BHP Mitsubishi Alliance

# Appendix F

## Groundwater Impact Assessment Report Including Groundwater Modelling Technical Report

# Saraji Mine Grevillea Pit Continuation Project

## Groundwater Impact Assessment

### Engeny on Behalf of BM Alliance Coal Operations Pty Ltd

480 Queen Street
Brisbane QLD 4000

Prepared by:

**SLR Consulting Australia**

SLR Project No.: 620.040484.00001

13 September 2024

Revision: 04

## Revision Record

| Revision | Date | Prepared By | Checked By | Authorised By |
|---|---|---|---|---|
| 01 | 14 May 2024 | David Western | Brian Rask | Brian Rask |
| 02 | 28 June 2024 | David Western | Brian Rask | Brian Rask |
| 03 | 13 August 2024 | David Western | Brian Rask | Brian Rask |
| 04 | 13 September 2024 | David Western | Brian Rask | Brian Rask |
| | | | | |

# Basis of Report

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

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

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

# Table of Contents

**Basis of Report** ..... **i**
**Acronyms and Abbreviations** ..... **vii**
**1.0 Introduction** ..... **1**
1.1 Overview and Scope ..... 1
1.2 Project Description ..... 1
1.2.1 Mining Methodology ..... 2
1.2.2 Mine Infrastructure ..... 5
1.3 Objectives ..... 5
**2.0 Legislative Requirements and Guidelines** ..... **7**
2.1 Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) ..... 7
2.2 EPBC Act Significant Impact Guidelines ..... 7
2.3 IESC Information Guidelines ..... 8
**3.0 Existing Environment** ..... **17**
3.1 Climate ..... 17
3.1.1 Rainfall ..... 17
3.1.2 Evapotranspiration ..... 18
3.2 Topography and Drainage ..... 20
3.3 Mining ..... 22
3.3.1 Historical Mining Activities ..... 22
3.3.2 Current and Future Mining ..... 22
3.3.3 Mine Pit Void Inflows ..... 24
3.4 Geology ..... 24
3.4.1 Regional Geology ..... 24
3.4.2 Local Geology ..... 30
3.5 Hydrogeology ..... 40
3.5.1 SRM Groundwater Monitoring ..... 40
3.5.2 Hydraulic Properties ..... 50
3.5.3 Groundwater Distribution, Flow, Recharge and Discharge ..... 54
3.5.4 Baseline Water Quality ..... 70
3.5.5 Groundwater Receptors ..... 75
3.6 Conceptual Site Model ..... 83
3.6.1 General ..... 83
**4.0 Groundwater Model** ..... **86**
4.1 Overview ..... 86

4.2 Model Details ..... 86
4.2.1 Model Objectives ..... 86
4.2.2 Model Design ..... 86
4.2.3 Model Calibration ..... 88
4.2.4 Model Performance and Limitations ..... 88
4.2.5 Model Predictions ..... 93
4.3 Predicted Groundwater Interception ..... 93
4.4 Maximum Predicted Groundwater Drawdown ..... 94
4.4.1 Incremental ..... 94
4.5 Incidental Water Impacts ..... 101
4.5.1 Alluvium ..... 101
4.5.2 Groundwater – Surface Water Interaction ..... 101
4.5.3 Cumulative ..... 101
4.6 Uncertainty Analysis ..... 111
4.6.1 Number of Realisations ..... 111
4.6.2 Uncertainty of Mine Ingress ..... 113
4.6.3 Groundwater Drawdowns from Mining ..... 113
4.6.4 Alluvium and Surface Water Flows ..... 118
**5.0 Impact Assessment ..... 119**
5.1 Potential Impact on Existing Groundwater Users ..... 119
5.1.1 Privately-Owned Supply Bores ..... 119
5.1.2 Ecological Sites ..... 121
5.2 Potential Impacts on Surface Drainage ..... 121
5.3 Potential Impacts on Groundwater Quality ..... 121
5.4 Risk Assessment ..... 121
5.5 Potential for Significant Impacts ..... 125
5.5.1 Value of Groundwater Resources ..... 125
5.5.2 Potential Additional Significant Impacts From the Grevillea Project ..... 125
**6.0 Management Measures ..... 127**
6.1 Groundwater Monitoring and Management Program ..... 127
**7.0 References ..... 128**

# Tables in Text

Table 1 SRM Mining Pits ..... 2
Table 2 IESC Information Guidelines Checklist ..... 9
Table 3 Operational BoM Weather Stations near to SRM ..... 17
Table 4 Average Monthly Rainfall ..... 17
Table 5 Average Monthly Potential Evapotranspiration ..... 19
Table 6 Average Monthly Actual Evapotranspiration ..... 19
Table 7 Regional Stratigraphy ..... 26
Table 8 SRM Groundwater Monitoring Network – Standpipe Bores ..... 42
Table 9 SRM Groundwater Monitoring Network – VWPs ..... 48
Table 10 Water Quality Objectives for Isaac River Sub-basin Environmental Values ..... 72
Table 11 Isaac River Sub-basin Zone 34 WQOs (DEHP, 2011) ..... 73
Table 12 Registered Groundwater Bore Details ..... 75
Table 13 2007 Bore Census Details (AECOM, 2016) ..... 82
Table 14 Model Layer and Thicknesses ..... 87
Table 15 Groundwater Model and Data Limitations ..... 90
Table 16 Consequence Assessment ..... 122
Table 17 Likelihood Assessment ..... 122
Table 18 Risk Analysis Matrix ..... 122
Table 19 Risk Assessment ..... 123

# Figures in Text

Figure 1 Project Site Location ..... 4
Figure 2 Grevillea Pit Continuation Project – Typical Mining Cross-Section ..... 5
Figure 3 Long term Monthly Rainfall and CDFM - Booroondarra (Station 35109) ..... 18
Figure 4 Average Monthly Rainfall and Evapotranspiration ..... 19
Figure 5 Topography and Drainage ..... 21
Figure 6 Mining Activities at SRM ..... 23
Figure 7 Structural Setting of the Bowen Basin (after Dickins and Malone, 1973) ..... 24
Figure 8 Solid Geology ..... 28
Figure 9 Surface Geology ..... 29
Figure 10 Base Elevation and Thickness of Surficial Units ..... 32
Figure 11 Schematic Diagram of Coal Seams at SRM (BHP, 2019) ..... 34
Figure 12 Base elevation of the Q Seam and Depth to Q Seam ..... 35
Figure 13 Base Elevation of the P Seam and Depth to P Seam ..... 36

Figure 14 Base Elevation of the H Seam and Depth to H Seam ..... 37
Figure 15 Base Elevation of the D Seam and Depth to D Seam ..... 38
Figure 16 SRM Groundwater Monitoring Network ..... 49
Figure 17 Summary Results for all Hydraulic Testing ..... 51
Figure 18 Histogram of Horizontal Hydraulic Conductivity Distribution ..... 52
Figure 19 Faulting Conceptual Model Developed by Coffey (2014) ..... 54
Figure 20 Alluvium Groundwater Elevations ..... 56
Figure 21 Hydrograph of Alluvial Groundwater Trends – Phillips Creek ..... 57
Figure 22 Hydrograph of Tertiary Groundwater Trends ..... 59
Figure 23 Q Seam Groundwater Elevations ..... 62
Figure 24 P Seam Groundwater Elevations ..... 63
Figure 25 H Seam Groundwater Elevations ..... 64
Figure 26 D Seam Groundwater Elevations ..... 65
Figure 27 Hydrograph for Q and P Seam Bores ..... 66
Figure 28 Hydrograph for H Seam Bores ..... 67
Figure 29 Hydrograph for D Seam Bores ..... 68
Figure 30 Hydrograph of Permian Coal Measures Interburden Groundwater Trends ..... 69
Figure 31 Durov Plot of SRM Bores ..... 70
Figure 32 FAO (2013) Salinity Ranking by Unit – SRM and Surrounding Area ..... 71
Figure 33 Registered Bores and Unregistered (Census) Bores ..... 81
Figure 34 Schematic Conceptual Model of the Groundwater System ..... 85
Figure 35 Predicted Groundwater Inflows ..... 93
Figure 36 Maximum Incremental Drawdown in Alluvium (Layer 1) ..... 95
Figure 37 Maximum Incremental Drawdown in Regolith (Layer 2) ..... 96
Figure 38 Maximum Incremental Drawdown in Q Seam (Layer 12) ..... 97
Figure 39 Maximum Incremental Drawdown in P Seam (Layer 14) ..... 98
Figure 40 Maximum Incremental Drawdown in H Seam (Layer 16) ..... 99
Figure 41 Maximum Incremental Drawdown in D Seam (Layer 18) ..... 100
Figure 42 Maximum Cumulative Drawdown in Quaternary Alluvium (Layer 1) ..... 103
Figure 43 Maximum Cumulative Drawdown in Regolith (Layer 2) ..... 104
Figure 44 Maximum Cumulative Drawdown in Leichhardt Seam (Layer 5) ..... 105
Figure 45 Maximum Cumulative Drawdown in Vermont Seam (Layer 7) ..... 106
Figure 46 Maximum Cumulative Drawdown in Q Seam (Layer 12) ..... 107
Figure 47 Maximum Cumulative Drawdown in P Seam (Layer 14) ..... 108
Figure 48 Maximum Cumulative Drawdown in H Seam (Layer 16) ..... 109
Figure 49 Maximum Cumulative Drawdown in D Seam (Layer 18) ..... 110

Figure 50 95 % Confidence Interval for Pit Inflows ..... 112
Figure 51 95 % Confidence Interval for Maximum Drawdowns ..... 112
Figure 52 Mine Inflow Uncertainty ..... 113
Figure 53 Uncertainty in Predicted 1 m Maximum Incremental Drawdown in Alluvium (Layer 1) ..... 114
Figure 54 Uncertainty in Predicted 1 m Maximum Incremental Drawdown in Regolith (Layer 2) ..... 115
Figure 55 Uncertainty in Predicted 1 m Maximum Incremental Drawdown in Q Seam (Layer 12) ..... 116
Figure 56 Uncertainty in Predicted 1 m Maximum Incremental Drawdown in D Seam (Layer 18) ..... 117
Figure 57 Bores located within the predicted maximum incremental drawdown ..... 120

# Appendices

**Appendix A Groundwater Modelling Technical Report**

# Acronyms and Abbreviations

| | |
|---|---|
| ADWG | Australian Drinking Water Guidelines |
| ANZECC | Australian and New Zealand Environment and Conservation Council |
| AWT | Associated Water Take |
| BMA | BM Alliance Coal Operations Pty Ltd |
| BCG | Back Creek Group |
| BoM | Bureau of Meteorology |
| BTEX | Benzene, Toluene, Ethylbenzene, Xylene |
| CDFM | Cumulative deviation from mean |
| CMB | Chloride mass balance |
| CSM | Conceptual site model |
| CQCA JV | Central Queensland Coal Associates Joint Venture |
| CSIRO | Commonwealth Scientific and Industrial Research Organisation |
| CVM | Caval Ridge Mine |
| DNM | Daunia Mine |
| DCCEEW | Commonwealth Department of Climate Change, Energy, the Environment and Water |
| EIS | Environmental Impact Statement |
| EA | Environmental Authority |
| EPBC Act | Environment Protection and Biodiversity Conservation Act 1999 |
| EPP | Environment Protection Policy |
| ET | Evapotranspiration |
| EV | Environmental Value |
| FCCM | Fort Cooper Coal Measures |
| FY | Financial Year |
| GWDB | Groundwater Database |
| GMA | Groundwater Management Area |
| GDE | Groundwater Dependent Ecosystem |
| HPE | Horse Pit Extension |
| IESC | Independent Expert Scientific Committee on Unconventional Gas Development and Large Coal Mining Development |
| Kh | horizontal hydraulic conductivity |
| km | kilometre |
| LVN | Lake Vermont North |
| LGA | Local Government Area |
| mAHD | metres Australian Height Datum |
| m | metres |

| | |
|---|---|
| mBGL | metres below ground level |
| mbTOC | metres below top of casing |
| MCM | Moranbah Coal Measures |
| m/day | metres per day |
| mg/L | milligrams per litre |
| mm | millimetres |
| MR Act | Mineral Resources Act 1989 |
| ML | Mining Lease |
| ML/day | Megalitres per day |
| ML/yr | Megalitres per year |
| Mtpa | Million tonnes per annum |
| PDM | Peak Downs Mine |
| PRC Plan | Progressive Rehabilitation and Closure Plan |
| QoI | Quantities of Interests |
| ROM | Run-of-Mine |
| SA | Surface Area |
| SRMS | Scaled Root Mean Square |
| SEMLP | Saraji East Mining Lease Project |
| SLR | SLR Consulting Australia Pty Ltd |
| SRM | Saraji Mine |
| SDSG | State (Queensland Government) Detailed Surface Geology |
| TDS | Total dissolved solid |
| Kv | vertical hydraulic conductivity |
| VWP | Vibrating Wire Piezometer |
| WQO | Water Quality Objective |
| yr | year |

# 1.0 Introduction

## 1.1 Overview and Scope

Engeny on behalf BM Alliance Coal Operations Pty Ltd (BMA) has engaged SLR Consulting Australia Pty Ltd (SLR) to undertake a groundwater impact assessment to support BMA's Saraji Mine (SRM) Grevillea Pit Continuation Project (the Grevillea Project) submission to the Department of Climate Change, Energy, the Environment and Water (DCCEEW) for assessment under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

Previously, SLR (2023) conducted groundwater modelling as a part of the updated Saraji East Mining Lease Project (SEMLP) Groundwater Assessment (AECOM, 2023) in response to submissions received on the Environmental Impact Statement (EIS) approvals submission. SLR (2023a) also undertook a hydrogeological assessment, including groundwater modelling, as part of the SRM transitional Progressive Rehabilitation and Closure Plan (PRC Plan).

This Groundwater Impact Assessment report builds upon the above previous body of work and includes a description of the groundwater resources, an assessment of environmental values, conceptualisation of the groundwater resources and assessment of potential impacts associated with the Grevillea Project and surrounds using predictive groundwater modelling.

Throughout this report, the terms "the Grevillea Project" and "Study Area" are used and defined as:

- The Grevillea Project is defined as the area covered by Mining Lease (ML) 700021 (refer **Figure 1**).
- The Study Area is the regional area surrounding the Grevillea Project necessary to inform the understanding of the regional scale groundwater system in which the Grevillea Project lies.

## 1.2 Project Description

SRM is owned and operated by BMA, on behalf of the Central Queensland Coal Associates Joint Venture (CQCA JV). The SRM is an open cut mine and has been in operation since 1974, operating using dragline and truck/shovel equipment, supplying hard coking (steel making) coal product for the export market. Currently, the SRM mines approximately 16 million tonnes per annum (Mtpa) of Run-of-Mine (ROM) coal. Located within the Isaac Regional Local Government Area (LGA), the SRM is located approximately 20 kilometres (km) north of Dysart in the Bowen Basin, Queensland.

The SRM is located primarily within ML 1775 and ML 1782, with industrial infrastructure located primarily within ML 1784 and ML 70142. The existing Grevillea Pit at the SRM is currently being mined within ML 1782.

Existing mining operations at the SRM are undertaken in a number of pits identified in **Table 1**. Due to mine progression, the existing Grevillea Pit will exhaust the current ML 1782 during Financial Year (FY) 25.

**Table 1 SRM Mining Pits**

| Mine | Pit Name | Mining Lease |
|---|---|---|
| SRM | Acacia | ML 1775 |
| | Bauhinia | |
| | Coolibah | |
| | Dogwood | |
| | Jacaranda | |
| | Ebony | ML 1782 |
| | Hakea | |
| | Grevillea (existing) | |
| | Grevillea (continuation) | ML 700021 |

In 2017, BMA submitted an Environmental Authority (EA) amendment application under the *Environmental Protection Act 1994* to authorise the continuation of Grevillea Pit to access further coal resources. An ML application for ML 700021 was submitted in conjunction with the EA amendment application in accordance with requirements under the *Mineral Resources Act 1989* (MR Act) and was granted in 2018. Surface Area (SA) rights (SA1) were obtained shortly after for the purpose of coal mining.

ML 700021 is positioned directly east of ML 1782 where current SRM mine operations are occurring, and is bordered by Spring Creek in the north, Phillips Creek in the south, and power easements for 132kV/66kV electrical transmission lines to the east.

As a result of mine sequencing and planning, mining operations within the existing Grevillea Pit will exhaust current resources within ML1782 during FY25. The Grevillea Project seeks to enable the continuation of existing open cut mining operations into ML 700021.

The Grevillea Project will be confined to ML 700021 and is shown on **Figure 1**.

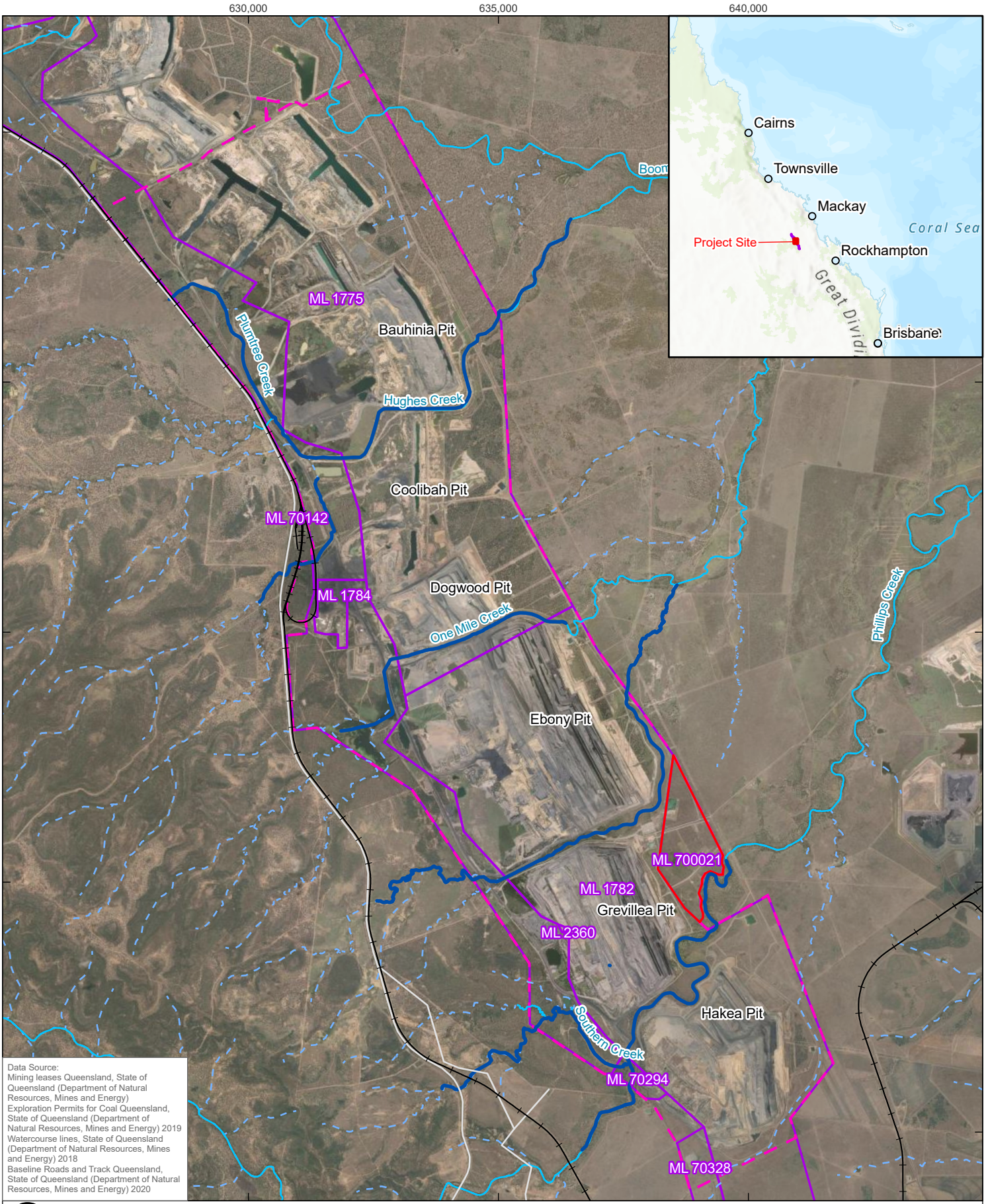
### 1.2.1 Mining Methodology

The key elements of the proposed action are listed below:

- Continuation of vegetation clearing, the removal and stockpiling of topsoil material, drilling and blasting of overburden and interburden material.
- Continuation of open cut mining (dragline, truck and shovel/excavation methods) of ROM coal from the coal measures to the east beyond the current ML 1782 from FY25.
- Continued use of existing SRM infrastructure (e.g., Coal Handling and Preparation Plant, ROM and product stockpiles, train load-out, water management system and other supporting infrastructure).
- Continued disposal of rejects and tailings in accordance with the EA.
- Construction and operation of new or relocated infrastructure associated with the Grevillea Project within ML 700021 to facilitate and/or support the continuation of open cut mining (detailed further below under Mine Infrastructure).
- Continuation of overburden and interburden material removal (dragline and truck and shovel/excavator methods) to uncover coal, which is placed as back fill in the mined-out pits (in-pit spoil dumps) as mining advances.

- Ongoing exploration activities within ML 700021.
- Continuation of progressive rehabilitation of disturbed areas.

A typical mining cross section proposed at ML 700021 is shown on **Figure 2**.




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

0 1 2 km

| | |
|---|---|
| Coordinate System: | GDA 1994 MGA Zone 55 |
| Scale: | 1:100,000 at A4 |
| Project Number: | 620.040484.00001 |
| Date Drawn: | 12-Sep-2024 |
| Drawn by: | RB |

**LEGEND**

- Rail Network
- Road and Track
- Creek Diversion
- Drainage Path
- Watercourse
- SRM EA Boundary
- SRM Mine Lease
- Project Area

# SARAJI MINE GREVILLEA PIT CONTINUATION PROJECT GROUNDWATER ASSESSMENT

## PROJECT LOCATION

SLR

DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.

**FIGURE 1**

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040484.00001 Saraji Mine Grevillea GW Model\06 SLR Data\01 CADGIS\GIS\ArcPro\GW Assessment\GW Assessment.aprx\620040484 F01 Project Location

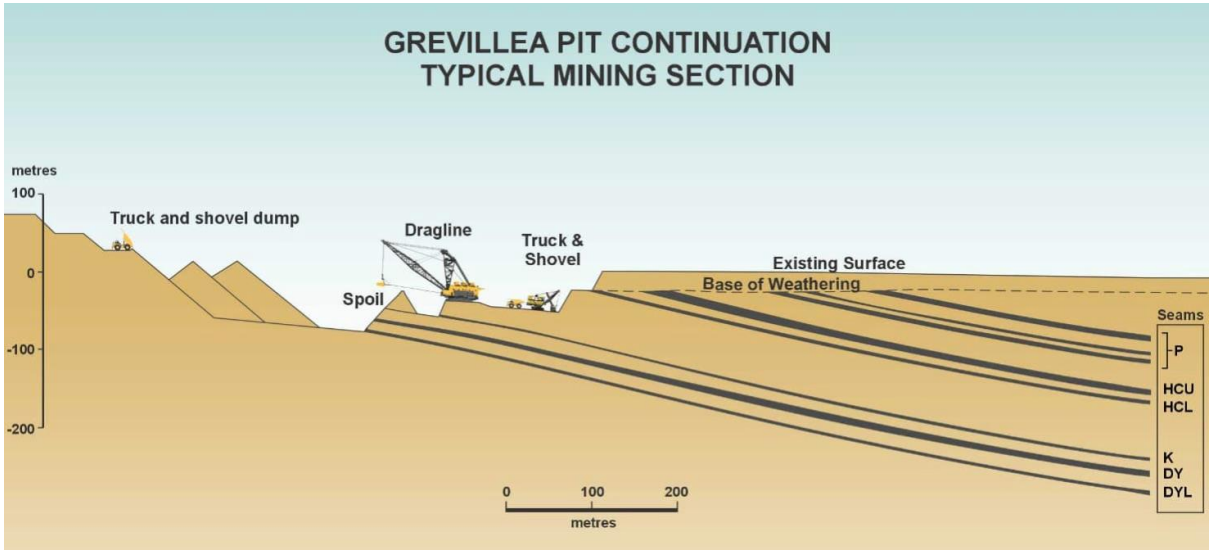



**Figure 2 Grevillea Pit Continuation Project – Typical Mining Cross-Section**

### 1.2.2 Mine Infrastructure

The key mine infrastructure currently within the ML 700021 includes:

- Mine access roads and borrow pits.
- Electrical infrastructure including 66kv overhead power lines and substations.
- Water management infrastructure such as dams, drains and pipelines.
- Earth-moving-equipment build pad.
- Flood protection levees.

Over the life of the SRM, the key mine infrastructure within ML 700021 will likely include:

- Haul roads (heavy vehicles), light vehicle roads and access roads including parking lots.
- Pit infrastructure such as floors, walls, benches, ramps and access roads and spoil stockpiles.
- Flood protection levees.
- Water management infrastructure such as dams, drains and pipelines.
- Relocated earth-moving-equipment build pad and supporting infrastructure.
- Electrical infrastructure including new or realigned stub lines and substations.

During pit progression, infrastructure will be relocated as required to support the mine operations within ML 700021. A 50-100 m lead on the high wall will remain to enable positioning of this support infrastructure up to the completion of mining in the pit.

## 1.3 Objectives

The main objective of this Groundwater Impact Assessment is to assess the potential groundwater related impacts as a result of the Grevillea Project, specifically the requirements of the Independent Expert Scientific Committee on Unconventional Gas

Development and Large Coal Mining Development (IESC) information guidelines (refer **Table 2**) and the EPBC Act Significant Impact Guidelines 1.3.

This Groundwater Impact Assessment report includes a description of the groundwater conditions, conceptualisation of the groundwater systems resources and an assessment of potential groundwater related impacts using a predictive groundwater numerical model.

# 2.0 Legislative Requirements and Guidelines

This section provides an overview of the relevant legislative requirements and guidelines for the Project, with respect to groundwater.

## 2.1 Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)

The EPBC Act is the Australian Government's main environmental legislation and is administered by DCCEEW. The EPBC Act provides a legal framework to protect and manage matters of national environmental significance, namely:

- Declared world heritage properties
- National heritage places
- Wetlands of international importance (listed under the Ramsar Convention)
- Listed threatened species and listed ecological communities
- Listed migratory species (protected under international agreements
- Commonwealth marine areas
- Great Barrier Reef Marine Park
- Nuclear actions (including uranium mines)
- Water resources (concerning coal seam gas and large coal mining development)

The EPBC Act provides a basis for the Minister to decide whether an action that has, will have or likely to have a significant impact on certain aspects of the environment should proceed.

## 2.2 EPBC Act Significant Impact Guidelines

The core purpose of the EPBC Act Significant Impact Guidelines 1.3 (DCCEEW, 2022) are to assist any person who proposes to take an action which involves a coal seam gas or a large coal mining development to decide whether the action has or is likely to have a significant impact on a water resource. The guidelines outline a "self-assessment' process, including detailed criteria, to assist persons in deciding whether or not referral may be required.

In terms of the definition of a significant impact to a water resource, the Significant Impact Guidelines 1.3 identify that "whether or not an action is likely to have a significant impact depends upon the sensitivity, value, and quality of the water resource that is impacted, and upon the intensity, duration, magnitude and geographic extent of the impacts", and then refer to the Significant Impact Guidelines 1.1 for further information on assessing the significance of impacts. In accordance with the Significant Impact Guidelines 1.1 the following matters should be considered by the proponent:

- Are there any matters of national significance located in the area of the Grevillea Project proposed action (action is to be considered broader than the immediate area: e.g. do any downstream or upstream impacts or areas immediately adjacent need to be considered)?
- Considering the project at its broadest scope, is there potential for impacts, including indirect impacts, on matters of national environmental significance?

- Are there any proposed measures to avoid or reduce impacts of national environmental significance (and if so, is the effectiveness of these measures certain enough to reduce the level of impact below the “significant impact” threshold)?
- Are any impacts of the Grevillea Project on matters of national environmental significance likely to be significant impacts (important, notable, or of consequence, having regard to their content or intensity)?

The Significant Impact Guidelines 1.3 also identify the requirement to consider cumulative impacts, noting that “existing operations may be taken into account in considering cumulative impacts” but that “a new approval for the existing operations will not be required”. As stated in the Significant Impact Guidelines 1.3:

- The term ‘cumulative impacts’ refers to the impacts of a number of different actions or other broader influences on a matter of national environmental significance which, when considered together, have a greater impact on that matter than each action or broader influence considered individually.
- The cumulative impact context may include existing developments that have an impact on particular water resources (i.e. existing operations), and other reasonably foreseeable developments (i.e. proposed operations) which may have an impact on particular water resources and/or the overall development of a region.
- The significance of an impact may also depend upon the context of other developments: an apparently small impact may still be a significant impact if there are substantial cumulative effects, factoring in existing and reasonably foreseeable prospective actions.
- The potential for the impact of an action to be significant is likely to be greater in a more developed system.
- Cumulative impacts should be considered at the local, aquifer or catchment, and regional scale.

## 2.3 IESC Information Guidelines

The IESC provides advice to the Commonwealth Environment Minister on coal seam gas and large coal mining development proposals that are likely to have a significant impact on water resources.

The IESC have produced information guidelines (IESC, 2024) which outline advice on the requirements for submission to IESC for coal seam gas and large coal mining development proposals. A checklist is provided in the IESC information guidelines to ensure that the information requirements for the IESC review have been addressed.

**Table 2** identifies the section(s) of this report where the requirements of the IESC information guidelines have been addressed.

## Table 2 IESC Information Guidelines Checklist

| Assessment Aspect and Checklist Item | Report Section Addressed |
|---|---|
| **Description of the proposed project** | |
| **General** | |
| Provide a regional overview of the proposed project area, including a description of the geological basin, coal resource, surface water catchments, groundwater systems, water-dependent assets (including terrestrial and aquatic GDEs), and past, present and reasonably foreseeable coal mining and CSG developments. | **Section 1.2** |
| Describe the proposal's location, purpose, scale, duration and disturbance area, and the means by which it is likely to have a significant impact on water resources and water-dependent assets. | |
| Assess the frequency (and time lags, if any), location, volume and direction of interactions between water resources, including surface water/groundwater connectivity, inter-aquifer connectivity and connectivity with sea water. | |
| **Regulatory Context** | |
| Describe the statutory context, including information on the proposal's status within the regulatory assessment process and any applicable water management policies or regulations. | **Section 2.0** |
| Describe how potentially impacted water resources are currently being regulated under state or Commonwealth law, including whether there are any applicable standard conditions. | |
| Describe existing water quality guidelines, environmental flow objectives and other requirements (e.g., water planning rules) for the surface water catchments and groundwater basins within which the development proposal is based. | |
| Describe public health, recreation, amenity, Indigenous, tourism and/or agricultural values for each water resource, and the plans relevant to their management and protection. | |
| **Groundwater Context** | |
| Describe and map the geology at an appropriate level of horizontal and vertical resolution, including:<br>• definition of the geological sequence(s) in the area, with names and descriptions of the formations and accompanying surface geology, cross-sections and any relevant field data<br>• identification of hydrogeological sequences and characteristics. | **Sections 3.4** and **3.5** |
| Define and describe or characterise significant geological structures (e.g., faults, folds, intrusives) and associated fracturing in the area and their influence on groundwater – particularly groundwater flow, discharge or recharge. | |

| Assessment Aspect and Checklist Item | Report Section Addressed |
|---|---|
| • Provide geological maps appropriately annotated with symbols that denote fault type, throw and the parts of sequences the faults intersect or displace (e.g., Murray and Power 2021).<br>• Include discussion of how the faults potentially influence regional-scale groundwater conditions. | |
| Describe the likely recharge, discharge and flow pathways for all hydrogeological units likely to be impacted by the proposed development.<br>• Identify current stressors, including impacts from any currently approved projects. | |
| Describe the existing water quality of all aquifers in the project area.<br>• Where groundwater is to be used for a given purpose such as irrigation, compare the data with relevant guideline values (ANZG 2018) and regional and local water quality objectives. | |
| **Environmental impact assessment** | |
| **General** | |
| Describe the intensity, duration, magnitude, timing and geographic extent of each potential impact, specifying the impact's significance and consequences, especially on the environmental condition and human values of each water resource. | Sections **5.1, 5.2, 5.3** and **5.5** |
| For proposed expansions or modifications, distinguish potential impacts from those of the existing project, and include the likely contribution of the proposed expansion to potential cumulative impacts | |
| Assess the significance of each impact with reference to the range of system behaviour found under pre-development conditions and natural environmental and climatic variability. | |
| **Risk-based assessment** | |
| Identify and assess all potential environmental risks to water resources and water-related assets, and their possible impacts. In selecting a risk-assessment approach, consideration should be given to the complexity of the project and the probability and potential consequences of the project's impacts. | Section 5.4 |
| Describe the consultation with relevant stakeholders and regulators about the likely risks to water resources and water-related assets. This initial engagement should include agreement about the nature of the action, which assets (including water resources) may be impacted, and the likely sources of impacts and the receptors that may be affected. | N/A |
| The risk assessment should include a systematic and evidence-based assessment of:<br>• the sources of environmental impacts in the project area | Section **5.0** |

| Assessment Aspect and Checklist Item | Report Section Addressed |
|---|---|
| • the exposure pathways by which impacts may be transferred from these sources to water resources (receptors), presented as one or more IPDs based on ecohydrological conceptualisation<br>• the likely response of each receptor, especially when the impact(s) may be severe and likely to cause irreversible damage (posing a high risk)<br>• 'hot spots', or areas in the project area (e.g., where vulnerable receptors occur close to impact sources) where risks are especially high<br>• 'hot moments', or periods during and after the project (e.g., when activities are likely to generate major impact) when risks are especially high. | |
| Specify where and how each risk can be avoided or mitigated (or, as a last resort, requires appropriate offsets and/or a conservation payment), and:<br>• provide evidence (preferably from equivalent activities and regions) for the feasibility and effectiveness of mitigation or offset methods<br>• describe how monitoring will be able to demonstrate the effectiveness of the mitigation measures. | Section **6.0** |
| Describe the risks of potential cumulative impacts of all past, present and reasonably foreseeable actions and activities that are likely to impact on water resources, including from multiple stressors arising from the Grevillea Project. | Sections **5.1, 5.2, 5.3** and **5.4** |
| Specify all sources of uncertainty in the assessments of each risk and describe how information has been and will be collected to reduce this uncertainty. | Sections **4.6** |
| Investigate relevant context for the risk assessment, such as bioregional assessments, Commonwealth and state water resource plans (e.g., Murray–Darling Basin Plan, Hunter River Salinity Trading Scheme) and state processes such as those that apply in the Surat Cumulative Management Area and the Commonwealth's Joint Industry Framework on Coal Seam Gas. | **Sections 2.0** and **5.4** |
| Assess residual risks remaining after the implementation of the proposed mitigation and management options, to determine whether these effectively reduce risks to an acceptable level based on the identified environmental objectives. | Not required. |
| ***Groundwater*** | |
| Undertake groundwater modelling in accordance with the *Australian groundwater modelling guidelines* (Barnett et al. 2012), including independent peer review. | **Section 4.0** and **Appendix A** |
| Describe each hydrogeological unit as incorporated in the groundwater model, including the thickness, storage and hydraulic characteristics, and hydraulic linkages between units, if any. | |

| Assessment Aspect and Checklist Item | Report Section Addressed |
|---|---|
| Describe the existing recharge/discharge pathways of the units and the changes that are predicted to occur upon commencement, throughout, and after completion of the proposed project. | |
| Select and justify appropriate boundary conditions across the model domain to enable a comparison of groundwater model outputs to seasonal field observations. | |
| Where possible, calibration should incorporate measurements of both potentiometric head (or pressure) and flux, such as measured mine inflows or measured discharges to streams or springs. | |
| Undertake sensitivity analysis of boundary conditions and hydraulic and storage parameters, and justify the conditions applied in the final groundwater model. Where the interaction between surface water and groundwater is important, parameters describing their connectivity, such as riverbed conductance, should be assessed. | |
| Assess the potential impacts of the proposal, including how impacts are predicted to change over time and any residual long-term impacts. Consider and describe:<br>• any hydrogeological units that will be directly or indirectly dewatered or depressurised (including lateral effects), interactions between water resources (inter-aquifer connectivity), and connectivity with sea water<br>• the magnitude, extent and change over time of drawdown/mounding, including the time for post-development equilibrium to be reached<br>• the extent of impacts on surface water/groundwater connectivity, water-dependent assets, flow direction and surface topography, including resultant impacts on the groundwater balance<br>• the potential range of drawdown at each affected bore, and clearly articulate the spatial and temporal scales of impacts on other water users<br>• the potential impacts on hydraulic and storage properties of hydrogeological units, including changes in storage, potential for physical transmission of water within and between units, and estimates of likelihood of leakage of contaminants through hydrogeological units<br>• the possible fracturing of and other damage to confining layers. | |
| Undertake an uncertainty analysis of key predictive outputs (i.e., quantities of interest as per Peeters and Middlemis 2023). | |
| For each relevant hydrogeological unit, describe the proportional increase in groundwater use and impacts as a consequence of the proposed project, including an assessment of any consequential increase in demand for groundwater from towns or other industries resulting from associated population or economic growth due to the proposal. | |

| Assessment Aspect and Checklist Item | Report Section Addressed |
|---|---|
| **Closure, rehabilitation and post-development final landforms and voids** | |
| Describe the timing and processes planned for cessation of operations and the closure of the development, particularly any risks of impacts on water-dependent assets that may arise during this phase (e.g., when dismantling and removing infrastructure). Explain how such risks will be avoided or mitigated. | Addressed in a separate PRCP report |
| If appropriate, qualitatively describe the various final landform options that were considered and their likely legacy impacts on water resources. This context will be useful for justifying the choice of the proposed final landform and how it avoids or mitigates risks of legacy impacts on water resources. | |
| Ideally, describe how land disturbed by mining activities will be progressively rehabilitated to a safe and stable landform that does not cause environmental harm to water resources and is able to sustain one or more approved post-mining land uses (PMLUs). Give details of the consultation with regulators and the community about the intended PMLUs, the targets associated with their achievement, and how achievement of these targets may be hampered by, for example, site geology and climatic extremes. | |
| If requested by regulators, specify and justify the methods and techniques that will be used to achieve particular rehabilitation targets and milestones. Explain how these methods may be constrained by project-specific features (e.g., topography, climate, geology and hydrology). | |
| If appropriate, describe how the effectiveness of the proposed rehabilitation methods and techniques for protecting or restoring water resources will be monitored, and present details (e.g., parameters, sampling frequency) of a monitoring program for demonstrating successful achievement of the targeted PMLUs across the project area after mining or CSG extraction has finished. These monitoring programs should be linked to explicit milestones for completion of progressive stages of rehabilitation, and should include appropriate baseline data against which to judge the effectiveness of the rehabilitation. | |
| Describe the final landform and any voids that may remain after closure, and specify the predicted legacy impacts that may persist, such as ongoing effects on surface water and groundwater movements and water quality, erosion and sedimentation, and habitat fragmentation of water-dependent species and communities. Evaluate the adequacy of the modelling underlying these predictions, especially all sources of uncertainty. | |
| Assess qualitatively the likely long-term risks of impacts on water resources and water-dependent assets posed by various options for the final landform design, including complete or partial backfilling of mining voids. Assessment of the final landform for which approval is being sought should consider:<br>• stability (e.g., resistance to erosion and slumping), soil geochemistry and quality (relevant for post-closure establishment of vegetation) and the likely effects of the final landform on long-term surface water and groundwater behaviour (e.g., fluxes and runoff) and on water quality, including salinity, pH, toxicity and concentrations of contaminants | |

| Assessment Aspect and Checklist Item | Report Section Addressed |
|---|---|
| • geochemistry and its potential effects on seepage through waste rock (e.g., fully or partially refilled voids, remnant rock dumps) and on the quality of water exiting from mine adits and other post-closure sources<br>• groundwater behaviour and rate and depths of water table recovery, including timeframe and final levels of stabilisation<br>• available measures (and their likely effectiveness and feasibility) to avoid or mitigate legacy impacts from the final landform and any voids on water resources and water-dependent assets. | |
| **Baseline data** | |
| For groundwaters, surface waters and ecological water-dependent assets that have been identified in the risk-based assessment, present data that are sufficient to establish pre-development (baseline) conditions and that have been collected at an appropriate sampling frequency and spatial coverage of monitoring sites, ideally over a period sufficiently long to characterise the impacts of climatic variability. | |
| **Groundwater** | |
| Provide data from surveyed boreholes to demonstrate the varying depths of the hydrogeological units and associated standing water levels or potentiometric heads, including directions of groundwater flow, contour maps and hydrographs. | **Sections 3.5** and **3.6** |
| Present information from site-specific studies (e.g., geophysical, coring/wireline logging) to characterise the local stress regime and fault structure (e.g., damage zone size, open/closed along fault plane, presence of clay/shale smear, fault jogs or splays). | |
| Provide site-specific values for hydraulic parameters (e.g., vertical and horizontal hydraulic conductivity and specific yield or specific storage characteristics, including the data from which these parameters were derived) for each relevant hydrogeological unit. In situ observations of these parameters should be sufficient to characterise the heterogeneity of these properties for modelling. | |
| Provide hydrochemical characterisation (e.g., acidity/alkalinity, electrical conductivity, metals and major ions) and a suitable suite of environmental tracers (e.g., heat; stable isotopes of water; tritium, helium, strontium isotopes) (e.g., Kurukulasuriya et al. 2022; OWS 2020) commensurate with the risks of the proposed development to water resources and water-dependent assets. | |
| Provide sufficient data on physical aquifer parameters and hydrogeochemistry to establish pre-development conditions, including fluctuations in groundwater levels at time intervals relevant to aquifer processes. This should include time-series data for water levels and water quality that represent seasonal and climatic cycles. | |
| Provide long-term groundwater monitoring data, including a comprehensive assessment of all relevant chemical parameters to inform changes in groundwater quality and detect potential contamination events. | |

| Assessment Aspect and Checklist Item | Report Section Addressed |
|---|---|
| **Monitoring and management** | |
| Describe the rationale for selected monitoring parameters and their sampling duration, frequency and methods, including the use of satellite or aerial imagery to identify and monitor large-scale impacts. Target monitoring programs to address key areas of uncertainty, especially for valued assets and water resources that are at greater risk of impacts from the proposed development. | **Section 6.0** |
| Ensure water quality monitoring complies with relevant National Water Quality Management Strategy guidelines (ANZG 2018) and relevant legislated state protocols (e.g., Queensland Government 2018). | |
| Identify and justify monitoring sites representative of the diversity of potentially affected water-dependent assets and the nature and scale of potential impacts. Match suitably replicated control and reference sites (BACI design, Downes et al. 2002) to enable detection and monitoring of potential impacts. | |
| Describe the processes employed to determine impact thresholds for water-dependent assets (e.g., threshold at which a significant impact on an asset may occur). | |
| Describe proposed mitigation and management actions, and their adequacy, for each significant impact identified, including any proposed mitigation or offset measures for long-term impacts post mining. | |
| Identify modifications or alternatives to avoid, minimise or mitigate potential cumulative impacts, and provide evidence of the likely success of these measures (e.g., case studies). | |
| Propose adaptive management measures and management responses, giving details of trigger action response plans (TARPs) for valued assets and water resources that are at greater risk of impacts from the proposed development. | |
| **Groundwater** | |
| Describe a robust groundwater monitoring program using dedicated groundwater monitoring bores – including nested arrays where there may be connectivity between hydrogeological units – and targeting specific aquifers, providing information on the groundwater regime and on recharge and discharge processes and identifying changes in quantities and quality of groundwater over time. | **Section 6.0** |
| Where reinjection schemes are proposed to manage wastewater (e.g., managed aquifer recharge), the monitoring program should include components specifically targeted at identifying any potential impacts from this management action. | N/A |

| Assessment Aspect and Checklist Item | Report Section Addressed |
|---|---|
| **Cumulative impacts** | |
| Assess the condition and likely responses of all water-dependent assets and water resources likely to be cumulatively impacted by the proposed development combined with all developments (past, present and/or reasonably foreseeable) and other water-intensive activities. | **Sections 4.5.3, 5.1** and **5.2** |
| Assess the cumulative impacts on potentially affected water-dependent assets and water resources, considering:<br>• the full extent of potential impacts from the proposed project (including whether there are alternative options for infrastructure and mine configurations which could reduce impacts)<br>• all stages of the development, including exploration, operations and post-closure/rehabilitation<br>• the likely spatial magnitude and timeframe over which cumulative impacts will occur (ensuring that the analysis has sufficiently broad geographic and temporal boundaries to include all potentially significant impacts)<br>• opportunities to work with other water users to avoid or mitigate potential cumulative impacts to meet specified environmental objectives. | |

# 3.0 Existing Environment

## 3.1 Climate

The climate at the Study Area is sub-tropical with higher temperatures, higher rainfall and higher evaporation occurring over the summer months (December to February). The closest Bureau of Meteorology (BoM) weather station is located at Dysart Post Office (35278), approximately 7.5 km to the south of SRM. This Dysart Post Office weather station operated between 1988 and 2006. The nearest weather station with a longer data record is Booroondarra (station 35109) located approximately 35km to the south of SRM. The Booroondarra weather station has been in operation since 1929 and has a continuous record with only a few occasional months of missing data. **Table 3** provides the details of the nearby operational weather stations.

**Table 3 Operational BoM Weather Stations near to SRM**

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

mAHD = metres Australian Height Datum

### 3.1.1 Rainfall

SILO Grid point data (Latitude: -22.40, Longitude: 148.30) was used to assess long-term rainfall trends in the vicinity of SRM. This dataset is interpolated from quality checked observational timeseries data collected at nearby stations by the BoM. Data from January 1953 until Mar 2024 was used to assess the long-term rainfall trends in the vicinity of SRM. According to SILO data, the average annual site rainfall is 578.3 millimetres (mm). The two highest annual rainfalls were recorded for the years 1956 and 2010, with annual rainfalls of 960.2 mm and 1,063 mm, respectively. The minimum annual rainfall occurred in 2018 with 268.6 mm. Monthly averages for the nearby BoM stations discussed as well as the SILO grid point are listed in **Table 4**.

**Table 4 Average Monthly Rainfall**

| Rainfall (mm) | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual Average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dysart PO | 91.5 | 85.7 | 46.0 | 28.5 | 37.1 | 23.1 | 7.8 | 30.0 | 9.6 | 43.4 | 48.1 | 115.4 | 523.6 |
| Dysart Station | 105.5 | 103.7 | 60.4 | 38.7 | 42.0 | 23.4 | 28.1 | 18.8 | 13.7 | 34.7 | 58.9 | 94.2 | 601.7 |
| Booroondarra | 118.1 | 102.6 | 74.0 | 34.5 | 37.0 | 24.2 | 24.7 | 23.0 | 16.3 | 41.9 | 58.8 | 99.7 | 654.2 |
| SILO Grid Point | 101.4 | 94.2 | 61.9 | 32.8 | 31.9 | 21.9 | 22.8 | 20.5 | 12.8 | 35.0 | 59.4 | 87.8 | 578.3 |

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

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

Rainfall trends for Booroondarra are indicated by analysis of the cumulative deviation from mean (CDFM) monthly rainfall (**Figure 3**). Positive gradients on this curve (rising limbs) confirm wetter conditions than normal, while negative gradients (falling limbs) indicate dry conditions. Average rainfall conditions are inferred during periods of stable residual mass. **Figure 3** shows that, over the past 50 years, the wettest periods occurred during 1954-1960, 1973-1979, and in 2010. The driest periods were 1991-1998, 2001-2007 and 2017-2021. As shown by the declining trend in the CDFM, since 2017 SRM has experienced drier than average conditions. It should be noted that the data gaps observed in the late 1960s have not been used in the CDFM calculation.

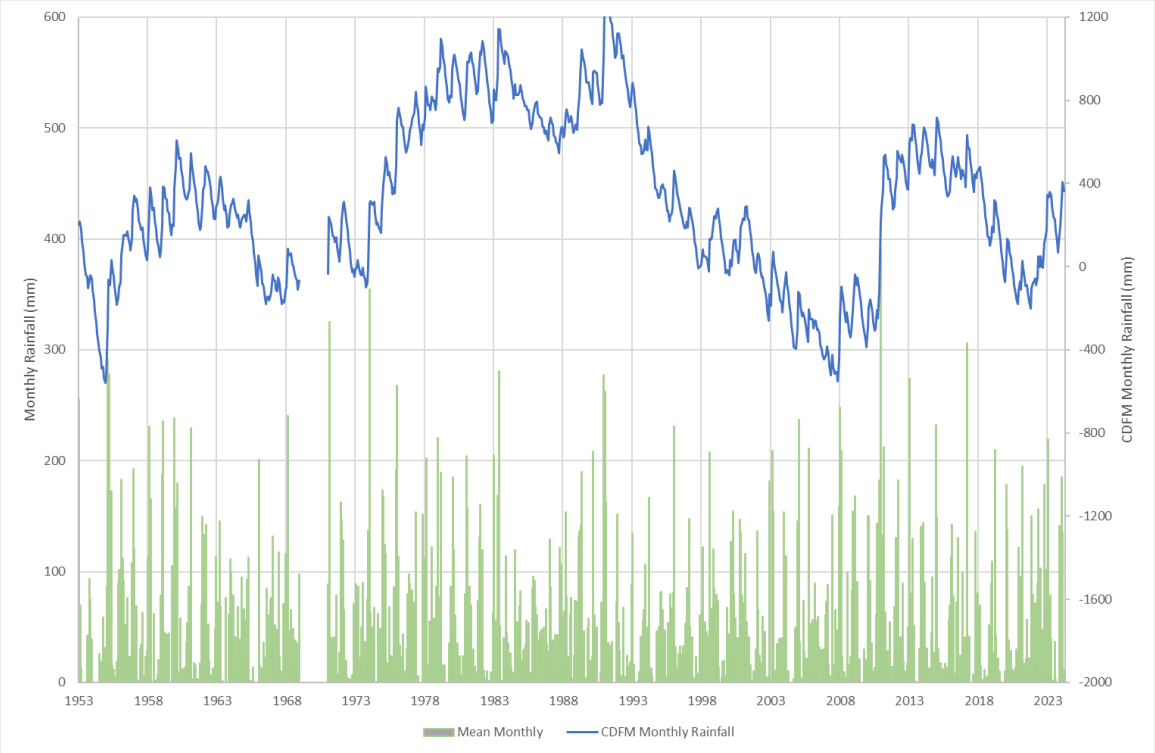



**Figure 3 Long term Monthly Rainfall and CDFM - Booroondarra (Station 35109)**

The CDFM performs an additional service: if rainfall recharge is a significant source of groundwater, the temporal variability in recorded groundwater levels can be expected to mimic the pattern of this curve. That is, natural fluctuations in the groundwater table result from temporal changes in rainfall recharge to groundwater systems. Typically, changes in groundwater elevation reflect the deviation between the long-term monthly (or yearly) average rainfall, and the actual rainfall, illustrated by the rainfall CDFM. Groundwater hydrographs showing the relationship between rainfall and groundwater levels are assessed in **Section 3.4.2**.

### 3.1.2 Evapotranspiration

Actual and potential evapotranspiration (ET) have been taken from BoM's Australia wide interpolation dataset at the locations of the weather stations (BoM, 2012). The potential ET in the district is about 2,388 mm/yr according to BoM (2012) (**Table 5**). The definition of potential ET is: *"… the ET that would take place, under the condition of unlimited water supply, from an area so large that the effects of any upwind boundary transitions are negligible and local variations are integrated to an areal average*". For example, this represents the ET which would occur over a very large wetland or large irrigated area, with a

never-ending water inflow. Further to this, where the water table approaches the ground surface, ET can also approach the potential ET value.

**Table 5 Average Monthly Potential Evapotranspiration**

| PE (mm) | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Booroondarra | 249.8 | 209.2 | 215.8 | 178.9 | 147.5 | 121.4 | 134.8 | 166.4 | 206.6 | 251.7 | 259.0 | 268.7 | 2409.7 |
| SILO Grid Point Data | 245.6 | 205.9 | 211.9 | 175.6 | 145.8 | 121.5 | 134.6 | 165.9 | 205.8 | 251.0 | 258.2 | 266.1 | 2387.9 |

PE = Potential Evapotranspiration

The actual ET in the district is about 1,106 mm/year according to BoM (2012) (**Table 6**). The definition for actual ET is: "... the ET that actually takes place, under the condition of existing water supply, from an area so large that the effects of any upwind boundary transitions are negligible and local variations are integrated to an areal average". For example, this represents the predicted ET that is occurring over a large area of land under the existing (mean) rainfall conditions.

**Table 6 Average Monthly Actual Evapotranspiration**

| AE (mm) | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Booroondarra | 137.6 | 119.8 | 115.7 | 81.8 | 50.7 | 35.8 | 39.9 | 59.9 | 81.4 | 107.0 | 121.6 | 138.8 | 1089.9 |
| SILO Grid Point Data | 137.3 | 121.8 | 118.3 | 86.0 | 54.8 | 38.5 | 42.3 | 62.2 | 82.3 | 105.8 | 119.9 | 136.7 | 1106.2 |

PE = Potential Evapotranspiration

**Figure 4** shows that the average potential monthly ET exceeds the average monthly rainfall over the entire year, often by more than double. Average actual ET is slightly greater than average rainfall for all months.

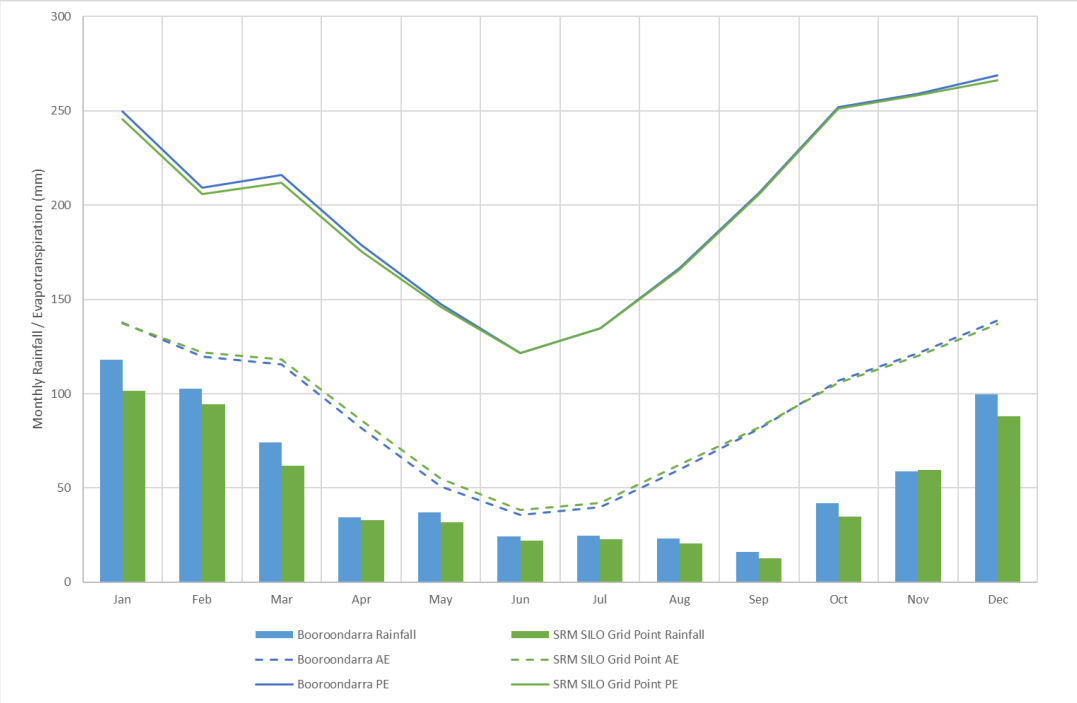



**Figure 4 Average Monthly Rainfall and Evapotranspiration**

## 3.2 Topography and Drainage

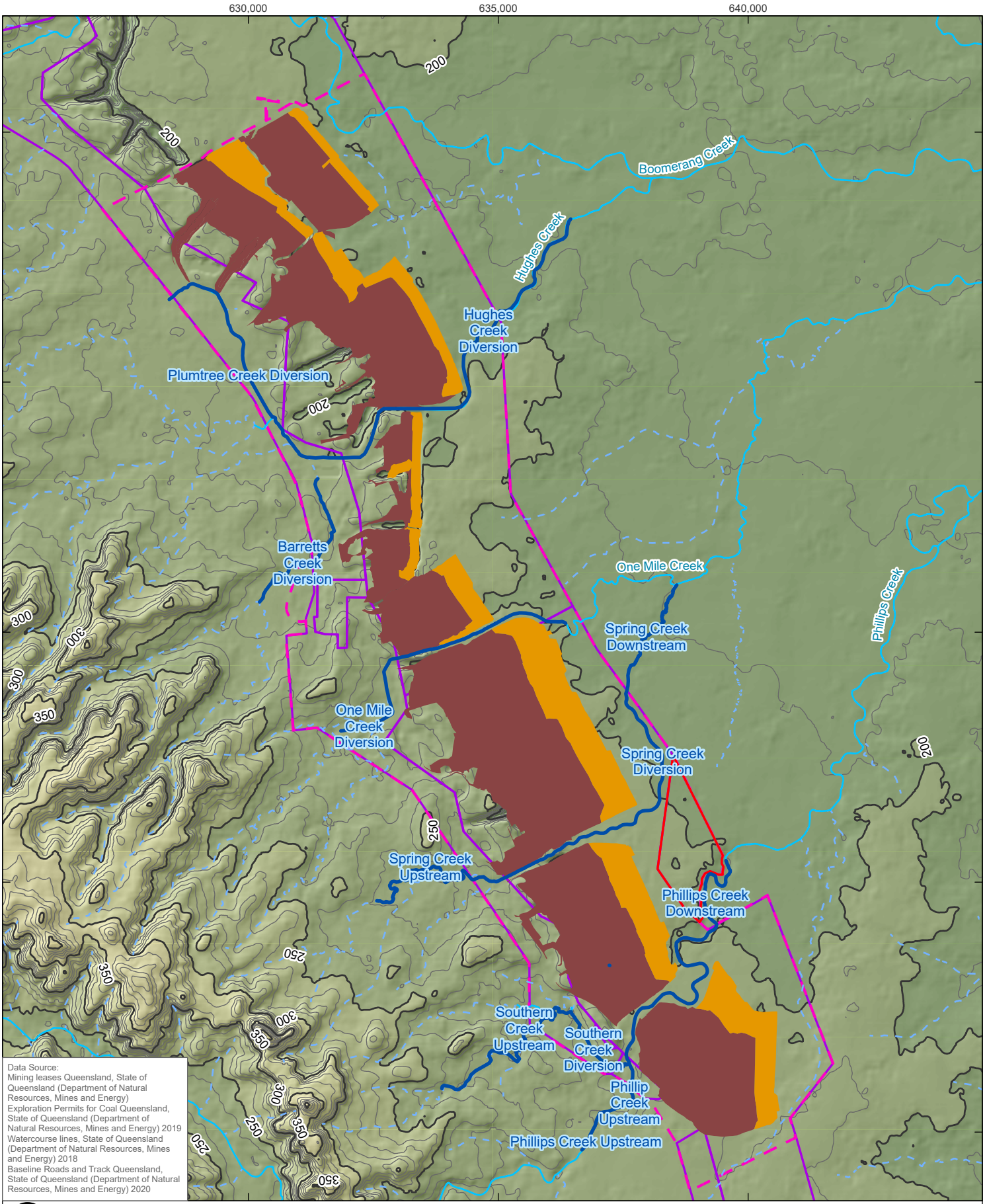
SRM is located in the Isaac River western upland tributaries sub-catchment of the Upper Isaac River Catchment of the Isaac River Sub-basin, part of the Fitzroy Basin. The topography of the SRM Area is relatively flat with gentle undulation and average elevations of approximately 195 mAHD (**Figure 5**). Elevations across SRM in general range between approximately 200 mAHD in the west to 190 mAHD in the east. The topography gently grades east-southeast towards the Isaac River, where elevations are approximately 165 mAHD.

The Isaac River, located approximately 18 km directly east of SRM, is the major drainage feature of the region and flows from northwest to southeast (**Figure 5**). Drainage across SRM includes Boomerang Creek, Hughes Creek, One Mile Creek, and Phillips Creek, all tributaries of the Isaac River. Stephens Creek is located to the south of SRM and also drains into the Isaac River to the east.

Boomerang Creek and One Mile Creek including its tributary Spring Creek join Hughes Creek downstream (east) of SRM. Phillips Creek, Stephens Creek and Downs Creek independently join the Isaac River downstream (east) of SRM. Spring and Phillips creeks are the closest drainage features to the Grevillea Project and are further discussed below.

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

Spring and Phillips creeks flow from southwest to northeast (**Figure 5**). Spring Creek joins One Mile Creek around 3 km north of the Grevillea Project. The confluence of Phillips Creek to the Isaac River is approximately 18 km northeast of SRM at an elevation of 162 mAHD. Phillips Creek crosses SRM in a southwest to northeast direction between Grevillea Pit and Hakea Pit in the south of the SRM Area. Phillips Creek is used as a controlled release point by SRM (authorised under EA EPML00862313).




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

0 1 2 km

| | |
|---|---|
| Coordinate System: | GDA 1994 MGA Zone 55 |
| Scale: | 1:100,000 at A4 |
| Project Number: | 620.040484.00001 |
| Date Drawn: | 12-Sep-2024 |
| Drawn by: | RB |

**LEGEND**

- Topographic Contour (50mAHD)
- Topographic Contour (10mAHD)
- Creek Diversion
- Drainage Path
- Watercourse
- Active Pit
- Spoil Dump
- SRM EA Boundary
- SRM Mine Lease
- Project Area

# SARAJI MINE GREVILLEA PIT CONTINUATION PROJECT GROUNDWATER ASSESSMENT

## TOPOGRAPHY AND DRAINAGE

SLR

DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.

**FIGURE 5**

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040484.00001 Saraji Mine Grevillea GW Model\06 SLR Data\01 CADGIS\GIS\ArcPro\GW Assessment\GW Assessment.aprx\620040484 F05 Topography

## 3.3 Mining

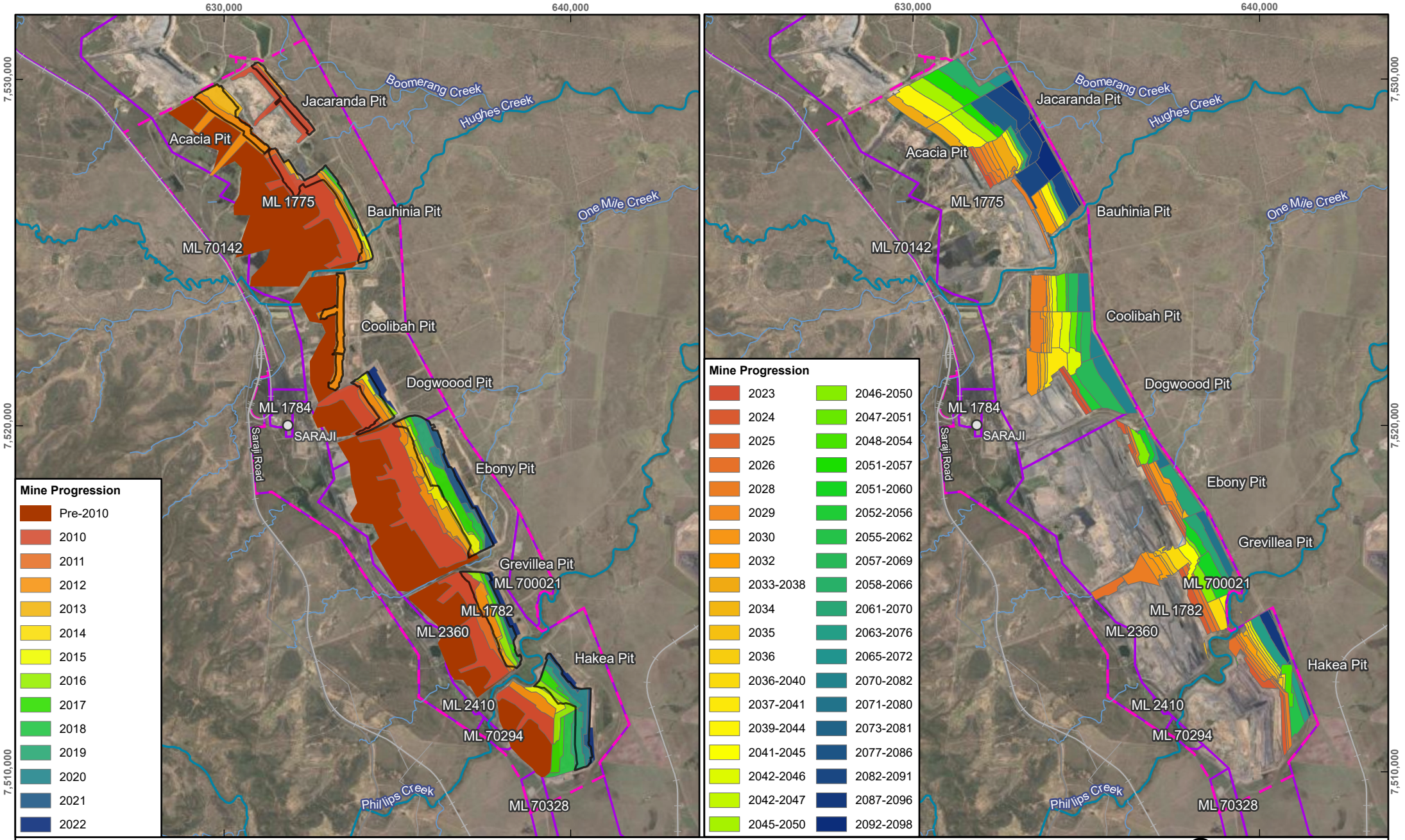
### 3.3.1 Historical Mining Activities

SRM began operations in 1974 with open pit drag line mining pre-strip activities along the length of the SRM mine. Mining at the existing Grevillea Pit commenced in 1987 with the “D” Seam being the deepest target seam.

Spoil is deposited to the west of the pit void adjacent to the pit ramp.

### 3.3.2 Current and Future Mining

Mining at SRM is expected to continue on the current approved operations until approximately 2098. The current future mine plan is provided on **Figure 6**, although this is regularly reviewed and updated. Th current mine plan involves continued generally eastwards mining towards the eastern SRM Area boundary, targeting economic areas of Moranbah Coal Measures seams dipping down to the east, with basal depth of mine void increasing in conjunction with the dipping geology.




Scale: 1:140,000 at A4
Coordinate System: GDA 1994 MGA Zone 55

Date Drawn: 29-Apr-2024
Project Number: 620.040484.00001

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

SLR

DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.

# SARAJI MINE GREVILLEA PIT CONTINUATION PROJECT GROUNDWATER ASSESSMENT

## MINING ACTIVITIES AT SRM

**FIGURE 6**

Path: \\au.slr.local\Corporate\Projects-SLR\620-BNE\620-BNE\620.040484.00001 Saraji Mine Grevillea GW Model\06 SLR Data\01 CADGIS\GIS\ArcPro\Saraji Mine Grevillea GW Model\Saraji Mine Grevillea GW Model.aprx\620040484 F06 Mining Activity

### 3.3.3 Mine Pit Void Inflows

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

Groundwater inflow estimates for SRM based on BMA's annual Associated Water Take (AWT) reporting to the Queensland Department of Resources (DoR) for the period November 2021 to October 2022 was equal to 1,515ML. Estimates are based on BMA's site water balance calculations using site climate data, pit void storage and pumped outflow data in accordance with the DNRME (2020) Associated Water Take Guideline, and as such inflow estimates are considered conservative.

## 3.4 Geology

### 3.4.1 Regional Geology

SRM is located in the northern part of the Bowen Basin, a foreland sedimentary basin of approximately 200,000 km$^2$ (**Figure 7**). The Bowen Basin is a north-northwest to south-southeast oriented basin and contains the largest coal reserves in Australia. The southern half of the Bowen Basin is covered by the Surat Basin, and the Galilee Basin exists to the west (Geoscience Australia, 2017).

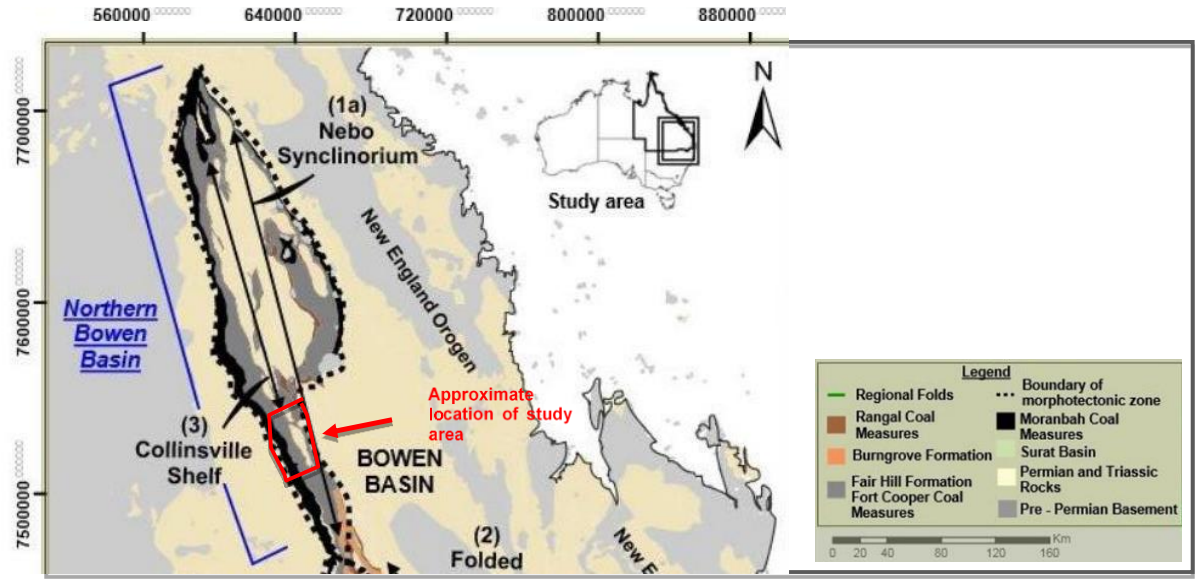



**Figure 7 Structural Setting of the Bowen Basin (after Dickins and Malone, 1973)**

Basin geology within the Collinsville Shelf includes the basal Permian aged Back Creek Group, which generally comprises of generally fine-grained clastic sedimentary rocks deposited in a fluvial to shallow marine environment. The Back Creek Group is conformably overlain by the Blackwater Group, which includes the Moranbah Coal Measures, Fort Cooper Coal Measures and Rangal Coal Measures. The economic seams at SRM are contained in the Moranbah Coal Measures. The Permian strata occur at outcrop on the eastern and western edges of the Basin and are unconformably overlain by the Triassic

aged consolidated sedimentary rocks of the Rewan Group. While not present in the vicinity of SRM, isolated pockets of remnant quartzose sandstones of the Middle Triassic Clematis Group are also mapped within the Study Area, on the eastern side of the Isaac River.

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

The generalised regional stratigraphy is summarised in **Table 7**. The solid geology is presented as **Figure 8** and the surface geology is presented as **Figure 9**.

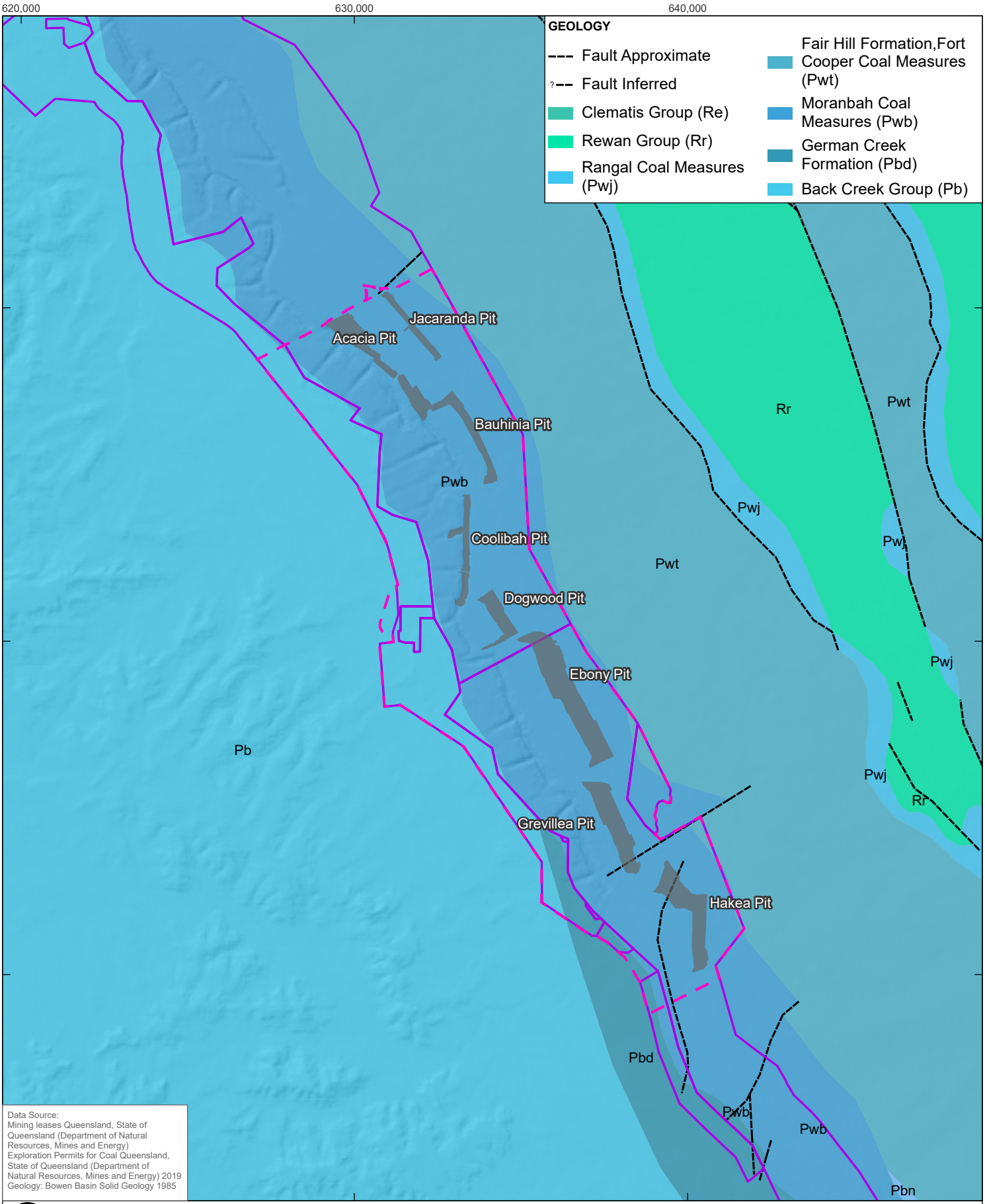
It should be highlighted that the stratigraphic summary provided in **Table 7** is based on regional scale mapping and that stratigraphic units and their thicknesses can vary considerably at a local scale.

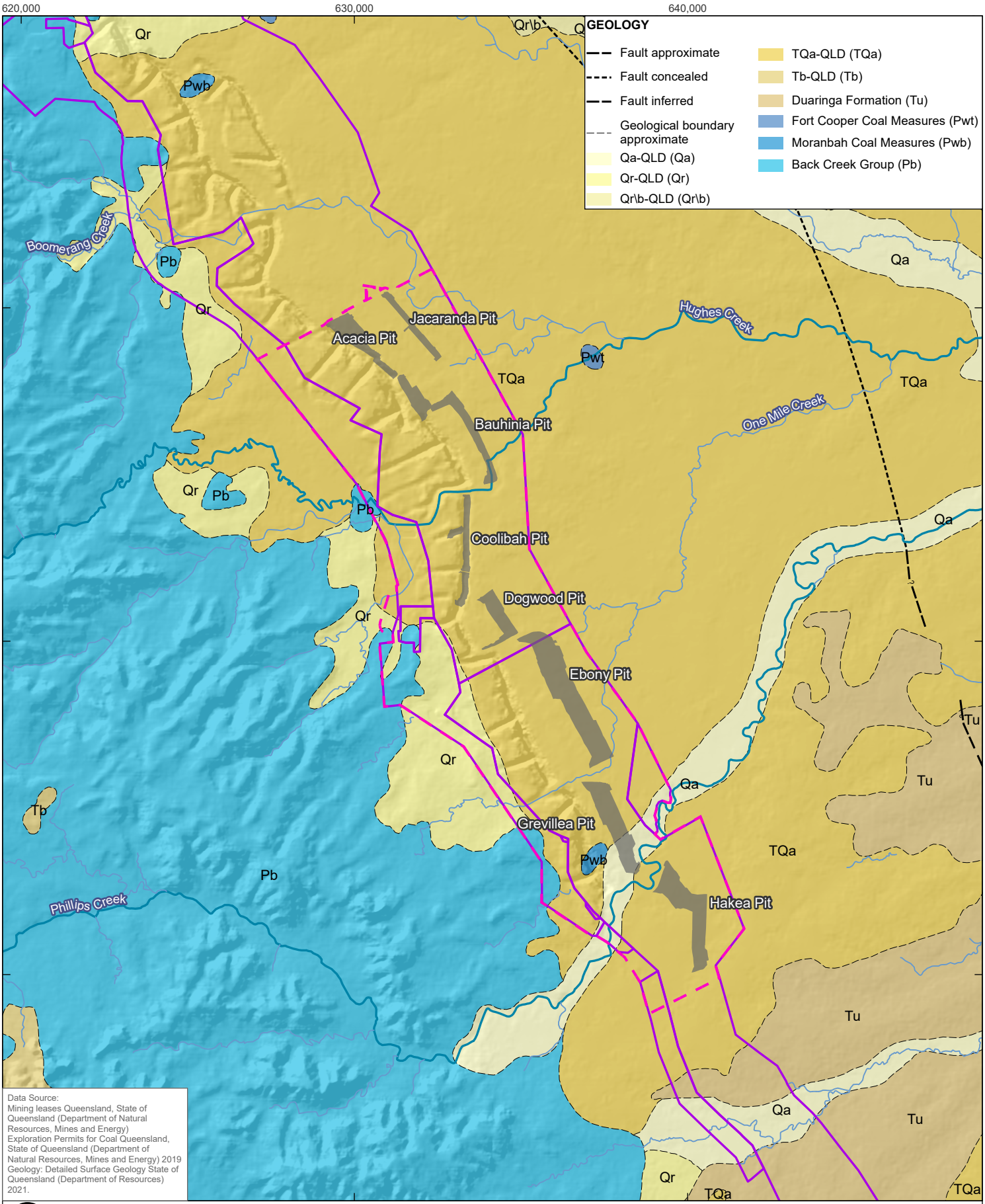
In particular, the maximum thickness of Quaternary alluvium in **Table 7** is not representative of the alluvium sequences observed at the Grevillea Project which are typically only present along present-day drainage lines such as Phillips Creek and are significantly thinner than those shown at the regional scale (refer to the Quaternary Alluvium discussion in **Section 3.4.2.1**).

## Table 7 Regional Stratigraphy

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

| Period | | Stratigraphic Unit | | Description | Mapped Distribution | Max Thickness (m) |
|---|---|---|---|---|---|---|
| Permian | Late | Blackwater Group | Rangal Coal Measures (Pwj) | Coal seams, carbonaceous shale and mudstone, tuff, siltstone and mudstone. | Subcrops 7km east of SRM Area / underlies eastern zones of Study Area. | ~200 |
| | | | Fort Cooper Coal Measures (Pwt) (Fair Hill Formation) | Coal, brown and green sandstone, conglomerate, carbonaceous shale, tuff. | Subcrops along total eastern extent of SRM Area and extends directly to the east. | ~350 |
| | | | Moranbah Coal Measures (Pwb) | Quartzose to sublabile locally argillaceous sandstone, siltstone, mudstone, carbonaceous mudstone and coal. | Within/underlies the whole of SRM. | ~ 400 |
| | Early to Middle | Back Creek Group (Pb) | | Quartzose to lithic sandstone, siltstone, carbonaceous shale, minor coal and sandy coquinite. | Within/underlies all of SRM; Outcrops west of the SRM Area. | ~400 |


620,000
630,000
640,000
7,530,000
7,520,000
7,510,000
GEOLOGY
Fault Approximate
Fault Inferred
Clematis Group (Re)
Rewan Group (Rr)
Rangal Coal Measures (Pwj)
Fair Hill Formation,Fort Cooper Coal Measures (Pwt)
Moranbah Coal Measures (Pwb)
German Creek Formation (Pbd)
Back Creek Group (Pb)
Jacaranda Pit
Acacia Pit
Bauhinia Pit
Coolibah Pit
Dogwood Pit
Ebony Pit
Grevillea Pit
Hakea Pit
Rr
Pwt
Pwj
Pwb
Pb
Pbd
Pbn
Data Source:
Mining leases Queensland, State of Queensland (Department of Natural Resources, Mines and Energy)
Exploration Permits for Coal Queensland, State of Queensland (Department of Natural Resources, Mines and Energy) 2019
Geology: Bowen Basin Solid Geology 1985
0
2.5
5
km
LEGEND
Active Pit
SRM EA Boundary
SRM Mine Lease
Coordinate System: GDA 1994 MGA Zone 55
Scale: 1:150,000 at A4
Project Number: 620.040484.00001
Date Drawn: 12-Sep-2024
Drawn by: RB
SARAJI MINE GREVILLEA PIT CONTINUATION PROJECT GROUNDWATER ASSESSMENT
SOLID GEOLOGY
SLR
DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.
FIGURE 8
Path: H:\Projects-SLR\620-BNE\620-BNE\620.040484.00001 Saraji Mine Grevillea GW Model\06 SLR Data\01 CADGIS\GIS\ArcPro\GW Assessment\GW Assessment.aprx\620040484 F08 Solid Geology




Data Source:
Mining leases Queensland, State of Queensland (Department of Natural Resources, Mines and Energy) Exploration Permits for Coal Queensland, State of Queensland (Department of Natural Resources, Mines and Energy) 2019 Geology: Detailed Surface Geology State of Queensland (Department of Resources) 2021.

0 2.5 5 km

| | |
|---|---|
| Coordinate System: | GDA 1994 MGA Zone 55 |
| Scale: | 1:150,000 at A4 |
| Project Number: | 620.040484.00001 |
| Date Drawn: | 12-Sep-2024 |
| Drawn by: | RB |

**LEGEND**

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

# SARAJI MINE GREVILLEA PIT CONTINUATION PROJECT GROUNDWATER ASSESSMENT

## SURFACE GEOLOGY

SLR

DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.

**FIGURE 9**

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040484.00001 Saraji Mine Grevillea GW Model\06 SLR Data\01 CADGIS\GIS\ArcPro\GW Assessment\GW Assessment.aprx\620040484 F09 Surface Geology

### 3.4.2 Local Geology

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

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

#### 3.4.2.1 Cainozoic

**Quaternary Alluvium**

State (Queensland Government) Detailed Surface Geology (SDSG) mapping (**Figure 9**) shows that Quaternary alluvium is localised along Phillips Creek, crossing the south of SRM and extending north-eastwards; and along Ripstone Creek to the northeast of SRM. Quaternary alluvium is also mapped extensively along the Isaac River to the east of SRM.

The mapped Quaternary alluvium associated with Phillips Creek is adjacent to Grevillea Pit and Hakea Pit and extends continuously to join with the Isaac River alluvium (refer **Figure 9**). Existing studies (e.g. AECOM, 2019) and SRM monitoring data (see **Section 3.5.3.1**) indicate that continual saturation of the Quaternary alluvium associated with Phillips Creek to the Isaac River is unlikely. Rather, groundwater occurrence in the Phillips Creek alluvium is highly sporadic and isolated, i.e. groundwater is not found broadly across the extent of Phillips Creek alluvium but only in a few isolated areas. Therefore, the groundwater resources of the Phillips Creek alluvium (where they exist) are likely hydraulically disconnected from those in the Isaac River alluvium. Further discussion is provided in **Section 3.5.3.1**.

**Tertiary Sediments**

SDSG mapping shows Tertiary sediments distributed across SRM and the surrounding area. The Tertiary sediments are defined in the SDSG metadata as a poorly consolidated or unconsolidated alluvial deposit in an ancestral valley, which has been dissected by more recent channel activity. SDSG mapping shows that the Tertiary sediments extend eastwards from SRM towards the Isaac River and are indicative of flood plain material associated with watercourses traversing the area. The inferred extent of the surficial material is presented in **Figure 9**.

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

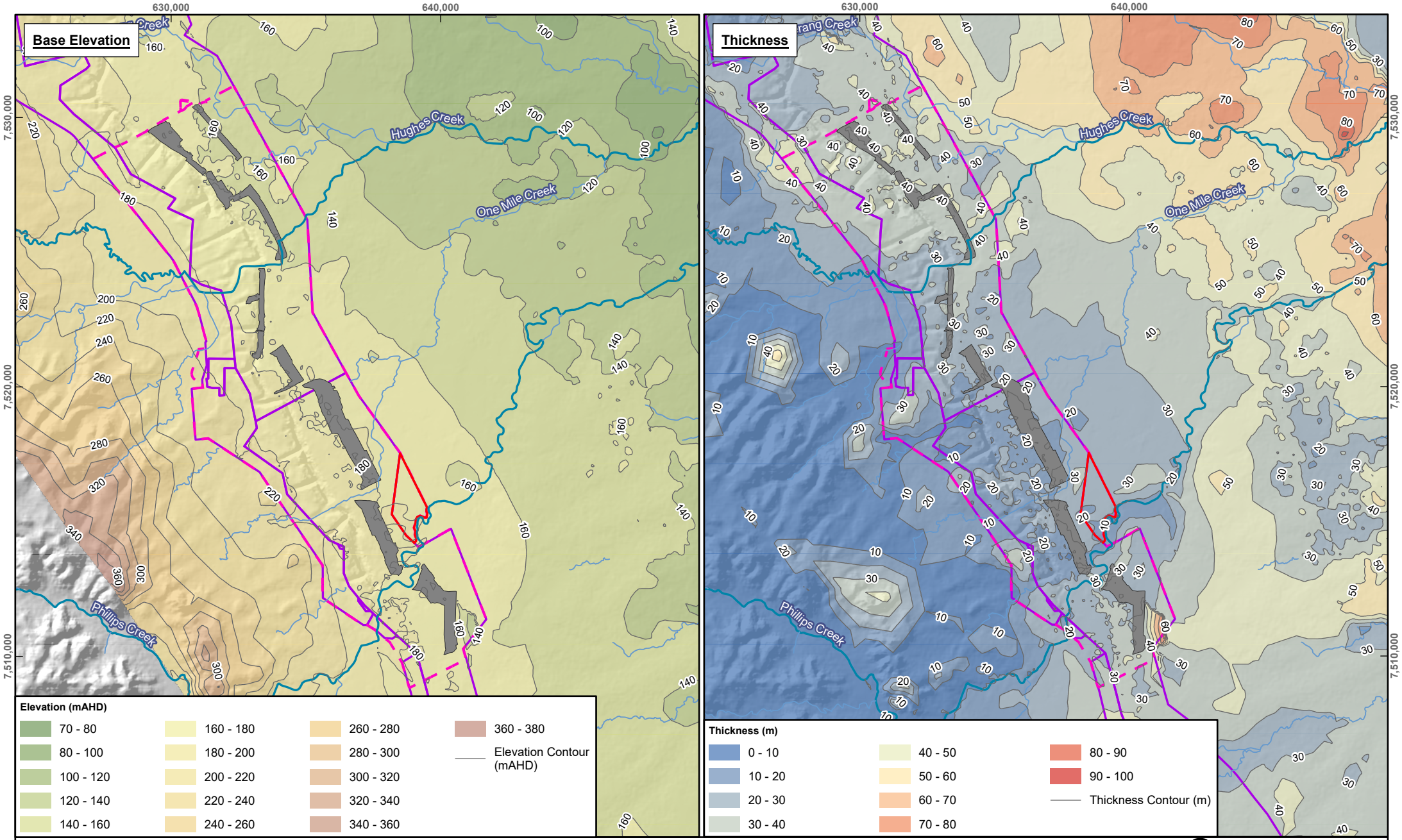
The Tertiary clay unit is the predominant Tertiary unit across the SRM Area, comprising a clay matrix with intercalation of clay and sand lithologies (AECOM, 2019).

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

### Regolith

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

SDSG mapping shows surficial regolith deposits to be localised in the west of the SRM Area (**Figure 9**), indicative of weathering of the Permian Back Creek Group by water courses as they traverse these locations. The extent and thickness of the regolith material is presented in **Figure 10**, interpolated based on SRM site geological data and the CSIRO Soil and Landscape Grid of Australia (CSIRO, 2015) data.




SLR

DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.

# SARAJI MINE GREVILLEA PIT CONTINUATION PROJECT GROUNDWATER ASSESSMENT

## BASE ELEVATION AND THICKNESS OF SURFICIAL UNITS

**FIGURE 10**

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040484.00001 Saraji Mine Grevillea GW Model\06 SLR Data\01 CADGIS\GIS\ArcPro\GW Assessment\GW Assessment.aprx\620040484 F10 Base Elevation and Thickness of Surficial Units

#### 3.4.2.2 Permian Coal Measures (Blackwater Group)

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

- Moranbah Coal Measures
- Fort Cooper Coal Measures
- Rangal Coal Measures

Each of these units is discussed further below.

**Moranbah Coal Measures**

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

There are four main coal seams (each comprised of multiple plies) within the Moranbah Coal Measures at SRM, in order of increasing depth these are known as the Q seams, P seams, the Harrow Creek (H) seams and the Dysart (D) seams. All seams split and recombine along the mine. These main coal seams subcrop on the western part of the SRM. **Figure 11** presents a schematic of the coal seams along the mine. It should be noted that although the Fort Cooper Coal Measures are shown on the schematic, these are not present within the SRM Area, instead subcropping immediately east of the SRM Area boundary (described further in the Fort Cooper Coal Measures discussion in **Section 3.4.2.2** below and as shown in **Figure 8**). A brief description of each seam is described as follows.

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

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

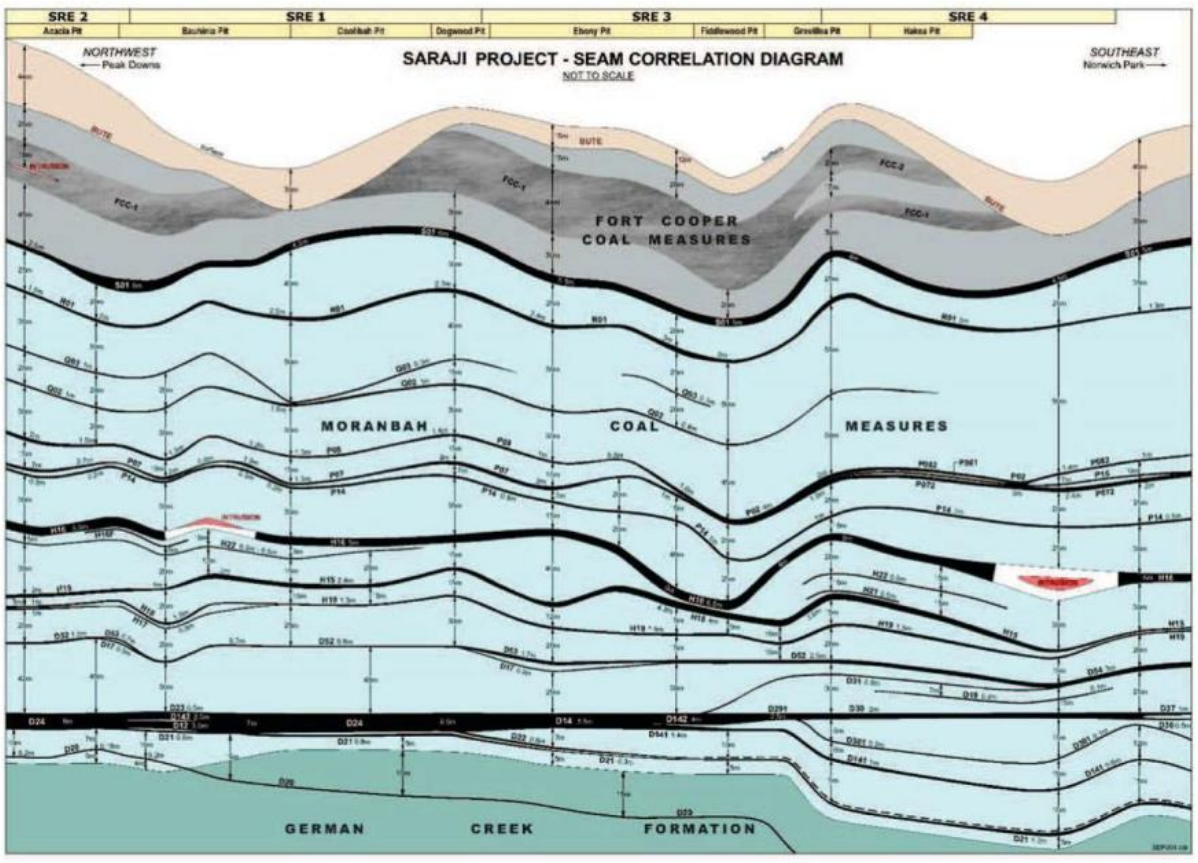



**Figure 11 Schematic Diagram of Coal Seams at SRM (BHP, 2019)**

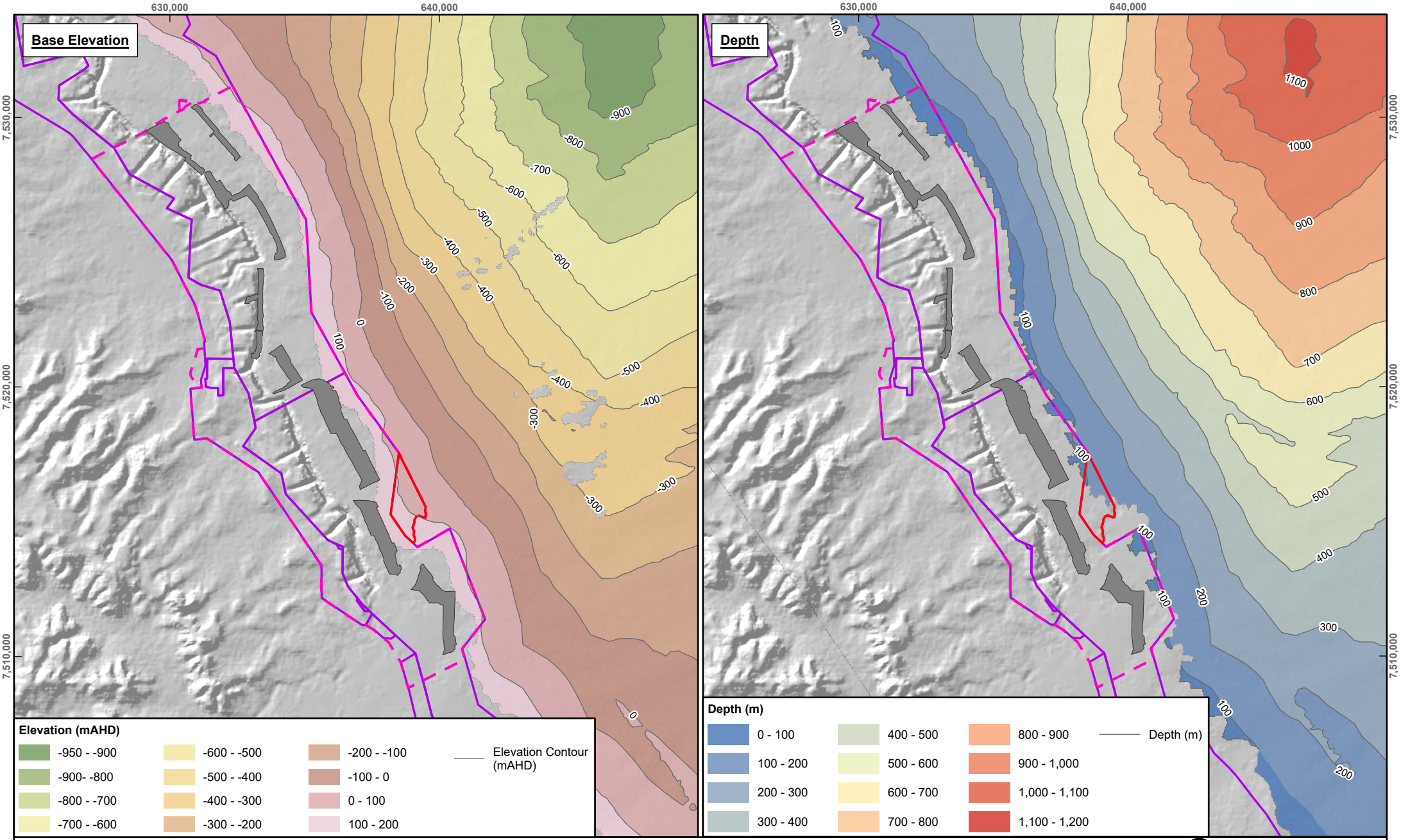
The average combined thicknesses of the constituent plies comprising each seam is given:

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

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

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

Interpolated structure and depth contours of the Q Seam, P Seam, H Seam and D Seam are presented in **Figure 12** to **Figure 15**. These contours have been based on the SRM geological model.




Scale: 1:180,000 at A4
Coordinate System: GDA 1994 MGA Zone 55

Date Drawn: 12-Sep-2024
Project Number: 620.040484.00001

Active Pit
SRM EA Boundary
SRM Mine Lease
Project Area

SLR

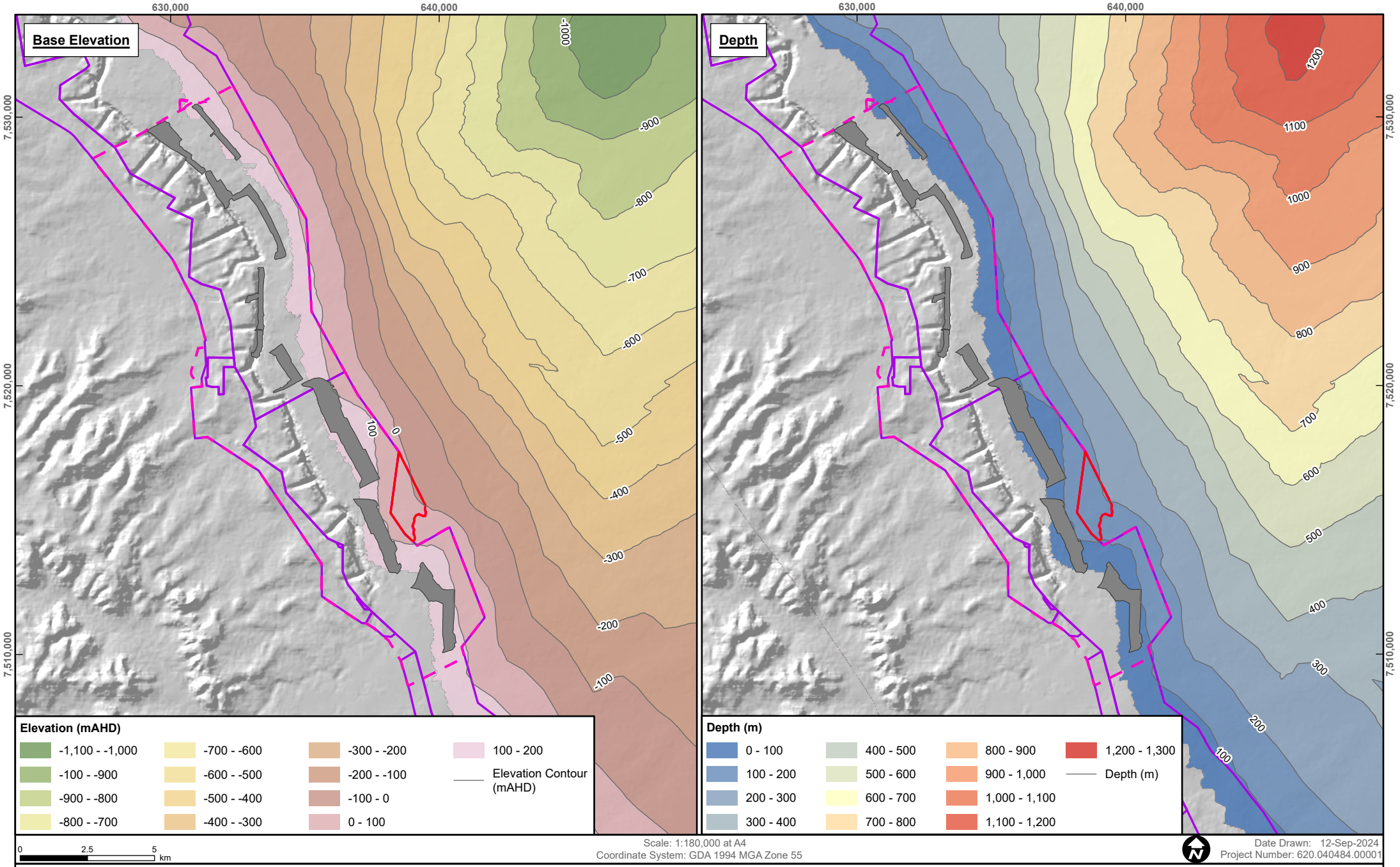
DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.

**SARAJI MINE GREVILLEA PIT CONTINUATION PROJECT GROUNDWATER ASSESSMENT**

**BASE ELEVATION OF THE Q SEAM AND DEPTH TO Q SEAM**

**FIGURE 12**

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040484.00001 Saraji Mine Grevillea GW Model\06 SLR Data\01 CADGIS\GIS\ArcPro\GW Assessment\GW Assessment.aprx\620040484 F12 Base elevation of the Q Seam and Depth to Q Seam




SLR

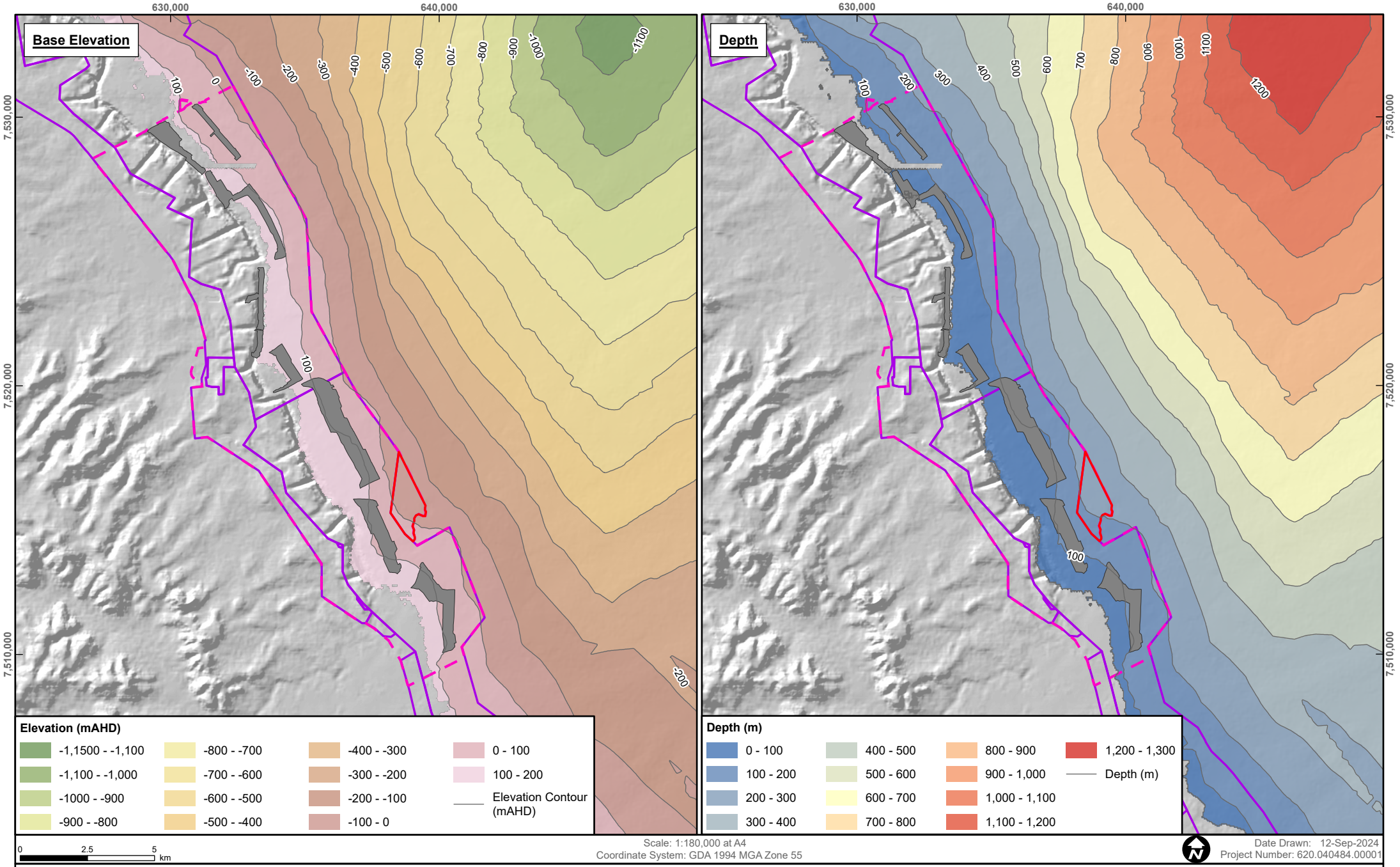
DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.

**SARAJI MINE GREVILLEA PIT CONTINUATION PROJECT GROUNDWATER ASSESSMENT**

**BASE ELEVATION OF THE P SEAM AND DEPTH TO P SEAM**

**FIGURE 13**

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040484.00001 Saraji Mine Grevillea GW Model\06 SLR Data\01 CADGIS\GIS\ArcPro\GW Assessment\GW Assessment.aprx\620040484 F13 Base Elevation of the P Seam and Depth to P Seam




SLR

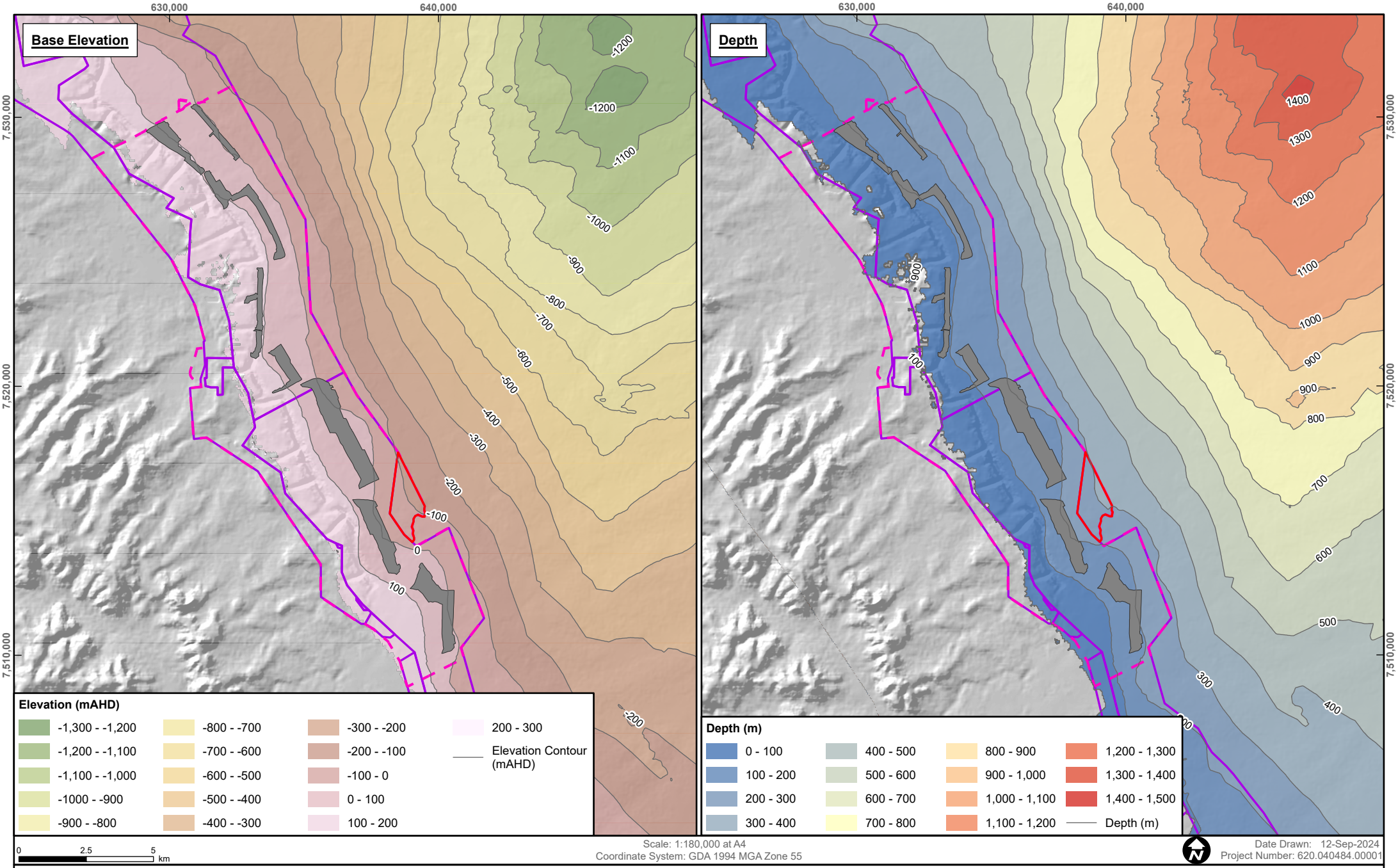
DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.

**SARAJI MINE GREVILLEA PIT CONTINUATION PROJECT GROUNDWATER ASSESSMENT**

**BASE ELEVATION OF THE H SEAM AND DEPTH TO H SEAM**

**FIGURE 14**

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040484.00001 Saraji Mine Grevillea GW Model\06 SLR Data\01 CADGIS\GIS\ArcPro\GW Assessment\GW Assessment.aprx\620040484 F14 Base Elevation of the H Seam and Depth to H Seam




Scale: 1:180,000 at A4
Coordinate System: GDA 1994 MGA Zone 55

Date Drawn: 12-Sep-2024
Project Number: 620.040484.00001

SLR

DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.

**SARAJI MINE GREVILLEA PIT CONTINUATION PROJECT GROUNDWATER ASSESSMENT**

**BASE ELEVATION OF THE D SEAM AND DEPTH TO D SEAM**

**FIGURE 15**

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040484.00001 Saraji Mine Grevillea GW Model\06 SLR Data\01 CADGIS\GIS\ArcPro\GW Assessment\GW Assessment.aprx\620040484 F15 Base Elevation of the D Seam and Depth to D Seam

**Fort Cooper Coal Measures**

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

**Rangal Coal Measures**

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

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

#### 3.4.2.3 Back Creek Group

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

#### 3.4.2.4 Structural Geology

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

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

Faults at SRM strike north to south, east to west and northeast and are associated with two dominant structural domains: one trends north north-west, the second trends north-south (AECOM, 2019). The majority of these faults are normal faults with maximum throws of 60m (BHP, 2019), however there is no indication of any marked disruption of the coal measures

because of faulting in the vicinity of the Jacaranda, Bauhinia, Coolibah and Dogwood pits in the northern and central parts of the SRM Area (AECOM, 2019). Some monocline structures are located within SRM that affect some coal seams. Major faults (considered where displacement is greater than 10m) are spatially wide spaced between 1 km to 5 km, with localised steepening around these structures (AGE, 2011). Three such structures are mapped in the southern part of the SRM Area, in the vicinity of the Ebony, Grevillea and Hakea pits (**Figure 8**).

## 3.5 Hydrogeology

Based on the understanding of the geological setting presented in **Section 3.4**, the hydrogeological regime relevant to SRM comprises the following key hydrogeological units:

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

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

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

### 3.5.1 SRM Groundwater Monitoring

The SRM groundwater monitoring network is presented in **Table 8** and **Table 9**.

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

- Quaternary Alluvium (17 monitoring bores)
- Fill material (two monitoring bores)
- Tertiary sediments (including regolith) (13 monitoring bores)
- Fort Cooper Coal Measures (four monitoring bores)
- The R seam of the Moranbah Coal Measures (one monitoring bore)
- The Q seam of the Moranbah Coal Measures (one monitoring bore)

- The P Seam of the Moranbah Coal Measures (three monitoring bores and two VWP sensor)
- The H Seam of the Moranbah Coal Measures (five monitoring bores and three VWP sensors)
- The D seam of the Moranbah Coal Measures (six monitoring bores and three VWP sensors)
- Interburden of the Moranbah Coal Measures (three monitoring bores)
- Back Creek Group (two monitoring bores).

Groundwater data collection from the groundwater monitoring network has been undertaken since 2008. The locations of the current monitoring network are shown in **Figure 16** and details provided in **Table 8**.

Where possible, data from monitoring bores proximal to the Grevillea Project has been used to describe the local groundwater conditions in the following sections.

**Table 8 SRM Groundwater Monitoring Network – Standpipe Bores**

| Bore ID | Easting (GDA94) | Northing (GDA94) | Surface Elevation (mAHD) | Screen Top Elevation (mAHD) | Screen Base Elevation (mAHD) | Monitored Unit | Install Date | Status | Water Level Data Availability | Water Quality Data Availability |
|---|---|---|---|---|---|---|---|---|---|---|
| MB31 (SJ1) | 626056 | 7522741 | 225 | Unknown | 180.81 (TD elevation) | BCG – Coal Seam (unknown) | Unknown - unregistered | Existing, monitored | 2014 to 2023 | 2009 to 2023 |
| MB32 (TG2) | 637709 | 7510897 | 208.1 | Unknown | 188.61 (TD elevation) | Alluvium | Unknown - unregistered | Existing, monitored | 2014 to 2023 | 2009 to 2023 |
| MB 33 (RN158014) | 636754 | 7520380 | 194.8 | 164.8 | 158.8 | Q Seam Group | Mar-12 | Existing, monitored | 2014 to 2023 | 2013 to 2023 |
| MB34 (RN158013) | 638040 | 7518450 | 195.9 | 96.4 | 90.4 | P Seam Group | Sep-12 | Existing, monitored | 2014 to 2023 | 2013 to 2023 |
| MB35 (RN158010) | 642760 | 7520291 | 184.6 | 157.6 | 151.6 | FCCM | Aug-12 | Existing, monitored | 2014 to 2023 | 2013 to 2023 |
| MB36 (RN158011) | 640264 | 7514464 | 197.8 | 173.3 | 167.3 | FCCM | Jun-12 | Existing, monitored | 2014 to 2023 | 2013 to 2023 |
| MB37 | 632503 | 7515752 | 234.8 | 200.8 | 192.3 | BCG - Interburden | Jun-12 | Existing, monitored | 2014 to 2023 | 2013 to 2023 |
| MB38 / MB19SRM01 A (RN169276) | 640146 | 7516041 | 194.3 | 188.8 | 185.8 | Alluvium | Jul-19 | Existing, monitored | 2019 to 2023 (Dry) | Dry |
| MB39 / MB19SRM03 P (RN169277) | 640132 | 7516057 | 194.3 | 110 | 103.8 | R Seam Group | Jul-19 | Existing, monitored | 2019 to 2023 | 2019 to 2023 |
| MB40 / MB19SRM02 T (RN169278) | 640140 | 7516048 | 194.4 | 180.4 | 174.4 | Tertiary | Jul-19 | Existing, monitored | 2019 to 2023 | 2019 to 2023 |

| Bore ID | Easting (GDA94) | Northing (GDA94) | Surface Elevation (mAHD) | Screen Top Elevation (mAHD) | Screen Base Elevation (mAHD) | Monitored Unit | Install Date | Status | Water Level Data Availability | Water Quality Data Availability |
|---|---|---|---|---|---|---|---|---|---|---|
| MB19SRM04P | 637174 | 7511222 | 208.7 | 172.7 | 166.7 | MCM – Interburden (sandstone) | Aug-19 | Existing, monitored | 2019 to 2023 | 2019 to 2023 |
| MB20SRM01A | 636036 | 7527845 | 194.4 | 178.6 | 175.6 | Alluvium | Oct-19 | Existing, monitored | None | None |
| MB20SRM02T | 636028 | 7527850 | 207.9 | 158.6 | 149.6 | Fort Cooper Coal Measures | Oct-19 | Existing, monitored | 2019 to 2023 | 2019 to 2023 |
| PZ00C | 632985 | 7529934 | 186.74 | 161.7 | 158.7 | Tertiary | Sep-18 | Existing, monitored | 2019 to 2023 | 2019 to 2023 |
| PZ00D | 631798 | 7530369 | 192.29 | 169.8 | 163.8 | MCM Interburden - Sandstone | Sep-18 | Existing, monitored | 2019 to 2023 | 2019 to 2023 |
| 2013MP06 | 630572 | 7524303 | 203.7 | 202.2 | 193.7 | Alluvium | Jul-05 | Existing, monitored | 2019 to 2023 | 2019 to 2023 |
| 2016BH05 | 631368 | 7524314 | 208.8 | 200.8 | 197.8 | Fill | 2016 | Existing, monitored | 2019 to 2023 | 2019 to 2023 |
| 2016BH08 | 631302 | 7523893 | 207 | 193 | 190 | Fill | 2016 | Existing, monitored | 2019 to 2023 | 2019 to 2023 |
| 2019MP01_D | 630680 | 7524322 | 209.6 | 196 | 192.6 | Alluvium | May-19 | Existing, monitored | 2019 to 2023 | 2019 to 2023 |
| 2019MP02_D | 630690 | 7524282 | 209.3 | 196.1 | 192.3 | Alluvium | May-19 | Existing, monitored | 2019 to 2023 | 2019 to 2023 |
| 2019MP03_D | 630685 | 7524258 | 209.1 | 198.1 | 195.1 | Alluvium | May-19 | Existing, monitored | 2019 to 2023 | 2019 to 2023 |

| Bore ID | Easting (GDA94) | Northing (GDA94) | Surface Elevation (mAHD) | Screen Top Elevation (mAHD) | Screen Base Elevation (mAHD) | Monitored Unit | Install Date | Status | Water Level Data Availability | Water Quality Data Availability |
|---|---|---|---|---|---|---|---|---|---|---|
| 2019MP04_D | 630700 | 7524177 | 208.6 | 196.6 | 190.6 | Alluvium | May-19 | Existing, monitored | 2019 to 2023 | 2019 to 2023 |
| 2019MP05_D | 630649 | 7524297 | 209.9 | 196.4 | 188.9 | Alluvium | May-19 | Existing, monitored | 2019 to 2023 | 2019 to 2023 |
| 2019MP06 | 630637 | 7524452 | 209.3 | 196.8 | 194.3 | Alluvium | May-19 | Existing, monitored | 2019 to 2023 | 2019 to 2023 |
| 2019MP07 | 630747 | 7524080 | 206.2 | 197.7 | 194.7 | Alluvium | May-19 | Existing, monitored | 2019 to 2023 | 2019 to 2023 |
| 2019MP07_D | 630587 | 7524531 | 208.9 | 196.4 | 192.4 | Alluvium | May-19 | Existing, monitored | 2019 to 2023 | 2019 to 2023 |
| 2019MP08 | 630551 | 7524025 | 201.6 | 198.6 | 189.6 | BCG - Overburden (siltstone) | May-19 | Existing, monitored | 2019 to 2023 | 2019 to 2023 |
| 2019MP09 | 630371 | 7524311 | 200.6 | 197.1 | 195.1 | Alluvium | May-19 | Existing, monitored | 2019 to 2023 | 2019 to 2023 |
| 2019MP10 | 630471 | 7524455 | 203.7 | 198.2 | 194.7 | Alluvium | May-19 | Existing, monitored | 2019 to 2023 | 2019 to 2023 |
| 2022EW01 | 630680 | 7524274 | 209.20 | 190.20 | 184.20 | Fill / Alluvium | Oct-22 | Existing, not actively monitored | None | None |
| 2022EW02 | 630690 | 7524258 | 209.03 | 196.03 | 190.03 | Fill / Alluvium | Oct-22 | Existing, not actively monitored | None | None |

| Bore ID | Easting (GDA94) | Northing (GDA94) | Surface Elevation (mAHD) | Screen Top Elevation (mAHD) | Screen Base Elevation (mAHD) | Monitored Unit | Install Date | Status | Water Level Data Availability | Water Quality Data Availability |
|---|---|---|---|---|---|---|---|---|---|---|
| 2022EW03 | 630696 | 7524233 | 209.1 | 201.1 | 192.1 | Fill / Alluvium | Oct-22 | Existing, not actively monitored | None | None |
| 2022EW04 | 630704 | 7524189 | 208.82 | 197.82 | 191.82 | Fill / Alluvium | Oct-22 | Existing, not actively monitored | None | None |
| 2022EW05 | 630712 | 7524135 | 206.95 | 196.95 | 190.95 | Fill / Alluvium | Oct-22 | Existing, not actively monitored | None | None |
| 2022EW06 | 630710 | 7524104 | 205.62 | 196.62 | 190.62 | Fill / Alluvium | Oct-22 | Existing, not actively monitored | None | None |
| 2022EW07 | 630711 | 7524084 | 205.5 | 197.5 | 193.5 | Fill / Alluvium | Oct-22 | Existing, not actively monitored | None | None |
| 2022MP01 | 630668 | 7524273 | 209.4 | 199.4 | 193.4 | Fill / Alluvium | Oct-22 | Existing, monitored | 2022 to 2023 | 2022 to 2023 |
| 2022MP02 | 630664 | 7524214 | 208.6 | 199.6 | 193.6 | Fill / Alluvium | Oct-22 | Existing, monitored | 2022 to 2023 | 2022 to 2023 |
| 2022MP03 | 630684 | 7524173 | 207.76 | 196.76 | 193.76 | Fill / Alluvium | Oct-22 | Existing, monitored | 2022 to 2023 | 2022 to 2023 |
| 2022MP04 | 630691 | 7524290 | 209.58 | 190.58 | 184.58 | Fill / Alluvium | Oct-22 | Existing, monitored | 2022 to 2023 | 2022 to 2023 |
| 2022MP05 | 630698 | 7524223 | 209.26 | 197.26 | 194.26 | Fill / Alluvium | Oct-22 | Existing, monitored | 2022 to 2023 | 2022 to 2023 |



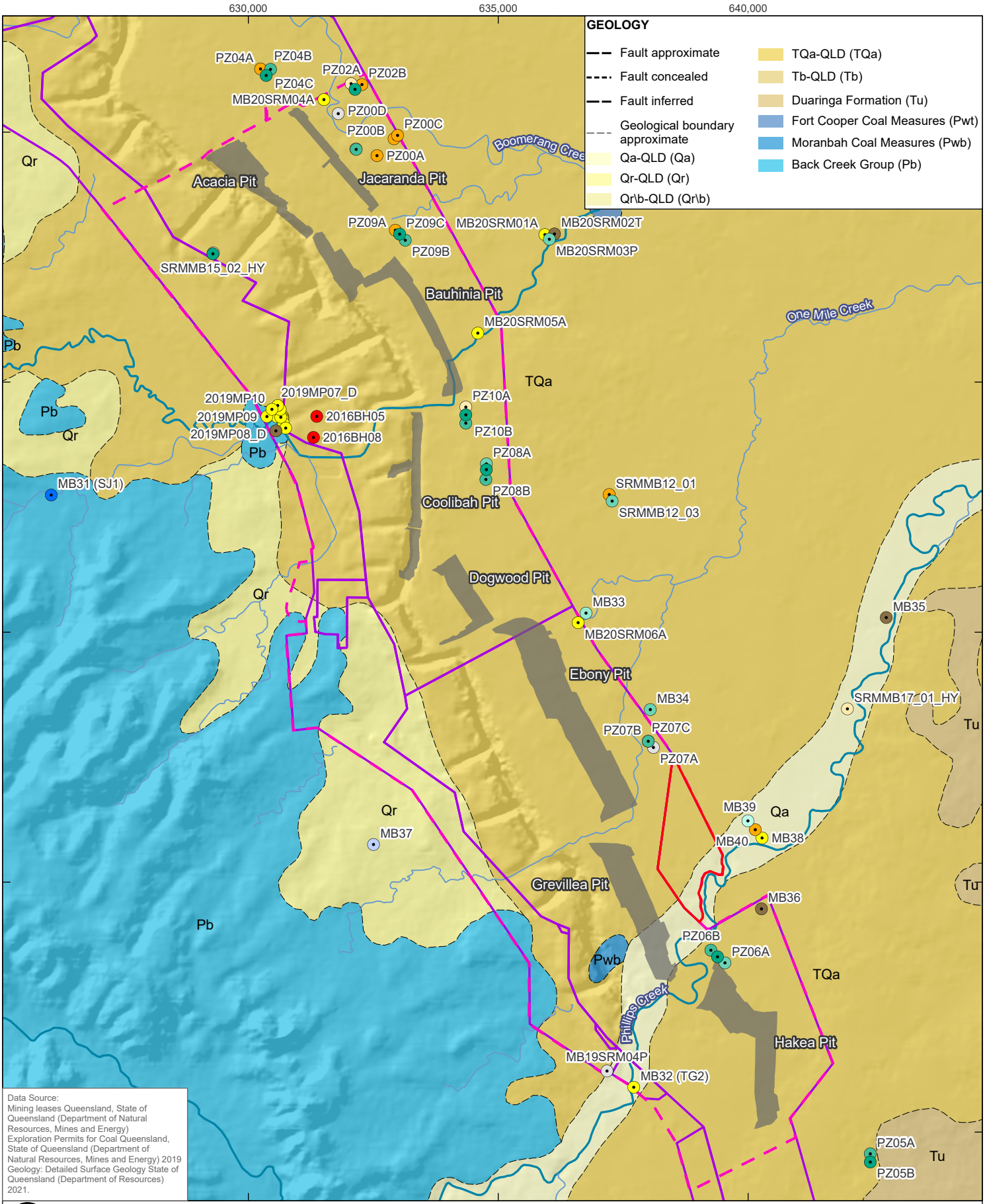


| Bore ID | Easting (GDA94) | Northing (GDA94) | Surface Elevation (mAHD) | Screen Top Elevation (mAHD) | Screen Base Elevation (mAHD) | Monitored Unit | Install Date | Status | Water Level Data Availability | Water Quality Data Availability |
|---|---|---|---|---|---|---|---|---|---|---|
| 2022MP06 | 630695 | 7524109 | 205.83 | 198.83 | 195.83 | Fill / Alluvium | Oct-22 | Existing, monitored | 2022 to 2023 | 2022 to 2023 |
| PZ02A | 632133 | 7530855 | 200.8 | 176.8 | 170.8 | Regolith | Jun-11 | Existing, not actively monitored | 2011 to 2012 | None |
| PZ02B | 632133 | 7530855 | 200.8 | 45.8 | 39.8 | MCM Interburden - Sandstone | Jun-11 | Existing, not actively monitored | 2011 to 2012 | None |
| PZ02C | 632133 | 7530855 | 200.8 | -68.2 | -74.2 | D Seam Group | Jun-11 | Existing, not actively monitored | 2011 to 2012 | None |
| PZ04A | 630356 | 7531133 | 209.9 | 190.9 | 184.9 | Tertiary - Regolith | Jun-11 | Existing, not actively monitored | 2011 to 2012 | None |
| PZ04B | 630356 | 7531133 | 209.9 | 157.9 | 153.9 | H Seam Group | Jun-11 | Existing, not actively monitored | 2011 to 2012 | None |
| PZ04C | 630356 | 7531133 | 209.9 | 53.9 | 35.9 | D Seam Group | Jun-11 | Existing, not actively monitored | 2011 to 2012 | None |
| PZ07A | 637999 | 7517817 | 196.9 | 188.9 | 185.9 | Tertiary - Claystone | Jun-11 | Existing, not actively monitored | None | None |
| PZ07B | 637999 | 7517817 | 196.9 | 12.9 | 0.9 | MCM – Interburden (Sandstone) | Jun-11 | Existing, not actively monitored | None | None |

| Bore ID | Easting (GDA94) | Northing (GDA94) | Surface Elevation (mAHD) | Screen Top Elevation (mAHD) | Screen Base Elevation (mAHD) | Monitored Unit | Install Date | Status | Water Level Data Availability | Water Quality Data Availability |
|---|---|---|---|---|---|---|---|---|---|---|
| PZ07C | 637999 | 7517817 | 196.9 | | | H Seam Group | Jun-11 | Existing, not actively monitored | None | None |
| PZ09A | 633026 | 7527959 | 198.24 | | | Tertiary | Jun-11 | Existing, not actively monitored | 2011 to 2012 | None |
| PZ09B | 633026 | 7527959 | 198.24 | 129.2 | 123.2 | H Seam Group | Jun-11 | Existing, not actively monitored | 2011 to 2012 | None |
| PZ09C | 633026 | 7527959 | 198.24 | 24.2 | 16.2 | D Seam Group | Jun-11 | Existing, not actively monitored | 2011 to 2012 | None |
| PZ10A | 634350 | 7524345 | 209.62 | | | Tertiary - Regolith | Jun-11 | Existing, not actively monitored | 2011 to 2012 | None |
| PZ10B | 634350 | 7524345 | 209.62 | 156.6 | 150.6 | H Seam Group | Jun-11 | Existing, not actively monitored | 2011 to 2012 | None |
| PZ10C | 634350 | 7524345 | 209.62 | 50.6 | 44.6 | D Seam Group | Jun-11 | Existing, not actively monitored | 2011 to 2012 | None |

**Table 9 SRM Groundwater Monitoring Network – VWPs**

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




Data Source:
Mining leases Queensland, State of Queensland (Department of Natural Resources, Mines and Energy)
Exploration Permits for Coal Queensland, State of Queensland (Department of Natural Resources, Mines and Energy) 2019
Geology: Detailed Surface Geology State of Queensland (Department of Resources) 2021.

0 1 2 km

| | |
|---|---|
| Coordinate System: | GDA 1994 MGA Zone 55 |
| Scale: | 1:100,000 at A4 |
| Project Number: | 620.040484.00001 |
| Date Drawn: | 12-Sep-2024 |
| Drawn by: | RB |

**LEGEND**

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

**Monitoring Locations - Aquifer Unit**

- Alluvium
- Fill
- Tertiary Sediments
- Regolith
- FCCM
- MCM – Interburden
- R Seam Group
- Q Seam Group
- P Seam Group
- H Seam Group
- D Seam Group
- BCG - Interburden
- BCG – Coal Seam

# SARAJI MINE GREVILLEA PIT CONTINUATION PROJECT GROUNDWATER ASSESSMENT

## SRM GROUNDWATER MONITORING NETWORK

SLR

DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.

**FIGURE 16**

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040484.00001 Saraji Mine Grevillea GW Model\06 SLR Data\01 CADGIS\GIS\ArcPro\GW Assessment\GW Assessment.aprx\620040484 F16 GW Monitoring Network

### 3.5.2 Hydraulic Properties

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

#### 3.5.2.1 Hydraulic Data

The database of available field results for horizontal (Kh) and vertical (Kv) hydraulic conductivity is presented graphically as **Figure 17**. Tests from the SRM Area are provided as a separate classification on the plot. The data are also presented separately for each test method as results can vary based on the type of testing and analysis undertaken.

**Figure 17** shows that the hydraulic conductivity of the alluvium is variable, ranging from 1 x $10^{-2}$ to almost 10 metres per day (m/day), which reflects the heterogeneous nature of the alluvial sediments. Hydraulic testing of the alluvium within SRM also found hydraulic conductivity to be at the lower end of this scale, with values ranging from 0.16 m/day to 8.64 m/day. Pumping tests of the Isaac River alluvium conducted in 2019 as part of the Moorvale South Project assessment reported hydraulic conductivity values in the range of 2.1 – 2.7 m/day, which is in the range of values provided by slug testing conducted across the Study Area.

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

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

The testing from both SRM and CVM reported the following horizontal hydraulic conductivities (Kh) ranges (in order of increasing depth) (**Figure 17**):

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

Interburden/overburden testing shows a hydraulic conductivity of at least an order of magnitude less than that of coal seams at similar depths, typically less than $10^{-4}$ m/day. **Figure 17** also shows that the hydraulic conductivity of the Permian coal measures generally declines with depth, due to increasing overburden pressure reducing the aperture of secondary porosity features.

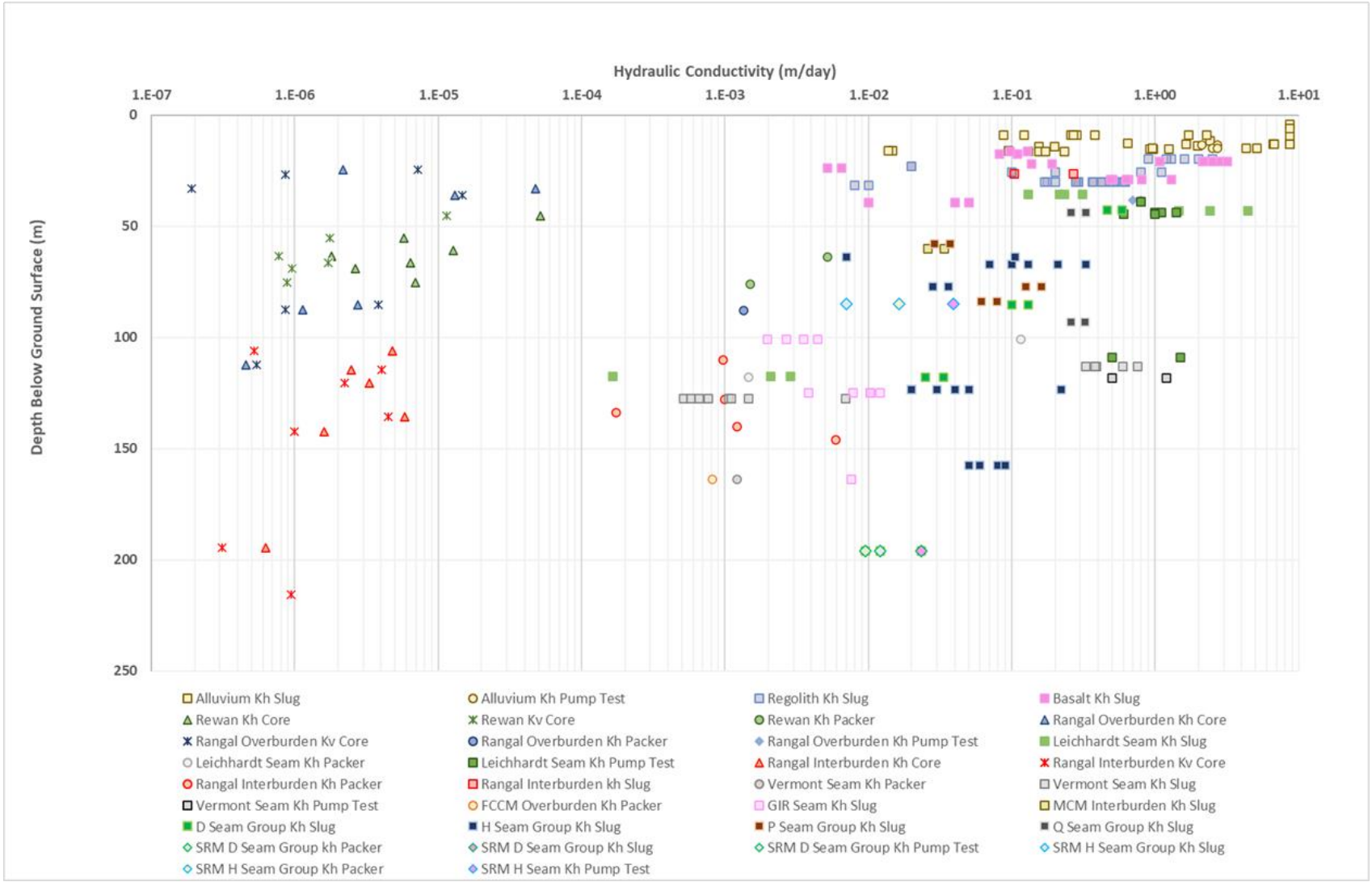



**Figure 17 Summary Results for all Hydraulic Testing**

### 3.5.2.2 Hydraulic Conductivity Ranges

A histogram of the spread of horizontal hydraulic conductivity (Kh) from the field testing at SRM, as well as at other nearby sites, is presented in **Figure 18**. The results are compared to the range of documented values for each relevant units as presented within a literature review previously completed by HydroSimulations (2018) based on a number of other studies within the Bowen Basin.

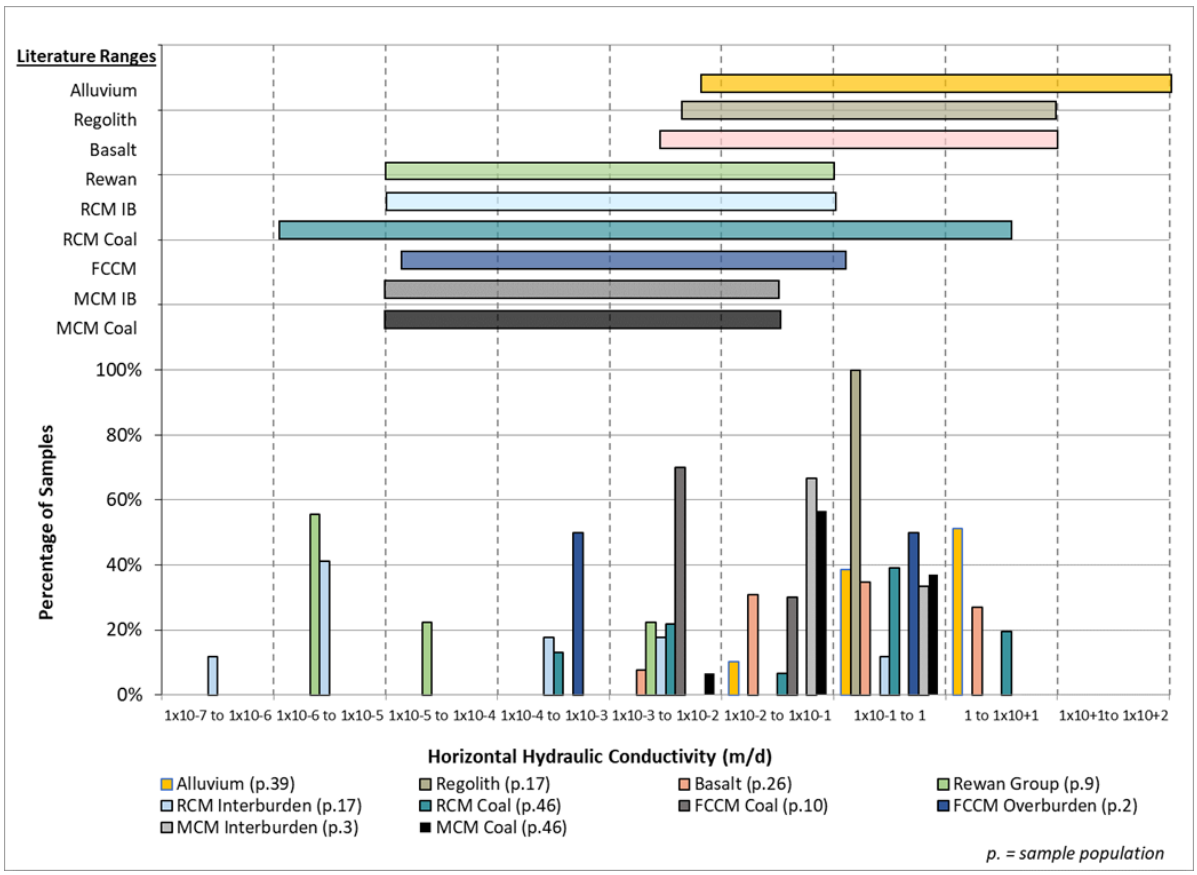



**Figure 18 Histogram of Horizontal Hydraulic Conductivity Distribution**

The comparison shows that the field results for Alluvium, Tertiary Sediments, Rangal Coal Measures and Fort Cooper Coal Measures within the Study Area and immediate surrounds fall within the range of field data collected through other studies across the Bowen Basin. Results for the Moranbah Coal Measures from the SRM Area recorded higher readings than previously identified in literature. Review of **Figure 17** shows that within the Moranbah Coal Measures the higher readings are attributed to the H seam where hydraulic conductivities are generally an order of magnitude greater than measured within the Q, P and D coal seams. As discussed in the Quaternary discussion under **Section 3.4.2.1** the H seam is generally thicker than the other seams, which may result in wider cleats and fissures within the unit. It should be noted that the type of testing undertaken at CVM (i.e. slug testing) typically yields hydraulic conductivity estimates limited to the bore scale, whereas the regional dataset (**Figure 17**) includes estimates derived from pumping tests that are considered more representative of aquifer-scale properties.

#### 3.5.2.3 Faulting

As discussed in the Fort Cooper Coal Measures discussion in **Section 3.4.2.4**, significant faulting is not present at SRM, however extensive faulting has been mapped within the Permian coal measures east of SRM (see **Figure 8**). As identified by Jourde et al. (2002), faulting can result in higher permeabilities within strata parallel with the fault plane, and lower permeabilities within strata perpendicular to the fault plane. However, this can also be dependent on whether faults are currently active (Paul et al., 2009). Faulting has been inactive within the Bowen Basin for over 140 million years (Clark et al., 2011), indicating that the fault zones are less likely to act as conduits to flow; this relates to filling of the fractured pore spaces over time through hydrothermal alteration and mineralisation (Uysal et al., 2000). Drill core logs from within the Study Area show that where fractures and faults have been geologically logged, many fractures are “healed” with calcite and siderite. This indicates that although the system contains a fracture network, many of the existing fractures are cemented, which reduces the effective permeability of the fracture when compared to any open fracture network.

Downhole hydraulic testing was conducted in the Permian coal measures for the Winchester South Project east of SRM (SLR, 2020). Fault zones were confirmed to be intersected at these drill holes due to the presence of fracturing, calcite infills, and slickensides in core obtained from the drill holes, all of which are considered an indicative marker of faulting. Testing results showed relatively low hydraulic conductivity values ranging from $6.93 \times 10^{-5}$ to $2.07 \times 10^{-3}$ m/day, and in line with those presented in **Figure 19**. These properties indicate that the faulting zones intercepted and tested are ‘healed’ and not pathways for preferential groundwater flow.

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

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

Based on a detailed literature review of the effect of faulting on groundwater flow, Coffey (2014) has developed a conceptual model for fault zone hydraulic characterisation in the Bowen Basin (**Figure 19**), largely based on Jourde et al. (2002) and Flodin et al. (2001). This conceptualisation provides a means of inferring hydraulic conductivities of the fault core and the fault damage zone from regional hydraulic conductivity, with the fault core typically

one to three orders of magnitude lower conductivity than the regional host rock, and the damage zone approximately an order of magnitude higher.

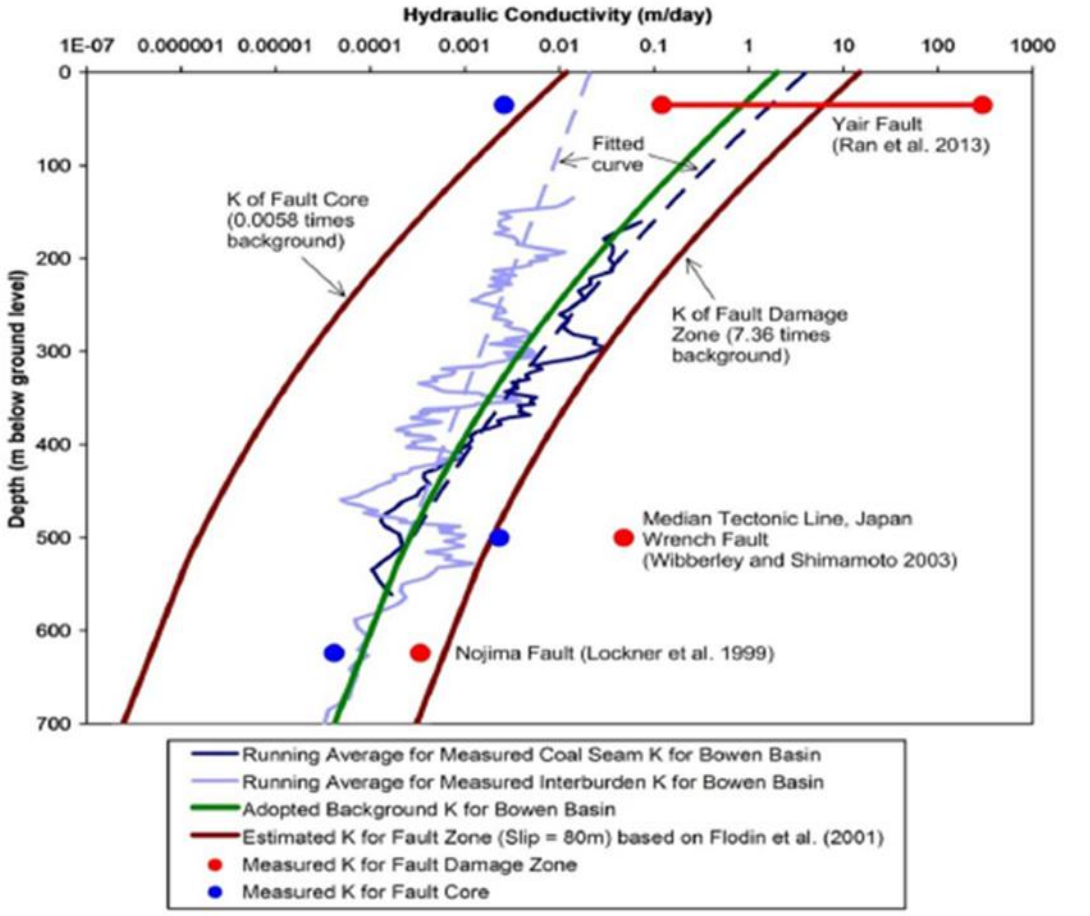



**Figure 19 Faulting Conceptual Model Developed by Coffey (2014)**

### 3.5.3 Groundwater Distribution, Flow, Recharge and Discharge

#### 3.5.3.1 Quaternary Alluvium

**Distribution and Flow**

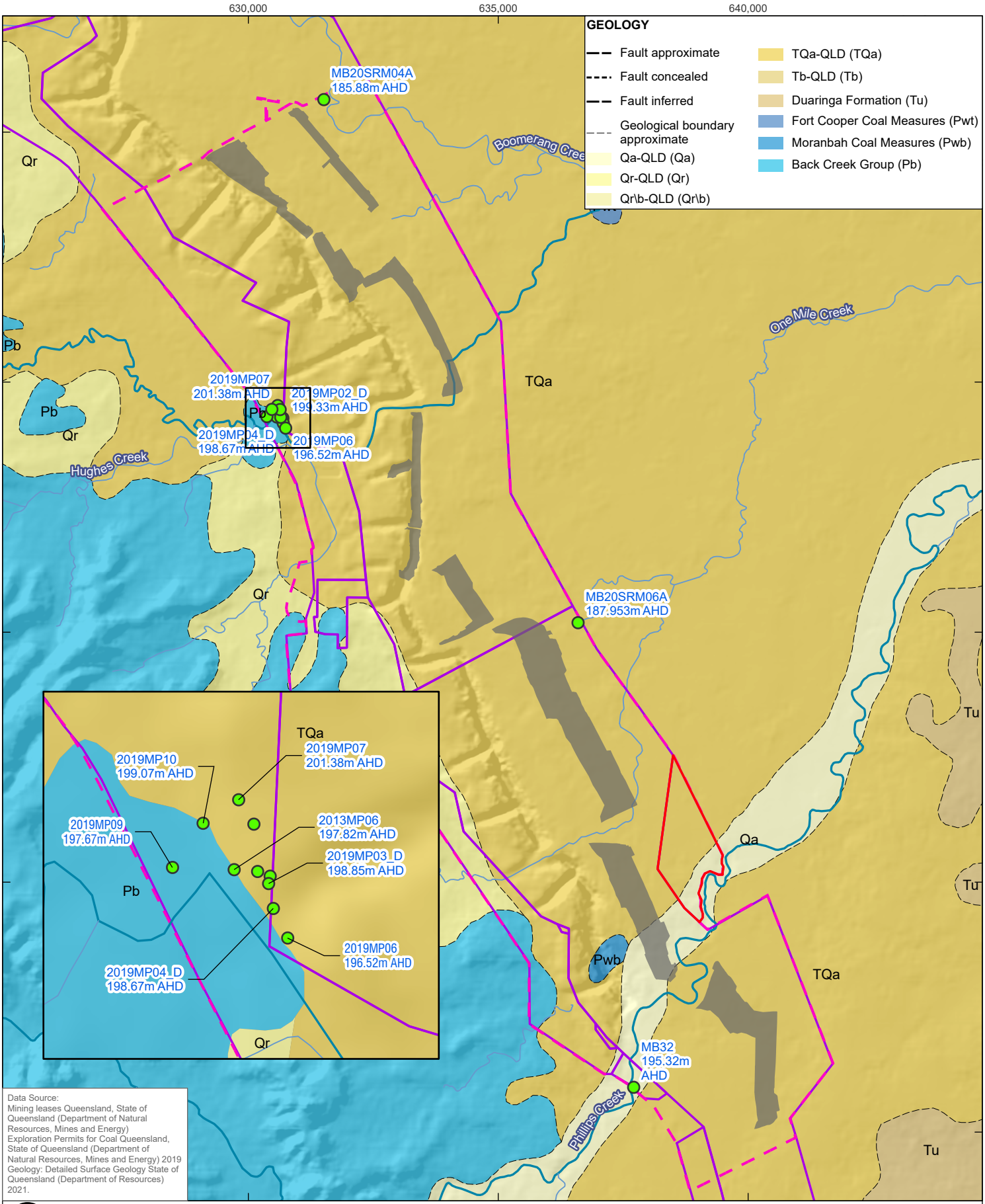
Due to the apparent heterogeneity and discontinuity, the Quaternary alluvium is not laterally extensive, being only associated with present-day drainage. The alluvium is not permanently saturated but is recharged episodically via creek flows and is hydraulically disconnected from underlying groundwater units. As there are very few (if any) landholders accessing the alluvium, it is not considered a significant groundwater resource.

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

Alluvial groundwater levels have been monitored at 17 bores at SRM (refer to **Table 8** and **Figure 16**) including EA compliance bores MB32 and MB38, which are interpreted to be screened within the Phillips Creek alluvium. MB32 was originally drilled for stock watering and was used for this purpose until 2007 (AECOM, 2019). MB32 is located upstream to the west of SRM and MB38 is located downstream of SRM, northeast of Grevillea Pit.

Available monitoring data shows groundwater elevations in the alluvium are approximately 185 mAHD to 201.5 mAHD. Groundwater elevations for bores within alluvium are displayed in **Figure 20**. As can be seen from **Figure 20**, the majority of groundwater in the alluvium occurs near Hughes Creek. The majority of alluvium monitoring bores away from Hughes Creek are dry.

Records for drillholes that have intersected the Phillips Creek alluvium indicate that there is limited or no sustainable groundwater resources associated with the Phillips Creek alluvium (AECOM, 2019). Phillips Creek alluvium groundwater monitoring records are only available for a single bore that has found groundwater (MB32); the other bore installed into the Phillips Creek alluvium (MB38) is consistently reported as dry since installation in July 2019. Records for the MB32 bore date back to July 2014, and generally show groundwater levels between 194.4 and 201 mAHD (8.5 to 14.8 m below top of casing (mbTOC)). Monitoring data from MB32 is presented in **Figure 21**; the hydrograph shows a correlation between groundwater elevations and CDFM monthly rainfall indicating a strong climatic influence on water levels. Monitoring bore MB38 has consistently been reported as dry, and the bore depth is approximately 10m shallower than MB32. These results suggest that groundwater within the Phillips Creek alluvium may only be found in somewhat isolated deeper pockets of alluvium that are more deeply incised into the underlying strata, and that widespread groundwater does not exist within the full mapped extents of the Phillips Creek alluvium.




Data Source:
Mining leases Queensland, State of Queensland (Department of Natural Resources, Mines and Energy) Exploration Permits for Coal Queensland, State of Queensland (Department of Natural Resources, Mines and Energy) 2019 Geology: Detailed Surface Geology State of Queensland (Department of Resources) 2021.

0 1 2 km

| | |
|---|---|
| Coordinate System: | GDA 1994 MGA Zone 55 |
| Scale: | 1:100,000 at A4 |
| Project Number: | 620.040484.00001 |
| Date Drawn: | 12-Sep-2024 |
| Drawn by: | RB |

**LEGEND**

- Monitoring Bore - Alluvium
- Major Watercourse
- Minor Watercourse
- Active Pit
- SRM EA Boundary
- SRM Mine Lease
- Project Area

# SARAJI MINE GREVILLEA PIT CONTINUATION PROJECT GROUNDWATER ASSESSMENT

## ALLUVIUM GROUNDWATER ELEVATIONS

SLR

DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.

**FIGURE 20**

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040484.00001 Saraji Mine Grevillea GW Model\06 SLR Data\01 CADGIS\GIS\ArcPro\GW Assessment\GW Assessment.aprx\620040484 F20 Alluvium Groundwater Elevations

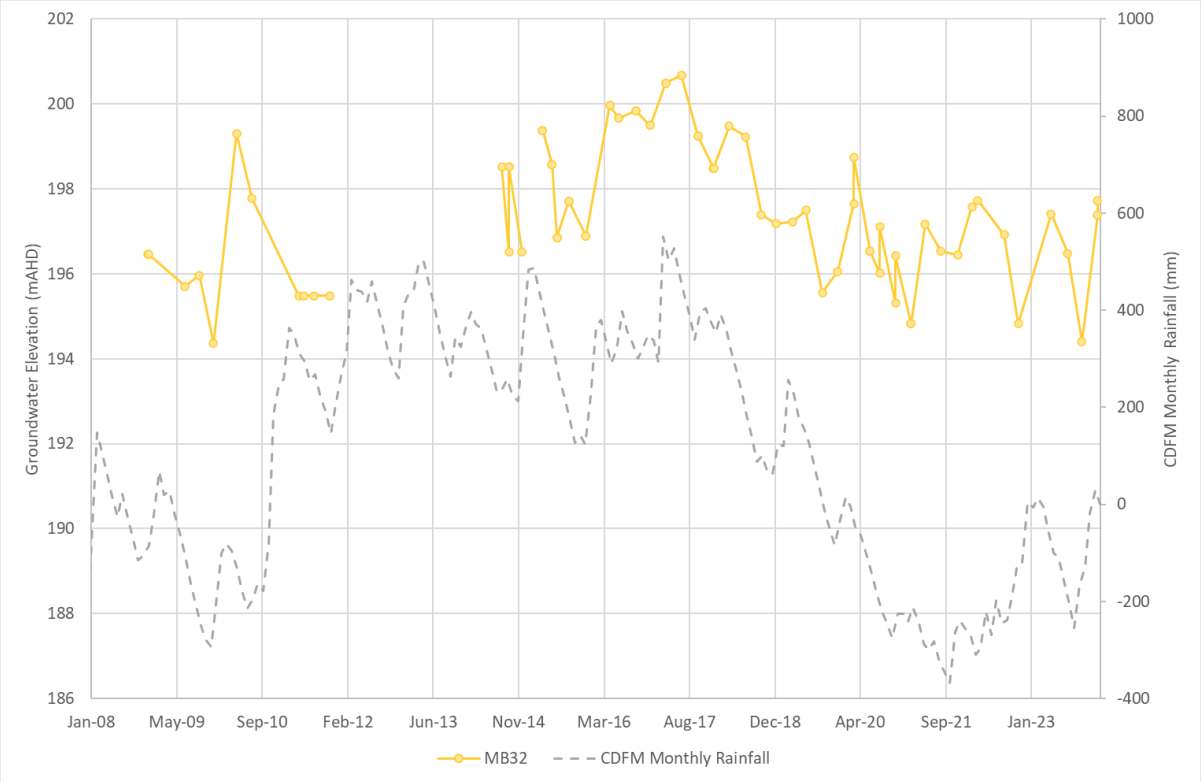



**Figure 21 Hydrograph of Alluvial Groundwater Trends – Phillips Creek**

### Recharge and Discharge

Recharge to the alluvium is considered to be mostly from stream flow or flooding (losing streams), with direct infiltration of rainfall also occurring where there are no substantial clay barriers in the shallow subsurface. Short term monitoring data available for monitoring bore MB32 shows a response in groundwater elevations with climate (**Figure 21**). As shown in **Figure 21** groundwater levels generally decline during drier than average conditions before showing slight recovery in response to wetter than average conditions experienced at the start of 2021. Limited responses to rainfall trends may relate to the presence of surficial clays restricting groundwater recharge, as discussed in **Section 3.4.2**, or that rainfall was not sufficient to wet the unsaturated zone within the alluvium above the water table as well as providing vertical groundwater flow towards the water table.

