SARAJI EAST MINING LEASE PROJECT

Environmental Impact Statement

Chapter 9
Groundwater

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9.0 Groundwater

9.1 Introduction

BM Alliance Coal Operations Pty Ltd (BMA) is seeking approval to develop the Saraji East Mining Lease Project (the Project) involving a single-seam underground mine and supporting infrastructure on Mining Lease Application (MLA) 70383 and MLA 70459 adjacent to, and accessed through, the existing open cut mine void within Mining Lease (ML) 1775.

This chapter of the Environmental Impact Statement (EIS) provides an assessment of the Project's potential impacts on groundwater resources, including groundwater dependent ecosystems (GDE). It presents an overview of the surrounding area's hydrogeological regimes, potential impacts of the Project and, where necessary, actions to avoid minimise or mitigate these impacts. A detailed groundwater assessment is provided in **Appendix F-3 Groundwater Technical Report**. A detailed GDE assessment is provided in **Appendix D-2 Groundwater Dependent Ecosystem Technical Report**.

9.2 Legislation and policy

9.2.1 Commonwealth Legislation

Environment Protection and Biodiversity Conservation Act 1999

The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) is the Australian Government's central piece of environmental legislation. It provides a legal framework to protect and manage nationally important environmental assets, defined in the EPBC Act as matters of national environmental significance (MNES).

The 'water trigger' amendment to the EPBC Act includes water resources as MNES in relation to coal seam gas (CSG) and large coal mining developments. This means that CSG and large coal mining developments require federal assessment and approval if they are likely to have a significant impact on a water resource.

The Department of Climate Change, Energy, the Environment and Water (DCCEEW), who are responsible for administering the EPBC Act, has determined that the Project has the potential for significant impacts on water resources. Water resources include groundwater and surface water, and organisms and ecosystems that depend on it to maintain ecological function and condition (otherwise termed GDE).

The EPBC Act requires that all CSG and large coal mining developments which are expected to have water-related impacts be referred to the Independent Expert Scientific Committee (IESC) for advice. The EIS for the Project must include a specific section responding to the information requirements in the IESC 'Information Guidelines for the Independent Expert Scientific Committee advice on coal seam gas and large coal mining development proposals' (Commonwealth of Australia, 2015). The EIS focusses on MNES including water resources and the IESC information requirements relevant to groundwater in **Chapter 21 Matters of National Environmental Significance**.

9.2.2 State legislation

Environmental Protection Act 1994

The *Environmental Protection Act 1994* (EP Act) has the objective to protect Queensland's environment while allowing for development that improves the total quality of life, both now and in the future, in a way that maintains ecological processes.

BMA is applying for a new site-specific Environmental Authority (EA) for the Project. The Department of Environment and Science (DES), who are responsible for the administration and regulation of resource activities under the EP Act, has confirmed that the Project requires assessment through an EIS.

The EP Act defines an environmental value (EV) as:

- A quality or physical characteristic of the environment that is conducive to ecological health or public amenity or safety; or
- Another quality of the environment identified and declared to be an environmental value under an environmental protection policy or regulation.

The amendments introduced by the *Environmental Protection (Underground Water Management) and Other Legislation Amendment Act 2016* (Underground Water Management Act) have introduced new information requirements into the EP Act. Section 126A outlines a list of information requirements to accompany a site-specific application where the resource activity or project involves the exercise of underground water rights. Section 227AA requires this information also be included with an amendment application where the proposed amendment involves a change in the exercise of underground water rights.

Water Act 2000

The *Water Act 2000* (Water Act) provides for the sustainable management of water and the management of impacts on underground water and for other purposes. The main purposes of the Water Act are to provide a framework for the following:

- sustainable management of Queensland's water resources by establishing a system for the planning, allocation, and use of water
- sustainable and secure water supply and demand management for the south-east Queensland region and other designated regions
- management of impacts on underground water caused by the exercise of underground water rights by the resource sector
- effective operation of water authorities.

The Water Act covers water in a watercourse, lake or spring, underground water (or groundwater), overland flow water, or water that has been collected in a dam.

Section 362 of the Water Act refers to bore trigger thresholds. The bore trigger threshold is the maximum allowable groundwater level decline in a groundwater bore, due to the exercise of resource tenure holders' underground water rights, prior to triggering an investigation into the water level decline. The bore trigger threshold for consolidated aquifers is five metres (5 m) and for unconsolidated aquifer it is two metres (2 m).

Under the transitional arrangements for the Underground Water Management Act (described below), the Project will require an Associated Water Licence (AWL) under the Water Act, which removes the requirement to prepare an Underground Water Impact Report (UWIR) for the Project.

Environmental Protection (Underground Water Management) and Other Legislation Amendment Act 2016

On 10 November 2016, the Underground Water Management Act was passed by the Queensland Parliament. The Underground Water Management Act amended the EP Act and Water Act to strengthen the effectiveness of the environmental assessment and ongoing management of underground water extraction by resource projects. These amendments commenced on 6 December 2016.

The right to take associated water in the mining sector is granted under s334ZP of the *Mineral Resources Act 1990.* As per s839 of the *Mineral Resources Act 1990*, if an application for an EA was made prior to 6 December 2016, s334ZP of the *Mineral Resources Act 1990* does not apply until the mining tenement holder has an associated water licence (AWL).

As the Project EA application was made prior to the 6 December 2016, the Project falls within the transitional arrangements, because the take of water from the new mining leases had not commenced, and an AWL under the Water Act will be required.

9.2.3 Policies, plans, and guidelines

Environmental Protection (Water and Wetland Biodiversity) Policy 2019

The purpose of the Environmental Protection (Water and Wetland Biodiversity) Policy 2019 (EPP Water and Wetland Biodiversity) is to achieve the object of the EP Act in relation to waters and wetlands; protecting Queensland's water environment while allowing for development that is ecologically sustainable.

Environmental values (EVs) and water quality objectives (WQOs) are determined progressively for Queensland waters. EVs define the uses of the water by aquatic ecosystems and for human uses (e.g. drinking water, irrigation, aquaculture, recreation). WQOs define objectives for the physical, chemical, and biological characteristics of the water (e.g. nitrogen content, dissolved oxygen, turbidity, toxicants, fish).

The management intent for waters is stated in section 15 of the EPP Water and Wetland Biodiversity. For waters of high ecological value, the water quality is to be maintained. For slightly disturbed waters, the water quality is to be improved where needed, to achieve the WQOs. For moderately disturbed waters, water quality is to be maintained, or improved where needed, to meet the WQOs. In highly disturbed waters, water quality is to be improved so that it achieves the WQOs.

As EVs and WQOs are established for Queensland waters in accordance with the EPP Water and Wetland Biodiversity, after approval they are included in Schedule 1. For waters not included in Schedule 1, the EVs and WQOs are respectively determined in accordance with section 6 and section 11 of the EPP Water and Wetland Biodiversity.

Groundwater environmental values relevant to the Project are presented in Section 9.4.11 of this chapter.

Water Plan (Fitzroy Basin) 2011

Water plans have been developed under the Water Act to sustainably manage and allocate water resources in Queensland. The Project is located within the Isaac Connors Groundwater Management Area (GMA) as defined in Schedule 3 of the Water Plan (Fitzroy Basin) 2011. The Project does not fall within the Isaac Conners Alluvium groundwater sub-area.

With the Isaac Connors GMA, water licences and/or development permits are not required for stock and domestic bores. Generally, groundwater monitoring bores are also excluded from the requirement for development permits.

Other groundwater-related activities, such as drilling of test pumping bores and undertaking pumping tests, require authorisation (by way of permits), as well as a development permit to allow drilling and construction of water bores. Any long-term water take or interference from groundwater sources requires authorisation by way of a licence. The Project will require a water licence for groundwater interfered with as a result of mining activities.

Fitzroy River Sub-basin Environmental Values and Water Quality Objectives

A review of the Fitzroy Basin Groundwater Zones was conducted to assess the relevant groundwater zone for the Project and identify scheduled WQOs to address submission on the draft EIS by the Queensland Department of Environment and Science (DES). The Fitzroy River sub-basin

Environmental Values and Water Quality Objectives (DEHP, 2013) identifies environmental values for groundwater in the Fitzroy River sub-basin, and WQOs to protect or enhance those EVs.

Figure 9-1 indicates the Isaac Connors GMA and the approximate Project location. The Groundwater Zones (WQ1310 – Fitzroy Basin Groundwater Zones) identified across the basin with associated EVs is included in Figure 9-2. As indicated on Figure 9-2, the Project is not wholly located within a Fitzroy Basin Groundwater Zone.

The scheduled groundwater WQOs, as included in the Environmental Impact Statement (EIS), for groundwater zone 34 (the closest groundwater zone which may contain the furthest down dip eastern portion of the Project) was used for the Project impact assessment.

Underground water rights

The Guideline EP Act Requirements for site-specific and amendment applications - underground water rights (DES, 2021) outlines information requirements for a new EA application or an application to amend an EA for resource projects or activities that:

- are carried out on one or more resource tenures for which the relevant tenure is a mineral development licence, mining lease or petroleum lease; and
- involve the exercise of underground water rights or a change to the exercise of underground water rights.

The guideline provides recommendations about the level of information required to meet the legislative requirements of sections 126A and 227AA of the EP Act, which are similar to requirements for an UWIR required to be prepared under Chapter 3 of the Water Act.

Underground water rights provide the tenure holder with a statutory right to take or interfere with underground water in the tenure if the taking or interference with that water is necessarily and unavoidably obtained in the process of extracting the resource. For example, mine dewatering to the extent necessary to achieve safe operating conditions. This is also known as associated water.

Sections 126A and 227AA of the EP Act complement Chapter 3 of the Water Act, by ensuring an upfront assessment of the impacts to environmental values from the exercise of these underground water rights has been undertaken and potential impacts are appropriately managed.

Figure 9-1 Water Plan (Fitzroy Basin) 2011 Schedule 3 Groundwater Management Areas (Project red dot)

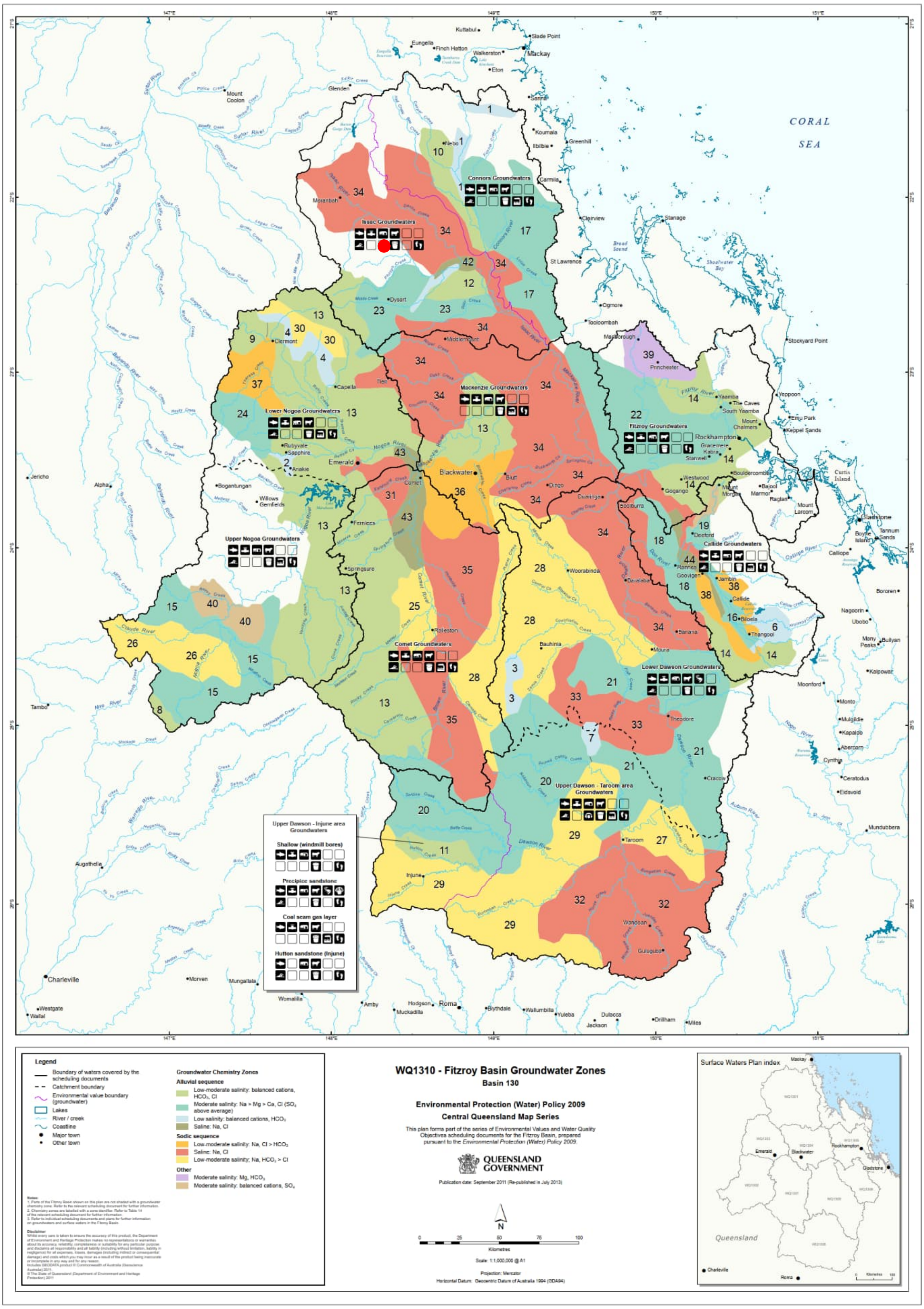

Figure 9-2 Fitzroy Basin Groundwater Zones (Project red dot)

9.3 Methodology

The groundwater impact assessment comprises description of the existing hydrogeological environment and an assessment of the impacts of mining on that environment, including:

- data review of historical groundwater studies undertaken for the Project, groundwater management reports for existing Saraji operations and publicly available data from bores on the surrounding agricultural land
- update of geological and groundwater baseline conditions and conceptualisation of current groundwater resources
- impact assessment used the Bowen Basin regional groundwater flow numerical model to assess and predict groundwater ingress rates to the underground mine and evaluate the potential impact of the Project.

9.3.1 Data review

Several groundwater studies have been undertaken including the previous groundwater impact assessment for underground longwall mining using a now outdated mine plan and schedule for the Project undertaken by AGE (2011), at the adjacent Saraji Mine, and of nearby mining projects.

These were reviewed to refine understanding of the hydrogeological system within and surrounding the Project. The groundwater modelling technical report, **Appendix F-1 Groundwater Modelling Technical Report**, compiled to assess the potential impacts of the Project on groundwater resources, included more regional geological and hydrogeological data. Together this data aided in describing and evaluation the hydrostratigraphic units within and adjacent to the Project Site.

Full details on the key reports reviewed for the groundwater impact assessment are provided in **Appendix F-3 Groundwater Resources Technical Report**.

9.3.2 Conceptualisation

9.3.2.1 Groundwater resources

The conceptualisation of current groundwater resources indicates three separate groundwater systems are relevant to the Project; these aquifer systems are associated with the following geological units:

- seasonal or sporadic alluvium groundwater
- localised basal sand and gravel at the base of Tertiary sediments
- deeper Permian coal seams.

Key understandings from the hydrogeological conceptualisation included the following:

- There are differences in groundwater levels measured in the Tertiary and deeper Permian aquifers which indicates that there is limited hydraulic connection between these groundwater systems.
- Recharge occurs from infiltration from rainfall and creek flows into the Tertiary and Permian aquifer sub-crop areas. Minor leakage from overlying aquifers may occur but is not evident based on groundwater level data.
- The regional groundwater levels are a subdued reflection of the surface topography except immediately adjacent to the open cut mine area where localised discharge / seepage into the pits results in steeper gradients around the pits.
- Regional groundwater discharge within the deeper aquifers is complex based on the horst and graben structures within the Bowen Basin. Groundwater flow is considered to flow down dip from sub-crop to the east. Groundwater level data indicates lower groundwater levels to the east. It is considered that faulting facilitates more complex groundwater movement to the east of the Project Site.
- Groundwater associated with the alluvium occurs as discontinuous and sporadic resource, which is recognised under the EP Act and Environmental Protection Regulation 2008. As such, this limited resource is recognised to have intrinsic environmental values.

9.3.2.2 Mine plan assessment

The Project is a single-seam operation involving extraction of the Dysart Lower (D14 / D24) seam, referred to as the target D seam. BMA selected the longwall underground mining method for the Project following an assessment of technical and economic feasibility.

Coal will be mined by longwall methods consisting of a northern region of panels and a southern region of panels separated by a portal which will be progressively mined out and developed as mining progresses. Mining will commence from within ML 1775 (in the west) adjacent to the existing Saraji Mine open cut operations and progress east into MLA 70383. The underground mine plan has been refined to a 20 year production schedule.

This chapter assesses the potential impacts to groundwater resources associated with the underground mine plan for the Project shown in Figure 9-3.

This assessment is informed by groundwater modelling undertaken to simulate the Project underground and the approved Saraji Mine open cut mining. The model incorporates a 20 year production schedule and the open cut mining, which ceases in approximately 2031.The assessment considers the potential for goaf alteration and subsidence related impacts resulting from longwall mining, as estimated in the **Appendix B-2 Subsidence Modelling Technical Report**.

The approved Saraji open cut mine plan (Figure 9-4), shows open cut operations currently extracting coal from the Dysart Lower seam are expected to continue until 2031 (in some pits reaching the ML boundary). According to the assessment scenario for the EIS, this means that the proposed underground mining and approved open cut mining will occur concurrently on the Project site between assessment scenario Year 1 and Year 9 (2023 and 2031) i.e. 8-9 year overlap. In areas where both open cut mining and underground mining are proposed, the sections of open cut have been removed and replaced by underground mining only. The Project and the revised version of the Saraji Mine open cut mine plan used in the predictive groundwater modelling is illustrated in Figure 9-5.

Given that the underground mine and open cut mine are intrinsically linked through drawdown contour overlap, operational scheduling overlap and proximity, impacts from underground mining were assessed by simulating continuous operation of the open cut (albeit a revised open cut mine plan to facilitate the underground mining on the MLs) and underground mining operations.

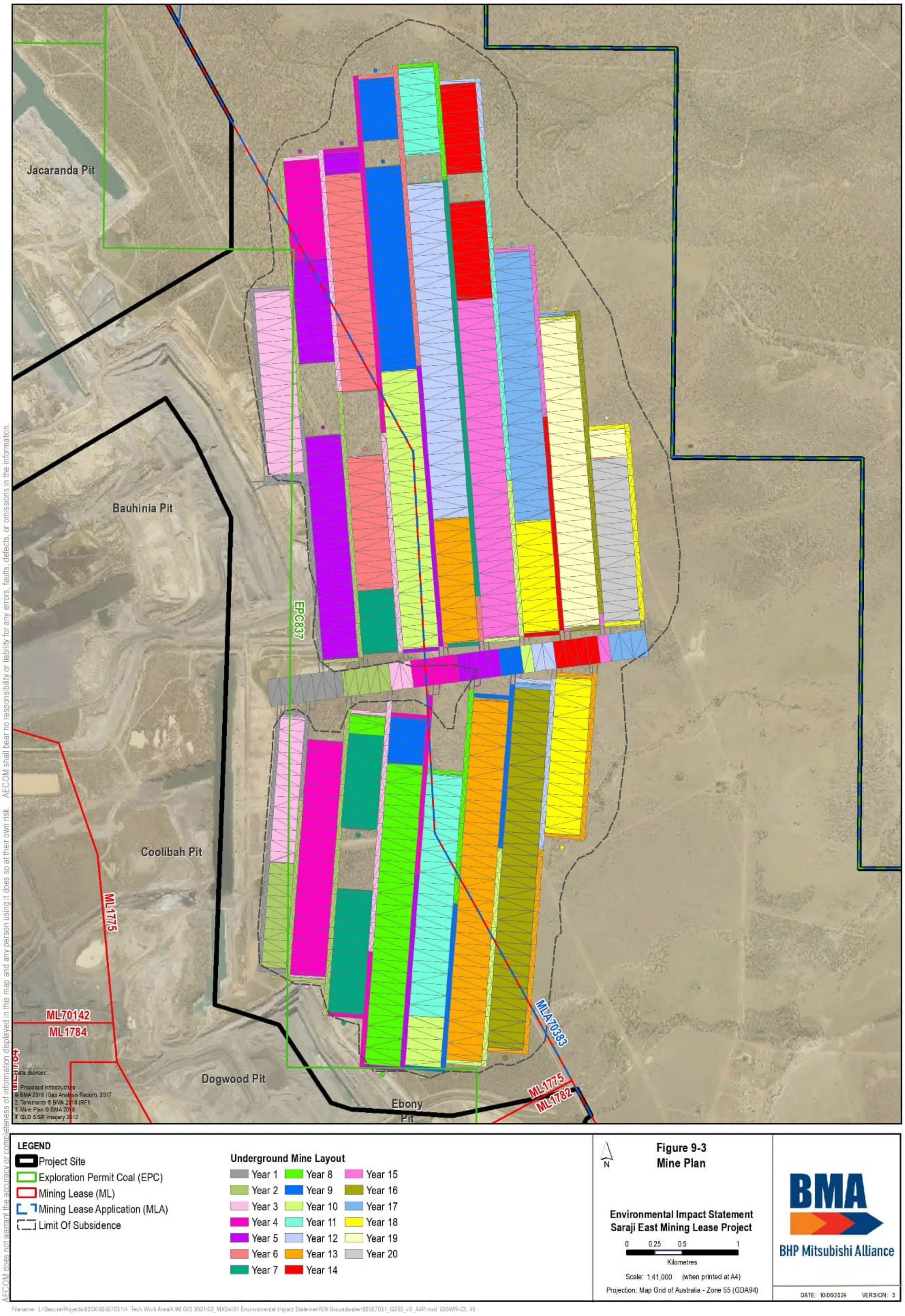

Figure 9-3 Underground mine plan

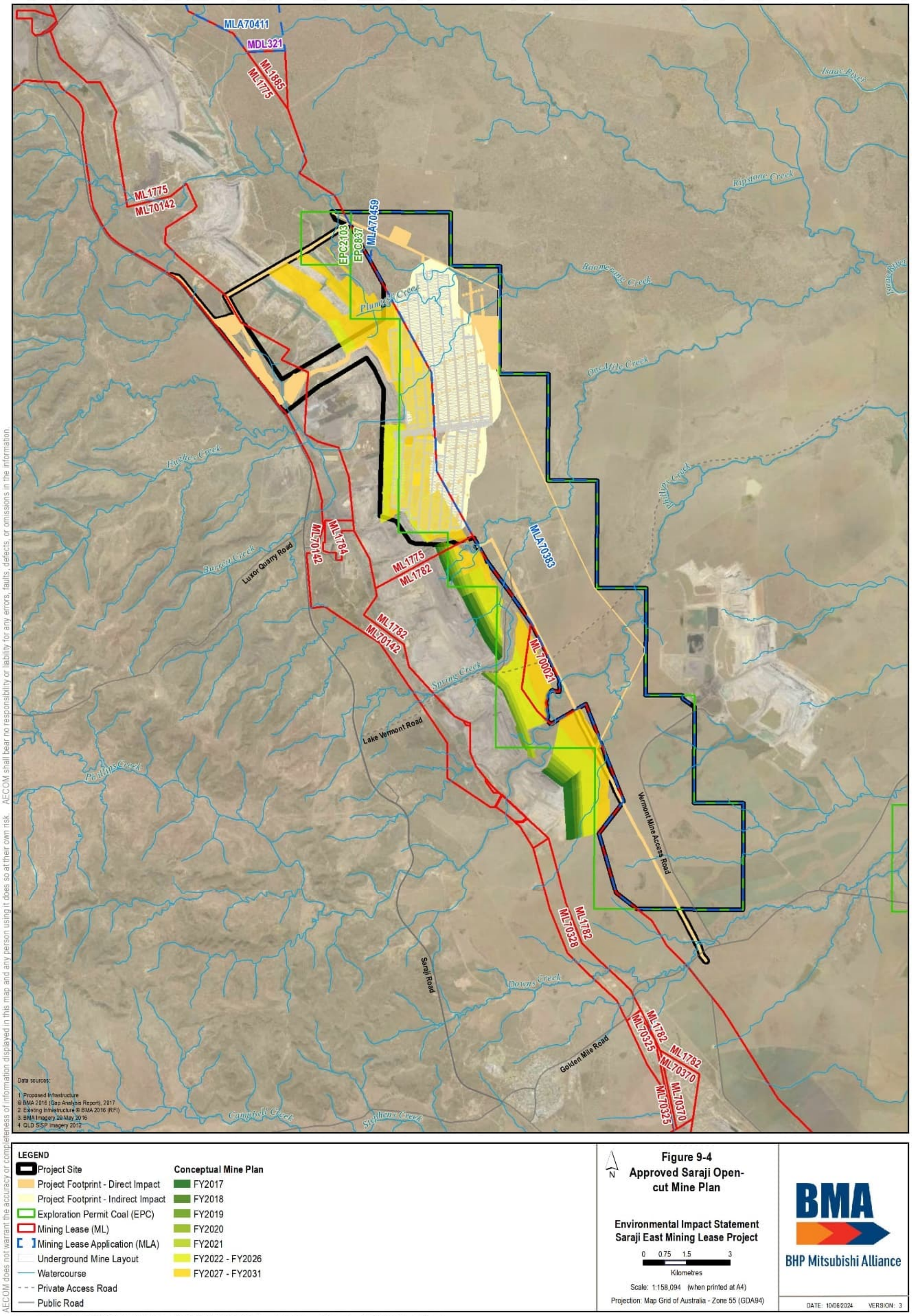

Figure 9-4 Approved Saraji open cut mine plan

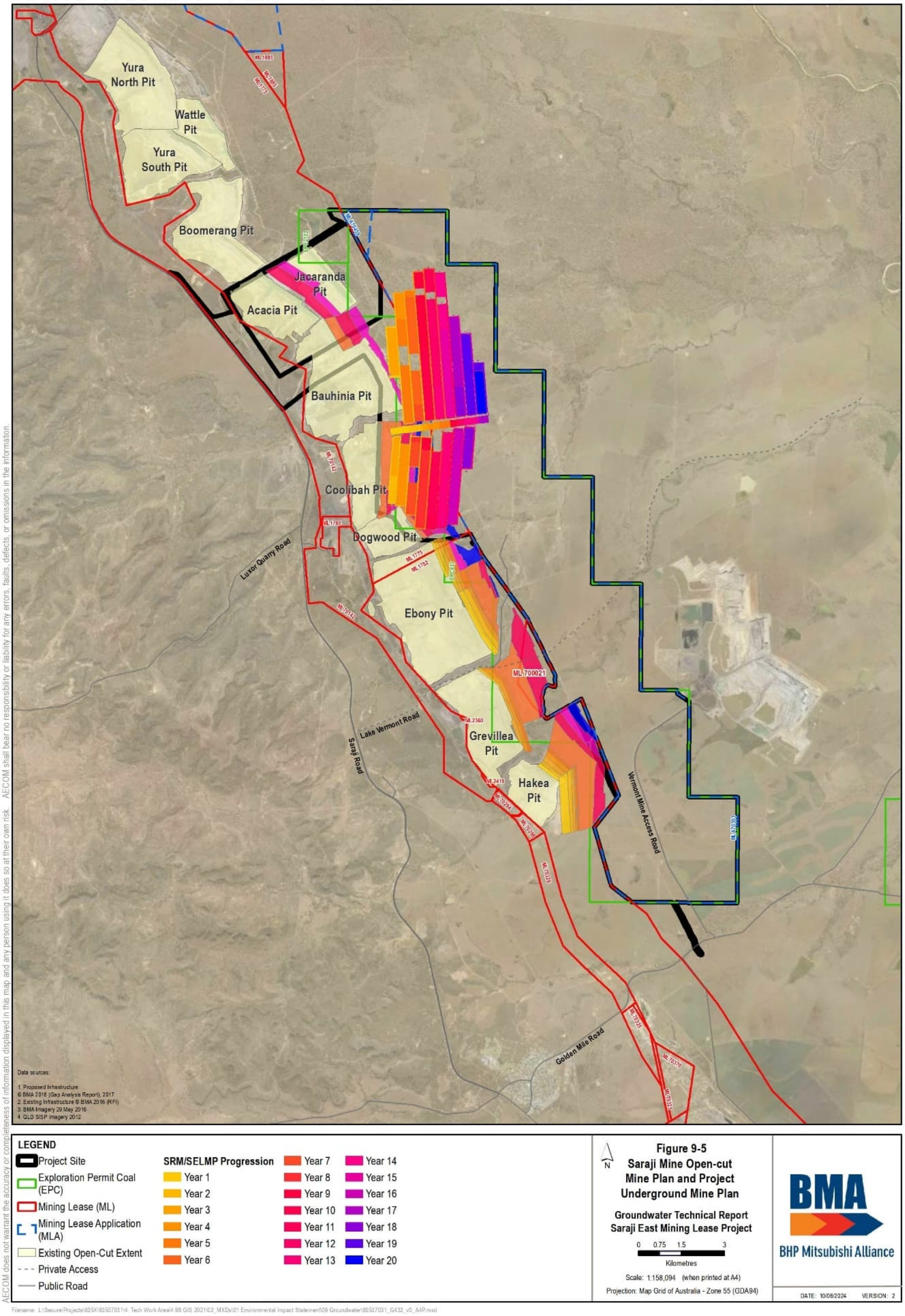

Figure 9-5 Saraji Mine open cut mine plan and Project underground mine plan

9.3.3 Impact assessment

Predictive groundwater modelling was conducted to assess the potential impacts of the proposed longwall mining. The modelling looked at mine dewatering impacts (groundwater ingress and groundwater level drawdown) considering all approved and foreseeable mining in the region, including the approved Saraji Mine open cut workings, with and without the Project.

