

Permit

Environmental Protection Act 1994

Environmental authority EPML00862313

This environmental authority is issued by the administering authority under Chapter 5 of the Environmental Protection Act 1994.

Environmental authority number: EPML00862313

Environmental authority takes effect on 28 May 2025

Environmental authority holder(s)

Name(s)	Registered address
BHP COAL PTY LTD	Level 14, 480 Queen Street BRISBANE CITY QLD 4000 Australia
Mitsubishi Development Pty Ltd	Level 16, 480 Queen Street BRISBANE CITY QLD 4000
QCT INVESTMENT PTY. LTD.	Level 16, 480 Queen Street BRISBANE CITY QLD 4000 Australia
Umal Consolidated Pty Ltd	Level 14, 480 Queen Street BRISBANE CITY QLD 4000
QCT Resources Pty Limited	Level 16, 480 Queen Street BRISBANE CITY QLD 4000
QCT MINING PTY. LTD.	Level 16, 480 Queen Street BRISBANE CITY QLD 4000 Australia
BHP Queensland Coal Investments Pty Ltd	Level 14, 480 Queen Street BRISBANE CITY QLD 4000

Environmentally relevant activity and location details

Environmentally relevant activity/activities	Location(s)
Schedule 3 13: Mining black coal	ML1775, ML1782, ML1784, ML2360, ML2410, ML70142, ML70294, ML70298, ML70328, ML700021
Ancillary 08 - Chemical Storage 3: Storing more than 500 cubic metres of chemicals of class C1 or C2 combustible liquids under AS 1940 or dangerous goods class 3 under subsection (1)(c)	ML1775, ML1782, ML1784, ML2360, ML2410, ML70142, ML70294, ML70298, ML70328, ML700021

Environmentally relevant activity/activities	Location(s)
Ancillary 31 - Mineral processing 2: Processing, in a year, the following quantities of mineral products, other than coke (b) more than 100,000t	ML1775, ML1782, ML1784, ML2360, ML2410, ML70142, ML70294, ML70298, ML70328, ML700021
Ancillary 60 - Waste disposal 2: Operating a facility for disposing of, in a year, the following quantity of waste mentioned in subsection (1)(b) (b) more than 2000t but not more than 5000t	ML1775, ML1782, ML1784, ML2360, ML2410, ML70142, ML70294, ML70298, ML70328, ML700021
Ancillary 63 - Sewage Treatment 1: Operating sewage treatment works, other than no-release works, with a total daily peak design capacity of (b-i) more than 100 but not more than 1500EP if treated effluent is discharged from the works to an infiltration trench or through an irrigation scheme	ML1775, ML1782, ML1784, ML2360, ML2410, ML70142, ML70294, ML70298, ML70328, ML700021

Additional information for applicants

Environmentally relevant activities

The description of any environmentally relevant activity (ERA) for which an environmental authority (EA) is issued is a restatement of the ERA as defined by legislation at the time the EA is issued. Where there is any inconsistency between that description of an ERA and the conditions stated by an EA as to the scale, intensity or manner of carrying out an ERA, the conditions prevail to the extent of the inconsistency.

An EA authorises the carrying out of an ERA and does not authorise any environmental harm unless a condition stated by the EA specifically authorises environmental harm.

A person carrying out an ERA must also be a registered suitable operator under the *Environmental Protection Act 1994* (EP Act).

Contaminated land

It is a requirement of the EP Act that an owner or occupier of land give written notice to the administering authority if they become aware of the following:

- the presence of, or happening of an event involving, a hazardous contaminant on the land that is causing, or is reasonably likely to cause, serious or material environmental harm (notice must be given within 24 hours); or
- if the land is contaminated land – a change in the condition of the land that is causing, or is reasonably likely to cause, serious or material environmental harm (notice must be given within 24 hours); or
- a notifiable activity (as defined in Schedule 3) having been carried out, or is being carried out, on the land (notice must be given within 20 business days).

For further information, including the form for giving written notice, refer to the Queensland Government website www.qld.gov.au, using the search term 'duty to notify'.

Take effect

Please note that, in accordance with section 200 of the EP Act, an EA has effect:

- if the authority is for a prescribed ERA and it states that it takes effect on the day nominated by the holder of the authority in a written notice given to the administering authority – on the nominated day; or

- b) if the authority states a day or an event for it to take effect – on the stated day or when the stated event happens; or
- c) otherwise – on the day the authority is issued.

However, if the EA is authorising an activity that requires an additional authorisation (a relevant tenure for a resource activity, a development permit under the *Planning Act 2016* or an SDA Approval under the *State Development and Public Works Organisation Act 1971*), this EA will not take effect until the additional authorisation has taken effect.

If this EA takes effect when the additional authorisation takes effect, you must provide the administering authority written notice within 5 business days of receiving notification of the related additional authorisation taking effect.

The anniversary day of this environmental authority is the same day each year as the effective date. The payment of the annual fee will be due each year on this day. An annual return will be due each year on 01 April.

If you have incorrectly claimed that an additional authorisation is not required, carrying out the ERA without the additional authorisation is not legal and could result in your prosecution for providing false or misleading information or operating without a valid environmental authority.



Signature

28 May 2025

Date

Jessica Johnson
Department of the Environment, Tourism, Science and Innovation
Delegate of the administering authority
Environmental Protection Act 1994

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Date issued: 28 May 2025

Obligations under the *Environmental Protection Act 1994*

In addition to the requirements found in the conditions of this environmental authority, the holder must also meet their obligations under the EP Act, and the regulations made under the EP Act. For example, the holder must comply with the following provisions of the Act:

- general environmental duty (section 319)
- duty to notify environmental harm (section 320-320G)
- offence of causing serious or material environmental harm (sections 437-439)
- offence of causing environmental nuisance (section 440)
- offence of depositing prescribed water contaminants in waters and related matters (section 440ZG)
- offence to place contaminant where environmental harm or nuisance may be caused (section 443)

Other permits required

This permit only provides an approval under the *Environmental Protection Act 1994*. In order to lawfully operate you may also require permits / approvals from your local government authority, other business units within the department and other State Government agencies prior to commencing any activity at the site. For example, this may include permits / approvals with your local Council (for planning approval), the Department of Transport and Main Roads (to access State controlled roads), the Department of Natural Resources and Mines Manufacturing and Regional and Rural Development (to clear vegetation), and the Department of Primary Industries (to clear marine plants or to obtain a quarry material allocation).

Conditions of environmental authority

Schedule A: General	
Condition number	Condition
A1	This environmental authority authorises environmental harm referred to in the conditions. Where there is no condition or this environmental authority is silent on a matter, the lack of a condition or silence does not authorise environmental harm.
A2	Prevent and /or minimise likelihood of environmental harm In carrying out the environmentally relevant activities, the environmental authority holder must take all reasonable and practicable measures to prevent and/or to minimise the likelihood of environmental harm being caused. Any environmentally relevant activity, that, if carried out incompetently, or negligently, may cause environmental harm, in a manner that could have been prevented, shall be carried out in a proper manner in accordance with the conditions of this environmental authority.
A3	Maintenance of measures, plant and equipment The environmental authority holder must ensure: a) that all measures, plant and equipment necessary to ensure compliance with the conditions of this environmental authority are installed; b) that such measures, plant and equipment are maintained in a proper condition; c) that such measures, plant and equipment are operated in a proper manner; and d) that all instruments and devices used for the measurement or monitoring of any parameter under any condition of this environmental authority are properly calibrated.
A4	Monitoring and records Except where specified otherwise in another condition of this environmental authority, all monitoring records and reports required by this environmental authority must be kept for a period of not less than five (5) years.
A5	Monitoring and determinations required under any condition of this environmental authority must be conducted by an appropriately qualified person(s).
A6	Upon request from the administering authority, copies of monitoring results, records, registers, management plans and reports required by the conditions of this environmental authority must be made available and provided to the administering authority within ten (10) business days or an alternative timeframe agreed between the administering authority and the environmental authority holder.

A7	Notification of emergencies, incidents and exceptions The environmental authority holder must notify the administering authority by written notification within twenty-four (24) hours after becoming aware of any emergency or incident that results in the release of contaminants not in accordance, or reasonably expected to be not in accordance, with the conditions of this environmental authority.
A8	Within ten (10) business days following the initial notification under condition A7, or the receipt of monitoring results associated with the notification made under condition A7, whichever is the latter, the environmental authority holder must provide further written advice to the administering authority, including the following: a) results and interpretation of any samples taken and analysed; b) outcomes of actions taken at the time to prevent or minimise unlawful environmental harm; and c) proposed actions to prevent a recurrence of the emergency or incident.
A9	Complaints The environmental authority holder must record all environmental complaints received about the mining activities, including: a) name, address and contact number for of the complainant; b) time and date of complaint; c) reasons for the complaint; d) investigations undertaken; e) conclusions formed; f) actions taken to resolve the complaint, including the use of appropriate dispute resolution if required; g) any abatement measures implemented; and h) person responsible for resolving the complaint.
A10	A register of alternative arrangements must be established and maintained by the environmental authority holder. The register must include: a) the location to which the alternative arrangement applies; b) the period of the alternative arrangement; c) details about the particular environmental nuisance impact or impacts the arrangement is for; and d) details about the mitigation measures, where relevant.

A11	Monitoring on request When requested by the administering authority, the environmental authority holder must investigate any nuisance, or contaminant release, or environmental harm, or complaint that is neither frivolous nor vexatious in the opinion of the authorised person, by: a) undertaking the monitoring specified by the administering authority; b) undertaking the monitoring in the timeframe nominated or agreed to by the administering authority; c) completing an analysis and interpretation of the monitoring results; and d) implementing abatement measures, where required.
A12	The results of the investigation undertaken in accordance with condition A11 must be provided to the administering authority within twenty (20) business days of completion of the monitoring timeframe in accordance with condition A11(b), or a longer timeframe agreed to by the administering authority.
A13	Term Lease This environmental authority also applies to term lease TL 0/233440. No mining is to be undertaken on the part of the term lease that is not also covered by a mining lease.

Schedule B: Air	
Condition number	Condition
B1	Odour nuisance The release of noxious or offensive odour or any other noxious or offensive airborne contaminant resulting from the mining activities must not cause an environmental nuisance, at any sensitive place or commercial place.
B2	If the administering authority determines odour released from the mining activities to constitute an environmental nuisance, the environmental authority holder must immediately implement abatement measures so that emissions from the mining activities do not result in further environmental nuisance.
B3	Dust nuisance The release of dust or particulate matter or both resulting from the mining activities must not cause an environmental nuisance, at any sensitive place or commercial place.
B4	Monitoring of dust and particulate matter resulting from the mining activities, undertaken in accordance with condition A11, must be carried out at a place relevant to the potentially affected sensitive place or commercial place and must not exceed the following levels when measured at any sensitive place or commercial place: e) dust deposition, measured as total insoluble matter, of 120 milligrams per square metre per day, averaged over one month, when monitored in accordance with the most recent version of Australian Standard <i>AS3580.10.1 Methods for sampling and analysis of ambient air – Determination of particulate matter – Deposited matter – Gravimetric method</i>. f) a concentration of particulate matter with an aerodynamic diameter of less than 10 micrometre (PM10) suspended in the atmosphere of 50 micrograms per cubic metre over a 24-hour averaging time, when monitored in accordance with the most recent version of either: i. Australian Standard <i>AS3580.9.6 Methods for sampling and analysis of ambient air – Determination of suspended particulate matter – PM10 high volume sampler with size selective inlet – Gravimetric method</i>; or ii. Australian Standard <i>AS3580.9.8 Methods for sampling and analysis of ambient air – Determination of suspended particulate matter – PM10 continuous direct mass method using a tapered element oscillating microbalance analyser</i>; or iii. Australian Standard <i>AS3580.9.9 Methods for sampling and analysis of ambient air – Determination of suspended particulate matter – PM10 low volume sampler – Gravimetric method</i>; or iv. Australian Standard <i>AS3580.9.11 Methods for sampling and analysis of ambient air – Determination of suspended particulate matter – PM10 beta attenuation monitors</i>. <i>NOTE: Exceedances due to events that cannot be managed by the environmental authority holder, such as bushfires, fuel reduction burning for fire management purposes or dust storms, would not be considered to be in breach of condition B4 if the environmental authority holder can demonstrate that the exceedance was caused by such events.</i>

B5	If monitoring, undertaken in accordance with condition A11 , indicates exceedance of the relevant limits in condition B4 , the environmental authority holder must immediately implement abatement measures so that emissions from the mining activities do not result in further environmental nuisance.
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Schedule C: Noise and Vibration	
Condition number	Condition
C1	Noise nuisance Noise from the mining activities must not cause an environmental nuisance, at any sensitive place or commercial place.
C2	Noise is not considered an environmental nuisance under condition C1 if monitoring shows that noise does not exceed the limits in Table C1 (Noise Limits) , at any sensitive place or commercial place.
C3	Noise monitoring Noise monitoring, undertaken in accordance with condition A11 , must comply with the most recent version of the administering authority's <i>Noise Measurement Manual</i> , and must include the following descriptors, characteristics and conditions: g) L_{A10}, adj, 10 mins; h) L_{A1}, adj, 10 mins; i) the level and frequency of occurrence of impulsive or tonal noise; j) atmospheric conditions including wind speed and direction; k) effects due to extraneous factors such as traffic noise; and l) location, date and time of recording.
C4	If monitoring, undertaken in accordance with condition A11 , indicates exceedance of the relevant limits in Table C1 (Noise Limits) , the environmental authority holder must immediately implement abatement measures so that emissions from the mining activities do not result in further environmental nuisance.

Table C1 (Noise Limits)

Noise Level dB(A)	Monday to Sunday (including public holidays)		
	Day (7am to 6pm)	Evening (6pm to 10pm)	Night (10pm to 7am)
Sensitive Place			
L_{A10} , adj, 10 mins	B/g + 5	B/g + 5	B/g + 3
L_{A1} , adj, 10 mins	B/g + 10	B/g + 10	B/g + 8
Commercial Place			
L_{A10} , adj, 10 mins	B/g + 10	B/g + 10	B/g + 5
L_{A1} , adj, 10 mins	B/g + 15	B/g + 15	B/g + 10

C5	Vibration nuisance Vibration from the mining activities must not cause an environmental nuisance, at any sensitive place or commercial place.
C6	Vibration is not considered an environmental nuisance under condition C5 if monitoring shows that vibration does not exceed the limits specified in Table C2 (Vibration Limits) .
C7	Airblast overpressure nuisance The airblast overpressure level from blasting operations on the mining leases must not cause an environmental nuisance, at any sensitive place or commercial place.
C8	Airblast overpressure is not considered an environmental nuisance under condition C7 if monitoring shows that airblast overpressure does not exceed the levels specified in Table C3 (Airblast Overpressure Level) .
C9	Vibration and/or airblast overpressure monitoring Vibration and/or airblast overpressure monitoring, undertaken in accordance with condition A11 , must comply with the most recent version of the administering authority's <i>Noise Measurement Manual</i> , and must include the following descriptors, characteristics and conditions: m) location of the blast(s) within the mining area (including which bench level); n) atmospheric conditions including temperature, relative humidity and wind speed and direction; and o) location, date and time of recording.
C10	If monitoring, undertaken in accordance with condition A11 , indicates exceedance of the relevant limits in Table C2 (Vibration Limits) or Table C3 (Airblast Overpressure Level) , the environmental authority holder must immediately implement abatement measures so that emissions from the mining activities do not result in further environmental nuisance.

Table C2 (Vibration Limits)

Location	Vibration Measured
Sensitive place or commercial place	5 mm/s peak particle velocity for nine (9) out of ten (10) consecutive blasts and not greater than 10 mm/s peak particle velocity at any time.

Table C3 (Airblast Overpressure Level)

Location	Airblast Overpressure Measured
Sensitive place or commercial place	115 dB (Linear peak) for nine (9) out of ten (10) consecutive blasts and not greater than 120 dB (Linear peak) at any time.

Schedule D: Waste	
Condition number	Condition
D1	Waste management A Waste Management Plan must be developed by an appropriately qualified person and implemented. The Waste Management Plan must include, but is not limited to: p) a description of the mining activities that may generate waste; q) a description of all waste activities being carried out; r) the location/s (including GPS coordinates) of where all waste activities are, or have been, carried out, including: i. the type of waste disposed of, treated, or reprocessed; and ii. the volume of waste disposed of, treated, or reprocessed; s) identification of the potential risk to the environment from all waste activities carried out; t) control measures to be implemented to minimise the potential for environmental harm associated with carrying out of the waste activities, including but not limited to: i. segregation of the wastes; ii. storage of the wastes; iii. transport of the wastes; and iv. monitoring and reporting matters concerning the wastes; u) how the waste will be managed in accordance with the waste management hierarchy (that is, avoid, reuse, recycling, energy recovery, disposal); v) the hazardous characteristics of the wastes generated including disposal procedures for hazardous wastes; w) procedures for reprocessing waste in accordance with condition D4; x) procedures for managing accidents, spills and other incidents; y) the indicators or other criteria on which the performance of the waste management plan will be assessed; and z) staff training.
D2	The environmental authority holder must submit the Waste Management Plan required by condition D1 to the administering authority prior to commencing a new process, or varying an existing process, for reprocessing or composting any waste.
D3	Waste receipt The only waste permitted to be received is: a) the types of waste specified in conditions D4 to D7 (inclusive); and b) sewage and sludge for treatment in accordance with Schedule H: Sewage Treatment; and c) from a BHP Billiton Mitsui Coal (BMC) or BHP Mitsubishi Alliance (BMA) site in Queensland.

D4	Waste reprocessing The only waste permitted to be reprocessed is: a) spoil or overburden; b) vegetation; c) water or sediment containing hydrocarbons; d) fuels, oils, lubricants and coolants; e) bulk rubber; f) inert waste; g) poly-pipe and other plastic; h) fibreglass; i) treated and untreated timber; and j) asphalt.
D5	Waste disposal Unless otherwise specified in conditions D6 and D7, waste, other than spoil or overburden or vegetation removed as part of the mining activity, must not be disposed of within the mining leases listed on this environmental authority and must be taken to a facility that is lawfully allowed to accept such waste under the provisions of the <i>Environmental Protection Act 1994</i>.
D6	The following types of waste are permitted to be disposed of within the specified features for the waste type: k) rejects and sediment containing hydrocarbons: i. in spoil emplacements; and ii. in regulated structures in accordance with Schedule G: Structures of this environmental authority; and iii. in pits or voids; and iv. in dedicated rejects emplacements; and l) tailings and water or sediment containing hydrocarbons: i. in regulated structures in accordance with Schedule G: Structures of this environmental authority; and ii. in pits or voids that are not regulated structures, provided a consequence category assessment in accordance with condition G1 has been completed.

D7	The following types of waste may be disposed of within the mining leases listed on this environmental authority: m) bulk rubber; n) inert waste; o) poly-pipe and other plastic; p) fibreglass; q) treated and untreated timber; r) asphalt; and s) asbestos. These types of waste may be disposed of: t) in pits or voids; u) in spoil emplacements; and v) left in situ below ground level.
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Schedule E: Land	
Condition number	Condition
E1	Topsoil Topsoil must be strategically stripped ahead of mining in accordance with a Topsoil Management Plan.
E2	A topsoil inventory, which identifies the topsoil requirements for rehabilitation and availability of suitable topsoil on site, must be provided with any Estimated Rehabilitation Cost application.
E3	PRCP schedule Progressive rehabilitation of the disturbed land must be carried out in accordance with the approved Progressive Rehabilitation and Closure Plan (PRCP) schedule P-PRCP-100734616 for this environmental authority.
E4	Preventing contaminant release to land Contaminants must not be released to land in manner that constitutes a nuisance, material harm or serious environmental harm.
E5	Storage and handling of chemicals and flammable or combustible liquids All chemicals and flammable or combustible liquids must be stored and handled in accordance with the most recent version of an Australian Standard where such is applicable. Where no relevant Australian Standard exists, store such materials within an effective on-site containment system.
E6	An undisturbed area of 60 hectares (ha) must be retained between Grevillea residual void and the eastern boundary of mining lease ML700021. A safety bund is authorised within the 60ha undisturbed area.
E7	Surrender The holder must meet the conditions and the rehabilitation milestones under the PRCP schedule prior to the surrender of the environmental authority.

Schedule F: Water	
Condition number	Condition
F1	Contaminant Release Contaminants that will or have the potential to cause environmental harm must not be released directly or indirectly to any waters as a result of the mining activities, except as permitted under the conditions of this environmental authority.
F2	Unless otherwise permitted under the conditions of this environmental authority, the release of mine affected water to waters must only occur from the release points specified in Table F1 (Mine Affected Water Release Points) .

Table F1 (Mine Affected Water Release Points)

Release Point (RP)	Easting (GDA94)	Northing (GDA94)	Mine Affected Water Source and Location	Monitoring Point	Receiving Waters Description
RP1	636496	7512487	Lake Lester	Dam spillway or pump line outlet	Phillips Creek
RP2	631289	7523326	Dudley's Dam	Dam spillway or pump line outlet	Hughes Creek
RP3	634012	7523001	Evaporation Ponds	Dam spillway	Hughes Creek
RP4	638558	7513774	Farmhouse-Ramp 15 High Wall Dams	Dam spillway or pump line outlet	Phillips Creek
RP5	632962	7518219	Campbell's Dam	Dam spillway or pump line outlet	One Mile Creek
RP6	633278	7524446	Coolibah Pit-HCD Back Access Road	Dam spillway or pump line outlet	Hughes Creek
RP7	635142	7520280	OMCD Back Access Road	Dam spillway or pump line outlet	One Mile Creek
RP9	630101	7524942	Ramp 2 Fill Dam	Dam spillway or pump line outlet	Hughes Creek
RP10	634801	7514837	Ebony Dam	Dam spillway or pump line outlet	Phillips Creek

F3	The release of mine affected water to waters in accordance with condition F2 must not exceed the release limits stated in Table F2 (Mine Affected Water Release Limits) when measured at the monitoring points specified in Table F1 (Mine Affected Water Release Points) for each quality characteristic.
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Table F2 (Mine Affected Water Release Limits)

Quality Characteristic	Release Limit	Monitoring Frequency
Electrical Conductivity (µS/cm)	10,000	Real-time monitoring of pH, EC and flow during active release (minimum frequency hourly mean). Where real time monitoring is not available, daily sampling during active release as soon as possible after commencement of active release, when safe access permits [^]
pH (pH units)	6.5 (minimum) 9.0 (maximum)	

NOTES:

[^] Generally during daylight hours only

F4	The release of mine affected water to waters from the release points must be monitored at the locations specified in Table F1 (Mine Affected Water Release Points) for each quality characteristic and at the frequency specified in Table F2 (Mine Affected Water Release Limits) and Table F3 (Release Contaminant Trigger Investigation Levels). <i>NOTE: the administering authority will take into consideration any extenuating circumstances prior to determining an appropriate enforcement response in the event condition F4 is contravened due to a temporary lack of safe or practical access. The administering authority expects the environmental authority holder to take all reasonable and practicable measures to maintain safe and practical access to designated monitoring locations.</i>
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Table F3 (Release Contaminant Trigger Investigation Levels)

Quality Characteristic ¹	Trigger Level (µg/L)	Comment of Trigger Level ^{2, 3}	Monitoring Frequency
Aluminium	416	For aquatic ecosystem protection, based on 80 th percentile of background data	As soon as possible after commencement of active release, when safe access permits, and weekly thereafter. For successive releases from the same site under similar circumstances, only one sample per week is required.
Chromium	1	For aquatic ecosystem protection, based on SMD guideline	
Copper	2	For aquatic ecosystem protection, based on LOR for ICPMS	
Iron	1130	For aquatic ecosystem protection, based on 80 th percentile of background data	
Uranium	1	For aquatic ecosystem protection, based on LOR for ICPMS	
Zinc	8	For aquatic ecosystem protection, based on SMD guideline	
Petroleum hydrocarbons (C6-C9)	20	For aquatic ecosystem protection, based on LOR	
Petroleum hydrocarbons (C10-C36)	100	For aquatic ecosystem protection, based on LOR	

NOTES:

1. All metals and metalloids must be measured as total (unfiltered) and dissolved (filtered). Trigger levels for metal/metalloids apply if dissolved results exceed trigger.

2. SMD – slightly moderately disturbed level of protection, guideline refers ANZECC & ARMCANZ (2000).

3. LOR – typical reporting for method stated. ICPMS/CV FIMS – analytical method required to achieve LOR.

F5	If quality characteristics of the release exceed any of the trigger levels specified in Table F3 (Release Contaminant Trigger Investigation Levels) during a release event, the environmental authority holder must compare the downstream results in the receiving waters to the trigger values specified in Table F3 (Release Contaminant Trigger Investigation Levels) and: (1) where the trigger values are not exceeded then no action is to be taken; or (2) where the downstream results exceed the trigger values specified in Table F3 (Release Contaminant Trigger Investigation Levels) for any quality characteristic, compare the results of the downstream site to the data from background monitoring sites and; (a) if the result is less than the background monitoring site data, then no action is to be taken; or (b) if the result is greater than the background monitoring site data, complete an investigation into the potential for environmental harm and provide a written report to the administering authority in the next annual return, outlining: i. details of the investigations carried out; and ii. actions taken to prevent environmental harm. <i>NOTE: Where an exceedance of a trigger level has occurred and is being investigated, in accordance with condition F5(2)(b), no further reporting is required for subsequent trigger events for that quality characteristic.</i>
F6	If an exceedance in accordance with condition F5(2)(b) is identified, the environmental authority holder must notify the administering authority via WaTERS within twenty-four (24) hours of receiving the result.
F7	Mine Affected Water Release Events The environmental authority holder must ensure a stream flow gauging station(s) is installed, operated and maintained to determine and record stream flows at the locations and flow recording frequency specified in Table F4 (Mine Affected Water Release During Flow Events).
F8	Notwithstanding any other condition of this environmental authority, the release of mine affected water to waters in accordance with condition F2 must only take place during periods of natural flow events in accordance with the receiving water flow criteria for discharge specified in Table F4 (Mine Affected Water Release During Flow Events) for the release point(s) specified in Table F1 (Mine Affected Water Release Points).
F9	Notwithstanding Condition F10, the release of mine affected water must not exceed the Limit values identified in Table F4A (Electrical Conductivity Limits at Downstream Monitoring Points) when measured at the monitoring points specified in Table F6 (Receiving Waters Upstream Background and Downstream Monitoring Points) during the release influence period. 1. Release influence period is the hours of release plus the lag period from the release point to the monitoring point specified in Table F6. 2. If the environmental authority holder becomes aware during the release influence period that the Limit value will be exceeded, the environmental authority holder must scale back or cease release of mine affected water.

F10	The 80th percentile of electrical conductivity (EC) values recorded at the downstream monitoring points in the Isaac River listed in Table F6 (Receiving Waters Upstream Background and Downstream Monitoring Points) must not exceed 2000µS/cm over the duration of the release influence period. The 80th percentile must be calculated using all EC values recorded by the monitoring station during the release influence period. Note: The release influence period is the period during which the downstream monitoring points are influenced by mine affected water includes both the duration of release and any lag time between release point/s and downstream monitoring points.
F11	The daily quantity of mine affected water released from each release point must be measured and recorded at the monitoring points in Table F1 (Mine Affected Water Release Points) .
F12	Releases to waters must be undertaken so as not to cause erosion of the bed and banks of the receiving waters, or cause a material build-up of sediment in such waters.

Table F4 (Mine Affected Water Release During Flow Events)

Receiving waters	Release Point (RP)	Gauging Station	Gauging Station Easting (GDA94)	Gauging Station Northing (GDA94)	Period	Receiving Water Flow Criteria for Discharge [#] (m³/s)	Receiving Water Flow Recording Frequency [^]
Isaac River	All RPs	Deverill	642119	7548391	All times	>3 m³/s	Continuous (minimum frequency hourly mean)
Hughes Creek	RP2	Gauging station 1	634503	7525720	1 November to 31 March	>0.1 m³/s	
	RP3				1 April to 31 October	>1.0 m³/s	
	RP6						
	RP9						
One Mile Creek	RP5	Gauging station 2	636582	7520210	1 November to 31 March	>0.1 m³/s	
	RP7				1 April to 31 October	>1.0 m³/s	
Phillips Creek	RP1	Gauging station 4	639138	7513910	1 November to 31 March	>0.1 m³/s	
	RP4				1 April to 31 October	>1.0 m³/s	
	RP10						

[^] Assumes access to real time telemetry monitoring is available. Where real time telemetry is not available, daily records will be calculated in accordance with Table F2.

[#] When the downstream flow gauge falls below the minimum flow trigger, the 6-week tail flow period commences. Tail flow restricted by trigger limits in receiving waters (**Table F5**).

* Receiving water minimum flow requirements at the time of commencement apply to the entire release event, where the release period changes.

Table F4A (Electrical Conductivity Limits at Downstream Monitoring Points)

Period	Trigger Value	Limit Values		
	Isaac River MP9 and MP10	Hughes Creek MP5	One Mile Creek MP6	Phillips Creek MP7
1 November to 31 March	2,000 µS/cm	6,000 µS/cm	6,000 µS/cm	10,000 µS/cm
1 April to 31 October	2,000 µS/cm	2,000 µS/cm	2,000 µS/cm	2,000 µS/cm

* Receiving water electrical conductivity limits at the time of commencement apply to the entire release event, where the release period changes.

F13	Notification of release event The environmental authority holder must notify the administering authority via WaTERS as soon as practicable and no later than twenty-four (24) hours after commencing to release mine affected water to the receiving environment. The release commencement notification must include the submission of written advice to the administering authority of the following information: a) release commencement date and time; b) expected release cessation date and time; c) release point(s); d) release rate; e) receiving water(s) including the natural flow rate; and f) any details (including available data) regarding likely impacts on the receiving water(s).
F14	The environmental authority holder must notify the administering authority via WaTERS as soon as practicable and no later than twenty-four (24) hours after cessation of a release event notified under condition F13. The release cessation notification must include the submission of written advice to the administering authority of the following information: a) release cessation date and time; b) receiving water(s) including the natural flow rate; and c) volume of water released. <i>NOTE: Successive or intermittent releases occurring within twenty-four (24) hours of the cessation of any individual release can be considered part of a single release event and do not require individual notification for the purpose of compliance with conditions F13 and F14 and F15, provided the relevant details of the release are included within the notification provided in accordance with conditions F13 and F14 and F15.</i>

F15	Within twenty-eight (28) days of notification under condition F14, the environmental authority holder must provide the administrating authority via WaTERS the following information in writing: a) confirmation of: i. the release commencement date and time; ii. the release cessation date and time; iii. receiving water(s) including the natural flow rate; iv. volume of water released; b) all in-situ, continuous and laboratory water quality monitoring results; c) details regarding the compliance of the release with the conditions of Schedule F: Water of this environmental authority (i.e. contamination limits, natural flow, discharge volume); d) whether the release of water resulted in any impacts to the receiving environment; and e) any other matter(s) pertinent to the water release event.
F16	Notification of release event exceedance If the release limits defined in Table F2 (Mine Affected Water Release Limits) are exceeded, the environmental authority holder must notify the administering authority via WaTERS within twenty-four (24) hours of receiving the results.
F17	The environmental authority holder must, within twenty-eight (28) days of the notification provided in accordance with condition F16, provide a report to the administering authority via WaTERS detailing: a) the reason for the release; b) the location of the release; c) the total volume of the release and which (if any) part of this volume was non-compliant; d) the total duration of the release and which (if any) part of this period was non-compliant; e) all water quality monitoring results; f) any general observations; g) all calculations; and h) any other matters pertinent to the water release event.
F18	Receiving Environment Monitoring and Contaminant Trigger Levels The quality of the receiving waters must be monitored at the locations specified in Table F6 (Receiving Water Upstream Background and Downstream Monitoring Points) for each quality characteristic and at the monitoring frequency stated in Table F5 (Receiving Waters Contaminant Trigger Levels) and Table F3 (Release Contaminant Trigger Investigation Levels).

F19	If quality characteristic(s) of the receiving water at the downstream monitoring point exceed any of the trigger levels specified in Table F5 (Receiving Waters Contaminant Trigger Levels) during a release event the environmental authority holder must compare the downstream results to the upstream results in the receiving waters and: (1) where the downstream result is the same or a lower value than the upstream value for the quality characteristic then no action is to be taken; or (2) where the downstream results exceed the upstream results, complete an investigation into the potential for environmental harm and provide a written report to the administering authority in the next annual return, outlining: (a) details of the investigations carried out; and (b) actions taken to prevent environmental harm. <i>NOTE: Where an exceedance of a trigger level has occurred and is being investigated in accordance with F19(2) of this condition, no further reporting is required for subsequent trigger events for that quality characteristic.</i>
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Table F5 (Receiving Waters Contaminant Trigger Levels)

Quality Characteristic	Trigger Level or Limit Value	Monitoring Frequency
pH (pH units)	6.5 to 9.0	Real-time monitoring of pH, EC, and flow during active or passive release (minimum frequency hourly mean).
Electrical Conductivity (µS/cm)	Trigger Level or Limit Values specified in Table F4A	Where real time monitoring is not available, daily sampling during active or passive release as soon as possible after commencement of release, when safe access permits^

NOTES:

^ Generally during daylight hours only

Table F6 (Receiving Waters Upstream Background and Downstream Monitoring Points)

Monitoring Point (MP)	Receiving Waters Location Description	Easting (GDA94)	Northing (GDA94)
Upstream Background Monitoring Points ^a			
MP1	Hughes Creek – 1500m upstream of RP2, 4470m upstream of RP3, 4300m upstream of RP6, 300m upstream of RP9	630293	7524050
MP2	One Mile Creek – 1600m upstream of RP5, 4300m upstream of RP7	631095	7516900
MP3	Phillips Creek – 5500m upstream of RP1, 10000m upstream of RP4	634067	7508900
Downstream Monitoring Points			
MP9 ^b	Isaac River – downstream of Seloh Nolem, downstream of RP2, RP3, RP6, RP9	651114	7529225
MP10 ^c	Isaac River – Beef Road Crossing, downstream of RP5, RP7, RP1, RP4	674851	7519770
MP5	Hughes Creek – 5400m downstream of RP2, 1930m downstream of RP3, 2100m downstream of RP6, 6900m downstream of RP9	634503	7525720
MP6	One Mile Creek – 4300m downstream of RP5, 1600m downstream of RP7	636582	7520210
MP7	Phillips Creek – 6900m downstream of RP1, 700m downstream of RP4, 10,300m downstream of RP10	639138	7513910

NOTES:

(a) The data from background monitoring points must not be used where they are affected by releases from other mines.

(b) MP5 to be used as backup when MP9 is unavailable.

(c) MP6 and MP7 to be used as backup with MP10 is unavailable.

F20	Receiving Environment Monitoring Program (REMP) The environmental authority holder must develop and implement a Receiving Environment Monitoring Program (REMP) to monitor, identify and describe any adverse impacts to surface water environmental values, quality and flows due to the authorised mining activity. This must include monitoring the effects of the mine on the receiving environment periodically (under natural flow conditions) and while mine affected water is being discharged from the site. For the purposes of the REMP, the receiving environment is the waters of the Hughes, One Mile, Spring and Phillips Creeks and connected or surrounding waterways within five (5) kilometres downstream of the release. The REMP should encompass any sensitive receiving waters or environmental values downstream of the authorised mining activity that will potentially be directly affected by an authorised release of mine affected water.
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F21	The REMP must: a) assess the condition or state of receiving waters, including upstream conditions, spatially within the REMP area, considering background water quality characteristics based on accurate and reliable monitoring data that takes into consideration temporal variation (e.g. seasonality); b) be designed to facilitate assessment against water quality objectives for the relevant environmental values that need to be protected; c) include monitoring from background reference sites (e.g. upstream or background) and downstream sites from the release (as a minimum, the locations specified in Table F6 (Receiving Water Upstream Background and Downstream Monitoring Points)); d) specify the frequency and timing of sampling required in order to reliably assess ambient conditions and to provide sufficient data to derive site specific background reference values in accordance with the <i>Queensland Water Quality Guidelines 2009</i>. This should include monitoring during periods of natural flow irrespective of mine or other discharges; e) include monitoring and assessment of dissolved oxygen saturation, temperature and all water quality parameters listed in Table F2 (Mine Affected Water Release Limits) and Table F3 (Release Contaminant Trigger Investigation Levels)); f) include, where appropriate, monitoring of metals/metalloids in sediments (in accordance with ANZECC & ARMCANZ 2000, BATLEY and/or the most recent version of AS5667.1 Guidance on Sampling of Bottom Sediments); g) include, where appropriate, monitoring of macroinvertebrates in accordance with the AusRivas methodology, h) apply procedures and/or guidelines from ANZECC & ARMCANZ 2000 and other relevant guideline documents; i) describe sampling and analysis methods and quality assurance and control; and j) incorporate stream flow and hydrological information in the interpretations of water quality and biological data.
F22	A report outlining the findings of the REMP, including all monitoring results and interpretations in accordance with conditions F20 and F21 must be prepared annually. This report must include the following: a) an assessment of background reference water quality; b) the condition of downstream water quality compared against water quality objectives; and c) the suitability of current discharge limits to protect downstream environmental values.

F23	Water reuse Mine affected water may be piped or trucked or transferred by some other means that does not contravene the conditions of this environmental authority and deposited into artificial water storage structures, such as farm dams or tanks, or used directly at properties owned by the environmental authority holder or a third party for the purpose of: a) supplying stock water subject to compliance with the quality release limits specified in Table F7 (Stock Water Release Limits); or b) supplying irrigation water subject to compliance with quality release limits in Table F8 (Irrigation Water Release Limits); or c) supplying water for construction and/or road maintenance in accordance with the conditions of this environmental authority.
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Table F7 (Stock Water Release Limits)

Quality Characteristic	Units	Minimum	Maximum
pH	pH units	6.5	8.5
Electrical Conductivity	µS/cm	N/A	5000

Table F8 (Irrigation Water Release Limits)

Quality Characteristic	Units	Minimum	Maximum
pH	pH units	6.5	8.5
Electrical Conductivity	µS/cm	N/A	Site specific value determined in accordance with ANZECC & ARMCANZ (2000) Irrigation Guidelines

F24	Mine affected water may be piped or trucked or transferred by some other means that does not contravene the conditions of this environmental authority and deposited into artificial water storage structures, such as dams or tanks, for the purpose of supplying water to any operation licensed for either ERA13 (mining black coal) or ERA31 (mineral processing). The volume, pH and electrical conductivity of water transferred must be monitored and recorded.
F25	If the responsibility for mine affected water is given or transferred to another person in accordance with conditions F23 or F24: a) the responsibility for the mine affected water must only be given or transferred in accordance with a written agreement (the third-party agreement); and b) the third-party agreement must include a commitment from the person utilising the mine affected water to use it in such a way as to prevent environmental harm or public health incidents and specifically make the persons aware of the General Environmental Duty (GED) under section 319 of the <i>Environmental Protection Act 1994</i>, environmental sustainability of the water disposal and protection of environmental values of waters; and c) the third-party agreement must be signed by both parties to the agreement.

F26	Water general All determinations of water quality and biological monitoring must be: a) performed by a person or body possessing appropriate experience and qualifications to perform the required measurements; b) made in accordance with methods prescribed in the latest edition of the administering authority's <i>Monitoring and Sampling Manual</i>; c) collected from the monitoring locations identified within this environmental authority, within ten hours of each other where possible; d) carried out on representative samples; and e) analysed at a laboratory accredited (e.g. NATA) for the method of analysis being used. <i>Note: Condition F26 requires the Monitoring and Sampling Manual to be followed and where it is not followed because of exceptional circumstances this should be explained and reported with the results.</i>
F27	The release of any contaminants as permitted by this environmental authority, directly or indirectly to waters, other than internal water management infrastructure that is installed and operated in accordance with a Water Management Plan that complies with conditions F29 to F30 inclusive: a) must not produce any visible discolouration of receiving waters; and b) must not produce any slick or other visible or odorous evidence of oil, grease or petrochemicals nor contain visible floating oil, grease, scum, litter or other objectionable matter.
F28	Annual water monitoring reporting The following information must be recorded in relation to all water monitoring required under the conditions of this environmental authority and submitted to the administering authority in the specified format with each annual return: a) the date on which the sample was taken; b) the time at which the sample was taken; c) the monitoring point at which the sample was taken; d) the measured or estimated daily quantity of mine affected water released from all release points; e) the release flow rate at the time of sampling for each release point; f) the results of all monitoring and details of any exceedances of the conditions of this environmental authority; and g) water quality monitoring data must be provided to the administering authority in the specified electronic format upon request.

F29	Water Management Plan A Water Management Plan must be developed by an appropriately qualified person(s) and implemented for all mining activities. The Water Management Plan must address, as a minimum, the following: a) provide for effective management of actual and potential environmental impacts resulting from water management associated with the mining activity carried out under this environmental authority; and b) be developed in accordance with administering authority's guideline <i>Preparation of water management plans for mining activities</i> and include: i. a study of the source of contaminants; ii. a water balance model for the site; iii. a water management system for the site; iv. measures to manage and prevent saline drainage; v. measures to manage and prevent acid rock drainage; vi. contingency procedures for emergencies; and vii. a program for monitoring and review of the effectiveness of the Water Management Plan.
F30	The Water Management Plan must be reviewed each calendar year by an appropriately qualified person(s).
F31	Saline drainage The environmental authority holder must ensure proper and effective measures are taken to avoid or otherwise minimise the generation and/or release of saline drainage.
F32	Acid rock drainage The environmental authority holder must ensure proper and effective measures are taken to avoid or otherwise minimise the generation and/or release of acid rock drainage.
F33	Stormwater and water sediment controls An Erosion and Sediment Control Plan must be developed by an appropriately qualified person for all stages of the mining activities on the site, and must include an Implementation Plan.
F34	The Erosion and Sediment Control Plan, including the Implementation Plan, required by condition F33 must be implemented to minimise erosion and the release of sediment to receiving waters and contamination of stormwater.
F35	The Erosion and Sediment Control Plan required by condition F33 must be reviewed each calendar year by an appropriately qualified person.

F36	By 30 November 2026, the environmental authority holder must complete a study/ies into long-term mitigation measures for erosion and sediment management at the site. The study must be completed by an appropriately qualified person and must: a) investigate the feasibility of erosion and sediment control measures for each catchment, and must: i. prioritise rehabilitation as a long-term measure; ii. consider long-term mine planning; iii. consider medium and long-term, and permanent measures; iv. present a feasible solution to be implemented for each area; b) be designed and implemented in accordance with the design standards and criteria contained in the Water Management Plan required by condition F29 and the Erosion and Sediment Control Plan required by condition F33; and c) consider the ongoing monitoring and maintenance of the measures; d) consider State and Federal regulatory approvals that may be required for each of the measures; and e) consider measures that may need to be implemented through the Progressive Rehabilitation and Closure Plan.
F37	By 31 January 2027, the environmental authority holder must submit to the administering authority a report that has been prepared by an appropriately qualified person, which includes: a) a summary of the findings of the study required by condition F36; b) details of the actions to be implemented; and c) a schedule for completion of the actions.
F38	By 31 March 2027, the environmental authority holder must update the Erosion and Sediment Control Plan, including the Implementation Plan, required by condition F33 to include the outcomes of conditions F37(b) and F37(c).
F39	On 31 July 2021, and by 31 July each year thereafter, the environmental authority holder must provide a report to the administering authority that includes: a) a summary of the actions completed in accordance with the Implementation Plan required by condition F33 during the previous 12 month period, between 1 July and 30 June, including before and after photographs and designs, where appropriate; b) a summary of any amendments made to the Implementation Plan by the environmental authority holder in the previous 12 months; and c) a list of those catchments which have been removed from the Implementation Plan due to all actions for those catchments having been completed.

F40	A report must be submitted to the administering authority on the completion of the Implementation Plan required by condition F33, which includes: a) evidence of completion of each action; b) a map which shows: i. the location (including GPS coordinates) of the erosion and sediment control measures and infrastructure established within each catchment; ii. the direction of runoff within the catchment; and iii. creeks and tributaries within the catchment, identifying their direction of flow; and c) details of ongoing monitoring and maintenance requirements of any works required as an outcome of each action.
F41	Stormwater, other than mine affected water, is permitted to be released to waters from: a) erosion and sediment control structures that are installed and operated in accordance with the Erosion and Sediment Control Plan required by condition F33; and b) water management infrastructure that is installed and operated, in accordance with a Water Management Plan that complies with conditions F29 to F30 inclusive, for the purpose of ensuring water does not become mine affected water; and c) catchments the subject of the current version of the Implementation Plan required by condition F33.
F42	The maintenance and cleaning of any vehicles, plant or equipment must not be carried out in areas from which contaminants can be released into any receiving waters.
F43	Any spillage of wastes, contaminants or other materials must be cleaned up as quickly as practicable to minimise the release of wastes, contaminants or materials to any stormwater drainage system or receiving waters.
RR1	Conditions F20 to F22 do not apply if the environmental authority holder is a participant of the FRREMP.
RR2	The environmental authority holder must notify the administering authority in a written statement within twenty (20) business days of ceasing to be a participant of the FRREMP. The written statement must detail how the environmental authority holder is going to fulfil the requirements of conditions F20 to F22.

Schedule G: Structures	
Condition number	Condition
G1	Assessment of consequence category The consequence category of any structure must be assessed by a suitably qualified and experienced person, in accordance with the <i>Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (Version 4, 10 April 2014) (EM635)</i>, at the following times: d) prior to the design and construction of the structure, if it is not an existing structure; or e) prior to any change in its purpose or the nature of its stored contents.
G2	A consequence assessment report and certification must be prepared for each structure assessed and the report may include a consequence assessment for more than one structure.
G3	Certification must be provided by the suitably qualified and experienced person who undertook the assessment, in the form set out in the <i>Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (Version 4, 10 April 2014) (EM635)</i> .
G4	Design and construction of a regulated structure Conditions G5 to G9 inclusive do not apply to existing structures. <i>NOTE: Construction of a dam includes modification of an existing dam – see definitions.</i>
G5	All regulated structures must be designed by, and constructed under the supervision of, a suitably qualified and experienced person in accordance with the requirements of the <i>Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (Version 4, 10 April 2014) (EM635)</i>. <i>NOTE: Certification of design and construction may be undertaken by different persons.</i>
G6	Construction of a regulated structure is prohibited unless the environmental authority holder has submitted a consequence category assessment report and certification to the administering authority has been certified by a suitably qualified and experienced person for the design and design plan and the associated operating procedures in compliance with the relevant condition of this environmental authority.
G7	Certification must be provided by the suitably qualified and experienced person who oversees the preparation of the design plan in the form set out in the <i>Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (Version 4, 10 April 2014) (EM635)</i> , and must be recorded in the Register of Regulated Structures.

G8	Regulated structures must: f) be designed and constructed in accordance with and conform to the requirements of the <i>Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (Version 4, 10 April 2014) (EM635)</i>; g) be designed and constructed with due consideration given to ensuring that the design integrity would not be compromised on account of: iv. floodwaters from entering the regulated dam from any watercourse or drainage line; and v. wall failure due to erosion by floodwaters arising from any watercourse or drainage line. h) for regulated dams associated with a failure to contain – seepage, have the floor and sides of the dam designed and constructed to prevent or minimise the passage of the wetting front and any entrained contaminants through either the floor or sides of the dam during the operational life of the dam and for any period of decommissioning and rehabilitation of the dam.
G9	Certification by the suitably qualified and experienced person who supervises the construction must be submitted to the administering authority on the completion of construction of the regulated structure, and state that: i) the 'as constructed' drawings and specifications meet the original intent of the design plan for that regulated structure; and j) construction of the regulated structure is in accordance with the design plan.
G10	Operation of a regulated structure Operation of a regulated structure, except for an existing structure, is prohibited unless the environmental authority holder has submitted to the administering authority: k) one paper copy and one electronic copy of the design plan and certification of the 'design plan' in accordance with condition G6; l) a set of 'as constructed' drawings and specifications; m) certification of those 'as constructed drawings and specifications' in accordance with condition G9; n) where the regulated structure is to be managed as part of an integrated containment system for the purpose of sharing the DSA volume across the system, a copy of the certified system design plan; o) the requirements of this environmental authority relating to the construction of the regulated structure have been met; p) the environmental authority holder has entered the details, required under this environmental authority, into the Register of Regulated Structures; and q) there is a current operational plan for the regulated structures.

G11	For existing structures that are regulated structures: a) where the existing structure that is a regulated structure is to be managed as part of an integrated containment system for the purpose of sharing the DSA volume across the system, the environmental authority holder must submit to the administering authority within twelve (12) months of the commencement of this condition a copy of the certified system design plan including that structure; and b) there must be a current operational plan for the existing structures.
G12	Each regulated structure must be maintained and operated, for the duration of its operational life until decommissioned and rehabilitated, in a manner that is consistent with the current operational plan and, if applicable, the current design plan and associated certified 'as constructed' drawings.
G13	Mandatory Reporting Level Conditions G14 to G17 inclusive only apply to regulated structures which have not been certified as low consequence category for 'failure to contain – overtopping'.
G14	The Mandatory Reporting Level (the MRL) must be marked on a regulated dam in such a way that, during routine inspections of that dam, it is clearly observable.
G15	The environmental authority holder must, as soon as practical and within forty-eight (48) hours of becoming aware, notify the administering authority when the level of the contents of a regulated dam reaches the MRL.
G16	The environmental authority holder must immediately on becoming aware that the MRL has been reached, act to prevent the occurrence of any unauthorised discharge from the regulated dam.
G17	The environmental authority holder must record any changes to the MRL in the Register of Regulated Structures.
G18	Design Storage Allowance The environmental authority holder must assess the performance of each regulated dam or linked containment system over the preceding November to May period based on actual observations of the available storage in each regulated dam or linked containment system taken prior to 1 July of each year.
G19	By 1 November of each year, storage capacity must be available in each regulated dam (or network of linked containment systems with a shared DSA volume), to meet the Design Storage Allowance (DSA) volume for the dam (or network of linked containment systems).
G20	The environmental authority holder must notify the administering authority as soon as possible and within forty-eight (48) hours of becoming aware that the regulated dam (or network of linked containment systems) will not have the available storage to meet the DSA volume on 1 November of any year.

G21	The environmental authority holder must, immediately on becoming aware that a regulated dam (or network of linked containment systems) will not have the available storage to meet the DSA volume on 1 November of any year, act to prevent the occurrence of any unauthorised discharge from the regulated dam or linked containment systems.
G22	Annual inspection report Each regulated structure must be inspected each calendar year by a suitably qualified and experienced person.
G23	At each annual inspection, the condition and adequacy of all components of the regulated structure must be assessed and a suitably qualified and experienced person must prepare an annual inspection report containing details of the assessment and include recommended actions to ensure the integrity of the regulated structure.
G24	The suitably qualified and experienced person who prepared the annual inspection report must certify the report in accordance with the <i>Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (Version 4, 10 April 2014) (EM635)</i> .
G25	The environmental authority holder must: a) within twenty (20) business days of receipt of the annual inspection report, provide to the administering authority: vi. the recommendations section of the annual inspection report; and vii. if applicable, any actions being taken in response to those recommendations; and b) if, following receipt of the recommendations and (if applicable) actions, the administering authority requests a full copy of the annual inspection report from the environmental authority holder, provide this to the administering authority within ten (10) business days of receipt of the request.
G26	Transfer arrangements The environmental authority holder must provide a copy of any reports, documentation and certifications prepared under this environmental authority, including but not limited to any Register of Regulated Structures, consequence assessment, design plan and other supporting documentation, to a new holder on transfer of this authority.
G27	Register of Regulated Structures A Register of Regulated Structures must be established and maintained by the environmental authority holder for each regulated structure.
G28	The environmental authority holder must provisionally enter the required information in the Register of Regulated Structures when a design plan for a regulated structure is submitted to the administering authority.
G29	The environmental authority holder must make a final entry of the required information in the Register of Regulated Structures once compliance with condition G10 and G11 has been achieved.

G30	The environmental authority holder must ensure that the information contained in the Register of Regulated Structures is current and complete on any given day.
G31	All entries in the Register of Regulated Structures must be approved by the chief executive officer for the environmental authority holder, or their delegate, as being accurate and correct.
G32	The environmental authority holder must, at the same time as providing the annual return, supply to the administering authority a copy of the records contained in the Register of Regulated Structures, in the electronic format required by the administering authority.
G33	Transitional arrangements All existing structures that have not been assessed in accordance with either, the Manual or the former <i>Manual for Assessing Hazard Categories and Hydraulic Performance of Dams</i>, must be assessed and certified in accordance with the Manual within six (6) months of amendment of the environmental authority adopting this schedule.
G34	All existing structures must subsequently comply with the timetable for any further assessments in accordance with the Manual specified in Table G1 (Transitional Requirements for Existing Structures) , depending on the consequence category for each existing structure assessed in the most recent previous certification for that structure.
G35	Table G1 (Transitional Requirements for Existing Structures) ceases to apply for a structure once any of the following events has occurred: a) it has been brought into compliance with the hydraulic performance criteria applicable to the structure under the Manual; or b) it has been decommissioned; or c) it has been certified as no longer being assessed as a regulated structure.
G36	Certification of the transitional assessment required by G33 and G34 (as applicable) must be provided to the administering authority within six (6) months of amendment of the environmental authority adopting this schedule.

Table G1 (Transitional Requirements for Existing Structures)

Transition period required for existing structures to achieve the requirements of the <i>Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (Version 4, 10 April 2014) (EM635)</i>			
Compliance with Criteria	High	Significant	Low
>90% and a history of good compliance performance in last 5 years	No transition required	No transition required	No transitional conditions apply. Review consequence assessment every 7 years.
>70% to ≤90%	Within 7 years, unless otherwise agreed with the administering authority, based on no history of unauthorised releases.	Within 10 years, unless otherwise agreed with the administering authority, based on no history of unauthorised releases.	No transitional conditions apply. Review consequence assessment every 7 years.
>50 to ≤70%	Within 5 years unless otherwise agreed with the administering authority, based on no history of unauthorised releases.	Within 7 years unless otherwise agreed with the administering authority, based on no history of unauthorised releases.	Review consequence assessment every 7 years.
≤50%	Within 5 years or as per compliance requirements (e.g. TEP timing)	Within 5 years or as per compliance requirements (e.g. TEP timing)	Review consequence assessment every 5 years.

Schedule H: Sewage Treatment	
Condition number	Condition
H1	Treated sewage effluent The cumulative total daily peak design capacity of the sewage treatment plant/s must not exceed 1500 equivalent persons (EP). Small package plants and/or septic systems, each with a daily peak design capacity less than 21EP, are not included in the cumulative total daily peak design capacity.
H2	Treated sewage effluent must not be directly released from the sewage treatment plant/s to any waters. <i>Note: 'waters' does not include structures associated with the mine affected water management system.</i>
H3	Treated sewage effluent may be: a) released to the mine affected water management system for mixing with other mine affected water; b) released to land via a sub-surface infiltration trench; c) irrigated or sprayed for dust suppression or firefighting or evaporation; or d) removed as waste.
H4	Treated sewage effluent that is released in accordance with condition H3(a) and has mixed with other mine affected water must be managed as mine affected water in accordance with the conditions of this environmental authority.
H5	Treated sewage effluent that is released in accordance with condition H3(b) or H3(c) must be carried out in a manner such that: a) vegetation is not damaged; b) there is no surface ponding of effluent; and c) there is no run-off of treated sewage effluent to waters.
H6	Treated sewage effluent released in accordance with condition H3(a) or H3(b) or H3(c) from any sewage treatment plant that has a daily peak design capacity of greater than 21EP must be monitored: a) at the point where the treated sewage effluent is released from the sewage treatment plant/s; b) for the quality characteristics specified in Table H1 (Treated Sewage Effluent Monitoring Requirements); and c) at the frequency specified in Table H1 (Treated Sewage Effluent Monitoring Requirements).

Table H1 (Treated Sewage Effluent Monitoring Requirements)

Quality Characteristic	Units	Monitoring Frequency
5-day Biochemical Oxygen Demand (uninhibited)	mg/L	Monthly
pH	pH units	Monthly
Thermotolerant coliforms	Colonies per 100mL	Monthly
Total nitrogen	mg/L	Monthly
Total phosphorus	mg/L	Monthly

H7	If treated sewage effluent is being released in accordance with condition H3(c): a) the results of monitoring in accordance with condition H6 must not exceed the release limits specified in Table H2 (Treated Sewage Effluent Contaminant Release Limits); and b) the release must not cause spray drift or over spray to any sensitive place or commercial place.
H8	If the release limits specified in Table H2 (Treated Sewage Effluent Contaminant Release Limits) are exceeded in accordance with condition H7(a), the environmental authority holder must notify the administering authority in accordance with conditions A7 and A8.

Table H2 (Treated Sewage Effluent Contaminant Release Limits)

Quality Characteristic	Release Limit	Units	Limit Type
5-day Biochemical Oxygen Demand (uninhibited)	50	mg/L	Maximum
pH	6.0 to 9.0	pH units	Range
Thermotolerant coliforms, based on the average of a minimum of five samples collected	1000	Colonies per 100mL	Maximum

Schedule I: Groundwater	
Condition number	Condition
I1	The holder of this environmental authority must not release contaminants to groundwater.
I2	Groundwater Monitoring and Management Program A Groundwater Monitoring and Management Program must be: a) developed by an appropriately qualified person; and b) implemented by the environmental authority holder for all stages of the mining activities.
I3	The Groundwater Monitoring and Management Program required by condition I2 must: a) identify potential groundwater impacts due to the mining activities; b) include a site conceptual groundwater model; c) describe the sampling and monitoring methodology; d) detail an appropriate quality assurance and quality control program; and e) provide the process for notifying the administering authority and investigating exceedances in accordance with conditions I4-I5.
I4	Groundwater monitoring Groundwater quality and standing water levels must be monitored: a) at the locations and at the frequencies specified in Table I1 (Groundwater Monitoring Locations); and b) for the quality characteristics specified in Table I2 (Groundwater Trigger Levels).
I5	If the groundwater contaminant trigger levels defined in Table I2 (Groundwater Contaminant Trigger Levels) are exceeded on three (3) consecutive monitoring occasions, the environmental authority holder must complete an investigation into the potential for environmental harm and notify the administering authority within twenty (20) business days of receiving the analysis results.
I6	The Groundwater Monitoring and Management Program must be reviewed by 31 November 2023 and thereafter every two (2) years by an appropriately qualified person. The review report must: a) analyse the results of groundwater monitoring to: i. describe any impacts to groundwater levels and groundwater quality due to the mining activity; ii. determine trends in groundwater levels and groundwater quality; b) assess the adequacy of the Groundwater Monitoring and Management Program; and c) provide recommendations to the environmental authority holder to address the findings of parts (a) and (b) of the review.

I7	Within twenty (20) business days of receiving the review report required by Condition I6, the environmental authority holder must provide to the administering authority: a) the review report; b) if applicable, any actions being taken by the environmental authority holder to address the recommendations of the review report; and c) if action is not being taken to address a recommendation, the environmental authority holder must provide justification for not taking action.
I8	Annual groundwater monitoring data must be submitted to the administering authority via WaTERS by 30 September each calendar year.
I9	Bore construction The construction, management, maintenance and decommissioning of groundwater monitoring bores must be undertaken in a manner that: a) prevents contaminants entering the groundwater; b) ensures the integrity of the bores to obtain representative groundwater samples from the target aquifer; and c) maintains the hydrogeological environment within the aquifer.

Table I1 (Groundwater Monitoring Locations and Frequency)

Monitoring Point ¹	Hydrogeological Unit	Easting (GDA94)	Northing (GDA94)	Monitoring Frequency	Screened Lithology
Interpretation Bores²					
MB31	Permian	625942	7522560	Quarterly	West of Jacaranda/Bauhinia and Coolabah/Dogwood voids
MB32	Alluvium	637595	7510716	Quarterly	Alluvium (Phillips Creek)
MB37	Tertiary Interburden / Permian Overburden	632389	7515571	Quarterly	Weathered shale and fresh siltstone interburden
Compliance Bores					
MB33	Tertiary Interburden / Permian Overburden	636640	7520199	Quarterly	Weather sandstone interburden (Permian overburden)
MB34	Tertiary Interburden / Permian Overburden	637926	7518269	Quarterly	Fresh siltstone interburden
MB35	Tertiary Interburden / Permian Overburden	642646	7520110	Quarterly	Weathered shale and fresh siltstone interburden
MB36	Tertiary Interburden / Permian Overburden	640150	7514283	Quarterly	Weathered shale and fresh siltstone interburden (Permian overburden)
MB38 ³	Alluvium	640032	7515860	Quarterly	Alluvium, Phillips Creek (sand and gravel with silty clay and sandy clay)
MB39	Permian	640018	7515876	Quarterly	Permian Moranbah coal measures (coal (seam S01) and siltstone underburden and overburden)
MB40	Tertiary	640026	7515867	Quarterly	Tertiary (gravel, clay and silt)

NOTES:

1. Monitoring is not required where a bore has been removed as a direct result of the mining activity.
2. Interpretation bores must:
 - (a) have a similar flow regime
 - (b) be from the same bio-geographic and climatic region
 - (c) have a similar geology, soil type and topography
 - (d) not be so close to the test sites that any disturbance at the test site also results in a change at the interpretation bore.
3. MB38 is dry. Trigger levels unable to be set.

Table I2 (Groundwater Contaminant Trigger Levels)

Quality Characteristic	Units	Trigger Levels						
		MB31, MB32, MB37	MB33	MB34	MB35	MB36	MB39	MB40
Water Level	RL	Monitored for interpretative reasons only – no triggers apply	Fluctuations in excess of 2m per year excluding changes from pumping of licenced bores					
pH	pH units		6.5 - 8.5	6.5 - 8.5	6.5 - 8.5	6.5 - 8.5	6.5 - 8.5	6.5 - 8.5
Electrical Conductivity	µS/cm		25,170	29,720	16,000	16,000	16,000	8,910
SO ₄	mg/L		2580	398	398	477	398	318
Iron ¹	mg/L		1.6	0.7	1.7	2.6	0.7	0.7
Aluminium ¹	mg/L		0.055	0.055	0.055	0.055	0.055	0.055
Arsenic ¹	mg/L		0.013	0.013	0.013	0.013	0.013	0.013
Mercury ¹	mg/L		0.0006	0.0006	0.0006	0.0006	0.0006	0.0006
Antimony ¹	mg/L		0.009	0.009	0.009	0.009	0.009	0.009
Molybdenum ¹	mg/L		0.034	0.034	0.034	0.034	0.034	0.034
Selenium ¹	mg/L		0.020	0.020	0.011	0.011	0.011	0.011
Silver ¹	mg/L		0.0014	0.0013	0.001	0.001	0.0012	0.001
TPH C6-C10	µg/L		20	20	20	20	20	20
TPH >C10-C40	µg/L		100	100	100	100	100	100

NOTES:

1. All metals and metalloids must be measured as total (unfiltered) and dissolved (filtered). Trigger levels for metal/metalloids apply if dissolved results exceed trigger value.

END OF CONDITIONS

Definitions

Key terms and/or phrases used in this document are defined in this section. Where a term is not defined, the definition in the *Environmental Protection Act 1994*, its regulations or environmental protection policies must be used. If a word remains undefined it has its ordinary meaning.

Acceptance criteria means the measures by which the actions implemented to rehabilitate the land are deemed to be complete. The acceptance criteria indicate the success of the rehabilitation outcome or remediation of areas which have been significantly been disturbed by the mining activities. Acceptance criteria may include information regarding:

- a) vegetation establishment, survival and succession;
- b) vegetation productivity, sustained growth and structure development;
- c) fauna colonisation and habitat development;
- d) ecosystem processes such as soil development and nutrient cycling, and the recolonisation of specific fauna groups such as collembola, mites and termites which are involved in these processes;
- e) microbiological studies including recolonisation by mycorrhizal fungi, microbial biomass and respiration;
- f) effects of various establishment treatments such as deep ripping, topsoil handling, seeding and fertiliser application on vegetation growth and development;
- g) resilience of vegetation to disease, insect attack, drought and fire; and
- h) vegetation water use and effects on ground water levels and catchment yields.

Acid rock drainage means any contaminated discharge emanating from a mining activity formed through a series of chemical and biological reactions, when geological strata is disturbed and exposed to oxygen and moisture as a result of mining activity.

Administering authority is the agency or department that administers the environmental authority provisions under the *Environmental Protection Act 1994*.

Airblast overpressure means energy transmitted from the blast site within the atmosphere in the form of pressure waves. The maximum excess pressure in this wave, above ambient pressure is the peak airblast overpressure measured in decibels linear (dBL).

Alternative arrangement in relation to a sensitive place or a commercial place, means:

- a) A written agreement:
 - i. between the environmental authority holder and a third party;
 - ii. that identifies a particular type(s) of environmental nuisance;
 - iii. about the way in which the particular environmental nuisance impact(s) will be dealt with;
 - iv. at a particular location; and
 - v. for a defined period of time.
- b) An alternative arrangement must make clear to the third party that by entering in to the agreement that:
 - i. their place will be excluded as a sensitive place or commercial place; and
 - ii. the consequences of exclusion as a sensitive place or commercial place.

Note: An alternative arrangement may include, but is not limited to, details of the nuisance abatement measures to be implemented, provision of alternative accommodation, or agreement between the parties that the location will not be considered a sensitive place or commercial place for the purposes of the Environmental Authority, for the duration of the alternative arrangement. The written agreement may be in any form, with some examples being a lease, or an agistment, or a conduct and compensation agreement under the *Mineral Resources Act 1989*.

Annual exceedance probability or AEP means the probability that at least one event in excess of a particular magnitude will occur in any given year.

Annual inspection report means an assessment prepared by a suitably qualified and experienced person containing details of the assessment against the most recent consequence assessment report and design plan (or system design plan):

- a) against recommendations contained in previous annual inspections reports;
- b) against recognised dam safety deficiency indicators;
- c) for changes in circumstances potentially leading to a change in consequence category;
- d) for conformance with the conditions of this authority;
- e) for conformance with the 'as constructed' drawings;
- f) for the adequacy of the available storage in each regulated dam, based on an actual observation or observations taken after 31 May each year but prior to 1 November of that year, of accumulated sediment, state of the containment barrier and the level of liquids in the dam (or network of linked containment systems); and
- g) for evidence of conformance with the current operational plan.

ANZECC means the Australian and New Zealand Guidelines for Fresh Marine Water Quality 2000

Appropriately qualified person means a person who has professional qualifications, training, skills or experience relevant to the nominated subject matter and can give authoritative assessment, advice and analysis on performance relative to the subject matter using the relevant protocols, standards, methods or literature.

Assessed or assessment by a suitably qualified and experienced person in relation to a consequence assessment of a dam, means that a statutory declaration has been made by that person and, when taken together with any attached or appended documents referenced in that declaration, all of the following aspects are addressed and are sufficient to allow an independent audit of the assessment:

- a) exactly what has been assessed and the precise nature of that determination;
- b) the relevant legislative, regulatory and technical criteria on which the assessment has been based;
- c) the relevant data and facts on which the assessment has been based, the source of that material, and the efforts made to obtain all relevant data and facts; and
- d) the reasoning on which the assessment has been based using the relevant data and facts, and the relevant criteria.

Associated works in relation to a dam, means:

- a) operations of any kind and all things constructed, erected or installed for that dam; and
- b) any land used for those operations.

Authority means an environmental authority or a development approval.

Bed and banks for a waters, river, creek, stream, lake, lagoon, pond, swamp, wetland or dam means land over which the water of the waters, lake, lagoon, pond, swamp, wetland or dam normally flows or that is normally covered by the water, whether permanently or intermittently; but does not include land adjoining or adjacent to the bed and banks that is from time to time covered by floodwater.

Beneficial use in respect of dams means that the current or proposed owner of the land on which a dam stands, has found a use for that dam that is:

- a) of benefit to that owner in that it adds real value to their business or to the general community;
- b) in accordance with relevant provisions of the *Environmental Protection Act 1994*;
- c) sustainable by virtue of written undertakings given by that owner to maintain that dam; and
- d) the transfer and use have been approved or authorised under any relevant legislation.

Biosolids means the treated and stabilised solids from sewage.

Blasting means the use of explosive materials to fracture:

- a) rock, coal and other minerals for later recovery; or
- b) structural components or other items to facilitate removal from a site or for reuse.

Bulk rubber means tyres, conveyor belt, and other similar rubber waste.

Certification in relation to regulated structures, means assessment and approval must be undertaken by a suitably qualified and experienced person in relation to any assessment or documentation required by the *Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (Version 4, 10 April 2014) (EM635)* or this environmental authority, including design plans, 'as constructed' drawings and specifications, construction, operation or an annual report regarding regulated structures, undertaken in accordance with the Board of Professional Engineers of Queensland Policy Certification by RPEQs (ID: 1.4 (2A)).

Certifying, certify or certified have a corresponding meaning as 'certification' in relation to regulated structures.

Chemical means:

- a) an agricultural chemical product or veterinary chemical product within the meaning of the *Agricultural and Veterinary Chemicals Code Act 1994 (Commonwealth)*; or
- b) a dangerous good under the dangerous goods code; or
- c) a lead hazardous substance within the meaning of the *Workplace Health and Safety Regulation 1997*; or
- d) a drug or poison in the Standard for the Uniform Scheduling of Drugs and Poisons prepared by the Australian Health Ministers' Advisory Council and published by the Commonwealth; or
- e) any substance used as, or intended for use as:
 - i. a pesticide, insecticide, fungicide, herbicide, rodenticide, nematocide, miticide, fumigant or related product; or
 - ii. a surface active agent, including, for example, soap or related detergent; or
 - iii. a paint solvent, pigment, dye, printing ink, industrial polish, adhesive, sealant, food additive, bleach, sanitiser, disinfectant, or biocide; or
 - iv. a fertiliser for agricultural, horticultural or garden use; or
- f) a substance used for, or intended for use for:
 - i. mineral processing or treatment of metal, pulp and paper, textile, timber, water or wastewater; or
 - ii. manufacture of plastic or synthetic rubber.

Commercial place means:

- a) A work place that is used as:
 - i. an office; or
 - ii. a place of business; or
 - iii. a place used for commercial purposes.
- b) Despite paragraph (a), the following places are not commercial places:
 - i. subject to paragraph (c), a place that is the subject of an alternative arrangement; or
 - ii. places that are part of the mining activity; or
 - iii. employees accommodation or public roads; or
 - iv. a property owned or leased by one or more of the environmental authority holders, or a related company, whether or not it is subject to an alternative arrangement.
- c) A place that is the subject of a current alternative arrangement in relation to a particular type(s) of environmental nuisance, is not a commercial place for the purposes of that type(s) of environmental nuisance, however remains a commercial place for the purpose of other types of environmental nuisances.

Consequence in relation to a structure as defined, means the potential for environmental harm resulting from the collapse or failure of the structure to perform its primary purpose of containing, diverting or controlling flowable substances.

Consequence category means a category, either low, significant or high, into which a dam is assessed as a result of the application of tables and other criteria in the *Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (Version 4, 10 April 2014) (EM635)*.

Construction or constructed in relation to a dam includes building a new dam and modifying or lifting an existing dam, but does not include investigations and testing necessary for the purpose of preparing a design plan.

Contaminate means to render impure by contact or mixture.

Contaminated means the substance has come into contact with a contaminant.

Contaminant can be

- a) a gas, liquid or solid; or
- b) an odour; or
- c) an organism (whether alive or dead), including a virus; or
- d) energy, including noise, heat, radioactivity and electromagnetic radiation; or
- e) a combination of contaminants.

Control measure means any action or activity that can be used to prevent or eliminate a hazard or reduce it to an acceptable level.

Dam means a land-based structure or a void that contains, diverts or controls flowable substances, and includes any substances that are thereby contained, diverted or controlled by that land-based structure or void and associated works.

Dam crest volume means the volume of material (liquids and/or solids) that could be within the walls of a dam at any time when the upper level of that material is at the crest level of that dam. That is, the instantaneous maximum volume within the walls, without regard to flows entering or leaving (for example, via spillway).

Design plan is a document setting out how all identified consequence scenarios are addressed in the planned design and operation of a regulated structure.

Design storage allowance or DSA means an available volume, estimated in accordance with the *Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (Version 4, 10 April 2014) (EM635)* published by the administering authority, must be provided in a dam as at 1 November each year in order to prevent a discharge from that dam to an annual exceedance probability (AEP) specified in that Manual.

Designer for the purposes of a regulated dam, means the certifier of the design plan for the regulated dam.

Disturbance of land includes:

- a) compacting, removing, covering, exposing or stockpiling of earth;
- b) removal or destruction of vegetation or topsoil or both to an extent where the land has been made susceptible to erosion;
- c) carrying out mining within a watercourse, waterway, wetland or lake;
- d) the submersion of areas by tailings or hazardous contaminant storage and dam/structure walls;
- e) temporary infrastructure, including any infrastructure (roads, tracks, bridges, culverts, dam/structures, bores, buildings, fixed machinery, hardstand areas, airstrips, helipads etc.) which is to be removed after the mining activity has ceased; or
- f) releasing of contaminants into the soil, or underlying geological strata.

However, the following areas are not included when calculating areas of disturbance:

- a) areas off lease (e.g. roads or tracks which provide access to the mining lease);
- b) areas previously disturbed which have achieved the rehabilitation outcomes;
- c) by agreement with the administering authority, areas previously disturbed which have not achieved the rehabilitation objective(s) due to circumstances beyond the control of the mine operator (such as climatic conditions);
- d) areas under permanent infrastructure. Permanent infrastructure includes any infrastructure (roads, tracks, bridges, culverts, dam/structures, bores, buildings, fixed machinery, hardstand areas, airstrips, helipads etc.) which is to be left by agreement with the landowner; or
- e) disturbance that pre-existed the grant of the tenure.

Dwelling means any of the following structures or vehicles that is principally used as a residence:

- a) a house, unit, motel, nursing home or other building or part of a building; or
- b) a caravan, mobile home or other vehicle or structure on land; or
- c) a water craft in a marina.

Effluent means treated waste water released from sewage treatment plants.

Emergency action plan means documentation forming part of the operational plan held by the holder or a nominated responsible officer, that identifies emergency conditions that sets out procedures and actions that will be followed and taken by the dam owner and operating personnel in the event of an emergency. The actions are to minimise the risk and consequences of failure, and ensure timely warning to downstream communities and the implementation of protection measures. The plan must require dam owners to annually update contact.

End of pipe means the location at which water is released to waters or land.

Environmental authority means an environmental authority granted in relation to an environmentally relevant activity under the *Environmental Protection Act 1994*.

Environmental authority holder means the holder of this environmental authority.

Environmentally relevant activity means an environmentally relevant activity as defined under section 18 of the *Environmental Protection Act 1994*.

EPBC means the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*.

ERC decision means a decision made by the administering authority under section 300 of the *Environmental Protection Act 1994* about the estimated rehabilitation cost for a resource activity.

ERC period for the estimated rehabilitation cost for a resource activity, means:

- a) if a PRCP schedule applies for the activity, the period of between 1 and 5 years stated in the application for an ERC decision under section 298(2)(b); or
- b) if the activity is a petroleum activity that is an ineligible ERA, other than a petroleum activity to which a plan of operations applies, or the activity relates to a 1923 Act petroleum tenure granted under the *Petroleum Act 1923*, the period of between 1 and 5 years stated in the ERC decision about the estimated rehabilitation cost; or
- c) if a plan of operations applies for the activities, the plan period for the plan of operations; or
- d) otherwise, the total period during which the resource activity is likely to be carried out under the environmental authority for the activity.

Estimated rehabilitation cost (ERC) for a resource activity, see section 300(2) of the *Environmental Protection Act 1994*.

Existing authority has the meaning in section 94 of the *Environmental Offsets Act 2014*.

Existing structure means a structure that was in existence prior to 31 October 2014.

Extreme storm storage means a storm storage allowance determined in accordance with the criteria in the *Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (Version 4, 10 April 2014) (EM635)* published by the administering authority.

Floodwater means water overflowing, or that has overflowed, from waters, river, creek, stream, lake, pond, wetland or dam onto or over riparian land that is not submerged when the watercourse or lake flows between or is contained within its bed and banks.

Flowable substance means matter or a mixture of materials that can flow under any conditions potentially affecting that substance. Constituents of a flowable substance can include water, other liquids fluids or solids, or a mixture that includes water and any other liquids fluids or solids either in solution or suspension.

Foreseeable future is the period used for assessing the total probability of an event occurring. Permanent structures and ecological sustainability should be expected to still exist at the end of a 150 year foreseeable future with an acceptable probability of failure before that time.

FRREMP means a Fitzroy Basin Receiving Environment Monitoring Program for the region in which the EA is located, that has been endorsed in writing by the administering authority.

General waste means waste other than regulated waste.

Hazardous waste means a substance, whether liquid, solid or gaseous that, if improperly treated, stored, disposed of or otherwise managed, is likely to cause environmental harm.

Holder, for a mining tenement, means a holder of the tenement under the *Mineral Resources Act 1989*, and the holder of the associated environmental authority under the *Environmental Protection Act 1994*.

Hydraulic performance means the capacity of a regulated dam to contain or safely pass flowable substances based on the design criteria specified for the relevant consequence category in the *Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (Version 4, 10 April 2014) (EM635)*.

Inert waste means bricks, pavers, ceramics, concrete, glass, steel, or similar waste that does not biodegrade or decompose.

Infrastructure means water storage dams, roads and tracks, buildings and other structures built for the purpose of mining activities but does not include other facilities required for the long-term management of mining impacts or the protection of potential resources. Such other facilities include dams, waste rock dumps, voids, or ore stockpiles and buildings as well as other structures whose ownership can be transferred and which have a residual beneficial use for the next owner of the mining leases or the background land owner.

L_{A10}, adj, 10 mins means the A-weighted sound pressure level, (adjusted for tonal character and impulsiveness of the sound) exceeded for 10% of any 10 minute measurement period, using Fast response.

L_{A1}, adj, 10 mins means the A-weighted sound pressure level, (adjusted for tonal character and impulsiveness of the sound) exceeded for 1% of any 10 minute measurement period, using Fast response.

Lake includes:

- a) lagoon, swamp or other natural collection of water, whether permanent or intermittent; and
- b) the bed and banks and any other element confining or containing the water.

Land in the “land schedule” of this document means land excluding waters and the atmosphere.

Land use describes the selected post mining use of the land, which is planned to occur after the cessation of mining operations.

Landfill means land used as a waste disposal site for lawfully putting solid waste on the land.

Levee means an embankment that only provides for the containment and diversion of stormwater or flood flows from a contributing catchment, or containment and diversion of flowable materials resulting from releases from other works, during the progress of those stormwater or flood flows or those releases; and does not store any significant volume of water or flowable substances at any other times.

Low consequence dam means any dam that is not a high or significant consequence category as assessed using the *Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (Version 4, 10 April 2014)* (EM635).

Mandatory reporting level or MRL means a warning and reporting level determined in accordance with the criteria in the *Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (Version 4, 10 April 2014)* (EM635) published by the administering authority.

Manual means the *Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (Version 4, 10 April 2014)* (EM635) published by the administering authority.

Matters of state environmental significance or MSES has the meaning in schedule 2 of the *Environmental Offsets Regulation 2014*.

Maximum extent of impact means the total, cumulative, residual extent and duration of impact to a prescribed environmental matter that will occur over a project’s life after all reasonable avoidance and reasonable on-site mitigation measures have been, or will be, undertaken.

mbgl means metres below ground level.

mg/L means milligrams per litre.

Mechanically reprocessing waste includes mechanically crushing, milling, grinding, shredding or sorting waste, whether or not for the purpose of recycling the waste.

Mine affected water means the following types of water:

- a) pit water, tailings dam water, processing plant water;
- b) water contaminated by a mining activity which would have been an environmentally relevant activity under Schedule 2 of the *Environmental Protection Regulation 2008* if it had not formed part of the mining activity;
- c) rainfall runoff which has been in contact with any areas disturbed by mining activities which have not yet been rehabilitated, excluding:
 - i. rainfall runoff discharging through release points associated with erosion and sediment control structures that have been installed in accordance with the standards and requirements of an Erosion and Sediment Control Plan to manage runoff containing sediment only, provided that this water has not been mixed with pit water, tailings dam water, processing plant water or workshop water; and
 - ii. rainfall runoff from catchments the subject of the current version of the Implementation Plan;
- d) groundwater which has been in contact with any areas disturbed by mining activities which have not yet been rehabilitated;
- e) groundwater from the mine's dewatering activities; or
- f) a mix of mine affected water (under any of paragraphs (a) to (e)) and other water.

Mineral means a substance which normally occurs naturally as part of the earth's crust or is dissolved or suspended in water within or upon the earth's crust and includes a substance which may be extracted from such a substance, and includes:

- a) clay if mined for use for its ceramic properties, kaolin and bentonite;
- b) foundry sand;
- c) hydrocarbons and other substances or matter occurring in association with shale or coal and necessarily mined, extracted, produced or released by or in connection with mining for shale or coal or for the purpose of enhancing the safety of current or future mining operations for coal or the extraction or production of mineral oil there from;
- d) limestone if mined for use for its chemical properties;
- e) marble;
- f) mineral oil or gas extracted or produced from shale or coal by in situ processes;
- g) peat;
- h) salt including brine;
- i) shale from which mineral oil may be extracted or produced;
- j) silica, including silica sand, if mined for use for its chemical properties; or
- k) rock mined in block or slab form for building or monumental purposes;

But does not include:

- a) living matter;
- b) petroleum within the meaning of the *Petroleum Act 1923*;
- c) soil, sand, gravel or rock (other than rock mined in block or slab form for building or monumental purposes) to be used or to be supplied for use as such, whether intact or in broken form; or
- d) water.

Mining activities means the activities:

- a) authorised as per the definition in section 110 of the *Environmental Protection Act 1994*; and
- b) all environmentally relevant activities authorised under this environmental authority;
- c) waste activities.

Modification or modifying (see definition of 'construction').

Natural flow means the flow of water through waters caused by nature.

Notice of election has the meaning in section 18(2) of the *Environmental Offsets Act 2014*.

Noxious means harmful or injurious to health or physical wellbeing.

Offensive means causing reasonable offence or displeasure; is disagreeable to the sense; disgusting, nauseous or repulsive, other than trivial harm.

Operational plan includes:

- a) normal operating procedures and rules (including clear documentation and definition of process inputs in the DSA allowance); and
- b) contingency and emergency action plans including operating procedures designed to avoid and/or minimise environmental impacts including threats to human life resulting from any overtopping or loss of structural integrity of the regulated structure.

Participant of the FRREMP means an environmental authority holder that is identified as a current participant by the organisation carrying out the Regional REMP.

Peak particle velocity or ppv means a measure of ground vibration magnitude which is the maximum rate of change of ground displacement with time, usually measured in millimetres/second (mm/s).

Prescribed environmental matters has the meaning in section 10 of the *Environmental Offsets Act 2014*, limited to the matters of State environmental significant listed in schedule 2 of the *Environmental Offsets Regulation 2014*.

Protected area means

- a) a protected area under the *Nature Conservation Act 1992*; or
- b) a marine park under the *Marine Parks Act 1992*; or
- c) a World Heritage Area.

Progressive rehabilitation means rehabilitation (defined below) undertaken progressively or a staged approach to rehabilitation as mining operations are ongoing.

Receiving environment, in relation to an activity that causes or may cause environmental harm, means the part of the environment to which the harm is, or may be, caused. The receiving environment includes (but is not limited to):

- a) a watercourse;
- b) groundwater;
- c) land; and
- d) sediments.

Receiving waters means the waters into which this environmental authority authorises releases of mine affected water.

Reference site (or analogue site) may reflect the original location, adjacent area or another area where rehabilitation success has been completed for a similar biodiversity. Details of the reference site may be as photographs, computer generated images and vegetation models etc.

Register of Regulated Structures includes:

- a) date of entry in the register;
- b) name of the dam, its purpose and intended/actual contents;
- c) the consequence category of the dam as assessed using the *Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (Version 4, 10 April 2014) (EM635)*;
- d) dates, names, and reference for the design plan plus dates, names, and reference numbers of all document(s) lodged as part of a design plan for the dam;
- e) name and qualifications of the suitably qualified and experienced person who certified the design plan and 'as constructed' drawings;
- f) for the regulated dam, other than in relation to any levees –
 - i. the dimensions (metres) and surface area (hectares) of the dam measured at the footprint of the dam;
 - ii. coordinates (latitude and longitude in GDA94) within five metres at any point from the outside of the dam including its storage area
 - iii. dam crest volume (megalitres);
 - iv. spillway crest level (metres AHD).
 - v. maximum operating level (metres AHD);
 - vi. storage rating table of stored volume versus level (metres AHD);
 - vii. design storage allowance (megalitres) and associated level of the dam (metres AHD);
 - viii. mandatory reporting level (metres AHD);
- g) the design plan title and reference relevant to the dam;
- h) the date construction was certified as compliant with the design plan;
- i) the name and details of the suitably qualified and experienced person who certified that the constructed dam was compliant with the design plan;
- j) details of the composition and construction of any liner;
- k) the system for the detection of any leakage through the floor and sides of the dam;
- l) dates when the regulated dam underwent an annual inspection for structural and operational adequacy, and to ascertain the available storage volume for 1 November of any year;
- m) dates when recommendations and actions arising from the annual inspection were provided to the administering authority; and
- n) dam water quality as obtained from any monitoring required under this authority as at 1 November of each year.

Regulated dam means any dam in the significant or high consequence category as assessed using the *Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (Version 4, 10 April 2014) (EM635)* published by the administering authority.

Regulated structure includes land-based containment structures, levees, bunds and voids, but not a tank or container designed and constructed to an Australian Standard that deals with strength and structural integrity.

Regulated waste is defined in the *Environmental Protection Regulation 2008*.

Rehabilitation means the process of reshaping and revegetating land to restore it to a stable landform and in accordance with the acceptance criteria set out in this environmental authority and, where relevant, includes remediation of contaminated land.

Rejects means:

- a) breaker rejects; or
- b) coarse rejects; or
- c) mid/fine size rejects; or
- d) tailings that have been dewatered; or
- e) any combination of rejects (under any of paragraphs a to d).

Representative means a sample set that covers the variance in monitoring or other data due to either natural changes or operational phases of the mining activities.

Reprocessing includes:

- a) recycling; or
- b) mechanical treatment; or
- c) thermal treatment; or
- d) biological treatment; or
- e) chemical treatment.

Residual void means an open pit resulting from the removal of ore and/or waste rock that will remain following the cessation of all mining activities and completion of rehabilitation processes.

Resource activity is an activity that involves

- a) a geothermal activity; or
- b) a GHG storage activity; or
- c) a mining activity; or
- d) a petroleum activity.

Saline drainage is the movement of waters, contaminated with salt(s), as a result of the mining activity.

Scheme fund means the scheme fund established under section 24 of the *Mineral and Energy Resources (Financial Provisioning) Act 2018*.

Sensitive place means:

- a) Any of the following:
 - i. a dwelling, residential allotment, mobile home or caravan park, residential marina or other residential premises; or
 - ii. a motel, hotel or hostel; or
 - iii. an educational institution; or
 - iv. a medical centre or hospital; or
 - v. a protected area; or
 - vi. a public park or gardens.
- b) Despite paragraph (a), the following places are not sensitive places:
 - i. subject to paragraph (c), a place that is the subject of an alternative arrangement; or
 - ii. a mining camp (i.e. accommodation and ancillary facilities for mine employees or contractors or both, associated with the mine the subject of the environmental authority), whether or not the mining camp is located within a mining tenement that is part of the mining project the subject of the environmental authority. For example, the mining camp might be located on neighbouring land owned or leased by the same company as one of the environmental authority holders for the mining project, or a related company; or
 - iii. a property owned or leased by one or more of the environmental authority holders, or a related company, whether or not it is subject to an alternative arrangement.
- c) A place that is the subject of a current alternative arrangement in relation to a particular type(s) of environmental nuisance, is not a sensitive place for the purposes of that type(s) of environmental nuisance, however remains a sensitive place for the purpose of other types of environmental nuisances.

Sewage means the used water of persons to be treated at a sewage treatment plant.

Significant residual impact has the meaning in section 8 of the *Environmental Offsets Act 2014*.

Spillway means a weir, channel, conduit, tunnel, gate or other structure designed to permit discharges from the dam, normally under flood conditions or in anticipation of flood conditions.

Stable in relation to land, means land form dimensions are or will be stable within tolerable limits now and in the foreseeable future. Stability includes consideration of geotechnical stability, settlement and consolidation allowances, bearing capacity (trafficability), erosion resistance and geochemical stability with respect to seepage, leachate and related contaminant generation.

Stormwater means all surface water runoff from rainfall.

Structure means dam or levee.

Suitably qualified and experienced person in relation to regulated structures means a person who is a Registered Professional Engineer of Queensland (RPEQ) under the provisions of the *Professional Engineers Act 2002*, and has demonstrated competency and relevant experience:

- a) for regulated dams, an RPEQ who is a civil engineer with the required qualifications in dam safety and dam design.
- b) for regulated levees, an RPEQ who is a civil engineer with the required qualifications in the design of flood protection embankments.

Note: It is permissible that a suitably qualified and experienced person obtain subsidiary certification from an RPEQ who has demonstrated competence and relevant experience in either geomechanics, hydraulic design or engineering hydrology.

System design plan means a plan that manages an integrated containment system that shares the required DSA and/or ESS volume across the integrated containment system.

Tailings means fines from mineral processing that have not been dewatered.

The Act means the *Environmental Protection Act 1994*.

Void means any constructed, open excavation in the ground.

Waste as defined in section 13 of the *Environmental Protection Act 1994*.

Waste activities means receiving, storing, disposing, treating, or reprocessing wastes, and does not include composting.

Waste and resource management hierarchy has the meaning given by section 9 of the *Waste Reduction and Recycling Act 2011*.

Water quality means the chemical, physical and biological condition of water.

Watercourse has the meaning in Schedule 4 of the *Environmental Protection Act 1994* and means a river, creek or stream in which water flows permanently or intermittently:

- a) in a natural channel, whether artificially improved or not; or
- b) in an artificial channel that has changed the course of the watercourse.

Watercourse includes the bed and banks and any other element of a river, creek or stream confining or containing water.

Waters includes all or any part of a river, stream, lake, lagoon, pond, swamp, wetland, unconfined surface water, unconfined water in natural or artificial watercourses, bed and banks of a watercourse, dams, non-tidal or tidal waters (including the sea), stormwater channel, stormwater drain, roadside gutter, stormwater run-off, and groundwater.

WaTERS means the Water Tracking and Electronic Reporting System.

Wet season means the time of year, covering one or more months, when most of the average annual rainfall in a region occurs. For the purposes of DSA determination, this time of year is deemed to extend from 1 November in one year to 31 May in the following year inclusive.

µg/L means micrograms per litre.

µS/cm means microsiemens per centimetre.

END OF ENVIRONMENTAL AUTHORITY

SARAJI MINE

Transitional PRC Plan Hydrogeology

Prepared for:

BMA
480 Queen St
Brisbane QLD 4000 Australia

SLR Ref: 620.30984.00000-R01
Version No: -v8.0
December 2023



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BASIS OF REPORT

This report has been prepared by SLR Consulting Australia Pty Ltd (SLR) with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with BMA (the Client). Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

This report is for the exclusive use of the Client. No warranties or guarantees are expressed or should be inferred by any third parties. This report may not be relied upon by other parties without written consent from SLR.

SLR disclaims any responsibility to the Client and others in respect of any matters outside the agreed scope of the work.

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APPENDICES

- Appendix A Recovery Model Starting Heads
- Appendix B Drier Climate Scenario Model Predictions
- Appendix C Wetter Climate Scenario Model Predictions

1 Introduction

1.1 Background

SLR Consulting Australia Pty Ltd (SLR) has been engaged by BM Alliance Coal Operations Pty Ltd (BMA) to undertake a hydrogeological assessment supporting the Saraji Mine (SRM) transitional Progressive Rehabilitation and Closure Plan (PRC Plan). This hydrogeological assessment is undertaken in accordance with the relevant requirements of the Queensland Government Department of Environment and Science (DES) Guideline: Progressive Rehabilitation and Closure Plans (DES Reference: ESR/2019/4964, version 2.00, effective 17 Mar 2021) - “the Guideline” and will be integrated into the design of the rehabilitation strategies and selection of post mining land uses (PMLUs) and Non-use Management Areas (NUMAs) within the SRM PRC Plan.

The SRM metallurgical open cut coal mine is located primarily on Mining Leases (ML) 1775 and 1782 within the Bowen Basin, approximately 18 kilometres (km) north of Dysart within the Isaac Regional Council Local Government Area (LGA) (**Figure 1-1**). Associated infrastructure for the SRM is located on ML 1784 and ML 70142. Running along strike north to south across SRM, mining operations have historically occurred across eight open cut pits: Acacia Pit, Jacaranda Pit, Bauhinia Pit, Coolibah Pit, Dogwood Pit, Ebony Pit, Grevillea Pit and Hakea Pit (**Figure 1-2**). Existing operations at SRM are undertaken under the conditions of Environmental Authority (EA) EPML00862313 (in effect as of 15 June 2022), EPBC Act approval 2008/4417 and the Coordinator-General’s imposed conditions.

Located immediately to the north of SRM is the existing BMA operation Peak Downs Mine, which in turn is located immediately to the south of BMA’s Caval Ridge Mine (CVM). Located approximately 6 km to the south of SRM is another existing BMA operation Saraji South Mine (previously named Norwich Park Mine). Located approximately 6 km to the east of the southernmost extent of SRM is the existing Lake Vermont Mine (**Figure 1-1**).

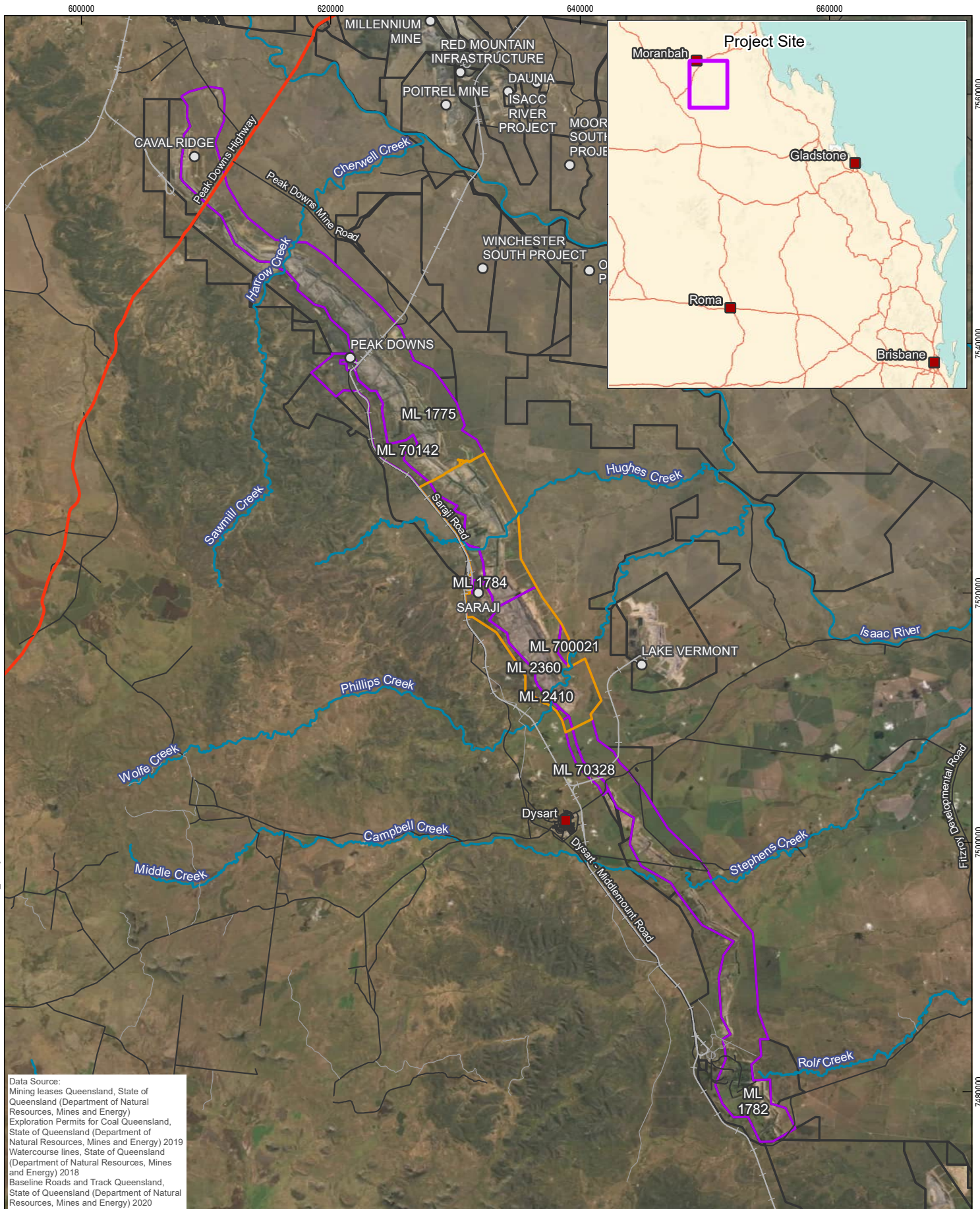
The most recent hydrogeological study relevant to the SRM transitional PRC Plan is that undertaken for the Saraji East Mining Lease Project (SEMLP) approvals (AECOM, 2019), that included a post-mining assessment. That body of work has been drawn upon as directly relevant to this hydrogeological assessment, including the development of a conceptual groundwater model for SRM as documented within AECOM, 2019.

Throughout this report, the terms “the SRM Area” and “Study Area” are used as defined by:

- The SRM Area is defined as areas covered by EA EPML00862313, which is underlain by ML 1775, ML 1782, ML 1784, ML 2360, ML 2410, ML 70142, ML 70294, ML 70298, ML 70328 and ML 700021 (**Figure 1-1**).
- The Study Area is the regional area surrounding SRM considered in detail within this assessment, necessary to inform the understanding of the regional scale groundwater system in which SRM lies.

1.2 Final Landform

The post-mining final SRM landform relevant to this hydrogeological assessment was provided by and is shown as **Figure 1-3**. The final landform contains four residual final voids: Jacaranda/Bauhinia Void, Coolibah/Dogwood Void, Ebony/Grevillia Void, and Hakea Void (Acacia Pit backfilled with spoil). The final landform was a preliminary final landform provided by BMA to assess the suitability of BMA’s intended Post Mining Land Use (PMLU) at SRM, which includes ‘Woodland habitat’, ‘Cattle grazing’, ‘Water storage’ and ‘Watercourse’ as defined within Table E1 of the EA.



Data Source:
Mining leases Queensland, State of Queensland (Department of Natural Resources, Mines and Energy)
Exploration Permits for Coal Queensland, State of Queensland (Department of Natural Resources, Mines and Energy) 2019
Watercourse lines, State of Queensland (Department of Natural Resources, Mines and Energy) 2018
Baseline Roads and Tracks Queensland, State of Queensland (Department of Natural Resources, Mines and Energy) 2020



0 5 10 km

Coordinate System: GDA 1994 MGA Zone 55

Scale: 1:400,000 at A4

Project Number: 620.30984

Date: 15-Sep-2022

Drawn by: NT

LEGEND

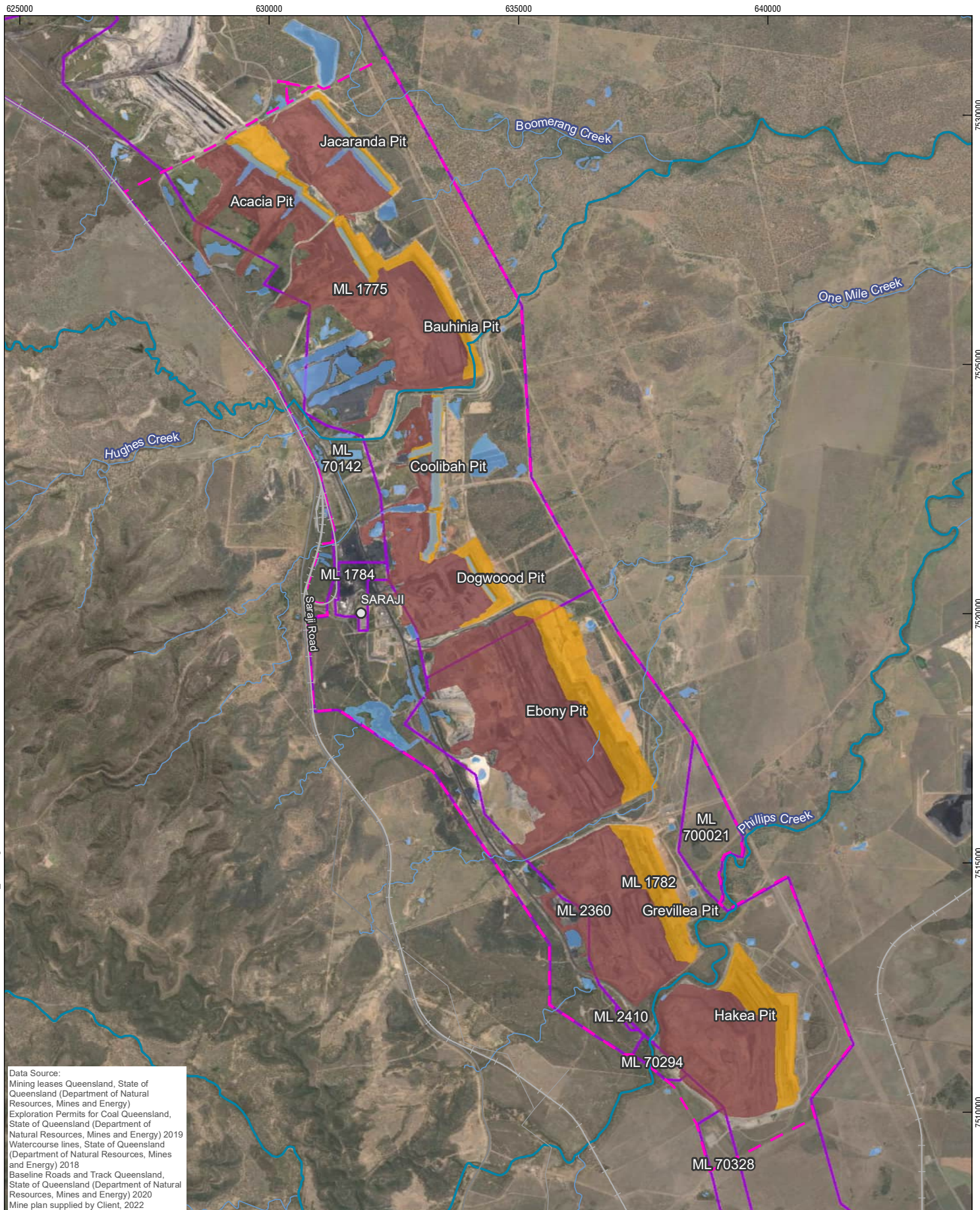
- | | |
|---|--|
| ■ City/Town | — Road |
| ○ Surrounding Mine | — Track |
| — Major Watercourse | SRM EA Boundary |
| —+— Rail | BMA Mine Lease |
| — Principal Road | Mine Lease |

SARAJI MINE TRANSITIONAL PRC PLAN HYDROGEOLOGY ASSESSMENT

LOCALITY PLAN



FIGURE 1-1



Data Source:
Mining leases Queensland, State of Queensland (Department of Natural Resources, Mines and Energy)
Exploration Permits for Coal Queensland, State of Queensland (Department of Natural Resources, Mines and Energy) 2019
Watercourse lines, State of Queensland (Department of Natural Resources, Mines and Energy) 2018
Baseline Roads and Track Queensland, State of Queensland (Department of Natural Resources, Mines and Energy) 2020
Mine plan supplied by Client, 2022



0 1 2 km

Coordinate System: GDA 1994 MGA Zone 55

Scale: 1:100,000 at A4

Project Number: 620.30984

Date: 15-Sep-2022

Drawn by: NT

LEGEND

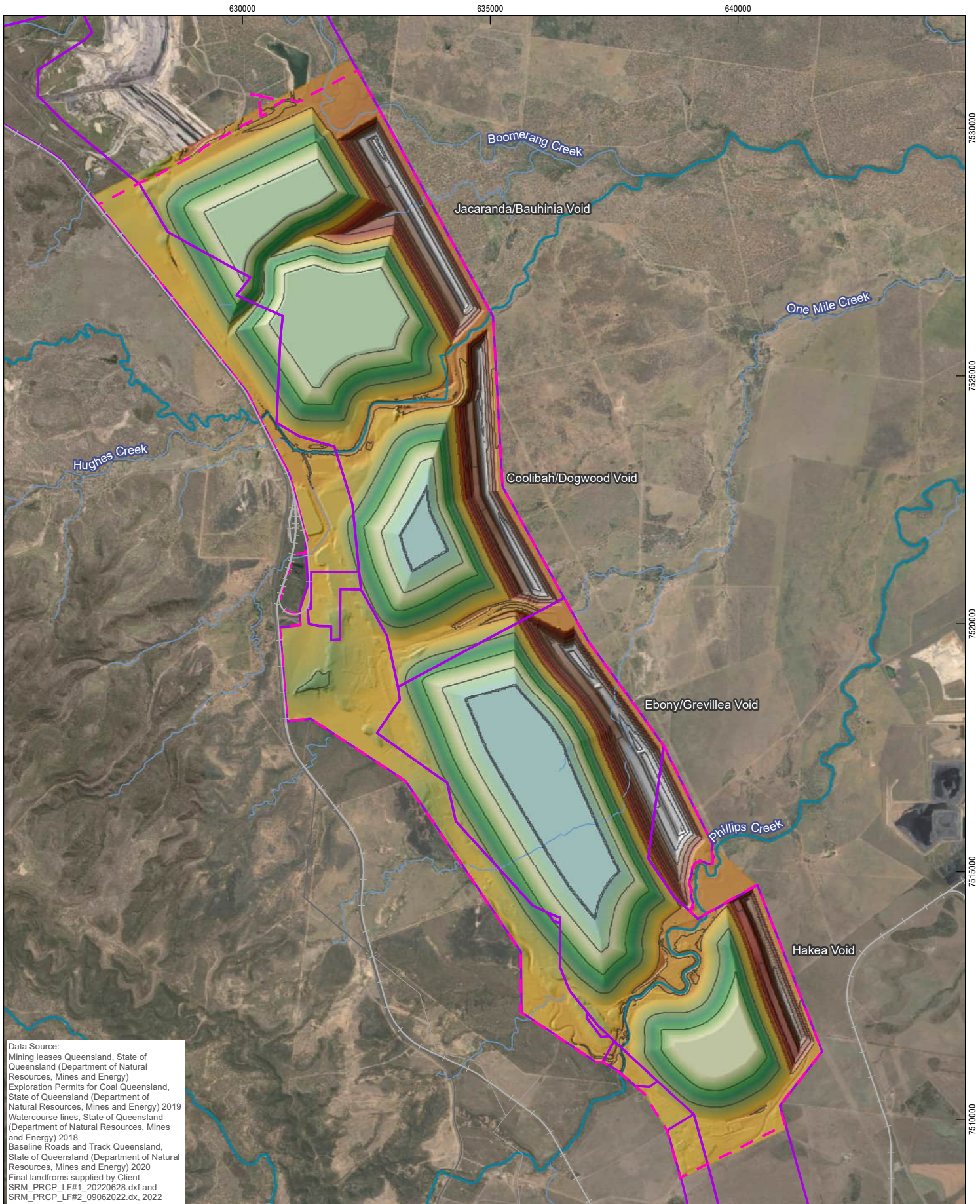
- Surrounding Mine
- Major Watercourse
- Minor Watercourse
- Rail
- Road
- Track
- Active Pit
- Spoil Dump
- Waterbody
- SRM EA Boundary
- SRM Mine Lease

SARAJI MINE TRANSITIONAL PRC PLAN HYDROGEOLOGY ASSESSMENT

SRM MINING AREAS



FIGURE 1-2



Data Source:
 Mining leases Queensland, State of Queensland (Department of Natural Resources, Mines and Energy)
 Exploration Permits for Coal Queensland, State of Queensland (Department of Natural Resources, Mines and Energy) 2019
 Watercourse lines, State of Queensland (Department of Natural Resources, Mines and Energy) 2018
 Baseline Roads and Track Queensland, State of Queensland (Department of Natural Resources, Mines and Energy) 2020
 Final landforms supplied by Client
 SRM_PRCP_LF#1_20220628.dxf and
 SRM_PRCP_LF#2_09062022.dxf, 2022



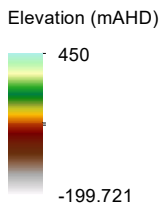
Coordinate System: GDA 1994 MGA Zone 55
 Scale: 1:100,000 at A4
 Project Number: 620.30984
 Date: 20-Sep-2022
 Drawn by: NT



LEGEND

- Major Watercourse
- Minor Watercourse
- Rail
- Road
- Track
- SRM EA Boundary
- SRM Mine Lease

LANDFORM



SARAJI MINE TRANSITIONAL PRC PLAN HYDROGEOLOGY ASSESSMENT

POST MINING LANDFORM (LANDFORM #2)

FIGURE 1-3

1.3 Objectives

The main objective of the hydrogeological assessment is to assess the potential groundwater related impacts at SRM at completion of mining and until conditions stabilise post rehabilitation (i.e. groundwater equilibrium). A focus of the hydrogeological assessment is demonstrating suitability of the landform for the intended PLMUs with respect of the SRM groundwater system. As such, the key specific objectives adopted in this assessment from which to demonstrate this suitability are:

- That the final landform is non-polluting with respect to groundwater:
 - Final voids are demonstrated to be sinks for groundwater, including groundwater contained within spoil.
 - Final void lake levels remain below shallow groundwater bearing units, i.e. there is sufficient freeboard to negate risk of void water discharge to any shallow groundwater system.
- That there are minimal additional impacts to groundwater receptors post-closure caused by the final landform that have not already occurred as a result of approved mining:
 - Little to no additional groundwater drawdown at potential groundwater dependant ecosystem (GDE) locations.
 - Little to no additional groundwater drawdown at anthropogenic bore users.

1.4 Guideline Criteria

As discussed in **Section 1.1**, this hydrogeology assessment is undertaken consistent with the Guideline: Progressive Rehabilitation and Closure Plans (ESR/2019/4964). A cross reference between the relevant Guideline requirements with respect of groundwater and specific components of this assessment is provided in **Table 1-1**.

Table 1-1 Guideline Requirements

Guideline Requirement	Section of this Report
Section 3.6.1 General rehabilitation practices – Hydrogeology	
Determining the groundwater occurrence including the existence of, and depth to, aquifers and aquitards	Section 3.2 Section 4.3
Locating groundwater recharge and discharge locations locally and regionally	Section 4.3
Groundwater quality within each of the aquifers and from surface expressions (i.e. seeps and springs)	Section 4.4
Current and potential future uses of groundwater including existing groundwater extraction bores	Section 4.5
Groundwater flow direction and velocity, including field tests to determine hydraulic conductivity	Section 4.2 Section 4.4
The development of potentiometric mapping and hydro stratigraphic cross sections	Section 4.3 Section 5 Section 8
Groundwater modelling to determine contaminant transport and potential changes to groundwater level from dewatering or waste storage.	Section 7

2 Physical Setting

2.1 Climate

The climate at the Study Area is sub-tropical with higher temperatures, higher rainfall and higher evaporation occurring over the summer months (December to February). The closest Bureau of Meteorology (BoM) weather station is located at Dysart Post Office (35278), approximately 7.5 km to the south of SRM. This Dysart Post Office weather station operated between 1988 and 2006. The nearest weather station with a longer data record is Booroondarra (station 35109) located approximately 35km to the south of SRM. The Booroondarra weather station has been in operation since 1929 and has a continuous record with only a few occasional months of missing data. **Table 2-1** provides the details of the nearby operational weather stations.

Table 2-1 Operational BoM Weather Stations near to SRM

Name	Site Number	Date Commenced	Easting (GDA94)	Northing (GDA94)	Elevation (mAHD)	Operational Status	Distance from SRM
Dysart Post Office	35278	1988	637975	7501644	200	Closed - 2006	7.5 km S
Dysart Station	35092	1956	639057	7498467	183	Closed - 2008	11 km S
Booroondarra	35109	1929	652913	7475845	200	Open	35 km S

mAHD = metres Australian Height Datum

SILO Grid point data (Latitude: -22.40, Longitude: 148.30) was used to assess long-term rainfall trends in the vicinity of SRM. This dataset is interpolated from quality checked observational timeseries data collected at nearby stations by the BoM. Data from January 1953 until July 2022 was used to assess the long-term rainfall trends in the vicinity of SRM. From this data, the average annual site rainfall is 579.6 millimetres (mm). The two highest annual rainfalls were recorded for the years 1956 and 2010, with annual rainfalls of 960.2 mm and 1,063 mm, respectively. The minimum annual rainfall occurred in 2018 with 268.6 mm. Monthly averages for the Booroondarra station discussed as well as the SILO grid point are listed in **Table 2-2**.

Table 2-2 Average Monthly Rainfall

Rainfall (mm)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Dysart Post Office	28.7	27.4	15.3	8.9	13.1	8.2	2.5	10.0	3.0	14.5	18.0	38.5	188.2
Dysart Station	72.4	65.8	37.2	23.8	25.1	13.5	16.2	9.5	7.9	20.4	34.3	54.6	380.8
Booroondarra	111.8	95.8	71.6	33.4	36.3	24.2	23.4	23.4	15.5	38.2	54.3	95.7	623.5
SILO Grid Point Data	99.5	95.1	62.4	33.1	32.4	22.2	21.1	21.0	12.4	34.6	57.4	88.4	579.6

Source: <http://www.bom.gov.au/climate/data/index.shtml>

Note: SILO Grid point data coordinates are Latitude: -22.40 and Longitude: 148.30.

Rainfall trends for Booroondarra are indicated by analysis of the cumulative deviation from mean (CDFM) monthly rainfall (**Figure 2-1**). Positive gradients on this curve (rising limbs) confirm wetter conditions than normal, while negative gradients (falling limbs) indicate dry conditions. Average rainfall conditions are inferred during periods of stable residual mass. **Figure 2-1** shows that, over the past 50 years, the wettest periods occurred during 1973-1979, and in 2010. The driest periods were 1965-1970, 1991-1998 and 2001-2007. As shown by the declining trend in the CDFM, since 2017 SRM has experienced drier than average conditions. It should be noted that the data gaps observed in the late 1960s have not been used in the CDFM calculation.

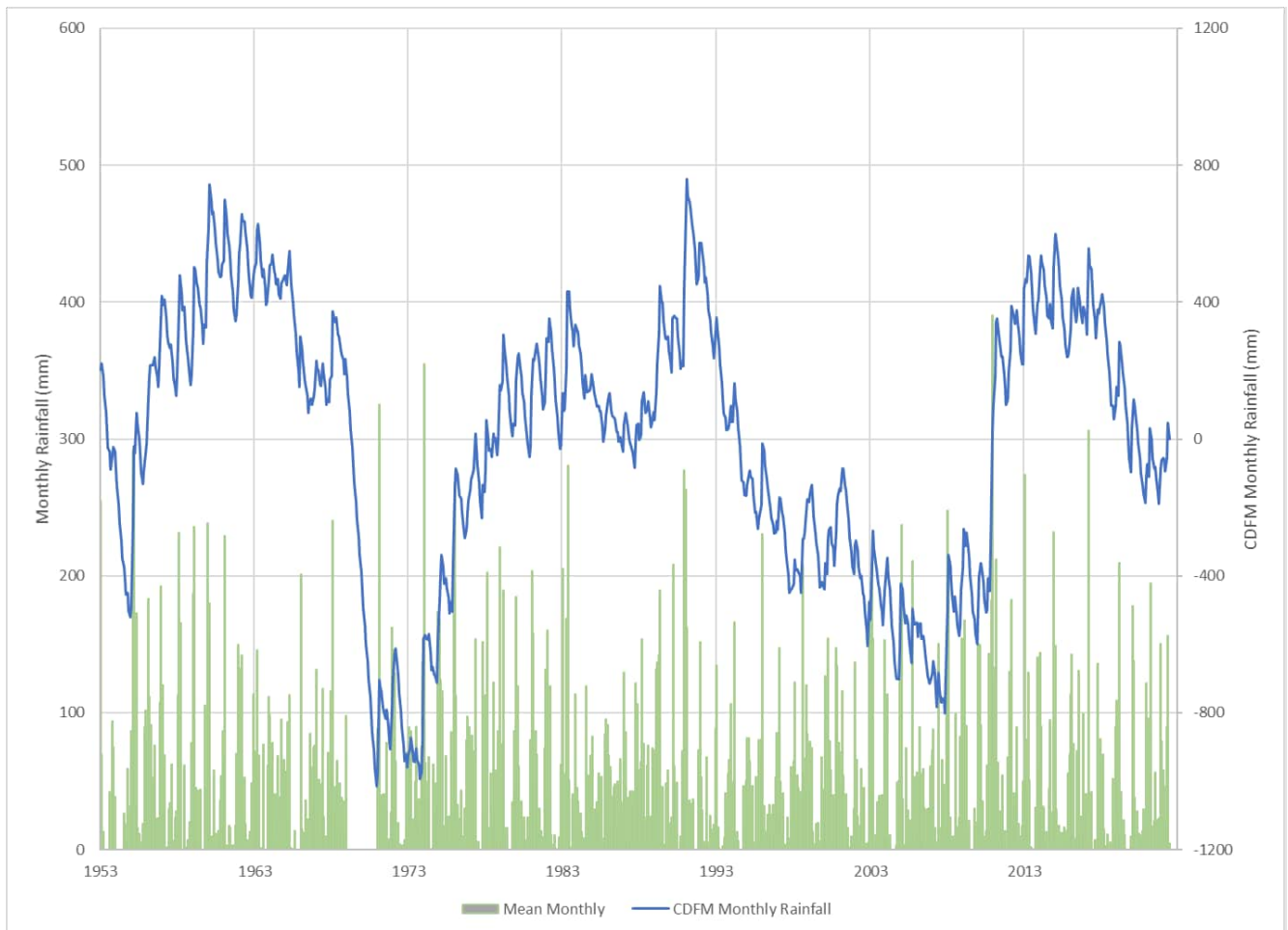


Figure 2-1 Long term Monthly Rainfall and Rainfall Cumulative Deviation from Mean monthly rainfall at Booroondarra (Station 35109)

The CDFM performs an additional service: if rainfall recharge is a significant source of groundwater, the temporal variability in recorded groundwater levels can be expected to mimic the pattern of this curve. That is, natural fluctuations in the groundwater table result from temporal changes in rainfall recharge to groundwater systems. Typically, changes in groundwater elevation reflect the deviation between the long-term monthly (or yearly) average rainfall, and the actual rainfall, illustrated by the rainfall CDFM. Groundwater hydrographs showing the relationship between rainfall and groundwater levels are assessed in **Section 4**.

Actual and potential evapotranspiration (ET) have been taken from BoM's Australia wide interpolation dataset at the locations of the weather stations (BoM, 2022). The potential ET in the district is about 2,357 mm/yr according to BoM (2012) (**Table 2-3**). The definition of potential ET is: "... the ET that would take place, under the condition of unlimited water supply, from an area so large that the effects of any upwind boundary transitions are negligible and local variations are integrated to an areal average". For example, this represents the ET which would occur over a very large wetland or large irrigated area, with a never-ending water inflow. Further to this, where the water table approaches the ground surface, ET can also approach the potential ET value.

Table 2-3 Average Monthly Potential Evapotranspiration

PE (mm)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Booroondarra	245	205	211	176	145	120	135	167	207	250	256	264	2,382
SILO Grid Point Data	241	202	207	173	143	120	135	167	206	249	255	261	2,357

PE = Potential Evapotranspiration

The actual ET in the district is about 1,058 mm/year according to BoM (2012) (**Table 2-4**). The definition for actual ET is: "... the ET that actually takes place, under the condition of existing water supply, from an area so large that the effects of any upwind boundary transitions are negligible and local variations are integrated to an areal average". For example, this represents the predicted ET that is occurring over a large area of land under the existing (mean) rainfall conditions.

Table 2-4 Average Monthly Actual Evapotranspiration

AE (mm)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Booroondarra	129	114	108	78	49	35	40	60	81	104	117	130	1,046
SILO Grid Point Data	128	115	111	82	53	38	42	62	82	103	115	128	1,058

AE = Actual Evapotranspiration

Figure 2-2 shows that the average potential monthly ET exceeds the average monthly rainfall over the entire year, often by more than double. Average actual ET is slightly greater than average rainfall for all months.

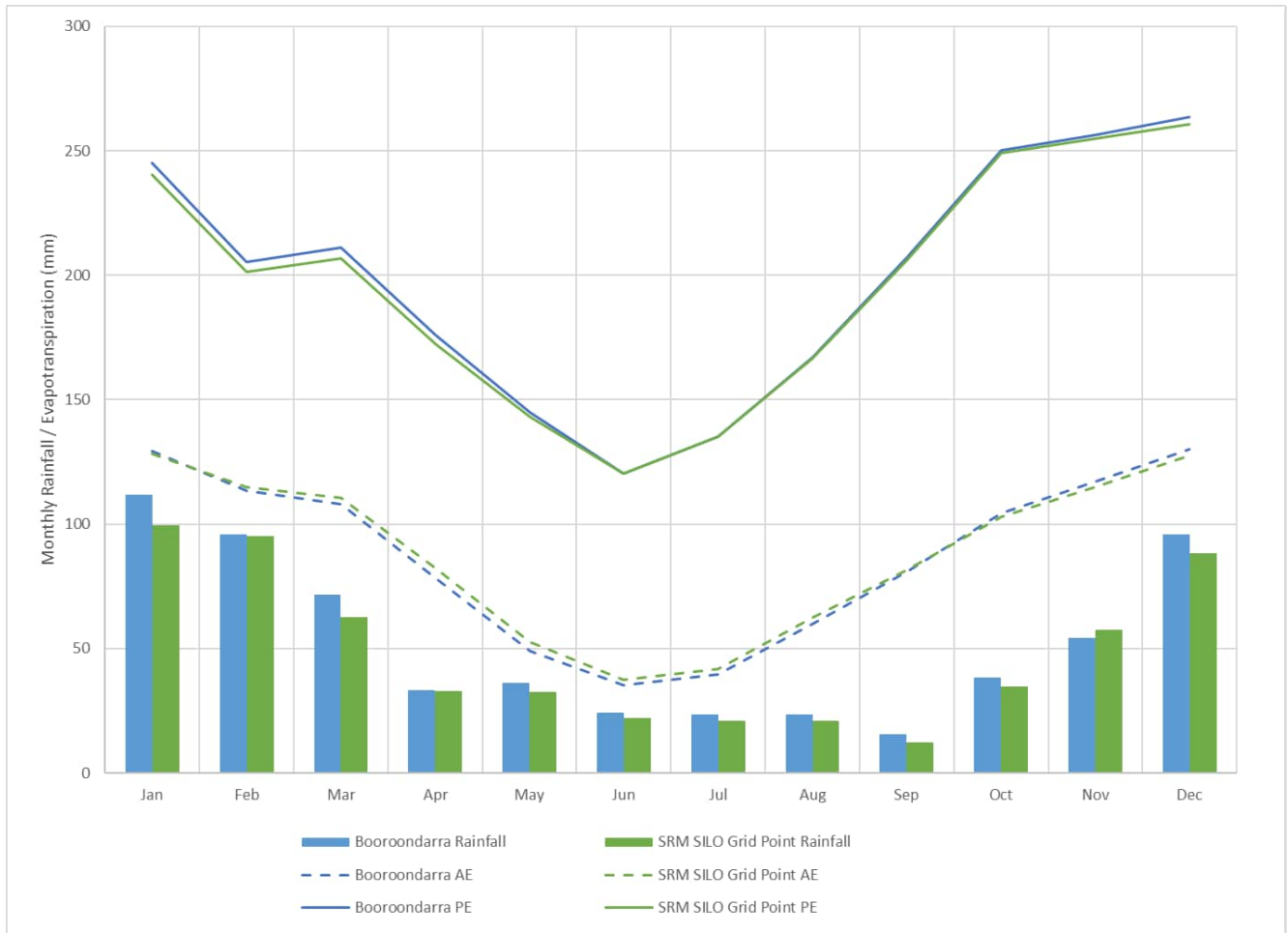


Figure 2-2 Average Monthly Rainfall and Evapotranspiration at Nearby Weather Stations

2.2 Topography and Drainage

SRM is located in the Isaac River western upland tributaries sub-catchment of the Upper Isaac River Catchment of the Isaac River Sub-basin, part of the Fitzroy Basin. The topography of the SRM Area is relatively flat with gentle undulation and average elevations of approximately 195 mAHD (**Figure 2-3**). Elevations across SRM in general range between approximately 200 mAHD in the west to 190 mAHD in the east. The topography gently grades east-southeast towards the Isaac River, where elevations are approximately 165 mAHD.

