Mavis South Underground Extension Project

Groundwater Model Technical Report

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SLR Project No.: 620.031508.00001

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2.0	23 November 2023	Minor edits	I Epari	I Epari
2.0	7 November 2023	P Rachakonda	A Mohajeri	I Epari

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 MetRes 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.

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1 Introduction

SLR Consulting Australia Pty Ltd (SLR) has been engaged by MetRes Pty Ltd (MetRes) to undertake a Groundwater Impact Assessment for the Mavis South Underground extension area (referred to from here on as the Project) in support of an EA amendment. Open-cut mining was approved in the proposed Mavis Area via 2011 Environmental Impact Statement and subsequent approvals of the mining leases and environmental authority with a recent amendment to include underground mining at Mavis. The impacts of the proposed underground development of Mavis South Area on the groundwater environment will be assessed. The proposed operation will commence from July 2024 and based on current estimate of resource schedule, will cease operation within one year (by June 2025).

As a part of the Mavis South Underground Extension Groundwater Assessment being prepared in, MetRes requested SLR to update the existing cumulative regional groundwater model to include known local hydrogeologic features and mining operations (historic, approved and proposed) at Millennium Mine relevant to 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 Millennium Mine by SLR (2021c) and MatrixPlus (2010).

1.1 Background

The updated regional groundwater model, referred to as the Millennium 2023 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) and 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). 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 Millennium 2023 model, where relevant.

1.2 Modelling Objectives

The overall objectives of this groundwater modelling are to:

- Estimate the groundwater inflow to the mine workings as a function of mine position and timing.
- Simulate and predict the extent and area of influence of dewatering and the level and rate of drawdown at specific locations.
- Identify areas, where groundwater impact mitigation / control measures may be necessary.

This assessment has predicted the impacts for the proposed underground mining extension at the Project.

1.3 This Report

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

The report is structured as follows:

- **Section 2.0**: Model construction and development, including model built and calibration/validation against historical data set.
- **Section 3.0**: Predictive Modelling, including inflow estimates and drawdown predictions.
- **Section 4.0**: Groundwater Recovery Model, which predicts the long-term recovery of the groundwater table after mining ceases.
- **Section 5.0:** Sensitivity Analysis.
- **Section 6.0**: Uncertainty Analysis.
- **Section 7.0**: Model Confidence and Limitation.
- **Section 8.0**: Conclusions.

This report documents the technical details of the items listed above for the regional Bowen Basis groundwater model, with a focus on the Millennium Mine area.

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 a recent version of industry standard MODFLOW code and was determined to be a 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 Millennium 2023 model, vadose zone properties have been excluded, and the unsaturated zone was simulated using the upstream-weighting method.

