Bowen Coking Coal

Broadmeadow East

Underground Water Impact Report

Final

DX70025A02

December 2021

TABLE OF CONTENTS

TABLE OF CONTENTS

(continued)

List of Tables

TABLE OF CONTENTS

(continued)

List of Figures

List of Appendices

1 INTRODUCTION

KCB Australia Pty Ltd (KCB) was commissioned by Coking Coal One Pty Ltd (CCO – a wholly owned subsidiary of Bowen Coking Coal (BCB) (the Proponent)) to prepare an Underground Water Impact Report (UWIR) for the proposed Broadmeadow East (BME) Project, herein referred to as 'the Project'.

This section provides a description of the Project and its approval status, the background to the UWIR and the scope and structure of the UWIR. It also provides an overview of planned facilities and operations for the BME Project, to the extent that they are relevant to the UWIR.

1.1 Project Overview

The Project is within the 947 ha, undeveloped mining lease (ML) 70257 that was formerly a part of the Burton Coal Mine, located to the northeast of Moranbah in Central Queensland's Bowen Basin, as shown in Figure 1.1. CCO commercially acquired the Project from Peabody (Burton Coal) Pty Ltd in mid-2020 and ML ownership was officially transferred on January 27, 2021. The Proponent intends to operate an open cut mining operation on the lease upon receipt of the appropriate approvals. The existing disturbance within the Project area includes four farm dams, approximately 105 exploration bore holes. A total of 17 groundwater monitoring bores are located within the vicinity of the BME Project area.

The Project will include an open pit, Mining Industrial Area (MIA), two waste rock dumps, dirty and clean water dams and topsoil stockpiles as shown in Figure 1.2. Produced coal is expected to be processed offsite at one of the many nearby wash plants; while existing rail infrastructure is to be used in transporting coal to port facilities. Details regarding the Project area tenure, proposed mining activities and associated infrastructure is presented in the following sections.

The Environmental Authority (EA) for the Project is EA0002465, last issued on August 24, 2020. It is currently undergoing a major amendment to authorise the planned mining activities.

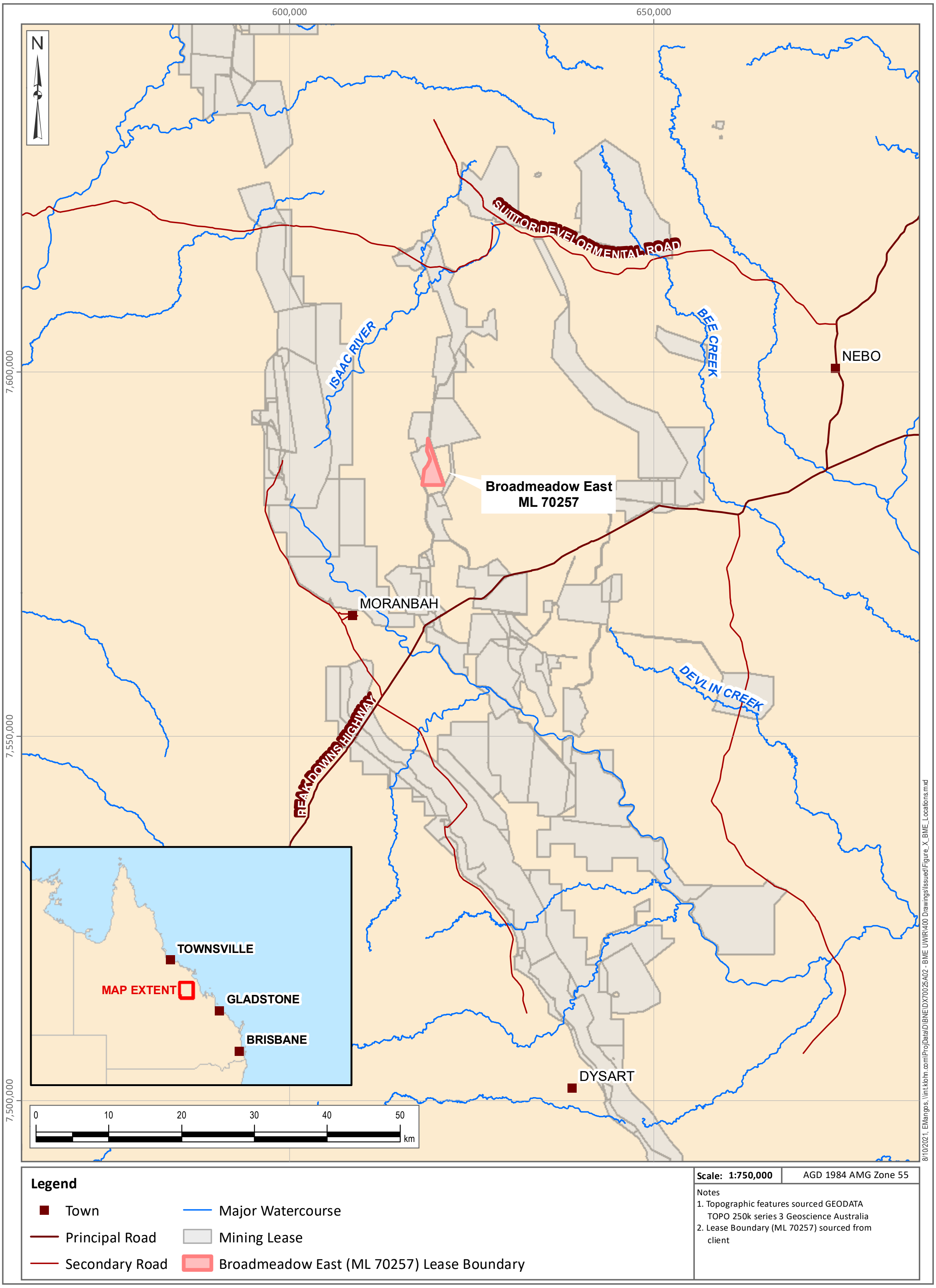

Figure 1.1 Location of BME Project

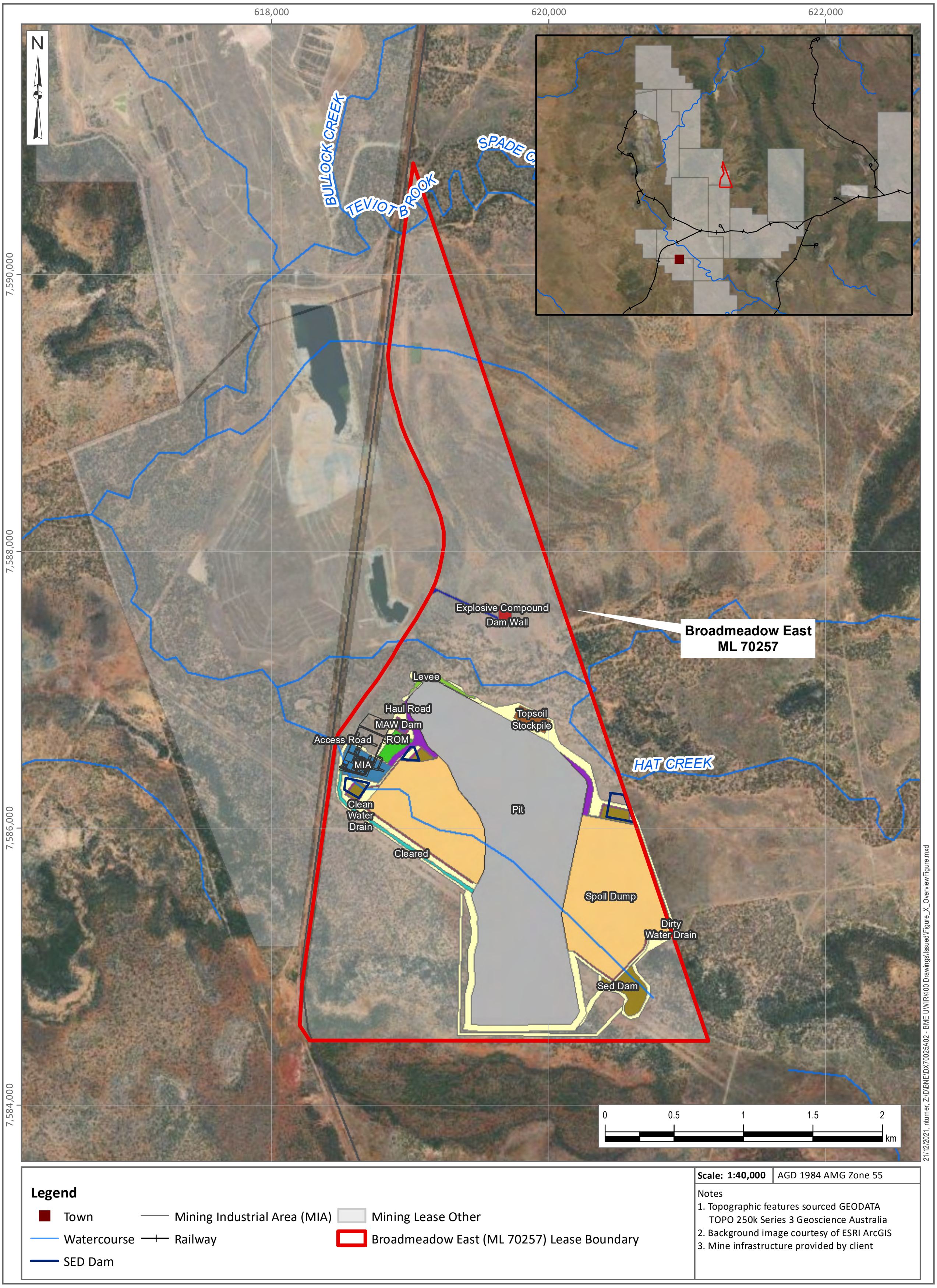

Figure 1.2 BME Project Area

The BME Project will comprise the following infrastructure:

- Mining Industrial Area (MIA) will be the central location related to the mine operation, comprising; office, crib rooms, toilet block, workshop, laydown and storage, fuelling station (diesel), Light and Heavy vehicle parking and wash bay;
- Run of Mine (ROM) stockpile;
- One open pit (comprised of North, Central and South locations);
- Two Out of Pit Dumps (OPD);
- Topsoil stockpiles;
- Flood protection levees;
- Sediment dams;
- Farm dam; and
- Diversion channels and associated clean and dirty water dams.

The coal resource will be transported offsite for processing and transport to the nearest port facilities via existing rail networks.

The BME Project proposes to extract an estimated 5 million tons of high-quality metallurgical coal over an estimated 7 years. The proposed open pit and associated infrastructure is centrally located on the widest section of the Project area.

Coal from the Leichhardt, Vermont and Girrah Seams of the Permian Rangal Coal Measures will be mined from the pit. The Permian Rangal Coal Measures outcrop and sub-crop within the Project area, the Rangal Coal Measures are overlain by the Rewan Group and underlain by the Fort Cooper Coal Measures.

The Project will employ open cut methods and intends to mine in a southerly direction. The truck and shovel mining method will be employed as the means to extract the resource from this entirely surface mining operation.

Pit development will involve the clearing of vegetation, removal of topsoil and removal of the overburden. Where possible, the stockpiled vegetation will be placed on completed rehabilitation areas to encourage the re-establishment of microecosystems. Topsoil will be stripped using dozers from the OPD areas; with the stripping occurring progressively from the mining areas as operations progress. Where possible, the topsoil will be stockpiled adjacent to the OPDs to avoid double handling and haulage as well as be available for progressive rehabilitation within the first two years of operation. Clearing of the pit area will occur progressively to preserve the topsoil and reduce erosion potential. Topsoil that cannot be stored adjacent to the OPD and pit area will be relocated to the north of Hat Creek using front end loaders and dump trucks. The overburden will be removed and placed into the OPDs initially. Coal mining will commence once sufficient overburden is removed.

The target coal measures dip to the east and the steepness of this dip will dictate the type of equipment that operates on the seam roof and floor. Mining will commence on the northern end of the deposit and proceed in a southerly direction along the strike with the strip laid out down dip in a method known as 'terrace mining'. The pit is excavated in a series of horizontal terraces which in turn exposes the coal and waste on every bench. Augers will be used to extract any coal resource exposed along the highwall.

The process of open cut mining will physically dewater groundwater held in the overburden and will act to depressurise the Leichhardt, Vermont and Girrah Seams. This will reduce water pressure and associated groundwater levels in the surrounding geology, beyond the mining area.

1.2 Background to the UWIR

The *Mineral Resources Act 1989* (MR Act) (State of Queensland 2021a) entitles the holder of a ML to take or interfere with underground water (i.e. groundwater) as part of approved mining operations. This entitlement is termed the ML holder's 'underground water rights'.

Groundwater that is taken or interfered with while exercising underground water rights is termed 'associated water'. The holder of the ML is entitled to use associated water for any purpose. In order to exercise the underground water rights for the project, the ML holder must:

- Obtain an Environmental Authority (EA) under the *Environmental Protection Act 1994* (EP Act) (State of Queensland 2021b); and
- Comply with its reporting obligations under Chapter 3 of the *Water Act 2000* (Water Act). The administering authority for Chapter 3 of the Water Act is the Department of Environment and Science (DES) (State of Queensland 2020). Lease holder obligations under Chapter 3 of the Water Act include undertaking baseline assessments of the groundwater regime and water supply bores, preparing UWIRs to provide for ongoing assessment and reporting of groundwater take and (where necessary) entering into make good agreements with owners of affected water supply bores.

The undertaking of the BME Project will be in accordance with the conditions outlined in Environmental Authority (EA) (EA0002465). The Project was previously authorised under the amended EA EPML00879213 held by Peabody (Burton Coal) Pty Ltd, however, upon the transfer of ownership of ML70257 to CCO a new EA was issued which took effect on the 24 August 2020. EA0002465 is held solely by CCO and includes only ML70257 (Queensland Government 2020).

An EA amendment to EA0002465 is required for the proposed Project activities required to develop the BME Project. Nitro Solutions produced an Environmental Impact Assessment Report (EAR) as part of documentation to support the EA amendment application, in accordance with the *Environmental Protection Act 1994* (EP Act). KCB completed a groundwater impact assessment as part of the EAR. The scope of work and methodology for the EAR groundwater impact assessment included:

- Conceptualising the groundwater regime of the Project area and its surrounds through:
  - Reviewing various groundwater, geotechnical and environmental reports related to BME and adjacent mines and projects in order to develop an appreciation of the hydrogeological setting of the project.

    - Reviewing relevant geological data including the geological block model of the BME Project area developed by Xenith Consulting Pty Ltd (Xenith), databases and exploration drilling logs developed by the proponent for the Project.
    - Reviewing hydrogeological data from the Department of Regional Development, Manufacturing and Water (DRDMW's) groundwater database of existing groundwater bores;
    - Undertaking a census of groundwater supply bores within a 5 km radius of the Project area to confirm bore locations, usage and water quality;
    - Undertaking a groundwater site investigation at the Project area. The site investigation included the installation of dedicated monitoring bores to measure groundwater levels, groundwater quality and hydraulic parameters in the key hydrostratigraphic units. The groundwater bores used in the site investigation are shown in Figure 4.3.
    - Compiling a groundwater monitoring dataset from over 750 exploration drill holes within the Project area and surroundings. Groundwater data was collected from 12 bores within the Project area, eight of which screening the Rewan Group and Rangal Coal Measures and four screening the shallower hydrostratigraphy (i.e. alluvium, Tertiary sediments, Tertiary basalt).
    - Compiling a groundwater quality dataset from monthly field testing and laboratory analysis of groundwater samples. Groundwater quality data collected from 12 bores including detailed field measurements and laboratory results for key hydrostratigraphic units within and surrounding the Project area.
    - Analysing the above listed data and using it to develop a conceptual model of the groundwater regime that includes a description of the recharge, flow and discharge of groundwater. The data was also used to gain an understanding of the environmental values of the groundwater.
- Developing a 3D numerical groundwater flow model for the Project to simulate the existing conditions of the groundwater regime and provide predictions of the potential impacts of the proposed mining activities. The model represented the hydrogeology of the Project area and its surrounds (based on the conceptual groundwater model) and the proposed mine plan and mining schedule.
- Undertaking predictive modelling for the project to determine the effects of mining on groundwater levels in the surrounding aquifers, and to inform the assessment of groundwater impacts during mine operations and post- closure. The groundwater modelling used conservative parameters and values and is considered to represent the worst-case scenario for potential groundwater impacts resulting from the Project.
- Assessing the groundwater impacts and developing feasible mitigation and management strategies in the event of potential adverse impacts being identified. Impacts assessed included:
    - Potential groundwater drawdown impacts on groundwater supply bores;
    - Potential groundwater drawdown impacts Hat Creek and other surface water features associated with the Teviot Brook catchment;

  - Potential groundwater drawdown impacts on Groundwater Dependent Ecosystems;
  - Potential cumulative drawdown impacts with local resource activities, including existing mines and coal seam gas activities; and
  - Potential impacts on stygofauna.
- Developing a groundwater monitoring program for the Project.

In reviewing the EA amendment for the project, the groundwater study recommended a further amendment to the EA monitoring bore network. The revised groundwater monitoring network (KCB 2021) ensures each of the key hydrostratigraphic units are monitored, and the network is suitable for monitoring the effects of the Project on the groundwater regime throughout the life of the Project. A summary of the revised groundwater monitoring network is provided in Section 7.

1.3 UWIR Scope and Structure

As part of BME Project development, BCB is required to prepare a UWIR. The UWIR is a requirement of the groundwater management framework legislated under Chapter 3 of the *Water Act 2020*. The main purpose of the UWIR is to describe the groundwater take due to the proposed development and any associated impacts over a three year period (the UWIR period).

This UWIR addresses the initial three years of the Project from the date the proponent exercises its underground water rights on the Project area. The proponent's exercise of its underground water rights on the Project area is currently scheduled to commence upon receipt of the appropriate approvals.

The planned mining activities during this UWIR period includes development and associated operation of the open cut mining operation. The proponent has not produced any groundwater or exercised its rights to take groundwater within the ML 70257 prior to this UWIR period.

The UWIR has been prepared in accordance with the UWIR content requirements described in Section 376 of the Water Act and the DES guideline *Underground water impact reports and final reports* ESR/2016/2000 (the UWIR guideline), where relevant. The requirements in Section 376 of the Water Act are complimentary to the information requirements of Sections 126A and 227AA of the EP Act.

Consistent with Section 2.3 of the UWIR guideline, this UWIR is based on the information provided in the groundwater study (KCB 2021) described in Section 4. DES is in the process of reviewing this information as part of the EA amendment approval process, including the groundwater data, conceptual groundwater model and numerical groundwater modelling. This information has been reproduced in the UWIR, where relevant. The specific scope of the UWIR includes:

- Presenting the relevant groundwater, geology and environmental information from the completed groundwater impact assessment;
- Undertake a review of the Queensland Government groundwater database and QSpatial database to confirm the current water bores registered within ML 70257, the immediate affected areas (IAA) and the long term affected areas (LTAA);

- Gathering updated information on the relevant water supply bores from bore owners in order to confirm the extent of groundwater use in the area;
- Presenting the conceptual groundwater regime within the Project area and its surrounds, based on the completed groundwater impact assessment and any updated data collected from the DRDMW database and bore owners;
- Presenting the groundwater modelling predictions for the life of the Project;
- Using the groundwater impact assessment model to produce predictions of the Project groundwater effects during the UWIR period, including drawdown predictions and predictions of groundwater take for years 1, 2 and 3 of the UWIR period;
- Presenting the predicted groundwater impacts from the groundwater impact assessment, updated as necessary to reflect the updated data collected from the DRDMW database and bore owners; and
- Confirmation of the existing approved EA groundwater monitoring program, the revised groundwater monitoring program, and management measures.

The UWIR comprises the following sections:

- Section 1 – Introduction
- Section 2 – Regulatory Requirements
- Section 3 – Physiographic Setting
- Section 4 – Assessment Methodology
- Section 5 – Conceptual Hydrogeological System
- Section 6 – Groundwater Impact Assessment
- Section 7 – Groundwater Monitoring Program
- Section 8 – UWIR Updates and Review
- Section 9 – Conclusions

Appendix I presents details of all groundwater monitoring bores within 5 km of the Project area. Appendix II provides groundwater hydrographs for the monitoring network. Appendix III provides a summary of the results of groundwater quality testing. Appendix IV provides a description of the numerical modelling undertaken for the Project, including details on model construction, calibration, predictive simulation, and sensitivity analysis.

2 REGULATORY REQUIREMENTS

Section 376 of the Water Act specifies the UWIR content requirements. Table 2.1 lists the specific content requirements and provides an explanation of where each requirement is addressed in this UWIR.

Table 2.1 UWIR Content Requirements

Water Act Section No.	Water Act Section Content	UWIR Cross Reference
376(1)(a)	An underground water impact report must include each of the following — for the area to which the report relates: (i) the quantity of water produced or taken from the area because of the exercise of any previous relevant underground water rights; and (ii) an estimate of the quantity of water to be produced or taken because of the exercise of the relevant underground water rights for a 3-year period starting on the consultation day for the report.	(i) To date, the proponent has not produced or taken groundwater due to the exercise of underground water rights on the Project area. (ii) Section 6.2 describes the estimated groundwater take over the UWIR period.
376(1)(b)	For each aquifer affected, or likely to be affected, by the exercise of the relevant underground water rights: (i) a description of the aquifer; (ii) an analysis of the movement of underground water to and from the aquifer, including how the aquifer interacts with other aquifers; and (iii) an analysis of the trends in water level change for the aquifer because of the exercise of the rights mentioned in paragraph (a)(i); (iv) a map showing the area of the aquifer where the water level is predicted to decline, because of the taking of the quantities of water mentioned in paragraph (a), by more than the bore trigger threshold within 3 years after the consultation day for the report; and (v) a map showing the area of the aquifer where the water level is predicted to decline, because of the exercise of relevant underground water rights, by more than the bore trigger threshold at any time.	(i) and (ii) Section 5 describes the groundwater regime in the relevant aquifers. (iii) To date, the proponent has not produced or taken groundwater due to the exercise of underground water rights on the Project area. (iv) Figure 6.3 to Figure 6.6 show the areas where depressurisation due to the Project activities is predicted to exceed the bore trigger threshold during the UWIR period. (iv) Figure 6.7 and Figure 6.8 shows the areas where depressurisation due to the Project activities is predicted to exceed the bore trigger threshold during the life of the Project.
376(1)(c)	A description of the methods and techniques used to obtain the information and predictions under paragraph (b).	Section 4 describes the UWIR methodology.
376(1)(d)	A summary of information about all water bores in the area shown on a map mentioned in paragraph (b)(iv), including the number of bores, and the location and authorised use or purpose of each bore.	Section 4.1 and Section 4.2 describe the water bores identified during the UWIR bore census. Section 6.5.2 describes the potential impacts to third-party groundwater users.
376(1)(da)	A description of the impacts on environmental values that have occurred, or are likely to occur, because of any previous exercise of underground water rights.	To date, the proponent has not produced or taken groundwater due to the exercise of underground water rights on the Project area.

Water Act Section No.	Water Act Section Content	UWIR Cross Reference
376(1)(db)	An assessment of the likely impacts on environmental values that will occur, or are likely to occur, because of the exercise of underground water rights: i. during the period mentioned in paragraph (a)(ii); and ii. over the projected life of the resource tenure.	Section 6.5 presents an assessment of potential groundwater impacts due to groundwater take.
376(1)(e)	A program for: i. conducting an annual review of the accuracy of each map prepared under paragraph (b)(iv) and (v); and ii. giving the chief executive a summary of the outcome of each review, including a statement of whether there has been a material change in the information or predictions used to prepare the maps.	Section 8 describes the UWIR review and reporting process for the affected aquifers.
376(1)(f)	A water monitoring strategy.	Section 7 describes the groundwater monitoring program.
376(1)(g)	A spring impact management strategy.	There are no springs within the Project area or its surrounds. Hence, a strategy for spring management is not required.
376(1)(h)	If the responsible entity is the office: i. a proposed responsible tenure holder for each report obligation mentioned in the report; and ii. for each immediately affected area—the proposed responsible tenure holder or holders who must comply with any make good obligations for water bores within the immediately affected area.	Not applicable.
376(1)(i)	The information or matters prescribed under a regulation.	No other relevant information or matters have been prescribed under a regulation.
376(2)	However, if the underground water impact report does not show any predicted water level decline in any area of an affected aquifer by more than the bore trigger threshold during the period mentioned in subsection (1)(b)(iv) or at any time as mentioned in subsection (1)(b)(v), the report does not have to include the program mentioned in subsection (1)(e).	Section 8 describes the UWIR review and reporting process for the affected aquifers.

Section 378 of the Water Act lists the content requirements for the water monitoring strategy. Table 2.2 lists the specific water monitoring content requirements and provides an explanation of where each requirement is addressed in this UWIR.

Table 2.2 UWIR Water Monitoring Strategy Content Requirements

Water Act Section No.	Water Act Section Content	UWIR Cross Reference
378(1)	A responsible entity's water monitoring strategy must include the following for each immediately affected area and long term affected area identified in its underground water impact report or final report: a) a strategy for monitoring— (i) the quantity of water produced or taken from the area because of the exercise of relevant underground water rights; and (ii) changes in the water level of, and the quality of water in, aquifers in the area because of the exercise of the rights; b) the rationale for the strategy; c) a timetable for implementing the strategy; d) a program for reporting to the office about the implementation of the strategy.	Section 7 describes the groundwater monitoring program.
378(2)	The strategy for monitoring mentioned in subsection (1)(a) must include: a) the parameters to be measured; b) the locations for taking the measurements; and c) the frequency of the measurements.	Section 7 describes the groundwater monitoring program.
378(3)	If the strategy is prepared for an underground water impact report, the strategy must also include a program for the responsible tenure holder or holders under the report to undertake a baseline assessment for each water bore that is: a) outside the area of a resource tenure; but b) within the area shown on the map prepared under section 376(b)(v).	Section 4.1 and Section 4.2 describe the water bores identified during the UWIR bore census. Section 6.5.2 describes the potential impacts to third-party groundwater users.
378(4)	If the strategy is prepared for a final report, the strategy must also include a statement about any matters under a previous strategy that have not yet been complied with.	Not applicable.

3 PHYSIOGRAPHIC SETTING

3.1 Project Location and Land Use

The Project is within the 947 ha undeveloped ML 70257 that was formerly a part of the Burton Coal Mine located to the north of the Moranbah township in Central Queensland's Bowen Basin. The existing disturbance within the Project area includes four farm dams, approximately 105 exploration bore holes and 12 groundwater monitoring bores.

A summary of the regional Project setting is provided below, with further details included in the remainder of the report:

- The target coal seam for the Project is within the Rangal Coal Measures, of the Permo-Triassic Bowen Basin (Section 5.2).
- The Project is located in the Isaac River Sub-Basin, which forms part of the larger Fitzroy Basin (Section 3.2).
- Groundwater in the Project area comprise two systems: 1. a partially saturated shallow aquifer associated with surficial Cenozoic sediments (Quaternary alluvium, Tertiary sediments); and 2. a deeper low permeability system associated with the Triassic Rewan Group and Permian strata (Section 5).

The Project area is dominated by sparse open vegetation communities, which have been historically cleared and predominantly utilised as pastoral land. The southwestern portion of the lease has a residual Tertiary laterite hill that rises approximately 40 m above the surface. A 132 kV powerline traverses the southern boundary of the deposit.

The Department of Resources (DR) defined land uses surrounding the Project area, which is within a region that is also generally used for mining and coal seam gas (CSG) activities. The Broadlea Mine is located about 3 km south of the area. Immediately west is the former Broadmeadow West ML held by Peabody. Located north of the Project area are the other MLs of the Burton Mine held by Peabody and New Hope. Arrow Energy and Blue Energy own several of the CSG gas fields located within a 10km radius of the Project area.

The Project area is within the Western Cropping Strategic Cropping Land (SCL) subzone, however, there are no areas mapped as SCL. Given the ML was granted prior to the introduction of the *Regional Planning Interests Act 2014*, this does not apply to the Project.

The Project is within a forest management area regulated by the *Forestry Act 1959 (Qld)*. This is linked with the underlying Pastoral Holding land tenure. Accordingly, the State of Queensland owns the 'forest products' located on within the Project area and will require sales permits to be issued before state-owned forest products are removed or sold.

The southwestern portion of the Project area is mapped as a quarry resource owned by the State of Queensland. The active quarry resource extraction area, known as Red Hill Quarry, is off lease to the immediate west of ML 70257. The mapped quarry resource area extends and overlaps the southwestern portion of the ML. This portion has not yet been disturbed nor do the proposed Project activities impact it apart from the establishment of one groundwater monitoring bore. The location of mines and mining projects in the vicinity of the Project area are presented in Figure 3.1.

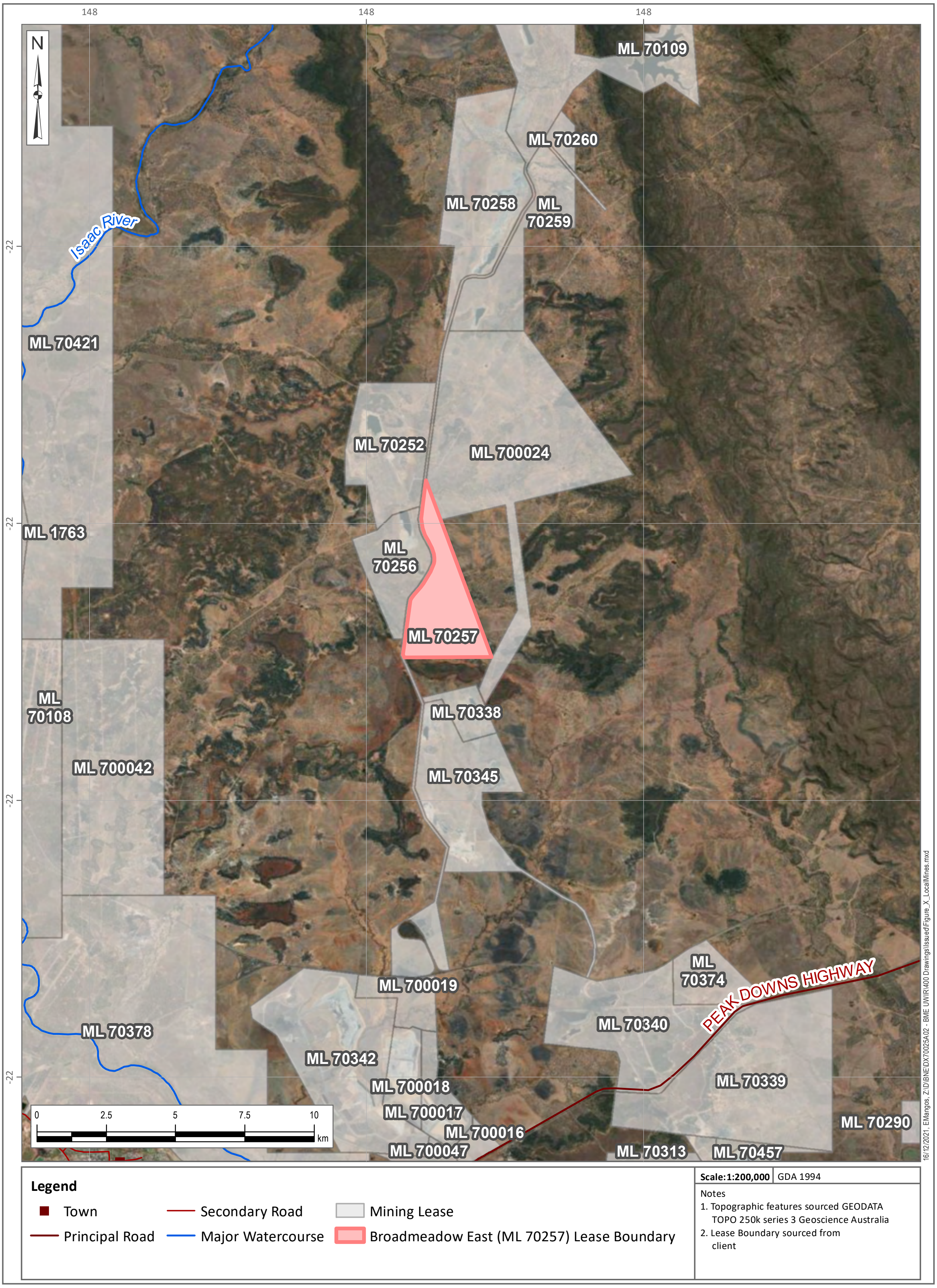

Figure 3.1 Local Mines and Mining Projects

3.2 Topography and Drainage

The Project is located in the Isaac River catchment, a sub-basin of the upper Fitzroy Basin. The Isaac River catchment covers an area of approximately 22,000 km^2, it discharges to the Connors River approximately 140 km to the southeast of the Project area, and subsequently into the Fitzroy River a further 180 km southeast. The Isaac River is located approximately 12 km to the west of the Project and flows in a north to south direction. The regional surface water drainage regime is provided in Figure 3.2.

The Project is located within the Teviot Brook catchment, a sub-catchment of the Isaac River with an area of approximately 260 km^2. Water courses within the Teviot Brook catchment are ephemeral with highly variable flows, characterised by short duration flows associated with episodic storm events during the wet season. Hat Creek, a tributary of Teviot Brook, flows from east to west and comprises numerous minor tributaries that transect the Project area.

The topography of the Project area is presented in Figure 3.2. Elevations range between 275 mAHD to 280 mAHD[1] towards the northwest and 295 to 300 mAHD in the southeast. To the south of the Project area a residual Tertiary laterite hill rises approximately 40 m above the general land surface. The Kerlong range is located to the east of the Project area, with the valley is 6 to 8 km wide and 26 km long.

There are no known springs in the vicinity of the Project area (Queensland Herbarium 2021).

[1] Metres above Australian Height Datum

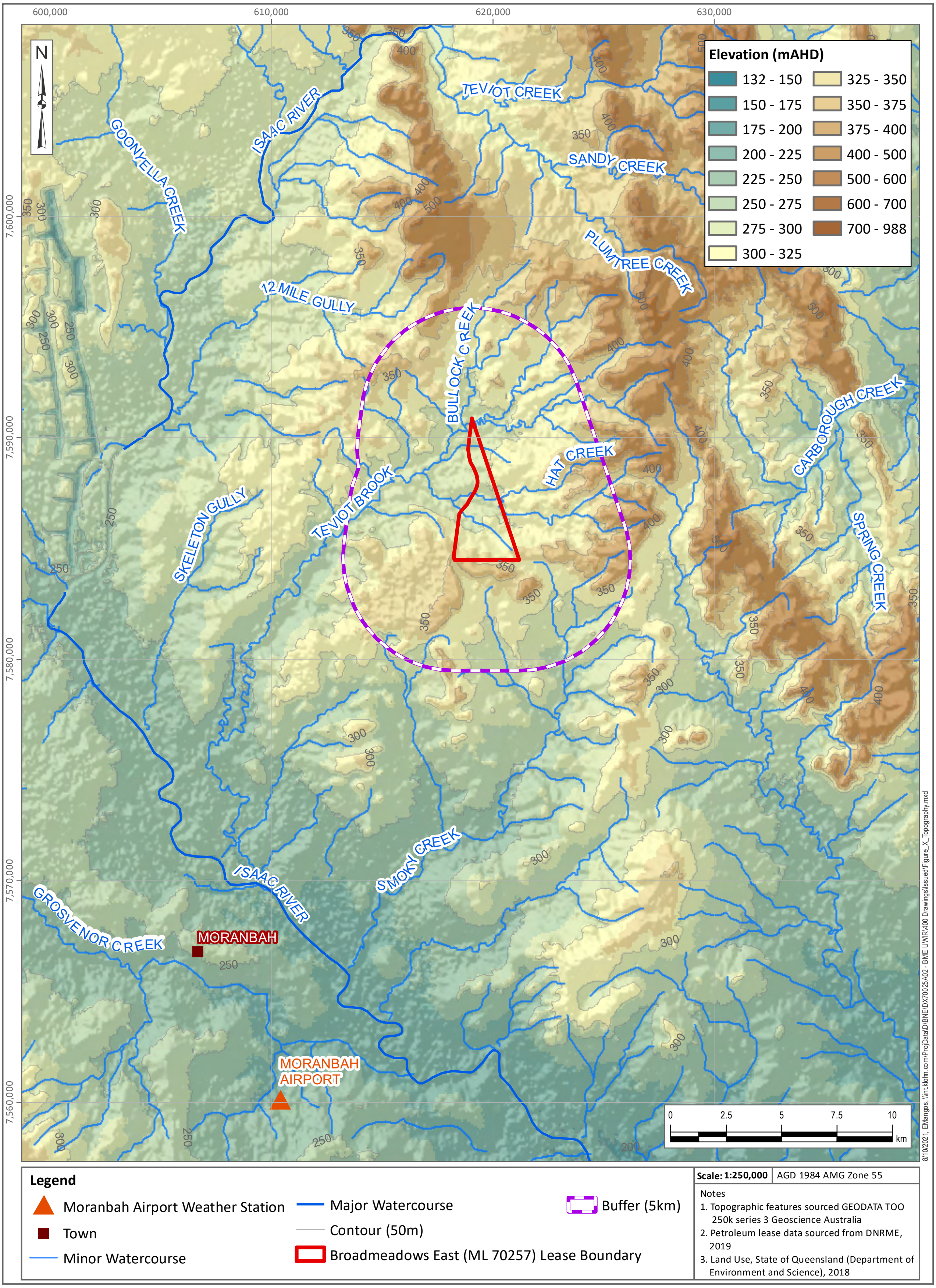

Figure 3.2 Project Area Topography and Associated Water Courses

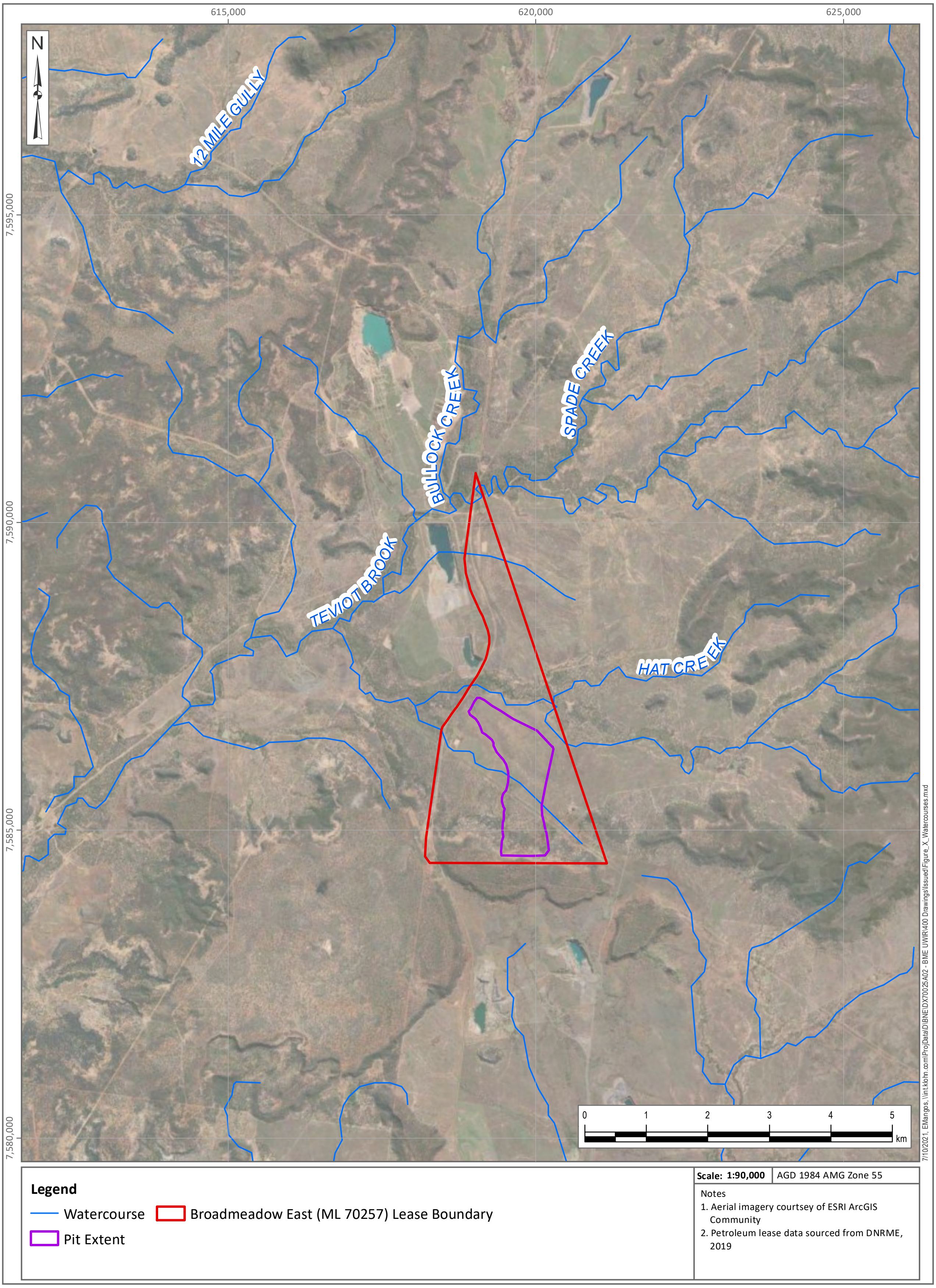

Figure 3.3 Project Area and Associated Watercourses

3.3 Climate

The climate of the Project area is sub-tropical continental, characterised by high variability in rainfall, temperature and evaporation, typical of the Central Queensland region, based on the modified Köppen classification system (BoM 2005). Evaporation rates are generally high and exceed rainfall throughout the year. Mean minimum and maximum monthly temperatures range from 8°C in July to 34°C in December, respectively.