The Isaac River, located approximately 18 km directly east of SRM, is the major drainage feature of the region and flows from northwest to southeast (**Figure 2-3**). Drainage across SRM includes Boomerang Creek, Hughes Creek, One Mile Creek, and Phillips Creek, all tributaries of the Isaac River. Stephens Creek is located to the south of SRM and also drains into the Isaac River to the east.

Boomerang Creek and One Mile Creek join Hughes Creek downstream (east) of SRM. Phillips Creek, Stephens Creek and Downs Creek independently join the Isaac River downstream (east) of SRM.

Hughes Creek, Phillips Creek and Stephens Creek are classified as Major water courses, with the remaining water courses described above classified as minor.

Hughes Creek is a secondary drainage feature in the Study Area and runs from southwest to northeast across SRM before draining eastwards (**Figure 2-3**). The course of Hughes Creek within the SRM Area boundary has been diverted to run between Bauhinia Pit and Coolibah Pit (**Figure 2-3**). Boomerang Creek and Ripstone Creek drain from across Peak Downs Mine (PDM) into Hughes Creek 3.8 km and 15 km northeast of SRM, respectively. The confluence of Hughes Creek to the Isaac River is approximately 16 km east of SRM at an elevation of 164 mAHD. Hughes Creek is used as a controlled release point by SRM (authorised under EA EPML00862313).

One Mile Creek is a secondary drainage feature in the Study Area and flows from southwest to northeast (**Figure 2-3**). One Mile Creek is used as a controlled release point by SRM (authorised under EA EPML00862313). The confluence of One Mile Creek to Hughes Creek is approximately 12 km northeast of SRM at an elevation of 169 mAHD. Spring Creek is a tributary of One Mile Creek, with the confluence of the two watercourses approximately 2 km northeast of SRM. Spring Creek crosses SRM in a southwest to northeast direction between Ebony Pit and Grevillea Pit in the south of the SRM Area, and will be diverted to Philips Creek in the future as part of approved SRM activities. The approved Spring Creek to Philips Creek diversion is designed to be permanent and relinquishable post-mining.

Phillips Creek is a secondary drainage feature in the Study Area and flows from southwest to northeast (**Figure 2-3**). The confluence of Phillips Creek to the Isaac River is approximately 18 km northeast of SRM at an elevation of 162 mAHD. Phillips Creek crosses SRM in a southwest to northeast direction between Grevillea Pit and Hakea Pit in the south of the SRM Area. Phillips Creek is used as a controlled release point by SRM (authorised under EA EPML00862313).

All watercourses and tributaries within and in the vicinity of SRM are highly ephemeral and only flow briefly after rainfall sufficient to generate surface runoff. After significant rainfall, water remains in ponds that are used as livestock water sources.

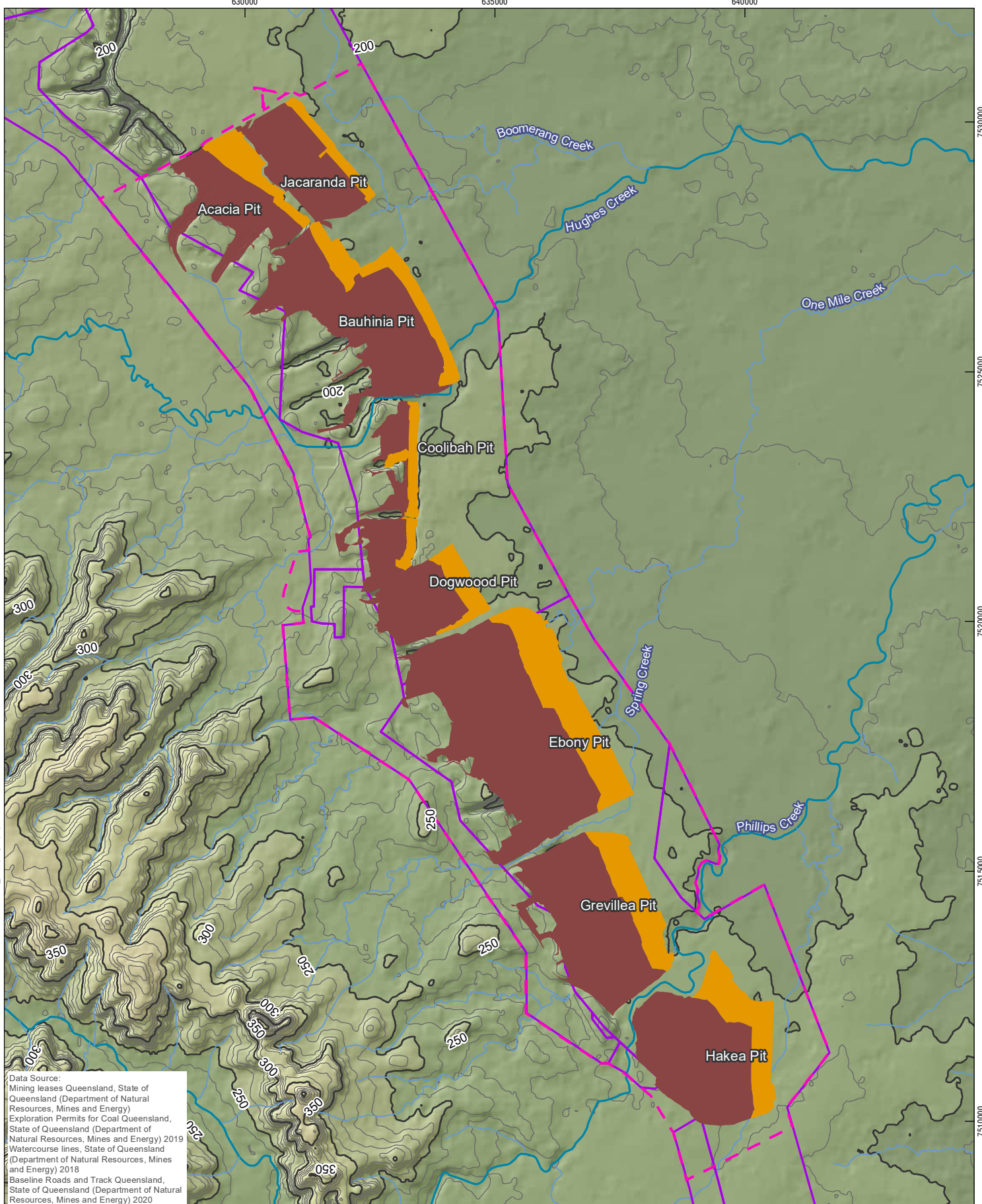
2.3 SRM Mining

This section outlines the historical mine progression and future mining plan at SRM, as relevant to assessing the effect of SRM on the groundwater system post-closure. This is considered important since post-closure groundwater conditions will in part be dictated by the conditions that are present as a result of existing mining activities at the time of closure.

2.3.1 Historical Mining Activities

SRM began operations in 1974 with open pit drag line mining pre-strip activities along the length of the SRM mine. **Table 2-5** lists the operating areas of SRM mine with the estimate of commencement date and target seams. **Figure 2-4** provides a mining history plan for SRM's eight open cut pits, noting that detailed mine progression data pre-2010 were not available for this study.

In all pits, spoil is deposited to the west of mine void adjacent to the pit ramps. The primary mine operations area including stockpile, workshops, coal processing facility and a tailings storage is located immediately west of Dogwood and Coolibah Pits.



Data Source:
Mining leases Queensland, State of
Queensland (Department of Natural
Resources, Mines and Energy)
Exploration Permits for Coal Queensland,
State of Queensland (Department of
Natural Resources, Mines and Energy) 2019
Watercourse lines, State of Queensland
(Department of Natural Resources, Mines
and Energy) 2018
Baseline Roads and Track Queensland,
State of Queensland (Department of Natural
Resources, Mines and Energy) 2020



0 1 2 km

Coordinate System: GDA 1994 MGA Zone 55

Scale: 1:100,000 at A4

Project Number: 620.30984

Date: 25-Oct-2022

Drawn by: NT

LEGEND

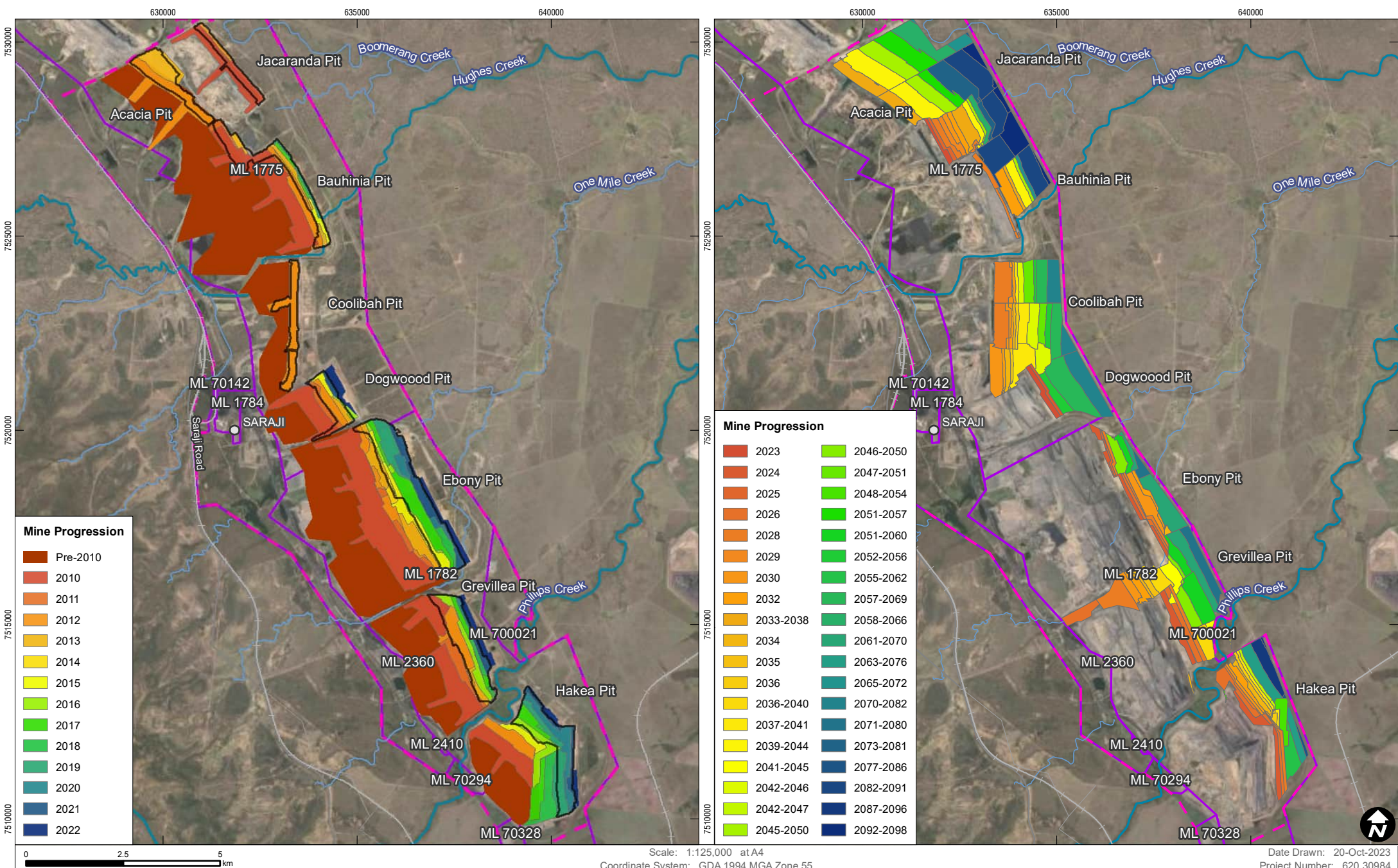
- Topographic Contour (50m AHD)
- Topographic Contour (10m AHD)
- Major Watercourse
- Minor Watercourse
- Active Pit
- Spoil Dump
- SRM Mine Lease
- SRM EA Boundary

SARAJI MINE TRANSITIONAL PRC PLAN HYDROGEOLOGY ASSESSMENT

TOPOGRAPHY AND DRAINAGE



FIGURE 2-3



Data Source:

LEGEND

- Surrounding Mine
- Track
- SRM EA Boundary
- Rail
- Major Watercourse
- SRM Mine Lease
- Road
- Minor Watercourse
- Current Pit Extent

**SARAJI MINE TRANSITIONAL PRC PLAN
HYDROGEOLOGY ASSESSMENT**

MINING ACTIVITIES AT SRM

FIGURE 2-4

Table 2-5 SRM Mining Areas and Basal Target Seams

Pit Name	Mining Commenced	Deepest Target Seam
Acacia Pit	1976	D Seams
Jacaranda Pit	2003	D Seams
Bauhinia Pit	1980	D Seams
Coolibah Pit	1974	D Seams
Dogwood Pit	1974	D Seams
Ebony Pit	1974	D Seams
Grevillea Pit	1987	D Seams
Hakea Pit	2003	H Seams

2.3.2 Current and Future Mining

Mining at SRM is expected to continue on the current approved operations until 2098. The current future mine plan, with polygons indicating timing for mine strip extraction is provided as **Figure 2-4**. This involves continued generally eastwards mining towards the eastern SRM Area boundary, targeting economic areas of Moranbah Coal Measures seams dipping down to the east, with basal depth of mine void increasing in conjunction with the dipping geology.

2.3.3 Mine Pit Void Inflows

Groundwater inflows from the Permian coal measures to SRM's active pit voids are generally small in volume and do not typically need to be actively managed via advance dewatering or other groundwater management methods, with evaporation from the pit void walls and floors accounting for most of the groundwater. Small volumes of groundwater inflow requiring management, when they occur, which are generally managed via the use of in-pit sumps to capture water that is then used for dust suppression purposes or circulated via the Mine water management system for use in coal washing.

Groundwater inflow estimates for SRM are provided in **Table 2-6** below based on BMA's annual Associated Water Take reporting to the Queensland Department of Resources (DoR). Estimates are based on BMA's site water balance calculations using site climate data, pit void storage and pumped outflow data in accordance with the DNRME (2020) Associated Water Take Guideline, and as such inflow estimates are considered conservative.

Table 2-6 Estimated Groundwater Inflow at SRM 2021/2022 (BMA, 2022)¹

Pit Name	Monthly Estimate (ML/mth)	Annual Estimate (ML/yr)
Acacia Pit	16	192
Jacaranda Pit	63	754
Bauhinia Pit	123	1,478
Coolibah Pit	18	220
Dogwood Pit	59	707
Ebony Pit	90	1,077
Grevillea Pit	-19	-223
Hakea Pit	-48	-578
Total		3,627

1. A negative calculated value for groundwater inflow may indicate inaccuracy in calculation of the other water balance terms and/or that the groundwater inflow volume is comparatively small (DNRME, 2020).

3 Geology

3.1 Regional Geology

SRM is located in the northern part of the Bowen Basin, a foreland sedimentary basin of approximately 200,000 km² (**Figure 3-1**). The Bowen Basin is a north-northwest to south-southeast oriented basin and contains the largest coal reserves in Australia. The southern half of the Bowen Basin is covered by the Surat Basin, and the Galilee Basin exists to the west (Geoscience Australia, 2017).

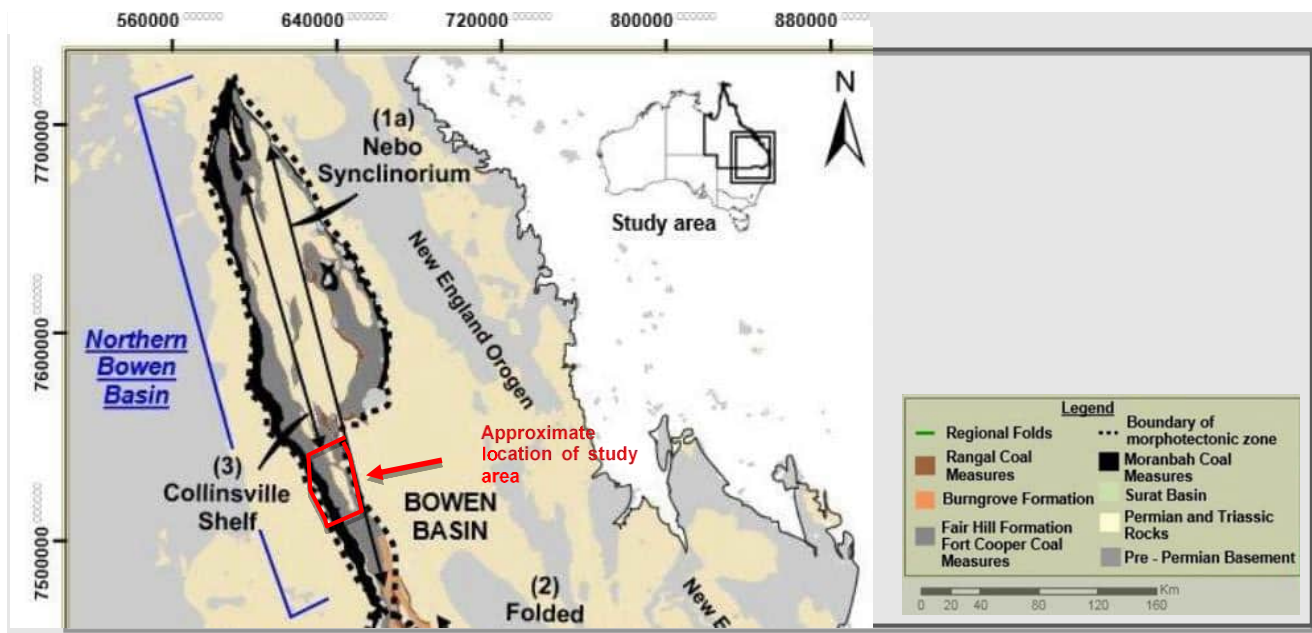


Figure 3-1 Structural Setting of the Bowen Basin (after Dickens and Malone, 1973)

Basin geology within the Collinsville Shelf includes the basal Permian aged Back Creek Group, which generally comprises of generally fine-grained clastic sedimentary rocks deposited in a fluvial to shallow marine environment. The Back Creek Group is conformably overlain by the Blackwater Group, which includes the Moranbah Coal Measures, Fort Cooper Coal Measures and Rangal Coal Measures. The economic seams at SRM are contained in the Moranbah Coal Measures. The Permian strata occur at outcrop on the eastern and western edges of the Basin and are unconformably overlain by the Triassic aged consolidated sedimentary rocks of the Rewan Group. While not present in the vicinity of SRM, isolated pockets of remnant quartzose sandstones of the Middle Triassic Clematis Group are also mapped within the Study Area, on the eastern side of the Isaac River.

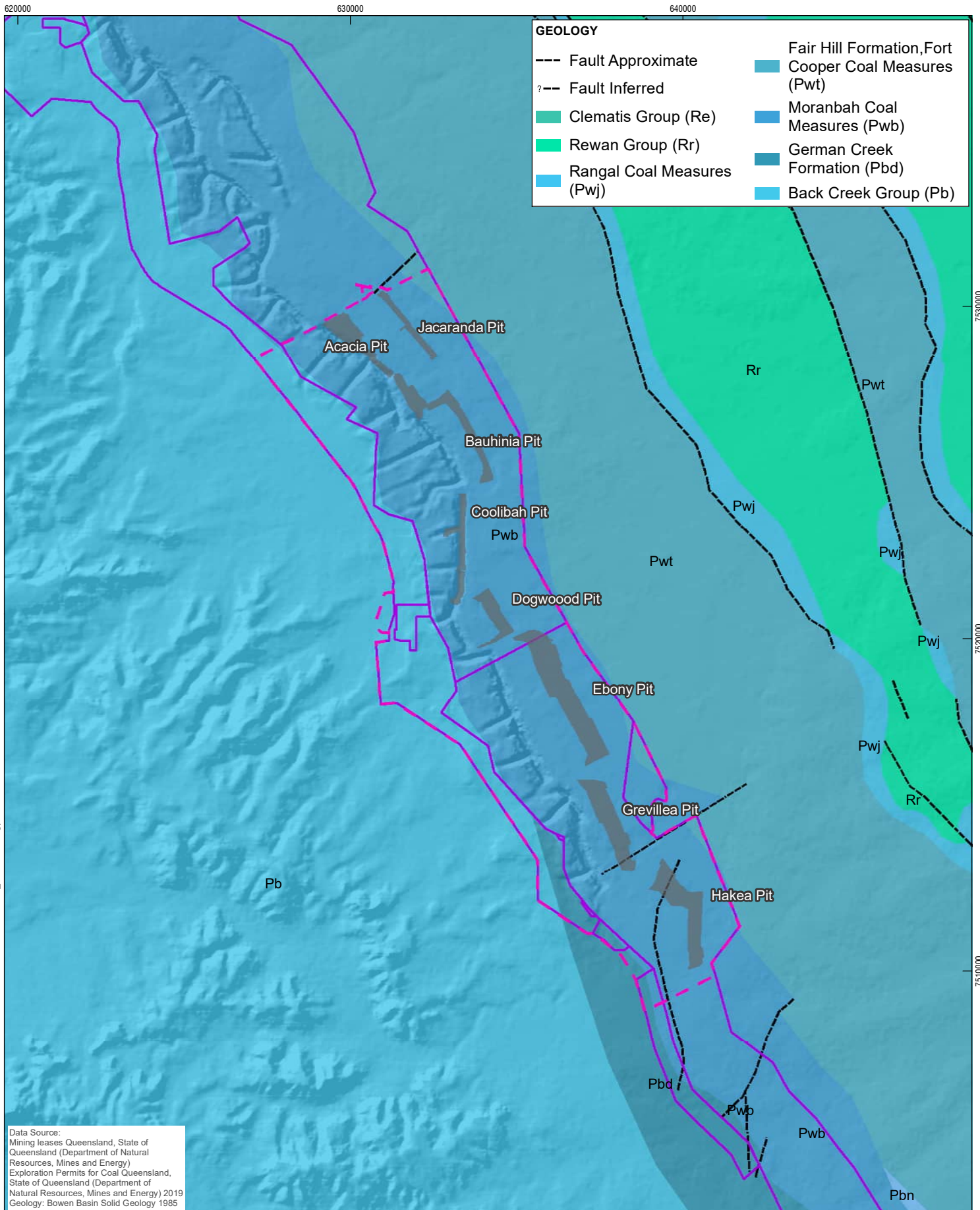
The Permian and Triassic units are covered by a thin veneer of unconsolidated to semi-consolidated Cainozoic sediments (Tertiary to Quaternary alluvium and colluvium). The alluvial sediments are localised along rivers and creeks (i.e., Isaac River, Hughes Creek, One Mile Creek and Phillips Creek). Volcanic extrusions (i.e., basalt) are also present within the region but are absent within the SRM Area.

The generalised regional stratigraphy is summarised in **Table 3-1**. The solid geology is presented as **Figure 3-2** and the surface geology is presented as **Figure 3-3**.

Table 3-1 Regional Stratigraphy

Period		Stratigraphic Unit		Description	Mapped Distribution	Max Thickness (m)
Cainozoic		Quaternary alluvium (Qa)		Flood plain alluvium comprising clay, silt, sand and gravel.	Surficial cover localised along Isaac River, Phillips Creek and Downs Creek	~ 50 m
		“Regolith” - alluvium, colluvium and other sediments in floodplains, alluvial fans, and high terraces (Qr, Qr\b and TQa)		Shallow unconsolidated and semi-consolidated sediments and weathered units outside of Quaternary alluvium (Qa), comprising colluvial and residual deposits of poorly sorted clay, silt, sand, gravel and black soils, silts and muds derived from weathered basalts.	Surficial cover throughout the SRM Area. TQa coverage throughout SRM Area extending eastwards until overlain by Qa deposits. Qr distributed in areas to the west of SRM, associated with weathering of Back Creek Group by watercourses traversing area	~ 20 m
		Suttor Formation (Tu)		Clay, silt, sand, gravel, colluvium, fluvial and lacustrine deposits including cross-bedded quartz sandstone, conglomerate, claystone	Surficial cover in the Study Area mainly north of the Isaac River. Not present at or within 30 km of SRM.	~ 120
		Tertiary Basalt (Tb)		Olivine basalt lava flows and some plugs; some areas of nephelinite and basanite	Surficial cover localised in parts of the Study Area. Not present in immediate SRM Area.	~30 m
		Duaringa Formation (Tu)		Mudstone, sandstone, conglomerate, siltstone, oil shale, lignite and basalt.	Surficial cover in localised areas to the east of the SRM Area. Not present within the SRM Area; closest mapped location 1.5 km east of the southern part of SRM Area. Present to north-west, north and northeast of the Study Area.	~100 m
Triassic		Mimosa Group	Clematis Group (Re)	Cross-bedded quartz sandstone, some quartz conglomerate and minor red-brown mudstone.	Isolated outcrop 40 km south-east of the Study Area.	~100 m
			Rewan Group (Rr) (Rewan Formation and Sagittarius Sandstone)	Rewan Formation: green lithic sandstone, pebbly lithic sandstone, green to reddish brown mudstone and minor volcanolithic pebble conglomerate (at base). Sagittarius Sandstone: lithic sandstone interbedded with mudstones and siltstones with scattered carbonaceous plant material.	Subcrops 7.5 km to the east of SRM / underlies eastern zones of Study Area.	~840
Permian	Late	Blackwater Group	Rangal Coal Measures (Pwj)	Coal seams, carbonaceous shale and mudstone, tuff, siltstone and mudstone.	Subcrops 7km east of SRM Area / underlies eastern zones of Study Area.	~200

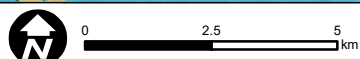
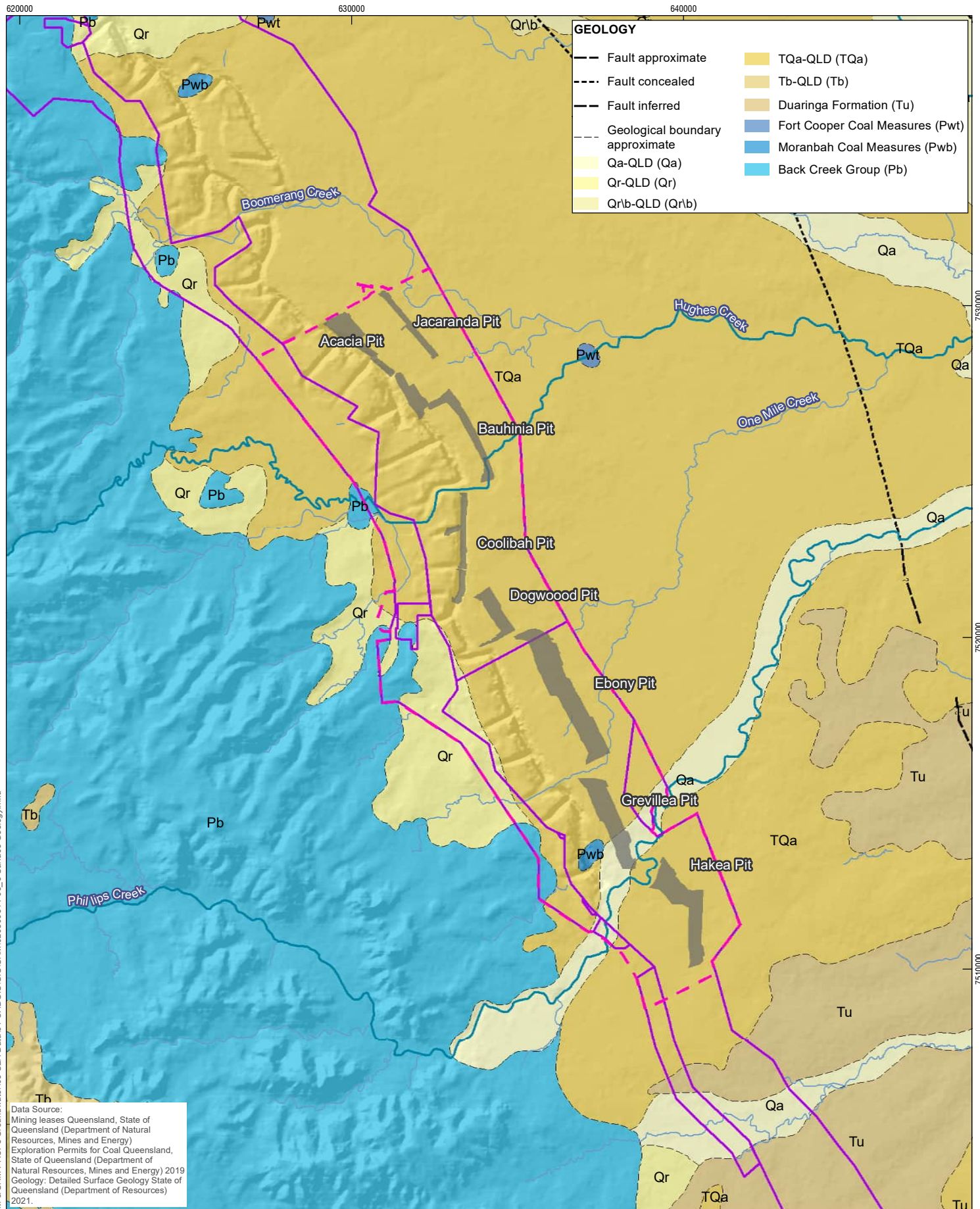
Period		Stratigraphic Unit		Description	Mapped Distribution	Max Thickness (m)
			Fort Cooper Coal Measures (Pwt) (Fair Hill Formation)	Coal, brown and green sandstone, conglomerate, carbonaceous shale, tuff.	Subcrops along total eastern extent of SRM Area and extends directly to the east.	~350
			Moranbah Coal Measures (Pwb)	Quartzose to sublabile locally argillaceous sandstone, siltstone, mudstone, carbonaceous mudstone and coal.	Within/underlies the whole of SRM.	~ 400
	Early to Middle	Back Creek Group (Pb)		Quartzose to lithic sandstone, siltstone, carbonaceous shale, minor coal and sandy coquinite.	Within/underlies all of SRM; Outcrops west of the SRM Area.	~400



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SOLID GEOLOGY

FIGURE 3-2



Coordinate System: GDA 1994 MGA Zone 55
Scale: 1:150,000 at A4
Project Number: 620.30984
Date: 26-Sep-2022
Drawn by: NT

LEGEND

- Major Watercourse
- Minor Watercourse
- Active Pit
- SRM EA Boundary
- SRM Mine Lease

SARAJI MINE TRANSITIONAL PRC PLAN HYDROGEOLOGY ASSESSMENT

SURFACE GEOLOGY



FIGURE 3-3

3.2 Local Geology

3.2.1 Cainozoic

The stratigraphic profile within the SRM Area comprises two distinct units:

- Cainozoic sediments (alluvium, colluvium, and regolith that includes weathered Permian strata); and
- Permian coal measures.

3.2.1.1 Quaternary Alluvium

State (Queensland Government) Detailed Surface Geology (SDSG) mapping (**Figure 3-3**) shows that Quaternary alluvium is localised along Phillips Creek, crossing the south of SRM and extending north-eastwards; and along Ripstone Creek to the northeast of SRM. Quaternary alluvium is also mapped extensively along the Isaac River to the east of SRM.

The mapped Quaternary alluvium associated with Phillips Creek is adjacent to Grevillea Pit and Hakea Pit and extends continuously to join with the Isaac River alluvium (refer **Figure 3-3**). Therefore, there would be potential for interaction between the Isaac River alluvium and the groundwater resources in the SRM Area should there be continual saturation of the alluvial sediments along Philips Creek from the SRM Area to where it joins the Isaac River Alluvium. However, existing studies (e.g. AECOM, 2019) and SRM monitoring data (see **Section 4.3.1**) indicate continual saturation is unlikely but rather groundwater occurrence in the Philips Creek alluvium is highly sporadic and isolated, i.e. groundwater is not found broadly across the extent of Philips Creek alluvium but only in a few isolated areas. Therefore the groundwater resources of the Phillips Creek alluvium (where they exist) are likely hydraulically disconnected from those in the Isaac River alluvium. Further discussion is provided in **Section 4.3.1**.

3.2.1.2 Tertiary Sediments

SDSG mapping shows Tertiary-Quaternary alluvium (TQa) deposits distributed across SRM and the surrounding area. TQa is defined in the SDSG metadata as a *poorly consolidated or unconsolidated alluvial deposit in an ancestral valley, which has been dissected by more recent channel activity*. SDSG mapping shows that the TQa deposits extend eastwards from SRM towards the Isaac River and are indicative of flood plain material associated with watercourses traversing the area. The inferred extent of the surficial material is presented in **Figure 3-3**.

AECOM (2019) report Tertiary sediments within the SRM Area as comprising 'tight' clays overlying an irregular discontinuous basal sand unit. Thickness of approximately 45m are reported across SRM increasing to 57m in the western portion of the SRM Area (AGE, 2011).

The Tertiary clay unit is the predominant Tertiary unit across the SRM Area, comprising a clay matrix with intercalation of clay and sand lithologies (AECOM, 2019).

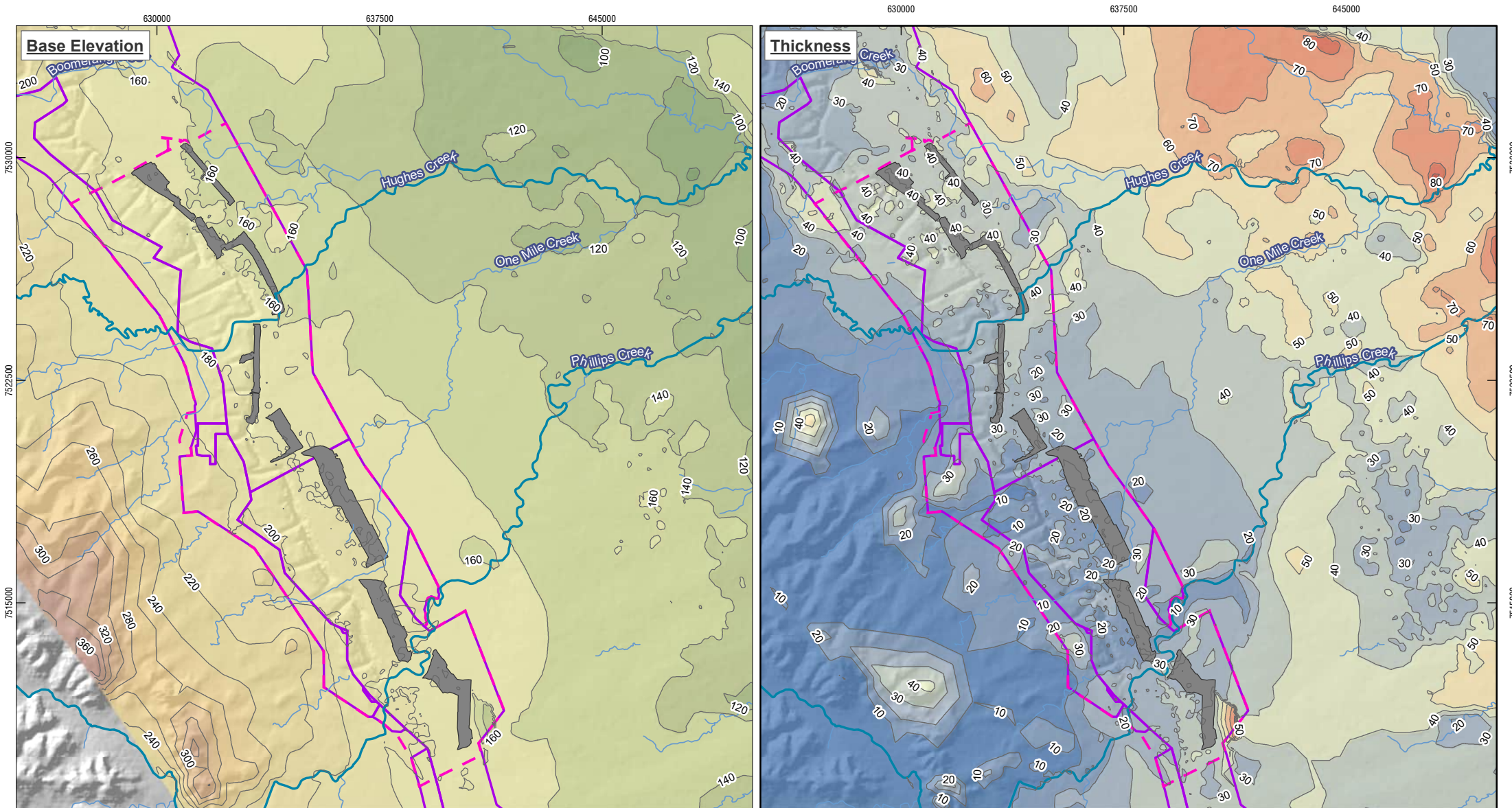
A basal sand and gravel unit is identified at the base of the Tertiary sediments comprising medium to coarse grained sands and fine gravels (AECOM, 2019). The unit is reported to have a maximum thickness of 3m and can be locally continuous. It is believed that the basal sands and gravels represent the presence of a laterally discontinuous paleo-channel system assumed to be related to a proto Phillips Creek system (AECOM, 2019).

SDSG mapping shows the Duaringa Formation (Tu) located approximately 10km east of the southern section of SRM (refer **Figure 3-3**). Tu is defined in the SDSG metadata as mudstone, sandstone conglomerate, siltstone, oil shale, lignite and basalt.

3.2.1.3 Regolith

The other undifferentiated surficial material covering much of the Study Area comprises unconsolidated sediments, including colluvium and residual deposits (Qr and Qr\b) derived from weathering of the underlying Permian strata; i.e. non-alluvial Quaternary sediments. Drill logs indicate the unconsolidated sediments in the SRM area comprise clay, silt, sand, gravel and soil. Within SRM, Permian units are, on average, highly weathered to a depth of 25 mBGL and the Tertiary to Quaternary aged deposits are on average weathered to 25 mBGL. In many recent previous groundwater studies (e.g. HydroSimulations 2018, SLR 2019, 2020 & 2021) these sediments are grouped with the Tertiary units and termed “regolith”, since in a hydrogeological sense they essentially function as a single unit.

SDSG mapping shows surficial regolith deposits to be localised in the west of the SRM Area (**Figure 3-3**), indicative of weathering of the Permian Back Creek Group by water courses as they traverse these locations. The extent and thickness of the regolith material is presented in **Figure 3-4**, interpolated based on SRM site geological data and the CSIRO Soil and Landscape Grid of Australia (CSIRO, 2015) data.



0 2.5 5 km

Coordinate System: GDA 1994 MGA Zone 55
 Scale: 1:175,000 at A4
 Project Number: 620.30984
 Date: 26-Oct-2022
 Drawn by: NT

LEGEND

- Major Watercourse
- Minor Watercourse
- Active Pit
- - - SRM EA Boundary
- SRM Mine Lease

ELEVATION (mAHD)

70 - 80	180 - 200	300 - 320
80 - 100	200 - 220	320 - 340
100 - 120	220 - 240	340 - 360
120 - 140	240 - 260	360 - 380
140 - 160	260 - 280	Elevation Contour (mAHD)
160 - 180	280 - 300	

THICKNESS (m)

0 - 10	50 - 60
10 - 20	60 - 70
20 - 30	70 - 80
30 - 40	80 - 90
40 - 50	90 - 100
Thickness Contour (m)	

SARAJI MINE TRANSITIONAL PRC PLAN HYDROGEOLOGY ASSESSMENT

BASE ELEVATION AND THICKNESS OF SURFICIAL UNITS

FIGURE 3-4

3.2.2 Permian Coal Measures (Blackwater Group)

Permian coal-bearing sedimentary rocks of the Blackwater Group form the main economic resource of the numerous mines in the Study Area. In decreasing depth (age) order, the major coal measures in the Study Area include the:

- Moranbah Coal Measures;
- Fort Cooper Coal Measures; and
- Rangal Coal Measures.

Each of these units is discussed further below.

3.2.2.1 Moranbah Coal Measures

The Moranbah Coal Measures are the lowermost coal-bearing sequence of the Blackwater Group and form the coal resource targeted by mining at SRM. These coal measures subcrop at SRM on the western limb of the Bowen Basin and are also mined at PDM and CVM immediately north of SRM. The Moranbah Coal Measures comprise volcanic lithic sandstones, with lesser siltstone, mudstone, conglomerate and coal.

There are four main coal seams (each comprised of multiple plies) within the Moranbah Coal Measures at SRM, in order of increasing depth these are known as the Q seams, P seams, the Harrow Creek (H) seams and the Dysart (D) seams. All seams split and recombine along the mine. These main coal seams subcrop on the western part of the SRM. **Figure 3-5** presents a schematic of the coal seams along the mine. It should be noted that although the Fort Cooper Coal Measures are shown on the schematic, these are not present within the SRM Area, instead subcropping immediately east of the SRM Area boundary (described further in **Section 3.2.2.2** and as shown in **Figure 3-2**). A brief description of each seam is described as follows.

The Q seam at SRM is too thin to be of economic value with thickness ranging from 0.4 m (Q03) to 0.7 m (Q02) (AECOM, 2019). The P seam comprises several coal intervals ranging in thickness from 1.2 m (P08) to 3.5 m (P02). The main Harrow Creek (H) group seams of interest include the Harrow Creek Upper (H16) and Harrow Creek Lower (H15 and H19). The H16 is up to 4.8 m thick, the H15 seam up to 3 m thick and the H19 up to 1.1 m thick.

The main Dysart (D) group seams of interest include the Dysart Upper (H52) seam and Dysart Lower (D14 and D24) seam. The D24 seam is generally the target seam coal seam across SRM. The Dysart Lower seam is located 17 m to 35 m below the Dysart Upper seam (D52) (AECOM, 2019). Where coalesced in the northern end of SRM (in the area ranging from Bauhinia Pit to Dogwood Pit), the Dysart Lower seam is typically 7 m thick. The seam thins to the north below Acacia Pit and Jacaranda Pit and progressively splits to the south into the D14, D142 and D291 plies, with thicknesses ranging from 2 m to 5.8 m (AECOM, 2019).

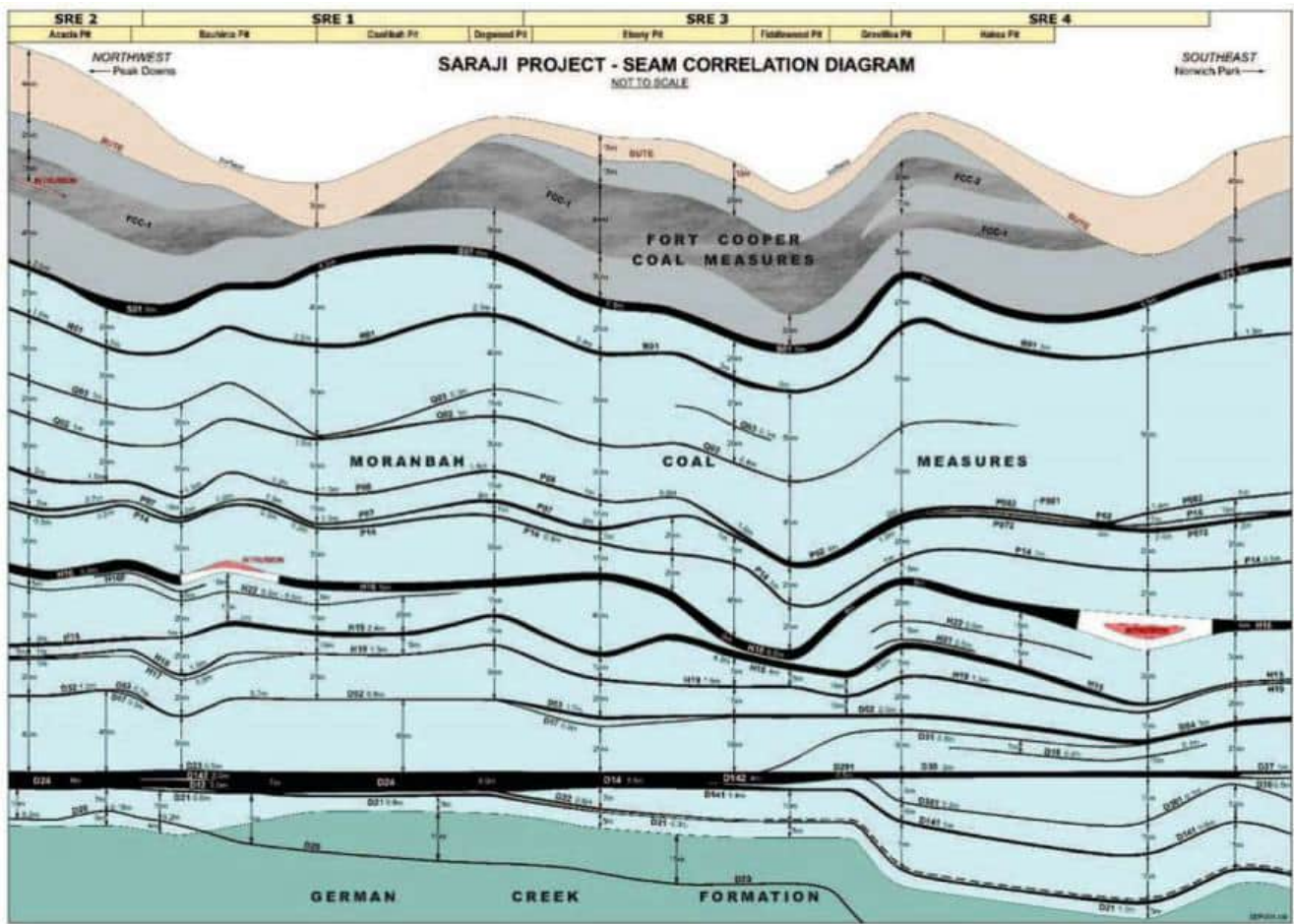


Figure 3-5 Schematic Diagram of Coal Seams at SRM (BHP, 2019)

The average combined thicknesses of the constituent plies comprising each seam is given:

- Q Seam Combined thickness = 0.4 to 0.7 m
- P Seams combined average thickness = 1 to 3.5 m
- H Seam combined thickness = up to 4.8 m
- D Seam combined thickness = Up to 7 m

From drillhole logs of groundwater monitoring bores within SRM the Moranbah Coal Measures were identified at the following depths (in general, depths were shallowest in the west of SRM and deepest in the east):

- Q Seam was encountered at 30 mBGL (164 mAHD) to 231 mBGL (185 mAHD);
- P Seams was encountered between 39 mBGL (167 mAHD) to 231 mBGL (-37 mAHD);
- H Seam was encountered between 52 mBGL (158 mAHD) to 203 mBGL (-6 mAHD); and
- D Seam was encountered between 156 mBGL (54 mAHD) to 239 mBGL (-42 mAHD).

Interpolated structure and depth contours of the Q Seam, P Seam, H Seam and D Seam are presented in **Figure 3-6 to Figure 3-9**. These contours have been based on the SRM geological model.

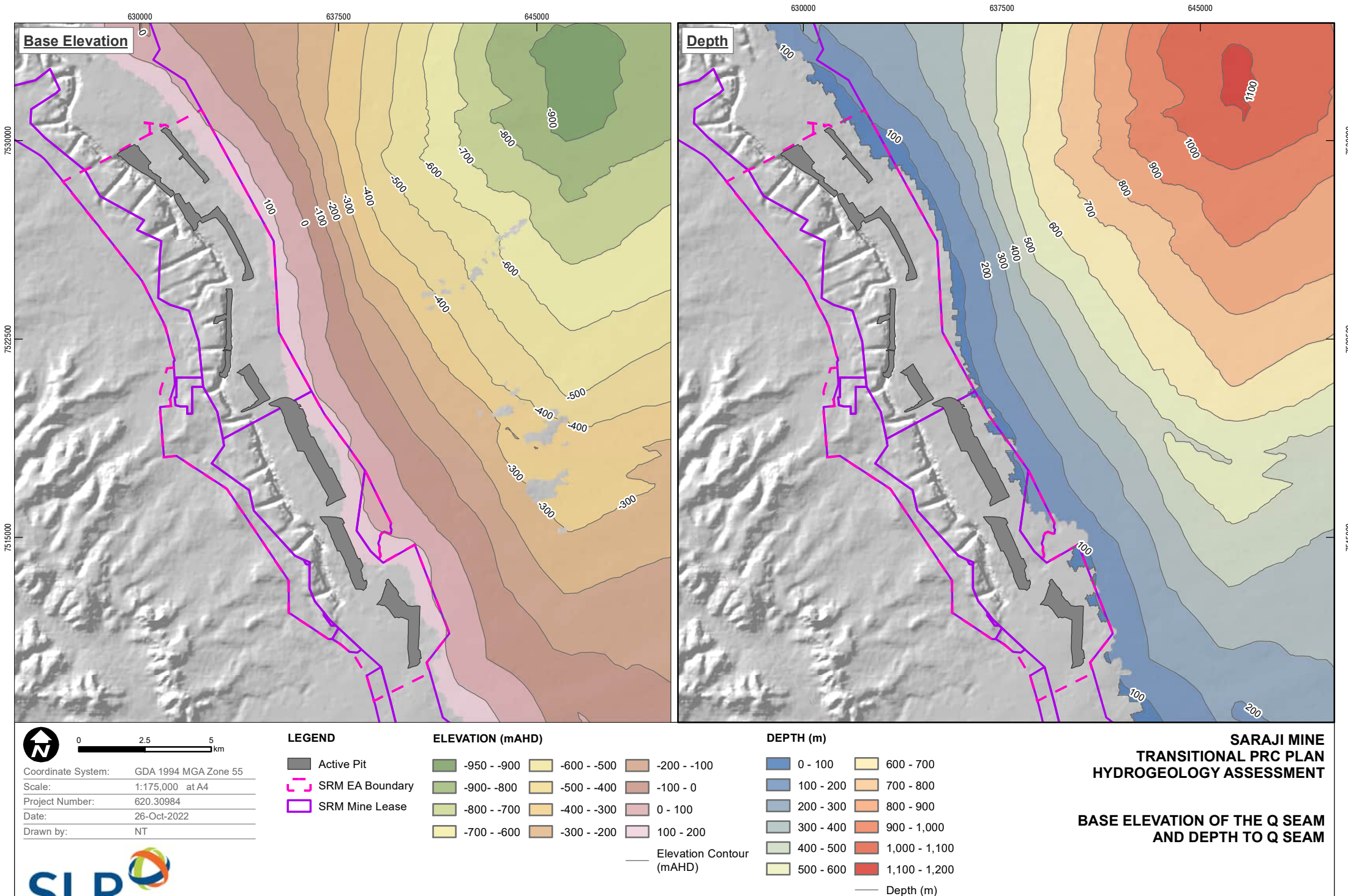
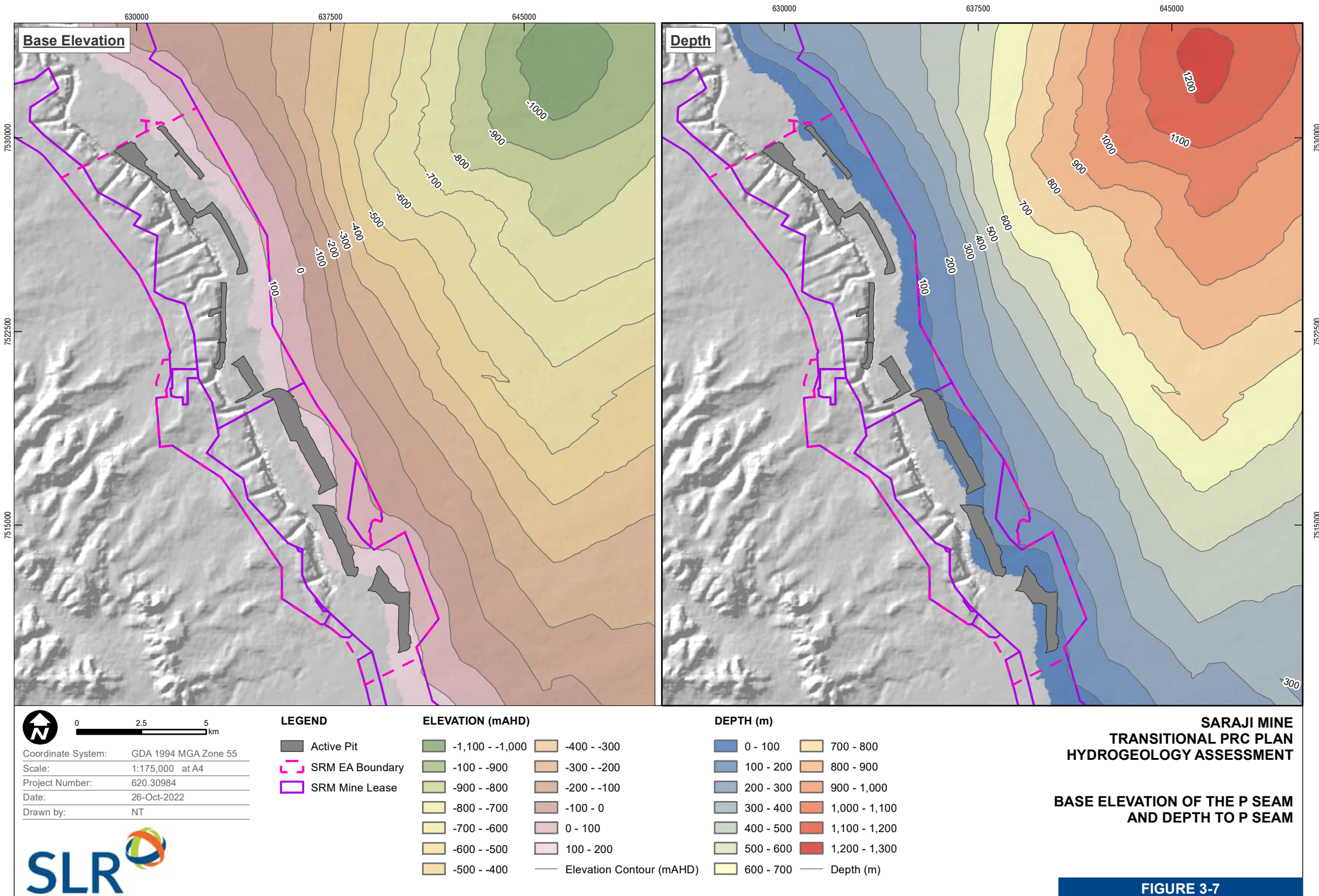
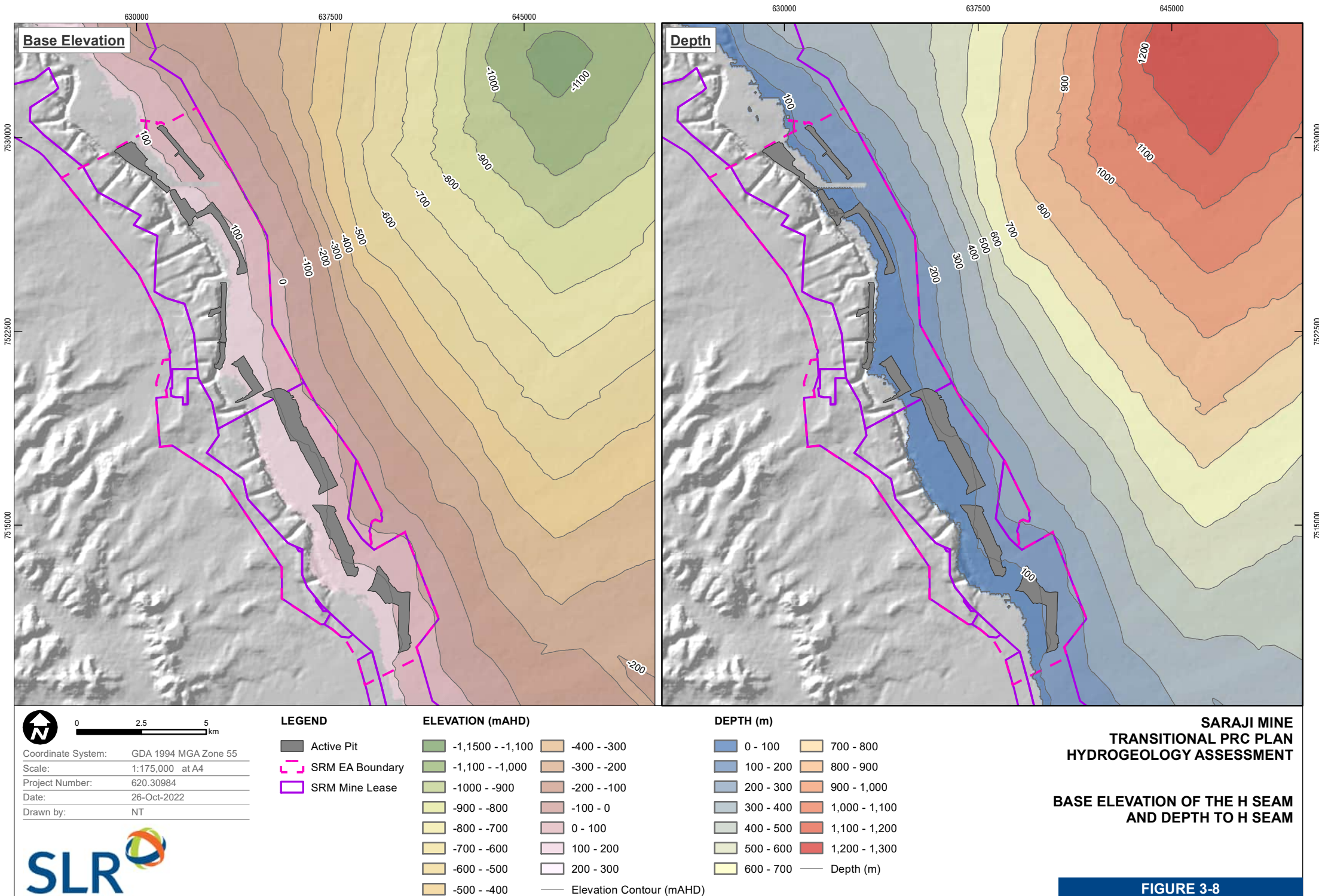
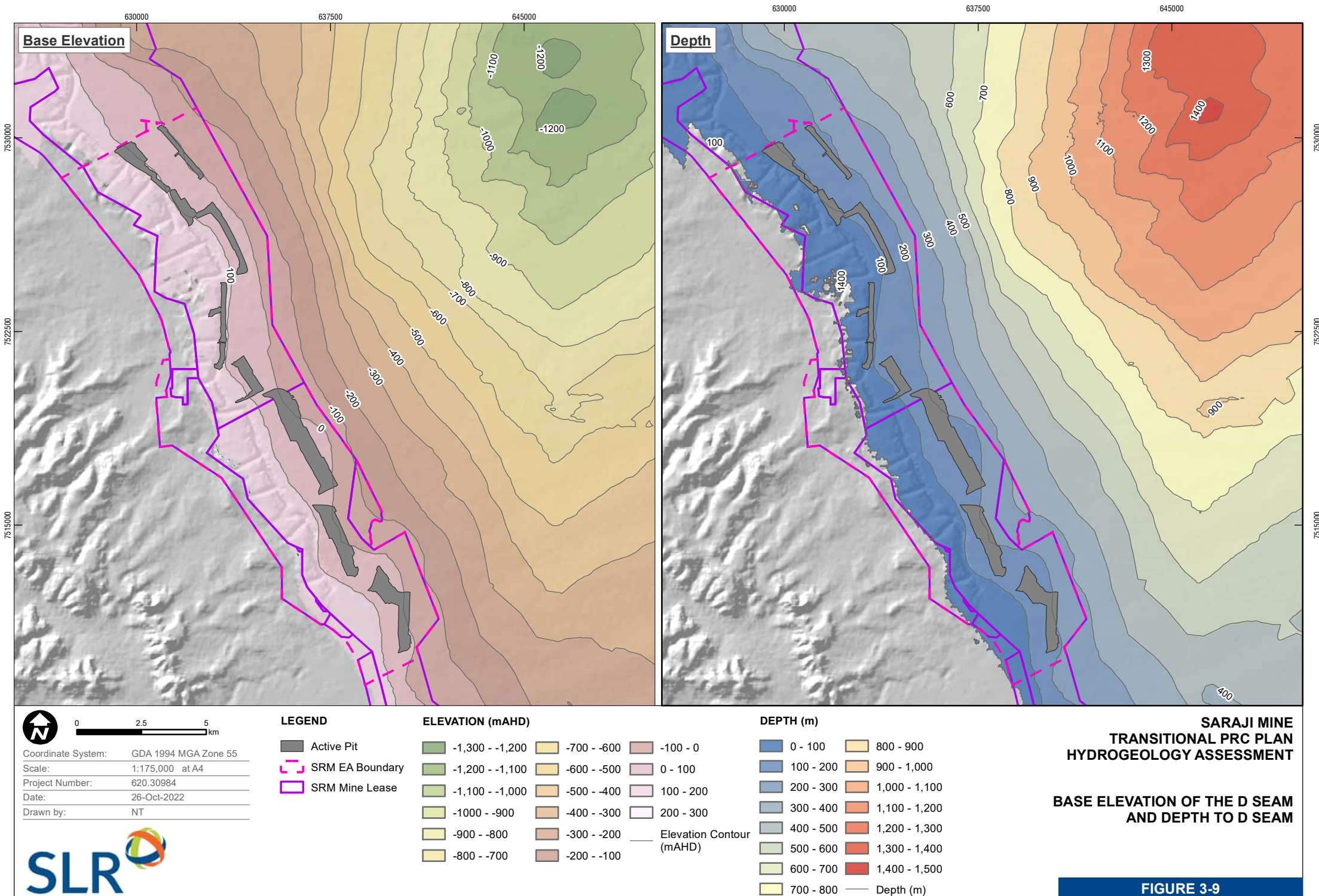


FIGURE 3-6







3.2.2.2 Fort Cooper Coal Measures

The Fort Cooper Coal Measures conformably overlie the Moranbah Coal Measures and subcrop immediately east of SRM but are not present within the SRM ML. Regionally, the formation has a maximum thickness of approximately 350 m (HydroSimulations, 2018a) and drill logs indicate the Fort Cooper Coal Measures comprise lithic sandstone, conglomerate, mudstone, carbonaceous shale, coal, tuff and tuffaceous (cherty) mudstone. The main coal seams within the Fort Cooper Coal Measures are the S seam (3 to 4 m thick) and the R seam (1 to 2 m thick) (BMA, 2020).

3.2.2.3 Rangal Coal Measures

Where they occur further east of SRM, the youngest Blackwater Group coal measures, the Rangal Coal Measures, overlie the Fort Cooper Coal Measures. The transition between the Rangal Coal Measures and the Fort Cooper Coal Measures is marked by the Yarrabee Tuff which immediately overlies the Vermont Lower Seam. The Yarrabee Tuff is a basin-wide marker bed comprised of weak, brown tuffaceous claystone, with an average thickness of 0.7 m. The Rangal Coal Measures comprise light grey, cross-bedded, fine to medium grained labile and well cemented sandstones, grey siltstones, mudstones, shale and coal seams. The non-coal portions of the sequence being predominantly sandstones, siltstones, mudstone and shales are referred to as interburden in the mining context.

The Leichhardt Seam is highly weathered where it occurs at subcrop near the surface. The Vermont Upper Seam is separated from the overlying Leichhardt Seam by interburden material ranging in thickness up to 90 m. The interburden between the Leichhardt and Vermont Seams consist primarily of sandstone, with some mudstone and siltstone.

3.2.3 Back Creek Group

The Back Creek Group underlies the Blackwater Group in the SRM Area and lies at outcrop immediately to the west of SRM. The consolidated fine-grained clastic sedimentary rocks that comprise this unit (sandstone, siltstone, shale and minor coal) are considered a semi-pervious confining lower boundary for groundwater flow in the overlying Blackwater Group units (i.e. a regional-scale aquitard) (Arrow Energy, 2012). As such, the unit can be regarded as hydrogeological basement and for the purposes of this hydrogeology assessment does not require further consideration.

3.2.4 Structural Geology

The Bowen Basin was subject to significant tectonic compression from the eastern side at the end of coal deposition in the late Triassic. The compression from the eastern side caused major thrust faulting, which resulted in the commercial viability of mining the coal deposits across the region. SRM is located within the regional Western Foreland structural domain of the Bowen Basin, located approximately 20km west of the Jellinbah Fault Zone. Fault throws up to and exceeding 100 m are associated with these regional scale structural features.

All units of the Permian sequence generally dip from west to east at an average of 4 degrees in the vicinity of SRM, steepening to 9 degrees on the eastern margin of MLA 70383 (AGE, 2011) towards the axis of a local syncline that is truncated by the north-south trending Isaac Thrust Fault.

Faults at SRM strike north to south, east to west and northeast and are associated with two dominant structural domains: one trends north north-west, the second trends north-south (AECOM, 2019). The majority of these faults are normal faults with maximum throws of 60 m (BHP, 2019), however there is no indication of any marked disruption of the coal measures because of faulting in the vicinity of the Jacaranda, Bauhinia, Coolibah and Dogwood pits in the northern and central parts of the SRM Area (AECOM, 2019). Some monocline structures are located within SRM that affect some coal seams. Major faults (considered where displacement is greater than 10m) are spatially wide spaced between 1 km to 5 km, with localised steepening around these structures (AGE, 2011). Three such structures are mapped in the southern part of the SRM Area, in the vicinity of the Ebony, Grevillea and Hakea pits (**Figure 3-2**).

4 Hydrogeology

Based on the understanding of the geological setting presented in **Section 3**, the hydrogeological regime relevant to SRM comprises the following key hydrogeological units:

- Cainozoic sediments:
 - Quaternary alluvium – unconfined aquifer (sporadically water-bearing strata of permeable unconsolidated sand or gravel) localised at and near to SRM along Hughes Creek, One Mile Creek and Phillips Creek, and regionally along the Isaac River where it is particularly well developed;
 - Quaternary to Tertiary non-alluvial sediments and weathered units (collectively termed ‘regolith’ in many recent relevant regional studies) – unconfined unit with limited saturation at SRM and in the Study Area.
- Permian coal measures with:
 - Low permeability interburden units with aquitard properties; and
 - Coal seams that exhibit water bearing properties associated with secondary porosity through cracks and fissures.

The coal seams within the Moranbah Coal Measures are the primary aquifer at SRM. The coal seams can be characterised as confined aquifers, with the Q Seam, P Seam, H Seam and D Seam forming the main aquifer units locally. The Moranbah Coal Measures overburden and interburden act as aquitards and are typically dry, or very low yielding.

This section discusses each of the hydrogeological units relevant to SRM, covering hydraulic properties, groundwater occurrence, hydraulic gradients, recharge, discharge, groundwater quality, and water use.

4.1 SRM Groundwater Monitoring

The SRM groundwater monitoring network comprises a total of 45 monitoring sites consisting of 36 monitoring bores (29 active and seven decommissioned) and three Vibrating Wire Piezometer (VWP) arrays (**Table 4-1** and **Table 4-2**).

The monitoring network was established in 2011 as part of the SEMLP approvals study (AGE, 2011), and expanded further in 2018 (AGE, 2018), 2019 (SRK, 2019), 2020 (GHD, 2020) and 2021 (BHP, 2021) in the context of supporting further environmental approvals, including for the SEMLP. The network’s monitoring bores intersect a range of hydrostratigraphic units, including:

- Quaternary Alluvium (17 monitoring bores);
- Fill material (two monitoring bores);
- Tertiary sediments (including regolith) (13 monitoring bores);
- Fort Cooper Coal Measures (four monitoring bores);
- the R seam of the Moranbah Coal Measures (one monitoring bore);
- the Q seam of the Moranbah Coal Measures (one monitoring bore);
- the P Seam of the Moranbah Coal Measures (three monitoring bores and two VWP sensor);
- the H Seam of the Moranbah Coal Measures (five monitoring bores and three VWP sensors);

-
- the D seam of the Moranbah Coal Measures (six monitoring bores and three VWP sensors);
 - interburden of the Moranbah Coal Measures (three monitoring bores); and
 - Back Creek Group (two monitoring bores).

Groundwater data collection from the groundwater monitoring network has been undertaken since 2008. The locations of the current monitoring network are shown in **Figure 4-1** and details provided in **Table 4-1**.

Table 4-1 SRM Groundwater Monitoring Network – Standpipe Bores

Bore ID	Easting (GDA94)	Northing (GDA94)	Surface Elevation (mAHD)	Screen Top Elevation (mAHD)	Screen Base Elevation (mAHD)	Monitored Unit	Install Date	Status	Water Level Data Availability	Water Quality Data Availability
MB31 (SJ1)	626056	7522741	225	Unknown	180.81 (TD elevation)	BCG – Coal Seam (unknown)	Unknown - unregistered	Existing, monitored	2014 to 2023	2009 to 2023
MB32 (TG2)	637709	7510897	208.1	Unknown	188.61 (TD elevation)	Alluvium	Unknown - unregistered	Existing, monitored	2014 to 2023	2009 to 2023
MB 33 (RN158014)	636754	7520380	194.8	164.8	158.8	Q Seam Group	Mar-12	Existing, monitored	2014 to 2023	2013 to 2023
MB34 (RN158013)	638040	7518450	195.9	96.4	90.4	P Seam Group	Sep-12	Existing, monitored	2014 to 2023	2013 to 2023
MB35 (RN158010)	642760	7520291	184.6	157.6	151.6	FCCM	Aug-12	Existing, monitored	2014 to 2023	2013 to 2023
MB36 (RN158011)	640264	7514464	197.8	173.3	167.3	FCCM	Jun-12	Existing, monitored	2014 to 2023	2013 to 2023
MB37	632503	7515752	234.8	200.8	192.3	BCG - Interburden	Jun-12	Existing, monitored	2014 to 2023	2013 to 2023
MB38 / MB19SRM01A (RN169276)	640146	7516041	194.3	188.8	185.8	Alluvium	Jul-19	Existing, monitored	2019 to 2023 (dry)	Dry
MB39 / MB19SRM03P (RN169277)	640132	7516057	194.3	110	103.8	R Seam Group	Jul-19	Existing, monitored	2019 to 2023	2019 to 2023

Bore ID	Easting (GDA94)	Northing (GDA94)	Surface Elevation (mAHD)	Screen Top Elevation (mAHD)	Screen Base Elevation (mAHD)	Monitored Unit	Install Date	Status	Water Level Data Availability	Water Quality Data Availability
MB40 / MB19SRM02T (RN169278)	640140	7516048	194.4	180.4	174.4	Tertiary	Jul-19	Existing, monitored	2019 to 2023	2019 to 2023
MB19SRM04P	637174	7511222	208.7	172.7	166.7	MCM – Interburden (sandstone)	Aug-19	Existing, monitored	2019 to 2023	2019 to 2023
MB20SRM01A	636036	7527845	194.4	178.6	175.6	Alluvium	Oct-19	Existing, monitored	None	None
MB20SRM02T	636028	7527850	207.9	158.6	149.6	Fort Cooper Coal Measures	Oct-19	Existing, monitored	2019 to 2023	2019 to 2023
PZ00C	632985	7529934	186.74	161.7	158.7	Tertiary	Sep-18	Existing, monitored	2019 to 2023	2019 to 2023
PZ00D	631798	7530369	192.29	169.8	163.8	MCM Interburden - Sandstone	Sep-18	Existing, monitored	2019 to 2023	2019 to 2023
2013MP06	630572	7524303	203.7	202.2	193.7	Alluvium	Jul-05	Existing, monitored	2019 to 2023	2019 to 2023
2016BH05	631368	7524314	208.8	200.8	197.8	Fill	2016	Existing, monitored	2019 to 2023	2019 to 2023
2016BH08	631302	7523893	207	193	190	Fill	2016	Existing, monitored	2019 to 2023	2019 to 2023
2019MP01_D	630680	7524322	209.6	196	192.6	Alluvium	May-19	Existing, monitored	2019 to 2023	2019 to 2023

Bore ID	Easting (GDA94)	Northing (GDA94)	Surface Elevation (mAHD)	Screen Top Elevation (mAHD)	Screen Base Elevation (mAHD)	Monitored Unit	Install Date	Status	Water Level Data Availability	Water Quality Data Availability
2019MP02_D	630690	7524282	209.3	196.1	192.3	Alluvium	May-19	Existing, monitored	2019 to 2023	2019 to 2023
2019MP03_D	630685	7524258	209.1	198.1	195.1	Alluvium	May-19	Existing, monitored	2019 to 2023	2019 to 2023
2019MP04_D	630700	7524177	208.6	196.6	190.6	Alluvium	May-19	Existing, monitored	2019 to 2023	2019 to 2023
2019MP05_D	630649	7524297	209.9	196.4	188.9	Alluvium	May-19	Existing, monitored	2019 to 2023	2019 to 2023
2019MP06	630637	7524452	209.3	196.8	194.3	Alluvium	May-19	Existing, monitored	2019 to 2023	2019 to 2023
2019MP07	630747	7524080	206.2	197.7	194.7	Alluvium	May-19	Existing, monitored	2019 to 2023	2019 to 2023
2019MP07_D	630587	7524531	208.9	196.4	192.4	Alluvium	May-19	Existing, monitored	2019 to 2023	2019 to 2023
2019MP08	630551	7524025	201.6	198.6	189.6	BCG - Overburden (siltstone)	May-19	Existing, monitored	2019 to 2023	2019 to 2023
2019MP09	630371	7524311	200.6	197.1	195.1	Alluvium	May-19	Existing, monitored	2019 to 2023	2019 to 2023
2019MP10	630471	7524455	203.7	198.2	194.7	Alluvium	May-19	Existing, monitored	2019 to 2023	2019 to 2023
2022EW01	630680	7524274	209.20	190.20	184.20	Fill / Alluvium	Oct-22	Existing, not actively monitored	None	None

Bore ID	Easting (GDA94)	Northing (GDA94)	Surface Elevation (mAHD)	Screen Top Elevation (mAHD)	Screen Base Elevation (mAHD)	Monitored Unit	Install Date	Status	Water Level Data Availability	Water Quality Data Availability
2022EW02	630690	7524258	209.03	196.03	190.03	Fill / Alluvium	Oct-22	Existing, not actively monitored	None	None
2022EW03	630696	7524233	209.1	201.1	192.1	Fill / Alluvium	Oct-22	Existing, not actively monitored	None	None
2022EW04	630704	7524189	208.82	197.82	191.82	Fill / Alluvium	Oct-22	Existing, not actively monitored	None	None
2022EW05	630712	7524135	206.95	196.95	190.95	Fill / Alluvium	Oct-22	Existing, not actively monitored	None	None
2022EW06	630710	7524104	205.62	196.62	190.62	Fill / Alluvium	Oct-22	Existing, not actively monitored	None	None
2022EW07	630711	7524084	205.5	197.5	193.5	Fill / Alluvium	Oct-22	Existing, not actively monitored	None	None
2022MP01	630668	7524273	209.4	199.4	193.4	Fill / Alluvium	Oct-22	Existing, monitored	2022 to 2023	2022 to 2023
2022MP02	630664	7524214	208.6	199.6	193.6	Fill / Alluvium	Oct-22	Existing, monitored	2022 to 2023	2022 to 2023
2022MP03	630684	7524173	207.76	196.76	193.76	Fill / Alluvium	Oct-22	Existing, monitored	2022 to 2023	2022 to 2023

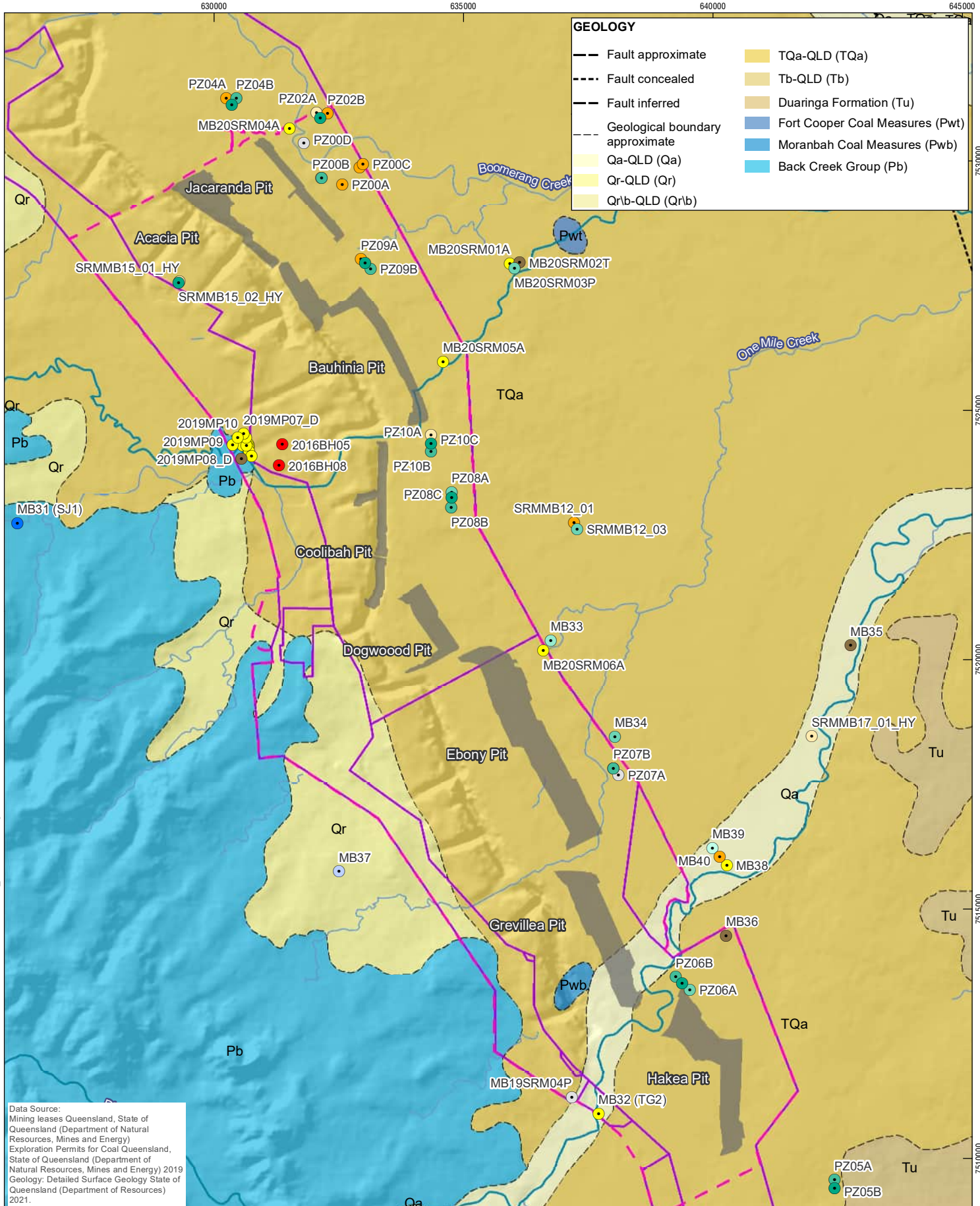
Bore ID	Easting (GDA94)	Northing (GDA94)	Surface Elevation (mAHD)	Screen Top Elevation (mAHD)	Screen Base Elevation (mAHD)	Monitored Unit	Install Date	Status	Water Level Data Availability	Water Quality Data Availability
2022MP04	630691	7524290	209.58	190.58	184.58	Fill / Alluvium	Oct-22	Existing, monitored	2022 to 2023	2022 to 2023
2022MP05	630698	7524223	209.26	197.26	194.26	Fill / Alluvium	Oct-22	Existing, monitored	2022 to 2023	2022 to 2023
2022MP06	630695	7524109	205.83	198.83	195.83	Fill / Alluvium	Oct-22	Existing, monitored	2022 to 2023	2022 to 2023
PZ02A	632133	7530855	200.8	176.8	170.8	Regolith	Jun-11	Existing, not actively monitored	2011 to 2012	None
PZ02B	632133	7530855	200.8	45.8	39.8	MCM Interburden - Sandstone	Jun-11	Existing, not actively monitored	2011 to 2012	None
PZ02C	632133	7530855	200.8	-68.2	-74.2	D Seam Group	Jun-11	Existing, not actively monitored	2011 to 2012	None
PZ04A	630356	7531133	209.9	190.9	184.9	Tertiary - Regolith	Jun-11	Existing, not actively monitored	2011 to 2012	None
PZ04B	630356	7531133	209.9	157.9	153.9	H Seam Group	Jun-11	Existing, not actively monitored	2011 to 2012	None
PZ04C	630356	7531133	209.9	53.9	35.9	D Seam Group	Jun-11	Existing, not actively monitored	2011 to 2012	None

Bore ID	Easting (GDA94)	Northing (GDA94)	Surface Elevation (mAHD)	Screen Top Elevation (mAHD)	Screen Base Elevation (mAHD)	Monitored Unit	Install Date	Status	Water Level Data Availability	Water Quality Data Availability
PZ07A	637999	7517817	196.9	188.9	185.9	Tertiary - Claystone	Jun-11	Existing, not actively monitored	None	None
PZ07B	637999	7517817	196.9	12.9	0.9	MCM – Interburden (Sandstone)	Jun-11	Existing, not actively monitored	None	None
PZ07C	637999	7517817	196.9			H Seam Group	Jun-11	Existing, not actively monitored	None	None
PZ09A	633026	7527959	198.24			Tertiary	Jun-11	Existing, not actively monitored	2011 to 2012	None
PZ09B	633026	7527959	198.24	129.2	123.2	H Seam Group	Jun-11	Existing, not actively monitored	2011 to 2012	None
PZ09C	633026	7527959	198.24	24.2	16.2	D Seam Group	Jun-11	Existing, not actively monitored	2011 to 2012	None
PZ10A	634350	7524345	209.62			Tertiary - Regolith	Jun-11	Existing, not actively monitored	2011 to 2012	None
PZ10B	634350	7524345	209.62	156.6	150.6	H Seam Group	Jun-11	Existing, not actively monitored	2011 to 2012	None

Bore ID	Easting (GDA94)	Northing (GDA94)	Surface Elevation (mAHD)	Screen Top Elevation (mAHD)	Screen Base Elevation (mAHD)	Monitored Unit	Install Date	Status	Water Level Data Availability	Water Quality Data Availability
PZ10C	634350	7524345	209.62	50.6	44.6	D Seam Group	Jun-11	Existing, not actively monitored	2011 to 2012	None

Table 4-2 SRM Groundwater Monitoring Network - VWP's

VWP ID	Easting (GDA94)	Northing (GDA94)	Surface Elevation (mAHD)	Total Depth (m bgl)	Sensor Depth (m bgl)	Sensor Elevation (mAHD)	Monitored Unit	Install Date
PZ05	642441	7509401	197.2	303	203	-5.8	H Seam Group	June 2011
					239	-41.8	D Seam Group	June 2011
PZ06	639385	7513506	203.4	199	40.5	162.9	P Seam Group	June 2011
					78.5	124.9	H Seam Group	June 2011
					167	36.4	D Seam Group	June 2011
PZ08	634761	7523250	205.2	189	38.5	166.7	P Seam Group	June 2011
					65	140.2	H Seam Group	June 2011
					180	25.2	D Seam Group	June 2011



0 1 2 km

Coordinate System: GDA 1994 MGA Zone 55

Scale: 1:100,000 at A4

Project Number: 620.30984

Date: 27-Oct-2022

Drawn by: NT



SARAJI MINE TRANSITIONAL PRC PLAN HYDROGEOLOGY ASSESSMENT

SRM GROUNDWATER MONITORING NETWORK

FIGURE 4-1

4.2 Hydraulic Properties

SRM groundwater hydraulic testing includes slug (rising and falling head) tests, packer tests and stress and permeability tests performed on monitoring network bores completed in 2011 (AGE, 2011) and 2020 (GHD, 2020 and BHP, 2020). This section presents a summary of the available field hydraulic data and comparison to reported hydraulic properties within external sources that BMA has access to through its regional data sharing agreement.

4.2.1 Hydraulic Data

The database of available field results for horizontal (K_h) and vertical (K_v) hydraulic conductivity is presented graphically as **Figure 4-2**. Tests from the SRM Area are provided as a separate classification on the plot. The data are also presented separately for each test method as results can vary based on the type of testing and analysis undertaken.

Figure 4-2 shows that the hydraulic conductivity of the alluvium is variable, ranging from 1×10^{-2} to almost 10 metres per day (m/day), which reflects the heterogeneous nature of the alluvial sediments. Hydraulic testing of the alluvium within SRM also found hydraulic conductivity to be at the lower end of this scale, with values ranging from 0.16 m/day to 8.64 m/day. Pumping tests of the Isaac River alluvium conducted in 2019 as part of the Moorvale South Project assessment reported hydraulic conductivity values in the range of 2.1 – 2.7 m/day, which is in the range of values provided by slug testing conducted across the Study Area.

The coal seams of the Permian coal measures generally record higher hydraulic conductivity than the majority of the interburden/overburden. This is due to the dual porosity of the coal seams, with a primary matrix porosity and a second (dominant) porosity provided by fractures (joints and cleats), which supports the concept of the coal seams themselves forming the dominant groundwater zones of the Permian units.

Slug tests, packer tests and stress and permeability tests were performed in 2011 on SRM monitoring bores targeting the H and D coal seams of the Moranbah Coal Measures. Testing of the P and Q coal seams was not undertaken at SRM during 2011. Hydraulic testing has been completed for the P and Q Seam at CVM to the north of SRM, with the results believed to be representative of these coal seams in the general area.

The testing from both SRM and CVM reported the following horizontal hydraulic conductivities (K_h) ranges (in order of increasing depth) (**Figure 4-2**).

- 0.26 – 0.33 m/day for the Q Seam (SLR, 2021);
- 0.024 – 0.16 m/day for the P Seam (SLR, 2021);
- 0.007 – 0.39 m/day for the H Seam; and
- 0.01 – 0.023 m/day for the D Seams

Interburden/overburden testing shows a hydraulic conductivity of at least an order of magnitude less than that of coal seams at similar depths, typically less than 10^{-4} m/day. **Figure 4-2** also shows that the hydraulic conductivity of the Permian coal measures generally declines with depth, due to increasing overburden pressure reducing the aperture of secondary porosity features.

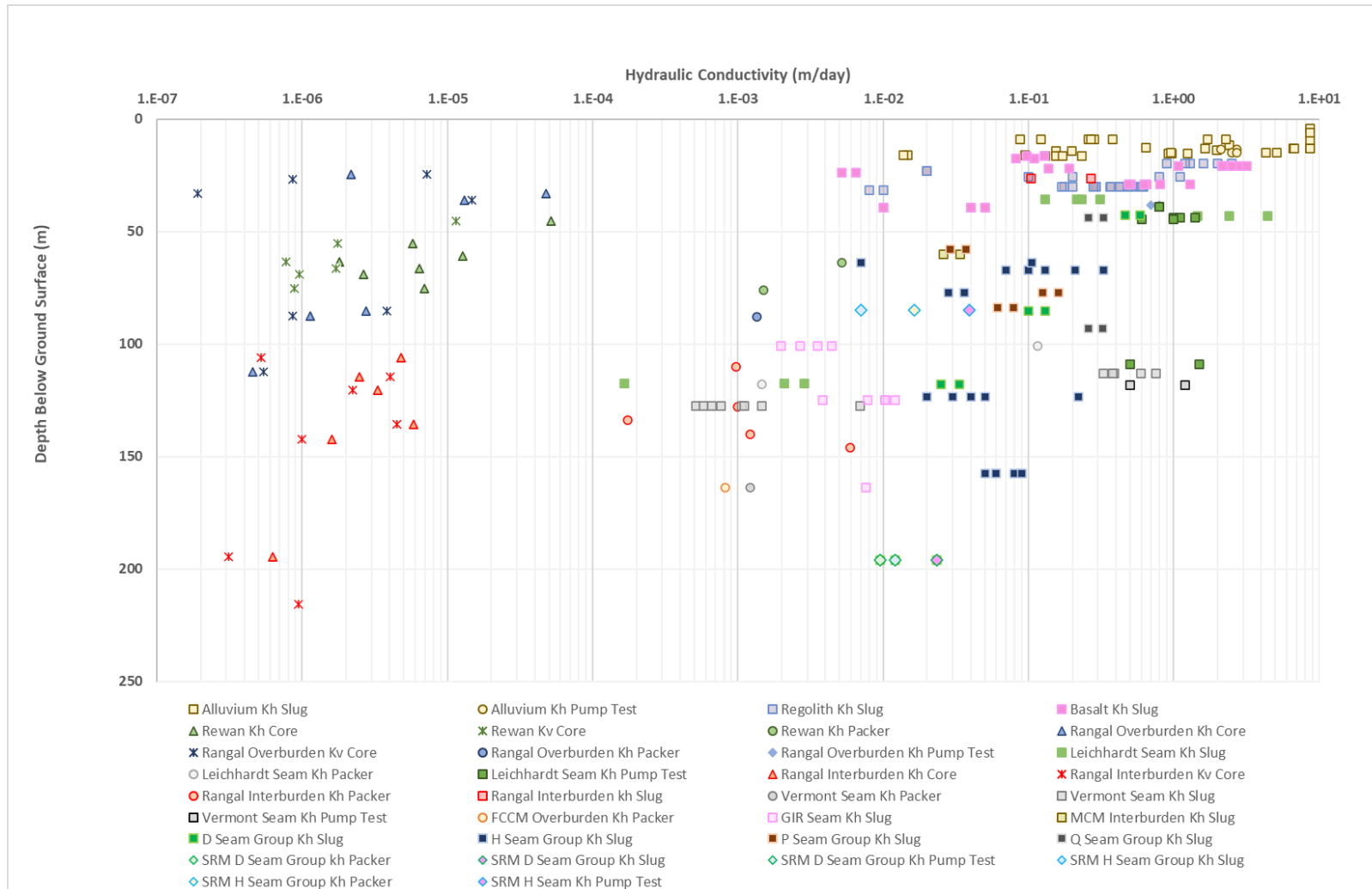


Figure 4-2 Summary Results for all Hydraulic Testing

4.2.2 Hydraulic Conductivity Ranges

A histogram of the spread of horizontal hydraulic conductivity (Kh) from the field testing at SRM, as well as at other nearby sites, is presented in **Figure 4-3**. The results are compared to the range of documented values for each relevant units as presented within a literature review previously completed by HydroSimulations (2018) based on a number of other studies within the Bowen Basin.

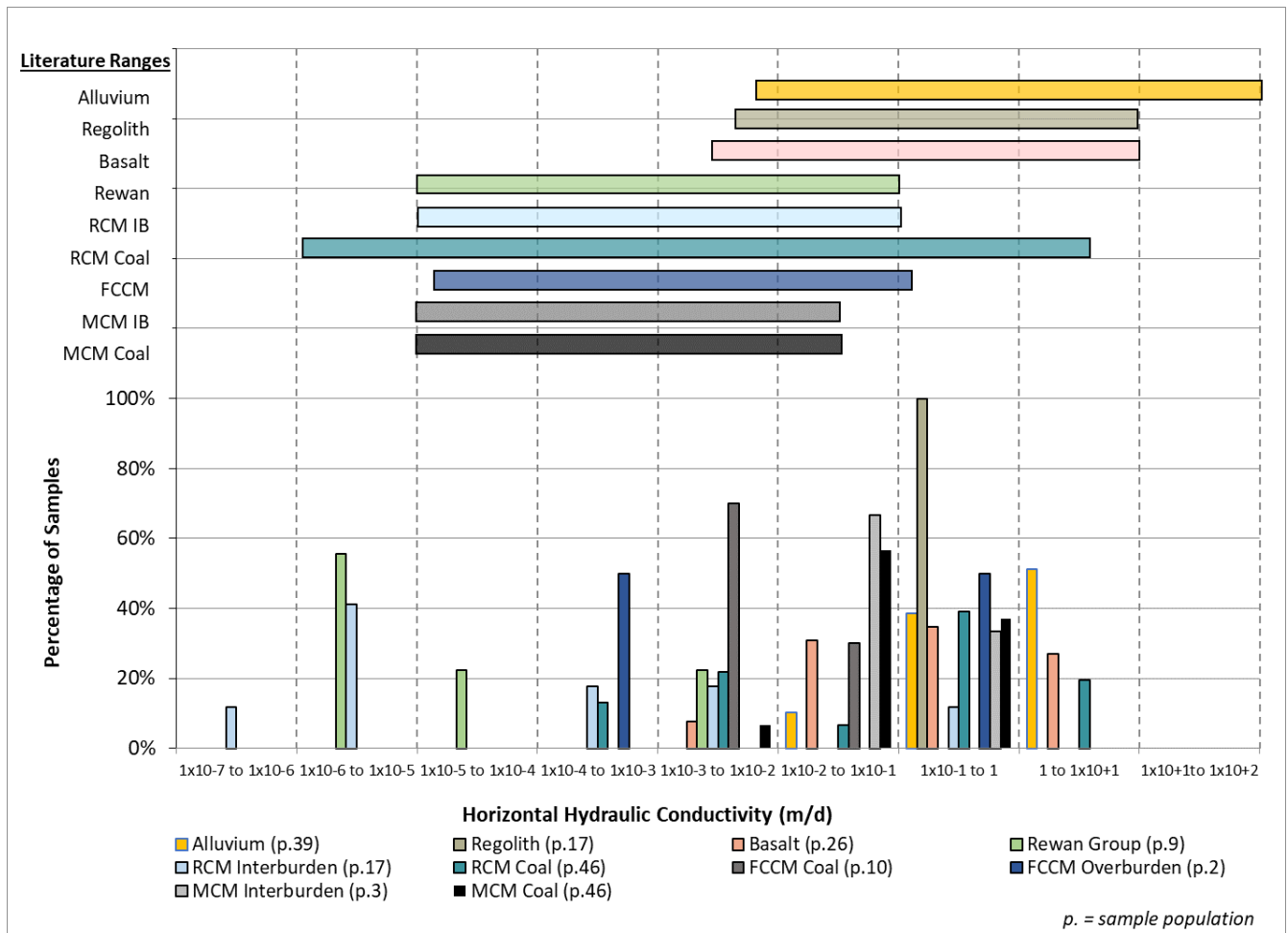


Figure 4-3 Histogram of Horizontal Hydraulic Conductivity Distribution

The comparison shows that the field results for alluvium, Tertiary sediments, Rangal Coal Measures and Fort Cooper Coal Measures within the Study Area and immediate surrounds fall within the range of field data collected through other studies across the Bowen Basin. Results for the Moranbah Coal Measures from the SRM Area recorded higher readings than previously identified in literature. Review of **Figure 4-2** shows that within the Moranbah Coal Measures the higher readings are attributed to the H seam where hydraulic conductivities are generally an order of magnitude greater than measured within the Q, P and D coal seams. As discussed in **Section 3.2.1.1** the H seam is generally thicker than the other seams, which may result in wider cleats and fissures within the unit. It should be noted that the type of testing undertaken at CVM (i.e. slug testing) typically yields hydraulic conductivity estimates limited to the bore scale, whereas the regional dataset (**Figure 4-2**) includes estimates derived from pumping tests that are considered more representative of aquifer-scale properties.

4.2.3 Faulting

As discussed in **Section 3.2.2.2**, significant faulting is not present at SRM, however extensive faulting has been mapped within the Permian coal measures east of SRM (see **Figure 3-2**). As identified by Jourde et al. (2002), faulting can result in higher permeabilities within strata parallel with the fault plane, and lower permeabilities within strata perpendicular to the fault plane. However, this can also be dependent on whether faults are currently active (Paul et al., 2009). Faulting has been inactive within the Bowen Basin for over 140 million years (Clark et al., 2011), indicating that the fault zones are less likely to act as conduits to flow; this relates to filling of the fractured pore spaces over time through hydrothermal alteration and mineralisation (Uysal et al., 2000). Drill core logs from within the Study Area show that where fractures and faults have been geologically logged, many fractures are “healed” with calcite and siderite. This indicates that although the system contains a fracture network, many of the existing fractures are cemented, which reduces the effective permeability of the fracture when compared to any open fracture network.

Downhole hydraulic testing was conducted in the Permian coal measures for the Winchester South Project east of SRM (SLR, 2020). Fault zones were confirmed to be intersected at these drill holes due to the presence of fracturing, calcite infills, and slickensides in core obtained from the drill holes, all of which are considered an indicative marker of faulting. Testing results showed relatively low hydraulic conductivity values ranging from 6.93×10^{-5} to 2.07×10^{-3} m/day, and in line with those presented in **Figure 4-4**. These properties indicate that the faulting zones intercepted and tested are ‘healed’ and not pathways for preferential groundwater flow.

Laboratory geotechnical analysis completed on core samples of interburden immediately above and below coal seams proximal to a fault zone has previously been undertaken in support of groundwater assessments in the Study Area (SLR, 2021). The samples recorded vertical hydraulic conductivity of 50% to 160% of horizontal hydraulic conductivity; i.e., although some samples show a typical K_v of somewhat less than K_h , some samples also suggest greater K_v than K_h which may be indicative of preferential vertical flow pathways associated with faulting. However, it was also noted that these areas of increased K_v are limited vertically, with samples collected from the same drill hole at horizons further above and below the fault zone (interburden and Rewan Group) returning a lower K_v of between 11% and 76% of K_h . This highlights the limitations of bore scale test methods (such as core or slug testing) that may bias results compared to methods that yield more aquifer scale estimates of hydraulic properties, such as pumping tests.

The impact of faults on groundwater flow within the Study Area was also assessed as part of the Bowen Gas Project (Arrow Energy, 2012). Kinnon (2010) assessed the movement of water and gas across a series of faults in the Bowen Basin using stable isotope and water quality analysis to assess zones of potential recharge, water mixing and flow pathways. Higher gas production rates were also observed on either side of a major fault, with differences in isotopic compositions of produced water for wells north and south of the major fault line at similar depths, implying little communication across the fault boundary, and suggesting that the fault acts as a horizontal permeability barrier to water and gas flow. The results of the study showed that compartmentalisation was evident and that this was due to the structural geology (faulting) in the basin.

Based on a detailed literature review of the effect of faulting on groundwater flow, Coffey (2014) has developed a conceptual model for fault zone hydraulic characterisation in the Bowen Basin (**Figure 4-4**), largely based on Jourde et al. (2002) and Flodin et al. (2001). This conceptualisation provides a means of inferring hydraulic conductivities of the fault core and the fault damage zone from regional hydraulic conductivity, with the fault core typically one to three orders of magnitude lower conductivity than the regional host rock, and the damage zone approximately an order of magnitude higher.

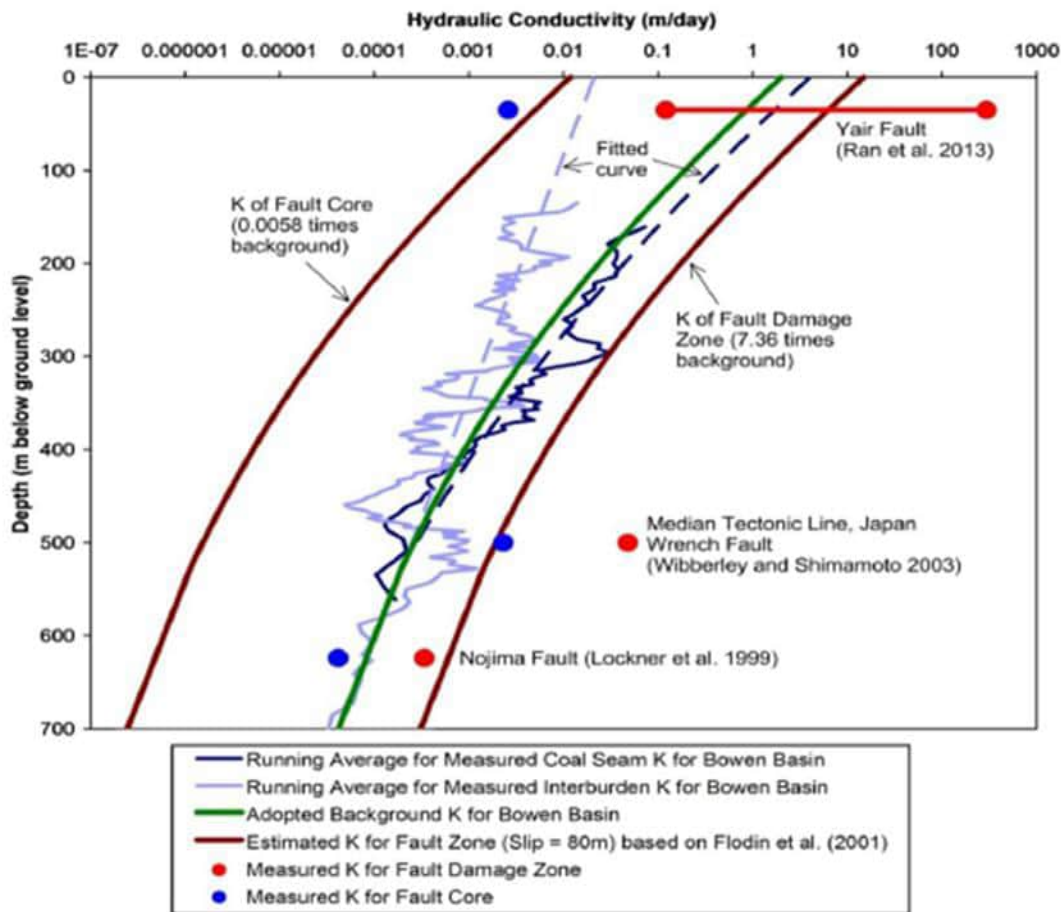


Figure 4-4 Faulting Conceptual Model Developed by Coffey (2014)

4.3 Groundwater Distribution, Flow, Recharge and Discharge

4.3.1 Quaternary Alluvium

4.3.1.1 Distribution and Flow

Due to the apparent heterogeneity and discontinuity of the Quaternary alluvium, pre-mining groundwater flow directions were not quantitatively assessed as part of the most recent relevant hydrogeological studies for SRM (AECOM, 2019). However, the groundwater flow direction in the vicinity of SRM, where the sediments were saturated, was qualitatively assessed at the time as likely to be topographically controlled, flowing from higher to lower elevations (AECOM, 2019), i.e. consistent with surface drainage patterns and representative of losing stream conditions. This is consistent with the outcomes of other recent relevant studies in the Study Area that have quantitatively assessed alluvial groundwater flow (e.g. SLR, 2021).

Alluvial groundwater levels have been monitored at 17 bores at SRM (refer to **Table 4-1** and **Figure 4-1**). The majority of available groundwater monitoring data for the alluvium relates to the area adjacent to Hughes Creek to the west of Bauhinia Pit (bore IDs prefixed by 2019MP). Additional monitoring data for the alluvium is attributed to EA compliance bores MB32 and MB38. MB32 was originally drilled for stock watering and was used for this purpose until 2007 (AECOM, 2019). Both MB32 and MB38 are interpreted to be screened within the Phillips Creek alluvium. MB32 is located upstream to the west of SRM and MB38 is located downstream of SRM, northeast of Grevillea Pit.

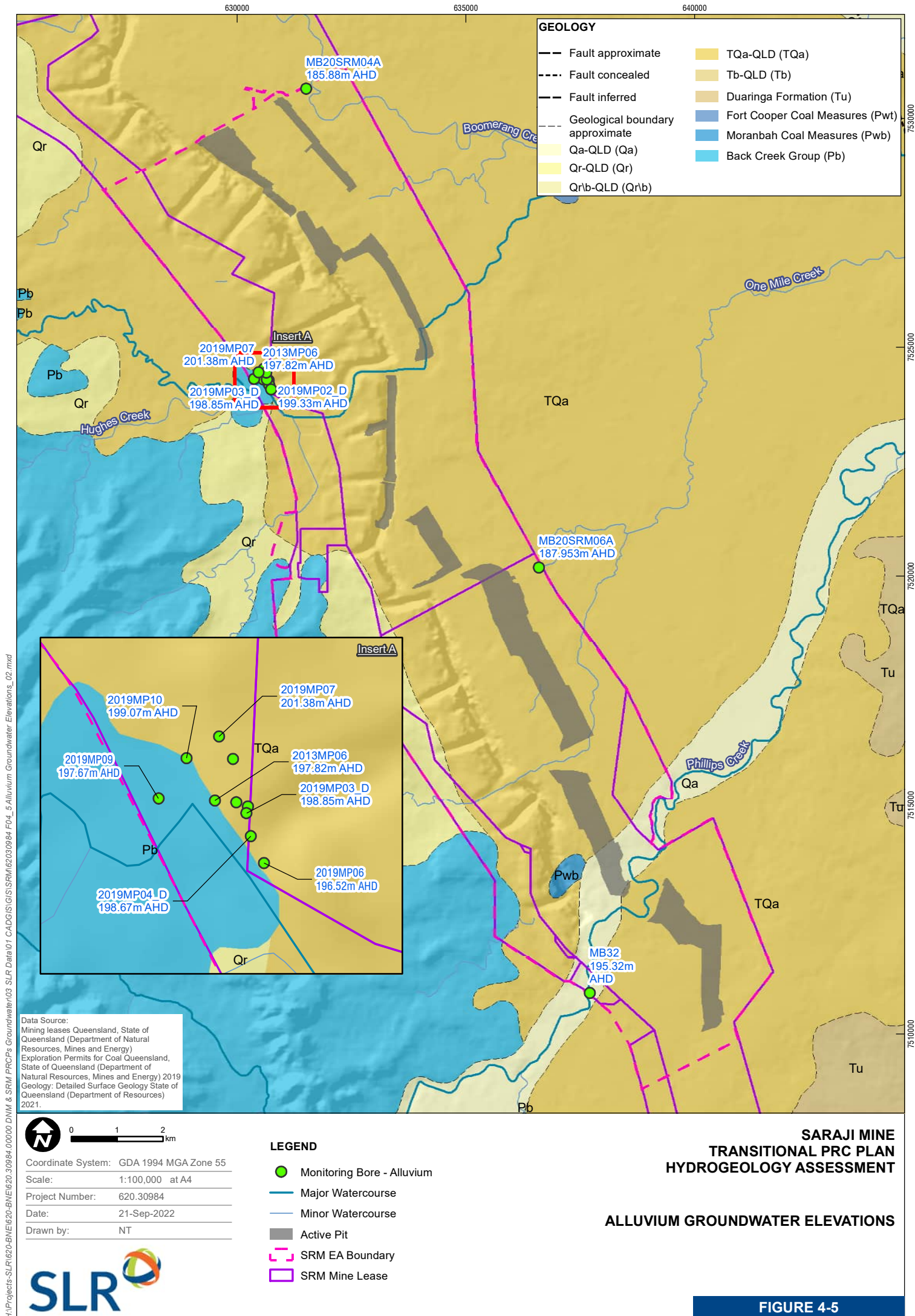
Additional alluvium monitoring bores installed downstream of SRM include MB20SRM01A and MB20SRM05A (located adjacent to Hughes Creek), MB20SRM04A (located adjacent to Boomerang Creek), and MB20SRM06A (located adjacent to One Mile Creek). Monitoring data for these bores is limited to records collected at the time of installation and development.

Available monitoring data shows groundwater elevations in the alluvium are approximately 195 mAHD to 203 mAHD. Groundwater elevations for bores within alluvium are displayed in **Figure 4-5**.

Records for drillholes that have intersected the Phillips Creek alluvium indicate that there is limited or no sustainable groundwater resources associated with the Phillips Creek alluvium (AECOM, 2019). Phillips Creek alluvium groundwater monitoring records are only available for a single bore that has found groundwater (MB32); the other bore installed into the Phillips Creek alluvium (MB38) is consistently reported as dry since installation in July 2019. Records for the MB32 bore date back to July 2014, and generally show groundwater levels between 196.4 and 201 mAHD (8.5 to 14.5 m below top of casing (mbTOC)). Monitoring data from MB32 is presented in **Figure 4-6**; the hydrograph shows a correlation between groundwater elevations and CDFM monthly rainfall indicating a strong climatic influence on water levels. Monitoring bore MB38 has consistently been reported as dry, and the bore depth is approximately 10m shallower than MB32. These results suggest that groundwater within the Phillips Creek alluvium may only be found in somewhat isolated deeper pockets of alluvium that are more deeply incised into the underlying strata, and that widespread groundwater does not exist within the full mapped extents of the Phillips Creek alluvium.

Records for the Hughes Creek alluvium monitoring bores generally date back to May 2019. Groundwater elevations for these bores have been found to range between 196.5 and 203 mAHD (across the monitoring bores this ranges from 3 to 11.5 mbTOC), however Hughes Creek alluvium monitoring bores MB20SRM01A and MB20SRM05A, located downstream of SRM, were both reported as dry during construction and development in late 2019. Monitoring data from the Hughes Creek alluvial monitoring bores is presented in **Figure 4-7**. The hydrograph shows that groundwater elevations generally decreased by 0.4m in the majority of bores between May 2019 and November 2020 corresponding to drier than average conditions. Increasing groundwater elevations corresponding to wetter than average climate conditions were observed between January 2020 and April 2020 and between November 2020 and March 2021. The correlation of these trends and fluctuations to CDFM rainfall are therefore indicative of climatic influences on alluvial groundwater levels.

Monitoring data shows a groundwater elevation of 185.9 mAHD from the Boomerang Creek bore MB20SRM04A (9.1 mbTOC) and 188 mAHD (5.65 mbTOC) from the One Mile Creek bore MB20SRM06A. Additional data following development of these bores was not available for analysis at the time of compiling this report and therefore they have not been considered further.



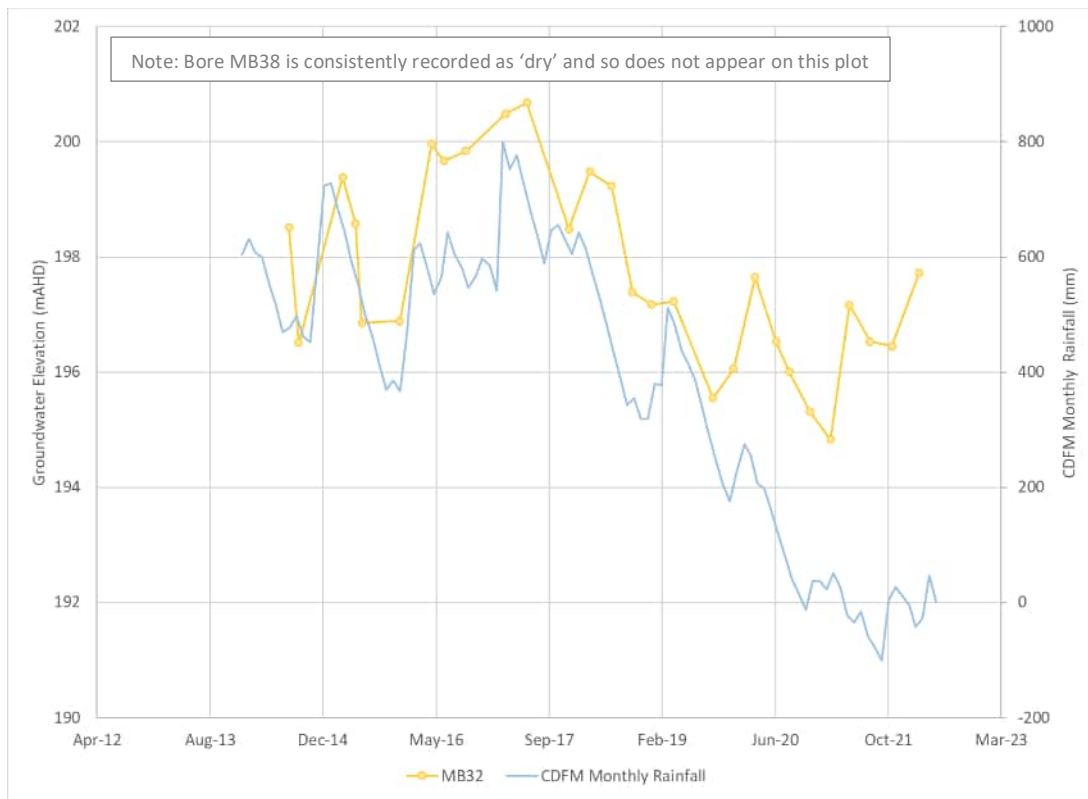


Figure 4-6 Hydrograph of Alluvial Groundwater Trends – Phillips Creek Monitoring Bore

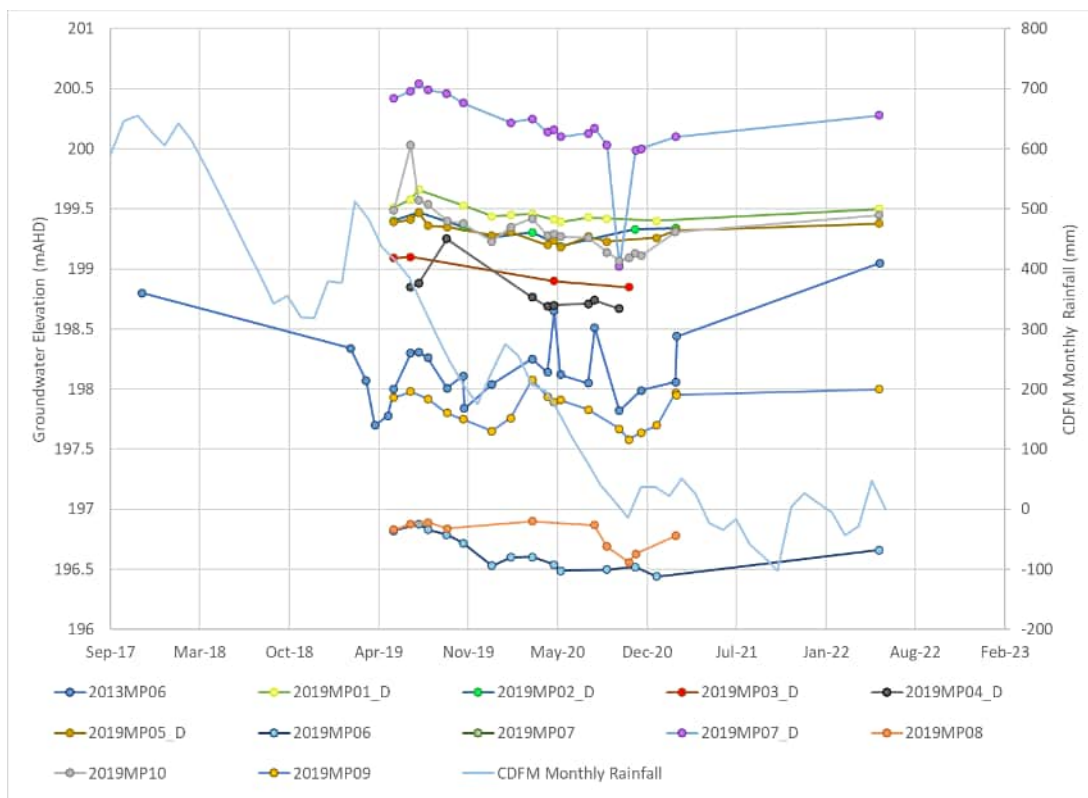


Figure 4-7 Hydrograph of Alluvial Groundwater Trends – Hughes Creek Monitoring Bores

4.3.1.2 Recharge and Discharge

Recharge to the alluvium is considered to be mostly from stream flow or flooding (losing streams), with direct infiltration of rainfall also occurring where there are no substantial clay barriers in the shallow subsurface. Short term monitoring data available for monitoring bores MB32 shows a response in groundwater elevations with climate. A subdued response is also shown in the Hughes Creek Monitoring Bores (**Figure 4-6**). As shown in **Figure 4-6** groundwater levels generally decline during drier than average conditions before showing slight recovery in response to wetter than average conditions experienced at the start of 2021. The limited response to rainfall trends may relate to the presence of surficial clays restricting groundwater recharge, as discussed in **Section 3.2**, or that rainfall was not sufficient to wet the unsaturated zone within the alluvium above the water table as well as providing vertical groundwater flow towards the water table.

Recharge rates were estimated using chloride mass balance (CMB) calculations by SLR (2021). The CMB calculations were based on available water quality results (chloride concentrations) collected from the monitoring bores at CVM and other monitoring bores within the broader Study Area. Using the CMB method recharge rates for the various alluvium units in the Study Area were calculated:

- Isaac River Channel Alluvium – 3 mm/yr
- Isaac River Flood Plain Alluvium – 1.3 mm/yr
- Other alluvium – 1.3 mm/yr

Groundwater within the alluvium is discharged as downstream throughflow, with some potential for evapotranspiration from deeper rooted riparian vegetation growing along water courses (particularly along the Isaac River) (**Section 4.5.2.1**), as well as potential baseflow contributions after significant rainfall and flood events. Groundwater within the alluvium is also discharged through the landholder use of bores in the region, particularly along the Isaac River (**Section 4.5.1.1**).

Geological logs in the Study Area indicate that the alluvium is underlain by low hydraulic conductivity stratigraphy (i.e., claystone, siltstone and sandstone), which restricts the rate of downward leakage to underlying formations. Localised perched water tables within the alluvium are evident where waterbodies continue to hold water throughout the dry period (e.g., pools in the Isaac River and floodplain wetlands) and occur where clay layers slow the percolation of surface water.

4.3.2 Tertiary Sediments

4.3.2.1 Distribution and Flow

Due to the apparent heterogeneity and discontinuity of the Tertiary sediments, pre-mining groundwater flow directions were not quantitatively assessed as part of the most recent relevant hydrogeological studies for SRM (AECOM, 2019). However, the groundwater flow direction (where the sediments were saturated) was qualitatively assessed at the time as likely to be topographically controlled, flowing from higher to lower elevations (AECOM, 2019), i.e., consistent with surface drainage patterns.

Tertiary sediments groundwater levels have been monitored at 11 bores at SRM (refer to **Table 4-1** and **Figure 4-1**). The majority of available groundwater monitoring data for the Tertiary sediments relates to EA compliance bore MB40 (collocated with MB38 to the northeast of Grevillea Pit) and PZ00A to PZ00C located adjacent to Jacaranda Pit. Additional monitoring data for the unit comes from PZ02A, PZ04A, PZ07A, PZ09A and PZ10A which were installed in 2011 to the east of SRM at points extending the entire strike of the mine (**Figure 4-1**). Monitoring data for these bores is limited to September 2011 to January 2012. An additional monitoring bore, SRMMB12_01, was installed within the Tertiary sediments to the east of Dogwood Pit in June 2021. Monitoring data is also limited for this bore.

Available monitoring data shows groundwater elevations in the Tertiary sediments are approximately 169 mAHD to 190 mAHD. Groundwater monitoring data available indicates groundwater levels across the Tertiary sediments to be generally greater than 17 mBGL.

2011 Tertiary sediment monitoring bores PZ09A and PZ10A were both drilled dry and the bores at the PZ07 site had to be removed due to construction issues. Groundwater elevations in PZ02A were initially reported at 181.8 mAHD (19 m BTOC) in August 2011, with the bore reported as dry in January 2012. Groundwater elevations in monitoring bore PZ04A fluctuated between 187.92 mAHD (21.99 mBTOC) and 189.61 mAHD (20.3 mBTOC) over the same period. AECOM (2019) reports that the 2011 Tertiary sediment monitoring bores generally became dry as a result of drawdown caused during routine sampling (AECOM, 2019). The lack of recharge following sampling therefore is believed to be indicative of limited sustainable yields for the Tertiary sediments.

Groundwater elevations for MB40 have gradually declined from 177.3 mAHD (17.15 mBTOC) in January 2020 to 176.6 mAHD in February 2022 (17.82 mBTOC). **Figure 4-8** shows that this decline correlates with drier than average conditions over this period, with slightly increases in elevations corresponding to wetter than average events. The slow rate of decline indicates a subdued climatic influence on groundwater levels at this location.

Groundwater elevations for the Tertiary sediment monitoring bores located near to Jacaranda Pit have remained relatively stable since installation ranging from 169.4 mAHD (24.1 mBTOC) in PZ00A to 175.8 mAHD (17 mBTOC) in PZ00D. Review of the hydrograph for these bores (**Figure 4-8**) shows that there does not appear to be any significant climatic influence on the groundwater levels at this location.

Although data is limited, groundwater flow within the Tertiary sediments is expected to be a subdued reflection of the topography, with flow from west to east towards the Isaac River (AECOM, 2019). This is consistent with the outcomes of other recent relevant studies in the Study Area (e.g. SLR, 2021).

This data shows variable groundwater levels both across the SRM Area and over time, with the Tertiary sediment monitoring bores generally becoming dry during the monitoring period (AGE, 2011). It is possible this could be a function of some of the monitoring bores being located in predominantly clayey sequences that respond very slowly to recharge following pumping and sampling. Stabilised Tertiary sediment aquifer water levels were only measured in bores PZ02A and PZ04A which ranged between 19.0m and 22.0m depth. Tertiary sediment groundwater levels in bores PZ09A and PZ10A were below the base of the Tertiary sediments and hence these monitoring bores have remained dry over the period of monitoring (AGE, 2011). It is considered the Tertiary sediment aquifer water levels would be about 20 mBGL within more porous sandy and gravelly type sediments (AGE, 2011).

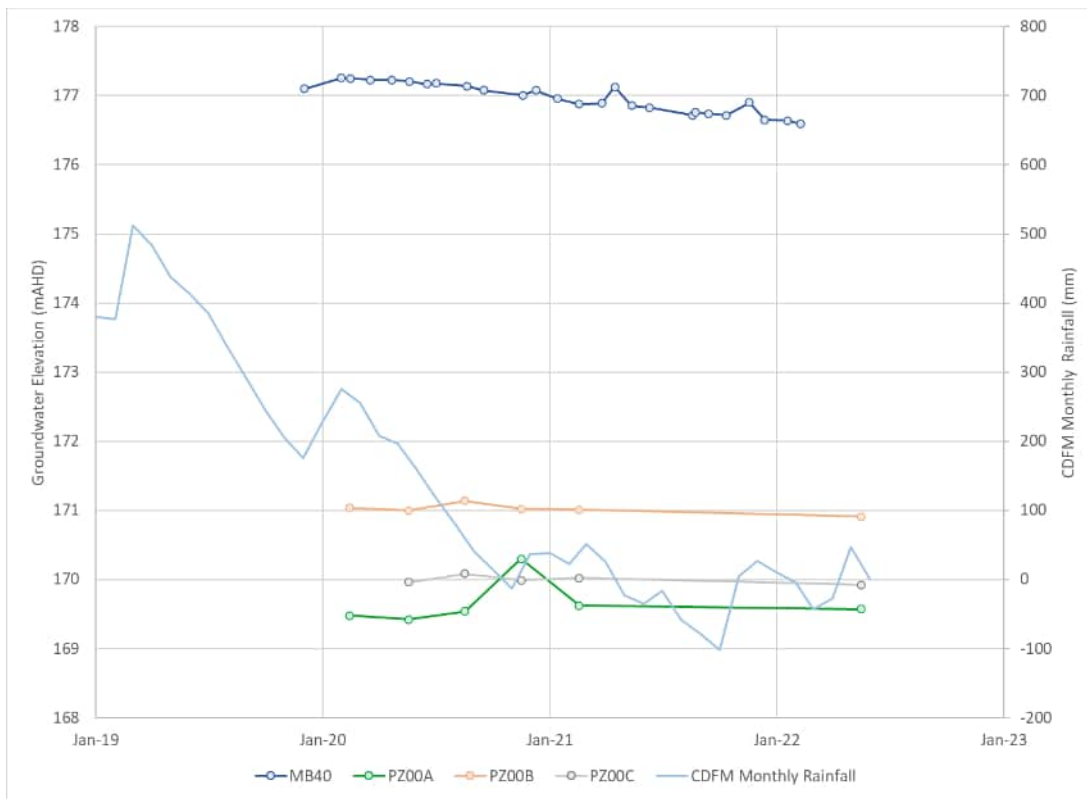


Figure 4-8 Hydrograph of Tertiary Groundwater Trends

4.3.2.2 Recharge and Discharge

Water within the Tertiary sediments, where saturated, occurs at depths of approximately 17 mBGL to 24 mBGL. As discussed in **Section 3.2.1.2**, the material comprises low hydraulic conductivity strata (i.e., clay and claystone), which restricts rainfall recharge. This is shown by the general limited response to climatic conditions in monitoring bores MB40, PZ00A, PZ00B and PZ00C. This is consistent with the outcomes of other recent relevant studies in the Study Area (e.g. SLR, 2020). This lack of response in monitoring bores within the Study Area may also be due to rainfall being insufficient to wet the unsaturated zone above the water table as well as providing vertical groundwater flow towards the water table.

Using the CMB method (refer **Section 4.3.1.2**) a recharge rate for the Tertiary sediments has been calculated as 0.1 mm/yr (SLR, 2021).

Groundwater discharge occurs primarily via evapotranspiration, with some baseflow to streams under wet climatic conditions. Vertical seepage through the Tertiary sediments is limited by the underlying low hydraulic conductivity of the Blackwater Group overburden and other aquitards such that the Tertiary sediments effectively form a perched groundwater system above the Permian strata.