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

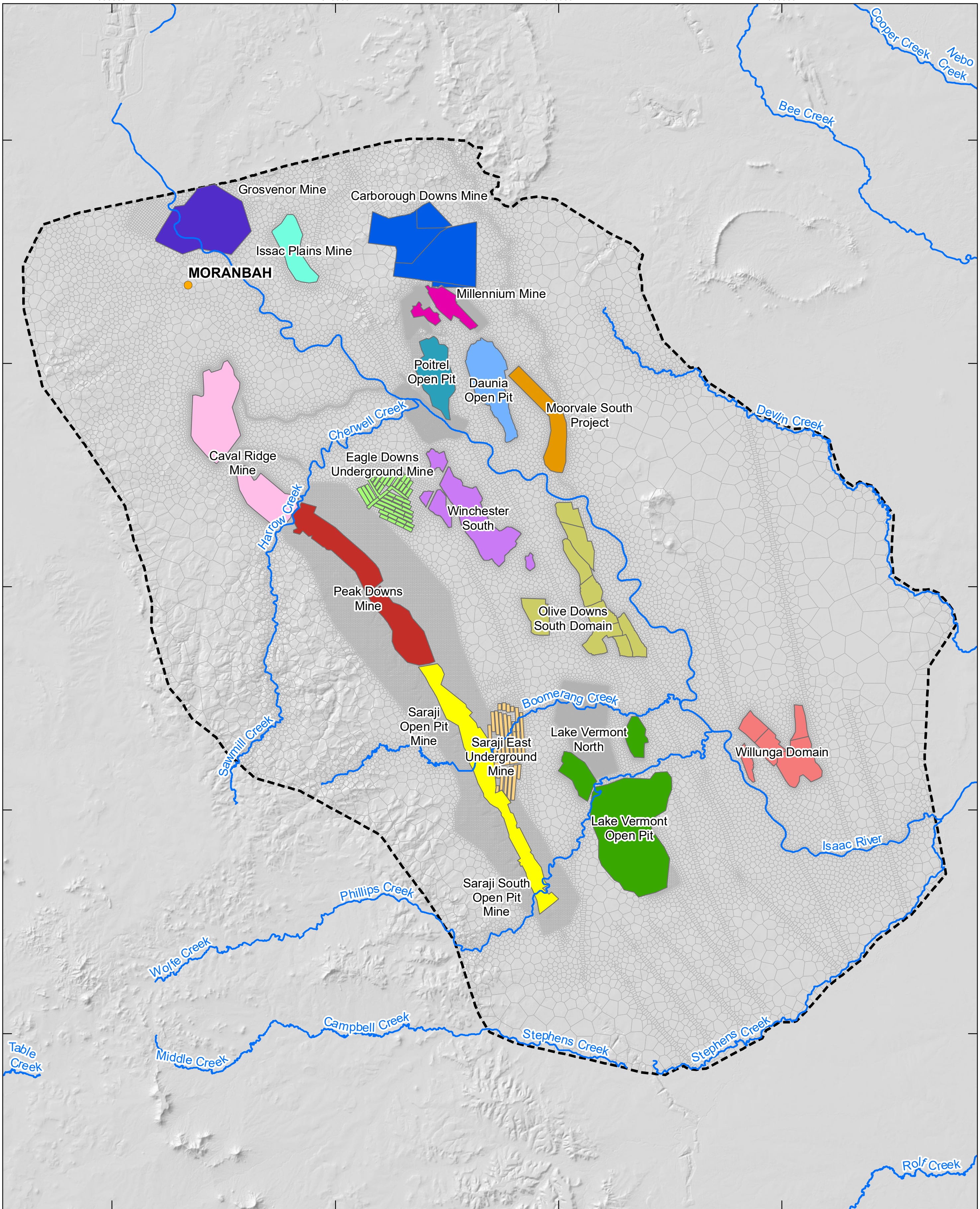
2.2 Model Extent and Mesh Design

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 extent was kept as per that of the SLR (2021c) model. The model encompasses the Millennium Mine with adjacent regional mining. Model elongation is in the direction of geological strike (northwest to southeast). At its widest extents, the model is approximately 62 km west-east by 95 km north-south. The model domain is intended to place boundary conditions sufficiently distant from Millennium and surrounding mines to allow the extent of potential impacts from mining activities on the groundwater system to be assessed.

The 2021 model grid was updated to provide greater grid resolution within and around the proposed Project mine footprint. The updated grid included a 50 m cell size constraint with an orientation of 45° NE.

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 121,439. The total number of cells in the model is 1,610,515. This is after pinching out areas in layers 3 to 19 where a layer is not present based on the mapped geology.



0 5 10 km

Coordinate System:	GDA 1994 MGA Zone 55
Scale:	1:450,000 at A4
Project Number:	620.031508
Date:	30-Oct-2023
Drawn by:	AS

- Place Name
- Major Drainage System
- Model Boundary
- Model Grid

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MODEL DOMAIN

SLR

FIGURE 2-1

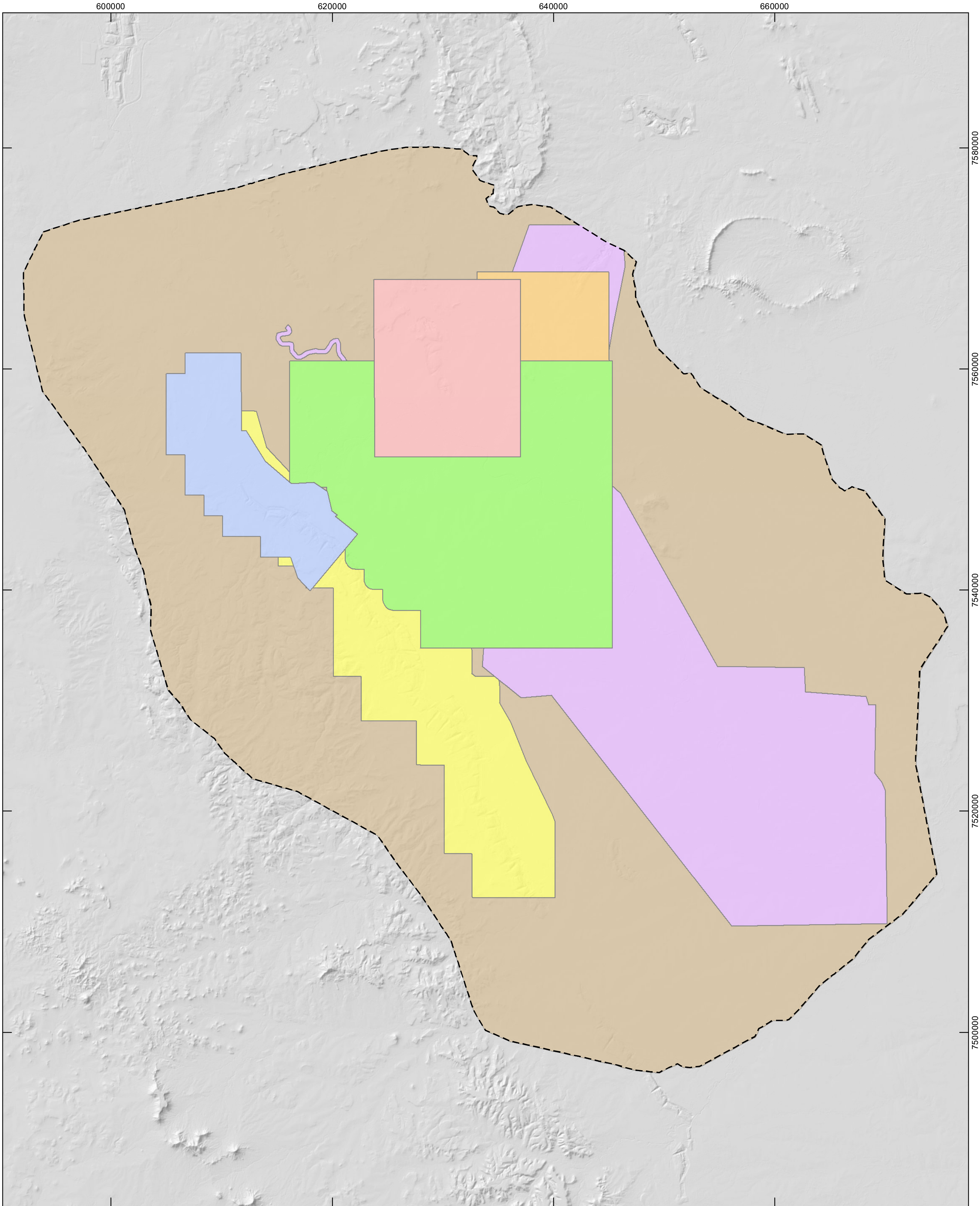
H:\Projects-SLR\620-BNE\620-BNE\620.031508.00001 Millennium Mine - Mavis South\06 SLR Data\01 CADGIS\GIS\Modelling Report\620031508 MOD F2-01 Model Domain.mxd

