



CHAPTER 5 – GROUNDWATER

NEW LENTON COAL PTY LTD
NEW LENTON COAL PROJECT

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5. GROUNDWATER

5.1 Introduction

This chapter describes the groundwater setting of the Project; outlines the environmental values relating to groundwater in the Project area, including groundwater dependent ecosystems (GDEs) and stygofauna; assesses the potential impacts from the Project on those environmental values; and outlines management measures and mitigation strategies. Based on the hydrogeological information for the Project and surrounding areas, a conceptual groundwater model has been developed which has informed the development of a numerical groundwater model.

The information in this chapter is based on the following reports:

- Groundwater Impact Assessment undertaken by SLR Consulting Australia Pty Ltd (SLR) provided in **Appendix 8**
- Independent Peer Review of the New Lenton Project Numerical Groundwater Model provided in **Appendix 9**
- Groundwater Dependent Ecosystem Assessment undertaken by 3D Environmental (3D) provided in **Appendix 10**
- Stygofauna Pilot Study Report undertaken by frc environmental (frc) provided in **Appendix 11**.
- Groundwater Dependent Ecosystem Monitoring and Management Plan undertaken by 3D provided in **Appendix 19**.
- Groundwater Dependent Ecosystem Habitat Quality Monitoring Program undertaken by AARC Environmental Solutions Pty Ltd (AARC) provided in **Appendix 20**.
- Assessment of Potential for Stygofauna Retention and Operational Phase Stygofauna Monitoring Program undertaken by SLR (formerly frc) provided in **Appendix 21**.
- Groundwater Monitoring and Management Plan undertaken by SLR provided in **Appendix 22**¹.
- Aquatic Groundwater Dependent Ecosystem Field Assessment undertaken by AARC provided in **Appendix 27**.

It addresses the relevant information required by the public environment report (PER) guidelines for the Project as they relate to groundwater, GDEs and stygofauna (refer to **Appendix 16**).

5.2 Relevant Legislation, Policy and Guidelines

5.2.1 Commonwealth

A Referral for the Project, under the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act) was lodged on 23/09/2020 (EPBC 2020/8778). On 22/10/2020, the delegate for the Minister for the Environment determined that the Project was a controlled action for water resource, in relation to coal seam gas development and large coal mining development (sections 24D & 24E).

The Project will be referred to the Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development (IESC) to assess the Project against the IESC Guidelines (IESC 2018). **Appendix 17** details how the relevant IESC Guidelines were addressed in relation to groundwater.

¹ The proponent notes that the same Groundwater Monitoring and Management Plan has also been provided as Appendix G to Appendix 8 (the Groundwater Assessment). The GMMP is provided as a standalone document in Appendix 22 for ease of reference.

5.2.2 State

5.2.2.1 Environmental Protection Act 1994

The proponent holds an environmental authority (EA) EPML00475513 under the *Environmental Protection Act 1994* (EP Act) for the Project's mining leases (MLs) (**Appendix 4**). An EA amendment application for the Project was submitted to the Queensland Department of Environment and Science (DES) in October 2019 in accordance with the requirements of the EP Act. The EA amendment was granted in January 2021. All Project related activities are conditioned by this EA, including the management of potential impacts to groundwater under Schedule D of the EA, with conditions summarised in Table 5-1.

Table 5-1 EA Conditions Relevant to Groundwater

EA Condition - Summary	Commentary
D1 – D3 relate to a baseline groundwater monitoring program to be implemented prior to the commencement of a Groundwater Management and Monitoring Program.	A baseline groundwater monitoring program has been implemented at the Project in accordance with the EA requirements.
D4 – D11 relate to monitoring of groundwater quality and levels against trigger levels for contaminants and levels, as well as notification and investigation procedures if required	As the Project has not commenced there are no impacts to groundwater quality and levels for comparison against trigger levels. The EA requires that additional information is required to define the pre-mining baseline groundwater levels and level trigger thresholds. Data developed for this PER will contribute to the development of pre-mining baseline groundwater levels and level trigger thresholds.
D12 – D13, D16 relate to standards for bore construction and groundwater monitoring and sampling	Bore construction and groundwater monitoring and sampling are undertaken in accordance with the relevant standards.
D14 – D15 require a Groundwater Management and Monitoring Program (GMMP) and an Annual Groundwater Monitoring Report (AGMR)	The GMMP is provided as Appendix 22², and described in Section 5.10.3. The EA requires that the GMMP is required 90 days prior to commencement of mining activities and hence the current GMMP has been prepared in advance of the EA requirement. The AGMR is required after the first year of mining activities.

5.2.2.2 Environmental Protection (Water and Wetland Biodiversity) Policy 2019

The *Environmental Protection (Water and Wetland Biodiversity) Policy 2019* (EPP Water) provides a framework to protect and/or enhance the suitability of Queensland waters for various beneficial uses. Groundwater resources within the Project area lie within the Isaac River catchment as listed in Schedule 1 of the EPP Water. The EPP Water provides water quality objectives (WQOs) to protect the various environmental values identified for waters within the Isaac River catchment which may include aquatic ecosystems, irrigation, farm supply, stock water, primary recreation, drinking water, and cultural and spiritual values. The groundwater WQOs for the Isaac River catchment are provided in *the Isaac River Sub-basin Environmental Values and Water Quality Objectives Basin No. 130 (part), including all waters of the Isaac River Sub-basin* (DES 2011) according to their chemistry zone and depth category. These guidelines were used in the formation of approved groundwater quality limits specified in the EA, which the Project will utilise to protect environmental values. Section 5.5.12 presents the groundwater quality data relevant to the Project and Section 5.10.3 provides the groundwater quality limits.

5.2.2.3 Water Act 2000

The water resource planning process under the *Water Act 2000* (Water Act) provides a framework for the development of catchment specific Water Plans. A Water Plan, along with Water Management Protocols, Resource Operations Licences and associated operations manuals, provides a management framework for water resources in a plan area, and includes outcomes, objectives and strategies for maintaining balanced and sustainable water use in that area. The Project area is located in the Isaac Connors Groundwater

² The proponent notes that the same GMMP has also been provided as Appendix G to Appendix 8 (the Groundwater Assessment). The GMMP is provided as a standalone document in Appendix 22 for ease of reference.

Management Area (GMA) under Schedule 3 of the *Water Plan (Fitzroy Basin) 2011* area. The potential impacts from the Project on groundwater resources are addressed in Section 5.8.8.

The Water Act regulates the taking and use of surface water and groundwater. The proponent does not propose to take surface water or groundwater for use in mining, other than associated water (groundwater inflows into the pit area). Holders of a ML are able to take or interfere with underground water in the area of the licence or lease where the taking or interference happens during the course of, or results from, the holder's authorised activities (associated water). Prior to changes to the Water Act in 2016, ML holders were required to hold a water licence for the take of associated water. The proponent holds an associated water licence (AWL) number 623885 for the New Lenton MLs, granted in May 2021 by the Department of Regional Development, Manufacturing and Water (DRDMW). The AWL is provided in **Appendix 6**. All requirements of the AWL will be complied with for the Project including any additional make good obligations and groundwater monitoring requirements identified in the groundwater assessment undertaken for this PER.

5.3 Methodology for Assessment, Field Work and Data Analysis

5.3.1 Groundwater Fieldwork

Numerous field programs, developed to address key areas of uncertainty in regards to groundwater, have been carried out for the Project, including hydrogeological field campaigns in 2014, 2018, 2020 and 2023. This PER incorporates the results of all past hydrogeological field campaigns. Each field program sought to build upon the previous programs and address residual gaps identified in the available information and dataset. The Project field programs have included:

- hydrogeological drilling campaigns
- hydraulic testing
- geophysical surveys
- surface water surveys
- GDE field studies
- routine groundwater level monitoring and groundwater quality sampling.

A hydrogeological investigation of the Project area and surrounds was reported in 2014. The report described the site's geology and hydrogeology, including documenting the installation of a groundwater monitoring bore network and recommendations for additional monitoring bore locations. Drilling and installation of an additional nine monitoring bores was reported in 2018. These bores were installed to augment the existing monitoring bore network that was established. The report documented the drilling and installation of groundwater monitoring bores, and lithology encountered during drilling. A drilling program was conducted in 2019 to install groundwater monitoring bores screened in the alluvium, regolith and Leichhardt / Vermont coal seams, targeting areas not covered in the 2014 or 2018 drilling campaigns, particularly in areas close to the Isaac River on the eastern boundary of the Project area. Most recently, additional bores were installed in 2022 in the alluvium of the eastern tributaries of the Isaac River for the adjacent Burton Mine monitoring network.

Groundwater hydraulic testing includes slug (rising and falling head) tests performed on Project monitoring bores in 2014 and 2019. Most recently in 2023 slug testing of Project monitoring bores installed in 2019 was undertaken to inform the PER groundwater assessment (**Appendix 8**).

An electromagnetic geophysical survey was conducted in 2019 to better characterise the alluvium in the riparian zones of the Isaac River (see Section 5.4.2). Five transects perpendicular to and intersecting the Isaac River were conducted. The transects were aligned with existing drilling data, including one which aligned with five bores from the 2019 drilling campaign in order to tie in the geophysical data with drillhole data.

Surveys undertaken by Burton Coal Mine personnel in July 2023, following a period of rains, confirmed no areas of pooling along the Isaac River. Furthermore, dry season ground-truthing for aquatic GDEs has (see

Sections 5.3.7 and 5.6.6) also identified groundwater does not discharge to the surface or maintain surface pools.

5.3.2 Groundwater Desktop Study

A search of relevant databases was undertaken to identify the presence of current and historical groundwater bores (see Section 5.6.2). A review of available groundwater reports, literature and groundwater studies (within the vicinity of the Project area and within comparable geological and environmental settings) was undertaken to support and refine the conceptual understanding of the local and regional groundwater regime.

5.3.3 Groundwater Monitoring Data

Routine groundwater level and quality monitoring has been conducted on all Project monitoring bores since 2014. As new bores have been installed in ongoing drilling campaigns, routine monitoring has commenced at those new bores.

The Project groundwater monitoring network that resulted from the field programs described above is presented in Table 5-2 and shown in Figure 5-1. Also provided in Table 5-2 is an indication of the data availability from each bore in the monitoring network to inform the groundwater assessment. Baseline water quality and level monitoring has been generally undertaken at quarterly intervals over the time periods identified in Table 5-2, while level monitoring from some bores equipped with loggers has been undertaken at minimum of daily readings.

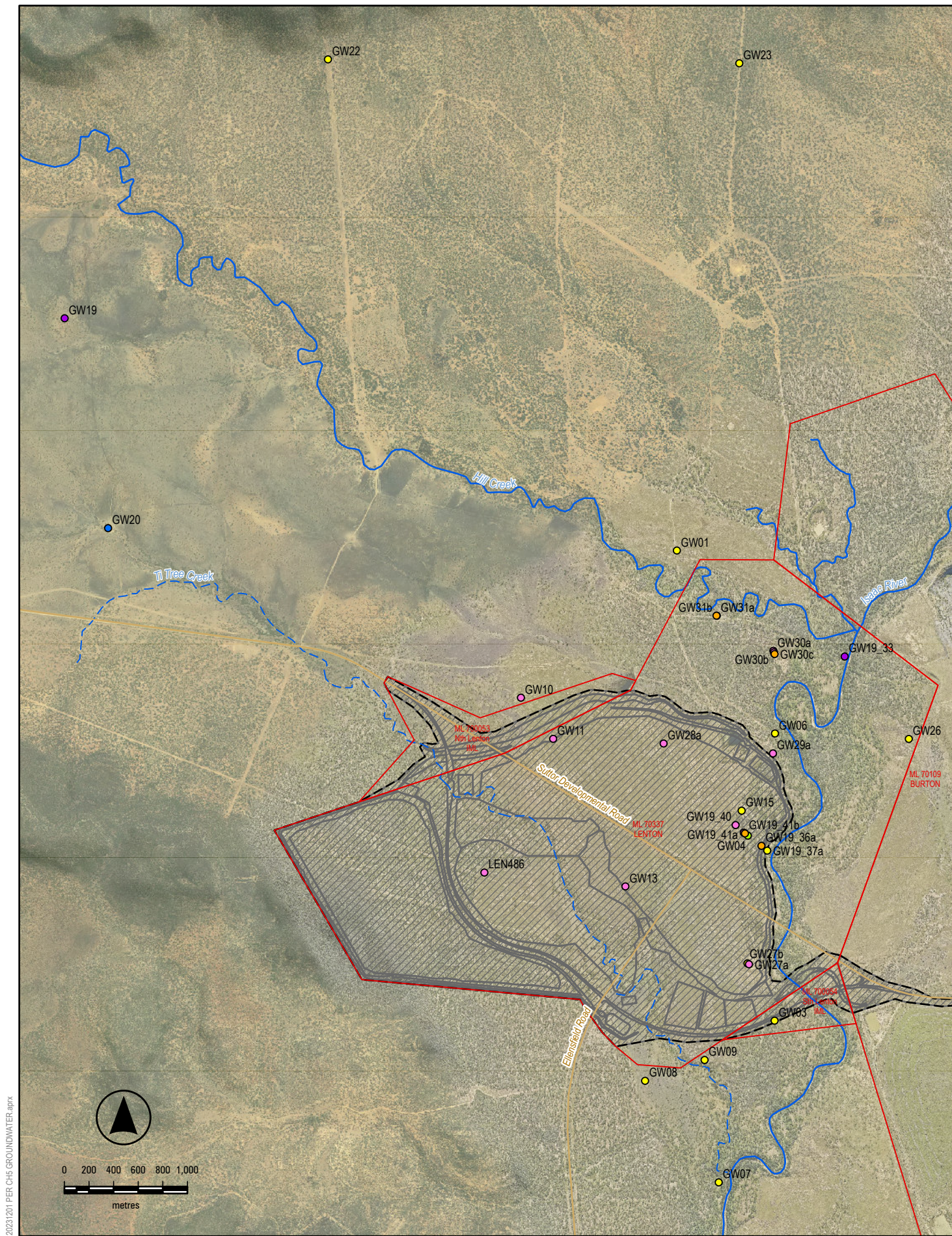
Given the close (adjacent) proximity of the Project to the Burton Mine, monitoring bores for the neighbouring Burton Mine have been incorporated into the PER groundwater assessment. The groundwater monitoring network at Burton includes 46 current and historic monitoring bores, as shown in Section 5.9 of **Appendix 8**.

Table 5-2 Groundwater Monitoring Network

Bore	Easting (GDA94 z55)	Northing (GDA94 z55)	Alternate Name	TOC (mAHD)	Bore Depth (mBGL)	Screen Interval (mBGL)	Monitored Unit	Water Quality Data	Water Level Data	status
GW01	617299	7618210	LEN489WB	326.8	15.2	6.17 – 12.17	Alluvium	2014 - 2018	2014 - 2023	Active
GW03	618094	7614389	LEN494WB	307.6	12.1	3.1 – 12.1	Alluvium	-	-	dry
GW04	617876	7615892	LEN490WB	311.3	16.8	13.8 – 16.8	Burton Rider/ weathered sandstone	2014 - 2019	2014 - 2023	Decommissioned
GW06	618097	7616723	LEN491WB	313.9	20.6	3.6 – 18.6	Alluvium	2014 - 2020	2014 - 2023	Active
GW07	617640	7613075	LEN492WB	299.5	24.5	9 – 18	Alluvium	2014 - 2023	2014 - 2023	Active
GW08	617041	7613900	LEN493WB	306.7	11.7	5.72 – 8.72	Alluvium	-	2019 - 2023	Active
GW09	617525	7614070	LEN495WB	307.1	24	6 – 18	Alluvium	2014 - 2018	2014 - 2023	Active
GW10	616032	7617014	LEN502WB	335.2	205.1	178.16– 190.16	Leichhardt / Vermont Seam	2014 - 2023	2014 - 2023	Active
GW11	616294	7616680	LEN499WB	332.3	150	114 – 126	Leichhardt / Vermont Seam	2014 - 2023	2017 - 2023	Active
GW13	616881	7615480	LEN505WB	319.3	192.4	170.5 – 179.5	Leichhardt / Vermont Seam	2014 - 2023	2017 - 2023	Active
GW15	617826	7616095	LEN504WB	312.8	13.5	9.5 – 12.9	Alluvium	-	-	dry
GW19	612323	7620097	LEN501WB	376.7	26.5	22.9 – 25.9	Alluvium/Weathered Sandstone	2014 - 2014	2014 - 2017	dry

Bore	Easting (GDA94 z55)	Northing (GDA94 z55)	Alternate Name	TOC (mAHD)	Bore Depth (mBGL)	Screen Interval (mBGL)	Monitored Unit	Water Quality Data	Water Level Data	status
GW19_33	618664	7617348	LEN540WB	312	16	11.1 – 12.6	Alluvium/Regolith	2019 - 2023	2019 - 2023	Active
GW19_36a	617987	7615810	LEN538WB	310	17	10.5 – 13.5	Weathered Sandstone (Rewan)	-	2019 - 2023	Active
GW19_37a	618034	7615771	LEN539WB	309.6	26	16.5 – 20.0	Alluvium	2019 - 2023	2019 - 2023	Active
GW19_40	617777	7615979	LEN541WB	311.6	86	65.0 – 78.5	Leichhardt Vermont Seam /	2019 - 2023	2019 - 2023	Active
GW19_41a	617843	7615917	LEN542WB	311.3	56	44.0 – 50.0	Leichhardt Vermont Seam /	2019 - 2023	2019 - 2023	Active
GW19_41b	617853	7615911	LEN543WB	311.3	17.5	14.25 – 17.25	Weathered Sandstone (Rewan)	2019 - 2023	2019 - 2023	Active
GW20	612676	7618392	LEN500WB	355.5	33.9	24 – 30	Basalt	2014 - 2015	2014 - 2017	Active
GW22	614463	7622201	LEN496WB	401.7	11.6	5 – 8	Alluvium	-	-	dry
GW23	617807	7622169	LEN498WB	369.9	11.6	5 – 8	Alluvium	-	-	dry
GW26	619185	7616679	LEN503WB	315.7	9.6	6 – 9	Alluvium	-	-	dry
GW27a	617885	7614847	-	310.7	173	134 – 170	Girrah Seam	2018 - 2020	2018 - 2023	Active
GW27b	617873	7614855	-	310.9	19.1	7 – 19	Alluvium	-	2019 - 2023	Active
GW28a	617192	7616641	-	318.6	206	194 – 203	Leichhardt Vermont Seam /	2018 - 2020	2018 - 2023	Active

Bore	Easting (GDA94 z55)	Northing (GDA94 z55)	Alternate Name	TOC (mAHD)	Bore Depth (mBGL)	Screen Interval (mBGL)	Monitored Unit	Water Quality Data	Water Level Data	status
GW29a	618081	7616561	-	313.6	83.6	62 – 80	Sandstone	2019 - 2023	2018 - 2023	Active
GW30a	618084	7617395	-	318.5	112.2	97 – 109	Leichhardt Vermont Seam	2018 - 2023	2018 - 2023	Active
GW30b	618088	7617382	-	318.5	76.2	70 – 73	Burton Rider Coal Seam	2018 - 2023	2018 - 2023	Active
GW30c	618094	7617368	-	318.2	31.1	23 – 29	Weathered Sagittarius Sandstone	2018 - 2023	2018 - 2023	Active
GW31A	617624	7617680	LEN523WB	321.9^	165.2	153 – 162	Leichhardt Vermont Seam	2018 - 2023	2018 - 2023	Active
GW31b	617621	7617680	LEN524WB	321.9^	21.2	17 – 20	Weathered Sandstone	2018 - 2023	2018 - 2023	Active
LEN486	615735	7615593	Lenton	325.9^	129.8	117.8 – 126.8	Leichhardt Vermont Seam	2014 - 2023	2017 - 2023	Active
^ Ground level										



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LEGEND

- Mining Lease
- Roads
- Watercourse
- Non-designated Watercourse
- Proposed Disturbance Area
- Project Layout

Monitored Unit

- Alluvium
- Alluvium/Regolith
- Basalt
- Burton Rider/Regolith
- Permian
- Regolith

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Groundwater Monitoring Network

5.3.4 Groundwater Numerical Modelling

5.3.4.1 Overview

Significant groundwater modelling simulation work has previously been completed for the Project. A groundwater model was developed by GHD in 2019 as part of a Project groundwater assessment for the EA amendment application (See Section 5.2.2.1). The 2019 numerical groundwater model underwent subsequent audit including a peer review. Further numerical modelling was then undertaken in 2020 to support the EA amendment process and the application for the AWL for the Project (see Section 5.2.2.3). The 2020 version of the numerical model has therefore been accepted by the State of Queensland for multiple environmental approvals for the Project.

Never-the-less, for the purposes of this PER and during the early stages of the groundwater assessment, feedback on the 2020 numerical groundwater model was provided by an independent peer reviewer engaged by the proponent. The peer reviewer acknowledged that the 2020 model was generally fit for purpose for the PER, however the following areas for potential improvement were identified:

- Geological heterogeneity apparent in the alluvium near the Project area could be better captured by revised model parameterisation (the use of pilot points in the alluvium was suggested).
- Calibration validation or re-calibration with history matching to data collected post-2019 would be advantageous.
- Uncertainty analysis methods adopted in the modelling should be updated to conform with current leading practice as documented within the IESC's own guidelines.
- Uncertainty in post-mining recovery modelling should be considered, as recommended in recently released Queensland State guidelines.

It was therefore decided to undertake a revision and update of the 2020 numerical groundwater model for the purpose of this PER. The subsequently updated 2023 numerical groundwater model is reported in Appendix D of **Appendix 8** and is the version of the model used to support this groundwater assessment.

5.3.4.2 Independent Peer Review

An independent peer review of the numerical groundwater model was undertaken by Manewell Groundwater (see **Appendix 9**). The peer review concluded that the model is fit for purpose, where the purpose is to produce a calibrated groundwater model up to 2023, and that the ensemble of predictive models are fit for purpose for use as a decision support tool to predict future impacts due to open cut mining at the Project.

5.3.4.3 Model Objectives

Numerical modelling was undertaken to assess the potential impacts of the Project's mining activities on the local groundwater regime. The objectives of the modelling were to:

- predict the incremental and cumulative drawdown in the groundwater system
- predict water take from the groundwater system
- predict the incremental and cumulative change in groundwater levels at identified groundwater users (i.e. registered bores, landholder bores, or GDEs) due to the proposed mining
- predict incremental changes in baseflow along the Isaac River due to the proposed mining
- predict incremental changes in alluvial water resources due to the proposed mining
- estimate groundwater inflows to the mining voids
- determine where groundwater impact mitigation/control measures may be required.

The predictions are required for the incremental impacts of the proposed mining at the Project, and for cumulative impacts considering both the Project and adjacent Burton Mine.

5.3.4.4 Model Design

The updated model was developed based on the updated conceptual groundwater model (see Section 5.5.13). Numerical modelling was undertaken using MODFLOW-USG, which is considered an industry standard.

Conceptualisation of the groundwater regime and the calibration of the model against observed data are key to achieving a reliable numerical model. Conceptualisation is a simplified overview of the groundwater regime (i.e. the distribution and flow of groundwater) based on available data and experience. Consistency between numerical model results and the conceptual understanding of the groundwater regime increases the credibility of the numerical model predictions.

The model domain is shown in Figure 2-1 of Appendix D of **Appendix 8**. The model extent was designed to be large enough to incorporate the Project and Burton Mine and to prevent boundary influence on model mining drawdowns.

5.3.4.5 Model Calibration

The updated numerical model includes a steady state and a transient calibration (1998 to 2023). A detailed description of the calibration procedure is provided in Appendix D of **Appendix 8**. The transient calibration captures historical mining at Burton Mine. Calibration of the model was carried out with the objective being to replicate the groundwater levels measured in the Project's and Burton Mine's monitoring networks, and other available observations including government and historical mine-monitoring bores, in accordance with Australian Groundwater Modelling Guidelines (Barnett et al., 2012).

The model achieved a scaled root mean square (SRMS) error of 10.7%. While there is no universally recommended SRMS error guidelines, the Australian Groundwater Modelling Guidelines suggests that setting SRMS targets as 5 or 10% may be appropriate in some circumstances. The peer review (**Appendix 9**) concluded that the model is reasonably well calibrated, and the likelihood of future predictions appear reasonable.

5.3.4.6 Model Performance and Limitations

The latest version of the IESC Explanatory Note for Uncertainty Analysis (Peeters and Middlemis, 2023) introduces a new concept on how model confidence can be assessed. The document also indicates that this change will follow in the next iteration of the Australian Modelling Guidelines and the new concept for assessing model confidence is hence applied for this model.

The latest version of the IESC Explanatory Note for Uncertainty Analysis defines a model fit for purpose when model results are usable, reliable and feasible. In order to assess these three points above, the four sources of scientific uncertainty (structural, parametrisation, measurement error, predictions) have been qualitatively assessed for key aspects of the groundwater model, as presented in Table 6-2 of **Appendix 8**. Overall, the model is considered fit for purpose to achieve the proposed objectives.

5.3.4.7 Uncertainty Analysis

A Type 3 Monte Carlo uncertainty analysis was undertaken in accordance with IESC Guidelines to estimate the uncertainty in the future impacts predicted by the model. This method operates by generating numerous alternative sets of input parameters to the deterministic groundwater flow model (realisations), executing the model independently for each realisation, and then aggregating the results for statistical analysis. A full description of the uncertainty analysis is provided in Section 6.8 and Appendix D of **Appendix 8**. Uncertainty analysis was conducted for:

- groundwater inflows during active mining
- post-mining residual void inflows
- groundwater drawdown during active mining
- groundwater drawdowns post-mining
- drawdown at landholder water supply bores

- influence on alluvium and surface water flow.

The uncertainty analysis was a key component of the independent peer review of the numerical groundwater model (see **Appendix 9**). The peer review concluded that the uncertainty analysis is robust and likely overstates expected impacts determined at the higher percentiles, and therefore stakeholders can have confidence that the model is a reasonable predictor of future mining impacts.

5.3.5 Groundwater Dependent Ecosystems

5.3.5.1 Overview

This section describes the methodology for the assessment of GDEs. The ecohydrological setting of the Project area was informed by the groundwater impact assessment (**Appendix 8**), terrestrial ecology impact assessment (**Appendix 12**) and publicly available data on potential GDEs (see Section 2 of **Appendix 10**).

The mapping of potential GDEs has been completed at a national level by the Bureau of Meteorology (BOM) which has produced the GDE Atlas (BOM 2020). The BOM GDE layer has been compiled with national scale datasets and rules to describe the potential for groundwater interaction and is not suitable for site specific GDE assessment. Potential GDEs from the BOM GDE Atlas are shown in Figure 11 of **Appendix 10**.

To assess any temporal changes in vegetation along the Isaac River that may have resulted from groundwater drawdown at Burton Mine, an analysis of aerial imagery adjacent to the Isaac River was undertaken using imagery from before any mining in areas adjacent the Isaac River (i.e. before 2003), during mining, and after mining ceased when a residual void was formed. These areas are located approximately 2 km upstream of the Project and hence provide a benchmark for temporal change in potential GDE areas over time.

GDE Assessment areas were identified based on hydrogeological information, ecological information and desktop data on potential GDEs. Field surveys were undertaken over a six day period from 20 February to 25 February 2023.

5.3.5.2 GDE Assessment Areas

The survey focused on areas mapped as potential aquatic and terrestrial GDEs in the GDE Atlas (BOM 2020) which are associated with woody vegetation occupying creek channels, floodplain vegetation and vegetation associated with older residual surfaces. In total, 13 sites (Figure 5-2) were chosen for targeted GDE assessment, to provide representative coverage of the major vegetation types, landform elements and drainage systems that have potential to demonstrate groundwater dependence.

The emphasis for survey was placed on those habitats which are mapped as ‘high potential’ GDEs in the BOM GDE Atlas, although field sampling included moderate and low potential areas, as well as areas where no groundwater dependence was indicated, particularly Ti-Tree Creek where a drainage diversion is planned.

For the ease of data interpretation, assessment sites were sub-divided in distinct creek catchments or localities with specific landform affinities:

- Isaac River
- Ti-Tree Creek
- Hill Creek and other northern tributary streams
- older residual landforms.

5.3.5.3 GDE Survey Techniques

Within each GDE Assessment area various techniques were employed to assess the presence of GDEs:

- Leaf water potential (LWP) was measured pre-dawn (prior to sunrise). Measurement of LWP pre-dawn gives an indication of the water availability to trees at each assessment site and provides an indication as to whether trees are tapping saturated zones of the soil profile where water is freely

accessible, or utilising moisture that is more tightly bound to soil particles. Leaves were collected from three to five mature canopy trees within each assessment site for LWP measurements.

- A hand auger was utilised to collect shallow soil samples at regular depths down the soil profile at selected sites, as well as opportunistic sampling of groundwater where it was intersected. Soils were sampled at regular intervals down a soil profile for measurement of soil moisture potential (SMP), with sampling interval dependent on the degree of structural and lithological heterogeneity. Soil sampling was undertaken for analysis of stable isotopes of oxygen ($\delta^{18}\text{O}$) and deuterium ($\delta^2\text{H}$)
- At each site chosen for auger sampling, the aim was to collect soil samples to the maximum depth of the auger penetration. Within each auger hole, the following observations were taken at regular depth intervals or where changes to soil structure were apparent:
 - soil structure, colour, and texture
 - presence of root matter
 - soil moisture / water and areas of saturation.
- A comparison was undertaken between the stable isotope ratios of water contained in plant xylem (from a twig or xylem core) with stable isotope ratios found in the various sources of water including a shallow groundwater table, potential sub-artesian aquifer water sources or shallow soil moisture. Water samples were collected from selected monitoring bores and shallow groundwater intercepted in soil augers. The analysis of stable isotope composition was undertaken at a specialist laboratory.

Detailed information on these techniques is provided in Section 3 of **Appendix 10**.

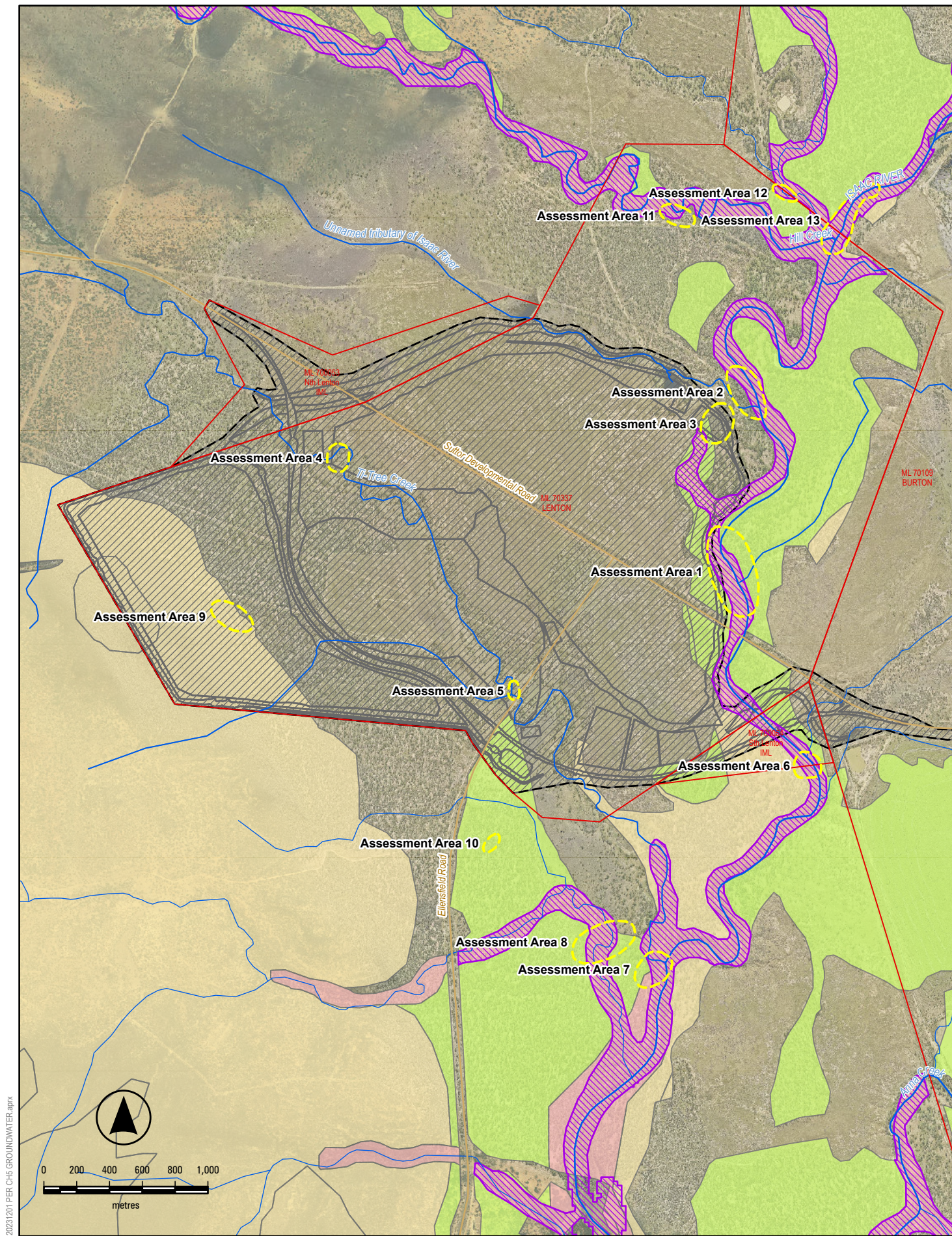
Trees may utilise water from a range of sources including the phreatic zone (saturated zone), the vadose zone (unsaturated zone) and surface water. The stable isotopes of water, oxygen 18 (^{18}O) and deuterium (^2H) are useful tools to help define the predominant source of water used by terrestrial vegetation. The method relies on a comparison between the stable isotope ratios of water contained in plant xylem (from a twig or xylem core) with stable isotope ratios found in the various sources of water including a shallow groundwater table, potential sub-artesian aquifer water sources or shallow soil moisture.

5.3.5.4 Data Interpretation

Interpretation of the data was used to determine the presence of GDEs. Data interpretation followed a structured approach in which multiple lines of evidence were filtered to provide an assessment of groundwater dependence. The biophysical measurement of LWP formed the primary assessment, followed by the adjunct comparison with SMP, with stable isotope data used to provide supplementary evidence. In addition, an overview of depth to groundwater table and groundwater salinity was completed as a final filter, to determine the accessibility of groundwater and suitability as a source of moisture to support transpiration at each assessment area. The approach is described below, and in more detail in Section 3 of **Appendix 10**.

- Step 1 – LWP. An initial comparison was undertaken to identify individual trees with LWP measurements within the expected range for known terrestrial GDEs subject to various salinity regimes. Trees that demonstrated LWP values that were more negative than expected ranges for the local groundwater salinity regime were considered not to be groundwater dependent and not subject to additional scrutiny, other than for comparative purposes.
- Step 2 – SMP. For trees where LWP was within the expected range of values for GDEs under specific local salinity regimes, an assessment of SMP from the auger profile was undertaken to identify the likelihood that moisture for transpiration was being supplied from the upper soil profile, or from a deeper source of moisture. This does not provide an absolute assessment of groundwater dependence, but identifies potential sources of moisture to provide context to assessment of stable isotopes.
- Step 3 – stable isotope signatures. For trees that demonstrate potential groundwater dependence from LWP measurements, stable isotope signatures from the xylem samples were compared to signatures from groundwater, surface water from any residual pools, and soil moisture (where this data was available) to provide a fingerprint for the source of moisture being utilised.

Where three lines of evidence indicated utilisation of a groundwater source, the tree was generally accepted as being groundwater dependent. Where ambiguity remained in the assessment, additional features were considered including site specific geology, geomorphology, soil physical properties, groundwater salinity, and depth to water table at the location to inform the final assessment of groundwater dependence for any tree or site.



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- LEGEND**
- Mining Lease
 - Roads
 - Watercourse
 - Proposed Disturbance Area
 - Project Layout
 - Lenton Assessment Areas

- Aquatic GDE**
- High potential GDE - from national assessment
- Terrestrial GDE**
- High potential GDE - from national assessment
 - Moderate potential GDE - from national assessment
 - Low potential GDE - from national assessment

5.3.6 Stygofauna

5.3.6.1 Desktop Data

A desktop review was used to determine the suitability of groundwater ecosystems of the Project area to provide habitat for stygofauna on the basis of geological, hydrological and water quality characteristics of local groundwater ecosystems, and included:

- review of previous studies to determine the recorded presence of stygofauna in the Project area and surrounds, and more broadly in the Isaac River sub-catchment
- review of hydrogeological data for the Project area, and
- review of groundwater pH, electrical conductivity (EC) and total dissolved solids (TDS) data within and surrounding the Project area.

5.3.6.2 Stygofauna Field Survey

Fifteen bores within and surrounding the Project area were surveyed for stygofauna from 14 – 16 December 2022, as shown in Figure 5-3. Detailed information on survey methods is provided in **Appendix 11**.

Stygofauna surveys were undertaken in accordance with the methods described for a stygofauna pilot study in the Guideline for the Environmental Assessment of Subterranean Aquatic Fauna (DoSITIA 2015), see also the DES's Water Monitoring and Sampling Manual (DES 2018) and supplementary document 'Sampling Bores for Stygofauna AEMF046'.

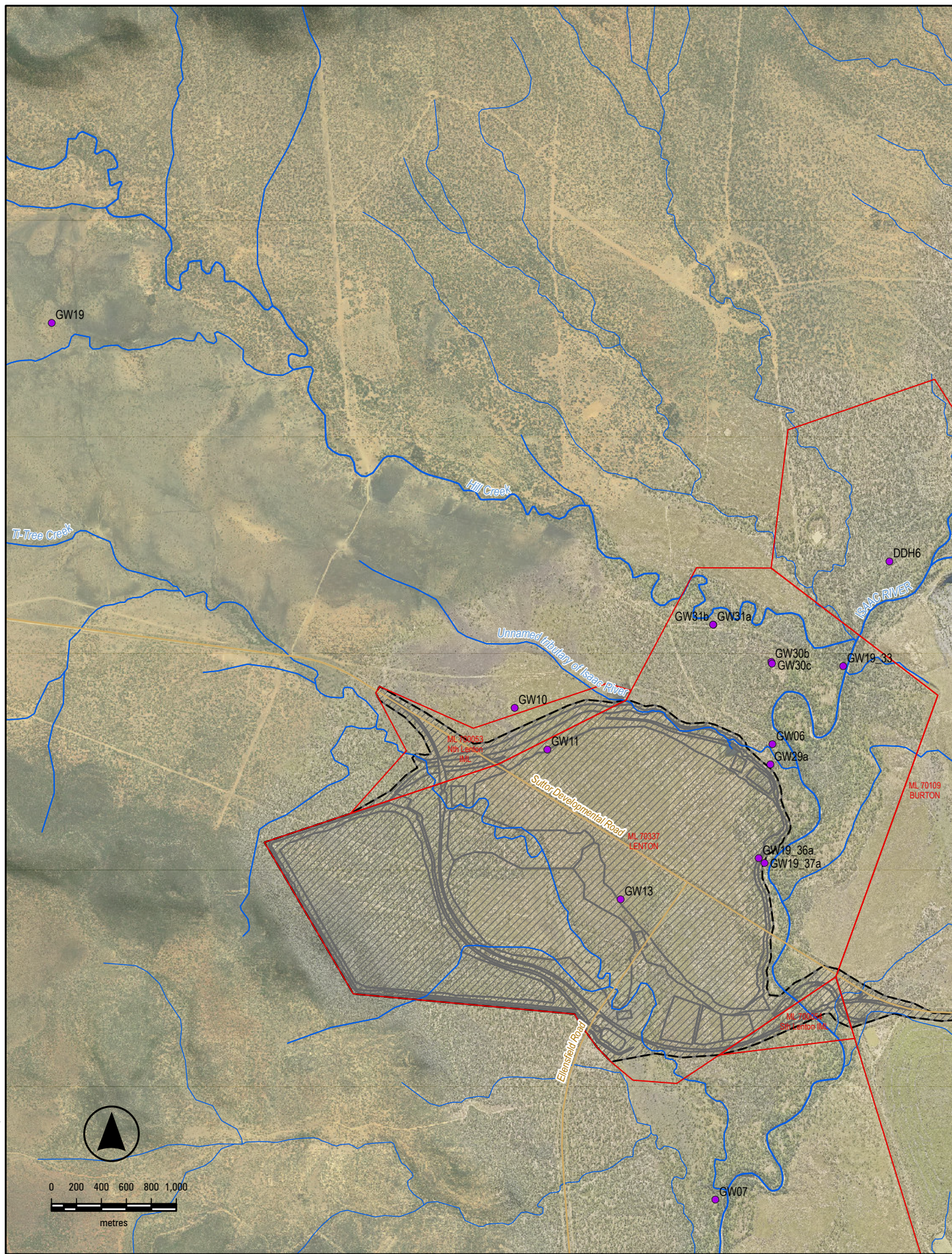
5.3.7 Aquatic GDE Field Assessment

An aquatic GDE field assessment was conducted between in September 2024, as described in **Appendix 27**. The assessment methodology involved thoroughly exploring, on foot, the pre-designated survey area, comprising all creeks and river systems potentially impacted by the Project (i.e. Isaac River, Ti-Tree Creek, unnamed tributaries of the Isaac River). A comprehensive examination was undertaken along the riparian zones of the Isaac River and its tributaries the objective of recording visual observations, if any, of the following:

- standing water
- saturated sediments, and
- changes in vegetation condition or vegetation type (e.g. aquatic plants or wetland plant species)

The assessment was conducted along the main channel of the creek and river systems within the survey area. For the Isaac River, this included the low-flow channel and the terraces where backwater might accumulate during flow events. Topographic low points along the survey area were specifically targeted as they have the potential to hold water.