Predictive simulations, including an evaluation of groundwater level drawdown, the prediction of groundwater ingress and an evaluation of groundwater level recovery was conducted.

The objective of groundwater modelling was to use a constructed and calibrated regional model, that:

- has been reviewed and assessed by an independent reviewer,
- suitably represents the current conceptual understanding of the groundwater systems within and beyond the Project Site, and
- allows for the prediction of changes in groundwater conditions and water resources due to the Project.

A numerical groundwater model for the Project was developed using BMA's regional numerical groundwater model as the foundation. The updated BMA regional groundwater model, referred to as the Project numerical groundwater model, builds on the regional scale Olive Downs Project model (i.e. the foundational model constructed and calibrated in 2018). The foundational model was subsequently updated for the following Bowen Basin mine projects:

- Moorvale South Project in 2019
- Winchester South Project in 2020
- Caval Ridge Mine and Horse Pit Extension Project in 2021
- Lake Vermont North Extension Project in 2021
- Millennium Mine Mavis Extension in 2021
- Daunia Mine Water Licence Review in 2021.

It is noted that this regional scale model has already been reviewed and accepted twice by State agencies and once by the Commonwealth for other project approval applications, as well as used by BMA to support various State mining compliance reporting requirements.

The numerical groundwater model, refined and calibrated for the Project, was subject to a Peer Review. The review comments are included in **Appendix F-2 Groundwater Modelling Peer Review**.

The overall objectives of the predictive groundwater modelling was to:

- estimate the groundwater inflow to the Project underground mine workings as a function of mine position and timing
- simulate and predict the extent of groundwater level drawdown due to the Project
- identify areas of potential environmental risk, where groundwater impact management measures may be necessary.

Technical model details relating to boundaries, boundary conditions, design, stresses, model layers, calibration, classification, and limitations are provided in the **Appendix F-1 Groundwater Modelling Technical Report**.

9.3.3.1 Predictive simulations

The calibrated groundwater model was utilised to assess potential impacts of the Project on groundwater resources. Groundwater level drawdown was evaluated in the following geological layers:

- Quaternary age alluvium, colluvium and Tertiary basalt, and weathered zone (regolith)
- Moranbah Coal Measures Q seam, P seam, and H seam
- the target Dysart Lower coal seam (D seam).

The model predictions of underground mining impacts also included simulation of the approved Saraji Mine open cut operations (including the proposed Grevillea Pit extension) as previously undertaken by AECOM (2016) and shown in the open cut mine plan.

As there was overlap between the approved open cut mine plan and the proposed underground mine plan, the open cut mine plan was modified for simulation of underground mining activities by removing those open-pit mining areas which overlapped with the proposed underground workings; the justification being these areas cannot be mined by open cut mining methods if they are being mined using the underground mining methods.

The predictive model simulations included the following:

- predictions of groundwater levels from the end of the transient calibration model from January 2022 to January 2044
- predictions of groundwater level recovery from January 2044 to January 4044 for 2,000 years
- the prediction of groundwater ingress into the proposed Project, allowing for the estimate of groundwater ingress into the underground mine over time.

9.3.3.1.1 Groundwater level drawdown

A combined steady sate, transient warm-up, and transient calibration model was developed, as follows:

- a steady state model with one stress period to simulate the water levels pre-mining
- a transient warm-up model with one 20-year stress period from January 1988 to December 2007)
- a transient calibration model with 56 quarterly stress periods from December 2007 to December 2021.

The first stress period of the model was steady-state and did not include any mining. The transient warm-up model was built to incorporate pre-2008 mining activities and their impacts on groundwater levels around the Project. The warm-up model provided appropriate starting conditions for the calibration model (i.e., starting heads and hydraulic properties).

The groundwater model was then used to simulate changes to pre-mining conditions within the model domain in response to the approved open cut and proposed underground mining plans; backfilling of the open cut pits was simulated to occur after one year. The combined simulation of backfill of open cut pits (recharge), open cut workings (dewatering), and underground workings (goaf alteration and dewatering) allowed for the evaluation of groundwater levels in response to complex mining operations.

9.3.3.1.2 Bore trigger thresholds

As defined in the Water Act, bore trigger threshold for an aquifer means a decline in the water level i.e.:

- five (5) metres for consolidated aquifers (e.g. sandstones)
- two (2) metres for unconsolidated aquifers (e.g. sand/alluvial aquifers).

To align with the requirements of the Water Act, groundwater drawdown contours were produced to be consistent with the bore trigger thresholds as follows:

- the Quaternary/Tertiary sediments (model layer 1) are unconsolidated and thus two (2) metre drawdown contours were produced consistent with the bore trigger threshold for unconsolidated Sediments
- the Permian sediments (model layers 6 and 10) are consolidated and therefore five (5) metre drawdown contours were produced consistent with the bore trigger threshold for consolidated sediments.
- The 2 m and 5 m triggers relate to change in groundwater levels from the initial groundwater levels at the start of model predictions (i.e. pre-activities).

9.3.3.2 Model code

MODFLOW-USG Transport was used as the model code (Panday et al. 2013). MODFLOW-USG is the recent version of industry standard MODFLOW code and was determined to be the most suitable modelling code for accomplishing the model objectives. MODFLOW-USG optimises the model grid and increases numerical stability by using unstructured, variably sized cells. These cells take any polygonal shape, with variable size constraints allowing for refinement in areas of interest (i.e., geological or mining features).

MODFLOW-USG was also used to simulate unsaturated conditions, allowing progressive mine dewatering and post mining rewetting to be represented by the model. For the Project model, vadose zone properties have been excluded, and the unsaturated zone was simulated using the upstream-weighting method.

Fortran code and a MODFLOW-USG edition of the Groundwater Data Utilities (Watermark Numerical Computing) were used to construct the MODFLOW-USG input files.

9.3.3.3 Modelling method

The BMA regional scale groundwater model was adopted as a base for the Project model. A range of updates to the BMA regional groundwater model were required for the model to be considered fit for purpose for the Project. The updates to the model design were as follow:

- updated fracture zone depth and hydraulic property changes above the proposed Project longwall panels based on **Appendix B-2 Subsidence Modelling Report**
- updated model layer geometry based on the Peak Downs Mine, Saraji Mine, the Project, and Saraji South (previously Norwich Park Mine) latest BMA geological models
- implemented historic and approved future mining operations at Saraji Mine and Peak Downs Mine and the proposed project underground operations
- refined surface elevations and hydrologic features.

9.3.3.4 Model extent

The model is a regional scale model with the domain extent designed to meet environmental approvals application requirements for cumulative impact assessment, (i.e. the domain is large enough to appropriately consider potential overlapping groundwater impacts from resource operations in the Bowen Basin). The model domain is presented in Figure 9-6.

The model domain place boundary conditions sufficiently distant from the Project and surrounding mines to allow the extent of potential impacts from mining activities on the groundwater system to be assessed. At its widest extents, the model is approximately 62 kilometres (km) west-east by 95 km north-south. The model domain from the previous approved version of the model (Caval Ridge – Horse Pit Extension) is appropriate for the Project based on the following considerations:

- the western boundary is represented by the outcrop boundary of the Back Creek Group, which is considered the regional low permeability basement for the purpose of this modelling
- the northern boundary contains the primary geological unit being targeted by the Project and is 30 km away from the proposed longwall panels
- the southern boundary is set along the Stephens Creek 30 km south of the Project and is expected to be far outside the range of predicted Project related drawdown
- the eastern boundary is set along the Delvin Creek 40 km east of the Project and is expected to be far outside the range of predicted Project related drawdown.

Full details of the model design, stresses, boundary conditions and calibration are provided in **Appendix F-1 Groundwater Modelling Technical Report**.

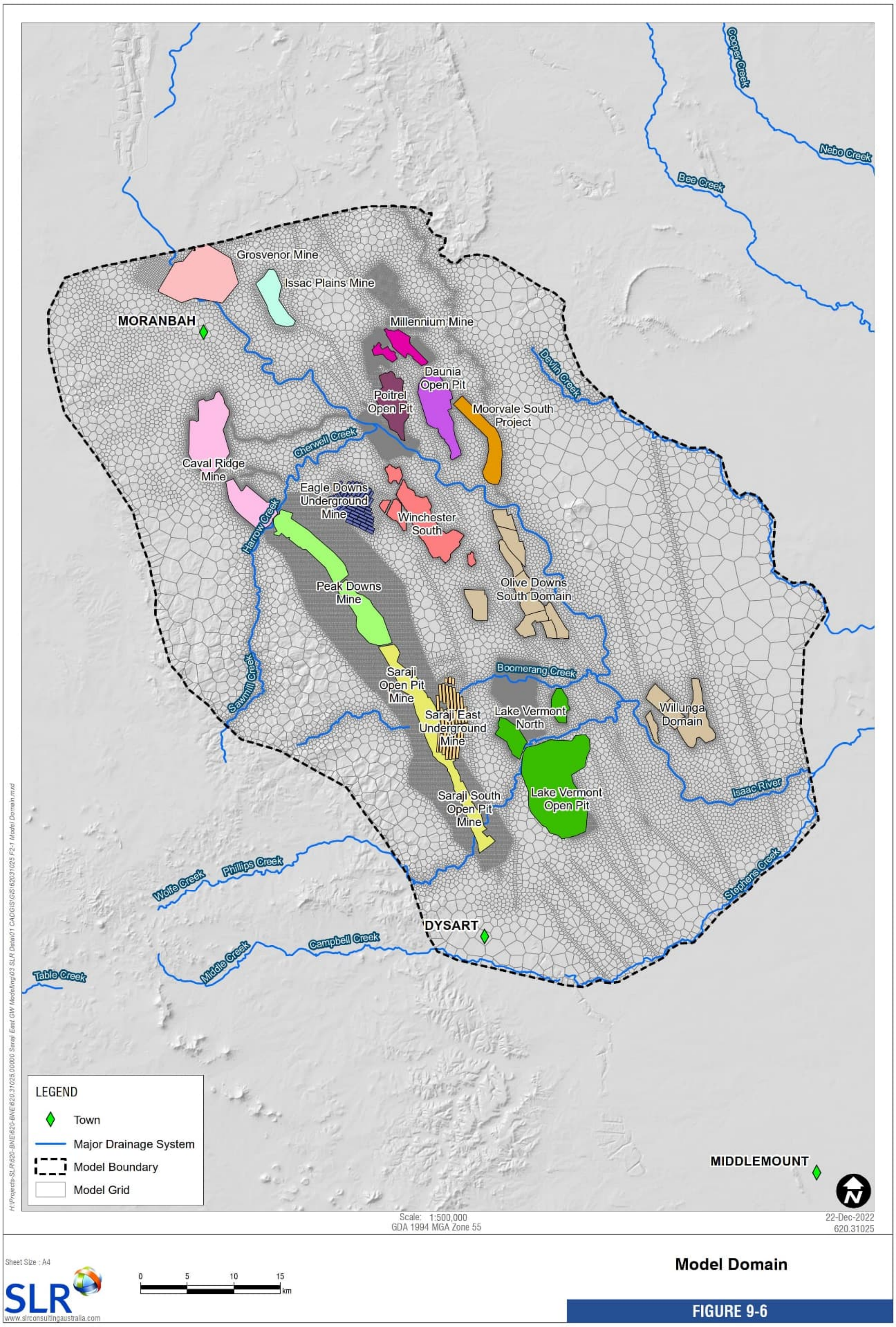

Figure 9-6 Model domain (SLR, 2023)

9.3.4 Longwall mining

Modelling of subsidence predictions specific to the proposed underground mine workings were undertaken, which allowed for an estimate of the vertical extents of alteration above the longwall mining panels. In addition, the subsidence assessment provided estimates of possible changes to aquifer hydraulic properties, dependent on the hydrostratigraphic unit, because of goaf.

The subsidence model was set up to include the major geological strata with properties which reflected pre-mining conditions. The subsidence model simulated the effect of bed separation, opening of joints and the formation of new cracks in the originally intact overburden rock mass. Changes in stress and the induced deformation in the surrounding rock mass associated with rock fracture and bedding plane separation were calculated.

Main findings of the subsidence modelling are summarised below:

- When overburden thickness is less than 300 m above the target D coal seam, the subsidence modelling results show continual volumetric strain and rock mass damage in the overburden strata extending from longwall edge to the surface. Shear cracks at the surface are predicted to form to a depth of 30 m to 70 m below the ground level.
  - The surface cracks were assumed not to heal in the groundwater modelling, and to be pervasive over the mining footprint, where the simulated effects of fracturing/cracking (upward from the goaf and downward from the surface subsidence) are continuous. This conservative approach allowed for the evaluation of potential impacts of longwall mining on water resources.
- When the overburden thickness is more than 300 m, the results indicate that the fractured zone extends to above 30 m to 50 m above the Harrow Creek seam (H Seam, layer 16 in the groundwater model). The overlying units will be undamaged rock mass. Longwall mining also induces shallow tension cracks which are predicted to extend to a maximum depth of 15 m below ground level.

9.3.4.1 Alteration due to Longwall mining

As longwall mining progresses through the coal seam, the void left behind collapses (goaf) and fills with collapsed rock from the formations directly above the coal seam (i.e., the caved zone). There is a sag in the bedded formations above the goaf zone and the deformation causes generally vertical fractures to occur. These fractures can provide new flow paths for groundwater and alter the permeability of the strata overlying longwall mining areas.

Based on the subsidence model findings, two different fracture zones were predicted and included in the model. These include:

- fracturing where the longwall panels have an overburden thickness > 300 m
- fracturing where the longwall panels have an overburden thickness < 300 m.

With respect to deeper longwalls (overburden thickness > 300 m), it was assumed that the fracture zone generally extends to 50 m above the Harrow Creek seam (H Seam) and the surface cracking occurs up the depth of 15 m.

Over shallower longwalls (i.e., overburden thickness < 300 m), the surface cracking extend to a depth of 50 m. It was assumed here that the fracturing occurs above the longwall up to the surface cracking zone. These fracture zones, as included in the groundwater model using the time-variant materials (TVM) package of MODFLOW-USG Transport.

The hydraulic parameter changes within the goaf induced fracture and surface shear crack zones were used in the groundwater modelling to simulate the fracturing above the coal seam.

9.3.4.2 Alteration due to Open cut mining

For open cut mining, the spoil and waste rock are more permeable than the undisturbed strata. Completed open cut mining areas, as identified within the Saraji Mine, have and will be backfilled with waste overburden as the extraction proceeds.

The model includes for the variation in hydraulic properties in the open-cut pits, using the MODFLOW TVM package, based on the operational mine plans. Horizontal hydraulic conductivity of 0.3 metre per day (m/day) and vertical hydraulic conductivity of 0.1 m/day is applied to the spoil. The storage parameters used for the spoil were a specific yield (S_y) of 0.1 and a storage coefficient (S) of 1.0 x 10^{-5}.

9.4 Description of environmental values

9.4.1 Geology

The description of the existing geology with relevance to groundwater resources is summarised below.

The Project is located on the western limb of the northern Bowen Basin, a north-south trending Early Permian to Middle Triassic geological basin. Summarised, the stratigraphic sequence in the Project Site comprises the following:

- Middle Permian Back Creek Group (basement)
- Late Permian Blackwater Group sediments (and coal measures)
- Tertiary sediments
- unconsolidated Quaternary alluvium sediments.

The mapped geology indicates that the stratigraphy typically comprises Permian coal measures overlain by a variable thickness of unconsolidated to poorly consolidated Tertiary and Quaternary age sediments. Table 9-1 summarises the stratigraphy of the Project Site and surrounds.

Existing surface geology is shown in Figure 9-7 and the basement geology in Figure 9-8.

Table 9-1 Stratigraphy

Age	Stratigraphic unit		Description	Average thickness (m)	Occurrence
Quaternary	Alluvial sediments		Clay, silts, sand, gravel, floodplain alluvium	0 - 25	Confined to present day stream and creek channels, specifically Phillips Creek and Isaac River
Tertiary	Clay		Clay, clayey sand, sandy clay, sand	4 - 45	Regular distribution across Project Site; individual lenses are discontinuous and lensoidal
	Basal Sand/Gravel		Sand	0 - 3	Irregular distribution generally observed where Tertiary sediments are thickest. Not reported within underground mining footprint
	Duaringa Formation		Mudstone, sandstone, conglomerate, siltstone	~ 20	Extensive outside of the underground mining footprint to the southeast
Permian	Fort Cooper Coal Measures (FCCM)	Burngrove Formation	Sandstone, siltstone, mudstone, carbonaceous shale and coal	Up to 400	Present beneath eastern portion of underground mining footprint
		Fairhill Formation			
	Moranbah Coal Measures (MCM)	MacMillan Formation	Sandstone, conglomerate, claystone, siltstone, coal. Contains target coal seam – D14/24	250 – 350	Present beneath entire underground mining footprint
		German Creek Formation			
Early to Middle Permian	Back Creek Group		Sandstone, siltstone, carbonaceous shale, minor coal	-	Underlies entire Project. Outcrops west of Saraji Mine and extends under mined areas to the east

Figure 9-7 Surface geology

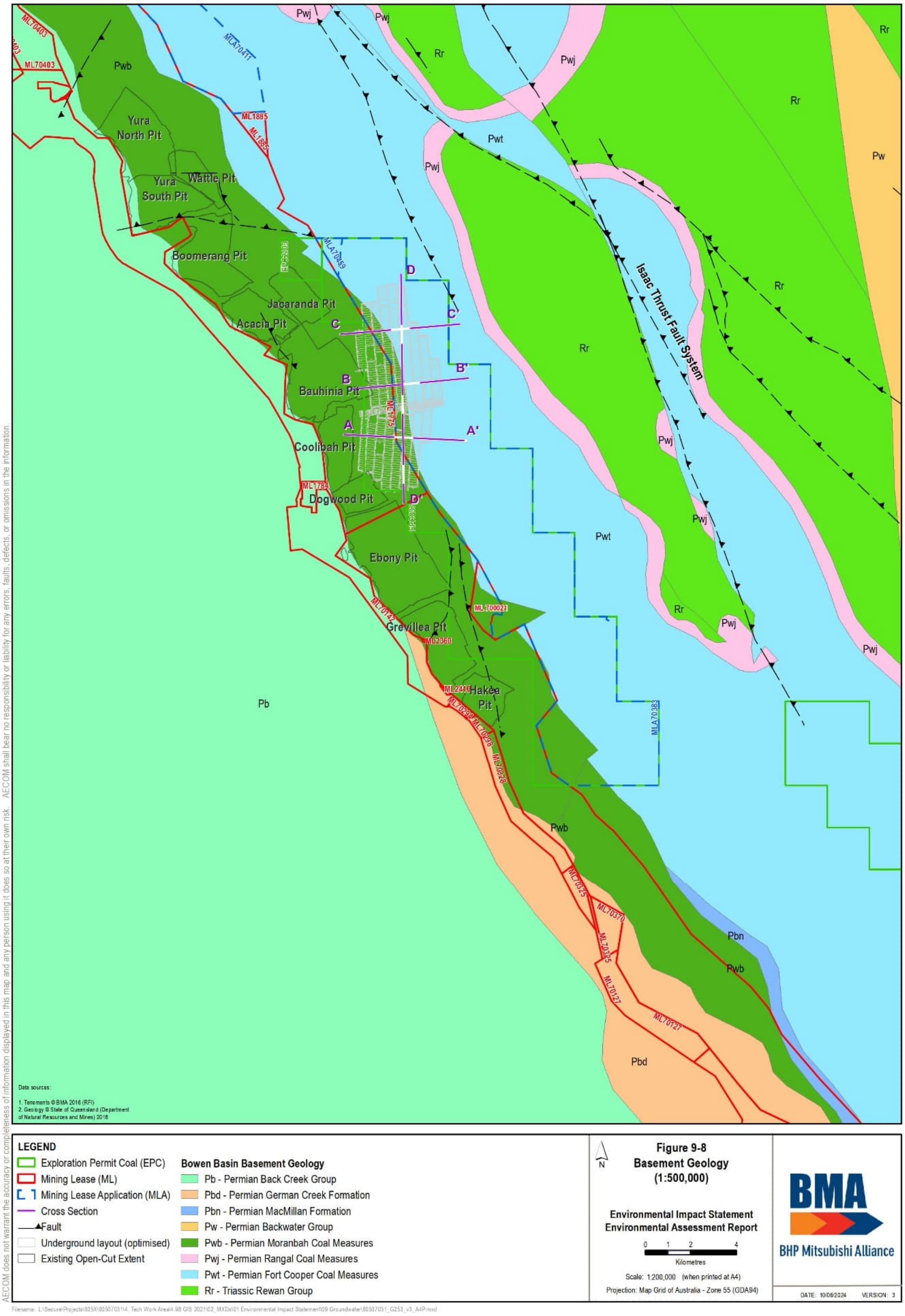

Figure 9-8 Basement geology

9.4.1.1 Structural geology

The location of mapped faults and structures within and surrounding the Project Site are shown in Figure 9-8. Mapped faults comprise both normal and thrust faults with mapped trends, which describe two dominant structural domains, one trends north north-west, the second trends north-south. The Isaac Fault, which is located to the east of the Project, separates relatively undisturbed sediments towards the west from a complex zone of folded and faulted sediments to the east. The Project mine plan takes these faults into consideration (i.e. underground layout longwall panels avoid faults).

The faults within the groundwater model domain are from the base BMA regional scale groundwater model, which used available fault mapping and site-specific geology models where available. Local fault displacements derived from the site-specific geological models have also been captured in the model layer elevations at these sites. There are three key regional northwest-southeast trending fault zones included in the BMA regional scale groundwater model, these include:

- extending 50 km, 500 m immediately east of the Project footprint (conservatively included as a continuous fault in the model)
- extending 70 km, 12 km to the east of the Project
- numerous shorter faults within a fault system, 15 km to the east of the Project.

9.4.1.2 Stratigraphy

The surface geology, shown in Figure 9-7, is based on the 1:100,000 scale Grosvenor Downs (Sheet 8553) geological map sheet. The mapped geology indicates that the stratigraphy typically comprises Permian coal measures overlain by a variable thickness of unconsolidated to poorly consolidated Tertiary and Quaternary age sediments.

Figure 9-7 shows that Tertiary sediments outcrop throughout the Project Area whilst mapped Quaternary sediments are associated with the present day channels of the Isaac River and Phillips Creek. It is noted that no alluvium is mapped within or adjacent to Boomerang Creek, Plumtree Creek, and the former Hughes Creek on the 1:100,000 scale map.

As no alluvium was mapped associated with creeks draining the Project footprint, bore logs, CSIRO mapping, plus site-specific auguring within the mine footprint were used to delineate the alluvium. The extent and depth of alluvium was extrapolated across the Project Footprint and included in the predictive groundwater modelling. This allowed for the potential impacts of longwall mining on groundwater resources associated with the alluvium across the Project to be determined.

The extrapolated alluvium is included in Figure 9-9.