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.
- Bord and Pillar mining for the Mavis Approved and Mavis South is represented with a 50 m cell size constraint.
- Open cut mine areas for the opencut mines including Millennium, Daunia, Peak Downs Mine (PDM), Saraji Mine (SRM), Caval Ridge Mine (CVM), Poitrel, Lake Vermont, Winchester South, and Olive Downs have a 100 m Voronoi cell size constraint.
- Longwall mining at Grosvenor, Carborough Downs, 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.

2.2.1 Model Topography

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 MetRes, was used to define local surface elevation within the project area. Outside the extents of the DEM dataset, LiDAR data from the Moorvale South Project, Winchester South Project, and the Olive Downs Project and Caval Ridge Mine (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.



0 5 10 km

Coordinate System: GDA 1994 MGA Zone 55
Scale: 1:450,000 at A4
Project Number: 620.031508
Date: 27-Oct-2023
Drawn by: AS

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

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TOPOGRAPHY AND DATA EXTENTS

FIGURE 2-2

H:\Projects-SLR\620-BNE\620-BNE\620.031508.00001 Millennium Mine - Mavis South\06 SLR Data\01 CADGIS\GIS\Modelling Report\620031508 MOD F2-02 Topography and Data Extents.mxd

2.2.2 Model Layers

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:

- MetRes Pty Ltd, Millennium site geological model.
- 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, PTM site 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.
- 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	6.5
2	Tertiary sediments, Tertiary basalt	Tertiary and minor Triassic Clematis Group, weathered Permian, Tertiary basalt	16.5
3	Rewan Group	Triassic	139.0
4	Rangal Coal Measures	Leichhardt overburden	36.0
5		Leichhardt seam	4.9
6		Interburden	36.5
7		Vermont seam	4.0
8		Vermont underburden	26.5
9	Fort Cooper Coal Measures	Fort Cooper overburden	61.5
10		Fort Cooper seams (combined)	61.5
11		Fort Cooper underburden	60.0
12	Moranbah Coal Measures	Q Seam	1.5
13		Interburden	17.0
14		P Seam	2.5
15		Interburden	41.0
16		H Seam	4.5
17		Interburden	65.5
18		D Seam (target coal seam for SEMLP)	8.5
19		Base of Model - aquitard	100.0

Model Layer 1 is fully extensive across the model with an average thickness of 6.5 m. The base of Layer 1 is largely consistent with the previous SLR (2021c) model.

Model Layer 2 is also fully present across the model area with a minimum thickness of 1 m. The Millennium, 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 of the Rangal and the Moranbah Coal Measures adopted in this version of the groundwater model is consistent with the (SLR, 2021c).

With regards to Moranbah Coal Measures, eight layers were included to account for all the coal seam targets within the Moranbah Coal Measures. This is not relevant for the local mining at Millennium, but important for the wider cumulative assessment. **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 Project and neighbouring mine area and reported as below:

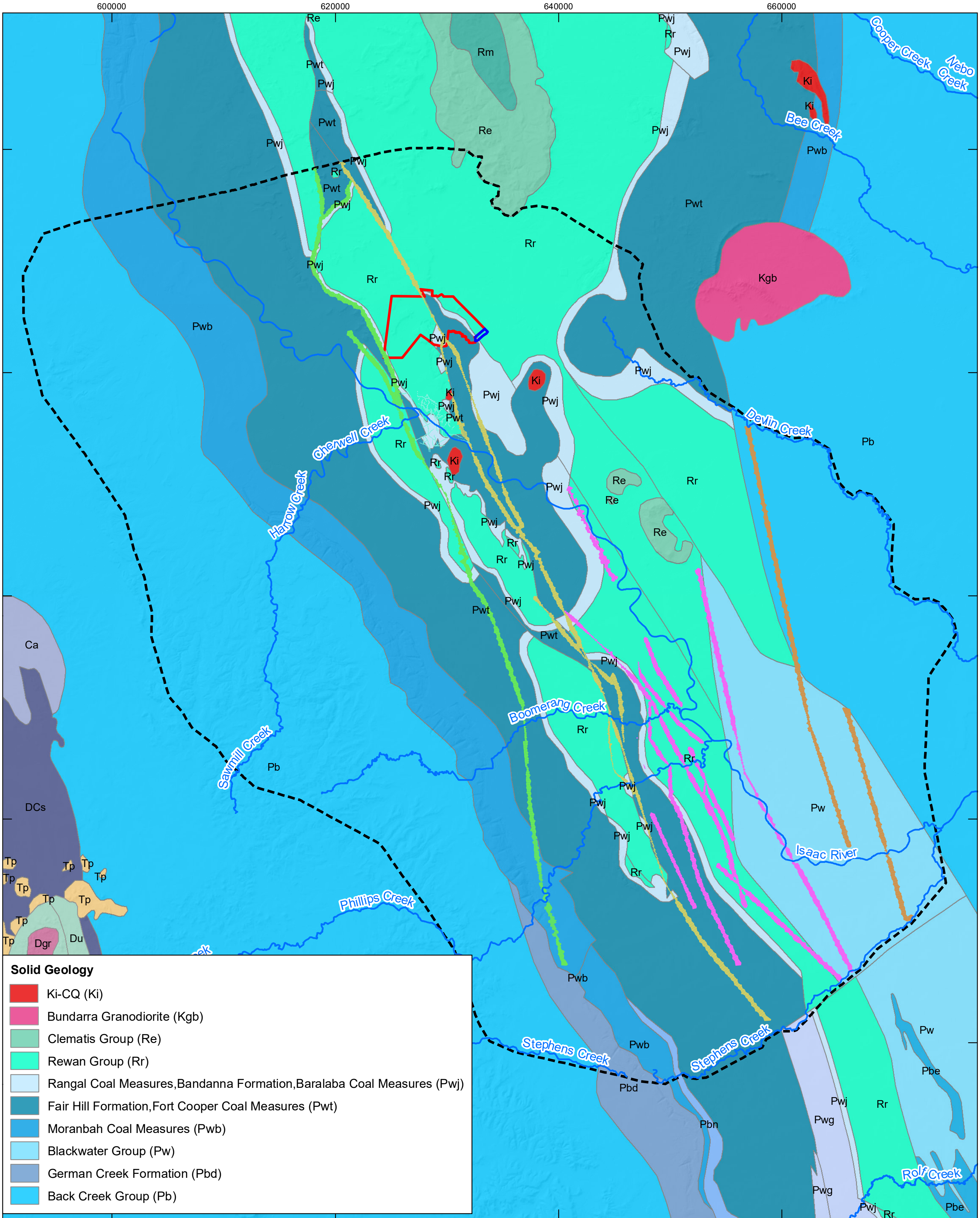
- Leichhardt Seam thickness: 4.9 m
- Vermont Seam Thickness: 4.0 m

