liquid material.

Therefore, this section has focused on detailing how the rheological characterisation confirms the above. The relevant rheological tests include yield stress versus solids concentration, viscosity versus shear rate, and the effect of flocculants. It is thus noted that the remainder of this section is focused on the Megacells at CM, with no detail provided for CH. This is because the Megacells are considered to be the only remaining tailings facilities that are active, with the rheological properties of the residual liquid material to be considered.

3.2.1 Basis of Findings

The development of Clermont Mine considered options for disposal of processing waste, concluding to adopt a co-disposal system (RTCA, 2004a). Where relevant, this information has informed the findings. Further to this, an additional review of the reject management philosophy was completed (ATC Williams, 2011) which subsequently outlined a range of options for life-of-mine disposal requirements (ATC Williams, 2012), and this information has informed this summary.

More recently, a range of studies have been completed from 2020 onwards, to optimise the adequacy of the tailings management solution, but also to ensure the design and risk characteristics of the current arrangement was well documented and met contemporary standards (Golder Associates 2021a, 2021b, 2021c, and 2021d).

3.2.2 Sampling Methodology

Testwork was conducted as part of the feasibility work for the mine, to investigate settling of the tailings, and determine design parameters for suitable disposal facilities. This consisted of sampling to

understand the underlying tailings material to be managed. Details of the methodology used for these investigations is only described as combining sufficient -0.125 mm material to provide a 20 kb (dry solids) composite (Sedgman, 2003).

The following aspects were sampled/analysed:

- Optimal flocculant type and dose;
- Settling rate;
- Underflow percentage solids (conventional and deep cone);
- Mud rheology; and
- Overflow clarity.

Further to this, additional testing was completed as part of the tailings disposal system review (ATC Williams, 2011), which followed a sampling methodology focused on both rheology and geotechnical considerations. Laboratory tests were conducted on samples of 'all in' coarse rejects and thickened tailings. The relevant rheological parameters tested are as follows:

- Shear stress; and
- Rheology testing (Plastic viscosity Vs Solids content).

3.2.3 Summary of Rheological Considerations

As explained above, the rejects solution at CM is an integrated disposal solution, with the Megacells wholly located within a WRD emplacement, and entirely encapsulated at closure. As such, the tailings areas will act in line with the surrounding WRD at rehabilitation. The following summary of rheological concerns is primarily relevant to ensuring a functional and stable disposal emplacement is maintained during operations, to be progressively rehabilitated at the end of the mine life. Primarily, the rheology assists in ensure a suitable pumping system to transport tailings to the disposal location.

The tailings rheology characteristics are also used for modelling of non-Newtonian flow behaviour, which is relevant to understanding geotechnical stability. As shown in ***Table 3-1*** below, a range of slurry densities are considered, with solid concentrations between 30.1% and 52% by mass. From testing, the following Bingham Yield Stress and Plastic Viscosity can be adopted to understand the viscosity, and therefore the ease of transport via pumping, of the tailings. These testing parameters have also informed the geotechnical failure assessment.

Table 3-1 - Summary of Rheology Properties

Solids content (%)	Bingham Yield Stress (*Pa)	Bingham Plastic Viscosity (mPa.S)
30.1	0	10
45.17	3.2	18.3
50.09	10.4	36.4
52.08	17.4	50

3.3 Geotechnical Characterisation

The expected geotechnical performance of a tailings storage facility is important for understanding the potential for failure of the facility, and what is required for these areas to be geotechnically safe and stable. For CM, as explained prior, this is actually governed by the surrounding WRD at the time

of rehabilitation. An understanding of considerations for the post-mining WRD landform is provided as Appendix 4.11 - Landform Design Report. A summary of geotechnical considerations for CCO is provided as Appendix 4.4 – Geotechnical Assessment, with relevant information incorporated herein.

3.3.1 Basis of Findings

As mentioned above, the overarching geotechnical investigations for the CM site have considered risks to the Megacells, being located within the WRD emplacement. A review of the safety and stability of the system was completed in 2013 (Worley Parsons, 2013). There have also been recent investigations completed to inform a consequence category assessment for the operation of the Megacells, which has consider the type and nature of any geotechnical failures that may occur, and to understand the risk of such events (Golder Associates, 2021a). Where relevant, this information has informed the findings. The geotechnical investigations to inform the PRCP has also considered Cement Hill, which is provided as Appendix 4.4 – Geotechnical Assessment, and summarised as relevant in this document.

3.3.2 Sampling Methodology

Geotechnical sampling was conducted as part of the feasibility work for the mine, to determine design parameters for suitable disposal facilities. Sampling has also been undertaken for the tailings disposal system review (ATC Williams, 2011). Details of the methodology used for these investigations is as described in ***Section 3.1.1.1***.

Past coarse and fine rejects samples have been laboratory tested for the following geotechnical material properties:

- Particle size distribution;
- Moisture content;
- Minimum and maximum dry density;
- Soil particle density;
- Solid content of tailings;
- pH, conductivity, total dissolved solids and fluid density;
- Atterberg limits;
- Settlement tests (both drained tray & tray); and
- Shrinkage limit density (Dry density Vs moisture content).

In addition, expert review of the geotechnical characteristics for all operational areas, including CH, has been completed as part of the geotechnical site inspection completed for Appendix 4.4 – Geotechnical Assessment.

Quality control and assurance processes have been applied to all samples, as is standard practice for NATA accredited laboratories, to verify internal quality control and quality assurance of samples.

3.3.3 Summary of Geotechnical Aspects

Table 3-2 provides a summary of geotechnical parameters for the tailings material at CM, which has been used to inform geotechnical investigations for the disposal and storage of the tailings.

Table 3-2 - Summary of Geotechnical Properties

Parameter	Unit	'all in' sample with Coarse rejects	Tailings paste
Particle Size Distribution	%	Clay - 0%/ Silt - 0%/ Sand - 29%/ Gravel – 71%	Clay - 11%/ Silt - 5%/ Sand - 34%/ Gravel - 50%
Moisture Content	%	21.9%	34.6%
Solid Content	%	Between 30% and 52%	45.3
Atterberg Limits	%	N/A	Liquid Limit – 40/ Plastic Limit - 30 Plasticity Index – 10
Specific Gravity	t/m^3	1.94	1.30
Density - Minimum/Maximum	t/m^3	1.06/1.1	N/A
Density - Settled	t/m^3	N/A	Undrained - 0.71/ Drained – 0.97
Density - Shrinkage Limit	t/m^3	N/A	1.01

4. Technical Design Specifications

4.1 General Design Principles

The general design philosophy adopted for CCO is one of integrated landform construction, whereby the tailings waste is disposed of and entirely encircled by a waste rock dump emplacement. At completion of each Megacell, waste rock will be pushed over the dessicated tailings to create a stable platform over the tailings with the waste rock material. In this way, the tailings material is encapsulated by solids.

All current and future tailings areas for CCO are designed, constructed and operated in line with leading practice, in accordance with sound geotechnical principles and cognisant of the known geochemical risks for the site. After closure, all historical facilities are required to remain safe, stable and non-polluting, requiring a sustainable landform and cover system.

4.2 Existing Design and Lining

4.2.1 Design Codes and Guidelines

There are several regulatory codes and guidelines that apply to the design and operations of the current and future Megacells for CCO. In order of precedence, this includes the following documents in ***Table 4-1***.

Table 4-1 - Applicable Design Codes and Guidelines

Type	Document
1. Queensland regulatory requirements	• DES – Guideline. Structures which are dams or levees constructed as part of environmentally relevant activities (Version 8, July 2017). • DES – Manual for assessing consequence categories and hydraulic performance of structures, March 2016. • DNRME – Guidelines for failure impact assessment of Water Dams, 2018.
2. Australian industry codes, standards and guidelines	• Australian National Committee on Large Dams (ANCOLD) – Guidelines on Tailings Dams; Planning Design, Construction, Operation and Closure, 2012 and 2019 Addendum. • ANCOLD – Guidelines on the Consequence Categories for Dams, 2012. • ANCOLD – Guidelines for Design of Dams and Appurtenant Structures for Earthquake, 2019.
3. Glencore internal protocols	• S19012108120 – Protocol for TSFs.

Type	Document
4. International industry codes, standards and guidelines	• Canadian Dam Association (CDA) – Dam Safety Guidelines 2007, 2013 Edition. • International Council on Mining and Metals (ICMM) – Global Industry Standard on Tailings Management.

4.2.2 Design Features for Megacell 2

Table 4-2 provides a summary of the design features of Megacell 2, which is approaching the end of its life but remains in periodic use until the Tailings Settling Cells are completed. This Megacell is enclosed by the Northern WRD on three sides, with an embankment across the western edge of the cell. An Operations, Monitoring and Maintenance Manual is in place for the current active facility (Megacell 2).

Table 4-2 - Active Megacell Characteristics

TSF Item		Description
General Information	Name	Megacell 2
	Dimensions	206 m L x 140 m W, approximately 32 m H
	Period of original construction and tailings deposition	2012 to date
Storage	Surface Area	2.8 ha
	Full supply level	RL 331.6 m
	Tailings storage volume	Undefined, bound by surrounding WRD
	Number of cells	1
Western embankment/ Surrounding WRD material	Material type	Mine waste rock (overburden). Benign/NAF in nature.
	Lining Material	Compacted Basalt at base. Basalt is Benign/AC in nature.
	Embankment height (max)	32 m
	Overall downstream slope	5:1 (H:V)
	Final crest elevation	RL 334.0 m
	Embankment crest width (max)	18 m

TSF Item		Description
Spillway	Description of spillway (materials)	None – freeboard for PMF
Decant Works	Description of decant	Submersible pump
	Location	Eastern side of Megacell
	Details of operation	Pumping as required

As previously noted, a number of experts in the design, operation and closure of tailings storage facilities have been involved in developing and reviewing the design for the Megacells.

4.2.3 Megacell Lining

As noted throughout this document, the geochemical risk posed by the tailings material is the main issue of concern at the CM, and in particular, the risk of AMD and spontaneous combustion occurring. The overarching approach to management of geochemical risks for the site is as detailed in Appendix 4.9 - Mine Waste Characterisation Report.

However, the risk of AMD at the Megacell is relatively low. Basalt material has lined the base of each Megacell, which is known to be acid consuming, and thus likely to neutralise any AMD that may occur. No specific linings have been installed along the sides of the Megacells, but upon closure the Megacell will be encapsulated within benign or NAF material.

4.2.4 Design Features for Settling Cells

Table 4-3 provides a summary of the design features for the recently commissioned Settling Cells.

Table 4-3 - Active Megacell Characteristics

TSF Item		Description
General Information	Name	Settling Cells
	Dimensions	150 m to 250 m L x 30m W (top width)/ 8 m W (base width). Maximum depth of 5.5 m (no embankment as cells are excavated)
	Period of original construction and tailings deposition	2021 to date
	Consequence Category	N/A – not a permanent storage location
Storage	Tailings storage volume	Total 14,473 m^3
	Number of cells	3

4.3 Cover Requirements

At closure, the tailings waste contained with the Megacells will be rehabilitated as an integrated landform, with total encapsulation by the surrounding waste rock dump emplacement. As such, the cover requirements are in line with standard and conservative leading practice to address geochemical concerns within WRD emplacements, and ensure sufficient buffering and isolation of reactive materials.

4.3.1 Encapsulation Criteria

Encapsulation of the tailings within the Megacells will occur in accordance with the schematic shown in ***Figure 4-1***.

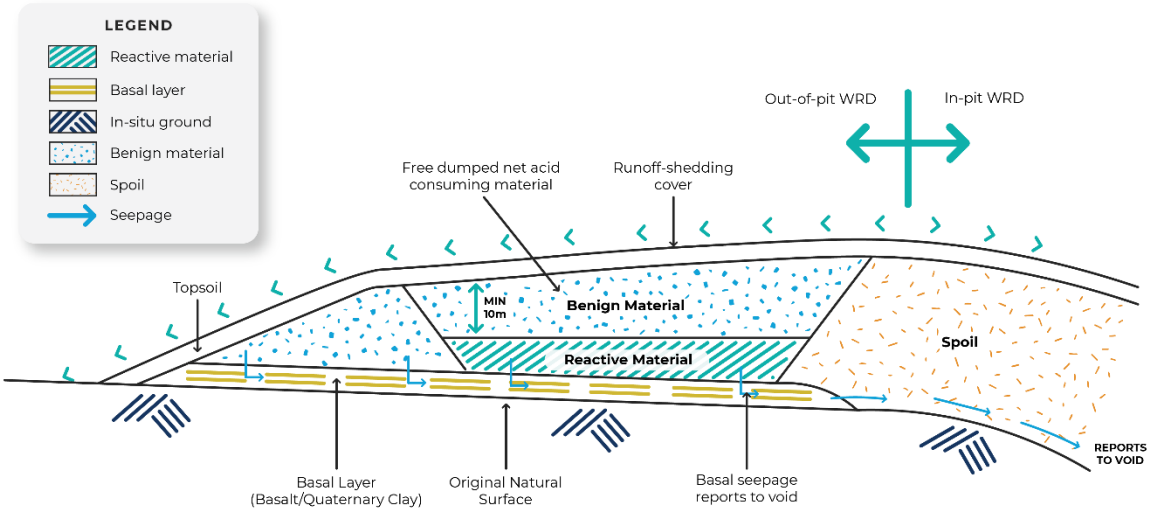

Figure 4-1 - Encapsulation Diagram for Reactive Tailings

The criteria for encapsulating reactive tailings materials is as follows:

- A basal layer of basalt (or some other net-acid-consuming material) must be placed. Note that clean waste is not automatically net-acid-consuming (the material's net acid producing potential, NAPP, must be greater than zero) but is considered non- acid forming (NAF) (sulphur content less than 0.5%). If available, Quaternary clay should be incorporated into the basal layer to reduce infiltration by water;
- Clean material must be free dumped such that no reactive material is located within 10 m of the final dump surface after the slope has been re-contoured at closure;
- The final lift of the reactive area of the waste rock dump must be a layer of clean material, no less than 10 m in thickness;
- The upper surface of the dump must be designed so that it only receives rainfall from the dump catchment itself, with no run-on from adjacent areas;
- Records must be maintained of the placement of reactive material in ex-pit dumps. These should indicate the masses of reactive material placed in each dump;
- Landform designs in areas containing encapsulated PAF material are to be reshaped to ensure the final surface does not encroach within 10 m of the net acid consuming material; and
- No PAF will be placed in outer batter or beneath outer batters of the WRD.

A key criterion of the encapsulation arrangement at CCO is that reactive material must be covered by 10 m of benign (or clean) material. The basis for this thickness comes from the Clermont Supplementary EMOS (RTCA, 2005). This thickness was suggested as a guideline, and if this thickness could not be achieved, consideration of additional controls should be contemplated. Treatment of reactive materials with limestone, and ensuring runoff into the pit or to a containment dam, were both highlighted as suitable additional control measures.

Encapsulation of Megacell 1 has already been completed and achieved at least 10 m clean or NAF material above the tailings. The landform concept design completed for the Northern Waste Rock Dump landform as part of this PRCP achieved a cover of 13 m on top and 30 m on the side.

4.3.2 Management of Spontaneous Combustion

The encapsulation arrangement and criteria required to manage the AMD risk will also minimise the risk of spontaneous combustion occurring. A guiding principle for management of spontaneous combustion is to limit oxidation. A range of options are typically adopted to achieve this, primarily consisting of subaqueous disposal of reactive waste; application of co-disposal storage systems or placement within encapsulated PAF cells.

As shown in ***Figure 4-1***, a designated PAF cell will be constructed and encapsulated for CCO. A co-disposal system has been utilized at CM, and it may be the case that, by depositing the tailings fines material in a wet or saturated state, this will also inhibit spontaneous combustion from occurring within the coarse reject component. Further, a saturated arrangement has been promoted, whereby the Megacells have residual water entrained within the emplacement, which would thus likely inhibit oxygen and minimize exposure of reactive material until encapsulation occurs. The cover applied post-operation will limit oxygen supply and the potential for spontaneous combustion once the material has dried out.

4.4 Leak Detection Systems

Leak detection systems include the observation, inspection and monitoring of activities, conditions, indicators and instrumentation related to tailings management (Golder Associates, 2021c). Monitoring prescriptions apply to both operational and post-operational phases.

4.4.1 Trigger Action Response Plan

A 'Trigger Action Response Plan' (TARP) document has been developed that defines the critical controls, trigger conditions, and actions when those trigger events occur. Trigger events are broken down into the following key concerns - cracking and seismic events; freeboard and decant blockage; piezometers and seepage; piping; and, embankment erosion.

4.4.2 Facility Monitoring

For all TARP triggers, visual inspections are to be conducted. Components undergo routine observation (daily) as well as comprehensive assessments (quarterly) depending on the underlying risk and the relevant critical controls in place. Inspections will consider the tailings discharge points, decant pond, embankment, a check on freeboard and review of all receiving drains.

4.4.3 Instrumentation Monitoring

Nine piezometers have been installed to the south west of Megacell 2, with the purpose and intent of measuring seepage levels to the nearest 0.01 m (AHD). The location of the nine piezometers are as shown on the conceptual site model (***Figure 5-1***). These piezometers will be monitored on a monthly basis and will inform the performance of the Megacell against TARP trigger values.

There is no other automated instrumentation located on the Megacell.

4.5 Leachate Management

The Megacells have been lined with clean (and/or acid-consuming) material intended to neutralise any inherent AMD from the PAF tailings material contained within the Megacell. It will improve the water quality of any residual seepage. Further, CCO have utilised thickened tailings technologies that will yield less free water to the Megacell, and the adoption of Settling Cells will further reduce available water being disposed of in the Megacell, which will reduce the quantity of any residual seepage.

Monitoring has been undertaken to understand if any residual seepage of leachate materials is occurring. Historically, there has been no evidence of leachate occurring, which may require additional management. However, it is now understood that some seepage is occurring from the Megacell area, and specifically from the decant pond, which is the north-eastern corner of Megacell 2. This seepage flows through the WRD to the east and is collected in the Western Diversion Drain, located along the mine haul road at the toe of the waste dump (Golder Associates, 2021b).

As such, further consideration of seepage monitoring, as well as the need for potential collection systems, is prescribed for CCO. The following subsections provide detail of appropriate seepage collection measures to understand, monitor and manage this risk.

4.5.1 Monitoring of Seepage

A number of piezometers have been installed to monitor seepage from the Megacell area to the east, which is a critical pathway to the receiving environment. These piezometers are to be monitored monthly, with management response to be in accordance with the TARP established for the site.

In conjunction with the TARP, monitoring of seepage quality and quantity is undertaken monthly in locations where seepage has been observed.

Current data and previous investigations of these bores indicate adequate buffering is occurring (RGS, 2021). ***Table 4-4*** provides a summary of leachate from kinetic testing, as well as from available seepage locations, including the Western Diversion Drain and the Pit Sump (RGS, 2021). This further illustrates that the expected 'worst case scenario' leachate from the KLC testing is within all relevant livestock water quality guidelines. Water quality analysis for the apparent seepage points once attenuated through the WRD also indicates acceptable water quality results for nearly all parameters. EC and sulphate measurements are marginally higher than the safe values specified for livestock drinking. However, seepage likely to occur is of minimal volume post operation, and would be further mixed in the receiving environment.

Thus, no particular treatment or collection is considered.

4.5.2 Seepage Collection Systems

There are no current seepage collections systems in place.

If seepage continues to occur via the eastern pathway observed, that this will result in seepage being collected under gravity and transported to the residual void (which is to be maintained as a NUMA). As such, irrespective of quality or quantity, any seepage will be entirely contained.

Monitoring should continue into the future, to understand and track any changes to the seepage quality or quantity. If any such changes occur to elevate the risk to downstream environments, that would make it more desirable to contain the seepage, this could likely be achieved relatively easily by intercepting seepage and redirecting the flow into the adjacent residual void under gravity flow.

Table 4-4 - Seepage Monitoring

Parameter			**Sample Source/Location**			
	Livestock drinking water Guideline (ANZECC)		Direct leachate testing (after 6 month KLC)	Megacell	Pit Sump	Western Diversion Drain
pH	-	-	4.07 (ALS assessment)	4.89	7.81	8.2
Electrical Conductivity (EC)	*3,589^*	µs/cm	575 (ALS assessment)	4580	3080	3880
Acidity (as CaCO3)	-	mg/L	19	-	-	-
Alkalinity (as CaCO3)	-	mg/L	<1	<1	<1	<1
Major Cations						
• Calcium (Ca)	*1,000*	mg/L	11	208	190	345
• Magnesium (Mg)	-	mg/L	25	249	144	227
• Sodium (Na)	-	mg/L	46	544	386	330
• Potassium (K)	-	mg/L	4	30	24	9
Major Anions						
• Chloride (Cl)	-	mg/L	13	655	148	494
• Fluoride (F)	*2*	mg/L	<0.1	0.2	0.2	0.1
• Sulfate (SO_4)	*1,000*	mg/L	217	1760	1360	1580
Soluble metals/metalloids						
• Aluminium (Al)	*5*	mg/L	0.15	2.23	0.25	0.2
• Arsenic (As)	*0.5*	mg/L	<0.001	0.002	0.005	<0.001
• Boron (B)	*5*	mg/L	0.06	0.47	0.1	<0.05
• Cadmium (Cd)	*0.01*	mg/L	0.0014	0.002	0.0006	<0.0001
	1	mg/L	<0.001	<1	<0.001	<0.001

Parameter			**Sample Source/Location**			
	Livestock drinking water Guideline (ANZECC)		Direct leachate testing (after 6 month KLC)	Megacell	Pit Sump	Western Diversion Drain
• Chromium (Cr)	*1*	mg/L	0.003	0.01	0.002	0.008
• Copper (Cu)	*1*	mg/L	0.796	0.388	0.184	0.001
• Cobalt (Co)	-	mg/L	0.19	3.22	0.8	0.27
• Iron (Fe)	*0.1*	mg/L	<0.0001	<0.0001	<0.0001	<0.0001
• Mercury (Hg)	-	mg/L	0.532	1.5	1.2	0.029
• Manganese (Mn)	*0.15*	mg/L	0.004	0.01	0.023	0.013
• Molybdenum (Mo)	*1*	mg/L	0.818	0.384	0.201	0.014
• Nickel (Ni)	-	mg/L	0.002	0.002	0.002	<0.001
• Lead (Pb)	*20*	mg/L	3.85	1.98	0.248	0.008
• Zinc (Zn)	*0.02*	mg/L	<0.01	<0.01	<0.01	0.03
• Selenium (Se)	-	mg/L	<0.01	<0.01	<0.01	<0.01
• Vanadium (Vn)						
Estimated volume/flow rate (m/s)	-	cm/s	n/a	n/a	Estimated as <0.1	

^ calculated based on total dissolved solids (TDS) conversion rate of 0.67% of EC. TDS is an approximate measure of inorganic dissolved salts and should not exceed 2,400mg/L for livestock drinking water (RGS, 2021).

5. Conceptual Site Model

A conceptual site model has been developed specifically to consider the active tailings storage facilities at CCO, to show the environmental risk posed by tailings material, as well as to indicate the source-pathway-receptor connections to the surrounding environment. This identifies site-specific factors that may result in geochemical risks, including consideration of the interaction of natural and anthropogenic processes that may influence management controls.

A separate conceptual site model for WRDs has also been provided within Appendix 4.9 - Mine Waste Characterisation Report, in order to provide sufficient detail to clearly show the source-pathway-receptor interactions.

The conceptual model provided below forms both a summary table (***Table 5-1***) and a schematic diagram to show key interactions between the TSFs and surrounding environment. The summary table considers the source-pathway-receptor linkages and highlights key geochemical risks as well as management controls and interventions required. Further, the schematic (provided as ***Figure 5-1***) presents the boundary conditions, site topography and climate, the in situ distribution and location of reactive materials and illustrates key hydrological and hydrogeological pathways.