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LEGEND

- Mining Lease
- Roads
- Watercourse
- Proposed Disturbance Area
- Project Layout
- Monitoring Bore

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Bores Sampled for Stygofauna

Figure | 5-3



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5.4 Geology

5.4.1 Overview

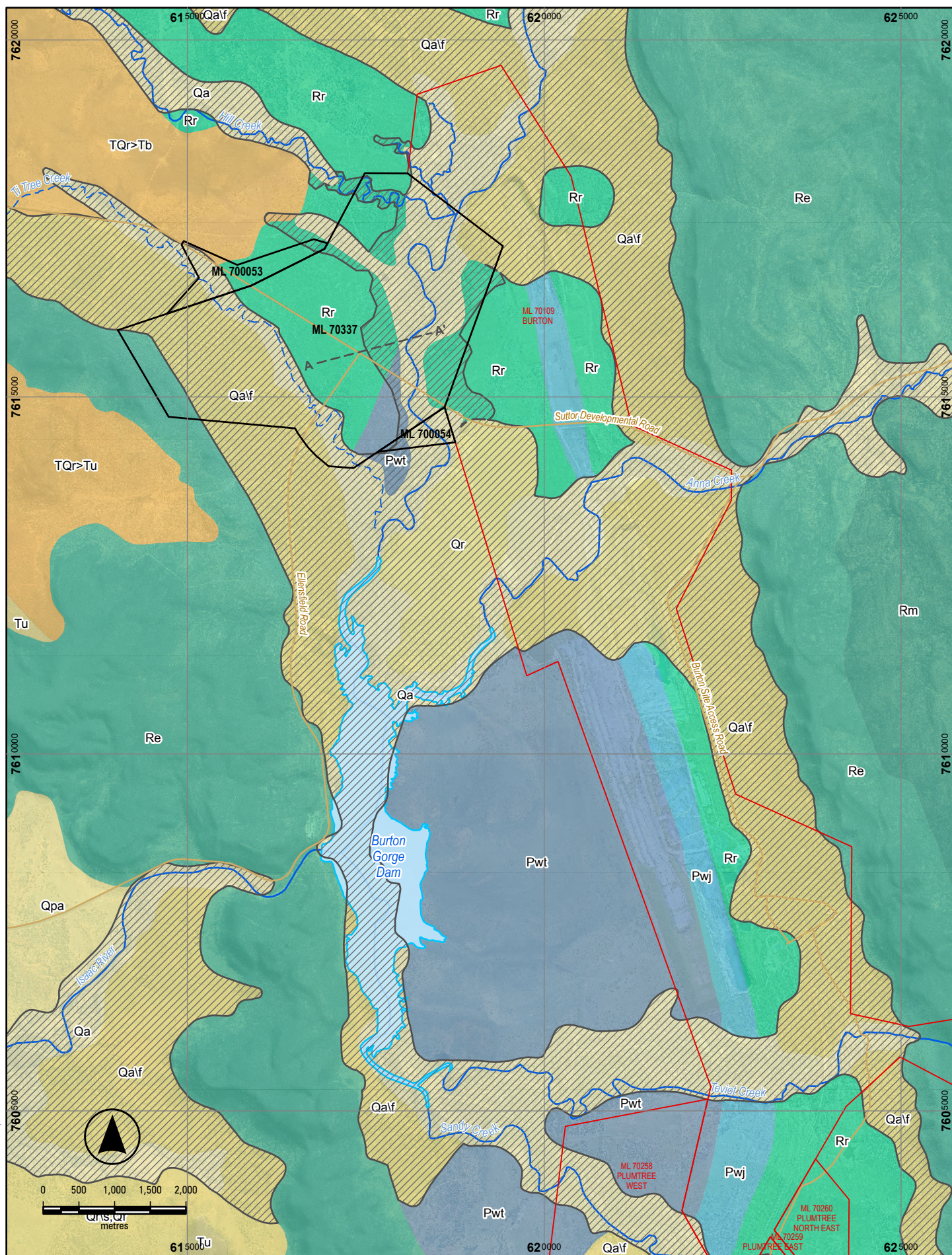
The geology of the Project area is summarised in Chapter 3 with additional information provided in this chapter.

The surficial geology and underlying solid geology in the vicinity of the Project area is shown in Figure 5-4 and Figure 5-5, respectively.

The local geology (and hydrogeology) can be divided into three main units:

- the Quaternary to Tertiary sediments (including alluvium) and weathered horizons (regolith);
- Rewan group; and
- the Permian coal measures bedrock.

The thickness and extent of these units is shown in Section 4.2 of **Appendix 8**.



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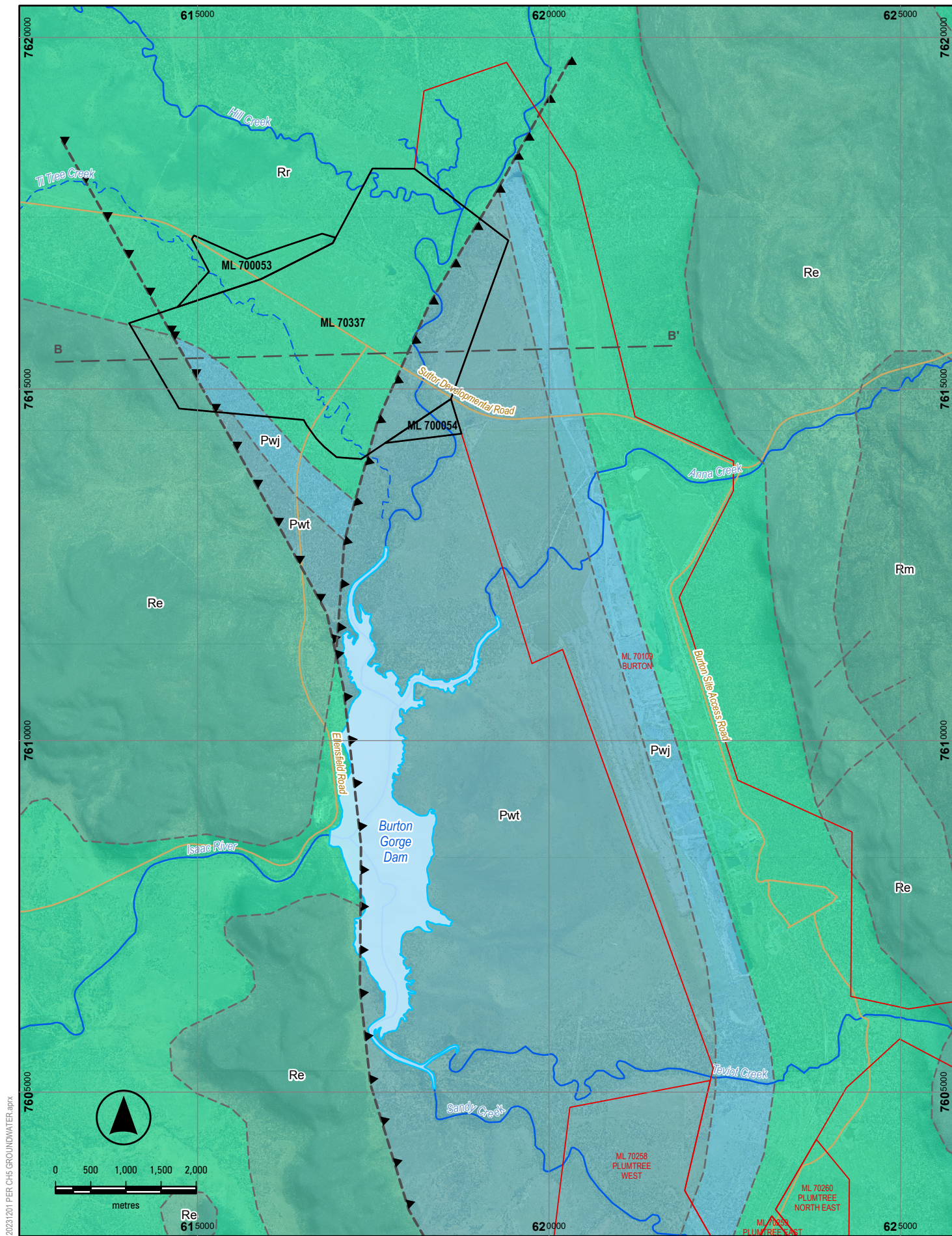
	New Lenton Mining Leases		Qaif-QLD (Qaif)
	Mining Lease		Qpa-QLD (Qpa)
	Watercourse		Qr-QLD (Qr)
	Non-designated Watercourse		Qris-QLD, Qf-QLD (Qris, Qf)
	Cross Section A-A'		Rangai Coal Measures (Pwj)
	Refined Extent of Alluvium		Rewan Group (Rr)
	Clematis Group (Re)		Suttor Formation (Tu)
	Fort Cooper Coal Measures (Pwt)		TQr-QLD>Suttor Formation (TQr>Tu)
	Moolayember Formation (Rm)		TQr-QLD>Tb-QLD (TQr>Tb)
	Qa-QLD (Qa)		

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Surface Geology

Figure | 5-4



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 Drawn: RA (Source: SLR)



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LEGEND

- | | |
|----------------------------|--|
| New Lenton Mining Leases | Fault |
| Mining Lease | Thrust Fault |
| Roads | Clematis Group (Re) |
| Watercourse | Fair Hill Formation, Fort Cooper Coal Measures (Pwt) |
| Non-designated Watercourse | Moolayember Formation (Rm) |
| Cross Section B-B' | Rangal Coal Measures, Bandanna Formation, Baralaba Coal Measures (Pwj) |
| | Rewan Group (Rr) |

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Solid Geology

5.4.2 Quaternary to Tertiary Sediments and Regolith

Regional geological mapping (Figure 5-4) shows that alluvium is localised along river channels. Quaternary floodplain alluvium associated with surface watercourses is comprised of clay, silt, sand, and gravel sediments. The thickness of the alluvium is greater close to the Isaac River channel and decreases with distance from the River. Borehole logs from targeted investigation drilling indicate that along the floodplain of the Isaac River and its tributaries, alluvium thickness ranges from less than 10 m up to 21 m. From bores drilled in the Isaac River alluvium and from hand auguring investigations (as part of the GDE assessment, refer to Section 5.6.3), it was observed that there is significant lithological heterogeneity in the alluvium with adjacent bores exhibiting variations in lithology with depth. The lithology of these deposits are described as clay, sandy clay, clayey sand, sand, gravelly sand and gravel.

An electromagnetic survey was conducted by GeoDiscovery (2019) to further assist in characterising the alluvium, and in particular its textural heterogeneity. The transects were aligned with existing drilling data to aid in verifying the geophysical data. This electromagnetic survey showed that the majority of the near surface (0 – 20 m depth) horizon identified as alluvium in surface mapping is of low to moderate resistivity, indicating a dominance of clay and weathered sediments over sand and gravel deposits. Only some areas close to the Isaac River riverbed or within the meander belt show high resistivity indicating a dominance of sand and gravel deposits.

These results are interpreted to indicate that the area mapped as ‘alluvium’ in State regional surface geology mapping is highly heterogenous, with the coarser grained alluvial sediments (that might form an aquifer) not as widespread as surface geology mapping suggests. On the basis of the assessment, it is apparent that mapped alluvial deposits are dominated by clay-based sediments with low hydraulic conductivity. The presence of higher hydraulic conductivity sediments only in the immediate proximity of the Isaac River channel is supported by hand auguring investigations (refer to Section 5.6.3) along the Isaac River channel and its tributaries which showed the dominant lithologies to be fine to medium sand, coarse sand and clayey sand. The site mapped alluvium, incorporating the results of the electromagnetic survey have resulted in the revised modelled extent of the alluvium shown in Figure 5-4.

The regolith in the Project area is mainly comprised of shallow Tertiary to Quaternary age colluvium and residual soils, derived from weathered underlying Triassic and Permian bedrock strata. The depth of weathering is variable across the Project area ranging from 10 m to 50 mBGL, with an average of approximately 25 mBGL. The thickness and extent of the regolith material has been interpolated based on Project area geological data and regional geology mapping.

5.4.3 Basalt

Tertiary age basalt flows outcrop to the north-west of the Project area. According to drillhole data, the Tertiary basalts include fresh, fractured and weathered layers with a thickness of up to 40 m. Due to its limited and isolated occurrences to the north-west of the Project, the Tertiary basalt has not been identified as a geologic unit of significance to the Project and its limited distribution north-west of the Project area, suggests it is not a key regional geologic unit.

5.4.4 Triassic Age Strata

Triassic age strata within and adjacent the Project area consists of the Moolayember Formation, Clematis Group, and the Rewan Formation. The Moolayember Formation consists of micaceous lithic sandstone and micaceous siltstone and conformably overlies the Clematis Group. The Clematis Group comprises medium to coarse-grained cross bedded quartzose to sublabile micaceous sandstone, siltstone, mudstone and granule to pebble conglomerate. The Clematis Group conformably overlies the Rewan Formation.

Both the Moolayember Formation and Clematis Group have been significantly eroded within the Project area, such that the Moolayember Formation is absent from the Project area and the Clematis Group is only present in the very west of the Project area. The Rewan Formation is a lithic sandstone (Sagittarius Sandstone) with a clayey matrix interbedded with mudstones and siltstones with scattered carbonaceous

plant material. The average thickness of the Rewan Formation is 440 m within the Project area although there is significant structural control of the unit resulting in reduced thickness towards the east of the Project area. The Rewan Formation unconformably overlies the Permian age Rangal Coal Measures over the majority of the Project area and surrounds. The contact is poorly defined between the Rewan Formation and underlying Rangal Coal Measures within the Project area, with no distinct visual, chemical or physical marker that highlights the transition in rock facies that can be used to identify the contact, either in the field or through geophysical logging.

5.4.5 Permian Coal Measures

The Rangal Coal Measures are the uppermost unit of coal-bearing strata in the Bowen Basin and the primary resource target within the Project area. Mining target seams within the Rangal Coal Measures include the Burton Rider seam and the Leichhardt / Vermont coal sequence (Leichhardt Upper and Leichhardt Lower, Vermont Upper and Vermont Lower seams). On the eastern side of ML 70337 the Rangal Coal measures dip steeply to the northwest and subcrop near the Isaac River beneath the alluvium/regolith. Drilling logs for bores near the Isaac River show coal seams within the Rangal Coal Measures subcropping beneath the weathered Rewan Group.

East of the Project area at the northern extent of the Burton Mine east of the Isaac River, the Leichhardt and Vermont seams coalesce to form the Burton Seam. The typical thickness of the Burton Rider and Leichhardt / Vermont sequence is 1 to 2 m and 8 m (including 2 m of ash and tuff partings), respectively. The two sequences are separated by an average of 20 to 25 m of non-coal interburden comprised of sandstone, siltstone and minor mudstone. The thickness and extent of the Leichhardt/Vermont seams based on site geological models, geological mapping and drill holes is presented in Figure 4-6 of **Appendix 8**.

The Rangal Coal Measures are underlain by the Fort Cooper Coal Measures, with coal seams of the respective formations separated by an average thickness of approximately 99 m of interburden. The Yarrabee Tuff is a regional marker unit defining the transition from the Rangal Coal Measures to the Fort Cooper Coal Measures. The main seam of the Fort Cooper Coal Measures is the Girrah Seam that is typically 30 m thick and has a high ash content. The Girrah Seam is not a target seam for the Project.

5.5 Hydrogeology

5.5.1 Overview

Extensive groundwater investigations undertaken within and surrounding the Project area have contributed towards defining the hydrostratigraphy in the vicinity of the Project area, as shown in Table 5-3. The four main aquifers identified at the Project are:

- Quaternary alluvium, where saturated, associated with the creeks and Isaac River
- Regolith where saturated (mainly comprised of weathered bedrock)
- Tertiary basalt aquifers, and
- Permian fractured rock aquifers.

Table 5-3 Hydrostratigraphy in the Vicinity of the Project Area

Geological unit	Coal sequences	Average thickness (m)	Groundwater unit type
Alluvium (Quaternary)		~ 14	Unconfined aquifer (where saturated)
Basalt (Tertiary)		~ 50	Semi confined aquifer
Regolith		~ 25	Unconfined aquifer (where saturated)

Geological unit	Coal sequences	Average thickness (m)	Groundwater unit type
Rewan Group (Triassic)		~ 500	Aquitard
Rangal Coal Measures (Permian)	Overburden	~ 50	Aquitard
	Burton Rider Seam	~ 1.5	Confined aquifer
	Interburden	~ 26	Aquitard
	Leichhardt/Vermont Coal seams	~ 8	Confined aquifer
	underburden	~ 100	Aquitard
Fort Cooper Coal Measures (Permian)		~ 200	Aquitard**

5.5.2 Alluvium

5.5.2.1 Hydrostratigraphy Overview

Groundwater presence in the alluvium is variable. Borehole logs and geophysical investigations at the Project indicate that much of the alluvium is dry, with coarser-grained, potentially groundwater bearing alluvial sediments not present extensively throughout the surface mapped alluvial extent but rather restricted to the area of the Isaac River meander belt close to the existing channel. That is, site investigations show that the alluvium is only saturated in immediate proximity to the current river channel.

As part of the GDE assessment, hand auguring investigations along the Isaac River channel and its tributaries intersected perched alluvial groundwater at locations adjacent the main river channel but not in the alluvium within the tributaries away from the channel (see Section 5.6.3.3). The hand auguring investigations also demonstrated that, at least at the time of the investigation (January 2023 following a wetter than average climatic period), the alluvium contained groundwater in both the basal alluvial sediments at 10 to 14 m depth but also a separate shallow perched (likely seasonally variable) groundwater system resting on relatively shallow alluvial clays close to the existing river channel at approximately 4 m depth. That is, a dual natured groundwater system within the alluvium is interpreted.

5.5.2.2 Groundwater Levels

Several groundwater bores installed into the basal parts of the Quaternary alluvium in the Project area are dry, indicating the alluvium is unsaturated and does not form an aquifer at these locations. Where groundwater is present in the basal alluvium closer to the Isaac River main channel however, groundwater elevations in most alluvial bores installed are reported between 292 and 303 m AHD (4 to 16 meters below top of casing (mBTC)) (see Section 5.10.2 of **Appendix 8** for groundwater bore level graphs and cumulative rainfall departure).

Groundwater flow is generally southward, coincident with flow direction of the Isaac River and general topographic trends. Higher levels reported at monitoring bore GW07 south of the Project area are likely attributed to proximity to the tail waters of the Burton Gorge Dam, which artificially raises alluvial groundwater levels south of the Project area. Review of available monitoring data from bores within the Project area suggests that groundwater levels within the basal Quaternary alluvium are up to 2 m higher than that of the underlying Permo-Triassic sandstone, indicating a downwards hydraulic gradient and alluvium groundwater levels not supported by groundwater flow from the underlying bedrock. Groundwater in several bores, particularly those screened within the basal Quaternary alluvium, have been noted to respond to rainfall events indicating relatively rapid recharge from rainfall.

In the Project area, alluvial groundwater levels do not appear affected by historic operations at the neighbouring Burton Mine. However, bores screened in the basal alluvium do show a general decreasing

water level trend correlating to reduced rainfall observed over the same period, as demonstrated by the cumulative rainfall departure plot.

Data suggests however that there is no indication of any groundwater discharge to the riverbed or surface water given the general depths to groundwater of more than 8 m in the basal alluvium. In January 2023, as part of the GDE Assessment, shallow perched alluvial water levels were measured in auger holes immediately adjacent the Isaac River channel (see Section 5.6.3.3). Water levels from the shallow perched alluvial water intersected in hand augering were around 5 m above groundwater levels in nearby bores monitoring the base of the alluvial sediments:

- Bore GW19_33: 7.7 mBTC or 7.1 mBGL (27-03-2023); near auger holes S13AU2 (4 mBGL) and S13AU1 (1 mBGL) (24-02-2023); and
- Bore GW19_37a: 10 mBTC or 9.3 mBGL (27-03-2023); near auger holes S1AU1 (0.7 mBGL) and S1AU2 (2.8 mBGL) (21-02-2023).

This indicates vertical hydraulic gradients exist within the alluvium and between the riverbed and the alluvium that would facilitate river sourced shallow perched groundwater to seep downwards to the deeper regional groundwater system hosted in the basal alluvial sediments. However, the intervening clay layers within the alluvial profile that exist above the groundwater system hosted in the basal alluvial sediments would inhibit the degree to which this downwards seepage occurs. It is these clay layers that facilitate the formation of the seasonally variable perched water approximately 5 m above the deeper alluvial groundwater levels, and the presence of the perching suggests a significant degree of hydraulic disconnection between the perched water and the deeper regional alluvial system.

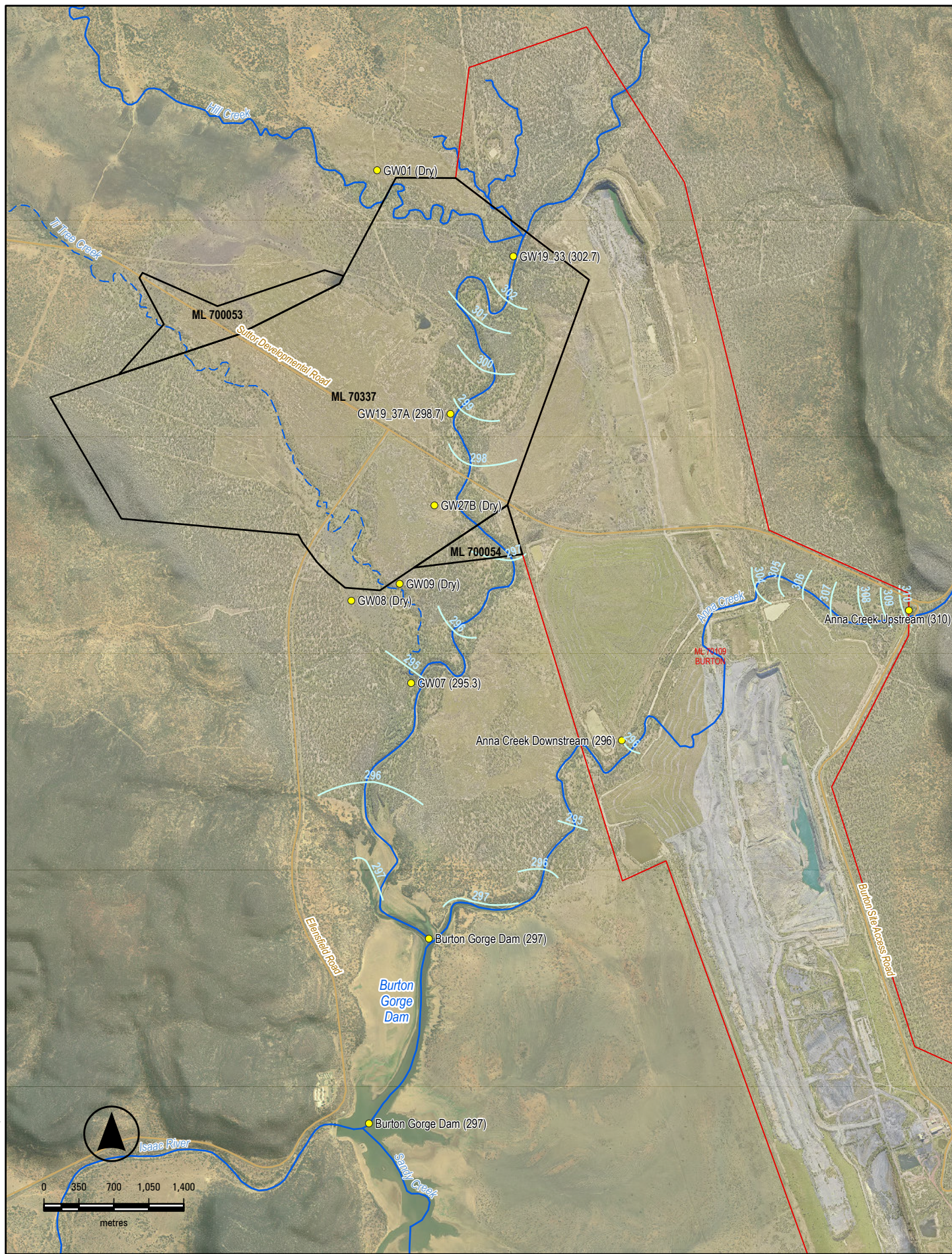
Groundwater level contours for the basal Quaternary alluvium in the vicinity of the Project area were developed using the most recent groundwater level data (from New Lenton and Burton monitoring network bores) and dam water level data for the Burton Gorge Dam. Groundwater levels in the alluvium in the vicinity of the Project area are shown in Figure 5-6 and flow southwest along Isaac River. The spatial extent of the aquifer in the vicinity of the Project area is limited to near the Burton Gorge Dam and along the Isaac River. The alluvium is dry along the Isaac River near GW01, and along the rivers western edge within the Project area near GW27b, GW09, GW08 and 60 m west of GW19_37a (at GW19_36a screened in the regolith). The contours point downwards along the flow direction of the Isaac River indicative of the rivers losing conditions. The water level in the Burton Gorge Dam is higher than the groundwater level directly adjacent to it and therefore the groundwater flow direction is towards the north in the direction of the Isaac River. This results in the convergence of groundwater flow between where it flows north and northeast from the Burton Gorge Dam and southwest along the Isaac River.

Groundwater level monitoring data from bores where saturation was recorded in the basal alluvial sediments show that the basal alluvial groundwater is hydraulically disconnected from both the shallow seasonally variable perched alluvial groundwater table and the Isaac River channel, with the river channel losing to the underlying groundwater system and forming the 'perched water' in some areas as it seeps down.

5.5.2.3 Groundwater Quality

The shallow perched alluvial waters from auger holes as part of the GDE assessment was noted to be very fresh ($EC < 300 \mu S/cm$) whereas the deeper regional basal alluvial water reports much higher salinities (517 to 16,500 $\mu S/cm$ EC, averaging 5,604 $\mu S/cm$ EC), further suggesting a dual natured groundwater system in the alluvium, and that the two components are not well hydraulically connected. Further discussion on water quality of the shallow perched alluvial water is provided in Section 5.5.9 and of the deeper regional basal alluvial water in Section 5.5.12.

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- LEGEND**
- New Lenton Mining Leases
 - Mining Lease
 - Roads
 - Watercourse
 - Non-designated Watercourse
 - Water Level Measurement (AHD)
 - Groundwater Elevation Contour Alluvium (mAHd)



5.5.3 Conceptualisation of Isaac River Alluvium

Based on the above data, a conceptual cross section through the Isaac River alluvium demonstrating its stratigraphy and perched and basal groundwater presence is shown in Figure 5-7, with the section location shown on Figure 5-4.

5.5.4 Regolith

The regolith, comprising of shallow weathered Triassic and Permian strata overlying fresh bedrock, has been identified as hosting groundwater at various locations across the Project area and surrounds.

Recent monitoring data collected from within the Project area shows groundwater levels in the regolith ranging from approximately 15 to 16 mBTC and 296 to 307 mAHD with one bore (GW19_36a) currently dry (see Section 5.10.2 of **Appendix 8** for groundwater bore level graphs and cumulative rainfall departure). Groundwater level data indicates that the inferred groundwater flow direction in the regolith, where present and saturated, is expected to follow topography, and has the potential to interact with groundwater within the alluvium where present along drainage alignments and rivers. Groundwater flow within the alluvial and regolith aquifers is limited and controlled by compartmentalisation due to lithological extent of the strata. On a regional scale however, where groundwater is present within the regolith, flow is expected to follow topography.

5.5.5 Basalt

Tertiary age basalt flows outcrop to the north west extent of the Project. Within the Project area the limited extent and discontinuity of this unit likely offers limited aquifer potential. Given the limited and isolated occurrence of basalt in the vicinity of the Project it has not been identified as a hydrostratigraphic unit of significance to the Project area.

5.5.6 Triassic Aged Strata

The Rewan Formation, overlying the Permian age Rangal Coal Measures, dominates a significant outcrop area within the Project area. The Rewan Formation is generally considered a major regional scale aquitard within the Bowen Basin, limiting groundwater connectivity between the underlying Permian coal measures and any overlying shallower groundwater systems. There is limited groundwater occurrence within the Rewan Formation itself, associated mainly with localised fracturing and weathered horizons. Within the Project area, no groundwater bores intercepted water in the Rewan Formation (except in the weathered bedrock/regolith above the fresh Rewan Formation). The Rewan Formation is up to 1000 m thick in areas further away from the Project area.

Based on the geological information presented in Section 5.4.4, neither the Moolayember Formation Clematis Group is considered a significant hydrostratigraphic unit in the context of the Project.

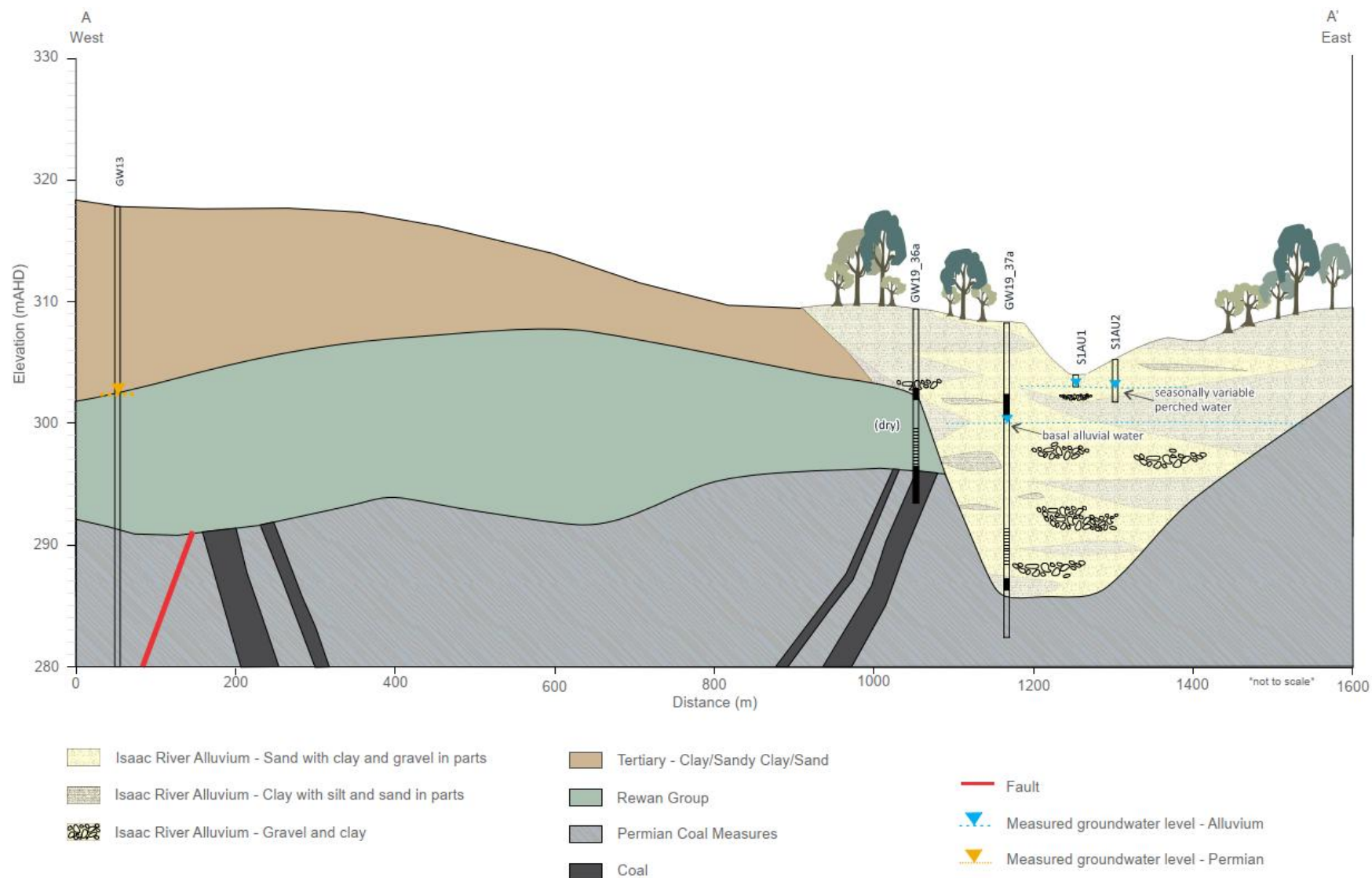


Figure 5-7 Conceptual Cross Section – Isaac River Alluvium

5.5.7 Permian Coal Measures

5.5.7.1 Hydrostratigraphy Overview

During drilling within and surrounding the Project area, groundwater was identified within the coal seams of the Rangal Coal Measures and the Fort Cooper Coal Measures. Groundwater within these Permian age coal measures is preferentially contained within, and flows via, the coal seams themselves along fractures and cleats, whilst the adjoining sandstone and siltstone interbeds act as low hydraulic conductivity confining units. Due to the limited vertical hydraulic connection between the individual coal seams, the Permian age Coal Measures are conceptualised to comprise multiple confined aquifers (coal seams) that are interbedded with aquitards (overburden, interburden, and underburden). Groundwater was typically not encountered within the overburden / interburden associated with the Permian age Coal Measures at the Project area during drilling investigations.

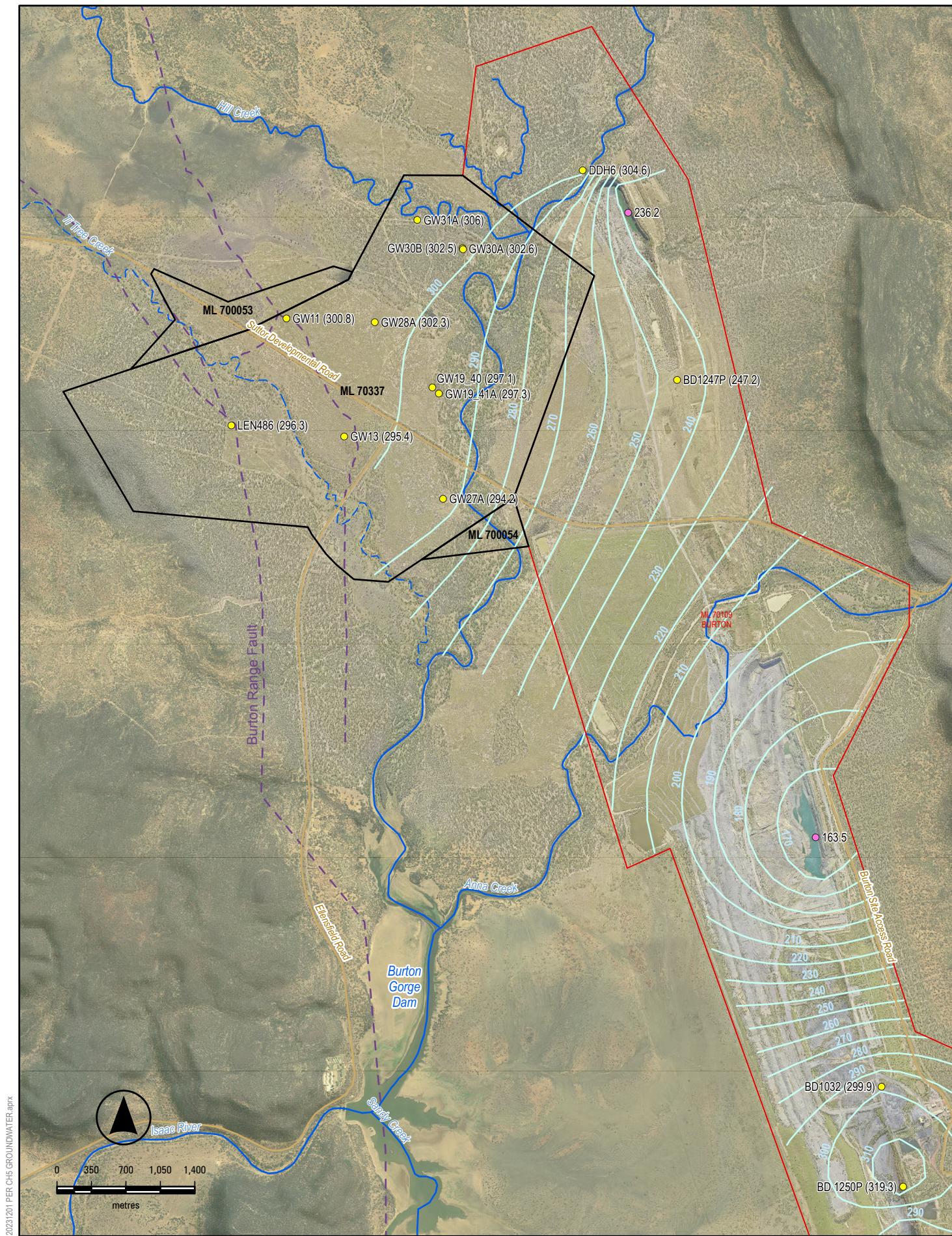
5.5.7.2 Groundwater Levels

Groundwater levels for bores screened in the Permian coal measures are presented in Section 5.10.2 of **Appendix 8**, along with cumulative rainfall departure. Historical data for bores screened in the Permian coal measures show groundwater levels range from approximately 296 and 305 mAHD in the Leichhardt/Vermont Seam (GW10, GW11, GW13, GW19_40, GW19_41A, GW28A, GW29A, GW31A and LEN486); 294 to 295 mAHD in the Girrah Seam (GW27a); and 302 to 303 mAHD in the Burton Rider Seam (GW30b).

Groundwater levels have remained relatively stable over the monitored period with minimal responses to rainfall events, suggesting low rates of rainfall recharge. Permian coal seam bores in proximity to the Permian subcrop beneath the alluvium display a stronger response to rainfall than other Permian coal seam bores further from the outcrop, suggesting the potential for a localised hydraulic connection between these two units with rainfall/surface flow infiltration passing through the alluvium into the coal seams.

At the Burton Mine, the impact of historical mining from 1998 to present can be observed in the Permian coal measures with depressurization of coal seams and subsequent recovery following backfilling of voids. Water level declines of up to 90m (down to 240mAHD) are observed followed by recovery back to within 10 m of pre-mining levels in most bores, indicating capacity of the Permian groundwater system to recover rapidly and significantly from mining activities. A hydrograph for Permian bores near Burton North and Burton Widening Pits is presented Section 5.10.2 of **Appendix 8**.

A potentiometric surface for the Permian coal measures in the vicinity of the Project area was developed using the most recent groundwater level data (from New Lenton and Burton monitoring network bores) and void water level data (for Burton Mine) (see Figure 5-8). Groundwater levels show that flow potential in the Permian is southeast from the Project area towards mined voids at Burton Mine. There is a strong overall gradient towards the Burton Widening pit which is interpreted to form a significant groundwater sink in the Permian. The effect of structural (i.e. faulting) control on the groundwater system is evident, with the north-south trending Burton Range Fault that separates the western portion of the Project area and limits the spatial extent of the aquifer to the south of the Project area.



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- LEGEND**
- New Lenton Mining Leases
 - Mining Lease
 - Roads
 - Watercourse
 - Non-designated Watercourse
 - Fault
 - Void Water Level (AHD)
 - Groundwater Level (AHD)
 - Groundwater Elevation Contour (mAHD)

5.5.8 Recharge and Discharge

Recharge to the water table occurs via diffuse rainfall recharge and leakage of surface water along creeks and drainage lines following significant rainfall events. Discharge of shallow groundwater occurs primarily via evapotranspiration, seepage into existing mine pits and mine dewatering from the neighbouring Burton Mine, and vertical seepage into underlying deeper layers.

Regionally, discharge from shallow groundwater (mainly alluvium) occurs via evapotranspiration from vegetation growing along creek beds and minor short duration baseflow events after significant rainfall/flooding. Infiltration to underlying formations is likely to be limited to areas in connection with relatively high permeability units such as coal seams and possibly faults.

Water levels in the alluvium are generally above the regolith or coal measures but below riverbed elevations, suggesting that river discharge to alluvium contributes to leakage recharge to underlying units.

Recharge to the alluvium is considered to be mostly from streamflow infiltration or flooding (losing streams), with direct infiltration of rainfall also occurring rapidly where there is no substantial clay present in the shallow sub-surface. Clay horizons within the alluvial sequence inhibit, or at least delay, streamflow derived recharge to the basal alluvial aquifer, and result in perching of alluvial groundwater in shallow horizons above the more regional basal alluvial saturated aquifer that would then leak downwards to the deeper basal alluvial aquifer.

The regolith is recharged from rainfall infiltration and leakage of surface water along creeks and drainage lines following episodic rainfall events.

In the Permian coal measures, recharge and discharge mechanisms are influenced by the outcropping/subcropping of Permian units. In these areas, the coal seams are exposed to semi-confined conditions which favour groundwater flow between the coal measures, the regolith and the alluvium. These conditions are limited to areas where the coal seams subcrop, where coal seams are in direct contact with the regolith or alluvium. Vertical recharge also occurs via diffuse vertical flow from units overlying the Permian coal measures.

Section 5.10.3 of **Appendix 8** described the chloride mass balance method used to estimate the recharge rate for each main aquifer in the Project area and surrounds. Recharge rates for the alluvium and regolith are much higher than the Permian (average of 0.3% to 8.6% of annual rainfall, compared to 0.1% of annual rainfall, respectively).

5.5.9 Groundwater - Surface Water Interaction

Watercourses and drainage features within and surrounding the Project area are ephemeral and no permanent waterholes have been identified, including along the Isaac River main channel where it traverses the eastern part of the Project area. Project monitoring data shows that surface water flow is only sustained for hours to several days following rainfall events (refer to Chapter 4). This indicates a distinct lack of groundwater discharge to these watercourses, including the Isaac River. However, some shallow groundwater recharge is expected to occur directly through the creek beds to the underlying unconsolidated shallow strata (i.e. alluvium) during significant flow events (i.e. in the downwards direction).

There are no registered groundwater springs or seeps within or surrounding the Project area. Measured alluvium/regolith groundwater levels remain well below the base of the surface water channels including the Isaac River, despite some significant variability in basal alluvial groundwater levels in the monitoring record.