4.3.3 Permian Coal Measures Coal Seams

4.3.3.1 Distribution and Flow

The coal seams of the Moranbah Coal Measures subcrop throughout the western portions of the SRM Area. Throughout the remainder of the SRM Area the coal seams underlie and subcrop beneath the surficial cover. Groundwater occurrence within the Permian coal measures is largely restricted to the more permeable coal seams that exhibit secondary porosity through fractures and cleats (**Section 4.2**). Regionally groundwater flow is to the east, consistent with local topography (AECOM, 2019). Differences in piezometric heads within the confined coal seam aquifers of the Moranbah Coal Measures drive groundwater flow eastwards across the Bowen Basin, from the slightly more elevated subcrop areas on the western flank of the Basin to the less elevated subcrop areas on the eastern flank (AECOM, 2019). However, mining activities throughout the region have created locally modified groundwater flow systems within the Permian coal measures that are superimposed on these regional flow gradients.

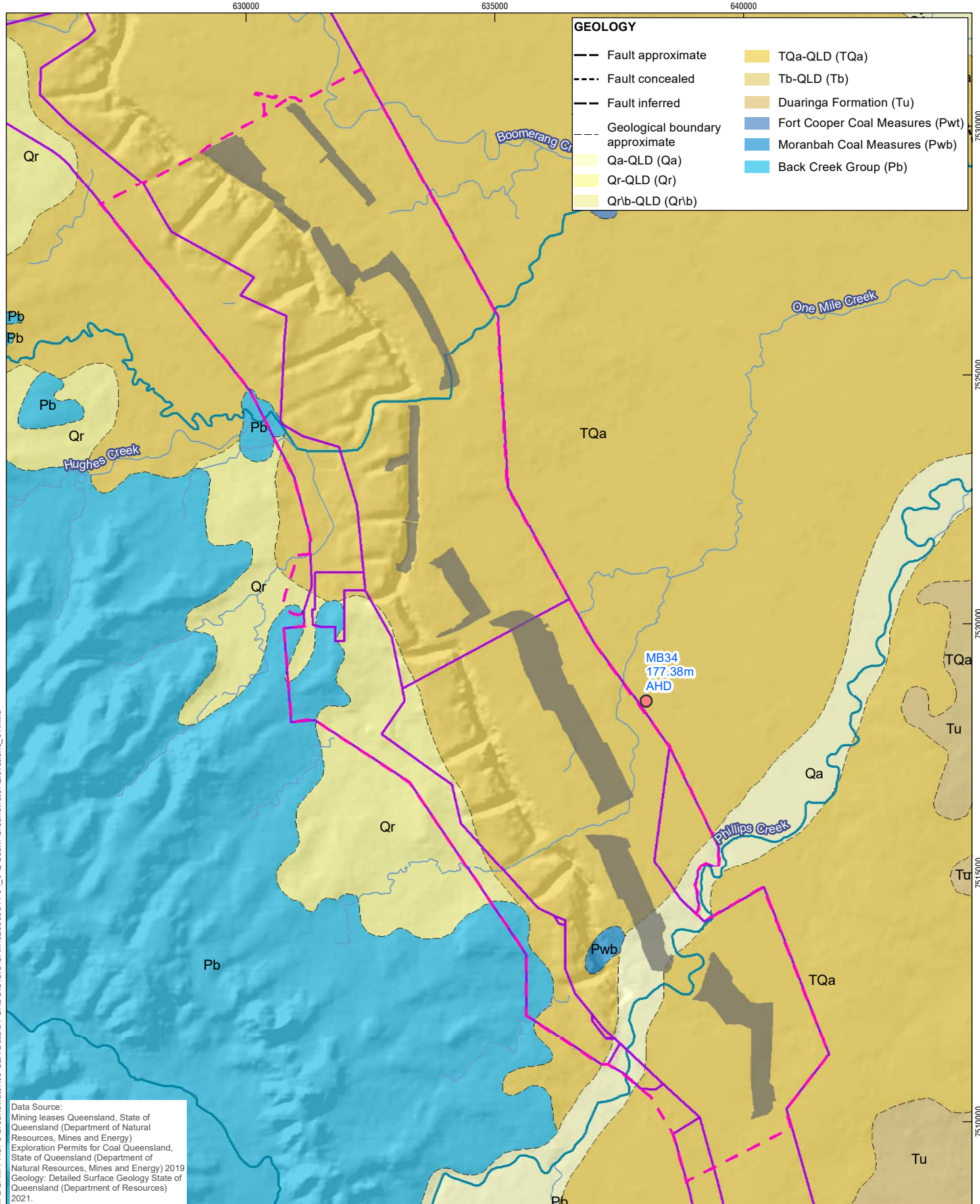
Mining at Saraji began in 1974, prior to consistent monitoring of groundwater being undertaken. Pre-mining potentiometric surface maps for the coal measures cannot be generated due to the absence of data for this period.

Active monitoring bores accessing the Permian coal seams within SRM are restricted to the R and Q seams of the Moranbah Coal Measures. Historic monitoring of the H and D seams of the Moranbah Coal Measures was completed between November 2011 and January 2012. The current and historic network comprises one bore within the R Seam (MB39), one within the Q Seam (MB33), three monitoring bores and two VWP sensors within the P Seam (monitoring bores MB34, MB30SRM03P and SRMMB12_03, and VWP sensors PZ06A and PZ08A), five monitoring bores and three VWP sensors within the H Seam (monitoring bores SRMMB14_03_HY, PZ04B, PZ07C, PZ09B and PZ10B and VWP sensors PZ05A, PZ06B and PZ08B), and four monitoring bores and three VWP sensors within the D Seam (monitoring bores SRMMB15_02_HY, PZ04C, PZ09C and PZ10C and VWP sensors PZ05B, PZ06C and PZ08C).

Three active monitoring bores are also screened within the Fort Cooper Coal Measures (MB35, MB36 and 2109MP08) and one monitoring bore is screened within an unknown coal seam of the Back Creek Group (MB31).

Groundwater monitoring of the Q Seam has been undertaken in the east of Ebony Pit (MB33) since 2014. Groundwater elevations for current Q Seam monitoring bores are displayed in **Figure 4-9**. Groundwater elevations within MB33 ranges from 173.25 mAHD to 178.52 mAHD. An insufficient number of data points are available to generate potentiometric contours for the Q Seam.

Groundwater monitoring of the P Seam has been undertaken in the east of Ebony Pit (MB34) since 2014 with historic monitoring undertaken east of Hakea Pit (PZ06A) and east of Coolibah Pit (PZ08A) between 2011 and 2012. Groundwater elevations for current P Seam monitoring bores are displayed in **Figure 4-10**. Groundwater elevations within MB34 range from 167.78 mAHD to 173.775 mAHD. Groundwater elevations within PZ06A and PZ08A range from range from 177.32 mAHD (PZ06A) to 184.39 mAHD (PZ08A). An insufficient number of data points are available to generate potentiometric contours for the P Seam.



0 1 2 km

LEGEND

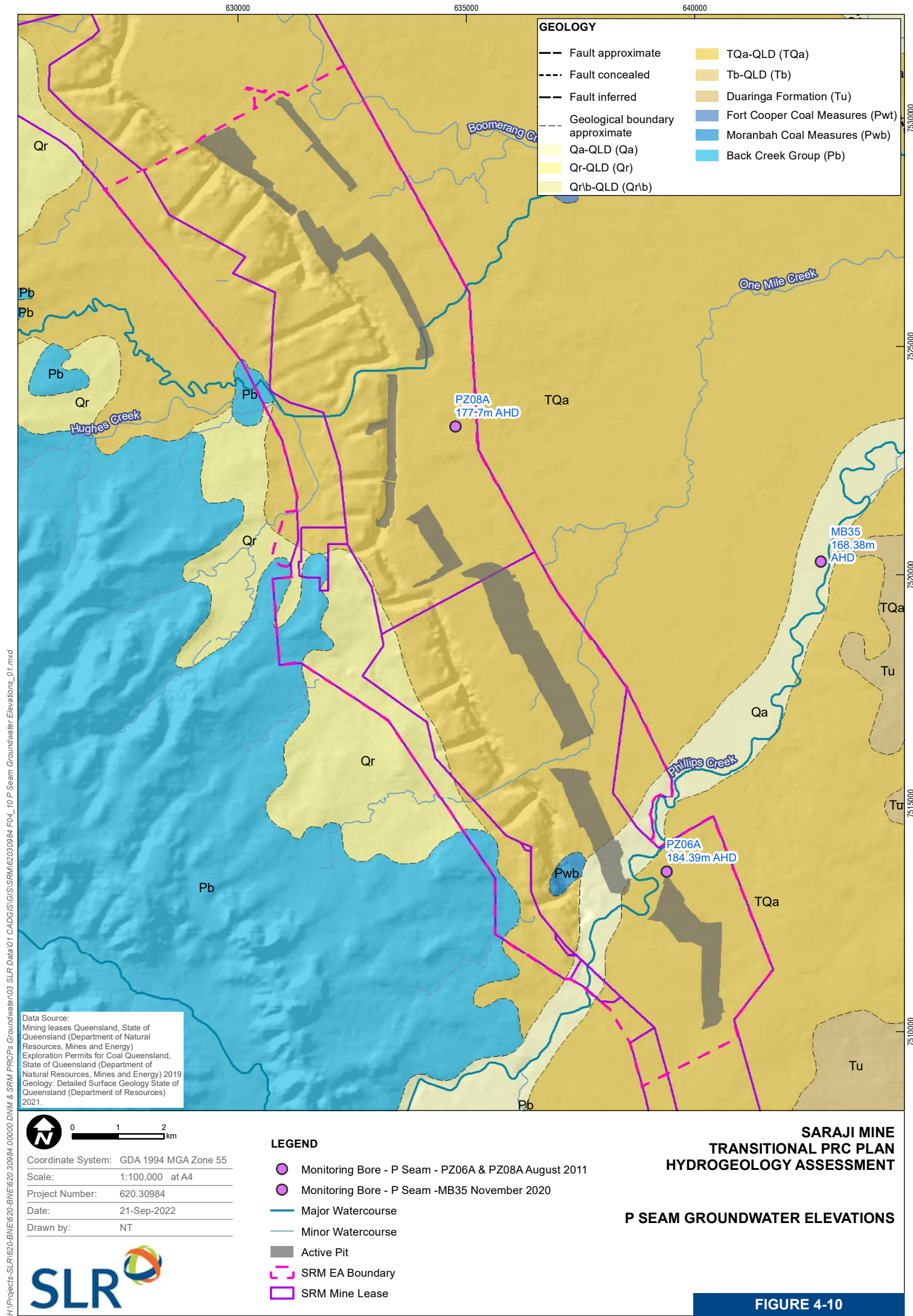
- Monitoring Bore - Q Seam
- Major Watercourse
- Minor Watercourse
- Active Pit
- SRM EA Boundary
- SRM Mine Lease

SARAJI MINE TRANSITIONAL PRC PLAN HYDROGEOLOGY ASSESSMENT

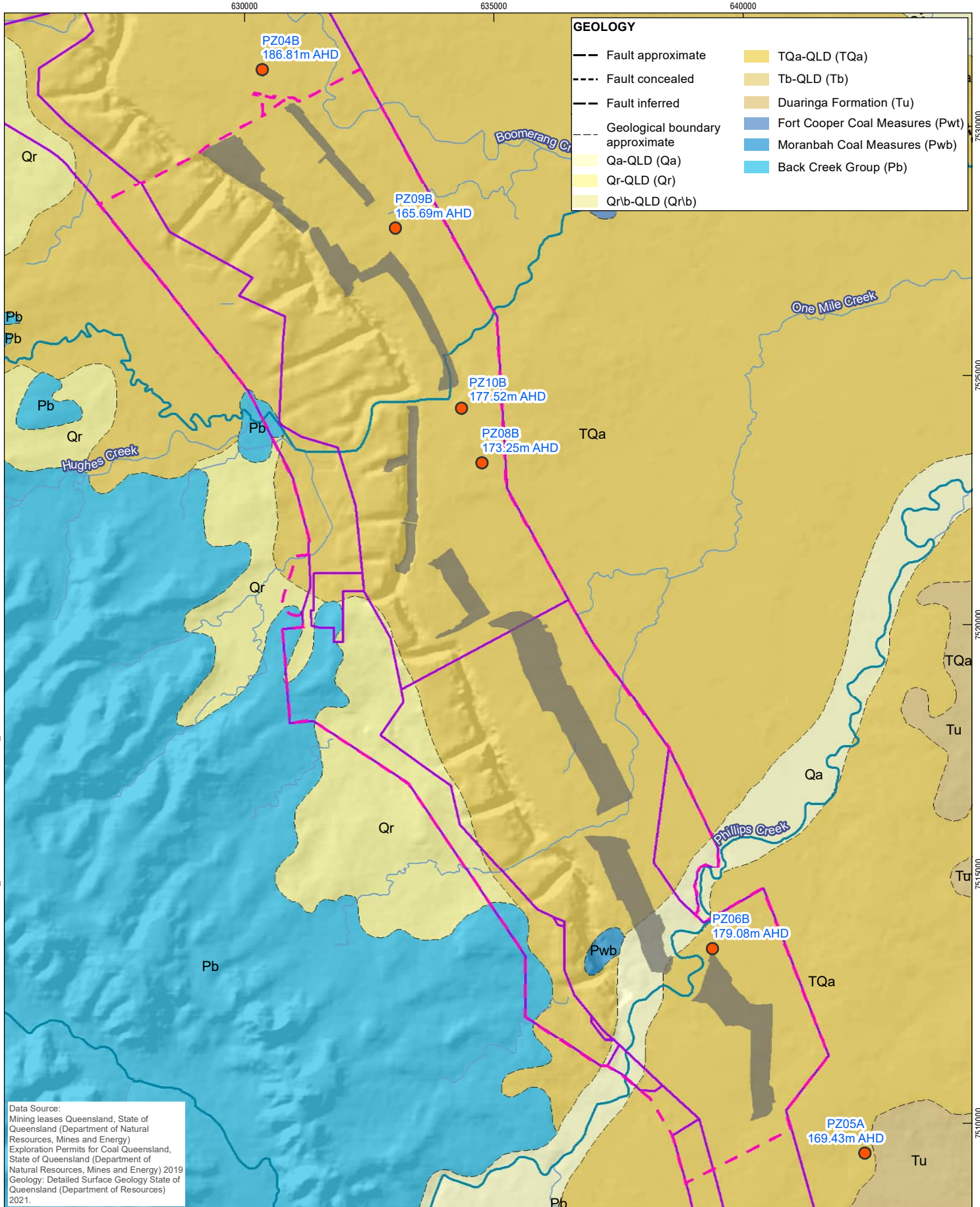
Q SEAM GROUNDWATER ELEVATIONS



FIGURE 4-9



Groundwater monitoring of the H and D seams was undertaken at locations along the strike of the mine between 2011 and 2012. Groundwater elevations for the H seam monitoring bores are presented in **Figure 4-11** and groundwater elevations for the D Seam monitoring bores are presented in **Figure 4-12**. Groundwater elevations in the H Seam ranged between 135.84 mAHD and 190.45 mAHD. Groundwater elevations in the D Seam ranged between 132.68 mAHD and 170.78 mAHD. **Figure 4-11** and **Figure 4-12** shows that during this period general groundwater elevations were more elevated in the northwest of the SRM Area and lower in the southeast, indicative of a general southeasterly groundwater flow direction. Monitoring data shows groundwater elevations to be generally higher in the H Seam than D seam, indicating confined nature of the seams and vertical gradients from the shallower H Seam to deeper D seam. Localised groundwater sinks are shown at the PZ09 bore site located close to Jacaranda Pit and Bauhinia Pit which were actively mined during this period (**Figure 4-1**). Although more recent data from recently drilled bores is not yet available for this report, it is assumed that similar influences from mining on groundwater elevations will occur as mining pits are progressed and the H Seam and D Seams are intersected. Commentary regarding the influence of limited recent local groundwater level data on numerical model calibration performance is provided in **Section 7.1.3**.



Coordinate System: GDA 1994 MGA Zone 55
 Scale: 1:100,000 at A4
 Project Number: 620.30984
 Date: 21-Sep-2022
 Drawn by: NT

LEGEND

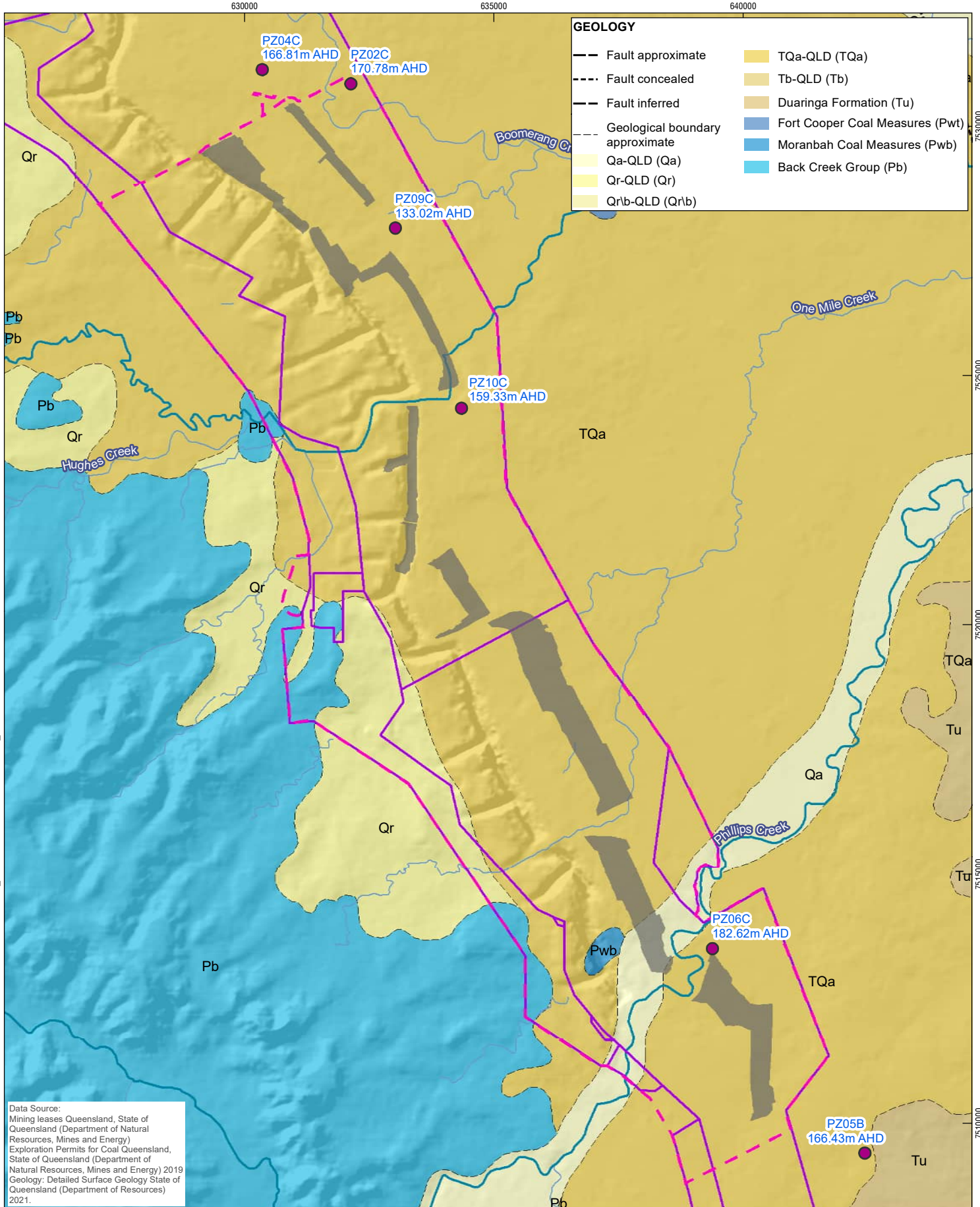
- Monitoring Bore - H Seam
- Major Watercourse
- Minor Watercourse
- Active Pit
- SRM Mine Lease



SARAJI MINE TRANSITIONAL PRC PLAN HYDROGEOLOGY ASSESSMENT

H SEAM GROUNDWATER ELEVATIONS

FIGURE 4-11



Coordinate System: GDA 1994 MGA Zone 55
 Scale: 1:100,000 at A4
 Project Number: 620.30984
 Date: 21-Sep-2022
 Drawn by: NT

LEGEND

- Monitoring Bore - D Seam
- Major Watercourse
- Minor Watercourse
- Active Pit
- SRM EA Boundary
- SRM Mine Lease

SARAJI MINE TRANSITIONAL PRC PLAN HYDROGEOLOGY ASSESSMENT

D SEAM GROUNDWATER ELEVATIONS



FIGURE 4-12

Groundwater level trends for monitoring bores intersecting the Moranbah Coal Measures coal seams within the SRM Area are presented in **Figure 4-13** to **Figure 4-15**.

Figure 4-13 shows that groundwater elevations within the Q seam monitoring bore MB33 have gradually increased since 2016, potentially indicating a declining influence from mining activities from the adjacent Ebony Pit. **Figure 4-1** shows that MB33 is located to the northeast of Ebony Pit which has been actively mined for the duration of the monitoring period. Although progressed toward MB33 during this time, mining appears to have been concentrated in the central and southern areas of the pit eastern boundary. The greater activity in the southern area of the pit may have resulted in the potential recovery of groundwater levels observed at MB33. **Figure 4-13** also shows that groundwater elevations within the P seam monitoring bore MB34 remained relatively stable between June 2015 to June 2018 before declining. **Figure 4-13** shows groundwater elevations within MB34 to correlate to CDFM rainfall indicating a climatic influence at this location. **Figure 4-13** shows that groundwater elevations within P Seam monitoring bore PZ06A slightly declined between August 2011 and January 2012, whereas groundwater elevations in monitoring bore PZ08A slightly increased. There is insufficient data to determine potential climatic influences on groundwater elevations at these locations. As previously discussed PZ06A is located north of Hakea Pit and east of Grevillea Pit and PZ08A is located to the east of Coolibah Pit. It is likely that the observed trends are responses to mining activities in these areas. Decreasing groundwater elevations at PZ06A are indicative of depressurisation of the P Seam as it was mined through.

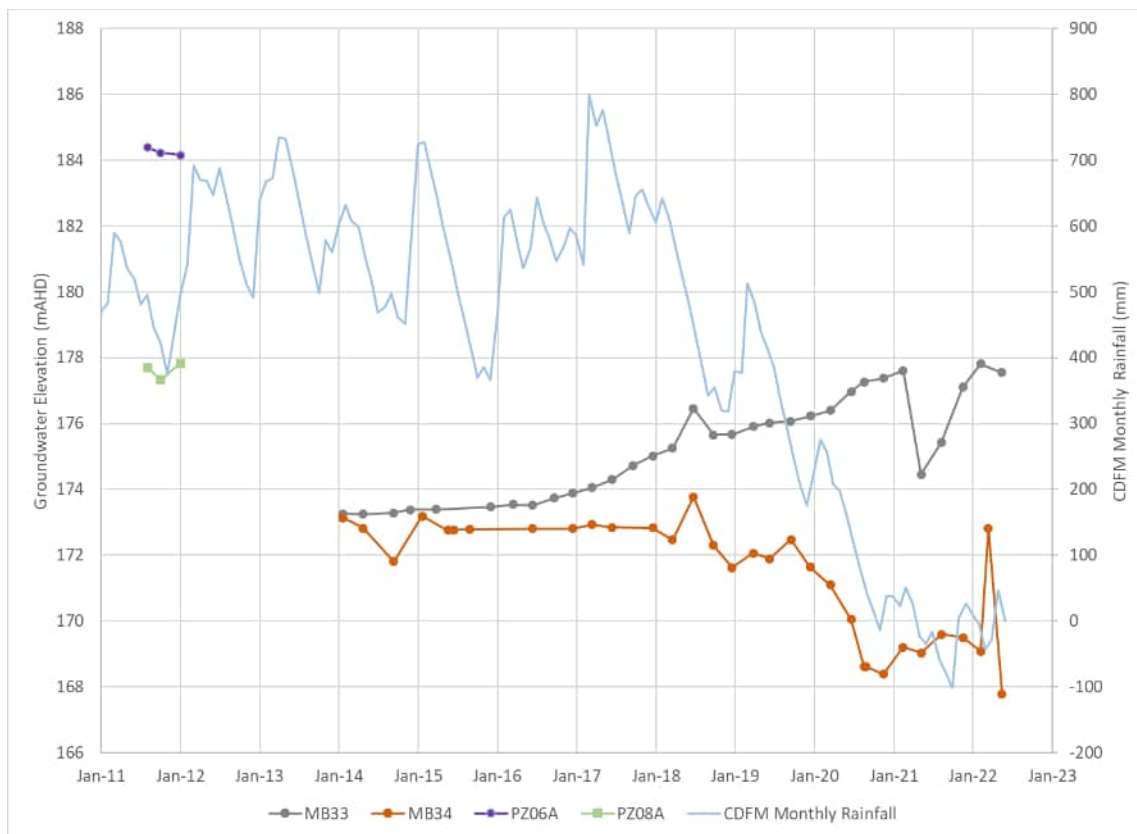


Figure 4-13 Hydrograph for Q and P Seam Bores

Figure 4-14 shows that groundwater elevations within the H Seam monitoring bores PZ04B, PZ05A, PZ06B, PZ09B and PZ10B. Groundwater elevations in monitoring bores PZ05A and PZ06B remained relatively stable over the approximately six month monitoring period indicating no influence from climate or mining at these locations at the time. Groundwater elevations in monitoring bore PZ04B increased slightly, whereas in PZ010B they decreased slightly. As per the P Seam it is likely that the observed trends are responses to mining activities in these areas. Groundwater elevations in monitoring bore PZ09B decreased from 165.7 mAHD to 135.8 mAHD between August 2011 to October 2011, before returning to 164.5 mAHD in January 2012. It is unknown whether this large variation is a data transcription error or due to mining influence at this location.

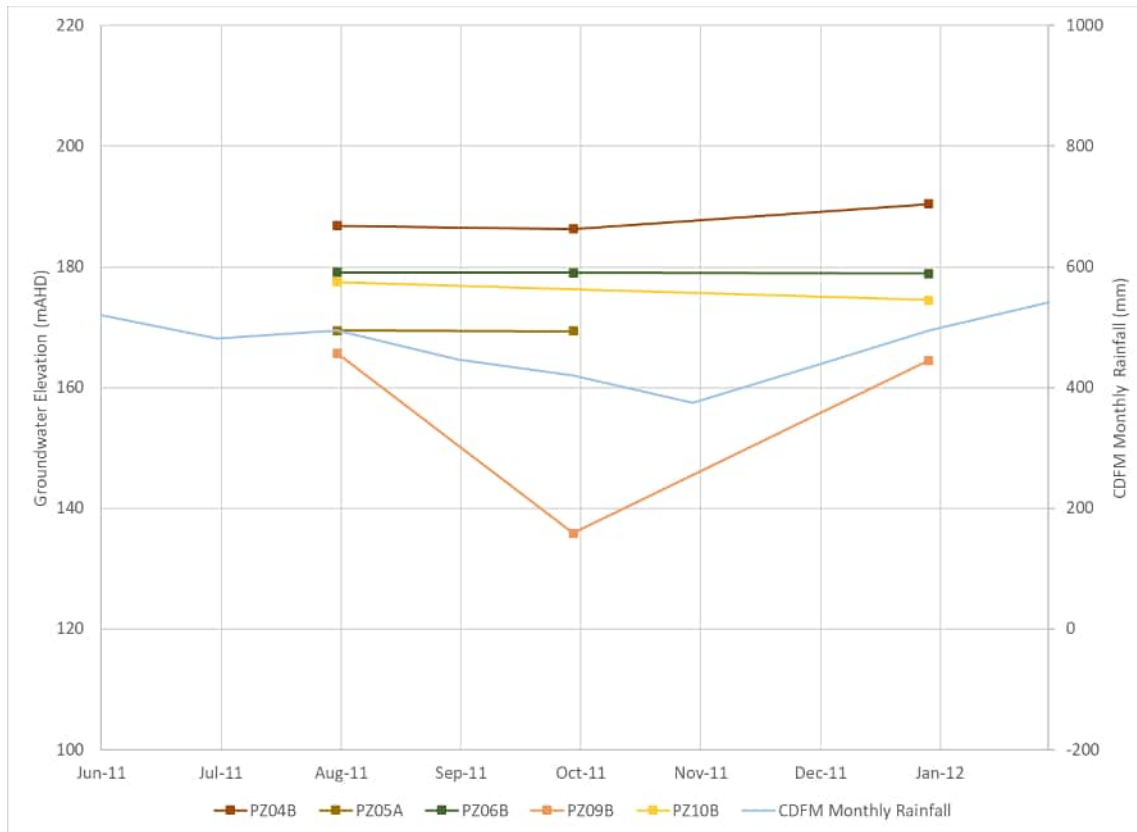


Figure 4-14 Hydrograph for H Seam Bores

Figure 4-15 shows that groundwater elevations within the D Seam monitoring bores PZ02C, PZ04C, PZ05B, PZ06C, PZ09C and PZ10C. Groundwater elevations in monitoring bores PZ06C, PZ05B and PZ09C remained relatively stable over the monitoring period indicating no influence from climate or mining at these locations at the time of monitoring. Groundwater elevations in monitoring bores PZ04C and PZ10C declined between August 2011 and October 2011 before stabilising. PZ04C is located to the north of Jacaranda Pit, with monitoring bore PZ10C located to the south Bauhinia Pit. Given the lack of climatic response observed in the other D Seam monitoring bores it is likely that the decrease in groundwater elevations is in response to mining of these pits.



Figure 4-15 Hydrograph for D Seam Bores

4.3.3.2 Recharge and Discharge

Recharge to the Permian coal measures coal seams, before mining, occurred where the seams were present at outcrop and subcrop. Using the CMB method a recharge rate for the weathered Permian units was calculated as 0.1 mm/yr by SLR (2021). Higher rates of recharge may occur where fresh Permian strata has been exposed by current mining activities. Due to the low hydraulic conductivity of the interburden material, groundwater largely flows horizontally within the coal measures, along the bedding plane of the coal seams themselves. Groundwater discharge occurs via evaporation and inflow into active mine pit void areas.

4.3.4 Permian Coal Measures Interburden

4.3.4.1 Distribution and Flow

Groundwater occurrence within the Permian coal measures interburden is largely restricted to weathered horizons or to secondary porosity through fractures where present (**Section 4.2**). The interburden functions dominantly as an aquitard that restricts groundwater movement (SLR, 2021). Groundwater monitoring of the Moranbah Coal Measures interburden at SRM has been undertaken east of Jacaranda Pit in the north of SRM (PZ02B; monitored between 2011 and 2012 and PZ00D; monitored since 2020) and west of Hakea Pit (MB19SRM04P; since 2020) in the south of SRM. Groundwater monitoring of the Back Creek Group interburden has also been undertaken since 2014 at MB37 located off lease to the west of Ebony Pit.

Figure 4-16 shows that monitoring of MB19SRM04P occurred between February 2020 and February 2021. Over this period groundwater elevations steadily declined from 189.7 mAHd to 189.21 mAHd. Groundwater elevations for PZ02B decreased between November 2011 and January 2012 from 173.78 mAHd to 168.4 mAHd. This decline is likely to be a response to mining activities associated with the nearby Jacaranda Pit during this period. The declining groundwater levels in both bores during their respective monitoring periods potentially indicates a response to nearby mining activities (mining of Hakea Pit immediately east of Hakea Pit and mining of Jacaranda Pit immediately west of PZ02B). Groundwater elevations at PZ00D have ranged between 174.8 mAHd (18.2 mBTC) to 175.8 mAHd (17.2 mBTC). **Figure 4-16** shows that elevations slightly increased between February 2020 and February 2021, before decreasing slightly. Groundwater elevations at PZ00D indicate a potentially subdued response to climatic influences with increasing levels corresponding to wetter than average conditions observed at the end of 2020.

Figure 4-16 shows that MB37 groundwater elevations gradually declined from 222.3 mAHd in September 2014 to 222 mAHd March 2016. Following this period groundwater elevations steadily increased to 223.43 mAHd in June 2018. Groundwater elevations gradually declined slightly after this point to 222.4 mAHd in November 2021. Since the end of 2021 groundwater elevations have been gradually increasing with an elevation of 223.2 mAHd recorded in February 2022. Given the distance of MB37 to the west of SRM and the fact it is installed in the Back Creek Group interburden rather than Moranbah Coal Measures, the observed changes in elevations are potentially a subdued response to climatic conditions rather than a response to mining activities. Overall however, the monitoring data suggests very little temporal changes in interburden groundwater levels.

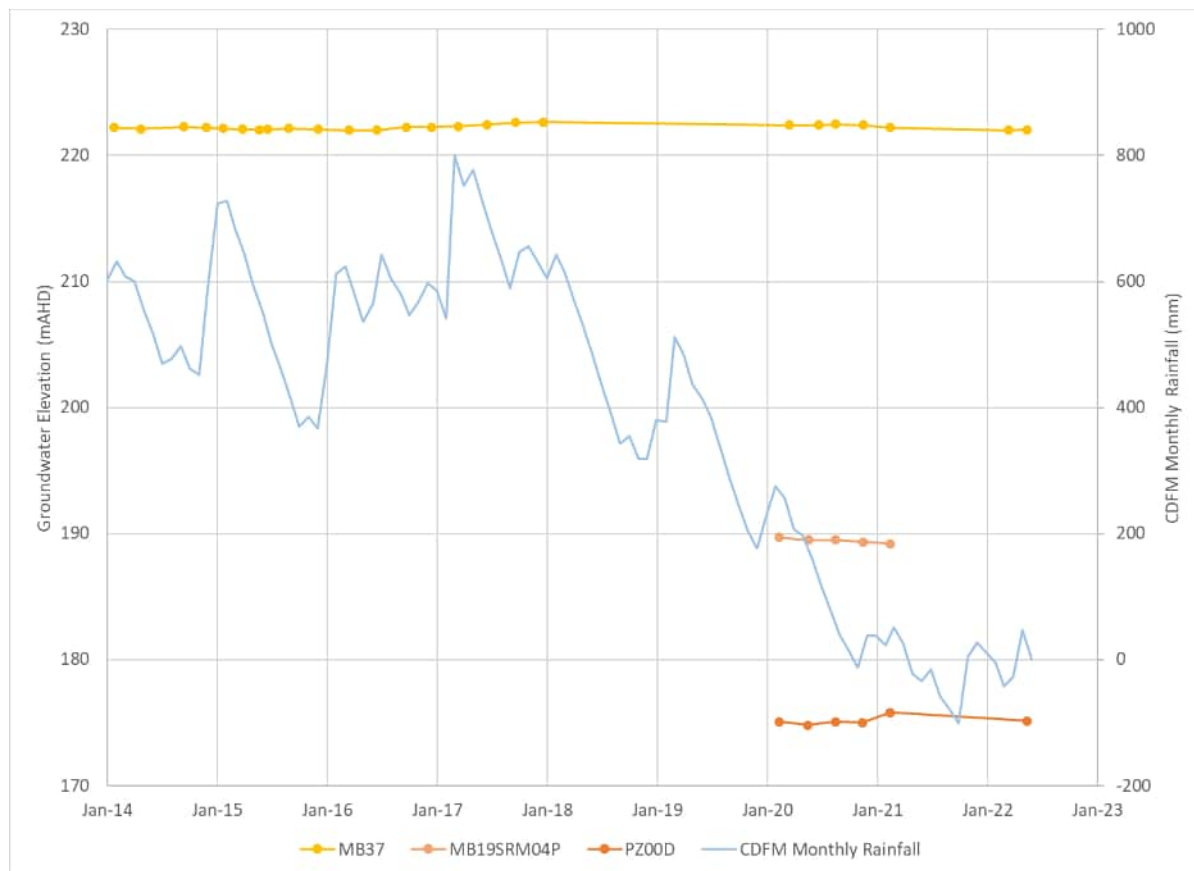


Figure 4-16 Hydrograph of Permian Coal Measures Interburden Groundwater Trends

4.3.4.2 Recharge and Discharge

Recharge to the Permian coal measures occurs at subcrop. Due to the low hydraulic conductivity of the interburden material however, recharge rates to the interburden would be significantly less than for the coal seams themselves. Groundwater discharge from the interburden occurs via evaporation from active mine pit void areas.

4.4 Baseline Water Quality

4.4.1 Water Type

The proportions of the major anions and cations were used to determine the hydrochemical facies of groundwaters sampled. The anion-cation balance from the SRM monitoring bores is shown on the Durov plot in **Figure 4-17**.

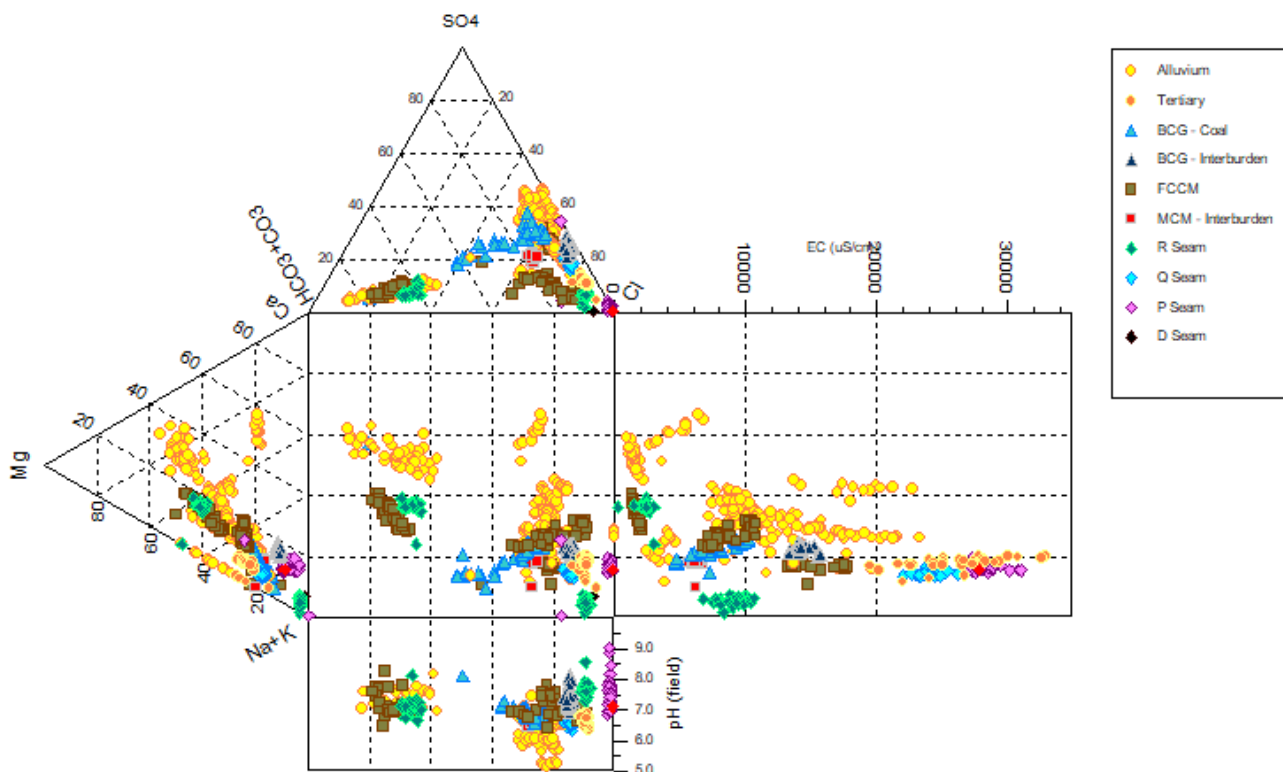


Figure 4-17 Durov Plot of SRM Bores

The results for these monitoring bores generally indicate that Na and Cl are the dominant major ions in groundwater across SRM. Surficial alluvial and Tertiary sediments generally display a more mixed water type, with higher proportions of magnesium and bicarbonate ions. The dominant water types in the unconsolidated alluvium and Tertiary sediments therefore generally Na-Mg-Cl and Na-Mg-Cl-HCO₃. Alluvium in the vicinity of Hughes Creek to the west of Bauhinia Pit show a greater proportion of sulfate ions.

Monitoring bores screened within both the Permian Moranbah Coal Measures (MB19SRM04P) and Back Creek Group (MB37) also showed mixed water types of Na-Cl-SO₄. Monitoring bores screened within the Permian Fort Cooper Coal Measures showed mixed water types ranging from Na-Mg-Cl and Na-Mg-HCO₃-Cl.

Within the Moranbah Coal Measures bores within the R Seam, Q Seam and P Seams consistently recorded a Na-Cl water type. Only one water quality record for the D Seam (MB20SRM07P) was available for review. Again, this showed a Na-Cl water type, consistent with the other coal seams.

Water types of the Q Seam, H Seam, D Seam are more variable with the distribution of the major ions appearing to be associated with the depth of the bore. In general, deeper bores, typically in the east of SRM, displayed Na-Cl water types, with shallower bores showing water types with higher proportions of calcium or magnesium ions. This is likely to be due to greater recharge from overlying surficial deposits in the shallower areas, the greater thickness of the unweathered material preventing the mobilisation of salts into the coal seams in the deeper locations. As the shallower bores are closer to the base of weathering, seepage of mobilised salts during recharge is more likely to occur. Within the deeper deposits, recharge from overlying units is likely to be less, with major ions distribution more influenced by secondary salinity mechanisms.

From the Durov plot (**Figure 4-17**) it is also clear that the aquifers in the SRM Area are generally neutral to slightly acidic and therefore have a greater proportion of bicarbonate to carbonate ions.

4.4.2 Salinity

Salinity is a key constraint to water management and groundwater use by receptors and can be described by total dissolved solid (TDS) concentrations. **Figure 4-18** presents the TDS data associated with waters screened in the various geological horizons for SRM monitoring bores, as well as registered bores and publicly available data for context. Salinity ranges represented on **Figure 4-18** are defined by the Food and Agriculture Organization of the United Nations (FAO).

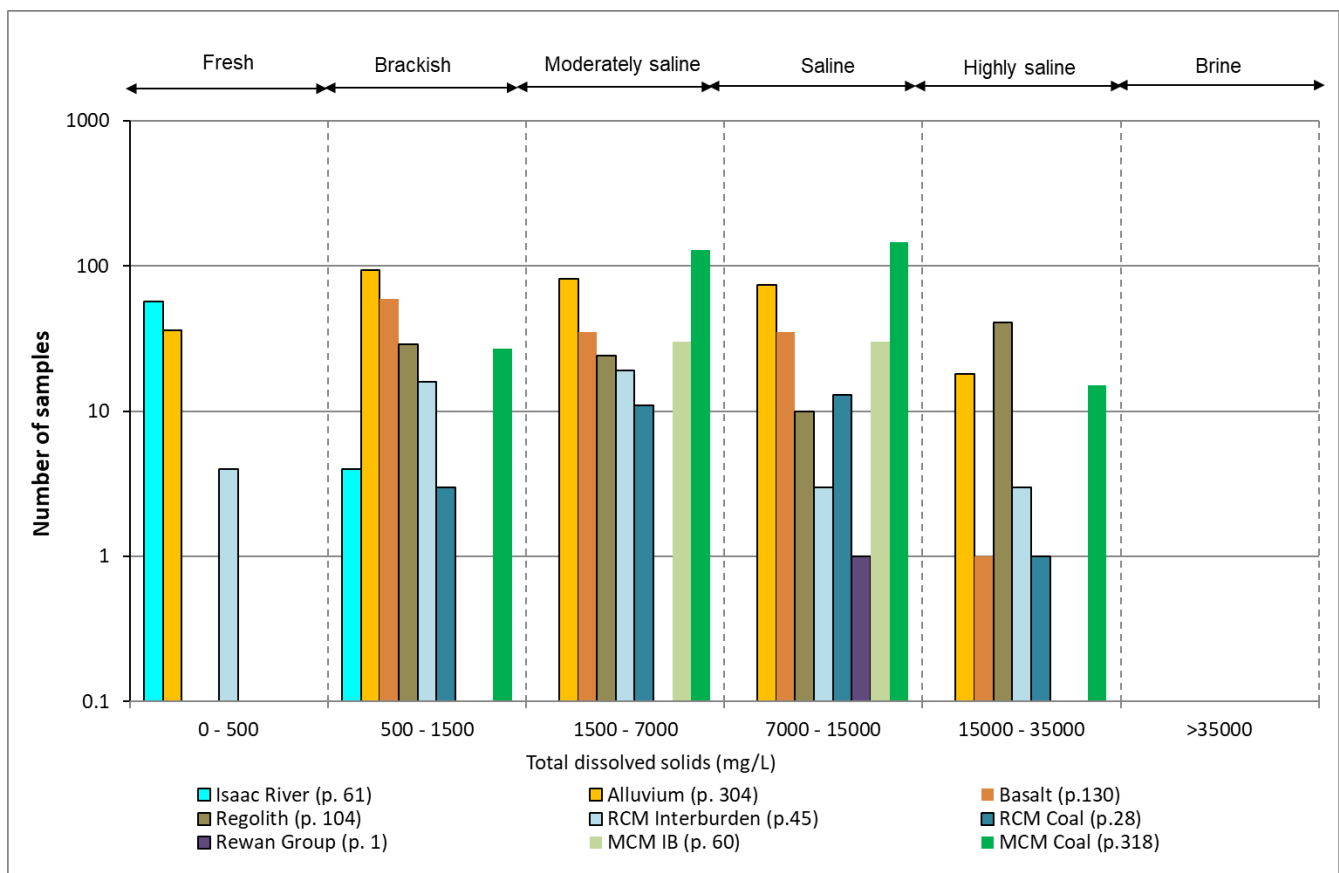


Figure 4-18 FAO (2013) Salinity Ranking by Unit – SRM and Surrounding Area

The graph shows that water within the alluvium is fresh to saline with an average TDS of 556 milligrams per litre (mg/L) (marginal) and ranging between 10 mg/L and 5,620 mg/L. Where water is present within the regolith material, it is generally highly saline, but can be brackish to moderately saline with an average TDS of 7,101 mg/L and ranging between 1,110 mg/L and 18,600 mg/L.

Water within the Moranbah Coal Measures is generally saline within the coal seams and moderately saline to saline interburden units but can range between fresh and highly saline. Groundwater quality within the coal seams was found to be variable, recording an average TDS of 7,598 mg/L but ranging between a fresh 720 mg/L and highly saline 24,704 mg/L. The interburden units of the Permian coal measures record an average TDS of 5,349 mg/L, ranging between 1,520 mg/L and 9,126 mg/L.

4.4.3 Beneficial Groundwater Use (Environmental Values)

SRM lies within the Isaac Connors Groundwater Management Area (GMA – Zone 34) of the Fitzroy Basin under the *Water Plan (Fitzroy Basin) 2011*. Within the GMA, alluvial groundwater is managed as Groundwater Unit 1 and water within the hard rock aquifers as Groundwater Unit 2 (sub-artesian aquifers). Volumetric limits apply to extraction of groundwater within the GMA for non-stock and domestic purposes.

Groundwater resources in the SRM Area are also scheduled under the *Environmental Protection (Water and Wetland Biodiversity) Policy 2019* as Isaac Groundwaters of the Isaac River Sub-basin of the Fitzroy Basin water plan (WQ1310). The legislated environmental values (EVs) for these groundwaters are:

- Biological integrity of aquatic ecosystems;
- Human use EVs:
 - Suitability of water supply for irrigation;
 - Farm water supply/use;
 - Stock watering;
 - Primary recreation;
 - Drinking water supply;
 - Cultural and spiritual values.

The EPP Water and Wetland Biodiversity provides water quality objectives (WQOs) for the scheduled EVs in WQ1310. WQOs are long-term goals for water quality management and the purpose of the WQOs is to support and protect EVs. They are numerical concentration levels or narrative statements of indicators established for receiving waters to support and protect the designated EVs for those waters. They are based on scientific criteria or water quality guidelines but may be modified by other inputs (e.g. social, cultural, economic).

Where groundwater quality analysis results exceed a particular WQO for a particular EV, it is considered indicative that the groundwater may be unsuitable for supporting that particular EV.

The WQ1310 WQOs for groundwater at SRM are shown in **Table 4-3**.

Table 4-3 Water Quality Objectives for Isaac River Sub-basin Environmental Values

Water Quality Indicator	Unit	ADWG Guidelines ¹		Isaac River Sub-basin EVs ²		
		Health	Aesthetic	Irrigation	Stock	Aquatic 95% spp ³
pH	-		6.5 to 8.5			6.5 to 8.5
Al	mg/L		0.2		5	0.055
Ca	mg/L				1000	
Cl	mg/L		250			
Mg	mg/L				2000	
Mn	mg/L	0.5	0.1	10		1.9
Na	mg/L		180			
SO ₄	mg/L				1000	
Zn	mg/L		3			0.008
As	mg/L	0.01		2	0.5	0.024
Cd	mg/L	0.002			0.01	0.0002
Cr	mg/L	0.05			1	0.001
Co	mg/L			0.1	1	
Cu	mg/L	2	1		1	0.0014
Pb	mg/L	0.01			0.1	0.0034
Hg	mg/L	0.001			0.002	0.0006
Ni	mg/L	0.02			1	0.011
Se	mg/L	0.01			0.02	0.005
Ag	mg/L	0.1				0.05

1. Table 4 of Isaac River Sub-basin Environmental Values and Water Quality Objectives: Drinking water EV.

2. Table 2, Table 9, Table 10 and Table 11 of Isaac River Sub-basin Environmental Values and Water Quality Objectives: Aquatic ecosystem – moderately disturbed.

3. Table 3.4.1 of Australian and New Zealand Guidelines for Fresh and Marine Water Quality: trigger values for slightly-moderately disturbed systems (95% level of protection).

The EPP Water and Wetland Biodiversity also provides limited WQOs specifically for underground aquatic ecosystem protection in Fitzroy Basin groundwaters. These WQOs vary across the Fitzroy Basin and are defined on the basis of groundwater Chemistry Zones. The applicable Chemistry Zone for the SRM is Isaac Groundwater (Zone 34; Sodic Sequence - Saline: Na, Cl). These WQOs are classified by groundwater depth ('shallow' being <30 m depth, and 'deep' being >30 m depth) and are summarised in **Table 4-4**. The management intent of Zone 34 WQOs is to "maintain each of 20th, 50th and 80th percentile values", i.e. that there should be no change to existing water quality (no statistical change in the natural range of values) (DES, 2022).

Table 4-4 Isaac River Sub-basin Zone 34 WQOs for groundwater resources (aquatic ecosystem protection) (DEHP, 2011)

Water Quality Indicator	Unit	Shallow Groundwater (<30m)			Deep Groundwater (>30m)		
		20 th Percentile	50 th Percentile	80 th Percentile	20 th Percentile	50 th Percentile	80 th Percentile
EC	µS/cm	498	2150	8910	3419	6100	16000
Hardness	mg/L as CaCO ₃	163	674	2228	359	919	3208
pH	-	7.1	7.75	8.1	7.4	7.8	8.03
Alkalinity	mg/L	154	435	752	156	275	536
Ca	mg/L	18	84	215	46	145	442
Mg	mg/L	27	108	389	35	115	491
Na	mg/L	135	747	1500	480	1100	2565
Cl	mg/L	171	1309	3185	753	1900	5905
SO ₄	mg/L	12	140	318	25	138	398
HCO ₃	mg/L	187	536	878	188	330	650
NO ₃	mg/L	0	0.95	5.3	0.01	2.15	14.92
SiO ₂	mg/L	21	36	52	16	25	36
F	mg/L	0.1	0.28	0.5	0.02	0.155	0.4
Fe	mg/L	0	0.03	0.14	0	0.05	0.246
Mn	mg/L	0	0.01	0.16	0	0.05	0.291
Zn	mg/L	0	0.015	0.06	0.01	0.025	0.317
Cu	mg/L	0	0.01	0.03	0.017	0.03	0.03
SAR	-	4.37	10.85	18.21	10.5	15.6	24.65
RAH	meq/L	0	0	2.3	0	0.24	6.25

In order to understand the groundwater resources within the SRM and Study Area, available water quality data have been compared to the:

- Australian Drinking Water Guidelines (ADWG) (NHMRC, 2011) (refer **Table 4-3**);
- ANZECC (2000) guidelines for irrigation (long-term and short-term), stock water supply, and 95% level of protection for aquatic ecosystems in slightly-moderately disturbed systems (refer **Table 4-3**); and
- Fitzroy Basin Zone 34 WQOs for groundwater resources (aquatic ecosystem protection) for deep and shallow groundwater (refer **Table 4-4**).

The summary results indicate that, where sampled at bore MB32, groundwater within the Phillips Creek alluvium generally meets the WQOs for all relevant EVs, however Fe concentrations do occasionally exceed guideline criteria for long term irrigation and Fitzroy Basin Zone 34 aquatic ecosystem protection (Shallow). Hughes Creek alluvial groundwater generally exceeds guideline levels for stock water supply, (SO₄, TDS), aquatic ecosystem protection (Al, Cu, Ni, Mn, Zn), drinking water (TDS, Cl and Na), and long-term irrigation (B and Fe). The Hughes Creek alluvial groundwater also records concentrations of EC, dissolved major ions and dissolved Mn above the Fitzroy Basin Zone 34 WQOs (Shallow) for aquatic ecosystem protection.

Results show that, where groundwater is present within the Tertiary sediments, it exhibits similar quality compared to the Hughes Creek alluvium and exceeds guideline values for stock watering (SO₄), 95% level of protection for aquatic ecosystems (Cu, Ni and Zn), long term irrigation (Bo, Co and Mo), and drinking water (TDS, Na and Cl). The groundwater within Tertiary sediments was also found to exceed the Fitzroy Basin Zone 34 WQOs (Shallow and Deep) for aquatic ecosystem protection (EC, HCO₃, Cl, Ca, Na, hardness, Mg, SO₄, Cu and Mn).

Comparison of groundwater quality monitoring results to the guideline WQOs indicates the Moranbah Coal Measures (interburden and coal) generally exceed guideline criteria for irrigation, drinking water and aquatic ecosystems. Groundwater within the Permian coal measures variably meets the WQOs for stock water supply, with guideline exceedances most common for TDS and SO₄.

Groundwater within the Permian coal measures coal seams has concentrations of:

- SO₄ (H Seam), Al (H Seam and D Seam), Cr (D Seam), Cu (P Seam), Ni (P Seam) and Zn (P Seam and D Seam) above the WQO for 95% level of protection for aquatic ecosystems;
- HCO₃ (D Seam) and Na (D Seam) above the Fitzroy Basin Zone 34 WQO (Deep); and
- EC (H Seam and D Seam), Mg (H Seam and D Seam), Na (H Seam and D Seam), Cl (H Seam and D Seam), SO₄ (H and D seams), Fe (H Seam and D Seam) and pH (D Seam) above the Fitzroy Basin Zone 34 WQO (Shallow and Deep).

Total petroleum hydrocarbon concentrations were mostly below the laboratory detection limits but reported detectable levels between 25 µg/L and 1,100 µg/L for C6–C35 fractions analysed in bores PZ09B and PZ10C. It is possible that the source for these hydrocarbon fractions is oil based lubricant used whilst drilling the borehole and not hydrocarbon contamination from within the aquifer. Similarly, aromatic (BTEX) hydrocarbons were mostly below the laboratory detection limits in both monitoring bores, except for detectable levels reported for toluene between 2 µg/L and 4 µg/L in bores PZ09B and PZ10C. Interference from naturally occurring organic matter is also a potential source of the hydrocarbons detected in the water samples.

4.5 Groundwater Receptors

4.5.1 Anthropogenic

A search of the Queensland Government's Groundwater Bore Database (GWBD) was carried out for registered bores within 5 km of SRM. The search indicated that there are 62 registered bores, of which 39 bores (63%) are likely used for groundwater monitoring and investigations, and only three bores (5%) are likely to have a water supply purpose. The remainder of bores have an unknown use (**Table 4-5**). **Figure 4-19** presents a locality plan.

Table 4-5 Registered use of Groundwater Bores within 5 km of SRM

Use	Count	Percent of Total
Groundwater monitoring (mine monitoring, water resource investigation etc)	39	63
Water Supply	3	5
Unknown	20	32
Total	62	100

A search of the Queensland Water Entitlement Database showed that none of the registered groundwater bores located within 15 km of SRM had water licences (AECOM, 2019).

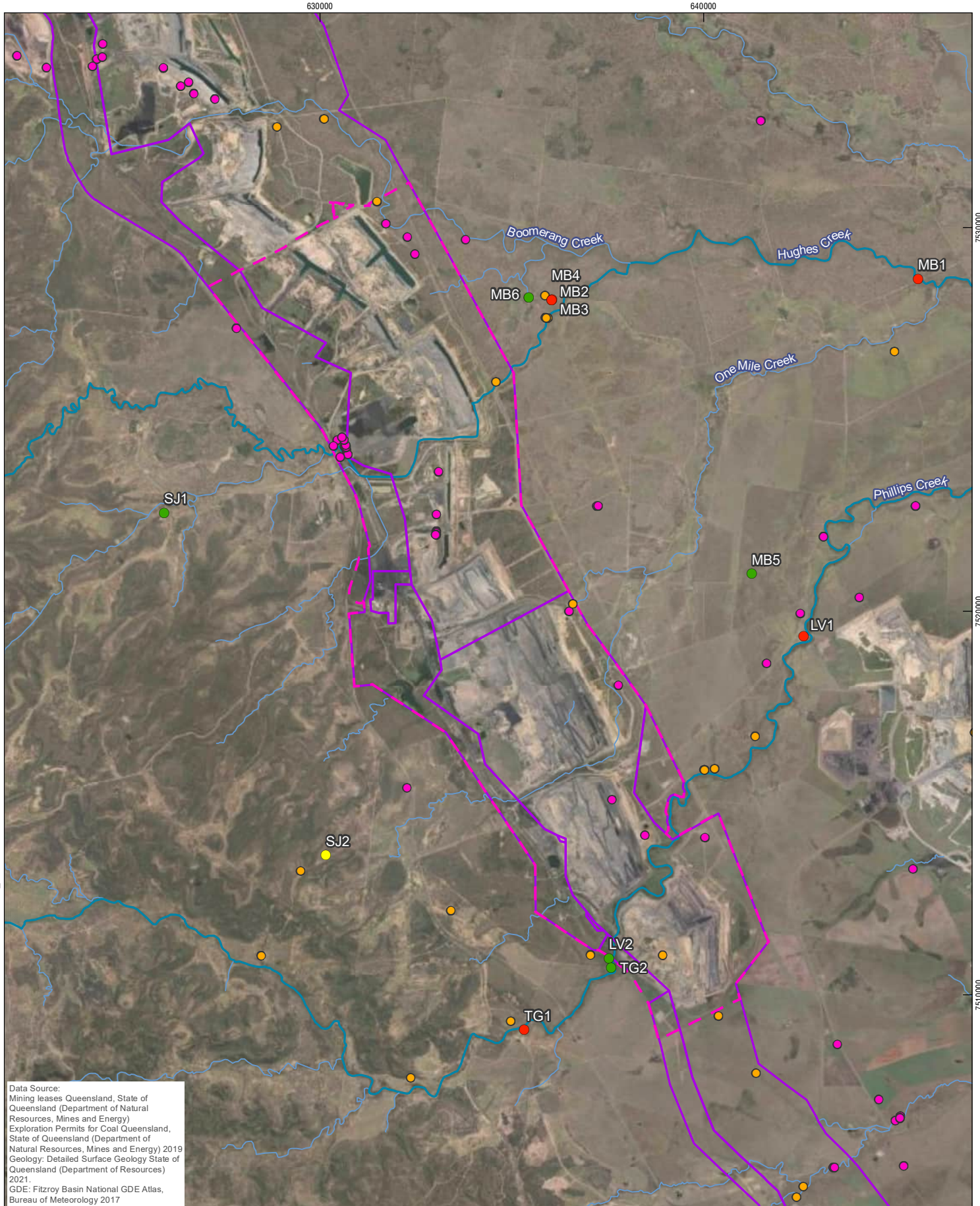
4.5.1.1 Field Bore Census

A bore census was undertaken by AGE in 2007 in support of the SEMLP (AECOM, 2019). The bore census identified 12 bores within 15 km of SRM on four separate landholder properties. **Table 4-6** presents a summary of information available for each bore, with the bore locations also presented on **Figure 4-19**. All 12 bores were found to not correlate with the registered bore database and as such were deemed unregistered bores, although four of the bores (MB2, MB3, MB4 and MB6, refer **Table 4-6** and **Figure 4-19**) were located within approximately 400 m of GWDB recorded registered bores RN132631 and RN136689 that have recorded screen depths between 315 m and 325 m depth (AECOM, 2019).

For the 12 bores surveyed in the bore census:

- 5 bores (42%) were equipped supply bores.
- 1 bore (8%) was an equipped supply bore that was non-operational.
- 1 bore (8%) was a supply bore undergoing maintenance (pump removed).
- 5 bores (42%) were not equipped.

Source aquifer information is not available for the 12 bores found in the bore census, however six of the bores were reported by AECOM (2019) to have known depth information. Five of the six bores with known depth information access groundwater from depths of less than 80 m. Comparison of the six known bore depths in **Table 4-6** with the SRM groundwater model (see **Section 7**) geological information indicates two of the bores likely access the shallow Regolith (MB4 and TG1) whilst the remainder likely access the Fort Cooper Coal Measures.



Data Source:
Mining leases Queensland, State of
Queensland (Department of Natural
Resources, Mines and Energy)
Exploration Permits for Coal Queensland,
State of Queensland (Department of
Natural Resources, Mines and Energy) 2019
Geology: Detailed Surface Geology State of
Queensland (Department of Resources)
2021.
GDE: Fitzroy Basin National GDE Atlas,
Bureau of Meteorology 2017



0 2.5 5 km

Coordinate System: GDA 1994 MGA Zone 55

Scale: 1:130,000 at A4

Project Number: 620.30984

Date: 31-Oct-2023

Drawn by: NT



LEGEND

2007 Bore Census

- Equipped
- Equipped – not operational
- Not equipped & not operational

GWDB Registered Bores

- Probable Exploration or Monitoring Bore
- Probable Private Supply Bore

— Major Watercourse

— Minor Watercourse

— SRM EA Boundary

— SRM Mine Lease

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REGISTERED BORES AND BORE CENSUS

FIGURE 4-19

Table 4-6 2007 Bore Census Details (AECOM, 2016)

Bore ID	Property	Easting (GDA94)	Northing (GDA94)	Standing Water Level (m)	Bore Depth (m)	pH (pH Unit)	EC (µS/cm)	Status
MB1	Meadowbrook	645599	7528659	20.63	79.4	7.962	2760	Pump removed
MB2	Meadowbrook	636046	7528117	22.86	60.94	-	-	Not Equipped
MB3	Meadowbrook	636052	7528122	23.82	50	6.67	6990	Not Equipped
MB4	Meadowbrook	636042	7528114	23.53	27.1	-	-	Not Equipped
MB5	Meadowbrook	641260	7520975	-	-	7.11	7270	Equipped
MB6	Meadowbrook	635449	7528173	-	-	8.23	5880	Equipped
LV1	Lake Vermont	642617	7519343	23.77	>100	7.32	916	New unequipped bore
LV2	Lake Vermont	637545	7510953	-	-	7.87	758	Equipped
SJ1*	Saraji Station	625942	7522560	7.85	-	7.74	8250	Equipped
SJ2	Saraji Station	630163	7513642	-	-	-	-	Equipped – not operational
TG1	Tay Glen	635329	7509084	9.42	15.06	8.23	1940	Not Equipped
TG2 **	Tay Glen	637595	7510716	-	-	7.88	754	Equipped

*Bore incorporated into SRM EA monitoring network as MB31

**Bore incorporated into SRM EA monitoring network as MB32

4.5.2 Environmental

4.5.2.1 Groundwater Dependent Ecosystems

A groundwater dependant ecosystem (GDE) is a natural ecosystem that requires “access to groundwater to meet all or some of their water requirements on a permanent or intermittent basis, so as to maintain their communities of plants and animals, ecosystem processes and ecosystem services” (Richardson, S., et al., 2011). GDEs can require access to groundwater on a permanent (obligate) or intermittent (facultative) basis to meet all or some of their water requirements so as to maintain their communities of plants and animals, ecological processes and ecosystem services (Doody *et al.*, 2019).

GDEs are typically classified as either:

- Aquatic GDEs (i.e. ecosystems dependent on the surface-expression of groundwater, such as aquatic species that inhabit groundwater-fed surface pools);
- Terrestrial GDEs (i.e. ecosystems dependent on the sub-surface presence of groundwater, including some riparian vegetation communities with rooting depths that intersect the groundwater table); and
- Subterranean GDEs (aquifer and cave ecosystems, such as stygofauna that can live within aquifer systems).

National Atlas of Groundwater Dependent Ecosystems

Broad-brush national scale desktop mapping of potential GDEs is available in the Bureau of Meteorology (BoM) National Atlas of GDEs (GDE Atlas). The GDE Atlas classifies ecosystems based on the potential for dependence on groundwater through desktop collation of multiple lines of scientific evidence. Ecosystems have been mapped as either:

- High potential for groundwater dependence (indicating a strong possibility the ecosystem is interacting with groundwater);
- Moderate potential for groundwater dependence; or
- Low potential for groundwater dependence (indicating it is relatively unlikely the ecosystem will be interacting with groundwater and will include ecosystems that are not interacting with groundwater).

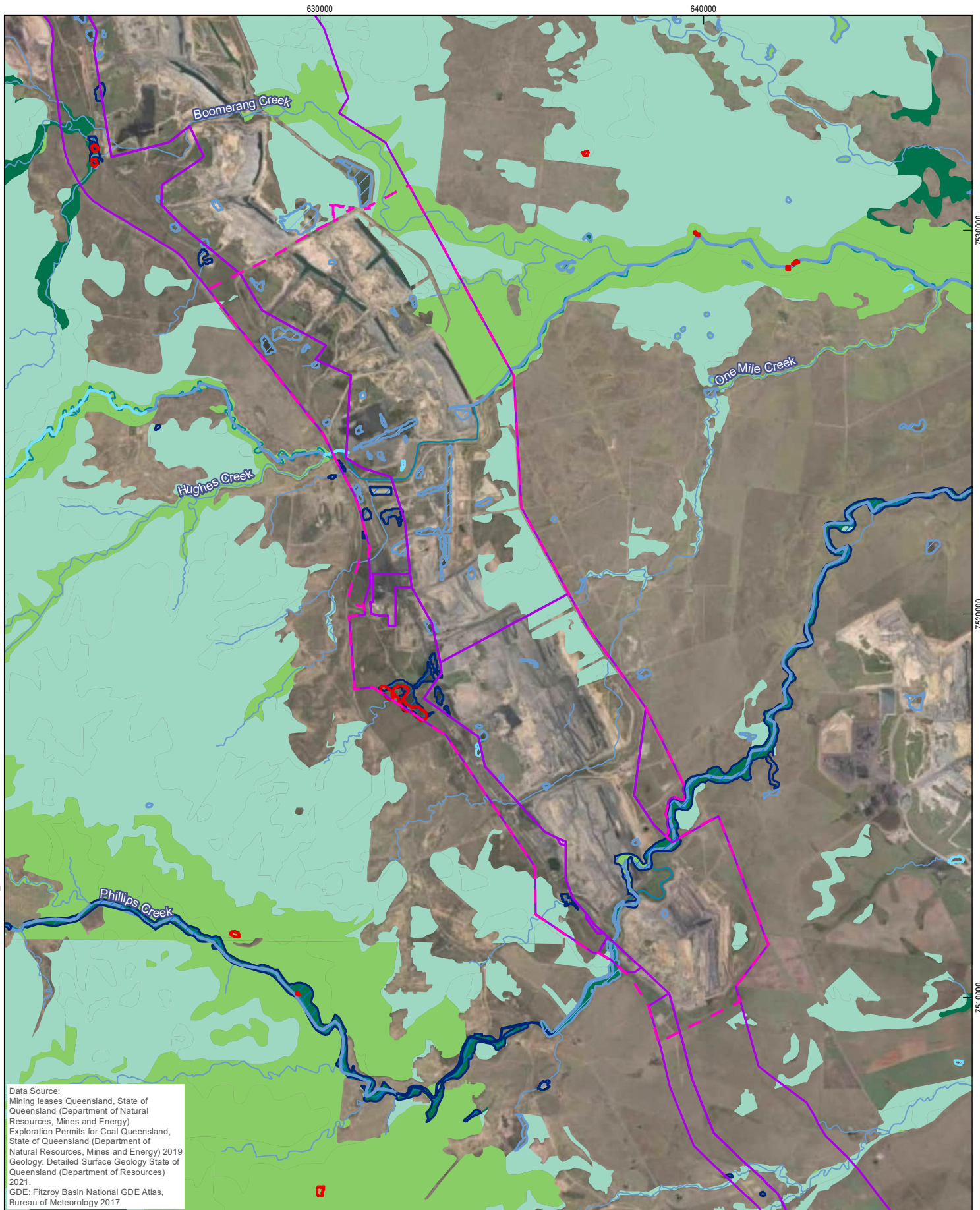
The broadbrush GDE Atlas mapping of potential aquatic and terrestrial GDEs indicates that areas with possible high, moderate and low potential for groundwater interaction occur in the vicinity of SRM including in the SRM Area (**Figure 4-20**) (BoM, 2017). Isolated areas of high and moderate potential GDE's are mapped by the AGDE Atlas within the SRM Area, with low potential GDE's identified predominantly around the SRM Area boundaries. The GDE Atlas mapping also indicates:

- East of SRM, terrestrial riparian vegetation associated with the downstream extent of Boomerang Creek and Hughes Creek River are mapped as having a moderate potential to be dependent on subsurface expression of groundwater.
- Aquatic habitat associated with the Isaac River and Phillips Creek downstream extent east of SRM are mapped as having a high potential to be dependent surface expression of groundwater.
- All other terrestrial vegetation and aquatic habitat within and adjacent SRM, is broadly mapped as having a low to moderate potential of being associated with the presence of groundwater (BoM, 2017).

AECOM (2019) undertook a desktop assessment of the likelihood that the potential GDEs identified in the GDE Atlas were actual GDEs in accordance with the criteria posed by Eamus et al (2006). The assessment found that:

- those areas mapped as having moderate to high potential for aquatic GDEs in the GDE Atlas are considered to have low potential for aquatic GDEs when considered in conjunction with site specific groundwater data; and
- those areas mapped as having moderate potential for terrestrial GDEs in the GDE Atlas are considered to have low potential for terrestrial GDEs when considered in conjunction with site specific groundwater data.

The remainder of BMA's previous GDE studies at SRM and the SEMLP, discussed below, further demonstrate that the GDE Atlas mapping discussed above is overly conservative with regards to identifying potential GDEs in and near to the SRM Area. The GDE Atlas mapping presented as **Figure 4-20** therefore should only be considered a first-pass indicator of potential GDE presence, but not adopted as environmental receptor identification for the purposes of this PRC Plan hydrogeological assessment.



0 2.5 5 km

Coordinate System: GDA 1994 MGA Zone 55

Scale: 1:130,000 at A4

Project Number: 620.30984

Date: 31-Oct-2023

Drawn by: NT



LEGEND

- Major Watercourse
- Minor Watercourse
- SRM EA Boundary
- SRM Mine Lease
- Remote Sensed Potential Terrestrial GDE Area (2rog, 2021)

Aquatic GDE

- High potential GDE
- Moderate potential GDE
- Low potential GDE

Terrestrial GDE

- High potential GDE
- Moderate potential GDE
- Low potential GDE

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POTENTIAL GDES

FIGURE 4-20

SRM GDE Studies

A remote sensing terrestrial GDE assessment was undertaken by 2rog (2021) as part of broader GDE assessments across BHP tenements within the region. Using the Australian Government Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development (IESC) recommended remote sensing approach, Landsat ETM imagery was selected following relatively wet and dry seasons and was analysed to identify areas of vegetation that were shown to be persistently wetter and greener than the surrounding areas, and thus may be areas of potential GDEs. Only a single area of potential terrestrial GDEs was identified within approximately 6 km of the SRM Area using the remote sensing method, on the western boundary of the SRM Area immediately adjacent/south of the SRM Mine Infrastructure Area (MIA) and west of Ebony Pit. It is worth noting that this area is also identified as a high potential aquatic GDE in the GDE Atlas (refer **Figure 4-20**). Small areas of potential terrestrial GDEs were also identified by 2rog (2021) approximately 6 km east of the SRM Area along Hughes Creek. Potential terrestrial GDEs were also mapped by 2rog (2021) located approximately 6 to 7 km to the west and southwest of the SRM Area, associated with elevated topography and outcropping Back Creek Group strata.

Terrestrial ecology studies completed by AECOM (2020) for the SEMLP (immediately east of SRM) found that the majority of floral assemblages within the area are characterised by drought tolerant species with low physiological sensitivity to water availability. Land use in and surrounding SRM is dominated by low intensity cattle grazing, with much of the native catchment and riparian vegetation having been cleared for pasture grasses (frc environmental, 2018).

AECOM (2020) document that Froend and Loomes (2004) suggest that groundwater is of reduced importance to vegetation when the water table is at depths greater than 10 m. They assume, however, that at depths between 10 m and 20 m there is still a probability of vegetation groundwater use, but this is thought to be negligible in terms of total plant water use. Groundwater in all formations at SRM is generally found at depths greater than 15 mBGL (**Section 4.3**). This depth is also outside the accessible reach for Eucalypt vegetation (Zolfagher et al, 2014) and the root biomass of *Acacia harpophylla* (brigalow) which is typically shallow <2m (Moore et al., 1967). AECOM (2020) state that open woodland communities would obtain groundwater from the soil moisture stored in the capillary fringe of predominantly clay soils. Riparian communities of the SRM site utilise soil moisture retained in stream banks (alluvium material) from ephemeral flows (AECOM, 2020).

Aquatic ecology studies by frc environmental (2018) for the SEMLP found that there are no high ecological value waters or surface expression groundwater dependent ecosystems in, or surrounding, the SRM Area. There are mapped lacustrine and palustrine wetlands surrounding the SRM Area, but relatively few mapped wetlands directly east of the site. The Isaac River distant from SRM is mapped as a riverine wetland, and Phillips Creek and the Isaac River have mapped riverine regional ecosystems in their riparian zones (frc environmental, 2018).

Baseline field aquatic ecology surveys were completed for the SEMLP in December 2007 and April 2010 by SKM (frc environmental, 2018). Field surveys were conducted at Phillips Creek, Plumtree Creek, Boomerang Creek, Lake Vermont, One Mile Creek and various dams. The surveys found that aquatic habitats in SRM and the surrounding areas were characterised by pools of variable sizes and depths, with pools in natural watercourses typically isolated, small and shallow. Artificial waterbodies (dams) were found to hold more permanent, extensive and deeper bodies of water. Of the sites visited, none were identified as having flowing water. It was also noted that substrate in Phillips Creek had a high proportion of sand whereas substrate at all other sites was dominated by silt/clay, suggesting perched surface water disconnected from the underlying water table.

Watercourses in the area are highly ephemeral (**Section 2.2**), and aquatic habitat is dominated by small, isolated pools within the channel interspersed with large areas of dry stream bed, with larger pools typically found in artificial waterbodies (frc environmental, 2018). Larger pools are likely to be perennial or near-perennial and important refugial habitats for aquatic fauna. Smaller shallower pools provide aquatic habitat for briefer periods after rainfall. Comparison with the depth to water table indicates that these pools are unlikely to be sustained by groundwater, confirming the low potential of aquatic GDEs at SRM and the surrounding area.

Stygofauna

Stygofauna sampling was undertaken in seven groundwater monitoring bores screened across Tertiary and Permian units during September 2011 (IESA, 2011a) and December 2011 (IESA, 2011b) as part of the SEMLP. Sampling was undertaken in accordance with Draft Guidance No. 54A - Sampling methods and survey considerations for subterranean fauna in Western Australia (WA EPA, 2007). It is noted that guidelines specific to Queensland have since become available, however the results of the 2011 sampling are still considered representative. No stygofauna species were detected during either the September 2011 and December 2011 sampling events.

5 Conceptual Site Model – End of Mining

A conceptual site model (CSM) of the groundwater regime has been developed based on the review of the hydrogeological information for SRM presented in the above report sections. The CSMs are based on the hydrogeological data review presented above, as well as the results of previous SRM groundwater modelling reported in AECOM (2019).

5.1 General

SRM is located within the northern part of the Bowen Basin, which comprises Permian aged coal measures that have been folded into a syncline structure that strikes in a north-west to south-east direction. The geology of SRM comprises the stratified sequences of the Moranbah Coal Measures at the westernmost extent of the syncline that dip towards the east. Mining at SRM targets the coal seams of the Moranbah Coal Measures, that occur at subcrop, and increase with depth towards the east. Surficial cover at SRM includes some alluvium associated with minor tributaries of the Isaac River, being Boomerang Creek in the north of SRM, Hughes Creek and One Mile Creek in the centre of SRM, and Phillips Creek in the south of SRM. Surficial cover at SRM outside of these creek lines consists of Quaternary to Tertiary sediments and weathering derived regolith.

The main hydrogeological features at SRM include:

- Cainozoic sediments and regolith:
 - Quaternary alluvium – unconfined aquifer (sporadically water-bearing strata of permeable unconsolidated sand or gravel) localised at and near to SRM along Phillips Creek, and regionally along the Isaac River where it is particularly well developed.
 - Quaternary to Tertiary sediments and regolith – unconfined and largely unsaturated unit at SRM and in the Study Area.
- Permian coal measures with:
 - Low permeability interburden units with aquitard properties; and
 - Coal seams that exhibit water bearing properties associated with secondary porosity through cracks and fissures.

Alluvium associated with the creek lines at SRM is poorly developed and sporadically saturated. The alluvial aquifer only becomes significantly water bearing when associated with the Isaac River alluvium, that occurs 18 km northeast of SRM at its closest. Where it occurs, groundwater within the alluvium is recorded at depths of between 8 mBGL to 14.5 mBGL, typically significantly disconnected from the streambed elevation. Regionally, groundwater flow within the alluvium is a subdued reflection of topography, with groundwater flowing in an east-south-easterly direction. Losing conditions from water courses to the underlying alluvium are evident during flow periods and recharge to the alluvium is considered to be primarily from stream flow or flooding, with direct infiltration of rainfall also occurring rapidly where there are no substantial clay barriers in the shallow sub surface. On a regional scale, discharge is via evapotranspiration from riparian vegetation growing along creek beds and minor short duration baseflow events after significant rainfall/flooding.

Water quality data for the alluvium within the broader Study Area indicates it can be fresh to saline and highly spatially and temporally variable. Water quality data from the alluvium across the Study Area indicates that it is mostly suitable for stock water supply and irrigation but exceeds guidelines for drinking water and protection of freshwater aquatic ecosystems. Based on previous ecological studies, it was identified that riparian vegetation has a low likelihood of dependence on alluvial groundwater. Alluvial bores within the SRM monitoring network were found to be on average, not suitable for long-term irrigation, with concentrations of boron and iron exceeding guideline levels. Review of the Queensland GWDB and a landholder census indicates alluvial groundwater associated with the Isaac River is used by local landholders, predominantly for stock water supply.

Tertiary-Quaternary aged sediments and weathering derived regolith present across SRM form the base of the unconfined shallow groundwater system. The groundwater flow processes are similar to those of the alluvium; however the fluxes are expected to be significantly lower due to the dominance of clay within the sediments. Within the Study Area, near the Isaac River and creeks, water has been detected within the Tertiary material at depths of around 8 mBGL to 19 mBGL. Water quality data for the Tertiary sediments and regolith indicates it is generally highly saline but can be brackish to moderately saline. Water is generally of poor quality and not considered suitable for stock, irrigation, aquatic ecosystems or drinking water.

In the Permian strata, groundwater is encountered mainly in the coal seams, and occasionally in the sandstone/siltstone units of lower hydraulic conductivity. As with the rest of the Bowen Basin, the coal seams are the main groundwater bearing units within the Permian sequences, with low hydraulic conductivity interburden generally confining the individual seams. The coal seams are dual porosity in nature with a primary matrix porosity and a secondary (dominant) porosity provided by fractures (joints and cleats). Hydraulic conductivity of the coal decreases with depth due to increasing overburden pressure reducing the aperture of fractures. Vertical movement of groundwater (including recharge) is limited by the confining interburden layers, meaning that groundwater flow is primarily horizontal through the seams with recharge only occurring at subcrop.

Review of fault behaviour within the Study Area and from external studies has identified that faults in the Permian strata can increase vertical hydraulic conductivity parallel to the fault trace and reduce it perpendicular to the fault trace (SLR, 2021). However, any increase in vertical hydraulic conductivity are limited to small vertical horizons (<20 m) and is variable between faults dependent on localised hydrothermal activity and mineralisation in-filling pore spaces. Hydraulic testing of faults within the Study Area indicate that faulting zones intercepted are not pathways for preferential flow (SLR, 2021).

Regionally, groundwater within the Permian coal measures flows in a south-easterly direction, but the flow system is significantly modified by mining activities in the region with ongoing discharge to mine workings, including at SRM. Review of water quality data indicates water within the Permian coal measures is generally saline at SRM but can range between brackish to highly saline. Groundwater within the coal measures at SRM exceeds guideline criteria for irrigation, drinking water and protection of aquatic ecosystems, and only variably meets the guideline criteria for stock water supply with guideline exceedances most common for salinity and sulfate.

5.2 End of Mining

The potential impacts to the groundwater system post-closure, as relevant to the hydrogeology assessment for the PRC Plan, are relative to how the groundwater system recovers from active mining. Therefore, it is important to understand the nature of the groundwater system at the conclusion of mining immediately prior to the closure period.

A visual representation of the end of mining CSM is provided as **Figure 5-1**, noting the features discussed above. Based on previous SRM groundwater modelling presented in AECOM (2019), key features relevant to the discussion of potential groundwater impacts post-mining are likely to be:

- Groundwater drawdown within the Moranbah Coal Measures, associated with passive dewatering into the SRM mine pit voids, results in inwards hydraulic flow gradients in the coal measures.
- Drawdown in the Moranbah Coal Measures at the end of mining is at, or close to, the maximum expected to occur as a result of SRM.
- Mine pit voids capture any seepage from spoil emplacements.
- Mine pit voids capture seepage from TSFs.
- Little to no impact on surficial aquifers including the Isaac River Alluvium.
- Little to no impact on environmental receptors.
- No impact on anthropogenic receptors.

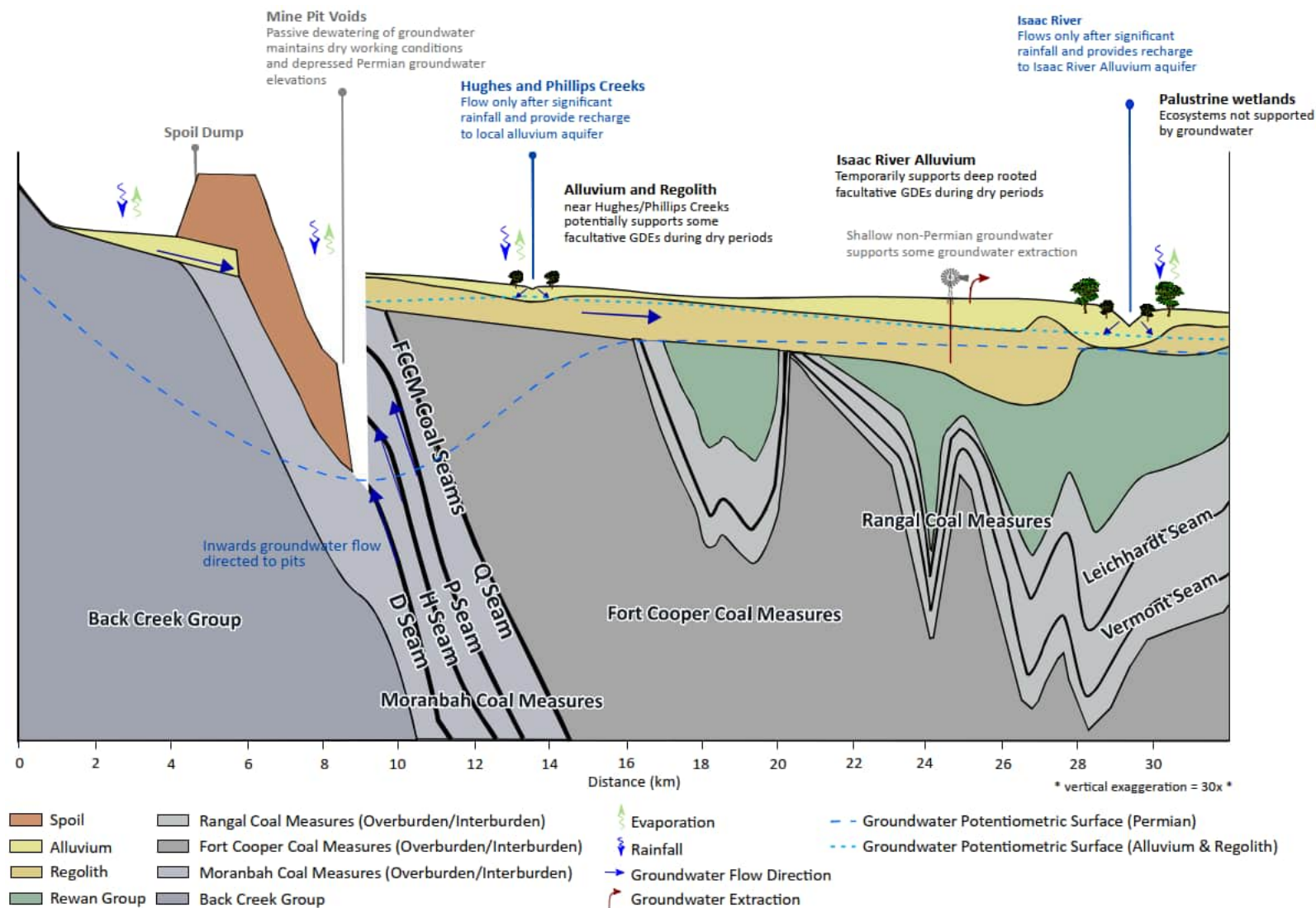


Figure 5-1 Conceptual Model of the Groundwater System – End of Mining

6 Potential Impacts

Potential Impacts associated with shallow sources of potential groundwater contamination at SRM are being assessed for the PRC Plan by a separate Contaminated Land Assessment. Therefore, this hydrogeology assessment focuses on the larger scale impacts to the SRM groundwater system. However, the movement of potential contaminants in groundwater that might be associated with seepage from spoil dumps or the MIA is considered within this hydrogeological assessment.

6.1 Groundwater System at End of Mining

The potential impacts to the groundwater system post-closure, as relevant to the hydrogeology assessment for the PRC Plan, are relative to how the groundwater system recovers from active mining including the groundwater flow regime that results from the final landform. Therefore, it is important to understand the nature of the groundwater system at the conclusion of mining immediately prior to the closure period. The AECOM (2019) work has been interrogated to provide an indication of the predicted nature of the SRM groundwater system at the end of mining, and potential groundwater system impacts that may have arisen at the end of mining. These can be summarised as:

- Groundwater level drawdown of the Permian coal measures, associated with passive dewatering into the active SRM mine pit void. The magnitude of this drawdown will be most significant in the immediate vicinity of the pit voids, but extend northwards, eastwards and southwards of SRM by several kilometres and interact with drawdown from nearby mines such as Peak Downs, Saraji South and Lake Vermont.
- Little to no groundwater level drawdown of the alluvium away from SRM.
- No groundwater-related effect on surface water flows of the Isaac River.
- Low potential for groundwater level drawdown impacts to potential GDE's along Hughes Creek and Phillips Creek, where the water table in the regolith material may be facultatively accessed by deeper rooted riparian species and may be subject to relatively small drawdowns.
- Limited potential for impacts to seasonal surface flows in Hughes Creek as a result of drawdown caused by flow from surface water to groundwater, in response to the reduction in groundwater levels of coal seams in areas below the creek.
- No potential for groundwater quality impacts outside of SRM associated with spoil dumps and TSFs, due to the inward groundwater flow gradients towards the pit voids capturing all potential seepage.

6.2 Groundwater System Post Mining

AECOM (2016) conducted a post-mining quantitative assessment of the SRM final voids for a period of 50 years after the end of mining. The results of the assessment can be considered indicative of the potential impacts to the groundwater system in the post-closure period as relevant to this hydrogeology assessment, that will be investigated further in this assessment by considering the PRC Plan's final landform. The post-closure predicted groundwater system documented in AECOM (2016) can be summarised as:

- There will be limited recovery in groundwater levels at the localised scale in the first 50 years post-closure, with groundwater recovery characterised as 'slow'. Limited predicted recovery of groundwater levels was considered to be due to:
 - limited rainfall recharge;

- long term mine dewatering (since 1974) that has resulted in groundwater being removed from storage which needs to be replaced before marked changes in groundwater levels will be observed;
- high evaporation over large final void areas modelled across the approximately 22.5 km strike length;
- low permeability within the sediments surrounding the open pits.
- Predictions were for the groundwater within the final voids to remain below pre-mining levels.
- Void water level recovery is expected to be significantly below the base of weathering or any shallow Cainozoic aquifers.
- Ongoing groundwater discharge to the final voids driven by the inwards hydraulic gradient between the void lakes and the surrounding groundwater system and maintained by ongoing evaporative discharge from the void.

The remainder of this report focuses on the detailed assessment of the PRC Plan's final landform, i.e. an update to the AECOM (2016) post-mining potential impacts discussed above.

7 Groundwater Modelling

7.1 Model Details

BMA's SRM numerical groundwater model was adopted for the PRC Plan's hydrogeological assessment. This section provides a summary of the design and development of the SRM numerical groundwater model. Full details of the SRM numerical groundwater model adopted in this hydrogeological assessment are included within SLR (2022a).

The SRM numerical groundwater model was deemed appropriate for the purposes of the PRC Plan for the following reasons:

- Adoption of the MODFLOW-USG code in the existing model allows for sufficient refinement of the model grid around the SRM operations such that the limitations of a regional model in terms of the grid design are mitigated.
- The model incorporates the SRM geologic model with model layer representation consistent with the geologic model.
- The model is robustly calibrated to SRM specific monitoring data as well as an extensive regional dataset including that collected at neighbouring mines.
- The model incorporates regional influences that may interact with the groundwater system (and model predictions) post-closure at SRM, including operations at the neighbouring Peak Downs Mine that are considered likely to interact with the SRM voids given their proximity.
- The SRM model adopted for the SRM PRC Plan is the latest update to the existing BMA regional numerical model that has been subject to multiple independent peer reviews, as well as State and Commonwealth regulator reviews, and has found widespread acceptance as a result of those reviews. In particular, the independent peer reviewer of the previous SLR (2021) Caval Ridge Mine version of the model found that "the documented groundwater assessment is best practice" and that the "groundwater modelling has been conducted to a very high standard" (HydroAlgorithmics, 2021).

7.1.1 Model Objectives

Numerical modelling was undertaken in support of this hydrogeology assessment for the PRC Plan to evaluate the potential impacts of Landform #2 (refer **Section 1.2**) on the groundwater regime. The objectives of the predictive modelling were to:

- Assess groundwater inflow to the final landform's voids;
- Simulate the level and rate of recovery of the void lakes, and the level and rate of mining-related groundwater drawdown recovery in the groundwater system surrounding the voids; and
- Identify areas of potential risk, such as private supply bores (**Section 4.5.1**) or GDEs (**Section 4.5.2**), where groundwater impact mitigation/control measures may be necessary post-closure.

7.1.2 Model Design

The recently updated SRM version of the BMA regional numerical groundwater model was developed primarily to support the SEMLP approvals process as well as future approvals processes for the neighbouring Peak Downs Mine. The model is regional in nature, designed primarily to predict regional scale mining impacts in a cumulative impact framework. That is, mines such as SRM are represented within the regional cumulative hydrogeological impact framework in which they sit.

The numerical model was developed using a Geographic Information System (GIS) in conjunction with MODFLOW-USG, which is distributed by the United States Geological Survey (USGS). MODFLOW-USG is a relatively new version of the popular MODFLOW code (McDonald and Harbaugh, 1988) developed by the USGS. MODFLOW is the most widely used code for groundwater modelling and has long been considered an industry standard.

The SRM numerical groundwater model builds on the Olive Downs Project EIS model (the foundational regional Bowen Basin model) (HydroSimulations, 2018). The foundational model was subsequently updated for the Moorvale South Project in 2019 (SLR, 2019), for the Winchester South Project EIS in 2020 (SLR, 2020), for the Lake Vermont North Project and Caval Ridge Mine Horse Pit Extension Project in 2021 (SLR, 2021), and most recently for the Peak Downs Mine Continued Operations Project and the SEMLP in 2022 (SLR, 2022a).

At the time of the most recent model revision (SLR, 2022a), a range of model updates were deemed required to ensure the previous iteration of the regional Bowen Basin model was fit for purpose for use at SRM (and Peak Downs). The updates to the model design that were undertaken for included:

- Model layers – update model layers to match SRM, SEMLP and Peak Downs Mine geological model surfaces.
- Timing – updated calibration model to extend to December 2021 and refined timing to capture seasonality and mine progression changes.
- Stresses – Maintained inputs, but with updates from more recent and site-specific data.

These updates resulted in a model that was deemed suitable for representation of all historic and future mining at SRM, as well as the post-mining period.

Model layering is based on a simplified regional scale representation of the central Bowen Basin hydrogeological framework. The model layer structure is presented in **Table 7-1**. Those layers identified in the table as not present at SRM are 'pinched out' at SRM within the MODFLOW-USG code.

Table 7-1 Model Layering

Model Layer	Geologic Formation	Hydrogeologic Unit	Present at SRM
1	Alluvium, colluvium, Tertiary basalt	Alluvium, surface cover	Yes
2	Tertiary sediments, Tertiary basalt	Tertiary sediments, weathered Permian, Tertiary basalt	Yes
3	Rewan Group	Triassic	No
4	Rangal Coal Measures	Leichhardt overburden	No
5		Leichhardt seam	No
6		Interburden	No
7		Vermont seam	No
8		Vermont underburden	No
9	Fort Cooper Coal Measures	Fort Cooper overburden	Yes (in part)
10		Fort Cooper seams (combined)	Yes (in part)
11		Fort Cooper underburden	Yes (in part)
12	Moranbah Coal Measures	Q Seam	Yes (in part)
13		Interburden	Yes (in part)
14		P Seam	Yes (in part)
15		Interburden	Yes
16		H Seam	Yes
17		Interburden	Yes
18		D Seam	Yes
19		Interburden	Yes

7.1.3 Model Calibration

A detailed description of the calibration procedure is provided in SLR (2022a). The numerical model includes a steady state and a transient calibration (2008 to 2021). In all, calibration used 3,499 target heads for 282 bores, including 43 observation sites at SRM. Both the steady-state and transient calibrations capture historical mining at SRM, Peak Downs, Caval Ridge, Lake Vermont, Poitrel, Daunia, Millennium, Isaac Plains, Olive Downs and Grosvenor mines. Mining was represented in the model using the MODFLOW drain package, with the drain cells set to the base of the target coal seam for each pit, and within the target coal seam for underground mines. Calibration of the model was carried out with the objective being to replicate the groundwater levels measured in the SRM, Caval Ridge, Lake Vermont, Winchester South Project, Olive Downs, Moranbah South Project, Moorvale South Project, Millennium, Poitrel, and Daunia monitoring networks, as well as some registered bores, in accordance with Australian Groundwater Modelling Guidelines (Barnett et al., 2012).

Given the regional scale model design, equal weighting was applied to all bores/data from each site so as not to bias model calibration to any one area/mine and potentially decrease model reliability elsewhere, but provide the most robust regional scale calibration possible given the regional cumulative hydrogeological impact framework. This approach also means that any data uncertainty associated with a single calibration point in any one model layer will not bias the calibration results, as all data for each layer from across the entire regional model domain is treated equally. Similarly, the calibration approach means that the influence on calibration performance of any perceived lack of local calibration points for a layer at any particular mine site, or a relatively short monitoring record at any one monitoring site, is somewhat mitigated by the regional scale approach to calibration where calibration is aiming to achieve the best fit to all available data across any one model layer. The number of model calibration points and associated target head measurements for each layer is provided in **Table 7-2**.

Table 7-2 Model Calibration Targets (SLR, 2022a)

Model Layer	Geologic Formation	Hydrogeologic Unit	Calibration Target Locations	Number of Target Head Measurements
1	Alluvium, colluvium, Tertiary basalt	Alluvium, surface cover	18	212
2	Tertiary sediments, Tertiary basalt	Tertiary sediments, weathered Permian, Tertiary basalt	93	910
3	Rewan Group	Triassic	15	153
4	Rangal Coal Measures	Leichhardt overburden	10	251
5		Leichhardt seam	28	358
6		Interburden	6	123
7		Vermont seam	23	259
8		Vermont underburden	5	175
9	Fort Cooper Coal Measures	Fort Cooper overburden	23	338
10		Fort Cooper seams (combined)	10	90
11		Fort Cooper underburden	4	29
12	Moranbah Coal Measures	Q Seam	3	117
13		Interburden	2	39
14		P Seam	6	99
15		Interburden	5	66
16		H Seam	14	85
17		Interburden	3	7
18		D Seam	14	138
19		Interburden	0	0
Totals			282	3449

Calibration for the model achieved a 10.4 m root mean square (RMS) error, equating to a 6.9% scaled root mean square (SRMS) error, which is within the recommended range (i.e. 10%) in the Australian Groundwater Modelling Guidelines (Barnett et al., 2012). Observations from the SRM monitoring bores achieved an RMS error of 8.8 m, which is lower than the RMS error for the entire model, reflecting slightly better calibration performance at SRM when compared to the entire model calibration dataset. Calibrated hydraulic parameters were shown to be all within the range of available field data (SLR, 2022a).

7.1.4 Model Performance and Limitations

The groundwater modelling was conducted in accordance with the Australian Groundwater Modelling Guidelines (Barnett et al. 2012), the Murray Darling Basin Commission (MDBC) Groundwater Flow Modelling Guideline (MDBC, 2001) and the released IESC Explanatory Note for Uncertainty Analysis (IESC, 2018). These are mostly generic guides and do not include specific guidelines on special applications, such as underground coal mine modelling.

The 2012 Australian Groundwater Modelling Guidelines has replaced the model complexity classification of the previous MDBC guideline by a "model confidence level" (Class 1, Class 2 or Class 3 in order of increasing confidence) typically depending on:

- Available data (and the accuracy of that data) for the conceptualisation, design and construction.
- Calibration procedures that are undertaken during model development.
- Consistency between the calibration and predictive analysis.
- Level of stresses applied in predictive models.

It is generally expected that a model confidence level of Class 2 is required for mining environmental impact assessment; the 2012 Australian Groundwater Modelling Guidelines state that a Class 2 model may be used for assessing impacts associated with mine dewatering (Barnett et al. 2012).

Table 7-3 summarises the subjective qualitative criteria allowing model classification, per Table 2.1 of the 2012 Australian Groundwater Modelling Guidelines. The classification of the SRM model as presented in **Table 7-3** has been assessed subjectively by a Principal level groundwater modeller and reviewed by a Technical Director level hydrogeologist/modeller, whereby:

1. The classification table was subjectively reviewed and the specialists mutually decided, in their professional opinion, which box most appropriately describes the various characteristics of the model.
2. Thereafter, the assessors assigned an overall classification class for the model based on the characteristics selected, i.e. which class has the most selected characteristics.

Table 7-3 Groundwater Model Classification Table^{1,2}

Class	Model Characteristics					
	Data		Calibration		Prediction	
1		Few or poorly distributed data points		Not possible		Predictive timeframe >> calibration timeframe
		Unavailable or sparse data in areas of greatest interest		Unacceptable levels of error		Temporal discretisation is different to calibration
	✓	No metered groundwater extraction data		Inadequate distribution of data		Transient prediction but steady state calibration
		Remote climate data		Targets incompatible with model purpose		Unacceptable validation
		Little or no useful data on land-use, soils, or river flows and stage elevations				
2		Some data but may not be adequate throughout domain	✓	Reasonable calibration statistics with errors in parts of the model	✓	Predictive timeframe > calibration timeframe
		Some metered groundwater extraction data		Long-term trends not replicated in all parts of domain		Long stress periods compared to calibration
	✓	Streamflow and stage measurements are available at some points		Transient calibration not extending to present day		New stresses not in calibration
		Reliable irrigation application data available in part	✓	Weak seasonal replication		Poor validation
				No use of calibration targets compatible with model purpose		
			✓	Validation not undertaken		
3	✓	Spatial and temporal distribution of data adequate	✓	Scaled RMS error or other calibration statistics are acceptable		Predictive timeframe ~ calibration timeframe
		Clearly defined aquifer geometry	✓	Long-term trends adequately replicated where important	✓	Temporal discretisation in predictive model consistent with transient calibration
		Reliable metered groundwater extraction data		Seasonal fluctuations adequately replicated	✓	Similar stresses to those in calibration
	✓	Rainfall and evaporation data is available	✓	Transient calibration is current		Steady state prediction consistent with steady state calibration
	✓	Aquifer testing data to define key parameters	✓	Model is calibrated to heads and fluxes		Model validation suggests calibration is appropriate
	✓	Good quality and adequate spatial coverage of DEM	✓	Key modelling outcomes dataset used in calibration		Steady-state predictions when the model is calibrated in steady-state
		Streamflow and stage measurements are available at many points				
		Reliable land-use and soil-mapping data available				
		Reliable irrigation application data available				

1. Refer Table 2.1 of the 2012 Australian Groundwater Modelling Guidelines (Barnett et al. 2012)

2. Grey highlighted cells = model has been subjectively assessed to meet the classification criteria for that Class

The assessment shown in **Table 7-3** indicates that, overall, the SRM groundwater model can be classified as primarily Class 3 using the 2012 Australian Groundwater Modelling Guidelines classification system (effectively “high confidence”), with some aspects meeting the lower Class 2 criteria. This is considered an appropriate level for this PRC Plan context. The classification of the previous iteration of the model as at least Class 2 has been validated by an independent expert hydrogeologist/modeller (HydroAlgorithmics, 2021), with that independent reviewer noting that “*all models are in fact mixtures of Class 1, Class 2 and Class 3*”.

7.2 PRC Plan Landform #2 Model

Post-mining groundwater impacts at SRM were investigated for the purposes of the PRC Plan’s hydrogeology assessment with a numerical groundwater recovery model for Landform #2 (i.e. four residual voids; refer **Section 1.2**).

7.2.1 Model Setup

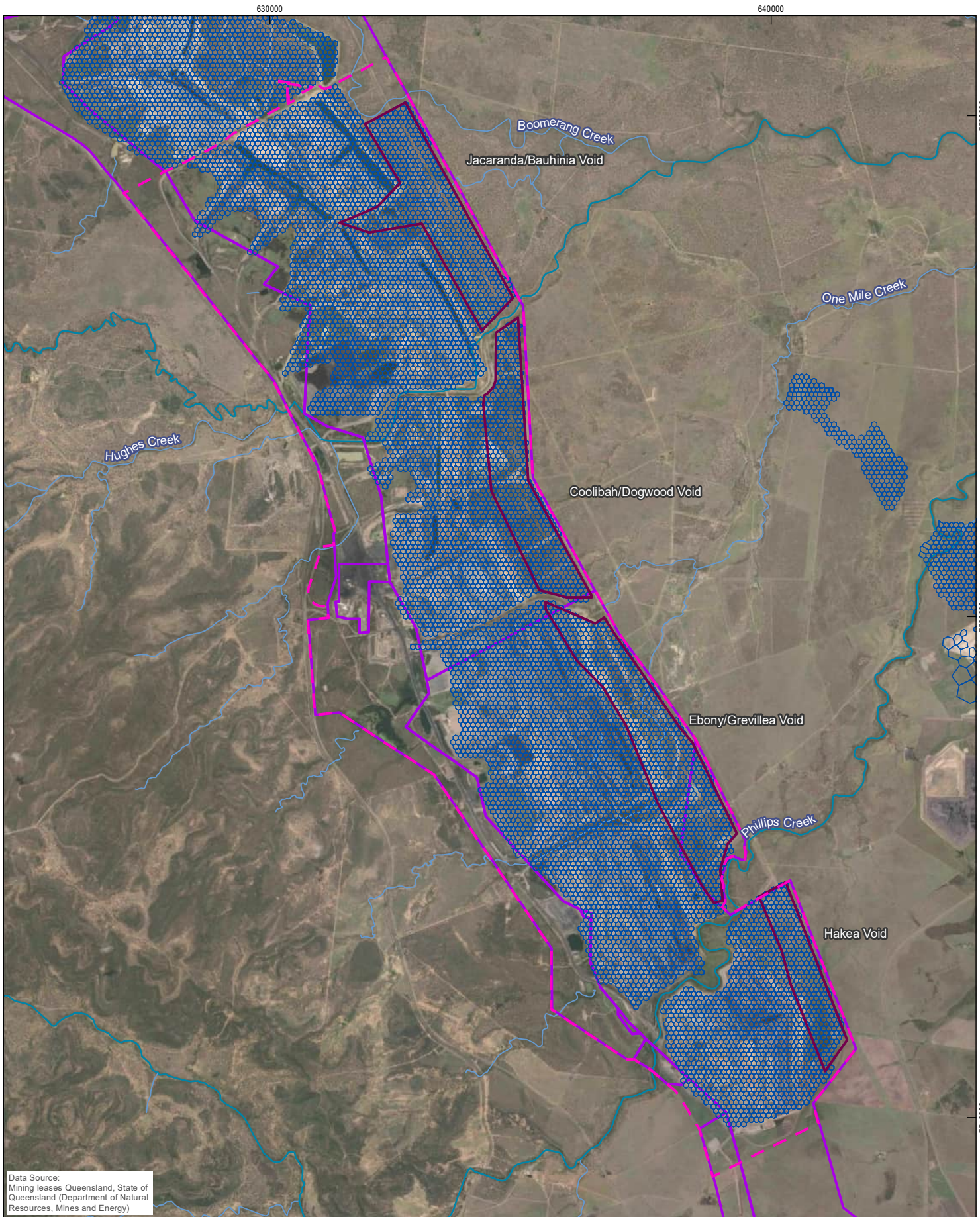
The PRC Plan’s proposed final landform was replicated in the recovery model, including areas of spoil emplacement within mined out pits and the four proposed final voids. The distribution of modelled spoil emplacement is shown on **Figure 7-1**, noting that modelled spoil emplacement occurs throughout the four residual void areas (i.e. beneath the residual void floor and above natural geology). The modelling of spoil emplacement within the residual voids themselves is an artefact of the modelling code and the automated process by which the final landform design is imported into the model. In reality, the final landform design does not include spoil emplaced at the lowest point of the residual void floors and the natural geology remains exposed at the base of the void lakes. This modelling nuance would not affect the predictive results discussed herein in terms of total groundwater inflows to the voids and groundwater system behaviour outside of the voids in the long term, but only the proportionality of void groundwater inflows that are partitioned between spoil and natural rock. Predicted residual void lake levels would also not be affected since total groundwater inflows would not be affected.

The recovery model commenced from the end of mining at SRM (end of the year 2095) and was run for 2249 years over 54 model stress periods. The model stress period setup is shown in **Table 7-4**.

Table 7-4 Recovery Model Stress Periods

Stress Period	Stress Period Duration (Years)	Starting Year (Post-Mining)	Ending Year (Post-Mining)
1 – 20	1.0	1	20
21 – 30	2.0	21	40
31 – 35	5.0	41	65
36 – 49	10.0	66	205
50 – 53	50.0	206	405
54	1843.0	406	2249

The final recovery model adopted for reporting in this hydrogeology assessment used end of mining predicted groundwater levels from the SEMLP predictive model (SLR, 2022a) as the starting heads, and removed all drain cells simulating the proposed mining areas at SRM to allow groundwater levels to equilibrate. The starting heads for each relevant hydrostratigraphic unit are provided in **Appendix A**.



Data Source:
Mining leases Queensland, State of
Queensland (Department of Natural
Resources, Mines and Energy)



Coordinate System: GDA 1994 MGA Zone 55
Scale: 1:100,000 at A4
Project Number: 620.30984
Date: 31-Oct-2023
Drawn by: AS

LEGEND

- Major Watercourse
- Minor Watercourse
- Void Extent
- SRM EA Boundary
- SRM Mine Lease



SARAJI MINE TRANSITIONAL PRC PLAN HYDROGEOLOGY ASSESSMENT

MODELLLED SPOIL EMPLACEMENT

FIGURE 7-1

Climate related boundary conditions (i.e. recharge and evapotranspiration [ET]) in the recovery model were set constant for the duration of the recovery model, at their values consistent with the SEMLP predictive model (SLR, 2022a). Recharge and ET were not applied to the final voids themselves in the groundwater model, since the WSP (2023) water balance model used iteratively with the groundwater model (see **Section 7.2.2**) accounts for these boundary conditions.

The properties of the residual void cells were converted to values representative of void values consistent with the methodology adopted in the SEMLP model (SLR, 2022a). That is, the void cells were assigned high horizontal and vertical hydraulic conductivities (1,000 m/day) and storage parameters based on the compressibility of water (specific yield of 1.0, storage coefficient of $5.0 \times 10^{-6} \text{ m}^{-1}$), to simulate free water movement within the residual void.

The simulation of Peak Downs Mine in the groundwater model, located immediately north of the SRM Area, has the potential to influence the model results particularly for Jacaranda/Bauhinia Void. The simulation of Peak Downs within the groundwater model is unchanged from the SEMLP version of the groundwater model (SLR, 2022a), i.e. mining at Peak Downs ceases in the model in the year 2095 (i.e. prior to the SRM recovery model simulation) and the mined out Peak Downs pits are parameterised as being wholly backfilled with spoil.

7.2.2 Integration with Residual Void Water Balance Model

Figure 7-2 presents a conceptual diagram of the post-mining modelling setup adopted for this hydrogeological assessment. As shown in **Figure 7-2**, the residual voids will accumulate water over time due to direct rainfall, surface water runoff and groundwater inflow from both spoil and natural rock as groundwater levels recover. Whilst the numerical groundwater model can reliably account for the groundwater inflow component, the surface components of direct rainfall, surface water runoff, as well as evaporative loss from the void lake, are considered to be better accounted for within a surface water balance model. This is due to the inherently more refined nature of simulating those surface components within a water balance model, as compared to a numerical groundwater model. This surface water modelling is discussed below.

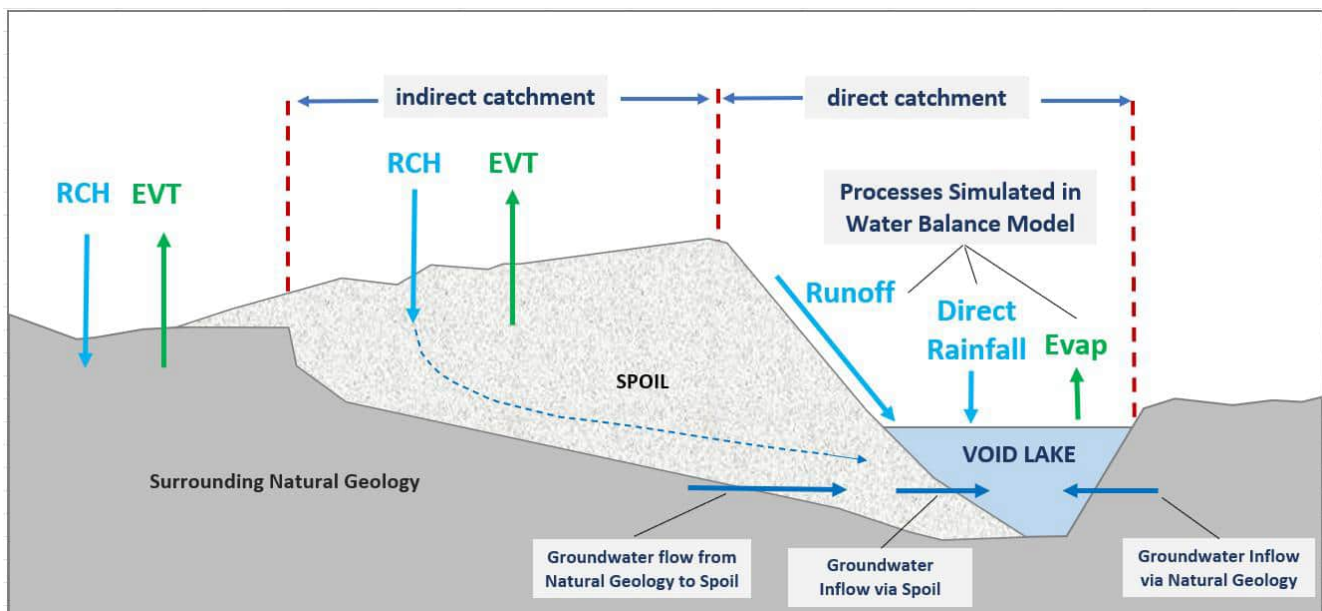


Figure 7-2 Residual Void Recovery Model Conceptual Diagram

The groundwater model was therefore used to predict the following fluxes to the residual voids:

- Groundwater inflow to the pit shell from the surrounding geology, including inflow from the natural geology to the spoil backfill and inflow from the natural geology directly to the residual voids; and
- Groundwater inflow originating from the indirect catchment (i.e. areas of spoil backfill that receive rainfall recharge that then flows through the spoil into the residual voids).

Void water levels were not predicted by the groundwater model, but were estimated by the balance between groundwater inflow and the direct rainfall and rainfall runoff from the surrounding catchment against the evaporation loss from the lake surface through iterative surface water balance modelling (WSP, 2023). The WSP (2023) surface water balance modelling included climate sensitivity and three climate scenarios reported therein were adopted for the groundwater model as instructed by BMA and shown in **Table 7-5**. That is, three sets of groundwater model predictions were generated for this hydrogeology assessment based on the three climate scenarios.

Table 7-5 Climate Scenarios Modelled

Climate Scenario	Climate Model	IPCC RCP Scenario ¹	WSP (2023) Realisation
Wetter	ACCESS1-0Q	4.5	R#1
Mid	ACCESS1-0Q	8.5	R#4
Drier	MPI-ESM-LRQ	8.5	R#6

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

The iterative modelling approach was undertaken in a stepwise manner as follows:

1. Initial predicted groundwater inflows with time to the SRM final landform residual voids from the SLR (2022a) SEMLP numerical groundwater model were incorporated in the water balance model prepared by WSP (2023).
2. The residual void lake levels with time were then predicted by the WSP (2023) water balance model for the range of climate scenarios, incorporating groundwater (Step 1) and surface water fluxes and processes.
3. To refine the groundwater model prediction of residual void groundwater inflows, the daily residual void water elevations derived from the WSP (2023) water balance modelling (Step 2) were then replicated within the numerical groundwater model for the final landform using the time variant constant head boundary (CHD) condition, adopting a simplified average of the WSP (2023) daily results over the relevant groundwater model stress period length.
4. Since the refined groundwater model predictions for fluxes to the residual voids from Step 3 were still in agreement with what was used as input to the water balance modelling (i.e. the initial predicted groundwater inflows with time to the voids per Step 1), it was considered by WSP (2023) that further iterations between the two models were not required and therefore the Step 3 groundwater model results were adopted for reporting in this hydrogeology assessment.

7.2.3 Residual Void Lake Recovery

Figure 7-3 through **Figure 7-6** provide a graphical representation of the final simulated recovery of water levels in the residual voids, based on the iterative groundwater and surface water balance modelling. Of note, there is an approximate 10 to 25 m range in equilibrium lake elevations between the three climate scenarios. It should be noted that, as predicted groundwater inflow to the voids is only 11% to 15% of the total volumetric inflow to the voids (see **Section 7.2.4**), within the water balance model the surface water fluxes are the dominant driver for the estimated void water levels and associated trends, rather than the predicted groundwater inflow volumes.

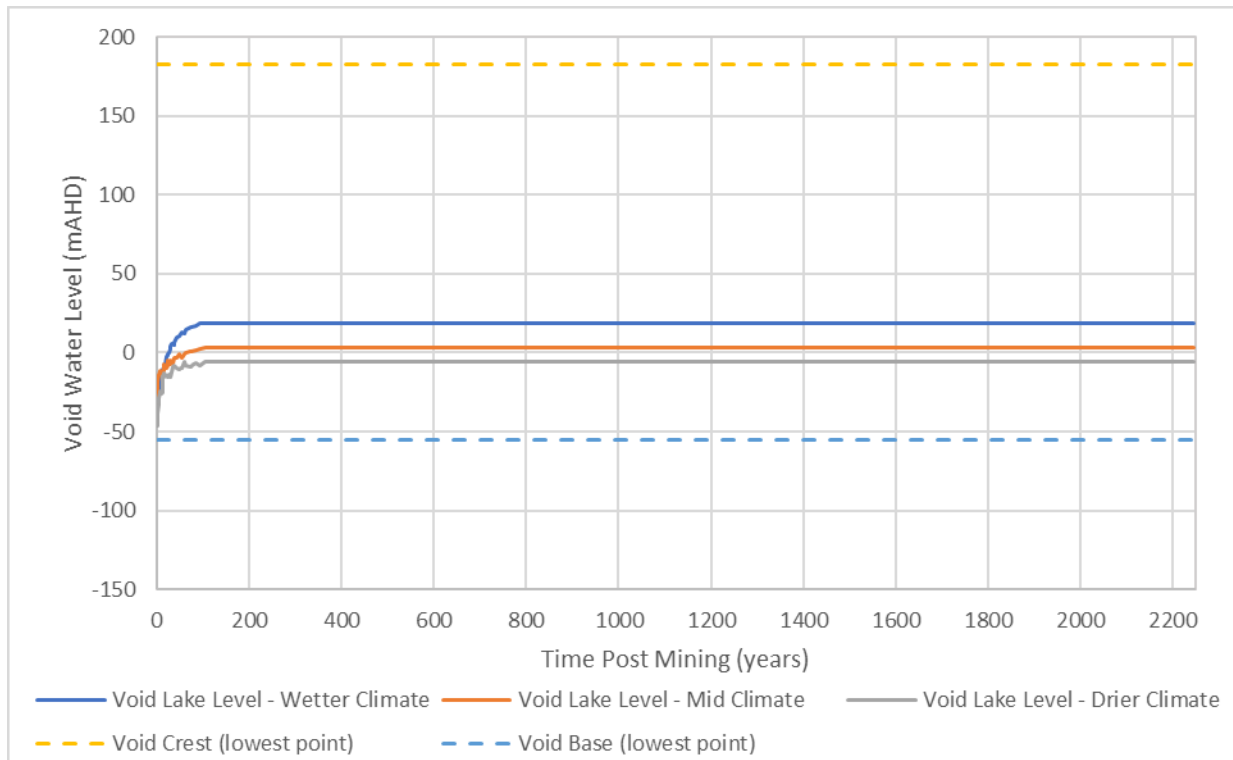


Figure 7-3 Simulated Void Water Level Recovery over Time – Jacaranda/Bauhinia Void (based on WSP, 2023)

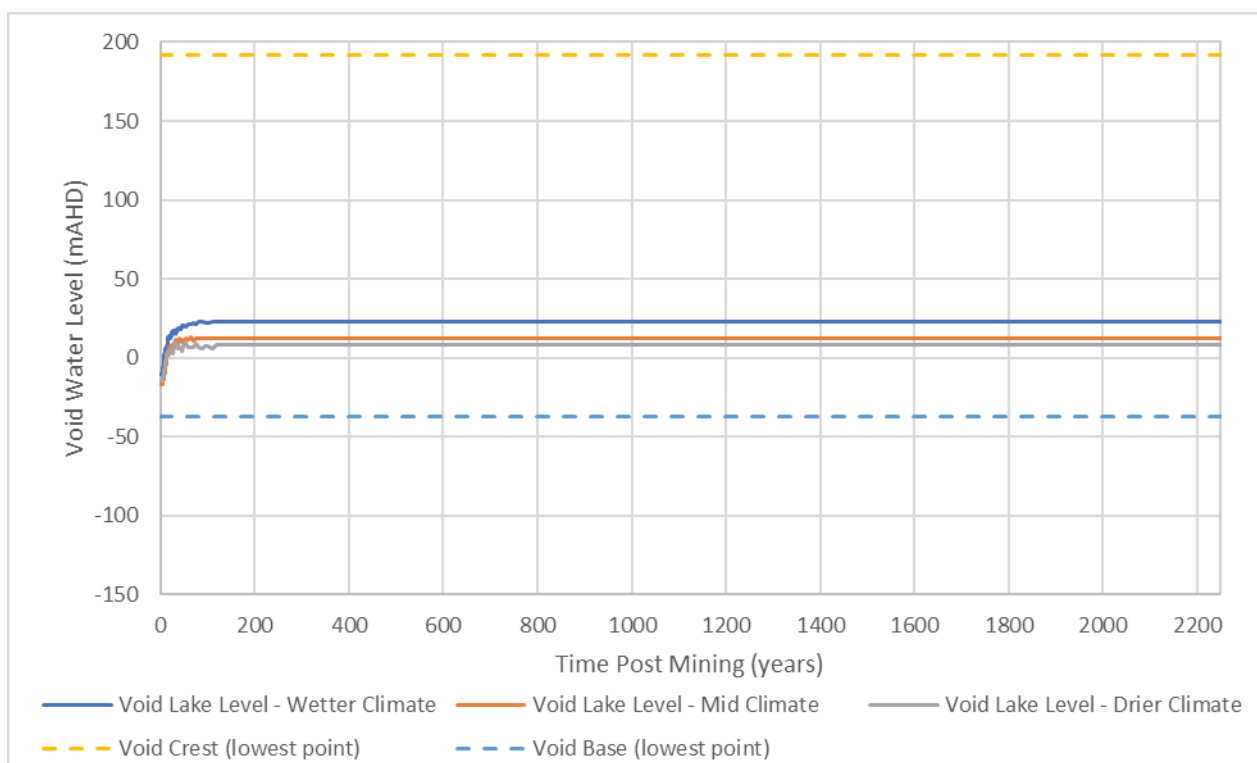


Figure 7-4 Simulated Void Water Level Recovery over Time – Coolibah/Dogwood Void (based on WSP, 2023)

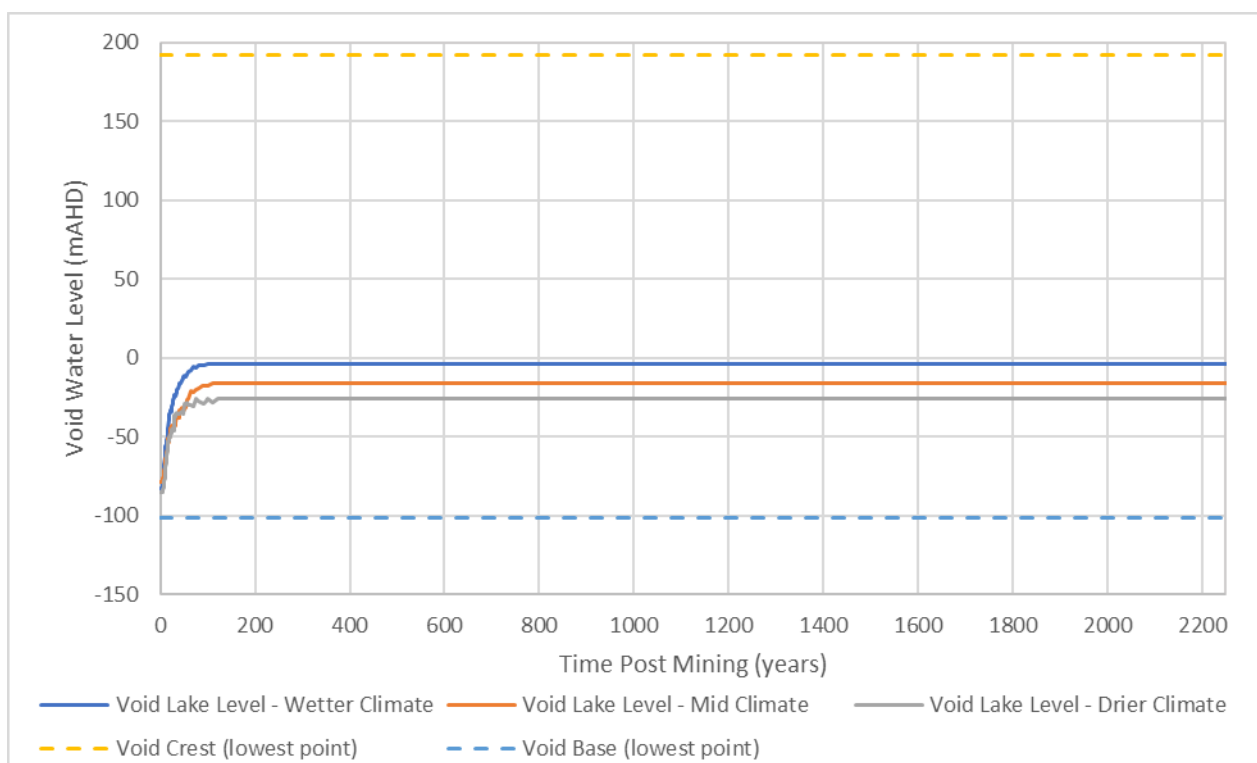


Figure 7-5 Simulated Void Water Level Recovery over Time – Ebony/Grevillia Void (based on WSP, 2023)

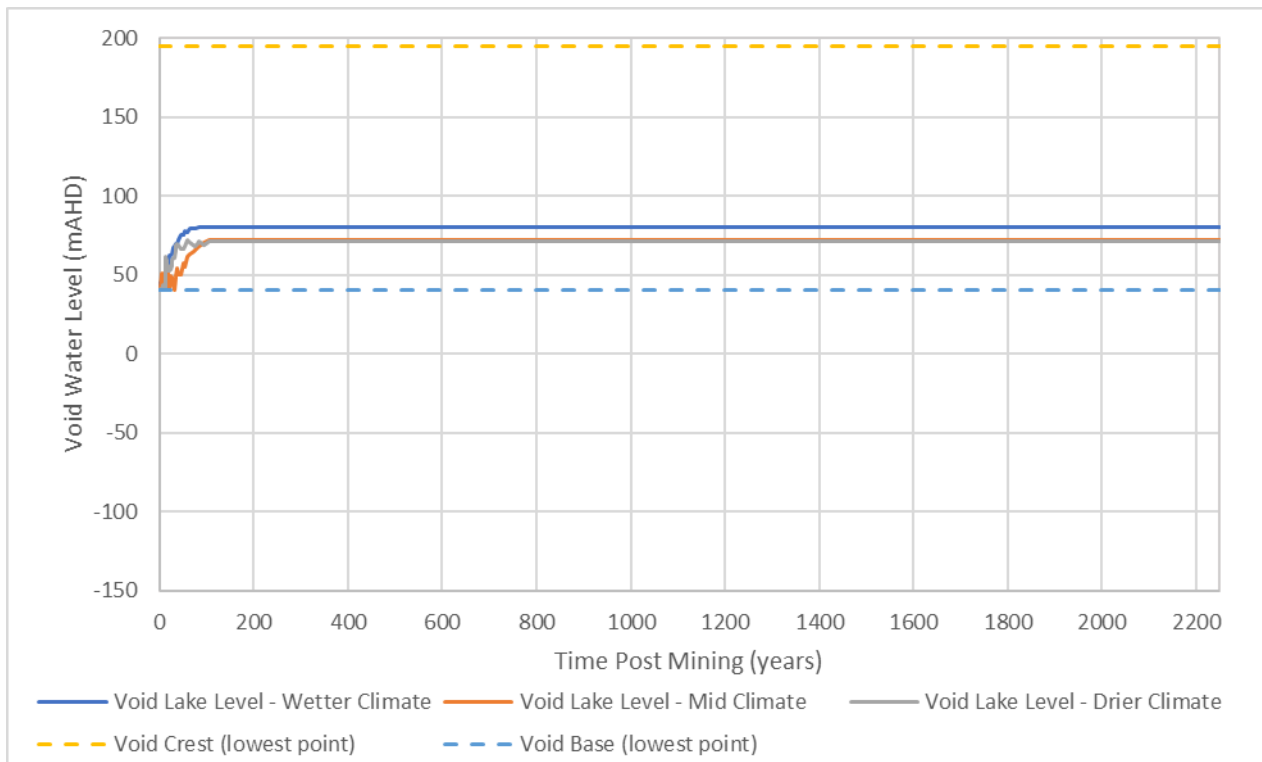


Figure 7-6 Simulated Void Water Level Recovery over Time – Hakea Void (based on WSP, 2023)

Figure 7-3 through **Figure 7-6** show that the residual void water level recovery is a process that takes decades with the recovery rate declining as the lakes reach equilibrium conditions. The majority of recovery in the voids is achieved within the first 100 years and equilibrium water level conditions are reached after approximately 105 to 120 years for all climate scenarios represented in the groundwater model. The predicted equilibrated water levels in the residual voids are shown in **Table 7-6**.