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

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

Groundwater within the alluvium is discharged as downstream throughflow, with some potential for evapotranspiration from deeper rooted riparian vegetation growing along water courses (particularly along the Isaac River) (**Section 3.5.5.2**), as well as potential baseflow contributions after significant rainfall and flood events. Groundwater within the alluvium is

also discharged through the landholder use of bores in the region, particularly along the Isaac River. However, the alluvium is not considered a significant groundwater resource near the Grevillea Project given there are limited (if any) local landholders accessing the alluvium.

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

#### 3.5.3.2 Regolith including Tertiary Sediments

**Distribution and Flow**

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

Tertiary sediments groundwater levels have been monitored at 11 bores at SRM (refer to **Table 8** and **Figure 16**). The majority of available groundwater monitoring data for the Tertiary sediments relates to EA compliance bore MB40 (collocated with MB38 to the northeast of Grevillea Pit) and PZ00A to PZ00C located adjacent to Jacaranda Pit. Additional monitoring data for the unit comes from PZ02A, PZ04A, PZ07A, PZ09A and PZ10A which were installed in 2011 to the east of SRM at points extending the entire strike of the mine (**Figure 16**). Monitoring data for these bores is limited to September 2011 to January 2012. An additional monitoring bore, SRMMB12_01, was installed within the Tertiary sediments to the east of Dogwood Pit in June 2021. Monitoring data is also limited for this bore.

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

In 2011 Tertiary sediment monitoring bores PZ09A and PZ10A were both drilled dry and the bores at the PZ07 site had to be abandoned due to construction issues. Groundwater elevations in PZ02A were initially reported at 181.8 mAHD (19 mbTOC) in August 2011, with the bore reported as dry in January 2012 and then at 17.8 mbTOC in August 2023. Groundwater elevations in monitoring bore PZ04A fluctuated between 187.92 mAHD (21.99 mbTOC) and 189.61 mAHD (20.3 mbTOC) over the same period. AECOM (2019) reports that the 2011 Tertiary sediment monitoring bores generally became dry as a result of drawdown caused during routine sampling (AECOM, 2019). The lack of water level recovery in bores following sampling therefore is believed to be indicative of limited sustainable yields for the Tertiary sediments.

Groundwater elevations for MB40 have gradually declined from 177.3 mAHD (17.15 mbTOC) in January 2020 to 176.4 mAHD in February 2024 (18.0 mbTOC). **Figure 22** shows that this decline correlates with drier than average conditions over this period, with slightly increases in elevations corresponding to wetter than average events. The slow rate of decline indicates a subdued climatic influence on groundwater levels at this location.

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

This data shows variable groundwater levels both across the SRM Area and over time, with the Tertiary sediment monitoring bores generally becoming dry during the monitoring period (AGE, 2011). It is possible this could be a function of some of the monitoring bores being located in predominantly clayey sequences that respond very slowly to recharge following pumping and sampling. It is considered the Tertiary sediment aquifer water levels would be about 20 mBGL within more porous sandy and gravelly type sediments (AGE, 2011).

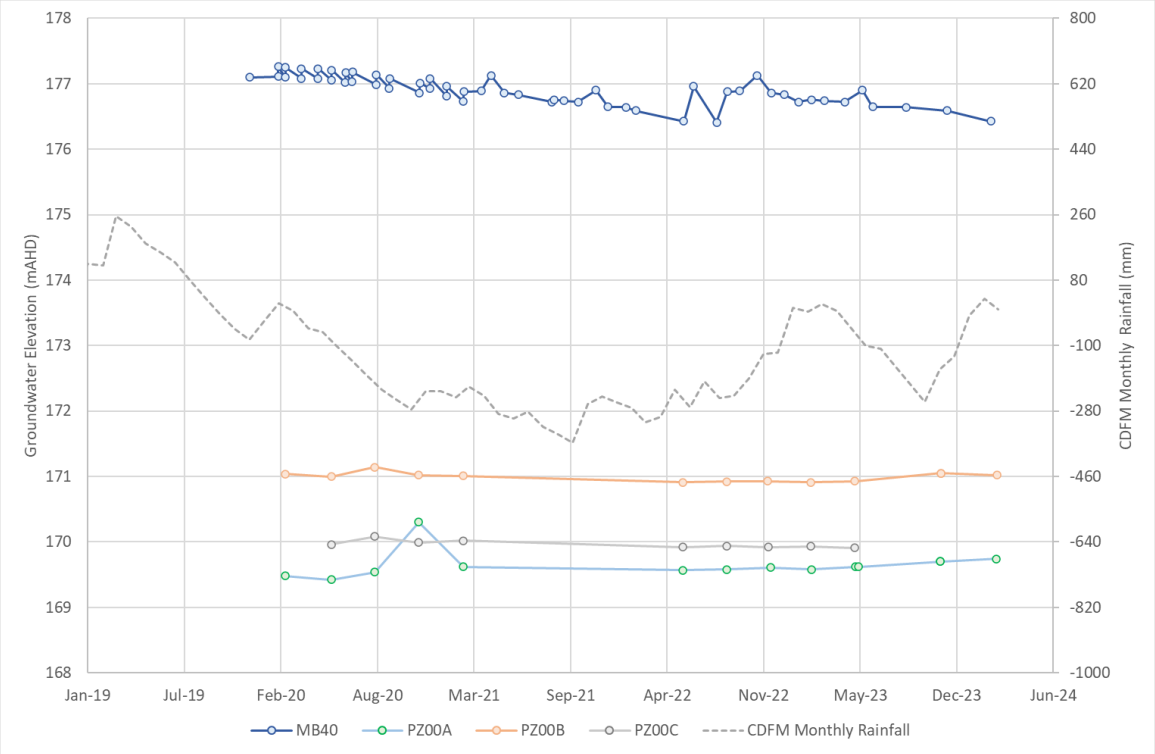



**Figure 22 Hydrograph of Tertiary Groundwater Trends**

### Recharge and Discharge

Water within the Tertiary sediments, where saturated, occurs at depths of approximately 17 mBGL to 24 mBGL. As discussed in the Tertiary Sediments in **Section 3.4.2.1**, the material comprises low hydraulic conductivity strata (i.e., clay and claystone), which restricts rainfall recharge. This is shown by the generally limited response to climatic conditions in monitoring bores MB40, PZ00A, PZ00B and PZ00C. This is consistent with the outcomes of other recent relevant studies in the Study Area (e.g., SLR, 2020). This lack of response in monitoring bores within the Study Area may also be due to rainfall being insufficient to wet the unsaturated zone above the water table as well as providing vertical groundwater flow towards the water table.

Using the CMB method (refer **Section 3.5.3.1)** a recharge rate for the Tertiary sediments has been calculated as 0.1 mm/yr (SLR, 2021).

Groundwater discharge occurs primarily via evapotranspiration, with some baseflow to streams under wet climatic conditions. Vertical seepage through the Tertiary sediments is limited by the underlying low hydraulic conductivity of the Blackwater Group overburden and

other aquitards such that the Tertiary sediments effectively form a perched groundwater system above the Permian strata.

#### 3.5.3.3 Permian Coal Measures Coal Seams

**Distribution and Flow**

The coal seams of the Moranbah Coal Measures subcrop throughout the western portions of the SRM Area. Throughout the remainder of the SRM Area the coal seams underlie and subcrop beneath the surficial cover. Groundwater occurrence within the Permian coal measures is largely restricted to the more permeable coal seams that exhibit secondary porosity through fractures and cleats (**Section 3.5.2**). Regionally groundwater flow is to the east, consistent with local topography (AECOM, 2019). Differences in piezometric heads within the confined coal seam aquifers of the Moranbah Coal Measures drive groundwater flow eastwards across the Bowen Basin, from the slightly more elevated subcrop areas on the western flank of the Basin to the less elevated subcrop areas on the eastern flank (AECOM, 2019). However, mining activities throughout the region have created locally modified groundwater flow systems within the Permian coal measures that are superimposed on these regional flow gradients.

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

Active monitoring bores accessing the Permian coal seams within SRM are restricted to the R and Q seams of the Moranbah Coal Measures. Historic monitoring of the H and D seams of the Moranbah Coal Measures was completed between November 2011 and January 2012. The current and historic network comprises one bore within the R Seam (MB39), one within the Q Seam (MB33), one monitoring bore and two VWP sensors within the P Seam (monitoring bores MB34 and VWP sensors PZ06A and PZ08A), four monitoring bores and three VWP sensors within the H Seam (monitoring bores, PZ04B, PZ07C, PZ09B and PZ10B and VWP sensors PZ05A, PZ06B and PZ08B), and four monitoring bores and three VWP sensors within the D Seam (monitoring bores PZ02C, PZ04C, PZ09C and PZ10C and VWP sensors PZ05B, PZ06C and PZ08C).

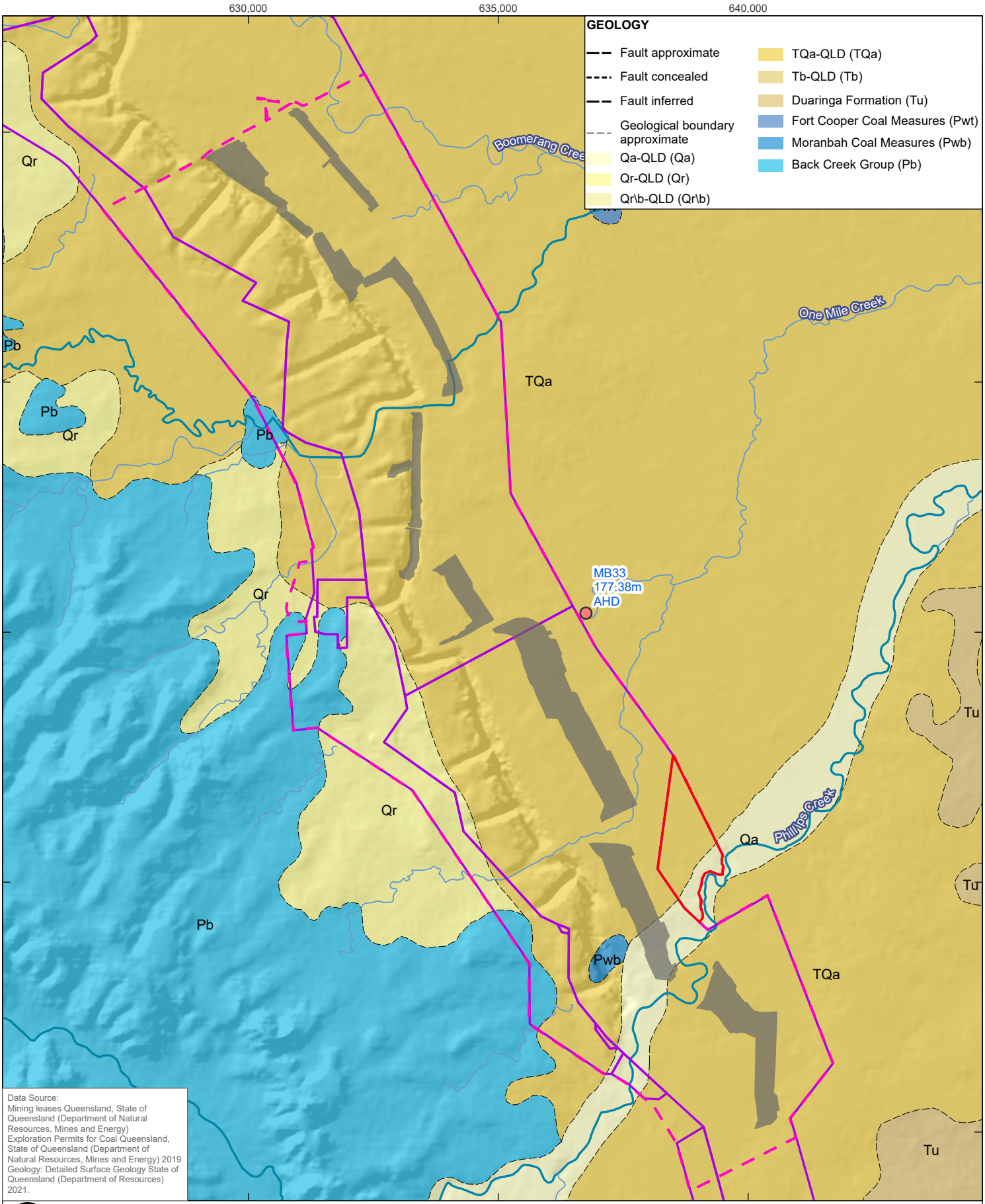
Three active monitoring bores are also screened within the Fort Cooper Coal Measures (MB35, MB36 and 2019MP08) and one monitoring bore is screened within an unknown coal seam of the Back Creek Group (MB31).

Groundwater monitoring of the Q Seam has been undertaken in the east of Ebony Pit (MB33) since 2014. Groundwater elevations for current Q Seam monitoring bores are displayed in **Figure 23**. Groundwater elevations within MB33 ranges from 173.25 mAHD to 180.07 mAHD. An insufficient number of data points are available to generate potentiometric contours for the Q Seam.

Groundwater monitoring of the P Seam has been undertaken east of Ebony Pit (MB34) since 2014 with historic monitoring undertaken east of Hakea Pit (PZ06A) and east of Coolibah Pit (PZ08A) between 2011 and 2012. Groundwater elevations for current P Seam monitoring bores are displayed in **Figure 24**. Groundwater elevations within MB34 range from 163.24 mAHD to 173.78 mAHD. Groundwater elevations within PZ06A and PZ08A range from 178.05 mAHD (PZ08A) to 185.1 mAHD (PZ06A). An insufficient number of data points are available to generate potentiometric contours for the P Seam.

Groundwater monitoring of the H and D seams was undertaken at locations along the strike of the mine between 2011 and 2012. Groundwater elevations for the H seam monitoring bores are presented in **Figure 25** and groundwater elevations for the D Seam monitoring

bores are presented in **Figure 26**. Groundwater elevations in the H Seam ranged between 135.84 mAHD and 190.45 mAHD. Groundwater elevations in the D Seam ranged between 132.68 mAHD and 170.78 mAHD. **Figure 25** and **Figure 26** shows that during this period general groundwater elevations were more elevated in the northwest of the SRM Area and lower in the southeast, indicative of a general southeasterly groundwater flow direction. Monitoring data shows groundwater elevations to be generally higher in the H Seam than D seam, indicating confined nature of the seams and vertical gradients from the shallower H Seam to deeper D seam. Localised groundwater sinks are shown at the PZ09 bore site located close to Jacaranda Pit and Bauhinia Pit which were actively mined during this period (**Figure 16**). Although more recent data from recently drilled bores is not yet available for this report, it is assumed that similar influences from mining on groundwater elevations will occur as mining pits are progressed and the H Seam and D Seams are intersected.




0 1 2 km

| | |
|---|---|
| Coordinate System: | GDA 1994 MGA Zone 55 |
| Scale: | 1:100,000 at A4 |
| Project Number: | 620.040484.00001 |
| Date Drawn: | 12-Sep-2024 |
| Drawn by: | RB |

**LEGEND**

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

# SARAJI MINE GREVILLEA PIT CONTINUATION PROJECT GROUNDWATER ASSESSMENT

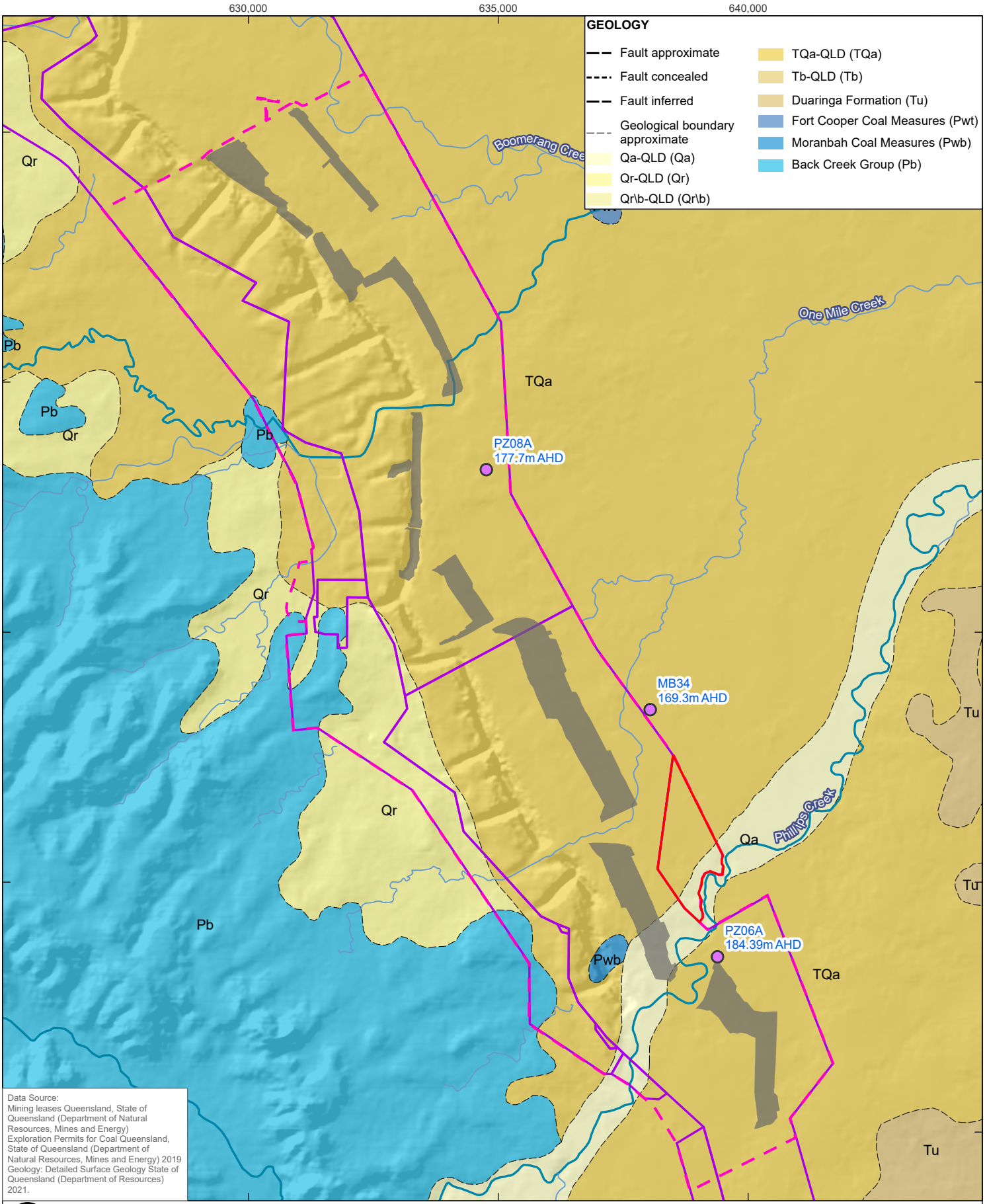
## Q SEAM GROUNDWATER ELEVATIONS

SLR

DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.

**FIGURE 23**

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040484.00001 Saraji Mine Grevillea GW Model\06 SLR Data\01 CADGIS\GIS\ArcPro\GW Assessment\GW Assessment.aprx\620040484 F23 Q Seam Groundwater Elevations




Data Source:
Mining leases Queensland, State of Queensland (Department of Natural Resources, Mines and Energy) Exploration Permits for Coal Queensland, State of Queensland (Department of Natural Resources, Mines and Energy) 2019 Geology: Detailed Surface Geology State of Queensland (Department of Resources) 2021.

0 1 2 km

| | |
|---|---|
| Coordinate System: | GDA 1994 MGA Zone 55 |
| Scale: | 1:100,000 at A4 |
| Project Number: | 620.040484.00001 |
| Date Drawn: | 12-Sep-2024 |
| Drawn by: | RB |

**LEGEND**

- Monitoring Bore - P Seam - PZ06A & PZ08A August 2011
- Monitoring Bore - P Seam - MB34 November 2020
- Major Watercourse
- Minor Watercourse
- Active Pit
- SRM EA Boundary
- SRM Mine Lease
- Project Area

# SARAJI MINE GREVILLEA PIT CONTINUATION PROJECT GROUNDWATER ASSESSMENT

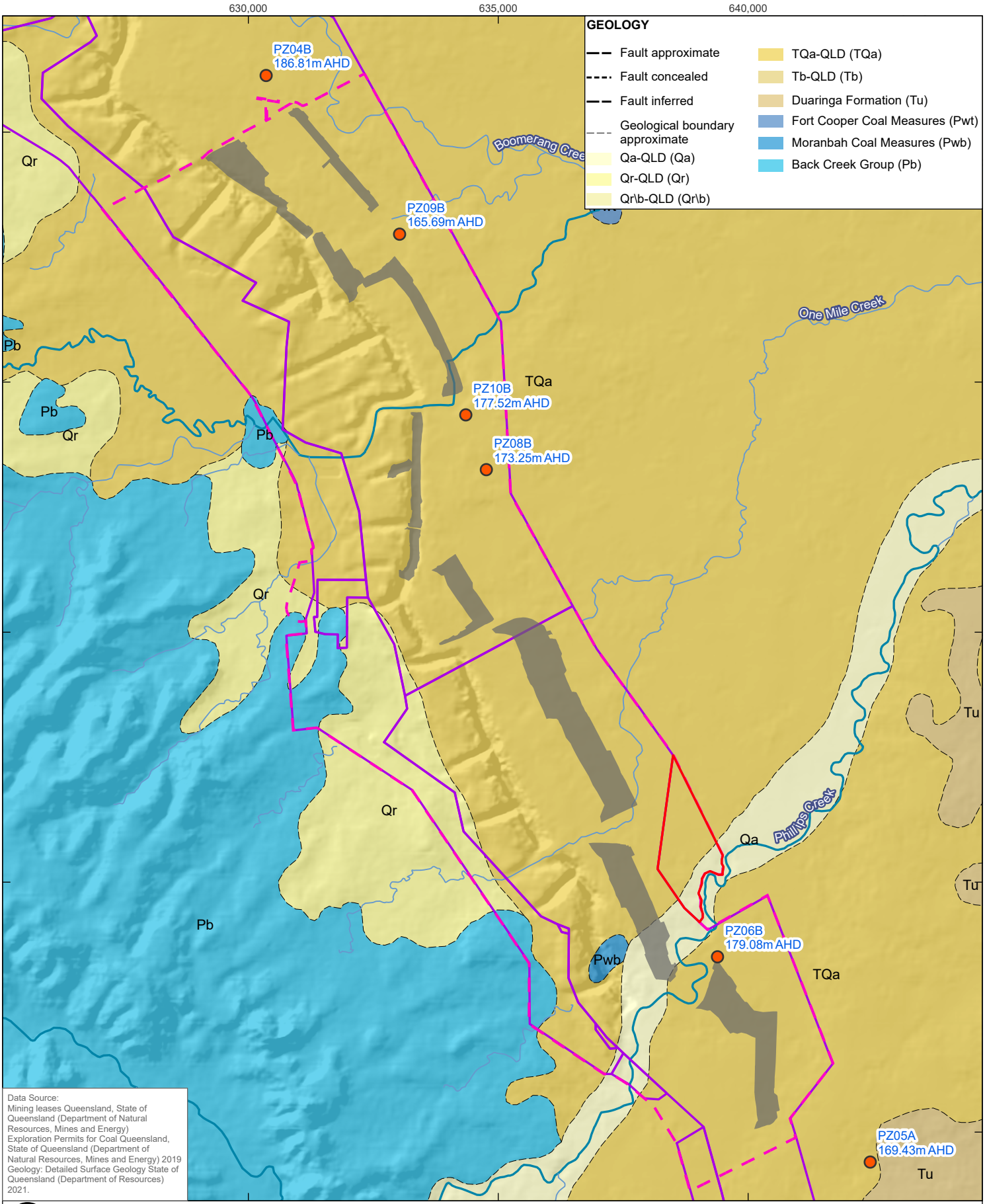
## P SEAM GROUNDWATER ELEVATIONS

SLR

DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.

FIGURE 24

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040484.00001 Saraji Mine Grevillea GW Model\06 SLR Data\01 CADGIS\GIS\ArcPro\GW Assessment\GW Assessment.aprx\620040484 F24 P Seam Groundwater Elevations




Data Source:
Mining leases Queensland, State of Queensland (Department of Natural Resources, Mines and Energy)
Exploration Permits for Coal Queensland, State of Queensland (Department of Natural Resources, Mines and Energy) 2019
Geology: Detailed Surface Geology State of Queensland (Department of Resources) 2021.

0 1 2 km

| | |
|---|---|
| Coordinate System: | GDA 1994 MGA Zone 55 |
| Scale: | 1:100,000 at A4 |
| Project Number: | 620.040484.00001 |
| Date Drawn: | 12-Sep-2024 |
| Drawn by: | RB |

**LEGEND**

- Monitoring Bore - H Seam
- Major Watercourse
- Minor Watercourse
- Active Pit
- SRM EA Boundary
- SRM Mine Lease
- Project Area

# SARAJI MINE GREVILLEA PIT CONTINUATION PROJECT GROUNDWATER ASSESSMENT

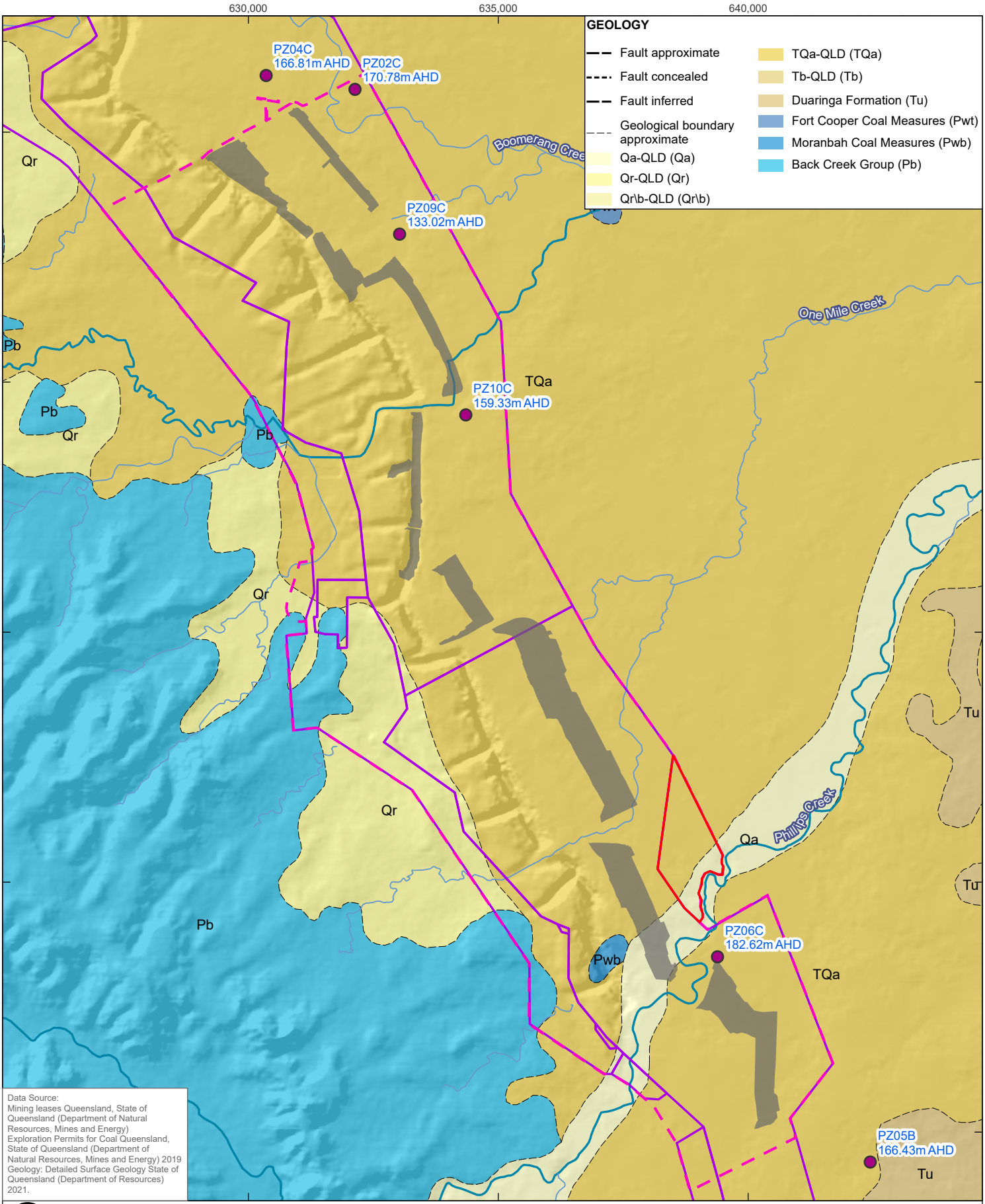
## H SEAM GROUNDWATER ELEVATIONS

SLR

DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.

FIGURE 25

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040484.00001 Saraji Mine Grevillea GW Model\06 SLR Data\01 CADGIS\GIS\ArcPro\GW Assessment\GW Assessment.aprx\620040484 F25 H Seam Groundwater Elevations




Data Source:
Mining leases Queensland, State of Queensland (Department of Natural Resources, Mines and Energy)
Exploration Permits for Coal Queensland, State of Queensland (Department of Natural Resources, Mines and Energy) 2019
Geology: Detailed Surface Geology State of Queensland (Department of Resources) 2021.

0 1 2 km

| | |
|---|---|
| Coordinate System: | GDA 1994 MGA Zone 55 |
| Scale: | 1:100,000 at A4 |
| Project Number: | 620.040484.00001 |
| Date Drawn: | 12-Sep-2024 |
| Drawn by: | RB |

**LEGEND**

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

# SARAJI MINE GREVILLEA PIT CONTINUATION PROJECT GROUNDWATER ASSESSMENT

## D SEAM GROUNDWATER ELEVATIONS

SLR

DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.

FIGURE 26

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040484.00001 Saraji Mine Grevillea GW Model\06 SLR Data\01 CADGIS\GIS\ArcPro\GW Assessment\GW Assessment.aprx\620040484 F26 D Seam Groundwater Elevations

Groundwater level trends for monitoring bores intersecting the Moranbah Coal Measures coal seams within the SRM Area are presented in **Figure 27** to **Figure 29**.

**Figure 27** shows that groundwater elevations within the Q seam monitoring bore MB33 have gradually increased since 2016, potentially indicating a declining influence from mining activities from the adjacent Ebony Pit. **Figure 16** shows that MB33 is located to the northeast of Ebony Pit which has been actively mined for the duration of the monitoring period. Although progressed toward MB33 during this time, mining appears to have been concentrated in the central and southern areas of the pit eastern boundary. The greater activity in the southern area of the pit may have resulted in the potential recovery of groundwater levels observed at MB33. **Figure 27** also shows that groundwater elevations within the P seam monitoring bore MB34 remained relatively stable between June 2015 to June 2018 before declining. **Figure 27** shows groundwater elevations within MB34 to correlate to CDFM rainfall indicating a climatic influence at this location, although it is noted that from around December 2021, the declining water level in MB34 deviates from the CDFM in MB34 which is likely to be associated with depressurisation from the adjacent pits. **Figure 27** shows that groundwater elevations within P Seam monitoring bore PZ06A slightly declined between August 2011 and January 2012, whereas groundwater elevations in monitoring bore PZ08A slightly increased. There is insufficient data to determine potential climatic influences on groundwater elevations at these locations. As previously discussed PZ06A is located north of Hakea Pit and east of Grevillea Pit and PZ08A is located to the east of Coolibah Pit. It is likely that the observed trends are responses to mining activities in these areas. Decreasing groundwater elevations at PZ06A are indicative of depressurisation of the P Seam as it was mined through.

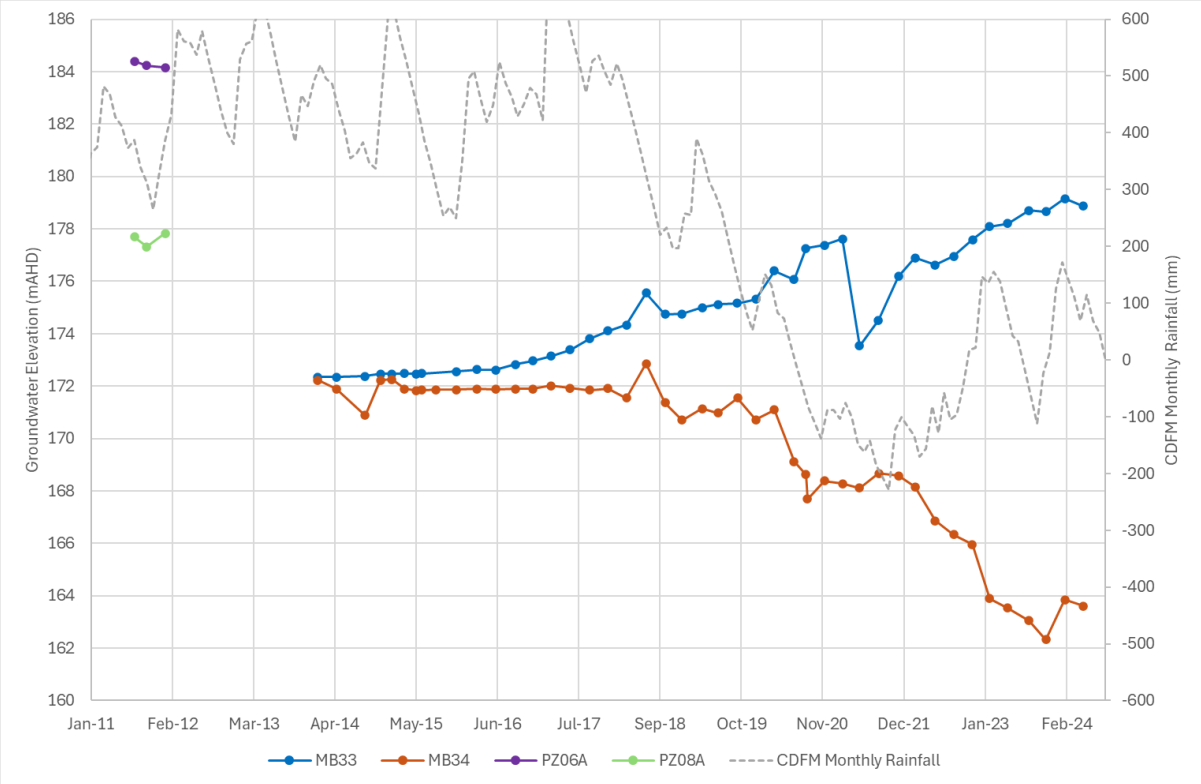



**Figure 27 Hydrograph for Q and P Seam Bores**

**Figure 28** shows that groundwater elevations within the H Seam monitoring bores PZ04B, PZ05A, PZ06B, PZ09B and PZ10B. Groundwater elevations in monitoring bores PZ05A and PZ06B remained relatively stable over the approximately six-month monitoring period indicating no influence from climate or mining at these locations at the time. Groundwater elevations in monitoring bore PZ04B increased slightly, whereas in PZ010B they decreased slightly. As per the P Seam it is likely that the observed trends are responses to mining activities in these areas. Groundwater elevations in monitoring bore PZ09B decreased from 165.7 mAHD to 135.8 mAHD between August 2011 to October 2011, before returning to 164.5 mAHD in January 2012. It is unknown whether this large variation is a data transcription error or due to mining influence at this location.

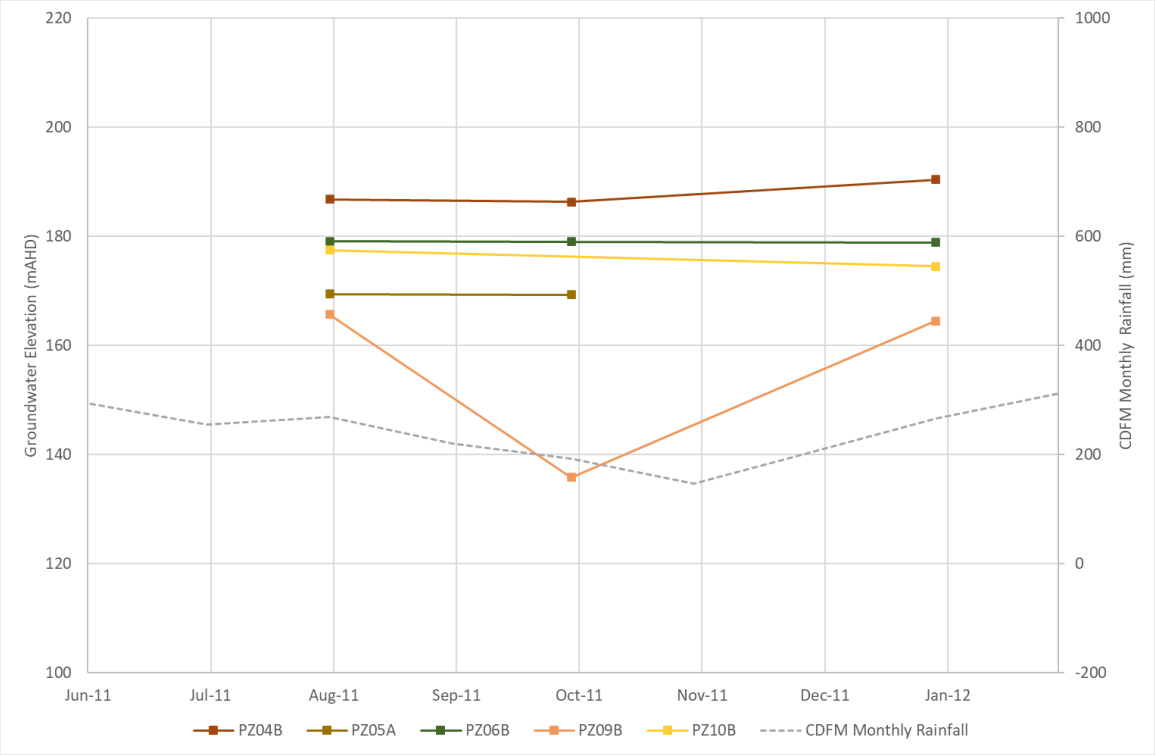



**Figure 28 Hydrograph for H Seam Bores**

**Figure 29** shows that groundwater elevations within the D Seam monitoring bores PZ02C, PZ04C, PZ05B, PZ06C, PZ09C and PZ10C. Groundwater elevations in monitoring bores PZ06C, PZ05B and PZ09C remained relatively stable over the monitoring period indicating no influence from climate or mining at these locations at the time of monitoring. Groundwater elevations in monitoring bores PZ04C and PZ10C declined between August 2011 and October 2011 before stabilising. PZ04C is located to the north of Jacaranda Pit, with monitoring bore PZ10C located to the south Bauhinia Pit. Given the lack of climatic response observed in the other D Seam monitoring bores it is likely that the decrease in groundwater elevations is in response to mining of these pits.

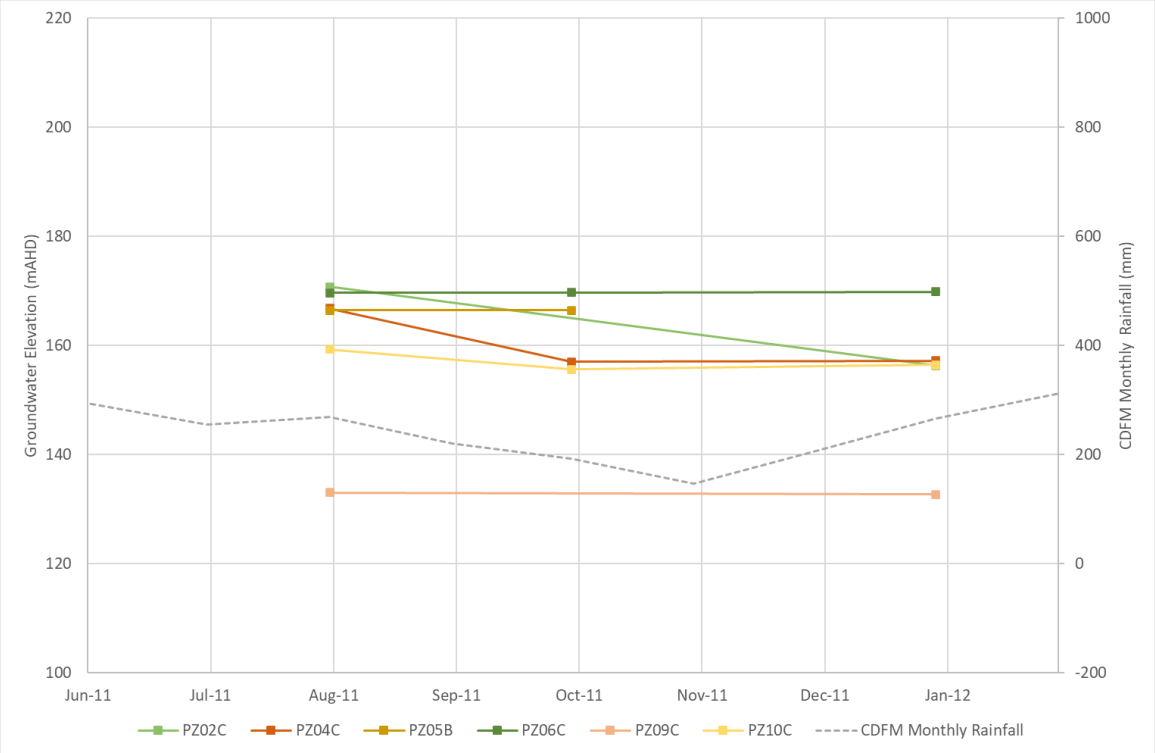



**Figure 29 Hydrograph for D Seam Bores**

### Recharge and Discharge

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

## 3.5.3.4 Permian Coal Measures Interburden

### Distribution and Flow

Groundwater occurrence within the Permian coal measures interburden is largely restricted to weathered horizons or to secondary porosity through fractures where present (**Section 3.5.2**). The interburden functions dominantly as an aquitard that restricts groundwater movement (SLR, 2021). Groundwater monitoring of the Moranbah Coal Measures interburden at SRM has been undertaken east of Jacaranda Pit in the north of SRM (PZ02B; monitored between 2011 and 2012 and PZ00D; monitored since 2020) and west of Hakea Pit (MB19SRM04P; since 2020) in the south of SRM. Groundwater monitoring of the Back Creek Group interburden has also been undertaken since 2014 at MB37 located off lease to the west of Ebony Pit.

**Figure 30** shows that monitoring of MB19SRM04P occurred between February 2020 and November 2023. Over this period groundwater elevations steadily declined from 189.7 mAHD to 188.88 mAHD in August 2022, then showed a relatively stable trend. Groundwater elevations for PZ02B decreased between November 2011 and January 2012 from 173.78

mAHD to 168.4 mAHD. This decline is likely to be a response to mining activities associated with the nearby Jacaranda Pit during this period. The declining groundwater levels in both bores during their respective monitoring periods potentially indicates a response to nearby mining activities (mining of Hakea Pit immediately east of Hakea Pit and mining of Jacaranda Pit immediately west of PZ02B). Groundwater elevations at PZ00D have ranged between 174.5 mAHD (18.5 mbTOC) to 175.8 mAHD (17.2 mbTOC). **Figure 30** shows that elevations slightly increased between February 2020 and February 2021, before decreasing slightly. Groundwater elevations at PZ00D indicate a potentially subdued response to climatic influences with increasing levels corresponding to wetter than average conditions observed at the end of 2020.

**Figure 30** shows that MB37 groundwater elevations gradually declined from 222.3 mAHD in September 2014 to 222 mAHD in June 2016. Following this period groundwater elevations steadily increased to 223.43 mAHD in June 2018. Groundwater elevations gradually declined slightly after this point to 222.4 mAHD in November 2021. Since the end of 2021 groundwater elevations have been gradually increasing with an elevation of 223.2 mAHD recorded in February 2022. From March 2022 to February 2024, groundwater elevations remained relatively stable, fluctuating between 221.75 and 222.5 mAHD. Given the distance of MB37 to the west of SRM and the fact it is installed in the Back Creek Group interburden rather than Moranbah Coal Measures, the observed changes in elevations are potentially a subdued response to climatic conditions rather than a response to mining activities. Overall however, the monitoring data suggests very little temporal changes in interburden groundwater levels.

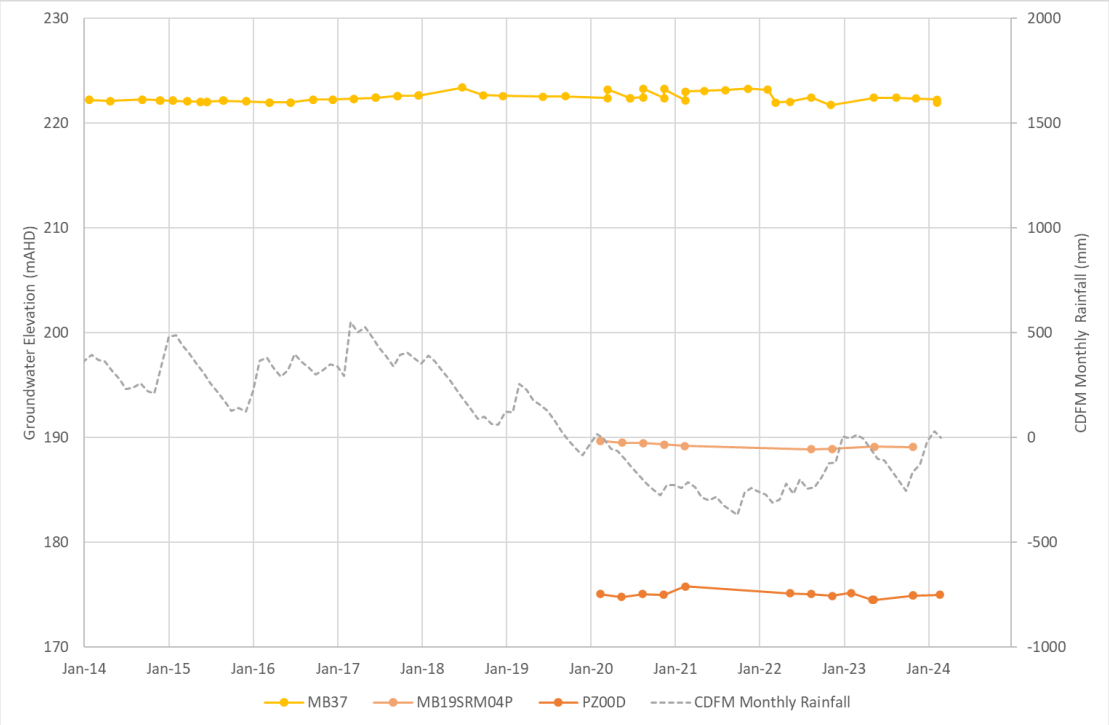



**Figure 30 Hydrograph of Permian Coal Measures Interburden Groundwater Trends**

### Recharge and Discharge

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

## 3.5.4 Baseline Water Quality

### 3.5.4.1 Water Type

The proportions of the major anions and cations were used to determine the hydrochemical facies of groundwaters sampled. The anion-cation balance from the SRM monitoring bores is shown on the Durov plot in **Figure 31**.

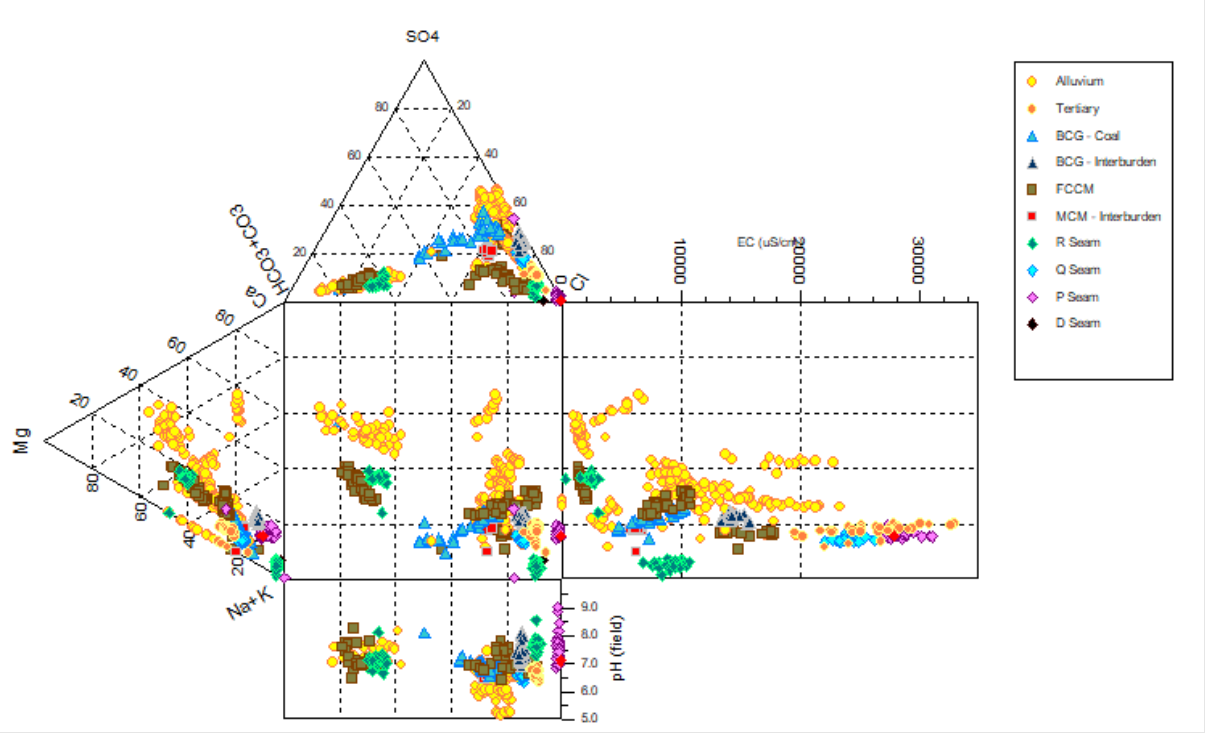



**Figure 31 Durov Plot of SRM Bores**

The results for these monitoring bores generally indicate that Na and Cl are the dominant major ions in groundwater across SRM. Surficial alluvial and Tertiary sediments generally display a more mixed water type, with higher proportions of magnesium and bicarbonate ions. The dominant water types in the unconsolidated alluvium and Tertiary sediments therefore generally Na-Mg-Cl and Na-Mg-Cl-$HCO_3$. Alluvium in the vicinity of Hughes Creek to the west of Bauhinia Pit show a greater proportion of sulfate ions.

Monitoring bores screened within both the Permian Moranbah Coal Measures (MB19SRM04P) and Back Creek Group (MB37) also showed mixed water types of Na-Cl-$SO_4$. Monitoring bores screened within the Permian Fort Cooper Coal Measures showed mixed water types ranging from Na-Mg-Cl and Na-Mg-$HCO_3$-Cl.

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

Water types of the Q Seam, H Seam, D Seam are more variable with the distribution of the major ions appearing to be associated with the depth of the bore. In general, deeper bores, typically in the east of SRM, displayed Na-Cl water types, with shallower bores showing water types with higher proportions of calcium or magnesium ions. This is likely to be due to greater recharge from overlying surficial deposits in the shallower areas, the greater thickness of the unweathered material preventing the mobilisation of salts into the coal

seams in the deeper locations. As the shallower bores are closer to the base of weathering, seepage of mobilised salts during recharge is more likely to occur. Within the deeper deposits, recharge from overlying units is likely to be less, with major ions distribution more influenced by secondary salinity mechanisms.

From the Durov plot (**Figure 31**) it is also clear that the aquifers in the SRM Area are generally neutral to slightly acidic and therefore have a greater proportion of bicarbonate to carbonate ions.

### 3.5.4.2 Salinity

Salinity is a key constraint to water management and groundwater use by receptors and can be described by total dissolved solid (TDS) concentrations. **Figure 32** presents the TDS data associated with waters screened in the various geological horizons for SRM monitoring bores, as well as registered bores and publicly available data for context. Salinity ranges represented on **Figure 32** are defined by the Food and Agriculture Organization of the United Nations (FAO).

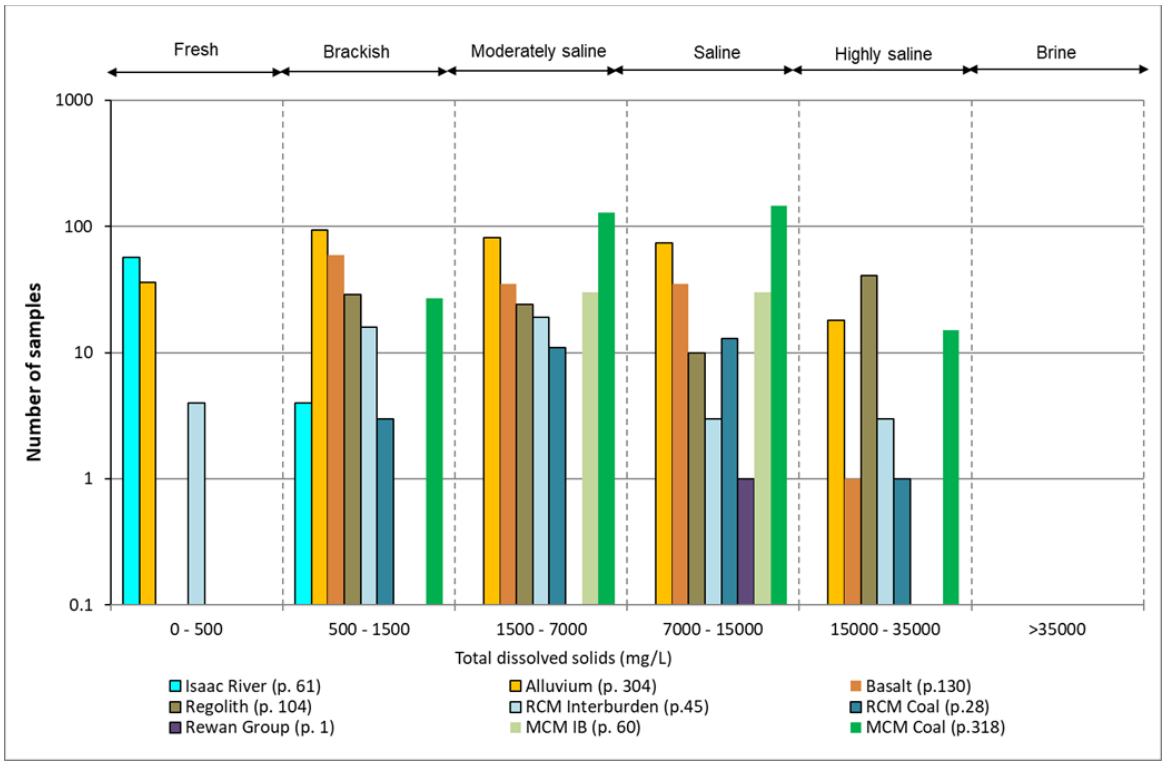



**Figure 32 FAO (2013) Salinity Ranking by Unit – SRM and Surrounding Area**

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

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

#### 3.5.4.3 Beneficial Groundwater Use (Environmental Values)

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

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

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

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

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

The WQ1310 WQOs for groundwater at SRM are shown in **Table 10**.

**Table 10 Water Quality Objectives for Isaac River Sub-basin Environmental Values**

| Water Quality Indicator | Unit | ADWG Guidelines[1] | | Isaac River Sub-basin EVs[2] | | |
|---|---|---|---|---|---|---|
| | | Health | Aesthetic | Irrigation | Stock | Aquatic 95% spp[3] |
| pH | - | | 6.5 to 8.5 | | | 6.5 to 8.5 |
| Al | mg/L | | 0.2 | | 5 | 0.055 |
| Ca | mg/L | | | | 1,000 | |
| Cl | mg/L | | 250 | | | |
| Mg | mg/L | | | | 2,000 | |
| Mn | mg/L | 0.5 | 0.1 | 10 | | 1.9 |
| Na | mg/L | | 180 | | | |
| $SO_4$ | mg/L | | | | 1,000 | |

| Water Quality Indicator | Unit | ADWG Guidelines[1] | | Isaac River Sub-basin EVs[2] | | |
|---|---|---|---|---|---|---|
| | | Health | Aesthetic | Irrigation | Stock | Aquatic 95% spp[3] |
| Zn | mg/L | | 3 | | | 0.008 |
| As | mg/L | 0.01 | | 2 | 0.5 | 0.024 |
| Cd | mg/L | 0.002 | | | 0.01 | 0.0002 |
| Cr | mg/L | 0.05 | | | 1 | 0.001 |
| Co | mg/L | | | 0.1 | 1 | |
| Cu | mg/L | 2 | 1 | | 1 | 0.0014 |
| Pb | mg/L | 0.01 | | | 0.1 | 0.0034 |
| Hg | mg/L | 0.001 | | | 0.002 | 0.0006 |
| Ni | mg/L | 0.02 | | | 1 | 0.011 |
| Se | mg/L | 0.01 | | | 0.02 | 0.005 |
| Ag | mg/L | 0.1 | | | | 0.05 |

1. Table 4 of Isaac River Sub-basin Environmental Values and Water Quality Objectives: Drinking water EV.
2. Table 2, Table 9, Table 10 and Table 11 of Isaac River Sub-basin Environmental Values and Water Quality Objectives: Aquatic ecosystem – moderately disturbed.
3. Table 3.4.1 of Australian and New Zealand Guidelines for Fresh and Marine Water Quality: trigger values for slightly-moderately disturbed systems (95% level of protection).

The EPP Water and Wetland Biodiversity also provides limited WQOs specifically for underground aquatic ecosystem protection in Fitzroy Basin groundwaters. These WQOs vary across the Fitzroy Basin and are defined on the basis of groundwater Chemistry Zones. The applicable Chemistry Zone for the SRM is Isaac Groundwater (Zone 34; Sodic Sequence - Saline: Na, Cl). These WQOs are classified by groundwater depth ('shallow' being <30 m depth, and 'deep' being >30 m depth) and are summarised in **Table 11**. The management intent of Zone 34 WQOs is to "maintain each of 20$^{th}$, 50$^{th}$ and 80$^{th}$ percentile values", i.e. that there should be no change to existing water quality (no statistical change in the natural range of values) (DES, 2022).

**Table 11 Isaac River Sub-basin Zone 34 WQOs (DEHP, 2011)**

| Water Quality Indicator | Unit | Shallow Groundwater (<30m) | | | Deep Groundwater (>30m) | | |
|---|---|---|---|---|---|---|---|
| | | 20$^{th}$ Percentile | 50$^{th}$ Percentile | 80$^{th}$ Percentile | 20$^{th}$ Percentile | 50$^{th}$ Percentile | 80$^{th}$ Percentile |
| EC | µS/cm | 498 | 2,150 | 8,910 | 3,419 | 6,100 | 16,000 |
| Hardness | mg/L as $CaCO_3$ | 163 | 674 | 2,228 | 359 | 919 | 3,208 |
| pH | - | 7.1 | 7.75 | 8.1 | 7.4 | 7.8 | 8.03 |
| Alkalinity | mg/L | 154 | 435 | 752 | 156 | 275 | 536 |
| Ca | mg/L | 18 | 84 | 215 | 46 | 145 | 442 |
| Mg | mg/L | 27 | 108 | 389 | 35 | 115 | 491 |
| Na | mg/L | 135 | 747 | 1,500 | 480 | 1,100 | 2,565 |
| Cl | mg/L | 171 | 1,309 | 3,185 | 753 | 1,900 | 5,905 |

| Water Quality Indicator | Unit | Shallow Groundwater (<30m) | | | Deep Groundwater (>30m) | | |
|---|---|---|---|---|---|---|---|
| | | 20th Percentile | 50th Percentile | 80th Percentile | 20th Percentile | 50th Percentile | 80th Percentile |
| $SO_4$ | mg/L | 12 | 140 | 318 | 25 | 138 | 398 |
| $HCO_3$ | mg/L | 187 | 536 | 878 | 188 | 330 | 650 |
| $NO_3$ | mg/L | 0 | 0.95 | 5.3 | 0.01 | 2.15 | 14.92 |
| $SiO_2$ | mg/L | 21 | 36 | 52 | 16 | 25 | 36 |
| F | mg/L | 0.1 | 0.28 | 0.5 | 0.02 | 0.155 | 0.4 |
| Fe | mg/L | 0 | 0.03 | 0.14 | 0 | 0.05 | 0.246 |
| Mn | mg/L | 0 | 0.01 | 0.16 | 0 | 0.05 | 0.291 |
| Zn | mg/L | 0 | 0.015 | 0.06 | 0.01 | 0.025 | 0.317 |
| Cu | mg/L | 0 | 0.01 | 0.03 | 0.017 | 0.03 | 0.03 |
| SAR | - | 4.37 | 10.85 | 18.21 | 10.5 | 15.6 | 24.65 |
| RAH | meq/L | 0 | 0 | 2.3 | 0 | 0.24 | 6.25 |

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

- Australian Drinking Water Guidelines (ADWG) (NHMRC, 2011) (refer **Table 10**).
- ANZECC (2000) guidelines for irrigation (long-term and short-term), stock water supply, and 95% level of protection for aquatic ecosystems in slightly-moderately disturbed systems (refer **Table 10**).
- Fitzroy Basin Zone 34 WQOs for groundwater resources (aquatic ecosystem protection) for deep and shallow groundwater (refer **Table 11**).

The summary results indicate that, where sampled at bore MB32, groundwater within the Phillips Creek alluvium generally meets the WQOs for all relevant EVs, however Fe concentrations do occasionally exceed guideline criteria for long term irrigation and Fitzroy Basin Zone 34 aquatic ecosystem protection (Shallow). Hughes Creek alluvial groundwater generally exceeds guideline levels for stock water supply, ($SO_4$, TDS), aquatic ecosystem protection (Al, Cu, Ni, Mn, Zn), drinking water (TDS, Cl and Na), and long-term irrigation (B and Fe). The Hughes Creek alluvial groundwater also records concentrations of EC, dissolved major ions and dissolved Mn above the Fitzroy Basin Zone 34 WQOs (Shallow) for aquatic ecosystem protection.

Results show that, where groundwater is present within the Tertiary sediments, it exhibits similar quality compared to the Hughes Creek alluvium and exceeds guideline values for stock watering ($SO_4$), 95% level of protection for aquatic ecosystems (Cu, Ni and Zn), long term irrigation (Bo, Co and Mo), and drinking water (TDS, Na and Cl). The groundwater within Tertiary sediments was also found to exceed the Fitzroy Basin Zone 34 WQOs (Shallow and Deep) for aquatic ecosystem protection (EC, $HCO_3$, Cl, Ca, Na, hardness, Mg, $SO_4$, Cu and Mn).

Comparison of groundwater quality monitoring results to the guideline WQOs indicates the Moranbah Coal Measures (interburden and coal) generally exceed guideline criteria for irrigation, drinking water and aquatic ecosystems. Groundwater within the Permian coal

measures variably meets the WQOs for stock water supply, with guideline exceedances most common for TDS and $SO_4$.

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

- $SO_4$ (H Seam), Al (H Seam and D Seam), Cr (D Seam), Cu (P Seam), Ni (P Seam) and Zn (P Seam and D Seam) above the WQO for 95% level of protection for aquatic ecosystems.
- $HCO_3$ (D Seam) and Na (D Seam) above the Fitzroy Basin Zone 34 WQO (Deep).
- EC (H Seam and D Seam), Mg (H Seam and D Seam), Na (H Seam and D Seam), Cl (H Seam and D Seam), $SO_4$ (H and D seams), Fe (H Seam and D Seam) and pH (D Seam) above the Fitzroy Basin Zone 34 WQO (Shallow and Deep).

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

### 3.5.5 Groundwater Receptors

#### 3.5.5.1 Anthropogenic

AECOM's (2023) search of the Queensland Government's Groundwater Bore Database (GWBD) identified 90 registered groundwater bores within and adjacent to the existing SRM (**Table 12**). Of the 90 registered bores identified, six are water supply bores.

**Figure 33** presents a locality plan.

**Table 12 Registered Groundwater Bore Details**

| Number (RN) | Easting | Northing | Depth (m) | Geology | Water Level (mbGL) | Yield (L/s) | Type / Name |
|---|---|---|---|---|---|---|---|
| 158014 | 636496 | 7519991 | 37.5 | MCM | 21.3 | 0.08 | MB33 / Saraji Mine |
| 158013 | 637781 | 7518065 | 107.0 | MCM | 23.1 | 0.05 | MB34 / Saraji Mine |
| 158012 | 632271 | 7515395 | 41.4 | Back Creek Group | 12.8 | 0.02 | MB37 / Saraji Mine |
| 158011 | 640035 | 7514095 | 32.0 | Fair Hill Formation | 17.96 | 0.09 | MW36 / Saraji Mine |
| 158010 | 642528 | 7519939 | 34.5 | Fair Hill Formation | 18.41 | 0.09 | MB35 / Saraji Mine |
| 165978 | 635945 | 7527652 | 10.5 | Quaternary | Dry | | MB20SRM01A |
| 165979 | 635904 | 7527647 | 36.5 | Tertiary | 23.5 | 0.05 – 0.075 | MB20SRM02T |

| Number (RN) | Easting | Northing | Depth (m) | Geology | Water Level (mbGL) | Yield (L/s) | Type / Name |
|---|---|---|---|---|---|---|---|
| 165977 | 635885 | 7527652 | 242.0 | Back Creek Group | 50.5 | 0.005 –0.015 | MB20SRM03P |
| 165976 | 631494 | 7530679 | 12.5 | Quaternary | 9 | 0.05 – 0.1 | MB20SRM04A |
| 165975 | 634596 | 7525982 | 24.0 | Quaternary | Dry | | MB20SRM05A |
| 165974 | 636599 | 7520190 | 9.7 | Quaternary | 6 | | MB20SRM06A |
| 165894 | 640032 | 7515860 | 8.5 | Quaternary | 8.1 | | MB38 / Saraji Mine |
| 165892 | 640018 | 7515876 | 91.5 | MCM | 12.2 | 0.3 | MB39 / Saraji Mine |
| 165893 | 640026 | 7515867 | 27 | Tertiary | 19 | | MB40 / Saraji Mine |
| 165325 | 640296 | 7515897 | 18.5 | Quaternary | Dry | | Piezo 3 |
| 84538 | 641354 | 7516737 | 109.7 | Open hole 27.4 to 109.7 mbGL | 18.3 | 0.67 | |
| 165323 | 637620 | 7515091 | 15 | Quaternary | Dry | | Piezo 1 |
| 165324 | 638481 | 7514161 | 15 | Quaternary | Dry | | Piezo 2 |
| 136092 | 633416 | 7512196 | 22 | Back Creek Group | 12 | 1.10 | Water supply |
| 165895 | 637063 | 7511046 | 42.5 | Back Creek Group | 12.7 | 0.2 | Mine monitoring |
| 190446 | 637223 | 7522750 | 33.8 | FCCM | 25.7 | 0.04 | SRMMB12_01 / Mine monitoring |
| 190447 | 637251 | 7522750 | 232.8 | MCM | | 0.5 | SRMMB12_03 / Mine monitoring |
| 57747 | 640392 | 7509441 | 126.5 | Back Creek Group | | 4.42 | Squirrel Bore / Water supply |
| 165980 | 641365 | 7507960 | 177.0 | Back Creek Group | 38 | 0.2 | MB20SRM07P? |
| 182125 | 631724 | 7530111 | 28.5 | Tertiary | 11.2 | 0.01 | BH01 |
| 182122 | 632287 | 7529754 | 32 | Tertiary | 10.5 | 0.01 | BH03 |
| 182124 | 632484 | 7529311 | 38.0 | Tertiary | 11.5 | 0.01 | BH02 |
| 182123 | 633800 | 7529686 | 34.0 | Tertiary | 10.1 | 0.01 | BH04 |
| 132631 | 635440 | 7528179 | 328.0 | Back Creek Group | 31 | 15 | Water supply |
| 136689 | 635868 | 7528234 | 328.0 | Duaringa Formation | 31 | 15 | Duplicate of RN132631 |
| 13040283 | 627834 | 7527375 | 68.5 | Back Creek Group | 38.14 | | NAP Isaac River Site 12 / |

| Number (RN) | Easting | Northing | Depth (m) | Geology | Water Level (mbGL) | Yield (L/s) | Type / Name |
|---|---|---|---|---|---|---|---|
| | | | | | | | DRDMW monitoring |
| 165837 | 633101 | 7523636 | 42 | Spoil | 23.8 | 1 | BH05 |
| 165838 | 633043 | 7522522 | 77.0 | Spoil, bedrock at 66 mbGL | 49 | 0.33 | BH06 |
| 165833 | 633038 | 7522086 | 54.0 | Clay, gravel | 39.8 | 0.02 | BH01 |
| 165834 | 633043 | 7522043 | 60.0 | Clay, sand, gravel | | 0.13 | BH02 |
| 165836 | 633024 | 7521999 | 54.0 | Spoil, bedrock at 45.5 mbGL | 36.5 | 0.01 | BH04A |
| 165835 | 633045 | 7521986 | 54.0 | Spoil, bedrock at 53.5 mbGL | 38.3 | 0.2 | BH03 |
| 165881 | 630581 | 7524539 | 17.0 | Quaternary | Dry | | MP07D |
| 165873 | 630457 | 7524462 | 10.0 | Quaternary | 4.5 | 0.23 | MP10 |
| 165877 | 630632 | 7524461 | 15.0 | Quaternary | 9.5 | 0.14 | MP06 |
| 165883 | 630353 | 7524308 | 7.0 | Quaternary | 2.6 | | MP09 |
| 165876 | 630672 | 7524328 | 18.0 | Quaternary | 10.2 | | MP01D |
| 165850 | 630648 | 7524297 | 23.0 | Quaternary | 10.5 | | MP05D |
| 165875 | 630692 | 7524283 | 18.0 | Quaternary | 10.5 | 0.01 | MP02D |
| 165874 | 630671 | 7524261 | 14.0 | Quaternary | 10.1 | | MP03D |
| 165851 | 630698 | 7524184 | 18.0 | Quaternary | 9.8 | | MP04D |
| 165872 | 630732 | 7524084 | 14.5 | Quaternary | 7.7 | | MP07 |
| 165882 | 630536 | 7524019 | 12.0 | Sandstone | 5 | | MP08 |
| 158686 | 643499 | 7508708 | 210.0 | Coal | 60 | 0.13 | MW9P |
| 122458 | 644983 | 7526770 | 50.5 | Back Creek Group | 26 | 1.88 | Water supply |
| 165123 | 647515 | 7526007 | 136.0 | Rangal Coal Measures | | | LV2372R / VWP Mine monitoring |
| 132627 | 649564 | 7525028 | 70.0 | Duaringa Formation | 30 | 0.95 | Water supply |
| 132628 | 648220 | 7524052 | 120.0 | Duaringa Formation | 77 | 0.76 | Water supply |
| 158484 | 648038 | 7523875 | 19.0 | Quaternary | | | LV2370 / Mine monitoring |
| 165124 | 648038 | 7523864 | 82.0 | Rangal Coal Measures | | | LV2375W / VWP Mine monitoring |

| Number (RN) | Easting | Northing | Depth (m) | Geology | Water Level (mbGL) | Yield (L/s) | Type / Name |
|---|---|---|---|---|---|---|---|
| 158482 | 645525 | 7522752 | 147.0 | Rangal Coal Measures | | | LV2218 / VWP Mine monitoring |
| 158483 | 645525 | 7522751 | 20.0 | Quaternary (clay) | Dry | | LV2369 / Mine monitoring |
| 158481 | 643132 | 7521949 | 102.0 | Rangal Coal Measures | | | LV2226 / VWP Mine monitoring |
| 158485 | 643132 | 7521943 | 22.0 | Quaternary (clay) | Dry | | LV2371 / Mine monitoring |
| 199088 | 626405 | 7541912 | 41.0 | Permian siltstone | 35 | 0.0 | Mine monitoring |
| 199089 | 626402 | 7541905 | 265.0 | Permian coal | | 2.0 | Mine monitoring |
| 199090 | 626412 | 7541903 | 183.0 | Permian coal | | 1.1 | Mine monitoring |
| 100291 | 626431 | 7542882 | 524.1 | German Creek Coal Measures | 17.16 | | Petroleum or gas bore |
| 141382 | 628490 | 7542693 | 52.0 | | 18.36 | 0.02 | MB5 |
| 182363 | 631318 | 7542814 | 83.0 | Blackwater Group | | | Mine monitoring |
| 182362 | 631743 | 7543062 | 65.0 | Sandstone | 30 | 0.17 | Mine monitoring |
| 182364 | 633262 | 7543161 | 56.0 | Blackwater Group | 38 | 0.08 | Mine monitoring |
| 182365 | 634668 | 7541867 | 60.0 | Blackwater Group | | | Mine monitoring |
| 162681 | 639329 | 7542012 | 10.0 | Isaac River Alluvium | Dry | | IF3835P (GW06S) |
| 165640 | 639334 | 7542009 | 203.0 | Fort Cooper Coal Measures | | | IF3836P (GW06D) / VWP Mine monitoring |
| 182925 | 626827 | 7538493 | 42.0 | Blackwater Group | | 0.20 | PDNMB05_02 / Mine monitoring |
| 182868 | 626828 | 7538498 | 81.0 | Blackwater Group | | | PBMMB05-03 / Mine monitoring |
| 182630 | 629971 | 7539627 | 7.0 | Quaternary | Dry | | EDS_MB02 / Mine monitoring |
| 190144 | 634716 | 7537427 | 10.0 | Quaternary | Dry | | EDS_MB01 / Mine monitoring |
| 182403 | 628880 | 7532630 | 30.5 | Back Creek Group | 11.5 | 0.20 | Mine monitoring |

| Number (RN) | Easting | Northing | Depth (m) | Geology | Water Level (mbGL) | Yield (L/s) | Type / Name |
|---|---|---|---|---|---|---|---|
| 182401 | 630100 | 7532833 | 167.0 | Back Creek Group | 14.6 | 0.20 | Mine monitoring |
| 182402 | 630114 | 7532835 | 10.0 | Quaternary | 6.5 | 0.1 | Mine monitoring |
| 165374 | 641498 | 7532790 | 42.5 | Duaringa Formation | 20 | 0.14 | VE3831P (GW12S) / mine monitoring |
| 165642 | 641492 | 7532790 | 520.0 | Rangal Coal Measures | | | VE3832P (GW12D) / VWP mine monitoring |
| 199214 | 632035 | 7529483 | 40 | Tertiary | 26.5 | 0.02 | Mine monitoring |
| 199215 | 632044 | 7529474 | 115 | MCM | 34 | 0.02 | Mine monitoring |
| 199250 | 633605 | 7526818 | 186 | MCM | 138 | 0.15 | Mine monitoring |
| 199251 | 633605 | 7526803 | 38 | Tertiary | 27.11 | 0.02 | Mine monitoring |
| Abandoned and destroyed bores:<br>RN100248, RN182406, RN182926, RN100252, RN13040179, RN13040178 and RN13040177 | | | | | | | |

Of the 90 registered groundwater bores, AECOM (2023) identified six (6) water supply bores within and adjacent to the existing SRM (RN136092, RN57747, RN132631, RN122458, RN132627 and RN132628).

Water supply bores RN136092, RN57747, RN132631, RN122458 are reported as targeting the Back Creek Group while RN132627 and RN132628 are reported as targeting the Duaringa Formation. The Duaringa Formation is not present within the SRM Area with the closest mapped location for this formation been 1.5 km east of the southern part of SRM Area. Therefore, water supply bores RN132627 and RN132628 are not considered further.

AECOM (2023) made the following observations on the Back Creek Group geology water supply bores:

- RN136092 intersected gravel and sand and course-grained sandstone and is 22 m deep. It is considered that the groundwater intersected within this bore is Quaternary age alluvium and not Back Creek Group.
- RN57747 was drilled before 1972 into basalt, coal, and sandstone to a depth of 126.5 m, but was measured to a total bore depth of 70.1 m in 1973. It is unclear what geological unit/s this water supply bore targets, however, based on its location and mining targets along strike, it is more likely to intersect Moranbah Coal Measures.
- RN132631 was drilled to 328 m below surface, intersecting groundwater at 321 to 328 m within fractured sandstone. Based on depth and lithology logged it is considered that this bore was drilled into a fault or fracture zone within the Fair Hill Formation of the Fort Copper Coal Measures.
- RN122458 was drilled to 50.5 m below surface, intersecting groundwater within fractured shale. Based on the location of the bore and the lithology logged it is considered that this bore intersected fractured Rewan Group sediments, which are not present at SRM. Therefore, water supply bore RN122458 is not considered further.

AECOM (2023) concluded that the groundwater yields attributed to the Back Creek Group water supply bores were inaccurate and that the Back Creek Group sediments have limited groundwater potential.

### Field Bore Census

A bore census was undertaken by AGE in 2007 in support of the SEMLP (AECOM, 2019). The bore census identified 12 bores within 15 km of SRM on four separate landholder properties. **Table 13** presents a summary of information available for each bore, with the bore locations also presented on **Figure 33**. All 12 bores were found to not correlate with the registered bore database and as such were deemed unregistered bores, although four of the bores (MB2, MB3, MB4 and MB6, refer **Table 13** and **Figure 33**) were located within approximately 400 m of GWDB recorded registered bores RN132631 and RN136689 that have recorded screen depths between 315 m and 325 m depth (AECOM, 2019).

For the 12 bores surveyed in the bore census:

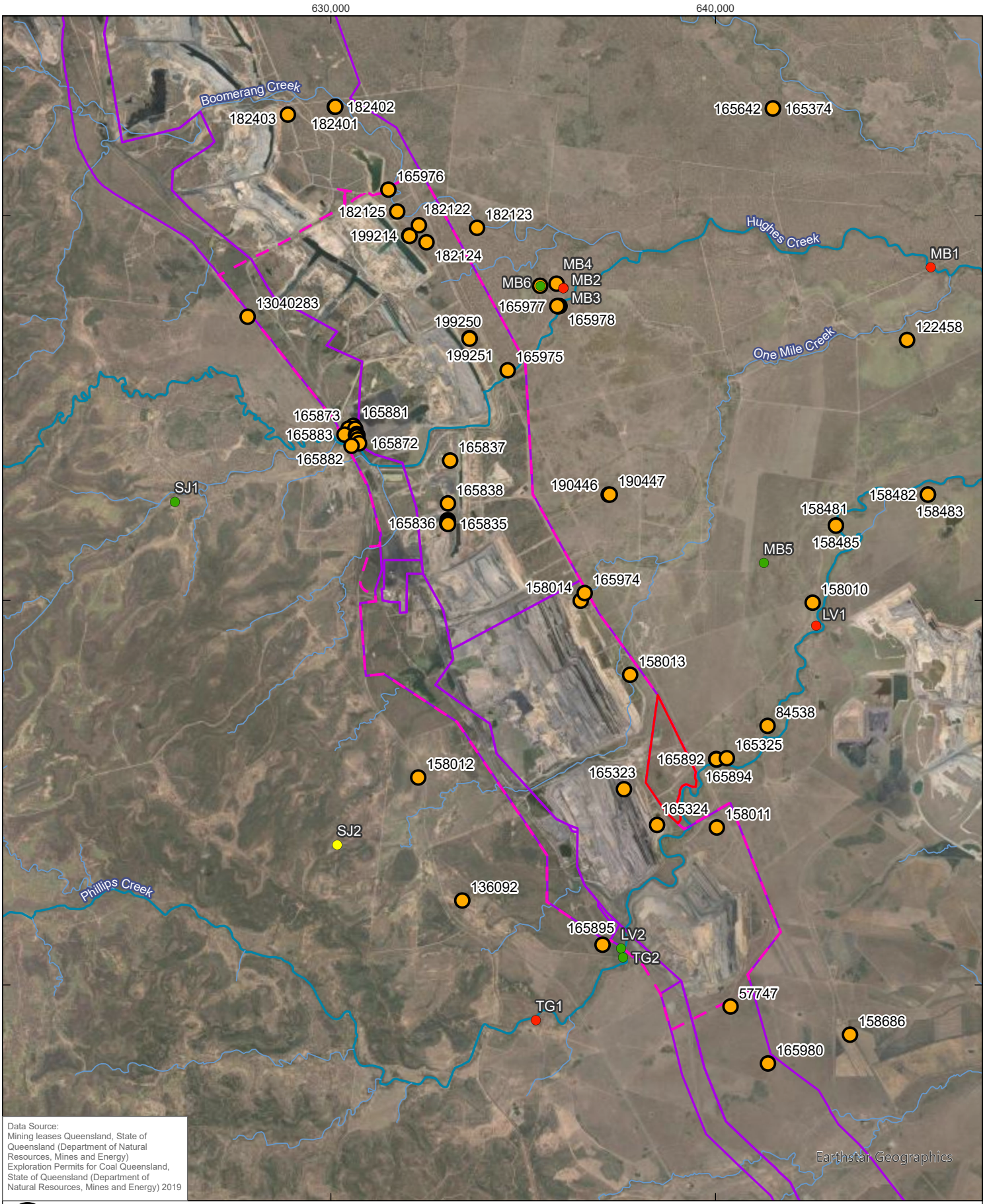
- 5 bores (42%) were equipped supply bores.
- 1 bore (8%) was an equipped supply bore that was non-operational.
- 1 bore (8%) was a supply bore undergoing maintenance (pump removed).
- 5 bores (42%) were not equipped.

Source aquifer information is not available for the 12 bores found in the bore census, however six of the bores were reported by AECOM (2019) to have known depth information. Five of the six bores with known depth information access groundwater from depths of less than 80 m. Comparison of the six known bore depths in **Table 13** with the SRM groundwater model geological information indicates two of the bores likely access the shallow Regolith (MB4 and TG1) whilst the remainder likely access the Fort Cooper Coal Measures.

The source aquifers for SJ1 (MB31) and TG2 (MB32) are the Back Creek Group and Alluvium respectively, based on details for their corresponding monitoring bore identifier in **Table 8.**

There is no source aquifer or bore depth information for MB5 and MB6, but based on a comparison with other MB (Meadowbrook) bores in **Table 13** and the corresponding discussion above, it is assumed that MB5 and MB6 access either the regolith or Fort Cooper Coal Measures.

There is also no source aquifer or bore depth information for LV2 and SJ2. Based on the location of these bores, LV2 is assumed to access either or both the regolith and Moranbah Coal Measures while SJ2 is assumed to access either or both the regolith and Back Creek Group.




# SARAJI MINE GREVILLEA PIT CONTINUATION PROJECT GROUNDWATER ASSESSMENT

## REGISTERED BORES AND BORE CENSUS

SLR

DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.

FIGURE 33

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040484.00001 Saraji Mine Grevillea GW Model\06 SLR Data\01 CADGIS\GIS\ArcPro\GW Assessment\GW Assessment.aprx\620040484 F33 Registered Bores and Bore Census

**Table 13 2007 Bore Census Details (AECOM, 2016)**

| Bore ID | Property | Easting (GDA94) | Northing (GDA94) | Standing Water Level (mbgl) | Bore Depth (m) | pH (pH Unit) | EC (µS/cm) | Status |
|---|---|---|---|---|---|---|---|---|
| MB1 | Meadowbrook | 645599 | 7528659 | 20.63 | 79.4 | 7.96 | 2,760 | Pump removed |
| MB2 | Meadowbrook | 636046 | 7528117 | 22.86 | 60.94 | - | - | Not Equipped |
| MB3 | Meadowbrook | 636052 | 7528122 | 23.82 | 50 | 6.67 | 6,990 | Not Equipped |
| MB4 | Meadowbrook | 636042 | 7528114 | 23.53 | 27.1 | - | - | Not Equipped |
| MB5 | Meadowbrook | 641260 | 7520975 | - | - | 7.11 | 7,270 | Equipped |
| MB6 | Meadowbrook | 635449 | 7528173 | - | - | 8.23 | 5,880 | Equipped |
| LV1 | Lake Vermont | 642617 | 7519343 | 23.77 | >100 | 7.32 | 916 | New unequipped bore |
| LV2 | Lake Vermont | 637545 | 7510953 | - | - | 7.87 | 758 | Equipped |
| SJ1* | Saraji Station | 625942 | 7522560 | 7.85 | - | 7.74 | 8,250 | Equipped |
| SJ2 | Saraji Station | 630163 | 7513642 | - | - | - | - | Equipped – not operational |
| TG1 | Tay Glen | 635329 | 7509084 | 9.42 | 15.06 | 8.23 | 1,940 | Not Equipped |
| TG2 ** | Tay Glen | 637595 | 7510716 | - | - | 7.88 | 754 | Equipped |

*Bore incorporated into SRM EA monitoring network as MB31

**Bore incorporated into SRM EA monitoring network as MB32

### 3.5.5.2 Environmental

#### Groundwater Dependent Ecosystems

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

GDEs are typically classified as either:

- Aquatic GDEs (i.e. ecosystems dependent on the surface expression of groundwater, such as aquatic species that inhabit groundwater-fed surface pools).

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

A separate GDE assessment has been undertaken for the Grevillea Pit Continuation project using data from this groundwater impact assessment, please refer to separate report (2Rog 2024).

## 3.6 Conceptual Site Model

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

### 3.6.1 General

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

The main hydrogeological features at SRM include:

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

Alluvium associated with the creek lines at SRM is poorly developed, sporadically saturated and hydraulically disconnected from underlying groundwater units. The alluvial aquifer only becomes significantly water bearing when associated with the Isaac River alluvium, that occurs 18 km northeast of SRM at its closest. Where it occurs, groundwater within the alluvium is recorded at depths of between 8 mBGL to 14.5 mBGL, typically significantly disconnected from the streambed elevation, i.e. limited groundwater-surface water interaction. Regionally, groundwater flow within the alluvium is a subdued reflection of topography, with groundwater flowing in an east-south-easterly direction. Losing conditions from water courses to the underlying alluvium are evident during flow periods and recharge to the alluvium is considered to be primarily from stream flow or flooding, with direct

infiltration of rainfall also occurring rapidly where there are no substantial clay barriers in the shallow sub surface. On a regional scale, discharge is via evapotranspiration from riparian vegetation growing along creek beds and minor short duration baseflow events after significant rainfall/flooding.

Water quality data for the alluvium within the broader Study Area indicates it can be fresh to saline and highly spatially and temporally variable. Water quality data from the alluvium across the Study Area indicates that it is mostly suitable for stock water supply and irrigation but exceeds guidelines for drinking water and protection of freshwater aquatic ecosystems. .. Alluvial bores within the SRM monitoring network were found to be on average, not suitable for long-term irrigation, with concentrations of boron and iron exceeding guideline levels. Further, due to the temporal nature of the alluvium to hold groundwater, it is not considered a viable groundwater supply. This is supported by the lack of landholder bores accessing the alluvium.

Tertiary aged sediments and weathering derived regolith present across SRM form an unconfined shallow groundwater system (watertable). Water quality data for the Tertiary sediments and regolith indicates it is generally highly saline but can be brackish to moderately saline. Water is generally of poor quality and not considered suitable for stock, irrigation, aquatic ecosystems or drinking water.

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

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

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

The potential impacts to the groundwater system as relevant to this groundwater impact assessment are relative to how the groundwater system responds to mining including the proposed Project. A visual representation of the CSM is provided as **Figure 34**, noting the features discussed above.

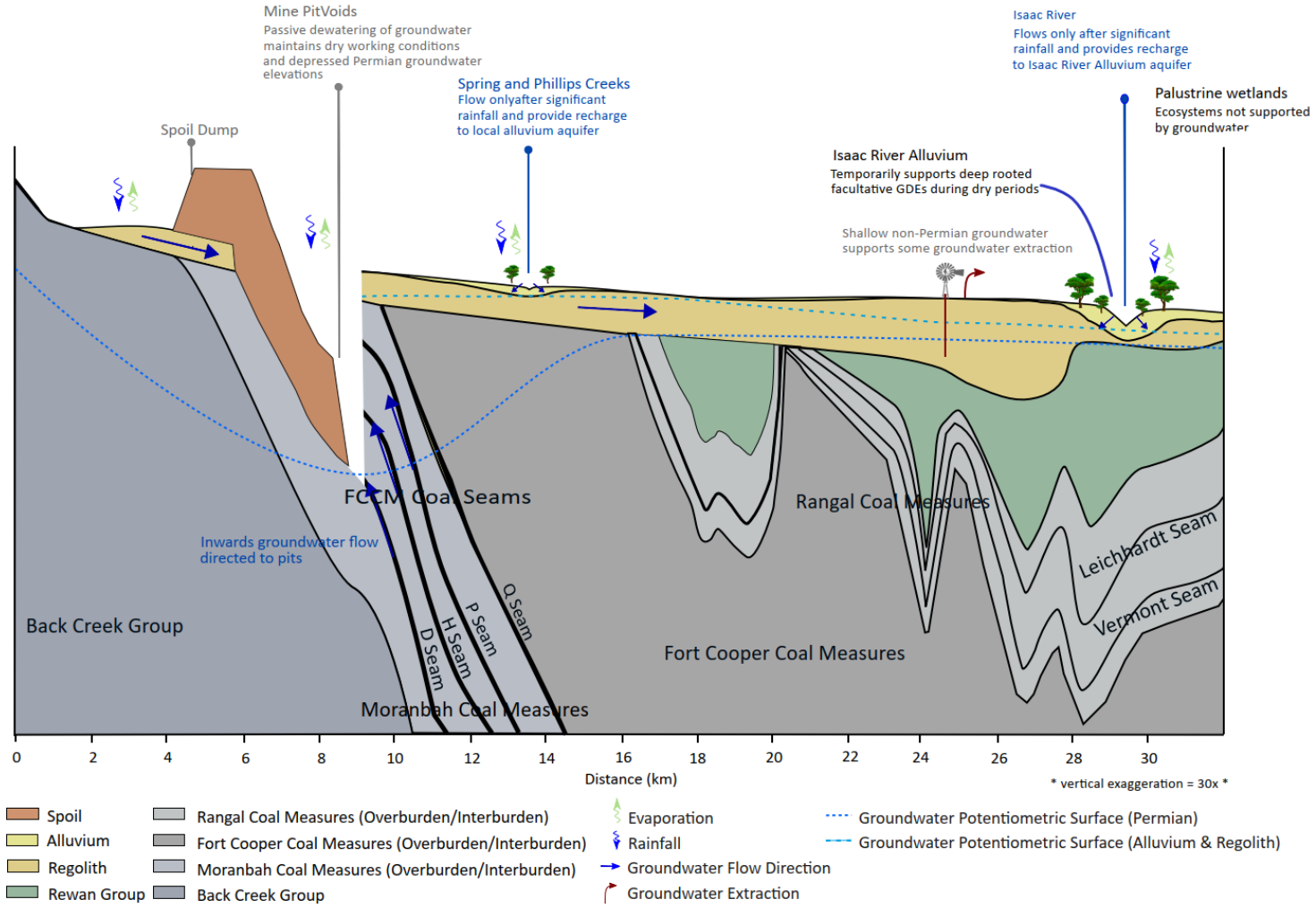



**Figure 34 Schematic Conceptual Model of the Groundwater System**

# 4.0 Groundwater Model

## 4.1 Overview

The updated regional groundwater model, referred to as the Grevillea numerical groundwater model in this report, builds on the regional scale Olive Downs Project model (i.e. the foundational model) (HydroSimulations, 2018). The foundational model was subsequently updated for the Moorvale South Project in 2019 (SLR, 2019), Winchester South Project in 2020 (SLR, 2020), Caval Ridge Mine (CVM) Horse Pit Extension (HPE) Project in 2021 (SLR, 2021a), Lake Vermont North (LVN) Extension Project (SLR, 2021b), Millennium Mine Mavis Extension (SLR, 2021c), and for the Daunia Mine (DNM) Water Licence Review (SLR, 2021d).

This regional scale model has been reviewed and accepted twice by State agencies and once by the Commonwealth for other project approval applications (such as Olive Downs Coking Coal Project). Additionally, BMA has used the model to support various State mining compliance reporting requirements. Data sharing agreements have been established by these project proponents that allow the sharing of groundwater information and modelling. Under these agreements, the groundwater models developed as part of each project's groundwater assessment were adopted as a base for the Grevillea model, where relevant.

The regional groundwater model was updated with the approved and proposed mine plans for the Grevillea Pit.

## 4.2 Model Details

This section provides a summary of the design and development of the 2024 updated numerical groundwater model used to support this groundwater impact assessment. Full details of the numerical groundwater model are included within the Groundwater Modelling Technical Report in **Appendix A**

### 4.2.1 Model Objectives

The overall objectives of this groundwater modelling are to:

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

### 4.2.2 Model Design

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

The model domain is intended to place boundary conditions sufficiently distant from the Grevillea Pit, surrounding SRM pits and nearby Bowen Basin mines to allow the extent of potential impacts from mining activities on the groundwater system to be assessed. At its widest extents, the model is approximately 62 km west-east by 95 km north-south.

The modelling of faults within the groundwater model uses the fault mapping and site-specific geology models where available. Local faults displacements derived from the PDM and SRM/Grevillea geological models have also been captured in the model layer elevations at these sites.

To allow stable numerical modelling of the large spatial area of the model domain, an unstructured grid with varying Voronoi cell sizes was designed using Algomesh (HydroAlgorithmics, 2014).

The model domain was vertically discretised into 19 layers, each layer comprising a cell count up to 121,225. The total number of cells in the model is 1,362,485.

The model domain is discretised into 19 layers, as listed in **Table 14** together with the average thicknesses across the model domain for each layer.

**Table 14 Model Layer and Thicknesses**

| Model Layer | Formation | Unit | Average Thickness (m) |
|---|---|---|---|
| 1 | Alluvium, colluvium, Tertiary basalt | Surface cover – alluvium, colluvium and Tertiary basalt | 8.3 |
| 2 | Regolith (Tertiary sediments, Tertiary basalt) | Tertiary and minor Triassic Clematis Group, weathered Permian, Tertiary basalt | 19.2 |
| 3 | Rewan Group | Triassic | 117.7 |
| 4 | Rangal Coal Measures | Leichhardt overburden | 36.6 |
| 5 | | Leichhardt seam | 4.6 |
| 6 | | Interburden | 35.6 |
| 7 | | Vermont seam | 3.8 |
| 8 | | Vermont underburden | 34.1 |
| 9 | Fort Cooper Coal Measures | Fort Cooper overburden | 206.6 |
| 10 | | Fort Cooper seams (combined) | 55.9 |
| 11 | | Fort Cooper underburden | 56.1 |
| 12 | Moranbah Coal Measures | Q Seam | 3.3 |
| 13 | | Interburden | 38.0 |
| 14 | | P Seam | 2.9 |
| 15 | | Interburden | 56.4 |
| 16 | | H Seam | 5.5 |
| 17 | | Interburden | 67.1 |
| 18 | | D Seam (target coal seam for Grevillea) | 8.4 |
| 19 | | Base of Model - aquitard | 100.0 |

### 4.2.3 Model Calibration

The previous version of the model was calibrated using PEST++ and, upon review of model calibration statistics after the updates for the Grevillea Project, was considered still reasonably calibrated. Therefore, the calibration methodology adopted for the Grevillea numerical model involved running the model numerous times using different parameter sets and investigating which model produce the best calibration statistics.

After running the 550 calibration realisations, the calibration statistics were then calculated for each realisation and the realisation that produced the lowest Scaled Root Mean Square error (SRMS) was considered to be the best calibrated model for the purposes of the Grevillea Project groundwater impact assessment. The remaining 549 realisations were then used to quantify the model uncertainty with respect to simulated heads and predictive variables.

The best calibrated model achieved a scaled root mean square (SRMS) error of 5.9%.

### 4.2.4 Model Performance and Limitations

The model confidence level (Class 1, Class 2 or Class 3 in order of increasing confidence) based on the Australian Groundwater Modelling Guidelines (Barnett et al. 2012) was previously widely used in the industry to provide a classification of model performance and limitations. The latest version of the IESC Explanatory Note for Uncertainty Analysis (Peeters and Middlemis, 2023) introduces a new concept on how model confidence can be assessed. The document also indicates that this change will follow in the next iteration of the Australian Modelling Guidelines and the new concept for assessing model confidence is hence applied for this model.

The latest version of the IESC Explanatory Note for Uncertainty Analysis defines a model fit for purpose when model results are:

- Usable -- Relevant to the decision-making process, providing information about the uncertainty in conceptualisations and modelling simulations in a way that allows decision-makers to understand the effects of uncertainty on project objectives and the effects of potential bias. The relevant Quantities of Interests (QoI) in this context are the groundwater inflows and drawdowns to assess licensing, site water management and drawdown impacts.
- Reliable -- Demonstrate that the range of model outcomes is consistent with the system knowledge and honours historical observations and provides objective evidence that uncertainties affecting decision-critical predictions of impacts on aquifer resources and dependent systems are not underestimated. The calibration performance was deemed acceptable, and a rigorous UA was undertaken to further improve confidence in the modelling outputs.
- Feasible -- Trade-offs due to budget, time and technical constraints are reasonable and justifiable within the risk context of the Project. This study is an update of an earlier model, which shows that there are several model revisions therefore mitigating budget and time trade-offs. Updated technical datasets are included in the most recent revision. The model has been peer reviewed for each revision. The model builds and associated review process are therefore deemed commensurate with the Project related risk to the groundwater environment.

In order to assess these three points above, the four sources of scientific uncertainty (structural, parametrisation, measurement error, predictions) have been qualitatively assessed with regards key aspects of the groundwater model, as presented in **Table 15**.





Overall, the model captures depressurisation due to active mining. The model is numerically stable with no mass balance error. The model shows a reasonable fit between observed and modelled groundwater levels. A depth dependence function was used for hydraulic conductivity, with the calibrated values showing a good fit to observed data. Overall, the model is considered fit for purpose to achieve the project objectives based on the data provided and the project timeframe.

**Table 15 Groundwater Model and Data Limitations**

| Type | Part | Status | Comment |
|---|---|---|---|
| Structural/ Conceptual | Grid and Model Extent | Fit for purpose | The model has an unstructured Voronoi grid that includes detailed cell refinement around site, neighbouring mines and along drainage features. |
| | Layers | Fit for purpose | Top of layer 1 incorporates site LiDAR data from Grevillea and SRM. |
| | | Fit for purpose | Representation of alluvium based on CSIRO (2015) regolith mapping and refined based on site drill data. |
| | Conceptualisation – Geological Structure | Fit for purpose | The local structure of the geology is based on detailed data at site, and regional model geometry (outside of site) interpolated based on neighbouring mines geology models (Winchester South, Lake Vermont, Moorvale South and Olive Downs South) and geological mapping.<br>Geophysical surveys across the Project Area have identified minor faulting in the Grevillea area. Faulting is typically confined to the coal seams of the Moranbah Coal Measures. No geological structures (i.e. faults) have been included within the Project area in the model other than through layer displacements from the site geological model. The most significant geological structure in the area is the Fault which is located 500m from the site and will not be intersected by mining. |
| | Conceptualisation – Surface Water Groundwater Interactions | Fit for purpose | The Permian coal measures outcrop along the western edge of the site. Therefore, how this is captured within the model influences the model predictions. The structure of the coal seams was checked to ensure it matches observed and mapped geology. The predictions of drawdown adjacent to mining was checked and the model shows a good fit between modelled and observed trends. |
| | Conceptualisation – Saturated Extent of Alluvium and Regolith | Fit for purpose | For the extent and thickness of alluvium in the vicinity of the Project Area (i.e., alluvium along Boomerang Creek) auger hole logs and Google satellite imagines were used. Any additional data or study on alluvium extent and thickness at Grevillea should be reviewed and captured (where relevant) in future updates of the model. Such improvements are not deemed required for the Project impact assessment however. |
| Parameterisation | Hydraulic Conductivity – Depth Dependence | Fit for purpose, future improvements possible | Field testing of hydraulic conductivity (horizontal and to a lesser extent vertical) has been conducted in the area. Hydraulic conductivity test results from the other sites within the model domain were also considered. The data shows a general decline in hydraulic conductivity with depth that is replicated in the model. |

| Type | Part | Status | Comment |
|---|---|---|---|
| | | | Further conductivity tests and measurements of storage properties can improve model calibration and refine model predictions but are not deemed required for the Project impact assessment. |
| | Spoil Properties | Fit for purpose, future improvements possible | Limited site-specific data is available for the spoil. Spoil properties were adopted using the previous studies. |
| | Rivers | Fit for purpose, future improvements possible | Isaac River stage height is changed temporally in the historical calibration model based on observed levels from government stream gauges, and long term annual average level assumed in the predictive model.<br>Watercourses within and in the vicinity of the Project Area are ephemeral and only flow briefly after rainfall. Therefore, river stage height of zero was assigned to these watercourses in the model.<br>Measurements of flow rates and stage height in the rivers can help with improving the model calibration and refining the model predictions but are not deemed required for the Project impact assessment. |
| | Recharge | Fit for purpose | Recharge zonation is based on mapped surface geology and calibrated recharge rates. |
| Measurement Error | Observation Data Quality | Fit for purpose | Bore logs and construction details available for most site bores, and long-term site water level data available for various units. |
| | Landholder Bore Data Quality | Fit for purpose | Impacts on registered landholder bores are influenced by the assumptions of the bore design, target geology and use. |
| | Temporal spread | Fit for purpose | Timeseries water level data from the site as well as the neighbouring mines (Winchester South, Moorvale South, Olive Downs South and Lake Vermont, Peak Downs, Moranbah South) for the alluvium and Permian coal measures. |
| Scenario Uncertainties<br>Future stresses/ conditions | Calibration | Fit for purpose | Transient warm-up (1988-2008) and transient (2008 to 2022) calibration model set up and a depth dependence function used and calibration to water levels conducted using automated (PEST) and manual methods. |
| | Predictive | Fit for purpose | Model captures approved and proposed development at Grevillea. The model also includes future mining at Saraji, Peak Downs mainly based on publicly available data. The actual future mine progression for these sites may vary. |

| Type | Part | Status | Comment |
|---|---|---|---|
| | Sensitivity and uncertainty | Fit for purpose | Uncertainty analysis has been conducted by stochastic modelling using an adapted Monte Carlo method with modern software packages. The Latin Hypercube Sampling (LHS) method was used to create random realisations from parameter and PEST++ was used to orchestrate the model runs. The uncertainty analysis quantified the variability in predictions with changes in maximum predicted drawdowns, mine inflows, impact on alluvium flow and impacts on surface water flow. |

### 4.2.5 Model Predictions

Transient predictive modelling was used to simulate the proposed mining for the Grevillea Project as well as mining at other approved and foreseeable mines within the model domain. The predictive part of the model comprises annual stress periods, starting from 2024 until 2063.

Transient predictive models have been developed for three model scenarios:

- No Mining.
- Approved mining without proposed Grevillea Pit.
- Approved mining with proposed Grevillea Pit.

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

## 4.3 Predicted Groundwater Interception

The predicted inflows for SRM excluding Grevillea ("*SRM Approved*") and SRM including Grevillea ("*SRM Approved+Grevillea*") are presented in **Figure 35**. The difference between the two cases represents the inflows to the Grevillea Pit. The percentage of predicted inflows from the Grevillea Project of all SRM approved + Grevillea inflows is also shown on **Figure 35**.

As shown in **Figure 35**, inflows at all of SRM including Grevillea are predicted to reach a maximum peak in year 2039 with 1900 ML/yr (5.2 ML/day). This is approximately 500 ML/yr higher than inflows for SRM excluding Grevillea, indicating the maximum inflow to Grevillea is approximately 1.34 ML/day. The inflows for all of Saraji including Grevillea then decrease gradually and remain predominantly between 200 ML/yr (0.56 ML/day) and 1200 ML/yr (3.29 ML/day) until 2054 (end of the Project). Inflows due to the Grevillea Project range are typically less than 25% except at the commencement of new mining strips in 2034 and 2049.

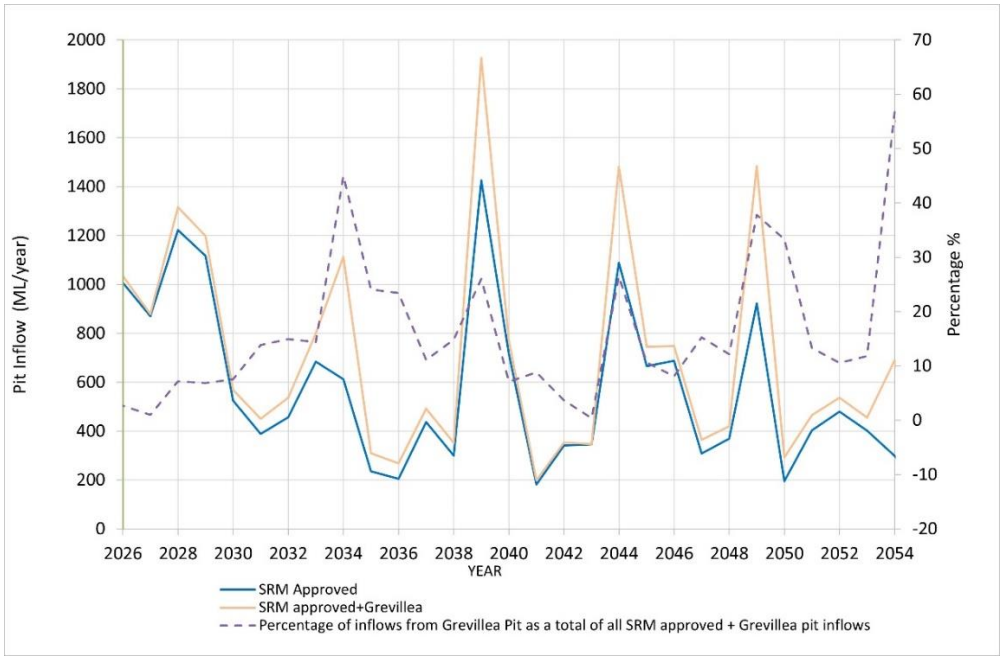



**Figure 35 Predicted Groundwater Inflows**

## 4.4 Maximum Predicted Groundwater Drawdown

### 4.4.1 Incremental

The process of mining directly removes water from the groundwater system and reduces water levels in surrounding groundwater units. The extent of the zone affected is dependent on the properties of the aquifers/aquitards and is referred to as the zone of drawdown. Groundwater drawdown is greatest at the working coalface and decreases with distance from the mine workings. Predictive modelling results presented in this report section are based on the single model (i.e. best calibrated model realisation discussed) and uncertainty with respect to the model predictions is investigated in detail in **Section 4.6.**

Maximum incremental drawdown refers to the drawdown impact associated with the Grevillea Project only and is obtained by comparing the difference in predicted aquifer groundwater levels for the SRM Approved scenario and the SRM Approved + Grevillea scenario at matching times. The maximum incremental drawdown represents the maximum drawdown values recorded at each model cell at any time over the model predictive simulation duration. Predicted drawdown figures (**Figure 36** to **Figure 41**) show where maximum incremental drawdown impacts are predicted to exceed 1 m.

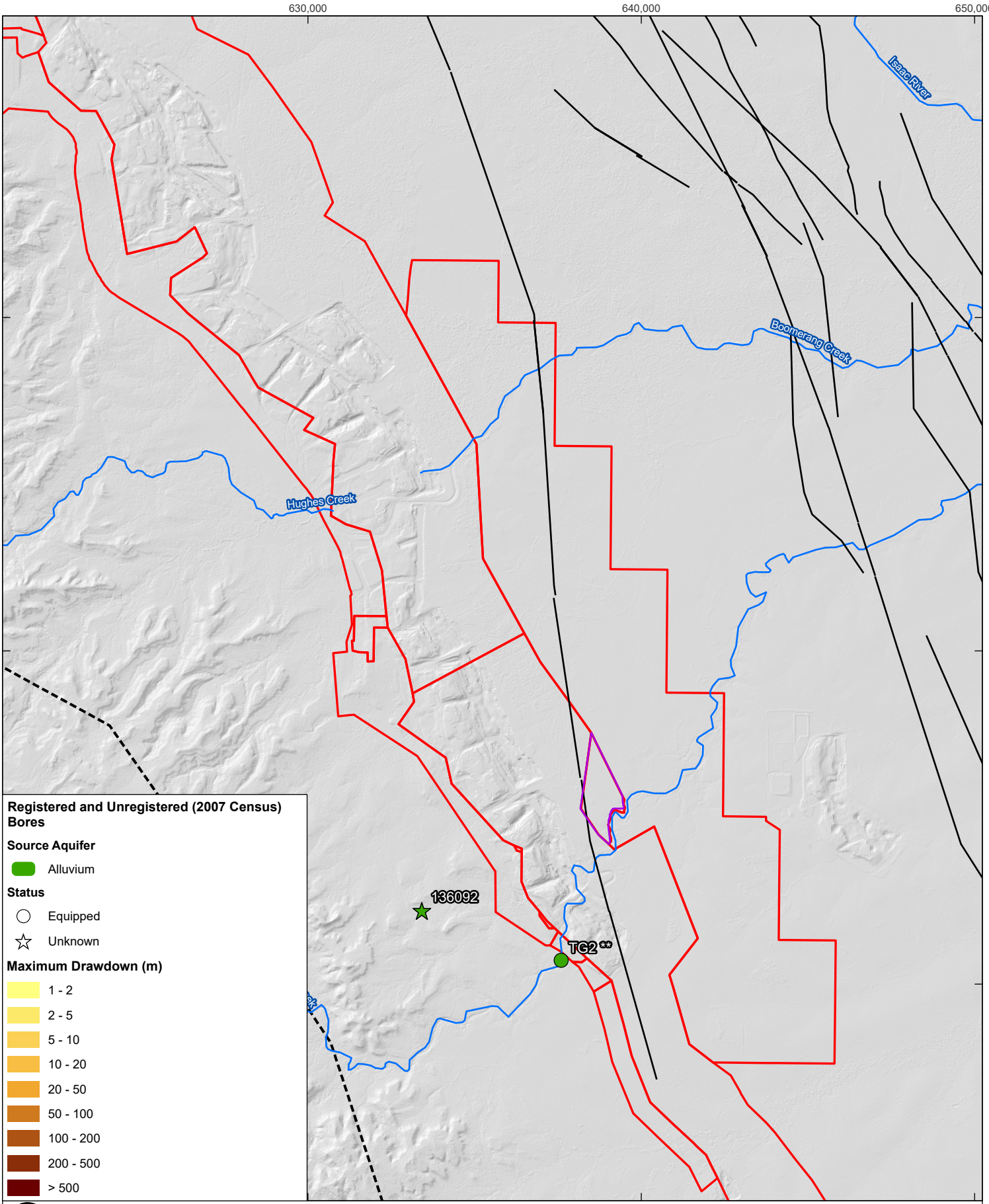
**Figure 36** shows that no incremental drawdown is predicted for the Quaternary alluvium as a result of the Grevillea Project.

The maximum predicted incremental drawdown within the regolith is shown in **Figure 37.** The incremental drawdown extent within the regolith (Layer 2) occurs mostly northeast of the Grevillea Project area. The 1 m drawdown influence is predicted to extend 2.6 km northeast of the Grevillea mine extent.

The coal seams of the Moranbah Coal Measures are the primary groundwater bearing strata at the Grevillea Project and will experience drawdowns as a result of mining at Grevillea. Groundwater level drawdown within the mined coal seams is influenced by unit structure and is confined to unit extents. **Figure 38** to **Figure 41** show the maximum predicted incremental drawdown for Q, P, H and D seam in the Moranbah Coal Measures. The figures show the extent of maximum predicted depressurisation of the Permian aged coal seams is limited to the west of Grevillea due to the depositional geology (i.e. coal seams subcrop).

The extent of maximum predicted incremental drawdown in the Moranbah Coal Measures coal seams are generally elongated along strike in the northeast-southwest direction and extend up to 5 km north and 6 km southeast of the Grevillea mine extent. Drawdowns propagate further within the shallower coal seams (i.e., Q and P seam) when compared to the D seam (i.e., coal seam target). Given the use of depth dependant equation for assigning the hydraulic properties in the model, the shallower units have higher hydraulic conductivities in comparison to deeper ones which facilitates the drawdowns.

The influence of fault near the Grevillea is also evident and it appears that it limits the drawdown propagation to the east.




| | |
|---|---|
| Coordinate System: | GDA 1994 MGA Zone 55 |
| Scale: | 1:150,000 at A4 |
| Project Number: | 620.040484.00001 |
| Date Drawn: | 12-Sep-2024 |
| Drawn by: | RB |

# SARAJI MINE GREVILLEA PIT CONTINUATION PROJECT GROUNDWATER ASSESSMENT

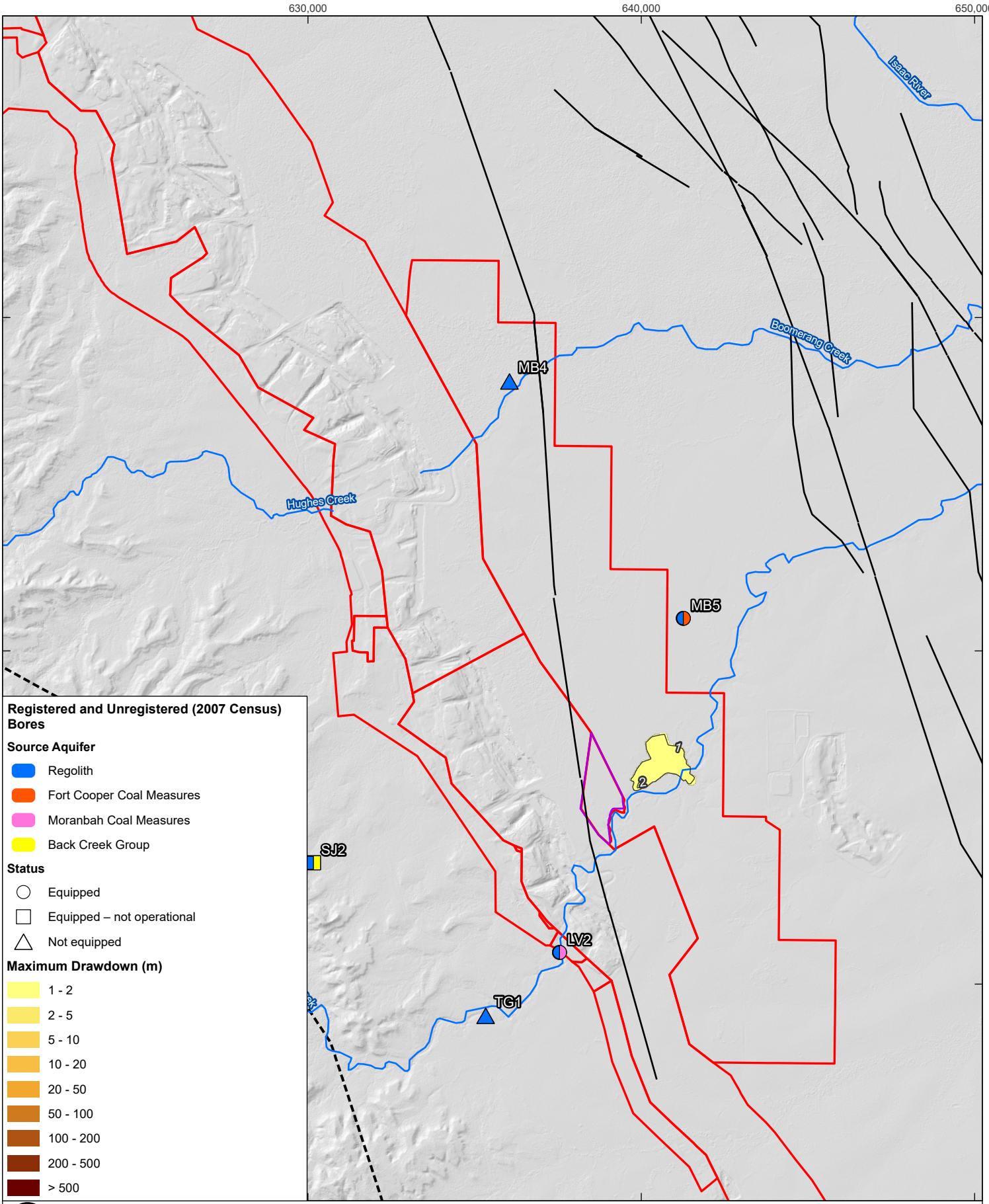
## MAXIMUM INCREMENTAL DRAWDOWN IN QUATERNARY ALLUVIUM (LAYER 1)

SLR

DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.

FIGURE 36

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040484.00001 Saraji Mine Grevillea GW Model\06 SLR Data\01 CADGIS\GIS\ArcPro\GW Assessment\GW Assessment.aprx\620040484 F36 Maximum Incremental Drawdown in Alluvium (Layer 1)




0 2.5 5 km

| | |
|---|---|
| Coordinate System: | GDA 1994 MGA Zone 55 |
| Scale: | 1:150,000 at A4 |
| Project Number: | 620.040484.00001 |
| Date Drawn: | 12-Sep-2024 |
| Drawn by: | RB |

**LEGEND**

- Modelled Fault
- Drawdown Contour (m)
- Major Drainage System
- Mining Lease
- Model Boundary
- Project Area

# SARAJI MINE GREVILLEA PIT CONTINUATION PROJECT GROUNDWATER ASSESSMENT

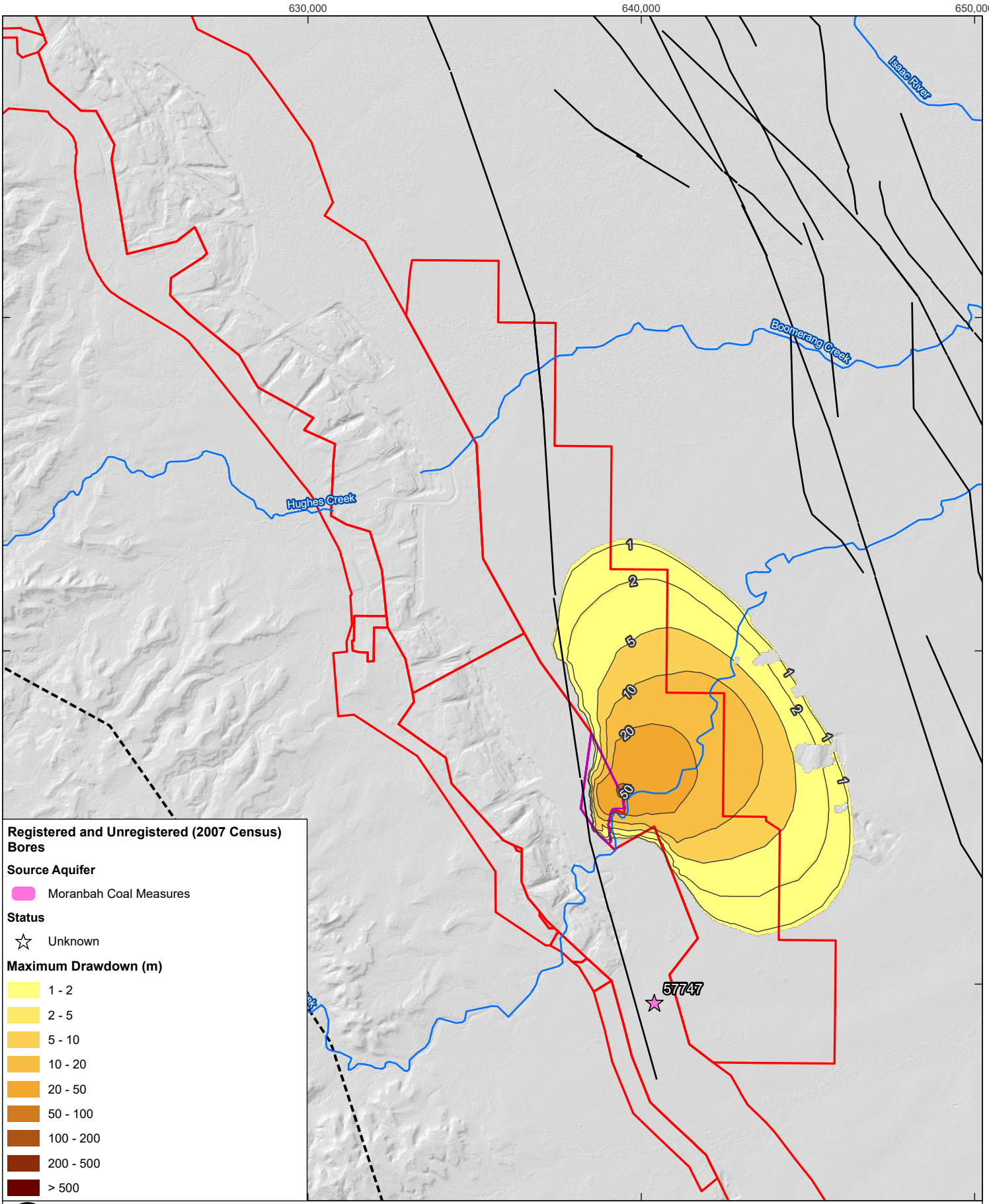
## MAXIMUM INCREMENTAL DRAWDOWN IN REGOLITH (LAYER 2)

SLR

DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.

**FIGURE 37**

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040484.00001 Saraji Mine Grevillea GW Model\06 SLR Data\01 CADGIS\GIS\ArcPro\GW Assessment\GW Assessment.aprx\620040484 F37 Maximum Incremental Drawdown in Regolith (Layer 2)




# SARAJI MINE GREVILLEA PIT CONTINUATION PROJECT GROUNDWATER ASSESSMENT

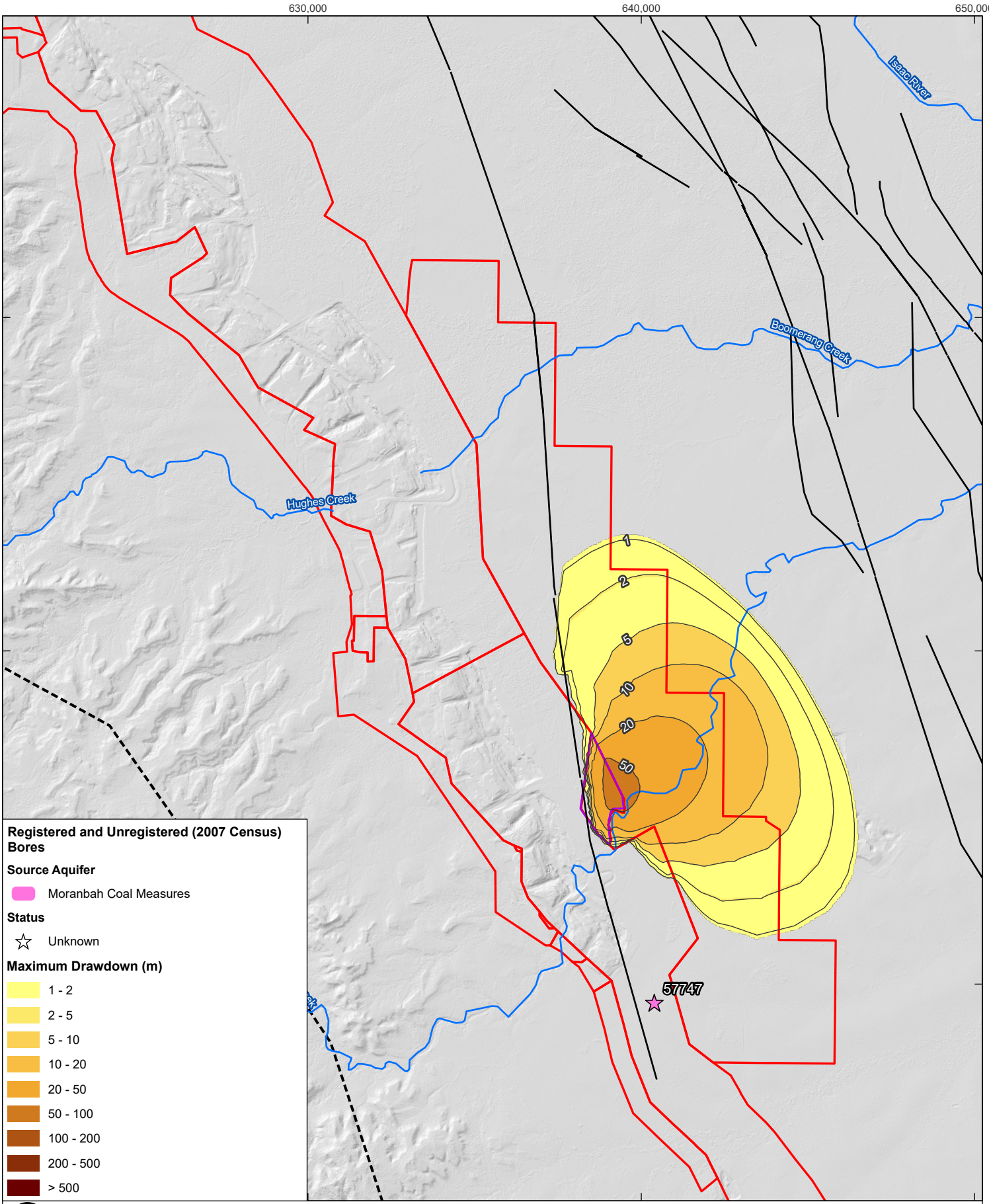
## MAXIMUM INCREMENTAL DRAWDOWN IN Q SEAM (LAYER 12)

SLR

DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.

FIGURE 38

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040484.00001 Saraji Mine Grevillea GW Model\06 SLR Data\01 CADGIS\GIS\ArcPro\GW Assessment\GW Assessment.aprx\620040484 F38 Maximum Incremental Drawdown in Q Seam (Layer 12)




0 2.5 5 km

| | |
|---|---|
| Coordinate System: | GDA 1994 MGA Zone 55 |
| Scale: | 1:150,000 at A4 |
| Project Number: | 620.040484.00001 |
| Date Drawn: | 12-Sep-2024 |
| Drawn by: | RB |

**LEGEND**

- Modelled Fault
- Drawdown Contour (m)
- Major Drainage System
- Mining Lease
- Model Boundary
- Project Area

# SARAJI MINE GREVILLEA PIT CONTINUATION PROJECT GROUNDWATER ASSESSMENT

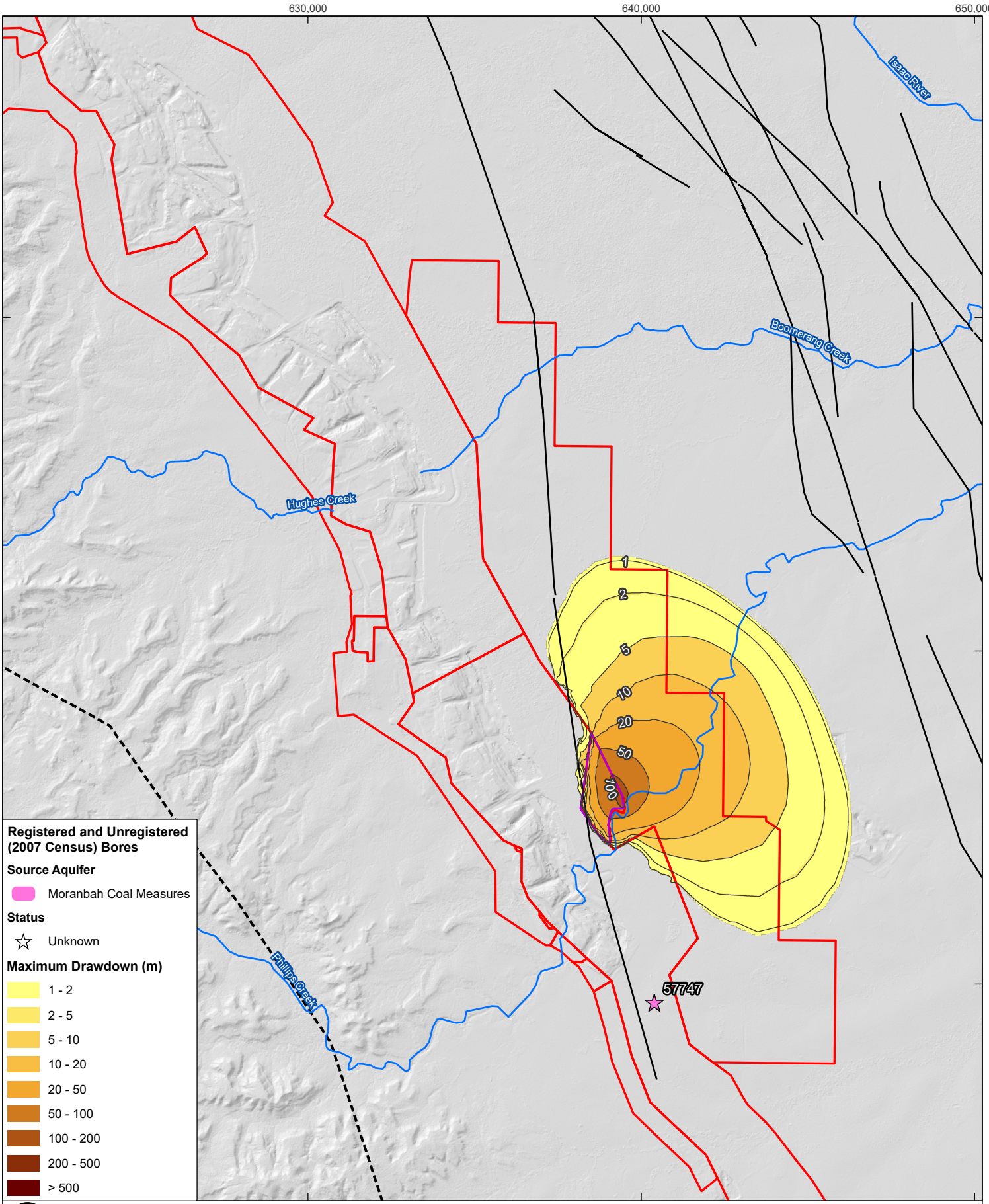
## MAXIMUM INCREMENTAL DRAWDOWN IN P SEAM (LAYER 14)

SLR

DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.

FIGURE 39

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040484.00001 Saraji Mine Grevillea GW Model\06 SLR Data\01 CADGIS\GIS\ArcPro\GW Assessment\GW Assessment.aprx\620040484 F39 Maximum Incremental Drawdown in P Seam (Layer 14)




0 2.5 5 km

| | |
|---|---|
| Coordinate System: | GDA 1994 MGA Zone 55 |
| Scale: | 1:150,000 at A4 |
| Project Number: | 620.040484.00001 |
| Date Drawn: | 12-Sep-2024 |
| Drawn by: | RB |

**LEGEND**

- Modelled Fault
- Drawdown Contour (m)
- Major Drainage System
- Mining Lease
- Model Boundary
- Project Area

# SARAJI MINE GREVILLEA PIT CONTINUATION PROJECT GROUNDWATER ASSESSMENT

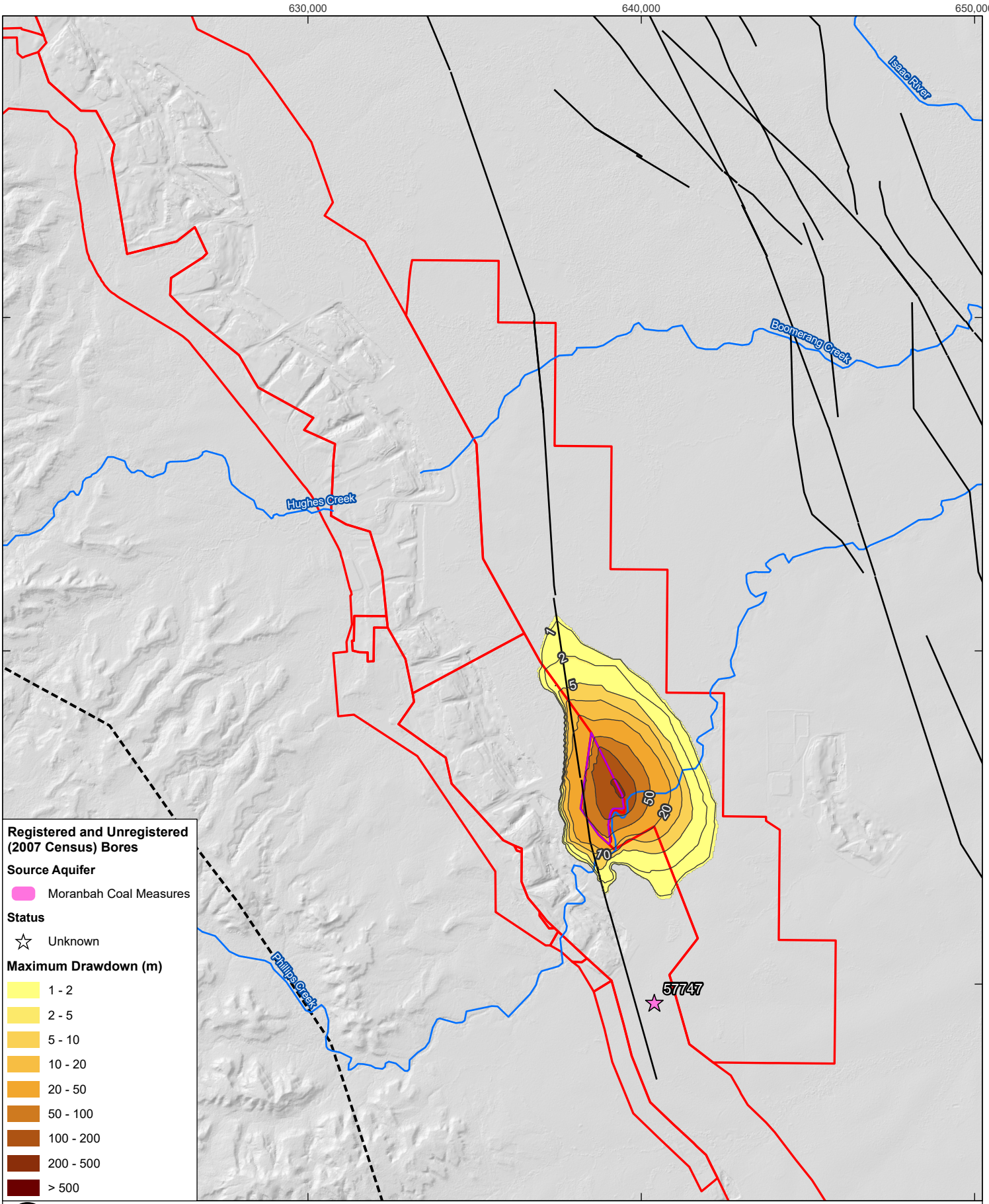
## MAXIMUM INCREMENTAL DRAWDOWN IN H SEAM (LAYER 16)

SLR

DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.

FIGURE 40

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040484.00001 Saraji Mine Grevillea GW Model\06 SLR Data\01 CADGIS\GIS\ArcPro\GW Assessment\GW Assessment.aprx\620040484 F40 Maximum Incremental Drawdown in H Seam (Layer 16)




0 2.5 5 km

| | |
|---|---|
| Coordinate System: | GDA 1994 MGA Zone 55 |
| Scale: | 1:150,000 at A4 |
| Project Number: | 620.040484.00001 |
| Date Drawn: | 12-Sep-2024 |
| Drawn by: | RB |

**LEGEND**

- Modelled Fault
- Drawdown Contour (m)
- Major Drainage System
- Mining Lease
- Model Boundary
- Project Area

# SARAJI MINE GREVILLEA PIT CONTINUATION PROJECT GROUNDWATER ASSESSMENT

## MAXIMUM INCREMENTAL DRAWDOWN IN D SEAM (LAYER 18)

SLR

DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.

**FIGURE 41**

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040484.00001 Saraji Mine Grevillea GW Model\06 SLR Data\01 CADGIS\GIS\ArcPro\GW Assessment\GW Assessment.aprx\620040484 F41 Maximum Incremental Drawdown in D Seam (Layer 18)

## 4.5 Incidental Water Impacts

### 4.5.1 Alluvium

The change in alluvial water resources was assessed by comparing water budgets for alluvial zones using the Project and Approved scenarios of the predictive model. Interference of the alluvial groundwater can occur due to the potential for increased leakage from mining induced groundwater drawdown.

Over the extent of Phillips Creek alluvium, the predicted loss of water from alluvium due to Grevillea is predicted to be less than 0.01 ML/d. With regards to the Isaac River alluvium, the model predicts that the alluvium take due to Grevillea is less than 0.003 ML/day.

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

### 4.5.2 Groundwater – Surface Water Interaction

The change in surface water drainage leakage to groundwater due to Grevillea was assessed by comparing the River cell flow budgets for the Isaac River in the Project scenario against the Approved scenario. This comparison showed that over the life of the Project, the change in the Isaac River net flow attributable to Grevillea is less than 0.0003 ML/day.

In the model, Phillips Creek (located within the Grevillea area) is represented with a stage height of 0.0 m which means it is simulated as a gaining system (i.e., negative net flow). The results indicate that there is no change to the estimated net flow for Phillips Creek due to Grevillea.

### 4.5.3 Cumulative

The simulated cumulative drawdown presented in this section show the impacts on different hydrostratigraphic units due to the existing approved mining within the model domain. The simulated cumulative drawdown shows whether the zone of impact from the neighbouring operations is predicted to interact with the zone of impact predicted for the Grevillea Project in different aquifers (alluvium none, regolith, MCM coal seams – only).

Maximum cumulative drawdown in proximity to the Grevillea Project are shown in **Figure 42** to **Figure 49**. Maximum cumulative drawdown predictions covering the entire model domain are provided in Appendix E of the groundwater modelling technical report (refer **Appendix A**).

These drawdowns represent the total impact to modelled groundwater levels resulting from all mining within the model domain, by comparing the maximum difference in aquifer groundwater levels for the Project model scenario with those in the theoretical “no mining” Null Run scenario, for all times during the predictive model period. The vast majority of these predicted cumulative drawdown impacts are not related to the Grevillea but result from other, existing mining activities represented in the model.

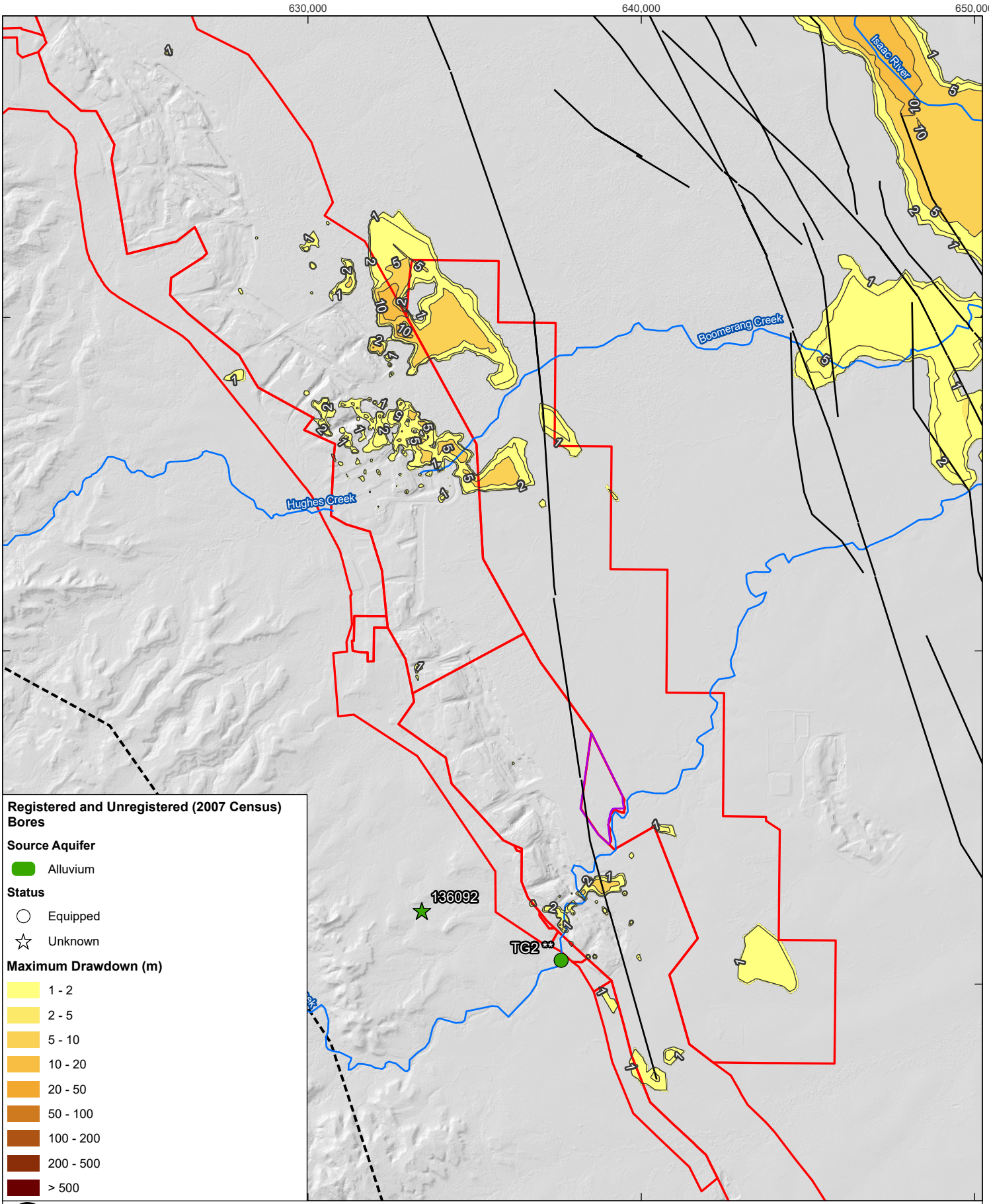
There are small amounts of cumulative drawdown impacts (not Project related) predicted for the Quaternary alluvium within or around the Grevillea Project (**Figure 42**).

Cumulative impacts within the regolith can be seen connecting the Project-related drawdown to the drawdown impacts at the PDM and SRM open cuts (**Figure 43**).

For the Leichhardt and Vermont coal seams of the Rangal Coal Measures, there was no drawdown interaction between the Grevillea area and the neighbouring mines since these seams are not present in the Grevillea area (**Figure 44** and **Figure 45**).

**Figure 46** to **Figure 49** show the maximum predicted cumulative drawdown in Q, P, H and D seams in the Moranbah Coal Measures. As shown in the figures the cumulative drawdown is predicted to interact with zone of impact from the PDM and SRM open cuts.

**Figure 49** shows that drawdowns occur along the north-south trending fault located on the east of SRM.




0 2.5 5 km

| | |
|---|---|
| Coordinate System: | GDA 1994 MGA Zone 55 |
| Scale: | 1:150,000 at A4 |
| Project Number: | 620.040484.00001 |
| Date Drawn: | 12-Sep-2024 |
| Drawn by: | RB |

**LEGEND**

- Modelled Fault
- Drawdown Contour (m)
- Major Drainage System
- Mining Lease
- Model Boundary
- Project Area

**SARAJI MINE GREVILLEA PIT CONTINUATION PROJECT GROUNDWATER ASSESSMENT**

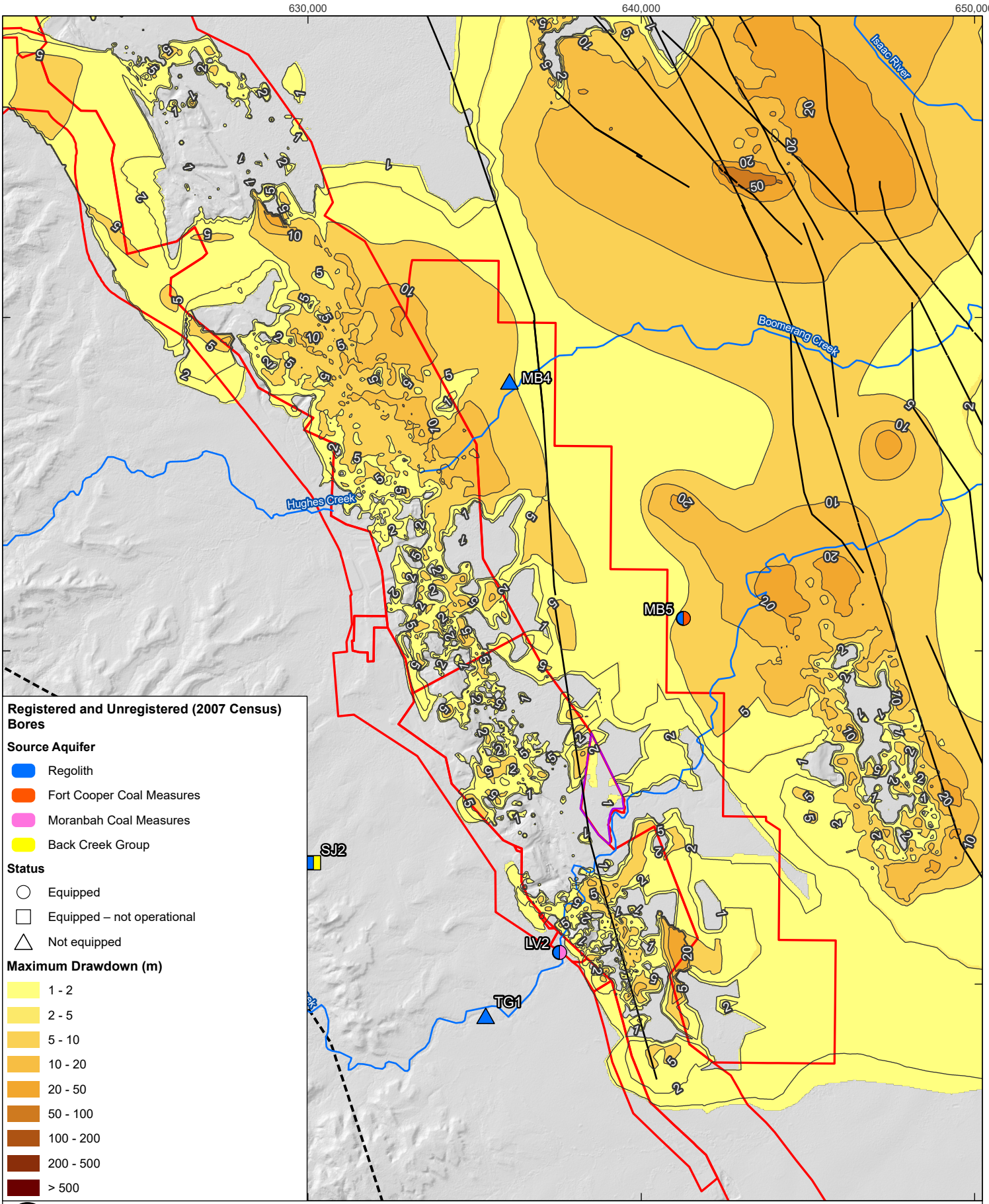
**MAXIMUM CUMULATIVE DRAWDOWN IN QUATERNARY ALLUVIUM (LAYER 1)**

SLR

DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.

**FIGURE 42**

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040484.00001 Saraji Mine Grevillea GW Model\06 SLR Data\01 CADGIS\GIS\ArcPro\GW Assessment\GW Assessment.aprx\620040484 F42 Maximum Cumulative Drawdown in Quaternary Alluvium (Layer 1)




0 2.5 5 km

| | |
|---|---|
| Coordinate System: | GDA 1994 MGA Zone 55 |
| Scale: | 1:150,000 at A4 |
| Project Number: | 620.040484.00001 |
| Date Drawn: | 12-Sep-2024 |
| Drawn by: | RB |

**LEGEND**

- Modelled Fault
- Drawdown Contour (m)
- Major Drainage System
- Mining Lease
- Model Boundary
- Project

# SARAJI MINE GREVILLEA PIT CONTINUATION PROJECT GROUNDWATER ASSESSMENT

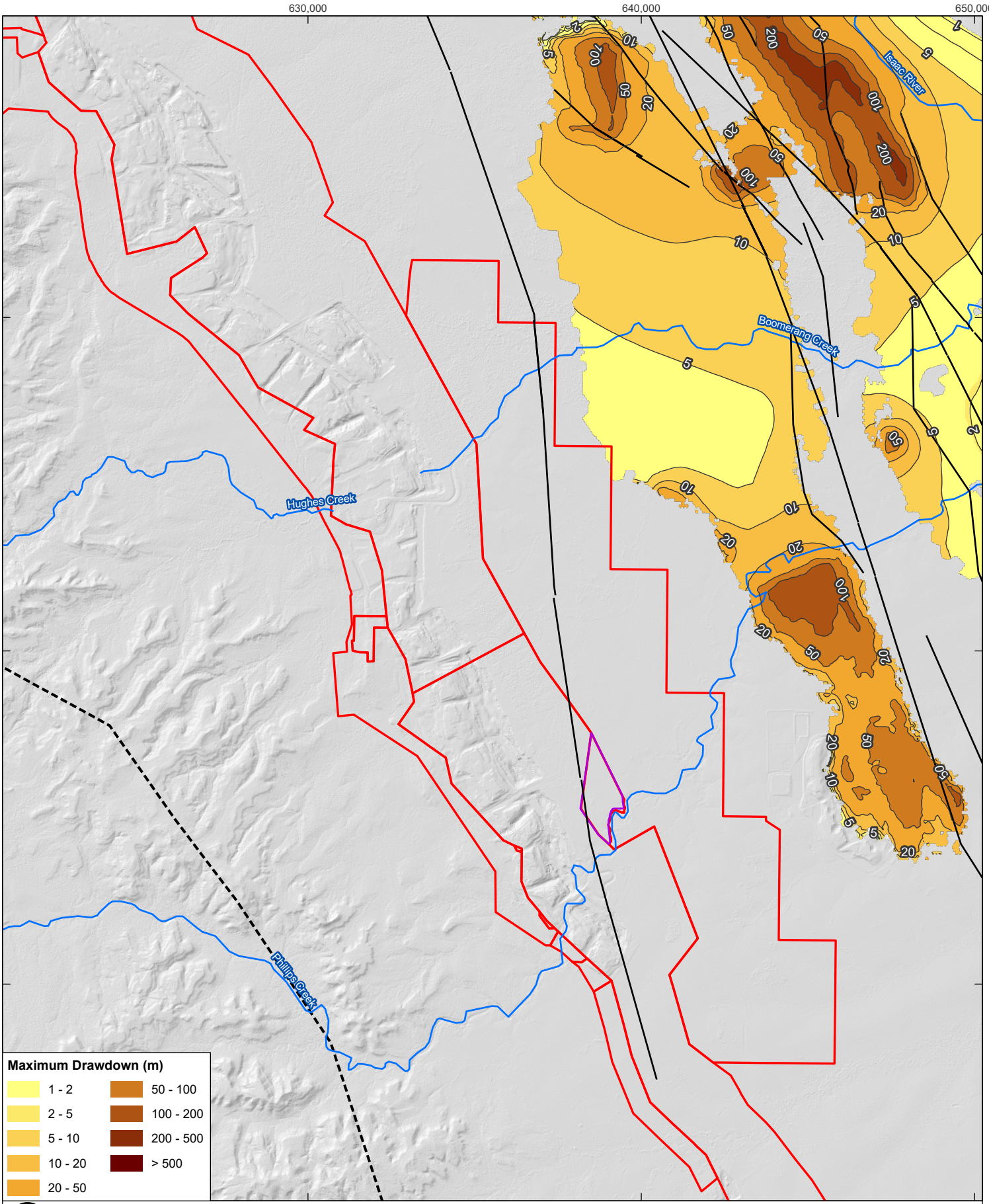
## MAXIMUM CUMULATIVE DRAWDOWN IN REGOLITH (LAYER 2)

SLR

DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.

**FIGURE 43**

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040484.00001 Saraji Mine Grevillea GW Model\06 SLR Data\01 CADGIS\GIS\ArcPro\GW Assessment\GW Assessment.aprx\620040484 F43 Maximum Cumulative Drawdown in Regolith (Layer 2)




0 2.5 5 km

| | |
|---|---|
| Coordinate System: | GDA 1994 MGA Zone 55 |
| Scale: | 1:150,000 at A4 |
| Project Number: | 620.040484.00001 |
| Date Drawn: | 12-Sep-2024 |
| Drawn by: | RB |

**LEGEND**

- Modelled Fault
- Drawdown Contour (m)
- Major Drainage System
- Mining Lease
- Model Boundary
- Project Area

# SARAJI MINE GREVILLEA PIT CONTINUATION PROJECT GROUNDWATER ASSESSMENT

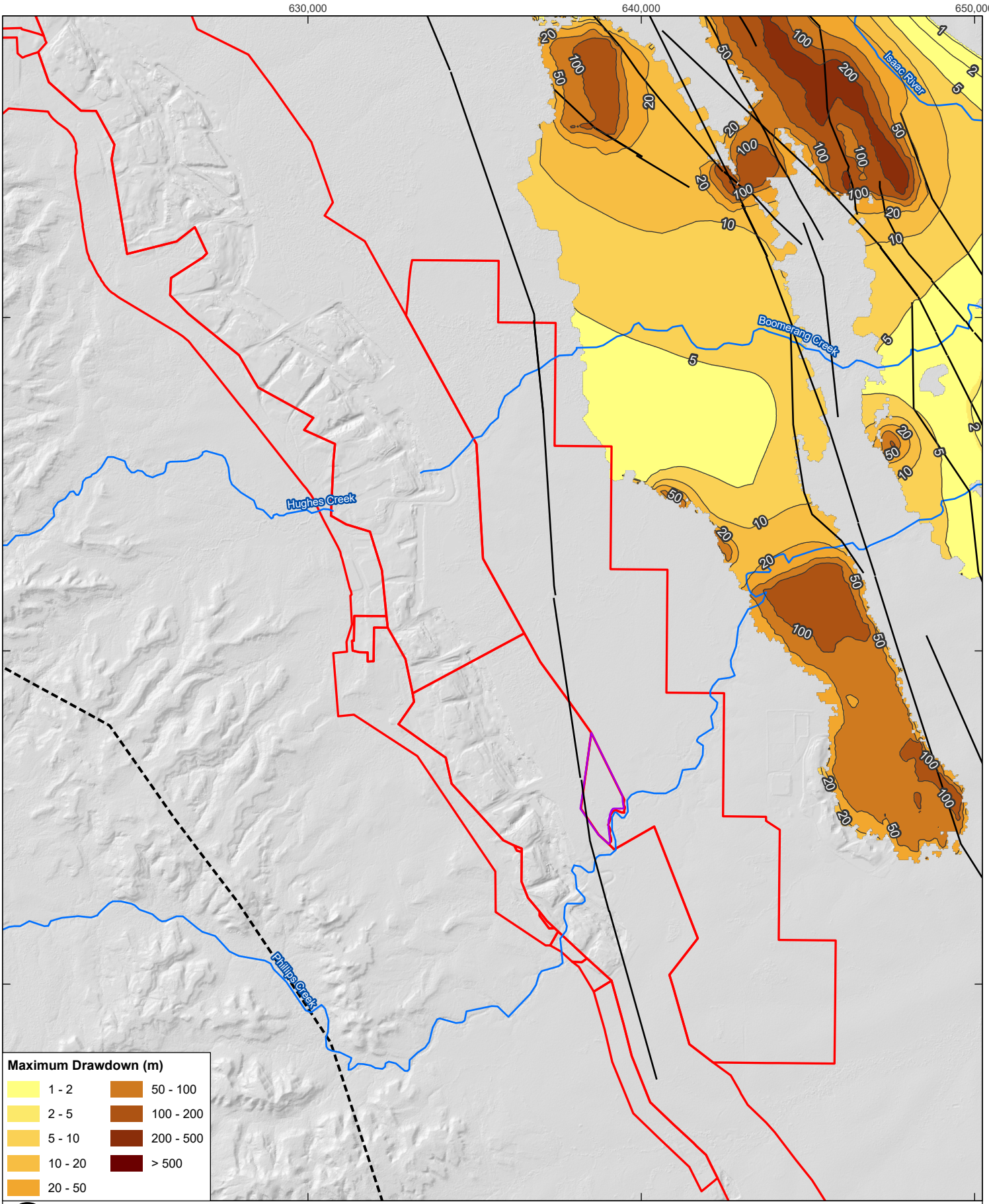
## MAXIMUM CUMULATIVE DRAWDOWN IN LEICHHARDT SEAM (LAYER 5)

SLR

DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.