Climate data (daily rainfall) has been obtained from the BoM database for the Moranbah Airport (Station 34035), located approximately 28 km to the south-southeast of the Project. Monitoring at this weather station has been undertaken since 2012. Summary monthly and annual statistics for rainfall is presented in Table 3.1. Rainfall occurrence is strongly seasonal, with ~64% of average annual rainfall occurring during the four-month period from December to March. Longer term synthetic rainfall data was also sourced from the Scientific Information for Landowners database (SILO). The rainfall data (1900 to current) is from a point location within the Project area (presented in Table 3.1).

The daily rainfall dataset for the Moranbah Airport weather station and the SILO data at the location of the Project site identifies that the long term average annual rainfall is 597.3 mm and 567.0 mm, respectively (Table 3.1).

Table 3.1 Climate Statistics – Moranbah Airport and SILO Data

Site	Moranbah Airport – Station 034035				SILO Data*
Statistic Element	Mean Monthly Maximum Temperature (°C)	Mean Monthly Minimum Temperature (°C)	Mean Daily Pan Evaporation (mm)	Mean Monthly Rainfall (mm)	Average Rainfall (mm)
Period of Record	2012 to 2021	2012 to 2021	2010 to 2021	2010 to 2021	1900 to current
January	33.58	21.37	6.95	109.99	106.77
February	32.86	21.40	6.22	104.19	98.99
March	31.30	20.27	5.18	100.74	68.69
April	29.10	16.84	4.56	24.94	30.21
May	26.09	12.62	3.70	26.43	25.98
June	23.46	9.82	3.05	16.13	28.10
July	23.86	8.82	3.30	25.24	20.52
August	25.90	9.12	4.45	20.39	17.60
September	29.16	12.88	5.83	11.53	12.18
October	31.65	16.05	6.85	22.73	27.64
November	33.35	18.69	7.60	43.92	50.50
December	34.02	20.54	7.49	91.07	82.91
Annual	**29.56**	**15.78**	**5.43**	**597.31**	**568.98**

*Data sourced from SILO (Coordinates: -21.95, 148.2).

The BoM rainfall data was analysed to produce a rainfall excess / deficit trend (Figure 3.4). Rainfall excess / deficit trends present a running deviation of long term actual rainfall against the average. This provides seasonal-scale identification of trends (wet / dry) and longer term (e.g., decadal) deviation from average conditions. These trends result in a natural tempering of peaks for rainfall events, and therefore support the correlation of rainfall events to aquifer responses.

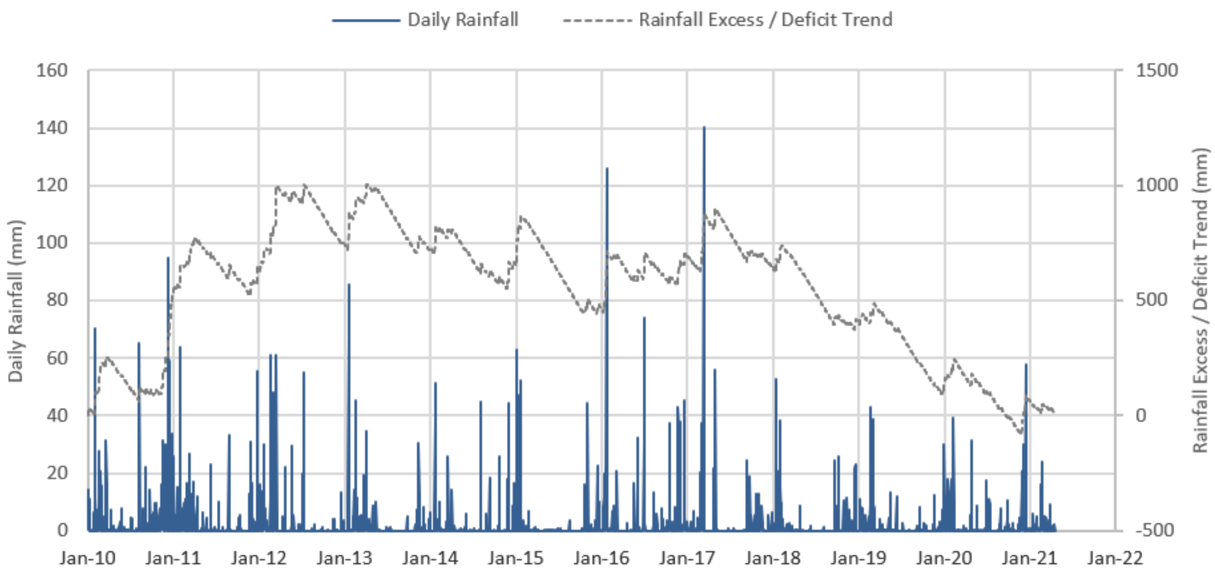

Figure 3.4 Daily Rainfall and Cumulative Rainfall Departure Trend (mm)

4 Assessment Methodology

4.1 Desktop Study

This section describes the UWIR methodology, including the desktop study of relevant groundwater bores, geological and environmental information, and groundwater monitoring data. It also provides an overview of the numerical groundwater modelling method. A detailed description of the numerical groundwater modelling method is provided in Appendix IV.

4.1.1 Database Searches for Groundwater Bores

A search of relevant Queensland databases was undertaken for the EAR groundwater study and updated for the UWIR. The purpose of this search was to:

- Identify the presence of current and historical ‘water bores’ and groundwater monitoring bores; and
- Collate drilling records and groundwater level, yield and quality data from relevant bores.

The database search area included the Project area and its surrounds within a radius of 5 km. The database search area was considered suitably representative of the geological and hydrogeological setting of the Project and includes the maximum extent of predicted groundwater level drawdown as a result of the proposed Project activities. A total of 43 registered bores were identified within the 5km search buffer, the location of these bores is presented in Figure 4.1 with further details provided in Appendix I.

The following databases and mapping were searched:

- The DRDMW Groundwater Database of registered water bore data from private water bores and Queensland Government groundwater investigation and monitoring bores. This database provided information on bore location, groundwater levels, bore construction details, stratigraphic logs, hydrogeological testing and groundwater quality.
- The Queensland Spatial Catalogue (QSpatial), via Queensland Globe. Records of registered petroleum and coal seam gas (CSG) exploration, production and monitoring wells are contained within this database.

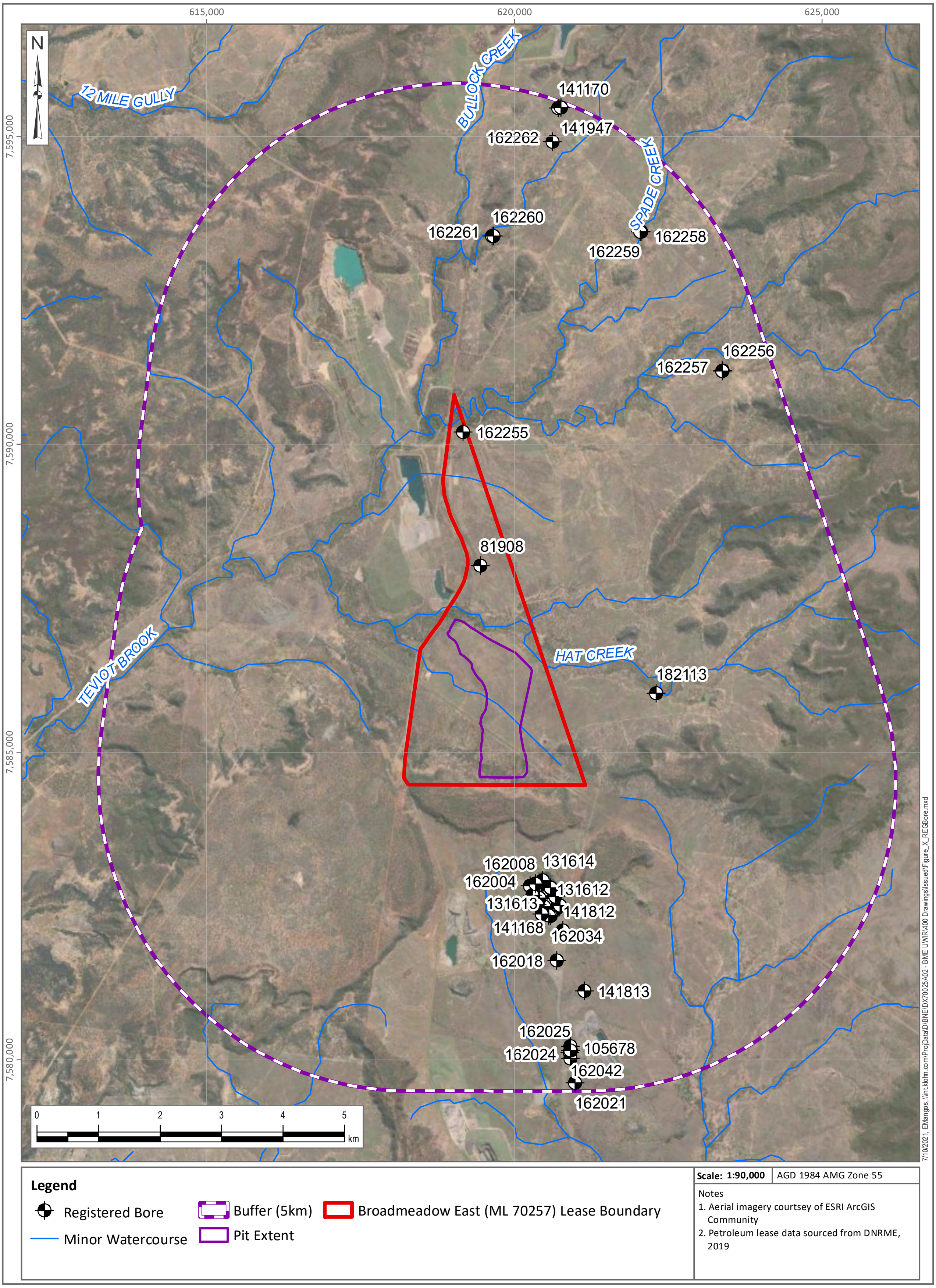

Figure 4.1 Registered Public Domain Bores within 5km of Project area

4.1.2 Database Searched for Sensitive Environmental Features

The groundwater impact assessment (KCB 2021), along with the EAR provides a detailed assessment of the potential for Groundwater Dependent Ecosystems (GDEs) to be present within the Project area and its surrounds. The GDE assessment involved identifying potential GDEs within the Project area from a search of the Queensland Springs Database and a search of the BoM's GDE Atlas.

GDE mapping provided in Queensland Globe (DNRME 2021) collates information from a number of sources into a central database, including published research and interpreted remote sensing data. These areas mapped in the GDE Atlas represent potential GDEs that access groundwater to meet all or some of its water requirements. This includes terrestrial vegetation, subsurface fauna communities and some vegetation which is associated with a surface water body. Although confidence levels are placed on the mapped extents of the GDEs, ground-truthing of the mapped areas is required to confirm presence of the GDEs.

Figure 4.2 presents the mapped areas within the vicinity of the Project that have potential for GDEs to be present. Based on the GDE mapping, "Moderate" and "High" potential GDEs are predominantly located adjacent to Hat Creek and vegetation located in the southwest corner of the Project area. These mapped areas of GDEs have been used as planning constraints for the mine plan, and as a result, the mine plan has been developed to avoid these mapped areas.

Field verification surveys, completed as part of the Ecological Assessment for broader environmental assessment documentation for BME (KCB 2021) confirmed the presence of several vegetation communities located within these mapped GDE areas. Areas of moderate GDE potential consisted entirely of RE 11.3.25 which was dominated by *Eucalyptus tereticornis* (Blue Gum). The communities associated with this vegetation species are restricted to the riparian corridors along Hat and Spade Creeks.

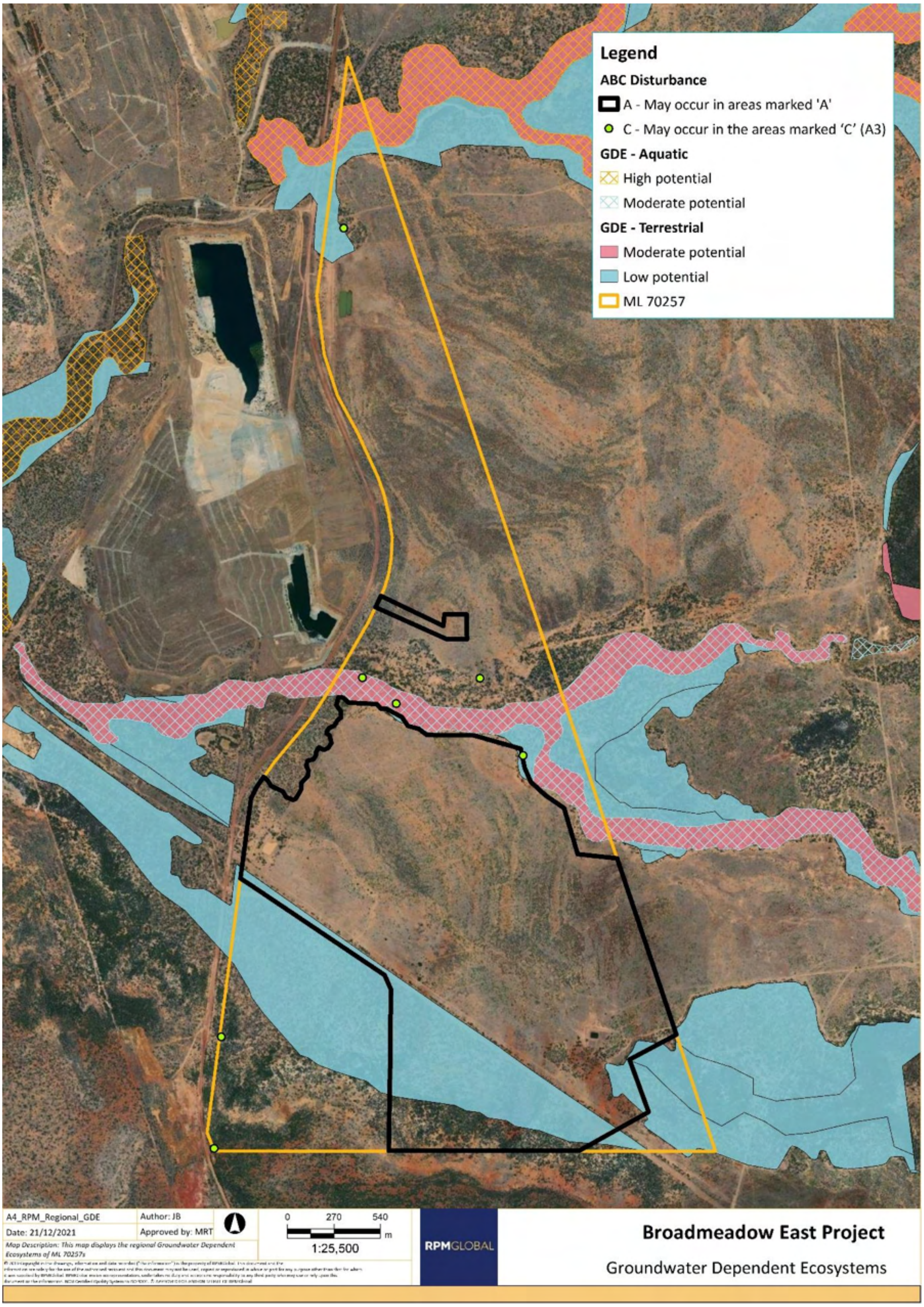

Figure 4.2 Desktop Review of Potential Terrestrial and Aquatic GDEs (from RPMGlobal)

4.1.3 Previous Groundwater Studies

A review of relevant groundwater studies was undertaken for the groundwater impact assessment (KCB 2021) to collect local and regional hydrogeological data. This was undertaken to support the development and validation of the hydrogeological setting of the Project area (described in Section 5). The review included the following groundwater studies undertaken within the vicinity of the Project area and within comparable geological and environmental settings:

- JBT Consulting (JBT Consulting 2016) prepared a groundwater review of groundwater data up to 2016 (when the review was completed). The review proposed an amended groundwater monitoring program for submission to the Department of Environment and Heritage Protection (DEHP – now, DES), with an intent to update the groundwater conditions associated with the applicable EA.
- JBT Consulting (JBT Consulting 2018) prepared a groundwater monitoring review, assessing monitoring bore requirements for the Burton Coal Mine closure operation.
- KCB prepared the Moranbah North Extension Project – Groundwater Report (KCB 2018) to support an *EPBC Act* (Commonwealth of Australia 2018) referral for the project.
- Xenith prepared a(Xenith 2020) coal resource estimate report of the Broadmeadow East Project (Xenith 2020).

A dedicated hydrogeological field investigation program was completed as part of the groundwater impact assessment. This comprised two field campaigns and was undertaken by KCB between January 26, 2021, and April 30, 2021. The purpose of this field investigation program was to update the current groundwater monitoring network and to characterise the hydrogeological conditions within the Project area. The field investigation program involved:

- Drilling and constructing a groundwater monitoring network comprising of eight groundwater monitoring bores;
- Measuring depth of groundwater strike and airlift yields in each groundwater monitoring bore during drilling to assess the water bearing strata and associated potential yield during drilling;
- Measuring static groundwater levels following bore completion and development;
- Installation of automated groundwater level loggers in each monitoring bore following bore completion and development;
- Permeability testing in groundwater monitoring bores where sufficient groundwater was present to measure the hydraulic conductivity of the screened hydrostratigraphic unit in each monitoring bore; and
- Field monitoring of three groundwater samples from Rewan Group and Rangal Coal Measures bores to establish baseline groundwater quality for relevant hydrostratigraphic units.

A copy of the site investigation report and further detail of the field investigation may be found in the groundwater impact assessment report (KCB 2021).

4.2 Data Collation and Analysis

Information compiled as part of the review of relevant data sets and previously completed assessments (Section 4.1.3) was analysed in detail to develop a conceptual understanding of the hydrogeological system and identify data gaps that required addressing as part of the site investigation program.

The collated local groundwater datasets that were then used to develop the conceptual hydrogeological understanding include:

- Geological data collected from the proponent's geology database of over 750 exploration drill holes within the Project mining area and surrounds, and lithological logs from 43 Department of Regional Development, Manufacturing and Water (DRDMW) registered bores (Section 5.7).
- Groundwater level data collected from eight bores screening the Rewan Group and Rangal Coal Measures within the Project area and it's surrounds. This includes manual and automated logger groundwater level data from the BME groundwater monitoring bores and surrounding mine monitoring bores. Four Monitoring bores were installed as part of the EAR groundwater impact assessment field investigation to monitor the shallower hydrostratigraphy (i.e. alluvium, Tertiary sediments, Tertiary basalt). Groundwater has not been observed in these bores since installation.
- Hydraulic testing results collected from three rising / falling head tests conducted on three BME groundwater monitoring bores; one screened within the Rewan Group and two screened within the Rangal Coal Measures. Testing was limited to the deeper hydrostratigraphy as limited groundwater was encountered in the shallower units.
- Groundwater quality data collected from 12 bores, including detailed field measurements and laboratory results for key hydrostratigraphic units within and surrounding the Project area.

4.2.1 Groundwater Levels and Flow

Spatially distributed groundwater level data were used to characterise groundwater flow directions, gradients and velocities. In addition, time variant groundwater level fluctuations were used to interpret the rate and distribution of recharge/discharge, influences from surrounding mining activities (e.g. residual pit voids) and pre-development variability in groundwater levels. Groundwater levels were recorded from an established groundwater monitoring bore network at the Project site, which is summarised in Table 4.1 and Table 4.2. The locations of these bores are provided in Figure 4.3.

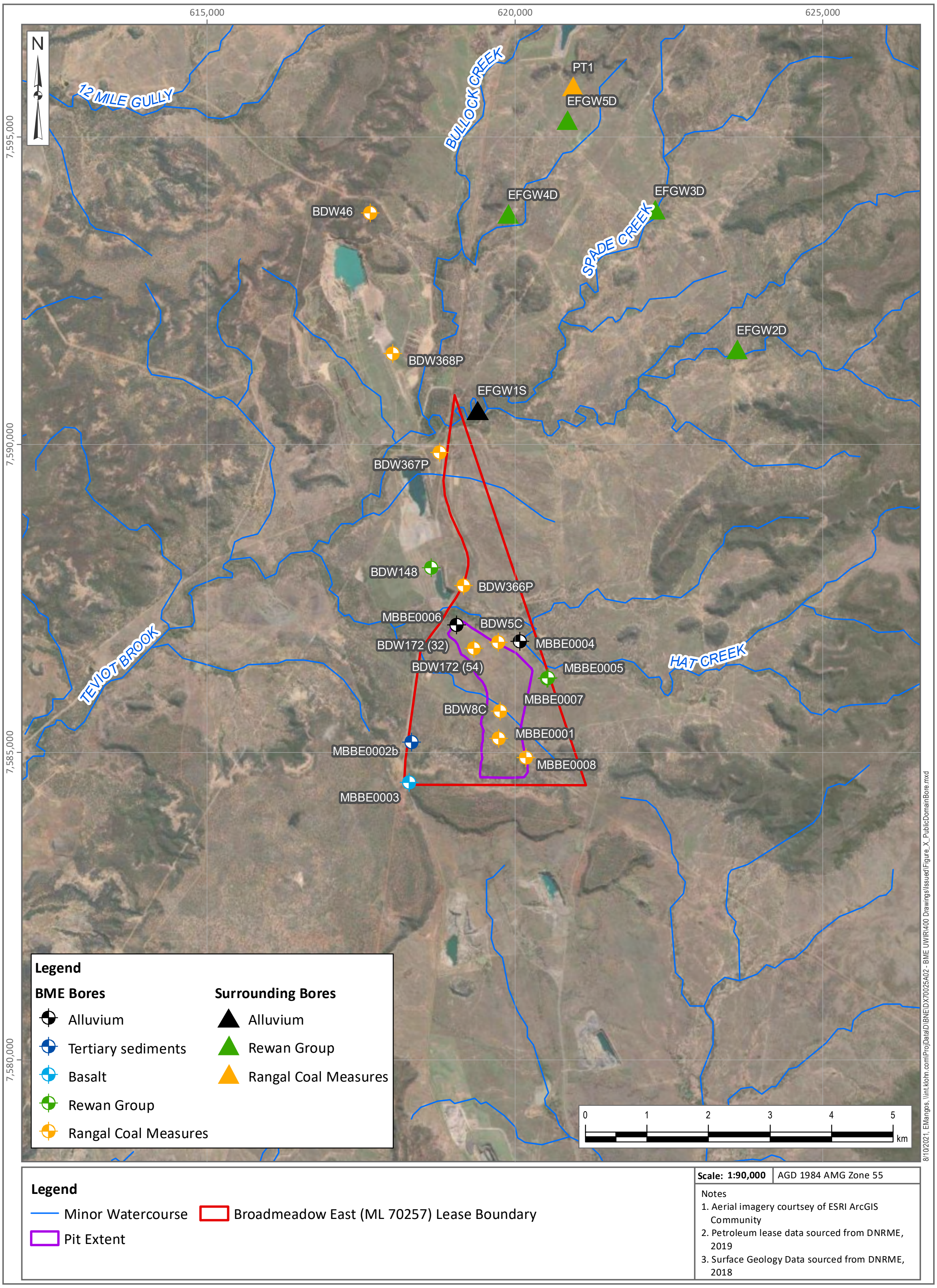

Figure 4.3 Regional Groundwater Monitoring Bore Network

Table 4.1 Summary of Regional Groundwater Monitoring Bore Network

Bore ID	Easting	Northing	Surface RL	Depth (m)	Stratigraphy
	(AMG84, Zone 55)		(mAHD)		
BDW172 (32)	619333	7586689	296	32	Rewan Group
BDW172 (54)	619333	7586689	296	54	Rangal Coal Measures
BDW366P	619163	7587710	292	94	Rangal Coal Measures
BDW5C	619731	7586791	296	99	Rangal Coal Measures
BDW8C	619762	7585670	304	79	Rangal Coal Measures
BDW148	618642	7587996	265	54	Rewan Group
BDW367P	618778	7589869	291	186	Rangal Coal Measures
BDW368P	618017	7591478	300	132	Rangal Coal Measures
BDW46	617650	7593762	348	251	Rangal Coal Measures
MBBE0001	619739	7585223	305	68	Rangal Coal Measures
MBBE0002b	618324	7585162	326	60	Tertiary sediments
MBBE0003	618281	7584512	347	20	Basalt
MBBE0004	620081	7586800	291	6	Alluvium
MBBE0005	620519	7586202	298	12	Rewan Group
MBBE0006	619056	7587072	284	6	Alluvium
MBBE0007	620535	7586212	298	52	Rewan Group
MBBE0008	620181	7584916	305	135	Rangal Coal Measures

Additional monitoring bores, with compiled groundwater monitoring records, located within the vicinity of the Ironbark No. 1 Coal Mine have also been identified and incorporated into this study to support the hydrogeological characterisation and numerical groundwater modelling. A summary of these surrounding groundwater monitoring bores is provided in Table 4.2, while their locations are provided in Figure 4.3.

Table 4.2 Summary of Surrounding Groundwater Monitoring Bores

Bore ID	Easting	Northing	Surface RL	Depth (m)	Stratigraphy
	(AMG84, Zone 55)		(mAHD)		
EFGW1S	619392	7590558	282.76	11.7	Alluvium
EFGW2D	623609	7591549	308.31	25.6	Rewan Group
EFGW3D	622271	7593815	306.19	30.4	Rewan Group
EFGW4D	619888	7593747	299.80	40.5	Rewan Group
EFGW5D	620848	7595275	320.34	59.1	Rewan Group
PT1	620938	7595822	329.36	138.0	Rangal Coal Measures

Groundwater level hydrographs from monitoring bores installed across the Project area and screened across the various hydrostratigraphic units are presented in Appendix III. These hydrographs were used to undertake the numerical model calibration (Section4.3).

4.2.2 Groundwater Quality

Groundwater quality data provides useful information on the hydrogeological regime, as it is influenced by interaction with the aquifer matrix, and groundwater recharge/discharge processes. Groundwater quality samples have been collected from the regional and surrounding monitoring bore network (Table 4.1 and Table 4.2), with a total of 183 samples collected between the years 2006 and 2021. A summary of the groundwater quality database is presented in Appendix II.

Salinity is a key constraint to the usability of groundwater resources for productive applications such as potable supply, irrigation, stock watering and industrial applications. If groundwater with elevated salinity levels is used for incompatible purposes or applications it may result in impacts to agricultural productivity, health and the environment.

A categorisation scheme for salinity proposed by (FAO 2013) is presented in Table 4.3. These results are compiled from laboratory analysis of groundwater samples collected from the current and historical BME groundwater monitoring bores. The dataset collected from these bores represents the most relevant and comprehensive, long term record of groundwater quality within the vicinity of the Project.

The majority of shallow monitoring bores across the Project area are dry.

Table 4.3 Salinity Classification Scale

Salinity	Range (TDS mg/L)	Groundwater Salinity in Monitoring Bores (Average TDS (mg/L))
Fresh	< 500	Nil
Brackish	500 – 1,500	MBBE0001 – 846
Moderately Saline	1,500 – 7,000	BDW368P – 5,290 (off lease)
		BDW8C – 2,153
		MBBE0002b – 5,200
		MBBE0008 – 1,520
Saline	7,000 – 15,000	BDW5C – 11,213
Highly Saline	15,000 – 35,000	BDW366P – 20,724 (off lease)
		BDW148 – 19,310 (off lease)
Brine	>35,000	MBBE0007 – 48,200

The proportional distribution of major ionic data for the Project and surrounding monitoring bores are summarised in a Piper and Durov plot presented in Figure 4.4. These have been created based on the groundwater quality database presented in Appendix II.

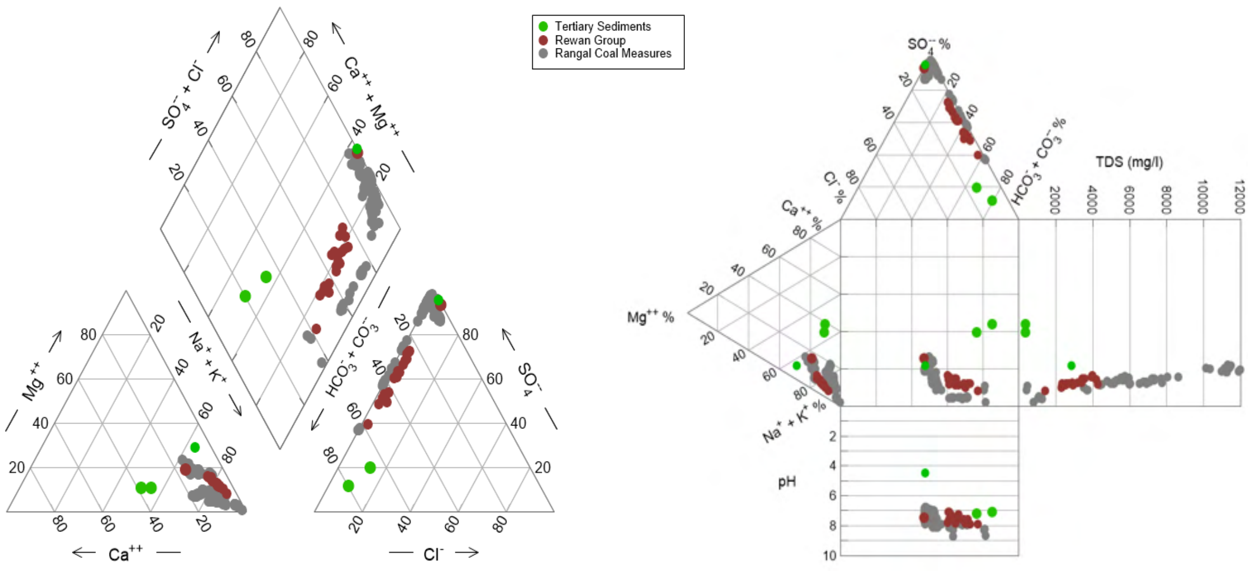

Figure 4.4 Piper and Durov Plots for Groundwater Samples Collected across the Project Area

4.3 Numerical Groundwater Modelling

A 3D numerical groundwater flow model was developed by KCB to predict the extents of depressurisation and the associated impacts on the groundwater regime and the surrounding environment. The groundwater model for the project was developed using MODFLOW software. MODFLOW is the most widely used groundwater modelling software in Australia and is considered to be the industry standard. A detailed description of the groundwater model is provided in Appendix IV.

The model represents the key hydrostratigraphic units using six layers and extends ~24 km north-south and ~21 km east-west. The Project area was located in the centre of the model domain.

The physical structure of the groundwater model was based on the detailed geological model developed by CCO, and data sets sourced from the public domain. Model development was supplemented by published geological maps, digital geological surfaces, DRDMW groundwater database, and information from surrounding mining operations and published approval documents.

The model was calibrated to existing groundwater levels using the Australian Groundwater Modelling Guidelines (Barnett et al. 2012) to frame the calibration process. A detailed description of the calibration method is provided in Appendix IV. The calibrated groundwater model was used to predict groundwater inflows, changes in groundwater levels and the associated groundwater level drawdown extent in response to the Project development over the duration of this UWIR (three years) and the overall Project development.

The sensitivity of the model predictions to the input parameters were tested and involved varying key model parameters in isolation and assessing the influence the change made on predictions of drawdown and mine inflow. Key model parameters were selected based on their potential to most influence model predictions. Sensitivity analysis included testing of the following parameters, which covered the range of likely uncertainty in key parameters:

- Horizontal hydraulic conductivity, vertical hydraulic conductivity, specific yield and specific storage of all geological units; and
- The rainfall recharge rate across the model domain.

The changes used to test the model sensitivity include extremes in the potential parameter ranges and encompass the full range of relevant measured values for these parameters. Full details of the results of the sensitivity analysis are discussed in Appendix IV. Overall, the results of the sensitivity analysis confirmed that the sensitivity of the model calibration and predictions to changes in model input parameters was in all instances acceptable and the model is fit for purpose.

The groundwater model has specifically been used to predict groundwater take and resulting groundwater depressurisation; with these predictions used to identify the Immediately Affected Areas (IAA) and Long Term Affected Areas (LTAA) for the UWIR. These predictions have also been used to assess the impacts of the project on groundwater users and the sensitive environmental features.

5 CONCEPTUAL HYDROGEOLOGICAL SYSTEM

5.1 Regional Geology

The Bowen Basin is the northernmost part of the 1,800 km long Bowen-Gunnedah-Sydney Basin in the eastern Queensland and New South Wales. The Project is in the western part of the central Bowen Basin. The basin comprises an accumulation of Permian and Triassic sediments. The economic coal seams in the Bowen Basin lie within the Permian Blackwater and Back Creek Groups. The Moranbah Coal Measures are within the Back Creek Group, while the Fort Cooper and Rangal Coal Measures exist within the Blackwater Group. All are late Permian coal-bearing sequences which were deposited in terrestrial (Blackwater Group) and marine environments (Back Creek Group). This Permian coal strata are overlain by the Triassic Rewan and Clematis Groups. The economic coal seam deposits specific to the Project target area occur within the Rangal Coal Measures.

The Bowen Basin is divided into broad morphotectonic zones that indicate maximum sediment accumulation and adjacent shelf areas. The subdivision of these areas is often bounded by major faults. The Project area occurs within a structurally complex zone on the eastern side of the Collinsville Shelf, which was formed in the early Permian. The structure of the Bowen Basin sequence is characterised compressional tectonics with a direction of transport to the west and southwest of the basin. A mid-Triassic thrust fault to the west of the Project area has upthrown and subsequently eroded the overlying Triassic strata to expose the Rangal Coal Measures.

The surface geology and bedrock geology within the vicinity of the Project area are provided in Figure 5.1 and Figure 5.2; while a summary of the stratigraphy is provided in Table 5.1.

In the vicinity of the Project, Quaternary alluvium is present across the entire Hat Creek extent within the Project area. The alluvium comprises sands, silts and clays associated with stream channels and flood deposits. Within the Project area the alluvium ranges in thickness from 3 m to 4 m.

Tertiary sediments are also present to the south of Hat creek which typically consists of semi-consolidated quartz sandstone, clayey sandstone, mudstone and conglomerate and fluvial lacustrine sediments. The Suttor Formation, mapped as *Tu*, has been extensively weathered and reworked during the Tertiary and Quaternary, resulting in an upper profile that includes Tertiary and Quaternary colluvial sheetwash deposits and residual soils (regolith) that comprise clay, silt, sand, gravel and soil. Tertiary and Quaternary Colluvium and regolith are mapped within the Project area and exhibit similar properties to each other and are considered comparable due to the predominance of clays. These sediments are also lithologically comparable to the underlying parent rock of the Suttor Formation.

Tertiary basalt has been mapped to the south of the Project area and comprises a heterogeneous profile of vesicular and massive basaltic lavas with minor tuff and ash. While not confirmed within the Project area to date, previous investigations at surrounding site have indicated that a Tertiary sand is present beneath the basalt paleochannel (KCB 2020). Where present, this unit is often referred to as basal sand.

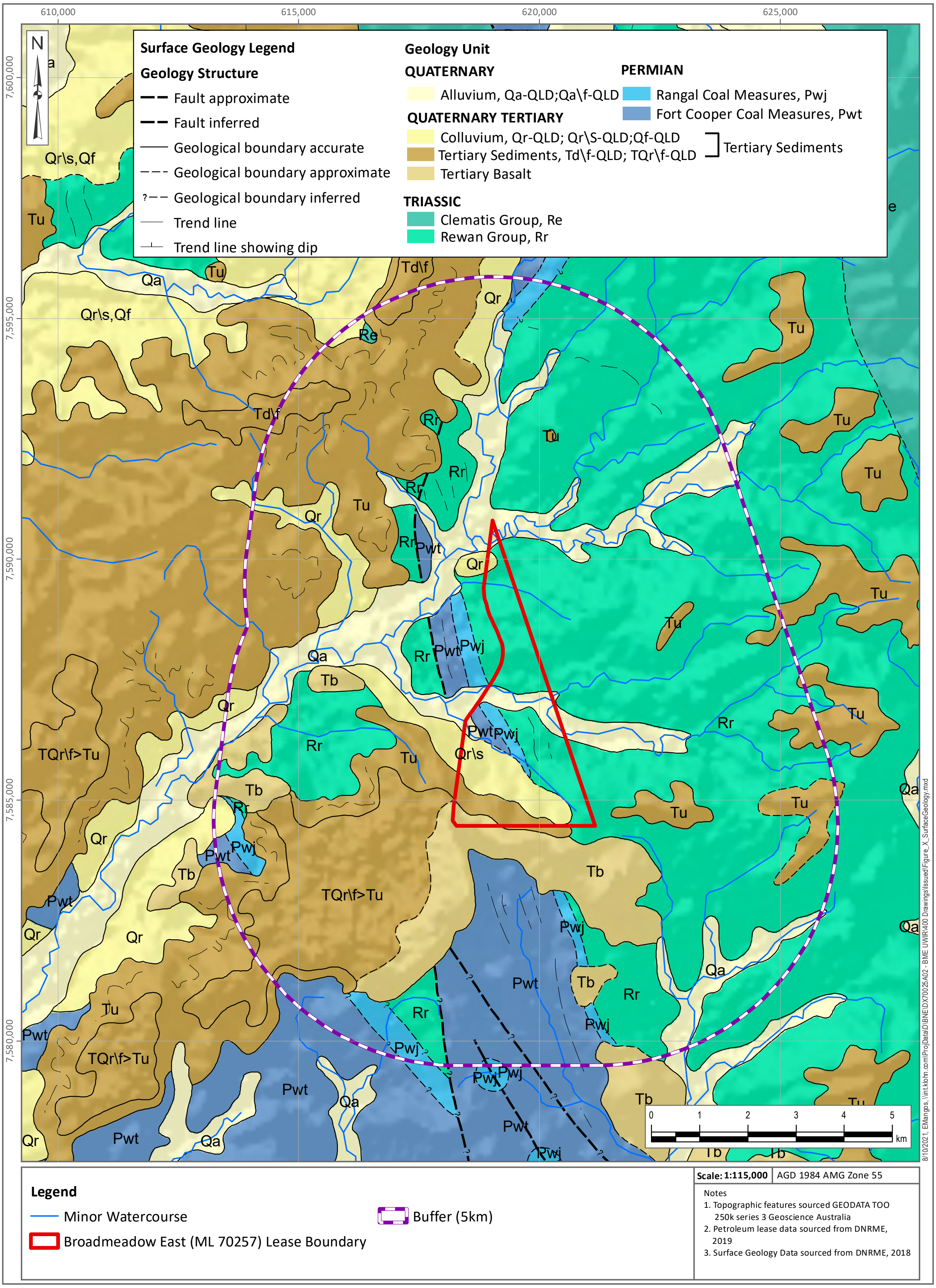

Figure 5.1 Surface Geology in the Vicinity of the Project Area

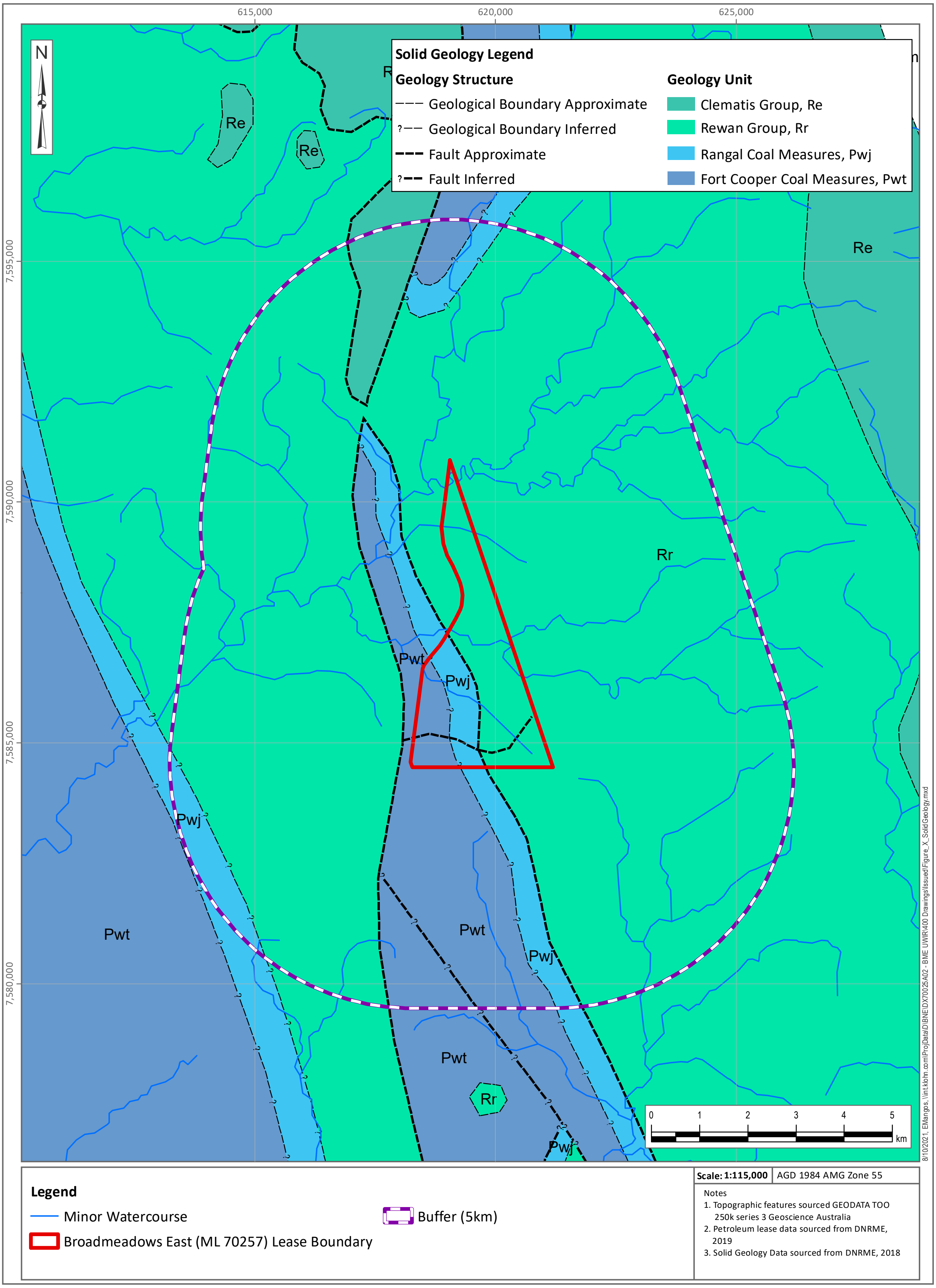

Figure 5.2 Bedrock Geology in the Vicinity of the Project Area

Table 5.1 Summary of Stratigraphy at the BME Project

Age	Group	Unit	Lithology
Quaternary	-	Recent alluvium	Soil, clay, silt, sand, gravel
Tertiary	-	Sediments (Suttor Formation and Duaringa Formation)	Sandstone, mudstone, conglomerate, siltstone
	-	Basalt	Olivine basalt of Clermont Springsure Basalt Province
Triassic	Clematis Group		Sandstone, siltstone, mudstone and granule to pebble conglomerate
	Rewan Group		Red and green mudstone, green lithic sandstone, occasional pebble conglomerate
Upper Permian	Blackwater Group	Rangal Coal Measures	Carbonaceous mudstone, siltstone, sandstone. Coal seams: ▪ Burton Seam (splitting to the Leichhardt and Vermont Seam) ▪ Girrah Seam
		Fair Hill Formation	Sandstone and mudstone with interbedded coal, tuffaceous claystone
		Fort Cooper Coal Measures	Coal seams, carbonaceous shale, mudstone, sandstone, siltstone, conglomerate

There are two Triassic units identified within the vicinity of the Project area; the Clematis Group and the Rewan Group. Outcrop of the Clematis Group is observed to the northeast of the Project area and is not encountered within the Project area. The Rewan Group is present across the Project area and represents a prominent lithological unit that separates the underlying Permian coal measures from the overlying shallow Cenozoic stratigraphy.