Table 7-6 Equilibrated Water Levels in the Residual Voids (based on WSP, 2023)

Climate Scenario	Residual Void	Initial water level (mAHD)	Approximate time to equilibrium (years)	Equilibrium water level (mAHD)
Wetter	Jacaranda/Bauhinia	-55.0	105	18.6
	Coolibah/Dogwood	-37.0	120	22.7
	Ebony/Grevillia	-101.0	120	-3.7
	Hakea	40.0	105	80.4
Mid	Jacaranda/Bauhinia	-55.0	105	2.8
	Coolibah/Dogwood	-37.0	120	12.2
	Ebony/Grevillia	-101.0	120	-16.2
	Hakea	40.0	105	71.2
Drier	Jacaranda/Bauhinia	-55.0	105	-7.0
	Coolibah/Dogwood	-37.0	120	6.9
	Ebony/Grevillia	-101.0	120	-26.9
	Hakea	40.0	105	69.9

The freeboard for each of the residual voids (i.e. the difference in elevation between the long-term water levels in the residual voids and the landform crest elevation) is as shown in **Table 7-7**. Predicted void lake levels remain significantly below the surface ‘spill’ level for each of the residual voids.

Table 7-7 Predicted Freeboard in the Residual Voids at Equilibrium

Climate Scenario	Residual Void	Freeboard (m)
Wetter	Jacaranda/Bauhinia	165.4
	Coolibah/Dogwood	167.3
	Ebony/Grevillia	194.1
	Hakea	114.8
Mid	Jacaranda/Bauhinia	181.2
	Coolibah/Dogwood	177.8
	Ebony/Grevillia	206.6
	Hakea	124
Drier	Jacaranda/Bauhinia	191
	Coolibah/Dogwood	183.1
	Ebony/Grevillia	217.3
	Hakea	125.3

The difference in elevation between the long-term water levels in the residual voids and the lowest point of the base of the shallow geologic formations (weathered regolith and basalt; model Layer 2) adjacent the voids is as shown in **Table 7-8**. Predicted residual void lake levels remain significantly below the base of the shallow geologic formations for each of the residual voids, even with the temporal fluctuations in void water levels predicted by the WSP (2023) water balance model. That is, there is never the potential for a flux of water to leave the residual voids and enter the shallow geologic formations.

Table 7-8 Predicted Difference between Residual Void Water Levels and Shallow Formations

Climate Scenario	Residual Void	Lowest Elevation of base of Model Layer 2 adjacent Void (mAHD)	Difference between void lake level and lowest elevation of base of Model Layer 2 adjacent Void (m) ¹	
			Start of Post-Mining	Post-Mining Equilibrium
Wetter	Jacaranda/Bauhinia	145.5	200.5	126.9
	Coolibah/Dogwood	150.2	187.2	127.5
	Ebony/Grevillia	165.5	266.5	169.2
	Hakea	123.5	83.5	43.1
Mid	Jacaranda/Bauhinia	145.5	200.5	142.7
	Coolibah/Dogwood	150.2	187.2	138.0
	Ebony/Grevillia	165.5	266.5	181.7
	Hakea	123.5	83.5	52.3
Drier	Jacaranda/Bauhinia	145.5	200.5	152.5
	Coolibah/Dogwood	150.2	187.2	143.3
	Ebony/Grevillia	165.5	266.5	192.4
	Hakea	123.5	83.5	53.6

1. A positive number means the base of Model Layer 2 is that many metres higher than the void lake level

7.2.4 Residual Void Groundwater Inflow

The final predicted groundwater inflows to the residual voids from the groundwater model are shown on **Figure 7-7** through **Figure 7-10**, with inflows partitioned between that which flows into the residual voids through spoil, and that which flows into the residual voids through surrounding natural geological formations.

In the first 50 years post-mining, groundwater levels are predicted to remain suppressed, particularly within the spoil around each residual void that is yet to saturate to a significant degree. During this time, groundwater fluxes to the voids are largely controlled by the difference between the predicted spoil groundwater levels and the predicted WSP (2023) residual void lake levels that rise and fall periodically (refer **Figure 7-3** through **Figure 7-6**) according to:

- the day-on-day climatic simulation within the WSP (2023) water balance model, and
- how the daily timestep water balance results are translated to the groundwater model's more simplified stress period setup.

Accordingly, there are periods of variable groundwater inflow and outflow predicted by the groundwater model in the first 16 years post-mining at Jacaranda/Bauhinia void, 33 years post-mining at Coolibah/Dogwood void, 55 years post-mining at Ebony/Grevillea, and 95 years post-mining at Hakea void. Over these time periods, rainfall derived surface water captured in the residual voids (per the WSP water balance model) is predicted to move into the spoil, as the groundwater levels in the surrounding in-pit spoil backfill (and natural geological formations) slowly recover from mining activities. All predicted outflows from the residual voids over this time occur to the spoil, that is, there is no predicted outflow from any of the voids to the natural geological formations. It is noted that any form of further backfilling of residual voids to above the groundwater level as a means to attempt to limit this early post-closure void water discharge will likely result in poorer environmental outcomes, as water in the backfilled voids will have a hydraulic head gradient toward the surrounding groundwater system. This will facilitate discharge outwards to the surrounding environment, in the absence of the hydraulic control (sink) caused by a relatively deep void lake that is maintained by evaporation in the long term (SLR, 2022b).

As groundwater levels in the spoil and natural geology recover to elevations above the void lakes and lake levels stabilise, the direction of flow out of the void lakes is reversed and long-term groundwater inflow to the lakes is established after 16 years post-mining at Jacaranda/Bauhinia void, 33 years post-mining at Coolibah/Dogwood void, 55 years post-mining at Ebony/Grevillea, and 95 years post-mining at Hakea void. Model results indicate that this inflow comes mostly via the spoil, originating mainly as local rainfall recharge applied to the spoil.

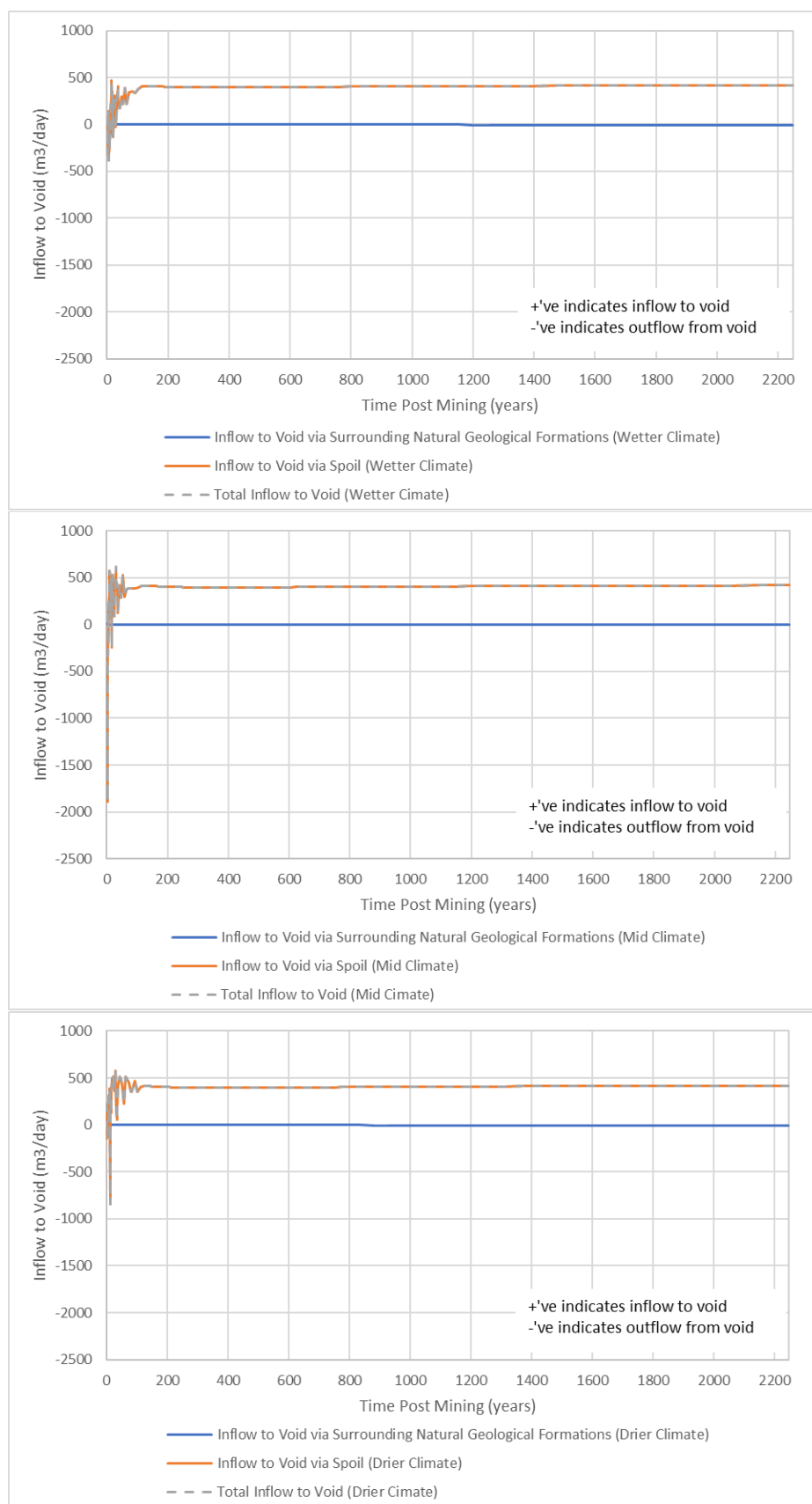


Figure 7-7 Predicted Void Groundwater Inflows – Jacaranda/Bauhinia Void

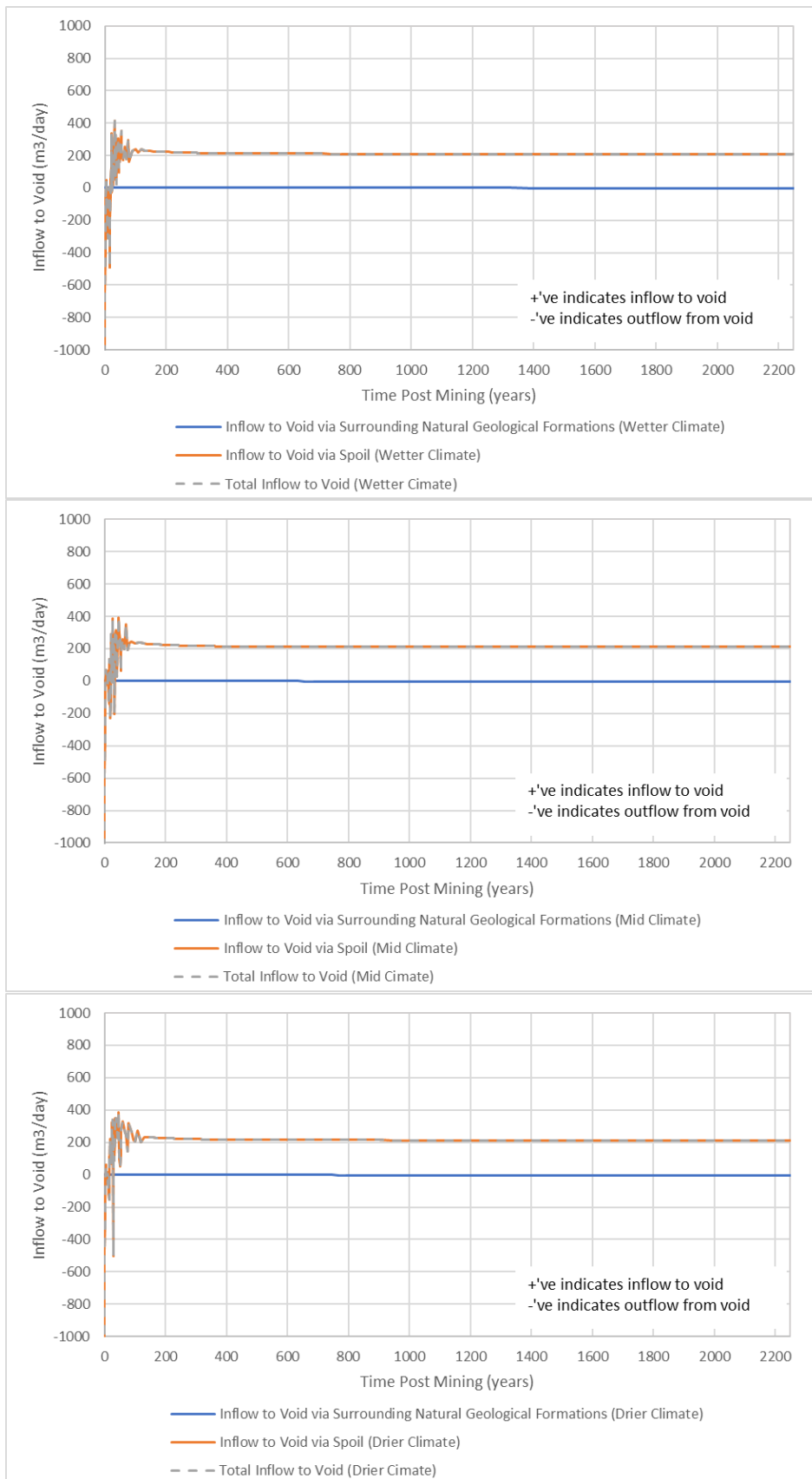


Figure 7-8 Predicted Void Groundwater Inflows – Coolibah/Dogwood Void

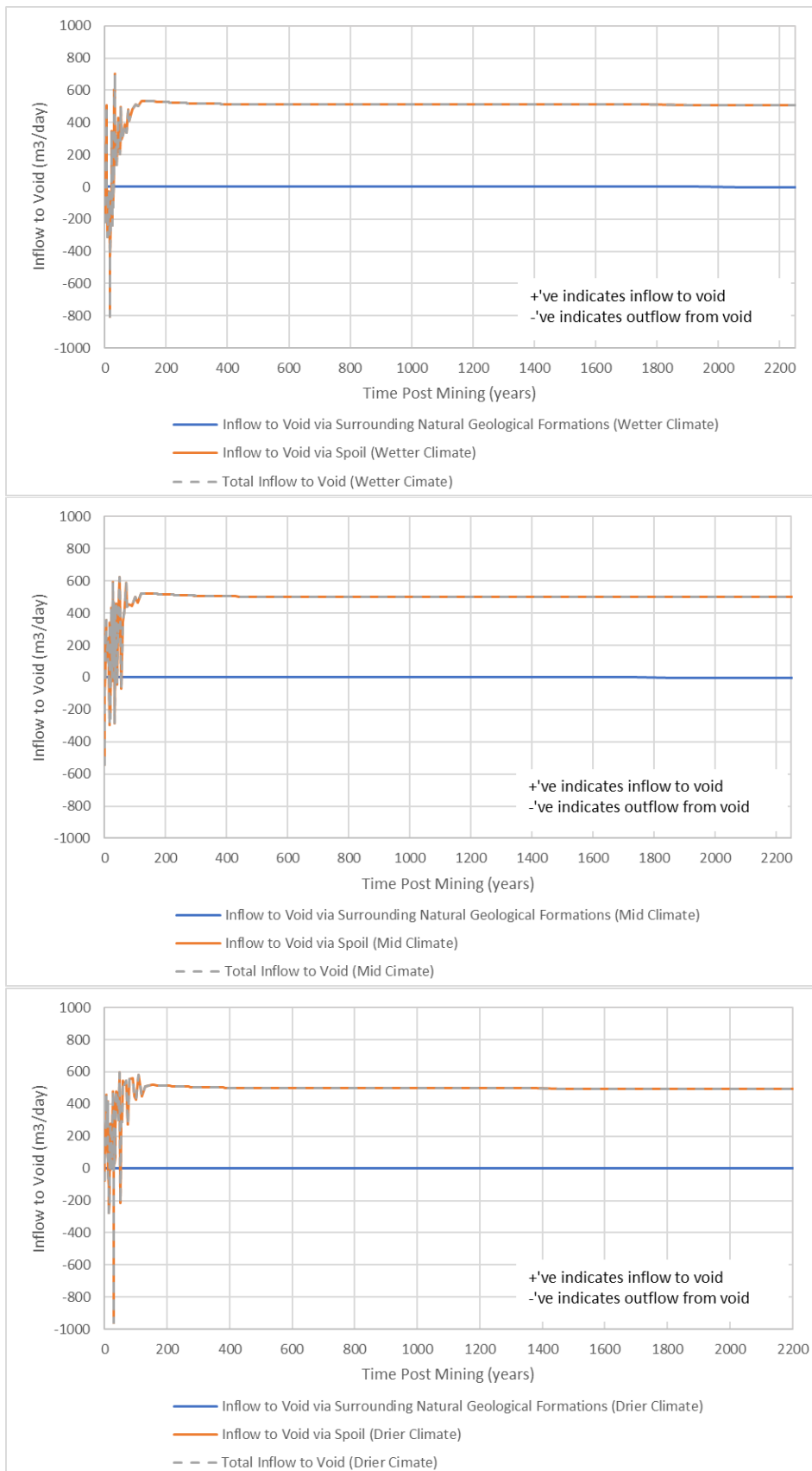


Figure 7-9 Predicted Void Groundwater Inflows – Ebony/Grevillia Void

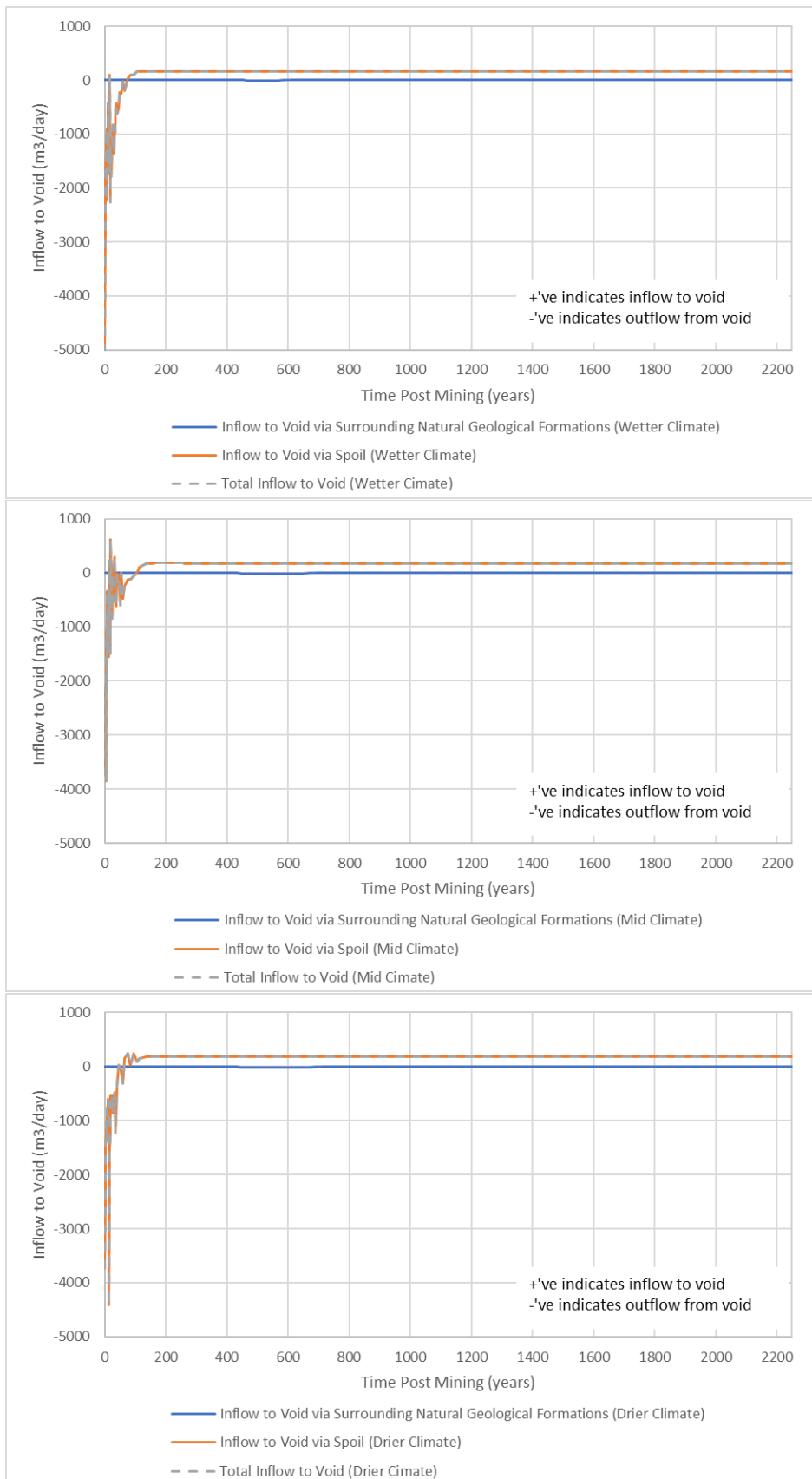


Figure 7-10 Predicted Void Groundwater Inflows – Hakea Void

Predicted equilibrium groundwater inflows to each of the voids for the three climate scenarios are presented in **Table 7-9**. Model results indicate that greater than 99% of the long term groundwater inflow to the voids comes via the spoil, with between 68% and 83% of this inflow originating as local recharge applied to the spoil, and between 16% and 32% coming from natural geological formations before moving through the spoil into the residual void lakes. The equilibrium groundwater inflows to each of the voids shown in **Table 7-9** represent approximately 11% to 15% of the total volumetric inflow to each residual void's water balance (WSP, 2023), that is, groundwater volumetric contribution the residual voids are very small in comparison to surface water (rainfall and runoff) contribution.

Table 7-9 Equilibrium Groundwater Inflow to the Residual Voids

Climate Scenario	Residual Void	Equilibrium Inflow Rate – Spoil (m ³ /day) ¹			Equilibrium Inflow Rate – Natural Geological Formations (m ³ /day) ³	Equilibrium Inflow Rate – Total (m ³ /day)
		From Natural Geological Formations into Spoil	From Local Recharge on Spoil	Total Inflow from Spoil to Residual Void ²		
Wetter	Jacaranda/Bauhinia	101.0	315.4	416.2	0.006	416.2
	Coolibah/Dogwood	39.5	169.3	209.8	0.006	209.8
	Ebony/Grevillia	165.3	345.3	509.5	0.03	509.5
	Hakea	26.5	134.3	160.9	0.09	160.9
Mid	Jacaranda/Bauhinia	101.8	315.4	416.8	0.007	416.8
	Coolibah/Dogwood	40.4	169.3	210.8	0.005	210.8
	Ebony/Grevillia	154.5	345.3	498.8	0.05	498.8
	Hakea	40.4	134.3	174.7	0.02	174.7
Drier	Jacaranda/Bauhinia	102.5	315.4	417.8	0.007	417.8
	Coolibah/Dogwood	42.7	169.3	213.1	0.005	213.1
	Ebony/Grevillia	151.5	345.3	495.8	0.06	495.8
	Hakea	41.5	134.3	175.8	0.02	175.8

1. Includes a component of groundwater from natural geological formations that moves into spoil, and a component of groundwater derived from local recharge on spoil, before discharging to the residual void lakes; refer **Figure 7-2**.
2. Any volumetric discrepancy between total inflow from spoil and the sum of the spoil inflow components is related to small ongoing residual changes in spoil storage occurring in the model as well as losses to evapotranspiration through spoil and rounding errors. Such discrepancies are typically less than 1% of the total spoil inflow.
3. Directly from natural geological formations into residual void lakes.

The total inflow volumes to the residual voids are only approximately 13% of the 3,627 ML/year (9,937 m³/day) estimate of associated water take from mining activities at SRM in 2021-22 (refer **Section 2.3.3**), noting the 2021-22 estimates were derived from an arguably less robust water balance calculation method (BMA, 2022).

7.2.5 Predicted Groundwater Levels

Groundwater level predictions and associated discussion presented herein is focussed primarily on the Mid Climate scenario with the Drier and Wetter scenario's reported as sensitivities. This is deemed appropriate given the relatively small difference in predicted residual void lake elevations (that drive groundwater levels) between the scenarios with respect to void lake levels that might pose a risk to the groundwater environment (refer **Section 7.2.2**).

7.2.5.1 Mid Climate Scenario

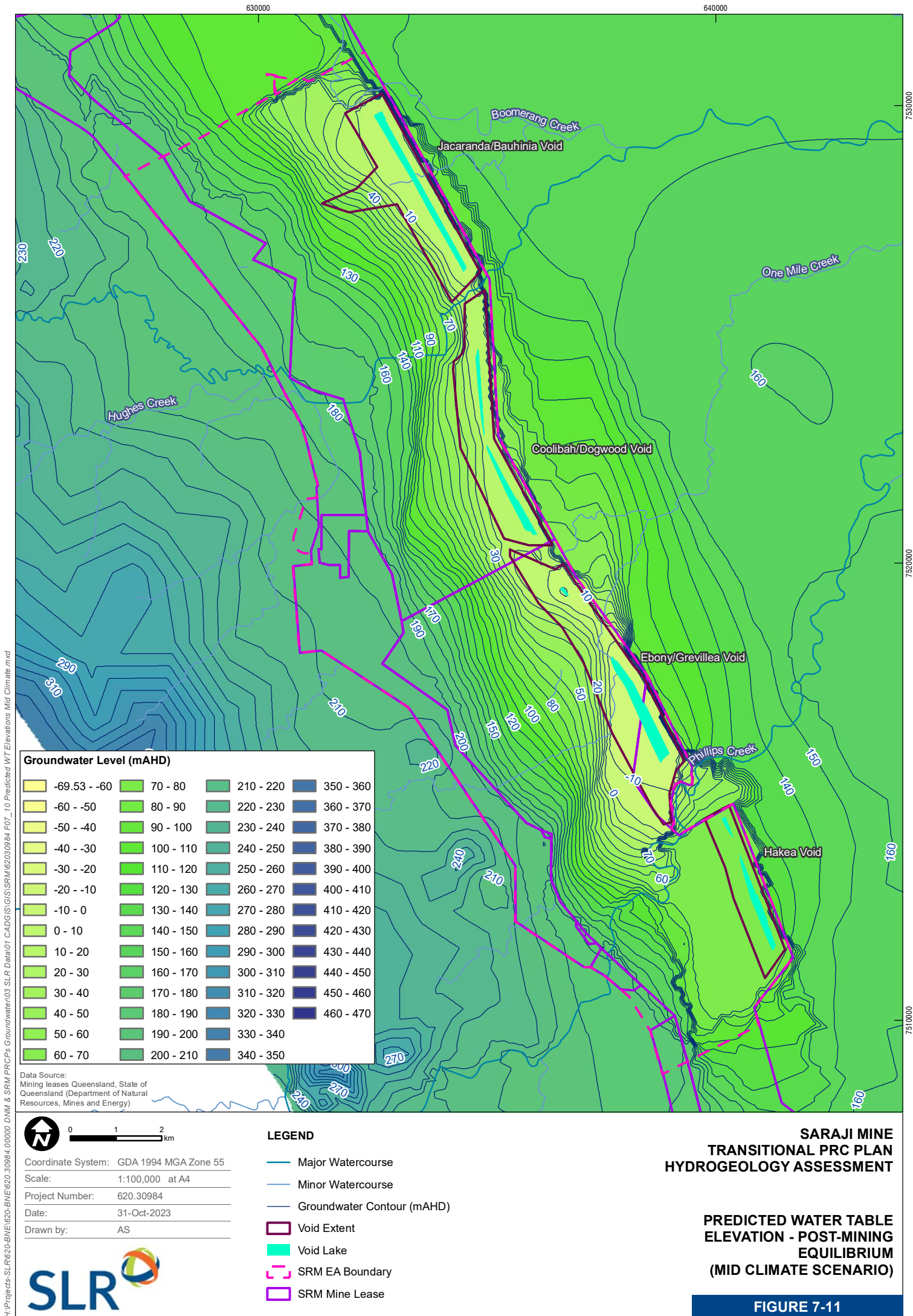
Groundwater Levels – General

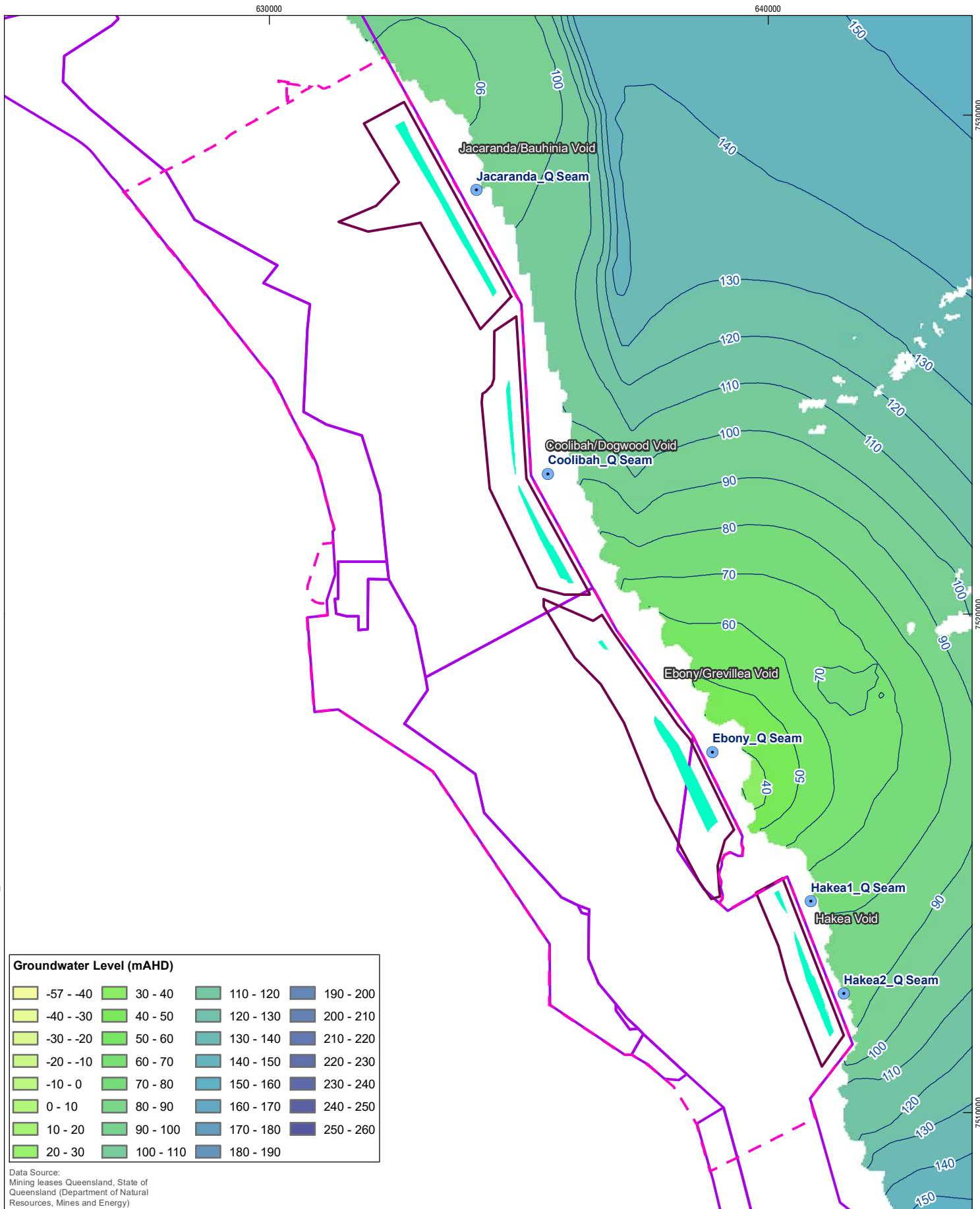
The predicted equilibrium water table elevation adjacent the residual voids is shown on **Figure 7-11** for the Mid Climate scenario. Predicted groundwater levels for the Q, P, H and D Seams of the Permian Coal Measures (model layers 12, 14, 16, and 18, respectively) outside of the residual voids are shown on **Figure 7-12** through to **Figure 7-15**, again at equilibrium for the Mid Climate scenario.

Groundwater levels surrounding the final void are controlled by the predicted residual void lake levels, which in turn are controlled by the rate of evaporation from the void lakes balancing mostly surface inflows and some groundwater inflows to the lakes (WSP, 2023), including a component of groundwater that moves out of the natural geological formations into the residual voids via the spoil (refer **Table 7-9**). The conceptual relationship between these components is displayed in **Figure 7-2**. That is, predicted groundwater levels are a function of predicted lake levels, which as discussed in **Section 7.2.3** are dominantly controlled by surface water fluxes and maintained by evaporation.

The water table is predicted to remain depressed in the immediate vicinity of the residual voids in the long term, driven by the ongoing groundwater discharge to the residual void lakes and governed by the lake elevations themselves. That is, long term inwards groundwater flow gradients are maintained post-mining for the water table. Steepest water table gradients occur on the northern end of the Jacaranda/Bauhinia Void, the southern end of the Ebony/Grevillia Void, and west of the residual voids within the spoil. Gradients in the natural rock away from the mining area to the east of the residual voids are somewhat shallower. Water table depression east of the SRM Area extends up to 2 km from the edge of the ML for the Coolibah/Dogwood, Ebony/Grevillia and Hakea residual voids, but less than 0.5 km off lease for the Jacaranda/Bauhinia Void.

Predicted groundwater levels for the Q, P, H and D Seams of the Permian Coal Measures indicate again that groundwater levels in the Permian sequence are predicted to remain depressed in the long term, driven by the ongoing groundwater discharge to the residual void lakes and governed by the lake elevations themselves. The Q seam is predicted to remain 'dry' in the long term across the SRM Area where it is not mined, with non-saturation present up to approximately 1 km east of the SRM Area. Additionally, dominant flow gradients towards the northern end of the Jacaranda/Bauhinia Void and southern end of the Ebony/Grevillia Void is apparent within the Q seam east of the SRM Area. The P Seam is predicted to remain unsaturated across much of the SRM Area, however remains saturated in the small area along Phillips Creek between Ebony/Grevillia and Hakea voids where a south to north flow gradient towards Ebony/Grevillia Void is apparent. Predicted H Seam groundwater levels show similar patterns to the P Seam, and levels are similar between the two units in the south of the SRM Area, however levels are approximately up to 60 m lower in the H Seam than the P Seam in the northern part of the SRM Area and therefore head gradients are significantly steeper there. D Seam levels and head gradients are similar to the H Seam, and the depression of D Seam groundwater levels extends significantly east of the SRM Area.





Coordinate System: GDA 1994 MGA Zone 55

Scale: 1:100,000 at A4

Project Number: 620.30984

Date: 31-Oct-2023

Drawn by: AS

LEGEND

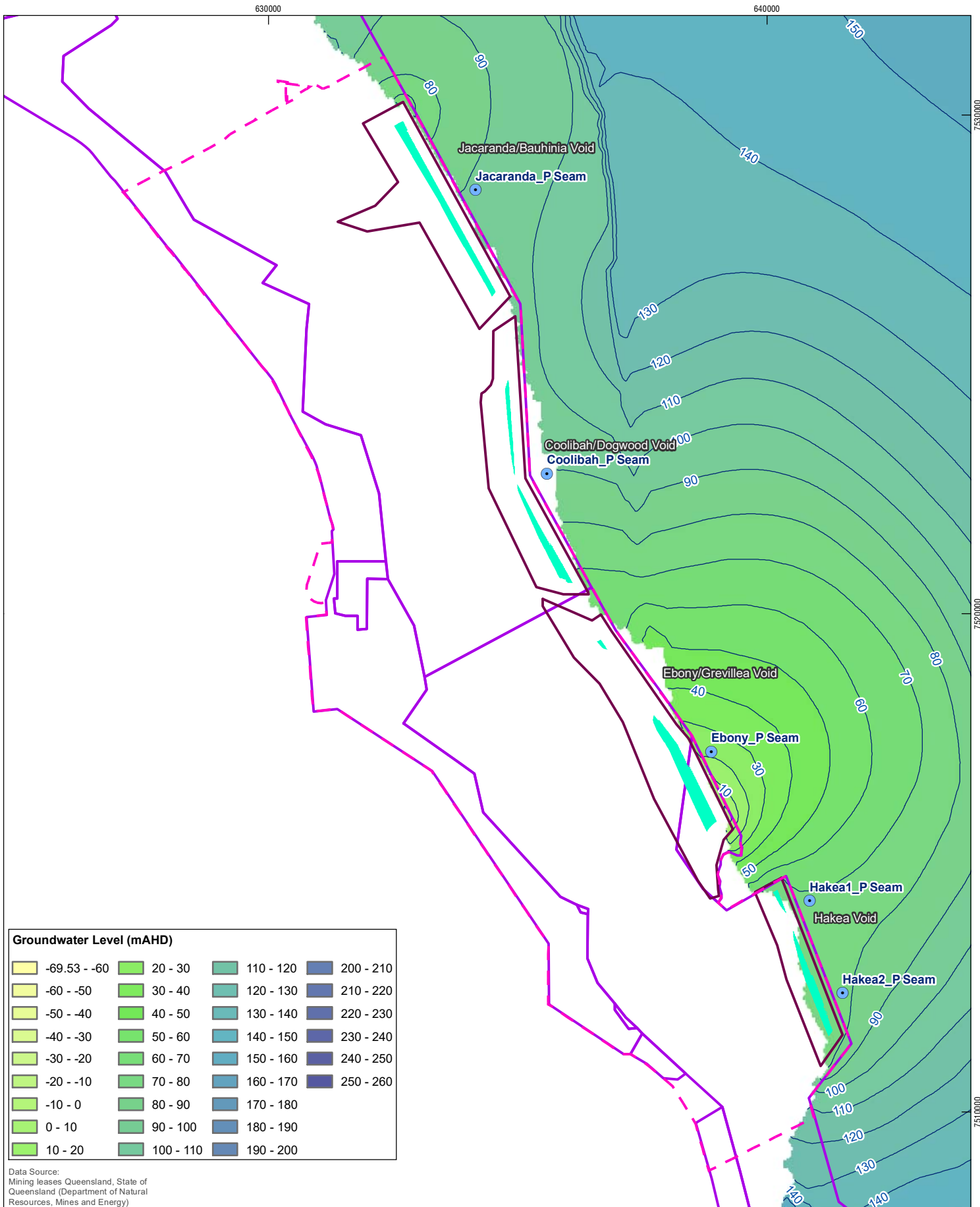
- Hydrograph Location
- Groundwater Contour (mAHD)
- Void Extent
- Void Lake
- SRM Mine Lease
- SRM EA Boundary

SARAJI MINE TRANSITIONAL PRC PLAN HYDROGEOLOGY ASSESSMENT

**PREDICTED GROUNDWATER
LEVELS IN THE Q SEAM (LAYER 12)
- POST-MINING EQUILIBRIUM
(MID CLIMATE SCENARIO)**

FIGURE 7-12

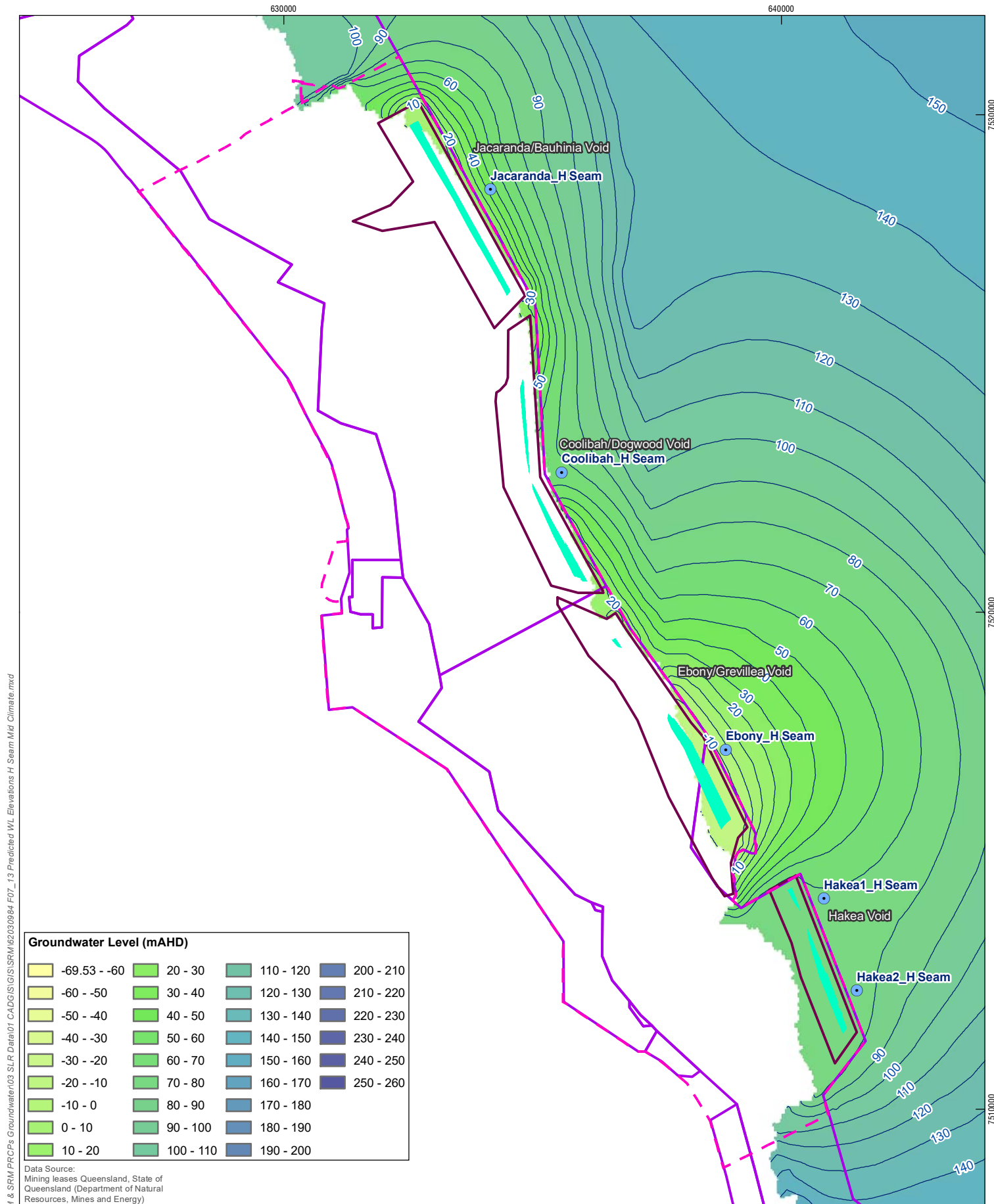
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**SARAJI MINE
TRANSITIONAL PRC PLAN
HYDROGEOLOGY ASSESSMENT**

**PREDICTED GROUNDWATER
LEVELS IN THE P SEAM (LAYER 14)
- POST-MINING EQUILIBRIUM
(MID CLIMATE SCENARIO)**

FIGURE 7-13



 0 1 2 km
 Coordinate System: GDA 1994 MGA Zone 55
 Scale: 1:100,000 at A4
 Project Number: 620.30984
 Date: 31-Oct-2023
 Drawn by: AS

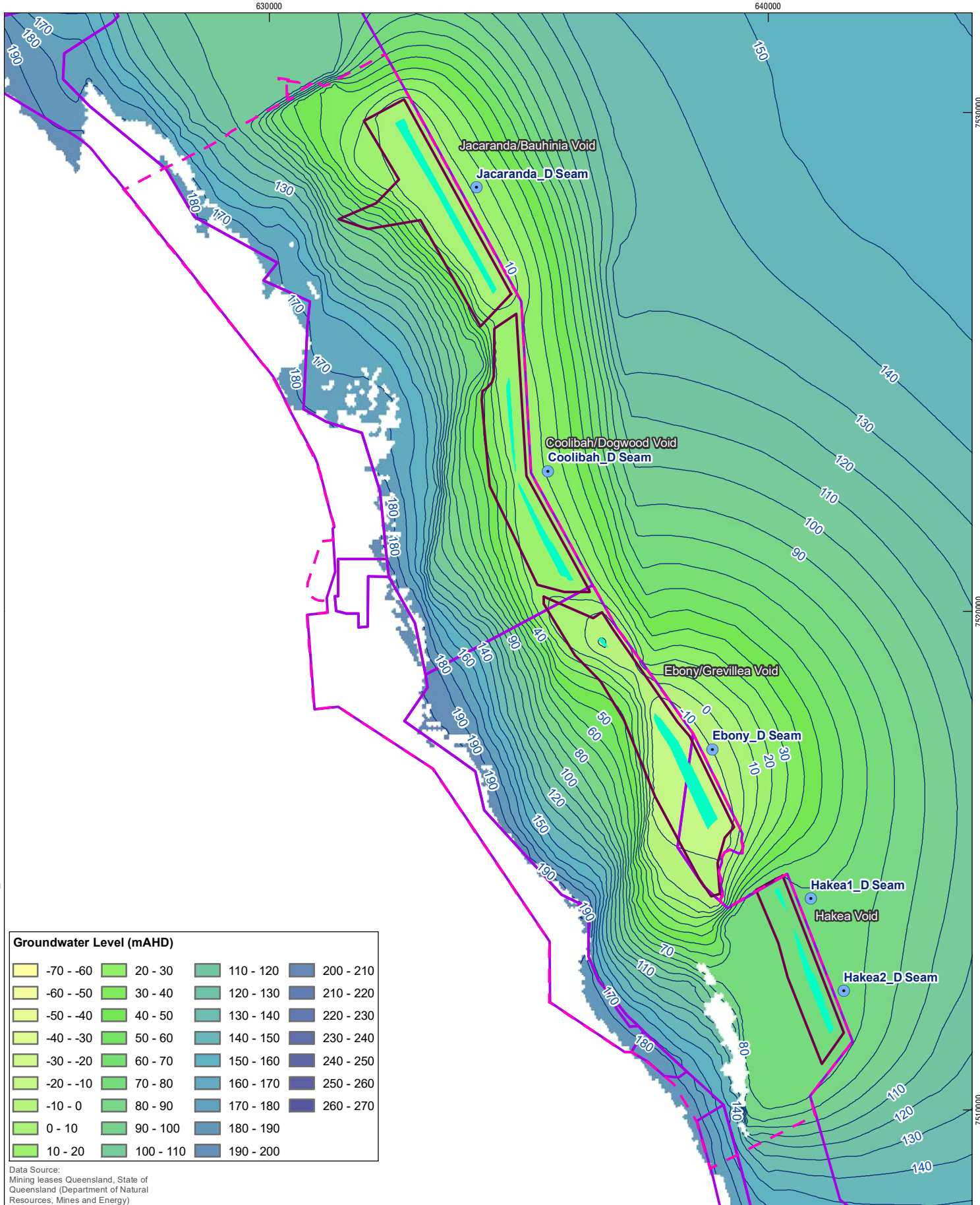
- LEGEND**
-  Hydrograph Location
 -  Groundwater Contour (mAHD)
 -  Void Extent
 -  Void Lake
 -  SRM Mine Lease
 -  SRM EA Boundary

**SARAJI MINE
TRANSITIONAL PRC PLAN
HYDROGEOLOGY ASSESSMENT**

**PREDICTED GROUNDWATER
LEVELS IN THE H SEAM (LAYER 16)
- POST-MINING EQUILIBRIUM
(MID CLIMATE SCENARIO)**

FIGURE 7-14

H:\Projects-SLR\620-BNE\620-30984-00000 DNM & SRM PRCs Groundwater\03 SLR Data\01 CAD\GIS\GIS\SRM\62030984_F07_13 Predicted WL Elevations H Seam Mid Climate.mxd



Coordinate System: GDA 1994 MGA Zone 55
Scale: 1:100,000 at A4
Project Number: 620.30984
Date: 31-Oct-2023
Drawn by: AS



LEGEND

- Hydrograph Location
- Groundwater Contour (mAHD)
- Void Extent
- Void Lake
- SRM Mine Lease
- SRM EA Boundary

SARAJI MINE TRANSITIONAL PRC PLAN HYDROGEOLOGY ASSESSMENT

**PREDICTED GROUNDWATER
LEVELS IN THE D SEAM (LAYER 18)
- POST-MINING EQUILIBRIUM
(MID CLIMATE SCENARIO)**

FIGURE 7-15

Predictive hydrographs showing the change in groundwater levels over time for the Q, P, H and D Seams of the Permian Coal Measures just outside (east) of the residual voids are shown as **Figure 7-16** through **Figure 7-20**, with the hydrograph locations shown on **Figure 7-12** through to **Figure 7-15**. Two sets of predictive hydrographs have been generated for the Hakea residual void, given that the predicted void lake elevation there would result in two individual lake areas, as shown on the figures. The hydrographs demonstrate that the vast majority of groundwater level drawdown in the Permian Coal Measures occurs during mining operations, with post-closure groundwater levels in the deeper coal seams recovering from their lowest point that occurred during mining. Furthermore, the hydrographs demonstrate very little effect on groundwater levels from the residual void inflow flux variability in the early post-closure period as shown and discussed in **Section 7.2.4**. The hydrographs also show that:

- For the Jacaranda/Bauhinia residual void, lake levels are predicted to recover to within approximately 39.9 m of the predicted H Seam groundwater elevation just outside the void and approximately 9.3 m of the predicted D Seam groundwater elevation just outside the void. The Q Seam is predicted to remain dry with its base approximately 110 m above the void lake level, and P Seam groundwater levels are predicted to remain more than 88 m above the void lake level.
- For the Coolibah/Dogwood residual void, lake levels are predicted to recover to within approximately 7.2 m of the predicted D Seam groundwater elevation just outside the void. The Q and P Seams are predicted to remain dry with their bases more than 143 m and 100 m (respectively) above the void lake level, and H Seam groundwater levels are predicted to remain more than 52 m above the void lake level.
- For the Ebony/Grevilia residual void, lake levels are predicted to recover to within approximately 15.7 m of the predicted H Seam groundwater elevation just outside the void and approximately 7.6 m of the predicted D Seam groundwater elevation just outside the void. The Q Seam is predicted to remain dry with its base more than 91 m above the void lake level, and P Seam groundwater levels are predicted to remain approximately 39.8 m above the void lake level.
- For the Hakea residual void:
 - At the northern end of the residual void (hydrograph site Hakea1), lake levels are predicted to recover to within approximately 0.5 m of the predicted P Seam, H Seam and D Seam groundwater elevations just outside the void. The Q Seam is predicted to remain dry with its base more than 31 m above the void lake level.
 - At the southern end of the residual void (hydrograph site Hakea2), lake levels are predicted to recover to within approximately 3.1 m of the predicted H Seam groundwater elevation just outside the void and approximately 2.8 m of the predicted D Seam groundwater elevation just outside the void. P Seam groundwater levels are predicted to remain approximately 4.8 m above the void lake level. The Q Seam is predicted to remain dry with its base more than 11 m above the void lake level.
 - The results of the hydrograph generation suggest that, although net inwards hydraulic gradients are maintained at the Hakea Void, the inwards gradient is reduced towards the northern end of the void compared to the southern end of the void. This analysis is supported by the potentiometric surfaces presented as **Figure 7-11** through to **Figure 7-15**.

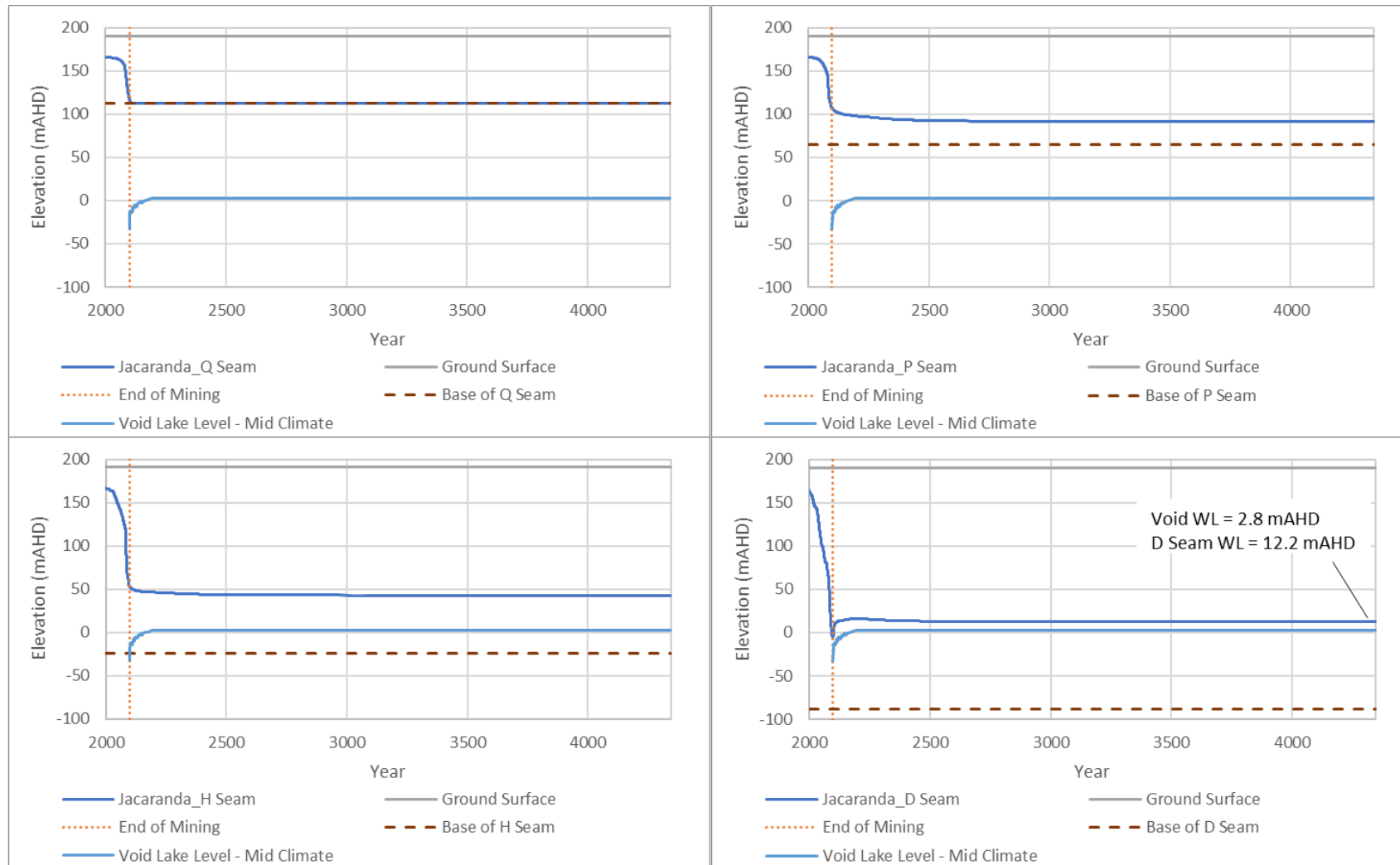


Figure 7-16 Permian Coal Measures Predictive Hydrographs adjacent Jacaranda/Bauhinia Void

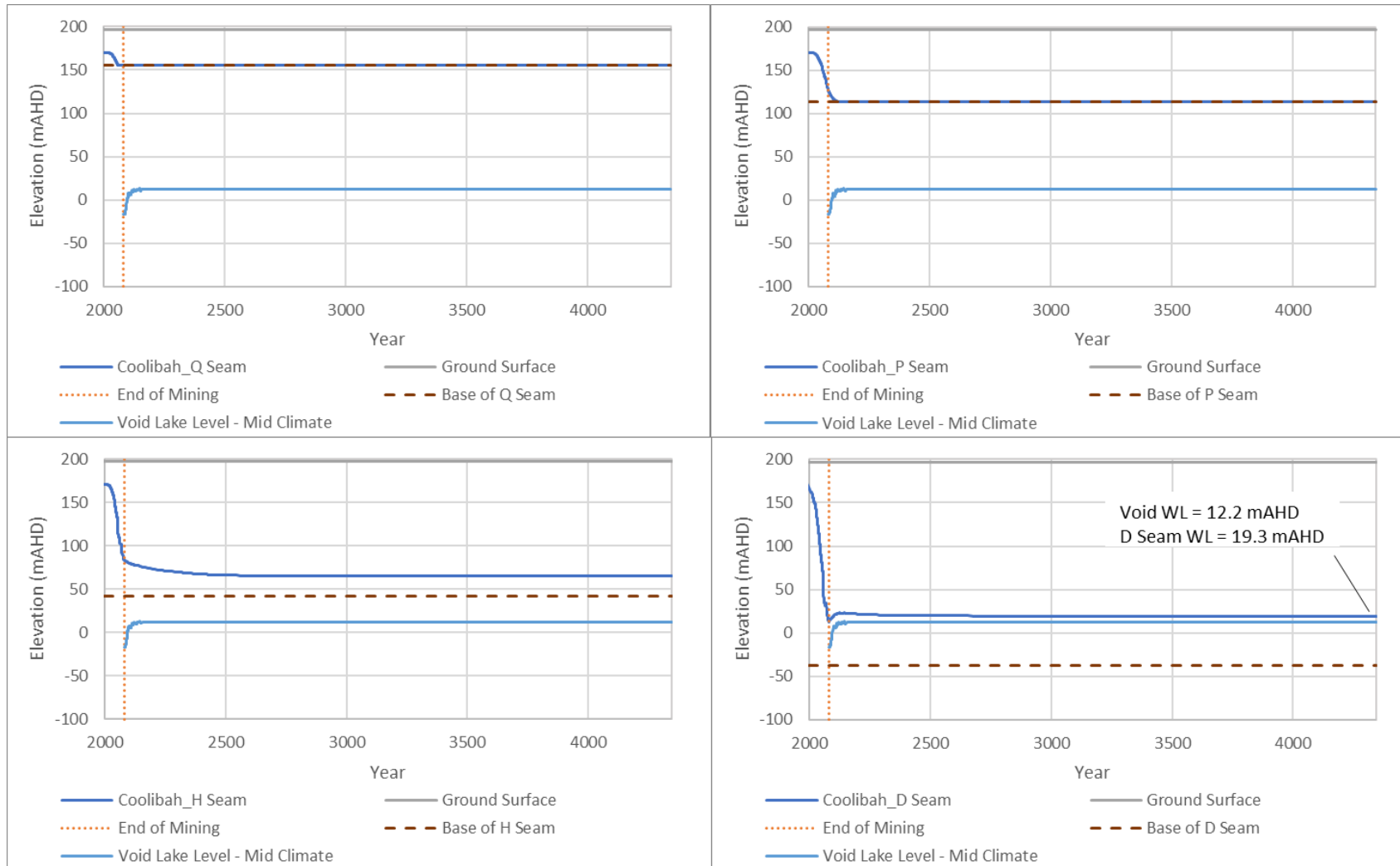


Figure 7-17 Permian Coal Measures Predictive Hydrographs adjacent Coolibah/Dogwood Void

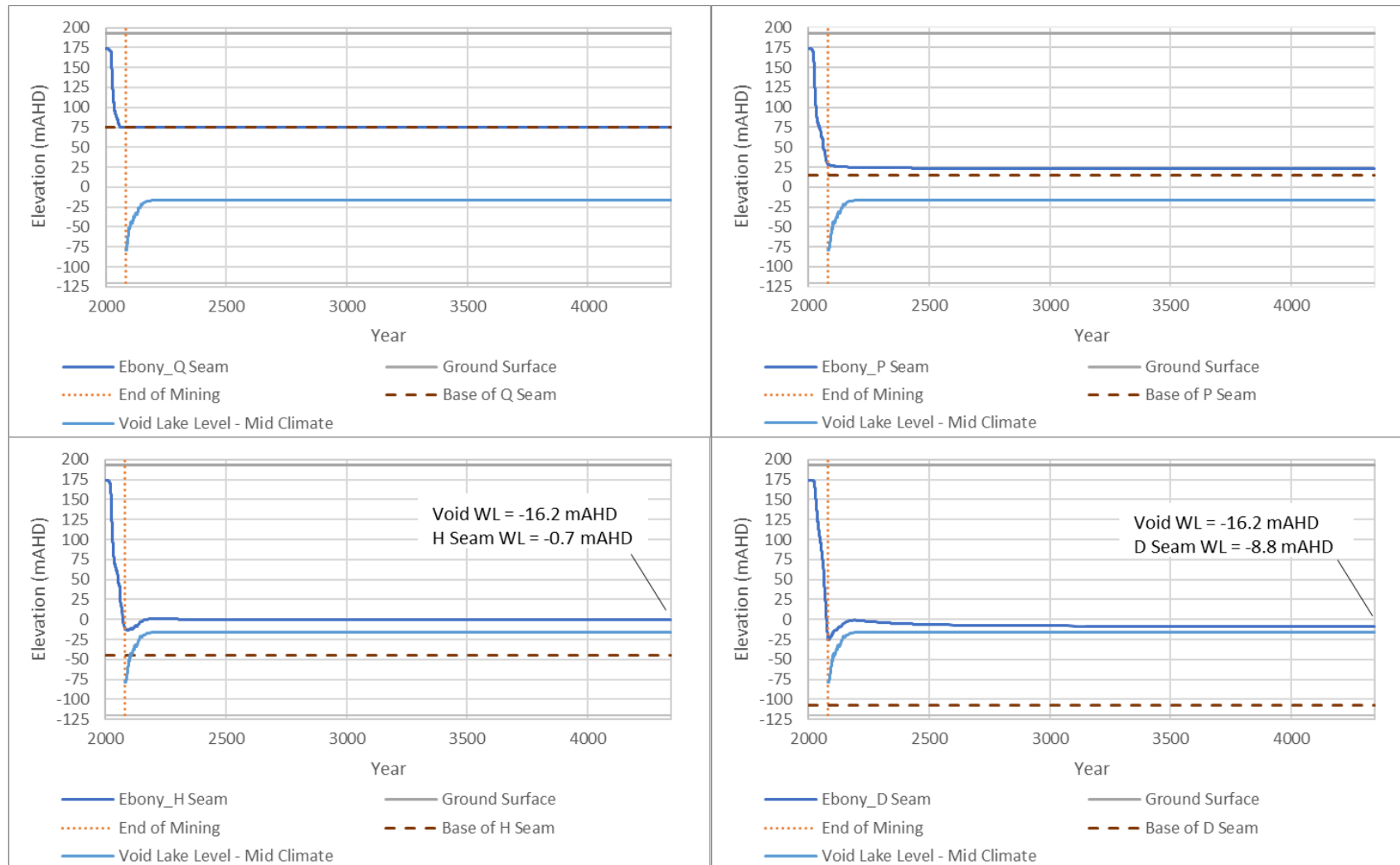


Figure 7-18 Permian Coal Measures Predictive Hydrographs adjacent Ebony/Grevillia Void

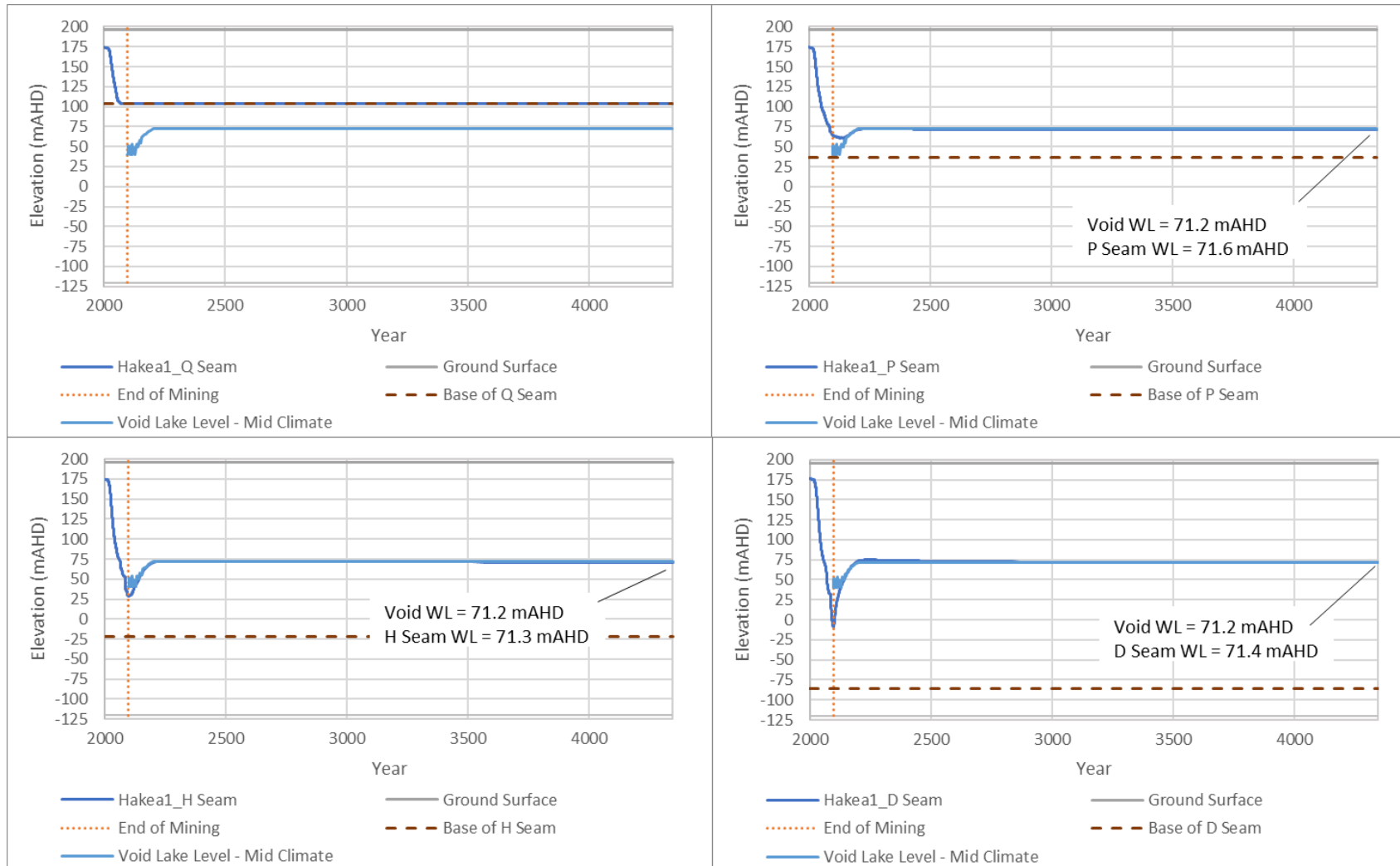


Figure 7-19 Permian Coal Measures Predictive Hydrographs adjacent Hakea Void (north)

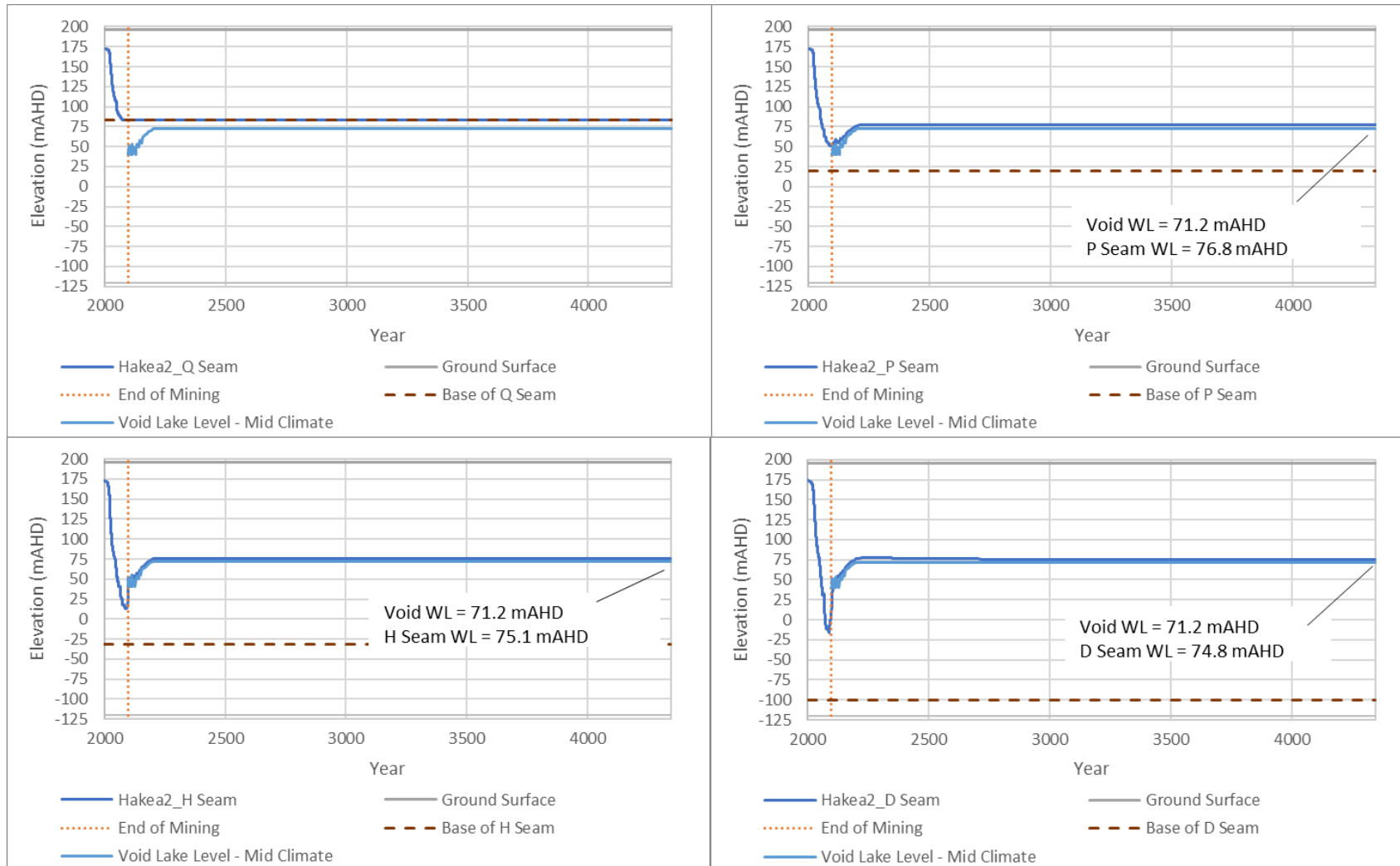


Figure 7-20 Permian Coal Measures Predictive Hydrographs adjacent Hakea Void (south)

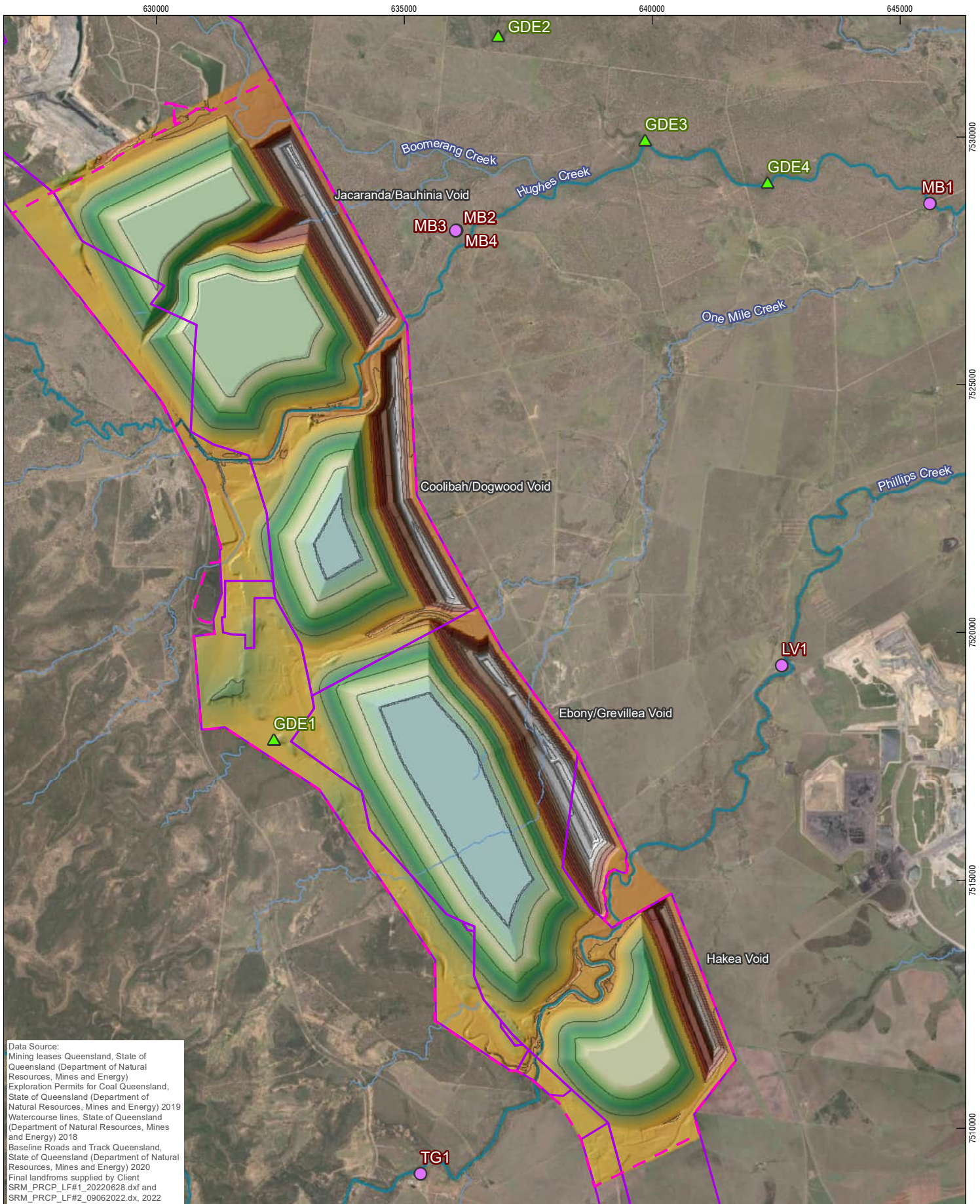
The hydrograph results for the H and D Seams suggest that, although model predictions indicate inwards flow gradients to all residual voids prevailing in the long term, the differences in predicted void lake levels and the predicted groundwater levels in those two seams immediately adjacent the voids are relatively small, particularly in the case of the Hakea Void. It should be noted that there is a distinct lack of groundwater environmental receptors identified in the H and D Seams (**Section 4.5**) and therefore there is little environmental risk posed by any void outflow to those seams. Additionally, net flux over the post-mining simulation remains inwards for each void, i.e. any outwards flux in the first few years post-mining is recaptured by the voids in the long term post-mining. Furthermore, since the deeper D Seam is not mined at Hakea Pit, there is no mechanism for direct hydraulic connection of the residual void lake in Hakea Void and the D Seam, limiting the potential for water exchange between Hakea Void and that particular seam.

Increasing the head gradient toward the residual void lakes from the surrounding groundwater system could be achieved by reducing predicted void lake levels via deepening the residual voids and/or limiting surface water inputs to the voids, noting that surface water inputs represent approximately 85% to 89% of the total volumetric inflow to each residual void (**Section 7.2.4**). Further backfilling of the residual voids, particularly to above the coal seams or above surrounding groundwater levels, would increase the void lake level elevation and therefore be likely to increase the potential for outflow, and therefore result in poorer environmental outcomes, particularly in the event that beneficial evaporative control of groundwater gradients is lost, rather than offer a means to reduce the potential for groundwater impacts (SLR, 2022b; refer **Section 7.2.4**).

Groundwater Level Impacts to Potential Receptors

Predictive hydrographs have been derived from the groundwater model to understand the nature of likely groundwater level change in the interpreted source aquifer for identified potential natural and anthropogenic groundwater receptors in the vicinity of the SRM Area (refer **Section 4.5**). The aim of the hydrographs is to assess the potential for additional impacts to these potential receptors in the period post-mining, i.e. identify additional potential impacts beyond those that have occurred during already approved mining operations that may be attributable to the PRC Plan's proposed final landform. **Figure 7-21** provides the hydrograph locations.

Predictive hydrographs for the water table at the potential GDE sites identified in and adjacent to the SRM Area (refer **Section 4.5.2**) are provided as **Figure 7-22** for the mid climate scenario. The hydrographs indicate that, given the initial predicted depth to the water table exceeds 10 m at all sites except at the potential GDE site located in the west of the SRM Area adjacent to the Mine Infrastructure Area (GDE1), it is very unlikely that these locations contain GDEs as the water table likely lies at a depth that indicates total plant groundwater use would be negligible (refer **Section 4.5.2.1**). The hydrographs indicate that no drawdown is predicted at the GDE1 location adjacent to the Mine Infrastructure Area. The hydrographs also indicate that much of the water table drawdown in the vicinity of the potential GDEs is predicted to occur prior to the end of mining (i.e. associated with approved SRM mining operations), with additional drawdown occurring over the post-mining period that continues the drawdown trends that commence prior to the end of mining. The shape of the hydrographs suggests that the additional drawdown impacts that occur in the post-mining period are residual impacts from approved previous active mining activities (i.e. a time lag from active mining), rather than new impacts caused by the PRC Plan's landform design; i.e. suggesting that the final landform is not contributing significantly to additional impacts at the potential GDE locations. The water table hydrograph at the potential GDE site located in the west of the SRM Area adjacent to the Mine Infrastructure Area (GDE1) shows no drawdown either during mining or post-closure. Note there is no difference in the hydrographs for the drier or wetter climate scenarios.



Data Source:
Mining leases Queensland, State of
Queensland (Department of Natural
Resources, Mines and Energy)
Exploration Permits for Coal Queensland,
State of Queensland (Department of
Natural Resources, Mines and Energy) 2019
Watercourse lines, State of Queensland
(Department of Natural Resources, Mines
and Energy) 2018
Baseline Roads and Track Queensland,
State of Queensland (Department of Natural
Resources, Mines and Energy) 2020
Final landforms supplied by Client
SRM_PRCP_LF#1_20220628.dxf and
SRM_PRCP_LF#2_09062022.dxf, 2022



Coordinate System: GDA 1994 MGA Zone 55
Scale: 1:100,000 at A4
Project Number: 620.30984
Date: 31-Oct-2023
Drawn by: NT



LEGEND

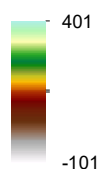
Hydrograph Location

- 2007 Surveyed Supply Bore with Depth Information
- ▲ Potential GDE – Hydrograph Location

- Major Watercourse
- Minor Watercourse
- SRM EA Boundary
- SRM Mine Lease

LANDFORM

Elevation (mAHD)



SARAJI MINE TRANSITIONAL PRC PLAN HYDROGEOLOGY ASSESSMENT

RECEPTOR PREDICTIVE HYDROGRAPH LOCATIONS

FIGURE 7-21

H:\Projects-SLR\620-BNE\620-BNE\620.30984_00000 DNM & SRM PRCPs Groundwater\03 SLR Data\01 CAD\GIS\GIS\SRM\62030984_F07_21 Receptor Hydrograph Locations.mxd

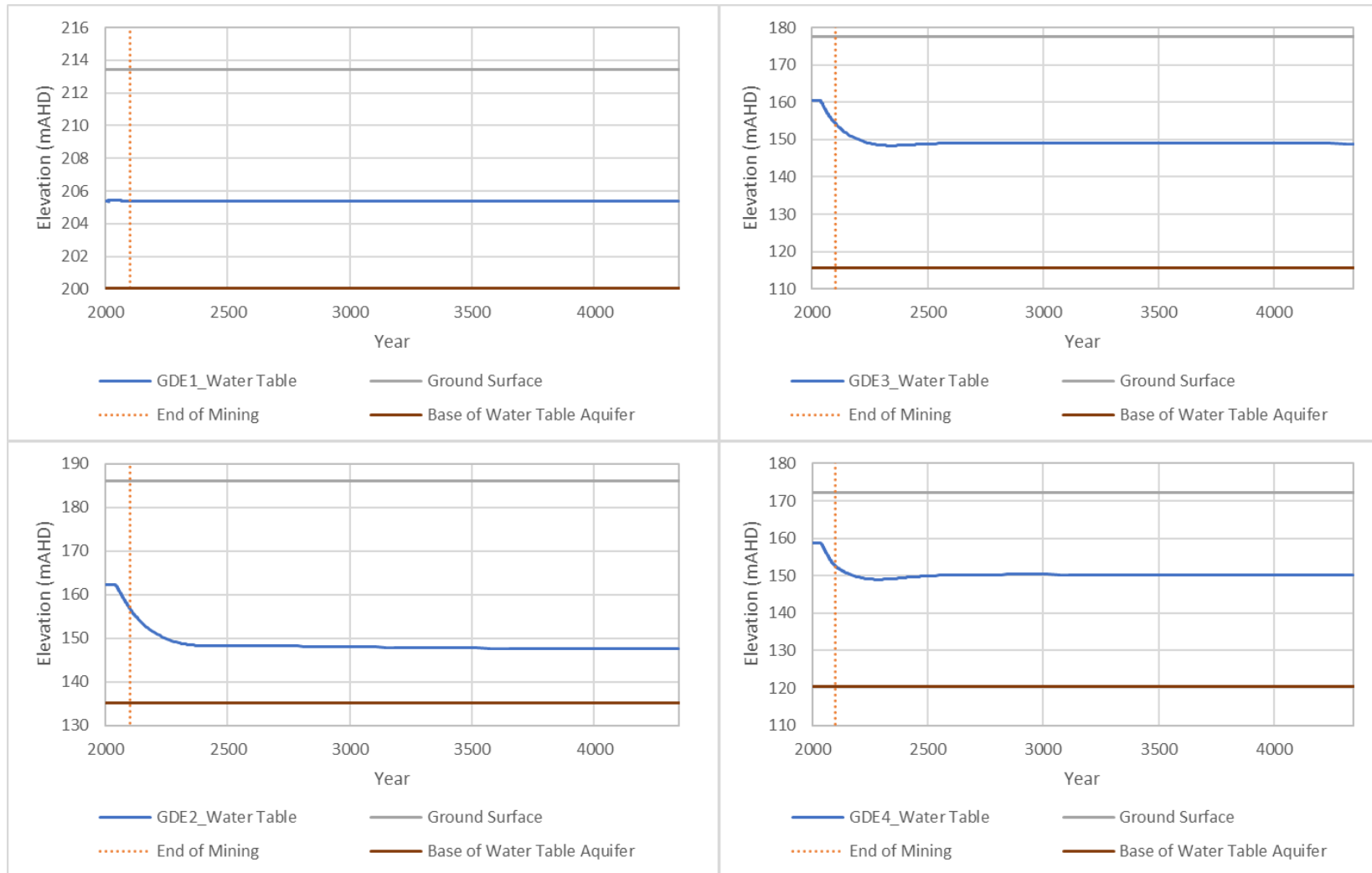


Figure 7-22 Water Table Hydrographs at Potential GDEs

Predictive hydrographs for the six identified third party water supply bores in the 2007 bore census with sufficient information to attribute a source aquifer (refer **Section 4.5.1.1**) are provided as **Figure 7-23** for the mid climate scenario. Negligible groundwater drawdown in the post-mining period is predicted at bore TG1, located southwest of the SRM Area in the regolith overlying the Back Creek Group.

Only a relatively small drawdown is predicted in the post-mining period for bore MB1 in the Fort Cooper Coal Measures along Hughes Creek 9 km east of SRM (~4.4 m post-mining and ~5.4 m overall including the during-mining period) noting that it takes hundreds of years for the maximum drawdown to occur, which is well beyond the expected service life of a groundwater bore. The maximum drawdown at this bore is only marginally greater than the relevant 5 m drawdown 'bore trigger threshold' for consolidated aquifers (i.e. the Fort Cooper Coal Measures) identified in Chapter 3 of the *Water Act 2000*, i.e. the threshold at which drawdown impacts may need to be further investigated for the purposes of determining any requirement to 'make good' a bore impairment.

Other bores located east of SRM in the Fort Cooper Coal Measures show groundwater drawdown trends commencing during SRM mining that continue post-mining on the same trend, before reaching maximums between approximately 130 years and 500 years post-mining. Again, this timeframe is well beyond the expected service life of a groundwater bore. With no change in the trends observed between the mining and post-mining periods, these drawdowns are considered to be mostly related to during-mining impacts, plus also regional scale influences represented in the model (i.e. other mining activities) given these bores access groundwater from the Fort Cooper Coal Measures, a geological unit not present across the vast majority of the SRM Area. Note there is no difference in the hydrographs for the drier or wetter climate scenarios.

7.2.5.2 Climate Sensitivity

Predicted groundwater levels for the Drier Climate scenario and Wetter Climate scenario are shown in **Appendix B** and **Appendix C**, respectively.

There is very little difference between the predicted groundwater levels outside the voids for the 3 climate scenarios as discussed in **Section 7.2.5.1**.

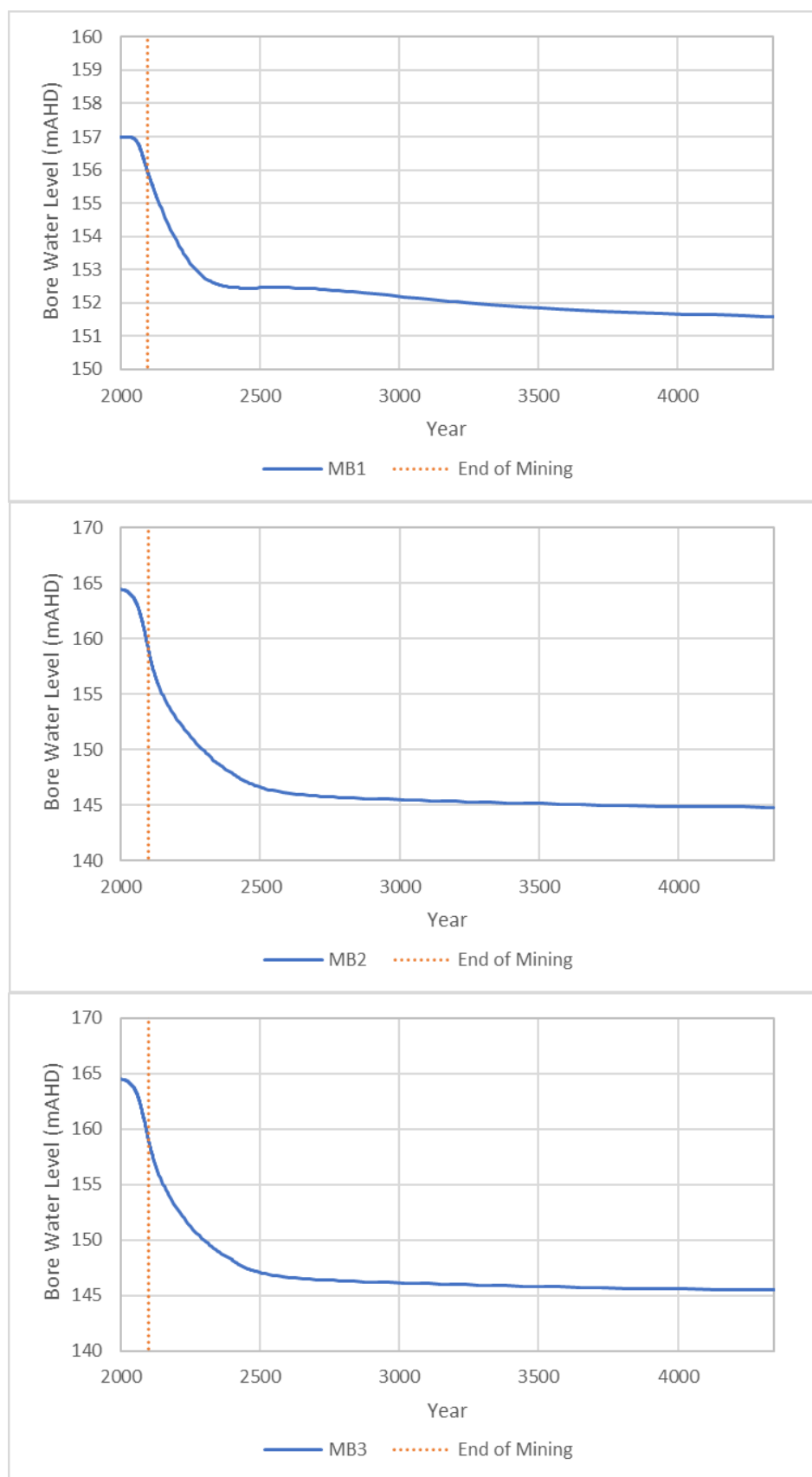


Figure 7-23 Hydrographs for Surveyed Third Party Supply Bores with Attributable Source Aquifer

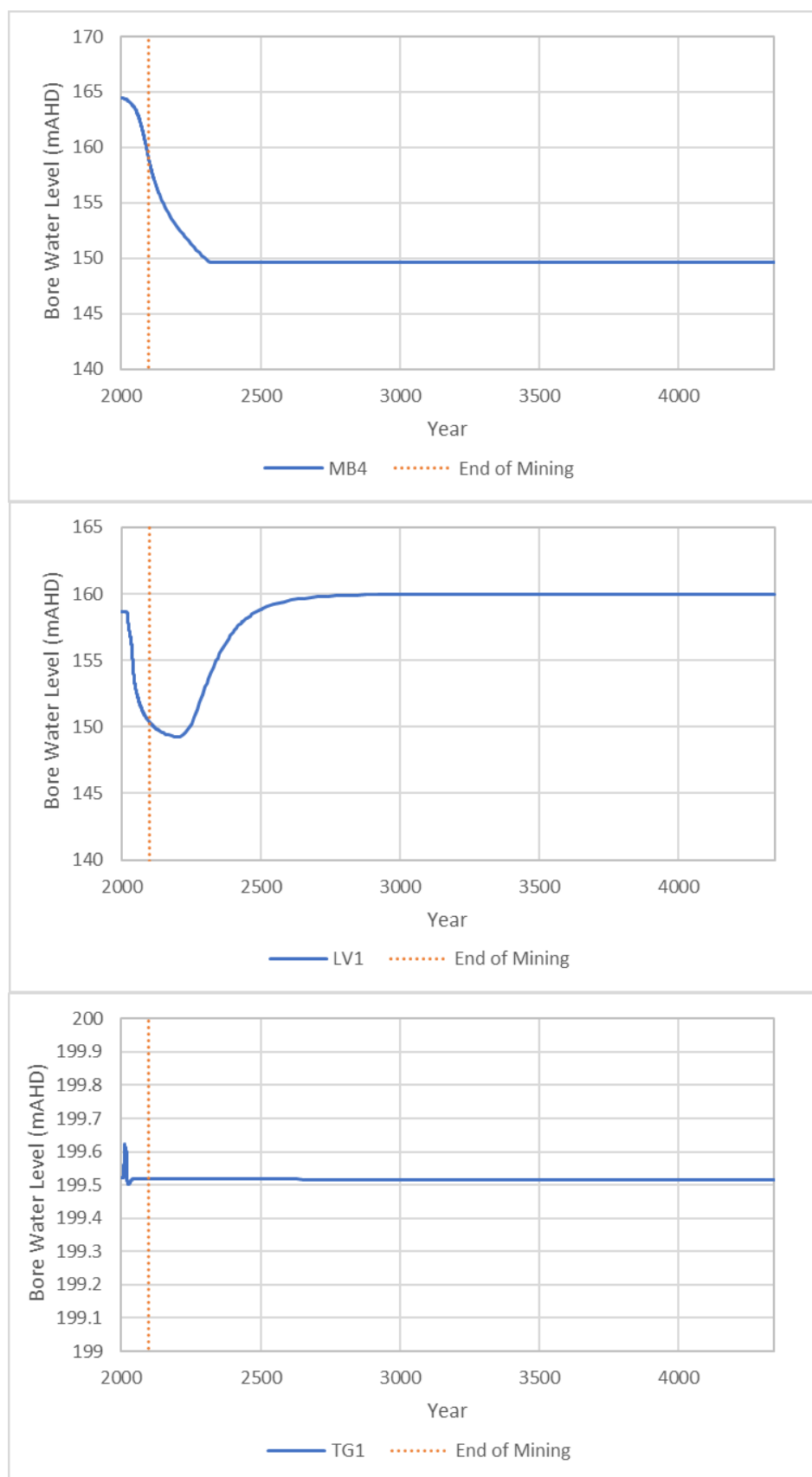


Figure 7-20 Hydrographs for Surveyed Third Party Supply Bores with Attributable Source Aquifer (cont.)

7.2.6 Flow Path Simulation

An analysis of the water movement within Landform #2 was undertaken to simulate and assess the movement and fate of water particles through the groundwater system post-mining. A number of particles were placed on the final landform and within the residual voids in the recovery groundwater model and the mod-PATH3DU code (S.S. Papadopoulos & Associates, Inc., 2018) was used to simulate particle pathways along the groundwater flow field during recovery (i.e., 2249 years). To run the mod-PATH3DU code the transient head outputs from the groundwater flow model were used by mod-PATH3DU to simulate particle flowpath lines.

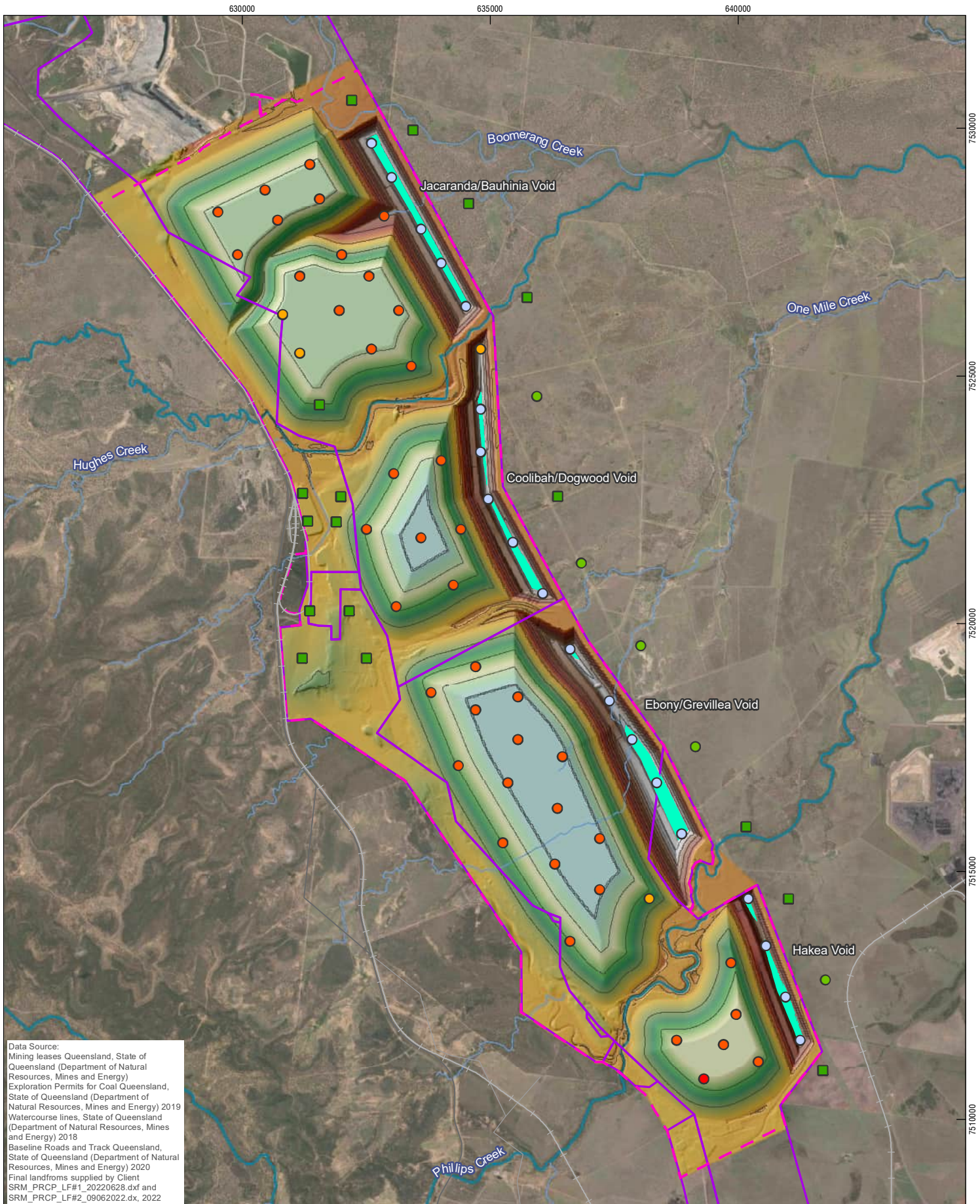
Figure 7-24 shows the initial location of particles on Landform #2. The particles were placed at the surface of the model and released at the start of the post-mining simulation, with the movement of the particles then recorded during the post-mining simulation. It should be noted that the mod-PATH3DU code automatically moves the particle from the model surface to the shallowest saturated layer at the commencement of the simulation; as shown on **Figure 7-24** for many of the particles this represents the Permian layers (including areas of spoil backfill in model layers that represent Permian units pre-mining) as the shallow layers (Layers 1 and 2) are unsaturated across much of the SRM Area at the commencement of the post-mining simulation. Locations where the model predicts saturation in the shallow groundwater system (i.e. Layer 2) at the end of mining and therefore where particles did commence in shallow groundwater include the MIA on the western side of the SRM Area, and just outside the eastern boundary of the SRM Area adjacent Jacaranda/Bauhinia Void and Hughes and Boomerang Creeks, Coolibah/Dogwood Void, Philips Creek, and Hakea Void (refer **Figure 7-24**).

7.2.6.1 Mid Climate Scenario

Figure 7-25 shows the predicted movement of water particles in the 2249 year recovery simulation of Landform #2 for the Mid Climate scenario. The colours along the predicted particle flow paths provides the model layer the particle was simulated to be moving through, with the green to red scale classification representing particles moving from shallow to deep model layers.

The colour changes along the paths on **Figure 7-25** indicate that particles situated within the shallower saturated layers at the beginning of the post-mining simulation generally move progressively toward deeper layers representing the Permian coal measures (or backfilled spoil where the coal measures has been mined out) over the post-mining period. The flow path analysis indicates the particles generally move toward the void lakes, with many of the particles captured in the voids. Some particles starting in the area of the void lakes themselves initially move outwards from the lakes before turning to flow inwards back into the lakes, with the flow path terminating in the lakes themselves, i.e. these particles are re-captured by the voids. Some particles located just east of the SRM Area are shown to initially move marginally outwards by less than 500 m in shallow layers before turning to flow back inwards towards the SRM Area in deeper layers, or not be captured by the voids within the 2249 year simulation. Given these particles starting locations are east of the SRM Area away from any SRM related potential contamination source, and head gradients remain towards the voids as shown on **Figure 7-25**, these results do not indicate any potential for increased environmental risk. Particles with starting locations within the Mine Infrastructure Area (MIA) are also shown to be captured by the Coolibah/Dogwood Void. Particles commencing in the Hakea Void remain captured in the residual void, suggesting sink conditions prevail at all times in this area. No particles are shown to move significantly away from the SRM Area to the broader receiving environment.

Overall, the particle movement simulation indicates that groundwater on SRM, including that flowing through spoil of the final landform and that beneath the MIA, would remain within the final landform (e.g. backfilled spoil and voids) in the long-term with no groundwater predicted to flow to the receiving environment, i.e. the voids would remain groundwater sinks and groundwater would not flow from the residual voids off-site.



Data Source:
Mining leases Queensland, State of Queensland (Department of Natural Resources, Mines and Energy)
Exploration Permits for Coal Queensland, State of Queensland (Department of Natural Resources, Mines and Energy) 2019
Watercourse lines, State of Queensland (Department of Natural Resources, Mines and Energy) 2018
Baseline Roads and Track Queensland, State of Queensland (Department of Natural Resources, Mines and Energy) 2020
Final landforms supplied by Client
SRM_PRCP_LF#1_20220628.dxf and SRM_PRCP_LF#2_09062022.dxf, 2022



Coordinate System: GDA 1994 MGA Zone 55
Scale: 1:100,000 at A4
Project Number: 620.30984
Date: 31-Oct-2023
Drawn by: NT



LEGEND

- Major Watercourse
- Minor Watercourse
- Rail
- Road
- Track
- SRM EA Boundary
- SRM Mine Lease
- Void Lake

Starting Location and Layer of Particle Simulation

- Void Lake
- 2
- 9
- 17
- 18
- 19

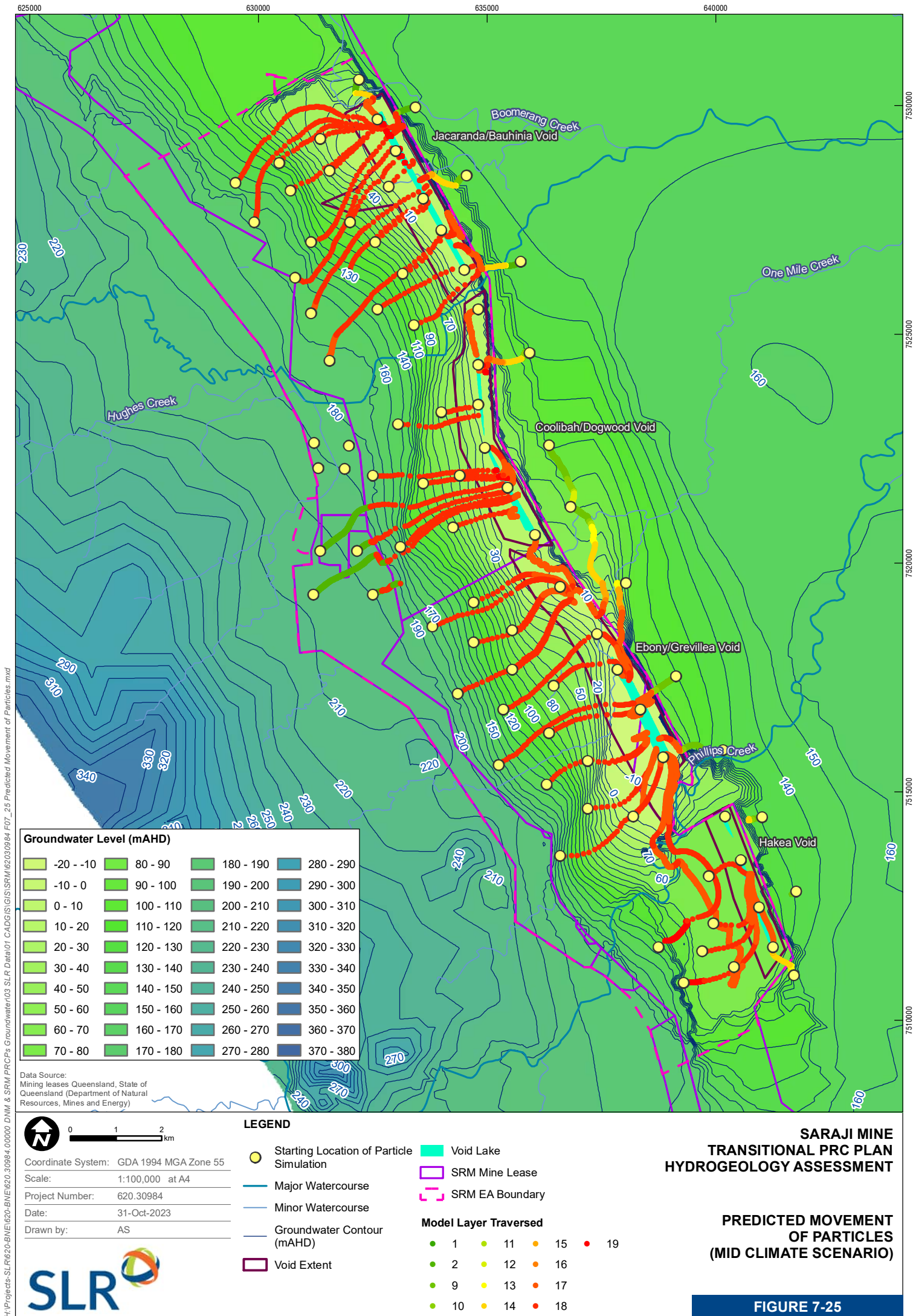
LANDFORM

Elevation (mAHd)
401
-101

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STARTING LOCATION OF PARTICLES

FIGURE 7-24



Given that the particle pathlines are simulated from the start of recovery, they generally follow predicted head gradients. However, the particle directions at times appear to be contrary to the head contours/gradients shown on **Figure 7-25**. It should be noted that the contours shown on **Figure 7-25** only represents the final head pattern when the aquifer has reached an equilibrium and hence does not necessarily show the transient head changes occurring during the 2249 years recovery simulation, given the recovery simulation commences from the first year post-mining. For example, head gradients will change over the 2249 years of recovery simulation as void lake levels stabilise and the groundwater system recovers partially from mining.

7.2.6.2 Climate Sensitivity

Flow path simulation results for the Drier Climate scenario and Wetter Climate scenario as shown in **Appendix B** and **Appendix C**, respectively.

As with the groundwater level predictions (**Section 7.2.5**), there is very little difference between the predicted particle movements for the Drier Climate scenario and Wetter Climate scenario, and the Mid Climate scenario discussed in **Section 7.2.6.1**. That is, all particles remain within the landform regardless of climate scenario with no groundwater predicted to flow to the receiving environment.

8 Conceptual Site Model – Post-Mining

8.1 Overview

A visual representation of the post mining CSM is provided as **Figure 8-1**, based on the end of mining CSM discussed in **Section 5** and the post-mining groundwater modelling presented in **Section 7**. There is no evidence from a groundwater perspective that the final landform is unsuitable for the proposed PMLUs and NUMAs, given the hydrogeological assessment objectives outlined in **Section 1.3** and the following key features:

- Residual void lake formation, with lake levels stabilising significantly below the pre-mining groundwater elevations and any shallow post-Permian strata regardless of climate scenario modelled, including the base of surficial weathering and shallow hydrostratigraphic units (i.e. alluvium, Tertiary units, and weathered regolith).
- Residual groundwater drawdown within the Moranbah Coal Measures as caused by the approved SRM mining operation, with ongoing evaporative discharge from the residual void lakes, resulting in continued inwards hydraulic flow gradients in the coal measures to the residual voids and no outflow in the long term regardless of climate scenario modelled.
- Residual voids continue to capture any seepage from spoil emplacements.
- Little to no additional impact on surficial aquifers, including the alluvial aquifers, caused by the PRC Plan's final landform.
- Little to no impact on environmental receptors caused by the PRC Plan's final landform.
- Little to no impact on anthropogenic receptors caused by the PRC Plan's final landform.

8.2 Source-Pathway-Receptor Analysis

A graphical representation of the CSM in source-pathway-receptor (SPR) format, with particular focus on the post-mining period, is presented as **Figure 8-2**.