As described in Section 5.6.3.4, in January 2023 as part of the GDE assessment, isotopic data (stable isotopes of water) were analysed from groundwater samples collected from Project bores and shallow auger holes from the Isaac River channel and tributaries, as well as two surface water pools in the Isaac River channel following a streamflow event (one in the Burton Gorge Dam tailwaters and one from a temporary pool within the Project area), as a means to characterise surface water-groundwater interaction. Similarities between the evaporative fractionation of isotopes between the surface water, perched water from auger

samples and monitoring bores support the theory that the sampled pooled water associated with the Isaac River channel is a temporary feature and is losing to the below groundwater in the alluvium/regolith.

As described in Section 5.5.2.3, groundwater quality data suggesting recharge is responsive to rainfall and ephemeral river flows, and there is hydraulic separation from the deeper regional basal alluvial water table. This implies that the perched water is susceptible to depletion during reduced rainfall, facilitated by evapotranspiration. The lateral extent of the perched water is thought to be controlled by the narrow extent of coarse sediment, which pinches out towards the floodplain.

The riverbed sands are conceptualised as being dry for the majority of the year and groundwater does not supply a baseflow component to the Isaac River, i.e. the river does not receive significant inflows from groundwater resources. This conceptualisation was based on the following:

- The ephemeral nature of the Isaac River and its tributaries which only flow following relatively intense rainfall events.
- The limited distribution of coarser channel sands with effective groundwater transmission and storage capacity.
- Groundwater level data from drilling on site indicates that, where groundwater in the alluvium does occur outside of the immediate river channel, groundwater was only encountered in the basal alluvium and the depth to groundwater was generally greater than 8 mBGL.

Burton Gorge Dam is located on the Isaac River immediately downstream of the Project area. Due to the dam impoundment lake being hydraulically connected to the groundwater of the alluvium and regolith, and the fact that the tail water of the impoundment extends to within around 3 km of the Project area, it is considered the only potential surface water receptor of groundwater drawdown arising from the Project.

5.5.10 Hydraulic Properties

Section 5.11 of **Appendix 8** presents a summary of the field hydraulic data and comparison to reported hydraulic properties within literature ranges. The comparison shows that the field results for alluvium, regolith, Rangal Coal Measures and Fort Cooper Coal Measures within and surrounding the Project area generally fall within the range of field data collected through other studies across the Bowen Basin.

Results recorded from the alluvium also had a lower range compared to literature values (0.01 vs 0.1), which reflects the heterogenous nature of the alluvium.

Results recorded in literature from the limited number of tests in the Rangal Coal Measures interburden and interburden/coal were higher than expected when compared to regional data for the coal seams. It is expected that in general across the Project area and surrounds the coal seams of the Permian coal measures have a higher hydraulic conductivity than the majority of the interburden/overburden, consistent with many other regional studies. This is due to the dual porosity of the coal seams, with a primary matrix porosity and a second (dominant) porosity provided by fractures (joints and cleats), which supports the concept of the coal seams themselves forming the dominant groundwater zones of the Permian units.

5.5.11 Faulting

Extensive geological faulting is present over and surrounding the Project area. The main structural feature of the Project area is the Burton Range Fault, which is marked by the eastern boundary of the Burton Range. The Burton Range Fault crosses the Project area from the southern boundary toward the north and northwest and is aligned adjacent to the western boundary of ML 70337. The fault has caused relatively large vertical displacements in the Permian geology (>700 m throw), isolating the Rangal Coal Measures on each side of the fault. Other faults with up to 200 m throw also isolate the coal seams of the Rangal Coal Measures within sections of the Project area.

An assessment of faulting within and surrounding the Project area, including a review of relevant literature, and the implications for Project hydrogeology, is provided in Section 5.11.3 of **Appendix 8**.

Faulting can result in higher permeabilities within strata parallel with the fault plane, and lower permeabilities within strata perpendicular to the fault plane. However, this can also be dependent on whether faults are currently active. Faulting has been inactive within the Bowen Basin for over 140 million years, indicating that the fault zones are less likely to act as conduits to flow; this relates to filling of the fractured pore spaces over time through hydrothermal alteration and mineralisation. Drill core logs from within the Project area show that where fractures and faults have been geologically logged, many fractures are 'healed' with calcite and siderite. This indicates that although the system contains a fracture network, many of the existing fractures are cemented, which reduces the effective permeability of the fracture when compared to any open fracture network.

The differing response to mining activities observed within some monitoring bores may indicate low hydraulic conductivity, and/or compartmentalisation of the groundwater system as a result of structural controls (i.e. faulting), which are known to be significant in and adjacent the Project area. Faults truncate the bedrock, juxtaposing coal seams against lower permeability interburden bedrock. In some cases, these faults may cause damming on one side of the fault, resulting in long groundwater residence times. The large offset (>700 m throw) Burton Range Fault on the western side of the Project area is currently predicted to act as a barrier to east-west groundwater flow with the juxtaposition of the Triassic strata on the west to the Permian Coal Measures on the east.

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

5.5.12 Groundwater Quality

Baseline water quality data has been collected for the Project area monitoring bores between 2006 and 2023. The baseline water quality is characterized below with summary statistics of historical data provided in Section 5.12 and Appendix C of **Appendix 8**.

5.5.12.1 EC and pH

Baseline (pre-Project between 2006 and 2023) groundwater quality monitoring data collected for the Project monitoring bores indicates the following:

- Alluvium: Mildly acidic to moderately alkaline pH (6.3 to 8.4, averaging near neutral at 7.1) and fresh to saline water quality (517 to 16,500 $\mu\text{S}/\text{cm}$ EC, averaging 5,604 $\mu\text{S}/\text{cm}$ EC).
- Regolith: Mildly acidic to mildly alkaline pH (6.7 to 7.9, averaging near neutral at 7.1) and mildly brackish to saline water quality (1,549 to 12,400 $\mu\text{S}/\text{cm}$ EC, averaging 9,902 $\mu\text{S}/\text{cm}$ EC).
- Permian coal seams: Mildly acidic to moderately alkaline pH (6.3 to 8.5, averaging 7.5) and mildly brackish to saline water quality (2,030 to 18,450 $\mu\text{S}/\text{cm}$ EC, averaging 9,921 $\mu\text{S}/\text{cm}$ EC).

5.5.12.2 Water Type

The proportions of the major anions and cations were used to determine the hydrochemical facies of groundwaters sampled. The anion-cation balance from Project monitoring bores is shown on the Durov plots in Section 5.12 of **Appendix 8**. The results show the following:

- Alluvium bores GW06, GW07 and GW01 are sodium chloride (Na-Cl) water dominant, whilst GW09 and GW19-37a are sodium sulphate (Na-SO₄) water dominant and GW19-33 (alluvium/regolith) is of magnesium bicarbonate (Mg-HCO₃) water dominance.

- Basalt bore GW20 is of sodium bicarbonate (Na-HCO₃) water dominance. Regolith bores GW19, GW30c and GW31b are Na-Cl water dominant.
- All Permian coal measures bores are of Na-Cl water dominance.

5.5.13 Conceptual Model

A conceptual hydrogeological model of the groundwater regime has been developed based on the review of the hydrogeological information for the Project area. A conceptual cross section is presented in Figure 5-9 with location shown in Figure 5-5. The cross section in Figure 5-9 is complemented by the conceptual cross section through the Isaac River alluvium in Figure 5-7 demonstrating its stratigraphy and perched and basal groundwater presence.

The main hydrogeological units, as shown in Figure 5-5, are:

- Quaternary alluvium – unconfined aquifer (water-bearing strata of unconsolidated silt, sand, or gravel) localised along Isaac River, Hill Creek and Anna Creek where groundwater is hosted in the basal alluvial sediments, and a secondary more limited seasonably variable perched water table disconnected from the basal system and hosted in shallow alluvial sediments immediately adjacent the Isaac River channel
- Regolith – (other shallow non-alluvial weathered material) unconfined with potential to interact with the alluvium where saturated
- Permian coal measures with:
 - Low permeability interburden units with aquitard properties; and
 - Coal seams that exhibit water bearing properties associated with secondary porosity through cracks and fissures.

Extensive thrust faulting and associated folding is present over and surrounding the Project area. The main structural feature is the Burton Range Fault (see Figure 5-5), which has caused the displacement and uplift of the Rangal Coal Measures where it is able to be mined at surface

Several Project groundwater bores installed into the alluvium are dry, indicating the alluvium is unsaturated and does not form an aquifer at these locations. Where groundwater is present in the basal alluvium closer to the Isaac River main channel however, groundwater levels in the alluvium are relatively flat, with flow generally towards and coincident with the Isaac River surface flow direction. Where it occurs, groundwater within the basal alluvium is recorded at depths of around 8 to 11 mBGL, typically significantly disconnected from the streambed elevation. Immediately below and adjacent the Isaac River channel and banks, limited seasonally recharged perched water is present around 5 m above the groundwater in the basal alluvium/regolith (around 1 to 4 mBGL).

The inferred groundwater flow direction in the regolith, where present and saturated, is expected to follow topography, and has the potential to interact with groundwater within the alluvium where present along drainage alignments and rivers.

Loss conditions from the Isaac River to the underlying alluvium and regolith are evident during flow periods and recharge to shallow groundwater is considered to be primarily from streamflow or flooding, with direct infiltration of rainfall also occurring rapidly where there are no substantial clay barriers in the shallow sub surface. Perching of recharged water inhibits the downwards migration of recharged water to the basal alluvium aquifer. Discharge of shallow groundwater occurs primarily via evapotranspiration, including from terrestrial GDEs that access the seasonably variable perched water but not the deeper basal alluvial groundwater.

Water quality data for the alluvium indicates a high degree of spatial and temporal variability. Elevated salinity levels at some Project area bores in the alluvium likely support the concept of a highly heterogeneous alluvial system with only some parts receiving regular freshwater contribution from surface flows.

In the Permian strata, groundwater is encountered in both the coal seams and the interburden units. The coal seams within the Rangal Coal Measures are typically considered the main aquifer units and may be

significantly more permeable than the interburden material of interbedded mudstone, siltstone, and sandstone. The Permian coal seams are classified as a dual-porosity, dual-permeability medium with water stored and transmitted through both the primary matrix porosity and secondary fracture porosity. Groundwater within these coal measures is considered confined and sub-artesian.

Recharge to the coal measures occurs where the coal seams outcrop or subcrop beneath the alluvium or regolith. The interburden material (sandstone and siltstone) typically has a low vertical hydraulic conductivity that limits the downward vertical movement of water. When groundwater levels are locally reduced in the coal seams due to mining, these interburden units will provide a source of water by vertical leakage into the depressurised coal seams. Discharge from this unit is dominated by evaporation and groundwater extraction from mining activities at the neighbouring Burton Mine.

Regionally groundwater levels in the Permian coal seams correlate with ground surface elevations, with groundwater flow dominantly horizontal through the coal seams themselves following the regional topography, but locally influenced by existing mining at the Burton Mine.

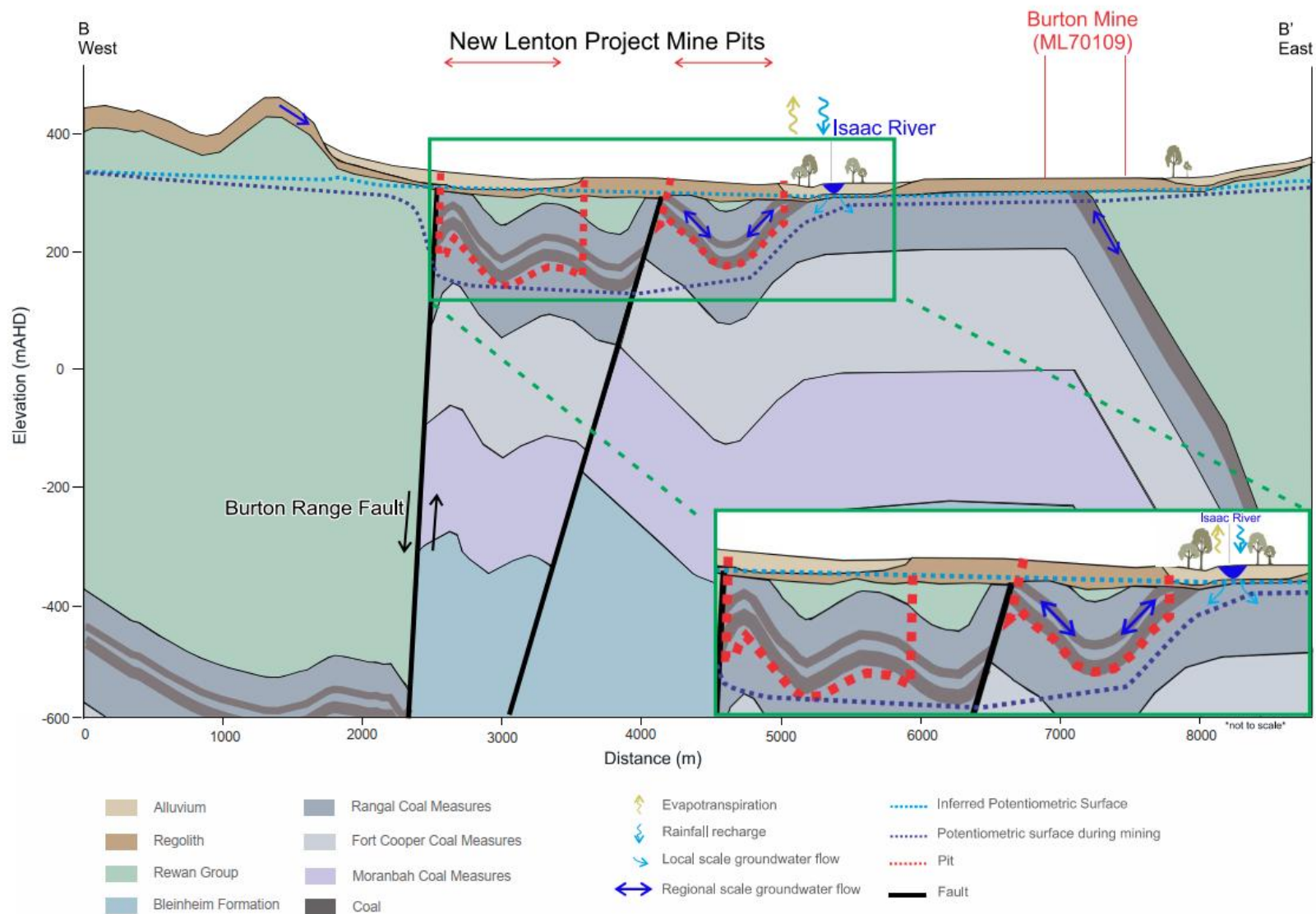


Figure 5-9 *Conceptual Hydrogeological Model*

5.6 Environmental Values and Groundwater Receptors

5.6.1 Potential Environmental Values

Groundwater resources within the vicinity of the Project are scheduled under the EPP (Water). The legislated environmental values for the groundwaters of the Isaac River sub-basin are:

- Biological integrity of aquatic ecosystems – these occur where groundwater baseflow supports streams and water holes to some extent (e.g. seasonally or permanently).
- Human use:
 - Suitability of water supply for irrigation – where groundwater is used to grow crops and pastures for commercial purposes.
 - Farm water supply/use – where groundwater is used to provide domestic supply and support growing of domestic produce.
 - Stock watering – where groundwater is used to provide stock water supplies.
 - Drinking water supply – where groundwater is used for potable water supply.
 - Primary recreation – where groundwater supports recreational use that involves direct contact and a high probability of being swallowed, e.g. diving, swimming, water skiing.
 - Cultural and spiritual values – where groundwater supports both indigenous and non-indigenous values, e.g. recreational fishing, heritage, ecology.

A comparison of Project area groundwater quality data to the relevant WQO levels under the EPP (Water) is provided in Section 5.12.3 of **Appendix 8**, and is summarised below.

Alluvium monitoring bore data generally suggests that alluvial groundwater from the Project Area is unsuitable for supporting the irrigation water EV with respect to fluoride, boron, iron, manganese, molybdenum or uranium. Alluvium groundwater data also generally indicates it is not suitable for supporting the aquatic ecosystems EV with respect to boron, chromium, cobalt, copper, nickel, uranium, vanadium or zinc. The 80th percentile values at the alluvial bores did not exceed any of the stock watering EV guidelines, except for EC (salinity) at GW06, suggesting that alluvial groundwater is mostly suitable for stock watering.

Regolith monitoring bore data generally suggests that groundwater from the regolith is unsuitable supporting the irrigation water EV with respect to boron, iron, manganese or uranium. Regolith groundwater data also suggests that is generally unsuitable to support the aquatic ecosystems EV with respect to cobalt, copper, nickel, uranium or zinc. The data also suggests that regolith groundwater is generally unsuitable for supporting the stock watering EV with respect to EC (salinity).

As with the Alluvium and Regolith, Permian monitoring bore data generally suggests that Permian groundwater at the Project Area is also unsuitable supporting the irrigation EV with respect to fluoride, boron, iron, manganese or molybdenum and the aquatic ecosystems EV with respect to pH, aluminium, arsenic, boron, cobalt, copper, molybdenum, uranium or zinc. The 80th percentile values at the Permian bores are above the stock watering EV with respect to EC (salinity) at four out of eleven bores, suggesting that Permian groundwater is suitable to support stock watering across most Permian bores, but approximately one third of Permian bores report groundwater salinities above stock tolerance levels.

Generally speaking, there is a high degree of observed variability in groundwater quality between hydrostratigraphic units, and between individual bores within individual hydrostratigraphic units. This inherent variability has been incorporated within the Project's site specific groundwater quality impact trigger derivation that provide the foundation for the groundwater quality limits in the EA (see Section 5.10.3).

5.6.2 Groundwater Users

A search of the Queensland Government's Registered Groundwater Bore Database was carried out for registered bores within 10 km of the Project area. The search returned 19 bores with registered uses as

mine monitoring, petroleum exploration, and unknown (one bore) (see Figure 5-10). The bore listed as unknown (RN85414) is located approximately 8.7 km northeast of ML 70337, and is 27.4 m deep.

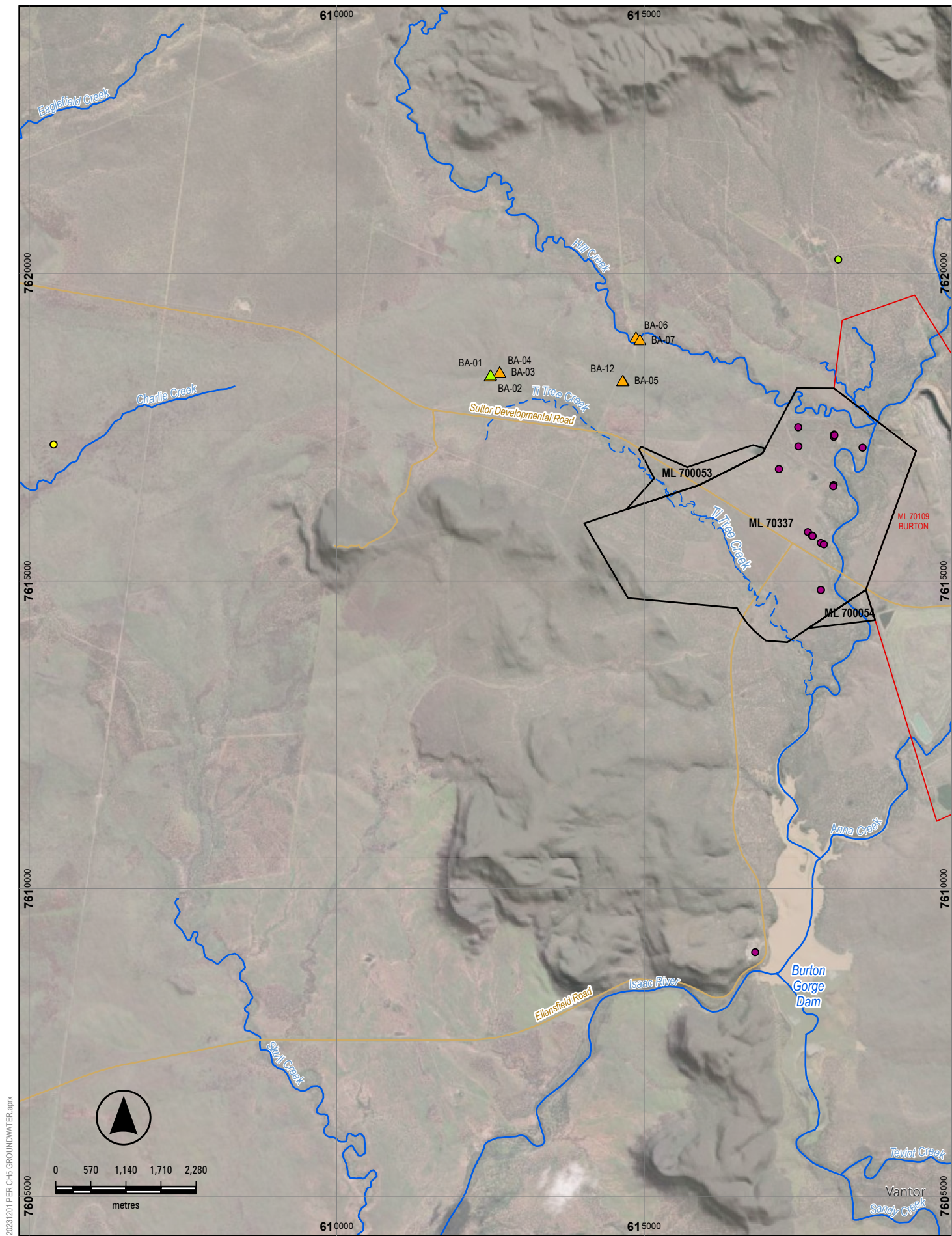
A landholder bore census was conducted December 2018 for an area extending 10 km from the Project area. The census identified eight unregistered bores (see Figure 5-10). The results of the survey, as presented in Table 5-4, indicated that one of the bores was in use while the others were not currently in use.

No information is available on the aquifer in which potential third party water supply bores (one registered and eight unregistered) are screened. A comparison of available bore depths with the Project's groundwater model layers infers that BA02, BA03, BA04 and RN85414 are screened in the regolith, while BA01 and BA05 are screened in the Triassic Strata.

A search of the water entitlements database did not identify any active third-party water licences for groundwater abstraction within and surrounding the Project area.

Table 5-4 Unregistered Bores

Bore	Easting	Northing	Status	Depth (m)	Survey Date
BA-01	612505	7618350	In use	51.05	2018
BA-05	614658	7618258	not currently in use	40.3	2018
BA-06	614868	7618966	not currently in use (blocked)	unknown	2018
BA-07	614931	7618923	not currently in use (filled)	unknown	2018
BA-12	614649	7618257	not currently in use (casing and rods in hole)	unknown	2018
BA-02	612494	7618333	Not currently in use	37.38	2018
BA-03	612652	7618396	Not currently in use	39	2018
BA-04	612652	7618396	Not currently in use	40.32	2018



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- LEGEND**
- New Lenton Mining Leases
 - Mining Lease
 - Roads
 - Watercourse
 - Non-designated Watercourse

- Groundwater Database Registered Bores within 10km of Project Area
- Mine Monitoring
 - Petroleum Exploration
 - Unknown
- Landholder Bore Census Unregistered Bores (GHD, 2018)
- ▲ In use
 - ▲ Not currently in use

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Registered and Unregistered Bores

5.6.3 Groundwater Dependent Ecosystems

The results of field surveys and temporal analysis of aerial imagery of vegetation was used to inform whether GDEs are present.

5.6.3.1 Potential GDE Species

Section 2.2 of **Appendix 10** identifies ecosystems and species with potential for groundwater dependence, the degree of potential dependence and the tolerance of the key species to change.

Forest red gum (*Eucalyptus tereticornis*) is the dominant riparian tree along creek and river frontages where it is associated with regional ecosystem (RE) 11.3.25, mixing with lesser proportions of river red gum (*Eucalyptus camaldulensis*). Forest red gum is the predominant species on the Isaac River within and surrounding the Project area. It is an adaptable species, occupying dry hill slopes in some localities and it would be expected to be more tolerant of changes to hydrological regime than *Eucalyptus camaldulensis* which is a riparian specialist. The two species are referred to as 'red gums' as they share the same physiological attributes, have similar ecological attributes, and can inhabit and mix within a similar ecological niche.

Flooding enables red gums to survive in semi-arid areas where stands are intimately associated with the surface-flooding regime of watercourses and related groundwater flow. Red gums are considered a facultative phreatophyte, shifting between a combination of surface soil moisture and groundwater during periods of high rainfall, then shifting to exclusive use of groundwater during drier periods.

Red gum has a number of traits that enable the species to be relatively resilient to all but the most extreme ecological change:

- The species is adapted to arid and semi-arid environments, and is opportunistic in its water use, sourcing water according to osmotic and matric water potential and source reliability.
- The species has capacity to survive high levels of water deficit with the major sources of water utilised for transpiration being:
 - groundwater including fresh to moderately saline aquifers
 - surface water held in river pools
 - soil moisture in the unsaturated zone, including infiltration of moisture from lateral bank recharge, overbank flooding and rainfall which also act to recharge groundwater.
- Red gum will often use saline groundwater in preference to fresh surface water, probably because it represents a more reliable supply.
- Red gum also has a capacity for genetic selection to increase capacity for the species to survive drought stress. Trees less able to survive drought tend to die off, hence the genes that are associated with drought tolerance traits become more common in the remaining population.
- Red gum is adapted to go through alternate phases of shedding and regaining its crown, depending on the availability of water over time. Trees have capacity to self-regulate and adjust their transpiration rates to match the average flood return interval.

Based on these observations from various studies around Australia, it is unlikely that forest or river red gum would be utilising a groundwater table deeper than 15 mbgl. It is unlikely that the terrestrial woody vegetation that characterises the Project area would have capacity to utilise groundwater that has salinity greater than 30,000 $\mu\text{S}/\text{cm}$, instead relying on whatever fresh moisture that can be extracted from the vadose zone. It is also unlikely that any tree would invest in the development of a deep root system to tap water from a saline water table, where the benefits in terms of increased water availability would be very marginal.

5.6.3.2 Leaf Water Potential

Detailed information of LWP at all trees surveyed is provided in Section 4.1 of **Appendix 10**. Figure 5-11 provides a spatial representation of average LWP at each GDE assessment area. In combination with

ecological information for GDE assessment areas, the potential for groundwater utilisation has been categorised as follows:

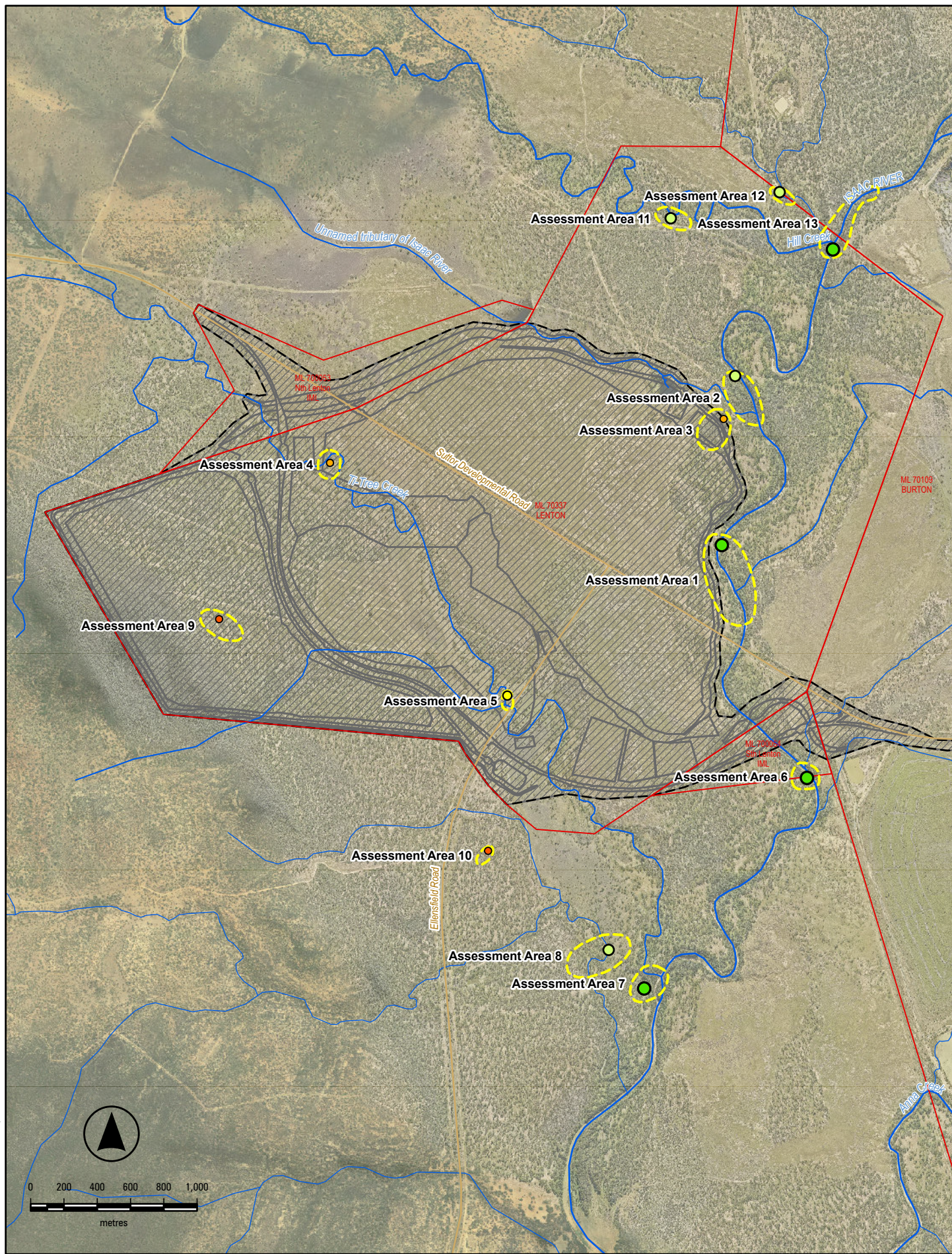
- Sites that have LWPs indicating extremely high and very high water availability, and demonstrate potential for utilisation of fresh groundwater based on data from relevant monitoring bores:
 - all Isaac River sites (Site 1, Site 2, Site 6, Site 7 and Site 13)
 - Site 8 on Ti-Tree Creek (near the junction with Isaac River)
 - Site 11 and Site 12 on northern tributaries.

Further investigation of SMP and stable isotopes was undertaken for these sites to determine the nature and degree of any groundwater dependence.

- Sites that have LWPs indicating high to moderate water availability, although data from groundwater monitoring bores suggests that groundwater is unlikely to be accessible (i.e. >15 mbgl). This includes Site 5 from Ti-Tree Creek, for which investigation of stable isotope values and groundwater levels from nearby monitoring bores was undertaken.
- Sites that have LWPs indicating moderate to low water availability and limited capacity for groundwater usage, which is supported by monitoring data from the nearest groundwater monitoring bores. This includes all sites on older alluvial and residual surfaces (Site 3, Site 9 and Site 10) as well as Site 4 from Ti-Tree Creek. These sites are unlikely to be utilising groundwater to any extent.

Based on LWP data, sites associated with the Isaac River (Site 1, Site 2, Site 6, Site 7 and Site 13) have the highest potential for groundwater utilisation. Data from individual trees within GDE assessment areas shows considerable variation in water availability, suggesting water availability varies with topographic position and distance to the river channel.

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Datum: MGA94 Zone 55
Scale: See Scale Bar (A4)
Date: 21/08/2026 1:52 PM
Drawn: RA (Source: 3d Environmental)



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LEGEND

- Mining Lease
- Roads
- Watercourse
- Proposed Disturbance Area
- Project Layout
- GDE Assessment Areas

Tree Water Availability - Average

- Extremely High
- Very High
- High
- Low
- Moderate

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Average LWP at GDE Assessment Areas

5.6.3.3 Hand Auger Profiling and Soil Moisture Potential

The purpose of the SMP testing is to identify, for those assessment areas / trees where LWP measurement indicate potential groundwater usage, whether sufficient moisture is available in the upper unsaturated portion of the soil profile (i.e. vadose zone) to explain LWP measurements or whether utilisation of groundwater can be inferred. The location for auger holes was selected during the field survey to cover sites where potential groundwater dependence was indicated by LWP values, or sites were considered representative of a particular habitat or landform. In total, 8 auger holes were installed. Results of the auger profiles and SMP results, with correlations drawn to LWP, are provided in Section 4.2 of **Appendix 10**.

5.6.3.4 Stable Isotope Sampling and Analyses

Stable isotope values ($\delta^{18}\text{O}$ and $\delta^2\text{H}$) from soil, surface water from the Isaac River (Site 2, Site 7), selected groundwater samples and twig xylem water were analysed to inform potential groundwater dependence of vegetation. Results of stable isotope analysis are provided in Section 4.3 of **Appendix 10**.

The strong overlap between isotopic values for xylem and groundwater samples suggests that groundwater was being utilised by at least some trees at the time of assessment.

The isotopic samples for twigs and soil for sites on Isaac River have been compared. The data shows the tight cluster of groundwater samples from alluvium (both monitoring bores and auger), regolith and coal seams which falls nearly within the centre of the cluster formed by twigs and overlap with the more enriched (heavier) samples collected from soil profiles. In combination with high LWP / SMP values and the physical presence of perched water, this indicates that the perched water is a significant input into the tree water requirements at sites along the Isaac River. Isotopic data analysis supports the interpretation that trees along the Isaac River were utilising perched groundwater at the time of assessment.

Isotopic data from twig samples, soil samples and groundwater samples for Ti-Tree Creek was analysed. The weak overlap between groundwater and soil samples is expected considering the demonstrated evolutionary continuum between these moisture sources. This data indicates trees are utilising moisture from unsaturated regions of the soil profile mostly below 1.5 mbgl, consistent with observed lack of perched groundwater. The relative consistency of xylem isotope values between sites Ti-Tree Creek suggests that trees are using moisture from unsaturated regions of the soil profile. This interpretation is supported by LWP and SMP measurement and there is no evidence that groundwater is being utilised to any degree by vegetation on Ti-Tree Creek.

Isotopic data from twig samples, soil samples and groundwater samples for Hill Creek and an unnamed tributary (both outside the Project disturbance area) was analysed. The data demonstrates clear separation between xylem isotope values and groundwater in Hill Creek indicating groundwater is unlikely being utilised at this sampling locality. For the unnamed tributary the stable isotope values can clearly be accounted for by soil moisture alone. This interpretation is consistent with the results of LWP and SMP analysis and there is no strong evidence that trees are utilising groundwater at these assessment sites.

Sites located on older alluvial / residual area (Site 3, Site 9, Site 10) are not included in the isotopic analysis due to LWPs that indicated limited potential for groundwater utilisation.

5.6.3.5 Temporal Analysis of Vegetation Condition

Historical imagery was reviewed to identify any impact to riparian vegetation structure or condition on the Isaac River, that could possibly be linked to historical mining at Burton Mine adjacent the Isaac River, approximately 2 km upstream from the Project disturbance area and near GDE Assessment Area 13. The assessment could not confirm any detectable change to vegetation health and condition on imagery that was captured prior to mining (1987 and 2000), spanning mining operations (2000 to 2004), and 16 years post mining based on recent imagery (approximately 2018). Imagery from these pre to post mining stages, as provided in Section 4.4 of **Appendix 10**, provides no evidence of mining related changes to vegetation structure and condition spanning the 30 years of imagery. This provides evidence that historical open cut mining in the vicinity of the Isaac River, near to the Project, has not resulted in drawdown of groundwater

that has impacted vegetation structure and condition. Therefore it could be expected that open cut mining associated with the Project will not result in drawdown of groundwater that will impact vegetation structure and condition.

5.6.3.6 Summary of Data Analysis

Data from LWP measurement, soil augering and SMP measurements, as well as stable isotope assessment demonstrates the following:

- Data from the Isaac River sites demonstrate that riparian vegetation was utilising groundwater from a shallow seasonally variable perched water table. This water table was hosted in river sand but resting on alluvial clay, above the deeper basal alluvial groundwater unit. This interpretation is consistent between all assessment parameters including LWP, SMP, stable isotopes and including direct observation of a perched water table intersected during shallow soil augering.
- For sites on older alluvial / residual landforms, any significant utilisation of groundwater has been excluded by the strongly negative LWP values and considerable depth to groundwater resources, below the rooting depth of relatively shallow rooted poplar box and ironbark.
- For sites on Ti-Tree Creek, use of groundwater is excluded by strongly negative LWP values or utilisation of water in the shallow soil profile, as suggested by both SMP and downhole stable isotope analysis, which is in agreement with the lack of intersection of a perched shallow water table. There is no indication that vegetation is utilising groundwater to any degree on Ti-Tree Creek.
- Data from Hill Creek and an unnamed tributary suggests soils account for the moisture being utilised by riparian vegetation at these localities, in agreement with soil auger profiling which did not identify a perched water table. Soil moisture is being supplied in the shallow portion of the soil profile (>1 mbgl) directly above the contact between the unconsolidated soil profile and regolith.

The following uncertainties are relevant to the assessment:

- The seasonality and persistence of the perched groundwater system that was supporting GDEs at the time of the assessment, and whether any connectivity between the perched groundwater system and the deeper basal alluvial groundwater unit exists, noting the current lack of evidence for a hydraulic linkage (see Section 5.5.3 and Section 5.5.13).
- Whether riparian vegetation that was utilising groundwater hosted in the seasonally variable perched groundwater system has developed a dimorphic root system that has capacity to utilise the seasonally variable perched system when present, shifting to utilisation of the deeper basal alluvial groundwater unit when the perched system is depleted.

5.6.4 Conceptual Site Models for GDEs

5.6.4.1 Suitability of Groundwater Resources to Support GDEs

The most significant control on groundwater dependence is a lack of well-developed alluvial deposits, except for the relatively narrow Isaac River floodplain and thin slivers of alluvium attenuating upstream along the larger tributary streams. Auger sampling on tributary streams suggest alluvium thins rapidly away from the Isaac River with only a thin mantle of residual soils retained over regolith. The lack of significant alluvium away from the Isaac River means that away from the drainage channels, groundwater is confined to the base of the regolith, as well as coal seams.

Depth to groundwater in the Permian coal seams ranges from 13.4 mbgl in the Burton Rider Seam (GW04) to approximately 35 mbgl in the Fort Cooper Coal Measures (GW27a), with groundwater in the regolith significantly shallower at 9.7 mbgl (GW31b). Depth to groundwater for monitoring bores installed in the alluvium range from 5.3 to 14.0 mbgl. Potential terrestrial GDEs on residual landforms (i.e. away from the Isaac River alluvium) are largely dominated by shallow rooted poplar box and narrow leaf ironbark meaning that even at the shallowest groundwater levels of approximately 10 mbgl, tree roots will not have capacity to penetrate to these depths. Groundwater salinity in the regolith ranges from brackish (2,130 $\mu\text{S}/\text{cm}$ at GW31b) to moderately saline (16,990 $\mu\text{S}/\text{cm}$ at GW19_41B). While even the upper salinity levels do not

preclude its utilisation by terrestrial vegetation, there is unlikely be any significant investment in deep root architecture when groundwater quality at depth provides only an extremely marginal moisture resource due to salinity constraints. Groundwater depth in the alluvial monitoring bores is typically much more amenable to vegetation utilisation with depths as shallow as 5.4 mbgl, which is well within the rooting depth of riparian vegetation. Salinity levels as high as 15,360 $\mu\text{S}/\text{cm}$ have however been reported in the alluvium (GW06), which would present only a marginal source of moisture for transpiration when all other moisture sources had been depleted. There is also physical evidence from auger profiling for a shallow perched water table in the alluvium that sits consistently at depths of up to 4 mbgl on the riverbanks at the time of the field assessment, which presented a highly suitable source of moisture to support riparian vegetation. This water is extremely fresh ($<300 \mu\text{S}/\text{cm}$), which suggests:

- recent and rapid recharge in response to rainfall and recent river flows (i.e. in response to the wetter than normal climatic conditions at the time of survey)
- hydraulic separation from the deeper regional alluvial groundwater table hosted in the basal alluvial sediments, that reports much higher salinities (3,770 $\mu\text{S}/\text{cm}$ to 16,800 $\mu\text{S}/\text{cm}$).

This seasonal recharge would also mean that the perched water would be susceptible to depletion during dryer periods, facilitated in part by evapotranspiration (i.e. the identified shallow perched water table would be highly seasonally variable). The lateral extent of this perched water would be controlled by the presence of a coarse river sand layer, which would be expected to thin with distance from the Isaac River. This implies that trees closest to the river would have the greatest degree of groundwater dependence and this dependence would decrease with distance from the river as the perched groundwater table pinches out towards the margins of the floodplain. The perched groundwater unit is inferred to be supported by a clay horizon which restricts downward leakage.

Groundwater level monitoring data from bores where saturation was recorded in the basal alluvial sediments show that the basal alluvial groundwater was hydraulically disconnected from both the shallow seasonally variable perched alluvial groundwater table and the Isaac River channel, with the river channel losing to the underlying groundwater system and forming the 'perched water' resting on shallow clay horizons in some areas as it seeps down. However, data from some monitoring bores suggests groundwater levels in the basal groundwater unit may temporarily rise to similar depths as the perched groundwater during extremely wet periods, which may facilitate a temporary hydraulic connection if intervening clays have sufficient permeability.

5.6.4.2 Nature of Groundwater Dependency and Conceptual Models

The results of GDE data analysis (see Section 5.6.3) indicate that the riparian vegetation associated with the Isaac River floodplain and alluvium presents the only terrestrial GDE. Groundwater usage by vegetation away from the river margins decreases with distance; and away from well-developed alluvial sediments, groundwater usage is restricted by the shallow rooting depth of vegetation, depth to the groundwater table (particularly in the regolith), and groundwater salinity levels.

Within the assessment area, the alluvial floodplain of the Isaac River forms a narrow sandy flood channel flanked by discontinuous upper and lower alluvial terraces with are confined between gentle rises in regolith mantled by residual sediments. At the time of assessment, groundwater was perched in fluvial sands beneath the sandy creek bed, and these coarse river sands and associated groundwater, extended as a unit laterally subtending the riverbanks, were intersected and sampled in shallow auger holes. The perched water that is recorded beneath the river terraces supports well developed riparian vegetation that fringes the river, typically comprising RE 11.3.25.