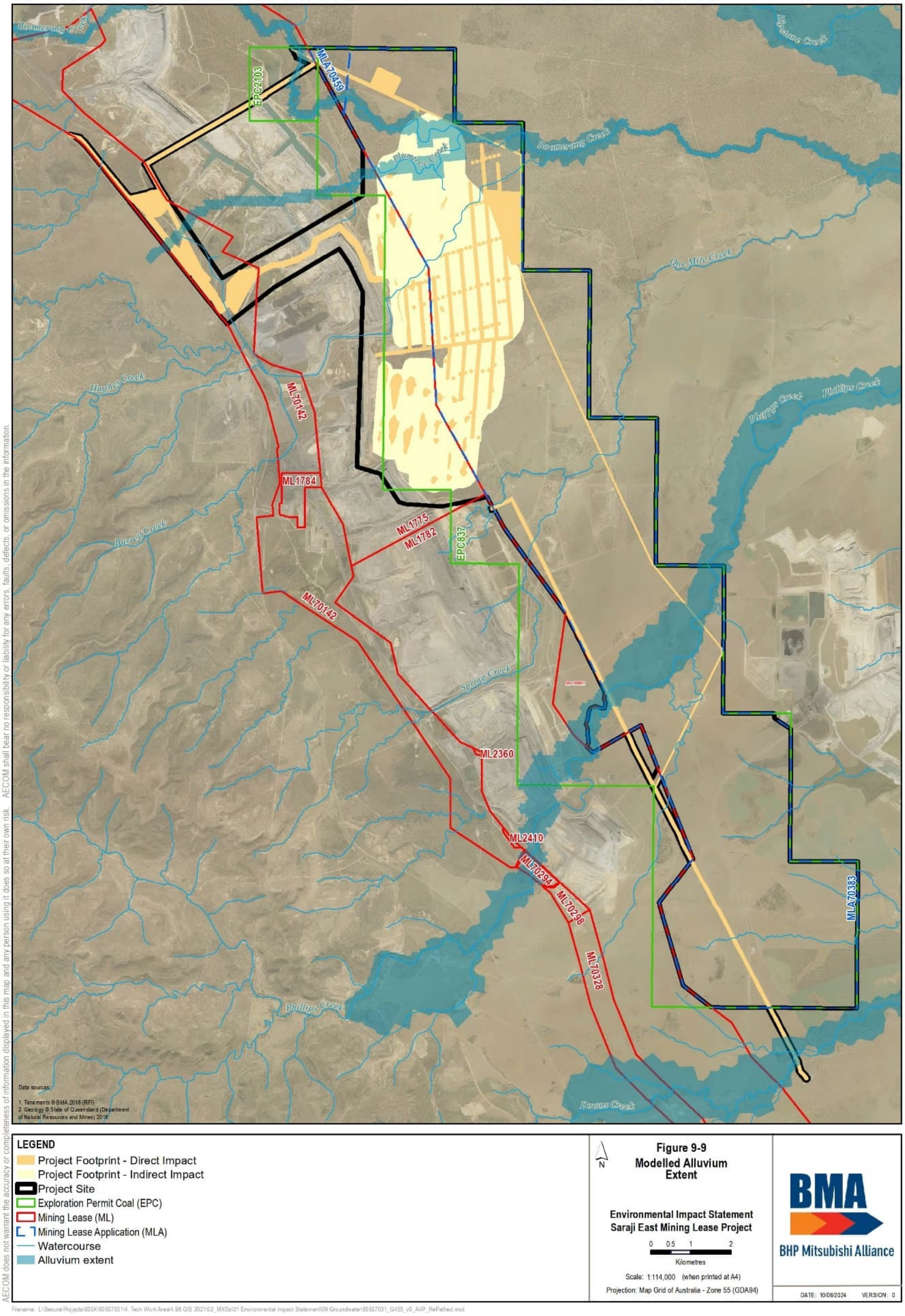

Figure 9-9 Modelled Alluvium Extent

9.4.2 Historic groundwater bore data points

Data assessed for the groundwater technical reporting included existing and historic groundwater bores at or adjacent to Saraji Mine, which comprised:

- two landholder bores
- ten single pipe monitoring bores
- seven monitoring locations comprising three nested groundwater piezometers (i.e. 21 monitoring points in total)
- eight vibrating wire piezometers (VWPs) located within three holes.

These bores provide detailed groundwater resource data for the Project. These monitoring bore and VWP locations are shown in Figure 9-10. These monitoring locations were drilled and constructed between 2011, 2012, and 2019, except landholder monitoring bores (MB31 and MB32). Construction details for each groundwater monitoring bore are provided in **Appendix F-3 Groundwater Resources Technical Report**.

The two landholder monitoring bores (MB31 and MB32) and single (stand) pipe monitoring bores (MB33, MB34, MB35, MB36, and MB37) are required to be monitored as part of the Saraji Mine EA conditions. Groundwater levels and water quality have been measured on a quarterly basis within all seven of these EA bores since July 2011. MB31 and MB32 also contain additional monitoring data dating back to 2008.

The monitoring records for the nested (individual standpipe bores constructed adjacent to one another, screened in different hydrostratigraphic units) groundwater monitoring bores and VWPs are variable reporting to be drilled dry or containing sporadic monitoring data (water levels and quality).

Available data for the Saraji Mine monitoring bores, compiled for DES, include data up until 2023 (Appendix A of **Appendix F-3 Groundwater Resources Technical Report**).

9.4.3 Registered groundwater bores

A search of the Department of Regional Development, Manufacturing and Water (DRDMW) Groundwater Database (GWDB) in May 2023 identified registered groundwater bores within and adjacent to the Project. The search identified 90 registered groundwater bores within and adjacent to the existing Saraji Mine. Of the 90 registered bores identified along strike and down dip of the underground mine footprint, 65 are related to mine monitoring with the remaining:

- seven described as being abandoned or destroyed (excluded from further assessment)
- eleven drilled dry
- six water supply bores
- one petroleum and gas well
- six are VWPs.

Potential impacts on these bores were assessed in Section 9.5.4.

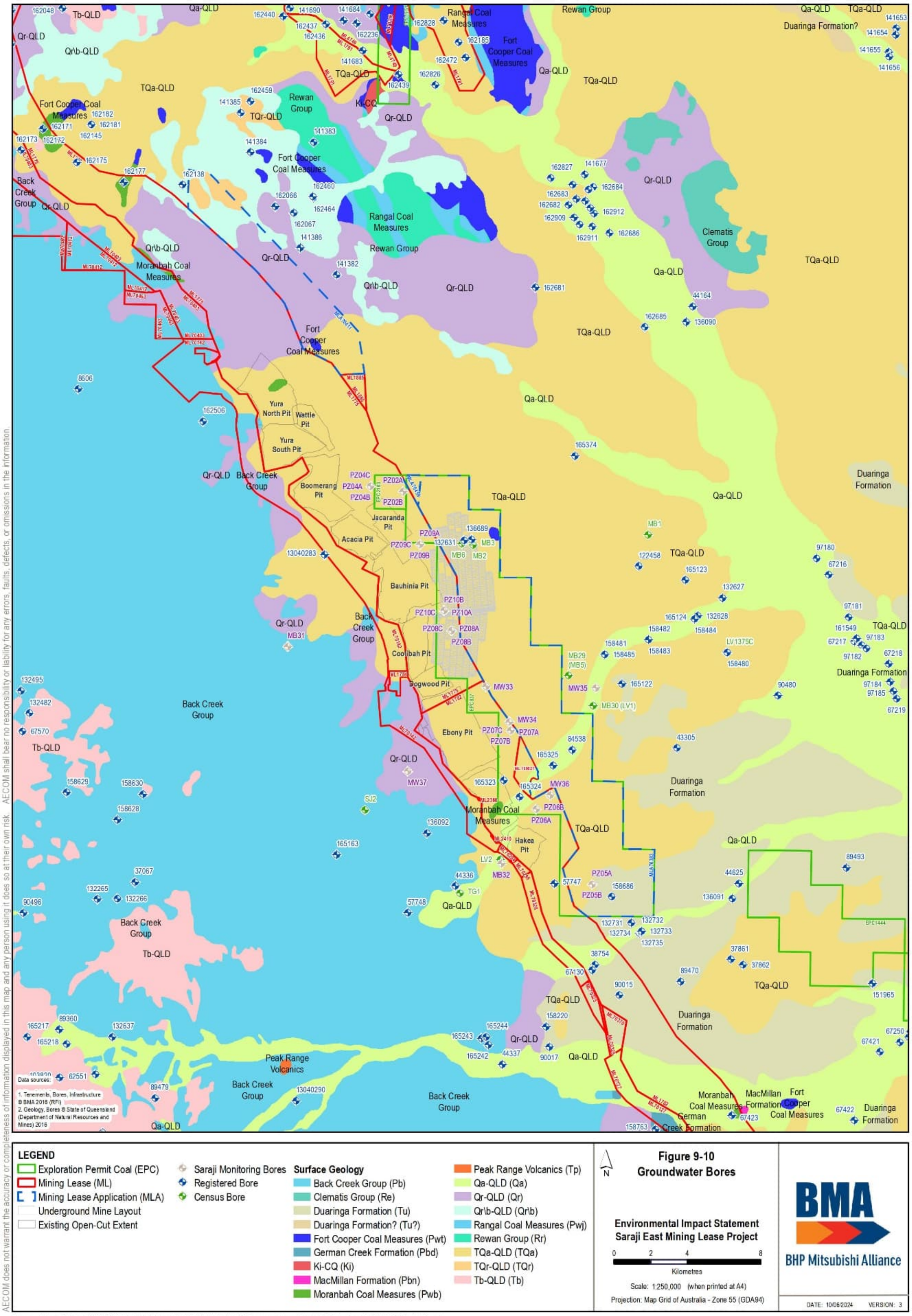

Figure 9-10 Groundwater bores

9.4.4 Bore census

A bore census was undertaken in 2007, which identified 12 unregistered landholder bores not listed on the GWDB at that time. Two of the identified landholder bores (MB31 and MB32) were subsequently monitored as part of the Saraji Mine monitoring program (Section 9.4.2).

9.4.5 Existing hydrogeological understanding

Within the Project Site, there are three aquifer systems acting as a groundwater bearing formation permeable to transmit and yield water in useable quantities, and one aquitard restricting flow of groundwater from one aquifer to another. These aquifers and aquitards are likely to be in hydraulic connection to the Project and are therefore sensitive to the Project's groundwater-affecting activities. The aquitards are formed by the Permian overburden and interburden (i.e. shale, mudstone, siltstone and sandstone). The three hydrostratigraphic units are associated with the following geological strata:

- Quaternary alluvium
- Tertiary sediments
- coal seams contained within the Permian coal measures.

Groundwater supply is not considered to be a major water source. Based on a review of available data, the beneficial use of groundwater in the Project Site is considered to be low due to available yields and poor groundwater quality. Figure 9-10 identifies existing bores within the Project Site.

These following sections detail the physical and chemical characteristics of these aquifers within the context of the prevailing regional hydrogeological regime.

Quaternary alluvium

Occurrence

Quaternary alluvium is not mapped within the footprint of the proposed underground mine (Figure 9-7). Quaternary alluvium occurs as historic channels associated with the present-day course of Phillips Creek. The alluvial aquifer is unconfined with a maximum thickness of 25 m adjacent to Phillips Creek. No alluvium is mapped on geological maps in association with Hughes Creek, which drains across the underground mining footprint. Alluvium extent derived from site-specific bore logs and auger holes, as discussed in Section 9.4.1.2, is included in Figure 9-9.

The Quaternary alluvium associated with Phillips Creek is considered to have limited groundwater potential for the following reasons:

- A review of DRDMW bores and site data indicates several bores have been drilled in close proximity to Phillips Creek and most of these bores did not intersect groundwater (i.e. the drilling results indicate limited or no sustainable groundwater resources associated with the alluvium).
- Phillips Creek is ephemeral and does not provide a permanent recharge source to the alluvium. As recognised in MB38 (MB19SRM01A), surface water – groundwater interaction along Phillips Creek is variable and not a continuous losing or gaining surface water system.

Hand augur bores and 2020 installed groundwater monitoring bores, as detailed in Section 5.2.3.1 of **Appendix F-3 Groundwater Resources Technical Report**, substantiate the limited alluvium along the non-perennial creeks (Boomerang Creek, Plumtree Creek, One Mile Creek, and the former Hughes Creek). These drilling results indicate:

- thin moist to dry alluvium within these creeks
- shallow bedrock below the non-perennial creeks
- limited effective storage in the river sand (i.e., dry due to drainage from the sand)
- the deepest alluvium within the Project footprint was 3.75 m deep.

The extent of the alluvium mapped for assessment in this groundwater study, based on the site data, is included in Figure 9-9.

Recharge, discharge and flow

The alluvial aquifers are strongly linked to surface water features with recharge primarily the result of high flow events. As Phillips Creek is ephemeral, recharge to the alluvium is likely to occur by the following mechanisms:

- discontinuous recharge from surface water flow or flooding
- infiltration of direct rainfall and overland flow where permeable river sand alluvium deposits are exposed, and no substantial clay barriers occur in the shallow sub-surface.

Available hydrological data suggests that water infiltrates/drains to the base of the alluvium relatively quickly after rainfall events where more permeable units occur at the surface. Based on the deep-water levels within the underlying Tertiary and Permian age sediments (some 20 metres below ground level (m bgL)) and the perched alluvium water level (6 to 10 m bgL) limited vertical hydraulic connection is identified (i.e. steep vertical gradient and > 10 m separation).

Based on site-specific data, it is conceptualised that the Quaternary alluvium will not contain permanent groundwater as recharge to the alluvium migrates downstream/downgradient within the creeks more readily than into the underlying bedrock and older sediments. Discharge from the alluvium is likely to include the following mechanisms:

- discharge to Phillips Creek during or after flow events as base flow. Limited effective storage (recognised due to the dry bores in the alluvium) results in the alluvium dewatering under gravity
- evapotranspiration from vegetation growing in the creek beds and along the banks
- minor stream loss and recharge to the underlying formations where the creeks intersect more permeable bedrock or sediments.

Groundwater flow is considered to mimic topography and is limited to the areas where the alluvium is present. It is also considered that discontinuous perched water may occur within the alluvium, which does not readily flow. This can occur in more porous sand surrounded by clay-rich sediments. This is considered to occur due to highly saline alluvium water being reported within the Project.

Hydraulic parameters

More extensive alluvium systems occur outside the Project Site, associated with ephemeral water courses such as the Isaac River (approximately 15 km to the east of the Project Footprint. Based on available information from the nearby Caval Ridge Mine, Quaternary alluvium deposits associated with creeks and main river tributaries could be expected to have a bulk hydraulic conductivity of approximately 0.1 m/day (URS, 2009).

For the alluvium intersected within the five alluvium monitoring bores installed at the Saraji Mine during 2020 (GHD, 2023), the following site-specific aquifer hydraulic information compiled during the bore development:

- Development on bore MB20SRM06A (MB20SRM06A_PZ) was not completed as BMA decided plug and abandon this bore and to redrill at this location at a later date.
- MB20SRM04A was developed using a bailer because of the low water volume within the bore and slow recharge. The estimated yield for this bore was 0.05 to 0.1 L/s (4 to 9 m^3/day).
- MB38 (MB19SRM01A) had an estimated yield of 0.0008 L/s (0.07 m^3/day).
  - This bore has recorded dry since installation, the estimated yield is based on aquifer testing within a similar unsaturated zone
- MB20SRM01A (MB20SRM01_PZ) and MB20SRM05A (MB20SRM05A_PZ) were dry and could not be developed.

These results indicate little or no groundwater yield capacity within the alluvium, when saturated.

Eleven (11) standpipes were installed at the Hughes Creek / Hughes Creek diversion at Saraji Mine (SRK, 2019). These bores interested a mix of heterogeneous fill, alluvium, and weathered zones; no marked groundwater potential was evident based on the yields.

Tertiary sediments

Occurrence

The Tertiary sediments maintain permanent groundwater resources particularly within the deeper sequences and the basal unit. The primary groundwater bearing strata of this unit is the basal sand/gravel unit, where it exists; however, it is recognised to be discontinuous.

Observations from the open cut pits at the existing Saraji Mine indicate groundwater discharges slowly from the Tertiary sediments and at the boundary (unconformable contact) between the Tertiary sediments and the underlying Permian strata. Based on these observations, the Tertiary sediments are considered to contain a series of poorly connected water-bearing horizons of low to moderate permeability, with drainage from the upper to lower horizons delayed by lower permeability horizons.

Groundwater ingress rates to the Saraji open cut pits are very low, resulting in damp pit walls. Evaporation rates are higher than the seepage such that this groundwater does not report directly or require management in the pits.

Groundwater is typically intersected near the base of the Tertiary sediments in the Project Site between 13 m and 35 m (Australasian Groundwater and Environmental Consultants (AGE), 2011). Based on bore logs reviewed, the sandy lenses and/or basal sand/gravel units are the primary storage for groundwater. The depth and occurrence of groundwater within the Tertiary sediments is considered variable and dependent on the extent and location of these porous, sandy layers within the sequence.

Groundwater levels within the Tertiary sediments from monitoring bores near the Project are reported to be at depths shallower than the recorded water strikes from drilling and installation. This indicates the aquifer is confined to semi-confined because of the clayey sediments in the upper Tertiary sequence.

A monitoring bore 2019 constructed adjacent to Phillips Creek for the Saraji Mine (MB40 (MB19SRM02T)) intersected clay and sandy clay below the alluvium. A zone of basal gravels and clay were intersected above bedrock sandstone. The Tertiary sediments were screened between 14 m and 20 m below ground level (above the sandstone), with water measured within the screen (unconfined) at 17.4 m below top of casting. This indicates that the Tertiary sediments are also unconfined in places.

Recharge, discharge and flow

Recharge to the Tertiary aquifers is considered to be the result of the following:

- direct infiltration of rainfall and/or surface water runoff where the sediments subcrop or outcrop at the surface
- leakage from overlying alluvium, where present.

Primary discharge mechanisms in the Tertiary aquifers are likely to include the following:

- through flow into underlying and/or adjacent aquifers such as the coal seams
- evapotranspiration
- groundwater extraction.

Direction of groundwater flow within the Tertiary aquifer is expected to reflect topography, from elevated areas in the west towards lower areas towards the east.

Hydraulic parameters

As the extent and nature of the Tertiary sediments are highly variable, the porosity and permeability of the aquifer is also likely to be highly variable. As a result, usable yields of groundwater are only expected to occur within the higher permeable sand and gravel lenses near the base of the sequence.

Results of rising head permeability tests (AGE, 2011) indicated a permeability range for the Tertiary aquifer between 1×10^{-2} m/day and 2×10^{-3} m/day (2 to 3 orders of magnitude lower than the alluvium). Site-specific aquifer hydraulic information compiled during the bore development included:

- development on bore MB20SRM02T resulted in an estimated yield of 0.001 to 0.016 L/s (0.09 to 1.4 m^3/day).

Permian sediments

Occurrence

Permian sediments in the Project Site include the FCCM and MCM. While the Permian sediments do not outcrop in the underground mining footprint, they subcrop under the Tertiary sediments. The extent of mapped Permian sediments (i.e. basement geology) is depicted in Figure 9-8.

As is the case throughout much of the Bowen Basin, the individual coal seams are typically regarded as the main water bearing units within the Permian coal measures. Groundwater movement and storage occurs within the coal seam cleats and fissures and within open fractures that intersect the seams. The coal seams are often the first unit where useable volumes of groundwater are encountered during drilling along the western edge of the Bowen Basin and therefore the coal seams may provide locally sufficient groundwater supplies where yields and quality are sufficient (typically for cattle stock watering or industrial purposes).

Other sediments in the coal overburden and interburden are relatively impermeable and generally form aquitards, except where fractured or faulted. It is recognised from the VWPs constructed in the FCCM the interburden units over and under the coal seams act as effective aquitards. These aquitards have very low vertical hydraulic conductivity resulting in marked differences in piezometric pressures between the different coal seams and interburden (i.e. a leaky aquitard would result in all bores having the same/similar piezometric levels).

Permian sediments may therefore be categorised into the following hydrogeological units:

- hydraulically ‘tight’ and hence very low yielding sandstone, siltstone, mudstone, carbonaceous shale and claystone that comprise most of the Permian overburden and interburden sediments
- low to moderately permeable coal seams which are the main water bearing strata within the Permian coal measures.

Recharge, discharge and flow

Groundwater monitoring bores constructed to intersect the Permian sediments have water levels which are higher in elevation than the horizon at which the water was first intersected, which indicates groundwater within the Permian sediments is confined. Groundwater recharge to the Permian sediments is likely to occur via the following mechanisms:

- direct infiltration from overland flow and rainfall in areas where the Permian sediments subcrop or outcrop at the surface
- downward seepage and/or through flow from adjacent or overlying Tertiary/Quaternary sediments in places where no substantial clay unit is present.

Discharge mechanisms of the Permian sediments are likely to include the following:

- through flow into adjacent coal seams or seepage into underlying aquifers (via structural discontinuities)
- downgradient Permian strata outcrop areas
- groundwater extraction from regional / local mine dewatering activities
- groundwater flow within the Permian deposits is expected to generally be down-dip.

The Permian sediments are relatively undisturbed and groundwater within the sediments is therefore unlikely to be influenced by faulting (i.e. mounding or lows in the groundwater flow patterns are not expected or identified, which can result from alteration of sediments due to fault throws).

Hydraulic parameters

Results of the permeability testing indicate the coal seam aquifers within the Project Site generally exhibit low to moderate hydraulic conductivity and that the deeper Dysart seam is slightly less permeable (less than one order of magnitude) than the overlying Harrow Creek seam. The hydraulic conductivity data, as determined during field tests, indicates a reducing hydraulic conductivity of the coal with depth.

Packer tests performed across Permian interburden yielded hydraulic conductivity values comparable to the coal seams which contrasts with the conceptual understanding that the Permian interburden is typically tight and less permeable than the coal seams. The higher hydraulic conductivity results for the packer tests across the Permian interburden suggest that the interburden material can be locally permeable but are not expected to be laterally continuous (AGE, 2011).

As part of the predictive model calibration (SLR, 2023), the Permian coal and interburden hydraulic parameters across several Bowen Basin mines and available Bowen Basin data were assessed to allow for the change in hydraulic parameters with depth to be recognised.

9.4.6 Groundwater levels and flows

Quaternary groundwater levels

Groundwater level data for Quaternary groundwater was limited due to the sporadic, discontinuous, and seasonal nature of the alluvium. For this unit depth-to-water measurement data includes:

- Seven bores (158484, 162681, 162685, 165323, 165324, 165325, 165326) with no water level data
- Twenty bores (MB38 (MB19SRM01A), MB20SRM01A (MB20SRM01_PZ), MB20SRM05A (MB20SRM05A_PZ), 165325, 165323, 165324, 165881, 165877, 165883, 165876, 165850, 165875, 165874, 165851, 165872, 158483, 158485, 162681, 182630, 190144) which were drilled dry
  - Monitoring bore MB38 (MB19SRM01A) has been monitored monthly since December 2019 and has been dry at all times (Gauge, 2021)
- Five bores (MB20SRM04A, MB20SRM06A (MB20SRM06A_PZ), 165833, 165873, 182402) with a single recorded water level measurement
  - The registered bores 165833, 165873, and 182402 has only one measurement on their bore cards
  - Monitoring bore MB20SRM04A was drilled dry and was measured once during development with a bailer
  - Monitoring bore MB20SRM06A (MB20SRM06A_PZ) was measured once before this bore could not be successfully completed as a monitoring bore (collapsed / lost bore, which will be replaced in the future).
- one bore with transient water level data (MB32).

Bore MB32 is a historic stock watering bore identified during a bore census. This bore is located upstream of the Saraji Mine on Phillips Creek. The available groundwater level data for MB32 shows fluctuations over an approximately 6 m range. Groundwater levels within MB32 readily correlate with the cumulative rainfall deviation (CRD) due to rainfall leading to surface water flow and recharge from Phillips Creek.

It is noted that the alluvium monitoring bore reflects the wet and dry climate conditions and thus does not include a Saraji Mine EA Condition related to water level fluctuation. Background monitoring bore MB32 does not have an associated water level fluctuation EA condition as the water level change in MB32 relates to surface water in Phillips Creek and not solely groundwater related.

Water level measurements compiled for MB32 (since the EIS) indicate no marked fluctuation (due to reduced rainfall and creek flow). Groundwater monitoring data (depth-to-water measurements) review (Gauge, 2021) indicated that groundwater levels have gradually declined since 2017 in reference bore MB32. The decline trend (using depth-to-water data) is not readily identifiable when groundwater data is converted to meters Australian Height Datum (m AHD).

The CRD data indicates decreased monthly rainfall between 2019 and 2021. The reduced rainfall resulted in reduced flow within Phillips Creek during this period. The water level data indicates the groundwater stored within the alluvium, at MB32, does not readily discharge to the creek (i.e., minimal baseflow component from groundwater in the Phillips Creek at MB32).

Available groundwater level data for the alluvium bores identified in **Appendix F-3 Groundwater Resources Technical Report** was compiled to identify current groundwater flow pattern(s) within the alluvium. Based on the large number of dry bores, discontinuous nature, and the separate alluvium deposits (within and immediately adjacent several creeks), no accurate groundwater flow patterns could be derived. Groundwater flow is envisaged to mimic topography and drain downstream when saturated.

Tertiary groundwater levels

BMA drilled several bores into the Tertiary sediments as part of their groundwater monitoring program. Bores PZ02A, PZ04A, and PZ07A were constructed as standpipe monitoring bores within the Tertiary sediments. PZ09A and PZ10A were also drilled to intersect Tertiary sediments but both were drilled dry. PZ07A was contaminated with bentonite and not used for monitoring.

Groundwater level measurements compiled during 2011 and 2012 indicate variable groundwater levels across the Project Site. Tertiary monitoring bores generally became dry during the monitoring period as a result of sampling, indicating limited sustainable yields. Tertiary groundwater levels measured in PZ02A and PZ04A indicate groundwater levels are generally greater than 20 m below ground level.

<u>Recent measurements</u>

Groundwater level monitoring occurs within MB40 (MB19SRM02T), a monitoring bore intersecting the Tertiary gravel, clay, and silt. This monitoring bore is 21 m deep and located on Phillips Creek. The groundwater level measurements, over the long term, have been relatively stable, with ~ 1 m fluctuation. There are no marked response to recharge or discharge. MB40 (MB19SRM02T) is compliant with the water level trigger set at >2 m fluctuation in the Saraji Mine EA Conditions.

<u>Tertiary groundwater flow pattern</u>

Available groundwater level data for all the Tertiary bores was compiled to evaluate current groundwater flow patterns within the Tertiary age sediments. The Tertiary groundwater level data and the spatial location of bores in the Tertiary are shown on Figure 9-11, this figure also presents the resultant groundwater flow pattern within the Tertiary.