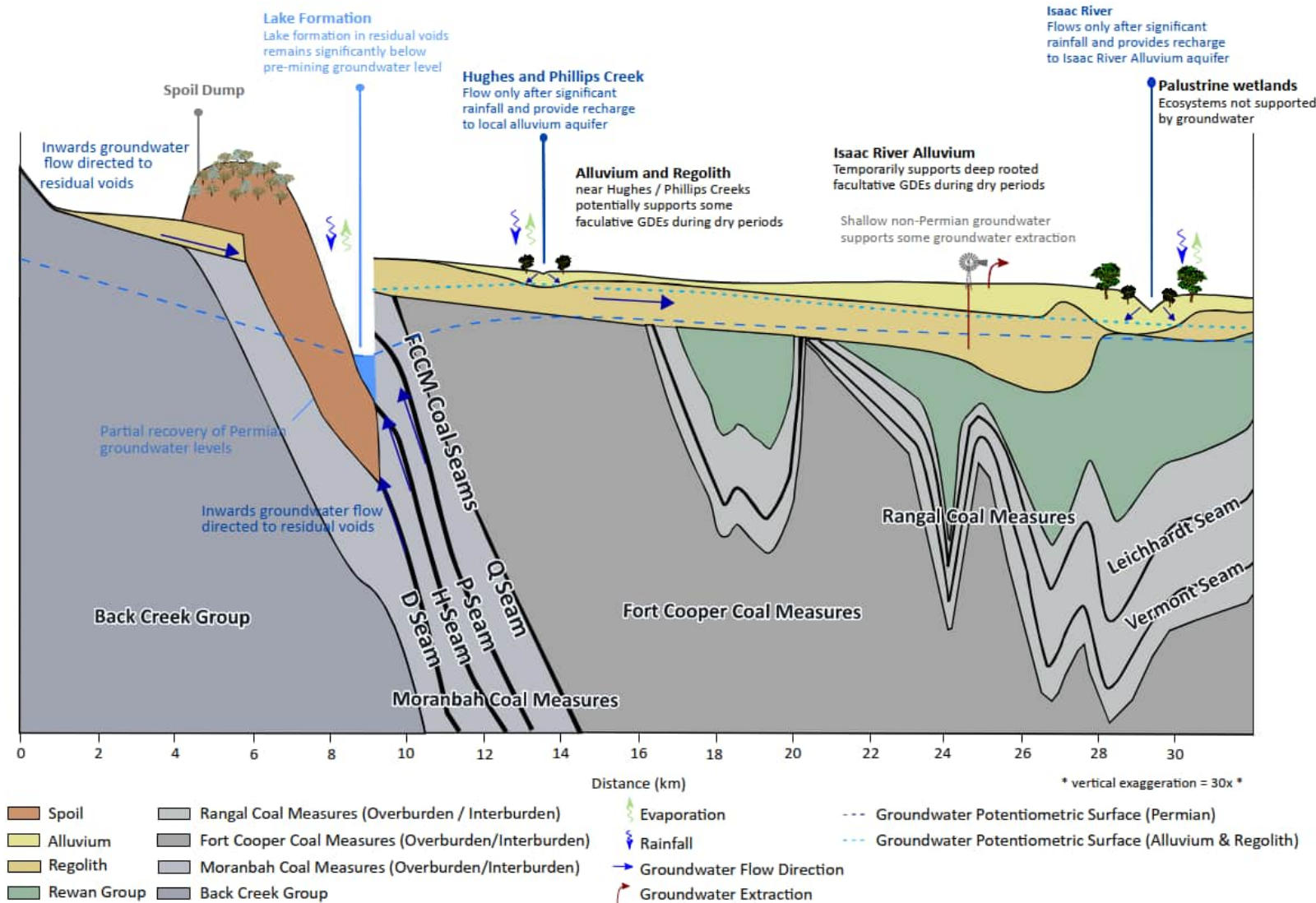


Figure 8-1 Conceptual Model of the Groundwater System – Post-Closure

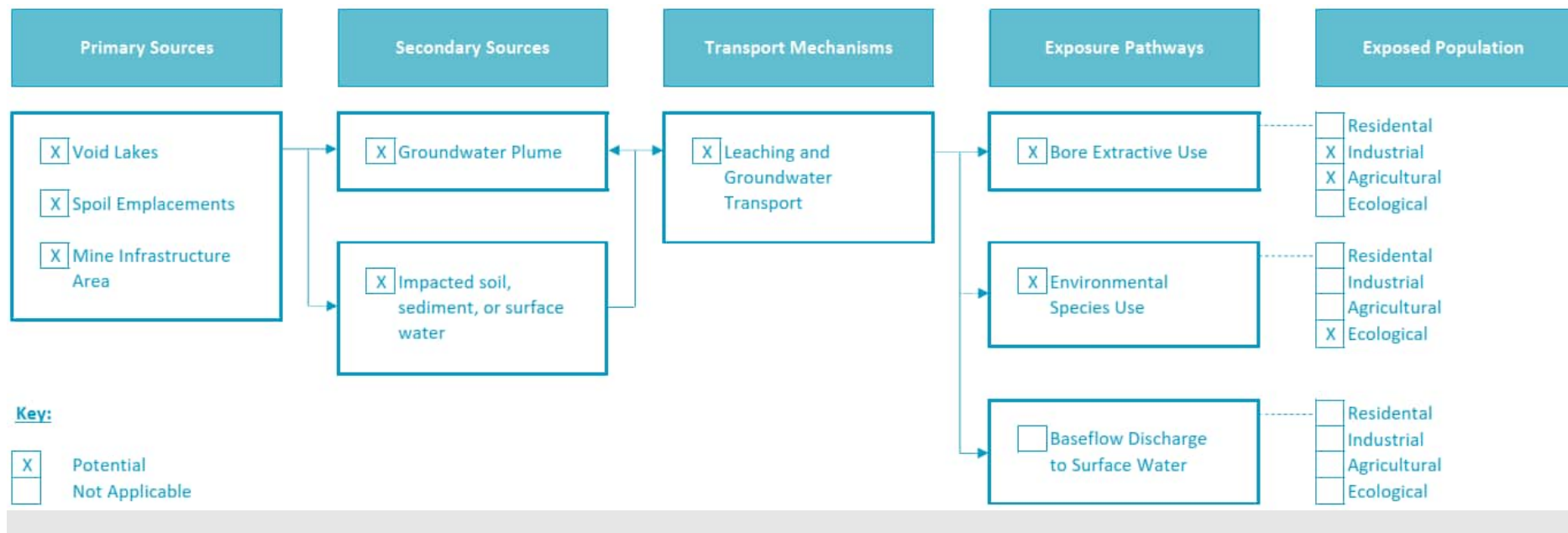


Figure 8-2 Source-Pathway-Receptor Presentation of CSM

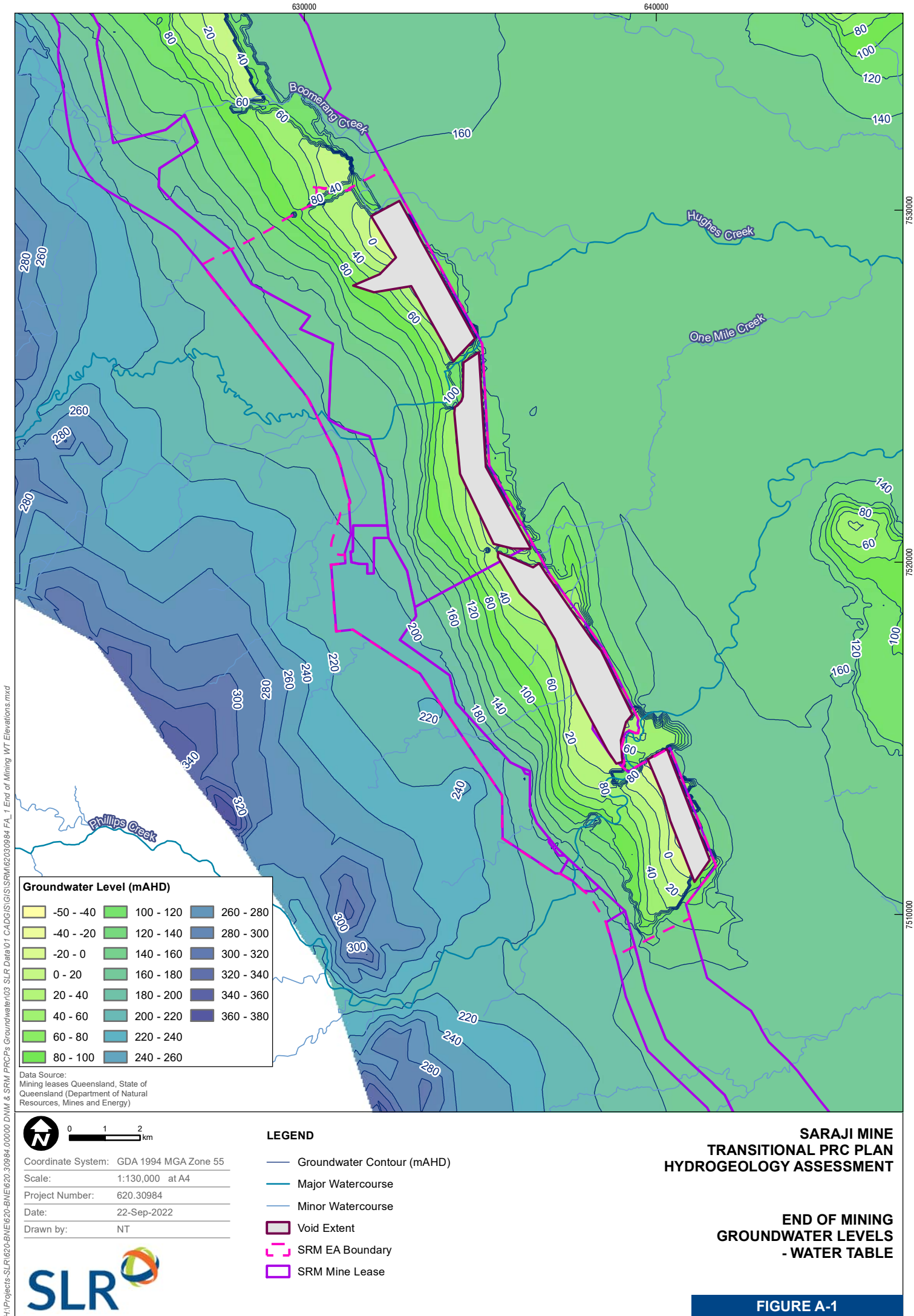
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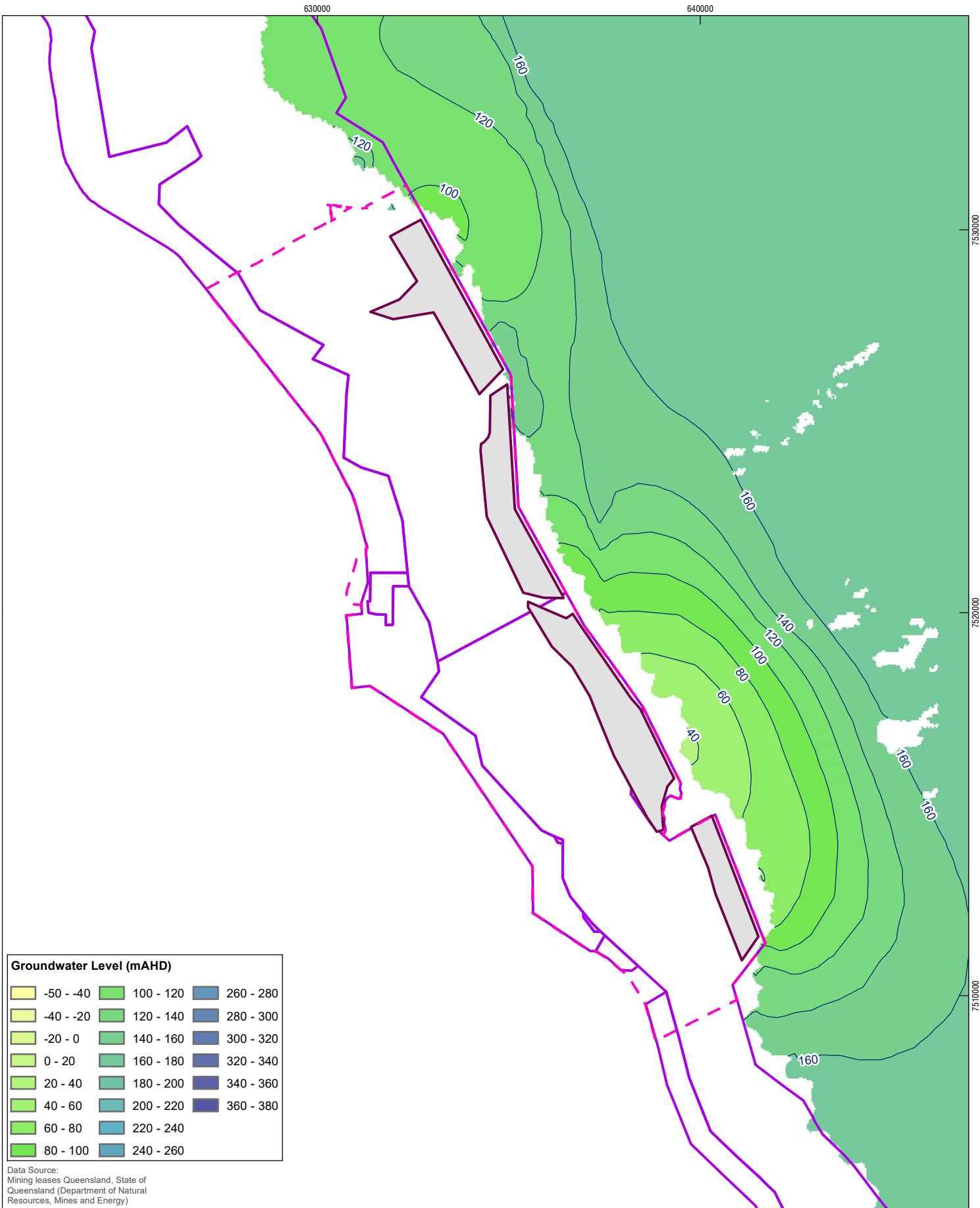
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Appendix A – Recovery Model Starting Heads



H:\Projects-SLR\620-BNE\620-30984-000000 DNM & SRM PRCs Groundwater\103 SLR Data\01 CAD\GIS\SRM\62030984 FA_2 End of Mining WL Elevations Q Seam.mxd



0 1 2 km

Coordinate System: GDA 1994 MGA Zone 55

Scale: 1:130,000 at A4

Project Number: 620.30984

Date: 22-Sep-2022

Drawn by: NT

LEGEND

— Groundwater Contour

■ Void Extent

--- SRM EA Boundary

— SRM Mine Lease

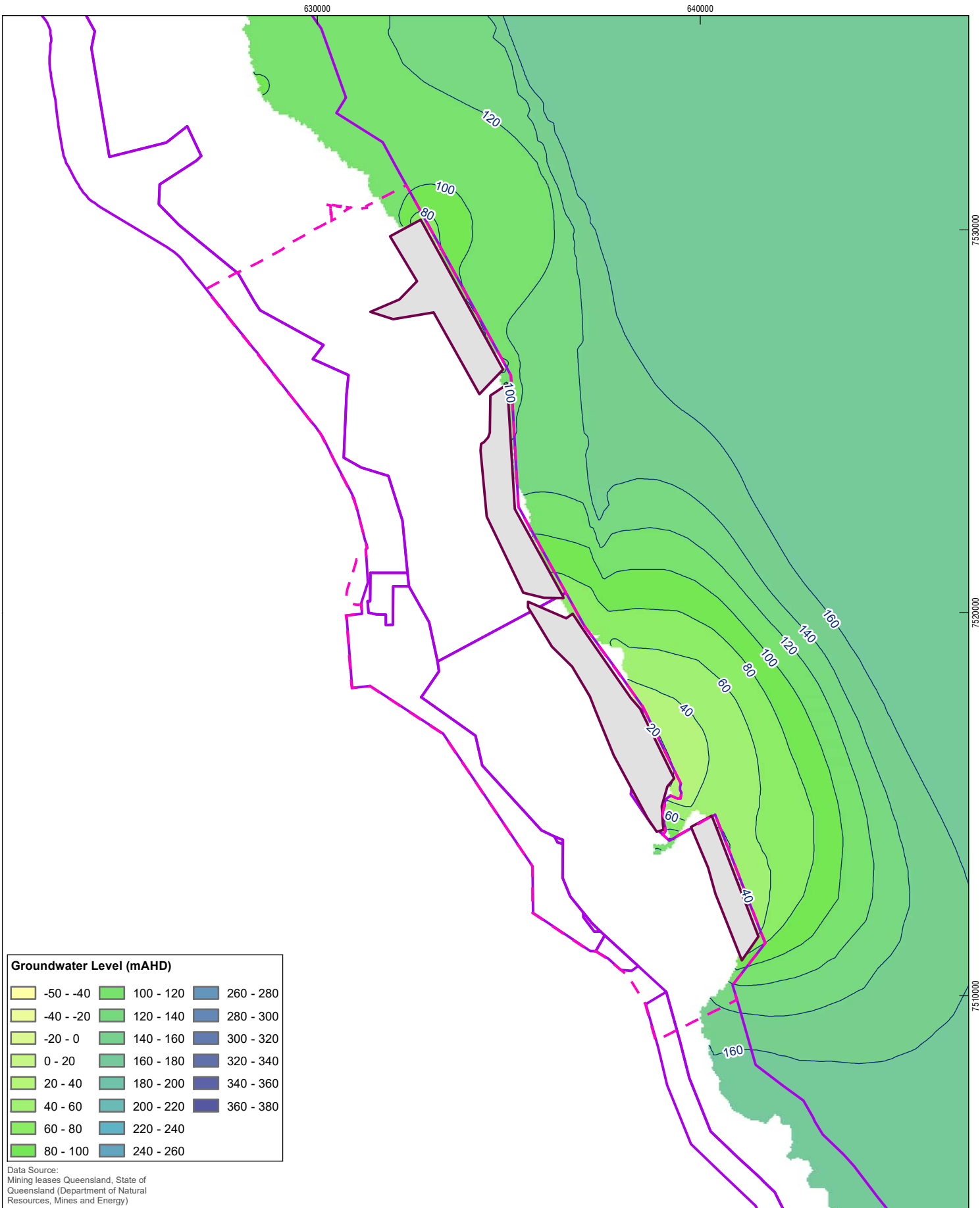
SARAJI MINE TRANSITIONAL PRC PLAN HYDROGEOLOGY ASSESSMENT

END OF MINING GROUNDWATER LEVELS - Q SEAM



FIGURE A-2

H:\Projects-SLR\620-BNE\620-30984-000000 DNM & SRM PRCs Groundwater\103 SLR Data\01 CAD\GIS\SRM\62030984 FA_3 End of Mining WL Elevations P Seam.mxd

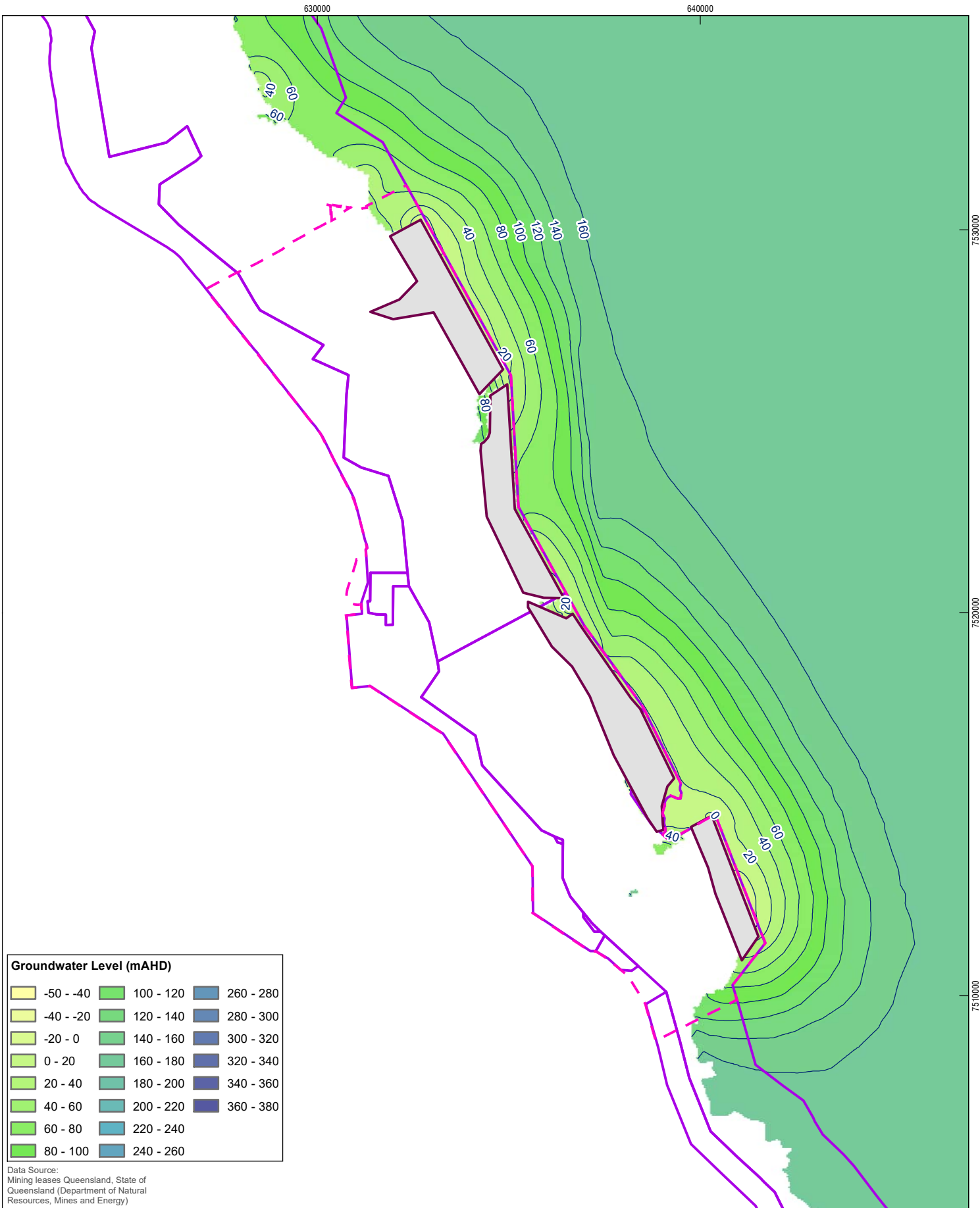


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TRANSITIONAL PRC PLAN
HYDROGEOLOGY ASSESSMENT**

**END OF MINING
GROUNDWATER LEVELS
- P SEAM**

FIGURE A-3

H:\Projects\SLR\620-BNE\620-BNE\620-30984-000000 DNM & SRM PRCs Groundwater\103 SLR Data\01 CAD\GIS\SRM\62030984 FA_4 End of Mining WL Elevations H Seam.mxd



0 1 2 km

Coordinate System: GDA 1994 MGA Zone 55

Scale: 1:130,000 at A4

Project Number: 620.30984

Date: 22-Sep-2022

Drawn by: NT

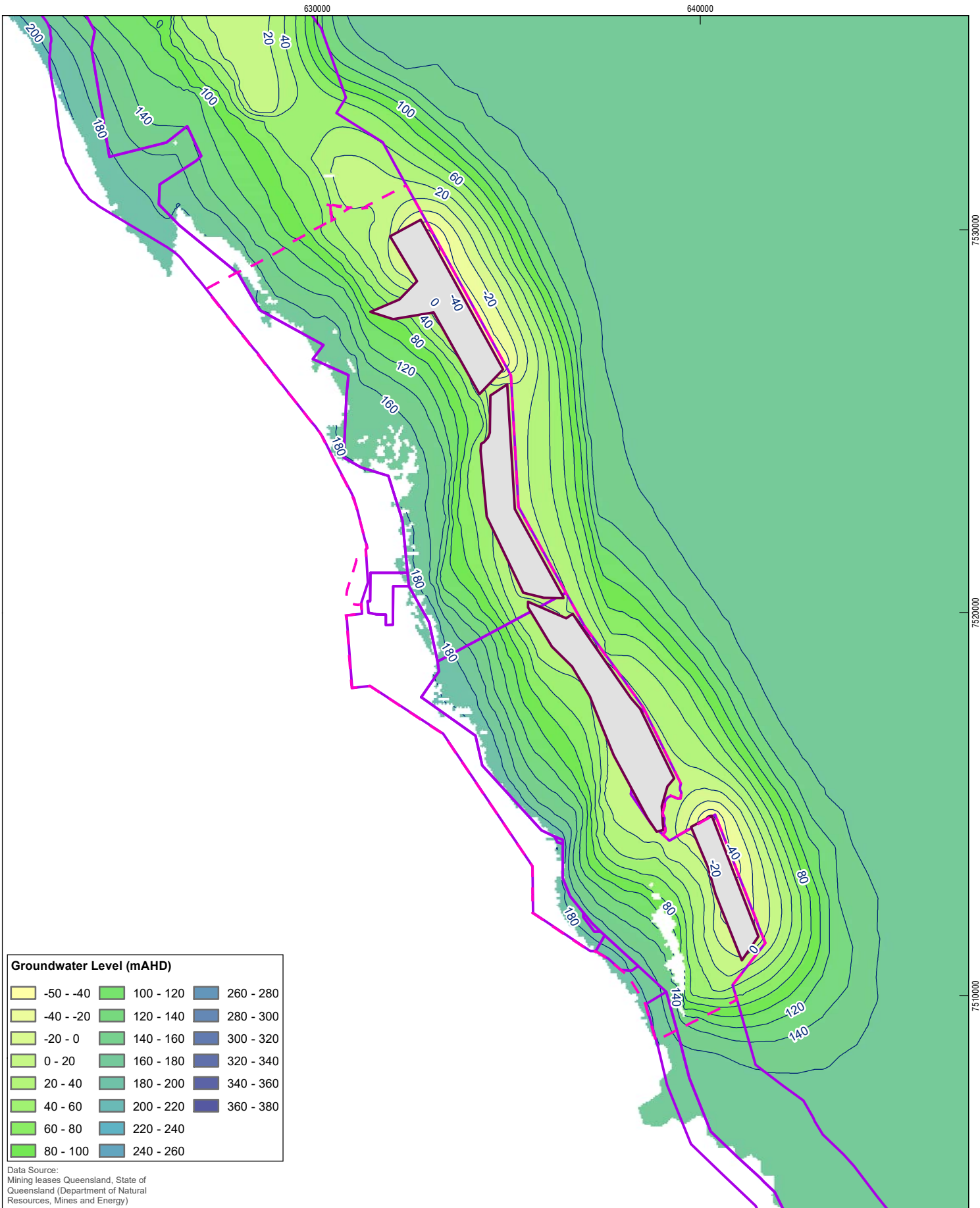


SARAJI MINE TRANSITIONAL PRC PLAN HYDROGEOLOGY ASSESSMENT

END OF MINING GROUNDWATER LEVELS - H SEAM

FIGURE A-4

H:\Projects\SLR\620-BNE\620-BNE\620-30984-000000 DMM & SRM PRCs Groundwater\03 SLR Data\01 CAD\GIS\SRM\62030984 FA_5 End of Mining WL Elevation D seam.mxd



0 1 2 km

Coordinate System: GDA 1994 MGA Zone 55

Scale: 1:130,000 at A4

Project Number: 620.30984

Date: 22-Sep-2022

Drawn by: NT

LEGEND

— Groundwater Contour (mAHD)

■ Void Extent

□ SRM EA Boundary

□ SRM Mine Lease

SARAJI MINE TRANSITIONAL PRC PLAN HYDROGEOLOGY ASSESSMENT

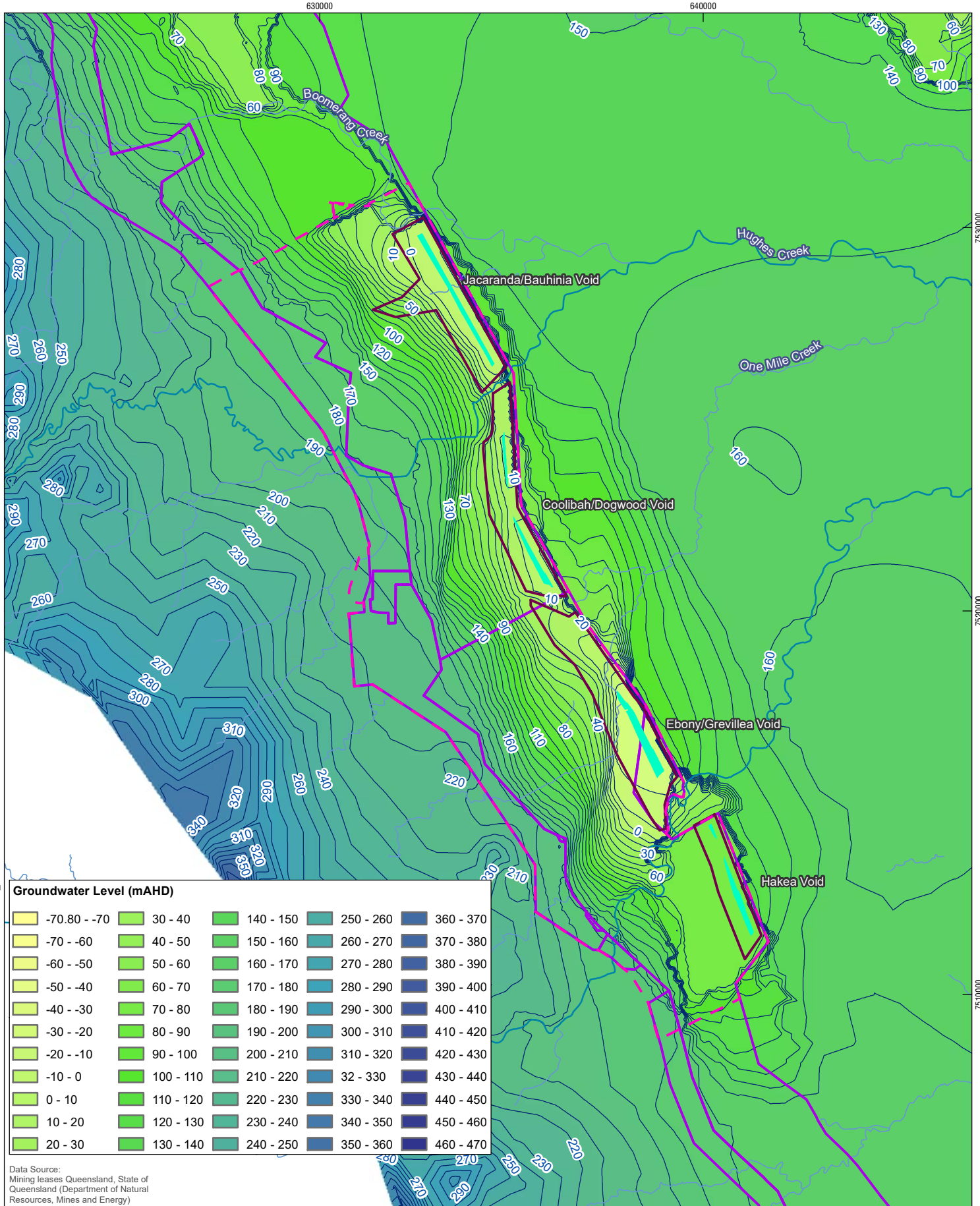
END OF MINING GROUNDWATER LEVELS - D SEAM



FIGURE A-5

Appendix B – Drier Climate Scenario Model Predictions

H:\Projects\SLR\620-BNE\620-30984-00000 DNM & SRM PRCs Groundwater\03 SLR Data\01 CAD\GIS\SRM\62030984_FB_01 Predicted WT Elevations Drier Climate.mxd



0 1 2 km

Coordinate System: GDA 1994 MGA Zone 55

Scale: 1:130,000 at A4

Project Number: 620.30984

Date: 12-Sep-2023

Drawn by: AS

LEGEND

- Major Watercourse
- Minor Watercourse
- Groundwater Contour (mAHd)
- Void Extent
- Void Lake
- SRM Mine Lease
- SRM EA Boundary

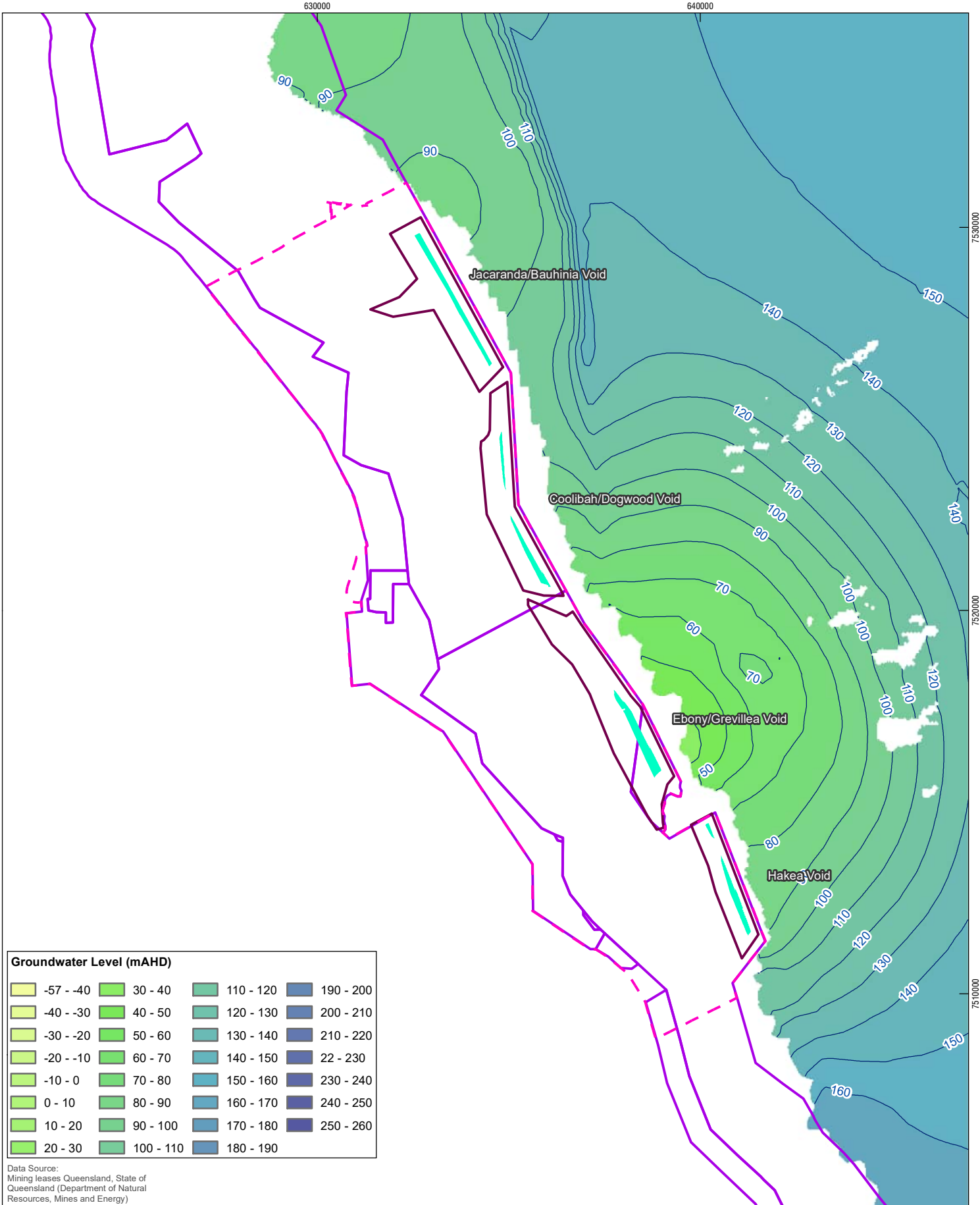
SARAJI MINE TRANSITIONAL PRC PLAN HYDROGEOLOGY ASSESSMENT

**PREDICTED WATER TABLE
ELEVATION - POST-MINING
EQUILIBRIUM
(DRIER CLIMATE SCENARIO)**

FIGURE B-1



H:\Projects-SLR\620-BNE\620-BNE\620-30984-00000 DNM & SRM PRCs Groundwater\03 SLR Data\01 CAD\GIS\SRM\62030984_FB_02 Predicted WL Elevations Q Seam Drier Climate.mxd



0 1 2 km

Coordinate System: GDA 1994 MGA Zone 55

Scale: 1:130,000 at A4

Project Number: 620.30984

Date: 12-Sep-2023

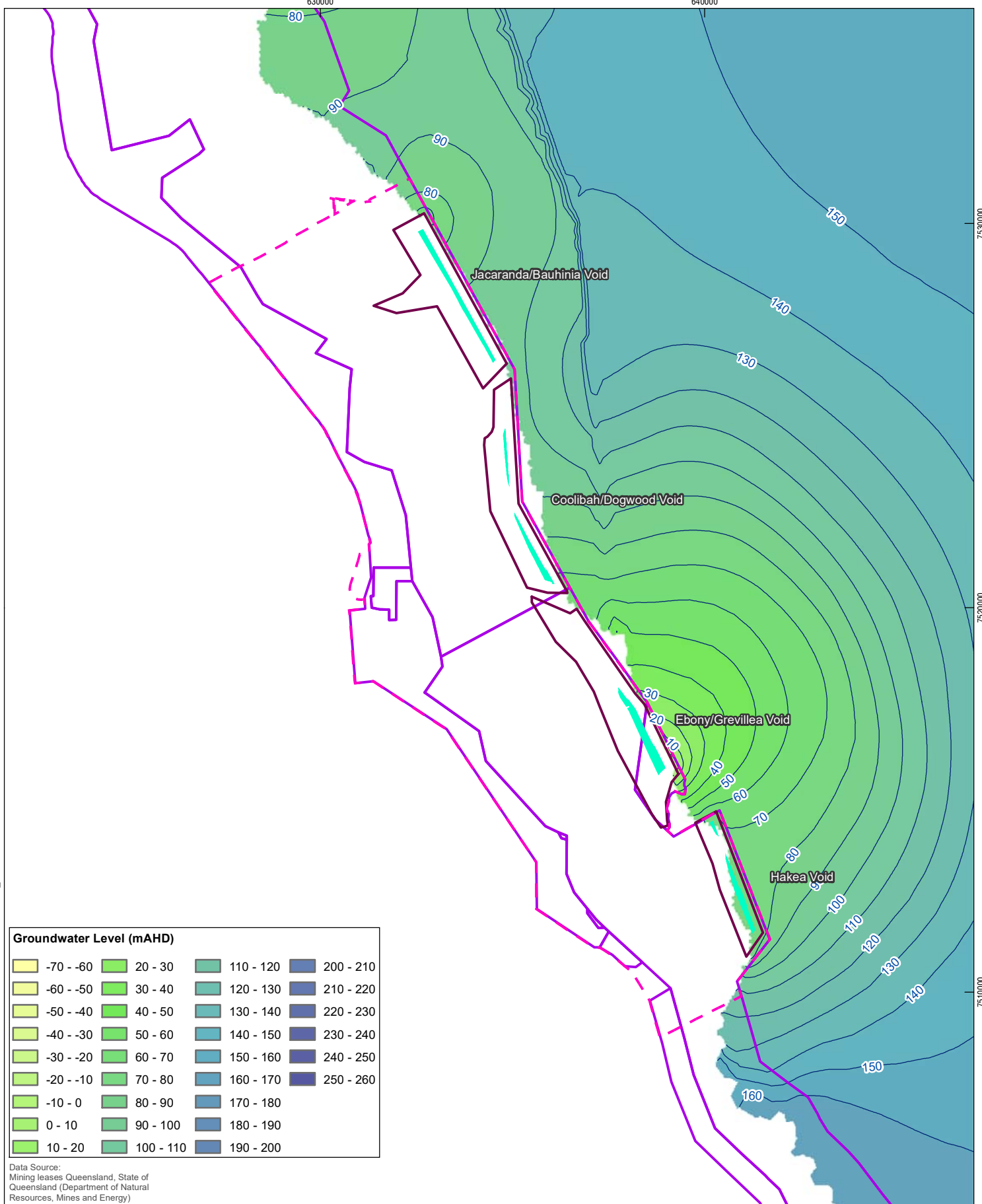
Drawn by: AS



SARAJI MINE TRANSITIONAL PRC PLAN HYDROGEOLOGY ASSESSMENT

**PREDICTED GROUNDWATER
LEVELS IN THE Q SEAM (LAYER 12)
- POST-MINING EQUILIBRIUM
(DRIER CLIMATE SCENARIO)**

FIGURE B-2

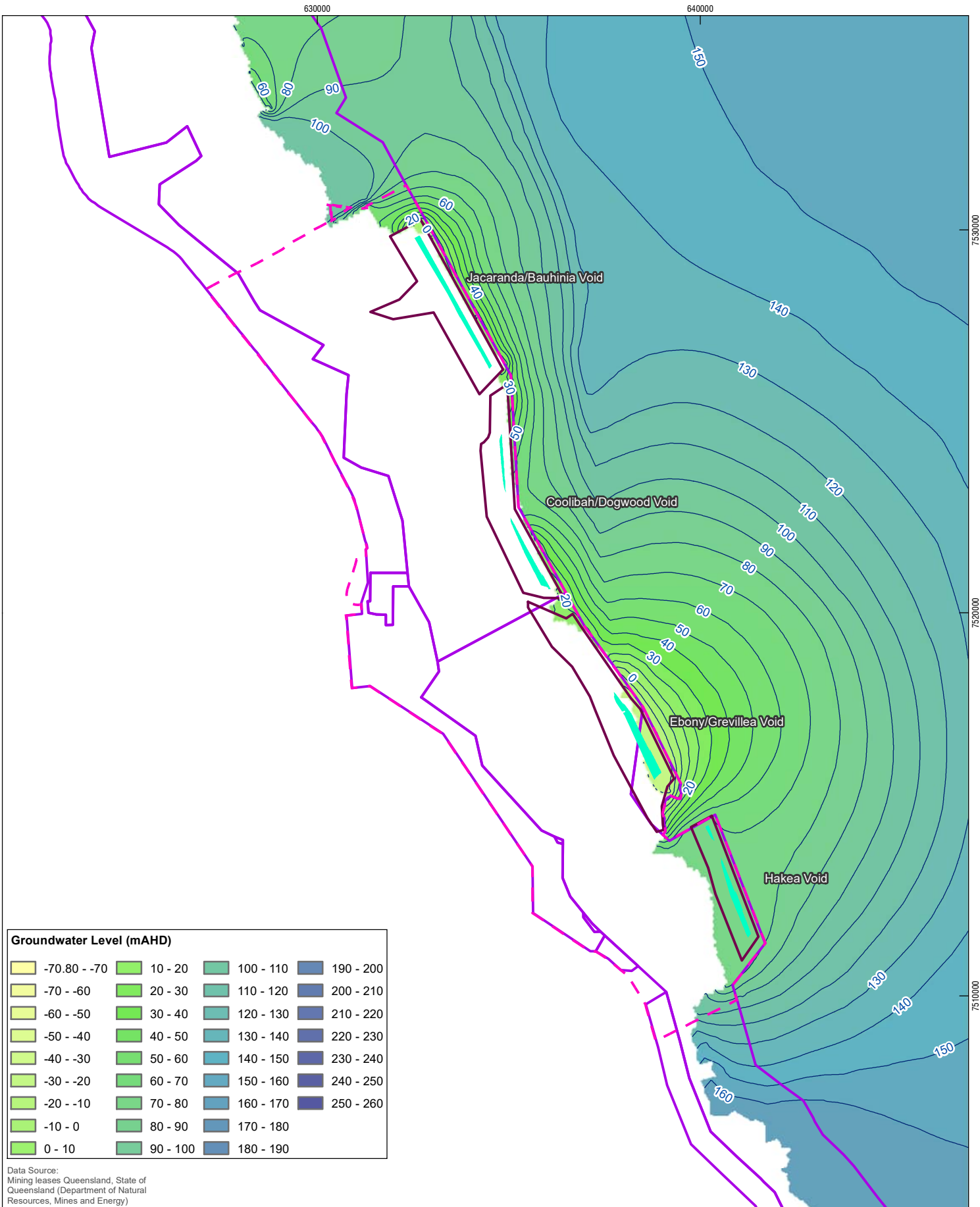


SARAJI MINE TRANSITIONAL PRC PLAN HYDROGEOLOGY ASSESSMENT

**PREDICTED GROUNDWATER
LEVELS IN THE P SEAM (LAYER 14)
- POST-MINING EQUILIBRIUM
(DRIER CLIMATE SCENARIO)**

FIGURE B-3

H:\Projects-SLR\620-BNE\620-BNE\620-30984-00000 DNM & SRM PRCs Groundwater\03 SLR Data\01 CAD\GIS\GISRM\62030984_FB_04 Predicted WL Elevations H Seam Drier Climate.mxd



0 1 2 km

Coordinate System: GDA 1994 MGA Zone 55

Scale: 1:130,000 at A4

Project Number: 620.30984

Date: 12-Sep-2023

Drawn by: AS

LEGEND

— Groundwater Contour (mAHD)

Void Extent

Void Lake

SRM Mine Lease

SRM EA Boundary

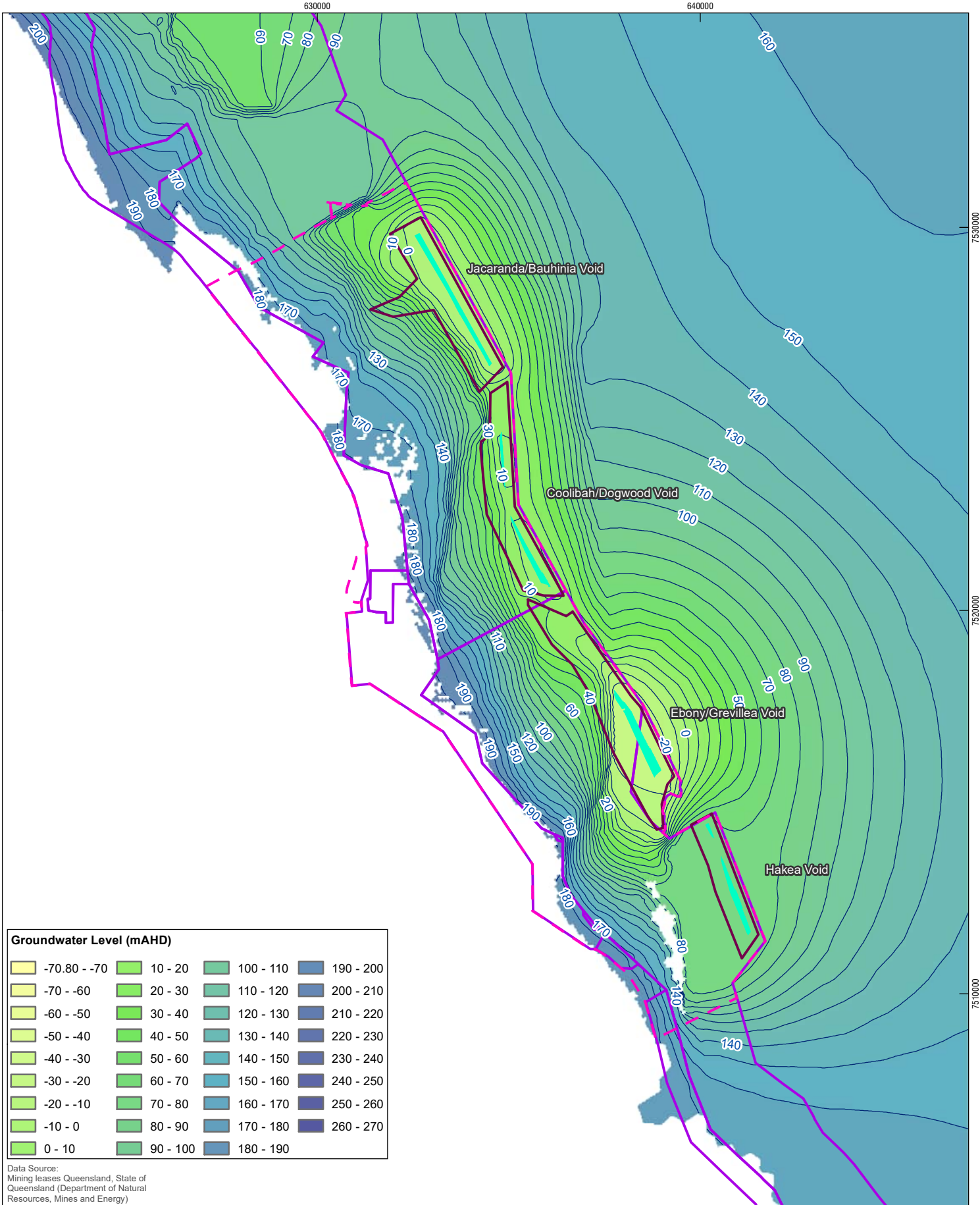


SARAJI MINE TRANSITIONAL PRC PLAN HYDROGEOLOGY ASSESSMENT

**PREDICTED GROUNDWATER
LEVELS IN THE H SEAM (LAYER 16)
- POST-MINING EQUILIBRIUM
(DRIER CLIMATE SCENARIO)**

FIGURE B-4

H:\Projects-SLR\620-BNE\620-BNE\620-30984-00000 DNM & SRM PRCs Groundwater\03 SLR Data\01 CAD\GIS\GISRM\62030984_FB_05 Predicted WL Elevations D Seam Drier Climate.mxd



0 1 2 km

Coordinate System: GDA 1994 MGA Zone 55

Scale: 1:130,000 at A4

Project Number: 620.30984

Date: 12-Sep-2023

Drawn by: AS

LEGEND

— Groundwater Contour (mAHd)

Void Extent

Void Lake

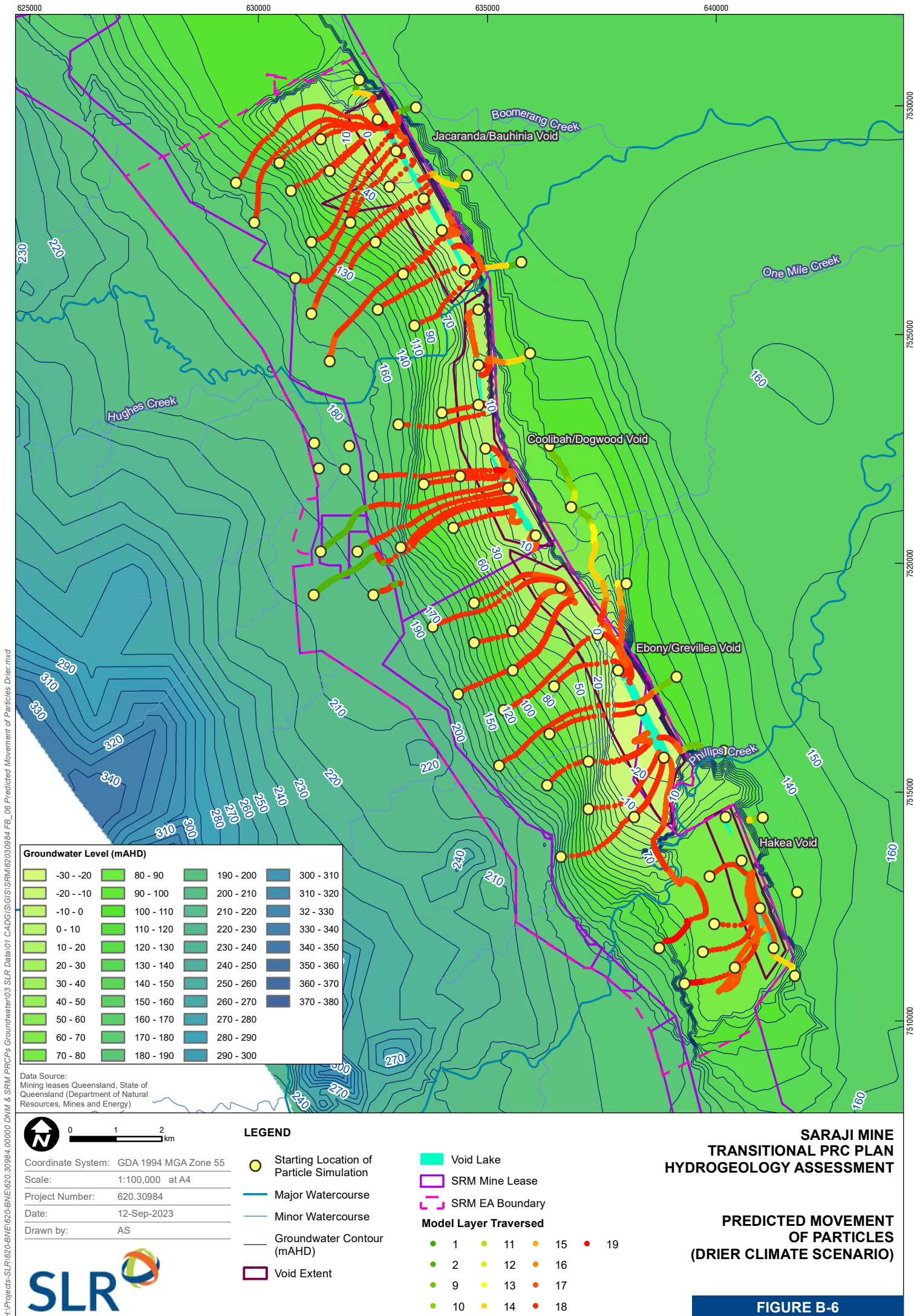
SRM Mine Lease

SRM EA Boundary

SARAJI MINE TRANSITIONAL PRC PLAN HYDROGEOLOGY ASSESSMENT

**PREDICTED GROUNDWATER
LEVELS IN THE D SEAM (LAYER 18)
- POST-MINING EQUILIBRIUM
(DRIER CLIMATE SCENARIO)**

FIGURE B-5



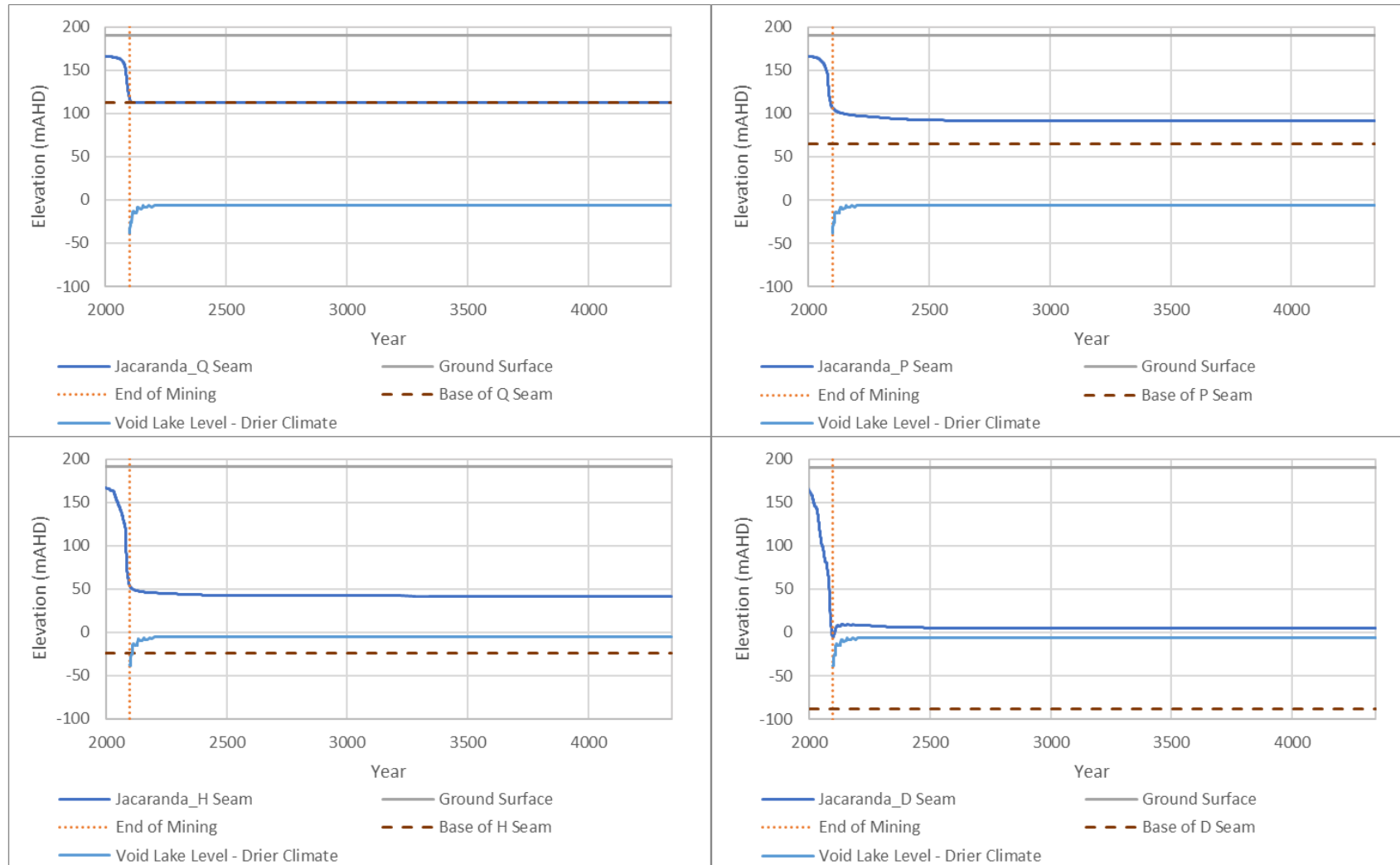


Figure B-7 Permian Coal Measures Predictive Hydrographs adjacent Jacaranda/Bauhinia Void (Drier Climate)

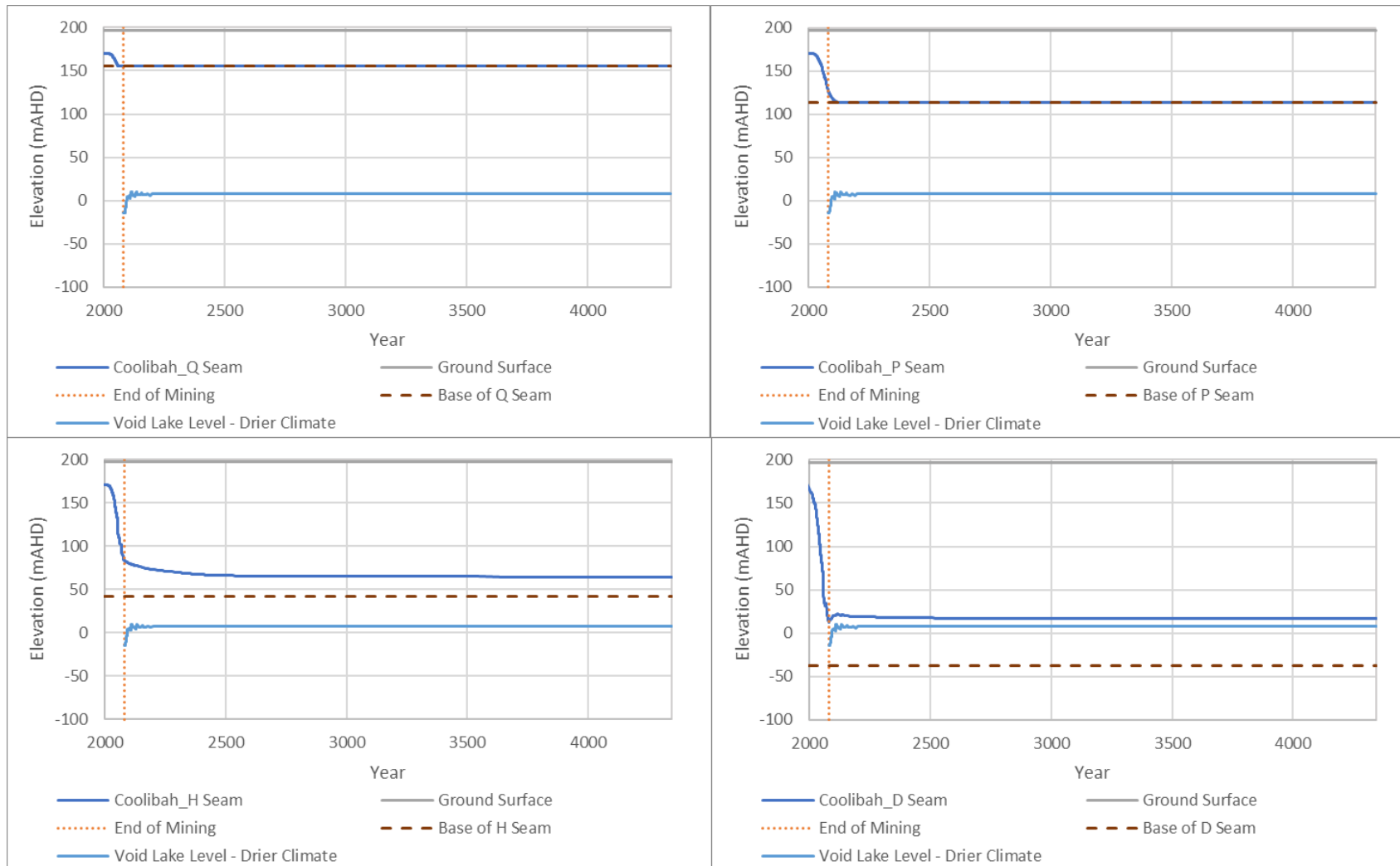


Figure B-8 Permian Coal Measures Predictive Hydrographs adjacent Coolibah/Dogwood Void (Drier Climate)

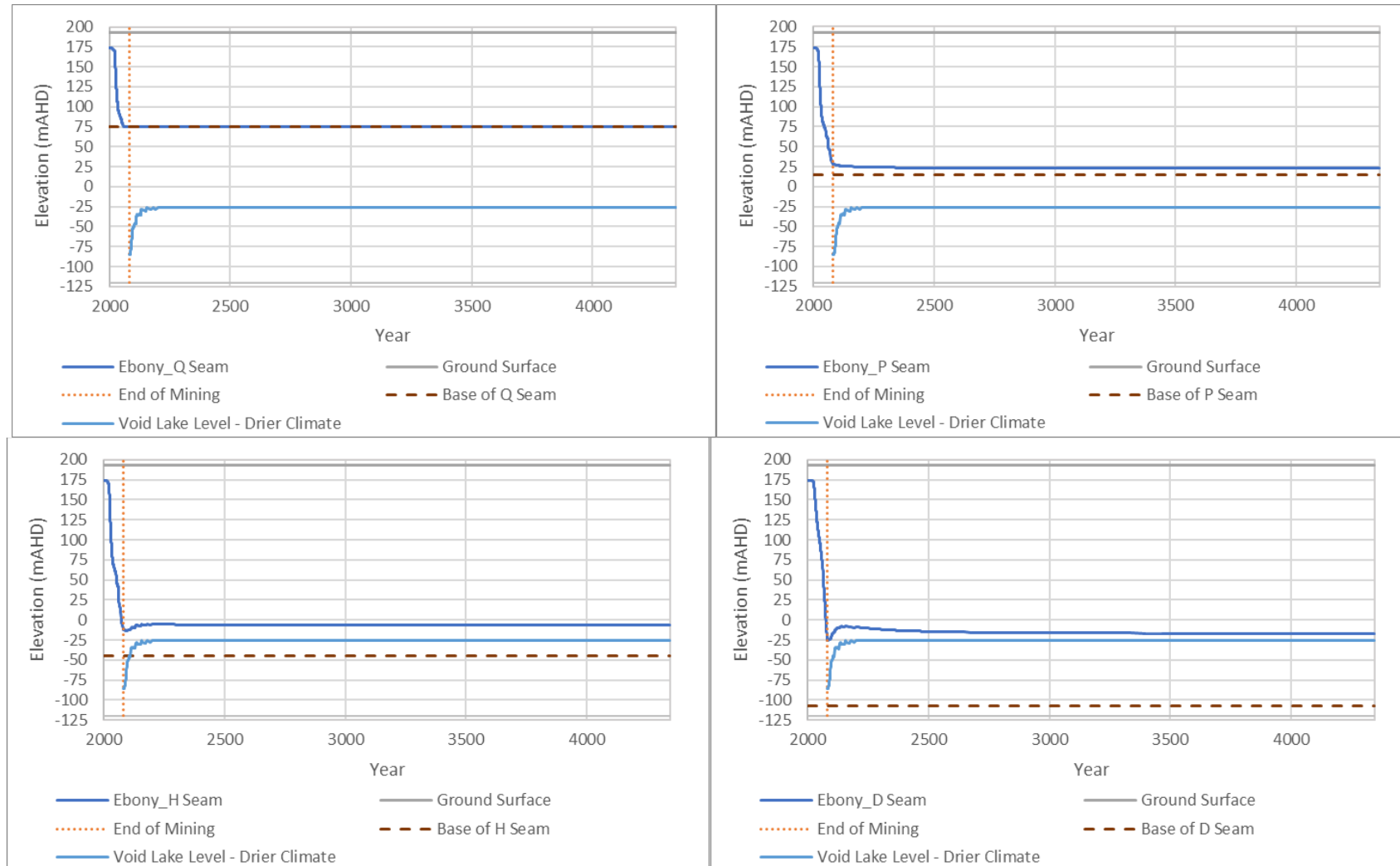


Figure B-9 Permian Coal Measures Predictive Hydrographs adjacent Ebony/Grevillia Void (Drier Climate)

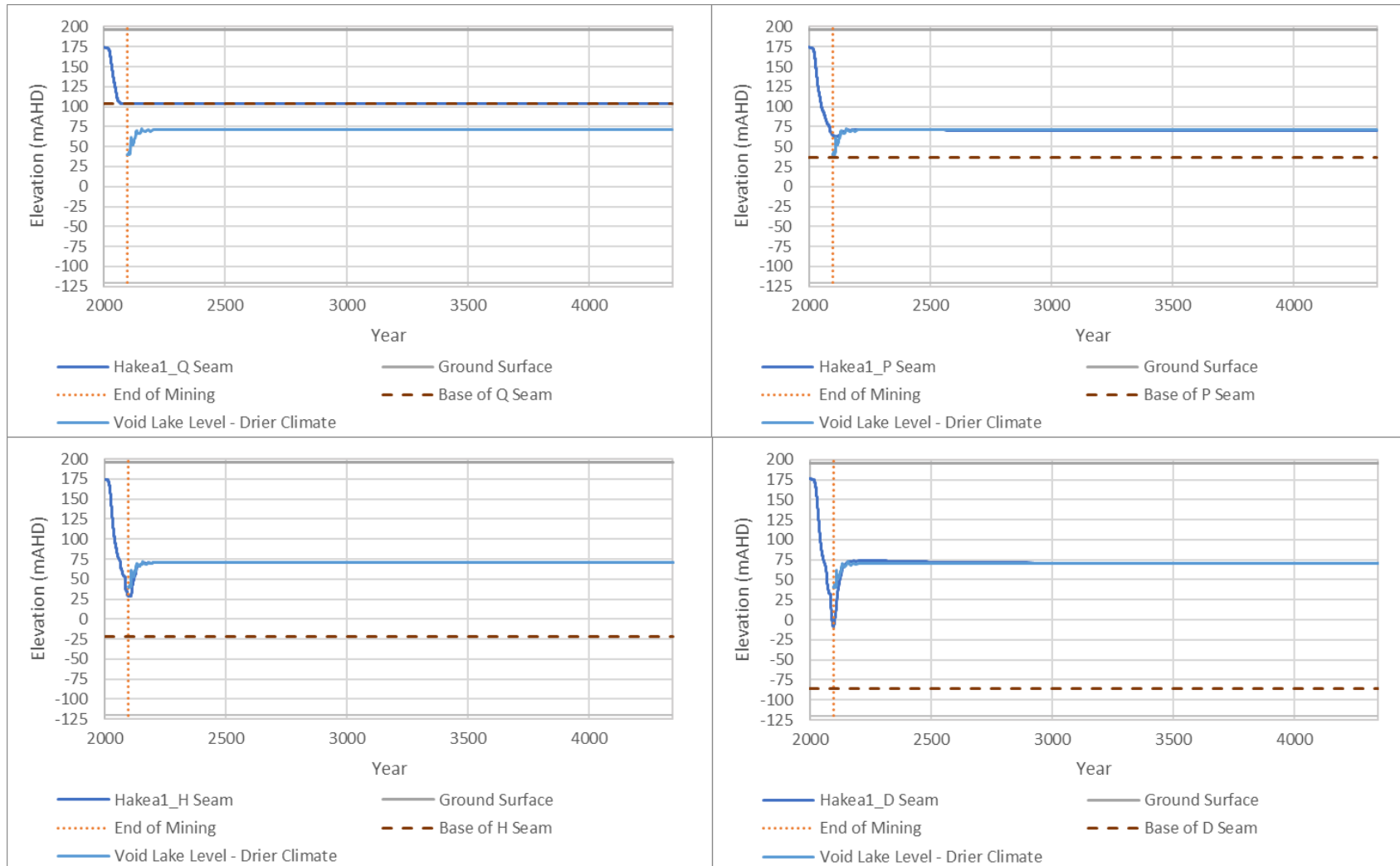


Figure B-10 Permian Coal Measures Predictive Hydrographs adjacent Hakea Void (north) (Drier Climate)

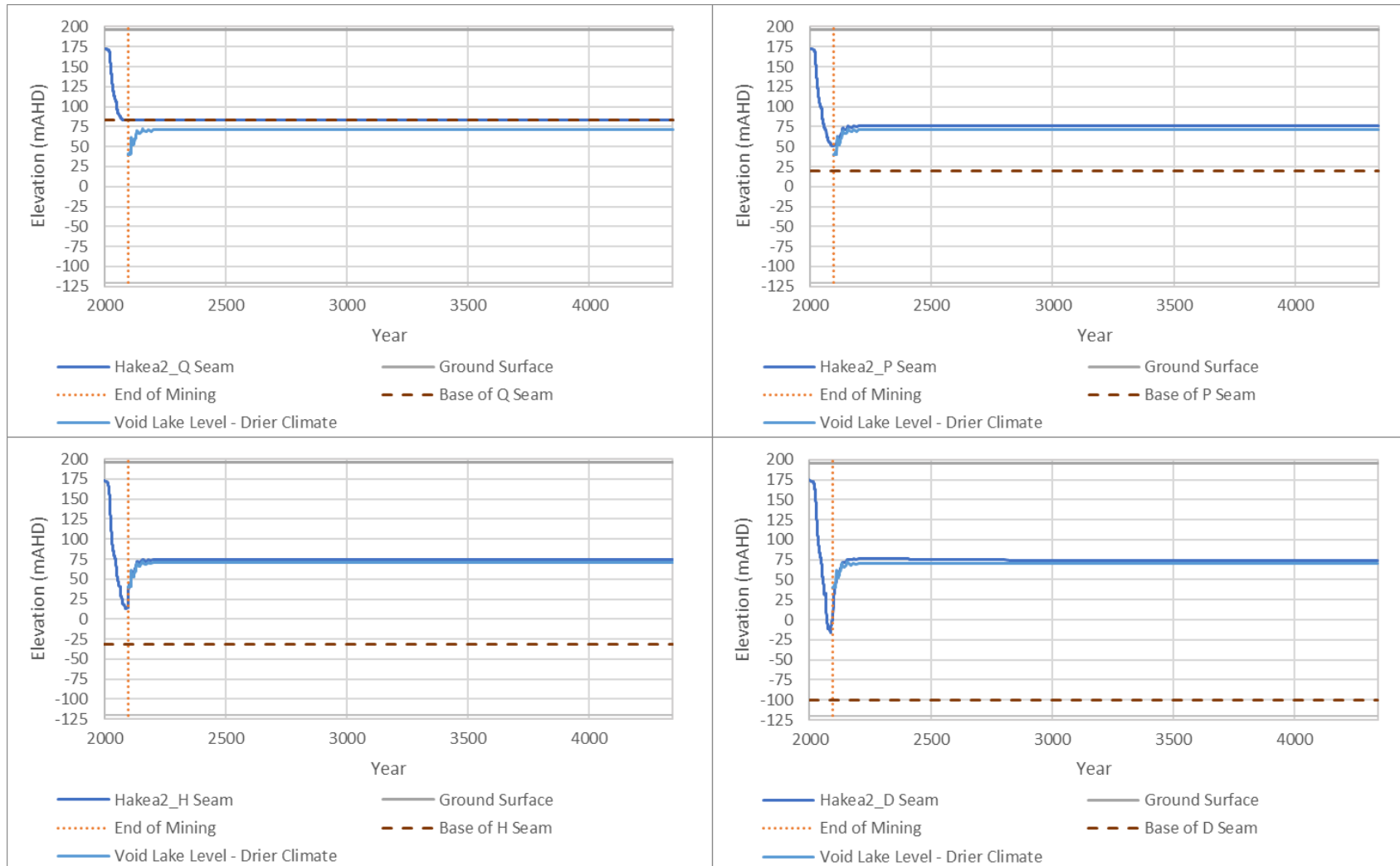
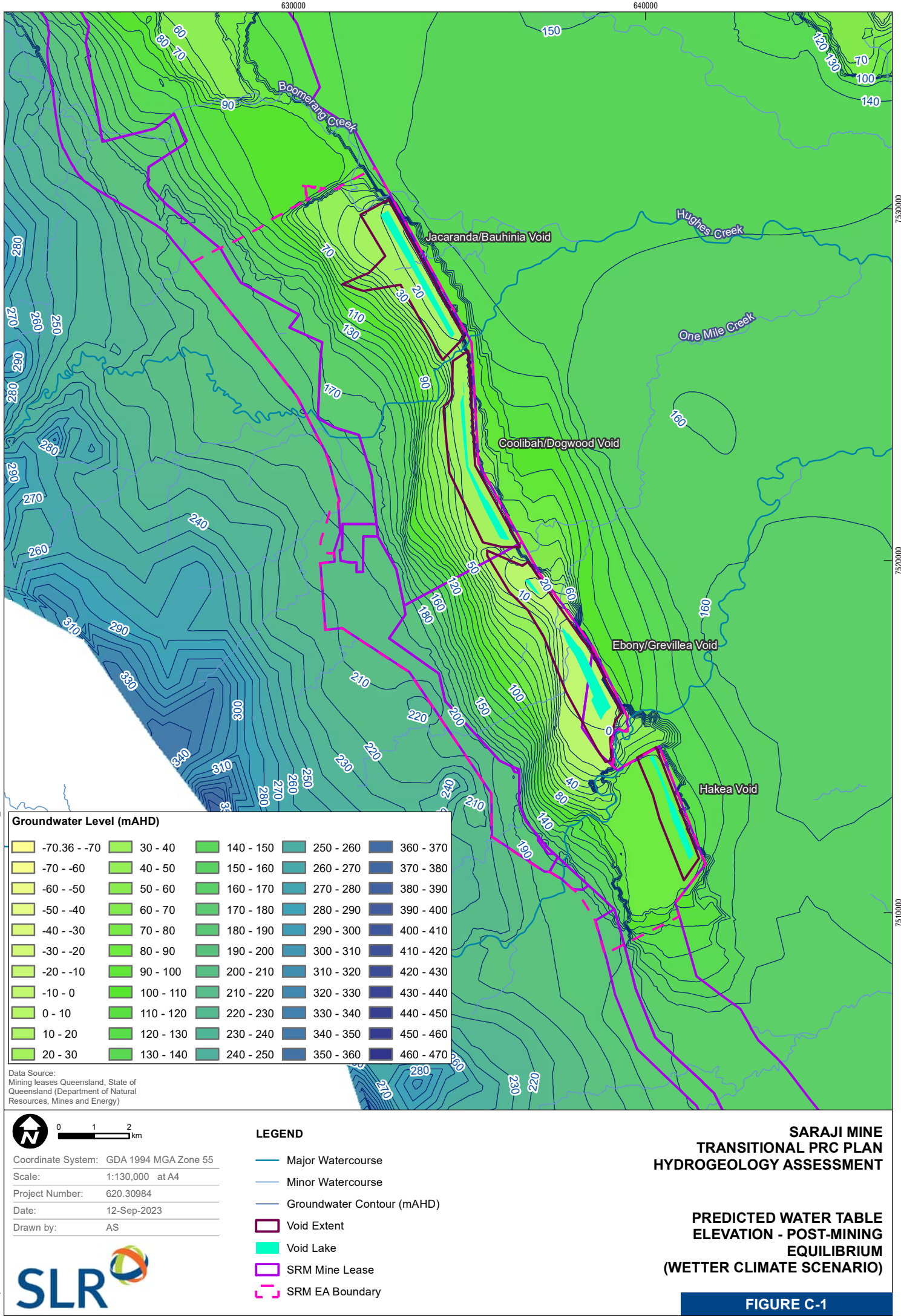


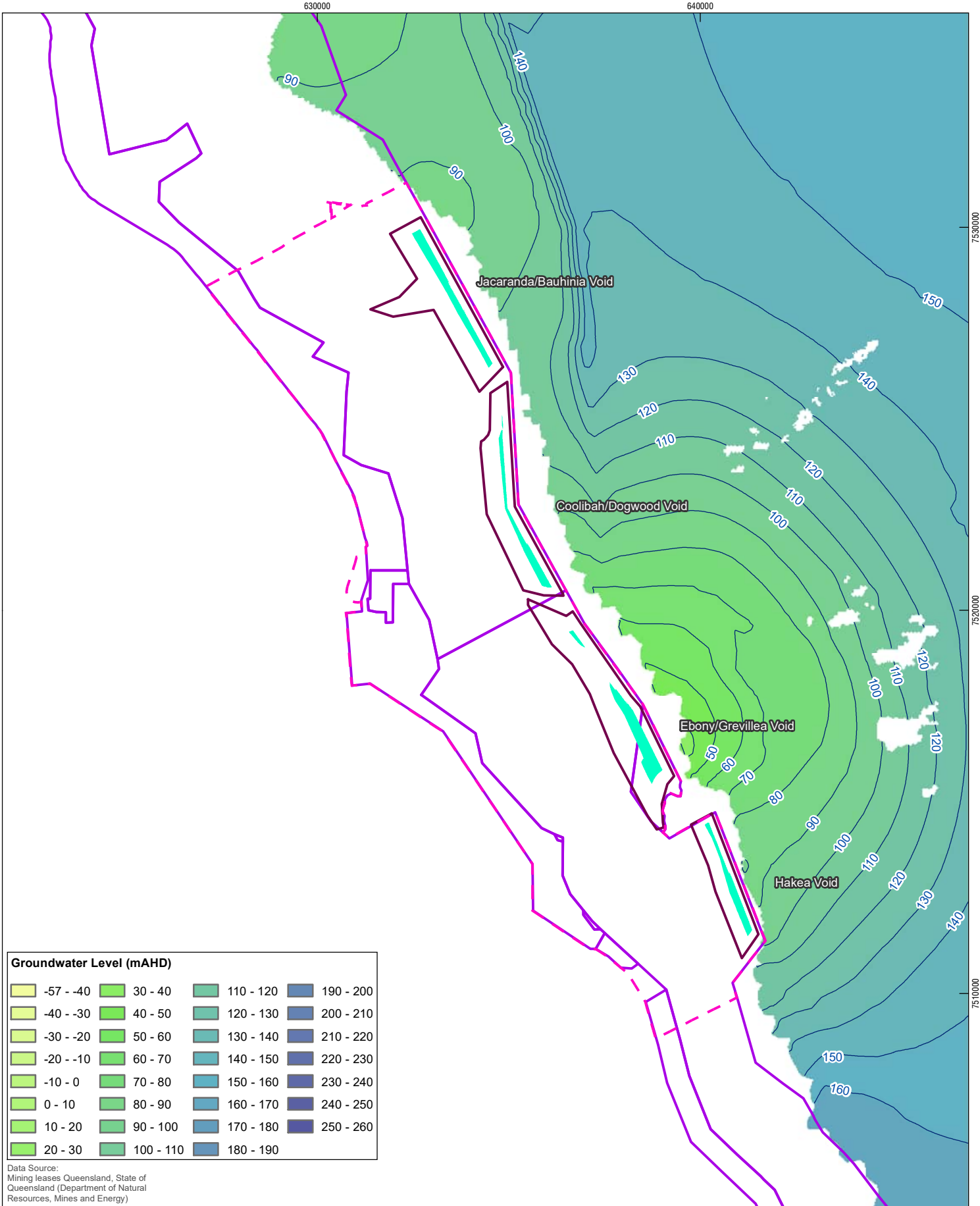
Figure B-11 Permian Coal Measures Predictive Hydrographs adjacent Hakea Void (south) (Drier Climate)

Appendix C – Wetter Climate Scenario Model Predictions

H:\Projects-SLR\620-BNE\620-BNE\620-30984-00000 DNM & SRM PRCs Groundwater\03 SLR Data\01 CAD\GIS\SRM\62030984_FC_1 Predicted WT Elevations Wetter Climate.mxd



H:\Projects-SLR\620-BNE\620-30984-00000 DNM & SRM PRCs Groundwater\03 SLR Data\01 CAD\GIS\SRM\62030984_FC_2_Predicted WL Elevations Q Seam Wetter Climate.mxd

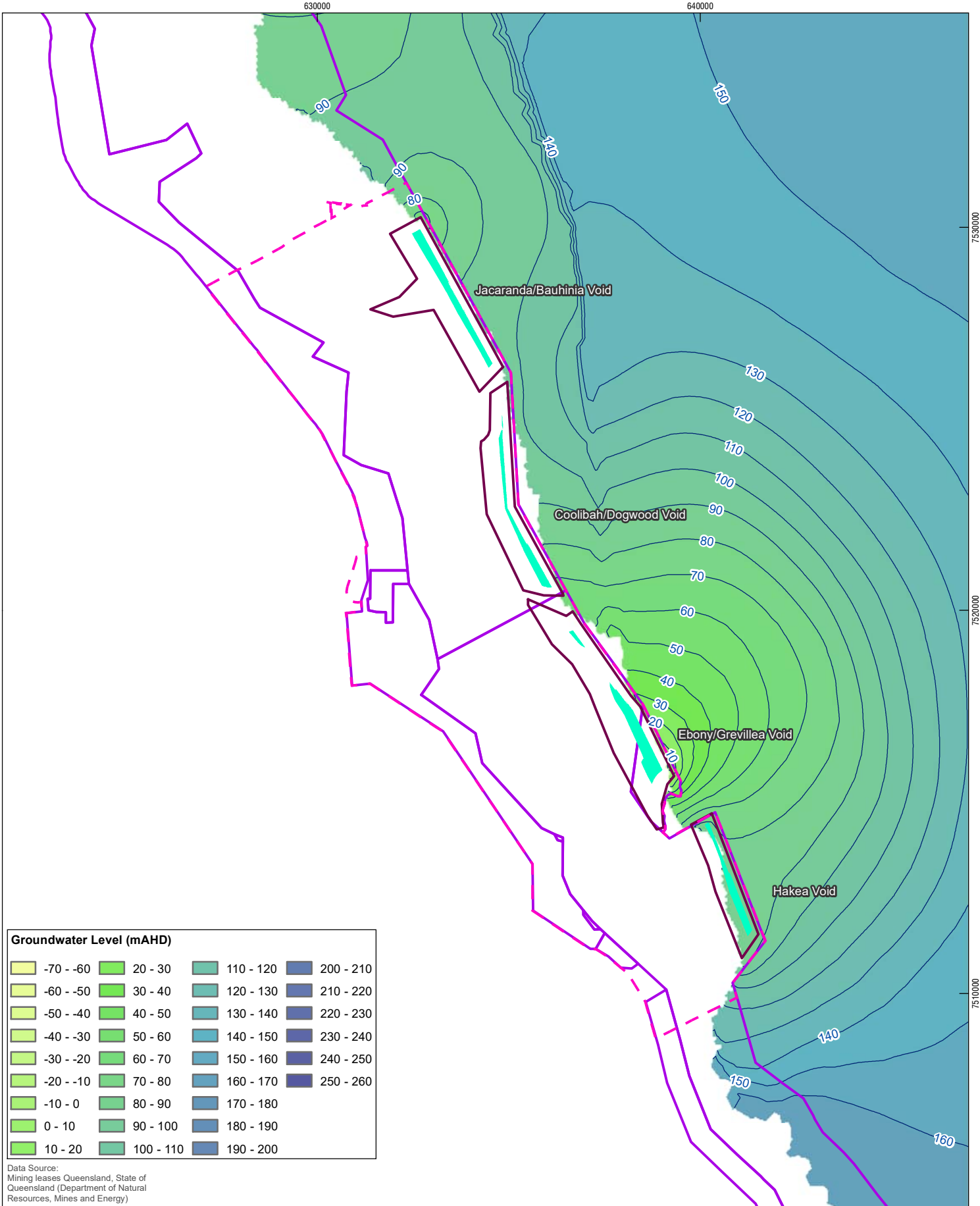


**SARAJI MINE
TRANSITIONAL PRC PLAN
HYDROGEOLOGY ASSESSMENT**

**PREDICTED GROUNDWATER
LEVELS IN THE Q SEAM (LAYER 12)
- POST-MINING EQUILIBRIUM
(WETTER CLIMATE SCENARIO)**

FIGURE C-2

H:\Projects-SLR\620-BNE\620-30984-00000 DNM & SRM PRCs Groundwater\03 SLR Data\01 CAD\GIS\SRM\62030984_FC_3 Predicted WL Elevations P Seam Wetter Climate.mxd

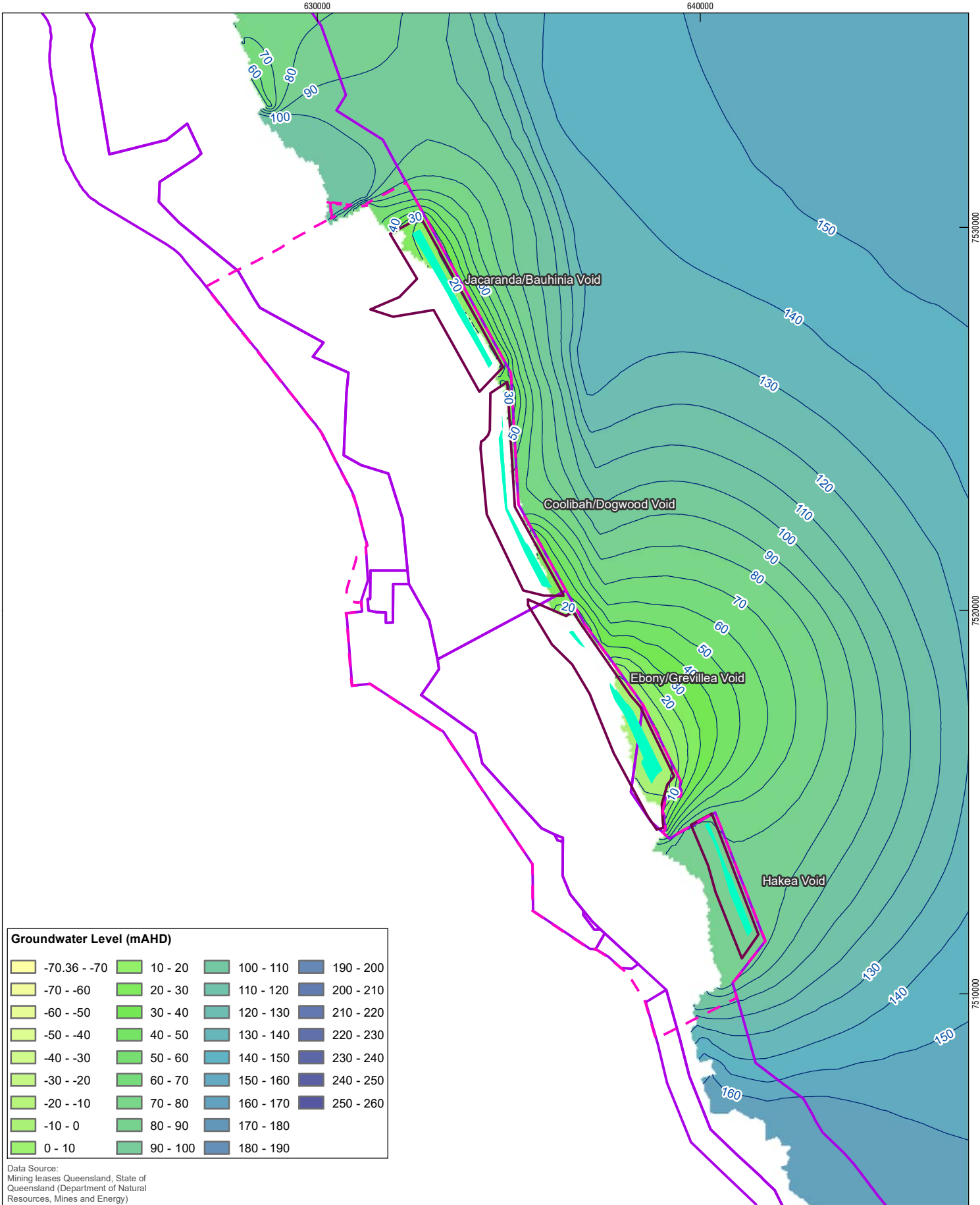


**SARAJI MINE
TRANSITIONAL PRC PLAN
HYDROGEOLOGY ASSESSMENT**

**PREDICTED GROUNDWATER
LEVELS IN THE P SEAM (LAYER 14)
- POST-MINING EQUILIBRIUM
(WETTER CLIMATE SCENARIO)**

FIGURE C-3

H:\Projects-SLR\620-BNE\620-BNE\620.30984_00000 DNM & SRM PRCs Groundwater\03 SLR Data\01 CAD\GIS\SRM\62030984_FC_4 Predicted WL Elevations H Seam Wetter Climate.mxd



0 1 2 km

Coordinate System: GDA 1994 MGA Zone 55

Scale: 1:130,000 at A4

Project Number: 620.30984

Date: 12-Sep-2023

Drawn by: AS

LEGEND

— Groundwater Contour (mAHd)

Void Extent

Void Lake

SRM Mine Lease

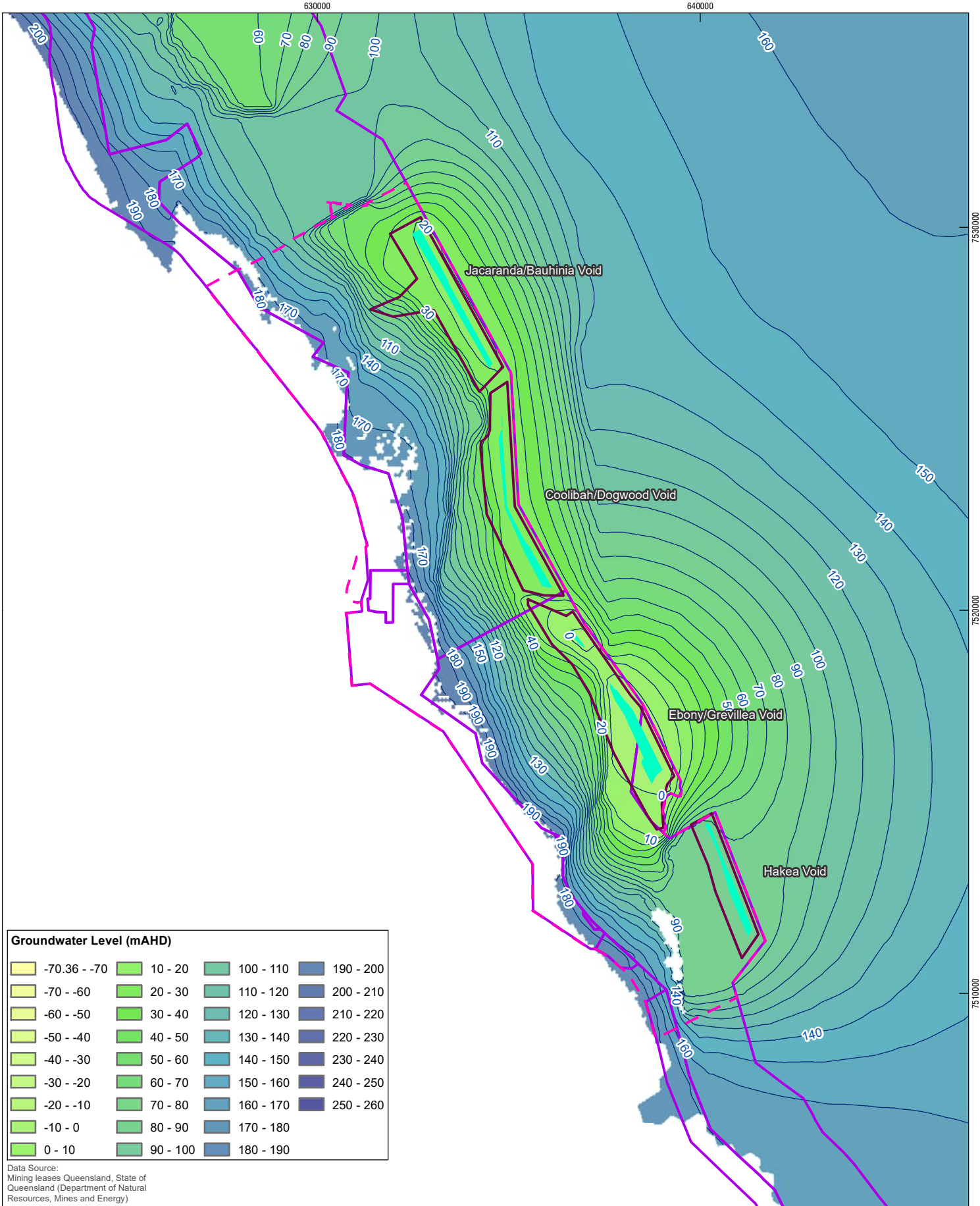
SRM EA Boundary



SARAJI MINE TRANSITIONAL PRC PLAN HYDROGEOLOGY ASSESSMENT

**PREDICTED GROUNDWATER
LEVELS IN THE H SEAM (LAYER 16)
- POST-MINING EQUILIBRIUM
(WETTER CLIMATE SCENARIO)**

FIGURE C-4



0 1 2 km

Coordinate System: GDA 1994 MGA Zone 55

Scale: 1:130,000 at A4

Project Number: 620.30984

Date: 12-Sep-2023

Drawn by: NT

LEGEND

— Groundwater Contour (mAHD)

□ Void Extent

□ Void Lake

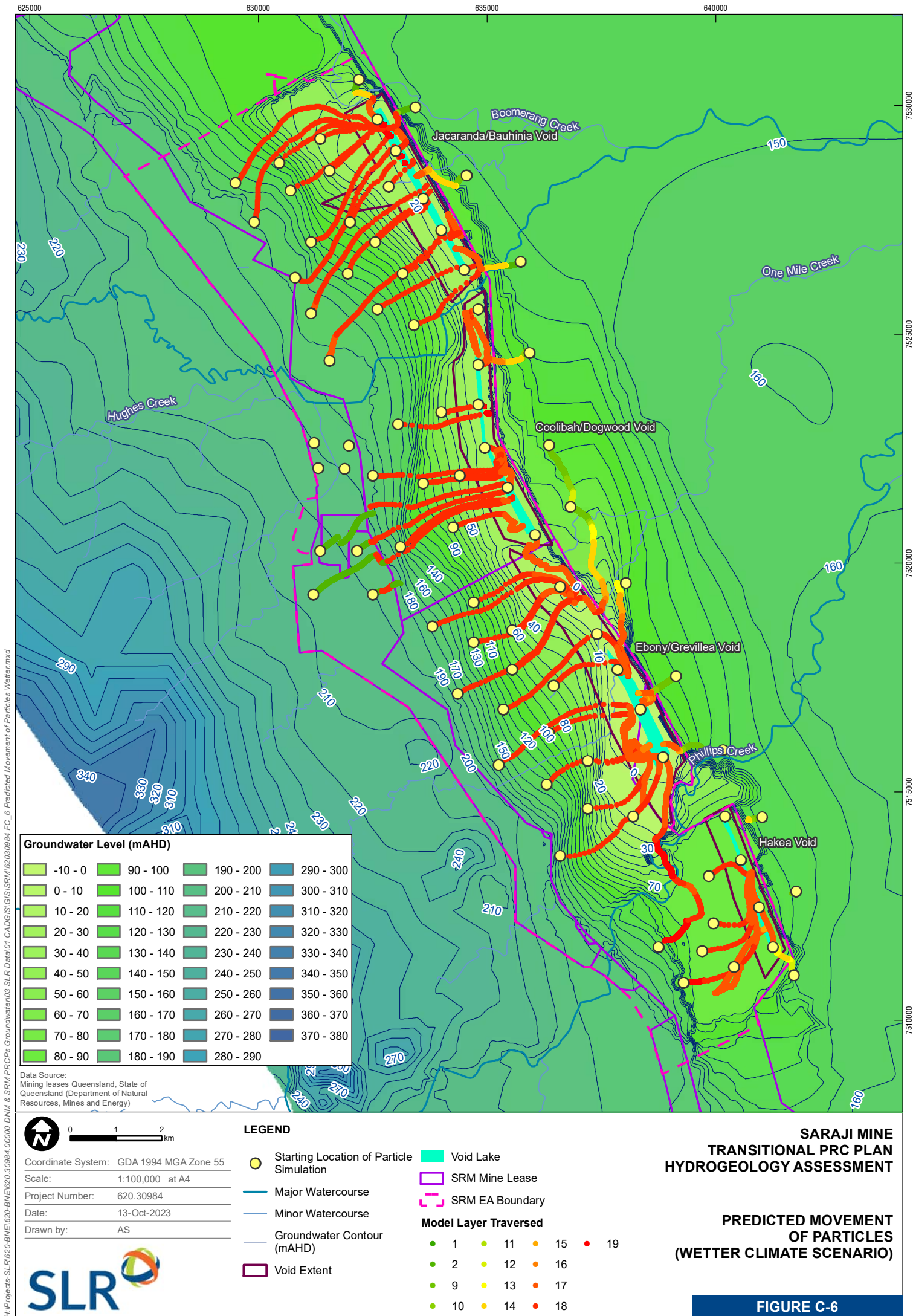
□ SRM Mine Lease

□ SRM EA Boundary

SARAJI MINE TRANSITIONAL PRC PLAN HYDROGEOLOGY ASSESSMENT

**PREDICTED GROUNDWATER
LEVELS IN THE D SEAM (LAYER 18)
- POST-MINING EQUILIBRIUM
(WETTER CLIMATE SCENARIO)**

FIGURE C-5



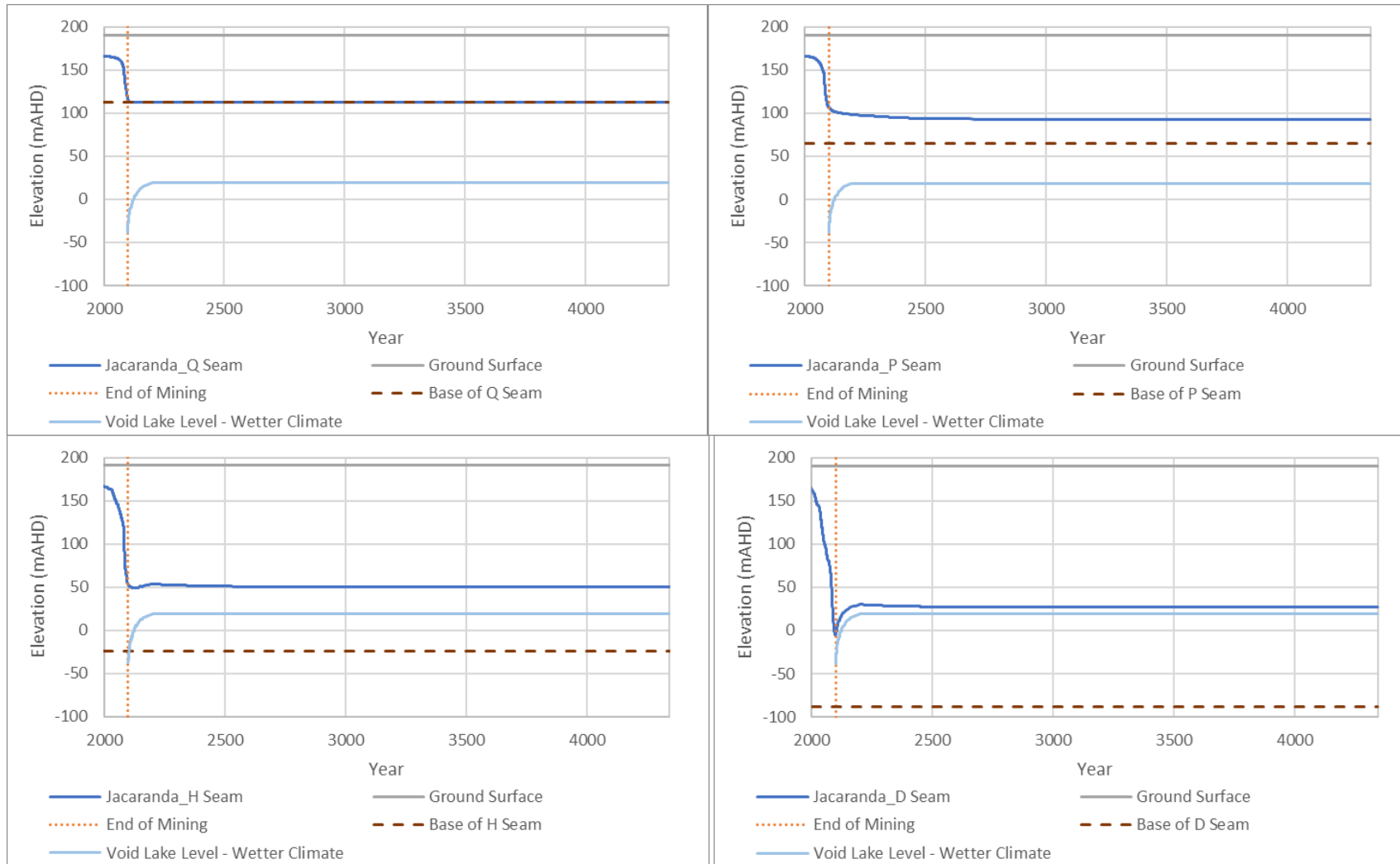


Figure C-7 Permian Coal Measures Predictive Hydrographs adjacent Jacaranda/Bauhinia Void (Wetter Climate)

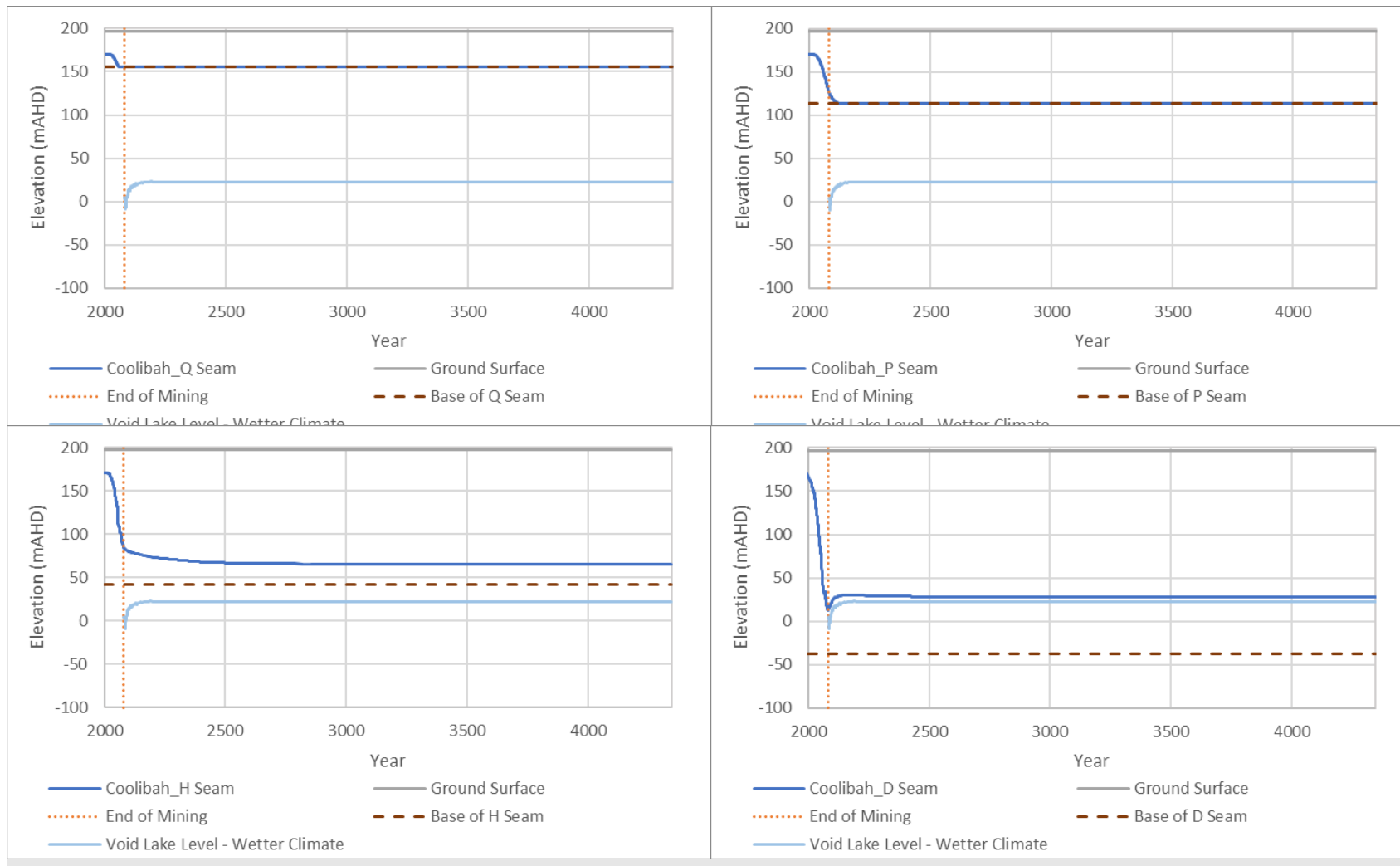


Figure C-8 Permian Coal Measures Predictive Hydrographs adjacent Coolibah/Dogwood Void (Wetter Climate)

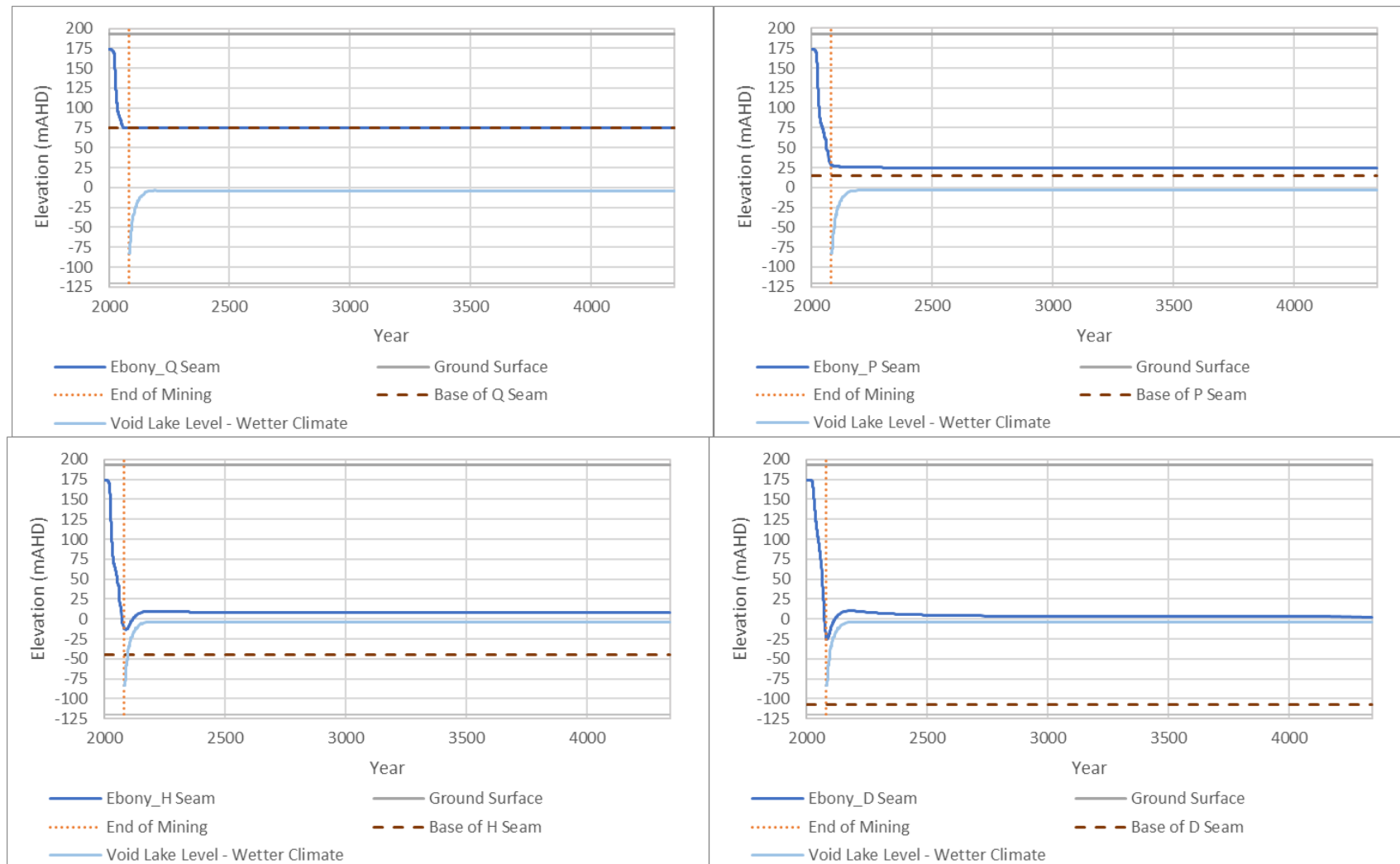
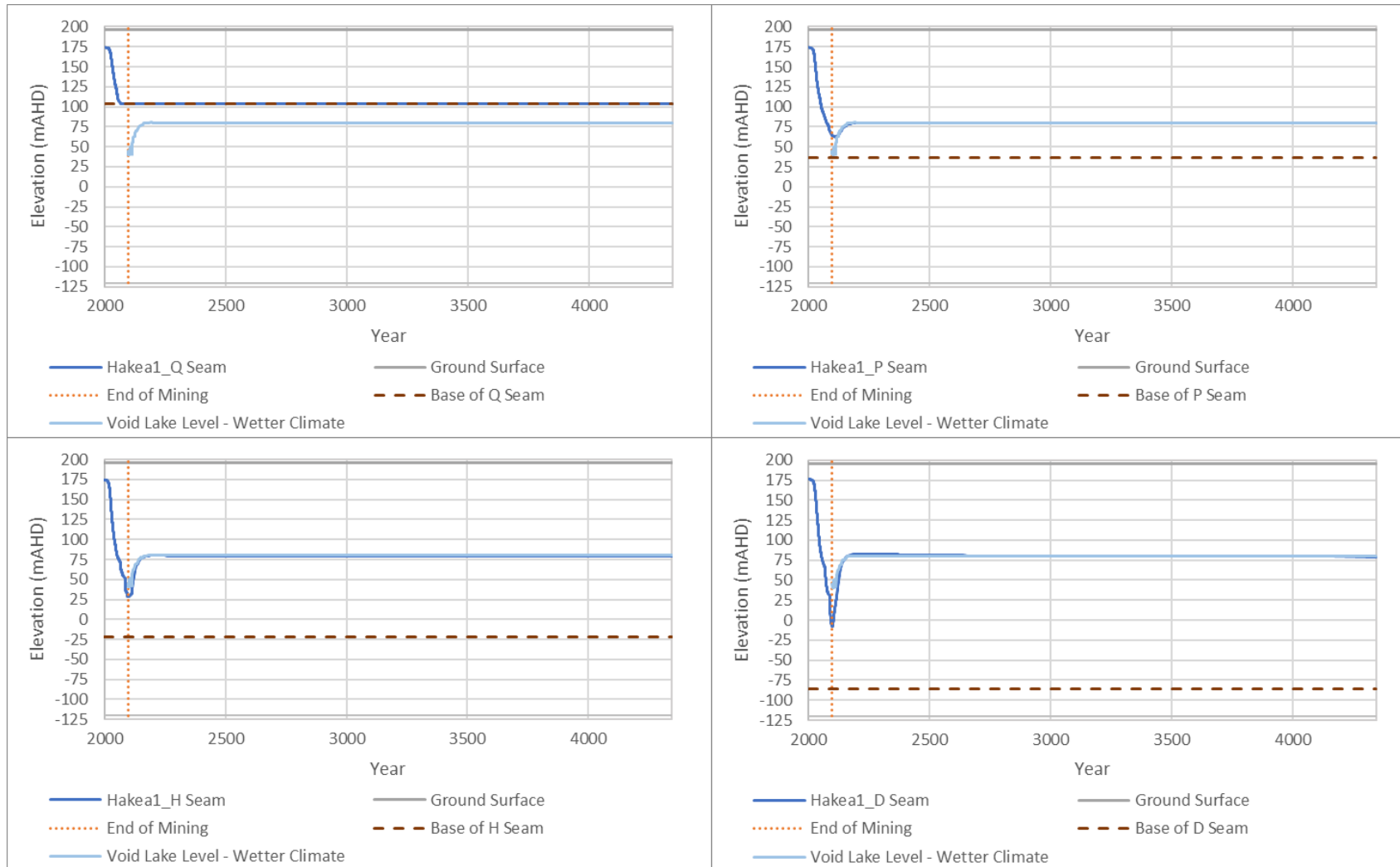
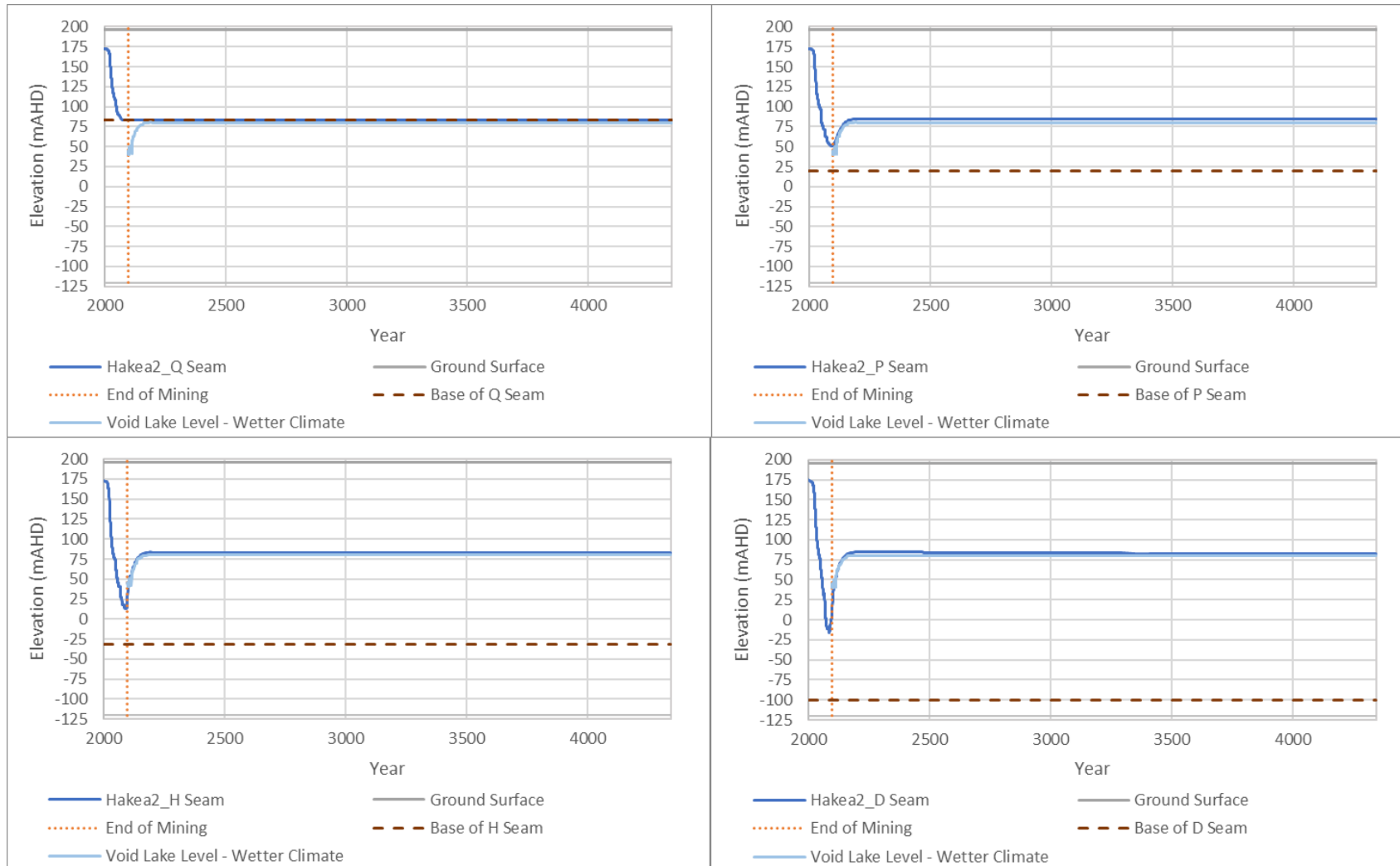


Figure C-9 Permian Coal Measures Predictive Hydrographs adjacent Ebony/Grevillia Void (Wetter Climate)



C-10 Permian Coal Measures Predictive Hydrographs adjacent Hakea Void (north) (Wetter Climate)



C-11 Permian Coal Measures Predictive Hydrographs adjacent Hakea Void (south) (Wetter Climate)

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SARAJI MINE (SRM) – MATERIAL CHARACTERISATION STUDY

October 2022



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Client: BMA

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1 INTRODUCTION

BHP Mitsubishi Alliance (BMA) has engaged Landloch to provide a material characterisation study of stockpiled materials at the Saraji Mine (SRM). Specifically, the study will evaluate the quality of materials for their use as growth media in rehabilitation.

To ensure rehabilitation success, the materials planned to be placed near the surface of the landforms need to be assessed for their suitability to support the vegetation required to meet the post-mining land use (PMLU).

This report evaluates the quality of materials for use as growth media for rehabilitation of the mine and identifies any gaps in the available information or resources.

1.1 Project Description

SRM is an open cut metallurgical coal mine operated by BMA, located approximately 15 km north of Dysart and 50 km south of Moranbah in Queensland's Bowen Basin. The current project area covers mining leases (ML) ML1775 (part), ML1782 (part), ML1784, ML70142, ML70294, ML70298, ML70328, ML2410, ML2360, ML700021, and lease 9SP235297 (rail loop). The general arrangement of SRM is provided in Figure A1 (Appendix A).

1.2 Scope of Work

The scope of work involved the following tasks:

- i. Reviewing previous soils and land assessments undertaken at SRM.
- ii. Reviewing available published soils and land data within the region.
- iii. Conducting data gap analysis to determine information required to:
 - a. Develop an inventory of materials available for rehabilitation; and
 - b. Assess the suitability of materials as a plant growth media.
- iv. Collating existing and recent soil laboratory data.
- v. Topsoil stockpile sampling and analysis.
- vi. Interpreting data, characterising materials, and preparing this report.

2 DESKTOP REVIEW

2.1 Climate

SRM is situated in Queensland's sub-tropical climatic zone, which is characterised by high summer temperatures, warm dry winters and a distinct wet and dry season. Average monthly maximum temperatures range from 24°C to 27°C in winter, and 33°C to 36°C in summer. Summer temperatures can exceed 40°C for short periods. Average monthly minimum temperatures range from 8°C to 10°C in winter, and 20°C to 22°C in summer (BoM, 2021).

Rainfall is concentrated through the summer with approximately 75% of yearly rainfall occurring between November and March. The median annual rainfall for the area, recorded at Moranbah airport, is 520 mm.

2.2 Topography

The pre-mining topography of SRM consists of predominantly flat areas, with several creeks passing through the MLs. The creeks include Phillips Creek, Boomerang Creek, One Mile Creek, Hughes Creek, South Creek, Spring Creek, Barrett Creek and Plumtree Creek. Most of the terrain within these catchments is undulating, with minor steep areas in the upper catchments.

2.3 Geology and Soils

2.3.1 Overburden geology

Overburden geology at SRM can be broadly classified into:

- Weathered zone materials: Cainozoic (Tertiary) clays, sands, claystones and sandstones. The Weathered Zone materials are typically sodic, highly erodible and prone to clay dispersion. These materials have varying levels of salinity, but their main constraint is their high erosion risk.
- Unweathered zone materials: Permian sandstones, siltstones and mudstones. Carbonaceous zones are present close to the coal seams. The physical and chemical properties of these materials are highly variable. They are generally sodic, alkaline and non-saline, although there are some materials with elevated salinity levels, and some carbonaceous strata are acidic. Erosion risk varies based on physical properties and sodicity, but generally the sandstones are more competent and resistant to weathering and erosion than are the siltstones and mudstones.

2.3.2 Regional soils

Soil mapping of the mine identifies two broad soil groups across the project area at a regional scale (State of Queensland (Department of Resources), 2021). These include:

- CC30 – Vertosols, and
- Va52 – Sodosols.

Relevant details of these soil groups are provided in Table 1.

Table 1: Summary details of regional soils across the project area.

Soil Landscape Code	Description	Associated Australian Soil Classification (ASC)
CC30	Cracking and self-mulching clays with >35% clay	Vertosol
Va52	Texture-contrast soils with sodic subsoils	Sodosol

2.3.3 Recoverable soils

Multiple soil assessments have been undertaken during the life of the project. A total of 23 soil management units (SMU) have been identified based on existing soil assessments and more recent gap soil assessments (GT Environmental, 2018). The SMUs for future topsoil stripping areas are shown in Figure A4 (Appendix A). The soil mapping informs the future topsoil stripping plans.

The assessments included a total of 148 sites recorded by B.R. Emmerton Pty Ltd (1999, March 2002, August 2002) and 270 sites recorded by GTES (2011). A summary of all SMUs, including Australian Soil Classification (ASC) and soil suitability details for grazing is provided in Table 2. Land suitability scores were recorded as part of the baseline assessments (GT Environmental, 2018) using the land suitability classes defined for use in Queensland (Department of Natural Resources and Mines, 2015). Land suitability decreases progressively from Class 1 to Class 5.

A soil map displaying broad ASC soil types for the SRM area is provided in Figure A5 (Appendix A). The soils data used to generate this map were not collected by Landloch. Rather, the mapping units are a synthesis of soils data and mapping sourced from existing soil assessments for the mine area completed by B.R. Emmerton Pty Ltd (1999, March 2002, August 2002) and GT Environmental (2018), along with existing land systems information sourced from the QLD Globe online spatial data system (State of Queensland 2022). The map is Landloch's interpretation of the available soils information.

Table 2: Summary details of the SMUs developed in the previous soil assessments for Saraji (GT Environmental, 2018).

SMU	Soil Details	ASC Soil Types	Grazing Land Suitability	Grazing Class (DNR, 2013)
2/20	Light sandy clay loam duplex soils to non-cracking clays on unconsolidated Cainozoic sediments	Chromosol, Sodosol, Dermosol	Suitable for beef cattle grazing / some moderate limitations	3
3	Sandy loam surfaced duplex soils on unconsolidated Cainozoic sediments	Chromosol, Sodosol	Soil type marginal for beef cattle grazing	4 – 5
4	Cracking clays with minor gilgai supporting brigalow and Dawson gum	Vertosol	Suitable for beef cattle grazing / some moderate limitations	3
5	Cracking and non-cracking clays supporting Dawson gum and brigalow on deep tertiary clays	Vertosol, Dermosol	Suitable for beef cattle grazing / some moderate limitations	3
8	Clay loam duplex soils on sediments supporting Dawson gum and brigalow (Breakaway areas)	Chromosol, Sodosol	Soil type marginal for beef cattle grazing	5
12	Sandy loam surfaced duplex soils on reworked Cainozoic sediments supporting poplar box	Chromosol, Sodosol	Soil type marginal for beef cattle grazing	4 – 5
13	Hard-set silty duplex supporting mixed species (heavy shrub layer)	Chromosol, Sodosol	Suitable for beef cattle grazing / some moderate limitations	3
16/23	Fine sandy loam to silt loam surfaced duplex and gradational soil (older alluvial duplex soils)	Chromosol, Sodosol	Soil type marginal for beef cattle grazing	4 – 5
17	Minor clay soils in anabranches	Vertosol	Soil type marginal for beef cattle grazing	4
18	Loamy sands, loams and gradational soils on stream banks and near stream levees	Kandosol, Tenosol	Suitable for beef cattle grazing / some moderate limitations	3 – 5
19	Loamy sand gradational soils present as relict alluvial levees	Kandosol, Tenosol	Suitable for beef cattle grazing / some moderate limitations	3
A1 & A1V	Poplar box on deep duplex loams	Chromosol, Sodosol	Suitable for beef cattle grazing / some moderate limitations	3
A2	Alluvial brigalow clay drainage lines	Vertosol	Suitable for beef cattle grazing / some moderate limitations	3
A3	Alluvial loamy creek channels	Kandosol, Tenosol	Suitable for beef cattle grazing / some moderate limitations	3

SMU	Soil Details	ASC Soil Types	Grazing Land Suitability	Grazing Class (DNRM, 2013)
B1	Undulating clay plains under brigalow or belah	Vertosol	Suitable for cropping with minor limitations and for beef cattle grazing / some moderate limitations	1
B2 & B2V	Mixed brigalow scrub on brown cracking clays	Vertosol	Suitable for beef cattle grazing / some moderate limitations	2
B3	Cracking bark brigalow clays with gilgai	Vertosol	Suitable for beef cattle grazing / some moderate limitations	2
B4	Melonhole brigalow clay plains	Vertosol	Suitable for beef cattle grazing / some moderate limitations	3 – 4
E1	Eucalypt woodlands on deep sandy loams	Tenosol	Suitable for beef cattle grazing / some moderate limitations	3
E2 & E2V	Mountain Coolibah on dark basalt soils	Vertosol, Dermosol	Suitable for cropping with minor limitations and for beef cattle grazing / some moderate limitations	2
E3	Poplar box on shallower loams	Chromosol, Sodosol	Soil type marginal for beef cattle grazing	4
T1	Sandy hard duplex poplar box	Chromosol, Sodosol	Soil type marginal for beef cattle grazing	4
T2	Deep sandy duplex plains with poplar box and ironbark	Chromosol, Sodosol	Suitable for beef cattle grazing / some moderate limitations	3

2.4 Waste Materials

The waste materials at SRM consist of overburden/interburden materials (spoil), coal rejects and tailings. The spoil generally consists of moderately weak to strong sandstone or siltstone, with minor mudstones and carbonaceous mudstones.

Tailings are not characterised in this report as they are not currently considered as a rehabilitation resource.

2.4.1 Spoil materials

Characterisation studies of the overburden were undertaken by B.R. Emmerton Pty Ltd (2003, 2007, 2009 and 2010) and Geomine Pty Ltd (2008). Generally, spoil materials at SRM were found to be:

- Non-acid forming, with acid neutralising capacity (ANC). Some minor potentially acid forming (PAF) material occurs in fresh Permian spoil, but this is considered a very low risk due to the high ANC of surrounding materials that are mixed during stripping;
- Strongly alkaline;
- Sodic to strongly sodic and dispersive;
- Moderately to highly saline; and
- Potentially elevated in selected metals.

B.R. Emmerton Pty Ltd (2009) concluded that the weathered Tertiary spoil alone was an undesirable growth medium due to stability limitations. The deeper, fresh Permian wastes were reported to be better suited to use on rehabilitated batter slopes and to provide a higher quality growth medium due to favourable pH, low salinity and competent structure.

2.4.2 Coal rejects

The coarse coal rejects are emplaced within the spoil material. They are not currently used as a rehabilitation resource but future studies and testing may identify some reject material that is beneficial for rehabilitation use due to its high organic carbon and coarse physical structure. Alternatively, strategies may be developed for mixing reject material with spoil of high acid neutralising capacity to deliver a more suitable growth medium.

2.5 Topsoil Stockpiles

Information on current stockpile materials and locations was provided by BHP (Table B3, Appendix B). The approximate volume of available stockpiled material is 10,759,532 m³ (in August 2021). Locations of current topsoil stockpiles on SRM are given in Figure 1.



Figure 1: Stockpiled topsoil materials across the Saraji Mine.

2.6 Post Mining Land Uses

The PMLUs are in accordance with the EA and include:

- Cattle grazing;
- Woodland habitat;
- Water storage; and
- Watercourse.

2.7 Revegetation Methodology

A range of rehabilitation methods have been trialled at SRM. These methods include:

- Topsoil over spoil;
- Rejects over sandy clay spoil;
- In situ amelioration of spoil (no topsoil); and
- Deep ripped topsoil spoil blends (mixing ratio not known).

Material characterisation and landform design studies aim to identify:

- Growth media placement depth and soil profile depths relevant to the PMLU;
- Growth media preparation details; and
- Expected growth media amelioration activities.

More details on the revegetation methodology can be found in SRM's PRC Plan.

3 METHODOLOGY

3.1 Materials

The following materials were targeted for consideration as potential growth media in the landform design process:

- Topsoil; and
- Spoil.

When considering the growth media at SRM, the quality of the stockpiled topsoil is more representative of the material available for rehabilitation, compared to the in situ topsoils. Therefore, stockpiled topsoil materials were sampled by Landloch in a field program completed as part of this work. Spoil data from previous projects was considered in the assessment of spoil as a potential growth media. All materials were characterised in terms of their basic chemical and physical fertility properties. Any materials with the potential to be placed at the surface for use as a primary growth media were subjected to additional fertility assessments.

3.2 Topsoil

3.2.1 Field program – topsoil stockpile sampling

The field program was undertaken between 7 and 21 February 2022. Site conditions were wet at the time of inspection with ponded water observed across SRM. For the preceding months, the Bureau of Meteorology recorded Moranbah's rainfall as 150 mm in November 2021, 84 mm in December 2021, and 97 mm in January 2022.

3.2.2 Topsoil sampling plan and intensity

The sampling plan is given in Table 3 and the stockpiles sampled are given in Figures A2 and A3 (Appendix A).

Table 3: Topsoil stockpile sampling program.

Stockpile ID	Sample Sites	Stockpile ID	Sample Sites	Stockpile ID	Sample Sites
4	1	58	1	119	1
7	1	63	1	121	1
10	3	64	1	123	1
13	1	70	1	127	1
15	1	72	1	128	1
16	1	73	1	129	2
17	1	74	1	130	1
21	2	75	2	131	1
24	1	78	1	133	1
25	1	81	1	134	1
28	1	83	1	135	1
30	1	85	1	139	1
31	1	86	1	142	1
34	1	88	1	144	2
36	1	89	1	145	1
38	1	90	1	148	1
39	1	94	1	149	1
40	1	95	1	152	4
41	1	97	1	153	1
42	1	103	1	154	1
43	1	106	1	158	2
45	1	108	1	160	1
46	1	109	1	163	3
48	1	113	1	169	1
50	1	115	1	173	1
51	1	116	1	176	1
52	1	118	1	178	1
				Total	94

The sample density for soil cover material is considered to be at a '*moderately high (detailed)*' intensity of 1:25,000, based on the McKenzie *et al.* (2008). This assumes soil will be placed at an average depth of 0.15 m at rehabilitation. Using these criteria, Table 4 shows the sampling intensity on a stockpile volume basis and based on soil reinstatement at rehabilitation to an average depth of 0.15 m.

Table 4: Sampling intensity for topsoil stockpiles.

Material	Volume (m ³)	Reinstatement Coverage (ha)	Total Samples	Sampling density	Sampling density	Survey Scale
Topsoil	10,759,532	7,173	376	1 sample/ 28,000 m ³	1 sample/ 19 ha	1:25,000

3.2.3 Sample collection

Samples and descriptions of materials were taken from test pits. Depth of excavation was to the base of the topsoil stockpile, or to the limit of excavation (~3–5 m). Samples were collected from the stockpiles at depth intervals of 0.5–1.0 m (e.g. 0.5–1.0 m, 1.5–2.0 m, 2.5–3.0 m etc.). Brief details about the collected materials were recorded in the field.

Sampling included composite and discrete samples. Each composite sample was composed of materials from three discrete samples.

3.2.4 Laboratory analysis

Laboratory analysis was undertaken by East West EnviroAg, a laboratory with National Association of Testing Authorities (NATA) and Australian Soil and Plant Analysis Council (ASPAC) accreditation. Analysis of composite samples used a 'topsoil suite' to characterise the soil nutrients and physio-chemical parameters of the stockpile. Laboratory analysis of discrete samples used a 'basic suite' of pH and salinity to indicate the heterogeneity (variability) within the stockpile and expose potential extreme values that may be masked in the testing of the composite samples. Laboratory analyses are described in Table 5.

Table 5: Laboratory analytical suites.

Analyses	Analysis Suite	
	Topsoil	Basic
pH and electrical conductivity (EC).	✓	✓
Exchangeable cations (with calculations of effective cation exchange capacity and exchangeable sodium percentage) and chloride	✓	
Total nitrogen and phosphorous; available phosphorous, potassium, and sulphur; trace nutrients (Cu, Zn, Mn, Fe, B), chloride, organic carbon and phosphorus buffer index (PBI), field texture	✓	
Dispersion potential	✓	
Total number of samples	94	282

3.3 Spoil

Geochemical and physical characterisation data for the spoils were collated from multiple assessments previously conducted for the project. These included:

- *Investigation of Overburden, Roof, Interburden and Floor Material from Future Mining Areas of Saraji Mine* (B.R. Emmerton Pty Ltd, 2009).
- *Stage 1 Investigation of Overburden, Roof, Interburden and Floor Material from Saraji Mine* (B.R. Emmerton Pty Ltd, 2007).
- *Investigation of Acid/Base Characteristics of Coal Rejects Material - Ramp 4 North, Saraji Mine* (B.R. Emmerton Pty Ltd, 2010).
- *Investigation of 14 South HCL Fine Sandstone Spoil, Saraji Mine* (B.R. Emmerton Pty Ltd, 2003).
- *Soil and waste erodibility and landform design: Saraji Mine* (Landloch Pty Ltd, 2018). Sampling locations are provided in Figure A6;
- *Coolibah Cainozoic RL180 Review-Geomine Report Number SARENV002-0508* (Geomine Pty Ltd, 2008).

4 FINDINGS

The two categories of materials available for rehabilitation, characterised as part of this assessment include:

1. Topsoil stockpiles; and
2. Spoil materials.

Details of these materials are provided below. Site location details are provided in Figures A2 and A3 (Appendix A) and in Table B1 (Appendix B). Stockpile description records are provided in Table B2 – B3 and laboratory results are provided in Tables B4 – B9 (Appendix B).

4.1 Topsoil Stockpiles

The topsoil stockpiles are representative of the material available for rehabilitation once topsoil is stripped and mixed in stockpiles. A total of 376 samples were collected from 94 locations within the topsoil stockpiles. A total of 94 samples were analysed for the topsoil suite and another 282 samples were analysed for the basic suite. Their locations are provided in Figures A2 and A3 (Appendix A) and laboratory data are presented in Tables B4 – B9 (Appendix B). Stockpiled topsoil for use in rehabilitation were categorised into three management groups:

1. Light textured loams and sands;
2. Heavy textured loams and clays; and
3. Cracking clays.

A summary of key chemical and physical properties is presented in Table 6. Topsoil within each management group is detailed in the sections below.

Table 6: Summary of key chemical and physical properties for topsoils at Saraji mine.

Analysis	Light Loams/Sands	Heavy Loams/Clays	Cracking Clays
Chemical Properties			
pH _{1:5} (H ₂ O)	Slightly acidic to strongly alkaline (6.1 – 8.5)	Slightly acidic to moderately alkaline (6.1 – 8.2)	Slightly alkaline to strongly alkaline (7.8 – 8.8)
EC _{1:5} (dS/m)	Low (<0.16)	Very low to moderate (0.07 – 0.26)	Low to moderate (0.13 – 0.34)
ESP (%)	Non-sodic to strongly sodic (2.2 – 16.9)	Sodic to strongly sodic (6 – 23.8)	Non-sodic to sodic (2.7 – 10.5)
Total N (mg/kg)	Very low (<500)	Low (<700)	Low (<1000)
Available P (mg/kg)	Low to moderate (14 – 37)	Low to moderate (14 – 37)	Low to moderate (11 – 35)
Available K (mg/kg)	Low (<140)	Low (<140)	Low to moderate (74 – 194)
Organic C (%)	Low (<1.0)	Low (<1.0)	Low to moderate (0.65 – 1.29)
CEC (meg/100g)	Low (<7)	Low (<7)	Low to high (7.7 – 29.1)
Ca/Mg (ratio)	Strongly imbalanced to low (0.6 – 2.5)	Strongly imbalanced to low (0.6 – 2.5)	Strongly imbalanced to low (0.8 – 2.2)
Physical Properties			
Clay content (%)	<20	20 – 40	>35
Rock content (%)	<10	<20	<10
Dispersion (EAT)	Dispersive to stable (2 – 7)	Dispersive to stable (2 – 7)	Slightly dispersive to stable (3b – 7)
Permeability *	Low	Moderate	Low
Erodibility *	Moderate to high	Moderate	High
Associated regional soil	Va52 (Sodosol)	Va52 (Sodosol)	CC30 (Vertosol)
Associated SMU	2/20, 3, 12, 16/23, 18, 19, E1, T1, T2	8, 13, A1, A1V, A3, E3	4, 5, 17, A2, B1, B2, B2V, B3, B4, E2, E2V

Note: Chemical properties are based on average 10th and 90th percentile values for all stockpile samples analysed.

* Based on measured erodibility parameters (Landloch Pty Ltd, 2018).

4.1.1 Light textured loams and sands

Light textured loams and clays are concentrated around the Jacaranda/Bauhinia pit areas and show similar physical properties between stockpiles. The topsoil materials are generally pale brown in colour with clayey sand to loam textures. Gravel content is generally less than 10 % with gravel size being less than 60 mm in diameter. The soils are susceptible to slaking and dispersion, thereby increasing the risk of erosion. The strongly sodic properties of most topsoil stockpiles are likely a result of collecting a portion of sodic subsoil together with topsoil during the initial stripping.

Based on available topsoil material, the light textured loams and sands would be the most difficult to rehabilitate. Soil erodibility studies (Landloch, 2018) found that they have very low infiltration capacity because of their sodic and dispersive nature despite the higher sand content; dispersion is to a degree that plant growth would be affected. Figure A6 (Appendix A) shows the locations of the samples taken as part of the erodibility studies.

Photographs 1 to 4 are representative of light textured loam and sand topsoils at SRM.

If this soil is to be used in rehabilitation, its chemical and physical limitations will need to be managed. Placement should be restricted to areas of very low gradient so that runoff rates are slow and infiltration rates are maximised.



Photograph 1: Soil material at stockpile 36.