**FIGURE 44**

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040484.00001 Saraji Mine Grevillea GW Model\06 SLR Data\01 CADGIS\GIS\ArcPro\GW Assessment\GW Assessment.aprx\620040484 F44 Maximum Cumulative Drawdown in Leichhardt Seam (Layer 5)




0 2.5 5 km

| | |
|---|---|
| Coordinate System: | GDA 1994 MGA Zone 55 |
| Scale: | 1:150,000 at A4 |
| Project Number: | 620.040484.00001 |
| Date Drawn: | 12-Sep-2024 |
| Drawn by: | RB |

**LEGEND**

- Modelled Fault
- Drawdown Contour (m)
- Major Drainage System
- Mining Lease
- Model Boundary
- Project Area

# SARAJI MINE GREVILLEA PIT CONTINUATION PROJECT GROUNDWATER ASSESSMENT

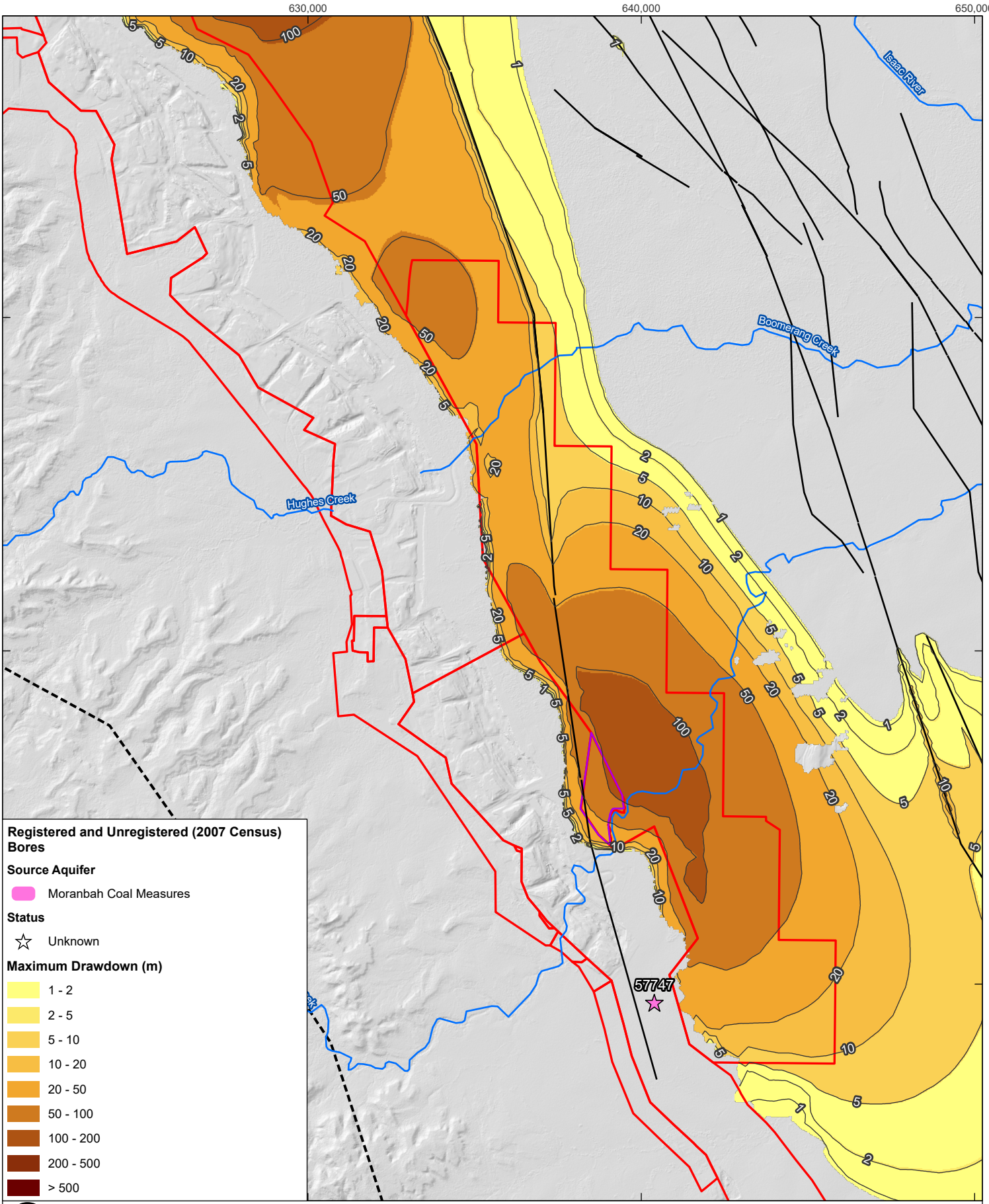
## MAXIMUM CUMULATIVE DRAWDOWN IN VERMONT SEAM (LAYER 7)

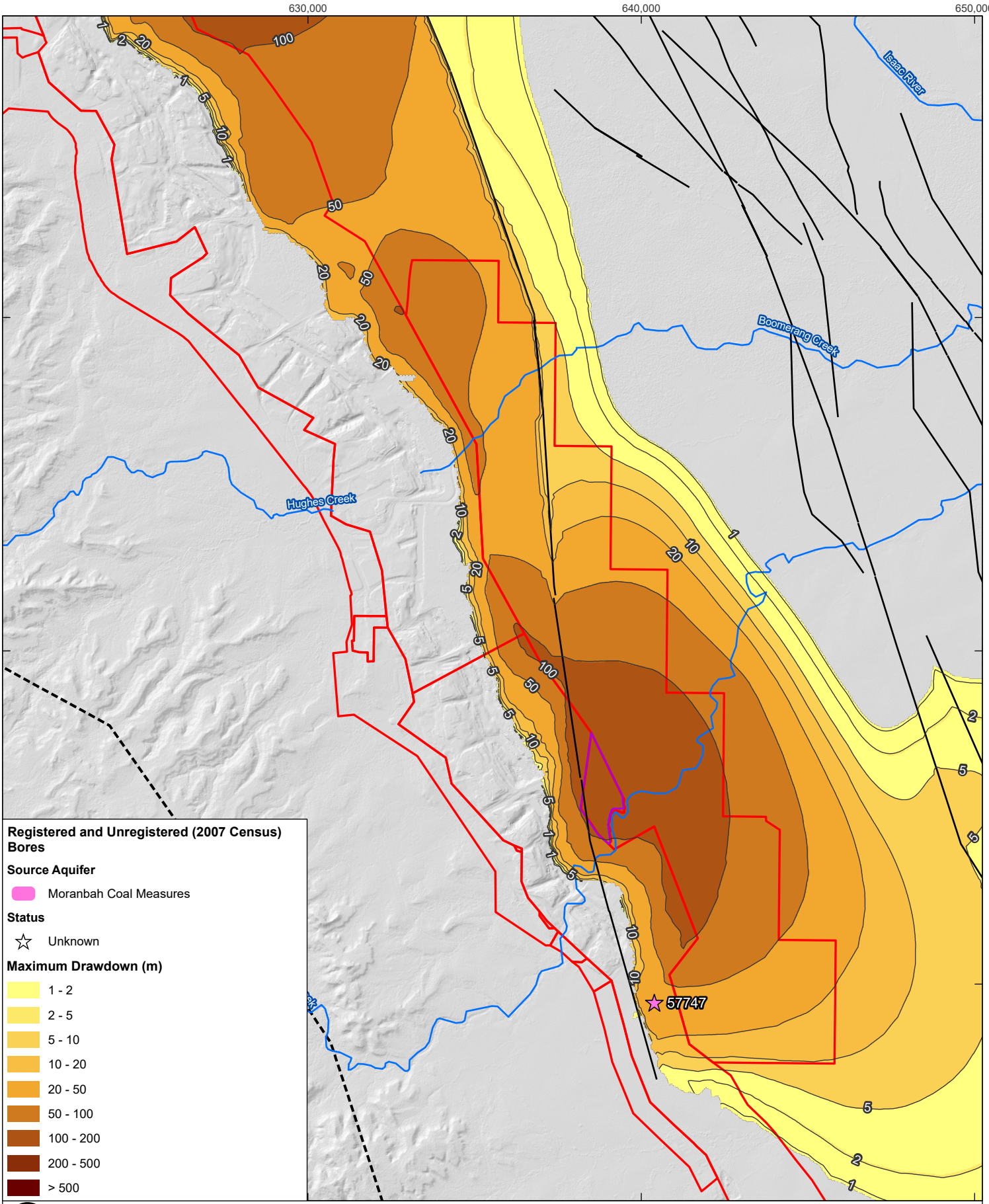
SLR

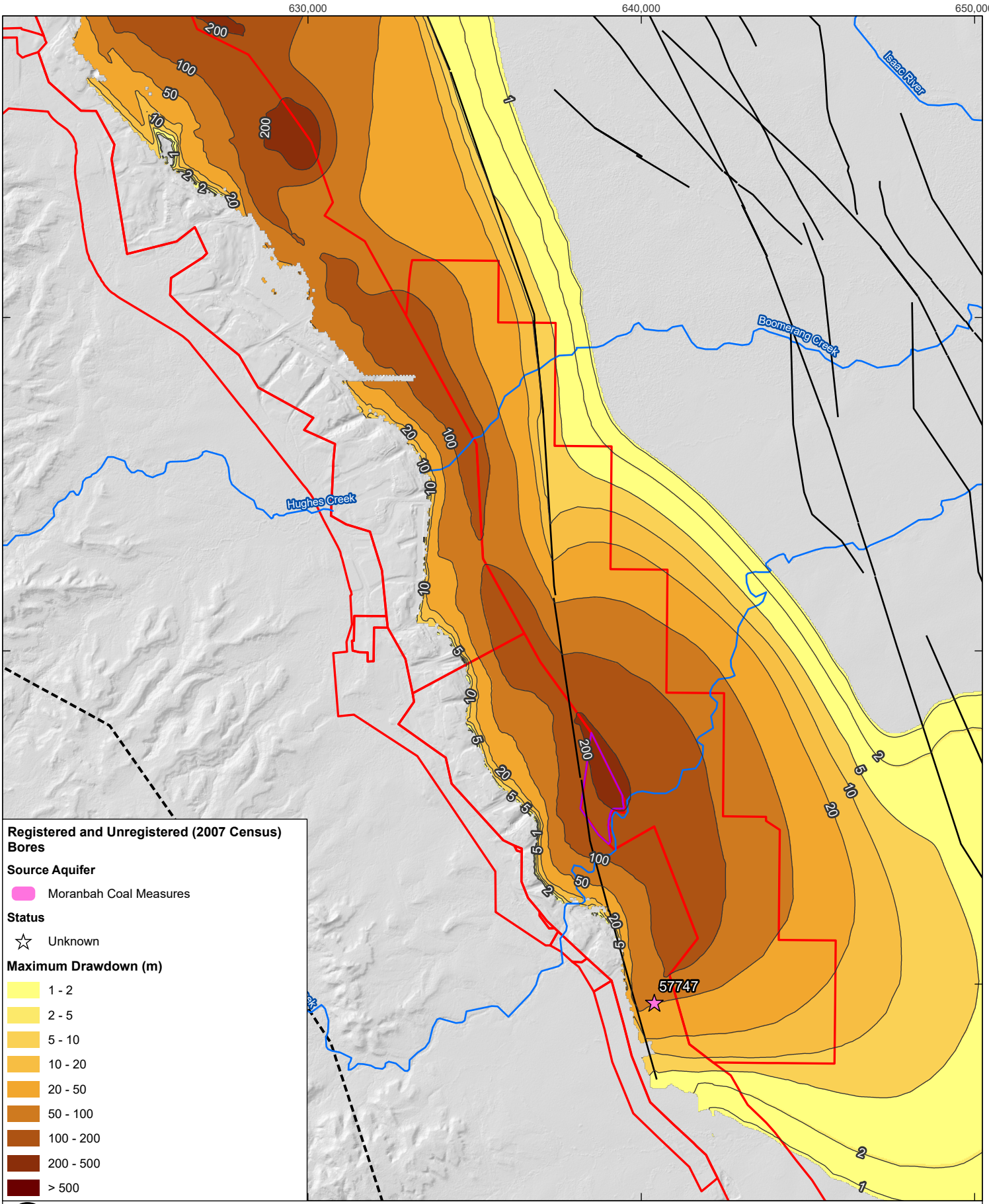
DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.

**FIGURE 45**

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040484.00001 Saraji Mine Grevillea GW Model\06 SLR Data\01 CADGIS\GIS\ArcPro\GW Assessment\GW Assessment.aprx\620040484 F45 Maximum Cumulative Drawdown in Vermont Seam (Layer 7)


630,000
640,000
650,000
7,530,000
7,520,000
7,510,000
Isaac River
Boomerang Creek
Hughes Creek
57747
Registered and Unregistered (2007 Census) Bores
Source Aquifer
Moranbah Coal Measures
Status
Unknown
Maximum Drawdown (m)
1 - 2
2 - 5
5 - 10
10 - 20
20 - 50
50 - 100
100 - 200
200 - 500
> 500
0
2.5
5
km
Coordinate System: GDA 1994 MGA Zone 55
Scale: 1:150,000 at A4
Project Number: 620.040484.00001
Date Drawn: 12-Sep-2024
Drawn by: RB
LEGEND
Modelled Fault
Drawdown Contour (m)
Major Drainage System
Mining Lease
Model Boundary
Project Area
SARAJI MINE GREVILLEA PIT CONTINUATION PROJECT GROUNDWATER ASSESSMENT
MAXIMUM CUMULATIVE DRAWDOWN IN Q SEAM (LAYER 12)
SLR
DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.
FIGURE 46
Path: H:\Projects-SLR\620-BNE\620-BNE\620.040484.00001 Saraji Mine Grevillea GW Model\06 SLR Data\01 CADGIS\GIS\ArcPro\GW Assessment\GW Assessment.aprx\620040484 F46 Maximum Cumulative Drawdown in Q Seam (Layer 12)


630,000
640,000
650,000
7,530,000
7,520,000
7,510,000
Isaac River
Boomerang Creek
Hughes Creek
57747
Registered and Unregistered (2007 Census) Bores
Source Aquifer
Moranbah Coal Measures
Status
Unknown
Maximum Drawdown (m)
1 - 2
2 - 5
5 - 10
10 - 20
20 - 50
50 - 100
100 - 200
200 - 500
> 500
0
2.5
5
km
Coordinate System: GDA 1994 MGA Zone 55
Scale: 1:150,000 at A4
Project Number: 620.040484.00001
Date Drawn: 12-Sep-2024
Drawn by: RB
LEGEND
Modelled Fault
Drawdown Contour (m)
Major Drainage System
Mining Lease
Model Boundary
Project Area
SARAJI MINE GREVILLEA PIT CONTINUATION PROJECT GROUNDWATER ASSESSMENT
MAXIMUM CUMULATIVE DRAWDOWN IN P SEAM (LAYER 14)
SLR
DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.
FIGURE 47
Path: H:\Projects-SLR\620-BNE\620-BNE\620.040484.00001 Saraji Mine Grevillea GW Model\06 SLR Data\01 CADGIS\GIS\ArcPro\GW Assessment\GW Assessment.aprx\620040484 F47 Maximum Cumulative Drawdown in P Seam (Layer 14)




0 2.5 5 km

LEGEND

- Modelled Fault
- Drawdown Contour (m)
- Major Drainage System
- Mining Lease
- Model Boundary
- Project Area

| | |
|---|---|
| Coordinate System: | GDA 1994 MGA Zone 55 |
| Scale: | 1:150,000 at A4 |
| Project Number: | 620.040484.00001 |
| Date Drawn: | 12-Sep-2024 |
| Drawn by: | RB |

# SARAJI MINE GREVILLEA PIT CONTINUATION PROJECT GROUNDWATER ASSESSMENT

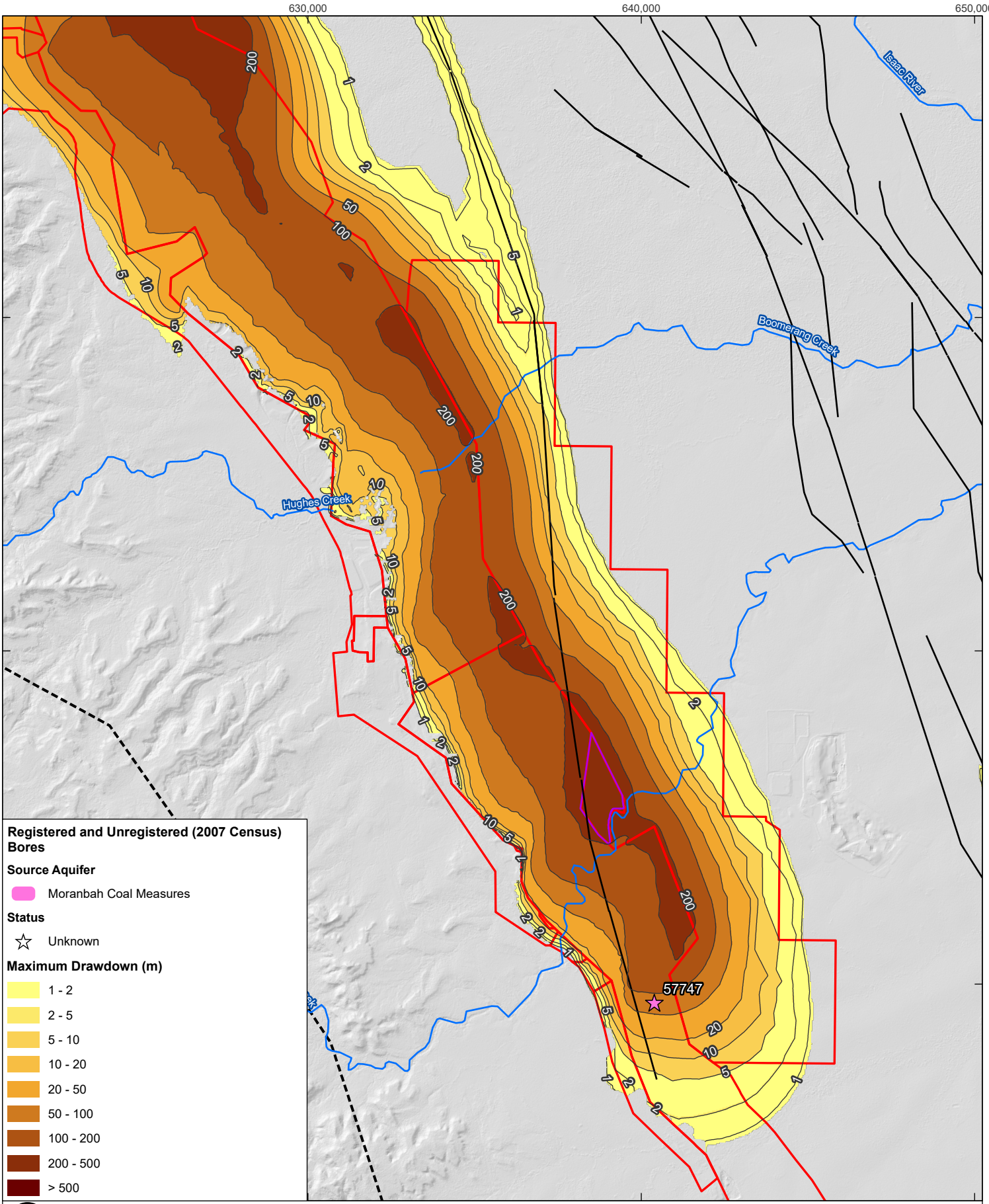
## MAXIMUM CUMULATIVE DRAWDOWN IN H SEAM (LAYER 16)

SLR

DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.

FIGURE 48

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040484.00001 Saraji Mine Grevillea GW Model\06 SLR Data\01 CADGIS\GIS\ArcPro\GW Assessment\GW Assessment.aprx\620040484 F48 Maximum Cumulative Drawdown in H Seam (Layer 16)




0 2.5 5 km

| | |
|---|---|
| Coordinate System: | GDA 1994 MGA Zone 55 |
| Scale: | 1:150,000 at A4 |
| Project Number: | 620.040484.00001 |
| Date Drawn: | 12-Sep-2024 |
| Drawn by: | RB |

**LEGEND**

- Modelled Fault
- Drawdown Contour (m)
- Major Drainage System
- Mining Lease
- Model Boundary
- Project Area

# SARAJI MINE GREVILLEA PIT CONTINUATION PROJECT GROUNDWATER ASSESSMENT

## MAXIMUM CUMULATIVE DRAWDOWN IN D SEAM (LAYER 18)

SLR

DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.

FIGURE 49

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040484.00001 Saraji Mine Grevillea GW Model\06 SLR Data\01 CADGIS\GIS\ArcPro\GW Assessment\GW Assessment.aprx\620040484 F49 Maximum Cumulative Drawdown in D Seam (Layer 18)

## 4.6 Uncertainty Analysis

A Type 3 Monte Carlo uncertainty analysis (IESC, 2018) was undertaken to estimate the uncertainty in the future impacts predicted by the model. This method operates by generating numerous alternative sets of input parameters to the deterministic groundwater flow model (realisations), executing the model independently for each realisation, and then aggregating the results for statistical analysis.

A full description of the uncertainty analysis is provided in **Appendix A**, and a summary is presented herein.

Uncertainty analysis results are presented herein in terms of different uncertainty percentiles including the 10th, 33rd, 50th, 67th and 90th percentile prediction bounds. Based on Table 4 of the IESC (2018 and 2023) guidelines these represent:

- 5th percentile indicates it is very likely the outcome is larger than this value.
- 10th – 33rd indicates it is likely that the outcome is larger than this value.
- 33rd - 67th indicate it is as likely as not that the outcome is larger or smaller than this value.
- 67th - 95th indicates it is unlikely that the outcome is larger than this value.
- 95th percentile indicates it is very unlikely the outcome is larger than this value.

### 4.6.1 Number of Realisations

71 realisations were selected as calibrated realisations and used for uncertainty analysis. The predictive model was run using the 71 parameters sets. The results from the predictive model were used to conduct statistical analyses to assess if additional realisations were likely to provide results that would significantly change the reported predictive results. The 95 % confidence interval was calculated for the mine inflows and the maximum drawdown.

**Figure 50** and **Figure 51** show the 95 % confidence intervals of the median predicted inflows and maximum drawdown, as well as the variance of the median and maximum predicted inflows and drawdown as more realisations are added to the uncertainty analysis. For example, the 95% confidence interval for the maximum drawdown is calculated by first estimating the maximum drawdown for each realisation and then calculating the 95 % confidence interval of the maximum drawdowns as each of the 71 realisations is added to the dataset. As shown in **Figure 50** and **Figure 51**, additional realisations will not significantly increase or decrease the confidence intervals of predictions of mine inflows and maximum drawdowns. Therefore, the results from the 71 realisations are considered sufficient for the estimation of uncertainty with respect to inflows and other prediction variables.

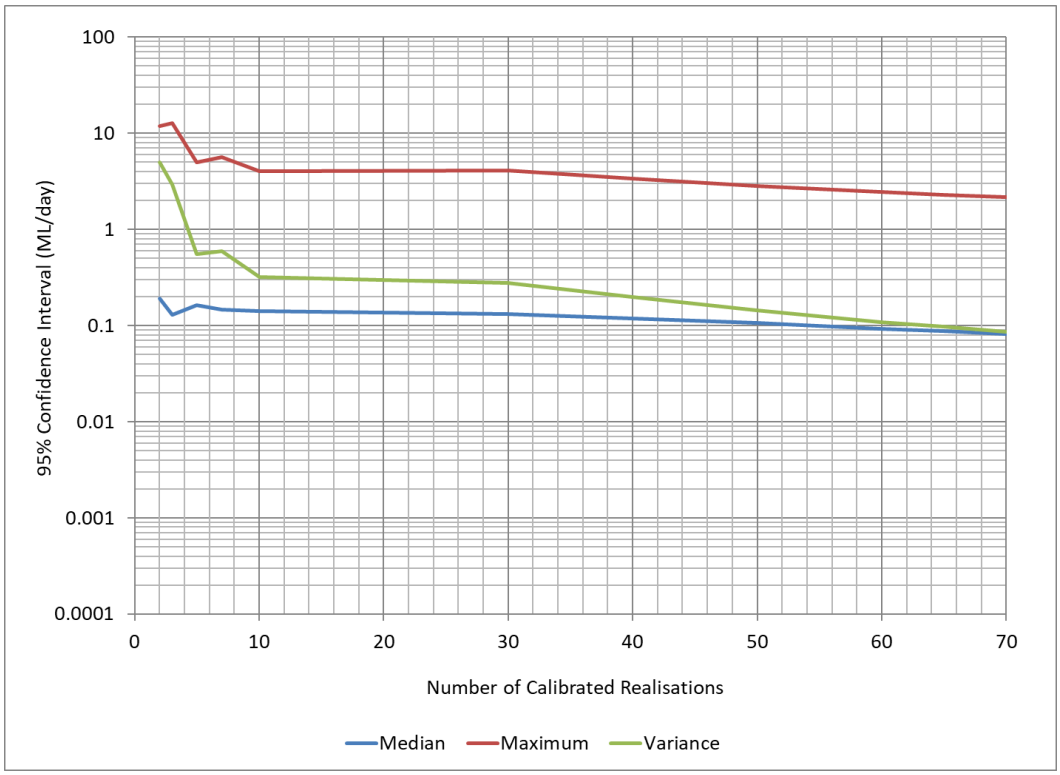



**Figure 50 95 % Confidence Interval for Pit Inflows**

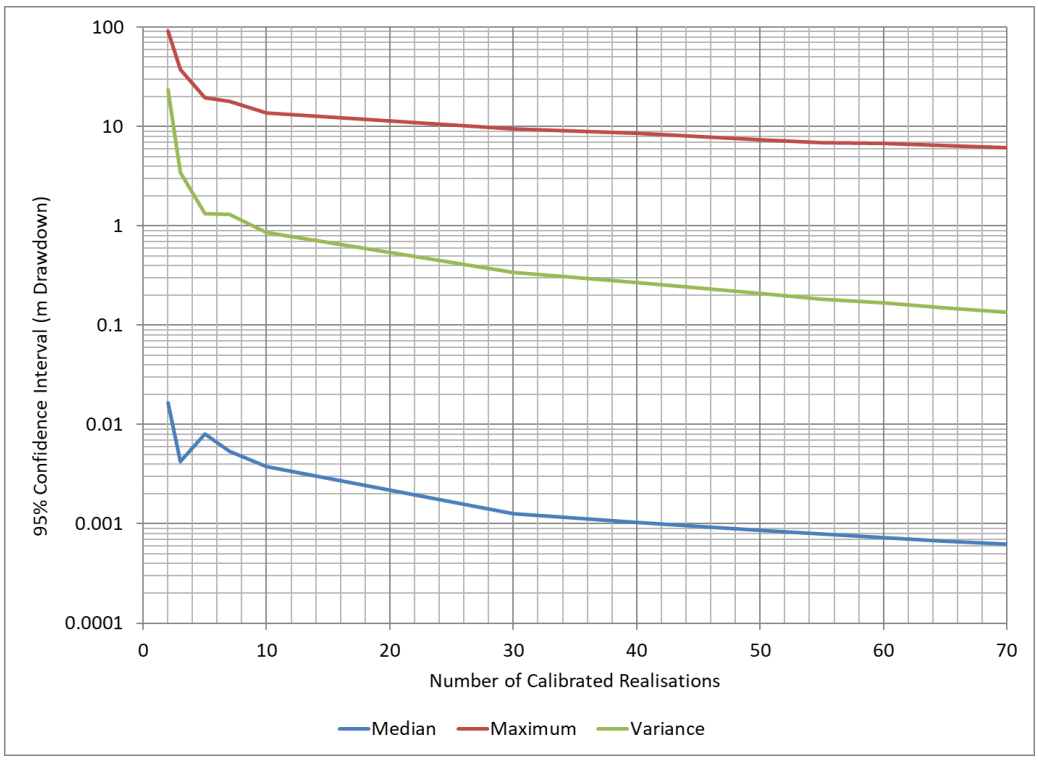



**Figure 51 95 % Confidence Interval for Maximum Drawdowns**

### 4.6.2 Uncertainty of Mine Ingress

**Figure 52** shows the predicted inflows for the Grevillea and different percentiles including 5th, 33rd, 50th, 67th and 95th prediction bounds. The peaks in predicted inflows represent the commencement of new mining strips.

The bounds in the figure demonstrate the uncertainty in the predicted inflow rate.

As shown in **Figure 52**, the maximum mine inflow in the uncertainty analysis was approximately 1,000 ML/yr (2.7 ML/d) (i.e. very unlikely that the outcome is larger than this value). The 50$^{th}$ percentile inflow ranges between 40 ML/yr and 450 ML/yr (0.1 to 1.2 ML/d).

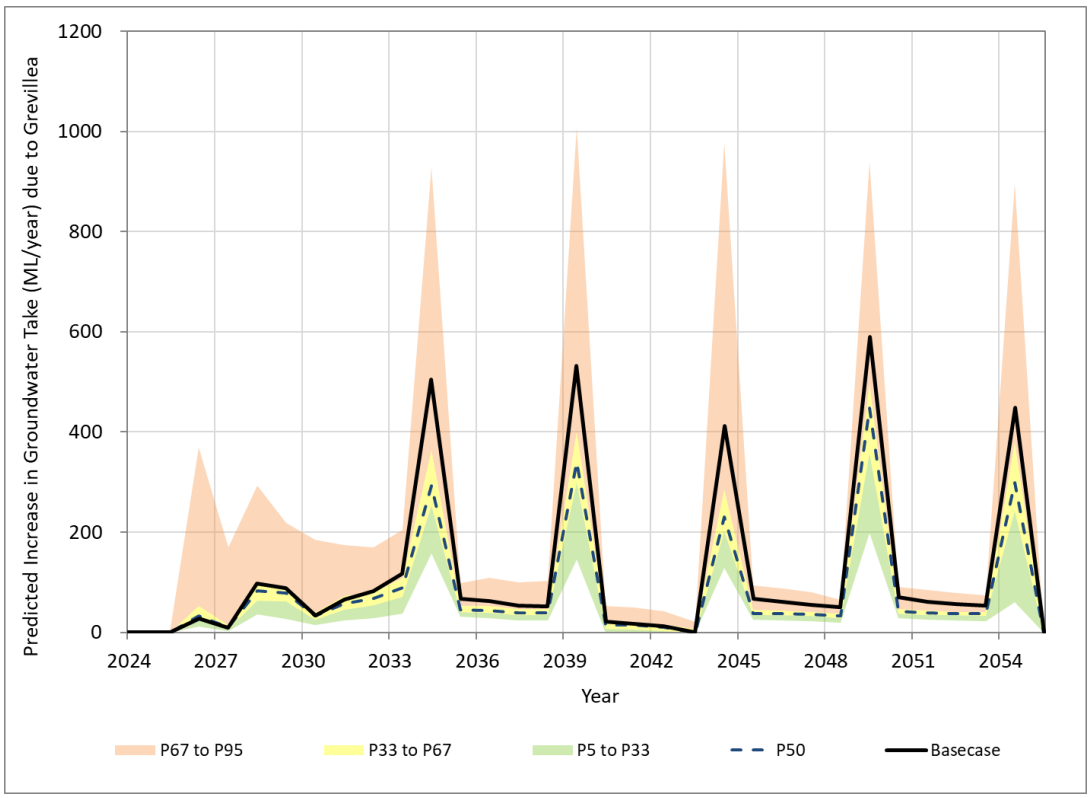



**Figure 52 Mine Inflow Uncertainty**

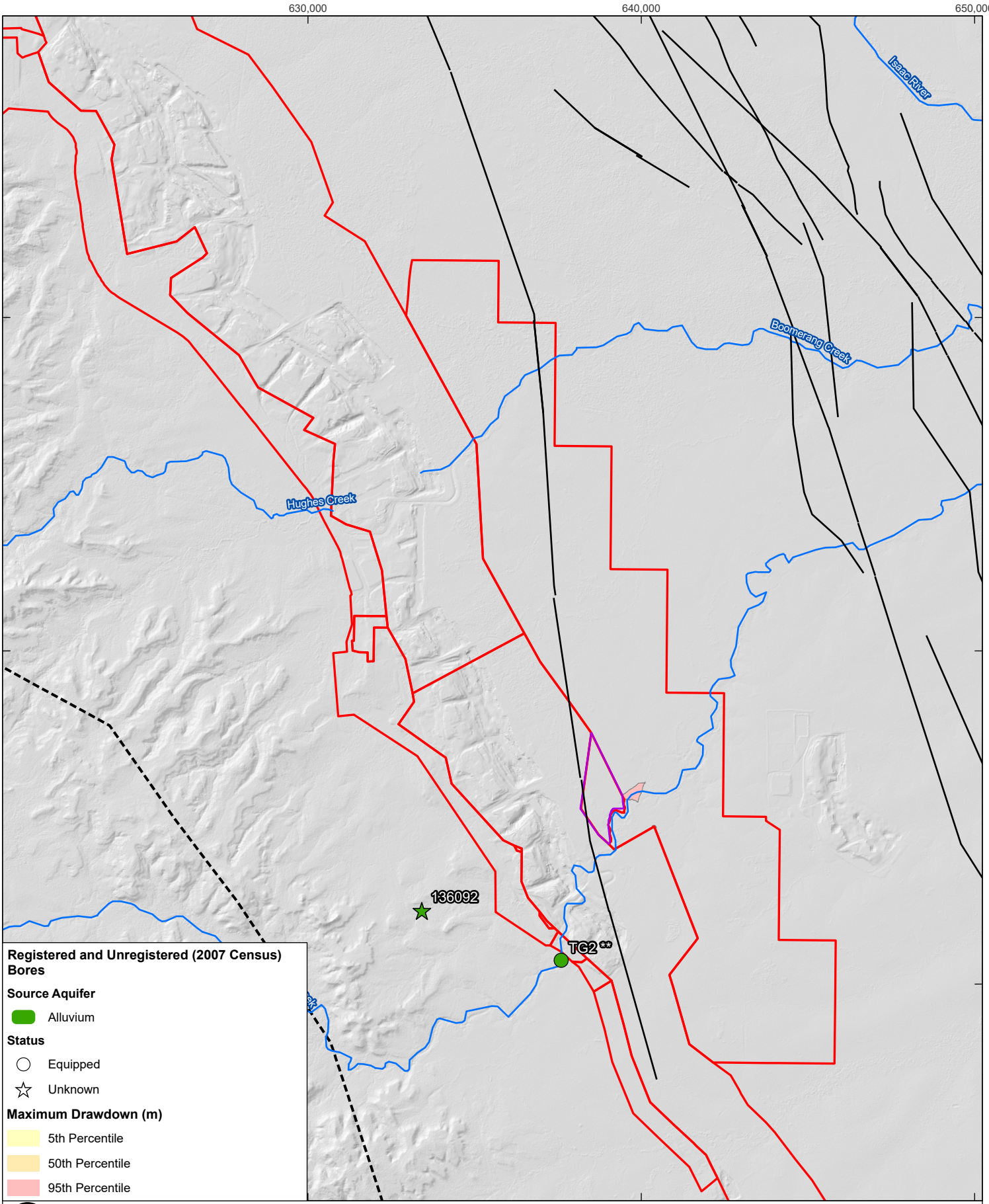
### 4.6.3 Groundwater Drawdowns from Mining

To illustrate the level of uncertainty in the extent of predicted drawdown, the 1 m drawdown due to the Grevillea Project is compared to 5th, 50th and 95th percentiles maximum drawdown from the uncertainty analysis.

**Figure 53** shows the 5th, 50th and 95th percentile maximum drawdowns in Alluvium. The uncertainty results indicate that the Project is very unlikely to impact alluvium.

**Figure 54** shows the uncertainty in the extent of predicted 1 m maximum incremental drawdown in regolith. As shown in this figure, the 5th, 50th and 95th percentile maximum drawdowns in the regolith are localised around the eastern side of the Project. With respect to the 95th percentile, the drawdown extends approximately 2.5 km northeast of the Project.

**Figure 55** and **Figure 56** show the uncertainty in the extent of predicted 1 m maximum incremental drawdown in the Q Seam and D Seam. The figures show that the 95th percentile drawdown in H Seam and D Seam extends between 5 and 10 km to the northwest and southeast of the Project.




0 2.5 5 km

| | |
|---|---|
| Coordinate System: | GDA 1994 MGA Zone 55 |
| Scale: | 1:150,000 at A4 |
| Project Number: | 620.040484.00001 |
| Date Drawn: | 12-Sep-2024 |
| Drawn by: | RB |

**LEGEND**

- Modelled Fault
- Major Drainage System
- Mining Lease
- Model Boundary
- Project Area

# SARAJI MINE GREVILLEA PIT CONTINUATION PROJECT GROUNDWATER ASSESSMENT

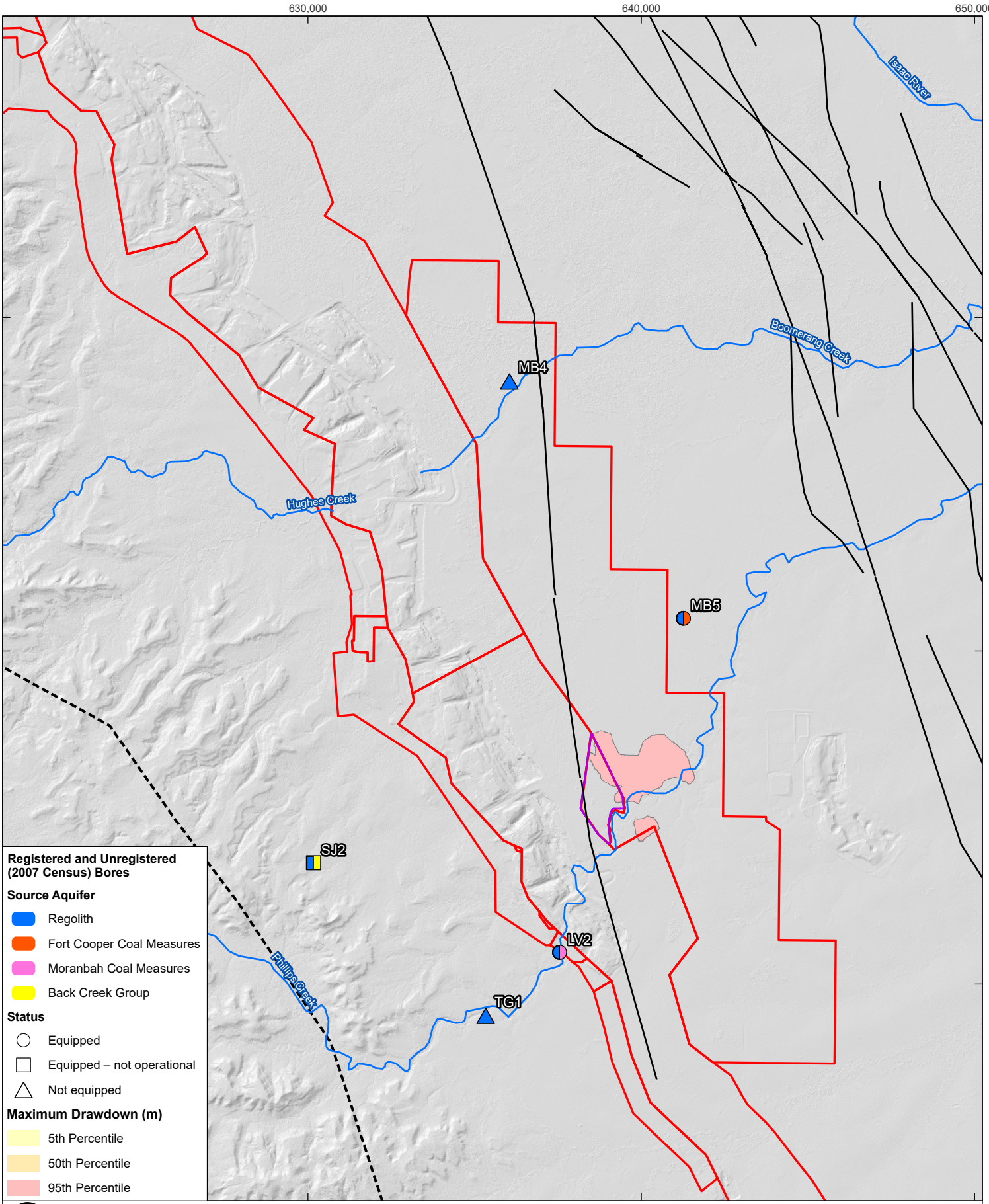
## UNCERTAINTY IN PREDICTED 1 M MAXIMUM INCREMENTAL DRAWDOWN IN ALLUVIUM (LAYER 1)

SLR

DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.

**FIGURE 53**

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040484.00001 Saraji Mine Grevillea GW Model\06 SLR Data\01 CADGIS\GIS\ArcPro\GW Assessment\GW Assessment.aprx\620040484 F53 Uncertainty in Predicted 1 m Maximum Incremental Drawdown in Alluvium (Layer 1)




0 2.5 5 km

| | |
|---|---|
| Coordinate System: | GDA 1994 MGA Zone 55 |
| Scale: | 1:150,000 at A4 |
| Project Number: | 620.040484.00001 |
| Date Drawn: | 12-Sep-2024 |
| Drawn by: | RB |

**LEGEND**

- Modelled Fault
- Major Drainage System
- Mining Lease
- Model Boundary
- Project Area

# SARAJI MINE GREVILLEA PIT CONTINUATION PROJECT GROUNDWATER ASSESSMENT

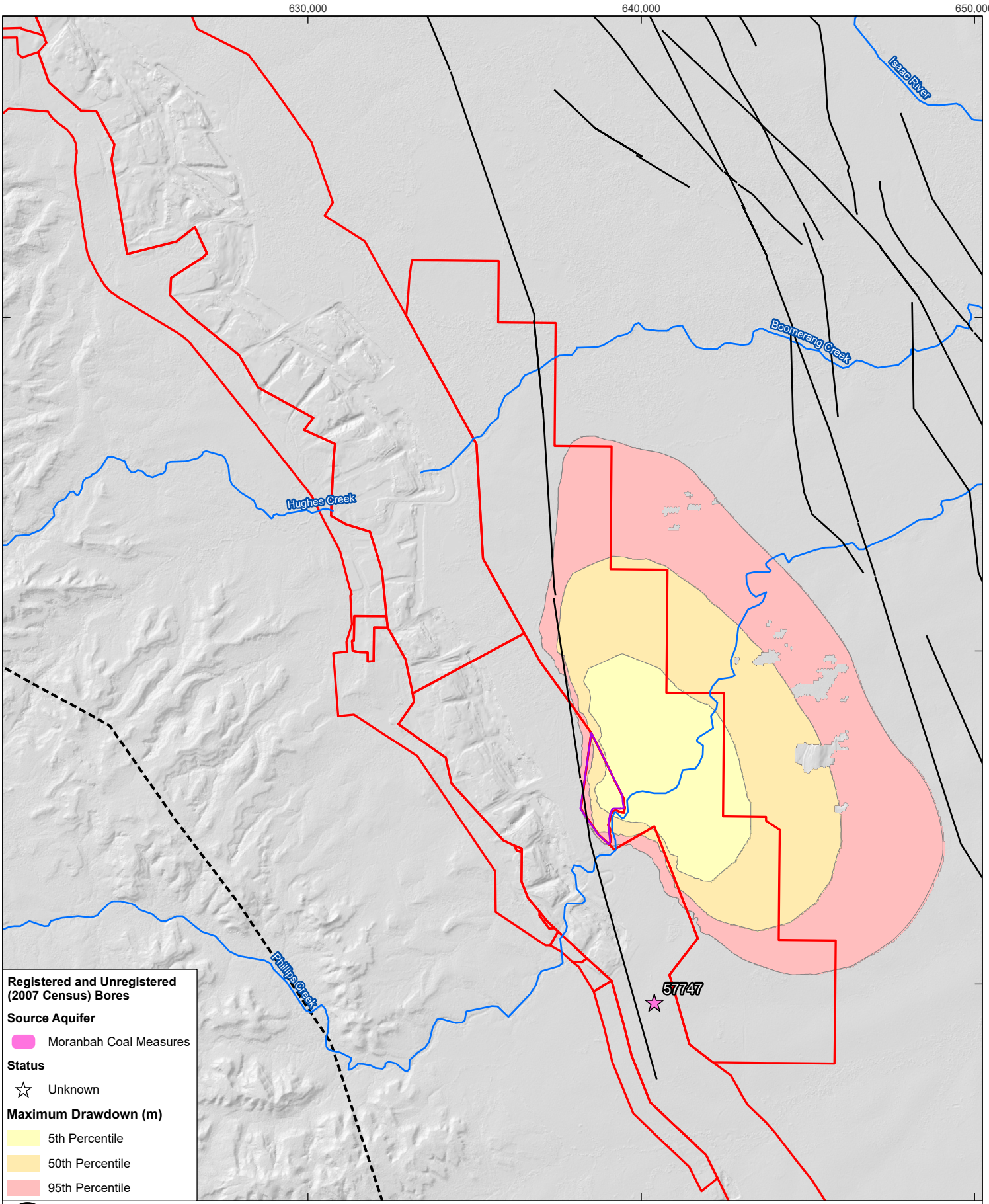
## UNCERTAINTY IN PREDICTED 1 M MAXIMUM INCREMENTAL DRAWDOWN IN REGOLITH (LAYER 2)

SLR

DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.

**FIGURE 54**

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040484.00001 Saraji Mine Grevillea GW Model\06 SLR Data\01 CADGIS\GIS\ArcPro\GW Assessment\GW Assessment.aprx\620040484 F54 Uncertainty in Predicted 1 m Maximum Incremental Drawdown in Regolith (Layer 2)




0 2.5 5 km

| | |
|---|---|
| Coordinate System: | GDA 1994 MGA Zone 55 |
| Scale: | 1:150,000 at A4 |
| Project Number: | 620.040484.00001 |
| Date Drawn: | 12-Sep-2024 |
| Drawn by: | RB |

**LEGEND**

- Modelled Fault
- Major Drainage System
- Mining Lease
- Model Boundary
- Project Area

# SARAJI MINE GREVILLEA PIT CONTINUATION PROJECT GROUNDWATER ASSESSMENT

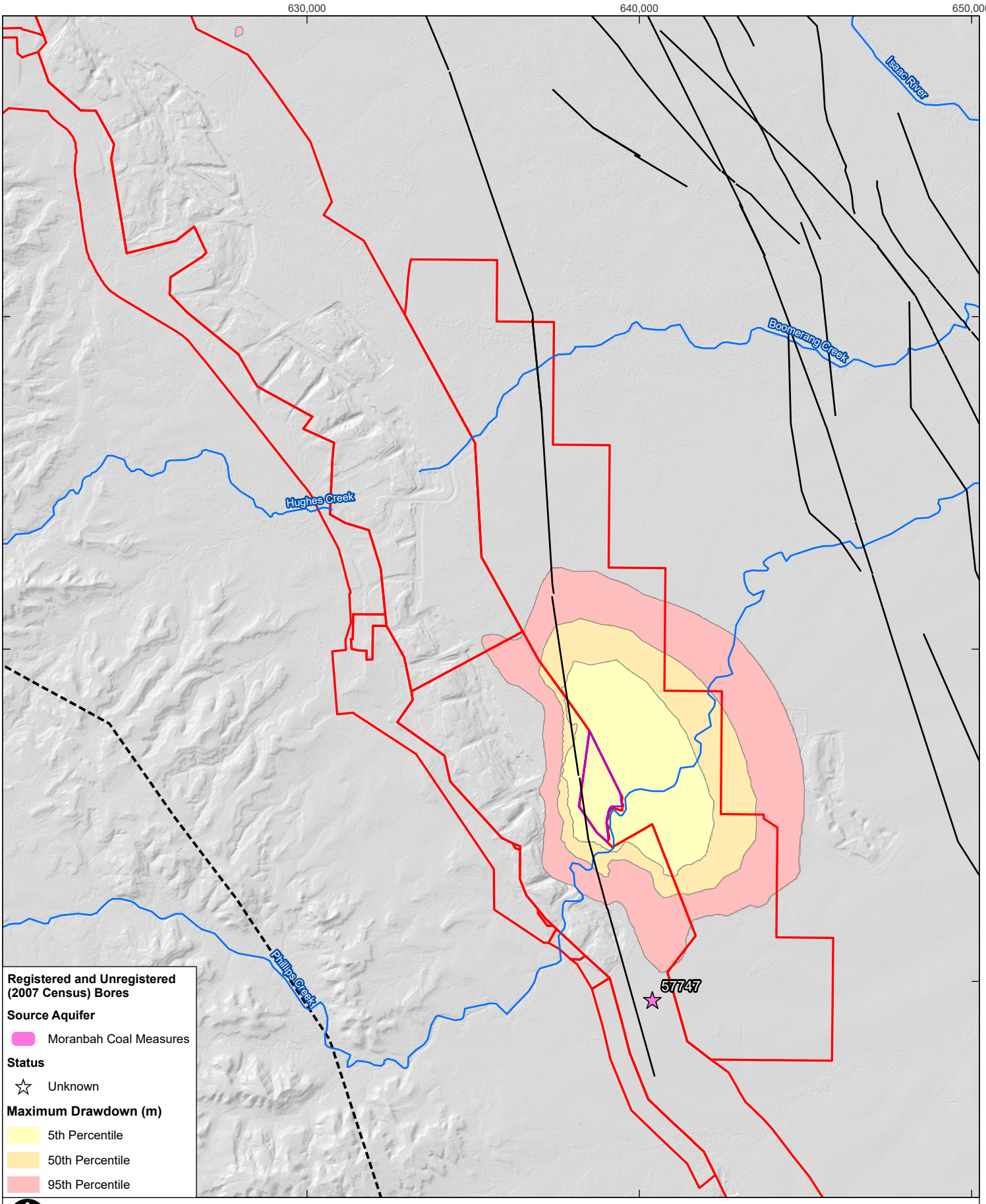
## UNCERTAINTY IN PREDICTED 1 M MAXIMUM INCREMENTAL DRAWDOWN IN Q SEAM (LAYER 12)

SLR

DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.

**FIGURE 55**

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040484.00001 Saraji Mine Grevillea GW Model\06 SLR Data\01 CADGIS\GIS\ArcPro\GW Assessment\GW Assessment.aprx\620040484 F55 Uncertainty in Predicted 1 m Maximum Incremental Drawdown in Q Seam (Layer 12)




0 2.5 5 km

| | |
|---|---|
| Coordinate System: | GDA 1994 MGA Zone 55 |
| Scale: | 1:150,000 at A4 |
| Project Number: | 620.040484.00001 |
| Date Drawn: | 12-Sep-2024 |
| Drawn by: | RB |

**LEGEND**

- Modelled Fault
- Major Drainage System
- Mining Lease
- Model Boundary
- Project Area

**SARAJI MINE GREVILLEA PIT CONTINUATION PROJECT GROUNDWATER ASSESSMENT**

**UNCERTAINTY IN PREDICTED 1 M MAXIMUM INCREMENTAL DRAWDOWN IN D SEAM (LAYER 18)**

SLR

DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.

**FIGURE 56**

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040484.00001 Saraji Mine Grevillea GW Model\06 SLR Data\01 CADGIS\GIS\ArcPro\GW Assessment\GW Assessment.aprx\620040484 F56 Uncertainty in Predicted 1 m Maximum Incremental Drawdown in D Seam (Layer 18)

### 4.6.4 Alluvium and Surface Water Flows

The uncertainty analysis results showed that even for the 95th percentile prediction, which is a very unlikely outcome, the take from the Isaac River alluvium due to the Project was insignificant and considered to be in the range of model error (<0.01 ML/d). The uncertainty analysis also showed that the Project has no effect on Phillips Creek alluvium. In addition, the uncertainty analysis indicates that there is no change to the net flow of Isaac River and Phillips Creek as the result of the Project.

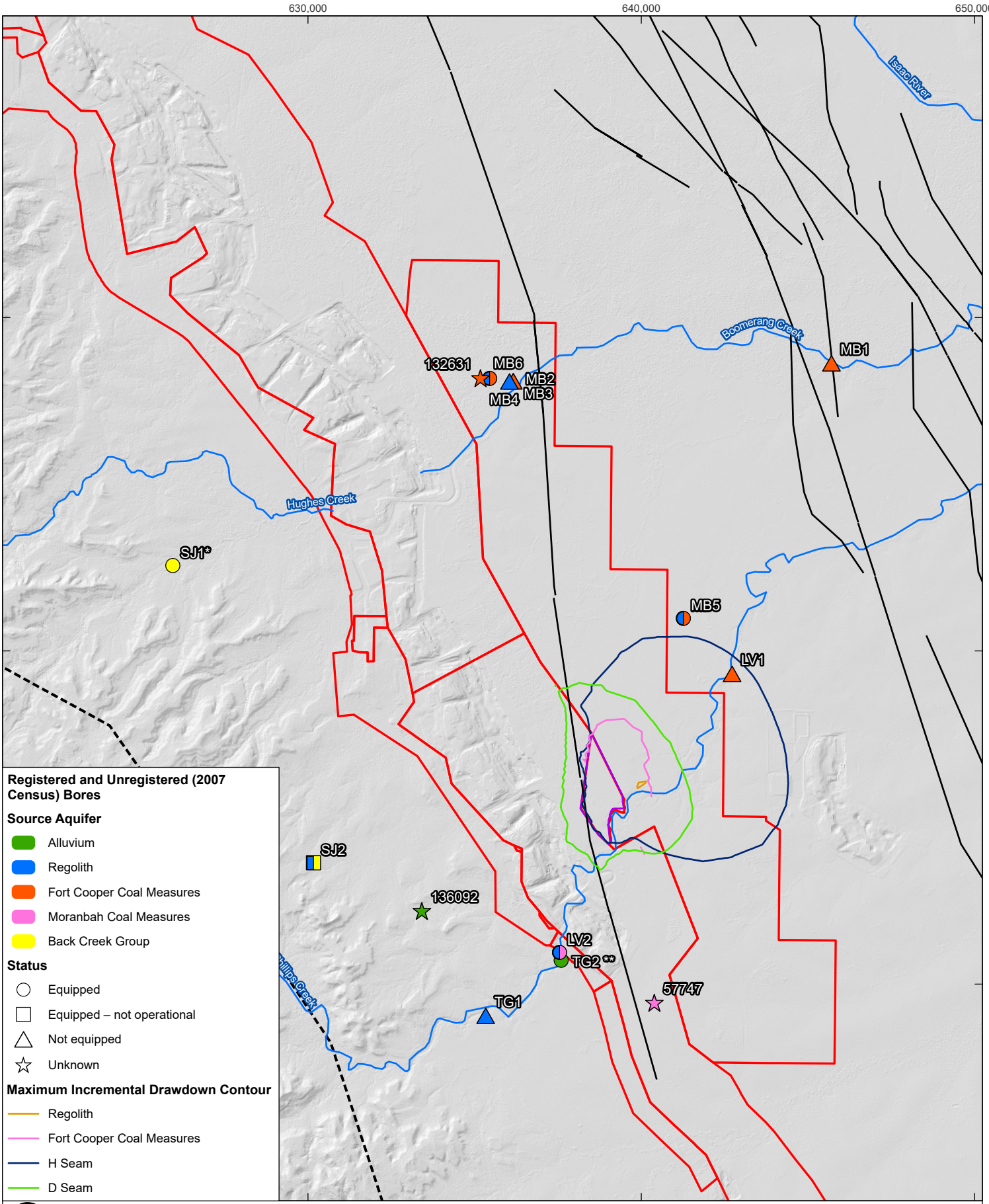
# 5.0 Impact Assessment

## 5.1 Potential Impact on Existing Groundwater Users

### 5.1.1 Privately-Owned Supply Bores

A key element of the Water Resources MNES in the EPBC Act is the potential for impacts to third party uses of a water resource. Within a Queensland context this can be assessed using the *Water Act 2000 (Qld)* which provides bore drawdown threshold triggers of 2 m for unconsolidated aquifers, and 5 m for consolidated aquifers. These are thresholds that are provided to aid in the assessment of the potential for impacts to bores that may be of a magnitude significant enough to warrant consideration of make good measures to restore water supply.

Predicted maximum incremental drawdown contours for the regolith, Fort Cooper Coal Measures and the deeper Moranbah Coal Measure seams (H and D), based on the relevant *Water Act 2000* trigger exceedance, are shown on **Figure 57**. There was no incremental drawdown predicted for the Quaternary alluvium.


630,000
640,000
650,000
7,530,000
7,520,000
7,510,000
Isaac River
Boomerang Creek
Hughes Creek
Phillips Creek
132631
MB6
MB2
MB3
MB4
MB1
SJ1*
MB5
LV1
SJ2
136092
LV2
TG2**
TG1
57747
Registered and Unregistered (2007 Census) Bores
Source Aquifer
Alluvium
Regolith
Fort Cooper Coal Measures
Moranbah Coal Measures
Back Creek Group
Status
Equipped
Equipped – not operational
Not equipped
Unknown
Maximum Incremental Drawdown Contour
Regolith
Fort Cooper Coal Measures
H Seam
D Seam
0
2.5
5
km
LEGEND
Modelled Fault
Major Drainage System
Mining Lease
Model Boundary
Project Area
Coordinate System: GDA 1994 MGA Zone 55
Scale: 1:150,000 at A4
Project Number: 620.040484.00001
Date Drawn: 12-Sep-2024
Drawn by: RB
SARAJI MINE GREVILLEA PIT CONTINUATION PROJECT GROUNDWATER ASSESSMENT
MAXIMUM INCREMENTAL DRAWDOWN, WATER SUPPLY BORES AND UNREGISTERED (2007 CENSUS) BORES
SLR
DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.
FIGURE 57
Path: H:\Projects-SLR\620-BNE\620-BNE\620.040484.00001 Saraji Mine Grevillea GW Model\06 SLR Data\01 CADGIS\GIS\ArcPro\GW Assessment\GW Assessment.aprx\620040484 F57 Bores located within the predicted maximum incremental drawdown

Based on **Figure 57**, there are no registered water supply bores or unregistered (2007 census) bores within the predicted extent of Project related drawdown that exceed the *Water Act 2000* trigger exceedances.

The uncertainty analysis results (refer **Figure 53, Figure 54, Figure 55 and Figure 56**) showed no water supply bores are predicted to experience 90th percentile maximum incremental drawdowns.

### 5.1.2 Ecological Sites

A separate GDE assessment has been undertaken for the Grevillea Pit Continuation project using data from this groundwater impact assessment, please refer to separate report (2Rog 2024).

## 5.2 Potential Impacts on Surface Drainage

The Isaac River is the major drainage feature of the region. It is located to the east of the Project and flows from northwest to southeast in the vicinity of the Project. Phillips Creek is proximal to the Grevillea Project, classified as a Major water course and joins the Isaac River downstream (east) of SRM.

There is a negligible (less than 0.0003 ML/d) reduction in Isaac River flows. This change in the estimated net flow for the Isaac River is considered to be within the error margin of the model.

The model predicts no change in Phillips Creek net flows over the life of the Project.

## 5.3 Potential Impacts on Groundwater Quality

There will be no chemicals or compounds used and an inward hydraulic gradient towards the pit will be developed during mining. Pit water from groundwater ingress will be removed as part of the mine water management system. Hence, the potential for changes and impacts to groundwater quality including existing environmental values are considered low.

## 5.4 Risk Assessment

A risk assessment matrix has been developed to summarise the potential risks on water resources arising from the Project's groundwater impacts discussed in the previous report sections. For each of the key groundwater related risks identified, the following were considered and recorded as part of the risk assessment:

- Brief description of the risk
- Likely cause
- Potential consequence
- Potential likelihood
- Risk rating and rank

To undertake the risk assessment, it is useful to define (in a descriptive sense) the various levels of consequence of a particular event and the likelihood of such an event occurring. Descriptions of the categories that were used to rank the likelihood of a risk are provided in **Table 16**.

**Table 16 Consequence Assessment**

| Rating | | Description |
|---|---|---|
| 5 | Severe | Environmental damage or effect (permanent; >10 years) |
| 4 | High | Long term (2 to 10 years) impact |
| 3 | Moderate | Medium term (<2 years impact) |
| 2 | Low | Short term (<1 year) impact |
| 1 | Negligible | No lasting environmental damage or effect |

The level of risk for each potential impact was determined by combining consequences defined in **Table 16** with likelihood as defined in **Table 17**. The numerical modelling uncertainty analysis discussed in **Section 4.6** allows quantification of the likelihood of a particular impact occurring. The resulting risk analysis matrix (combining consequence and likelihood) is presented in **Table 18**.

**Table 17 Likelihood Assessment**

| Likelihood | Probability | Basis of Rating |
|---|---|---|
| A | Highly Likely | Expected to occur |
| B | Likely | More likely to occur than not to occur |
| C | Possible | As likely to occur as not to occur |
| D | Unlikely | More likely to not occur than to occur |
| E | Highly Unlikely | Very unlikely to occur |

**Table 18 Risk Analysis Matrix**

| | | Likelihood | | | | |
|---|---|---|---|---|---|---|
| | | E | D | C | B | A |
| Consequence | 5 | Insignificant | Low | High | High | High |
| | 4 | Insignificant | Low | Moderate | High | High |
| | 3 | Insignificant | Low | Moderate | Moderate | Moderate |
| | 2 | Insignificant | Low | Low | Low | Low |
| | 1 | Insignificant | Insignificant | Insignificant | Insignificant | Insignificant |

The risk assessment is presented in **Table 19**.

It should be noted that risks to GDEs have been separately assessed by GDE specialists, please refer to separate report (2Rog 2024).

**Table 19 Risk Assessment**

| Potential Receptor | Risk Description | Likely cause | Potential Impact | Consequence | Likelihood | Risk Rating |
|---|---|---|---|---|---|---|
| Third party bores. | Loss of supply (yield) from third party bores. | Drawdown of groundwater levels in the bore source aquifer. | Reduction in, or complete loss of, supply (yield) from third party bores. | High (4).<br>Drawdown and therefore reduction or loss of bore yield may persist in the long term. | Highly Unlikely (E).<br>Modelling results indicate no registered third-party water supply bores or unregistered (census) bores will be subject to incremental drawdowns exceeding the relevant *Water Act 2000* bore trigger threshold, even at the 90$^{th}$ percentile predictive uncertainty. | Insignificant |
| Third party bores. | Reduction in water quality at third party bores. | Release of contaminants (including salts) to the groundwater system from the Project that enter the bore source aquifer and migrate to the bore. | Bore water quality no longer suitable for the intended use. | High (4).<br>Water quality change may persist in the long term. | Highly Unlikely (E).<br>During mining, the inward hydraulic flow gradients to the Grevillea Pit would inhibit any migration of water outwards to the regional groundwater system. Therefore, there would be no mechanism for potential contaminants in groundwater to migrate to a third party bore.<br>No chemicals or compounds will be introduced and pit water from groundwater ingress will be removed as part of the mine water management system. | Insignificant |
| Surface water systems. | Reduction in flow in surface water systems | Drawdown of groundwater levels in the shallow groundwater system either reduces baseflow to the surface water system or increases | Impact to environmental receptors reliant on flow in surface water systems | High (4).<br>Surface flow changes may persist in the long term. | Highly Unlikely (E).<br>Modelling indicates no net losses in Phillips Creek and a negligible reduction (within modelling error margins) in Isaac River flows over the life of the Project. | Insignificant |

| Potential Receptor | Risk Description | Likely cause | Potential Impact | Consequence | Likelihood | Risk Rating |
|---|---|---|---|---|---|---|
| | | leakage out of the surface water system. | | | | |
| Surface water systems. | Reduction in water quality in surface water systems. | Release of contaminants (including salts) to the groundwater system from the Project that then enter the surface water systems. | Surface water quality no longer suitable for environmental users. | High (4).<br>Water quality change may persist in the long term. | Highly Unlikely (E).<br>During mining the inward hydraulic flow gradients to the Grevillea Pit would inhibit any migration of water outwards to the regional groundwater system. Therefore, there would be no mechanism for contaminants in water leaving the site in groundwater and discharging to surface water systems.<br>No chemicals or compounds will be introduced and pit water from groundwater ingress will be removed as part of the mine water management system. | Insignificant |
| Terrestrial GDEs | Loss of groundwater availability to Terrestrial GDEs | Drawdown of groundwater levels in the perched groundwater system utilised by TGDEs | Decline in health of TGDEs | Refer to separate assessments undertaken by GDE specialists 2Rog | | |
| Terrestrial GDEs | Reduction in water quality used by Terrestrial GDEs. | Release of contaminants (including salts) to the groundwater system from the Project that then enter the perched groundwater system utilised by TGDEs. | Decline in health of TGDEs | Refer to separate assessments undertaken by GDE specialists 2Rog | | |

## 5.5 Potential for Significant Impacts

A qualitative assessment of significant impacts to groundwater quantity and quality against the EPBC Act Significant Impact Guidelines 1.3 is provided in the following sections.

A separate assessment on GDE's has been undertaken for the Grevillea Pit Continuation project using data from this groundwater impact assessment, please refer to separate report (2Rog 2024).

### 5.5.1 Value of Groundwater Resources

**Sections 3.5.3, 3.5.4** and **3.5.5** provide background on the groundwater resources in the Grevillea Project area. The following points summarise relevant information on the value including sensitivity and quality of those groundwater resources:

- Quaternary Alluvium:
  - Associated with present-day drainage, not laterally extensive and discontinuous.
  - Isolated to deeper pockets of alluvium that are more deeply incised into the underlying strata.
  - Recharged episodically via creek flows and not permanently saturated.
  - Groundwater does not exist within the full mapped extents of the Phillips Creek alluvium and is not widespread.
  - Hydraulically disconnected from underlying groundwater systems.
  - Limited registered and unregistered landholder usage.
- Regolith including Tertiary:
  - Limited groundwater sustainability based on the lack of water level recovery in monitoring bores following sampling.
  - Generally highly saline, but can be brackish to moderately saline with an average TDS of 7,101 mg/L and ranging between 1,110 mg/L and 18,600 mg/L.
  - Limited registered and unregistered landholder usage.
- Permian:
  - Generally saline within the coal seams and moderately saline to saline interburden units but can range between fresh and highly saline.
  - Limited registered and unregistered landholder usage.

Overall, the value of the groundwater resources in the Grevillea Project area are not considered significant.

### 5.5.2 Potential Additional Significant Impacts From the Grevillea Project

#### 5.5.2.1 Mining Duration and Footprint

The SRM has been in operation since 1974 and currently produces approximately 16 Mtpa of ROM coal. Mining at Grevillea Pit commenced in 1987 with the "D" Seam being the deepest target seam.

Mining at SRM is expected to continue at the current approved operations until approximately 2098. The Grevillea Project is forecast to commence around 2026 and continue with current approved operations until approximately 2054. The duration of mining

of the Grevillea Project represents around 30 years which includes planned mining at other SRM pits, of more than 100 years of mining at SRM based on the current mine schedule.

The approved mining footprint extends along strike for several tens of kilometres. The additional mining footprint due to the Grevillea Project represents a small fraction of the current SRM mining footprint.

As the magnitude and geographic extent of potential groundwater impacts resulting from additional mining can be approximated to the impacts of groundwater take from mining activity to date, this would suggest that the potential for significant additional impacts would be relatively small.

#### 5.5.2.2 Changes to Hydrology

The changes to the magnitude and geographic extent of the groundwater resources over the duration of Grevillea Project are shown on the maximum predicted incremental drawdown maps provided in **Section 4.4**.

These maps illustrate that the magnitude and extent of groundwater change is negligible in the Quaternary Alluvium and relatively minor in the regolith including Tertiary groundwater resources.

Relatively greater amounts of drawdown are experienced in the MCM seams which are greatest at the working coal face (where groundwater is removed due to mining of waterbearing horizons), rapidly lessening with distance from the pits as would be expected. Drawdowns extend up to 5 km north and 6 km southeast of the Grevillea mine extent.

These amounts of drawdown are considered insignificant given the saline nature of the MCM groundwater resources and limited third party usage. It is highlighted that there are no third-party bores within the predicted extent of Project related drawdown.

The loss of water from alluvium due to Grevillea is predicted to be less than 0.01 ML/d, which is in the range of model error and considered negligible from a significant impact sense. Further, there is no change to the estimated net flow for Phillips Creek due to Grevillea, which is also considered negligible from a significant impact sense.

A qualitative risk assessment which considered the consequence and likelihood of a risk event occurring, found that the following risk events were insignificant:

- Loss of supply (yield) from third party bores.
- Release of contaminants (including salts) to the groundwater system from the Project that enter the bore source aquifer and migrate to the bore.
- Reduction in water quality at third party bores.
- Reduction in flow in surface water systems.
- Reduction in water quality in surface water systems.

#### 5.5.2.3 Changes to Water Quality

The potential for significant changes to groundwater quality including existing environmental values is considered low. There will no chemicals or compounds introduced and an inward hydraulic gradient towards the pit will be developed and maintained during mining. Pit water from groundwater ingress will be removed as part of the mine water management system.

# 6.0 Management Measures

## 6.1 Groundwater Monitoring and Management Program

A Groundwater Monitoring and Management Program (GMMP) (BMA, 2023) exists for SRM which is of appropriate detail and scale for detecting any marked changes to groundwater due to the Project.

The purpose of the GMMP is to monitor the magnitude and distribution of actual changes to groundwater resources due to existing operations at SRM and to provide early detection of any unforeseen impacts to groundwater levels or groundwater quality.

At this time it is expected the GMMP will be updated to include the extent of ML700021 to capture future mining activities. However, changes to water management actions from current arrangements are not deemed necessary based on groundwater impact assessment results. The implementation of the GMMP will evolve and respond to the various stages of the Project including pre-mining, operations, and post-mining activities.

During the life of the Project, data collected through the GMMP will be used to review and if deemed necessary update and refine the Project groundwater model and its impact predictions, to reflect the actual activities undertaken on site (e.g. mine development) and the results of regular groundwater monitoring.

# 7.0 References

2rog Consulting [2rog]. (2024). Groundwater-Dependent Ecosystem Impact Assessment Technical Report. Prepared for BMA.

AECOM, 2016, Saraji Open Cut Extension Project Groundwater Technical Report. Report Ref: 60507031.

AECOM, 2019, Saraji East Mining Lease Project Groundwater Technical Report, Report Ref: 60507031.

AECOM, 2020, Saraji East Mining Lease Project Baseline Environmental Studies: Terrestrial Ecology Technical Report.

AECOM, 2023. Saraji East Mining Lease Project Environmental Impact Statement: Groundwater Technical Report, Report Ref: 60507031. Prepared for BMA Alliance Coal Operations Pty Ltd, 19 September 2023.

AGE, 2011, Report of Saraji East Project Groundwater Impact Assessment, Ref: G1549.

AGE, 2018, Jacaranda Pit Water Storage Monitoring Bore Installation Program, Report Ref: G1929B.

ANZECC & ARMCANZ, 2000. Australian and New Zealand Guidelines for Fresh and Marine Water Quality.

Arrow Energy, 2012, Chapter 14: Groundwater, Arrow Bowen Gas Project – Environmental Impact Statement.

BHP, 2019, Black Book Mineral System (Volume 1) A geological summary of BHP coal assets.

BHP, 2021, Coal Hydro Drilling Report SRM Program FY21 (DRAFT).

BMA, 2023. SRM PLN Groundwater Monitoring & Management Program - SRM-PLN-0106, Doc ID # 014089407, Version 1.0, 14 November 2023.

Bureau of Meteorology (BoM), 2012. *Climate Data Online.* Available at: http://www.bom.gov.au/climate/data/index.shtml.

Bureau of Meteorology (BoM), 2017. Groundwater Dependent Ecosystems Atlas. Available at: http://www.bom.gov.au/water/groundwater/gde/map.shtml.

Clark, D., McPherson, A. and Collins, C., 2011. Australia's seismogenic neotectonic record. Geoscience Australia record 2011/11.

Coffey, 2014. Appendix E - Supplementary Groundwater Assessment, Arrow Energy Bowen Gas Project. Supplementary Report to the EIS. 17 April 2014.

CSIRO, 2015. Soil and Landscape Grid of Australia – Depth of Regolith, Available at http://www.clw.csiro.au/aclep/soilandlandscapegrid/.

DCCEEW, 2022. Significant Impact Guidelines 1.3: Coal Seam Gas and Large Coal Mining Developments – Impacts on Water Resources. Department of Climate Change, Energy, the Environment and Water, Canberra.

Department of Environment and Heritage Protection (DEHP), 2011. Environmental Protection (Water) Policy 2009. Isaac River Sub-basin Environmental Values and Water Quality Objectives Basin No. 130 (part), including all waters of the Isaac River Sub-basin (including Connors River). September 2011.

Department of Environment and Science (DES), 2022. Guideline - Environmental Protection (Water and Wetland Biodiversity) Policy 2019. Deciding aquatic ecosystem indicators and local water quality guideline values.

Dickins, J. M., & Malone, E. J., 1973. Geology of the Bowen Basin, Queensland. Bureau of Mineral Resources. Geology and Geophysics, Bulletin, 130.

Doody TM., Hancock PJ., Pritchard JL., 2018. Information Guidelines Explanatory Note: Assessing groundwater-dependent ecosystems. Report prepared for the Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development through the Department of the Environment and Energy, Commonwealth of Australia 2019.

Eamus. D, Froend. R, Loomes. R, Hose. G and Murray. B, 2006. A functional methodology for determining the groundwater regime needed to maintain health of groundwater-dependent vegetation. Australian Journal of Botany 54(2): 97-114

Flodin, E.A., Aydin, A., Durlofsky, L.J. and Yeten, B., 2001. Representation of Fault Zone Permeability in Reservoir Flow Models. SPE Annual Technical Conference and Exhibition, New Orleans, Louisiana.

Food and Agriculture Organization of the United Nations (FAO), 2013. Chapter 2 – Saline waters as resources. Available at: http://www.fao.org/3/t0667e/t0667e05.htm.

FRC environmental, 2018, Saraji East Mining Lease Environmental Impact Statement: Aquatic Ecology Assessment.

Froend, R. and R. Loomes (2004). Approach to Determination of Ecological Water Requirements of Groundwater Dependent Ecosystems in Western Australia – A report of the Department of Environment, Edith Cowan University. Perth.

Geoscience Australia, 2017. Bowen Basin. Available at: http://www.ga.gov.au/scientific-topics/energy/province-sedimentary-basin-geology/petroleum/onshore-australia/bowen-basin

GHD, 2020, BHP BMA Saraji Groundwater Well Installation: 120509874, Prepared for BHP Pty Ltd.

HydroAlgorithmics,2014. AlgoMesh User Manual.

HydroSimulations, 2018, Olive Downs Project – Groundwater Assessment. Prepared for Pembroke Olive Downs Pty Ltd, May 2018.

IESC, 2018, Uncertainty analysis – Guidance for groundwater modelling within a risk management framework, Commonwealth of Australia.

IESC, 2023, Uncertainty analysis for groundwater modelling – Information Explanatory Note.

IESC 2024. Information guidelines for proponents preparing coal seam gas and large coal mining development proposals, Commonwealth of Australia.

Jourde H, Flodin E.A., Aydin A., Durlofsky L.J., and Wen X.H., 2002. Computing permeability of fault zones in eolian sandstone from outcrop measurements. AAPG Bulletin, v. 86, no. 7, p. 1187–1200.

Kinnon, E. C., 2010. Analysis of Gas and Water Production Pathways in Coal Seams. Master of Philosophy thesis, University of Queensland.

Moore, A.W., J.S. Russell, and J.E. Coldrak. 1967. Dry matter and nutrient content of a subtropical semiarid forest of Acacia haropohylla F. Muell (Brigalow). Aust. J. Bot. 15:11-24 doi:10.1071/bt9670011.

NHMRC, NRMMC (2011) Australian Drinking Water Guidelines Paper 6 National Water Quality Management Strategy.

Paul P.K, Zoback M.D, and Hennings P.H. 2009. Fluid Flow in a Fractured Reservoir Using a Geomechanically Constrained Fault-Zone-Damage Model for Reservoir Simulation. SPE Reservoir Evaluation & Engineering, Volume 12, Number 4, p. 562-575.

Peeters and Middlemis, 2023. Information Guidelines Explanatory Note: Uncertainty analysis for groundwater modelling. A report prepared for the Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development through the Department of Climate Change, Energy, the Environment and Water, Commonwealth of Australia, 2023.

Richardson, S, Irvine, E, Froend, R, Boon, P, Barber, S & Bonneville, B, 2011, Australian groundwater-dependent ecosystem toolbox part 1: assessment framework, Waterlines report, National Water Commission, Canberra.

SLR, 2019. Moorvale South Project Groundwater Assessment. Report prepared for Peabody Energy, Ref 620.13122.10000-R01-v3.0.

SLR, 2020. Winchester South Project Groundwater Impact Assessment. Report prepared for Whitehaven Coal Ltd, Ref 620.13245.10000-R01-v3.4.

SLR, 2021a. Caval Ridge Mine Horse Pit Extension Project. Groundwater Assessment Report. Report for BMA.

SLR, 2021b. Caval Ridge Mine Horse Pit Extension Project. Surface Water Assessment Report. Report for BMA.

SLR, 2021c. Millennium Mine Groundwater Mavis Underground Operations. Groundwater Impact Assessment. Groundwater Modelling Technical Report. Report for MetRes Pty Ltd.

SLR, 2021d. Daunia Mine FY21 Water Licence Performance Review Report . Groundwater Modelling Technical Report. Report for BHP Billiton Mitsubishi Alliance.

SLR, 2022a, Saraji East Mining Lease Project Groundwater Modelling Technical Report. Draft Report being prepared for AECOM Australia Pty Ltd, Ref 620.31025.00005-R01-v0.1.

SLR, 2023. Groundwater Modelling Technical Report. Report prepared for AECOM Australia Pty Ltd, May 2023.

SLR, 2023a. Transitional PRC Plan Hydrogeology Report prepared for BMA, December 2023.

SRK Consulting, 2019, Project Memo: Hughes Creek, Ramps 2 and 3 TSF Seepage Investigation: Standpipe piezometer installation logs.

Uysal, T., Golding, S. and Glikson, M., 2000. Thermal and Fluid Flow History in the Bowen Basin. Bowen Basin Symposium 2000.

WA EPA (2007) Sampling methods and survey considerations for subterranean fauna in Western Australia (Guidance Statement 54A) draft.

Zolfaghar, Sepideh & Villalobos-Vega, Randol & Cleverly, Jamie & Zeppel, Melanie & Rumman, Rizwana & Eamus, Derek. (2014). The influence of depth-to-groundwater on structure and productivity of Eucalyptus woodlands. Australian Journal of Botany. 62. 428-437. 10.1071/BT14139.

# Appendix A Groundwater Modelling Technical Report

## Saraji Mine Grevillea Pit Continuation Project

### Groundwater Impact Assessment

**Engeny on Behalf of BM Alliance Coal Operations Pty Ltd**

SLR Project No.: 620.040484.00001

13 September 2024

# Saraji Mine Grevillea Pit Continuation Project

## Groundwater Modelling Technical Report

### Engeny on Behalf of BM Alliance Coal Operations Pty Ltd

540 Wickham Street Fortitude Valley
Brisbane QLD 4006

Prepared by:

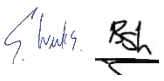
**SLR Consulting Australia**

SLR Project No.: 620.040484.00000

12 September 2024

Revision: 3.0

## Revision Record

| Revision | Date | Prepared By | Checked By | Authorised By |
|---|---|---|---|---|
| 3.0 | 27 June 2024 | Banafsheh Sheikhipoor/ Dariarne Edwards | Scott Weeks | |
| 2.0 | 22 August 2024 | Banafsheh Sheikhipoor | Scott Weeks | |
| 3.0 | 12 September 2024 | Banafsheh Sheikhipoor | Scott Weeks |  |

# Basis of Report

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

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

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

# Table of Contents

**Basis of Report** ..... i
**Acronyms and Abbreviations** ..... vii
**1.0 Introduction** ..... 1
1.1 Background ..... 1
1.2 Modelling Objectives ..... 2
**2.0 Model Construction and Development** ..... 2
2.1 Model Code ..... 2
2.2 Model Extent and Mesh Design ..... 2
2.3 Model Layers ..... 5
2.3.1 Geological Faults ..... 9
2.4 Model Stresses and Boundary Conditions ..... 11
2.4.1 Regional Groundwater Flow ..... 11
2.4.2 Watercourses ..... 11
2.4.3 Rainfall Recharge ..... 14
2.4.4 Evapotranspiration ..... 14
2.4.5 Groundwater Use ..... 14
2.4.6 Mining ..... 15
2.5 Timing ..... 17
2.6 Calibration ..... 17
2.6.1 Calibration Method ..... 17
2.6.2 Groundwater Levels ..... 17
2.6.3 Calibration Statistics ..... 18
2.6.4 Calibration Fit ..... 25
2.6.5 Model Water Balance ..... 29
2.7 Calibrated Hydraulic Parameters ..... 30
2.8 Calibrated Storage Properties ..... 35
2.9 Calibrated Recharge ..... 36
**3.0 Predictive Modelling** ..... 38
3.1 Timing and Mining ..... 38
3.2 Water Balance ..... 40
3.3 Predicted Groundwater Level Change ..... 42
3.4 Maximum Predicted Drawdowns ..... 49
3.4.1 Maximum Incremental Drawdown ..... 49
3.4.2 Cumulative Drawdown ..... 56

3.5 Predicted Groundwater Ingress ..... 65
3.6 Incidental Water Impacts ..... 65
3.6.1 Influence on Alluvium ..... 65
3.6.2 Groundwater – Surface Water Interaction ..... 66
**4.0 Sensitivity Analysis ..... 67**
4.1 Calibration Identifiability ..... 67
4.2 Prediction Identifiability ..... 70
**5.0 Uncertainty Analysis ..... 73**
5.1 Parameter Distribution ..... 73
5.2 Uncertainty Results ..... 78
5.2.1 Number of Realisations ..... 78
5.2.2 Uncertainty of Mine Inflows ..... 79
5.2.3 Groundwater Drawdowns ..... 80
5.2.4 Uncertainty of Influence on Alluvium and Surface Water Flow ..... 85
**6.0 Model Confidence Level Classification ..... 86**
**7.0 Groundwater Model and Data Limitation ..... 89**
**8.0 Conclusions ..... 93**
**9.0 References ..... 94**

# Tables in Text

Table 2-1 Model Layers and Thicknesses ..... 5
Table 2-2 River and Surface Water Features in the Model ..... 11
Table 2-3 Average Stage Heights (m) Used to Develop Transient Sequence ..... 11
Table 2-4 Hydraulic Parameter Changes Within the Fracture Zone ..... 16
Table 2-5 Calibration Statistics – Best Calibrated Model ..... 19
Table 2-6 Average Residual by Model Layer ..... 22
Table 2-7 Average Residual by Project ..... 23
Table 2-8 Steady State Model Water Balance ..... 29
Table 2-9 Transient Model Water Balance ..... 30
Table 2-10 Hydraulic Conductivity – Best Calibrated Model ..... 31
Table 2-11 Hydraulic Conductivity of Faults – Best Calibrated Model ..... 34
Table 2-12 Calibrated Storage Parameters – Best Calibrated Model ..... 35
Table 2-13 Calibrated Rainfall Recharge – Best Calibrated Model ..... 36
Table 3-1 Average Simulated Water Balance over the Prediction Period – Cumulative ..... 40
Table 3-2 Average Simulated Water Balance over the Prediction Period – Approved ..... 41

Table 3-3 Average Simulated Water Balance over the Prediction Period – Null Run..... 41
Table 5-1 Uncertainty Parameter Range for Horizontal Hydraulic Conductivity ..... 73
Table 5-2 Uncertainty Parameter Range for Vertical to Horizontal Conductivity (Kv/Kx) . 74
Table 5-3 Uncertainty Parameter Range for Specific Yield..... 75
Table 5-4 Uncertainty Parameter Range for Specific Storage (1/m)..... 76
Table 5-5 Uncertainty Ranges for Recharge Rates..... 77
Table 6-1 Groundwater Model Classification Table[1,2]..... 86
Table 7-1 Groundwater Model and Data Limitations ..... 90

# Figures in Text

Figure 2-1 Model Domain..... 4
Figure 2-2 Topography Data Extents ..... 8
Figure 2-3 Modelled Fault Zones..... 10
Figure 2-4 Stream and River Cells ..... 13
Figure 2-5 Details of Fracture Zone..... 16
Figure 2-6 Calibration Scattergram – Modelled vs Observed Groundwater Levels (All Bores)..... 19
Figure 2-7 Calibration Scattergram – Modelled vs Observed Groundwater Levels (SRM Bores)..... 20
Figure 2-8 Calibration Residual Histogram Scattergram..... 21
Figure 2-9 Transient Calibration Average Head Residuals (m)..... 24
Figure 2-10 Calibration Fit - Alluvium Bores ..... 26
Figure 2-11 Calibration Fit - Permian Bores (D,Q, P and H seams)..... 27
Figure 2-12 Calibration Fit - Other Bores..... 28
Figure 2-13 Hydraulic Conductivity vs Depth – Interburden / Overburden ..... 33
Figure 2-14 Hydraulic Conductivity vs Depth – Coal..... 33
Figure 2-15 Hydraulic Parameters Estimates vs Best Calibrated Hydraulic Parameters..... 34
Figure 2-16 CMB Recharge Estimates vs Modelled Recharge..... 37
Figure 3-1 Mine Progression (Grevillea Pit Continuation)..... 39
Figure 3-2 Predicted Water Level within Quaternary Alluvium (Layer 1) at End of Mining – Approved Scenario ..... 43
Figure 3-3 Predicted Water Level within Regolith (Layer 2) at End of Mining – Approved Scenario ..... 44
Figure 3-4 Predicted Water Level within Permian Coal Measures (Layer 18) at End of Mining – Approved Scenario ..... 45
Figure 3-5 Predicted Water Level within Quaternary Alluvium (Layer 1) at End of Mining – Cumulative Scenario..... 46

Figure 3-6 Predicted Water Level within Regolith (Layer 2) at End of Mining – Cumulative Scenario ..... 47
Figure 3-7 Predicted Water Level within Permian Coal Measures (Layer 18) at End of Mining – Cumulative Scenario ..... 48
Figure 3-8 Maximum Incremental Drawdown in Alluvium (Layer 1) ..... 50
Figure 3-9 Maximum Incremental Drawdown in Regolith (Layer 2) ..... 51
Figure 3-10 Maximum Incremental Drawdown in Q Seam (Layer 12) ..... 52
Figure 3-11 Maximum Incremental Drawdown in P Seam (Layer 14) ..... 53
Figure 3-12 Maximum Incremental Drawdown in H Seam (Layer 16) ..... 54
Figure 3-13 Maximum Incremental Drawdown in D Seam (Layer 18) ..... 55
Figure 3-14 Maximum Cumulative Drawdown in Quaternary Alluvium (Layer 1) ..... 57
Figure 3-15 Maximum Cumulative Drawdown in Regolith (Layer 2) ..... 58
Figure 3-16 Maximum Cumulative Drawdown in Leichhardt Seam (Layer 5) ..... 59
Figure 3-17 Maximum Cumulative Drawdown in Vermont Seam (Layer 7) ..... 60
Figure 3-18 Maximum Cumulative Drawdown in Q Seam (Layer 12) ..... 61
Figure 3-19 Maximum Cumulative Drawdown in P Seam (Layer 14) ..... 62
Figure 3-20 Maximum Cumulative Drawdown in H Seam (Layer 16) ..... 63
Figure 3-21 Maximum Cumulative Drawdown in D Seam (Layer 18) ..... 64
Figure 3-22 Predicted Groundwater Inflows ..... 65
Figure 4-1 Identifiability – Horizontal Hydraulic Conductivity (Kx) ..... 68
Figure 4-2 Identifiability – Anisotropy (Kv/Kx) ..... 68
Figure 4-3 Identifiability – Specific Yield (Sy) ..... 69
Figure 4-4 Identifiability – Specific Storage (SS) ..... 69
Figure 4-5 Identifiability – Recharge (RCH) ..... 70
Figure 4-6 Uncertainty Contribution (predicted mine inflow) versus Identifiability ..... 71
Figure 4-7 Uncertainty Contribution (maximum incremental drawdown) versus Identifiability ..... 72
Figure 5-1 95 % Confidence Interval for Pit Inflows ..... 78
Figure 5-2 95 % Confidence Interval for Maximum Drawdowns ..... 79
Figure 5-3 Mine Inflow Uncertainty ..... 80
Figure 5-4 Uncertainty in Predicted 1 m Maximum Incremental Drawdown in Alluvium ..... 81
Figure 5-5 Uncertainty in Predicted 1 m Maximum Incremental Drawdown in Regolith ..... 82
Figure 5-6 Uncertainty in Predicted 1 m Maximum Incremental Drawdown in Q Seam (Layer 12) ..... 83
Figure 5-7 Uncertainty in Predicted 1 m Maximum Incremental Drawdown in D Seam (Layer 18) ..... 84

# Appendices

**Appendix A** **Calibration Residuals**

**Appendix B** **Calibration Hydrographs**

**Appendix C** **Hydraulic Parameters and Recharge Zone Distribution**

**Appendix D** **Stress Periods and Simulated Active Mine Timings**

**Appendix E** **Uncertainty Analysis Parameter Distributions**

# Acronyms and Abbreviations

| | |
|---|---|
| AGE | Australasian Groundwater and Environmental Consultants Pty Ltd |
| ATS | Adaptive Time-Stepping |
| BMA | BM Alliance Coal Operations Pty Ltd |
| CMB | Chloride mass balance |
| CSIRO | Commonwealth Scientific and Industrial Research Organisation |
| CVM | Caval Ridge Mine |
| DEM | Digital Elevation Model |
| DNM | Daunia Mine |
| DRN | Drain |
| EIS | Environmental Impact Statement |
| EPBC Act | Environment Protection and Biodiversity Conservation Act 1999 |
| EVT | Evapotranspiration |
| FCCM | Fort Cooper Coal Measures |
| GHB | General Head Boundary |
| GW | Groundwater |
| H Seam | Harrow Creek seam |
| HPE | Horse Pit Extension |
| I/B | Interburden |
| IESC | Independent Expert Scientific Committee on Unconventional Gas Development and Large Coal Mining Development |
| Kh | horizontal hydraulic conductivity |
| km | kilometre |
| Kv | vertical hydraulic conductivity |
| Kx | horizontal hydraulic conductivity |
| kz | vertical hydraulic conductivity |
| LHS | Latin Hypercube Sampling |
| LiDAR | Light Detection and Ranging |
| LVN | Lake Vermont North |
| m | metres |
| mAHD | metres Australian Height Datum |
| MCM | Moranbah Coal Measures |
| MDBC | Murray Darling Basin Modelling Guidelines |
| ML | Mining Lease |
| ML/d | Megalitres per day |
| ML/day | Megalitres per day |
| ML/yr | Megalitres per year |

| | |
|---|---|
| mm | millimetres |
| mm/year | milligrams per year |
| O/B | Overburden |
| PDM | Peak Downs Mine |
| PEST | Parameter Estimation |
| QoI | Quantities of Interests |
| RCH | Recharge |
| RCM | Rangal Coal Measures |
| RIV | River |
| RMS | root mean square |
| SEMLP | Saraji East Mining Lease Project |
| SILO | Scientific Information and Learning Observatory |
| SLR | SLR Consulting Australia Pty Ltd |
| SRM | Saraji Mine |
| SRMS | Scaled Root Mean Square error |
| SS | Specific Storage |
| Sy | Specific Yield |
| TVM | Time-variant materials |
| U/B | Underburden |
| VK | Vertical Hydraulic Conductivity |
| VWP | Vibrating Wire Piezometer |
| WS | Winchester South |
| yr | year |

# 1.0 Introduction

SLR Consulting Australia Pty Ltd (SLR) has been engaged by Engeny Pty Ltd (Engeny) to conduct groundwater modelling in support of a referral under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) for the Grevillea Pit Continuation Project (the Project) for mining lease ML700021. The Project is proposed by BM Alliance Coal Operations Pty Ltd (BMA) and the continuation of mining activities located within BMA's Saraji Mine (SRM) in Queensland's Bowen Basin.

Engeny requested SLR to update the existing regulatory accepted BMA regional groundwater model to include known local hydrogeologic features and mining operations (historic, approved and proposed) in the vicinity of the Project, in order to provide estimates of potential impacts to groundwater and relevant receptors. This new modelling supersedes the earlier groundwater modelling works completed for the Grevillea area by AECOM (2019), AECOM (2016) and AGE (2012).

## 1.1 Background

Previously, SLR (2023) conducted groundwater modelling as a part of the updated Saraji East Mining Lease Project (SEMLP) Groundwater Assessment (AECOM, 2023) which was based on the regional scale Olive Downs Project model (i.e. the foundational model) (HydroSimulations, 2018). The foundational model was subsequently updated for the Moorvale South Project in 2019 (SLR, 2019), Winchester South Project in 2020 (SLR, 2020), Caval Ridge Mine (CVM)  Horse Pit Extension (HPE) Project in 2021 (SLR, 2021a), Lake Vermont North Extension Project (SLR, 2021b), Millennium Mine Mavis Extension (SLR, 2021c), the Daunia Mine (DNM) Water Licence Review (SLR, 2021d) and the SEMLP (SLR, 2023). This regional scale model has been reviewed and accepted twice by State agencies and once by the Commonwealth for project approval applications. Additionally, BMA has used the model to support various State mining compliance reporting requirements. Data sharing agreements have been established by these project proponents that allow the sharing of groundwater information and modelling. Under these agreements, the groundwater models developed as part of each project's groundwater assessment were adopted as a base for the Grevillea model, where relevant.

- An update to the BMA regional groundwater model was required for the model to be considered fit for purpose for the Project. The update to the model design included implementing historic and approved future mining operations at SRM and the proposed operations for the Project.

This report has been prepared documenting technical details of the numerical groundwater model, to support the Project and other future applications of the model.

Further details on the model updates completed for the Project are discussed in **Section 2.0** of this modelling report, which presents how the conceptualisation has been developed as a numerical groundwater model, and **Section 2.6** presents how well the model replicates observed data (calibration). Details on how the model represents the Project and other future mining activities approved or under assessment within the model domain is outlined within **Section 3.0** of this report.

It is important to note that this report does not present an updated groundwater impact assessment for the Project, which is provided separately (SLR, 2024). Similarly, conceptualisation of the groundwater regime relevant to the Project is included in the updated groundwater impact assessment.

## 1.2 Modelling Objectives

The overall objectives of the groundwater modelling are to:

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

# 2.0 Model Construction and Development

## 2.1 Model Code

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

Where previous MODFLOW versions restricted interlayer flow to vertical connectivity, MODFLOW-USG offers lateral connectivity between model layers. Lateral connectivity enables more accurate representations of hydrostratigraphic units, particularly those that pinch out, outcrop, or cross geological faults.

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

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

## 2.2 Model Extent and Mesh Design

The groundwater model extent is shown in **Figure 2-1**. The model is a regional scale model with the domain extent designed to meet environmental approvals application requirements for cumulative impact assessment, (i.e., the domain is large enough to appropriately consider all potential overlapping groundwater impacts from resource operations in the Bowen Basin).

The model domain extent has been kept consistent with the previous version of the model (SLR, 2021a, 2023). The model domain is intended to place boundary conditions sufficiently distant from existing Grevillea pits, the Project and surrounding mines to allow the extent of potential impacts from mining activities on the groundwater system to be assessed. At its widest extents, the model is approximately 62 km west-east by 95 km north-south. The model domain is deemed appropriate for the Project based on the following considerations:

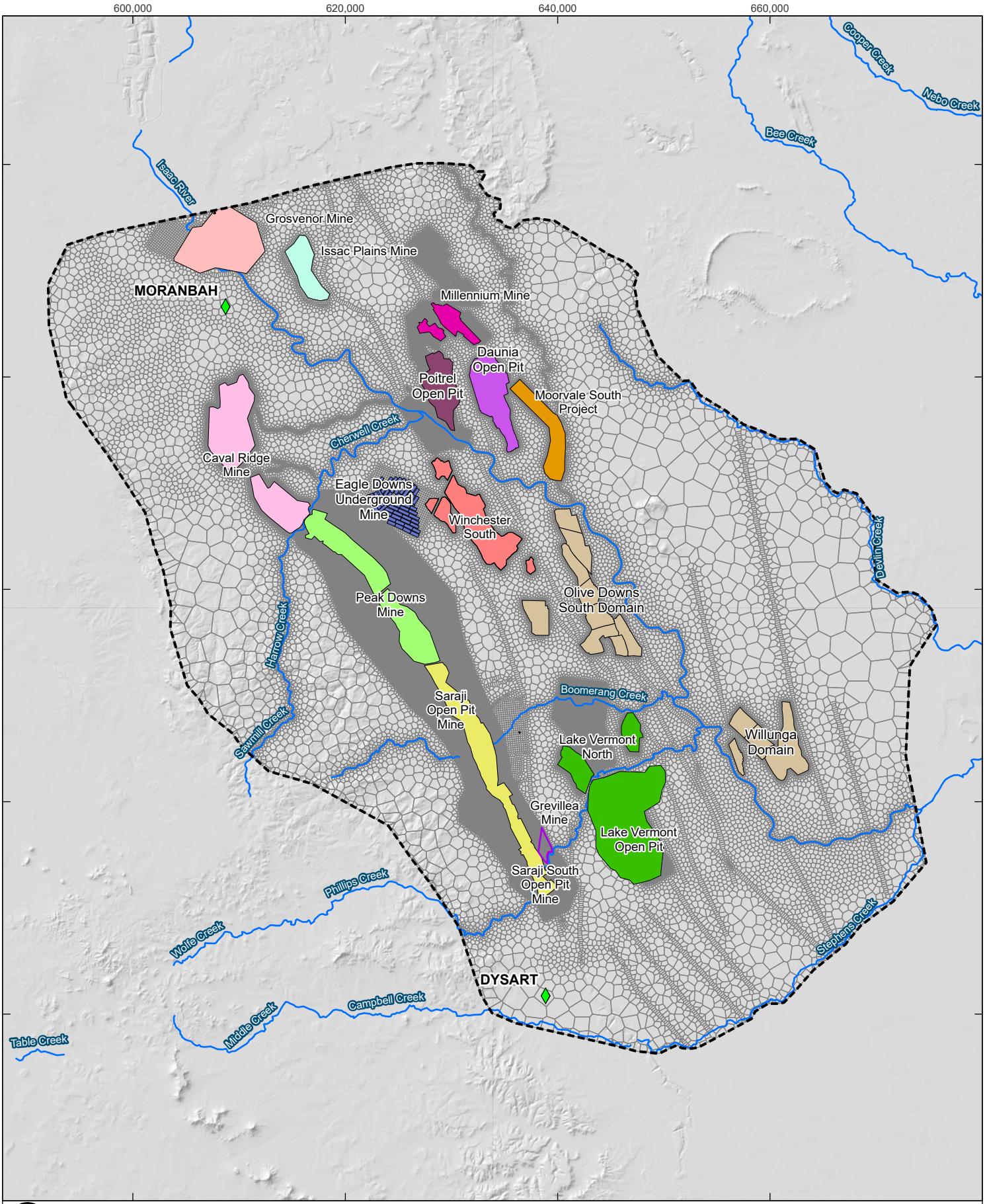
- The western boundary is represented by the outcrop boundary of the Back Creek Group, which is considered the regional low permeability basement for the purpose of this modelling.
- The northern boundary is 70 km distant from the Project.

- The southern boundary is set along the Stephens Creek 25 km south of the Project and is expected to be far outside the range of predicted related drawdown.
- The eastern boundary is set along the Delvin Creek 40 km east of the Grevillea and is expected to be far outside the range of predicted Project related drawdown.

To allow stable numerical modelling of the large spatial area of the model domain, an unstructured grid with varying Voronoi cell sizes was designed using Algomesh (HydroAlgorithmics, 2014). Varying Voronoi cell sizes allowed refinement around areas of interest, while a coarser resolution elsewhere reduces the total cell count to a manageable size. The model domain was vertically discretised into 19 layers, each layer comprising a cell count up to 121,225. The total number of cells in the model is 1,362,485. This is after pinching out areas in layers 3 to 19 where a layer is not present based on the mapped geology.

The following features have been included in the grid design:

- The Isaac River is represented in the model with a 50 metre (m) Voronoi cell size constraint.
- Open cut mine areas for the opencut mines including PDM, SRM, CVM, Poitrel, Daunia, Millennium, Lake Vermont, Winchester South, and Olive Downs have a 100 m Voronoi cell size constraint.
- Longwall mining at Grosvenor and Eagle Downs has an oriented regular grid of 100 m width squares to represent longwalls.
- Faults are represented using a 200 m Voronoi cell constraint.


600,000
620,000
640,000
660,000
7,580,000
7,560,000
7,540,000
7,520,000
7,500,000
Cooper Creek
Nebo Creek
Bee Creek
Isaac River
Grosvenor Mine
Issac Plains Mine
MORANBAH
Millennium Mine
Daunia Open Pit
Poitrel Open Pit
Moorvale South Project
Cherwell Creek
Caval Ridge Mine
Eagle Downs Underground Mine
Winchester South
Devlin Creek
Peak Downs Mine
Olive Downs South Domain
Harrow Creek
Boomerang Creek
Saraji Open Pit Mine
Stewmill Creek
Lake Vermont North
Willunga Domain
Grevillea Mine
Lake Vermont Open Pit
Saraji South Open Pit Mine
Phillips Creek
Wolfe Creek
Stephens Creek
DYSART
Campbell Creek
Middle Creek
Table Creek
0
5
10
km
LEGEND
Town
Major Drainage System
Model Boundary
Model Grid
Project Area
Coordinate System: GDA 1994 MGA Zone 55
Scale: 1:470,757 at A4
Project Number: 620.040484.00001
Date Drawn: 11-Sep-2024
Drawn by: RB
SARAJI MINE GREVILLEA PIT CONTINUATION PROJECT MODELLING TECHNICAL REPORT
MODEL DOMAIN
SLR
DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.
FIGURE 2-1
Path: H:\Projects-SLR\620-BNE\620-BNE\620.040484.00001 Saraji Mine Grevillea GW Model\06 SLR Data\01 CADGIS\GIS\ArcPro\GW Modelling\GW Modelling.aprx\620040484 MOD F02-1 Model Domain

## 2.3 Model Layers

Topography within the model domain has been defined using numerous sources of varying accuracy. Data extents of the sources used to construct model topography are shown in **Figure 2-2**. High resolution (1 m) Digital Elevation Model (DEM) data, provided by BMA, was used to define local surface elevation within the Project area. Outside the extents of the DEM dataset for the Project, LiDAR data from the Moorvale South Project, Winchester South Project, and the Olive Downs Project, SEMLP and CVM were used to define surface elevation, where available. Public domain 25 m DEM data sourced from Geoscience Australia (with 3 m subtracted for consistency between datasets) was used to define topography in the remainder of the model domain.

The model domain is discretised into 19 layers, as listed in **Table 2-1**. **Table 2-1** also presents the average thicknesses across the model domain for each layer. Model layer extents (lateral and vertical) have been defined using data from the following sources:

- BMA, SRM site geological model
- BMA, Saraji South site geological model
- BMA, DNM site geological model
- BMA, CVM site geological model and bore hole logs
- BMC, Poitrel Minesite geological model
- Jellinbah Mining Pty Ltd, Lake Vermont, Lake Vermont North and Lake Vermont Meadowbrook site geological models and bore hole logs
- Whitehaven WS Pty Ltd - Winchester South Project site geological model and bore hole logs
- MetRes Pty Ltd, Millennium site geological model
- Peabody Energy Limited, Moorvale South Project site geological model and bore hole logs
- Pembroke Resources Limited, Olive Downs Project site geological model and bore hole logs
- CSIRO Regolith depth survey
- Queensland Globe bore hole logs
- Queensland surface geology and basement geological maps.

**Table 2-1 Model Layers and Thicknesses**

| Model Layer | Formation | Unit | Average Thickness (m) |
|---|---|---|---|
| 1 | Alluvium, colluvium, Tertiary basalt | Surface cover – alluvium, colluvium and Tertiary basalt | 8.3 |
| 2 | Regolith (Tertiary sediments, Tertiary basalt) | Tertiary and minor Triassic Clematis Group, weathered Permian, Tertiary basalt | 19.2 |
| 3 | Rewan Group | Triassic | 117.7 |
| 4 | Rangal Coal Measures | Leichhardt overburden | 36.6 |
| 5 | | Leichhardt seam | 4.6 |

| Model Layer | Formation | Unit | Average Thickness (m) |
|---|---|---|---|
| 6 | | Interburden | 35.6 |
| 7 | | Vermont seam | 3.8 |
| 8 | | Vermont underburden | 34.1 |
| 9 | Fort Cooper Coal Measures | Fort Cooper overburden | 206.6 |
| 10 | | Fort Cooper seams (combined) | 55.9 |
| 11 | | Fort Cooper underburden | 56.1 |
| 12 | Moranbah Coal Measures | Q Seam | 3.3 |
| 13 | | Interburden | 38.0 |
| 14 | | P Seam | 2.9 |
| 15 | | Interburden | 56.4 |
| 16 | | H Seam | 5.5 |
| 17 | | Interburden | 67.1 |
| 18 | | D Seam (target coal seam for Grevillea) | 8.4 |
| 19 | | Base of Model - aquitard | 100.0 |

Model Layer 1 is fully extensive across the model with an average thickness of 8.3 m. The base of Layer 1 is largely consistent with the previous version of the model, with local updates using the bore logs available for the Grevillea area. With respect to Phillips Creek (the creek south of the Grevillea), the alluvium associated with the creek was set a uniform thickness of 3.75 m consistent with Engeny conceptualisation based on drill hole logs along the creek.

Model Layer 2 is also fully present across the model area with a minimum thickness of 1 m. The SRM, the Project, South Saraji, Peak Downs, Winchester South and CVM site geology models were used to define the base of model Layer 2. Outside these site geology models the base of Layer 2 was interpreted from CSIRO regolith survey depths and Queensland Globe bore log lithology data consistent with the previous version of the model.

The underlying Triassic and Permian layers are present only to their outcrop extents, with some inference made for the presence of older units beneath the surface outcrop due to folding and faulting. The layering above the Moranbah Coal Measures is generally consistent with the CVM HPE model.

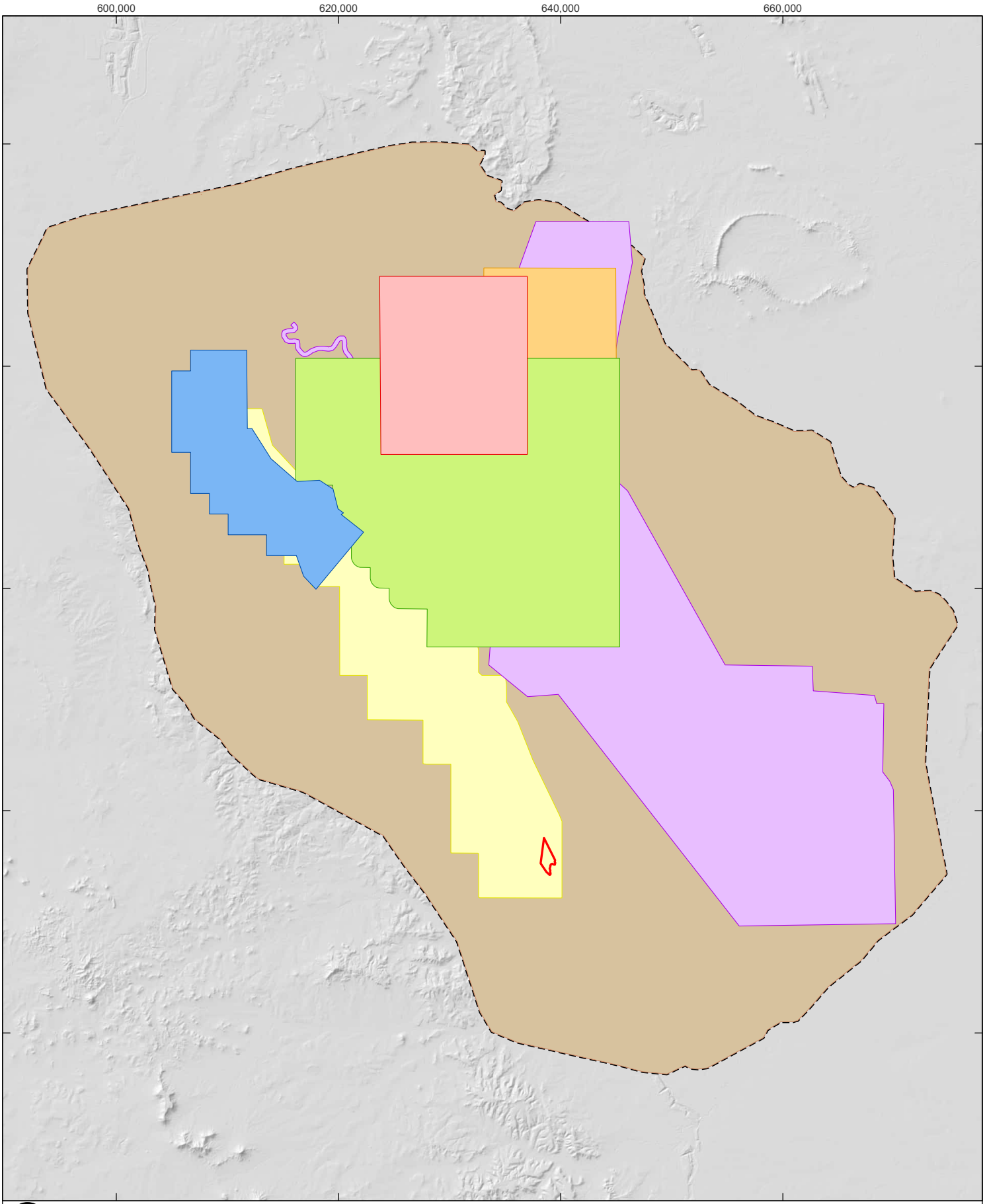
With regards to Moranbah Coal Measures, eight layers were included to account for all the coal seam targets within the Moranbah Coal Measures at the CVM, PDM, SRM, and the Project sites. The PDM and SRM/Grevillea site geology models were used for updating the construction of layers 12 to 19 representing the Moranbah Coal Measures. It is not possible to represent every individual coal seam or ply in the model layers representing the Moranbah Coal Measures, therefore a ‘combined thickness’ totalling the approximate thickness of coal for the main seams has been simulated, consistent with the previous version of the model. The major coal seams represented in the model are the Q, P, H and D seams. In doing so, the thicknesses of each individual coal seam (typically < 1m thickness) were combined separately for the major coal seams and the combined thicknesses were used in the model. The base of the lowest coal seam at each group was used to assign the bottom of the model layer. Outside of the geology model extents, where bore logs with information on Moranbah

Coal Measures were available, this information was included in the layer elevations. Elsewhere, average thicknesses were extrapolated out into the extended model area and Queensland Surface Geology maps were used to pinch-out the layers when the geology unit discontinues and does not exist laterally.

**Table 2-1** reports the average thicknesses of each layer over the entire model area. In order to provide an estimate of coal seam thicknesses within the mine area, the average thicknesses of major coal seams were calculated only within SRM/Grevillea area and reported as below:

- Q Seam thickness: 1.5 m
- P Seam Thickness: 2.5 m
- H Seam Thickness: 4.5 m
- D Seam Thickness: 8.5 m

The basement layer has the thickness of 100m and considered to replicate the Back Creek Group. The Back Creek Group in general has low permeability and will act as a regional aquitard, suppressing downward vertical flow.




0 5 10 km

| | |
|---|---|
| Coordinate System: | GDA 1994 MGA Zone 55 |
| Scale: | 1:450,000 at A4 |
| Project Number: | 620.040484.00001 |
| Date Drawn: | 11-Sep-2024 |
| Drawn by: | RB |

**LEGEND**

- Project Area
- Model Boundary
- Caval Ridge 1m DEM Data
- Daunia & Poitrel LiDAR Data
- Whitehaven 1m DEM Data
- Peabody LiDAR Data
- Pembroke LiDAR Data
- Saraji and Peaks Downs pre Mining
- Geoscience Australia DEM Data

# SARAJI MINE GREVILLEA PIT CONTINUATION PROJECT MODELLING TECHNICAL REPORT

## TOPOGRAPHY DATA EXTENTS

SLR

DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.

**FIGURE 2-2**

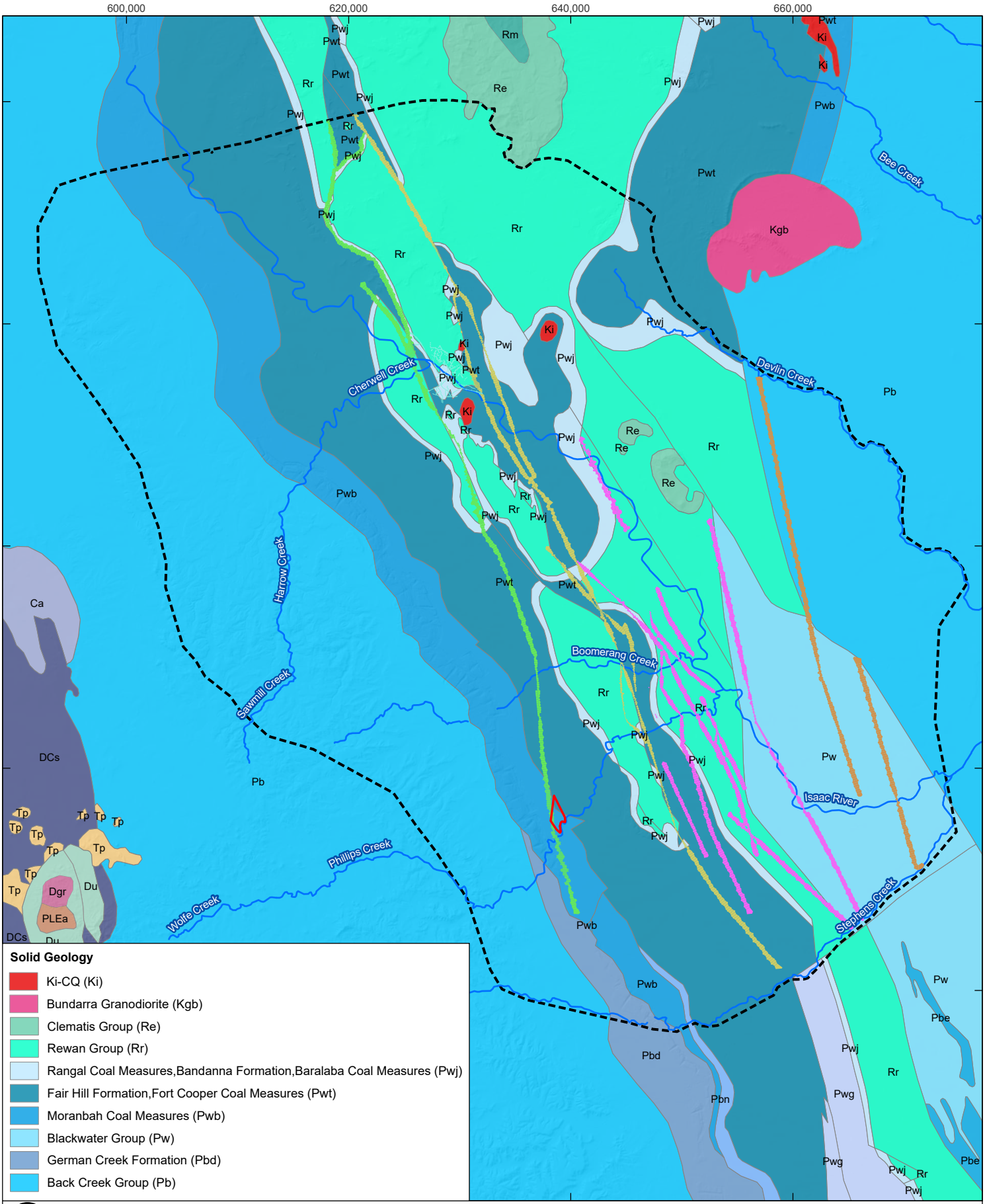
Path: H:\Projects-SLR\620-BNE\620-BNE\620.040484.00001 Saraji Mine Grevillea GW Model\06 SLR Data\01 CADGIS\GIS\ArcPro\GW Modelling\GW Modelling.aprx\620040484 MOD F02-2 Topography Data Extents

### 2.3.1 Geological Faults

As discussed in the AECOM (2019) groundwater conceptualisation report, there are faults present in and around the Project. The modelling of faults within the groundwater model domain uses the fault mapping and site-specific geology models where available.

Local faults displacements derived from the PDM and SRM/Grevillea geological models have also been captured in the model layer elevations at these sites. There are three key regional northwest-southeast trending fault zones included in the model:

- Extending 70 km, 0 m to the west of Grevillea
- Extending 50 km, 10 km to the east of Grevillea
- Numerous shorter faults extending 46 km total, 25 km to the east of Grevillea
- Mesh refinement (200m) has been used along fault lines to allow for isolated changes of hydraulic properties along fault zones during calibration. **Figure 2-3** shows the locations of geological fault zones represented in the model.




| | |
|---|---|
| Coordinate System: | GDA 1994 MGA Zone 55 |
| Scale: | 1:450,000 at A4 |
| Project Number: | 620.040484.00001 |
| Date Drawn: | 11-Sep-2024 |
| Drawn by: | RB |

# SARAJI MINE GREVILLEA PIT CONTINUATION PROJECT MODELLING TECHNICAL REPORT

## MODELLED FAULT ZONES

SLR

DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.

FIGURE 2-3

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040484.00001 Saraji Mine Grevillea GW Model\06 SLR Data\01 CADGIS\GIS\ArcPro\GW Modelling\GW Modelling.aprx\620040484 MOD F02-3 Modelled Fault Zones

## 2.4 Model Stresses and Boundary Conditions

### 2.4.1 Regional Groundwater Flow

General Head Boundary (GHB) have been specified along the eastern, southern, and part of the northern model boundaries. The GHB boundary condition is used to represent the regional flow into and out of the model area and has been assigned using GHB cells in all layers using pre-mining head elevations. Groundwater will enter the model where the head set in the GHB is higher than the modelled head in the adjacent cell and will leave the model when the water level is lower in the GHB. GHB conductance is calculated using the hydraulic conductivity and the dimensions of each GHB cell and is therefore variable in this model due to variable cell-size.

A no flow boundary was applied to the western boundary of the model that represents the outcrop of the Back Creek Group.

A drain boundary condition was used in the northern model boundary to simulate the mining at the Grosvenor Mine.

### 2.4.2 Watercourses

Major rivers (including Isaac River) as well as minor creeks were built into the model using MODFLOW-USG RIV package. River cells in the model are shown in **Figure 2-4**. Streams within and around the  Project that were included in the RIV package are presented in **Table 2-2**.

**Table 2-2 River and Surface Water Features in the Model**

| Boundary | River Stage (m) | River Bed Kz (m/day) |
|---|---|---|
| Isaac River | Warm Up Simulation - Long term Average (2008-2020)<br>Calibration simulation - Historical Quarterly Averages<br>Prediction simulation- Fixed Stage Height- Long term Average (2008-2020) | $1.0 \times 10^{-2}$ |
| One Mile Creek | 0 | $1.0 \times 10^{-1}$ |
| Boomerang Creek | 0 | $1.0 \times 10^{-1}$ |
| Other Minor Creeks | 0 | $1.0 \times 10^{-2}$ to $1.0 \times 10^{-1}$ |

Surveyed river stage data was available at several locations along the Isaac River. The closest gauging station to the site, located at Deverill, records average monthly water levels as shown in **Table 2-3**. This data was extrapolated to provide continuous stage elevations.

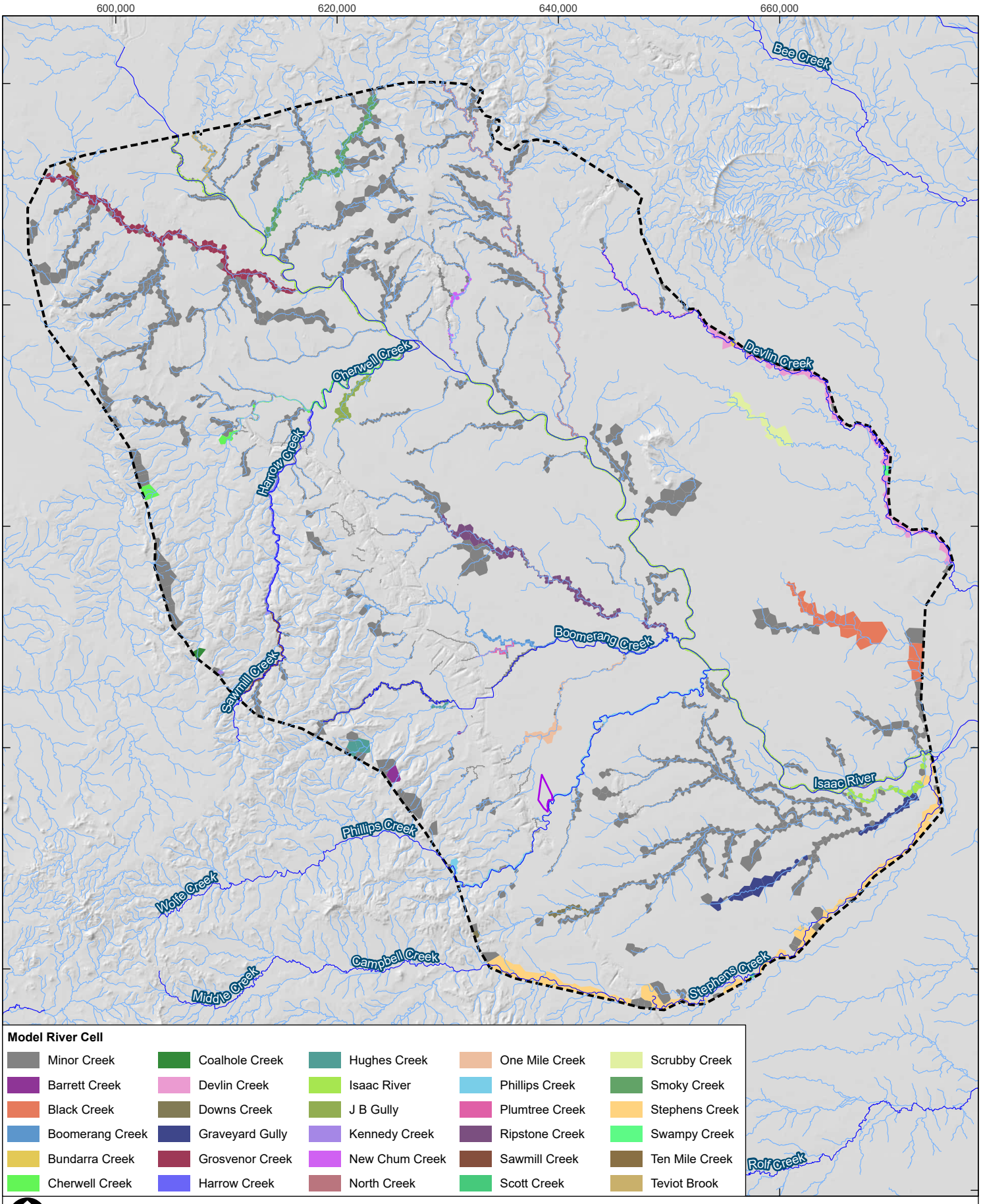
**Table 2-3 Average Stage Heights (m) Used to Develop Transient Sequence**

| Station | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual Average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Isaac River at Deverill | 0.46 | 0.89 | 0.68 | 0.39 | 0.23 | 0.15 | 0.16 | 0.10 | 0.08 | 0.02 | 0.09 | 0.41 | 0.31 |

River and creek widths, thickness and conductance values were adopted from the CVM HPE model. The rivers are set with the riverbed 1 to 10 m below the surrounding topography to represent the steep-banked incised channels. The river widths were assumed to be fixed for each river in the model. The river widths were estimated using aerial photography and aligned with assumptions within the CVM HPE model.

The river conductance was calculated using river width, river length, riverbed thickness, and the vertical hydraulic conductivity of riverbed material (Kz). Therefore, the river conductance is variable due to the non-constant spatial discretisation in each of the model river cells. The vertical hydraulic conductivity of riverbeds for different rivers in the model were adopted from the CVM HPE model.

The river stage height in the minor tributaries or drainage lines was set to 0 m (i.e., river stage elevation was equal to river bottom elevation). Therefore, the minor tributaries or drainage lines act as drains to the groundwater system and do not result in any recharge from the watercourse to the groundwater system.




| | |
|---|---|
| Coordinate System: | GDA 1994 MGA Zone 55 |
| Scale: | 1:450,000 at A4 |
| Project Number: | 620.040484.00001 |
| Date Drawn: | 11-Sep-2024 |
| Drawn by: | RB |

# SARAJI MINE GREVILLEA PIT CONTINUATION PROJECT MODELLING TECHNICAL REPORT

## STREAM AND RIVER CELLS

SLR

DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.

FIGURE 2-4

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040484.00001 Saraji Mine Grevillea GW Model\06 SLR Data\01 CADGIS\GIS\ArcPro\GW Modelling\GW Modelling.aprx\620040484 MOD F02-4 Stream and River Cells

### 2.4.3 Rainfall Recharge

The dominant mechanism for recharge to the groundwater system is through diffuse infiltration of rainfall through the soil profile and subsequent deep drainage to underlying groundwater systems. Diffuse rainfall recharge to the model was represented using the MODFLOW-USG Recharge package (RCH).

The recharge rates were established through the calibration process, with bounds based on the conceptual understanding of the system and comparing them with other groundwater models prepared for the region. The starting values adopted in the calibration process were from the CVM HPE model. Rainfall recharge was imposed as a percentage of actual rainfall from the SILO Grid Point observations. Long-term average rainfall was used for the steady state model. For the transient calibration model, quarterly averages of the historical rainfall data were used (2008 to 2020). For the prediction model, annual averages of 1990-2020 rainfall data were used.

The model included 7 recharge zones as listed below:

- Isaac River Flood Plain Alluvium
- Isaac River Channel Alluvium
- Alluvium – rest of the model
- Regolith
- Basalt
- Duaringa Formation
- Weathered Permian

An enhanced recharge of 100 % is applied to residual mine pit voids in the prediction model, where void lakes are not represented. No recharge is applied to constant head cells representing void lakes during recovery predictions. Recharge to mine spoil is set to 1 % of average annual rainfall (Mackie, C.D., 2009).

The calibrated recharge rates are discussed in **Section 2.9**. Overall, the recharge rates range from 0.1 to 2.3 mm/year.

### 2.4.4 Evapotranspiration

The MODFLOW Evapotranspiration (EVT) package was used to simulate evapotranspiration from the groundwater system.

Evapotranspiration extinction depths were set to 2 m below ground across the model domain. The extinction depth parameter defines the maximum depth from which water can be extracted by vegetation through transpiration. Any water that is available below this depth is assumed to be unavailable to plants. Maximum potential rates were set using actual evapotranspiration values (from the Bureau of Meteorology), with the average value (600 mm/year) used as the transient calibration evapotranspiration rate. An EVT rate of 0 was assigned to the model cells representing the rivers.

### 2.4.5 Groundwater Use

Private groundwater pumping bores have not been included in the model due to lack of information regarding abstraction rates across the model domain. Due to generally low groundwater abstraction across the model area, it is likely that the bores have very localised drawdowns and will not significantly impact model results.

### 2.4.6 Mining

The MODFLOW Drain (DRN) package is used to simulate mine dewatering in the model for the Project and surrounding mines. Boundary conditions for drain cells allow one-way flow of water out of the model. When the computed head drops below the stage elevation of the drain, the drain cells become inactive. This is an effective way of theoretically representing removal of water seeping into a mine over time, with the actual removal of water being via pumping and evaporation.

Extraction at the Project is represented using drain cells in model layer 18 (D Seam; lowermost coal seam in Moranbah Coal Measures (MCM)) and the fractured zone extended above the H seam is discussed in **Section 2.4.6.2**. The cover depth of overburden over the Project varies between 110 m and 470 m.

The drain cells representing the surrounding mines are consistent with the CVM HPE version of the model. To simulate open cut mines in the model, drain cells are applied to all active layers from the surface to the base of the lowermost mined seam. Longwall extraction at Grosvenor Mine and Eagle Downs Mine are represented as drain cells in model layer 18 (D Seam; lowermost coal seam in Moranbah Coal Measures) and the fracture zone extended up to layer 10 consistent with the CVM HPE model.

#### 2.4.6.1 Variation in Hydraulic Properties - Open Cut Mining

For open cut mining, Hawkins (1998) and Mackie (2009) indicate that spoil and waste rock are more permeable than the undisturbed strata. Completed open cut mining areas will be backfilled with waste overburden as the extraction proceeds. The model cell properties were updated to spoil properties guided by operational mine plans. The hydraulic properties were varied with time using the Time-variant materials (TVM) package of MODFLOW-USG Transport. Horizontal hydraulic conductivity of 0.3 m/day and vertical hydraulic conductivity of 0.1 m/day is applied to the spoil. The storage parameters used for the spoil were a specific yield of 0.1 and a storage coefficient of 1.0 x 10-5.

#### 2.4.6.2 Variation in Hydraulic Properties - Longwall Mining

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

**Figure 2-5** provides the detail of fracturing applied in the groundwater model in the layers above the longwall panels. This is mainly derived from a subsidence report recently completed by Minserve (2022) for Saraji East Underground Mine. Below are the major findings from the subsidence report (Minserve, 2022):

- When overburden thickness is less than 300m above the target D coal seam, the subsidence modelling results show continual volumetric strain and rock mass damage in the overburden strata extending from longwall edge to the surface. Shear cracks at the surface are predicted to form to a depth of 30m to 70m below the ground level.
- When the overburden thickness is more than 300m, the results indicate that the fractured zone extends to 30m to 50m above the Harrow Creek seam (H Seam, layer 16 in the groundwater model). The overlying units will be undamaged rock mass.

Longwall mining also induces shallow tension cracks, which are predicted to extend to a maximum depth of 15m below ground level.

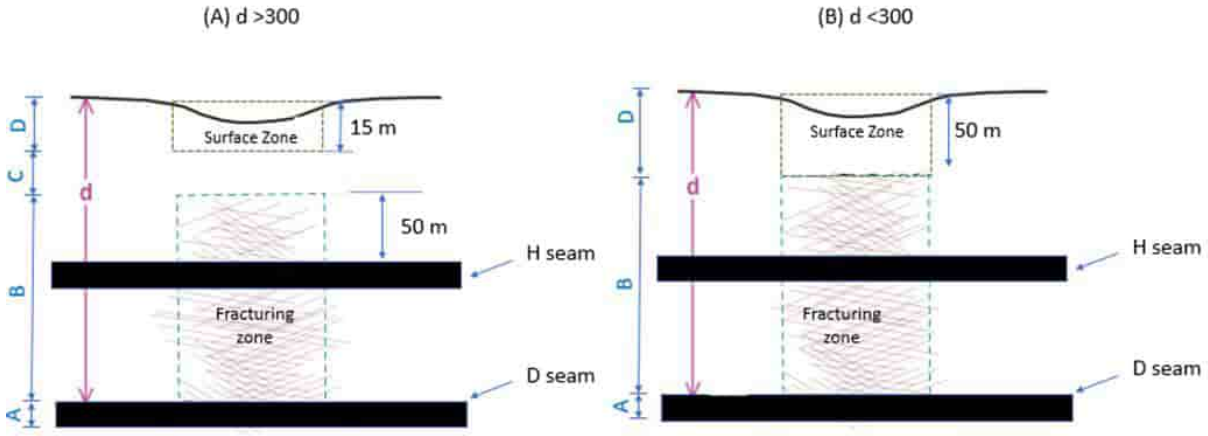



**Figure 2-5 Details of Fracture Zone**

A = Mined zone, B = Fracture Zone, C = Constrained Zone, D = Surface cracking

Based on the above subsidence findings, two different fracture zones were developed in the model; one for where the longwalls have an overburden thickness > 300m, and another where the longwalls have an overburden thickness < 300m. With respect to deeper longwalls (overburden thickness > 300 m), it was assumed that the fracture zone generally extends to 50m above the Harrow Creek seam (H Seam) and the surface cracking occurs up the depth of 15m. Over shallower longwalls (i.e., overburden thickness < 300m), the surface cracking extend to a depth of 50m. It was assumed here that the fracturing occurs above the longwall up to the surface cracking zone.

**Table 2-4** shows the hydraulic parameter changes applied within the goaf induced fracture and surface shear crack zones. The values are the average numbers being used in the groundwater modelling to simulate the fracturing above the coal seam. In this study, it was assumed that any change to hydraulic and storage properties will be kept until the end of model predictive run, (i.e., there is no 'self-sealing of subsidence fracturing over time). This approach is considered to be conservative given that the overlying Tertiary sediments, particularly those at the surface zone, usually swell and self-seal over time, and therefore any surface cracks fill with sediments reducing their hydrological effect over time.

**Table 2-4 Hydraulic Parameter Changes Within the Fracture Zone**

| Conceptual zone | Zone (refer Figure 2-5) | Change in the hydraulic properties |
|---|---|---|
| Surface Cracking | D | HK_host no change<br>VK_host*10 |
| Constrained Zone | C | No change |
| Fractured Zone | B | HK_host*3<br>VK_host*100 |
| Mined Zone (Extracted seam) | A | HK 100 m/day<br>VK 100 m/day<br>Sy 0.16 |

#### 2.4.6.3 Simulation of Incidental Mine Gas Extraction

Gas extraction from CSG operators is not simulated in the model.

## 2.5 Timing

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

- A steady state model with one stress period to simulate the water levels pre-mining.
- A transient warm-up model with one 20-year stress period from January 1988 to December 2007.
- A transient calibration model with 56 quarterly stress periods from December 2007 to December 2021.
- A transient prediction model with 42 stress periods from December 2021 to December 2095.

The first stress period of the model was steady state and did not include any mining. The transient warm-up model was built to incorporate pre-2008 mining activities and their impacts on groundwater levels around the Project. The warm-up model provided appropriate starting conditions for the calibration model (i.e., starting heads and hydraulic properties). Together, the steady state, warm-up and transient calibrations comprise 58 stress periods.

A summary of the calibration validation model stress periods and simulated active mine timings is shown in **Appendix D**. The first stress period of the warm-up model was steady state and did not include any mining. This was to simulate the pre-mining conditions within the model domain.

A transient predictive simulation was then developed to commence from the end of the transient calibration period (January 2022) and extending to the end of 2095.

To assist the model in overcoming the numerical difficulties, MODFLOW-USG Adaptive Time-Stepping (ATS) option was used. The ATS option of MODFLOW automatically decreases time-step size when the simulation becomes numerically difficult and increases it when the difficulty passes. The minimum time step size used in the simulations was 1 day.

## 2.6 Calibration

### 2.6.1 Calibration Method

The previous version of the model was calibrated using PEST++ and, upon review of model calibration statistics after the updates for the Project, was considered still reasonably calibrated.

### 2.6.2 Groundwater Levels

As reported for the previous version of the model, the groundwater levels recorded between January 2008 to December 2021 were used for the calculation of Scaled Root Mean Square (SRMS, a measure of fit between observed data and model simulated results). In all, 3,449 target heads were established for 281 bores from the following sites:

- SRM/Grevillea: included 34 groundwater level observation sites and VWPs (vibrating wire piezometers).
- Lake Vermont: included 30 groundwater level observations sites and VWPs.

- Winchester South: 16 bores including 2 VWPs.
- Olive Downs Project: included 38 groundwater level observations sites and VWPs.
- Peak Downs Mine: included 6 bores.
- Caval Ridge Mine: comprised 33 bores including VWPs.
- Other sites: 124 other bores, including available data from Moorvale South Mine, Millennium Mine, Lake Vermont Meadowbrook Mine, Eagle Downs Mine, Poitrel Mine, Daunia Mine, Moranbah South Mine and some Queensland Globe bore monitoring observations.

Groundwater targets were selected where:

- Valid information on bore construction or geology information was available for the site.
- Targets were manually reviewed to ensure the measurements were realistic.

During calibration, each groundwater bore was assigned a weight of 1, and the weight for each observed water level was calculated by dividing 1 by the number of groundwater levels recorded at each bore. Details on each of the observation points and their residuals are presented in **Appendix A** of this report. The locations of these bores are identified in **Figure 2-6**.

The hydraulic properties (i.e., horizontal, vertical conductivity, specific yield, and specific storage) and recharge rates were adjusted during the calibration to provide best match between the groundwater level measurements and model simulated heads.

### 2.6.3 Calibration Statistics

The overall transient calibration statistics are presented in **Table 2-5** for the best calibrated model. One of the industry standard methods to evaluate the calibration of the model is to examine the statistical parameters associated with the calibration. This is done by assessing the error between the modelled and observed (measured) water levels in terms of the root mean square (RMS). An RMS is expressed as:

$$RMS = \left[1/n \sum (h_o - h_m)_i^2\right]^{0.5}$$

where: n = number of measurements

$h_o$ = observed water level

$h_m$ = simulated water level

RMS is considered to be the best measure of error if errors are normally distributed. The RMS error calculated for the calibrated model is 8.9 m.

The acceptable value for the calibration criterion depends on the magnitude of the change in heads over the model domain. If the ratio of the RMS error to the total head change in the system is small, the errors are considered small in relation to the overall model response(s). The total measured head change across the model domain is 156 m; therefore, the ratio of RMS to the total head change (i.e., SRMS) is 5.9 %. While there is no recommended universal SRMS error, the Australian Groundwater Modelling Guidelines suggests that setting SRMS targets such as 5 % or 10 % may be appropriate in some circumstances (Barnett et al., 2012).

**Table 2-5 Calibration Statistics – Best Calibrated Model**

| Statistic | Value |
|---|---|
| Sum of Squares ($m^2$) | 275362.7 |
| Mean of Squares (m) | 79.8 |
| Root of Mean of Squares (RMS) (m) | 8.9 |
| Scaled Root Mean Square (SRMS) (%) | **5.9** |
| Sum of Residuals (m) | 23025.2 |
| Mean Residual (m) | 6.7 |
| Scaled Mean Residual (%) | 4.4 |
| Coefficient of Determination (tend to unity) | 1.2 |
| Targets within ±2m (% of total) | 740 (21%) |
| Targets within ±5m (% of total) | 1728 (50%) |
| Targets within ±20m (% of total) | 3327(96%) |

**Figure 2-6** presents the observed and simulated groundwater levels graphically as a scattergram for the historic transient calibration (2008 to 2022).

**Figure 2-7** shows the observed and simulated groundwater levels graphically only for the SRM/Grevillea bores. The RMS for the SRM/Grevillea bores is 8.4 m, which is lower than the RMS for the entire model (8.9 m) indicating slightly better local calibration performance.

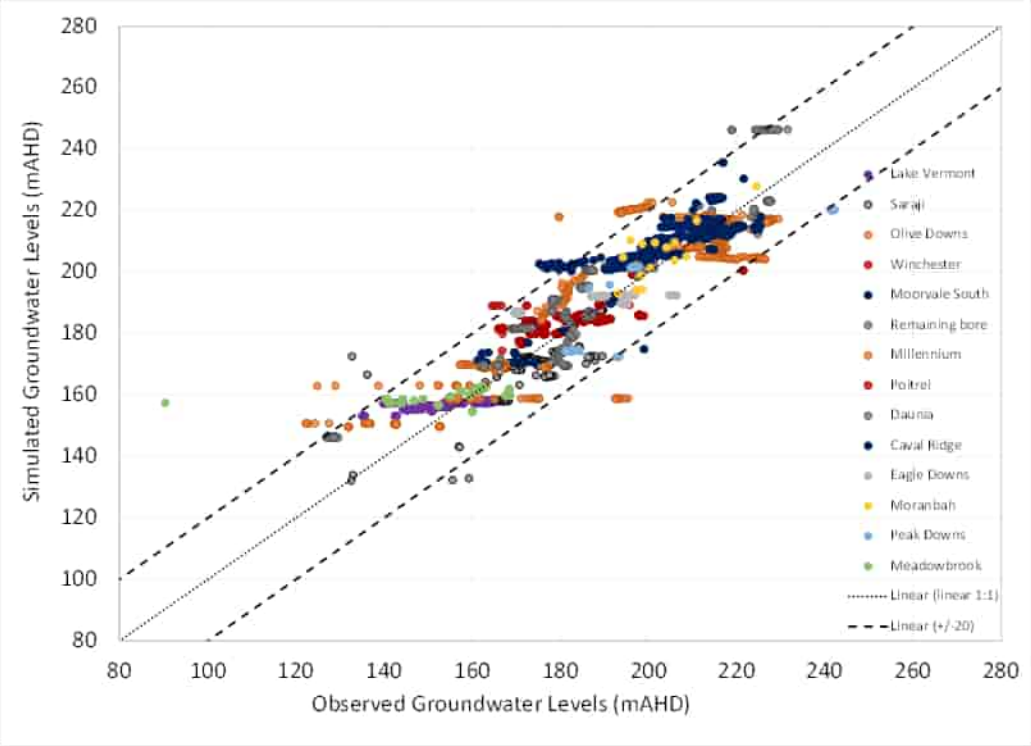



**Figure 2-6 Calibration Scattergram – Modelled vs Observed Groundwater Levels (All Bores)**

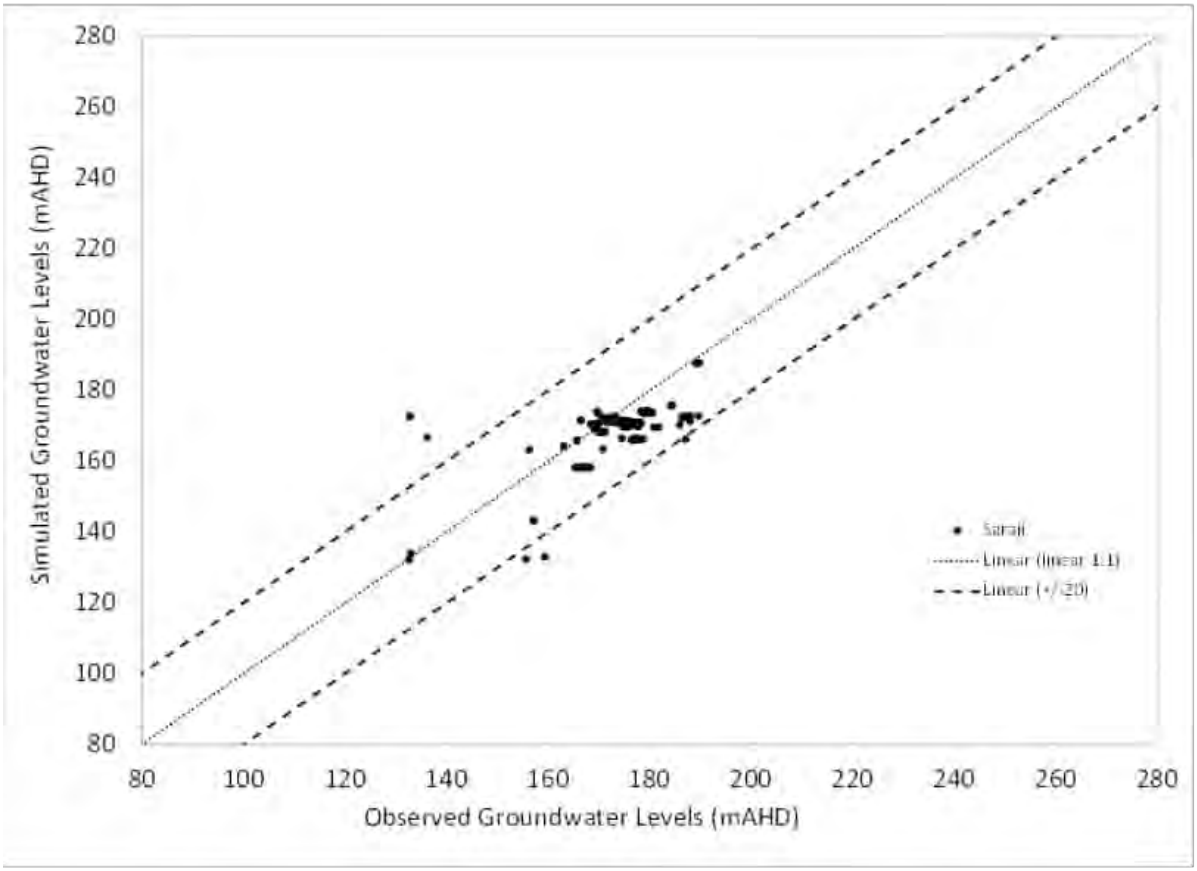



**Figure 2-7 Calibration Scattergram – Modelled vs Observed Groundwater Levels (SRM Bores)**

**Figure 2-8** shows the distribution of calibration residuals for the entire model. As shown in the figure, the calibration residuals in the majority of the calibration data points are within ± 20m. **Figure 2-8** indicates that in general the model tends to slightly over predict groundwater levels, but **Figure 2-7** suggests a tendency to underpredict groundwater levels in the SRM area.

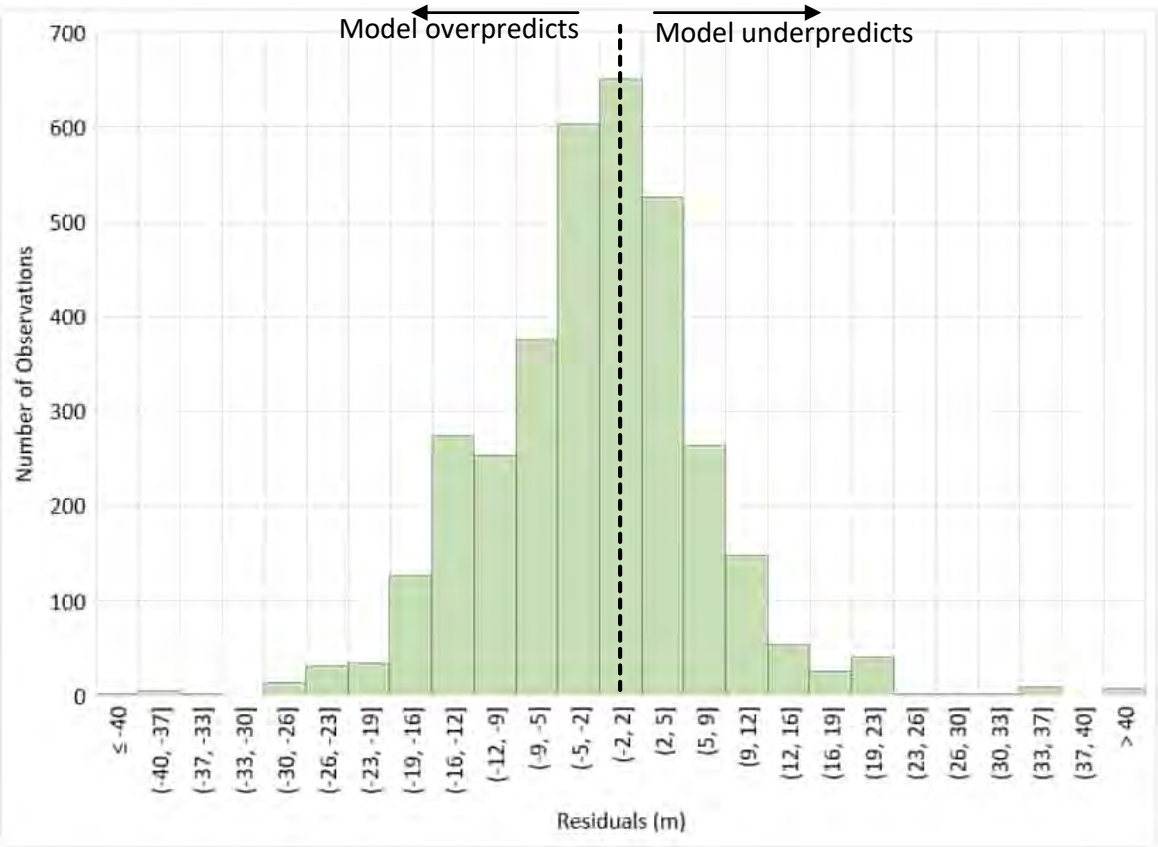



**Figure 2-8 Calibration Residual Histogram Scattergram**

**Table 2-6** shows the average calibration residual and absolute average residual per model layer. The residual is the difference between the measured and the modelled water level at each bore. A negative residual represents an over estimation of water levels, while a positive residual represents an underestimate. **Table 2-6** shows an overall overestimation of water levels in the model layers across the model domain. The table shows layer 3 has the highest absolute average residual and layer 15 has the highest average residual. The table also shows that overall the simulated groundwater levels are closer to the observed groundwater levels in the model layers representing the Moranbah Coal Measures (layers 12 to 18), excluding layer 15 which has a small number of observation bores (5).

**Table 2-7** shows the average calibration residual and absolute average residual per each site within the model domain. As indicated in the table, there is an average overestimation of 6.7 m in the bores. The table shows the PDM bores have the highest average absolute residuals.

**Table 2-6 Average Residual by Model Layer**

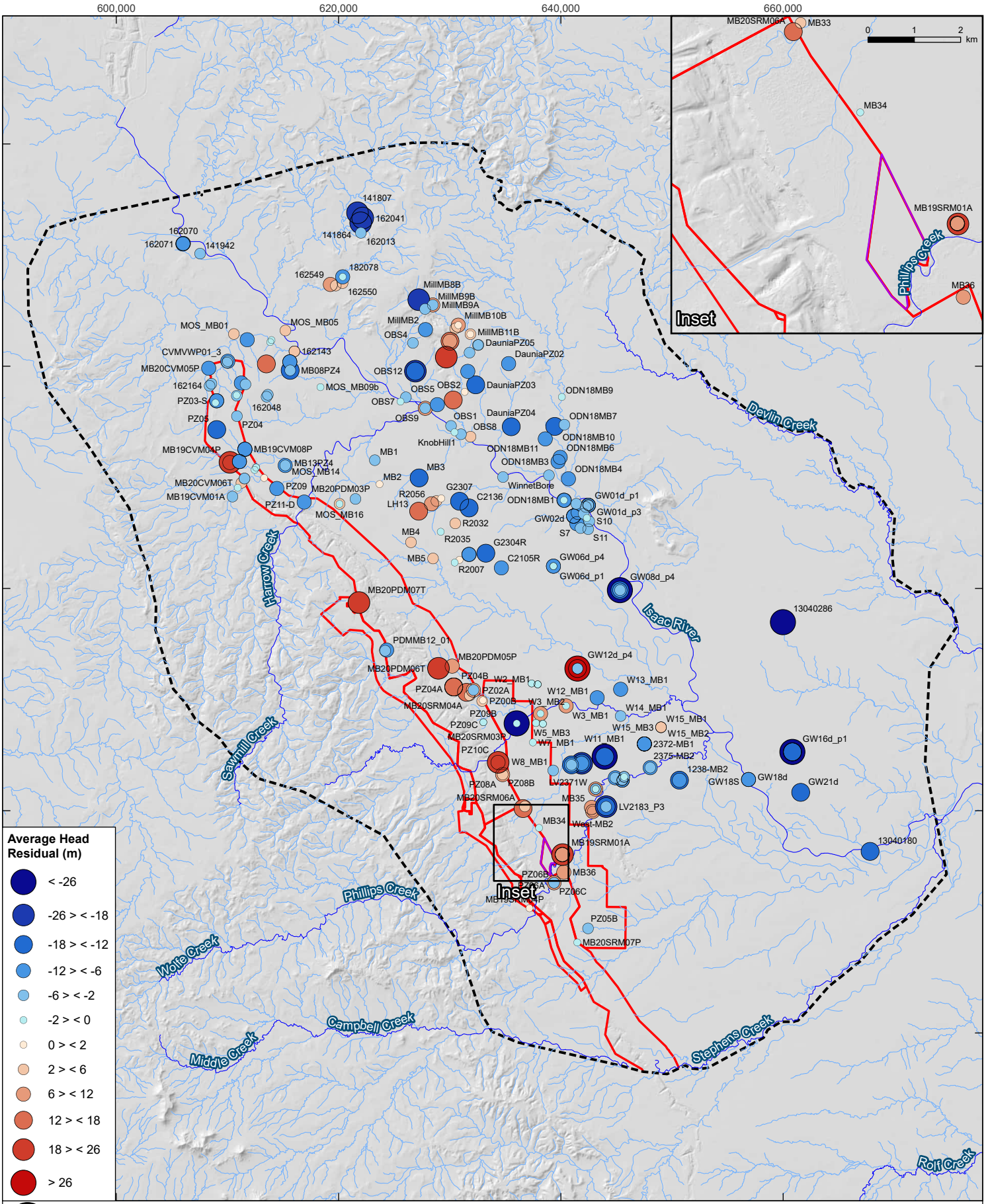
| Model Layer | Formation | Unit | Average Residual (m) | Average Absolute Residual (m) | Number of Observation Targets | Number of bores |
|---|---|---|---|---|---|---|
| 1 | Alluvium, colluvium, Tertiary basalt | Surface cover | -5.1 | 5.8 | 212 | 18 |
| 2 | Tertiary sediments, Tertiary basalt | Tertiary and minor Triassic Clematis, weathered Permian, Tertiary basalt | 2.3 | 6.3 | 910 | 93 |
| 3 | Rewan Group | Triassic | -6.0 | 17.6 | 153 | 15 |
| 4 | Rangal Coal Measures | Leichhardt overburden | -4.6 | 6.8 | 251 | 10 |
| 5 | | Leichhardt seam | -2.3 | 7.0 | 358 | 28 |
| 6 | | Interburden | -7.2 | 9.2 | 123 | 6 |
| 7 | | Vermont seam | -7.4 | 9.3 | 259 | 23 |
| 8 | | Vermont underburden | -7.2 | 7.8 | 175 | 5 |
| 9 | Fort Cooper Coal Measures | Fort Cooper overburden | 1.3 | 3.8 | 338 | 23 |
| 10 | | Fort Cooper seams (combined) | 2.9 | 9.3 | 90 | 10 |
| 11 | | Fort Cooper underburden | 6.8 | 7.3 | 29 | 4 |
| 12 | Moranbah Cooper Coal Measures | Q Seam | 0.0 | 2.6 | 117 | 3 |
| 13 | | Interburden | -2.1 | 4.5 | 39 | 2 |
| 14 | | P Seam | -2.5 | 6.0 | 99 | 6 |
| 15 | | Interburden | -10.4 | 10.4 | 66 | 5 |
| 16 | | H Seam | -3.7 | 6.0 | 85 | 14 |
| 17 | | Interburden | -5.6 | 9.5 | 7 | 3 |
| 18 | | D Seam | -4.7 | 6.5 | 138 | 14 |
| 19* | | Interburden | - | - | - | - |

**Table 2-7 Average Residual by Project**

| Site | Average Residual (m) | Average Absolute Residual (m) | Number of Observation Targets | Number of Bores |
|---|---|---|---|---|
| Lake Vermont | -0.8 | 9.3 | 353 | 31 |
| Saraji \ Grevillea | 6.1 | 7.0 | 237 | 35 |
| Caval Ridge | -3.2 | 5.6 | 599 | 33 |
| Olive Downs South | -4.0 | 9.2 | 212 | 38 |
| Winchester South | -2.9 | 5.1 | 488 | 16 |
| Other Monitoring Bores | -3.9 | 8.6 | 232 | 27 |
| Moorvale South | -5.7 | 6.6 | 21 | 13 |
| Millennium | 0.7 | 9.4 | 297 | 12 |
| Poitrel | -2.8 | 5.3 | 324 | 11 |
| Daunia | -6.6 | 7.1 | 333 | 9 |
| Eagle Downs | -0.9 | 6.7 | 220 | 6 |
| Moranbah | -3.3 | 5.1 | 15 | 15 |
| Peak Downs | 11.4 | 14.1 | 41 | 6 |
| Lake Vermont Meadowbrook | -3.2 | 5.7 | 77 | 30 |

The spatial distribution of average residuals for each bore from the transient calibration is shown in **Figure 2-9.**

.