Table 5-1 - Conceptual site model for tailings at CCO

SPR	Issue	Potential for environmental harm	Key interventions and management strategies
Source	• PAF materials within Megacells	Interaction of PAF material with water resulting in mobilisation of AMD	Design criteria to be met for Megacell – requiring NAF material base and minimum side and top benign material capping distance
Pathway	• Seepage via western embankment	Preferential flow pathways may result in geotechnical instability Poor quality seepage released into drainage network	Monitor geotechnical stability Monitor apparent seepage WQ and manage if required
	• Seepage occurring through surrounding WRD areas and daylighting at natural surface interfaces	Interactions between daylighting locations and surrounding surface environment	Monitor seepage locations and manage if required

SPR	Issue	Potential for environmental harm	Key interventions and management strategies
Receptor	• Residual void (NUMA)	N/A	N/A
	• Receiving surface water environment	Impact to sensitive receptors – human or animal, or aquatic ecosystems Undesirable modification to WQ within downstream surface water catchments	Monitor receiving environment and apply EA WQ criteria

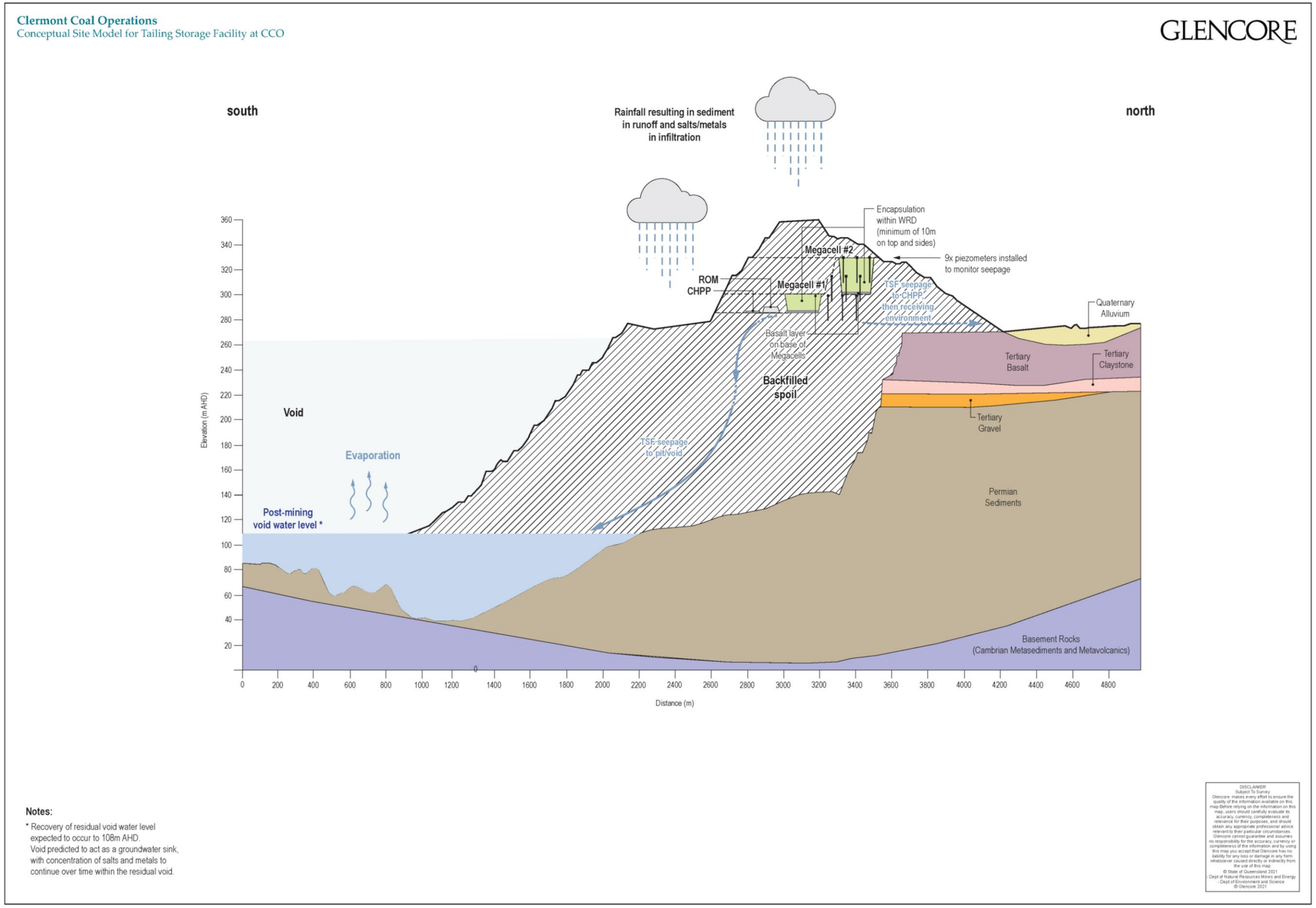

Figure 5-1 - Conceptual site model for tailings at CCO

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Appendix 4.11 - Landform Design Report

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1. Introduction

1.1 Purpose

The purpose of this report is to address the requirements of the PRC Plan statutory guideline by reviewing and assessing existing knowledge and data related to the landform design process, for Clermont Coal Operations (CCO).

1.2 Scope

This document covers all areas of CCO and applies to the Clermont main (CM) deposit, Cement Hill (CH) void and the Train Load-Out facility (TLO). This document focuses on the landform design aspects relevant to rehabilitation and closure of the CCO area. A rehabilitation landform concept has been in development for CCO since 2015, and has been an iterative process as the operation has continued.

2. Background to Landform Design Development

The landform design for CCO is considered to be highly constrained due to close proximity to the highways either side of the mine. ***Figure 2-1*** below illustrates the initial EIS conceptual site layout final landform. Some points made in the EIS relating to landform design includes:

- Maximise in-pit dumping and minimise out of pit dumping;
- Selective placement and burial of PAF waste rock materials to control AMD;
- Implementation of practical landform designs, to prevent erosion, establish final landform stability, ensure sustainability and planning for a nominated final land use;
- Avoid placement of sodic/dispersive waste material on final external batters, near the surface of dumps and within the plant root zone due to their tendency to form low permeability soil horizons, accelerating erosion and inhibiting plant growth (also should not be used as construction material unless treated since they are prone to tunnelling and collapse); and
- Construction of a geotechnically stable landform consisting of north-west and south-west dumps with a self-sustaining native vegetation community, and a final void at the south end of the pit.

Originally, the landform design method was restricted by the EA condition as illustrated below:
"EA 19/01/2015 – Condition F3 - The maximum distance between contour or graded banks on rehabilitated slopes must conform to the values set out in Table F2."

Slope Angle	Maximum vertical interval between banks
< 5%	20 m
5 – 10%	17.5 m
10 – 17%	15 m

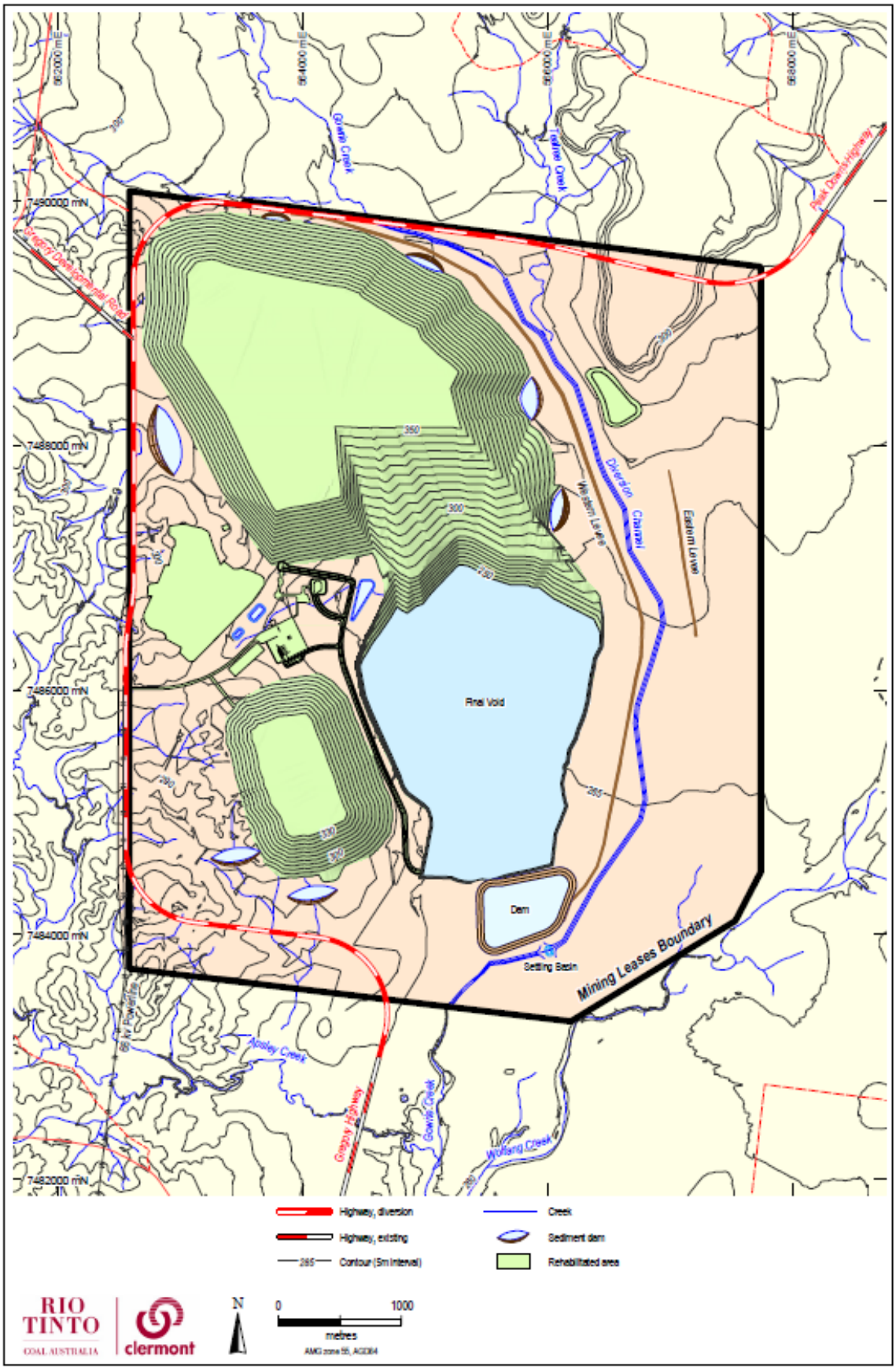


Figure 2-1 - EIS Conceptual Site Layout – Final Landform

As the operations continued, it was considered essential that a landform concept was developed that optimised the operational requirements whilst also ensuring environmental outcomes. In order to achieve this, some core principles as to natural landform establishment and erosion were recognised. Primarily, it was acknowledged that changes to slope angle or steepness typically have a much greater effect on erosion than a similar change to slope length. Natural landforms have a dominantly concave landform in semi-arid areas. Concave slopes tend to counteract the increased potential for erosion downslope (***Figure 2-2***).

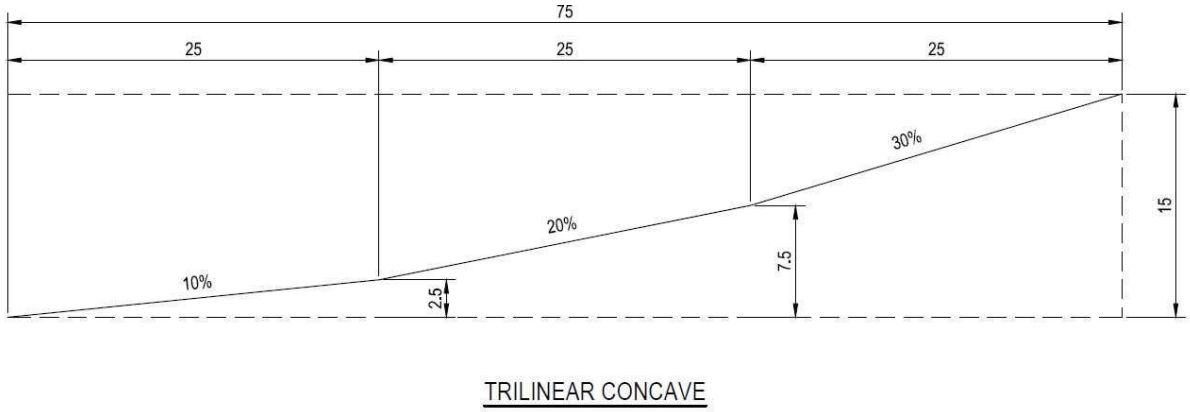


Figure 2-2 – Tri-linear Concave – general design principle for external slopes (CCO, 2020)

It was found that the trilinear landform design highlighted a significant reduction in expected erosion and improved surface stability. As a result CCO were able to amend the EA, and proceed with adopting this new landform concept. The landform concept applies a trilinear slope, and has water management features installed to shed water rather than allow for retention or infiltration. The design has been established and modelled to perform adequately considering the local climatic conditions, rainfall regime and with an understanding of the composition and characterisation of the waste materials.

Key stakeholder consultation indicated the desires relating to landform design were:

- Establish native vegetation as the primary end land use;
- Surface water is to be diverted around the final void and off site to provide water of suitable quality to downstream users; and
- To minimise the area of the void.

Historical issues raised and commitments made are discussed in further detail in Appendix 4.2 of the PRCP.

Rehabilitation planning is an ongoing process, for which some aspects are dynamically updated, and tie into other mine planning processes. This landform design report has been informed by the rehabilitation and mine planning schedule and constraints at the time of writing, which may change over the remaining life of the operation.

3. Development of Design Concept

On the basis of the improved trilinear performance, with respect to erosivity and surface stability, further work was conducted to integrate this concept into the overall design concept. This involved optimising landform height, slope gradient and vegetation covers to achieve acceptable erosion rates over the long-term. Community desires were kept in mind as the design was further developed. The following sections detail the process by which the design was developed.

3.1 Design Methodology

Initial design development occurred in 2016 to provide concept drainage and landform designs and drawings for the final rehabilitated footprint. An iterative process was adopted to understand and explore appropriate standards for the landform design. It was common that no official guidelines or standards were in place to guide design criteria, and CCO were required to interpret from industry knowledge and experience as well as from practices from analogous situations.

Once an initial design concept had been developed, various workshops were held with the specialist landform consultant (O'Kane Consultants) and site stakeholders to share the design concept and discuss potential planning constraints for the final rehabilitation landform design. These workshops provided a forum for discussion of available options to align the mine/operational planning function and ensure the design concept was acceptable to all parts of CCO, and achieved acceptable long term performance as well as being cost effective to construct.

Since the initial design concept was accepted and applied, further changes to the site footprint has occurred, including exploring the opportunity to maximise useful land at natural surface (i.e. between the northern WRD and the void) and further considering the likely final void base case design. Concerns around the potential for flood interactions with the final rehabilitation landform has also identified the need for additional flood protection features in the landform at the southern extent of the void. Design concept iterations incorporated improvements to the design concept based on the performance of the existing rehabilitation areas.

The concept has continued to be refined in a continuous improvement loop drawing on observations of landform and rehabilitation performance. This will continue for the remainder of the mine life as additional data is collected.

4. Key Landform Design Principles

4.1 Landform Areas to be Rehabilitated

4.1.1 Clermont Mine

For CM, the following rehabilitation landform areas require design or have been rehabilitated:

- Northern Waste Rock Dump (NWRD);
- South-West Rock Dump (SWRD);
- South-East Waste Rock Dump (SEWRD);
- Natural surface interface (NSI);
- In-pit void slopes;
- Final void; and
- Southern Landform.

4.1.2 Cement Hill

At CH, despite some early attempts at rehabilitation in the early 1990s substantial additional work is required. The following rehabilitation landform areas require reshaping to meet contemporary standards:

- Waste Rock Dumps (WRD);
- Historic tailings area (TA); and
- Void.

4.1.3 Train Load-Out

At the TLO, there is an area of historic rehabilitation that dates from across the 1990s and 2000s, which overall is performing well. However there is one area where erosion is occurring, and landform reshaping and drainage works are required to repair that area. In addition, the West Dam wall will be bulked out to form a permanent landform. The Rail Loop diversion will be removed and the original flow path reinstated.

These areas are as shown together on ***Figure 4-1***.

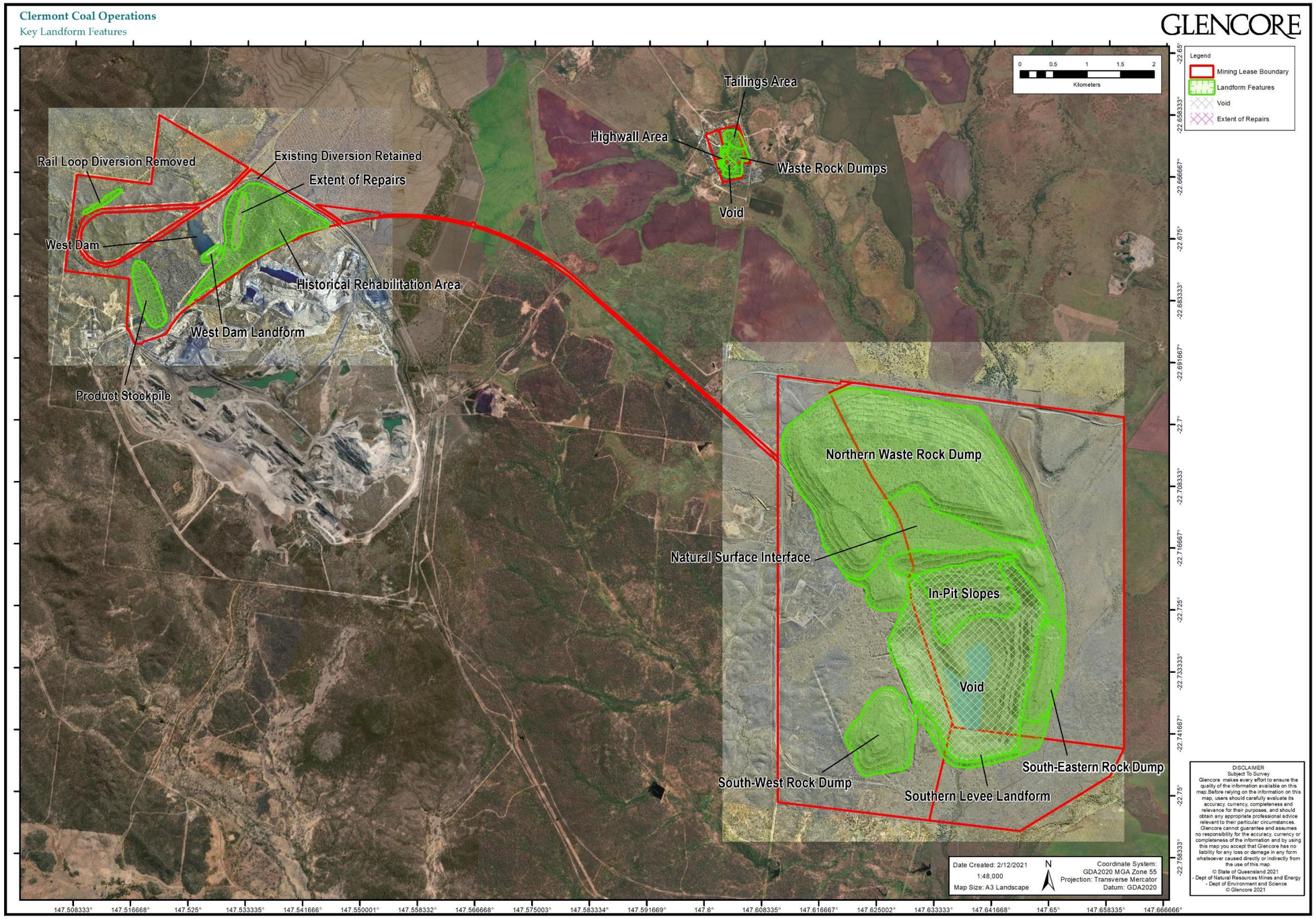


Figure 4-1 - Key landform areas to be rehabilitated at CCO

4.2 Environmental Factors

The following ***Table 4-1*** has been included as a compilation of relevant factors that has informed the landform design concept and development process. All environmental or technical factors of relevance to rehabilitation and closure have been considered, as required, for the landform design.

4.3 Earthworks Design

The earthworks component of the rehabilitation design concept considers:

- Integration and harmonising with the natural surface surrounding the mine;
- High-level consideration of material balanced 'cut and fill';
- Tri-linear design surfaces (15 m lifts above natural surface and 20 m lifts below natural surface), consisting of continuous sections of 30%-20%-10%;
- Each lift will then have a contour bank at the top, of 10 m width and with 10% fall running back towards the dump; and
- All sections of the landform are to have a minimum of 1% longitudinal fall along the slope.

4.4 Water Management

The landform design concept has considered high level water management designs that indicate general drainage directions and indicative chute locations. This is to inform integrated water management during WRD design and construction, and also to ensure landform evolution modelling (LEM) can be conducted. A summary of the landform design principles is provided below. As rehabilitation activities are progressed, concept drainage designs will be further developed and included in the rehabilitation concept design model. A set of guiding drainage design principles are applied to the development of the surface.

Large ponding or standing water bodies is avoided on all rehabilitated landforms. It is expected that the primary contaminant from newly rehabilitated landforms will be sediment, and therefore all runoff from rehabilitation areas will have sediment controls in place for the initial period whilst revegetation is establishing. Depending on the location of the rehabilitated landform, existing sediment dams may be utilised or new structures will be incorporated.

Table 4-1 - Environmental Factors and Constraints of relevance to Landform Design

Key Environmental Factor	Issue or Constraint	Implications for Landform Design
Hydrogeology	• Long-term groundwater inflow into residual void expected • Water to be entrained in backfilled spoil	Nothing of concern.
Flooding	• Much of CCO is located in proximity to 'floodplains' • Flood protection structures are in place for most parts of site, to reduce operational flood risk	Need to be conscious of floodplain extent and patterns. Important to maintain current flood performance. Ensure continued flood protection is incorporated into rehabilitation landform as required.
Soil and Capping Materials	• Suitable topsoil or growth media materials area available to support revegetation • Need to adopt site soil class hierarchy • Plan to remediate existing in-situ topsoil resources for works at CH and TLO	Ensure appropriate topsoil spreading depths. Ameliorate as recommended.
Waste Characterisation	• Majority of waste materials are 'Clean' and can be placed anywhere • A small portion is 'Reactive', and must be subject to selective handling and placement strategies.	All 'Reactive' material to follow site placement strategy (geochemistry). 'Reactive' material placed in-pit and encapsulated with more than 10 m clean material.
Geotechnical Stability	• Weathered zone on upper western wall at CM likely to require lay-back • Pit wall material at CM may require buttressing as part of mining, and may also be required for closure • Geotechnically competent materials occur at CH and TLO	Continually assess geotechnical risks and apply layback and/or buttresses as needed CM void to be retained as NUMA CH high wall to be retained as is For TLO, retain EDD walls as is

Key Environmental Factor	Issue or Constraint	Implications for Landform Design
Landform/ Long-term Erosive Stability	• Significant WRD emplacements in early stages of CM operations, constrained footprint • Less material at CH to be reshaped • Overall, historic rehabilitation at TLO is performing well, apart from erosion in isolated areas	Adopt trilinear for CM Adopt 15% slopes for CH Repair failed rehabilitation at TLO, retain existing stable vegetation
Cover Design	• Not applicable – as tailings areas will be encapsulated within WRD	Not applicable
Water Management	• Site contributes to a number of ephemeral surface water catchments • Strong season rainfall patters with intense wet season flows • Source – pathway – receptor model indicates CM void will prevent off site impacts	Adopt water-shedding philosophy using contour drains with longitudinal fall. Install water management structures and distribute catchments to minimise reliance on any single drainage feature
Revegetation	• Woodland and Light Grazing is proposed as a primary outcome for revegetation	Need to ensure landform slopes include areas suitable for grazing Ensure timing of rehabilitation to support seeding timeframes Aim to incorporate micro-habitats and habitat features into landform design
Tailings Storage Facilities	• Tailings areas will be encapsulated within WRD – implement 'Reactive' waste placement strategy	Need to ensure minimum encapsulation of 10 m 'Clean' net acid consuming material on top/side of all Megacells Tailings to be underneath a gently sloping surface, rather than WRD batter that can promote infilration

Key Environmental Factor	Issue or Constraint	Implications for Landform Design
Voids	• CM residual void to be retained as a NUMA	Ensure signage and abandonment bund and/or fencing is installed
Underground	• Historic underground workings at TLO area have been previously treated and present negligible risk.	No treatment required
Built Infrastructure	• A number of infrastructure features placed on natural ground are to be decommissioned • Infrastructure areas may require top surface scalping to remove contaminated materials	Ensure scalped material can be placed in pit and encapsulated (as per Reactive waste placement strategy

4.4.1 Tri-linear Benches

- Bench drain dimensions are defined by the civil design and application of a tri-linear slope. Drains are 'v' shaped with 1:10 side slopes and 1:100 longitudinal slope;
- Bench drains are typically 1 m deep. A minimum freeboard of 300 mm is to be provided from the design water level to the top level of all drains; and
- The layout of chutes will determine the bench drain lengths and catchment areas. The concept drainage is designed such that bench drains can convey the runoff from a 1% AEP flood event.

4.4.2 Rock Chutes

- Chute drains are to be sized to convey the runoff from a 5% AEP flood event;
- A nominal maximum longitudinal slope of 6% is applied, based on prior experience to limit rock size. This maximum can be adjusted with appropriate hydraulic assessment during detailed design;
- Chute drains are to be designed as 'trapezoidal' drains with 1:4 side slopes and varying base width to provide required conveyance. Minimum 4 m width to be applied;
- A minimum freeboard of 300 mm is to be provided from the design water level to the top level of all chutes. Flow depth to be limited to 700 mm;
- Rock material to be placed as required in areas of high velocity (i.e. > 1.5 m/s) with a nominal maximum D_{50} of 300 mm; and
- Channel roughness for rock chutes varies depending upon rock sizing required for stability. Manning's 'n' values will be estimated based on the equation '$0.05 \times (3.28 \times D_{50})_{1/6}$' where D50 – median rock size (mm).

4.4.2.1 Run-off Design Flows

The 1% AEP and 5% AEP peak flows will be estimated using the hydrological runoff-routing software XP-RAFTS as per the ARR 2019 procedures. Appendix 4.6 of the PRCP goes into further details of CCO's hydrological assessment in relation the landform design. The adopted hydrological values are listed in ***Table 4-2*** below.