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

2.2.3 Geological Faults

As discussed in groundwater conceptualisation report (SLR, 2023), there are faults present in and around the Millennium Mine. The modelling of faults within the groundwater model domain is from the SLR (2021c) model using the fault mapping and site-specific geology models where available.

Mesh refinement (200 m) 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.



0 5 10 km

Coordinate System: GDA 1994 MGA Zone 55
Scale: 1:450,000 at A4
Project Number: 620.031508
Date: 27-Oct-2023
Drawn by: AS

Major Drainage System
Project Boundary
Project Mining Lease Boundary
Model Boundary

Modelled Fault Zone
1
2
3
4
5

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MODELLED FAULT ZONES

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FIGURE 2-3

H:\Projects-SLR\620-BNE\620-BNE\620.031508.00001 Millennium Mine - Mavis South\06 SLR Data\01 CADGIS\GIS\Modelling Report\620031508 MOD F2-03 Modelled Fault Zones.mxd

2.3 Model Stresses and Boundary Conditions

2.3.1 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 cells and is therefore variable in this model due to variable cell-size.

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.

2.3.2 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 Millennium Mine 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 (2008-2021) Calibration simulation - Historical Quarterly Averages Prediction simulation- Fixed Stage Height- Long term Average (2008-2021)	1.0×10^{-2}
New Chum Creek	0	1.0×10^{-2}
Other Minor Creeks	0	1.0×10^{-3} to 1.0×10^{-2}

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

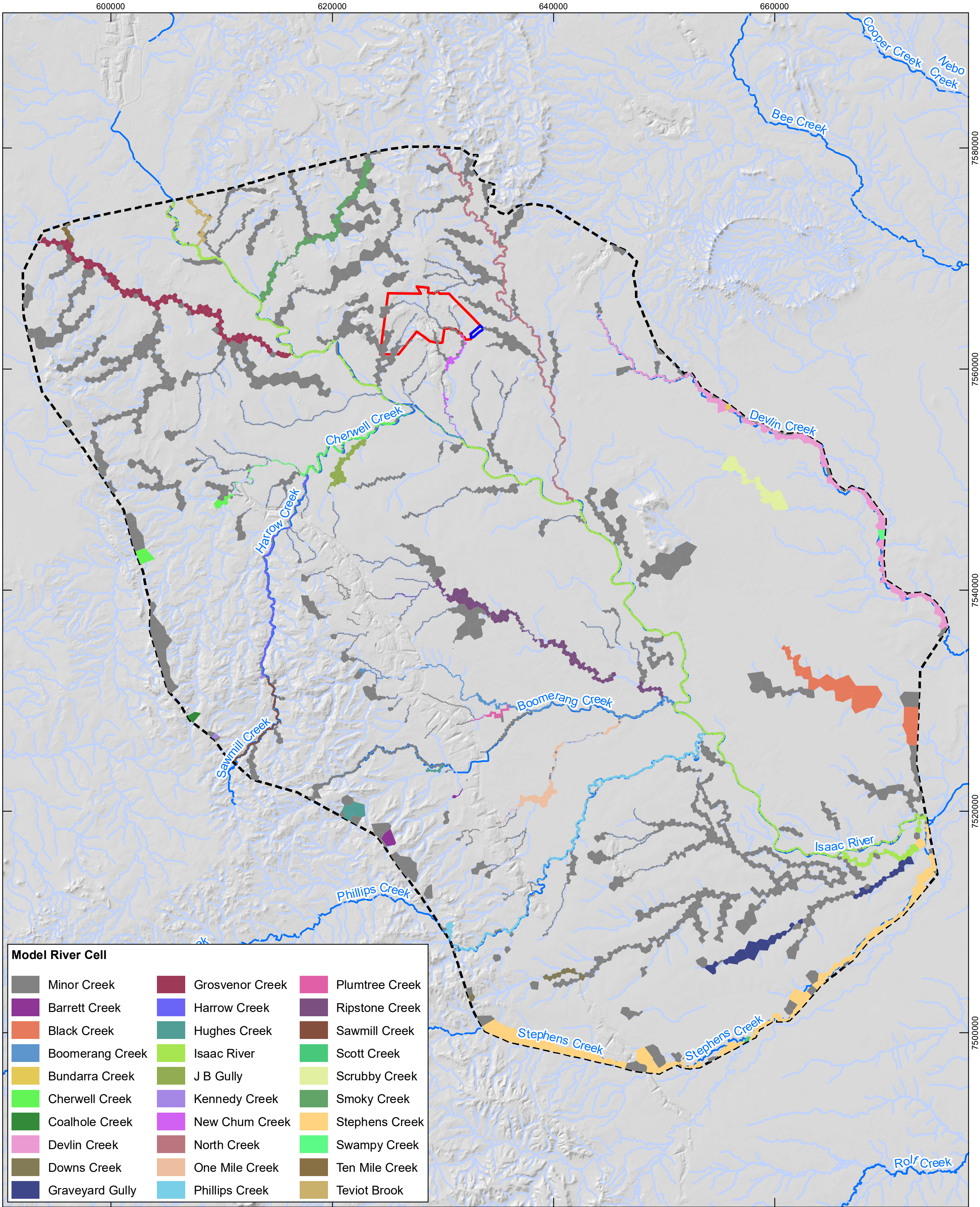
Table 2-3 Average Stage Heights (m) Used to Develop Transient Sequence