The Permian Rangal Coal Measures comprises the target coal seams for this Project. This unit outcrops and sub-crops within the Project area, which is overlain by the Rewan Group and underlain by the Fort Cooper Coal Measures. Target coal seams include the Leichhardt, Vermont and Girrah Seams, which are separated by interbeds of carbonaceous mudstone, siltstone and sandstone.

5.2 Local Hydrostratigraphy

The local hydrostratigraphic units in the vicinity of the Project area are based on the geological units summarised in Table 5.1 and presented in Figure 5.1 and Figure 5.2. Details for each of the hydrostratigraphic units are provided in the following section, while a conceptual hydrogeological cross-section through the Project area is presented in Figure 5.3.

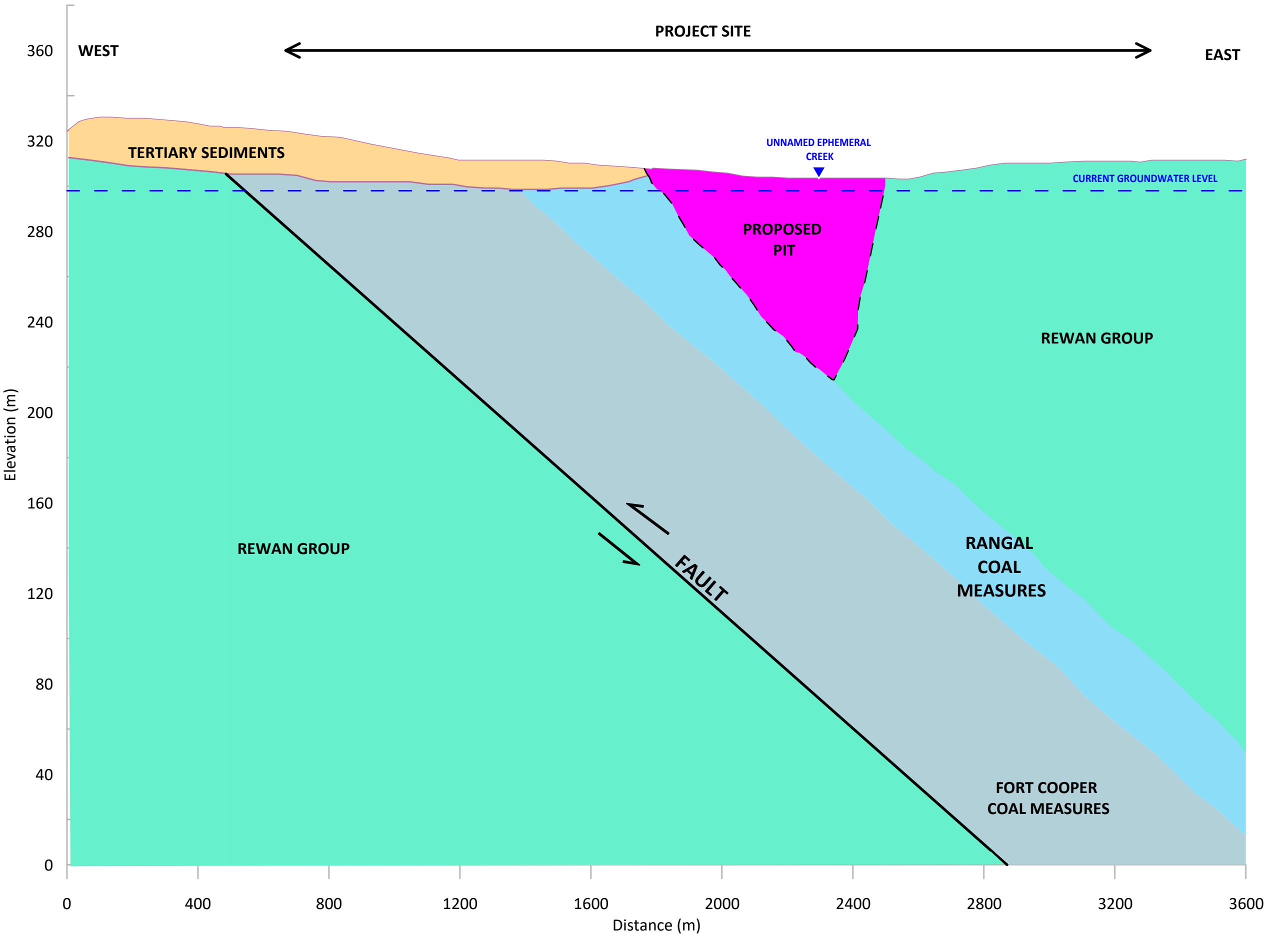

Figure 5.3 Conceptual Hydrogeological Cross-Section

5.2.1 Quaternary Alluvium

The alluvial deposits associated with the Isaac River, located approximately 15 km to the west of the Project area, comprises the largest accumulation of Quaternary alluvium within the vicinity of the Project area. This alluvium comprises sequences of gravel, sand, silt and clay (Xenith, 2020). Spade Creek and Hat Creek, which flow through the north and central portions of the Project area, respectively, are tributaries of the Isaac River and have been mapped to have alluvium associated with the watercourses (Figure 5.1).

Within the vicinity of the Project area, the distribution of alluvium is limited to the watercourse and associated floodplains of Spade Creek and Hat Creek (Figure 5.1). Previous hydrogeological investigations (KCB 2018) located downstream, and to the west of the Project area, identify that the regional groundwater table is typically located several metres below the base of the alluvium (associated with Teviot Brook). This significant separating depth identifies that the alluvium is typically dry and unsaturated. Drilling and bore installations completed as part of the field investigations (Appendix I) have also confirmed that the alluvium associated with Hat and Spade Creek within the vicinity of the Project area are also dry.

The thickness of the alluvium within the Project area has been confirmed to range from 3 m to 4 m. The alluvium thickness in the vicinity of the Project area is presented in Figure 5.4.

5.2.2 Tertiary Sediments

The Tertiary sediments comprise a heterogeneous profile of semi-consolidated quartz sandstone, clayey sandstone, mudstone and conglomerate, fluvial lacustrine sediments, and minor interbedded basalt.

The Suttor Formation has been extensively weathered and reworked during the Tertiary and Quaternary, resulting in an upper profile that includes Tertiary and Quaternary colluvial sheetwash deposits and residual soils (regolith) that comprise clay, silt, sand, gravel and soil. The colluvium and regolith exhibit similar properties to each other and are considered comparable due to the predominance of clays. These sediments are also lithologically comparable to the underlying parent rock of the Suttor Formation.

These sediments are predominantly located to the south of the Project area, and sporadically within a 5 km buffer of the Project area (Figure 5.1). Where present they form a thin veneer, of up to 15 m thick, overlying the Rewan Group and Permian Coal Measures (Figure 5.5).

The Tertiary sediments do not store significant groundwater due to their generally limited thickness (<15 m) and are not considered a significant aquifer. As with the alluvium, the Tertiary sediments are typically located above the regional groundwater table and are therefore generally unsaturated. In the vicinity of the Project area, groundwater in the Tertiary sediments is observed to the west of the proposed pit area.

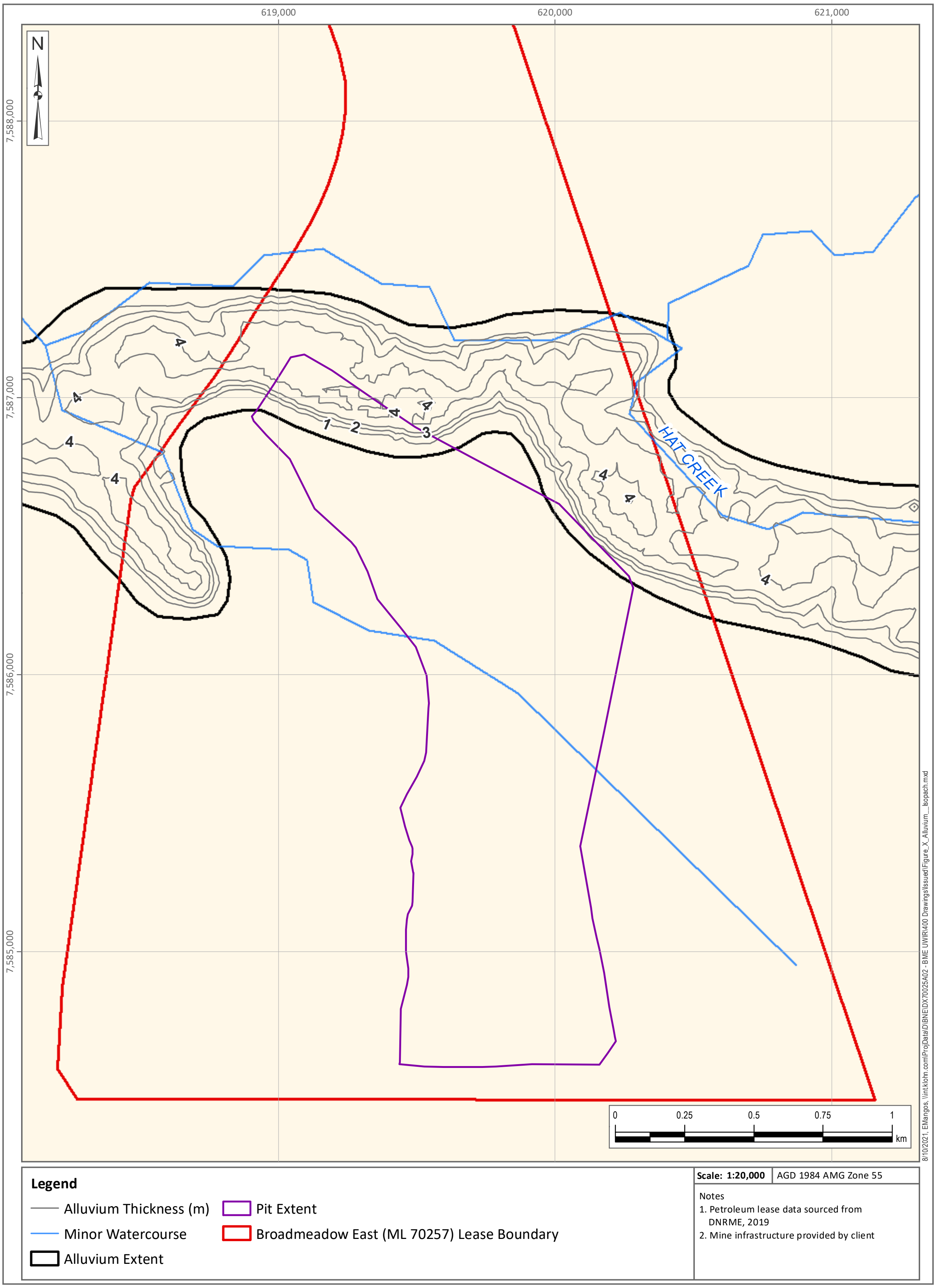

Figure 5.4 Alluvium Thickness in the Vicinity of the Project Area

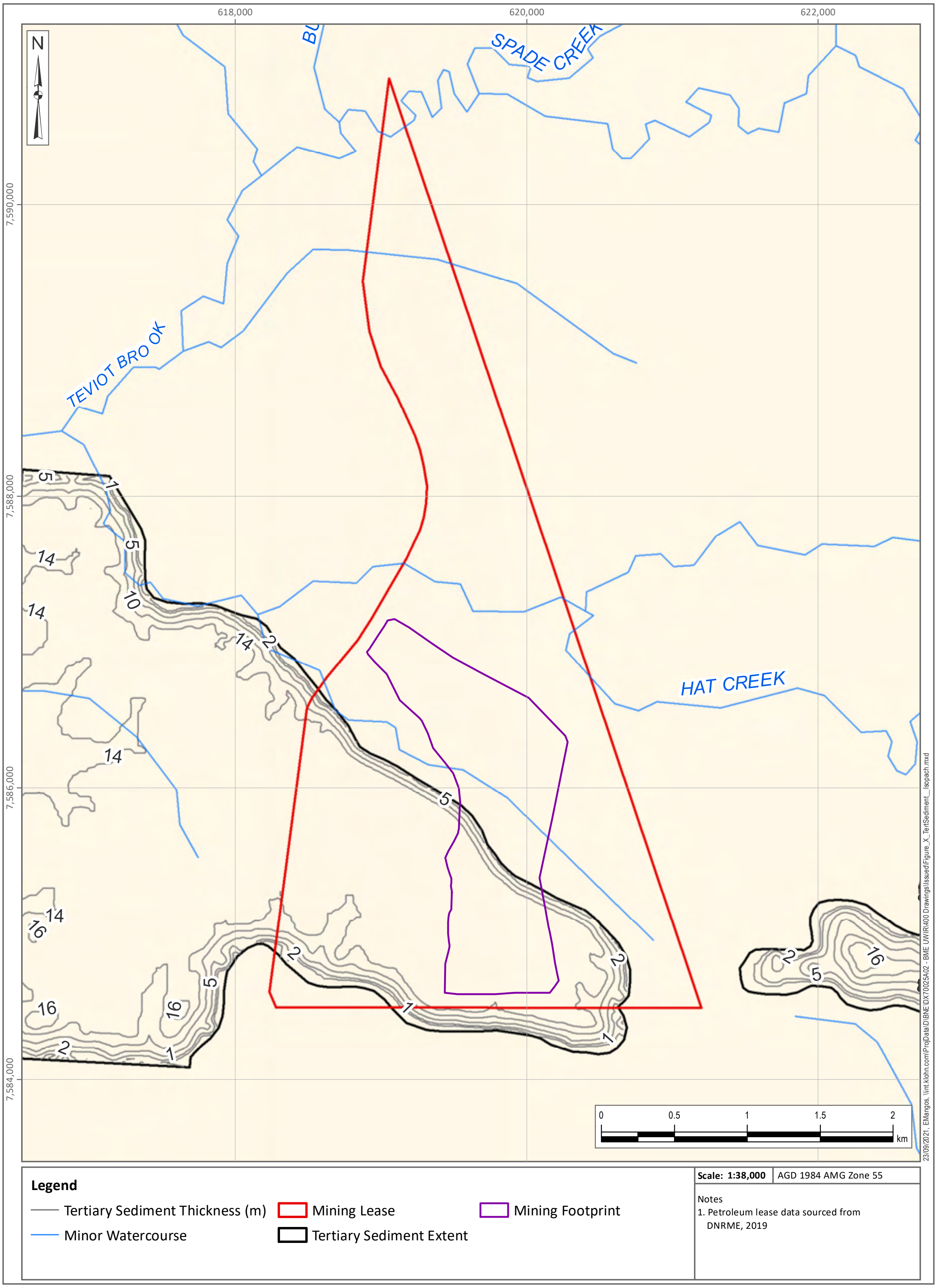

Figure 5.5 Tertiary Sediments Thickness in the Vicinity of the Project Area

5.2.3 Tertiary Basalt

Consistent with other occurrence of Tertiary basalt at projects surrounding the Project area, the Tertiary basalt underlies the Tertiary sediments and overlies the Rewan Group or Permian coal measures, typically occurring as a single composite unit comprising massive and vesicular lava, tuff and ash flows. The upper basalt profile is highly weathered and comprises a basaltic clay; and has been mapped to the south of the Project area.

The hydraulic properties of the basalt can vary considerably as groundwater is primarily stored within highly compartmentalised fractures and vesicular zones (KCB 2018). Massive zones without either of these properties will have a very low hydraulic conductivity. Furthermore, highly weathered basalt breaks down to clay with a very low hydraulic conductivity. Shallow highly weathered basalt, therefore, will generally not contain significant groundwater and can act as a barrier to flow. In contrast, localised vesicular and fractured zones can store and transmit larger volumes of groundwater. In the vicinity of the Project area, limited occurrence of groundwater is observed in the basalt as the majority of basalt in this area comprised weathered, low hydraulic conductivity basalt.

Tertiary basal sands, comprising medium to coarse grained unconsolidated sand, have been previously identified to be underlying the basalt at other locations across the Bowen Basin. These basal sands are not laterally extensive and are generally thin (<5 m thick). They form discrete lenses below the basalt, restricted to the palaeo-channels. The Tertiary basal sands are hydraulically connected to the overlying basalts and together form a single aquifer system. Basal sands were not encountered within the vicinity of the Project area, and are not anticipated to be present, as the basalt in the vicinity of the Project area is on the periphery of the palaeo-channel, away from the channel centre where the basal sands are likely to be present.

5.2.4 Triassic Rewan Group

The Rewan Group is a thinly interbedded sequence of siltstone, claystone and minor fine-grained sandstone that overlies the Permian coal measures. This unit outrops across the majority of the eastern portion of the Project area and sub-crops beneath the alluvium, Tertiary sediments and basalt where present.

The Rewan Group is uniformly saturated at depth and may become unsaturated where it outcrops or sub-crops above the regional groundwater table.

The Rewan Group is recognised as a regional aquitard and acts as a confining unit overlying the Permian sediments. This unit is characterised by low primary porosity and as a result, groundwater movement is controlled by local fracture sets. Where fractures are intersected, this unit shows slightly higher permeability, and conversely, where limited fractures are intersected this unit shows lower permeability associated with the primary porosity. Bulk permeability of this unit is therefore constrained by the degree of connection between localised fractures. This means that at the regional scale the representative average hydraulic conductivity is expected to be towards the lower end of the values measured by field testing.

5.2.5 Permian Coal Measures

The Permian coal measures include the Rangal Coal Measures and the Fort Cooper Coal Measures (Figure 5.1). They comprise alternating layers of fine to medium grained sandstone, siltstone and coal, including the target Leichhardt and Upper Vermont seams of the Rangal Coal Measures. Permian strata occur across the Project area as a regular layered sedimentary sequence dipping to the east, with outcrops of these units observed within the Project area and sub-cropping beneath the Rewan Group towards the east. The Permian strata also sub-crop beneath the alluvium, Tertiary sediments and basalt within the vicinity of the Project area.

The coal measures are bounded to the west by a north-south striking regional fault. Faulted strata can exhibit a range of hydraulic characteristics, and in extreme circumstances can act as either a barrier or a conduit to groundwater flow. In this setting, the faults are likely to restrict groundwater flow in the horizontal direction, compared to un-faulted areas. Further discussion on the fault hydraulic characteristics is provided in Section 5.2.6.

Individual coal seams form the principal water bearing strata within the coal measures and are therefore typically saturated throughout their full thickness but may become unsaturated where they outcrop or sub-crop above the regional groundwater table. Groundwater storage and movement occurs within the coal seam cleats and fissures and within open fractures that intersect the seams.

5.2.6 Structural Features

Geological mapping completed in the vicinity of the Project area have identified a north-south striking regional fault structure located to the west of the Project area. Movement along this fault plane has caused the uplift and associated erosion of the Permian coal measures to the east of the fault, resulting in the outcrop and sub-crop of the Permian strata. Similar north-south striking regional faults are present across the Bowen Basin, which display hydraulic characteristics that restrict groundwater flow in the horizontal direction. The reasons for which this fault is considered a barrier to groundwater flow are as follows:

- Fractures associated with the faults in the vicinity of the Project are typically sealed by mineralisation and precipitation.
- The high clay content of the Permian coal measures means that there is a significant likelihood of clay smearing across the fault plane that is likely to reduce the fault hydraulic conductivity by several orders of magnitude compared to the un-faulted areas.
- The coal seams are thin (up to ~3 m) and represent an extremely small proportion of the overall thickness of the Permo-Triassic sediments (i.e. less than 1%). There is therefore a greater than 99% probability that fault displacement has resulted in a coal seam being juxtaposed with less permeable Permian interburden or Rewan Group sediments on the other side of the fault.
- Previous mining experience in the Bowen Basin indicates that coal seams are typically highly compartmentalised by faulting.

The low permeability of the fault zones is therefore likely to restrict groundwater flow, compared to un-faulted areas (OGIA 2016).

5.3 Hydraulic Properties

The following bullets provide a summary of the hydraulic conductivity of the key hydrostratigraphic units across the Project area. These hydraulic conductivity estimates are based on hydraulic testing completed as part of the Site Investigation Program (Section 4.2) and referenced investigations completed on mining projects in the vicinity of the Project area.

- Alluvium – The hydraulic conductivity of the alluvium, based on referenced investigations completed in the vicinity of the Project area (KCB 2018) indicate that the hydraulic conductivity of the alluvium is highly variable, and is a function of the relative proportions of sand and fine clay and silt. Typically, the unconsolidated sediments of the smaller tributaries of the surface water catchment (e.g. Hat Creek, Spade Creek) comprise bed sands within the watercourse channel. This differs from larger watercourses (e.g. Isaac River) where alluvial terraces have formed on floodplains adjacent to the main watercourse channel. The alluvium associated with the bed sands have a higher hydraulic conductivity than the floodplain alluvium, however, these bed sands are localised to the smaller creek channels.

  The hydraulic conductivity of the bed sands ranges from 8.9 metres/day (m/d) to 45 m/d (KCB 2018).

- Tertiary sediments – The Tertiary sediments in the vicinity of the Project area is predominantly unsaturated, indicating that the regional groundwater level is below this unit. As a result, site specific testing of the hydraulic conductivity for this unit was unable to be undertaken. However, hydraulic testing has been completed on the Tertiary sediments unit at surrounding projects (KCB 2018). Results from the test work completed on surrounding projects indicate that the hydraulic conductivity for the Tertiary sediments ranges from 7×10^{-4} m/d to 1.22 m/d.

- Tertiary basalt – The Tertiary basalt is a key water bearing unit in the Bowen Basin, however, within the vicinity of the Project area there is limited occurrence of this unit. Tertiary basalt is present in the southern extent of the Project area, however, the encountered basalt in this area is relatively thin (~7 m), highly weathered and unsaturated (Appendix I). As a result, hydraulic testing of the encountered basalt was unable to be undertaken. Hydrogeological investigations completed at surrounding projects have undertaken hydraulic testing of the weathered Tertiary basalt (KCB 2018; 2020). Results of these test estimate the range of hydraulic conductivity to be 0.002 m/d to 2.6 m/d.

- Rewan Group – The measured hydraulic conductivity of the Rewan Group within the Project area is 2.4 m/d. In comparison, the tested Rewan Group units at surrounding projects indicate a hydraulic conductivity range from 1×10^{-3} m/d to 6.5 m/d (KCB 2018; 2020). In general, the Rewan Group is recognised as a regional aquitard and acts as a confining unit overlying the Permian coal measures; and is typically characterised by low primary porosity.

  The difference in the hydraulic conductivity of the Rewan Group at the Project area (2.4 m/d) and the general low hydraulic conductivity of the Rewan Group across the region is interpreted to be due to localised fracturing being intersected in the Rewan Group in the Project area. Where these fractures are intersected, this unit shows slightly higher hydraulic conductivity, and conversely, where limited fractures are intersected this unit shows lower hydraulic conductivity associated with the primary porosity. Bulk permeability of this unit is therefore constrained by the degree of connection between any localised fractures. This means that at the regional scale the representative average hydraulic conductivity is expected to be towards the lower end of the values measured.

- Rangal Coal Measures – The hydraulic conductivity of the Leichhardt seam estimated from hydraulic tests completed as part of the Site Investigations range from 0.19 m/d to 0.36 m/d. These values correlate with other hydraulic tests completed on the Leichhardt seam at surrounding projects (KCB 2020), with an estimated hydraulic conductivity ranging from 0.07 m/d to 2.3 m/d. Hydraulic testing have also been completed on the Rangal Coal Measures overburden/interburden between the coal, which have resulted in an estimated hydraulic conductivity of 1×10^{-5} m/d to 2 m/d.

5.4 Groundwater Levels, Flow, Recharge and Discharge

A summary of the groundwater levels, flow conditions and recharge/discharge mechanisms for each of the relevant hydrostratigraphic units across the Project area is provided in the following sections. The depth to the regional groundwater level, from below the ground surface is provided in Figure 5.6.

5.4.1 Quaternary Alluvium

Appendix II presents the groundwater level hydrographs for a monitoring bore (EFGW1S) within the vicinity of the Project area that is screened within the Quaternary alluvium. This bore is located to the north of the Project area and has been installed adjacent to Teviot Brook. Groundwater levels in this bore, over the period of monitoring, fluctuate by approximately 3 m, with higher water levels observed during the wet season and lower water levels observed during the dry season. In comparison to Hat Creek, the watercourse adjacent to the north of the proposed pit, Teviot Brook is a larger watercourse with a larger accumulation of alluvium and a higher potential for groundwater storage.

Two monitoring bores have been installed in the alluvium associated with Hat Creek (MBBE0004 and MBBE0006) and since installation (January 2021) groundwater has not been observed within the bores. It is anticipated that groundwater in the alluvium of Hat Creek is ephemeral and is associated with surface water flow within Hat Creek during and following rainfall events. Mechanisms for recharge to the alluvium include:

- Direct rainfall infiltration to the alluvium; and
- Seepage of surface water into the creek bed during seasonal flow events in the creek. Based on stream gauging from surrounding projects the surface water flow in the creek is anticipated to be limited to short duration events during and immediately following sustained seasonal rainfall. These flow events result in discrete, short duration recharge events through the alluvium that will dissipate to the surrounding groundwater regime and/or flow downstream within the alluvium.

Regionally, the piezometric surface and groundwater flows within in the alluvium is a compartmentalised reflection of surface topography. Within the Project area, groundwater flow in the alluvium is from east to west and follows the gradient and alignment of Hat Creek.

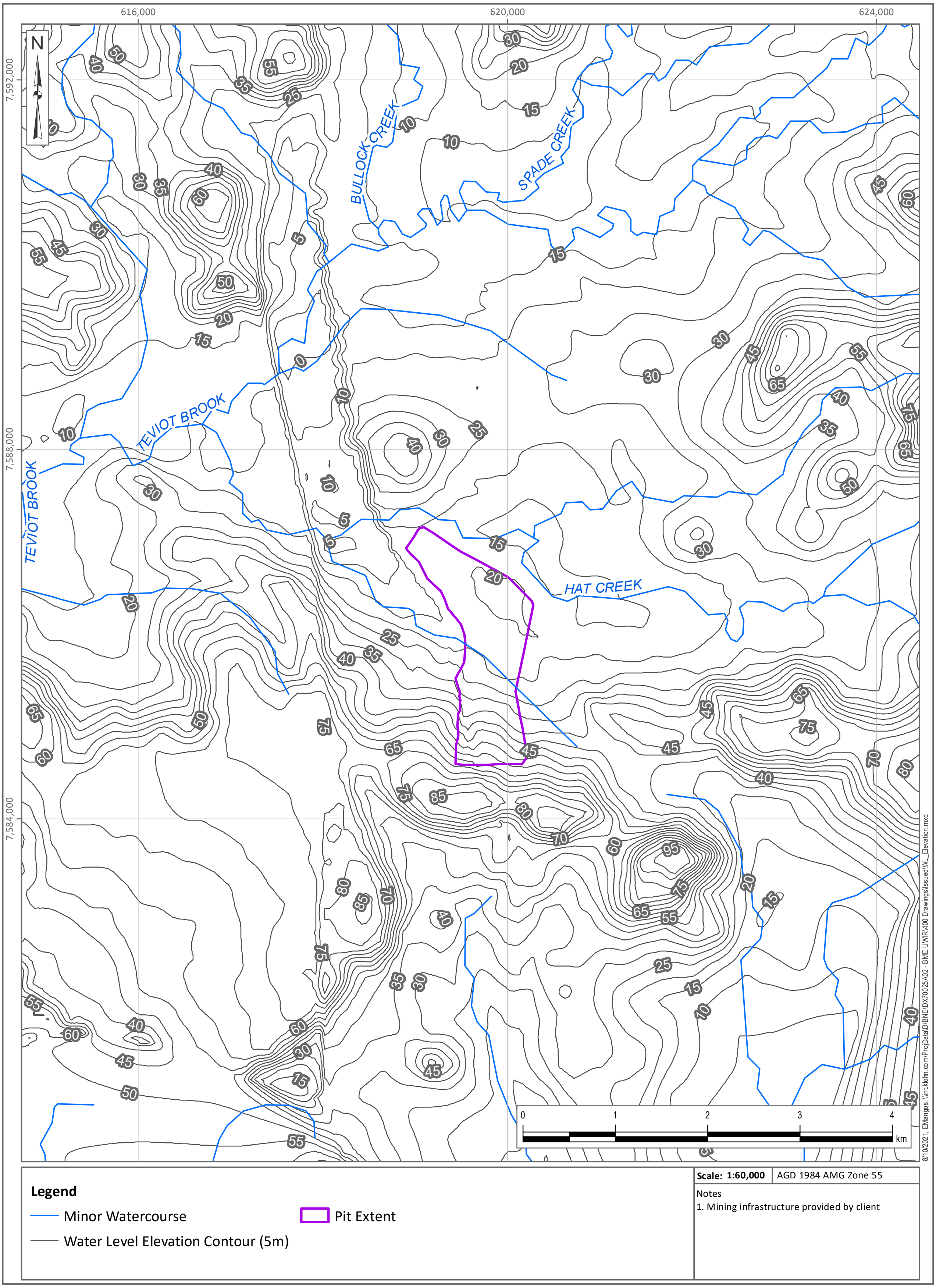

Figure 5.6 Depth to Regional Groundwater Level

5.4.2 Tertiary Sediments

The Tertiary sediments are recharged by direct infiltration from rainfall where these sediments are present at the surface. Short duration recharge also occurs via seepage from the alluvium (where present) for short periods following surface water flow events. However, due to the limited thickness of the Tertiary sediments in the vicinity of the Project area (maximum thickness of ~15 m) and the depth of the regional groundwater level being below the Tertiary sediments (i.e. Tertiary sediments are unsaturated in the vicinity of the Project area) the residence time of the groundwater in the Tertiary sediments is low and infiltration to the underlying hydrostratigraphic units generally occurs.

Groundwater is observed in one monitoring bores screened in the Tertiary sediments located to the west of the proposed pit area (MBBE0002). Groundwater was not encountered during the drilling and installation of this bore as part of the site investigation program, however, delayed groundwater recharge of the bore occurred following installation. Subsequent groundwater monitoring rounds conducted on this bore have identified groundwater within the bore. Groundwater level records from MBBE0002 indicates limited change in the water level during the monitoring period, which is a reflection of limited recharge to the Tertiary sediments.

5.4.3 Tertiary Basalt

Groundwater was not encountered in the Tertiary basalt located to the south of the Project area during the site investigation program. This is likely due to the limited extent of basalt mapped in this area and the limited thickness of basalt encountered during the site investigation. Additionally, the basalt encountered as part of site investigation program in MBBE0003 is located above the interpreted regional groundwater level, and therefore, is unsaturated.

5.4.4 Rewan Group

Groundwater level hydrographs from monitoring bores screened within the Rewan Group are provided in Appendix II. These Rewan Group bores comprise four bores located approximately 4 to 5 km to the north of the Project area (EFGW2D, EFGW3D, EFGW4D and EFGW5D) and two Rewan Group bores located within the Project area (BDW172(32) and MBBE0007). The groundwater level records from these bores indicate limited variability in levels over the duration of the monitoring period (February 2019 to April 2021), with limited variability as a result of seasonal changes; indicating limited connectivity with overlying strata or the surface water system.

Across the Project area, the Rewan Group is identified as the highest strata in the stratigraphic profile that hosts the regional groundwater level. The depth to groundwater level in the Rewan Group ranges from 18 metres below ground level (mbgl) to 27 mbgl across the Project area.

5.4.5 Rangal Coal Measures

Generally, groundwater in the Rangal Coal Measures is present within the coal seams of the strata as opposed to the low permeability overburden and interburden units. Appendix II presents the groundwater level hydrographs for the Rangal Coal Measures, which identifies limited changes in groundwater levels for the duration of the monitoring period, with the exception of monitoring bores located adjacent to mining activities where mine dewatering and groundwater level recovery trends are observed (e.g. BDW366P, BDW368P). There is also limited changes in water levels due to seasonal climatic variability, indicating limited connectivity with overlying strata the surface water system.

Recharge occurs via rainfall infiltration on localised outcrops of the Permian coal measures located within the Project area. As a result, the groundwater recharge to the Permian coal measures is typically very low.

Conceptually, the interpreted groundwater flow direction in the Permian coal measures is towards west-southwest, which is a subdued reflection of the surface topography. However, historical coal mining activities in the vicinity of the Project area has resulting in zones of depressurisation in the groundwater, particular in the vicinity of adjacent residual open pit voids where pit lakes, in connection with the groundwater system, are present. These pit lakes have caused a reduction in the potentiometric surface creating a hydraulic gradient towards the pit lake. Therefore, the current groundwater flow direction in the vicinity of the Project area is a reflection of this hydraulic gradient, with groundwater flowing towards these pit lakes (i.e. towards the northwest).

5.5 Groundwater Chemistry

Groundwater quality data for the groundwater-bearing hydrostratigraphic units in the vicinity of the Project area from the site investigations identified that groundwater was only encountered in the Tertiary sediments, Rewan Group and Rangal Coal Measures within the Project area. Durov and Piper plots for these hydrostratigraphic units are presented in Figure 4.4. These plots indicate that the proportion of major ionic constituents for all three units are relatively similar with the water types being Na/K–SO_4 to Na/K–HCO_3/CO_3 types.

Salinity concentrations and associated salinity characteristics are summarised in Table 4.3. This table identifies the salinity characteristics for the following units:

- Tertiary sediments – moderately saline;
- Rewan Group – brine; and
- Rangal Coal Measures – variable from brackish to moderately saline.

5.6 Groundwater-Surface Water Interactions

Public domain information of mapped springs and wetlands (DNRME 2018), indicate that there are no known springs or wetlands located within 5 km of the project area.

Groundwater Dependent Ecosystem (GDE) mapping provided in Queensland Globe (DNRME 2018) collates information from a number of sources into a central database, including published research and interpreted remote sensing data. These areas mapped in the GDE Atlas represent potential GDEs that access groundwater to meet all or some of its water requirements. This includes terrestrial vegetation, subsurface fauna communities and some vegetation which is associated with a surface water body. Although confidence levels are placed on the mapped extents of the GDEs, ground-truthing of the mapped areas is required to confirm presence of the GDEs.

Figure 4.2 presents the mapped GDE areas within the vicinity of the Project that have potential for GDEs to be present. Based on the GDE mapping, “Moderate” and “High” potential GDEs are predominantly located adjacent to Hat Creek and vegetation located in the southwest corner of the Project area.

Field verification surveys, completed as part of the Baseline Ecological Assessment for the EAR (Nitro Solutions 2020), confirmed the presence of several vegetation communities located within these mapped GDE areas. Areas of moderate GDE potential consisted entirely of RE 11.3.25 which was dominated by *Eucalyptus tereticornis* (Blue Gum). The communities associated with this vegetation species are restricted to the riparian corridors along Hat and Spade Creeks. The remaining areas mapped as having potential to contain terrestrial GDEs (TGDEs) have been field verified and determined to be unlikely to support TGDEs. The field verification process also determined the presence of Aquatic GDEs to be unlikely along Hat Creek. Further details on the field verification process is provided in the Baseline Ecological Assessment report (Nitro Solutions 2020).

5.7 Third-Party Groundwater Users

Table 5.2 summarises the registered bores from the DRDMW groundwater bore database that occur within a 5 km buffer of the Project area. A total of 43 registered bores are present within the 5 km buffer of the Project. Figure 5.7 presents the location of these registered bores, which comprise:

- 1 bore screened in the Quaternary alluvium;
- 3 bores screened in in the Tertiary sediments;
- 8 bores screened in the Tertiary basalt;
- 3 bores screened in the Rewan Group;
- 15 bores screened in the Rangal Coal Measures;
- 4 bores screened in the Blackwater Group; and
- 9 bores screened in the Fort Cooper Coal Measures.

Of the 43 registered bores two bores are recorded as water supply bores in the DRDMW groundwater bore database.

Further investigations into the water supply bores 81908 and 105678 identified in Table 5.2 have been completed by the proponent, which included site inspections and discussions with the pastoral lease manager. The site inspections did not identify the presence of the bores or any associated infrastructure for groundwater abstraction; and discussion with the pastoral lease manager indicate that there are no water supply bores located within or in the immediate vicinity of ML 70257. Therefore, these bores will not be considered as potential third-party groundwater supply bores (i.e. potential groundwater receptors) as part of this assessment.