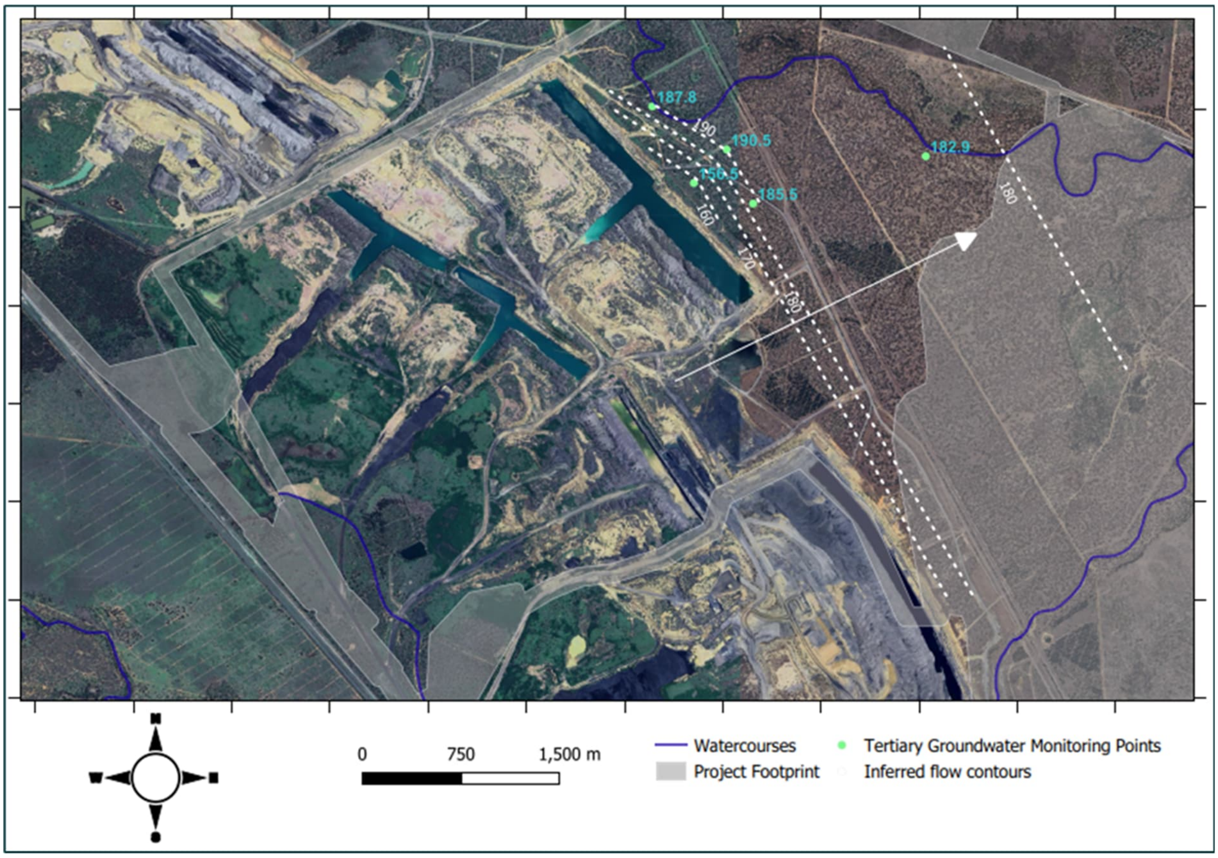

Figure 9-11 Tertiary groundwater flow patterns

Groundwater levels are recognised to be elevated in the north due to possible artificial recharge from existing mine waste and water storage infrastructure. Groundwater flow is recognised to mimic surface water flow from west to east across the Project Site. Flow back towards the west is, based on limited data (i.e., from RN19924), which is located adjacent to the Saraji Mine open-cut pits (i.e., the lowest groundwater elevation, 156.5 mAHD, influences the contouring).

Note: Monitoring at PZ02A and PZ04A discontinued in 2012, when the groundwater monitoring bore network was revised to reflect the groundwater monitoring conditions included in the Saraji Mine approval conditions.

Permian groundwater levels

Groundwater monitoring bores and vibrating wire piezometers (VWPs) have been constructed within the Harrow Creek (H16) and Dysart (D14 / D24) coal seam. These bores include:

- Harrow Creek – PZ02B, PZ04B, PZ05A, PZ06B, PZ07C, PZ08B, PZ09B, and PZ10B
- Dysart – PZ02C, PZ04C, PZ05B, PZ06C, PZ07B, PZ08C, PZ09C, and PZ10C.

Groundwater levels measured in the monitoring bores range from 27 m bgL (PZ02B) to 64.5 m bgL (PZ07C) for the Harrow Creek H16 seam and from 20.8 m bgL (PZ06C) to 65.2 m bgL (PZ09C) for the Dysart Lower (D14 / D24) seam.

The potentiometric surface (groundwater elevation) of the Permian sequences indicates a gradient from around 185 mAHD in the north-west to around 170 mAHD in the south-east across the Project Site. This is similar to the regional groundwater contours generated for the Permian coal seams across the entire Bowen Basin. The regional groundwater flow pattern across the Project Site indicates flow from north-west to south-east. There is a groundwater low indicated on the regional groundwater flow pattern in this area. It is considered that this low could be a result of abstraction or faulting.

Permian groundwater levels indicate no marked seasonal fluctuation (response to dry and wet seasons) and no large scale influence of mine dewatering (even though the mining at the existing Saraji Mine has been operating since 1974).

Transient groundwater level data for the Permian groundwater monitoring bores is included in Figure 9-12.

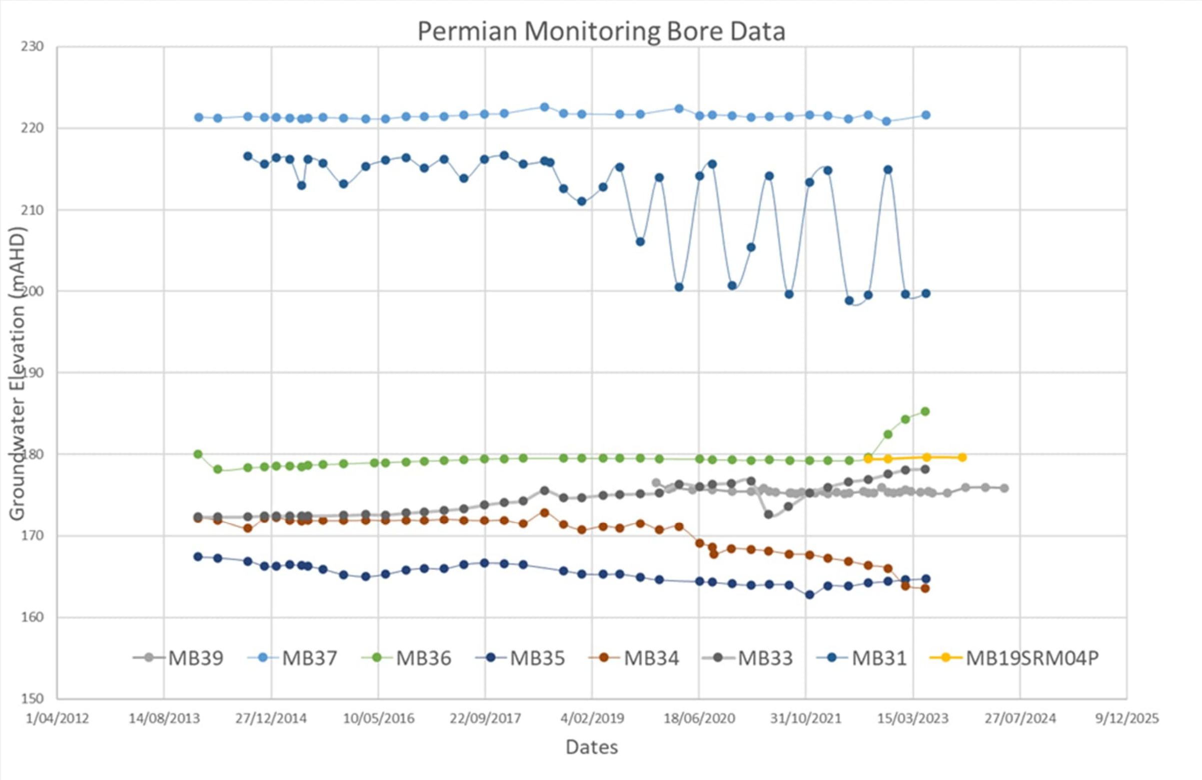

Figure 9-12 Permian monitoring bore water level hydrographs

The Saraji Mine EA condition water level trigger for these bores is “fluctuations in excess of 2 m from background”. Considering the water level triggers for Permian monitoring bores at Saraji Mine, which include MB33, MB34, MB35, MB36, and MB39 (MB19SRM03P), the following is observed:

- MB33 indicates a long-term increase in groundwater level of ~ 6 m from 2014 to 2023 in the Permian over burden away from the mining activities.
- MB34 in the Permian interburden away from the mining activities, indicates a 9 m decrease in groundwater level between 2014 and 2023, where the rate of decline increased from mid-2019.
  - Based on faults mapped at MB34 is in proximity to the main fault mapped across the Project Footprint. Based on the location of the bore and the fault, the fault is considered to possibly facilitate discrete increased mine dewatering impacts. This is based on consideration of the limited drawdown in the Permian overburden adjacent to the Saraji Mine open cut workings elsewhere at the Project.
- This bore may be influenced by faulting, such that the fault facilitates discrete increased mine dewatering impacts.
- MB35, located in the Permian overburden underlying Phillips Creek alluvium, is relatively stable over time with the hydrograph indicating a muted response to wet and dry conditions over time
- MB36 indicates more recent increased groundwater recharge, with groundwater levels rising from background (178 mAHD) to 185 mAHD between 2022 and 2023. This monitoring bore, like MB33, is in the Permian over burden away from the mining activities.
- MB39 (MB19SRM03P), located in the Permian coal seam S01, is relatively stable over time.

The transient groundwater level data does not readily indicate the direct or indirect impact of mining on these bores, rather the data indicates complex water level fluctuation related to wet and dry climate conditions and mining activities. The adopting of a simple 2 m fluctuation, as per the Saraji Mine EA conditions, in conditions for the Project is not considered suitable, based on these water level data trends, for the Project. Section 9.7 requires water level triggers to include consideration of the groundwater model predictions (rate and extent of drawdown).

Permian groundwater flow pattern

A composite groundwater level contour plan was generated from local groundwater level data at Saraji Mine and Lake Vermont Mine (GHD, 2020). This composite data (compiled from monitoring bores within different Permian age sediments) indicates a general groundwater flow southwest to northeast across the area. This flow direction does not readily indicate the influence of the mining but is consistent with the surface water drainage flow direction.

Vertical gradients

Groundwater levels measured in the nested bores PZ02, PZ04, PZ07, PZ09, PZ10 and VWPs PZ05, PZ06, and PZ08 were assessed to determine vertical groundwater gradients across the Project Site.

Overall, the 2011 nest piezometer groundwater level data shows that there are distinct differences in groundwater levels between the Tertiary sediments and Permian sediments, and between the Permian interburden/overburden sediments and Permian coal seams. The vertical hydraulic gradients were recognised to be predominantly downwards.

The latest groundwater monitoring data assessment report (Gauge 2021) provides groundwater level data for the nested monitoring bores, MB38 (MB19SRM01A) (alluvium), MB40 (MB19SRM02T) (Tertiary), and MB39 (MB19SRM03P) (MCM coal) indicating varying vertical gradient (direction and separation) over time within the Tertiary and Permian sediments. The alluvium is always dry. Comparing the available groundwater elevation data, the vertical groundwater gradient is mainly upward from the MCM coal (MB39) to the Tertiary sediments (MB40 (MB19SRM02T)).

Dewatering from existing mining

Those monitoring bores with several years of monitoring data (MB31 to MB37) do not readily indicate declining trends in groundwater levels as a result of mining, despite some bores being located within close vicinity (and down dip) to existing open cut pits (MB32 is located approximately 600 m from existing pits whilst MB33 is located some 1,500 m away and indicates a water level increase over time).

The lack of uniform, large extent groundwater level decline within the long-term groundwater monitoring bores suggests these bores have not been impacted by mine dewatering (i.e. induced flow is not evident).

Given that Saraji Mine has been operating since 1974, the absence of a downwards water level trend indicates that the zone of influence has not yet extended to those bores and is considered restricted to the immediate vicinity of the pits due to the low permeability of the sediments. It is considered the long term mine activities have not markedly impacted on the regional groundwater resources.

9.4.7 Groundwater quality

Quaternary deposits

Groundwater quality of alluvial sediments associated with creeks and river systems within the Isaac-Connors sub-catchment are moderately to highly variable, ranging from fresh to very saline (URS, 2012).

The groundwater monitoring bores across the area reported to be screened through the alluvium are dry, except for bore MB32. Available water quality data for MB32 compiled by Gauge (2016) shows groundwater associated with the alluvium is generally brackish and bicarbonate dominant. Elevated major ions were reported during 2015/16, however major ion concentrations have since reported below the Fitzroy River groundwater zone 34 (the closest groundwater zone to the Project) scheduled groundwater WQOs. The concentration of total dissolved solids (TDS) indicates the water is not suitable for drinking but can be used for livestock watering.

Groundwater quality from the new alluvium monitoring bore, MB20SRM04A, were compared to the Zone 34 WQOs. These data indicate exceedances including Total Iron, which is not readily representative of groundwater (dissolved iron concentrations are at or below limit of reporting).

These alluvium data, MB20SRM04A compared to MB32, indicates marked variation due to the disconnected nature and differing recharge mechanisms across the alluvium (groundwater unit). The discontinuous (spatially and saturated) nature of the alluvium and where groundwater is intersected it is in isolated “pockets’ of water which are not readily recharged or discharged from the alluvium, leading to long residence times and thus high salinity (MB20SRM04A). The surface water recharge to MB32 facilitates lower salinity.

Tertiary sediments

Tertiary groundwater quality was determined from historic Saraji Mine monitoring bores PZ02A and PZ04A. The Tertiary groundwater ranges from slightly acidic to slightly alkaline and is dominated by sodium and chloride with TDS exceeding 6,000 milligrams per litre (mg/L). This means the water is brackish to saline and exceeds the livestock guideline level for cattle. A relatively high sulphate level was recorded in PZ02A; however, this was still within the range for livestock.

Metal concentrations for all parameters analysed were either below the laboratory detection limit or below relevant guideline levels.

Total petroleum hydrocarbon concentrations were below the laboratory detection limits in PZ02A but reported detectable levels between 140 micrograms per litre (µg/L) and 890 µg/L for the C_{10}–C_{36} fractions analysed. It is possible that the source for these hydrocarbon fractions might be oil-based lubricant used whilst drilling the borehole and not hydrocarbon contamination from within the aquifer. Interference from naturally occurring organic matter is also a potential source of the hydrocarbons detected in the water samples. Aromatic (BTEX) hydrocarbons were all below the laboratory detection limits in both monitoring bores. Additional sampling events reported the historic Tertiary monitoring bores contain insufficient groundwater to collect additional samples.

Samples taken from monitoring bore MB40 (MB19SRM02T) provide a contemporary understanding of Tertiary sediments. Monitoring bore MB40 (MB19SRM02T) intersects the Tertiary gravel, clay, and silt, adjacent to Phillips Creek. The major ion data for 2020 and 2021 shows the groundwater is sodium bicarbonate dominant and indicates a mixed consistent water type within MB40 (MB19SRM02T). The groundwater in the Philips Creek Tertiary age deposits show high bicarbonate concentrations (678 to 1,010 mg/L at MB40) with EC ranging from 1,980 to 2,480 µS/cm at MB40 (MB19SRM02T), supporting the primary aquifer recharge mechanism of infiltration of precipitation and of surface water flows.

Groundwater quality data for Tertiary monitoring bore MB40 (MB19SRM02T), when compared to the EA condition groundwater contaminant trigger levels, indicates that the monthly groundwater quality data for 2020 complies with the trigger values derived in the EA. The 2020 MB40 (MB19SRM02T) water quality exceeds the deeper Fitzroy Basin Groundwater Zone 34 WQOs as the water quality in MB40 (MB19SRM02T) has elevated bicarbonate compared to the guidelines.

Groundwater quality compiled for MB40 (MB19SRM02T) and a single sample from MB20SRM02T, indicate that the Tertiary groundwater in comparison to the Fitzroy Zone 34 guidelines contains naturally elevated bicarbonate and total iron concentrations. It is noted that dissolved iron concentrations are all below the laboratory limit-of-reporting (LOR) at 25 µg/L.

This water quality within the Project Footprint, is considered baseline quality of the Tertiary prior to any mining at the proposed Project.

Permian hydrostratigraphic units

Representative samples of the Permian coal seam aquifers were collected from historic groundwater bores PZ02B, PZ04B, and PZ09B for the Harrow Creek Upper (H16) Coal Seam and from PZ04C, PZ09C, and PZ10C for the Dysart Lower Coal Seam.

The analyses indicated the Permian coal seam groundwater range from slightly acidic to alkaline and is dominated by sodium and chloride with TDS levels ranging from 3,300-20,000 mg/L. The coal seam water is brackish to saline and typically not suitable for stock watering. Metal concentrations for parameters analysed were either below the laboratory detection limit or below the relevant guideline level. Total petroleum hydrocarbon concentrations were mostly below the laboratory detection limits but reported detectable levels between 25-1,100 µg/L for C_6–C_{35} 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 2-4 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.

Groundwater monitoring undertaken by GHD in 2021 characterised groundwater in the Permian strata by sodium-chloride major ion chemistry. However, close to Phillips Creek the groundwater has a sodium-bicarbonate chemistry (MB35) and lower TDS. This supports the concept that the Permian bedrock is also recharged from the overlying strata, particularly along creek lines.

The groundwater is brackish to saline, which is indicative of longer residence times of the groundwater and overall lower hydraulic conductivity in comparison to the overlying alluvial deposits. The Moranbah Coal Measures (MB33 and MB34) is characterised by the highest EC values, ranging between 16,000-31,000 µS/cm, and is considered to be of poor quality and unsuitable for stock (AGE 2007).

Up gradient to the west, the EC of the Back Creek Group is lower, and ranges from 2,500-14,800 µS/cm (MB31 and MB37), which reflects the proximity of the unit to outcropping strata and recharge areas to the west.

Down-gradient to the east, the EC of the Fair Hill Formation ranges from 2,500-16,000 µS/cm (MB36) away from the influences of the recharge area along Phillips Creek. Near Phillips Creek, the infiltration of surface water through the overlying Quaternary and Tertiary/Quaternary deposits results in a zone of comparatively fresher groundwater within the Permian strata, in the order of 1,000-2,000 µS/cm (MB35).

<u>Saraji EA monitoring bores</u>

Seven monitoring bores (MB31 to MB37) form part of the existing Saraji Mine groundwater monitoring network. All of these bores, except MB32 (alluvium), provide ongoing hydrochemistry data for the Permian interburden/overburden strata across and adjacent to the Saraji Mine. Available hydrochemical data for these Permian bores was compiled by Gauge (2021) and assessed by GHD (2021) indicated the following:

- Bores MB33 and MB34 had the highest salinities, with electrical conductivity (EC) of 23,000-35,000 µs/cm associated with deeper Permian interburden (indicating increased salinity with depth due to slow movement and interaction with Permian sediments).
- Groundwater quality parameters monitored include pH, EC, TDS, calcium (Ca), magnesium (Mg), sodium (Na), potassium (K), carbonate (CO_3), Bicarbonate (HCO_3), chloride (Cl), sulphate (SO_4), reactive phosphorus (P), nitrate (NO_3), aluminium (Al), iron (Fe), arsenic (As), mercury (Hg), antimony (Sb), and petroleum hydrocarbons.
- Bores MB33 and MB34 have the highest salinities, with an EC range of 17,400-31,000 µS/cm associated with deeper Permian interburden indicating increased salinity with depth due to slow movement and interaction with Permian sediments.
- The lowest salinities occurred within the Phillips Creek bores MB32 (alluvium) and MB35 (Fairhill Formation directly below alluvium) with EC concentrations less than 2,500 µs/cm. The salinity values in MB35 suggest this bore is likely to receive recharge from the overlying alluvium.
- All bores had TDS concentrations greater than 500 mg/L which exceeds the drinking water guideline.
- Sulphate concentrations in MB31, MB33, and MB37 were greater than the cattle stock watering guideline (1,000 mg/L).
- total metals in groundwater samples were less than the Australia and New Zealand Environment and Conservation Council (ANZECC) stock water guidelines.
- Concentrations of nitrate were all below guideline values.
- Orthophosphate (reactive phosphate) concentrations were highest in MB31, a bore located within farming land up gradient of Saraji Mine.
- Low levels of hydrocarbons were still being measured in MB34 considered to have been contaminated during construction.

These ongoing groundwater monitoring results are comparable with the initial baseline data and indicate little or no measurable impact due to current mine operations.

Baseline Permian water quality prior to the Project

Available groundwater quality for Permian bore with EA condition groundwater contaminant trigger levels were compiled and compared to the relevant bore trigger levels, allowing for the establishment of baseline groundwater quality prior to mining at the Project. Groundwater quality data for MB33 from 2013 to 2022 indicates, as with the Tertiary groundwater data, the groundwater compiles with the trigger levels.

Groundwater quality data for MB34, MB35, MB36, and MB39 (MB19SRM03P) indicates the groundwater includes outliers (possible erroneous concentrations or naturally occurring concentrations outside the adopted percentile for the water quality triggers) but no increasing trends (i.e. no indication of deterioration of water chemistry over time).

9.4.8 Stock watering suitability

The groundwater quality data across the site is variable and ranges from brackish to saline. Although the groundwater is generally within the guidelines for livestock, Section 4.3.3.5 of the ANZECC Guidelines (2000) states a loss of production and a decline in animal health occurs if stock are exposed to high TDS and saline water for prolonged periods. For beef cattle, this TDS limit is in range of 5,000 mg/L to 10,000 mg/L. Given TDS for the Tertiary and Permian sediments are generally above 5,000 mg/L, the regional groundwater is generally not be considered suitable for prolonged livestock supply.

9.4.9 Trigger levels

Available water quality data across and adjacent to Saraji Mine was compiled as per the DES request to allow for the evaluation of data and aid in the compilation of proposed trigger levels for the Project. The data from the Saraji Mine monitoring bores, used to describe baseline groundwater conditions, have trigger levels, which have been included in the Saraji Mine EA conditions (EPML00862313, dated 10 March 2022). These monitoring bores and trigger levels included in Table 9-2 will be used for the Project.

Table 9-2 Groundwater contaminant trigger levels (Table I2)

<table>
<tr><th>Quality characteristic</th><th>Unit</th><th>MB31, MB32, MB37</th><th>MB33</th><th>MB34</th><th>MB35</th><th>MB36</th><th>MB39</th><th>MB40</th></tr>
<tr><td>Water level</td><td>RL</td><td rowspan="13">Monitored for interpretative reasons only – no triggers apply</td><td colspan="6">Fluctuations in excess of 2 m from background excluding changes from pumping of licenced bores</td></tr>
<tr><td>pH Value</td><td>pH units</td><td colspan="6">6.5 – 8.5</td></tr>
<tr><td>Electrical Conductivity</td><td>µS/cm</td><td>25,170</td><td>29,720</td><td>16,000</td><td>16,000</td><td>16,000</td><td>8,910</td></tr>
<tr><td>Sulphate</td><td>mg/L SO_4</td><td>2,580</td><td>398</td><td>398</td><td>477</td><td>398</td><td>318</td></tr>
<tr><td>Iron</td><td>mg/L Fe</td><td>1.6</td><td>0.7</td><td>1.7</td><td>2.6</td><td>0.7</td><td>0.7</td></tr>
<tr><td>Aluminium</td><td>mg/L Al</td><td colspan="6">0.055</td></tr>
<tr><td>Arsenic</td><td>mg/L As</td><td colspan="6">0.013</td></tr>
<tr><td>Mercury</td><td>mg/L Hg</td><td colspan="6">0.0006</td></tr>
<tr><td>Antimony</td><td>mg/L Sb</td><td colspan="6">0.009</td></tr>
<tr><td>Molybdenum</td><td>mg/L Mo</td><td colspan="6">0.034</td></tr>
<tr><td>Selenium</td><td>mg/L Se</td><td>0.020</td><td>0.020</td><td>0.011</td><td>0.011</td><td>0.011</td><td>0.011</td></tr>
<tr><td>Silver</td><td>mg/L Ag</td><td>0.0014</td><td>0.0013</td><td>0.001</td><td>0.001</td><td>0.0012</td><td>0.001</td></tr>
<tr><td>Total petroleum</td><td>µg/L</td><td colspan="6">20</td></tr>
</table>

Quality characteristic	Unit	MB31, MB32, MB37	MB33	MB34	MB35	MB36	MB39	MB40
hydrocarbons (TPH) C6-C10								
TPH C10-C40	µg/L		100					

The development of the groundwater contaminant trigger levels for the Saraji Mine is included in the Saraji Mine - Groundwater Contaminant Trigger Levels Report (GHD, 2021).

9.4.9.1 Triggers for new monitoring bores

The additional new monitoring wells, included in Figure 9-10 for Saraji Mine catchment scale monitoring, will be included in the Project monitoring bore network.

Broadly, the methodology adopted for determination of proposed trigger levels for the additional new monitoring bores included:

- Available water quality data was compiled (as included in **Appendix F-3 Groundwater Resources Technical Report**).
- The water quality data were reviewed for outliers and screened to remove bias from the dataset.
- Statistics were calculated for use in the derivation of contaminant trigger values for each of the new monitoring wells to be included in the Project groundwater monitoring. These include:
  - MB20SRM02T, MB20SRM03P, and MB20SRM04A
  - note: MB38 (MB19SRM01A), MB20SRM01A (MB20SRM01_PZ), and MB20SRM05A (MB20SRM05A_PZ) were dry.
- Environmental values were reviewed and WQOs were selected for each hydrostratigraphic unit based on protecting the most sensitive EV applicable to each hydrostratigraphic unit (alluvium, Tertiary, and Permian age sediments).
- Contaminant trigger values were derived for each new monitoring bore and compliance parameters were based on review of the monitoring data and review of data trends using the DES (2021) monitoring data assessment methodologies.

9.4.9.2 Water quality objectives

As described in detail in **Appendix F-3 Groundwater Resources Technical Report**, interim water quality trigger levels for the new monitoring bores considered the following WQOs and guidelines:

- Environmental Protection (Water) Policy 2009 (EPP (Water) 2009) Isaac River Sub-basin Environmental Values and Water Quality Objectives Basin No. 130 (part), including all waters of the Isaac River Sub-basin (including Connors River) September 2011.
  - WQOs for Fitzroy Basin groundwaters according to the chemistry zone 34 (refer plan WQ 1310) and depth category.
- ANZG (2018) freshwater (FW) guidelines at the 95 per cent level of protection, where no regional WQO was defined
- ANZG (2018) unknown level of species protection, where there is no guideline for the 95% level of protection
- in the absence of a published guideline for iron at the 95 per cent species protection level, the draft ANZG (2018) guideline for 95 per cent species protection of 0.7 mg/L has been adopted as the WQO for dissolved iron, as the Saraji Mine trigger study (GHD, 2021).