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 SLR (2021c) 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 SLR (2021c) 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 SLR (2021c) 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.



0 5 10 km

Coordinate System:	GDA 1994 MGA Zone 55
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Major Drainage System
Minor Drainage
Project Boundary
Project Mining Lease Boundary
Model Boundary

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STREAMS AND RIVER CELLS

SLR

FIGURE 2-4

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2.3.3 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 previous Millennium Mine Mavis Extension modelling project. 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 2021). For the prediction model, annual averages of 1990-2021 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
- Tertiary 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 2.5.6**. Overall, the recharge rates range from 0.1 to 2.3 mm/year.

2.3.4 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 Evapotranspiration 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.

2.3.5 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.

2.3.6 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.

2.3.6.1 Active mining

Bord and Pillar extraction at the Mavis Approved and the Project is represented as drain cells in model layer 5 (Leichhardt Seam). In the Mavis Pit (Pit E), historical open cut mining is simulated through drain cells applied from Layer 1 to Layer 5 (Leichardt seam).

The drain cells representing the surrounding mines are consistent with the SLR (2021c) 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 existing model.

2.3.6.2 Post-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. Backfilling of open cut mine areas with spoil was also modelled using the Time-variant materials (TVM) package. The model cell properties were updated to spoil properties guided by operational mine plans. 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 0.05 and a storage coefficient of 1.0×10^{-5} m^{-1}.

The change of hydraulic properties for the post-mining period for the Bord and Pillar Mining at Mavis Approved and the Project underground mine was also modelled using the time-variant materials (TVM) package. The model cell properties were updated based on the operational mine plans. Horizontal hydraulic conductivity of 1 m/day and vertical hydraulic conductivity of 1 m/day was applied to the Bord and Pillar zone. The storage parameters used for the zone were a specific yield of 0.5 and a storage coefficient of 5.0×10^{-6} m^{-1}.

2.4 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 2022.

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).

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.

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.

2.5 Calibration Validation

The SLR (SLR, 2021c) model was calibrated using a data set of 3,449 measured groundwater levels collated for 283 sites, dating to December 2021 (SLR, 2021c). As this updated version of the model includes revisions to the model domain, structure and calibration period, the calibration period of the model was re-run for the updated model with the previously calibrated SLR model parameters to verify the validity of the updated Project model.

The model calibration data set from the existing model (SLR, 2021c) has been updated with additional bores and groundwater measurements for use in the calibration validation. The calibration validation data set includes a total of 3,782 measured groundwater levels for 288 bores across the model domain, dating to July 2023. The calibration validation data set includes data from 5 additional bores from the Millennium Mine. Groundwater bores used for the calibration validation were weighted as 1 each in the calibration validation.

As discussed in the following sections, the results of the validation process were deemed to indicate that the parameterisation from the existing SLR model (SLR, 2021c) remains appropriate for the Project model.

Details on each of the observation points and their residuals are presented in **Appendix A** of this report. The locations of these bores are shown in **Figure 2-8**.

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.

2.5.1 Calibration Validation Statistics

The overall transient calibration validation statistics are presented in **Table 2-4** 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). RMS is expressed as:

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

where:	n	=	number of measurements
	ho	=	observed water level
	hm	=	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 11.22 m.

The RMS error calculated for the validated model is 11.22 m, compared with 11.98 m for the Millennium site observation bores. This equates to a scaled RMS (ratio of RMS to the total head change, SRMS) of 7.19% across the model domain, with 21.95% for the Millennium bores being due to the narrower range of groundwater measurements at site.

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 2-4 Calibration Validation Statistics – Best Calibrated Model

Statistic	Value
Mean Residual (m)	-2.4
Sum of Squares (m^2)	476364.01
Root Mean Square Error (RMS) (m)	11.22
Scaled RMS (SRMS) (%)	7.19%
Sum of Residuals (m)	28775.59
Mean Residual (m)	7.61
Range in Observations (m)	156.01
Number of Observations	3782
Targets within ±2m (% of total)	788 (21%)
Targets within ±5m (% of total)	1852 (49%)
Targets within ±20m (% of total)	3535(94%)

Figure 2-5 presents the observed and simulated groundwater levels graphically as a scattergram for the historic transient calibration validation (2008 to 2023).