Table 4-2 - Hydrological Parameters

Hydrological parameter	Value
Rainfall intensity	Sourced from AR&R 2019
Temporal patterns	Sourced from AR&R 2019
Areal reduction factor (ARF)	1.0
Fraction impervious	5% for mine area
Hydrological roughness	0.035 for pervious area and 0.025 for impervious area
5% AEP initial loss / continuing loss	Sourced from AR&R 2019 with median 5% AEP pre-burst (IL = 26 mm, CL = 1.5 mm/hr)

4.4.3 Hydraulic Design

The hydraulic performance of the benches and rock chutes have been measured against 1% AEP and 5% AEP events respectively. A table relating catchment size for the chutes to the required base width and rock size is applied to guide the designer. Chutes will be incorporated into the design in accordance with this information.

Table 4-3 below lists the proposed chute design parameters to be used within the analysis.

Table 4-3 - Proposed Drainage Channel Design Parameters

Channel Property	Design Parameters
Batter Slopes	1 (vertical) in 4 (horizontal)
Base Width	Vary between 4 - 6 m
Channel Depth	Limit to 0.7 m depth of flow, 1 m channel depth
Freeboard Requirement	Nominally 300 mm
Bench Drain Roughness	0.04 (Manning's value)
Rock Chute Roughness	Varies dependent upon D50 rock sizing
Rock Sizing	D50 size varies to provide a minimum FOS of 1.5 for stability for the defined rock sizing from stockpiles
Rock Depth	Nominally 2 X D50 (if required)
Slopes	Nominally 1% for bench drains and 6% for rock chutes

5. Final Rehabilitation Design Concept

A 3D design model has been produced for the PRCP, and is envisaged to be a 'living' design that is updated whenever new information is available or when new decisions are made with regards to the final landform. The landform design model was developed using the mine 'block model'.

The block model indicates the final pit shell and WRD emplacements at the end of production. The landform design concept has been applied to it to generate rehabilitation and closure landforms. This has consisted of reshaping to adopt the form of 'tri-linear' slopes, and installation of conceptual drainage elements, such as benches and rock chutes.

Visualisations have been produced to show the design features, as well as demonstrate how the final landform is expected to look once rehabilitation and closure activities are complete. The design presented is concept only and subject to revision as detailed design is progressively completed over the remaining mine life.

5.1 Clermont Mine

CCO has adopted a rehabilitation landform design that is atypical for coal mines in the Bowen Basin, due to the significant volume of material dumped ex-pit (prior to space becoming available in-pit) and the relatively small footprint of the mining lease. This means a number of the dumps are in the order of 75 m or more above surface level and were placed at angle of repose. In response to these constraints, CCO has implemented a tri-linear design for rehabilitation slopes to reduce erosion when compared to the original slope design proposed in the EIS (maximum 17 percent slopes with contour benches every 15 m of elevation).

Geotechnical constraints to landform design were informed by a Geotechnical Assessment, which is covered in Appendix 4.4 of the PRCP. Suitable material identification and availability for landform rehabilitation is discussed within Appendix 4.8 of the PRCP.

The CCO rehabilitation does not require any form of lining to prevent water or air ingress to minimise the potential for seepage, as it was found that CCO has a very low seepage risk. As there is a low risk of seepage occuring, there are no monitoring performace requirements, nor liners or seepage collection systems utilised at CCO. This is further discussed in Appendix 4.7 as well as in Appendix 4.10 of the PRCP.

5.1.1 Summary of Key Features

Landform design characteristics are detailed in ***Figure 5-1*** for each landform area within the CM area. The main landforms relevant to the CM area include the Northern Waste Rock Dump (NWRD); South-West Rock Dump (SWRD); South-Eastern Waste Rock Dump (SEWRD); Natural Surface Interface (NSI); In-Pit Slopes; Void and the Southern Landform. ***Table 5-1*** details the key features of each landform for the CM area, and is reflective of the final design concept. A view of the 3D design work has been included for each feature.

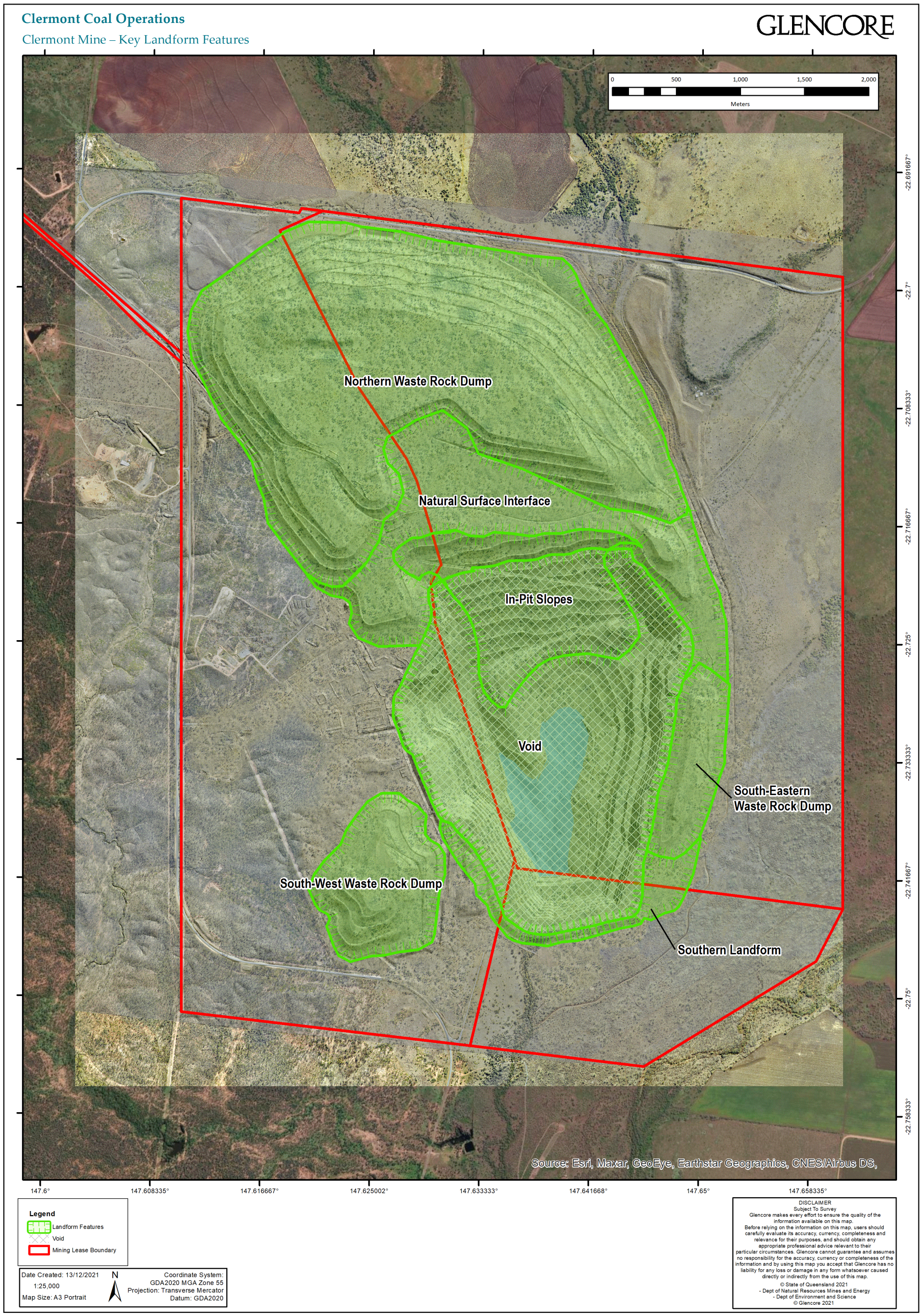
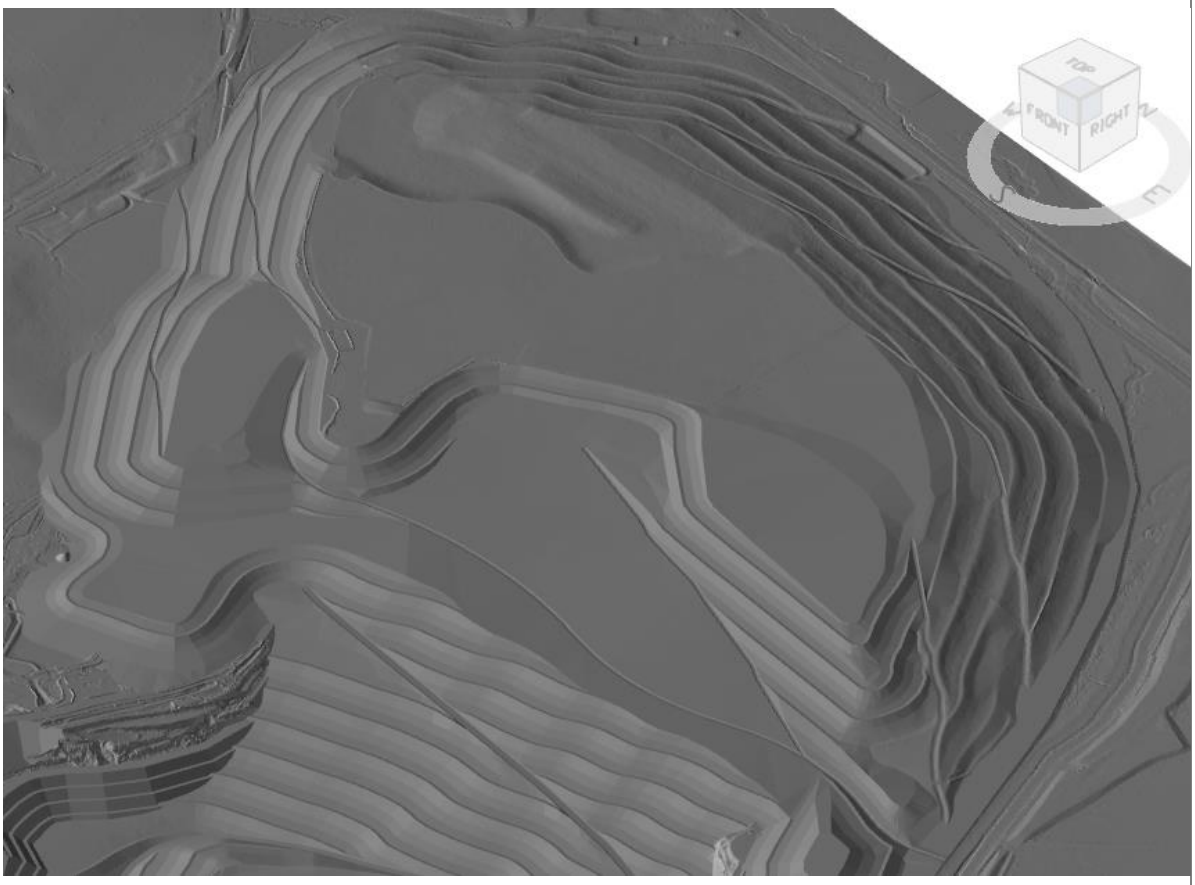
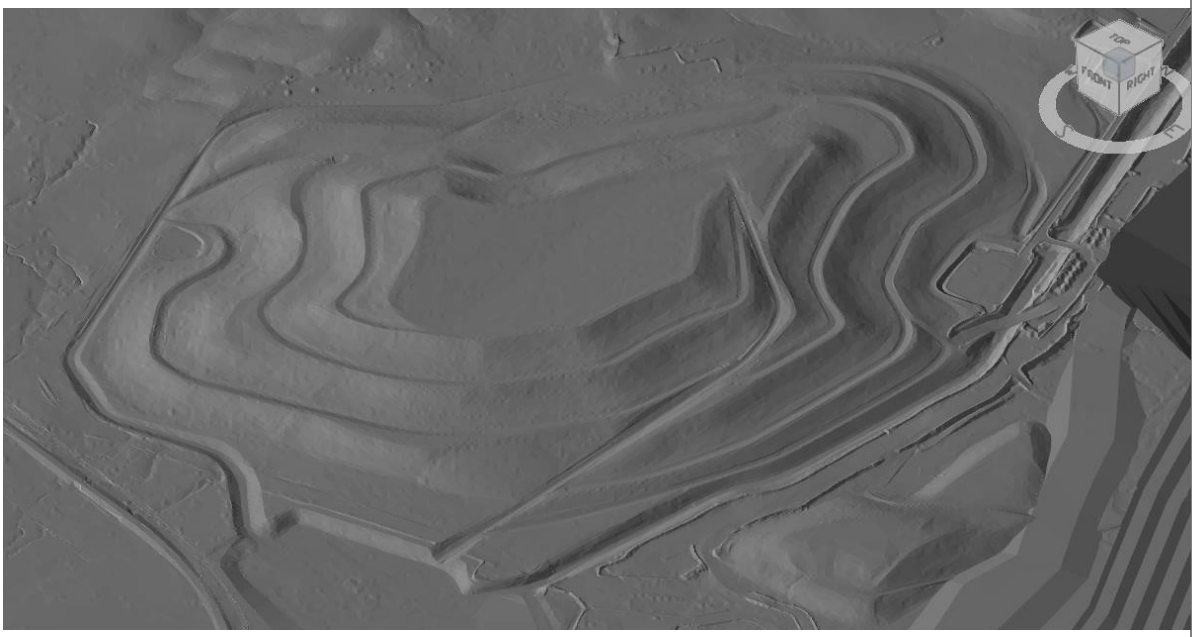
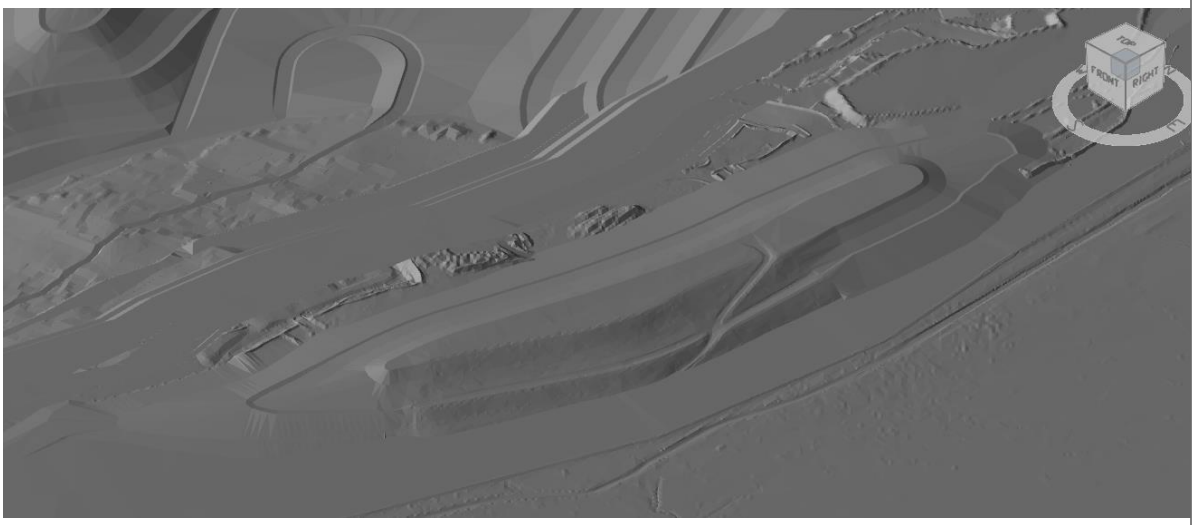


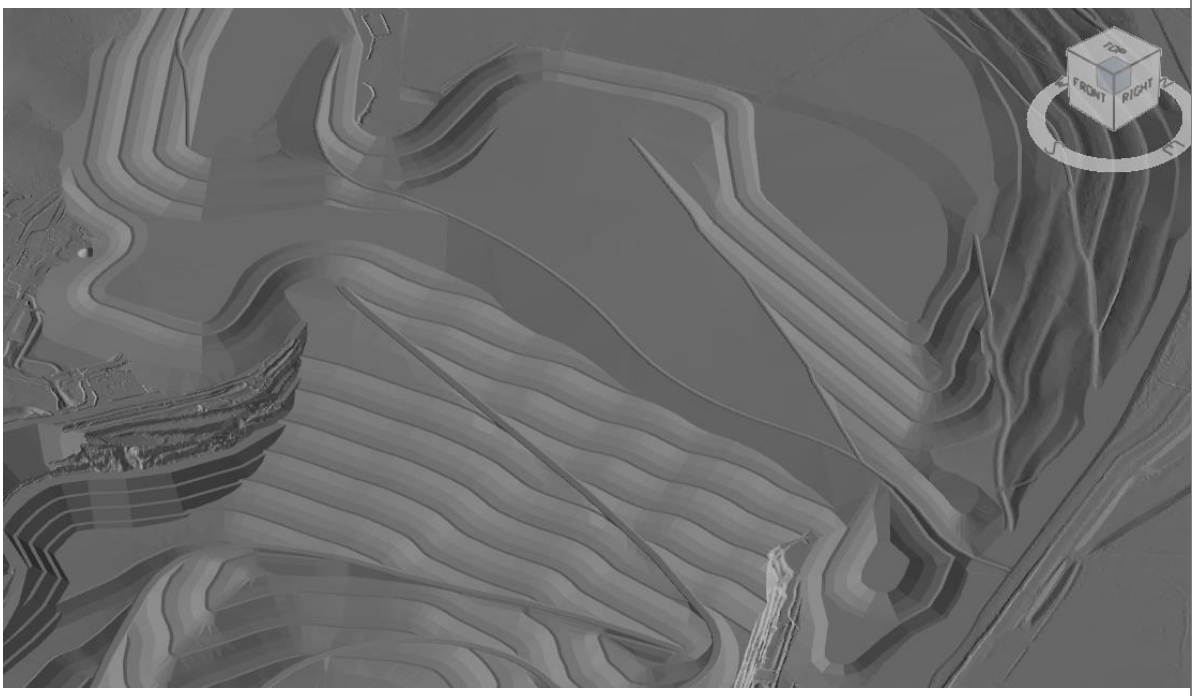
Figure 5-1 - Key landform features for CM area

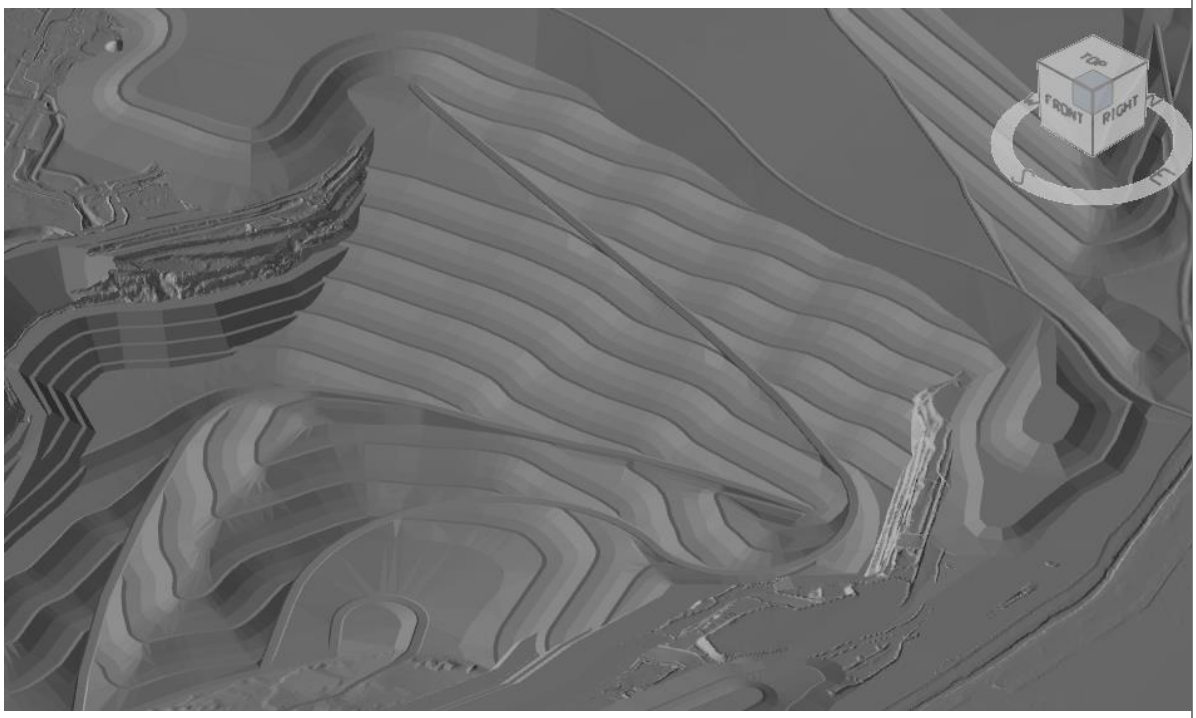
Table 5-1 - Key features by landform for CM

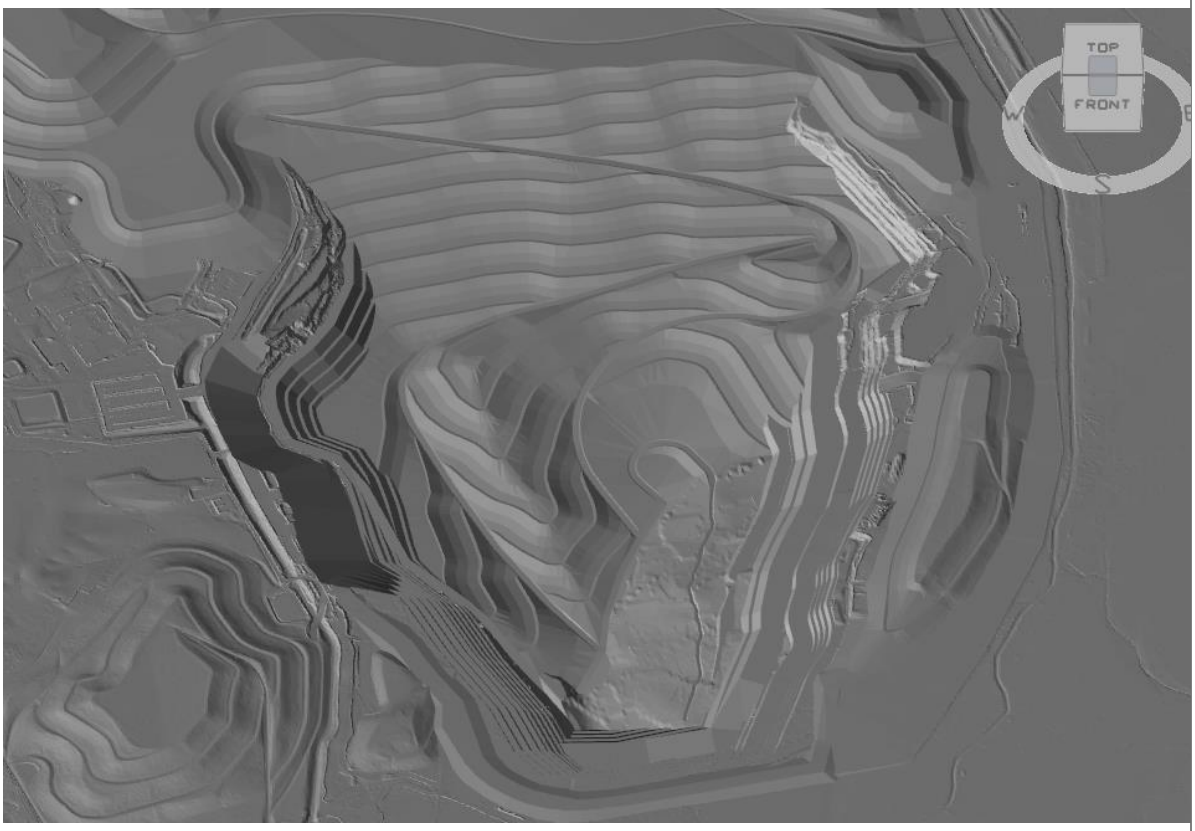
Northern Waste Rock Dump	**Dimensions**
	
Landform footprint	654 ha
Landform height	360 m AHD, ~75 m high from natural ground
Slope gradient & typical length	Trilinear (30/20/10%)
Lift height	15 m
Surface water philosophy	Water shedding
Surface treatment	Revegetated
Landform PMLU	Woodland & Light Grazing
Key design constraints and considerations	Highway at northern toe, visual impacts of concern. Significant landform overall size and height Need to manage local catchment runoff effectively. Ensure toe to north and east ties into existing operational levee, with permanent landform to be extended to top of levee and levee structure retained intact to provide toe protection during flood events.