The GDE field assessment was completed at the tail of an extended period of climatic wetting, and the perched alluvial groundwater features may dry during extended drought periods, accelerated by evapotranspiration. In this sense, these perched, and most likely discontinuous alluvial aquifers are likely to be seasonal features with riparian trees demonstrating facultative dependence on the groundwater resource, with a shift to utilisation of soil moisture when the seasonally variable perched water is depleted.

Water levels from hand augering show that the seasonally variable perched water table may have only limited separation with the basal alluvial aquifer during wet periods (approximately 2.3m in July 2022), although this separation will become much greater during dryer periods when the perched system is diminished. Vertical hydraulic gradients exist within the alluvium that would facilitate the shallow perched water to leak downwards to the deeper basal alluvial groundwater unit in the absence of an intervening barrier. However, the clay layers within the alluvial profile that exist above the basal alluvial groundwater unit and upon which the perched water sits would significantly inhibit the degree to which this downwards seepage occurs, and it is the low permeability of these clay layers that allows the seasonally variable perched groundwater unit to exist.

Recharge of the Isaac River alluvial groundwater system occurs during flood events where overbank flow pushes water laterally into the riverbanks and adjacent terraces. Lateral infiltration of surface flows into the alluvial terraces continues until the level of the surface water drops below the level of the recharged alluvial water table, after which recharged water may temporarily discharge back into the river channel as low volume seepage / baseflow in the short-term.

The inferred spatial extent of terrestrial GDEs on the Isaac River floodplain is presented in Figure 5-12. Based on this assessment, terrestrial GDEs are only defined in well-developed riparian vegetation that fringes the Isaac River, and terrestrial GDEs are not present any significant distance upstream along tributary watercourses. A hydro-ecological conceptualisation of Isaac River at Site 1 (see Figure 5-11) is shown in Figure 5-13, which demonstrates the inferred extent of the seasonally perched water table and its hydraulic relationship to deeper regional scale aquifer systems. Figure 5-13 presents models which demonstrate seasonal groundwater recharge and discharge mechanisms across the dry season, wet season and post wet season (note figure numbering within images relates to the figure numbering in **Appendix 10**). The wet season model also demonstrates the variable response in the basal alluvial groundwater table in response to recharge, with inferred bulging. Based on field data, as illustrated in the conceptual models, there is no evidence that groundwater in the coal seams, or regolith supports any GDEs in the Project area.



Datum: MGA94 Zone 55
 Scale: See Scale Bar (A4)
 Date: 21/08/2026 1:52 PM
 Drawn: RA (Source: 3d Environmental)

LEGEND

- Mining Lease
- Roads
- Watercourse
- Proposed Disturbance Area
- Project Layout
- Known / Likely GDE Areas

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Known or Likely GDE Areas

Figure 38a. Isaac River Floodplain and Tributary - Dry Season

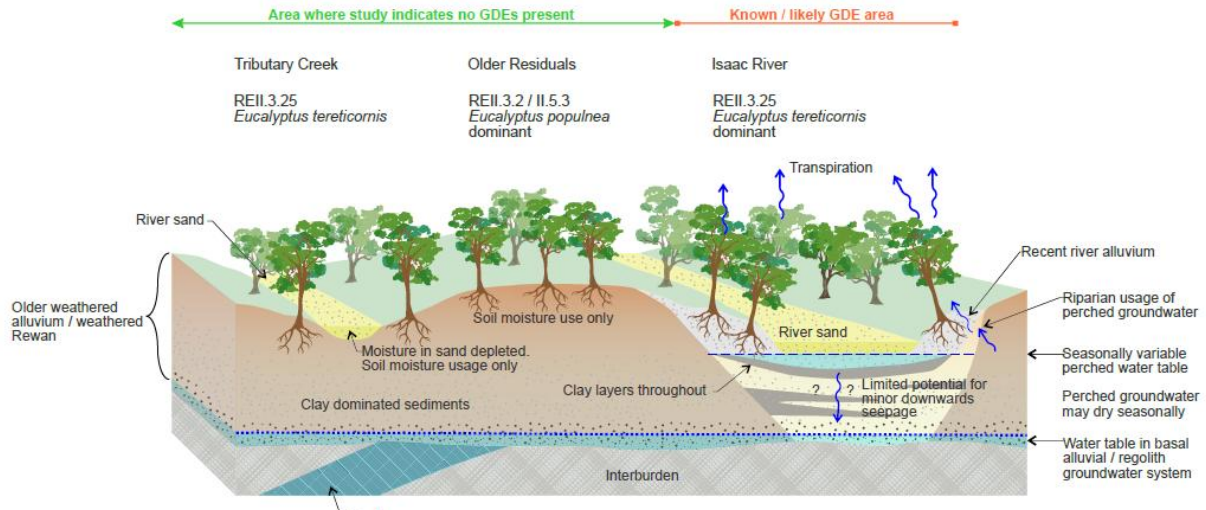


Figure 38b. Isaac River Floodplain and Tributary - Wet Season

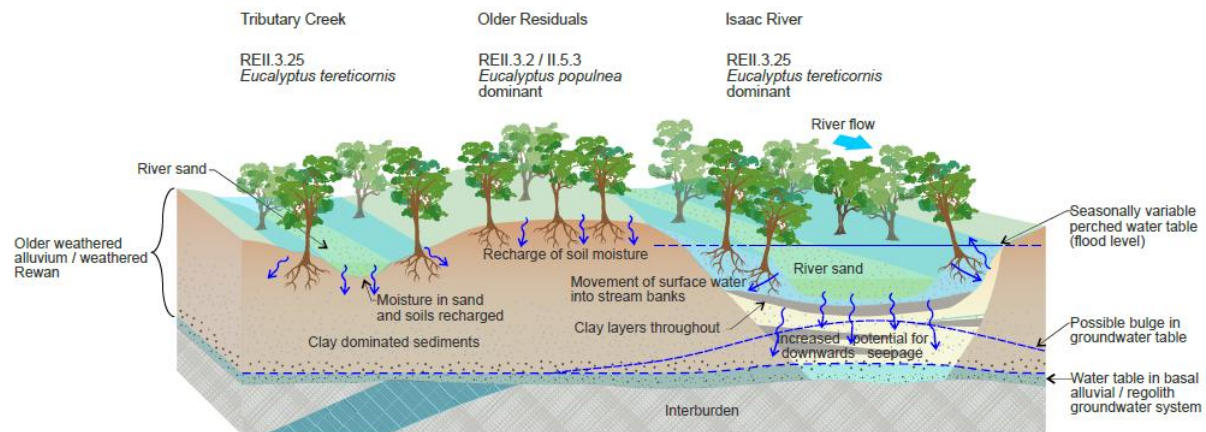


Figure 38c. Isaac River Floodplain and Tributary - Post Wet Season Baseflow Regime

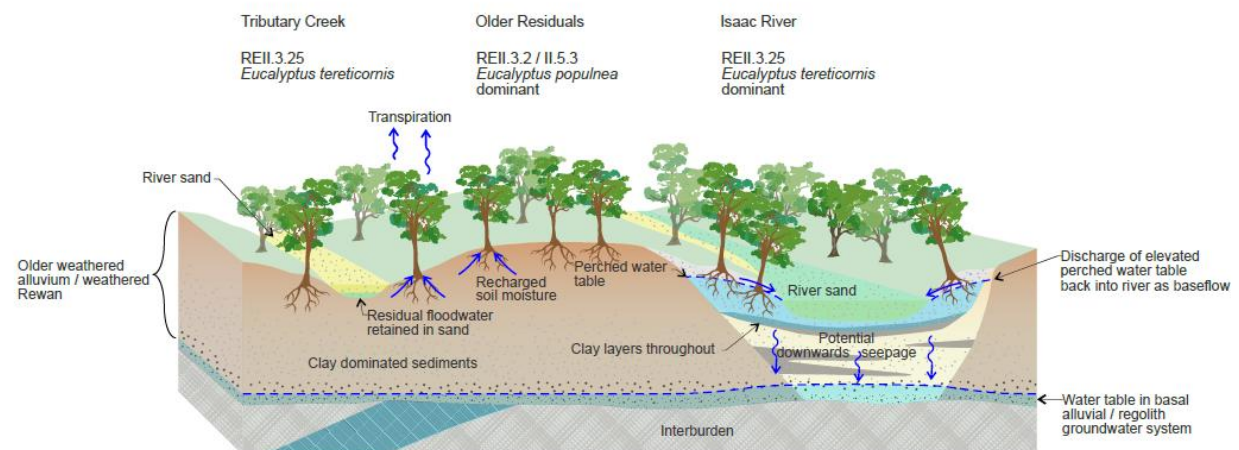


Figure 5-13 Hydro-ecological Conceptualisation of the Isaac River Terrestrial GDE System

5.6.5 Stygofauna

5.6.5.1 Stygofauna of the Region

The diversity of stygofauna reported across Australia's coal regions is reported in **Appendix 11**, with key findings synthesised from 12 studies for the Bowen Basin being:

- stygofauna, including syncarids, amphipods, and harpacticoid and cycloid copepods, were most frequently recorded from alluvial aquifers, but also from basalt aquifers and coal seams
- stygofauna were recorded where standing water level was between 1.4 and 45 m below ground level, and
- stygofauna were recorded from groundwaters with the following water quality characteristics:
 - EC: 342 – 9,975 $\mu\text{S}/\text{cm}$
 - pH: 6.39 – 10.27, and
 - dissolved oxygen: 0.93 – 6.54 mg/L.

Review of frc's in-house database indicates one stygobitic higher taxon (i.e. Parabathynellidae) has been previously sampled from shallow alluvial aquifers at several locations adjacent to large waterways in the region, including several locations adjacent to the Isaac River. A range of stygoxene taxa (e.g. Copepod, Ostracod, Oligochaete, Acarina, Nematoda and Dugesiidae) have also been found in the region, predominantly (but not exclusively) in alluvium at a range of depths.

5.6.5.2 Habitat Suitability

Preliminary discovery rates of stygofauna in Queensland indicate that:

- no stygofauna have been recorded in mudstone or siltstone to date
- stygofauna are less common in clay, coal and basalt dominated geologies
- stygofauna are most common in alluvium, granite, gravel, sand, sandstone, silt, and volcanic geological units.

The geology of the Project area, from shallowest to deepest, comprises:

- surface layers of alluvium and regolith
- the Rewan Group (composed of sandstone and mudstone)
- the Rangal Coal Measures (including the Burton Rider Seam and the Leichardt/Vermont Seams), and
- Fort Cooper Coal Measures.

The diversity of stygofauna in Queensland is highest in alluvium. The Project area therefore includes geological units that are known to provide habitat for stygofauna.

The depth to water table of bores in shallow alluvium within the Project area is generally less than 15 mbgl (i.e. shallow groundwater systems), with the maximum depth to water table being 36.3 mbgl at bore GW10 within the Leichhardt / Vermont Coal Seam. Therefore, the depth to water table ranges at bores in the Project area are consistent with depth to water table where diverse stygofauna have been reported elsewhere in eastern Australia.

EC, pH and TDS at bores in the Project area was generally consistent with that recorded groundwater elsewhere in eastern Australia where diverse stygofauna have been recorded.

5.6.5.3 Stygofauna of the Project Area

Results of the stygofauna survey indicated:

- a total of five stygofauna taxa were recorded, with one stygobite (i.e. Bathynellidae) and four stygoxene taxa
- the stygobite was recorded at bore GW19-33 that targeted alluvium/regolith, with two stygoxene taxa also found at this bore (i.e. bore GW19-33 had the highest diversity of stygofauna).

- bores GW19-33 and GW06 that both targeted shallow alluvium/regolith each had two stygofauna taxa that were not found at any other bore (i.e. 4 of the 5 taxa were found at only two bores)
- the stygoxene taxon *Acaina* sp. 1 was the most widespread species, occurring at seven (47%) of the bores, and
- only bores targeting alluvium or regolith had stygofauna, and all bores at which stygofauna were recorded, except bore GW31b, were in close proximity to the Isaac River.

Shallow groundwater of the Project area within alluvial and regolith lithologies in close proximity to the Isaac River area has moderate stygofauna values, based on the presence of a stygobitic species and suitable hydrogeological conditions for stygofauna. There was also a moderate diversity of stygoxene taxa. A single stygoxene taxon (i.e. a mite) was also found in regolith adjacent to Hill Creek, a tributary of the Isaac River, and in shallow coal seams at bores relatively close to the Isaac River.

The results of this assessment therefore indicate that shallow groundwater of the Project area, especially within alluvial and regolith lithologies, in close proximity to the Isaac River, provides suitable habitat for stygobitic fauna.

5.6.6 Aquatic GDEs

Following the field assessment described in Section 5.3.7, no surface expressions of permanent or semi-permanent water or aquatic ecosystems were identified in any of the creeks or river systems assessed. No signs of vegetation indicating regularly inundated areas were observed during the survey.

Given that the watercourses show no evidence of relying on the surface expression of groundwater, it is considered that none of these watercourses are groundwater-dependent aquatic ecosystems.

5.7 Groundwater Model Predictions

5.7.1 Model Design

The model has been discretised into 19 layers. The model layer structure is presented in Table 5-5. Those layers identified in the table as east/west of Burton Range Fault (BRF) represent the geological units displaced by the fault and are represented by different layers based on their location on either side of the fault; i.e. the model simulates the fault via layers being offset on either side of the fault.

It should be noted that the model is unable to simulate the dual natured alluvial groundwater system discussed in the conceptualisation (see Sections 5.5.3 and 5.5.13). In particular, a perched water table within layer 1 is unable to be represented in the model, and groundwater present in layer 1 of the model represents only the basal alluvial groundwater system discussed in Section 5.5.3 and 5.5.13. Nevertheless, assessment of potential impacts on the seasonally variable perched water table has been undertaken as part of the GDE Assessment (see Sections 5.6.3 and 5.6.4).

Table 5-5 Model Layering

Layer	Geological Age	Lithology	Average Thickness (m)	Spatial Extent
1	Quaternary/Tertiary	Alluvium & Shallow Regolith	5.0	Model domain
2		Regolith & Basalt	14.2	Model domain
3	Triassic	Triassic (top)	175.3	West of BRF
4		Triassic (top)	148.2	East of BRF
5		Triassic (middle)	176.6	West of BRF
6		Triassic (middle)	148.2	East of BRF

Layer	Geological Age	Lithology	Average Thickness (m)	Spatial Extent
7	Permian	Rewan (bottom)	176.5	West of BRF
8		Rewan (bottom)	148.2	East of BRF
9		Overburden (Rangal Coal Measures (RCM))	48.2	West of BRF
10		Overburden (RCM)	47.7	East of BRF
11		Burton Rider Seam (RCM)	1.5	West of BRF
12		Burton Rider Seam (RCM)	1.8	East of BRF
13		Interburden (RCM)	26.0	West of BRF
14		Interburden (RCM)	25.2	East of BRF
15		Leichhardt/Vermont Seams (RCM)	8.2	West of BRF
16		Leichhardt/Vermont Seams (RCM)	8.3	East of BRF
17		Underburden (RCM)	100.0	West of BRF
18		Underburden (RCM)	99.8	East of BRF
19		Coal Measures (FCCM)	100.0	Model domain

5.7.2 Overview of Model Predictions

Transient predictive modelling was undertaken to simulate both the proposed mining at the Project and the planned mining at the neighbouring Burton Mine from July 2023 to January 2042. The predictive model timing used quarterly stress periods to January 2024, followed by annual stress periods until January 2040 and biennial stress periods thereafter.

Three transient predictive numerical model scenarios were run:

- Cumulative – proposed mining at New Lenton (the Project) plus future approved mining at Burton Mine.
- Approved – approved future mining at Burton Mine.
- Null – no historic or future mining within the region.

Project-only (incremental) impacts are derived from the difference between the Cumulative and Approved model scenarios, whilst cumulative impacts are derived from the difference between the Cumulative and Null model scenarios.

Consideration of climate change was not considered warranted within the predictive modelling through to the end of mining given the relatively short lifespan of the Project.

5.7.3 Predicted Groundwater Interception

Predicted groundwater inflows to the proposed West and East open cut pits at the Project are presented in Figure 5-14. The groundwater inflows to the West Pit are predicted to peak in 2027 at 524 ML/year, while for East Pit a peak of 856 ML/year is predicted in 2030. The total groundwater inflow to the Project pits is predicted to reach a maximum of 1,026 ML/year in 2030, coinciding with operations commencing at the second pit (East Pit). The model predicts an average of 434.5 ML/year groundwater take over the duration of mining at the Project. It should be noted that this total volume includes water removed in rock material

with mining, as well as water evaporated from the surface of the pit walls and floor. It is therefore an over-estimate of groundwater that could report to the site water balance or require physical management within the mine water management system.

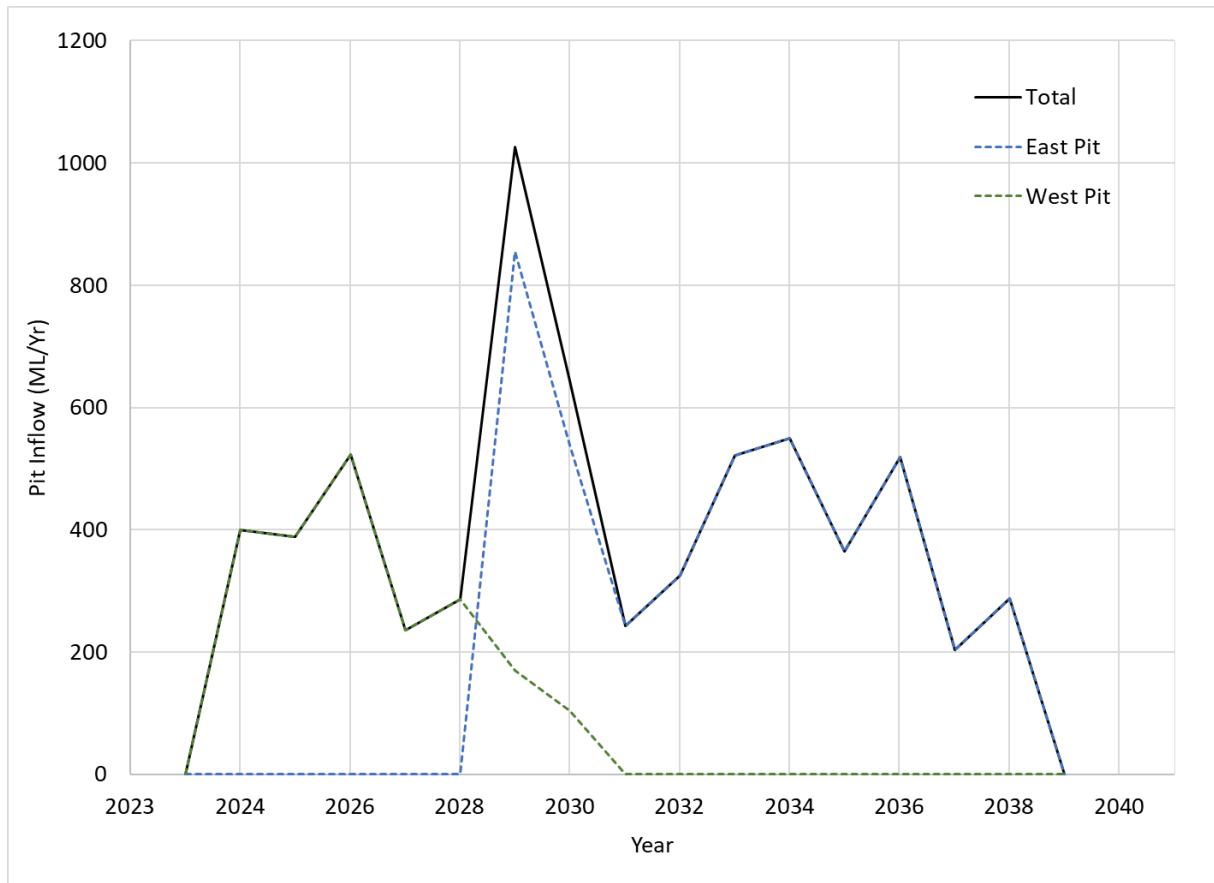


Figure 5-14 Predicted Project Mine Pit Inflows

5.7.4 Predicted Maximum Incremental Groundwater Level Drawdown

The process of mining reduces water levels in surrounding groundwater units. The extent of the zone affected is dependent on the properties of the aquifers/aquitards and is referred to as the zone of depressurisation in a confined aquifer and zone of drawdown within the water table. Depressurisation and drawdown are greatest at the working coal-face, and gradually reduces with distance from the mine.

Maximum incremental drawdown due to the proposed mining at the Project was obtained by comparing the difference in predicted groundwater levels for the Approved scenario and the Cumulative scenario, and are shown in Figure 5-15 to Figure 5-19 for the key model layers. The maximum drawdown is a combination of the maximum drawdown values recorded at each cell at any time from the start of active mining at the Project (January 2025)³ to one year after end of the mining at the Project (December 2040).

There are no areas with predicted drawdowns of >1 m that intersect known private bores.

Figure 5-15 shows that the 1 m contour of the predicted maximum incremental water table drawdown extends approximately 2 km to the north and south of the Project mine pits and 1 km to the east and west. This drawdown does not represent any particular aquifer unit but the shallowest saturated unit at any particular location.

Figure 5-16 shows the maximum incremental drawdown predicted within the Isaac River alluvium due to proposed mining at the Project reaches up to 12 m in magnitude along the south-eastern edge of East Pit,

³ Whilst the proposed start date is likely to be from 2027, in the context of groundwater model predictions over hundreds of years, this change in timeframe is immaterial to results presented in this PER.

where the Isaac River is within 150 m of the mine pit crest. Predicted drawdown of approximately 2 m in the alluvium extends 2 km downstream and 1 km upstream of East Pit at the Project.

Figure 5-17 shows the maximum incremental drawdown predicted in the Regolith (model layer 2). Predicted drawdowns extents are very similar to that for the water table (refer Figure 5-15), which is expected given the Regolith contains the water table in areas outside mapped alluvium.

Figure 5-18 and Figure 5-19 show the extent of maximum predicted depressurisation of the Permian coal seams (Burton/Rider and Leichhardt/Vermont seams, respectively). Predicted depressurisation of the Permian coal seams extends 2.5 km to the northeast. As the Permian units sub-crop to the south and west of the Project pits the model layers are not present in these areas.

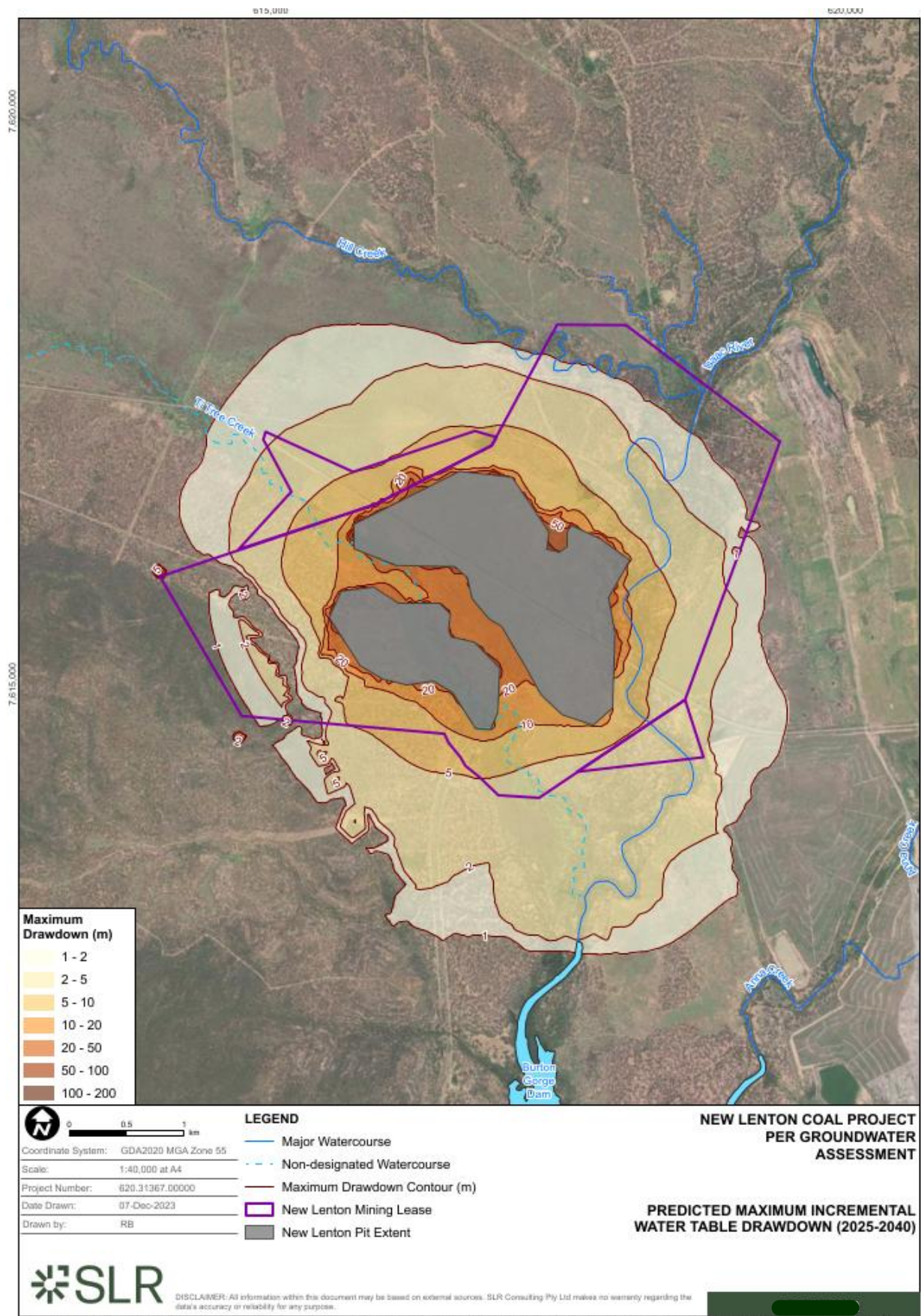


Figure 5-15 Predicted Maximum Incremental Water Table Drawdown (2025-2040)

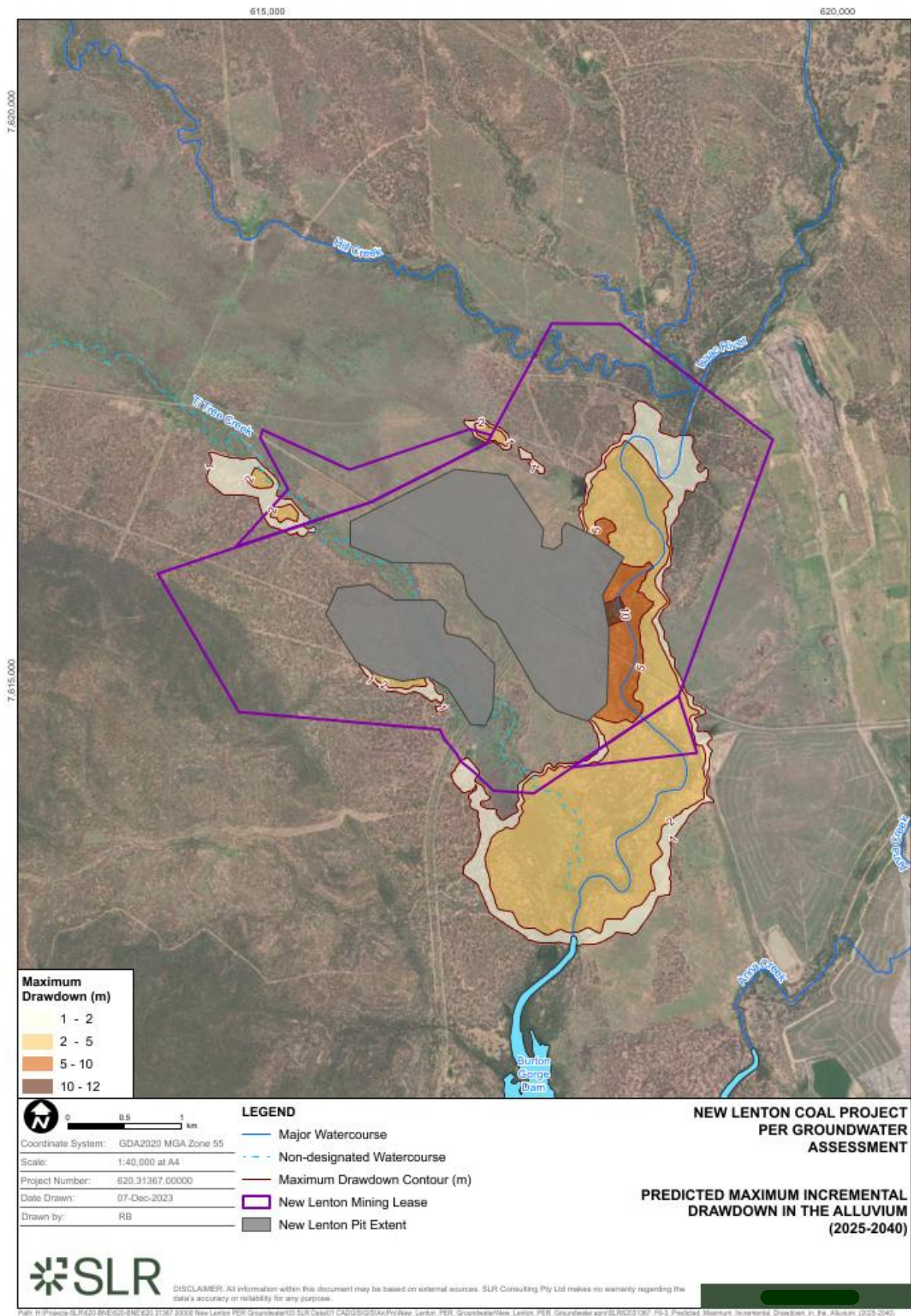


Figure 5-16 Predicted Maximum Incremental Drawdown in the Alluvium (2025-2040)

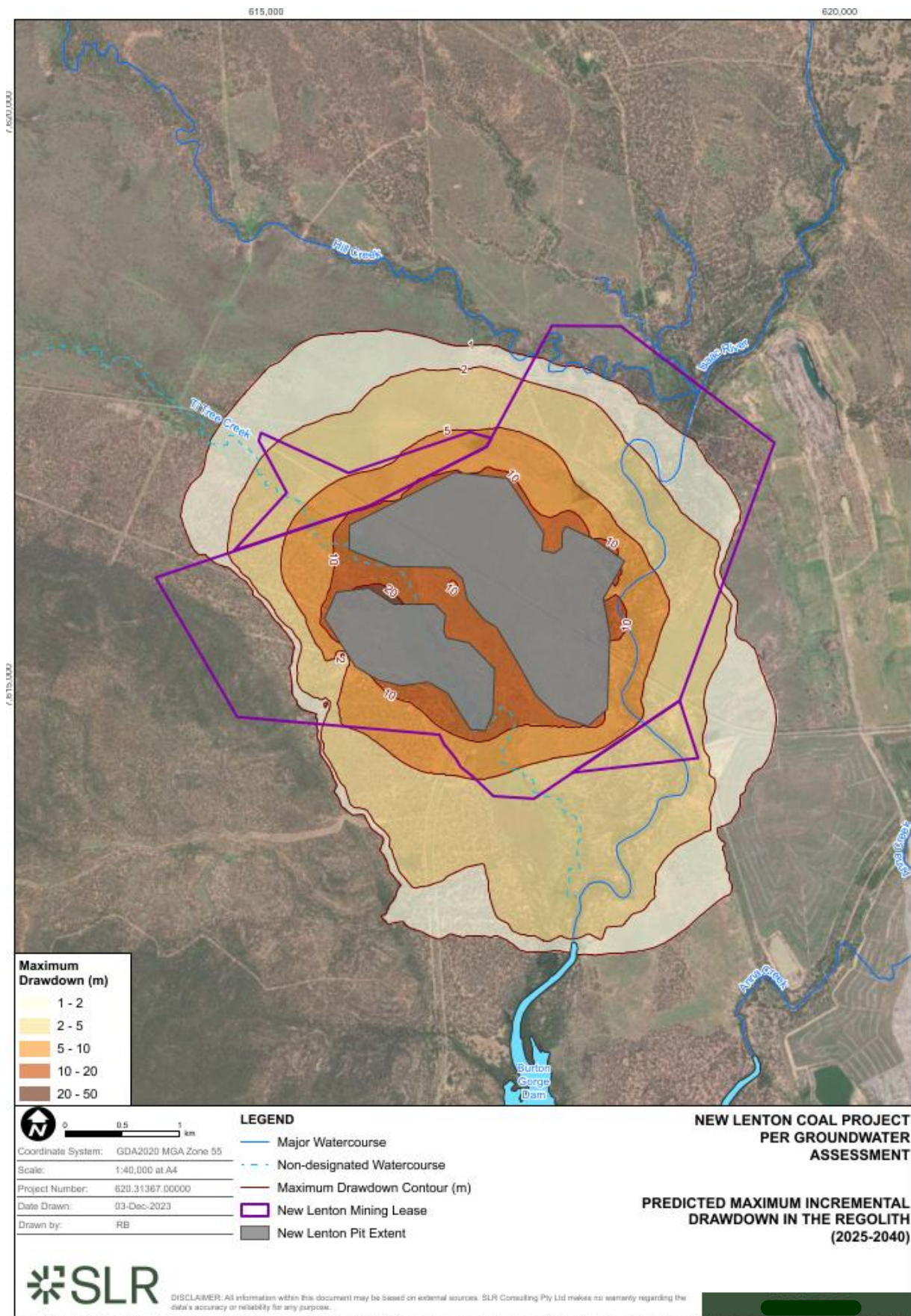


Figure 5-17 Predicted Maximum Incremental Drawdown in the Regolith (2025-2040)

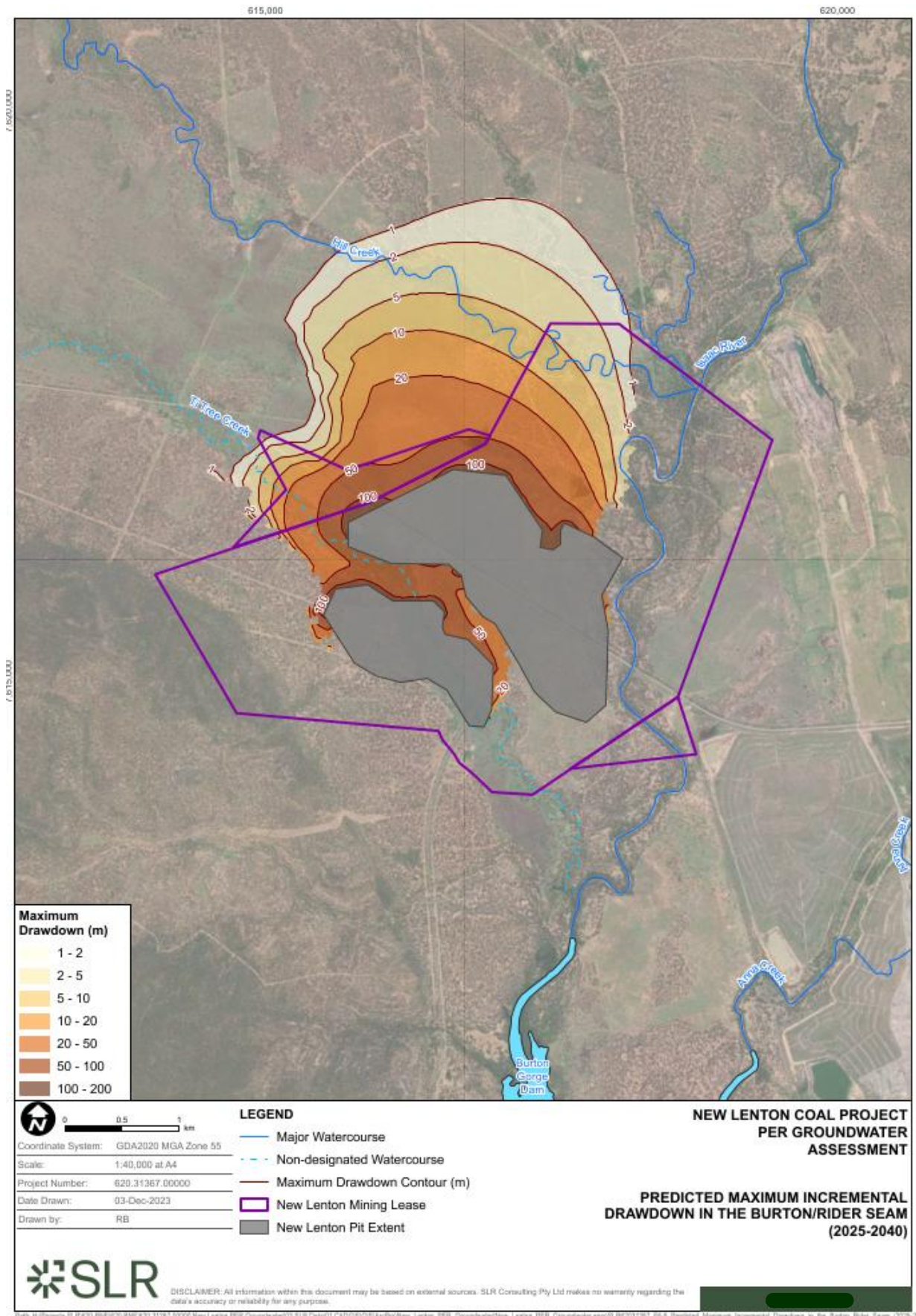


Figure 5-18 Predicted Maximum Incremental Drawdown in the Burton/Rider Seam (2025-2040)

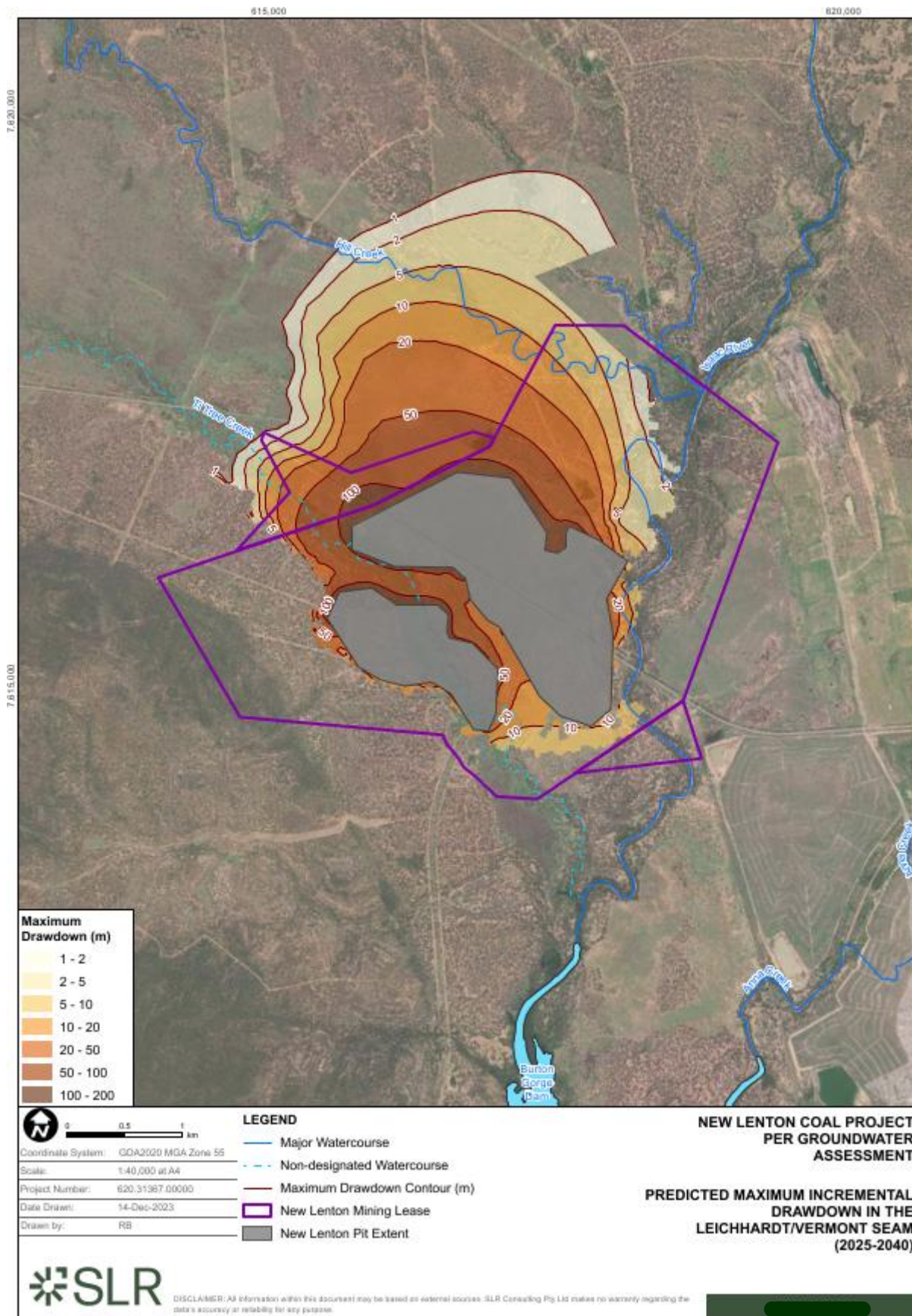


Figure 5-19 Predicted Maximum Incremental Drawdown in the Leichhardt/Vermont Seam (2025-2040)

5.7.5 Influence on River Flow

The predicted change in surface water flow due to proposed mining at the Project was calculated by comparing the river cell flow budget for the Isaac River (within 3 km of the Project area) for the Approved and Cumulative scenarios. The model predicted no baseflow in either the Approved or Cumulative scenario therefore no change to Isaac River baseflow was identified due to simulated mining at the Project. Model predictions are consistent with the conceptualisation, i.e. that the alluvium associated with the Isaac River near the site does not supply a baseflow component to the Isaac River.