Figure 2-6 shows the observed and simulated groundwater levels graphically only for the Millennium bores.

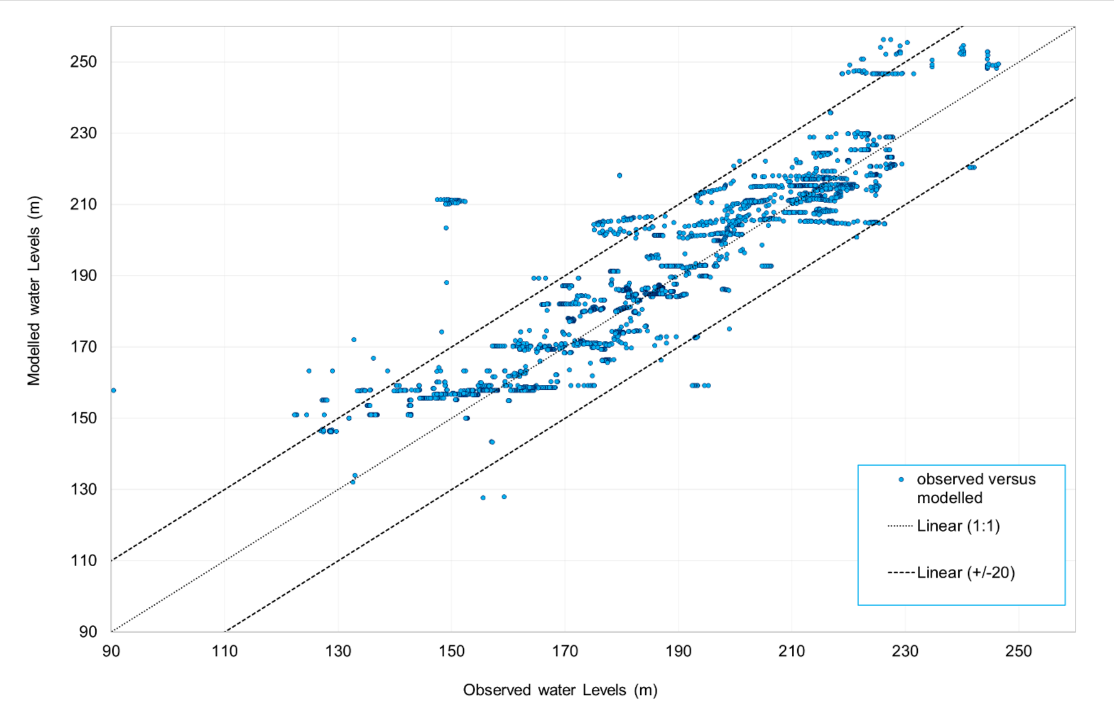


Figure 2-5 Calibration Validation Scattergram – Modelled vs Observed Groundwater Levels (All Bores)

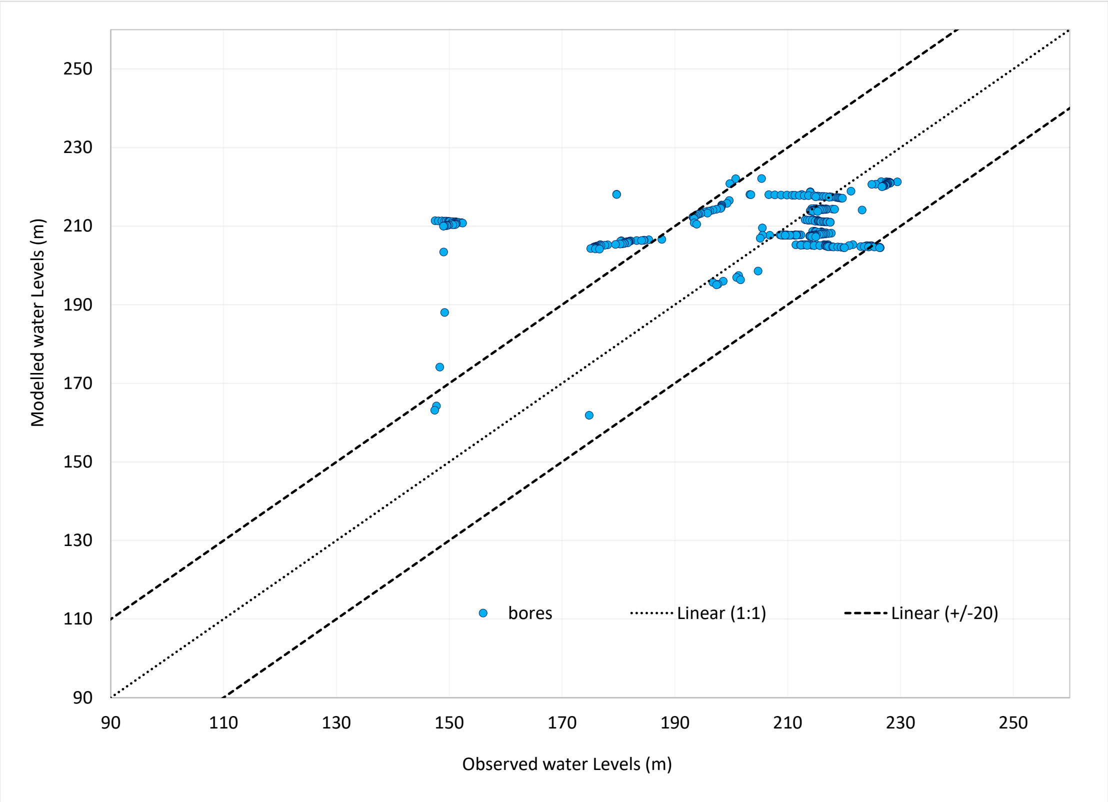


Figure 2-6 Calibration Validation Scattergram – Modelled vs Observed Groundwater Levels (Millennium Bores)

Figure 2-7 shows the distribution of calibration validation residuals for the entire model. As shown in the figure the calibration residuals in majority of the calibration data points are within ± 20 m. **Figure 2-7** indicates that in general the model tends to slightly over predict groundwater levels, but **Figure 2-6** suggests a tendency to local underprediction.