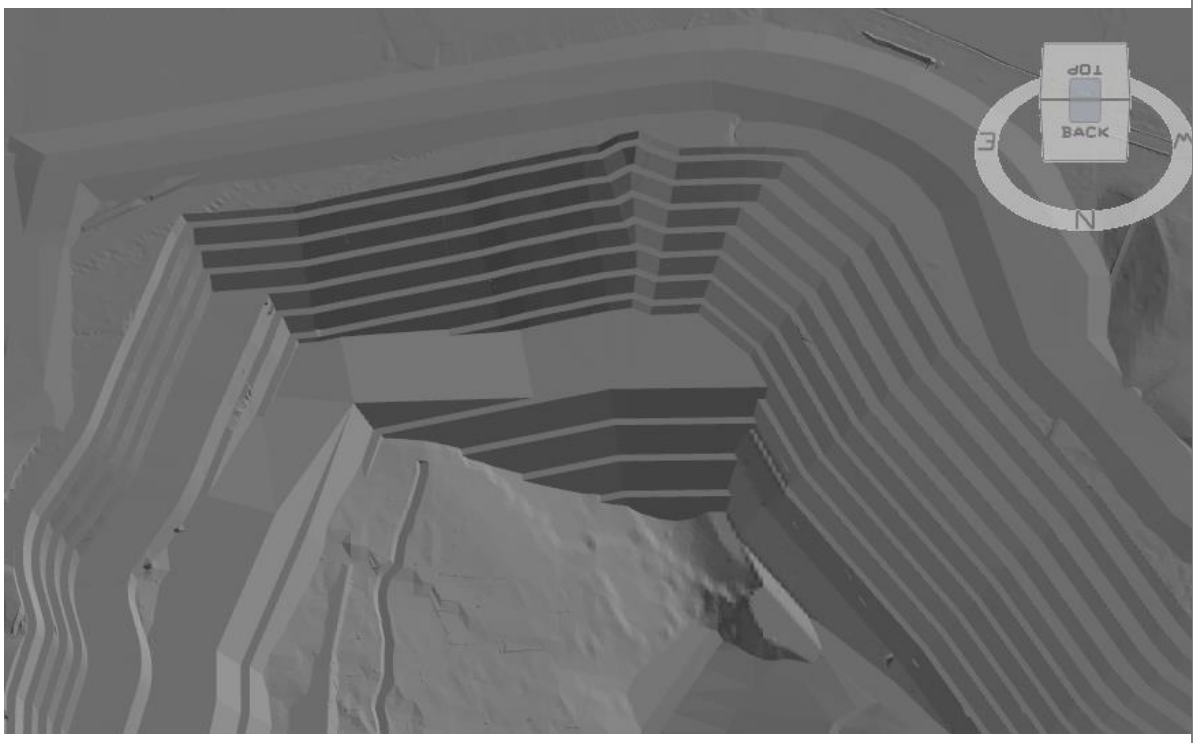
South-West Rock Dump	Dimensions
	
Landform footprint	98 ha
Landform height	310 m AHD, ~40 m high from natural ground
Slope gradient & typical length	Trilinear (30/20/10%)
Lift height	15 m
Surface water philosophy	Water shedding
Surface treatment	Revegetated
Landform PMLU	Woodland & Light Grazing
Key design constraints and considerations	*This is an existing rehabilitated area.* Highway to south of WRD, visual impacts of concern. Constrained by surface drainage features to the west.

South-Eastern Waste Rock Dump	Dimensions
	
Landform footprint	60 ha
Landform height	295 m AHD, ~250 m high from natural ground
Slope gradient & typical length	Reduced trilinear due to lower landform height (30/20/10%)
Lift height	Maximum of 15 m
Surface water philosophy	Water shedding
Surface treatment	Revegetated
Landform PMLU	Woodland & Light Grazing
Key design constraints and considerations	Ensure toe to east ties into and incorporates the existing operational levee. The landform is to be extended to the crest of the levee, and the levee structure retained intact, to provide toe protection during flood events.

Natural Surface Interface	Dimensions
	
Landform footprint	198 ha
Landform height	Between 270 – 325 m AHD, sloping down to natural ground surface ~270 m AHD Up to 55 m high from natural ground
Slope gradient & typical length	Linear slope, contoured to meet in with natural surface, with reshaping to achieve drainage. Average gradient of ~3%
Lift height	N/A
Surface water philosophy	Water shedding
Surface treatment	Revegetated
Landform PMLU	Woodland & Light Grazing
Key design constraints and considerations	Tie into natural surface to east and west Maximise ex-pit drainage and ensure slope grade to support catchment functionality Provide areas with access to top of NWRD plateau for livestock grazing

In-Pit Slopes	Dimensions
	
Landform footprint	149 ha
Landform height	From natural ground surface ~270 m AHD down to ~ 100 m AHD ~170 m high from base of slopes to natural ground
Slope gradient & typical length	Extended trilinear for in pit areas (30/20/10%)
Lift height	20 m
Surface water philosophy	Water shedding
Surface treatment	Revegetated
Landform PMLU	Woodland & Light Grazing
Key design constraints and considerations	Significant in pit catchment/backfilled material Ensure adequate surface water management with chute concept

Void	Dimensions
	
Landform footprint	582 ha
Landform height	From natural ground surface ~270 m AHD down to ~ 75 m AHD ~195 m high from base of void to natural ground
Slope gradient & typical length	Contoured to meet in with natural surface, with reshaping to achieve drainage
Lift height	N/A
Surface water philosophy	Water shedding
Surface treatment	Revegetated
Landform PMLU	Woodland & Light Grazing
Key design constraints and considerations	Abandonment bund and/or fencing is required Weathered zone on upper western wall likely to require lay-back Pit wall material may require buttressing as part of mining, and may also be required for closure

Southern Landform	Dimensions
	
Landform footprint	42 ha
Landform height	Up to 270 m AHD, on natural ground between 262-265 m AHD. Up to 5 m high
Slope gradient & typical length	Linear slopes adopted for sides (15%), with a minimum 50 m wide top surface
Lift height	N/A
Surface water philosophy	Water shedding
Surface treatment	Revegetated
Landform PMLU	Woodland & Light Grazing
Key design constraints and considerations	Current operational levee will be bulked out as a permanent landform installation to provide long term flood immunity to the void Tie into existing landforms to the east

5.1.2 Summary of Landform Design

The CM landform design adopts:

- Tri-linear slopes and drainage features should be applied for all areas, including in-pit;
- Tri-linear (30%, 20% and 10%) batters to be used as standard, with 15 m lifts above natural surface and 20 m lifts below ground;
- Gowrie Creek levee will be decommissioned and incorporated into the landform design;
- Weathered zone on upper western wall likely to require lay-back for long term stability. Pit wall material may require buttressing as part of mining, and may also be required for closure. Aim to achieve a geotechnically safe and stable outcomes, with Factor of Safety as a guide but not a further criteria to be met. Certification to be obtained by a geotechnical expert;
- Exposed coal will be covered by backfill to manage spontaneous combustion risks, in line with 'Reactive' waste placement strategy;
- The Natural Surface Interface between the NWRD and the final void to be retained as useable land and area maximised;
- Void catchment should be minimised with external flows diverted away from the pit; and
- Permanent flood immunity is required for the final void, to be achieved through converting levee structures into permanent landforms.

5.1.2.1 Exceptions

There are some areas that have required deviation from the general design principles as outlined. These are listed below with their associated reasons for deviating:

- 2015 NWRD (14.6 ha). Area reshaped in accordance with the original EA conditions and prior to the adoption of the tri-linear design;
- 2016 NWRD ridge (~20 ha). Tying in either side of the ridgeline along the top of the 2016 NWRD required an element of field fit where changes in compaction factors resulted in less material than anticipated. These areas are largely slopes of around 10%, much shallower than the alternative design;
- 2016 NWRD toe (~10 ha). Blending the lowest bench into natural surface required an element of field fit where changes in compaction factors resulted in a net excess of material. These areas are a tri-linear landform with the 10% component of the slope increased to accommodate the excess material. This deviation effectively reduces the average slope angle; and
- Isolated areas around drainage chutes (<0.5 ha) may have been field fit to achieve acceptable real world outcomes. Similarly, for small areas where drainage chutes intersect slopes.

5.1.3 Proposed Rehabilitation Activities

The key rehabilitation activities proposed for the CM landforms are summarised in ***Table 5-2***. This indicates how the environmental, technical and constraints have informed the current landform design. This identities the rehabilitation feature that is the subject of the activity, the scope of activity required, and why it is needed.

Table 5-2 - Clermont Landform Rehabilitation Activities

Feature	Scope	Purpose
Reshaping	Provide 15 m or 20 m height trilinear slopes depending on constraints of WRD	Erosional stability
Encapsulation	Ensure all reactive materials are encapsulated in no less than 10 m of clean material Follow specific design arrangement for Megacell areas	Mitigation of geochemical risks
Highwall treatment	Weathered zone on upper western wall likely to require lay-back for long term stability Pit wall material may require buttressing as part of mining, and may also be required for closure.	Geotechnical stability and management of spontaneous combustion risks
Surface treatment	Rock mulching on lower half of lay back of pit highwall weathered zone No rock mulching required elsewhere	Erosion protection
Drainage	Bench drains between all areas of trilinear slopes, with longitudinal fall	Drainage and erosion protection
	Rock lined chutes directing flow from bench drains to receiving environment	Drainage and erosion protection
Revegetation	Topsoil and seed all areas to support PMLU	Erosion control and potential future grazing activity within PMLU
Flood protection	Bulk out the Gowrie Creek levee to create a permanent landform Required for all landforms along the eastern and southern extent of the site, including NWRD, SEWRD and Southern Landform	Final void flood immunity for events up to 0.1% AEP
Void Abandonment bund	Construct abandonment bund on the western wall of the void and tie into the southern landform	Deter access of people, vehicles and animals to the high wall

5.1.4 Overall 3D Design – Clermont Mine

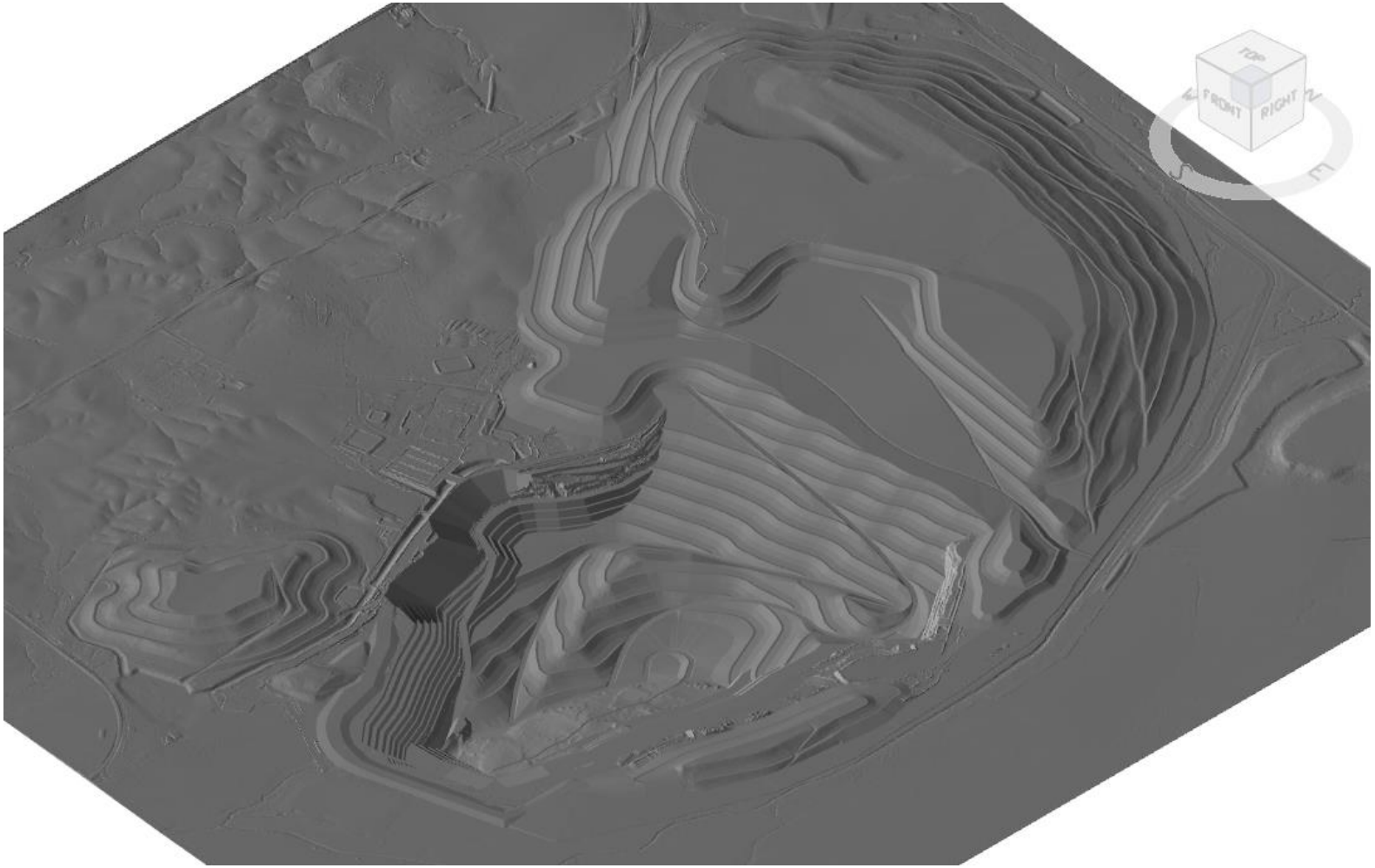


Figure 5-2 – Overview of 3D landform design for CM footprint for rehabilitation and closure

5.2 Cement Hill

The Cement Hill leases have been partly rehabilitated previously, and now consist of an undular landform that includes an excavated void with ponded water, relatively flat former waste rock dumps, and dried-out shallow flat cells containing fines from process screening and washing circuits. All Cement Hill landforms were assessed to be geotechnically stable as-is.

Despite the previous rehabilitation efforts in the early 1990s, CCO have assessed that no part of the CH area is considered to be rehabilitated at present. The landform design has considered the rehabilitation requirements of the areas assuming all areas may require some reworking. The residual void at CH currently acts as a water storage feature, which is utilised by stakeholders, and is expected to continue to do so post closure.

5.2.1 Summary of Key Features

Landform design characteristics have been detailed in ***Figure 5-3*** for each landform area within the CH area. Key features of each of the rehabilitated landforms is as identified, including landform footprint and height, as well as a range of other relevant factors. CCO has sought to optimise the long term rehabilitation outcomes for the site. The key design decisions, constraints and considerations have also been summarised, these represent the aspects that have influenced the landform design at each location.

The main landforms relevant to the CH area include the Waste Rock Dumps (WRDs); Tailings Area (TA); the High Wall (HW) and the Void. The following ***Table 5-3*** details the key features of each landform for the CH area, and are reflective of the final design concept. A view of the 3D design work has been included for each feature, positioned so as to best show the nature of each landform feature.

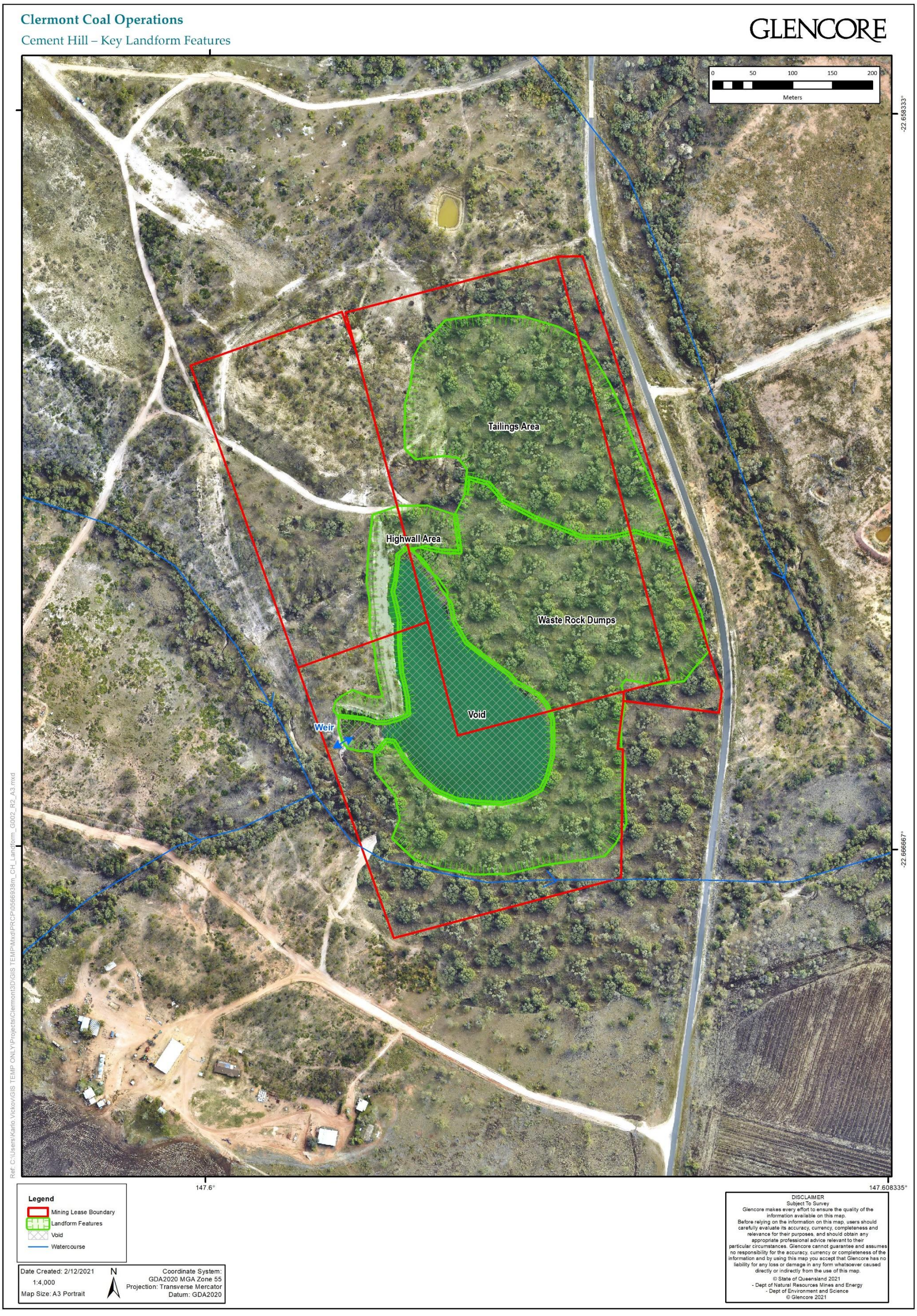
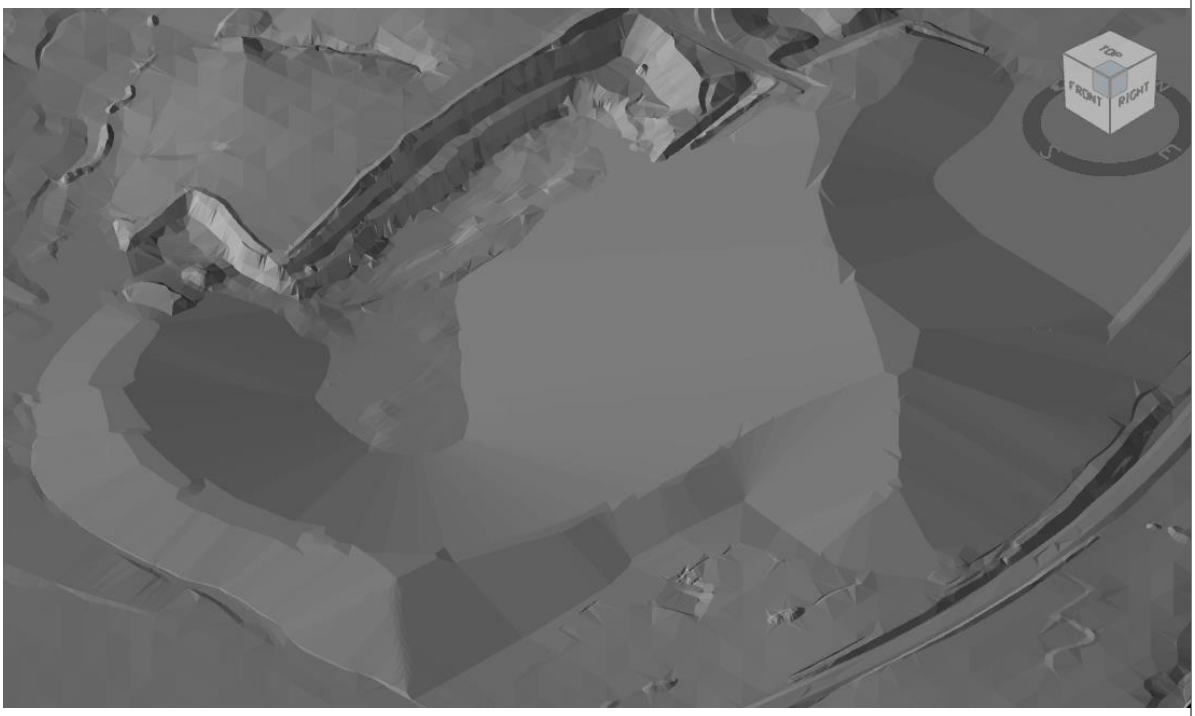
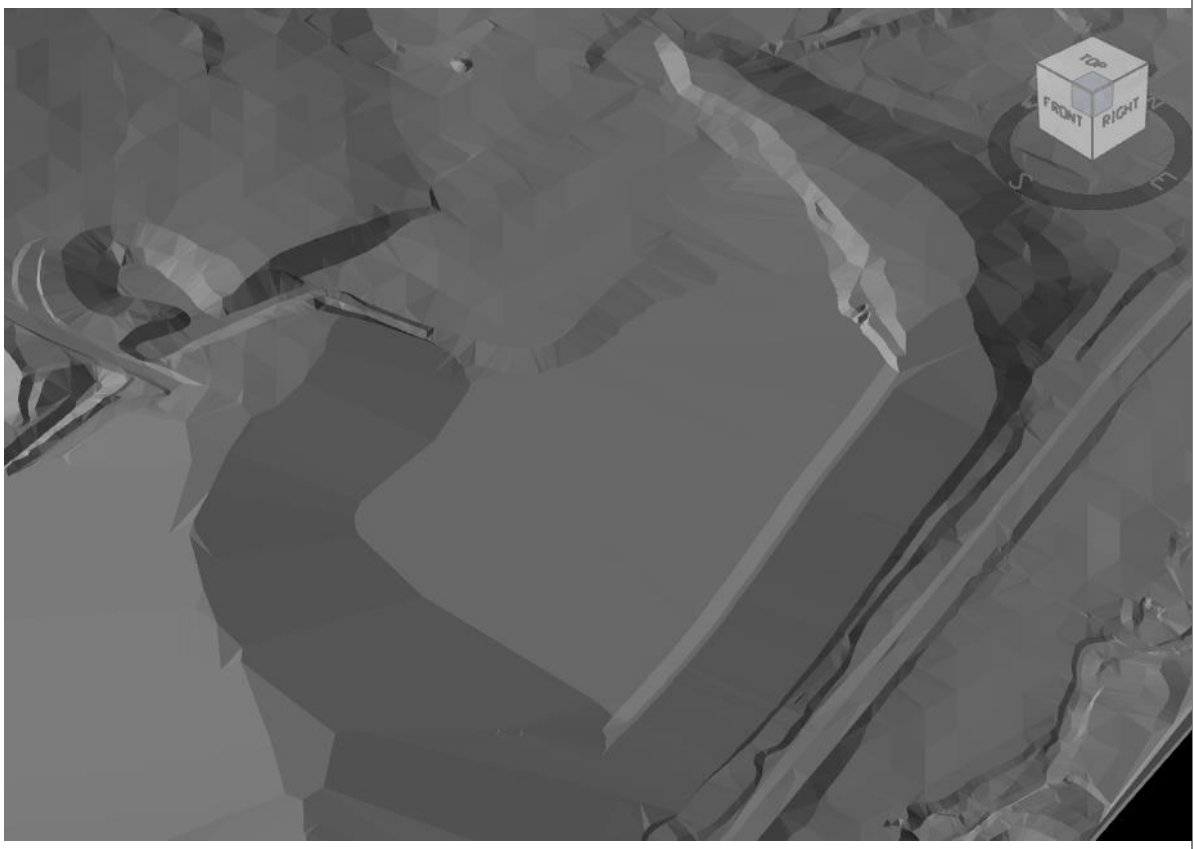
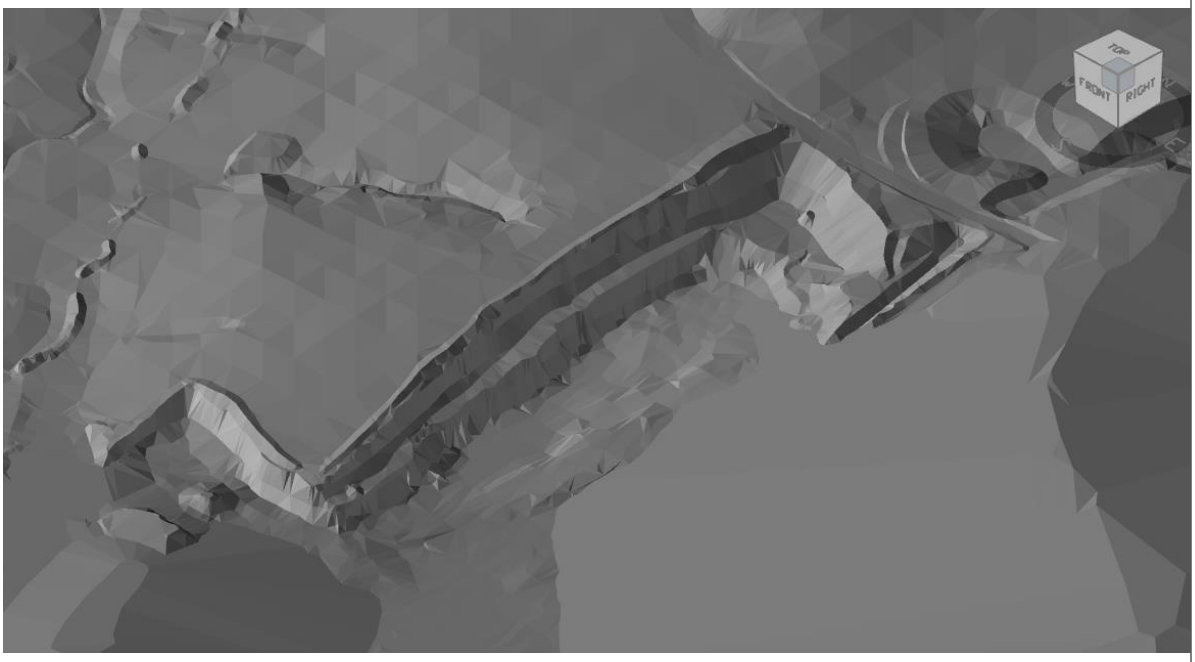