Photograph 2: Soil material at stockpile 34.



Photograph 3: Vegetation cover on topsoil stockpile 7.



Photograph 4: Vegetation cover on topsoil stockpile 90.

4.1.2 Heavy textured loams and clays

Heavy textured loams and clays are concentrated around the Coolibah, Dogwood and Ebony pits and show similar physical properties between stockpiles. The topsoil materials are generally pale brown, brown or reddish brown in colour, with sandy clay loam to light clay textures. Gravel content is generally less than 10 % with gravel size being less than 60 mm in diameter,

although sometimes gravel content is as much as 20 %, and cobble (<200 mm diameter) can be present. The soils are susceptible to slaking and dispersion, thereby increasing the risk of erosion. The strongly sodic properties of the topsoil stockpiles are likely a result of collecting a portion of sodic subsoil together with topsoil during the initial stripping.

Erodibility studies (Landloch, 2018) indicate these are the most stable topsoils available at the mine for rehabilitation. The heavy textured loams and clays would be the best suited topsoil for rehabilitation of sloping areas, as the erosion potential is much lower than that of the other soils available.

Photographs 5 to 8 are representative of heavy textured loam and clay topsoils at SRM.

The main requirement for this soil is to ensure that its chemical fertility is managed to ensure vigorous vegetation growth in the initial stage of rehabilitation, and maintenance of suitable levels of surface groundcover in the longer term. Any sodicity issues will also need to be addressed by incorporating gypsum prior to rehabilitation.



Photograph 5: Soil material at stockpile 109.



Photograph 6: Soil material at stockpile 115.



Photograph 7: Vegetation cover on topsoil stockpile 16.



Photograph 8: Vegetation cover on topsoil stockpile 115.

4.1.3 Cracking clays

Cracking clay topsoil stockpiles are concentrated around the Grevillea and Hakea pits and are relatively similar at all locations. The topsoil materials are generally dark brown or black in colour with medium to heavy clay textures. Gravel content is generally less than 10 % with gravel size being less than 60 mm in diameter. The soils are susceptible to slaking and dispersion, thereby increasing the risk of erosion.

Photographs 9 to 12 are representative of cracking clay topsoils at SRM.

Cracking clays show higher chemical and physical fertility than other topsoils and would be the preferred option for revegetation on areas of low erosion risk, such as flat areas on the tops of waste dumps where high-quality vegetation establishment and performance is required. If placed on outer batter slopes, management of erosion risk during the period of vegetation establishment would be critical for rehabilitation success, and establishment of appropriate levels of vegetation groundcover will be essential.



Photograph 9: Topsoil stockpile material (Stockpile 152) newly disturbed.



Photograph 10: Topsoil stockpile material (Stockpile 163) newly disturbed.



Photograph 11: Vegetation cover on topsoil stockpile 144.



Photograph 12: Vegetation cover on topsoil stockpile 152.

4.1.4 Excluded stockpiles

Chemical analysis at stockpile 81 indicates limiting soil properties, including very high acidity. The material consists of pale brown and pale orange gravelly sandy clay loams (Photograph 13). Groundcover observations (Table B2, Appendix B) indicates limited vegetation had established across the stockpile surface at the time of sampling (Photograph 14). Its chemical and physical properties indicate the bulk of this stockpile is likely to be subsoil material.



Photograph 13: Sandy clay loam soil present at stockpile 81.



Photograph 14: Vegetation cover on topsoil stockpile 81 is limited and in patches.

This stockpile is located on the western side of the mine, close to stockpile 86 which is also highly acidic. This may indicate that additional material in this area may have acidity issues. It is recommended that this material is excluded from use as primary growth media where possible. If the stockpiled material is required for use as a growth medium, additional sampling is recommended to identify the volume of acidic soil present. Mixing with strongly alkaline topsoils and spoils or incorporation of lime at rehabilitation may help neutralise acidity.

4.2 Spoil Materials

From the previous assessments detailed in Section 3.3, broad spoil characteristics were found to be similar across all studies. Spoils are categorised into three spoil management groups:

- Fresh Permian spoil;
- Weathered Permian spoil; and
- Weathered Tertiary spoil.

A summary of key chemical and physical properties is presented in Table 7. Each spoil group is then described in further detail in the proceeding sections.

Table 7: Summary of key chemical and physical properties for spoils at Saraji mine.

Analysis	Fresh Permian	Weathered Permian	Weathered Tertiary
Chemical Properties			
pH _{1:5} (H ₂ O)	Strongly acidic to strongly alkaline (2.7 – 10.1)	Neutral to strongly alkaline (7.0 – 9.9)	Strongly acidic to strongly alkaline (4.2 – 10.0)
EC _{1:5} (dS/m)	Moderate to high (0.6 – 1.3)	Low to extreme (0.33 – 2.9)	Low to extreme (0.04 – 2.38)
ANC (H ₂ SO ₄ /t)	Low to high (-7 – 126)	Moderate to high (13 – 81)	Low to high (0 – 58)
PAF	Occasionally	No	No
ESP (%)	High to extremely sodic (9 – 47)	High to extremely sodic (13 – 31)	High to extremely sodic (19 – 49)
Ca/Mg (ratio)	Strongly imbalanced to low (0.4 – 1.9)	Strongly imbalanced (<0.7)	Strongly imbalanced (<0.5)
Elevated metals	B, Ba, Bi, Cr, F, S, Te, Ni, and V	As, B, Ba, F, Mn, Ni and V	B, Bi, Ba, Cr, F, Ni and V
Physical Properties			
Clay content (%)	6 – 28	13 – 31	27 – 56
Rock content (%)	20 – 50	5 – 20	10 – 20
Slake durability (%)	Moderate to high 60 – 95	Moderate to high 60 – 95	Low <50
Permeability	Moderate to high	Low	Low
R1 Dispersion index	Non limiting to extreme (0.40 – 0.97)	High to extreme (0.73 – 0.85)	High to extreme (0.71 – 0.95)
Dispersion risk	Moderate	High	High

4.2.1 Fresh Permian spoil

Generally, fresh Permian spoil is a rocky material consisting primarily of sandstone with clay content ranging from 6 – 28%, resulting in low water holding capacity. It is generally grey in colour. However, fresh Permian spoil at the mine can vary depending on the strata location and degree of carbonaceous inclusions present. The material ranges from non-dispersive to highly dispersive. Some minor areas are PAF but they present a very low risk for rehabilitation when mixed with the surrounding alkaline spoil.

Photograph 15 is representative of fresh Permian sandstone spoil at SRM.

Of the three spoil materials, fresh Permian is considered the most suitable option for placement close to the final rehabilitated surface. Discrete testing should be conducted prior to rehabilitation. Competent (durable), fresh Permian sandstone may be used as a rock armour to greatly increase batter slope resistance to erosion and to stabilise steeper areas. Consequently,

such material has considerable value for rehabilitation purposes. Sampling records from the overburden assessment (B.R. Emmerton Pty Ltd, 2009) indicate that harder sandstone material is present between the H17/18/19 seams and the Dysart seam. Additional studies and testing in these strata is suggested.



Photograph 15: Fresh Permian sandstone material present at the mine. Large competent rock is present throughout the stockpile.

4.2.2 Weathered Permian spoil

Generally consisting of Permian mudstone or siltstone and minor sandstone, weathered Permian is a rocky material with clay content ranging from 13 – 31%, resulting in low to moderate water holding capacity. It is generally grey in colour but colour can range to a pale brown. They are often highly dispersive and erosive (although occasional materials may be competent and stable).

Photograph 16 is representative of weathered Permian spoil at SRM.

Placement of this material close to the final rehabilitated surface is not recommended on higher slope angles (preferred angles are <5% for low quality materials and <10% for higher quality materials). The weathered Permian spoil is not suitable for use as cladding/surfacing on the outer faces of elevated waste dumps.



Photograph 16: Weathered Permian mudstone material stockpiled at the mine (red circle). Some Tertiary material is present in the background.

4.2.3 Weathered Tertiary spoil

Weathered Tertiary spoil is a highly weathered material containing portions of fragile rock. It has a clay content of 27 – 56%, resulting in moderate water holding capacity. It is typically pale brown to pale orange in colour. The materials are often highly saline and prone to capillary rise of salts. Compared to fresh Permian spoil, the weathered Tertiary spoil is more susceptible to slaking and dispersion.

17 is representative of weathered Tertiary spoil at SRM.

Placement of this material close to the final rehabilitated surface is not recommended due its high erodibility and potential toxicities to plant growth. Photograph



Photograph 17: Weathered Tertiary spoil stockpiled at the mine (red circle) next to weathered Permian material.

5 GROWTH MEDIA SUITABILITY AND AMELIORATION

The materials encountered have been classified according to their ability to support plant growth, as either *primary* or *secondary* growth media.

5.1 Primary Growth Media

Primary growth media infers the ability of materials to be used as a topsoil or topsoil surrogate.

It is the upper-most layer of soil/material placed over the rehabilitated area. It can be applied at various thicknesses depending on the PMLU and consists of surface soil (topsoil) materials recovered prior to mining and applied over the area, or a growth medium developed from spoil, ameliorated to a standard suitable to support sustainable plant growth.

It is typically higher in organic matter and macro- and micronutrients and has low to negligible limitations to plant growth. Its primary purposes are to provide nutrients and a stable surface for vegetation establishment.

If sufficient suitable topsoil is not available, an alternative may be derived from high quality spoil with amelioration. If this is required, analysis of macronutrients is to be conducted to determine the fertility stores needed to sustain healthy vegetation growth and identify any additional amelioration requirements. Amelioration products and application rates for the primary growth media should be assessed by a suitably qualified professional prior to rehabilitation and consider the desired PMLU and vegetation.

5.2 Secondary Growth Media

Secondary growth media infers the ability of materials to be used as a substrate or substrate surrogate.

It may consist of the spoil material that is capped with the primary growth medium or may be an intermediate layer placed on the spoil material and then capped with primary growth media.

The main purposes of the secondary growth medium are to increase the soil water storage capacity of the soil profile and/or meet the soil depth criterion for certain vegetative PMLUs and target vegetation communities.

In some circumstances, secondary growth media may be able to be sufficiently improved by the addition of ameliorants (e.g. gypsum, lime, organic matter) to convert them to a primary growth medium.

5.3 Suitability Classification

A four-class suitability system is applied in the evaluation of materials as growth media. These classes are defined as follows:

Class A – Good Quality

- Negligible limitations to plant growth.
- Good quality material for intended purpose.
- Nil to low levels of ameliorants will be required.

Class B – Fair Quality

- Minor limitations to plant growth.
- Reasonable quality material for intended purpose.
- Low to moderate levels of ameliorants may will be required.

Class C – Marginal Quality

- Moderate limitations to plant growth.
- Moderate to high levels of ameliorants may be required to improve material quality to support plant growth.

Class D – Not Suitable

- Severe limitations to plant growth.
- It will generally be uneconomic or unviable to amend these materials to the degree needed to support plant growth.

The suitability of materials as primary or secondary growth media is presented with recommendations in Table 8.

Table 8: Fertiliser and ameliorant treatment rates for materials and growth media suitability classification.

Material	Limitations	Amendments	Suitability Class	
			Primary (1)	Secondary (2)
Light textured loam and sand topsoil	• Sometimes strongly alkaline. • Often sodic and dispersive. • Low ability to retain nutrients. • Low N, P, K, Ca and B. • Extremely low TOC. • High erodibility.	• Gypsum: due to heterogeneity between stockpiles, rates should be calculated for individual stockpile prior to use. • Fertiliser and/or compost rates are to be determined by a suitably qualified person prior to individual stockpiles being used in rehabilitation.	1B	2A
Heavy textured loam and clay topsoil	• Sometimes strongly alkaline. Stockpiles 81 and 86 are highly acidic. • Sodic to strongly sodic and dispersive. • Low ability to retain nutrients. • Low N, K, Ca, and TOC. • Often low P.	• Gypsum: due to heterogeneity between stockpiles, rates should be calculated for individual stockpile prior to use. • Additional sampling required for stockpiles 81 and 86 to determine the volume of acidic soil present. • Fertiliser and/or compost rates are to be determined by a suitably qualified person prior to individual stockpiles being used in rehabilitation.	1A	2A
Cracking clay topsoil	• Strongly alkaline. • Elevated salinity at stockpile 178. • Often sodic and susceptible to slaking. • Often low N, K and Ca. • Sometimes low P and TOC. • High erodibility.	• Gypsum: due to heterogeneity between stockpiles, rates should be calculated for individual stockpile prior to use. • Fertiliser and/or compost rates are to be determined by a suitably qualified person prior to individual stockpiles being used in rehabilitation.	1B	2A
Fresh Permian spoil	• Often strongly alkaline. • Occasionally PAF. • Moderate to high salinity. • Sodic to strongly sodic and dispersive. • Elevated metals. • Rock content up to 50 %.	• Gypsum: due to heterogeneity between spoil samples, rates should be calculated for broad spoil areas after placement. • Bury all saline material to a depth greater than 2 m below the surface. • If to be used as a primary growth media further assessment by a suitably qualified person is required to determine amelioration required.	1B/C	2B

Material	Limitations	Amendments	Suitability Class	
			Primary (1)	Secondary (2)
Weathered Permian spoil	- Often strongly alkaline. - Often high salinity. - Sodic to strongly sodic and dispersive. - Occasionally susceptible to rapid weathering. - Elevated metals. - Low permeability.	- Gypsum: due to heterogeneity between spoil samples, rates should be calculated for broad spoil areas after placement for rehabilitation. - Bury all saline material to a depth greater than 2 m below the surface.	1D	2B/C
Weathered Tertiary spoil	- Often strongly alkaline. - Often high salinity. - Slake durability below 50%. - Sodic to strongly sodic and dispersive. - Highly sodic. - Elevated metals. - Low permeability.	- Nil treatment - Soil quality low	1D	2C/D

Notes: Class A – Good Quality: Negligible limitations to plant growth; Class B – Fair Quality: Minor limitations to plant growth; Class C – Marginal Quality: Moderate limitations to plant growth; Class D – Not Suitable: Severe limitations to plant growth.

5.4 Fertiliser and Ameliorants

Fertiliser and amelioration rates for soil materials are dependent on the intended PMLU for a rehabilitated area. For example, cattle grazing requires generation of biomass from the growth media and planted grass species. Nitrogen and phosphorus based amendments would be recommended for these areas. As a guide amelioration application for grazing PMLU should aim to provide:

- Available phosphorus (Colwell) content of the growth media to within a target concentration of 25–40 mg/kg;
- An appreciable source of starter nitrogen;
- Adequate macro- and micronutrients; and
- Gypsum to reduce potential for dispersion.

Amelioration recommendation for woodland areas should be assessed on a case-by-case basis and represent the specific requirements of the target vegetation community.

5.4.1 Fertiliser

A balanced NPK fertiliser such as Crop King (CK) 55 (N: ~13.5 %, P: ~15 %, K: 12.5 %) and slow-release nitrogen source such as Coated Urea (N: ~46 %) or organic compost is recommended to provide a balanced source of nutrients to plants during rehabilitation. Any composted material should comply with the Australian Standard for Composting (AS4454-2012).

Accurate application rates and fertiliser types based on the required nutrients should be determined by a suitably qualified person prior to use in rehabilitation.

Fertiliser and mulch/compost should be applied at seeding. It can be broadcast with a spreader, or applied hydraulically or pneumatically. Spreaders are typically suitable for slopes with gradients <35 %, and hydraulic or pneumatic applications will be required for steeper slopes.

5.4.2 Gypsum

Gypsum application has been recommended for sodic/dispersive materials or where calcium is low. It should be applied during soil preparation stages, in a manner that allows for as thorough mixing as is practicable of the surface materials. Gypsum should be applied prior to seeding and fertilising.

Depth of sodicity amelioration depends on erosion risk/land gradient. Generally, for slopes with gradients less than ~35 % incorporate gypsum into the upper 0.3 m depth of sodic materials.

Considering the annual rainfall depth at SRM is approximately 520 mm, it is expected that (as a 'rule of thumb') gypsum will dissolve at a rate of 0.5–1.0 t/ha/y. Hence, there is benefit in applying gypsum at the time materials are recovered (i.e. stripped) or as soon as is practicable in the rehabilitation program to allow the gypsum to be as effective as possible.

6 SUMMARY AND RECOMMENDATIONS

This material characterisation summary describes and characterises the materials identified on-site for use in rehabilitation, as per the topsoil stockpile assessment, previous soil and spoil assessments, and other SRM project-related documents.

6.1 Topsoil Stockpiles

Generally, the topsoil material is considered to be of adequate quality for use as a primary growth media. Due to the high degree of heterogeneity in the topsoil material, the summarised laboratory data should be considered representative of the topsoil materials as a whole, and not representative of individual stockpiles. The sampling program is considered adequate to describe these materials into broad management groups. Therefore, any stockpile not included in this assessment should be sampled and characterised prior to use in rehabilitation.

The main limitations of topsoil materials for use in rehabilitation are sodicity and low fertility.

Amelioration of sodicity requires the thorough incorporation of gypsum. Due to the high degree of heterogeneity in measured sodicity within stockpiles, gypsum rates should be calculated for individual stockpiles prior to use in rehabilitation.

It is noted that chemical fertility of the available topsoils is quite low. A balanced NPK fertiliser or compost should be applied during rehabilitation to provide a starter source of nutrients for initial vegetation growth. Additional applications may be required to maintain adequate fertility levels.

Amelioration products and application rates should be assessed by a suitably qualified professional prior to use for rehabilitation and to complement the desired PMLU.

6.2 Spoil Materials

Generally, Permian spoil materials at the mine have potential to be used as secondary growth media through varying degrees of amelioration. Fresh Permian spoil is considered the most suitable for use in the upper soil profile as it has minimal limitations to plant growth. Where possible, placing weathered Tertiary spoil in the upper soil profile should be avoided.

The laboratory analysis and erodibility testing of spoil materials identified competent, relatively benign fresh Permian spoil present between the H17/18/19 seams and the Dysart seam; it is considered suitable for use as a growth media with amelioration. This material has only minor chemical limitations and is unlikely to significantly reduce growth of most plant species used in rehabilitation. This area is primarily sandstone, which has the lowest erodibility and highest slaking durability of materials tested. Data suggest that competent rock from between these seams could be used as a rock armour to greatly increase batter slope resistance to erosion and to stabilise steeper areas.

Spoil testing did not consider fertility of the fresh Permian. It is recommended that analysis of macronutrients be conducted to determine the fertility stores needed to sustain healthy vegetation growth and identify any additional amelioration requirements for the spoil materials if used as a primary growth media.

In covering areas where reject materials are disposed, placement of relatively coarse Permian waste would be advised if the priority for the area is to prevent capillary rise of salts.

6.3 Growth Media for PMLU

Physical and chemical properties of the soil and spoil materials available on site meet the requirements to establish the PMLU for rehabilitated areas of cattle grazing or woodland habitat. It is recommended that the growth media is assessed by a suitably qualified person prior to rehabilitation, to identify the required ameliorants and fertilisers.

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APPENDIX A: MAPS AND FIGURES

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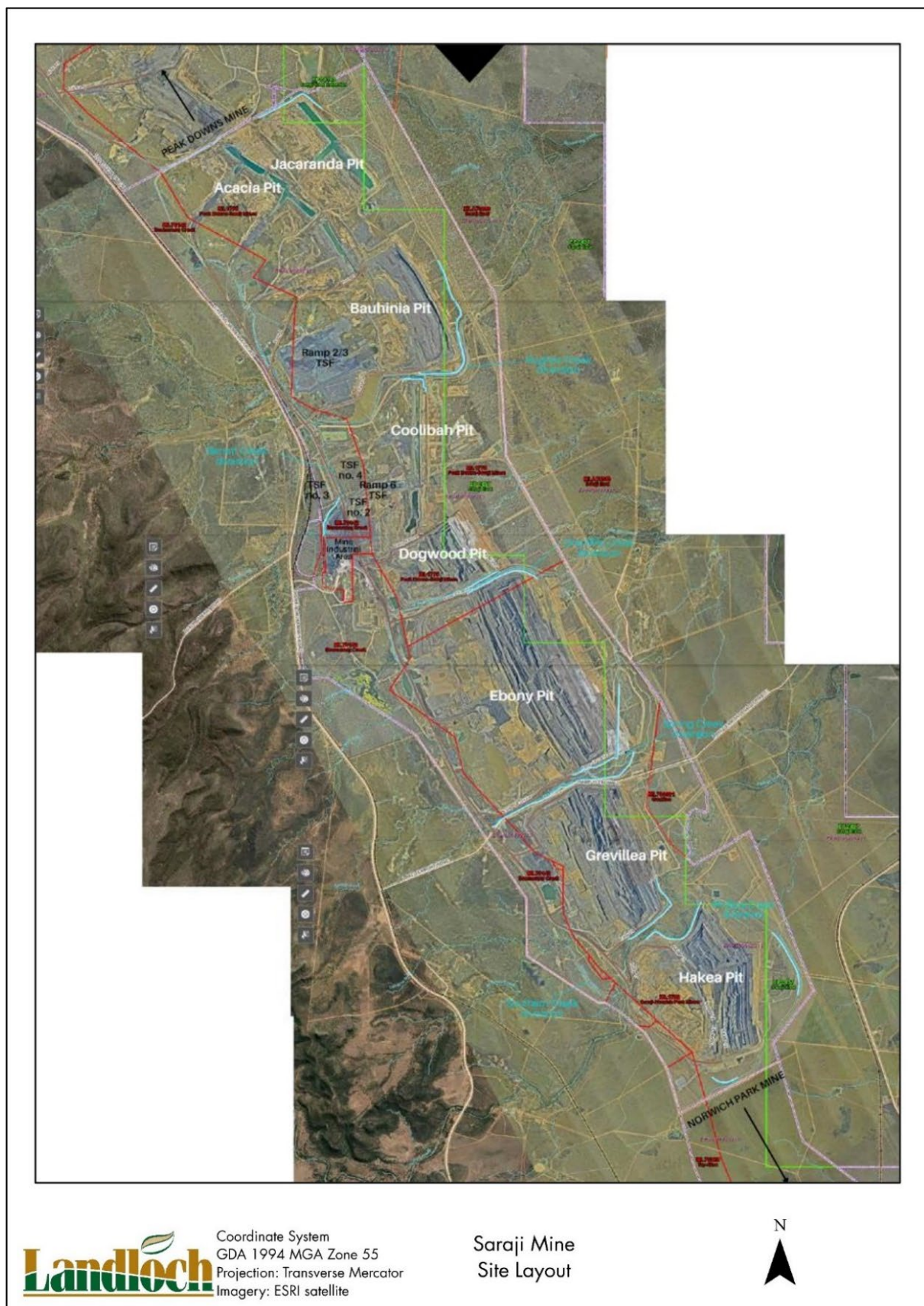


Figure A1: SRM site layout (October 2021).

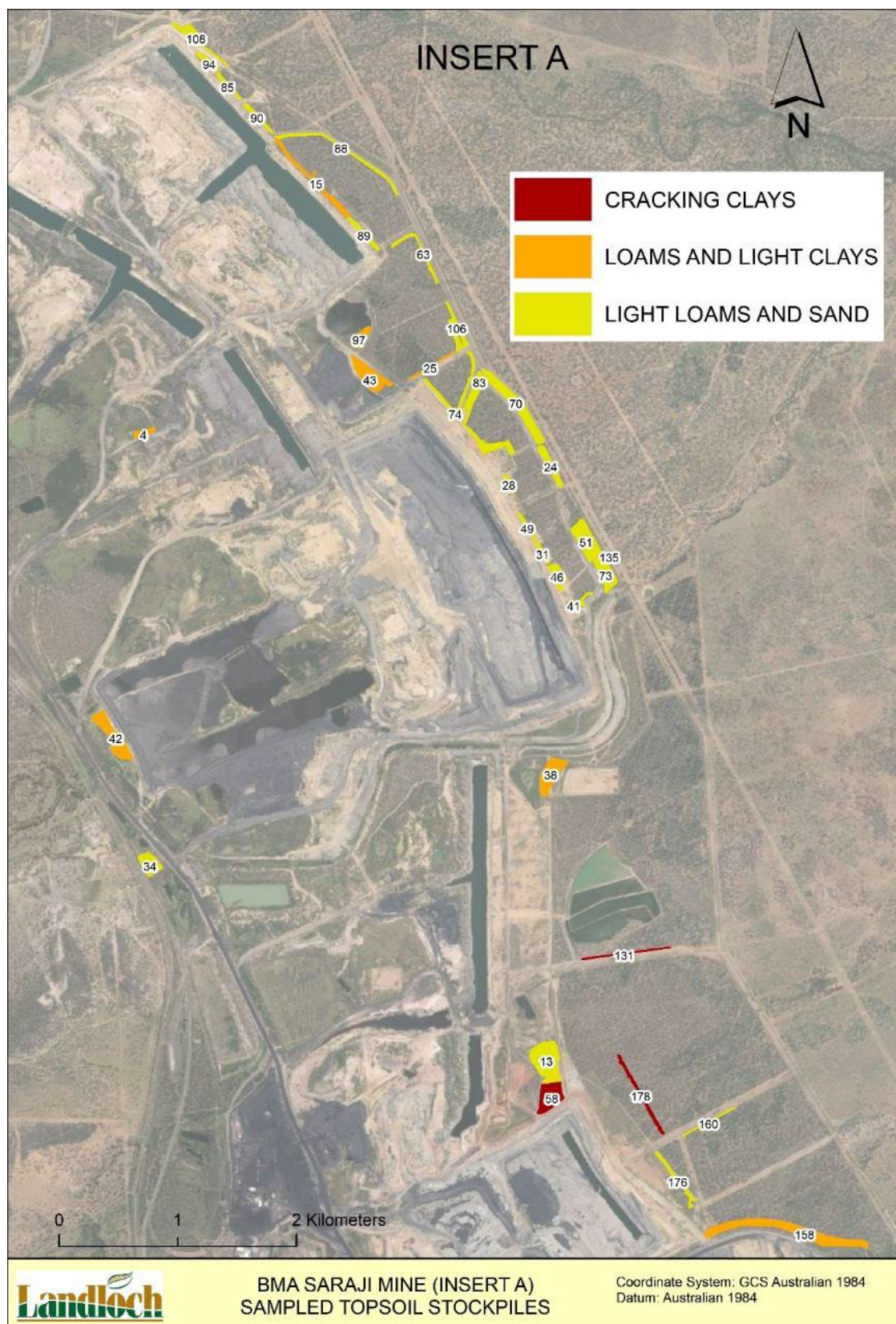


Figure A2: Distribution of stockpiled topsoil materials and sampling location at Saraji Mine (Part A).

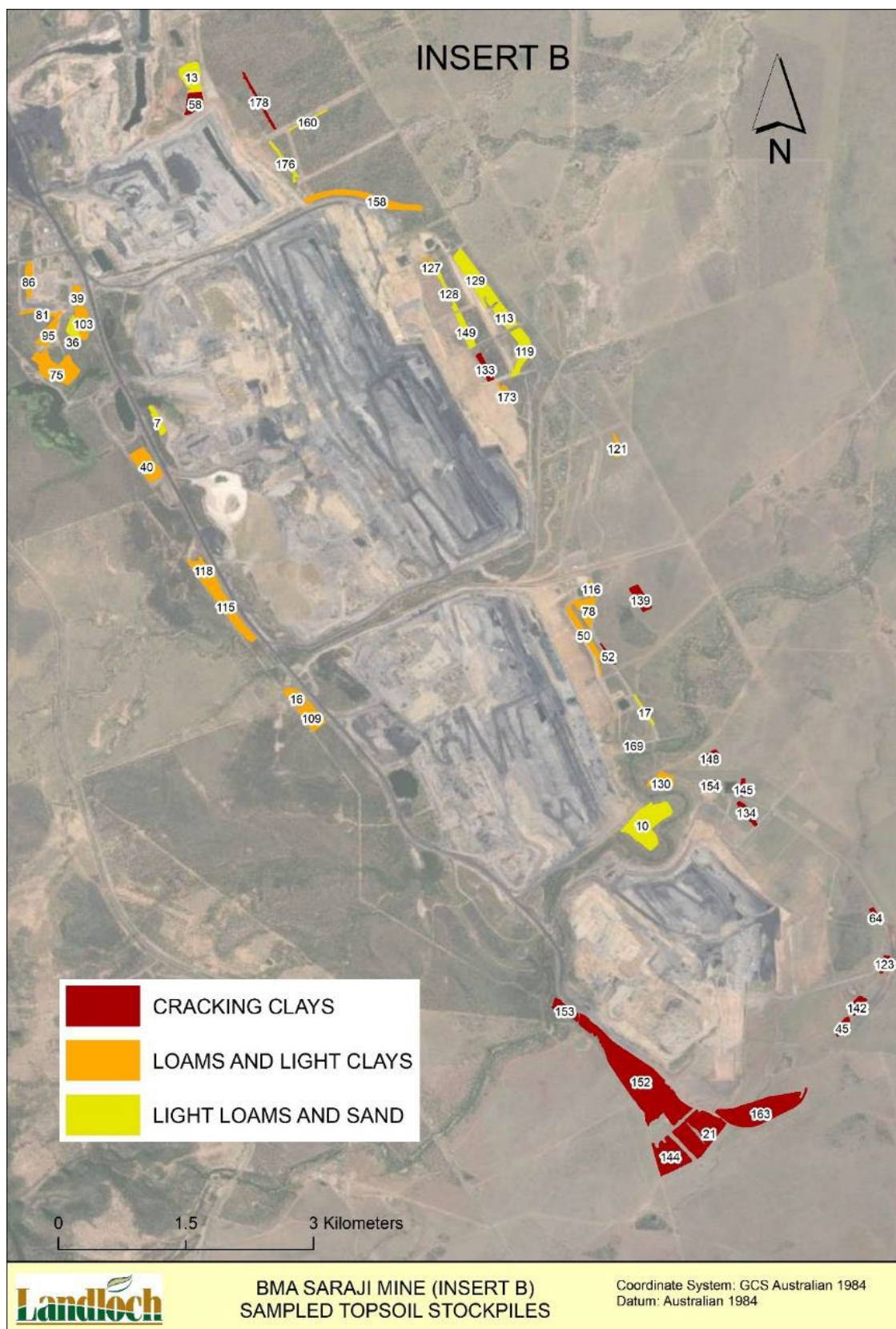
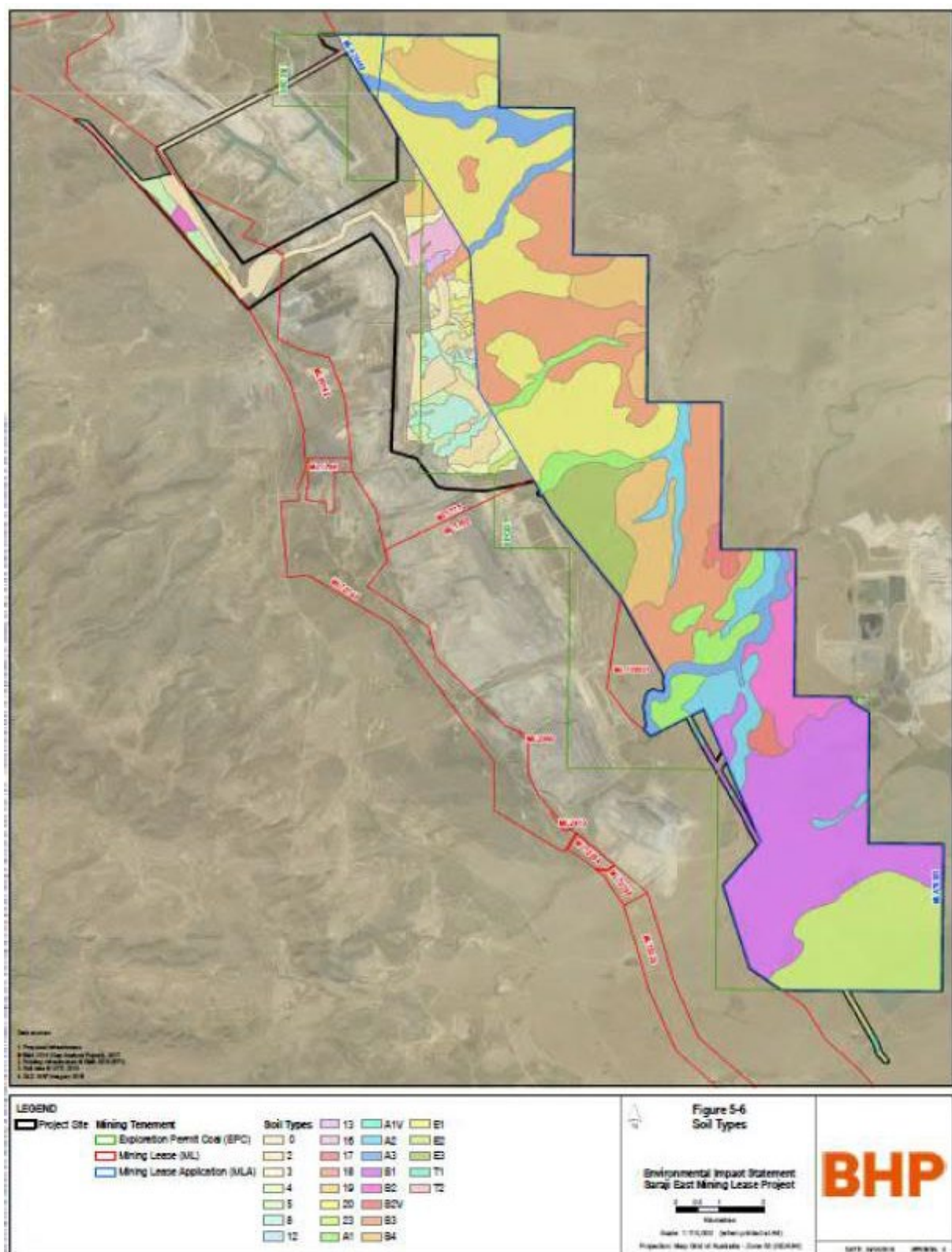


Figure A3: Distribution of stockpiled topsoil materials and sampling location at Saraji Mine (Part B).



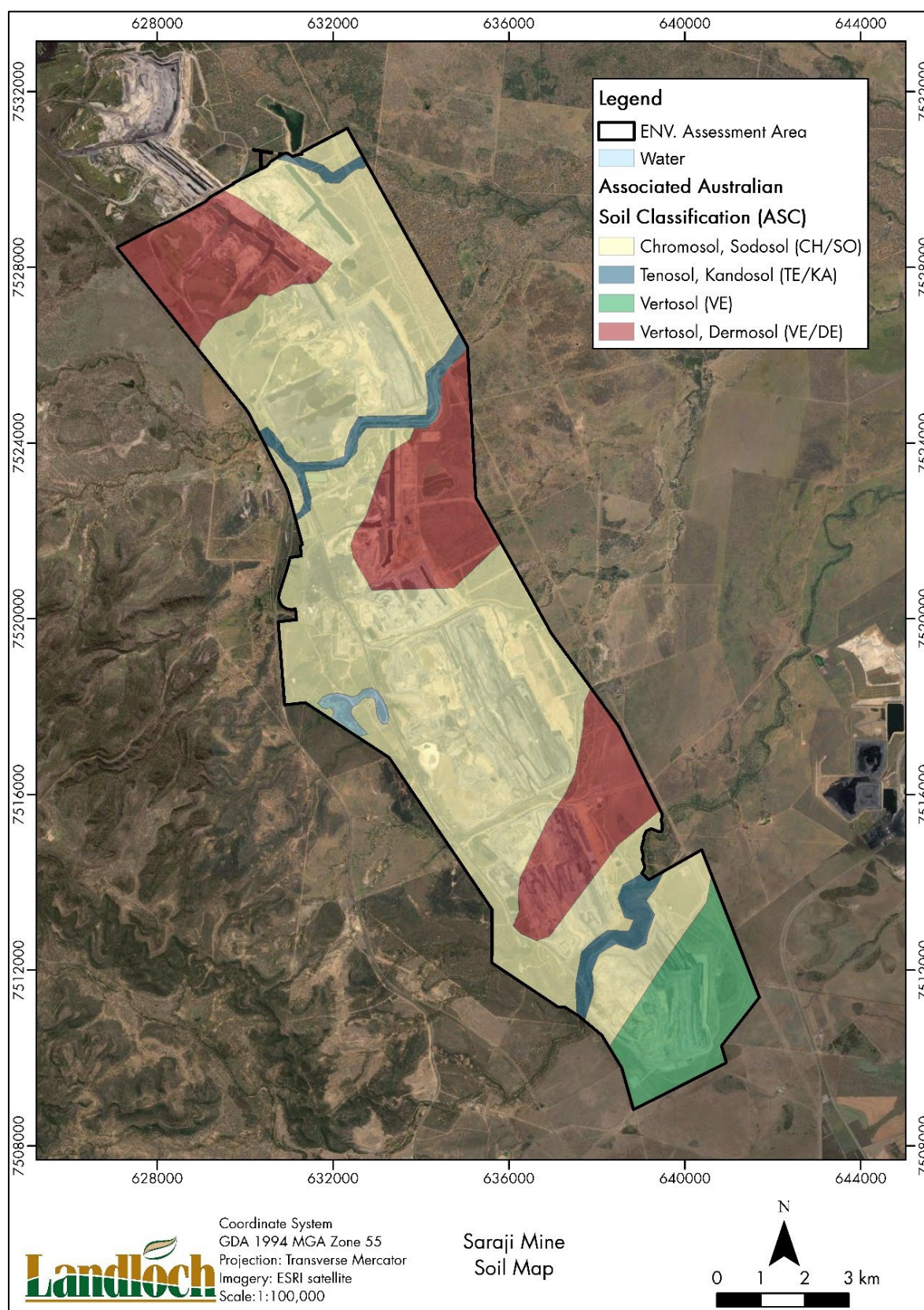


Figure A5: ASC soil mapping synthesised from existing soil assessments (B.R. Emmerton Pty Ltd, 1999, March 2002, August 2002; GT Environmental, 2018).

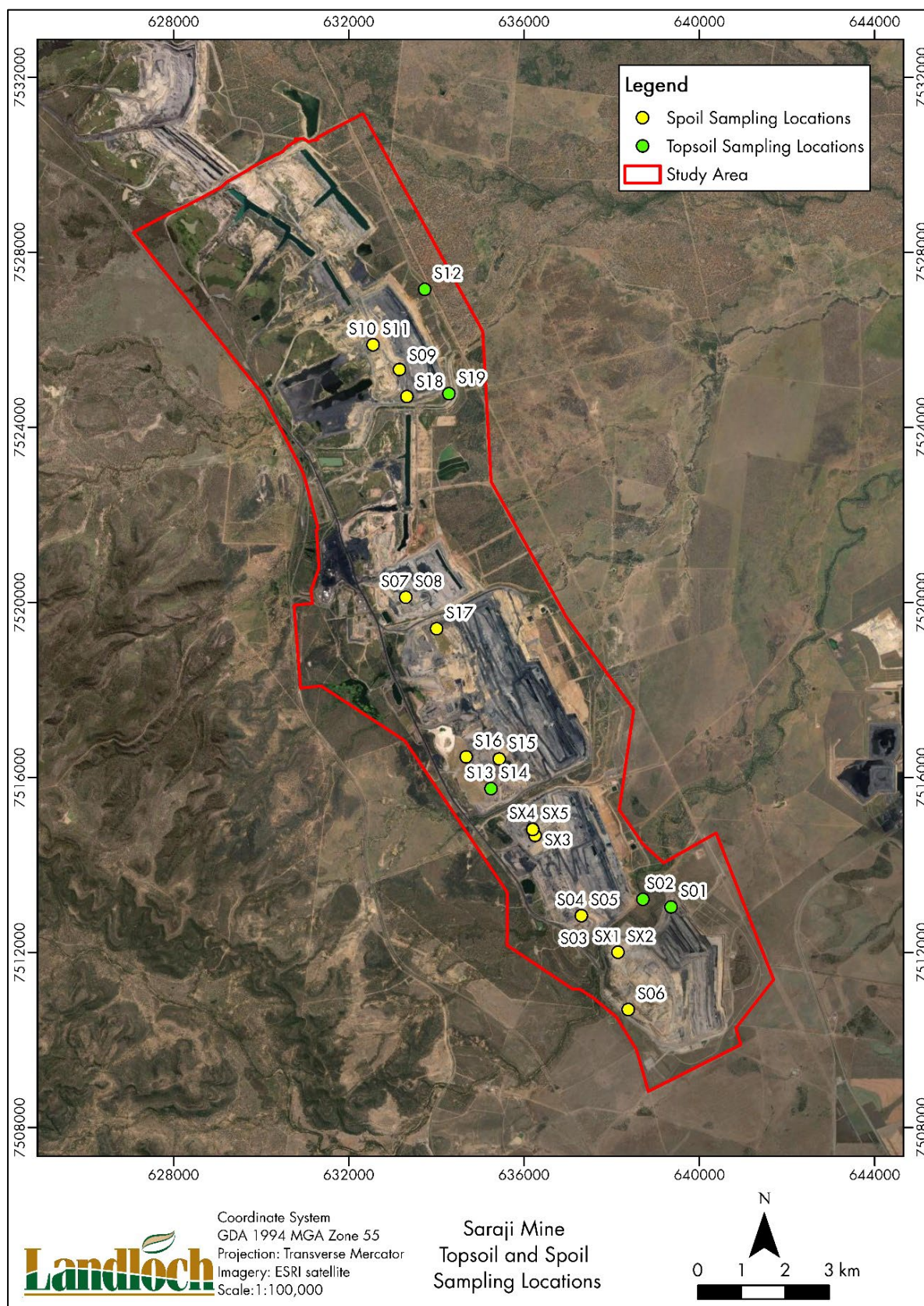


Figure A6: Topsoil and spoil sampling locations for erodibility studies (Landloch Pty. Ltd., 2018).

APPENDIX B: DATA TABLES

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Table B1: Sampling site locations.

Site ID	Type	UTM	LATITUDE	LONGITUDE
4	Topsoil stockpile	55 K 630718.55 7527084.688	-22.35719528	148.2695257
7	Topsoil stockpile	55 K 633506.86 7517618.286	-22.44247936	148.2973935
10a	Topsoil stockpile	55 K 638940.44 7513168.949	-22.48223077	148.3505743
10b	Topsoil stockpile	55 K 638720.69 7512962.480	-22.48411338	148.3484567
10c	Topsoil stockpile	55 K 638542.78 7512947.822	-22.48426022	148.3467291
13	Topsoil stockpile	55 K 633945.50 7521640.726	-22.40611536	148.3013166
15	Topsoil stockpile	55 K 632057.73 7529256.323	-22.33747878	148.2823497
16	Topsoil stockpile	55 K 634911.22 7514517.913	-22.47037071	148.3113014
17	Topsoil stockpile	55 K 638686.60 7514415.709	-22.47099128	148.3479984
21a	Topsoil stockpile	55 K 639233.93 7509137.691	-22.51861507	148.3537809
21b	Topsoil stockpile	55 K 639162.45 7509551.947	-22.51487957	148.3530497
24	Topsoil stockpile	55 K 633871.59 7526951.877	-22.35815185	148.3001528
25	Topsoil stockpile	55 K 633011.74 7527647.247	-22.35193819	148.2917458
28	Topsoil stockpile	55 K 633624.35 7526617.742	-22.36118897	148.2977801
30	Topsoil stockpile	55 K 632571.67 7528756.141	-22.34195681	148.2873808
31	Topsoil stockpile	55 K 633823.91 7526136.881	-22.36551647	148.2997582
34	Topsoil stockpile	55 K 630793.42 7523462.200	-22.38990761	148.2705496
36	Topsoil stockpile	55 K 632548.24 7518902.048	-22.43095928	148.2879726
38	Topsoil stockpile	55 K 633929.60 7524235.826	-22.3826782	148.3009441
39	Topsoil stockpile	55 K 632587.72 7519251.947	-22.427796	148.288327
40	Topsoil stockpile	55 K 633344.06 7517247.086	-22.44584466	148.2958429
41	Topsoil stockpile	55 K 634104.78 7525649.287	-22.36989841	148.3025266
42	Topsoil stockpile	55 K 630489.15 7524575.974	-22.37987128	148.2675033
43	Topsoil stockpile	55 K 632545.02 7527533.003	-22.35300612	148.2872236
45	Topsoil stockpile	55 K 640830.17 7510612.264	-22.50516637	148.3691667
46	Topsoil stockpile	55 K 633991.45 7525915.214	-22.36750546	148.3014037
48	Topsoil stockpile	55 K 633686.36 7526389.874	-22.3632422	148.2984013
50	Topsoil stockpile	55 K 638080.10 7515237.303	-22.46362017	148.3420332
51	Topsoil stockpile	55 K 634197.07 7526103.720	-22.36578684	148.3033846
52	Topsoil stockpile	55 K 638398.57 7514917.876	-22.4664793	148.3451556
58	Topsoil stockpile	55 K 633951.19 7521573.171	-22.40672506	148.3013776
63	Topsoil stockpile	55 K 632902.35 7528727.219	-22.34219249	148.2905938
64	Topsoil stockpile	55 K 641221.59 7511911.716	-22.49339811	148.3728554
70	Topsoil stockpile	55 K 633823.33 7527017.282	-22.35756488	148.2996788
72	Topsoil stockpile	55 K 635556.68 7521525.792	-22.40702665	148.3169763
73	Topsoil stockpile	55 K 634307.31 7525959.613	-22.36707976	148.3044672
74	Topsoil stockpile	55 K 633196.01 7527250.609	-22.3555063	148.293568
75a	Topsoil stockpile	55 K 632243.27 7518422.124	-22.43531746	148.2850496
75b	Topsoil stockpile	55 K 632414.50 7518337.554	-22.43606804	148.2867203
78	Topsoil stockpile	55 K 638138.98 7515608.588	-22.46026212	148.342573
81	Topsoil stockpile	55 K 632236.01 7519050.383	-22.42964371	148.2849269
83	Topsoil stockpile	55 K 633525.58 7526972.816	-22.35798968	148.2967914
85	Topsoil stockpile	55 K 631375.80 7530101.810	-22.32989466	148.2756596
86	Topsoil stockpile	55 K 632084.49 7519484.686	-22.42573287	148.2834189
88	Topsoil stockpile	55 K 632520.50 7529343.610	-22.3366548	148.2868353

Site ID	Type	UTM	LATITUDE	LONGITUDE
89	Topsoil stockpile	55 K 632579.60 7528650.186	-22.34291318	148.2874667
90	Topsoil stockpile	55 K 631632.72 7529793.587	-22.33265886	148.2781792
94	Topsoil stockpile	55 K 631316.33 7530208.519	-22.32893541	148.2750735
95	Topsoil stockpile	55 K 632280.24 7518773.956	-22.43213693	148.2853796
97	Topsoil stockpile	55 K 632510.47 7527910.096	-22.34960292	148.2868568
103	Topsoil stockpile	55 K 632641.23 7518960.440	-22.43042468	148.2888711
106	Topsoil stockpile	55 K 633213.66 7527834.275	-22.35023333	148.2936907
108	Topsoil stockpile	55 K 631245.66 7530412.191	-22.32710125	148.2743708
109	Topsoil stockpile	55 K 635089.04 7514301.238	-22.47231359	148.3130479
113	Topsoil stockpile	55 K 637231.51 7518973.813	-22.42994184	148.3334645
115b	Topsoil stockpile	55 K 634285.96 7515430.354	-22.46217911	148.3051481
116	Topsoil stockpile	55 K 638165.00 7515778.791	-22.45872281	148.342811
118	Topsoil stockpile	55 K 633910.47 7516071.066	-22.45642187	148.3014453
119	Topsoil stockpile	55 K 637415.42 7518705.595	-22.43234952	148.3352743
121	Topsoil stockpile	55 K 638446.63 7517417.745	-22.44389769	148.3454047
123	Topsoil stockpile	55 K 641295.38 7511321.654	-22.49872108	148.3736252
127	Topsoil stockpile	55 K 636410.31 7519544.049	-22.42485734	148.3254377
128	Topsoil stockpile	55 K 636540.24 7519445.584	-22.42573628	148.3267084
129a	Topsoil stockpile	55 K 636810.34 7519594.113	-22.42437324	148.3293195
129b	Topsoil stockpile	55 K 637110.94 7519145.905	-22.42839724	148.3322783
130	Topsoil stockpile	55 K 639000.59 7513507.001	-22.47917276	148.3511292
131	Topsoil stockpile	55 K 634168.47 7522659.416	-22.39689733	148.3033966
133	Topsoil stockpile	55 K 637028.97 7518309.042	-22.43596205	148.3315541
134	Topsoil stockpile	55 K 639757.99 7513186.700	-22.48200369	148.358518
135	Topsoil stockpile	55 K 634352.46 7525978.961	-22.36690148	148.304904
139	Topsoil stockpile	55 K 638687.31 7515665.386	-22.45970471	148.3478962
142	Topsoil stockpile	55 K 641005.25 7510863.598	-22.50288199	148.3708461
144a	Topsoil stockpile	55 K 638881.80 7509242.620	-22.51769615	148.3503487
144b	Topsoil stockpile	55 K 639071.70 7509092.589	-22.51903566	148.3522078
145	Topsoil stockpile	55 K 639793.43 7513427.487	-22.47982613	148.3588412
148	Topsoil stockpile	55 K 639397.99 7513755.502	-22.47689601	148.3549695
149	Topsoil stockpile	55 K 636801.92 7518810.412	-22.43145203	148.3293051
152a	Topsoil stockpile	55 K 638929.17 7509702.341	-22.51354033	148.3507688
152b	Topsoil stockpile	55 K 638675.55 7509724.588	-22.51336007	148.3483015
152c	Topsoil stockpile	55 K 638691.64 7510082.064	-22.51013022	148.3484266
152g	Topsoil stockpile	55 K 638452.61 7510316.050	-22.50803642	148.3460826
153	Topsoil stockpile	55 K 637881.11 7510817.198	-22.50355662	148.3404839
154	Topsoil stockpile	55 K 639411.88 7513463.976	-22.47952779	148.3551301
158a	Topsoil stockpile	55 K 635381.26 7520421.462	-22.41701453	148.3153663
158b	Topsoil stockpile	55 K 635881.47 7520337.459	-22.41773359	148.3202325
160	Topsoil stockpile	55 K 634995.62 7521211.155	-22.40991268	148.3115532
163a	Topsoil stockpile	55 K 640286.84 7509731.656	-22.51316433	148.3639636
163b	Topsoil stockpile	55 K 640019.87 7509719.136	-22.51329937	148.3613696
163d	Topsoil stockpile	55 K 639666.50 7509612.778	-22.51428893	148.357944
169	Topsoil stockpile	55 K 638578.80 7513941.606	-22.47528191	148.3469922
173	Topsoil stockpile	55 K 637284.62 7518005.819	-22.43868014	148.334064
176	Topsoil stockpile	55 K 634909.31 7520856.235	-22.41312503	148.3107449
178	Topsoil stockpile	55 K 634613.10 7521474.763	-22.40756196	148.3078152

Table B2: Ground observations and surface descriptions.

Site ID	Type	Stoniness (abundance)	Stoniness (size)	Groundcover % (veg)	Veg/Litter	Erosion Type	Erosion Severity	Erosion State
4	Topsoil stockpile		2-6mm	80-100%	100/0			
7	Topsoil stockpile	2-10%	2-6mm	80-100%	80/20	Rill (<0.3m	Moderate	Active
10a	Topsoil stockpile	2-10%	2-6mm	80-100%	80/20	Sheet	Minor	Stabilised
10b	Topsoil stockpile	2-10%	2-6mm	80-100%	80/20	Sheet	Minor	Stabilised
10c	Topsoil stockpile	2-10%	2-6mm	80-100%	80/20	Sheet	Minor	Stabilised
13	Topsoil stockpile			80-100%	100/0			
15	Topsoil stockpile			80-100%	100/0	Rill (<0.3m	Minor	Stabilised
16	Topsoil stockpile	2-10%	2-6mm	80-100%	80/20	Sheet	Minor	Stabilised
17	Topsoil stockpile	2-10%	2-6mm	60-80%	60/40	Rill (<0.3m	Moderate	Active
21a	Topsoil stockpile	2-10%	2-6mm	80-100%	80/20	Sheet	Minor	Stabilised
21b	Topsoil stockpile	2-10%	2-6mm	80-100%	80/20	Sheet	Minor	Stabilised
24	Topsoil stockpile		2-6mm	80-100%	100/0			
25	Topsoil stockpile			80-100%	100/0			
28	Topsoil stockpile			80-100%	100/0			
30	Topsoil stockpile			80-100%	40/60			
31	Topsoil stockpile			80-100%	100/0			
34	Topsoil stockpile	<2%	2-6mm	80-100%	100/0			
36	Topsoil stockpile							
38	Topsoil stockpile			80-100%	100/0			
39	Topsoil stockpile	10-20%	<20mm	0-20%		Rill (<0.3m	Minor	Active
40	Topsoil stockpile	2-10%	2-6mm	80-100%	80/20	Sheet	Minor	Stabilised
41	Topsoil stockpile			80-100%	100/0			
42	Topsoil stockpile		<20mm	80-100%	100/0			
43	Topsoil stockpile			80-100%	100/0			
45	Topsoil stockpile	2-10%	2-6mm	80-100%	80/20	Sheet	Minor	Stabilised
46	Topsoil stockpile			80-100%	100/0			
48	Topsoil stockpile			80-100%	100/0			
50	Topsoil stockpile		2-6mm	80-100%	80/20	Sheet	Minor	Stabilised
51	Topsoil stockpile			80-100%	100/0			
52	Topsoil stockpile	2-10%	2-6mm	80-100%	60/40	Sheet	Minor	Stabilised
58	Topsoil stockpile			40-60%	50/50	Rill (<0.3m	Moderate	Active
63	Topsoil stockpile	<2%		80-100%	80/20	Rill (<0.3m	Minor	Stabilised
64	Topsoil stockpile	2-10%	2-6mm	80-100%	80/20	Sheet	Minor	Stabilised
70	Topsoil stockpile			80-100%	100/0			
72	Topsoil stockpile							
73	Topsoil stockpile			80-100%	100/0			
74	Topsoil stockpile			80-100%	100/0			
75a	Topsoil stockpile			80-100%	100/0			
75b	Topsoil stockpile	2-10%	<20mm	80-100%	100/0			
78	Topsoil stockpile	2-10%	2-6mm	80-100%	80/20	Sheet	Minor	Stabilised
81	Topsoil stockpile	10-20%	<20mm	40-60%	40/60			
83	Topsoil stockpile			80-100%	100/0			
85	Topsoil stockpile		2-6mm	80-100%	100/0			Stabilised
86	Topsoil stockpile	<2%		80-100%	100/0			
88	Topsoil stockpile			80-100%	100/0	Rill (<0.3m	Minor	

Site ID	Type	Stoniness (abundance)	Stoniness (size)	Groundcover % (veg)	Veg/Litter	Erosion Type	Erosion Severity	Erosion State
89	Topsoil stockpile			80-100%	100/0			
90	Topsoil stockpile							
94	Topsoil stockpile			80-100%	100/0			
95	Topsoil stockpile		<20mm	80-100%	100/0			
97	Topsoil stockpile			80-100%	100/0			
103	Topsoil stockpile			80-100%	100/0			
106	Topsoil stockpile			80-100%	100/0			
108	Topsoil stockpile							
109	Topsoil stockpile	2-10%	2-6mm	80-100%	80/20	Sheet	Minor	Stabilised
113	Topsoil stockpile	20-50%	2-6mm	80-100%	80/20	Sheet	Minor	Stabilised
115b	Topsoil stockpile	2-10%	2-6mm	80-100%	80/20	Sheet	Minor	Active
116	Topsoil stockpile	20-50%	2-6mm	80-100%	80/20	Sheet	Minor	Stabilised
118	Topsoil stockpile	2-10%	2-6mm	80-100%	80/20	Sheet	Minor	Stabilised
119	Topsoil stockpile	2-10%	2-6mm	80-100%	80/20	Sheet	Minor	Stabilised
121	Topsoil stockpile	2-10%	2-6mm	80-100%	80/20	Sheet	Minor	Stabilised
123	Topsoil stockpile	2-10%	2-6mm	80-100%	80/20	Sheet	Minor	Stabilised
127	Topsoil stockpile	<2%	2-6mm	60-80%	80/20	Rill (<0.3m	Moderate	Active
128	Topsoil stockpile	<2%	2-6mm	60-80%	80/20		Minor	Stabilised
129a	Topsoil stockpile	2-10%	2-6mm	60-80%	60/40	Rill (<0.3m	Moderate	Stabilised
129b	Topsoil stockpile			60-80%	100/0			
130	Topsoil stockpile	2-10%	2-6mm	80-100%	80/20	Rill (<0.3m	Moderate	Active
131	Topsoil stockpile			60-80%	100/0			
133	Topsoil stockpile	20-50%	<20mm	20-40%	60/40	Rill (<0.3m	Moderate	Active
134	Topsoil stockpile	2-10%	2-6mm	80-100%	80/20	Sheet	Minor	Stabilised
135	Topsoil stockpile			80-100%	100/0			
139	Topsoil stockpile	2-10%	2-6mm	80-100%	80/20	Sheet	Minor	Stabilised
142	Topsoil stockpile	2-10%	2-6mm	80-100%	80/20	Sheet	Minor	Stabilised
144a	Topsoil stockpile	2-10%	2-6mm	80-100%	80/20	Sheet	Minor	Stabilised
144b	Topsoil stockpile	2-10%	2-6mm	80-100%	80/20	Sheet	Minor	Stabilised
145	Topsoil stockpile	2-10%	2-6mm	80-100%	80/20	Sheet	Minor	Stabilised
148	Topsoil stockpile	2-10%	2-6mm	80-100%	80/20	Sheet	Minor	Stabilised
149	Topsoil stockpile	<2%	2-6mm	60-80%	80/20	Rill (<0.3m	Minor	Stabilised
152a	Topsoil stockpile	2-10%	2-6mm	80-100%	80/20	Sheet	Minor	Stabilised
152b	Topsoil stockpile	2-10%	2-6mm	80-100%	80/20	Sheet	Minor	Stabilised
152c	Topsoil stockpile	2-10%	2-6mm	80-100%	80/20	Sheet	Minor	Stabilised
152g	Topsoil stockpile	2-10%	2-6mm	80-100%	80/20	Sheet	Minor	Stabilised
153	Topsoil stockpile	2-10%	2-6mm	80-100%	80/20	Sheet	Minor	Stabilised
154	Topsoil stockpile	2-10%	2-6mm	80-100%	80/20	Sheet	Minor	Stabilised
158a	Topsoil stockpile	2-10%	2-6mm	60-80%	60/40	Sheet	Minor	Stabilised
158b	Topsoil stockpile		2-6mm	60-80%	60/40	Rill (<0.3m	Moderate	Active
160	Topsoil stockpile	20-50%	2-6mm	20-40%	80/20	Rill (<0.3m	Moderate	Active
163a	Topsoil stockpile	2-10%	2-6mm	80-100%	80/20	Sheet	Minor	Stabilised
163b	Topsoil stockpile	2-10%	2-6mm	80-100%	80/20	Sheet	Minor	Stabilised
163d	Topsoil stockpile	2-10%	2-6mm	80-100%	80/20	Sheet	Minor	Stabilised
169	Topsoil stockpile	2-10%	2-6mm	80-100%	80/20	Rill (<0.3m	Minor	Stabilised
173	Topsoil stockpile	2-10%	2-6mm	60-80%	80/20	Sheet	Moderate	Stabilised
176	Topsoil stockpile	2-10%	2-6mm	60-80%	60/40	Rill (<0.3m	Moderate	Active
178	Topsoil stockpile		2-6mm	20-40%	60/40	Rill (<0.3m	Moderate	Active

Table B3: Morphological description of stockpiled soil materials.

Field Order	Date	Site ID	Total Depth (m)	Texture Group 1°	Texture Group 2°	Colour (rapid)		Total Coarse Fragment %	Origin (i.e topsoil, subsoil, overburden); Parent Materials; and Proportions	Comments	Sample ID / Depth (m)	Sample Type
						Primary	Secondary					
1	8/02/2022	75a	2.5	LOAM	CLAY	Pale Brown		<2	topsoil	grass cover 1m high, very few mounds bare and 20% angular stone 5-20mm	SRM_75a_0.5_20220208	Composite
2	8/02/2022	75b	3	LOAM	CLAY	Pale Brown		5-10	topsoil	100% grass cover 1m high, very few mounds bare and 20% angular stone 5-20mm	SRM_75b_0.5_20220208	Composite
3	8/02/2022	95	3	LOAM	CLAY	Pale Brown		5-10	topsoil	cover 1m high, very few mounds bare and 20% angular stone 5-20mm	SRM_95_0.5_20220208	Composite
4	8/02/2022	36	2.8	LOAM	SAND	Pale Brown	Pale Brown	<2	topsoil	cover 1m high. stockpile goes deeper	SRM_36_0.5_20220208	Composite
5	8/02/2022	81	2.4	LOAM	CLAY	Pale Brown	Pale Orange	10-20	topsoil	mostly litter in spots, massive peds 50-100mm moderate consistence	SRM_81_0.5_20220208	Composite
6	8/02/2022	39	3m	LOAM	CLAY	Pale Brown		10-20	topsoil	30mm 10%. very firm peds 80% 50-300mm massive. stockpile is much deeper around 5m. ground cover sparse and patchy	SRM_39_0.5_20220208	Composite
7	9/02/2022	86	2.6	LOAM	CLAY	Pale Brown		<2	topsoil	or not, massive peds 10-50mm moderate consistence, 80-100% ground cover grass and black wattle	SRM_86_0.5_20220209	Composite
8	9/02/2022	103	3.5	LOAM	CLAY	Pale Brown		2-5	topsoil	moderately firm	SRM_103_0.5_20220209	Composite
9	9/02/2022	34	3	LOAM	SAND	Pale Brown		2-5	topsoil	grass tall 100% cover. massive peds 5-50mm firm	SRM_34_0.5_20220209	Composite
10	9/02/2022	42	3	LOAM	CLAY	Brown	Black	10-20	topsoil	100mm with orange and white/grey steaks light clay. stockpile goes deeper	SRM_42_0.5_20220209	Composite
11	9/02/2022	4	3	LOAM	CLAY	Pale Brown		2-5	topsoil	depth towards east	SRM_4_0.5_20220209	Composite
12	9/02/2022	94	3	LOAM	SAND	Pale Brown		2-5	topsoil	paddock dumped 4-5m in places	SRM_94_0.5_20220209	Composite
13	10/02/2022	85	3	LOAM	SAND	Pale Brown		2-5	topsoil	paddock dumped 4-5m in places	SRM_85_0.5_20220210	Composite
14	10/02/2022	108	3	LOAM	SAND	Pale Brown		2-5	topsoil	5m in places	SRM_108_0.5_20220210	Composite
15	10/02/2022	90	3	LOAM	SAND	Pale Brown		<2	topsoil	6m in places, ironstone segregations on surface 5-10mm 10-20%	SRM_90_0.5_20220210	Composite
16	10/02/2022	109	3	LOAM	SAND	Pale Brown		<2	topsoil	6m in places, ironstone segregations on surface 5-10mm 10-20%,	SRM_109_0.5_20220210	Composite
17	10/02/2022	15	3	LOAM	CLAY	Pale Brown		<2	topsoil	5m in places	SRM_15_0.5_20220210	Composite
18	10/02/2022	88	3	LOAM	SAND	Pale Brown		<2	topsoil	massive with firm peds 10-200mm, grass cover 80-100%,	SRM_88_0.5_20220210	Composite
19	10/02/2022	63	3	LOAM	SAND	Pale Brown		<2	topsoil	massive with firm peds 10-200mm, grass cover 80-100%,	SRM_63_0.5_20220210	Composite
20	11/02/2022	89	3	LOAM	SAND	Pale Brown		<2	topsoil	massive with firm peds 10-200mm, grass cover 80-100%,	SRM_89_0.5_20220211	Composite
21	11/02/2022	36	3	LOAM	SAND	Pale Brown		<2	topsoil	massive with firm peds 10-200mm, grass cover 80-100%,	SRM_36_0.5_20220211	Composite
22	11/02/2022	97	3	LOAM	CLAY	Pale Brown		<2	topsoil	massive with firm peds 10-200mm, grass cover 80-100%, stockpile 5-6m	SRM_97_0.5_20220211	Composite
23	11/02/2022	43	3	LOAM	CLAY	Brown		<2	topsoil	light clay, sandy. stockpile 4-5m high. 80-100% grass cover	SRM_43_0.5_20220211	Composite
24	11/02/2022	106	3	LOAM	SAND	Pale Brown		<2	topsoil	massive with firm peds 10-200mm, grass cover 80-100%,	SRM_106_0.5_20220211	Composite
25	11/02/2022	25	3	LOAM	CLAY	Pale Brown		<2	topsoil	massive with firm peds 10-200mm, grass cover 80-100%,	SRM_25_0.5_20220211	Composite
26	11/02/2022	74	3	LOAM	SAND	Pale Brown		<2	topsoil	massive with firm peds 10-200mm, grass cover 80-100%,	SRM_74_0.5_20220211	Composite
27	11/02/2022	70	3	LOAM	SAND	Pale Brown		<2	topsoil	massive with firm peds 10-100mm, grass cover 80-100%,	SRM_70_0.5_20220211	Composite
28	11/02/2022	83	3	LOAM	SAND	Pale Brown		<2	topsoil	massive with firm peds 10-200mm, grass cover 80-100%,	SRM_83_0.5_20220211	Composite
29	11/02/2022	24	3	LOAM	SAND	Pale Brown		<2	topsoil	massive with firm peds 10-100mm, grass cover 80-100%,	SRM_24_0.5_20220211	Composite
30	11/02/2022	28	3	LOAM	SAND	Pale Brown		<2	topsoil	massive with firm peds 10-100mm, grass cover 80-100%,	SRM_28_0.5_20220211	Composite
31	12/02/2022	46	3	LOAM	SAND	Pale Brown		<2	topsoil	massive with firm peds 10-100mm, grass cover 80-100%,	SRM_46_0.5_20220212	Composite
32	12/02/2022	49	3	LOAM	SAND	Pale Brown		<2	topsoil	massive with firm peds 10-100mm, grass cover 80-100%,	SRM_49_0.5_20220212	Composite
33	12/02/2022	31	3	LOAM	SAND	Pale Brown		<2	topsoil	massive with firm peds 10-100mm, grass cover 80-100%,	SRM_31_0.5_20220212	Composite
34	12/02/2022	51	3	LOAM	SAND	Pale Brown		<2	topsoil	massive with firm peds 10-100mm, grass cover 80-100%, coarse grain sand	SRM_51_0.5_20220212	Composite
35	12/02/2022	73	3	LOAM	SAND	Pale Brown		<2	topsoil	stockpile 3-4m	SRM_73_0.5_20220212	Composite
36	12/02/2022	135	3	LOAM	SAND	Pale Brown		<2	topsoil	stockpile 3-4m	SRM_73_0.5_20220212	Composite
37	12/02/2022	41	3	LOAM	SAND	Pale Brown		<2	topsoil	massive with firm peds 10-100mm, grass cover 80-100%, stockpie 4-5m	SRM_41_0.5_20220212	Composite
38	12/02/2022	38	3	LOAM	CLAY	Dark Brown		<2	topsoil	original A horizon on bottom of stockpile etc. stockpile has been ploughed. possibly a transition soil between black cracking clays and brown sandy loams 80-100% grass	SRM_38_0.5_20220212	Composite

Field Order	Date	Site ID	Total Depth (m)	Texture Group 1°	Texture Group 2°	Colour (rapid)		Total Coarse Fragment %	Origin (i.e topsoil, subsoil, overburden); Parent Materials; and Proportions	Comments	Sample ID / Depth (m)	Sample Type
						Primary	Secondary					
39	12/02/2022	58	3	CLAY		Dark Brown		<2	topsoil	paddock dumped	SRM_85_0.5_20220212	Composite
40	12/02/2022	13	3	LOAM	SAND	Pale Brown		<2	topsoil	10% surface	SRM_41_0.5_20220212	Composite
41	13/02/2022	131	3	CLAY		Dark Brown		<2	topsoil	light clay, sandy. surface ironstone 5-10mm 10-20%, some bald ridges	SRM_131_0.5_20220213	Composite
42	13/02/2022	178	3	CLAY		Brown		<2	topsoil	few ironstone on top of piles	SRM_178_0.5_20220213	Composite
43	13/02/2022	160	3	LOAM	SAND	Pale Brown		<2	topsoil	few ironstone	SRM_160_0.5_20220213	Composite
44	13/02/2022	70	3	LOAM	SAND	Pale Brown		<2	topsoil	ironstone	SRM_70_0.5_20220213	Composite
45	13/02/2022	176	3	LOAM	SAND	Pale Brown		<2	topsoil	iron stone	SRM_176_0.5_20220213	Composite
46	13/02/2022	158a	3	LOAM	CLAY	Pale Brown		<2	topsoil	clay Peds mixed in	SRM_158a_0.5_20220213	Composite
47	13/02/2022	158b	3	LOAM	CLAY	Pale Brown		<2	topsoil	large clay peds	SRM_158a_0.5_20220213	Composite
48	13/02/2022	129a	3	LOAM	SAND	Pale Brown		<2	topsoil	small clay peds	SRM_129a_0.5_20220213	Composite
49	13/02/2022	129b	3	LOAM	SAND	Pale Grey		<2	topsoil	small clay peds	SRM_129b_0.5_20220213	Composite
50	13/02/2022	113	3	LOAM	SAND	Pale Brown		5-10	topsoil	small clay peds	SRM_113_0.5_20220213	Composite
51	13/02/2022	119	3	LOAM	SAND	Pale Brown		<2	topsoil	stockpile 6 meters high	SRM_119_0.5_20220213	Composite
52	14/02/2022	127	3	LOAM	CLAY	Pale Brown		5-10	topsoil	paddock dumped soil	SRM_127_0.5_20220214	Composite
53	14/02/2022	128	3	LOAM	SAND	Pale Grey		5-10	topsoil	paddock dumped soil	SRM_128_0.5_20220214	Composite
54	14/02/2022	149	3	LOAM	SAND	Pale Grey		2-5	topsoil	paddock dump	SRM_149_0.5_20220214	Composite
55	14/02/2022	133	3	CLAY		Pale Brown		5-10	topsoil	paddock dumped soil	SRM_133_0.5_20220214	Composite
56	14/02/2022	173	3	LOAM	CLAY	Pale Grey		<2	topsoil	paddock dumped soil	SRM_173_0.5_20220214	Composite
57	14/02/2022	121	3	LOAM	CLAY	Pale Grey		5-10	topsoil	large clay peds	SRM_121_0.5_20220214	Composite
58	14/02/2022	116	3	LOAM	CLAY	Brown		2-5	topsoil	clay peds in every depth	SRM_116_0.5_20220214	Composite
59	14/02/2022	78	3	LOAM	CLAY	Brown		2-5	topsoil	clay peds in ever layer	SRM_78_0.5_20220214	Composite
60	14/02/2022	50	3	LOAM	CLAY	Pale Brown		2-5	topsoil	sandy texture	SRM_50_0.5_20220214	Composite
61	15/02/2022	21b	3	CLAY		Black		2-5	topsoil	thick grass cover	SRM_21b_0.5_20220215	Composite
62	15/02/2022	21a	3	CLAY		Dark Brown		2-5	topsoil	thick grass cover, section of side wall exposed, erosion happening	SRM_21a_0.5_20220215	Composite
63	15/02/2022	144b	3	CLAY		Dark Brown		2-5	topsoil	thickbgrass cover, large clay peds through out profile	SRM_144b_0.5_20220215	Composite
64	15/02/2022	144a	3	CLAY		Black		5-10	topsoil	thick grass cover, coarse fragments, large clay peds through all depths	SRM_144a_0.5_20220215	Composite
65	15/02/2022	163d	3	CLAY		Black		2-5	topsoil	thick grass cover 80-100%, large clay peds, small coarse fragments 2 mm	SRM_144a_0.5_20220215	Composite
66	15/02/2022	163b	3	CLAY		Black		<2	topsoil	thick grass cover 80-100%,	SRM_144a_0.5_20220215	Composite
67	15/02/2022	163a	3	CLAY		Black		<2	topsoil	thick grass cover 80-100%	SRM_144a_0.5_20220215	Composite
68	15/02/2022	45	3	CLAY		Black		<2	topsoil	weeds and grass cover	SRM_45_0.5_20220215	Composite
69	16/02/2022	142	3	CLAY		Pale Brown		5-10	topsoil	first 40 cm of soil is black coloured soil, below that is pale brown yellowish colour	SRM_142_0.5_20220216	Composite
70	16/02/2022	123	3	CLAY		Black		2-5	topsoil	large clay clumps, carbonates in soil	SRM_123_0.5_20220216	Composite
71	16/02/2022	64	3	CLAY		Black		<2	topsoil	large clay clumps all through pit	SRM_64_0.5_20220216	Composite
72	16/02/2022	134	3	CLAY		Black		<2	topsoil	large clay clumps, clumpy soil. black soil through profile	SRM_134_0.5_20220216	Composite
73	16/02/2022	145	3	CLAY		Black		<2	topsoil	full of large clumps of clay, thick roots through stockpile	SRM_145_0.5_20220216	Composite
74	16/02/2022	154	3	CLAY		Black	Pale Brown	<2	topsoil	large clumps through soil, small rocks in different layers	SRM_154_0.5_20220216	Composite
75	16/02/2022	130	3	LOAM	CLAY	Pale Brown		<2	topsoil	small clumps through stockpile, sandy loose, high walls	SRM_130_0.5_20220216	Composite
76	16/02/2022	148	3	CLAY		Black		2-5	topsoil	clay clumps althrough soil stockpile,	SRM_148_0.5_20220216	Composite
77	16/02/2022	10b	3	LOAM	SAND	Pale Brown		<2	topsoil	clay clumps small, sandy throughout	SRM_10b_0.5_20220216	Composite
78	16/02/2022	10a	3	LOAM	SAND	Pale Brown		<2	topsoil	small clay clumps, sandy throughout	SRM_10a_0.5_20220216	Composite
79	16/02/2022	10c	3	LOAM	SAND	Pale Brown		<2	topsoil	carbonates	SRM_10c_0.5_20220216	Composite
80	16/02/2022	169	3	LOAM	SAND	Pale Brown		<2	topsoil	and used recently. lzrge amount of litter on ground	SRM_169_0.5_20220216	Composite

Field Order	Date	Site ID	Total Depth (m)	Texture Group 1 ^a	Texture Group 2 ^a	Colour (rapid)		Total Coarse Fragment %	Origin (i.e topsoil, subsoil, overburden); Parent Materials; and Proportions	Comments	Sample ID / Depth (m)	Sample Type
						Primary	Secondary					
81	17/02/2022	17	3	LOAM	SAND	Pale Brown		<2	topsoil	side hole collapsed, deep rills on side of stockpile, small clay clumps,	SRM_17_0.5_20220217	Composite
82	17/02/2022	52	3	CLAY		Dark Brown		2-5	topsoil	black clay, large clay clumps throughout,	SRM_52_0.5_20220217	Composite
83	17/02/2022	139	3	CLAY		Dark Brown		2-5	topsoil	dark brown clay, large clumps through stockpile, loose soil as well.	SRM_139_0.5_20220217	Composite
84	17/02/2022	152a	3	CLAY		Dark Brown		<2	topsoil	dark brown, clay clumps, small calcuim flecs in bottom two layers	SRM_152a_0.5_20220217	Composite
85	17/02/2022	152b	3	CLAY		Black		2-5	topsoil	black soil ontop of a black soil, small rocks through pit, large clay clumps	SRM_152b_0.5_20220217	Composite
86	17/02/2022	152c	3	CLAY		Black		2-5	topsoil	clumps	SRM_152c_0.5_20220217	Composite
87	17/02/2022	152g	3	CLAY		Brown	Pale Orange	2-5	topsoil	clay clumps on top layer	SRM_152g_0.5_20220217	Composite
88	18/02/2022	153	3	CLAY		Black	Brown	<2	topsoil	large black clay clumps in top layer	SRM_153_0.5_20220218	Composite
89	18/02/2022	109	3	LOAM	CLAY	Dark Brown		20-30	topsoil	large rocks and rock fragments, clay clumps	SRM_109_0.5_20220218	Composite
90	18/02/2022	16	3	LOAM	CLAY	Brown		5-10	topsoil	clay clumps with fines	SRM_16_0.5_20220218	Composite
91	18/02/2022	115b	3	LOAM	CLAY	Pale Brown		5-10	topsoil	sandy fines with clay peds and stones	SRM_115b_0.5_20220218	Composite
92	18/02/2022	118	3	LOAM	CLAY	Pale Brown		2-5	topsoil	clay peds , sandy	SRM_118_0.5_20220218	Composite
93	18/02/2022	40	3	LOAM	CLAY	Pale Brown		<2	topsoil	clay peds, sand	SRM_40_0.5_20220218	Composite
94	18/02/2022	7	3	LOAM	SAND	Pale Brown		<2	topsoil	sandy, dry clay peds	SRM_7_0.5_20220218	Composite

Table B4: Laboratory analysis data for light loam topsoils. Part 1 of 7.

TABLE B4. Laboratory Results Loam/Sand													
	Lab No	220725-17		220725-37		220725-49		220725-53		220725-57		220725-61	
	Sample ID	SRM_36		SRM_34		SRM_94		SRM_85		SRM_108		SRM_90	
	Sample Depth (m)	Composite		Composite		Composite		Composite		Composite		Composite	
Analyses	Unit												
pH - Water	pH units	8.27	M.Alk	8.60	H.Alk	8.24	M.Alk	7.38	Neutral	7.24	Neutral	8.50	H.Alk
Electrical Conductivity	dS/m	0.04	VL.Sal	0.09	L.Sal	0.06	VL.Sal	0.05	VL.Sal	0.03	VL.Sal	0.09	L.Sal
Chloride	mg/kg	23.2	VL.Sal	24.3	VL.Sal	23.5	VL.Sal	24.6	VL.Sal	17.8	VL.Sal	19.0	VL.Sal
Total Nitrogen - Kjeldahl	mg/kg	63.2	VL	207	VL	<50.0	FALSE	<50.0	FALSE	<50.0	FALSE	224	VL
Total Phosphorus - Nitric/Perchloric	mg/kg	85.3	*	142	*	71.3	*	251	*	71.7	*	82.7	*
Phosphorus - Colwell extr	mg/kg	21.0	H	28.9	H	17.5	M	52.2	H	14.9	M	28.7	H
Potassium - Colwell ext	mg/kg	130	L	151	M	146	L	136	L	105	L	137	L
Sulphur - KCl	mg/kg	6.9	L	15.5	H	6.6	L	7.9	L	3.4	VL	8.8	M
Organic Carbon	%	<0.05	FALSE	0.55	VL	0.16	EL	0.13	EL	0.19	EL	0.36	EL
Copper	mg/kg	0.26	L	0.38	M	<0.20	FALSE	0.28	L	<0.20	FALSE	0.24	L
Iron	mg/kg	18.2	*	7.92	*	11.7	*	23.6	*	36.5	*	36.2	*
Manganese	mg/kg	2.48	M	2.46	M	2.16	M	2.42	M	2.72	M	1.90	L
Zinc	mg/kg	<0.20	FALSE	0.22	VL	<0.20	FALSE	<0.20	FALSE	<0.20	FALSE	<0.20	FALSE
Boron	mg/kg	<0.20	FALSE	0.39	VL	0.31	VL	0.23	VL	<0.20	FALSE	0.39	VL
Cation Extraction Method	Rayment& Lyons	15C1	*	15C1	*	15C1	*	15C1	*	15A1	*	15C1	*
Cation Exchange Capacity	meq/100g	1.6	VL	3.6	VL	1.8	VL	1.8	VL	1.9	VL	2.7	VL
Ex Calcium Percent	%	46.28	L	47.51	L	51.53	L	47.99	L	58.11	L	62.92	L
Ex Magnesium Percent	%	33.18	H	37.26	H	25.31	H	30.50	H	20.82	H	23.72	H
Ex Potassium Percent	%	9.16	H	4.15	Normal	14.12	H	12.98	H	13.44	H	8.88	H
Ex Sodium Percent	%	10.69	Sodic	10.78	Sodic	8.44	Sodic	7.91	Sodic	7.0	Sodic	4.07	N.Sodic
Ex Aluminium Percent	%	0.69	VL	0.31	VL	0.61	VL	0.62	VL	0.58	VL	0.41	VL
Exchangeable Calcium	meq/100g	0.75	VL	1.70	VL	0.95	VL	0.86	VL	1.11	VL	1.70	VL
Exchangeable Magnesium	meq/100g	0.53	L	1.33	M	0.46	L	0.54	L	0.40	L	0.64	L
Exchangeable Potassium	meq/100g	0.15	VL	0.15	VL	0.26	L	0.23	L	0.26	L	0.24	L
Exchangeable Sodium	meq/100g	0.17	L	0.39	M	0.15	L	0.14	L	0.13	L	0.11	L
Exchangeable Aluminium	meq/100g	0.01	H	0.01	H	0.01	H	0.01	H	0.01	H	0.01	H
Calcium/Magnesium Ratio	-	1.4	Low Ca	1.3	Low Ca	2.0	Low Ca	1.6	Low Ca	2.8	Low Ca	2.7	Low Ca
Emerson Aggregate	Class	2.0	Disp.	3b	Slight Disp	3b	Slight Disp	3b	Slight Disp	3b	Slight Disp	3b	Slight Disp
Phosphorus Buffer Index	mg/kg	24.5	*	33.3	*	20.6	*	28.2	*	22.3	*	32.9	*

	Highly acidic		Extremely alkaline		High salinity		Sodic		Strongly sodic
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Table B4: Laboratory analysis data for light loam topsoils. Part 2 of 7.

TABLE B4. Laboratory Results Loam/Sand													
	Lab No	220725-65		220725-73		220725-77		220725-81		220725-85		220725-97	
	Sample ID	SRM_109		SRM_88		SRM_63		SRM_89		SRM_36		SRM_106	
	Sample Depth (m)	Composite		Composite		Composite		Composite		Composite		Composite	
Analyses	Unit												
pH - Water	pH units	6.84	Neutral	6.49	L.Acid	5.71	M.acid	8.62	H.Alk	6.46	L.Acid	6.85	Neutral
Electrical Conductivity	dS/m	0.02	VL.Sal	0.02	VL.Sal	0.02	VL.Sal	0.08	L.Sal	0.04	VL.Sal	0.03	VL.Sal
Chloride	mg/kg	16.1	VL.Sal	13.8	VL.Sal	17.4	VL.Sal	17.8	VL.Sal	23.9	VL.Sal	14.7	VL.Sal
Total Nitrogen - Kjeldahl	mg/kg	<50.0	FALSE	<50.0	FALSE	71.3	VL	97.6	VL	97.9	VL	126	VL
Total Phosphorus - Nitric/Perchloric	mg/kg	51.5	*	85.3	*	64.9	*	82.9	*	77.2	*	79.4	*
Phosphorus - Colwell extr	mg/kg	21.1	H	15.2	M	30.4	H	22.1	H	20.1	H	21.6	H
Potassium - Colwell ext	mg/kg	122	L	103	L	133	L	139	L	130	L	106	L
Sulphur - KCl	mg/kg	4.1	L	3.8	VL	4.3	L	5.3	L	8.6	M	3.1	VL
Organic Carbon	%	0.08	EL	0.15	EL	0.14	EL	0.25	EL	0.23	EL	0.27	EL
Copper	mg/kg	0.20	L	0.26	L	0.40	M	0.26	L	0.48	M	0.2	L
Iron	mg/kg	42.2	*	45.3	*	100	*	23.7	*	40.7	*	110	*
Manganese	mg/kg	2.36	M	5.86	M	22.5	M	2.54	M	7.32	M	4.48	M
Zinc	mg/kg	<0.20	FALSE	<0.20	FALSE	<0.20	FALSE	<0.20	FALSE	<0.20	FALSE	<0.20	FALSE
Boron	mg/kg	<0.20	FALSE	<0.20	FALSE	0.21	VL	0.34	VL	0.28	VL	<0.20	FALSE
Cation Extraction Method	Rayment& Lyons	15A1	*	15A1	*	15A1	*	15A1	*	15A1	*	15A1	*
Cation Exchange Capacity	meq/100g	1.7	VL	2.0	VL	1.9	VL	5.6	VL	4.4	VL	3.8	VL
Ex Calcium Percent	%	50.16	L	57.62	L	49.85	L	75.95	Normal	54.68	L	60.04	L
Ex Magnesium Percent	%	19.36	H	20.52	H	25.19	H	15.30	H	35.99	H	19.55	H
Ex Potassium Percent	%	18.68	H	12.25	H	10.59	H	5.26	H	8.07	H	6.17	H
Ex Sodium Percent	%	11.1	Sodic	9.0	Sodic	12.0	Sodic	3.3	N.Sodic	1.0	N.Sodic	13.9	Sodic
Ex Aluminium Percent	%	0.66	VL	0.56	VL	2.39	VL	0.20	VL	0.26	VL	0.29	VL
Exchangeable Calcium	meq/100g	0.84	VL	1.14	VL	0.95	VL	4.26	L	2.38	L	2.27	L
Exchangeable Magnesium	meq/100g	0.32	L	0.40	L	0.48	L	0.86	L	1.57	M	0.74	L
Exchangeable Potassium	meq/100g	0.31	M	0.24	L	0.20	L	0.29	L	0.35	M	0.23	L
Exchangeable Sodium	meq/100g	0.19	L	0.18	L	0.23	L	0.18	L	0.04	VL	0.53	M
Exchangeable Aluminium	meq/100g	0.01	H	0.01	H	0.05	E	0.01	H	0.01	H	0.01	H
Calcium/Magnesium Ratio	-	2.6	Low Ca	2.8	Low Ca	2.0	Low Ca	5.0	Balanced	1.5	Low Ca	3.1	Low Ca
Emerson Aggregate	Class	3b	Slight Disp	3b	Slight Disp	3b	Slight Disp	3b	Slight Disp	3b	Slight Disp	7	Stable
Phosphorus Buffer Index	mq/ka	19.7	*	24.5	*	26.4	*	27.3	*	27.8	*	21.5	*

	Highly acidic		Extremely alkaline		High salinity		Sodic		Strongly sodic
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Table B4: Laboratory analysis data for light loam topsoils. Part 3 of 7.

TABLE B4. Laboratory Results Loam/Sand													
	Lab No	220725-105		220725-109		220725-113		220725-117		220725-121		220725-125	
	Sample ID	SRM_74		SRM_70		SRM_83		SRM_24		SRM_28		SRM_46	
	Sample Depth (m)	Composite		Composite		Composite		Composite		Composite		Composite	
Analyses	Unit												
pH - Water	pH units	6.80	Neutral	8.77	H.Alk	7.48	L.Alk	6.49	L.Acid	7.74	L.Alk	7.94	M.Alk
Electrical Conductivity	dS/m	0.07	L.Sal	0.08	L.Sal	0.02	VL.Sal	0.04	VL.Sal	0.10	L.Sal	0.17	M.Sal
Chloride	mg/kg	40.1	VL.Sal	37.1	VL.Sal	25.8	VL.Sal	24.1	VL.Sal	66.4	VL.Sal	170	L.Sal
Total Nitrogen - Kjeldahl	mg/kg	103	VL	66.9	VL	82.9	VL	122	VL	416	VL	215	VL
Total Phosphorus - Nitric/Perchloric	mg/kg	95.0	*	87.8	*	72.9	*	100	*	124	*	114	*
Phosphorus - Colwell extr	mg/kg	10.9	L	20.2	H	10.0	L	14.0	M	18.7	M	18.2	M
Potassium - Colwell ext	mg/kg	140	L	118	L	113	L	131	L	158	M	149	L
Sulphur - KCl	mg/kg	12.0	H	13.2	H	6.4	L	9.2	M	13.2	H	17.8	H
Organic Carbon	%	0.22	EL	0.23	EL	0.22	EL	0.22	EL	0.4	VL	0.19	EL
Copper	mg/kg	0.24	L	<0.20	FALSE	0.26	L	0.32	M	0.28	L	0.3	M
Iron	mg/kg	47.4	*	40.5	*	28.4	*	46.2	*	15.6	*	8.86	*
Manganese	mg/kg	4.58	M	2.54	M	2.72	M	4.76	M	2.62	M	2.20	M
Zinc	mg/kg	<0.20	FALSE	<0.20	FALSE	<0.20	FALSE	<0.20	FALSE	0.28	VL	0.22	VL
Boron	mg/kg	<0.20	FALSE	0.24	VL	0.20	VL	<0.20	FALSE	0.48	VL	0.28	VL
Cation Extraction Method	Rayment & Lyons	15A1	*	15C1	*	15C1	*	15A1	*	15C1	*	15C1	*
Cation Exchange Capacity	meq/100g	3.4	VL	1.5	VL	1.5	VL	4.1	VL	3.5	VL	3.9	VL
Ex Calcium Percent	%	50.57	L	61.69	L	62.51	L	57.32	L	59.50	L	42.04	L
Ex Magnesium Percent	%	27.02	H	23.44	H	22.25	H	23.42	H	29.49	H	35.25	H
Ex Potassium Percent	%	4.49	Normal	10.04	H	10.93	H	4.54	Normal	5.71	H	6.15	H
Ex Sodium Percent	%	17.6	H.Sodic	4.10	N.Sodic	3.56	N.Sodic	14.5	H.Sodic	4.99	N.Sodic	16.28	H.Sodic
Ex Aluminium Percent	%	0.33	VL	0.74	VL	0.75	VL	0.27	VL	0.32	VL	0.28	VL
Exchangeable Calcium	meq/100g	1.70	VL	0.93	VL	0.93	VL	2.35	L	2.09	L	1.65	VL
Exchangeable Magnesium	meq/100g	0.91	L	0.35	L	0.33	L	0.96	L	1.03	M	1.38	M
Exchangeable Potassium	meq/100g	0.15	VL	0.15	VL	0.16	VL	0.19	VL	0.20	L	0.24	L
Exchangeable Sodium	meq/100g	0.59	M	0.06	VL	0.05	VL	0.59	M	0.17	L	0.64	M
Exchangeable Aluminium	meq/100g	0.01	H	0.01	H	0.01	H	0.01	H	0.01	H	0.01	H
Calcium/Magnesium Ratio	-	1.9	Low Ca	2.6	Low Ca	2.8	Low Ca	2.4	Low Ca	2.0	Low Ca	1.2	Low Ca
Emerson Aggregate	Class	3b	Slight Disp	3b	Slight Disp	3b	Slight Disp	3b	Slight Disp	3b	Slight Disp	2	Disp.
Phosphorus Buffer Index	mg/kg	34.6	*	38.9	*	37.2	*	38.8	*	43.8	*	39.2	*

	Highly acidic		Extremely alkaline		High salinity		Sodic		Strongly sodic
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Table B4: Laboratory analysis data for light loam topsoils. Part 4 of 7.

TABLE B4. Laboratory Results Loam/Sand													
	Lab No	220725-129		220725-133		220725-137		220725-141		220725-145		220725-149	
	Sample ID	SRM_49		SRM_31		SRM_51		SRM_73		SRM_135		SRM_41	
	Sample Depth (m)	Composite		Composite		Composite		Composite		Composite		Composite	
Analyses	Unit												
pH - Water	pH units	8.32	<i>M.Alk</i>	6.05	<i>M.acid</i>	8.11	<i>M.Alk</i>	6.86	<i>Neutral</i>	7.62	<i>L.Alk</i>	6.24	<i>L.Acid</i>
Electrical Conductivity	dS/m	0.07	<i>L.Sal</i>	0.07	<i>L.Sal</i>	0.05	<i>VL.Sal</i>	0.03	<i>VL.Sal</i>	0.05	<i>VL.Sal</i>	0.07	<i>L.Sal</i>
Chloride	mg/kg	30.5	<i>VL.Sal</i>	44.5	<i>VL.Sal</i>	44.8	<i>VL.Sal</i>	28.0	<i>VL.Sal</i>	33.1	<i>VL.Sal</i>	30.8	<i>VL.Sal</i>
Total Nitrogen - Kjeldahl	mg/kg	330	<i>VL</i>	436	<i>VL</i>	144	<i>VL</i>	290	<i>VL</i>	366	<i>VL</i>	361	<i>VL</i>
Total Phosphorus - Nitric/Perchloric	mg/kg	173	*	206	*	95.4	*	139	*	117	*	135	*
Phosphorus - Colwell extr	mg/kg	18.7	<i>M</i>	27.3	<i>H</i>	15.7	<i>M</i>	15.9	<i>M</i>	13.0	<i>L</i>	12.7	<i>L</i>
Potassium - Colwell ext	mg/kg	156	<i>M</i>	147	<i>L</i>	138	<i>L</i>	137	<i>L</i>	129	<i>L</i>	202	<i>H</i>
Sulphur - KCl	mg/kg	7.7	<i>L</i>	17.6	<i>H</i>	12.9	<i>H</i>	9.4	<i>M</i>	8.5	<i>M</i>	7.0	<i>L</i>
Organic Carbon	%	0.37	<i>EL</i>	0.45	<i>VL</i>	0.32	<i>EL</i>	0.39	<i>EL</i>	0.41	<i>VL</i>	0.72	<i>L</i>
Copper	mg/kg	0.26	<i>L</i>	0.56	<i>M</i>	0.27	<i>L</i>	0.36	<i>M</i>	0.32	<i>M</i>	0.44	<i>M</i>
Iron	mg/kg	29.4	*	74.0	*	14.9	*	28.0	*	12.8	*	43.8	*
Manganese	mg/kg	3.02	<i>M</i>	10.1	<i>M</i>	1.72	<i>L</i>	5.82	<i>M</i>	3.70	<i>M</i>	6.52	<i>M</i>
Zinc	mg/kg	0.36	<i>L</i>	0.44	<i>L</i>	<0.20	<i>FALSE</i>	0.26	<i>L</i>	0.24	<i>VL</i>	0.36	<i>L</i>
Boron	mg/kg	0.22	<i>VL</i>	0.22	<i>VL</i>	<0.20	<i>FALSE</i>	<0.20	<i>FALSE</i>	<0.20	<i>FALSE</i>	<0.20	<i>FALSE</i>
Cation Extraction Method	Rayment& Lyons	15C1	*	15A1	*	15C1	*	15A1	*	15C1	*	15A1	*
Cation Exchange Capacity	meq/100g	3.7	<i>VL</i>	5.7	<i>VL</i>	2.0	<i>VL</i>	4.3	<i>VL</i>	2.8	<i>VL</i>	5.7	<i>VL</i>
Ex Calcium Percent	%	78.32	<i>Normal</i>	56.18	<i>L</i>	42.60	<i>L</i>	64.72	<i>L</i>	71.89	<i>Normal</i>	57.98	<i>L</i>
Ex Magnesium Percent	%	13.92	<i>Normal</i>	27.90	<i>H</i>	31.70	<i>H</i>	27.06	<i>H</i>	19.75	<i>H</i>	27.57	<i>H</i>
Ex Potassium Percent	%	5.95	<i>H</i>	2.78	<i>Normal</i>	12.30	<i>H</i>	3.82	<i>Normal</i>	5.62	<i>H</i>	3.08	<i>Normal</i>
Ex Sodium Percent	%	1.51	<i>N.Sodic</i>	13.0	<i>Sodic</i>	12.83	<i>Sodic</i>	4.1	<i>N.Sodic</i>	2.34	<i>N.Sodic</i>	11.2	<i>Sodic</i>
Ex Aluminium Percent	%	0.30	<i>VL</i>	0.19	<i>VL</i>	0.56	<i>VL</i>	0.26	<i>VL</i>	0.40	<i>VL</i>	0.20	<i>VL</i>
Exchangeable Calcium	meq/100g	2.93	<i>L</i>	3.21	<i>L</i>	0.84	<i>VL</i>	2.77	<i>L</i>	1.99	<i>VL</i>	3.30	<i>L</i>
Exchangeable Magnesium	meq/100g	0.52	<i>L</i>	1.59	<i>M</i>	0.63	<i>L</i>	1.16	<i>M</i>	0.55	<i>L</i>	1.57	<i>M</i>
Exchangeable Potassium	meq/100g	0.22	<i>L</i>	0.16	<i>VL</i>	0.24	<i>L</i>	0.16	<i>VL</i>	0.16	<i>VL</i>	0.18	<i>VL</i>
Exchangeable Sodium	meq/100g	0.06	<i>VL</i>	0.74	<i>H</i>	0.25	<i>L</i>	0.18	<i>L</i>	0.06	<i>VL</i>	0.63	<i>M</i>
Exchangeable Aluminium	meq/100g	0.01	<i>H</i>	0.01	<i>H</i>	0.01	<i>H</i>	0.01	<i>H</i>	0.01	<i>H</i>	0.01	<i>H</i>
Calcium/Magnesium Ratio	-	5.6	<i>Balanced</i>	2.0	<i>Low Ca</i>	1.3	<i>Low Ca</i>	2.4	<i>Low Ca</i>	3.6	<i>Low Ca</i>	2.1	<i>Low Ca</i>
Emerson Aggregate	Class	3b	<i>Slight Disp</i>	7	<i>Stable</i>	2	<i>Disp.</i>	3b	<i>Slight Disp</i>	3b	<i>Slight Disp</i>	3b	<i>Slight Disp</i>
Phosphorus Buffer Index	mg/kg	43.3	*	44.5	*	40.6	*	38.2	*	40.0	*	36.9	*

	Highly acidic		Extremely alkaline		High salinity		Sodic		Strongly sodic
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Table B4: Laboratory analysis data for light loam topsoils. Part 5 of 7.

TABLE B4. Laboratory Results													
Loam/Sand													
	Lab No	220725-161		220725-173		220725-177		220725-181		220725-193		220725-197	
	Sample ID	SRM_13		SRM_160		SRM_70		SRM_176		SRM_129a		SRM_129b	
	Sample Depth (m)	Composite		Composite		Composite		Composite		Composite		Composite	
Analyses	Unit												
pH - Water	pH units	6.91	Neutral	6.14	L.Acid	5.71	M.acid	5.46	H.Acid	7.82	L.Alk	7.99	M.Alk
Electrical Conductivity	dS/m	0.16	M.Sal	0.12	L.Sal	0.06	VL.Sal	0.06	VL.Sal	0.07	L.Sal	0.11	L.Sal
Chloride	mg/kg	124	L.Sal	84.8	VL.Sal	61.8	VL.Sal	52.1	VL.Sal	60.3	VL.Sal	67.9	VL.Sal
Total Nitrogen - Kjeldahl	mg/kg	178	VL	365	VL	314	VL	358	VL	234	VL	297	VL
Total Phosphorus - Nitric/Perchloric	mg/kg	89.6	*	144	*	131	*	191	*	104	*	86.1	*
Phosphorus - Colwell extr	mg/kg	21.7	H	25.6	H	20.5	H	18.0	M	22.0	H	14.4	M
Potassium - Colwell ext	mg/kg	124	L	41.7	VL	47.4	VL	88.2	L	151	M	104	L
Sulphur - KCl	mg/kg	32.1	VH	11.0	M	7.3	L	10.3	M	14.4	H	14.1	H
Organic Carbon	%	0.13	EL	0.35	EL	0.25	EL	0.48	VL	0.10	EL	0.33	EL
Copper	mg/kg	0.44	M	0.42	M	0.28	L	0.36	M	0.26	L	0.2	L
Iron	mg/kg	25.1	*	427	*	237	*	119	*	29.0	*	7.60	*
Manganese	mg/kg	4.30	M	9.86	M	9.08	M	8.58	M	2.64	M	5.40	M
Zinc	mg/kg	<0.20	FALSE	0.32	L	<0.20	FALSE	0.30	L	<0.20	FALSE	0.32	L
Boron	mg/kg	0.20	VL	0.44	VL	0.32	VL	0.26	VL	0.26	VL	<0.20	FALSE
Cation Extraction Method	Rayment& Lyons	15A1	*	15A1	*	15A1	*	15A1	*	15C1	*	15C1	*
Cation Exchange Capacity	meq/100g	16.7	M	4.9	VL	3.2	VL	3.8	VL	1.8	VL	1.6	VL
Ex Calcium Percent	%	33.22	L	26.02	L	24.89	L	55.50	L	34.31	L	49.30	L
Ex Magnesium Percent	%	47.12	H	44.55	H	43.07	H	25.80	H	32.75	H	32.71	H
Ex Potassium Percent	%	1.21	Normal	1.37	Normal	2.25	Normal	3.77	Normal	7.16	H	9.20	H
Ex Sodium Percent	%	18.4	H.Sodic	27.6	H.Sodic	25.6	H.Sodic	14.5	H.Sodic	16.87	H.Sodic	8.09	Sodic
Ex Aluminium Percent	%	0.07	VL	0.48	VL	4.17	VL	0.44	VL	8.90	L	0.69	VL
Exchangeable Calcium	meq/100g	5.54	M	1.28	VL	0.79	VL	2.12	L	0.63	VL	0.79	VL
Exchangeable Magnesium	meq/100g	7.86	H	2.18	M	1.37	M	0.98	L	0.60	L	0.52	L
Exchangeable Potassium	meq/100g	0.20	L	0.07	VL	0.07	VL	0.14	VL	0.13	VL	0.15	VL
Exchangeable Sodium	meq/100g	3.07	VH	1.35	H	0.81	H	0.55	M	0.31	M	0.13	L
Exchangeable Aluminium	meq/100g	0.01	H	0.02	VH	0.13	E	0.02	H	0.16	E	0.01	H
Calcium/Magnesium Ratio	-	0.7	Low Ca	0.6	Low Ca	0.6	Low Ca	2.2	Low Ca	1.0	Low Ca	1.5	Low Ca
Emerson Aggregate	Class	2	Disp.	2	Disp.	3b	Slight Disp	7	Stable	2	Disp.	5	Slaking
Phosphorus Buffer Index	mq/kg	42.6	*	49.0	*	41.0	*	42.7	*	43.2	*	37.9	*

	Highly acidic		Extremely alkaline		High salinity		Sodic		Strongly sodic
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Table B4: Laboratory analysis data for light loam topsoils. Part 6 of 7.

TABLE B4. Laboratory Results Loam/Sand													
	Lab No	220725-201		220725-205		220725-213		220725-217		220725-309		220725-313	
	Sample ID	SRM_113		SRM_119		SRM_128		SRM_149		SRM_10b		SRM_10a	
	Sample Depth (m)	Composite		Composite		Composite		Composite		Composite		Composite	
Analyses	Unit												
pH - Water	pH units	7.38	Neutral	7.44	L.Alk	7.41	L.Alk	7.50	L.Alk	8.46	M.Alk	7.33	Neutral
Electrical Conductivity	dS/m	0.07	L.Sal	0.07	L.Sal	0.05	VL.Sal	0.17	M.Sal	0.16	M.Sal	0.07	L.Sal
Chloride	mg/kg	60.5	VL.Sal	51.0	VL.Sal	41.0	VL.Sal	133	L.Sal	41.5	VL.Sal	28.5	VL.Sal
Total Nitrogen - Kjeldahl	mg/kg	379	VL	322	VL	372	VL	374	VL	445	VL	371	VL
Total Phosphorus - Nitric/Perchloric	mg/kg	121	*	88.9	*	117	*	117	*	271	*	230	*
Phosphorus - Colwell extr	mg/kg	14.8	M	18.7	M	14.3	M	11.2	L	23.4	H	37.4	H
Potassium - Colwell ext	mg/kg	84.2	L	91.0	L	134	L	86.3	L	154	M	159	M
Sulphur - KCl	mg/kg	7.7	L	13.6	H	8.8	M	19.8	H	11.5	M	11.1	M
Organic Carbon	%	0.54	VL	0.24	EL	0.39	EL	0.37	EL	0.42	VL	0.32	EL
Copper	mg/kg	0.32	M	0.40	M	0.26	L	0.30	M	0.28	L	0.54	M
Iron	mg/kg	20.3	*	11.8	*	10.6	*	9.94	*	4.00	*	23.6	*
Manganese	mg/kg	6.60	M	8.82	M	6.22	M	7.66	M	3.78	M	6.70	M
Zinc	mg/kg	0.34	L	0.34	L	0.32	L	0.34	L	0.42	L	0.43	L
Boron	mg/kg	<0.20	FALSE	0.38	VL	0.22	VL	0.40	VL	0.68	L	0.20	VL
Cation Extraction Method	Rayment& Lyons	15C1	*	15C1	*	15C1	*	15C1	*	15C1	*	15C1	*
Cation Exchange Capacity	meq/100g	2.2	VL	2.3	VL	2.0	VL	2.5	VL	10.5	L	3.9	VL
Ex Calcium Percent	%	47.19	L	56.57	L	68.68	Normal	52.71	L	80.54	H	69.34	Normal
Ex Magnesium Percent	%	33.65	H	29.66	H	19.20	H	28.30	H	16.65	H	21.28	H
Ex Potassium Percent	%	7.04	H	5.08	H	8.23	H	4.99	Normal	1.70	Normal	6.81	H
Ex Sodium Percent	%	11.61	Sodic	8.22	Sodic	3.33	N.Sodic	13.56	Sodic	1.01	N.Sodic	2.28	N.Sodic
Ex Aluminium Percent	%	0.49	VL	0.48	VL	0.56	VL	0.45	VL	0.11	VL	0.28	VL
Exchangeable Calcium	meq/100g	1.06	VL	1.31	VL	1.37	VL	1.31	VL	8.47	M	2.72	L
Exchangeable Magnesium	meq/100g	0.76	L	0.68	L	0.38	L	0.70	L	1.75	M	0.83	L
Exchangeable Potassium	meq/100g	0.16	VL	0.12	VL	0.16	VL	0.12	VL	0.18	VL	0.27	L
Exchangeable Sodium	meq/100g	0.26	L	0.19	L	0.07	VL	0.34	M	0.11	L	0.09	VL
Exchangeable Aluminium	meq/100g	0.01	H	0.01	H	0.01	H	0.01	H	0.01	H	0.01	H
Calcium/Magnesium Ratio	-	1.4	Low Ca	1.9	Low Ca	3.6	Low Ca	1.9	Low Ca	4.8	Balanced	3.3	Low Ca
Emerson Aggregate	Class	3b	Slight Disp	2	Disp.	7	Stable	2	Disp.	5	Slaking	3b	Slight Disp
Phosphorus Buffer Index	mq/kg	42.8	*	42.3	*	35.9	*	39.7	*	57.7	*	55.2	*

	Highly acidic		Extremely alkaline		High salinity		Sodic		Strongly sodic
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Table B4: Laboratory analysis data for light loam topsoils. Part 7 of 7.

TABLE B4. Laboratory Results Loam/Sand													
	Lab No	220725-317		220725-321		220725-325		220725-377		Mean		Min	Max
	Sample ID	SRM_10c		SRM_169		SRM_17		SRM_7					
	Sample Depth (m)	Composite		Composite		Composite		Composite					
Analyses	Unit												
pH - Water	pH units	8.54	H.Alk	6.51	L.Acid	6.11	L.Acid	6.57	L.Acid	7.3	Neutral	5.5	8.8
Electrical Conductivity	dS/m	0.19	M.Sal	0.02	VL.Sal	0.09	L.Sal	0.09	L.Sal	0.07	VL.Sal	0.02	0.19
Chloride	mg/kg	68.9	VL.Sal	25.1	VL.Sal	43.5	VL.Sal	75.5	VL.Sal	46	VL.Sal	14	170
Total Nitrogen - Kjeldahl	mg/kg	531	L	306	VL	414	VL	275	VL	267	VL	63	531
Total Phosphorus - Nitric/Perchloric	mg/kg	320	*	228	*	126	*	83.3	*	126	*	52	320
Phosphorus - Colwell extr	mg/kg	22.1	H	25.7	H	17.3	M	17.4	M	20		10	52
Potassium - Colwell ext	mg/kg	159	M	124	L	26.1	VL	90.3	L	123		26	202
Sulphur - KCl	mg/kg	24.6	VH	7.6	L	7.6	L	10.4	M	10.63	M	3.13	32.10
Organic Carbon	%	0.67	L	0.26	EL	0.34	EL	0.35	EL	0.31	EL	0.08	0.72
Copper	mg/kg	0.38	M	0.34	M	0.50	M	0.24	L	0.33	M	0.20	0.56
Iron	mg/kg	5.56	*	17.0	*	22.4	*	49.7	*	48	*	4	427
Manganese	mg/kg	5.52	M	14.1	M	6.84	M	12.1	M	5.69	M	1.72	22.50
Zinc	mg/kg	0.38	L	0.30	L	0.31	L	0.42	L	0.33	L	0.22	0.44
Boron	mg/kg	0.42	VL	<0.20	FALSE	0.30	VL	0.28	VL	0.31	VL	0.20	0.68
Cation Extraction Method	Rayment& Lyons	15C1	*	15A1	*	15A1	*	15A1	*	*	*	*	*
Cation Exchange Capacity	meq/100g	8.5	L	6.5	L	6.3	L	3.5	VL	3.9	VL	1.5	16.7
Ex Calcium Percent	%	66.91	Normal	66.71	Normal	63.41	L	62.04	L	55.6	L	24.9	80.5
Ex Magnesium Percent	%	27.93	H	21.14	H	29.50	H	22.42	H	27.3	H	13.9	47.1
Ex Potassium Percent	%	3.12	Normal	3.56	Normal	1.08	Normal	6.25	H	6.8	H	1.1	18.7
Ex Sodium Percent	%	1.91	N.Sodic	8.4	Sodic	5.8	N.Sodic	9.0	Sodic	9.5	Sodic	1.0	27.6
Ex Aluminium Percent	%	0.13	VL	0.17	VL	0.18	VL	0.32	VL	0.8	VL	0.1	8.9
Exchangeable Calcium	meq/100g	5.71	M	4.34	L	4.00	L	2.17	L	2.2	L	0.6	8.5
Exchangeable Magnesium	meq/100g	2.38	M	1.38	M	1.86	M	0.78	L	1.1	M	0.3	7.9
Exchangeable Potassium	meq/100g	0.27	L	0.23	L	0.07	VL	0.22	L	0.2	VL	0.1	0.4
Exchangeable Sodium	meq/100g	0.16	L	0.55	M	0.37	M	0.31	M	0.4	M	0.0	3.1
Exchangeable Aluminium	meq/100g	0.01	H	0.01	H	0.01	H	0.01	H	0.0	VH	0.0	0.2
Calcium/Magnesium Ratio	-	2.4	Low Ca	3.2	Low Ca	2.1	Low Ca	2.8	Low Ca	2.3	Low Ca	0.6	5.6
Emerson Aggregate	Class	5	Slaking	3b	Slight Disp	7	Stable	3b	Slight Disp	*	*	*	*
Phosphorus Buffer Index	mg/ka	60.4	*	57.0	*	55.4	*	54.8	*	*	*	*	*

	Highly acidic		Extremely alkaline		High salinity		Sodic		Strongly sodic
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Table B5: Laboratory analysis data for heavy loam topsoils. Part 1 of 5.

TABLE B5. Laboratory Results Loam/Clay													
	Lab No	220725-4		220725-8		220725-12		220725-21		220725-25		220725-29	
	Sample ID	SRM_75a		SRM_75b		SRM_95		SRM_81		SRM_39		SRM_86	
	Sample Depth (m)	Composite		Composite		Composite		Composite		Composite		Composite	
Analyses	Unit												
pH - Water	pH units	6.22	<i>L.Acid</i>	8.02	<i>M.Alk</i>	5.71	<i>M.acid</i>	4.72	<i>VH.Acid</i>	8.15	<i>M.Alk</i>	5.25	<i>H.Acid</i>
Electrical Conductivity	dS/m	0.12	<i>L.Sal</i>	0.34	<i>M.Sal</i>	0.14	<i>L.Sal</i>	0.04	<i>VL.Sal</i>	0.41	<i>M.Sal</i>	0.03	<i>VL.Sal</i>
Chloride	mg/kg	72.5	<i>VL.Sal</i>	92.0	<i>VL.Sal</i>	87.0	<i>VL.Sal</i>	14.1	<i>VL.Sal</i>	299	<i>L.Sal</i>	21.1	<i>VL.Sal</i>
Total Nitrogen - Kjeldahl	mg/kg	436	<i>VL</i>	532	<i>L</i>	826	<i>L</i>	443	<i>VL</i>	555	<i>L</i>	435	<i>VL</i>
Total Phosphorus - Nitric/Perchloric	mg/kg	217	<i>*</i>	149	<i>*</i>	255	<i>*</i>	118	<i>*</i>	219	<i>*</i>	124	<i>*</i>
Phosphorus - Colwell extr	mg/kg	35.7	<i>M</i>	27.8	<i>M</i>	36.6	<i>M</i>	21.7	<i>M</i>	42.2	<i>H</i>	18.2	<i>M</i>
Potassium - Colwell ext	mg/kg	105	<i>VL</i>	125	<i>L</i>	122	<i>L</i>	118	<i>L</i>	144	<i>L</i>	104	<i>VL</i>
Sulphur - KCl	mg/kg	24.1	<i>VH</i>	172	<i>VH</i>	37.6	<i>VH</i>	6.9	<i>L</i>	131	<i>VH</i>	7.4	<i>L</i>
Organic Carbon	%	0.90	<i>L</i>	0.06	<i>EL</i>	0.09	<i>EL</i>	<0.05	<i>FALSE</i>	0.08	<i>EL</i>	<0.05	<i>FALSE</i>
Copper	mg/kg	0.62	<i>M</i>	0.66	<i>M</i>	1.18	<i>M</i>	0.86	<i>M</i>	0.56	<i>M</i>	0.78	<i>M</i>
Iron	mg/kg	154	<i>*</i>	9.90	<i>*</i>	733	<i>*</i>	1277	<i>*</i>	11.1	<i>*</i>	883	<i>*</i>
Manganese	mg/kg	4.30	<i>M</i>	1.90	<i>L</i>	6.16	<i>M</i>	4.24	<i>M</i>	3.42	<i>M</i>	3.14	<i>M</i>
Zinc	mg/kg	0.90	<i>M</i>	0.88	<i>M</i>	1.50	<i>M</i>	1.44	<i>M</i>	1.12	<i>M</i>	1.13	<i>M</i>
Boron	mg/kg	0.41	<i>VL</i>	0.39	<i>VL</i>	0.53	<i>L</i>	0.29	<i>VL</i>	0.33	<i>VL</i>	0.41	<i>VL</i>
Cation Extraction Method	Rayment& Lyons	15A1	<i>*</i>	15C1	<i>*</i>	15A1	<i>*</i>	15A1	<i>*</i>	15C1	<i>*</i>	15A1	<i>*</i>
Cation Exchange Capacity	meq/100g	5.8	<i>VL</i>	4.5	<i>VL</i>	6.0	<i>L</i>	2.6	<i>VL</i>	4.3	<i>VL</i>	3.1	<i>VL</i>
Ex Calcium Percent	%	36.75	<i>L</i>	30.64	<i>L</i>	32.36	<i>L</i>	34.41	<i>L</i>	28.82	<i>L</i>	35.62	<i>L</i>
Ex Magnesium Percent	%	46.44	<i>H</i>	49.04	<i>H</i>	49.36	<i>H</i>	26.95	<i>H</i>	49.18	<i>H</i>	38.41	<i>H</i>
Ex Potassium Percent	%	3.18	<i>Normal</i>	3.82	<i>Normal</i>	2.46	<i>Normal</i>	10.98	<i>H</i>	3.70	<i>Normal</i>	9.92	<i>H</i>
Ex Sodium Percent	%	13.0	<i>Sodic</i>	21.5	<i>H.Sodic</i>	15.5	<i>H.Sodic</i>	2.9	<i>N.Sodic</i>	30.1	<i>H.Sodic</i>	11.1	<i>Sodic</i>
Ex Aluminium Percent	%	0.64	<i>VL</i>	0.25	<i>VL</i>	0.34	<i>VL</i>	24.81	<i>H</i>	0.26	<i>VL</i>	4.91	<i>VL</i>
Exchangeable Calcium	meq/100g	2.13	<i>L</i>	1.39	<i>VL</i>	1.95	<i>VL</i>	0.90	<i>VL</i>	1.25	<i>VL</i>	1.11	<i>VL</i>
Exchangeable Magnesium	meq/100g	2.69	<i>M</i>	2.22	<i>M</i>	2.97	<i>M</i>	0.71	<i>L</i>	2.13	<i>M</i>	1.19	<i>M</i>
Exchangeable Potassium	meq/100g	0.18	<i>VL</i>	0.17	<i>VL</i>	0.15	<i>VL</i>	0.29	<i>L</i>	0.16	<i>VL</i>	0.31	<i>M</i>
Exchangeable Sodium	meq/100g	0.75	<i>H</i>	0.73	<i>H</i>	0.93	<i>H</i>	0.07	<i>VL</i>	0.78	<i>H</i>	0.35	<i>M</i>
Exchangeable Aluminium	meq/100g	0.04	<i>E</i>	0.01	<i>H</i>	0.02	<i>VH</i>	0.65	<i>E</i>	0.01	<i>H</i>	0.15	<i>E</i>
Calcium/Magnesium Ratio	-	0.8	<i>Low Ca</i>	0.6	<i>Low Ca</i>	0.7	<i>Low Ca</i>	1.3	<i>Low Ca</i>	0.6	<i>Low Ca</i>	0.9	<i>Low Ca</i>
Emerson Aggregate	Class	3a	<i>Disp.</i>	2.0	<i>Disp.</i>	7.0	<i>Stable</i>	5.0	<i>Slaking</i>	2.0	<i>Disp.</i>	3b	<i>Slight Disp</i>
Phosphorus Buffer Index	mg/kg	14.1	<i>*</i>	10.2	<i>*</i>	14.2	<i>*</i>	52.6	<i>*</i>	34.7	<i>*</i>	44.6	<i>*</i>

	Highly acidic		Extremely alkaline		High salinity		Sodic		Strongly sodic
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Table B5: Laboratory analysis data for heavy loam topsoils. Part 2 of 5.

TABLE B5. Laboratory Results Loam/Clay													
	Lab No	220725-33		220725-41		220725-45		220725-69		220725-89		220725-93	
	Sample ID	SRM_103		SRM_42		SRM_4		SRM_15		SRM_97		SRM_43	
	Sample Depth (m)	Composite		Composite		Composite		Composite		Composite		Composite	
Analyses	Unit												
pH - Water	pH units	6.24	L.Acid	7.96	M.Alk	7.08	Neutral	6.30	L.Acid	7.67	L.Alk	8.00	M.Alk
Electrical Conductivity	dS/m	0.18	L.Sal	0.10	L.Sal	0.07	VL.Sal	0.19	M.Sal	0.06	VL.Sal	0.08	VL.Sal
Chloride	mg/kg	130	L.Sal	45.0	VL.Sal	70.3	VL.Sal	24.6	VL.Sal	16.0	VL.Sal	36.8	VL.Sal
Total Nitrogen - Kjeldahl	mg/kg	330	VL	613	L	64.0	VL	423	VL	164	VL	106	VL
Total Phosphorus - Nitric/Perchloric	mg/kg	175	*	174	*	52.4	*	113	*	82.8	*	76.5	*
Phosphorus - Colwell extr	mg/kg	28.8	M	37.4	M	19.6	M	38.5	M	22.4	M	25.3	M
Potassium - Colwell ext	mg/kg	117	L	156	L	112	L	139	L	128	L	132	L
Sulphur - KCl	mg/kg	44.1	VH	25.7	VH	10.6	M	10.9	M	6.9	L	9.3	M
Organic Carbon	%	0.83	L	1.42	M	0.19	EL	0.47	VL	0.43	VL	0.33	EL
Copper	mg/kg	0.84	M	0.72	M	0.50	M	0.42	M	0.50	M	0.56	M
Iron	mg/kg	103	*	13.6	*	40.3	*	45.6	*	29.9	*	19.7	*
Manganese	mg/kg	6.10	M	4.07	M	7.74	M	8.72	M	4.38	M	3.76	M
Zinc	mg/kg	0.64	M	0.98	M	<0.20	FALSE	0.28	L	<0.20	FALSE	<0.20	FALSE
Boron	mg/kg	0.43	VL	0.47	VL	0.29	VL	0.37	VL	0.30	VL	0.32	VL
Cation Extraction Method	Rayment& Lyons	15A1	*	15C1	*	15A1	*	15A1	*	15C1	*	15C1	*
Cation Exchange Capacity	meq/100g	5.5	VL	3.6	VL	3.6	VL	5.6	VL	2.9	VL	3.7	VL
Ex Calcium Percent	%	24.66	L	41.97	L	49.31	L	64.39	L	54.31	L	46.54	L
Ex Magnesium Percent	%	42.17	H	45.63	H	27.86	H	27.65	H	31.42	H	39.24	H
Ex Potassium Percent	%	5.88	H	3.65	Normal	9.93	H	3.80	Normal	8.76	H	6.66	H
Ex Sodium Percent	%	26.7	H.Sodic	11.0	Sodic	12.6	Sodic	4.0	N.Sodic	7.8	Sodic	8.1	Sodic
Ex Aluminium Percent	%	0.59	VL	0.31	VL	0.31	VL	0.20	VL	0.38	VL	0.30	VL
Exchangeable Calcium	meq/100g	1.35	VL	1.51	VL	1.77	VL	3.59	L	1.57	VL	1.70	VL
Exchangeable Magnesium	meq/100g	2.30	M	1.64	M	1.00	M	1.54	M	0.91	L	1.43	M
Exchangeable Potassium	meq/100g	0.32	M	0.13	VL	0.36	M	0.21	L	0.25	L	0.24	L
Exchangeable Sodium	meq/100g	1.46	H	0.30	M	0.45	M	0.22	L	0.15	L	0.27	L
Exchangeable Aluminium	meq/100g	0.03	E	0.01	H	0.01	H	0.01	H	0.01	H	0.01	H
Calcium/Magnesium Ratio	-	0.6	Low Ca	0.9	Low Ca	1.8	Low Ca	2.3	Low Ca	1.7	Low Ca	1.2	Low Ca
Emerson Aggregate	Class	2	Disp.	3b	Slight Disp	3b	Slight Disp	5	Slaking	7	Stable	3b	Slight Disp
Phosphorus Buffer Index	mq/ka	37.7	*	35.1	*	29.3	*	12.2	*	28.7	*	41.7	*

	Highly acidic		Extremely alkaline		High salinity		Sodic		Strongly sodic
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Table B5: Laboratory analysis data for heavy loam topsoils. Part 3 of 5.

TABLE B5. Laboratory Results Loam/Clay													
	Lab No	220725-101		220725-153		220725-185		220725-189		220725-209		220725-225	
	Sample ID	SRM_25		SRM_38		SRM_158a		SRM_158b		SRM_127		SRM_173	
	Sample Depth (m)	Composite		Composite		Composite		Composite		Composite		Composite	
Analyses	Unit												
pH - Water	pH units	7.04	Neutral	7.61	L. Alk	6.40	L. Acid	7.24	Neutral	6.77	Neutral	6.47	L. Acid
Electrical Conductivity	dS/m	0.13	L. Sal	0.10	L. Sal	0.09	L. Sal	0.15	L. Sal	0.12	L. Sal	0.13	L. Sal
Chloride	mg/kg	40.8	VL. Sal	72.6	VL. Sal	75.8	VL. Sal	104.0	L. Sal	62.8	VL. Sal	54.6	VL. Sal
Total Nitrogen - Kjeldahl	mg/kg	479	VL	599	L	315	VL	345	VL	625	L	585	L
Total Phosphorus - Nitric/Perchloric	mg/kg	150	*	165	*	183	*	170	*	178	*	119	*
Phosphorus - Colwell extr	mg/kg	21.3	M	17.2	L	24.9	M	33.7	M	15.1	L	13.6	L
Potassium - Colwell ext	mg/kg	121	L	119	L	67.9	VL	66.7	VL	195	M	111	L
Sulphur - KCl	mg/kg	10.6	M	8.7	M	17.0	H	21.5	VH	17.7	H	25.5	VH
Organic Carbon	%	0.57	VL	1.25	M	0.23	EL	0.29	EL	0.77	L	0.55	VL
Copper	mg/kg	0.68	M	0.68	M	0.5	M	0.54	M	0.56	M	0.46	M
Iron	mg/kg	29.6	*	64.3	*	109	*	43.2	*	12.2	*	27.8	*
Manganese	mg/kg	11.40	M	10.8	M	11.3	M	4.92	M	14.4	M	13.2	M
Zinc	mg/kg	0.44	L	0.28	VL	0.20	L	<0.20	FALSE	0.70	M	0.44	L
Boron	mg/kg	0.54	L	0.66	L	0.28	VL	0.48	VL	0.26	VL	0.24	VL
Cation Extraction Method	Rayment& Lyons	15A1	*	15C1	*	15A1	*	15A1	*	15A1	*	15A1	*
Cation Exchange Capacity	meq/100g	8.1	L	5.0	VL	3.5	VL	6.5	L	6.4	L	5.4	VL
Ex Calcium Percent	%	50.88	L	58.61	L	39.99	L	33.54	L	67.48	Normal	59.16	L
Ex Magnesium Percent	%	33.73	H	28.88	H	34.89	H	41.35	H	17.18	H	27.54	H
Ex Potassium Percent	%	2.71	Normal	4.85	Normal	3.20	Normal	2.08	Normal	5.93	H	5.11	H
Ex Sodium Percent	%	12.5	Sodic	13.1	Sodic	21.6	H. Sodic	22.9	H. Sodic	9.2	Sodic	8.0	Sodic
Ex Aluminium Percent	%	0.14	VL	0.22	VL	0.32	VL	0.17	VL	0.17	VL	0.21	VL
Exchangeable Calcium	meq/100g	4.11	L	2.96	L	1.39	VL	2.17	L	4.32	L	3.21	L
Exchangeable Magnesium	meq/100g	2.73	M	1.46	M	1.21	M	2.68	M	1.10	M	1.49	M
Exchangeable Potassium	meq/100g	0.22	L	0.24	L	0.11	VL	0.13	VL	0.38	M	0.28	L
Exchangeable Sodium	meq/100g	1.01	H	0.38	M	0.75	H	1.48	H	0.59	M	0.43	M
Exchangeable Aluminium	meq/100g	0.01	H	0.01	H	0.01	H	0.01	H	0.01	H	0.01	H
Calcium/Magnesium Ratio	-	1.5	Low Ca	2.0	Low Ca	1.1	Low Ca	0.8	Low Ca	3.9	Low Ca	2.1	Low Ca
Emerson Aggregate	Class	7	Stable	3b	Slight Disp	3b	Slight Disp	2	Disp.	3b	Slight Disp	5	Slaking
Phosphorus Buffer Index	mg/kg	46.5	*	61.9	*	47.0	*	47.7	*	44.6	*	44.7	*

	Highly acidic		Extremely alkaline		High salinity		Sodic		Strongly sodic
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Table B5: Laboratory analysis data for heavy loam topsoils. Part 4 of 5.