600,000
620,000
640,000
660,000
7,580,000
7,560,000
7,540,000
7,520,000
7,500,000
Inset
0 1 2 km
MB20SRM06A
MB33
MB34
MB19SRM01A
MB36
Phillips Creek
Average Head Residual (m)
< -26
-26 > < -18
-18 > < -12
-12 > < -6
-6 > < -2
-2 > < 0
0 > < 2
2 > < 6
6 > < 12
12 > < 18
18 > < 26
> 26
Devlin Creek
Harrow Creek
Isaac River
Sawmill Creek
Phillips Creek
Wolfe Creek
Campbell Creek
Middle Creek
Stephens Creek
Rolf Creek
0 5 10 km
LEGEND
Minor Drainage System
Major Drainage System
Mining Lease
Model Boundary
Project Area
Coordinate System: GDA 1994 MGA Zone 55
Scale: 1:450,000 at A4
Project Number: 620.040484.00001
Date Drawn: 12-Sep-2024
Drawn by: RB
SARAJI MINE GREVILLEA PIT CONTINUATION PROJECT MODELLING TECHNICAL REPORT
TRANSIENT CALIBRATION AVERAGE HEAD RESIDUALS (M)
SLR
DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.
FIGURE 2-9
Path: H:\Projects-SLR\620-BNE\620-BNE\620.040484.00001 Saraji Mine Grevillea GW Model\06 SLR Data\01 CADGIS\GIS\ArcPro\GW Modelling\GW Modelling.aprx\620040484 MOD F02-9 Transient Calibration Average Head Residuals (m)

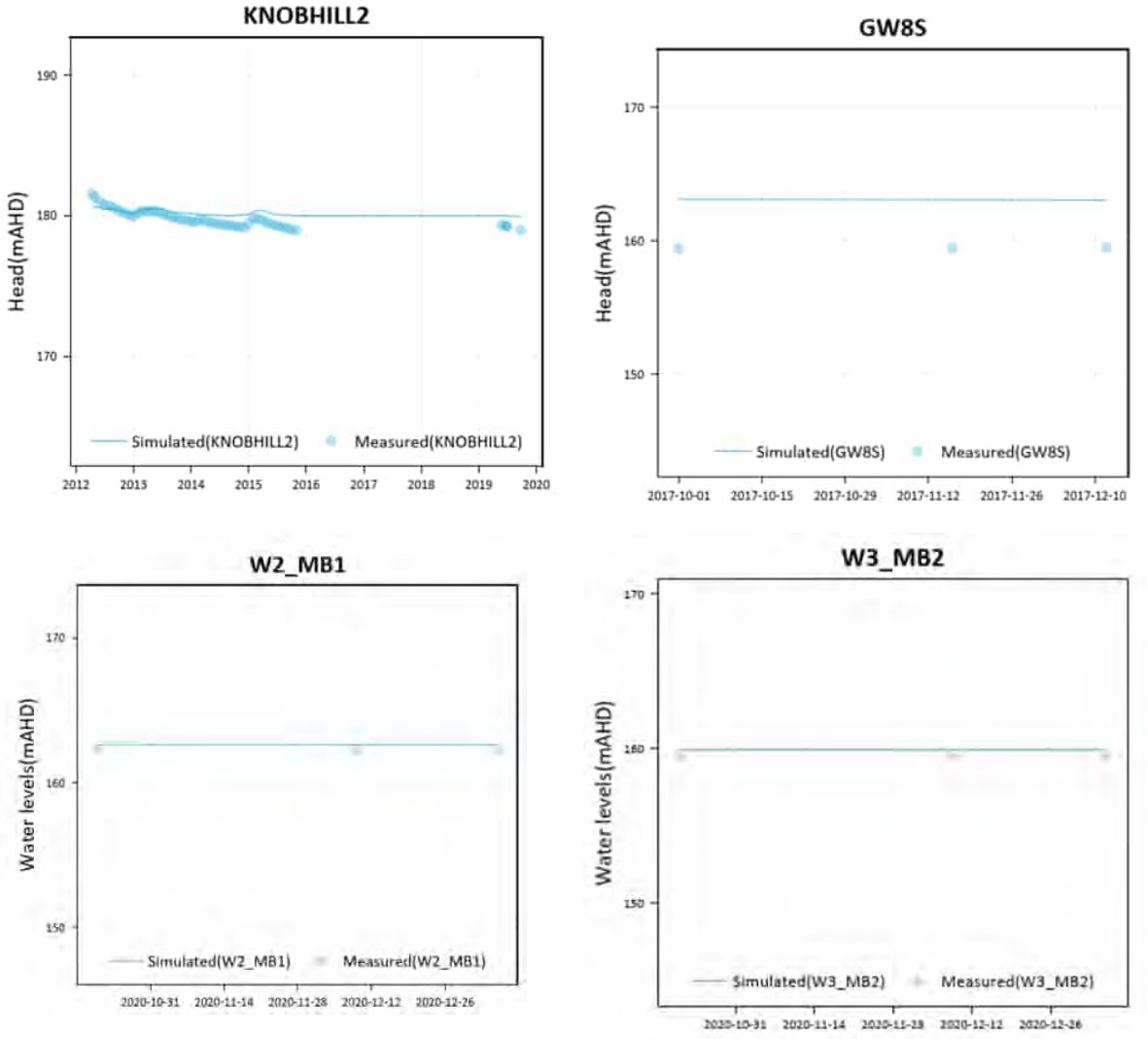
### 2.6.4 Calibration Fit

This section provides discussion on the modelled to observed groundwater level trends (calibration hydrographs) for key bores across the SRM and Grevillea sites. Calibration hydrographs for the full calibration dataset is presented as **Appendix B**.

#### 2.6.4.1 Alluvium and Tertiary

It should be noted here that there are no bores screened in Alluvium within the Grevillea area noting that this is a relatively small area in the context of the entire model domain. In order to show how the model simulates water level within alluvium, two Isaac alluvium bores were selected and shown in **Figure 2-10**. The two bores are GW08S and Knob Hill 2 close to Olive Downs and Winchester South mines respectively, with the distance of approximately 23 km and 37 km from the Project. As the graphs indicate there is a good match between the observation and simulation, including to some extent, the water level fluctuations due to climatic variation in Knob Hill 2.

**Figure 2-10** also presents the fit between simulated and observed heads in the four bores (W2_MB1, W3_MB2, PZ00C and PZ00B) within the Tertiary sediments. The hydrographs for bores W2_MB1 and W3_MB2 located northeast of the Project (**Figure 2-9**) show a very close match between simulated and measured groundwater levels.



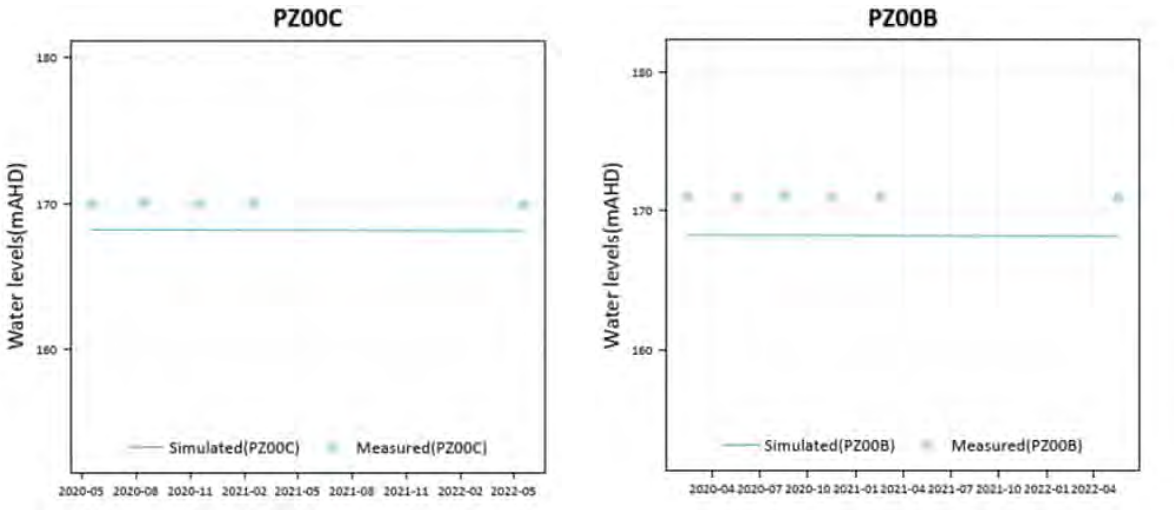



**Figure 2-10 Calibration Fit - Alluvium Bores**

The hydrograph for PZ00C and PZ00B located northwest of the Project shows the model slightly under predicts the groundwater levels at these bores by around 4.0 m. As shown in the hydrographs in **Appendix B**, regionally there is a good match between the simulated and measured groundwater levels in alluvial bores such as Olive Downs S series, Winchester South ODN series, Knob Hill 1 and Knob Hill 2.

### 2.6.4.2 Permian Coal Measures

The bores screened in the Permian Coal Measures within Grevillea have not been subject to monitoring for a significant period of time. Consequently, there is limited availability of water level information for Permian Coal Measures within the Grevillea Project area.

**Figure 2-11** shows the water levels in the Permian Coal Measures, specifically in the D, Q, P, and H seams. Given the lack of water level data in Grevillea and to demonstrate the impact of mining on water levels within the Permian Coal Measures, two bores (i.e., PZ01 and PZ07D were chosen and are shown in **Figure 2-11**. The simulation results indicate that the water level decline attributable to mining activities was successfully reproduced in PZ01. PZ01 is located 25 km northwest of the Project. Furthermore, model outputs for PZ07D demonstrate that the model can replicate the minor water level decrease at this bore following 2016. PZ07D is located northwest of the Project.

MB34 is located 2km northwest of the Project. The modelling results indicate the model can simulate the gradual decline observed in water level between 2016 and 2022.

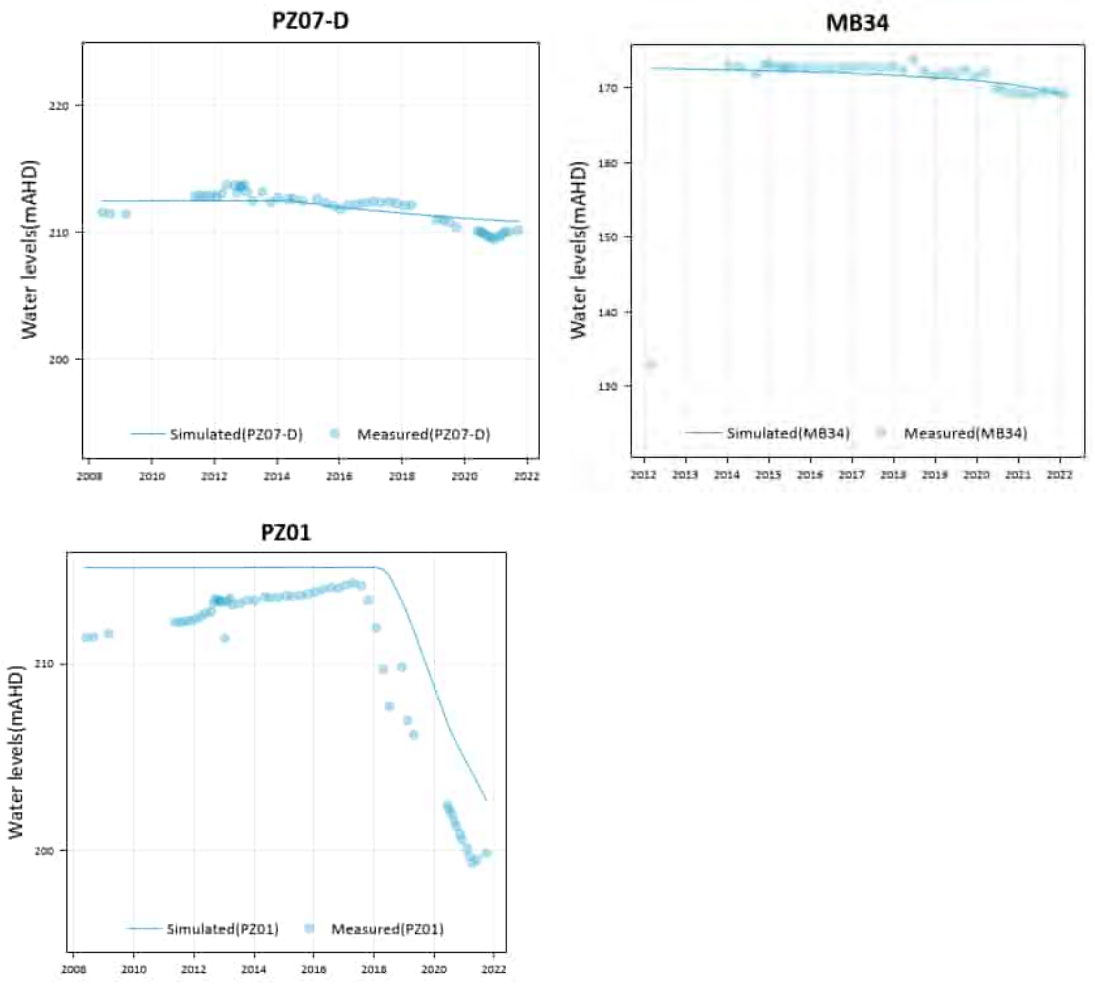



**Figure 2-11 Calibration Fit - Permian Bores (D,Q, P and H seams)**

### 2.6.4.3 Bores in Other Formations

**Figure 2-12** shows the hydrographs for other site monitoring bores including the basalt and regolith bores. The hydrographs show that the model results in a reasonable (± 10 m) fit between modelled and observed groundwater levels (PZ06-S, PZ12-S, R2008 and OBS10).

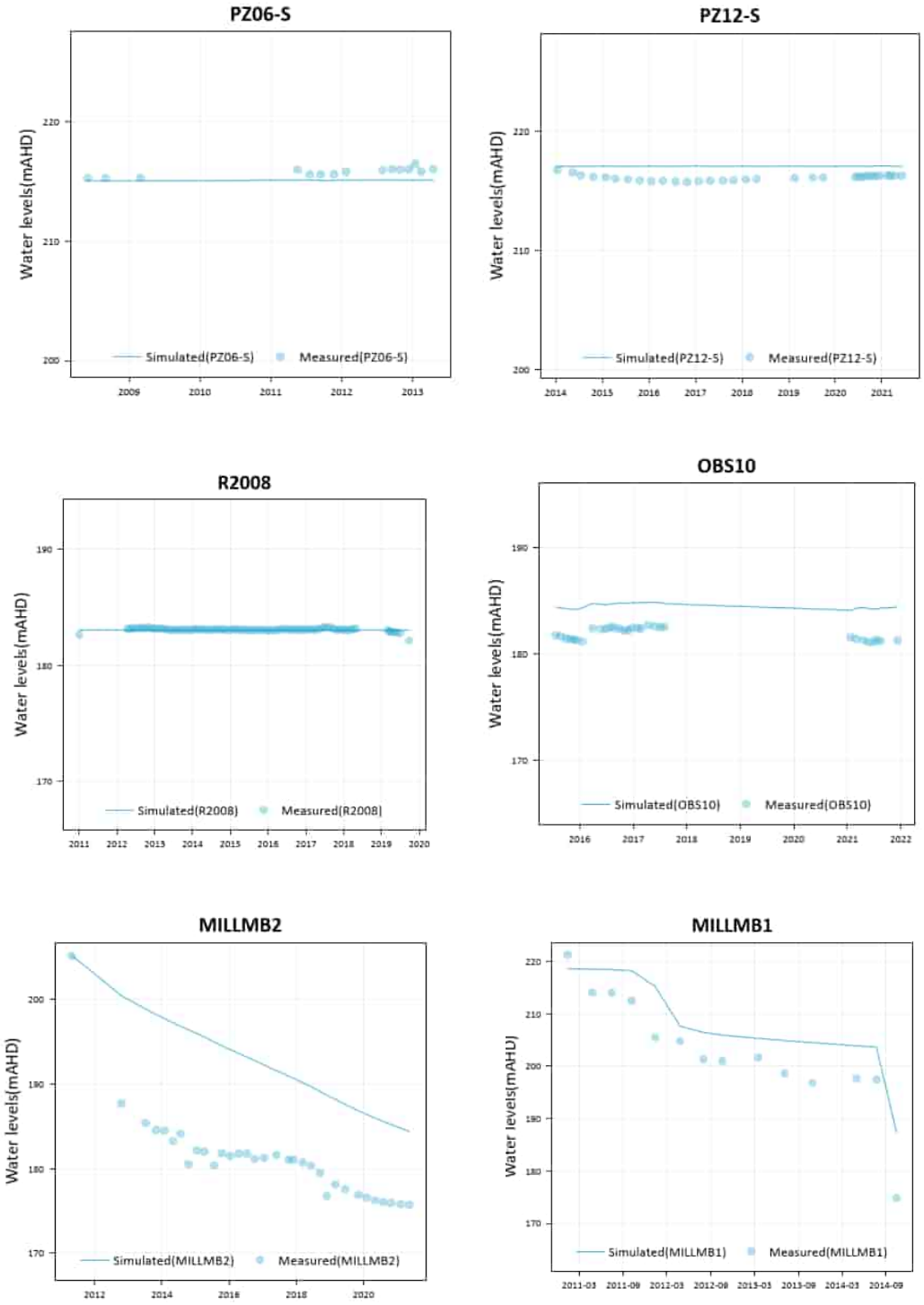



**Figure 2-12 Calibration Fit - Other Bores**

### 2.6.5 Model Water Balance

#### 2.6.5.1 Steady State Calibration

The water balance for the steady state model calibration is shown in **Table 2-8**. The water balance for the steady state model indicates that recharge was the largest net inflow contributor to the steady state model (4.2 ML/d). Regional groundwater inflow and outflow are 2.2 ML/d and 0.2 ML/d, respectively, indicating that groundwater enters the model domain through this boundary.

A net outflow of 2.3 ML/d from the steady state model occurs due to baseflow seepage to the Isaac River (i.e. surface water and groundwater interaction in the Isaac River). Other factors that contribute to outflow from the groundwater system are evapotranspiration (3.1 ML/d outflow) and baseflow seepage to minor drainage systems (0.8 ML/d outflow). The mass balance error for the steady state calibration is less than 0.01 %, within the error threshold recommended by the Australian Groundwater Modelling Guidelines (Barnett et al., 2012), and indicating the model is stable and achieves an accurate numerical solution.

**Table 2-8 Steady State Model Water Balance**

| Component | Inflow (ML/d) | Percent of Total Inflow (%) | Outflow (ML/d) | Percent of Total Inflow (%) |
|---|---|---|---|---|
| Recharge (RCH) | 4.20 | 29.92 | 0.00 | 0.00 |
| ET (from GW) (EVT) | 0.00 | 0.00 | 3.09 | 22.03 |
| SW-GW Interaction Isaac River (RIV) | 7.63 | 54.36 | 9.97 | 71.06 |
| SW-GW Interaction Phillips Creek (RIV) | 0.00 | 0.00 | 0.006 | 0.05 |
| SW-GW Interaction other rivers (RIV)* | 0.00 | 0.00 | 0.75 | 5.35 |
| Regional GW Flow (GHB) | 2.21 | 15.72 | 0.21 | 1.51 |
| Mines (DRN) | 0.00 | 0.00 | 0.00 | 0.00 |
| Storage | 0.00 | 0.00 | 0.00 | 0.00 |
| Total | 14.03 | 100.00 | 14.03 | 100.00 |

* The other tributaries or drainage lines in the model are set as drains to the groundwater system and do not result in any recharge.

#### 2.6.5.2 Transient Calibration

The model water balance for the transient simulation averaged over the duration of the calibration period is presented in **Table 2-9**. The mass balance error, that is the difference between calculated model inflows and outflows at the completion of the transient calibration, was 0.00 %, which indicates the model is stable and achieves an accurate numerical solution. **Table 2-9** shows 3.1 ML/d is lost to evapotranspiration in areas where the water table is within 2 m of the land surface. In total 11.4 ML/d is discharged via surface drainages, with the vast majority of that attributed to the Isaac River. A net flow loss of approximately 2.5 ML/d occurs to the Isaac River (reach within the model domain) indicates a net gaining condition in the river in the calibration period.





**Table 2-9 Transient Model Water Balance**

| Component | Inflow (ML/d) | Percent of Total Inflow (%) | Outflow (ML/d) | Percent of Total Inflow (%) |
|---|---|---|---|---|
| Recharge (RCH) | 4.89 | 17.92 | 0.00 | 0.00 |
| ET (from GW) (EVT) | 0.00 | 0.00 | 3.11 | 11.40 |
| SW-GW Interaction Isaac River (RIV) | 8.18 | 29.96 | 10.71 | 39.24 |
| SW-GW Interaction Phillips Creek (RIV) | 0.00 | 0.00 | 0.007 | 0.026 |
| SW-GW Interaction other rivers (RIV)* | 0.00 | 0.00 | 0.74 | 2.69 |
| Regional GW Flow (GHB) | 2.26 | 8.27 | 0.22 | 0.81 |
| Mines (DRN) | 0.00 | 0.00 | 5.89 | 21.59 |
| Storage | 11.96 | 43.85 | 6.61 | 24.23 |
| Total | 27.28 | 100.00 | 27.28 | 100.00 |

* The other tributaries or drainage lines in the model are set as drains to the groundwater system and do not result in any recharge.

Other rivers contribute to a loss of approximately 0.74 ML/d from the groundwater system over the transient calibration with no inflow component. The fluxes from the GHB component (inflow and outflow) are 2.3 and 0.2 ML/d respectively. The GHB net inflow is less than 9 % of the total inflow, and the GHB net outflow is less than 1 % of the total outflow. This indicates that a small volume of water enters the model domain through this boundary and therefore, this boundary condition does not have a significant influence on the model predictions.

5.89 ML/d is removed from the model by the drain boundary condition that represents historical mining (1988-2022) in the model. The average simulated historical ingress for major active mines active during the calibration period are:

- SRM – 1.3 ML/d
- PDM – 1.6 ML/d
- CVM – 0.6 ML/d
- Daunia – 0.3 ML/d
- Poitrel – 0.3 ML/d
- Millennium – 0.6 ML/d
- Lake Vermont – 0.6 ML/d.

## 2.7 Calibrated Hydraulic Parameters

**Table 2-10** provides a summary of the model layer parameter values for horizontal and vertical hydraulic conductivity in the best calibrated model. The hydraulic parameter zones in all the model layers are presented in **Appendix C**.

**Table 2-10 Hydraulic Conductivity – Best Calibrated Model**

| Model Layer | Formation | Unit | Horizontal Hydraulic Conductivity (m/day) | Anisotropy Kv/Kx |
|---|---|---|---|---|
| 1 | Isaac River Alluvium | Surface cover | 54 | 0.28 |
| 1 | Regolith | Surface cover | 4.6 | 0.04 |
| 1 | Weathered Permian | Surface cover | 0.35 | 0.4 |
| 1 | Duaringa Formation | Surface cover | 1.8 | 0.4 |
| 1 & 2 | Tertiary Basalt | Tertiary basalt | 2.7 | 0.1 |
| 2 | Regolith | Surface cover | 0.35 | 0.2 |
| 3 | Rewan Group | Triassic | $4.8 \times 10^{-3}$ | 0.5 |
| 4 | Rangal Coal Measures | Leichhardt overburden | $5.0 \times 10^{-5}$ to $8.5 \times 10^{-3}$ | 0.1 |
| 5 | | Leichhardt seam | $1.0 \times 10^{-4}$ to $1.0 \times 10^{-1}$ | 0.15 |
| 6 | | Interburden | $5.0 \times 10^{-5}$ to $8.9 \times 10^{-4}$ | 0.002 |
| 7 | | Vermont seam | $1.0 \times 10^{-4}$ to $1.9 \times 10^{-2}$ | 0.5 |
| 8 | | Vermont underburden | $5.0 \times 10^{-5}$ to $7.6 \times 10^{-3}$ | 0.03 |
| 9 | Fort Cooper Coal Measures | Fort Cooper overburden | $5.0 \times 10^{-5}$ to $6.3 \times 10^{-3}$ | 0.001 |
| 10 | | Fort Cooper seam | $1.0 \times 10^{-4}$ to $3.5 \times 10^{-3}$ | 0.5 |
| 11 | | Fort Cooper underburden | $5.0 \times 10^{-5}$ to $3.5 \times 10^{-3}$ | 0.2 |
| 12 | Moranbah Coal Measures | Q Seam | $1.0 \times 10^{-4}$ to $5.9 \times 10^{-2}$ | 0.003 |
| 13 | | Interburden | $5.0 \times 10^{-5}$ to $1.0 \times 10^{-2}$ | 0.06 |
| 14 | | P Seam | $1.0 \times 10^{-4}$ to $1.0 \times 10^{-1}$ | 1 |
| 15 | | Interburden | $5.0 \times 10^{-5}$ to $1.0 \times 10^{-2}$ | 0.5 |
| 16 | | H Seam | $1.0 \times 10^{-4}$ to $7.4 \times 10^{-2}$ | 0.01 |
| 17 | | Interburden | $25.0 \times 10^{-5}$ to $1.0 \times 10^{-3}$ | 0.2 |
| 18 | | D Seam | $1.0 \times 10^{-4}$ to $4.9 \times 10^{-2}$ | 0.2 |
| 19 | | Interburden | $5.0 \times 10^{-5}$ to $6.6 \times 10^{-5}$ | 0.001 |

The hydraulic conductivity of the Permian interburden material in the Rangal Coal Measures, Fort Cooper Coal Measures and Moranbah Coal Measures reduces with depth to reflect field observations. As the decrease of Kx within the interburden rock units is driven by an increase in overburden pressure, the relationship between Kx and depth is different from that of coal seams. The hydraulic conductivity for the interburden material is capped at a minimum of $5.0 \times 10^{-5}$ m/day and the hydraulic conductivity of the coal seams is capped at a minimum of $1.0 \times 10^{-4}$ m/day.

The hydraulic conductivity of the interburden/overburden and coal seam layers decreases with depth according to Equation 1, Equation 2 (exponential) and Equation 3 (power). Equations 1 and 2 were adopted from the Winchester South Project groundwater model. Equation 3 was suggested by AGE (2016) for the interburden units within the Moranbah





Coal Measures based upon recent studies in the area. With regards to the faults, an exponential equation (Equation 4) was used to replicate changes in hydraulic conductivities of fault at depth.

| | | |
|---|---|---|
| Coal: | $HC = HC0 \times e^{(-0.015 \times depth)}$ | (Eq. 1) |
| Interburden (RCM and FCCM): | $HC = HC0 \times e^{(-0.018 \times depth)}$ | (Eq. 2) |
| Interburden (MCM): | $HC = HC0 \times -2.1^{depth}$ | (Eq. 3) |
| Fault: | $HC = HC0 \times e^{(-0.018 \times depth)}$ | (Eq. 4) |

Where:

- HC is horizontal hydraulic conductivity at specific depth
- HC0 is horizontal hydraulic conductivity at depth of 0 m (intercept of the curve)
- Depth is depth of the floor of the layer (thickness of the cover material)
- Slope is a term representing slope of the formula (steepness of the curve)
- RCM, FCCM and MCM refer to the Rangal, Fort Cooper and Moranbah Coal Measures, respectively.

HC0 was estimated in the calibration. It varies for the coal seams and for the interburden and overburden units in the model. The slope function and coefficient of the coal and interburden depth dependence equations were not calibrated. The Kx vs depth relationships for the interburden/overburden are presented in **Figure 2-13**, while the calibrated relationships for coal units are presented in **Figure 2-14**. The figures present the Olive Downs site data (2018), Winchester South site data, Lake Vermont North site data and Coffey (2014) Bowen Basin data. The AGE (2016) and the hydraulic conductivity measurements in the Moranbah Coal Measures are also shown in the figures. “Caval Ridge Model” refers to the previous version of the numerical model.

**Figure 2-14** presents the lower and upper range for coal horizontal conductivity against depth relationship in Moranbah Coal Measures estimated during the calibration. **Figure 2-14** also shows the coal horizontal conductivity against depth relationship for the Leichhardt and the Vermont Seam of the Rangal Coal Measures.

**Figure 2-15** illustrates the range in horizontal hydraulic conductivity obtained from site testing and publicly available data. The data are focused on the key site units, being the alluvium, regolith, Rewan Group and the coal and interburden sequences of the Rangal and Moranbah Coal Measures. The data are compared to the horizontal hydraulic conductivity values used in the model. A depth dependence equation for the coal measures was used in the numerical groundwater model and therefore the calibrated hydraulic conductivity values vary across the model domain. As shown in **Figure 2-15**, the modelled horizontal hydraulic conductivity values are all within the range of field data.

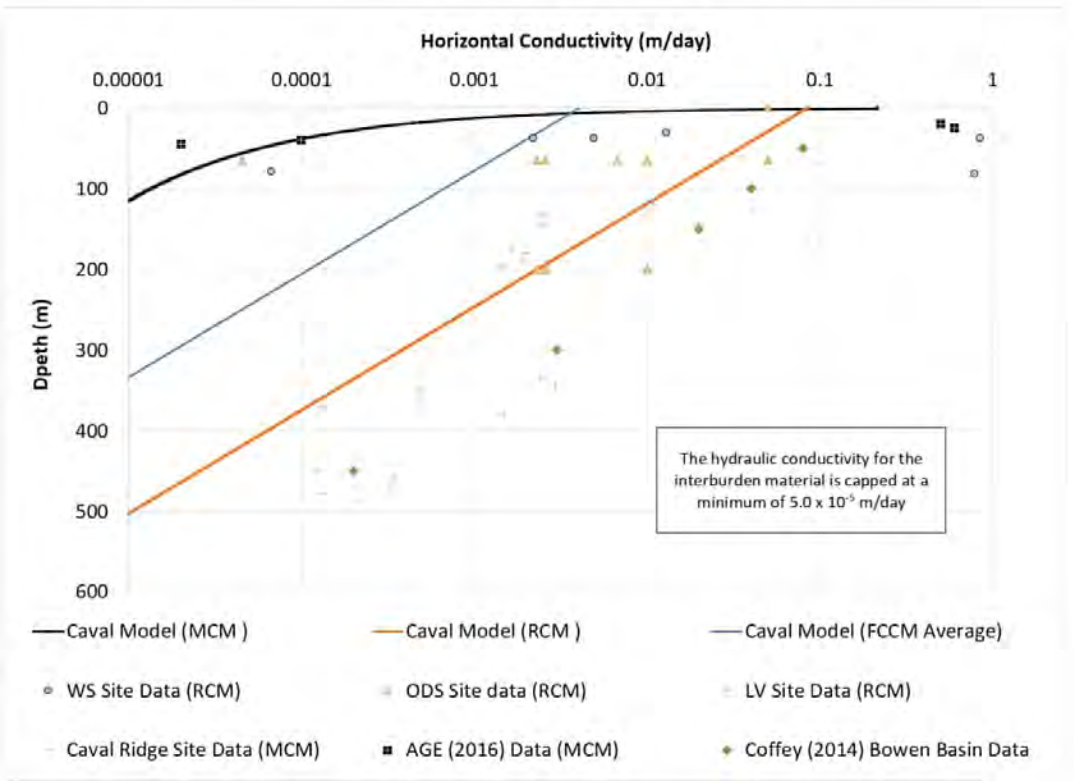



**Figure 2-13 Hydraulic Conductivity vs Depth – Interburden / Overburden**

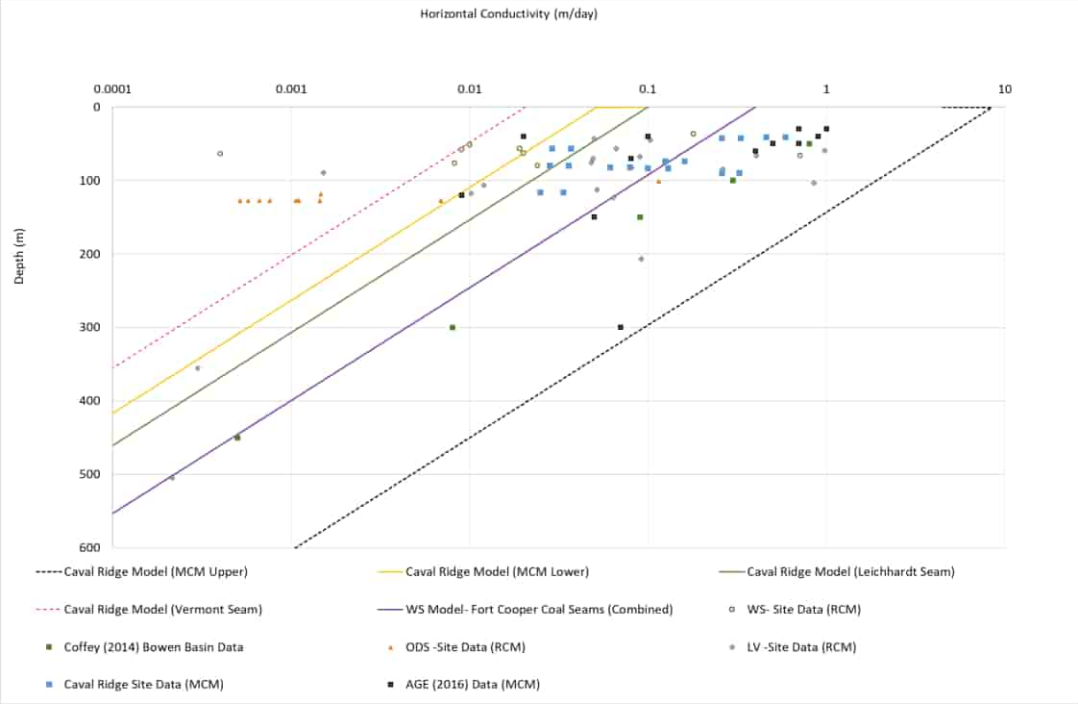



**Figure 2-14 Hydraulic Conductivity vs Depth – Coal**

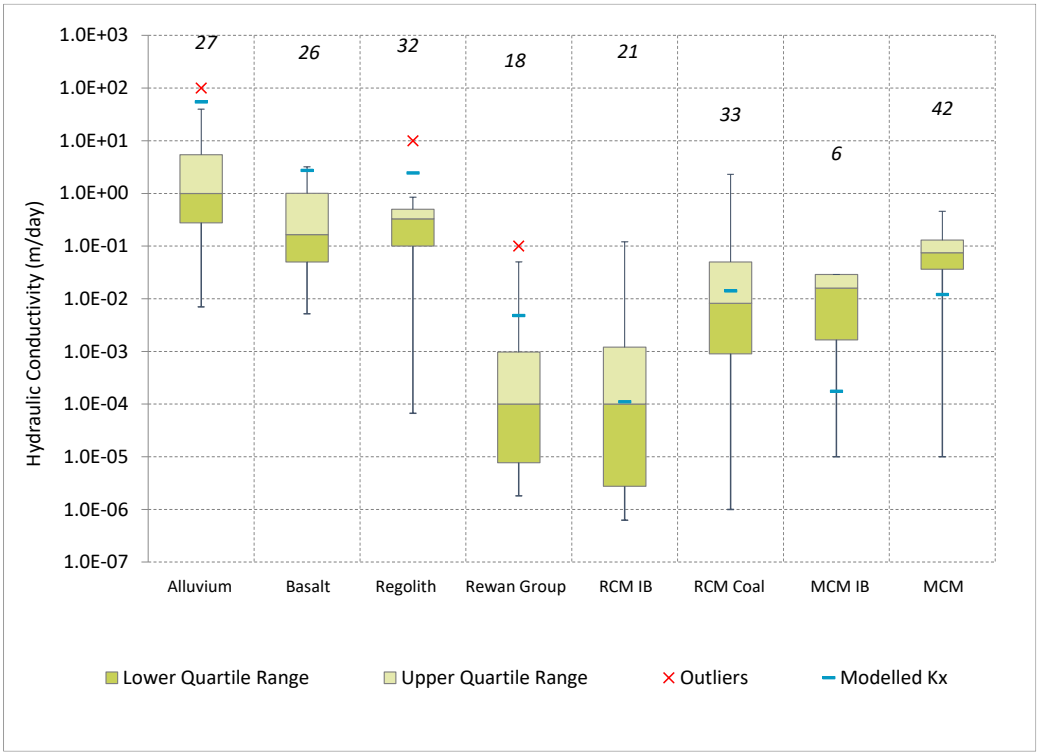



**Figure 2-15 Hydraulic Parameters Estimates vs Best Calibrated Hydraulic Parameters**

In order to show how the hydraulic conductivities changes at depth within the faults, the hydraulic parameters within faults were calculated for each layer and are shown in **Table 2-11**.

**Table 2-11 Hydraulic Conductivity of Faults – Best Calibrated Model**

| Model Layer | Formation | Unit | Average Horizontal Hydraulic Conductivity (m/day) | Anisotropy Kv/Kx |
|---|---|---|---|---|
| 3 | Rewan Group | | $9.8 \times 10^{-3}$ | 0.35 |
| 4 | Rangal Coal Measures | Leichhardt overburden | $9.1 \times 10^{-3}$ | 0.34 |
| 5 | | Leichhardt seam | $9.0 \times 10^{-3}$ | 0.32 |
| 6 | | Interburden | $8.5 \times 10^{-3}$ | 0.30 |
| 7 | | Vermont seam | $8.0 \times 10^{-3}$ | 0.29 |
| 8 | | Vermont underburden | $7.7 \times 10^{-3}$ | 0.27 |
| 9 | Fort Cooper Coal Measures | Fort Cooper overburden | $7.3 \times 10^{-3}$ | 0.35 |
| 10 | | Fort Cooper seam | $6.3 \times 10^{-3}$ | 0.18 |
| 11 | | Fort Cooper underburden | $4.9 \times 10^{-3}$ | 0.12 |
| 12 | | Q Seam | $4.3 \times 10^{-3}$ | 0.17 |

| Model Layer | Formation | Unit | Average Horizontal Hydraulic Conductivity (m/day) | Anisotropy Kv/Kx |
|---|---|---|---|---|
| 13 | Moranbah Coal Measures | Interburden | $4.1 \times 10^{-3}$ | 0.19 |
| 14 | | P Seam | $3.8 \times 10^{-3}$ | 0.19 |
| 15 | | Interburden | $3.7 \times 10^{-3}$ | 0.23 |
| 16 | | H Seam | $3.3 \times 10^{-3}$ | 0.21 |
| 17 | | Interburden | $3.0 \times 10^{-3}$ | 0.22 |
| 18 | | D Seam | $2.6 \times 10^{-3}$ | 0.21 |
| 19 | | Interburden | $1.9 \times 10^{-3}$ | 0.18 |

## 2.8 Calibrated Storage Properties

**Table 2-12** summarises the calibrated values of specific storage and specific yield for the hydrostratigraphic units.

**Table 2-12 Calibrated Storage Parameters – Best Calibrated Model**

| Model Layer | Formation | Unit | Specific Yield Sy (%) | Specific Storage Ss ($m^{-1}$) |
|---|---|---|---|---|
| 1 | Alluvium | Surface cover | 4.2 | $1.0 \times 10^{-5}$ |
| 1 | Regolith | Surface cover | 3.6 | $5.5 \times 10^{-6}$ |
| 1 | Weathered Permian | Surface cover | 1.0 | $1.0 \times 10^{-6}$ |
| 1 | Duaringa Formation | Surface cover | 2.1 | $1.0 \times 10^{-6}$ |
| 1 & 2 | Tertiary Basalt | Tertiary basalt | 3.4 | $1.2 \times 10^{-6}$ |
| 2 | Regolith | Surface cover | 2.8 | $1.0 \times 10^{-6}$ |
| 3 | Rewan Group | Triassic | 4.2 | $7.0 \times 10^{-7}$ |
| 4 | Rangal Coal Measures | Leichhardt overburden | 2.8 | $4.7 \times 10^{-6}$ |
| 5 | | Leichhardt Seam | 0.8 | $9.0 \times 10^{-7}$ |
| 6 | | Interburden | 0.1 | $7.0 \times 10^{-7}$ |
| 7 | | Vermont Seam | 0.2 | $3.1 \times 10^{-6}$ |
| 8 | | Vermont underburden | 0.2 | $1.6 \times 10^{-6}$ |
| 9 | Fort Cooper Coal Measures | Fort Cooper overburden | 0.1 | $7.0 \times 10^{-7}$ |
| 10 | | Fort Cooper seam | 0.5 | $3.2 \times 10^{-6}$ |
| 11 | | Fort Cooper underburned | 0.6 | $1.9 \times 10^{-6}$ |
| 12 | Moranbah Coal Measures | Q Seam | 0.1 | $4.8 \times 10^{-6}$ |
| 13 | | Interburden | 0.4 | $1.7 \times 10^{-6}$ |

| Model Layer | Formation | Unit | Specific Yield Sy (%) | Specific Storage Ss ($m^{-1}$) |
|---|---|---|---|---|
| 14 | | P Seam | 0.1 | $9.0 \times 10^{-6}$ |
| 15 | | Interburden | 0.13 | $1.4 \times 10^{-6}$ |
| 16 | | H Seam | 0.1 | $9.0 \times 10^{-6}$ |
| 17 | | Interburden | 0.32 | $3.4 \times 10^{-6}$ |
| 18 | | D Seam | 0.1 | $9.7 \times 10^{-6}$ |
| 19 | | Interburden | 0.39 | $3.5 \times 10^{-6}$ |
| | Fault | | 0.2 to 3.9 | $7.0 \times 10^{-7}$ to $6.3 \times 10^{-6}$ |
| | Spoil | | 5 | $1.0 \times 10^{-5}$ |

## 2.9 Calibrated Recharge

**Table 2-13** presents the calibrated recharge rates for each geological unit in the model. These calibrated recharge rates have been adopted into the predictive model. The recharge zones in the model layers are presented in **Appendix C**. The mean annual rainfall was assumed to 565 mm/year.

**Table 2-13 Calibrated Rainfall Recharge – Best Calibrated Model**

| Model Geology Zone | (mm/year) | % Mean annual rainfall |
|---|---|---|
| Isaac River Flood Plain Alluvium | 1.3 | 0.24 |
| Isaac River Channel Alluvium | 0.3 | 0.05 |
| Other Alluvium | 0.7 | 0.13 |
| Duaringa Formation | 0.2 | 0.03 |
| Tertiary basalts | 2.3 | 0.4 |
| Weathered Permian | 0.5 | 0.1 |
| Regolith | 0.1 | 0.01 |

**Figure 2-16** compares the calibrated recharge rates in the model against the recharge rates previously estimated using a chloride mass balance (CMB) method for the various units (SLR, 2021a).

As per the conceptual model, higher recharge occurs through the alluvium and lower recharge in regolith and Permian outcrops. Increased recharge through the alluvium of the Isaac River channel has been used to simulate the potential for the Isaac River to provide rapid recharge to the alluvial groundwater system during rainfall events.

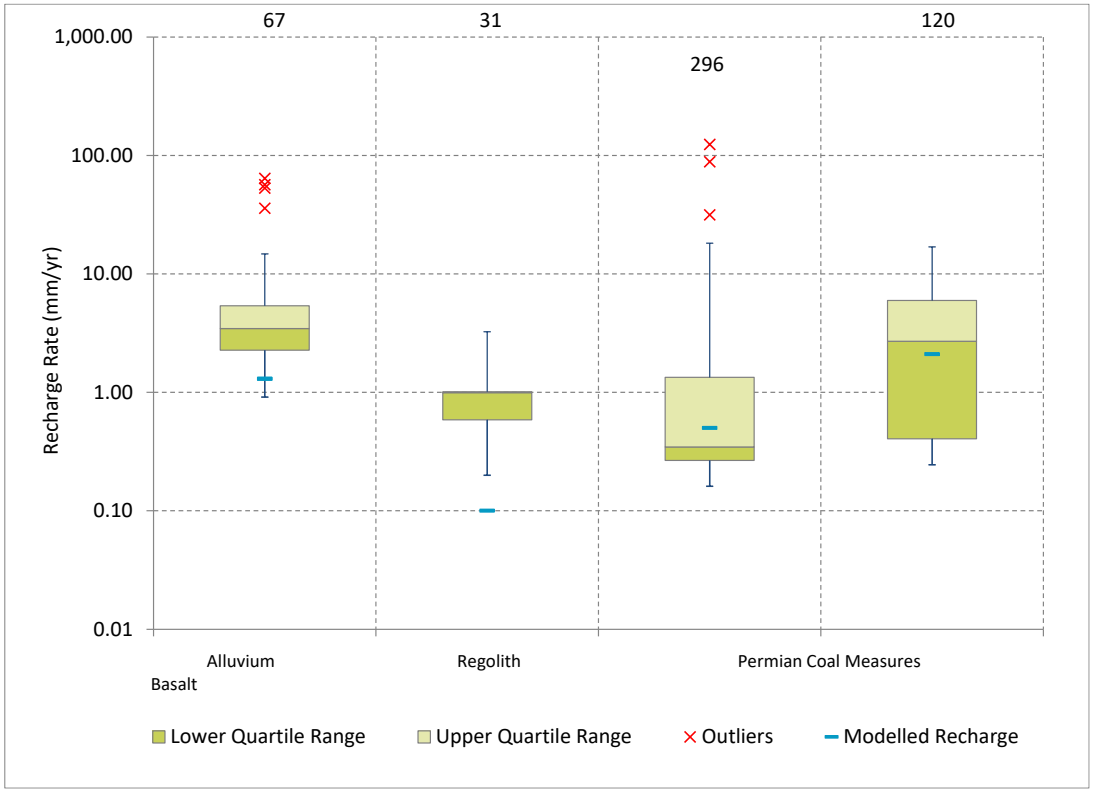



**Figure 2-16 CMB Recharge Estimates vs Modelled Recharge**

# 3.0 Predictive Modelling

## 3.1 Timing and Mining

Transient predictive modelling was used to simulate the proposed mining at the Project as well as mining at other approved and foreseeable mines within the model domain. The predictive part of the model comprises annual stress periods, starting from 2024 until 2054. The predictive model stress period setup is detailed in **Appendix D**, alongside simulated mine timings.

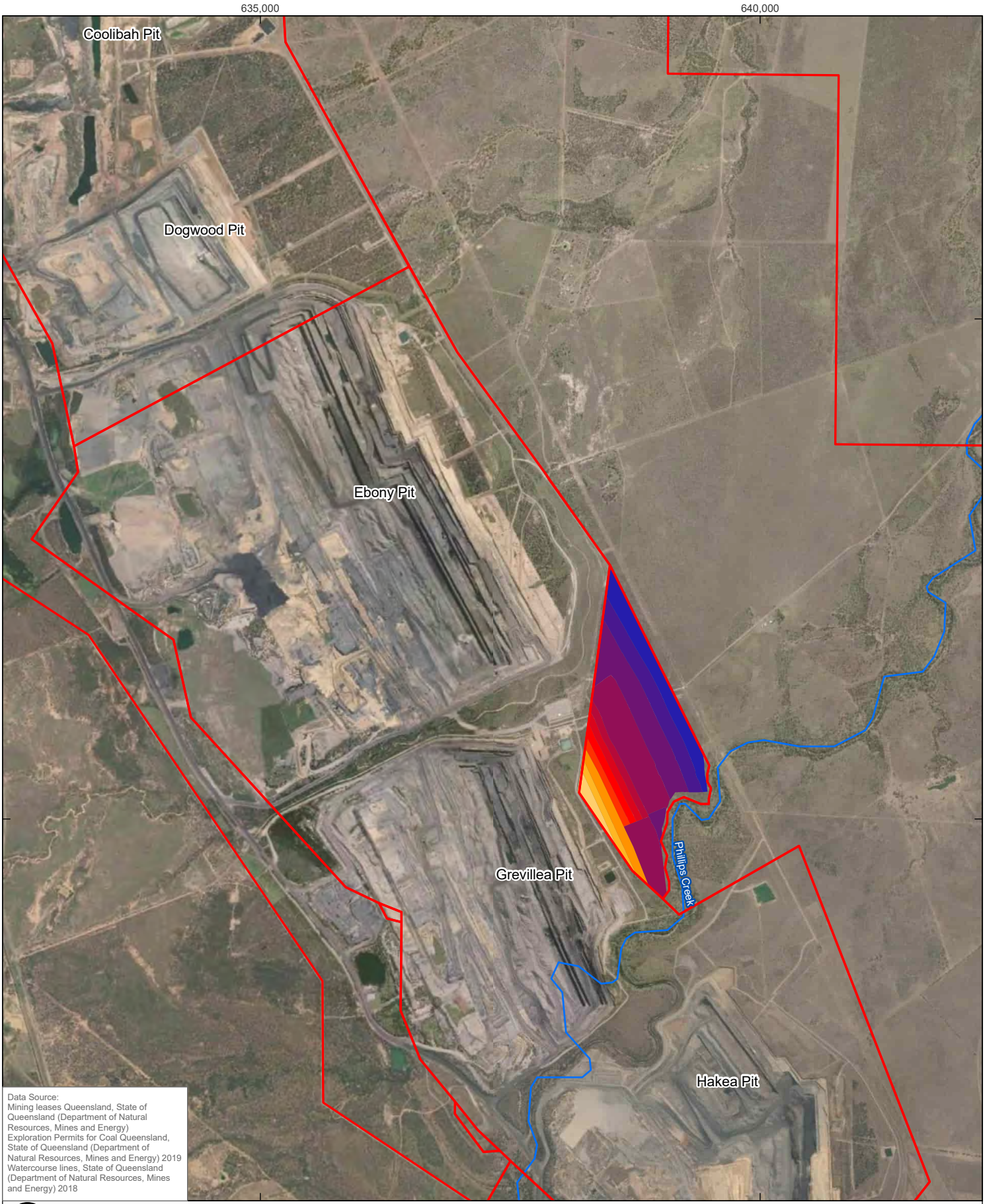
Transient predictive models have been developed for three model scenarios:

- Cumulative – all approved mining in region including SRM open cut plus the Grevillea Project.
- Approved – all approved mining in region includes SRM open cut only i.e. excludes the Grevillea Project.
- Null Run – no mining within region.

Mining cells progressed annually and drain cells simulating the mined coal were projected down to the base of the lowermost target coal seam (i.e. the D seam). The drains at the Project remain active during active mining and one year following the completion of the panel. After the drains have been deactivated, the MODFLOW Time Varying Materials (TVM) package is used to assign spoil properties to the cells.

All mines included in the model were simulated using the MODFLOW Drain (DRN) package. A nominally high drain conductance of 100 square metres per day ($m^2$/day) was applied to drain cells to simulate rapid removal of water from the system. **Figure 3-1** shows the Project mine progression.

Predictive modelling results presented in this report section are based on the single model (i.e. best calibrated model realisation discussed in **Section 2.6**) and uncertainty with respect to the model predictions is investigated in detail in **Section 5.0**.




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

0 0.5 1 km

| | |
|---|---|
| Coordinate System: | GDA 1994 MGA Zone 55 |
| Scale: | 1:50,000 at A4 |
| Project Number: | 620.040484.00001 |
| Date Drawn: | 11-Sep-2024 |
| Drawn by: | RB |

**LEGEND**

- Major Drainage System
- Mining Lease
- Pit Names

**Mine Progression**

| | |
|---|---|
| 2026 | 2033 |
| 2027 | 2034-2038 |
| 2028 | 2039-2043 |
| 2030 | 2044-2048 |
| 2031 | 2049-2053 |
| 2032 | |

# SARAJI MINE GREVILLEA PIT CONTINUATION PROJECT MODELLING TECHNICAL REPORT

## MINE PROGRESSION (GREVILLEA)

SLR

DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.

**FIGURE 3-1**

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040484.00001 Saraji Mine Grevillea GW Model\06 SLR Data\01 CADGIS\GIS\ArcPro\GW Modelling\GW Modelling.aprx\620040484 MOD F03-1 Mine Progression (Grevillea)

## 3.2 Water Balance

**Table 3-1** to **Table 3-3** provide average flow rates for water transfer into and out of the predictive model (from January 2022 to the end of 2095) for the three predictive model scenarios, the Cumulative, Approved and Null Run. The mass balance error for all three scenarios was less than 0.01 % indicating that the model was stable and achieved an accurate numerical solution. All scenarios maintained mass balance errors below 1 % for all time steps throughout the simulations. The low error achieved indicates that the predictive model is stable, and the solution achieved is accurate (Barnett et al., 2012).

The tables show that simulated recharge increased from 4.2 ML/d in the Null Run scenario to around 8.6 ML/d in the Cumulative and Approved scenarios. The increase in recharge is due to the presence of open cut mining and enhanced recharge through the spoil to the groundwater system in the Cumulative and Approved scenarios.

**Table 3-1** to **Table 3-3** show in all the three predictive model scenarios, groundwater enters the model through regional groundwater flow (GHB). The GHB net flow is increased from 2.2 ML/d for the Null Run to 2.7 ML/d for Cumulative and Approved scenarios.

Evapotranspiration for the predictive models is approximately 2.8 ML/d for the Cumulative and Approved scenarios and 3.08 ML/d for the Null Run. The loss to evapotranspiration happens where the water table is within 2 m of the land surface across the model domain, which is primarily along the saturated extent of Isaac River alluvium near the Isaac River. It should be mentioned that the open cut void lakes are not generated during the predictive period of active mining and the groundwater model does not simulate a loss to evaporation. Therefore, the evapotranspiration component reported here only replicates evapotranspiration from shallow water tables particularly within alluvium.

**Table 3-3** shows a negative river net baseflow (-2.2 ML/d) in the Null Run indicating flow from the groundwater system to Isaac River within the model domain. However, **Table 3-1** shows that in the Cumulative scenario the net river exchange flux (RIV) is positive (8.27 ML/d), which indicates that overall, the Isaac River is losing water to the groundwater system. The difference in river net fluxes is likely due to the modelled influence from all mining activities from 2024, resulting in lower groundwater levels and an increase in modelled leakage (along reaches where it occurs) from the Isaac River to the groundwater system. **Table 3-2** indicates that Approved scenario creates the same river loss as Cumulative scenario, indicating that the Project mining activities do not impact the flow out of the Isaac River. Further detail about the impact of proposed the Project on the Isaac River is provided in **Section 3.6**.

Groundwater outflow from the model mostly occurs via drain cells, used to simulate open cut and underground mining activity in the model. **Table 3-1** and **Table 3-2** show that the Cumulative scenario resulted in an increase in the average drain outflow (from 19.42 ML/d predicted for the Approved scenario to 19.55 ML/d) (i.e. 0.13 ML/d or 161 ML/yr).

**Table 3-1 Average Simulated Water Balance over the Prediction Period – Cumulative**

| Component | Inflow (ML/d) | Percent of Total Inflow (%) | Outflow (ML/d) | Percent of Total Inflow (%) |
|---|---|---|---|---|
| Recharge (direct rainfall) | 8.60 | 15.51 | 0.00 | 0.00 |
| CHD | 4.98 | 8.98 | 1.22 | 2.20 |
| Evapotranspiration (EVT) | 0.00 | 0.00 | 2.84 | 5.13 |

| Component | Inflow (ML/d) | Percent of Total Inflow (%) | Outflow (ML/d) | Percent of Total Inflow (%) |
|---|---|---|---|---|
| SW/GW Interaction Isaac River (RIV) | 14.20 | 25.61 | 5.93 | 10.70 |
| SW/GW Interaction Phillips River (RIV) | 0.00 | 0.00 | 0.007 | 0.01 |
| SW/GW Interaction Other Rivers (RIV)* | 0.00 | 0.00 | 0.48 | 0.87 |
| Regional GW flow (GHB) | 2.72 | 4.90 | 0.21 | 0.37 |
| Drains (Mine inflows) | 0.00 | 0.00 | 19.55 | 35.26 |
| Storage | 24.95 | 45 | 25.19 | 45.43 |
| Gas drainage wells (WEL) | 0.00 | 0.00 | 00.00 | 0.00 |
| **Total** | **55.45** | **99.99** | **55.44** | **100.00** |

* The other tributaries or drainage lines in the model are set as drains to the groundwater system and do not result in any recharge.

**Table 3-2 Average Simulated Water Balance over the Prediction Period – Approved**

| Component | Inflow (ML/d) | Percent of Total Inflow (%) | Outflow (ML/d) | Percent of Total Inflow (%) |
|---|---|---|---|---|
| Recharge (direct rainfall) | 8.59 | 15.54 | 0.00 | 0.00 |
| CHD | 4.98 | 9 | 1.22 | 2.21 |
| Evapotranspiration (ET) | 0.00 | 0.00 | 2.84 | 5.15 |
| SW/GW Interaction Isaac River (RIV) | 14.20 | 25.67 | 5.93 | 10.73 |
| SW/GW Interaction Phillips River (RIV) | 0.00 | 0.00 | 0.007 | 0.01 |
| SW/GW Interaction Other Rivers (RIV)* | 0.00 | 0.00 | 0.48 | 0.87 |
| Regional GW flow (GHB) | 2.72 | 4.91 | 0.21 | 0.37 |
| Drains (Mine inflows) | 0.00 | 0.00 | 19.42 | 35.14 |
| Storage | 24.81 | 44.86 | 25.16 | 45.51 |
| Gas drainage wells (WEL) | 0.00 | 0.00 | 0.00 | 0.00 |
| **Total** | **55.30** | **99.99** | **55.28** | **100.00** |

* The other tributaries or drainage lines in the model are set as drains to the groundwater system and do not result in any recharge.

**Table 3-3 Average Simulated Water Balance over the Prediction Period – Null Run**

| Component | Inflow (ML/d) | Percent of Total Inflow (%) | Outflow (ML/d) | Percent of Total Inflow (%) |
|---|---|---|---|---|
| Recharge (direct rainfall) | 4.20 | 29.75 | 0.00 | 0.0 |
| Evapotranspiration (ET) | 0.00 | 0.0 | 3.08 | 21.9 |
| SW/GW Interaction Isaac River (RIV) | 7.68 | 54.4 | 9.88 | 70.12 |
| SW/GW Interaction Phillips River (RIV) | 0.0 | 0.0 | 0.007 | 0.05 |
| SW/GW Interaction Other Rivers (RIV)* | 0.0 | 0.0 | 0.75 | 5.32 |

| Component | Inflow (ML/d) | Percent of Total Inflow (%) | Outflow (ML/d) | Percent of Total Inflow (%) |
|---|---|---|---|---|
| Regional GW flow (GHB) | 2.21 | 15.67 | 0.21 | 1.5 |
| Drains (Mine inflows) | 0.00 | 0.0 | 0.00 | 0.0 |
| Storage | 0.02 | 0.17 | 0.16 | 1.3 |
| Gas drainage wells (WEL) | 0.00 | 0.0 | 0.00 | 0.0 |
| **Total** | **14.11** | **100.0** | **14.10** | **99.99** |

* The other tributaries or drainage lines in the model are set as drains to the groundwater system and do not result in any recharge.

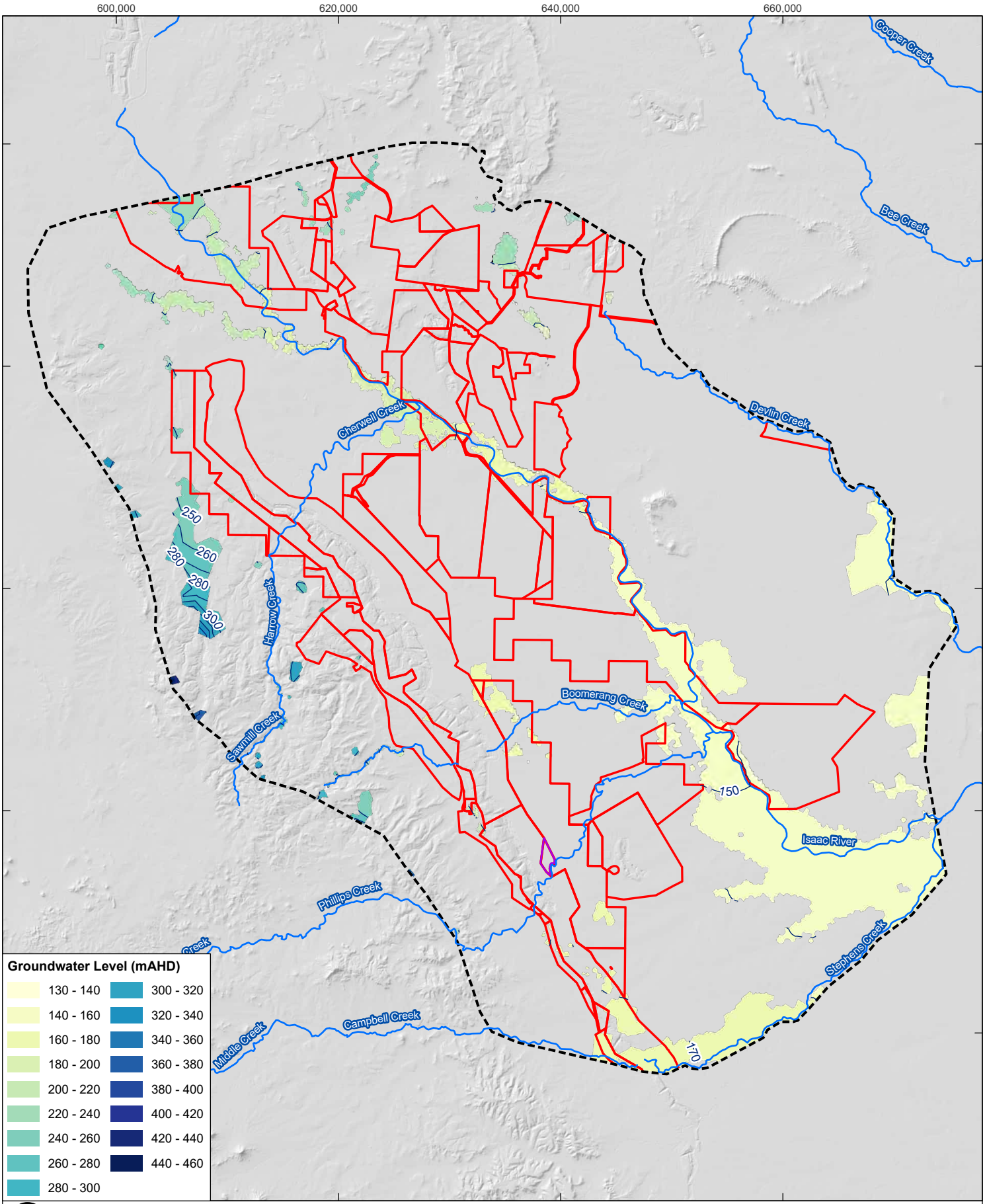
## 3.3 Predicted Groundwater Level Change

Predicted groundwater levels at the end of mining operations for the Approved and Cumulative scenarios are provided in **Figure 3-2** to **Figure 3-7**. The gaps in the water level grids represent unsaturated areas (i.e., where the simulated water level elevation is below the base of cell).

These predicted groundwater levels indicate that there is no change to alluvial groundwater levels when comparing the Cumulative to the Approved mining scenario (**Figure 3-2** and **Figure 3-5**).

**Figure 3-3** and **Figure 3-6** show predicted groundwater levels in the regolith at the end of mining for the Cumulative and Approved mining scenarios. Dewatering of the Regolith caused by the Project can be seen by slightly larger unsaturated zone within the Grevillea area for the Cumulative scenario (**Figure 3-6**), relative to the Approved mining scenario (**Figure 3-3**).

**Figure 3-4** and **Figure 3-7** show the predicted water levels in the target D coal seam (Layer 18) at the end of mining for Cumulative and Approved mining scenarios. Respectively, a regional south-easterly hydraulic gradient can be observed, reflecting the downstream flow gradient of the Isaac River. Zones of depressurisation at the Project and surrounding mines are shown to cause localised interruptions to the regional flow gradient. A discussion on groundwater drawdown within the Permian Coal Measures is included in **Section 3.4**.




**Groundwater Level (mAHD)**

| | |
|---|---|
| 130 - 140 | 300 - 320 |
| 140 - 160 | 320 - 340 |
| 160 - 180 | 340 - 360 |
| 180 - 200 | 360 - 380 |
| 200 - 220 | 380 - 400 |
| 220 - 240 | 400 - 420 |
| 240 - 260 | 420 - 440 |
| 260 - 280 | 440 - 460 |
| 280 - 300 | |

0 5 10 km

**LEGEND**

- Groundwater Level Contour (mAHD)
- Major Drainage System
- Mining Lease
- Model Boundary
- Project Area

| | |
|---|---|
| Coordinate System: | GDA 1994 MGA Zone 55 |
| Scale: | 1:450,000 at A4 |
| Project Number: | 620.040484.00001 |
| Date Drawn: | 11-Sep-2024 |
| Drawn by: | RB |

# SARAJI MINE GREVILLEA PIT CONTINUATION PROJECT MODELLING TECHNICAL REPORT

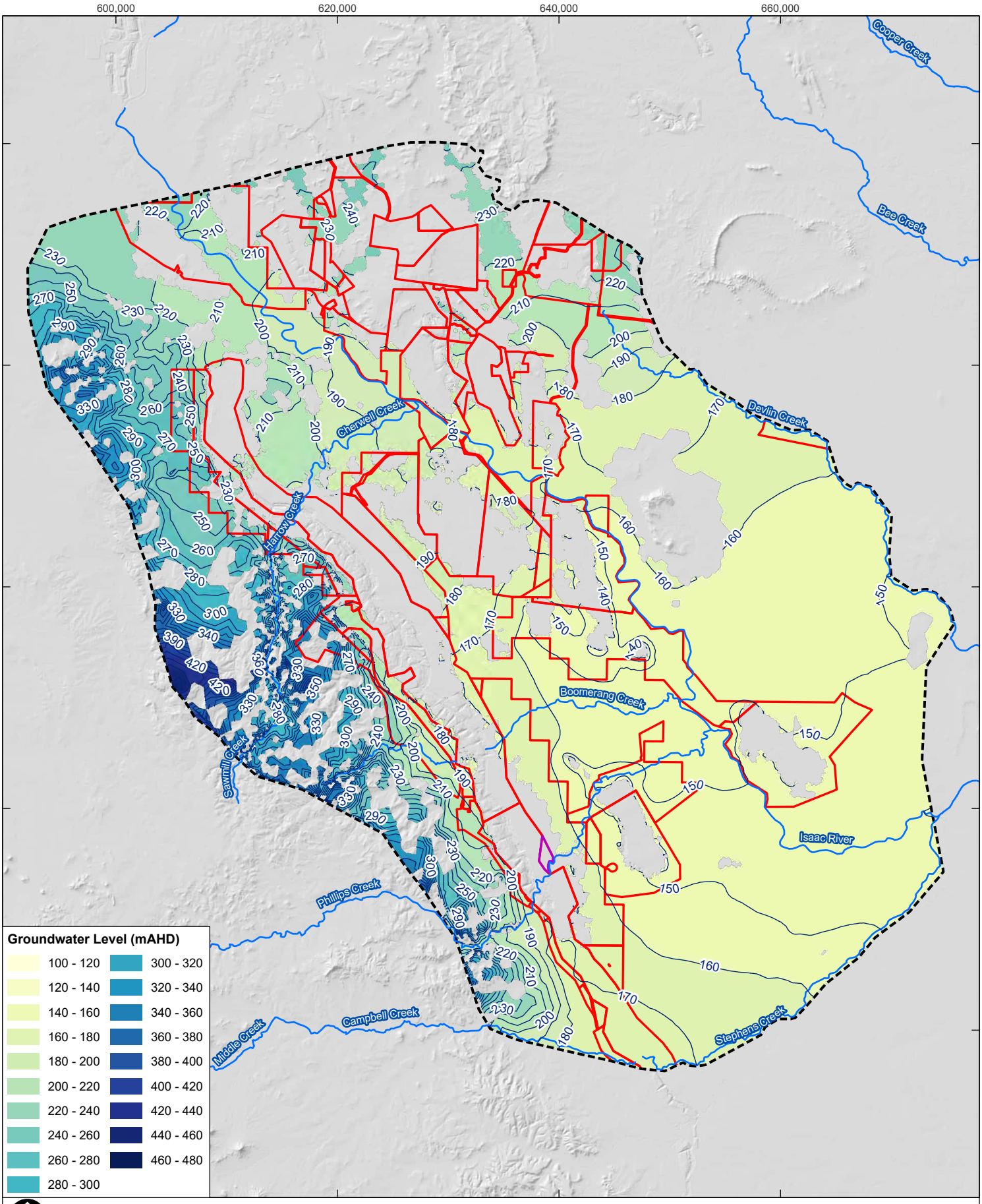
## PREDICTED WATER LEVEL WITHIN QUATERNARY ALLUVIUM (LAYER 1) AT END OF MINING – APPROVED SCENARIO

SLR

DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.

**FIGURE 3-2**

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040484.00001 Saraji Mine Grevillea GW Model\06 SLR Data\01 CADGIS\GIS\ArcPro\GW Modelling\GW Modelling.aprx\620040484 MOD F03-2 Predicted Water Level within Quaternary Alluvium (Layer 1) at End of Mining – Approved Scenario




**Groundwater Level (mAHD)**

| | |
|---|---|
| 100 - 120 | 300 - 320 |
| 120 - 140 | 320 - 340 |
| 140 - 160 | 340 - 360 |
| 160 - 180 | 360 - 380 |
| 180 - 200 | 380 - 400 |
| 200 - 220 | 400 - 420 |
| 220 - 240 | 420 - 440 |
| 240 - 260 | 440 - 460 |
| 260 - 280 | 460 - 480 |
| 280 - 300 | |

0 5 10 km

| | |
|---|---|
| Coordinate System: | GDA 1994 MGA Zone 55 |
| Scale: | 1:450,000 at A4 |
| Project Number: | 620.040484.00001 |
| Date Drawn: | 11-Sep-2024 |
| Drawn by: | RB |

**LEGEND**

- Groundwater Level Contour (mAHD)
- Major Drainage System
- Mining Lease
- Model Boundary
- Project Area

# SARAJI MINE GREVILLEA PIT CONTINUATION PROJECT MODELLING TECHNICAL REPORT

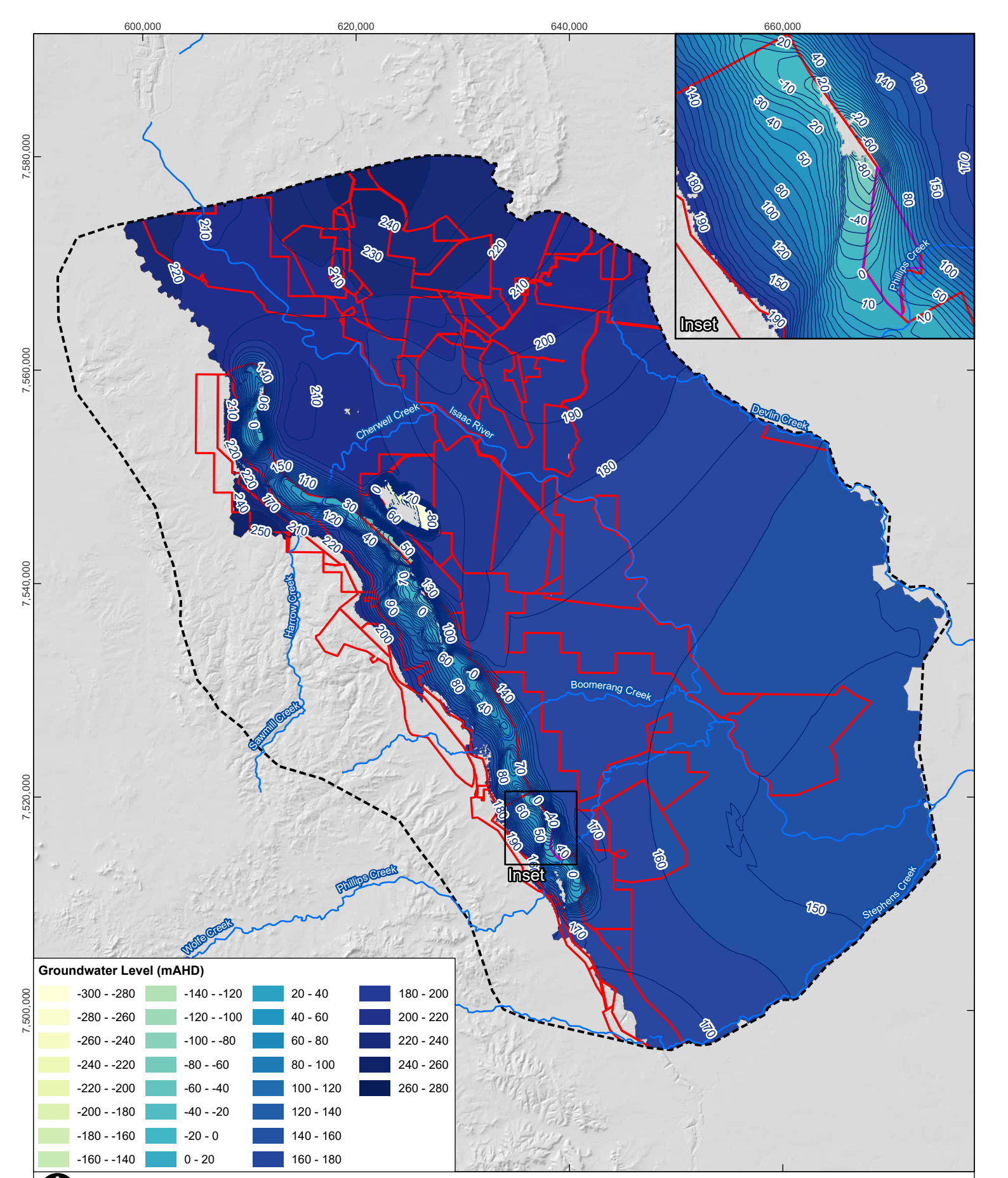
## PREDICTED WATER LEVEL WITHIN REGOLITH (LAYER 2) AT END OF MINING – APPROVED SCENARIO

SLR

DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.

**FIGURE 3-3**

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040484.00001 Saraji Mine Grevillea GW Model\06 SLR Data\01 CADGIS\GIS\ArcPro\GW Modelling\GW Modelling.aprx\620040484 MOD F03-3 Predicted Water Level within Regolith (Layer 2) at End of Mining – Approved Scenario




**LEGEND**

- Groundwater Level Contour (mAHD)
- Major Drainage System
- Mining Lease
- Model Boundary
- Project Area

| | |
|---|---|
| Coordinate System: | GDA 1994 MGA Zone 55 |
| Scale: | 1:450,000 at A4 |
| Project Number: | 620.040484.00001 |
| Date Drawn: | 11-Sep-2024 |
| Drawn by: | RB |

# SARAJI MINE GREVILLEA PIT CONTINUATION PROJECT MODELLING TECHNICAL REPORT

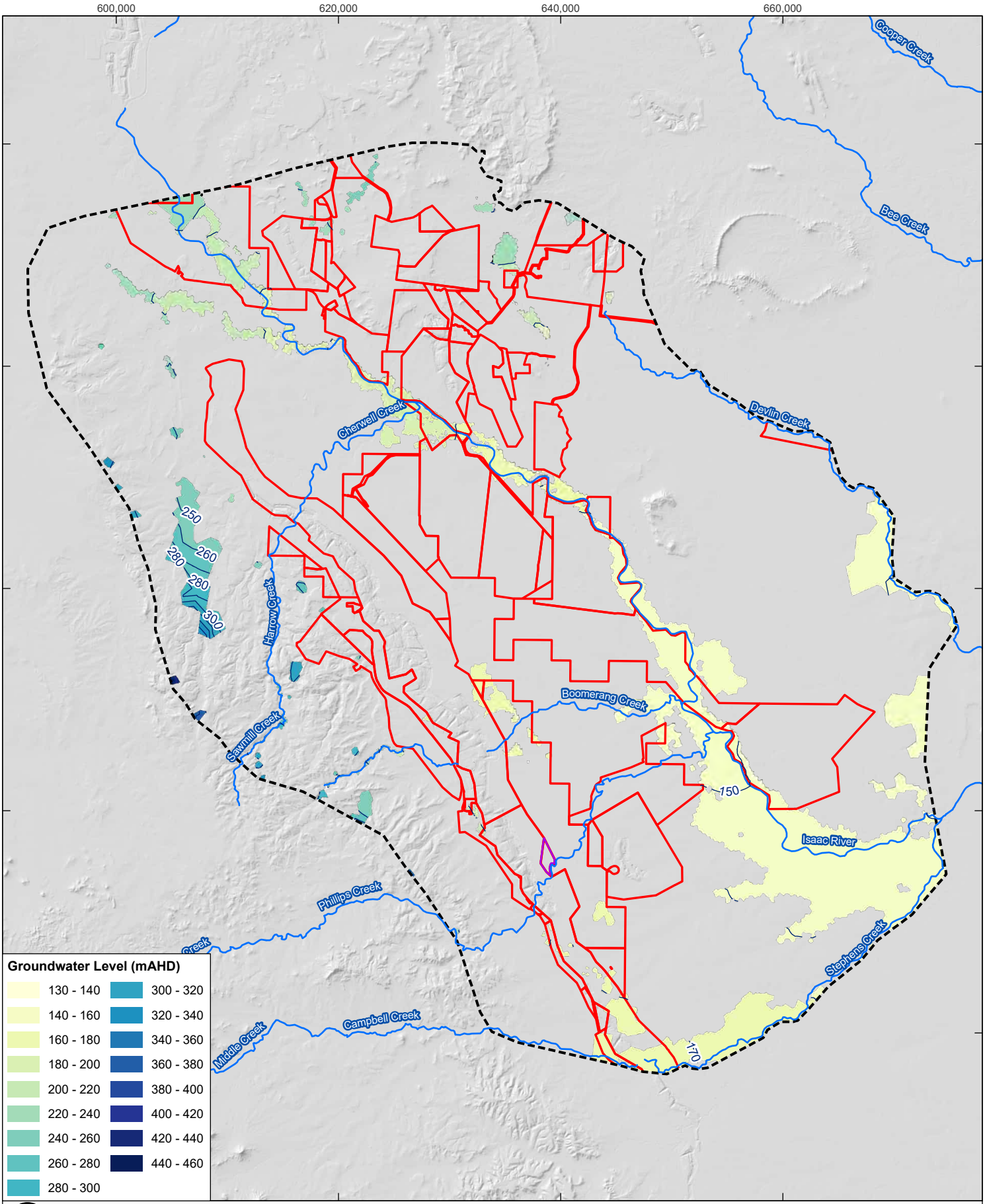
## PREDICTED WATER LEVEL WITHIN PERMIAN COAL MEASURES (LAYER 18) AT END OF MINING – APPROVED SCENARIO

SLR

DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.

**FIGURE 3-4**

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040484.00001 Saraji Mine Grevillea GW Model\06 SLR Data\01 CADGIS\GIS\ArcPro\GW Modelling\GW Modelling.aprx\620040484 MOD F03-4 Predicted Water Level within Permian Coal Measures (Layer 18) at End of Mining – Approved Scenario




| | |
|---|---|
| Coordinate System: | GDA 1994 MGA Zone 55 |
| Scale: | 1:450,000 at A4 |
| Project Number: | 620.040484.00001 |
| Date Drawn: | 11-Sep-2024 |
| Drawn by: | RB |

# SARAJI MINE GREVILLEA PIT CONTINUATION PROJECT MODELLING TECHNICAL REPORT

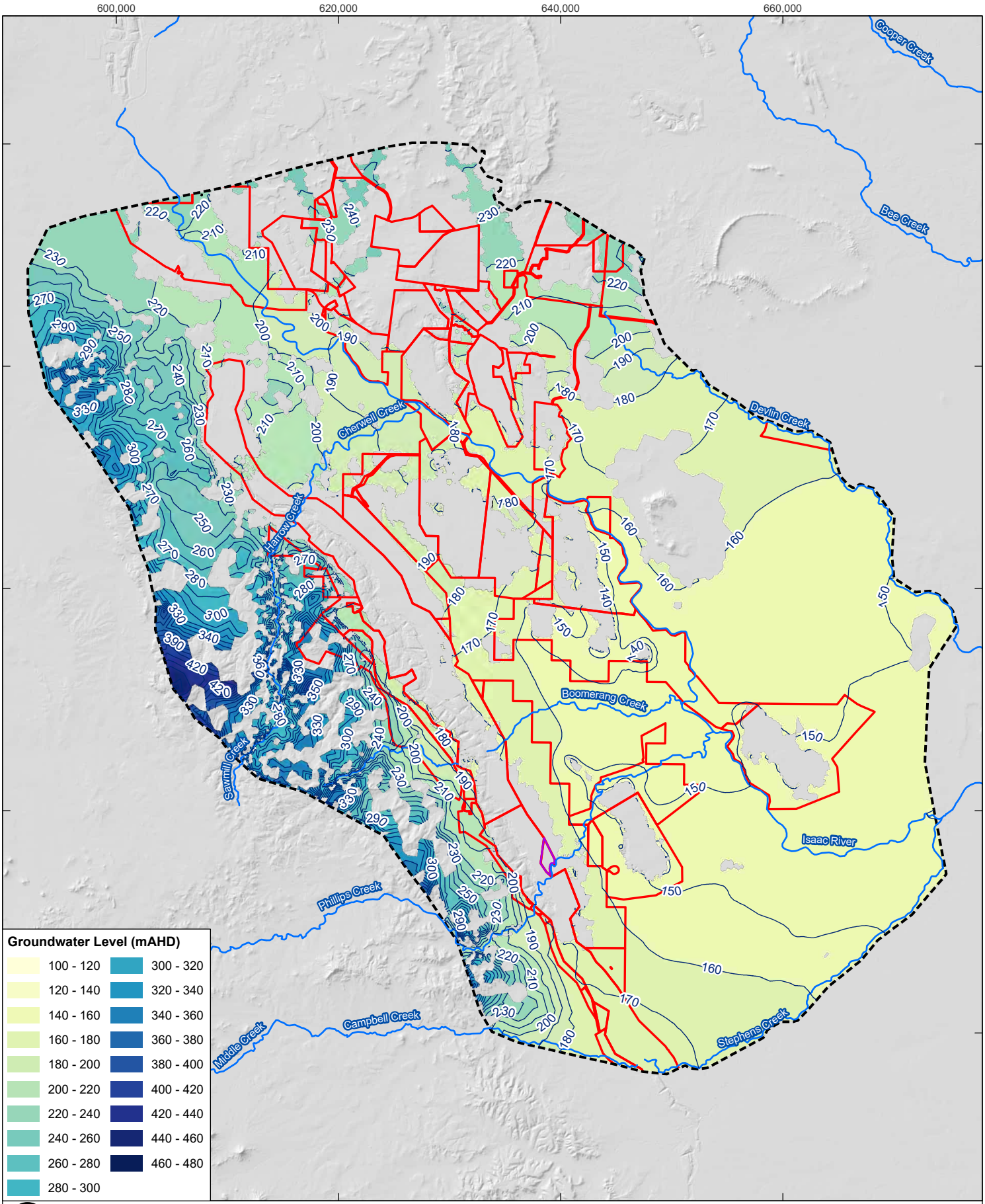
## PREDICTED WATER LEVEL WITHIN QUATERNARY ALLUVIUM (LAYER 1) AT END OF MINING – CUMULATIVE SCENARIO

SLR

DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.

FIGURE 3-5

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040484.00001 Saraji Mine Grevillea GW Model\06 SLR Data\01 CADGIS\GIS\ArcPro\GW Modelling\GW Modelling.aprx\620040484 MOD F03-5 Predicted Water Level within Quaternary Alluvium (Layer 1) at End of Mining – Cumulative Scenario




| | |
|---|---|
| Coordinate System: | GDA 1994 MGA Zone 55 |
| Scale: | 1:450,000 at A4 |
| Project Number: | 620.040484.00001 |
| Date Drawn: | 11-Sep-2024 |
| Drawn by: | RB |

# SARAJI MINE GREVILLEA PIT CONTINUATION PROJECT MODELLING TECHNICAL REPORT

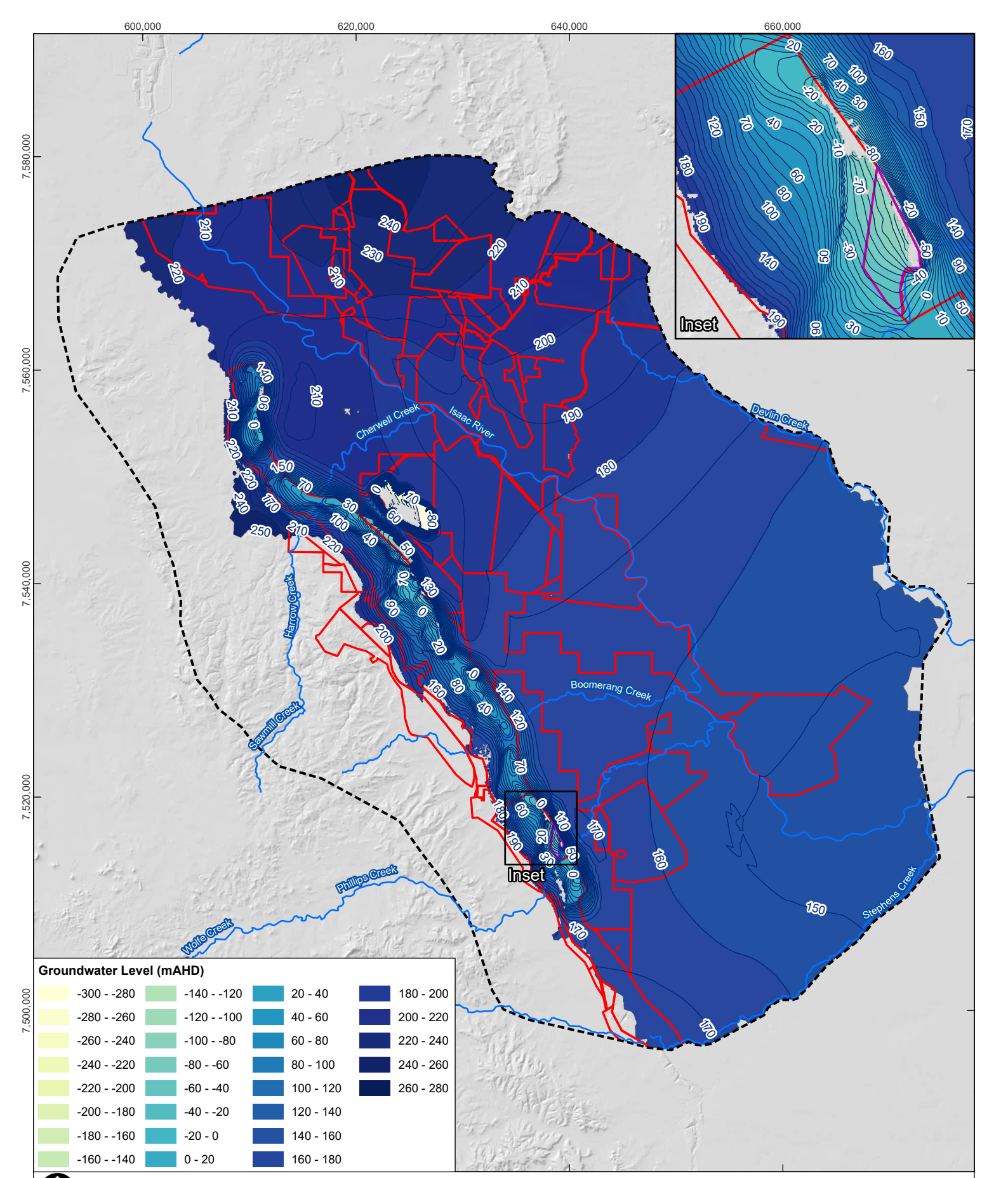
## PREDICTED WATER LEVEL WITHIN REGOLITH (LAYER 2) AT END OF MINING – CUMULATIVE SCENARIO

SLR

DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.

FIGURE 3-6

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040484.00001 Saraji Mine Grevillea GW Model\06 SLR Data\01 CADGIS\GIS\ArcPro\GW Modelling\GW Modelling.aprx\620040484 MOD F03-6 Predicted Water Level within Regolith (Layer 2) at End of Mining – Cumulative Scenario




| | |
|---|---|
| Coordinate System: | GDA 1994 MGA Zone 55 |
| Scale: | 1:450,000 at A4 |
| Project Number: | 620.040484.00001 |
| Date Drawn: | 12-Sep-2024 |
| Drawn by: | RB |

**LEGEND**

- Groundwater Level Contour (mAHD)
- Major Drainage System
- Mining Lease
- Model Boundary
- Project Area

# SARAJI MINE GREVILLEA PIT CONTINUATION PROJECT MODELLING TECHNICAL REPORT

## PREDICTED WATER LEVEL WITHIN PERMIAN COAL MEASURES (LAYER 18) AT END OF MINING – CUMULATIVE SCENARIO

SLR

DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.

**FIGURE 3-7**

## 3.4 Maximum Predicted Drawdowns

### 3.4.1 Maximum Incremental Drawdown

The process of mining directly removes water from the groundwater system and reduces water levels in surrounding groundwater units. The extent of the zone affected is dependent on the properties of the aquifers/aquitards and is referred to as the zone of drawdown. Groundwater drawdown is greatest at the working coalface and decreases with distance from the mine workings. Predictive modelling results presented in this report section are based on the single model (i.e. best calibrated model realisation) discussed in **Section 2.6** and uncertainty with respect to the model predictions is investigated in detail in **Section 5.0**.

In this report, maximum incremental drawdown refers to the drawdown impact associated with the Project only and is obtained by comparing the difference in predicted aquifer groundwater levels for the Approved scenario and the Cumulative scenario at matching times. The maximum incremental drawdown represents the maximum drawdown values recorded at each model cell at any time over the model predictive simulation duration. Predicted drawdown figures (**Figure 3-8** to **Figure 3-13**) show where maximum incremental drawdown impacts are predicted to exceed 1 m.

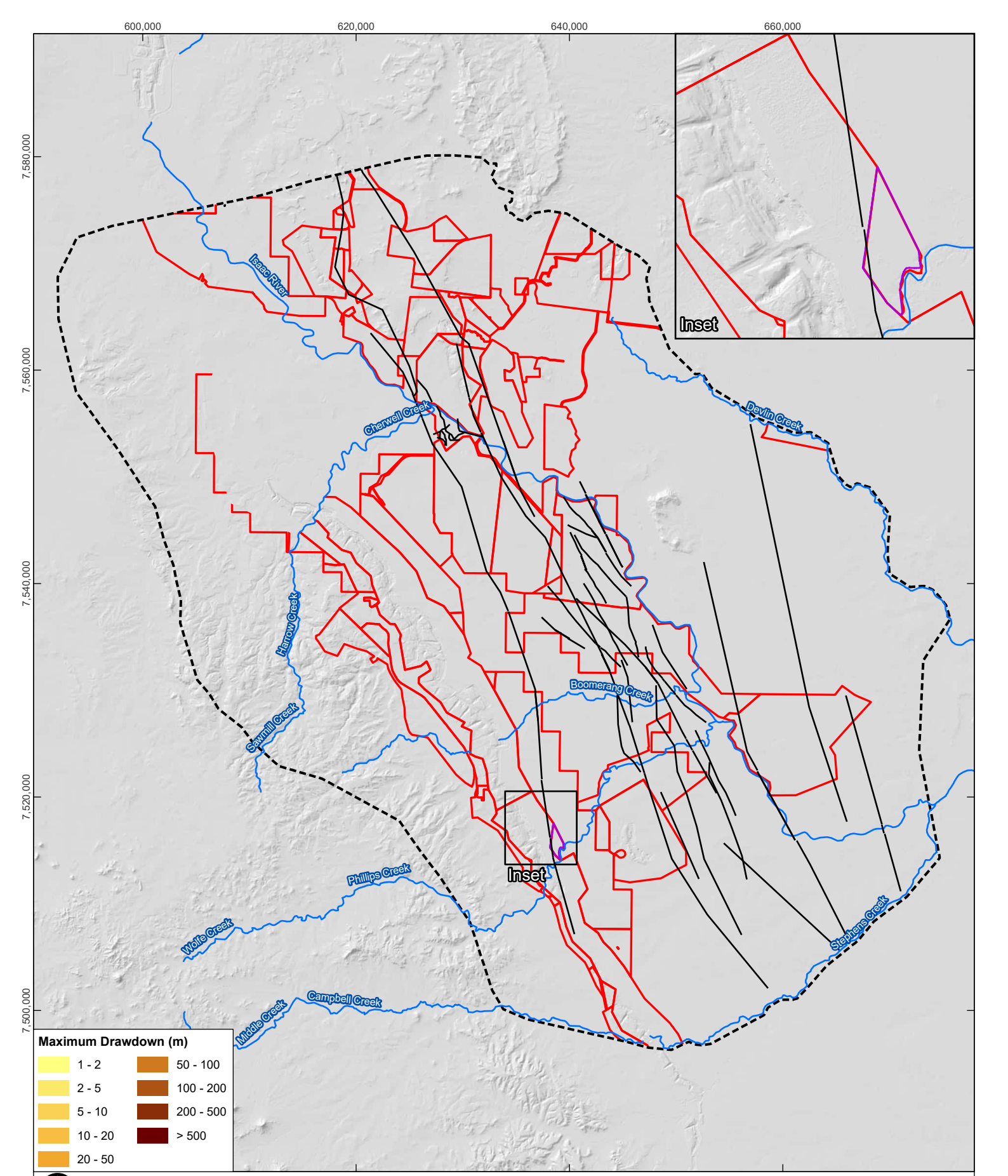
**Figure 3-8** shows that no incremental drawdown impacts are predicted for the Quaternary alluvium as a result of the Project.

The maximum predicted incremental drawdown impacts associated with the Project within the regolith is shown in **Figure 3-9**. The incremental drawdown extent within the regolith (Layer 2) occurs just northeast of the Project. The 1 m drawdown influence is predicted to extend 2.6 km northeast of the Project.

The coal seams of the Moranbah Coal Measures are the primary groundwater bearing strata at Grevillea and will experience drawdowns as a result of mining there. Groundwater level drawdown within the mined coal seams is influenced by unit structure and is confined to unit extents. **Figure 3-10** to **Figure 3-13** show the maximum predicted incremental drawdown for Q, P, H and D seam in the Moranbah Coal Measures. The figures show the extent of maximum predicted depressurisation of the Permian aged coal seams is limited to the west due to the depositional geology (i.e. coal seams subcrop).

The extent of maximum predicted incremental drawdown in the Moranbah Coal Measures coal seams are generally elongated along strike in the northeast-southwest direction and extend up to 5 km north and 6 km southeast of the Project mine extent. Drawdowns propagate further within the shallower coal seams (i.e., Q and P seam) when compared to the D seam (i.e., coal seam target). Given the use of depth dependant equation for assigning the hydraulic properties in the model, the shallower units have higher hydraulic conductivities in comparison to deeper ones which facilitates the drawdowns.

The influence of fault near Grevillea is also evident and it appears that it limits the drawdown propagation to the east.




0 5 10 km

| | |
|---|---|
| Coordinate System: | GDA 1994 MGA Zone 55 |
| Scale: | 1:450,000 at A4 |
| Project Number: | 620.040484.00001 |
| Date Drawn: | 12-Sep-2024 |
| Drawn by: | RB |

**LEGEND**

- Modelled Fault
- Drawdown Contour (m)
- Major Drainage System
- Mining Lease
- Model Boundary
- Project Area

# SARAJI MINE GREVILLEA PIT CONTINUATION PROJECT MODELLING TECHNICAL REPORT

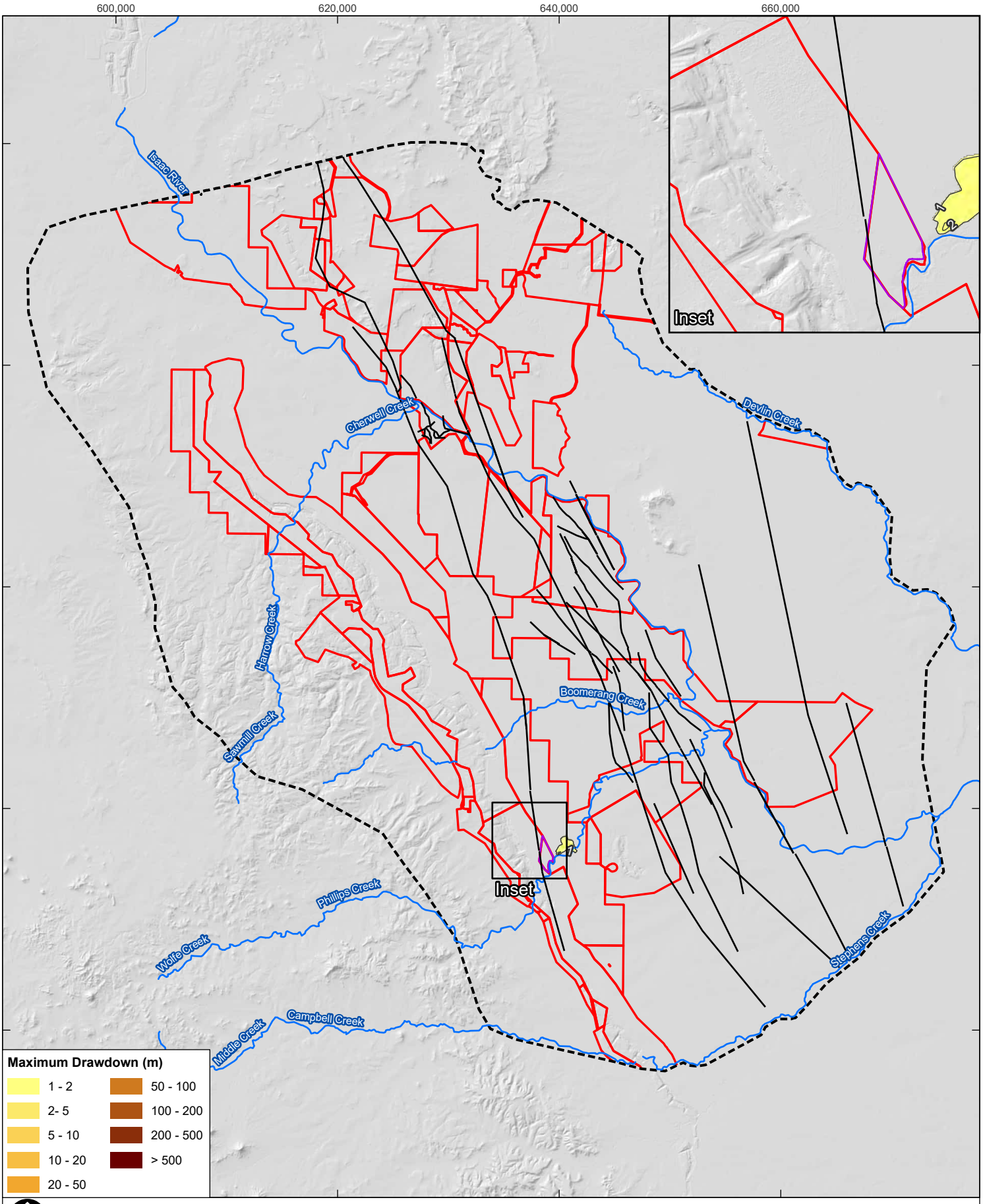
## MAXIMUM INCREMENTAL DRAWDOWN IN QUATERNARY ALLUVIUM (LAYER 1)

SLR

DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.

**FIGURE 3-8**

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040484.00001 Saraji Mine Grevillea GW Model\06 SLR Data\01 CADGIS\GIS\ArcPro\GW Modelling\GW Modelling.aprx\620040484 MOD F03-8 Maximum Incremental Drawdown in Alluvium (Layer 1)




**LEGEND**

- Modelled Fault
- Drawdown Contour (m)
- Major Drainage System
- Mining Lease
- Model Boundary
- Project Area

| | |
|---|---|
| Coordinate System: | GDA 1994 MGA Zone 55 |
| Scale: | 1:450,000 at A4 |
| Project Number: | 620.040484.00001 |
| Date Drawn: | 12-Sep-2024 |
| Drawn by: | RB |

# SARAJI MINE GREVILLEA PIT CONTINUATION PROJECT MODELLING TECHNICAL REPORT

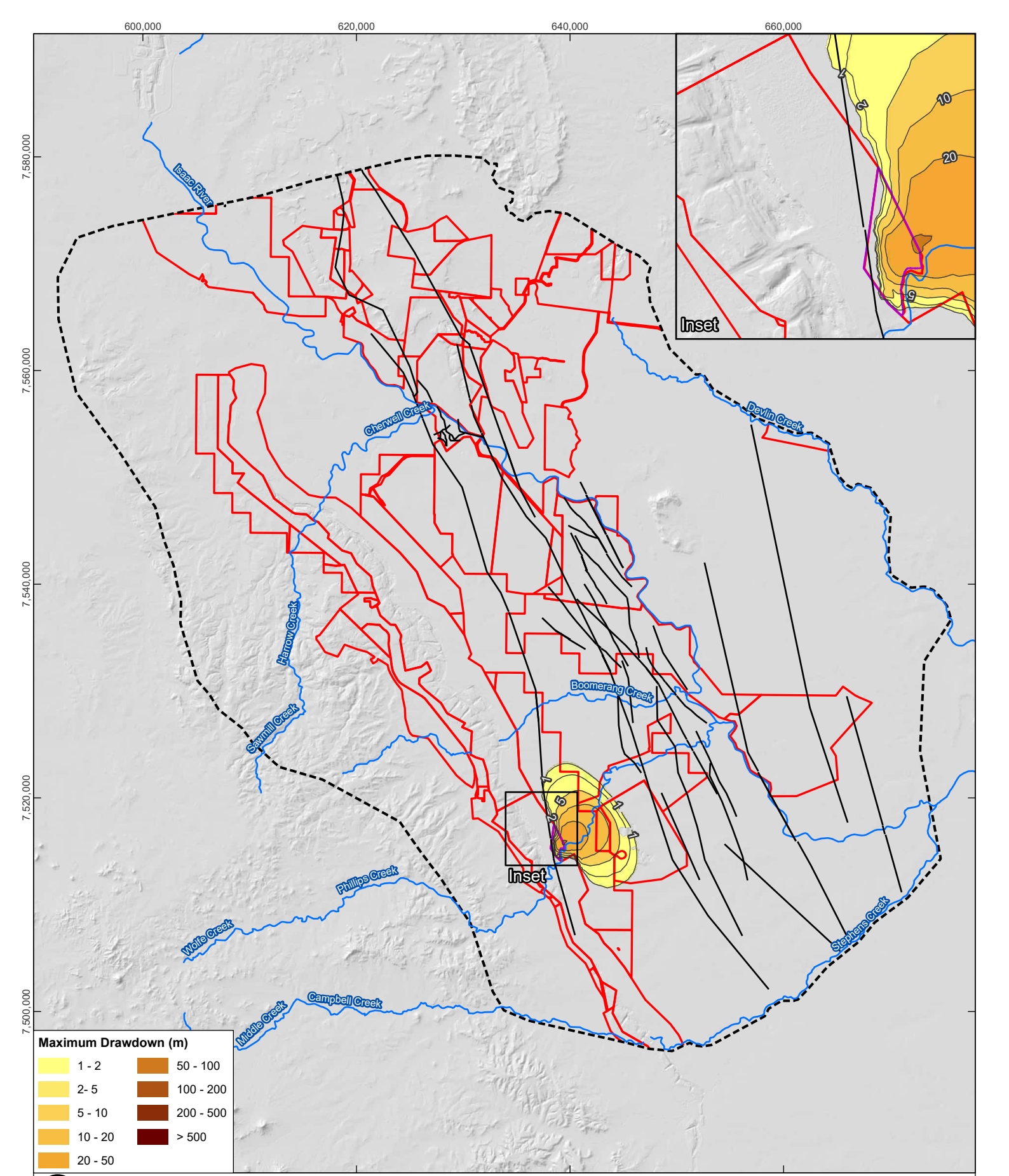
## MAXIMUM INCREMENTAL DRAWDOWN IN REGOLITH (LAYER 2)

SLR

DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.

**FIGURE 3-9**

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040484.00001 Saraji Mine Grevillea GW Model\06 SLR Data\01 CADGIS\GIS\ArcPro\GW Modelling\GW Modelling.aprx\620040484 MOD F03-9 Maximum Incremental Drawdown in Regolith (Layer 2)




0 5 10 km

| | |
|---|---|
| Coordinate System: | GDA 1994 MGA Zone 55 |
| Scale: | 1:450,000 at A4 |
| Project Number: | 620.040484.00001 |
| Date Drawn: | 12-Sep-2024 |
| Drawn by: | RB |

**LEGEND**

- Modelled Fault
- Drawdown Contour (m)
- Major Drainage System
- Mining Lease
- Model Boundary
- Project Area

# SARAJI MINE GREVILLEA PIT CONTINUATION PROJECT MODELLING TECHNICAL REPORT

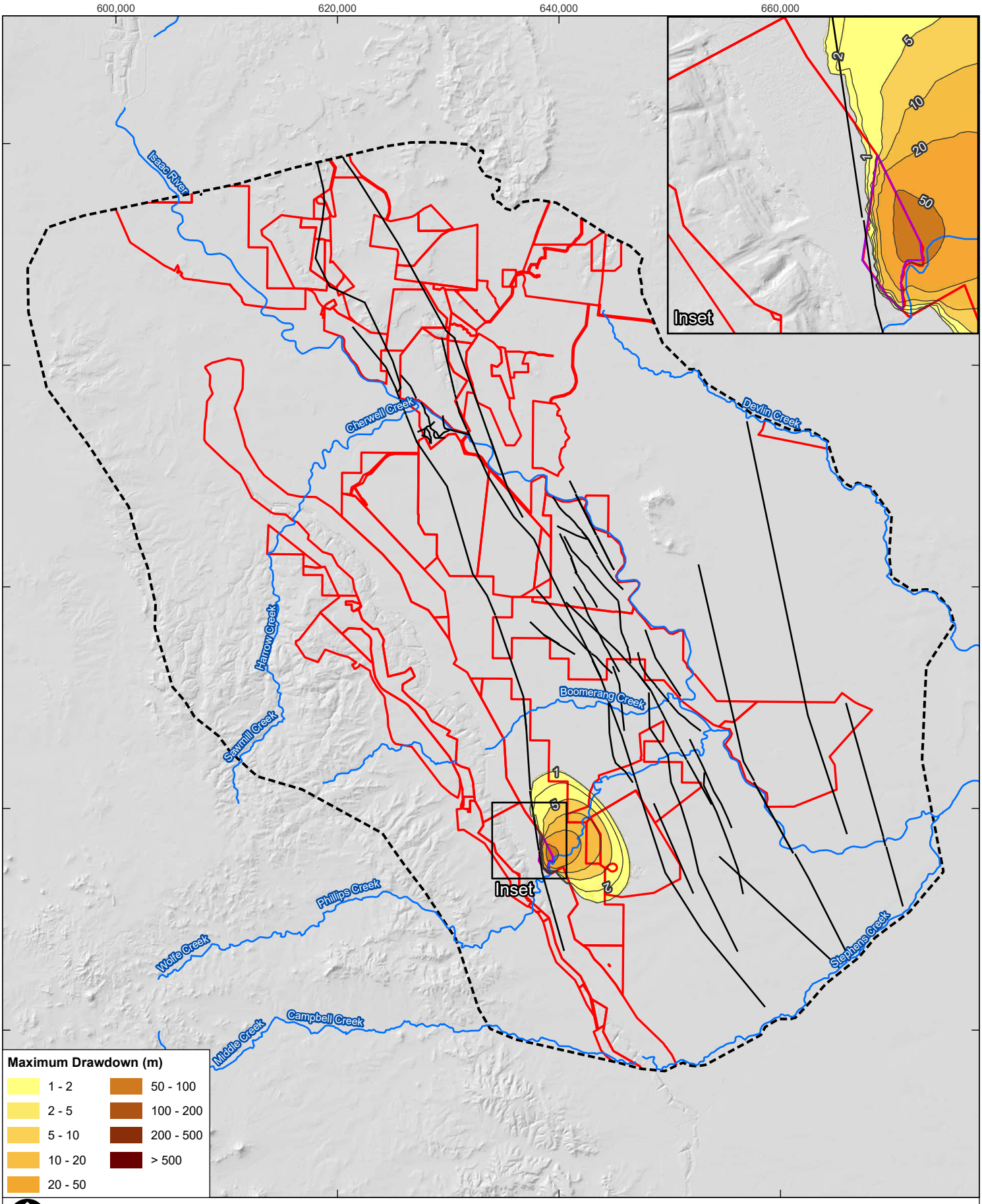
## MAXIMUM INCREMENTAL DRAWDOWN IN Q SEAM (LAYER 12)

SLR

DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.

**FIGURE 3-10**

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040484.00001 Saraji Mine Grevillea GW Model\06 SLR Data\01 CADGIS\GIS\ArcPro\GW Modelling\GW Modelling.aprx\620040484 MOD F03-10 Maximum Incremental Drawdown in Q Seam (Layer 12)




**LEGEND**

- Modelled Fault
- Drawdown Contour (m)
- Major Drainage System
- Mining Lease
- Model Boundary
- Project Area

| | |
|---|---|
| Coordinate System: | GDA 1994 MGA Zone 55 |
| Scale: | 1:450,000 at A4 |
| Project Number: | 620.040484.00001 |
| Date Drawn: | 12-Sep-2024 |
| Drawn by: | RB |

# SARAJI MINE GREVILLEA PIT CONTINUATION PROJECT MODELLING TECHNICAL REPORT

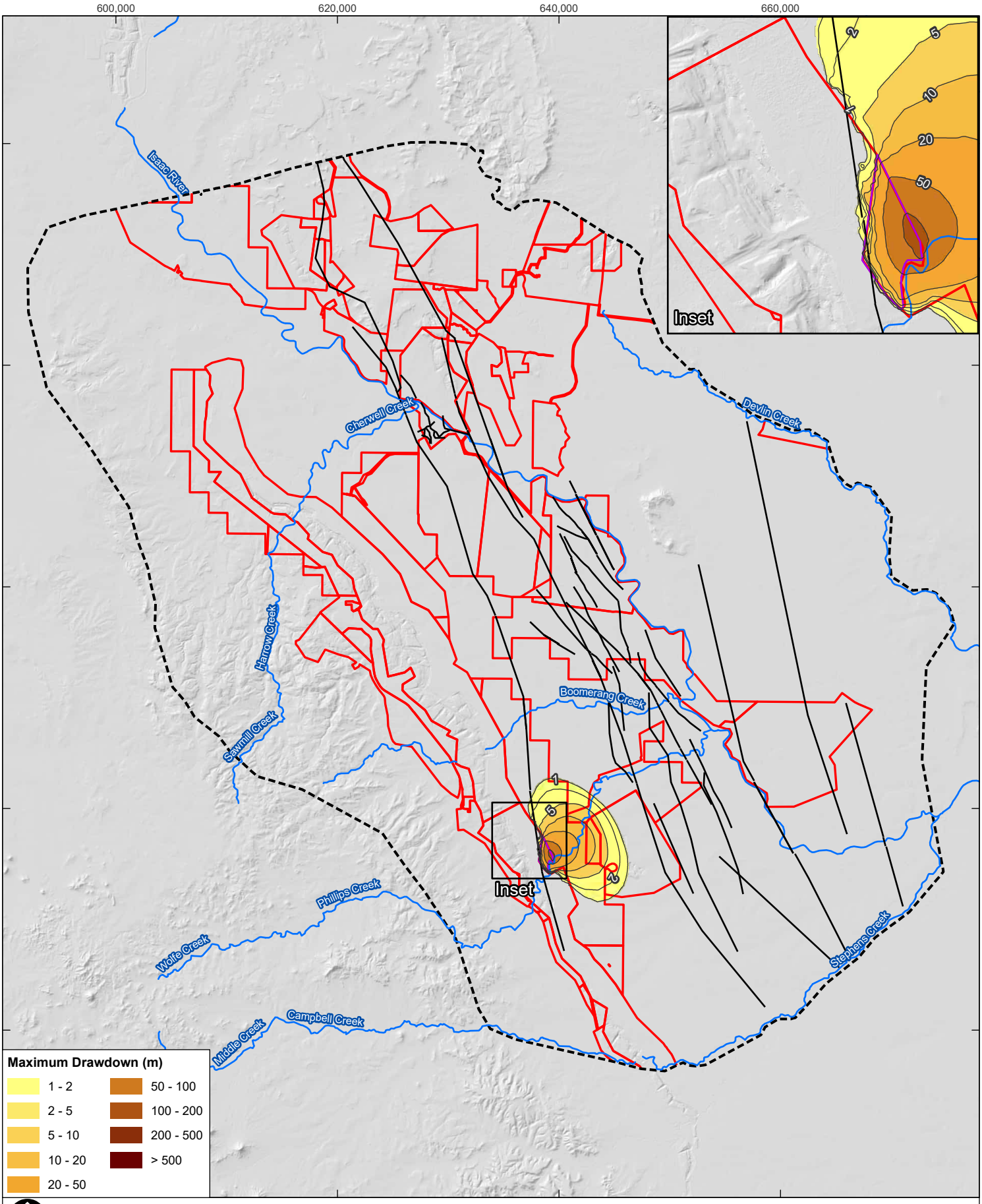
## MAXIMUM INCREMENTAL DRAWDOWN IN P SEAM (LAYER 14)

SLR

DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.

**FIGURE 3-11**

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040484.00001 Saraji Mine Grevillea GW Model\06 SLR Data\01 CADGIS\GIS\ArcPro\GW Modelling\GW Modelling.aprx\620040484 MOD F03-11 Maximum Incremental Drawdown in P Seam (Layer 14)




| | |
|---|---|
| Coordinate System: | GDA 1994 MGA Zone 55 |
| Scale: | 1:450,000 at A4 |
| Project Number: | 620.040484.00001 |
| Date Drawn: | 12-Sep-2024 |
| Drawn by: | RB |

# SARAJI MINE GREVILLEA PIT CONTINUATION PROJECT MODELLING TECHNICAL REPORT

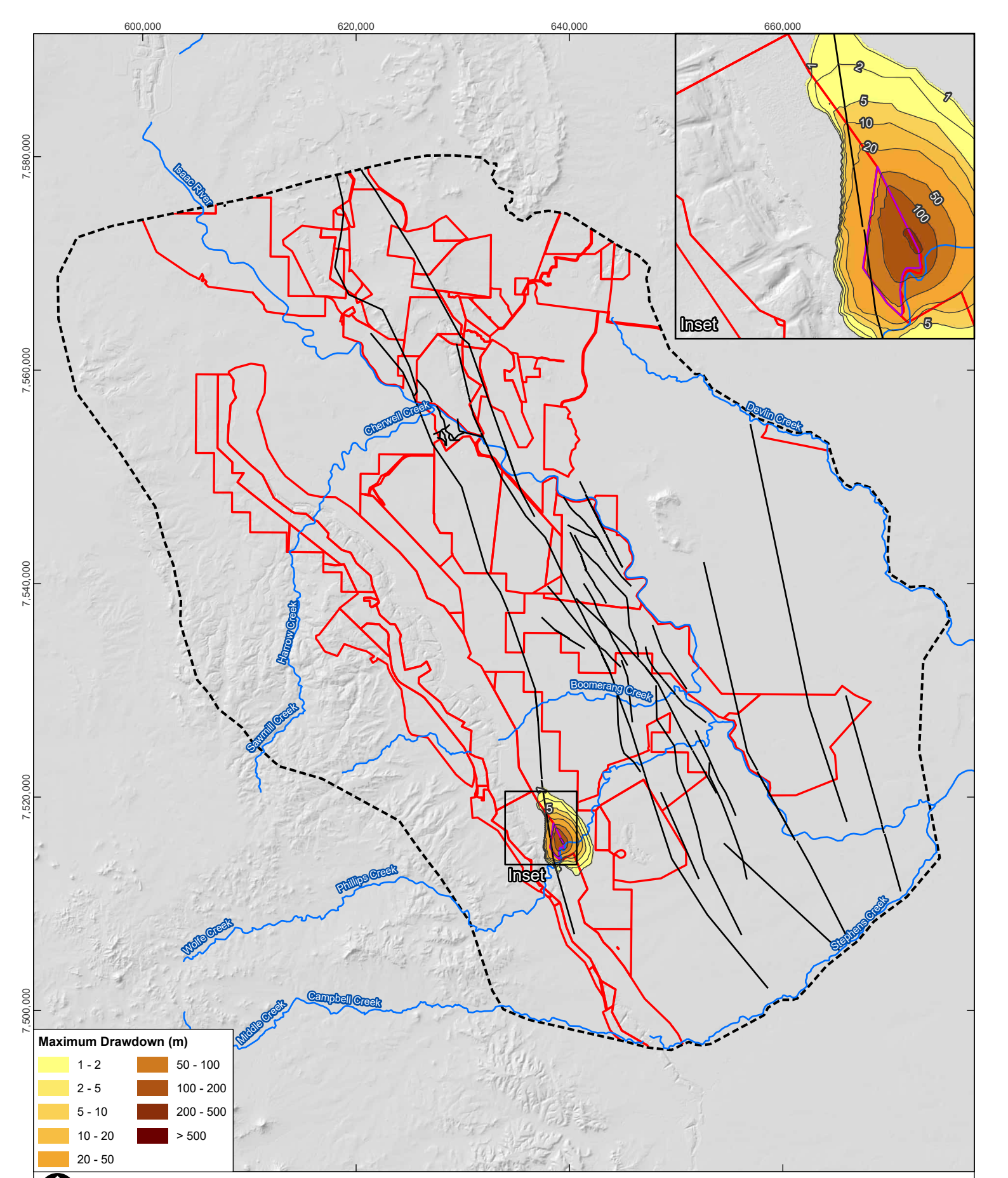
## MAXIMUM INCREMENTAL DRAWDOWN IN H SEAM (LAYER 16)

SLR

DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.

FIGURE 3-12

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040484.00001 Saraji Mine Grevillea GW Model\06 SLR Data\01 CADGIS\GIS\ArcPro\GW Modelling\GW Modelling.aprx\620040484 MOD F03-12 Maximum Incremental Drawdown in H Seam (Layer 16)




0 5 10 km

| | |
|---|---|
| Coordinate System: | GDA 1994 MGA Zone 55 |
| Scale: | 1:450,000 at A4 |
| Project Number: | 620.040484.00001 |
| Date Drawn: | 12-Sep-2024 |
| Drawn by: | RB |

**LEGEND**

- Modelled Fault
- Drawdown Contour (m)
- Major Drainage System
- Mining Lease
- Model Boundary
- Project Area

# SARAJI MINE GREVILLEA PIT CONTINUATION PROJECT MODELLING TECHNICAL REPORT

## MAXIMUM INCREMENTAL DRAWDOWN IN D SEAM (LAYER 18)

SLR

DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.

**FIGURE 3-13**

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040484.00001 Saraji Mine Grevillea GW Model\06 SLR Data\01 CADGIS\GIS\ArcPro\GW Modelling\GW Modelling.aprx\620040484 MOD F03-13 Maximum Incremental Drawdown in D Seam (Layer 18)

### 3.4.2 Cumulative Drawdown

The simulated cumulative drawdown presented in this section show the impacts on different hydro stratigraphic units due to the existing approved mining within the model domain. The simulated cumulative drawdown shows whether the zone of impact from the neighbouring operations is predicted to interact with the zone of impact predicted for the Project in different aquifers (alluvium none, regolith, MCM coal seams – only).

Maximum cumulative drawdown impacts in proximity to the Project are shown in **Figure 3-14** to **Figure 3-21**. These drawdowns represent the total impact to modelled groundwater levels resulting from all mining within the model domain, by comparing the maximum difference in aquifer groundwater levels for the Project model scenario with those in the theoretical “no mining” Null Run scenario, for all times during the predictive model period. The vast majority of these predicted cumulative drawdown impacts are not related to the Project but result from existing mining activities represented in the model.

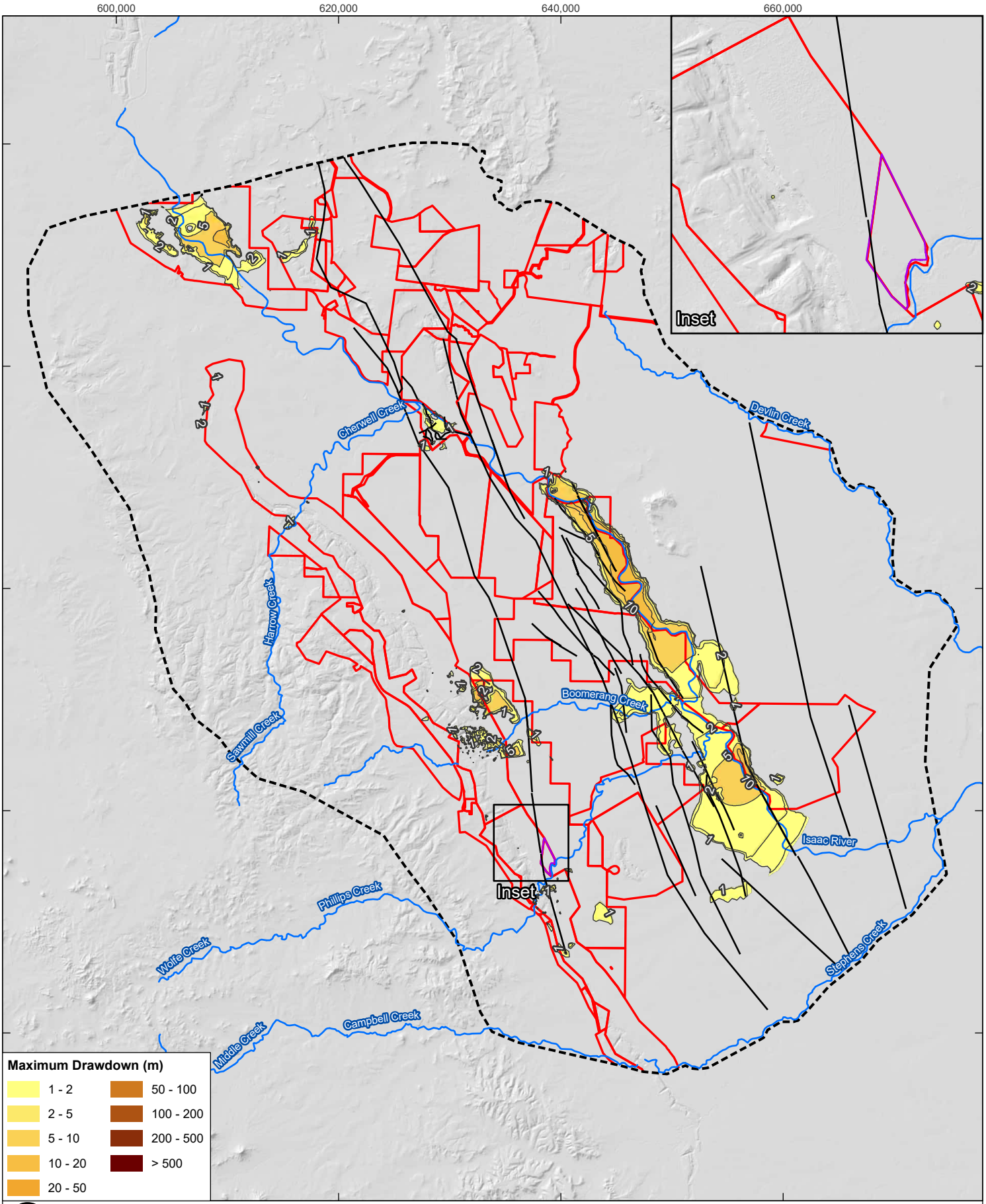
There is some cumulative drawdown impacts predicted for the Quaternary alluvium south of the Project (**Figure 3-14**).

Cumulative impacts within the regolith can be seen connecting the Project-related drawdown to the drawdown impacts at the PDM and SRM open cuts (**Figure 3-15**) (discussed in **Section 3.4.1**).

For the Leichhardt and Vermont coal seams of the Rangal Coal Measures, there was no drawdown interaction between the Project area and the neighbouring mines because these seams are not present in the Project area (**Figure 3-16** and **Figure 3-17**).

**Figure 3-18** to **Figure 3-21** show the maximum predicted cumulative drawdown in Q, P, H and D seams in the Moranbah Coal Measures. As shown in the figures, the cumulative drawdown is predicted to interact with zone of impact from the PDM and SRM open cuts.

**Figure 3-21** shows that drawdowns occur along the north-south trending fault located on the east of SRM.




0 5 10 km

| | |
|---|---|
| Coordinate System: | GDA 1994 MGA Zone 55 |
| Scale: | 1:450,000 at A4 |
| Project Number: | 620.040484.00001 |
| Date Drawn: | 12-Sep-2024 |
| Drawn by: | RB |

**LEGEND**

- Modelled Fault
- Drawdown Contour (m)
- Major Drainage System
- Mining Lease
- Model Boundary
- Project Area

**SARAJI MINE GREVILLEA PIT CONTINUATION PROJECT MODELLING TECHNICAL REPORT**

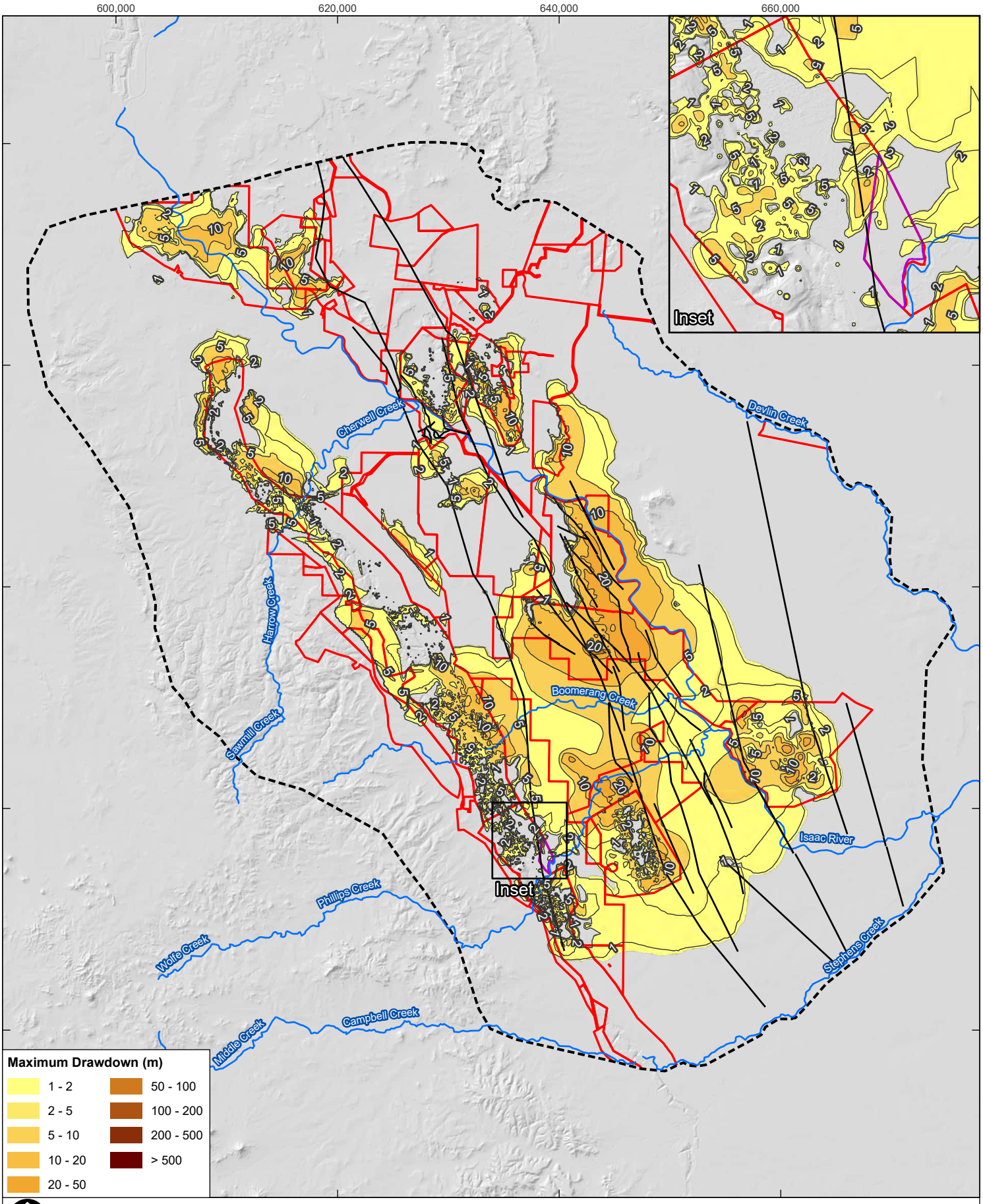
**MAXIMUM CUMULATIVE DRAWDOWN IN QUATERNARY ALLUVIUM (LAYER 1)**

SLR

DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.

**FIGURE 3-14**

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040484.00001 Saraji Mine Grevillea GW Model\06 SLR Data\01 CADGIS\GIS\ArcPro\GW Modelling\GW Modelling.aprx\620040484 MOD F03-14 Maximum Cumulative Drawdown in Quaternary Alluvium (Layer 1)




0 5 10 km

| | |
|---|---|
| Coordinate System: | GDA 1994 MGA Zone 55 |
| Scale: | 1:450,000 at A4 |
| Project Number: | 620.040484.00001 |
| Date Drawn: | 12-Sep-2024 |
| Drawn by: | RB |

**LEGEND**

- Modelled Fault
- Drawdown Contour (m)
- Major Drainage System
- Mining Lease
- Model Boundary
- Project Area

# SARAJI MINE GREVILLEA PIT CONTINUATION PROJECT MODELLING TECHNICAL REPORT

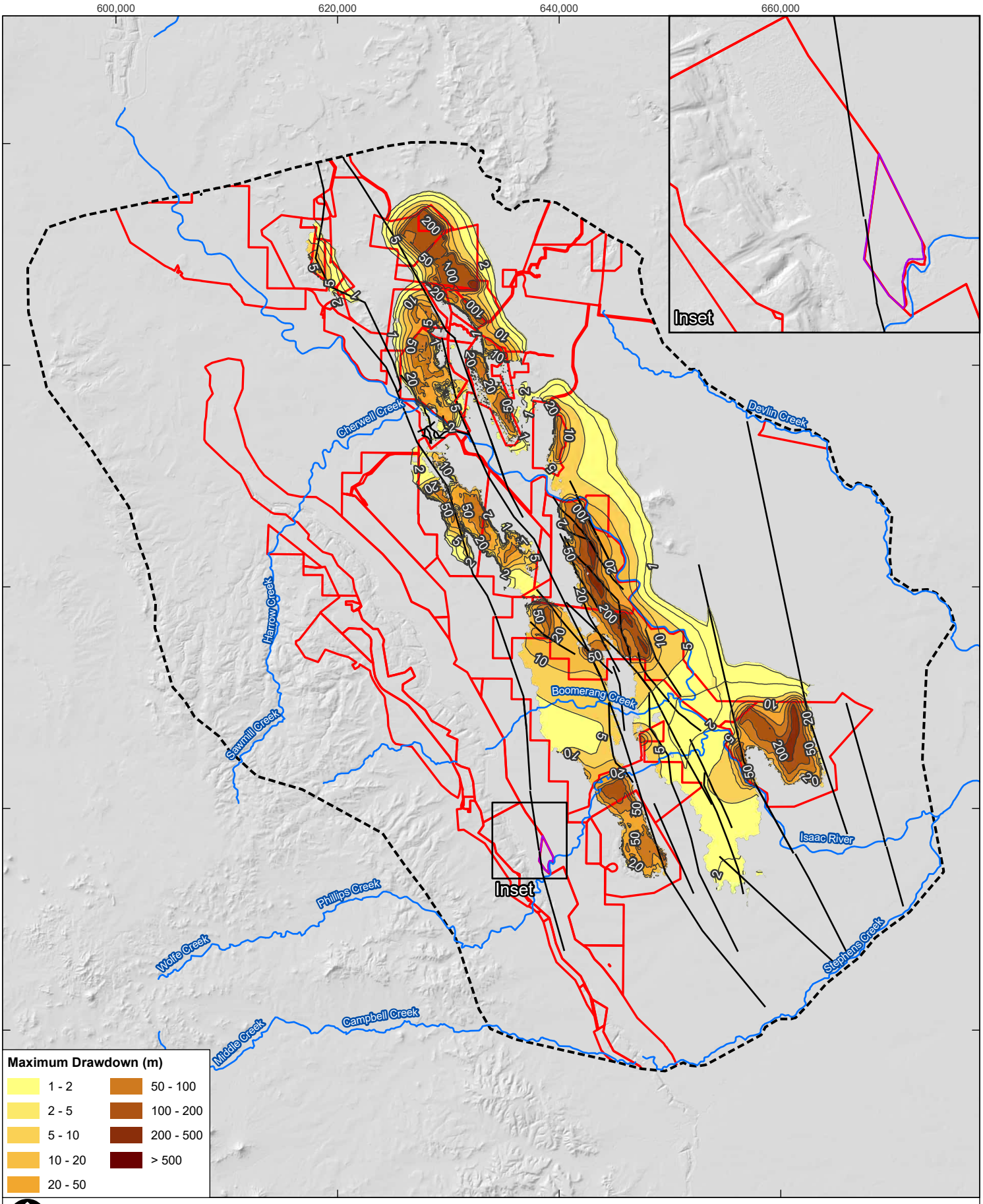
## MAXIMUM CUMULATIVE DRAWDOWN IN REGOLITH (LAYER 2)

SLR

DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.

**FIGURE 3-15**

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040484.00001 Saraji Mine Grevillea GW Model\06 SLR Data\01 CADGIS\GIS\ArcPro\GW Modelling\GW Modelling.aprx\620040484 MOD F03-15 Maximum Cumulative Drawdown in Regolith (Layer 2)




0 5 10 km

| | |
|---|---|
| Coordinate System: | GDA 1994 MGA Zone 55 |
| Scale: | 1:450,000 at A4 |
| Project Number: | 620.040484.00001 |
| Date Drawn: | 12-Sep-2024 |
| Drawn by: | RB |

**LEGEND**

- Modelled Fault
- Drawdown Contour (m)
- Major Drainage System
- Mining Lease
- Model Boundary
- Project Area

**SARAJI MINE GREVILLEA PIT CONTINUATION PROJECT MODELLING TECHNICAL REPORT**

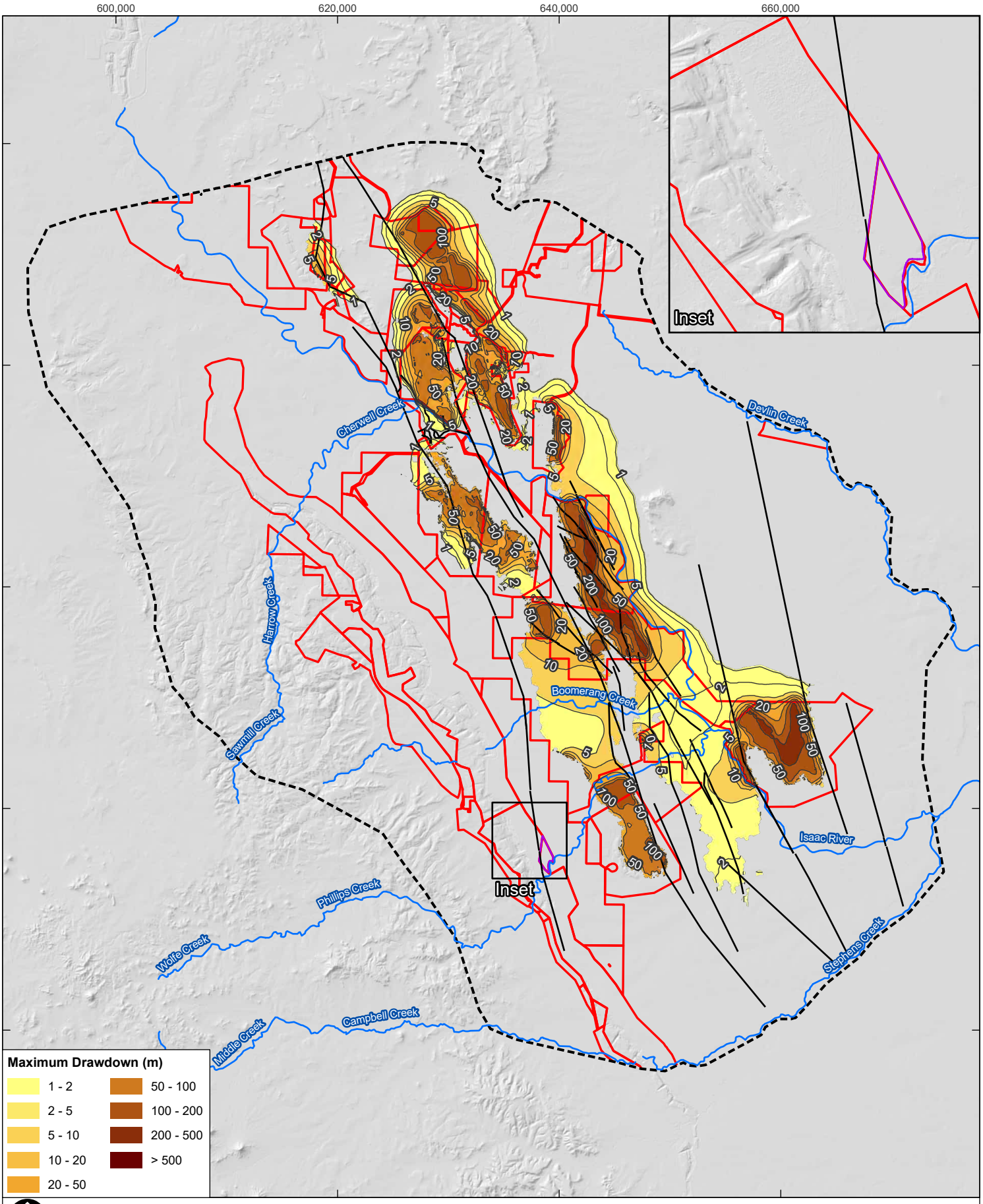
**MAXIMUM CUMULATIVE DRAWDOWN IN LEICHHARDT SEAM (LAYER 5)**

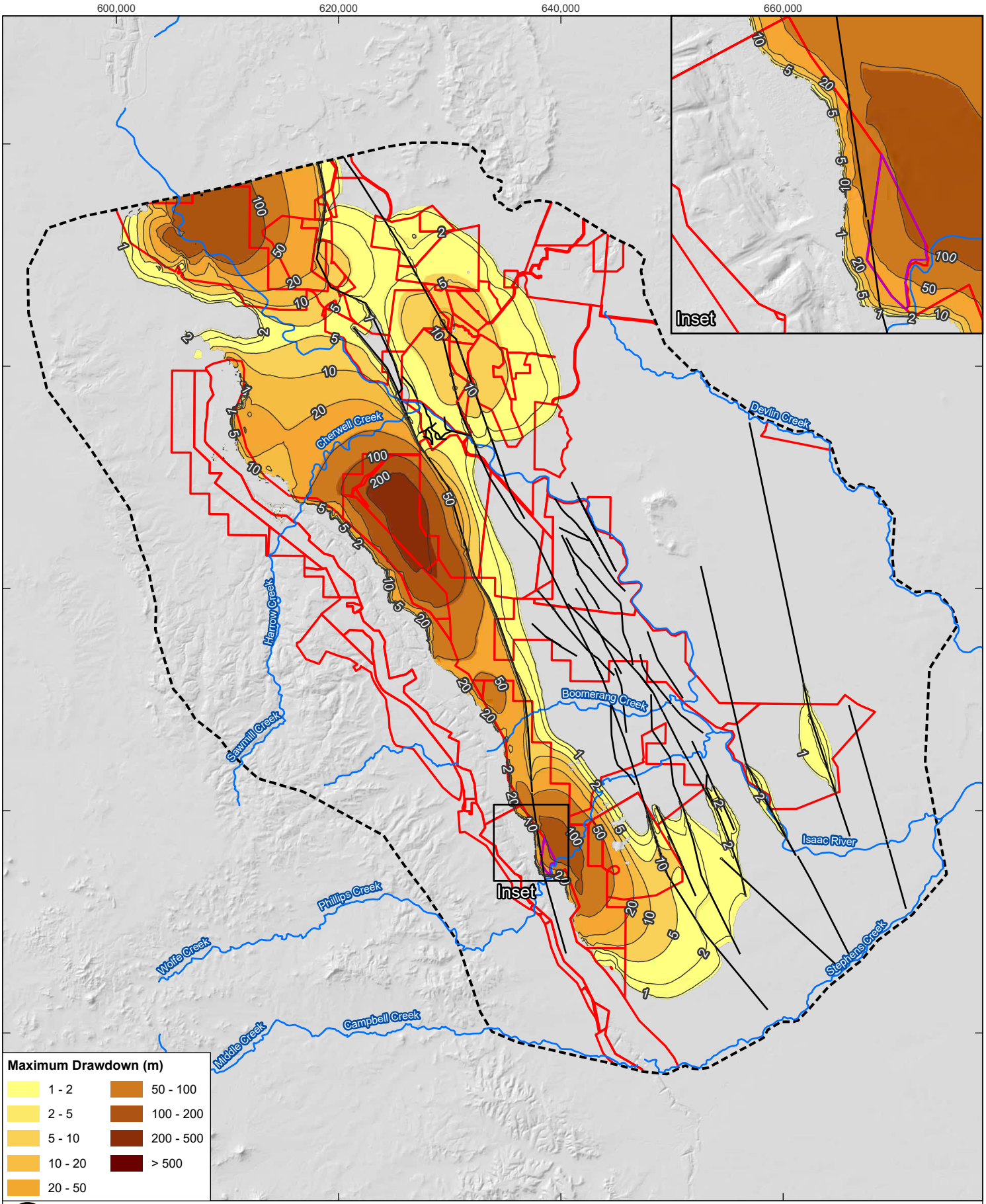
SLR

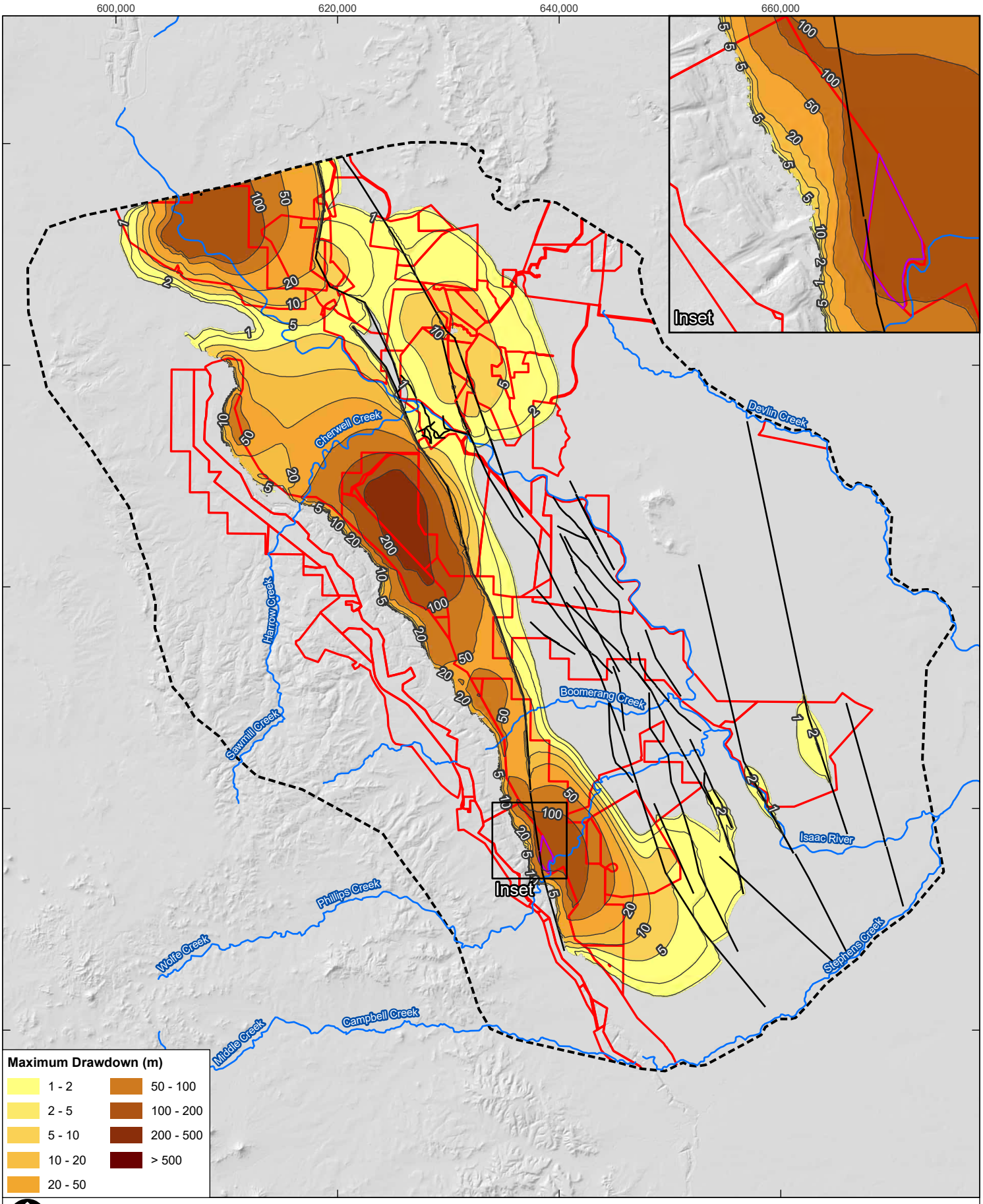
DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.

**FIGURE 3-16**

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040484.00001 Saraji Mine Grevillea GW Model\06 SLR Data\01 CADGIS\GIS\ArcPro\GW Modelling\GW Modelling.aprx\620040484 MOD F03-16 Maximum Cumulative Drawdown in Leichhardt Seam (Layer 5)


600,000
620,000
640,000
660,000
7,580,000
7,560,000
7,540,000
7,520,000
7,500,000
Inset
Inset
Cherwell Creek
Devlin Creek
Harrow Creek
Sawmill Creek
Boomerang Creek
Isaac River
Phillips Creek
Wolfe Creek
Campbell Creek
Middle Creek
Stephens Creek
Maximum Drawdown (m)
1 - 2
2 - 5
5 - 10
10 - 20
20 - 50
50 - 100
100 - 200
200 - 500
> 500
0
5
10
km
LEGEND
Modelled Fault
Drawdown Contour (m)
Major Drainage System
Mining Lease
Model Boundary
Project Area
Coordinate System: GDA 1994 MGA Zone 55
Scale: 1:450,000 at A4
Project Number: 620.040484.00001
Date Drawn: 12-Sep-2024
Drawn by: RB
SARAJI MINE GREVILLEA PIT CONTINUATION PROJECT MODELLING TECHNICAL REPORT
MAXIMUM CUMULATIVE DRAWDOWN IN VERMONT SEAM (LAYER 7)
SLR
DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.
FIGURE 3-17
Path: H:\Projects-SLR\620-BNE\620-BNE\620.040484.00001 Saraji Mine Grevillea GW Model\06 SLR Data\01 CADGIS\GIS\ArcPro\GW Modelling\GW Modelling.aprx\620040484 MOD F03-17 Maximum Cumulative Drawdown in Vermont Seam (Layer 7)


600,000
620,000
640,000
660,000
7,580,000
7,560,000
7,540,000
7,520,000
7,500,000
Inset
Inset
Cherwell Creek
Devlin Creek
Harrow Creek
Boomerang Creek
Sawmill Creek
Isaac River
Phillips Creek
Wolfe Creek
Stephens Creek
Campbell Creek
Middle Creek
Maximum Drawdown (m)
1 - 2
2 - 5
5 - 10
10 - 20
20 - 50
50 - 100
100 - 200
200 - 500
> 500
0
5
10
km
LEGEND
Modelled Fault
Drawdown Contour (m)
Major Drainage System
Mining Lease
Model Boundary
Project Area
Coordinate System: GDA 1994 MGA Zone 55
Scale: 1:450,000 at A4
Project Number: 620.040484.00001
Date Drawn: 12-Sep-2024
Drawn by: RB
SARAJI MINE GREVILLEA PIT CONTINUATION PROJECT
MODELLING TECHNICAL REPORT
MAXIMUM CUMULATIVE DRAWDOWN IN Q SEAM (LAYER 12)
SLR
DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.
FIGURE 3-18
Path: H:\Projects-SLR\620-BNE\620-BNE\620.040484.00001 Saraji Mine Grevillea GW Model\06 SLR Data\01 CADGIS\GIS\ArcPro\GW Modelling\GW Modelling.aprx\620040484 MOD F03-18 Maximum Cumulative Drawdown in Q Seam (Layer 12)




0 5 10 km

| | |
|---|---|
| Coordinate System: | GDA 1994 MGA Zone 55 |
| Scale: | 1:450,000 at A4 |
| Project Number: | 620.040484.00001 |
| Date Drawn: | 12-Sep-2024 |
| Drawn by: | RB |

**LEGEND**

- Modelled Fault
- Drawdown Contour (m)
- Major Drainage System
- Mining Lease
- Model Boundary
- Project Area

# SARAJI MINE GREVILLEA PIT CONTINUATION PROJECT MODELLING TECHNICAL REPORT

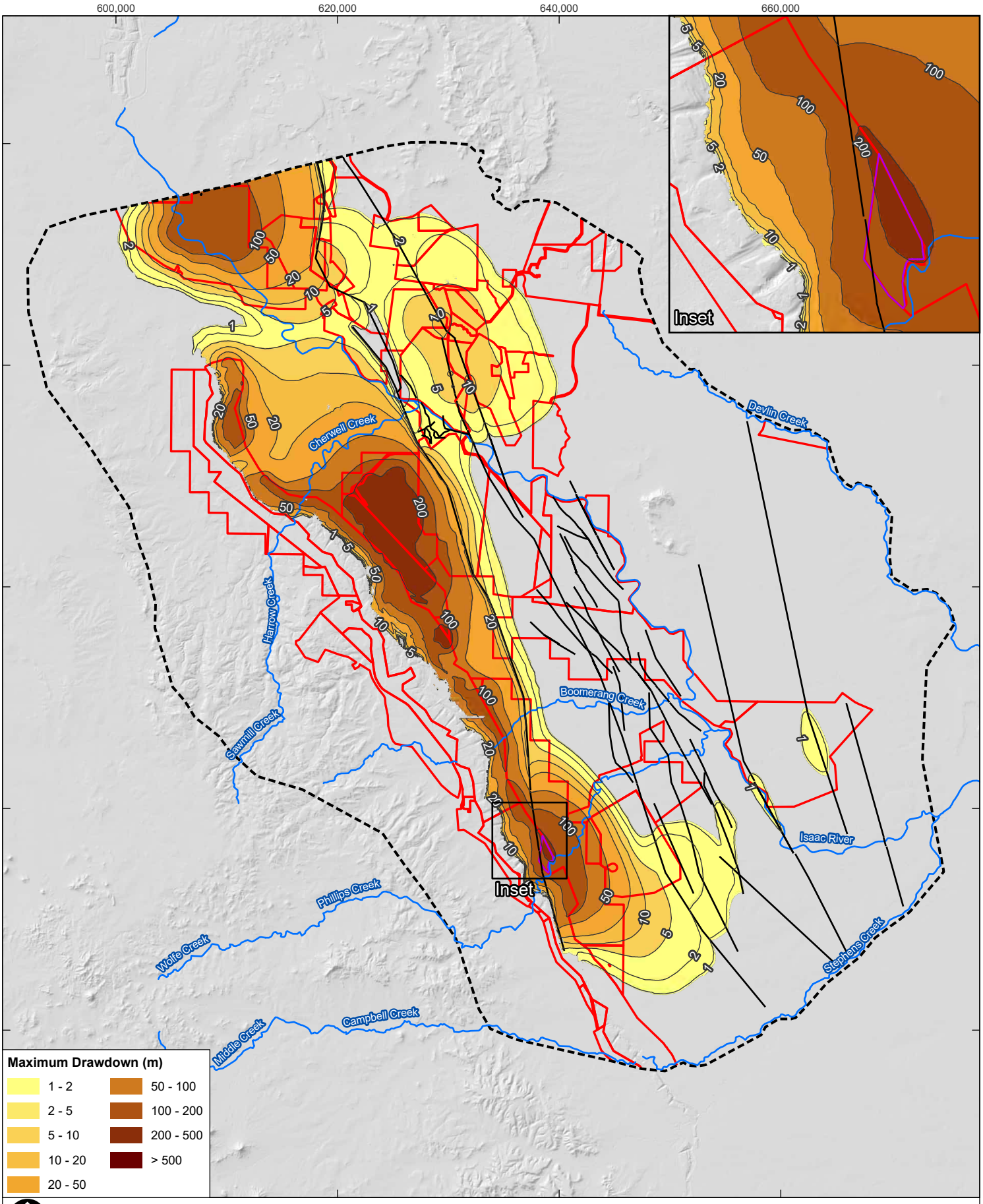
## MAXIMUM CUMULATIVE DRAWDOWN IN P SEAM (LAYER 14)

SLR

DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.