Alluvium

Groundwater chemistry data for the new alluvium monitoring bore proposed to be included in the Project groundwater monitoring bore network, MB20SRM04A, have been compiled and compared to the Isaac River Sub-basin Environmental Values and Water Quality Objectives Table 14 (shallow) Zone

34. Only one groundwater sample result is available and as such no proposed trigger levels can yet be proposed for this monitoring bore. Once sufficient groundwater quality data is available (a minimum of 12 sample events) triggers will be developed for MB20SRM04A.

Tertiary

Groundwater chemistry data for new monitoring bore MB20SRM02T, has been compiled and compared to the Isaac River Sub-basin Environmental Values and Water Quality Objectives Table 14 (deep) Zone 34. Only one groundwater sample result is available and as such no proposed trigger levels can yet be proposed for this monitoring bore. Once sufficient groundwater quality data is available (a minimum of 12 sample events) triggers will be developed for MB20SRM02T.

Permian

Groundwater chemistry data for new monitoring bore MB20SRM03P was compiled and compared to the Isaac River Sub-basin Environmental Values and Water Quality Objectives Table 14 (deep) Zone 34. Only one groundwater sample result is available and as such no proposed trigger levels can yet be proposed for this monitoring bore. Once sufficient groundwater quality data is available (a minimum of 12 sample events) triggers will be developed for MB20SRM02P.

<u>Interim triggers</u>

It is considered that the water quality triggers developed for Saraji Mine will be adopted in the interim, until sufficient data is available for the new Project monitoring bores.

9.4.10 Groundwater dependent ecosystems

9.4.10.1 Definitions

Groundwater dependent ecosystems (GDEs) are defined as ecosystems accessing groundwater on a permanent or intermittent basis to meet all or some of their water requirements to maintain their communities of plants and animals, ecological processes, and ecosystem services (Richardson et al, 2011). GDEs can be grouped into three categories in Queensland based on the type of groundwater reliance:

- aquatic GDE
- terrestrial GDE
- subterranean GDE.

Aquatic GDEs are dependent on the surface expression of groundwater (springs) and rely on groundwater after it has been discharged to the surface i.e. spring fed streams, rivers, and wetland systems.

Terrestrial GDEs are dependent on the presence of subsurface groundwater to meet all or some of its water requirements i.e. terrestrial vegetation with typically deep-rooted trees.

Subterranean GDEs occur within caves and aquifers. Cave GDEs occur in caves which have some degree of groundwater connectivity. Aquifer GDEs typically occur within the intergranular void space, rock fractures and solution cavities. Aquatic animals that live in groundwater are referred to as stygofauna.

9.4.10.2 Mapped groundwater dependent ecosystems

The National Atlas of groundwater dependent ecosystems (GDE Atlas) was consulted to identify whether GDEs have been mapped within the area. GDE Atlas comprises maps that show the location of both known and potential GDEs across Australia, as well as ecological and hydrogeological information for each GDE. The database containing the GDE mapping is hosted by BoM and accessible through the BoM website (http:\\www.bom.gov.au).

Where no known aquatic or terrestrial GDEs were mapped within the GDE Atlas, the potential for aquatic or terrestrial GDEs were further assessed by using the Stage 1 assessment approach recommended within the Australian groundwater-dependent ecosystem toolbox part 1: assessment framework (GDE Toolbox) (Richardson et al, 2011). The GDE Toolbox Stage 1 assessment relies heavily on the methodology outlined by Eamus et al (2006) for identifying aquatic and terrestrial GDEs. Eamus et al (2006) pose a series of questions to help determine the likelihood of whether an ecosystem is potentially dependent on groundwater. They suggest that an affirmative answer to one or more of these questions means there is potentially a GDE present. The questions are reproduced in Table 22 and Table 23. Where no known subterranean GDEs were mapped within the GDE Atlas; the potential for subterranean GDEs was assessed from a literature review and site specific sampling results.

The BOM GDE mapping layer has been compiled with national scale datasets and rules to describe the potential for groundwater interaction, and within the assessment area corresponds directly with GDE and potential aquifer mapping produced by DES (2020). The mapping of GDEs over the Project Site and surrounds, as produced by BOM (2020b) in Figure 9-13 shows:

- **aquatic**: No springs mapped within proximity to the Project Footprint; however, Phillips Creek (south of the Project Footprint) is mapped as a ‘High Potential’ Aquatic GDE, Boomerang Creek is mapped as ‘Moderate Potential’ Aquatic GDE and the Boomerang Creek floodplain wetland is also mapped as a ‘Moderate Potential’ Aquatic GDE
- **terrestrial**: ‘Low Potential’ for Terrestrial GDE associated with elevated residual plains, and ‘High Potential’ and ‘Moderate Potential’ for Terrestrial GDE associated with floodplain alluvium
- **subterranean**: No mapped subterranean GDE.

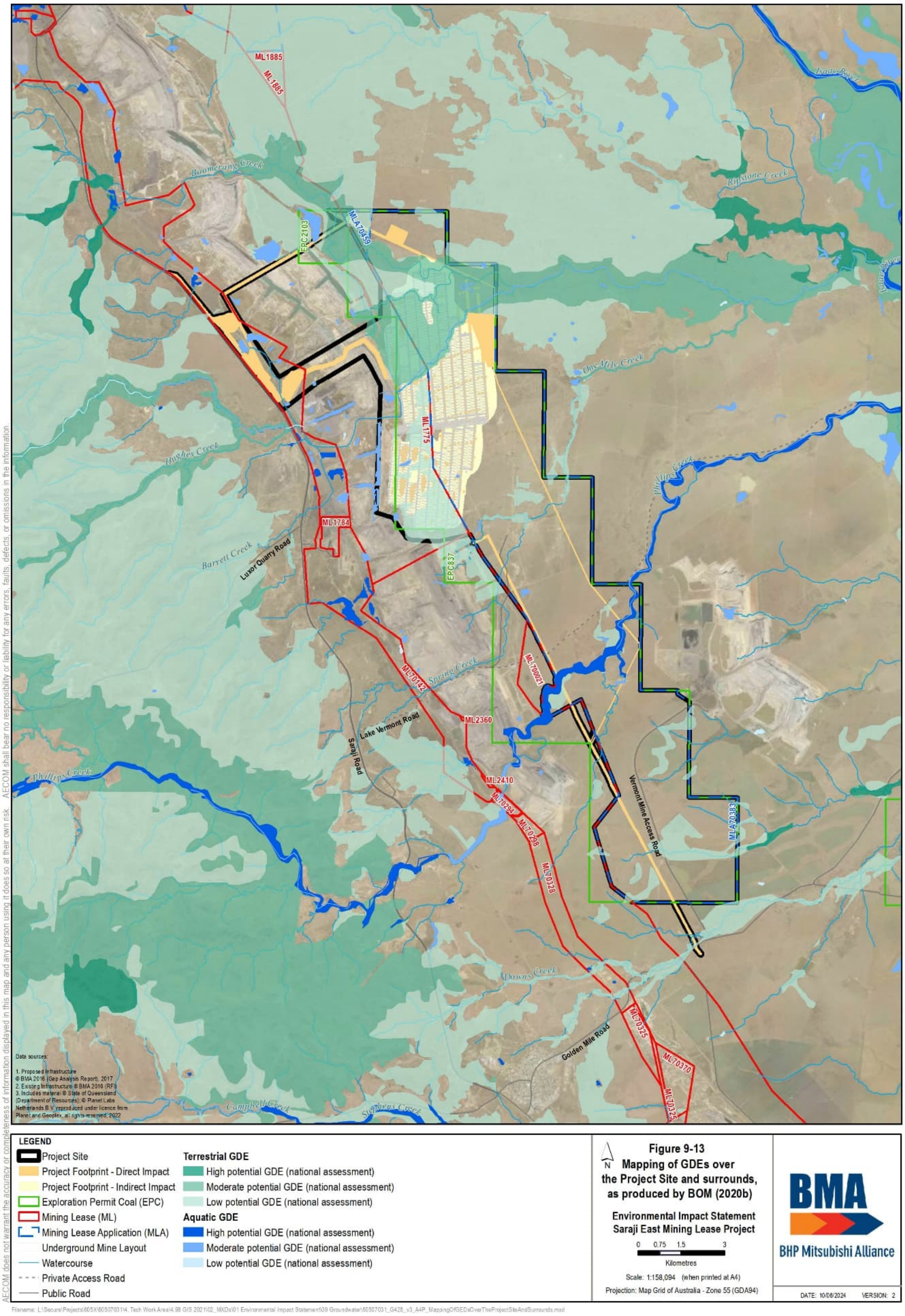

Figure 9-13 Mapping of GDEs over the Project Site and surrounds (BOM, 2020b)

9.4.10.3 GDE investigations

A GDE assessment was conducted for the Project (3D Environmental, 2022) and findings presented in **Appendix D-2 Groundwater Dependent Ecosystems**, which confirmed no known or likely GDE occur within the Project Footprint.

The field survey concluded Terrestrial GDE are present on Phillips Creek, which passes south of the Project Footprint. Field data indicated Phillips Creek is highly likely to function as a Terrestrial GDE where groundwater dependence varies on a seasonal basis; the highest degree of groundwater usage occurs post seasonal flooding events, which recharge groundwater in associated alluvial deposits. There is no indication that Phillips Creek represents an Aquatic GDE.

Known and/or likely Terrestrial GDE were also identified on Hughes Creek downstream of the Project. These Terrestrial GDEs host variable groundwater volumes and are seasonally recharged via surface flows and flooding. No specific impediment to tree water use of Tertiary or Permian groundwater is recognised based on salinity values; however, water held in these aquifers has a potentiometric surface generally >17 mbgL, which is significantly below the maximum rooting depth of facultative phreatophytes associated with the major drainage channels across the Project.

Vegetation on Tertiary plains east of the Project has limited potential for groundwater dependency, due to both the shallow rooted nature of the dominant poplar box and brigalow and the significant depth to the groundwater table. Vegetation fringing Hughes Creek does not meet the hydrological or ecological criteria for a Terrestrial GDE. The transition of Hughes Creek into a Terrestrial GDE to the east of the Project is most likely associated with a thickening and widening of creek alluvium eastward toward the Isaac River where there is greater capacity for storage of perched groundwater.

Within the Project Site, the alluvial landform hosting Hughes, Boomerang, and Plum Tree creeks is extremely shallow, with outcropping sedimentary basement evident in some channel exposures. The Boomerang Creek wetland (assessed at Site 13_AU1) is a surface feature and there is no indication of any hydrological linkage between surface water and groundwater. The Boomerang Creek wetland does not meet the hydrological or ecological criteria for either a Terrestrial GDE or Aquatic GDE.

Vegetation fringing One Mile Creek and adjacent woodland does not meet the hydrological criteria for a Terrestrial GDE with field assessment confirming moisture requirements of vegetation are being supported within the unsaturated portion of the soil profile.

An assessment of predicted groundwater impacts (**Appendix F-1 Groundwater Modelling Technical Report**) indicated the risk to GDE posed by Project is ‘Low to Insignificant’ and there is no interaction between modelled groundwater drawdown and the Terrestrial GDE identified on Phillips Creek (Figure 9-14).

9.4.10.4 Potential for stygofauna

No known or potential subterranean GDEs have been identified within the GDE Atlas for the Project Site and surrounds. As the alluvium in and adjacent to the Project Site is ephemeral, discontinuous, and can be saline it is considered that the alluvium is unlikely to contain sufficient permanent suitable groundwater to support stygofauna populations. Several previous investigations have been undertaken to assess the suitability of sediments within the Bowen Basin for stygofauna; available information indicating no stygofauna have been detected in coal seams within the Bowen Basin. The potential for subterranean GDEs to exist within the Tertiary and Permian sediments is considered to be low for the following reasons:

- the saline nature of the Tertiary and Permian sediments (>5,000 µS/cm) and depth to groundwater (>17 m) are likely to preclude the presence of stygofauna
- two sampling events of the Tertiary and Permian sediments during September 2011 and December 2011 detected no stygofauna species.

As the alluvium in and adjacent to the Project area is ephemeral, discontinuous, and can be saline it is considered that the alluvium is unlikely to contain sufficient permanent suitable groundwater to support stygofauna populations.

The alteration of rock parameters due to longwall mining was adopted in the groundwater model. The fracture zone is taken to merge with the cracking zone for D-seam depths of cover less than 300 m, giving continuous vertical connectivity over most of the southern panels and the western half of the northern panels. As surface cracks are assumed not to heal in the groundwater model, and to be pervasive over the mining footprint, the simulated effects of fracturing/cracking are highly conservative (**Appendix F-2 Groundwater Modelling Peer Review**). The approach to increase the hydraulic conductivity in the fracture zone during the uncertainty analysis adds to the degree of conservatism. This modelling approach, to evaluate possible impacts on alluvium groundwater resources and surface water across a range of aquifer parameters conclude that there is no discernible drawdown in the alluvium at any level of probability.

Based on the Project not impacting on alluvium, such that it would be dewatered, the recommendation to sample for Stygofauna (with limited potential / habitat in the alluvium) will not change the impact assessment.

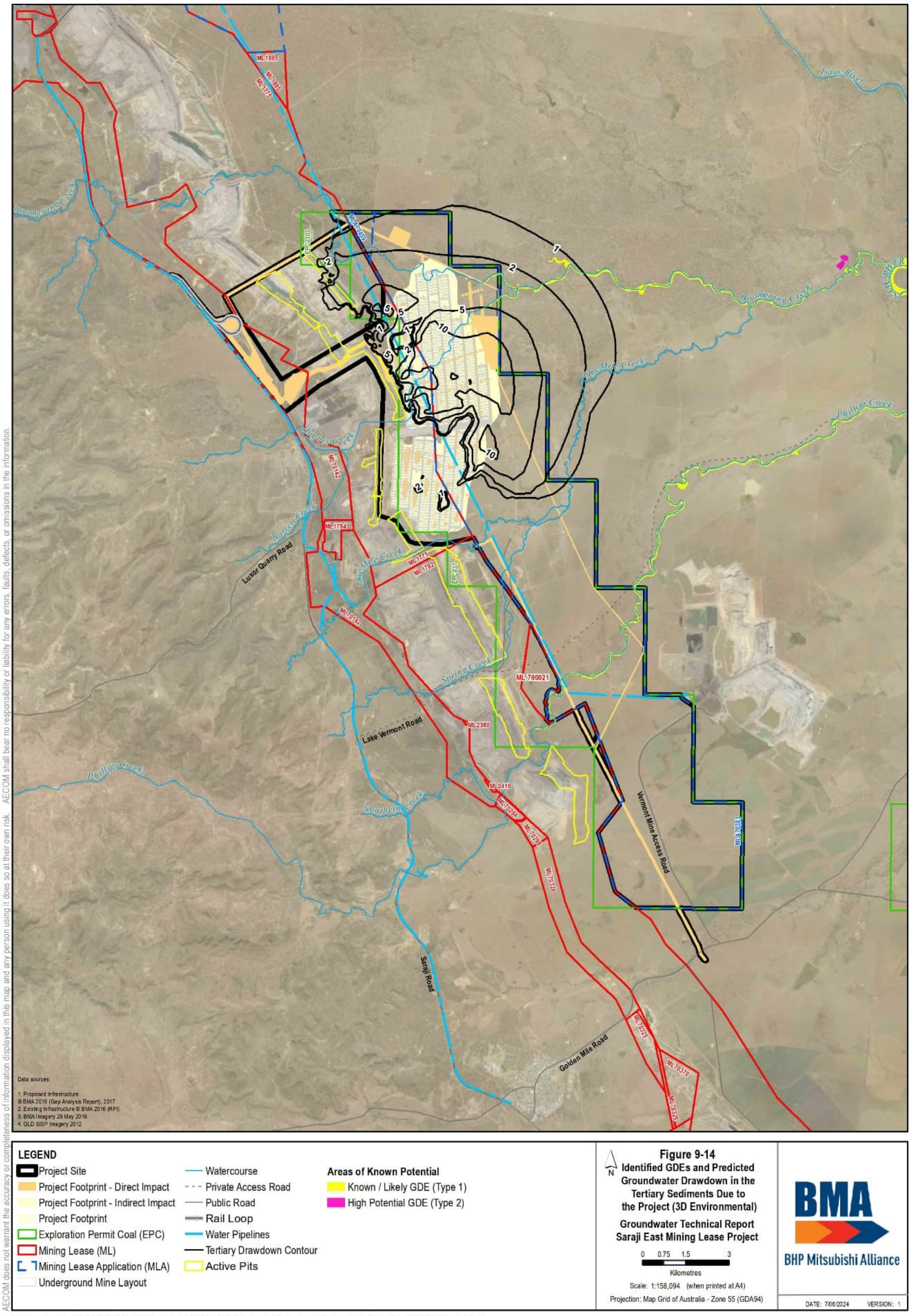

Figure 9-14 Identified GDEs and predicted groundwater drawdown in the Tertiary sediments due to the Project (3D Environmental)

9.4.11 Groundwater environmental values

Groundwater related environmental values in the Project Site have been described in line with groundwater chemistry zone 34 (the eastern most portion of the Project is assumed to be included within groundwater chemistry zone 34) included in the Environmental Protection (Water) Policy 2009 WQ1310 - Fitzroy Basin Groundwater Zones Basin 130. Groundwater chemistry zone 34 (Figure 9-2) identified the following Isaac Groundwater EVs (the eastern most portion of the Project is assumed to be included within groundwater chemistry zone 34):

- aquatic ecosystems
- irrigation
- farm supply
- stock water
- primary recreation
- drinking water
- cultural and spiritual values.

The enhancement of groundwater environmental values and the protection of groundwater are required. For the purposes of this EIS assessment the groundwater EVs are those attributes of the groundwater systems within the potential impact area that are sufficiently important to be protected or enhanced.

The Project is located within the Isaac River sub-basin of the Fitzroy Basin as described in Schedule 1 of the EPP (Water and Wetland Biodiversity). Environmental values and water quality objectives for groundwater within the Isaac River sub-basin are provided in the Isaac River Sub-basin Environmental Values and Water Quality Objectives 2011. The environmental values for groundwater to be enhanced or protected in the Project Site are listed Table 9-3.

Table 9-3 Environmental values for groundwater

Environmental value	Relevance to the Project Site
Aquatic ecosystems	Aquatic ecosystems represent a community of organisms living within or adjacent to water, including riparian or foreshore area. There is no known or likely aquatic or subterranean GDE identified within the Project Site. Field data indicates Phillips creek is highly likely to function as a Terrestrial GDE where groundwater dependence varies on a seasonal basis and a small Terrestrial GDE identified east of the Project Footprint on Hughes Creek, which accompanies a downstream thickening and widening of the alluvial landform.
Irrigation	Section 4.2.4 of the ANZECC guidelines (2000) states that the threshold salinity tolerances for plants grown in loamy to clayey soils are 600 µS/cm to 7,200 µS/cm. Given that groundwater salinity within Tertiary and Permian sediments is generally greater than 5,000 µS/cm, groundwater would not be considered suitable for irrigation. A lack of licensed groundwater bores within 15 km of the Project Site also suggests that groundwater is not useable as a source of irrigation water.
Farm water supply/use	The high salinity of the groundwater generally precludes it from being suitable for farm supply uses such as laundry or produce preparation.
Stock watering	The review of DNRME registered bores and the bore census data indicates that groundwater in the area is used for stock watering. Although the groundwater is generally within the guidelines for livestock, Section 4.3.3.5 of the ANZECC guidelines (2000) states that loss of production and a decline in animal health occurs if stock are exposed to high TDS and saline water for prolonged periods. For beef cattle, this TDS limit is in range the range of 5,000 mg/L to 10,000 mg/L. Given the variable salinity levels for groundwater hosted in the Tertiary and Permian aquifers are within this range and there are some cases greater than 10,000 mg/L, the regional groundwater would generally not be considered suitable for livestock. However, the regional groundwater may still be useable in times of drought or for mixing with other available fresher water supply.

Environmental value	Relevance to the Project Site
Primary recreation	This category of environmental value is considered not applicable to groundwater in-situ. There are also no registered groundwater springs in the Project Site that could be considered for recreational use. Groundwater seepage from the alluvium and/or Tertiary units into water courses can provide short duration baseflow into rivers and creeks immediately after heavy rains or flooding, however, after larger flood events suitability of these waters for recreation may be limited by other factors. This value is more common for surface water features that are accessible for recreational use and visual interaction; however, there is currently no evidence to suggest that groundwater is directly used for recreational or aesthetic purposes in the Project Site.
Drinking water supply	The suitability of water for human consumption is defined in the Australian Drinking Water Guidelines (NHMRC and NRMMC, 2011). The groundwater quality data indicates that groundwater is unsuitable for human consumption before treatment due to elevated levels of salinity. Groundwater resources within the Project Site are, therefore, considered to require significant treatment before utilisation for drinking. The availability of rainwater tanks and the generally low sustainable yield and poor quality of the groundwater bores in the area, are also factors that preclude the usage and potential for usage of the groundwater as a drinking water source.
Cultural and spiritual values	There are no registered groundwater springs or seeps that supply surface water bodies in the Project site.

In summary, the evaluation of groundwater environmental values in the area enveloping the Project indicates that groundwater associated with the Tertiary and Permian sediments are of limited suitability for most uses.

Groundwater associated with the alluvium, which has recorded saturated alluvium with good quality groundwater quality, is sporadic and seasonal and is not considered to provide a sustainable supply in the Project area.

From a hydrogeological perspective, the assessment of available groundwater resources (potential and chemistry) indicates that the only recognised groundwater use within the Project Site is stock watering.

9.5 Potential impacts

9.5.1 Overview

Construction phase

As the proposed mining activities will start within the existing open cut pits (high wall), the construction phase activities are thus considered to include the start of the portal to facilitate access to the longwall mining panels. This construction will occur within the dewatered Permian sediments immediately adjacent to the high wall, thus no additional groundwater impacts are envisaged during construction.

Operational phase

The principal activities during the operational phase of the Project which may impact groundwater resources occur during longwall mining of the underground mine layout and include:

- dewatering of workings
- alteration of geology, and associated aquifer hydraulic properties, due to subsidence/goaf formation
- the cumulative drawdown of open cut mining along strike, with the extended down-dip underground mining (portal construction and dewatering)
- operational aspects such as using mine affected water for dust suppression, and the generation of low salinity rainfall runoff and seepage.

Dewatering may be required (dependent on strata permeability, influence of existing mine dewatering, and model predictions) to lower groundwater levels to the base of the proposed workings for safe and efficient operation of the underground mining. As a result, groundwater levels will be drawn down during the operational phase.

Dewatering has the potential to reduce groundwater levels in existing groundwater bores that fall within the cone of influence of the proposed mine and hence has the potential to impact on existing groundwater supplies and extend outside the Project Footprint. The dewatering impacts have been predicted using a regional scale numerical groundwater model (as described in **Appendix F-1 Groundwater Modelling Technical Report**) and summarised further in this section.

Mine dewatering can result in drawdown of the coal seam potentiometric surface, which can extend beneath the non-perennial creeks draining across the Project and has the potential to increase the frequency or duration of no flow in the creeks. A conservative approach was adopted in the modelling, where no self-sealing of the subsidence fracturing to surface is included in the simulations ensuring any change to hydraulic and storage properties in the model remain. Even adopting this approach, modelling predicts:

- no predicted loss of water from the alluvium along the extent of Boomerang Creek mapped across the Project footprint
- no predicted loss of water from the Isaac River alluvium due to the Project
- no predicted change in surface water flows in the local creeks including Boomerang Creek due to the Project
- no predicted change to surface water flows in the Isaac River due to the Project.

The longwall mining may have some indirect dewatering impacts through goaf induced flow, including:

- drawdown in the saturated Tertiary and possible seasonally saturated Quaternary-age sediments, above the mined longwall panels
- additional leakage from the overlying altered (due to goaf) Permian units to the dewatered and depressurised target D coal seam.

Note: A conservative approach was adopted in the modelling, where **no self-sealing of the subsidence fracturing to surface** is included in the simulations. This approach ensures that any change to hydraulic and storage properties in the model remain. Even adopting this approach no impact on alluvium or surface water resources is predicted.

Post closure

On completion of the proposed underground workings, the existing Saraji Mine open cut final voids will be in place. Assessment of the post closure phase of the Project considers the potential impacts on groundwater resources related to the partial backfilling of the open cut pits (final voids), such that groundwater levels are considered to recover within the underground workings up into the final voids. Principally, the reduced groundwater levels and alterations to the groundwater regime are due to ongoing evaporation from final void areas.

Closed open cut pits, referred to as final voids, can gradually fill with water once dewatering operations have ceased. Evaporation losses from the voids will exceed predicted groundwater inflow and hence the water level within the pit will be reduced. The long-term predictions are for the groundwater to recover within the Project Site but not to pre-mining levels across the Project Site due to final voids.

9.5.2 Impacts on groundwater levels

The inflows at the Project are predicted to reach a maximum peak in mine year 16, of 500 ML/year (1.4 ML/day). The average inflow rate for the Project is estimated at 183 ML/year (0.5 ML/day). This impact is not considered to be significant due to the absence of privately owned bores in the drawdown areas.

Based on predicted groundwater ingress into the mine works, groundwater level drawdown was predicted for Project and Approved mining model scenarios. By assessing assess drawdown within selected monitoring bores, both for the Approved and Project model scenarios, the model predictions were used evaluate additional contribution of the Project on the groundwater regimes. Groundwater level change predictions within the hydrostratigraphic units include:

- Alluvium – no change to alluvium groundwater levels when comparing the Project to Approved mining scenarios.
- Tertiary – predicted groundwater levels in the Tertiary age units at the end of mining for the Project and Approved mining scenarios indicate dewatering caused by the Project result in a slightly larger unsaturated zone within the Project Site for the Project scenario compared to the Approved mining scenario (Figure 9-15).
- Permian – predicted groundwater levels in the target D coal seam at the end of mining for Project and Approved mining scenarios demonstrate a regional south-easterly hydraulic gradient across the model towards the Isaac River for both scenarios (Figure 9-16). Zones of depressurisation at the Project and surrounding mines are shown to cause localised interruptions to the regional flow gradient.