Table 5.2 Summary of Available Data for Public Domain Bores

Bore	Screened Lithology (Bore Card)	Screens (m)	Recorded Use
81908	Rewan Group	50	Water Supply
105678	Tertiary basalt	38.6 to 43.6	Water Supply
131612	Blackwater Group (sand/silt)	21 to 100.5	Mine Monitoring
131613	Blackwater Group (sand/silt)	28.5 to 100.5	Mine Monitoring
131614	Blackwater Group (mud/sand/silt)	29.2 to 101.2	Mine Monitoring
131615	Blackwater Group (mud/sand/silt)	31.1 to 97.1	Mine Monitoring
141168	Fort Cooper Coal Measures	16 to 31.6	Mine Monitoring
141170	Rangal Coal Measures	126 to 138	Mine Monitoring
141812	Tertiary basalt	52 to58	Mine Monitoring
141813	Tertiary basalt	18 to24	Mine Monitoring
141947	Rangal Coal Measures	128 to 140	Mine Monitoring
162000	Rangal Coal Measures	116 to 120.25	Mine Monitoring
162001	Rangal Coal Measures	114.77 to115.77	Mine Monitoring
162002	Fort Cooper Coal Measures	33.7 to42.15	Mine Monitoring
162003	Fort Cooper Coal Measures	32.2 to 40.3	Mine Monitoring
162004	Fort Cooper Coal Measures	21 to 29	Mine Monitoring
162005	Rangal Coal Measures	18 to 112.45	Mine Monitoring
162006	Rangal Coal Measures	18 to 108.55	Mine Monitoring
162007	Rangal Coal Measures	17 to 105	Mine Monitoring
162008	Fort Cooper Coal Measures	11.2 to 57.95	Mine Monitoring
162009	Rangal Coal Measures	7 to 20.09	Mine Monitoring
162010	Rangal Coal Measures	7 to 31	Mine Monitoring
162018	Tertiary basalt	13 to 19	Mine Monitoring
162021	Tertiary basalt	36 to 42	Mine Monitoring
162024	Tertiary basalt	29 to 35.44	Mine Monitoring
162025	Tertiary basalt	42.8 to 49.27	Mine Monitoring
162029	Tertiary basalt	43.2 to 49.2	Mine Monitoring
162034	Rangal Coal Measures	51.6 to 60.5	Mine Monitoring
162035	Rangal Coal Measures	11.2 to 50.7	Mine Monitoring
162036	Fort Cooper Coal Measures	7.5 to 14.4	Mine Monitoring
162037	Fort Cooper Coal Measures	10.7 to 14.7	Mine Monitoring
162038	Fort Cooper Coal Measures	12.9 to 17.2	Mine Monitoring
162039	Fort Cooper Coal Measures	59 to 65	Mine Monitoring
162042	Rewan Group	74 to 80	Mine Monitoring
162255	Rewan Group	8.72 to 11.72	Mine Monitoring
162256	Tertiary sediments	1.88 to 4.88	Mine Monitoring
162257	Rangal Coal Measures	25.58 to 28.58	Mine Monitoring
162258	Tertiary sediments	1.18 to 4.18	Mine Monitoring
162259	Rangal Coal Measures	26.5 to 30.4	Mine Monitoring
162260	Tertiary sediments	1.5 to 4.5	Mine Monitoring
162261	Rangal Coal Measures	37.5 to 40.5	Mine Monitoring
162262	Rangal Coal Measures	56.06 to 59.06	Mine Monitoring
182113	Quaternary alluvium	15 to 24	Mine Monitoring

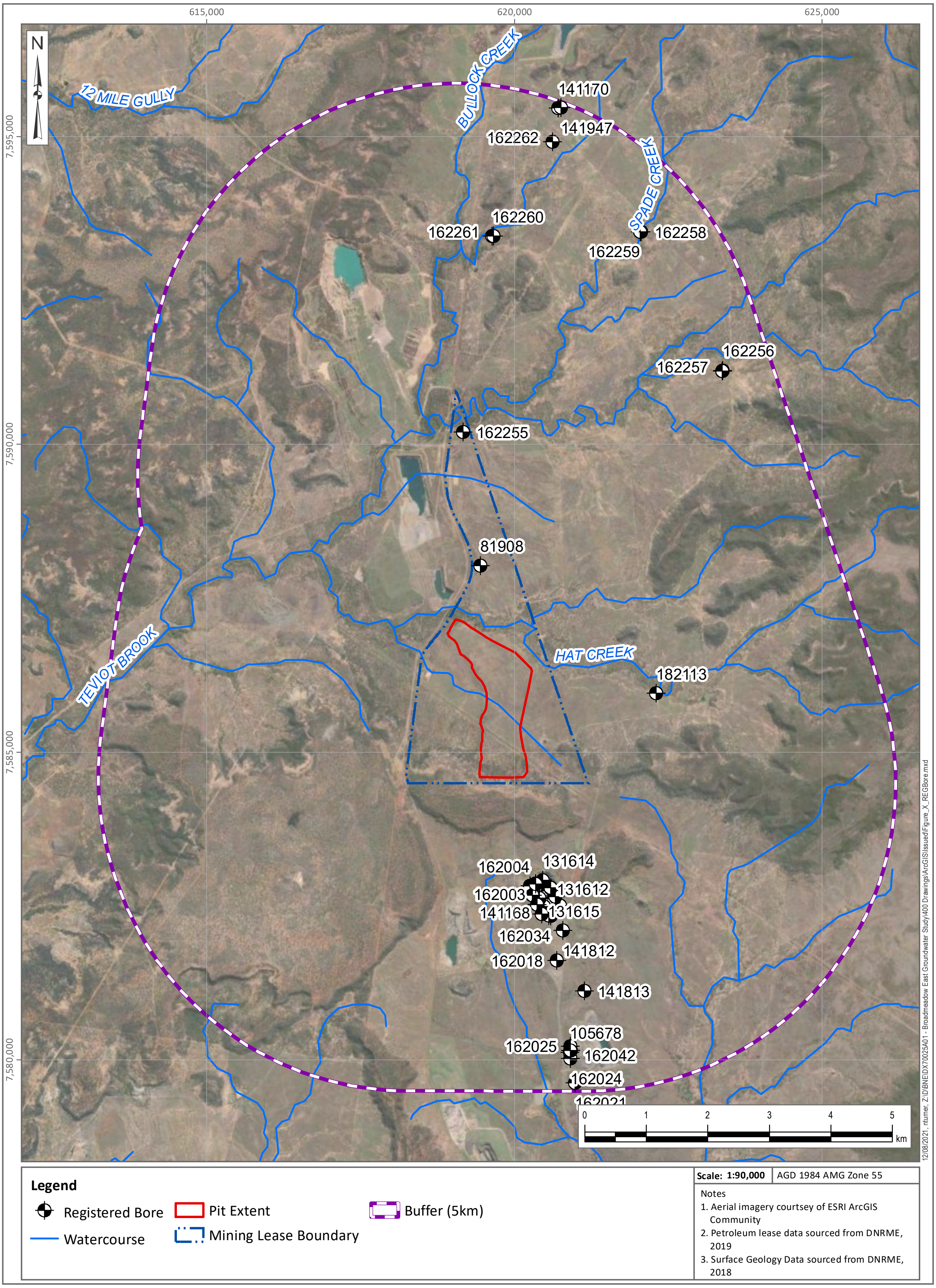

Figure 5.7 Location of Registered Groundwater Bores within 5 km of the Project Area

6 Groundwater Impact Assessment

6.1 Introduction

The following sections comprise:

- An overview of the project activities relevant to the groundwater assessment is provided in Sections 6.1.1;
- Predicted groundwater take for Years 1, 2 and 3 of the UWIR period, presented in Section 6.2;
- Groundwater depressurisation predictions during the UWIR period and over the life of mine, presented in Section 6.3 and Section 6.4, respectively; and
- Potential impacts to groundwater users and the environment have been presented in Section 6.5.

6.1.1 Open Pit Mining Activities

Only Project activities relevant to the groundwater assessment are provided in this section, full details of the mining methods to be used at BME are provided in Section 1.1.

Groundwater abstraction, as part of the open pit dewatering activities, will be undertaken to support the mine development. Dewatering is anticipated to occur concurrently with the mining activities with the use of sump pumping from the pit floor; with active management of the sump pumps relative to the active areas of the pit floor.

Groundwater abstraction will aim to dewater groundwater held in the overburden and will act to depressurise the Leichhardt, Vermont and Girrah Seams. This will reduce water pressure and associated groundwater levels in the surrounding geology, beyond the mining area.

6.2 Groundwater Take

Table 6.1 presents the annual groundwater take for Years 1, 2, and 3 of the UWIR period. The gradual increase from 24 ML in Year 1 to 71 ML in Year 3 is a result of the increasing depth and extent of the open pit workings over the UWIR period, resulting in increased groundwater inflow rates.

Table 6.1 Predicted Volume of Groundwater Take during the UWIR Period

Year of UWIR Period	Predicted Inflow (ML)
1	24
2	54
3	71
Total for UWIR Period	**149**

The predicted groundwater take represents the theoretical volume of groundwater that could be removed from the groundwater regime. The actual volume of groundwater pumped from the open pit mining area will be less than predicted by the numerical model, as a component of the groundwater will be lost to wetting of surfaces and retained moisture within the extracted coal. The groundwater take presented in Table 6.1 does not account for the above-mentioned losses that will occur when converting groundwater take to mine dewatering rates.

6.3 Groundwater Depressurisation during the UWIR Period

Figure 6.1 to Figure 6.6 show the predicted depressurisation within the two water bearing units, the Rewan Group and Rangal Coal Measures, during Years 1, 2 and 3 of the UWIR. Figure 6.3 and Figure 6.6 also show the extent of the IAA (i.e. predicted drawdown/depressurisation at Year 3). The IAA encompasses the area where drawdown during the UWIR period is predicted to exceed the applicable bore trigger threshold of 5 m for consolidated aquifers.

The groundwater model predicts no drawdown will occur in the alluvium, Tertiary sediments or the Tertiary basalt during the period of the UWIR due to these units being unsaturated at the commencement of the Project development.

Predicted groundwater level drawdown/depressurisation associated with the proposed Project development is typical of the depressurisation/drawdown characteristics for an open pit development, where the extent of depressurisation/drawdown is localised to the vicinity of the proposed pit area. This is particularly the case for this Project, with limited groundwater in the water bearing hydrostratigraphic units, restricting the depressurisation/drawdown extent to the vicinity of the proposed pit.

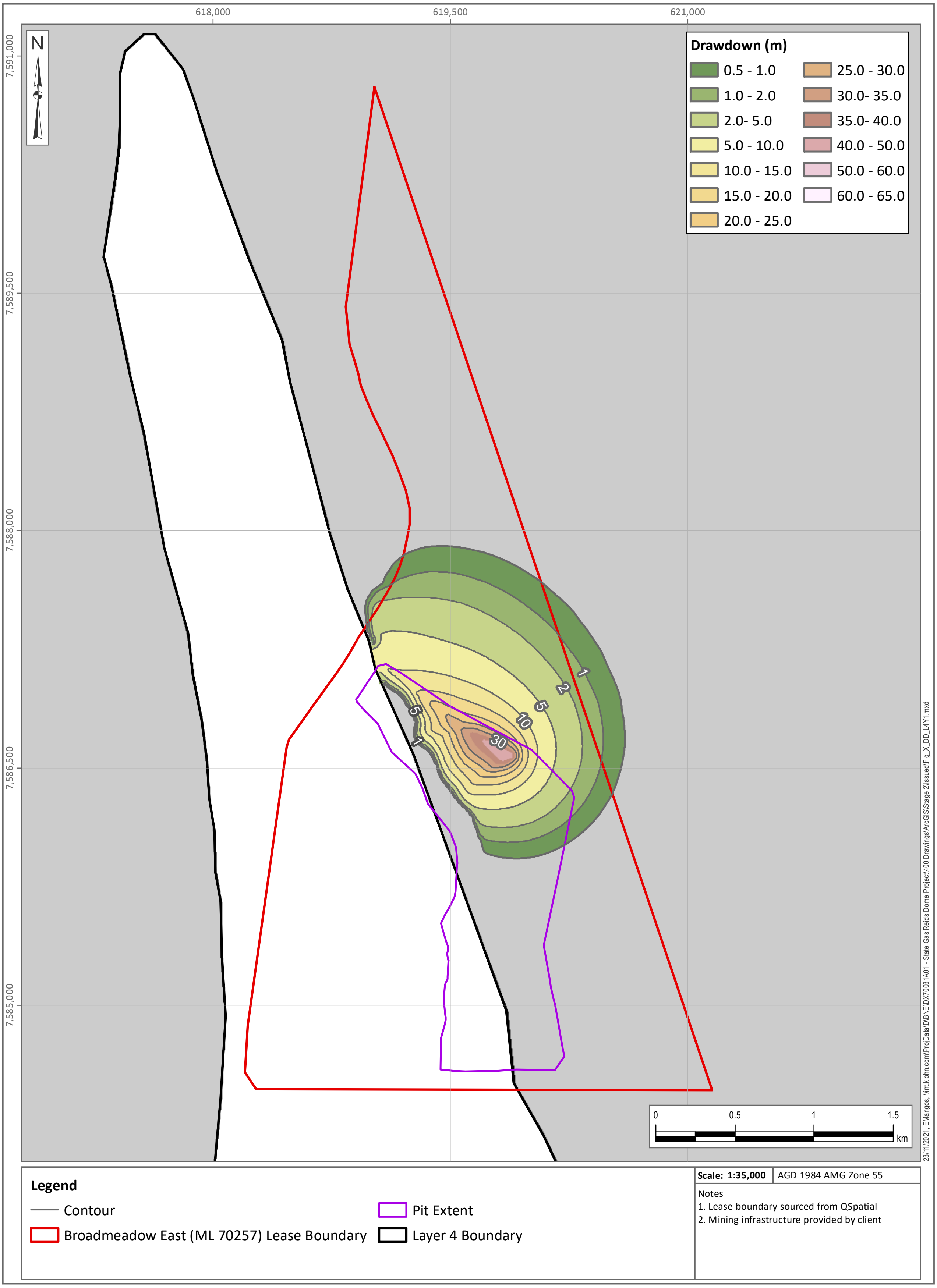

Figure 6.1 Predicted Depressurisation in the Rewan Group – Year 1

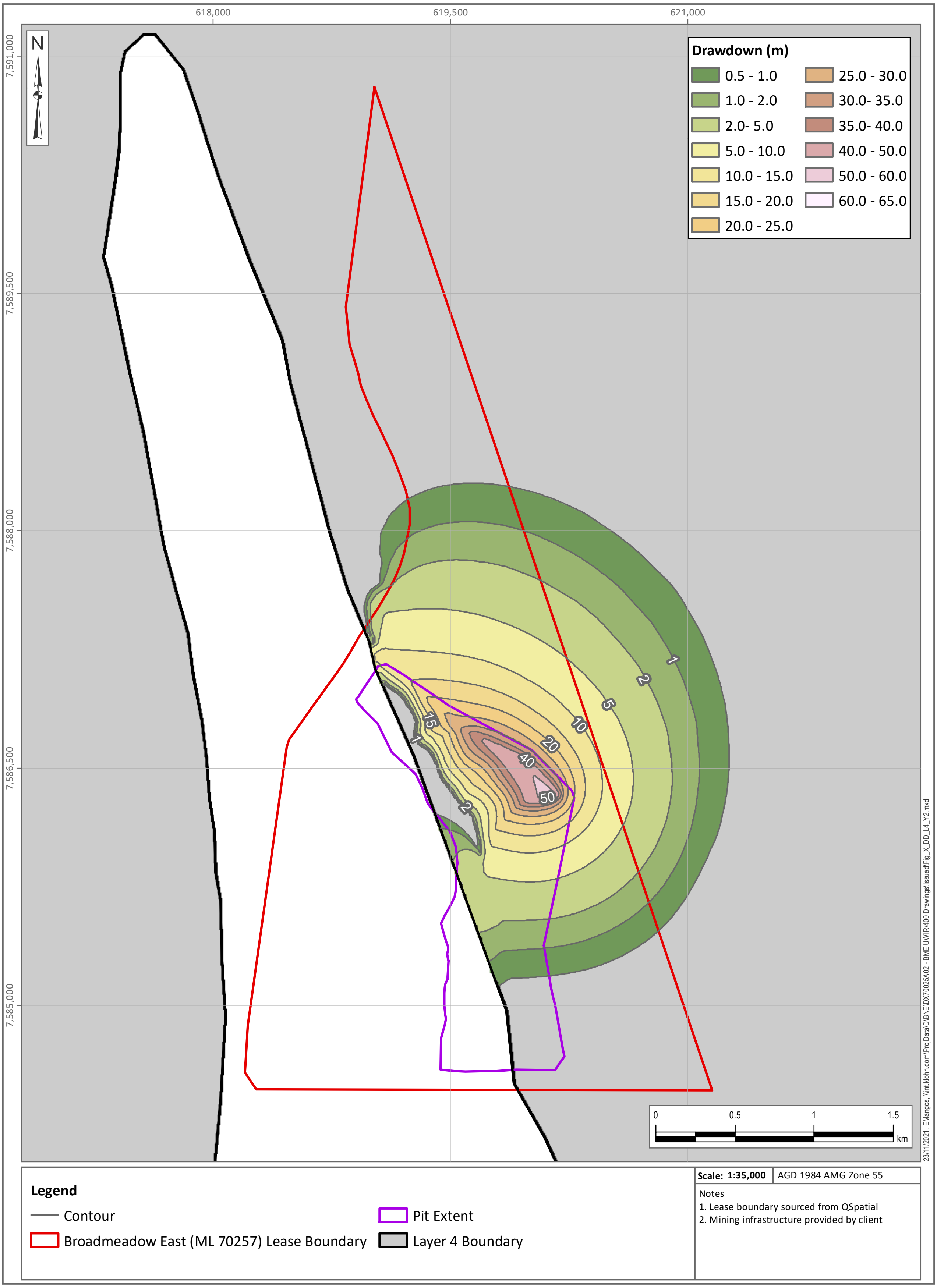

Figure 6.2 Predicted Depressurisation in the Rewan Group – Year 2

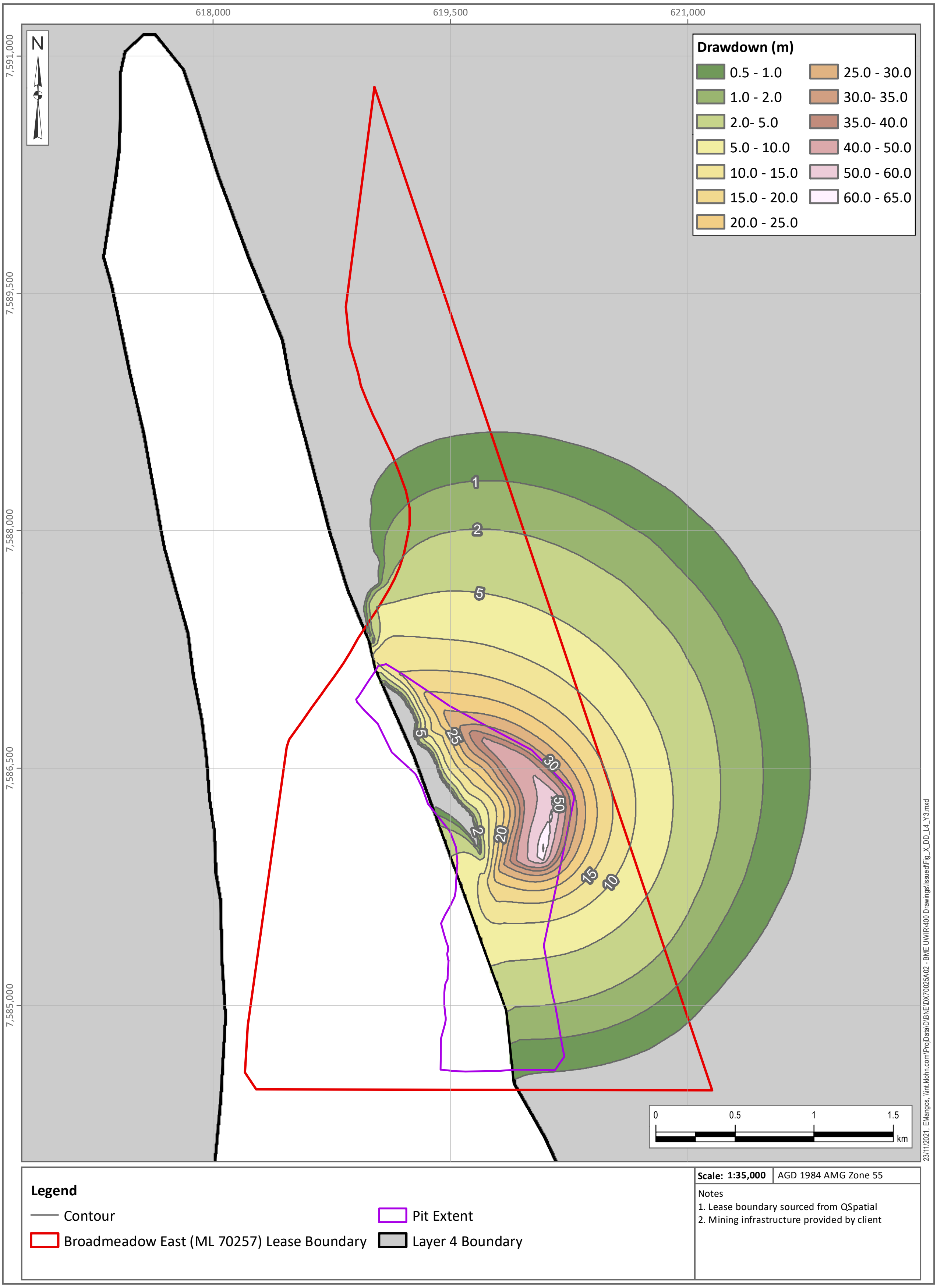

Figure 6.3 Predicted Depressurisation in the Rewan Group – Year 3 (IAA)

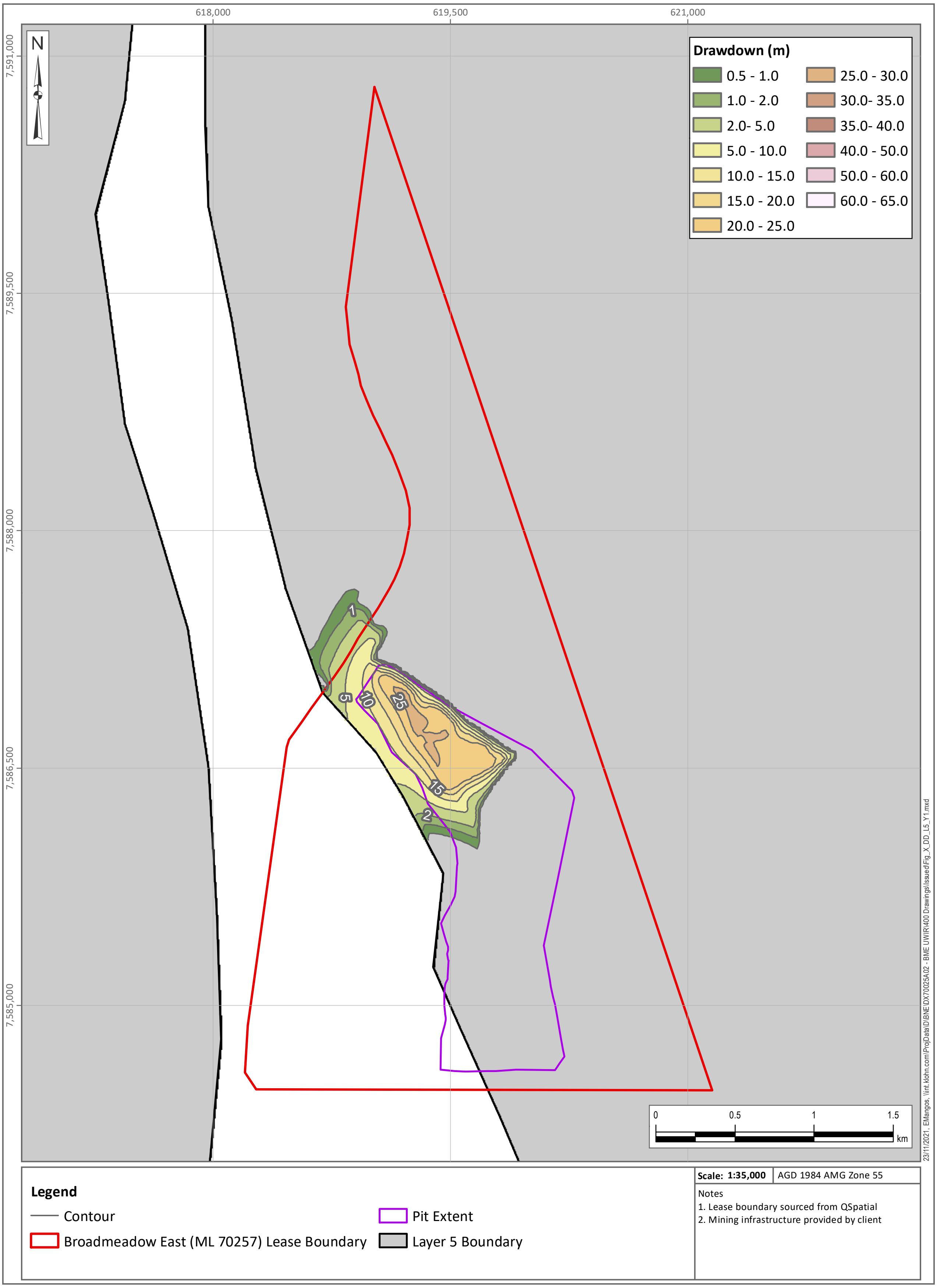

Figure 6.4 Predicted Depressurisation in the Rangal Coal Measures – Year 1

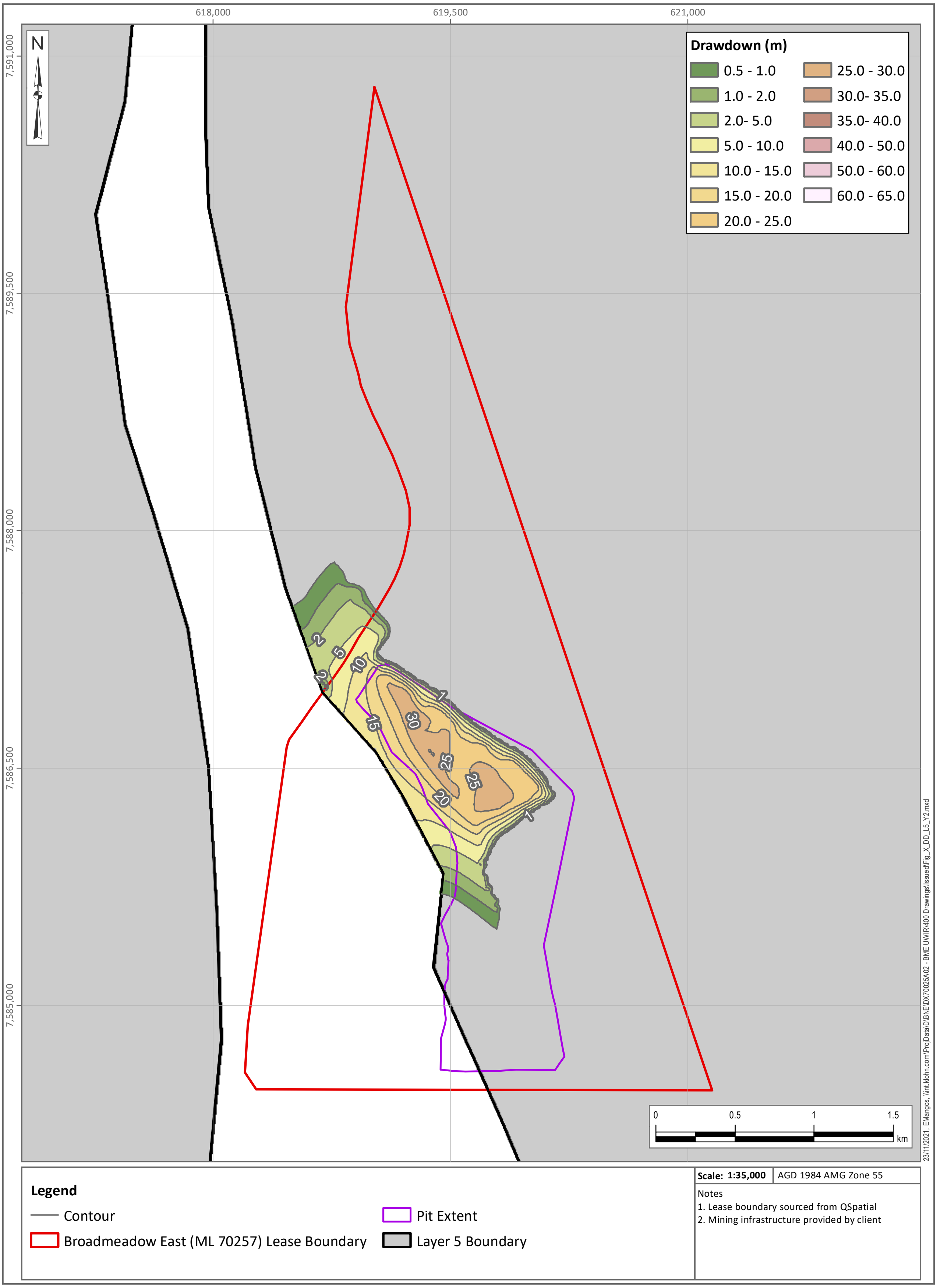

Figure 6.5 Predicted Depressurisation in the Rangal Coal Measures – Year 2

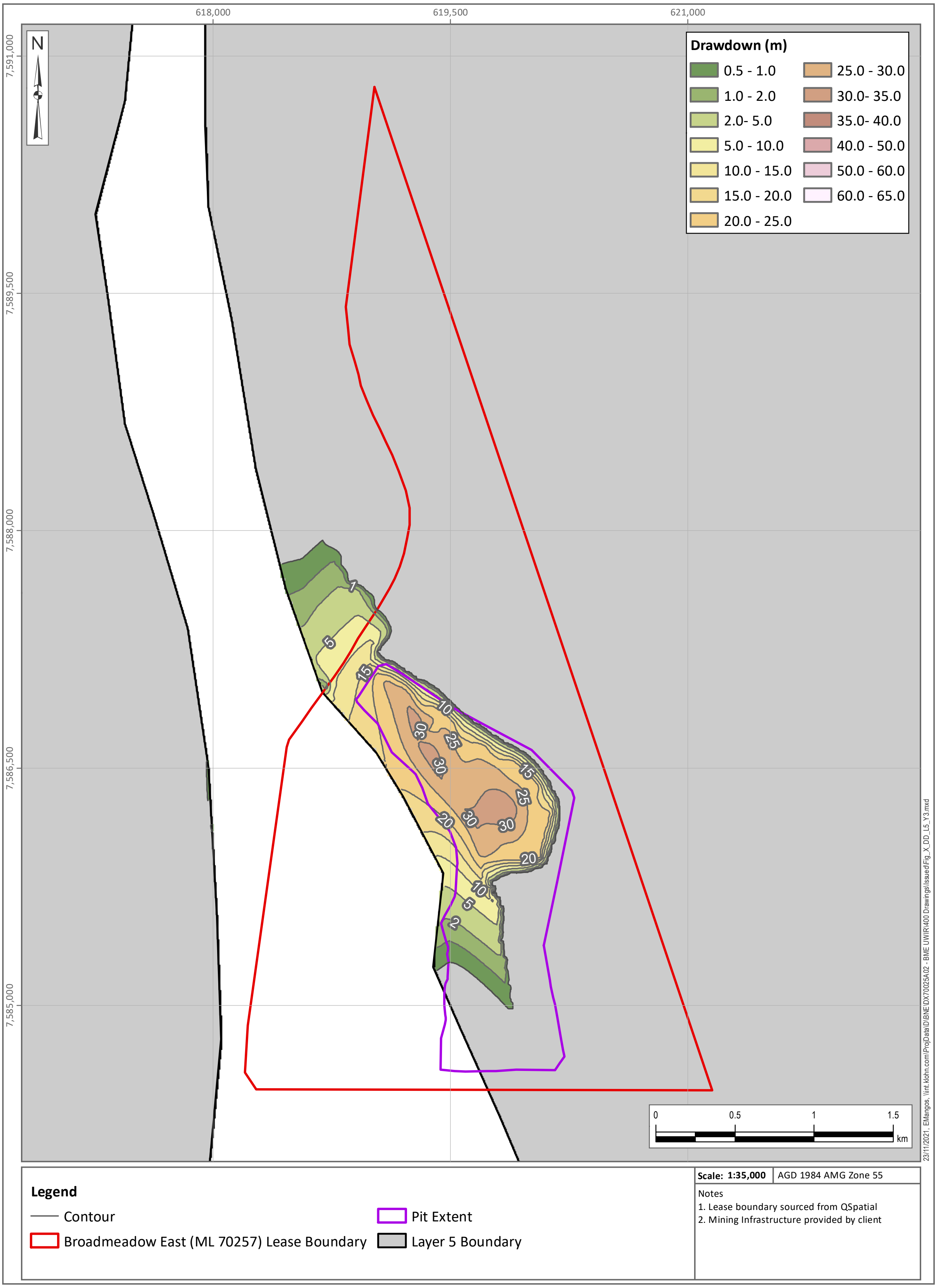

Figure 6.6 Predicted Depressurisation in the Rangal Coal Measures – Year 3 (IAA)

6.4 Groundwater Depressurisation Over the Mine Life

The groundwater model predicts no depressurisation/dewatering will occur in the alluvium, Tertiary sediments or the Tertiary basalt as a result of the proposed mine development over the life of the mine.

Depressurisation is predicted to occur in the Rewan Group over the duration of the mine development (Figure 6.7). Maximum depressurisation of ~64 m in the Rewan Group is predicted within the proposed pit, while the drawdown will extend approximately 2.5 km away from the edge of the pit towards the north, east and southeast.

Figure 6.8 presents the drawdown/depressurisation in the Rangal Coal Measures as a result of proposed mine development. A maximum drawdown/depressurisation in the Rangal Coal Measures of ~65 m is predicted within the proposed pit outline. The drawdown extent is predicted to extend along strike of the unit (north-northwest to south-southeast) by up to ~1 km from the edge of the pit.

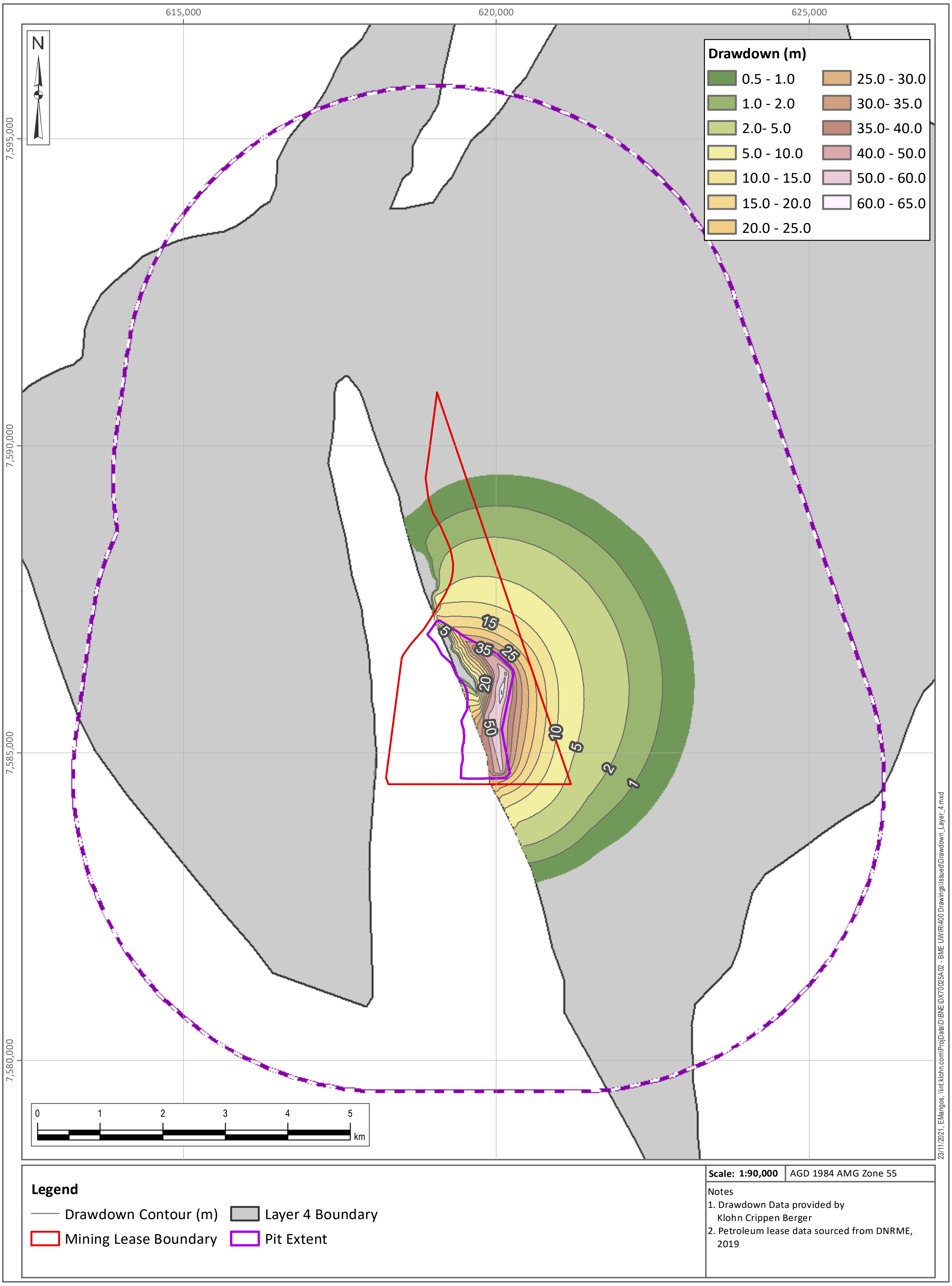

Figure 6.7 Maximum Predicted Depressurisation in the Rewan Group (Life of Operation) (LTAA)

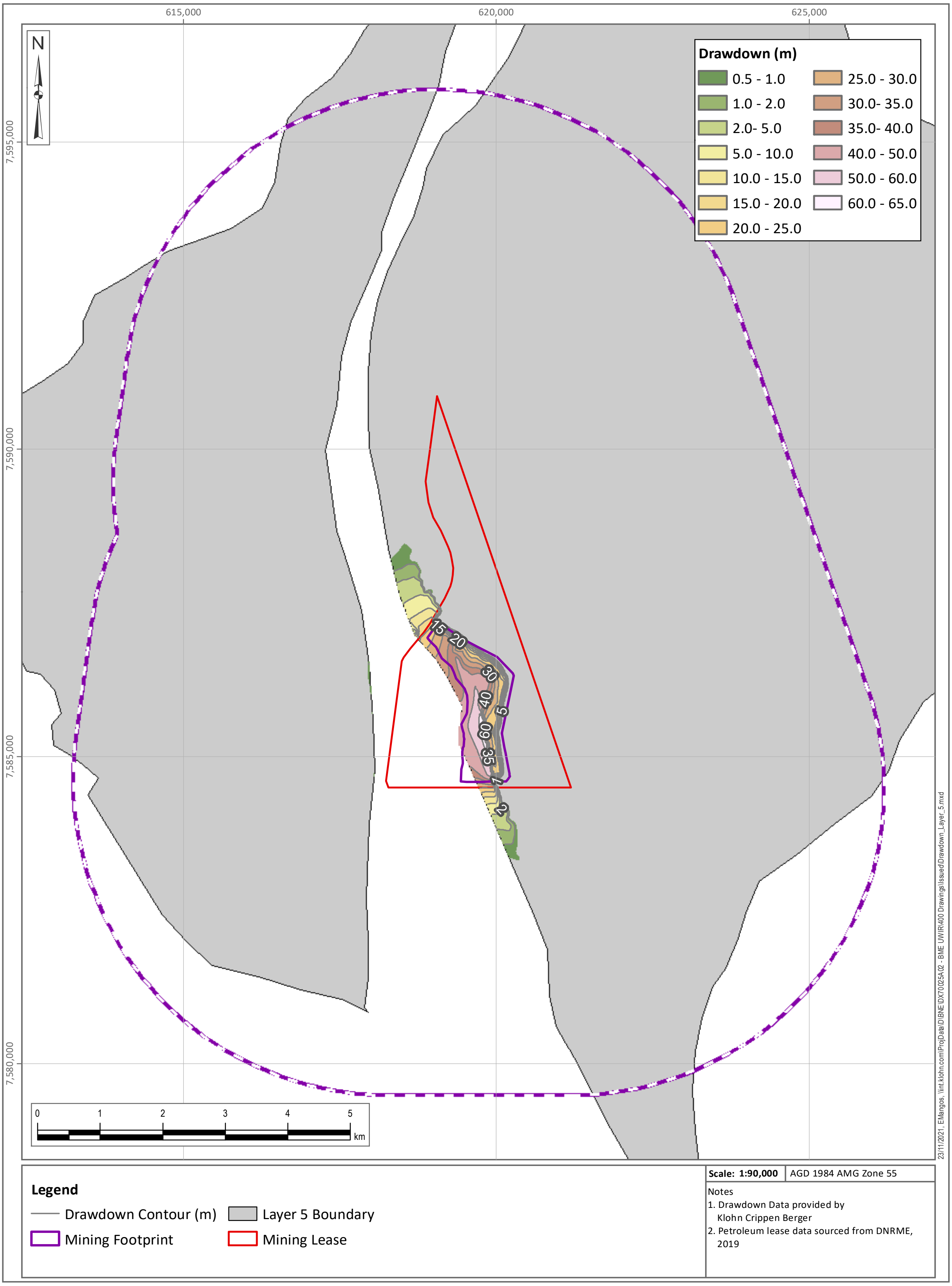

Figure 6.8 Maximum Predicted Depressurisation in the Rangal Coal Measures (Life of Operation) (LTAA)

6.5 Environmental Impacts

This section describes the environmental impacts of the Project during the UWIR period on the following receptors:

- Groundwater resources;
- Groundwater users;
- Surface water features;
- Springs;
- Groundwater dependent ecosystems; and
- Groundwater quality.