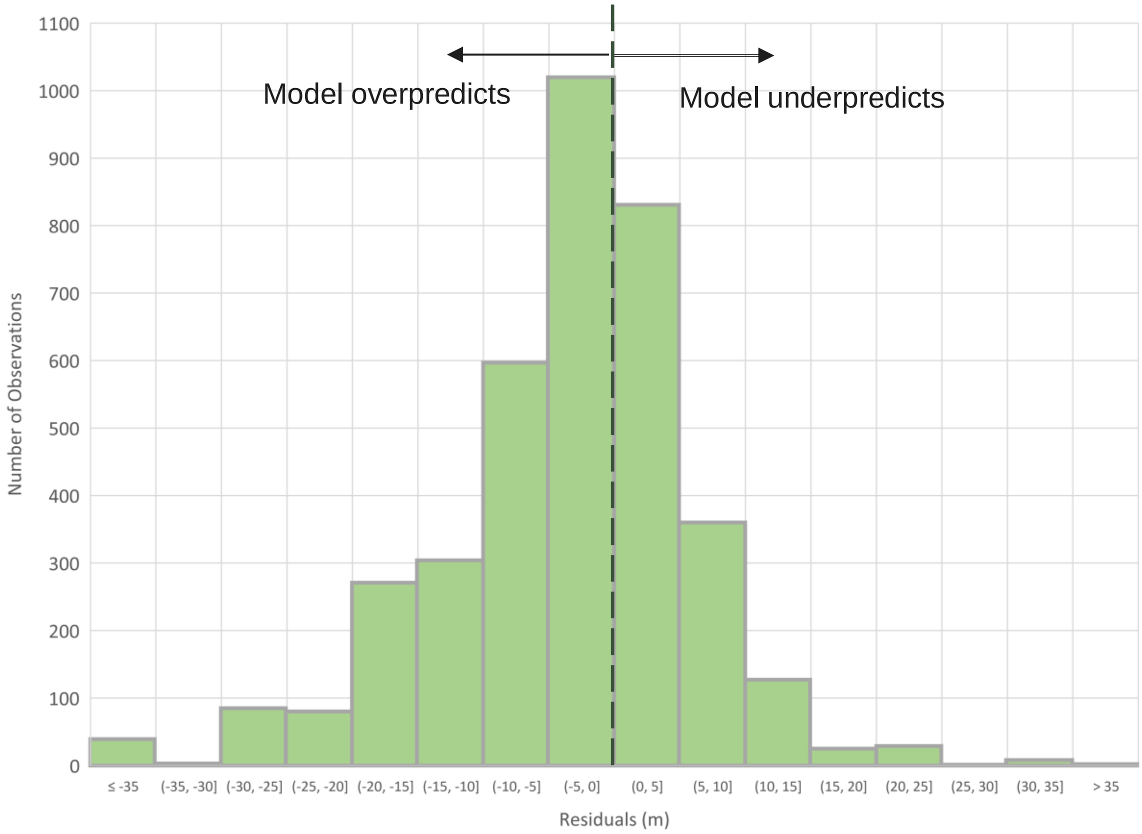


Figure 2-7 Calibration Validation Residual Histogram Scattergram

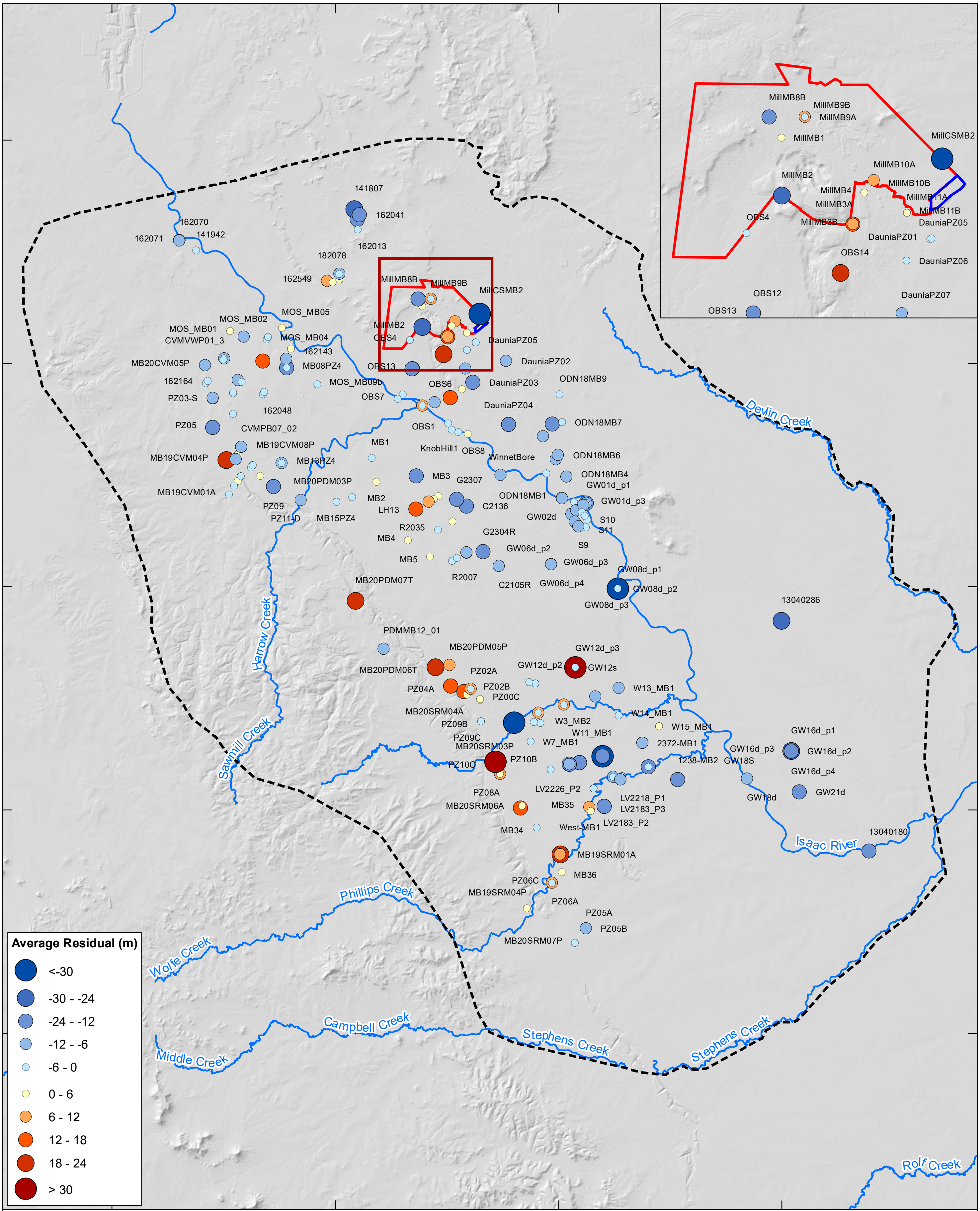
Table 2-5 shows the average calibration residual and absolute average residual per model layer. The residual is the difference between the measured and the modelled water level at each bore. A negative residual represents an over estimation of water levels, while a positive residual represents an underestimate. **Table 2-5** 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 show 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 2-5 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.

Table 2-5 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	--5.34	6.18	213	18
2	Tertiary sediments, Tertiary basalt	Tertiary and minor Triassic Clematis, weathered Permian, Tertiary basalt	-0.47	7.06	1137	93
3	Rewan Group	Triassic	-9.30	15.09	153	15
4	Rangal Coal Measures	Leichhardt overburden	-3.07	5.17	207	8
5		Leichhardt seam	-9.98	11.18	463	31
6		Interburden	-6.77	10.13	137	6
7		Vermont seam	-7.81	9.38	259	23
8		Vermont underburden	-8.77	8.77	149	4
9	Fort Cooper Coal Measures	Fort Cooper overburden	0.91	3.78	364	23
10		Fort Cooper seams (combined)	1.52	8.19	90	10
11		Fort Cooper underburden	0.95	6.91	65	5
12	Moranbah Cooper Coal Measures	Q Seam	-0.16	2.51	117	3
13		Interburden	-2.58	4.21	39	2
14		P Seam	-2.45	5.95	99	6
15		Interburden	10.63	10.63	66	5
16		H Seam	-3.97	5.92	85	14
17		Interburden	-5.52	9.61	7	3
18		D Seam	-4.79	6.55	135	14
19*		Interburden	-	-	-	-

*There are no observation bores in Layer 19



Coordinate System: GDA 1994 MGA Zone 55

Scale: 1:160,000 at A4

Project Number: 620.031508

Date: 07-Nov-2023

Drawn by: AS

- Major Drainage System
- Project Boundary
- Project Mining Lease Boundary
- Model Boundary

MAVIS SOUTH UNDERGROUND EXTENSION GROUNDWATER MODELLING REPORT

TRANSIENT CALIBRATION VALIDATION AVERAGE HEAD RESIDUALS (M)

SLR