The process of mining directly removes groundwater and reduces water levels in surrounding hydrostratigraphic units. The extent of the zone affected is dependent on the hydraulic properties of the hydrostratigraphic units (aquifers/aquitards) and is referred to as the zone of drawdown. Groundwater drawdown is greatest at the working coalface and decreases with distance from the mine workings. The maximum incremental drawdown refers to the potential drawdown impact associated with the Project only and was determined by comparing the difference in predicted groundwater levels for the Approved scenario and the Project scenario at matching times (i.e. additional drawdown predicted to occur as a result of the Project). Maximum incremental drawdown impacts predicted to exceed 1 m within the hydrostratigraphic units include:

- Alluvium – no incremental drawdown impacts are predicted for the Quaternary alluvium due to mining at the Project.
- Tertiary – incremental drawdown extent within model Layer 2, largely confined to the Project Footprint or down dip of only the northern panels where 1 m drawdown influence is predicted to extend 4.2 km northeast of the Project mine workings.
- Permian – extent of maximum predicted depressurisation is limited to the west due to the coal subcrop in this area; generally elongated along strike in the northwest-southeast direction and up to 5 km and 8 km northwest and southeast of the Project mine extent, respectively. The influence of fault adjacent to the Project footprint is evident and it appears that it limits potential drawdown to the east.

Maximum cumulative drawdown predictions, representing the total impact to modelled groundwater levels resulting from all mining within the model domain, indicate the potential impacts on the Tertiary and target D seam (no drawdown in the alluvium due to the Project is predicted). The simulated cumulative drawdown shows whether the zone of impact from all the neighbouring mine operations within the model is predicted to interact with the predicted Project zone of impact in the Tertiary and the target D seam. While most of the predicted cumulative drawdown impacts are not related to the Project but result from existing mining activities represented in the model, the evaluation of cumulative drawdown impacts on the regional model scale indicated:

- Alluvium – no cumulative drawdown impacts predicted for the Quaternary alluvium within or adjacent to the Project Footprint.
- Tertiary – Project-related drawdown extends and interacts with the drawdown associated with the Peak Downs Mine and Saraji Mine open cut pits.
- D-seam – maximum predicted cumulative drawdown is predicted to interact with zone of impact from the Peak Downs Mine and Saraji Mine open cut pits. This cumulative drawdown is predicted to elongate along the north-south trending fault located adjacent to the Project footprint.

Long term groundwater levels are predicted to be influenced by the Saraji Mine final voids, which act as groundwater ‘sinks’ because of water loss through evaporation. This maintenance of a pseudo-steady pit water level will maintain cones of drawdown immediately around the final voids.

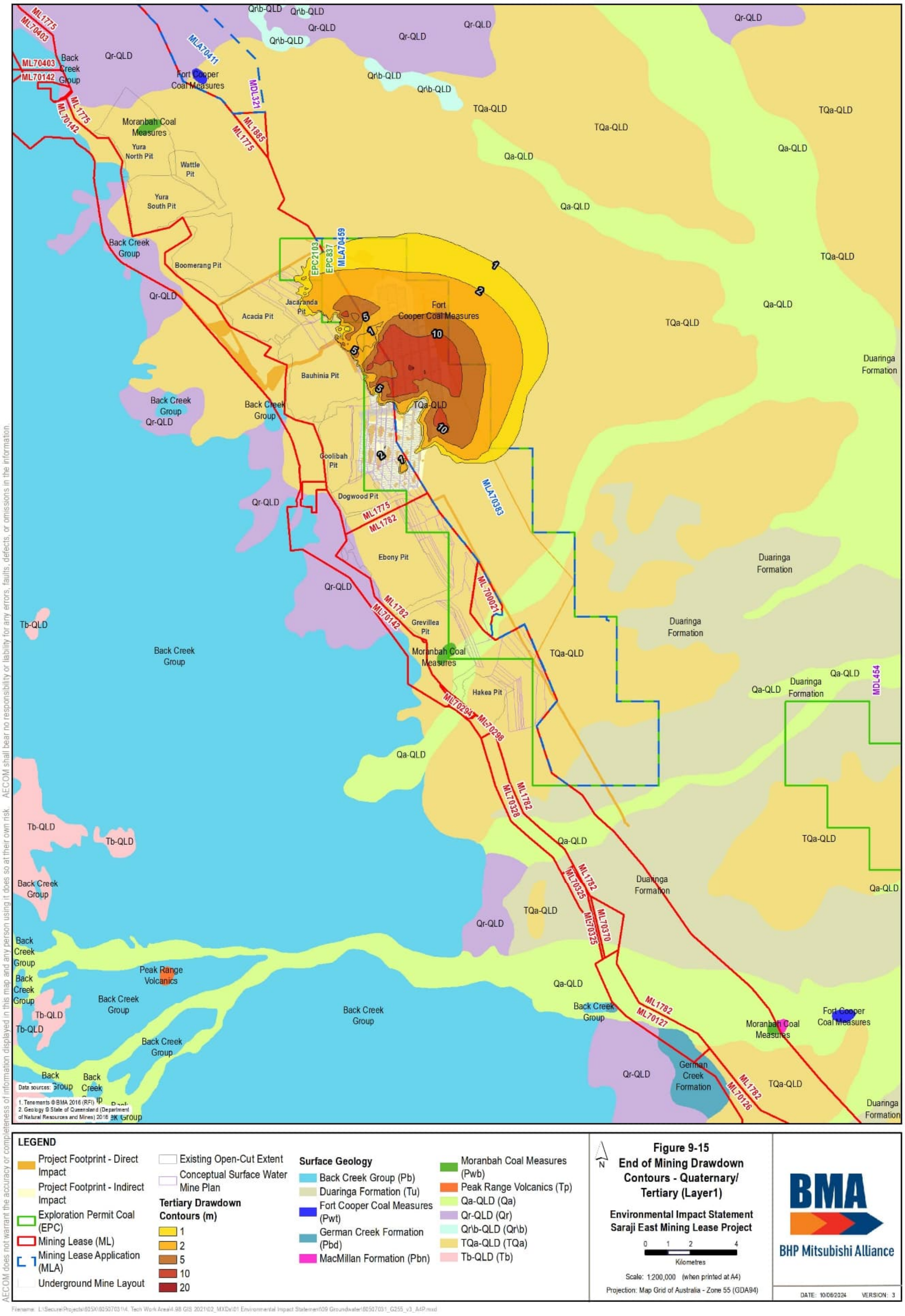

Figure 9-15 End of mining drawdown in the Quaternary/Tertiary unit (Model Layer 1)

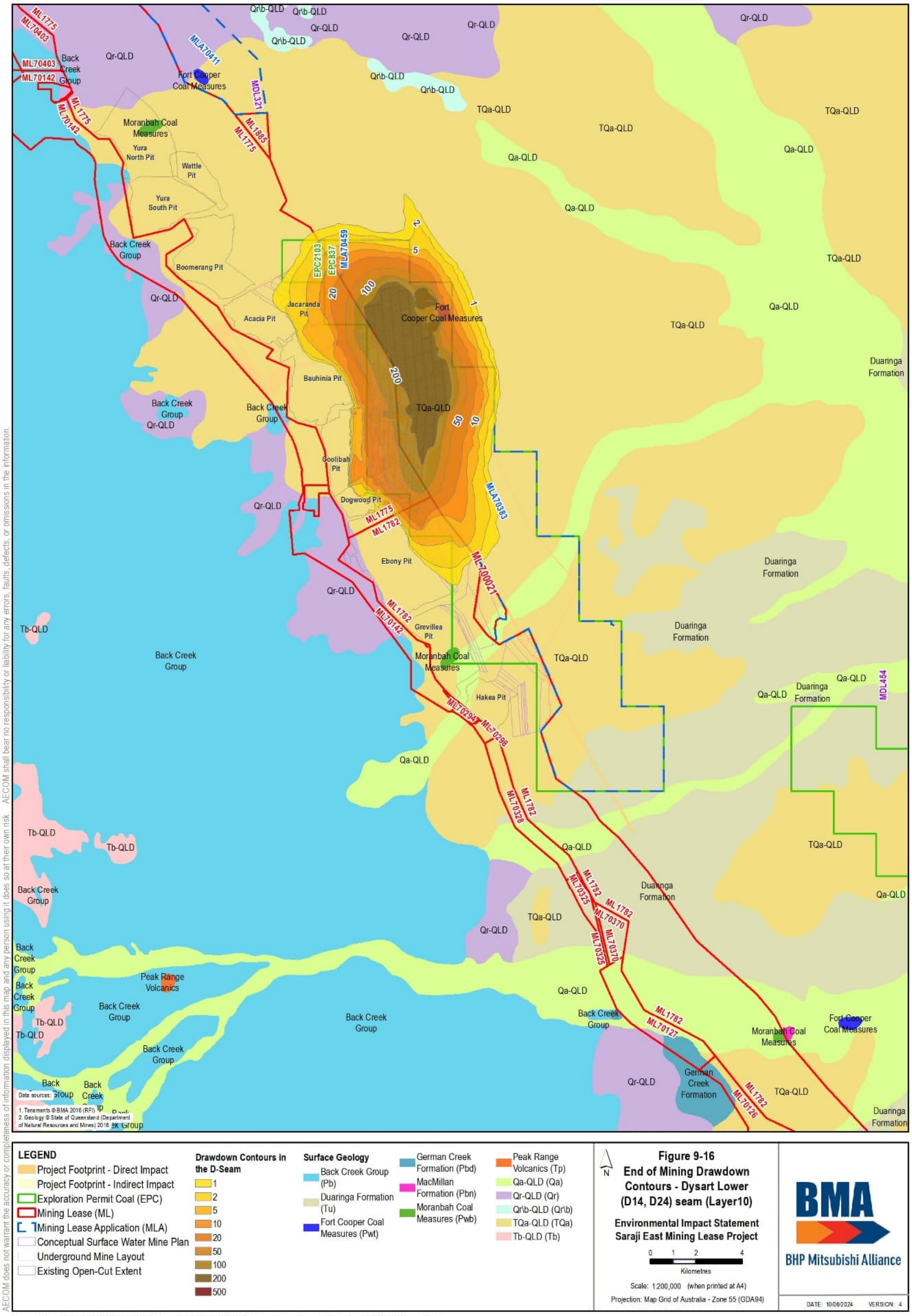

Figure 9-16 End of mining drawdown in the Dysart Lower (D14, D24) seam (Model Layer 10)

9.5.3 Impacts on Saraji Mine infrastructure

Potential impacts of groundwater drawdown on the mine water storages (described in **Chapter 8 Surface Water**) and waste storage facilities (described in **Chapter 10 Geochemistry and Mine Waste**) are assessed in **Appendix F-3 Groundwater Technical Report**.

No drawdown due to Project in Alluvium is predicted.

Predicted groundwater drawdown due to Project within the Tertiary age sediments, which can underly the mine water storages and waste storage facilities, does not extend up dip into the Saraji Mine, thus no impact on Saraji Mine water and waste storage facilities is predicted. To demonstrate, the maximum incremental drawdown is presented on Figure 9-17 with the locations of the proposed Project mine water storages and waste storage facilities.

No drawdown in the footwall sediments, the Back Creek Group, is predicted to occur as such no drawdown impacts are predicted for mine water and waste storage facilities located on the Back Creek Group.

9.5.4 Impacts on existing groundwater users

The predicted drawdown of groundwater levels due to the Project were assessed using the bore thresholds as defined in the Water Act to evaluate potential impacts on neighbouring groundwater bores.

There are 24 groundwater bores within the 1-2 m predicted maximum incremental drawdown contours for the Tertiary and target D seam units, including 20 registered bores and 4 unregistered bores (described in Section 9.4.3 and 9.4.4). Figure 9-18 shows the location of existing registered bores plus additional bores identified during the bore census in relation to the predicted maximum incremental drawdown in the Tertiary and target D seam, where the predicted maximum incremental drawdown refers to the potential drawdown impact associated with the Project. Full bore details are presented in **Appendix F-3 Groundwater Resources Technical Report.**

Of the 24 bores predicted to be impacted, none are identified as potential ‘make-good’ bores for a combination of the following reasons:

- no water supply bores are located within the Project drawdown zones
- alluvium bores are either dry or not predicted to be impacted
- they are located on BMA owned land
- they are identified as being abandoned or destroyed
- deep bores are screened within the Back Creek Group, which is located below the target D seam and not predicted to be impacted.

Of the 12 unregistered bores identified during the bore census in Section 9.4.4, four unregistered bores are within the predicted Project drawdown zones. There is limited data available for these bores, which are located within the BMA lease area. It is unlikely BMA will require any ‘make-good’ agreements for these bores. Thus, it is unlikely the Project will have material impacts on existing groundwater users.

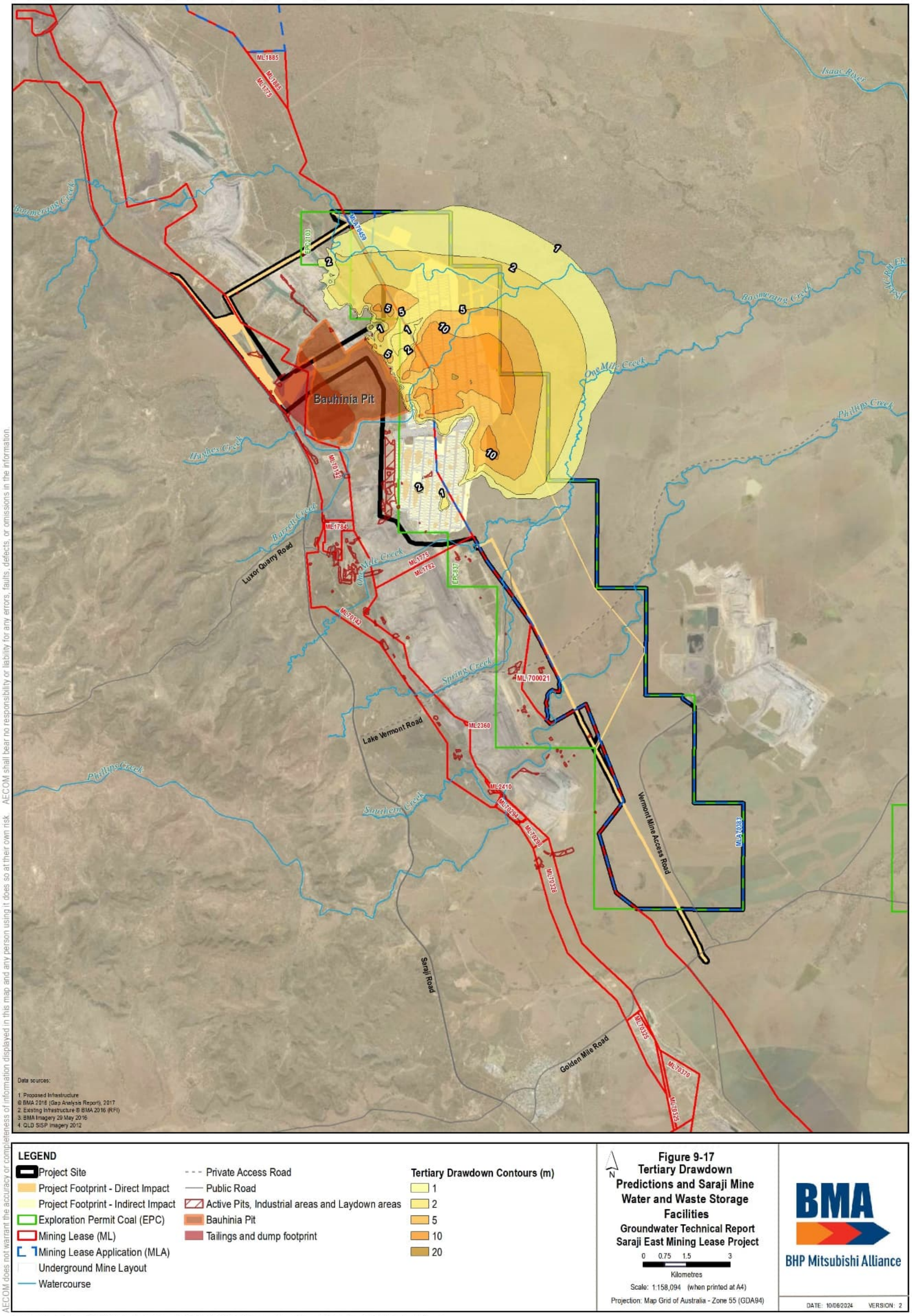

Figure 9-17 Tertiary drawdown predictions and Saraji Mine Waste and Waste Storage Facilities

Figure 9-18 Bores located within the predicted maximum incremental drawdown in the Tertiary and target D seam

9.5.5 Impacts on groundwater quality

During mining, a cone of depression is likely to develop around the underground mining footprint due to incidental mine gas management (coal seam groundwater extraction) and development of goaf above the longwall panels. This will result in localised groundwater flow into the underground panels. The risk of water contained in the underground panels (a blend of groundwater from different strata) impacting on groundwater quality, away from the underground workings is therefore considered limited.

Due to high salinity groundwater, it is unlikely that there will be a marked alteration in water quality due to blending/mixing within the cone of depression predicted to envelop the underground workings. It is noted, based on available groundwater level and water quality data, that induced flow potential is limited.

The mixing of groundwater types from the three different hydrostratigraphic units (alluvium, Tertiary, and Permian), if it occurs, would not markedly impact upon any existing groundwater environmental values.

9.5.6 Potential environmental impacts

The Project is predicted to have long term locally contained impacts on the quantity and quality of groundwater resources, including:

- localised drawdown due to mining of underground panels
- blending (mixing of groundwater from the different hydrostratigraphic units) within the underground mine footprint.

The potential environmental impacts of the proposed Project are considered low as:

- The surface water system in the Project Site is ephemeral and limited surface water – groundwater interaction is evident, particularly related to GDE.
- The Quaternary age alluvium is thin, discontinuous and sporadic across the Project footprint. The thicker saturated (in places) alluvium associated with the Phillips Creek are located outside the predicted drawdown resulting from the Project.
- The clay-rich Tertiary sediments have low recharge potential and low permeability resulting in insufficient yield and low usage potential.
- The predicted drawdown within the target D seam is predicted to elongate along strike and does not extend to the Isaac River to the east. The Project is not predicted to impact on the Isaac River or associated alluvium groundwater resources.
- The groundwater quality in the three hydrostratigraphic units present within the Project Site is not suitable for drinking, too deep for terrestrial ecosystems, and is often too saline for livestock watering.
- The surface water systems are separated from the predicted impacted groundwater resources by low permeable sediments, which reduce the potential for the Project to impact on the alluvium and surface water flows.

To protect against unexpected impacts and ensure ongoing validation of the predictive modelling in the vicinity of the proposed underground workings, ongoing groundwater monitoring during and after the Project development will be conducted. The groundwater monitoring approach, including adaptive management and the instigation of further investigations, is detailed in Section 9.7.1.2.

9.5.7 Impacts on alluvium

The change in alluvium water resources was assessed by comparing water budgets for alluvium zones using the Project and Approved model scenarios of the predictive model. Impacts on the alluvium groundwater can occur due to the potential for increased leakage, due to longwall mining.

Predictive modelling indicated:

- over the extent of Boomerang Creek alluvium mapped across the Project footprint, the predicted loss of water from alluvium as a result of the Project is predicted to be zero

- with regards to the Project impact on the Isaac River alluvium, the model predicts that the alluvium take due to the Project is also zero.

It is noted that any change in flux below than 0.01 ML/day is beyond the model ability to be able to predict it. Therefore, any flux changes derived from the model that are below 0.01 ML/day are considered to be within the range of model error.

Predicted total groundwater inflows to the Project amount to 183 ML/year on average (between 2022 and 2042). This groundwater extraction is not predicted to result in any groundwater drawdown in the alluvium due to the Project.

9.5.8 Impacts on groundwater – surface water interaction

The change in surface water drainage leakage to groundwater due to the Project was assessed by comparing the River cell flow budgets for the Isaac River in the Project scenario against the Approved scenario. This comparison showed that over the life of the Project, the change in the Isaac River net flow attributable to the Project is zero.

Boomerang, Hughes, and Plumtree creeks located within the Project area are all set up with a stage height of 0.0, which means they are simulated as gaining systems (i.e., negative net flow). The predictive model results indicate that there is no change to the estimated net flow for the above creeks as the result of Project.

The predictive modelling, therefore, indicates:

- no change in surface water flows in the local creeks including Boomerang Creek is predicted due to the Project
- no change is predicted to surface water flows in the Isaac River due to the Project.

Note: A conservative approach was adopted in the modelling, where no self-sealing of the subsidence fracturing to surface is included in the simulations. This approach ensures that any change to hydraulic and storage properties in the model remain. Even adopting this approach no impact on alluvium or surface water resources is predicted.

9.5.8.1 Streamflow impacts

Appendix E-3 Hydrology, Hydraulics and Geomorphology Report concludes that minor alteration to flow behaviour will be expected due to subsidence, this potential impact/s on streamflow and geomorphology are considered temporary as channels infill and ponded areas slowly accrete (as observed at other longwall operations in the Bowen Basin, the elevated sediment supply overwhelms the pools).

The general effects are a reduction in total flow some 11 per cent to 0.5 per cent reduction depending on the rainfall events. The reduction is more notable for the most frequent and extreme events and a delay in flow associated with the increased attenuation capacity of the subsided landscape. Residual pools will occur in parts of the landscape post-subsidence; this will account for the reduction in flow volume leaving the Project Site. In time, with sediment movement in the system these ponded volumes will decrease (i.e. flow reduction is temporary).

The reduction in flows due to the ponding within subsided areas has the potential to impact on water quality downstream through reduced flows and hence less dilution after dry spells. However, impacts on water quality are likely to be minor and on a short temporal scale, as the predicted variation in flow between pre- and post-subsidence environment will keep decreasing over time as pools and channel beds fill in, and ephemeral wetlands slowly accrete.

The ponded water, albeit of short duration, has the potential to increase groundwater recharge over the Project footprint. This increase in shallow groundwater resources will be mitigated by minor remedial drainage works. Subsidence modelling was used to identify future ponding areas. The ponding areas develop gradually over the life-of-mine. The minor remedial drainage works will reduce persistent ponding in the landscape.

Subsidence monitoring will detect areas subject to persistent ponding of overland flow and remedial drainage works will ensure a free-draining landform. Subsidence ponding can be further alleviated through appropriate design and mitigation measures outlined in **Appendix K-2 Subsidence Management Plan**.

9.5.9 Recovery / long-term water levels

The post-mining recovery modelling included simulation of groundwater level recovery within the Project underground workings. A 2,000-year transient model was created to ascertain post-mining recovery. This recovery model included the Saraji Mine open-cut pits.

All drain cells representing the Project were removed at the end of mining, allowing for the start of the groundwater level recovery in the underground workings and the overlying water-bearing strata.

The underground workings maintained the hydraulic parameters adopted in the model cells to reflect mined-out areas and goaf effects from the prediction model. These parameters allow for enhanced vertical and horizontal hydraulic conductivity in the fractured layers overlying longwall panels and the increased storage in the mined seam.

For the Saraji Mine open-cut pits, all the open cut mine workings were areas were changed to spoil with only the sections of open-cut pits closest to the Project (i.e., areas mined at the final year of the Saraji Mine) were not backfilled and remained as voids. The voids were assigned high horizontal and vertical hydraulic conductivities (1,000 m/day) and storage parameters. This allowed for the simulation of free water movement. No extra recharge or evapotranspiration was applied to the voids, and it was assumed that the voids will be filled through groundwater recovery.

Based on two pilot points, located within the northern and southern longwall panels, the groundwater model predicts the groundwater system will reach equilibrium approximately 1,800 years post-mining), the groundwater level recovers to approximately 176.5 mAHD and stabilises. This groundwater level is approximately 7.0 m above the pre-mining (all open cut and underground mining) groundwater levels.

The recovered groundwater levels within the northern and southern longwall panels, stabilise at between 10 to 20 m below ground level. This indicates that the influence of the final voids will be limited, resulting in localised drawdown around the voids.

9.5.9.1 Final voids

The potential impact of the final voids at the Saraji Mine will depend on the Progressive rehabilitation and closure plans (PRC Plans) to be developed for the Project, which is outside the scope of the Project EIS.

The Saraji Mine transitional PRC Plan (submitted pending approval), which details the closure of the open cut mines, includes an assessment of groundwater interaction with the final voids and predictions of pseudo steady state pit water levels. The hydrogeological study (SLR, 2023b) and the PRC Plan submission was assessed to aid in evaluating the influence of the final voids on groundwater.

9.5.9.1.1 Final void lakes

The Saraji Mine PRC plan includes the prediction of pit water levels at the end of mining and post closure (rehabilitation). The final void lake levels were included in a Saraji Mine PRCP groundwater model as part of an iterative modelling approach between the groundwater model and the water balance model. The modelling results identify the residual voids develop as long-term ‘sinks’ with respect to groundwater for all climate change scenarios modelled. Stabilised lake levels in all the final voids are predicted to remain below the recovered groundwater levels (SLR, 2023b).

Consideration of water level predictions at the Coolibah / Dogwood pits, the pits with the highwall access for the Project, have been summarised for consideration of long-term groundwater flow patterns.

A dedicated final void water balance model, based on the final closure landform design, was completed for the period 2080 to 2199 (120-years), to understand water balance behaviour (including climate change considerations) within the residual voids over time. The findings for the Coolibah / Dogwood final void was:

- the decant level is 190 mAHD (i.e., level where water could overtop / spill from the void)
- after 2120 pit water levels start to stabilise, with simulated mean inflows of 783 ML/year being very similar to mean outflows of 784 ML/year

- this indicates that the mean water balance has reached an equilibrium
- the long-term final void lake levels range between 24 and 7 mAHD (BMA, 2023).

The numerical groundwater modelling (SLR, 2023b) shows the establishment of sustained inward groundwater flow gradients to all the voids. The groundwater flow patterns are driven by the evaporative discharges from void lakes. The final void water levels stabilise below the modelled groundwater elevations and below the shallow hydrogeological units, (i.e., alluvium and Tertiary).

Therefore, once the final void lakes and groundwater levels have stabilised, the modelling indicates the residual voids will continue to act as groundwater sinks.

Groundwater modelling, considering wet, base, and dry climate conditions, indicated that groundwater ingress represents 5 per cent to 13 per cent of the total volumetric inflow to each final void based on the water balance model predictions. The majority of the groundwater ingress comes via the spoil. Based on the depth of the water within the voids, driven by evaporation, groundwater from the hydrostratigraphic units within the highwall flow into the final voids resulting in localised groundwater drawdown.

The post-mining groundwater elevations, contours, and drawdown for the target D seam is predicted across the Project footprint. The groundwater elevations, based on the Saraji Mine recovery predictions, are around 140 mAHD.

Groundwater levels within the Project are predicted, considering Saraji Mine open cuts and the Project underground workings, to recover to 176.5 m AHD in the long term), this is >100 m above the pit water levels of between 7 m to 24 m AHD.

This comparison of groundwater recovery levels in the Project and long-term levels associated with the Saraji Mine post-closure indicates groundwater flow will be towards the deep water levels within the final void where the Coolibah / Dogwood final void (predicted to be 7 m to 24 m AHD).