**FIGURE 3-19**

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040484.00001 Saraji Mine Grevillea GW Model\06 SLR Data\01 CADGIS\GIS\ArcPro\GW Modelling\GW Modelling.aprx\620040484 MOD F03-19 Maximum Cumulative Drawdown in P Seam (Layer 14)




0 5 10 km

| | |
|---|---|
| Coordinate System: | GDA 1994 MGA Zone 55 |
| Scale: | 1:450,000 at A4 |
| Project Number: | 620.040484.00001 |
| Date Drawn: | 12-Sep-2024 |
| Drawn by: | RB |

**LEGEND**

- Modelled Fault
- Drawdown Contour (m)
- Major Drainage System
- Mining Lease
- Model Boundary
- Project Area

# SARAJI MINE GREVILLEA PIT CONTINUATION PROJECT MODELLING TECHNICAL REPORT

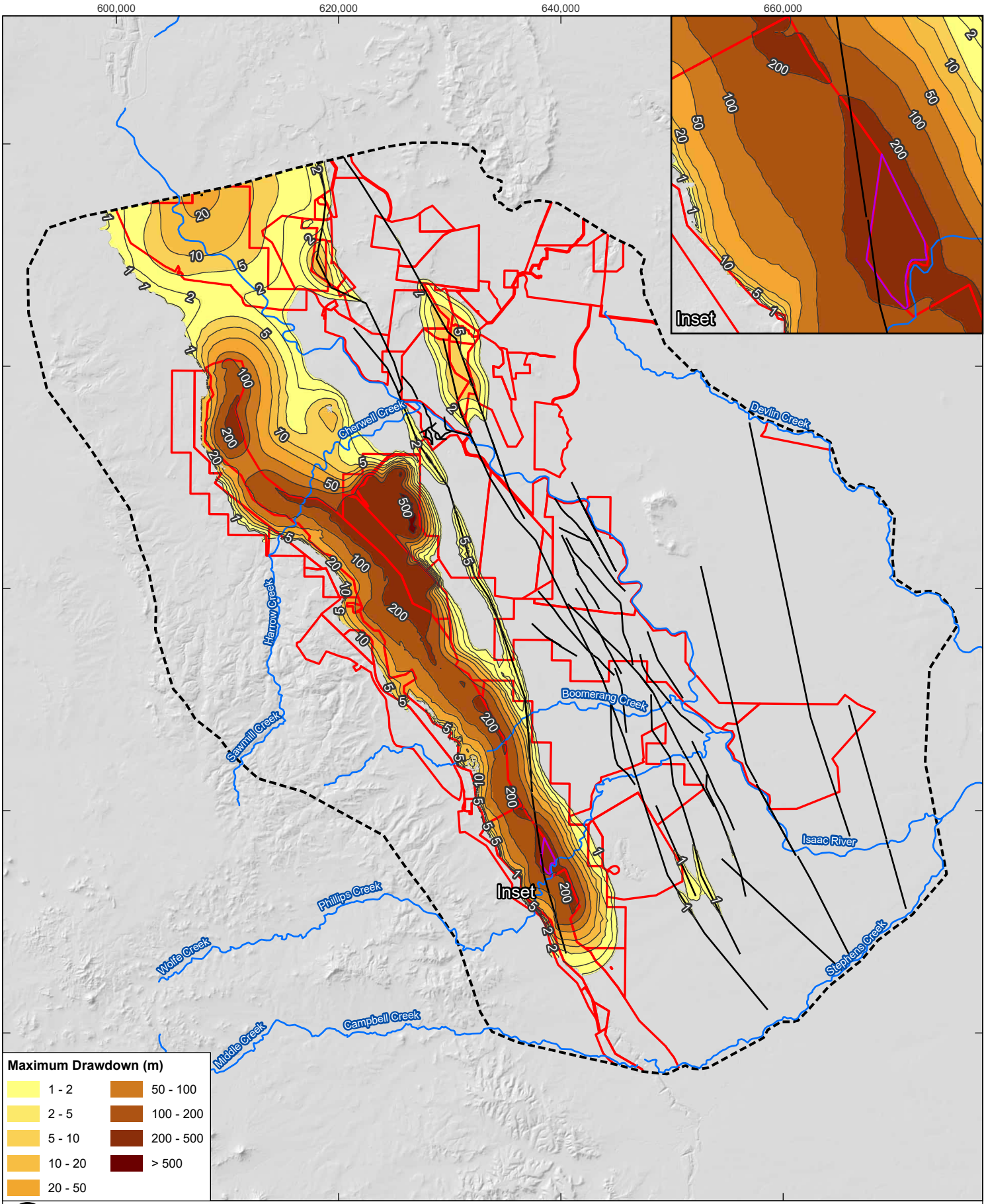
## MAXIMUM CUMULATIVE DRAWDOWN IN H SEAM (LAYER 16)

SLR

DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.

**FIGURE 3-20**

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040484.00001 Saraji Mine Grevillea GW Model\06 SLR Data\01 CADGIS\GIS\ArcPro\GW Modelling\GW Modelling.aprx\620040484 MOD F03-20 Maximum Cumulative Drawdown in H Seam (Layer 16)




0 5 10 km

| | |
|---|---|
| Coordinate System: | GDA 1994 MGA Zone 55 |
| Scale: | 1:450,000 at A4 |
| Project Number: | 620.040484.00001 |
| Date Drawn: | 12-Sep-2024 |
| Drawn by: | RB |

**LEGEND**

- Modelled Fault
- Drawdown Contour (m)
- Major Drainage System
- Mining Lease
- Model Boundary
- Project Area

# SARAJI MINE GREVILLEA PIT CONTINUATION PROJECT MODELLING TECHNICAL REPORT

## MAXIMUM CUMULATIVE DRAWDOWN IN D SEAM (LAYER 18)

SLR

DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.

**FIGURE 3-21**

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040484.00001 Saraji Mine Grevillea GW Model\06 SLR Data\01 CADGIS\GIS\ArcPro\GW Modelling\GW Modelling.aprx\620040484 MOD F03-21 Maximum Cumulative Drawdown in D Seam (Layer 18)

## 3.5 Predicted Groundwater Ingress

Project mine pit inflow volumes have been estimated as time weighted averages of the outflow reported by ZoneBudget software for drain cells representing mining. The predicted inflows for SRM excluding the Project (*"SRM"*) and SRM including the Project (*"SRM +The Project"*) are presented in **Figure 3-22**. The difference between the two cases represents the flows into the Project.

As shown in **Figure 3-22**, inflows for SRM + The Project are predicted to reach a maximum peak in year 2039 with 1900 ML/Yr (5.2 ML/d). This is approximately 500 ML/Yr higher than inflows for SRM, indicating the maximum inflow to the Project is approximately 1.34 ML/day. The inflows for SRM + The Project then decrease gradually and remain predominantly between 200 ML/Yr (0.56 ML/day) and 1200 ML/Yr (3.29 ML/day) until 2054 (end of the Project).

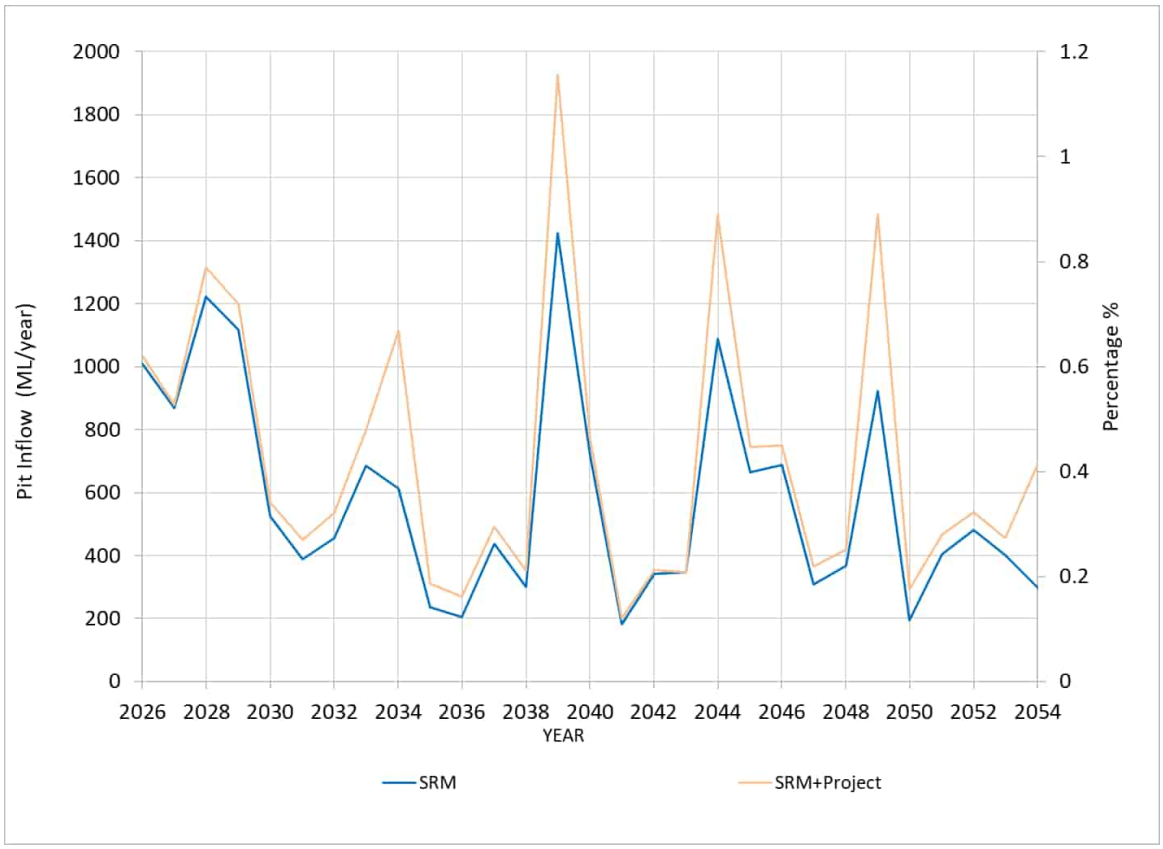



**Figure 3-22 Predicted Groundwater Inflows**

## 3.6 Incidental Water Impacts

### 3.6.1 Influence on Alluvium

The change in alluvial water resources was assessed by comparing water budgets for alluvial zones using the Cumulative and Approved scenarios of the predictive model. Interference of the alluvial groundwater can occur due to the potential for increased leakage from mining induced groundwater drawdown.

Over the extent of Phillips Creek alluvium, the predicted loss of water from alluvium due the Project is predicted to be less than 0.01 ML/d. With regards to the Isaac River alluvium, the model predicts that the alluvium take due to the Project is less than 0.003 ML/day.

It should be noted that any change in flux less than 0.01 ML/d is beyond the model ability to be able to predict it. Therefore, any flux changes derived from the model that are below than 0.01 ML/d are considered to be in the range of model error. This is consistent with the absence of drawdown shown in the alluvium.

### 3.6.2 Groundwater – Surface Water Interaction

The change in surface water drainage leakage to groundwater due to the Project was assessed by comparing the river cell flow budgets for the Isaac River in the Cumulative scenario against the Approved scenario. This comparison showed that over the life of the Project, the change in the Isaac River net flow attributable to the Project is less than 0.0003 ML/d.

In the model, Phillips Creek (located adjacent to the Project area) is represented with a stage height of 0.0 m which means it is simulated as a gaining system (i.e., negative net flow). The results indicate that there is no discernible change to the estimated net flow for Phillips Creek due to the Project.

# 4.0 Sensitivity Analysis

## 4.1 Calibration Identifiability

Identifiability describes a parameter's capability to be constrained by the model calibration. Identifiability values range from zero to one. As identifiability approaches one, the parameter is increasingly able to be constrained. Likewise, as values approach zero the parameter is increasingly unable to be constrained by the calibration and uncertainty of model results is not reduced through calibration.

The PEST utility GENLINPRED was used to provide an estimate of parameter identifiability for each of the model parameters. Estimated identifiability values for the calibrated parameters horizontal hydraulic conductivity, anisotropy, specific yield, and recharge are summarised in **Figure 4-1** through **Figure 4-5**.

**Figure 4-1** indicates that in general the calibration process was successful in constraining the horizontal hydraulic conductivity. Notably, the horizontal hydraulic conductivity of Rewan Group, Leichhardt Seam, Vermont Seam, MCM D Seam and Q Seam units are well constrained by calibration (high identifiability values above 0.80).

The horizontal hydraulic conductivity of most of the faults generally has not been able to be constrained well during calibration, relative to their surrounding unit. The exception to this is the Isaac fault zone (i.e., Kx_Fault_1), which has been constrained during the calibration.

Identifiability of hydraulic conductivity anisotropy for model zones is presented in **Figure 4-5**. Anisotropy in the weathered Permian, Moranbah Coal Measures interburden, Fort Cooper Coal Measures interburden and Moranbah Coal Measures interburden have high identifiability values indicating these can be constrained and contribute to reducing model uncertainty. All other zones feature low values (equal to and below 0.40) and are less constrained by calibration.

**Figure 4-3** shows that specific yield of Regolith, Rewan Group, and Isaac fault zone is highly identifiable, whilst other zones in the model domain have low identifiability.

**Figure 4-4** shows that the specific storage of D seam appears to be the most identifiable parameters among the zones.

**Figure 4-5** shows that the recharge zones for all the zones except the Isaac River Channel, are constrained by the calibration. Note that the stream channel alluvium represents a narrow zone along the Isaac River, with a small area relative to the other recharge zones. It is, therefore, considered less impactful to model predictions.

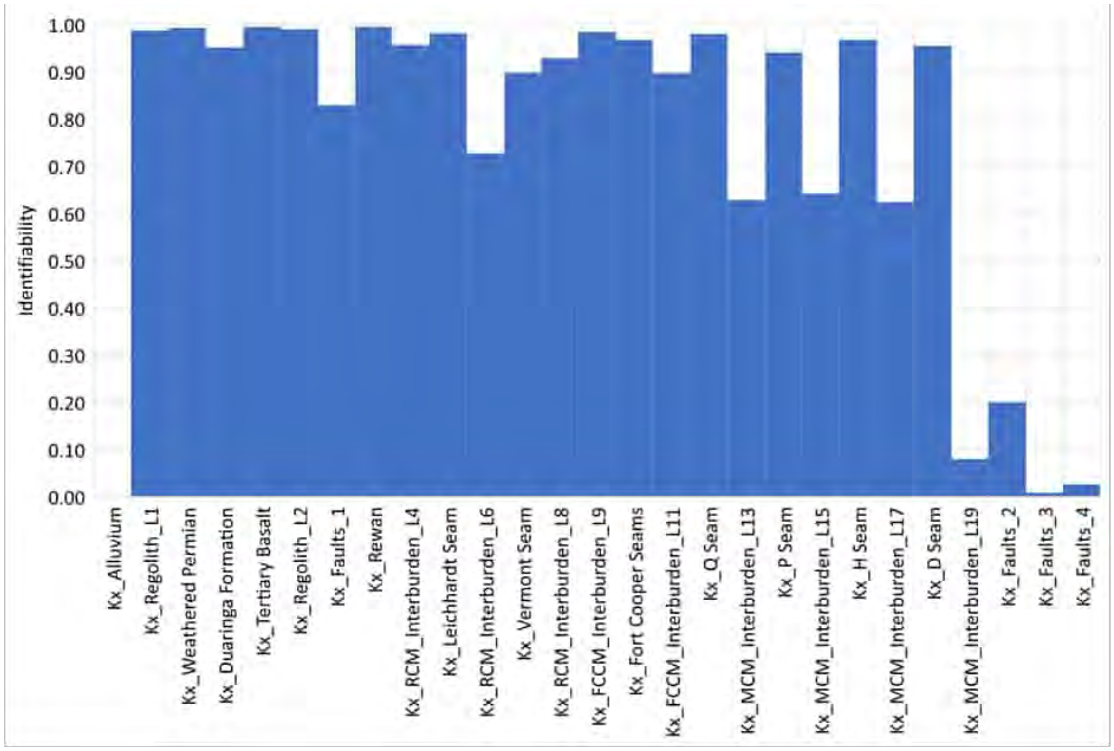



**Figure 4-1 Identifiability – Horizontal Hydraulic Conductivity (Kx)**

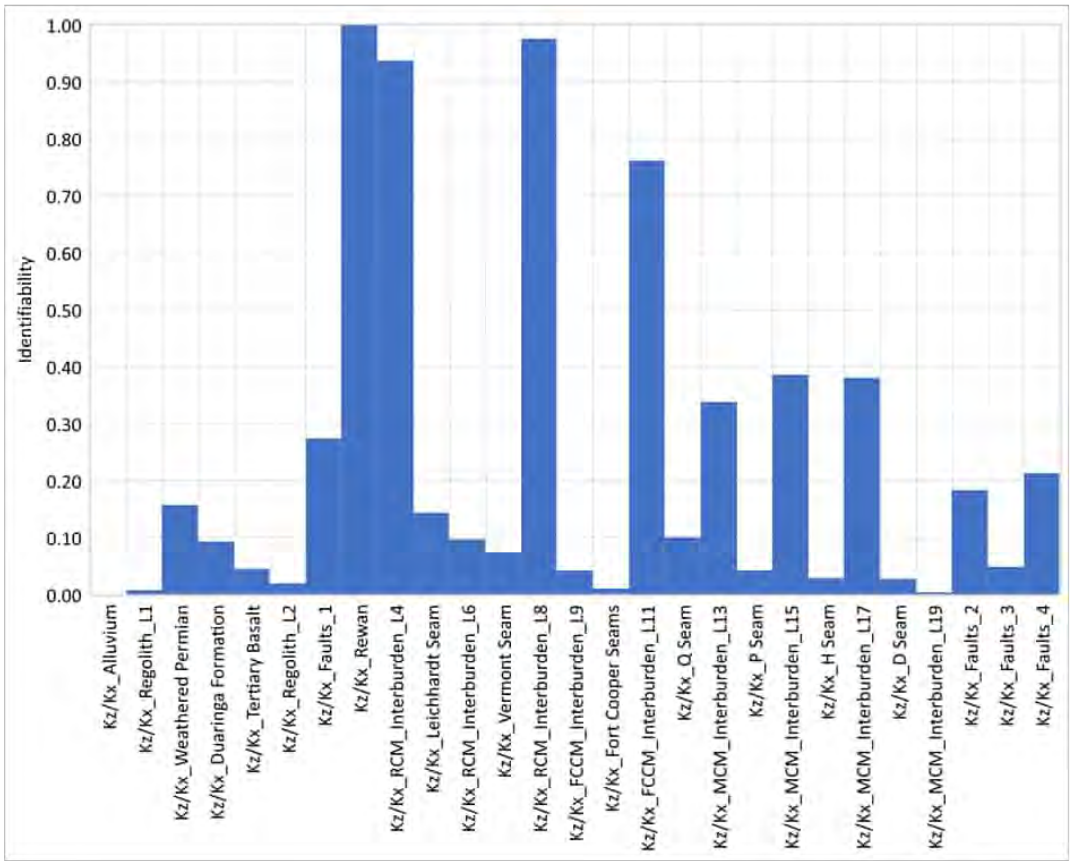



**Figure 4-2 Identifiability – Anisotropy (Kv/Kx)**

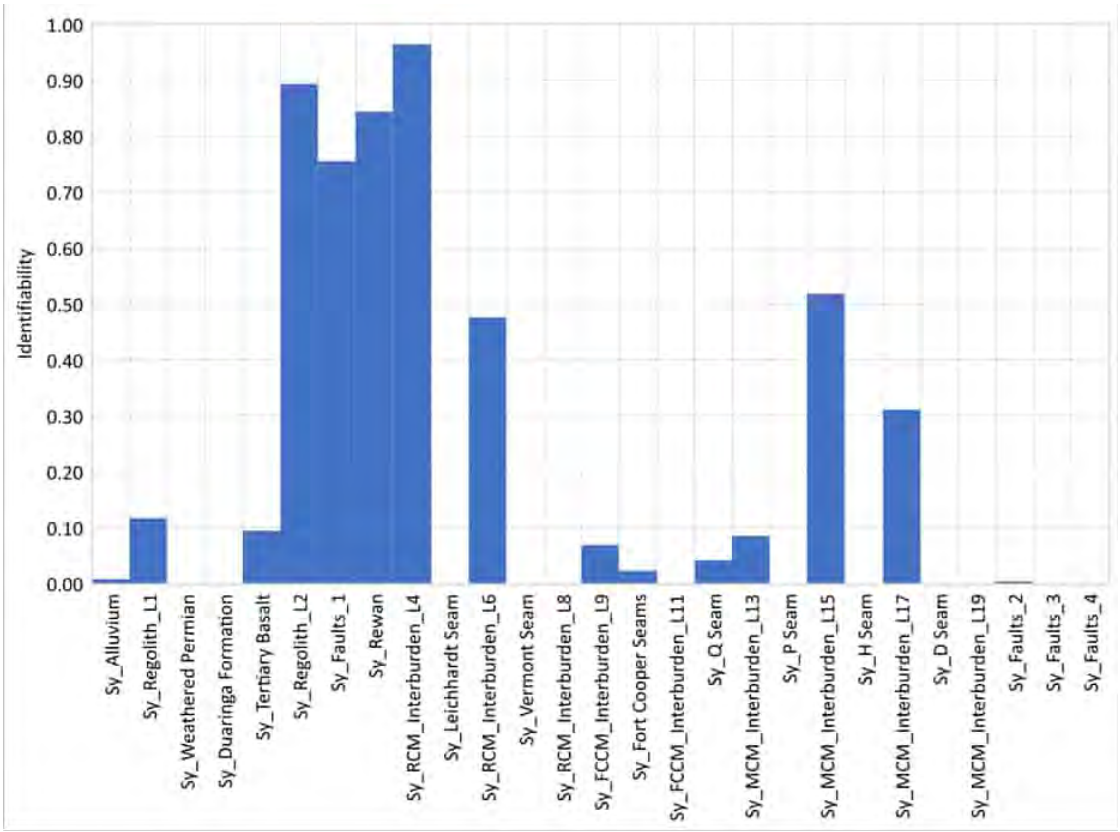



**Figure 4-3 Identifiability – Specific Yield (Sy)**

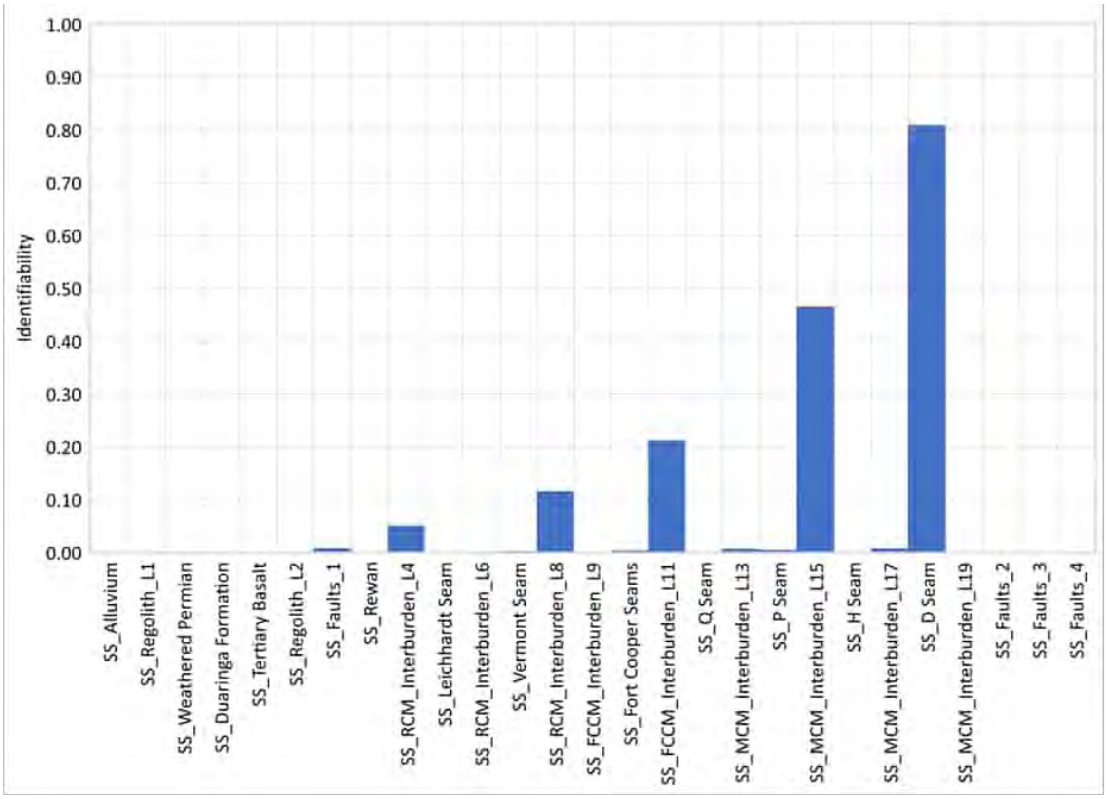



**Figure 4-4 Identifiability – Specific Storage (SS)**

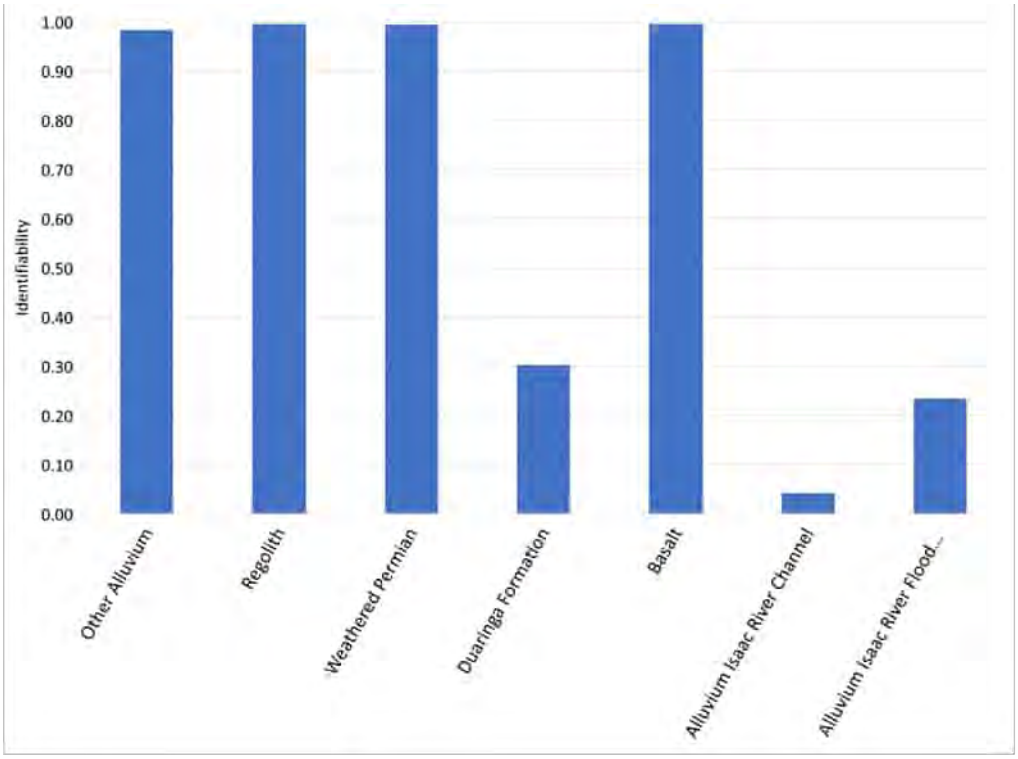



**Figure 4-5 Identifiability – Recharge (RCH)**

## 4.2 Prediction Identifiability

Prediction identifiability describes parameters capability to influence the model predictions. To calculate the prediction identifiability the groundwater model is run once per each parameter. The predictions included in the analysis were the project only inflows and maximum incremental drawdowns. The analysis then utilised the GENLINPRED utility to provide an estimate of parameter identifiability for each of the model parameters.

As identifiability approaches one, the parameter is increasingly able to change model predictions. On the contrary, as values approach zero the parameter is increasingly unable to change model predictions.

The Murray Darling Basin Modelling Guidelines (MDBC, 2000) recommends classifying sensitivity by the resultant changes (or contribution) to the model calibration and predictions. According to this process models can be classified as one of the four main types:

- Type I: Insignificant changes to calibration (low identifiability) and prediction (low uncertainty contribution).
- Type II: Significant changes to calibration (high identifiability) – insignificant changes to predictions (low uncertainty contribution).
- Type III: Significant changes to calibration (high identifiability) –significant changes to predictions (high uncertainty contribution).
- Type IV: Insignificant changes to calibration (low identifiability) –significant changes to predictions (high uncertainty contribution).

Types I-III are of less concern, as these Types have an insignificant impact on model predictions or are constrained by calibration. Type IV is classed as 'a cause for concern' as non-uniqueness in a model input might allow a range of valid calibrations but the choice of value impacts significantly on a prediction (MDBC, 2000).

To classify the sensitivity contribution to the model calibration and predictions for each model parameter, the calibration and prediction Identifiability were compared against each other for each parameter.

**Figure 4-6** presents the relationship between the identifiability of the inflows and the identifiability of the calibration. Sensitivity classifications for the sensitivity types have been assigned using judgement based on the range of the identifiability. The results show that the key parameters that require further work to reduce their influence on predictive uncertainty in relation to groundwater inflows include the specific yield of the Moranbah Coal Measures interburden (model layer 13) and anisotropy of the fault to the east of the Project.

**Figure 4-7** presents the relationship between identifiability of the maximum predicted drawdown and the identifiability of the calibration. Sensitivity classifications for the sensitivity types have been assigned using judgement based on the range of the posterior predictions. The results show that the key parameter that require further work to reduce its influence on predictive uncertainty in relation to the maximum drawdown extent are specific storage of the Moranbah Coal Measures interburden_L17 (i.e., interburden above the target coal seam), specific yield for 2 overlying interburden layers (Layers 9 and 13) and the anisotropy of the fault to the east of the Project.

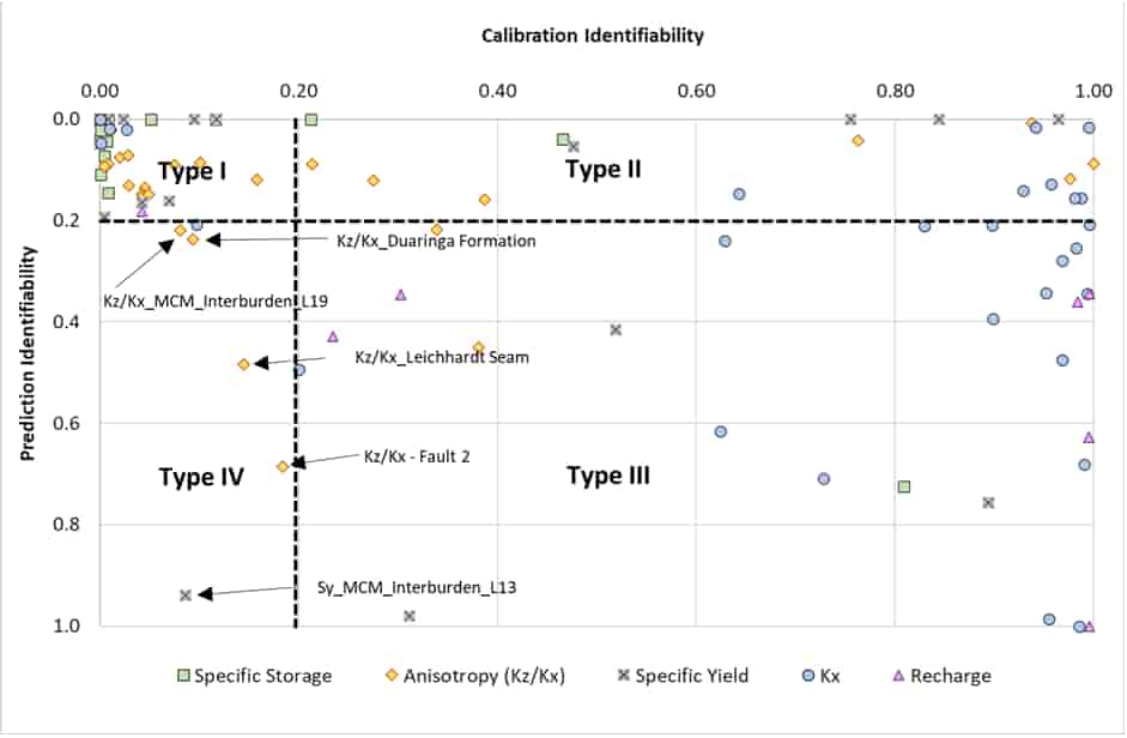



**Figure 4-6 Uncertainty Contribution (predicted mine inflow) versus Identifiability**

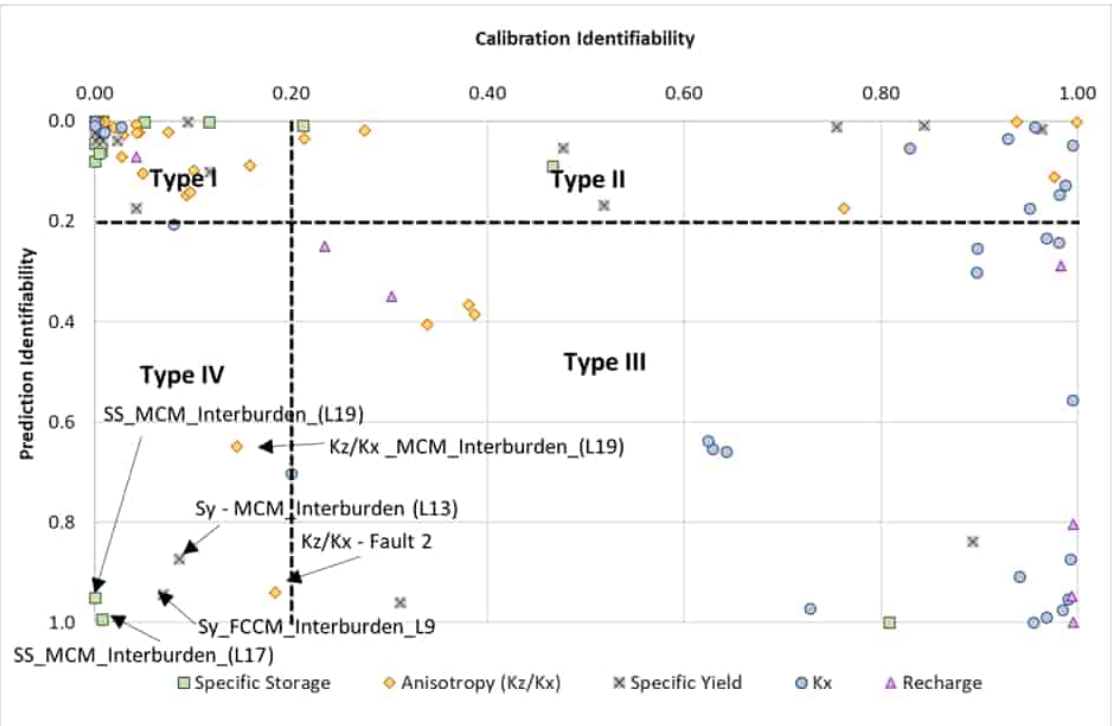



**Figure 4-7 Uncertainty Contribution (maximum incremental drawdown) versus Identifiability**

# 5.0 Uncertainty Analysis

A Type 3 Monte Carlo uncertainty analysis (IESC, 2018) was undertaken to estimate the uncertainty in the future impacts predicted by the model. This method operates by generating numerous alternative sets of input parameters to the deterministic groundwater flow model (realisations), executing the model independently for each realisation, and then aggregating the results for statistical analysis.

The first step in Monte Carlo analysis is to define the parameter distribution and range. The parameters are assumed to be log-normally distributed around the optimum value derived from the calibration and the standard deviation attributed to the log (base 10) of parameter is 0.5. The distribution for each parameter were checked and constrained such that upper or lower ranges do not go beyond ranges in literature for physical constraints. 1000 model realisations were generated, each having differing values of key parameters. The realisations were run, and calibration quality was assessed.

Of the 1000 model runs, 71 model runs were accepted as sufficiently calibrated, with SRMS values ranging between 5.9% and 7.9%. These were used in all model scenarios (Cumulative Mining, Approved Mining and no mining) and statistically analysed for uncertainty analysis.

## 5.1 Parameter Distribution

**Table 5-1** to **Table 5-5** show the parameter ranges explored during the uncertainty analysis simulation.

Parameters were assumed to possess a log-Normal distribution. Instead of simple random sampling, the Latin Hypercube Sampling (LHS) method was used to create random realisations from parameter distribution. LHS aims to spread the sample points evenly across all possible values. In doing so, it divides parameter space into N intervals of equal probability and chooses one sample from each interval. The generated random numbers derived from LHS approach is distributed sufficiently across the parameter space even at the small sample size. The main advantage of LHS over simple random sampling is that a lower number of realisations are needed to obtain a reasonable convergence of the uncertainty results. The parameter distributions for prior (i.e. from the 1000 model realisations) and posterior (i.e. from 71 accepted realisations) are provided as **Appendix E**.

**Table 5-1 Uncertainty Parameter Range for Horizontal Hydraulic Conductivity**

| Zone | Layer - Unit | Horizontal Hydraulic Conductivity (m/day) | |
|---|---|---|---|
| | | Mean (Log10) | Constraint |
| 1 | Layer 1 - Alluvium | 1.08 | No constraint |
| 2 | Layer 1 - Regolith | 0.00 | < Kx_Alluvium |
| 3 | Layer 1 - Weathered Permian | -0.19 | < Kx_Alluvium |
| 4 | Layer 1 - Duaringa Formation | -0.30 | < Kx_Alluvium |
| 5 | Layer 1/2 - Tertiary Basalt | 0.51 | < Kx_Alluvium |
| 6 | Layer 2 - Regolith | 0.00 | < Kx_Alluvium |
| 7 | Layer 3-19- Faults_zone1 | -0.91 | No constraint |
| 8 | Layer 3-Rewan | -2.63 | < Kx_Alluvium |
| 9 | Layer 4 - RCM O/B | -2.16 | < Kx_Alluvium |

| Zone | Layer - Unit | Horizontal Hydraulic Conductivity (m/day) | |
|---|---|---|---|
| | | Mean (Log10) | Constraint |
| 10 | Layer 5 - Leichhardt Seam | -1.02 | < Kx_Alluvium |
| 11 | Layer 6 - RCM I/B | -2.93 | < Kx_Alluvium |
| 12 | Layer 7 - Vermont Seam | -1.96 | < Kx_Alluvium |
| 13 | Layer 8 - RCM U/B | -3.00 | < Kx_Alluvium |
| 14 | Layer 9 - FCCM O/B | -3.00 | < Kx_Alluvium |
| 15 | Layer 10 - FCCM Seam | -2.94 | < Kx_Alluvium |
| 16 | Layer 11 - FCCM U/B | -0.39 | < Kx_Alluvium |
| 17 | Layer 12 - Q Seam | -1.00 | < Kx_Alluvium |
| 18 | Layer 13 - MCM U/B | 0.69 | < Kx_Alluvium |
| 19 | Layer 14 - P Seam | 0.69 | < Kx_Alluvium |
| 20 | Layer 15 -MCM I/B | -0.52 | < Kx_Alluvium |
| 21 | Layer 16 - H Seam | -0.98 | < Kx_Alluvium |
| 22 | Layer 17 - MCM I/B | -0.65 | < Kx_Alluvium, |
| 23 | Layer 18 - D Seam | -1.00 | < Kx_Alluvium |
| 24 | Layer 19 - MCM U/B | -0.56 | < Kx_Alluvium |
| 25 | Layer 3-19 - Faults zone 2 | -0.46 | No constraint |
| 26 | Layer 7 - Faults zone 3 | -0.32 | No constraint |
| 27 | Layer 8 - Faults zone 4 | -0.40 | No constraint |
| 28 | Layer 3-7 Faults zone 5 | -3.00 | No constraint |

Standard deviation = 0.5 order of magnitude for all units.

O/B = Overburden.

I/B = Interburden.

U/B = Underburden.

RCM = Rangal Coal Measures.

FCCM = Fort Cooper Coal Measures.

MCM = Moranbah Coal Measures.

**Table 5-2 Uncertainty Parameter Range for Vertical to Horizontal Conductivity (Kv/Kx)**

| Zone | Layer - Unit | Anisotropy (Kv/Kx) | |
|---|---|---|---|
| | | Mean (Log10) | Constraint |
| 1 | Layer 1 - Alluvium | -0.70 | < 1.0 |
| 2 | Layer 1 - Regolith | -1.00 | < 1.0 |
| 3 | Layer 1 - Weathered Permian | -1.18 | < 1.0 |
| 4 | Layer 1 - Duaringa Formation | -1.25 | < 1.0 |
| 5 | Layer 1/2 - Tertiary Basalt | -1.00 | < 1.0 |

| Zone | Layer - Unit | Anisotropy (Kv/Kx) | |
|---|---|---|---|
| | | Mean (Log10) | Constraint |
| 6 | Layer 2 - Regolith | -1.52 | < 1.0 |
| 7 | Layer 3-19 - Faults zone1 | -1.02 | < 1.0 |
| 8 | Layer 3 - Rewan | -1.11 | < 1.0 |
| 9 | Layer 4 - RCM O/B | -1.01 | < 1.0 |
| 10 | Layer 5 - Leichhardt Seam | -2.66 | < 1.0 |
| 11 | Layer 6 - RCM I/B | -0.97 | < 1.0 |
| 12 | Layer 7 - Vermont Seam | -1.43 | < 1.0 |
| 13 | Layer 8 - RCM U/B | -2.65 | < 1.0 |
| 14 | Layer 9 - FCCM O/B | -1.00 | < 1.0 |
| 15 | Layer 10 - FCCM Seam | -0.79 | < 1.0 |
| 16 | Layer 11 - FCCM U/B | -2.33 | < 1.0 |
| 17 | Layer 12 - Q Seam | -0.70 | < 1.0 |
| 18 | Layer 13 - MCM U/B | -0.70 | < 1.0 |
| 19 | Layer 14 - P Seam | -1.29 | < 1.0 |
| 20 | Layer 15 -MCM I/B | -1.33 | < 1.0 |
| 21 | Layer 16 - H Seam | -2.14 | < 1.0 |
| 22 | Layer 17 - MCM I/B | -1.21 | < 1.0 |
| 23 | Layer 18 - D Seam | -1.42 | < 1.0 |
| 24 | Layer 19 - MCM U/B | -2.23 | < 1.0 |
| 25 | Layer 3-19 - Faults zone 2 | -1.02 | < 1.0 |
| 26 | Layer 7 - Faults zone 3 | -2.99 | < 1.0 |
| 27 | Layer 8 - Faults zone 4 | -2.21 | < 1.0 |
| 28 | Layer 3-7 - Faults zone 5 | -2.00 | < 1.0 |

Standard deviation = 0.5 order of magnitude for all units.

### Table 5-3 Uncertainty Parameter Range for Specific Yield

| Zone | Layer - Unit | Specific Yield (Sy) | |
|---|---|---|---|
| | | Mean (Log10) | Constraint |
| 1 | Layer 1 - Alluvium | -1.60 | < 0.20 |
| 2 | Layer 1 - Regolith | -1.67 | < Sy_Alluvium; < 0.05 |
| 3 | Layer 1 - Weathered Permian | -2.73 | < Sy_Alluvium; < 0.05 |
| 4 | Layer 1 - Duaringa Formation | -1.71 | < Sy_Alluvium; < 0.05 |
| 5 | Layer 1/2 - Tertiary Basalt | -1.74 | < Sy_Alluvium; < 0.05 |
| 6 | Layer 2 - Regolith | -1.30 | < Sy_Alluvium; < 0.05 |
| 7 | Layer 3-19- Faults_zone 1 | -2.09 | < Sy_Alluvium; < 0.05 |

| Zone | Layer - Unit | Specific Yield (Sy) | |
|---|---|---|---|
| | | Mean (Log10) | Constraint |
| 8 | Layer 3-Rewan | -2.02 | < Sy_Alluvium; < 0.05 |
| 9 | Layer 4 - RCM O/B | -2.00 | < Sy_Alluvium; < 0.02 |
| 10 | Layer 5 - Leichhardt Seam | -3.00 | < Sy_Alluvium; < 0.02 |
| 11 | Layer 6 - RCM I/B | -2.00 | < Sy_Alluvium; < 0.02 |
| 12 | Layer 7 - Vermont Seam | -2.68 | < Sy_Alluvium; < 0.02 |
| 13 | Layer 8 - RCM U/B | -2.40 | < Sy_Alluvium; < 0.02 |
| 14 | Layer 9 - FCCM O/B | -2.98 | < Sy_Alluvium; < 0.02 |
| 15 | Layer 10 - FCCM Seam | -2.46 | < Sy_Alluvium; < 0.02 |
| 16 | Layer 11 - FCCM U/B | -2.34 | < Sy_Alluvium; < 0.02 |
| 17 | Layer 12 - Q Seam | -3.00 | < Sy_Alluvium; < 0.02 |
| 18 | Layer 13 - MCM U/B | -2.76 | < Sy_Alluvium; < 0.02 |
| 19 | Layer 14 - P Seam | -2.80 | < Sy_Alluvium; < 0.02 |
| 20 | Layer 15 -MCM I/B | -2.57 | < Sy_Alluvium; < 0.02 |
| 21 | Layer 16 - H Seam | -2.74 | < Sy_Alluvium; < 0.02 |
| 22 | Layer 17 - MCM I/B | -2.99 | < Sy_Alluvium; < 0.02 |
| 23 | Layer 18 - D Seam | -3.00 | < Sy_Alluvium; < 0.02 |
| 24 | Layer 19 - MCM U/B | -2.42 | < Sy_Alluvium; < 0.02 |
| 25 | Layer 3-19 - Faults zone 2 | -2.60 | < Sy_Alluvium; < 0.05 |
| 26 | Layer 7 - Faults zone 3 | -2.22 | < Sy_Alluvium; < 0.05 |
| 27 | Layer 8 - Faults zone 4 | -2.67 | < Sy_Alluvium; < 0.05 |
| 28 | Layer 3-7 Faults zone 5 | -2.00 | < Sy_Alluvium; < 0.05 |

Standard deviation = 0.5 order of magnitude for all units.

### Table 5-4 Uncertainty Parameter Range for Specific Storage (1/m)

| Zone | Layer - Unit | Specific Storage (SS) 1/m | |
|---|---|---|---|
| | | Mean (Log10) | Constraint |
| 1 | Layer 1 - Alluvium | -5.83 | $< 1 \times 10^{-5}$ |
| 2 | Layer 1 - Regolith | -5.55 | < SS_Alluvium;$< 1 \times 10^{-5}$ |
| 3 | Layer 1 - Weathered Permian | -6.99 | < SS_Alluvium;$< 1 \times 10^{-5}$ |
| 4 | Layer 1 - Duaringa Formation | -6.49 | < SS_Alluvium;$< 1 \times 10^{-5}$ |
| 5 | Layer 1/2 - Tertiary Basalt | -6.17 | < SS_Alluvium;$< 1 \times 10^{-5}$ |
| 6 | Layer 2 - Regolith | -6.75 | < SS_Alluvium;$< 1 \times 10^{-5}$ |
| 7 | Layer 3-19- Faults zone1 | -5.52 | < SS_Alluvium;$< 1 \times 10^{-5}$ |
| 8 | Layer 3-Rewan | -6.25 | < SS_Alluvium;$< 1 \times 10^{-5}$ |
| 9 | Layer 4 - RCM O/B | -5.48 | < SS_Alluvium;$< 1 \times 10^{-5}$ |

| Zone | Layer - Unit | Specific Storage (SS) 1/m | |
|---|---|---|---|
| | | Mean (Log10) | Constraint |
| 10 | Layer 5 - Leichhardt Seam | -6.30 | < SS_Alluvium;< 1 x $10^{-5}$ |
| 11 | Layer 6 - RCM I/B | -6.30 | < SS_Alluvium;< 1 x $10^{-5}$ |
| 12 | Layer 7 - Vermont Seam | -6.30 | < SS_Alluvium;< 1 x $10^{-5}$ |
| 13 | Layer 8 - RCM U/B | -5.89 | < SS_Alluvium;< 1 x $10^{-5}$ |
| 14 | Layer 9 - FCCM O/B | -6.28 | < SS_Alluvium;< 1 x $10^{-5}$ |
| 15 | Layer 10 - FCCM Seam | -5.64 | < SS_Alluvium;< 1 x $10^{-5}$ |
| 16 | Layer 11 - FCCM U/B | -5.66 | < SS_Alluvium;< 1 x $10^{-5}$ |
| 17 | Layer 12 - Q Seam | -5.60 | < SS_Alluvium;< 1 x $10^{-5}$ |
| 18 | Layer 13 - MCM U/B | -5.43 | < SS_Alluvium;< 1 x $10^{-5}$ |
| 19 | Layer 14 - P Seam | -5.64 | < SS_Alluvium;< 1 x $10^{-5}$ |
| 20 | Layer 15 -MCM I/B | -5.30 | < SS_Alluvium;< 1 x $10^{-5}$ |
| 21 | Layer 16 - H Seam | -6.16 | < SS_Alluvium;< 1 x $10^{-5}$ |
| 22 | Layer 17 - MCM I/B | -5.87 | < SS_Alluvium;< 1 x $10^{-5}$ |
| 23 | Layer 18 - D Seam | -5.32 | < SS_Alluvium;< 1 x $10^{-5}$ |
| 24 | Layer 19 - MCM U/B | -6.15 | < SS_Alluvium;< 1 x $10^{-5}$ |
| 25 | Layer 3-19 - Faults zone 2 | -6.24 | < SS_Alluvium;< 1 x $10^{-5}$ |
| 26 | Layer 7 - Faults zone 3 | -5.42 | < SS_Alluvium;< 1 x $10^{-5}$ |
| 27 | Layer 8 - Faults zone 4 | -6.13 | < SS_Alluvium;< 1 x $10^{-5}$ |
| 28 | Layer 3-7 Faults zone 5 | -5.00 | < SS_Alluvium;< 1 x $10^{-5}$ |

Standard deviation = 0.5 order of magnitude for all units.

### Table 5-5 Uncertainty Ranges for Recharge Rates

| Zone | Unit | Mean % of rainfall | Constraints |
|---|---|---|---|
| 1 | Other Alluvium | 0.23 | No Constraint |
| 2 | Regolith | 0.01 | < Other Alluvium |
| 3 | Weathered Permian | 0.06 | < Other Alluvium |
| 4 | Duaringa Formation | 0.01 | < Other Alluvium |
| 5 | Tertiary Basalt | 0.32 | No Constraint |
| 6 | Alluvium Isaac River Channel | 0.53 | No Constraint |
| 7 | Alluvium Isaac River | 0.23 | No Constraint |

Standard deviation = 0.5 order of magnitude for all units.

## 5.2 Uncertainty Results

### 5.2.1 Number of Realisations

71 realisations were selected as calibrated realisations and used for uncertainty analysis. The predictive model was then run using the 71 parameter sets. The results from the predictive model were used to conduct statistical analyses to assess if additional realisations were likely to provide results that would significantly change the reported predictive results. The 95 % confidence interval was calculated for the mine inflows and the maximum drawdown.

**Figure 5-1** and **Figure 5-2** show the 95 % confidence intervals of the median predicted inflows and maximum drawdown, as well as the variance of the median and maximum predicted inflows and drawdown as more realisations are considered. For example, the 95% confidence interval for the maximum drawdown is calculated by first estimating the maximum drawdown for each realisation and then calculating the 95 % confidence interval of the maximum drawdowns as each realisation is added to the dataset. As shown in **Figure 5-1** and **Figure 5-2**, any additional realisations (beyond the 71 considered) will not significantly increase or decrease the confidence intervals of predictions of mine inflows and maximum drawdowns. Therefore, the results from the 71 realisations are considered sufficient for the estimation of uncertainty with respect to inflows and other prediction variables.

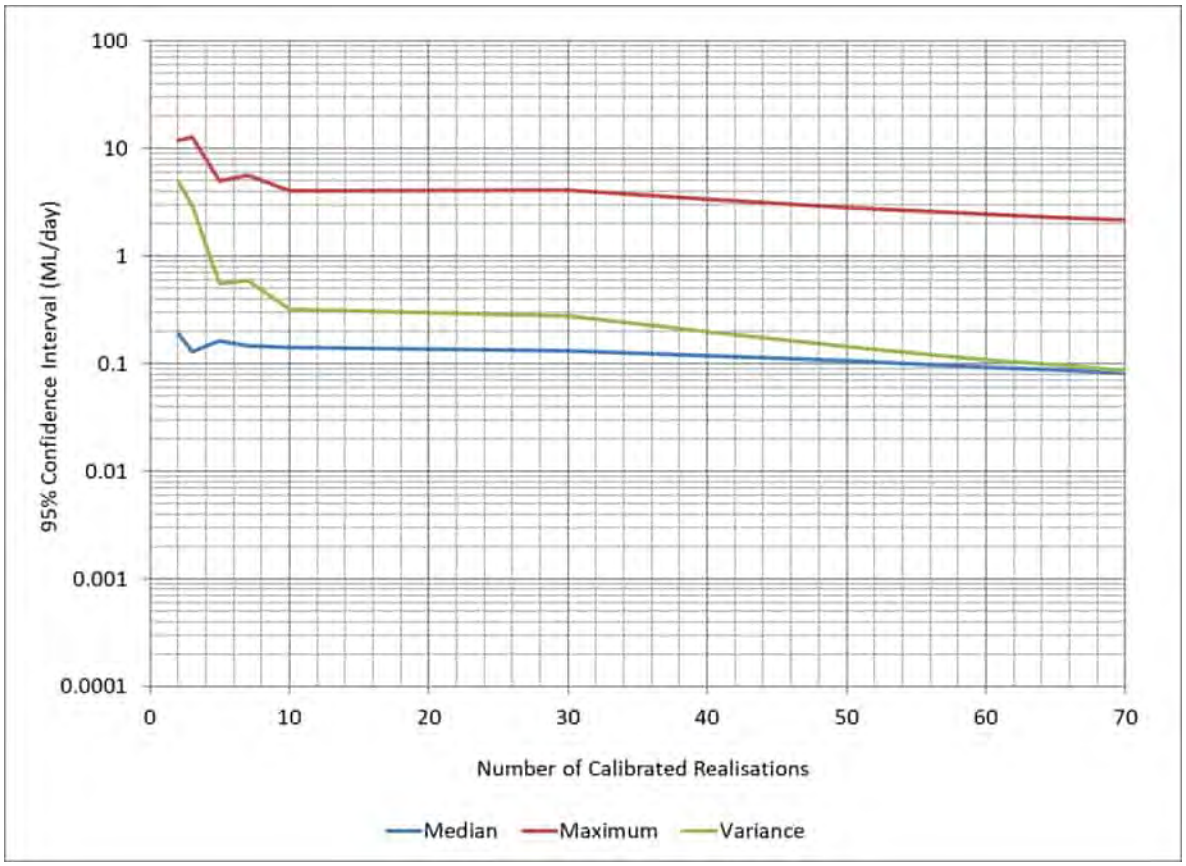



**Figure 5-1 95 % Confidence Interval for Pit Inflows**

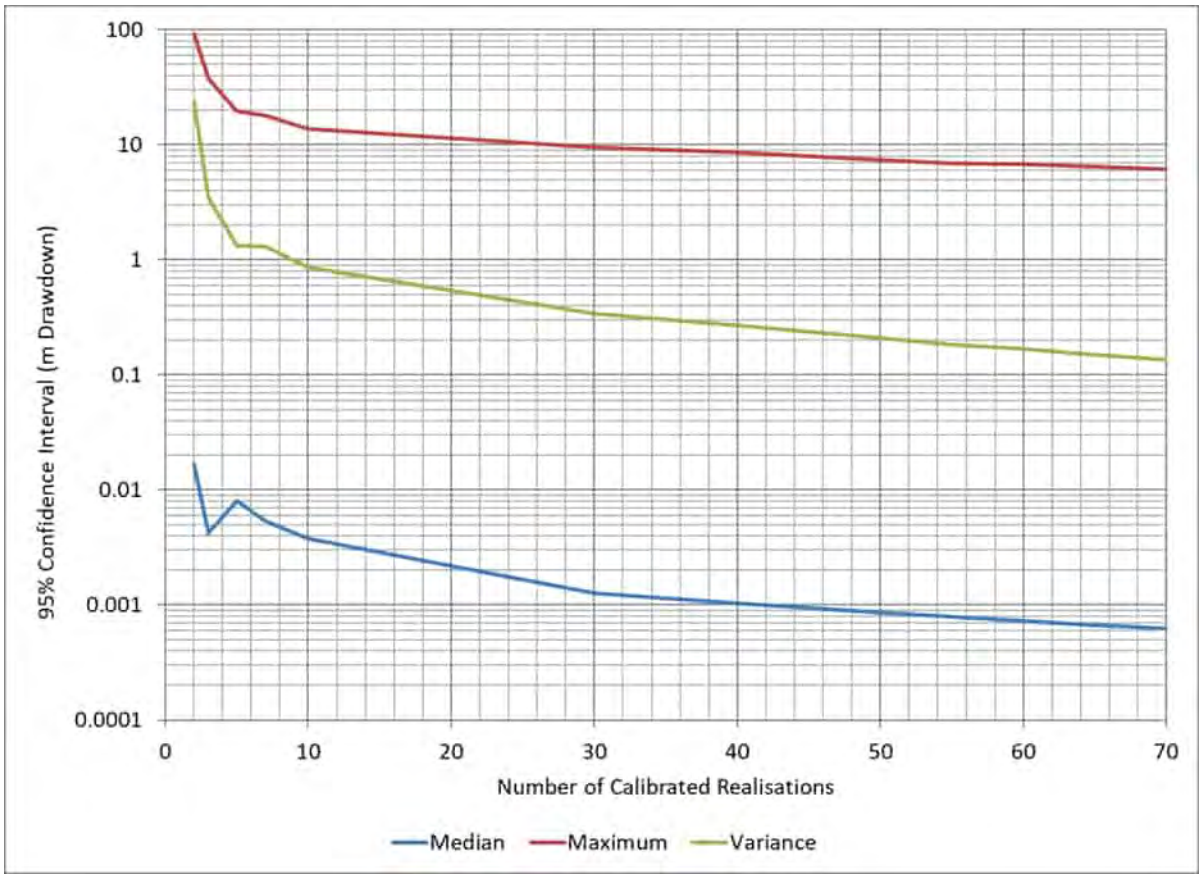



**Figure 5-2 95 % Confidence Interval for Maximum Drawdowns**

### 5.2.2 Uncertainty of Mine Inflows

**Figure 5-3** shows the predicted inflows for the Project and different percentiles including 5th, 33rd, 50th, 67th and 95th prediction bounds. Based on the IESC (2018, 2023) guidelines these percentiles represent:

- 5th percentile indicates it is very likely the outcome is larger than this value.
- 5th - 33rd indicates it is likely that the outcome is larger than this value.
- 33rd - 67th indicate it is as likely as not that the outcome is larger or smaller than this value.
- 67th - 95th indicates it is unlikely that the outcome is larger than this value.
- 95th percentile indicates it is very unlikely the outcome is larger than this value.

The bounds in the figure demonstrate the uncertainty in the predicted inflow rate.

As shown in **Figure 5-3**, the maximum mine inflow for the Project in the uncertainty analysis was approximately 1,000 ML/yr (2.7 ML/d) (i.e. very unlikely that the outcome is larger than this value). The Base Case inflow for the Project ranges from 40 ML/yr to 500 ML/yr whilst the 50$^{th}$ percentile inflow ranges between 40 ML/yr and 450 ML/yr (0.1 to 1.2 ML/d).

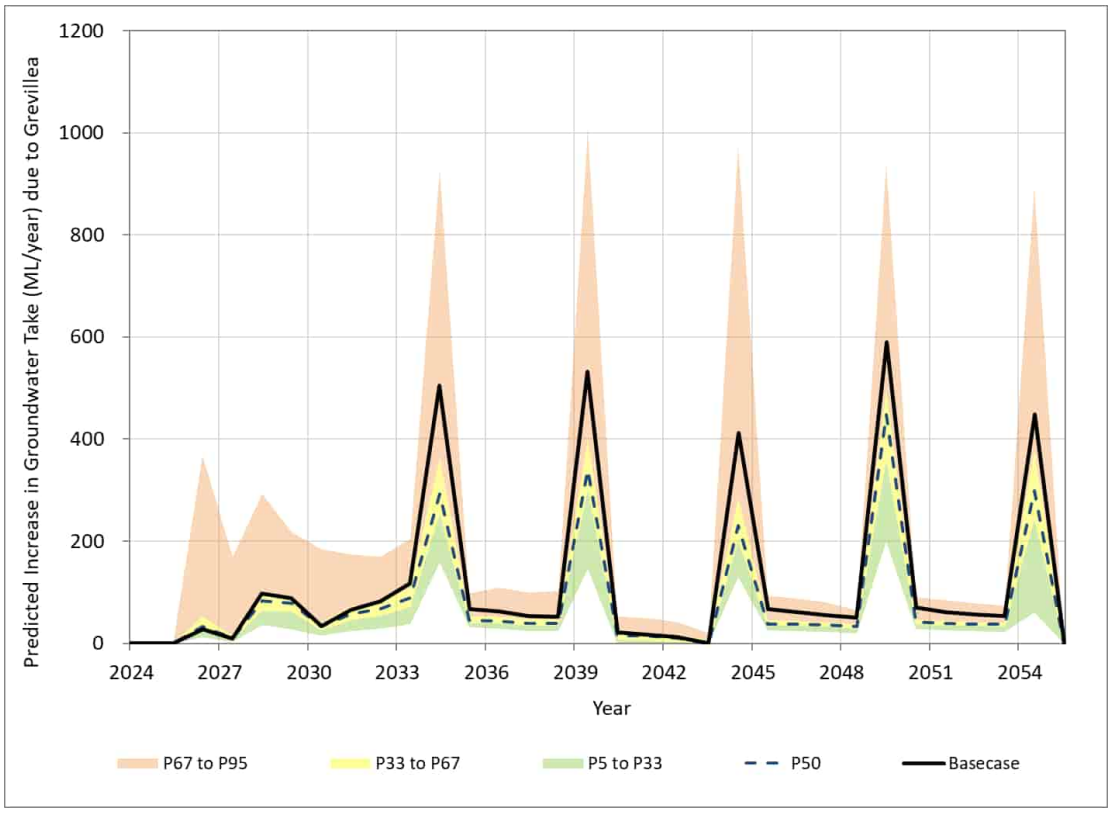



**Figure 5-3 Mine Inflow Uncertainty**

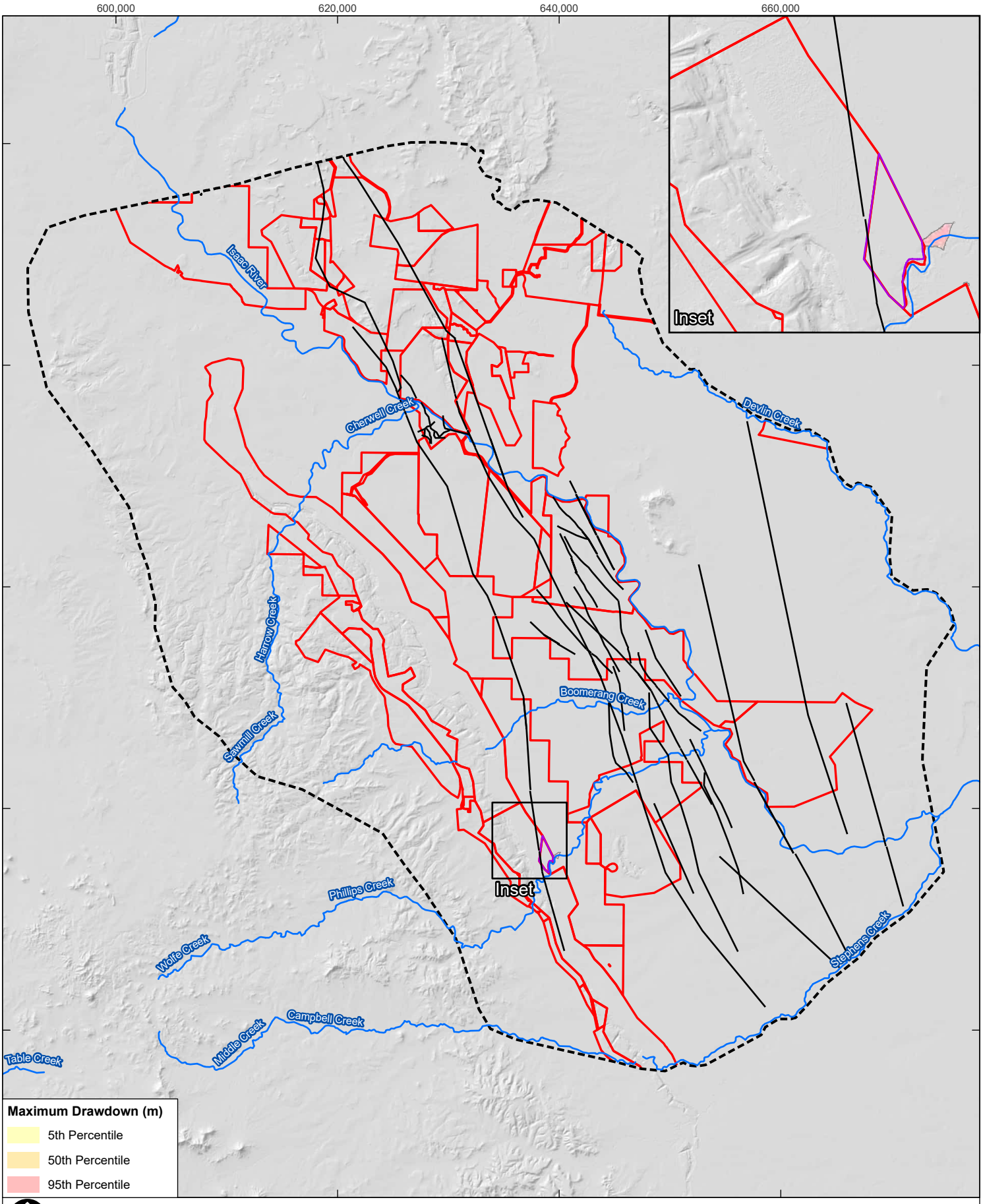
### 5.2.3 Groundwater Drawdowns

To illustrate the level of uncertainty in the extent of predicted drawdown, the 1 m drawdown due to the Grevillea Project is compared to 5th, 50th and 95th percentiles maximum drawdown from the uncertainty analysis.

**Figure 5-4** shows the 5th, 50th and 95th percentile maximum drawdowns in Alluvium. The uncertainty results indicate that the Project is very unlikely to impact alluvium.

**Figure 5-5** shows the uncertainty in the extent of predicted 1 m maximum incremental drawdown in regolith. As shown in this figure, the 5th, 50th and 95th percentile maximum drawdowns in the regolith are localised around the eastern side of the Project. With respect to the 95th percentile, the drawdown extends approximately 2.5 km northeast of the Project.

**Figure 5-6** and **Figure 5-7** show the uncertainty in the extent of predicted 1 m maximum incremental drawdown in the Q Seam and D Seam. The figures show that the 95th percentile drawdown in H Seam and D Seam extends between 5 and 10 km to the northwest and southeast of the Project.




0 5 10 km

| | |
|---|---|
| Coordinate System: | GDA 1994 MGA Zone 55 |
| Scale: | 1:450,000 at A4 |
| Project Number: | 620.040484.00001 |
| Date Drawn: | 12-Sep-2024 |
| Drawn by: | RB |

**LEGEND**

- Modelled Fault
- Major Drainage System
- Mining Lease
- Model Boundary
- Project Area

# SARAJI MINE GREVILLEA PIT CONTINUATION PROJECT MODELLING TECHNICAL REPORT

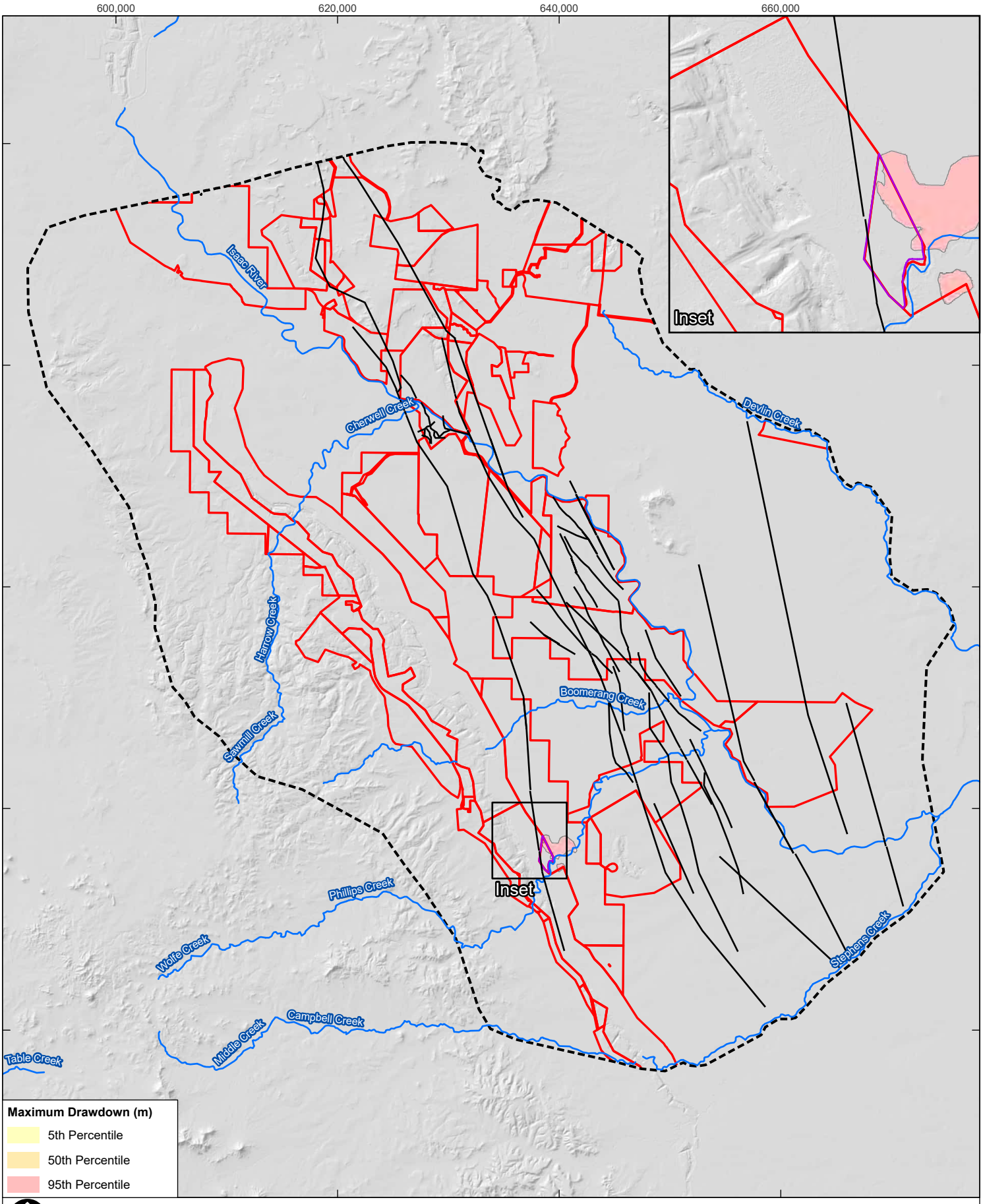
## UNCERTAINTY IN PREDICTED 1 M MAXIMUM INCREMENTAL DRAWDOWN IN ALLUVIUM (LAYER 1)

SLR

DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.

**FIGURE 5-4**

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040484.00001 Saraji Mine Grevillea GW Model\06 SLR Data\01 CADGIS\GIS\ArcPro\GW Modelling\GW Modelling.aprx\620040484 MOD F05-5 Uncertainty in Predicted 1 m Maximum Incremental Drawdown in Alluvium (Layer 1)




0 5 10 km

| | |
|---|---|
| Coordinate System: | GDA 1994 MGA Zone 55 |
| Scale: | 1:450,000 at A4 |
| Project Number: | 620.040484.00001 |
| Date Drawn: | 12-Sep-2024 |
| Drawn by: | RB |

**LEGEND**

- Modelled Fault
- Major Drainage System
- Mining Lease
- Model Boundary
- Project Area

# SARAJI MINE GREVILLEA PIT CONTINUATION PROJECT MODELLING TECHNICAL REPORT

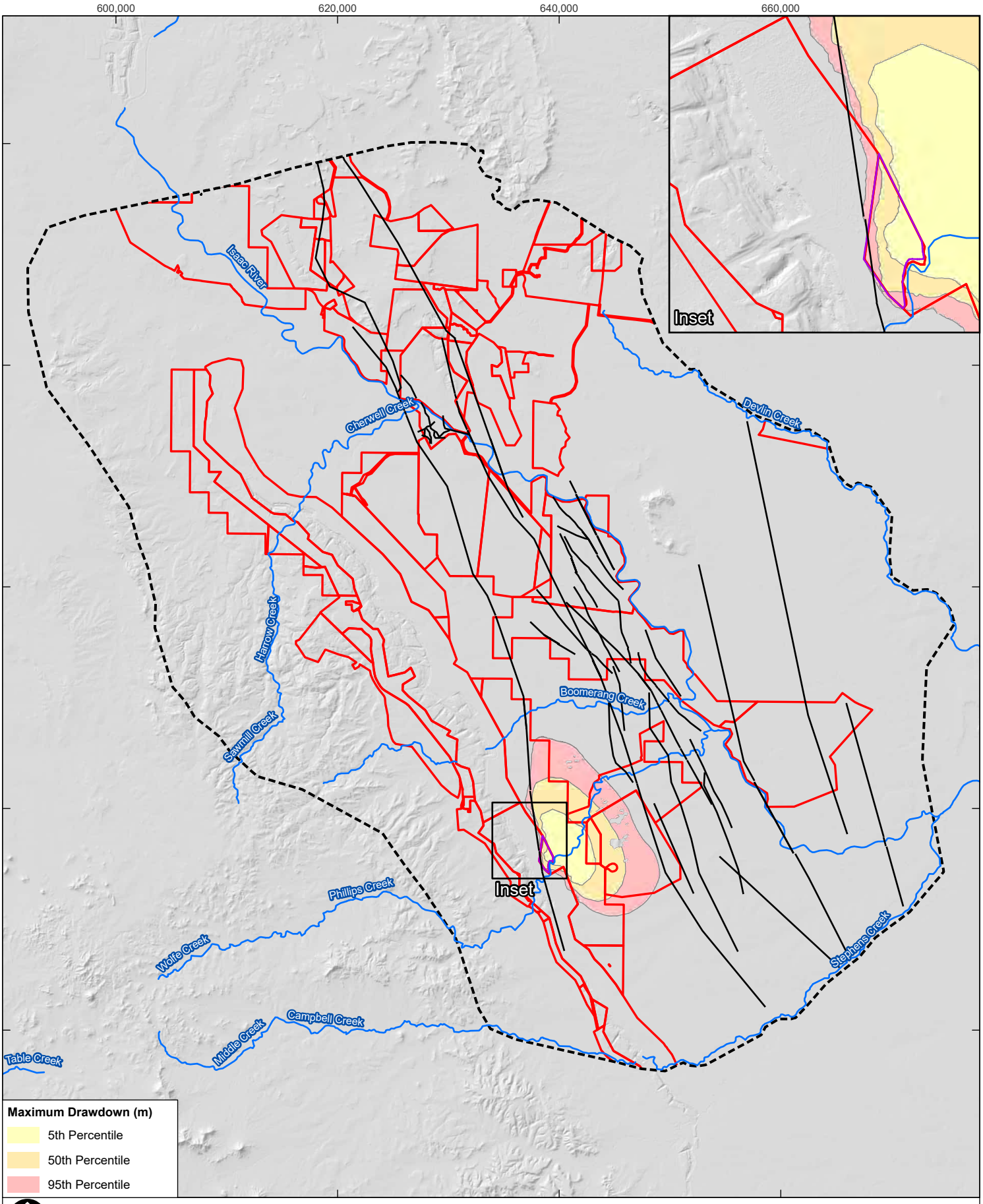
## UNCERTAINTY IN PREDICTED 1 M MAXIMUM INCREMENTAL DRAWDOWN IN REGOLITH (LAYER 2)

SLR

DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.

**FIGURE 5-5**

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040484.00001 Saraji Mine Grevillea GW Model\06 SLR Data\01 CADGIS\GIS\ArcPro\GW Modelling\GW Modelling.aprx\620040484 MOD F05-6 Uncertainty in Predicted 1 m Maximum Incremental Drawdown in Regolith (Layer 2)




0 5 10 km

| | |
|---|---|
| Coordinate System: | GDA 1994 MGA Zone 55 |
| Scale: | 1:450,000 at A4 |
| Project Number: | 620.040484.00001 |
| Date Drawn: | 12-Sep-2024 |
| Drawn by: | RB |

**LEGEND**

- Modelled Fault
- Major Drainage System
- Mining Lease
- Model Boundary
- Project Area

**SARAJI MINE GREVILLEA PIT CONTINUATION PROJECT MODELLING TECHNICAL REPORT**

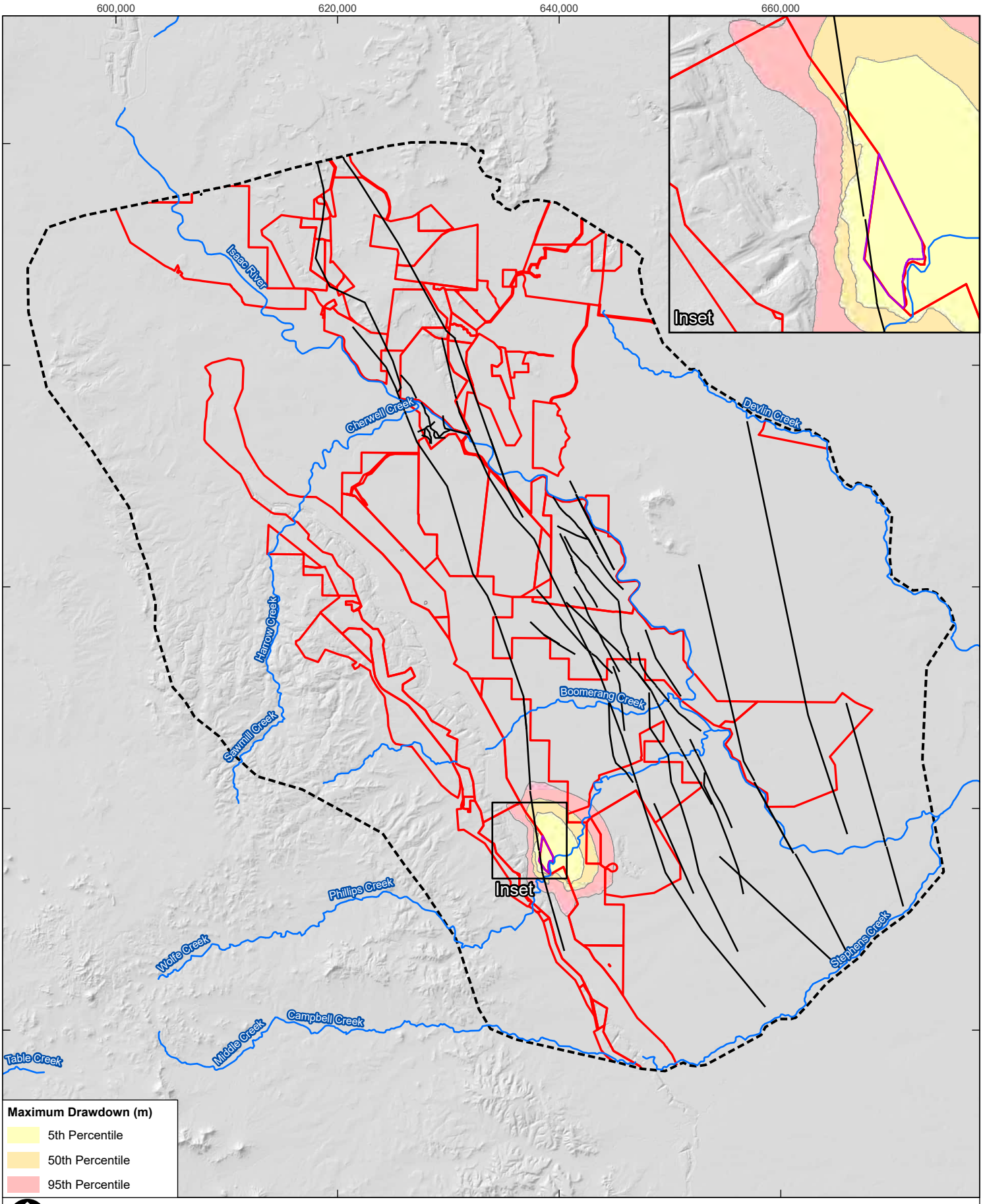
**UNCERTAINTY IN PREDICTED 1 M MAXIMUM INCREMENTAL DRAWDOWN IN Q SEAM (LAYER 12)**

SLR

DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.

**FIGURE 5-6**

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040484.00001 Saraji Mine Grevillea GW Model\06 SLR Data\01 CADGIS\GIS\ArcPro\GW Modelling\GW Modelling.aprx\620040484 MOD F05-7 Uncertainty in Predicted 1 m Maximum Incremental Drawdown in Q Seam (Layer 12)




0 5 10 km

| | |
|---|---|
| Coordinate System: | GDA 1994 MGA Zone 55 |
| Scale: | 1:450,000 at A4 |
| Project Number: | 620.040484.00001 |
| Date Drawn: | 12-Sep-2024 |
| Drawn by: | RB |

**LEGEND**

- Modelled Fault
- Major Drainage System
- Mining Lease
- Model Boundary
- Project Area

# SARAJI MINE GREVILLEA PIT CONTINUATION PROJECT MODELLING TECHNICAL REPORT

## UNCERTAINTY IN PREDICTED 1 M MAXIMUM INCREMENTAL DRAWDOWN IN D SEAM (LAYER 18)

SLR

DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.

**FIGURE 5-7**

Path: H:\Projects-SLR\620-BNE\620-BNE\620.040484.00001 Saraji Mine Grevillea GW Model\06 SLR Data\01 CADGIS\GIS\ArcPro\GW Modelling\GW Modelling.aprx\620040484 MOD F05-8 Uncertainty in Predicted 1 m Maximum Incremental Drawdown in D Seam (Layer 18)

### 5.2.4 Uncertainty of Influence on Alluvium and Surface Water Flow

The uncertainty analysis results showed that even for the 95th percentile prediction, which is a very unlikely outcome, the influence on the Isaac Alluvium due to the Project was negligible and considered to be in the range of model error (< 0.01 ML/d). The uncertainty analysis also showed that the Project had no discernible effect on the Phillips Creek Alluvium. In addition, the uncertainty analysis indicates that there is no discernible change to the net flow of Isaac River and Phillips Creek as the result of the Project.

# 6.0 Model Confidence Level Classification

The groundwater modelling was conducted in accordance with the Australian Groundwater Modelling Guidelines (Barnett et al., 2012), the Murray Darling Basin Commission (MDBC) Groundwater Flow Modelling Guideline (MDBC, 2001) and the released IESC Explanatory Note for Uncertainty Analysis (IESC, 2023). These are mostly generic guides and do not include specific guidelines on special applications, such as underground coal mine modelling.

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

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

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

**Table 6-1** summarises the subjective qualitative criteria allowing model classification, per Table 2.1 of the 2012 Australian Groundwater Modelling Guidelines. The classification of the Grevillea model as presented in **Table 6-1** has been assessed subjectively by a Principal level groundwater modeller and reviewed by a Technical Director level hydrogeologist/modeller, whereby:

1 The classification table was subjectively reviewed, and the specialists mutually decided, in their professional opinion, which box most appropriately describes the various characteristics of the model.

2 Thereafter, the assessors assigned an overall classification class for the model based on the characteristics selected, i.e. which class has the most selected characteristics.

The assessment shown in **Table 6-1** indicates that, overall, the groundwater model can be classified as primarily Class 3 using the 2012 Australian Groundwater Modelling Guidelines classification system (effectively “high confidence”), with some aspects meeting the lower Class 2 (“medium confidence”) criteria. This is considered an appropriate level for the Project groundwater assessment context.

**Table 6-1 Groundwater Model Classification Table[1,2]**

| Class | Model Characteristics | | | | | |
|---|---|---|---|---|---|---|
| | Data | | Calibration | | Prediction | |
| 1 | | Few or poorly distributed data points | | Not possible | | Predictive timeframe >> calibration timeframe |
| | | Unavailable or sparse data in areas of greatest interest | | Unacceptable levels of error | | Temporal discretisation is different to calibration |

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

| Class | Model Characteristics | | | | | |
|---|---|---|---|---|---|---|
| | Data | | Calibration | | Prediction | |
| | | Streamflow and stage measurements are available at many points | | | | |
| | | Reliable land-use and soil-mapping data available | | | | |
| | | Reliable irrigation application data available | | | | |

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

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

# 7.0 Groundwater Model and Data Limitation

The latest version of the IESC Explanatory Note for Uncertainty Analysis defines a model fit for purpose when model results are:

- Usable - Relevant to the decision-making process, providing information about the uncertainty in conceptualisations and modelling simulations in a way that allows decision-makers to understand the effects of uncertainty on project objectives and the effects of potential bias. The relevant Quantities of Interests (QoI) in this context are the groundwater inflows and drawdowns to assess licensing, site water management and drawdown impacts.
- Reliable - Demonstrate that the range of model outcomes is consistent with the system knowledge and honours historical observations and provides objective evidence that uncertainties affecting decision-critical predictions of impacts on aquifer resources and dependent systems are not underestimated. The calibration performance was deemed acceptable, and a rigorous UA was undertaken to further improve confidence in the modelling outputs.
- Feasible - Trade-offs due to budget, time and technical constraints are reasonable and justifiable within the risk context of the Project. This study is an update of an earlier model, which shows that there are several model revisions therefore mitigating budget and time trade-offs. Updated technical datasets are included in the most recent revision. The model has been peer reviewed for each revision. The model builds and associated review process are therefore deemed commensurate with the Project related risk to the groundwater environment.

The IESC uncertainty analysis guidelines (2018, 2023) identify four key sources of scientific uncertainty affecting groundwater model simulations:

- Structural/conceptual.
- Parameterisation.
- Measurement error.
- Scenario uncertainties.

These four sources of scientific uncertainty have been qualitatively assessed with regards key aspects of the groundwater model, as presented in **Table 7-1**.

Overall, the model captures depressurisation due to active mining. The model is numerically stable with no mass balance error. The model shows a reasonable fit between observed and modelled groundwater levels (**Section 2.6.4**). A depth dependence function was used for hydraulic conductivity, with the calibrated values showing a good fit to observed data as presented in **Section 2.7**. Overall, the model is considered fit for purpose to achieve the objectives outlined in **Section 1.0** based on the data provided and the project timeframe.

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

**Table 7-1 Groundwater Model and Data Limitations**

| Type | Part | Status | Comment |
|---|---|---|---|
| Structural/ Conceptual | Grid and Model Extent | Fit for purpose | The model has an unstructured Voronoi grid that includes detailed cell refinement around site, neighbouring mines and along drainage features. |
| | Layers | Fit for purpose | Top of layer 1 incorporates site LiDAR data from Grevillea and SRM. |
| | | Fit for purpose | Representation of alluvium based on CSIRO (2015) regolith mapping and refined based on site drill data. |
| | Conceptualisation – Geological Structure | Fit for purpose | The local structure of the geology is based on detailed data at site, and regional model geometry (outside of site) interpolated based on neighbouring mines geology models (Winchester South, Lake Vermont, Moorvale South and Olive Downs South) and geological mapping.<br>Geophysical surveys across the Project Area have identified minor faulting in the Grevillea area. Faulting is typically confined to the coal seams of the Moranbah Coal Measures. No geological structures (i.e. faults) have been included within the Project area in the model other than through layer displacements from the site geological model. The most significant geological structure in the area is the Fault which is located 500m from the site and will not be intersected by mining. |
| | Conceptualisation – Surface Water Groundwater Interactions | Fit for purpose | The Permian coal measures outcrop along the western edge of the site. Therefore, how this is captured within the model influences the model predictions. The structure of the coal seams was checked to ensure it matches observed and mapped geology. The predictions of drawdown adjacent to mining was checked and the model shows a good fit between modelled and observed trends. |
| | Conceptualisation – Saturated Extent of Alluvium and Regolith | Fit for purpose | For the extent and thickness of alluvium in the vicinity of the Project Area (i.e., alluvium along Boomerang Creek) auger hole logs and Google satellite imagines were used. Any additional data or study on alluvium extent and thickness at Grevillea should be reviewed and captured (where relevant) in future updates of the model. Such improvements are not deemed required for the Project impact assessment however. |
| Parameterisation | Hydraulic Conductivity – Depth Dependence | Fit for purpose, future improvements possible | Field testing of hydraulic conductivity (horizontal and to a lesser extent vertical) has been conducted in the area. Hydraulic conductivity test results from the other sites within the model domain were also considered. The data shows a general decline in hydraulic conductivity with depth that is replicated in the model. |





| Type | Part | Status | Comment |
|---|---|---|---|
| | | | Further conductivity tests and measurements of storage properties can improve model calibration and refine model predictions but are not deemed required for the Project impact assessment. |
| | Spoil Properties | Fit for purpose, future improvements possible | Limited site-specific data is available for the spoil. Spoil properties were adopted using the previous studies. |
| | Rivers | Fit for purpose, future improvements possible | Isaac River stage height is changed temporally in the historical calibration model based on observed levels from government stream gauges, and long term annual average level assumed in the predictive model.<br>Watercourses in the vicinity of the Project Area are ephemeral and only flow briefly after rainfall. Therefore, river stage height of zero was assigned to these watercourses in the model.<br>Measurements of flow rates and stage height in the rivers can help with improving the model calibration and refining the model predictions but are not deemed required for the Project impact assessment. |
| | Recharge | Fit for purpose | Recharge zonation is based on mapped surface geology and calibrated recharge rates. |
| Measurement Error | Observation Data Quality | Fit for purpose | Bore logs and construction details available for most site bores, and long-term site water level data available for various units. |
| | Landholder Bore Data Quality | Fit for purpose | Impacts on registered landholder bores are influenced by the assumptions of the bore design, target geology and use. |
| | Temporal spread | Fit for purpose | Timeseries water level data from the site as well as the neighbouring mines (Winchester South, Moorvale South, Olive Downs South and Lake Vermont, Peak Downs, Moranbah South) for the alluvium and Permian coal measures. |
| Scenario Uncertainties<br>Future stresses/ conditions | Calibration | Fit for purpose | Transient warm-up (1988-2008) and transient (2008 to 2022) calibration model set up and a depth dependence function used and calibration to water levels conducted using automated (PEST) and manual methods. |
| | Predictive | Fit for purpose | Model captures approved and proposed open cut at Grevillea. The model also includes future mining at Saraji and Peak Downs mainly based on publicly available data. The actual future mine progression for these sites may vary. |

| Type | Part | Status | Comment |
|---|---|---|---|
| | Sensitivity and uncertainty | Fit for purpose | Uncertainty analysis has been conducted by stochastic modelling using an adapted Monte Carlo method with modern software packages. The LHS method was used to create random realisations from parameter and PEST++ was used to orchestrate the model runs. The uncertainty analysis quantified the variability in predictions with changes in maximum predicted drawdowns, mine inflows, impact on alluvium flow and impacts on surface water flow. |





# 8.0 Conclusions

The numerical groundwater model developed for the Project has successfully achieved the modelling objectives, as outlined in **Section 1.0**.

The numerical groundwater model covered a large domain due to extensive historic and approved mining within the region. Existing and approved mines are represented in the model.

The calibrated model showed a reasonable match between simulated and observed water levels across the model domain and therefore the model parameterisation was considered appropriate for the Project modelling.

The key conclusions from the modelling are summarised as follows:

- Predicted groundwater inflows to the Project range between 0.1 to 1.2 ML/d (between 2033 and 2055) up to a maximum in the order of 1.34 ML/d.
- There is no groundwater drawdown predicted in the alluvium due to the Project.
- Groundwater drawdown in the regolith occurs to the northeast of the Project where the model predicts the regolith is saturated.
- Groundwater drawdown in Permian coal seams is limited to the west due to coal seam subcrops/existing open pit mining, and extends a maximum of 5 km north and 6 km southeast of the Project.
- No change in surface water flows in Phillips Creek is predicted due to the Project. Similarly, no change is predicted to surface water flows in the Isaac River due to the Project.

# 9.0 References

AECOM, 2016. Saraji Open-Cut Extension Project – Groundwater Technical. Report.

AECOM, 2019. Saraji East Mining Lease Project, Environmental Impact Statement Appendix F-1, Ground water Technical Report, Project No. 60507031.

AGE, 2012. Saraji East Project Groundwater Impact Assessment, For Sinclair Knight Merz, Project No. G1549.

AGE, 2016. G200s Project Grosvenor Groundwater Impact Assessment Report, For Hansen Bailey Pty Ltd, Project Number G1807A.

Barnett, B., Townley, L.R., Post, V., Evans, R.E., Hunt, R.J., Peters, L., Richardson, S., Werner, A.D., Knapton, A. and Boronkay, A. ,2012. Australian Groundwater Modelling Guidelines. Waterlines Report Series No. 82.

Groundwater Imaging Pty Ltd (Allen, D), 2018. Moorvale South AgTEM survey for Groundwater Investigation, near Coppabella, Bowen Basin, QLD. Report for Peabody Energy.

Hawkins, J.W., 1998. Hydrogeologic characteristics of surface-mine spoil. In Coal Mine Drainage Prediction and Pollution Prevention in Pennsylvania, ed. Brady, Smithy and Schueck. Harrisburg, Pennsylvania. Available at: http://www.techtransfer.osmre.gov/nttmainsite/Library/pub/cmdpppp/chapter3.pdf.

HydroAlgorithmics,2014. AlgoMesh User Manual.

HydroSimulations, 2018. Olive Downs South and Willunga. Appendix B. Modelling Appendix. Report for Pembroke Resources Pty Ltd.

IESC, 2018, Uncertainty analysis – Guidance for groundwater modelling within a risk management framework.

IESC, 2023, Uncertainty analysis for groundwater modelling – Information Explanatory Note.

Mackie, C.D., 2009. Hydrogeological characterisation of Coal Measures and overview of impacts of coal mining on groundwater systems in the upper Hunter Valley of NSW. PhD thesis at University of Technology, Sydney.

MDBC (Middlemis, H., Merrick, N., and Ross, J.), 2000. Murray-Darling Basin Commission – Groundwater Flow Modelling Guideline. Report for MDBC.

Minserve, 2022. Subsidence over Longwall Panels Saraji East Underground Mine.

Panday, S., Langevin, C.D., Niswonger, R.G., Ibaraki, M., and Hughes, J.D., 2013., MODFLOW–USG version 1: An unstructured grid version of MODFLOW for simulating groundwater flow and tightly coupled processes using a control volume finite-difference formulation: USGS Techniques and Methods 6-A45.

SLR, 2019. Moorvale South Groundwater Assessment. Appendix B1 Groundwater Modelling Technical Appendix. Report for Peabody Energy.

SLR, 2020. Winchester South Project EIS. Groundwater Impact Assessment Baseline Report. Report for Whitehaven Coal.

SLR, 2021. BHP - Horse Pit Approvals November 2020 Bore Survey. Report for BMA.

SLR, 2021a. Caval Ridge Mine Horse Pit Extension Project. Groundwater Assessment Report. Report for BMA.

SLR, 2021b. Caval Ridge Mine Horse Pit Extension Project. Surface Water Assessment Report. Report for BMA.





SLR, 2021c. Millennium Mine Groundwater Mavis Underground Operations. Groundwater Impact Assessment. Groundwater Modelling Technical Report. Report for MetRes Pty Ltd.

SLR, 2021d. Daunia Mine FY21 Water Licence Performance Review Report . Groundwater Modelling Technical Report. Report for BHP Billiton Mitsubishi Alliance.

SLR, 2023. Saraji East Mining Lease Project Groundwater Modelling Technical Report. Report for AECOM, SLR Ref: 620.31025.00000-R01.

SLR, 2024 Saraji Mine Grevillea Pit Continuation Project Groundwater Impact Assessment. SLR Ref 620.040484.00001-R01

# Appendix A Calibration Residuals

**Groundwater Modelling Technical Report**

**Engeny on Behalf of BM Alliance Coal Operations Pty Ltd**

SLR Project No.: 620.040484.00000

12 September 2024

| ID | Easting | Northing | Layer | Average Residual | Min | Max |
|---|---|---|---|---|---|---|
| **141807** | 621693 | 7573807 | 2 | -25.8 | -28.6 | -23.4 |
| **141864** | 621978 | 7572901 | 2 | -19.6 | -29.6 | -11.3 |
| **141942** | 607531 | 7570131 | 1 | -5.5 | -5.5 | -5.5 |
| **162013** | 621998 | 7572002 | 2 | -5.6 | -15.4 | -1.8 |
| **162041** | 622162 | 7573331 | 3 | -20.9 | -27.5 | -14.9 |
| **162043** | 613496 | 7560208 | 2 | 12.4 | 12.4 | 12.4 |
| **162044** | 615613 | 7560397 | 2 | -8.2 | -8.2 | -8.2 |
| **162048** | 613513 | 7557249 | 2 | -3.5 | -3.5 | -3.5 |
| **162068** | 605993 | 7571041 | 2 | -10.1 | -10.1 | -10.1 |
| **162070** | 606033 | 7571055 | 2 | -10.7 | -10.7 | -10.7 |
| **162071** | 605990 | 7571006 | 2 | -10.3 | -10.3 | -10.3 |
| **162141** | 613846 | 7562175 | 2 | -0.6 | -0.6 | -0.6 |
| **162143** | 616018 | 7561336 | 2 | 3.0 | 3.0 | 3.0 |
| **162164** | 608384 | 7558233 | 2 | -5.7 | -5.8 | -5.7 |
| **162165** | 608920 | 7556710 | 2 | -1.8 | -7.1 | 2.3 |
| **162169** | 611129 | 7551675 | 2 | 0.6 | 0.3 | 1.2 |
| **162171** | 612441 | 7550671 | 2 | -0.7 | -0.8 | -0.6 |
| **162173** | 611249 | 7549500 | 2 | 4.2 | 1.6 | 5.7 |
| **162549** | 619260 | 7567365 | 2 | 6.3 | 5.3 | 6.7 |
| **162550** | 620351 | 7567479 | 2 | 4.4 | 3.7 | 4.6 |
| **162682** | 641151.5 | 7546517 | 2 | -7.0 | -7.5 | -6.8 |
| **162684** | 642471.2 | 7547492 | 2 | -3.7 | -4.0 | -3.4 |
| **182078** | 620368 | 7568049 | 2 | -6.7 | -15.4 | -1.8 |
| **182079** | 620368 | 7568046 | 2 | -1.2 | -1.6 | -0.8 |
| **182080** | 619740 | 7567253 | 2 | 3.4 | 3.3 | 3.5 |
| **13040180** | 667824 | 7516333 | 1 | -17.8 | -19.6 | -16.5 |
| **13040286** | 659983 | 7536966 | 2 | -27.1 | -27.6 | -26.8 |
| **1238-MB1** | 650670.9 | 7522741 | 2 | -10.5 | -10.7 | -10.3 |
| **1238-MB2** | 650670.4 | 7522744 | 7 | -17.8 | -18.1 | -17.5 |
| **2218-MB2** | 645525.7 | 7522756 | 3 | -4.2 | -5.0 | -3.3 |
| **2218-MB3** | 645523 | 7522754 | 5 | -4.5 | -5.0 | -4.0 |
| **2226-MB2** | 643134.1 | 7521947 | 4 | 3.6 | 3.0 | 4.1 |
| **2226-MB3** | 643133.3 | 7521950 | 5 | 0.5 | 0.3 | 0.7 |
| **2372-MB1** | 647519.8 | 7526012 | 2 | -10.2 | -10.4 | -10.0 |
| **2372-MB2** | 647519.3 | 7526010 | 4 | -9.9 | -10.1 | -9.7 |
| **2372-MB3** | 647517.7 | 7526008 | 7 | -9.2 | -9.3 | -9.0 |
| **2375-MB2** | 648041.7 | 7523874 | 9 | -12.0 | -12.1 | -11.9 |
| **2393-MB1** | 645696.1 | 7523043 | 2 | -1.9 | -2.4 | -1.4 |
| **2393-MB2** | 645693.5 | 7523043 | 5 | -4.0 | -4.4 | -3.5 |
| **2393-MB3** | 645690.9 | 7523043 | 7 | -4.2 | -4.8 | -3.4 |
| **2394-MB1** | 644897.8 | 7522962 | 2 | -6.3 | -6.4 | -6.1 |
| **2394-MB2** | 644895.2 | 7522962 | 3 | -4.2 | -4.4 | -4.0 |
| **C2105R** | 634650 | 7541857 | 5 | -7.6 | -7.6 | -7.6 |
| **C2136** | 631742 | 7547243 | 5 | -15.4 | -15.7 | -15.2 |
| **CVMMB16_02** | 611247.7 | 7558493 | 16 | -6.7 | -6.8 | -6.5 |
| **CVMPB07_01** | 611564.7 | 7552523 | 2 | 6.6 | 6.6 | 6.6 |

| ID | Easting | Northing | Layer | Average Residual | Min | Max |
|---|---|---|---|---|---|---|
| **CVMPB07_02** | 611564.7 | 7552540 | 14 | -6.3 | -6.3 | -6.3 |
| **CVMVWP01_3** | 610027.7 | 7560450 | 16 | -8.5 | -9.1 | -7.8 |
| **CVMVWP01_4** | 610027.7 | 7560450 | 18 | -4.8 | -6.0 | -3.7 |
| **DauniaPZ01** | 632534 | 7561905 | 8 | -3.6 | -4.9 | -2.7 |
| **DauniaPZ02** | 635300 | 7560237 | 6 | -6.9 | -14.9 | 10.5 |
| **DauniaPZ03** | 632332 | 7558326 | 8 | -12.1 | -12.9 | -9.0 |
| **DauniaPZ04** | 635531 | 7554554 | 8 | -12.0 | -12.7 | -8.2 |
| **DauniaPZ05** | 632576 | 7561914 | 8 | -2.6 | -4.6 | -1.0 |
| **DauniaPZ06** | 631776 | 7561217 | 7 | -3.9 | -11.7 | -0.1 |
| **DauniaPZ07** | 631627 | 7559539 | 10 | -9.8 | -10.7 | -8.7 |
| **G2304R** | 633245 | 7543171 | 7 | -13.2 | -13.2 | -13.2 |
| **G2307** | 630881 | 7547844 | 7 | -14.8 | -14.9 | -14.6 |
| **GW01d_p1** | 642475.4 | 7547489 | 7 | -7.9 | -9.1 | -6.6 |
| **GW01d_p2** | 642475.4 | 7547489 | 5 | -11.8 | -12.6 | -10.5 |
| **GW01d_p3** | 642475.4 | 7547489 | 3 | -6.4 | -6.6 | -5.9 |
| **GW01d_p4** | 642475.4 | 7547489 | 3 | -4.2 | -4.4 | -3.5 |
| **GW01s** | 642471.2 | 7547492 | 2 | -3.0 | -3.3 | -2.8 |
| **GW02d** | 641148.2 | 7546512 | 7 | -7.1 | -7.2 | -7.1 |
| **GW02s** | 641151.5 | 7546517 | 2 | -7.2 | -7.2 | -7.1 |
| **GW06d_p1** | 639333.8 | 7542009 | 9 | 7.7 | 7.3 | 8.0 |
| **GW06d_p2** | 639333.8 | 7542009 | 10 | -1.4 | -1.9 | -1.0 |
| **GW06d_p3** | 639333.8 | 7542009 | 9 | -1.7 | -2.0 | -1.5 |
| **GW06d_p4** | 639333.8 | 7542009 | 9 | -6.2 | -7.0 | -4.1 |
| **GW08d_p1** | 645312 | 7539846 | 5 | -12.2 | -15.0 | -10.6 |
| **GW08d_p2** | 645312 | 7539846 | 3 | -6.6 | -6.8 | -6.4 |
| **GW08d_p3** | 645312 | 7539846 | 3 | 0.0 | 0.0 | 0.1 |
| **GW08d_p4** | 645312 | 7539846 | 3 | -32.2 | -38.2 | -24.4 |
| **GW12d_p1** | 641492.4 | 7532790 | 5 | 1.6 | 0.4 | 6.0 |
| **GW12d_p2** | 641492.4 | 7532790 | 5 | -3.3 | -4.2 | -2.0 |
| **GW12d_p3** | 641492.4 | 7532790 | 3 | 15.1 | 12.2 | 16.3 |
| **GW12d_p4** | 641492.4 | 7532790 | 3 | 34.5 | 33.6 | 36.4 |
| **GW12s** | 641497.8 | 7532791 | 2 | -2.2 | -2.2 | -2.2 |
| **GW16d_p1** | 660834 | 7525288 | 7 | -27.1 | -28.5 | -23.2 |
| **GW16d_p2** | 660834 | 7525288 | 5 | -15.1 | -15.2 | -15.0 |
| **GW16d_p3** | 660834 | 7525288 | 3 | -14.8 | -15.0 | -14.5 |
| **GW16d_p4** | 660834 | 7525288 | 3 | -14.1 | -14.2 | -13.9 |
| **GW18d** | 656890.7 | 7522809 | 7 | -8.3 | -8.3 | -8.3 |
| **GW18S** | 656884.6 | 7522810 | 1 | -7.7 | -7.9 | -7.6 |
| **GW21d** | 661579.5 | 7521648 | 10 | -17.8 | -17.8 | -17.7 |
| **GW21s** | 661580.2 | 7521653 | 2 | 2.9 | 2.7 | 3.0 |
| **GW8S** | 645323.5 | 7539847 | 1 | -3.6 | -3.7 | -3.6 |
| **KnobHill1** | 631005 | 7553874 | 1 | -3.5 | -3.7 | -3.3 |
| **KnobHill2** | 630431 | 7554061 | 1 | -0.4 | -1.0 | 0.9 |
| **LH13** | 627200 | 7546952 | 9 | 13.0 | 12.3 | 13.9 |
| **LV2183_P2** | 644067.9 | 7520358 | 5 | -3.9 | -5.6 | -1.8 |
| **LV2183_P3** | 644067.9 | 7520358 | 6 | -22.8 | -23.8 | -21.7 |

| ID | Easting | Northing | Layer | Average Residual | Min | Max |
|---|---|---|---|---|---|---|
| **LV2183_P4** | 644067.9 | 7520358 | 7 | -15.5 | -17.4 | -13.0 |
| **LV2218_P1** | 645525.9 | 7522753 | 5 | -5.7 | -7.1 | -5.2 |
| **LV2218_P2** | 645525.9 | 7522753 | 6 | -8.8 | -9.3 | -8.6 |
| **LV2218_P3** | 645525.9 | 7522753 | 7 | -8.0 | -9.4 | -7.3 |
| **LV2226_P1** | 643129.4 | 7521950 | 4 | 5.0 | 4.6 | 5.3 |
| **LV2226_P2** | 643129.4 | 7521950 | 5 | -0.4 | -1.6 | 0.5 |
| **LV2226_P3** | 643129.4 | 7521950 | 6 | -1.8 | -2.5 | -1.2 |
| **LV2226_P4** | 643129.4 | 7521950 | 7 | -3.7 | -3.8 | -3.5 |
| **LV2370W** | 648036.5 | 7523878 | 2 | -4.0 | -4.2 | -3.9 |
| **LV2371W** | 643131.4 | 7521947 | 2 | 6.1 | 5.5 | 7.1 |
| **LV2372R_P1** | 647515.2 | 7526007 | 6 | -8.4 | -9.7 | -6.7 |
| **LV2372R_P4** | 647515.2 | 7526007 | 7 | -10.3 | -10.9 | -8.1 |
| **MB08PZ4** | 615638 | 7559628 | 16 | -14.5 | -14.5 | -14.5 |
| **MB1** | 623254 | 7551541 | 9 | -3.2 | -5.2 | -1.6 |
| **MB13PZ4** | 615195 | 7551070 | 16 | -10.6 | -10.6 | -10.6 |
| **MB15PZ4** | 620083 | 7547608 | 16 | -1.0 | -1.0 | -1.0 |
| **MB19CVM01A** | 610443 | 7548264 | 2 | -2.0 | -2.3 | -1.6 |
| **MB19CVM03T** | 610214 | 7551338 | 2 | 9.9 | 7.6 | 11.1 |
| **MB19CVM04P** | 610215 | 7551344 | 18 | 24.1 | 24.1 | 24.1 |
| **MB19CVM05T** | 611082 | 7551428 | 2 | -9.8 | -11.9 | -7.0 |
| **MB19CVM06P** | 611075 | 7551429 | 16 | -8.5 | -10.3 | -5.5 |
| **MB19CVM07T** | 611578 | 7552537 | 2 | 5.1 | 4.9 | 5.6 |
| **MB19CVM08P** | 611579 | 7552526 | 16 | -6.3 | -7.4 | -3.5 |
| **MB19CVM09A** | 612560 | 7550879 | 2 | 1.9 | 1.6 | 2.4 |
| **MB19CVM10P** | 613294 | 7549948 | 16 | 0.7 | -1.1 | 3.6 |
| **MB19SRM01A** | 640145.8 | 7516041 | 1 | 20.9 | 20.9 | 20.9 |
| **MB19SRM02T** | 640139.8 | 7516048 | 2 | 10.9 | 10.9 | 10.9 |
| **MB19SRM03P** | 640131.8 | 7516057 | 9 | 10.9 | 10.9 | 10.9 |
| **MB19SRM04P** | 637173.7 | 7511222 | 2 | 1.8 | 1.6 | 2.1 |
| **MB2** | 623684 | 7549391 | 9 | 2.0 | 1.4 | 2.4 |
| **MB20CVM01A** | 610028 | 7560466 | 2 | 0.2 | -0.3 | 1.1 |
| **MB20CVM04T** | 608307 | 7559829 | 2 | 2.7 | 2.3 | 3.4 |
| **MB20CVM05P** | 608312 | 7559824 | 18 | -8.2 | -10.9 | -6.1 |
| **MB20CVM06T** | 610921 | 7549067 | 2 | -1.5 | -3.6 | -0.8 |
| **MB20PDM03P** | 621512.8 | 7548051 | 15 | -4.7 | -5.4 | -3.9 |
| **MB20PDM05P** | 630220.5 | 7533012 | 14 | 8.2 | 7.0 | 10.3 |
| **MB20PDM06T** | 628975.9 | 7532808 | 2 | 20.5 | 20.4 | 20.8 |
| **MB20PDM07T** | 621822.7 | 7538727 | 2 | 21.4 | 21.1 | 21.9 |
| **MB20SRM02T** | 636027.9 | 7527850 | 9 | -1.1 | -1.1 | -1.1 |
| **MB20SRM03P** | 636020.9 | 7527857 | 18 | -30.5 | -30.5 | -30.5 |
| **MB20SRM04A** | 631510.9 | 7530650 | 1 | 15.7 | 15.7 | 15.7 |
| **MB20SRM06A** | 636595.8 | 7520189 | 2 | 16.7 | 16.7 | 16.7 |
| **MB20SRM07P** | 641475.7 | 7508141 | 18 | -1.5 | -1.5 | -1.5 |
| **MB3** | 627240 | 7549946 | 3 | -16.6 | -17.2 | -15.6 |
| **MB34** | 638039.8 | 7518450 | 14 | -0.6 | -39.8 | 2.2 |
| **MB35** | 642759.8 | 7520291 | 2 | 8.7 | 7.2 | 10.2 |

| ID | Easting | Northing | Layer | Average Residual | Min | Max |
|---|---|---|---|---|---|---|
| **MB36** | 640263.8 | 7514464 | 2 | 6.0 | 4.2 | 6.7 |
| **MB39** | 640131.8 | 7516057 | 10 | 11.4 | 10.4 | 12.3 |
| **MB4** | 626507 | 7544152 | 9 | 4.0 | 3.8 | 4.2 |
| **MB40** | 640139.8 | 7516048 | 2 | 10.9 | 10.6 | 11.2 |
| **MB5** | 628491 | 7542693 | 9 | 5.0 | 4.1 | 5.4 |
| **MillMB1** | 627777.1 | 7565148 | 4 | -5.5 | -12.6 | 2.7 |
| **MillMB10A** | 630772.2 | 7563698 | 8 | 1.8 | -0.2 | 9.2 |
| **MillMB10B** | 630772.2 | 7563698 | 11 | 7.8 | 6.2 | 9.9 |
| **MillMB11A** | 631857.9 | 7562882 | 2 | 0.9 | -2.5 | 3.2 |
| **MillMB11B** | 631857.9 | 7562882 | 2 | 2.9 | 1.5 | 4.2 |
| **MillMB2** | 627819.4 | 7563299 | 4 | -11.1 | -15.9 | -0.1 |
| **MillMB3A** | 630019.1 | 7562255 | 2 | 16.7 | 8.1 | 22.2 |
| **MillMB3B** | 630019.1 | 7562255 | 2 | 11.0 | 6.4 | 15.9 |
| **MillMB4** | 630485.8 | 7563384 | 2 | 4.4 | 1.8 | 6.9 |
| **MillMB8B** | 627205.6 | 7565983 | 4 | -24.0 | -26.5 | -17.4 |
| **MillMB9A** | 628476.3 | 7565513 | 10 | 10.7 | 8.3 | 12.0 |
| **MillMB9B** | 628476.3 | 7565513 | 9 | -5.9 | -38.4 | 2.8 |
| **MOS_MB01** | 610570 | 7562897 | 2 | 3.5 | 3.5 | 3.5 |
| **MOS_MB02** | 611777 | 7562388 | 15 | -10.7 | -10.7 | -10.7 |
| **MOS_MB04** | 613961 | 7562355 | 2 | -0.6 | -0.6 | -0.6 |
| **MOS_MB05** | 615206 | 7563212 | 2 | 4.1 | 4.1 | 4.1 |
| **MOS_MB06** | 616017 | 7561336 | 2 | 3.0 | 3.0 | 3.0 |
| **MOS_MB07** | 615613 | 7560398 | 2 | -8.2 | -8.2 | -8.2 |
| **MOS_MB08b** | 615638 | 7559628 | 11 | -3.8 | -3.8 | -3.8 |
| **MOS_MB09b** | 618366 | 7558118 | 9 | -0.1 | -0.1 | -0.1 |
| **MOS_MB11** | 611617 | 7558367 | 15 | -5.8 | -5.8 | -5.8 |
| **MOS_MB12** | 613627 | 7557429 | 2 | -3.5 | -3.5 | -3.5 |
| **MOS_MB14** | 615195 | 7551070 | 11 | -3.9 | -3.9 | -3.9 |
| **MOS_MB16** | 620083 | 7547608 | 11 | 2.0 | 2.0 | 2.0 |
| **OBS1** | 630111 | 7554627 | 2 | -5.7 | -6.9 | -5.0 |
| **OBS10** | 627784 | 7556229 | 5 | -2.6 | -3.1 | -2.1 |
| **OBS11** | 630313 | 7556960 | 2 | 12.2 | 11.7 | 13.1 |
| **OBS12** | 626899 | 7559552 | 5 | -23.6 | -24.6 | -22.5 |
| **OBS13** | 626891 | 7559550 | 7 | -16.8 | -16.8 | -16.7 |
| **OBS14** | 629680 | 7560815 | 2 | 20.8 | 20.8 | 20.9 |
| **OBS2** | 631341 | 7557693 | 9 | 0.3 | -0.7 | 1.2 |
| **OBS4** | 626685 | 7562094 | 4 | -2.6 | -3.2 | -2.2 |
| **OBS5** | 626050 | 7557202 | 2 | -5.1 | -6.7 | -4.3 |
| **OBS6** | 628887 | 7556546 | 5 | -11.2 | -12.0 | -10.4 |
| **OBS7** | 625570 | 7556820 | 1 | -1.7 | -2.1 | -1.3 |
| **OBS8** | 631867 | 7553655 | 1 | 2.9 | 2.6 | 3.2 |
| **OBS9** | 627800 | 7556217 | 6 | 6.1 | 5.4 | 6.7 |
| **ODN18MB1** | 640275 | 7547943 | 5 | -8.7 | -8.8 | -8.7 |
| **ODN18MB10** | 639450.5 | 7554580 | 10 | -15.2 | -15.2 | -15.2 |
| **ODN18MB11** | 638599.4 | 7553465 | 10 | -9.8 | -9.8 | -9.8 |
| **ODN18MB12** | 640277 | 7547944 | 5 | -0.9 | -1.2 | -0.6 |

| ID | Easting | Northing | Layer | Average Residual | Min | Max |
|---|---|---|---|---|---|---|
| **ODN18MB2** | 640263 | 7547944 | 1 | 1.5 | 1.5 | 1.5 |
| **ODN18MB3** | 639750.5 | 7551426 | 5 | -11.3 | -11.3 | -11.3 |
| **ODN18MB4** | 640684.3 | 7549869 | 2 | -9.7 | -10.1 | -9.3 |
| **ODN18MB6** | 639943.7 | 7551802 | 5 | -10.1 | -10.1 | -10.1 |
| **ODN18MB7** | 640310.3 | 7554734 | 2 | -4.3 | -4.3 | -4.3 |
| **ODN18MB8** | 638921.3 | 7550183 | 2 | -3.5 | -3.5 | -3.4 |
| **ODN18MB9** | 640088.8 | 7557236 | 4 | -0.3 | -0.3 | -0.3 |
| **ODN18TB1** | 640318 | 7547935 | 5 | -7.7 | -7.9 | -7.4 |
| **ODN18TB2** | 640303 | 7547935 | 1 | 3.6 | 3.4 | 3.8 |
| **PDMMB11_01** | 624187.3 | 7534394 | 17 | -4.7 | -4.7 | -4.7 |
| **PDMMB12_01** | 624324.5 | 7534454 | 17 | -8.3 | -8.3 | -8.3 |
| **PZ00B** | 632913.9 | 7529866 | 2 | 2.8 | 2.7 | 2.9 |
| **PZ00C** | 632984.9 | 7529934 | 2 | 1.8 | 1.7 | 1.9 |
| **PZ00D** | 631797.9 | 7530369 | 13 | 5.4 | 5.1 | 6.1 |
| **PZ01** | 609954 | 7560323 | 18 | -2.8 | -7.0 | -0.8 |
| **PZ02** | 608553 | 7558420 | 2 | -2.8 | -4.9 | -1.6 |
| **PZ02A** | 632133.4 | 7530855 | 2 | 11.8 | 11.3 | 12.2 |
| **PZ02B** | 632133.4 | 7530855 | 15 | -2.1 | -2.1 | -2.0 |
| **PZ02C** | 632133.4 | 7530855 | 18 | 0.3 | -6.8 | 7.4 |
| **PZ03-D** | 609029 | 7556890 | 18 | -8.8 | -11.7 | -7.4 |
| **PZ03-S** | 609028 | 7556894 | 2 | -7.2 | -12.0 | -2.9 |
| **PZ04** | 610844 | 7555504 | 12 | -4.0 | -5.0 | -3.3 |
| **PZ04A** | 630356 | 7531133 | 2 | 15.4 | 14.2 | 16.9 |
| **PZ04B** | 630356 | 7531133 | 16 | 14.2 | 14.0 | 14.5 |
| **PZ04C** | 630356 | 7531133 | 18 | 13.9 | 13.7 | 14.2 |
| **PZ05** | 609030 | 7554296 | 18 | -16.3 | -18.9 | -8.8 |
| **PZ05A** | 642440.6 | 7509401 | 16 | 0.0 | 0.0 | 0.1 |
| **PZ05B** | 642440.6 | 7509401 | 18 | -5.1 | -5.1 | -5.0 |
| **PZ06A** | 639385.5 | 7513506 | 14 | 8.6 | 8.6 | 8.7 |
| **PZ06B** | 639385.5 | 7513506 | 16 | 5.4 | 5.3 | 5.5 |
| **PZ06C** | 639385.5 | 7513506 | 18 | -3.9 | -4.3 | -3.4 |
| **PZ06-S** | 611237 | 7551854 | 2 | 0.7 | 0.2 | 1.4 |
| **PZ07-D** | 612578 | 7550882 | 12 | 0.0 | -1.5 | 1.3 |
| **PZ07-S** | 612584 | 7550881 | 2 | 0.2 | -0.5 | 2.0 |
| **PZ08A** | 634760.8 | 7523250 | 14 | 7.1 | 6.8 | 7.3 |
| **PZ08B** | 634760.8 | 7523250 | 16 | 2.4 | 2.3 | 2.5 |
| **PZ08-D** | 611526 | 7549891 | 17 | -5.1 | -14.2 | 7.5 |
| **PZ08-S** | 611524 | 7549887 | 2 | 5.4 | 1.7 | 6.4 |
| **PZ09** | 614439 | 7549000 | 15 | -11.9 | -25.7 | -3.8 |
| **PZ09B** | 633025.7 | 7527959 | 16 | -0.2 | -0.3 | -0.2 |
| **PZ09C** | 633025.7 | 7527959 | 18 | -0.2 | -1.0 | 0.5 |
| **PZ10B** | 634350.2 | 7524345 | 16 | 9.5 | 8.0 | 11.0 |
| **PZ10C** | 634350.2 | 7524345 | 18 | 24.8 | 23.3 | 26.4 |
| **PZ11-D** | 616904 | 7547778 | 14 | -7.8 | -27.6 | 2.0 |
| **PZ12-D** | 610834 | 7557342 | 13 | -3.9 | -5.0 | -1.3 |
| **PZ12-S** | 610825 | 7557397 | 2 | -1.0 | -1.3 | -0.3 |

| ID | Easting | Northing | Layer | Average Residual | Min | Max |
|---|---|---|---|---|---|---|
| **R2007** | 630447.5 | 7542330 | 7 | -0.8 | -0.8 | -0.8 |
| **R2008** | 630879 | 7542573 | 5 | 0.0 | -0.9 | 0.2 |
| **R2010** | 631743 | 7543062 | 5 | -6.3 | -7.7 | -6.0 |
| **R2010R** | 631730 | 7543070 | 5 | -6.6 | -6.6 | -6.6 |
| **R2032** | 630495 | 7545853 | 5 | 4.4 | 1.2 | 4.8 |
| **R2035** | 629190 | 7545103 | 9 | -0.5 | -0.8 | 0.1 |
| **R2054** | 629240 | 7548107 | 4 | 1.6 | -3.5 | 2.8 |
| **R2055** | 628798 | 7547863 | 7 | 3.5 | 2.3 | 3.7 |
| **R2056** | 628364.3 | 7547623 | 9 | 6.3 | 6.3 | 6.3 |
| **S10** | 642551.8 | 7546035 | 2 | -3.4 | -3.4 | -3.4 |
| **S11** | 642455.2 | 7545332 | 1 | -3.1 | -3.1 | -3.1 |
| **S2** | 641385.5 | 7547617 | 1 | -4.7 | -4.7 | -4.7 |
| **S4** | 641566.7 | 7546845 | 1 | -8.0 | -8.8 | -7.2 |
| **S5** | 642239.4 | 7547332 | 2 | -5.8 | -5.8 | -5.8 |
| **S6** | 642054.2 | 7546721 | 1 | -4.1 | -4.1 | -4.1 |
| **S7** | 641442.7 | 7545828 | 2 | -7.1 | -7.1 | -7.1 |
| **S8** | 642339.6 | 7546343 | 1 | -2.0 | -2.1 | -1.9 |
| **S9** | 641766.9 | 7545426 | 2 | -5.8 | -5.8 | -5.8 |
| **W1_MB1** | 637914 | 7531373 | 2 | -1.0 | -1.0 | -1.0 |
| **W1_MB2** | 637916 | 7531372 | 5 | -0.6 | -0.6 | -0.5 |
| **W1_MB3** | 637919 | 7531372 | 7 | -0.6 | -0.6 | -0.5 |
| **W10_MB1** | 641869 | 7524259 | 4 | -9.9 | -9.9 | -9.9 |
| **W10_MB2** | 641869 | 7524259 | 7 | -18.3 | -18.5 | -18.0 |
| **W10_MB3** | 641869 | 7524261 | 7 | -14.5 | -14.5 | -14.4 |
| **W11_MB1** | 643941 | 7524860 | 3 | -33.1 | -67.0 | -15.7 |
| **W11_MB2** | 643943 | 7524861 | 5 | -13.5 | -13.8 | -13.3 |
| **W12_MB1** | 643268 | 7530165 | 2 | -11.3 | -11.4 | -11.2 |
| **W13_MB1** | 645381 | 7530927 | 9 | -8.5 | -8.5 | -8.4 |
| **W14_MB1** | 645373 | 7528515 | 2 | -4.4 | -4.6 | -4.2 |
| **W15_MB1** | 649009 | 7527504 | 2 | 5.4 | 5.4 | 5.4 |
| **W15_MB2** | 649009 | 7527504 | 7 | 5.4 | 5.4 | 5.5 |
| **W15_MB3** | 649009 | 7527504 | 7 | 5.4 | 5.4 | 5.6 |
| **W2_MB1** | 637368 | 7531452 | 2 | -0.4 | -0.4 | -0.3 |
| **W2_MB2** | 637370 | 7531452 | 10 | -0.5 | -0.5 | -0.5 |
| **W3_MB1** | 640470 | 7529435 | 2 | 8.4 | 7.7 | 8.8 |
| **W3_MB2** | 640468 | 7529435 | 2 | -0.4 | -0.5 | -0.4 |
| **W4_MB1** | 638172 | 7528735 | 2 | 6.6 | 6.5 | 6.7 |
| **W4_MB2** | 638169 | 7528735 | 9 | -0.8 | -1.1 | -0.7 |
| **W5_MB1** | 638387 | 7527823 | 3 | -0.5 | -0.5 | -0.4 |
| **W5_MB2** | 638385 | 7527820 | 5 | 0.5 | 0.5 | 0.5 |
| **W5_MB3** | 638384 | 7527817 | 7 | -1.5 | -1.5 | -1.4 |
| **W6_MB1** | 637758 | 7527892 | 9 | -0.5 | -1.2 | 0.1 |
| **W6_MB2** | 637761 | 7527893 | 10 | 0.6 | 0.5 | 0.8 |
| **W7_MB1** | 637484 | 7526145 | 9 | -0.6 | -0.6 | -0.6 |
| **W8_MB1** | 639306 | 7523618 | 10 | -3.8 | -3.9 | -3.7 |
| **W9_MB1** | 640953 | 7524117 | 2 | -4.5 | -4.6 | -4.4 |

| ID | Easting | Northing | Layer | Average Residual | Min | Max |
|---|---|---|---|---|---|---|
| **W9_MB2** | 640953 | 7524119 | 9 | -12.2 | -12.4 | -11.9 |
| **W9_MB3** | 640952 | 7524121 | 9 | -11.0 | -11.0 | -10.9 |
| **West-MB1** | 642872.3 | 7519929 | 2 | 4.4 | 3.9 | 5.1 |
| **West-MB2** | 642872.9 | 7519932 | 9 | 6.0 | 5.6 | 6.5 |
| **WinnetBore** | 634791 | 7550023 | 1 | -5.8 | -7.1 | -5.3 |

# Appendix B Calibration Hydrographs

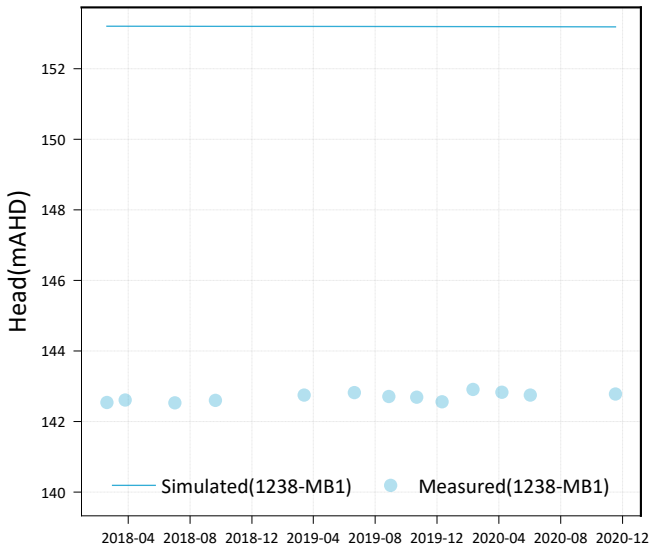
**Groundwater Modelling Technical Report**

**Engeny on Behalf of BM Alliance Coal Operations Pty Ltd**

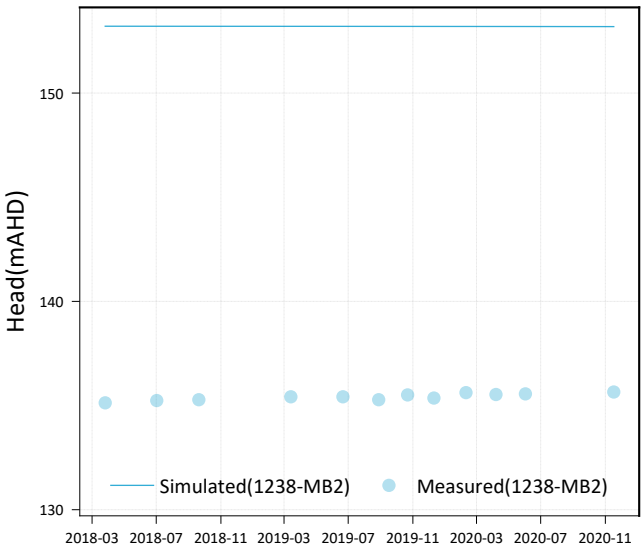
SLR Project No.: 620.040484.00000

12 September 2024

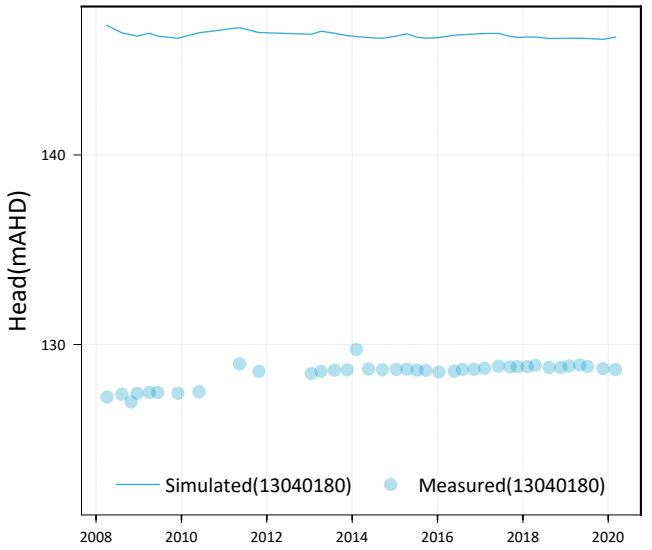
## 1238-MB1



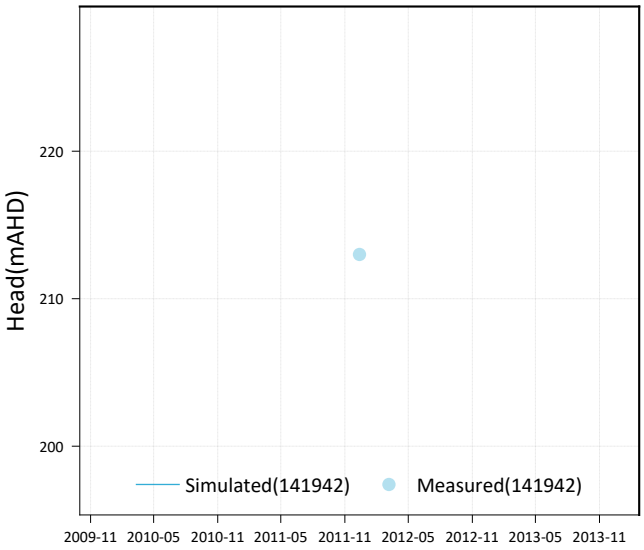

## 1238-MB2



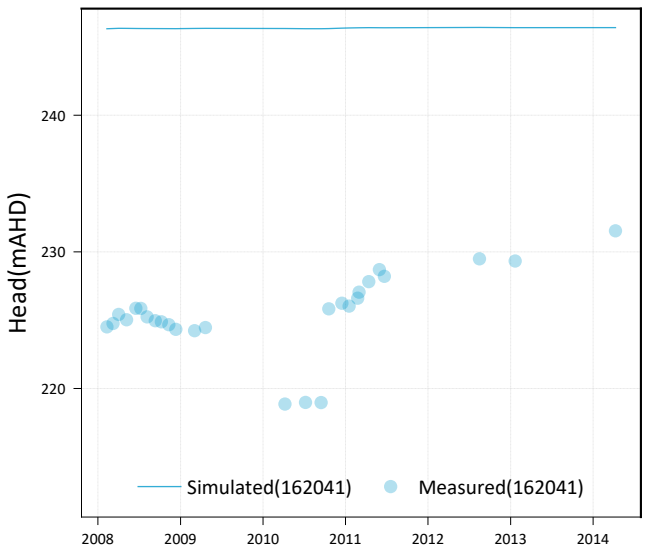

## 13040180



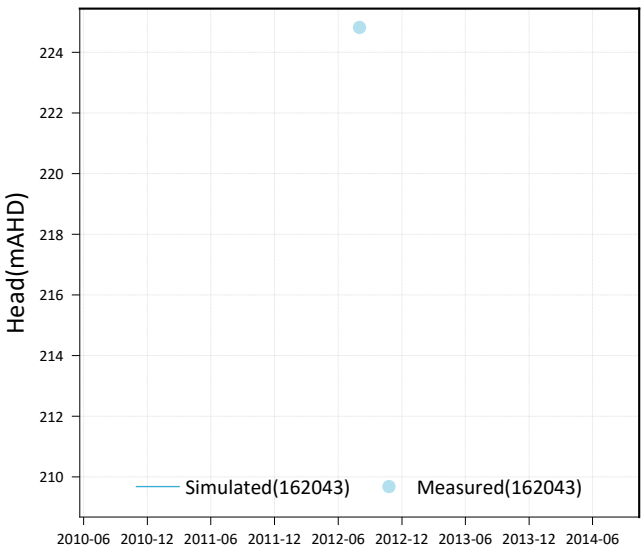

## 141942

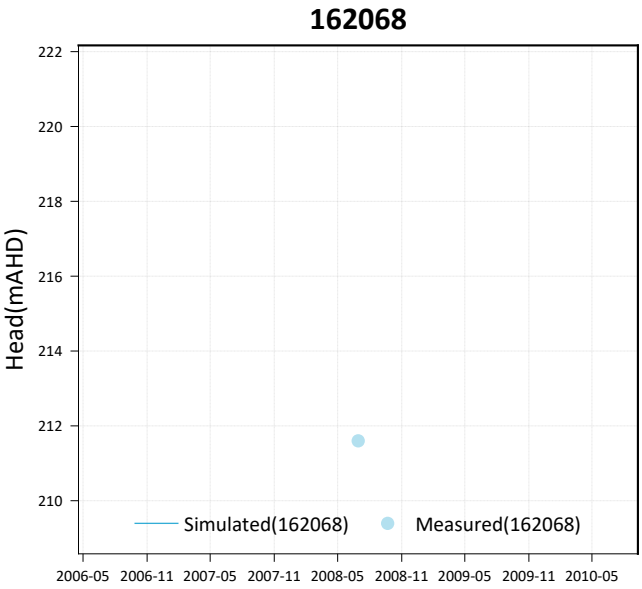


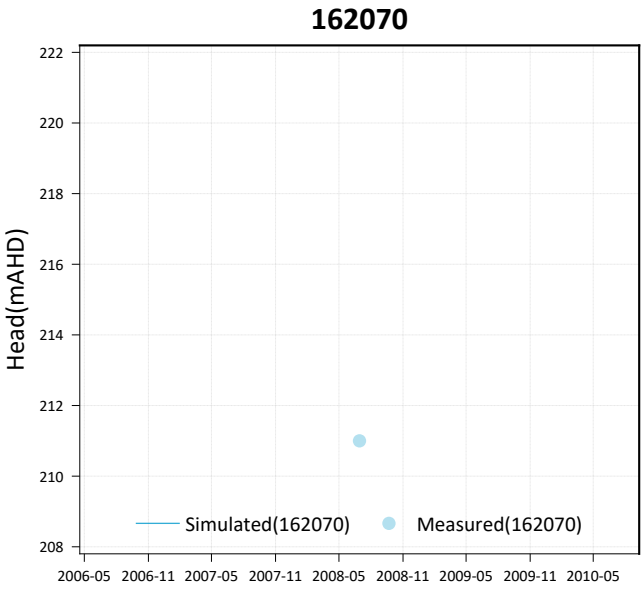

## 162041

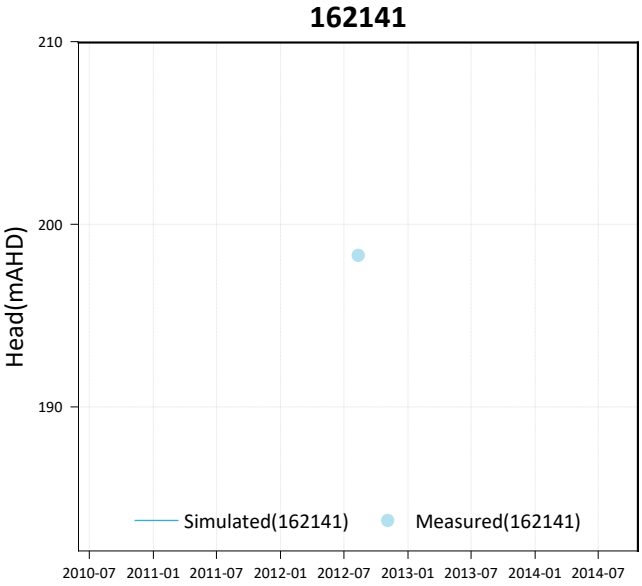


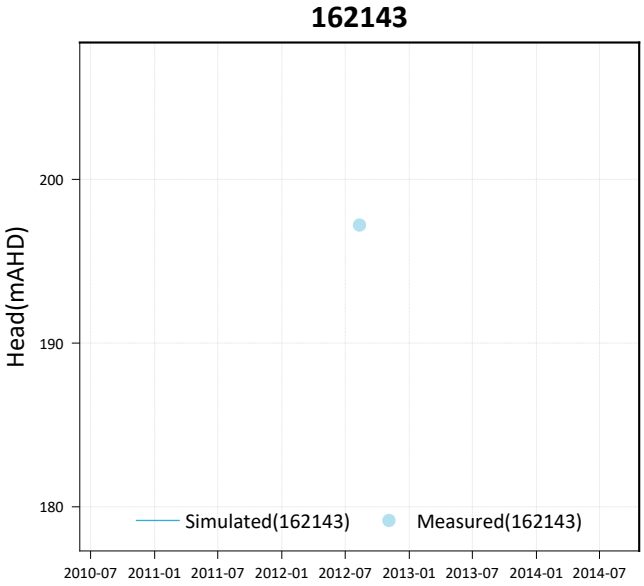

## 162043

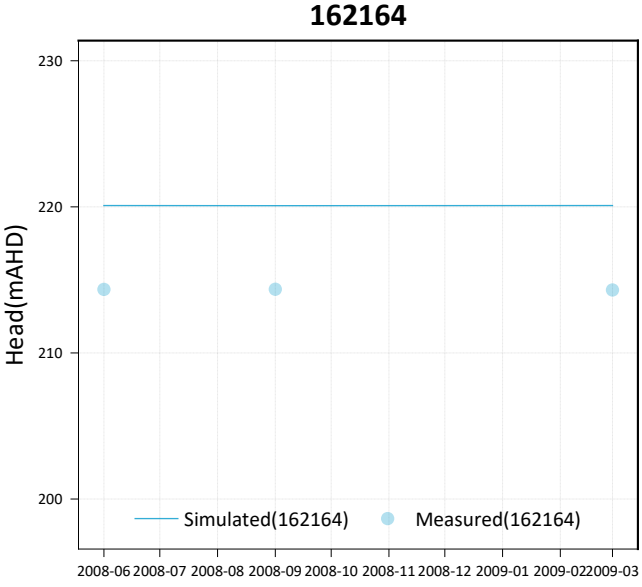


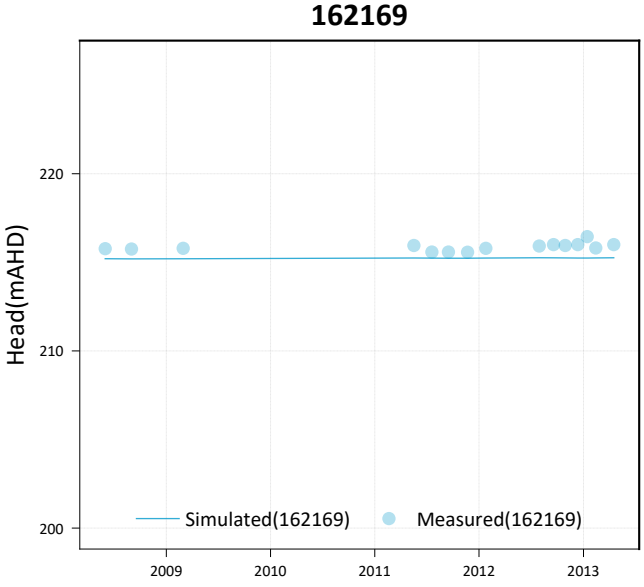

162068
Head(mAHD)
222
220
218
216
214
212
210
Simulated(162068)
Measured(162068)
2006-05 2006-11 2007-05 2007-11 2008-05 2008-11 2009-05 2009-11 2010-05

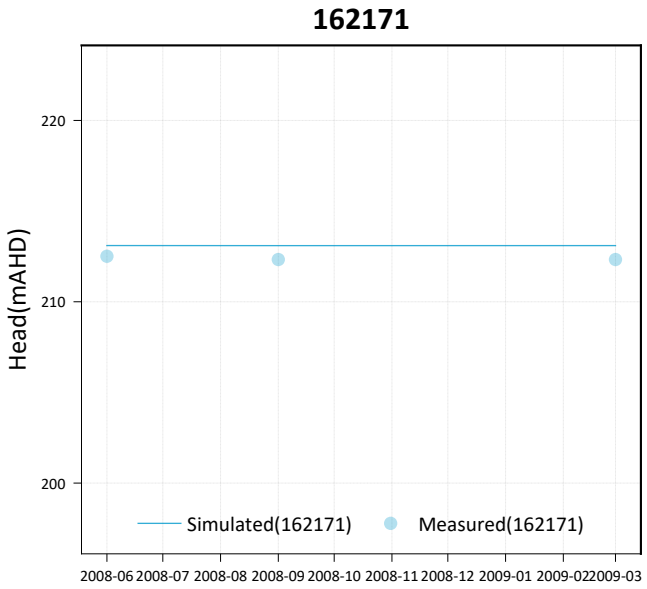

162070
Head(mAHD)
222
220
218
216
214
212
210
208
Simulated(162070)
Measured(162070)
2006-05 2006-11 2007-05 2007-11 2008-05 2008-11 2009-05 2009-11 2010-05

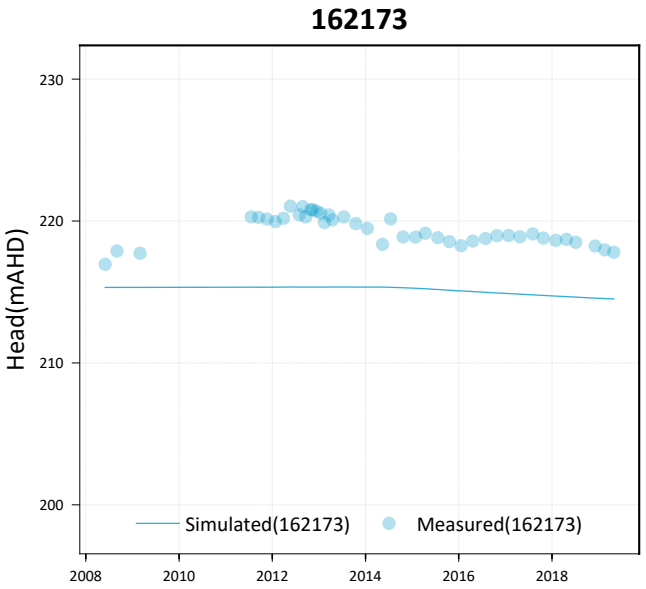

162141
Head(mAHD)
210
200
190
Simulated(162141)
Measured(162141)
2010-07 2011-01 2011-07 2012-01 2012-07 2013-01 2013-07 2014-01 2014-07

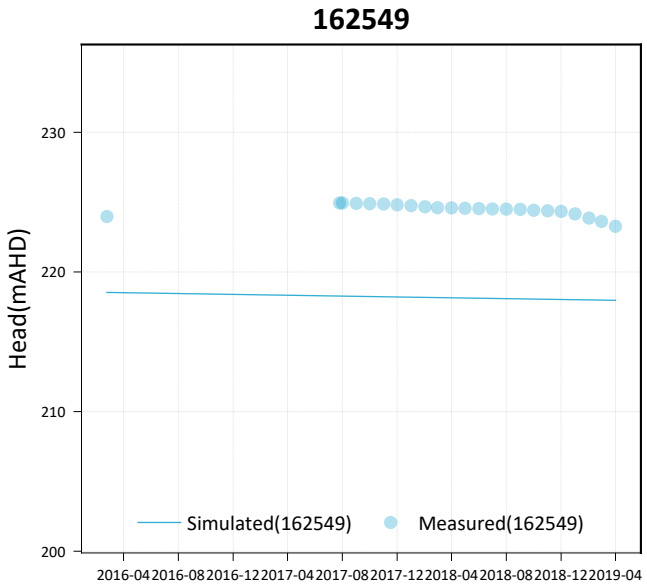

162143
Head(mAHD)
200
190
180
Simulated(162143)
Measured(162143)
2010-07 2011-01 2011-07 2012-01 2012-07 2013-01 2013-07 2014-01 2014-07

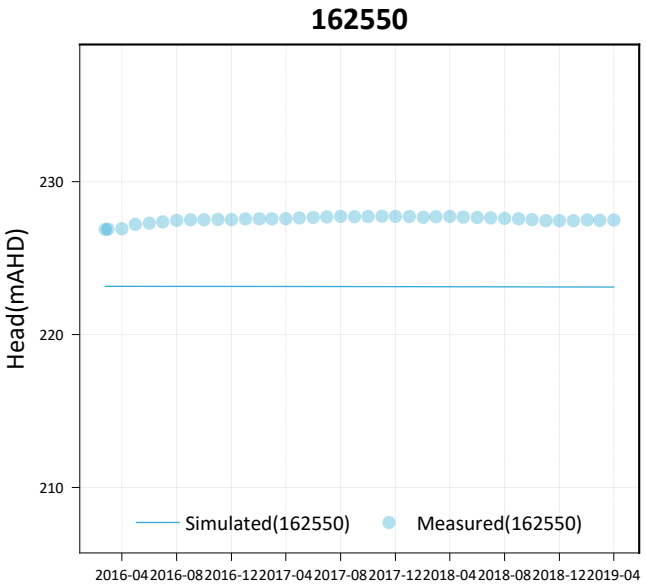

162164
Head(mAHD)
230
220
210
200
Simulated(162164)
Measured(162164)
2008-06 2008-07 2008-08 2008-09 2008-10 2008-11 2008-12 2009-01 2009-02 2009-03

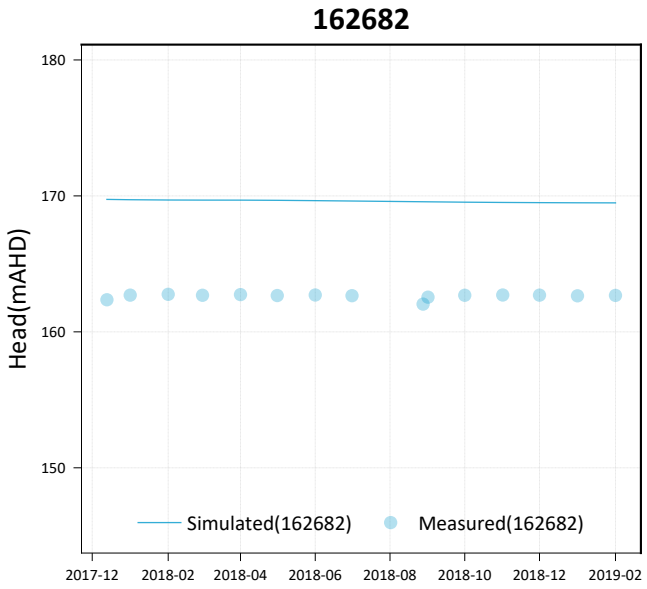

162169
Head(mAHD)
220
210
200
Simulated(162169)
Measured(162169)
2009 2010 2011 2012 2013

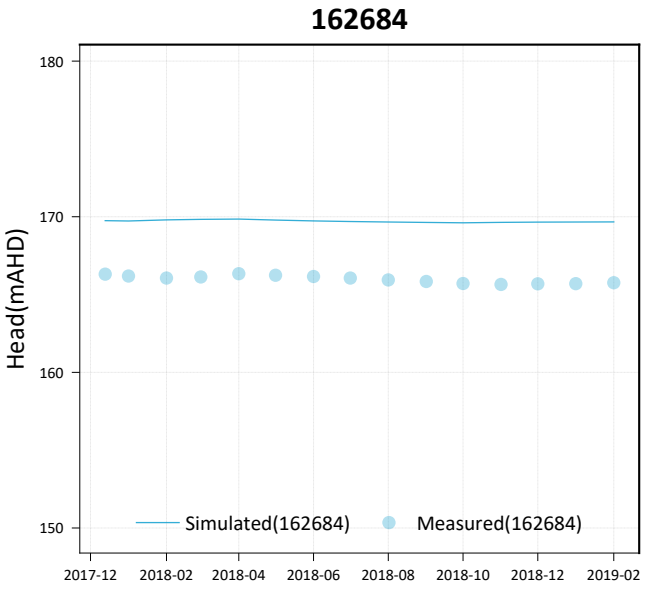

162171
Head(mAHD)
220
210
200
Simulated(162171)
Measured(162171)
2008-06 2008-07 2008-08 2008-09 2008-10 2008-11 2008-12 2009-01 2009-02 2009-03

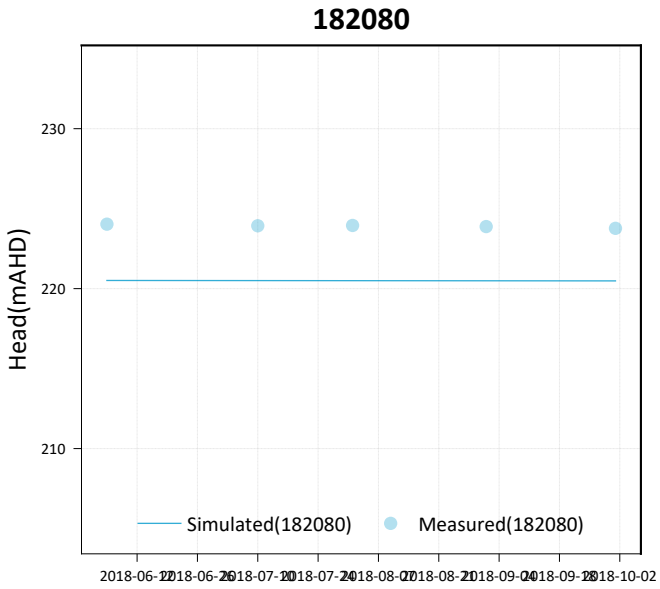

162173
Head(mAHD)
230
220
210
200
Simulated(162173)
Measured(162173)
2008
2010
2012
2014
2016
2018

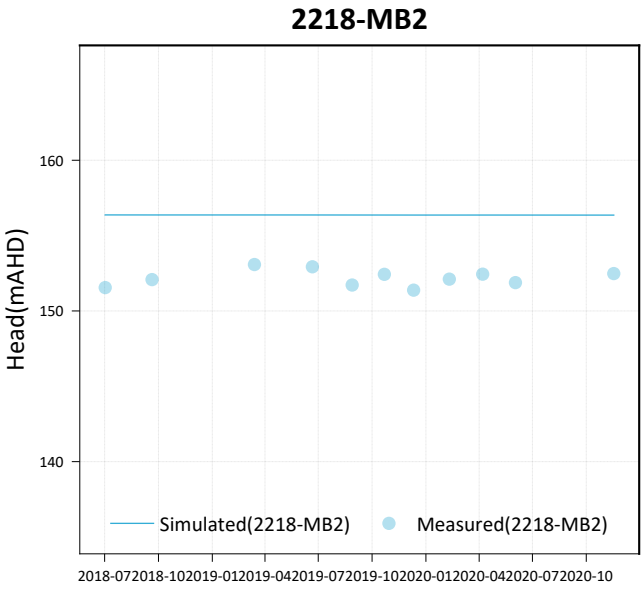

162549
Head(mAHD)
230
220
210
200
Simulated(162549)
Measured(162549)
2016-04 2016-08 2016-12 2017-04 2017-08 2017-12 2018-04 2018-08 2018-12 2019-04

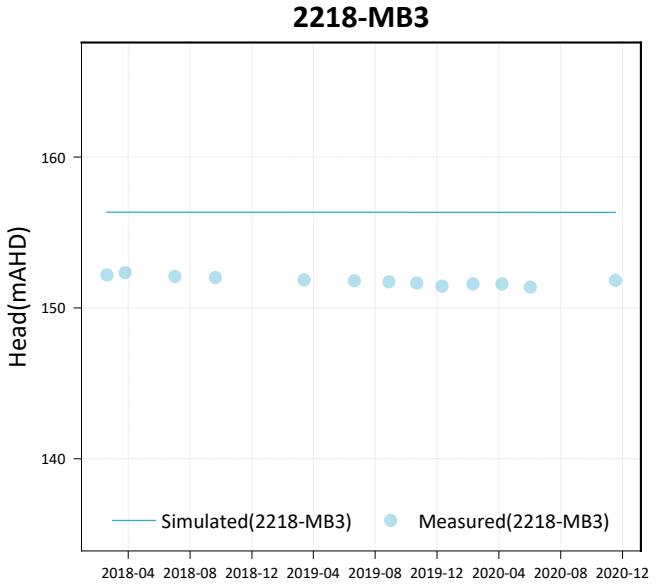

162550
Head(mAHD)
230
220
210
Simulated(162550)
Measured(162550)
2016-04 2016-08 2016-12 2017-04 2017-08 2017-12 2018-04 2018-08 2018-12 2019-04