5.7.6 Cumulative Impacts

The maximum cumulative drawdowns are obtained by the calculating the maximum difference in heads between the Cumulative and Null scenarios at each cell at any time, from the end of the calibration period (July 2023) to one year after the end of the proposed mining at the Project (December 2040).

Figure 5-20 to Figure 5-24 show the maximum predicted cumulative drawdown for the water table, as well as depressurisation within individual model layers. This includes drawdown within the alluvium and Regolith, and depressurisation within the Burton/Rider and Leichhardt/Vermont seams.

Figure 5-20 shows that water table drawdown is greatest within or closely around the mining areas, and gradually reduces with distance from the mines. It should be noted that the figure presents maximum drawdown in the uppermost saturated model layer, including the Triassic units that overlie the Permian coal measures.

Figure 5-21 shows that cumulative drawdown is predicted in the alluvium where drainage lines run between the mine pits at the Project and Burton Mine. The predicted maximum cumulative drawdown extent in the Isaac River alluvium extends a further 3 km upstream than the predicted incremental drawdown extent shown in Figure 5-16. In the area of predicted incremental drawdown in the alluvium, the predicted cumulative drawdown map shows negligible increase in drawdown magnitude between the incremental and cumulative predictions (i.e. Burton Mine doesn't exacerbate the Project predicted drawdown), although Burton Mine contributes its own drawdown to the north in the Isaac River.

Figure 5-22 shows the maximum predicted cumulative drawdown extent in the Regolith, which as expected extends further to the southeast and northeast than the predicted incremental drawdown shown in Figure 5-17 and is similar to the extent of cumulative drawdown in the water table shown in Figure 5-20.

The greatest cumulative depressurisation occurs in the deeper coal seams that are mined at the Project and Burton Mine. Figure 5-23 and Figure 5-24 show drawdowns in the Permian Burton/Rider and Leichhardt/Vermont seams around the Project interact with depressurisation around the northern-most Burton pits. However, the extent of depressurisation in the coal seams is limited to the west of the Project by the sub-crop of the Permian coal seams.

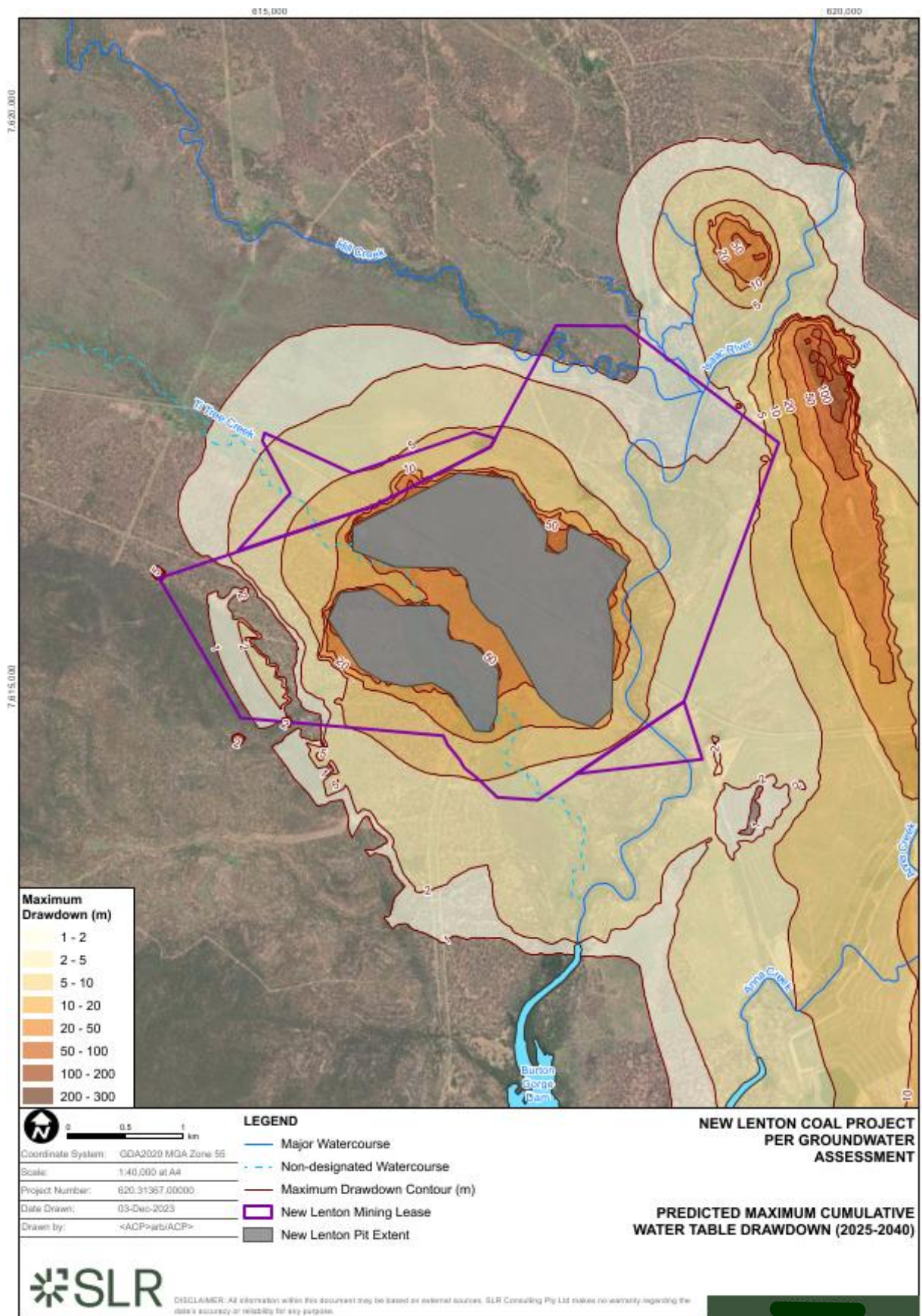


Figure 5-20 Predicted Maximum Cumulative Water Table Drawdown (2025-2040)

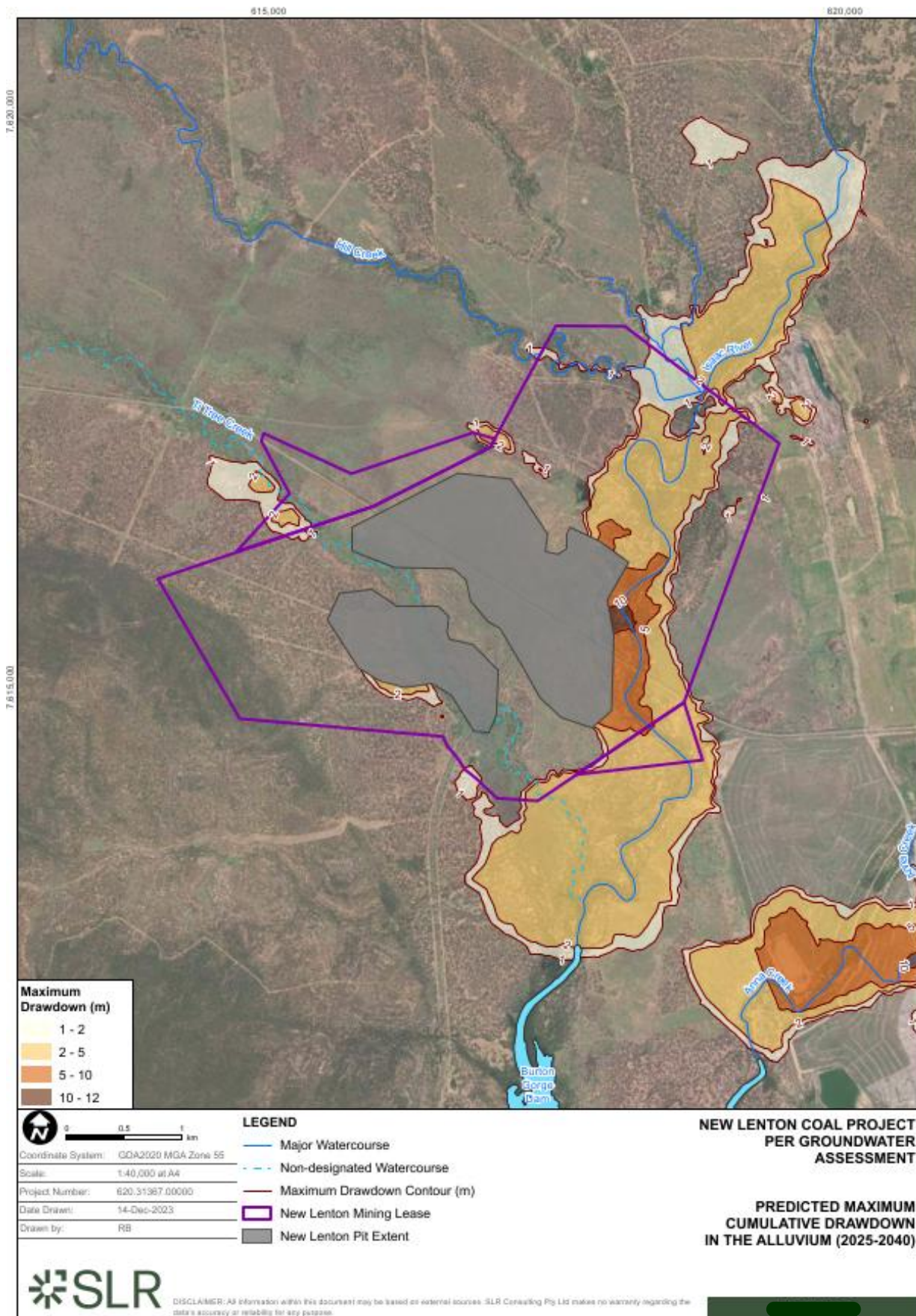


Figure 5-21 Predicted Maximum Cumulative Drawdown in the Alluvium (2025-2040)

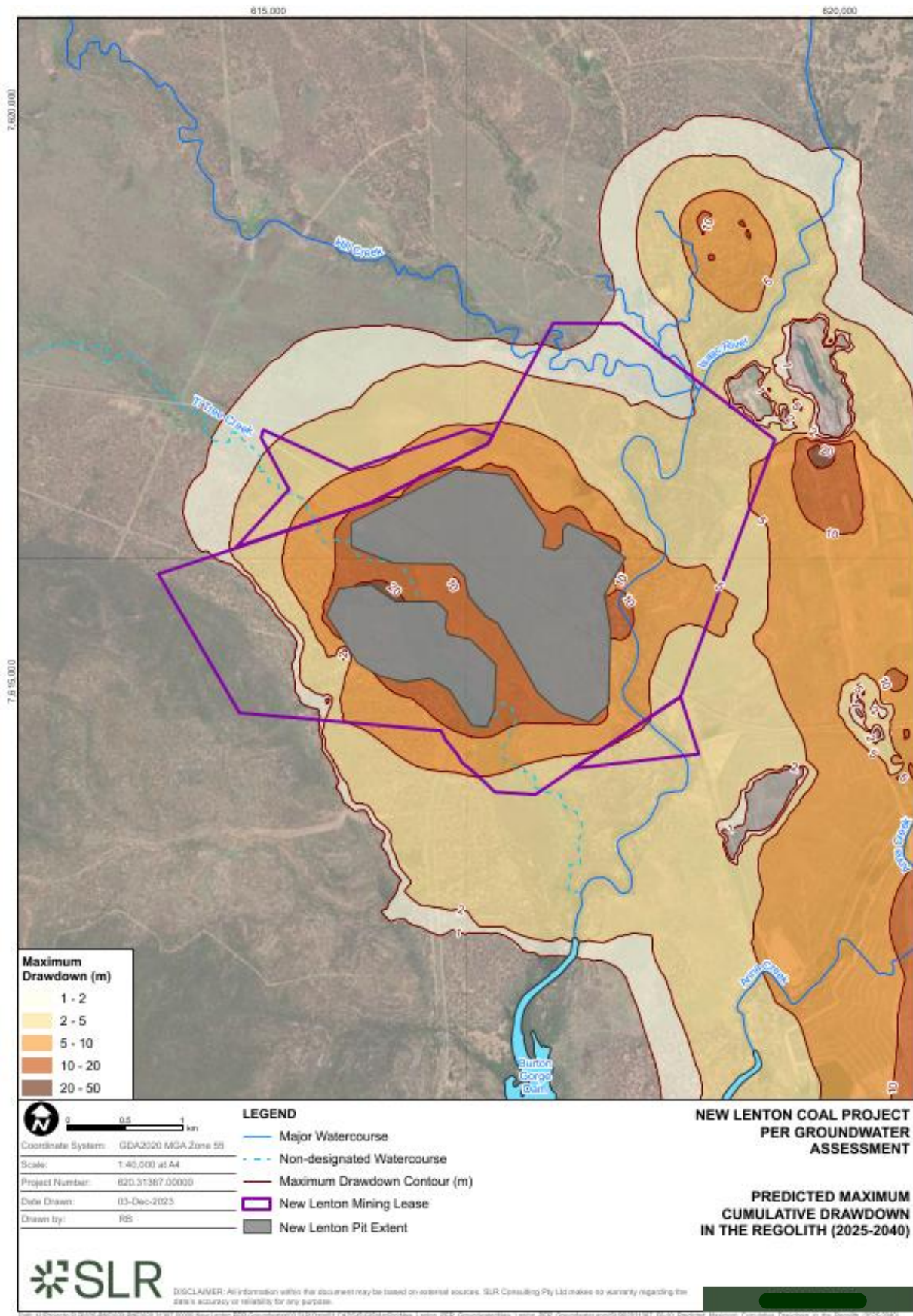


Figure 5-22 Predicted Maximum Cumulative Drawdown in the Regolith (2025-2040)

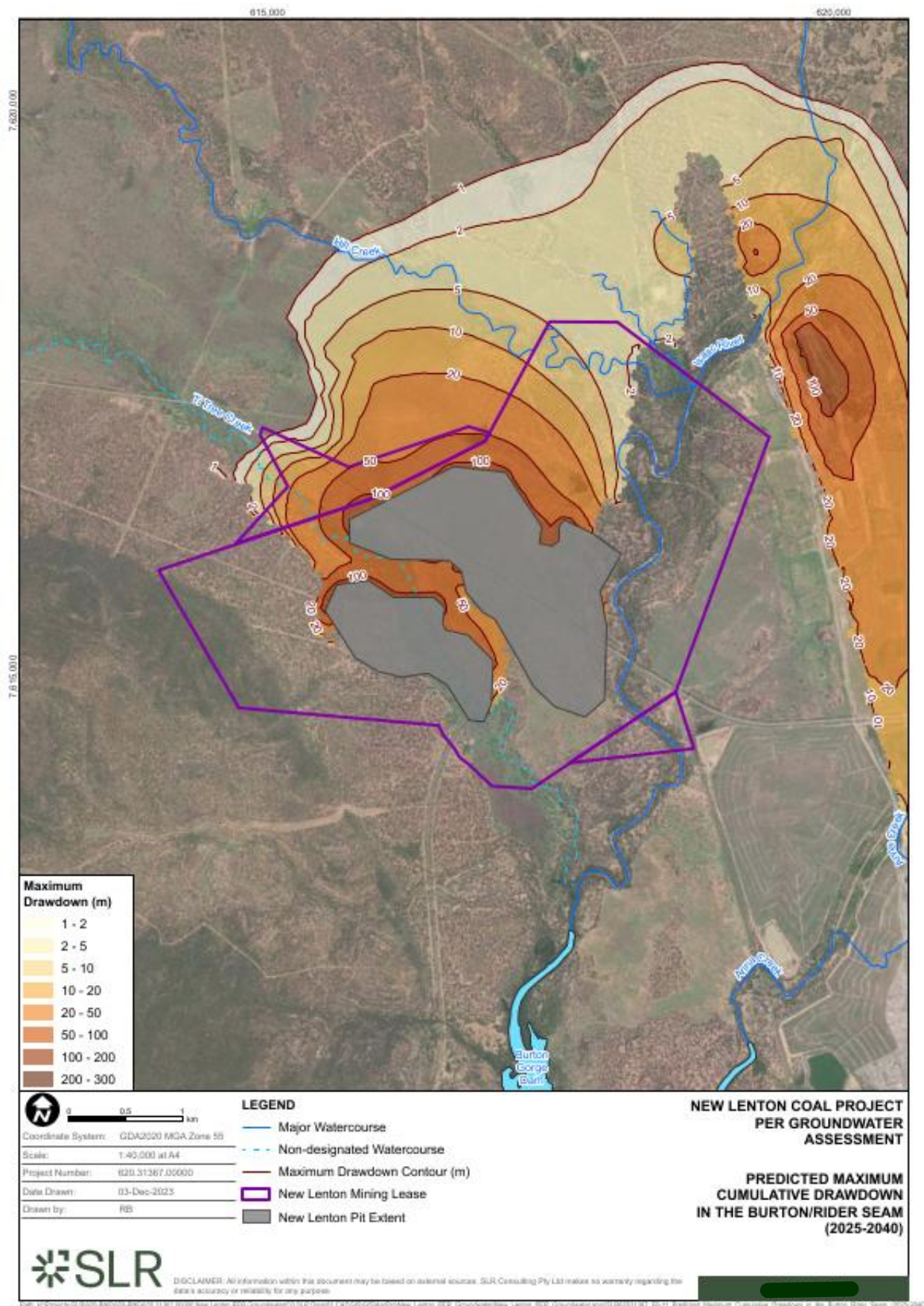


Figure 5-23 Predicted Maximum Cumulative Drawdown in the Burton/Rider Seam (2025-2040)

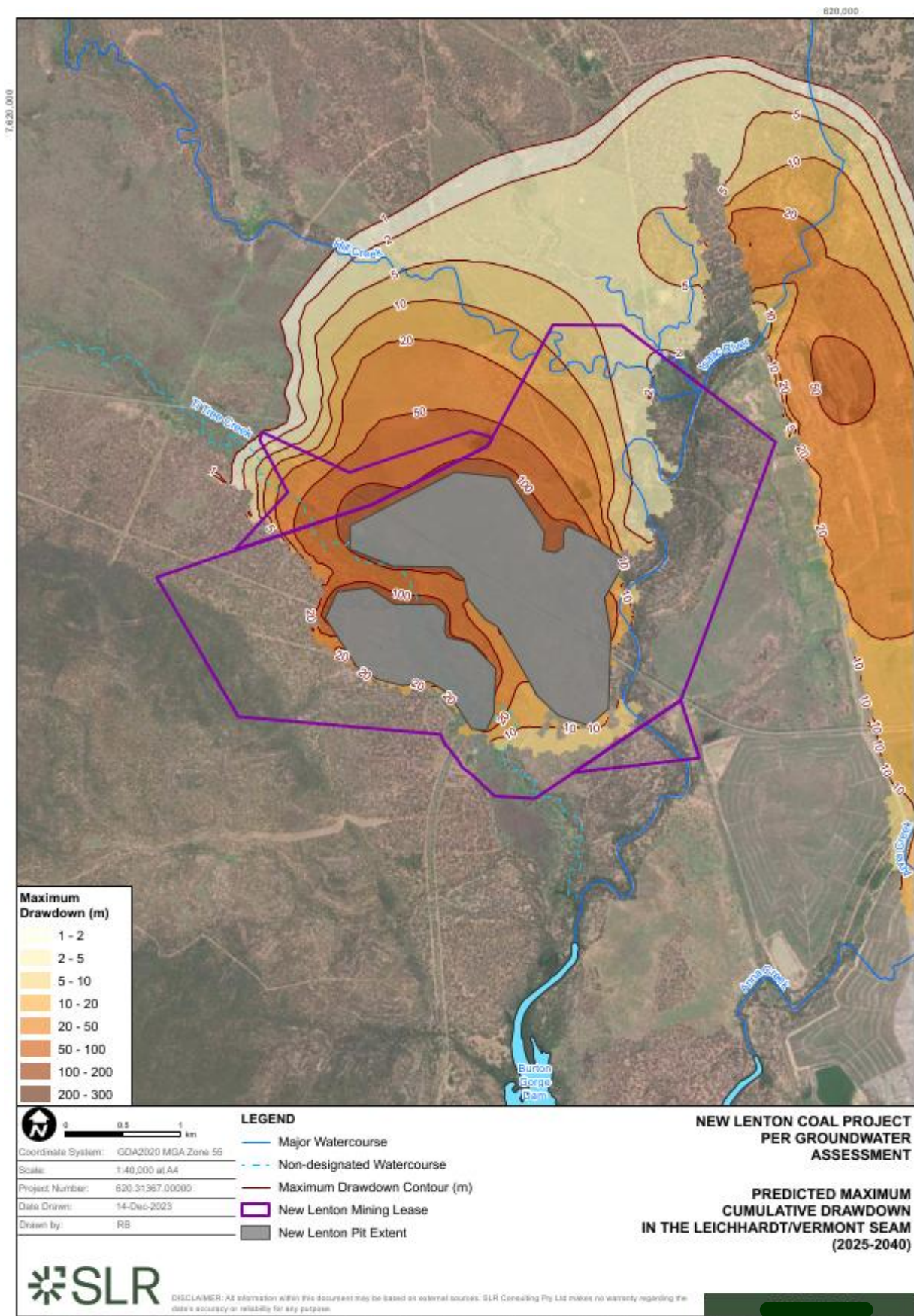


Figure 5-24 Predicted Maximum Cumulative Drawdown in the Leichhardt/Vermont Seam (2025-2040)

5.8 Post-Mining Model Simulation

5.8.1 Model Setup

Transient predictive modelling was used to simulate groundwater responses following the cessation of all mining operations in the model domain, encompassing both Project and the adjacent Burton Mine, given that groundwater in the post-mining landforms at the two sites is likely to interact.

The post-mining recovery model starts at the end of mining at the Project (2040)⁴ and continues for approximately 730 years (2040 to 2770). Simulated mining at Burton Mine ceases by 2036. The recovery model consists of biennial stress periods for the first 20 years post-mining, followed by stress periods of increasing length of up to 100-years.

Three transient predictive recovery model scenarios have been developed, to allow the assessment of incremental and cumulative post-mining impacts on the groundwater system:

- Cumulative – post-mining at the Project plus at the Burton Mine.
- Approved – post-mining at the Burton Mine, no mining at New Lenton anytime in the past or future.
- Null – no mining within the region anytime in the past or future.

Project-only (incremental) post-mining impacts are derived from the difference between the Cumulative and Approved model scenarios, whilst cumulative post-mining impacts are derived from the difference between the Cumulative and Null model scenarios. The proposed final landforms for the Project (refer to Chapter 3) and the adjacent Burton Mine have been replicated in the model, including areas of waste rock (overburden) within mined out pits and the residual voids. Further information in the post mining model setup is provided in Section 6.7 of **Appendix 8**.

5.8.2 Post Mining Residual Void

The residual void will accumulate water over time due to direct rainfall, surface water runoff and groundwater inflow from both overburden and natural rock as groundwater levels recover. Whilst the numerical groundwater model can reliably account for the groundwater inflow component, the surface components of direct rainfall, surface water runoff, as well as evaporative loss from the void lake have been accounted for in the final void water balance model (refer to Section 4.8 of Chapter 4).

Project residual void water levels were not predicted by the groundwater model, but were estimated by the balance between groundwater inflow and the direct rainfall and rainfall runoff from the surrounding catchment against the evaporation loss from the lake surface through void water balance modelling (refer to Section 4.8 of Chapter 4). A number of iterative steps were run for the groundwater model and void water balance model, such that models reached agreement on predicted groundwater inflows. The inflows are partitioned between flow into the residual void through overburden, and that which flows into the residual void through only surrounding natural geological formations (i.e. where the natural geology remains exposed to the void shell). The modelled residual void lake level, based the agreed predicted groundwater inflows, is provided in Section 4.8 of Chapter 4.

5.8.3 Predicted Post-Mining Groundwater Levels

To demonstrate the groundwater system transient response following the end of mining through to post-mining equilibrium conditions, predictive hydrographs showing the change in groundwater levels over time at ‘dummy bore’ locations have been produced from the post-mining groundwater recovery model. The hydrographs have been developed just outside the residual void for each of the units present adjacent the residual void, being the Regolith, Burton/Rider and Leichhardt/Vermont seams. The hydrographs and the

⁴ Whilst the proposed end of mining date is likely to be from 2042, in the context of groundwater model predictions over hundreds of years, this change in timeframe is immaterial to results presented in this PER.

location of the hydrographs are shown in Section 6.7.5 of **Appendix 8**. An example of the hydrographs is shown in Figure 5-25⁵.

The hydrographs demonstrate that at all times post-mining, groundwater levels in each aquifer unit surrounding the residual void remain above the predicted void lake level, meaning no potential for outflow from the void lake to the groundwater system and permanent inflow only (sink) conditions are maintained post-mining. Furthermore, the hydrographs show void lake levels remain below the base of the shallow groundwater system (regolith) at all times, further suggesting no potential for void lake outflow to that unit.

5.8.4 Climate Change Scenarios

Void water balance modelling included an assessment of lake levels under a number of climate change scenarios (refer to Section 4.8.4 of Chapter 4). The climate change assessment demonstrated that there is no risk of void lake overflow even under the most conservative climate change scenarios. The assessment also demonstrated that the void lake level under the 'worst case' climate scenario is very similar to the baseline climate scenario, and therefore there would be minimal effect on resulting groundwater levels at equilibrium between the 'worst case' climate change scenario and the baseline climate scenario results. Under the climate change scenarios the voids will continue to act as sink for groundwater post mining.

⁵ The hydrographs include the following nomenclature and features: for the Regolith, Burton/Rider seam (BR Seam) and Leichhardt/Vermont seam (LV Seam), and with locations north (N), east (E), south (S) and west (W) of the residual void

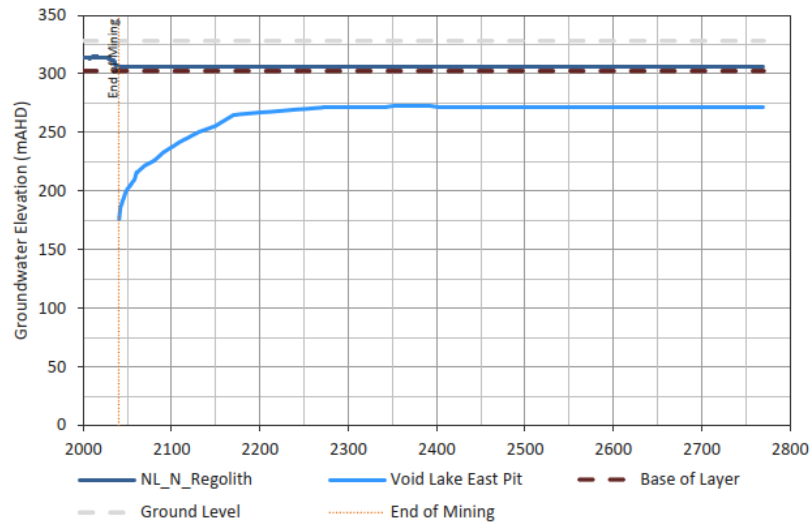
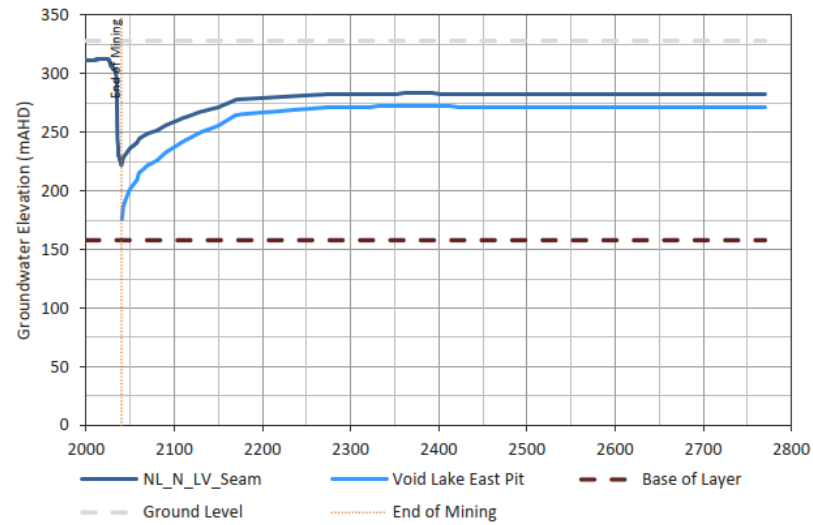
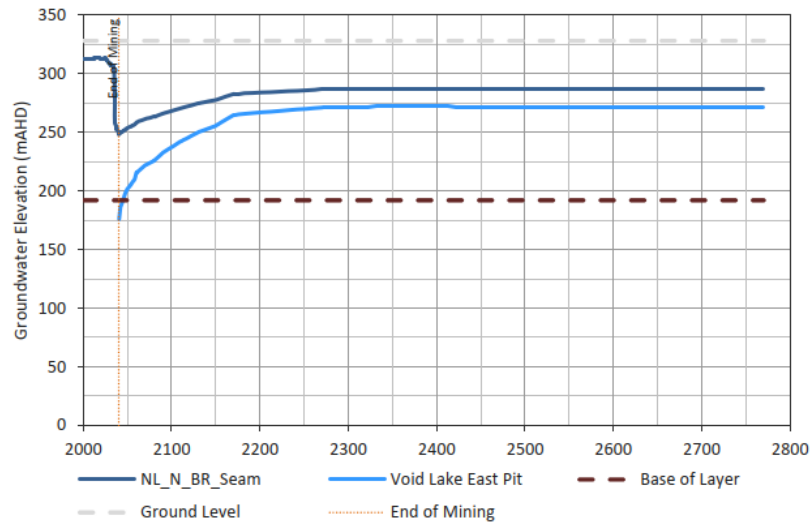


Figure 5-25 Predictive Hydrographs to the North of the Residual Void

5.8.5 Residual Groundwater Level Drawdown at Post-Mining Equilibrium

The predicted equilibrium incremental residual groundwater level drawdown in the water table is shown in Figure 5-26. Predicted equilibrium residual drawdown for the Alluvium, Regolith, Burton/Rider and Leichhardt/Vermont seam layers are shown on Figure 5-27 to Figure 5-30.

There are no areas with predicted post-mining equilibrium drawdowns of >1 m that intersect known private bores.

Figure 5-26 shows that the 1 m contour of the predicted maximum incremental water table drawdown at post-mining equilibrium is similar in extent to the maximum incremental extent during mining (Figure 5-15), however drawdown magnitudes are lesser within the Project area due to recovery post-mining. Note that this drawdown does not represent any particular aquifer unit but the shallowest saturated unit at any particular location.

Figure 5-27 shows the maximum incremental drawdown predicted within the Isaac River alluvium at post-mining equilibrium remains similar in extent and magnitude as maximum incremental drawdown during mining (Figure 5-16), dominantly remaining within the Project area but also extending southwards up to approximately 2 km downstream of the Project.

Figure 5-28 shows the maximum incremental drawdown predicted in the Regolith (model layer 2) at post-mining equilibrium. Predicted post-mining drawdowns extents are very similar to that for the water table which is expected given the Regolith contains the water table in areas outside mapped alluvium. Within the Project area drawdown magnitudes in the Regolith are lesser than the maximums predicted during mining (refer Figure 5-17) due to recovery post-mining.

Figure 5-29 and Figure 5-30 show the extent of predicted depressurisation of the Permian coal seams (Burton/Rider and Leichhardt/Vermont seams, respectively) at post-mining equilibrium. The 1 m drawdown contour extends approximately 1 km further to the northwest than the maximum extent during mining (refer Figure 5-18 and Figure 5-19), however drawdown magnitudes are significantly less close to the Project area as a result of post-mining recovery.

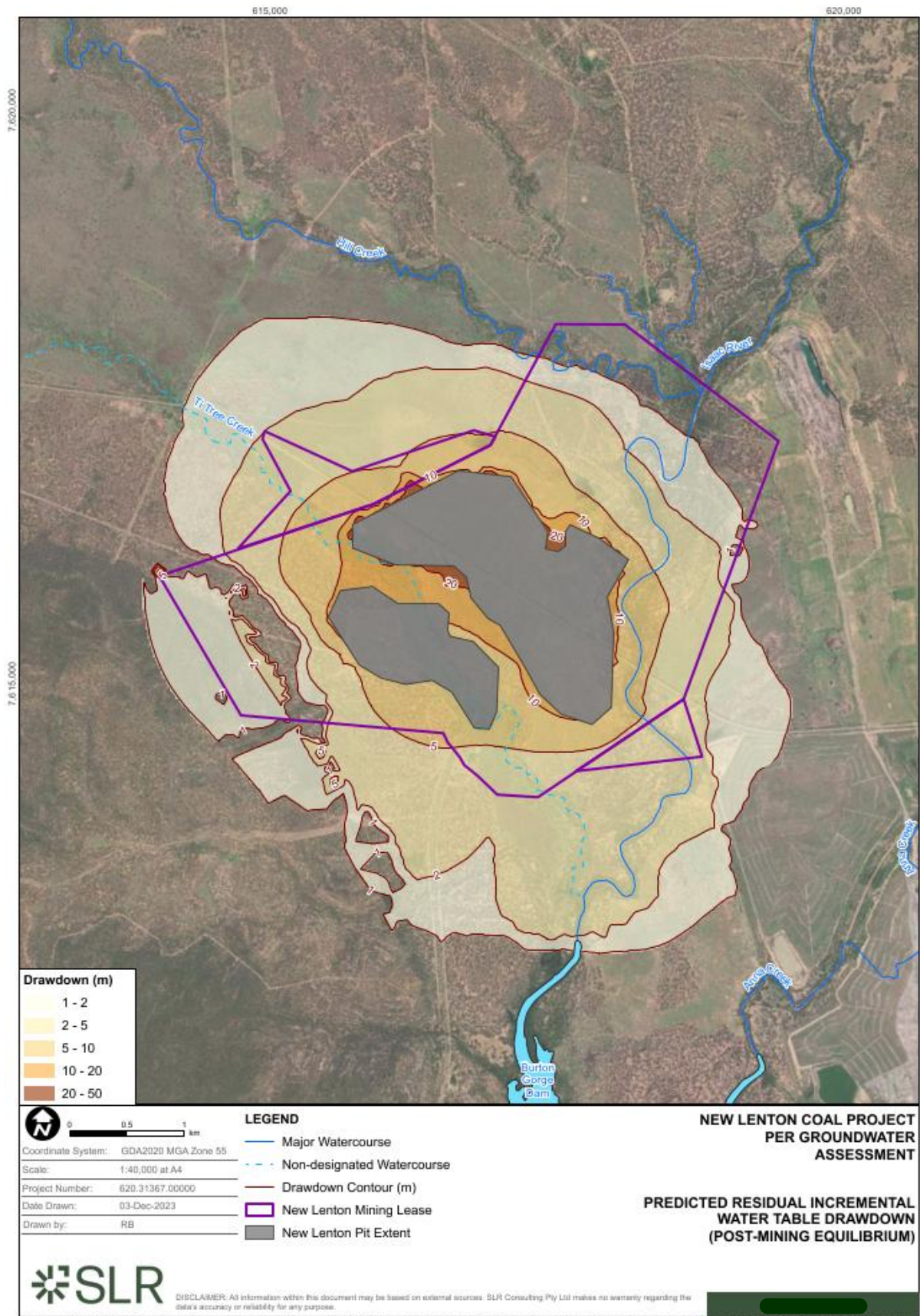


Figure 5-26 Predicted Residual Groundwater Level Drawdown in the Water Table at Post-Mining Equilibrium

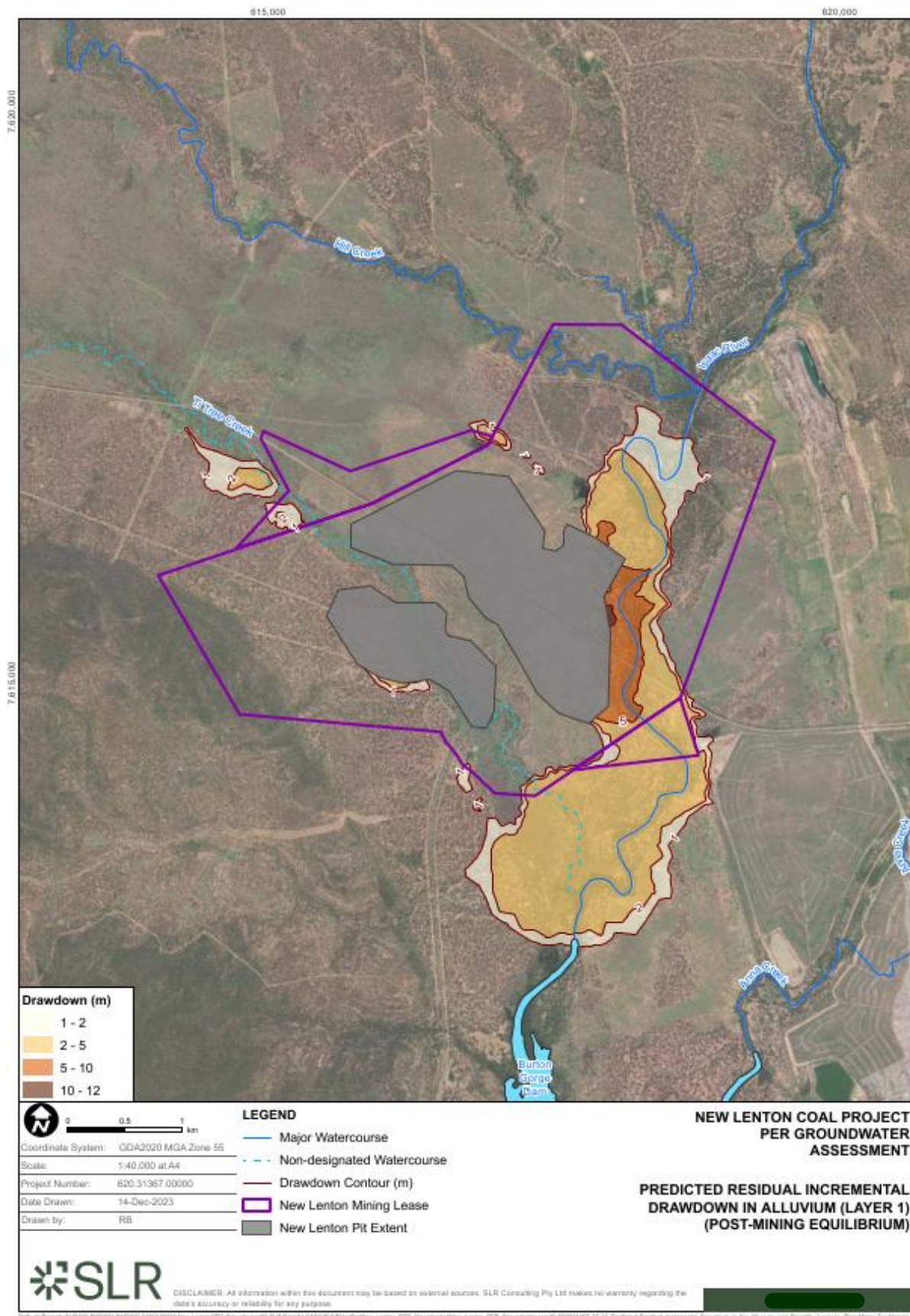


Figure 5-27 Predicted Residual Groundwater Level Drawdown in the Alluvium (Layer 1) at Post-Mining Equilibrium

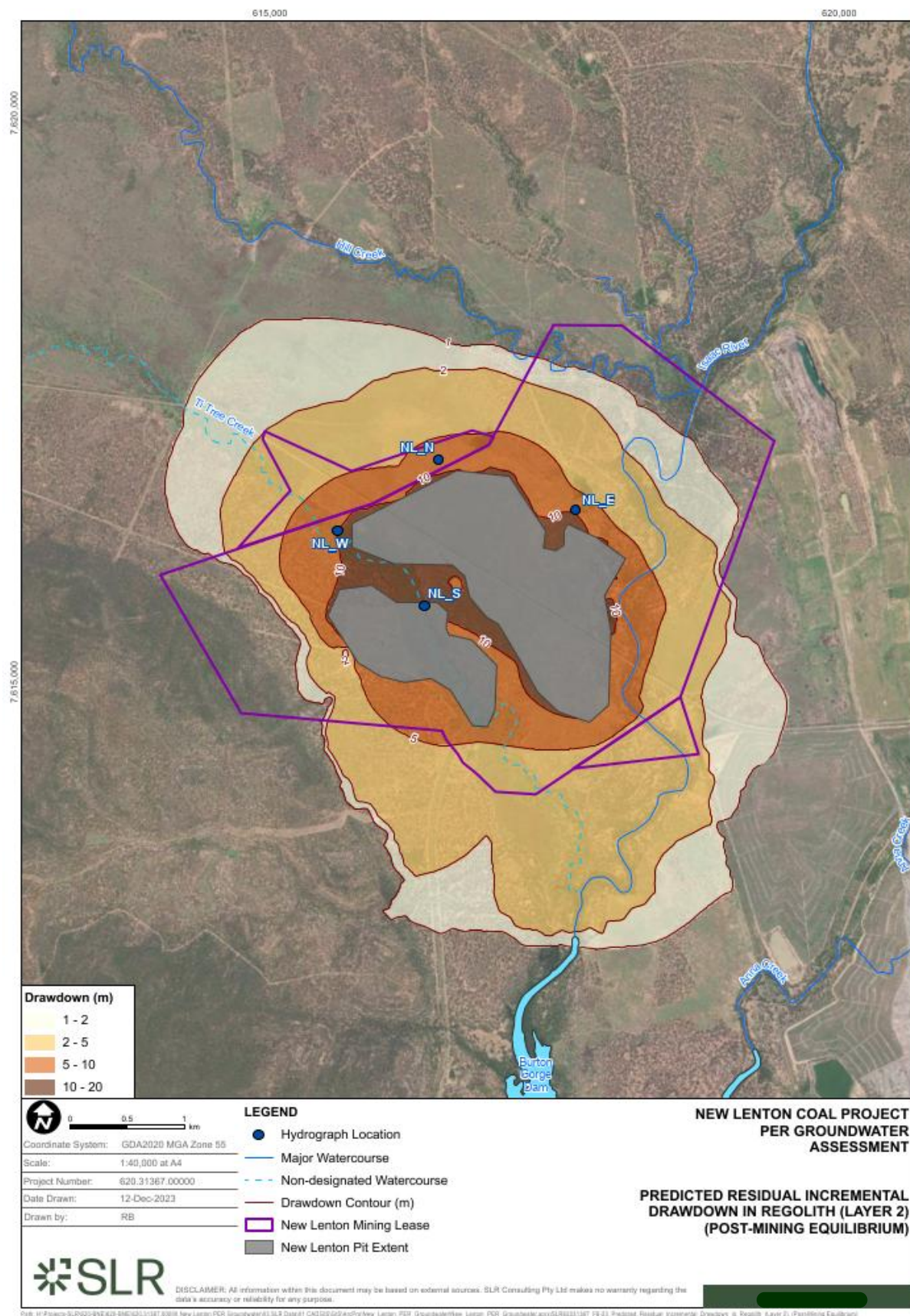


Figure 5-28 Predicted Residual Groundwater Level Drawdown in the Regolith (Layer 2) at Post-Mining Equilibrium