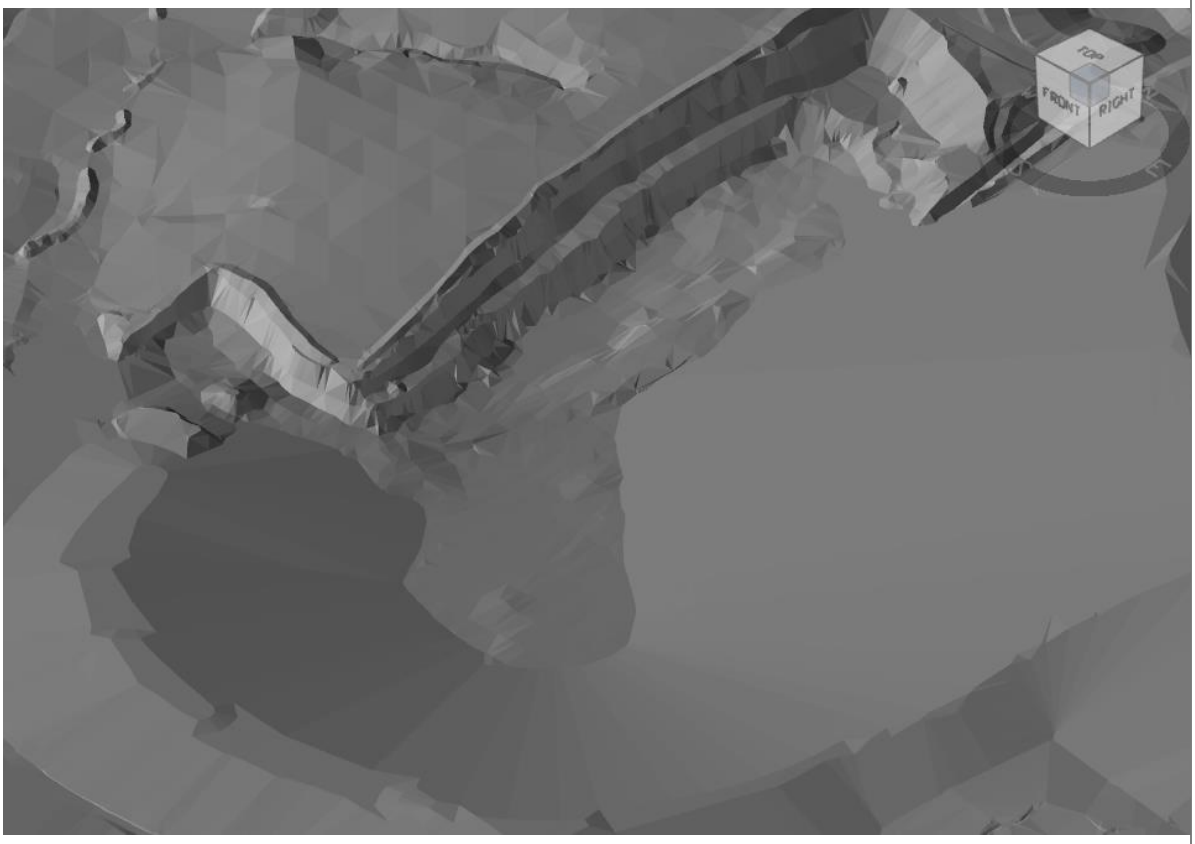
Figure 5-3 - Key landform features for CH area

Table 5-3 - Key features by landform for CH

Waste Rock Dumps	Dimensions
	
Landform footprint	10 ha
Landform height	320 m AHD, ~20 m high from natural ground
Slope gradient & typical length	Linear (15%), focus on achieving cut/fill balance
Lift height	20 m
Surface water philosophy	Water shedding
Surface treatment	Revegetated
Landform PMLU	Woodland & Light Grazing
Key design constraints and considerations	Highway at eastern extent, and previous dump footprint encroached beyond ML boundary Maintain void capacity for water storage and supply Ensure saline/compacted area on top of previous surface was reshaped Floodplain interactions to the south impacted on position of southern WRDs

Tailings Area	Dimensions
	
Landform footprint	6 ha
Landform height	310 m AHD, ~10 m high from natural ground
Slope gradient & typical length	Overall flat, terraced from 310 m AHD to 308 m AHD. Eastern batter to achieve 15% linear slope (15%)
Lift height	N/A
Surface water philosophy	Water shedding from higher areas, to be ponded in lower terrace/cell area
Surface treatment	Revegetated
Landform PMLU	Woodland & Light Grazing
Key design constraints and considerations	Highway at eastern extent, with angle of repose outer batter very close to the road Geotechnically considered acceptable to remain as water ponding feature, also noted as having some natural revegetation Ensure earthworks solution removed operational landform features (such as inner cell wall)

High wall Area	Dimensions
	
Landform footprint	1 ha
Landform height	320 m AHD (with water level ~300 m AHD)
Slope gradient & typical length	Angle of repose
Lift height	N/A
Surface water philosophy	N/A
Surface treatment	Retained as is
Landform PMLU	Woodland & Light Grazing
Key design constraints and considerations	Geotechnically considered acceptable to remain as is, without modification or layback

Final Void	Dimensions
	
Landform footprint	3 ha
Landform height	Base of void at ~290 mAHD, compared to natural ground surface ~300 mAHD (10 m deep)
Slope gradient & typical length	Linear (15%), focus on achieving cut/fill balance
Lift height	N/A
Surface water philosophy	Water shedding
Surface treatment	Revegetated
Landform PMLU	Woodland & Light Grazing
Key design constraints and considerations	Maintain void capacity for water storage and supply Need to ensure shaping of the WRD areas to the base of the void Ensure weir level continued to maintain flushing frequency as currently occurs

5.2.2 Summary of Landform Design

The CH landform design is based on the following:

- Saline soils to be selectively placed within the WRD such that they are covered;
- A comparison between the tri-linear slope profile and a linear 15% slope showed minimal cost differential and erosion performance. A linear slope has been adopted;
- Floodplain modelling revealed a need to remove the southern satellite dump due to undesirable flood velocities modelled;
- Geotechnical assessment indicated that the high wall was not considered at risk, and was suitable to be retained as is (unchanged);
- The value of the water to surrounding stakeholders was a primary driver in retaining the void;
- Minor stabilisation of the entry and exit points to the in-situ rock weir linking the void to the nearby watercourse is required;
- The outer walls of the Tailings area was agreed to be flattened to 15% linear slope and to remove the internal cells or windrows, creating a terraced landform draining to the primary (lower) cell; and
- A concrete water tank located on the southern batter of the tailings area will be removed.

5.2.3 Proposed Rehabilitation Activities

The key rehabilitation activities proposed for the CH landforms are summarised in ***Table 5-4***. This indicates how the environmental, technical and constraints have informed the current landform design. This identities the rehabilitation feature that is the subject of the activity, the scope of activity required, and why it is needed.

Table 5-4 - Cement Hill Landform Rehabilitation Activities

Feature	Scope	Purpose
Reshaping	Adopt a linear slope arrangement for stability	Erosional stability
Selective placement	Saline soils to be selectively placed within the WRD such that they are covered	Mitigation of geochemical risks
Highwall treatment	Not required	N/A
Surface treatment	Not required	N/A
Drainage	Small and short linear slopes removed the need for bench drains or rock lined chutes	Drainage and erosion protection
Revegetation	Topsoil and seed all areas to support PMLU	Erosion control and potential future grazing activity within PMLU
Flood protection	Need to remove the entirety of the satellite dump to the south, to relieve floodplain restriction Modelling also revealed a second potential void inflow point. Targeted reshaping was proposed to ensure a single point of water exchange	Ensure adequate flood performance, particular in relation to velocities
Void Abandonment bund	Not required	N/A

5.2.4 Overall 3D Design – Cement Hill

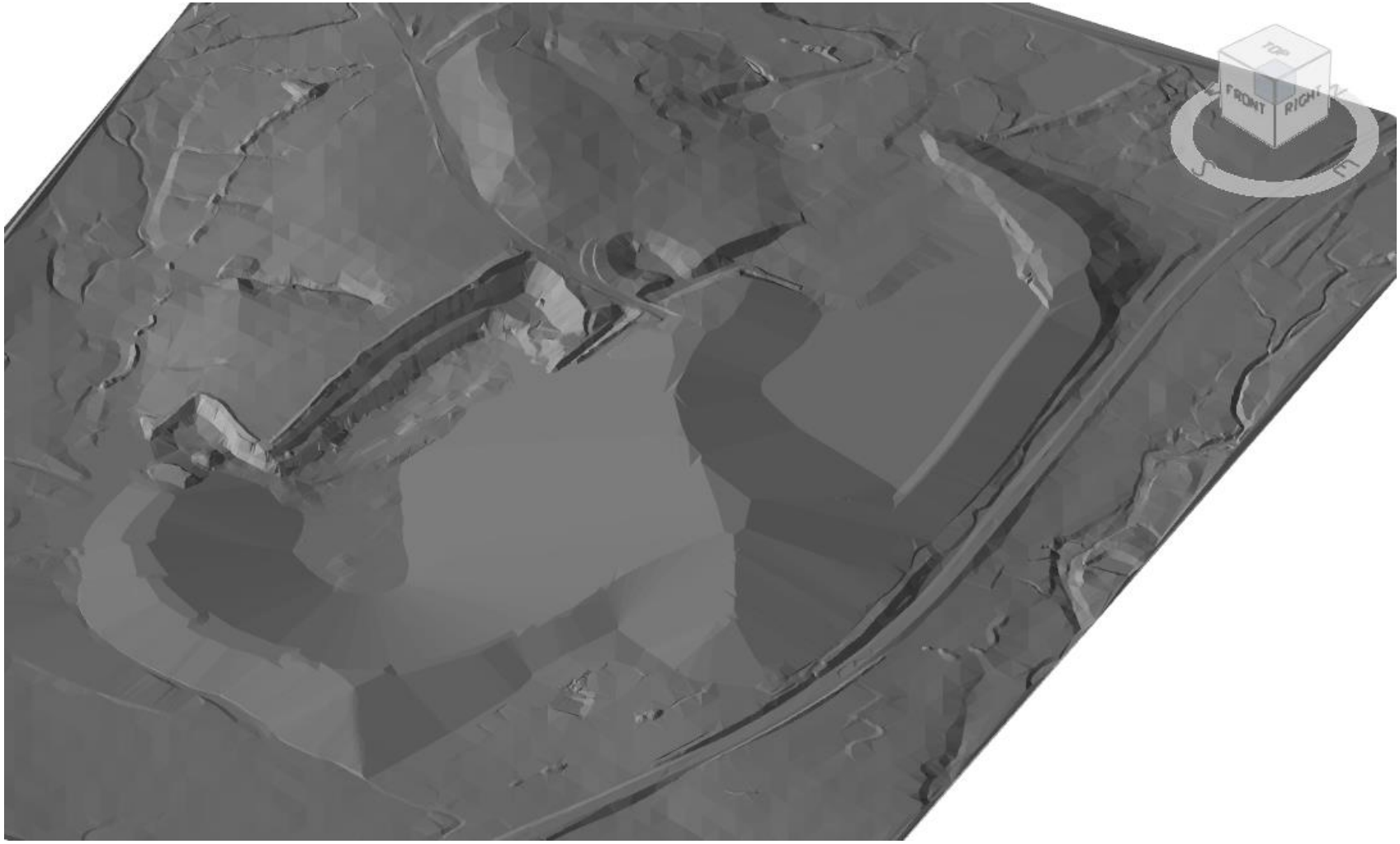


Figure 5-4 – Overview of 3D landform design for CH footprint for rehabilitation and closure

5.3 Train Load-Out Area

The TLO comprises the coal load-out facilities for CM, with coal transported from CM to TLO via the OLC. Key features that require investigation for rehabilitation include: Rail Loop diversion, Northern Boundary diversion, West Dam and Stockpile Dam.

The geotechnical assessment concludes that the TLO is safe and stable to remain as is. Works will be undertaken to bulk out the dam wall into a landform and remove the need for ongoing maintenance and inspection, so effectively removing any risk of failure. Maintaining West Dam provides environmental values and is essential for hydraulic performance of the Northern Boundary diversion.

No battering down of the diversion is required, as the batters have been exposed to erosional forces for a number of years and slopes have undergone little erosion and are comparable to the original design.

There will be some rework of selected areas within existing rehabilitation areas that have undergone erosion.

5.3.1 Summary of Key Features

Landform design characteristics have been detailed in ***Figure 5-5*** for each landform area within the TLO area. Key features of each of the rehabilitated landforms is as identified, including landform footprint and height, as well as a range of other relevant factors. The key design decisions, constraints and considerations have also been summarised, these represent the aspects that have influenced the landform design at each location.

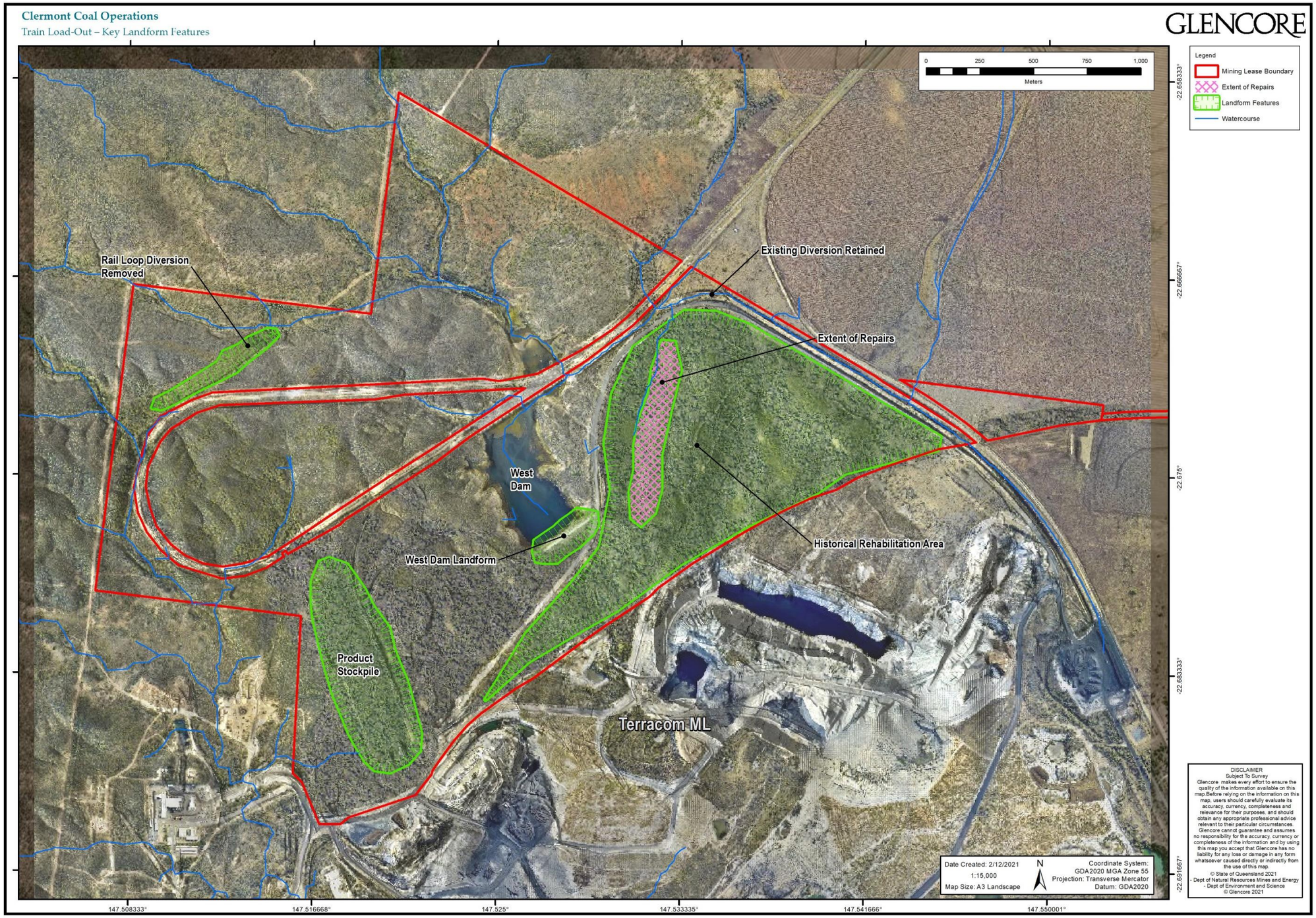
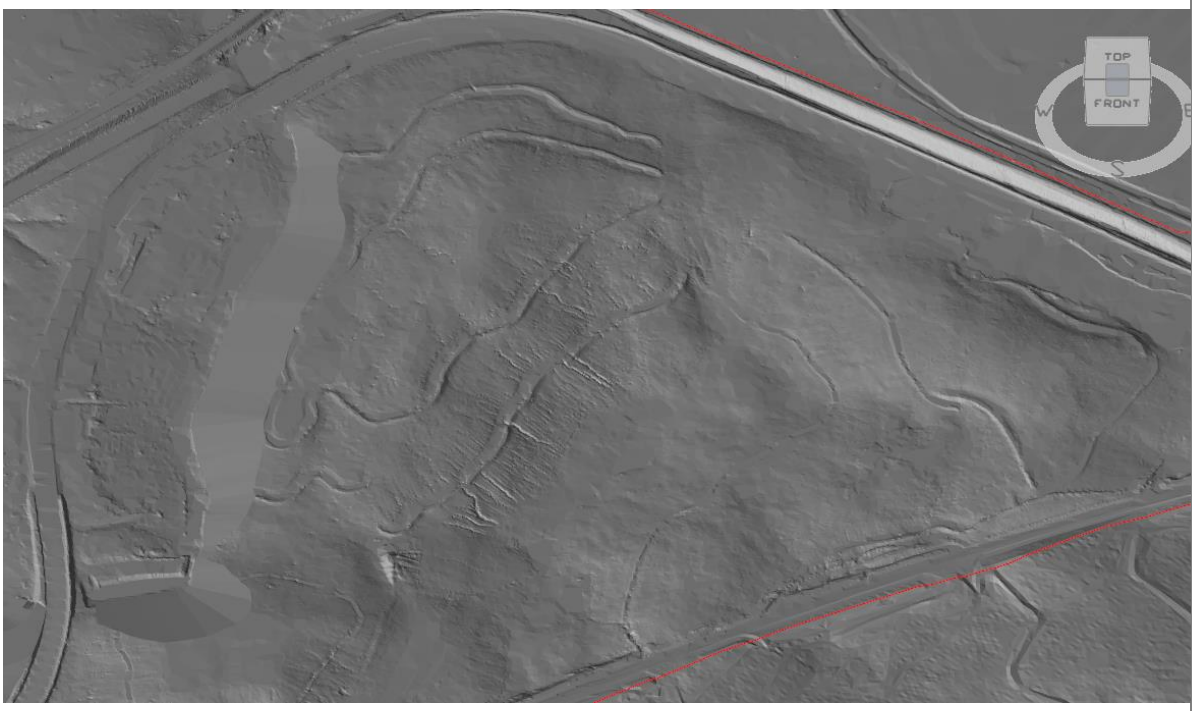
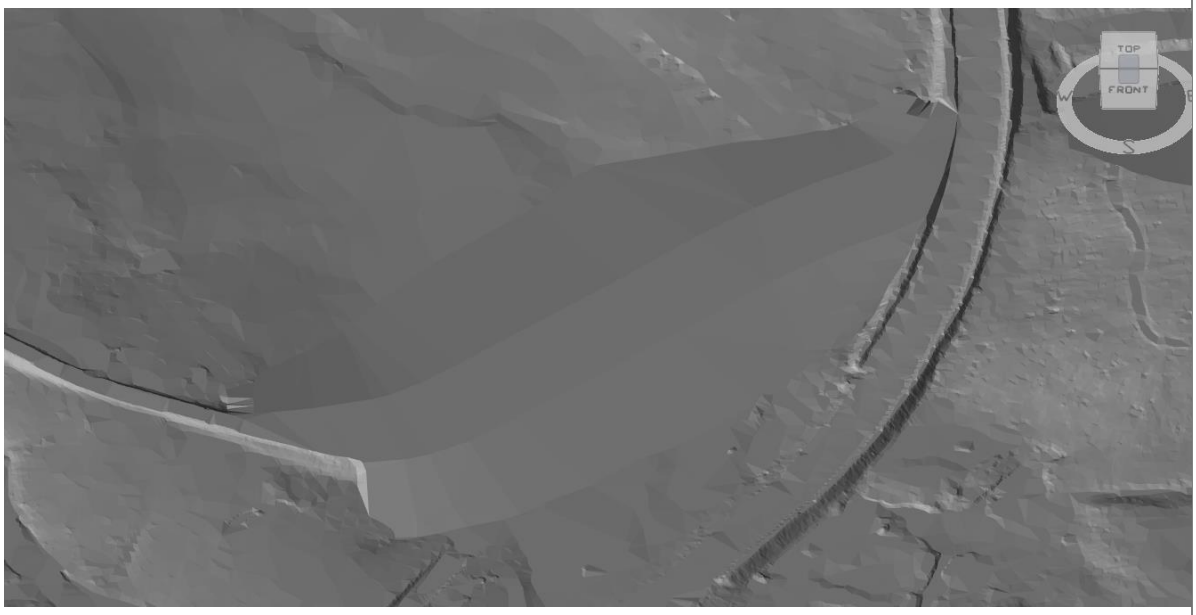


Figure 5-5 - Key Landform Features for TLO area

The main landforms relevant to the TLO area include the Historic Rehabilitation Area and the West Dam Landform. There are a number of other rehabilitation and closure activities required at the TLO, which have been captured in Section 5.3.2. The following ***Table 5-5*** details the key features of each landform, and is reflective of the final design concept. A view of the 3D design work has been included for each feature, positioned so as to best show each landform feature.

Table 5-5 - Key Features by Landform for TLO

Historic Rehabilitation Area	**Dimensions**
	
Landform footprint	125 ha (Extent of repairs = 10 ha)
Landform height	340 m AHD, ~15 m high from natural ground
Slope gradient & typical length	Historic adoption of linear slopes (15%)
Lift height	N/A
Surface water philosophy	Water shedding
Surface treatment	Revegetated
Landform PMLU	Woodland
Key design constraints and considerations	Need to repair historic erosion features Previous contour arrangement did not support water shedding landform, need to re-establish drainage concept Aim to retain as much existing revegetated area as possible

West Dam Landform	Dimensions
	
Landform footprint	4 ha
Landform height	335 m AHD, ~10 m high from natural ground
Slope gradient & typical length	West Dam wall will be bulked out into a landform Linear slopes (15%) and a 50 m flat top
Lift height	N/A
Surface water philosophy	Water shedding
Surface treatment	Revegetated
Landform PMLU	Woodland
Key design constraints and considerations	Aim to retain existing structure of dam wall intact and bulk around to ensure long term stability

5.3.2 Summary of Landform Design

Previous design decisions and considerations have been taken into account in further developing the landform concept. This area is largely an infrastructure area, so landform related design requirements are limited. The key landform design features at the TLO include:

- Maintain the Northern Boundary diversion. Based on geotechnical assessment the structure is suitable to be retained as is. No battering down of side walls is required;
- Bulk out West Dam wall into a landform. This will provide an ongoing water resource and is essential for hydraulic performance of the Northern Boundary diversion; and
- Reshape targeted areas within the Historical Rehabilitation Area that are prone to significant erosion and/ or considered to be too steep.

5.3.3 Proposed Rehabilitation Activities

The rehabilitation activities proposed for the TLO area are summarised in ***Table 5-6***.