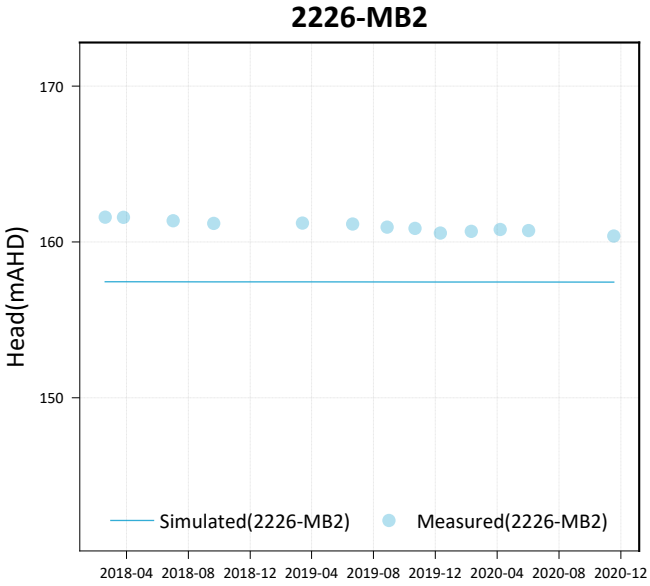

162682
Head(mAHD)
180
170
160
150
Simulated(162682)
Measured(162682)
2017-12 2018-02 2018-04 2018-06 2018-08 2018-10 2018-12 2019-02

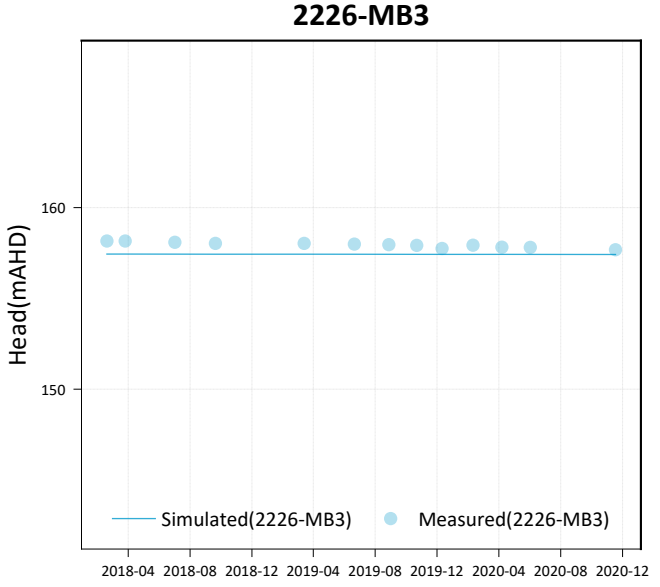

162684
Head(mAHD)
180
170
160
150
Simulated(162684)
Measured(162684)
2017-12 2018-02 2018-04 2018-06 2018-08 2018-10 2018-12 2019-02

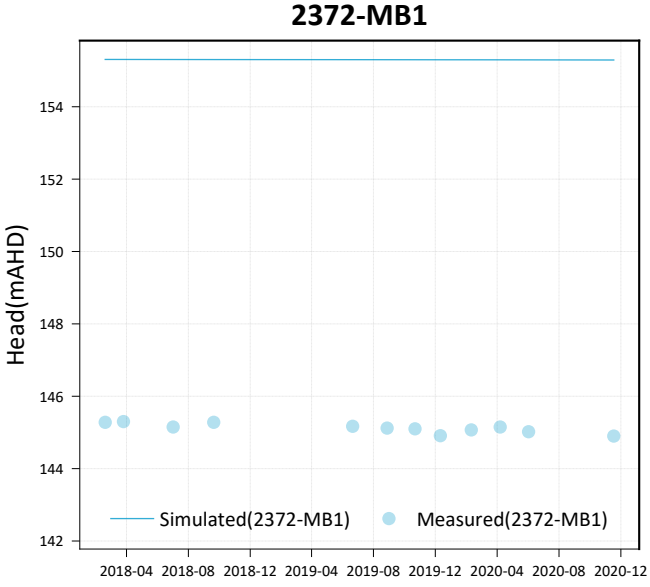

182080
Head(mAHD)
230
220
210
Simulated(182080)
Measured(182080)
2018-06-22
2018-06-26
2018-07-20
2018-07-24
2018-08-07
2018-08-21
2018-09-04
2018-09-28
2018-10-02

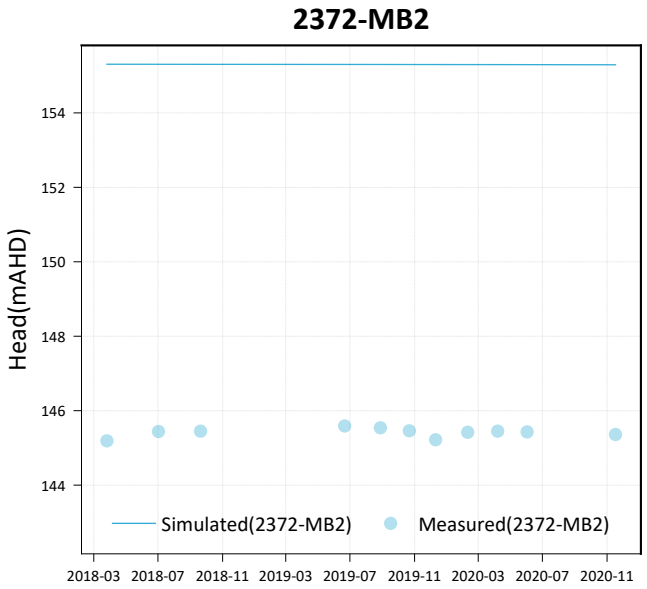

2218-MB2
Head(mAHD)
160
150
140
Simulated(2218-MB2)
Measured(2218-MB2)
2018-07
2018-10
2019-01
2019-04
2019-07
2019-10
2020-01
2020-04
2020-07
2020-10

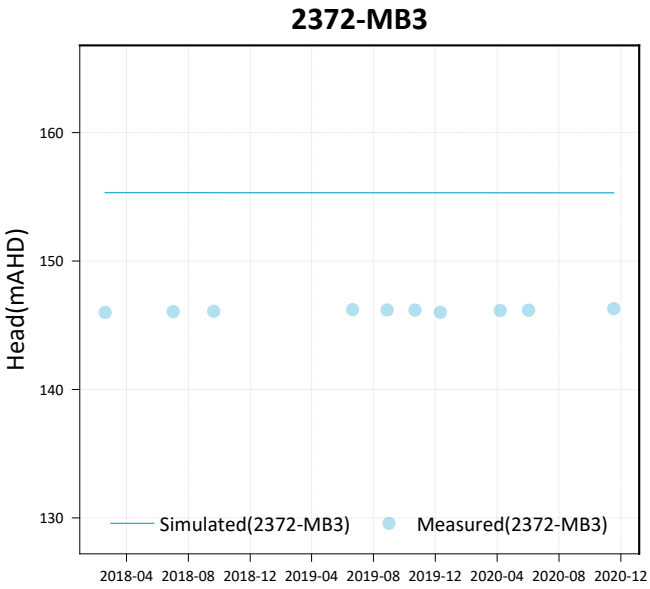

2218-MB3
Head(mAHD)
160
150
140
Simulated(2218-MB3)
Measured(2218-MB3)
2018-04
2018-08
2018-12
2019-04
2019-08
2019-12
2020-04
2020-08
2020-12

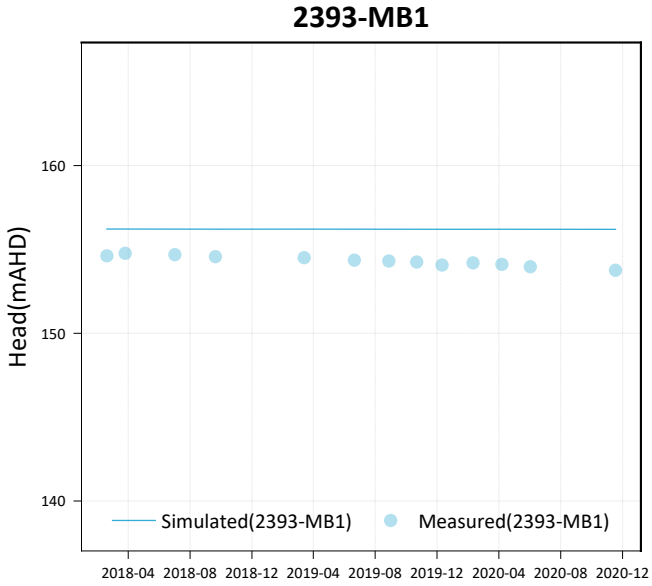

2226-MB2
Head(mAHD)
170
160
150
Simulated(2226-MB2)
Measured(2226-MB2)
2018-04
2018-08
2018-12
2019-04
2019-08
2019-12
2020-04
2020-08
2020-12

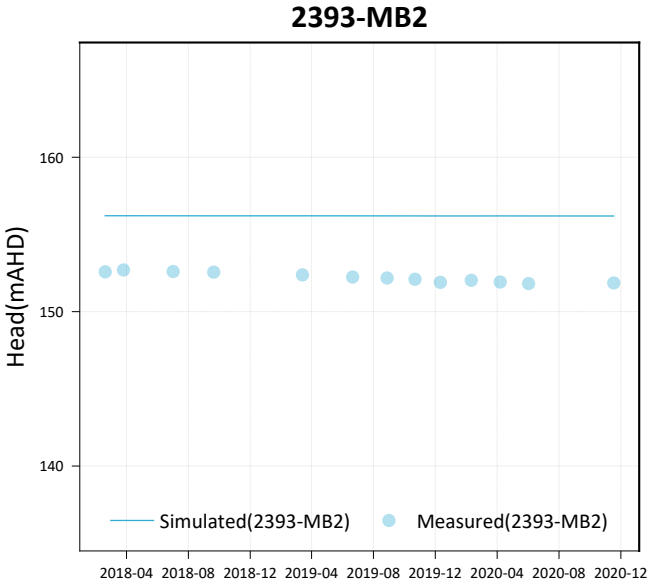

2226-MB3
Head(mAHD)
160
150
Simulated(2226-MB3)
Measured(2226-MB3)
2018-04
2018-08
2018-12
2019-04
2019-08
2019-12
2020-04
2020-08
2020-12

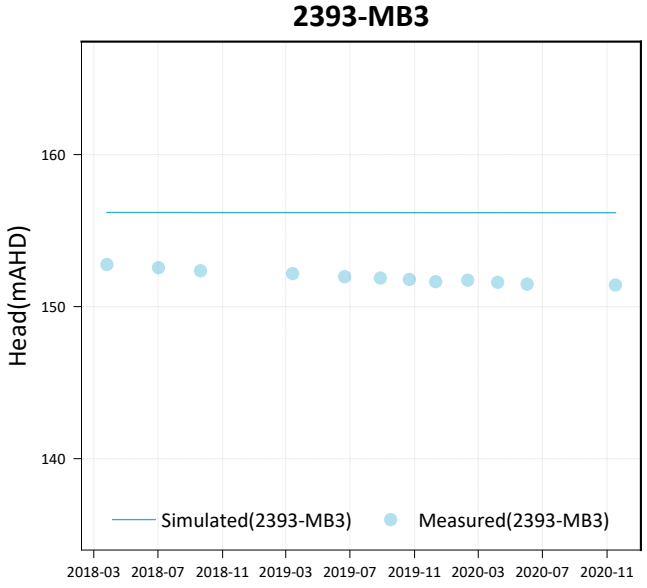

2372-MB1
Head(mAHD)
154
152
150
148
146
144
142
Simulated(2372-MB1)
Measured(2372-MB1)
2018-04
2018-08
2018-12
2019-04
2019-08
2019-12
2020-04
2020-08
2020-12

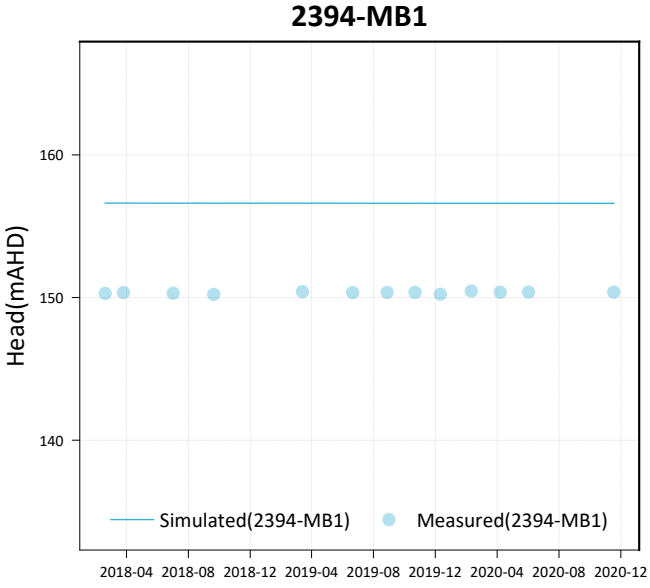

2372-MB2
Head(mAHD)
154
152
150
148
146
144
Simulated(2372-MB2)
Measured(2372-MB2)
2018-03 2018-07 2018-11 2019-03 2019-07 2019-11 2020-03 2020-07 2020-11


2372-MB3
Head(mAHD)
160
150
140
130
Simulated(2372-MB3)
Measured(2372-MB3)
2018-04 2018-08 2018-12 2019-04 2019-08 2019-12 2020-04 2020-08 2020-12

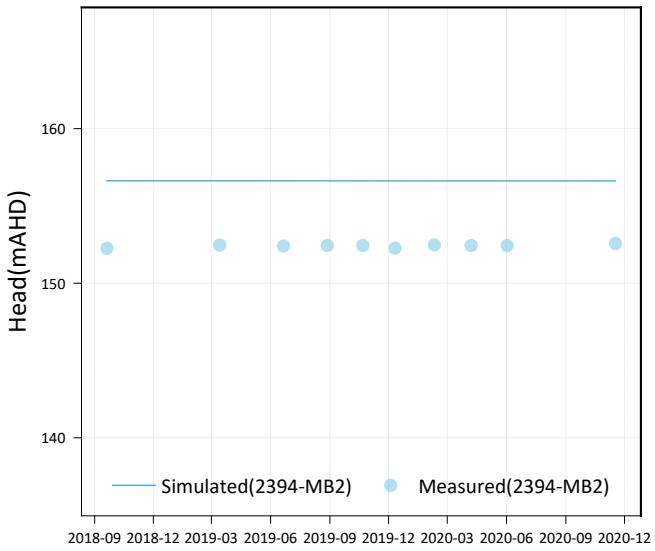

2393-MB1
Head(mAHD)
160
150
140
Simulated(2393-MB1)
Measured(2393-MB1)
2018-04 2018-08 2018-12 2019-04 2019-08 2019-12 2020-04 2020-08 2020-12


2393-MB2
Head(mAHD)
160
150
140
Simulated(2393-MB2)
Measured(2393-MB2)
2018-04 2018-08 2018-12 2019-04 2019-08 2019-12 2020-04 2020-08 2020-12

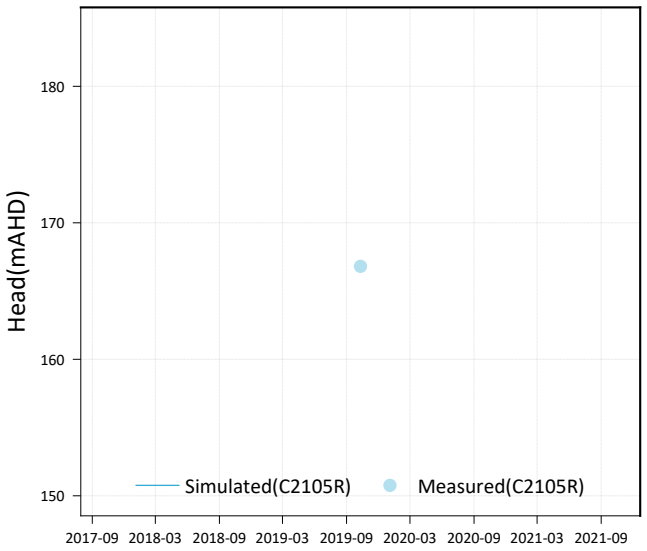

2393-MB3
Head(mAHD)
160
150
140
Simulated(2393-MB3)
Measured(2393-MB3)
2018-03 2018-07 2018-11 2019-03 2019-07 2019-11 2020-03 2020-07 2020-11


2394-MB1
Head(mAHD)
160
150
140
Simulated(2394-MB1)
Measured(2394-MB1)
2018-04 2018-08 2018-12 2019-04 2019-08 2019-12 2020-04 2020-08 2020-12

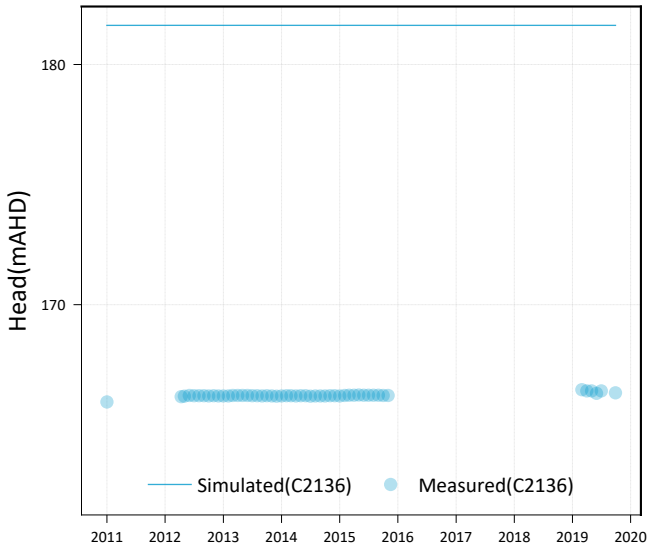
## 2394-MB2



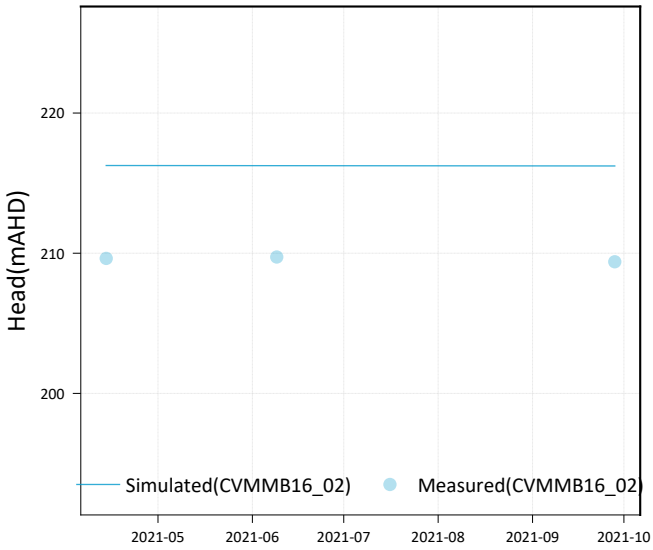

## C2105R



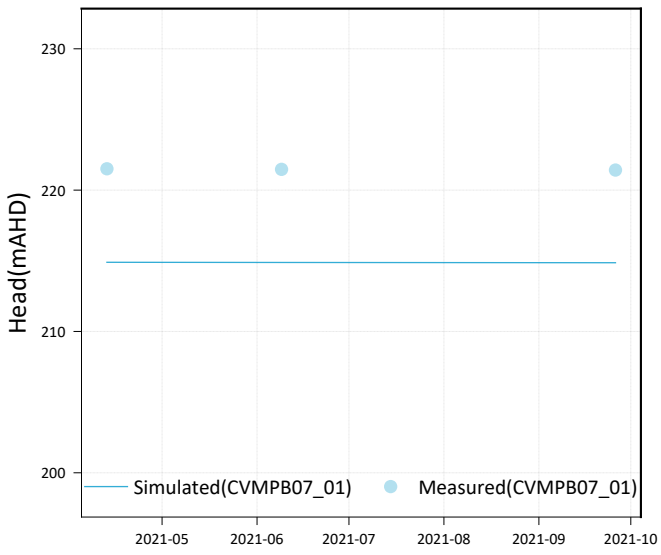

## C2136



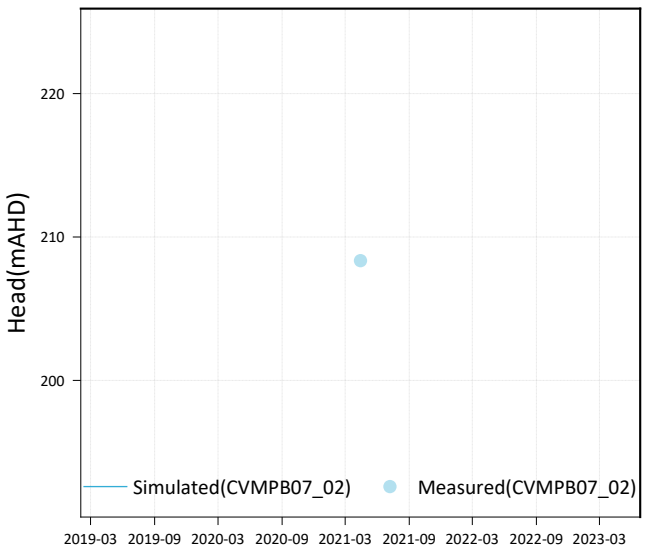

## CVMMB16_02

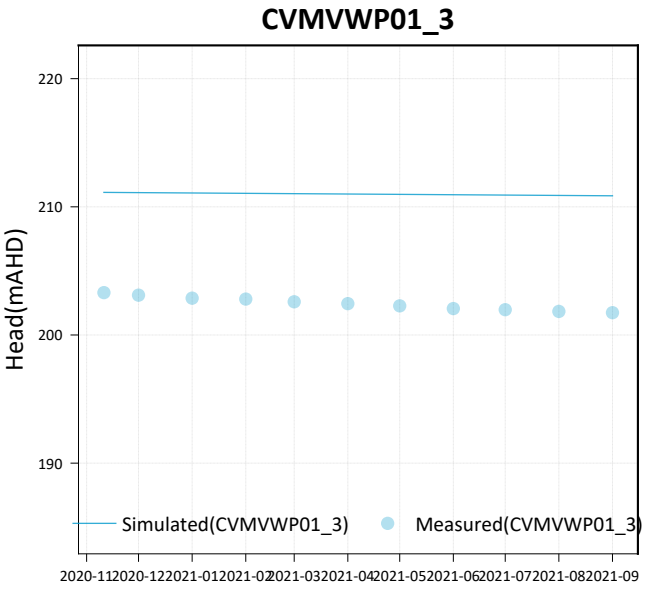


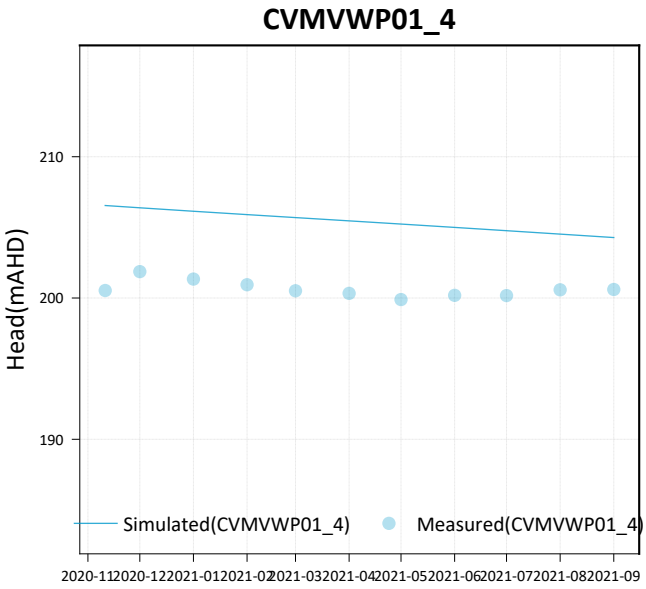

## CVMPB07_01

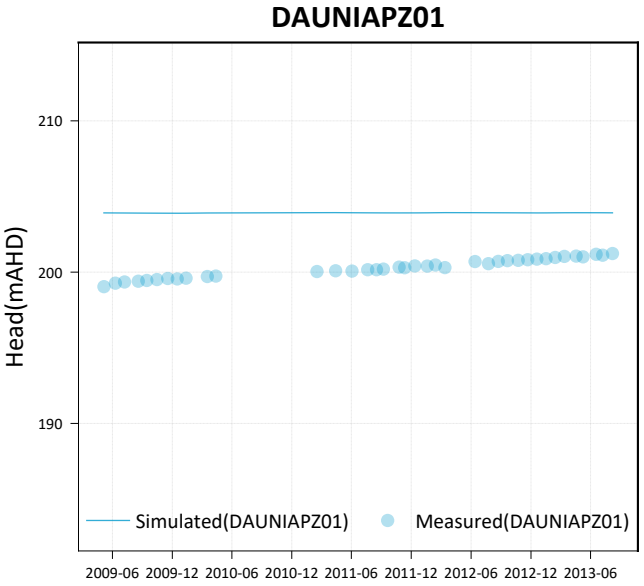


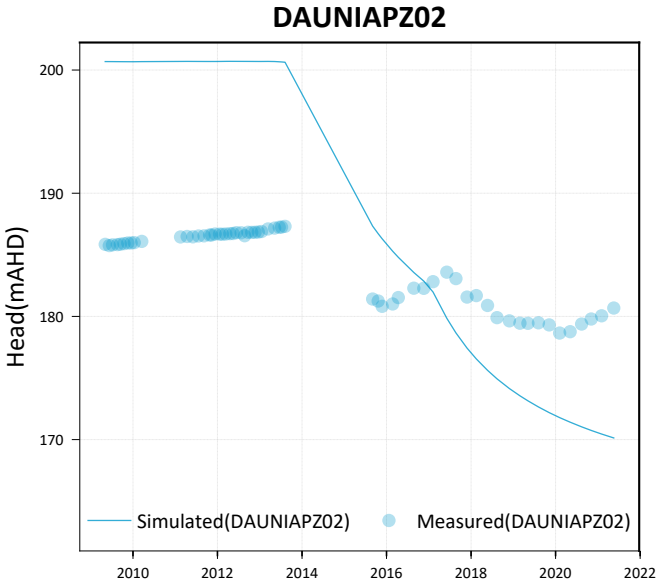

## CVMPB07_02

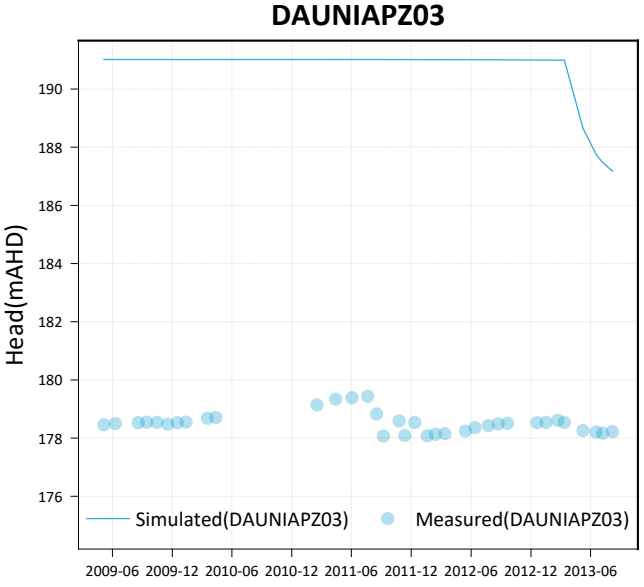


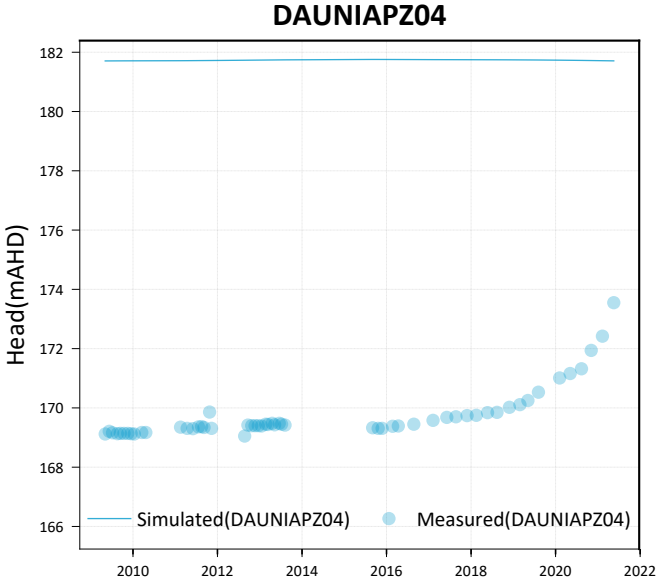

CVMVWP01_3
Head(mAHD)
220
210
200
190
Simulated(CVMVWP01_3)
Measured(CVMVWP01_3)
2020-11 2020-12 2021-01 2021-02 2021-03 2021-04 2021-05 2021-06 2021-07 2021-08 2021-09

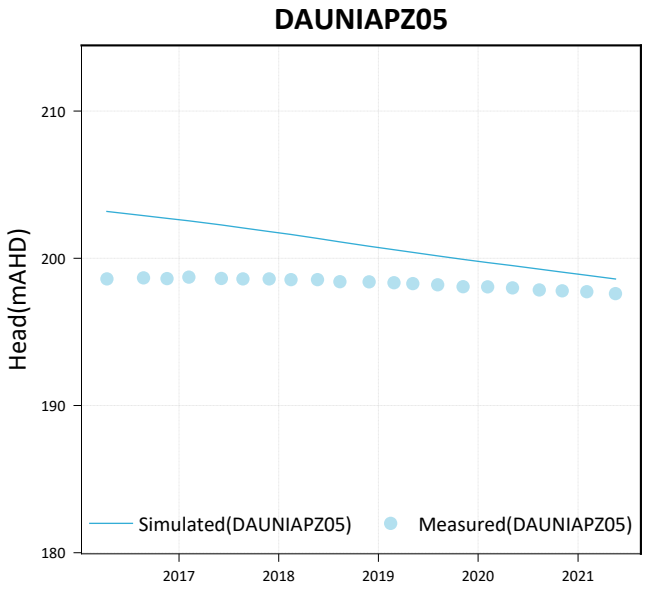

CVMVWP01_4
Head(mAHD)
210
200
190
Simulated(CVMVWP01_4)
Measured(CVMVWP01_4)
2020-11 2020-12 2021-01 2021-02 2021-03 2021-04 2021-05 2021-06 2021-07 2021-08 2021-09

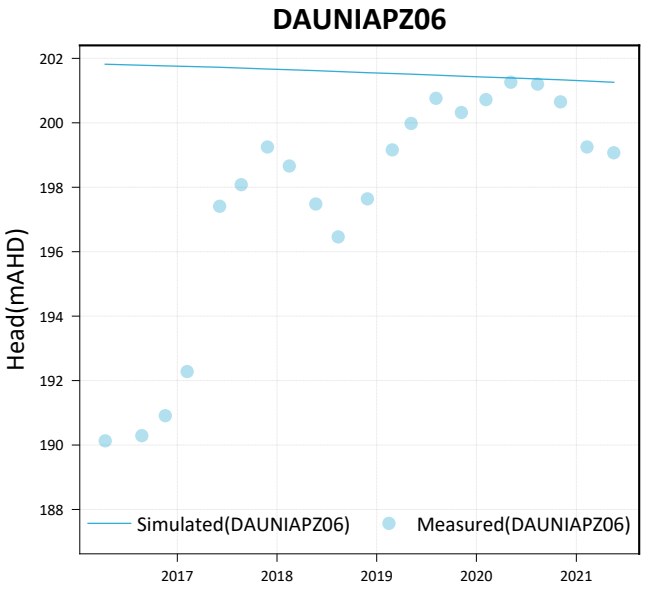

DAUNIAPZ01
Head(mAHD)
210
200
190
Simulated(DAUNIAPZ01)
Measured(DAUNIAPZ01)
2009-06 2009-12 2010-06 2010-12 2011-06 2011-12 2012-06 2012-12 2013-06

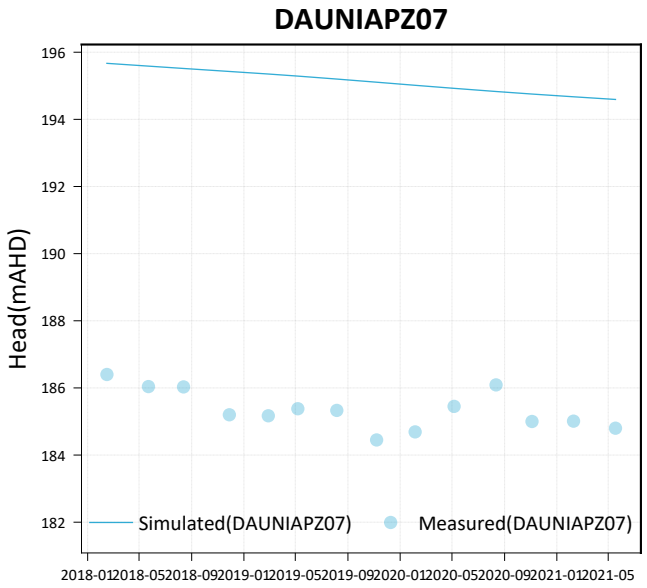

DAUNIAPZ02
Head(mAHD)
200
190
180
170
Simulated(DAUNIAPZ02)
Measured(DAUNIAPZ02)
2010 2012 2014 2016 2018 2020 2022

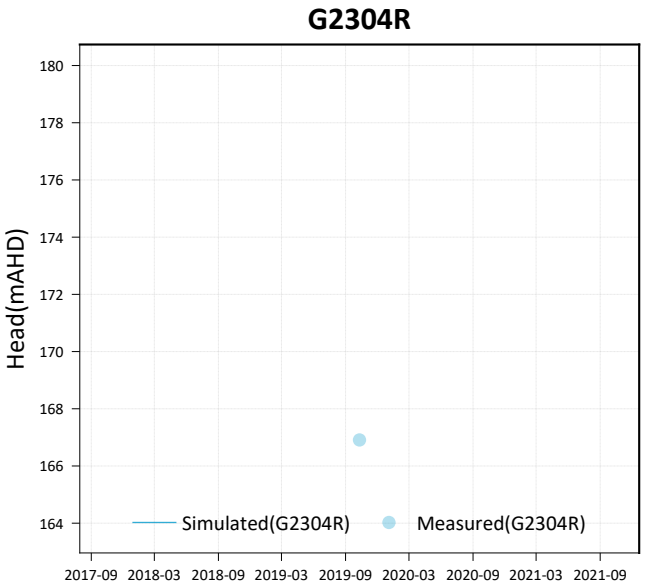

DAUNIAPZ03
Head(mAHD)
190
188
186
184
182
180
178
176
Simulated(DAUNIAPZ03)
Measured(DAUNIAPZ03)
2009-06 2009-12 2010-06 2010-12 2011-06 2011-12 2012-06 2012-12 2013-06


DAUNIAPZ04
Head(mAHD)
182
180
178
176
174
172
170
168
166
Simulated(DAUNIAPZ04)
Measured(DAUNIAPZ04)
2010 2012 2014 2016 2018 2020 2022

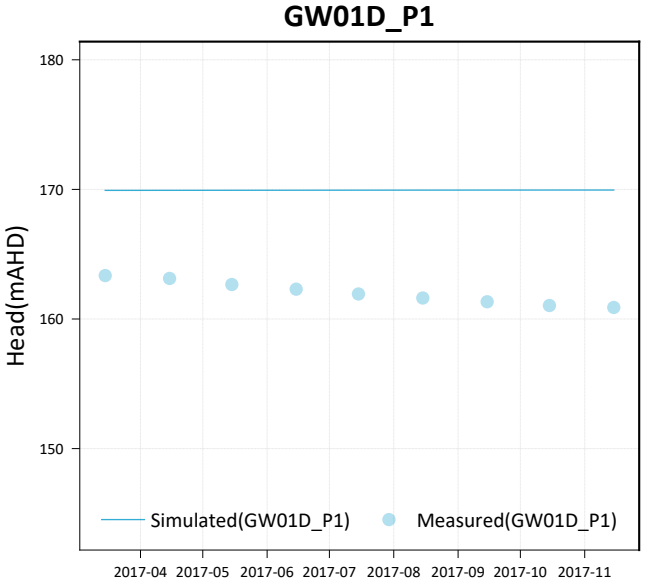

DAUNIAPZ05
Head(mAHD)
210
200
190
180
2017
2018
2019
2020
2021
Simulated(DAUNIAPZ05)
Measured(DAUNIAPZ05)

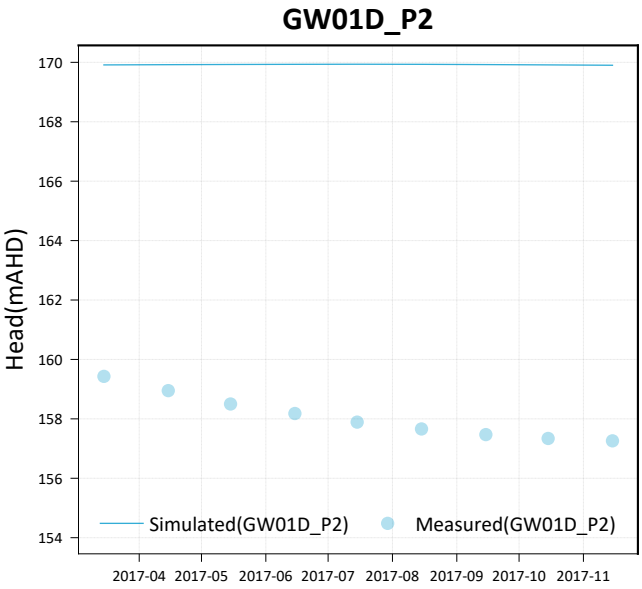

DAUNIAPZ06
Head(mAHD)
202
200
198
196
194
192
190
188
2017
2018
2019
2020
2021
Simulated(DAUNIAPZ06)
Measured(DAUNIAPZ06)

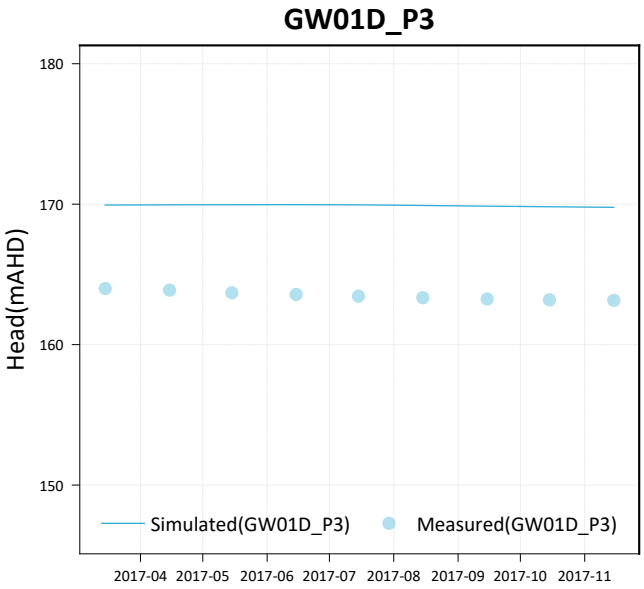

DAUNIAPZ07
Head(mAHD)
196
194
192
190
188
186
184
182
2018-01
2018-05
2018-09
2019-01
2019-05
2019-09
2020-01
2020-05
2020-09
2021-01
2021-05
Simulated(DAUNIAPZ07)
Measured(DAUNIAPZ07)

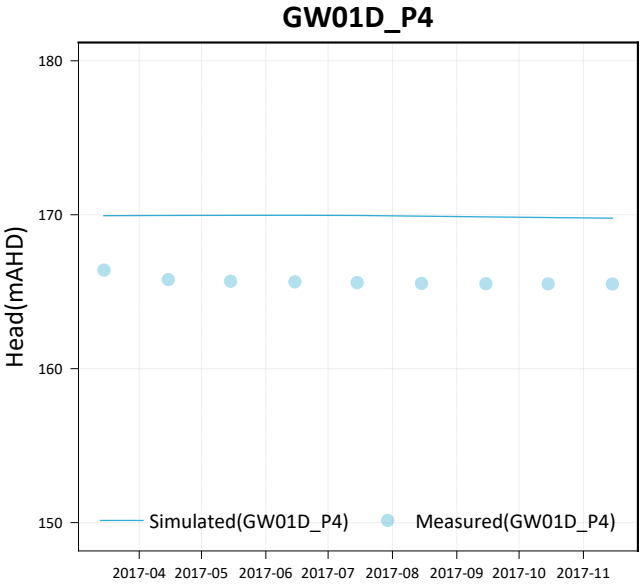

G2304R
Head(mAHD)
180
178
176
174
172
170
168
166
164
2017-09
2018-03
2018-09
2019-03
2019-09
2020-03
2020-09
2021-03
2021-09
Simulated(G2304R)
Measured(G2304R)

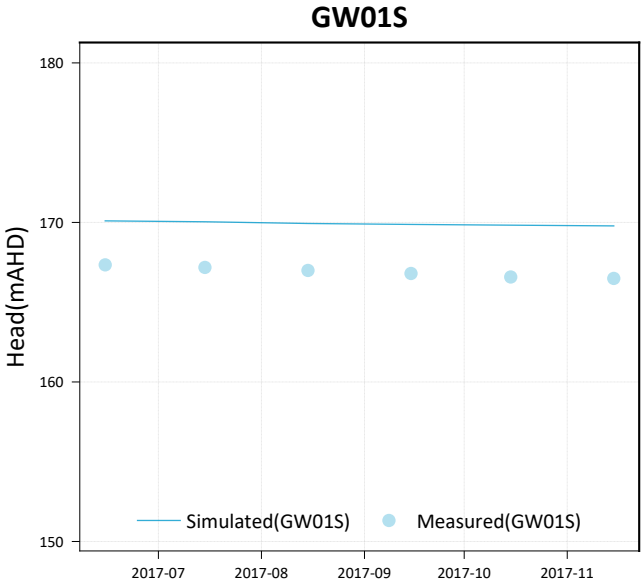

G2307
Head(mAHD)
180
170
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
Simulated(G2307)
Measured(G2307)


GW01D_P1
Head(mAHD)
180
170
160
150
2017-04
2017-05
2017-06
2017-07
2017-08
2017-09
2017-10
2017-11
Simulated(GW01D_P1)
Measured(GW01D_P1)

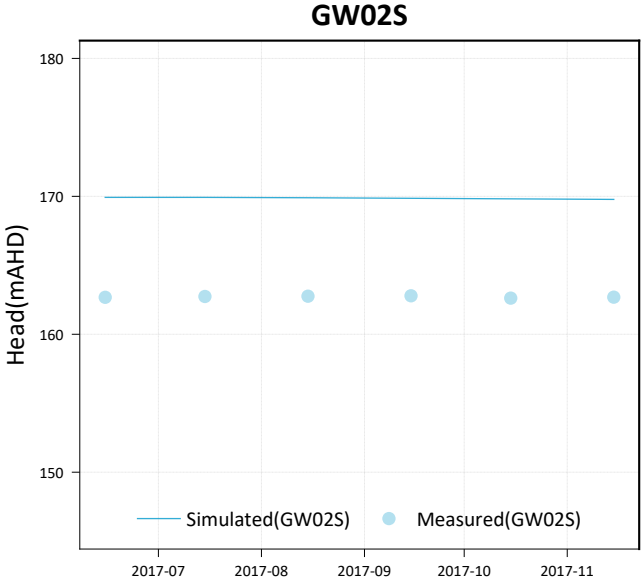

GW01D_P2
Head(mAHD)
170
168
166
164
162
160
158
156
154
Simulated(GW01D_P2)
Measured(GW01D_P2)
2017-04 2017-05 2017-06 2017-07 2017-08 2017-09 2017-10 2017-11

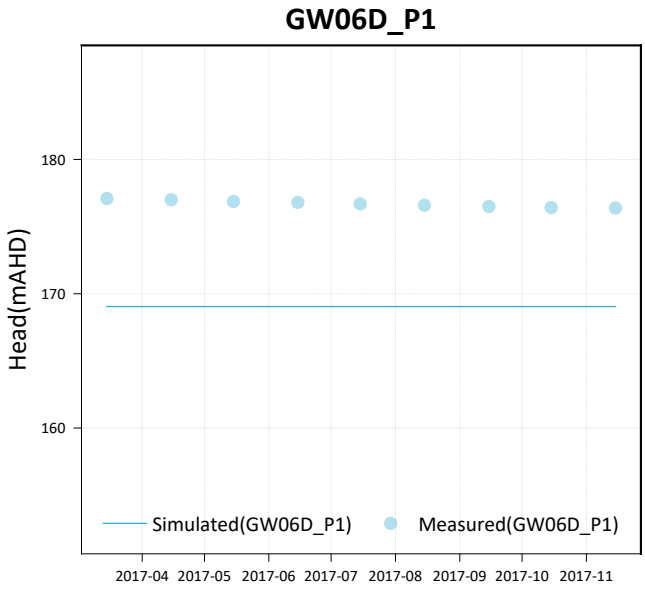

GW01D_P3
Head(mAHD)
180
170
160
150
Simulated(GW01D_P3)
Measured(GW01D_P3)
2017-04 2017-05 2017-06 2017-07 2017-08 2017-09 2017-10 2017-11

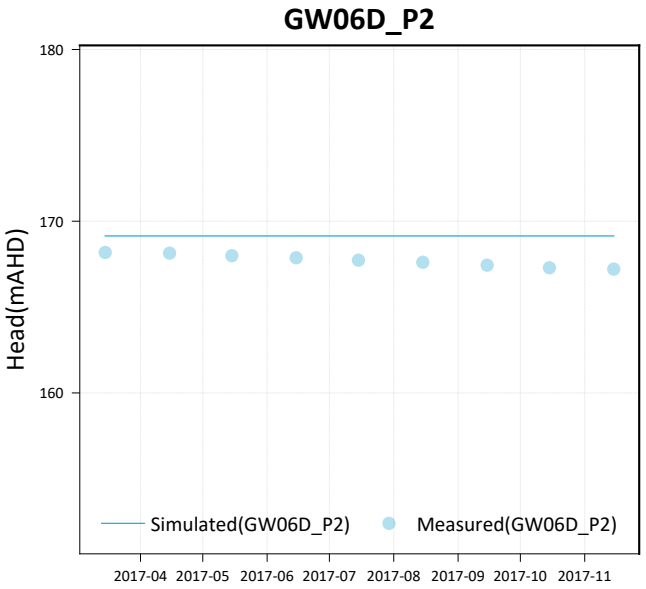

GW01D_P4
Head(mAHD)
180
170
160
150
Simulated(GW01D_P4)
Measured(GW01D_P4)
2017-04 2017-05 2017-06 2017-07 2017-08 2017-09 2017-10 2017-11

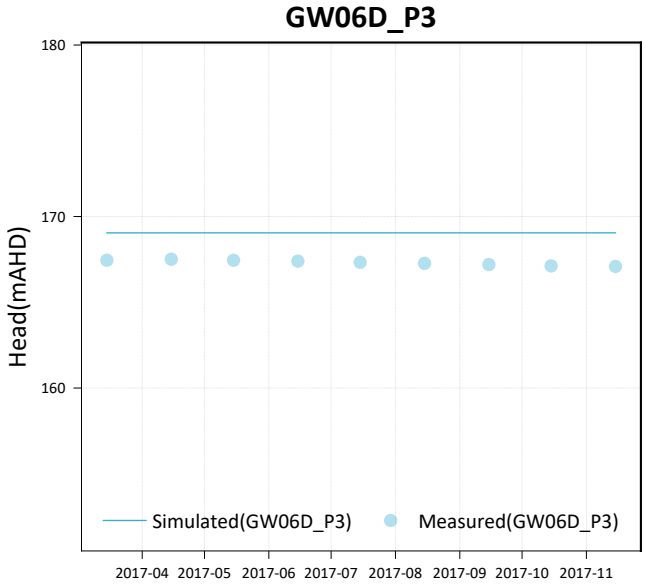

GW01S
Head(mAHD)
180
170
160
150
Simulated(GW01S)
Measured(GW01S)
2017-07 2017-08 2017-09 2017-10 2017-11

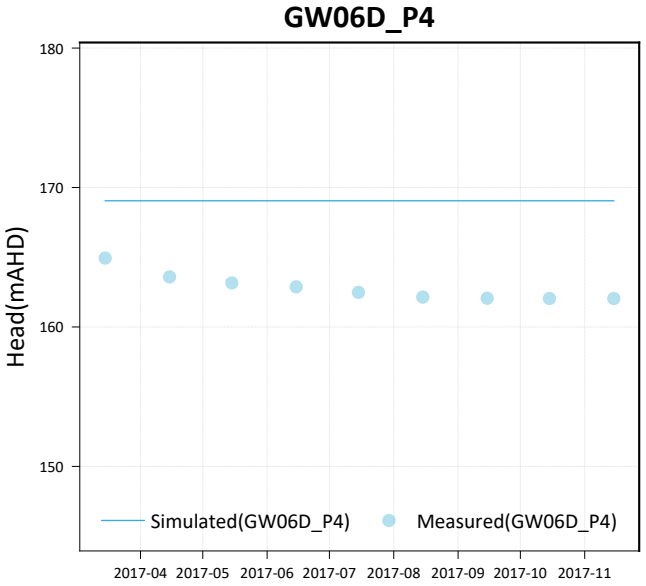

GW02D
Head(mAHD)
180
170
160
150
Simulated(GW02D)
Measured(GW02D)
2017-07 2017-08 2017-09 2017-10 2017-11

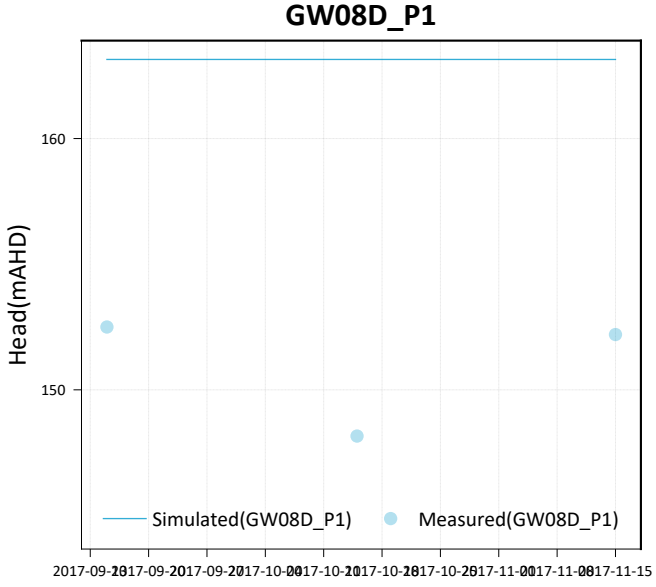

GW02S
Head(mAHD)
180
170
160
150
Simulated(GW02S)
Measured(GW02S)
2017-07 2017-08 2017-09 2017-10 2017-11

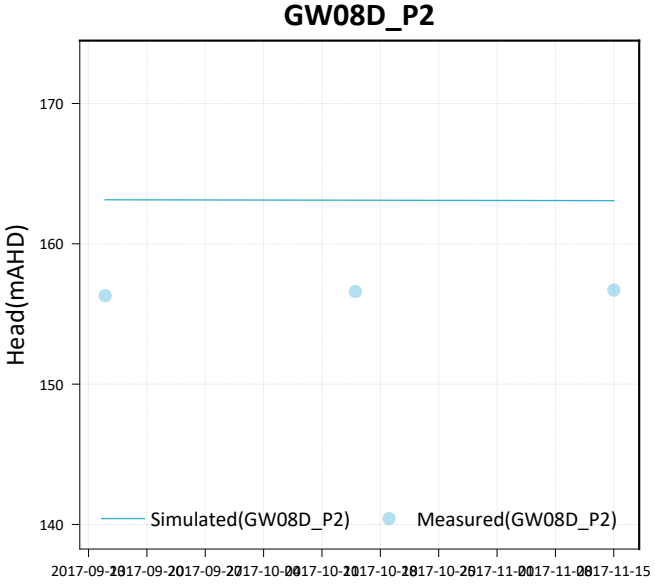

GW06D_P1
Head(mAHD)
180
170
160
Simulated(GW06D_P1)
Measured(GW06D_P1)
2017-04 2017-05 2017-06 2017-07 2017-08 2017-09 2017-10 2017-11

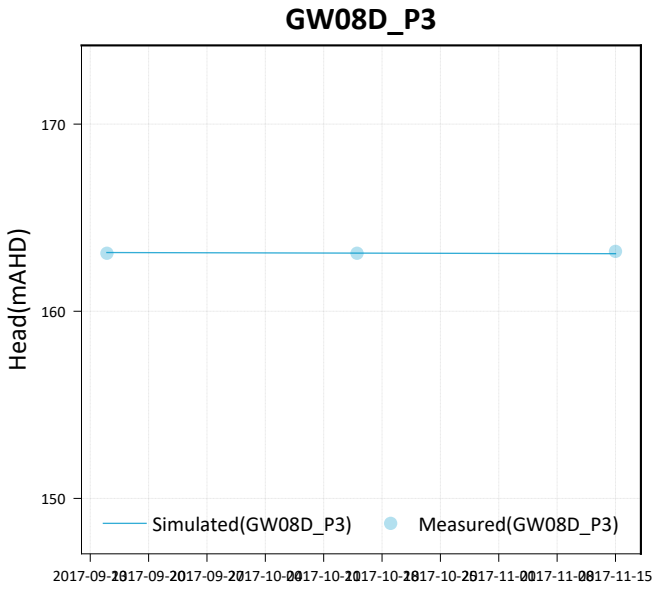

GW06D_P2
Head(mAHD)
180
170
160
Simulated(GW06D_P2)
Measured(GW06D_P2)
2017-04 2017-05 2017-06 2017-07 2017-08 2017-09 2017-10 2017-11

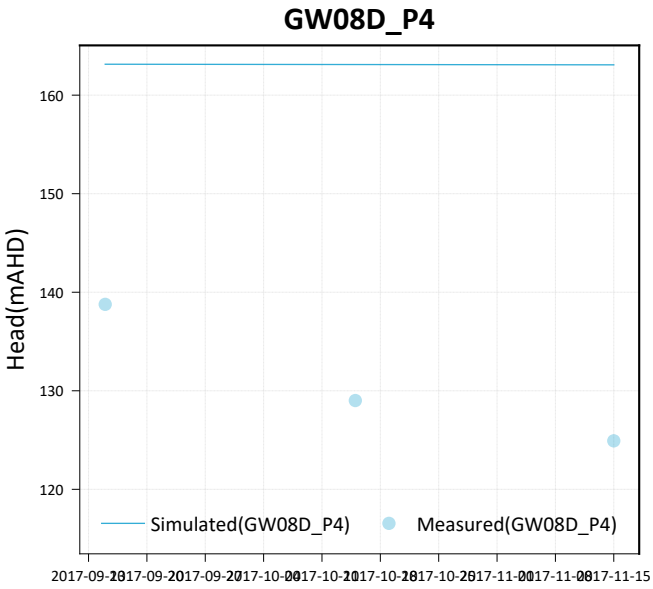

GW06D_P3
Head(mAHD)
180
170
160
Simulated(GW06D_P3)
Measured(GW06D_P3)
2017-04 2017-05 2017-06 2017-07 2017-08 2017-09 2017-10 2017-11

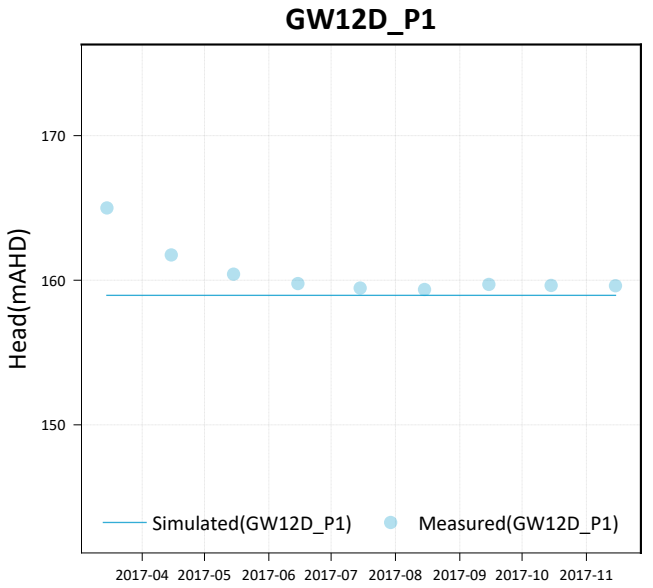

GW06D_P4
Head(mAHD)
180
170
160
150
Simulated(GW06D_P4)
Measured(GW06D_P4)
2017-04 2017-05 2017-06 2017-07 2017-08 2017-09 2017-10 2017-11

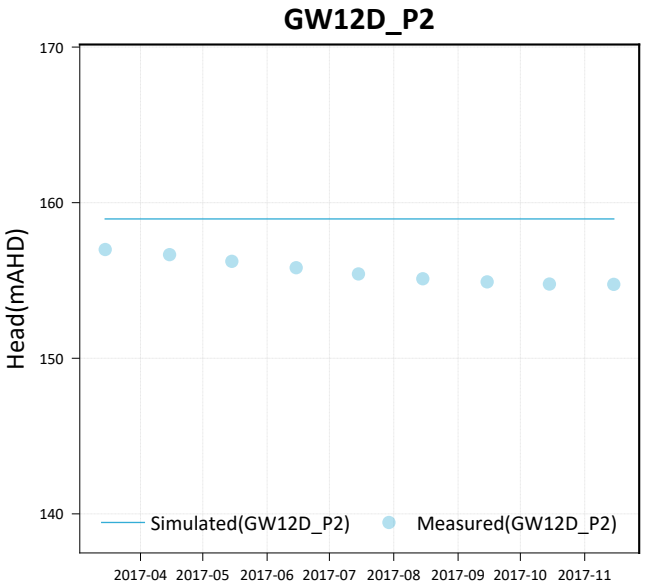

GW08D_P1
Head(mAHD)
160
150
Simulated(GW08D_P1)
Measured(GW08D_P1)

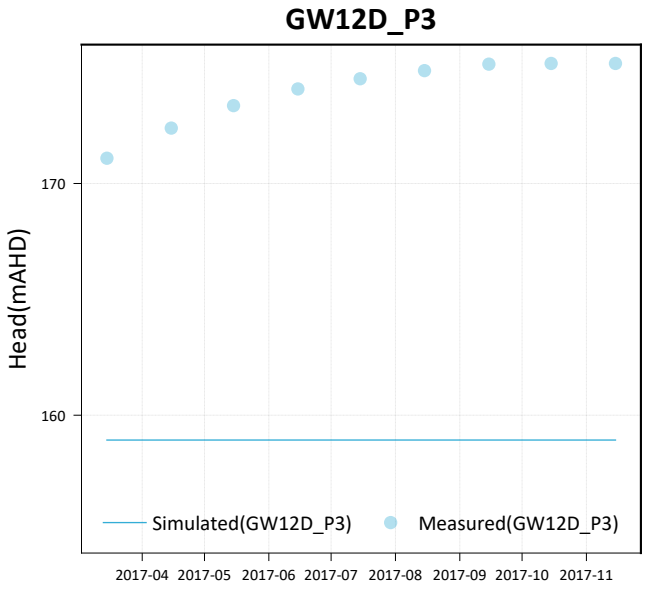

GW08D_P2
Head(mAHD)
170
160
150
140
Simulated(GW08D_P2)
Measured(GW08D_P2)

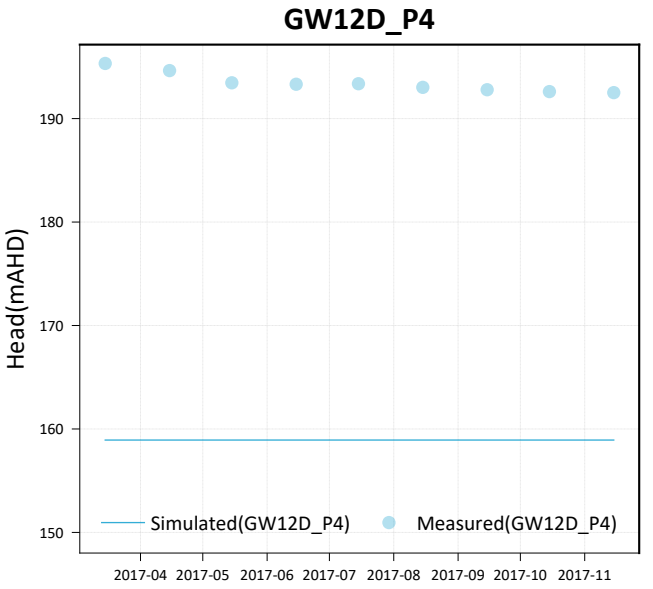

GW08D_P3
Head(mAHD)
170
160
150
Simulated(GW08D_P3)
Measured(GW08D_P3)

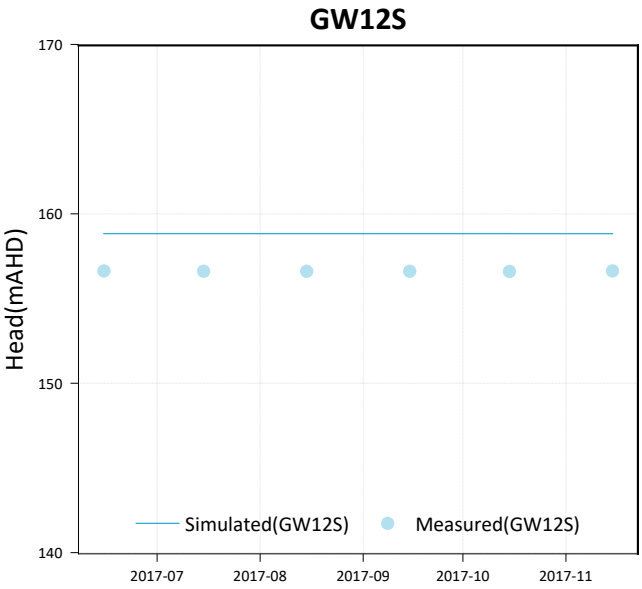

GW08D_P4
Head(mAHD)
160
150
140
130
120
Simulated(GW08D_P4)
Measured(GW08D_P4)

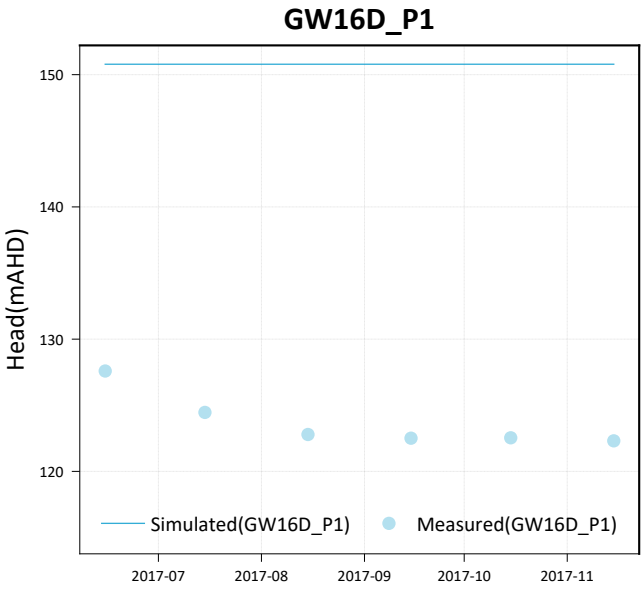

GW12D_P1
Head(mAHD)
170
160
150
Simulated(GW12D_P1)
Measured(GW12D_P1)
2017-04 2017-05 2017-06 2017-07 2017-08 2017-09 2017-10 2017-11

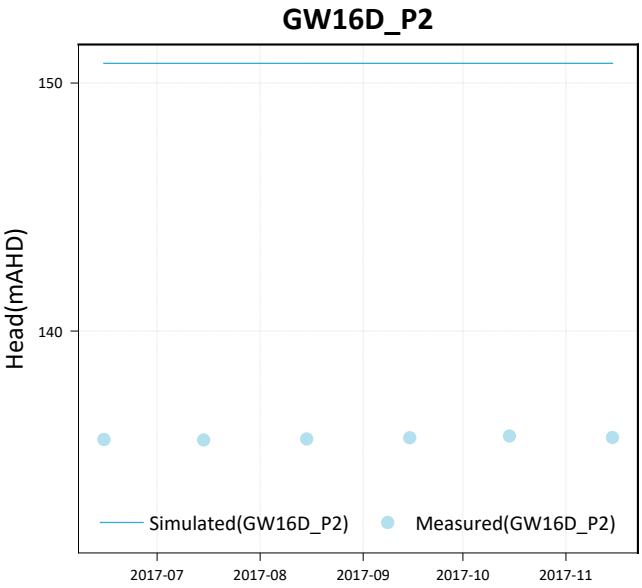

GW12D_P2
Head(mAHD)
170
160
150
140
Simulated(GW12D_P2)
Measured(GW12D_P2)
2017-04 2017-05 2017-06 2017-07 2017-08 2017-09 2017-10 2017-11

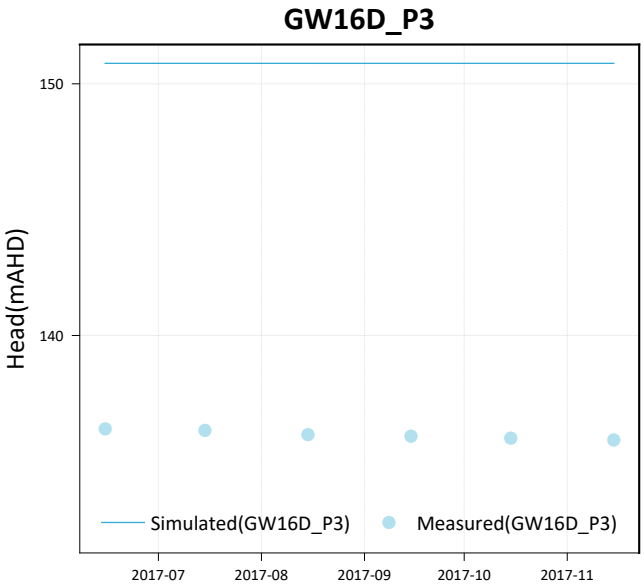

GW12D_P3
Head(mAHD)
170
160
Simulated(GW12D_P3)
Measured(GW12D_P3)
2017-04 2017-05 2017-06 2017-07 2017-08 2017-09 2017-10 2017-11

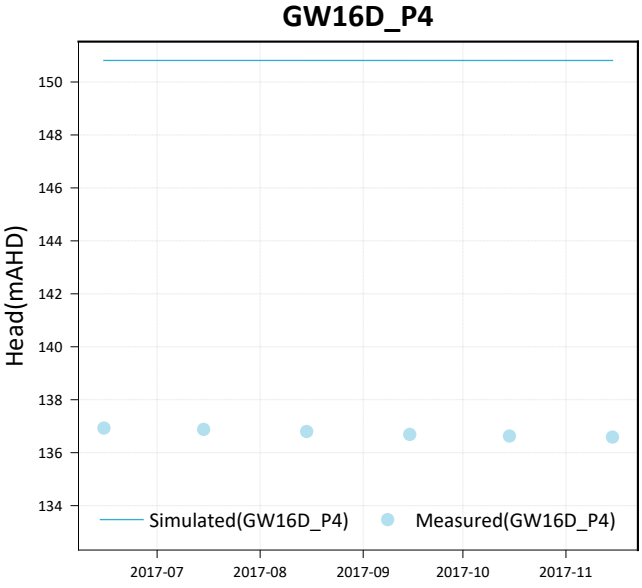

GW12D_P4
Head(mAHD)
190
180
170
160
150
Simulated(GW12D_P4)
Measured(GW12D_P4)
2017-04 2017-05 2017-06 2017-07 2017-08 2017-09 2017-10 2017-11

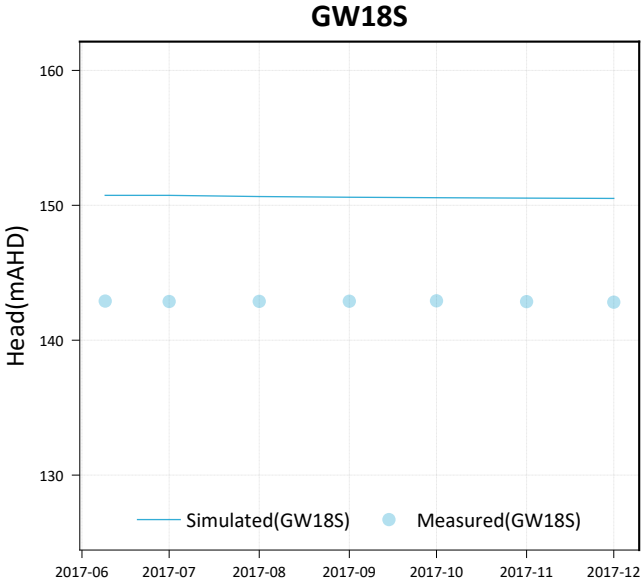

GW12S
Head(mAHD)
170
160
150
140
2017-07
2017-08
2017-09
2017-10
2017-11
Simulated(GW12S)
Measured(GW12S)

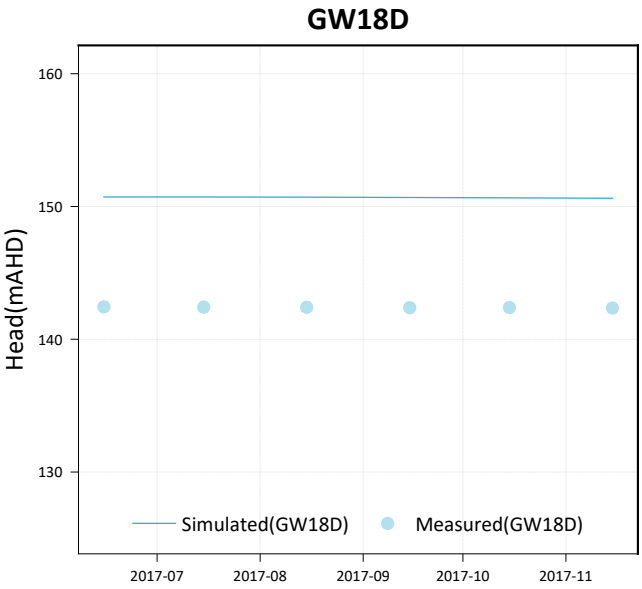

GW16D_P1
Head(mAHD)
150
140
130
120
2017-07
2017-08
2017-09
2017-10
2017-11
Simulated(GW16D_P1)
Measured(GW16D_P1)

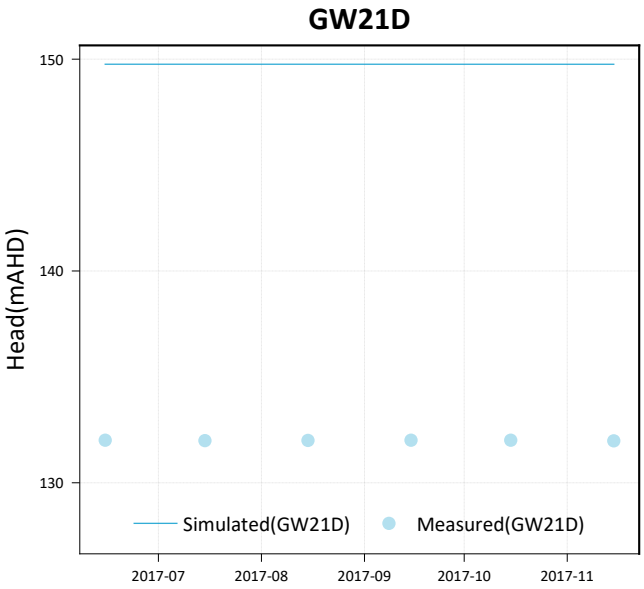

GW16D_P2
Head(mAHD)
150
140
2017-07
2017-08
2017-09
2017-10
2017-11
Simulated(GW16D_P2)
Measured(GW16D_P2)

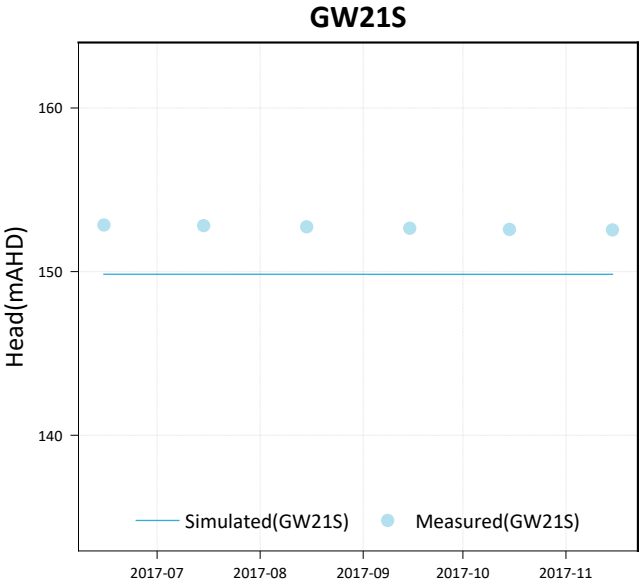

GW16D_P3
Head(mAHD)
150
140
2017-07
2017-08
2017-09
2017-10
2017-11
Simulated(GW16D_P3)
Measured(GW16D_P3)

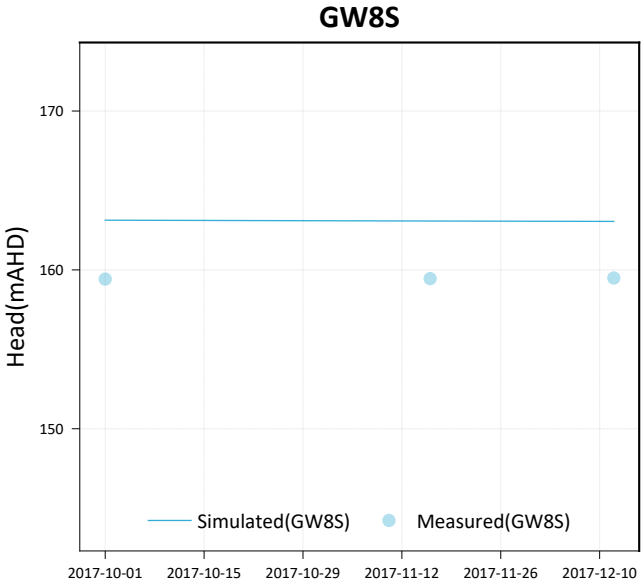

GW16D_P4
Head(mAHD)
150
148
146
144
142
140
138
136
134
2017-07
2017-08
2017-09
2017-10
2017-11
Simulated(GW16D_P4)
Measured(GW16D_P4)

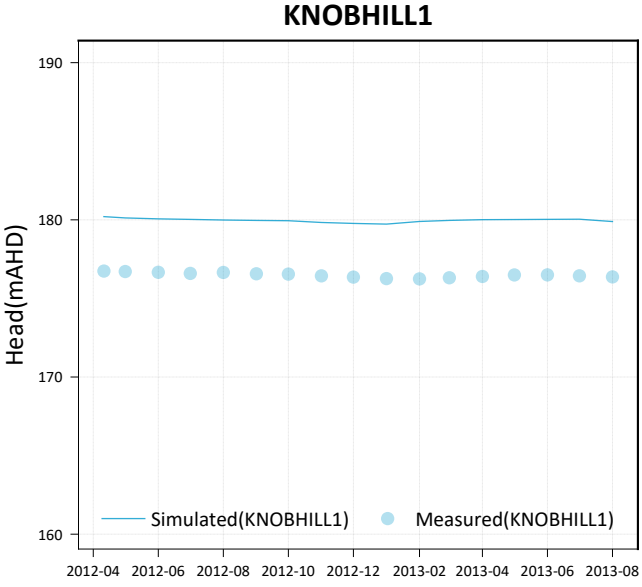

GW18S
Head(mAHD)
160
150
140
130
2017-06
2017-07
2017-08
2017-09
2017-10
2017-11
2017-12
Simulated(GW18S)
Measured(GW18S)

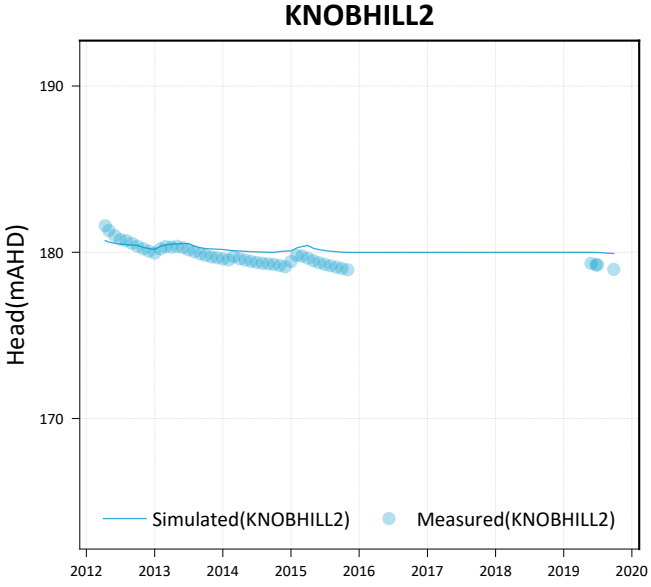

GW18D
Head(mAHD)
160
150
140
130
Simulated(GW18D)
Measured(GW18D)
2017-07
2017-08
2017-09
2017-10
2017-11

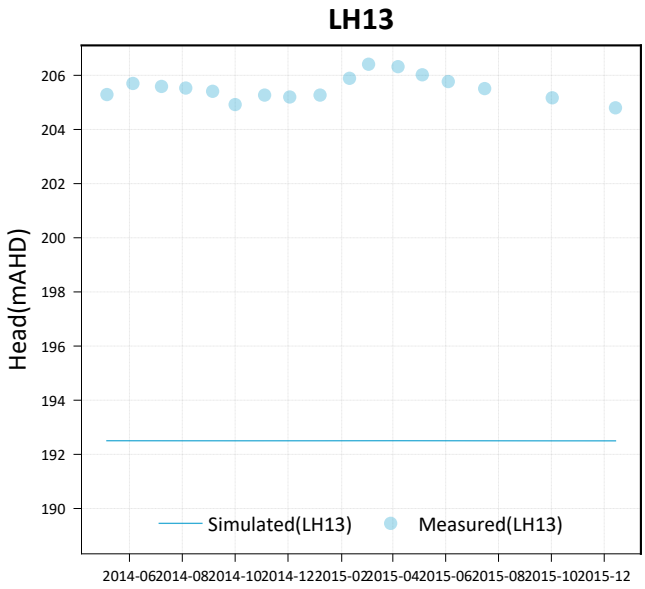

GW21D
Head(mAHD)
150
140
130
Simulated(GW21D)
Measured(GW21D)
2017-07
2017-08
2017-09
2017-10
2017-11

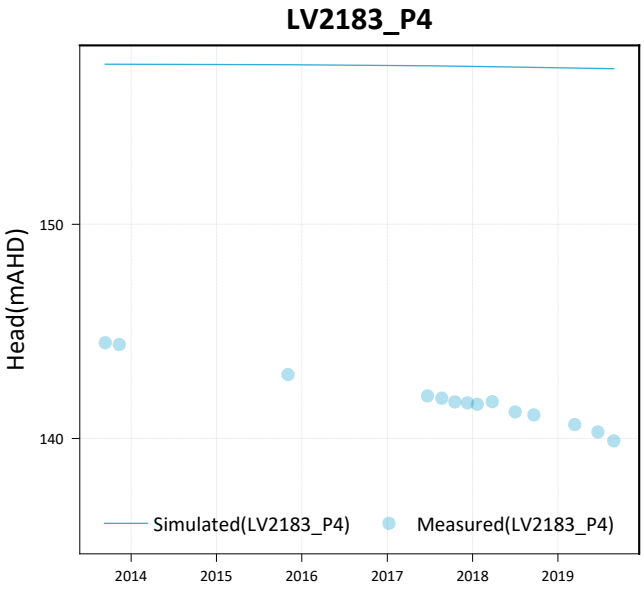

GW21S
Head(mAHD)
160
150
140
Simulated(GW21S)
Measured(GW21S)
2017-07
2017-08
2017-09
2017-10
2017-11

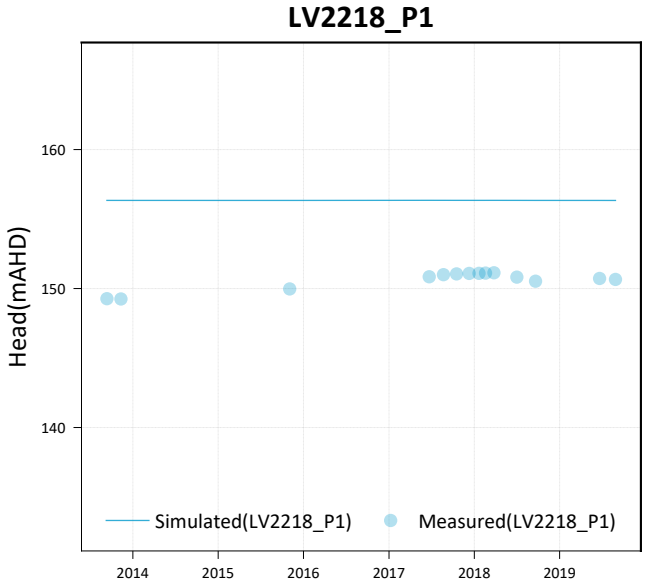

GW8S
Head(mAHD)
170
160
150
Simulated(GW8S)
Measured(GW8S)
2017-10-01
2017-10-15
2017-10-29
2017-11-12
2017-11-26
2017-12-10

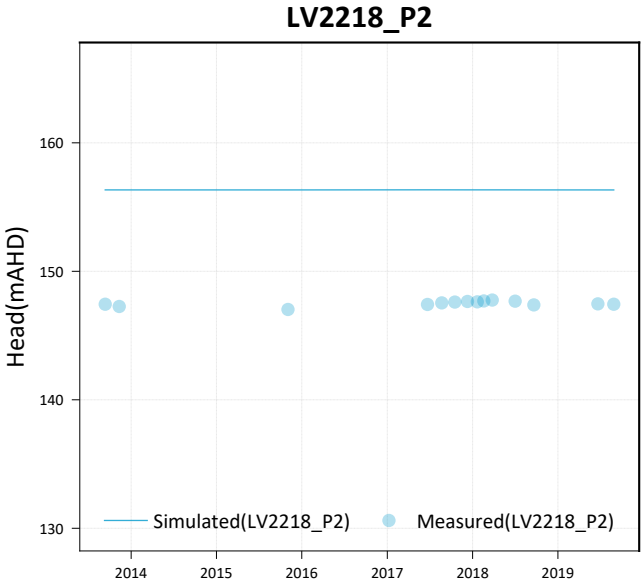

KNOBHILL1
Head(mAHD)
190
180
170
160
Simulated(KNOBHILL1)
Measured(KNOBHILL1)
2012-04
2012-06
2012-08
2012-10
2012-12
2013-02
2013-04
2013-06
2013-08

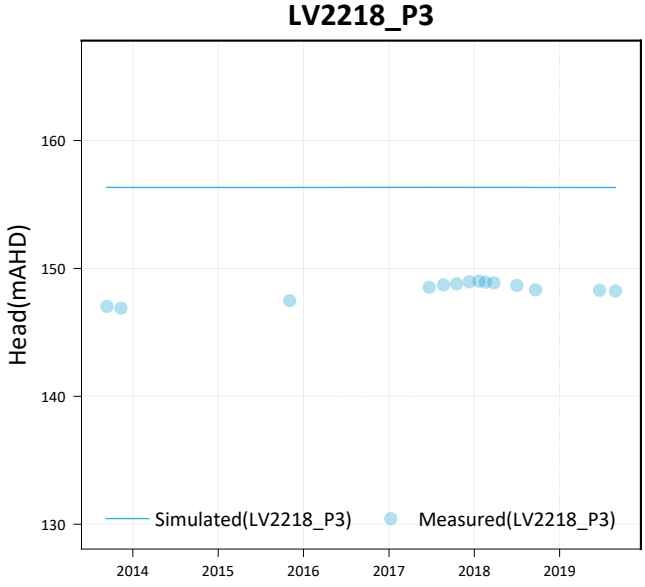

KNOBHILL2
Head(mAHD)
190
180
170
Simulated(KNOBHILL2)
Measured(KNOBHILL2)
2012
2013
2014
2015
2016
2017
2018
2019
2020

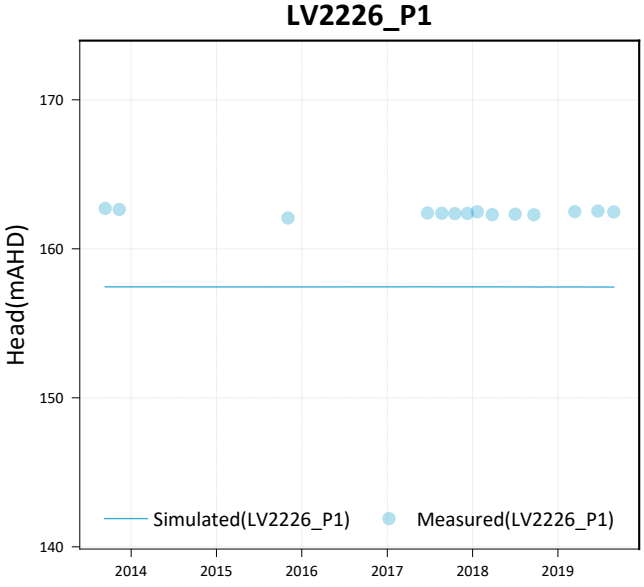

LH13
Head(mAHD)
206
204
202
200
198
196
194
192
190
Simulated(LH13)
Measured(LH13)
2014-06
2014-08
2014-10
2014-12
2015-02
2015-04
2015-06
2015-08
2015-10
2015-12


LV2183_P4
Head(mAHD)
150
140
Simulated(LV2183_P4)
Measured(LV2183_P4)
2014
2015
2016
2017
2018
2019

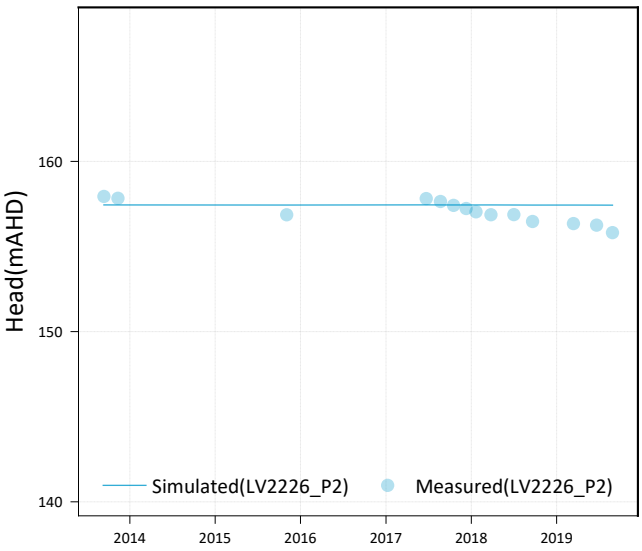

LV2218_P1
Head(mAHD)
160
150
140
Simulated(LV2218_P1)
Measured(LV2218_P1)
2014
2015
2016
2017
2018
2019


LV2218_P2
Head(mAHD)
160
150
140
130
Simulated(LV2218_P2)
Measured(LV2218_P2)
2014
2015
2016
2017
2018
2019

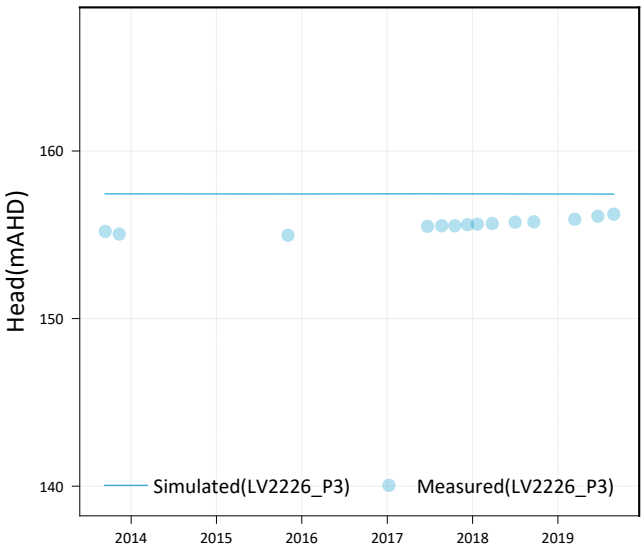

LV2218_P3
Head(mAHD)
160
150
140
130
Simulated(LV2218_P3)
Measured(LV2218_P3)
2014
2015
2016
2017
2018
2019


LV2226_P1
Head(mAHD)
170
160
150
140
Simulated(LV2226_P1)
Measured(LV2226_P1)
2014
2015
2016
2017
2018
2019

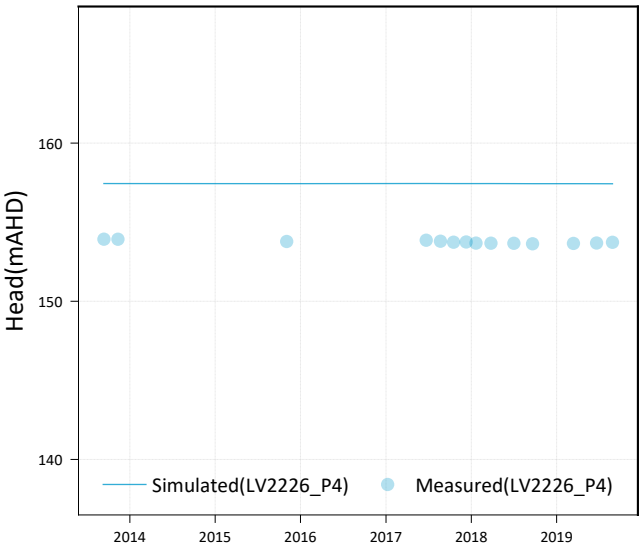
## LV2226_P2



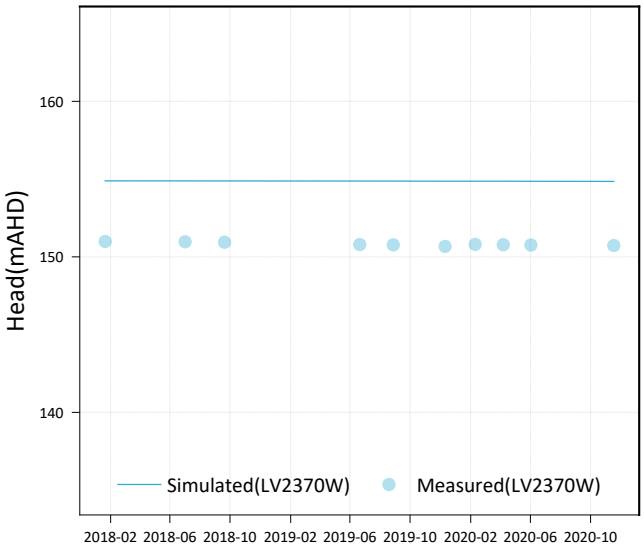

## LV2226_P3



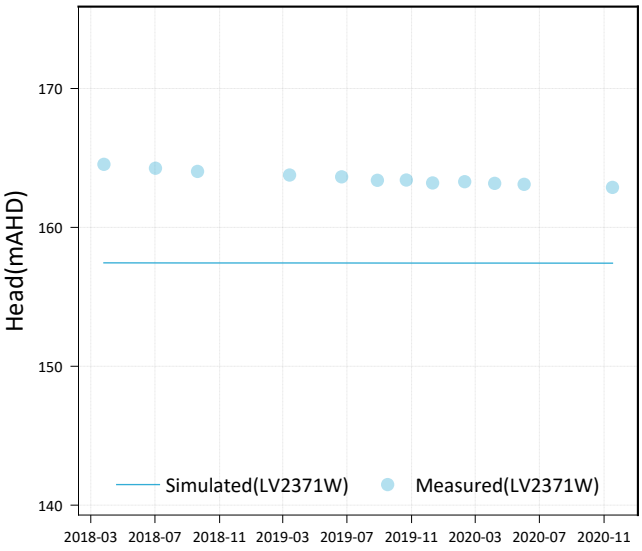

## LV2226_P4



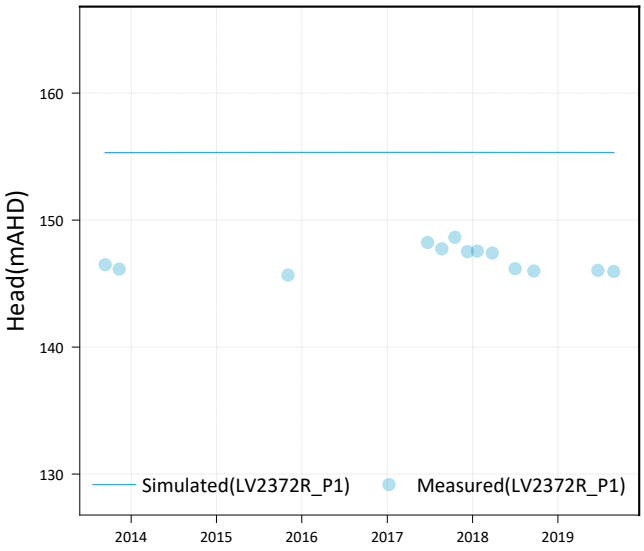

## LV2370W

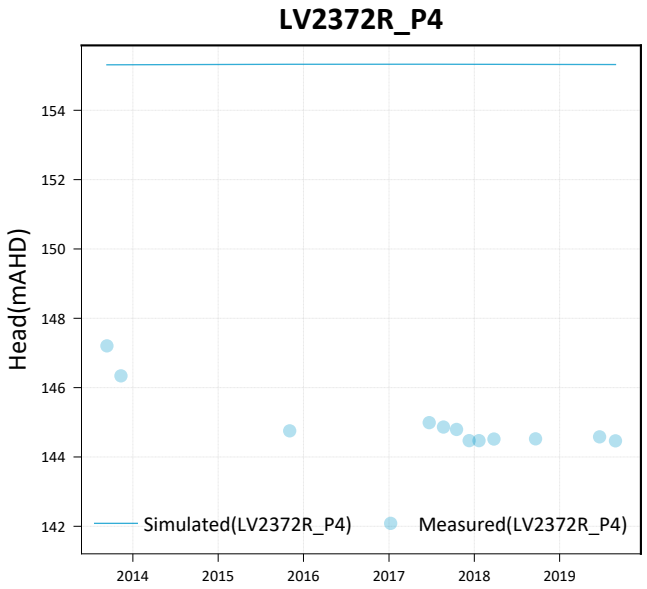


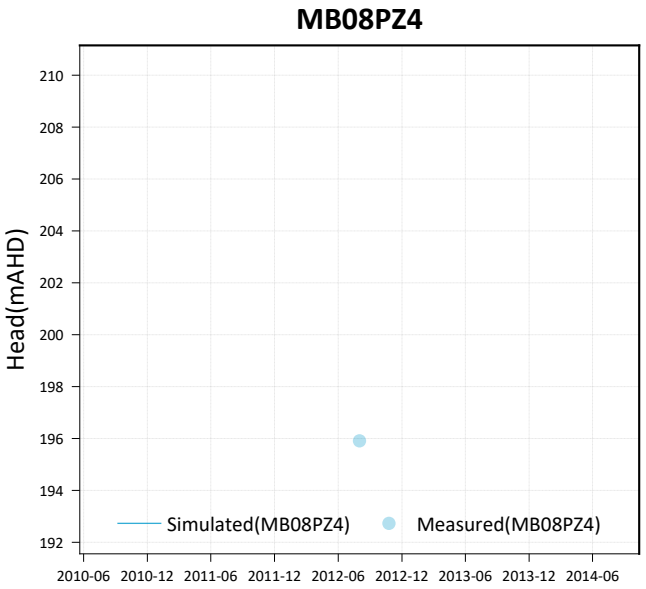

## LV2371W

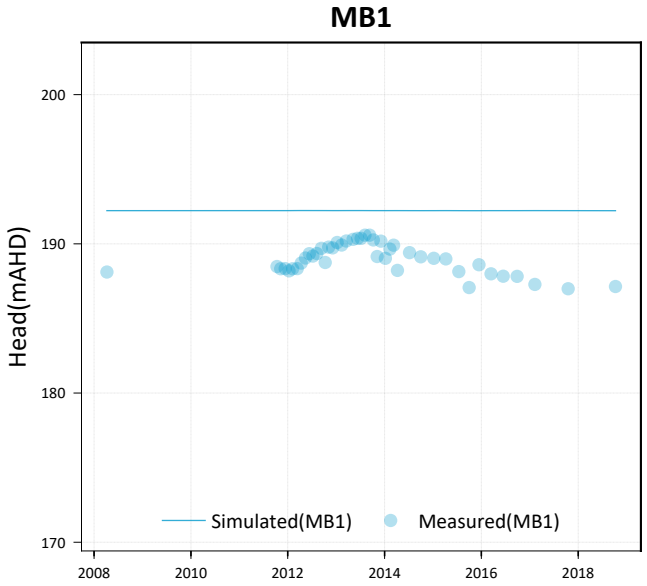


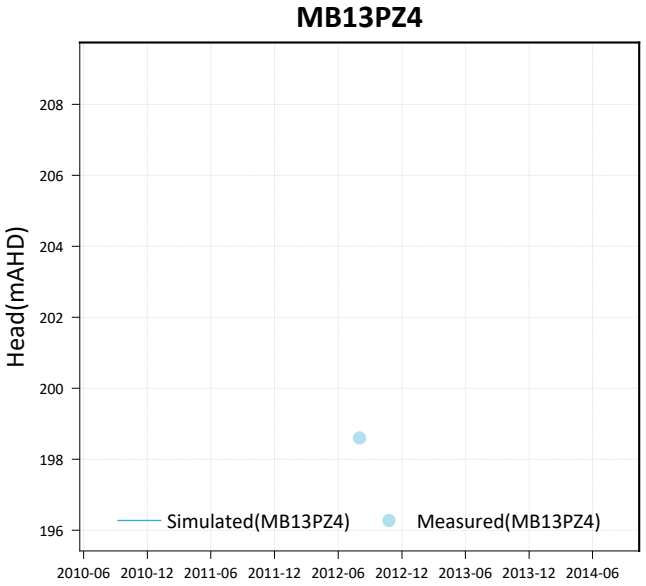

## LV2372R_P1

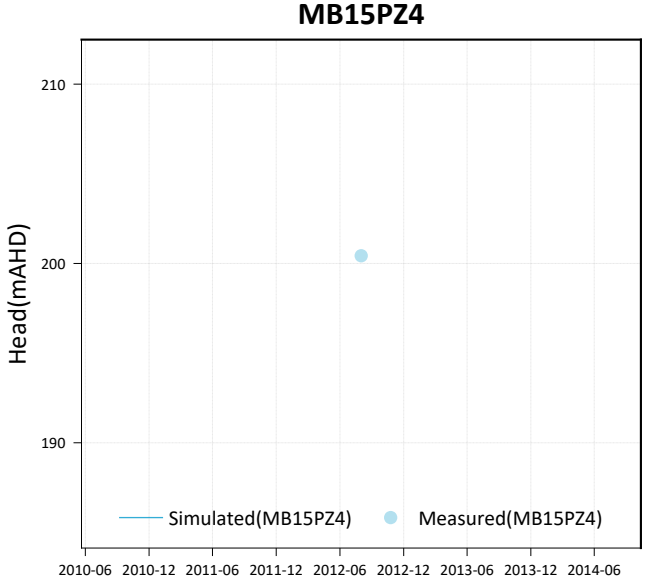


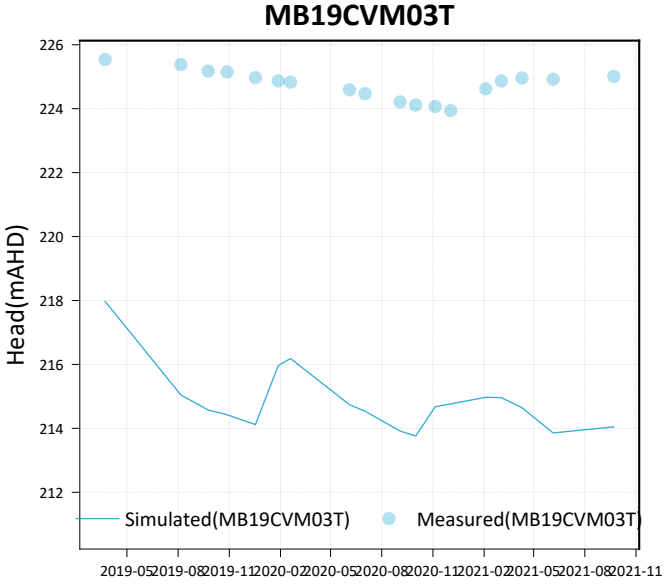

LV2372R_P4
Head(mAHD)
154
152
150
148
146
144
142
2014
2015
2016
2017
2018
2019
Simulated(LV2372R_P4)
Measured(LV2372R_P4)

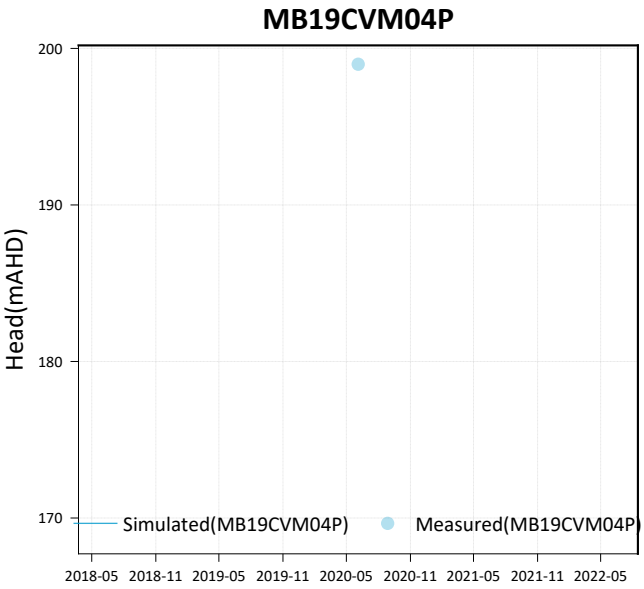

MB08PZ4
Head(mAHD)
210
208
206
204
202
200
198
196
194
192
2010-06
2010-12
2011-06
2011-12
2012-06
2012-12
2013-06
2013-12
2014-06
Simulated(MB08PZ4)
Measured(MB08PZ4)

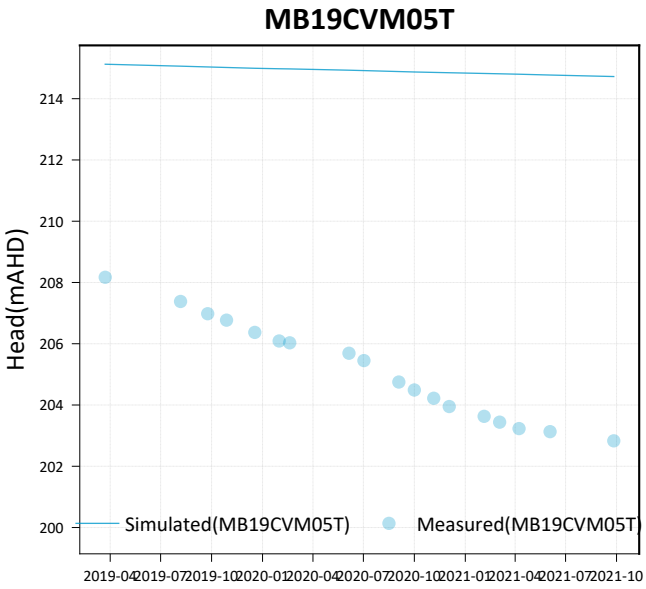

MB1
Head(mAHD)
200
190
180
170
2008
2010
2012
2014
2016
2018
Simulated(MB1)
Measured(MB1)

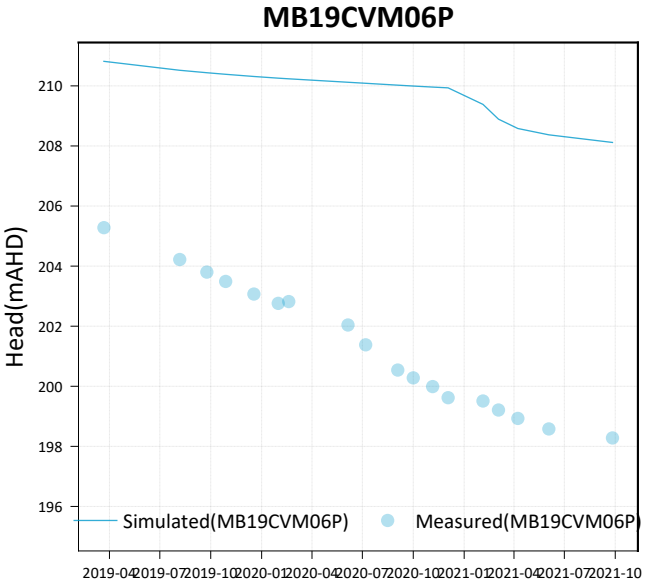

MB13PZ4
Head(mAHD)
208
206
204
202
200
198
196
2010-06
2010-12
2011-06
2011-12
2012-06
2012-12
2013-06
2013-12
2014-06
Simulated(MB13PZ4)
Measured(MB13PZ4)

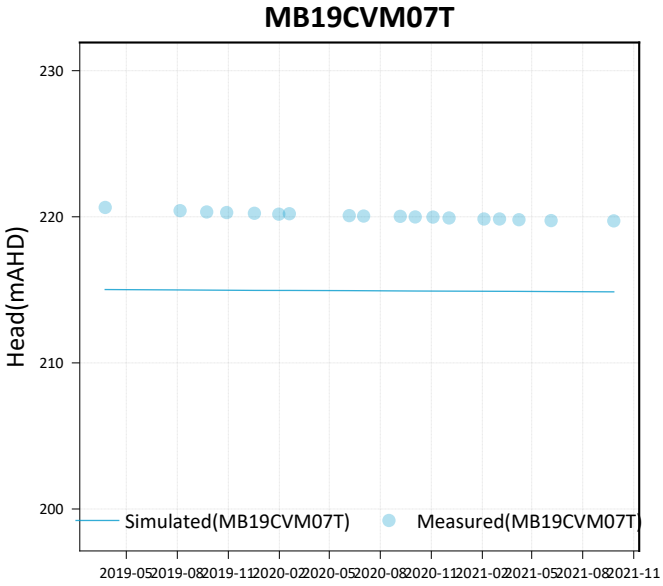

MB15PZ4
Head(mAHD)
210
200
190
2010-06
2010-12
2011-06
2011-12
2012-06
2012-12
2013-06
2013-12
2014-06
Simulated(MB15PZ4)
Measured(MB15PZ4)

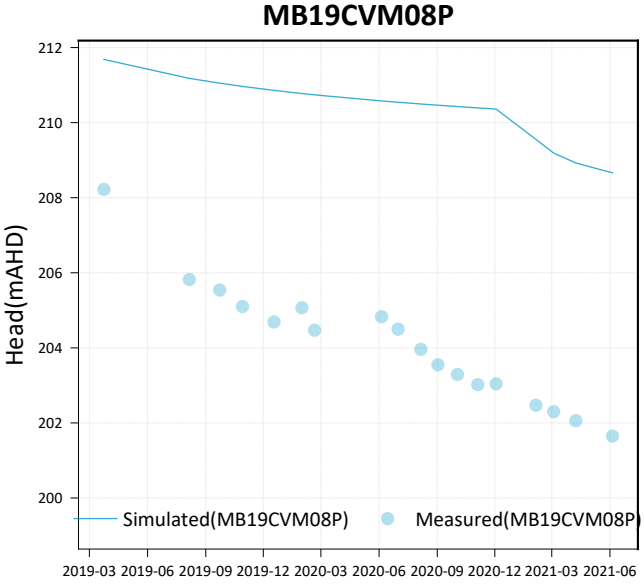

MB19CVM03T
Head(mAHD)
226
224
222
220
218
216
214
212
2019-05
2019-08
2019-11
2020-02
2020-05
2020-08
2020-11
2021-02
2021-05
2021-08
2021-11
Simulated(MB19CVM03T)
Measured(MB19CVM03T)

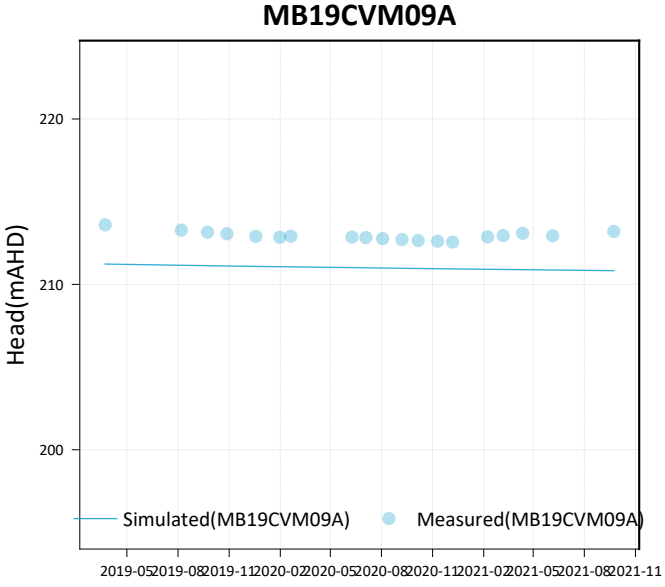

MB19CVM04P
Head(mAHD)
200
190
180
170
Simulated(MB19CVM04P)
Measured(MB19CVM04P)
2018-05 2018-11 2019-05 2019-11 2020-05 2020-11 2021-05 2021-11 2022-05

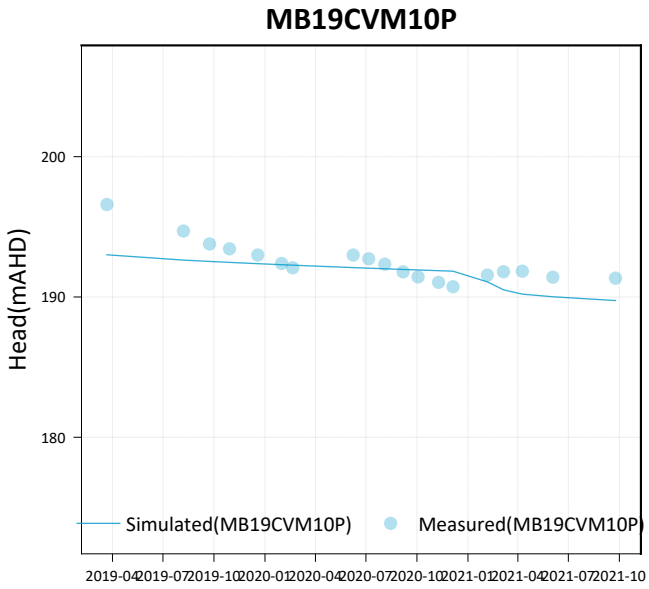

MB19CVM05T
Head(mAHD)
214
212
210
208
206
204
202
200
Simulated(MB19CVM05T)
Measured(MB19CVM05T)
2019-04 2019-07 2019-10 2020-01 2020-04 2020-07 2020-10 2021-01 2021-04 2021-07 2021-10

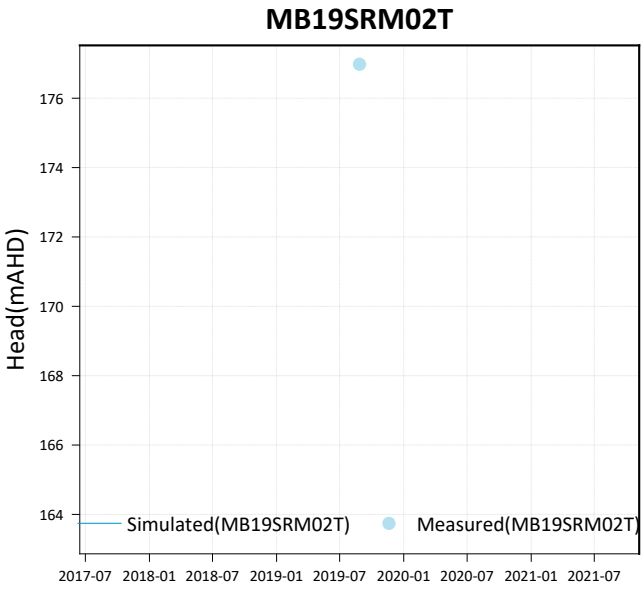

MB19CVM06P
Head(mAHD)
210
208
206
204
202
200
198
196
Simulated(MB19CVM06P)
Measured(MB19CVM06P)
2019-04 2019-07 2019-10 2020-01 2020-04 2020-07 2020-10 2021-01 2021-04 2021-07 2021-10

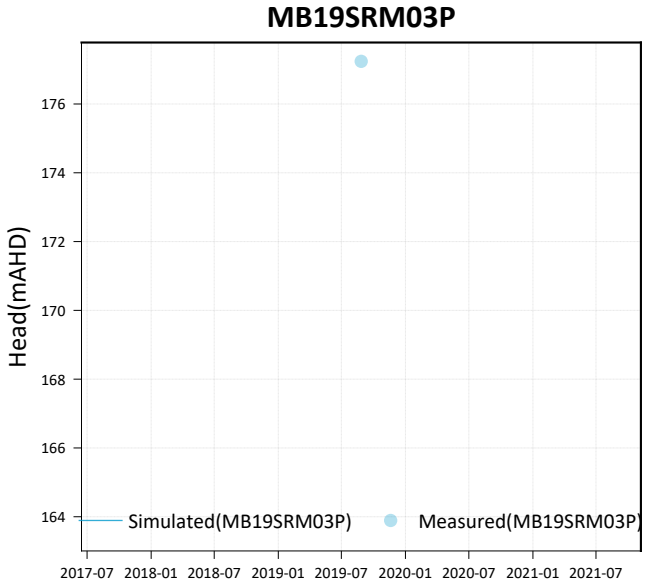

MB19CVM07T
Head(mAHD)
230
220
210
200
Simulated(MB19CVM07T)
Measured(MB19CVM07T)
2019-05 2019-08 2019-11 2020-02 2020-05 2020-08 2020-11 2021-02 2021-05 2021-08 2021-11

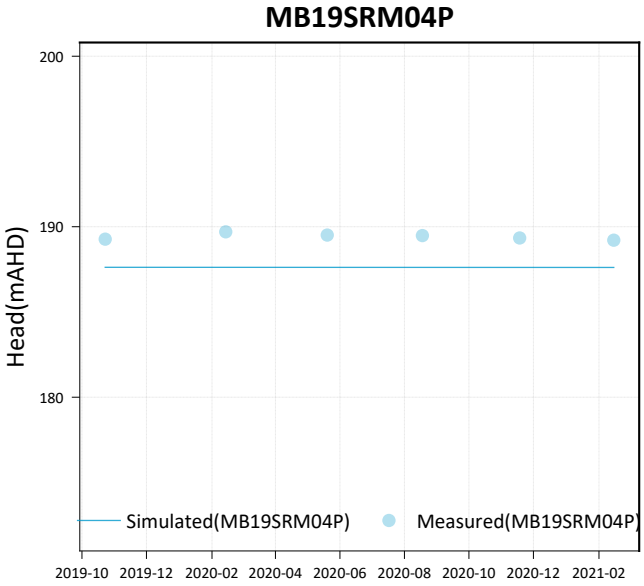

MB19CVM08P
Head(mAHD)
212
210
208
206
204
202
200
Simulated(MB19CVM08P)
Measured(MB19CVM08P)
2019-03 2019-06 2019-09 2019-12 2020-03 2020-06 2020-09 2020-12 2021-03 2021-06

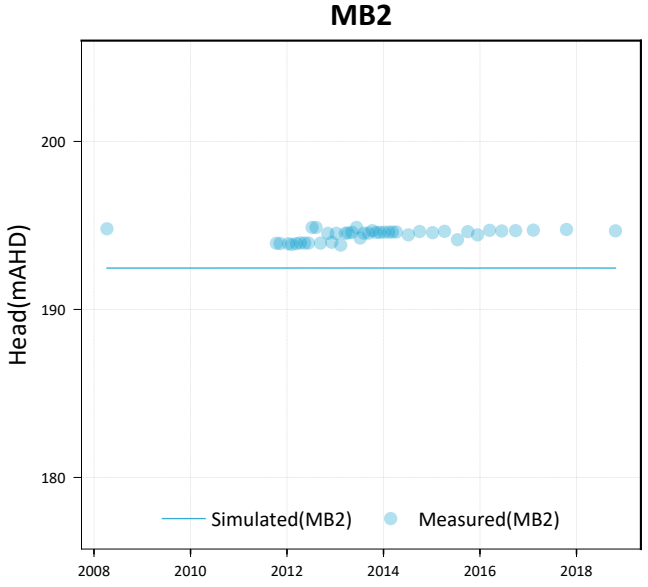

MB19CVM09A
Head(mAHD)
220
210
200
Simulated(MB19CVM09A)
Measured(MB19CVM09A)
2019-05 2019-08 2019-11 2020-02 2020-05 2020-08 2020-11 2021-02 2021-05 2021-08 2021-11

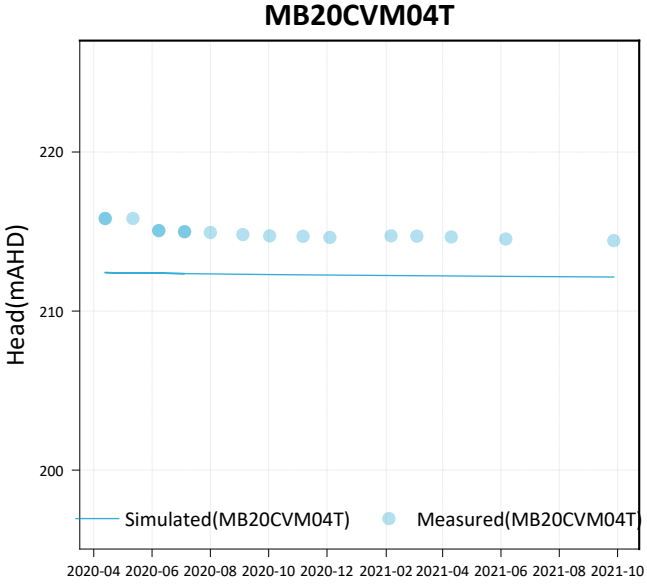

MB19CVM10P
Head(mAHD)
200
190
180
Simulated(MB19CVM10P)
Measured(MB19CVM10P)
2019-04 2019-07 2019-10 2020-01 2020-04 2020-07 2020-10 2021-01 2021-04 2021-07 2021-10

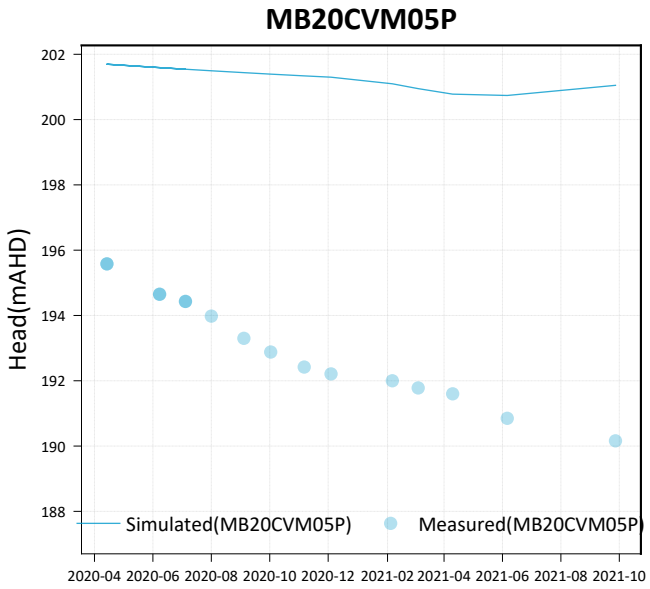

MB19SRM02T
Head(mAHD)
176
174
172
170
168
166
164
Simulated(MB19SRM02T)
Measured(MB19SRM02T)
2017-07 2018-01 2018-07 2019-01 2019-07 2020-01 2020-07 2021-01 2021-07

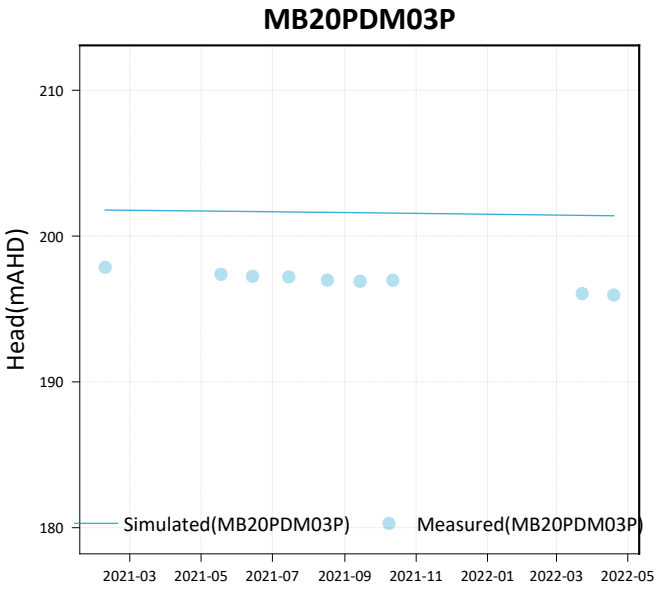

MB19SRM03P
Head(mAHD)
176
174
172
170
168
166
164
Simulated(MB19SRM03P)
Measured(MB19SRM03P)
2017-07 2018-01 2018-07 2019-01 2019-07 2020-01 2020-07 2021-01 2021-07

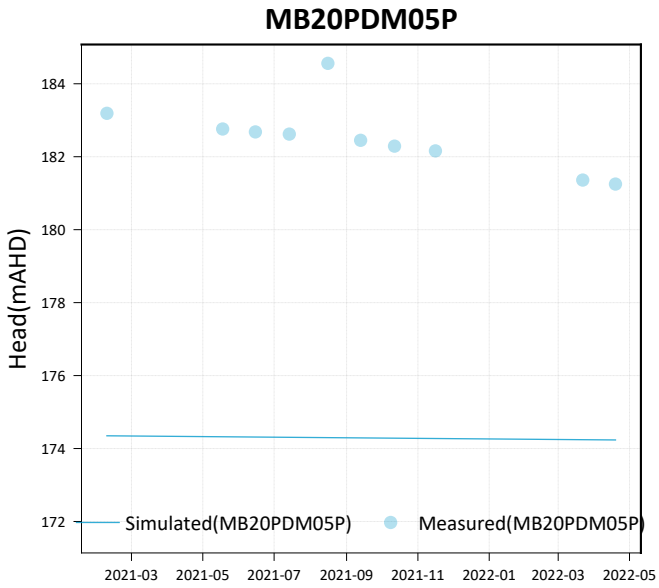

MB19SRM04P
Head(mAHD)
200
190
180
Simulated(MB19SRM04P)
Measured(MB19SRM04P)
2019-10 2019-12 2020-02 2020-04 2020-06 2020-08 2020-10 2020-12 2021-02

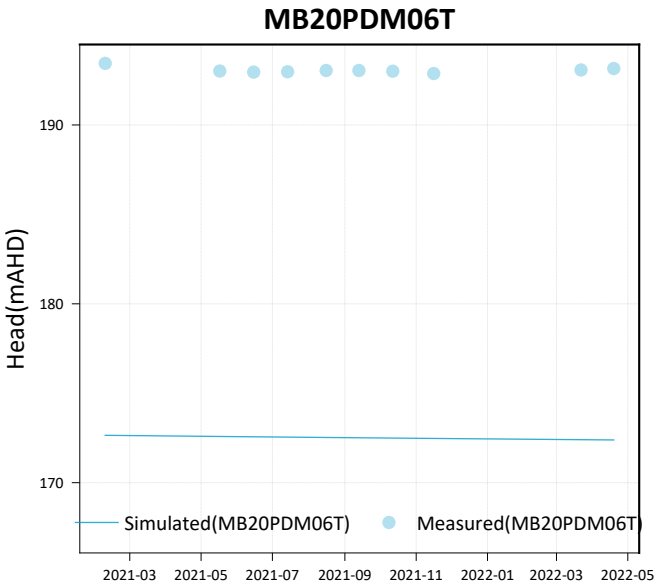

MB2
Head(mAHD)
200
190
180
Simulated(MB2)
Measured(MB2)
2008 2010 2012 2014 2016 2018

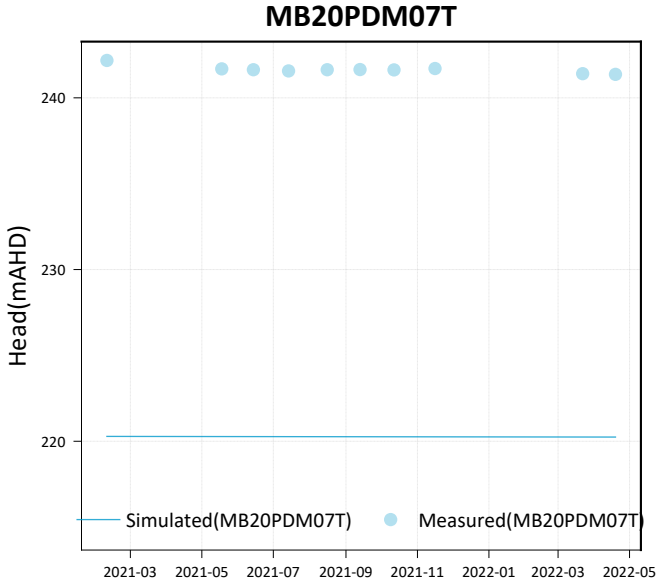

MB20CVM04T
Head(mAHD)
220
210
200
Simulated(MB20CVM04T)
Measured(MB20CVM04T)
2020-04 2020-06 2020-08 2020-10 2020-12 2021-02 2021-04 2021-06 2021-08 2021-10

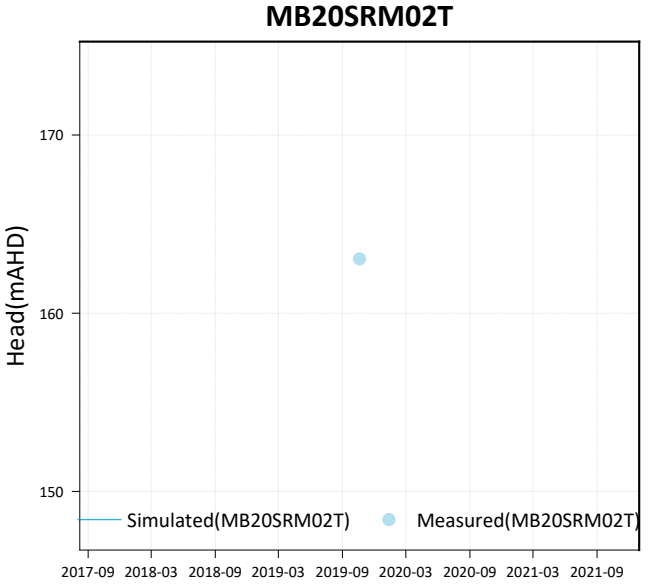

MB20CVM05P
Head(mAHD)
202
200
198
196
194
192
190
188
Simulated(MB20CVM05P)
Measured(MB20CVM05P)
2020-04 2020-06 2020-08 2020-10 2020-12 2021-02 2021-04 2021-06 2021-08 2021-10

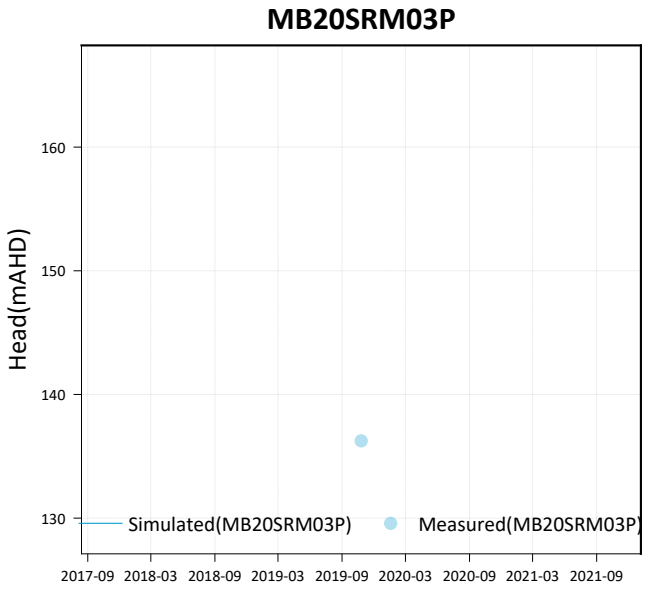

MB20PDM03P
Head(mAHD)
210
200
190
180
Simulated(MB20PDM03P)
Measured(MB20PDM03P)
2021-03 2021-05 2021-07 2021-09 2021-11 2022-01 2022-03 2022-05

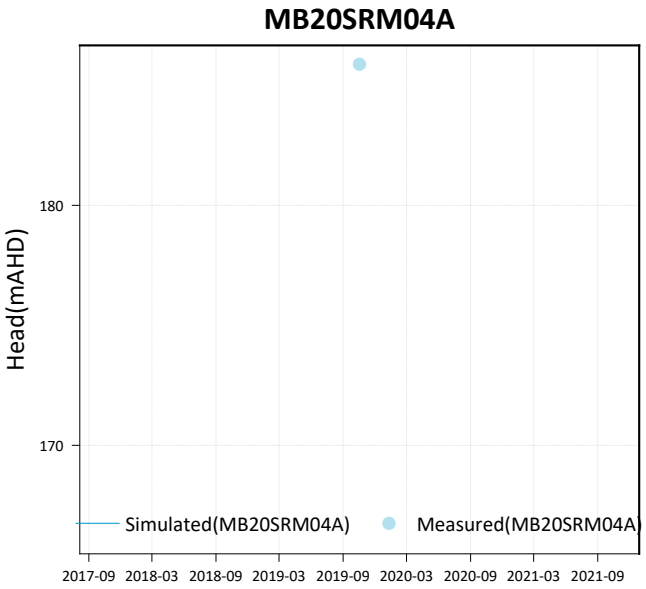

MB20PDM05P
Head(mAHD)
184
182
180
178
176
174
172
Simulated(MB20PDM05P)
Measured(MB20PDM05P)
2021-03 2021-05 2021-07 2021-09 2021-11 2022-01 2022-03 2022-05

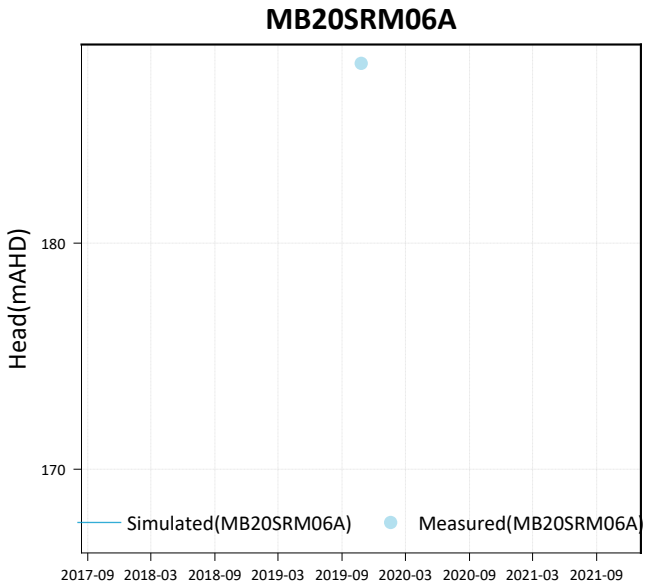

MB20PDM06T
Head(mAHD)
190
180
170
Simulated(MB20PDM06T)
Measured(MB20PDM06T)
2021-03 2021-05 2021-07 2021-09 2021-11 2022-01 2022-03 2022-05

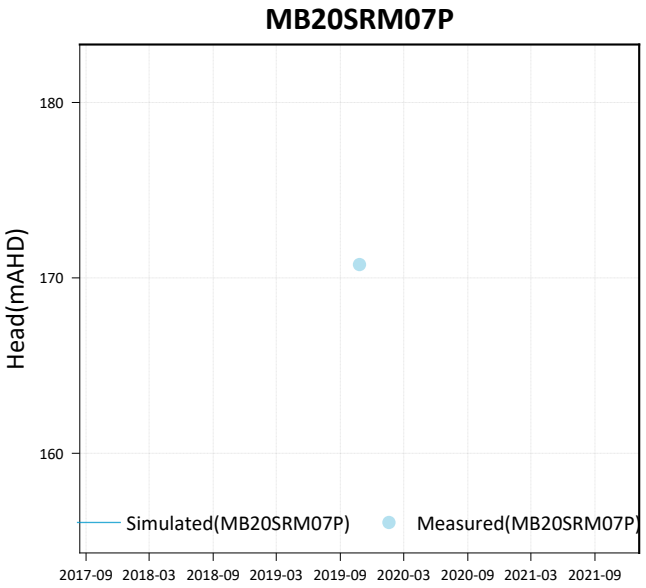

MB20PDM07T
Head(mAHD)
240
230
220
Simulated(MB20PDM07T)
Measured(MB20PDM07T)
2021-03 2021-05 2021-07 2021-09 2021-11 2022-01 2022-03 2022-05

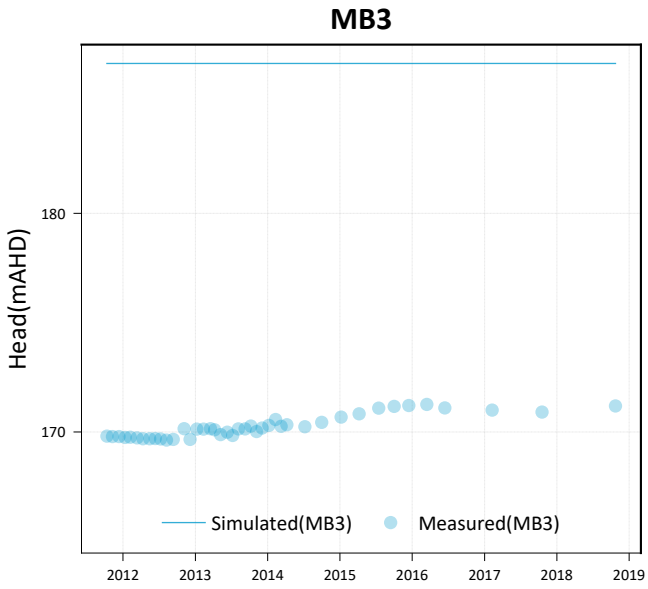

MB20SRM02T
Head(mAHD)
170
160
150
Simulated(MB20SRM02T)
Measured(MB20SRM02T)
2017-09 2018-03 2018-09 2019-03 2019-09 2020-03 2020-09 2021-03 2021-09

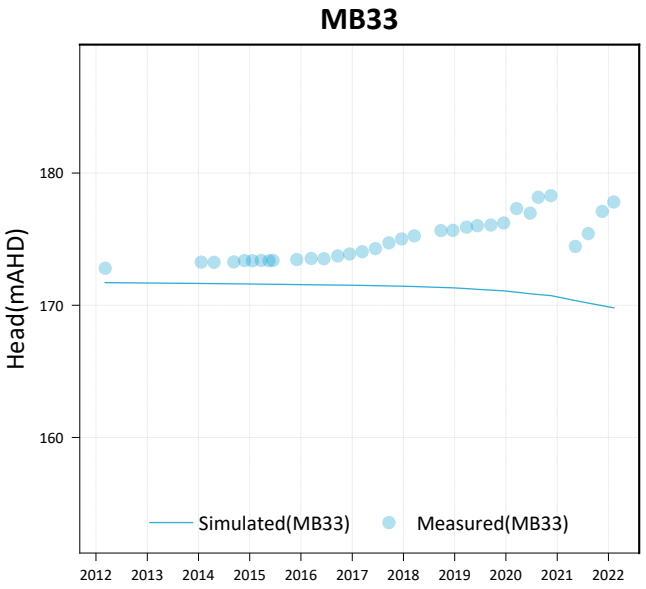

MB20SRM03P
Head(mAHD)
160
150
140
130
Simulated(MB20SRM03P)
Measured(MB20SRM03P)
2017-09 2018-03 2018-09 2019-03 2019-09 2020-03 2020-09 2021-03 2021-09

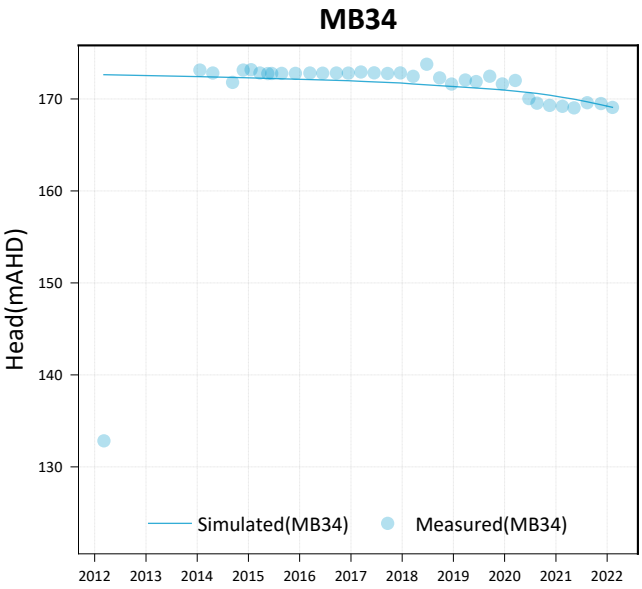

MB20SRM04A
Head(mAHD)
180
170
Simulated(MB20SRM04A)
Measured(MB20SRM04A)
2017-09 2018-03 2018-09 2019-03 2019-09 2020-03 2020-09 2021-03 2021-09

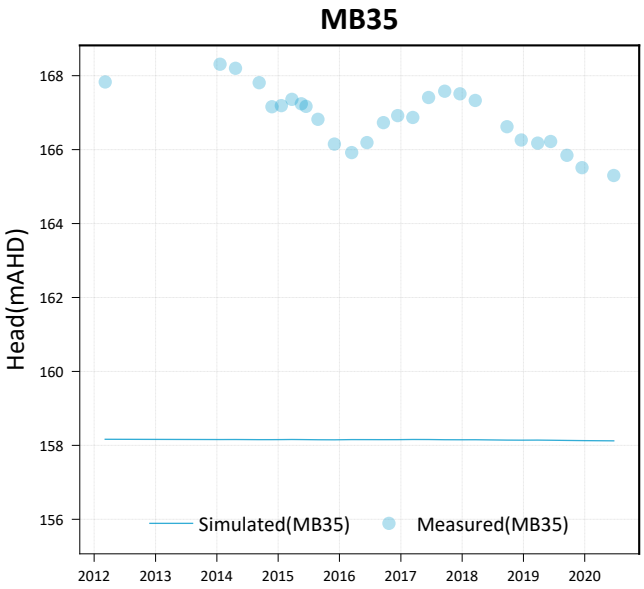

MB20SRM06A
Head(mAHD)
180
170
Simulated(MB20SRM06A)
Measured(MB20SRM06A)
2017-09 2018-03 2018-09 2019-03 2019-09 2020-03 2020-09 2021-03 2021-09

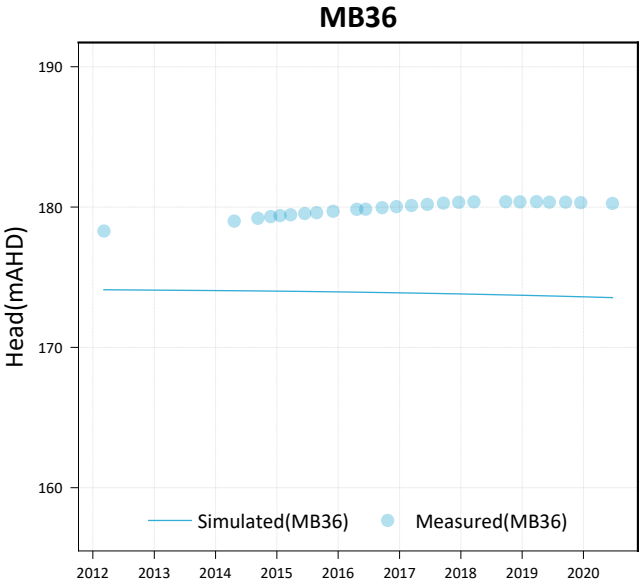

MB20SRM07P
Head(mAHD)
180
170
160
Simulated(MB20SRM07P)
Measured(MB20SRM07P)
2017-09 2018-03 2018-09 2019-03 2019-09 2020-03 2020-09 2021-03 2021-09

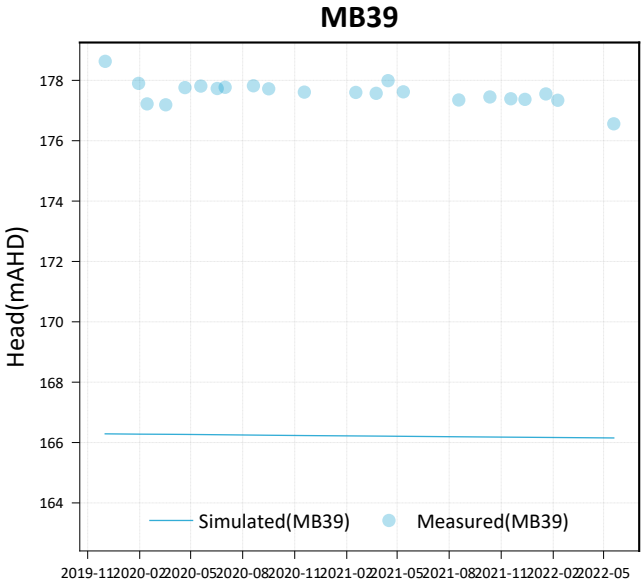

MB3
Head(mAHD)
180
170
Simulated(MB3)
Measured(MB3)
2012 2013 2014 2015 2016 2017 2018 2019

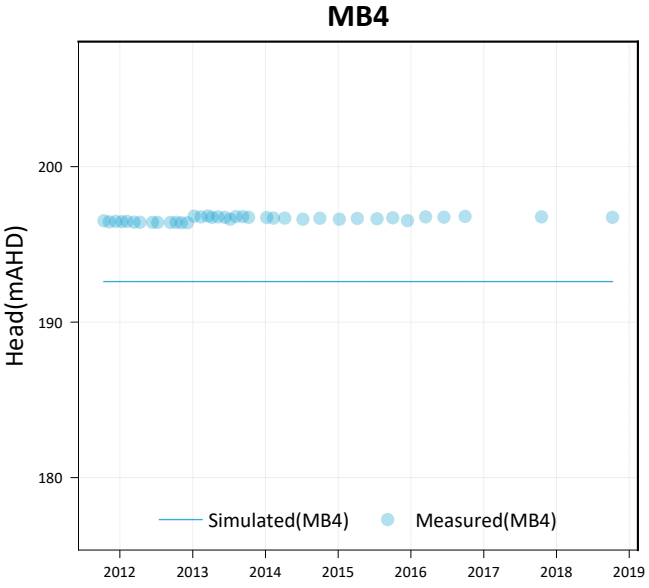

MB33
Head(mAHD)
180
170
160
Simulated(MB33)
Measured(MB33)
2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022

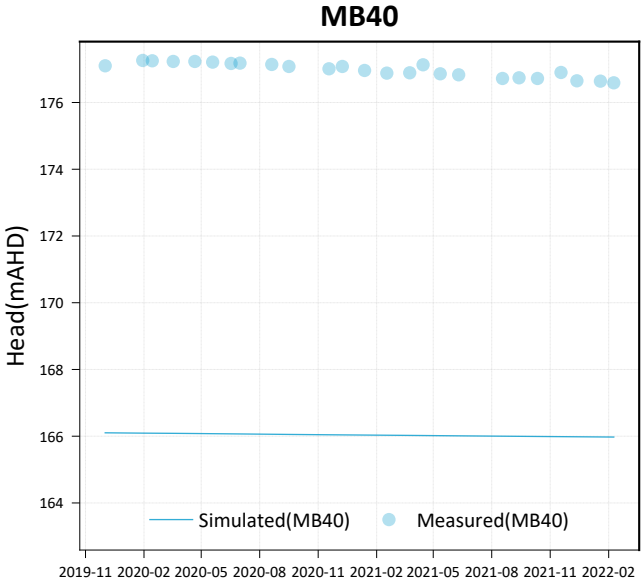

MB34
Head(mAHD)
Simulated(MB34)
Measured(MB34)

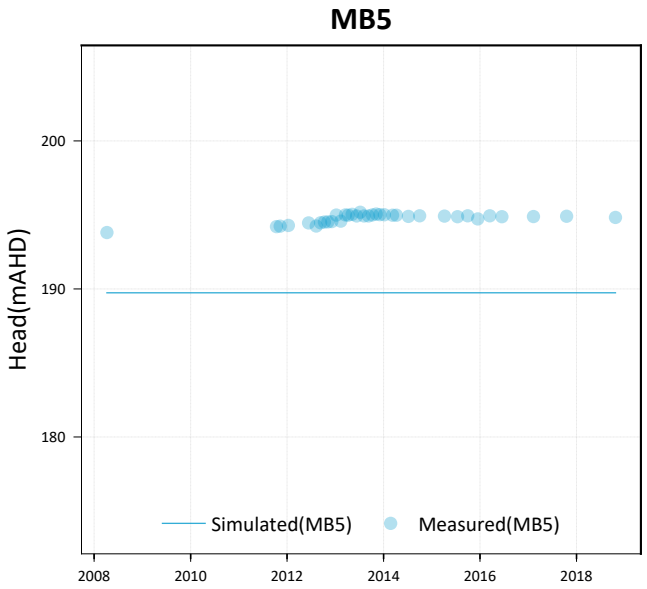

MB35
Head(mAHD)
Simulated(MB35)
Measured(MB35)

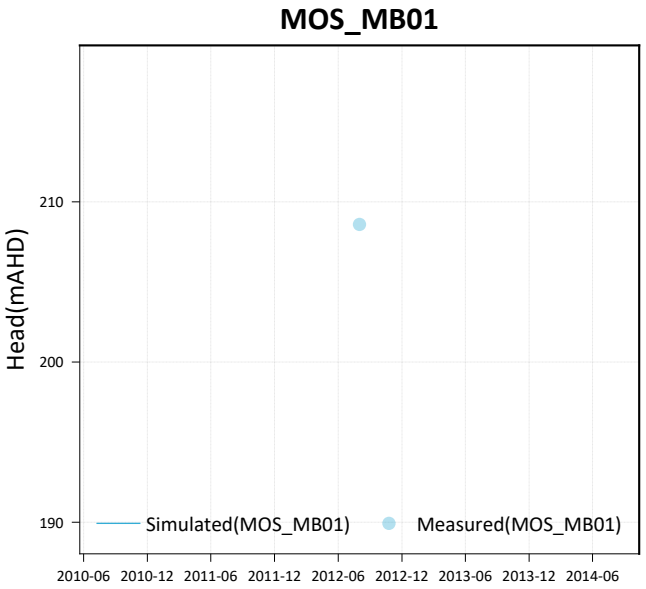

MB36
Head(mAHD)
Simulated(MB36)
Measured(MB36)

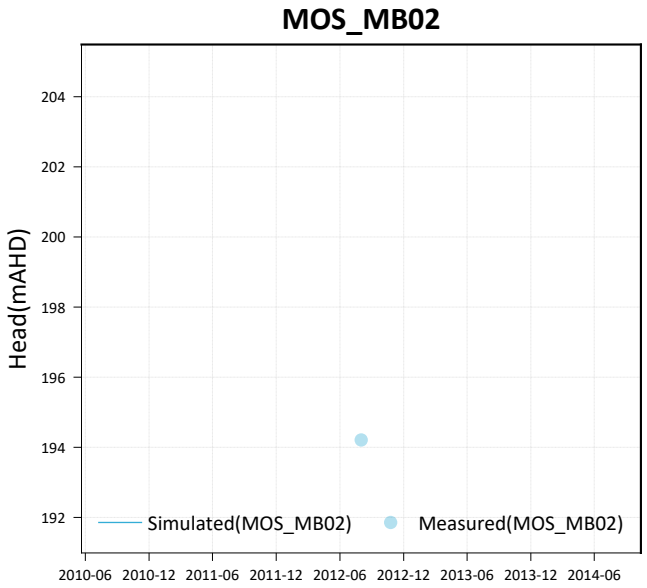

MB39
Head(mAHD)
Simulated(MB39)
Measured(MB39)

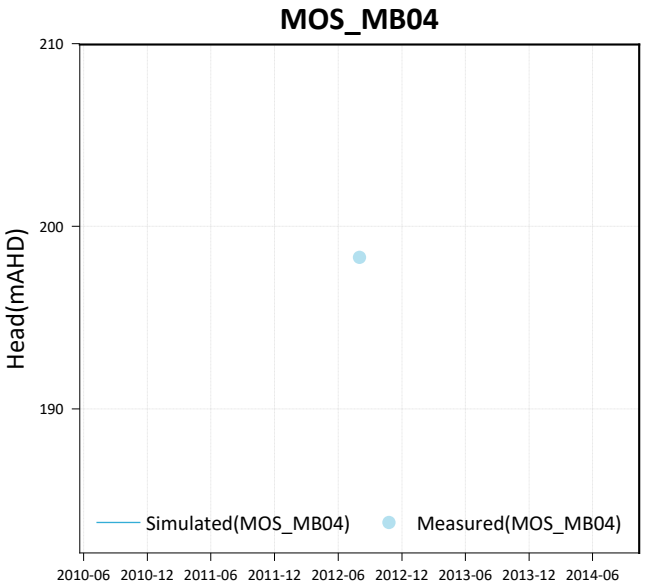

MB4
Head(mAHD)
Simulated(MB4)
Measured(MB4)

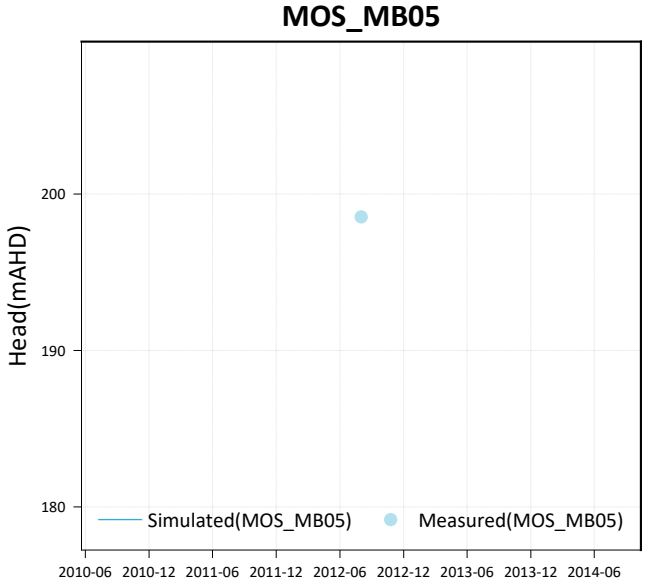

MB40
Head(mAHD)
Simulated(MB40)
Measured(MB40)

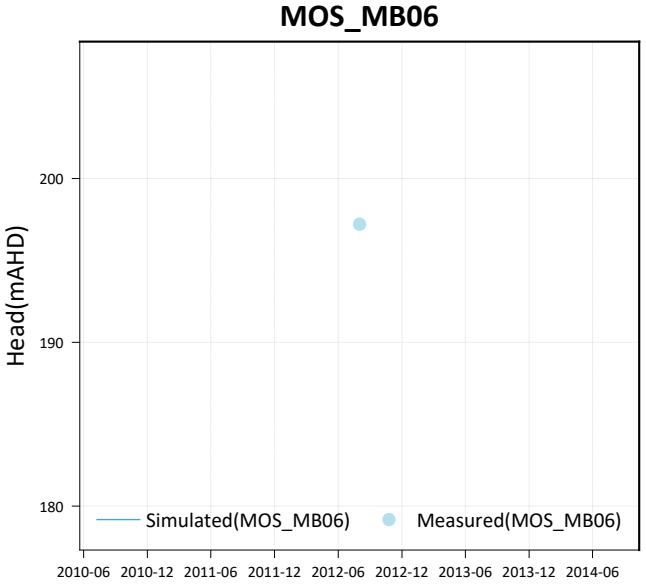

MB5
Head(mAHD)
200
190
180
Simulated(MB5)
Measured(MB5)
2008
2010
2012
2014
2016
2018

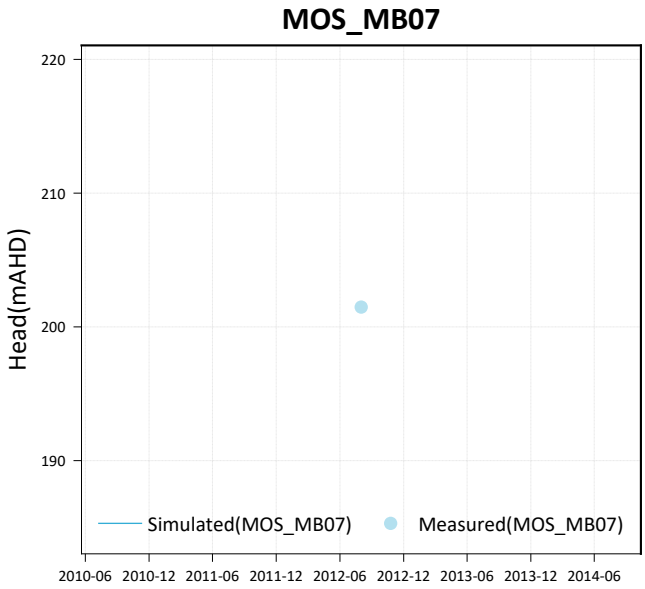

MOS_MB01
Head(mAHD)
210
200
190
Simulated(MOS_MB01)
Measured(MOS_MB01)
2010-06
2010-12
2011-06
2011-12
2012-06
2012-12
2013-06
2013-12
2014-06

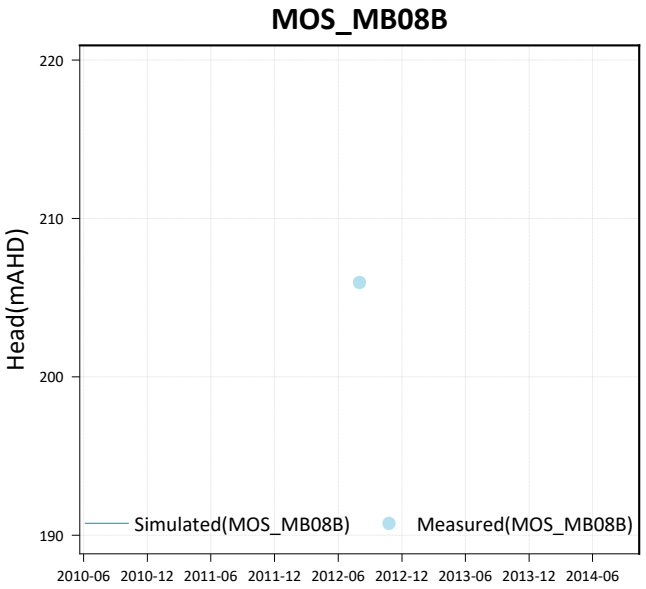

MOS_MB02
Head(mAHD)
204
202
200
198
196
194
192
Simulated(MOS_MB02)
Measured(MOS_MB02)
2010-06
2010-12
2011-06
2011-12
2012-06
2012-12
2013-06
2013-12
2014-06