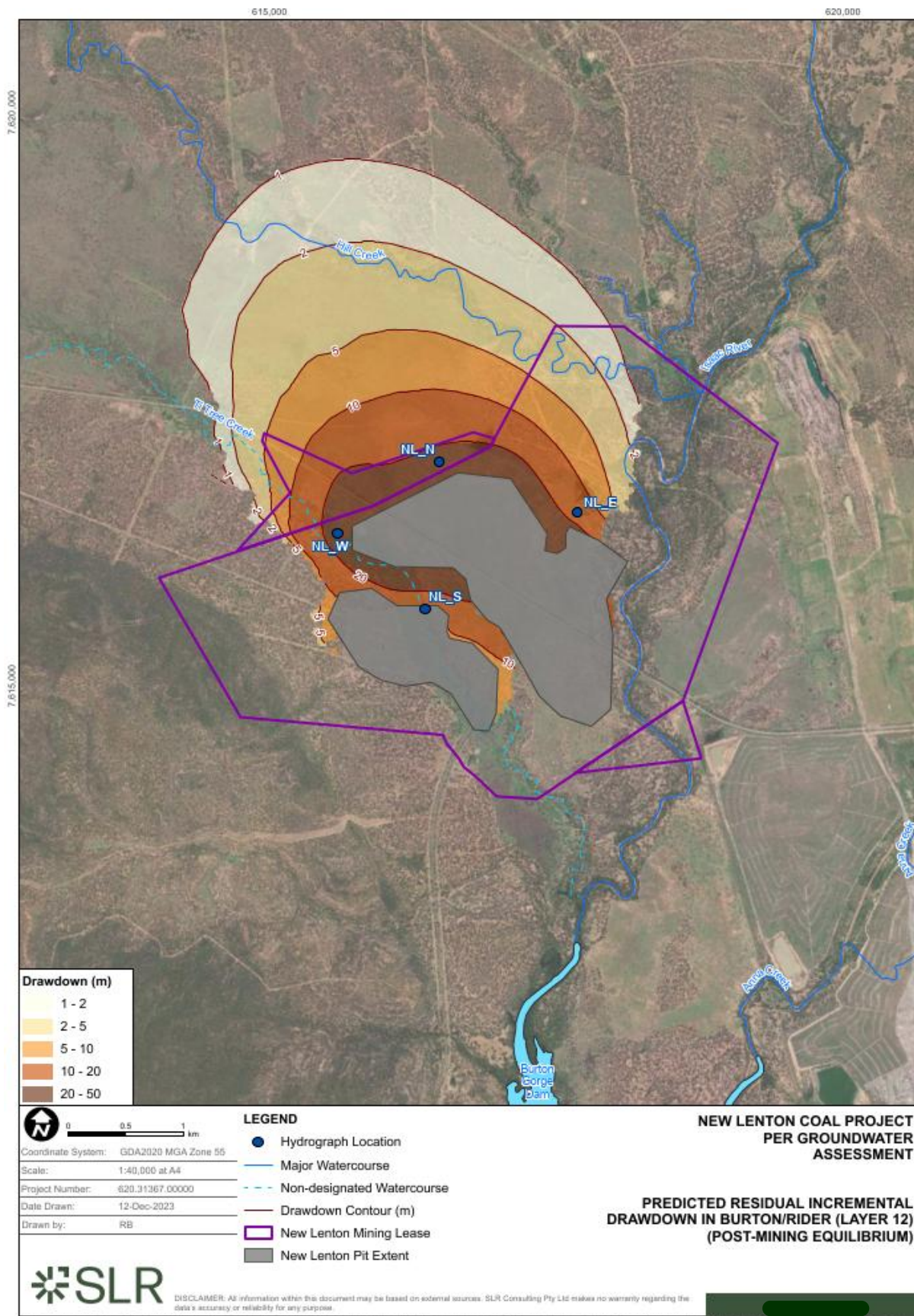


Figure 5-29 Predicted Residual Groundwater Level Drawdown in the Burton/Rider Seam (Layer 12) at Post-Mining Equilibrium

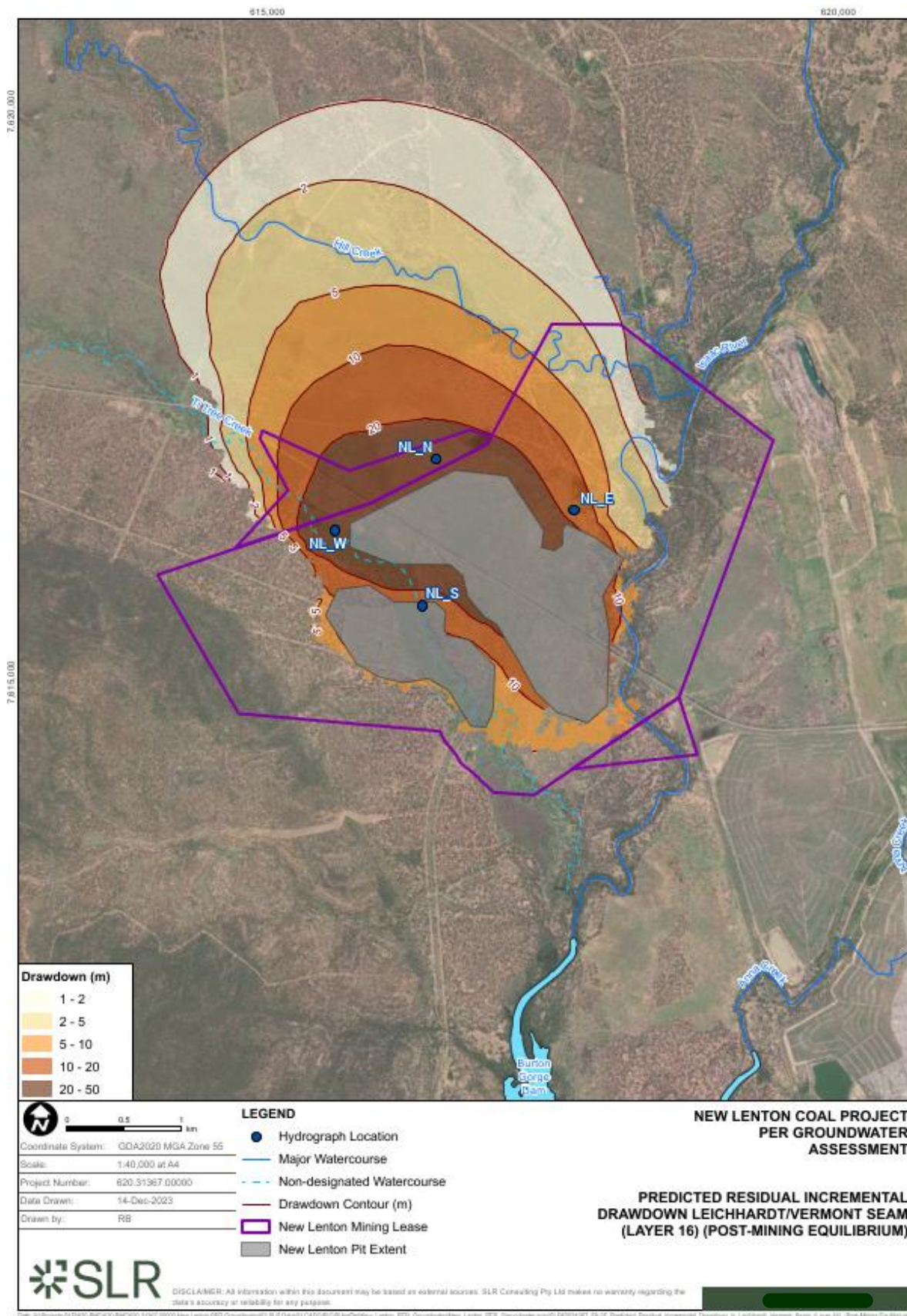


Figure 5-30 *Predicted Residual Groundwater Level Drawdown in the Leichhardt/Vermont Seam (Layer 16) at Post-Mining Equilibrium*

5.8.6 Post Mining Drawdown and Receptors

Predictive hydrographs have been derived from the groundwater recovery model, to understand the nature of likely groundwater level change in the interpreted source aquifer for landholder bores and potential source aquifer (i.e. water table) for GDEs post mining. Hydrographs at selected locations along the Isaac River and at identified landholder bores where the source aquifer is known are presented in Section 6.7.6 of **Appendix 8**.

The hydrograph predictions refer to the regional water table and not to the seasonally variable perched water table that supports GDEs (refer Section 5.6.4). Any impacts to the seasonally variable perched table would be contingent on hydraulic connection with the regional water table represented in the model, with evidence suggesting any such connection is limited.

The water table hydrographs indicate for sites along the Isaac River there is nil to minimal additional water table drawdown predicted to occur over the post-mining period. These results indicate that additional post-mining impacts (i.e. beyond those that could occur during operations) to the water table are not predicted.

Minimal (<1 m) additional groundwater drawdown is predicted at these third party bores over the post-mining period. Most of the third party bores are predicted to show up to 0.5 m groundwater level recovery in the post-mining period. These results indicate that additional post-mining impacts (i.e. beyond those that could occur during operations) to any landholder bores are not predicted.

5.8.7 Flow Path Simulation (Particle Tracking)

Particle tracking was undertaken to illustrate the simulated post-mining groundwater flow field (advection) in the vicinity of the mined pits. Section 6.7.7 of **Appendix 8** described the methods for particle tracking. Particles were placed around and within the residual void and across waste rock dumps in the recovery groundwater model. The model simulates the movement of these particles through the groundwater flow field from the end of mining, during recovery through to the end of the recovery simulation (730 years).

The particles were placed at the ground surface of the model around the pit shells, residual void and across areas of waste rock backfill and out of pit waste rock (overburden) dumps. Figure 5-31 shows the initial location and the predicted movement of water particles in the 730-year recovery simulation. The flow path analysis indicates generally the particles move toward the residual void lake, with particles that enter the void lake remaining there once they have entered the lake. Particles commencing in the residual void remain in the residual void for the duration of the simulation, indicating no potential for water discharge to the surrounding groundwater environment.

No particle leaves the void lake after entering the lake. No particles are shown to enter the shallow groundwater system adjacent the Project area (i.e. along alluvium). Therefore, the model indicates no potential for offsite discharge to the alluvium of any potentially poor quality water within the residual void landform.

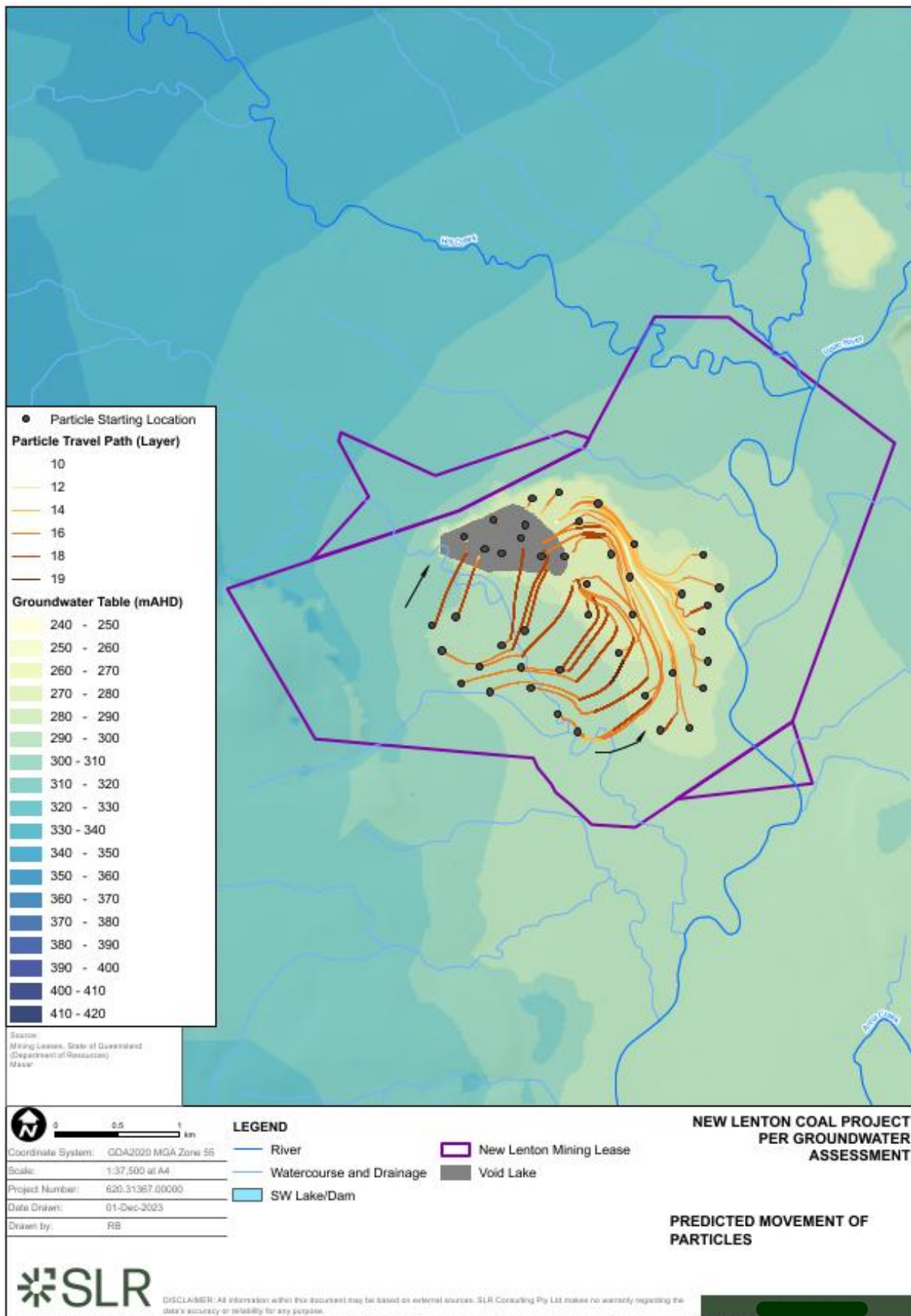


Figure 5-31 Predicted Movement of Particles

5.8.8 Climate Sensitivity

As presented in Appendix F of **Appendix 8**, climate scenario groundwater modelling has been undertaken to assess the effect of climate change on the post-mining groundwater predictions.

The numerical groundwater model discussed in the previous sections was adopted for consideration of climate change in the post-mining model predictions. No changes to the model were made other than the simulation of additional transient post-mining recovery model scenarios, whereby the time-variant constant head boundary conditions applied to the residual voids were updated to reflect the predicted void lake levels from the void water balance modelling (see Section 4.8 of Chapter 4). Two additional climate scenarios were modelled, being the ‘best case’ and ‘worst case’ climate scenarios reported the void water balance. Results indicate:

- Lake water levels in the residual void recover at a similar rate for the three climate scenarios, reaching equilibrium conditions after approximately 300 years.
- Equilibrium lake water levels vary by an approximate 46 m range across the climate scenarios, and are very similar between the ‘worst case’ scenario and the base case reported in the preceding sections, such that minimal difference in groundwater model outputs would be expected between these two scenarios. The ‘best case’ scenario results in void lake levels approximately 46 m below the levels predicted in the ‘worst case’ scenario.
- Total groundwater inflow volumes to the residual void in the two climate extremes vary over a range of less than 6% of the base case groundwater inflows reported in the preceding sections, considered very small. That is, the climate extremes do not result in a significant change in predicted groundwater inflow volumes to the residual void.
- Predicted groundwater levels and residual drawdown in all aquifers are almost identical between the ‘worst case’ scenario and the base case reported in the preceding sections, which is to be expected given the very similar void lake levels in these scenarios. Very minor additional drawdown is predicted for the ‘best case’ scenario, driven by the lower void lake levels under that scenario. The additional drawdown would not result in a meaningful change in impact assessment outcomes.
- The climate extremes do not result in a significant change in predicted groundwater flux associated with alluvium or the Isaac River. That is, any change in alluvium or River water quantity impacts resulting from the climate extremes is negligible compared to the base case reported in the preceding sections.
- Particle tracking simulations show no change in the predicted fate of groundwater movement in the final landform under the climate extremes compared to the base case reported in the preceding sections. That is, all groundwater emanating from the landform continues to be captured by the final void.

5.9 Assessment of Impacts

5.9.1 Landholder Bores

There are no known landholder water supply bores (see Figure 5-10) within the unconsolidated (alluvium and regolith) or consolidated (Permian coal measures) aquifers that lie within the predicted extent of Project related drawdown greater than 1 m, as shown in Figure 5-16 to Figure 5-19,

The uncertainty analysis results showed no water supply bores are predicted to experience 90th percentile maximum incremental drawdowns greater than the relevant bore Water Act drawdown threshold trigger (2 m for unconsolidated aquifers, and 5 m for consolidated aquifers).

Minimal (<1 m) additional groundwater drawdown is predicted at landholder bores over the post-mining period.

5.9.2 Surface Drainage

Baseline groundwater system characterisation indicates that where it occurs, groundwater within the basal alluvium is recorded at depths of around 8 to 11 mBGL, typically significantly disconnected from the streambed elevation. A natural hydraulic gradient exists between the Isaac River and the associated alluvium that results in seepage from the Isaac River to the alluvium (i.e. a losing system). Watercourses within the Project area are highly ephemeral where surface water flow is only sustained for hours to several days following rainfall events. Overall these factors indicate a distinct lack of groundwater discharge to these watercourses such that there is no groundwater baseflow and therefore no potential for groundwater drawdown to manifest as a decrease in surface water flow.

The change in groundwater levels induced by mining has the potential to increase the hydraulic gradient between the Isaac River and associated alluvium. However, the model does not predict that the average rate of seepage from the Isaac River to the alluvium will increase over the life of the Project and therefore there are no predicted groundwater-related impacts to surface drainage as a result of the Project. Furthermore, surveys undertaken by Burton Coal Mine personnel in July 2023, following a period of rains, confirmed no areas of pooling along the Isaac River; and dry season ground-truthing for aquatic GDEs has (see Sections 5.3.7 and 5.6.6) also identified groundwater does not discharge to the surface or maintain surface pools. As a result the project does not support aquatic GDEs and therefore no associated impacts to aquatic GDEs could occur.

Diversion of Ti-Tree Creek has the potential to influence groundwater conditions, particularly for the shallow groundwater system if surface flows in Ti-Tree Creek are a significant source of groundwater recharge. In the groundwater modelling methodology adopted for this assessment, recharge is distributed in zones across the model domain according to outcropping geology, and the numerical groundwater model assigns a proportion of annual rainfall to each of these zones based on the recharge parameters derived during the model calibration process. Where open cut mining for the Project is proposed in areas where existing streams are mapped (i.e. Ti-Tree Creek), recharge from these streams is removed from the groundwater numerical model since no recharge is applied in active mining areas in the model. Therefore, the results derived from the numerical groundwater model presented in **Appendix 8** account for the reduction in recharge to the shallow groundwater system that might result from diverting Ti-Tree Creek.

5.9.3 Groundwater Quality

5.9.3.1 Out of Pit Waste Rock Dumps

As the mining operations progress, waste rock material would be placed within selected out of pit waste rock dumps. The out of pit waste rock dumps may produce seepage as a result of rainfall inundation, that theoretically could alter the existing groundwater quality. During mining, the inward hydraulic flow gradients from the waste rock dumps to the open cut voids would inhibit any seepage to the shallow regional groundwater system. Therefore, there would be no mechanism for seepage from the out of pit waste rock dumps to impact on groundwater quality in the alluvium and regolith. Post-mining, model particle tracking results (see Section 5.8.7) indicate that the residual void continues to form a hydraulic sink for water emanating within out of pit waste rock dumps such that there is no discharge offsite to the surrounding environment.

5.9.3.2 In-Pit Waste Rock Dumps

The in-pit waste rock dumps would be rehabilitated progressively as the mining operations progress. Water levels within backfilled areas are predicted to recover back towards pre-mining levels. During mining, the inward hydraulic flow gradients from the waste rock dumps to the open cut voids would inhibit the potential for any seepage outflow. Post-mining, model particle tracking results (see Section 5.8.7) indicate that the residual void continues to form a hydraulic sink for water emanating within in-pit waste rock dumps such that there is no discharge offsite to the surrounding environment.

5.9.3.3 Blasting

Blasting activities have the potential to release metals, metaloids and ammonia associated with chemical reactions during the blasting process. During mining, the inward hydraulic flow gradients to the open cut pits would inhibit the potential for any outflow of such potential contaminants. Post-mining, model results indicate that the residual void continues to form a hydraulic sink such that there is no discharge offsite to the surrounding environment.

5.9.3.4 Final Void

The predicted equilibrated final void water levels are approximately 30 m below the pre-mining groundwater levels, which means the final void would act as a sink to groundwater flow with no potential for outflow to the surrounding groundwater system.

Water within the final void would evaporate from the final void water body surface and draw in groundwater from the surrounding strata and runoff from the final void catchment areas. As the final void would act as a sink, evaporation from the final void water body would overtime concentrate salts in the final void water body. However, the gradual increase in salinity of the final void water body would not pose a risk to the surrounding groundwater regime as the final void would remain as a groundwater sink in perpetuity.

5.9.4 Groundwater Dependent Ecosystems

The GDE Toolbox (Richardson et al 2011), provides a basis for investigating potential impacts on GDEs exposed to threat through the following impact mechanisms:

- A total or partial loss or reduction in the volume or pressure of the aquifer being utilised by GDEs.
- A change in the magnitude and timing of volume fluctuations in the aquifer being utilised by GDEs.
- Changes to the interaction between surface flows and aquifers being utilised by a GDE.
- Change in chemical composition of an aquifer detrimentally impacting the health of a GDE.

5.9.4.1 Direct clearing

A total of 2.2 ha of mapped known / likely GDEs is within the Project disturbance area, associated with the two crossings of the Isaac River. Impacts associated with direct clearing of vegetation, including any terrestrial GDEs are assessed in Chapter 6.

5.9.4.2 Aquifer Depressurisation

Figure 5-16 shows the maximum incremental drawdown predicted within the Isaac River alluvium due to proposed mining at the Project. Figure 5-32 shows the drawdown contours overlaid on the identified terrestrial GDE area. There is a maximum drawdown associated with mining operations of less than 12 m within a restricted area that overlaps GDEs along the Isaac River, with lower drawdown levels elsewhere.

Conceptual models (see Section 5.6.4) demonstrate that the seasonally variable perched groundwater system that was supporting GDEs at the time of the assessment is disconnected from the deeper basal alluvial / regolith aquifer system during drier climatic periods. The integrity of the perching layer will not be affected by development of mining pits, although groundwater drawdown will occur in the basal alluvial groundwater system. The impact of this drawdown on the seasonally variable perched groundwater system is predicted to be subtle, and no impact is predicted if clay layers are sufficiently tight to limit infiltration. During wet season surface flows, there may be enhanced hydraulic connection between the perched and basal groundwater systems, driven through lateral penetration of surface flows into riverbanks and increased downward leakage. As recharge of both the perched and basal groundwater systems is driven by surface flows, there is unlikely to be any significant change in groundwater regimes while recharge is occurring.

The water table hydrographs indicate for sites along the Isaac River there is nil to minimal additional water table drawdown predicted to occur over the post-mining period. These results indicate that additional post-mining impacts (i.e. beyond those that could occur during operations) to the water table are not predicted.



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Datum: MGA94 Zone 55
 Scale: See Scale Bar (A4)
 Date: 21/08/2026 1:52 PM
 Drawn: RA (Source: 3d Environmental)



DISCLAIMER: Third party data sources are used in this map compilation. Minserve makes no warranty regarding this data's accuracy or currency.

- LEGEND**
- Mining Lease
 - Roads
 - Watercourse
 - Proposed Disturbance Area
 - Project Layout
 - Known / Likely GDE Areas
 - Drawdown Contours

5.9.4.3 Changes to Surface Water Flows

Volume fluctuations in the basal alluvial groundwater unit are correlated to rainfall, which drives diffuse recharge and leakage of surface water along creeks and drainage lines following episodic rainfall events. Episodic surface water flows in the Isaac River are a significant driver of groundwater recharge, with sustained recharge after surface water has receded into the river sand. Data demonstrates the correlation between surface flow events in the Isaac River and groundwater levels in alluvial bore GW19_33 during a period of continuous monitoring between August 2019 and January 2023.

Flood modelling is presented in Chapter 4. The results of the flood modelling show that the impacts of the Project (e.g. levees and Isaac River crossings) on the hydraulic characteristics (such as levels, extents, velocity, bed shear stress and stream power) of the Isaac River are insignificant to minor. Ti-Tree Creek will continue to discharge to the Isaac River via the Ti-Tree Creek diversion. Furthermore, the Project results in negligible changes to flood duration hydrographs (i.e. flood flows are not attenuated or lengthened). Therefore the duration of flooding for developed conditions is similar to existing conditions, which in both cases demonstrates that flood events in the region around the Project have a very short duration for minor to extreme rainfall events. The insignificant to minor changes to surface flow levels are not of sufficient magnitude to affect groundwater recharge, and there is no mechanism that could influence surface flow timing. Therefore changes in surface flows are not predicted to impact GDEs.

5.9.4.4 Changes in Water Quality

Groundwater modelling identifies a permanent cone of depression around the mining void into which groundwater flows will be directed (see Sections 5.7 and 5.8). This will facilitate drainage of groundwater directly into the mining void where this discharge will be captured within the mine water management system (see Chapter 4) during mining. Post mining a residual void lake will form that will be a long-term groundwater sink. The potential for saline water from mine water collected from, or remaining within, the void to contaminate any fresh perched groundwater system is negligible and there is no risk of upward propagation of saline groundwater into the seasonal alluvial groundwater system which supports GDEs. Seepage from overburden will be managed in the mine water management system during mining or collected in the residual void post mining.

Geochemical assessment of the overburden (see Chapter 3) indicates that any generated runoff will be moderately alkaline and fresh, non-acid forming with low sulphur content, and low concentrations of soluble metals. Overburden will generate low salinity rainfall runoff and seepage which will be captured by sediment dams during operations (see Chapter 4). Following rehabilitation of overburden dumps, runoff quality will be similar to existing runoff from undisturbed catchments in the Project area.

With the water management system controls proposed for mine water and sediment water (during and post mining) it is unlikely that there will be a risk of contamination of surface water flows, which are a major contributor to groundwater recharge. Therefore there is negligible risk of impact to the water quality of the seasonally variable perched alluvial groundwater unit that support GDEs.

5.9.4.5 GDE Risk Zones

The above sections demonstrate that the most significant risk of impact to GDEs is associated with drawdown of the basal alluvial groundwater unit during mine development, which may provide a minor control on the rate of drying and persistence of the seasonally variable perched groundwater system. Ameliorating factors that act to decrease the risk of impact to GDEs are:

- There is no evidence that groundwater hosted in the Permian coal seams that are subject to mining impacts support GDEs.
- The seasonally variable perched groundwater system that supports terrestrial GDEs on the frontage of the Isaac River is supported and recharged by surface flows. The impact of the Project on surface flows is insignificant to minor.

Based on the assessment of potential Project impacts to GDEs, 'Risk Zones' were identified based on the predicted groundwater drawdown in the basal alluvium. These Risk Zones are shown on Figure 5-33 and comprise areas of intersection of groundwater drawdown in the alluvium and mapped terrestrial GDEs on the Isaac River:

- Risk Zone 1 - highest risk with drawdown of 10m to 12m.
- Risk Zone 2 - drawdown >5 m to <10 m
- Risk Zone 3 - drawdown >2 m to <5 m)
- Risk Zone 4 – lowest drawdown <2m.

With Risk Zone 1, the seasonally variable perched groundwater unit that supports GDEs on the Isaac River is perched above the basal alluvial groundwater unit, although the two groundwater units may interact during extremely wet climatic period following river flow and resultant groundwater recharge. Drawdown in the basal alluvial groundwater unit may result in more rapid drying of the perched unit decreasing its seasonal persistence and viability. The adaptability of the dominant riparian species to ecological change in this zone would suggest these impacts will be low in areas where aquifer drawdown response is greatest (i.e. 10 -12m drawdown) and the risk to GDE function will decrease with decreasing drawdown magnitude. As is evident on Figure 5-33 Risk Zone 1 is a very small area adjacent the mining area.

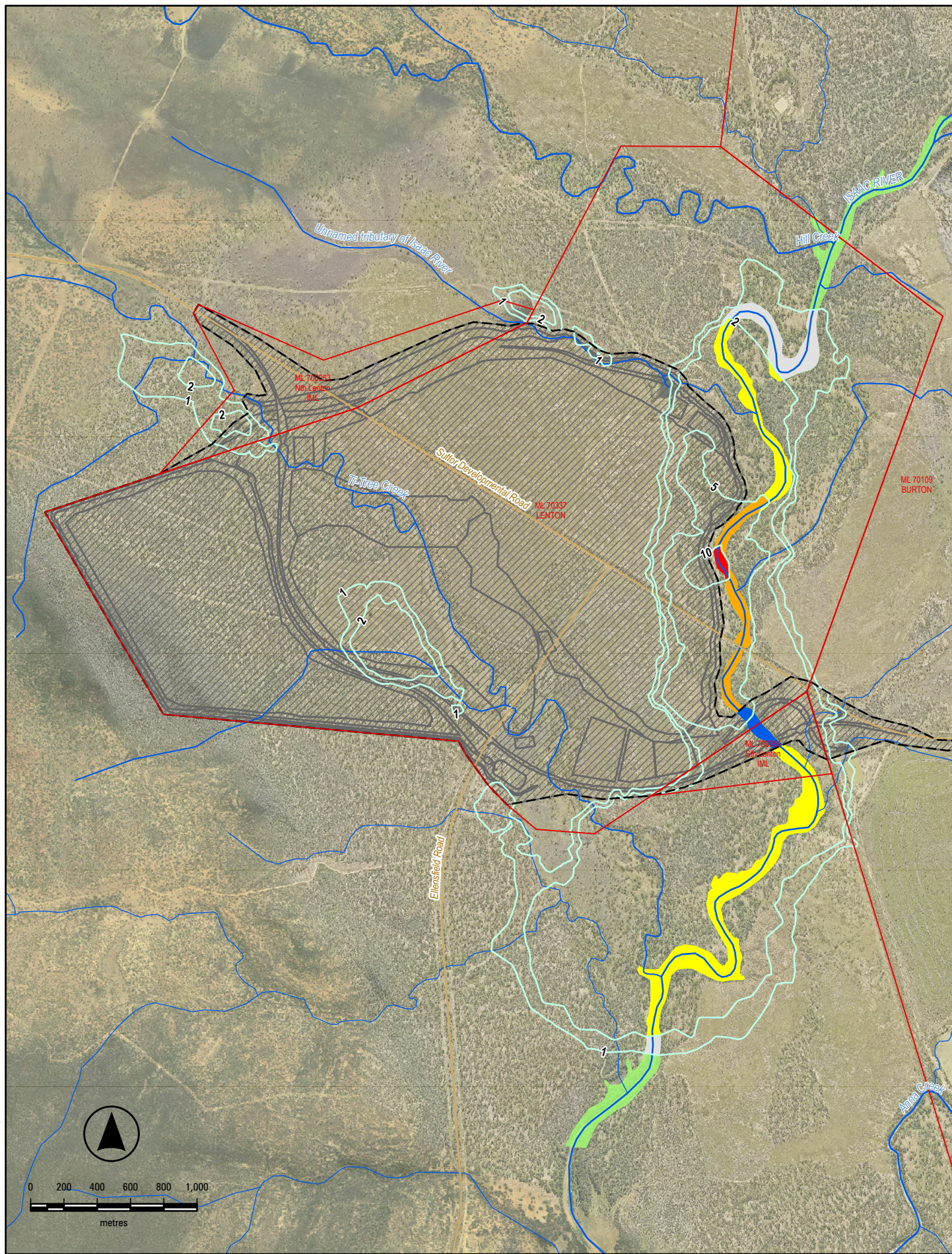
Risk Zone 2 represents a reduction in the likelihood and magnitude of potential impacts to GDEs over Risk Zone 1. Groundwater drawdown is reduced to >5 m to <10 m in the basal alluvial groundwater unit resulting in faster recharge during surface flow events. The influence of more rapid drying on the seasonally variable perched groundwater unit will be lessened.

In Risk Zones 3 and 4, the effect of low-level drawdown on the basal alluvial groundwater unit will have insignificant impact on the seasonally variable perched groundwater unit and any riparian vegetation which is dependent on it.

5.9.4.6 Cumulative Impacts

Except for Burton Mine, all other mines are too far downstream to experience cumulative impacts on GDEs adjacent the Project mining areas. Time series aerial photography examined for the northern extent of the Burton Mine could not detect any noticeable changes to riparian vegetation structure or condition on the Isaac River fringing the most northern extent of the pit, consistent with observations made during the field assessment at GDE Assessment area 13 (see Section 5.6.3.5). Therefore, this indicates minimal potential for cumulative impacts to GDEs associated with groundwater drawdown from the existing Burton Mine.

Cumulative groundwater modelling is provided in Section 5.7.6. This demonstrates that in the area of predicted incremental drawdown in the alluvium, the predicted cumulative drawdown shows negligible increase in drawdown magnitude between the incremental and cumulative predictions (i.e. Burton Mine doesn't exacerbate the Project predicted drawdown), although Burton Mine contributes its own drawdown to the north in the Isaac River. There is no predicted increase in the magnitude of groundwater drawdown for the Project as a result of the existing Burton Mine operations.



Datum: MGA94 Zone 55
 Scale: See Scale Bar (A4)
 Date: 21/08/2026 1:52 PM
 Drawn: RA (Source: 3d Environmental)



DISCLAIMER: Third party data sources are used in this map compilation. Minserve makes no warranty regarding this data's accuracy or currency.

LEGEND

- Mining Lease
- Roads
- Watercourse
- Proposed Disturbance Area
- Project Layout
- Drawdown Contours

- Zone**
- GDEs Subject to Clearing
 - Risk Zone 1 (10 to 12m)
 - Risk Zone 2 (>5 to <10m)
 - Risk Zone 3 (2 to 5m)
 - Risk Zone 4 (>1 to <2m)
 - Outside Drawdown (<1m)

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GDE Risk Zones

Figure | 5-33

5.9.5 Stygofauna

5.9.5.1 Overview

The potential impacts of the Project on stygofauna include:

- physical disturbance of groundwater ecosystems, including direct impacts and dewatering (groundwater drawdown), which may cause direct impact to stygofauna habitat.
- localised contamination of groundwater (e.g. accidental hydrocarbon spills)
- vegetation clearing, which may cause direct impact to stygofauna habitat.

5.9.5.2 Direct Physical Disturbance and Drawdown of Aquifers

Stygofauna of the Project area are concentrated in their distribution within alluvium and regolith in proximity to the Isaac River, with bores GW06 and GW19-33 representing all the stygofauna diversity that was recorded, and bore GW19-33 having a stygobitic taxon present.

The Project will cause direct physical disturbance by mining to areas within the Project area. However, the mined areas are not within 50 m of the Isaac River and mining will not occur in the locations of either bore GW06 or GW19-33. That is, there is a buffer of alluvium and sandstone (regolith) units between the mined areas and the Isaac River that will not be mined, and thus the key area of stygofauna distribution in the Project area will not be directly impacted.

The Project will result in groundwater drawdown in the water bearing lithologies of the Project area (see Section 5.7). Of most relevance is the predicted drawdown in alluvium and regolith (sandstone) lithologies along the Isaac River, where stygobitic stygofauna were found, and the diversity and abundance of stygoxenes was concentrated.

Groundwater modelling indicates that groundwater in alluvium and regolith within the Project area along the Isaac River will be reduced in extent and saturated thickness along a section of the Isaac River adjacent to the Project area.

The consequence of direct physical disturbance and drawdown on stygofauna is moderate, because a portion of stygofauna habitat would be lost. However, stygofauna of the Project area are concentrated along the Isaac River, including at bores upstream and downstream of the Project area, and at a bore adjacent to Hill Creek. Connected groundwater systems within a single sub-catchment (in this case along the main stem of a major river and adjoining floodplain areas) are likely to represent minimum distributional ranges for most stygofaunal species, with the results of the stygofauna assessment suggesting that stygofauna likely occur more widely in shallow groundwater systems along the Isaac River, both upstream and downstream of the Project area, including along tributaries of the Isaac River. Thus, it is likely that only a small portion of stygofauna habitat will be lost.

Additional analysis of the potential impacts to stygofauna has been undertaken, with an 'Assessment of Potential for Stygofauna Retention and Operational Phase Stygofauna Monitoring Program' provided as **Appendix 21**, which found that:

- Drawdown of shallow groundwater due to operation of the Project will reduce saturated thickness along a relatively small stretch of the Isaac River (approximately 1 km in length), likely causing localised loss of suitable habitat for stygofauna.
- Within the extent of drawdown, areas where residual saturated thickness that is >2 m will be retained in the post-mining scenarios, suggesting that stygofauna could be retained in these areas.
- The development of stygofauna triggers and design of the operational phase monitoring program as presented in **Appendix 21** will facilitate operational phase environmental management of stygofauna within the Project area.

5.9.5.3 Vegetation Clearing

Clearing of vegetation may reduce the habitat quality of shallow groundwater ecosystems for stygofauna. Potential impacts would be localised to the immediate area of clearing. Vegetation along the Isaac River where stygofauna were concentrated will be retained, although some areas where stygofauna are likely to occur will be subject to vegetation clearing. The consequence of terrestrial vegetation clearing on stygofauna is low because diverse stygofauna have been found in heavily cleared (or very sparsely vegetated) areas, suggesting that the presence of terrestrial vegetation is not an essential habitat element for stygofauna occurrence.

5.9.5.4 Contamination of Groundwater

Contamination of groundwater includes accidental spillage of fuels, oils and other lubricants required for the operation of vehicles and machinery. Potential impacts would depend on the magnitude of any chemical, fuel or oil spill, but a small chemical, fuel or oil spill would likely cause impact on a relatively local scale within the potential impact area. Furthermore, the risk of contamination of groundwater by fuel and chemical spills is low due to standard management measures described in Section 5.10.1.

The controlled release of mine affected water from site is only permissible in accordance with conditions outlined in the EA, which were developed in accordance with State requirements for protecting downstream environmental values, including the values of underlying groundwater ecosystems. Therefore, controlled release of mine affected water to waterways is not predicted to cause adverse impact to stygofauna in underlying groundwaters.

5.9.6 Potential Impacts on Aquifer Physical Integrity and Hydraulic Properties

The process of open pit mining will result in the removal of the aquifer and aquitard layers within the mine pit footprints. It is considered that there is no potential for any other impacts to the physical integrity of any of the identified aquifer and aquitard units, since there is no mechanism for physical impacts to the geology to propagate away from the open pits (for example, as might be associated with underground mining subsidence). As such, there would be no potential for impacts to the hydraulic properties of the identified aquifer and aquitard units outside of the open pit footprints.

5.10 Mitigation, Management and Monitoring

5.10.1 Environmental Authority

The EA for the Project conditions the management and monitoring of groundwater. A GMMP is provided in **Appendix 22**, and described in Section 5.10.3. The GMMP is designed to detect a change in groundwater quality values and levels due to activities that are part of the authorised mining activities. The GMMP is reviewed on an annual basis to assess the suitability of the groundwater monitoring network and groundwater quality or trigger levels. The EA specifies the groundwater monitoring locations and trigger levels for water quality and levels. The EA defines bore maintenance and construction requirements.

5.10.2 Associated Water Licence

The AWL for the Project requires make good obligation for water bores (including entering make good agreements with landholders if required) and bore assessments of landholder bores. Furthermore monitoring and assessment must be conducted in accordance an underground water monitoring program. The Project's numerical groundwater model must be reviewed by an appropriately qualified person within two years from the commencement of the take of associated water under the licence and at least every five years thereafter.

5.10.3 Groundwater Monitoring and Management Plan

5.10.3.1 Overview

A groundwater monitoring and management plan (GMMP) has been prepared for the Project to satisfy the relevant requirements of the Project's EA, PRCP schedule, AWL and to support approval under the EPBC Act. The GMMP is provided in **Appendix 22** and summarised below. The GMMP outlines the groundwater monitoring plan for the Project and associated groundwater impact limits and triggers that will invoke further assessment and groundwater impact management during the life of the Project and in the early years post-closure

The GMMP for the Project includes procedures and processes required to determine and assess the hydrogeological regime and develop specific, measurable and time bound trigger levels, contaminant limits, and groundwater level thresholds, which will be used to assess the mining activities potential impacts on groundwater resources.

Routine monitoring includes groundwater level and quality monitoring. Details of monitoring protocols and QA/QC procedures are provided in the GMMP (**Appendix 22**).