Table 5-6 - TLO Rehabilitation Activities

Feature	Scope	Purpose
Reshaping	Repair a significant areas of erosion within the Historic Rehabilitation Area	Erosional stability
Selective placement	Not required	N/A
Highwall treatment	Not required	N/A
Surface treatment	Amelioration of sodic and dispersive soils	Erosional stability
Drainage	Re-establish drainage within the Historic Rehabilitation Area Remove Rail Loop diversion and reinstate original flow path Retain Northern Boundary diversion	Drainage and erosion protection Minimise impact on downstream water users
Flood protection	Bulk out the West Dam Wall into a permanent landform Remove drop structure and lower spillway of West Dam	Ensure adequate flood performance over long term
Revegetation	Topsoil and seed the rehabilitated areas where repairs have been conducted	Erosion control and potential future grazing activity
Abandonment bund	Not required	N/A
Infrastructure	Remove infrastructure planned to be decommissioned. In particular, remove the Stockpile Dam.	Redundant infrastructure removal

5.3.4 Overall 3D Design – Train Load-Out

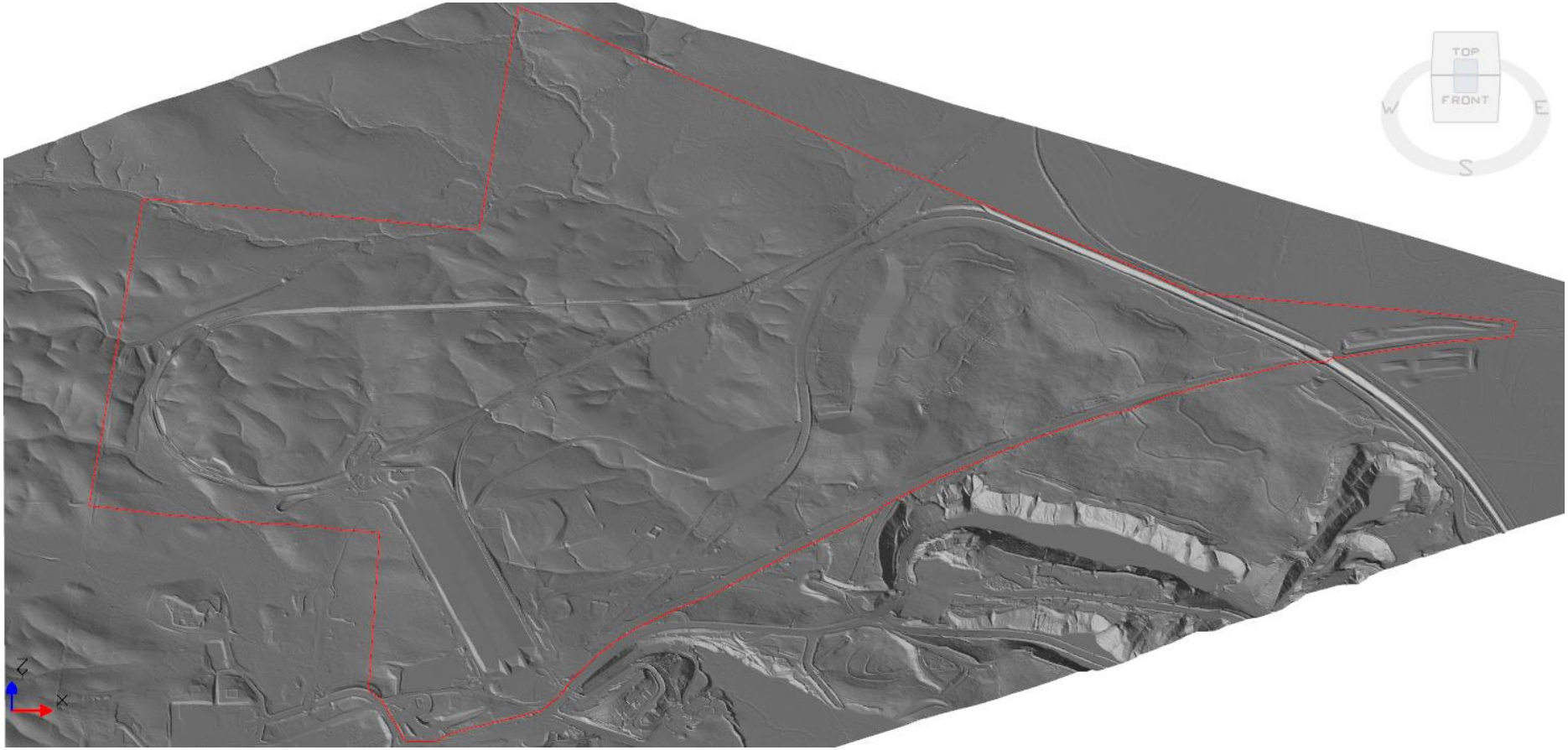


Figure 5-6 – Overview of 3D landform design for TLO footprint for rehabilitation and closure

6. Landform Performance Assessment

6.1 Soil Loss/Erosion Modelling

Erosion modelling (using RUSLE) was completed initially, to compare the tri-linear design to the previously approved slope design for CCO. This modelling confirmed that the tri-linear slope would reduce erosion by 24.07 t/ha/yr compared to the approved linear slope. The tri-linear design also results in a shorter horizontal slope length than the original design, enabling creation of a suitable landform within the boundary constraints and reducing the volume of bulk material required for reshaping.

6.2 Landform Evolution Modelling

As the landform design concept has been developed, erosion assessment was conducted using landform evolution modelling (LEM) to assess erosion rates over the long-term. LEM was undertaken utilising SIBERIA to assess the long-term erosion performance of the concept design. The modelling results were used to identify aspects of the landform that may be more prone to erosion and require reconsideration of the design. In this way LEM has been used in an iterative manner to optimise landform design and erosion outcomes.

Settlement and geotechnical stability over time has been addressed in Appendix 4.4 of the PRCP.

6.2.1 Assessment Methodology

The tool used to undertake the assessment was SIBERIA Version 8.3, which is the industry standard tool for the long term simulation of landform evolution of rehabilitated waste rock dumps. A 2 m grid size was adopted, with model domains representing each major landform feature being investigated for CCO. The model grid discretisation was selected such that key features associated with the landscape, including the slope profile and bench drains, could be appropriately represented with the modelling. Simulations considered a 300 year forecast.

Previous model calibration that has been undertaken is as detailed ***Table 6-1*** (KBR, 2020), with these parameters adopted for further assessments of landform designs developed during PRC Plan compilation.

Table 6-1 - Key parameters used in Siberia modelling

Parameter	Description	Value
β1	Controls erosion rate representing the coefficient in the fluvial sediment transport formula.	0.00025
m1	Controls erosion form representing the discharge exponent in the fluvial sediment transport formula.	2.5
n1	Controls erosion form representing the slope exponent in the sediment transport formula.	2.0
Bulk	Effective porosity of soil.	1.3
Cover	Vegetation cover factor	1.0

Parameter	Description	Value
Initial surface roughness	Applies a 'natural' roughness to the surface	+/- 0.2*random number (0–1) m

6.2.2 Benchmarking

An assessment of long-term erosion rates has been conducted, and although there are no agreed standards or guidelines for acceptable erosion rates, there is an extensive body of literature and scientific practices that can be used for benchmarking. There is also a regulatory expectation that erosion will be minimised, and vegetation cover established. The target applied is for the erosional performance of the landform to ultimately approach an acceptable reference point or benchmark from the surrounding area.

A review was conducted of information on erosion rates, and in particular the environments of (and analogous to) Central Queensland. Based on the available data, identification of a singular value, or acceptable range, is not available and landform performance overall must be taken as a matter of judgement.

Measured values for acceptable rates of erosion range from 0.75 t/ha/yr (Waters, 2004) to 8 t/ha/yr (Bowen *et al.* 1998). Based on information around gully development, it was also recognised that there would be a ceiling to selected values. Significant gully and rill development is a metric of slope stability and long term performance. Studies by Klingbiel and Montgomery (1961), and Howard and Loch (2019), suggest an erosion rate cap of 10 t/ha/yr, as acceptable, to mitigate the formation of rills and gullies. Studies conducted at Collinsville Coal Mine identified erosion rates of up to 20 t/ha/yr are erosionally stable.

Therefore, a range of erosion rates of approximately 2-6 t/ha/y have been adopted as the benchmark against which modelled outcomes are compared. This is at the low end of rates observed within the Bowen Basin.

6.2.3 Outcomes

The outcomes of the modelling are represented in ***Table 6-2***. The first series of figures present each landform as it transforms from 0 years (design) to 300 years. The next series demonstrate the 'difference' map comparing the 100 year surface to the 0 year surface.

An initial 'randomised' surface roughness is applied to the model to transform it from a 'design' surface to a 'natural' surface. The design model comprises areas of both LiDAR capture (for as-constructed rehabilitated surfaces and surrounding natural environments) as well as the landform design surfaces (yet to be constructed). The model results demonstrate higher levels of erosion in the existing or natural environment areas where a rougher starting condition was experienced.

Key findings of the landform evolution modelling are:

- Generally the tri-linear slope concept performs well. Higher erosion occurs in the steeper sections where the chutes have been cut in at steeper angles. It is recommended that detail design of chutes incorporate local widening of the benches so that the tri-linear slope is maintained; and
- Bench drains accumulate sediment from the upper slope, however, over time the upper slope will have become more stable and there is less reliance on the bench drain to divert run-off. Bench drains have been designed with an allowance for sediment accumulation.

6.2.4 Model Limitations and Assumptions

SIBERIA is a computer model for simulating the evolution of landscapes under the action of runoff and erosion over long times scales (typically more than a few years). Due to being a model, it can only work as accurately as the input data utilised as it cannot discriminate between good or poor data.

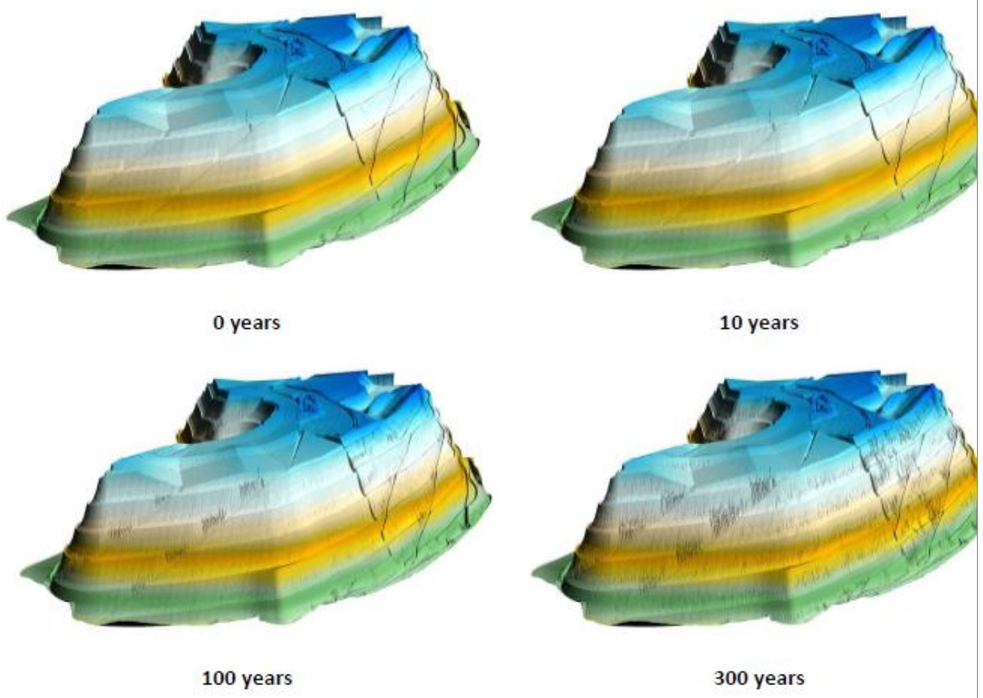
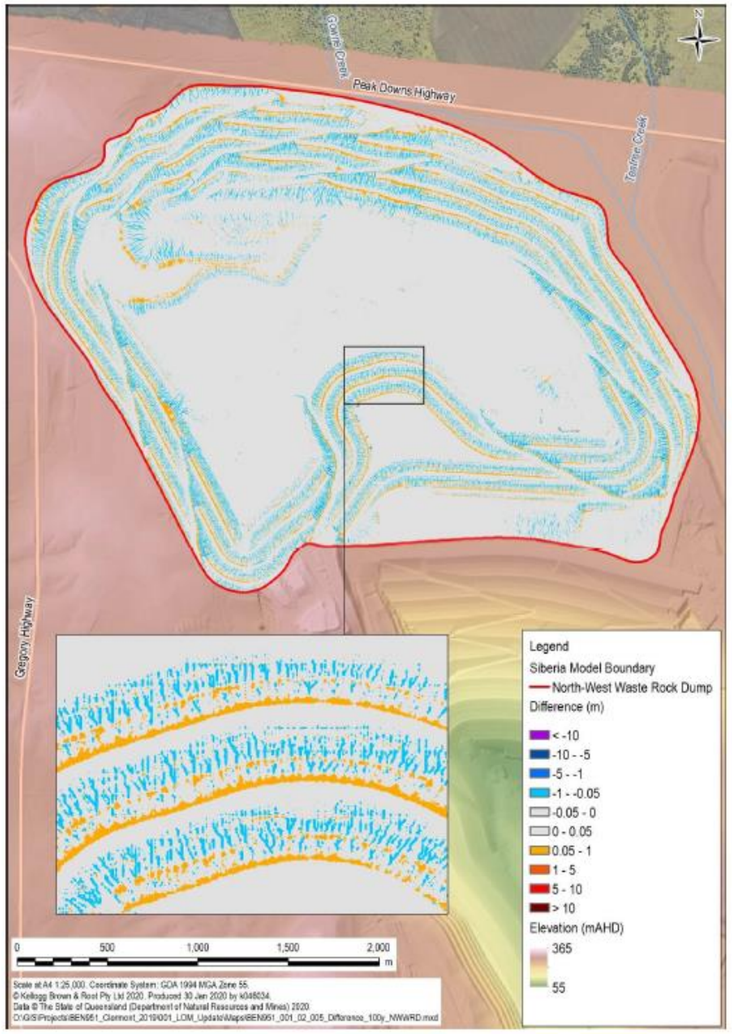
Landscape evolution models (LEMs) such as SIBERIA require a digital elevation model (DEM) to represent the landscape surface. The DEM needs to be accurate and reliable, as well as at a resolution (have a grid cell size) that represents the landform feature of interest as SIBERIA can be sensitive to the information it receives.

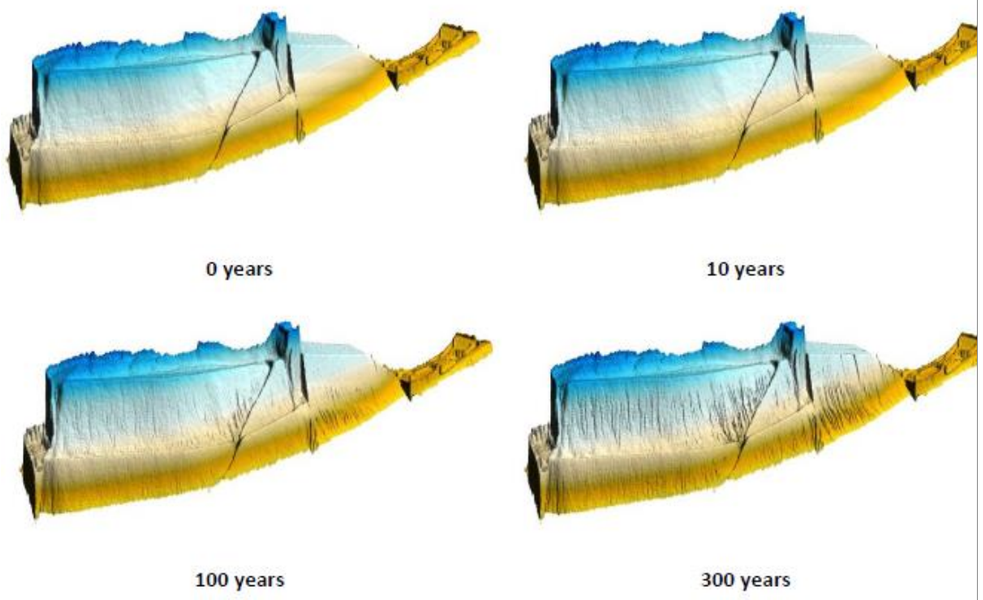
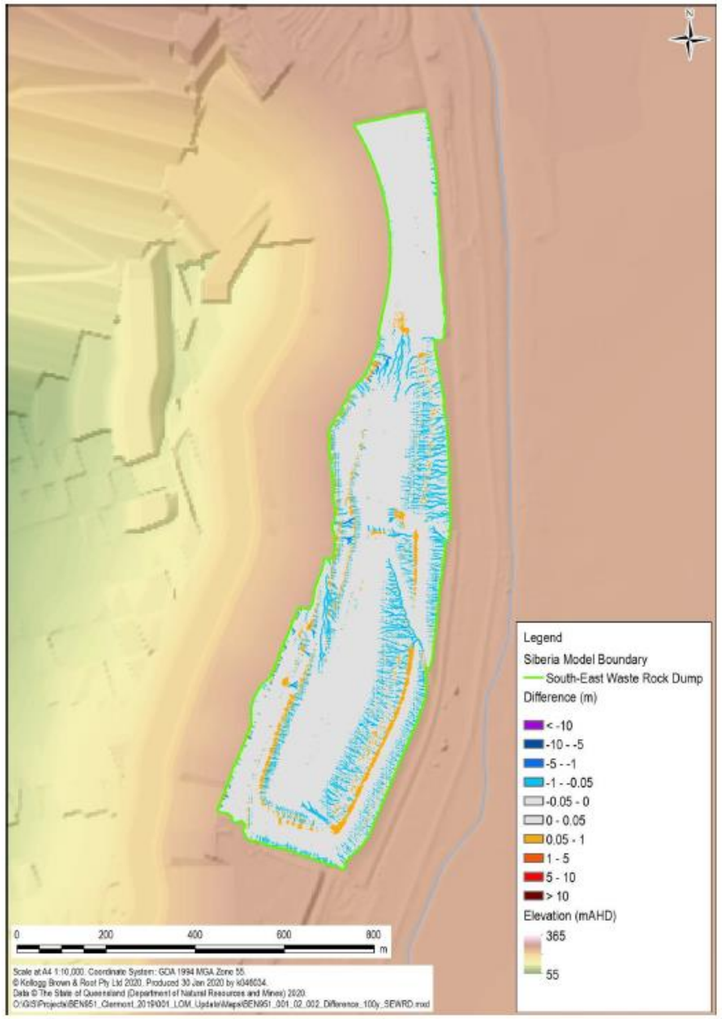
SIBERIA does not account for weathering, surface armouring and soil maturation. It also cannot consider gully and tunnel erosion from interactions between the underlying overburden and cannot account for 'non-typical' environmental conditions such as the effects of climate change.

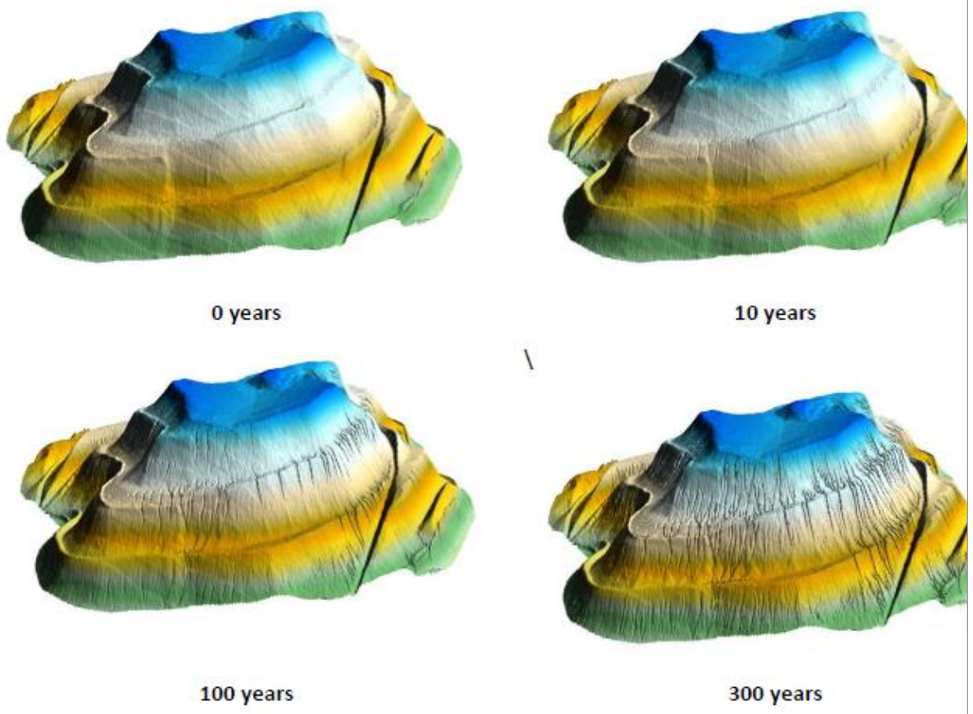
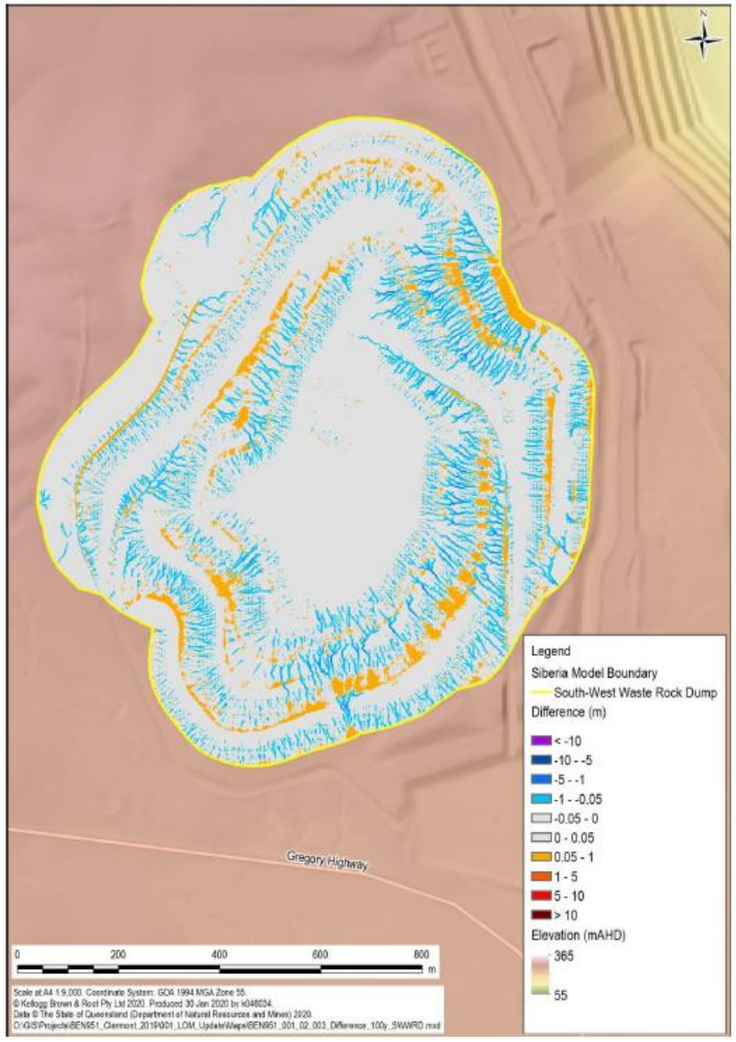
Similiarly, the model assumes the entire catchment has the same hydrology parameter values. As a result, the simulation results cannot be considered to be an entirely reliable indication of the erosion and deposition likely to occur on the landform, particularly on the disturbed areas.