The groundwater assessment also investigated potential impacts on groundwater quality due to the use of hydrocarbons and chemicals.

6.5.1 Impact on Groundwater Resources

The Project is located within the Isaac Connors Groundwater Management Area (GMA). Groundwater in the Isaac Connors GMA is managed under the *Water Plan (Fitzroy Basin) 2011 (the Water Plan).* The Isaac Connors GMA comprises two groundwater units. Groundwater Unit 1 includes alluvial aquifers and Groundwater Unit 2 comprises of all other sub-artesian aquifers.

As highlighted in Section 5, there is limited alluvium in the vicinity of the Project area, along Hat Creek. Additionally, this alluvium is ephemeral in nature, in terms of groundwater storage, with groundwater only being present during and immediately following flow events in Hat Creek. Further, the regional groundwater level across the Project area ranges from ~12 mbgl to ~27 mbgl, which is below the alluvium at the Project (3-4 m thickness). Therefore, when groundwater is present in the alluvium the system is considered to be perched and not in connection with the regional groundwater system. As a result, there will be no groundwater take from the alluvium (i.e. Groundwater Unit 1) as a result of the Project development and therefore, the Project will not impact on this groundwater resource.

Groundwater dewatering/depressurisation is limited to the Rewan Group and Rangal Coal Measures, which forms part of Groundwater Unit 2. The Project is estimated to result in a total groundwater take of up to approximately 522 ML over the life of the mine. Groundwater take during Years 1, 2 and 3 (the UWIR period) are presented in Table 6.1. The Project total groundwater take for the UWIR period is estimated to be ~149 ML.

6.5.2 Impact on Groundwater Users

An assessment of third-party groundwater bores was undertaken as part of this groundwater assessment to identify potential groundwater users that could potentially be impacted by the Project development. The results of the assessment were presented in Section 5.7, which identified 43 registered groundwater bores within a conservative 5 km buffer of the Project area, of which, two bores were recorded as water supply bores on the DRDMW groundwater bore database, the remaining being mine groundwater monitoring bores. Further investigations into the two recorded water supply bores have identified that if the bores have been previously installed at the recorded locations, there is no pumping infrastructure at these locations that woul d support current or recent groundwater abstraction; and the pastoral lease manager for the land at the recorded water supply bore locations is not aware of water supply bores being present at the recorded locations. Therefore, for the assessment of potential impacts on third-party groundwater users, it is identified that there are currently no water supply bores within a 5 km buffer of the Project area, and therefore, currently no predicted potential impacts on third-party groundwater users as a result of the mine development, for the UWIR period (IAA) or the Project duration (LTAA).

However, over the duration of the Project development (i.e. 7 years) water supply bores may be installed within the 5 km buffer of the Project area. Should this occur, the UWIR process (described in Section 2) will capture these newly installed bores as part of the impact assessment process. Further discussion on the UWIR process is provided in Section 8.

6.5.3 Impact on Surface Drainage

The Project is located within the Teviot Brook Catchment. Watercourses within the Teviot Brook catchment, which includes Hat Creek, are ephemeral and are associated with episodic storm events during the wet season. The regional groundwater level across the Project area ~12 mbgl to ~27 mbgl which is significantly below the bed of drainage features such as Hat Creek. The significant depth separating the groundwater table and the bed of these drainage features identifies that there is unlikely to be a direct connection between the regional groundwater level and surface water flows in the Project area. Surface waters are therefore not interpreted to be in hydraulic connection to groundwater and thus groundwater does not provide baseflow to surface waters in the vicinity of the Project area.

As discussed in Section 6.5.1, Hat Creek may temporarily be in hydraulic connection to groundwater present in localised alluvium. Such occurrence is considered to represent a perched aquifer in the alluvium that is not in connection with the regional groundwater system. Therefore, the perched aquifer and the associated surface water course will not be impacted by groundwater depressurisation/dewatering associated with the mine operation.

6.5.4 Impact on Springs

Section 5.6 has identified that there are no springs or wetlands within a 5 km buffer of the Project area. Therefore, there will be no impacts to springs or wetlands as a result of the Project development.

6.5.5 Impact on Groundwater Dependent Ecosystems

A GDE assessment was completed across the Project area as part of the environmental studies for the Project (Nitro Solutions 2020), which has been summarised in Section 5.6. This assessment confirmed the presence of potential GDEs (*Eucalyptus tereticornis* (Blue Gum)) along Hat Creek and associated with the alluvium adjacent to the creek. Literature reviews completed on the identified GDE species (Nitro Solutions 2020) indicate a maximum rooting depth of this species of approximately 10 m.

The potential for groundwater to be present within the alluvium of Hat Creek is not considered high due to the ephemeral nature of this system (i.e. groundwater is only present during and immediately following surface water flow events in the creek); and the groundwater system being perched above the regional groundwater level when groundwater is present. Drilling completed within Hat Creek indicated that the alluvium ranges in thickness from 3 m to 4 m, which results in the alluvium being above the regional groundwater level.

The depth to groundwater level across the Project area ranges from 12 mbgl to 27 mbgl. Along the alignment of Hat Creek groundwater levels have been interpreted to vary from 15 mbgl to 20 mbgl. Therefore, based on the referenced rooting depth of the GDE located along Hat Creek (~10 m), it is interpreted that the GDE is not sourcing water from the regional groundwater system, but potentially from the shallower, perched alluvium when water is present. As a result, any drawdown in the underlying regional groundwater system due to the proposed Project development will have no discernible impact on the GDEs along Hat Creek.

6.5.6 Impact on Groundwater Quality

A summary of the Project components and associated activities is provided in Section 1.1. Processing and associated management of rejects from processing activities will be handled offsite at an existing facility. Therefore, the potential for contamination of the groundwater will be in relation to spills associated with hydrocarbon and chemical usage at the Project site. However, the storage of hydrocarbons and chemicals will be managed in accordance with standard management practices, including the use of bunding and the immediate clean-up of spill, which are typically legislated requirements at mine sites.

Therefore, based on the proposed Project components and limited associated activities, there will be limited potential for groundwater contamination to occur as a result of hydrocarbon or chemical contamination. Therefore, the potential for operational activities of the Project to impact on groundwater quality is low and is limited to accidental releases of hydrocarbons or chemicals during operations.

6.5.6.1 Hydrocarbon and Chemical Storage

The storage of hydrocarbon and chemicals will continue to be managed in accordance with the existing BME management practices, including the use of bunding and immediate clean-up of spills which are standard practice and a legislated requirement at mine sites that will prevent the contamination of the groundwater regime.

Given the limited activities proposed, and the controls that will be adopted, the Project has a very limited potential to give rise to groundwater contamination as a result of hydrocarbon and chemical contamination.

7 GROUNDWATER MONITORING PROGRAM

The following sections describe the monitoring and management measures for groundwater levels and quality, groundwater take and hydraulic stimulation. Each section provides an overview of the existing monitoring requirements and a detailed description of the approved monitoring and management measures. These measures will be implemented.

7.1 Groundwater Level and Quality Monitoring and Management

This section provides an overview of the requirements of the groundwater monitoring and management conditions at the Project. A groundwater monitoring and management plan (GMMP) will be developed in conjunction with this UWIR. The GMMP provides a detailed methodology and protocol for groundwater monitoring and management at BME site.

7.1.1 Environmental Authority Requirements

Schedule C of the BME EA Conditions (EA0002465) stipulates groundwater monitoring and management conditions for the Project. Table 7.1 summarises the groundwater-related EA conditions. Further conditions, which have been considered in the development of the GMMP may be found in the GMMP.

Table 7.1 EA Conditions Relevant to Groundwater

EA Condition	Condition Description
C25	**Water general** All determinations of water quality and biological monitoring must be: a) performed by a person or body possessing appropriate experience and qualifications to perform the required measurements; b) made in accordance with methods prescribed in the latest edition of the administering authorities Monitoring and Sampling Manual; c) collected from the monitoring locations identified within this environmental authority, within ten (10) hours of each other where possible; d) carried out on representative samples; and e) analysed at a laboratory accredited (e.g. NATA) for the method of analysis being used. NOTE: ***Condition C25*** *requires the Monitoring and Sampling Manual to be followed and where it is not followed because of exceptional circumstances this should be explained and reported with the results.*
C27	**Annual water monitoring reporting** The following information must be recorded in relation to all water monitoring required under the conditions of this environmental authority and submitted to the administering authority in the specified format with each annual return: a) the date on which the sample was taken; b) the time at which the sample was taken; c) the monitoring point at which the sample was taken; d) the measured or estimated daily quantity of mine affected water released from all release points; e) the release flow rate at the time of sampling for each release point; and f) the results of all monitoring and details of any exceedances of the conditions of this environmental authority.

EA Condition	Condition Description
C39	**Groundwater** Groundwater affected by the mining activities must be monitored for pH, Electrical Conductivity and water levels at frequencies and locations defined in Table C7 (Groundwater monitoring locations and frequency) and shown in Figure 2 (Broadmeadow Mine Groundwater Monitoring Locations) of this authority. Environment authority holder must provide details of the new groundwater monitoring locations to the administering authority as part of an environment authority amendment application to complete the Table C7 and update Figure 2, before commencement of any resource extraction activities.
C40	Groundwater levels must be monitored, and groundwater draw down fluctuations in excess of two metres per year, not resulting from the pumping of licensed bores, must be notified within fourteen (14) days to the administering authority following completion of monitoring.
C42	The method of water sampling required by this environmental authority must comply with that set out in the latest edition of the administering authority's *Water Quality Sampling Manual.*

The details of the bores that require groundwater monitoring under the EA Condition C39 are summarised in Table 7.2. Of the 4 bores outlined in the EA, three bores monitor the various coal seams of the Rangal Coal Measures whilst one bore (BDW172(32)) monitors the groundwater in the Rewan Group. As part of the groundwater impacts assessment for BME, completed by KCB (KCB 2021), a revised groundwater monitoring network was proposed; this is discussed in Section 7.1.2.

Table 7.2 Monitoring Bore Network Details and Monitoring Requirements (DES 2020)

Monitoring Point	Easting	Northing	Monitoring frequency	Aquifer / Monitored interval
	(AGD 84)			
BDW172 (32)	619333	7586689	Quarterly – Water levels only	Sediments above Leichhardt Seam (Rewan Group)
BDW172 (54)	619333	7586689	Quarterly – Water levels only	Leichhardt and Upper Vermont Seams
BDW5C	619731	7586791	Quarterly	Leichhardt and Upper Vermont Seams
BDW8C	619762	7585670	Quarterly	Leichhardt and Upper Vermont Seams

7.1.2 Monitoring and Management Measures

7.1.2.1 Revised Water Monitoring Locations

The groundwater impact assessment (KCB 2021) completed for BME identified new sample locations based on geologic mapping, bore design and water quality parameters to update the relevant conditions in the Major EA Amendment. New monitoring bores were drilled and installed at these locations during site investigations completed by KCB.

The revised groundwater monitoring network (KCB 2021) ensures each of the key hydrostratigraphic units are monitored, and the network is suitable for monitoring the effects of the Project on the groundwater regime throughout the life of the Project. A summary of the proposed additional groundwater monitoring network, including monitoring frequency, for the Project is provided in Table 7.3.

Condition C39 of the EA (EA0002465) requires that the EA holder must provide details of new groundwater monitoring locations to the administering authority prior to commencement of any resource extraction activities (Table 7.1). An amendment will be required to include the revised groundwater monitoring network outlined in Table 7.3.

Table 7.3 BME Proposed Groundwater Monitoring Network

Bore ID	Easting	Northing	Monitoring Frequency	Screened Stratigraphy
	(AMG84, Zone 55)			
BDW172 (32)	619333	7586689	Quarterly	Rewan Group
BDW172 (54)	619333	7586689	Quarterly	Rangal Coal Measures
BDW5C	619731	7586791	Quarterly	Rangal Coal Measures
BDW8C	619762	7585670	Quarterly	Rangal Coal Measures
MBBE0001	619739	7585223	Quarterly	Rangal Coal Measures
MBBE0002b	618324	7585162	Quarterly	Tertiary sediments
MBBE0003	618281	7584512	Quarterly	Basalt
MBBE0004	620081	7586800	Quarterly	Alluvium
MBBE0006	619056	7587072	Quarterly	Alluvium
MBBE0007	620535	7586212	Quarterly	Rewan Group
MBBE0008	620181	7584916	Quarterly	Rangal Coal Measures

7.1.2.2 Water Quality Monitoring

In accordance with the current EA requirements, the following monitoring conditions will be undertaken as part of the groundwater monitoring program:

- Groundwater levels will be recorded on a quarterly basis, which will enable natural groundwater level fluctuations (such as seasonal responses to rainfall) to be distinguished from potential water level impacts due to depressurisation resulting from mining activities; and
- Groundwater quality monitoring will be undertaken on a quarterly basis to enhance the existing baseline dataset. This will be used to detect any changes in groundwater quality during- and post-mining. Water quality samples will be analysed for physico-chemical parameters including pH, electrical conductivity, total dissolved solids, alkalinity, hardness, major ions (Ca, Mg, Na, K, Cl and SO_4), metals and metalloids (Al, Ag, As, Fe, Hg, Mo, Sb, Se, Cu, Cd, Pb, Ni and Zn) and total petroleum hydrocarbons.

Results from the groundwater monitoring program will be reviewed annually, and the groundwater monitoring program revised, as necessary.

Prior to the commencement of mining activities, a GMMP will be developed for the Project. The GMMP will be used as a “live” document that can be referred to during operations to provide instructions for groundwater-related compliance with the relevant EA conditions.

7.2 Groundwater Take Monitoring and Management

7.2.1 Regulatory Requirements

BCC has an obligation to quantify its actual groundwater take from the Project area under the *Mineral Resources Act*. The DRDMW Guideline for quantifying the volume of take of associated water under a mining lease or mineral development license (Groundwater Take Guideline) describes the acceptable methods for monitoring and quantifying actual groundwater take under the *Mineral Resources Act*. The acceptable methods include direct measurement, water balance modelling, and numerical / analytical groundwater flow modelling.

7.2.2 Approved Monitoring and Management Measures

In accordance with the requirements of the *Mineral Resources Act*, BCC will assess actual groundwater take using the acceptable methods. The method used will be reviewed annually and revised, as necessary.

The actual groundwater take assessed under the *Mineral Resources Act* requirements will be compared to the predicted groundwater take presented in this UWIR. This comparison will be undertaken annually. If the monitoring program shows groundwater take exceeds the predictions presented in this UWIR, an investigation will be undertaken to confirm whether the actual impacts on groundwater users or sensitive environmental features are likely to be significantly greater than expected. The investigation outcomes will be considered as part of the annual UWIR review described in Section 8.

8 UWIR UPDATES AND REVIEW

8.1 Roles and Responsibilities

BCC is responsible for ensuring that the UWIR is implemented.

8.2 Review and Revision

As discussed in Section 6.5.2, depressurisation/dewatering of the Rangal Coal Measures is not expected to exceed the bore trigger threshold within the UWIR period.

The UWIR has been designed to align with the current EA groundwater conditions. It is therefore necessary to review and update the UWIR in response to any material changes to the EA groundwater conditions.

8.3 Reporting and Record Keeping

The outcome of each annual review will be reported to the DES following completion of each annual review. The reported outcomes will include a statement of whether there has been a material change in the information or predictions used to prepare the maps.

9 CONCLUSIONS

The key conclusions of this UWIR are as follows:

- The impacts of the project over the UWIR period and the life of the mine have been assessed as part of the groundwater impact assessment completed as part of the BME EAR.
- The approved mining operations will result in localised depressurisation of the Rewan Group and Rangal Coal Measures. The depressurisation characteristics predicted for this Project development is typical of an open pit develop where the extent of depressurisation is localised to the vicinity of the proposed pit area. This is particularly the case for this Project, with limited groundwater in the water bearing hydrostratigraphic units, restricting the depressurisation extent to the vicinity of the proposed pit.
- The other potential aquifers and shallow formations (i.e. the Tertiary basalt, Tertiary sediments and alluvium) are not predicted to be depressurised/dewatered by the Project.
- The Project will not impact surface waters or alluvial aquifers during the UWIR period because:
  - Localised alluvium that is present in the vicinity of the Project area is typically unsaturated, relatively thin and compartmentalised, and it does not represent a significant aquifer;
  - All creeks near the Project area are ephemeral, with no measurable baseflow and therefore there is no significant groundwater contribution to surface water baseflow; and
  - The regional groundwater level is identified to be below the base of the alluvium in the vicinity of the Project area and is therefore not in hydraulic connection with the alluvium.
- There are no groundwater users or other sensitive environmental features dependent upon groundwater from the Rewan Group or Rangal Coal Measures within the Project area or its surrounds, and therefore no discernible groundwater impacts are predicted as a result of the Project development.
- There is a very low potential for groundwater contamination as a result of the Project.

10 CLOSING

This report is an instrument of service of Klohn Crippen Berger (KCB). The report has been prepared for the exclusive use of Bowen Coking Coal (Client) for the specific application to the Broadmeadow East, and it may not be relied upon by any other party without KCB's written consent.

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KCB AUSTRALIA PTY LTD.

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APPENDIX I

Summary of Groundwater Monitoring Bores

Appendix I
Registered Groundwater Monitoring Bores

RN Number	Screened Lithology (Bore Card)	Screens (m)	Recorded Use
81908	Rewan Group	50	Water Supply (not present)
105678	Tertiary basalt	38.6 to 43.6	Water Supply (not present)
131612	Blackwater Group (sand/silt)	21 to 100.5	Mine Monitoring
131613	Blackwater Group (sand/silt)	28.5 to 100.5	Mine Monitoring
131614	Blackwater Group (mud/sand/silt)	29.2 to 101.2	Mine Monitoring
131615	Blackwater Group (mud/sand/silt)	31.1 to 97.1	Mine Monitoring
141168	Fort Cooper Coal Measures	16 to 31.6	Mine Monitoring
141170	Rangal Coal Measures	126 to 138	Mine Monitoring
141812	Tertiary basalt	52 to58	Mine Monitoring
141813	Tertiary basalt	18 to24	Mine Monitoring
141947	Rangal Coal Measures	128 to 140	Mine Monitoring
162000	Rangal Coal Measures	116 to 120.25	Mine Monitoring
162001	Rangal Coal Measures	114.77 to115.77	Mine Monitoring
162002	Fort Cooper Coal Measures	33.7 to42.15	Mine Monitoring
162003	Fort Cooper Coal Measures	32.2 to 40.3	Mine Monitoring
162004	Fort Cooper Coal Measures	21 to 29	Mine Monitoring
162005	Rangal Coal Measures	18 to 112.45	Mine Monitoring
162006	Rangal Coal Measures	18 to 108.55	Mine Monitoring
162007	Rangal Coal Measures	17 to 105	Mine Monitoring
162008	Fort Cooper Coal Measures	11.2 to 57.95	Mine Monitoring
162009	Rangal Coal Measures	7 to 20.09	Mine Monitoring
162010	Rangal Coal Measures	7 to 31	Mine Monitoring
162018	Tertiary basalt	13 to 19	Mine Monitoring
162021	Tertiary basalt	36 to 42	Mine Monitoring
162024	Tertiary basalt	29 to 35.44	Mine Monitoring
162025	Tertiary basalt	42.8 to 49.27	Mine Monitoring
162029	Tertiary basalt	43.2 to 49.2	Mine Monitoring
162034	Rangal Coal Measures	51.6 to 60.5	Mine Monitoring
162035	Rangal Coal Measures	11.2 to 50.7	Mine Monitoring
162036	Fort Cooper Coal Measures	7.5 to 14.4	Mine Monitoring
162037	Fort Cooper Coal Measures	10.7 to 14.7	Mine Monitoring
162038	Fort Cooper Coal Measures	12.9 to 17.2	Mine Monitoring
162039	Fort Cooper Coal Measures	59 to 65	Mine Monitoring
162042	Rewan Group	74 to 80	Mine Monitoring
162255	Rewan Group	8.72 to 11.72	Mine Monitoring
162256	Tertiary sediments	1.88 to 4.88	Mine Monitoring
162257	Rangal Coal Measures	25.58 to 28.58	Mine Monitoring
162258	Tertiary sediments	1.18 to 4.18	Mine Monitoring
162259	Rangal Coal Measures	26.5 to 30.4	Mine Monitoring
162260	Tertiary sediments	1.5 to 4.5	Mine Monitoring
162261	Rangal Coal Measures	37.5 to 40.5	Mine Monitoring
162262	Rangal Coal Measures	56.06 to 59.06	Mine Monitoring
182113	Quaternary alluvium	15 to 24	Mine Monitoring

APPENDIX II

Groundwater Hydrographs

Sample Information		Physico-chemical														Dissolved Metals							
Sample Location	Date	pH	Electrical Conductivity @ 25°C	Turbidity	Hydroxide Alkalinity as CaCO3	Carbonate Alkalinity	Bicarbonate Alkalinity as CaCO3	Total Alkalinity as CaCO3	Sulfate as SO4	Chloride	Calcium	Magnesium	Sodium	Potassium	Aluminium	Arsenic	Lead	Manganese	Zinc	Iron	Aluminium	Arsenic	Lead
BDW 148	09/02/2006	6.54	19000					321	248	6800	506	635	2900	42		0.001	0.001		0.023				
BDW 148	01/05/2006	6.6	19620					341	274	6460	512	641	2900	39		<0.001	0.002		0.121				
BDW 366P	09/02/2006	7.2	25600					167	162	7160	598	484	3360	42		<0.001	<0.001		0.011				
BDW 366P	01/05/2006	7.12	18900					159	75	6930	552	452	3350	30		<0.001	<0.001		0.065				
BDW 366P	01/09/2006	7.14	19100					165	67	6990	589	454	3280	32		<0.001	0.003		0.009				
BDW 366P	01/03/2007	7.18	25200					172	49	7740	626	441	3350	30		<0.001	<0.001		0.013				
BDW 366P	01/08/2007	nd	nd					163	32	7520	576	460	3200	34		0.004	<0.001		0.012				
BDW 366P	01/11/2007	6.94	21200					153	22	9260	712	497	3820	30		0.002	<0.001		0.012				
BDW 366P	01/04/2008	7.13	21200					170	14	6610	560	433	3200	27		0.004	<0.001		0.023				
BDW 366P	20/06/2008	7.07	21100					151	16	7320	569	440	3160	22		<0.001	<0.001		0.006				
BDW 366P	03/09/2008	7.03	21000					192	12	7390	620	447	3320	27		<0.001	<0.001		0.009				
BDW 366P	12/11/2008	7.23	23700					196	11	6750	610	433	3110	27		<0.001	<0.001		0.01				
BDW 366P	16/06/2009	7.65	21600					306	4.00	7610	585	476	3270	29		<0.001	<0.001		0.015				
BDW 366P	29/09/2009	7.67	19500					341	10.00	7070	614	494	3380	28	<0.01	0.004	<0.001		0.009	1.05			
BDW 366P	09/12/2009	7.43	16500					321	12.00	7470	601	469	3180	27	<0.01	<0.001	<0.001		0.009	0.35			
BDW 366P	01/04/2010	7.2	16500					279	24.00	7800	632	483	3180	30	<0.01	0.004	<0.001		0.008	0.18			
BDW 366P	01/07/2010	7.68	20800					334	26.00	6950	566	461	3100	28	<0.01	<0.001	<0.001		0.008	0.36			
BDW 366P	12/10/2010	7.25	20200					323	31	7130	610	481	3170	29	<0.01	<0.001	<0.001		0.008	<0.05			
BDW 366P	01/06/2011	7.47	21400					255	286	7280	597	540	2960	24	<0.01	0.002	<0.001		<0.005	<0.50			
BDW 366P	01/12/2011	7.46	21600					314	343	8260	652	598	3960	34	<0.10	<0.010	<0.010		<0.050	6.41			
BDW 366P	23/01/2012	7.33	21000					379	309	7730	646	613	3090	35	<0.01	0.004	<0.001		0.006	2.12			
BDW 366P	11/09/2012	7.33	20000					452	361	6820	554	563	3210	39	<0.01	<0.001	<0.001	0.364	0.136	<0.05			
BDW 366P	20/03/2013	7.44	20200																				
BDW 366P	01/05/2013	7.39	18900																				
BDW 5C	01/05/2006	7.46	9780					138	<1	3090	159	63	1790	17		<0.001	<0.001		0.067				
BDW 5C	01/09/2006	7.05	13180					166	16	4240	238	142	2300	24		<0.001	<0.001		0.017				
BDW 5C	01/03/2007	7.19	11050					143	4	3420	189	78	1940	19		<0.001	<0.001		0.011				
BDW 5C	01/08/2007	nd	nd					291	223	7670	549	497	3380	49		<0.001	<0.001		0.007				
BDW 5C	01/11/2007	7.03	13130					149	15	4550	276	147	2500	26		<0.001	<0.001		<0.005				
BDW 5C	01/04/2008	7.37	11170					128	2	3500	197	77	1930	18		0.001	<0.001		0.016				
BDW 5C	20/06/2008	7.17	13610					146	4	4450	268	135	2240	19		<0.001	<0.001		0.005				
BDW 5C	03/09/2008	7.42	11150					144	2	3930	207	83	2110	18		<0.001	<0.001		0.01				
BDW 5C	12/11/2008	7.16	11040					131	6	3330	193	74	2010	15		<0.001	<0.001		0.009				
BDW 5C	16/06/2009	7.67	9830					150	2	3540	178	71	1930	16		<0.001	<0.001		0.012				
BDW 5C	29/09/2009	7.88	9860					142	1	3140	170	67	1830	16	<0.01	0.003	<0.001		0.008	0.86			
BDW 5C	09/12/2009	7.69	9300					169	7	3640	186	81	1930	17	<0.01	0.001	<0.001		0.009	0.11			
BDW 5C	01/04/2010	7.7	10900					115	3	4500	284	108	2250	18	<0.01	0.004	<0.001		0.007	0.25			
BDW 5C	01/07/2010	7.67	12000					125	1	4040	246	82	2210	17	<0.01	<0.001	<0.001		0.008	0.81			
BDW 5C	12/10/2010	7.56	11600					113	<1	4110	260	79	2160	15	<0.01	<0.001	<0.001		0.008	1.8			
BDW 5C	01/06/2011	7.64	10600					134	1	3620	196	64	1900	11	<0.01	<0.001	<0.001		<0.005	0.45			
BDW 8C	01/09/2006	7.85	2360					371	<1	521	13	8	474	4		0.002	<0.001		0.022				
BDW 8C	01/03/2007	7.87	2230					367	<1	486	13	8	449	5		<0.001	0.001		0.038				
BDW 8C	01/08/2007	nd	nd					343	<1	501	14	8	416	5		<0.001	<0.001		<0.005				
BDW 8C	01/11/2007	7.79	2190					322	<1	561	14	8	488	5		<0.001	<0.001		<0.005				
BDW 8C	01/04/2008	7.97	2200					352	<1	461	13	7	448	4		<0.001	<0.001		0.024				
BDW 8C	20/06/2008	7.87	2170					241	<1	479	12	7	424	3		<0.001	<0.001		<0.005				
BDW 8C	03/09/2008	7.92	2280					362	<1	457	13	7	463	4		<0.001	<0.001		0.006				
BDW 8C	12/11/2008	7.91	2050					347	2.00	450	12	6	434	4		<0.001	<0.001		<0.005				
BDW 8C	16/06/2009	8.11	2130					353	<1	494	13	7	458	4		<0.001	<0.001		<0.005				
BDW 8C	29/09/2009	8.29	2030					351	<1	459	13	7	435	4	<0.01	<0.001	<0.001		<0.005	0.09			
BDW 8C	09/12/2009	8.22	2130					353	<1	480	11	6	448	4	<0.01	<0.001	<0.001		<0.005	<0.05			
BDW 8C	01/04/2010	8.17	2020					305	<1	487	10	6	420	3	<0.01	<0.001	<0.001		<0.005	0.09			
BDW 8C	01/07/2010	8.15	2120					366	<1	477	11	7	462	4	<0.01	<0.001	<0.001		<0.005	0.08			
BDW 8C	12/10/2010	8.77	1960					357	<1	452	12	6	428	3	<0.01	<0.001	<0.001		<0.005	0.07			
BDW 8C	01/06/2011	7.98	2270					338	4.00	531	11	7	507	4	<0.01	0.001	<0.001		<0.005	0.09			
BDW368P	01/05/2013	7.59	5290																				
EFGW1S	17/01/2018	7.84	6360		<1	<1	596	596	66	1720	102	119	1090	7		0.002	<0.001	1.73	0.073	<0.05		0.004	0.011
EFGW1S	25/07/2018	7.59	5500	6.2	<1	<1	777	777	68	1330	76	105	1010	5		<0.001	<0.001	2.78	0.024	<0.05		0.001	<0.001
EFGW1S	30/08/2018	7.53	5700	216	<1	<1	785	785	80	1450	83	104	1060	6		0.001	<0.001	1.27	0.026	<0.05		0.002	0.004
EFGW1S	27/09/2018	7.71	4050	35.7	<1	<1	728	728	44	823	42	49	710	4		<0.001	<0.001	0.218	0.027	<0.05		<0.001	0.001
EFGW1S	24/10/2018	7.92	2320	65.8	<1	<1	632	632	23	415	17	20	425	2		<0.001	<0.001	0.364	0.031	<0.05		<0.001	<0.001
EFGW1S	16/11/2018	7.63	4560	75.8	<1	<1	649	649	55	1080	56	66	882	5		0.003	<0.001	0.24	0.034	0.14		0.003	<0.001
EFGW1S	26/02/2019	7.88	4600	73.8	<1	<1	606	606	52	1100	50	63	785	6		<0.001	<0.001	0.423	0.012	<0.05		<0.001	0.001

Sample Information		Physico-chemical														Dissolved Metals							
Sample Location	Date	pH	Electrical Conductivity @ 25°C	Turbidity	Hydroxide Alkalinity as CaCO3	Carbonate Alkalinity	Bicarbonate Alkalinity as CaCO3	Total Alkalinity as CaCO3	Sulfate as SO4	Chloride	Calcium	Magnesium	Sodium	Potassium	Aluminium	Arsenic	Lead	Manganese	Zinc	Iron	Aluminium	Arsenic	Lead
EFGW1S	26/03/2019	7.28	5070	150	<1	<1	593	593	60	1380	58	77	939	5		<0.001	<0.001	0.114	0.032	<0.05		0.001	0.004
EFGW1S	30/04/2019	7.47	5390	334	<1	<1	677	677	67	1460	62	80	958	5		<0.001	<0.001	0.178	0.011	0.05		0.002	0.005
EFGW1S	22/05/2019	7.86	3670	120	<1	<1	727	727	38	837	33	44	701	4		<0.001	<0.001	0.048	0.01	<0.05		0.001	0.003
EFGW1S	21/06/2019	7.12	6660	115	<1	<1	636	636	66	1780	98	107	1190	7		0.002	<0.001	0.53	0.008	1.01		0.001	0.002
EFGW1S	16/07/2019	7.1	6840	222	<1	<1	709	709	66	1880	66	77	1070	6		<0.001	<0.001	0.163	0.008	<0.05		0.002	0.006
EFGW1S	27/08/2019	7.53	4700	82.5	<1	<1	642	642	49	1180	47	61	831	5		<0.001	<0.001	0.057	0.006	<0.05		<0.001	0.002
EFGW1S	06/11/2019	7.29	3760	9.4	<1	<1	591	591	41	949	35	46	634	4	<0.01	<0.001	<0.001	0.011	0.012	<0.05	0.03	<0.001	<0.001
EFGW1S	26/02/2020	7.59	6270	32.8	<1	<1	642	642	77	1590	95	112	1070	6	<0.01	0.001	<0.001	1.93	0.016	0.15	0.13	0.001	<0.001
EFGW1S	26/05/2020	7.64	4000	28.2	<1	<1	731	731	54	899	39	47	668	4	<0.01	<0.001	<0.001	1.42	0.039	0.08	0.71	0.002	0.004
EFGW1S	27/08/2020	7.6	4260	11.5	<1	<1	878	878	44	933	45	50	695	4	<0.01	<0.001	<0.001	1.17	0.116	0.34	0.18	<0.001	<0.001
EFGW1S	24/11/2020	7.96	4060	10.3	<1	<1	851	851	37	813	42	52	668	4	<0.01	0.001	<0.001	0.055	0.413	<0.05	0.19	0.001	<0.001
EFGW1S	04/02/2021	7.62	3760	6.7	<1	<1	750	750	70	795	44	55	695	4	<0.01	<0.001	<0.001	1.8	0.058	<0.05	0.15	0.001	<0.001
EFGW2D	16/01/2018	8.18	5870		<1	<1	293	293	6	1660	78	18	1130	6		0.01	<0.001	0.389	<0.005	<0.05		0.01	0.001
EFGW2D	24/07/2018	8.15	5610	7860	<1	<1	385	385	12	1590	88	20	1100	7		0.013	<0.001	0.241	<0.005	<0.05		0.032	0.102
EFGW2D	30/08/2018	7.75	9430	26.6	<1	<1	168	168	3	3340	238	56	1830	11		0.009	<0.001	1.13	0.006	0.06		0.01	0.001
EFGW2D	27/09/2018	7.76	9230	516	<1	<1	177	177	3	3080	198	44	1660	10		0.01	<0.001	0.941	0.008	<0.05		0.014	0.007
EFGW2D	23/10/2018	7.91	8790	366	<1	<1	223	223	2	2590	223	48	1650	10		0.009	<0.001	1	0.023	0.08		0.013	0.017
EFGW2D	16/11/2018	8	8150	29.5	<1	<1	196	196	3	2500	151	37	1490	9		0.008	<0.001	0.578	0.012	<0.05		0.01	0.003
EFGW2D	26/02/2019	8	7120	26.7	<1	<1	263	263	6	1960	122	34	1310	11		0.012	<0.001	0.584	0.03	<0.05		0.013	0.002
EFGW2D	26/03/2019	7.57	7600	144	<1	<1	230	230	6	2440	189	52	1720	11		0.008	<0.001	0.89	0.034	<0.05		0.011	0.004
EFGW2D	30/04/2019	7.56	8900	39.6	<1	<1	202	202	8	2810	187	51	1620	10		0.007	<0.001	0.933	0.037	<0.05		0.009	0.002
EFGW2D	22/05/2019	7.98	8630	18.2	<1	<1	217	217	7	2980	192	50	1680	10		0.007	<0.001	0.929	0.032	<0.05		0.009	0.002
EFGW2D	21/06/2019	7.45	9130	11.2	<1	<1	178	178	2	2910	235	49	1660	11		0.008	<0.001	0.955	0.042	<0.05		0.01	0.002
EFGW2D	16/07/2019	7.52	8960	17.2	<1	<1	222	222	7	2750	211	54	1770	11		0.007	<0.001	0.948	0.04	<0.05		0.009	0.003
EFGW2D	27/08/2019	7.66	8960	16	<1	<1	200	200	1	2710	202	48	1670	10		0.007	<0.001	1.05	0.036	<0.05		0.01	0.003
EFGW2D	06/11/2019	7.5	8210	9.4	<1	<1	235	235	8	2580	156	43	1460	10	<0.01	0.007	<0.001	0.837	0.059	<0.05	0.08	0.008	0.001
EFGW2D	26/02/2020	7.87	8220	22.1	<1	<1	247	247	7	2380	152	40	1540	9	<0.01	0.01	<0.001	0.747	0.049	<0.05	0.52	0.012	0.004
EFGW2D	26/05/2020	7.86	7910	2.5	<1	<1	228	228	2	2400	156	39	1540	10	<0.01	0.011	<0.001	0.722	0.034	<0.05	0.1	0.012	0.001
EFGW2D	26/08/2020	7.81	8380	0.3	<1	<1	228	228	4	2580	190	42	1580	10	<0.01	0.009	<0.001	0.836	0.046	<0.05	<0.01	0.01	0.001
EFGW2D	19/11/2020	7.96	7010	0.5	<1	<1	266	266	2	2220	112	30	1260	8	<0.01	0.01	0.002	0.66	0.091	<0.05	0.01	0.011	0.005
EFGW2D	04/02/2021	7.92	5920	10.1	<1	<1	292	292	3	1760	78	23	1180	7	<0.01	0.014	<0.001	0.416	0.072	<0.05	0.06	0.014	0.004
EFGW3D	18/01/2018	7.96	17900		<1	<1	626	626	45	6410	486	222	3290	31		<0.001	<0.001	0.96	<0.005	0.13		0.003	0.008
EFGW3D	25/07/2018	7.71	17400	45.2	<1	<1	340	340	161	6100	504	214	3280	32		0.001	<0.001	0.964	<0.005	<0.05		<0.001	0.002
EFGW3D	30/08/2018	7.51	17800	71	<1	<1	254	254	138	6570	536	228	3570	33		<0.001	<0.001	0.955	<0.005	0.49		0.001	0.002
EFGW3D	26/09/2018	7.43	17700	17.2	<1	<1	129	129	149	6410	657	163	3400	34		<0.001	<0.001	0.746	<0.005	0.3		0.001	0.001
EFGW3D	23/10/2018	7.55	18100	18.1	<1	<1	84	84	168	6540	698	160	3380	35		0.006	<0.001	0.585	0.059	0.19		0.007	0.002
EFGW3D	15/11/2018	7.24	18200	4.3	<1	<1	69	69	200	6420	766	168	3620	37		0.003	<0.001	0.542	0.062	<0.05		0.004	0.001
EFGW3D	26/02/2019	7.63	18100	6.6	<1	<1	72	72	190	6170	625	187	3320	44		0.004	<0.001	0.742	0.077	<0.05		0.004	0.002
EFGW3D	26/03/2019	7.08	18100	14.6	<1	<1	53	53	186	6990	705	158	3380	35		0.001	<0.001	0.684	0.093	<0.05		0.002	0.001
EFGW3D	30/04/2019	7.04	19100	4.3	<1	<1	52	52	187	6830	685	160	3310	34		0.002	<0.001	0.64	0.032	<0.05		0.002	<0.001
EFGW3D	22/05/2019	7.41	19200	9.1	<1	<1	53	53	192	7030	713	171	3620	36		<0.005	<0.005	0.699	0.069	<0.05		<0.005	<0.005
EFGW3D	20/06/2019	6.87	19600	3.5	<1	<1	57	57	192	7180	760	165	3380	35		0.002	<0.001	0.598	0.059	<0.05		0.002	<0.001
EFGW3D	16/07/2019	7.05	19600	4	<1	<1	61	61	178	6720	741	173	3470	36		0.002	<0.001	0.519	0.055	<0.05		0.003	<0.001
EFGW3D	27/08/2019	7.23	19200	1.9	<1	<1	67	67	194	6510	656	168	3290	34		0.002	<0.001	0.631	0.048	<0.05		0.004	<0.001
EFGW3D	06/11/2019	7.07	19300	6.6	<1	<1	82	82	175	6790	607	164	3100	33	<0.01	0.003	<0.001	0.7	0.101	<0.05	0.09	0.003	<0.001
EFGW3D	26/02/2020	7.49	20100	4.1	<1	<1	79	79	192	6720	615	177	3520	34	<0.01	0.002	<0.001	0.713	0.057	<0.05	0.04	0.003	<0.001
EFGW3D	26/05/2020	7.27	19000	5.5	<1	<1	71	71	186	7890	640	182	3590	35	<0.01	0.002	<0.001	0.748	0.127	<0.05	0.08	0.003	<0.001
EFGW3D	26/08/2020	7.46	19200	12.1	<1	<1	86	86	180	6980	710	173	3470	34	<0.01	0.002	<0.001	0.691	0.009	<0.05	0.26	0.002	<0.001
EFGW3D	24/11/2020	7.35	19300	8	<1	<1	96	96	184	7390	616	188	3470	35	<0.01	0.002	<0.001	0.732	0.081	<0.05	0.08	0.002	<0.001
EFGW3D	04/02/2021	7.27	18900	4.5	<1	<1	88	88	163	6880	576	190	3560	36	<0.01	0.002	<0.001	0.726	0.016	<0.05	0.06	0.002	<0.001
EFGW4D	17/01/2018	7.52	16400		<1	<1	376	376	618	8890	610	535	4330	77		0.002	<0.001	0.797	<0.005	4.22		0.003	0.003
EFGW4D	24/07/2018	7.93	24600	56.7	<1	<1	439	439	636	8570	602	583	4470	81		0.003	<0.001	0.756	<0.005	4.47		0.003	<0.001
EFGW4D	31/08/2018	7.11	22700	45.7	<1	<1	445	445	734	8790	605	607	4640	84		0.003	<0.001	0.768	<0.005	4.06		0.003	<0.001
EFGW4D	27/09/2018	7.1	28600	47.5	<1	<1	463	463	631	8330	632	593	4600	84		0.002	<0.001	0.755	0.02	4.11		0.002	0.002
EFGW4D	24/10/2018	7.48	16100	35.6	<1	<1	442	442	590	8640	628	591	4510	81		0.002	<0.001	0.72	0.031	4.1		0.002	0.001
EFGW4D	15/11/2018	6.9	28800	93.5	<1	<1	416	416	698	8780	656	651	4870	87		0.002	<0.001	0.74	0.015	3.8		0.003	0.003
EFGW4D	26/02/2019	7.77	25600	28.1	<1	<1	420	420	691	8520	586	649	4520	106		0.002	<0.001	0.694	0.014	3.15		0.002	<0.001
EFGW4D	26/03/2019	7	25900	39	<1	<1	445	445	683	9300	606	595	4470	83		0.002	<0.001	0.751	0.015	3.59		0.002	<0.001
EFGW4D	30/04/2019	6.86	26800	30.8	<1	<1	451	451	668	9290	591	611	4480	80		0.002	<0.001	0.714	0.012	4.04		0.003	0.002
EFGW4D	22/05/2019	7.47	25800	41.4	<1	<1	452	452	704	9120	610	628	4800	83		<0.005	<0.005	0.741	<0.025	1.95		<0.005	<0.005
EFGW4D	21/06/2019	6.84	27400	40.7	<1	<1	414	414	670	9260	642	696	4900	90		<0.005	<0.005	0.783	<0.025	4.1		<0.005	<0.005
EFGW4D	16/07/2019	6.78	27400	37.3	<1	<1	448	448	677	8600	664	625	4640	85		<0.005	<0.005	0.723	<0.025	4.04		<0.005	<0.005
EFGW4D	27/08/2019	6.99	28400	7.6	<1	<1	463	463	633	8520	584	592	4550	83		0.002	<0.001	0.749	0.009	4.28		0.002	<0.001