Routine monitoring prior to the commencement of the mining operation (i.e. baseline period) will provide for continued assessment and characterisation of the pre-mining groundwater system, including quantification of natural variability. Continuing to capture data to quantify natural variability is important on the context of allowing the proponent to distinguish any future mining related impacts from inherent natural variability later during the Project's operational phase. Consistent with condition D2 of the EA, the baseline monitoring program will continue until the during-mining monitoring phase commences.

Routine monitoring during the mining operation will provide early warning of any variation in the response of the groundwater system to that predicted. This will enable the proponent to undertake mitigation measures, if required, to minimise impact on surrounding groundwater users and the environment, such as the implementation of make good measures.

5.10.3.2 Groundwater Monitoring Network

The GMMP monitoring network includes reference and compliance bores as detailed in Table 5-6 and shown in Figure 5-34. Compliance bores are bores that have impact criteria thresholds established in the GMMP, whereas reference bores are bores primarily intended to provide for background monitoring data outside of the potential mining impact area that would support the assessment of any limit or trigger breach at a compliance bore.

The monitoring network contains sufficient monitoring points in terms of spatial spread of monitoring across all formations of interest to develop sufficient pre-mining groundwater conditions, building on data already collected. A process of continual improvement of the monitoring network (see Section 5.10.3.8) will ensure continued appropriateness of the monitoring program to assess groundwater impacts from the development of the Project.

As evident in Table 5-6, there are some differences between the groundwater monitoring programs required by the Project's EA and AWL, stemming from different State government agencies imposing slightly different conditions. On the whole the groundwater monitoring programs are consistent, and the proponent will seek to ensure improved consistency between monitoring programs through engagement with State regulators.

Table 5-6 Groundwater Monitoring Locations

Bore	Easting ¹	Northing ¹	Casing RL (mAHD)	Bore Depth	Screen (mBGL)	Aquifer	Status	Current AWL Bore?	Current EA Bore?	GMMP Bore Type
GW01	617299	7618210	326.8	15.2	6.17 – 12.17	Alluvium	dry	Reference	Interpretation	Reference
GW19	612323	7620097	376.7	26.5	22.9 – 25.9	Alluvium/Regolith	dry	Reference	-	Reference
GW20	612676	7618392	355.5	33.9	24 – 30	Basalt	Active	Reference	-	Reference
GW22	614463	7622201	401.7	11.6	5 – 8	Alluvium	dry	Reference	-	Reference
GW23	617807	7622169	369.9	11.6	5 – 8	Alluvium	dry	Reference	-	Reference
GW06	618097	7616723	313.9	20.6	3.6 – 18.6	Alluvium	dry	Compliance	Compliance	Compliance
GW03	618094	7614389	307.6	12.1	3.1 – 12.1	Alluvium	dry	Compliance	Compliance	Compliance
GW09	617525	7614070	307.1	24	6 – 18	Alluvium	Active	Compliance	Compliance	Compliance
GW19_37a	618034	7615771	309.6	26	16.5 – 20.0	Alluvium	Active	Compliance	Compliance	Compliance
GW08	617041	7613900	306.7	11.7	5.72 – 8.72	Alluvium	dry	Compliance	Compliance	Compliance
GW07	617640	7613075	299.5	24.5	9 – 18	Alluvium	Active	Reference	Compliance	Compliance
GW26	619185	7616679	315.7	9.6	6 – 9	Alluvium	dry	Compliance	-	Compliance
GW19_33	618664	7617348	312	16	11.1 – 12.6	Alluvium/Regolith	Active	Compliance	Compliance	Compliance
GW30c	618094	7617368	318.2	31.1	23 – 29	Regolith	Active	Compliance	Compliance	Compliance
GW31b	617621	7617680	322*	21.2	17 – 20	Regolith	Active	Compliance	Compliance	Compliance
GW30b	618088	7617382	318.5	76.2	70 – 73	Permian (Burton Seam)	Active	Compliance	Compliance	Compliance
GW10	616032	7617014	335.2	205.1	178.16– 190.16	Permian (L/V Seam)	Active	Compliance	Compliance	Compliance
GW13	616881	7615480	319.3	192.4	170.5 – 179.5	Permian (L/V Seam)	Active	Compliance	Compliance	Compliance
GW30a	618084	7617395	318.5	112.2	97 – 109	Permian (L/V Seam)	Active	Compliance	Compliance	Compliance
GW31a	617624	7617680	321.9*	165.2	153 – 162	Permian (L/V Seam)	Active	Compliance	Compliance	Compliance
GW11	616294	7616680	332.3	150	114 – 126	Permian (L/V Seam)	Active	Compliance	Compliance	Compliance

Bore	Easting ¹	Northing ¹	Casing RL (mAHD)	Bore Depth	Screen (mBGL)	Aquifer	Status	Current AWL Bore?	Current EA Bore?	GMMP Bore Type
GW29a	618081	7616561	313.6	83.6	62 – 80	Permian (sandstone)	Active	Compliance	Compliance	Compliance
1 Coordinates are GDA94 z55; * Ground level; L/V = Leichhardt / Vermont Seam										



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5.10.3.3 Monitoring Regime – Groundwater Levels

Groundwater level monitoring will be undertaken through manual measurements and the use of automatic level loggers. Manual groundwater level monitoring will be undertaken as follows:

- On a quarterly basis for compliance bores where groundwater level trigger thresholds (see Section 5.10.3.5) and level reference values have been established.
- On a quarterly basis for reference bores.
- On a bi-monthly (every 2 months) basis for compliance bores where groundwater level trigger thresholds or level reference values are not yet defined, until such time as they are established or it's determined that a bore is permanently dry.

Groundwater level monitoring will be undertaken using automated level loggers in each of the GMMP bores described in Section 5.3.1 of **Appendix 22**. Logging intervals will be set to record a measurement at daily intervals. A barometric pressure logger will be installed and the water level logger data will be barometric pressure corrected using the barometric pressure logger data prior to any analysis.

Loggers will be downloaded at least every three months (quarterly). At the time of each download, a manual water level measurement will be recorded at each bore to confirm logger data accuracy. Any discrepancies observed in the automated monitoring data when compared to the manual measurements will be immediately investigated and where necessary the loggers reset or replaced to ensure data reliability.

5.10.3.4 Monitoring Protocols – Groundwater Quality

Groundwater quality sampling will be undertaken as follows:

- On a quarterly basis for compliance bores where groundwater quality limits (see Section 5.10.3.6) have been established.
- On a quarterly basis for reference bores.
- On a bi-monthly (every 2 months) basis for compliance bores where groundwater quality limits are not yet defined, until such time as they are established, or it's determined that a bore is permanently dry.

The groundwater quality parameter suite identified in Table 5-7 has been selected to detect the potential changes in groundwater quality.

Table 5-7 Groundwater Quality Parameter Suite

Parameter Group	Parameter (units)	Method
Physico-Chemical Parameters	pH	Field
	Electrical Conductivity (EC)	Field and Lab
	Total Dissolved Solids (TDS)	Field and Lab
Major Ions (for interpretation purposes only)	Calcium	Lab
	Carbonate	Lab
	Chloride	Lab
	Potassium	Lab
	Magnesium	Lab

Parameter Group	Parameter (units)	Method
	Sodium	Lab
	Bicarbonate	Lab
	Sulfate	Lab
Nutrients	Ammonia as N	Lab
Metals (dissolved and total)	Aluminium	Lab
	Arsenic	Lab
	Boron	Lab
	Cadmium	Lab
	Cobalt	Lab
	Chromium	Lab
	Copper	Lab
	Mercury	Lab
	Lead	Lab
	Manganese	Lab
	Molybdenum	Lab
	Nickel	Lab
	Silver	Lab
	Selenium	Lab
	Uranium	Lab
	Vanadium	Lab
	Zinc	Lab

5.10.3.5 Groundwater Level Drawdown Triggers (Level Trigger Thresholds)

The GMMP (**Appendix 22**) describes the detailed statistical analysis used to derive groundwater level drawdown triggers (level trigger thresholds) for compliance bores, which are presented in Table 5-8. The predictive results of the numerical groundwater model have been utilised to develop bore specific groundwater Level trigger thresholds as detailed in **Appendix 22**. Note that no level trigger thresholds are provided for GMMP reference bores, or for dry bores.

Consistent with EA condition D5, the groundwater level triggers are considered breached if groundwater levels at the compliance bores (which are not dry) exceed the groundwater level trigger thresholds specified in Table 5-8. EA condition D5 specifies that the current level trigger thresholds must be amended to the actual trigger level thresholds prior to the commencement of mining. The GMMP has developed updated trigger level thresholds.

Where there is an exceedance of the groundwater level trigger thresholds, the EA specifies investigation and notification protocols in conditions D7 to D11.

If the investigation determines that the exceedance was the result of mining authorised under the EA, then investigations must be undertaken by the EA holder to establish whether environmental harm has occurred or may occur. Within twenty-eight (28) days of the investigation the EA holder must:

- have implemented short-term measures to mitigate the potential for environmental harm; and
- developed long-term mitigation measures to address any existing groundwater contamination and prevent recurrence of groundwater contamination; and
- if environmental harm has occurred as a result of groundwater drawdown exceedances:
 - determine any actions required to reduce the potential for environmental harm; and
 - determine any mitigation measures required to limit the drawdown in the affected groundwater resource.

Table 5-8 Groundwater Level Monitoring Trigger Threshold Levels

Aquifer	Compliance Bore	Level Trigger Threshold (m)
Alluvium	GW06	Dry bore, no Level Trigger Threshold proposed
Alluvium	GW03	Dry bore, no Level Trigger Threshold proposed
Alluvium	GW09	Dry bore, no Level Trigger Threshold proposed
Alluvium	GW19_37a	7.1 ^{1,2}
Alluvium	GW08	Dry bore, no Level Trigger Threshold proposed
Alluvium	GW07	3.8 ¹
Alluvium	GW26	3.6 ³
Alluvium/Regolith	GW19_33	3.4 ⁴
Regolith	GW30c	4.7 ⁴
Regolith	GW31b	3.7 ⁴
Permian (Burton Seam)	GW30b	9.2 ¹
Permian (L/V Seam)	GW10	86.3 ¹
Permian (L/V Seam)	GW13	75.1 ¹
Permian (L/V Seam)	GW30a	10.1 ¹
Permian (L/V Seam)	GW31a	23.8 ¹
Permian (L/V Seam)	GW11	108.3 ^{1,2}
Permian (sandstone)	GW29a	15.2 ¹
L/V Seam = Leichhardt / Vermont Seam 1. Maximum cumulative 90th percentile modelled drawdown prediction. 2. Maximum drawdown limited to base of model layer. 3. Based on the range of natural variability observed at this bore. 4. Based on the average range of natural variability observed at all existing alluvium/regolith bores.		

5.10.3.6 Groundwater Quality Limits

The GMMP (**Appendix 22**) describes the detailed statistical analysis used to derive groundwater quality limits for compliance bores. Groundwater quality limits for compliance bores have been established in accordance with the DES (2021) guideline ‘Using monitoring data to assess groundwater quality and potential environmental impacts’.

The groundwater quality limits are presented in Table 5-9. Note that no groundwater quality limits are provided for GMMP reference bores.

Consistent with EA condition D4, the groundwater quality is not compliant with the limits when three consecutive samples for any particular bore exceed any of the relevant contaminant limits. Where there is an exceedance, the EA specifies investigation and notification protocols in conditions D7 to D11.

If the investigation determines that the exceedance was the result of mining authorised under the EA, then investigations must be undertaken by the EA holder to establish whether environmental harm has occurred or may occur. Within twenty-eight (28) days of the investigation the EA holder must:

- have implemented short-term measures to mitigate the potential for environmental harm; and
- developed long-term mitigation measures to address any existing groundwater contamination and prevent recurrence of groundwater contamination; and
- if environmental harm has occurred as a result of groundwater drawdown exceedances:
 - determine any actions required to reduce the potential for environmental harm; and
 - determine any mitigation measures required to limit the drawdown in the affected groundwater resource.

Table 5-9 Groundwater Quality Triggers

Analyte	pH (Field)	EC (Lab)	Ca	NH ₃ -N	SO ₄	Al	As	B	Cd	Co	Cr	Cu	Hg	Pb	Mn	Mo	Ni	Ag	Se	U	V	Zn
Unit	-	µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
GW06	6.5 - 8.5	TBD	TBD	0.9	TBD	0.055	0.013	TBD	0.0002	0.0014	0.001	0.0014	0.00006	0.0034	1.9	0.034	0.011	0.00005	0.005	TBD	0.006	0.008
GW03	6.5 - 8.5	720	1000	0.9	25	0.055	0.013	0.94	0.0002	0.0014	0.001	0.0014	0.00006	0.0034	1.9	0.034	0.011	0.00005	0.005	0.0005	0.006	0.008
GW09	6.5 - 8.5	TBD	TBD	0.9	42	0.055	0.013	0.94	0.0002	0.0014	0.001	TBD	0.00006	0.0034	1.9	0.034	0.011	0.00005	0.005	TBD	0.006	TBD
GW19_37a	6.5 - 8.5	2500	1000	0.9	31	0.055	0.013	0.94	0.0002	0.0014	0.001	TBD	0.00006	0.0034	1.9	0.034	0.025	0.00005	0.005	0.002	0.006	TBD
GW08	6.5 - 8.5	720	1000	0.9	25	0.055	0.013	0.94	0.0002	0.0014	0.001	0.0014	0.00006	0.0034	1.9	0.034	0.011	0.00005	0.005	0.0005	0.006	0.008
GW07	6.5 - 8.5	8661	271	0.9	51	0.055	0.013	0.94	0.0002	0.004	0.001	0.0046	0.00006	0.0034	1.9	0.034	0.021	0.00005	0.005	0.012	0.006	0.038
GW26	6.5 - 8.5	720	1000	0.9	25	0.055	0.013	0.94	0.0002	0.0014	0.001	0.0014	0.00006	0.0034	1.9	0.034	0.011	0.00005	0.005	0.0005	0.006	0.008
GW19_33	6.5 - 8.5	720	63	0.9	25	0.055	0.013	0.94	0.0002	0.0014	0.001	TBD	0.00006	0.0034	1.9	0.034	0.018	0.00005	0.005	TBD	0.006	0.019
GW30c	6.5 - 8.5	15875	357	0.9	185	0.055	0.013	0.94	0.0002	0.0014	0.001	0.0014	0.00006	0.0034	1.9	0.034	0.011	0.00005	0.005	TBD	0.006	0.008
GW31b	6.5 - 8.5	2739	90	0.9	25	0.055	0.013	0.94	0.0002	0.0014	0.001	0.0014	0.00006	0.0034	1.9	0.034	0.011	0.00005	0.005	0.002	0.006	TBD
GW30b	6.5 - 8.5	18285	679	3.9	25	0.055	0.013	0.94	0.0002	0.0014	0.001	TBD	0.00006	0.0034	1.9	0.034	0.011	0.00005	0.005	0.0005	0.006	0.029
GW10	6.5 - 8.5	6244	60	1.3	25	0.055	0.013	0.94	0.0002	0.0014	TBD	0.0014	0.00006	0.0034	1.9	0.049	0.027	0.00005	0.005	0.0005	0.006	0.009
GW13	6.5 - 8.5	12700	143	3.5	25	0.055	0.013	0.94	0.0002	0.0014	0.001	0.0014	0.00006	0.0034	1.9	0.034	0.011	0.00005	0.005	0.0005	0.006	0.024
GW30a	6.5 - 8.5	15600	299	3.6	25	0.055	0.013	0.94	0.0002	0.0014	0.001	TBD	0.00006	0.0034	1.9	0.034	0.011	0.00005	0.005	0.0005	0.006	0.023
GW31a	6.5 - 8.5	4820	23	1.0	25	0.055	0.013	0.94	0.0002	0.0014	0.001	0.0014	0.00006	0.0034	1.9	0.034	0.011	0.00005	0.005	0.0005	0.006	0.008
GW11	6.5 - 8.5	4161	106	1.9	25	0.055	0.013	0.94	0.0002	0.0014	0.001	0.0014	0.00006	0.0034	1.9	0.034	0.011	0.00005	0.005	0.0005	0.006	0.018
GW29a	6.5 - 8.5	9870	140	TBD	25	0.055	0.013	0.94	0.0002	0.0014	0.001	0.0014	0.00006	0.0034	1.9	0.034	0.011	0.00005	0.005	0.0005	0.006	0.02

5.10.3.7 Post Mining

Post-mining groundwater monitoring will be subject to detailed closure/relinquishment conditions including those conditioned by the Project's PRCP schedule (**Appendix 5**).

The GMMP groundwater monitoring program will continue unchanged in the post-mining period until relinquishment of the EA and MLs, with the exception of incorporating any additional requirements that may arise through the PRCP implementation process.

The post-mining monitoring program will also include additional monitoring for the residual void lake as follows:

- void water level - quarterly survey consistent with the frequency of groundwater level monitoring at groundwater bores.
- void water quality – quarterly sampling consistent with the frequency and parameter suite (for groundwater quality monitoring at groundwater bores).

5.10.3.8 Reporting, Review and Improvement Process

Section 8.0 of the GMMP (**Appendix 22**) describes the following reporting, review and improvement processes:

- Annual groundwater monitoring reports - conduct an annual review of the environmental performance of this GMMP. The annual review will be reported in an annual groundwater monitoring report (AGMR) and will satisfy requirements under EA condition D15 and AWL condition 47.
- GMMP review - consistent with condition D14 of the EA, the GMMP will include a review process to identify improvements to the program, where deemed warranted as part of an AGMR. The GMMP will be reviewed and modified as necessary over the mine life based on revisions to the Project's groundwater model, reviews of monitoring results and/or changed mining conditions, as identified in any AGMR.
- Groundwater impact prediction, validation and review - during the life of the Project (starting from commencement of the take of associated water), as deemed required data collected through the GMMP may be used to review and if deemed necessary update and refine the Project groundwater model and its impact predictions consistent with AWL conditions 49 and 50.
- Monitoring network maintenance – the proponent will proactively maintain the groundwater monitoring network, replacing bores as necessary, and use the regular review of monitoring data to inform the location of additional monitoring bores, if required.

5.10.4 Spill Management

The MIA workshop and fuel/chemical storage areas at the Project will be developed in accordance with relevant legislative requirements and Australian Standards. This includes refuelling areas and chemical storage areas designed with adequate bunding and equipped for immediate spill clean-up. A spill prevention and response procedure will be implemented.

These controls represent standard practice and a legislated requirement at mining operations for preventing the contamination of the groundwater regime. Therefore, there is considered to be limited potential for groundwater contamination to occur from accidental release of hydrocarbons or chemicals.

5.10.5 Stygofauna

5.10.5.1 Mitigation Measures

The following management measures will be implemented for the Project, which will aid in reducing impacts on stygofauna:

- Disturbing only areas needed for Project activities and implementing vegetation clearing controls.

- Implementing groundwater water level and quality monitoring across an appropriately designed bore field.
- Releasing mine affected water in accordance with EA conditions
- Implementing spill management procedures (see Section 5.10.4) to reduce the risk of potential contamination from spills.

5.10.5.2 Monitoring Program

Appendix 21 provides an operational phase monitoring program for stygofauna, based on the derivation of stygofauna triggers.

Of the 15 bores surveyed for stygofauna in December 2022, stygobitic stygofauna were recorded at one bore (1/15 = 7% of bores), and stygoxenes were recorded at eight bores (8/15 = 53% of bores). These percentages represent trigger values for detection rates of stygobites and stygoxenes, respectively, per monitoring event.

A single stygobitic taxon was recorded in 2022 (Bathynellidae sp. 1), while three stygoxene taxa were recorded. Ongoing monitoring is intended to demonstrate no reduction in the diversity or species composition of stygobites and stygoxenes over time.

Annual monitoring of stygofauna will be undertaken at 11 bores listed in **Appendix 21** in the dry season (notionally September or October) each year. All bores target alluvium or alluvium/regolith geological units.

An annual stygofauna monitoring report will be prepared each year, presenting the methods and results of the stygofauna monitoring event. Stygofauna are to be classed as stygobite or stygoxene, using nomenclature of the baseline stygofauna pilot study. The annual stygofauna monitoring report will also assess the monitoring results with reference to:

- the stygofauna triggers, and present conclusions whether the stygofauna triggers were exceeded, and
- the classes of residual thickness, and present conclusions about the groundwater characteristics within which stygofauna are retained.

Where the routine stygofauna monitoring results indicate an exceedance of the triggers, then review of the most recent groundwater monitoring results will be implemented to determine if there are unexpected changes to groundwater levels. If groundwater changes that are unexpected have occurred, then review the suitability of the bores surveyed for the stygofauna monitoring program.

If two consecutive years of annual monitoring both indicate an exceedance of the triggers, then a supplemental monitoring event will be implemented in the following wet season to verify results. Where the repeat survey continues to indicate an exceedance of the stygofauna triggers, then an investigation will be implemented into the reasons why the repeat monitoring results exceeded the trigger levels.

5.10.6 Groundwater Dependent Ecosystems

As described in Chapter 4, water management measures will be implemented at the Project to mitigate impacts on surface water resources. A groundwater dependent ecosystem monitoring and management plan (GDEMMP) is proposed, and this will be complemented by a receiving environment monitoring program (REMP) (see Section 6.3.7 of Chapter 6) and ongoing groundwater monitoring.

The combination of the GDEMMP and REMP will allow for detection of potential impacts to GDEs, monitoring to determine if changes in health are the result of mining activities, development of mitigation measures if required, or provision of offsets for significant residual impacts should they occur.

5.10.6.1 Measures to Avoid Impacts

The proponent has avoided direct impacts on terrestrial GDEs by locating mining activities outside of the GDE zone, with only the Isaac River crossings located within the GDE zone. A proposed disturbance area has been nominated for the crossings, although it is likely that the construction width for the crossings will be

less than the width of the proposed disturbance area. Opportunities to reduce clearing impacts will be sought during construction. Chapter 6 assesses direct impacts to vegetation. Biodiversity offsets have been proposed for this clearing of GDEs associated with the crossings as it comprises habitat for listed species (see Chapter 7).

The design and construction of the new bridge for the Suttor Developmental Road realignment and the bed level crossing of the Isaac River are described in Section 4.12.5 of Chapter 4. The conceptual design for the bridge crossing is to replicate the existing Suttor Developmental Road bridge crossing. The design and construction of the bed level crossing aims to minimise impacts on the hydrological function of the river, and to minimise erosion and sedimentation from the crossing. Following operations the bed level crossing will be decommissioned and rehabilitated, thereby mitigating any long term impacts.

5.10.6.2 Water Management System

The mine and sediment affected water management systems are designed to minimise impacts on the receiving environment (see Section 4.7 of Chapter 4). The water management system for the Project will operate throughout the life of the Project to protect downstream environmental values, including GDEs along the Isaac River.

5.10.6.3 Receiving Environment Monitoring Program

An outline of the REMP is provided in Section 6.3.7 of Chapter 6. The REMP will be developed to comply with EA conditions with an intent to monitor, identify and describe any impacts to the environmental values, water quality and flows within the receiving environment. Annual monitoring, reporting and analysis of long-term trends and potential impacts will be undertaken, and outcomes will inform further mitigation and remediation of existing mitigation measures as required.

5.10.6.4 Groundwater Monitoring

Proposed groundwater monitoring is described in Section 5.10.3. A comprehensive groundwater monitoring network, including monitoring bores installed within all the major groundwater units including the regional Tertiary and Coal Seam aquifers, and alluvial groundwater systems will be maintained for the duration of the Project. The primary purpose of the groundwater monitoring network will be to enable the natural groundwater fluctuations to be detected and distinguished from groundwater level impacts associated with de-watering of aquifers impacted by the Project. Additional monitoring bores may be recommended as part of a GDEMMP to provide more specific information on the degree of hydraulic interaction between the seasonally variable perched groundwater unit, and the basal alluvial groundwater unit to inform the management of potential impacts to GDEs.

5.10.6.5 Groundwater Dependent Ecosystem Monitoring and Management Plan

A GDEMMP has been developed for the Project (refer to **Appendix 19**) and is summarised below.

The GDEMMP addresses and manages the uncertainties associated with the environmental impacts of the Project on GDEs through the development of consistently applied monitoring actions, analysis and reporting of data trends, and development of 'early warning' triggers to identify a decline in GDE health. Corrective actions (mitigations) are described for implementation when statistically significant impacts on GDE function caused by mining activity are detected. The GDEMMP will be used as a reference for management actions during construction, operation, rehabilitation and closure. The GDEMMP includes a specific two-year 'baseline' assessment phase of monitoring, which will provide increased certainty to the findings of the GDE Assessment (**Appendix 10**), ensuring that post-baseline GDE monitoring focuses specifically on ecosystems that are groundwater dependent.

A sequential approach to monitoring and management has been applied which allows for adaptive implementation of monitoring and management protocols reliant on results of prior assessment activities. The major components of the GDEMMP include:

- Apply monitoring and assessment techniques that support development of an environmental baseline for GDE function commencing prior to operations, including upstream and downstream control sites for GDE monitoring.
- Produce a statistically robust multi-parameter dataset that can be used to validate perturbations in GDE function that fall beyond thresholds of natural seasonal variation.
- Allow a flexible approach to monitoring which is subject to ongoing review and allows methods to be adapted based on results of lead-up monitoring and data analysis.
- Utilise biophysical and ecological parameters to establish an appropriate:
 - ecological trigger threshold, applied to indicate requirement for further investigation or corrective action; and
 - disturbance level threshold applied to indicate requirement for offsets should corrective actions not be successful.
- Develop a comprehensive suite of management actions and corrective measures which will be applied if a breach of trigger threshold is identified, noting that the suite of management actions implemented will depend on impacts identified, and all may not be required for any given breach of a trigger threshold.
- Assess the effectiveness of management actions and corrective measures, determine if significant residual impacts to MSES or MNES have occurred, and where significant residual impacts have occurred, provide offsets.

The approach is consistent with the GDE Toolbox approach (Richardson 2011) which recommends a sequential assessment.

The monitoring and management program has been separated into two stages:

- Two years of intensive data collection during which the GDE monitoring program will be refined, and investigative thresholds will be defined.
- The period after 2 years, comprising the remainder of operations and the post mining period, which will utilise data collected in the initial two years to re-assess the developed thresholds.

The process for establishing thresholds is described in Section 10 of **Appendix 19**, involving collection of data from the impact site (i.e., drawdown area) and two control sites located upstream and downstream from the mining impact area (i.e., outside the area of drawdown) on the Isaac River. The thresholds for impact are linked to vegetation health and provide a comparison between the control and impact sites. Should the established thresholds be exceeded, this will trigger an investigation that will make use of other monitoring data that considers the bio-physical function of groundwater dependent vegetation, groundwater, and surface water to determine the cause of a threshold exceedance. If drawdown of the groundwater table is found to be the cause of the threshold exceedance, then mitigation measures (see Section 5.10.6.6) will be implemented, and the effect of mitigation measures monitored. If mitigation measures are not effective, habitat quality data from a GDE habitat quality monitoring program (see **Appendix 20** and Section 5.10.6.7) will be used to assess whether there has been a significant residual impact to riparian habitat and habitat for MNES. The GDE habitat quality monitoring program has been established in conjunction implementation of this GDEMMP.

GDE monitoring and analysis techniques are described in Section 8 of **Appendix 19**.

Figure 5-35 (taken from Figure 10 of the GDEMMP) shows the location of proposed GDE monitoring and threatened ecological community (TEC) assessment sites relative to GDE risk zones (see Figure 5-33) and groundwater drawdown contours. Figure 5-36 (taken from Figure 11 of the GDEMMP) shows proposed assessment sites relative to groundwater monitoring bores and REMP sites. Both maps show the extent of mapped Poplar Box TEC based on the ecology survey results presented in Chapter 6.

The proposed GDE monitoring areas overlap with sites from the GDE Assessment (**Appendix 10**) and coincide with the location of groundwater monitoring bores. Field reconnaissance in September 2024

completed investigative auger sampling at four monitoring sites to confirm the potential location of shallow groundwater monitoring bores (see Figure 5-36) and monitor the seasonality and persistence of the perched groundwater unit.

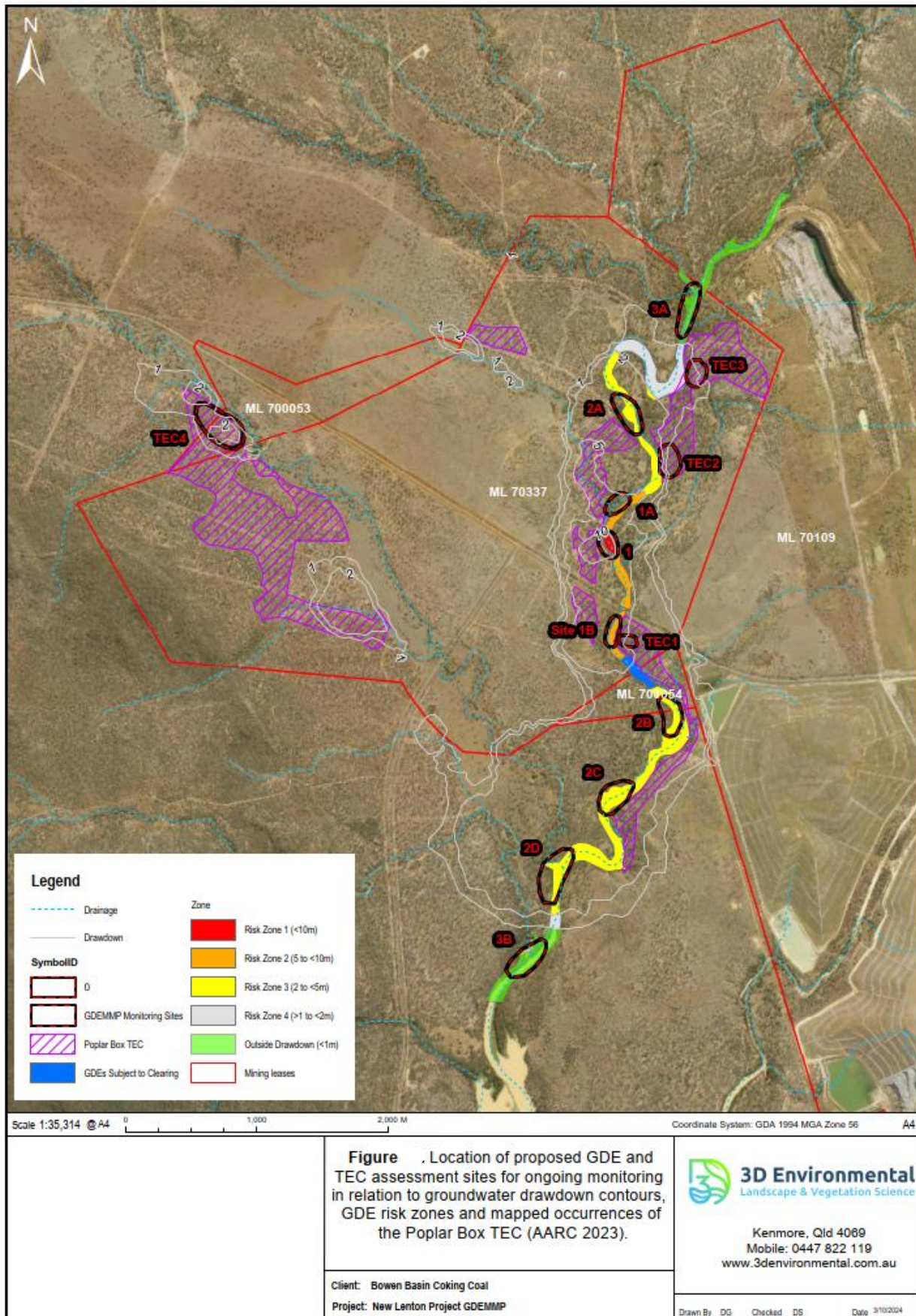


Figure 5-35 GDE Monitoring and TEC Assessment Sites

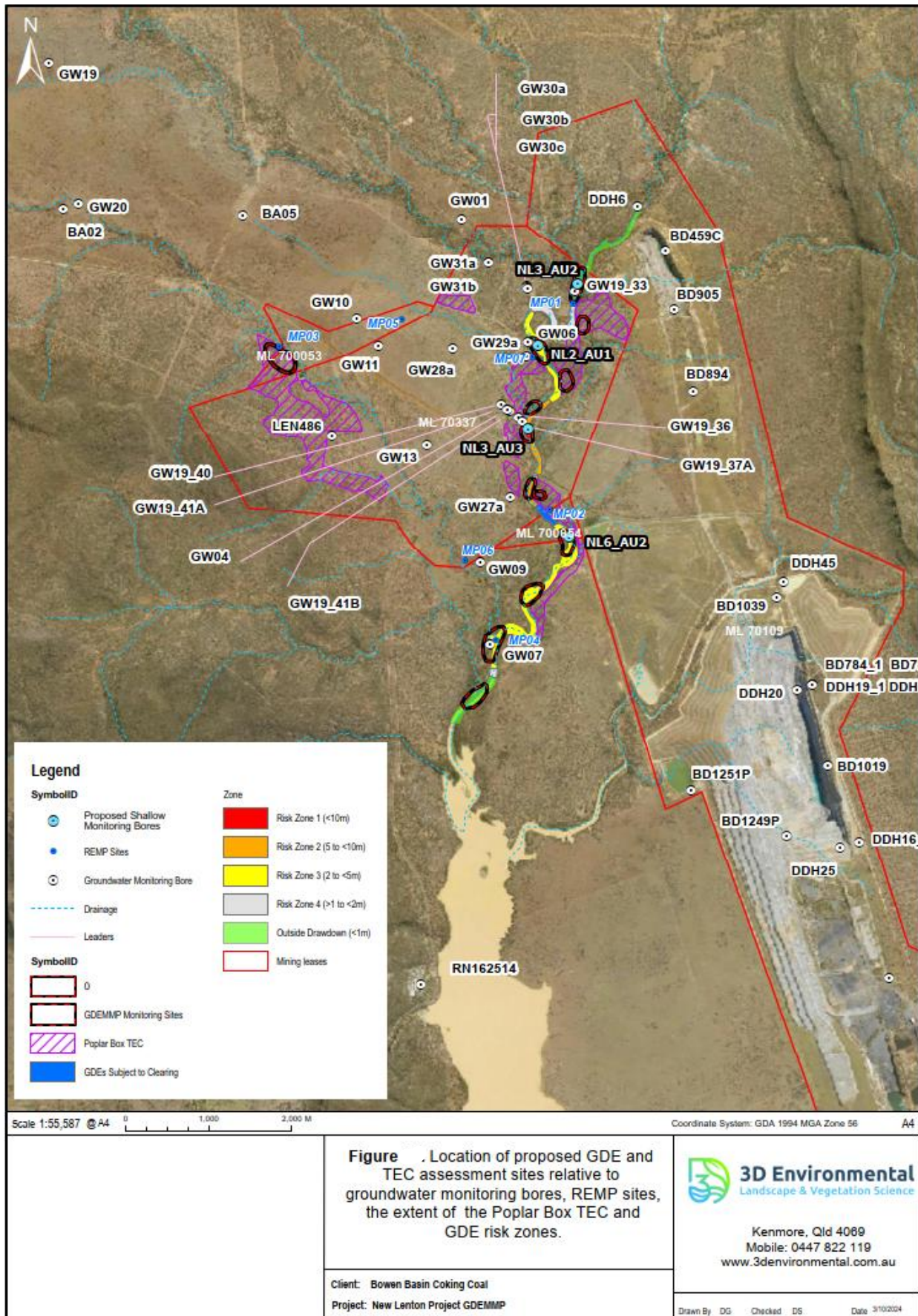


Figure 5-36 GDE and TEC Assessment Sites and Groundwater Monitoring Bores

While groundwater is an abiotic control on the ecohydrological function of GDEs, it is the ecological attributes and condition of terrestrial vegetation that defines GDE habitat values. Therefore, the monitoring of GDE function and condition should be based on vegetation indices to provide a baseline for ecological health and define trigger thresholds for initiation of investigative action. The indices best applied to define trigger thresholds, including potential parameters applied during investigative actions include Leaf Area Index (LAI), LWP, NDVI⁶ and temporal assessment of stable isotopes in twig xylem, water, and soils.

LAI is a precursor to more intensive impacts to habitat values, should these occur. LAI varies on a seasonal basis dependent on water availability, generally within the space of weeks to months, with the highest values lagging slightly behind moisture recharge events. Doody et al (2015) document typical annual LAI variation in the range of 14% to 35%, with LAI = 0.5 (i.e. 50% foliage to canopy ratio) identified as a potential threshold, indicative of critical water stress beyond which vegetation health rapidly declines. This value is taken from river red gum forest on the Murray River and it may not have similar applicability to the GDEs with and surrounding the Project area. However, the LAI threshold can be adapted based on the results of pre-impact monitoring assessments. The process for thresholds based on LAI applies the following principles:

- Collection of time series data of LAI from control and impact sites for a period of approximately two years to establish and test thresholds applied to vegetation indices.
- Identifying appropriate thresholds which will be applied as a trigger for investigation and provide a mechanism to review the appropriateness of the derived trigger.
- Statistical analysis of time series data to characterise seasonal differences in assessment parameters at control and impact sites to identify if a threshold breach occurs.

Data collection will be site based to provide data collection across all identified GDE Risk Zones.

The application of a threshold value for LAI is intended to provide an 'early warning' which will trigger a requirement for investigation to identify causal factors. This will allow mitigations to be applied to restore vegetation health if a threshold breach is linked to mining activities. NDVI may similarly be utilised to define a trigger threshold where it can be correlated to field measured LAI, supported by a suitable period of data collection. Where a threshold breach occurs, appropriate baseline data from a range of biotic and abiotic parameter will be available to provide a sound basis for investigation.

Figure 5-37 details the process and decision framework proposed for the GDEMMP, from initial data collection through to corrective actions in the case that a threshold breach can be linked to mining activity. The initial two years of the assessment covers wet and dry season surveys, to provide a baseline against which future vegetation condition trends can be assessed. The two-year baseline assessment and decision-making process are as follows:

- Establish the proposed monitoring sites to capture LAI and supporting biophysical data (LWP and NDVI) at the proposed monitoring area prior mining operations (i.e. pit development).
- Establish an appropriate trigger threshold value based on percentile methodologies. The proposed process for establishment of the investigative trigger thresholds is:
 - Collect LAI data from the proposed impact and control sites at permanently located monitoring points in the initial GDE assessment.
 - Undertake statistical analysis (t-test) to compare dataset means and ensure the appropriateness of the control site for comparative purposes.
 - If a significant difference is detected between the mean values of control and impact datasets in the initial assessment, the location of the control site will be re-evaluated.
 - Assuming suitability of the control site, set the lower of the 10th percentile (or LAI of 0.5 as per Doody et al 2015, whatever value is lowest) as a trigger value for investigative action.
- Collect seasonal data from a follow up assessment to provide an initial (one year) baseline dataset which considers seasonal variation.

⁶ NDVI is a remotely sensed measurement of vegetation productivity that describes the greenness and the relative density / health of forest biomass.

- Undertake an additional two monitoring events in the following year to complete the two-year baseline dataset. This will allow the appropriateness of applied thresholds to be tested and provide sufficient data to test for significant differences in means (t-test) to identify if a threshold breach occurs.

At each stage, decision pathways are provided when threshold breaches are identified, including requirements for investigative action and corrective measures where causal factors can be linked to mining activity. Following the two-year baseline assessment, statistical correlation between various assessment parameters will be drawn, particularly the relationship between LAI and NDVI to allow ongoing monitoring to be completed remotely on an annual basis if necessary, and trigger thresholds to be adapted.

The process that occurs after the two-year intensive data collection period will follow the process shown in the flowchart in Figure 5-37. Instead of using LAI as a threshold parameter however, NDVI may be applied if a suitable statistical correlation with LAI can be confirmed, although there will be a continued requirement for field assessment of both LAI and LWP completed every two years at a minimum as a control measure. Both NDVI and follow up field assessment will be completed in the dry season at impact and control sites to determine if the threshold is exceeded. Should the thresholds be exceeded, this will trigger an investigation that will make use of other monitoring data (e.g. groundwater monitoring, REMP, vegetation surveys) that relates to vegetation health, groundwater and surface water to determine the cause of an exceedance of a threshold. If the Project is found to be the cause of the threshold exceedance then mitigation measures (see Section 5.10.6.6) will be implemented and the effect of mitigation measures monitored. If mitigation measures are not effective, habitat quality data from the vegetation monitoring will be used to assess whether there has been a significant residual impact to habitat for listed species, and hence whether biodiversity offsets are required.

The management framework is intended to be adaptive, with future capacity for update dependent on the ongoing results of the baseline assessment, and any information gaps identified. Data derived from the groundwater monitoring program, specifically water level and water quality data, will provide supporting information to be used in the case that vegetation threshold values are breached, and investigative actions are necessary.