Future groundwater modelling envisaged for the PRC Plan for the Project and/or revisions of the Saraji Mine PRC Plan will allow for the reassessment of cumulative groundwater recovery of these two mines, plus the use of particle tracking to show groundwater flow patterns adjacent and into the final voids.

9.6 Prediction uncertainty

Groundwater modelling, detailed in **Appendix F-1 Groundwater Modelling Technical Report**, included sensitivity and uncertainty analysis to allow for increased confidence in the model predictions. The detailed assessment of the model, including peer review, included assessment of key areas related to groundwater resources, including the influence of faults and the simulation of longwall mining alteration.

9.6.1 Fault approach

Geological faults, fractures in the rock where the rock has been displaced parallel to the plane of movement, are mapped within and adjacent to Project. These geological structures can, depending on the nature of the fault (i.e. filled, or open) plus the amount of displacement on the fault can influence groundwater flow.

The faults, acting as barriers or preferential flow pathways, can influence groundwater ingress and groundwater drawdown at SEMLP. To best include faults and assess potential impacts on groundwater, the nature of the faulting was assessed through model calibration and uncertainty analysis.

As per industry best practice, if the nature of a fault, or other hydraulic feature, is unknown, then the parameterisation of the fault should be sufficiently large to capture all plausible conceptualisations (i.e. the fault is filled, open, or partially filled). This is the practice employed within the SLR (2023) modelling, and development of the calibrated ensemble; in particular, the allowed parameter ranges during calibration allowed representation of the fault as a full barrier, full conduit, and all possibilities in between.

Calibration of the hydraulic conductivity of the fault is allowed during the calibration process based upon the calibration dataset and its sensitivity to fault hydraulic conductivities. Where insensitive, the calibrated range in conductivities will then remain large; therefore, incorporating the conceptual uncertainty within the numerical uncertainty of the model results.

Appendix F-1 Groundwater Modelling Technical Report provides the ranges in conductivities for the different fault zones within the model. The range in values within the ensemble varies by orders of magnitude and as such the predictive uncertainty captures the uncertainty in the conceptualisation on the nature of the faults.

In this sense, the predictive results incorporate the possibility of faults being barriers, conduits, and / or both. The modelling approach is recognised to assess the fault/s influence on groundwater ingress and drawdown.

9.6.2 Subsidence uncertainty

Modelling of underground mines requires assumptions as to the degree of fracturing above the mined coal seam and the enhancement of permeabilities and storage properties in the fracture zone. As the longwall panel width is broad (320 m) and the cutting height is high (3.6 m), a substantial vertical fracture zone is to be expected. A separate subsidence assessment by Minserve (2022), based on FLAC-3D geotechnical modelling, provided estimates of the degree of subsurface fracturing and surface cracking, as well as estimates of enhanced permeabilities and porosities. These predictions were used to assess potential impacts on alluvium and surface water systems. The uncertainty analysis allowed for the evaluation of possible impacts across a range of aquifer parameters. This approach adequately addresses the variation in rock strength considered in **Appendix B-2 Subsidence Modelling** and **Appendix B-3 Subsidence Modelling Peer Review.**

The alteration of rock parameters due to longwall mining was adopted in the groundwater model, based on the **Appendix B-2 Subsidence Modelling** predictions. The fracture zone is taken to merge with the cracking zone for D-seam depths of cover less than 300 m, giving continuous vertical connectivity over most of the southern panels and the western half of the northern panels.

As surface cracks are assumed not to heal in the groundwater model, and to be pervasive over the mining footprint, the simulated effects of fracturing/cracking are highly conservative (in the opinion of the groundwater model peer reviewer (**Appendix F-2**)). The approach to increase the hydraulic conductivity in the fracture zone during the uncertainty analysis adds to the degree of conservatism.

The conclusions, therefore, include consideration of possible impacts on alluvium groundwater resources and surface water across a range of aquifer (rock parameter) parameters and conclude that:

- there is no discernible drawdown in the alluvium at any level of probability
- no material impacts on Isaac River or the overlying Boomerang Creek are anticipated at any level of probability.

9.7 Mitigation measures

9.7.1 Groundwater monitoring bore network

Potential impacts requiring ongoing monitoring include:

- shallow Quaternary age alluvium groundwater levels and quality
- Tertiary groundwater levels and quality
- Permian coal seam target D seam groundwater levels and quality.

From the existing groundwater monitoring bores, groundwater level measurements are collected manually from monitoring wells located across the site. Manual readings are procured during each monitoring event (prior to any sampling). It is recommended automated readings via dedicated level logger are reinstated and that these loggers are programmed to collect static water level (SWL) measurements at least once a week. Existing groundwater monitoring bores are shown in Figure 9-19.

The existing groundwater monitoring network will be augmented near the proposed underground mine (and over time) to ensure the extent and magnitude of drawdown in each hydrostratigraphic unit near the proposed underground workings is adequately monitored for comparison to modelled projections over time. The groundwater monitoring network will, during operations, act as an early warning system for potential drawdown impacts. The monitoring bore network augmentation will ensure the replacement of monitoring points lost during mining, and the groundwater monitoring program is modified in response to mine activities change (i.e. operations or closure).

In addition to the existing monitoring bore network described in Section 9.4.2, additional monitoring bores are proposed to be installed prior to the Project mining activities to ensure ongoing collection of representative groundwater monitoring data to assess potential predicted impacts of the Project on local groundwater resources. These are described in Table 9-4 and Figure 9-19.

Table 9-4 Additional Project monitoring bores

Additional bore	Easting	Northing	Target
SEMLP1T	637628	7528964	Tertiary sediments adjacent to Boomerang Creek, within the mapped fault
SEMLP1P	637735	7528962	Target D seam, adjacent to Boomerang Creek, and within the mapped fault
SEMLP2T	637672	7523955	Tertiary sediments, within the inferred fault
SEMLP2P	637863	7524055	Target D seam, within the inferred fault

These proposed bores are to be located down dip of the Project underground mine panels and along the inferred fault to allow for:

- the verification of drawdown within the Tertiary and target D seam
- the assessment of the fault (and possible refinement of the model)
- the evaluation of the fault in terms of influence on drawdown (i.e., groundwater level change due to compartmentalisation, elongation along fault, or across the fault)
- assessment of vertical gradients and potential induced flow (from Tertiary to Permian)
- evaluation of potential blending of groundwater quality
- recovery (post-closure).

All monitoring bores are to be drilled using a water bore drilling rig, using mud-rotary, air-percussion, or other appropriate techniques. The groundwater monitoring bores are to be designed in accordance with the Minimum Construction Requirements for Water Bores in Australia, 4th Edition (National Water Commission, 2020) or as current.

Consideration must be given to casing and annular seal requirements to ensure that no pathway is provided for the movement of water between hydrostratigraphic units (i.e. the bore does not act as a connecting pathway).

Based on the predictive modelling, which allowed for the assessment of additional groundwater drawdown due to the Project, no impact on the existing Saraji Mine water and waste storage facilities is predicted. As these mine water and waste storage facilities are up dip or on Back Creek Group sediments, the drawdown associated with the Project will not extend to these facilities. As such, no Project related groundwater monitoring is proposed for the existing Saraji Mine water and waste storage facilities.

9.7.1.1 Project groundwater monitoring bore network summary

Table 9-5 provides a summary of the groundwater monitoring bores for the Project, as included in Figure 9-19. The summary included available data (monitoring period), bore depth, target geology, purpose and location.

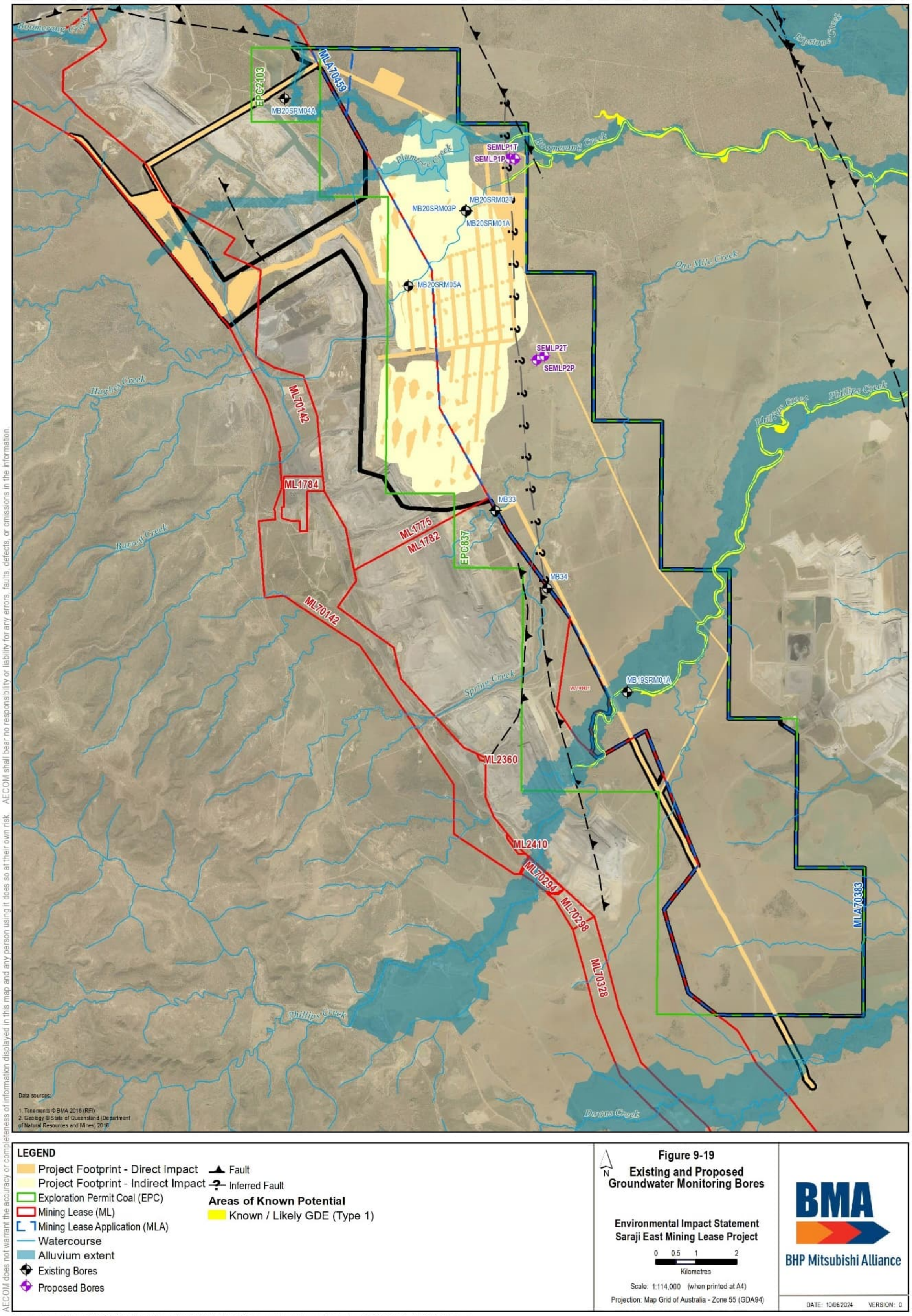

Figure 9-19 Existing and proposed groundwater monitoring bores

Table 9-5 Project groundwater monitoring bore network with alluvium and faults

Bore ID	Easting (GDA94)	Northing (GDA94)	Monitoring Period	Elevation (mAHD)	Depth (mbgl)	Geology	Purpose	Location
Existing								
MB34	637926	7518269	2013 - ongoing	195.9	107.0	Moranbah Coal Measures interburden	• validate model predictions • assess dewatering trend (9 m decline over time) - located on possible fault leading to preferential drawdown.	Along strike from Project underground on One Mile Creek
MB33	636640	7520199	2013 - ongoing	194.8	37.5	Moranbah Coal Measures Q seam	• validate model predictions • assess groundwater recharge, influence of cracking and ponding • predicted to go dry.	Along strike between Project underground workings and One Mile Creek and Philipps Creek
MB19SRM01A	639919	7515681	2019 - ongoing	194.41	8.5	Alluvium	• validate water level (dry /wet) condition of alluvium • no impact predicted – validate no impact due to the Project noting Saraji Mine Grevillea Pit expansion impacts likely.	On Phillips Creek
MB20SRM04A	631397	7530470	2019 - ongoing	194.95	12.0	Alluvium	• validate no impact on alluvium upstream on Boomerang Creek of the Project.	Along strike and up dip of Project underground
MB20SRM01A (MB20SRM01_ PZ)	635922	7527665	2019 - ongoing	186.42	10.5	Alluvium	• validate dry alluvium • assess groundwater recharge, influence of cracking and ponding • predicted to remain dry.	On Plumtree Creek
MB20SRM05A (MB20SRM05A _PZ)	634476	7525798	2019 - ongoing	191.43	24.0	Alluvium	• validate dry alluvium • assess groundwater recharge, influence of cracking and ponding	On Hughes Creek

Bore ID	Easting (GDA94)	Northing (GDA94)	Monitoring Period	Elevation (mAHD)	Depth (mbgl)	Geology	Purpose	Location
							• predicted to remain dry.	
MB20SRM02T	635914	7527670	2019 - ongoing	186.61	36.5	Tertiary	• validate model predictions • assess groundwater recharge, influence of cracking and ponding.	Above the Project
MB20SRM03P	635907	7527677	2019 - ongoing	185.87	242.7	Moranbah Coal Measures P seam	• validate model predictions • assess rate and fluctuation of groundwater level as per predictions in response to mine plan.	Above the Project
Proposed								
SEMLP1T	637628	7528964	-	TBC	TBC	Tertiary	Tertiary sediments adjacent to Boomerang Creek, within the mapped fault. Assess drawdown adjacent to the Boomerang surface water wetland.	
SEMLP1P	637735	7528962	-	TBC	TBC	D seam	Target D seam, adjacent to Boomerang Creek, and within the mapped fault.	
SEMLP2T	637672	7523955	-	TBC	TBC	Tertiary	Tertiary sediments, down dip of the Project and adjacent to the inferred fault. Assess fault barrier or preferential drawdown.	
SEMLP2P	637863	7524055	-	TBC	TBC	D seam	Target D seam, down dip of the Project and adjacent to the inferred fault. Assess fault barrier or preferential drawdown.	

9.7.1.2 Monitoring bore network assessment

To assess the longevity of these selected groundwater monitoring bores predictions of groundwater level change over time within each of the monitoring bores was conducted. The aim of the assessment was to determine the longevity of the monitoring locations, the prediction of maximum drawdown within each of the hydrostratigraphic units screened within the monitoring bores and evaluate the risk of the monitoring bores becoming dry: These predictive water level over time hydrographs allow for informed decision making regarding the need to augment (replace) some or all of these monitoring bores over time.

The cumulative drawdown predictions for each groundwater monitoring bore selected for the SEMLP indicate the need to allow for the augmentation of the groundwater monitoring bore network over time, to ensure assessment of impacts, validation of groundwater modelling, and to allow for informed decision making regarding management and mitigation measures.

A summary of longevity assessment, allowing for predictions related to the selected groundwater monitoring bore network, are included in Table 9-6.

Table 9-6 Longevity assessment summary and predictions

Monitoring bore	Prediction summary	Predictions
MB34 (Existing Saraji Mine monitoring bore)	Predicted to run dry in 2032	Unit predicted to run dry in 2036 Groundwater recovery can be monitored in the long term A replacement monitoring bore is may be installed into the MCM interburden adjacent to MB35 in 2032 – in agreement with Saraji Mine.
MB33 (Existing Saraji Mine monitoring bore)	Predicted to run dry in 2029	Unit predicted to run dry It is considered that SEMLP2P will provide MCM groundwater monitoring, further down dip, in proximity to this bore. Based on SEMLP2P and predicted poor groundwater recovery it is not required to replace MB33 once it runs dry.
Alluvium bores: MB19SRM01A, MB20SRM04A, MB20SRM01A (MB20SRM01_PZ), and MB20SRM05A (MB20SRM05A_PZ)	Dry or not predicted to drawdown	Used to validate model predictions No longevity risks predicted
MB20SRM02T	Predicted to run dry (bore and Tertiary unit) after 2141	Long term groundwater monitoring can occur at this bore.
MB20SRM03P	Bore and unit not predicted to run dry	Long term groundwater monitoring can occur at this bore.
Proposed bore SEMLP1T	Bore and unit not predicted to run dry	Long term groundwater monitoring can occur at this bore.
Proposed bore SEMLP1P	Bore and unit not predicted to run dry	Long term groundwater monitoring can occur at this bore.
Proposed bore SEMLP2T	Bore and unit is predicted to run dry after 2085	Long term groundwater monitoring can occur at this bore.
Proposed bore SEMLP2P	Bore and unit not predicted to run dry	Long term groundwater monitoring can occur at this bore.

9.7.2 Surface cracking

The groundwater assessment, using predictive groundwater modelling and uncertainty analysis, identified that there is no discernible drawdown in the alluvium and no material impacts on surface water creeks are anticipated at any level of probability.

The assessment assessed the scenario of continuous vertical connectivity (cracks from surface and cracks upward from the goaf) over the shallowest panels (< 300 m deep) which will experience the largest subsidence. In addition, the surface cracks were assumed not to heal in the groundwater model, and to be pervasive over the mining footprint, thus the simulated effects of fracturing/cracking (upward from the goaf and downward from the surface subsidence) are highly conservative.

Although the alteration of the overlying geological units, due to longwall mining, have been assessed through a range of differing model layer parameters in the uncertainty analysis, BMA have included a subsidence monitoring program to actively manage surface cracks, thus reducing the potential for surface water – groundwater interaction.

Appendix K-2 Subsidence Management Plan includes the monitoring proposed to be undertaken as part of subsidence management. It also includes surface crack repairs. Monitoring of the Project area, including waterways within the Project area, will occur during the operational phase of the Project to identify cracks and assess the type/amount of work needed to repair individual surface cracks. Cracks obscured by alluvial sediment within waterways may not be able to be identified visually, however, any adverse environmental impacts that occur as a result of these cracks will be identified through other forms of monitoring (e.g. streamflow monitoring, groundwater monitoring, erosion monitoring, riparian vegetation monitoring, etc).

Surface assessment above the longwall panels will be conducted to identify smaller cracks (e.g. less than 50 mm) to determine if repair is required or if the safety and environmental risks associated with the smaller cracks are negligible. Areas disturbed by surface crack repair works will be monitored to ensure that they re-establish vegetation and achieve rehabilitation completion criteria.

BMA will adopt the following approach:

- Subsidence cracks in the landscape will be managed according to erosion risk and likelihood of self-repair / healing. Mechanical ripping and disturbance within the landscape will be limited and targeted to those areas of high erosion risk and low probability of self-repair.
- The basis for this approach is to minimise the risk of secondary erosion issues developing from land and vegetation disturbance associated with ripping and ploughing.

9.7.3 Groundwater monitoring plan

A groundwater monitoring program (GMP) will be developed to ensure an appropriate level of detail and scale. The purpose of the program will be to monitor the magnitude and distribution of actual changes to groundwater conditions in response to the Approved and Project mining and to provide early detection of any unforeseen impacts to groundwater levels, groundwater flows or groundwater quality. The selected groundwater monitoring bore network, to be included in GMP, will monitor potential effects of the proposed Project on overlying and underlying hydrostratigraphic units, so that informed management decisions can be made.

The fundamental components of the GMP are as follows:

- the monitoring network and subsequent monitoring program will be developed prior to the commencement of mining
  - baseline seasonal trends for groundwater levels and quality will continue to be compiled for the new monitoring bores installed in 2019 / 2020
  - data from Saraji Mine groundwater bores will be used, as included in this EIS report, to detail the current groundwater quality prior to the Project commencement
  - this groundwater quality data will be used as comparison with the groundwater quality data compiled during the Project (construction and operation) to assess potential impacts or alteration.

- where appropriate, groundwater level and quality data from existing monitoring bores will be incorporated into the monitoring data compiled in the GMP
    - as some drawdown impacts are predicted for registered bores, representative private bores (or new sentinel sites) are likely to also be incorporated into the monitoring bore network.
- site-specific groundwater quality will be monitored to determine additional bore specific trigger levels, evaluate spatial and temporal trends, and gauge whether water quality objectives are being protected or enhanced
    - an objective of the GMP will be to detect possible water quality change trends, which could materially change water quality (i.e., no longer able to meet WQOs or current use) due to the Project.
- there are no local springs or aquatic GDEs to monitor.

The GMP will include, based on the mines up dip and along strike of the Project are all owned and operated by BMA, opportunities to combine groundwater monitoring data, refine the regional Bowen Basin groundwater models and model predictions, and assess mining operations to evaluate potential cumulative impacts.

The more regional groundwater monitoring, which allows BMA to detect and monitor potential groundwater related cumulative impacts, will assist in developing mine operation and closure plans to avoid, minimise, or mitigate pre- and post-closure impacts.

9.7.4 Groundwater monitoring and sampling program

This section describes the groundwater monitoring program attributes to guide implementation before, during, and after the proposed mining activities. In accordance with an adaptive management approach, these monitoring attributes will be modified on an on-going basis to ensure optimal understanding of the groundwater regimes and the envisaged mining impacts.

It is important that a rigorous sampling protocol is followed to ensure representative parameters are measured, and due diligence is maintained in tracking of the samples and the results. Appropriate quality assurance and quality control (QA/QC) of samples and procedures will be implemented. All groundwater monitoring, water level measurements and sample collection, storage and transportation is to be undertaken in accordance with the procedures outlined by the DES Monitoring and Sampling Manual (2018) and the Murray Darling Basin Groundwater Quality Sampling Guidelines (1997).

The parameter suite for analysis for each groundwater sample is likely to include, but not limited to:

- pH, EC, and turbidity (field and laboratory determinations)
- TDS (laboratory analysis)
- anions - carbonate, bicarbonate, chloride, sulphate, fluoride (laboratory analysis)
- cations - calcium, magnesium, sodium, potassium (laboratory analysis)
- dissolved and total metals - aluminium, antimony, arsenic, iron, manganese, molybdenum, selenium, silver, mercury (laboratory analysis)
- nutrients - nitrate, nitrite, phosphorus, ammonia
- Total petroleum hydrocarbons (TPH)
    - TPH C_6 – C_{10}
    - TPH >C_{10} -C_{40}.

Appendix F-3 Groundwater Resources Technical Report details instrumentation and control.

9.7.4.1 Groundwater level monitoring

Groundwater level monitoring is the key parameter for assessing changes to the groundwater regime, particularly as the ‘make good’ agreements with landholders are typically predicated on a water level change.

At a minimum, groundwater levels within the groundwater monitoring network are reviewed annually. Most of the groundwater monitoring bores will have permanent groundwater level monitoring devices (automated water level loggers) installed. These data loggers compile water level data at a minimum weekly interval, with the data being downloaded and assessed on a regular basis (during groundwater sampling events).

Groundwater level monitoring is to continue through operations and post closure at selected representative groundwater monitoring points (providing representative assessment of groundwater level changes in the various hydrostratigraphic units). During post closure it is envisaged that the groundwater level data will provide recovery data, which will be compared to long-term model predictions.

Changes in quantity of groundwater (or availability of groundwater), flow volumes in hydrostratigraphic units, and interaction between groundwater and surface water features are primarily determined based on groundwater level/pressure levels and related changes in these levels.

Mining-induced changes in groundwater levels can be caused by the removal of groundwater from a hydrostratigraphic unit, changes in groundwater balances (due to land cover changes including backfilling), and pressure effects due to mine dewatering and depressurisation.

The primary indicator for groundwater quantity is, therefore, defined as the temporal change to groundwater level/pressure in a defined hydrostratigraphic unit at an established monitoring location.

As a result, groundwater levels will be assessed against the background data which has been collected to date. Comparison to established baseline conditions will be used to assess mine related influences.

9.7.4.1.1 Groundwater level triggers

The transient groundwater level data does not readily indicate the direct or indirect impact of mining on these bores, rather the data indicates complex response to wet and dry climate conditions in the different hydrostratigraphic units. The adopting of a simple 2 m per year fluctuation, as included in the Saraji Mine EA is not considered suitable for the Permian monitoring bores, based on these water level data trends, for the Project.

It is considered that the groundwater level monitoring data, across the groundwater monitoring bores proposed, be derived based on impact assessment and consideration of groundwater model predictions. The groundwater level predictions, considering surrounding projects and the Project, are included in **Appendix F-3 Groundwater Resources Technical Report**.

Based on the groundwater resource/s assessment, the potential indirect impacts of the SEMLP underground mining, and the groundwater model predictions (Section 9.7.1.2), the following groundwater level triggers have been compiled:

- No groundwater level triggers are included for the Permian units directly impacted by mining. This absence of water level trigger is based on the assessment that no sensitive receptor/s will be impacted by the resultant mining related drawdown.
    - No groundwater level triggers have been proposed for MB33, MB34, MB20SRM03P, SEMLP1P, and SEMLP2P.
- For shallow (surficial sediments) monitoring bores the investigation trigger is the 2 m per year variation (as included for Saraji Mine in Section 9.4.6). These surficial sediments are more readily influenced by seasonal changing climatic conditions. The trigger, noting several Saraji Mine monitoring bores increased more than 2 m, is set as a decline in water level more than 2 m within a year.
    - The 2 m per year variation trigger is derived for MB38 (MB19SRM01A), MB20SRM04A, MB20SRM01A (MB20SRM01_PZ), and MB20SRM05A (MB20SRM05A_PZ).
- For the Tertiary monitoring bores, MB20SRM02T, SEMLP1T, and SEMLP2T, the maximum predicted drawdown (in mAHD) from the model at these locations will be the investigation triggers.

- MB20SRM02T trigger level of 150 mAHD[1]
- SEMLP1T trigger level 148 mAHD[1]
- SEMLP2T trigger level of 151 mAHD[1].

The transient groundwater level monitoring data, will be corrected for barometric pressure, calculated in mAHD, and compiled into hydrographs. The groundwater level data trends will be compared, rate and amount of drawdown over time, to predictive modelling at regular intervals.

Groundwater level drawdown reaching water level triggers will instigate investigation, as per the groundwater Trigger Action Response Plans (TARP) (Section 9.7.5.3).

9.7.4.2 Groundwater quality monitoring

Groundwater samples have and will be obtained from the representative groundwater monitoring points, which have allowed for establishing representative groundwater chemistry concentrations and trends prior to the Project. The groundwater units monitored on site, based on the potential for mine activities to impact on these units, include:

- Quaternary alluvium
- Tertiary sediments
- Permian non-coal bearing strata
- Permian target coal seam.