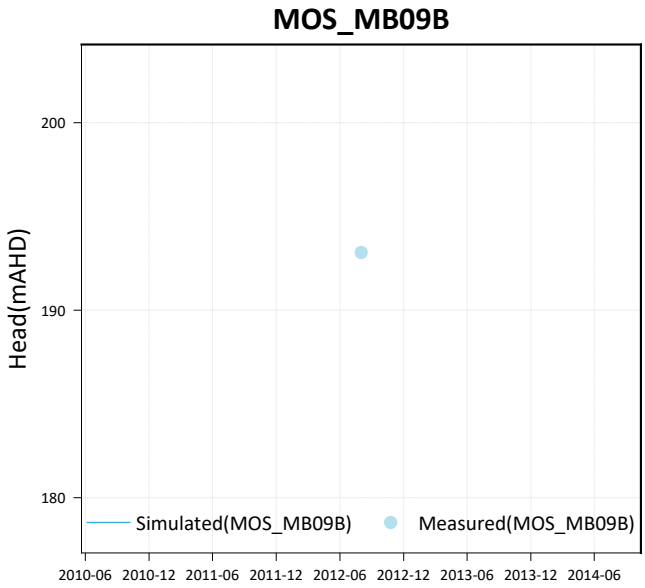

MOS_MB04
Head(mAHD)
210
200
190
Simulated(MOS_MB04)
Measured(MOS_MB04)
2010-06
2010-12
2011-06
2011-12
2012-06
2012-12
2013-06
2013-12
2014-06

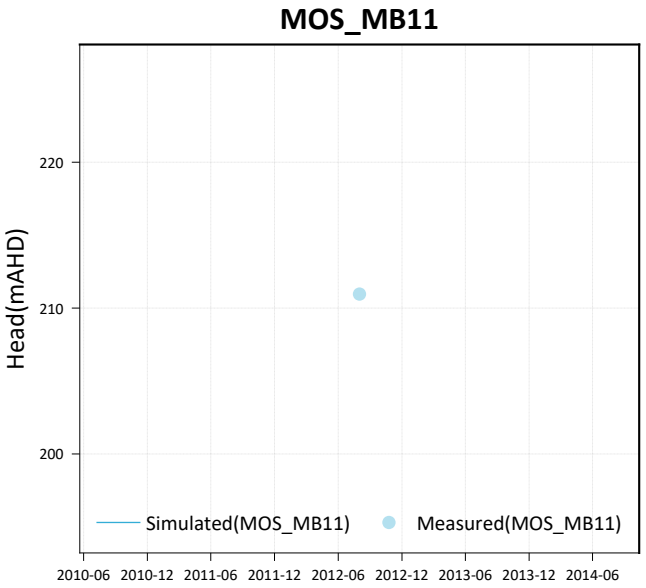

MOS_MB05
Head(mAHD)
200
190
180
Simulated(MOS_MB05)
Measured(MOS_MB05)
2010-06
2010-12
2011-06
2011-12
2012-06
2012-12
2013-06
2013-12
2014-06

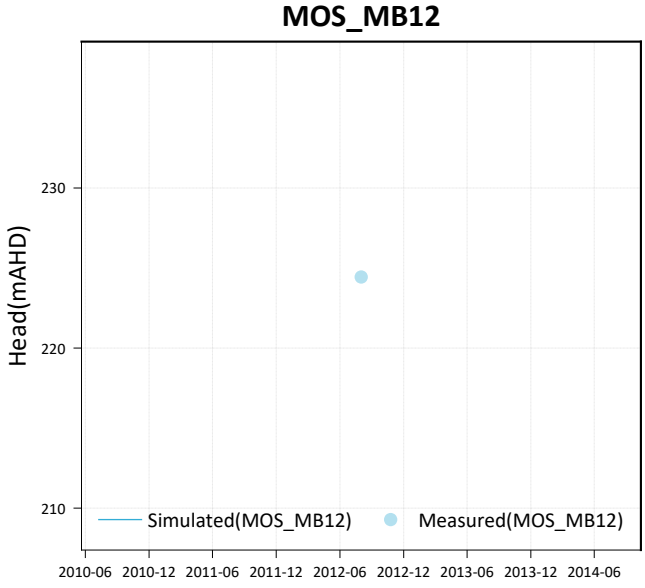

MOS_MB06
Head(mAHD)
200
190
180
Simulated(MOS_MB06)
Measured(MOS_MB06)
2010-06
2010-12
2011-06
2011-12
2012-06
2012-12
2013-06
2013-12
2014-06

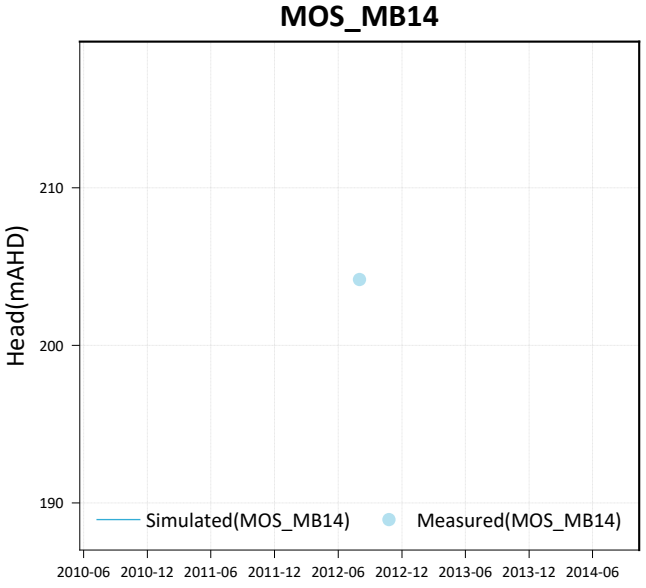

MOS_MB07
Head(mAHD)
220
210
200
190
Simulated(MOS_MB07)
Measured(MOS_MB07)
2010-06 2010-12 2011-06 2011-12 2012-06 2012-12 2013-06 2013-12 2014-06


MOS_MB08B
Head(mAHD)
220
210
200
190
Simulated(MOS_MB08B)
Measured(MOS_MB08B)
2010-06 2010-12 2011-06 2011-12 2012-06 2012-12 2013-06 2013-12 2014-06

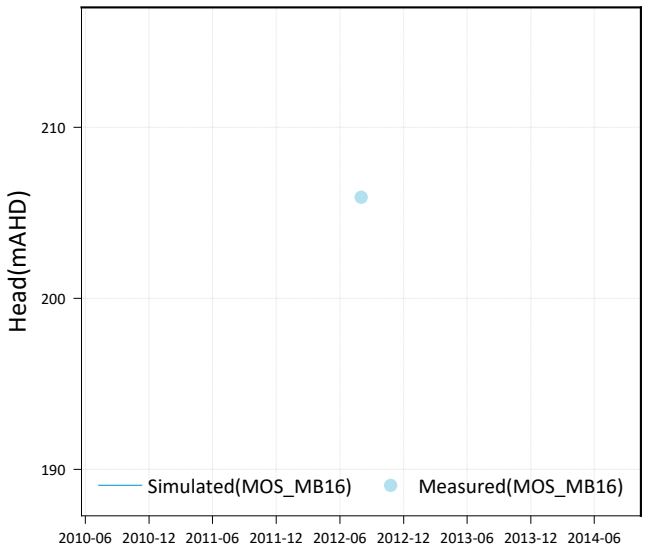

MOS_MB09B
Head(mAHD)
200
190
180
Simulated(MOS_MB09B)
Measured(MOS_MB09B)
2010-06 2010-12 2011-06 2011-12 2012-06 2012-12 2013-06 2013-12 2014-06


MOS_MB11
Head(mAHD)
220
210
200
Simulated(MOS_MB11)
Measured(MOS_MB11)
2010-06 2010-12 2011-06 2011-12 2012-06 2012-12 2013-06 2013-12 2014-06

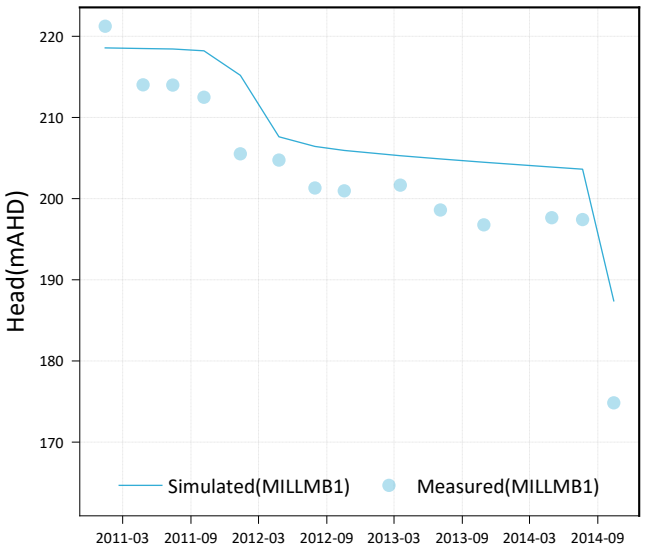

MOS_MB12
Head(mAHD)
230
220
210
Simulated(MOS_MB12)
Measured(MOS_MB12)
2010-06 2010-12 2011-06 2011-12 2012-06 2012-12 2013-06 2013-12 2014-06


MOS_MB14
Head(mAHD)
210
200
190
Simulated(MOS_MB14)
Measured(MOS_MB14)
2010-06 2010-12 2011-06 2011-12 2012-06 2012-12 2013-06 2013-12 2014-06

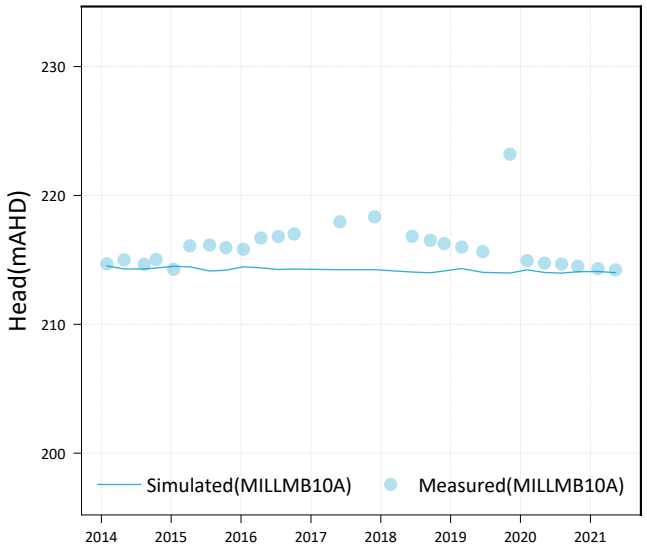
## MOS_MB16



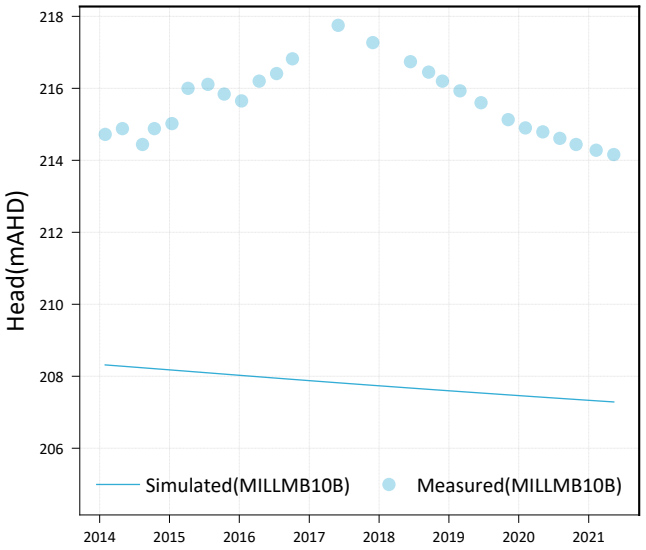

## MILLMB1



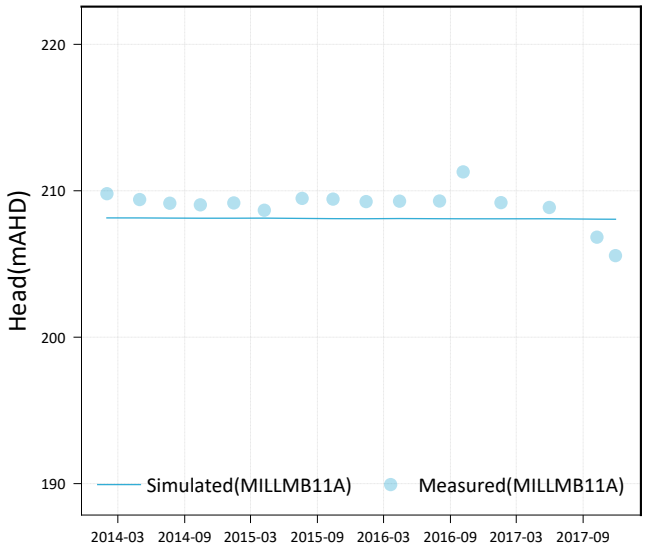

## MILLMB10A



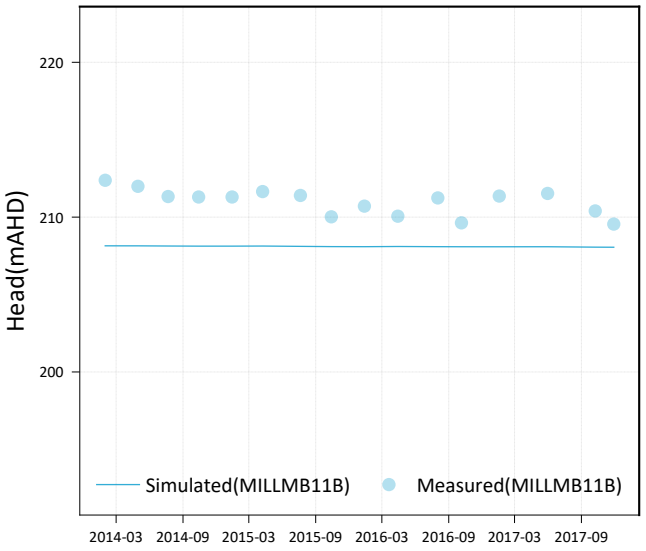

## MILLMB10B

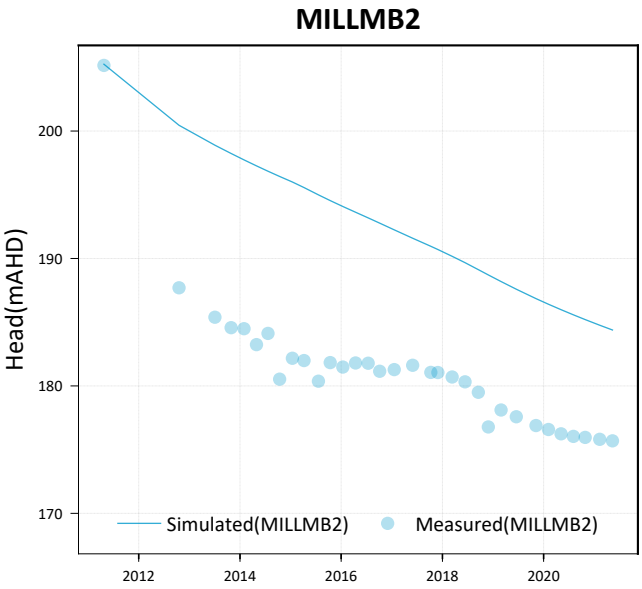


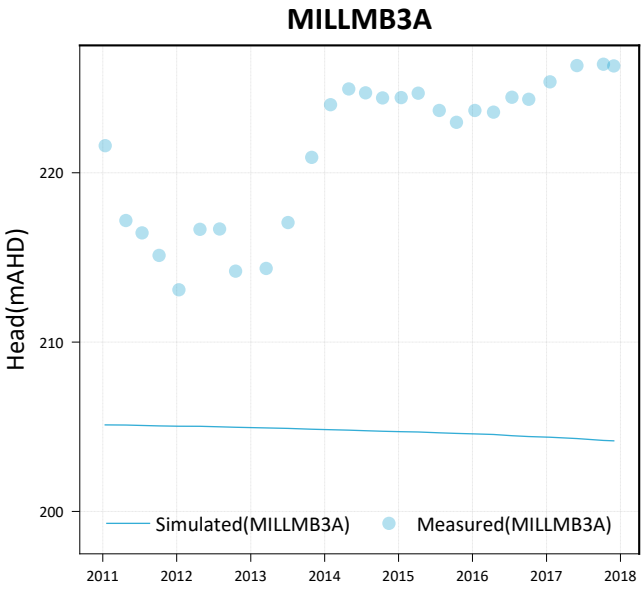

## MILLMB11A

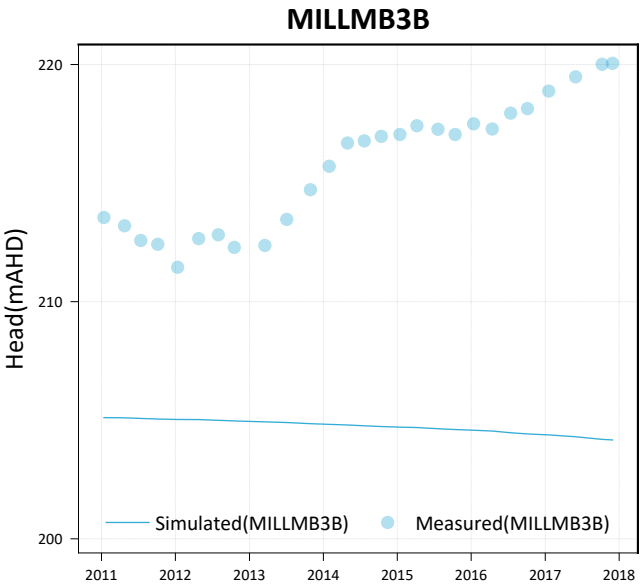


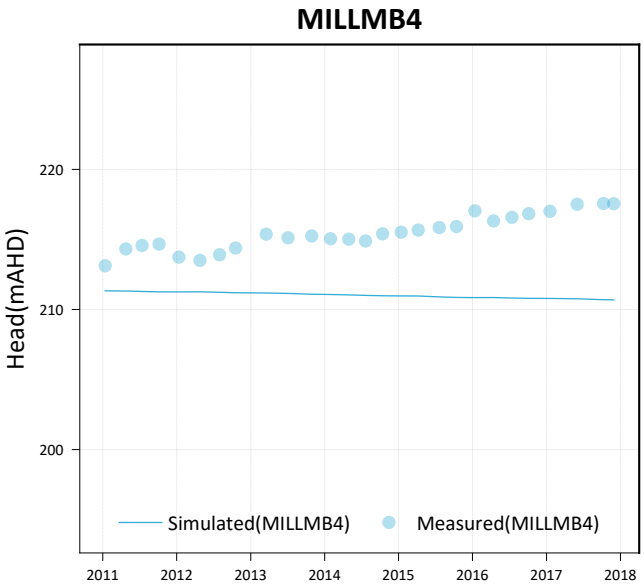

## MILLMB11B

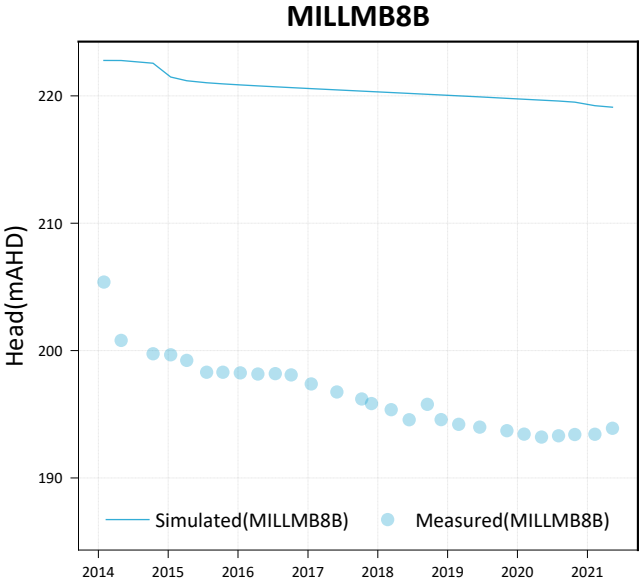


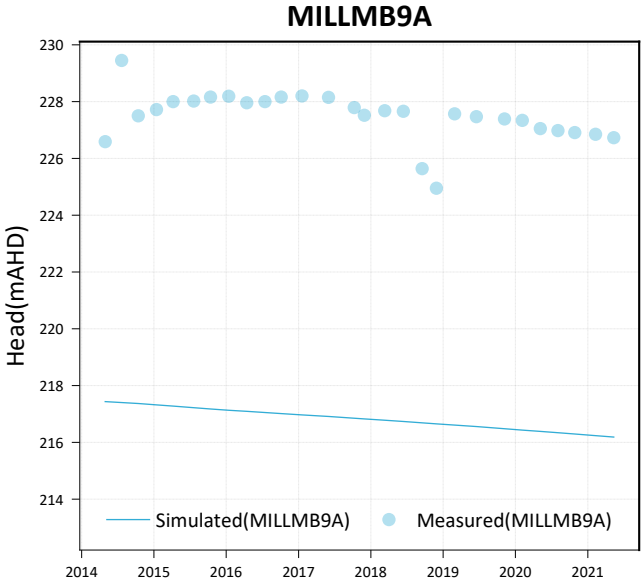

MILLMB2
Head(mAHD)
200
190
180
170
2012
2014
2016
2018
2020
Simulated(MILLMB2)
Measured(MILLMB2)

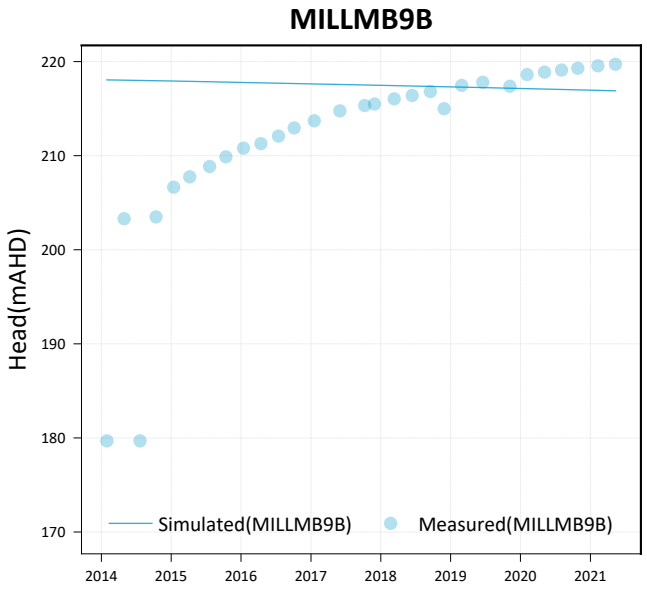

MILLMB3A
Head(mAHD)
220
210
200
2011
2012
2013
2014
2015
2016
2017
2018
Simulated(MILLMB3A)
Measured(MILLMB3A)

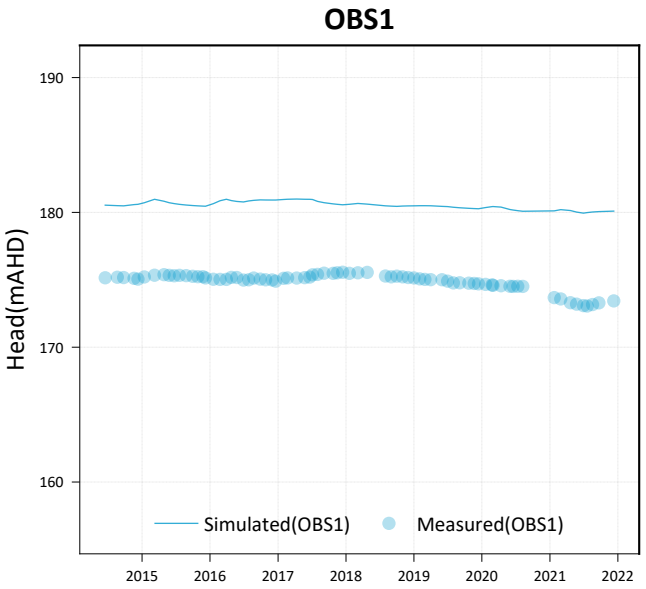

MILLMB3B
Head(mAHD)
220
210
200
2011
2012
2013
2014
2015
2016
2017
2018
Simulated(MILLMB3B)
Measured(MILLMB3B)

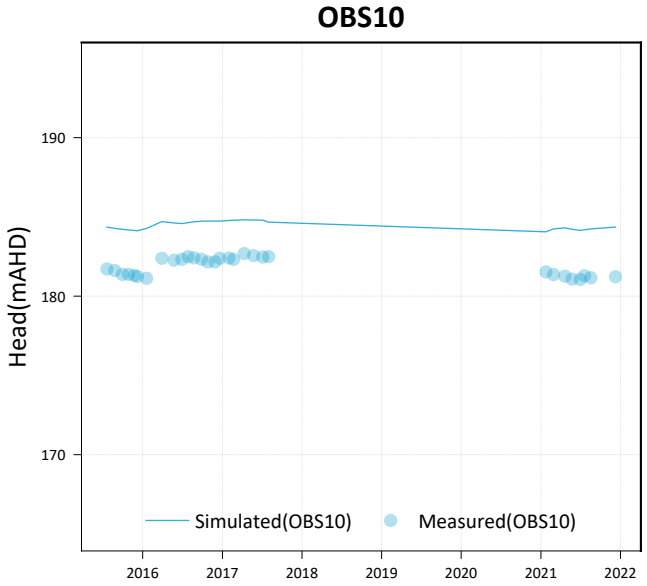

MILLMB4
Head(mAHD)
220
210
200
2011
2012
2013
2014
2015
2016
2017
2018
Simulated(MILLMB4)
Measured(MILLMB4)

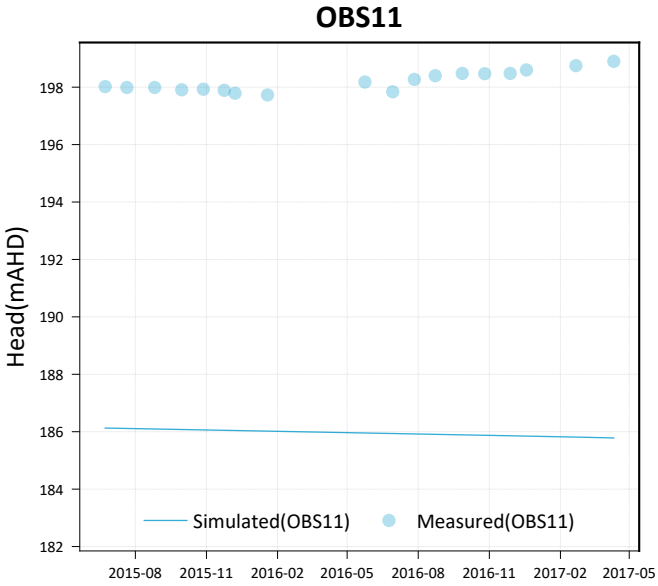

MILLMB8B
Head(mAHD)
220
210
200
190
2014
2015
2016
2017
2018
2019
2020
2021
Simulated(MILLMB8B)
Measured(MILLMB8B)

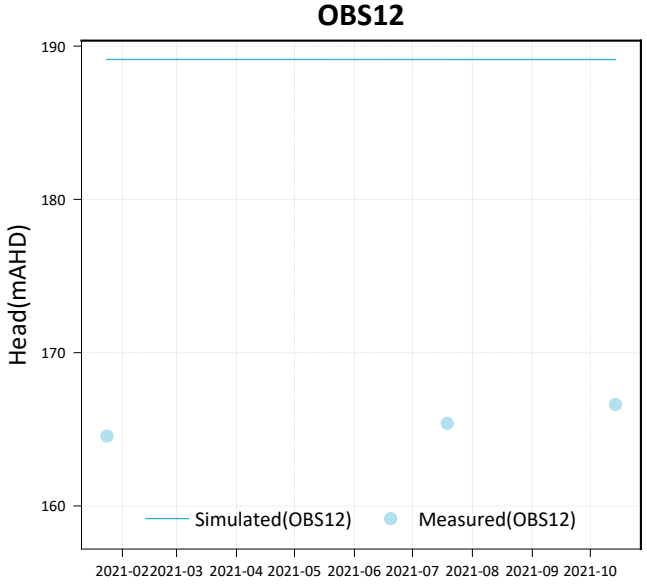

MILLMB9A
Head(mAHD)
230
228
226
224
222
220
218
216
214
2014
2015
2016
2017
2018
2019
2020
2021
Simulated(MILLMB9A)
Measured(MILLMB9A)

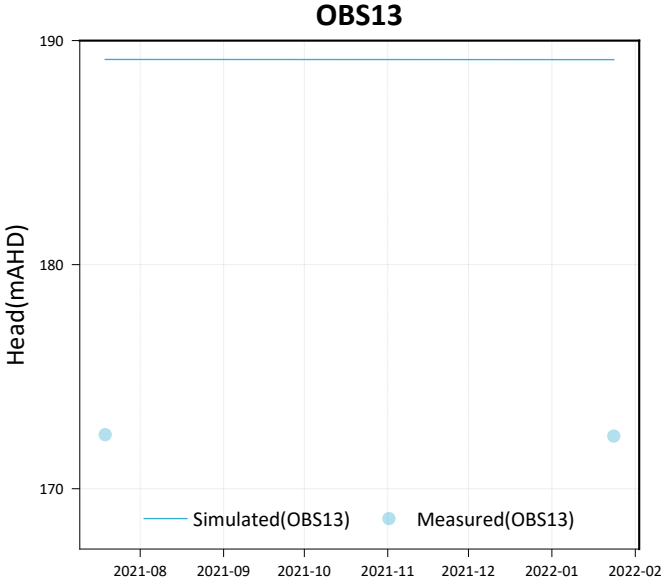

MILLMB9B
Head(mAHD)
220
210
200
190
180
170
2014
2015
2016
2017
2018
2019
2020
2021
Simulated(MILLMB9B)
Measured(MILLMB9B)

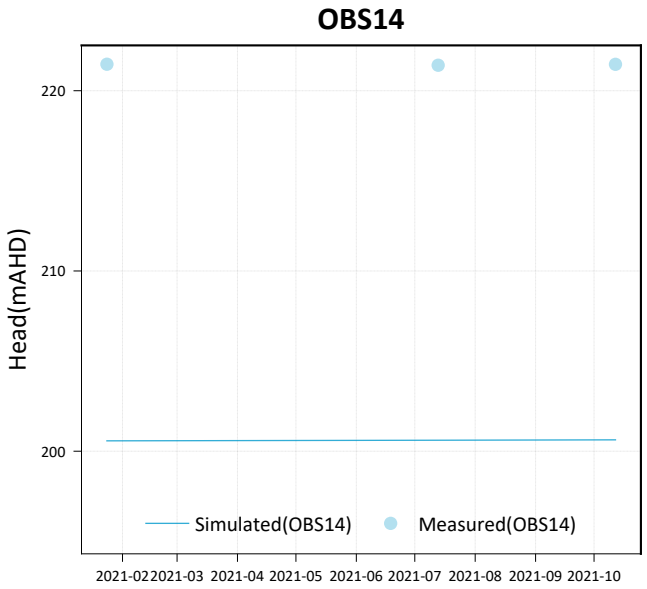

OBS1
Head(mAHD)
190
180
170
160
2015
2016
2017
2018
2019
2020
2021
2022
Simulated(OBS1)
Measured(OBS1)

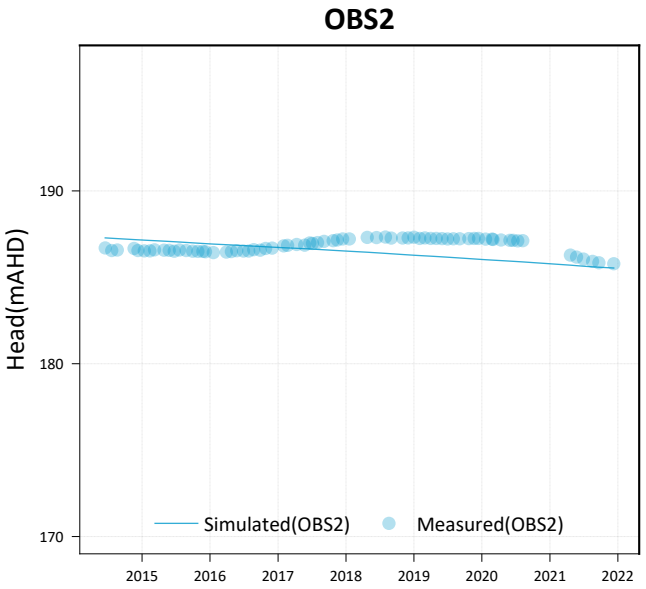

OBS10
Head(mAHD)
190
180
170
2016
2017
2018
2019
2020
2021
2022
Simulated(OBS10)
Measured(OBS10)

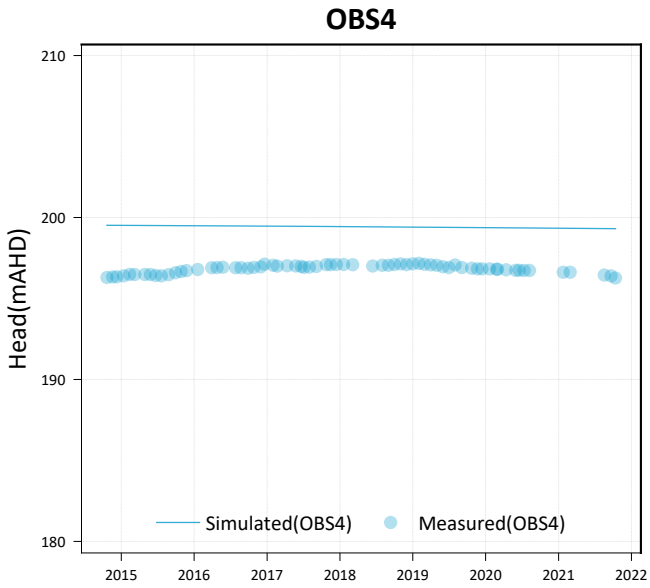

OBS11
Head(mAHD)
198
196
194
192
190
188
186
184
182
2015-08
2015-11
2016-02
2016-05
2016-08
2016-11
2017-02
2017-05
Simulated(OBS11)
Measured(OBS11)

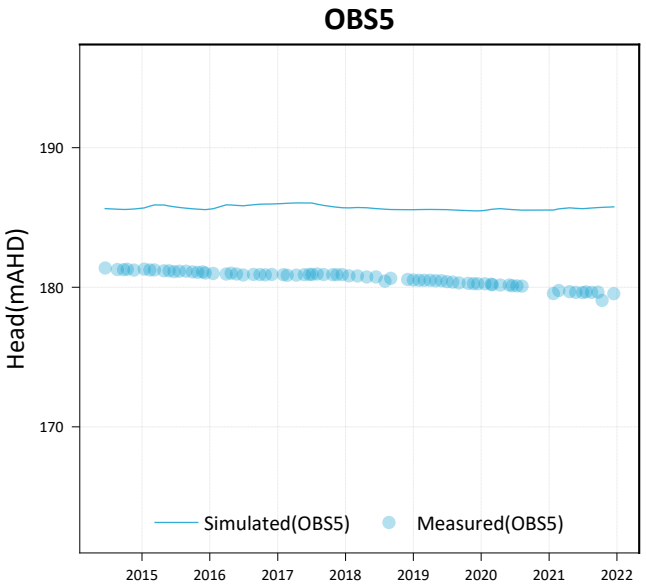

OBS12
Head(mAHD)
190
180
170
160
2021-02
2021-03
2021-04
2021-05
2021-06
2021-07
2021-08
2021-09
2021-10
Simulated(OBS12)
Measured(OBS12)

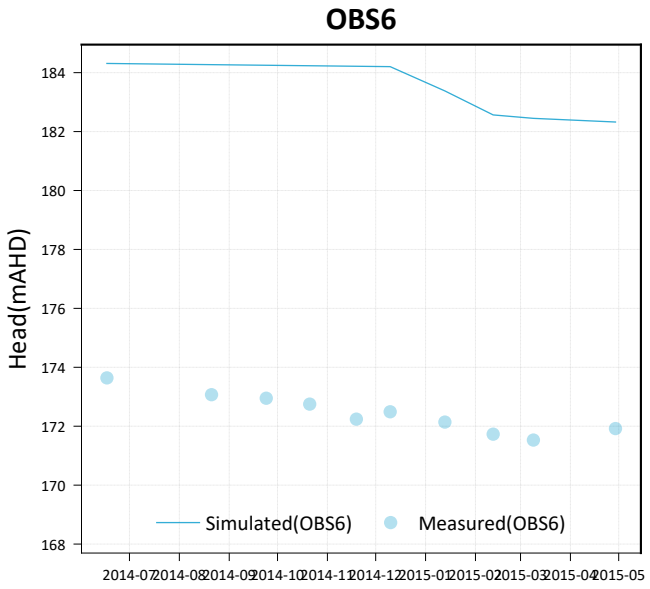

OBS13
Head(mAHD)
190
180
170
2021-08
2021-09
2021-10
2021-11
2021-12
2022-01
2022-02
Simulated(OBS13)
Measured(OBS13)

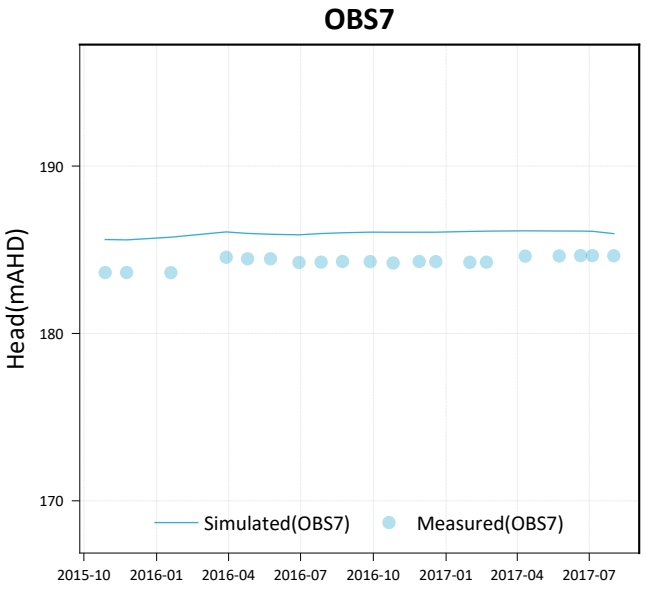

OBS14
Head(mAHD)
220
210
200
Simulated(OBS14)
Measured(OBS14)
2021-02 2021-03 2021-04 2021-05 2021-06 2021-07 2021-08 2021-09 2021-10

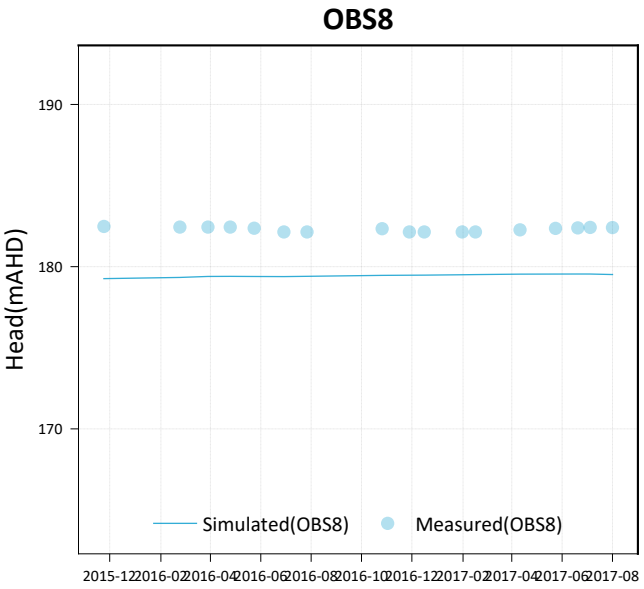

OBS2
Head(mAHD)
190
180
170
Simulated(OBS2)
Measured(OBS2)
2015 2016 2017 2018 2019 2020 2021 2022

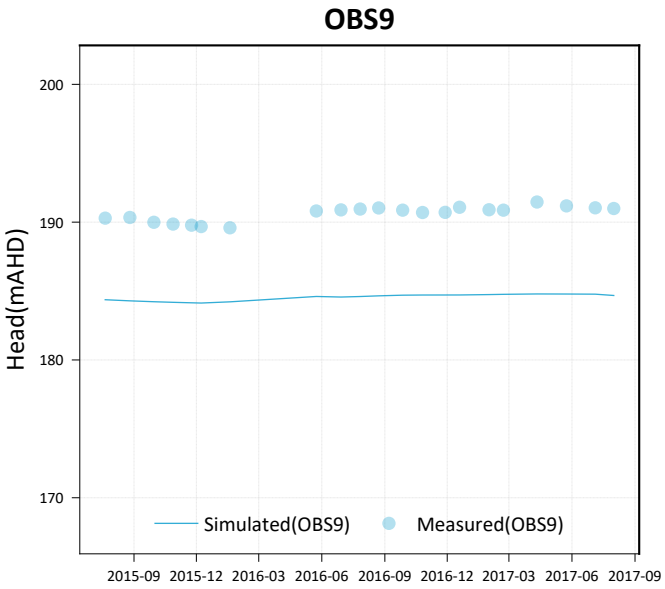

OBS4
Head(mAHD)
210
200
190
180
Simulated(OBS4)
Measured(OBS4)
2015 2016 2017 2018 2019 2020 2021 2022

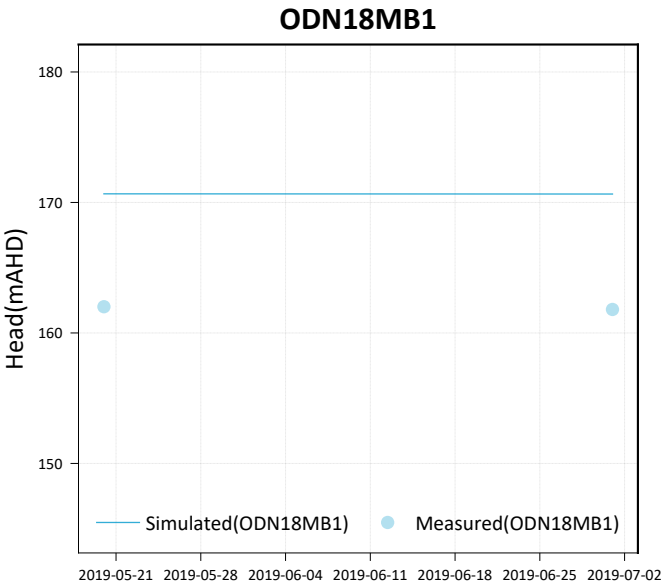

OBS5
Head(mAHD)
190
180
170
Simulated(OBS5)
Measured(OBS5)
2015 2016 2017 2018 2019 2020 2021 2022

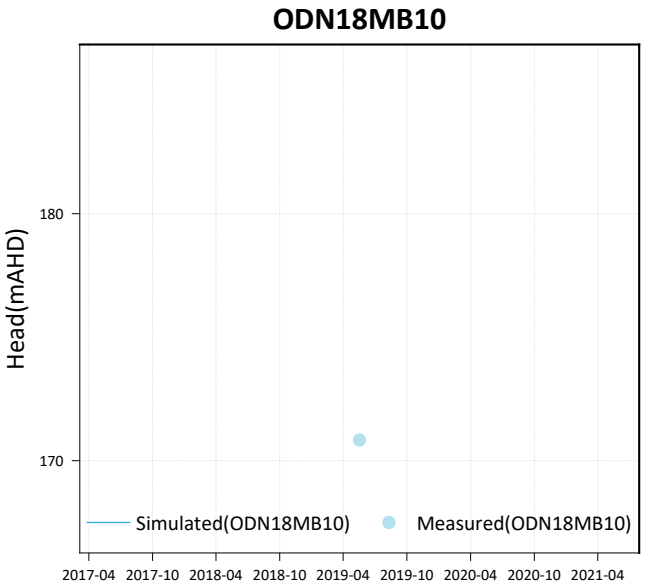

OBS6
Head(mAHD)
184
182
180
178
176
174
172
170
168
Simulated(OBS6)
Measured(OBS6)
2014-07 2014-08 2014-09 2014-10 2014-11 2014-12 2015-01 2015-02 2015-03 2015-04 2015-05

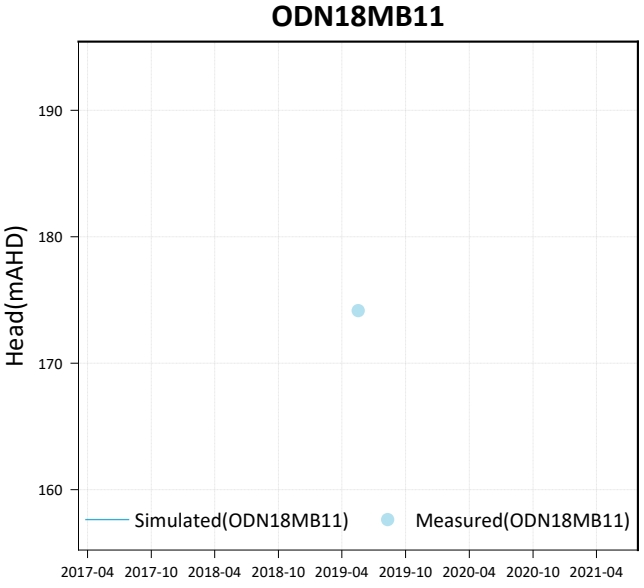

OBS7
Head(mAHD)
190
180
170
Simulated(OBS7)
Measured(OBS7)
2015-10 2016-01 2016-04 2016-07 2016-10 2017-01 2017-04 2017-07

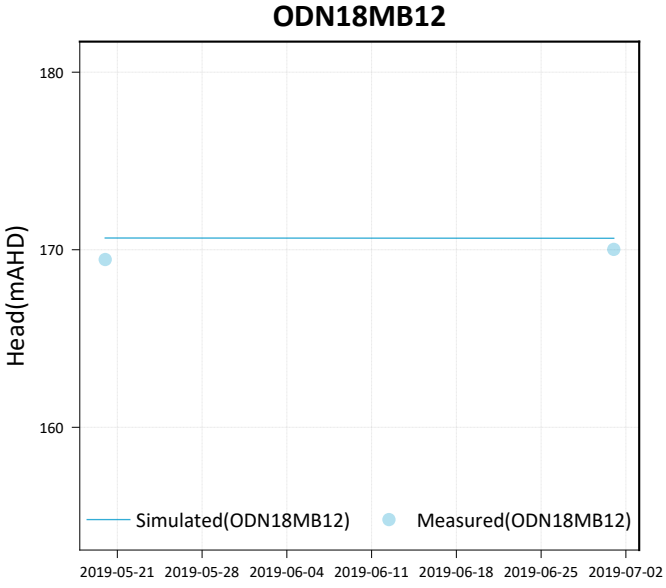

OBS8
Head(mAHD)
190
180
170
Simulated(OBS8)
Measured(OBS8)
2015-12
2016-02
2016-04
2016-06
2016-08
2016-10
2016-12
2017-02
2017-04
2017-06
2017-08

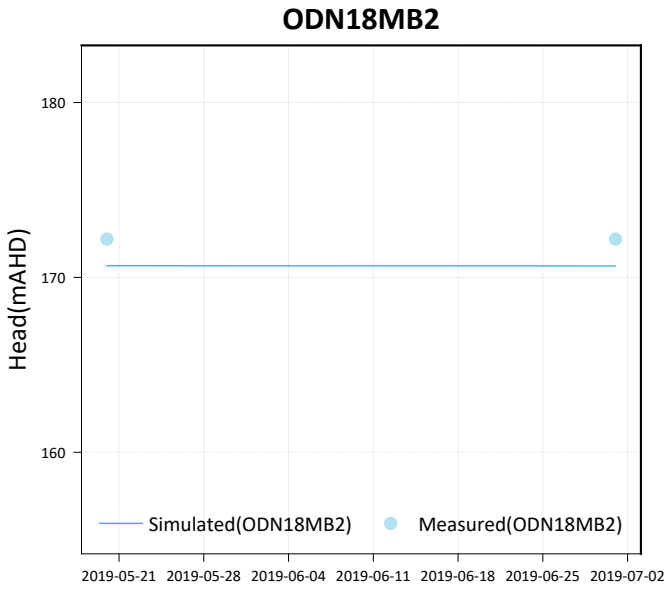

OBS9
Head(mAHD)
200
190
180
170
Simulated(OBS9)
Measured(OBS9)
2015-09
2015-12
2016-03
2016-06
2016-09
2016-12
2017-03
2017-06
2017-09

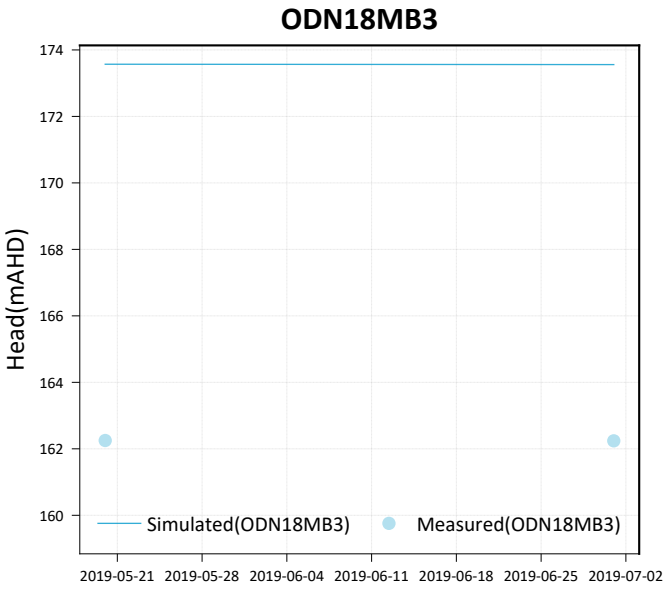

ODN18MB1
Head(mAHD)
180
170
160
150
Simulated(ODN18MB1)
Measured(ODN18MB1)
2019-05-21
2019-05-28
2019-06-04
2019-06-11
2019-06-18
2019-06-25
2019-07-02

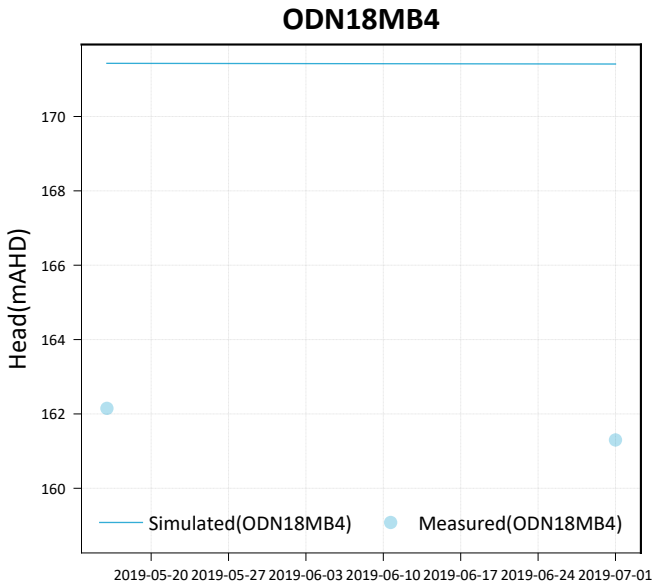

ODN18MB10
Head(mAHD)
180
170
Simulated(ODN18MB10)
Measured(ODN18MB10)
2017-04
2017-10
2018-04
2018-10
2019-04
2019-10
2020-04
2020-10
2021-04

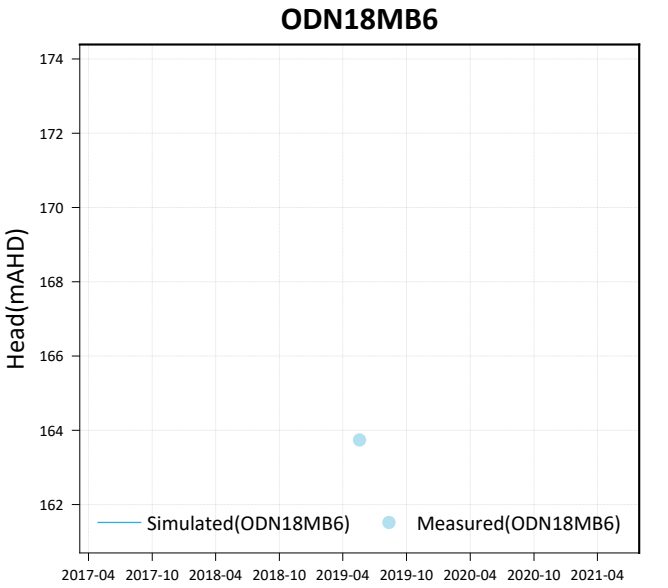

ODN18MB11
Head(mAHD)
190
180
170
160
Simulated(ODN18MB11)
Measured(ODN18MB11)
2017-04
2017-10
2018-04
2018-10
2019-04
2019-10
2020-04
2020-10
2021-04

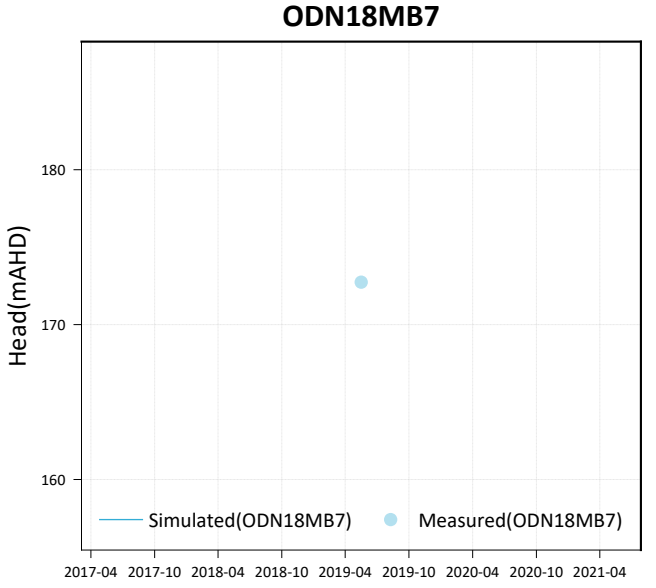

ODN18MB12
Head(mAHD)
180
170
160
Simulated(ODN18MB12)
Measured(ODN18MB12)
2019-05-21
2019-05-28
2019-06-04
2019-06-11
2019-06-18
2019-06-25
2019-07-02

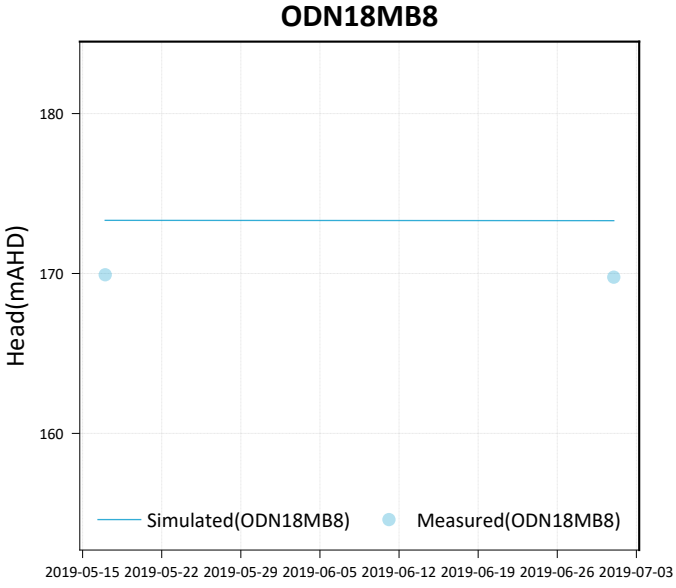

ODN18MB2
Head(mAHD)
180
170
160
Simulated(ODN18MB2)
Measured(ODN18MB2)
2019-05-21 2019-05-28 2019-06-04 2019-06-11 2019-06-18 2019-06-25 2019-07-02

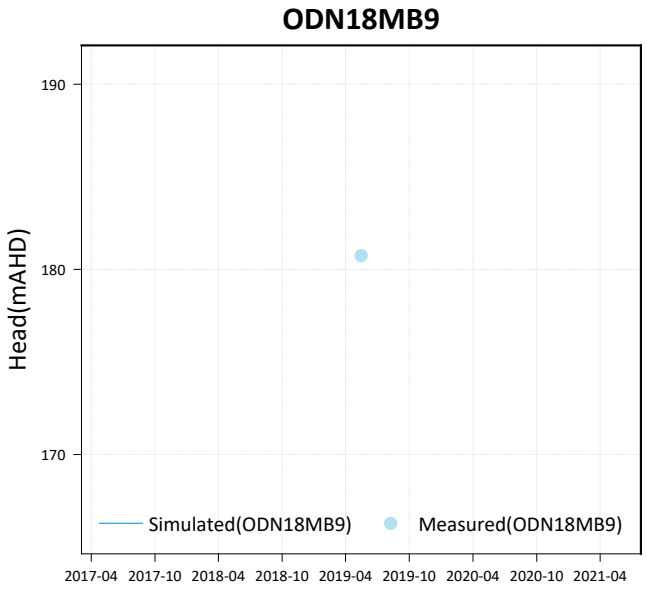

ODN18MB3
Head(mAHD)
174
172
170
168
166
164
162
160
Simulated(ODN18MB3)
Measured(ODN18MB3)
2019-05-21 2019-05-28 2019-06-04 2019-06-11 2019-06-18 2019-06-25 2019-07-02

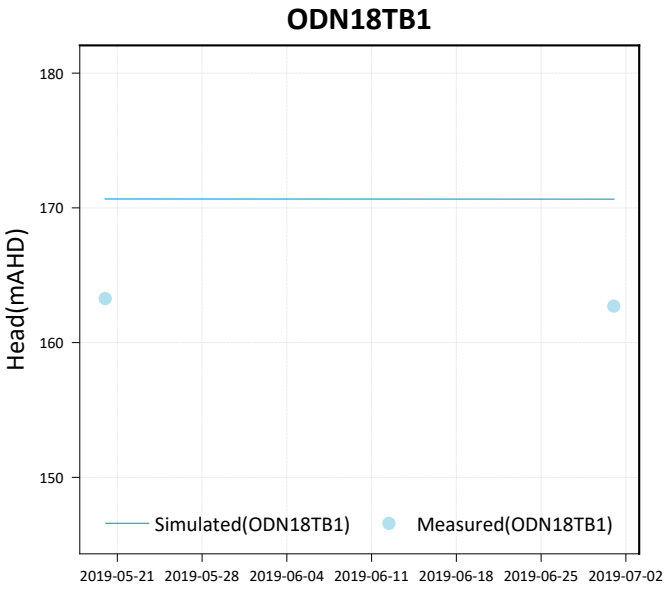

ODN18MB4
Head(mAHD)
170
168
166
164
162
160
Simulated(ODN18MB4)
Measured(ODN18MB4)
2019-05-20 2019-05-27 2019-06-03 2019-06-10 2019-06-17 2019-06-24 2019-07-01

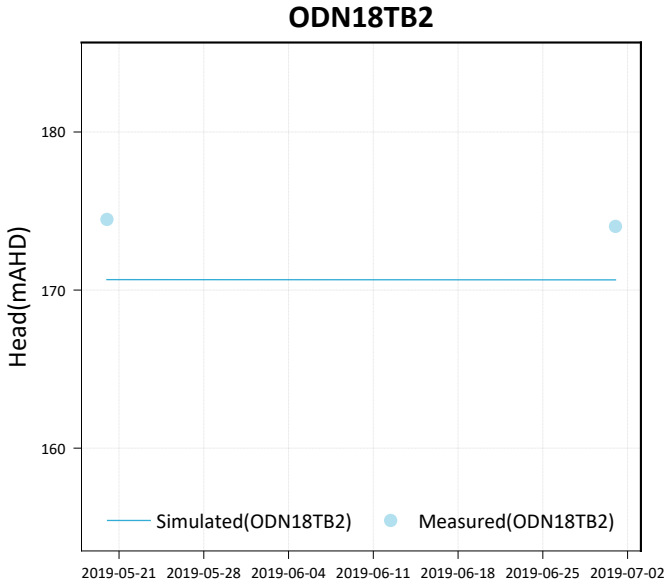

ODN18MB6
Head(mAHD)
174
172
170
168
166
164
162
Simulated(ODN18MB6)
Measured(ODN18MB6)
2017-04 2017-10 2018-04 2018-10 2019-04 2019-10 2020-04 2020-10 2021-04

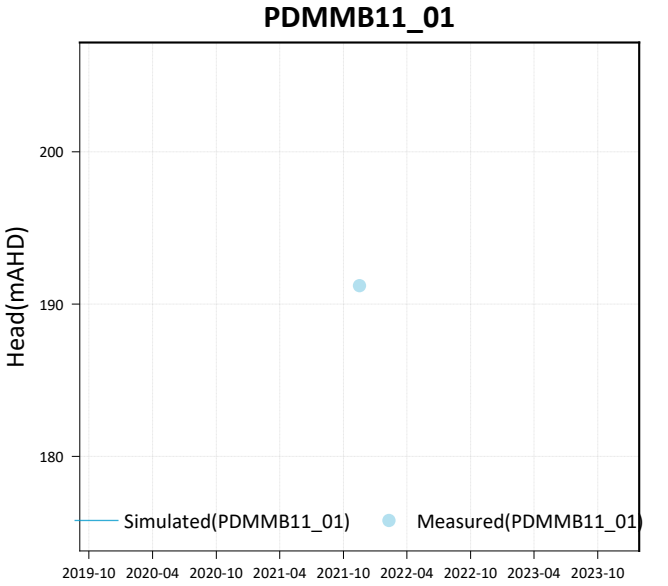

ODN18MB7
Head(mAHD)
180
170
160
Simulated(ODN18MB7)
Measured(ODN18MB7)
2017-04 2017-10 2018-04 2018-10 2019-04 2019-10 2020-04 2020-10 2021-04

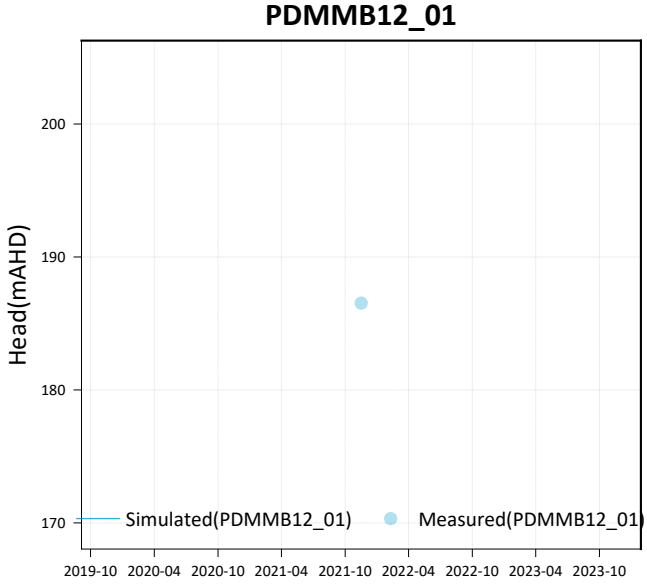

ODN18MB8
Head(mAHD)
180
170
160
Simulated(ODN18MB8)
Measured(ODN18MB8)
2019-05-15 2019-05-22 2019-05-29 2019-06-05 2019-06-12 2019-06-19 2019-06-26 2019-07-03

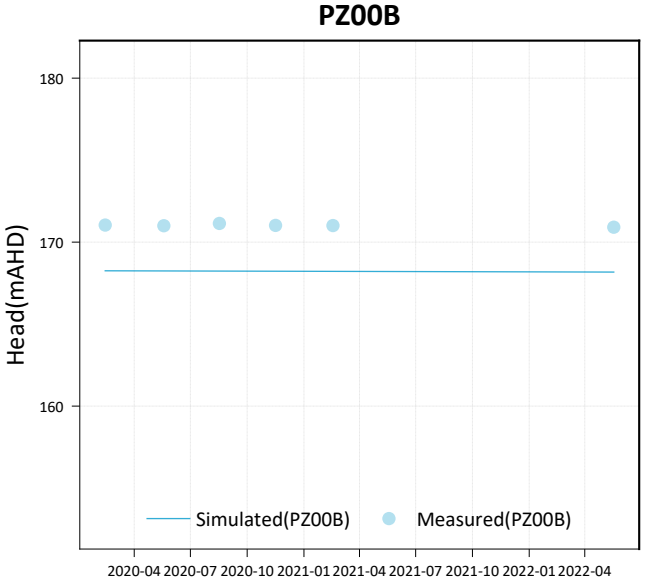

ODN18MB9
Head(mAHD)
190
180
170
Simulated(ODN18MB9)
Measured(ODN18MB9)
2017-04
2017-10
2018-04
2018-10
2019-04
2019-10
2020-04
2020-10
2021-04

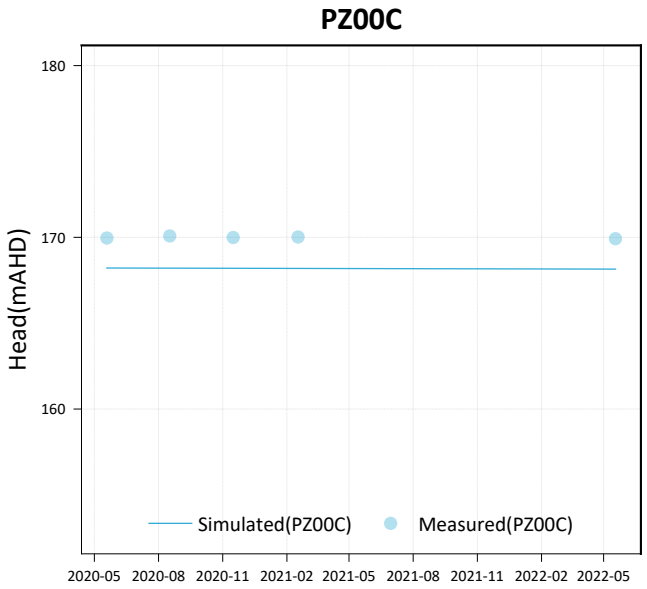

ODN18TB1
Head(mAHD)
180
170
160
150
Simulated(ODN18TB1)
Measured(ODN18TB1)
2019-05-21
2019-05-28
2019-06-04
2019-06-11
2019-06-18
2019-06-25
2019-07-02

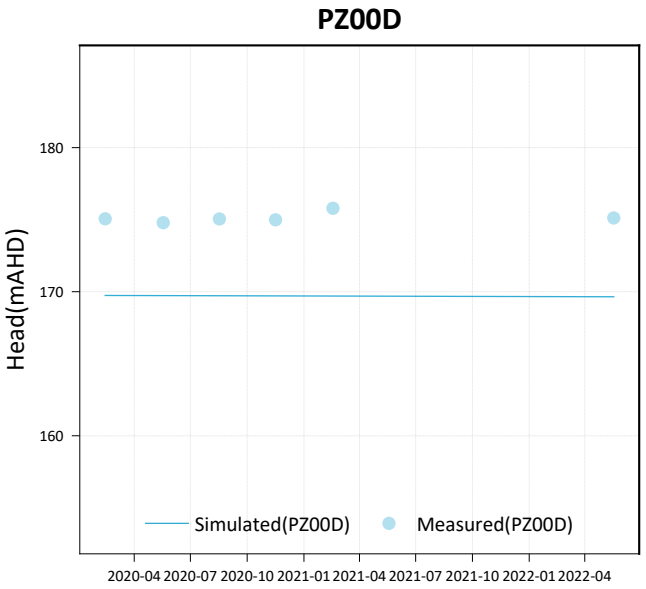

ODN18TB2
Head(mAHD)
180
170
160
Simulated(ODN18TB2)
Measured(ODN18TB2)
2019-05-21
2019-05-28
2019-06-04
2019-06-11
2019-06-18
2019-06-25
2019-07-02

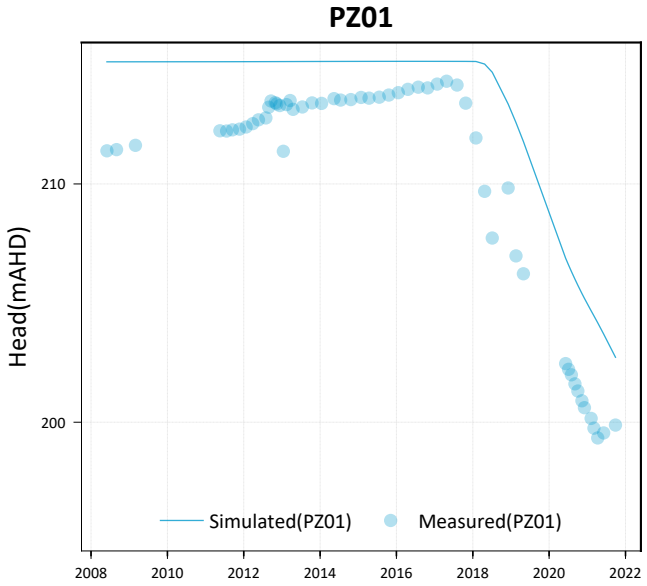

PDMMB11_01
Head(mAHD)
200
190
180
Simulated(PDMMB11_01)
Measured(PDMMB11_01)
2019-10
2020-04
2020-10
2021-04
2021-10
2022-04
2022-10
2023-04
2023-10

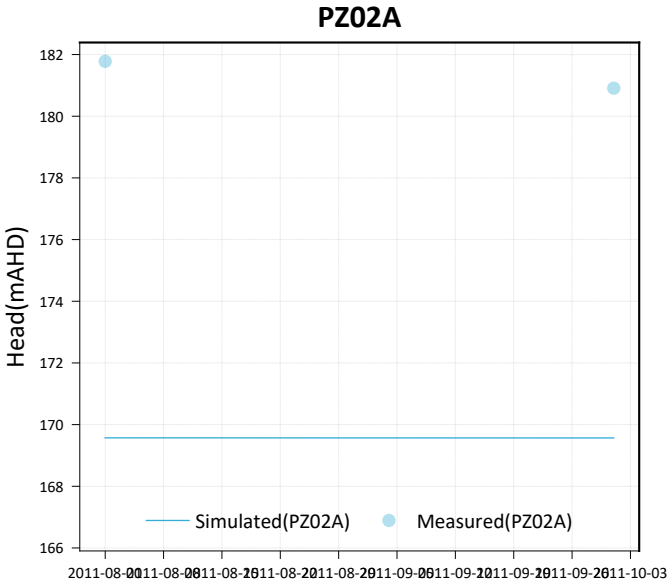

PDMMB12_01
Head(mAHD)
200
190
180
170
Simulated(PDMMB12_01)
Measured(PDMMB12_01)
2019-10
2020-04
2020-10
2021-04
2021-10
2022-04
2022-10
2023-04
2023-10

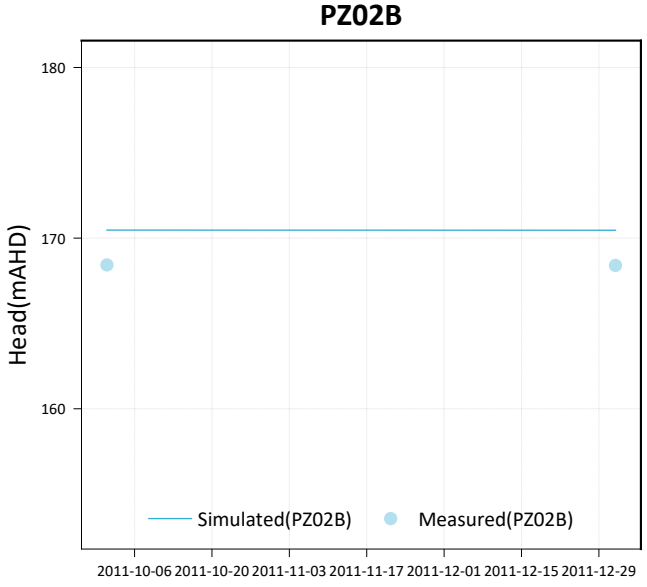

PZ00B
Head(mAHD)
180
170
160
Simulated(PZ00B)
Measured(PZ00B)
2020-04
2020-07
2020-10
2021-01
2021-04
2021-07
2021-10
2022-01
2022-04

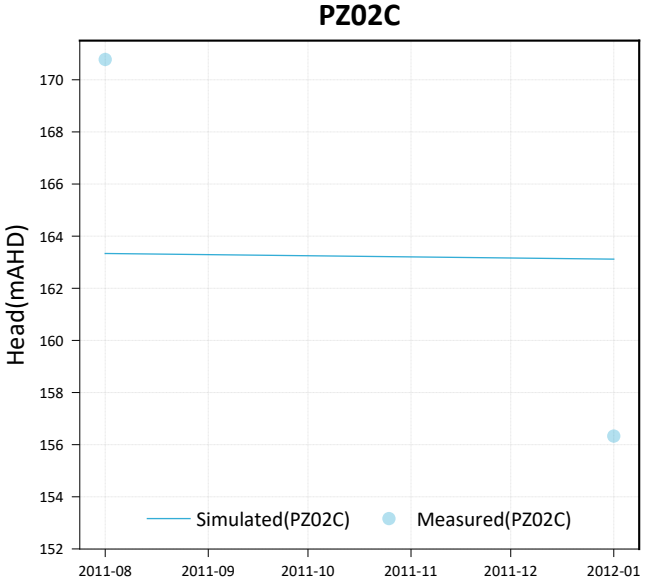

PZ00C
Head(mAHD)
180
170
160
Simulated(PZ00C)
Measured(PZ00C)
2020-05 2020-08 2020-11 2021-02 2021-05 2021-08 2021-11 2022-02 2022-05

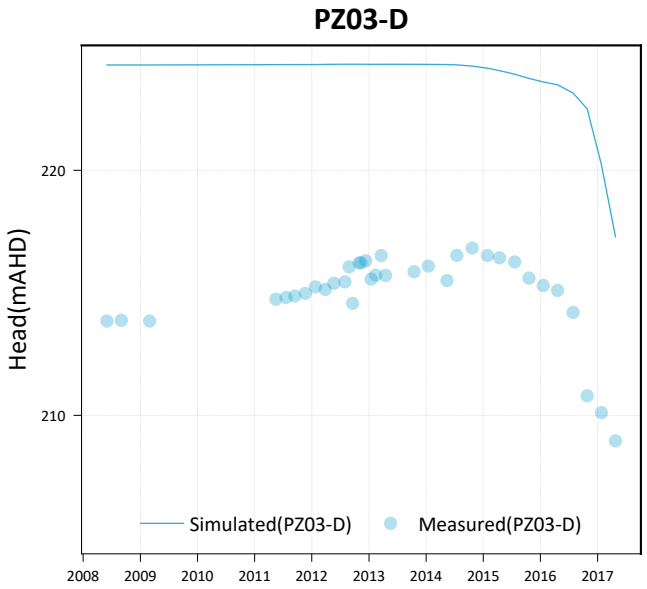

PZ00D
Head(mAHD)
180
170
160
Simulated(PZ00D)
Measured(PZ00D)
2020-04 2020-07 2020-10 2021-01 2021-04 2021-07 2021-10 2022-01 2022-04

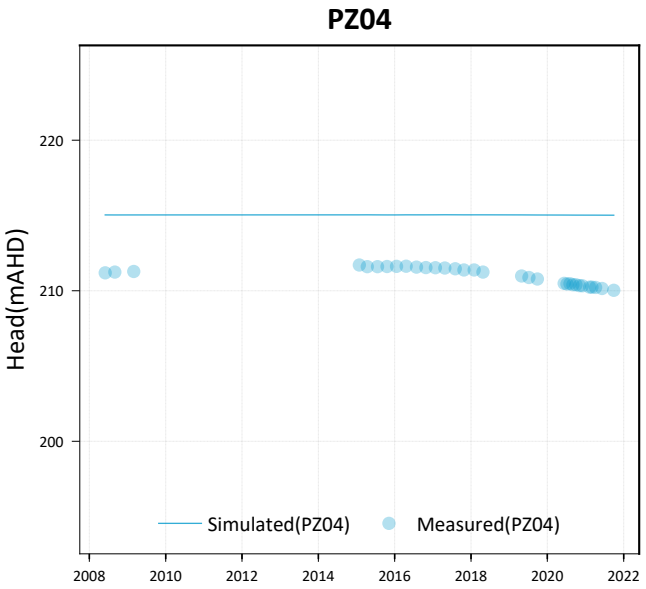

PZ01
Head(mAHD)
210
200
Simulated(PZ01)
Measured(PZ01)
2008 2010 2012 2014 2016 2018 2020 2022

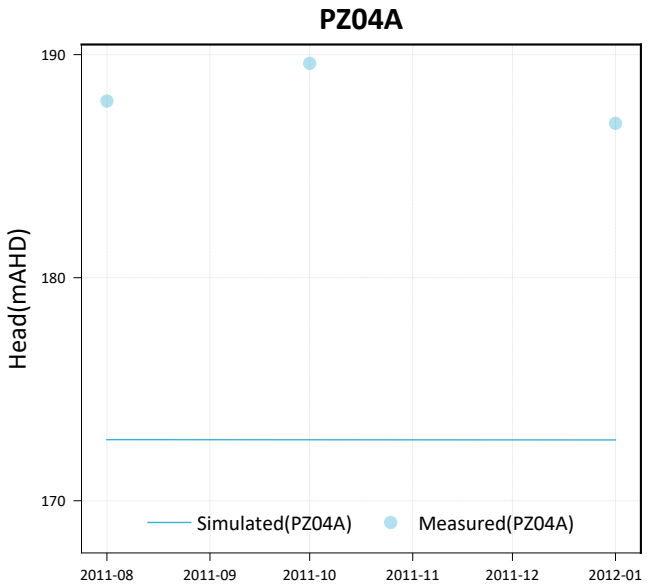

PZ02A
Head(mAHD)
182
180
178
176
174
172
170
168
166
Simulated(PZ02A)
Measured(PZ02A)

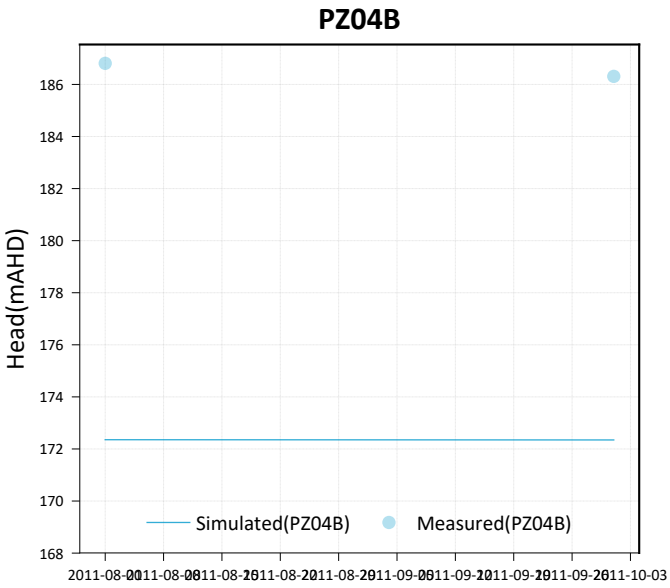

PZ02B
Head(mAHD)
180
170
160
Simulated(PZ02B)
Measured(PZ02B)
2011-10-06 2011-10-20 2011-11-03 2011-11-17 2011-12-01 2011-12-15 2011-12-29

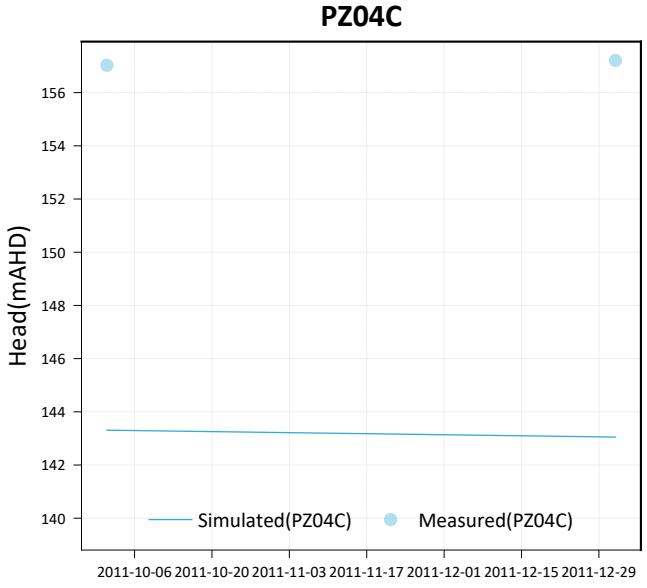

PZ02C
Head(mAHD)
170
168
166
164
162
160
158
156
154
152
Simulated(PZ02C)
Measured(PZ02C)
2011-08 2011-09 2011-10 2011-11 2011-12 2012-01

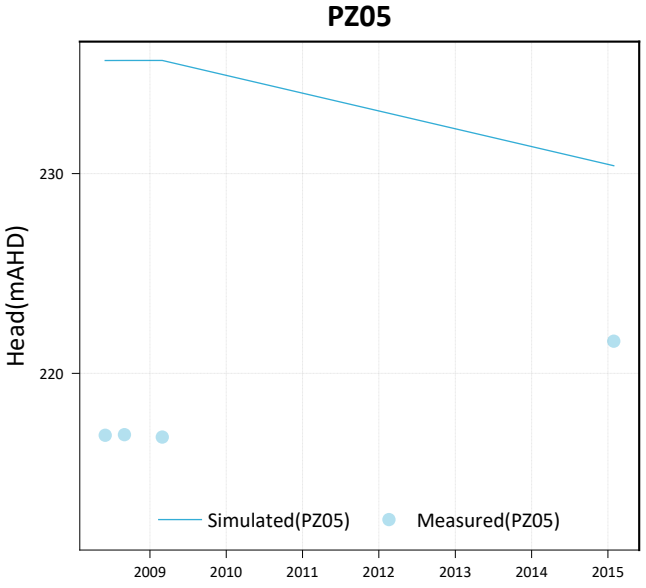

PZ03-D
Head(mAHD)
220
210
Simulated(PZ03-D)
Measured(PZ03-D)
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017

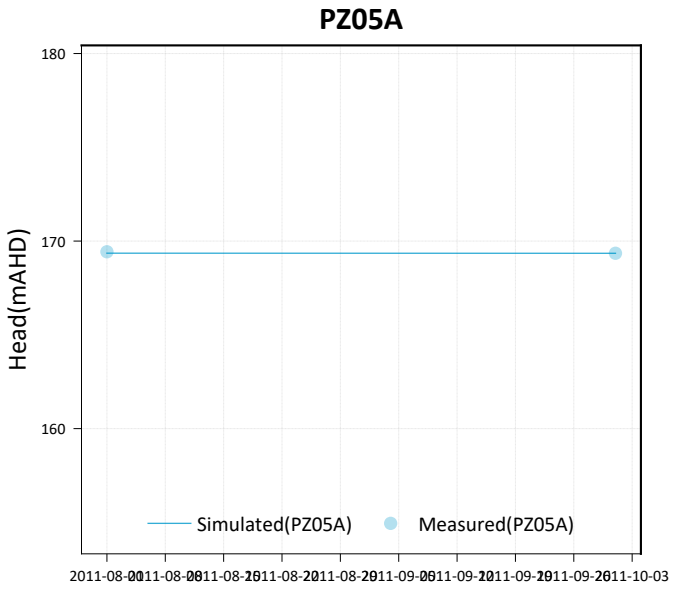

PZ04
Head(mAHD)
220
210
200
Simulated(PZ04)
Measured(PZ04)
2008
2010
2012
2014
2016
2018
2020
2022

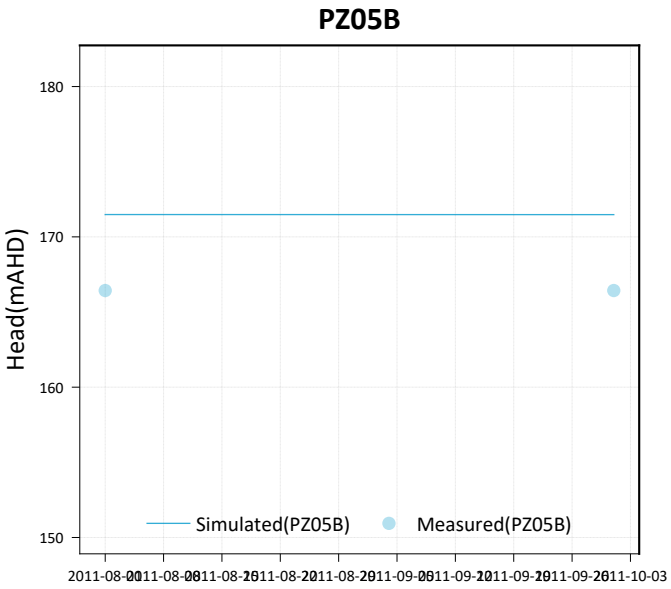

PZ04A
Head(mAHD)
190
180
170
Simulated(PZ04A)
Measured(PZ04A)
2011-08
2011-09
2011-10
2011-11
2011-12
2012-01

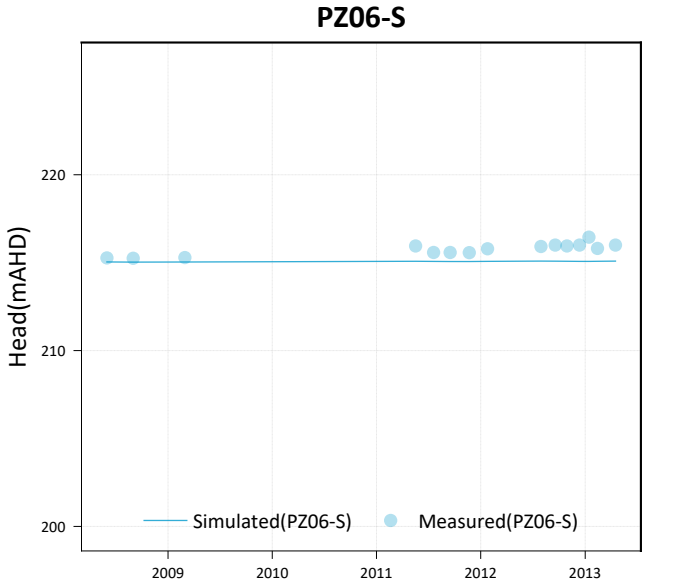

PZ04B
Head(mAHD)
186
184
182
180
178
176
174
172
170
168
Simulated(PZ04B)
Measured(PZ04B)

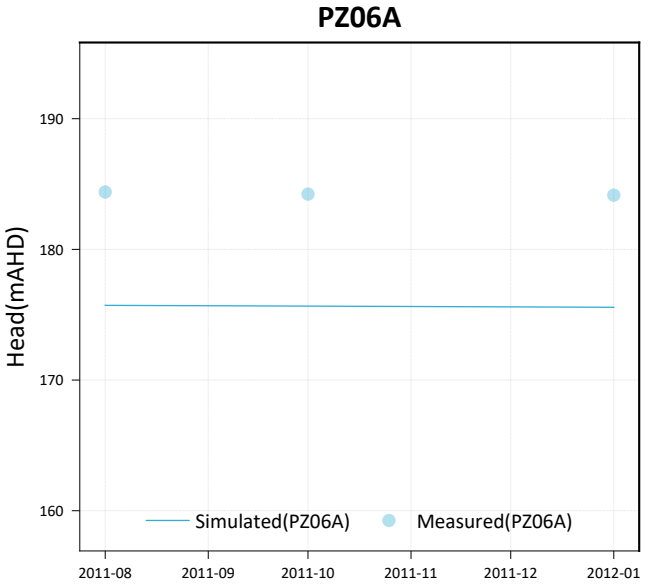

PZ04C
Head(mAHD)
156
154
152
150
148
146
144
142
140
Simulated(PZ04C)
Measured(PZ04C)
2011-10-06
2011-10-20
2011-11-03
2011-11-17
2011-12-01
2011-12-15
2011-12-29

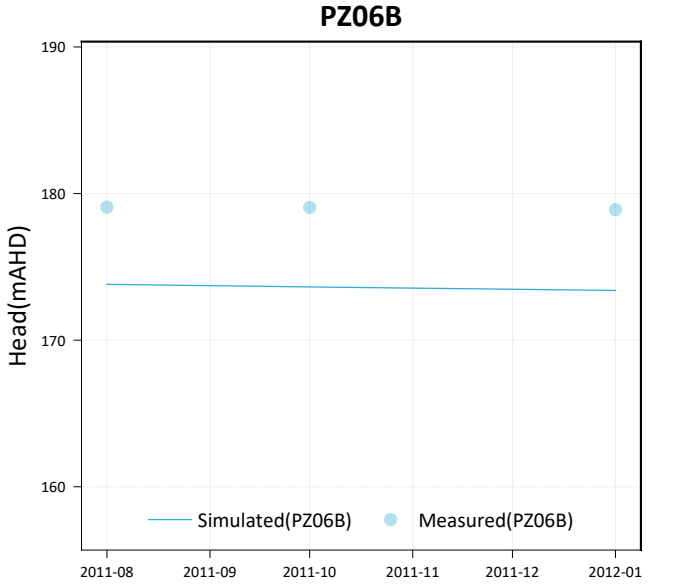

PZ05
Head(mAHD)
230
220
Simulated(PZ05)
Measured(PZ05)
2009
2010
2011
2012
2013
2014
2015

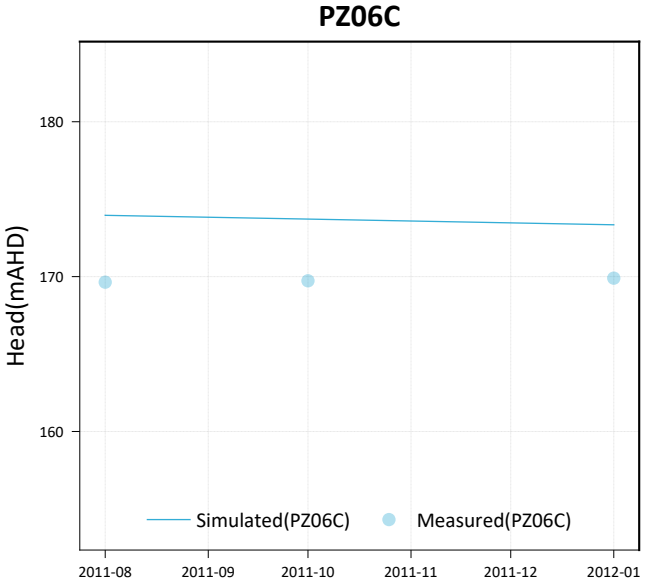

PZ05A
Head(mAHD)
180
170
160
Simulated(PZ05A)
Measured(PZ05A)

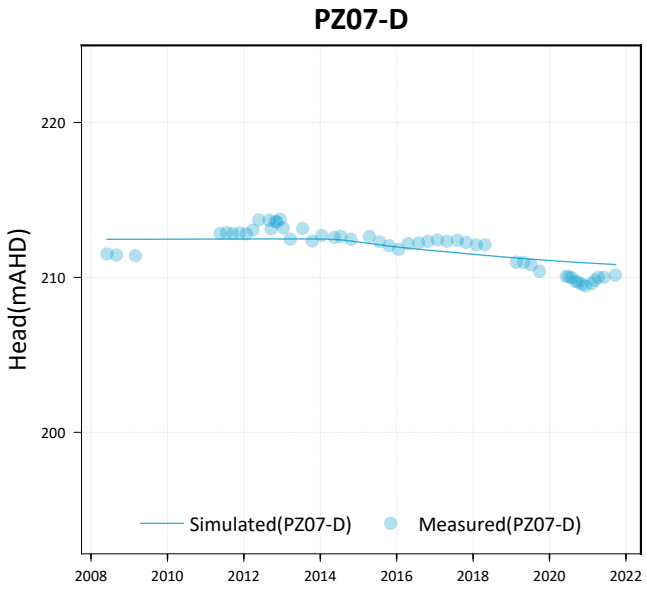

PZ05B
Head(mAHD)
180
170
160
150
Simulated(PZ05B)
Measured(PZ05B)

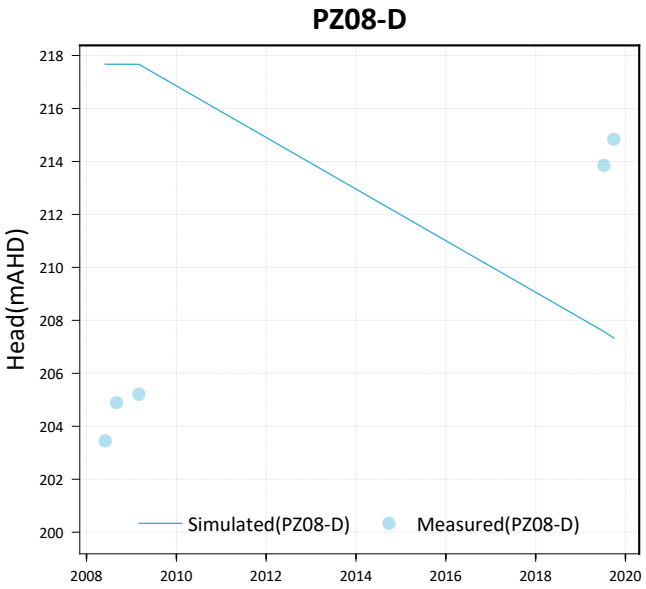

PZ06-S
Head(mAHD)
220
210
200
2009
2010
2011
2012
2013
Simulated(PZ06-S)
Measured(PZ06-S)

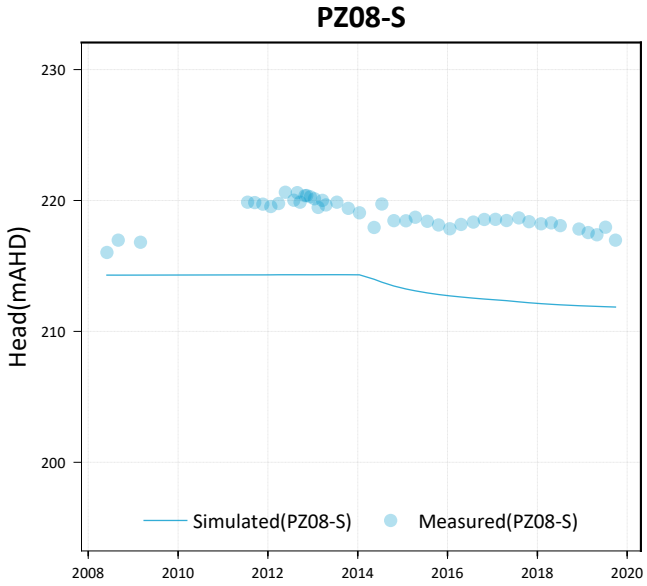

PZ06A
Head(mAHD)
190
180
170
160
2011-08
2011-09
2011-10
2011-11
2011-12
2012-01
Simulated(PZ06A)
Measured(PZ06A)

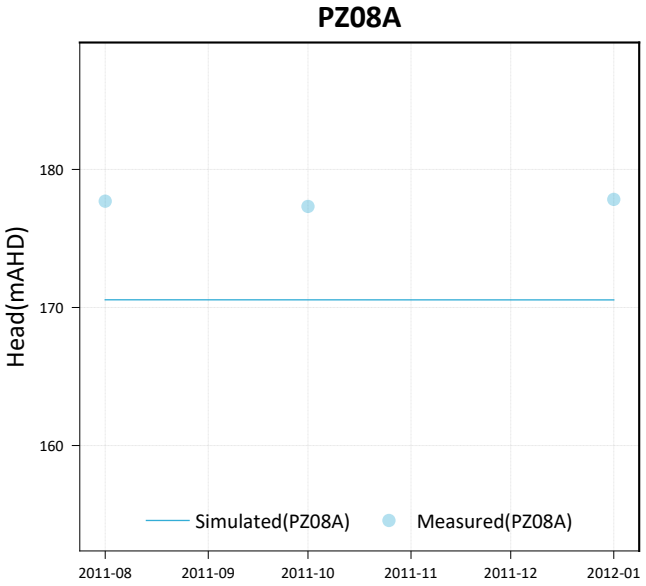

PZ06B
Head(mAHD)
190
180
170
160
2011-08
2011-09
2011-10
2011-11
2011-12
2012-01
Simulated(PZ06B)
Measured(PZ06B)

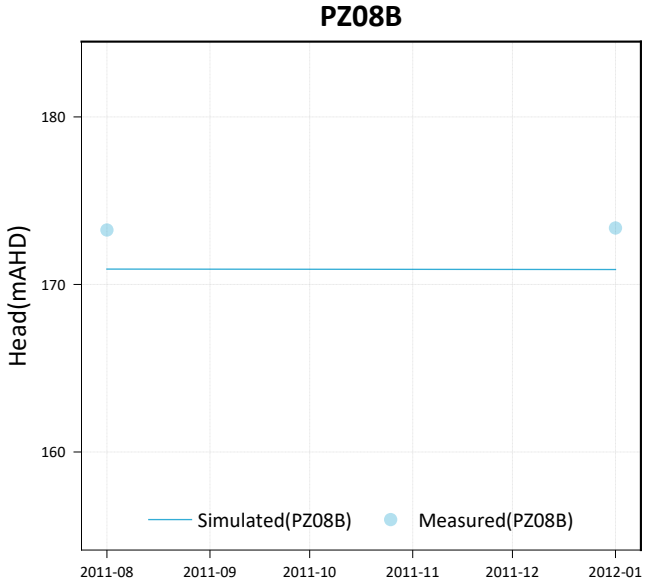

PZ06C
Head(mAHD)
180
170
160
2011-08
2011-09
2011-10
2011-11
2011-12
2012-01
Simulated(PZ06C)
Measured(PZ06C)

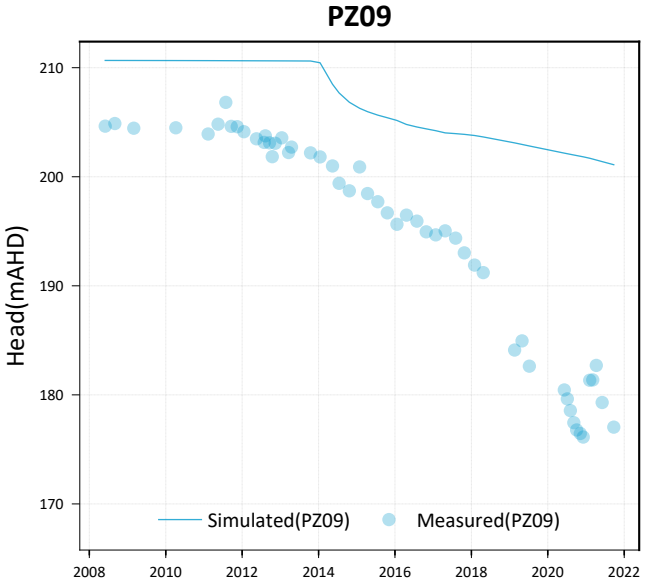

PZ07-D
Head(mAHD)
220
210
200
2008
2010
2012
2014
2016
2018
2020
2022
Simulated(PZ07-D)
Measured(PZ07-D)

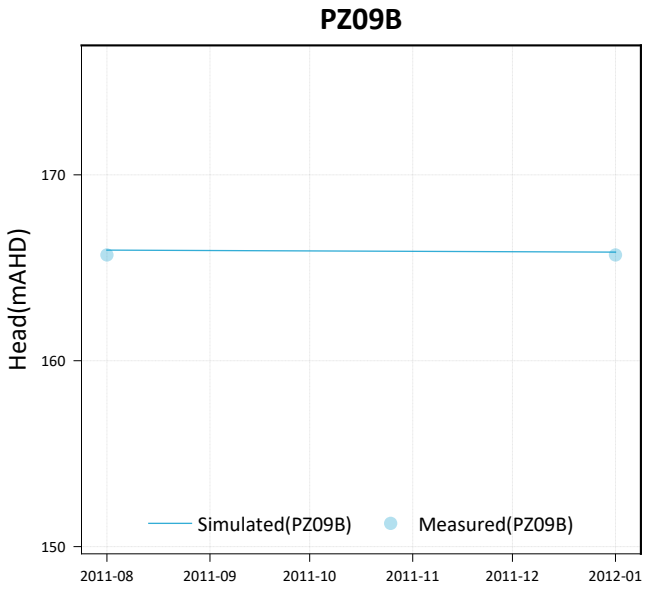

PZ08-D
Head(mAHD)
218
216
214
212
210
208
206
204
202
200
2008
2010
2012
2014
2016
2018
2020
Simulated(PZ08-D)
Measured(PZ08-D)

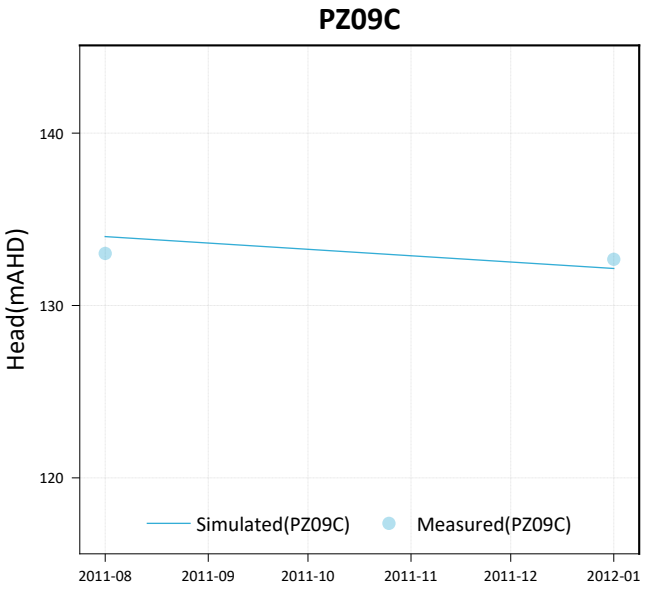

PZ08-S
Head(mAHD)
230
220
210
200
2008
2010
2012
2014
2016
2018
2020
Simulated(PZ08-S)
Measured(PZ08-S)

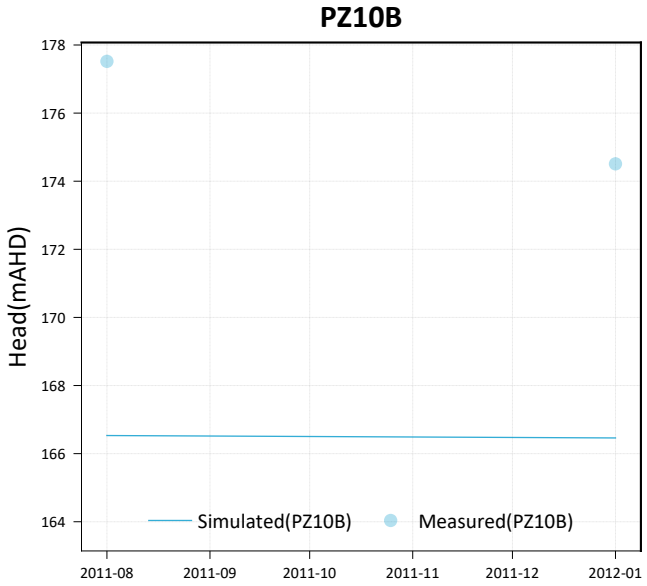

PZ08A
Head(mAHD)
180
170
160
2011-08
2011-09
2011-10
2011-11
2011-12
2012-01
Simulated(PZ08A)
Measured(PZ08A)

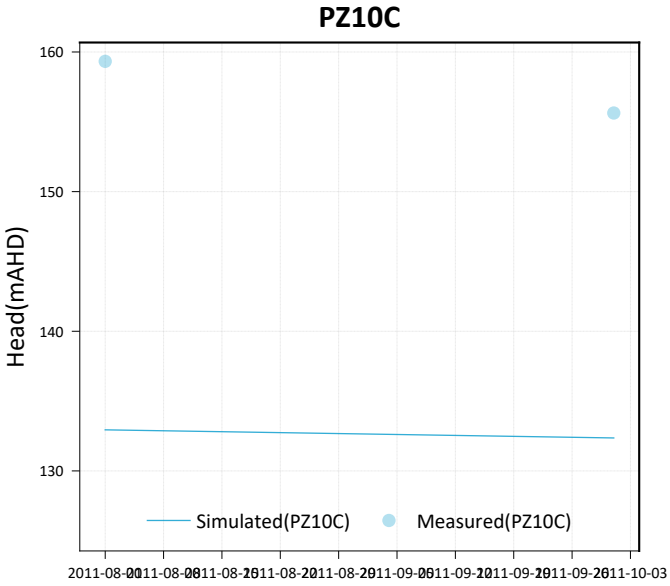

PZ08B
Head(mAHD)
180
170
160
2011-08
2011-09
2011-10
2011-11
2011-12
2012-01
Simulated(PZ08B)
Measured(PZ08B)

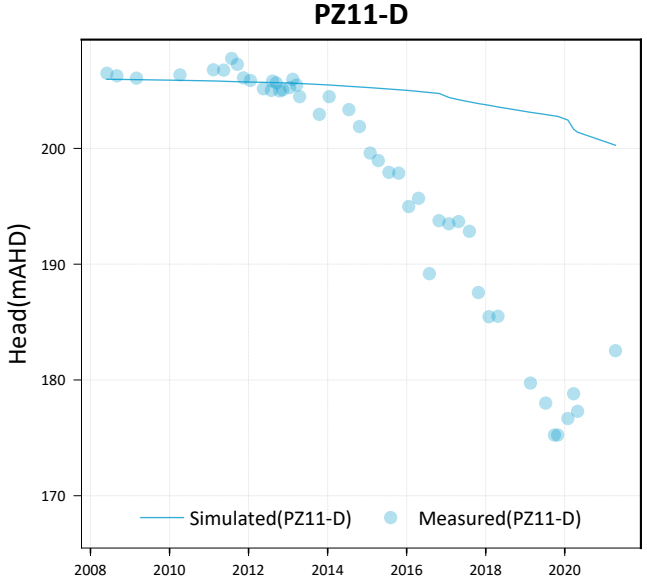

PZ09
Head(mAHD)
210
200
190
180
170
2008
2010
2012
2014
2016
2018
2020
2022
Simulated(PZ09)
Measured(PZ09)

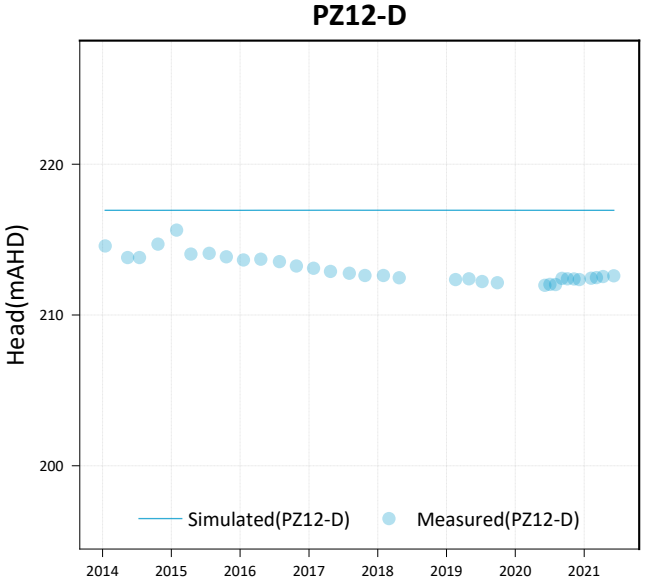

PZ09B
Head(mAHD)
170
160
150
Simulated(PZ09B)
Measured(PZ09B)
2011-08
2011-09
2011-10
2011-11
2011-12
2012-01

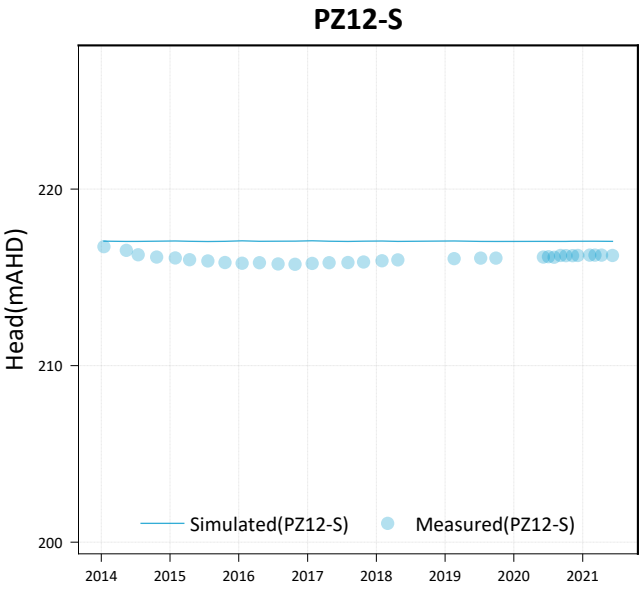

PZ09C
Head(mAHD)
140
130
120
Simulated(PZ09C)
Measured(PZ09C)
2011-08
2011-09
2011-10
2011-11
2011-12
2012-01

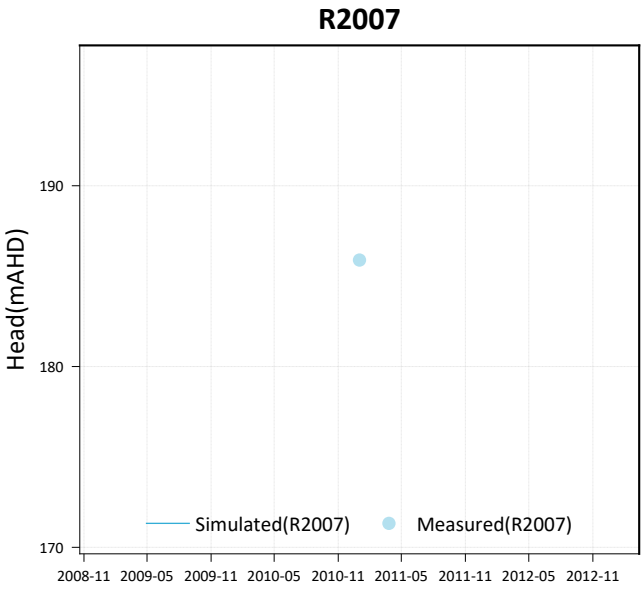

PZ10B
Head(mAHD)
178
176
174
172
170
168
166
164
Simulated(PZ10B)
Measured(PZ10B)
2011-08
2011-09
2011-10
2011-11
2011-12
2012-01

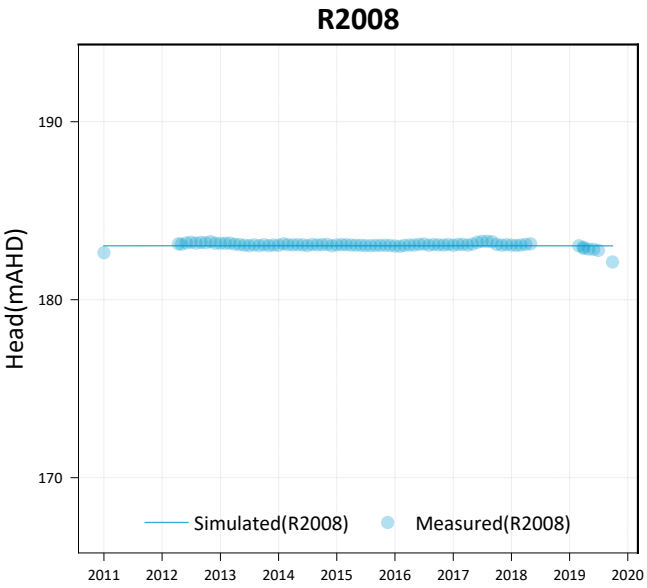

PZ10C
Head(mAHD)
160
150
140
130
Simulated(PZ10C)
Measured(PZ10C)

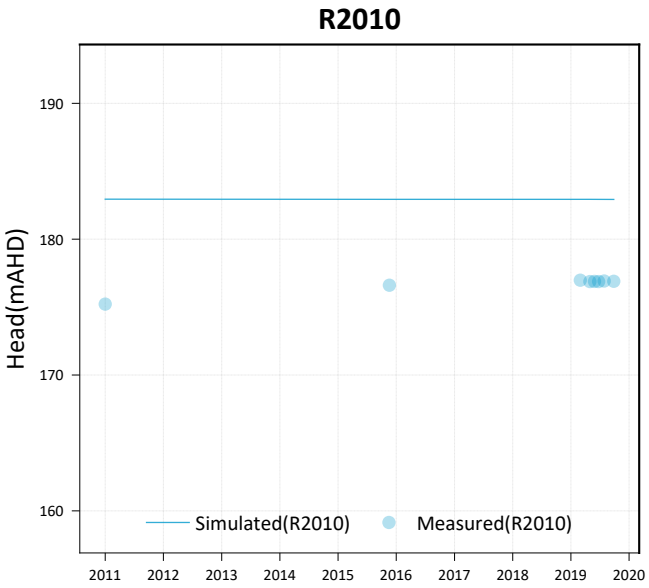

PZ11-D
Head(mAHD)
200
190
180
170
Simulated(PZ11-D)
Measured(PZ11-D)
2008
2010
2012
2014
2016
2018
2020

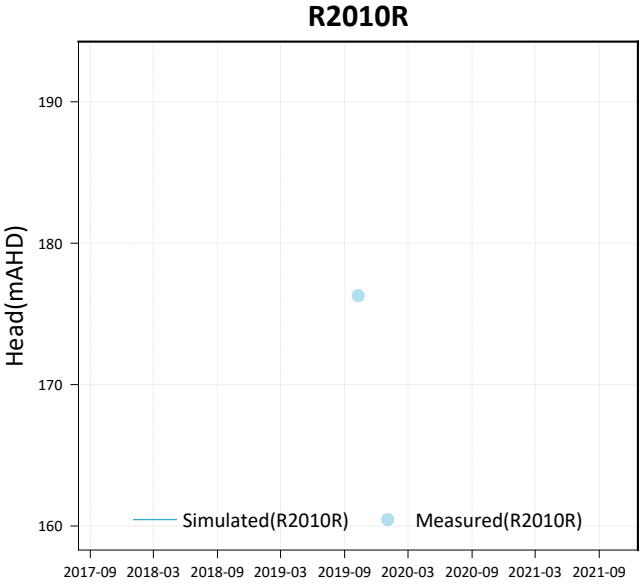

PZ12-D
Head(mAHD)
220
210
200
Simulated(PZ12-D)
Measured(PZ12-D)
2014
2015
2016
2017
2018
2019
2020
2021

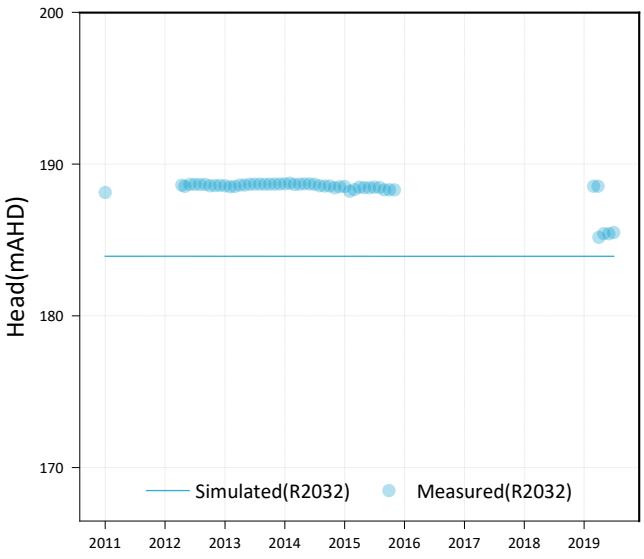

PZ12-S
Head(mAHD)
220
210
200
2014
2015
2016
2017
2018
2019
2020
2021
Simulated(PZ12-S)
Measured(PZ12-S)

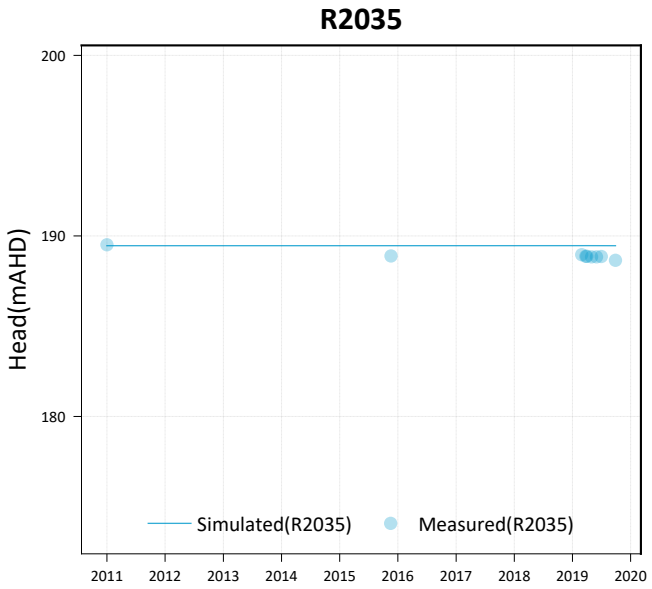

R2007
Head(mAHD)
190
180
170
2008-11
2009-05
2009-11
2010-05
2010-11
2011-05
2011-11
2012-05
2012-11
Simulated(R2007)
Measured(R2007)

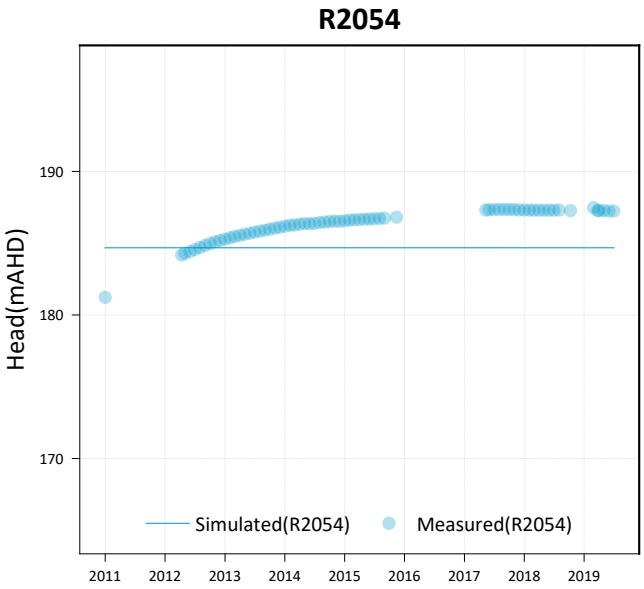

R2008
Head(mAHD)
190
180
170
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
Simulated(R2008)
Measured(R2008)

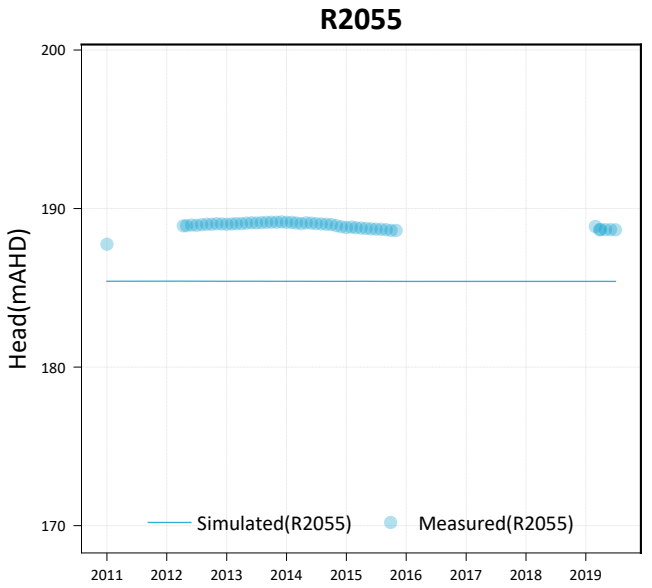

R2010
Head(mAHD)
190
180
170
160
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
Simulated(R2010)
Measured(R2010)

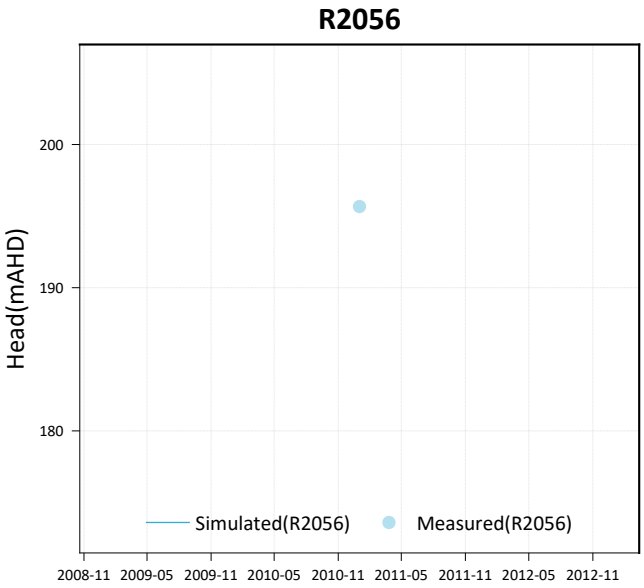

R2010R
Head(mAHD)
190
180
170
160
2017-09
2018-03
2018-09
2019-03
2019-09
2020-03
2020-09
2021-03
2021-09
Simulated(R2010R)
Measured(R2010R)

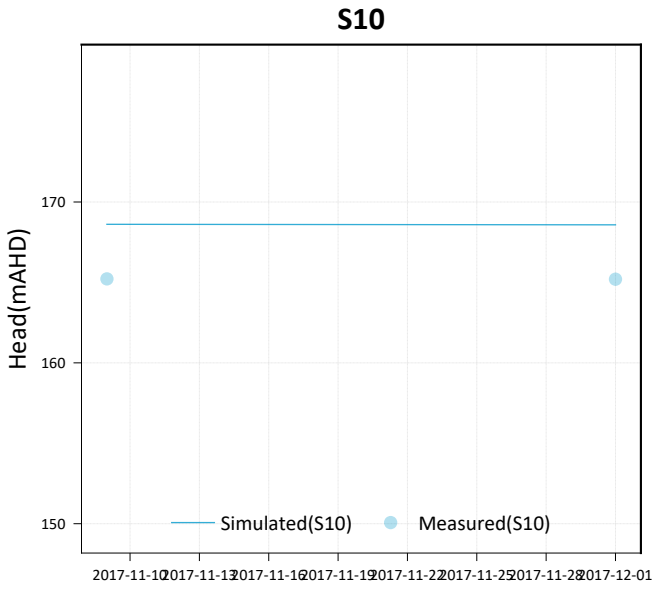

R2032
Head(mAHD)
200
190
180
170
2011
2012
2013
2014
2015
2016
2017
2018
2019
Simulated(R2032)
Measured(R2032)

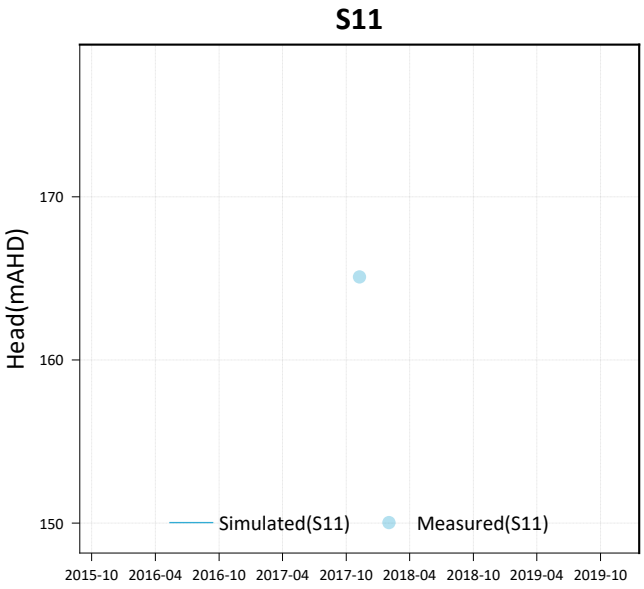

R2035
Head(mAHD)
200
190
180
Simulated(R2035)
Measured(R2035)
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020

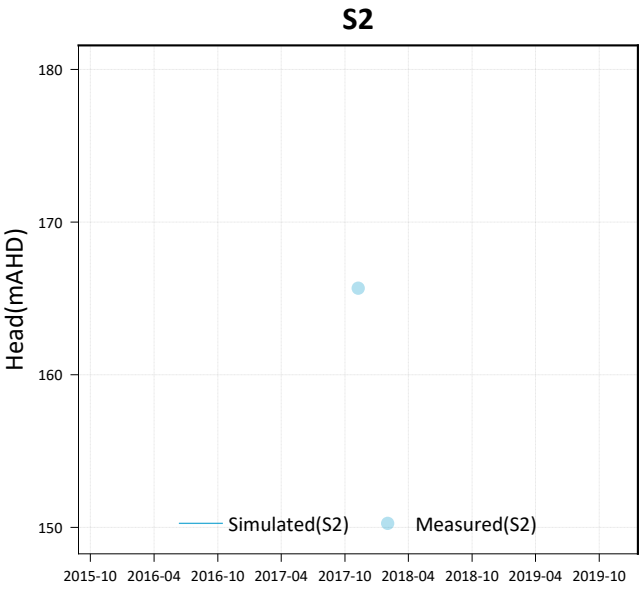

R2054
Head(mAHD)
190
180
170
Simulated(R2054)
Measured(R2054)
2011
2012
2013
2014
2015
2016
2017
2018
2019

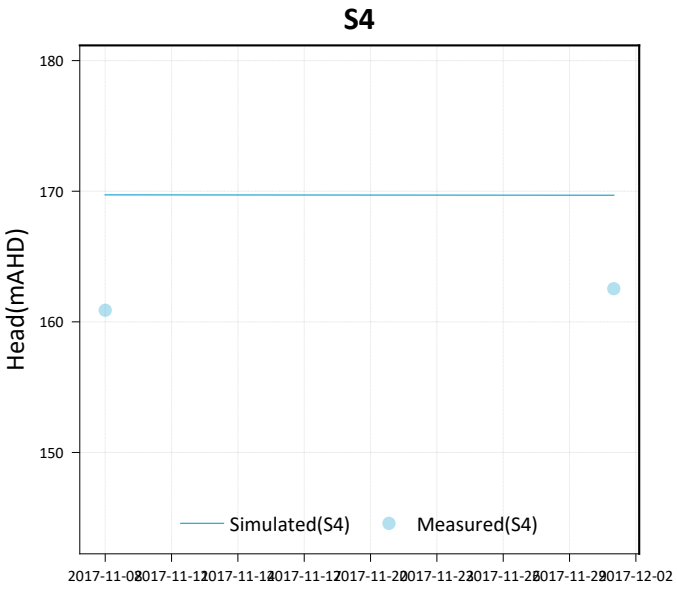

R2055
Head(mAHD)
200
190
180
170
Simulated(R2055)
Measured(R2055)
2011
2012
2013
2014
2015
2016
2017
2018
2019

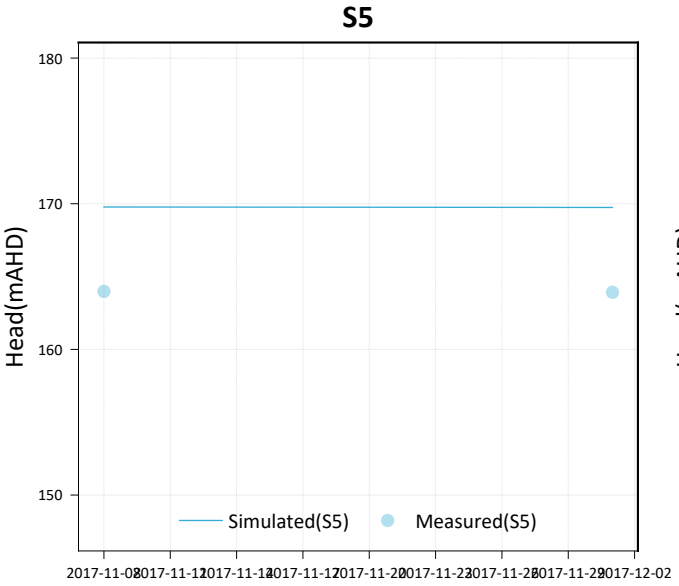

R2056
Head(mAHD)
200
190
180
Simulated(R2056)
Measured(R2056)
2008-11
2009-05
2009-11
2010-05
2010-11
2011-05
2011-11
2012-05
2012-11

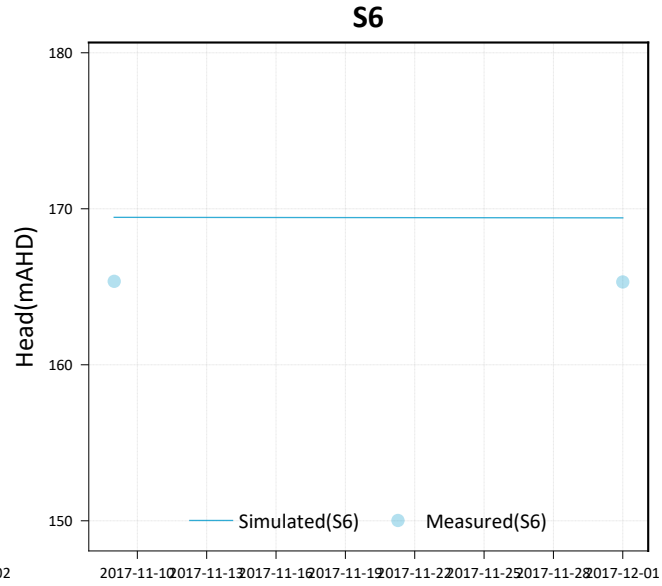

S10
Head(mAHD)
170
160
150
Simulated(S10)
Measured(S10)
2017-11-10
2017-11-13
2017-11-16
2017-11-19
2017-11-22
2017-11-25
2017-11-28
2017-12-01

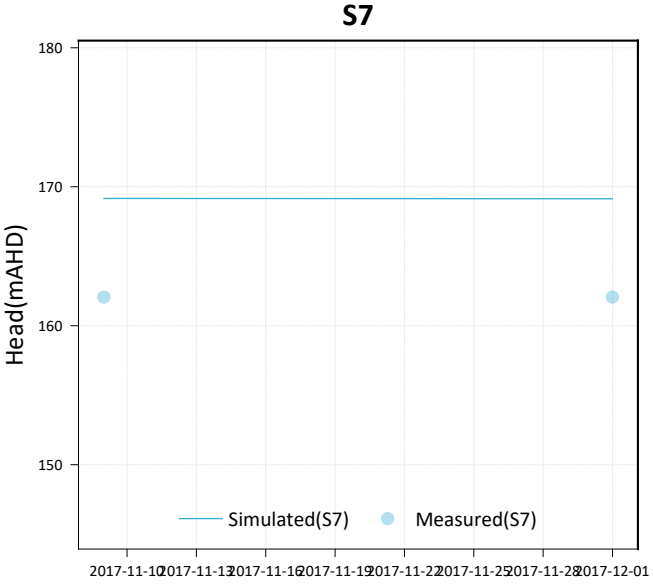

S11
Head(mAHD)
170
160
150
Simulated(S11)
Measured(S11)
2015-10
2016-04
2016-10
2017-04
2017-10
2018-04
2018-10
2019-04
2019-10

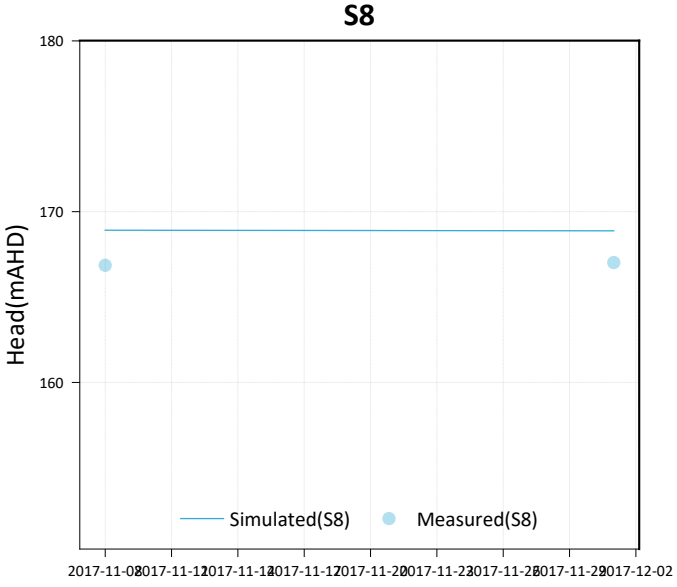

S2
Head(mAHD)
180
170
160
150
Simulated(S2)
Measured(S2)
2015-10
2016-04
2016-10
2017-04
2017-10
2018-04
2018-10
2019-04
2019-10

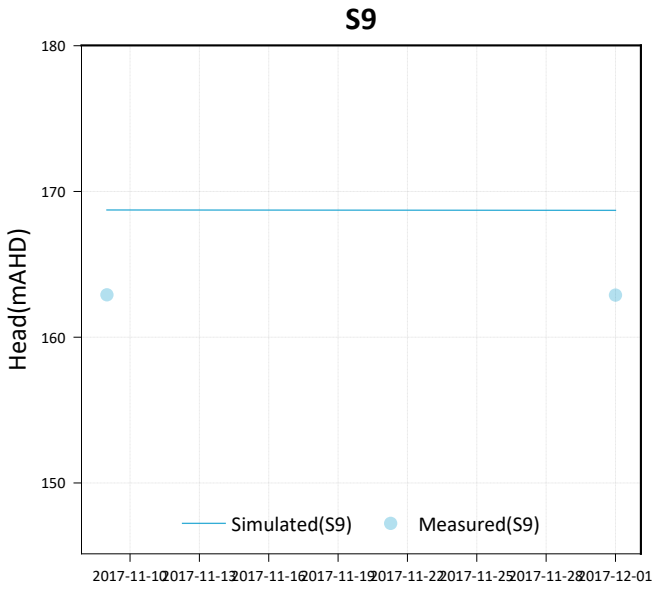

S4
Head(mAHD)
180
170
160
150
Simulated(S4)
Measured(S4)
2017-11-08
2017-11-11
2017-11-14
2017-11-17
2017-11-20
2017-11-23
2017-11-26
2017-11-29
2017-12-02

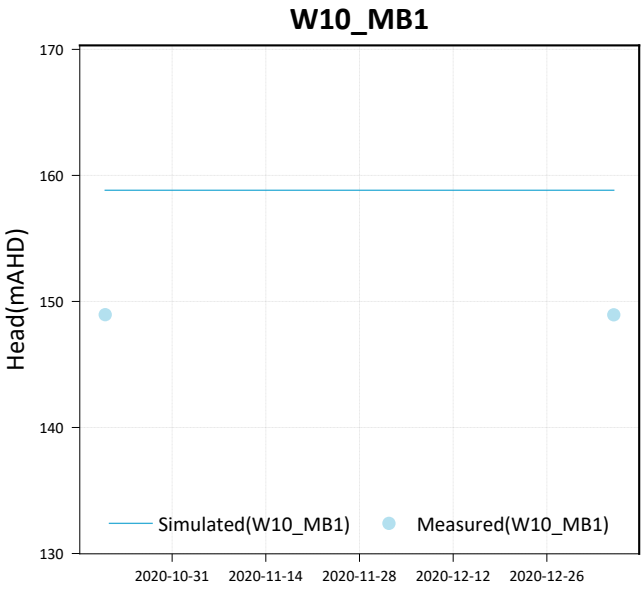

S5
Head(mAHD)
180
170
160
150
Simulated(S5)
Measured(S5)
2017-11-08
2017-11-11
2017-11-14
2017-11-17
2017-11-20
2017-11-23
2017-11-26
2017-11-29
2017-12-02

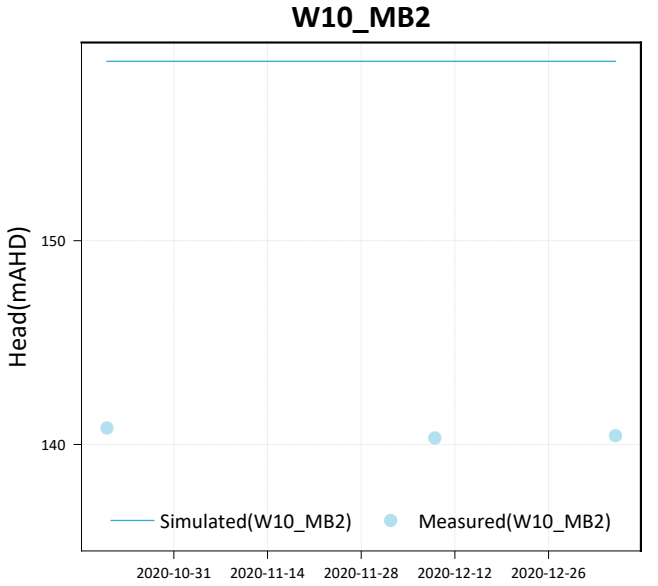

S6
Head(mAHD)
180
170
160
150
Simulated(S6)
Measured(S6)
2017-11-10
2017-11-13
2017-11-16
2017-11-19
2017-11-22
2017-11-25
2017-11-28
2017-12-01

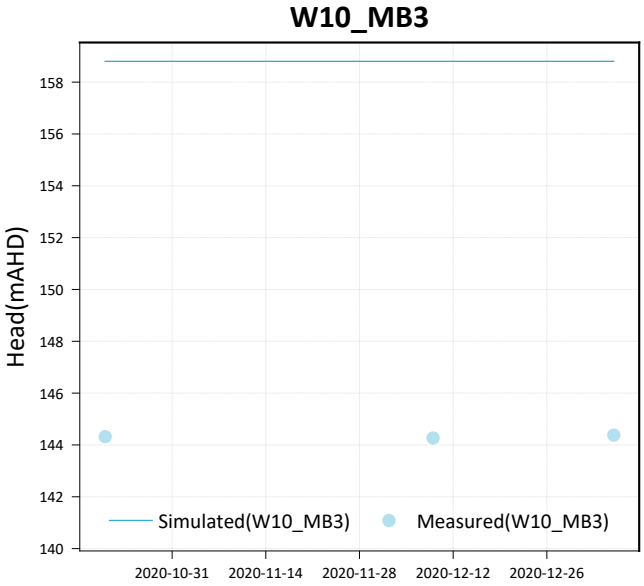

S7
Head(mAHD)
180
170
160
150
Simulated(S7)
Measured(S7)
2017-11-10
2017-11-13
2017-11-16
2017-11-19
2017-11-22
2017-11-25
2017-11-28
2017-12-01

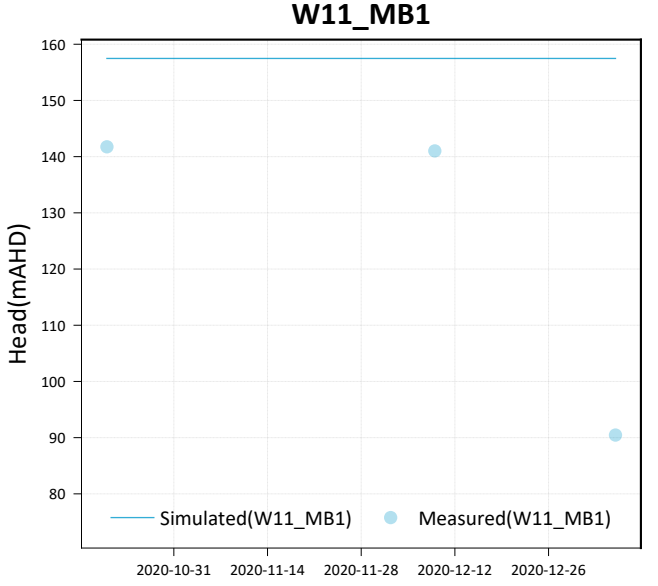

S8
Head(mAHD)
180
170
160
Simulated(S8)
Measured(S8)
2017-11-08
2017-11-11
2017-11-14
2017-11-17
2017-11-20
2017-11-23
2017-11-26
2017-11-29
2017-12-02

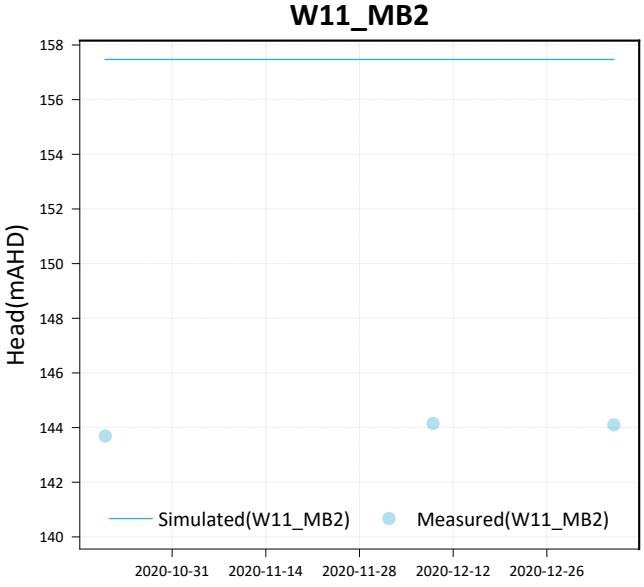

S9
Head(mAHD)
180
170
160
150
Simulated(S9)
Measured(S9)
2017-11-10
2017-11-13
2017-11-16
2017-11-19
2017-11-22
2017-11-25
2017-11-28
2017-12-01

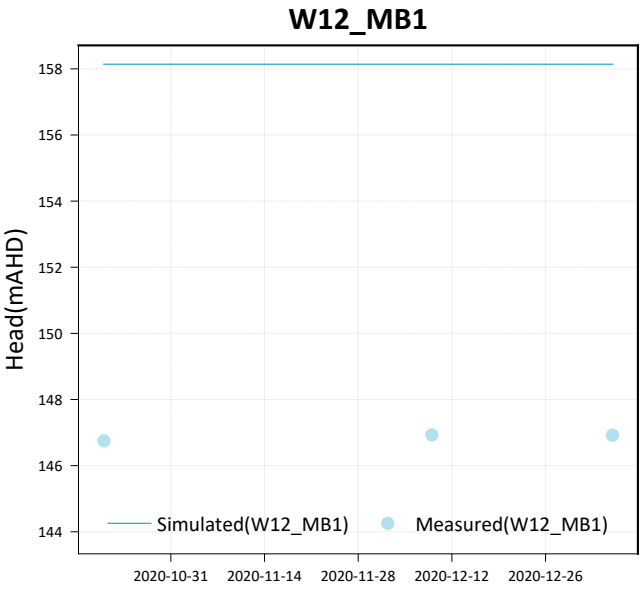

W10_MB1
Head(mAHD)
170
160
150
140
130
Simulated(W10_MB1)
Measured(W10_MB1)
2020-10-31
2020-11-14
2020-11-28
2020-12-12
2020-12-26

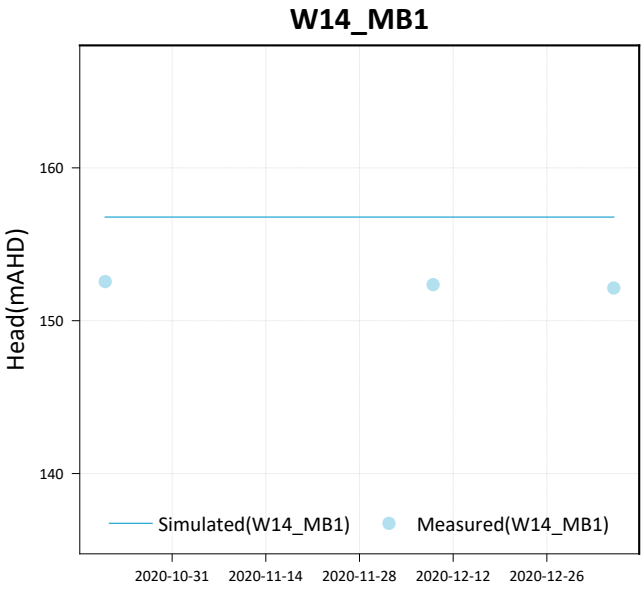

W10_MB2
Head(mAHD)
150
140
Simulated(W10_MB2)
Measured(W10_MB2)
2020-10-31
2020-11-14
2020-11-28
2020-12-12
2020-12-26

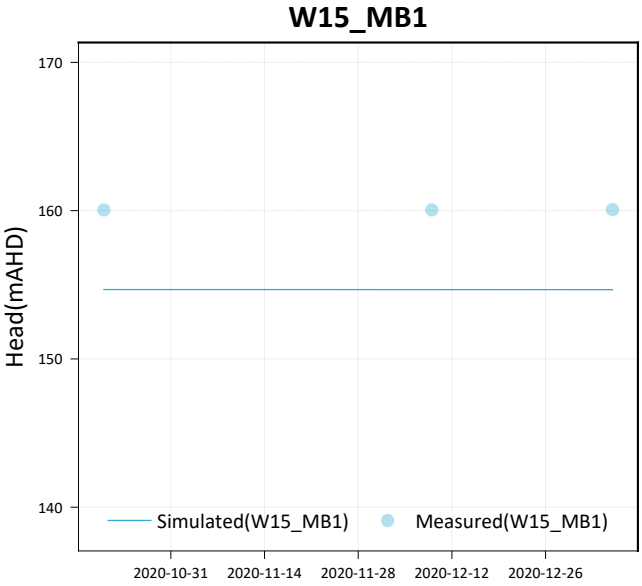

W10_MB3
Head(mAHD)
158
156
154
152
150
148
146
144
142
140
Simulated(W10_MB3)
Measured(W10_MB3)
2020-10-31
2020-11-14
2020-11-28
2020-12-12
2020-12-26

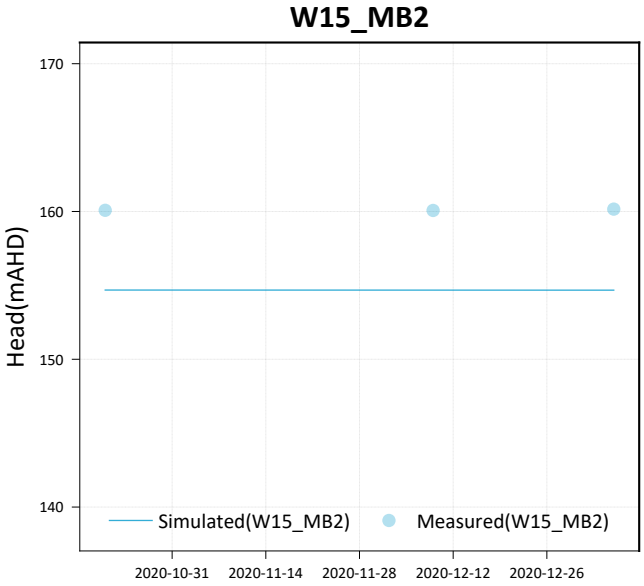

W11_MB1
Head(mAHD)
160
150
140
130
120
110
100
90
80
Simulated(W11_MB1)
Measured(W11_MB1)
2020-10-31
2020-11-14
2020-11-28
2020-12-12
2020-12-26

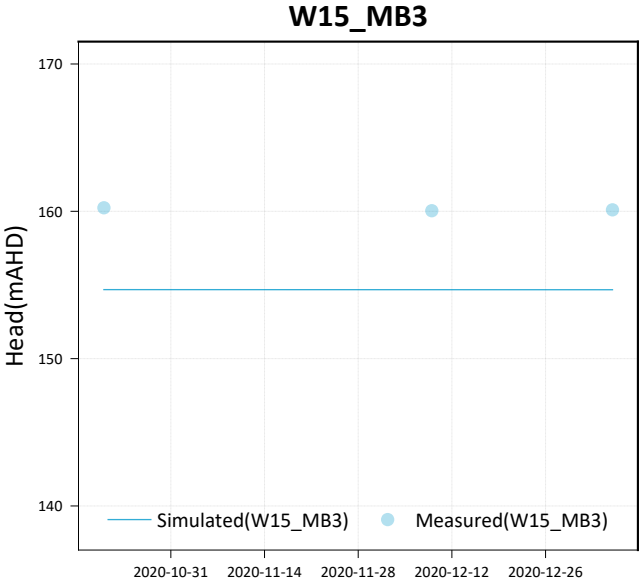

W11_MB2
Head(mAHD)
158
156
154
152
150
148
146
144
142
140
Simulated(W11_MB2)
Measured(W11_MB2)
2020-10-31
2020-11-14
2020-11-28
2020-12-12
2020-12-26

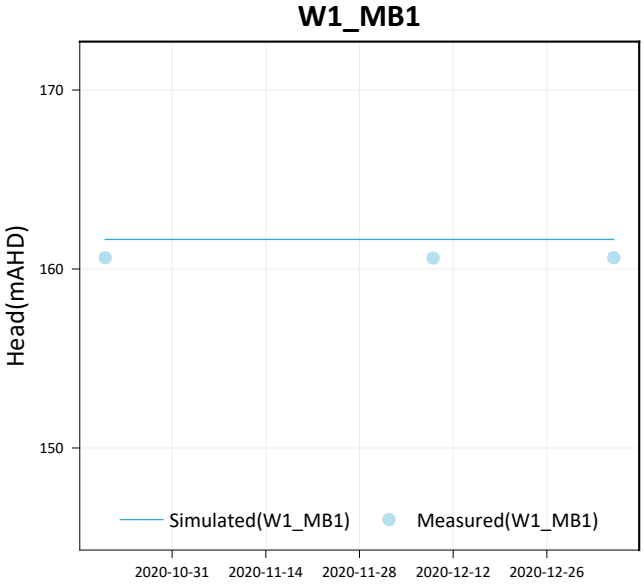

W12_MB1
Head(mAHD)
158
156
154
152
150
148
146
144
Simulated(W12_MB1)
Measured(W12_MB1)
2020-10-31
2020-11-14
2020-11-28
2020-12-12
2020-12-26

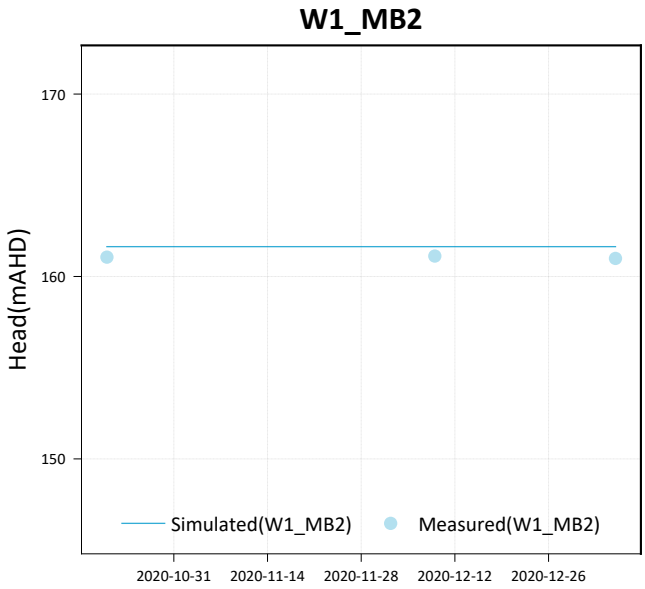

W14_MB1
Head(mAHD)
160
150
140
Simulated(W14_MB1)
Measured(W14_MB1)
2020-10-31
2020-11-14
2020-11-28
2020-12-12
2020-12-26

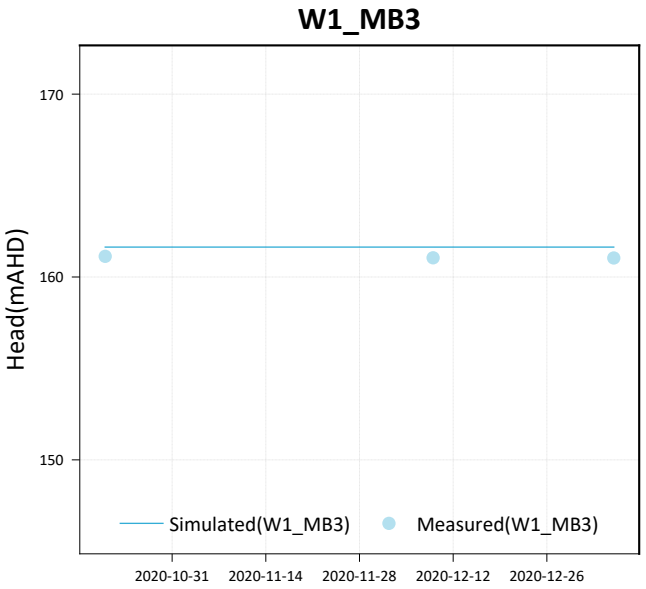

W15_MB1
Head(mAHD)
170
160
150
140
Simulated(W15_MB1)
Measured(W15_MB1)
2020-10-31
2020-11-14
2020-11-28
2020-12-12
2020-12-26

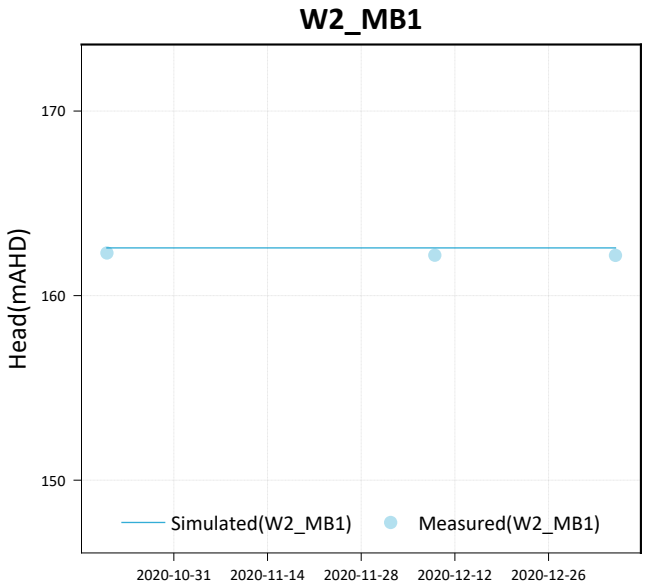

W15_MB2
Head(mAHD)
170
160
150
140
Simulated(W15_MB2)
Measured(W15_MB2)
2020-10-31
2020-11-14
2020-11-28
2020-12-12
2020-12-26

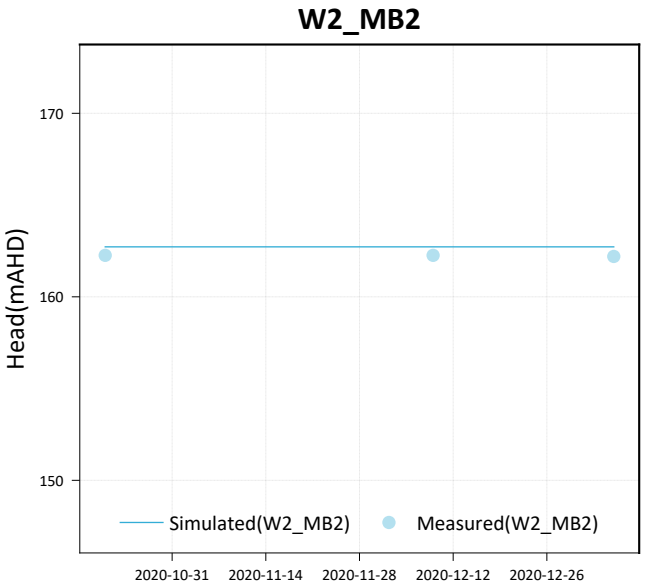

W15_MB3
Head(mAHD)
170
160
150
140
Simulated(W15_MB3)
Measured(W15_MB3)
2020-10-31
2020-11-14
2020-11-28
2020-12-12
2020-12-26