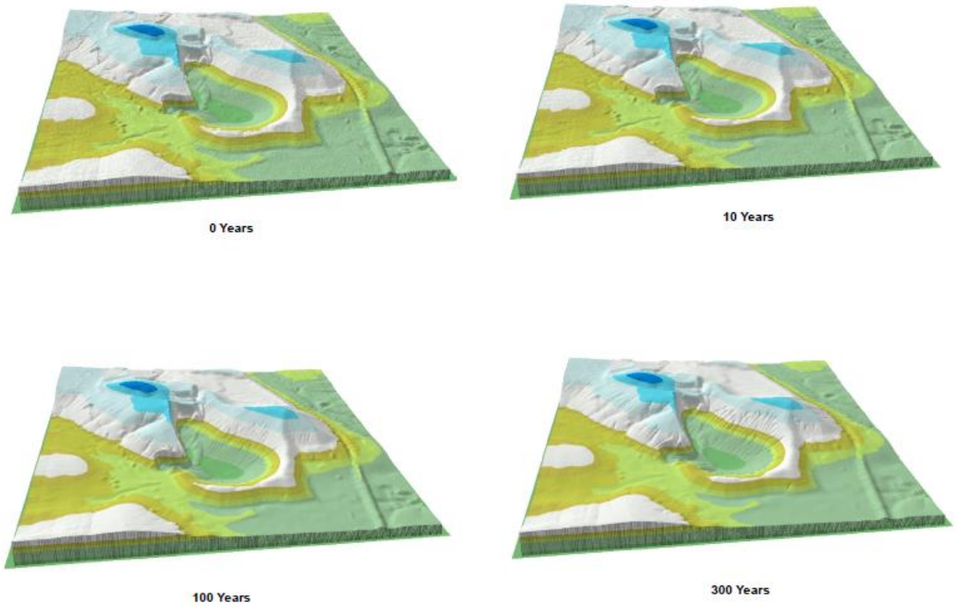
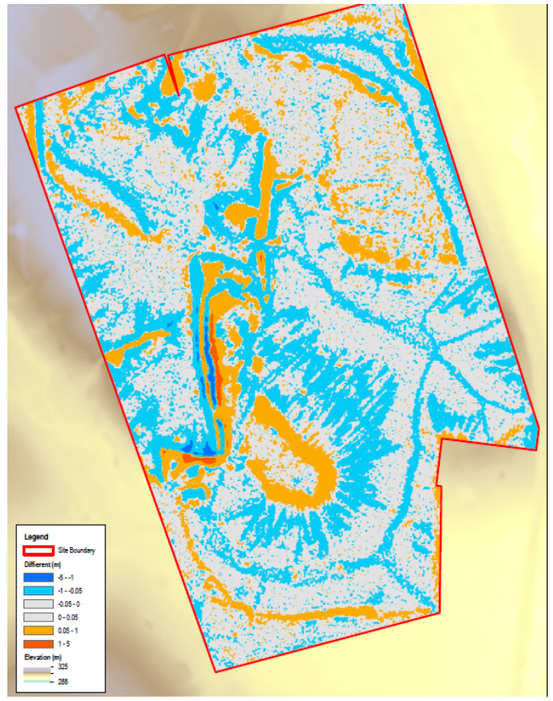
No model is a perfect representation of field processes and the reliability of any predictions made using LEM are open to question. SIBERIA is often considered to provide a conservative, worst case scenario. External altering factors, many of which cannot be accounted for in the model, means that once constructed the landform is likely to have erosion than predicted. Hancock et al. (2016) has demonstrated that there was a five-fold reduction in erosion in the first five years post-construction due to surface armouring. He concluded that any parameterisation based on new landscapes may be overestimating erosion.

Table 6-2 - Siberia Modelling Outcomes

Landform as it transforms from 0 years (design) to 300 years	'Difference' map comparing the 100 year surface to the 0 year surface	Description
Northern Waste Rock Dump  *5 x vertical exaggeration has been applied*	Northern Waste Rock Dump erosion and deposition at 100 years  *Orange zones indicate deposition and blue indicates erosion.*	Tri-linear slope concept performs well. Erosion begins to develop around the 100 year point but is stable overall. There is a loss from the trilinear slope sections upslope of the benches of between 5-100 cm, which is then deposited locally in the benches below. Net erosion from the landform falls within the benchmarked target erosion rate.

Landform as it transforms from 0 years (design) to 300 years	'Difference' map comparing the 100 year surface to the 0 year surface	Description
South-east Waste Rock Dump  *5 x vertical exaggeration has been applied*	South-east Waste Rock Dump erosion and deposition at 100 years  *Orange zones indicate deposition and blue indicates erosion.*	Modelling was run on the eastern face of the SEWRD, as shown. The eastern face is approximately 30 m high with a single bench, which conforms to the general concept design (15 m lifts). However, given that the landform elevation is less than a typical tri-linear section, the overall slope is 20% vs the average tri-linear slope of approximately 18% (30%, 20% and 10%). The tri-linear slope concept performs well under simulation, with a rate of soil loss of 5-100 cm over 100 years. The sediment is deposited locally in the bench below. Net erosion from the landform falls within the benchmarked target erosion rate.

Landform as it transforms from 0 years (design) to 300 years	'Difference' map comparing the 100 year surface to the 0 year surface	Description
South-west Waste Rock Dump  *5 x vertical exaggeration has been applied*	South-west Waste Rock Dump erosion and deposition at 100 years  *Orange zones indicate deposition and blue indicates erosion.*	The tri-linear design has been applied to the SWRD. The tri-linear slope concept performs well under simulation, with a rate of soil loss of 5-100 cm over 100 years. The sediment is deposited locally in the bench below. Net erosion from the landform falls within the benchmarked target erosion rate.

Landform as it transforms from 0 years (design) to 300 years	'Difference' map comparing the 100 year surface to the 0 year surface	Description
Cement Hill  *5 x vertical exaggeration has been applied*	 *Orange zones indicate deposition and blue indicates erosion.*	A linear slope design (at 15%) has been applied to the Cement Hill landform, with erosion rates over 100 years considered to be acceptable against industry standards. Most parts of the site that experience erosion are at a rate of soil loss of 5-100 cm over 100 year. It is noted that the high wall area has not be reshaped, however this is not a loose material landform, but rather is a hard rock high wall and thus is not likely to erode in this manner. The majority of landforms within the site report to the void, which largely prevents sediment export.

7. Landform Rehabilitation Process

7.1 Construction Methodology

Rehabilitation and landform design at CCO occurs throughout the rehabilitation planning processes. Concept design is a high level design intended to address whole landforms and is largely intended to align with site planning activities and timelines. Once a concept design is in place for the overall landform, the mine can understand the operational scheduling constraints to determine when areas will become available. Annual rehabilitation programs are then defined, with detailed landform and drainage design progressed for these areas at a higher resolution. The intent is to develop design outputs which can support construction, whilst still remaining true to the design principles and philosophy as established for CCO.

These general principles may be modified with appropriate justification during the detailed design phase to ensure the most appropriate outcome is achieved, and in particular to ensure that adequate water management structures can be accommodated. CCO manage rehabilitation planning, design and execution using both internal and external resources. Management strategies to mitigate environmental and rehabilitation risks during the construction and decommissioning phase around waste placement are contained within Appendix 4.9 and Appendix 4.10 of the PRCP.

7.1.1 Earthworks

CCO typically dump overburden/spoil using the truck and shovel fleet, and progressively bulk shape available areas into suitable landform with dozers. Construction specific plans will be developed for each rehabilitation slope, as part of normal site planning and operational processes, and will align with the landform design concept outlined in this document. As such, shaping of the landform will normally include an allowance for initial drainage aspects to be designed and constructed (i.e. reshaping to include drainage lines).

A trilinear slope arrangement is quite difficult to construct, and in particular, requires skilled earthwork operators to achieve the required slope profiles. Transitoning from a 30% to 20% to 10% slope angle requires significant planning, with multiple earthworks passes to achieve a slope profile that reflects the design intent.

Application of buffer zones for the transition of each part of the trilinear is important for constructibility, however such buffer zones of the tri-linear design should not extend further than 12.5 linear metres. Within the buffer zone, a 5% slope angle tolerance factor will be deemed to apply. This buffer zone allows for a smooth transition between each segment and ensures conformity to the original tri-linear design. This approach also accommodates the error associated with the use of heavy equipment.

The earthworks stage is actually comprised of two different aspects – an initial ‘bulk’ reshaping activity intended to reshape from an operational form to one that conform to the final landform design. Water management/installation of drainage structures are then progressed. Then, there is typically a ‘final’ reshaping or trim stage employed as a second earthworks phase, which aims to improve landform conformance, ensure all tie-ins have been completed and that the finer scale aspects of the design is satisfactorily constructed.

7.1.2 Drainage Structures

Rehabilitated landforms are treated like any other disturbed catchment at CCO until water quality monitoring demonstrates compliance milestone criteria. The primary contaminant from newly rehabilitated landforms is expected to be sediment and as such all runoff from rehabilitation areas will have sediment controls in place.

Depending on the physical location, existing sediment dams may be utilised or new structures will be developed during detailed design. Sediment basin design for rehabilitated areas is to be sized to contain the expected runoff volumes, after losses, from a 5%AEP, 24 hour duration storm event.

Bench drains and stormwater chutes will typically be constructed by the internal Rehabilitation Crew, althrough external civil contractors may also be used. Geo-fabric, rock armouring and scour protection appropriate for the expected velocities must be considered and implemented as per detailed designs to armour downslope structures.

Runoff from undisturbed (non mine-affected) catchments will be diverted around the mining activities as much as possible via diversion drains and levee banks to discharge into natural watercourses.

7.2 QA/QC Requirements

7.2.1 Conformance to Design

CCO undertake survey and 'conformance to design' reviews of bulk push areas to track and highlight any variations to design and short-term rehabilitation targets. This information then feeds into a internal CCO Annual Rehabilitation Signoff and Handover form for approval by relevant departments.

7.2.2 Annual Rehabilitation Inspections

On an annual basis, after the year's planned rehabilitation works have been implemented, an independent party from within GCAA (accompanied by CCO site personnel) undertake an inspection of the rehabilitation works completed during the previous year. The objective of the rehabilitation self-assessment criteria is to provide for rehabilitation works to be well-controlled and implemented with minimal variation from the planned and approved design standards.

Variation from the design has shown to lead to poor implementation and failure of rehabilitated areas, therefore leading to increased maintenance or re-work and costs and a potential extension of time before standards acceptable for relinquishment can be achieved. Review of rehabilitation works requires a combination of survey control, physical inspection, and verification of actual progressive sign-off of works at specific stages.

The inspection may also cover rehabilitation completed in previous years. A report documenting the findings of this inspection is provided to each site following the inspection and may include actions for site to address. These actions are then monitored by GCAA and the ratings from the review used to inform the performance of CCO against relevant performance indicators.

7.2.3 Rehabilitation Reporting

CCO assess land indicators using various processes on a monthly or quarterly basis, to inform the completion of rehabilitation landform works and understand progress against annual completion schedules. An annual process is also in place to review areas of completed rehabilitation to identify requirements for aftercare and/or maintenance activities. The outcomes of these reporting processes are tracking in accordance with normal CCO systems.

7.3 Trials

Given that CCO is a transitional PRCP site, with a strong operational history of completing progressive rehabilitation, much is understood about what is required to produce high quality rehabilitation. Further, GCAA is considered to be leading the mining industry with in terms of rehabilitation practices. As such, a significant body of practical experience, technical knowledge and industry know-how exists within GCAA that can be drawn on by CCO. Trials are not considered essential to verify the predicted success of the final landform design. The actual performance of the quality and nature of progressive rehabilitation are evidence to this.

CCO does not conduct formal rehabilitation trials, but rather, trials through practise. The CCO rehabilitation practices have been informed through a positive feedback loop, utilising any relevant technical information developed, as well as considering annual monitoring rehabilitation summaries and performance data from monitoring metrics. The Rehabilitation Report Card (RRC) process is in place to monitor how areas of progressive rehabilitation are tracking towards relinquishment outcomes.

Each year, the rehabilitation progression is reviewed, and from there CCO carefully modifies the rehabilitation practices moving forward, to improve rehabilitations outcomes, and verify the success of rehabilitation. This 'trial through practice' method is likely to identify any issues with rehabilitation works early on to facilitate more targeted monitoring, or allow for early intervention for more significant concerns. In this way, CCO dynamically monitor, then address and amend issues as they arise. It has also assisted CCO with identifying, informing and modifying the landform design.

8. Summary

This Landform Design Report focuses on the landform design aspects relevant to rehabilitation and closure of the CCO area, providing detail of an existing rehabilitation landform concept. Landform design details are described and explained for all parts of CCO. An iterative process has been applied to further expand and develop existing concepts and to test how the landforms will perform over the long-term.

Overall, the rehabilitation landforms provide acceptable performance and can be considered safe and stable in the short (10 years) and long term (100+ years). All design modifications have been captured, so as to explain and provide context to the enhanced environmental understanding developed for this PRC Plan.

9. Document Information

Number	Title
Clermont Coal Operations (CCO) (2015)	Clermont Rehabilitation landform design and erosivity assessment.
Clermont Coal Operations (CCO) (2020)	Annual Rehabilitation and Closure Plan.
Clermont Coal Operations (CCO) (2020)	Rehabilitation Management Plan.
Cohen, Willgoose and Hancock, 2009; Welivitiya et al. (2016)	Sustainable mine rehabilitation – 25 years of the SIBERIA landform evolution and long-term erosion model.
Howard and Loch (2019)	Acceptable erosion rates for mine waste landform rehabilitation modelling in the Pilbara, Western Australia.
KBR (2019)	Clermont Coal Operations – Landform Evolution Assessment: Pivot Point Northern Waste Rock Dump.
KBR (2020)	Clermont Life of Mine (LOM): Concept Design Report.
Klingebiel, A.A., Montgomery P.H. (1961)	Land Capability Classification. Agriculture Handbook N. 210. U.S.D.A., Soil Conservation Service, Washington.
Rio Tinto Coal Australia (2004)	Clermont Coal Mine Project: Environmental Impact Statement (EIS).
Waters, D. (2004)	Enhancing pasture stability and profitability for producers with Aristida Bothriochloa pastures under Eucalypt Woodland, Queensland Department of Natural Resources & Mines, Toowoomba.

CLERMONT
COAL OPERATIONS

GLENCORE

Appendix 4.12 - Revegetation Methodology

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1. Introduction

1.1 Purpose

Revegetation is an important step in achieving a sustainable cover on land surfaces disturbed during mining operations. The type of revegetation undertaken is intimately linked to the type of PMLU that can be achieved, and, hence, revegetation will need to be carefully planned to ensure that the PMLUs can be realised post-closure.

This appendix focusses on the revegetation to be undertaken for the CCO closure. It will include planning for self-sustaining vegetation as well as establishing fauna habitats and other ecological services.

1.2 Scope

This appendix outlines the revegetation objectives for Clermont Coal Operations (CCO) and how CCO will achieve its revegetation objectives. The appendix identifies displaced flora and fauna as well as flora and fauna currently, giving some background context to Clermont Mine (CM), the Overland Conveyor (OLC), Cement Hill (CH), and the Train Load-Out (TLO). It then goes on to discuss key flora species, species of conservation significance as well as fauna habitat use requirements.

This appendix also covers CCO's revegetation process and site preparation strategies to achieve their revegetation objectives which covers topsoil, fertilising, seeding, offset management, weed and pest management, and fencing to support and sustain the areas PMLU.

1.3 Revegetation Objectives

"Woodland and Light Grazing" is the intended PMLU across most of the CCO. This PMLU is intended to contain vegetation consisting of both appropriate native and non-native cover species.

Plant species native to the region, occurring on similar landforms, and on similar soils, are used to maximise the self-sustaining capacity of the vegetation communities, as these species have evolved in conditions likely to be experienced within the nominated rehabilitation domains over the long term. The native plant species component of the Woodland and Light Grazing vegetation would provide habitat to native fauna.

In addition, to maximise rapid cover on newly rehabilitated surfaces, additional selected non-native species are also used, including legumes and grasses.

2. Background

2.1 Clermont Mine and Overland Conveyour

2.1.1 Displaced Flora and Fauna

Various levels of disturbance were observed on the CM prior to mining. In the western parts of the CM, the greatest level of disturbance occurred in the understorey, while the over-storey remained relatively intact. Most of the eastern mining area was cleared previously for cropping and improved pastures for grazing with very little remnant vegetation in the area. Aspley State Forest, a high quality remnant habitat area, is located directly west of ML70343 (CM).

Nine Regional Ecosystems (REs) were identified within the CM and OLC during the 2004 EIS, three of which were Threatened Ecological Communities (TECs) under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and five of which were classified as Endangered or Of Concern under the Queensland *Vegetation Management Act 1999* (VMA), at the time of the EIS process. The most widespread of these were:

- RE 11.3.3 Coolibah *(Eucalyptus coolabah)* woodland with a grassy understorey, in the eastern part of the site between Gowrie Creek and Wolfang Creek (Of Concern RE);
- RE 11.11.1 Narrow-leaved Ironbark *(Eucalyptus crebra)* woodland with a moderate to dense understorey of Rosewood *(Acacia rhodoxylon)*, in a mosaic with RE 11.5.3 and RE 11.4.8 in the western part of the CM;
- RE 11.5.3 Silver-leaved Ironbark *(Eucalyptus melanophloia)* open woodland with scattered Poplar Box *(Eucalyptus populnea)* , in a mosaic with RE 11.11.1 and RE 11.4.8 in the western part of the CM;
- RE 11.4.8 Dawson Gum (*Eucalyptus cambageana*) woodland with Brigalow (*Acacia harpophylla*), in a mosaic with RE 11.5.3 and RE 11.11.1 in the western part of the CM;
- RE 11.8.11 Grassland dominated by Queensland Bluegrass (*Dichanthium sericeum*) within Brigalow Belt Bioregion (North) (Of Concern RE and TEC); and
- RE 11.4.9 Brigalow (*Acacia harpophylla*) and Yellowwood (*Terminalia oblongata*) woodland occurred in a smaller patch along the OLC, between the TLO and CM (Endangered RE and TEC).

RE 11.4.8, 11.8.11, and 11.4.9 are listed as TEC under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*. RE 11.4.8 and 11.4.9 are also listed as Endangered under the Queensland *Vegetation Management Act* 1999 (VM Act), while RE 11.8.11 and RE 11.3.3 are listed as Of Concern under the VM Act.

Two conservation significant flora species were also identified within CM MLs, being the Belyando Cobblers Peg *(Trioncinia retroflexa)* and King Bluegrass *(Dichanthium queenslandicum)*. They are listed as Endangered and Vulnerable, respectively, under the Queensland *Nature Conservation Act* 1992 (NC Act), with King Bluegrass also listed as Endangered under the EPBC Act. Both these species occur within RE 11.8.11, on undulating downs country with cracking black clay soils.

Fauna species of current conservation significance previously recorded within the CM area included:

- Northern Quoll *(Dasyurus hallucatus)* (listed as Endangered under the EPBC Act), recorded as roadkill by a landholder in 2001, but not recorded since, despite detailed surveys by URS (2006) and Ausecology (2014);

- Squatter Pigeon *(Geophaps scripta scripta)* (listed as Vulnerable under both NC Act and EPBC Act); and the
- Koala (*Phascolarctos cinereus*) (listed as Vulnerable under both NC Act and EPBC Act).

In accordance with the CCO Commonwealth and State approvals, a number of biodiversity offsets were required to be established. The offsets are designed to compensate for the unavoidable residual impacts caused by the CCO operations, and are located both on the mining lease and off-site, within dedicated offset properties. Two offsets are located within the CM, one for Belyando Cobblers Peg and one for Bluegrass, as discussed below. The remaining offsets, for Brigalow TECs, are located on non-operational land and are not discussed further in this PRCP.

2.1.2 Current Flora and Fauna

Currently, remnant vegetation and habitat as described in the previous section is restricted to the perimeter of the CM site, particularly in the south-east (open eucalypt forests), along Gowrie Creek diversion (Coolibah forest and woodland), and north-east (Bluegrass).

The remaining surfaces have largely been, or will be, mined or otherwise disturbed for infrastructure development (OLC) purposes. Substantial areas have also been rehabilitated since mining. ***Section 0*** outlines the process of revegetation on rehabilitated surfaces.

2.2 Cement Hill

No documentation remains on the vegetation and habitats at Cement Hill prior to its development as an alluvial gold mine in the 1980s. However, pre-clearing mapping undertaken by the Queensland Herbarium indicates that the site was largely covered with:

- RE 11.11.16 *Eucalyptus cambageana*, *Acacia harpophylla* woodland;
- RE 11.11.2 *Acacia shirleyi* or *A. catenulata* low open forest;
- RE 11.8.5 *Eucalyptus orgadophila* open woodland; and
- RE 11.11.15 *Eucalyptus crebra* woodland.

The southern portion of the CH would have consisted of RE 11.3.3/11.4.9 (RE 11.3.3 - Coolibah woodland; RE 11.4.9 - Brigalow).

Similar vegetation is mapped on the current RE map for the site, in small areas in the south-western corner. RE 11.3.3/11.4.9 (in respective proportions 80%/20%) along the creek flowing through the south-western corner of the site, and a small area of RE 11.11.16/11.11.2/11.8.5/11.11.15 (25% each) along the south-western boundary.

Field observations undertaken for this PRCP indicate that other vegetation consists of regenerating low open woodland and shrub land dominated by Wattles on the previously mined surfaces, spoil dumps, and tailings cells.

No existing records of any threatened species on the CH site or in its immediate surroundings are known.

2.3 Train Load-Out

No documentation remains on the vegetation and habitats existing on the TLO site prior to development within the site, including the creation of West Dam, creek diversion systems, previous mining, and the development of the TLO.

However, unlike the CH, nearly half of the TLO still contains remnant vegetation as shown on the RE map for the site. The largest area of remnant vegetation consists of a variety of Eucalypts *(Eucalyptus spp.)* and Wattles *(Acacia spp.)*:

- RE 11.11.1 *Eucalyptus crebra* +/- *Acacia rhodoxylon* woodland (75%);
- RE 11.11.2 *Acacia shirleyi* or *A. catenulata* low open forest (15%); and
- RE 11.5.3 *Eucalyptus populnea* +/- *E. melanophloia* +/- *Corymbia clarksoniana* (10%).

Most occurs along the northern and western boundary of the TLO, with additional areas within the rail loop, and areas west of West Dam. Smaller areas of RE 11.11.16 (*Eucalyptus cambageana* and Brigalow) occur in the north-western part of the TLO. The remainder of the site consists of infrastructure (TLO, access roads, OCL, etc.), West Dam, and rehabilitated surfaces over previously mined land, spoil dumps, or otherwise disturbed land. Most rehabilitation is located south-east of West Dam, dating from 1999 (i.e. well before the development of the CM), with smaller areas around the TLO, some of which date from 1984 (Landloch, 2012). The vegetation on the rehabilitated land is represented by species from the surrounding native vegetation, including Rosewood *(Acacia spania)*, Lancewood *(Acacia shirleyi)*, and a variety of Eucalypts over sparse grasses including Buffel Grass *(Cenchrus ciliaris)* (Highlands Environmental, 2020).

No existing records of any threatened species on the TLO site or in its immediate surroundings are known.

3. Key Flora Species Selection

When targeting vegetation communities for rehabilitation at CCO, consideration is given to the regulatory constraints of the approvals, the surrounding and post-mining land use concept, and the capacity of the available topsoil resources at the time of revegetation to support the selected species. As noted above, the PMLU across the entire CCO mine disturbance footprint, except for the Void NUMA, will be Woodland and Light Grazing. It allows for a resilient vegetation adapted to the conditions, while providing habitat and light grazing values.

Also, one of the rehabilitation aims is to provide biodiversity connectivity with surrounding woodlands to the west of the open cut put area and grasslands in the east. A koala corridor is developing along the Gowrie Creek Diversion (Engeny, 2015).

There is no expectation that a specific, recognised regional ecosystem (RE) or Threatened Ecological Community (TEC) could be re-created on any previously disturbed surface. However, species mixes have been selected based on species present within the surrounding region. The framework species list, as show in ***Table 3-1***, is a list of native species targeted for revegetation based on the natural occurrence of these species within surrounding region, with proximate similarity of natural habitat with final landform conditions at CCO, and/or successful establishment in mine rehabilitation elsewhere within the Bowen Basin region. Selection of species for inclusion in seed mixes applied to rehabilitation areas will be strongly influenced by availability of seed supplied by commercial seed vendors in quantities required to achieve optimum seeding rates. It is anticipate that the seed mix will vary from year-to-year based on species availability.

Cover crops may be used in addition to framework species in areas where rapid stabilisation is required. The cover crops selected are not of a persistent nature so as to avoid any potential to restrict development of the targeted vegetation types.

Table 3-1 - Framework Species

	Steep-rocky slopes	Flatter surfaces	Comments
TREES			
Allocasuarina leuhmannii	✓	✓	Common species in variety of situations. Fixes nitrogen.
Brachychiton rupestris	✓	✓	Species common to the region, can grow in variety of locations.
Corymbia citriodora	✓	✓	Common species in variety of situations.
Corymbia clarksoniana		✓	Species common to the region.
Corymbia dallachiana		✓	In RE adjacent to site usually with deep uniform sands with minor areas of sandy red earths.
Corymbia erythrophloia	✓	✓	Common in variety of habitats in region.
Corymbia leichhardtii	✓	✓	Species occurring in sandy, rocky situation of the region.
Corymbia tessellaris		✓	Already present in rehabilitation area. In RE adjacent to site usually with deep uniform sands with minor areas of sandy red earths.
Eucalyptus cambageana		✓	Species from local area. Often occurs with Brigalow, but could be good in slightly more saline areas.
Eucalyptus crebra	✓	✓	Common species in variety of situations.
Eucalyptus melanophloia		✓	Already present in rehabilitation area. In RE adjacent to site typical of variable soil types including texture contrast, deep uniform clays, massive earths and sometimes cracking clays.
Eucalyptus orgadophila		✓	Common species in variety of situations.

	Steep-rocky slopes	Flatter surfaces	Comments
Eucalyptus populnea		✓	In RE adjacent to site typical of variable soil types including texture contrast, deep uniform clays, massive earths and sometimes cracking clays.
Eucalyptus tereticornis		✓	Already present in rehabilitation area.
Eucalyptus thozetiana	✓	✓	Already present in rehabilitation area.
Ficus rubiginosa	✓	✓	Typical of rocky locations in region.
Lysiphyllum hookeri	✓	✓	Already present in rehabilitation area. Fixes nitrogen.
Melaleuca bracteata		✓	Occurs in various parts of CCO, in low lying areas.
TALL SHRUBS/SMALL TREES			
Acacia bancroftiorum	✓	✓	Already present in rehabilitation area. Often present in rehabilitation within region. Fixes nitrogen.
Acacia cambagei	✓	✓	Species from slightly further afield to west, but good on steep slopes. Fixes nitrogen.
Acacia catenulata	✓		Common on skeletal soils on hills and slopes of the region. Fixes nitrogen.
Acacia crassa	✓	✓	Widespread in region in various locations. Fixes nitrogen.
Acacia cretata	✓		Often encountered in hills of region. Fixes nitrogen.
Acacia excelsa	✓	✓	Already present in rehabilitation area. Occurs naturally in wide range of habitats, including in RE adjacent to site typical of variable soil types including texture contrast, deep uniform clays, massive earths and sometimes cracking clays. Fixes nitrogen.