Sample Information		Physico-chemical														Dissolved Metals							
Sample Location	Date	pH	Electrical Conductivity @ 25°C	Turbidity	Hydroxide Alkalinity as CaCO3	Carbonate Alkalinity	Bicarbonate Alkalinity as CaCO3	Total Alkalinity as CaCO3	Sulfate as SO4	Chloride	Calcium	Magnesium	Sodium	Potassium	Aluminium	Arsenic	Lead	Manganese	Zinc	Iron	Aluminium	Arsenic	Lead
EFGW4D	06/11/2019	6.81	29200	33.3	<1	<1	452	452	614	9330	528	561	4170	77	<0.01	0.002	<0.001	0.696	0.011	3.64	<0.01	0.002	<0.001
EFGW4D	26/02/2020	7.37	26700	30.6	<1	<1	438	438	707	9060	572	592	4770	85	0.02	0.005	<0.001	0.276	<0.005	5.34	2.61	0.006	0.002
EFGW4D	26/05/2020	7.25	26300	32.2	<1	<1	414	414	627	8740	584	601	4740	84	<0.01	0.002	<0.001	0.725	0.008	3.57	0.31	0.003	<0.001
EFGW4D	26/08/2020	7.43	25800	45	<1	<1	428	428	665	9080	639	570	4610	82	<0.01	0.003	<0.001	0.828	0.129	3.63	0.02	0.003	0.002
EFGW4D	24/11/2020	7.25	26100	70.9	<1	<1	431	431	616	9630	587	602	4600	88	<0.01	0.002	0.002	0.808	0.295	3.68	1.78	0.003	0.008
EFGW4D	04/02/2021	7.38	21600	47.9	<1	<1	390	390	692	8900	564	588	4680	89	<0.01	0.003	0.002	0.796	0.265	4.07	0.19	0.003	0.004
EFGW5D	16/01/2018	8.15	10400		<1	<1	429	429	44	3460	120	140	1870	41		<0.001	<0.001	0.23	<0.005	<0.05		0.002	0.003
EFGW5D	25/07/2018	8.02	20600	2180	<1	<1	552	552	<1	7520	295	444	3860	76		0.005	<0.001	0.25	0.007	7.37		0.01	0.02
EFGW5D	31/08/2018	7.42	21600	231	<1	<1	567	567	2	7620	306	456	4020	78		0.003	<0.001	0.332	0.115	4.34		0.007	0.025
EFGW5D	27/09/2018	7.41	20400	275	<1	<1	536	536	<1	7360	336	451	4030	80		0.004	<0.001	0.284	0.016	9.44		0.004	0.003
EFGW5D	24/10/2018	7.67	20700	189	<1	<1	493	493	16	7670	334	461	3950	78		0.004	<0.001	0.256	0.016	11.1		0.005	0.001
EFGW5D	16/11/2018	7.22	20900	159	<1	<1	451	451	3	7870	357	520	4440	85		0.004	<0.001	0.261	0.021	10		0.004	0.001
EFGW5D	18/12/2018	7.4	23900	154	<1	<1	473	473	<1	7500	263	438	3920	80		0.004	<0.001	0.238	0.016	9.73		0.005	0.002
EFGW5D	26/02/2019	7.59	21200	82.9	<1	<1	458	458	<1	7660	284	488	3920	100		0.002	<0.001	0.245	0.014	3.07		0.004	0.001
EFGW5D	26/03/2019	7.11	22600	104	<1	<1	468	468	<1	8360	326	476	4130	81		0.004	<0.001	0.255	0.015	10.1		0.005	<0.001
EFGW5D	30/04/2019	7.22	22500	94.3	<1	<1	463	463	3	8140	294	481	4060	80		0.003	<0.001	0.234	0.01	9.7		0.004	<0.001
EFGW5D	22/05/2019	7.64	22600	78.2	<1	<1	466	466	3	8150	330	506	4390	84		<0.005	<0.005	0.215	<0.025	8.52		<0.005	<0.005
EFGW5D	21/06/2019	7.01	23400	110	<1	<1	433	433	<1	8340	383	471	4100	83		0.004	<0.001	0.229	0.024	9.19		0.004	<0.001
EFGW5D	16/07/2019	7.1	23000	87.1	<1	<1	463	463	2	7940	350	507	4310	86		<0.005	<0.005	0.232	<0.025	9.13		<0.005	<0.005
EFGW5D	27/08/2019	7.26	22800	63.5	<1	<1	470	470	<1	7670	322	474	4100	83		0.004	<0.001	0.233	0.024	9.73		0.006	<0.001
EFGW5D	06/11/2019	7.12	22600	97.4	<1	<1	487	487	<1	7900	280	419	3540	77	<0.01	0.003	<0.001	0.238	0.023	7.82	0.07	0.004	<0.001
EFGW5D	26/02/2020	7.68	24000	73.4	<1	<1	457	457	<1	8130	298	459	4180	82	<0.01	0.002	<0.001	0.744	0.202	3.43	0.17	0.003	0.002
EFGW5D	26/05/2020	7.48	21700	80.2	<1	<1	457	457	<1	8060	312	477	4340	84	<0.01	0.003	<0.001	0.262	0.02	10.1	0.12	0.004	0.002
EFGW5D	26/08/2020	7.49	23900	684	<1	<1	462	462	<1	8150	338	454	4150	79	<0.01	0.003	<0.001	0.251	0.019	9.24	2.53	0.007	0.007
EFGW5D	24/11/2020	7.55	23300	148	<1	<1	464	464	<1	8650	298	480	4200	84	<0.01	0.003	<0.001	0.266	0.012	9.38	1.42	0.006	0.002
EFGW5D	04/02/2021	7.67	21100	994	<1	<1	420	420	<1	8010	289	476	4280	88	<0.01	0.003	<0.001	0.27	<0.005	9.46	10.3	0.006	0.005
MBBE0001	01/06/2021	8.26	894		<1	<1	236	236	<1	131	11	7	157	6	0.08	0.002				0.07	0.07	0.001	
MBBE0002B	01/06/2021	4.48	5200		<1	<1	<1	<1	53	1530	57	145	612	3	4.72	<0.001				0.05	6.65	<0.001	
MBBE0002B	03/08/2021	4.57	4870		<1	<1	<1	<1	48	1590	52	147	658	2	6.73	<0.001				0.16	7.00		
MBBE0007	03/08/2021	7.34	47600		<1	<1	106	106	907	18500	1710	1390	9160	75	<0.05	<0.005				2.51	0.13	<0.005	
MBBE0007	01/06/2021	7.53	48200		<1	<1	116	116	943	18700	1730	1220	8130	84	0.37	<0.010				4.35	<0.10	<0.010	
MBBE0008	03/08/2021	8.65	1510		<1	25	408	433	1	240	2	1	340	4	0.12	0.001				<0.05	0.52	<0.001	
MBBE0008	01/06/2021	8.72	1520		<1	25	408	433	1	234	4	<1	323	5	0.09	0.001				<0.05	0.45	<0.001	
MBBE0001	31/01/2021	8.33	797	0.7	<1	6	220	226	<1	130	8	7	161	6							0.02	<0.001	<0.001
MBBE0001	03/08/2021	8.03	856		<1	<1	237	237	<1	137	10	7	167	6	0.06	0.001				<0.05	0.30	<0.001	
PT1	18/01/2018	8.03	11600		<1	<1	236	236	1	4050	178	50	2250	10		0.014	<0.001	0.032	0.008	0.28		0.015	<0.001
PT1	25/07/2018	8.09	11200	7	<1	<1	233	233	<1	3800	146	50	2190	10		0.013	<0.001	0.028	<0.005	0.65		0.015	<0.001
PT1	30/08/2018	7.71	11000	5.9	<1	<1	231	231	<1	3880	168	51	2260	10		0.01	<0.001	0.028	0.01	0.15		0.012	<0.001
PT1	27/09/2018	7.8	11100	9.3	<1	<1	224	224	<1	3810	179	49	2230	10		0.012	<0.001	0.029	0.011	0.6		0.014	<0.001
PT1	24/10/2018	7.91	10900	8	<1	<1	235	235	<1	3290	181	51	2230	10		0.013	<0.001	0.028	0.01	0.76		0.012	<0.001
PT1	15/11/2018	7.61	10800	6.4	<1	<1	213	213	18	3560	189	56	2420	10		0.012	<0.001	0.028	0.005	0.7		0.013	<0.001
PT1	18/12/2018	7.83	11000	7.3	<1	<1	206	206	2	3390	141	51	2160	10		0.01	<0.001	0.033	0.007	0.44		0.012	<0.001
PT1	26/02/2019	8.09	10900	4.5	<1	<1	213	213	<1	3460	138	50	2100	12		0.003	<0.001	0.024	0.008	<0.05		0.01	<0.001
PT1	26/03/2019	7.52	10800	6.3	<1	<1	218	218	<1	3620	180	50	2220	10		0.004	<0.001	0.012	<0.005	0.2		0.011	<0.001
PT1	30/04/2019	7.65	11200	6.2	<1	<1	223	223	<1	3730	148	51	2170	9		0.009	<0.001	0.026	0.008	0.49		0.011	<0.001
PT1	22/05/2019	7.97	11200	6.5	<1	<1	222	222	<1	3650	174	53	2360	10		0.008	<0.001	0.025	0.012	0.44		0.012	<0.001
PT1	21/06/2019	7.45	11500	6.4	<1	<1	209	209	<1	3600	209	50	2250	10		0.01	<0.001	0.026	0.01	0.62		0.01	<0.001
PT1	16/07/2019	7.54	11400	5.1	<1	<1	222	222	<1	3620	182	54	2380	10		0.009	<0.001	0.024	0.01	0.49		0.012	<0.001
PT1	27/08/2019	7.67	11200	4.6	<1	<1	228	228	<1	3360	168	50	2230	10		0.008	<0.001	0.027	0.014	0.43		0.012	<0.001
PT1	06/11/2019	7.56	11200	4.9	<1	<1	223	223	<1	3540	138	44	1890	9	<0.01	0.008	<0.001	0.024	0.01	0.41	<0.01	0.009	<0.001
PT1	26/02/2020	8	11300	3.8	<1	<1	204	204	<1	3390	154	47	2280	10	<0.01	0.003	<0.001	0.248	0.031	8.66	0.03	0.004	<0.001
PT1	26/05/2020	7.85	11200	4.3	<1	<1	202	202	<1	3550	152	49	2300	10	<0.01	0.009	<0.001	0.024	0.012	0.5	<0.01	0.011	<0.001
PT1	26/08/2020	7.79	11400	5.4	<1	<1	222	222	<1	3600	167	47	2290	10	<0.01	0.01	<0.001	0.029	0.036	0.55	<0.01	0.01	<0.001
PT1	19/11/2020	7.92	11400	16.7	<1	<1	188	188	6	3790	194	47	2120	9	<0.01	0.003	<0.001	0.135	0.049	<0.05	0.07	0.004	0.002
PT1	04/02/2021	8.01	11000	1.4	<1	<1	212	212	<1	3950	135	48	2340	10	<0.01	0.007	<0.001	0.073	0.056	<0.05	0.03	0.007	0.002

Total Metals				Total Petrolueum Hydrocarbons					Total Recoverable Hydrocarbons - NEPM 2013 Fractions									
Sample Location	Manganese	Zinc	Iron	C6 - C9 Fraction	C10 - C14 Fraction	C15 - C28 Fraction	C29 - C36 Fraction	C10 - C36 Fraction (sum)	C6 - C10 Fraction	C6 - C10 Fraction minus BTEX (F1)	>C10 - C16 Fraction	>C16 - C34 Fraction	>C34 - C40 Fraction	>C10 - C40 Fraction (sum)	>C10 - C16 Fraction minus Naphthalene (F2)	Benzene	Toluene	Ethylbenzene
BDW 148																		
BDW 148																		
BDW 366P																		
BDW 366P																		
BDW 366P																		
BDW 366P																		
BDW 366P																		
BDW 366P																		
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BDW 8C																		
BDW 8C																		
BDW 8C																		
BDW 8C																		
BDW368P																		
EFGW1S	2.7	0.364	12.1															
EFGW1S	2.84	0.041	0.43	<20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100	<100	<1	<2	<2
EFGW1S	1.44	0.072	2.27	<20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100	<100	<1	<2	<2
EFGW1S	0.256	0.036	0.9	<20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100	<100	<1	<2	<2
EFGW1S	0.412	0.046	0.71	<20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100	<100	<1	<2	<2
EFGW1S	0.252	0.04	0.51	<20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100	<100	<1	<2	<2
EFGW1S	0.434	0.03	0.65	<20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100	<100	<1	<2	<2

Total Metals				Total Petrolueum Hydrocarbons					Total Recoverable Hydrocarbons - NEPM 2013 Fractions									
Sample Location	Manganese	Zinc	Iron	C6 - C9 Fraction	C10 - C14 Fraction	C15 - C28 Fraction	C29 - C36 Fraction	C10 - C36 Fraction (sum)	C6 - C10 Fraction	C6 - C10 Fraction minus BTEX (F1)	>C10 - C16 Fraction	>C16 - C34 Fraction	>C34 - C40 Fraction	>C10 - C40 Fraction (sum)	>C10 - C16 Fraction minus Naphthalene (F2)	Benzene	Toluene	Ethylbenzene
EFGW1S	0.258	0.086	3.32	<20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100	<100	<1	<2	<2
EFGW1S	0.325	0.069	4.04	<20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100	<100	<1	<2	<2
EFGW1S	0.152	0.048	2.61	<20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100	<100	<1	<2	<2
EFGW1S	0.257	0.029	1.3	<20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100	<100	<1	<2	<2
EFGW1S	0.4	0.061	5.28	<20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100	<100	<1	<2	<2
EFGW1S	0.145	0.026	1.43	<20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100	<100	<1	<2	<2
EFGW1S	0.038	0.015	0.08	<20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100	<100	<1	<2	<2
EFGW1S	2.3	0.022	0.4	<20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100	<100	<1	<2	<2
EFGW1S	1.53	0.096	0.96	<20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100	<100	<1	<2	<2
EFGW1S	1.17	0.199	0.63	<20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100	<100	<1	<2	<2
EFGW1S	0.101	0.411	0.42	<20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100	<100	<1	<2	<2
EFGW1S	1.93	0.075	0.51	<20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100	<100	<1	<2	<2
EFGW2D	0.445	0.026	1.39															
EFGW2D	5.55	0.533	151	<20	<50	1180	1280	2460	<20	<20	<100	2020	1210	3230	<100	<1	<2	<2
EFGW2D	1.18	0.006	0.8	<20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100	<100	<1	<2	<2
EFGW2D	1.4	0.059	12	<20	<50	140	100	240	<20	<20	<100	200	<100	200	<100	<1	<2	<2
EFGW2D	1.49	0.123	12.4	<20	60	260	150	470	20	<20	<100	350	130	480	<100	<1	6	<2
EFGW2D	0.635	0.035	1.9	<20	<50	140	<50	140	<20	<20	<100	150	<100	150	<100	<1	<2	<2
EFGW2D	0.614	0.048	0.41	<20	<50	160	<50	160	<20	<20	<100	160	<100	160	<100	<1	<2	<2
EFGW2D	1.02	0.099	3.39	<20	<50	370	50	420	<20	<20	<100	400	<100	400	<100	<1	<2	<2
EFGW2D	1.04	0.058	2.32	<20	<50	150	<50	150	<20	<20	<100	140	<100	140	<100	<1	<2	<2
EFGW2D	0.902	0.056	0.56	<20	<50	210	<50	210	<20	<20	<100	240	<100	240	<100	<1	<2	<2
EFGW2D	1.02	0.05	0.56	<20	<50	170	<50	170	<20	<20	<100	180	<100	180	<100	<1	<2	<2
EFGW2D	0.989	0.07	0.88	<20	<50	160	<50	160	<20	<20	<100	160	<100	160	<100	<1	<2	<2
EFGW2D	1.01	0.071	0.76	<20	<50	250	<50	250	<20	<20	<100	260	<100	260	<100	<1	<2	<2
EFGW2D	0.865	0.062	0.16	<20	60	420	80	560	<20	<20	<100	440	<100	440	<100	<1	<2	<2
EFGW2D	0.837	0.087	0.97	<20	<50	500	50	550	<20	<20	<100	510	<100	510	<100	<1	<2	<2
EFGW2D	0.763	0.044	0.24	<20	<50	240	<50	240	<20	<20	<100	260	<100	260	<100	<1	<2	<2
EFGW2D	0.839	0.052	0.07	<20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100	<100	<1	<2	<2
EFGW2D	0.589	0.099	0.08	<20	<50	320	<50	320	<20	<20	<100	310	<100	310	<100	<1	<2	<2
EFGW2D	0.442	0.078	0.16	<20	<50	300	<50	300	<20	<20	<100	280	<100	280	<100	<1	<2	<2
EFGW3D	1.27	0.166	16															
EFGW3D	1.02	0.106	0.84	480	60	<100	60	120	470	470	<100	130	<100	130	<100	<1	<2	<2
EFGW3D	0.979	0.114	1.8	610	120	110	60	290	600	600	120	150	<100	270	120	<1	<2	<2
EFGW3D	0.751	0.028	0.87	300	<50	<100	<50	<50	340	340	<100	<100	<100	<100	<100	<1	4	<2
EFGW3D	0.651	0.111	0.9	140	<50	<100	50	50	140	140	<100	120	<100	120	<100	<1	4	<2
EFGW3D	0.549	0.059	0.39	<20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100	<100	<1	<2	<2
EFGW3D	0.767	0.086	0.16	100	<50	<100	<50	<50	90	90	<100	<100	<100	<100	<100	<1	<2	<2
EFGW3D	0.701	0.1	0.74	<20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100	<100	<1	<2	<2
EFGW3D	0.661	0.034	0.13	<20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100	<100	<1	<2	<2
EFGW3D	0.778	0.095	0.24	<20	<50	120	<50	120	<20	<20	<100	140	<100	140	<100	<1	<2	<2
EFGW3D	0.625	0.052	0.13	<20	<50	110	<50	110	<20	<20	<100	100	<100	100	<100	<1	<2	<2
EFGW3D	0.552	0.086	0.17	<20	<50	110	<50	110	<20	<20	<100	110	<100	110	<100	<1	<2	<2
EFGW3D	0.603	0.065	0.08	<20	<50	110	<50	110	<20	<20	<100	110	<100	110	<100	<1	<2	<2
EFGW3D	0.72	0.096	0.22	<20	<50	250	<50	250	<20	<20	<100	270	<100	270	<100	<1	<2	<2
EFGW3D	0.85	0.054	0.12	30	<50	<100	<50	<50	30	30	<100	<100	<100	<100	<100	<1	<2	<2
EFGW3D	0.77	0.149	0.27	20	<50	400	60	460	20	20	<100	430	<100	430	<100	<1	<2	<2
EFGW3D	0.694	0.023	0.43	20	<50	<100	<50	<50	20	20	<100	<100	<100	<100	<100	<1	<2	<2
EFGW3D	0.811	0.079	0.2	40	<50	<100	<50	<50	40	40	<100	<100	<100	<100	<100	<1	<2	<2
EFGW3D	0.774	0.019	0.16	40	<50	<100	<50	<50	30	30	<100	<100	<100	<100	<100	<1	<2	<2
EFGW4D	0.918	0.018	7.81															
EFGW4D	0.79	<0.005	4.72	<20	<50	220	<50	220	<20	<20	<100	220	<100	220	<100	<1	<2	<2
EFGW4D	0.79	0.006	4.31	<20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100	<100	<1	<2	<2
EFGW4D	0.728	0.021	5.12	<20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100	<100	<1	<2	<2
EFGW4D	0.801	0.037	5.25	<20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100	<100	<1	<2	<2
EFGW4D	0.799	0.025	5.96	<20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100	<100	<1	<2	<2
EFGW4D	0.694	0.012	3.39	<20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100	<100	<1	<2	<2
EFGW4D	0.788	0.012	4.75	<20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100	<100	<1	<2	<2
EFGW4D	0.754	0.018	4.76	<20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100	<100	<1	<2	<2
EFGW4D	0.803	<0.026	4.24	<20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100	<100	<1	<2	<2
EFGW4D	0.72	<0.026	4.43	<20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100	<100	<1	<2	<2
EFGW4D	0.782	<0.026	4.45	<20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100	<100	<1	<2	<2
EFGW4D	0.709	0.013	4.11	<20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100	<100	<1	<2	<2

Total Metals				Total Petrolueum Hydrocarbons					Total Recoverable Hydrocarbons - NEPM 2013 Fractions									
Sample Location	Manganese	Zinc	Iron	C6 - C9 Fraction	C10 - C14 Fraction	C15 - C28 Fraction	C29 - C36 Fraction	C10 - C36 Fraction (sum)	C6 - C10 Fraction	C6 - C10 Fraction minus BTEX (F1)	>C10 - C16 Fraction	>C16 - C34 Fraction	>C34 - C40 Fraction	>C10 - C40 Fraction (sum)	>C10 - C16 Fraction minus Naphthalene (F2)	Benzene	Toluene	Ethylbenzene
EFGW4D	0.72	0.009	3.7	<20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100	<100	<1	<2	<2
EFGW4D	0.288	0.021	9.72	<20	60	570	110	740	<20	<20	<100	630	<100	630	<100	<1	<2	<2
EFGW4D	0.756	0.01	3.61	<20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100	<100	<1	<2	<2
EFGW4D	0.831	0.146	4.01	<20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100	<100	<1	<2	<2
EFGW4D	0.956	0.324	6.8	<20	<50	360	<50	360	<20	<20	<100	320	<100	320	<100	<1	<2	<2
EFGW4D	0.864	0.282	4.41	<20	<50	150	<50	150	<20	<20	<100	130	<100	130	<100	<1	<2	<2
EFGW5D	0.251	0.051	0.3															
EFGW5D	0.651	0.176	69	130	<50	490	280	770	130	130	<100	680	230	910	<100	<1	<2	<2
EFGW5D	0.464	0.383	15.8	130	<50	140	<50	140	120	120	<100	150	<100	150	<100	<1	<2	<2
EFGW5D	0.307	0.041	16.1	30	<50	<100	<50	<50	40	40	<100	<100	<100	<100	<100	<1	<2	<2
EFGW5D	0.312	0.037	16.1	60	<50	<100	<50	<50	60	60	<100	<100	<100	<100	<100	<1	2	<2
EFGW5D	0.273	0.033	13.4	<20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100	<100	<1	<2	<2
EFGW5D	0.258	0.046	12.7	30	<50	<100	<50	<50	30	30	<100	<100	<100	<100	<100	<1	<2	<2
EFGW5D	0.25	0.04	8.96	30	<50	<100	<50	<50	30	30	<100	<100	<100	<100	<100	<1	<2	<2
EFGW5D	0.272	0.036	13.5	<20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100	<100	<1	<2	<2
EFGW5D	0.224	0.033	10.6	<20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100	<100	<1	<2	<2
EFGW5D	0.261	0.035	11.1	<20	60	<100	<50	60	<20	<20	<100	<100	<100	<100	<100	<1	<2	<2
EFGW5D	0.241	0.034	10.6	<20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100	<100	<1	<2	<2
EFGW5D	0.247	0.042	9.95	<20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100	<100	<1	<2	<2
EFGW5D	0.243	0.107	9.96	<20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100	<100	<1	<2	<2
EFGW5D	0.237	0.042	9.45	<20	<50	110	<50	110	<20	<20	<100	120	<100	120	<100	<1	<2	<2
EFGW5D	0.885	0.207	4.77	<20	<50	110	<50	110	<20	<20	<100	120	<100	120	<100	<1	<2	<2
EFGW5D	0.261	0.082	9.29	<20	<50	350	<50	350	<20	<20	<100	360	<100	360	<100	<1	<2	<2
EFGW5D	0.314	0.326	17.5	<20	<50	290	70	360	<20	<20	<100	340	<100	340	<100	<1	<2	<2
EFGW5D	0.304	0.281	14	30	<50	<100	<50	<50	30	30	<100	<100	<100	<100	<100	<1	<2	<2
EFGW5D	0.327	0.235	34.1	<20	<50	240	140	380	<20	<20	<100	340	<100	340	<100	<1	<2	<2
MBBE0001			0.06															
MBBE0002B			0.64															
MBBE0002B			0.35															
MBBE0007			3.14															
MBBE0007			3.22															
MBBE0008			0.23															
MBBE0008			0.18															
MBBE0001	0.013	<0.005	<0.05															
MBBE0001			0.21															
PT1	0.049	0.013	0.75															
PT1	0.029	0.012	0.77	<20	<50	140	<50	140	<20	<20	<100	160	<100	160	<100	<1	<2	<2
PT1	0.029	0.009	0.71	<20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100	<100	<1	<2	<2
PT1	0.03	<0.005	0.81	<20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100	<100	<1	<2	<2
PT1	0.03	0.012	0.74	<20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100	<100	<1	<2	<2
PT1	0.027	0.009	0.79	<20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100	<100	<1	<2	<2
PT1	0.034	0.012	0.83	<20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100	<100	<1	<2	<2
PT1	0.025	0.007	0.51	<20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100	<100	<1	<2	<2
PT1	0.028	0.008	0.76	<20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100	<100	<1	<2	<2
PT1	0.026	0.012	0.75	<20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100	<100	<1	<2	<2
PT1	0.028	0.018	0.68	<20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100	<100	<1	<2	<2
PT1	0.026	0.009	0.72	<20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100	<100	<1	<2	<2
PT1	0.028	0.017	0.78	<20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100	<100	<1	<2	<2
PT1	0.031	0.023	0.67	<20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100	<100	<1	<2	<2
PT1	0.024	0.009	0.66	<20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100	<100	<1	<2	<2
PT1	0.278	0.068	11	<20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100	<100	<1	<2	<2
PT1	0.026	0.01	0.67	<20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100	<100	<1	<2	<2
PT1	0.03	0.047	0.65	<20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100	<100	<1	<2	<2
PT1	0.137	0.075	0.34	<20	<50	190	<50	190	<20	<20	<100	190	<100	190	<100	<1	<2	<2
PT1	0.083	0.067	0.24	<20	<50	<100	<50	<50	<20	<20	<100	<100	<100	<100	<100	<1	<2	<2

BTEXN						TPH(V)/BTEX Surrogates		
Sample Location	meta- & para-Xylene	ortho-Xylene	Total Xylenes	Sum of BTEX	Naphthalene	1.2-Dichloroethane-D4	Toluene-D8	4-Bromofluorobenzene
BDW 148								
BDW 148								
BDW 366P								
BDW 366P								
BDW 366P								
BDW 366P								
BDW 366P								
BDW 366P								
BDW 366P								
BDW 366P								
BDW 366P								
BDW 366P								
BDW 366P								
BDW 366P								
BDW 366P								
BDW 366P								
BDW 366P								
BDW 366P								
BDW 366P								
BDW 366P								
BDW 366P								
BDW 366P								
BDW 366P								
BDW 366P								
BDW 5C								
BDW 5C								
BDW 5C								
BDW 5C								
BDW 5C								
BDW 5C								
BDW 5C								
BDW 5C								
BDW 5C								
BDW 5C								
BDW 5C								
BDW 5C								
BDW 5C								
BDW 5C								
BDW 5C								
BDW 5C								
BDW 8C								
BDW 8C								
BDW 8C								
BDW 8C								
BDW 8C								
BDW 8C								
BDW 8C								
BDW 8C								
BDW 8C								
BDW 8C								
BDW 8C								
BDW 8C								
BDW 8C								
BDW 8C								
BDW 8C								
BDW368P								
EFGW1S								
EFGW1S	<2	<2	<2	<1	<5	99.8	102	96.4
EFGW1S	<2	<2	<2	<1	<5	104	103	100
EFGW1S	<2	<2	<2	<1	<5	80.6	106	98.8
EFGW1S	<2	<2	<2	<1	<5	87.5	85.9	106
EFGW1S	<2	<2	<2	<1	<5	99.5	94.6	99.5
EFGW1S	<2	<2	<2	<1	<5	109	98	99.2

BTEXN						TPH(V)/BTEX Surrogates		
Sample Location	meta- & para-Xylene	ortho-Xylene	Total Xylenes	Sum of BTEX	Naphthalene	1.2-Dichloroethane-D4	Toluene-D8	4-Bromofluorobenzene
EFGW1S	<2	<2	<2	<1	<5	88.4	99.9	98.8
EFGW1S	<2	<2	<2	<1	<5	92.7	104	103
EFGW1S	<2	<2	<2	<1	<5	96.6	102	100
EFGW1S	<2	<2	<2	<1	<5	99.1	100	98.6
EFGW1S	<2	<2	<2	<1	<5	109	96.2	99
EFGW1S	<2	<2	<2	<1	<5	96.6	97	105
EFGW1S	<2	<2	<2	<1	<5	95.2	109	77.5
EFGW1S	<2	<2	<2	<1	<5	104	101	107
EFGW1S	<2	<2	<2	<1	<5	100	97	99.4
EFGW1S	<2	<2	<2	<1	<5	86	99.6	105
EFGW1S	<2	<2	<2	<1	<5	99.5	98.5	100
EFGW1S	<2	<2	<2	<1	<5	98.7	99	106
EFGW2D								
EFGW2D	<2	<2	<2	<1	<5	98.4	100	97.5
EFGW2D	<2	<2	<2	<1	<5	99	107	102
EFGW2D	<2	<2	<2	<1	<5	77.8	99.9	102
EFGW2D	<2	<2	<2	6	<5	102	99.5	104
EFGW2D	<2	<2	<2	<1	<5	99.1	94.5	103
EFGW2D	<2	<2	<2	<1	<5	108	97.4	97.9
EFGW2D	<2	<2	<2	<1	<5	89.6	103	100
EFGW2D	<2	<2	<2	<1	<5	93.1	103	106
EFGW2D	<2	<2	<2	<1	<5	85	103	108
EFGW2D	<2	<2	<2	<1	<5	104	99.1	104
EFGW2D	<2	<2	<2	<1	<5	109	98.2	98.5
EFGW2D	<2	<2	<2	<1	<5	97	98	108
EFGW2D	<2	<2	<2	<1	<5	95.6	101	102
EFGW2D	<2	<2	<2	<1	<5	103	99.8	104
EFGW2D	<2	<2	<2	<1	<5	97.8	95.1	95.9
EFGW2D	<2	<2	<2	<1	<5	88.8	100	106
EFGW2D	<2	<2	<2	<1	<5	97.8	96.9	108
EFGW2D	<2	<2	<2	<1	<5	97	97.5	105
EFGW3D								
EFGW3D	<2	<2	<2	<1	<5	101	98.8	103
EFGW3D	<2	<2	<2	<1	<5	101	102	103
EFGW3D	<2	<2	<2	4	<5	100	98.6	101
EFGW3D	<2	<2	<2	4	<5	93.8	101	102
EFGW3D	<2	<2	<2	<1	<5	97.4	95.7	102
EFGW3D	<2	<2	<2	<1	<5	107	95.2	99
EFGW3D	<2	<2	<2	<1	<5	90.1	104	102
EFGW3D	<2	<2	<2	<1	<5	96.7	103	103
EFGW3D	<2	<2	<2	<1	<5	89.4	104	108
EFGW3D	<2	<2	<2	<1	<5	102	101	99.2
EFGW3D	<2	<2	<2	<1	<5	106	94.3	93.8
EFGW3D	<2	<2	<2	<1	<5	96.4	96.5	106
EFGW3D	<2	<2	<2	<1	<5	92.8	99.1	102
EFGW3D	<2	<2	<2	<1	<5	102	99.2	103
EFGW3D	<2	<2	<2	<1	<5	98.3	95.9	99.8
EFGW3D	<2	<2	<2	<1	<5	85.6	103	105
EFGW3D	<2	<2	<2	<1	<5	97.1	96.8	98.8
EFGW3D	<2	<2	<2	<1	<5	94.6	97.8	89.2
EFGW4D								
EFGW4D	<2	<2	<2	<1	<5	99.4	100	109
EFGW4D	<2	<2	<2	<1	<5	104	106	107
EFGW4D	<2	<2	<2	<1	<5	71.9	98.3	100
EFGW4D	<2	<2	<2	<1	<5	83.8	94.5	105
EFGW4D	<2	<2	<2	<1	<5	100	92.8	99.6
EFGW4D	<2	<2	<2	<1	<5	116	97.2	100
EFGW4D	<2	<2	<2	<1	<5	88.8	99.8	98.2
EFGW4D	<2	<2	<2	<1	<5	91.4	99.5	107
EFGW4D	<2	<2	<2	<1	<5	92.7	99.4	111
EFGW4D	<2	<2	<2	<1	<5	102	99.1	100
EFGW4D	<2	<2	<2	<1	<5	102	95.2	106
EFGW4D	<2	<2	<2	<1	<5	98.3	97.5	108

BTEXN						TPH(V)/BTEX Surrogates		
Sample Location	meta- & para-Xylene	ortho-Xylene	Total Xylenes	Sum of BTEX	Naphthalene	1.2-Dichloroethane-D4	Toluene-D8	4-Bromofluorobenzene
EFGW4D	<2	<2	<2	<1	<5	99	102	107
EFGW4D	<2	<2	<2	<1	<5	105	99.4	104
EFGW4D	<2	<2	<2	<1	<5	100	98.9	99.8
EFGW4D	<2	<2	<2	<1	<5	85.5	99.5	104
EFGW4D	<2	<2	<2	<1	<5	108	93.5	105
EFGW4D	<2	<2	<2	<1	<5	102	94.4	102
EFGW5D								
EFGW5D	<2	<2	<2	<1	<5	98.9	101	100
EFGW5D	<2	<2	<2	<1	<5	110	104	103
EFGW5D	<2	<2	<2	<1	<5	76.6	100	107
EFGW5D	<2	<2	<2	2	<5	101	100	103
EFGW5D	<2	<2	<2	<1	<5	99.7	92.7	103
EFGW5D	<2	<2	<2	<1	<5	100	97.4	98.1
EFGW5D	<2	<2	<2	<1	<5	104	100	106
EFGW5D	<2	<2	<2	<1	<5	87.9	101	100
EFGW5D	<2	<2	<2	<1	<5	92.8	103	106
EFGW5D	<2	<2	<2	<1	<5	98.9	99.4	104
EFGW5D	<2	<2	<2	<1	<5	103	99.5	97.9
EFGW5D	<2	<2	<2	<1	<5	107	97.3	96.2
EFGW5D	<2	<2	<2	<1	<5	96.6	95.6	103
EFGW5D	<2	<2	<2	<1	<5	96.2	97.9	102
EFGW5D	<2	<2	<2	<1	<5	106	98.8	105
EFGW5D	<2	<2	<2	<1	<5	95.7	96	99.5
EFGW5D	<2	<2	<2	<1	<5	85.7	102	106
EFGW5D	<2	<2	<2	<1	<5	108	89.8	98.6
EFGW5D	<2	<2	<2	<1	<5	101	97.4	108
MBBE0001								
MBBE0002B								
MBBE0007								
MBBE0008								
MBBE0001								
PT1								
PT1	<2	<2	<2	<1	<5	96.4	98.9	95.7
PT1	<2	<2	<2	<1	<5	108	107	106
PT1	<2	<2	<2	<1	<5	69.4	101	104
PT1	<2	<2	<2	<1	<5	87.3	91.3	105
PT1	<2	<2	<2	<1	<5	101	93.8	100
PT1	<2	<2	<2	<1	<5	99.6	97.2	99.5
PT1	<2	<2	<2	<1	<5	106	100	107
PT1	<2	<2	<2	<1	<5	88.5	103	101
PT1	<2	<2	<2	<1	<5	91.3	103	105
PT1	<2	<2	<2	<1	<5	95	101	102
PT1	<2	<2	<2	<1	<5	102	102	105
PT1	<2	<2	<2	<1	<5	108	96.6	97.2
PT1	<2	<2	<2	<1	<5	101	98.2	107
PT1	<2	<2	<2	<1	<5	95	101	104
PT1	<2	<2	<2	<1	<5	108	98.3	102
PT1	<2	<2	<2	<1	<5	98	95.9	98.4
PT1	<2	<2	<2	<1	<5	86.8	103	106
PT1	<2	<2	<2	<1	<5	95.8	95.6	105
PT1	<2	<2	<2	<1	<5	101	99.4	106

APPENDIX III

Summary of Groundwater Quality

Appendix II
Groundwater Hydrographs

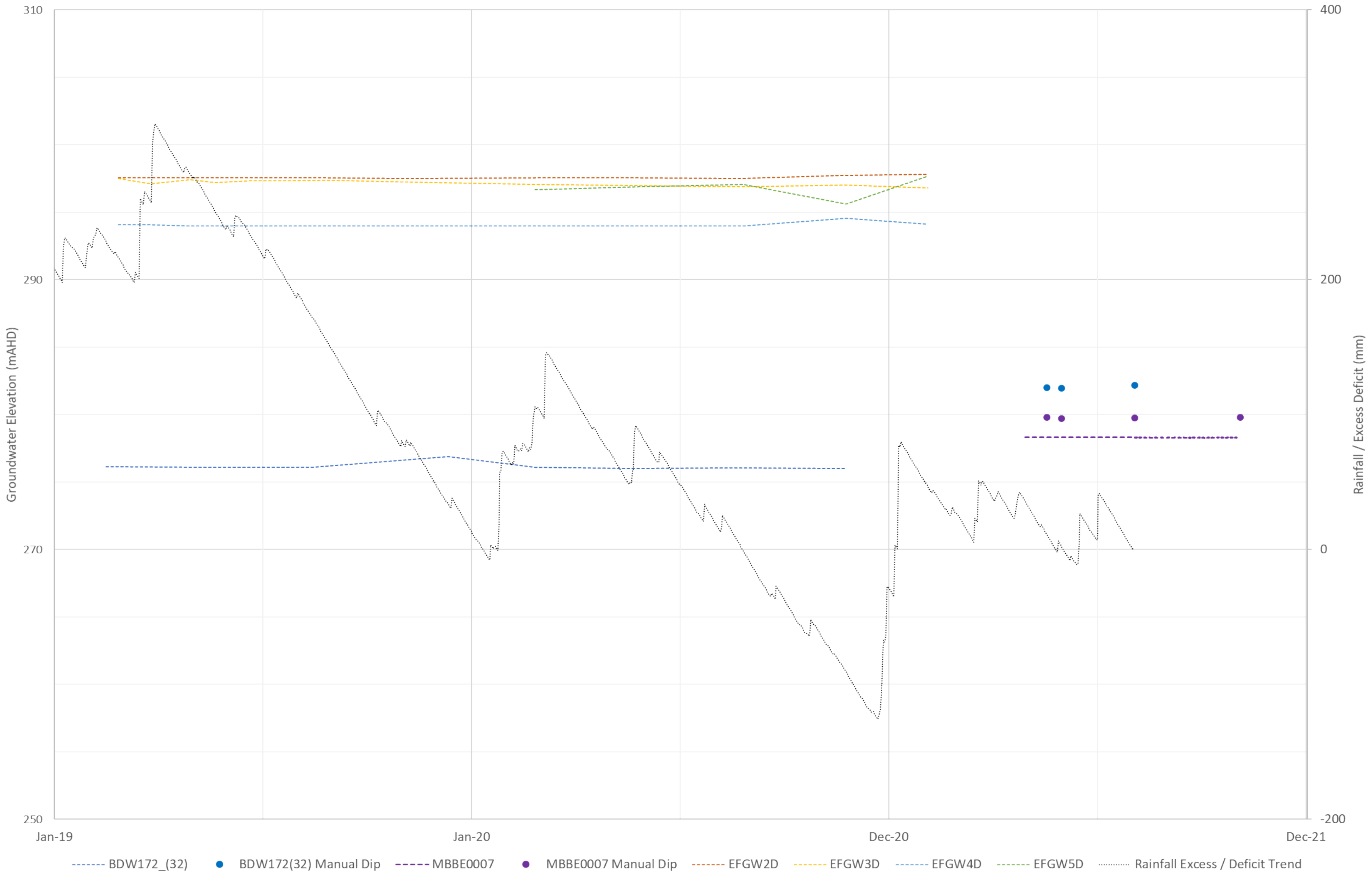

Figure III-1 Rewan Group Hydrograph

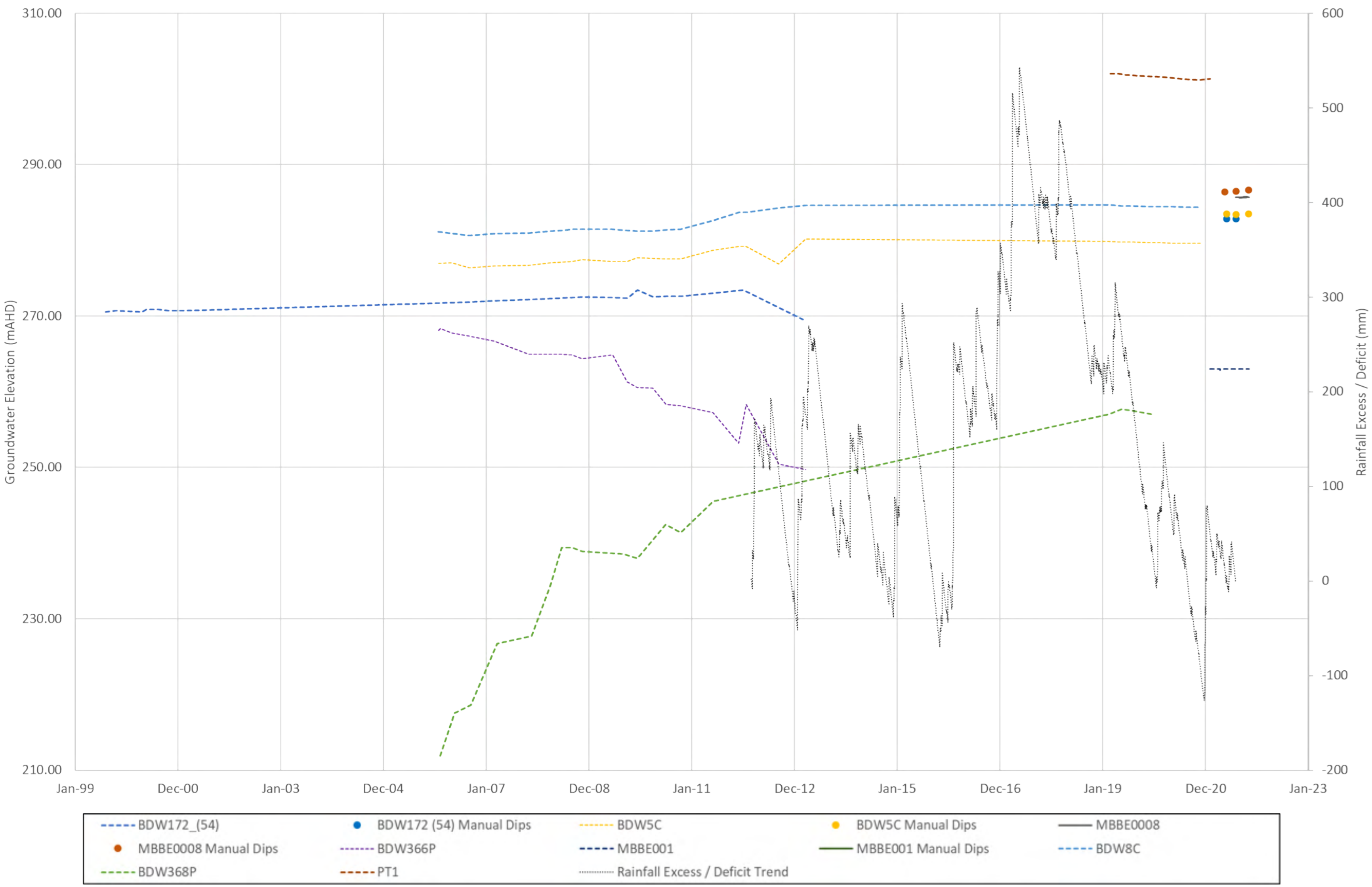

Figure III-2 Rangal Group Hydrograph

APPENDIX IV

Summary of Numerical Modelling

Klohn Crippen Berger

30 August 2021

RPMGlobal
Level 14
310 Ann Street
Brisbane, QLD
4000

Monique Roberts-Thomson
Senior Environmental Advisor

Dear Ms. Roberts-Thomson:

Broadmeadows East Project
Numerical Groundwater Modelling Report

KCB Australia Pty Ltd (KCB) is pleased to provide RPMGlobal Holdings Limited (RPMGlobal) with this Numerical Groundwater Modelling Report for the Broadmeadow East (BME) Project. This report supports, and is to be read in conjunction with, the BME Project Groundwater Impact Assessment (KCB 2021). Please contact Chris Strachotta (cstrachotta@klohn.com) if you have any queries regarding this document.