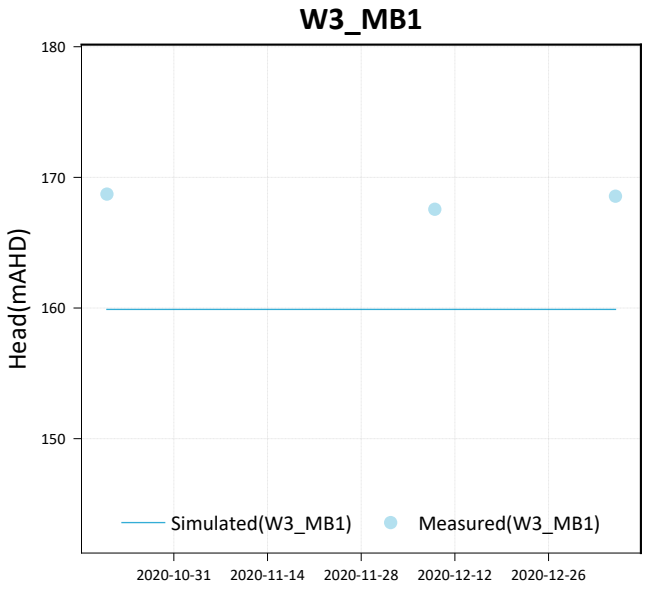

W1_MB1
Head(mAHD)
170
160
150
Simulated(W1_MB1)
Measured(W1_MB1)
2020-10-31
2020-11-14
2020-11-28
2020-12-12
2020-12-26

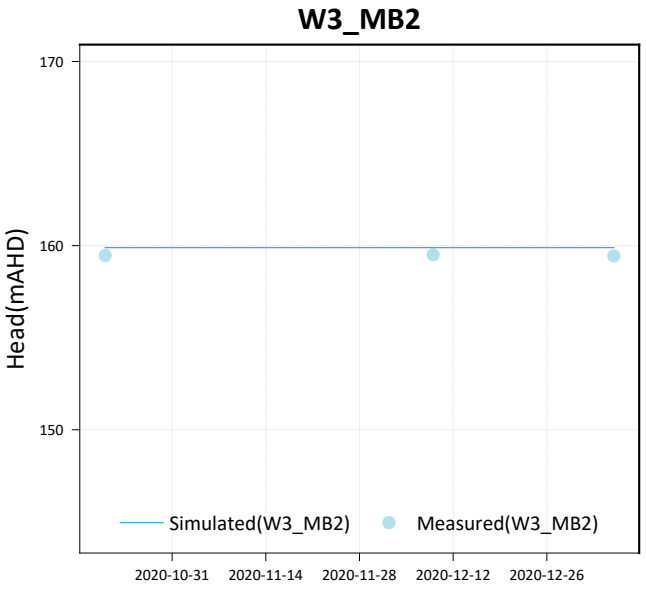

W1_MB2
Head(mAHD)
170
160
150
Simulated(W1_MB2)
Measured(W1_MB2)
2020-10-31
2020-11-14
2020-11-28
2020-12-12
2020-12-26

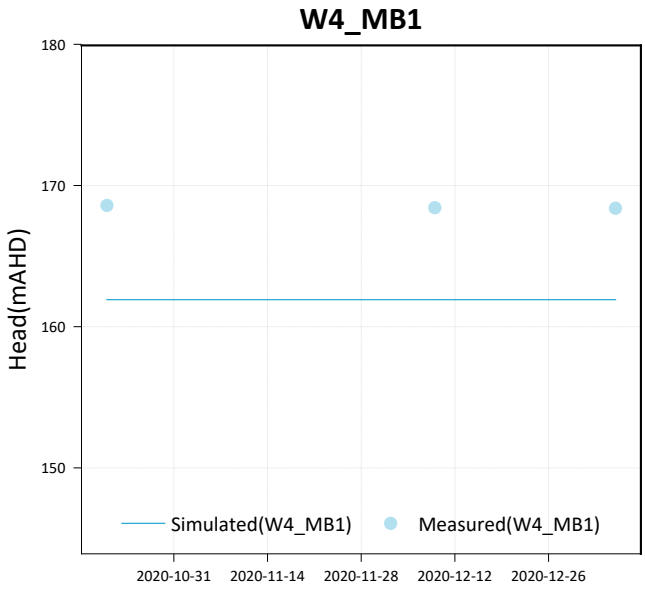

W1_MB3
Head(mAHD)
170
160
150
Simulated(W1_MB3)
Measured(W1_MB3)
2020-10-31
2020-11-14
2020-11-28
2020-12-12
2020-12-26

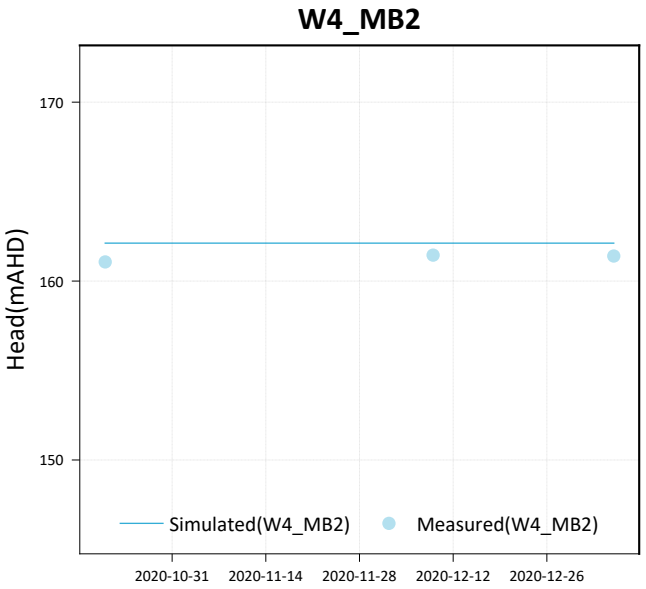

W2_MB1
Head(mAHD)
170
160
150
Simulated(W2_MB1)
Measured(W2_MB1)
2020-10-31
2020-11-14
2020-11-28
2020-12-12
2020-12-26

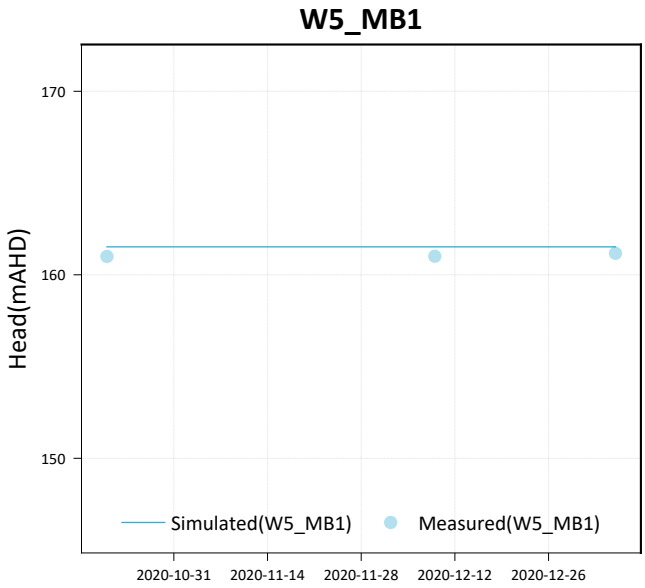

W2_MB2
Head(mAHD)
170
160
150
Simulated(W2_MB2)
Measured(W2_MB2)
2020-10-31
2020-11-14
2020-11-28
2020-12-12
2020-12-26

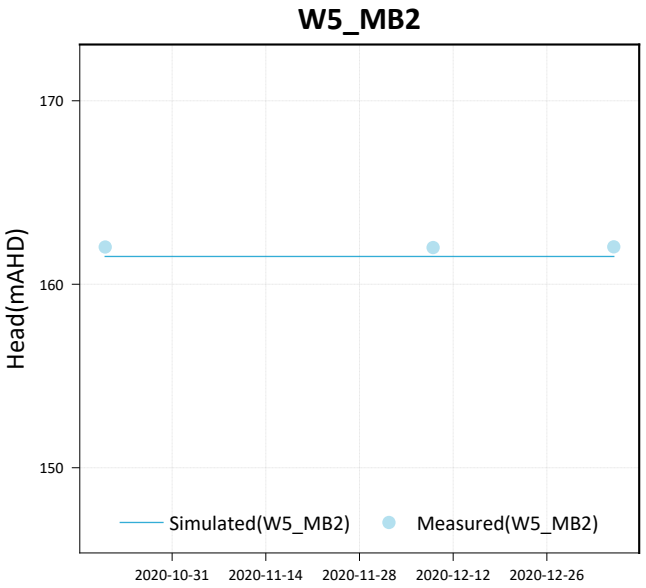

W3_MB1
Head(mAHD)
180
170
160
150
Simulated(W3_MB1)
Measured(W3_MB1)
2020-10-31
2020-11-14
2020-11-28
2020-12-12
2020-12-26

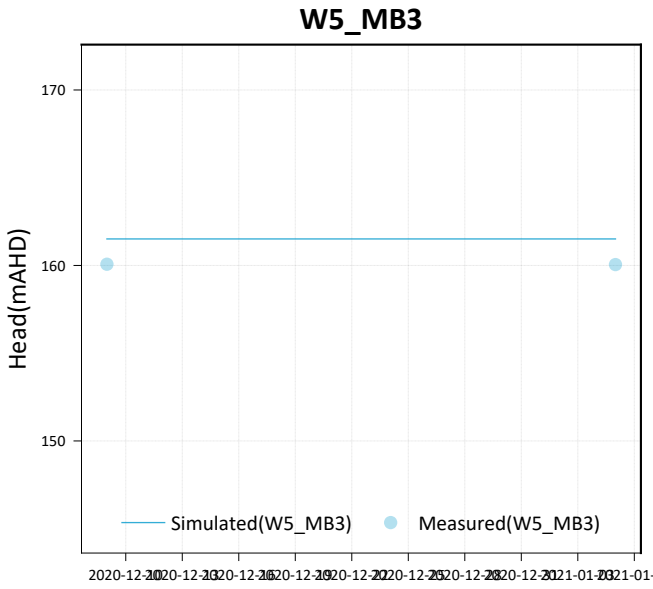

W3_MB2
Head(mAHD)
170
160
150
Simulated(W3_MB2)
Measured(W3_MB2)
2020-10-31
2020-11-14
2020-11-28
2020-12-12
2020-12-26

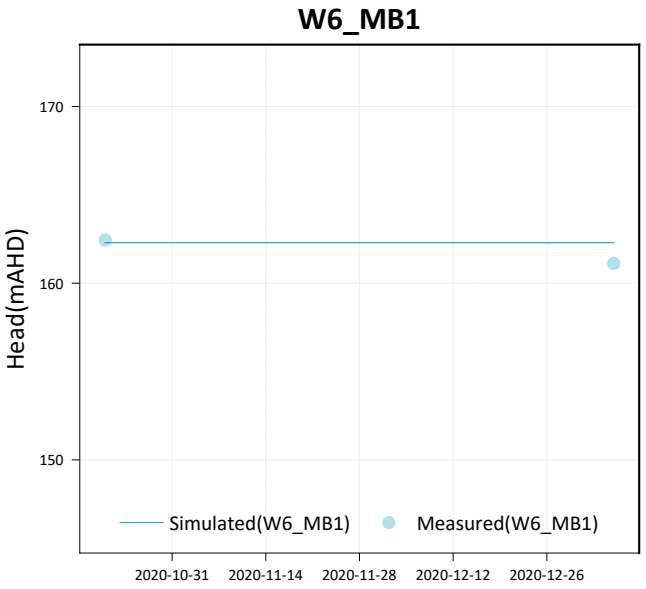

W4_MB1
Head(mAHD)
180
170
160
150
Simulated(W4_MB1)
Measured(W4_MB1)
2020-10-31
2020-11-14
2020-11-28
2020-12-12
2020-12-26

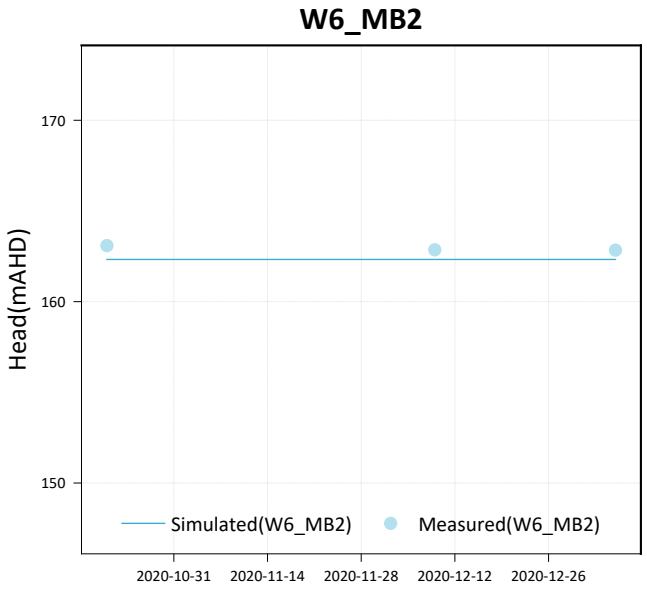

W4_MB2
Head(mAHD)
170
160
150
Simulated(W4_MB2)
Measured(W4_MB2)
2020-10-31
2020-11-14
2020-11-28
2020-12-12
2020-12-26

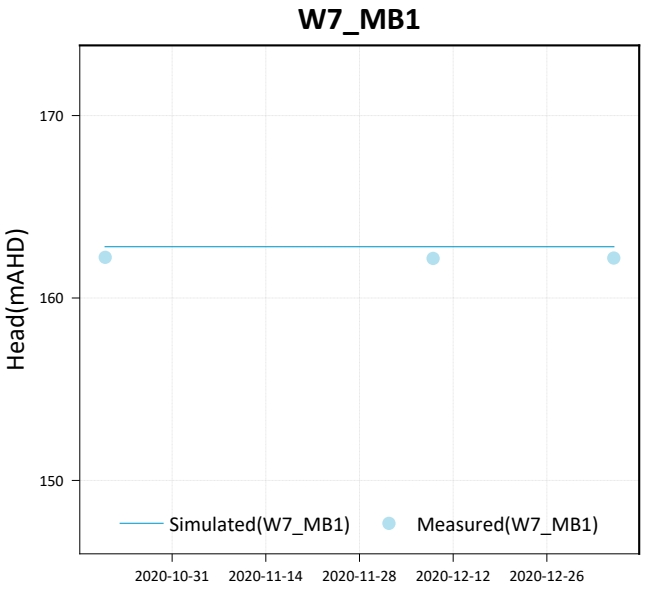

W5_MB1
Head(mAHD)
170
160
150
Simulated(W5_MB1)
Measured(W5_MB1)
2020-10-31
2020-11-14
2020-11-28
2020-12-12
2020-12-26

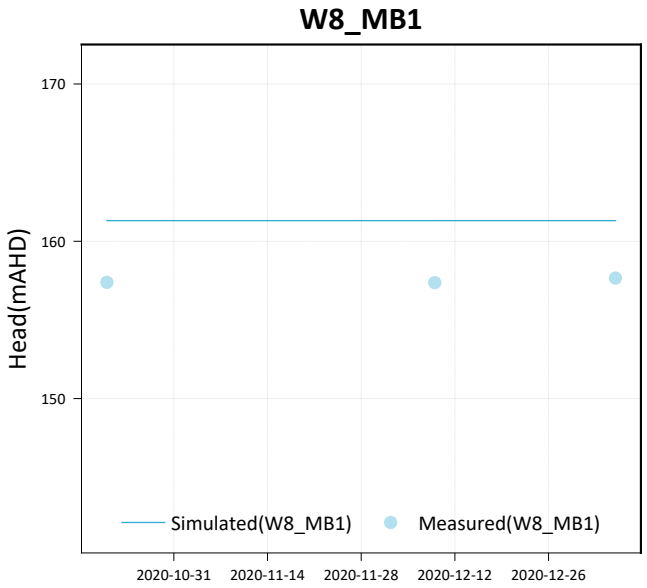

W5_MB2
Head(mAHD)
170
160
150
Simulated(W5_MB2)
Measured(W5_MB2)
2020-10-31
2020-11-14
2020-11-28
2020-12-12
2020-12-26

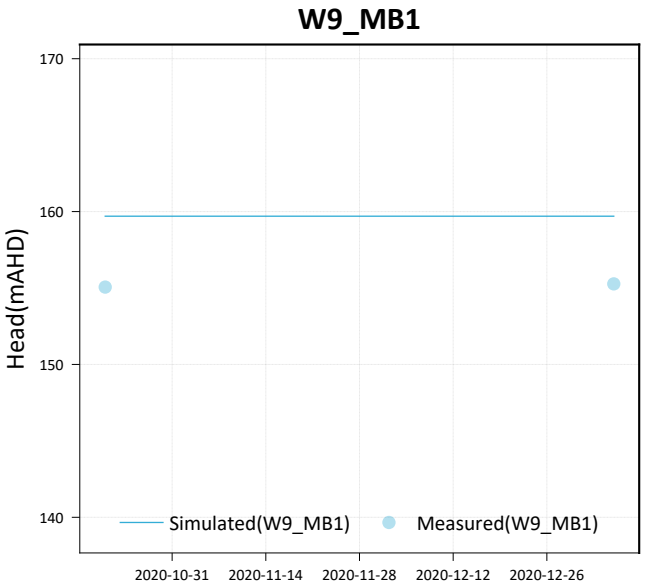

W5_MB3
Head(mAHD)
170
160
150
Simulated(W5_MB3)
Measured(W5_MB3)

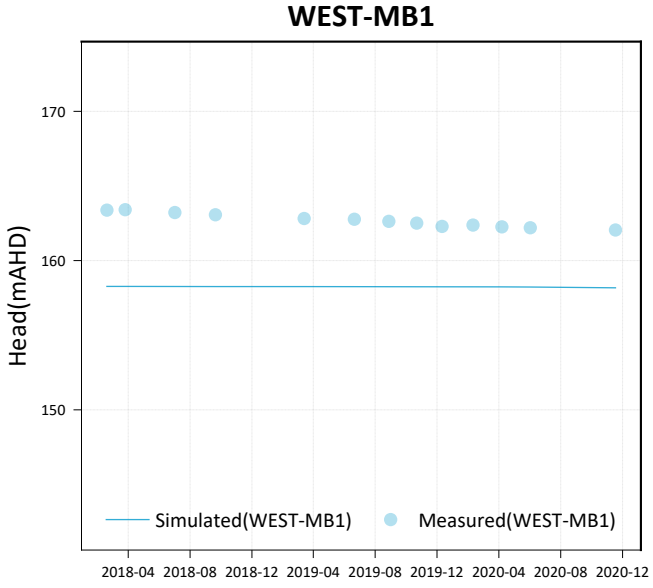

W6_MB1
Head(mAHD)
170
160
150
Simulated(W6_MB1)
Measured(W6_MB1)
2020-10-31
2020-11-14
2020-11-28
2020-12-12
2020-12-26

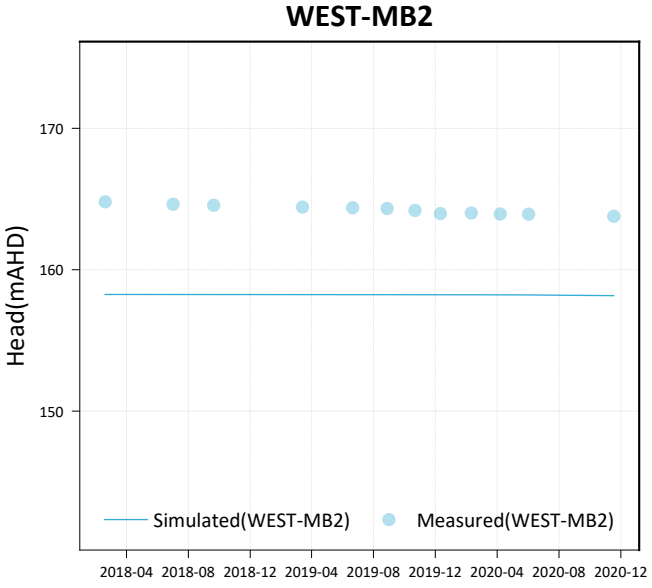

W6_MB2
Head(mAHD)
170
160
150
Simulated(W6_MB2)
Measured(W6_MB2)
2020-10-31
2020-11-14
2020-11-28
2020-12-12
2020-12-26

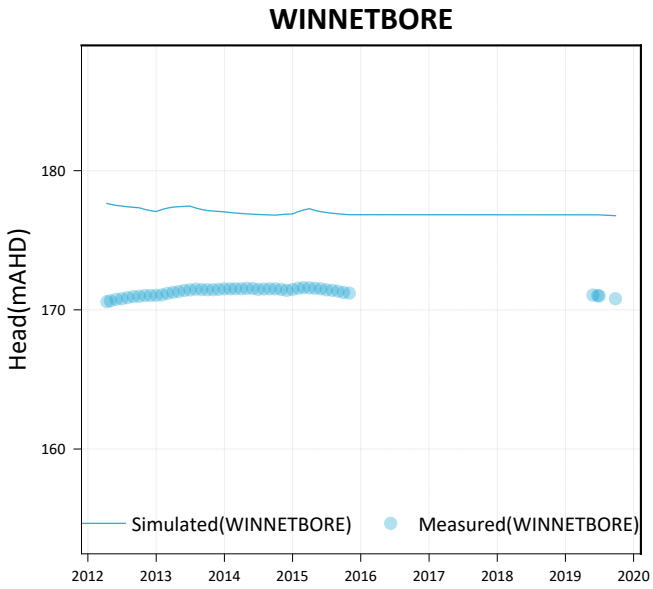

W7_MB1
Head(mAHD)
170
160
150
Simulated(W7_MB1)
Measured(W7_MB1)
2020-10-31
2020-11-14
2020-11-28
2020-12-12
2020-12-26


W8_MB1
Head(mAHD)
170
160
150
Simulated(W8_MB1)
Measured(W8_MB1)
2020-10-31
2020-11-14
2020-11-28
2020-12-12
2020-12-26


W9_MB1
Head(mAHD)
170
160
150
140
Simulated(W9_MB1)
Measured(W9_MB1)
2020-10-31
2020-11-14
2020-11-28
2020-12-12
2020-12-26


WEST-MB1
Head(mAHD)
170
160
150
Simulated(WEST-MB1)
Measured(WEST-MB1)
2018-04
2018-08
2018-12
2019-04
2019-08
2019-12
2020-04
2020-08
2020-12


WEST-MB2
Head(mAHD)
170
160
150
Simulated(WEST-MB2)
Measured(WEST-MB2)
2018-04
2018-08
2018-12
2019-04
2019-08
2019-12
2020-04
2020-08
2020-12


WINNETBORE
Head(mAHD)
180
170
160
Simulated(WINNETBORE)
Measured(WINNETBORE)
2012
2013
2014
2015
2016
2017
2018
2019
2020

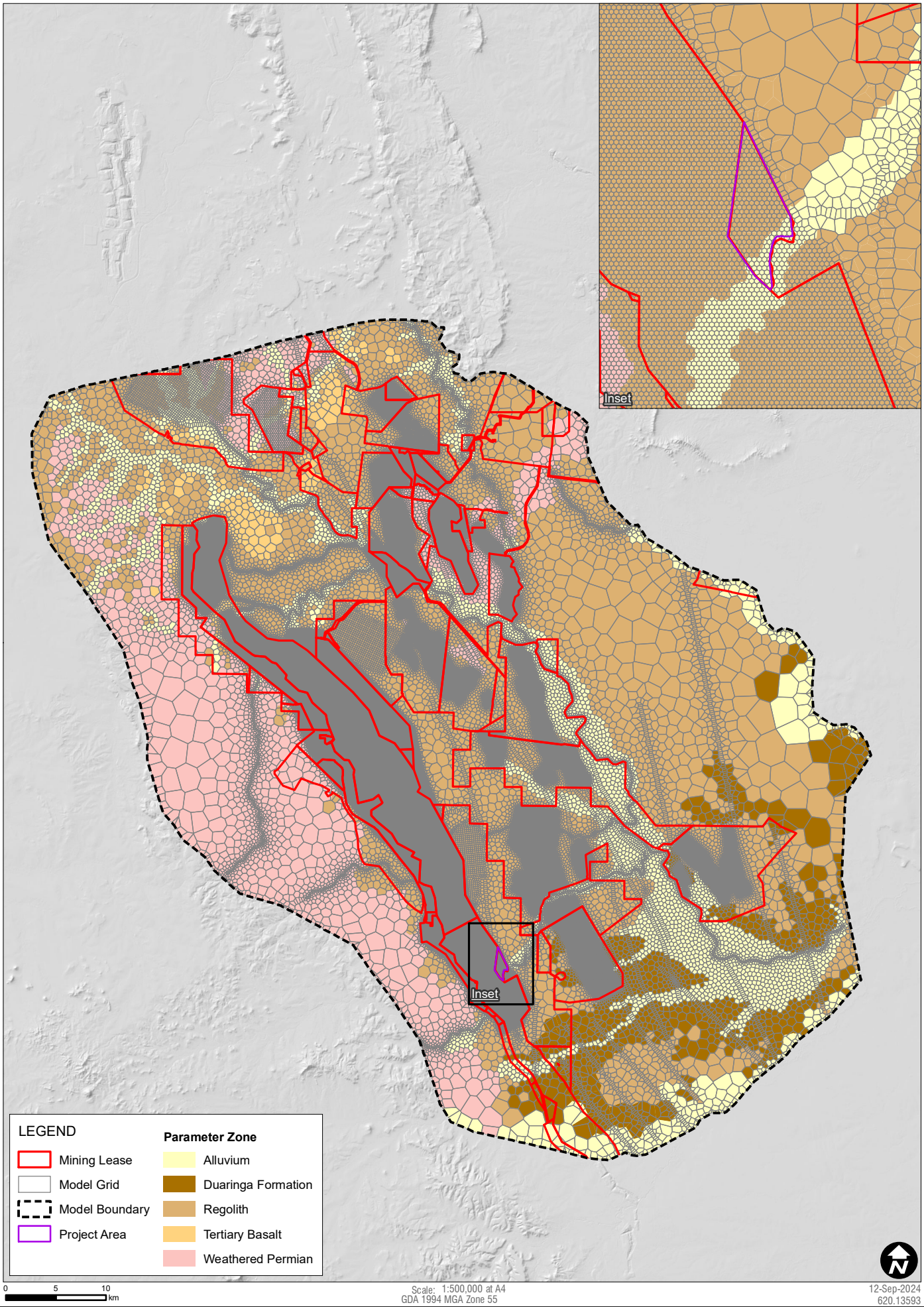
# Appendix C Hydraulic Parameters and Recharge Zone Distribution

**Groundwater Modelling Technical Report**

**Engeny on Behalf of BM Alliance Coal Operations Pty Ltd**

SLR Project No.: 620.040484.00000

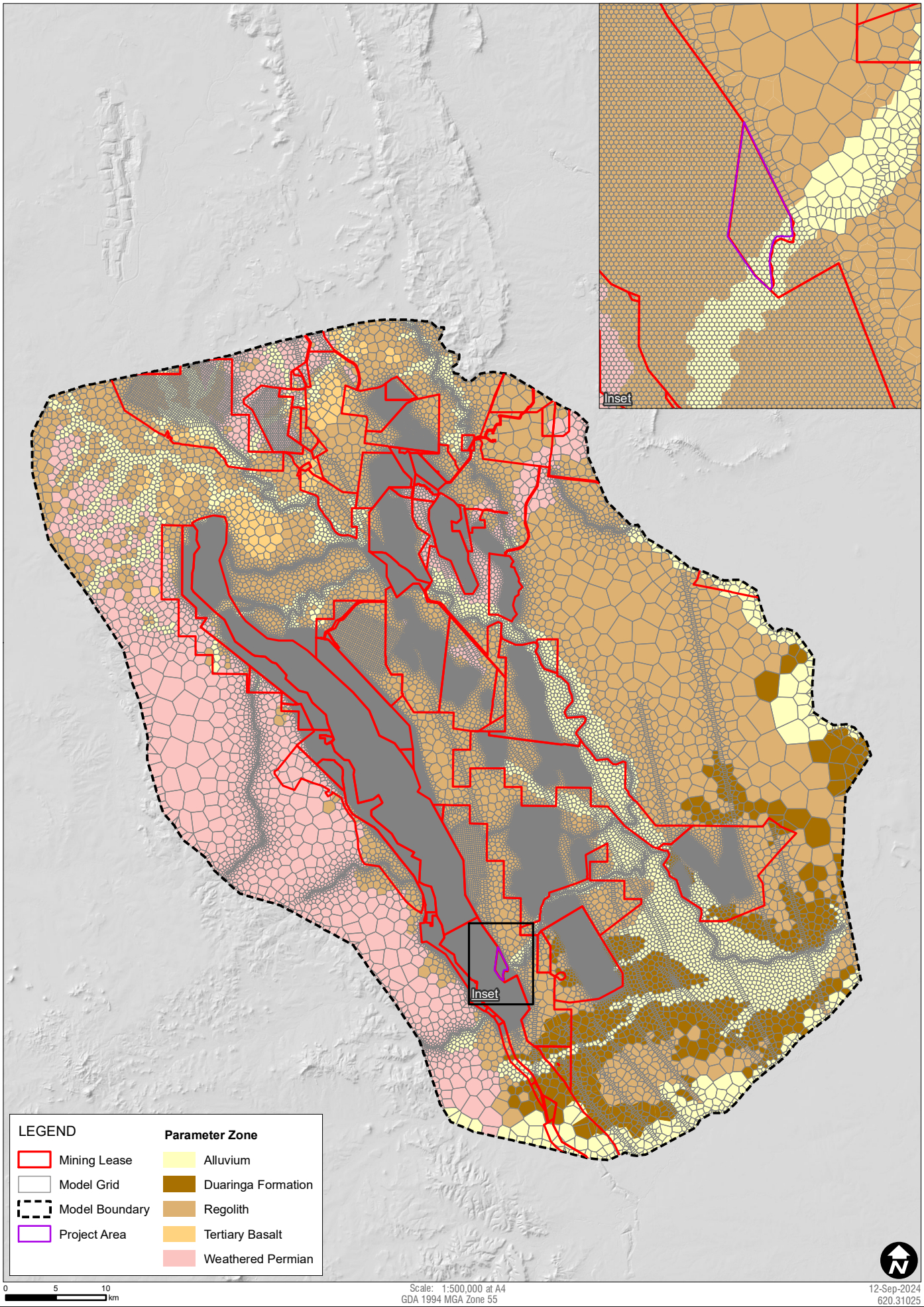
12 September 2024




SLR

**Hydraulic Parameter Zone Distribution Layer 1**

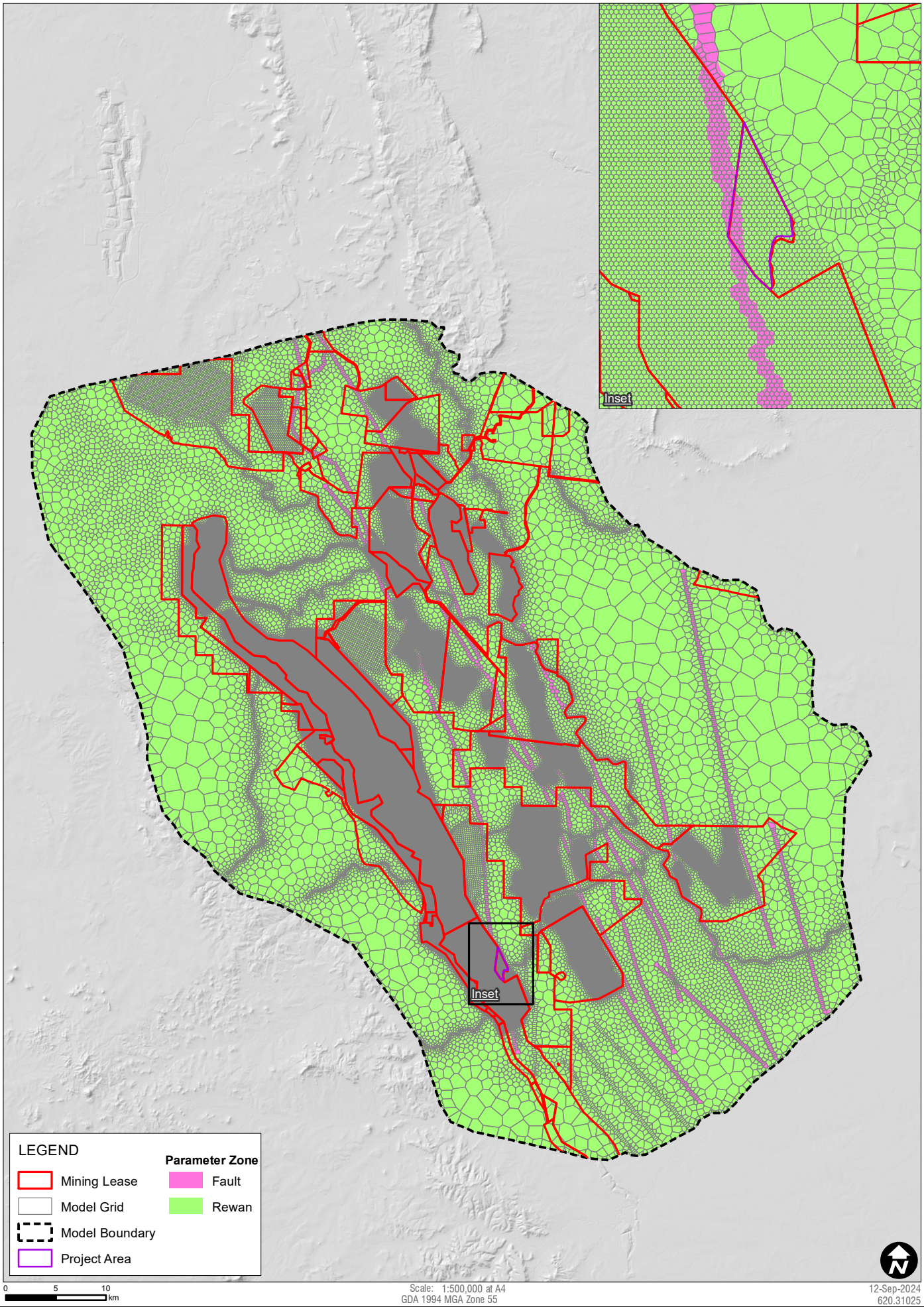
**FIGURE C-1**




SLR

**Hydraulic Parameter Zone Distribution Layer 2**

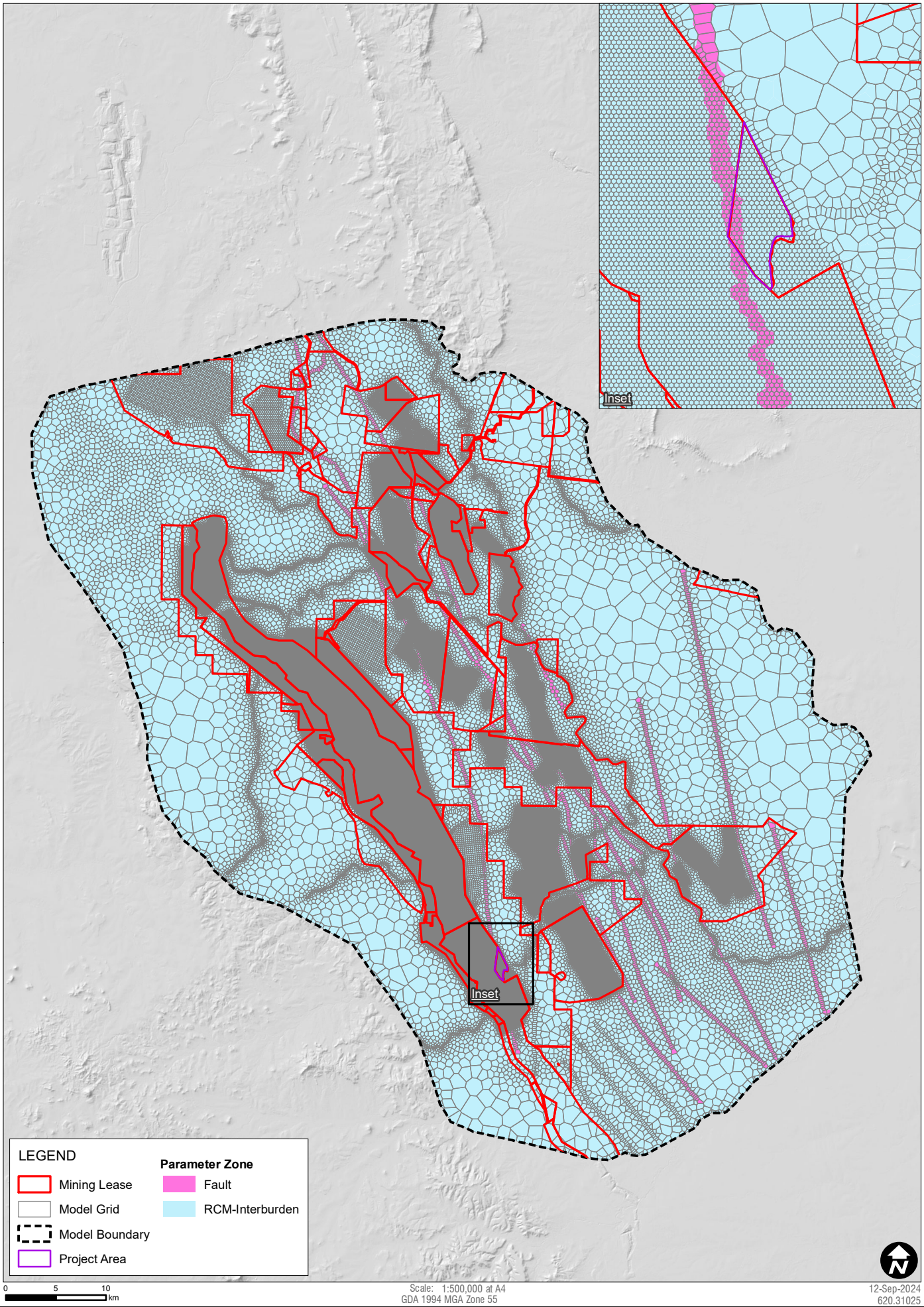
**FIGURE C-2**




SLR

**Hydraulic Parameter Zone Distribution Layer 3**

**FIGURE C-3**




H:\Projects-SLR\620-BNE\620-BNE\620.31025.00000 Saraji East GW Model\mg\03 SLR Data\01 CAD\GIS\GIS\620\31025 C-4 Hydraulic Zone L4.mxd

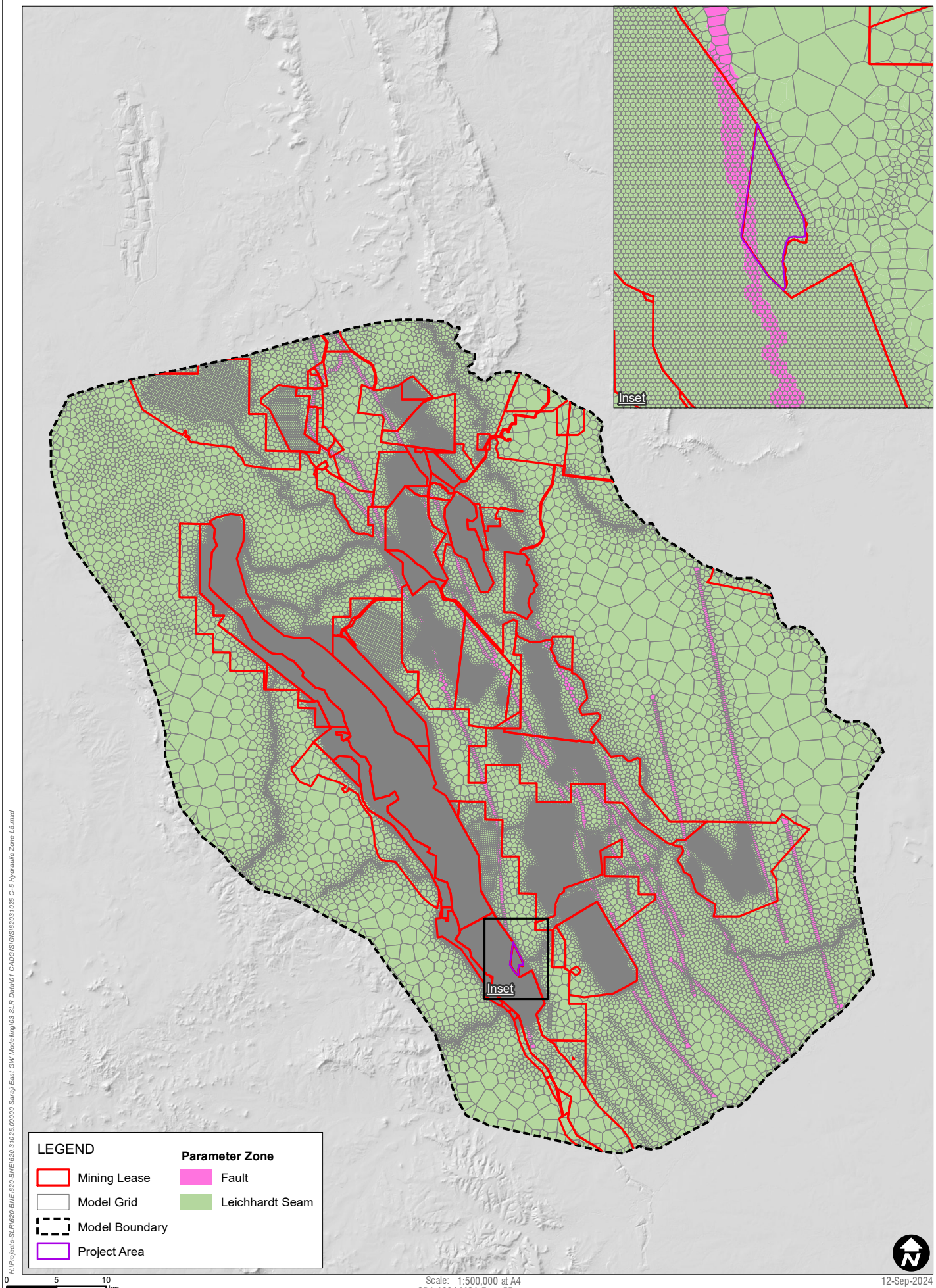
Scale: 1:500,000 at A4
GDA 1994 MGA Zone 55

12-Sep-2024
620.31025

SLR

**Hydraulic Parameter Zone Distribution Layer 4**

**FIGURE C-4**



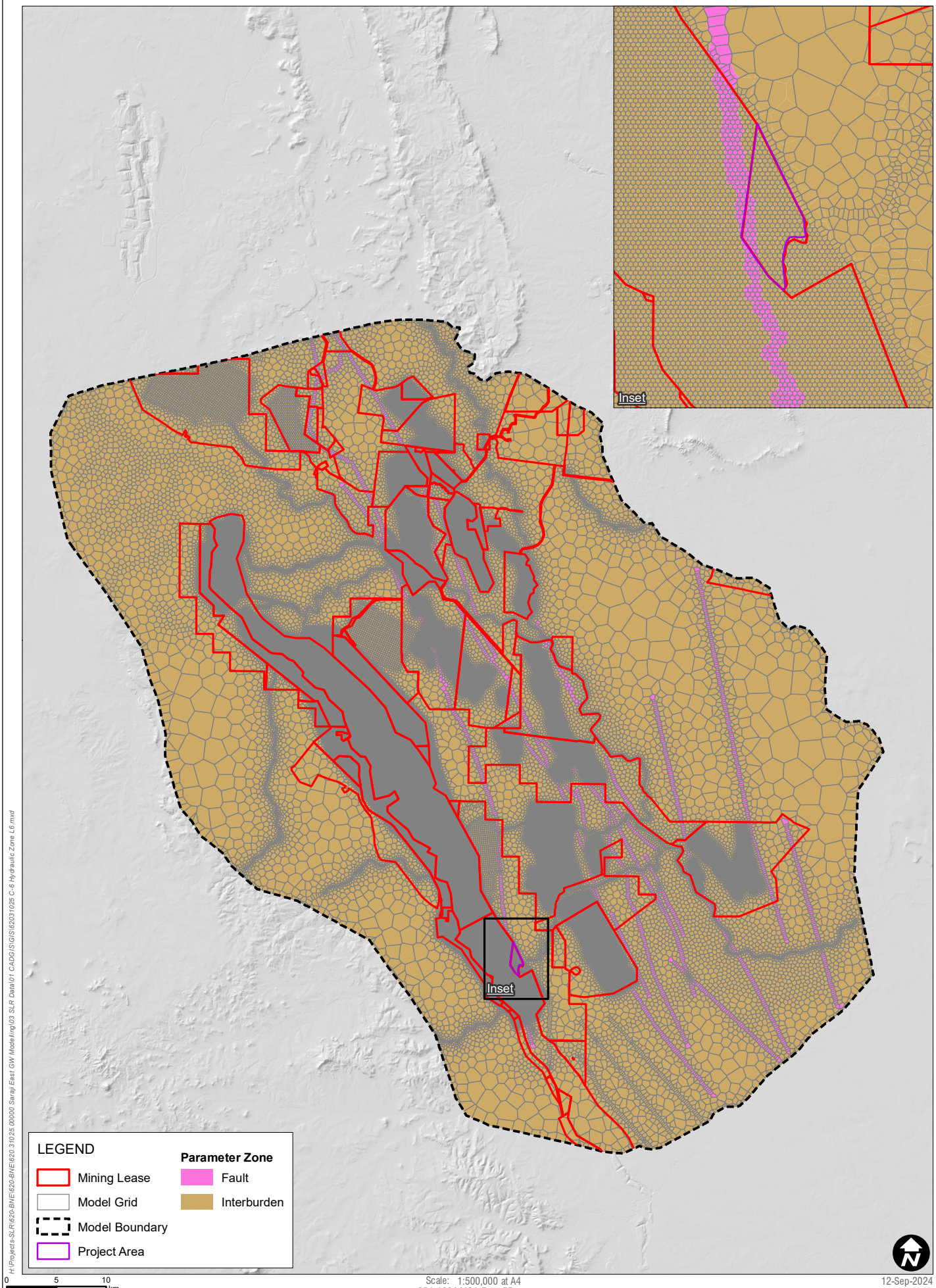

Scale: 1:500,000 at A4
GDA 1994 MGA Zone 55

12-Sep-2024
620.31025

SLR

**Hydraulic Parameter Zone Distribution Layer 5**

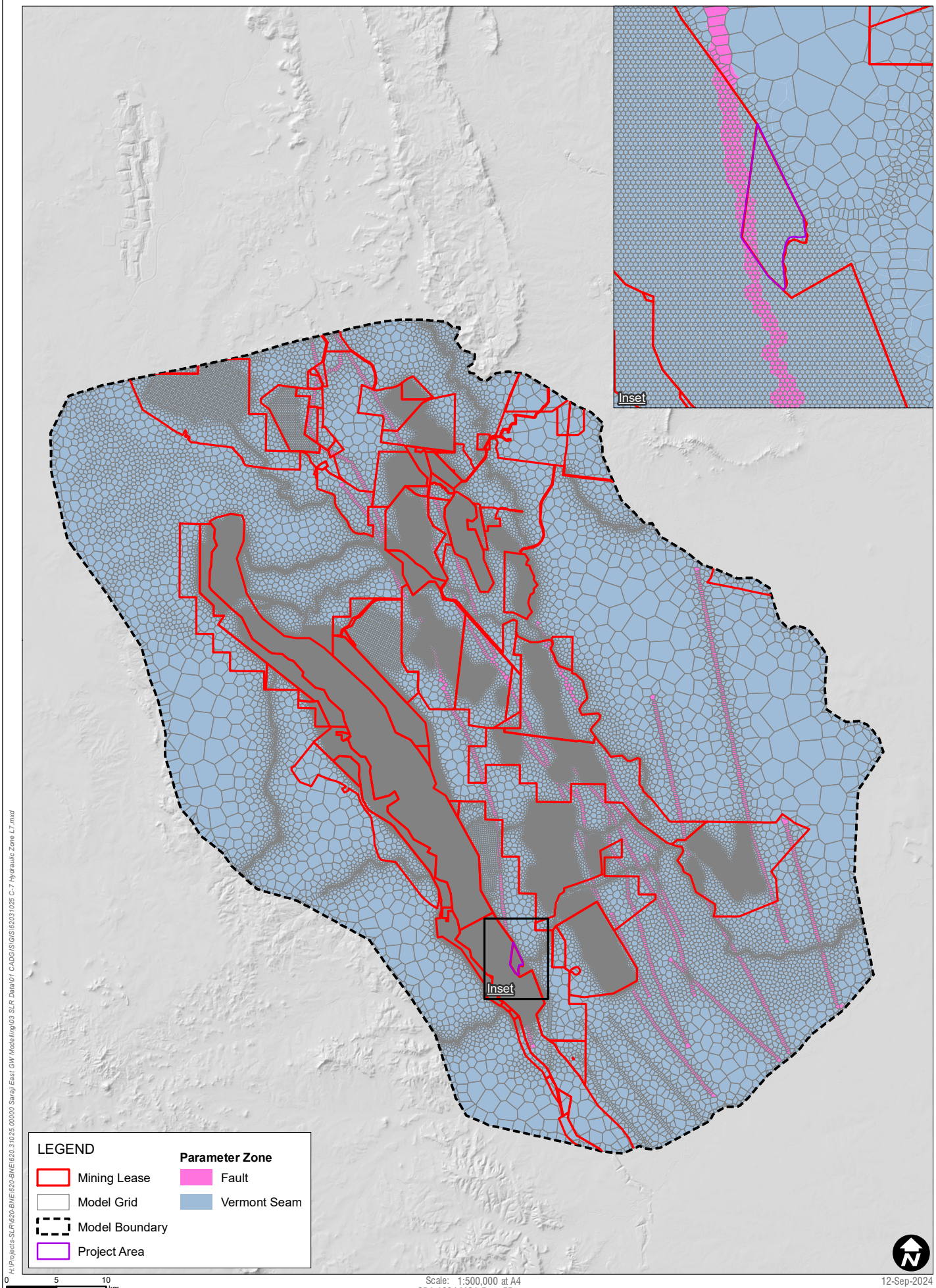
**FIGURE C-5**




SLR

**Hydraulic Parameter Zone Distribution Layer 6**

**FIGURE C-6**



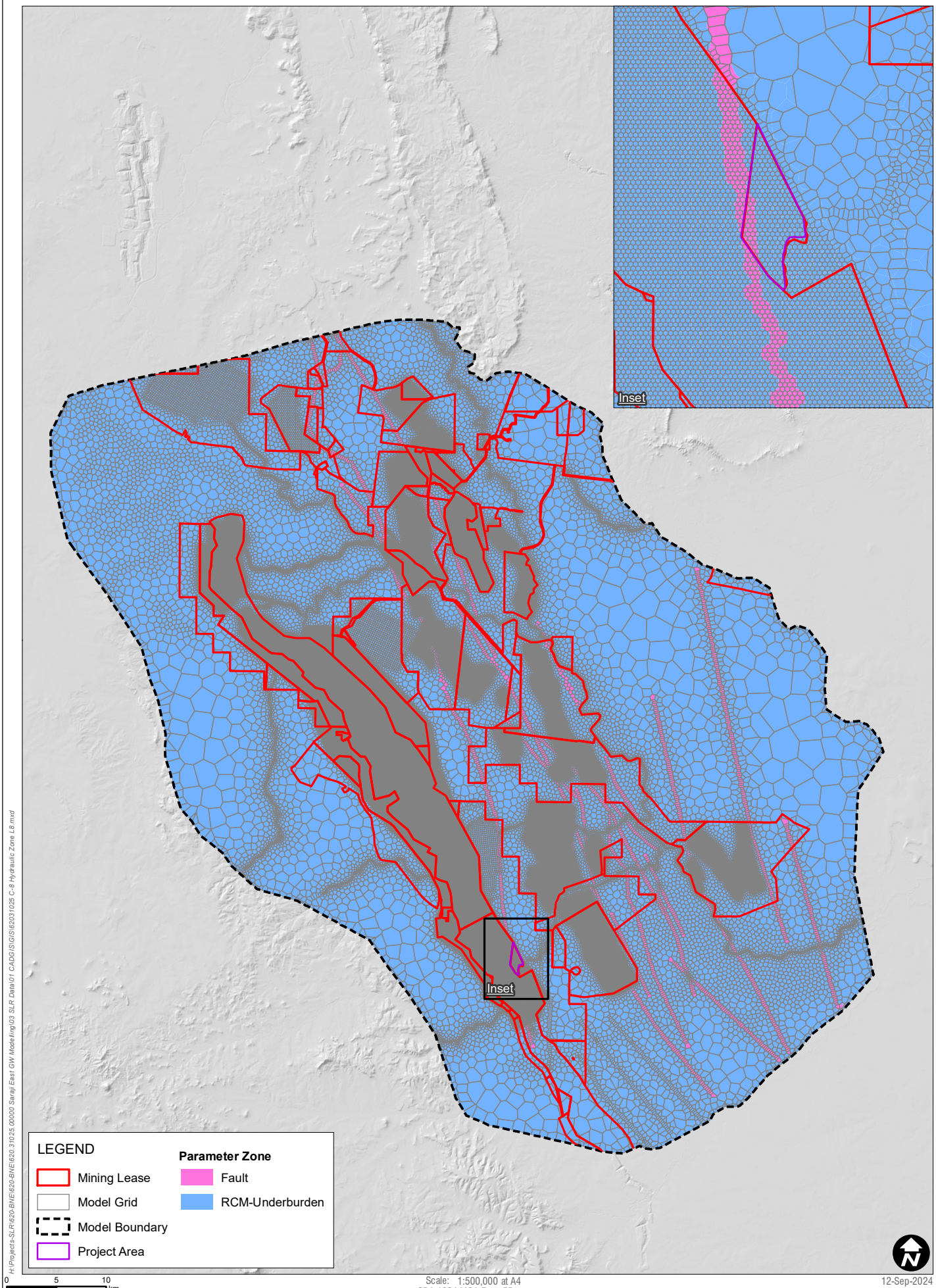

Scale: 1:500,000 at A4
GDA 1994 MGA Zone 55

12-Sep-2024
620.31025

SLR

**Hydraulic Parameter Zone Distribution Layer 7**

**FIGURE C-7**




H:\Projects-SLR\620-BNE\620-BNE\620.31025.00000 Saraji East GW Model\mg\03 SLR Data\01 CAD\GIS\GIS\620\31025 C-8 Hydraulic Zone L8.mxd

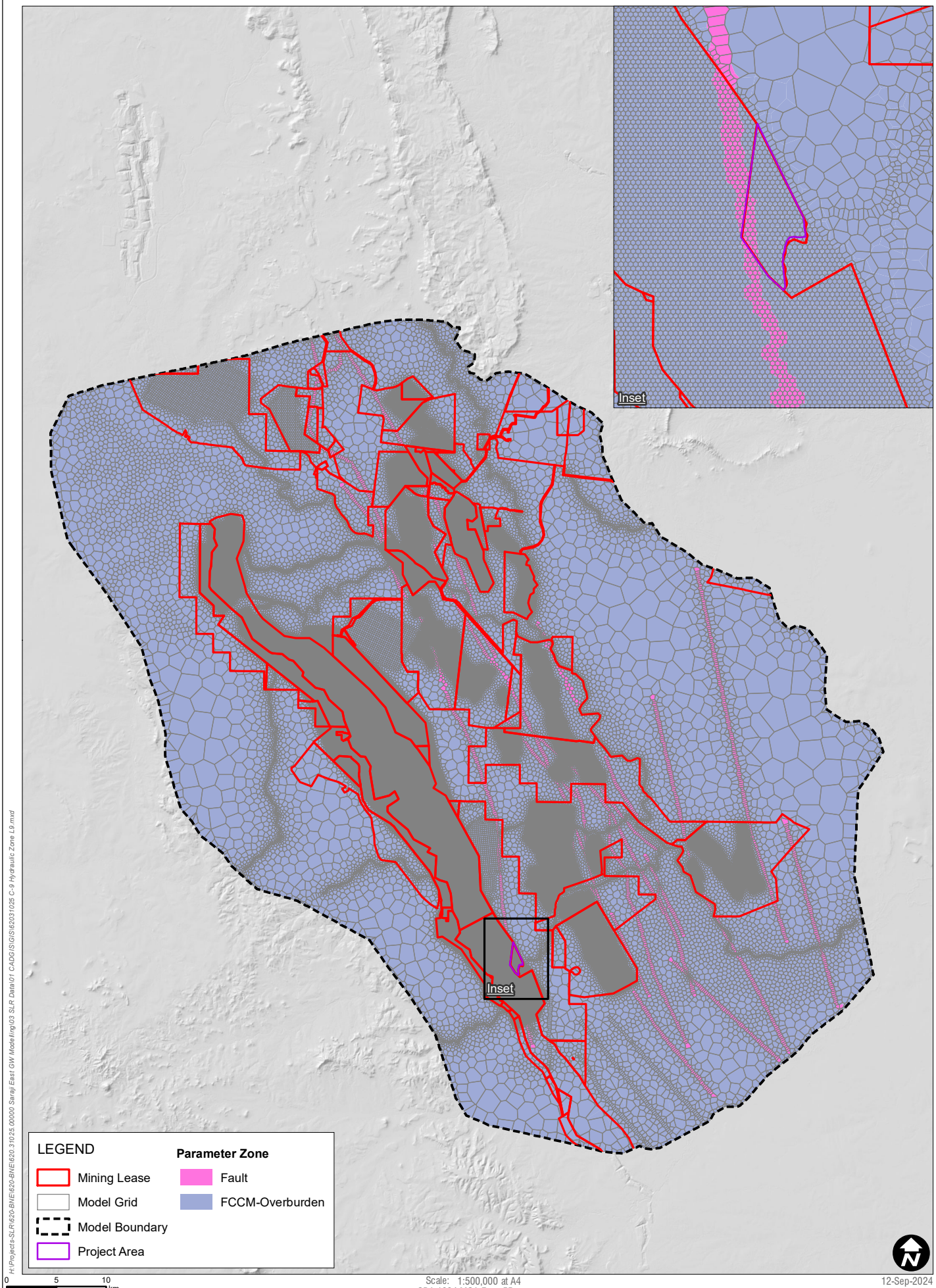
Scale: 1:500,000 at A4
GDA 1994 MGA Zone 55

12-Sep-2024
620.31025

SLR

**Hydraulic Parameter Zone Distribution Layer 8**

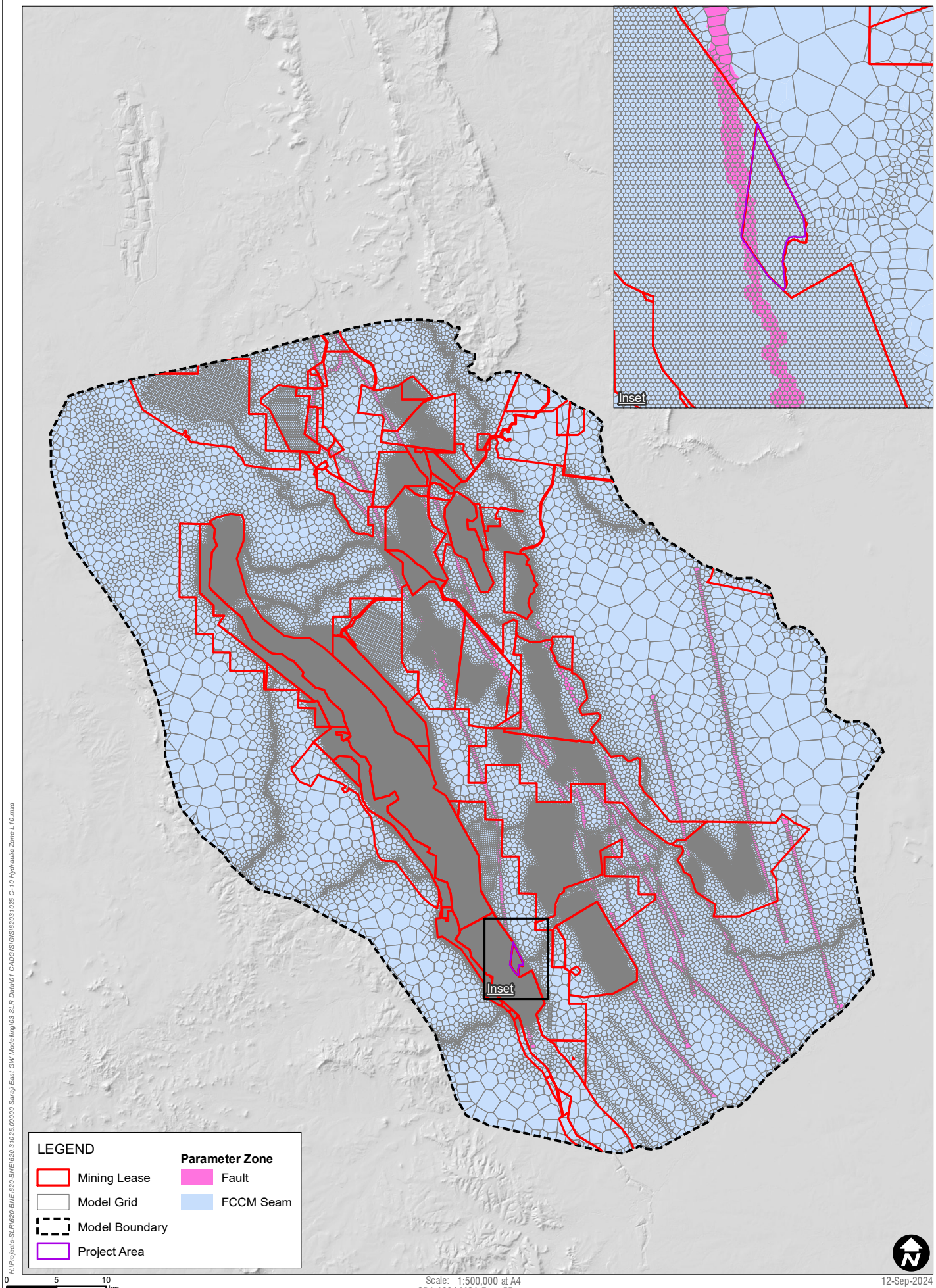
**FIGURE C-8**




SLR

**Hydraulic Parameter Zone Distribution Layer 9**

**FIGURE C-9**



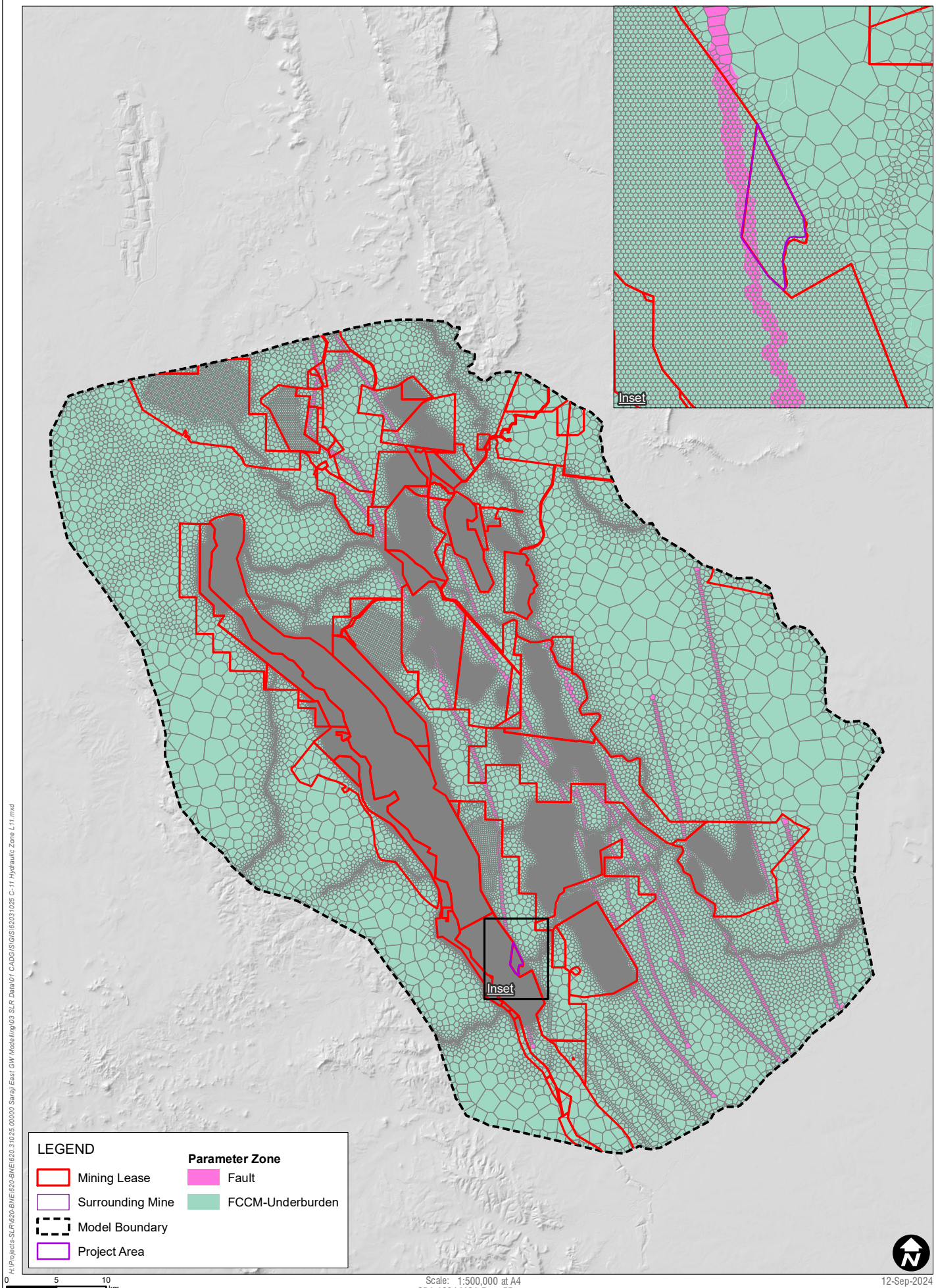

Scale: 1:500,000 at A4
GDA 1994 MGA Zone 55

12-Sep-2024
620.13593

SLR

**Hydraulic Parameter Zone Distribution Layer 10**

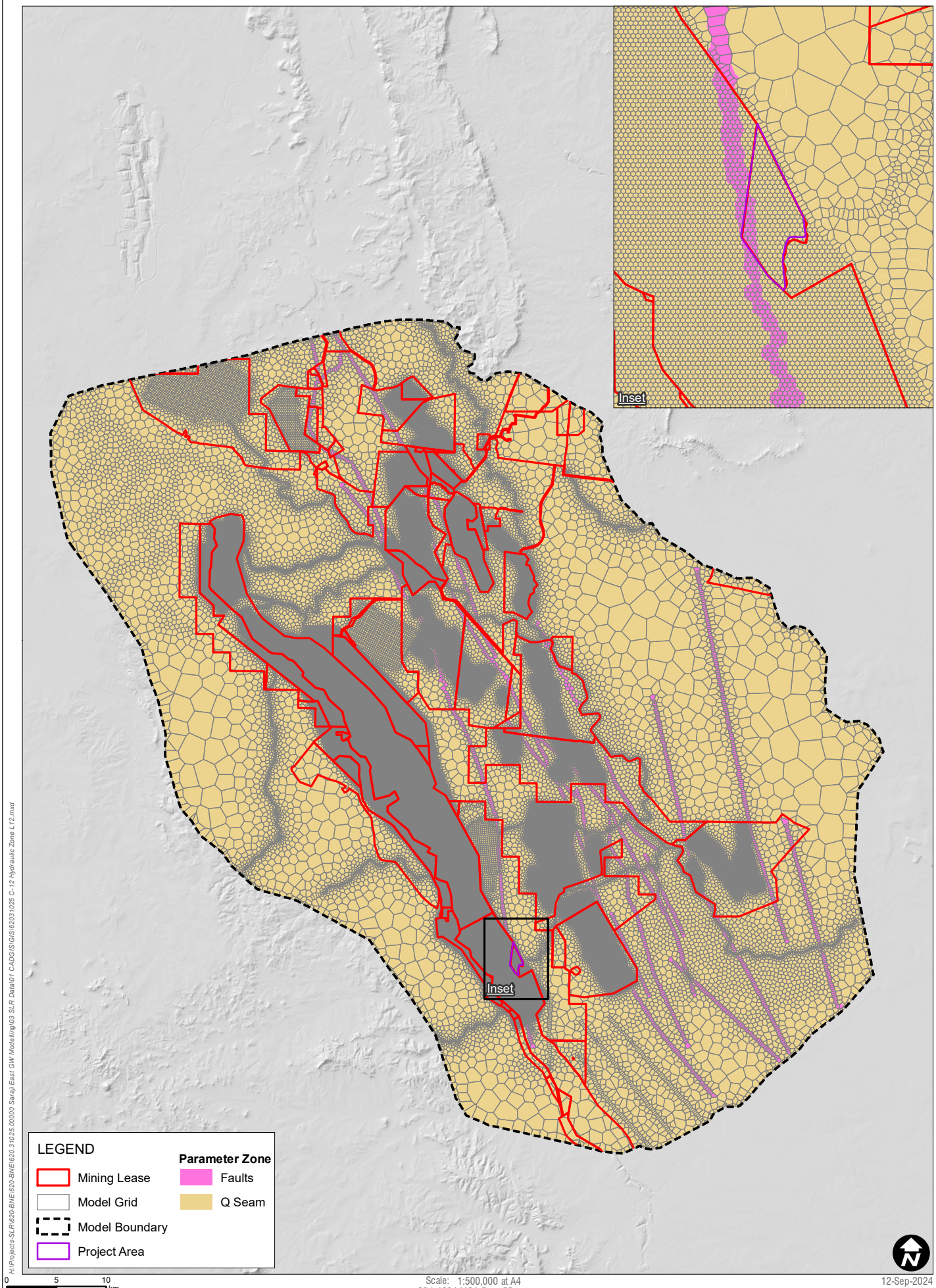
**FIGURE C-10**




SLR

**Hydraulic Parameter Zone Distribution Layer 11**

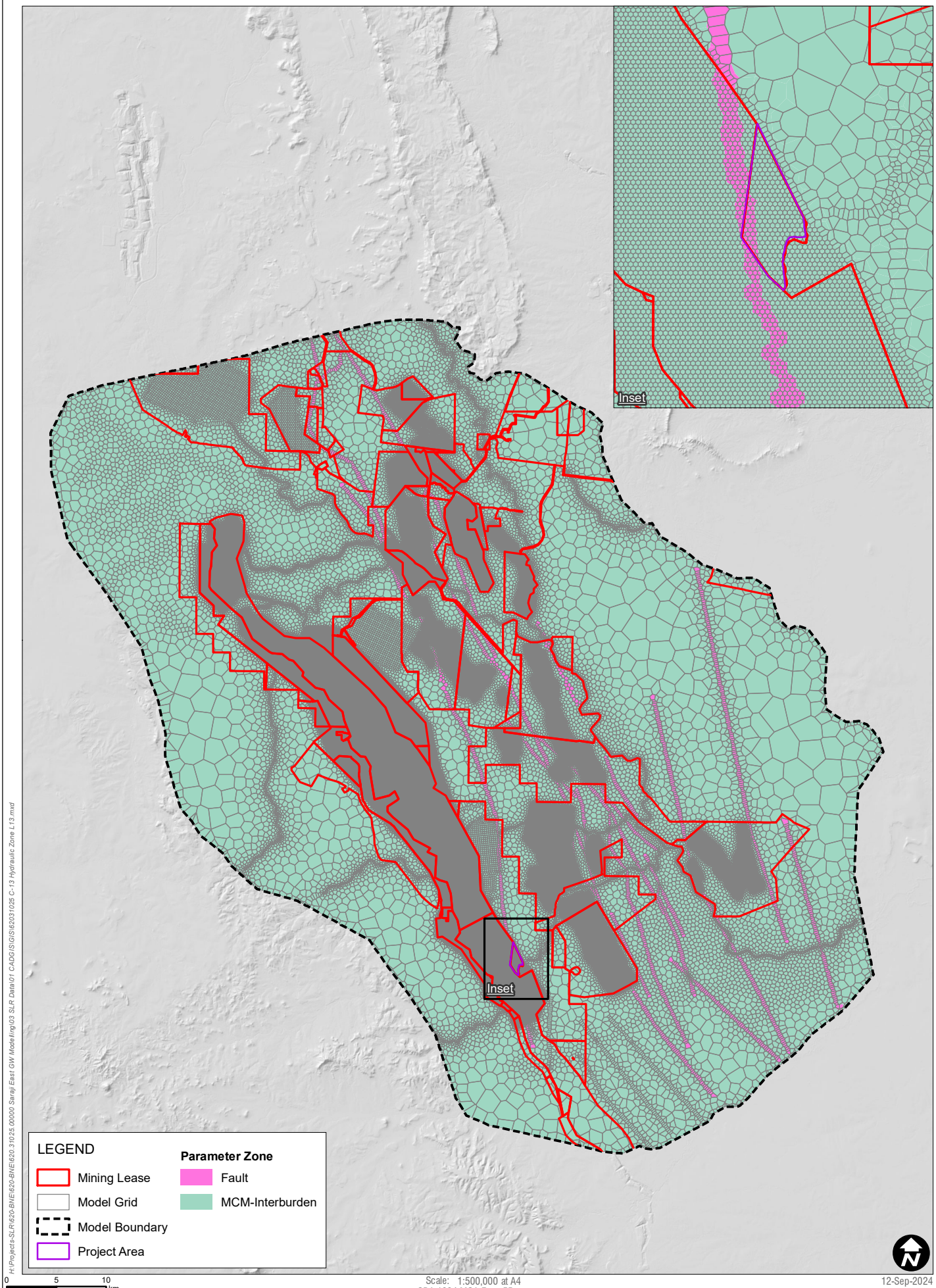
**FIGURE C-11**




SLR

**Hydraulic Parameter Zone Distribution Layer 12**

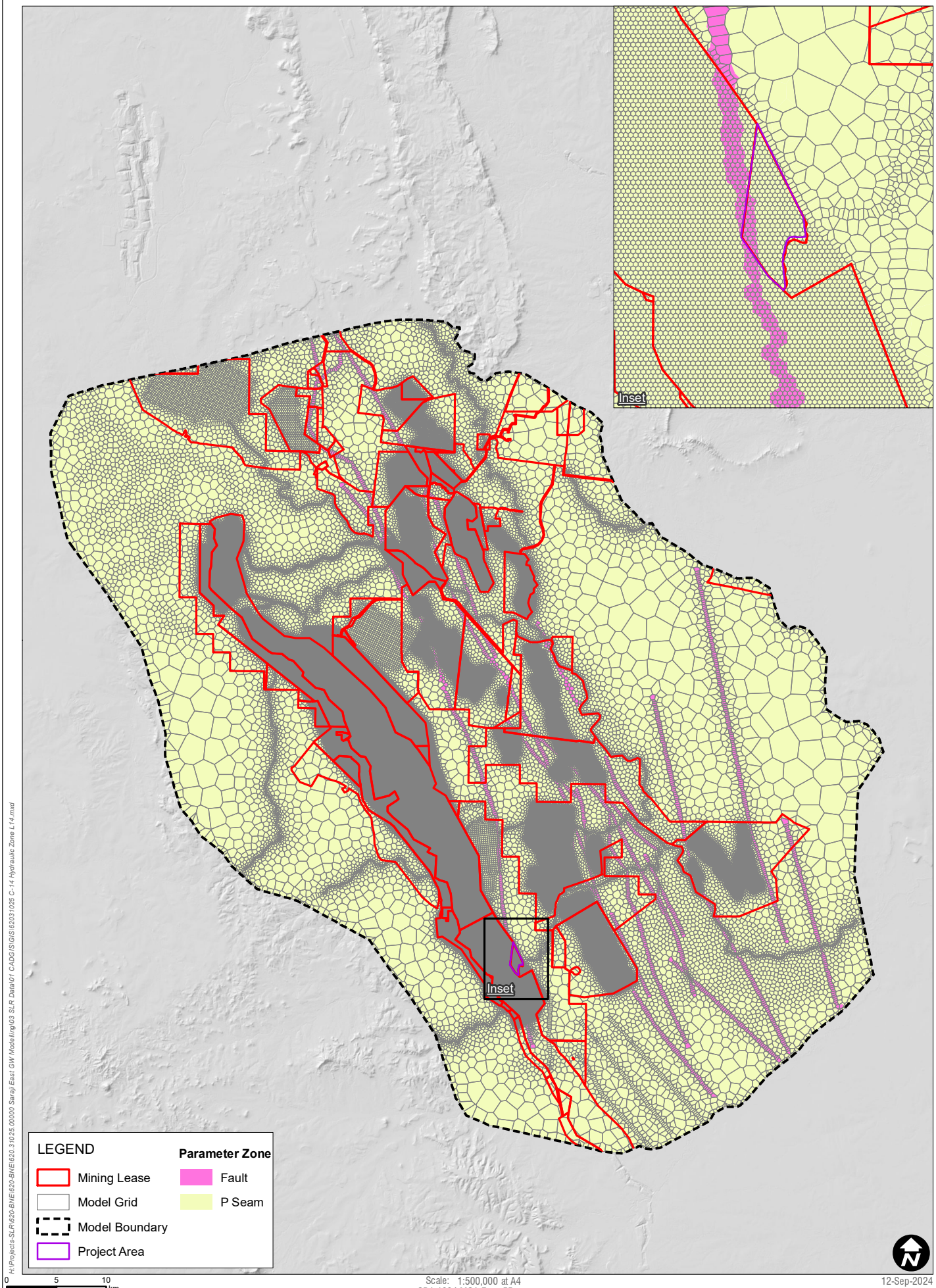
**FIGURE C-12**




SLR

**Hydraulic Parameter Zone Distribution Layer 13**

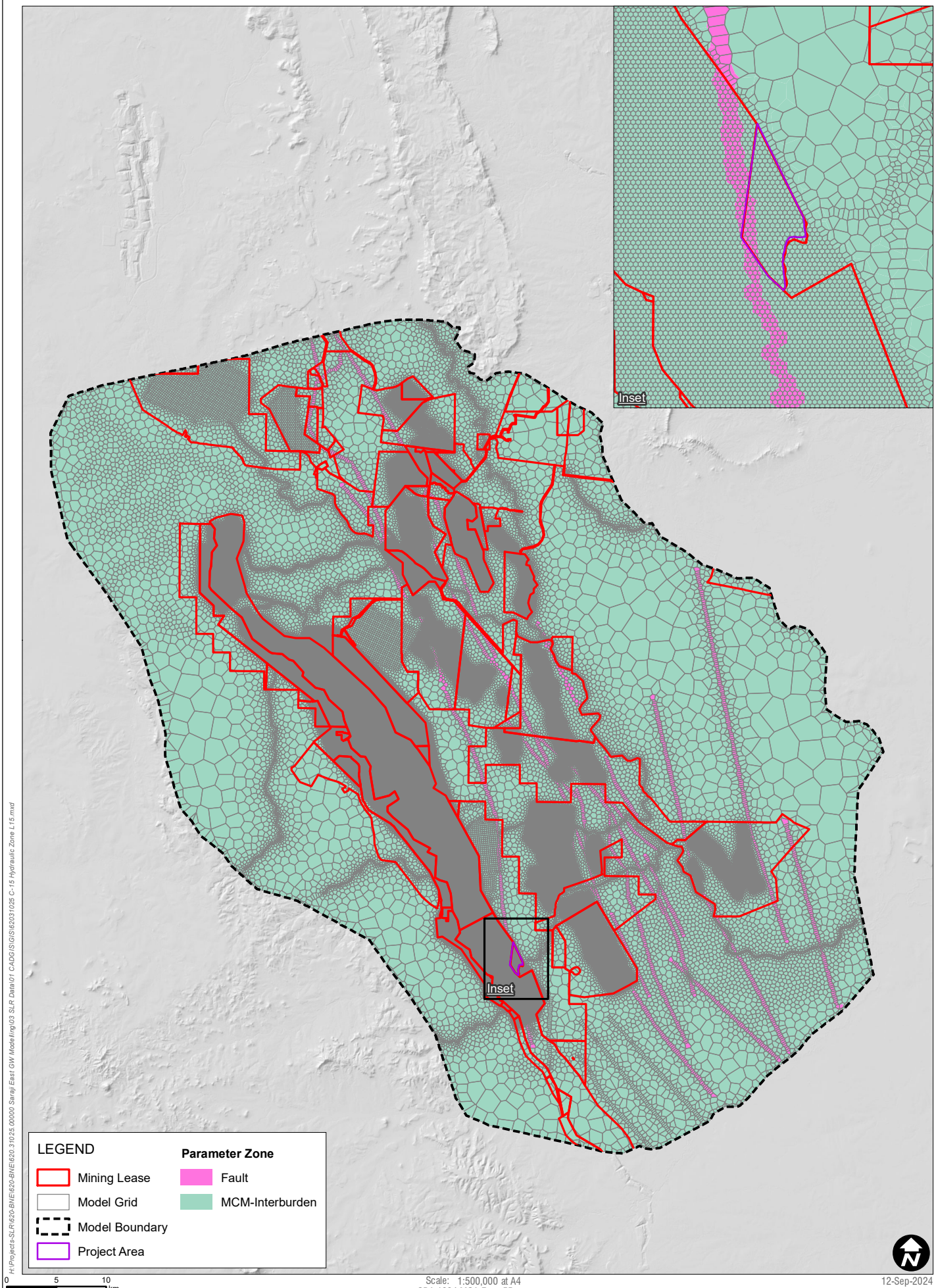
**FIGURE C-13**




SLR

**Hydraulic Parameter Zone Distribution Layer 14**

**FIGURE C-14**



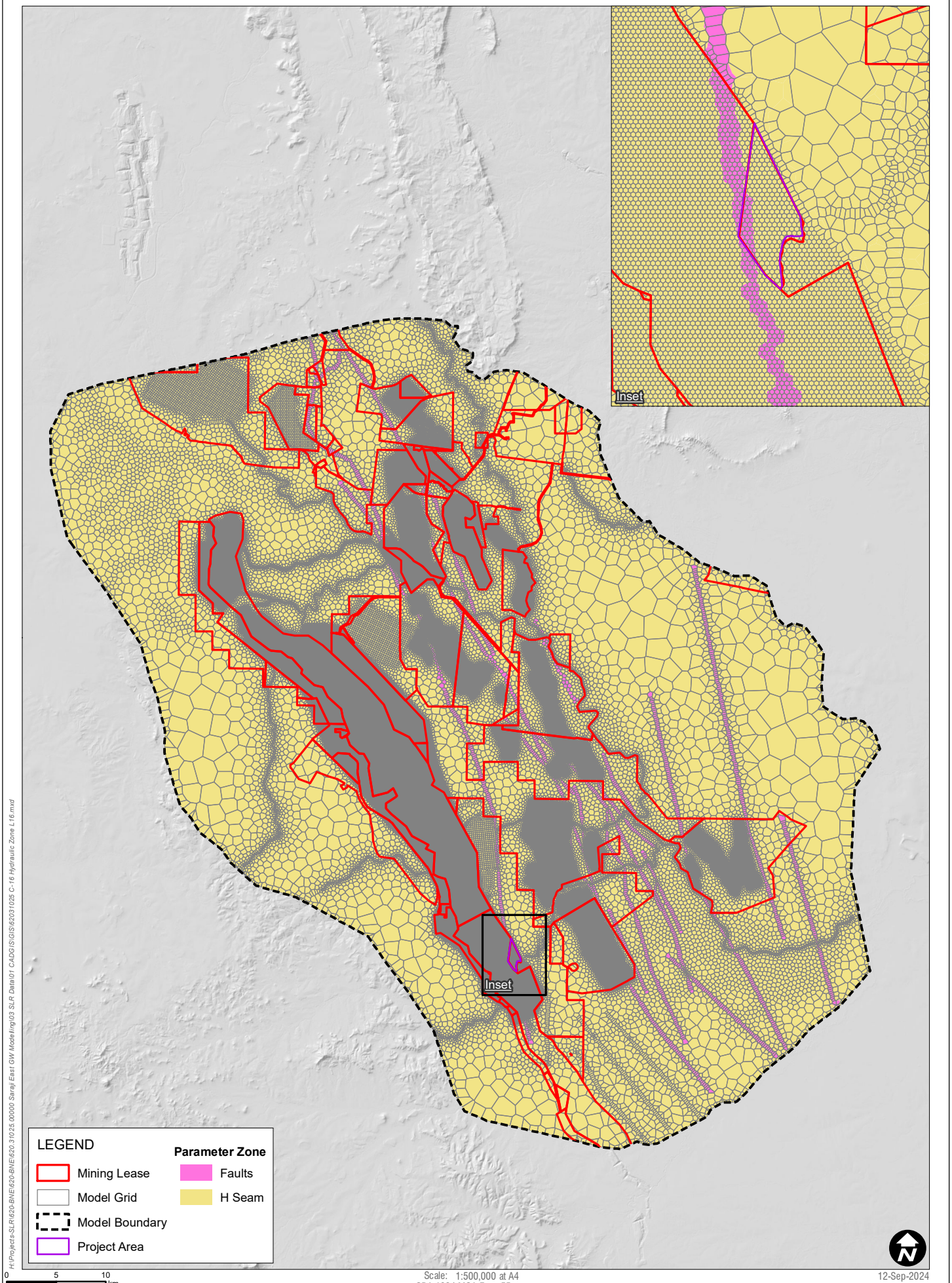

Scale: 1:500,000 at A4
GDA 1994 MGA Zone 55

12-Sep-2024
620.31025

SLR

**Hydraulic Parameter Zone Distribution Layer 15**

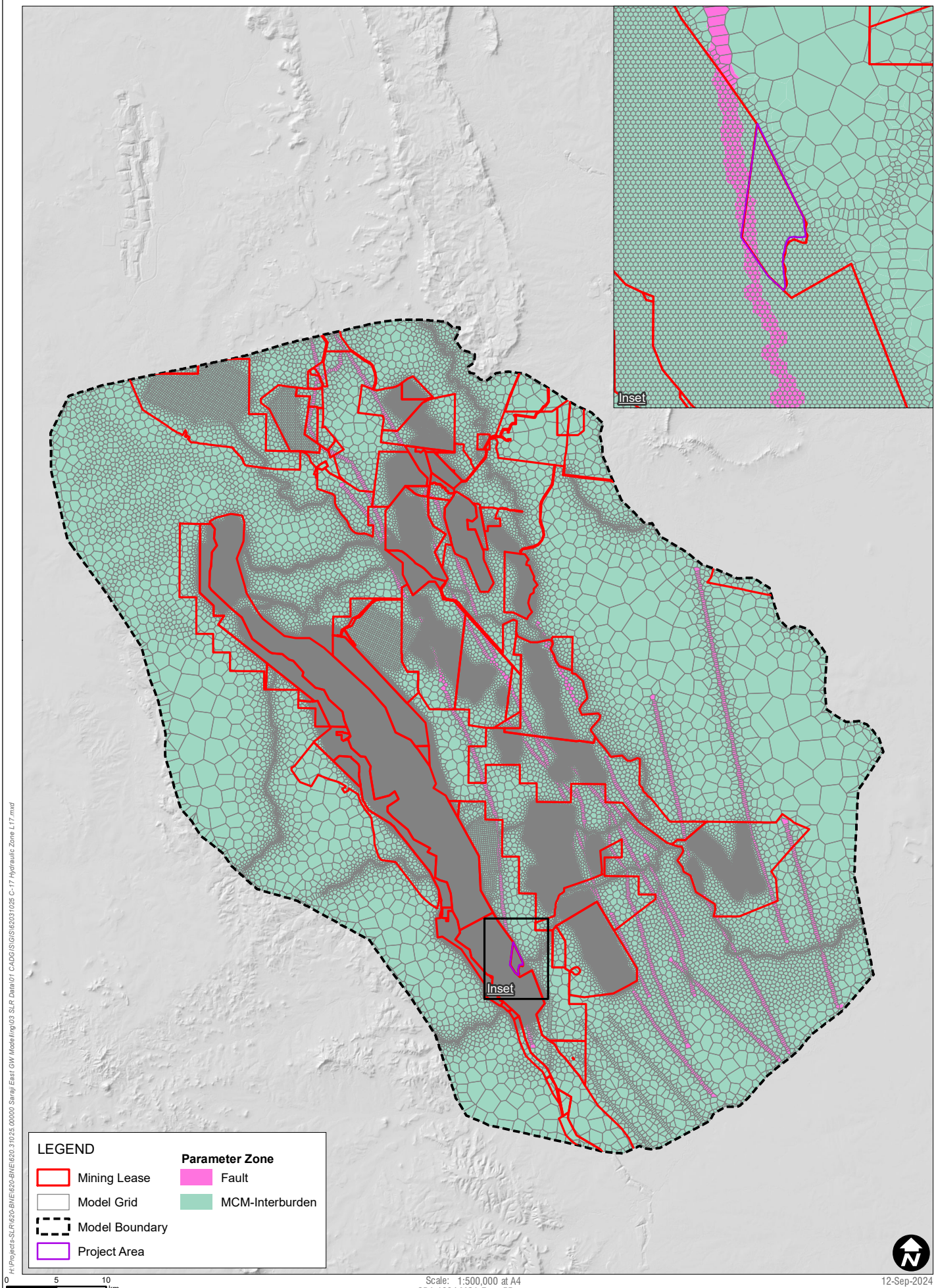
**FIGURE C-15**




SLR

**Hydraulic Parameter Zone Distribution Layer 16**

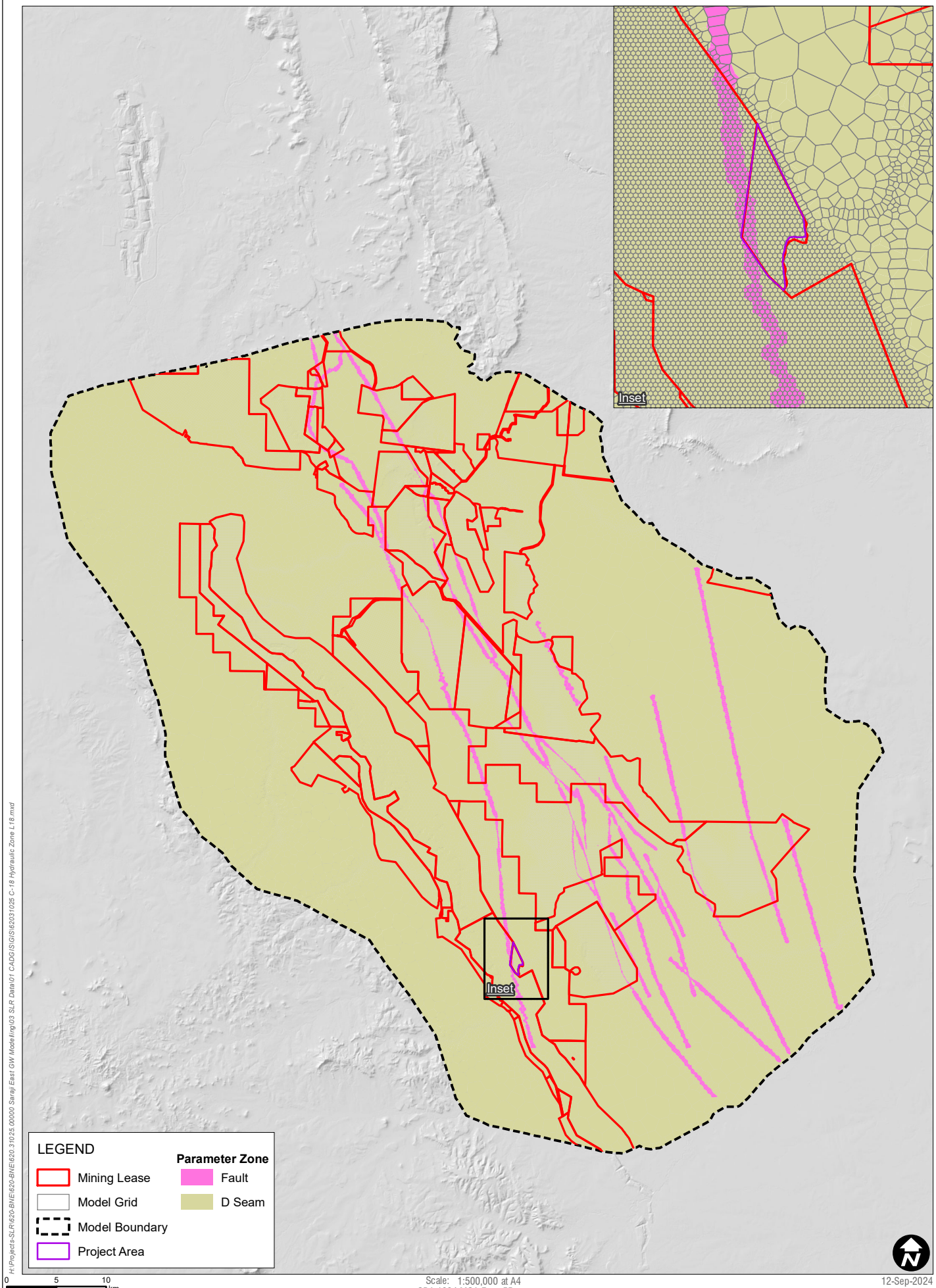
**FIGURE C-16**




SLR

**Hydraulic Parameter Zone Distribution Layer 17**

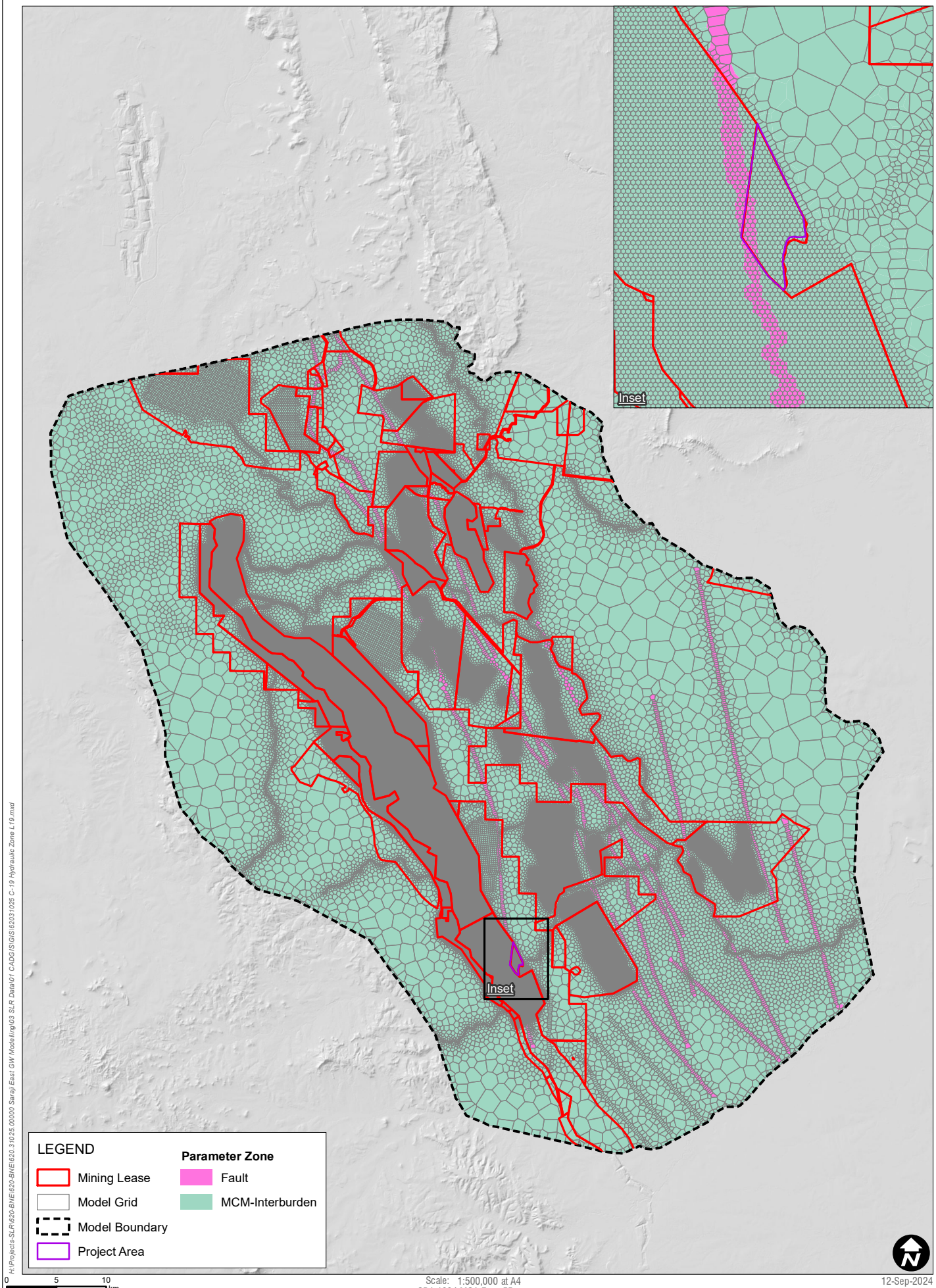
**FIGURE C-17**




SLR

**Hydraulic Parameter Zone Distribution Layer 18**

**FIGURE C-18**



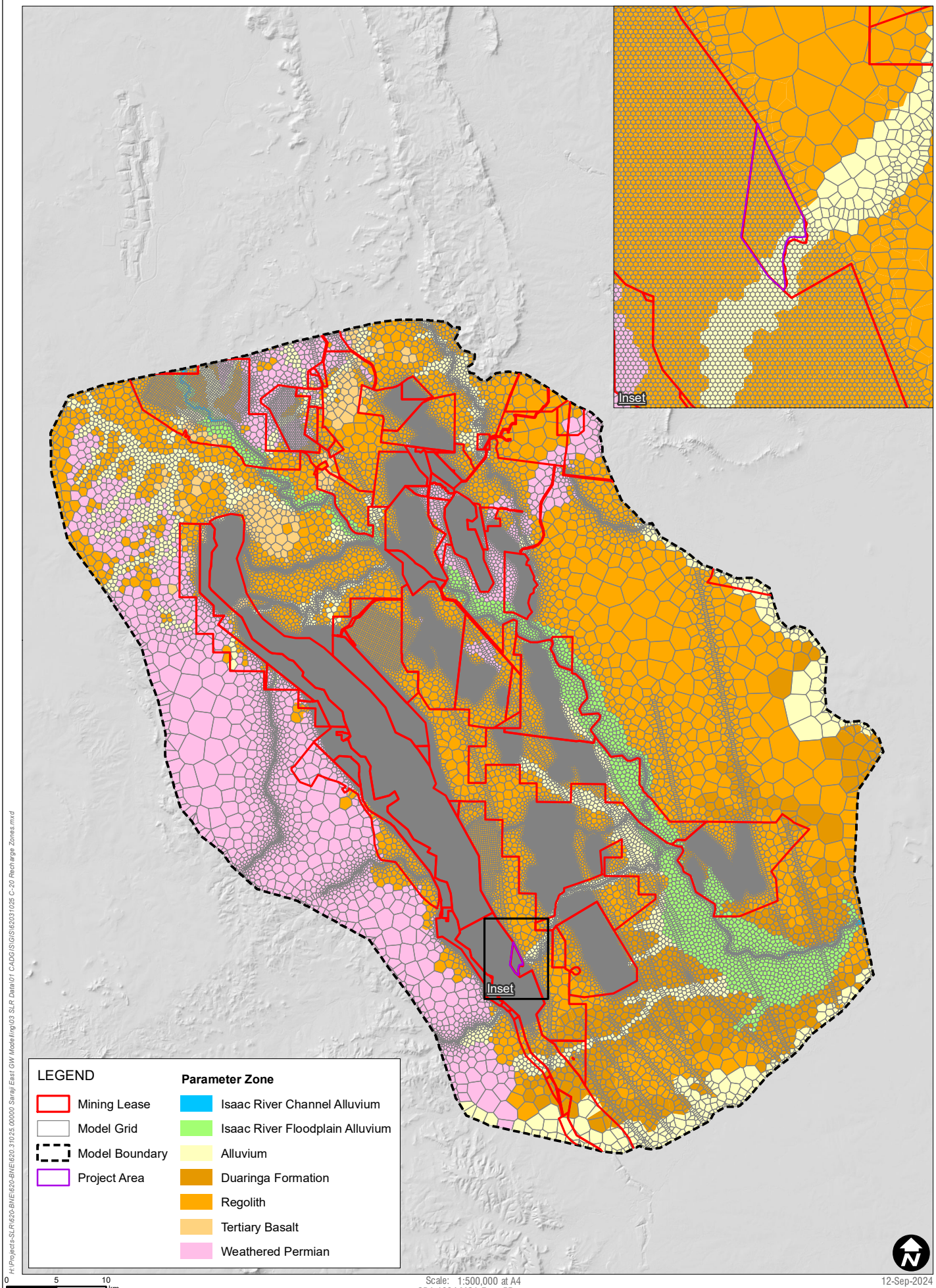

Scale: 1:500,000 at A4
GDA 1994 MGA Zone 55

12-Sep-2024
620.31025

SLR

**Hydraulic Parameter Zone Distribution Layer 19**

**FIGURE C-19**




H:\Projects-SLR\620-BNE\620-BNE\620.31025.00000 Saraji East GW Model\rpt\03 SLR Data\01 CAD\GIS\GIS\620\31025 C-20 Recharge Zones.mxd

Scale: 1:500,000 at A4
GDA 1994 MGA Zone 55

12-Sep-2024
620.31025

SLR

## Recharge Zone Distribution

FIGURE C-20

# Appendix D Stress Periods and Simulated Active Mine Timings

**Groundwater Modelling Technical Report**

**Engeny on Behalf of BM Alliance Coal Operations Pty Ltd**

SLR Project No.: 620.040484.00000

12 September 2024

| Calibration Period | Interval | Stress Period | Date (from) | Date (to) | Moorvale South (OC) | CVM (OC) | Peak Downs (OC) | Saraji (OC) | Saraji (UG) | Grosvenor (UG) | Poitrel (OC) | Winchester South (OC) | Daunia (OC) | Millennium (OC) | Isaac Plains (OC) | Olive Downs (OC) | Eagle Downs (UG) | Lake Vermont (OC) | Lake Vermont North (OC) | Grev (OC) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Steady state | | 1 | Steady state | | | | | | | | | | | | | | | | | |
| Warm-up | 20 Years | 2 | Transient Warm up | | | | | x | | | x | | | x | | | | | | |
| Calibration | Quarterly | 3 | 01-01-2008 | 01-04-2008 | | | | x | | | x | | | x | x | | | | | |
| | Quarterly | 4 | 01-04-2008 | 01-07-2008 | | | | x | | | x | | | x | x | | | | | |
| | Quarterly | 5 | 02-07-2008 | 01-10-2008 | | | | x | | | x | | | x | x | | | | | |
| | Quarterly | 6 | 01-10-2008 | 31-12-2008 | | | | x | | | x | | | x | x | | | | | |
| | Quarterly | 7 | 31-12-2008 | 01-04-2009 | | | | x | | | x | | | x | x | | | x | | |
| | Quarterly | 8 | 02-04-2009 | 02-07-2009 | | | | x | | | x | | | x | x | | | x | | |
| | Quarterly | 9 | 02-07-2009 | 01-10-2009 | | | | x | | | x | | | x | x | | | x | | |
| | Quarterly | 10 | 01-10-2009 | 31-12-2009 | | | | x | | | x | | | x | x | | | x | | |
| | Quarterly | 11 | 01-01-2010 | 02-04-2010 | | | x | x | | | x | | | x | x | | | x | | |
| | Quarterly | 12 | 02-04-2010 | 02-07-2010 | | | x | x | | | x | | | x | x | | | x | | |
| | Quarterly | 13 | 02-07-2010 | 01-10-2010 | | | x | x | | | x | | | x | x | | | x | | |
| | Quarterly | 14 | 01-10-2010 | 31-12-2010 | | | x | x | | | x | | | x | x | | | x | | |
| | Quarterly | 15 | 01-01-2011 | 02-04-2011 | | | x | x | | | x | | | x | x | | | x | | |
| | Quarterly | 16 | 02-04-2011 | 02-07-2011 | | | x | x | | | x | | | x | x | | | x | | |
| | Quarterly | 17 | 02-07-2011 | 01-10-2011 | | | x | x | | | x | | | x | x | | | x | | |
| | Quarterly | 18 | 02-10-2011 | 01-01-2012 | | | x | x | | | x | | | x | x | | | x | | |
| | Quarterly | 19 | 01-01-2012 | 01-04-2012 | | | x | x | | | x | | | x | x | | | x | | |
| | Quarterly | 20 | 01-04-2012 | 01-07-2012 | | | x | x | | | x | | | x | x | | | x | | |
| | Quarterly | 21 | 02-07-2012 | 01-10-2012 | | | x | x | | | x | | | x | x | | | x | | |

| Calibration Period | Interval | Stress Period | Date (from) | Date (to) | Moorvale South (OC) | CVM (OC) | Peak Downs (OC) | Saraji (OC) | Saraji (UG) | Grosvenor (UG) | Poitrel (OC) | Winchester South (OC) | Daunia (OC) | Millennium (OC) | Isaac Plains (OC) | Olive Downs (OC) | Eagle Downs (UG) | Lake Vermont (OC) | Lake Vermont North (OC) | Grev (OC) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Quarterly | 22 | 01-10-2012 | 31-12-2012 | | | x | x | | | x | | | x | x | | | x | | |
| | Quarterly | 23 | 31-12-2012 | 01-04-2013 | | x | x | x | | | x | | x | x | x | | | x | | |
| | Quarterly | 24 | 02-04-2013 | 02-07-2013 | | x | x | x | | | x | | x | x | x | | | x | | |
| | Quarterly | 25 | 02-07-2013 | 01-10-2013 | | x | x | x | | | x | | x | x | x | | | x | | |
| | Quarterly | 26 | 01-10-2013 | 31-12-2013 | | x | x | x | | | x | | x | x | x | | | x | | |
| | Quarterly | 27 | 01-01-2014 | 02-04-2014 | | x | x | x | | | x | | x | x | x | | | x | | |
| | Quarterly | 28 | 02-04-2014 | 02-07-2014 | | x | x | x | | | x | | x | x | x | | | x | | |
| | Quarterly | 29 | 02-07-2014 | 01-10-2014 | | x | x | x | | | x | | x | x | x | | | x | | |
| | Quarterly | 30 | 01-10-2014 | 31-12-2014 | | x | x | x | | | x | | x | x | x | | | x | | |
| | Quarterly | 31 | 01-01-2015 | 02-04-2015 | | x | x | x | | | x | | x | x | x | | | x | | |
| | Quarterly | 32 | 02-04-2015 | 02-07-2015 | | x | x | x | | | x | | x | x | x | | | x | | |
| | Quarterly | 33 | 02-07-2015 | 01-10-2015 | | x | x | x | | | x | | x | x | x | | | x | | |
| | Quarterly | 34 | 02-10-2015 | 01-01-2016 | | x | x | x | | | x | | x | x | x | | | x | | |
| | Quarterly | 35 | 01-01-2016 | 01-04-2016 | | x | x | x | | x | x | | x | x | x | | | x | | |
| | Quarterly | 36 | 01-04-2016 | 01-07-2016 | | x | x | x | | x | x | | x | x | x | | | x | | |
| | Quarterly | 37 | 02-07-2016 | 01-10-2016 | | x | x | x | | x | x | | x | x | x | | | x | | |
| | Quarterly | 38 | 01-10-2016 | 31-12-2016 | | x | x | x | | x | x | | x | x | x | | | x | | |
| | Quarterly | 39 | 31-12-2016 | 01-04-2017 | | x | x | x | | x | x | | x | x | x | | | x | | |
| | Quarterly | 40 | 02-04-2017 | 02-07-2017 | | x | x | x | | x | x | | x | x | x | | | x | | |
| | Quarterly | 41 | 02-07-2017 | 01-10-2017 | | x | x | x | | x | x | | x | x | x | | | x | | |
| | Quarterly | 42 | 01-10-2017 | 31-12-2017 | | x | x | x | | x | x | | x | x | x | | | x | | |

| Calibration Period | Interval | Stress Period | Date (from) | Date (to) | Moorvale South (OC) | CVM (OC) | Peak Downs (OC) | Saraji (OC) | Saraji (UG) | Grosvenor (UG) | Poitrel (OC) | Winchester South (OC) | Daunia (OC) | Millennium (OC) | Isaac Plains (OC) | Olive Downs (OC) | Eagle Downs (UG) | Lake Vermont (OC) | Lake Vermont North (OC) | Grev (OC) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Quarterly | 43 | 31-12-2017 | 01-04-2018 | | x | x | x | | x | x | | x | x | x | | | x | | |
| | Quarterly | 44 | 01-04-2018 | 01-07-2018 | | x | x | x | | x | x | | x | x | | | | x | | |
| | Quarterly | 45 | 01-07-2018 | 30-09-2018 | | x | x | x | | x | x | | x | x | | | | x | | |
| | Quarterly | 46 | 30-09-2018 | 31-12-2018 | | x | x | x | | x | x | | x | x | | | | x | | |
| | Quarterly | 47 | 31-12-2018 | 01-04-2019 | | x | x | x | | x | x | | x | x | | | | x | | |
| | Quarterly | 48 | 01-04-2019 | 01-07-2019 | | x | x | x | | x | x | | x | x | | | | x | | |
| | Quarterly | 49 | 01-07-2019 | 01-10-2019 | | x | x | x | | x | x | | x | x | | | | x | | |
| | Quarterly | 50 | 01-10-2019 | 31-12-2019 | | x | x | x | | x | x | | x | x | | | | x | | |
| | Quarterly | 51 | 31-12-2019 | 31-03-2020 | | x | x | x | | x | x | | x | x | | | | x | | |
| | Quarterly | 52 | 31-03-2020 | 30-06-2020 | | x | x | x | | x | x | | x | x | | | | x | x | |
| | Quarterly | 53 | 30-06-2020 | 30-09-2020 | x | x | x | x | | x | x | | x | x | | | | x | x | |
| | Quarterly | 54 | 30-09-2020 | 31-12-2020 | x | x | x | x | | x | x | | x | x | | x | | x | x | |
| | Quarterly | 55 | 01-01-2021 | 01-04-2021 | x | x | x | x | | x | x | | x | x | | x | | x | x | |
| | Quarterly | 56 | 02-04-2021 | 01-07-2021 | x | x | x | x | | x | x | | x | x | | x | | x | x | |
| | Quarterly | 57 | 02-07-2021 | 30-09-2021 | x | x | x | x | | x | x | | x | x | | x | | x | x | |
| | Quarterly | 58 | 01-10-2021 | 31-12-2021 | x | x | x | x | | x | x | | x | x | | x | | x | x | |
| Predictive | Annual | 59 | 30-12-2021 | 30-12-2022 | x | x | x | x | | x | x | | x | x | | x | | x | x | |
| | Annual | 60 | 30-12-2022 | 30-12-2023 | x | x | x | x | | x | x | | x | x | | x | | x | x | |
| | Annual | 61 | 30-12-2023 | 29-12-2024 | x | x | x | x | | x | x | x | x | x | | x | | x | x | |
| | Annual | 62 | 29-12-2024 | 30-12-2025 | x | x | x | x | | x | x | x | x | x | | x | | x | x | |
| | Annual | 63 | 30-12-2025 | 30-12-2026 | x | x | x | x | | x | x | x | x | x | | x | | x | x | x |

| Calibration Period | Interval | Stress Period | Date (from) | Date (to) | Moorvale South (OC) | CVM (OC) | Peak Downs (OC) | Saraji (OC) | Saraji (UG) | Grosvenor (UG) | Poitrel (OC) | Winchester South (OC) | Daunia (OC) | Millennium (OC) | Isaac Plains (OC) | Olive Downs (OC) | Eagle Downs (UG) | Lake Vermont (OC) | Lake Vermont North (OC) | Grev (OC) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Annual | 64 | 30-12-2026 | 30-12-2027 | x | x | x | x | | x | x | x | x | x | | x | | | x | x |
| | Annual | 65 | 30-12-2027 | 29-12-2028 | | x | x | x | | x | | x | x | | | x | x | | x | x |
| | Annual | 66 | 29-12-2028 | 30-12-2029 | | x | x | x | | x | | x | x | | | x | x | | x | x |
| | Annual | 67 | 30-12-2029 | 30-12-2030 | | x | x | x | | x | | x | x | | | x | x | | x | x |
| | Annual | 68 | 30-12-2030 | 30-12-2031 | | x | x | x | | x | | x | x | | | x | x | | x | x |
| | Annual | 69 | 30-12-2031 | 29-12-2032 | | x | x | | | x | | x | x | | | x | x | | x | x |
| | Annual | 70 | 29-12-2032 | 30-12-2033 | | x | x | | | x | | x | x | | | x | x | | x | x |
| | Annual | 71 | 30-12-2033 | 30-12-2034 | | x | x | | | x | | x | x | | | x | x | | x | x |
| | Annual | 72 | 30-12-2034 | 30-12-2035 | | x | x | | | x | | x | x | | | x | x | | x | x |
| | Annual | 73 | 30-12-2035 | 29-12-2036 | | x | x | | | x | | x | x | | | x | x | | x | x |
| | Annual | 74 | 29-12-2036 | 30-12-2037 | | x | x | | | x | | x | x | | | x | x | | x | x |
| | Annual | 75 | 30-12-2037 | 30-12-2038 | | x | x | | | x | | x | x | | | x | x | | x | x |
| | Annual | 76 | 30-12-2038 | 30-12-2039 | | x | x | | | x | | x | | | | x | x | | x | x |
| | Annual | 77 | 30-12-2039 | 29-12-2040 | | x | x | | | x | | x | | | | x | x | | x | x |
| | Annual | 78 | 29-12-2040 | 30-12-2041 | | x | x | | | x | | x | | | | x | x | | x | x |
| | Annual | 79 | 30-12-2041 | 30-12-2042 | | x | x | | | x | | x | | | | x | x | | x | x |
| | Annual | 80 | 01-01-2043 | 31-12-2043 | | x | x | | | x | | x | | | | x | x | | x | x |
| | Annual | 81 | 01-01-2044 | 30-12-2044 | | x | x | | | x | | x | | | | x | x | | x | x |
| | Annual | 82 | 31-12-2044 | 31-12-2045 | | x | x | | | x | | x | | | | x | x | | x | x |
| | Annual | 83 | 01-01-2046 | 31-12-2046 | | x | x | | | x | | x | | | | x | x | | x | x |
| | Annual | 84 | 01-01-2047 | 31-12-2047 | | x | x | | | x | | x | | | | x | x | | x | x |

| Calibration Period | Interval | Stress Period | Date (from) | Date (to) | Moorvale South (OC) | CVM (OC) | Peak Downs (OC) | Saraji (OC) | Saraji (UG) | Grosvenor (UG) | Poitrel (OC) | Winchester South (OC) | Daunia (OC) | Millennium (OC) | Isaac Plains (OC) | Olive Downs (OC) | Eagle Downs (UG) | Lake Vermont (OC) | Lake Vermont North (OC) | Grev (OC) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Annual | 85 | 01-01-2048 | 30-12-2048 | | x | x | | | x | | x | | | | x | x | | x | x |
| | Annual | 86 | 31-12-2048 | 31-12-2049 | | x | x | | | | | x | | | | x | x | | x | x |
| | Annual | 87 | 01-01-2050 | 31-12-2050 | | x | x | | | | | x | | | | x | x | | x | x |
| | Annual | 88 | 01-01-2051 | 31-12-2051 | | x | x | | | | | x | | | | x | x | | x | x |
| | Annual | 89 | 01-01-2052 | 30-12-2052 | | | x | | | | | x | | | | x | x | | x | x |
| | Annual | 90 | 31-12-2052 | 31-12-2053 | | | x | | | | | | | | | x | x | | x | x |
| | Annual | 91 | 01-01-2054 | 31-12-2054 | | | x | | | | | | | | | x | x | | x | |
| | Annual | 92 | 01-01-2055 | 31-12-2055 | | | x | | | | | | | | | x | x | | x | |
| | 5 Years | 93 | 01-01-2056 | 30-12-2060 | | | x | | | | | | | | | x | x | | x | |
| | 5 Years | 94 | 31-12-2060 | 31-12-2065 | | | x | | | | | | | | | x | x | | x | |
| | 5 Years | 95 | 01-01-2066 | 31-12-2070 | | | x | | | | | | | | | x | x | | x | |
| | 5 Years | 96 | 01-01-2071 | 31-12-2075 | | | x | | | | | | | | | x | x | | x | |
| | 5 Years | 97 | 01-01-2076 | 30-12-2080 | | | x | | | | | | | | | x | x | | x | |
| | 5 Years | 98 | 31-12-2080 | 31-12-2085 | | | x | | | | | | | | | x | x | | x | |
| | 5 Years | 99 | 01-01-2086 | 31-12-2090 | | | x | | | | | | | | | x | x | | | |
| | 5 Years | 100 | 01-01-2091 | 31-12-2095 | | | x | | | | | | | | | | x | | | |

# Appendix E Uncertainty Analysis Parameter Distributions

**Groundwater Modelling Technical Report**

**Engeny on Behalf of BM Alliance Coal Operations Pty Ltd**

SLR Project No.: 620.040484.00000

12 September 2024

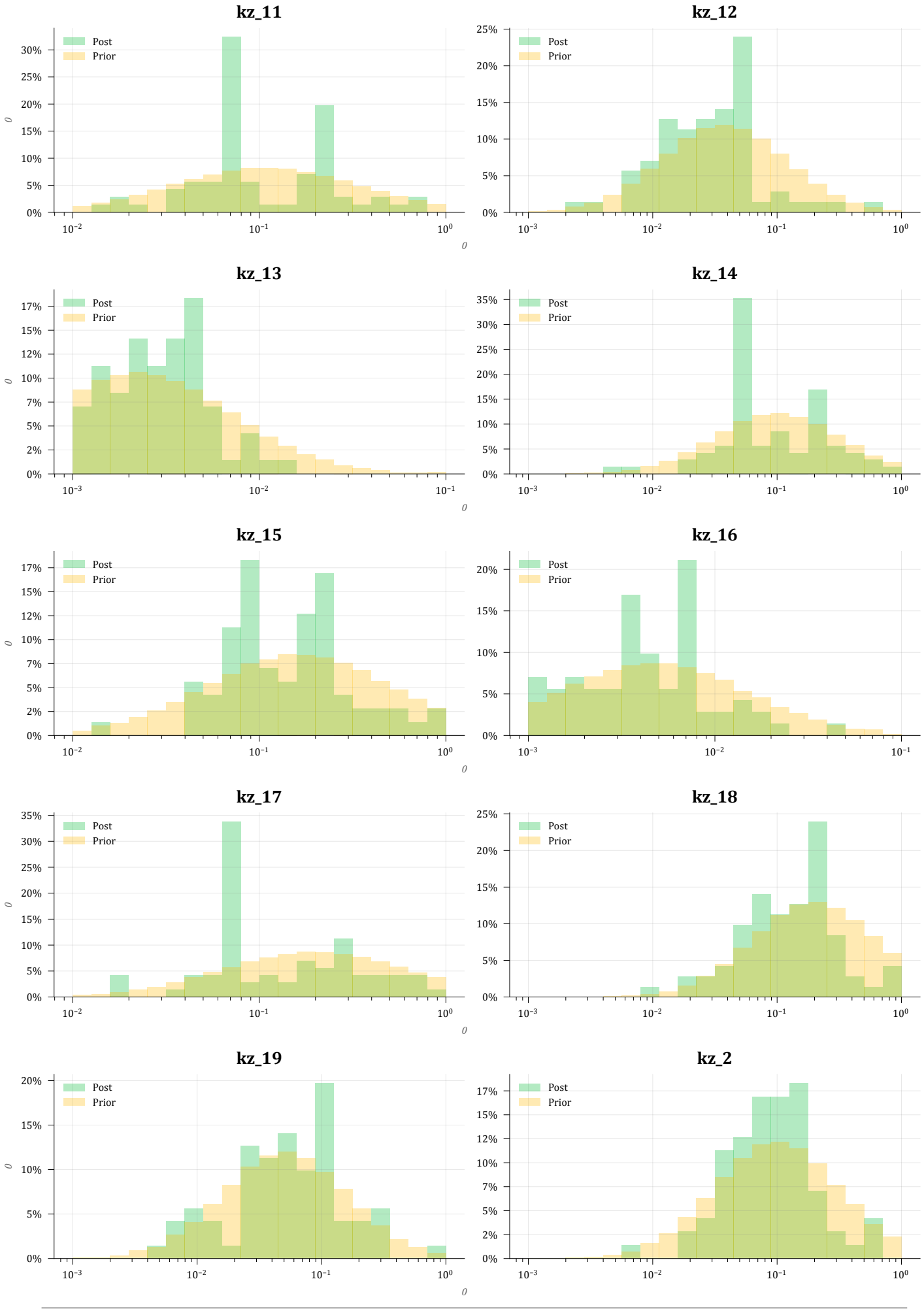

Riv_Vk1
Riv_Vk10
Riv_Vk11
Riv_Vk12
Riv_Vk13
Riv_Vk14
Riv_Vk15
Riv_Vk2
Riv_Vk3
Riv_Vk4
Post
Prior
0

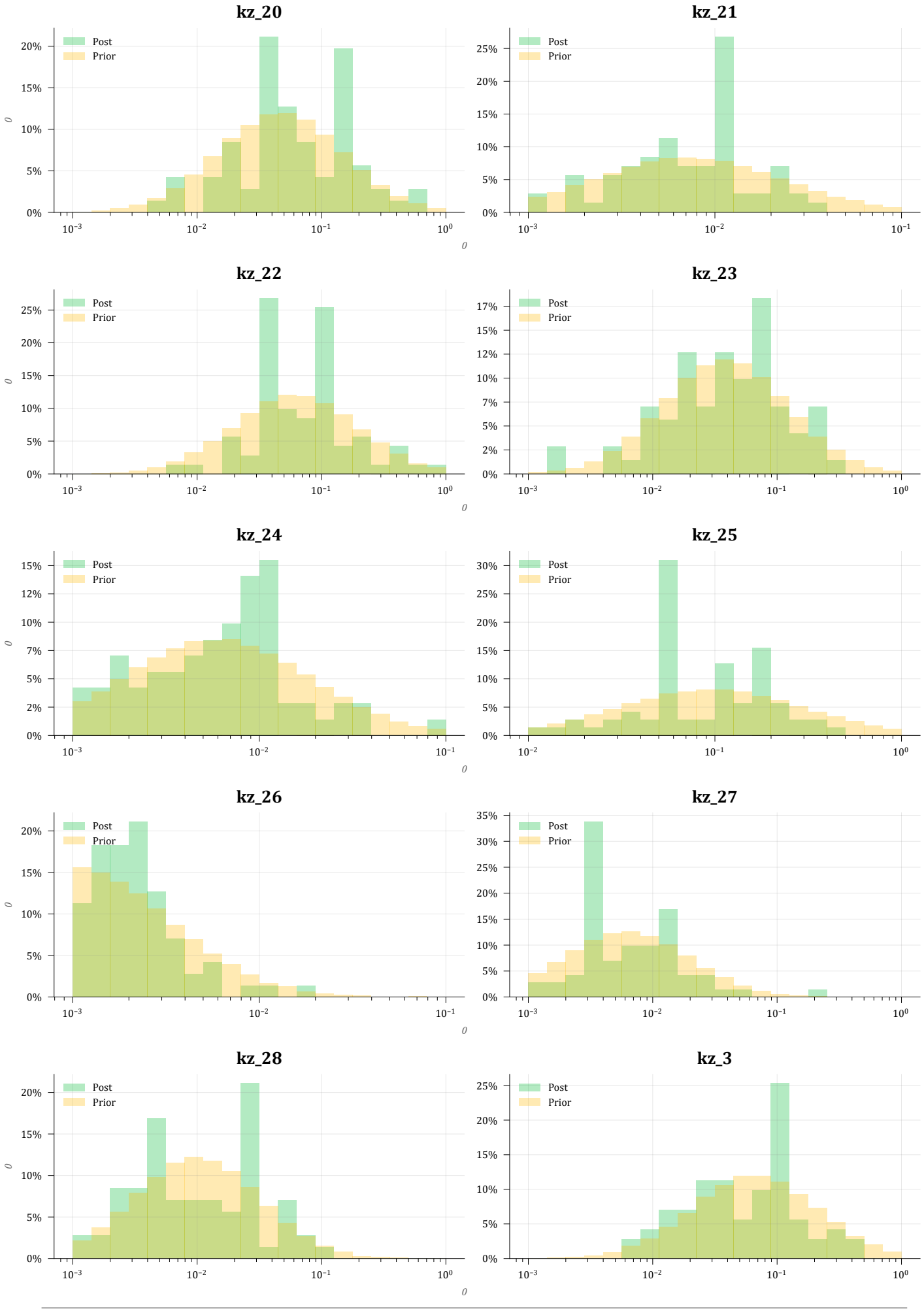

Riv_Vk5
Riv_Vk6
Riv_Vk7
Riv_Vk8
Riv_Vk9
SPl_Ss
SPl_Sy
SPl_kx
SPl_kz
Spl_rch
Post
Prior
0
Parameters


kx_1
kx_10
kx_11
kx_12
kx_13
kx_14
kx_15
kx_16
kx_17
kx_18
Post
Prior
0
Parameters

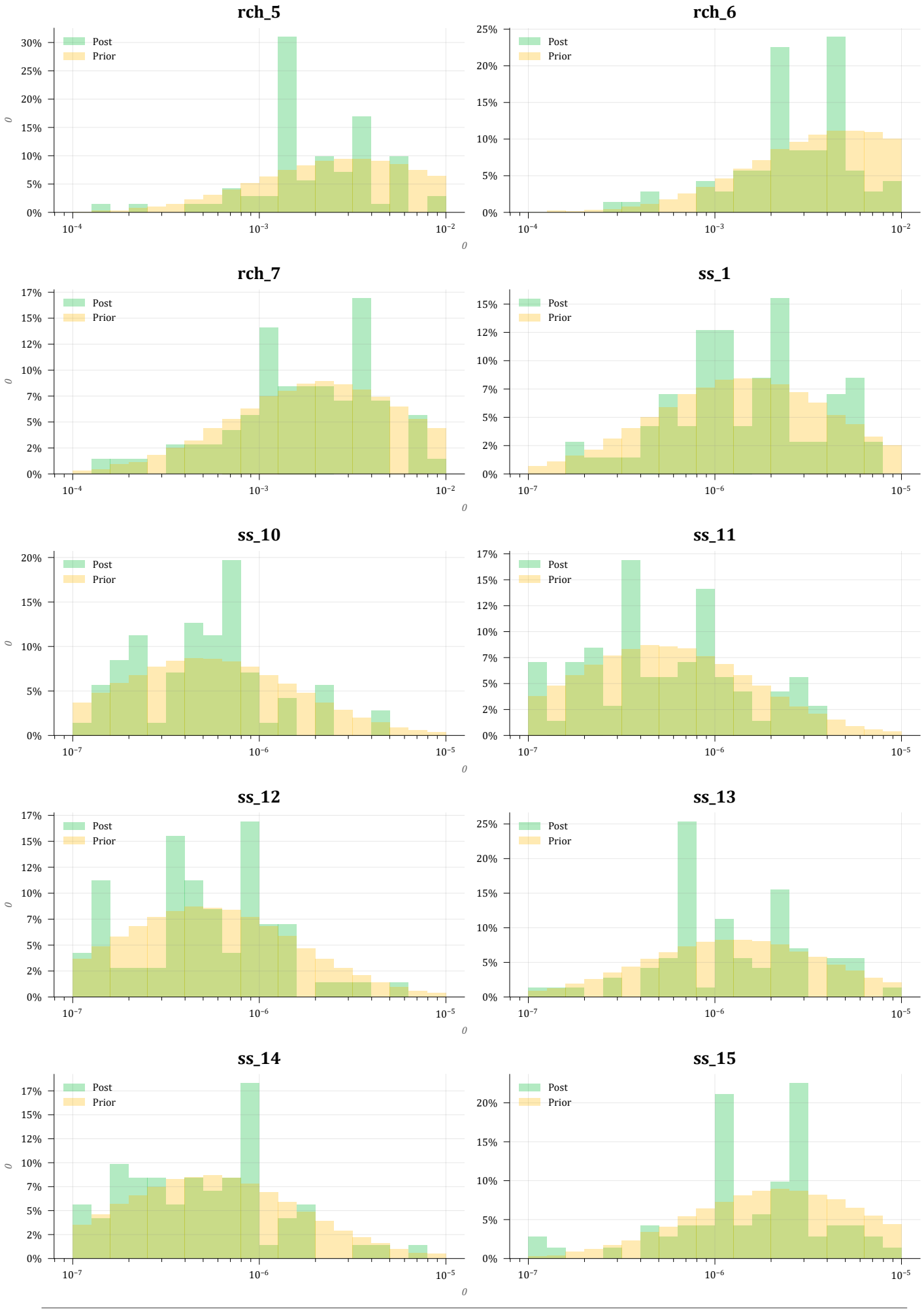

kx_19
kx_2
kx_20
kx_21
kx_22
kx_23
kx_24
kx_25
kx_26
kx_27
Post
Prior
0
Parameters

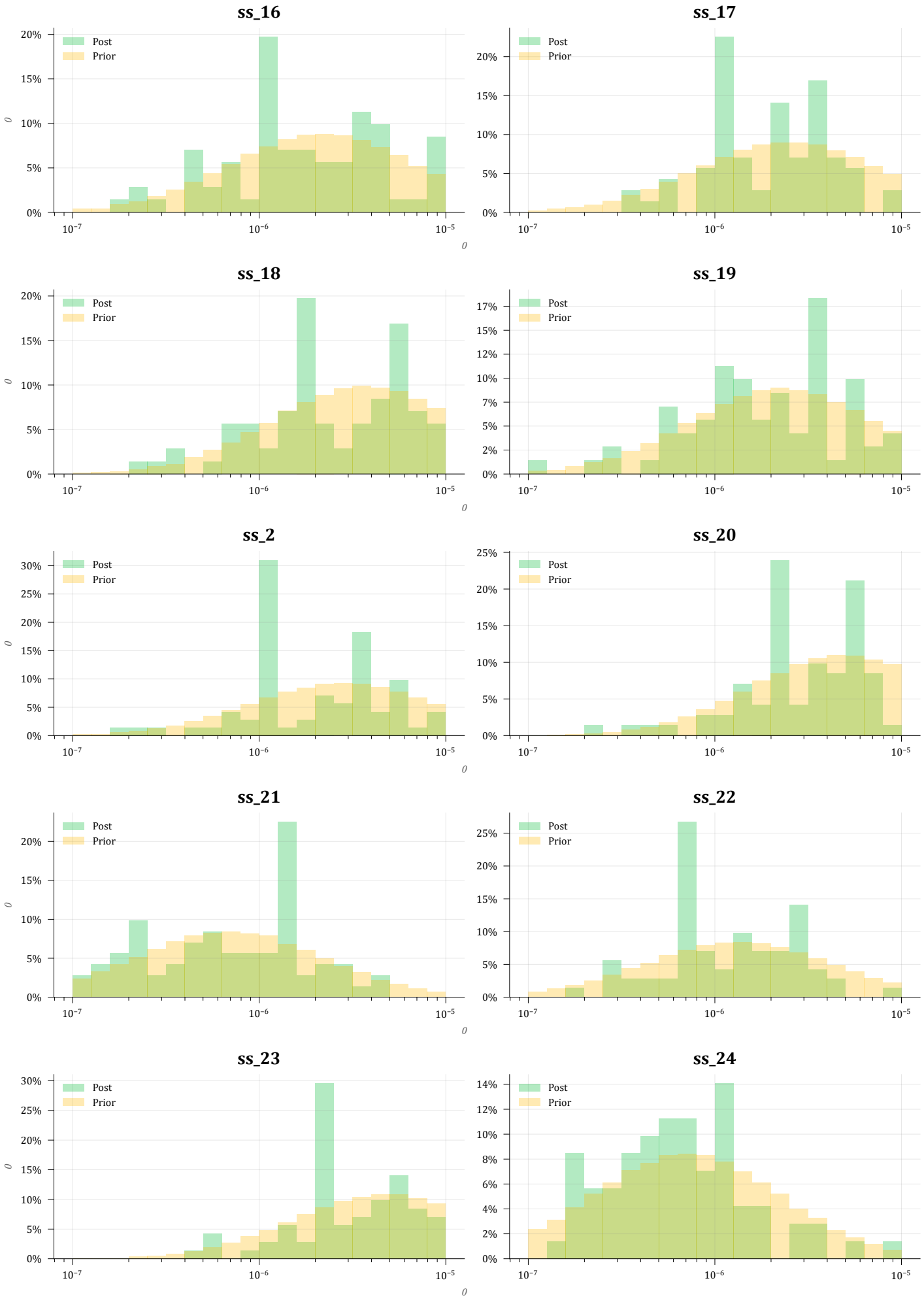

kx_28
kx_3
kx_4
kx_5
kx_6
kx_7
kx_8
kx_9
kz_1
kz_10
Post
Prior
0
Parameters


kz_11
kz_12
kz_13
kz_14
kz_15
kz_16
kz_17
kz_18
kz_19
kz_2
Post
Prior
0
Parameters

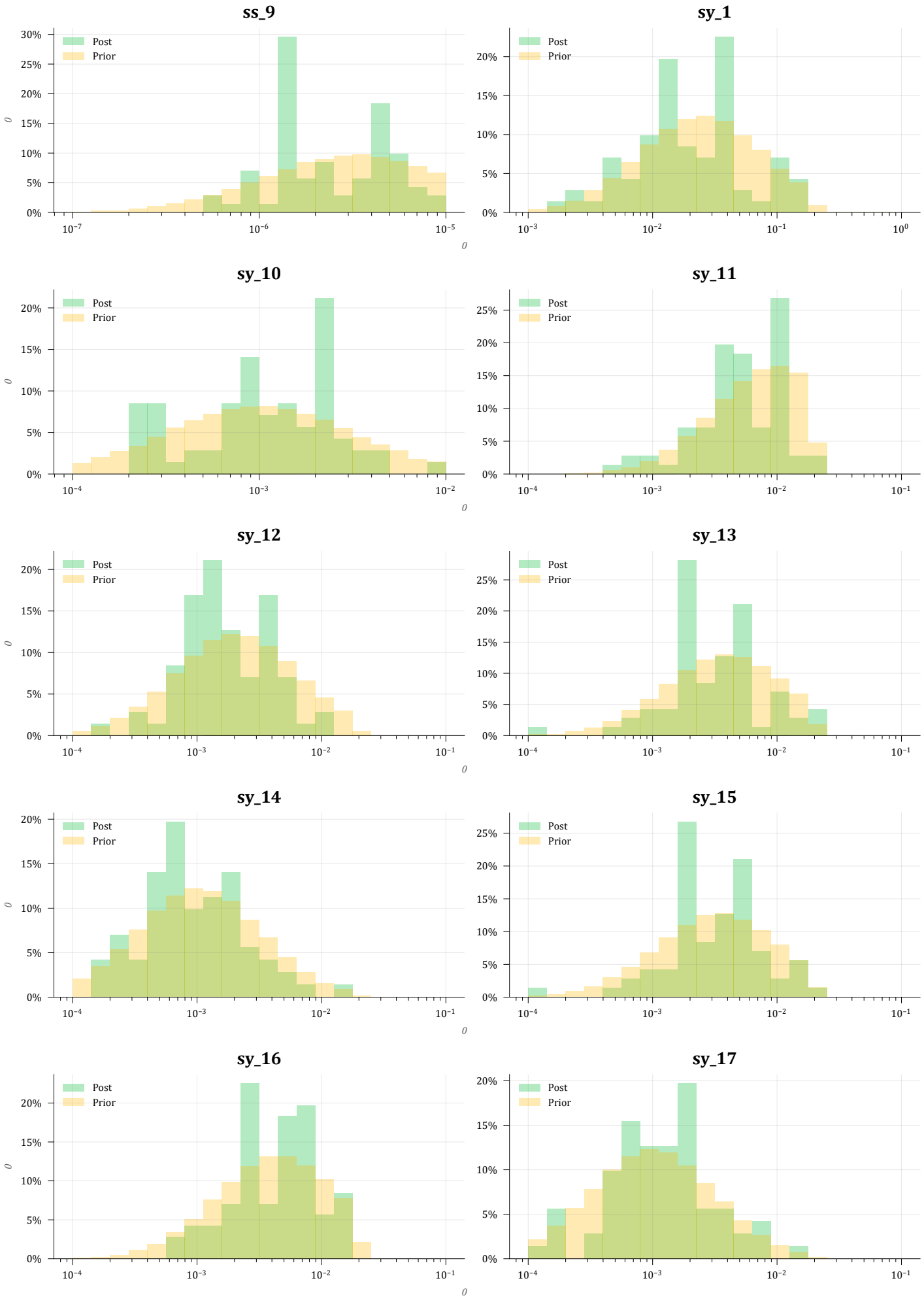

kz_20
kz_21
kz_22
kz_23
kz_24
kz_25
kz_26
kz_27
kz_28
kz_3
Post
Prior
0
Parameters


kz_4
kz_5
kz_6
kz_7
kz_8
kz_9
rch_1
rch_2
rch_3
rch_4
Post
Prior
Parameters


rch_5
rch_6
rch_7
ss_1
ss_10
ss_11
ss_12
ss_13
ss_14
ss_15
Post
Prior
0
Parameters

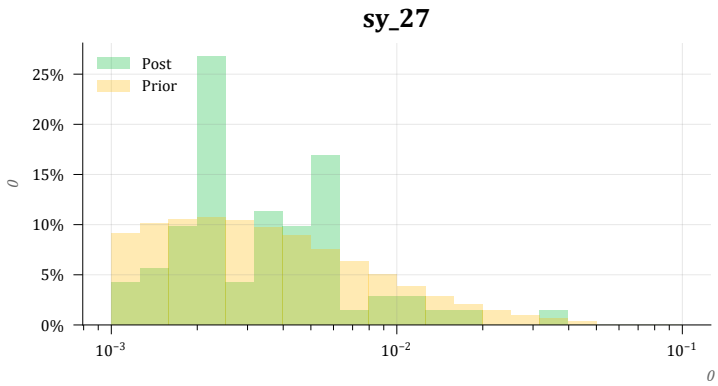

ss_16
ss_17
ss_18
ss_19
ss_2
ss_20
ss_21
ss_22
ss_23
ss_24
Post
Prior
0
Parameters

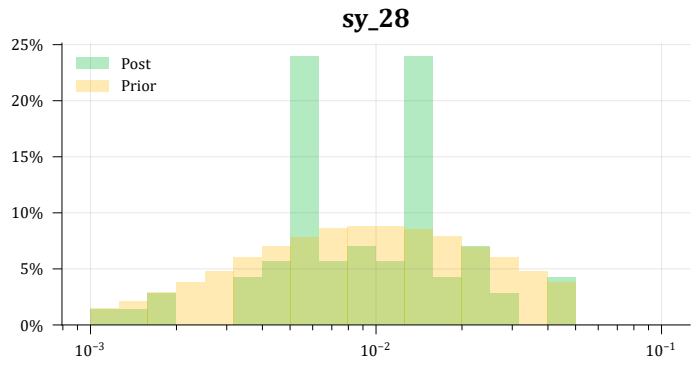

ss_25
ss_26
ss_27
ss_28
ss_3
ss_4
ss_5
ss_6
ss_7
ss_8
Post
Prior
0
Parameters

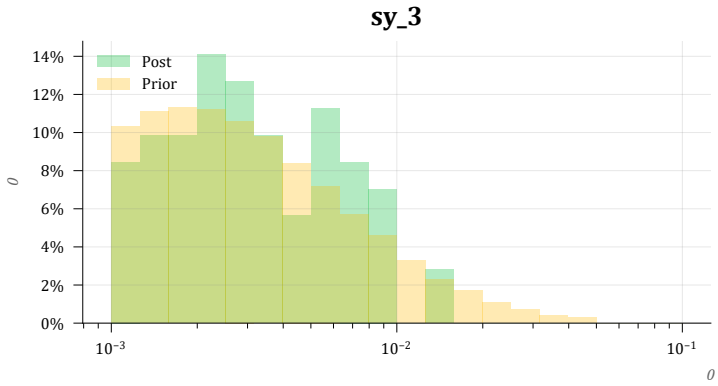


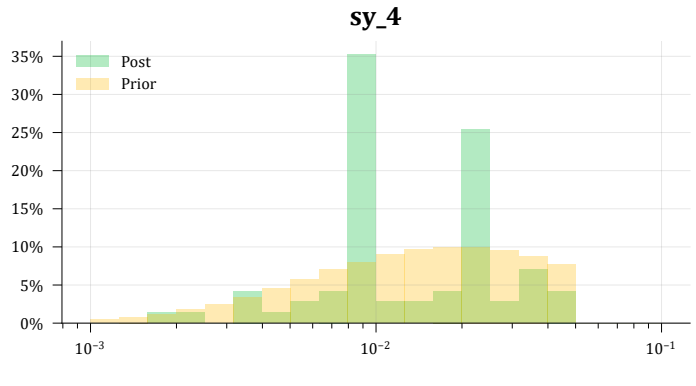

*Parameters*

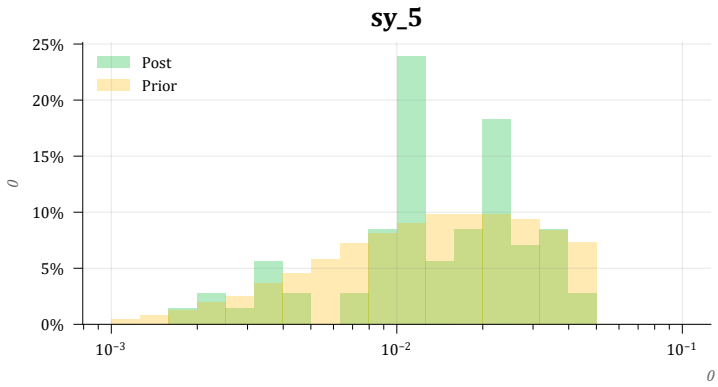

sy_18
sy_19
sy_2
sy_20
sy_21
sy_22
sy_23
sy_24
sy_25
sy_26
Post
Prior
0
Parameters

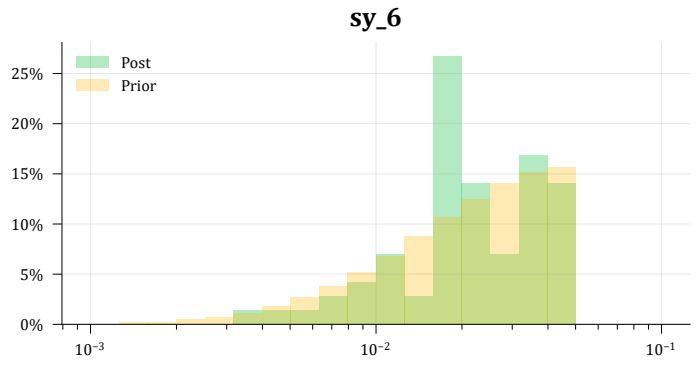

sy_27
Post
Prior
0
0
25%
20%
15%
10%
5%
0%
$10^{-3}$
$10^{-2}$
$10^{-1}$

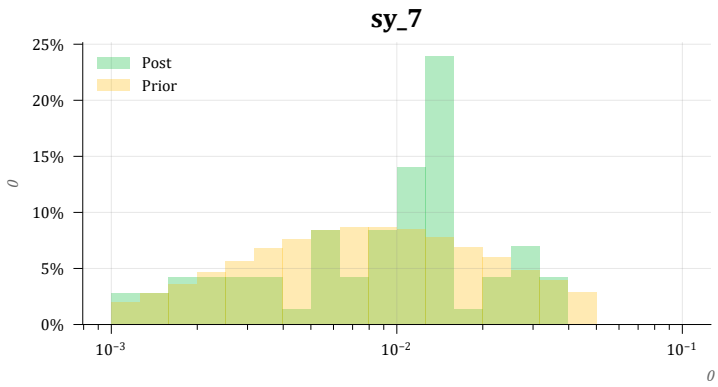

sy_28
Post
Prior
25%
20%
15%
10%
5%
0%
$10^{-3}$
$10^{-2}$
$10^{-1}$

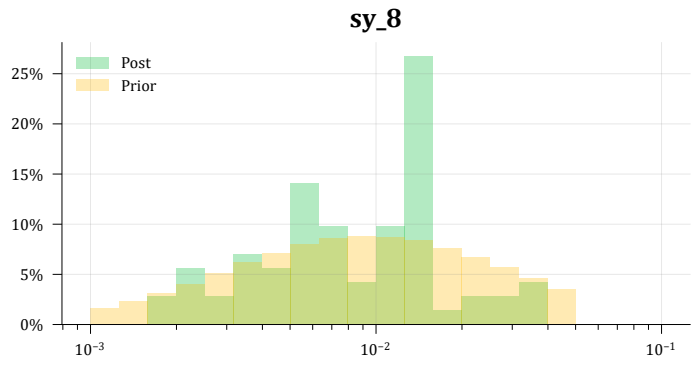

sy_3
Post
Prior
0
0
14%
12%
10%
8%
6%
4%
2%
0%
$10^{-3}$
$10^{-2}$
$10^{-1}$

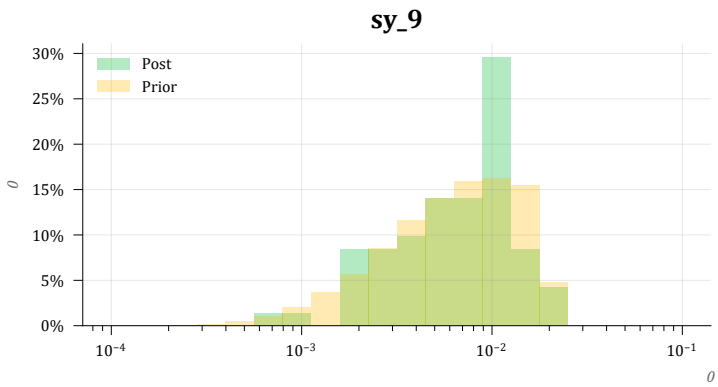

sy_4
Post
Prior
35%
30%
25%
20%
15%
10%
5%
0%
$10^{-3}$
$10^{-2}$
$10^{-1}$

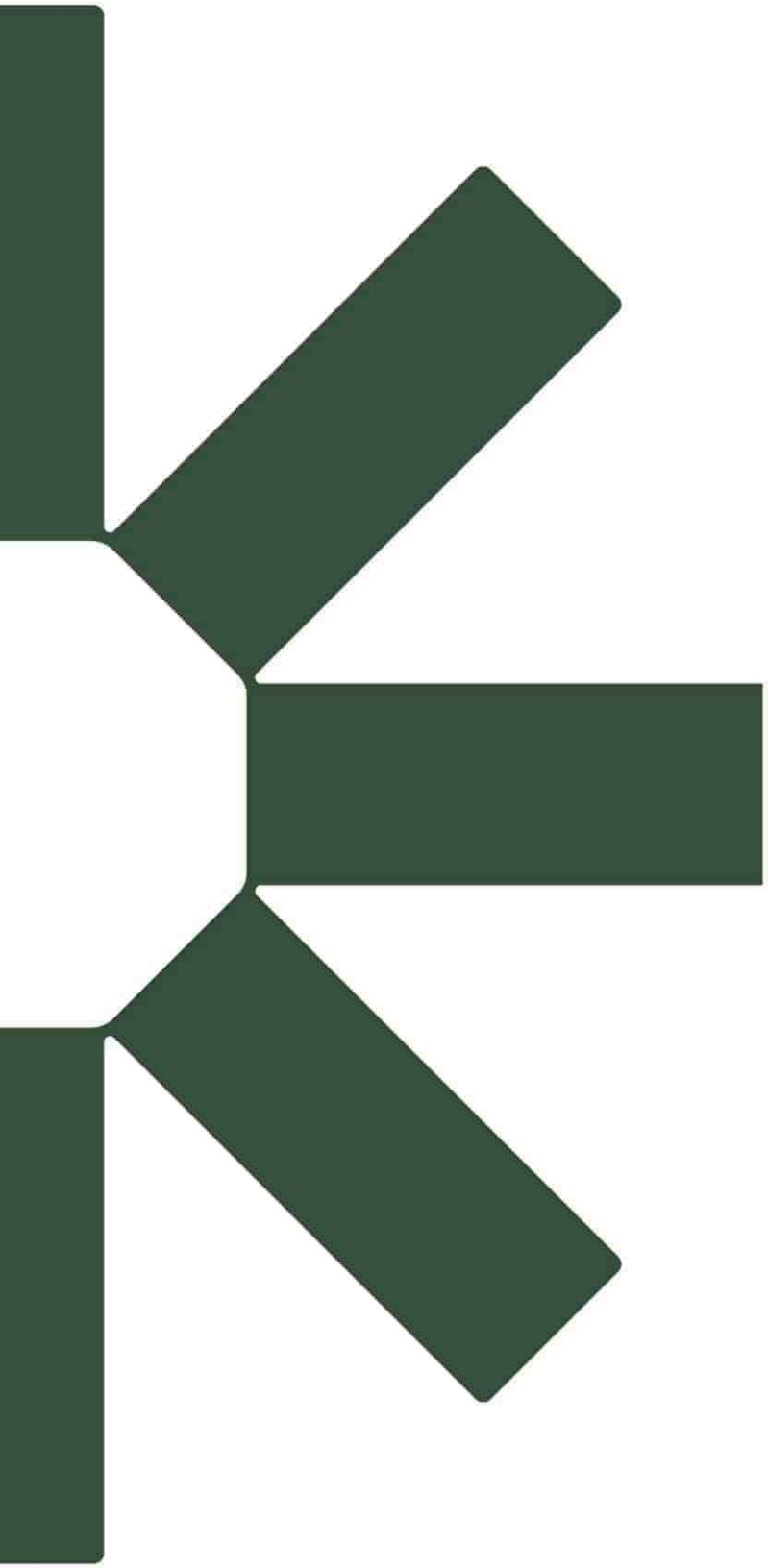

sy_5
Post
Prior
0
0
25%
20%
15%
10%
5%
0%
$10^{-3}$
$10^{-2}$
$10^{-1}$


sy_6
Post
Prior
25%
20%
15%
10%
5%
0%
$10^{-3}$
$10^{-2}$
$10^{-1}$

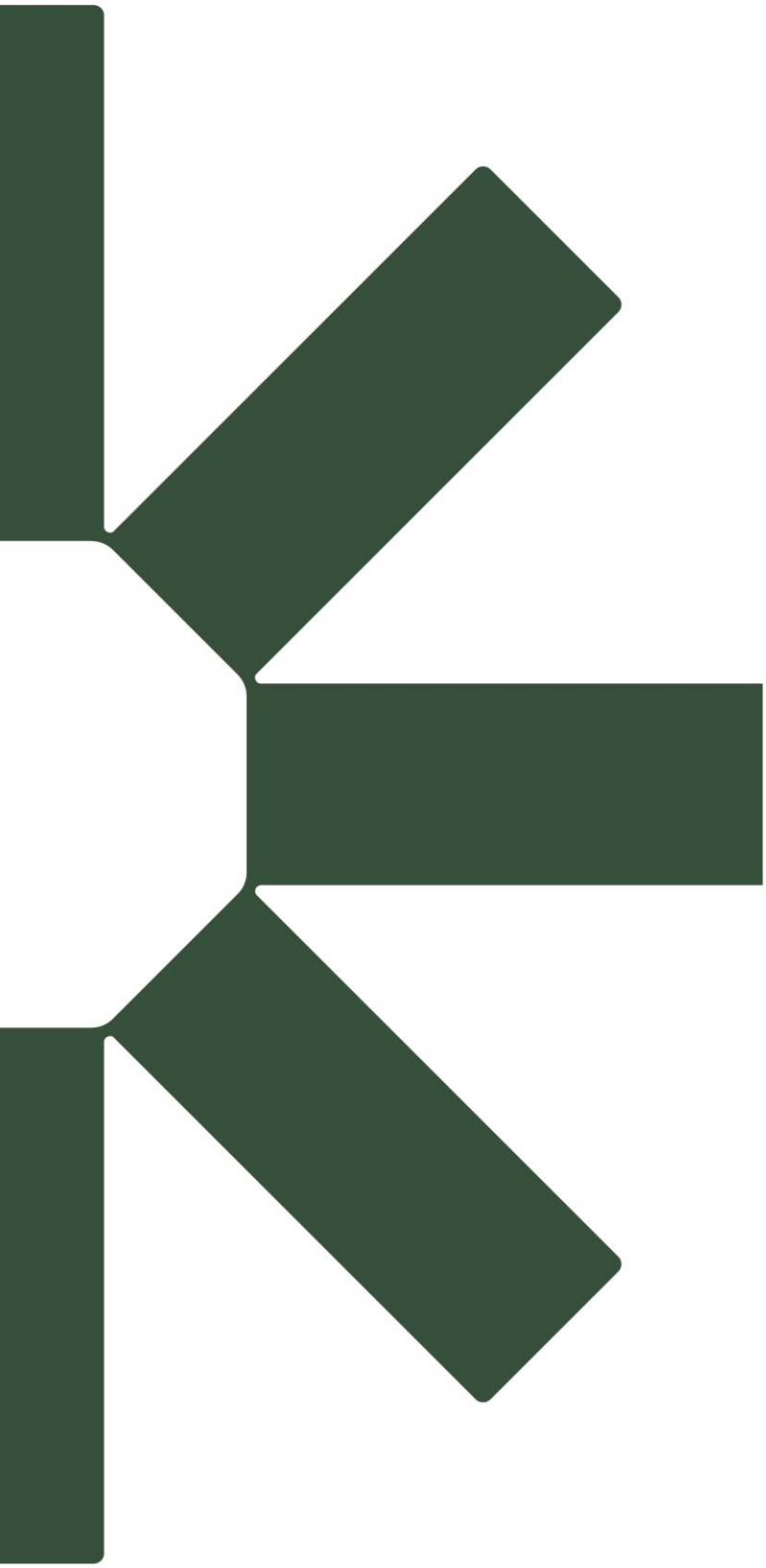

sy_7
Post
Prior
0
0
25%
20%
15%
10%
5%
0%
$10^{-3}$
$10^{-2}$
$10^{-1}$


sy_8
Post
Prior
25%
20%
15%
10%
5%
0%
$10^{-3}$
$10^{-2}$
$10^{-1}$


sy_9
Post
Prior
0
0
30%
25%
20%
15%
10%
5%
0%
$10^{-4}$
$10^{-3}$
$10^{-2}$
$10^{-1}$



Making Sustainability Happen



Making Sustainability Happen