TABLE B5. Laboratory Results Loam/Clay													
	Lab No	220725-229		220725-233		220725-237		220725-241		220725-301		220725-357	
	Sample ID	SRM_121		SRM_116		SRM_78		SRM_50		SRM_130		SRM_109	
	Sample Depth (m)	Composite		Composite		Composite		Composite		Composite		Composite	
Analyses	Unit												
pH - Water	pH units	7.14	Neutral	7.47	L.Alk	7.96	M.Alk	8.93	H.Alk	6.47	L.Acid	8.51	H.Alk
Electrical Conductivity	dS/m	0.10	L.Sal	0.11	L.Sal	0.16	L.Sal	0.31	M.Sal	0.07	VL.Sal	0.24	M.Sal
Chloride	mg/kg	60.7	VL.Sal	53.8	VL.Sal	81.5	VL.Sal	176	L.Sal	39.1	VL.Sal	149.0	L.Sal
Total Nitrogen - Kjeldahl	mg/kg	432	VL	559	L	641	L	403	VL	479	VL	274	VL
Total Phosphorus - Nitric/Perchloric	mg/kg	121	*	125	*	173	*	198	*	265	*	129	*
Phosphorus - Colwell extr	mg/kg	16.5	L	21.6	M	25.0	M	20.0	M	21.0	M	13.3	L
Potassium - Colwell ext	mg/kg	112	L	80.1	VL	80.8	VL	84.5	VL	136	L	74.2	VL
Sulphur - KCl	mg/kg	16.2	H	7.8	L	22.1	VH	51.5	VH	9.8	M	51.1	VH
Organic Carbon	%	0.68	L	0.46	VL	0.56	VL	0.43	VL	0.73	L	0.70	L
Copper	mg/kg	0.46	M	0.43	M	0.50	M	0.60	M	0.48	M	0.28	L
Iron	mg/kg	26.2	*	10.1	*	7.84	*	7.08	*	22.0	*	6.90	*
Manganese	mg/kg	9.84	M	8.63	M	7.72	M	8.70	M	14.9	M	6.64	M
Zinc	mg/kg	0.38	L	0.36	L	0.48	L	0.40	L	0.42	L	0.48	L
Boron	mg/kg	0.38	VL	0.54	L	0.62	L	0.58	L	0.28	VL	0.32	VL
Cation Extraction Method	Rayment& Lyons	15A1	*	15C1	*	15C1	*	15C1	*	15A1	*	15C1	*
Cation Exchange Capacity	meq/100g	4.5	VL	4.2	VL	6.0	VL	7.4	L	7.7	L	3.6	VL
Ex Calcium Percent	%	57.62	L	56.75	L	61.53	L	40.87	L	57.31	L	53.78	L
Ex Magnesium Percent	%	23.82	H	33.78	H	29.40	H	44.43	H	31.84	H	28.27	H
Ex Potassium Percent	%	4.52	Normal	3.33	Normal	2.39	Normal	1.90	Normal	4.05	Normal	4.33	Normal
Ex Sodium Percent	%	13.8	Sodic	5.88	N.Sodic	6.50	Sodic	12.65	Sodic	6.1	Sodic	26.1	H.Sodic
Ex Aluminium Percent	%	0.25	VL	0.26	VL	0.19	VL	0.15	VL	0.71	VL	0.31	VL
Exchangeable Calcium	meq/100g	2.58	L	2.38	L	3.68	L	3.02	L	4.43	L	1.95	VL
Exchangeable Magnesium	meq/100g	1.07	M	1.42	M	1.76	M	3.28	H	2.46	M	1.03	M
Exchangeable Potassium	meq/100g	0.20	L	0.14	VL	0.14	VL	0.14	VL	0.31	M	0.16	VL
Exchangeable Sodium	meq/100g	0.62	M	0.25	L	0.39	M	0.93	H	0.47	M	0.48	M
Exchangeable Aluminium	meq/100g	0.01	H	0.01	H	0.01	H	0.01	H	0.06	E	0.01	H
Calcium/Magnesium Ratio	-	2.4	Low Ca	1.7	Low Ca	2.1	Low Ca	0.9	Low Ca	1.8	Low Ca	1.9	Low Ca
Emerson Aggregate	Class	3b	Slight Disp	3b	Slight Disp	3b	Slight Disp	3b	Slight Disp	3b	Slight Disp	2	Disp.
Phosphorus Buffer Index	mg/kg	40.2	*	47.0	*	51.0	*	49.7	*	61.5	*	53.6	*

	Highly acidic		Extremely alkaline		High salinity		Sodic		Strongly sodic
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Table B5: Laboratory analysis data for heavy loam topsoils. Part 5 of 5.

TABLE B5. Laboratory Results													
Loam/Clay										Mean		Min	Max
	Lab No	220725-361		220725-365		220725-369		220725-373					
	Sample ID	SRM_16		SRM_115b		SRM_118		SRM_40					
	Sample Depth (m)	Composite		Composite		Composite		Composite					
Analyses	Unit												
pH - Water	pH units	7.79	L. Alk	8.3	M. Alk	8.19	M. Alk	8.09	M. Alk	7.2	Neutral	4.7	8.9
Electrical Conductivity	dS/m	0.13	L. Sal	0.14	L. Sal	0.12	L. Sal	0.19	M. Sal	0.14	L. Sal	0.03	0.41
Chloride	mg/kg	76.3	VL. Sal	74.3	VL. Sal	78.0	VL. Sal	82.8	VL. Sal	78	VL. Sal	14	299
Total Nitrogen - Kjeldahl	mg/kg	407	VL	337	VL	210	VL	273	VL	425	VL	64	826
Total Phosphorus - Nitric/Perchloric	mg/kg	156	*	95.3	*	103	*	84.7	*	149	*	52	265
Phosphorus - Colwell extr	mg/kg	11.3	L	29.5	M	16.4	L	12.8	L	24		11	42
Potassium - Colwell ext	mg/kg	101	VL	83.8	VL	87.5	VL	129	L	113		67	195
Sulphur - KCl	mg/kg	24.2	VH	27.4	VH	20.7	VH	25.2	VH	30.12	VH	6.93	172.00
Organic Carbon	%	0.75	L	0.41	VL	0.73	L	0.36	EL	0.55	VL	0.06	1.42
Copper	mg/kg	0.46	M	0.48	M	0.54	M	<0.20	FALSE	0.59	M	0.28	1.18
Iron	mg/kg	13.8	*	9.28	*	24.5	*	13.4	*	134	*	7	1277
Manganese	mg/kg	10.1	M	5.10	M	2.92	M	4.64	M	7.26	M	1.90	14.90
Zinc	mg/kg	0.42	L	0.43	L	0.42	L	0.36	L	0.63	L	0.20	1.50
Boron	mg/kg	0.38	VL	0.44	VL	0.36	VL	0.32	VL	0.40	VL	0.24	0.66
Cation Extraction Method	Rayment& Lyons	15C1	*	15C1	*	15C1	*	15C1	*	*	*	*	*
Cation Exchange Capacity	meq/100g	4.7	VL	3.5	VL	1.9	VL	2.7	VL	4.7	VL	1.9	8.1
Ex Calcium Percent	%	66.91	Normal	60.89	L	52.44	L	74.66	Normal	49.0	L	24.7	74.7
Ex Magnesium Percent	%	25.35	H	26.32	H	27.10	H	16.37	H	33.7	H	16.4	49.4
Ex Potassium Percent	%	2.73	Normal	4.95	Normal	6.91	H	5.91	H	4.9	Normal	1.9	11.0
Ex Sodium Percent	%	10.8	Sodic	15.6	H. Sodic	22.1	H. Sodic	12.0	Sodic	13.7	Sodic	2.9	30.1
Ex Aluminium Percent	%	0.24	VL	0.32	VL	0.59	VL	0.42	VL	1.4	VL	0.1	24.8
Exchangeable Calcium	meq/100g	3.15	L	2.14	L	1.00	VL	1.98	VL	2.3	L	0.9	4.4
Exchangeable Magnesium	meq/100g	1.19	M	0.93	L	0.51	L	0.43	L	1.6	M	0.4	3.3
Exchangeable Potassium	meq/100g	0.13	VL	0.17	VL	0.13	VL	0.16	VL	0.2	L	0.1	0.4
Exchangeable Sodium	meq/100g	0.22	L	0.26	L	0.25	L	0.07	VL	0.5	M	0.1	1.5
Exchangeable Aluminium	meq/100g	0.01	H	0.01	H	0.01	H	0.01	H	0.0	E	0.0	0.6
Calcium/Magnesium Ratio	-	2.6	Low Ca	2.3	Low Ca	1.9	Low Ca	4.6	Balanced	1.7	Low Ca	0.6	4.6
Emerson Aggregate	Class	7	Stable	2	Disp.	2	Disp.	5	Slaking	*	*	*	*
Phosphorus Buffer Index	mg/kg	60.6	*	59.2	*	55.2	*	55.2	*	*	*	*	*

	Highly acidic		Extremely alkaline		High salinity		Sodic		Strongly sodic
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Table B6: Laboratory analysis data for clay topsoils. Part 1 of 5.

TABLE B6. Laboratory Results													
Clay													
	Lab No	220725-157		220725-165		220725-169		220725-		220725-		220725-	
	Sample ID	SRM_58		SRM_131		SRM_178		SRM_133		SRM_21b		SRM_21a	
	Sample Depth (m)	Composite		Composite		Composite		Composite		Composite		Composite	
Analyses	Unit												
pH - Water	pH units	8.00	M.Alk	7.65	L.Alk	7.21	Neutral	8.44	M.Alk	7.4	L.Alk	8.76	H.Alk
Electrical Conductivity	dS/m	0.22	L.Sal	0.27	M.Sal	0.57	H.Sal	0.26	M.Sal	0.16	L.Sal	0.13	L.Sal
Chloride	mg/kg	201	L.Sal	183	L.Sal	603	H.Sal	172	L.Sal	104	L.Sal	63.8	VL.Sal
Total Nitrogen - Kjeldahl	mg/kg	409	VL	908	L	1078	L	827	L	792	L	905	L
Total Phosphorus - Nitric/Perchloric	mg/kg	166	*	198	*	242	*	215	*	142	*	193	*
Phosphorus - Colwell extr	mg/kg	18.9	L	20.2	L	44.4	M	16.5	L	12.3	L	24.6	L
Potassium - Colwell ext	mg/kg	78.7	VL	85.7	VL	78.5	VL	102	VL	109	VL	69.8	VL
Sulphur - KCl	mg/kg	29.3	VH	12.1	H	13.9	H	15.3	H	17.1	H	11.7	M
Organic Carbon	%	0.81	L	1.25	M	0.54	VL	0.80	L	0.79	L	0.83	L
Copper	mg/kg	0.64	M	0.62	M	1.06	M	0.74	M	1.04	M	0.44	M
Iron	mg/kg	14.8	*	35.0	*	55.6	*	9.90	*	14.30	*	6.26	*
Manganese	mg/kg	2.82	M	4.48	M	11.7	M	8.12	M	9.06	M	4.94	M
Zinc	mg/kg	0.32	L	0.32	L	0.62	L	0.52	L	0.36	L	0.36	L
Boron	mg/kg	0.98	L	1.10	M	1.28	M	1.18	M	0.86	L	1.06	M
Cation Extraction Method	Rayment& Lyons	15C1	*	15C1	*	15A2	*	15C1	*	15C1	*	15C1	*
Cation Exchange Capacity	meq/100g	6.4	L	6.2	L	19.9	M	10.1	L	16.4	M	12.5	M
Ex Calcium Percent	%	28.16	L	39.43	L	34.93	L	51.64	L	55.70	L	55.53	L
Ex Magnesium Percent	%	51.59	H	38.07	H	52.05	H	38.51	H	38.47	H	36.97	H
Ex Potassium Percent	%	2.22	Normal	2.66	Normal	0.93	L	1.67	Normal	1.01	Normal	1.14	Normal
Ex Sodium Percent	%	17.86	H.Sodic	19.65	H.Sodic	12.04	Sodic	8.07	Sodic	4.75	N.Sodic	6.27	Sodic
Ex Aluminium Percent	%	0.17	VL	0.18	VL	0.06	VL	0.11	VL	0.07	VL	0.09	VL
Exchangeable Calcium	meq/100g	1.81	VL	2.46	L	6.94	M	5.23	M	9.12	M	6.94	M
Exchangeable Magnesium	meq/100g	3.32	H	2.38	M	10.33	VH	3.90	H	6.30	H	4.62	H
Exchangeable Potassium	meq/100g	0.14	VL	0.17	VL	0.18	VL	0.17	VL	0.17	VL	0.14	VL
Exchangeable Sodium	meq/100g	1.15	H	1.23	H	2.39	VH	0.82	H	0.78	H	0.78	H
Exchangeable Aluminium	meq/100g	0.01	H	0.01	H	0.01	H	0.01	H	0.01	H	0.01	H
Calcium/Magnesium Ratio	-	0.5	Low Ca	1.0	Low Ca	0.7	Low Ca	1.3	Low Ca	1.4	Low Ca	1.5	Low Ca
Emerson Aggregate	Class	3b	Slight Disp	3b	Slight Disp	5	Slaking	4	Slaking	7	Stable	3b	Slight Disp
Phosphorus Buffer Index	mg/kg	54.2	*	62.4	*	89.4	*	73.2	*	91.7	*	78.9	*

	Highly acidic		Extremely alkaline		High salinity		Sodic		Strongly sodic
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Table B6: Laboratory analysis data for clay topsoils. Part 2 of 5.

TABLE B6. Laboratory Results													
Clay													
	Lab No	220725-253		220725-257		220725-261		220725-265		220725-269		220725-273	
	Sample ID	SRM_144b		SRM_144a		SRM_163d		SRM_163b		SRM_163a		SRM_45	
	Sample Depth (m)	Composite		Composite		Composite		Composite		Composite		Composite	
Analyses	Unit												
pH - Water	pH units	8.8	H.Alk	9.02	E.Alk	8.29	M.Alk	8.70	H.Alk	8.17	M.Alk	8.55	H.Alk
Electrical Conductivity	dS/m	0.17	L.Sal	0.19	L.Sal	0.30	M.Sal	0.27	M.Sal	0.28	M.Sal	0.15	L.Sal
Chloride	mg/kg	72.7	VL.Sal	81.7	VL.Sal	180	L.Sal	142	L.Sal	139	L.Sal	39.7	VL.Sal
Total Nitrogen - Kjeldahl	mg/kg	954	L	694	L	959	L	827	L	1239	L	1065	L
Total Phosphorus - Nitric/Perchloric	mg/kg	186	*	158	*	119	*	112	*	243	*	215	*
Phosphorus - Colwell extr	mg/kg	20.3	L	12.4	L	71.0	M	10.9	L	20.4	L	18.0	L
Potassium - Colwell ext	mg/kg	69.3	VL	119	VL	207	M	100	VL	269	M	88.9	VL
Sulphur - KCl	mg/kg	12.9	H	15.8	H	46.8	VH	16.4	H	50.0	VH	6.9	L
Organic Carbon	%	0.86	L	0.69	L	1.04	M	0.86	L	1.32	M	1.14	M
Copper	mg/kg	0.96	M	0.76	M	0.94	M	1.08	M	1.10	M	0.48	M
Iron	mg/kg	5.30	*	3.52	*	6.90	*	5.22	*	8.96	*	4.02	*
Manganese	mg/kg	5.84	M	4.54	M	5.68	M	4.80	M	6.54	M	5.12	M
Zinc	mg/kg	0.40	L	0.34	L	0.38	L	0.40	L	0.36	L	0.38	L
Boron	mg/kg	1.24	M	1.48	M	1.86	M	0.88	L	2.10	H	0.78	L
Cation Extraction Method	Rayment& Lyons	15C1	*	15C1	*	15C1	*	15C1	*	15C1	*	15C1	*
Cation Exchange Capacity	meq/100g	17.6	M	24.5	M	26.6	H	34.1	H	31.7	H	20.4	M
Ex Calcium Percent	%	52.65	L	53.10	L	48.18	L	57.38	L	48.52	L	66.97	Normal
Ex Magnesium Percent	%	38.86	H	38.96	H	43.76	H	35.41	H	43.59	H	30.17	H
Ex Potassium Percent	%	0.82	L	0.69	L	1.34	Normal	0.44	L	1.41	Normal	0.67	L
Ex Sodium Percent	%	7.60	Sodic	7.21	Sodic	6.68	Sodic	6.74	Sodic	6.44	Sodic	2.13	N.Sodic
Ex Aluminium Percent	%	0.06	VL	0.05	VL	0.04	VL	0.03	VL	0.04	VL	0.05	VL
Exchangeable Calcium	meq/100g	9.28	M	13.01	H	12.84	H	19.56	H	15.36	H	13.67	H
Exchangeable Magnesium	meq/100g	6.85	H	9.54	VH	11.66	VH	12.07	VH	13.80	VH	6.16	H
Exchangeable Potassium	meq/100g	0.14	VL	0.17	VL	0.36	M	0.15	VL	0.45	M	0.14	VL
Exchangeable Sodium	meq/100g	1.34	H	1.77	H	1.78	H	2.30	VH	2.04	VH	0.43	M
Exchangeable Aluminium	meq/100g	0.01	H	0.01	H	0.01	H	0.01	H	0.01	H	0.01	H
Calcium/Magnesium Ratio	-	1.4	Low Ca	1.4	Low Ca	1.1	Low Ca	1.6	Low Ca	1.1	Low Ca	2.2	Low Ca
Emerson Aggregate	Class	3b	Slight Disp	7	Stable	7	Stable	7	Stable	7	Stable	7	Stable
Phosphorus Buffer Index	mq/ka	83.5	*	89.2	*	118	*	94.9	*	109	*	79.5	*

	Highly acidic		Extremely alkaline		High salinity		Sodic		Strongly sodic
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Table B6: Laboratory analysis data for clay topsoils. Part 3 of 5.

TABLE B6. Laboratory Results Clay													
	Lab No	220725-277		220725-281		220725-285		220725-289		220725-293		220725-297	
	Sample ID	SRM_142		SRM_123		SRM_64		SRM_134		SRM_145		SRM_154	
	Sample Depth (m)	Composite		Composite		Composite		Composite		Composite		Composite	
Analyses	Unit												
pH - Water	pH units	9.16	E.Alk	8.57	H.Alk	8.21	M.Alk	8.14	M.Alk	8.60	H.Alk	7.87	L.Alk
Electrical Conductivity	dS/m	0.34	M.Sal	0.15	L.Sal	0.14	L.Sal	0.19	L.Sal	0.34	M.Sal	0.22	L.Sal
Chloride	mg/kg	218	L.Sal	12.2	VL.Sal	26.7	VL.Sal	89.0	VL.Sal	176	L.Sal	131	L.Sal
Total Nitrogen - Kjeldahl	mg/kg	<50.0	FALSE	846	L	947	L	447	VL	415	VL	770	L
Total Phosphorus - Nitric/Perchloric	mg/kg	295	*	138	*	158	*	145	*	131	*	229	*
Phosphorus - Colwell extr	mg/kg	6.7	L	11.2	L	12.1	L	12.3	L	7.5	L	20.1	L
Potassium - Colwell ext	mg/kg	77.0	VL	75.6	VL	101	VL	181	M	112	VL	154	L
Sulphur - KCl	mg/kg	7.3	L	7.1	L	8.0	L	15.9	H	22.9	VH	12.8	H
Organic Carbon	%	0.86	L	1.20	M	1.43	M	0.89	L	0.95	L	0.60	L
Copper	mg/kg	<0.20	FALSE	0.36	M	0.66	M	0.86	M	0.74	M	3.40	M
Iron	mg/kg	0.98	*	3.96	*	10.5	*	8.28	*	5.60	*	15.2	*
Manganese	mg/kg	2.44	M	5.26	M	6.52	M	5.50	M	4.48	M	13.1	M
Zinc	mg/kg	0.26	VL	0.34	L	0.34	L	0.30	L	0.28	VL	1.22	M
Boron	mg/kg	1.02	M	0.74	L	0.72	L	1.34	M	1.70	M	1.12	M
Cation Extraction Method	Rayment& Lyons	15C1	*	15C1	*	15C1	*	15C1	*	15C1	*	15C1	*
Cation Exchange Capacity	meq/100g	33.2	H	17.3	M	22.6	M	26.2	H	25.2	H	24.5	M
Ex Calcium Percent	%	33.67	L	65.57	Normal	67.98	Normal	52.61	L	43.10	L	46.72	L
Ex Magnesium Percent	%	57.20	H	30.98	H	30.25	H	41.29	H	46.98	H	44.69	H
Ex Potassium Percent	%	0.24	L	0.60	L	0.63	L	1.29	Normal	0.84	L	1.13	Normal
Ex Sodium Percent	%	8.86	Sodic	2.78	N.Sodic	1.09	N.Sodic	4.77	N.Sodic	9.04	Sodic	7.41	Sodic
Ex Aluminium Percent	%	0.03	VL	0.06	VL	0.05	VL	0.04	VL	0.04	VL	0.05	VL
Exchangeable Calcium	meq/100g	11.18	H	11.38	H	15.36	H	13.81	H	10.88	H	11.46	H
Exchangeable Magnesium	meq/100g	18.98	VH	5.38	H	6.83	H	10.83	VH	11.86	VH	10.96	VH
Exchangeable Potassium	meq/100g	0.08	VL	0.10	VL	0.14	VL	0.34	M	0.21	L	0.28	L
Exchangeable Sodium	meq/100g	2.94	VH	0.48	M	0.25	L	1.25	H	2.28	VH	1.82	H
Exchangeable Aluminium	meq/100g	0.01	H	0.01	H	0.01	H	0.01	H	0.01	H	0.01	H
Calcium/Magnesium Ratio	-	0.6	Low Ca	2.1	Low Ca	2.2	Low Ca	1.3	Low Ca	0.9	Low Ca	1.0	Low Ca
Emerson Aggregate	Class	4	Slaking	7	Stable	7	Stable	7	Stable	7	Stable	3b	Slight Disp
Phosphorus Buffer Index	mg/kg	69.3	*	75.3	*	96.0	*	120	*	113	*	97.0	*

	Highly acidic		Extremely alkaline		High salinity		Sodic		Strongly sodic
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Table B6: Laboratory analysis data for clay topsoils. Part 4 of 5.

TABLE B6. Laboratory Results													
Clay													
	Lab No	220725-305		220725-329		220725-333		220725-337		220725-341		220725-345	
	Sample ID	SRM_148		SRM_52		SRM_139		SRM_152a		SRM_152b		SRM_152c	
	Sample Depth (m)	Composite		Composite		Composite		Composite		Composite		Composite	
Analyses	Unit												
pH - Water	pH units	8.65	H.AIk	8.30	M.AIk	8.47	M.AIk	8.38	M.AIk	8.72	H.AIk	8.21	M.AIk
Electrical Conductivity	dS/m	0.33	M.Sal	0.21	L.Sal	0.25	M.Sal	0.17	L.Sal	0.27	M.Sal	0.12	L.Sal
Chloride	mg/kg	155.0	L.Sal	88.4	VL.Sal	129	L.Sal	88.5	VL.Sal	142.0	L.Sal	51.0	VL.Sal
Total Nitrogen - Kjeldahl	mg/kg	562	L	652	L	2122	M	515	L	596	L	498	VL
Total Phosphorus - Nitric/Perchloric	mg/kg	208	*	138	*	588	*	216	*	290	*	215	*
Phosphorus - Colwell extr	mg/kg	13.9	L	10.7	L	253	FALSE	18.5	L	16.3	L	16.3	L
Potassium - Colwell ext	mg/kg	124	L	72.1	VL	287	M	128.0	L	112.0	VL	109	VL
Sulphur - KCl	mg/kg	19.4	H	9.2	M	15.9	H	16.1	H	28.5	VH	11.9	M
Organic Carbon	%	0.72	L	0.69	L	1.83	H	0.89	L	0.79	L	0.71	L
Copper	mg/kg	0.74	M	0.78	M	0.76	M	0.62	M	0.78	M	0.48	M
Iron	mg/kg	4.11	*	8.50	*	6.28	*	9.28	*	4.92	*	5.58	*
Manganese	mg/kg	5.77	M	12.7	M	10.0	M	5.32	M	5.02	M	4.74	M
Zinc	mg/kg	0.28	VL	0.42	L	1.38	M	0.34	L	0.48	L	0.34	L
Boron	mg/kg	1.12	M	0.68	L	1.48	M	0.82	L	1.35	M	0.66	L
Cation Extraction Method	Rayment& Lyons	15C1	*	15C1	*	15C1	*	15C1	*	15C1	*	15C1	*
Cation Exchange Capacity	meq/100g	25.4	H	11.9	L	12.1	M	7.9	L	12.8	M	9.1	L
Ex Calcium Percent	%	47.01	L	59.10	L	57.88	L	54.09	L	55.68	L	57.82	L
Ex Magnesium Percent	%	45.06	H	33.27	H	32.59	H	36.97	H	35.18	H	35.23	H
Ex Potassium Percent	%	0.83	L	0.81	L	2.85	Normal	1.88	Normal	1.19	Normal	2.21	Normal
Ex Sodium Percent	%	7.07	Sodic	6.73	Sodic	6.59	Sodic	6.91	Sodic	7.87	Sodic	4.61	N.Sodic
Ex Aluminium Percent	%	0.04	VL	0.09	VL	0.09	VL	0.14	VL	0.09	VL	0.12	VL
Exchangeable Calcium	meq/100g	11.95	H	7.03	M	7.03	M	4.26	L	7.11	M	5.28	M
Exchangeable Magnesium	meq/100g	11.45	VH	3.96	H	3.96	H	2.91	M	4.49	H	3.22	H
Exchangeable Potassium	meq/100g	0.21	L	0.10	VL	0.35	M	0.15	VL	0.15	VL	0.20	L
Exchangeable Sodium	meq/100g	1.80	H	0.80	H	0.80	H	0.54	M	1.00	H	0.42	M
Exchangeable Aluminium	meq/100g	0.01	H	0.01	H	0.01	H	0.01	H	0.01	H	0.01	H
Calcium/Magnesium Ratio	-	1.0	Low Ca	1.8	Low Ca	1.8	Low Ca	1.5	Low Ca	1.6	Low Ca	1.6	Low Ca
Emerson Aggregate	Class	5	Slaking	5	Slaking	7	Stable	3b	Slight Disp	5	Slaking	7	Stable
Phosphorus Buffer Index	ma/kq	112	*	76.2	*	53.7	*	72.9	*	79.4	*	63.3	*

	Highly acidic		Extremely alkaline		High salinity		Sodic		Strongly sodic
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Table B6: Laboratory analysis data for clay topsoils. Part 5 of 5.

TABLE B6. Laboratory Results Clay									
	Lab No	220725-349		220725-353		Mean		Min	Max
	Sample ID	SRM_152g		SRM_153					
	Sample Depth (m)	Composite		Composite					
Analyses	Unit								
pH - Water	pH units	7.99	M.Alk	7.90	M.Alk	8.3	M.Alk	7.2	9.2
Electrical Conductivity	dS/m	0.12	L.Sal	0.10	VL.Sal	0.23	M.Sal	0.10	0.57
Chloride	mg/kg	51.8	VL.Sal	44.2	VL.Sal	130	L.Sal	12	603
Total Nitrogen - Kjeldahl	mg/kg	357	VL	610	L	800	L	357	2122
Total Phosphorus - Nitric/Perchloric	mg/kg	226	*	258	*	209	*	112	588
Phosphorus - Colwell extr	mg/kg	26.0	L	24.0	L	28		7	253
Potassium - Colwell ext	mg/kg	159	L	118	VL	123		69	287
Sulphur - KCl	mg/kg	17.1	H	18.1	H	17.63	H	6.90	50.00
Organic Carbon	%	0.61	L	0.75	L	0.92	L	0.54	1.83
Copper	mg/kg	1.30	M	0.38	M	0.87	M	0.36	3.40
Iron	mg/kg	8.62	*	7.58	*	10	*	1	56
Manganese	mg/kg	4.12	M	5.79	M	6.32	M	2.44	13.10
Zinc	mg/kg	0.42	L	0.36	L	0.44	L	0.26	1.38
Boron	mg/kg	0.88	L	0.56	L	1.12	M	0.56	2.10
Cation Extraction Method	Rayment& Lyons	15C1	*	15C1	*	*	*	*	*
Cation Exchange Capacity	meq/100g	11.1	L	7.5	L	18.2	M	6.2	34.1
Ex Calcium Percent	%	55.99	L	66.72	Normal	52.2	L	28.2	68.0
Ex Magnesium Percent	%	36.60	H	27.66	H	39.2	H	27.7	57.2
Ex Potassium Percent	%	1.22	Normal	2.81	Normal	1.3	Normal	0.2	2.9
Ex Sodium Percent	%	6.09	Sodic	2.66	N.Sodic	7.2	Sodic	1.1	19.7
Ex Aluminium Percent	%	0.10	VL	0.15	VL	0.1	VL	0.0	0.2
Exchangeable Calcium	meq/100g	6.24	M	5.03	M	9.4	M	1.8	19.6
Exchangeable Magnesium	meq/100g	4.08	H	2.08	M	7.4	H	2.1	19.0
Exchangeable Potassium	meq/100g	0.14	VL	0.21	L	0.2	VL	0.1	0.4
Exchangeable Sodium	meq/100g	0.68	M	0.20	L	1.2	H	0.2	2.9
Exchangeable Aluminium	meq/100g	0.01	H	0.01	H	0.0	H	0.0	0.0
Calcium/Magnesium Ratio	-	1.5	Low Ca	2.4	Low Ca	1.4	Low Ca	0.5	2.4
Emerson Aggregate	Class	3b	Slight Disp	7	Stable	*	*	*	*
Phosphorus Buffer Index	mg/kg	70.8	*	64.0	*	*	*	*	*

	Highly acidic		Extremely alkaline		High salinity		Sodic		Strongly sodic
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Table B7: Laboratory analysis data for discrete light loam and sand topsoils. Part 1 of 2.

TABLE B7. Laboratory Results ALL SITES																					
	Lab No	220725-1		220725-2		220725-3		220725-5		220725-6		220725-7		220725-9		220725-10		220725-11		220725-18	
	Sample ID	SRM_75a		SRM_75a		SRM_75a		SRM_75b		SRM_75b		SRM_75b		SRM_95		SRM_95		SRM_95		SRM_81	
	Sample Depth (m)	0.5		1		2		0.5		1.5		2.5		0.5		1.5		3		0.5	
Analyses	Unit																				
pH - Water	pH units	6.24	L.Acid	6.18	L.Acid	6.44	L.Acid	9.20	E.Alk	8.25	M.Alk	8.40	M.Alk	6.02	M.Acid	5.63	M.Acid	5.70	M.Acid	4.90	VH.Acid
Electrical Conductivity	dS/m	0.14	L.Sal	0.12	L.Sal	0.15	M.Sal	0.12	L.Sal	0.45	H.Sal	0.15	M.Sal	0.08	L.Sal	0.15	M.Sal	0.15	M.Sal	0.02	VL.Sal
	Lab No	220725-19		220725-20		220725-22		220725-23		220725-24		220725-26		220725-27		220725-28		220725-30		220725-31	
	Sample ID	SRM_81		SRM_81		SRM_39		SRM_39		SRM_39		SRM_86		SRM_86		SRM_86		SRM_103		SRM_103	
	Sample Depth (m)	1		2		0.5		1.5		2.5		0.5		1.5		2.5		0.5		1.5	
Analyses	Unit																				
pH - Water	pH units	4.80	VH.Acid	4.80	VH.Acid	7.44	L.Alk	8.37	M.Alk	7.81	L.Alk	5.32	H.Acid	5.19	H.Acid	6.03	M.Acid	6.50	L.Acid	6.35	L.Acid
Electrical Conductivity	dS/m	0.02	VL.Sal	0.06	VL.Sal	0.18	M.Sal	0.49	H.Sal	0.50	H.Sal	0.03	VL.Sal	0.03	VL.Sal	0.03	VL.Sal	0.09	L.Sal	0.39	H.Sal
	Lab No	220725-19		220725-20		220725-22		220725-23		220725-24		220725-26		220725-27		220725-28		220725-30		220725-31	
	Sample ID	SRM_81		SRM_81		SRM_39		SRM_39		SRM_39		SRM_86		SRM_86		SRM_86		SRM_103		SRM_103	
	Sample Depth (m)	1		2		0.5		1.5		2.5		0.5		1.5		2.5		0.5		1.5	
Analyses	Unit																				
pH - Water	pH units	4.80	VH.Acid	4.80	VH.Acid	7.44	L.Alk	8.37	M.Alk	7.81	L.Alk	5.32	H.Acid	5.19	H.Acid	6.03	M.Acid	6.50	L.Acid	6.35	L.Acid
Electrical Conductivity	dS/m	0.02	VL.Sal	0.06	VL.Sal	0.18	M.Sal	0.49	H.Sal	0.50	H.Sal	0.03	VL.Sal	0.03	VL.Sal	0.03	VL.Sal	0.09	L.Sal	0.39	H.Sal
	Lab No	220725-32		220725-38		220725-39		220725-40		220725-42		220725-43		220725-44		220725-66		220725-67		220725-68	
	Sample ID	SRM_103		SRM_42		SRM_42		SRM_42		SRM_4		SRM_4		SRM_4		SRM_15		SRM_15		SRM_15	
	Sample Depth (m)	3		0.5		1.5		2.5		0.5		1.5		2.5		0.5		1.5		2.5	
Analyses	Unit																				
pH - Water	pH units	5.61	M.Acid	8.29	M.Alk	7.65	L.Alk	8.04	M.Alk	6.79	Neutral	7.18	Neutral	7.13	Neutral	6.52	L.Acid	6.20	L.Acid	6.52	L.Acid
Electrical Conductivity	dS/m	0.21	M.Sal	0.10	L.Sal	0.09	L.Sal	0.15	M.Sal	0.02	VL.Sal	0.05	VL.Sal	0.21	M.Sal	0.09	L.Sal	0.11	L.Sal	0.20	M.Sal
	Lab No	220725-86		220725-87		220725-88		220725-90		220725-91		220725-92		220725-98		220725-99		220725-100		220725-150	
	Sample ID	SRM_97		SRM_97		SRM_97		SRM_43		SRM_43		SRM_43		SRM_25		SRM_25		SRM_25		SRM_38	
	Sample Depth (m)	0.5		1.5		2.5		0.5		1.5		2.5		0.5		1.5		2.5		0.5	
Analyses	Unit																				
pH - Water	pH units	7.62	L.Alk	7.09	Neutral	7.92	M.Alk	8.18	M.Alk	8.16	M.Alk	7.29	Neutral	6.67	Neutral	6.68	Neutral	7.32	Neutral	7.30	Neutral
Electrical Conductivity	dS/m	0.03	VL.Sal	0.04	VL.Sal	0.10	L.Sal	0.10	L.Sal	0.11	L.Sal	0.06	VL.Sal	0.15	M.Sal	0.13	L.Sal	0.13	L.Sal	0.03	VL.Sal
	Lab No	220725-151		220725-152		220725-182		220725-183		220725-184		220725-186		220725-187		220725-188		220725-206		220725-207	
	Sample ID	SRM_38		SRM_38		SRM_158a		SRM_158a		SRM_158a		SRM_158b		SRM_158b		SRM_158b		SRM_127		SRM_127	
	Sample Depth (m)	1.5		2.5		0.5		1.5		2.5		0.5		1.5		2.5		0.5		1.5	
Analyses	Unit																				
pH - Water	pH units	7.23	Neutral	7.37	Neutral	7.08	Neutral	6.47	L.Acid	6.35	L.Acid	7.22	Neutral	7.91	M.Alk	6.93	Neutral	7.19	Neutral	6.83	Neutral
Electrical Conductivity	dS/m	0.15	M.Sal	0.13	L.Sal	0.07	L.Sal	0.11	L.Sal	0.06	VL.Sal	0.07	L.Sal	0.14	L.Sal	0.21	M.Sal	0.12	L.Sal	0.14	L.Sal
	Lab No	220725-208		220725-222		220725-223		220725-224		220725-226		220725-227		220725-228		220725-230		220725-231		220725-232	
	Sample ID	SRM_127		SRM_173		SRM_173		SRM_173		SRM_121		SRM_121		SRM_121		SRM_116		SRM_116		SRM_116	
	Sample Depth (m)	2.5		0.5		1.5		2.5		0.5		1.5		2.5		0.5		1.5		2.5	
Analyses	Unit																				
pH - Water	pH units	6.76	Neutral	6.66	Neutral	6.85	Neutral	6.36	L.Acid	8.08	M.Alk	6.75	Neutral	7.53	L.Alk	7.55	L.Alk	8.02	M.Alk	6.85	Neutral
Electrical Conductivity	dS/m	0.13	L.Sal	0.04	VL.Sal	0.07	L.Sal	0.18	M.Sal	0.21	M.Sal	0.11	L.Sal	0.05	VL.Sal	0.24	M.Sal	0.07	L.Sal	0.06	VL.Sal
	Lab No	220725-234		220725-235		220725-236		220725-238		220725-239		220725-240		220725-298		220725-299		220725-300		220725-354	
	Sample ID	SRM_78		SRM_78		SRM_78		SRM_50		SRM_50		SRM_50		SRM_130		SRM_130		SRM_130		SRM_109	
	Sample Depth (m)	0.5		1.5		2.5		0.5		1.5		2.5		0.5		1.5		2.5		0.5	
Analyses	Unit																				
pH - Water	pH units	9.06	E.Alk	8.22	M.Alk	7.36	Neutral	8.66	H.Alk	9.11	E.Alk	8.88	H.Alk	6.72	Neutral	6.28	L.Acid	6.88	Neutral	8.74	H.Alk
Electrical Conductivity	dS/m	0.07	L.Sal	0.19	M.Sal	0.20	M.Sal	0.39	H.Sal	0.24	M.Sal	0.28	M.Sal	0.04	VL.Sal	0.14	L.Sal	0.03	VL.Sal	0.36	H.Sal

	Highly acidic		Extremely alkaline		High salinity
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Table B7: Laboratory analysis data for discrete light loam and sand topsoils. Part 2 of 2.

TABLE B7. Laboratory Results																						
ALL SITES																						
	Lab No	220725-355		220725-356		220725-358		220725-359		220725-360		220725-362		220725-363		220725-364		220725-366		220725-367		
	Sample ID	SRM_109		SRM_109		SRM_16		SRM_16		SRM_16		SRM_115b		SRM_115b		SRM_115b		SRM_118		SRM_118		
	Sample Depth (m)	1.5		2.5		0.5		1.5		2.5		0.5		1.5		2.5		0.5		1.5		
Analyses	Unit																					
pH - Water	pH units	7.01	Neutral	8.62	H.Aik	7.43	L.Aik	7.88	L.Aik	7.59	L.Aik	8.82	H.Aik	8.12	M.Aik	8.19	M.Aik	7.58	L.Aik	8.56	H.Aik	
Electrical Conductivity	dS/m	0.08	L.Sal	0.19	M.Sal	0.04	VL.Sal	0.06	VL.Sal	0.13	L.Sal	0.22	M.Sal	0.08	L.Sal	0.11	L.Sal	0.09	L.Sal	0.13	L.Sal	
	Lab No	220725-368		220725-370		220725-371		220725-372														
	Sample ID	SRM_118		SRM_40		SRM_40		SRM_40														
	Sample Depth (m)	2.5		0.5		1.5		2.5														
Analyses	Unit																					
pH - Water	pH units	7.01	Neutral	7.76	L.Aik	7.10	Neutral	7.78	L.Aik													
Electrical Conductivity	dS/m	0.11	L.Sal	0.05	VL.Sal	0.18	L.Sal	0.21	L.Sal													

Table B8: Laboratory analysis data for discrete heavy loam and clay topsoils. Part 1 of 2.

TABLE B8. Laboratory Results ALL SITES																					
	Lab No	220725-13	220725-15	220725-16	220725-34	220725-35	220725-36	220725-46	220725-47	220725-48	220725-50										
	Sample ID	SRM_36	SRM_36	SRM_36	SRM_34	SRM_34	SRM_34	SRM_94	SRM_94	SRM_94	SRM_85										
	Sample Depth (m)	0.5	1.5	2.5	0.5	1.5	2.5	0.5	1.5	2.5	0.5										
Analyses	Unit																				
pH - Water	pH units	8.22	M.Alk	8.01	M.Alk	8.55	H.Alk	8.11	M.Alk	8.76	H.Alk	8.70	H.Alk	8.39	M.Alk	8.63	H.Alk	7.83	L.Alk	8.38	M.Alk
Electrical Conductivity	dS/m	0.13	L.Sal	0.03	VL.Sal	0.04	VL.Sal	0.04	VL.Sal	0.08	L.Sal	0.08	L.Sal	0.04	VL.Sal	0.06	VL.Sal	0.08	L.Sal	0.03	VL.Sal
	Lab No	220725-51	220725-52	220725-54	220725-55	220725-56	220725-58	220725-59	220725-60	220725-62	220725-63										
	Sample ID	SRM_85	SRM_85	SRM_108	SRM_108	SRM_108	SRM_90	SRM_90	SRM_90	SRM_109	SRM_109										
	Sample Depth (m)	1.5	2.5	0.5	1.5	2.5	0.5	1.5	2.5	0.5	1.5										
Analyses	Unit																				
pH - Water	pH units	7.46	L.Alk	6.88	Neutral	6.85	Neutral	7.59	L.Alk	7.66	L.Alk	8.5	H.Alk	8.17	M.Alk	7.86	L.Alk	6.79	Neutral	6.60	Neutral
Electrical Conductivity	dS/m	0.11	L.Sal	0.05	VL.Sal	0.02	VL.Sal	0.02	VL.Sal	0.05	VL.Sal	0.06	VL.Sal	0.06	VL.Sal	0.08	L.Sal	0.02	VL.Sal	0.03	VL.Sal
	Lab No	220725-64	220725-70	220725-71	220725-72	220725-74	220725-75	220725-76	220725-78	220725-79	220725-80										
	Sample ID	SRM_109	SRM_88	SRM_88	SRM_88	SRM_63	SRM_63	SRM_63	SRM_89	SRM_89	SRM_89										
	Sample Depth (m)	2.5	0.5	1.5	2.5	0.5	1.5	2.5	0.5	1.5	2.5										
Analyses	Unit																				
pH - Water	pH units	9.74	E.Alk	6.50	L.Acid	6.88	Neutral	6.71	Neutral	5.88	M.Acid	5.72	M.Acid	5.64	M.Acid	8.58	H.Alk	8.67	H.Alk	7.89	L.Alk
Electrical Conductivity	dS/m	0.05	VL.Sal	0.02	VL.Sal	0.01	VL.Sal	0.03	VL.Sal	0.02	VL.Sal	0.03	VL.Sal	0.02	VL.Sal	0.08	L.Sal	0.09	L.Sal	0.06	VL.Sal
	Lab No	220725-82	220725-83	220725-84	220725-94	220725-95	220725-96	220725-102	220725-103	220725-104	220725-106										
	Sample ID	SRM_36	SRM_36	SRM_36	SRM_106	SRM_106	SRM_106	SRM_74	SRM_74	SRM_74	SRM_70										
	Sample Depth (m)	0.5	1.5	2.5	0.5	1.5	2.5	0.5	1.5	2.5	0.5										
Analyses	Unit																				
pH - Water	pH units	6.68	Neutral	6.28	L.Acid	6.35	L.Acid	6.94	Neutral	6.72	Neutral	6.57	L.Acid	7.76	L.Alk	6.50	L.Acid	6.66	Neutral	8.78	H.Alk
Electrical Conductivity	dS/m	0.03	VL.Sal	0.05	VL.Sal	0.06	VL.Sal	0.02	VL.Sal	0.06	VL.Sal	0.05	VL.Sal	0.05	VL.Sal	0.11	L.Sal	0.04	VL.Sal	0.08	L.Sal
	Lab No	220725-107	220725-108	220725-110	220725-111	220725-112	220725-114	220725-115	220725-116	220725-118	220725-119										
	Sample ID	SRM_70	SRM_70	SRM_83	SRM_83	SRM_83	SRM_24	SRM_24	SRM_24	SRM_28	SRM_28										
	Sample Depth (m)	1.5	2.5	0.5	1.5	2.5	0.5	1.5	2.5	0.5	1.5										
Analyses	Unit																				
pH - Water	pH units	8.83	H.Alk	8.49	M.Alk	6.84	Neutral	7.37	Neutral	7.95	M.Alk	7.01	Neutral	6.72	Neutral	6.51	L.Acid	8.39	M.Alk	7.59	L.Alk
Electrical Conductivity	dS/m	0.09	L.Sal	0.08	L.Sal	0.02	VL.Sal	0.02	VL.Sal	0.03	VL.Sal	0.01	VL.Sal	0.02	VL.Sal	0.07	L.Sal	0.09	L.Sal	0.15	M.Sal
	Lab No	220725-120	220725-122	220725-123	220725-124	220725-126	220725-127	220725-128	220725-130	220725-131	220725-132										
	Sample ID	SRM_28	SRM_46	SRM_46	SRM_46	SRM_49	SRM_49	SRM_49	SRM_31	SRM_31	SRM_31										
	Sample Depth (m)	2.5	0.5	1.5	2.5	0.5	1.5	2.5	0.5	1.5	2.5										
Analyses	Unit																				
pH - Water	pH units	7.58	L.Alk	8.42	M.Alk	7.18	Neutral	7.82	L.Alk	6.53	L.Acid	8.32	M.Alk	6.54	L.Acid	6.11	L.Acid	6.48	L.Acid	5.59	H.Acid
Electrical Conductivity	dS/m	0.10	L.Sal	0.18	M.Sal	0.25	M.Sal	0.34	H.Sal	0.03	VL.Sal	0.07	L.Sal	0.02	VL.Sal	0.07	L.Sal	0.07	L.Sal	0.09	L.Sal
	Lab No	220725-134	220725-135	220725-136	220725-138	220725-139	220725-140	220725-142	220725-143	220725-144	220725-146										
	Sample ID	SRM_51	SRM_51	SRM_51	SRM_73	SRM_73	SRM_73	SRM_135	SRM_135	SRM_135	SRM_41										
	Sample Depth (m)	0.5	1.5	2.5	0.5	1.5	2.5	0.5	1.5	2.5	0.5										
Analyses	Unit																				
pH - Water	pH units	8.79	H.Alk	8.77	H.Alk	7.21	Neutral	7.11	Neutral	6.97	Neutral	7.22	Neutral	7.45	L.Alk	8.13	M.Alk	7.13	Neutral	6.96	Neutral
Electrical Conductivity	dS/m	0.06	VL.Sal	0.04	VL.Sal	0.19	M.Sal	0.02	VL.Sal	0.02	VL.Sal	0.06	VL.Sal	0.06	VL.Sal	0.03	VL.Sal	0.09	L.Sal	0.02	VL.Sal
	Lab No	220725-147	220725-148	220725-158	220725-159	220725-160	220725-170	220725-171	220725-172	220725-174	220725-175										
	Sample ID	SRM_41	SRM_41	SRM_13	SRM_13	SRM_13	SRM_160	SRM_160	SRM_160	SRM_70	SRM_70										
	Sample Depth (m)	1.5	2.5	0.5	1.5	2.5	0.5	1.5	2.5	0.5	1.5										
Analyses	Unit																				
pH - Water	pH units	6.12	L.Acid	6.00	M.Acid	7.06	Neutral	7.11	Neutral	7.05	Neutral	6.10	L.Acid	6.23	L.Acid	6.28	L.Acid	5.67	M.Acid	5.87	M.Acid
Electrical Conductivity	dS/m	0.08	L.Sal	0.10	L.Sal	0.21	M.Sal	0.14	L.Sal	0.15	M.Sal	0.07	L.Sal	0.11	L.Sal	0.13	L.Sal	0.06	VL.Sal	0.07	L.Sal
		Highly acidic				Extremely alkaline				High salinity											

	Highly acidic		Extremely alkaline		High salinity
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Table B8: Laboratory analysis data for discrete heavy loam and clay topsoils. Part 2 of 2.

TABLE B8. Laboratory Results																					
ALL SITES																					
	Lab No	220725-176		220725-178		220725-179		220725-180		220725-190		220725-191		220725-192		220725-194		220725-195		220725-196	
	Sample ID	SRM_70		SRM_176		SRM_176		SRM_176		SRM_129a		SRM_129a		SRM_129a		SRM_129b		SRM_129b		SRM_129b	
	Sample Depth (m)	2.5		0.5		1.5		2.5		0.5		1.5		2.5		0.5		1.5		2.5	
Analyses	Unit																				
pH - Water	pH units	5.38	H.Acid	5.21	H.Acid	5.64	M.Acid	5.47	H.Acid	8.02	M.Alk	7.69	L.Alk	6.85	Neutral	7.90	M.Alk	6.87	Neutral	8.63	H.Alk
Electrical Conductivity	dS/m	0.06	VL.Sal	0.05	VL.Sal	0.04	VL.Sal	0.07	L.Sal	0.07	L.Sal	0.08	L.Sal	0.06	VL.Sal	0.07	L.Sal	0.09	L.Sal	0.12	L.Sal
	Lab No	220725-198		220725-199		220725-200		220725-202		220725-203		220725-204		220725-210		220725-211		220725-212		220725-214	
	Sample ID	SRM_113		SRM_113		SRM_113		SRM_119		SRM_119		SRM_119		SRM_128		SRM_128		SRM_128		SRM_149	
	Sample Depth (m)	0.5		1.5		2.5		0.5		1.5		2.5		0.5		1.5		2.5		0.5	
Analyses	Unit																				
pH - Water	pH units	8.43	M.Alk	6.40	L.Acid	6.64	Neutral	7.86	L.Alk	7.43	L.Alk	7.22	Neutral	7.25	Neutral	7.21	Neutral	7.34	Neutral	7.26	Neutral
Electrical Conductivity	dS/m	0.04	VL.Sal	0.07	L.Sal	0.13	L.Sal	0.03	VL.Sal	0.12	L.Sal	0.11	L.Sal	0.02	VL.Sal	0.05	VL.Sal	0.05	VL.Sal	0.03	VL.Sal
	Lab No	220725-215		220725-216		220725-306		220725-307		220725-308		220725-310		220725-311		220725-312		220725-314		220725-315	
	Sample ID	SRM_149		SRM_149		SRM_10b		SRM_10b		SRM_10b		SRM_10a		SRM_10a		SRM_10a		SRM_10c		SRM_10c	
	Sample Depth (m)	1.5		2.5		0.5		1.5		2.5		0.5		1.5		2.5		0.5		1.5	
Analyses	Unit																				
pH - Water	pH units	7.34	Neutral	7.90	M.Alk	8.37	M.Alk	8.38	M.Alk	8.81	H.Alk	7.96	M.Alk	7.24	Neutral	7.77	L.Alk	8.88	H.Alk	8.29	M.Alk
Electrical Conductivity	dS/m	0.23	M.Sal	0.33	M.Sal	0.16	M.Sal	0.20	M.Sal	0.09	L.Sal	0.04	VL.Sal	0.04	VL.Sal	0.17	M.Sal	0.08	L.Sal	0.24	M.Sal
	Lab No	220725-316		220725-318		220725-319		220725-320		220725-322		220725-323		220725-324		220725-374		220725-375		220725-376	
	Sample ID	SRM_10c		SRM_169		SRM_169		SRM_169		SRM_17		SRM_17		SRM_17		SRM_7		SRM_7		SRM_7	
	Sample Depth (m)	2.5		0.5		1.5		2.5		0.5		1.5		2.5		0.5		1.5		2.5	
Analyses	Unit																				
pH - Water	pH units	8.56	H.Alk	6.51	L.Acid	6.48	L.Acid	6.58	L.Acid	6.18	L.Acid	6.06	M.Acid	6.17	L.Acid	6.48	L.Acid	6.8	Neutral	6.59	L.Acid
Electrical Conductivity	dS/m	0.19	M.Sal	0.02	VL.Sal	0.03	VL.Sal	0.02	VL.Sal	0.10	L.Sal	0.10	L.Sal	0.12	L.Sal	0.05	VL.Sal	0.03	VL.Sal	0.31	M.Sal

Table B9: Laboratory analysis data for discrete cracking clay topsoils.

TABLE B9. Laboratory Results ALL SITES																					
	Lab No	220725-154	220725-155	220725-156	220725-162	220725-163	220725-164	220725-166	220725-167	220725-168	220725-218										
	Sample ID	SRM_58	SRM_58	SRM_58	SRM_131	SRM_131	SRM_131	SRM_178	SRM_178	SRM_178	SRM_133										
	Sample Depth (m)	0.5	1.5	2.5	0.5	1.5	2.5	0.5	1.5	2.5	0.5										
Analyses	Unit																				
pH - Water	pH units	7.41	L.Aik	8.32	M.Aik	7.83	L.Aik	8.58	H.Aik	7.60	L.Aik	6.88	Neutral	6.97	Neutral	6.63	Neutral	7.18	Neutral	8.11	M.Aik
Electrical Conductivity	dS/m	0.30	M.Sal	0.39	H.Sal	0.17	M.Sal	0.25	M.Sal	0.26	M.Sal	0.27	M.Sal	0.45	H.Sal	0.57	H.Sal	0.58	H.Sal	0.14	L.Sal
	Lab No	220725-219	220725-220	220725-242	220725-243	220725-244	220725-246	220725-247	220725-248	220725-250	220725-251										
	Sample ID	SRM_133	SRM_133	SRM_21b	SRM_21b	SRM_21b	SRM_21a	SRM_21a	SRM_21a	SRM_144b	SRM_144b										
	Sample Depth (m)	1.5	2.5	0.5	1.5	2.5	0.5	1.5	2.5	0.5	1.5										
Analyses	Unit																				
pH - Water	pH units	8.13	L.Acid	8.41	M.Aik	7.35	Neutral	7.53	L.Aik	7.50	L.Aik	8.86	H.Aik	8.85	H.Aik	8.89	H.Aik	8.58	H.Aik	8.83	H.Aik
Electrical Conductivity	dS/m	0.19	L.Sal	0.26	M.Sal	0.15	M.Sal	0.15	M.Sal	0.14	L.Sal	0.13	L.Sal	0.18	M.Sal	0.17	M.Sal	0.13	L.Sal	0.16	M.Sal
	Lab No	220725-252	220725-254	220725-255	220725-256	220725-258	220725-259	220725-260	220725-262	220725-263	220725-264										
	Sample ID	SRM_144b	SRM_144a	SRM_144a	SRM_144a	SRM_163d	SRM_163d	SRM_163d	SRM_163b	SRM_163b	SRM_163b										
	Sample Depth (m)	2.5	0.5	1.5	2.5	0.5	1.5	2.5	0.5	1.5	2.5										
Analyses	Unit																				
pH - Water	pH units	8.69	H.Aik	8.76	H.Aik	8.97	H.Aik	8.97	H.Aik	7.89	L.Aik	8.87	H.Aik	8.32	M.Aik	8.58	H.Aik	8.96	H.Aik	8.43	M.Aik
Electrical Conductivity	dS/m	0.19	M.Sal	0.14	L.Sal	0.21	M.Sal	0.19	M.Sal	0.16	M.Sal	0.22	M.Sal	0.34	H.Sal	0.26	M.Sal	0.19	M.Sal	0.31	M.Sal
	Lab No	220725-266	220725-267	220725-268	220725-270	220725-271	220725-272	220725-274	220725-275	220725-276	220725-278										
	Sample ID	SRM_163a	SRM_163a	SRM_163a	SRM_45	SRM_45	SRM_45	SRM_142	SRM_142	SRM_142	SRM_123										
	Sample Depth (m)	0.5	1.5	2.5	0.5	1.5	2.5	0.5	1.5	2.5	0.5										
Analyses	Unit																				
pH - Water	pH units	7.90	M.Aik	8.89	H.Aik	8.49	M.Aik	8.7	H.Aik	8.44	M.Aik	8.47	M.Aik	8.91	H.Aik	9.13	E.Aik	9.05	E.Aik	8.70	H.Aik
Electrical Conductivity	dS/m	0.14	L.Sal	0.21	M.Sal	0.30	M.Sal	0.14	L.Sal	0.16	M.Sal	0.16	M.Sal	0.48	H.Sal	0.33	M.Sal	0.38	H.Sal	0.12	L.Sal
	Lab No	220725-279	220725-280	220725-282	220725-283	220725-284	220725-286	220725-287	220725-288	220725-290	220725-291										
	Sample ID	SRM_123	SRM_123	SRM_64	SRM_64	SRM_64	SRM_134	SRM_134	SRM_134	SRM_145	SRM_145										
	Sample Depth (m)	1.5	2.5	0.5	1.5	2.5	0.5	1.5	2.5	0.5	1.5										
Analyses	Unit																				
pH - Water	pH units	8.40	M.Aik	8.53	H.Aik	8.39	M.Aik	8.16	M.Aik	8.26	M.Aik	7.99	M.Aik	8.17	M.Aik	8.09	M.Aik	8.86	H.Aik	8.49	M.Aik
Electrical Conductivity	dS/m	0.20	M.Sal	0.18	M.Sal	0.12	L.Sal	0.13	L.Sal	0.12	L.Sal	0.23	M.Sal	0.20	M.Sal	0.18	M.Sal	0.22	M.Sal	0.28	M.Sal
	Lab No	220725-292	220725-294	220725-295	220725-296	220725-302	220725-303	220725-304	220725-326	220725-327	220725-328										
	Sample ID	SRM_145	SRM_154	SRM_154	SRM_154	SRM_148	SRM_148	SRM_148	SRM_52	SRM_52	SRM_52										
	Sample Depth (m)	2.5	0.5	1.5	2.5	0.5	1.5	2.5	0.5	1.5	2.5										
Analyses	Unit																				
pH - Water	pH units	8.57	H.Aik	8.11	M.Aik	8.14	M.Aik	7.97	M.Aik	8.51	H.Aik	8.22	M.Aik	8.52	H.Aik	8.98	H.Aik	7.53	L.Aik	8.25	M.Aik
Electrical Conductivity	dS/m	0.26	M.Sal	0.28	M.Sal	0.25	M.Sal	0.24	M.Sal	0.35	H.Sal	0.13	L.Sal	0.30	M.Sal	0.20	M.Sal	0.31	M.Sal	0.29	M.Sal
	Lab No	220725-330	220725-331	220725-332	220725-334	220725-335	220725-336	220725-338	220725-339	220725-340	220725-342										
	Sample ID	SRM_139	SRM_139	SRM_139	SRM_152a	SRM_152a	SRM_152a	SRM_152b	SRM_152b	SRM_152b	SRM_152c										
	Sample Depth (m)	0.5	1.5	2.5	0.5	1.5	2.5	0.5	1.5	2.5	0.5										
Analyses	Unit																				
pH - Water	pH units	8.81	H.Aik	8.49	M.Aik	8.50	H.Aik	8.65	H.Aik	8.46	M.Aik	8.62	H.Aik	9.02	E.Aik	8.68	H.Aik	8.54	H.Aik	8.86	H.Aik
Electrical Conductivity	dS/m	0.33	M.Sal	0.3	M.Sal	0.23	M.Sal	0.25	M.Sal	0.21	M.Sal	0.21	M.Sal	0.29	M.Sal	0.33	M.Sal	0.36	H.Sal	0.24	M.Sal
	Lab No	220725-343	220725-344	220725-346	220725-347	220725-348	220725-350	220725-351	220725-352												
	Sample ID	SRM_152c	SRM_152c	SRM_152g	SRM_152g	SRM_152g	SRM_153	SRM_153	SRM_153												
	Sample Depth (m)	1.5	2.5	0.5	1.5	2.5	0.5	1.5	2.5												
Analyses	Unit																				
pH - Water	pH units	8.43	M.Aik	8.49	M.Aik	7.62	L.Aik	8.62	H.Aik	8.62	H.Aik	8.31	M.Aik	7.87	L.Aik	7.89	L.Aik				
Electrical Conductivity	dS/m	0.25	M.Sal	0.14	L.Sal	0.09	L.Sal	0.29	M.Sal	0.26	M.Sal	0.14	L.Sal	0.13	L.Sal	0.12	L.Sal				

	Highly acidic		Extremely alkaline		High salinity
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Saraji Mine

Community Consultation Plan

Progressive Rehabilitation and Closure Plan

27 December 2023



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Review tracker

Version	Date	Author	Reviewers
Draft V.1	28 November 2022	Dee Elliott	Raina Hattingh
Draft V.2	7 December 2022	Dee Elliott	Trudy Mazucco Jasmine Cadd Jennifer Leach Craig Lockhart Melissa Millward
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Terms and abbreviations

Term/Abbreviation	Definition
BBAC	Barada Barna Aboriginal Corporation
BMA	BHP Mitsubishi Alliance
Consultation	Community consultation is a key component of the PRC plan and is intended to ensure that anyone impacted by proposed rehabilitation and closure activities at the site has an opportunity to provide input to the planning process (PRC plan Guideline, DES, 2019)
CCP	Community consultation plan, required to be submitted with the PRC Plan
CHMP	Cultural Heritage Management Plan
CHPP	Coal handling and processing plant
DCCEEW	Department of Climate Change, Energy, the Environment and Water (Commonwealth)
DES	Department of Environment and Science. DES is responsible for assessing PRC Plans and schedules
DoR	Department of Resources
EA	Environmental Authority
EIS	Environmental Impact Statement – primary approval document for major projects under the State Development and Public Organisations Act 1971 and EP Act
EP Act	Environmental Protection Act 1994 (Queensland)
FIFO	Fly-in/fly-out
GM	General Manager
ILUA	Indigenous Land Use Agreement
LGA	Local Government Area
LOA	Life-of-Asset
LOD	Land outcomes document
MERCPA	<i>Mineral and Energy Resources (Common Provisions) Act 2014 (Qld)</i>
MERFP Act	<i>Mineral and Energy Resources (Financial Provisioning) Act 2018 (Qld)</i>
ML	Mining Lease
NUMA	Non-use management area - means an area of land the subject of a PRC plan that cannot be rehabilitated to a stable condition after all relevant activities for the PRC plan carried out on the land have ended. 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 post-mining land use.
PDM	Peak Downs Mine
PMLU	Post-mining land use – means the purpose for which the land will be used after all relevant activities for the PRC plan carried out on the land have ended
PRCP	Progressive Rehabilitation and Closure Plan, comprising a PRC Plan and PRCP Schedule

Term/Abbreviation	Definition
PIE	Public Interest Evaluation - The MERFP Act introduces requirements for a PIE to be carried out for any EA applications that include a NUMA in a PRC plan schedule
QR	Queensland Rail
RDA	Regional Development Australia
SRM	Saraji Mine
SSM	Saraji South Mine (previously known as Norwich Park Mine)
STAC	Smart Transformation Advisory Council
TLO	Train load-out

1 Introduction

This document represents the Community Consultation Plan (CCP) to be delivered as part of Saraji Mine (SRM) Progressive Rehabilitation and Closure Plan (PRCP). It includes:

- consultation requirements for PRC planning;
- the objectives and desired outcomes for community consultation in PRC planning for SRM;
- the consultation process and program, including proposed frequency of consultation;
- information to be released for community consultation; and
- how community feedback will be considered in PRC plan updates.

This CCP has been compiled by Elliott Whiteing, with community consultation assistance from BHP Mitsubishi Alliance (BMA), team members. Implementation of the consultation requirements as part of ongoing rehabilitation and closure planning for the site will continue to be led by the Corporate Affairs team and the site, with support from the BMA Closure Planning team.

2 Community consultation requirements

2.1 SRM context

SRM, operated by BMA, is a hard coking coal resource in the Bowen Basin, Queensland, within the Isaac Local Government Area (LGA). SRM is located approximately 30 km north of Dysart and 167 km south-west of Mackay. SRM initiated operations in 1974 and is defined by and operates under Environmental Authority (EA) EPML00862313.

SRM comprises the following Mining Leases (MLs): ML 1775 (part), ML 1782 (part), ML 1784, ML 2360, ML 2410, ML 70142 (part), ML 70294 ML 70298, ML 70328 (part) and ML 700021. Land parcels SL12/43830, T/L 233438, TL233440 (part), 201SP321205 (part) and 9SP235297 (part) are also within the EA. The majority of coal mining activities occur on ML 1775 and ML 1782, with a small portion having occurred on ML 2360 and ML 2410. Ancillary services are located on the remaining MLs.

The SRM site comprises a mix of BMA freehold land (i.e. BMA-owned land) and leasehold land (i.e. land leased by BMA from underlying alternative landholders). The TLO and rail loop located to the west of the SRM Mine Industrial Area (MIA), are owned by Queensland Rail (QR) and operated by Aurizon.

Saraji Road, which is an Isaac Regional Council (IRC) asset, runs in a north-south direction adjacent to SRM's western boundary. Due to agreed closure of Lake Vermont Road, BMA has a Conduct and Compensation Agreement to allow Arrow Energy access via SRM to eastern petroleum tenements.

An easement held by Sunwater accommodating the Eungella Water Pipeline (which is owned by Sunwater) is located on BMA-owned land within ML1775 to the north. This easement continues south on BMA-owned land to the east of ML1775 and ML1782, and adjacent to ML700021.

An easement held by Q.E.C. Ltd is also located on BMA-owned land east of ML1775 and cutting through a short distance of ML7182 to the south.

The portion of land highlighted in Figure 1 as not being owned by BHP is not contained within the SRM tenement boundaries but is contained in the EA boundaries.

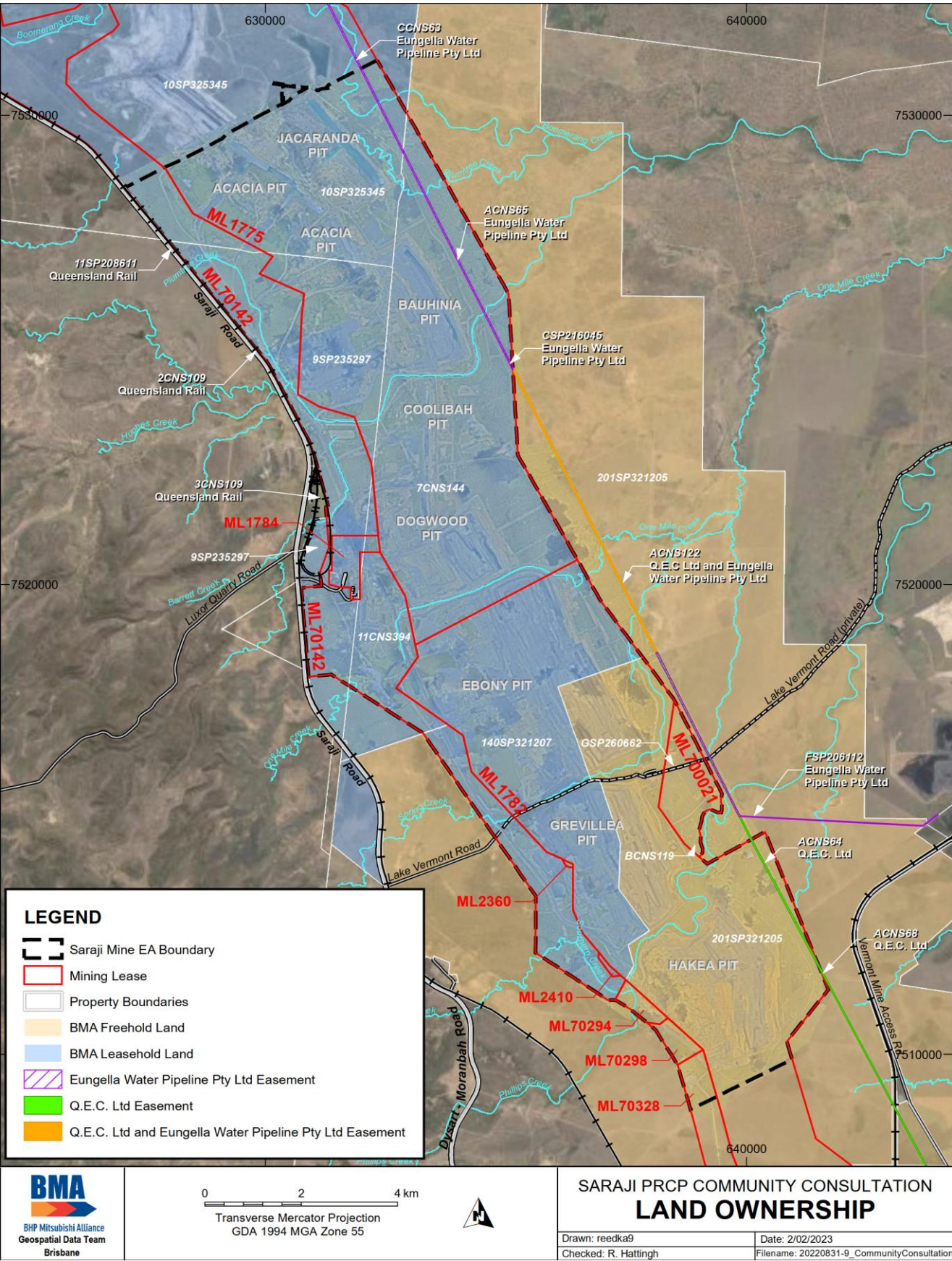


Figure 1: SRM land ownership

2.2 Regulatory requirements

2.2.1 PRCP context

SRM's PRCP - and therefore this CCP - has been prepared under the *Mineral and Energy Resources (Financial Provisioning) Act 2018* (MERFP Act) transitional arrangements.

A PRCP must be submitted under the MERFP Act as part of an application for an EA for a new mining activity relating to a mining lease, and when submitting an application for a Major EA amendment. The MERFP Act makes allowance for transitional provisions for existing mines, such as SRM, which includes providing a specified date by which a PRCP must be developed and submitted to the Department of Environment and Science (DES) for approval. The PRCP for SRM is required for submission to DES by 1 April 2023.

A PRCP consists of two parts: a PRC Plan and PRCP Schedule. The PRC Plan must include the information required under section 126C of the EP Act and is to provide evidence and justification to support the development of the proposed PRCP Schedule. The PRCP Schedule will include maps of rehabilitation and closure outcomes for the site and tables of time-based milestones.

The intent of the PRCP is to specify:

- site rehabilitation commitments, including the amount, type, location and time in which rehabilitation activities are to be completed; and
- mining activities, including duration, post-mining land uses and how rehabilitation will be carried out.

Transitional PRCPs are required to meet the legislative requirements in section 126C(1)(c) of the EP Act, including a community consultation plan, regardless of whether the site has an existing EA.

2.2.2 Consultation context

Environmental Protection Act 1994 (EP Act) section 126C(c) requires that, in addition to a proposed PRCP Schedule and a detailed description of how and where the relevant activities are to be carried out, the PRCP must include:

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

The DES *Guideline - Progressive rehabilitation and closure plans* (DES, 2019) (PRCP Guideline) provides that 'community consultation is a key component of the PRC plan and is intended to ensure that anyone impacted by proposed rehabilitation and closure activities at the site has an opportunity to provide input to the planning process'. The DES Guideline requires that the applicant must attempt to consult all relevant members of the community, noting that 'the community may include, but are not limited to:

- affected landholders (such as underlying and adjoining land holders, and holders of land necessary for access to the land to which the proposed PRC plan relates);
- Traditional Owners;
- Local government; and
- local community groups'.

The Queensland Government's *Information sheet ESR/2019/5101 Version 1: Community consultation for Progressive Rehabilitation and Closure Plan (November 2021)* states that community members to be included in consultation must have a genuine, demonstrable and legitimate interest in:

- the land where the activity will occur;
- the land adjacent to where the activity will occur; or
- the land/amenities surrounding where the activity will occur that are likely to be impacted by the activity.

Genuine interest may include direct impact interest (e.g. underlying and adjacent land holders), cultural interest (e.g. Traditional Owners), land use interest (e.g. overlapping tenure holders, or local government), or heritage, environmental, recreational or health interests (e.g. state or local government or relevant community groups).

Under Section 126C(1)(d) of the EP Act, a PRCP is required to state how the PMLU is consistent with the outcomes of consultation with the community (DES, 2019). Where there are land outcomes identified in a land outcome document (LOD) the applicant must include the details of any previous community consultation undertaken (see Section 3.3).

2.3 Community Consultation Plan

A PRC plan must include details of the consultation undertaken by the applicant in developing the proposed PRC plan. This includes previous rehabilitation-related consultation undertaken as part of existing EA approvals (see Section 3), as well as the outcomes of that consultation (i.e. how stakeholder inputs have informed the outcomes stated in the PRC Plan, as described in the Community Consultation Register which is to be submitted as part of the PRC Plan).

In order to comply with section 126C(1)(c)(iv) of the EP Act, the PRC plan must include a CCP detailing how ongoing consultation will be undertaken in relation to the rehabilitation to be carried out under the PRC Plan. The CCP must include details of:

- the objectives for community consultation;
- engagement type;
- proposed consultation frequency;
- what information will be released for community consultation; and
- how feedback/comments will be considered.

The DES *PRCP Guideline* notes that ongoing community consultation is expected to continue throughout the stages of the mine life so that progressive rehabilitation and the socio-economic and environmental impacts related to mine closure can be discussed with the community. Consultation is required prior to any PRC plan schedule amendments that are likely to impact the community, and the consultation register needs to be updated when this consultation is undertaken.

3 Consultation on SRM's Transitional PRC plan

3.1 Stakeholder analysis

This section summarises stakeholders considered to have a genuine interest in SRM's PRC planning, who include:

- Barada Barna people as the Traditional Owners;
- landholders whose properties are adjacent to the SRM MLs;
- licensees with agistments on BMA-owned land ;
- Isaac Regional Council (IRC), as the local government;
- the owners of utility assets within and adjacent to SRM;
- SRM's workforce;
- the owners of nearby mining projects and operations;
- the owners of adjacent petroleum tenements;
- local residents, businesses, and community groups and organisations; and
- relevant State and Federal departments.

The SRM site comprises a mix of BMA freehold land (i.e. BMA-owned land) and leasehold land (i.e. land leased by BMA from underlying alternative landholders). There are no compensation agreements held with third parties that entitle them to consultation on rehabilitation outcomes within SRM. The only land parcel that falls within the SRM Mine EA is 9SP235297 for which a compensation agreement is not required.

Table 1 documents identified stakeholders and details on current BMA relationships with these stakeholders. It also provides associated potential issues and potential areas of interest with respect to SRM's PRC planning. Further detail is provided in the SRM PRCP Community Consultation Register. BMA teams, including SRM, PDM and SSM site teams, support the engagement required in the CCP.

Table 1: Stakeholders identified as having a genuine interest in SRM PRC planning

Stakeholder	Existing BMA relationship	Potential areas of interest
Traditional Owners		
Barada Barna Peoples, represented by BBAC	- BMA has a constructive working relationship with Barada Barna Peoples and meets with them regularly. - Barada Barna Peoples' native title to areas of land within the Isaac, Central Highlands and Mackay LGAs was determined by the Native Title Tribunal in June 2016. - BMA has also undertaken negotiations with the Barada Barna Peoples on a comprehensive Indigenous Land Use Agreement (ILUA); SRM will fall within the proposed agreement area. An ILUA is a voluntary agreement between native title parties and other people or bodies about the use and management of areas of land and/or waters. BMA has reached an in principal agreement with the Barada Barna Peoples and will work towards finalisation in the coming year. From a PRCP perspective BMA are working with Barada Barna people specifically on provision of seed for rehabilitation and contracting opportunities across operations for rehabilitation execution, in line with ILUA commitments.	- Aspirations around rehabilitation and potential commercial opportunities as a PMLU - How operational management and/or rehabilitation could contribute to future use of the areas - Recognition and management of cultural heritage impacts - Native Title and land acquisition interests - PMLUs, NUMAs and landform/landscape - Future access to and ownership of land - Environmental management/stewardship - Employment and business opportunities in rehabilitation, environmental management and monitoring
Adjacent property owners and licensees		

Stakeholder	Existing BMA relationship	Potential areas of interest
Owners and licensees of: - Tay-Glen Station (property owner) - Saraji Station (property owner) - Lake Vermont Station (agistment license – currently vacant) - Meadowbrook (agistment license - currently vacant) - Anglo Coal (German Creek) Pty Ltd (EPC 747 tenement holder)	BMA has constructive working relationships, engaging on an as-needs basis with nearby property owners and agistment licence holders (who are previous landowners).	- Environmental management/stewardship - PMLU, NUMAs and closure landforms - PRCP Schedule - Future access to and ownership of land - Water usage, quality and access to groundwater and surface water (e.g. water allocations, water pipelines, etc.) - Potential impacts on land, water, property and future business value relating to PMLUs, NUMAs and timing of impacts
Utility owners		
Corporations and Government agencies: - IRC - Queensland Rail (QR) - Aurizon (rail) - Q.E.C Ltd (transmission lines) - Sunwater (water pipeline) - Energex (power supply) - Powerlink (power supply)	BMA has constructive working relationships and engages with utility owners as required (issue-specific or transactional engagement). This includes engagement on: - Saraji Road and Lake Vermont; both of which are IRC assets. (The portion of Lake Vermont Road within the SRM ML (and extending to the east within the BMA tenement) is owned by BMA). - The TLO and rail loop which are owned by QR and operated by Aurizon (located on land leased from BMA). - The easement within the MLs on which Energex and Powerlink powerlines, owned by Q.E.C Ltd, are located	- Impact on assets/asset value - Remediation of impacts on assets - Any service disruptions and mitigations - Crossing/interface agreements - Timeframe for decommissioning utilities that only service SRM (e.g. rail loop, electricity transmission, etc.) - Cost of decommissioning utilities

Stakeholder	Existing BMA relationship	Potential areas of interest
	The easement within the MLs on which Sunwater's Eungella Water Pipeline is located	
BMA operations		
SRM workforce	BMA maintains ongoing communication with its workforce through 'toolbox' talks and a bi-monthly newsletter, Coal Connect.	- Timing of closure - Rehabilitation obligations - Employment continuity
Adjoining/nearby resource interests		
Mining interests: - Whitehaven Coal WS – Winchester South - Pembroke Resources - Olive Downs - Bengal Coal - Dysart East - Bowen Basin Coal/Jellinbah Group – Lake Vermont Mine - Vitrinite P/L – Vulcan Coal Mine Petroleum (gas) tenements: - Arrow Energy/CH4 P/L - Eureka Petroleum Pty Ltd	BMA liaises with adjoining and nearby mining and resource interests on an as-needed basis, in relation to <i>Mineral and Energy Resources (Common Provisions) Act 2014</i> (Queensland) (MERCPA) requirements for petroleum overlap activities, and as part of industry associations and research partnerships.	- Future land use and ownership - Collaboration on good industry rehabilitation and closure practices - Cumulative impacts and opportunities of mine closures
Local residents and businesses		

Stakeholder	Existing BMA relationship	Potential areas of interest
Dysart community members	BMA utilises a wide range of communication, consultation and social investment strategies to develop and maintain relationships with Bowen Basin communities.	- Local employment and business opportunities, and future jobs - Opportunities to participate in supply chain (e.g. environmental management, rehabilitation)
- Dysart Smart Transformation Advisory Council (STAC) members - Dysart Community Support Group	- The Dysart STAC is sponsored by BMA and represents a broad cross-section of community and business interests. - The Dysart Community Support Group is supported by BMA and provides community services to Dysart's most vulnerable groups and members of the community.	- With closure, loss of jobs and supply opportunities, and changes to demands for services (e.g. childcare and schools) - Potential for cumulative job losses if other mines close in a similar timeframe - Economic transformation (towards post-mining), and industry diversification - Educational and childcare opportunities - Wellbeing and health/healthcare provision - Economic and community sustainability - Environmental management - PMLUs and NUMAs - Community and economic transformation
Local Government		
Isaac Regional Council	- BMA has a long established and cooperative relationship with IRC. - BMA and IRC meet at least twice each year. During 2022, BMA had two briefings with Council regarding PRC planning requirements (May 2022 and November 2022). These updates will continue.	- Local employment - Effects on Council services and infrastructure - Environmental management/stewardship - Rehabilitation progress and PRCP Schedule - PMLUs, NUMAs and closure landforms

Stakeholder	Existing BMA relationship	Potential areas of interest
		• Management of closure impacts on employment and businesses • Alignment of rehabilitation plans with local and regional planning goals, and regional transformation/diversification • Economic transformation (towards post-mining) and community sustainability • Cumulative impacts of closure of multiple mining assets in a similar timeframe (e.g. job and population losses)
Government departments		
• Queensland Government • DoR - Office of the Minister, Deputy Director-General Georesources, Acting Director Native Title Services and Coal Hub, Rockhampton, Executive Director, Minerals and Coal • DES - Office of the Minister, MERPF Act implementation team	• BMA has constructive working relationships with DoR and DES. • BHP Corporate Affairs conducts as-needed engagement with Ministers and Members of Parliament. • DoR's Deputy Director-General Georesources has asked to be kept informed on PRC planning. • Consultation on SRM's PRC Plan is not expected to be required by other State Government stakeholders, but they are briefed as necessary.	• Legislative compliance • Resource development • Employment and growth opportunities • Public interest • Environmental management • Economic transformation (towards post-mining) • Financial assurance • Environmental risk management • Future PMLUs, NUMAs and closure landforms • Company responses to stakeholder views • Industry best practice, and innovative future-looking approaches

3.2 PRC Plan consultation

3.2.1 Pre-PRC plan development

Operations commenced at SRM in 1974. At this time, from a regulatory perspective, an Environmental Impact Statement (EIS) and associated community consultation were not required. However, the following consultation relevant to rehabilitation and closure planning has subsequently taken place:

During 2016, BMA submitted an EA Amendment application to include an extension to the existing approved operations in the Grevillea Pit. This application included development of a Rehabilitation Management Plan (RMP) for the pit, aligned to the requirements of the existing site-wide RMP. This was approved by the administering authority.

During 2018, BMA engaged with DES on the PMLUs and associated Acceptance Criteria within the EA. These PMLUs and Acceptance Criteria were included in the 18 November 2019 SRM EA amendment, reflected as Table E1 (Rehabilitation Requirements).

Historically, community consultation was conducted and resulted in the agreed PMLUs and NUMAs that are included in the conditions of the EA.

Since 2021, BHP has been providing regular PRC planning briefings to the IRC as part of bi-annual and special purpose meetings. This has included briefing the IRC on the commencement of the SRM PRCP process (May and November 2022).

Since 2021, BHP has also undertaken ongoing consultation with the Barada Barna Aboriginal Corporation (BBAC), who represent the Barada Barna Peoples as Traditional Owners. This has included various rehabilitation-related aspects. BBAC's feedback has included a request to work together with BHP to understand how they can get involved in rehabilitation execution activities over time, as guided by the PRCP Schedules to be submitted for approval.

BMA continues to engage with neighbouring landholders on land management and lease/licence conditions, and on operational matters (such as air quality monitoring), as required.

3.2.2 Part of PRC plan development

Consultation undertaken as part of PRC plan preparation for SRM included letters via email to:

- IRC;
- BBAC;
- Adjacent property owners and agistment licensees (currently vacant);
- Owners of utilities within and adjacent to SRM;
- Smart Transformation Advisory Council (STAC) members representing community members, groups and businesses in Dysart and that included the Dysart Community Support Group;
- Authorised Holder Representatives of adjacent mining operations and petroleum license; and
- DoR.

The following information was provided through letters to stakeholders:

- SRM location, approved activities and production;
- requirements and timing for PRC plan development;
- SRM life-of-asset (LOA);
- rehabilitation requirements and timing;
- approved PMLUs and NUMAs;
- publication of rehabilitation schedule as part of PRC plan;

- commitment to future engagement regarding PRC Planning for SRM; and
- contact details for the relevant BMA team (e.g. for landholders, the Land Access and Management team) for further information, discussion or feedback.

Information was also provided to BMA employees and community and groups through the online Coal Connect newsletter (a weekly newsletter to all internal coal personnel) and the Community Connect newsletter which is a hard copy and electronic bi-monthly newsletter distributed to more than 15,000 community members' letterboxes throughout the Bowen Basin. This included:

- sustainability and progressive rehabilitation as a key focus;
- PRC plan requirements and purpose;
- timing for PRC plan development;
- commitment to ongoing engagement; and
- contacts for further information.

Consultation and engagement conducted by BMA was to transition the PMLUs and NUMAs within the EA to the PRCP. In most cases, no feedback was received as part of consultation. Any feedback received was consistent with PMLUs and NUMAs as described in both the EA and the PRCP. The results of engagement are shown in the Community Consultation Register submitted as part of the PRC plan, as outlined below.

3.3 Community Consultation Register

A Community Consultation Register has been provided as part of the PRC plan in compliance with section 126C(1)(c)(iii) of the EP Act and includes:

- identification of each community member/stakeholder;
- all recorded previous engagements with the community;
- consultation date(s);
- description of consultation type (letter, meetings etc.);
- information provided to the community;
- issues raised/discussed;
- how issues raised and the outcomes of engagement have been considered in decision making; and
- commitments made by BMA.

The community consultation register will be a live instrument for recording future consultation on SRM's PRC Plan.

4 Future, ongoing PRC Plan-related community consultation

4.1 Existing consultation mechanisms

Communities and stakeholders within the Isaac LGA are experiencing multiple demands for their participation in PRC planning. To minimise additional demands on communities and stakeholders, BMA will utilise its existing community consultation mechanisms for PRC consultation wherever possible, as described in .

Table 2: Using existing BMA consultation mechanisms

Mechanism	Mechanism and frequency
Landholder meetings	BMA's Land Management team engages regularly with landholders near SRM's MLs. Consultation with landowners adjacent to SRM will be conducted throughout the life of the PRC plan, through regular meetings on-site or in Dysart.
IRC meetings	Bi-annual meetings are held with IRC. The meetings have a fluid agenda based on key topics/issues at the time. As a minimum, updates on PRC Planning will be offered as an agenda item for bi-annual briefings, by agreement with Council.
Traditional Owner meetings	Bi-monthly meetings are generally held with Barada Barna People. The Indigenous Affairs and Cultural Heritage team will be provided with information to support consultation with Traditional Owners, which may include site-specific or broader PRC Planning issues.
Community Connect newsletter	This monthly newsletter is distributed to more than 15,000 letterboxes throughout the Bowen Basin and will include updates on PRC Planning.
Coal Connect	This weekly electronic employee newsletter will provide updates on PRC planning as relevant.

4.2 PRCP consultation program

Once the SRM transitional PRCP has been approved, consultation as part of implementing the SRM PRC Plan will be informed by the program documented in Table 3, which includes:

- consultation objectives;
- community members addressed by each objective;
- engagement type; and
- proposed frequency of consultation.
- BMA will monitor progress against these objectives as part of its regular reviews of consultation commitments and outcomes.
- Section 5 describes the information to be released to the community, and Section 6 describes how feedback or comments will be considered.

Table 3: Consultation program for PRC plan implementation

Consultation objective	1. To engage key stakeholders in identifying community objectives and aspirations for post-mining land use and landform, and social value opportunities to be considered in PRC Planning	
Stakeholders	Engagement type	Proposed consultation frequency
- Landowners and agistment licensees adjacent to SRM MLs - Barada Barna Peoples (BBAC) - IRC - Dysart community members	Advise adjacent landowners and licensees, BBAC and IRC in writing when the PRC plan is approved.	Once-off
	Communicate with agistment licensees during the terms of their licences and seek their inputs on SRM's PRCP schedule and approved PMLUs and NUMAs.	As part of future updates and/or amendments of the SRM PRC Plan
	Meet with adjacent landholders, BBAC and IRC to provide an update on the PRC plan and progress with rehabilitation, and invite their inputs and feedback on: - the approved PMLUs, NUMAs and post-mining landforms, including any particular values or opportunities in specific disturbed areas - rehabilitation methods which would optimise future woodland habitat and/or grazing opportunities, and potential land management requirements - shared value initiatives, e.g. infrastructure retention, capacity building, environmental management, or research partnerships - rehabilitation methods, schedule and progress towards milestones.	As requested, or as agreed with representatives
	As part of bi-annual meetings with IRC, and addressing BMA's portfolio rather than individual assets: - provide an update on the status of the PRC plans and rehabilitation, and forecast upcoming PRC plan consultation for BMA assets - seek to understand Council's strategic analysis and planning for Isaac LGA and the SRM mining area - share information to support understanding of challenges, opportunities and community aspirations of relevance to mine closure and rehabilitation - co-operate if advocacy is required to achieve better PRC planning outcomes in the Isaac LGA - build in consideration of the outcomes of Smart Transformation's projects as relevant, and the IRC's intended transformation approach	Bi-annually, or as agreed with IRC

Consultation objective	1. To engage key stakeholders in identifying community objectives and aspirations for post-mining land use and landform, and social value opportunities to be considered in PRC Planning	
Stakeholders	Engagement type	Proposed consultation frequency
	Participate in Council, community or industry-led initiatives including research partnerships which aim to harness social value from mine closure and rehabilitation planning, and/or work towards economic transformation/transition.	As invited
	In cooperation with BBAC and other First Nations within Isaac LGA, and on a portfolio-wide basis: - communicate the pipeline of opportunities relating to rehabilitation work and land management - develop a shared understanding of business capabilities relevant to closure and rehabilitation works - plan and implement an Indigenous business capability development program to match rehabilitation opportunities if this is required.	Ongoing engagement process
	Via the Dysart STAC, and/or PRC plan-specific workshops or focus groups, seek the involvement of community members and groups in articulating community aspirations for rehabilitation, PMLUs and economic transformation.	To be supported by BMA-wide consultation, as required
	Provide community updates on SRM's PRCP if there are any substantive changes and associated PRCP Amendments required, via Community Connect	As relevant
Consultation objective:	2. To support transparent access to information about SRM's PRC planning and implementation, enabling opportunities for BHP personnel and communities within the Isaac LGA to provide feedback on rehabilitation and closure outcomes	
Stakeholders	Engagement type	Proposed consultation frequency
BMA employees and contractors	Keep the SRM workforce updated (via Coal Connect, a weekly email newsletter to personnel) if there are changes to the PRC plan.	Ongoing engagement process
Nearby landholders and homestead residents	Write to nearby landholders (within approximately 5 km) to advise of any substantive changes to the PRC plan.	As relevant
Dysart community members and groups	Using Community Connect (BMA's bi-monthly community newsletter) and community forums such as interagency meetings, the Dysart STAC, partnership meetings and community and	Ongoing engagement process

Consultation objective:	2. To support transparent access to information about SRM's PRC planning and implementation, enabling opportunities for BHP personnel and communities within the Isaac LGA to provide feedback on rehabilitation and closure outcomes	
Stakeholders	Engagement type	Proposed consultation frequency
	business networks including Dysart Community Support Group, provide community updates on PRC Planning (SRM-specific as relevant, and portfolio wide).	
BMA licensees	Write to agistment licensees to advise of any substantive changes to the SRM PRC plan.	As relevant
Local businesses and BMA suppliers	Provide information about the pending closure of SRM and potential future supply opportunities as part of closure and rehabilitation to local businesses, Traditional Owner businesses and BMA suppliers via C-RES	Five years prior to decommissioning; subsequent consultation to be agreed
Elected representatives and Government agencies	Provide updates via letters and/or meetings on PRC Planning to: - Office of the Minister for Resources (Queensland) - Office of the Minister for Environment, Great Barrier Reef, Science and Youth Affairs (Queensland) - Shadow Minister for Resources - Shadow Minister for Environment, Great Barrier Reef, Science and Youth Affairs Resources - Member for Burdekin (Queensland Parliament) - DES PRCP Team - Director, Native Title Services and Coal Hub, Department of Resources - Deputy Director-General Georesources, Department of Resources - Assistant Secretary Assessments and Governance Branch, DCCEE	As requested, or as agreed with representatives
Consultation objective	3. To engage with utility owners, and adjacent mining and energy tenement holders, to provide information about SRM's closure planning that supports them to manage their assets and interests	
Stakeholders	Engagement type	Proposed consultation frequency
Queensland Rail and Aurizon	Maintain correspondence with Queensland Rail and Aurizon regarding progressive rehabilitation activities as they affect the SRM TLO and rail loop which are owned by QR and located on land	As requested, or as agreed with representatives

Consultation objective	3. To engage with utility owners, and adjacent mining and energy tenement holders, to provide information about SRM's closure planning that supports them to manage their assets and interests	
Stakeholders	Engagement type	Proposed consultation frequency
	leased from BMA, and undertake consultation regarding the decommissioning of the rail interface.	
Utility owners: • Q.E.C. Ltd • Powerlink • Sunwater • Energex • IRC	• Engage with relevant utility owners to inform them of closure timelines and rehabilitation activities relevant to the land either: • leased from BMA within SRM's MLs (Sunwater, QEC Pty Ltd, Energex and Powerlink); or • privately owned (QR and IRC).	• Initiated three years prior to decommissioning
	• Maintain correspondence regarding progressive rehabilitation and undertake consultation regarding crossing/interface agreements, as required if rehabilitation will affect utilities.	• During the three years prior to decommissioning
• Whitehaven Coal • Pembroke Resources • Bengal Coal • Bowen Basin Coal/Jellinbah Group • Vitrinite P/L • Arrow Energy/CH4 P/L • Eureka Petroleum Pty Ltd	• Write to advise adjacent and nearby resource interests if there are any substantive changes to the closure and rehabilitation schedule in future iterations of the SRM PRC Plan. At a business level, BHP will participate in industry and research partnerships of relevance to PRCP and rehabilitation.	• As requested, or as agreed with representatives/mining operations
• Department of Resources	• Provide updates on PRCP to the Director Native Title Services and Coal Hub, Rockhampton and the Deputy Director General, Department of Resources, in writing or through regular meetings.	• As requested, or as agreed with Department of Resources representatives

5 Information to be released for community consultation

Whilst many stakeholders in the Isaac LGA and broader Mackay-Isaac-Whitsunday Region are well-educated about mining operations, there is less understanding of planning for life-of-mine, rehabilitation and closure planning. The CCP recognises the following social context:

- talk of closure planning will lead to community concerns, requiring careful and consistent messaging;
- PRC plan consultations by a range of companies for a variety of assets will represent considerable cumulative demands on stakeholders, and a coordinated, strategic approach will be required to manage consultation fatigue; and
- community members are becoming increasingly aware of climate change and the impacts of resource activities and energy policies on the environment. Accordingly, community and stakeholder expectations with regards to mine rehabilitation are expected to increase over time, and need to be continuously understood.

Information to be released for community consultation, as part of future, ongoing SRM PRC planning and implementation will include:

- the rationale and scope for PRC Planning;
- the approved activities, PMLUs and NUMAs for SRM;
- on-site activities and areas of disturbance;
- proposed rehabilitation methods, schedule and milestones;
- alignment with long-term transformation planning occurring through IRC, Regional Development Australia (RDA) and others; and
- opportunities for community consultation as part of the PRC Plan's implementation.

Communication tools could include:

- a holding statement for general enquiries;
- frequently asked questions and answers (FAQs) and a PRC planning fact sheet available to support consultation activities;
- face to face and virtual meetings; and
- updates and fact sheets about PRC planning for BMA assets through Community Connect.

6 How feedback/comments will be considered

As noted in the DES *PRCP Guideline*, in addition to the annual return requirements that relate to EAs, if a PRC plan schedule applies to the activities then the annual return must also include an evaluation of the effectiveness of the PRC plan schedule, including the environmental management carried out under the schedule, for the year to which the annual return relates.

BMA will internally monitor and report on the progress and outcomes of progressive rehabilitation activities against rehabilitation milestones provided in the PRC Schedule. This monitoring will aim to demonstrate a successful rehabilitation trajectory towards achievement of the approved PMLU, and/or to inform corrective action where required.

As required, PRCP Schedule progress will be reported as part of annual return submissions to the DES.

Information about rehabilitation progress will also be delivered as part of the consultation methods detailed in Table 3, and feedback will be documented in PRC plan updates or amendments.

The PRC plan Consultation Register will also be updated as community consultation activities outlined in Table 3 are completed. All stakeholder feedback recorded in the Consultation Register will be considered in framing and detailing future PRC plan amendments for SRM.

This may include feedback on, for example:

- vegetation species most suitable to the approved PMLUs;
- rehabilitation methods to protect cultural heritage and achieve optimal use for the PMLUs;
- the PRCP (rehabilitation) schedule;
- water management (e.g. availability for beneficial use as part of the PMLUs, or adjacent uses); and/or
- development of business capacity programs to equip local and Indigenous businesses for rehabilitation works.

BMA has sought IRC's views on consultation options to involve Council in future PRC plan consultation for BMA assets. BMA will utilise Council's preferred options to seek inputs on, for example, community aspirations for PMLU and social value opportunities. As all but one of BMA's mines are located within the Isaac LGA, this would include working with Council to understand BMA-wide rehabilitation objectives and the overall sequence for mine closures,

7 PRC plan CCP review

Review of the SRM PRC plan will be undertaken as legislatively required. Review and update of the CCP, incorporating community feedback to date, will be aligned to any PRC plan updates or amendments.

Saraji Mine PRC Plan Community Consultation Register

COMMUNITY MEMBERS AND PREVIOUS ENGAGEMENT				PRC PLAN DEVELOPMENT ENGAGEMENT			ENGAGEMENT OUTCOMES			
Group	Stakeholder Title	Organisation/ Property	Previous engagement	Consultation type	Consultation date	Information provided	Issues raised/discussed	How issues were considered	Decisions/outcomes of engagement	BMA commitments
Traditional Owners	CEO	Barada Barna Peoples via Barada Barna Aboriginal Corporation (BBAC)	BMA has regular engagement with BBAC on a range of issues ranging from native title and cultural heritage to community and economic development. Since 2021, BHP has undertaken ongoing consultation with the Barada Barna Aboriginal Corporation (BBAC), who represent the Barada Barna Peoples as Traditional Owners. This has included various rehabilitation-related aspects. BBAC's feedback has included a request to work together with BHP to understand how they can get involved in rehabilitation execution activities over time, as guided by the PRCP Schedules to be submitted for approval.	Letter, via email	21/11/2022	SRM location, approved activities and production PRC plan requirements and timing for PRC Plan development SRM Life of Asset Rehabilitation requirements and timing Approved PMLUs and NUMAs Publication of rehabilitation schedule as part of PRC Plan Commitment to future engagement regarding PRC Planning for SRM Contact for further information	No specific issues raised with respect to SRM, but existing interest in opportunities to be involved in rehabilitation execution and post mining land forms.	BMA is considering the potential for involvement of Traditional Owners and Indigenous businesses in future mine rehabilitation works.	Traditional owners' interest in environmental management and mine rehabilitation will be part of ongoing engagement with them, addressing portfolio-wide opportunities.	BMA will continue to consult with BBAC and seek their inputs on rehabilitation and PMLUs. BMA will engage with Traditional Owners and Indigenous businesses to understand business capabilities and the pipeline of opportunities that relate to rehabilitation work and land management, on a portfolio-wide basis.
				Meetings to discuss PRC planning requirements and ILUA related opportunities.	31 August 2023 4 September 2023	Details on the amount of rehabilitation (hectares to be seeded)	Species to be selected for woodland revegetation.	BMA provided the full species list for further feedback from Barada Barna.	Seed mix was updated following a meeting with Barada Barna on 4th September 2023 to include Gumbby Gumbby (Pittosporum angustifolium) in the Tree/ Shrub mix for Woodland Habitat as it has cultural importance	
Adjacent and nearby landholders (within 5 km)	Adjacent landowner (and agistment licensee)	Tay-Glen	BMA has a long and constructive working relationship with Tay-Glen's owner, including with respect to an agistment licence. BMA continues to engage with neighbouring landholders on land management and lease/licence conditions, and on operational matters as required.	Letter, via email	30/11/2022	As above	No feedback or enquiries were received. BMA's regular engagements with landowners indicate that their issues of interest include environmental management, land access under current land access and lease agreements, and access to BMA land for grazing use whilst is not required for mining.	Stakeholder did not raise any issues.	Land within the MLs will continue to be available for grazing under existing agreements between BMA and landholders. Landholders and cattle will be excluded from affected areas whilst land disturbance is occurring. As disturbed land becomes available, it will be rehabilitated to a state suitable for the approved post-mining land use (PMLU) e.g. grazing, woodland, water courses, or managed as a non-use management area (NUMA).	BMA will continue to consult with adjacent landholders and seek their inputs on SRM's rehabilitation schedule and approved PMLUs.
	Adjacent landowner (and agistment licensee)	Saraji	BMA has a constructive working relationship with the property owners as agistment licensees and in respect to a coexistence agreement. BMA continues to engage with neighbouring landholders on land management and lease/licence conditions, and on operational matters as required.	Letter, via email	30/11/22	N/A	No feedback or enquiries were received. BMA's regular engagements with landowners indicate that their issues of interest include environmental management, land access under current land access and lease agreements, and access to BMA land for grazing use whilst is not required for mining.	Stakeholder did not raise any issues.	As above	BMA will continue to consult with adjacent landholders and seek their inputs on SRM's rehabilitation schedule and approved PMLUs.
	Agistment licensee (currently vacant, noted for future consultation)	Meadowbrook	BMA has had constructive working relationships with its agistment licensees. Meadowbrook, owned by BMA, is not currently occupied.	N/A - property vacant	N/A	N/A	N/A	N/A	N/A	BMA will consult with future licensees as part of future PRC plan development.
	Agistment licensee (currently vacant, noted for future consultation)	Lake Vermont	BMA has had constructive working relationships with agistment licensees. Lake Vermont, owned by BMA, is not currently occupied.	N/A - property vacant	N/A	As above, with information also provided on PRC Planning consultation requirements, and provision of supporting information to enable communication with contractors and personnel	N/A	N/A	N/A	BMA will consult with future licensees as part of future PRC plan development.
Saraji Mine personnel	General Manager	Saraji Mine	BMA's Closure Planning Team is in regular consultation with Saraji Mine's General Manager.	Meeting to discuss PRC planning requirements and support for communication with personnel.	1/11/2022	Progressive rehabilitation as a key focus for BMA PRC Plan requirements and purpose Timing for PRC Plan development Approved PMLUs Rehabilitation schedule Contact details for further information or queries.	PRC plan requirements Rehabilitation and post-mining land use Approved PMLUs Rehabilitation schedule	Agreement to ongoing engagement in PRC Planning	Ongoing cooperation between SRM and BMA's Closure Planning team	BMA will involve its asset managers in PRC planning processes, to build capacity for community engagement on PRC planning issues and support effective delivery of PRC Plans.
	Personnel	Saraji Mine	BMA communicates with its personnel on a continual basis through toolbox talks, emails, safety meetings, Community Connect and Coal Connect, which are regular newsletters.	Information provided for distribution through Coal Connect	9/11/2022	SRM location, approved activities and production PRC plan requirements and timing for PRC Plan development SRM Life of Asset Rehabilitation requirements and timing Approved PMLUs and NUMAs Publication of rehabilitation schedule as part of PRC Plan Commitment to future engagement regarding PRC Planning for SRM Contact for further information	No feedback or enquiries were received.	Stakeholders did not raise any issues.	BMA will keep the workforce updated as PRC Plans are implemented and revised.	BMA will keep the workforce updated if there are changes to the PRC plan, and as the PRC Plan reaches its renewal date. BMA will provide a communication channel for personnel to ask questions or contribute to discussions about PRC Planning and rehabilitation.
Utility owners	Property Projects Coordinator	Q.E.C Ltd Trading as Powerlink	Engagement with Powerlink is via routine correspondence on commercial and statutory issues.	Letter, via email	14/03/2023	As above	No feedback or enquiries were received.	As above	BMA will maintain correspondence with Q.E.C. Ltd. regarding progressive rehabilitation activities as they affect Q.E.C. Ltd assets, and undertake consultation regarding crossing/interface agreements, if required.	BMA will work with Q.E.C. Ltd. to develop/ update an agreement if required, with terms and conditions tailored to the closure/rehabilitation activity affecting Q.E.C. Ltd's asset.
	Senior Advisor Community Engagement	Aurizon/Queensland Rail	Engagement with QR and Aurizon is via routine correspondence on commercial and statutory issues, with meetings held as required on specific issues.	Letter, via email	3/03/2023	As above	No feedback or enquiries were received.	As above	BMA will advise Aurizon and Queensland Rail of any substantive changes to closure planning or the rehabilitation schedule as part of future PRC planning processes for SRM.	BMA will maintain engagement with Aurizon and Queensland Rail regarding its progressive rehabilitation activities as they affect QR assets, and undertake engagement regarding the decommissioning of the train load out facility/trail interface prior to its closure, in accordance with agreements between BMA and Aurizon at the time.
	Property Projects Coordinator	Powerlink	Engagement with Powerlink is via routine correspondence on specific issues.	Letter, via email	3/03/2023	As above	No feedback or enquiries were received.	As above	BMA will maintain correspondence with Powerlink regarding progressive rehabilitation activities as they affect Powerlink assets, and undertake consultation regarding crossing/interface agreements, if required.	BMA will advise and consult Powerlink regarding any impacts of the closure/rehabilitation activity that may affect Powerlink's asset.
	Property Projects Coordinator	Energex	Engagement with Energex is via routine correspondence on specific issues.	Letter, via email	3/03/2023	As above	No feedback or enquiries were received.	As above	BMA will maintain correspondence with Energex regarding progressive rehabilitation activities as they affect Energex assets, and undertake consultation regarding crossing/interface agreements, if required.	BMA will advise and consult Energex regarding any impacts of the closure/rehabilitation activity that may affect Energex's asset.
	Senior Advisor Community Engagement	Sunwater	Sunwater's Eungella Water Pipeline is adjacent to the MLs and has a small area of overlap with ML1782 to the south. Engagement with Sunwater is on an as-needed basis.	Letter, via email	3/03/2023	As above, with information also provided on PRC Planning consultation requirements, and provision of supporting information to enable communication with contractors and personnel	No feedback or enquiries were received.	Sunwater's Eungella Water Pipeline is adjacent to the MLs and has a small area of overlap with ML1782 to the south, which may need to be considered in PRC planning.	BMA will maintain correspondence with Sunwater regarding progressive rehabilitation activities as they affect the Eungella Water Pipeline, and undertake consultation regarding crossing/interface agreements, if required.	BMA will work with Sunwater to develop an agreement addressing any closure/rehabilitation impacts affecting the Eungella Water Pipeline, as relevant.
Adjacent and nearby mining interests	General Manager	Peak Downs Mine (BMA)	BMA's Closure Planning Team is in regular consultation with Peak Downs Mine's General Manager.	Phone call and email to discuss PRC planning requirements and support for communication with personnel.	30/11/2022	SRM location, approved activities and production PRC plan requirements and timing for PRC Plan development SRM Life of Asset Rehabilitation requirements and timing Approved PMLUs and NUMAs Publication of rehabilitation schedule as part of PRC Plan Commitment to future engagement regarding PRC Planning for SRM Contact for further information	No issues raised.	No issues raised.	GM is prepared for future engagement in PRC planning for Peak Downs Mine.	BMA will continue to engage internal stakeholders in PRC planning and associated stakeholder engagement processes.
	Site Senior Executive	Whitehaven Coal WS	Whitehaven has proposed the Winchester South Mine to the east of SRM. BMA has engaged Whitehaven Coal as part of a previous BMA PRCP consultation process.	Letter, via email	9/11/2022	As above	No feedback or enquiries were received.	As above	BMA will update Whitehaven Coal on any substantive future changes to the PRC Plan.	BMA will advise Whitehaven Coal if there are any substantive changes to the closure and rehabilitation schedule in future iterations of the PRC Plan.

Saraji Mine PRC Plan Community Consultation Register

COMMUNITY MEMBERS AND PREVIOUS ENGAGEMENT				PRC PLAN DEVELOPMENT ENGAGEMENT			ENGAGEMENT OUTCOMES			
Group	Stakeholder Title	Organisation/ Property	Previous engagement	Consultation type	Consultation date	Information provided	Issues raised/discussed	How issues were considered	Decisions/outcomes of engagement	BMA commitments
	Site Senior Executive	Bowen Basin Coal/Jellinbah Group	Bowen Basin Coal/Jellinbah's Lake Vermont Mine is located to the southeast of SRM. There has been no recent engagement with Bowen Basin Coal or Jellinbah Group.	Letter, via email	9/11/2022	As above	No feedback or enquiries were received.	As above	BMA will update Bowen Basin Coal/Jellinbah Group Coal on any substantive future changes to the PRC Plan.	BMA will advise Bowen Basin Coal/Jellinbah Group if there are any substantive changes to the closure and rehabilitation schedule in future iterations of the PRC Plan.
	Site Senior Executive	Bengal Coal	Bengal Coal's Dysart East project is located to the east of SRM. There has been no recent engagement with Bengal Coal	Letter, via email	9/11/2022	As above	No feedback or enquiries were received.	As above	BMA will update Bengal Coal on any substantive future changes to the PRC Plan.	BMA will advise Bengal Coal if there are any substantive changes to the closure and rehabilitation schedule in future iterations of the PRC Plan.
	Site Senior Executive	Vitrinite	Vitrinite's Vulcan Coal project is located to the west of SRM. BMA has engaged Vitrinite as part of a previous BMA PRCP consultation process.	Letter, via email	9/11/2022	As above	No feedback or enquiries were received.	As above	BMA will update Vitrinite Coal on any substantive future changes to the PRC Plan.	BMA will advise Vitrinite Coal if there are any substantive changes to the closure and rehabilitation schedule in future iterations of the PRC Plan.
	Operations Manager/SSE	Pembroke Resources	Pembroke Resources has approval to construct and operate the Olive Downs Project to the east of SRM. BMA has engaged Pembroke Resources as part of a previous BMA PRCP consultation process. There has been no previous engagement with respect to Saraji Mine.	Letter, via email	9/11/2022	As above	No feedback or enquiries were received.	As above	BMA will update Pembroke Resources on any substantive future changes to the PRC Plan.	BMA will advise Pembroke Resources if there are any substantive changes to the closure and rehabilitation schedule in future iterations of the PRC Plan.
Petroleum tenement holders	Tenement Manager/Authorised Holder Representative	Eureka Petroleum Pty. Ltd.	Eureka Petroleum Pty. Ltd. has an ATP which overlaps the ML to the northwest. BMA and Eureka Petroleum Pty. Ltd communicate regarding tenure overlaps on an as-needed basis.	Letter, via email	4/11/2022	As above	Acknowledgement of engagement received.	As above	BMA will advise Eureka Petroleum Pty. Ltd of any substantive changes to closure or rehabilitation schedule as part of future PRC planning processes for SRM.	BMA will advise Eureka Petroleum Pty. Ltd of any substantive changes to closure or rehabilitation schedule as part of future PRC planning processes for SRM.
	Principal Technical Adviser	Arrow/CH4 P/L	CH4 P/L has an ATP which overlaps the ML to the east. BMA and CH4 P/L communicate regarding tenure overlaps on an as-needed basis.	Letter, via email	4/11/2022	Progressive rehabilitation as a key focus for BMA PRC Plan requirements and purpose Timing for PRC Plan development Commitment to ongoing engagement Contact details for further information or queries.	Acknowledgement of engagement received.	As above	BMA will update Arrow/CH4 P/L on any substantive future changes to the PRC Plan.	BMA will advise Arrow/CH4 P/L of any substantive changes to closure or rehabilitation schedule as part of future PRC planning processes for SRM.
Community members and groups	Community members, Moranbah, Dysart and Isaac Region	Various	BMA conducts a range of engagement activities with community members, from one-off responses to enquiries, to regular community information processes, ongoing engagement process such as the Smart Transformation Advisory Councils, and partnerships with community organisations and industry bodies.	Inclusion of information in 'Community Connect' which is distributed to 15,000 households	15/01/2023	SRM location, approved activities and production PRC plan requirements and timing for PRC Plan development SRM Life of Asset Rehabilitation requirements and timing Approved PMLUs and NUMAs Publication of rehabilitation schedule as part of PRC Plan Commitment to future engagement regarding PRC Planning for SRM Contact for further information	No feedback or enquiries were received.	As above	BMA will provide community updates on PRC planning for SRM if there are any substantive changes or updates, and associated PRCP Amendments required to the PRC plan, via Community Connect.	BMA will provide community updates on PRC planning, and seek the involvement of community members and groups in understanding community aspirations for rehabilitation, post mining land use and economic transformation, as part of portfolio-wide engagement. BMA will involve IRC, community members and businesses in identifying social value as part of PRC planning processes. This will include identifying local capacity for involvement in rehabilitation work. BMA will participate in initiatives led by the Council, industry or local communities which aim to harness social value from mine closure and rehabilitation planning, and/or work towards from economic transformation.
Moranbah and Dysart Smart Transformation Advisory Council (STAC)	Community members, and businesses, Moranbah and Dysart	Various	The STAC is sponsored by BMA and represents a broad cross-section of community and business interests in Dysart.	Letter, via email	17/11/2022	As above	No feedback or enquiries were received.	Stakeholders did not raise any issues.	CBMA will continue to provide community information and opportunities for feedback as part of future PRC planning processes.	Via the Dysart Smart Transformations Advisory Committee, and/or PRC plan-specific workshops or focus groups, BMA will seek the involvement of community members and groups in articulating community aspirations for rehabilitation, PMLUs and economic transformation
Local Government	Mayor	Isaac Regional Council	Since 2021, BHP has been providing regular PRC planning briefings to the IRC as part of bi-annual and special purpose meetings. This has included briefing the IRC on the SRM PRCP process (May and November 2022). Issues raised during IRC-BMA meetings that discussed PRC planning included: - Council engagement in PRC planning for BMA assets - Cumulative consultation demands of PRC planning - Key principal is cooperation to get the best outcome for communities, industry and Council - Interest in rehabilitation	Letter, via email. Follow up at November 2022 IRC-BMA meeting	3/11/2022	Provision of draft PRC Plan and discussion of requirements	Acknowledgement of information and ongoing consultation process between IRC and BMA.	BMA recognises the cumulative demands for Council involvement in PRC Plan engagement.	IRC will require ongoing engagement regarding PRC planning for SRM and other BMA assets. PRC planning updates are provided at each meeting. BMA will also consult IRC on management plans if rehabilitation and/or closure activities would impact on IRC assets such Lake Vermont Road, Saraji Road or waste management/recycling facilities. Subsequent reviews of the CCP and community consultation for other assets' PRC Plans will consider Council's preferred options for engagement. Future engagement with Council will include discussion of rehabilitation methods and milestones.	BMA will engage with IRC to understand Council's strategic analysis and planning for Isaac LGA and the Saraji Mine project area as relevant. BMA will engage with IRC regarding any impacts on Lake Vermont Road or Saraji Road as part of the progressive rehabilitation and closure process, and will update IRC on PRC planning regularly. BMA will keep IRC updated on the PRC Planning schedule for its portfolio in the Isaac LGA. BMA will share the results of its research and industry partnership projects relevant to rehabilitation with Council at bi-annual meetings between Council and BMA. BMA will work with Council and other stakeholders in future PRC plan consultations to identify and implement social value opportunities.
	Councillors									
	CEO									
State Government	PRC Planning Team	DES	During 2018, BMA engaged with DES on the PMLUs and associated Acceptance Criteria within the EA. These PMLUs and Acceptance Criteria were included in the 18 November 2019 SRM EA amendment. During 2022-23, consultation with DES has included meetings and correspondence regarding the preparation and delivery of the PRC Plan.	Pre-lodgement meetings	Various	SRM location, approved activities and production PRC plan requirements and timing for PRC Plan development SRM Life of Asset Rehabilitation requirements and timing Approved PMLUs and NUMAs Publication of rehabilitation schedule as part of PRC Plan Commitment to future engagement regarding PRC Planning for SRM	As per pre-lodgement meetings.	DES feedback was considered in the development of the PRC Plan.	The PRC plan will be completed in accordance with BMA's agreements with DES.	BMA will comply with the legislative and regulatory requirements for PRC Plans.
	Deputy Director-General Georesources	Department of Resources	BMA provides briefings to the DDG on an as-needed basis.	Letter via email	14/11/2022	As above	The Department of Resources appreciates the update on the PRC Plan for SRM and anticipates future updates from BMA on the plan.	The PRC Plan's Community Consultation Plan includes provision of annual updates to Department of Resources.	BMA will provide a copy of the SRM PRC plan to DDG Georesources, and update the DDG Georesources on any future changes to the PRC Plan.	BMA will provide updates on PRC planning to the Deputy Director General Georesources as requested
	Acting Director Native Title Services and Coal Hub, Rockhampton	Department of Resources	BMA provides briefings on an as needed basis, and meets and corresponds with Department of Resources regarding resource development commitments.	Letter via email	14/11/2022	As above	The Department of Resources appreciates the update on the PRC Plan for SRM and anticipates future updates from BMA on the plan.	The PRC Plan's Community Consultation Plan includes provision of annual updates to Department of Resources.	BMA will advise the availability of the SRM PRC plan to Director Native Title Services and Coal Hub, Rockhampton, and provide updates on any substantive future changes to the PRC Plan.	BMA will provide updates on PRC planning to the Director Native Title Services and Coal Hub, Rockhampton as requested.
	Executive Director, Minerals and Coal	Department of Resources	As above.	Letter via email	15/07/2022	As above	The Department of Resources appreciates the update on the PRC Plan for SRM and anticipates future updates from BMA on the plan.	The PRC Plan's Community Consultation Plan includes provision of annual updates to Department of Resources.	BMA will advise the availability of the SRM PRC plan to the Principal Mining Registrar, Coal Assessment Hub and Executive Director, Minerals and Coal, Department of Resources, and provide updates on any substantive future changes to the PRC Plan.	BMA will provide updates on PRC planning to the Director Native Title Services and Coal Hub, Rockhampton as requested.
	Chief of Staff/Secretary	Office of the Minister for Energy, Renewables and Hydrogen and Minister for Public Works and Procurement	BMA provides briefings to the Minister's office on an as-needed basis.	Discussion of PRC plans as part of a future briefing	During 2023 and in response to any queries	As above	No enquiries were received.	Not applicable	BMA will update the Office of the Minister on any substantive future changes to the PRC Plan.	BMA will provide updates on PRC planning to the Minister's office as requested.
	Chief of Staff/Secretary	Office of the Minister for Agriculture Industry Development and Fisheries and Minister Regional Communities	BMA provides briefings to the Minister's office on an as-needed basis.	Discussion of PRC plans as part of a future briefing	During 2023 and in response to any queries	As above	No enquiries were received.	Stakeholders did not raise any issues.	BMA will update Office of the Minister on any substantive future changes to the PRC Plan.	BMA will provide updates on PRC planning to the Minister's office as requested.
	Chief of Staff/Secretary	Office of the Minister for Regional Development and Manufacturing and Minister for Water	BMA provides briefings to the Minister's office on an as-needed basis.	Discussion of PRC plans as part of a future briefing	During 2023 and in response to any queries	As above	No enquiries were received.	Stakeholders did not raise any issues.	BMA will update Office of the Minister on any substantive future changes to the PRC Plan.	BMA will provide updates on PRC planning to the Minister's office as requested.
	Dale Last MP	Queensland Parliament - Member for Burdekin	BMA provides briefings to the Member for Burdekin's office on an as-needed basis.	Discussion of PRC plans as part of a future briefing	During 2023 and in response to any queries	As above	No enquiries were received.	Stakeholders did not raise any issues.	BMA will update the Member for Burdekin on any substantive future changes to the PRC Plan.	BMA will provide updates on PRC planning to the Member's office as requested.
	Chief of Staff/Secretary	Queensland Government Office of the Minister for the Environment and the Great Barrier Reef and Minister for Science and Youth Affairs	BMA provides briefings to the Minister's office on an as-needed basis.	Discussion of PRC plans as part of a future briefing	During 2023 and in response to any queries	As above	No enquiries were received.	Stakeholders did not raise any issues.	BMA will update Office of the Minister on any substantive future changes to the PRC Plan.	BMA will provide updates on PRC planning to the Minister's office as requested.
Federal Government		Office of the Minister and Dep. Sec. Environment Protection, DAWE	BMA provides briefings to the Minister's office on an as-needed basis.	Discussion of PRC plans as part of a future briefing	During 2023 and in response to any queries	As above	No enquiries were received.	Stakeholders did not raise any issues.	BMA will update Office of the Minister on any substantive future changes to the PRC Plan.	BMA will provide updates on PRC planning to the Minister's office as requested.

SARAJI MINE

Transitional Progressive Rehabilitation and Closure Plan Voids in Floodplain Assessment

Prepared for:

BHP Metcoal Holdings Pty Ltd

SLR Ref: 620.30403.00000-R01
Version No: -v1.1
June 2022



PREPARED BY

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BASIS OF REPORT

This report has been prepared by SLR Consulting Australia Pty Ltd (SLR) with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with BHP Metcoal Holdings Pty Ltd (the Client). Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

This report is for the exclusive use of the Client. No warranties or guarantees are expressed or should be inferred by any third parties. This report may not be relied upon by other parties without written consent from SLR.

SLR disclaims any responsibility to the Client and others in respect of any matters outside the agreed scope of the work.

DOCUMENT CONTROL

Reference	Date	Prepared	Checked	Authorised
620.30403.00000-R01-v1.1	10 June 2022	H Munck	M Della	M Della
620.30403.00000-R01-v1.0	18 October 2021	H Munck	M Della	B Philby

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APPENDICES

Appendix A	Pre-lodgement BHP/DES Workshop for PRCPs – Floodplain modelling and flood risks – Memorandum
Appendix B	TUFLOW Model Results

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Appendix C TUFLOW Model Results – Sensitivity Analysis

1 Introduction

SLR was engaged by BHP in March 2021 to undertake floodplain modelling at Saraji Mine (SRM). The modelling was undertaken to inform the Transitional Progressive Rehabilitation and Closure Plan (PRCP) for SRM.

SRM is located in Central Queensland, approximately 45 kilometres south-east of Moranbah, and immediately adjacent to Peak Downs Mine which is located to the north-west. SRM is located within the catchment of the Isaac River. A number of local watercourses traverse the site, including Boomerang Creek, Hughes Creek and Phillips Creek. **Figure 1** illustrates the location of SRM and key surrounding features.

The assessment detailed in this document was undertaken specifically to address the voids in floodplain modelling as part of the PRCP requirements for SRM.

1.1 Aims and Objectives

Saraji Mine requires a PRCP to be completed in accordance with SRM's Environmental Authority (EA), (No. EPML00862313). The EA is held by the Central Queensland Coal Associates Joint Venture (CQCA JV). The EA relates to SRM on Mining Leases (ML) 1775, 1782, 1784, 2360, 2410, 70142, 70294, 70298, 70328 and 700021. As part of the PRCP for SRM, it is proposed to incorporate five final voids as Non-Use Management Areas (NUMAs). **Figure 1** illustrates the location and extent of the proposed final voids at SRM.

To meet the requirements of the Environmental Protection Act 1994 (EP Act) and Environmental Protection Regulation 2019 (EP Regulation), floodplain modelling is required for all relevant watercourses in the vicinity of voids, to assess the flood immunity and extents for the final landform conditions.