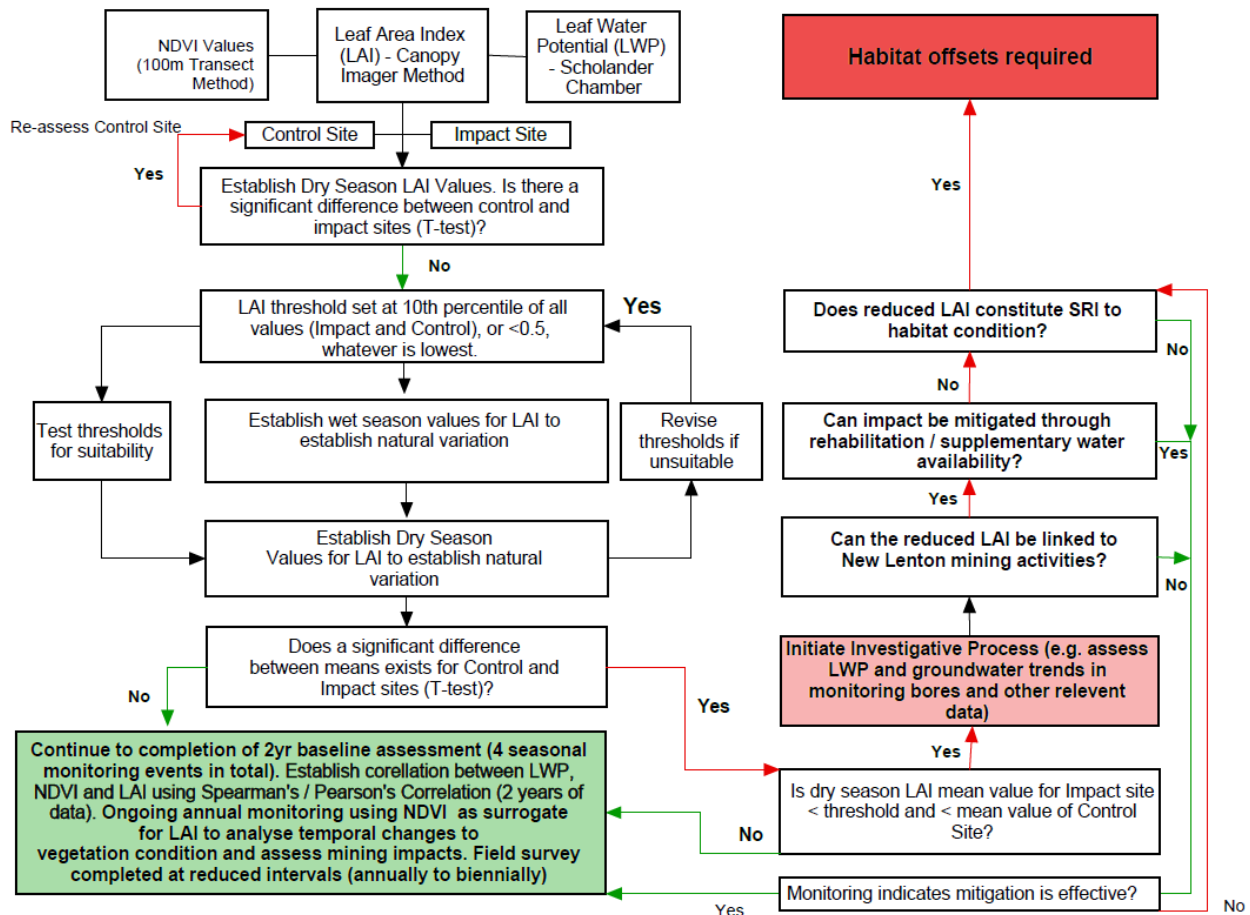


Figure 5-37 Flow Chart of GDEMMP Process

5.10.6.6 Mitigation Measures

The GDEMMP proposes mitigations for remediation, should impacts to GDEs from the Project be detected. These may include:

- Injection of water into the tree root zone for any trees that show significant signs of drought stress that can be linked to groundwater drawdown. Mechanisms for injection of water in tree root zones will be investigated if required, but could include using available sediment water to sustain ecological health subject to meeting water quality criteria.
- Infill planting where decline in riparian tree health can be linked to groundwater drawdown. Infill planting would be conducted with tolerant groundwater dependent species such as Forest red gum, which is already present along the Isaac River.

If mining related impacts are identified that cannot be mitigated with the suggested measures, disturbance thresholds to the habitat of threatened species (those species identified as known or likely to occur in **Chapter 6**) will consider the following criteria to determine whether a significant impact has been incurred. The disturbance thresholds that indicate a requirement for offsetting of habitat for listed species, including habitat for koala and greater glider, are described in the GDE habitat quality monitoring program (see Section 5.10.6.7. To adequately assess whether any detected reduction in habitat quality constitutes a threshold exceedance requiring an offset, it may be necessary to continue monitoring over an extended period (nominally two years). This will ensure that the original exceedance event represents a trend toward a longer-term decline in habitat condition or is a short-term perturbation that can be corrected with the application of appropriate mitigation or a return to normal climatic regimes.

5.10.6.7 Groundwater Dependent Ecosystem Habitat Quality Monitoring Program

A Groundwater Dependent Ecosystem Habitat Quality Monitoring Program (GDEHQMP) has been developed for the Project (refer to **Appendix 20**) and is summarised below. The GDEHQMP supports the GDEMMP described in Section 5.10.6.5.

The purpose of GDEHQMP is to identify potential changes in GDE habitat quality within the area of predicted groundwater drawdown, in particular:

- establish a GDE baseline monitoring program, assessing GDE habitat quality within the area of predicted groundwater drawdown prior Project activities that could result in drawdown in areas with GDEs;
 - providing an understanding of natural seasonal variation in GDE habitat quality; and
 - allowing GDE habitat quality threshold criteria (for GDEs associated with MNES values) to be refined, representing significant declines in habitat quality and providing triggers for environmental offset requirements, noting the initial GDE habitat quality threshold criteria are provided below.
- establish an ongoing GDE habitat quality monitoring program, to be carried out during operations:
 - providing for early detection of potential declining habitat condition in GDEs impacted by drawdown; and
 - enabling the operator to investigate and implement early mitigation measures for the protection of GDEs, as required.

Monitoring data collected as part of the GDEHQMP will be used to assist in the measurement of the significance of Project-related impacts to GDEs and associated threatened species habitat, in conjunction with the GDEMMP.

Habitat quality will be monitored in the regional ecosystem identified in the GDE assessment (**Appendix 10**) as being a terrestrial GDE, namely RE 11.3.25 (riparian vegetation fringing the Isaac River) as well as RE 11.3.2 which is associated with the Poplar Box TEC (noting that the GDE assessment determine that Poplar BOX TEC was not a terrestrial GDE). RE 11.3.25 is associated with habitat for the Koala and Greater Glider. RE 11.3.2 is associated with habitat for the Koala, Greater Glider and Squatter Pigeon.

Proposed monitoring locations are associated with monitoring under the GDEMMP. The proposed locations of GDE habitat quality monitoring sites are shown in relation to the GDEMMP monitoring sites in Figure 5-38. There are 9 monitoring sites within RE 11.3.25 and 5 monitoring sites within RE 11.3.2, including control and potential impact sites.

The monitoring methodology is based on the 'Guide to Determining Terrestrial Habitat Quality Version 1.3' (DES 2020), comprising:

- site-based attributes assessment (in accordance with the BioCondition assessment methodology) and
- species habitat attributes assessment.

Monitoring methods and frequency are described in **Appendix 20**.

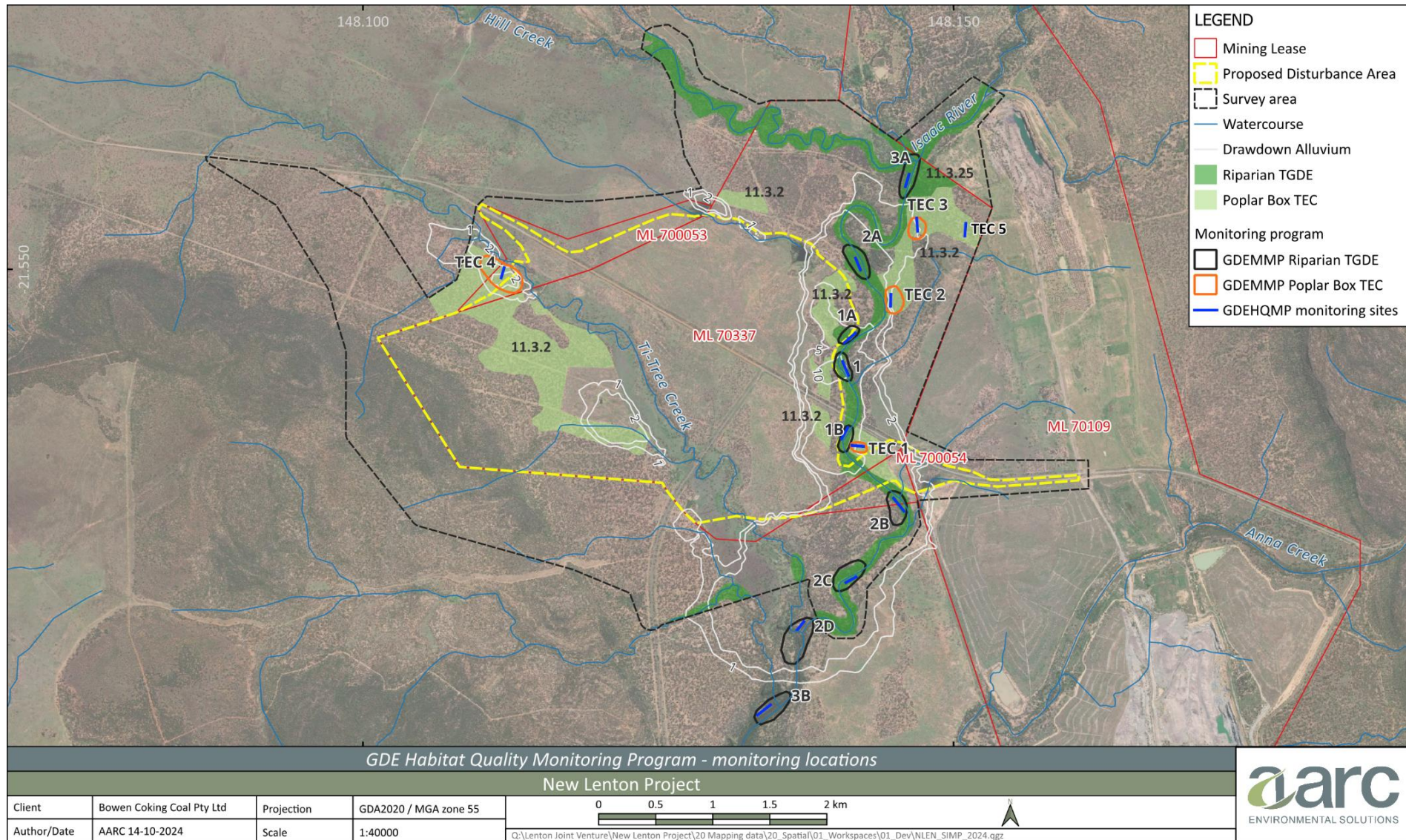


Figure 5-38 GDEHQMP – Monitoring Locations

The initial GDE habitat quality threshold criteria provided below will apply to activities commencing in the baseline period, and be subject to further refinement.

GDE habitat quality threshold criteria have been developed from BioCondition class, and methods to measure BioCondition class are described in the 'BioCondition Assessment Manual, Version 2.2' (Eyre et al. 2015). The methodology defines four condition classes; where Class 1 represents a functional biodiversity condition and Class 4 represents a dysfunctional biodiversity condition (Eyre et al. 2015). The Biocondition classes and associated Biocondition scores are:

- Class 1, > 0.80
- Class 2, 0.60 – 0.80
- Class 3, 0.40 – 0.59
- Class 4, < 0.40.

A decline in class condition by two BioCondition classes, relative to a site's baseline class, will indicate an overall condition decline in the vegetation of the site/s. A decline in Biocondition is considered to represent a potentially significant decline in GDE habitat quality. A decrease in BioCondition of two classes is the threshold limit to trigger the requirement an assessment against the 'Significant Impact Guidelines 1.1: Matters of National Environmental Significance' (DoE 2013) for relevant MNES by a suitably qualified person (i.e., Ecologist). This will occur after implementation of any GDE mitigation measures implemented under the GDEMMP.

Species habitat assessment scores collected during the monitoring program will be used as an assessment tool to support significant impact assessments for the Project, to determine whether biodiversity offsets are required.

The GDEMMP is intended to be adaptive, and the GDEHQMP has been designed in accordance with this approach. As such, the threshold criteria may be adapted during the baseline assessment or during ongoing management, dependent on monitoring results and any future information gaps identified.

Reporting for GDE habitat quality will be completed after each monitoring event. Results will also be incorporated into a consolidated report after the four baseline monitoring events have been undertaken. The results will determine whether there has been a decrease in habitat quality using the threshold limits for GDE habitat quality (after allowance for implementation of any mitigation measures under the GDEMMP). The results will be used to determine whether a significant impact to GDE habitat has occurred.

A data review will be undertaken following the completion of the monitoring program, in conjunction with the GDEMMP, to guide further monitoring requirements. The Program will be subject to review every five years or under the following conditions:

- a change in GDEMMP methods/frequency of ongoing monitoring following completion of baseline assessment
- a change to approval conditions and/or reporting requirements
- a significant change to current mine plan/operations.

5.11 Assessment of Significance of Impacts

5.11.1 Methodology

Potential impacts of the Project to water resources were assessed with reference to Significant impact guidelines 1.3: Coal seam gas and large coal mining developments – impacts on water resources (DoE, 2013) (the Guidelines)⁷.

A 'significant impact' is an impact which is important, notable, or of consequence, having regard to its context or intensity. Whether or not an action is likely to have a significant impact depends upon the

⁷ As per the requirements of the PER Guideline

sensitivity, value, and quality of the water resource which is impacted, and upon the intensity, duration, magnitude and geographic extent of the impacts.

The impacts on groundwater from the Project have been summarised in Section 5.8.8, with proposed mitigation measures summarised in Section 5.10 and the groundwater monitoring program summarised in Section 5.10.3. These outputs have been assessed against the criteria for significant residual impacts in the Guidelines using a consequence and likelihood matrix to rate each impact's significance. Those with a rating of high or extreme are considered to constitute a significant residual impact. Those with a rating of very low, low, or medium are considered to be unlikely to have a significant residual impact. This assessment considered the sensitivity of the environment, and the Guidelines.

5.11.2 Sensitivity

The sensitivity of an environmental value is determined from its susceptibility or vulnerability to threatening processes, and as a consequence of its intrinsic value. The attributes of sensitivity that were considered are:

- conservation status
- intactness
- uniqueness or rarity
- resilience to change
- replacement potential.

Applying these attributes enables the sensitivity of an environmental value to be ranked as high, moderate or low, as per Table 5-10. The sensitivity of an environmental value, once determined, does not change unless proposed actions or activities reduce the sensitivity of the value to adverse effects.

Table 5-10 **Criteria for Sensitivity**

Sensitivity	Description
High	• The environmental value is listed on a recognised or statutory state, national or international register as being of conservation significance. • The environmental value is intact and retains its intrinsic value. • The environmental value is unique to the environment in which it occurs. It is isolated to the affected system/area which is poorly represented in the region, territory, country or the world. • It has not been exposed to threatening processes, or they have not had a noticeable impact on the integrity of the environmental value. Proposed activities would have an adverse effect on the value.
Moderate	• The environmental value is recorded as being important at a regional level, and may have been nominated for listing on recognised or statutory registers. • The environmental value is in a moderate to good condition despite it being exposed to threatening processes. It retains many of its intrinsic characteristics and structural elements. • It is relatively well represented in the systems/areas in which it occurs but its abundance and distribution are limited by threatening processes. • Threatening processes have reduced its resilience to change. Consequently, changes resulting from Project activities may lead to degradation of the prescribed value. • Replacement of unavoidable losses is possible due to its abundance and distribution.

Sensitivity	Description
Low	- The environmental value is not listed on any recognised or statutory register. It might be recognised locally by relevant suitably qualified experts or organisations. - It is in a poor to moderate condition as a result of threatening processes which have degraded its intrinsic value. - It is not unique or rare and numerous representative examples exist throughout the system/area. - It is abundant and widely distributed throughout the host systems/areas. - There is no detectable response to change or change does not result in further degradation of the environmental value. - The abundance and wide distribution of the environmental value ensures replacement of unavoidable losses is achievable.

5.11.3 Impact Assessment Ranking

The qualitative impact analysis was conducted in accordance with *AS ISO 31000:2018 – Risk Management Standard* and *HB 203:2012 Environmental Risk Management Principals and Processes*. It involves consideration of impact consequences and the likelihood to determine an impact significance rating.

Specific consequence ratings have been developed, as described in Table 5-11, which considers sensitivity and the consequence criteria, including intensity, duration, magnitude and geographic extent of impacts.

Consequence is defined as the outcome of an event which may have the potential to change the existing environmental values.

As an event can have one or more occurrences and can have several causes and several consequences the most probable worst-case consequences are defined after the application of mitigation and management measures. This was determined from the assessment of impacts predicted through modelling in the surface water and groundwater impact assessments, and professional judgement from specialists. ‘Moderate’, ‘major’ and ‘catastrophic’ consequences are considered as potential to be a ‘significant impact’ for changes to the hydrology or water quality of a water resource, once combined with the likelihood of occurrence.

Table 5-11 Consequence Definitions

Descriptor	Environmental Impact
Insignificant	- Negligible environmental impact. Minor transient release within the WQOs and environmental approval limits. - No impact to water users. - Negligible change in flows or hydrology. No users or 3rd party infrastructure affected. - No change to surface and groundwater interactions.
Minor	- Controlled or planned release in accordance within the WQOs and environmental approval limits. - Onsite unplanned contaminant spill immediately contained without outside assistance. - No ongoing or repeat exceedances of water quality release limits or persistent or increasing exceedances of the WQOs detected in receiving waters. - Reduces utility of 1 to 2 water users, which can be compensated through make good arrangements. - Minor changes in flows or hydrology with potential for localised or short-term impacts on downstream or upstream users or 3rd party infrastructure. - Minor / localised impact to GDEs and localised impact to aquatic ecosystems. - Possible minor interactions with surface and groundwater with very minor impacts.
Moderate	- Short term unplanned release that exceeds the WQOs or release limits but does not have lasting impacts to aquatic ecosystems. - Onsite contaminant spill contained with outside assistance.

Descriptor	Environmental Impact
(potentially significant)	- Long term discharge of pollutant, non-persistent, but possible widespread water quality impacts above the WQOs however the receiving environment remains within the 80% of the ecosystem protection guideline. - Impact can be remediated without long term loss or very localised long persistent damage. - Surface and groundwater interaction caused by mining activities with no risk of contaminant transfer or mobilization. - Moderate changes in flows or hydrology, with potential for -sub-catchment scale or medium-term impacts on downstream or upstream users or 3rd party infrastructure. - Significantly reduces utility of less than 5 downstream water users. - Changes to groundwater levels and / or baseline surface flows with potential to impact GDEs or aquatic ecosystems. - Alterations to floodplains, without no major change in flood behaviour and no loss of riparian vegetation causing creek destabilizing.
Major (potentially significant)	- Short to medium term off-site or long-term release that exceeds exposure limits known for downstream aquatic ecosystems. - Long term change in water quality is greater than that required for 'slightly to moderately disturbed' systems. - Significantly reduces current utility of more than 10 downstream water users with minor future impacts. - Surface and groundwater interaction cause contaminant mobilization or hydrological flow changes that have regional impacts 10 to 50 years beyond the life of the Project. - Major changes in flows or hydrology, with potential for regional or long term downstream or upstream impacts on users or 3rd party infrastructure. - Major impacts to regulating services by material alterations to the watercourse flows or floodplains, loss of riparian vegetation causing creek destabilizing, changes to groundwater levels and baseline surface flows, causing impacts to aquatic ecosystems or GDEs.
Catastrophic (potentially significant)	- Significant extensive detrimental long-term impacts on the local environment, with moderate impacts in the regional catchment. - Catastrophic and/or extensive chronic discharge or persistent hazardous pollutant that frequently or continuously exceed water quality trigger levels for aquatic ecosystem protection causing impacts to downstream ecosystem health and resilience. - Catastrophic changes in flows or hydrology, with potential for permanent regional scale downstream or upstream impacts on users or 3rd party infrastructure. - Damage to an extensive portion of aquatic ecosystem or GDEs through major combined impacts to surface water and groundwater resources. - Current and long-term future impact on water resource utility.

Table 5-12 sets out the frequency categories for the risk assessment. The Guidelines state that to be 'likely', it is not necessary for a significant impact to have a greater than 50 per cent chance of happening; it is sufficient if a significant impact on a water resource is a real or not remote chance or possibility. Thus, 'likely' has been considered to include unusual (3) to frequent (5) likelihood events in this impact assessment, which when combined with consequence have the potential to be a significant residual impact.

The likelihood considers the frequency of the consequence severity occurring from a casual event or activity and not the frequency of the event or activity. Where the impact or risk exposure is limited in duration or carries long-term potential consequences, then probability scores have been adopted; and where the impacts or risks are generated from ongoing activities over the life of the Project then frequency of occurrence has been applied.

Table 5-12 Frequency Categories for Likelihood

Category	Frequency	Probability
5	Frequent Event – certain impact will occur	99% chance
4	Normal Event – occur once in a year	50% chance
3	Unusual Event - less than once in 5 years	10% chance
2	Rare Event – less than once per 10 years	1% chance
1	Very Rare Event – less than once per 50 years and unlikely to occur during project life (20 years)	0.1% chance

The impact significance is ranked by combining consequence and likelihood and applying the risk analysis matrix in Table 5-13. Those risks which are considered likely to have a significant impact, in accordance with the Guidelines, are those ranked as either high or extreme risks.

Table 5-13 Risk Analysis Matrix

Likelihood	Consequence				
	5 Catastrophic	4 Major	3 Moderate	2 Minor	1 Insignificant
5 Frequent	25	23	20	16	11
4 Normal	24	21	17	12	7
3 Unusual	22	18	13	8	4
2 Rare	19	14	9	5	2
1 Very Rare	15	10	6	3	1
Key:					
	Very Low		High (Significant Residual Impact Likely)		
	Low		Extreme (Significant Residual Impact Likely)		
	Medium				

5.11.4 Sensitivity of the Receiving Environment

A summary of the key groundwater values and qualities at the Project and surrounds which determine and influence the sensitivity of the receiving environment are provided in Table 5-14. These were compared to sensitivity criteria to determine the level of sensitivity.

Table 5-14 Sensitivity of Groundwater Values

Aspect	Description of Sensitivity, Value and Quality	Sensitivity
Groundwater Resource Values	- Low provisioning services with no use of the resource due to high salinity, limited yields of regional groundwater units. Groundwater in the region is not used by local industries or the community. Minimal use by local landholder bores within 5km of Project. - Perched groundwater system within the Isaac River hydraulically separated from the basal alluvial system, and recharged by surface flows. - Lack of well-developed alluvial deposits, except for the relatively narrow Isaac River floodplain. - Alluvium associated with the Isaac River near the site does not supply a baseflow component to the Isaac River	Low to Moderate

Aspect	Description of Sensitivity, Value and Quality	Sensitivity
	Low cultural services (including recreation and tourism, science and education).	
Groundwater regime	- Drawdown will change aquifer pressure and groundwater levels in the local area. Water from coal seams in the Permian sediments is not a groundwater supply for landholders or ecosystems. - No predicted drawdown at local landholder bore and no ecological dependencies on other regional aquifers with groundwater (regolith, coal seams). - A permanent cone of depression around the mining void into which groundwater flows will be directed, preventing the release of any contaminants.	Low
Groundwater quality	- Water quality is variable but can be suitable for stock watering. - Residual voids act as a permanent groundwater sink, so no recharge of groundwater aquifers.	Low
Interconnections between ground and surface regimes	- No perennial flows in the vicinity of the Project. - Groundwater does not provide baseflow to surface waters in the vicinity of the Project. - Drawdown on the groundwater table will therefore not impact surface flows.	Low
GDE	- Perched groundwater system within the Isaac River hydraulically separated from the basal alluvial system, and recharged by surface flows. - GDEs identified along Isaac River. No other GDEs identified through field surveys. No GDEs in Ti-Tree Creek.	Low to Moderate
Stygofauna	Moderate environmental value of stygofauna community based on field survey results.	Moderate
Cumulative Impacts	- Groundwater has been depressurized by surrounding resource projects. - Predicted cumulative alluvium drawdown map shows negligible increase in drawdown magnitude between the incremental and cumulative predictions (i.e. Burton Mine doesn't exacerbate the Project predicted drawdown)	Low

5.11.5 Residual Significant Impact Assessment

An assessment of the significance of the Project's residual impacts to groundwater is provided in Table 5-15, which demonstrates that residual impacts of the Project on groundwater values are either very low or low and do not result in significant impacts to groundwater resources.

Table 5-15 Assessment of Significance of Residual Impacts to Groundwater

Event	Potential Impact	Causes	Controls	Residual Impact			Significance of Residual Impacts
				C	L	Score	
Hydrology of Groundwater Resources							
Aquifer depressurisation – landholder water supply bores	Reduction in water levels in landholder groundwater supply bores.	- Mining results in drawdown of groundwater within aquifers used by landholders. - Decline in groundwater level / pressure at water bores, reducing water supplies.	- Numerical groundwater modelling predicts that there will be less than 1m reduction in water levels at landholder supply bores. - A make good agreement (as required by AWL) will be implemented with local landholders for the provision of water if there are impacted bore from Project activities. - The groundwater monitoring program will be ongoing. - EA trigger level thresholds and quality limits apply to monitoring bores, with investigations required is trigger or limit thresholds are exceeded.	2	2	Low (5)	No Significant Residual Impact - Modelling demonstrates < 1m drawdown at landholder bores. - Make good agreement if required. - EA and AWL conditions regulate groundwater impacts on landholder bores. - Groundwater bore monitoring to detect if changes in levels or quality in monitoring bores.
Aquifer depressurization – change to surface water base flows	Drawdown of aquifers resulting in a change to surface water base flows.	- Aquifer depressurisation	- A natural hydraulic gradient exists between the Isaac River and the associated alluvium that results in seepage from the Isaac River to the alluvium (i.e. a losing system). - There are no predicted groundwater-related impacts to surface drainage as a result of the Project.	2	1	Very Low (3)	No Significant Residual Impact - Groundwater does not contribute to surface water base flows.
Aquifer depressurisation – GDEs	Drawdown of aquifers resulting in a reduction of groundwater	Aquifer depressurisation where there may be GDEs.	- The seasonally variable perched groundwater unit supports GDEs on the	2	3	Low (8)	No Significant Residual Impact - GDE reliance on perched alluvial groundwater

Event	Potential Impact	Causes	Controls	Residual Impact			Significance of Residual Impacts
				C	L	Score	
	availability, potentially impacting GDEs.		Isaac River, but is perched above the basal alluvial groundwater unit. - Perched groundwater system recharged by seasonal surface flows. - The adaptability of the dominant riparian species to ecological change suggests any impacts will be low in areas where basal alluvial drawdown occurs. - No GDEs within Ti-Tree Creek or other areas - GDEMMP, GDE habitat quality monitoring program, REMP and groundwater monitoring program.				rather than basal alluvium. - GDEMMP, GDE habitat quality monitoring program, REMP and groundwater monitoring program. - GMMP
Change in hydrology of surface waters that provide water to the perched groundwater system utilised by GDEs	Changes in Isaac River surface flows, resulting in altered hydrology of perched groundwater system that supports GDEs.	Infrastructure or mining within Isaac River catchment. Infrastructure or mining within floodplain, thereby altering flood depths and velocities.	- Minor to insignificant changes to hydrology and geomorphology predicted (refer to Chapter 4). - Minor change in Isaac River catchment size during and post mining. - Isaac river crossings have minimal impact on flood levels and velocities. Bed level crossing will be decommissioned and rehabilitated following operations.	2	2	Low (5)	No Significant Residual Impact - GDEMMP - Minimal changes hydrology and geomorphology.
Aquifer depressurisation – stygofauna. Physical disturbance of aquifers – stygofauna.	Drawdown of aquifers resulting in a reduction of groundwater availability, potentially materially impacting stygofauna. Removal of aquifers within the mine pit area.	Mining and aquifer depressurisation. Removal of vegetation, topsoil and overburden.	- The area of mining and depressurisation for the Project is relatively small and limited to the local area. - Disturbing only areas needed for Project activities. - Groundwater monitoring - Stygofauna monitoring program	1	4	Low (7)	No Significant Residual Impact - Moderate stygofauna values identified within groundwater impacted by the Project. - Low sensitivity of stygofauna.

Event	Potential Impact	Causes	Controls	Residual Impact			Significance of Residual Impacts
				C	L	Score	
							- Localised impacts only, with surrounding unimpacted habitat
Additional demand on the State's groundwater resources for mine operations	Allocation of State groundwater resources to mining operations results in less volume available to other State water users.	- Groundwater allocation, other than associated water sought.	- Maximise re-use of onsite water, including use of mine affected water and sediment affected water for dust suppression. - Modelling shows that no external water supplies are required for the Project. - All groundwater inflows as a result of mining are 'associated water' for which the proponent holds an AWL. No additional groundwater supplies are required.	2	1	Very Low (3)	No Significant Residual Impact - No additional external water supply required. - No impact on groundwater resources available under State water resource plans. - Associated water take approved under water licences. - No requirement for additional groundwater supplies.
Cumulative impacts on groundwater levels	Cumulative drawdown of groundwater aquifers.	- Other resource projects with cumulative impacts, in particular Burton Mine	- In the area of predicted incremental drawdown in the alluvium, the predicted cumulative drawdown map shows negligible increase in drawdown magnitude between the incremental and cumulative predictions (i.e. Burton Mine doesn't exacerbate the Project predicted drawdown). - Cumulative impacts on the coal seams is predicted although these have limited, if any, use for landholders or GDEs. The extent of depressurisation in the coal seams is limited to the west of the Project	2	3	Low (8)	No Significant Residual Impact - Project has minimal contribution to cumulative impacts in alluvium - Cumulative impacts on coal seams unlikely to affect landholder bores or GDEs. - GMMP

Event	Potential Impact	Causes	Controls	Residual Impact			Significance of Residual Impacts
				C	L	Score	
			by the sub-crop of the Permian coal seams. - Ongoing water level and quality monitoring across the monitoring network at the Project and Burton Mine.				
Groundwater Quality							
Spills of fuels or chemicals	Localised groundwater contamination	- Accidental spills or releases	- Spill control procedures will be implemented for the Project. - Locations of fuel and chemical storages designed in accordance with relevant Australian Standards, bunded and with runoff control structures.	2	2	Low (5)	No Significant Residual Impact - Low sensitivity of receiving environment. - Controls in place. - Any accidental release likely to be localised, and easily contained and remediated.
Changes in water quality – mine affected water during operations or residual void lake water enters groundwater system and migrates to other water resources (e.g. landholder bores, GDE water sources)	Contamination of groundwater with mine affected water or residual void water during or post mine life.	- Mine affected water enters groundwater system - Residual void water balance stabilises at a level that results in recharging of groundwater.	- During mining, the inward hydraulic flow gradients to the open cut voids would inhibit any migration of water outwards to the regional groundwater system. - Mine water management system. - Modelling for the residual void water levels demonstrates that water levels will stabilise below the groundwater source /sink level – i.e. voids will remain a sink post mining.	2	1	Very low (3)	No Significant Residual Impact - No mechanism for contaminants in mine water or residual void water to enter the groundwater system. - No predicted recharge of residual void water to groundwater post mine life, as void water level below source / sink level.

5.12 Conclusion

The Project area and surrounds are located along the south-western section of the Nebo Synclinorium in the northern part of the Bowen Basin. The local geology (and hydrogeology) can be divided into three main units: the Quaternary to Tertiary sediments (including alluvium) and weathered horizons (regolith), Rewan group, and the Permian coal measures bedrock. The main structural feature of the Project area is the Burton Range Fault.

Numerous field programs have been conducted to understand the hydrogeology of the Project area and surrounds. The main aquifers identified within and surrounding the Project area are:

- Quaternary alluvium, where saturated, associated with the creeks and Isaac River (basal alluvium)
- Regolith where saturated (mainly comprised of weathered bedrock)
- Permian fractured rock aquifers.

A conceptual hydrogeological model of the groundwater regime has been developed based on the review of the hydrogeological information for the Project area.

Groundwater presence in the alluvium is variable, with field investigations showing that the alluvium is only saturated in immediate proximity to the Isaac River channel. Field investigations for the GDE assessment identified that the basal alluvium (10 – 14 m depth) is separated from shallow perched (likely seasonally variable) groundwater system resting on relatively shallow alluvial clays close to the existing Isaac River channel at approximately 4 m depth. That is, a dual natured groundwater system within the alluvium is interpreted. Water quality in the basal alluvium is mildly acidic to moderately alkaline pH (6.3 to 8.4, averaging near neutral at 7.1) and fresh to saline (517 to 16,500 $\mu\text{S}/\text{cm}$ EC, averaging 5,604 $\mu\text{S}/\text{cm}$ EC).

The regolith, comprising of shallow weathered Triassic and Permian strata overlying fresh bedrock, has been identified as hosting groundwater at various locations across the Project area and surrounds. Water quality in the regolith is acidic to mildly alkaline, and mildly brackish to saline (averaging 9,902 $\mu\text{S}/\text{cm}$).

The Rewan Formation, overlying the Permian age Rangal Coal Measures, dominates a significant outcrop area within the Project area. The Rewan Formation is generally considered a major regional scale aquitard within the Bowen Basin.

Groundwater was identified within the coal seams of the Rangal Coal Measures and the Fort Cooper Coal Measures. Due to the limited vertical hydraulic connection between the individual coal seams, the Permian age Coal Measures are conceptualised to comprise multiple confined aquifers (coal seams) that are interbedded with aquitards (overburden, interburden, and underburden). Water quality in the Permian coal seams is acidic to moderately alkaline, and mildly brackish to saline (averaging 9,921 $\mu\text{S}/\text{cm}$).

Baseline groundwater system characterisation indicates that where it occurs, groundwater within the basal alluvium is recorded at depths of around 8 to 11 mBGL, typically significantly disconnected from the streambed elevation. A natural hydraulic gradient exists between the Isaac River and the associated alluvium that results in seepage from the Isaac River to the alluvium (i.e. a losing system). Watercourses within the Project area are highly ephemeral where surface water flow is only sustained for hours to several days following rainfall events. Overall these factors indicate a distinct lack of groundwater discharge to these watercourses such that there is no groundwater baseflow and therefore no potential for groundwater drawdown to manifest as a decrease in surface water flow.

The large offset (>700 m throw) Burton Range Fault on the western side of the Project area is predicted to act as a barrier to east-west groundwater flow with the juxtaposition of the Triassic strata on the west to the Permian Coal Measures on the east.

Registered and unregistered landholder bores within 10 km of the Project area were identified. Only one bore is currently in use.

Site specific hydrogeological information, ecological information and desktop data on potential GDEs was used to inform the location for GDE field surveys. Surveys were undertaken along the Isaac River, Ti-Tree Creek, Hill Creek and other northern tributary streams and older residual landforms. Field surveys and subsequent laboratory analysis comprised an assessment of leaf water potential from trees, soil moisture potential from auger holes and comparison of stable isotope signatures in leaves, soil moisture and groundwater. This data was complemented by data on site-specific geology, geomorphology, soil physical properties, depth to water table and historical aerial imagery of riparian vegetation. The information was analysed to determine if GDEs were present. Data from the Isaac River GDE survey sites demonstrate that riparian vegetation was utilising groundwater from a shallow, seasonally variable, perched water table. The results of GDE data analysis indicate that the riparian vegetation associated with the Isaac River presents the only GDE, and was utilising groundwater from the perched water table. Groundwater usage by vegetation away from the river margins decreases with distance; and away from well-developed alluvial sediments, groundwater usage is restricted by the shallow rooting depth of vegetation, depth to the groundwater table (particularly in the regolith), and groundwater salinity levels. The dominant species that are a potential GDE are forest red gum and river red gum. Red gum species have a number of traits that enable the species to be relatively resilient to all but the most extreme ecological change.

Fifteen bores within and surrounding the Project area were surveyed for stygofauna. A total of five stygofauna taxa were recorded, with one stygobite and four stygoxene taxa. The results of stygofauna survey and assessment of relevant hydrogeological information indicates that shallow groundwater within alluvial and regolith lithologies, in close proximity to the Isaac River, provides suitable habitat for stygobitic fauna.

Significant numerical groundwater modelling simulation work has previously been completed for the Project to inform State approvals processes (i.e. the approved EA and AWL). The numerical groundwater model was revised and updated, in accordance with the latest guidelines and standards, to inform this PER. The model was developed to enable predictions of the incremental impacts of the Project and cumulative impacts from the Project and the adjacent Burton Mine.

The updated model was developed based on the conceptual groundwater model. Numerical modelling was undertaken using MODFLOW-USG, which is considered an industry standard. The updated numerical model includes a steady state and a transient calibration. A Type 3 Monte Carlo uncertainty analysis was undertaken in accordance with IESC Guidelines to estimate the uncertainty in the future impacts predicted by the model. Overall, the model is considered fit for purpose.

An independent peer review of the numerical groundwater model was undertaken which concluded that the model was fit for purpose and that stakeholders can have confidence that the model is a reasonable predictor of future mining impacts.

The model was used to predict incremental and cumulative drawdown in the groundwater system, predict water take from the groundwater system, incremental and cumulative change in groundwater levels at identified groundwater users (e.g. landholder bores or GDEs), incremental changes in baseflow along the Isaac River, incremental changes in alluvial water resources and groundwater inflows to the mining voids.

Maximum incremental drawdown predicted within the Isaac River basal alluvium due to proposed mining at the Project reaches up to 12 m in magnitude along the south-eastern edge of East Pit, where the Isaac River is within 150 m of the mine pit crest. Predicted drawdown of approximately 2 m in the alluvium extends 2 km downstream and 1 km upstream of East Pit at the Project.

Any impacts to the seasonally variable perched table would be contingent on hydraulic connection with the regional water table represented in the model (e.g. the basal alluvium), with evidence suggesting any such connection is limited.

In the area of predicted incremental drawdown in the alluvium, the predicted cumulative drawdown map shows negligible increase in drawdown magnitude between the incremental and cumulative predictions (i.e. Burton Mine doesn't exacerbate the Project predicted drawdown), although Burton Mine contributes its own drawdown to the north in the Isaac River.

The predicted maximum incremental water table drawdown extends approximately 2 km to the north and south of the Project mine pits and 1 km to the east and west. This drawdown does not represent any particular aquifer unit but the shallowest saturated unit (e.g. Regolith or coal seam) at any particular location.

Cumulative impacts are predicted for the coal seams. However, the extent of depressurisation in the coal seams is limited to the west of the Project by the sub-crop of the Permian coal seams.

The model does not predict that the average rate of seepage from the Isaac River to the alluvium will increase over the life of the Project and therefore there are no predicted groundwater-related impacts to surface drainage as a result of the Project.

Post mining, the residual void will accumulate water over time due to direct rainfall, surface water runoff and groundwater inflow from both overburden and natural rock as groundwater levels recover. The model was used to simulate groundwater responses following the cessation of all mining operations. A number of iterative steps were run for the groundwater model and void water balance model, such that models reached agreement on predicted groundwater inflows. The model demonstrates that at all times post-mining, groundwater levels in each aquifer unit surrounding the residual void remain above the predicted void lake level, meaning no potential for outflow from the void lake to the groundwater system and permanent inflow only (sink) conditions are maintained post-mining. Furthermore, the hydrographs show void lake levels remain below the base of the shallow groundwater system (regolith) at all times, further suggesting no potential for void lake outflow to that unit.

Particle tracking was undertaken to illustrate the simulated post-mining groundwater flow field in the vicinity of the mined pits. No particle leaves a void lake after entering the lake. No particles are shown to enter the shallow groundwater system adjacent the Project area (i.e. along alluvium). Therefore, the model indicates no potential for offsite discharge to the alluvium from the residual void.

During mining, the inward hydraulic flow gradients from the waste rock dumps to the open cut voids would inhibit the potential for any seepage outflow. Post-mining, model particle tracking results indicate that the residual void continues to form a hydraulic sink for water emanating within waste rock dumps such that there is no discharge offsite to the surrounding environment.

There is nil to minimal additional (i.e. beyond those that could occur during operations) drawdown of the water table at landholder bores predicted to occur over the post-mining period. There are no known landholder water supply bores within the unconsolidated (alluvium and Regolith) or consolidated (Permian coal measures) aquifers that lie within the predicted extent of Project related drawdown greater than 1 m.

Conceptual models demonstrate that the seasonally variable perched groundwater system that was supporting GDEs at the time of the assessment is disconnected from the deeper basal alluvial / regolith aquifer system during drier climatic periods. The integrity of the perching layer will not be affected by development of mining pits, although groundwater drawdown will occur in the basal alluvial groundwater system. The impact of this drawdown on the seasonally variable perched groundwater system is predicted to be subtle, and no impact is predicted if clay layers are sufficiently tight to limit infiltration. During wet season surface flows, there may be enhanced hydraulic connection between the perched and basal groundwater systems, driven through lateral penetration of surface flows into riverbanks and increased downward leakage. As recharge of both the perched and basal groundwater systems is driven by surface flows, there is unlikely to be any significant change in groundwater regimes while recharge is occurring. Furthermore The dominant riparian species (red gums) is adaptable to ecological change.

Despite the conceptual models showing a lack of connection between the perched groundwater system and basal alluvium, a GDEMMP and GDEHQMP have been developed to allow for detection of potential impacts to GDEs. The GDEMMP includes setting of thresholds to determine changes in vegetation health and habitat quality, monitoring of a range of parameters to establish baseline conditions and determine whether changes are a result of mining activities, development of mitigation measures if required, and the requirement for biodiversity offsets if there are significant residual impacts to GDEs.

A groundwater monitoring and management plan (GMMP) has been prepared for the Project consistent with the relevant requirements of the Project's EA and AWL. The GMMP has been developed for the Project to detect any changes to groundwater quantity or quality due to mining activities. The monitoring network contains sufficient monitoring bores in terms of spatial spread in all formations of interest to develop sufficient pre-mining groundwater conditions and to detect changes in groundwater once mining commences. The EA sets water level triggers and water quality limits, which if exceeded, require investigation and potentially mitigation measures. All requirements of the Project's AWL will be complied with, including any additional make good obligations and groundwater monitoring requirements.

Potential impacts of the Project on groundwater resources were assessed with reference to *Significant impact guidelines 1.3: Coal seam gas and large coal mining developments – impacts on water resources* (DoE, 2013) (the Guidelines). The assessment demonstrates that residual impacts of the Project on groundwater resource values are either very low or low; and hence are not likely to result in a significant impact to the water quality or hydrology of groundwater resources.

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