Yours truly,

KCB AUSTRALIA PTY LTD.

Chris Strachotta RPGeo
Principal Hydrogeologist

CS:JW

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TABLE OF CONTENTS

List of Tables

TABLE OF CONTENTS

List of Figures

1 INTRODUCTION

KCB Australia Pty Ltd (KCB) has developed a 3D numerical groundwater flow model for the Broadmeadows East (BME) Project (the Project) to simulate the existing conditions of the groundwater regime and provide predictions of the potential impacts of the proposed mining activities. The Project is defined by ML 70257, which was formerly a part of the Burton Coal Mine Complex, located to the northeast of Moranbah in Central Queensland's Bowen Basin.

The model represents the hydrogeology of the Project area and its surrounds based on the conceptual groundwater model described in the Groundwater Impact Assessment Report; and, the proposed mine plan and mining schedule of the Project. The modelling results presented in this appendix have been used to support the assessment of groundwater impacts presented in the Groundwater Impact Assessment Report.

1.1 Model Objectives

A calibrated groundwater flow model was developed for the Project and its surrounds to assess the impact of groundwater dewatering/depressurisation on the local and regional groundwater systems.

The objectives of the model were to quantify:

- Changes to local and regional groundwater flow patterns due to the Project;
- Project dewatering/depressurisation on groundwater resources, users and the environment;
- Groundwater inflow into the project open pit; and
- Groundwater recovery following cessation of the Project operations.

The sensitivity of the model to key parameter changes was tested.

1.2 Model Domain and Hydrogeological Study Area

Figure 1 and Figure 2 presents the spatial extents of the groundwater flow model domain. The model domain was selected to reflect the regional hydrostratigraphic units while also ensuring sufficient lateral extents to include relevant historical, existing and approved future (if present) mining operations in the region. In setting the model domain, the potential extent of Project groundwater impacts was also considered. In details:

- The established model domain boundaries are primarily defined by topography and hence coincides locally with groundwater divide conditions; which represents the northeast, northwest and southeast boundaries. It also encompasses the mining activities in the vicinity of proposed mining areas.
- The southwestern boundary of the model domain is located at a distance from the Project area such that drawdown impacts resulting from the proposed mining activities are not interpreted to extend to the boundary; and, the model boundary does not include additional catchment of Smoky Creek not relevant to the assessment.

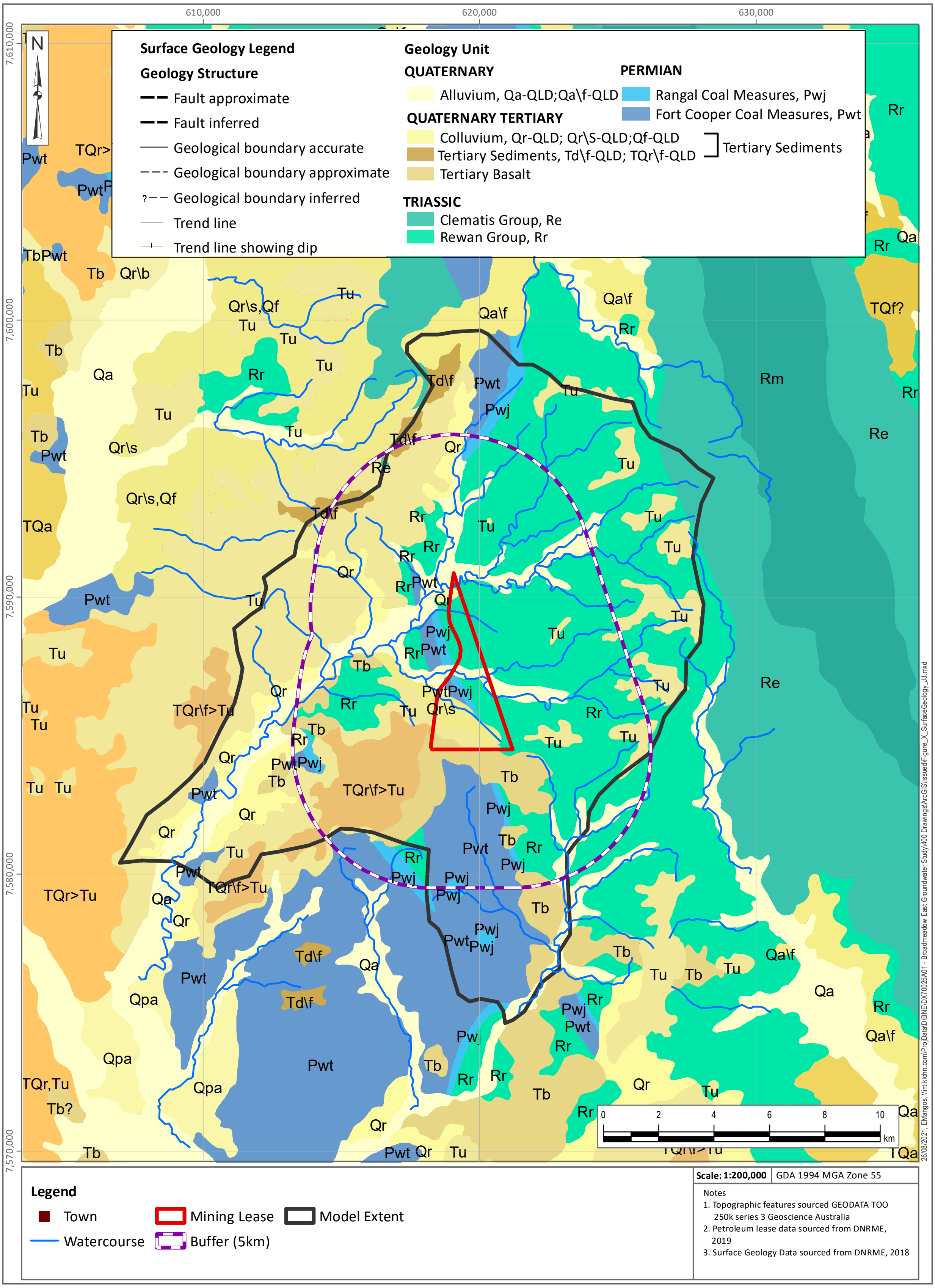


Figure 1: Surface Geology with Numerical Groundwater Model Extent

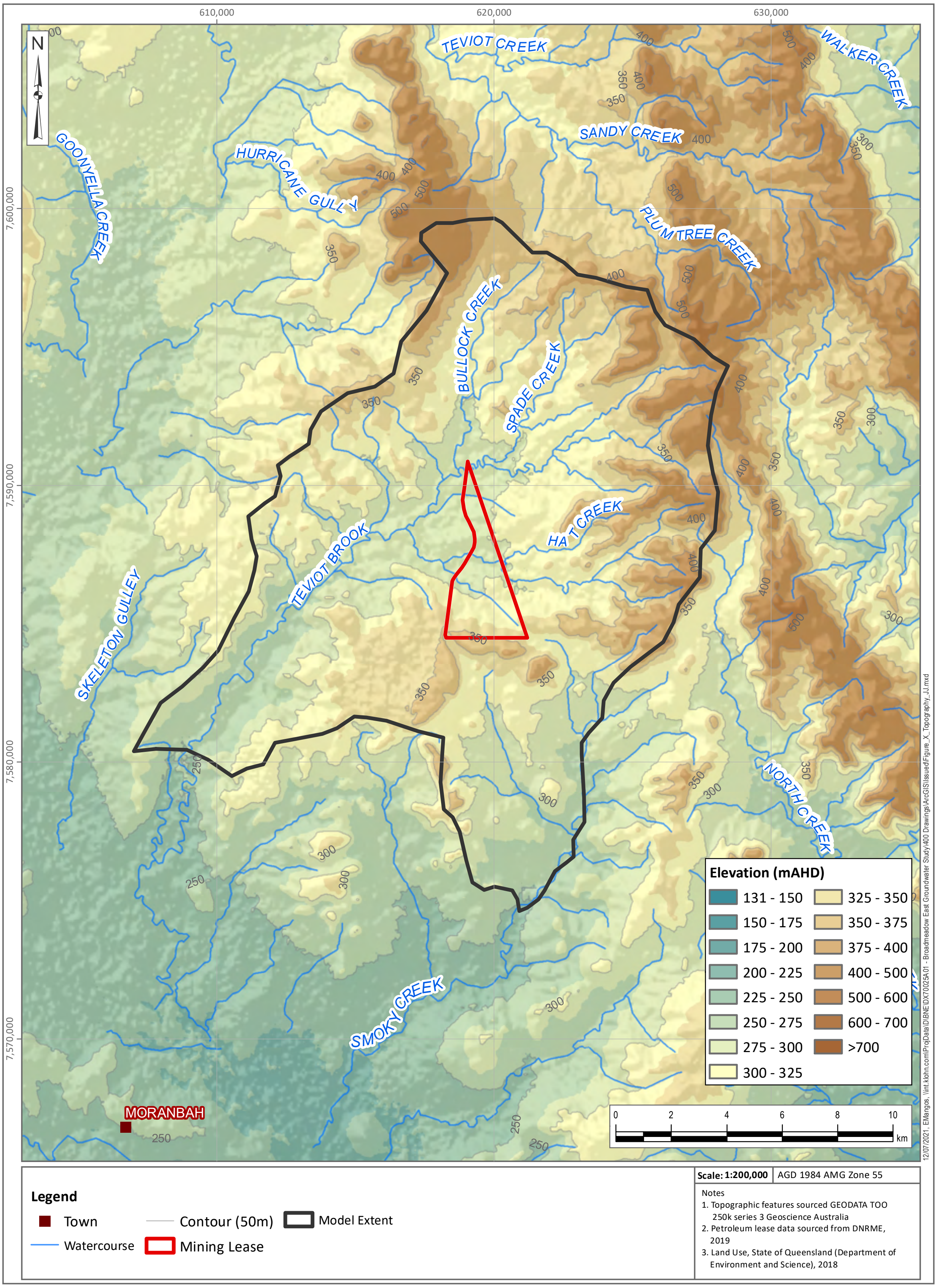


Figure 2: Surface Topography with Numerical Groundwater Model Extent

1.3 Application of Conceptual Model

Development of the groundwater flow model is based on the conceptualisation of the hydrogeological system. This conceptualisation is described in Section 6 of the Groundwater Impact Assessment Report. The hydrogeological conceptualisation is a descriptive representation of the groundwater flow system and stresses. The closer the conceptual understanding approximates the field situation, the better the performance of the numerical model in making predictions (Anderson and Woessner, 1991). The conceptual understanding defines the key processes of the groundwater system with consideration to the influence of stresses (Barnett et al., 2012).

The application of the conceptual understanding to the groundwater flow model required synthesis and description of the geology framework and consideration of the groundwater flow systems that are present within the vicinity of the Project area.

A thrust fault to the west of the Project area has upthrown and subsequently eroded the overlying Triassic strata to expose the Rangal Coal Measures. The position of the thrust fault defines the location of appreciable hydrostratigraphic unit displacement and has been represented by model layer elevations and hydraulic property changes. In this conceptual setting the fault restricts groundwater flow as a flow barrier in the horizontal direction.

2 MODEL DESIGN

2.1 Model Code Selection

Structurally, the water bearing formations within the study area are complex. Due to the processes that formed the upper Tertiary units, along with the folding nature of the pre-Tertiary sediments, along with the influence of the regional thrust fault, all modelled units with the exception the bottom model layer are discontinuous across the model domain. This can be difficult to reproduce using modelling platforms that are based on regular grid arrangements, as all layers are required to be laterally extensive across the model domain.

MODFLOW-USG is an “unstructured grid” version of MODFLOW that has the capabilities to use an irregular grid structure with arbitrary cell/node connections. This enables focused grid refinement to occur in areas where detail is important, without the need for continuation of grid refinement to the extents of the model domain. It also facilitates implementation of pinching-out layers and/or layer discontinuities within the modelled domain. In complex models, this can greatly reduce the number of grid cells within the model domain and thus greatly reduce model runtimes. In addition, MODFLOW-USG implements an “upstream weighting” formulation of the groundwater flow equation that allows cells to dewater and re-saturate with relative impunity. Ideal for simulating mining activities where dewatering and groundwater recovery is prominent. For these reasons, MODFLOW-USG was selected for this assessment.

2.2 Model Processing and Discretisation

Algomesh was used to develop an unstructured grid based on Voronoi polygons and to calculate cell connectivity along with geometries of connected cell interfaces necessary for execution of the MODLOW-USG model. In doing so, grid mesh refinement was focused on the extent of the Quaternary alluvium, major surface water drainage lines, major structures and the proposed mine development areas. The key hydrostratigraphic units are refined with average mesh size ranges from 300 to 350 m, and the minimum allowable internal angle in any single cell was set to 30 degrees. The proposed mining area were discretised into fine rectangular meshes with orientations in line with the mining schedule. The minimum allowable cell thickness was set as at 0.2 m thereby instructing Algomesh to pinch-out cells that have thicknesses less than this.

The resulting grid cell mesh developed from these settings is shown in Figure 3 and Figure 4. Six model layers were used to represent the hydrostratigraphic units underlying the Project area; these are discussed further in the following section. The final model grid comprises 45,733 active cells.

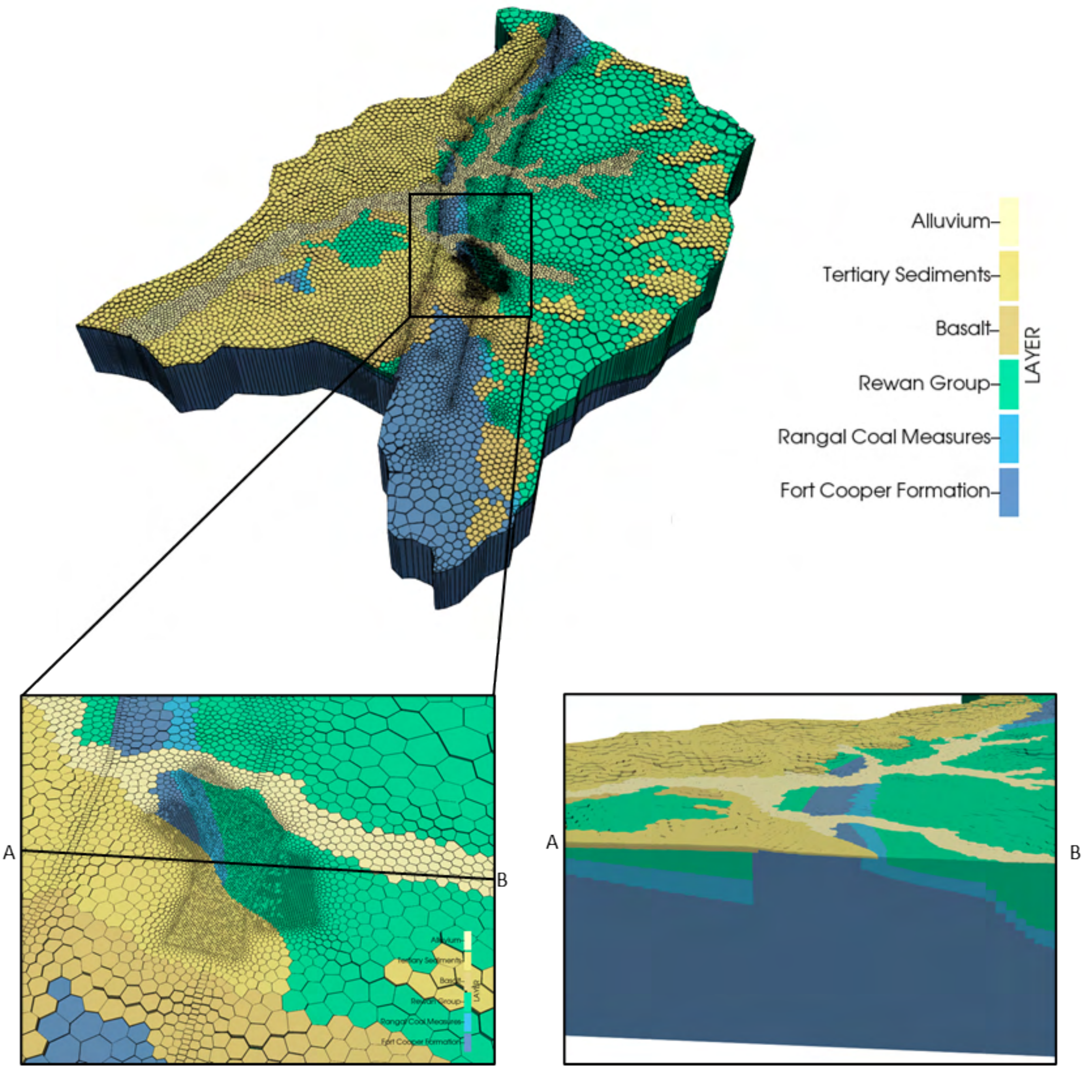


Figure 3: 3D Diagram of Groundwater Model Geometry (Vertical exaggeration = 2x)

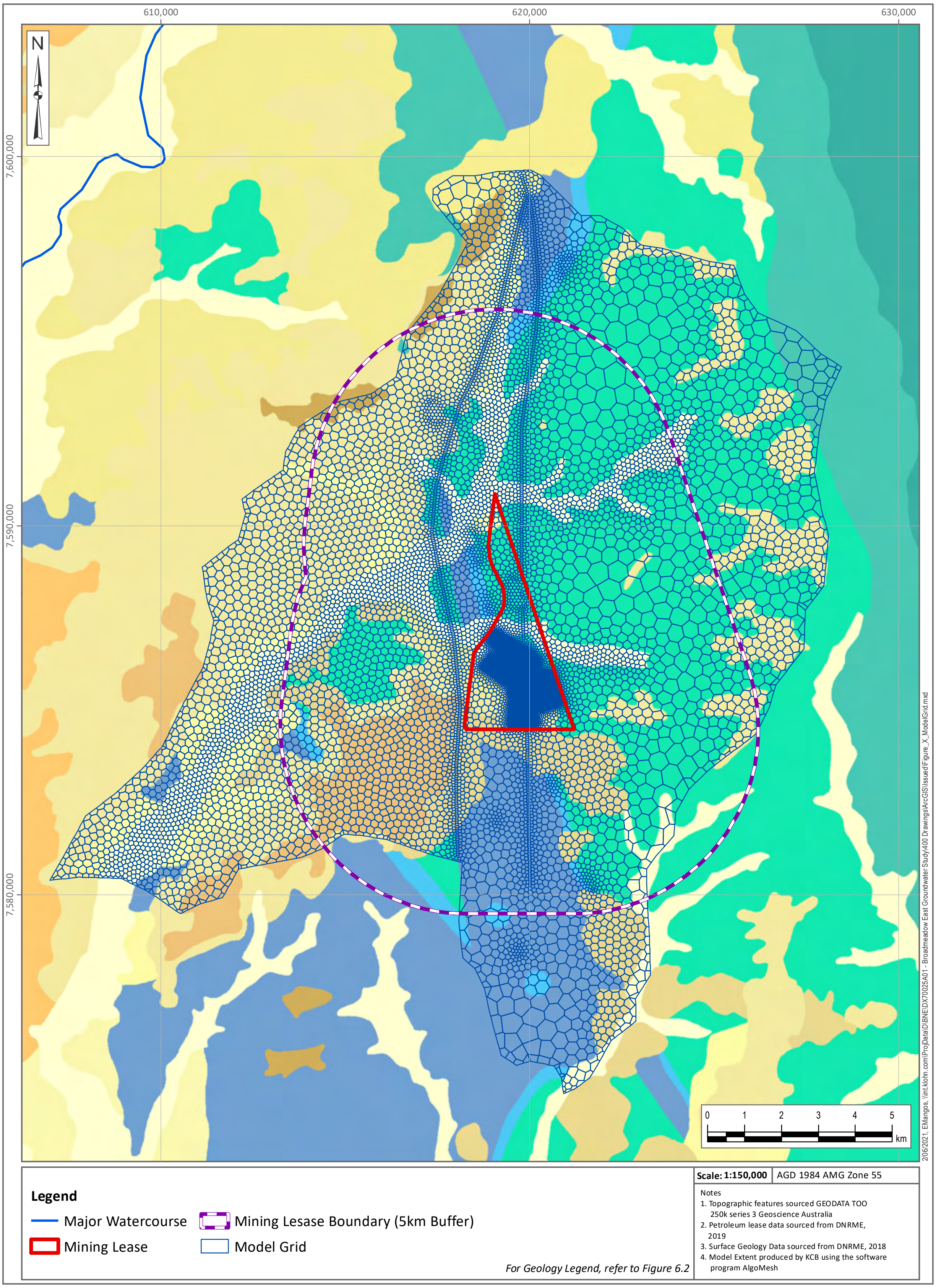


Figure 4: Groundwater Model Domain and Grid Mesh

2.3 Units and Datum

The time unit for the model is days and the length unit is meters. In the horizontal plane the model uses the AMG84 Zone 55 projection, while the vertical datum is the Australian Height Datum (AHD) in meters.

2.4 Model Layers

The hydrostratigraphy of the Project area was represented using six model layers that are predominantly discontinuous across the model domain. The uppermost surface is defined by a digital elevation model derived from SRTM data and is used in its unaltered form. Table 1 and Figure 5 present the model layers and the primary geological units that are represented by each.

Table 1: Summary of Model Layers

Model Layer	Hydrogeological Unit	Geological age
1	Alluvium	Quaternary
2	Tertiary Sediments	Tertiary
3	Basalt	
4	Rewan Group	Triassic
5	Rangal Coal Measures	Permian
6	Fort Cooper Coal Measures	

The surfaces that were used to develop the above layers are derived from the following:

1. Surfaces and isopachs provided by Zenith and NitroSolutions.
2. Borehole logs from Geological Survey of Queensland drilled investigation holes;
3. Publicly available CSG drilling logs accessed from the QDEX database;
4. Surfaces and data from the Bowen Basin Supermodel 2000; and,
5. Outcrop locations of surface geology mapping.

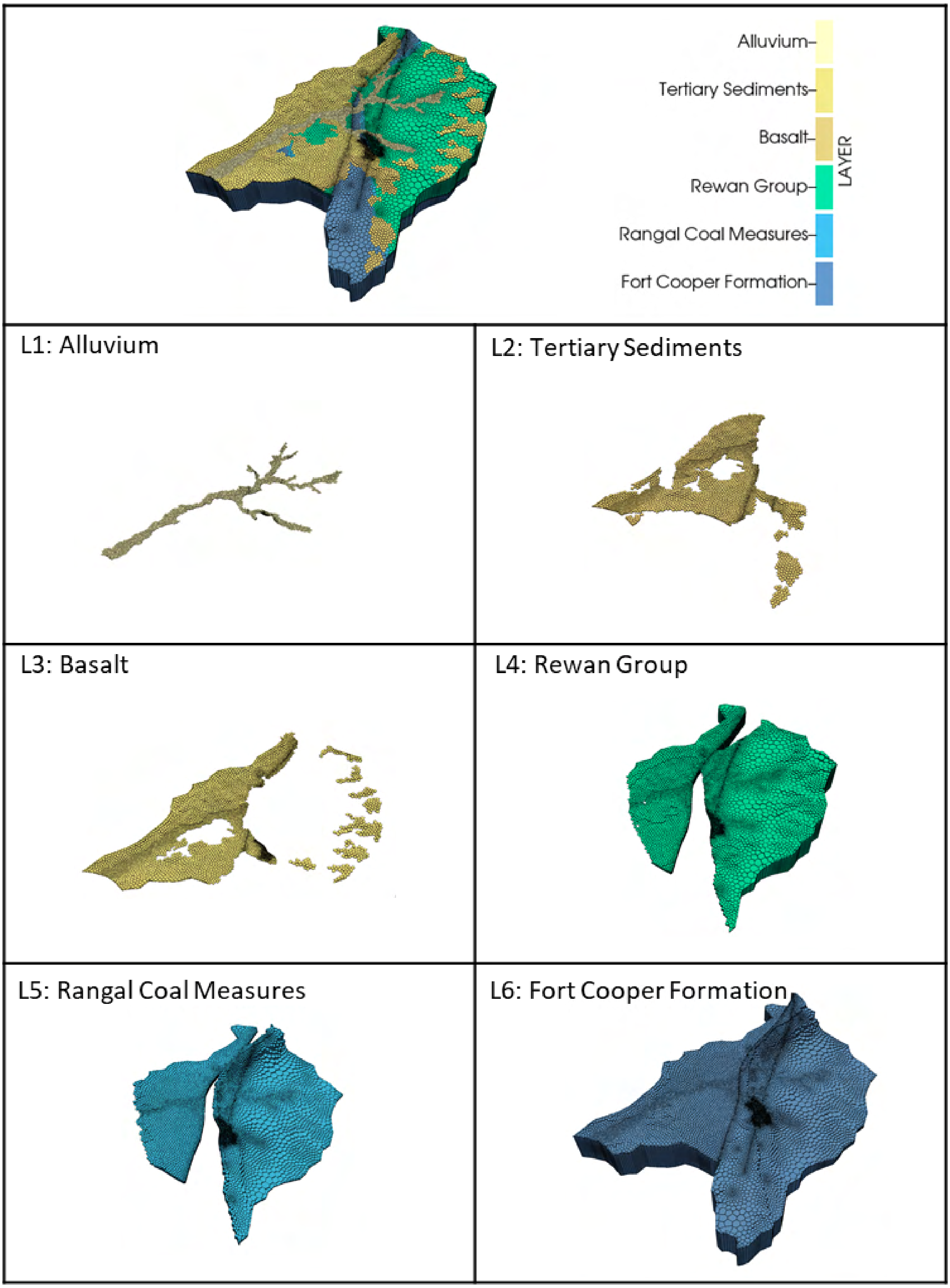


Figure 5: Layer Extents and Morphology in the Numerical Groundwater Model

2.5 Model Boundary Conditions

Boundary conditions are necessary for the solution of the 3D groundwater flow equation that is implemented by MODFLOW-USG. They also provide a means by which auxiliary groundwater fluxes and stresses can be specified within the model. The following boundary conditions have been adopted in the model:

- Rainfall Recharge was applied in zones based on the extents of outcropping geological units, using the RCH package of MODFLOW. Recharge is regarded as the fraction of rainfall that passes through the unsaturated zone and arrives at the groundwater system. Within the model it has been calculated as a percentage of historically recorded quarterly rainfall totals. Four recharge zones are defined, each of which has a unique recharge rate that reflects the porosity of the strata through which it infiltrates. The percentage of rainfall that enters the model as recharge in each zone was adjusted during calibration. The recharge zones are defined by the extents/outcrop of Quaternary alluvium, Tertiary sediments, Tertiary basalt, and Permian sediments.

- Evapotranspiration is a boundary component of the water budget for the groundwater system. In this model, it has been implemented using the MODFLOW EVT package. A uniform extinction depth has been applied across the domain and set at 1.5 m below the natural surface, below which evaporative losses from the groundwater surface are zero. Where the groundwater elevation is above this level, water is removed from the system at a maximum rate of 1,200 mm/annum. This value is adopted from the average areal potential evapotranspiration map (BOM, 2008), which is based on a standard 30-year climatology from 1961-1990.

- General Head Boundary cells (GHB package) were implemented around the active perimeter of the model domain. They are applied to all layers of the model. Use of this boundary type allows for the regional groundwater flow system to be better replicated in the semi-regional model developed here. Conductance values applied to the GHB cells were calculated to be consistent with hydraulic conductivity values for each hydrostratigraphic unit and the dimensions of the boundary cells. A reference head for these cells was obtained from steady-state model heads in a pre-development scenario. This boundary is sufficiently distant from the study area so as not to materially influence model prediction performance.

- General head Boundary cells have also been applied to simulate current mining activities in the vicinity of the proposed mining area. Boundary cells are placed in model top with head values extracted from Google Earth, and these values are slightly modified during the calibration to provide a better performance.

- The major water courses in the model domain are represented using the MODFLOW Drains package (DRN). The surface drainage system of the area is ephemeral in nature. When stream flows do happen, they are usually rapid and persist for short periods of time. Under these circumstances use of drains along these reaches is considered appropriate. In these cells the reference head was specified as the model top and a conductance was calculated to be consistent with the hydraulic conductivity and dimensions of the cell in which they are placed.

- Drains cells have also been used to simulate open-cut activities across the model domain. In the Project area itself, drains are placed in all layers above and including the target coal seam layer, in accordance with the mining schedule provided by NitroSolutions. Reference drain elevations were specified in accordance with this schedule, while conductance values for these drain cells were set nominally high values of more than 10 m^2/day.
- The default, no flow boundary condition is used on the base of the model which is located far below the Fort Cooper Coal Measures. This boundary is located at a significant depth below the Project mining area and has no material influence on the model results.

2.6 Application of Hydraulic Parameters

Hydraulic properties for the model layers, corresponding to the Quaternary to Permian sediments, have been applied under the assumption of homogeneity across the model domain. Vertical hydraulic conductivity in all layers is calculated as a factor of the horizontal hydraulic conductivity.

2.7 Calibration Process and Metrics

Model calibration was performed based on the adjustment of model parameter values to allow better replication of historical observations of the system. The outcome of the calibration process also provides the initial conditions for transient predictive simulations used to assess potential impacts of the project on the groundwater regime.

The transient period used for model calibration consists of quarterly stress periods over the duration March 2019 to Feb 2021. This was preceded by a steady-state stress period to condition the model prior to the transient calibration. For predictive model runs a quarterly stress period sequence was adopted.

2.7.1 Calibration Approach

The location of the Project area is within an area of the Bowen Basin that is heavily exploited and comprises numerous mining operations that have previously been in operation. As a result groundwater levels from monitoring bores adjacent to historical operations display variability as a result of these mining activities (e.g. drawdown due to dewatering, recovery at the cessation of mining operations). Without an understanding of the historical mining activities and associated schedules, it is difficult to match modelled results with certain monitoring bore as part of the calibration process. Therefore, a review of the available monitoring bore network was undertaken to identify monitoring bores, and associated water level records, that could be incorporated into the calibration process. Further, calibration focused on the more recent system condition (over the period March 2019 to Feb 2021), where limited mining activities were undertaken.

The calibration model run was initiated as a steady state simulation with boundary conditions applied to replicate known mining development before March 2019. Following this initial model conditioning period, the model transitions to transient mode for the aforementioned calibration period, during which quarterly stress periods are implemented. This stress period length readily accommodates the inclusion of seasonal, climatic variations in rainfall records. All observations used as calibration targets pertain to the transient component of the simulation. In all, 28 adjustable parameters were used. These include hydraulic conductivities, storage properties and recharge factors.

2.7.2 Calibration Targets

All observations that comprise the calibration dataset are water level measurements. These measurements were compiled from 11 monitoring bores for which reliable water level measurements were available over the transient calibration simulation period. In total, 99 individual measurements are used in the calibration process, with the majority of these collected from monitoring bores. A number of monitoring bore installed across the Project area in the upper hydrostratigraphic units (e.g. Quaternary alluvium, Tertiary sediments, Tertiary basalt) were dry, indicating unsaturated conditions, and therefore, no groundwater level records. Although there were no groundwater level records from the upper hydrostratigraphic units, this unsaturated characteristic also provided a calibration criteria for the model.

2.7.3 Calibration Results

Figure 6 presents a comparison between groundwater level measurements and the calibrated model output equivalents. During calibration, all measurements of the calibration dataset were given equal weight, thereby seeking to extract maximum information from the calibration dataset during estimation of parameters.

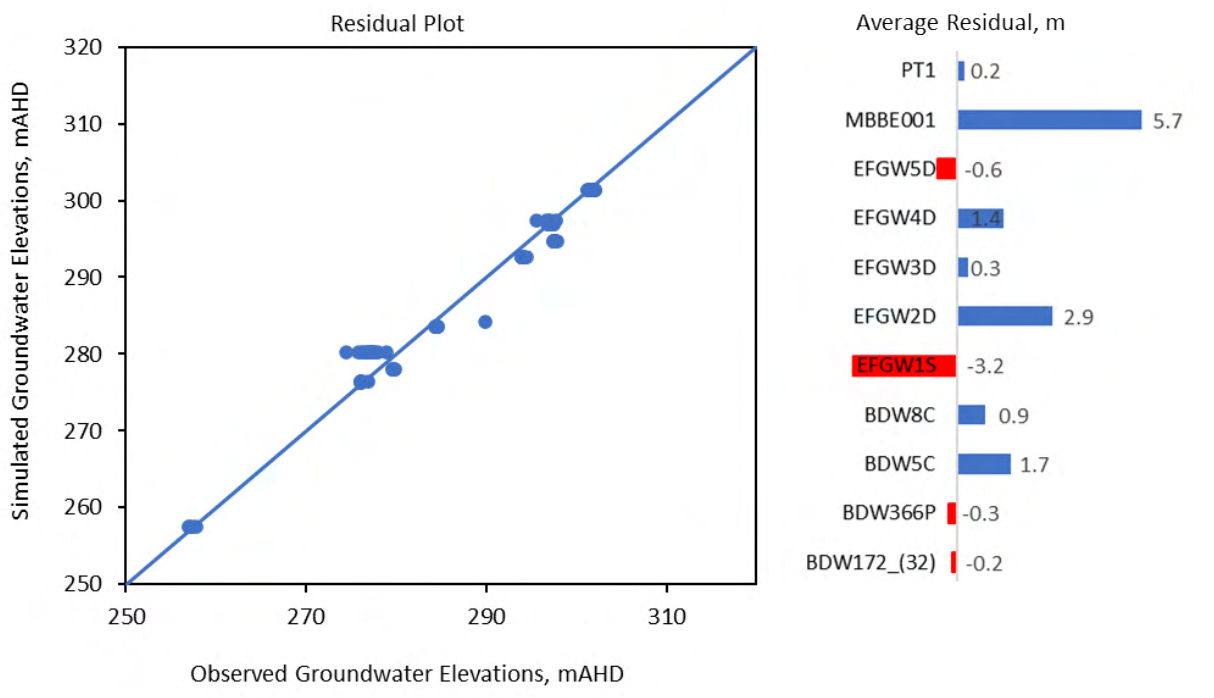


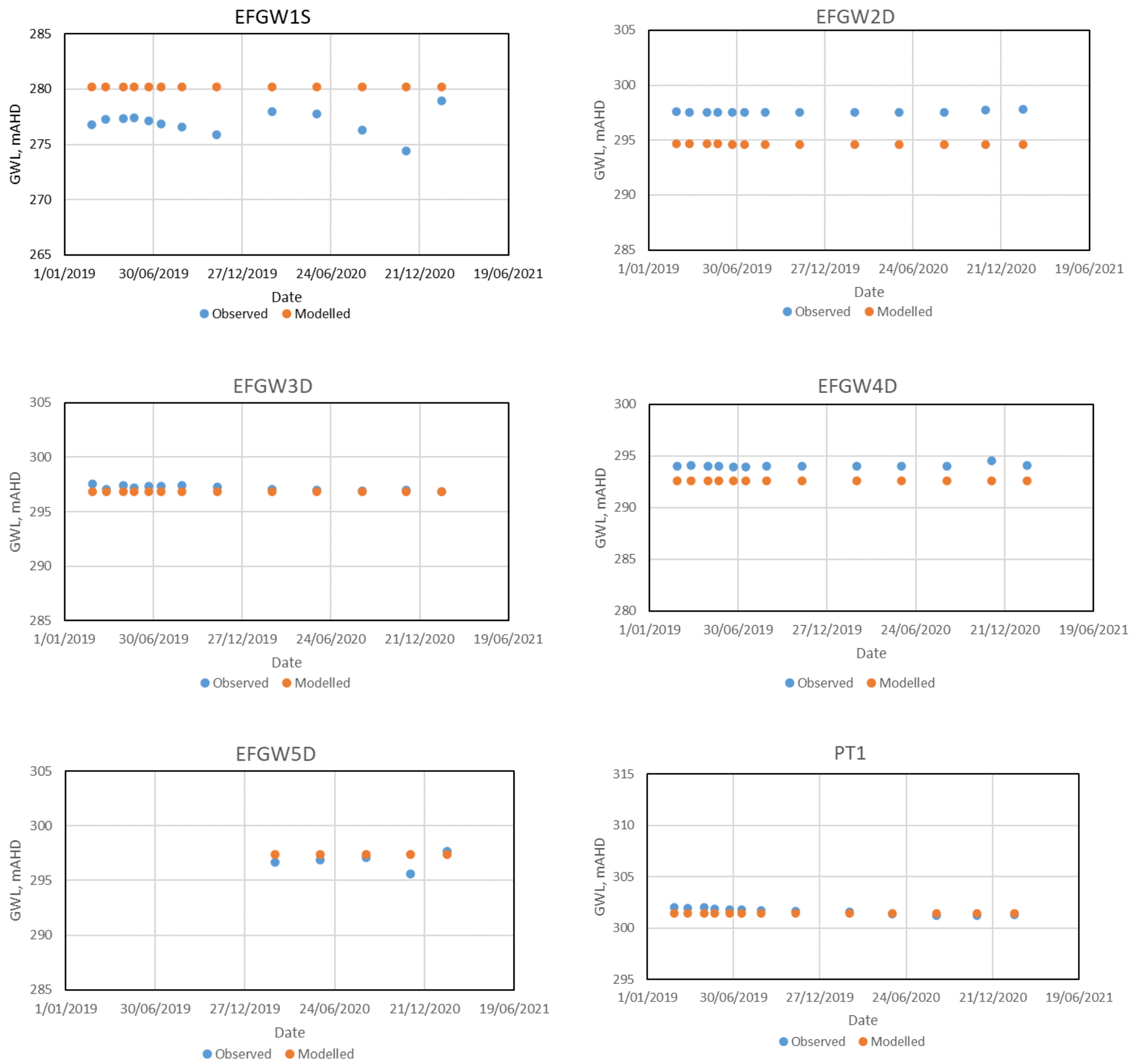
Figure 6: Cross-Plot of Calibration Residuals

Table 2 presents statistics from the calibration process. The scaled root Mean Square (SRMS) of errors from the calibration is 4.2%, which is within the guidance limits recommended by the Australian Groundwater Modelling Guidelines (Barnett et al., 2012) of 10% SRMS.