The scope of this project is to undertake floodplain modelling of the relevant watercourses as defined by the EP Regulation in relation to the proposed voids, including the following key tasks:

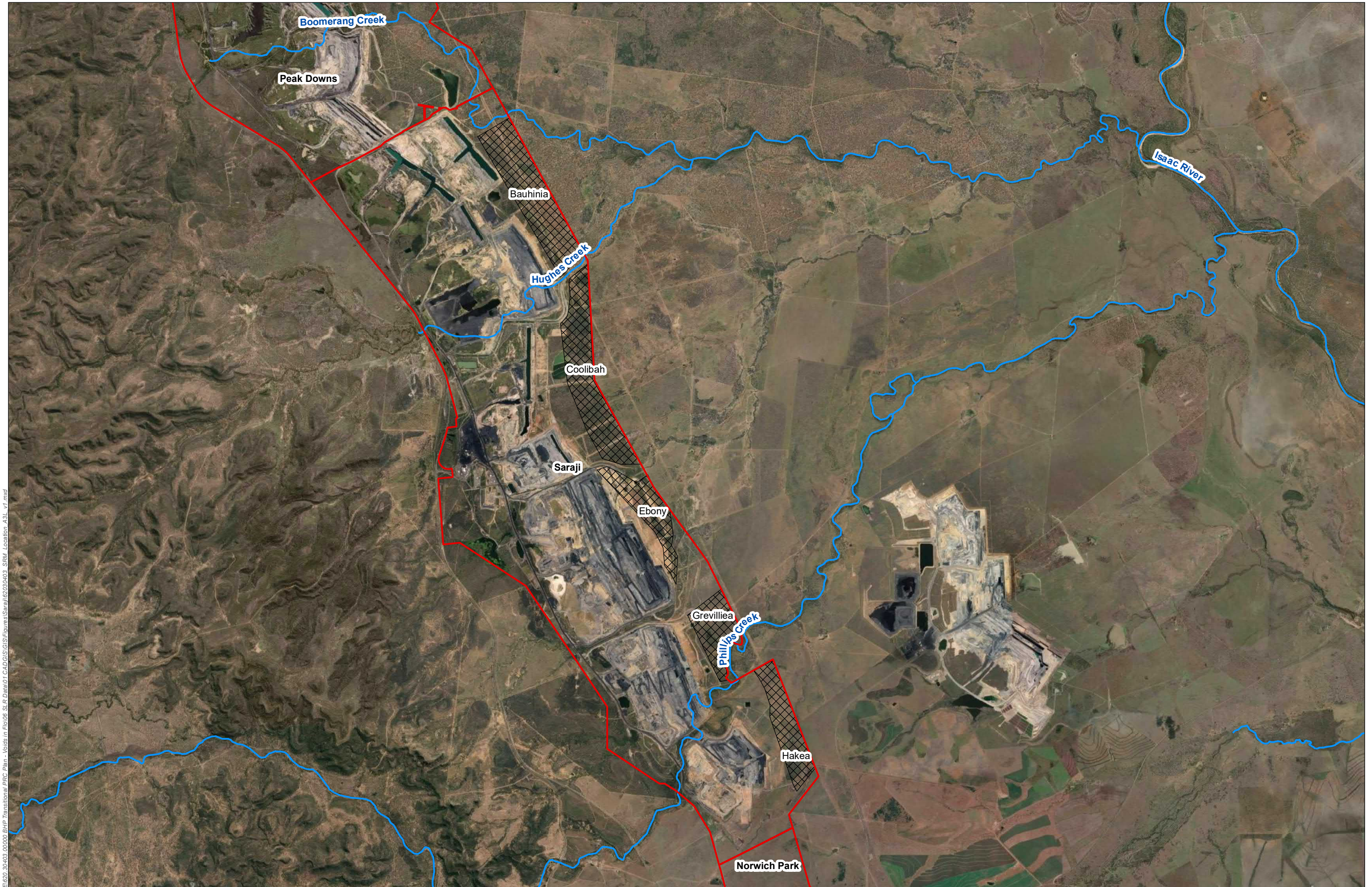
- Undertake a catchment study for each proposed void in the floodplain, including determining the pre-mining landform and developing or updating hydrologic modelling to be consistent with the requirements of Australian Rainfall and Runoff (AR&R 2019). The study includes watercourses classified as stream order four or higher, and their contributing tributaries.
- Update and/or develop hydraulic models for the purpose of identifying flood risks posed to the proposed voids. The purpose of this is to define the baseline flood risks caused by the major creeks, which will be used to assess the inundation risk in the 0.1% Annual Exceedance Probability (AEP) flood event for each void, informed by the re-constructed pre-mining topography.
- Produce a Voids in Floodplain Model Report detailing the methodology and findings of the above assessments, including all relevant mapping of flood extents, levels and depths. GIS data and models will also be provided as an output of this assessment.

The assessments detailed in this report were undertaken and reviewed by appropriately qualified persons.

1.2 Input Data

Data for the assessment was provided by BHP and included pre-mining topographic data, design surface data for the PRCP landform and aerial imagery for SRM.

Further data was obtained for use in the assessment from public sources, including additional topographic data, rainfall data, catchment specific hydrologic data and stream flow data. Further detail on the data utilised in the assessment is provided in **Section 3**.



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Legend

- EA Boundary
- Final Void Extent
- Watercourse

1.3 Relevant Documentation

This assessment was undertaken in accordance with the following guidelines and documentation:

- *Environmental Protection Act 1994*;
- *Environmental Protection Regulation 2019*;
- *'Guideline – Progressive Rehabilitation and Closure Plans'*, Department of Environment and Science, March 2021 (PRCP Guideline);
- *'Information Sheet – Environmental Protection Act 1994 – Voids in Flood Plains'*, Department of Environment and Science, March 2020 (Voids in Flood Plains Information Sheet); and
- *'Australian Rainfall and Runoff (2019)'* (ARR).

In addition to the documentation listed above, the assessment was undertaken in accordance with the methodology that was agreed between BHP and DES during the pre-lodgement workshop for PRCPs (**Appendix A**).

1.4 Assumptions and Limitations

This assessment was undertaken specifically for the purposes for undertaking floodplain modelling of relevant watercourses in accordance with the requirements of the EP Act and EP Regulation. The following assumptions and limitations apply to this assessment.

- The accuracy of the assessment is reliant on the accuracy of the utilised data, as detailed in **Section 3**. SLR has assumed all source data to be fit for purpose and sufficiently accurate for the purpose of this assessment. Except where noted, no verification of accuracy of the information has been carried out. In the event that some of the information which was relied upon for this assessment is found to be inaccurate, then some or all of the findings may change.
- Floodplain modelling was undertaken only for relevant watercourses as defined in the Voids in Floodplain Information Sheet, i.e. watercourses with a stream order of 4 or higher under the Strahler stream order classification system.
- Generation of the model landform for the assessment was undertaken in accordance with the Voids in Flood Plains Information Sheet. Due to the requirement to include artificial features outside of the subject Mine Lease, the modelled floodplain may differ from the true pre-mining floodplain in areas where adjacent artificial features effect a relevant watercourse (for example, the Boomerang Creek floodplain is affected by the adjacent artificial features of the Peak Downs Mine site).
- Consideration was made as to the potential effects of groundwater on the floodplain extent. It was considered that groundwater will have no significant impact on the extent of the floodplain. An initial rainfall loss of 0 mm was adopted in the hydrologic studies. This assumption represents fully saturated catchment conditions (i.e. soil stores at the surface were full), which was considered to be a conservative approach.
- Although the analyses undertaken as detailed in this report were done so with the appropriate care and professionalism, this report shall only be used for the purposes intended. The analyses detailed in this report were undertaken solely for the purpose of addressing the requirements for voids in floodplain modelling for Saraji Mine in accordance with the relevant documentation as detailed in Section 1.3.

- This report should be read in full and no excerpts are to be taken as representative of the findings. This report has been prepared on behalf of BHP Metcoal Holdings Pty Ltd and SLR accepts no liability or responsibility whatsoever for, or in respect of, any use of, or reliance upon, this report by any third party.

1.5 Document Structure

The structure of this report is set out as follows:

- **Section 2** - Relevant legislation and guidelines;
- **Section 3** - Data review and gap analysis, including details of the model landform development methodology and results;
- **Section 4** - Hydrologic modelling of the Isaac River and local Saraji catchments, including calibration methodology;
- **Section 5** - Hydraulic modelling of relevant watercourses including Boomerang Creek, Hughes Creek and Phillips Creek, including results and outcomes of the floodplain modelling in relation to the proposed final voids; and
- **Section 6** – Summary of the study and conclusions.

Details of each component of the assessment are provided below.

2 Legislation and Guidelines

2.1 Relevant Legislation and Guidelines

This assessment has been undertaken in accordance with the following legislation and guidelines:

- *Environmental Protection Act 1994*;
- *Environmental Protection Regulation 2019*;
- *'Information Sheet – Environmental Protection Act 1994 – Voids in Flood Plains'*, Department of Environment and Science, March 2020; and
- *'Guideline – Progressive Rehabilitation and Closure Plans'*, Department of Environment and Science, March 2021 (PRCP Guideline).

The Environmental Protection Act 1994 states:

'In accordance with section 126D(3) of the EP Act, if land the subject of the proposed PRCP schedule will contain a void situated wholly or partly in a flood plain, the schedule must provide for the rehabilitation of the land to a stable condition.'

The Environmental Protection Regulation 2019 section 41C(3) also states:

"The administering authority must treat the land as a flood plain to the extent the results of the flood plain modelling show that, when all relevant activities carried out on the land have ended, the land is the same height as, or lower than, the level modelled as the peak water level 0.1% AEP for a relevant watercourse under the ARR"

Further guidance is provided in the PRCP Guideline and the Voids in Flood Plains Information Sheet.

Sections 3.4 and 3.6.1 of the PRCP Guideline both require a floodplain assessment to be carried out. Specifically, section 3.4 requires a Void in Floodplain assessment for all unapproved NUMA voids (i.e. floodplain assessment of the pre-mining landform), whilst section 3.6.1 requires a post-mining landform assessment irrespective whether a post-mining land use (PMLU) or NUMA is proposed.

2.2 Applicability to the Project

Based on the review of the EP Act, EP Regulation, PRCP Guideline and the Voids in Floodplains information sheets, it is considered that the legislative requirements set out in **Table 1** are applicable to the project.

Table 1 Applicable Legislative Requirements

Requirement	Application to the Project	Source
For transitional sites, a floodplain assessment is required where: - A void has been identified as a NUMA in a land outcome document but the location has not been specified; or - Where there are no land outcomes in the land outcome document.	The PRCP for Saraji Mine includes five final voids which are proposed to be developed as NUMAs. Therefore, floodplain assessment is required.	PRCP Guideline Section 3.4

Requirement	Application to the Project	Source
Floodplains associated with a stream order 4 or greater are required to be modelled.	The following watercourses are of Strahler stream order 4 or greater and may affect the proposed voids: - Boomerang Creek; - Hughes Creek; and - Phillips Creek Therefore, the above Creeks are relevant watercourses and floodplain modelling was undertaken for each.	Voids in Flood Plains Information Sheet Section 5.
The modelling must not include any artificial features on the site. However, the modelling must include all existing and approved artificial features that, at the time of modelling, are located outside of the mining tenure boundary.	A Digital Elevation Model (DEM) of the area was created to be used as the model landform for the assessment. The model landform DEM was developed to represent the pre-mining topography within the Mining Lease (ML), and existing and future topography outside of the ML, including on adjacent MLs where applicable. The topography outside of the ML included existing and future artificial features, based on available data.	Voids in Flood Plains Information Sheet Section 4.
The requirement for a flood assessment under section 3.6.1 of the Guideline applies to the post mining landform across the whole site irrespective of whether a PMLU or a NUMA are proposed. Furthermore, section 3.6.1 is not only required to indicate flood risk but also to demonstrate the final landform (including waste rock dumps and diversions) will remain in a stable condition in a range of flood flow conditions.	Not included in the scope of this assessment.	PRCP Guideline Section 3.6.1

2.3 Definitions and Terminology

Table 2 provides the definitions and terminology that are utilised in this assessment, in accordance with the PRCP Guideline and the Voids in Flood Plains Information Sheet.

Table 2 Definitions and Terminology

Term	Definition	Source
Voids	An area of land to be excavated in carrying out a mining activity. Therefore, all voids (PMLU or NUMA) are subject to the requirements of the EP Act.	Section 126D of the EP Act
Flood plain	A void is considered to be located in a flood plain if the flood plain modelling shows that, when all relevant activities carried out on the land have ended, the land is the same height as, or lower than, the level modelled as the peak water level 0.1% AEP for a relevant watercourse under the guideline Australian Rainfall and Runoff (2019)(ARR).	Section 41C of the EP Regulation; and PRCP Guideline Section 3.4.
Stable condition	- The land is safe and structurally stable; - There is no environmental harm being caused by anything on or in the land; and - The land can sustain a PMLU.	Section 126D(3) of the EP Act; and PRCP Guideline Section 3.6.3.
Relevant watercourse	(a) A watercourse classified as stream order 4 or higher under the Strahler stream order classification system; or (b) If a watercourse mentioned in paragraph (a) is permanently diverted under – (i) A condition, or proposed condition, of an environmental authority mentioned in the Water Act 2000, section 98; or (ii) A water license or proposed water license under the Water Act 2000; the watercourse as permanently diverted.	PRCP Guideline Section 8; and Voids in Flood Plains information Sheet Section 5
Flood plain modelling	For land the subject of a PRCP schedule, means modelling of the landform of the land – (a) Carried out under the ARR; (and) (b) Excluding any artificial features for the land	PRCP Guideline Section 8; and Voids in Flood Plains information Sheet Section 4

Term	Definition	Source
Artificial feature	For land the subject of a PRCP schedule, means – (a) A structure or feature that is temporary and, under the PRCP schedule or otherwise, is to be removed from the land; or (b) A structure or feature that, under the PRCP schedule, will require a level of maintenance after the land is surrendered that is greater than the level of maintenance that would be required for the land if the relevant activities the subject of the PRCP schedule had not been carried out; or (c) A feature forming part of the landform of the land, other than the natural landform, if the feature interferes with or affects – (i) A relevant watercourse; or (ii) The natural flow of water on the land.	PRCP Guideline Section 8; and Voids in Flood Plains information Sheet Section 6.

3 Data Review and Gap Analysis

3.1 Available Data

A data package was provided to SLR by BHP for use in the assessment. The package included:

- Pre-mining topography for Saraji (2 metre interval contour data, date unknown);
- Pre-mining topography for the adjacent Peak Downs and Norwich Park Mines (2 metre interval contour data, date unknown);
- Proposed PRCP NUMA landform DEM including final voids for SRM;
- Proposed PRCP NUMA landform DEM including final voids for Peak Downs Mine; and
- Saraji aerial imagery dated 1985.

Additional data was obtained from publicly available sources including:

- 1 second SRTM Derived Hydrological Digital Elevation Model topographic data (Geoscience Australia);
- Queensland road, rail and place names GIS datasets (Department of Resources (DR), 2021); and
- Historic gauged stream flow data for the Goonyella and Deverill Stream Gauges (DNRM).

The provided data was analysed for suitability for the purposes of this assessment. The outcomes of the review are detailed below.

3.2 Watercourses

A review of the existing watercourses in the vicinity of SRM was undertaken using hydrologic streamline data sourced from DR. The dataset contained Strahler Stream Order classifications for each watercourse, which ranged from order 1 to order 7 within the extent of the data, as illustrated in **Figure 2**. The reviewed showed that the following watercourses are of Strahler stream order 4 or greater and may affect the proposed voids:

- Boomerang Creek;
- Hughes Creek; and
- Phillips Creek.

Therefore, the above creeks are relevant watercourses and floodplain modelling was undertaken for each.

The Isaac River is of a Strahler Stream Order of 6 and was considered as a possible relevant watercourse. Further consideration showed that the Isaac River is located some 20 km downstream of the site, and ground levels at the site are generally 30 m above the Isaac River floodplain ground levels. Therefore, the Isaac River is not a relevant watercourse for the project.

Preliminary review of the above watercourses in relation to the proposed voids showed that Boomerang Creek and Hughes Creek traverse directly adjacent to the Bauhinia and Coolibah pits and therefore floodplain modelling of these systems is required. Similarly, Phillips Creek runs between the Grevillia and Hakea pits, thereby requiring floodplain modelling.



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Legend

- EA Boundary
- Final Void Extent

Strahler Stream Order

- 1 — 5 —
- 2 — 6 —
- 3 —
- 4 —

3.3 Landforms

The 'pre-mining' ALS for Saraji was processed into a 1 metre spaced DEM and combined with the Peak Downs final landform DEM. Review of these DEMs showed a lack of detail in some areas. Additionally, it was concluded that artificial features of the PRCP landform within the Peak Downs Mine lease will have an impact on the Boomerang Creek catchment. The location of these features can be seen in the DEM illustrated in **Figure 3**.

While the voids were considered when estimating the flow in Boomerang Creek, they were not included in the hydraulic model as they were located outside of the floodplain extent. Due to the nature of the DEM extents and the location of Phillips Creek, no artificial features on the Norwich Park lease were expected to impact the floodplain and were therefore not required for the final model landform.

3.4 Artificial Features

Existing and proposed artificial features within the model domain were identified based on the available information at the time of the assessment. A summary of the identified artificial features and relevant details are provided in **Table 3**. Consideration was made for each artificial feature to determine if the feature was necessary to include in the hydrologic and hydraulic models, based on the feature's respective influence on 0.1% AEP flooding conditions in the vicinity of the voids.

Table 3 Artificial Features

Artificial Feature / Description	Source	Hydraulic model inclusion status
On-tenure		
Lake Vermont Road	Department of Resources (DR)	All on lease artificial features not included in model as per EP Regulation requirements.
Bauhinia Pit	PRCP Landform DEM (BHP).	
Coolibah Pit	PRCP Landform DEM (BHP).	
Ebony Pit	PRCP Landform DEM (BHP).	
Grevilliea Pit	PRCP Landform DEM (BHP).	
Hakea Pit	PRCP Landform DEM (BHP).	
Hughes Creek Diversion	BHP	
Phillips Creek Diversion	BHP	
Haul Road	BHP	
Off-tenure		
Boomerang Pit PRCP final void	Peak Downs PRCP Landform DEM (BHP).	Included (hydrologic model).
Boomerang Pit PRCP waste rock dump	Peak Downs PRCP Landform DEM (BHP).	Included (hydrologic model).
Wattle Pit PRCP final void	Peak Downs PRCP Landform DEM (BHP).	Included (hydrologic model).
Wattle Pit PRCP waste rock dump	Peak Downs PRCP Landform DEM (BHP).	Included (hydrologic model).

Artificial Feature / Description	Source	Hydraulic model inclusion status
Boomerang Creek Diversion	Peak Downs PRCP Landform DEM (BHP).	Included (hydrologic model).
Dysart Road	DR	Not included – no material effect on 0.01% AEP flood levels in vicinity of voids.
Saraji Road	DR	Not included – no material effect on 0.01% AEP flood levels in vicinity of voids.
Unnamed Roads and Tracks	DR	Not included – no material effect on 0.01% AEP flood levels in vicinity of voids.
Goonyella System Railway	DR	Not included – no material effect on 0.01% AEP flood levels in vicinity of voids.
Lake Vermont Mine	DR	Not included – no material effect on 0.01% AEP flood levels in vicinity of voids.
Norwich Park Mine	DR	Not included – no material effect on 0.01% AEP flood levels in vicinity of voids.

The existing Hughes Creek crossing of Saraji Road and the Goonyella System Railway was considered as an artificial feature with potential to affect flood levels in the vicinity of the NUMA voids. Further investigation showed that ground levels at the location of the crossing are approximately 200 m AHD, some 6 km upstream of the Bauhinia and Coolibah NUMA voids, where ground levels are in the order of 188 m AHD. Additionally, given the crossing is located upstream of the area of interest, it is conservative to assume that the structures at the Saraji Road and the Goonyella System Railway crossings will be overwhelmed in a 0.1% AEP flood event, therefore significant detention of flows is unlikely to occur. Considering the above, it was considered the structures would not materially affect the model results in the vicinity of the NUMA voids and therefore the structures were not included in the hydraulic model landform.

Based on the review of information available at the time of the assessment, no other artificial features are known to exist or proposed outside of the SRM MLs that will influence flooding conditions. The incorporation of the model landform DEM into the hydraulic model is outlined in **Section 5.3.1**.

4 Hydrologic Modelling

4.1 Software

Hydrologic modelling was undertaken to estimate runoff hydrographs at various locations throughout the catchments of Boomerang Creek, Hughes Creek and Phillips Creek. The model was developed using the Watershed Bounded Network Model Version 2019 (WBNM). WBNM is an industry standard rainfall-runoff routing software package.

4.2 Model Setup

4.2.1 Approach

The catchments of Boomerang Creek, Hughes Creek and Phillips Creek are tributaries of the Isaac River. To encompass the above catchments, a WBNM model of the Isaac River to the point immediately upstream of its junction with Devlin Creek was developed.

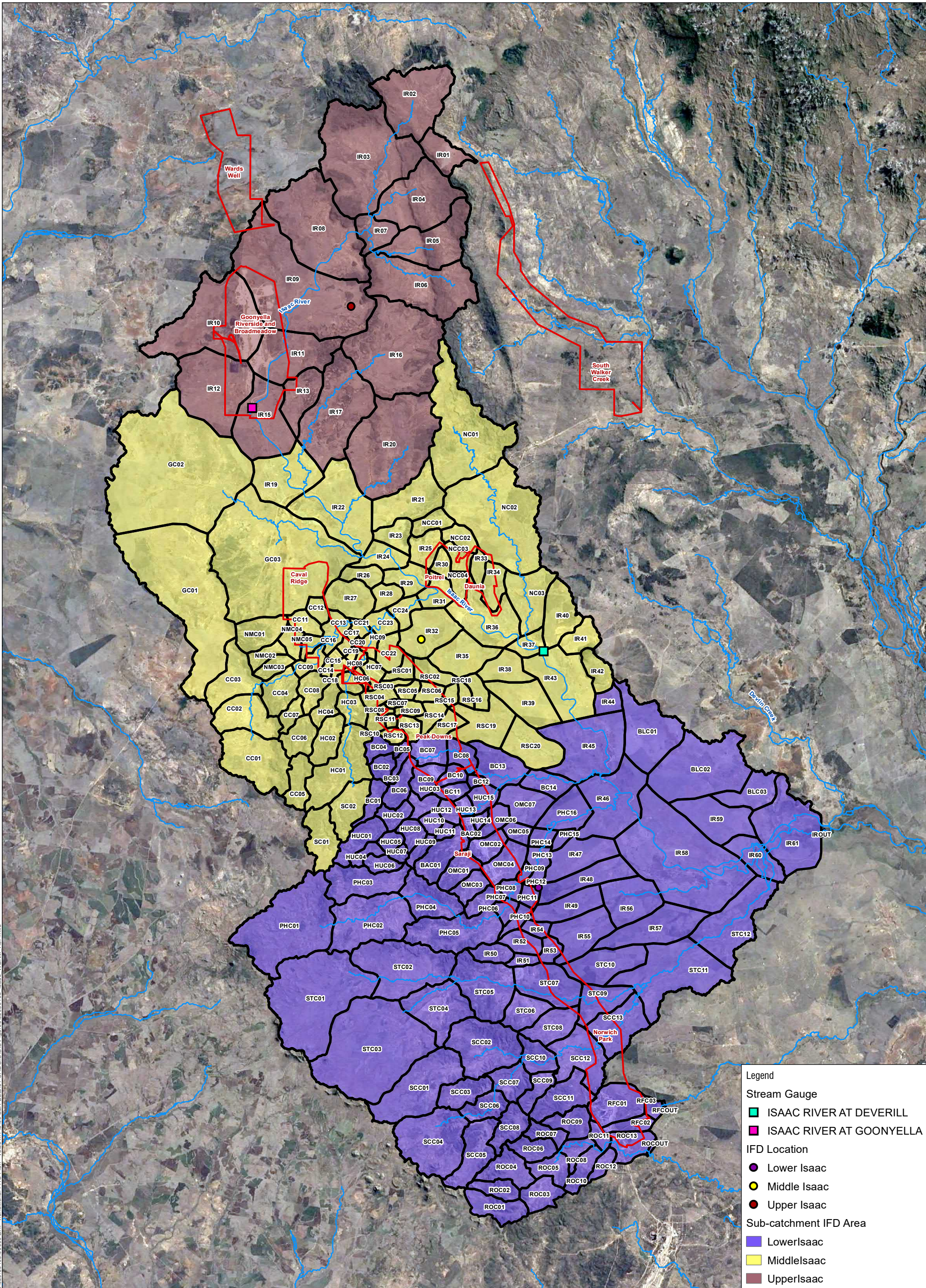
An additional factor contributing to model development including the wider Isaac River catchment was to allow the model to be calibrated against the results of a Flood Frequency Analysis (FFA) undertaken at the nearest suitable location(s), being the Goonyella (130414A) and Deverill (130410A) stream gauges. This was considered appropriate given the 0.1% AEP flood event is the critical event for the assessment and the long period of record at the gauges provides the best estimation of peak flows with this exceedance probability. Further detail on the model calibration process is provided in **Section 4.3**.

4.2.2 Catchment Details

The Isaac River model covers a catchment area of approximately 8,300 km², of which sub-catchments were delineated using hydrologically enforced 1 second SRTM 30 metre DEM terrain data sourced from Geoscience Australia. The model extent and sub-catchment delineation are illustrated in **Figure 4**.

4.2.3 Intensity-Frequency-Duration Rainfall Data

Rainfall Intensity-Frequency-Duration (IFD) data for the catchment was sourced from the Bureau of Meteorology (BoM) online IFD data portal for a range of Annual Exceedance Probabilities (AEP). Spatial variability of IFD data was accounted for by sourcing data separately for the upper catchment, middle catchment and lower catchment of the model area. Each sub-catchment was allocated the IFD data of each relevant IFD location based on proximity, as illustrated in **Figure 4**.



4.2.4 Losses

Storm rainfall loss data for the catchment was obtained from the ARR data hub. The initial and continuing losses are provided in **Table 4**. Based on the ARR Data Hub data, an initial loss of 0 mm was adopted as for the 0.1% AEP event.

Table 4 Rainfall Losses

Global Storm Loss	Loss
Initial loss (pervious)	0 mm
Continuing loss (pervious)	1.0 mm/h

4.2.5 Lag Parameter

A catchment lag parameter of 1.90 was adopted in the WBNM model. The WBNM documentation recommends a lag parameter value between 1.40 and 1.80 is suitable for most catchments, however if reliable calibration data is available the lag parameter should be adjusted to provide accurate calibration of the model, as was the case for this assessment.

4.2.6 Storm Events

The 0.1% AEP event was the primary design storm event for this assessment. In accordance with ARR, Probable Maximum Flood (PMF) temporal patterns were adopted for the 0.1% AEP event. ARR recommends the Generalised Short Duration Method (GSDM) for events with a duration up to 6 hours, and the Revised Generalised Tropical Storm Method (GTSMR) for durations of 24 hours or more. There is no set guidance for which method to adopt for storms with durations between 6 and 12 hours, therefore the GSDM temporal pattern was adopted for all durations up to and including the 12 hour duration, and the GTSMR temporal patterns for durations of between 12 hours and 72 hours.

4.2.7 Aerial Reduction Factor

Aerial reduction factors were applied to the model based on the catchment area draining to the Deverill gauge (refer **Section 4.3.1**), which is approximately 4,090 km².

4.3 Calibration

4.3.1 Flood Frequency Analysis

An FFA was undertaken using recorded streamflow data sourced from the Department of Regional Development, Manufacturing and Water (DRDMW). Two gauge locations exist on the Isaac River within the catchment of the area of assessment, located at Goonyella (130414A) and Deverill (130410A). The locations of the gauges are illustrated in **Figure 4**.

The Goonyella gauge has continuous streamflow records beginning in 1983 (38 years), while the Deverill gauge has records beginning in 1968 (53 years). It was noted during the analysis that the catchment to the Deverill gauge, including the Goonyella gauge, has been modified significantly by various mining operations since approximately 2002. The WBNM model was developed based on SRTM topographic data which generally predates 2002, therefore streamflow data from 2003 onwards was excluded from the Deverill gauge data in the FFA. With these records excluded, a total of 35 years data was available for use from the Deverill gauge, which was considered sufficient to produce an estimate of flows for the 0.1% AEP. The full 38 years of record was adopted for the Goonyella gauge, given excluding the post-2002 flows would leave only 20 years of data, which was considered insufficient.

For both gauges, a Log-Pearson III (LP3) flood frequency distribution was fitted to the annual maximum data series. For each gauge, low flow outliers were excluded from the data series using the Grubbs Beck Test method, prior to fitting the distribution.

4.3.2 Calibration Results

Results of the flood frequency analysis, in comparison to the results of the WBNM hydrologic model, are illustrated in **Figure 5** and **Figure 6**.

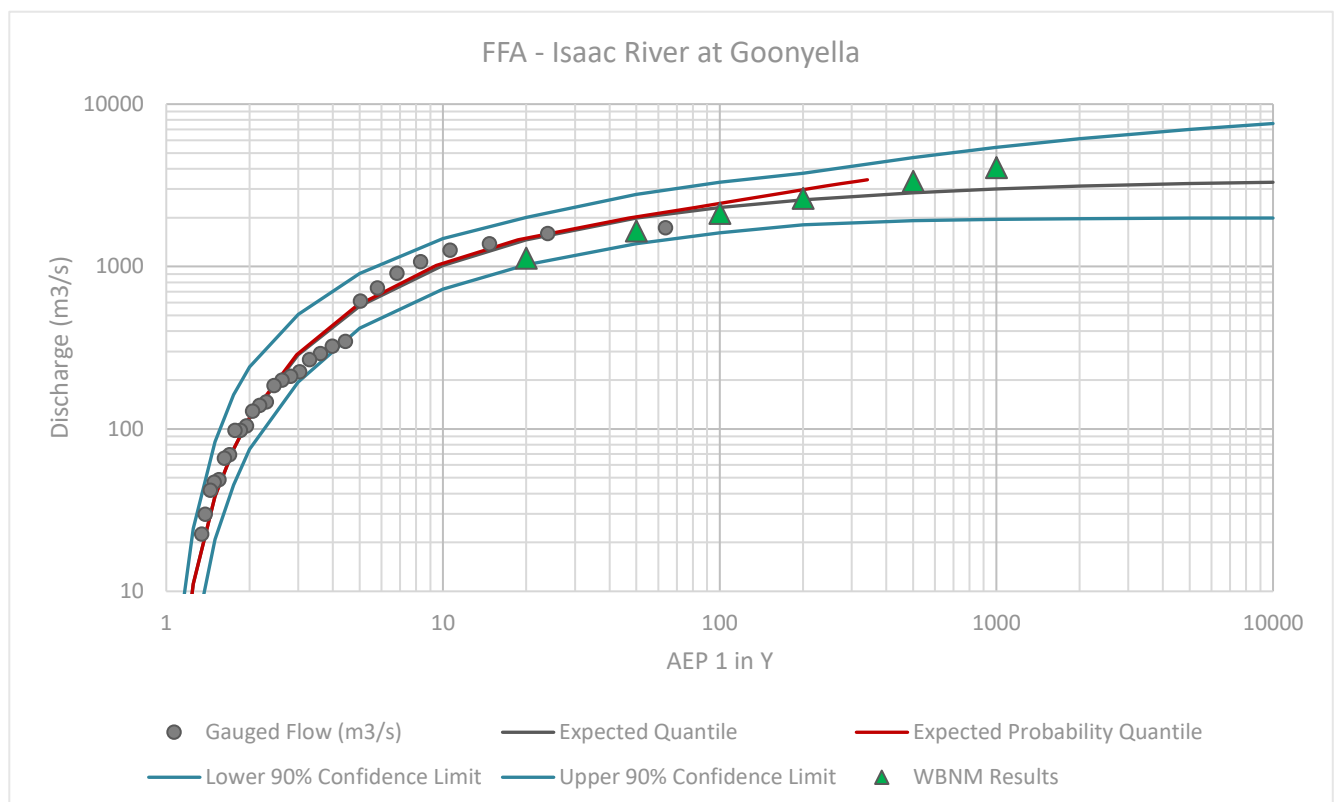


Figure 5 Flood Frequency Analysis Results – Isaac River at Goonyella Gauge

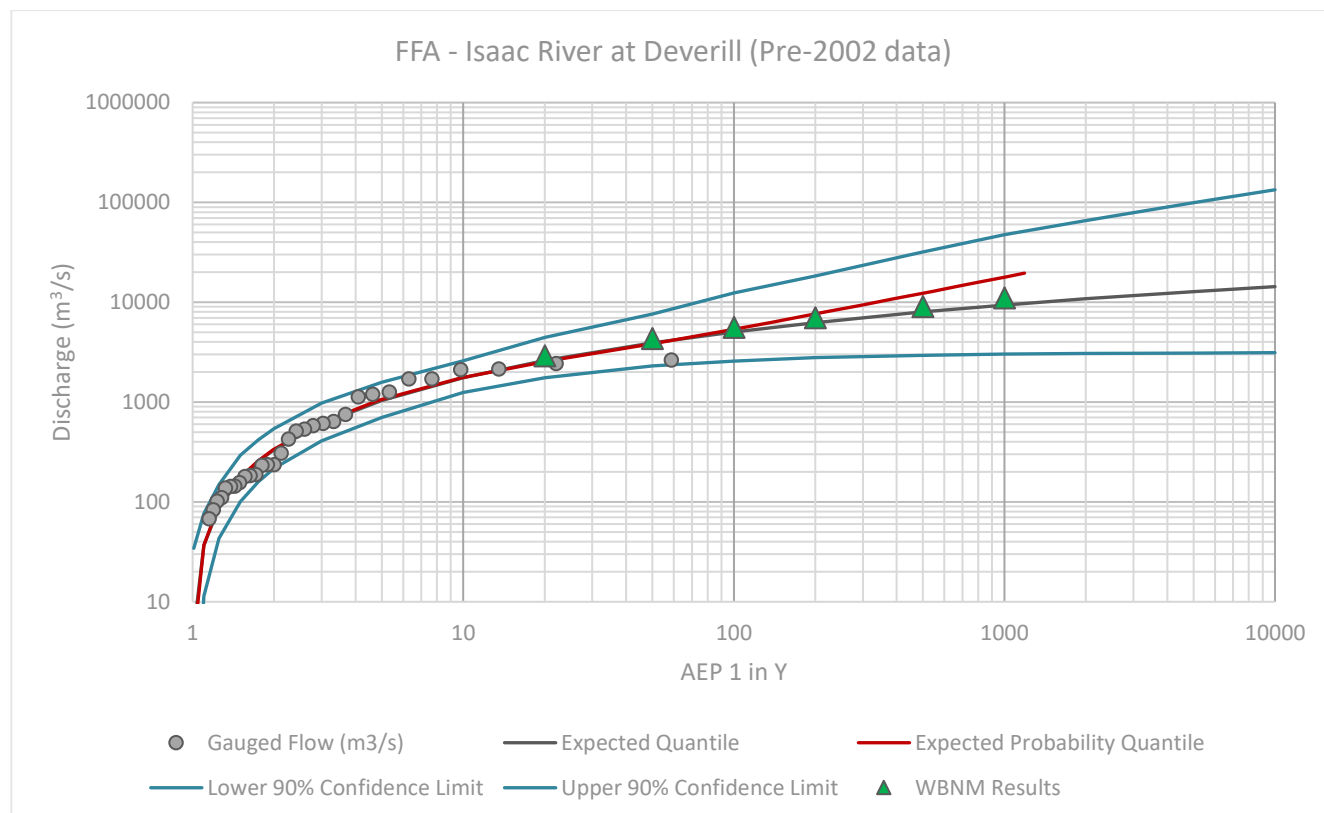


Figure 6 Flood Frequency Analysis Results – Isaac River at Deverill Gauge

The WBNM model results were compared against previous modelling of the catchment undertaken by others, as illustrated in **Table 5**. The following studies were reviewed and referenced:

- ‘Winchester South Project Environmental Impact Statement – Surface Water and Flooding Assessment’, WRM, 20 May 2021 (WRM 1)
- ‘Goonyella and Broadmeadow Hydraulic Assessment’, WRM, 2 August 2019 (WRM 2)
- ‘G200s Project – Flood Modelling Report’, Alluvium, September 2016 (Alluvium)

Table 5 WBNM Model Results – Comparison to previous assessments

Isaac River Location	1% AEP				0.1% AEP			
	SLR WBNM	WRM 1	WRM 2	Alluvium	SLR WBNM	WRM 1	WRM 2	Alluvium
Goonyella (m³/s)	2,130	-	2,079	-	4,078	-	3,808	-
Deverill (m³/s)	5,589	5,051	-	4,500	11,023	10,009	-	7,500

As illustrated by the above, the WBNM model produced results in line with the results of the FFAs, particularly with the results of the Deverill gauge data. The model results are also generally consistent with the results of the reviewed analyses by others. Therefore, the model was considered suitable for use for the purposes of this assessment.

4.4 Saraji Sub-model

A sub-model of the Isaac River hydrologic model was developed for the Saraji area, including the catchments of Boomerang Creek, Hughes Creek and Phillips Creek. The model was required for the following reasons:

- Revision of sub-catchment delineation based on the Model Landform DEM; and
- Application of Aerial Reduction Factors (ARF) relevant to the local catchment area of 1,070 km².

All other model parameters were retained from the Isaac River model. The model extent and sub-catchment delineation of the Saraji sub-model are illustrated in **Figure 7**.

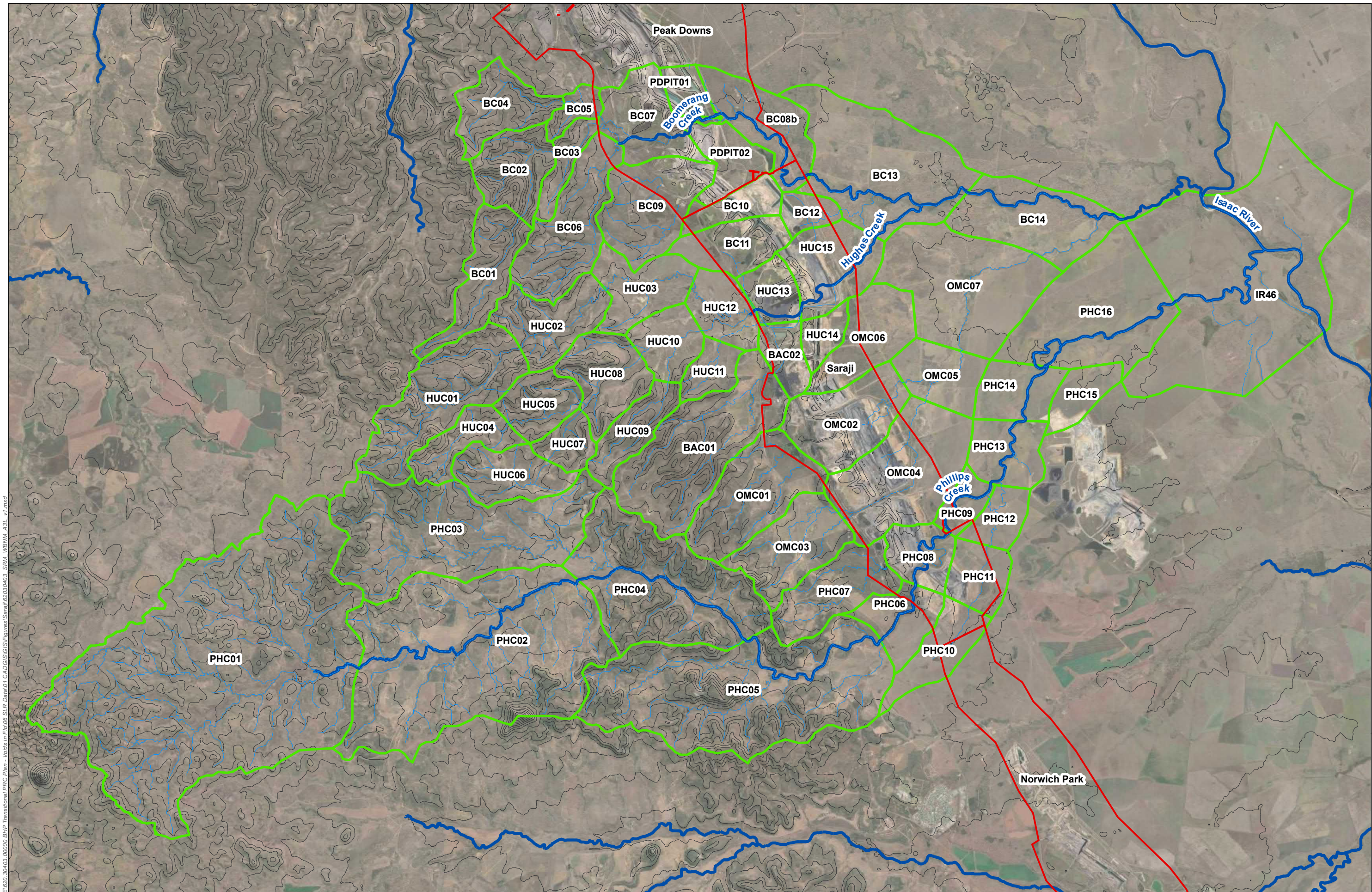
As detailed in **Section 4.3.1**, the Isaac River model was developed based on SRTM topographic data, which generally pre-dates mining activities throughout much of the Isaac catchment and thus typically represents pre-mining catchments. Therefore, the catchment area within the SRM MLs was generally consistent between the Isaac River model and SRM sub-model. Outside of the MLs, catchments were updated to account for artificial features. The only changes to the catchments in the hydrologic model were around the Boomerang Creek diversion in the adjacent Peak Downs ML. The resulting change in catchment area was a reduction of 12 km² (approximately 3% of the Boomerang Creek catchment including Hughes Creek), as illustrated in **Table 6**.

The results of the sub-model were compared to the results of the Isaac River model at the outflow point of sub-catchments BC08 (Boomerang Creek), HUC15 (Hughes Creek) and PHC13 (Phillips Creek) (refer **Figure 7**), shown in **Table 6**. The results show that the higher aerial reduction factor adopted in the sub-model results in a higher peak flow at the comparison location, as would be expected.

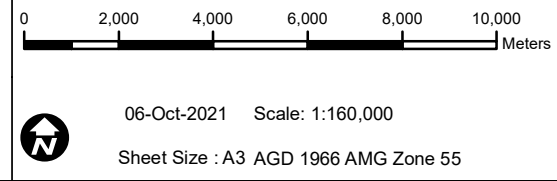
Table 6 WBNM Model Results Comparison

Model	0.1% AEP Flow (m ³ /s)	Aerial Reduction Factor	Catchment Area (km ²)
Boomerang Creek (BC08)			
Isaac River model	447	0.675	99 km ²
Saraji Sub-model	603	0.894	91 km ²
Hughes Creek (HUC15)			
Isaac River model	831	0.675	188 km ²
Saraji Sub-model	1,141	0.871	188 km ²
Phillips Creek (PHC08)			
Isaac River model	1,032	0.699	385 km ²
Saraji Sub-model	1,386	0.849	385 km ²

Based on the above, the Saraji sub-model was deemed suitable for use in the assessment.



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- Legend
- WBNM Sub-catchments
 - Watercourse
 - Stream Order 4 or Greater
 - SRTM 30m Contours
 - EA Boundary

Transitional PRC Plan - Voids in Floodplain Modelling
Saraji Mine
WBNM Layout
Saraji Sub-Model
Figure 7

5 Hydraulic Modelling

5.1 Software

A hydraulic model of the catchment was developed for the purpose of assessing pre-mining flood extents.

The industry standard hydrodynamic modelling software TUFLOW (build 2020-10-AA) was utilised for the hydraulic modelling. The sub-grid sampling (SGS) feature of TUFLOW suited the modelling required for the assessment. SGS provides an increased definition of model terrain and flow conveyance, enabling model resolution to be improved without significant increases in model runtimes.

5.2 Models

The hydraulic model developed as part of this assessment covered two main areas:

- The catchments including Boomerang and Hughes Creeks; and
- The Phillips Creek catchment.

Details of the model assumptions, methodology and results are provided below.

5.3 Saraji Mine

5.3.1 Topography

The model landform DEM as detailed in **Section 3** was utilised as the topography for the model. The DEM for the model area is shown in **Figure 10** Drainage features of this DEM were reinforced using gully lines to ensure reasonable conveyance within the watercourses.

5.3.2 Model Grid Cell Size

A grid cell size of 10 metres was adopted for the model. In combination with a 1 metre SGS sampling distance, this was considered to provide adequate model resolution for the purposes of the analysis undertaken, while providing a reasonable runtime.

5.3.3 Hydraulic Roughness

Hydraulic roughness across the model area was assessed based on the supplied aerial imagery from 1985. This was the most suitable available imagery for the area and was considered a decent representation of the pre-mining land use. However, mining activities had commenced at some areas of the site prior to 1985 and therefore assumptions were made about the Manning's roughness values for these areas. The Manning's roughness values adopted for the various land use types within the model domains are shown in **Table 7** and in **Figure 12**.

Table 7 TUFLOW Model Manning's Roughness Values

Land Use	Manning's n Value
Sparse Vegetation	0.06
Dense Vegetation	0.08
Creek Beds	0.05

5.3.4 Downstream Boundaries

The downstream boundaries for the TUFLOW model were positioned on Boomerang Creek and Hughes Creek, approximately 3 km upstream of their confluence, as well as on Phillips Creek, approximately 17 km upstream of the confluence with the Isaac River. Stage-discharge relationships were based on the topography gradient at these locations as summarised in Table 7. The location and extent of the downstream boundary is shown in **Figure 10**.

Table 8 TUFLOW Downstream Boundaries

Watercourse	Gradient (%)
Boomerang Creek	0.2
Hughes Creek	0.1
Phillips Creek	0.2

5.3.5 Model Inflows

Flow hydrographs for the model were extracted from the Saraji WBNM sub-model for each sub-catchment. These hydrographs were applied as inflow boundaries, as either total or local inflows where relevant, to the hydraulic model at appropriate locations, as shown in **Figure 10**.

Flow results of the hydraulic model at the downstream boundary were compared with flows produced by the WBNM at the outlets of the corresponding sub-catchments. For the northern section, the sum of flows from sub-catchments BC08b, BC12 and HUC15 were compared with the sum of the TUFLOW result flows from Boomerang and Hughes Creeks, while in the southern section the Phillips Creek TUFLOW result flows were compared with the sum of outflows from PHC09 and PHC12. This was undertaken for the critical duration event and indicates that the TUFLOW model calculates similar flows and the general trends of the hydrographs were similar. **Figure 8** and **Figure 9** illustrate these comparisons.

A sensitivity assessment was undertaken on the modelled inflow boundaries. For the assessment, a 20% increase in magnitude was applied to the inflow hydrographs. The results of the assessment are detailed in Section 5.4.

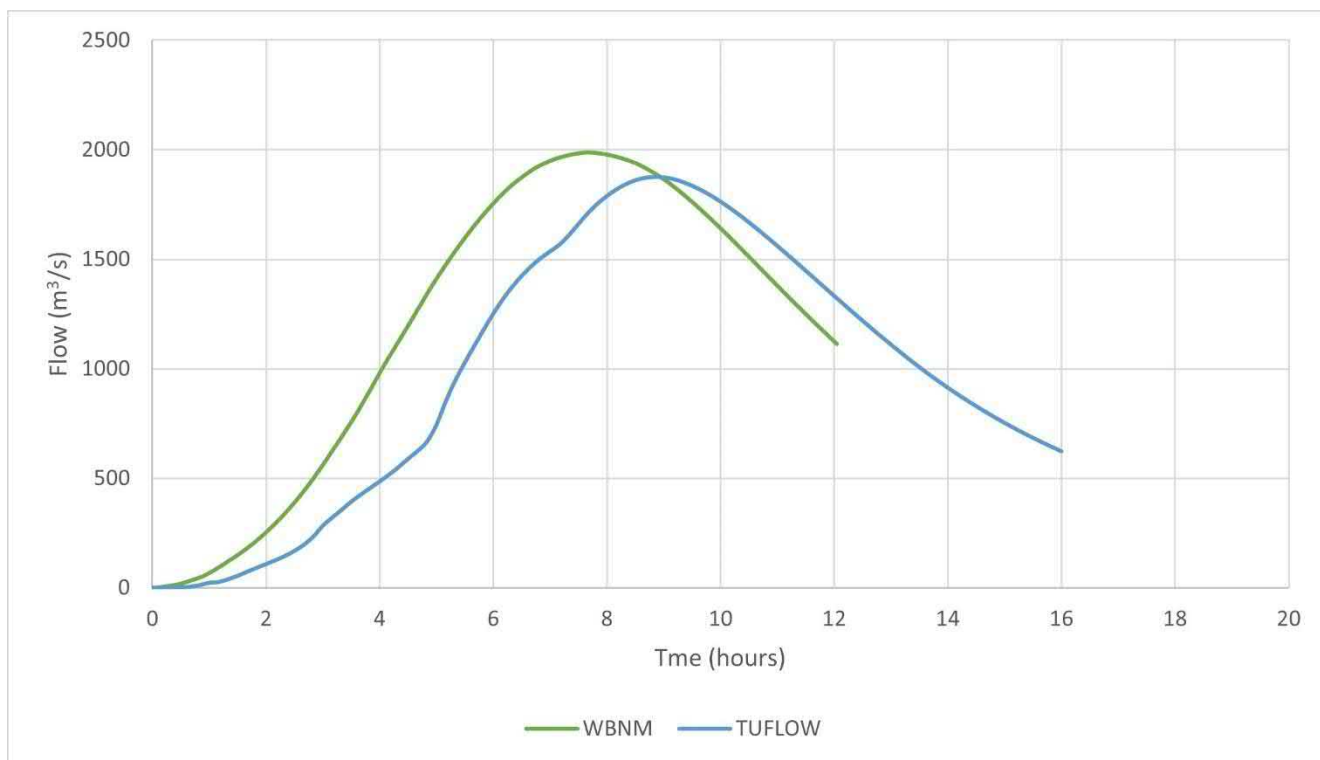


Figure 8 9 hour 0.1% AEP WBNM and TUFLOW Results Comparison

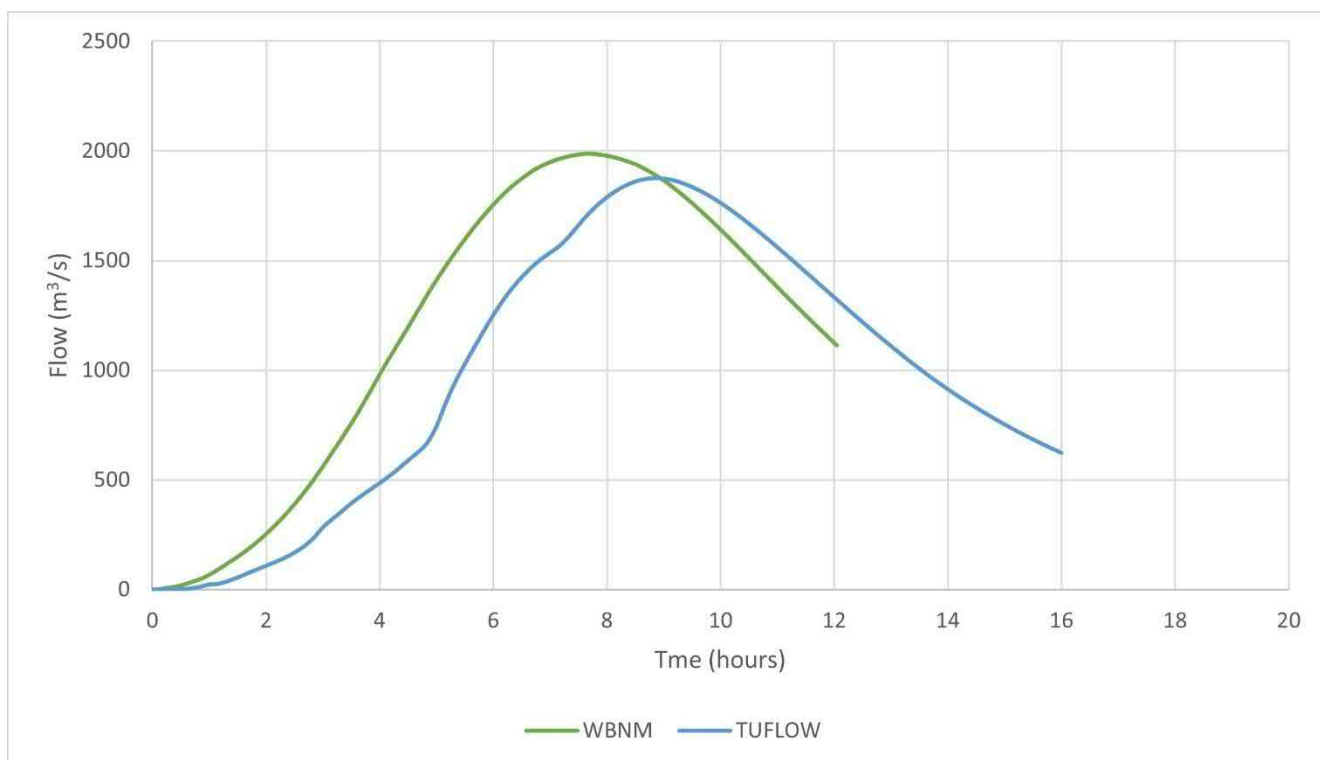


Figure 9 12 hour 0.1% AEP WBNM and TUFLOW Results Comparison

5.3.6 Critical Storm Durations

In accordance with the recommendations of ARR, a suite of design storm events were simulated in the hydraulic models for the 0.1% AEP event and durations between 1 and 72 hours. The results of the various storm durations were cross-referenced to determine the critical duration for the focal point of the model, i.e. the proposed void locations. The results showed that the 9 hour and 12 hour storm durations were the critical events.

5.4 Results

The results of the Saraji TUFLOW model for peak water surface levels and depths for the 0.1% AEP event are illustrated in **Appendix B**. The results illustrate that the proposed NUMA void for Bauhinia Pit is located within the modelled floodplains of Boomerang Creek and Hughes Creek.

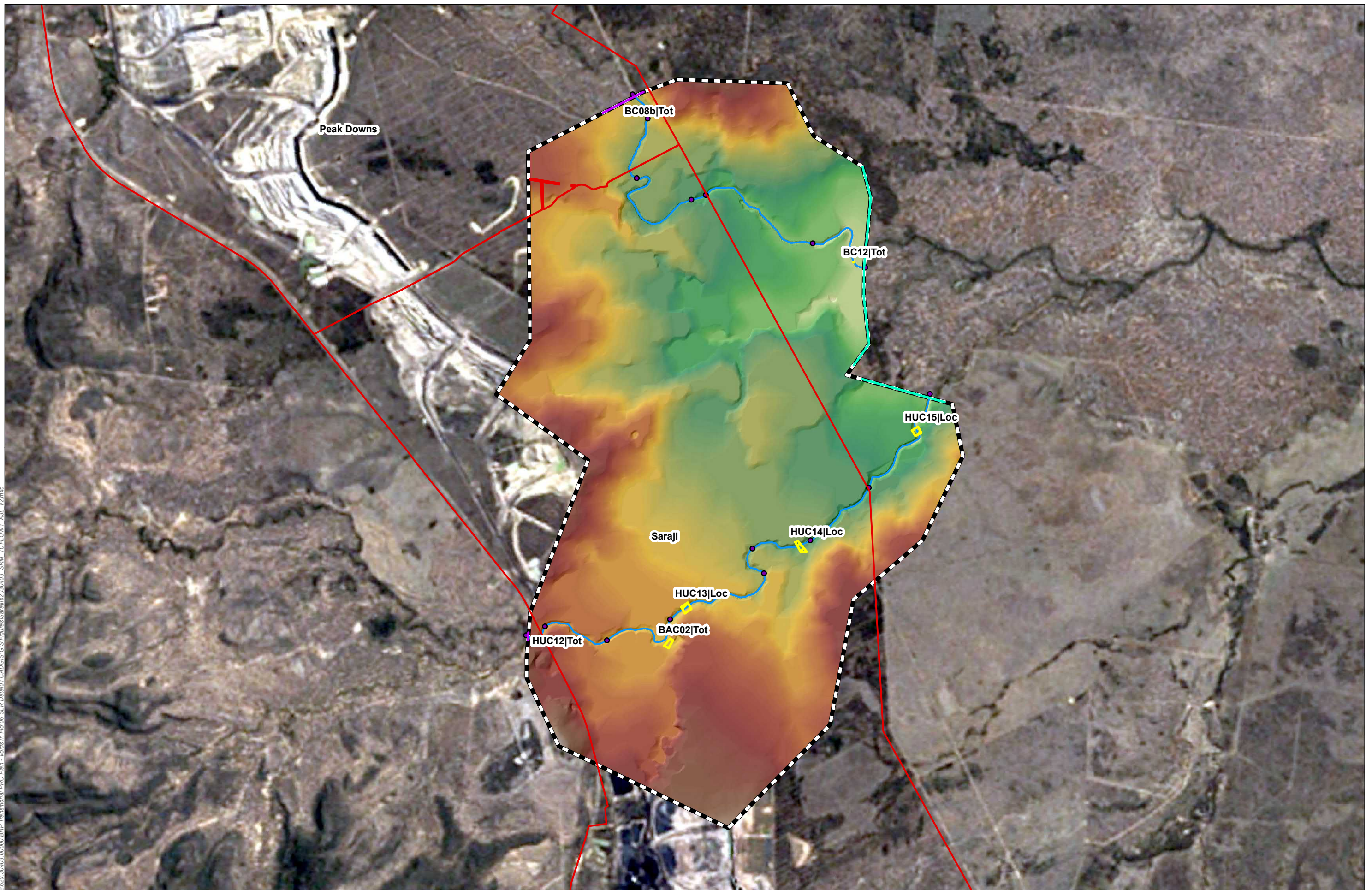
Flows from Hughes Creek break out from the main flowpath in a northerly direction before joining the Boomerang Creek floodplain. The Bauhinia Pit void is also located within the inundation extent of this breakout.

As shown in **Figure 14** and **Figure 15**, the proposed footprints of Coolibah Pit and Grevilliea Pit encroach into the modelled floodplains for Boomerang Creek / Hughes Creek and Phillips Creek respectively. The encroachments for these pits occur on the fringes of the floodplain.

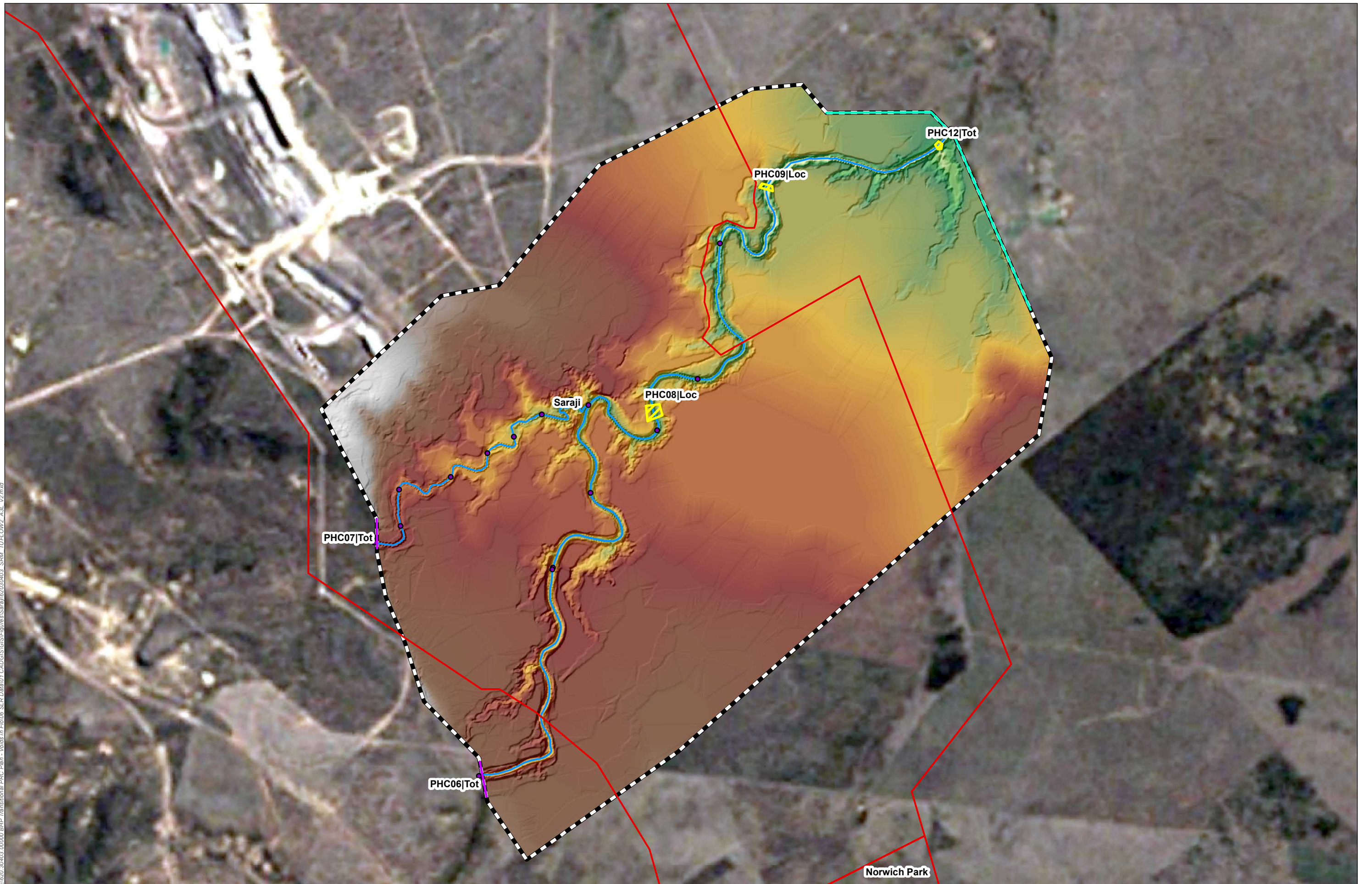
The results of the sensitivity assessment as detailed in Section **5.3.5** are provided in **Appendix C**. The model results indicate that the applied 20% increase in flows leads to a marginal increase in the floodplain extents of Boomerang Creek and Hughes Creek. The marginal increase does not materially alter the outcomes of the assessment for the Bauhinia and Coolibah final voids in comparison to the base model scenario.

The results of the sensitivity assessment show the Phillips Creek floodplain extent is increased significantly. As illustrated in **Appendix C5**, a breakout of flows occurs to the south of Phillips Creek across an expansive area of flat terrain. This breakout causes the floodplain extent to encroach into the norther area of the Hakea final void footprint. It is possible that the floodplain extent in the breakout area is overstated due to the coarse nature of the underlying topographic data, which does not provide adequate resolution to represent localised changes in ground levels of less than 2m. The model results show that flow depths across the breakout flowpath are less than 1m, therefore would be affected by local variance in ground levels of between 1m and 2m. Review of the model results indicate that the breakout flowpath is caused by flows breaking out of the Phillips Creek main channel some 2.5 km upstream of the Hakea final void, moving unimpeded along the flat terrain south of Phillips Creek to the Hakea final void. The peak flood level within the Phillips Creek main channel in the vicinity of the Hakea final void is 197.8 m AHD, while the adjacent overbank ground level between Phillips Creek and the Hakea final void is at least 199.0 m AHD. The peak flood level in the location of the floodplain extent encroachment into the Hakea Final void is 199.04. Therefore, the area of inundation within the Hakea final void is likely overstated due to the relatively coarse nature of the underlying topographic data.

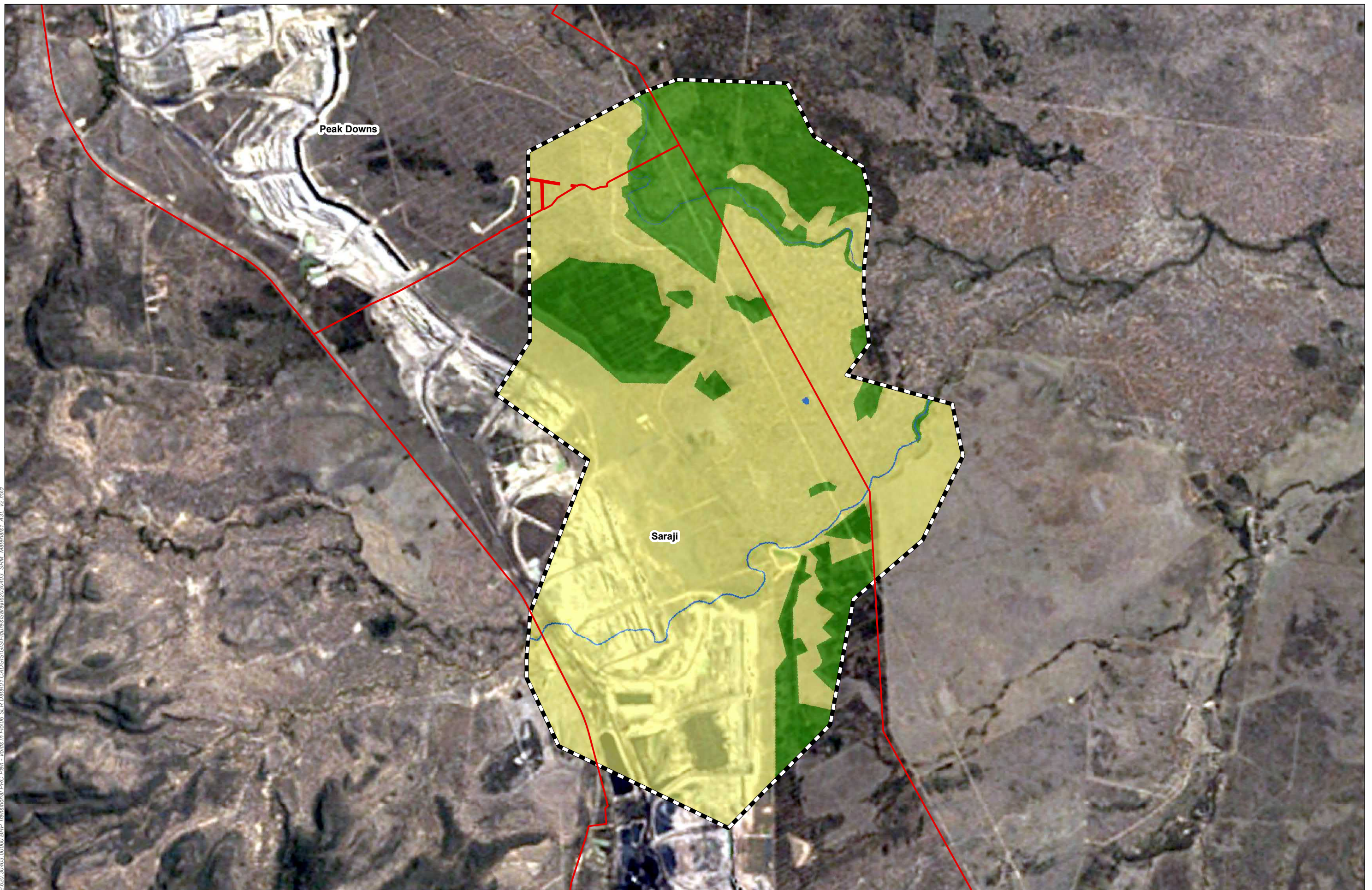
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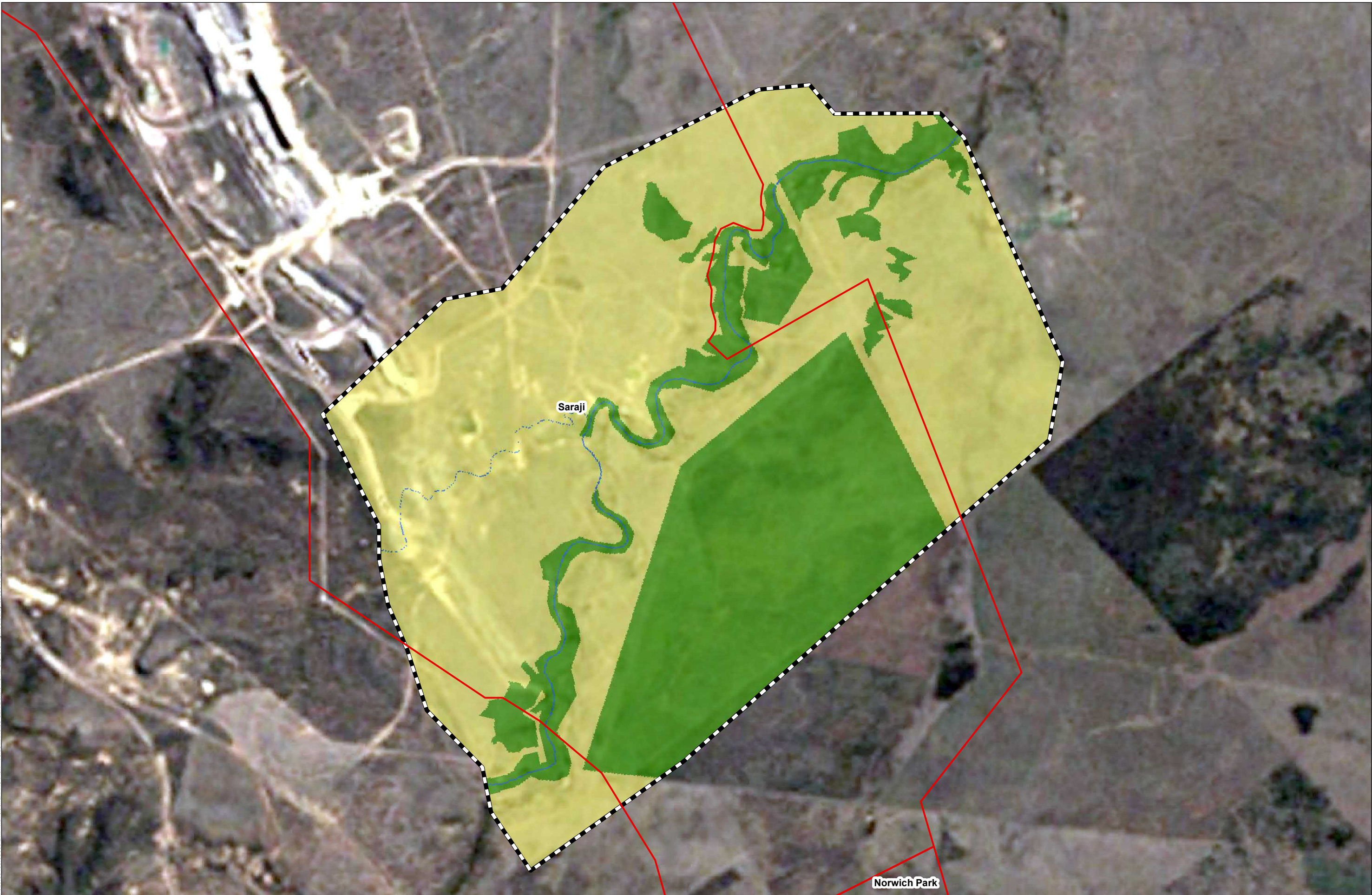
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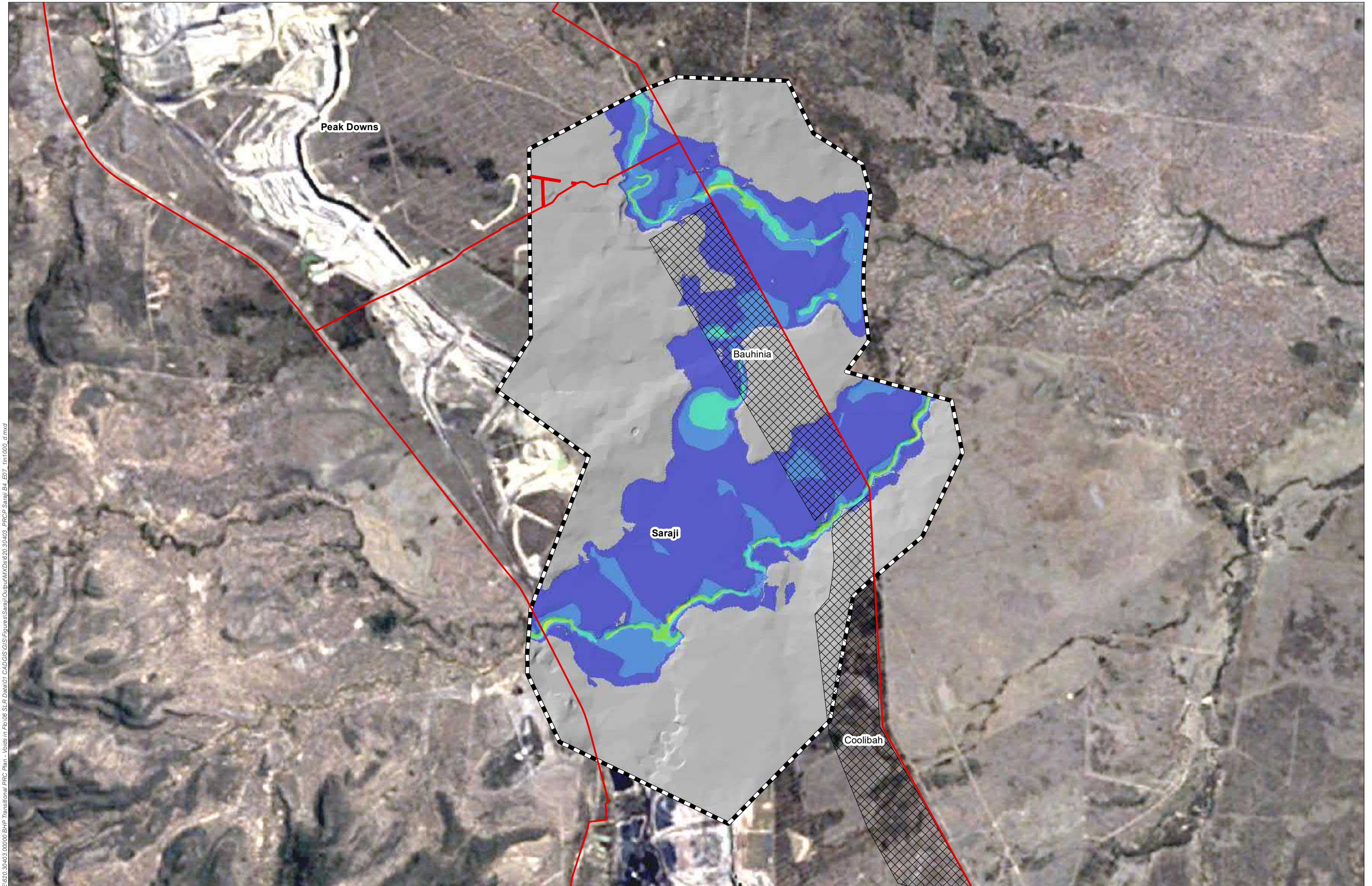


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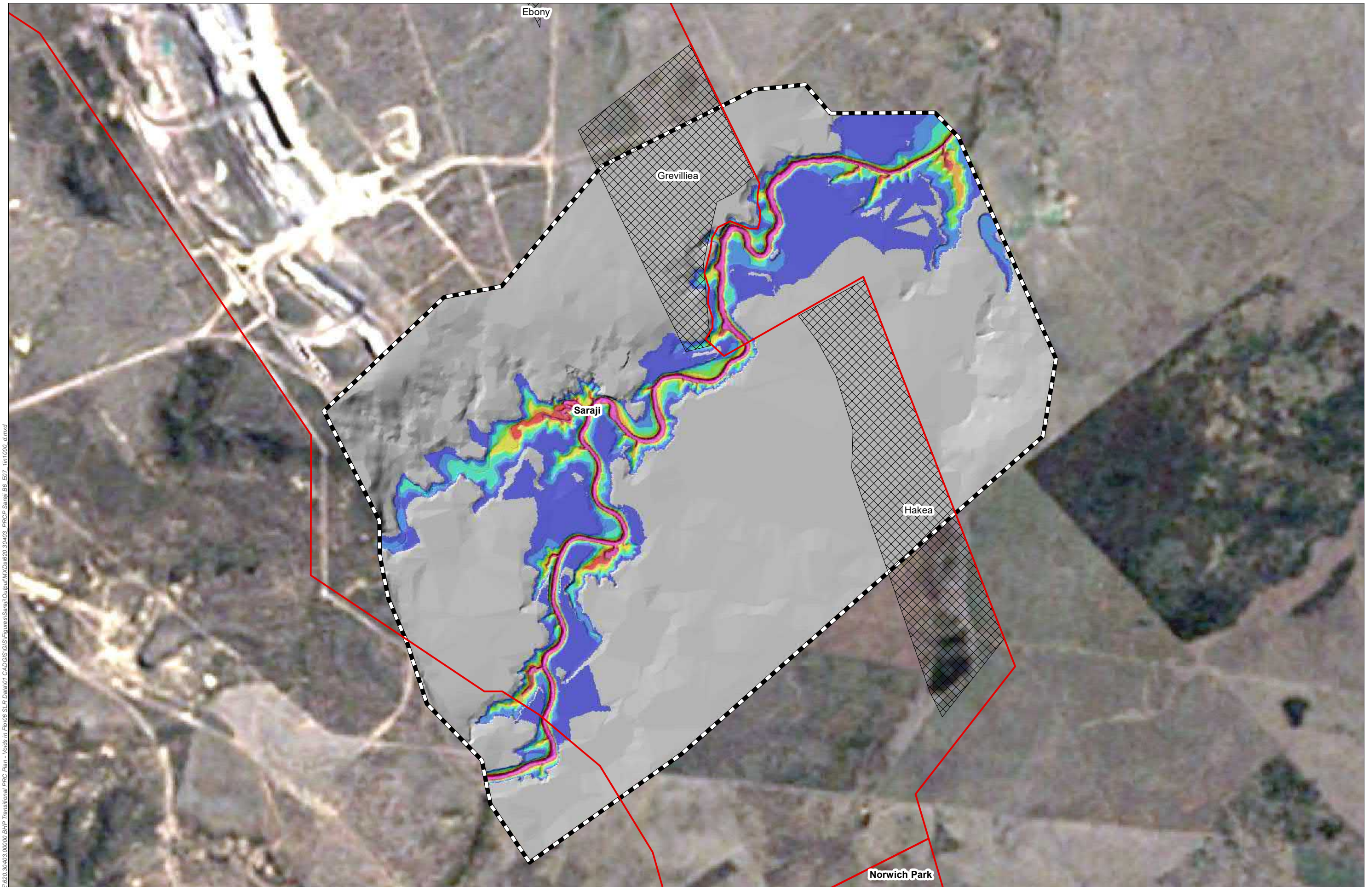


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6 Summary

As part of the PRCP for Saraji Mine, it is proposed to incorporate two final voids as NUMAs. Therefore, in accordance with the EP Act and EP Regulation and specifically section 3.4 of the PRCP Guideline, floodplain modelling has been undertaken for all relevant watercourses that may affect the voids.

Data for the assessment was provided by BHP, and sourced from various public providers including BoM, DRDMW and Geoscience Australia. The data was reviewed and modified for use where appropriate. Model landforms were developed to account for artificial features outside of the ML, and pre-mining topography within the ML based on the information available at the time of the study.

A hydrologic assessment was undertaken for the portion of the Isaac River catchment that encompasses the Mine and the relevant watercourses. The model was calibrated against the results of Flood Frequency Analyses undertaken using data obtained at Goonyella and Deverill stream gauge stations located on the Isaac River.

A sub-model of the Isaac River hydrologic model was developed for the local Saraji Mine covering the catchments of the relevant watercourses in the area being Boomerang Creek, Hughes Creek and Phillips Creek.

Hydraulic models were developed for the Saraji Mine area. Hydrographs extracted from the hydrologic models at relevant locations were applied as inflows to the hydraulic models.

Consideration was made as to the potential effects of groundwater on the floodplain extent. It was considered that groundwater will have no significant impact on the extent of the floodplain. An initial rainfall loss of 0 mm was adopted in the hydrologic studies. This assumption represents fully saturated catchment conditions (i.e. soil stores at the surface were full), which was considered to be a conservative approach.

The results of the hydraulic models provided the predicted 0.1% AEP flood event inundation extent. Predicted peak flood levels and depths were also produced by the hydraulic models. The results showed the proposed NUMA void for Bauhinia Pit is located within the floodplain of Hughes Creek. The remaining NUMA voids are located outside the floodplain, with the exception of fringe encroachments at the extents of the Coolibah Pit and Grevilliea Pit voids.

APPENDIX A

Pre-lodgement BHP/DES Workshop for PRCPs – Floodplain modelling and flood risks – Memorandum

Voids in flood plains

The PRCP guideline Section 3.4 outlines considerations to be included for PRC plan submissions relating specifically to voids in flood plains. Table 1 lists the key points that will be considered based on the guideline for flood modelling for voids and subsequent inclusion in the PRC plan submissions for relevant BHP sites.

Table 1: Guideline considerations for Voids in Floodplains

Guideline Considerations	BHP PRCP Deliverables
Voids located in floodplain to be rehabilitated to a stable condition	✓
Sites with a void proposed as a NUMA will have flood plain modelling*	✓
Flood plain modelled with peak water level 0.1% AEP	✓
Flood plain modelled for relevant watercourse – stream order 4 or higher including permanent diversions	✓
Modelling carried out under the ARR	✓
Modelling to exclude any <i>artificial features</i> for the land within the tenure boundary	✓
Modelling to include catchment data outside of the tenure including all existing and approved artificial features (as per Information Sheet)	BHP to use best endeavours
Modelling to include the location of the watercourse after the temporary diversions has been removed (as per Information Sheet)	Modelling to include watercourse classified as stream order 4 or higher, or current approved permanent diversions (stream order 4 or higher). Temporary diversions are not included in this modelling.
Flood plain model report developed by an appropriately qualified person	✓
Flood model report to contain:	
Details provided of the data used to develop the model in accordance with section 4.13.3. of the ARR	✓
Identification of all <i>artificial features</i> proposed or present within the tenure boundary	✓
Identification of all watercourses within the immediate catchment with the Strahler method of stream ordering applied	✓
Identification of any approved permanent watercourse diversions within the tenure boundaries and the relevant approval of the diversion	✓
Consideration of how groundwater may impact the flood plain extent	✓
A hydrologic model	Model report only
A hydraulic model	Model report only
Model assumptions and limitations	✓
Model calibration and sensitivity analysis	✓
Spatial data outlining the extent of the flood plain.	✓

* Unless the conditions of the applicability to transitional PRC plans are met for where flood plain modelling is not required.

The PRCP Guideline Section 3.4 describes that “Flood plain modelling is required for all sites with a void proposed as a NUMA” with “the level modelled as the peak water level 0.1% AEP for a relevant watercourse”.

BHP will complete flood plain modelling in accordance with the ARR, and a model report for all sites with a void proposed as a NUMA. In accordance with the EP Regulation, the flood plain will be treated as the land where flood plain modelling shows that, when all relevant activities carried out on the land have ended, the land is the same height as, or lower than, the level modelled as the peak water level 0.1% Annual Exceedance Probability (AEP) for a relevant watercourse under the Australian Rainfall and Runoff Guideline (2019).

Artificial Feature

The PRCP Guideline details flood plain modelling must “exclude any artificial features for the land within the tenure boundary”. An artificial feature is detailed as:

Artificial feature, for land the subject of a PRCP schedule, means—
(a) a structure or feature that is temporary and, under the PRCP schedule or otherwise, is to be removed from the land; or
(b) a structure or feature that, under the PRCP schedule, will require a level of maintenance after the land is surrendered that is greater than the level of maintenance that would be required for the land if the relevant activities the subject of the PRCP schedule had not been carried out; or
(c) a feature forming part of the landform of the land, other than the natural landform, if the feature interferes with or affects—
(i) a relevant watercourse; or
(ii) the natural flow of water on the land.

The DES have advised that the intent of the policy is that flood plain modelling must be based on pre-mining state. Therefore, temporary structures including those that will require a level of maintenance after the land is surrendered within the tenure boundary, will not be included in the flood plain modelling. Additionally, a feature that does not form part of the natural landform and interferes or affects a relevant water course or the natural flow of water on the land will not be included in the flood plain modelling. In accordance with the definition of artificial feature, the structures or features that will not be included in the flood plain modelling may include::

- final dumps
- final voids
- final subsidence
- creek diversions (in the current temporary approved state)

If a watercourse diversion over the course of the future mine life requires further approval, then new information will be provided at that point.

Whilst the DES have confirmed their position, BHP maintain that this may result in an impracticable application of the flood plain modelling, and could fail to ensure the relevant risks associated with flood plains are properly addressed and managed.

Relevant Watercourse

BHP have confirmed with the DES and both are in agreement that the flood plain modelling will include the relevant watercourses, as defined under the EP Regulation:

Relevant watercourse means—

(a) a watercourse classified as stream order 4 or higher under the Strahler stream order classification system; or

(b) if a watercourse mentioned in paragraph (a) is permanently diverted under—

(i) a condition, or proposed condition, of an environmental authority mentioned in the Water Act 2000, section 98; or

(ii) a water licence or proposed water licence under the Water Act 2000;

the watercourse as permanently diverted.

The DES have advised that the statement in the information sheet regarding “The application for voids in the flood plain of streams with a stream order of three and lower are still assessed against the decision criteria in the EP Act and may be refused”, is in relation to rehabilitation practices for flooding.

Spatial Extent of Modelling

The information sheet details the need for considering catchment data outside of the relevant tenure in determining the extent of the flood plain model and final mapped flood plain extent.

As the spatial extent of data that is required for each catchment and model is a highly technical matter. The DES and BHP are in agreement that BHP will default to the expert judgement of those performing the flood modelling in determining this extent.

With respect to artificial features outside of the tenure boundary, the information sheet details that the flood plain model includes a combination of data:

- within the mining tenure boundary, to exclude any artificial features;
- outside of the mining tenure boundary to include all existing and approved artificial features.

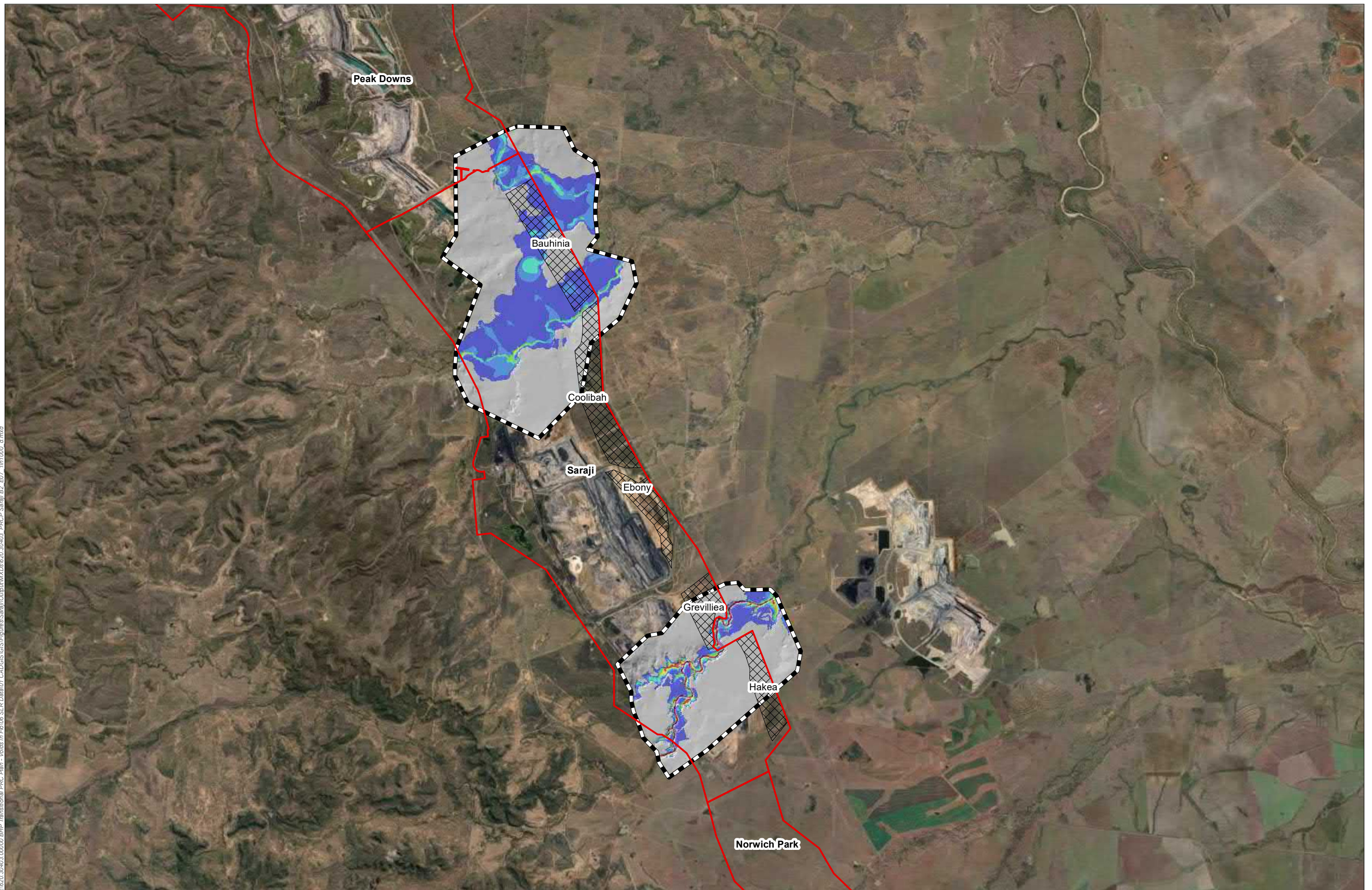
BHP is unclear on what is intended, because it potentially results in an unrealistic hybrid scenario containing both past and future features being modelled. For example, BMA's Saraji Mine PRCP *must not* include flood modelling with Saraji's artificial features, but also *must* include the artificial features on the adjacent BMA Peak Downs Mine. BHP has several sites this will be relevant to and foreshadows that this requirement may result in flood plain modelling results that appear unusual when compared between PRCP's. This is because every site will likely need to be modelled separately and will produce flood plain modelling results that could well differ in the flood plain extent shown in an adjacent site's PRCP. Further afield, an example is the Burton Gorge Dam operated by Peabody upstream of BMA's Goonyella Riverside Mine on the Isaac River that will be included in the model.

Nonetheless, BHP will use best endeavours to obtain information on artificial features outside of the mining tenure boundary for inclusion in the flood plain modelling. In addition to this, the flood plain modelling undertaken by BHP will include artificial features obtained outside of the mining tenure boundary based on current as at time of modelling.

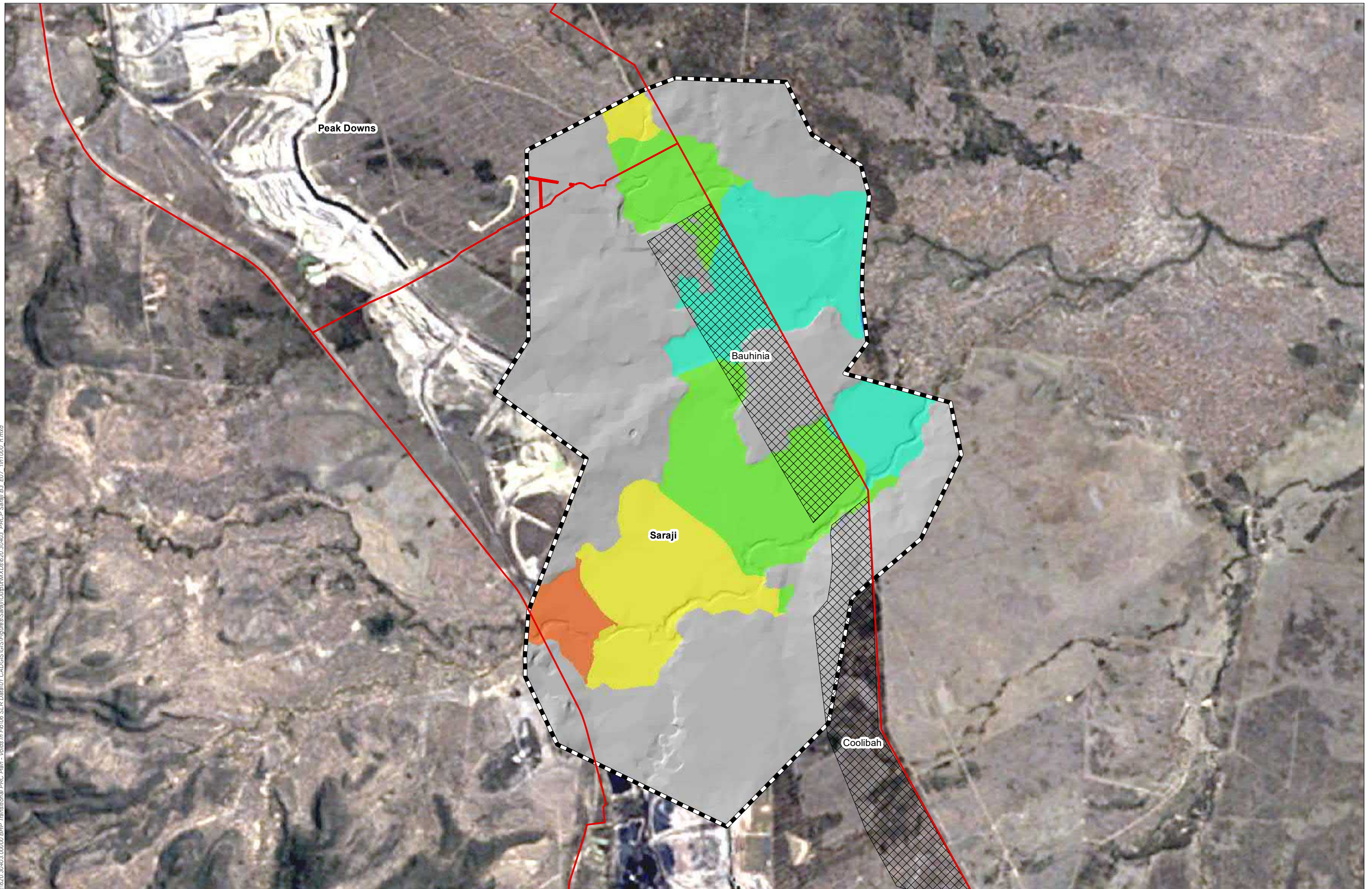
APPENDIX B

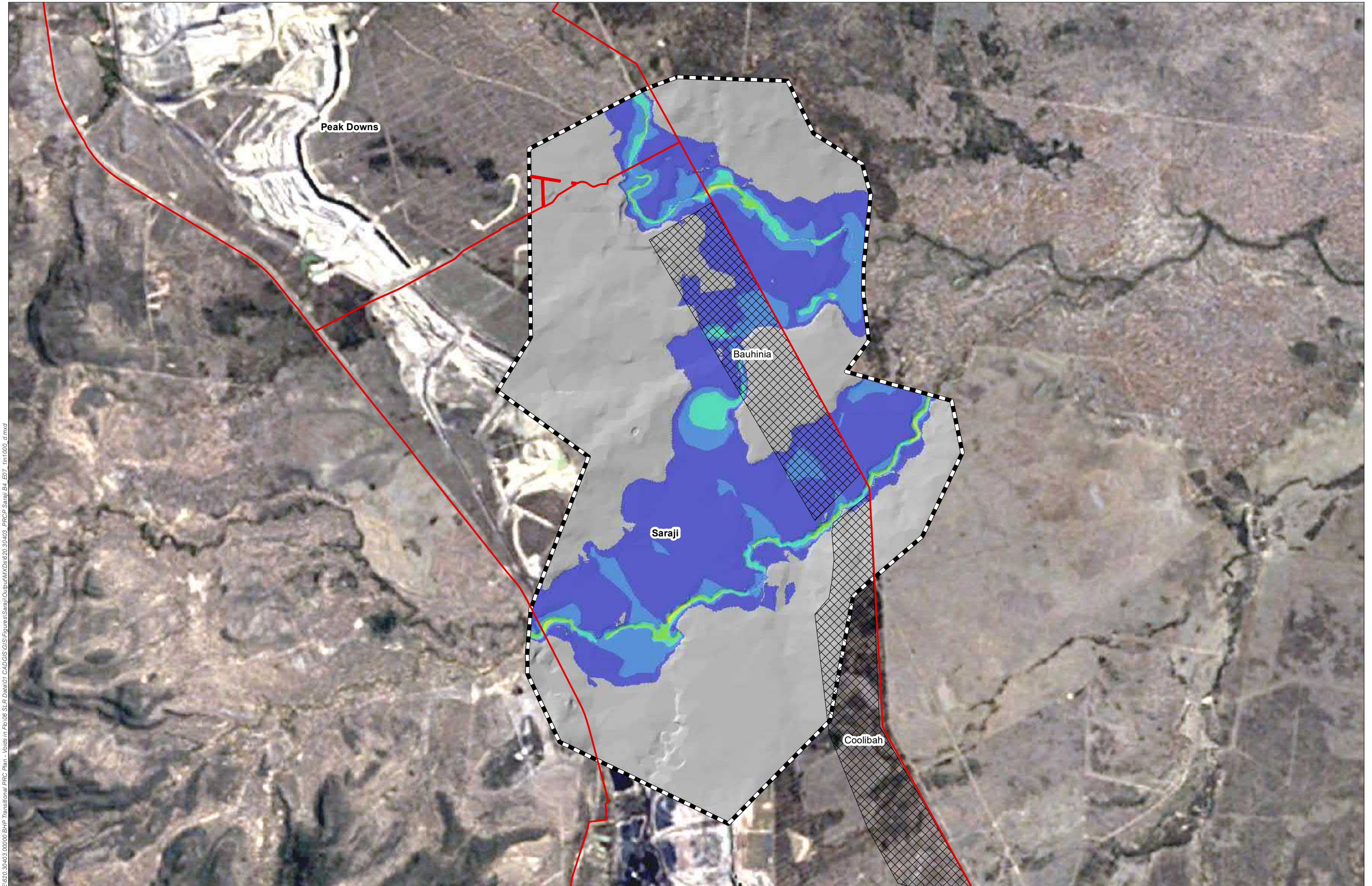
TUFLOW Model Results

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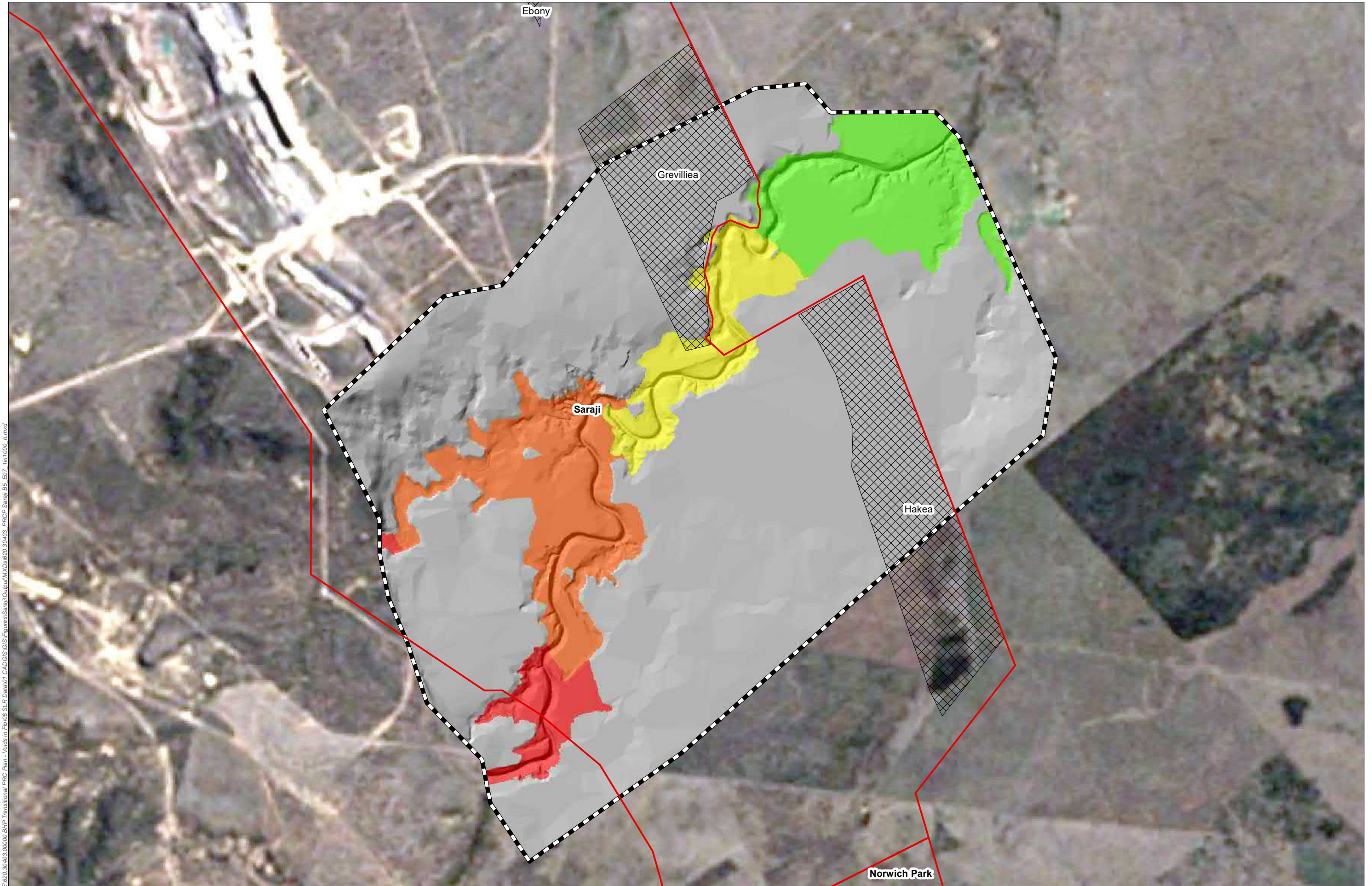


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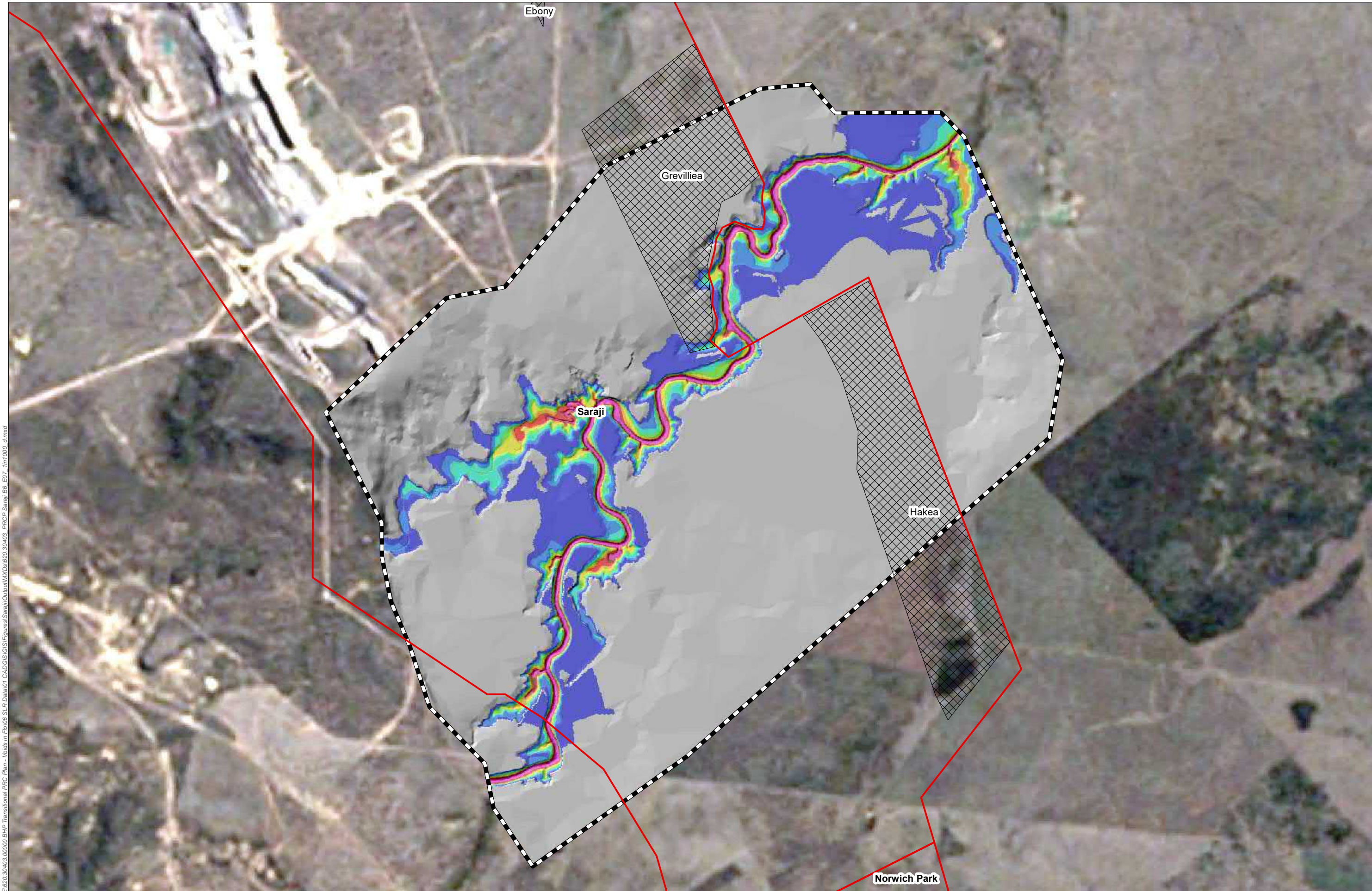




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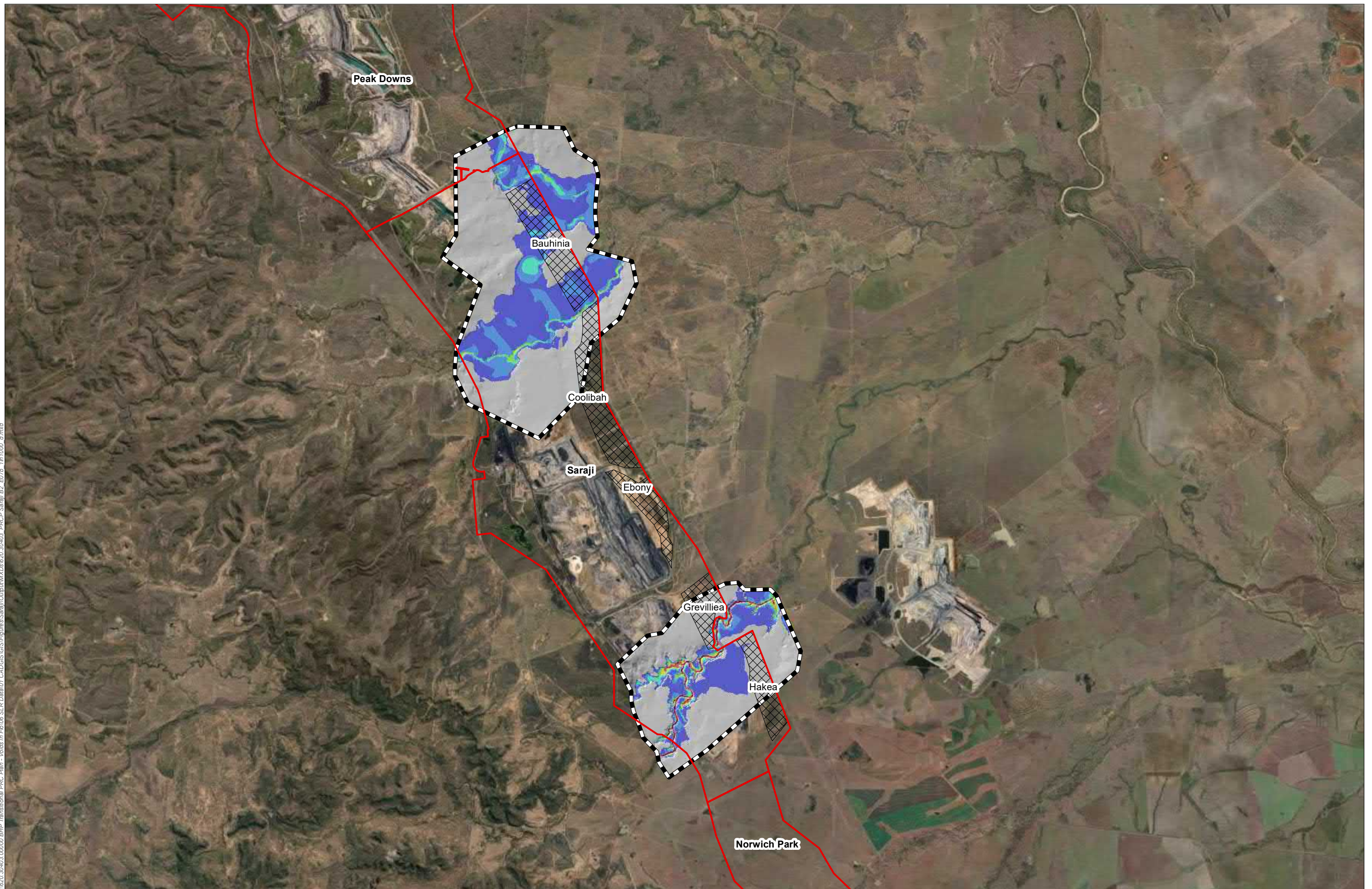


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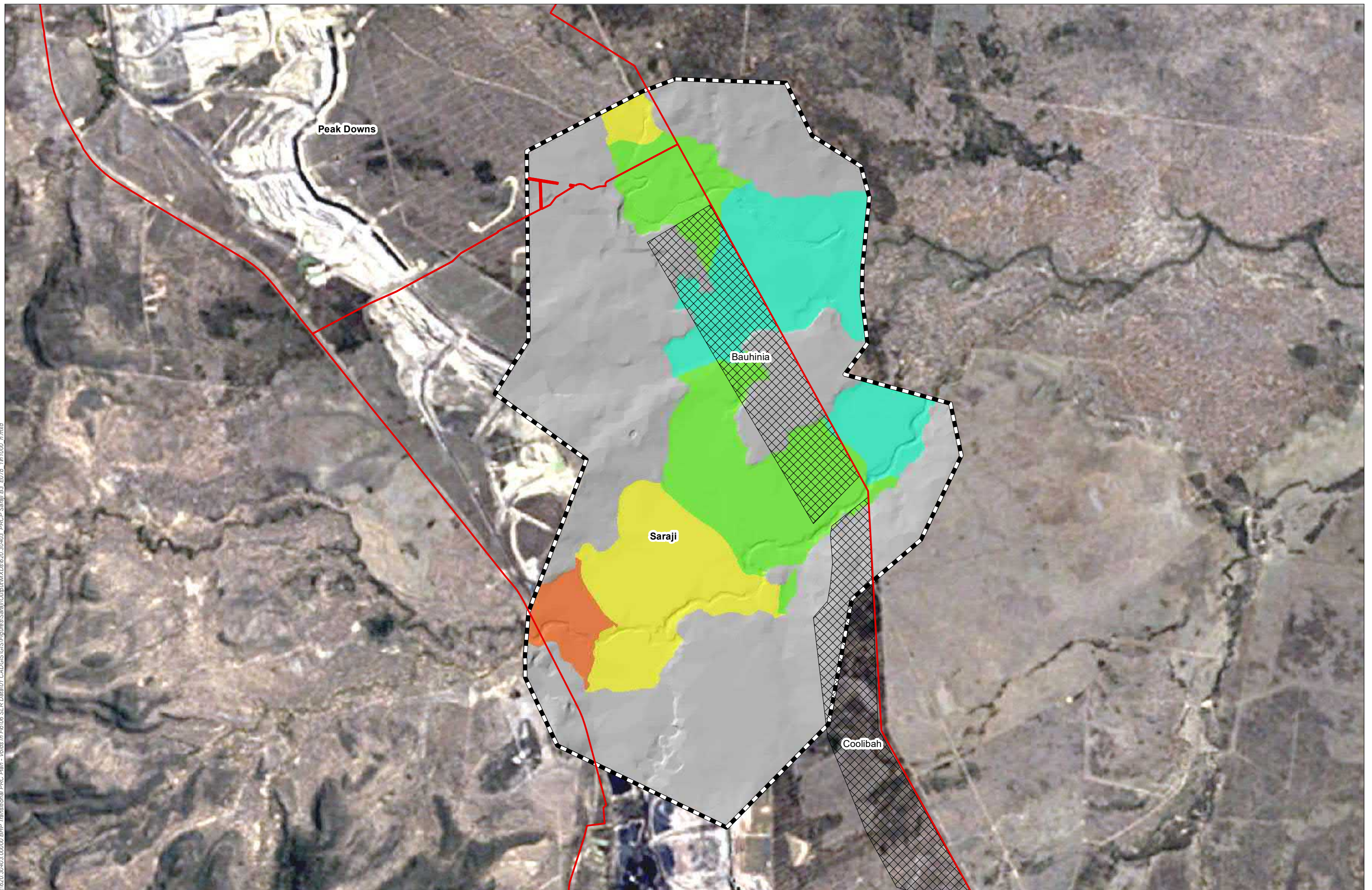
APPENDIX C

TUFLOW Model Results – Sensitivity Analysis

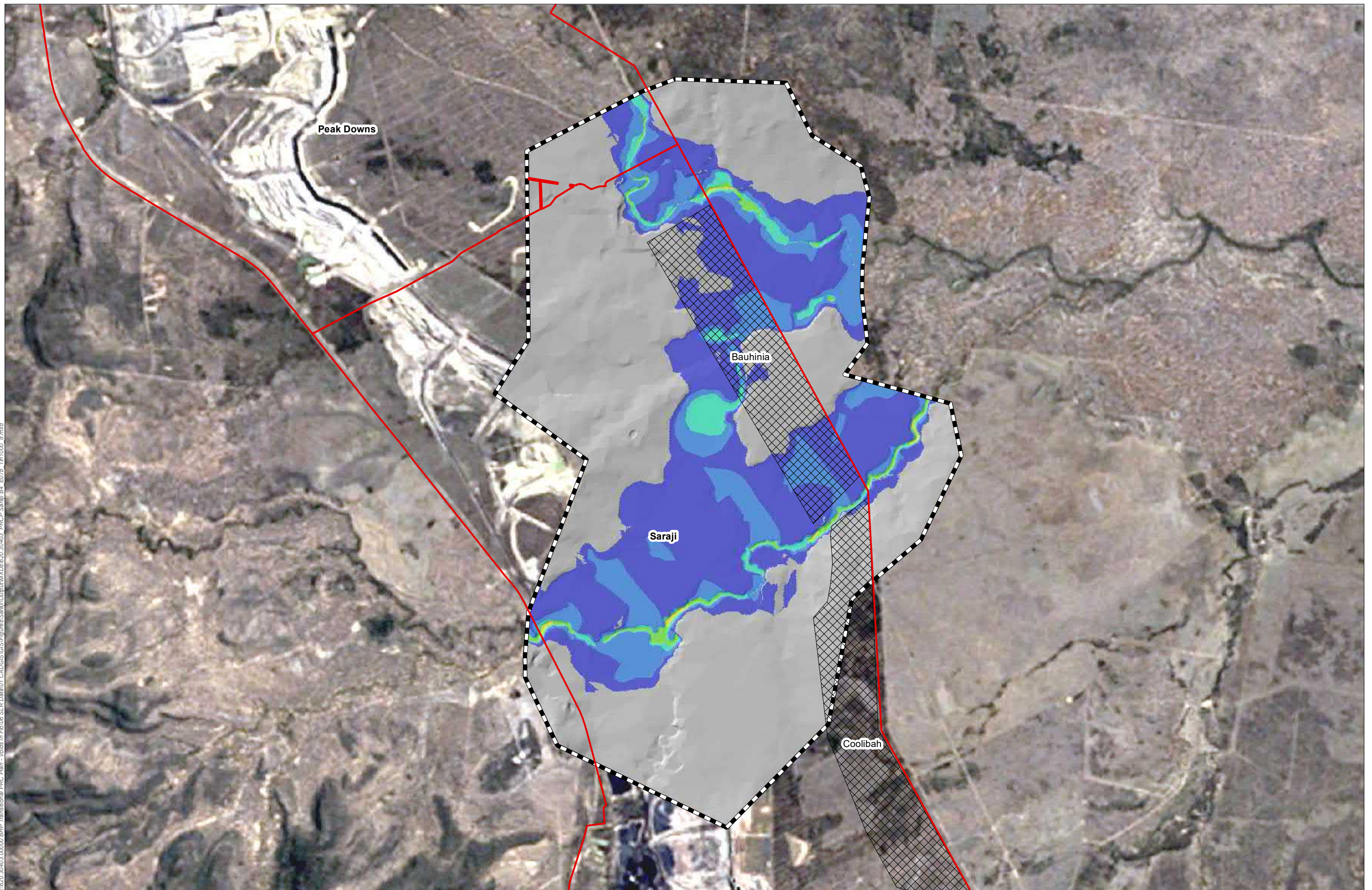
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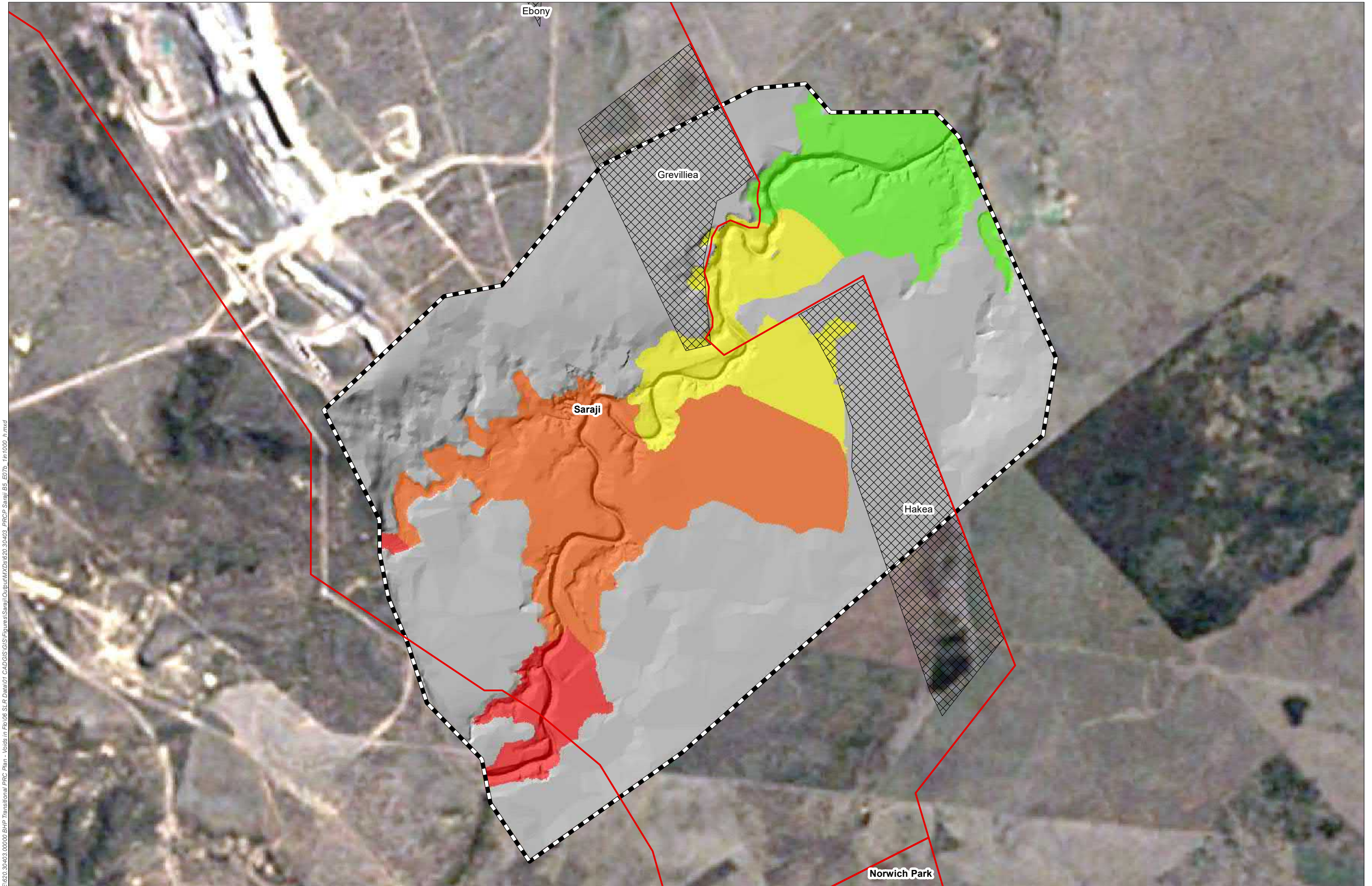


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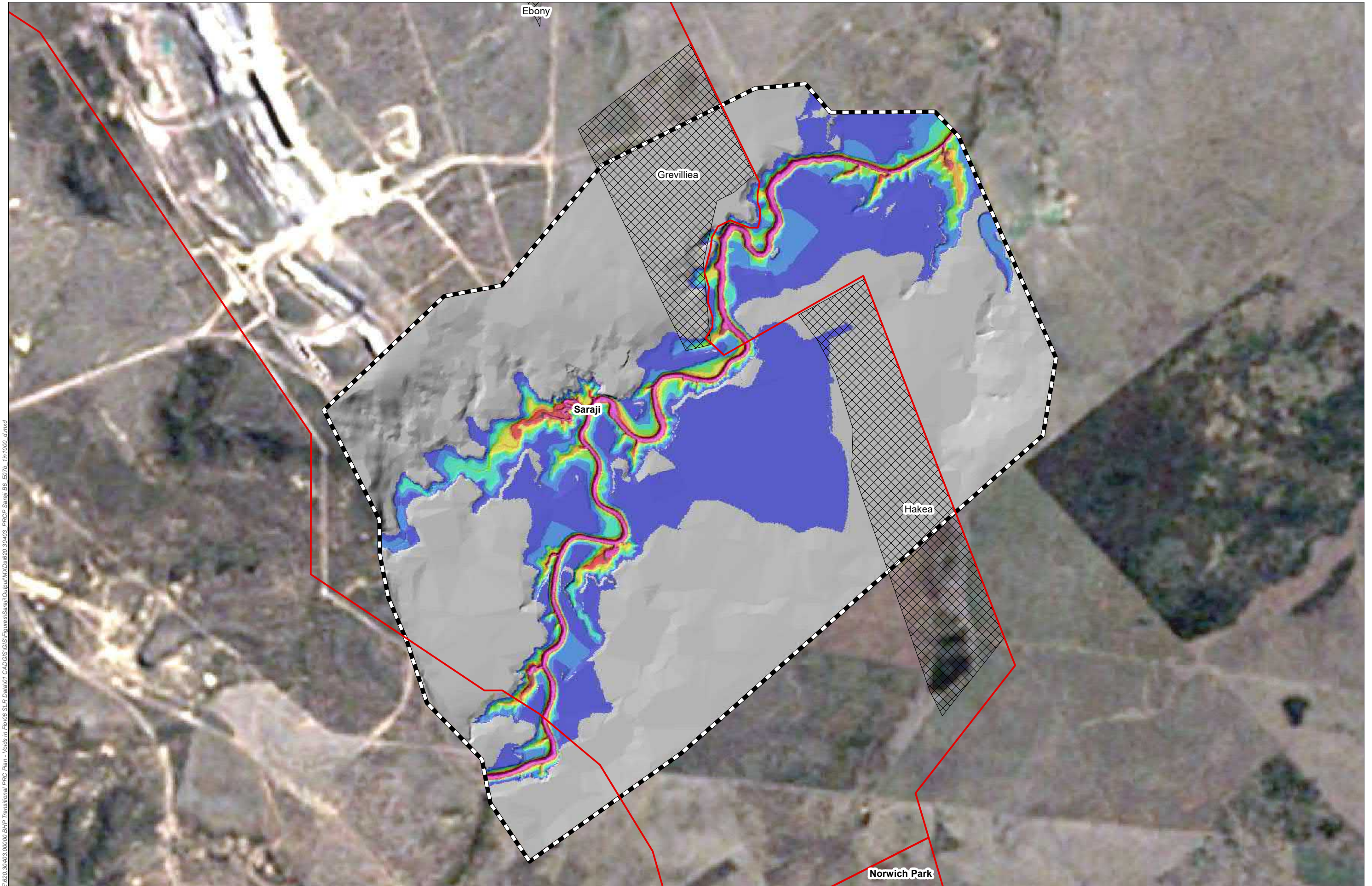


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