	Steep-rocky slopes	Flatter surfaces	Comments
Acacia julifera	✓		Frequently encountered in surrounding region on sand-stone. Fixes nitrogen.
Acacia pendula		✓	Species common in lower lying areas within region.
Acacia rhodoxylon	✓	✓	Common on skeletal soils on hills of the region. Fixes nitrogen.
Acacia salicina	✓	✓	Already present in rehabilitation area. Often present in rehabilitation in region. Fixes nitrogen.
Acacia shirleyi	✓		Already present in rehabilitation area. Common on rocky slopes of region. Fixes nitrogen.
Acalypha eremorum	✓	✓	Occurs in variety of habitats in region, including in RE adjacent to site typical of generally deep texture contrast with thick sandy surface horizons with some deep red earths.
Alectryon diversifolius		✓	Species from local area.
Alstonia constricta	✓	✓	Already present in rehabilitation area.
Alphitonia excelsa		✓	Widespread species occurring in variety of situations. Common pioneer.
Archidendropsis basaltica	✓	✓	Occurs in variety of habitats in region, including in RE adjacent to site typical of generally deep texture contrast with thick sandy surface horizons with some deep red earths.
Atalaya hemiglauca		✓	Already within rehabilitation area. Common pioneer.
Cassia brewsteri	✓	✓	Common in region in variety of habitats. Common in RE adjacent to site typical of variable soil types including texture contrast, deep uniform clays, massive earths and sometimes cracking clays. Fixes nitrogen.

	Steep-rocky slopes	Flatter surfaces	Comments
Eremophila mitchellii		✓	Common in RE adjacent to site typical of variable soil types including texture contrast, deep uniform clays, massive earths and sometimes cracking clays.
Flindersia dissosperma	✓	✓	Species from local area.
Geijera parvifolia	✓	✓	Widespread species occurring in variety of situations. Common pioneer.
Leptospermum lamellatum	✓	✓	Species from local area.
Leptospermum polygalifolium	✓	✓	Species from local area.
Owenia acidula	✓	✓	Species from local area. Variety of habitats.
Petalostigma pubescens	✓	✓	Species from local area. Variety of habitats.
Pittosporum angustifolium		✓	Preferred by traditional custodians.
Psydrax oleifolia	✓	✓	Occurs in variety of habitats in region, including in RE adjacent to site typical of generally deep texture contrast with thick sandy surface horizons with some deep red earths.
Santalum lanceolatum	✓	✓	Preferred by traditional custodians.
Senna gaudichaudii	✓	✓	Species from local area. Fixes nitrogen.
Terminalia oblongata		✓	Species occurs widely in region.
Ventilago viminalis	✓	✓	Species occurs widely in region.

	Steep-rocky slopes	Flatter surfaces	Comments
LOW SHRUBS			
Breynia oblongifolia		✓	Species from local area.
Carissa ovata		✓	Occurs in variety of habitats in region, including in RE adjacent to site typical of generally deep texture contrast with thick sandy surface horizons with some deep red earths.
Clerodendrum floribundum		✓	Species from local area. Quite often used in rehab.
Corchorus trilocularis		✓	Already present in rehabilitation area.
Dodonaea viscosa		✓	Species from local area. Used effectively in rehab elsewhere.
Eremophila bignoniiflora		✓	Species from local area.
Erythroxylum australe	✓	✓	Occurs in variety of habitats in region, including in RE adjacent to site typical of generally deep texture contrast with thick sandy surface horizons with some deep red earths.
Grewia latifolia	✓	✓	Species from local area. Variety of habitats.
Senna artemisioides	✓	✓	Species from local area. Drought tolerant. Fixes nitrogen.
VINES			
Boerhavia dominii		✓	Species from local area.
Capparis lasiantha	✓	✓	Species occurs widely in region.
Desmodium brachypodum	✓	✓	Species from local area. Nitrogen fixing.

	Steep-rocky slopes	Flatter surfaces	Comments
Eustrephus latifolius	✓	✓	Species from local area. Widespread.
Evolvulus alsinoides		✓	Species from local area.
Galactia tenuiflora	✓	✓	Species from local area. Nitrogen fixing.
Glycene latifolia	✓	✓	Species from local area. Nitrogen fixing.
Hardenbergia violacea	✓	✓	Species from local area. Nitrogen fixing.
Ipomoea plebeia		✓	Species from local area.
Jasminum didymum	✓	✓	Already present in rehabilitation area.
Kennedia rubicunda	✓	✓	Species from local area. Nitrogen fixing.
Neptunia spp.		✓	Already present in rehabilitation area.
Pandorea pandorana	✓	✓	Species from local area. Widespread.
Passiflora aurantia	✓	✓	Species from local area.
Polymeria calycina	✓	✓	Already present in rehabilitation area.
Rhynchosia minima	✓	✓	Already present in rehabilitation area.
Vigna lanceolata	✓	✓	Species from local area. Nitrogen fixing.
GRASSES			

	Steep-rocky slopes	Flatter surfaces	Comments
Aristida caput-medusae	✓		Species from local area.
Aristida latifolia	✓	✓	Species from local area.
Aristida leptopoda		✓	Already present in rehabilitation area.
Astrebla lappacea		✓	Already present in rehabilitation area.
Bothriochloa bladhii	✓	✓	Species from local area.
Bothriochloa decipiens	✓	✓	Species from local area.
Bothriochloa ewartiana		✓	Species from local area.
Brachyachne convergens		✓	Species from local area.
Chloris divaricata		✓	Species from local area.
Chrysopogon fallax	✓	✓	Species from local area.
Cymbopogon bombycinus	✓	✓	Species from local area.
Dactylotenium radulans		✓	Species from local area.
Dichanthium sericeum		✓	Already present in rehabilitation area.
Digitaria brownii		✓	Species from local area.
Digitaria ciliaris		✓	Species from local area.

	Steep-rocky slopes	Flatter surfaces	Comments
Enneapogon lindleyanus	✓	✓	Species from local area.
Enteropogon acicularis		✓	Already present in rehabilitation area.
Entolasia stricta	✓	✓	Species from local area.
Eragrostis lacunaria		✓	Species from local area.
Eriochloa crebra		✓	Species from local area.
Heteropogon contortus	✓	✓	Already present in rehabilitation area.
Iseilema spp.		✓	Already present in rehabilitation area.
Panicum decompositum		✓	Already present in rehabilitation area.
Panicum queenslandicum	✓	✓	Species from local area.
Paspalidium caespitosum		✓	Species from local area.
Sporobolus caroli		✓	Already present in rehabilitation area.
Sporobolus creber	✓	✓	Species from local area.
Themeda triandra	✓	✓	Species from local area.
Triodia sp.	✓		Species from local area.
FORBS			

	Steep-rocky slopes	Flatter surfaces	Comments
Alysicarpus muelleri	✓	✓	Already present in rehabilitation area.
Atriplex muelleri		✓	Species from local area.
Basilicum polystachyon	✓	✓	Species from local area.
Calotis spp.	✓	✓	Species from local area.
Cheilanthes sieberi	✓	✓	Species from local area.
Cullen tenax	✓	✓	Species already in rehabilitation area.
Dianella longifolia	✓	✓	Species from local area.
Einadia nutans		✓	Already present in rehabilitation area.
Enchylaena tomentosa		✓	Already present in rehabilitation area.
Gossypium australe	✓	✓	Species already in rehabilitation area.
Hibiscus meraukensis	✓	✓	Species already in rehabilitation area.
Hibiscus sturtii	✓	✓	Species from local area.
Lomandra confertifolia	✓	✓	Species from local area.
Maireana enchylaenoides		✓	Species from local area.
Pterocaulon spp.	✓	✓	Species from local area.

	Steep-rocky slopes	Flatter surfaces	Comments
Ptilotus exaltatus		✓	Species from local area.
Salsola australis	✓	✓	Already present in rehabilitation area.
Sida spp. (Native)	✓	✓	Species from local area.
Zaleya galericulata	✓	✓	Already present in rehabilitation area.

4. Species of Conservation Significance

4.1 Belyando Cobblers Peg

The Belyando Cobblers Peg *(Trioncinia retroflexa)* is a small perennial daisy that is listed as Endangered under the provisions of the Queensland Nature Conservation Act 1992 (NC Act), and is known to occur on CM MLs. There were two BCP populations recorded on CM's MLs, with one small population situated within ML 1884 (referred to as the northern population) and a larger population located to the south, within ML 70343 (the southern population). There are also additional areas of the species that occur within the mining footprint and either have been, or will be, cleared for the mine.

The northern population was stripped of topsoil in 2021 and mining will progress through this. Due to its threatened status, a clearing permit from the administering authority was required, which contained a number of conditions including the establishment of a Nature Refuge Agreement for the existing bottom two thirds of the southern (main) population. However, a minimum of 100 ha is required to satisfy the establishment of a Nature Refuge, and therefore a Voluntary Declaration (VDec) under the VMA was advised by the administering authority as an appropriate alternative mechanism to protect the southern BCP population. The VDec is currently in place.

The southern population at CCO was one of the largest known populations of this species, with an estimated population of between 500 to 3000 plants recorded at the time of the clearing permit application (2008). This population was significant on a local, regional, state and national scale. However, subsequent monitoring of the population over recent years has seen a significant decline in numbers, with the latest monitoring event detecting only 13 individuals (Ausecology, 2019).

In 2019, a BCP VDec Management Plan (KBR 2019) was developed to provide the framework for managing the proposed VDec area and support the request for a VDec, and includes the procedures CCO will follow with the aim of protecting the southern BCP population. Whilst the population is not considered sustainable, evidence of recruitment in 2018 provides a good sign that recruitment is possible when conditions are suitable (Ausecology, 2019).

4.2 Bluegrass

Native Grassland dominated by Queensland Bluegrass *(Dichanthium sericeum)* within Brigalow Belt Bioregion – North (RE 11.8.11) is listed as a Threatened Ecological Community under the EPBC Act. One constituent species of this community, King Bluegrass *(Dichanthum queenslandicum)*, is moreover listed as Vulnerable under the NC Act, and as Endangered under the EPBC Act.

A number of population areas have been recorded on CM MLs. To the northeast of mining lease ML1884, 120ha has been conserved as a Nature Refuge, offsetting the loss of 56ha of Bluegrass community disturbed under the current EPBC approval. Another 25 ha of direct offset has been added to compensate for the increase in impact on 4 ha of Native Grasslands after GIS reconciliation (based on DAWE Offset Assessment Guide). An area of 25 ha adjacent to the eastern boundary of the existing Bluegrass Nature Reserve, but still within the mine lease, has been identified as suitable for the purposes of extending the Bluegrass Nature Reserve offset area.

Recent monitoring has indicated that the retained grasslands remain in good condition and show a high diversity and cover of native perennial grass species, including grassland TEC indicator species *(Dichanthium spp.)* (Ausecology, 2019).

5. Fauna Habitat or Use Requirements

The predominant post-mining land use for the mine leases will be Woodland and Light Grazing, a combination of habitat and low-intensity grazing. In particular, revegetation with native species aims to connect habitat areas east of CM (e.g. bluegrass) with the more extensive native habitat areas west of the CM, such as the Aspley State Forest. Logs and other woody debris are distributed in revegetated areas to provide fauna habitat opportunities. As further described in the PRCP, rehabilitated and revegetated sites are monitored on an annual basis for a range of fauna habitat complexity (quality) indicators, including canopy (tree and shrub) cover, ground cover, logs, rocks, woody debris, free standing water and soil moisture, and tree hollows. While the currently revegetated areas are still relatively immature, it is expected that habitat quality will improve over time as the vegetation complexity increases.

In addition, CCO has undertaken a number of tree planting exercises along the Gowrie Creek diversion. Under the advice and guidance of UQ, Coolibah *(Eucalyptus coolabah)* seedlings were planted along the Gowrie Creek Diversion to provide a continuous vegetation corridor with the aim of supporting the growth and habitat of local koala populations. Future Coolibah seedling planting campaigns may be undertaken to enhance the koala corridor along the Gowrie Creek Diversion. Findings from the 2016 monitoring report indicate progress towards rehabilitation of the Gowrie Creek Diversion is positive (Glencore, 2020). Further plantings of Coolibah are expected to shade out and assist with the control of nuisance vegetation species Bulrush *(Typha spp.)* colonising the low flow channel in the downstream reach.

6. Reference Sites

As noted in the PRCP, post-mining land use in most of the CCO is intended to be Woodland and Light Grazing. Re-creation of the original vegetation communities on the newly created land surfaces would be impossible because of the transformations to hydrology, topography and geology due to the mining process (Erskine and Fletcher, 2014). Although topsoil is stripped and saved prior to the remaining mining process, the physical act of stripping, storage and respreading also negatively alters a range of soil properties (e.g. soil structure, nutrients, organic matter, permeability, soil seedbank viability and health of soil biota), impacting on the establishment of species and vegetation communities on reconstructed landforms over time.

Thus, revegetation efforts should be guided by the vegetation that has established elsewhere in the region under conditions similar to those that are anticipated to be experienced within the rehabilitation areas post-mining. That is, vegetation growing on similar landforms, soils, and drainage conditions. Such sites are termed analogue or reference sites.

As detailed in Appendix 4.3 – Progressive Rehabilitation Monitoring Summary Report, three analogue sites were identified within each of four forested REs previously (and still) occurring on the CM site (MCaffrey et al., 2015). Three reference sites within grazed land in the area (P01-P03), and six reference sites within bluegrass dominant grasslands (T1-T6) have since been established.

The selection of the reference sites was aimed to enable sampling a combination of:

- The range of natural vegetation present in the CCO mining lease and surrounding areas;
- The current and planned landforms; and
- Likely soil and geological formations.

However, no analogue sites are available that closely resemble CM's batter slopes (i.e. black alluvial soils placed on slopes). Whilst use of alluvial soils is accepted as good practice for re-establishment of native vegetation on the batter slopes, these alluvial soils occur naturally in flat (alluvial) plains. REs naturally evolving within these flat areas can therefore not be expected to be re-created on slopes where moisture conditions are more limiting. Thus, the analogue sites are still useful for comparative purposes but the targeted proportions of the revegetation (in comparison to the analogue sites) have been reduced in the completion criteria to reflect the expected reduced height, stem density, biomass and cover characteristics of vegetation communities on slopes.

7. Revegetation Process and Site Preparation Strategies

The overall rehabilitation process, and results to date, is described in detail within Appendix 4.3 - Progressive Rehabilitation Monitoring Summary Report. Revegetation represents the final stage in the rehabilitation process, with details outlined below.

7.1 Topsoil

7.1.1 Types and Management

Three types of topsoil can be found at CCO, being alluvial soils (clay), basaltic soils (cracking clay), and metamorphic soils (duplex on clay sediment and brown and red cracking clays).

Topsoil is stripped, mainly via the use of scrapers, from all mine progression areas to ensure suitable high quality growth media is available for all rehabilitation surfaces. Regular inventory reconciliations of topsoil stockpile locations and volumes are conducted to evaluate topsoil resources available for application to current and projected disturbed areas. Topsoil stripping requirements are incorporated into site clearance processes, so that any clearing activities require the identification of topsoil management requirements.

Where possible, preference will be given to using scrapers for recovery of soil from areas that are being cleared as the mine advances and employing direct placement of the topsoil resource onto areas that have been prepared for rehabilitation. The use of 'fresh' topsoil on rehabilitation areas provides improved rehabilitation outcomes as long term storage of topsoil can result in gradual degradation of seed, organic matter and micro-organisms that occur naturally within the upper soil profile. Areas selected for soil harvesting are inspected for weed infestations prior to application of this method to limit the potential for weed spread.

The standard depth of topsoil placement is between 100 and 300 mm, and the minimum depth considered suitable is 100 mm.

Amelioration will be applied as informed by soil analysis results and advised by soil science consultants. The advantage of direct placement is that the natural seed bank within the topsoil remains viable and is directly available for revegetation, thus reducing reliance on applied seed for vegetation establishment.

If direct placement is not possible, topsoil will be stockpiled using scrapers for later use in revegetation. In this instance, representative stockpile samples may be taken for a growth medium suitability assessment. On advice from soil science consultants, amelioration and fertiliser will be applied (if required).

Weed infested topsoil stockpiles may also be "scalped" of the upper layer of the topsoil dump (containing weeds and their propagules). This material would be treated or discarded to limit the spread of weeds in rehabilitated areas. Similarly, where a tree seed mix is intended to be grown, any topsoil used will have been scalped of its outer layer should the source dump be densely covered with grasses. Stripping the topsoil of these grasses and their propagules minimises the competition between the intended tree cover and grasses during the initial years of tree and shrub establishment. The grass containing upper topsoil layer would instead be used on any areas proposed for pasture establishment, or in rock chutes or drainage structures where establishment of grass may assist in providing protection against erosion.

Target vegetation communities and seed mixes for trees and grasses/legumes will be selected based on topsoil soil type. Within a week prior to seed spreading, the topsoiled area will be deep ripped across the slope (along the contour) to a depth of at least 500 mm, using a dozer or equivalent to create a "key between the soil and subsoil/capping materials. Seeding and fertilising will occur as soon as possible to prevent surface soil sealing and crusting and to encourage establishment of vegetative cover. If a soil crust forms in the period between ripping and seeding, usually as a result of rainfall, light harrowing or scarification can be undertaken in conjunction with seed application to provide a suitable surface for seed lodgement.

7.1.2 Topsoil Inventory

As detailed in Appendix 4.8 – Soils and Capping Material Assessment, there are significant topsoil resources held in stockpiles plus a good understanding of the expected volume of topsoil to be stripped for the remainder of the mining operations at CM. The volume of topsoil materials require to complete rehabilitation and revegetation is well known for the total projected disturbance footprint. There is sufficient topsoil material to meet the rehabilitation needs for CCO. Reconciliation of expected topsoil and remediable subsoil resources occurs annually to ensure expected volumes of topsoil are being salvaged for use.

Two main stockpiles are established to the north-west and north-east of the CM pit. These areas may be extended, or further suitable locations identified. Topsoil management aims to place topsoil locally to the area to be rehabilitated, ideally within the footprint where it is to be re-spread. Scheduling also attempts to allow for placement of topsoil to be synchronised with stripping, as discussed in the previous Section.

Stockpile dimensions will be dictated by the topsoil material – biologically active topsoil material (stripped to 0.2 m) will be restricted to 2-3 m in height, whilst subsoil material (which is not biologically active, but otherwise a suitable growth media) will be allowed to be stockpiled to 10 m height.

A selective stripping topsoil strategy is implemented, where topsoil resource is selectively harvested according to quality, suitability, and need for rehabilitation. A topsoil management strategy is developed each year to support that years' topsoiling requirements.

7.2 Fertilising

Prior to re-use for rehabilitation, topsoil samples are tested to determine their suitability as a growth medium. Optimum values for a number of key soil properties are listed in ***Table 7-1***. Where the soil samples indicate deficiencies, amelioration will be undertaken. As such, fertilisers or manures are spread prior to seeding to increase soil fertility and organic carbon characteristics, or to adjust soil pH or sodicity if required.

Table 7-1 - Optimum Criteria for Key Soil Properties

Parameter	Land use – Pasture	Land use – Woodland
pH	5.5 – 7.5	5.0 – 8.5
EC (µS/cm)	< 700	< 700
Sulphates (mg/kg)	5 – 10	5 – 10
Nitrates (mg/kg)	> 12.5	> 12.5

Parameter	Land use – Pasture	Land use – Woodland
Kjeldahl Nitrogen Total (mg/kg)	200-1000	200-1000
Phosphorus (mg/kg)	≥ 50	≥ 50
Chloride (mg/kg)	< 350	< 350
Cation Exchange Capacity (CEC) and Exchangeable cations (m_{eq}/100g)	>5	>5
Exchangeable Sodium Percentage (ESP) (%)	< 5	< 5
Organic Matter (mg/kg)	2-3	2-3

7.3 Seeding

The highest priority for rehabilitation of any areas is to establish a dense, vigorous and sustainable vegetation cover to stabilise the final landform. Apart from the target species (that is, framework species), cover crop species such as Japanese Millet (summer) or Oats (winter) may also be added to the required tree or grass seed mix and applied at a rate of 7-10 kg/ha. The cover crop will act as an effective short term ground cover and a bulking agent for seed distribution. It is intended that seed will be spread using the aerial seeding heli-drone method employed by external contractors, although alternative options are available and are being trialled.

Further mulching or straw blowing may also be undertaken following seeding to also achieve final landform stability depending on prior performance in particular rehabilitation areas and short-term weather forecasts. Timing of seeding works will aim for completion by mid-September to early October to take advantage of potential early wet season rains which tend to be of lower erosivity than storms in December and January. Seeding in summer is less desirable as there is an elevated risk that germination of seed initiated by a storm event could be followed period of hot, dry weather, resulting in poor field survival rates.

To alleviate the potential problems with tree establishment on black soils, seeding may take place in two stages. At first, a cover crop (e.g. Japanese millet at 30 kg/ha + fertiliser at 100 kg/ha) is grown for six months. This cover is subsequently ripped in as a green manure, with tree seeding following immediately after ripping. This approach and the use of other organic wastes or materials to provide variation in black soils texture may be applied for future areas of rehabilitation to enhance revegetation success.

In areas where germination rates from direct seeding are low, planting of tubestock may be undertaken in the order of 40 tubestock/ha, where practicable. This is the least preferred method of vegetation establishment as plants established tubestock are less resilient than plants emerging from sown seed during the early establishment phase and require regular rainfall or artificial watering in order to establish.

7.3.1 Seed Sourcing

Seed will be sourced from reliable suppliers with evidence of appropriate seed analysis quality control reports detailing species seed count per unit weight, seed purity, absence of weed seed, seed viability, and anticipated field germination rates. Seeding rates may be refined over time based on observed field survival rates for each of the species within the seed mix. Refinement of the seeding methodology may be informed via ongoing investigations of pre-treatment and pelleting options for differing species to improve germination and establishment.

7.4 Offset Management

Management of Belyando Cobblers Pegs (BCP) and Bluegrass offset areas is described under separate management plans. Management prescriptions include the use of mosaic burning to create space and potentially allow greater opportunity for Belyando Cobblers Pegs germination, and undertaking seed collection, propagation and planting to increase the population at the site to a sustainable level. There is an annual requirement to monitor areas of Belyando Cobblers Pegs and Bluegrass on the CM area. This is to help inform 6-monthly progress reporting requirements to the regulators, and to track the success of the management measures outlined in each management plan respectively. Belyando Cobblers Pegs and Bluegrass must be considered as part of normal site disturbance processes.

7.5 Weed and Pest Management

CCO conducts weed management consistent with the local shire (Isaac Regional Council) weed strategy for management of any identified and controlled weed species that have been recorded on the site. Management of animal pests is also undertaken with the local shire pest strategy, and in accordance with feral animal control priorities of relevance to the local community.

At closure, the noxious weed eradication program will continue across the CCO areas to ensure identification and eradication of noxious weeds at each stage of growth, as required to meet proposed completion criteria. In addition, CCO will continue pest management activities at closure with an objective to keep pest animals at low density, to protect landscape values.

7.6 Fencing

Grazing paddocks may be established where suitable, such as on the flat topped dump surfaces. Fences will be required to manage livestock, in particular to exclude it from areas incompatible with grazing (such as the Belyando Cobbler's Peg offset area, or newly establishing revegetation) and to facilitate stock rotation management practices. Fencing will consist of standard stock fence or no-climb stock fence.

8. Document Information

Reference	Title
Ausecology (2014)	Northern Quoll Detection Survey Report Clermont Open Cut, Clermont Queensland.
Erskine, P. and A. Fletcher (2014)	Rehabilitation Monitoring Manual of Glencore Coal Operations, Queensland. Report produced for Glencore Coal Operations. Centre for Mine Land Rehabilitation, University of Queensland.
Glencore (2020)	Rehabilitation Management Plan.
Highlands Environmental (2020)	Blair Athol rehabilitation assessment and recommendations. Report prepared for Glencore Coal Assets Australia.
KBR (2019)	Belyando Cobblers Pegs VDec Management Plan. Report produced for Clermont Coal Operations.
Landloch (2012)	Rehabilitation Monitoring on Blair Athol Coal Mine, Queensland. Draft Report prepared for Rio Tinto.
McCaffrey, N, M.Gravina, P.Erskine, and A.Fletcher (2015)	Rehabilitation Monitoring Manual of Glencore Coal Operations: Reference Site Establishment for Clermont Open Cut Mine. Report produced for Glencore Coal Operations. Centre for Mine Land Rehabilitation, University of Queensland.
URS (2006)	Significant Vegetation and Northern Quoll Targeted Surveys. Report produced for Rio Tinto.