Hydrographs demonstrating the fit between modelled and measured observations, achieved through the calibration process, are shown in Figure 7.

Table 2: Summary Model Calibration Performance

Statistical Metric	Value
Number of Observations	99
RMS error (m)	1.9
Scaled RMS (%)	4.2
Mean Sum of Residuals (m)	0.44
Scaled Mean Sum of Residuals (%)	0.97
Correlation coefficient	0.98



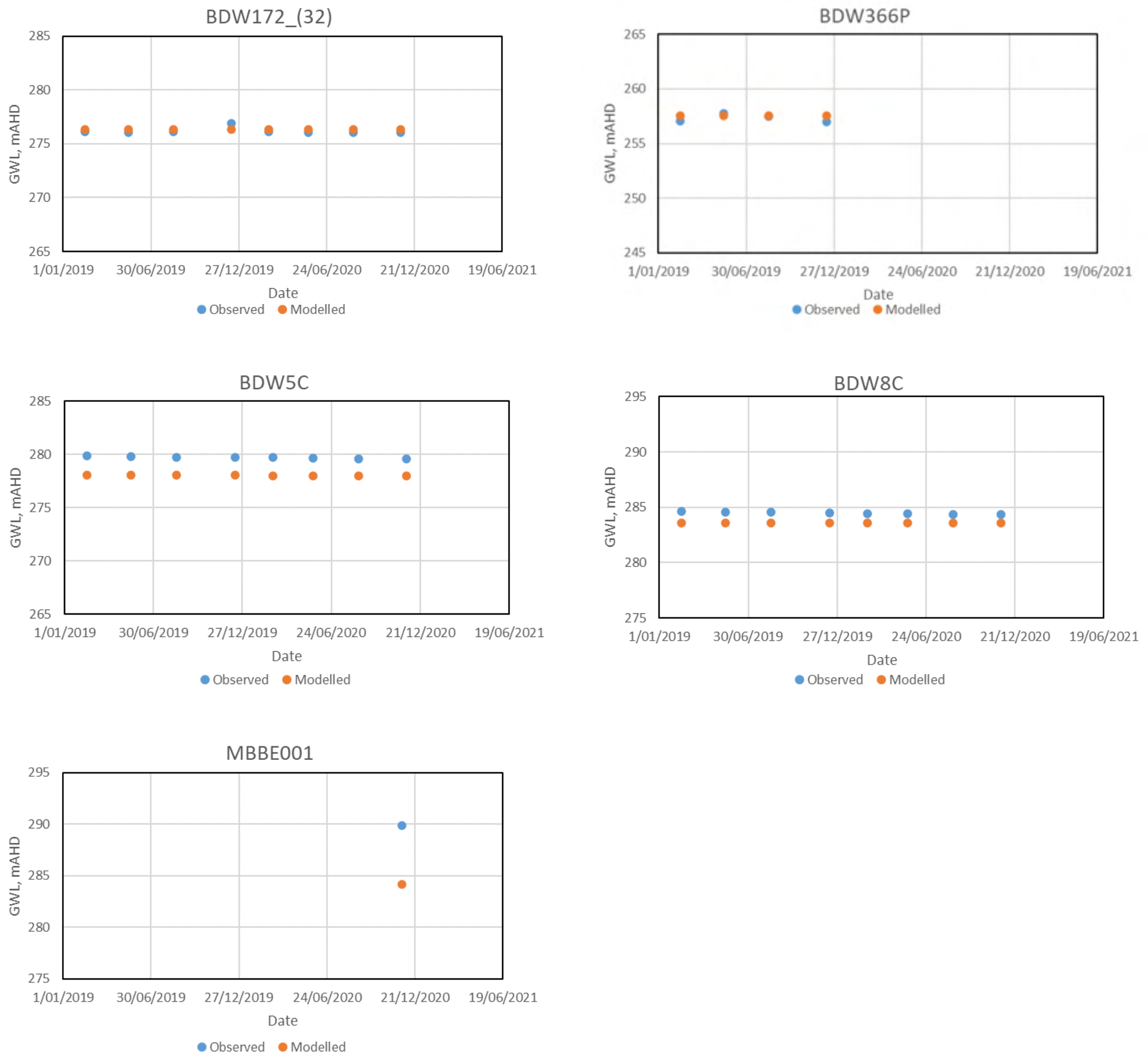


Figure 7: Modelled and Observed Hydrographs

The transient calibration results are based on monitored groundwater levels for each of the key hydrostratigraphic units within the vicinity of the Project area, and from monitoring bores distributed across the Project area; which highlights the lateral and vertical distribution of the calibration targets. Furthermore, transient groundwater level trends identified in the groundwater level monitoring records, as a result of seasonal rainfall variability, have been captured by the transient calibration simulation. Therefore, the model calibration is considered robust and adequate for undertaking subsequent predictive simulations.

2.8 Calibrated Hydraulic Parameters

Table 3 provides a summary of calibrated hydraulic property values for each hydrostratigraphic unit represented in the model.

Table 3 : Summary Calibrated Hydraulic Properties

Geological Unit	Calibrated Kxy (m/d)	Calibrated Kz (m/d)	Calibrated Specific Yield (-)	Calibrated Specific Storage (m^{-1})
Quaternary Alluvium	21.1	7.46	2.10E-01	5.13E-04
Tertiary Sediments	0.53	0.02	1.28E-03	4.86E-06
Tertiary Basalt	4.6	0.11	8.63E-03	2.64E-04
Rewan Group	0.0159	0.0011	7.08E-04	1.47E-05
Rangal Coal Measures	0.0037	0.0003	2.90E-03	1.33E-05
Fort Cooper Coal Measures	0.0019	4.33E-05	8.00E-04	3.14E-05

2.9 Calibrated Recharge Rates

Recharge to the model domain was calculated as a percentage of recorded rainfall within the model domain during each stress period of the calibration model run. During the steady-state conditioning period, long-term average annual rainfall was converted to daily rainfall, while during the quarterly transient periods, recorded quarterly rainfall totals were used. Factors by which rainfall is multiplied to arrive at recharge were estimated during calibration and these are provided in Table 4.

Table 4: Summary Calibrated Recharge Rates

Modelled Recharge Zone	Percentage of Daily Rainfall
Quaternary Alluvium	0.53
Tertiary Sediments	0.13
Tertiary Basalt	0.60
Triassic and Permian Strata	0.22

2.10 Calibrated Water Balance

The mass balance error of the transient calibration model represents the difference between model inflows and model outflows calculated by the model. An error of approximately 1% is considered acceptable (Anderson and Woessner, 1991). The model reported water budget for the final stress period of the transient calibration model is presented in Table 5. The water balance error is less than 1%, indicating that convergence of the numerical solution of the groundwater flow problem has been achieved.

Table 5: Summary Water Balance at the End of Calibration Period

Water Budget Item	Inflow (m³/day)	Outflow (m³/day)
Recharge (Rainfall deep drainage)	34	0
General Head Boundary Throughflow (Regional flow across model extents and Current mines)	1,399	1,419
Evapotranspiration (from surface heating/vegetation)	0	0
TOTAL	1,433	1,419
Mass Balance error	<1%	

2.11 Model Classification

Barnett et al. (2012) developed a system to classify the confidence level of groundwater flow models based on the calibration process used and the predictive capability of the model. Three classes of model were developed: Class 1, Class 2 and Class 3. A Class 3 model has the greatest confidence level, and a Class 1 model has the least. Factors that are considered when determining model confidence level are:

- Data availability;
- Calibration procedures;
- Consistency between calibration and predictive analyses; and
- Stresses induced on the model.

The model outlined in this report is considered a Class 2 model because:

- A transient calibration was undertaken and mining-induced groundwater trends have been replicated;
- Independent observations and calculations were used to support the calibration process; and,
- The water balance error is less than 1%.

The model meets the criteria for a Class 2 model, and, exceeds the criteria for a Class 1 model. The exceedance of the Class 1 classification is driven by the following:

- Model is calibrated and key calibration statistics have been met;
- Calibration has been undertaken to transient conditions; and,
- Model parameters are within the range of conceptualised hydraulic parameters.

The model is therefore assessed as being a suitable tool for assessing groundwater impacts that may arise as a result of the Project.

3 MODEL SIMULATIONS

3.1 Operational Dewatering/Depressurisation

The transient model for the predictive scenarios simulating dewatering/depressurisation of the Rangal Coal Measures and overlying hydrostratigraphic units is an extension of the transient calibration model, and, comprises quarterly stress periods for a seven-year duration starting at the final step of the transient calibration. Mine development for the predictive scenarios comprises the progressive assignment of MODFLOW drain cells representing open-cut mining operations. In detail, drain cells were assigned to all layers above and the corresponding target coal seams with the reference drain elevation in accordance with the mine plan elevation. A drain conductance value of 10 m^2/d was applied to each drain.

3.1.1 Drawdown and Dewatering/Depressurisation During Mining Operations

Figure 8 shows the predicted dewatering/depressurisation within the target Rangal Coal Measures due to the project development (i.e. BME open cut pits). Dewatering/depressurisation of the Rangal Coal Measures is generally constrained to the proposed Project mining area, however, the extent of drawdown in the Rangal Coal Measures is predicted to extend to approximately 1.3 km along the strike (northwest–southeast) of the unit. Maximum drawdown is predicted to be approximately 65 m, which is located within the proposed pit area.

Dewatering/depressurisation also extends into the Rewan Group overlying the Rangal Coal Measures. The Rewan Group is predicted to have a maximum drawdown of approximately 64 m within the proposed pit area, with a drawdown extent extending to approximately 2.5 km away from the centre of the pit towards the north, east and southeast (Figure 9).

Dewatering/depressurisation is not predicted to occur in the Cenozoic hydrostratigraphic units above the Rewan Group.

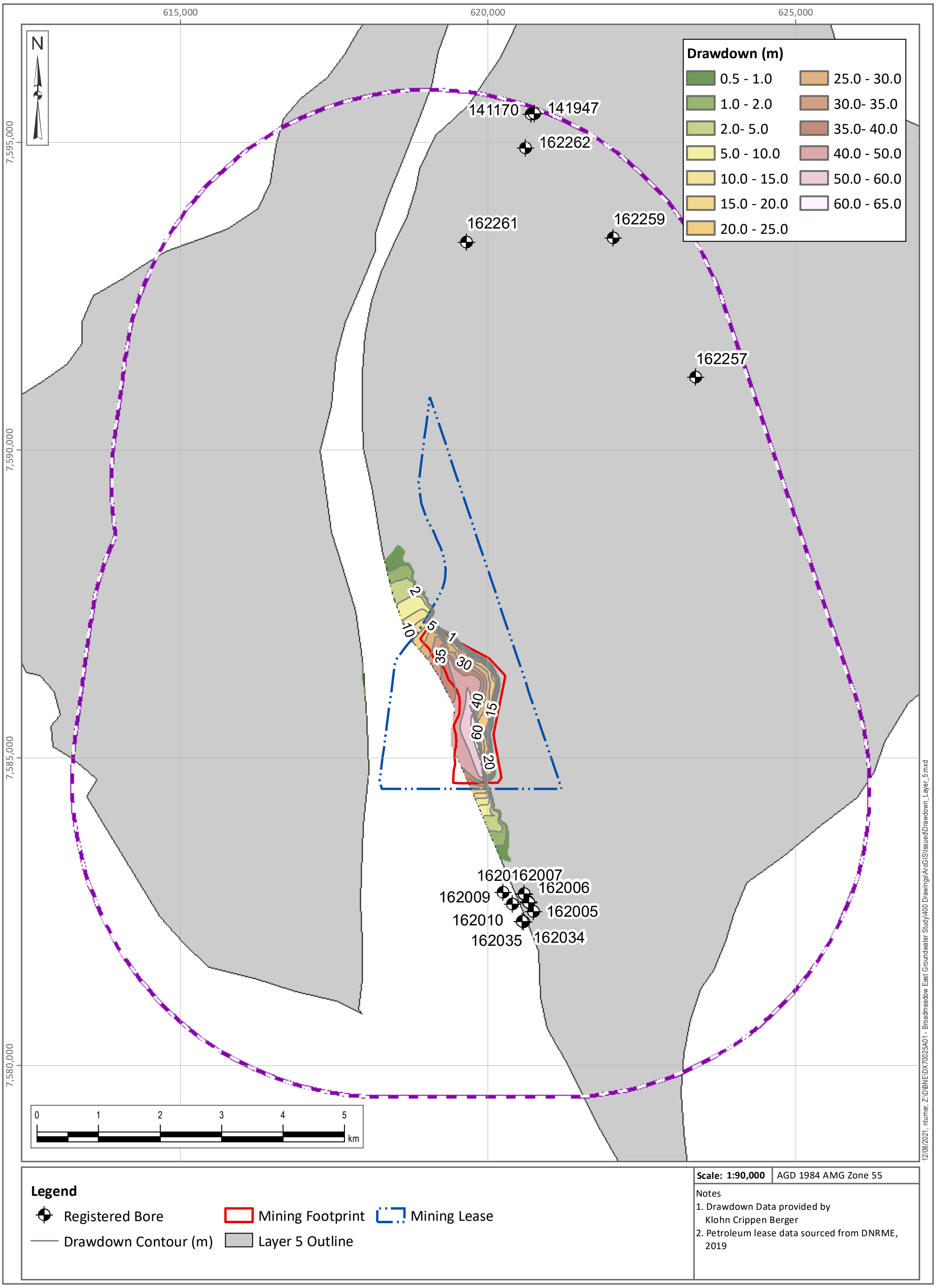


Figure 8: Predicted Dewatering/Depressurisation in the Rangal Coal Measures

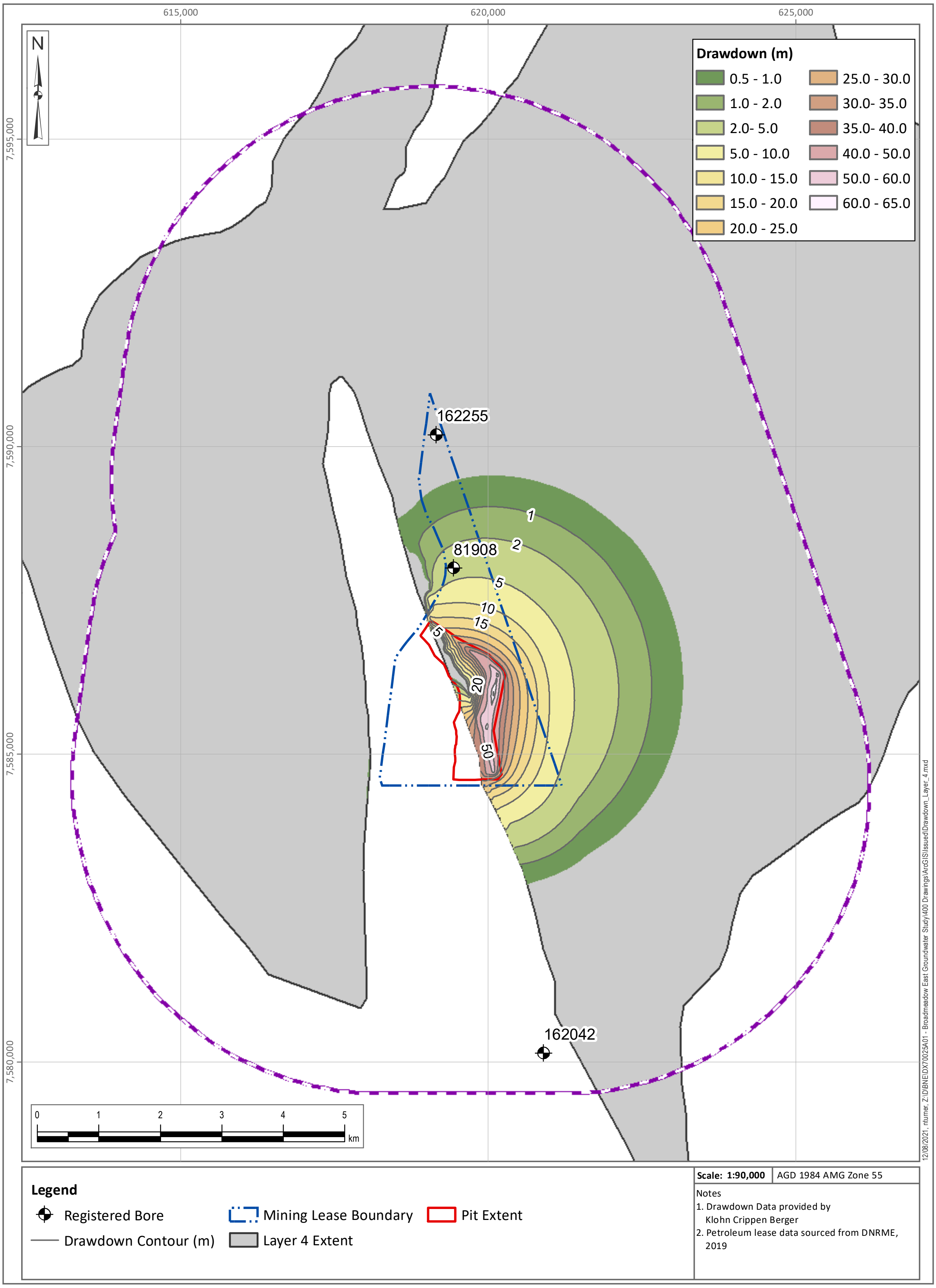


Figure 9: Predicted Dewatering/Depressurisation in the Rewan Group

3.1.2 Groundwater Inflow Estimates

Predicted groundwater inflow into the proposed BME pit over the duration of the proposed development is presented in Figure 10. The predicted rate of groundwater inflow is controlled by factors such as initial groundwater level, mining depth and extent, the thickness and hydraulic conductivity of the groundwater-bearing hydrostratigraphic units and the hydraulic gradients induced by dewatering.

The modelled groundwater inflow gradually increases as mining within the pit progresses towards the south. Inflow predominantly occurs from the Rangal Coal Measures and the Rewan Group, as the remainder of the overlying hydrostratigraphic units (i.e. Tertiary basalt, Tertiary sediments, Quaternary alluvium) are predominantly unsaturated in the vicinity of the Project area. The modelled groundwater inflow peaks at approximately 296 m^3/d, near the cessation of mining operations. This estimate of groundwater inflow represents the theoretical volume of groundwater that could be removed from the groundwater regime, and it does not account for water losses associated with the wetting of surfaces, evaporation from the pit wall surfaces, or retained moisture within the coal measures.

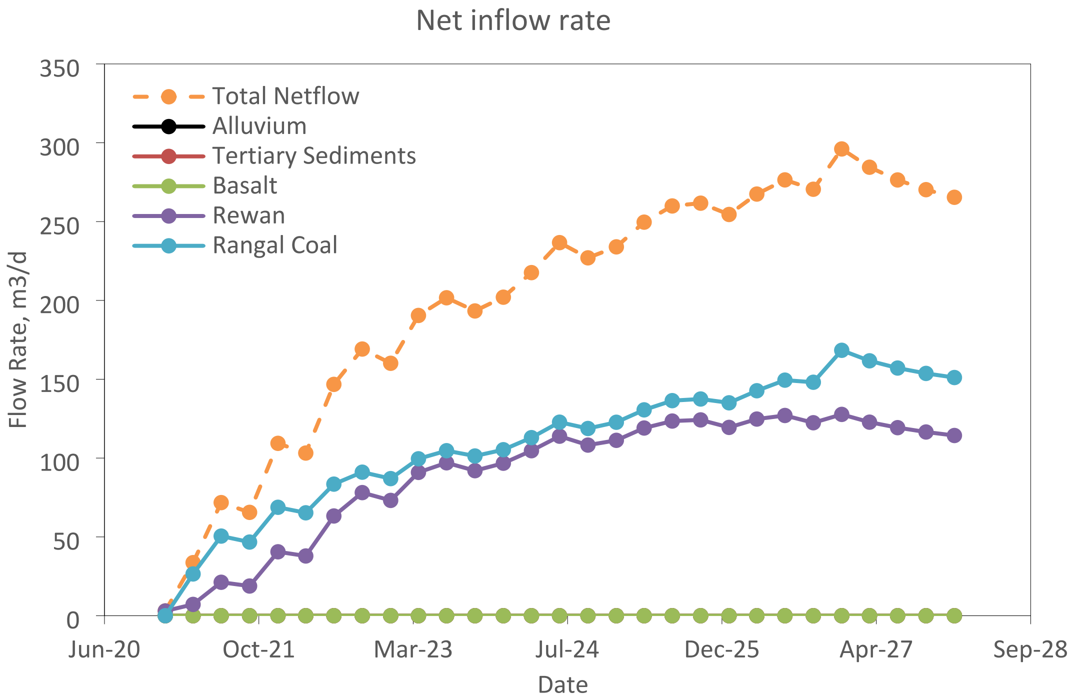


Figure 10: Open pit inflow rate during the operational depressurization

3.2 Post-closure Groundwater Level Recovery

The simulation of post-closure groundwater conditions was undertaken to assess the final lake elevations within the proposed post-closure landforms. Final pit void lake elevations were simulated using a water balance model, which was completed as part of the surface water assessment for the Project (Engeny Water Management 2021). This water balance incorporated all contributing fluxes to the pit void, which included the groundwater inflow.

The post-closure groundwater inflow flux was simulated for a range of pit void lake elevations, from the maximum inflow rate when groundwater levels are at the base of the pit to the pre-mining groundwater level elevation where no groundwater inflow is observed. The groundwater inflow-elevation curve for the BME pit void lake is provided in Figure 11. This curve was incorporated into the pit void water balance as an input flux (Engeny Water Management 2021).

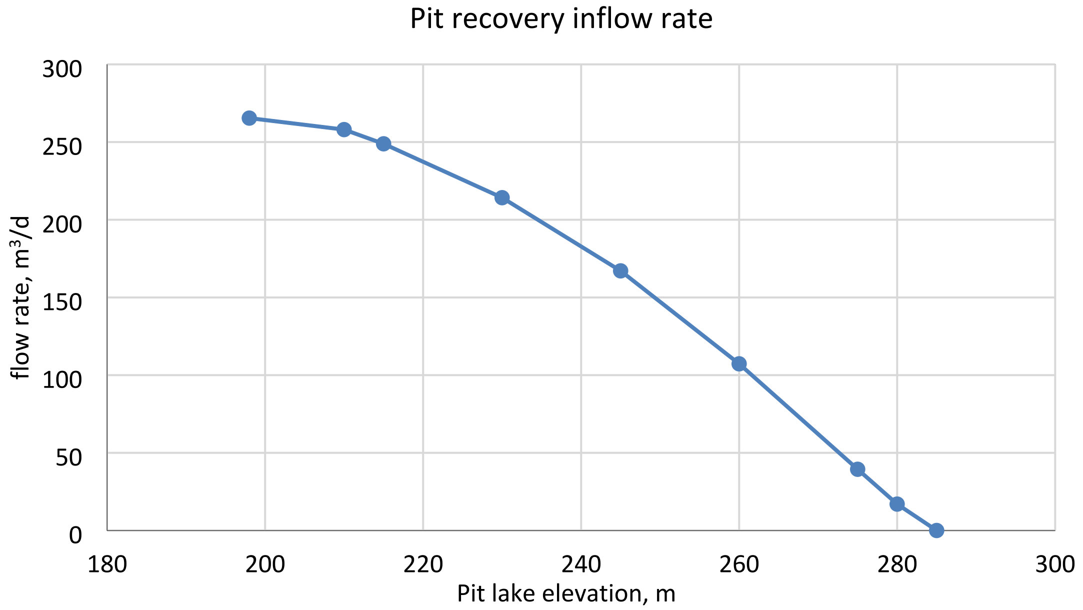


Figure 11: Groundwater Inflow Flux into the Pit Void

Post-closure steady-state elevations of the pit lakes associated with the final landform were calculated by Engeny from the water balance model (Engeny Water Management 2021). The predicted post-closure elevations of the north and south pit lakes are ~268 mAHD and ~255 mAHD, respectively. Extents for the steady-state pit voids, and the respective elevations, were applied to the groundwater model, using constant-head boundaries, to simulate the post-closure groundwater characteristics within the vicinity of the Project area. This simulation was conducted for a 500 year duration, using mean annual rainfall recharge, to allow groundwater levels to recover to equilibrium / steady-state conditions. The post-closure groundwater level elevations in the vicinity of the Project area are provided in Figure 12.

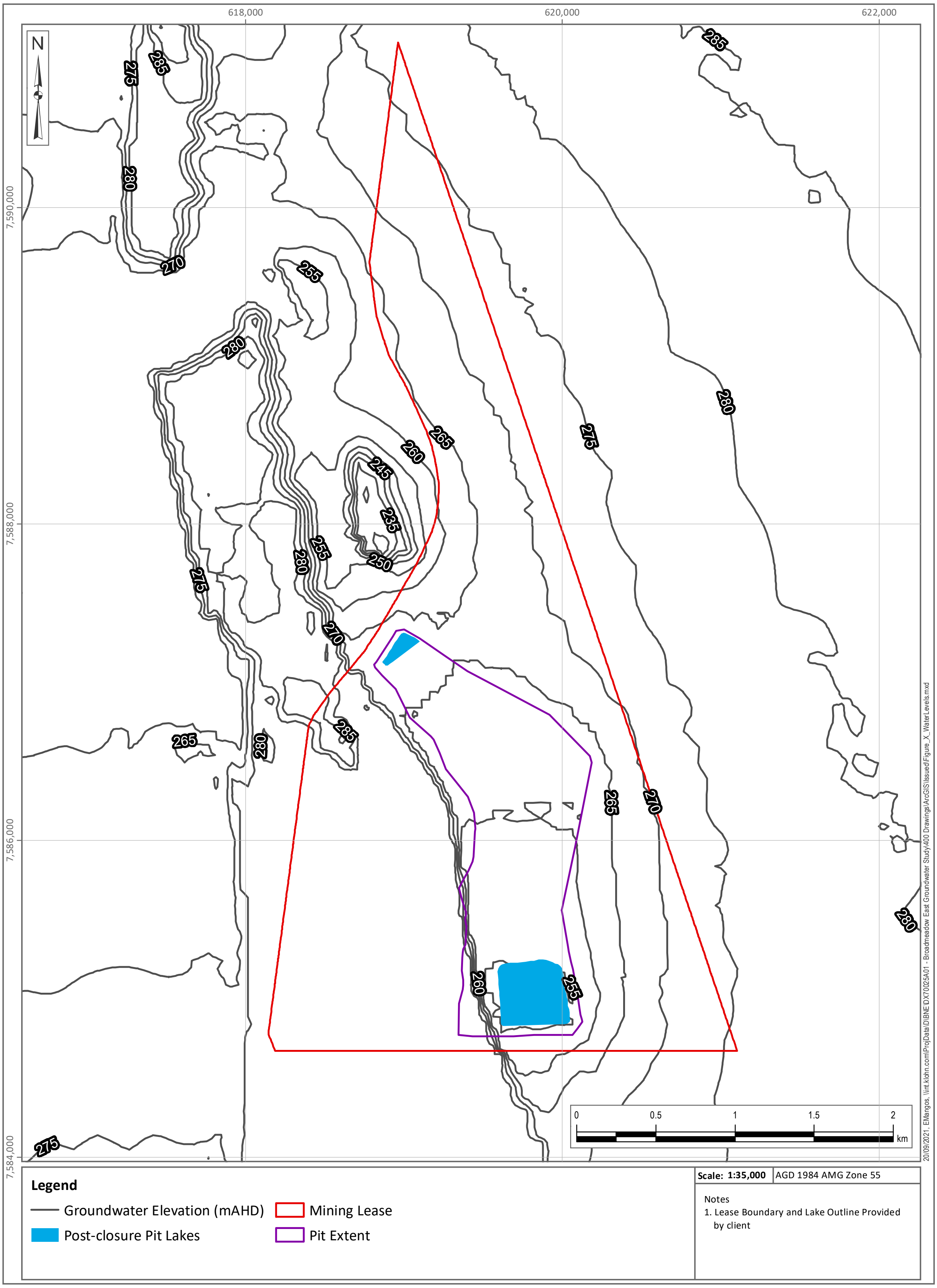


Figure 12: Post-closure Groundwater Conditions in the Vicinity of the Project Area

3.3 Sensitivity Analysis for Predicted Project Impacts

3.3.1 Overview

A sensitivity analysis of the numerical model predictions was undertaken as a method of uncertainty analysis. This adopted method of uncertainty analysis, also identified as "deterministic scenario analysis with subjective probability assessment" (IESC 2018), is an acceptable uncertainty quantification technique that has been identified by the Independent Expert Scientific Committee (IESC) on Coal Seam Gas and Large Coal Mining Development. The sensitivity analysis was performed to assess the response of the model to varying hydraulic properties and recharge rates. This analysis provides for a comparison of the influence of these properties on the outcomes of predictions made by the model. Impacts to predictions of mine groundwater inflows and maximum drawdown due to changes in hydraulic properties have been examined.

Parameters that were assessed during predictive sensitivities were grouped and varied in the following manner:

- Horizontal (Kh) and vertical (Kv) hydraulic conductivity of all layers was varied by 100% above and below calibrated values;
- Specific storage (Ss) and specific yield (Sy) values for all layers were varied by 100% above and below calibrated values; and,
- Recharge rates (Rch) were varied by 100% above and below calibrated values;

The adopted sensitivity analysis range (i.e. +/- 100%) is considered appropriate to assess the uncertainty associated with the adopted model parameters as the range broadly captures the range of measured parameter values from within the vicinity of the project area.

3.3.2 Pit Inflow Estimates

The effects of the sensitivity scenarios on predicted pit inflows are shown in Figure 13. Table 6 presents a summary of the change in predicted mine inflows resulting from scenarios tested in the sensitivity analysis. This table shows that the prediction of pit inflows are most sensitive to changes in hydraulic conductivity, however, although hydraulic conductivity is the most sensitive of model parameters test, the SRMS associated with the parameter change demonstrates that changes in the hydraulic conductivity significantly "de-calibrates" the model. Therefore, these scenarios represent extreme cases and are not an accurate reflection of real world conditions.

Predicted mine inflows are also sensitive to large variations in storage parameters, though this sensitivity is smaller than that observed with changes in hydraulic conductivity. Changes in storage parameters have negligible impact on the model calibrated condition.

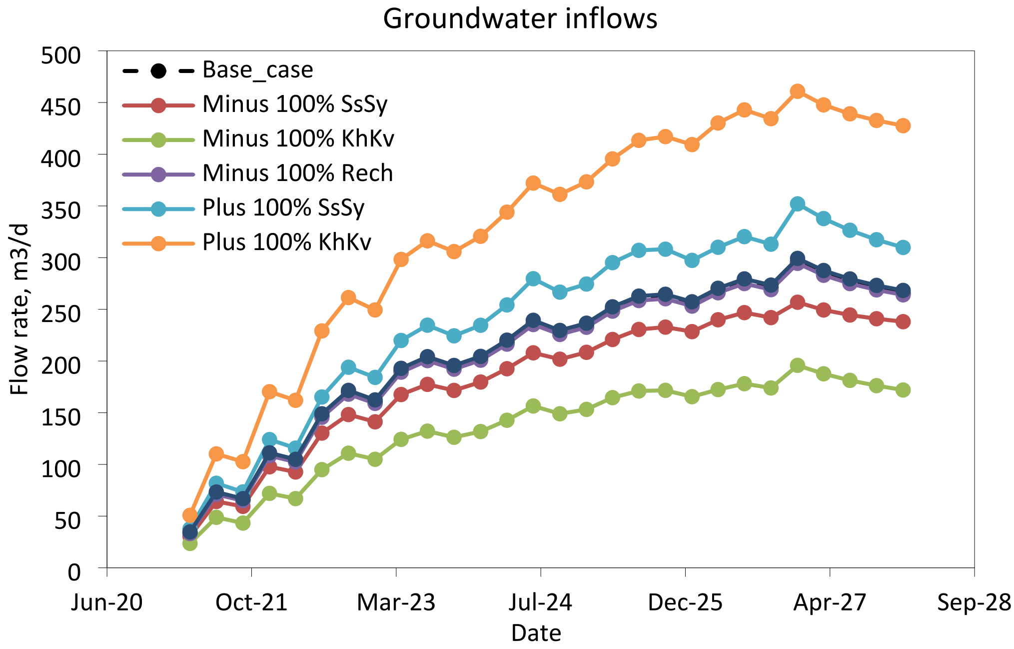


Figure 13: Sensitivity of predicted mine inflows

Table 6: Summary Results from Sensitivity Analysis

Sensitivity Scenario	Parameter Adjustment	Transient SRMS (%)	Maximum Mine Groundwater Inflow (m^3/d)	Average Mine Groundwater Inflow (m^3/d)
Calibrated – Baseline	NA	4.23	296	207
1	Kx and Kz: Minus 100%	15.35	196	135
2	Kx and Kz: Plus 100%	17.66	461	328
3	Recharge: Minus 100%	4.41	294	206
4	Recharge: Plus 100%	4.08	299	209
5	Ss and Sy: Minus 100%	4.23	257	184
6	Ss and Sy: Plus 100%	4.23	352	241

3.3.3 Drawdown Extents

The maximum extent of Project induced drawdown that results from the scenarios outlined in Section 3.3.1 are shown in Figure 14 and Figure 15. The extent of drawdown (defined by the 1 m drawdown contour) for the Rangal Coal Measures and Rewan Group, for the various sensitivity analysis cases, is similar to what was observed for the Base Case simulation (Figure 8 and Figure 9). Therefore, the drawdown extents in both the Rangal Coal Measures and Rewan Group are not sensitivity to changes in the groundwater model input parameters.

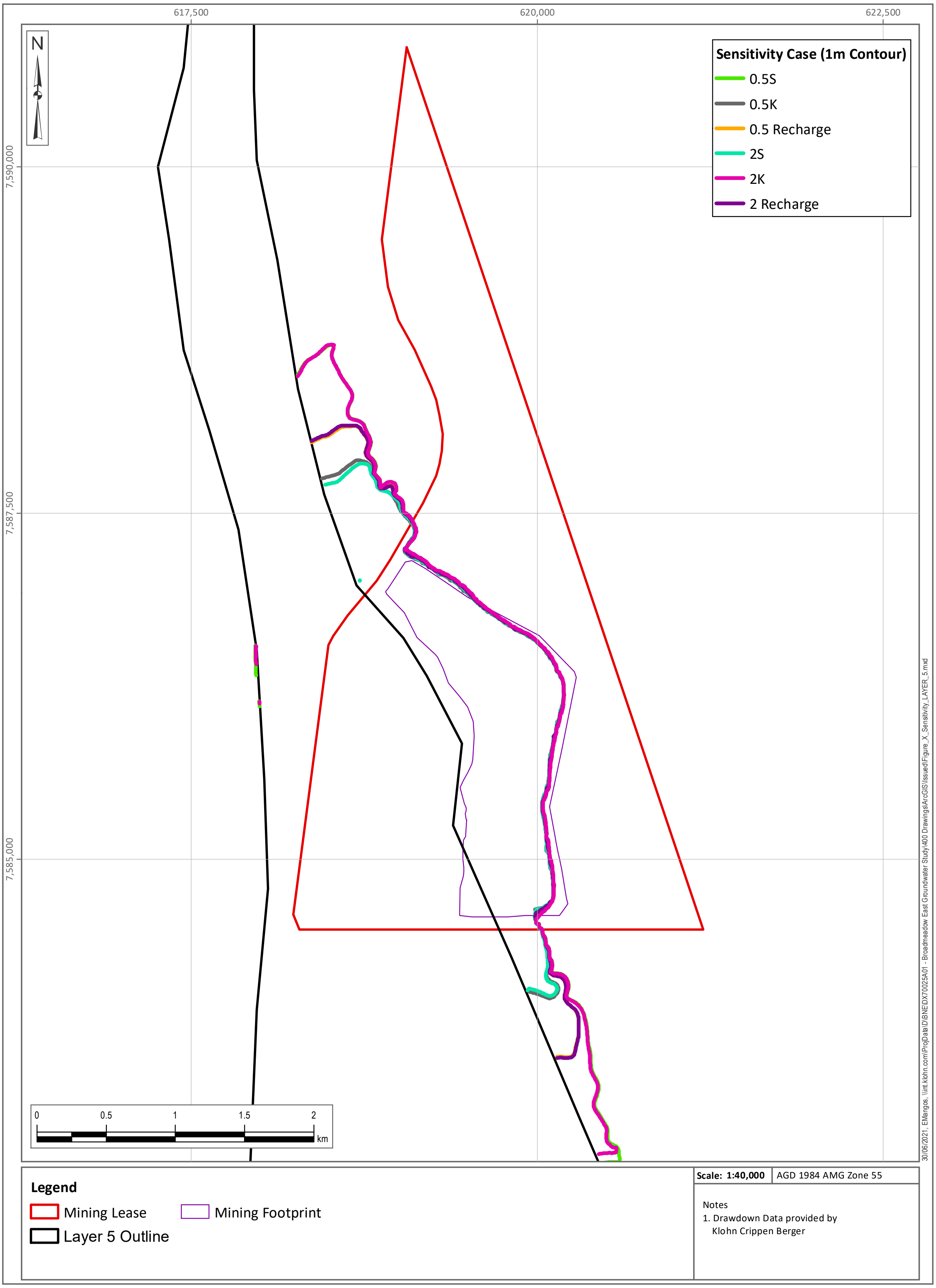


Figure 14: Rangal Coal Measures Drawdown (1 m Drawdown Contour) – Sensitivity Analysis

Figure 15: Rewan Group Drawdown (1 m Drawdown Contour) – Sensitivity Analysis

3.3.4 Sensitivity Classification

The Murray Darling Basin Modelling Guidelines (MDBC, 2000) provide a framework for classification of a predictive model parameters in terms of their impacts on the model. These can be summarised as follows:

- Type I: Insignificant changes to calibration and predictions;
- Type II: Significant changes to calibration with insignificant changes to predictions;
- Type III: Significant changes to calibration with significant changes to predictions; and
- Type IV: Insignificant changes to calibration and significant changes to prediction.

Types I to III present no concern where management decisions are to be based on the model, provided the model is calibrated and encapsulates sufficient complexity to replicate the system. However, Type IV classification may be of concern as calibration may have done little to reduce potential for predictive error.

With consideration to the results of the sensitivity analysis, parameters employed in this model can be considered Type I to II classification and are suitable for the purpose of supporting a groundwater assessment for the Project.

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