The low-flow sampling method is to be adopted to minimise the volume of purge water to be managed while ensuring that samples collected are representative of the groundwater unit. Groundwater sampling is to be undertaken in accordance with the most recent edition of the DES Water Quality Sampling Manual, which allows for the collection of repeatable representative groundwater data.

9.7.4.3 Groundwater data analysis

Different methods exist for the assessment of groundwater monitoring data, one of which is the use of statistical tests for the development of indicator parameter limits. It is recognised that alternative methods exist, however, statistics honour natural data variability and facilitate tracking of quality and quantity trends. The groundwater level thresholds will be based on predictive groundwater modelling.

Once sufficient (statistical) groundwater dataset is available (a minimum of 18 sets of data within a 24 month period) and assessment of statistical trends for representative parameters within each new proposed groundwater monitoring bore will be derived. Trends can be identified, and follow-up investigations initiated per the approach outlined in Section 9.7.5. The intent of the investigative follow-up is to identify natural exceptions to the proposed trigger levels and contaminant limits and facilitate revision of the targets as per the adaptive management approach (i.e. an assessment of potential for environmental harm will be conducted and if it is found that the trigger levels are exceeded due to natural conditions (not mine related) then the limits are to be re-evaluated).

To identify potential drawdown impacts, the monitoring points will act as early warning and model prediction validation points, when assessing underground mine drawdown impacts.

9.7.5 Investigation and response processes

The administering authority will be notified within 24 hours of becoming aware of any water quality or water level trigger exceedance.

9.7.5.1 Hydrochemistry

Should any agreed groundwater quality trigger levels be exceeded, an investigation will be undertaken with 28 days to determine if the exceedance is a result of:

- mining activities authorised under the Project EA
- natural variation

[1] Estimate only - trigger level to be finalised upon drilling of bore and location determined

- neighbouring land use resulting in groundwater impacts.

If the investigation determines that the exceedance was the result of Project mining, then investigations will be undertaken to establish whether environmental harm has occurred or may occur.

This will include:

- the relevant monitoring point(s) will be resampled, and the samples analysed for major cations and anions, and selected dissolved metals
- if elevated concentrations (above trigger levels) are recorded on three consecutive sampling events then an investigation into cause, optimum response, and the potential for environmental harm will be conducted.

The results of the investigations will result in the development of appropriate responses.

9.7.5.2 Water levels

If groundwater levels decline in excess of the trigger levels defined through predictive modelling is identified, an investigation will be instigated within 28 days of detection.

The investigation will aim at determining if the fluctuations in groundwater levels are a result of:

- mining activities authorised under the Project EA
- pumping from licensed bores
- seasonal variation
- neighbouring land use resulting in groundwater impacts.

If the water level trigger exceedance is as a result of authorised Project mining activities, then BMA will notify the administering authority within 28 days and provide the following:

- details of whether actual environmental harm has occurred or is likely to occur
- any proposed mitigation measures required to address the affected groundwater resource
- proposed actions to reduce the potential for environmental harm.

9.7.5.3 Groundwater TARPs

Once sufficient baseline data has been compiled, water level and water quality, for the new and proposed Project groundwater monitoring bores then the site-specific groundwater TARP will be finalised.

Draft groundwater TARPS have been compiled and presented below.

Aspect	Normal state	Trigger 1	Trigger 2	Action
Groundwater quality	Groundwater quality within historic range for all parameters	Trigger: • Groundwater quality concentrations outside of the adopted trigger value for at least one parameter for more than three consecutive monitoring rounds. Response: • Repeat sampling. • Identify any potential contributing factors. • Investigate the source for the change in groundwater quality and whether it was caused by mining related activities.	Trigger: • Groundwater quality concentrations trending outside of the adopted trigger values for at least one parameter, for more than 12 months. Response: • Increase investigations to determine if the source for the change in groundwater quality is mining related. • Undertake additional monitoring until water quality improves or source/cause is identified.	Trigger 1: • Notify BMA management and DESI. Trigger 2: • Inform regulators of findings and mitigation measures.
Groundwater level	Groundwater level change within historical range or groundwater model predictions, based on climatic variation and mine plan / schedule.	Triggers: • Groundwater level triggers are exceeded on three (3) consecutive occasions, where the triggers include: - No groundwater level triggers are included for the Permian units directly impacted by mining. - For shallow aquifers the investigation trigger is a decline >2 m in a year. - For the Tertiary monitoring bores, the trigger is the maximum predicted drawdown in the Tertiary at the bore locations. Response: • Identify any potential contributing factors. • Investigate the source for the change in groundwater level and whether it was caused by mining related activities. • Use the monitoring water level data and recalibrate the predictive groundwater model to re-evaluate potential impacts, risks for environmental harm, and the need for mitigation	Trigger: • Groundwater levels do not recover after six months (water level or rate of drawdown). • Investigation into Trigger 1 identifies that change in groundwater level is due to mining-related activity. Response: • Implement appropriate mitigation and management measures, which may include advice from independent groundwater specialists. • Undertake additional monitoring of mitigation and management measures. • Review of hydrogeological modelling predictions.	Trigger 1: • Notify BMA management and DESI. Trigger 2: • Inform regulators of findings and mitigation measures.

Aspect	Normal state	Trigger 1	Trigger 2	Action
Groundwater inflows	Groundwater inflows consistent with modelled predictions	Trigger: • Groundwater inflow volume exceeds predictions by more than 10 per cent for three consecutive monitoring events. Response: • Review monitoring/inflow estimation methodology and validate inflow data. • Identify any potential contributing factors. • Investigate the source for the change in groundwater inflows and whether it is sourced from aquifers or a contribution from seepage through spoils.	Trigger: • Groundwater inflow volume exceeds predictions by more than 20% for three consecutive months. Response: • Review water balance for associated groundwater pit, including consideration of seepage through spoils. • Implement appropriate mitigation and management measures, which may include advice from independent groundwater specialists. • Undertake additional monitoring of mitigation and management measures. • Review of hydrogeological modelling predictions.	Trigger 1: • Notify BMA management and DESI. Trigger 2: • Inform regulators of findings and mitigation measures.
Downstream water users - surface water users and groundwater users	No complaints from downstream water users regarding loss of surface water or groundwater availability (quality and/or quantity)	Trigger: • Complaint/s from downstream water user/s regarding loss of water (surface and / or groundwater) availability (quality and/or quantity). Response: • Implement Complaints Management Protocol. • Review of relevant historical monitoring results (water quality and/or flow). • Identification of any potential contributing factors. • Investigate whether the change in water availability is due to mining-related activity. • Provide feedback to complainant.	Trigger: • Investigation into Trigger 1 identifies that change in downstream water availability is due to mining-related activity. Response: • Implement appropriate mitigation and management measures, which may include advice from independent water resource specialists. • Undertake additional monitoring of mitigation and management measures. • Provide compensatory water supply to any landowner whose water supply has been adversely and directly impacted.	Trigger 1: Notify BMA management and DESI. Trigger 2: • Inform regulators of findings and mitigation measures.

(Modified Glencore 2024)

9.7.6 Groundwater dependent ecosystems monitoring

Baseline data collection provides a basis for detection of unexpected declines in ecological condition of GDE subject to monitoring linked to mining related activities.

Consistent with the intent of the groundwater monitoring program, additional baseline conditions data collection will be undertaken prior to commencing mining to further characterise the seasonal ecohydrological function and baseline condition of terrestrial GDE associated with Hughes Creek downstream of the Project in the event unexpected impacts due to groundwater level changes are detected in future. Following collection of two years' baseline data, a review of requirements for ongoing monitoring would be undertaken, and methods tailored to the assessed level of risk to GDE function.

Groundwater Dependent Ecosystem Monitoring and Management Plan

Baseline data collection forms the basis of a Groundwater Dependent Ecosystem Monitoring and Management Plan (GDEMMP) providing protocols for:

1. Collection of further baseline ecological condition data (Biocondition and Leaf Area Index) for terrestrial GDEs associated with Hughes Creek downstream of the Project.
2. Prescriptive methods for GDE monitoring over the life of the mine and post mining periods tailored to the assessed levels of ongoing risk to GDE function.
3. Mitigations and methods of adaptive management to be implement if impacts to GDEs are detected and linked either directly or indirectly to mining operations associated with the Project or other mining operations. Possible mitigations include GDE avoidance (direct clearing), biodiversity offsets, habitat augmentation and injection of water into the tree root zone.

Existing Saraji systems and plans

In addition to groundwater level changes, terrestrial GDE may be impacted by changes to surface water volume and quality. The existing Saraji Mine Water Management System (WMS) described in **Chapter 8 Surface Water** will be operational during all stages of the Project, with the primary objective of minimising environmental harm. Implementation of the WMS, including the groundwater plan, and associated Erosion and Sediment Control Plan (ESCP) and Receiving Environment Monitoring Program (REMP), will be directly applicable to collecting data to inform and manage potential impacts to GDEs occurring within the influence of the Project. These management plans are introduced in **Chapter 8 Surface Water**.

The GDEMMP will remain a live document and provide the basis for ongoing management and detection of change and assessment of source of impact.

9.7.7 Data reporting

All documentation and information related to groundwater level and groundwater quality monitoring will be kept in a secure archive, and readily available to scrutinise against regulatory criteria and trigger levels. All calibration records, laboratory chain-of-custody forms, photographs, laboratory certificates, and laboratory reports should be up-to-date and archived. A dedicated groundwater monitoring database will be developed and maintained on at least a monthly basis to ensure compliance conditions are met and any impacts are detected as soon as practicably possible.

The groundwater monitoring program will be reviewed annually by a suitably qualified hydrogeologist to identify unforeseen potential impacts, update the monitoring schedule, and factor in any changes to the mine plan that could influence groundwater impacts.

9.7.7.1 Post-mining period

A post-mining monitoring program will be developed by a suitably qualified hydrogeologist towards the end of mining operations (e.g. within two years of mine closure). The program will be customised to address recovery of actual groundwater drawdown impacts observed during operation of the underground mine.

9.7.7.2 Future modelling

In case of future use of the Project model, updates could be conducted to further refine the model if it was deemed that an increase in model confidence level was required, but the applicability of this would be dependent on the purpose of the future modelling and availability of data to inform future changes. As it stands, the current model is deemed fit for purpose for the Project impact assessment.

9.7.7.2.1 Fitness for Purpose of Model Context

The groundwater model, based on the Project and use on numerous other mining activities within the Bowen Basin, is recognised (regulators and peer review) to be fit for purpose given the predicted risk to groundwater resources. Noting that the groundwater resources associated with alluvium and other hydrostratigraphic units do not allow for widespread groundwater use and are recognised not to provide a significant / useable freshwater resource (i.e., the alluvium at the Project is not a groundwater target like it is in other basins, such as the Condamine Alluvium in the Surat Basin).

In this context, this groundwater model is considered appropriate and fit for purpose. In addition, the model is not uncalibrated and includes 282 transient calibration points across the regional Bowen Basin scale model domain (refer to **Appendix F-1a** appendix response letter). Figure 2-9 of **Appendix F-1 Groundwater Modelling Technical Report** provides a spatial distribution of calibration residuals. This figure shows the location of the bores used in calibration as well as a spatial distribution of calibration error at each of those bores.

A review of the groundwater model against the Murray-Darling Basin Commission (MDBC) Groundwater Flow Modelling Guideline, issued in 2001, and guidelines issued by the National Water Commission (NWC) in June 2012 (Barnett et al., 20123) concludes that the groundwater model is “fit for purpose”, where the purpose was defined by the model objectives. The Project modelling objectives included:

- estimate the groundwater inflow to the Project mine workings as a function of mine position and timing
- simulate and predict the extent of groundwater level drawdown due to the Project
- identify areas of potential environmental risk, where groundwater impact management measures may be necessary.

The peer reviewer (**Appendix F-2 Groundwater Modelling Peer Review**) is of the opinion that the documented groundwater modelling is best practice and concludes that the model is fit for purpose, where the purpose is defined by the objectives above.

9.8 Residual impacts

9.8.1 Groundwater

Potential impacts to groundwater because of the Project have been considered in detail as part of this groundwater assessment. Residual impacts are anticipated in the short to medium term. These concern groundwater flow and height and are relative to the duration of dewatering. Beyond closure, groundwater aquifers will continue to flow into the Saraji Mine final voids until flows occur at a steady state. During this period the loss of water from the Tertiary and Permian aquifers are not expected to have a significant impact on beneficial use or natural ecosystem values. Saraji Mine has been operating since the 1970s and groundwater resources adjacent to the mine do not indicate material impact to groundwater levels or yields.

The groundwater model was used to provide a prediction of long-term groundwater level variation and recovery assuming Saraji Mine open-cut operations will cease at the end of 2031 (when the open-cut pits reach the ML boundaries) and all underground mining will cease at the end of 2042; this in line with the current open-cut approvals and the proposed Project life of mine.

The model predicted marked recovery of groundwater levels for the first 100 years following cessation of underground mining, followed by slow recovery. Predictive modelling indicates groundwater system will reach equilibrium approximately 1,800 years post-mining due to:

- recovery is slowed drawdown because of on-going extraction (through evaporation) from the open-cut final voids
- the marked groundwater rebound is considered to occur within the goaf and underground workings until water reaches the open-cut final voids

- limited rainfall recharge over the region
- the long term mine dewatering (since 1974) has resulted in groundwater being removed from storage which needs to be replaced
- high evaporation (due to large final void areas) is expected to remain after 2031 (across the approximately 22.5 km strike length of the open-cut mine)
- low permeability within the sediments surrounding the open-cut pits.

Groundwater is predicted to rebound following cessation of mining in 2042, but the rate of recovery is influenced by the natural limited groundwater resources and mechanisms plus the final voids in the Saraji Mine open-cut pits. During the slow recovery to equilibrium, approximately 1,800 years post-mining, deeper groundwater levels are recognised as residual impacts which will reduce available drawdown (water column within neighbouring bores within the zone of influence of the Project). Reduced available drawdown can reduce the bore capacity (extraction volumes and bore yields).

Assessment of the impacts on existing groundwater bores concluded it is unlikely that the Project will have any material impacts on existing groundwater users.

9.8.2 Groundwater dependent ecosystems

Potential impacts to GDE due to the Project were considered in detail within **Appendix D-2 Groundwater Dependent Ecosystems Assessment**. With implementation of management measures, which includes development of suitable mitigations should impacts to GDE be identified, the risk to GDE posed by mine development is ‘Low to Insignificant’.

9.9 Summary and conclusions

9.9.1 Environmental values

The Project is located on the western limb of the geological Bowen Basin and is underlain by Quaternary and Tertiary sediments, which overlie the Permian strata, which hosts the target D seam. The sediments across the Project are generally undisturbed and gently dip approximately 8 degrees to the east.

The alluvium comprises irregular sequences of unconsolidated clay, silt, sand, and gravel. The alluvium aquifer is not a permanent source of groundwater in the non-perennial creeks across the Project. The alluvium associated with the larger Phillips Creek includes monitoring bores, which contain groundwater in places. The records of dry bores indicate the alluvium have limited storage and do not readily store groundwater, are non-continuous, and have variable groundwater quality (ranging from fresh to saline).

The Tertiary aged sediments in the Project Site maintain permanent groundwater particularly within the deeper basal sediments; these basal sands are locally extensive but regionally discontinuous. Minor groundwater ingress into the Saraji Mine pits indicates that the Tertiary sediments comprise a series of poorly connected low to moderate permeability aquifers. Tertiary groundwater quality ranges from slightly acidic to slightly alkaline and is dominated by sodium and chloride with TDS more than 6,000 mg/L. This means the water is brackish to saline and exceeds the recommended level for cattle, however, could still be useful in times of drought or for mixing with fresher water sources.

The Permian overburden/interburden sediments comprise sandstone, siltstone, and shale. The Permian coal seams comprise the main groundwater units, where the cleats and fractures within the coal provide enhanced groundwater potential. Permian coal seam groundwater ranges from slightly acidic to alkaline and is dominated by sodium and chloride with TDS levels ranging from 3,300 mg/L to 20,000 mg/L. The coal seam water is brackish to saline and typically not suitable for stock watering.

The land use surrounding the Project is predominantly coal mining and cattle grazing. Given that TDS for the Tertiary and Permian sediments are generally above 5,000 mg/L, the regional groundwater would generally not be considered suitable for livestock. However, the water could be useful if mixed with fresher water sources or in times of drought.

Based on the low groundwater yield potential and typically poor quality groundwater resources in the Project Site, groundwater environmental values are restricted to include limited stock watering and industrial purposes (coal mine operations).

Terrestrial GDEs, along the Phillips Creek and to the east of the Project lease area along Hughes Creek, are not predicted to be impacted by the Project as they are associated with the alluvium. There are no known aquatic GDEs. No known springs are present within the Project Site.

From a hydrogeological perspective. The assessment of available groundwater resources (potential and chemistry) indicates that the only recognised groundwater use within the Project area is stock watering.

9.9.2 Mining alteration

9.9.2.1 Mining

Groundwater impacts from the approved open-cut operations and the Project underground mining was modelled by SLR in 2023. Given that the underground mine and open-cut mine are intrinsically linked through drawdown contour overlap, operational scheduling overlap and proximity, impacts from underground mining were assessed by simulating continuous operation of the open-cut and underground mining operations. This approach means that drawdown contours and impacts from underground mining were considered as cumulative impacts with the Saraji Mine open-cut mining.

The predictive groundwater modelling also included a no mining within the region model scenario. This scenario aided in the evaluation of predicted cumulative drawdown impacts.

9.9.2.2 Longwall mining impacts

To estimate mine impacts and estimates of groundwater ingress from underground longwall mining activities, aquifer alteration due to mining (longwall goaf) was taken into consideration. Longwall mining results in collapse and alteration of the overlying rock strata. The collapse propagates upwards from the extracted seam until the tensile strength of the rock is sufficient to hold up the overburden without failure. Where propagation extends to the land surface, subsidence of the land surface occurs.

Subsidence modelling simulated the effect of bed separation, opening of joints and the formation of new cracks in the originally intact overburden rock mass. Changes in stress and the induced deformation in the surrounding rock mass associated with rock fracture and bedding plane separation were predicted. These predictions included:

- When overburden thickness is less than 300 m above the target D coal seam, the subsidence modelling results show continual volumetric strain and rock mass damage in the overburden strata extending from longwall edge to the surface.
- When the overburden thickness is more than 300 m, the results indicate that the fractured zone extends to above 30 m to 50 m above the Harrow Creek seam with the overlying units undamaged.

In the Groundwater Assessment, the groundwater modelling assumed that any change to hydraulic conductivity and storage properties of the units predicted to be affected by subsidence remained over the period of model simulation, (i.e., there is no ‘self-sealing’ of subsidence fracturing over time). This approach is considered to be conservative given that the overlying Tertiary sediments, particularly those at the surface zone, swell and self-seal over time, and therefore any surface cracks fill with sediments reducing their hydrological effect over time. This phenomena is recognised in the Bowen Basin, as evident at the Goonyella Broadmeadow Riverside Mine complex, where water ponding occurs above subsided areas.

This approach ensures that any change to hydraulic and storage properties in the model remain. Even adopting this approach no impact on alluvium or surface water resources is predicted.

9.9.3 Potential impacts

Predictive groundwater modelling was conducted to assess the potential impacts of the proposed longwall mining. The modelling looked at mine dewatering impacts (groundwater ingress and groundwater level drawdown) considering the approved mining within the regional model with and without the Project. Predictive simulations, including an evaluation of groundwater level drawdown, the prediction of groundwater ingress, and an evaluation of groundwater level recovery was conducted using the predictive model.

Predictive modelling of groundwater level drawdown resulting from the Project indicated:

- no impact on alluvium groundwater resources is predicted due to the Project

- the drawdown predictions in the Tertiary are influenced by the distribution of saturated zones. At the northern panels, 1 m drawdown influence is predicted to extend 4.2 km northeast of the Project mine workings
- the extent of maximum predicted incremental drawdown impacts in the Moranbah Coal Measures coal seams are generally elongated along strike in the northwest-southeast direction and extents maximum of 5 km and 8 km northwest and southeast of the Project mine extent, respectively.

The inflows at the Project are predicted to reach a maximum peak in mine year 16, of 500 ML/year (1.4 ML/day). The average inflow rate for the Project is estimated at 183 ML/year (0.5 ML/day). This impact is not considered to be significant due to the absence of privately owned bores in the drawdown areas.

Impacts of the mine dewatering associated with the proposed underground workings, considered in connection with the approved Saraji open cut operations, are considered low for the following reasons:

- Surface water creeks in the area are ephemeral and groundwater levels (more than 17 m below surface) are below the level that would provide baseflow to existing alluvium or to root zone of plants, with the potential exception of incised creek channels of Hughes and Boomerang Creeks where groundwater may be closer to the surface.
- Groundwater level drawdown will occur predominantly within the Permian coal seams, which are separated from surficial groundwater regimes by aquitards and are not expected to impact surface ecosystems, with the potential exception of terrestrial GDEs associated with Hughes Creek.

It is unlikely significant dewatering impact will occur on the non-perennial creeks, which drain across the Project. No Project related impact to Phillips Creek is predicted. The potential environmental impacts of the Project are considered low as:

- the surface water system at the Project is ephemeral and limited surface water-groundwater interaction is evident, particularly related to GDE
- the alluvium is of limited extent, discontinuous and dry in most bores
- Tertiary sediments often have insufficient yield/low recharge potential indicating low permeability and low potential for usage
- The Project is not predicted to impact on the Isaac River to the east
- groundwater quality is not suitable for drinking, too deep for Terrestrial ecosystems at the Project footprint, and is often too saline for livestock watering
- the surface water systems are separated from the predicted impacted groundwater resources by low permeable self-sealing Tertiary sediments, which reduce the potential for the Project to impact on surface water flows.

Only one landholder water supply bore is located within the predicted drawdown as a result of the Project. This registered bore, RN132631 (duplicate RN136689) is 328 m deep and is complete within the Fort Cooper Coal Measures. No predicted induced drawdown, from the Fort Copper Coal Measures to the target Moranbah Coal Measures, due to interbedded low permeable aquitards is predicted as a result of the Project.

9.9.4 Uncertainty

To verify or validate the predictions, a Type 3 Monte Carlo uncertainty analysis (IESC, 2018) was undertaken to estimate the uncertainty in the potential impacts predicted by the model. This uncertainty analysis method generates numerous alternative sets of model input parameters to the groundwater flow model.

9.9.4.1 Predictions

Modelling of underground mines requires assumptions as to the degree of fracturing above the mined coal seam and the enhancement of permeabilities and storage properties in the fracture zone. As the longwall panel width is broad (320 m) and the cutting height is high (3.6 m), a substantial vertical fracture zone is to be expected. A separate subsidence assessment by Minserve (2022), based on FLAC-3D geotechnical modelling, provided estimates of the degree of subsurface fracturing and surface cracking, as well as estimates of enhanced permeabilities and porosities. These predictions were used to assess potential impacts on alluvium and surface water systems. The uncertainty analysis allowed for the evaluation of possible impacts across a range of aquifer parameters.

The alteration of rock parameters due to longwall mining was adopted in the groundwater model, based on the subsidence model predictions. The fracture zone is taken to merge with the cracking zone for D-seam depths of cover less than 300 m, giving continuous vertical connectivity over most of the southern panels and the western half of the northern panels.

As surface cracks are assumed not to heal in the groundwater model, and to be pervasive over the mining footprint, the simulated effects of fracturing/cracking are highly conservative (**Appendix F-2 Groundwater Modelling Peer Review**). The approach to increase the hydraulic conductivity in the fracture zone during the uncertainty analysis adds to the degree of conservatism.

The conclusions derived, therefore, include consideration of possible impacts on alluvium groundwater resources and surface water across a range of aquifer (rock parameter) parameters and conclude that:

- there is no discernible drawdown in the alluvium at any level of probability
- no material impacts on Isaac River or the overlying Boomerang Creek are anticipated at any level of probability.

9.9.4.2 Faulting

As faults can act as barriers or conduits to groundwater flow, which can influence ingress and groundwater drawdown, the nature of the faulting was assessed through model calibration and uncertainty analysis.

As per industry best practice, if the nature of a fault, or other hydraulic feature, is unknown, then the parameterisation of the fault should be sufficiently large to capture all plausible conceptualisations. This is the practice employed within the groundwater modelling, and development of the calibrated ensemble; in particular, the allowed parameter ranges during calibration allowed representation of the fault as a full barrier, full conduit, and all possibilities in between.

Calibration of the hydraulic conductivity of the fault was allowed during the calibration process and in the numerical uncertainty assessment of the model.

The predictive results incorporate the possibility of faults being barriers, conduits, and / or both. This modelling approach allowed for the assessment of the fault/s influence on groundwater ingress and drawdown.

9.9.5 Surface cracks

The groundwater assessment, using predictive groundwater modelling and uncertainty analysis, identified that there is no discernible drawdown in the alluvium and no material impacts on surface water creeks are anticipated at any level of probability.

The assessment assessed the scenario of continuous vertical connectivity (cracks from surface and cracks upward from the goaf) over the shallowest panels (< 300 m deep) which will experience the largest subsidence. In addition, the surface cracks were assumed not to heal in the groundwater model, and to be pervasive over the mining footprint, thus the simulated effects of fracturing/cracking are highly conservative.

Although the alteration of the overlying geological units, due to longwall mining, have been assessed through a range of differing model layer parameters in the uncertainty analysis, BMA have included a subsidence monitoring program to actively manage surface cracks, thus reducing the potential for surface water – groundwater interaction.

9.9.6 Long-term groundwater levels

Groundwater levels within the Project are predicted to recover to 176.5 mAHD in the long term, the comparison of groundwater recovery levels in the Project and long-term levels associated with the Saraji Mine post-closure indicates groundwater flow will be towards the final void where the Coolibah / Dogwood final void water level is predicted to be 7 to 24 mAHD, which is > 100 m lower than surrounding recovered groundwater levels.

Long term groundwater levels are therefore predicted to be influenced by the Saraji Mine final voids, which act as groundwater 'sinks' because of water loss through evaporation. This generation of deep water levels below the alluvium and Tertiary age sediments and within the target coal seams, results in localised cones of drawdown immediately around the final voids.

9.9.7 Management measures

A GMP will be developed for the Project, which will allow for the validation of model predictions and allow for the instigation of investigations into potential for environmental harm should groundwater monitoring results differ from predictions.

To ensure the collection of representative groundwater monitoring data, allow for the assessment of the potential predicted impacts of the Project on local groundwater resources, and consider the existing groundwater monitoring bore network, additional monitoring bores are required prior to the Project mining activities.

The assessment indicates significant, long-term impacts on groundwater will not result from the Project.

9.9.7.1 TARPs

Preliminary site-specific groundwater triggers have been compiled to assist in mitigating and managing potential Project impacts on the groundwater resources (see Section 9.7.5.3).