FIGURE 2-8

H:\Projects-SLR\620-BNE\620.031508.00001 Millennium Mine - Mavis South\06 SLR Data\01 CADGIS\GIS\Modelling Report\620031508 MOD F2-08 Transient Calibration Average Head Residuals.mxd

2.5.2 Calibration Fit

This section provides discussion on the modelled to observed water level trends (calibration hydrographs) for select monitoring bores across the Millennium site.

The calibration hydrographs for Millennium site bores MILLMB1, MILLMB4, MILLMB8B, and MILLMB10A are shown in **Figure 2-9**.

- The hydrograph for MILLMB1, located in the Rangal Coal Measures overburden, near the centre of the Millennium Mine area, shows the model closely matches observed water levels at this location. No water levels were recorded at bore MILLMB1 after October 2014 due to the bore being lost to mining.
- Modelled water levels in MILLMB4, located in the Tertiary Sandstone sediments with variable thickness, about 2 km to the northwest of the Mavis South Project area, provide a similar trend to the observed water levels at this location. However, there is approximately four metres difference between the observed and modelled water level at the location of this bore, with the model underpredicting groundwater heads at this location.
- The hydrograph for MILLMB8B, located in the Rangal Coal Measures overburden toward the north of the Millennium Mine area, shows the model overpredicts water levels at this location by approximately 20 m. The overprediction may be a result of structural features present at this location that are not currently represented in the model. The Millennium geological model indicates a 4 km fault runs to the south-southeast, between bore MILLMB8B and bore MILLMB1, along which permeability may be higher. However, the modelled water level trend matches the observed trend, which is deemed acceptable.
- The hydrograph for MILLMB10A, located in the Fort Cooper Coal Measures-Interburden close to the MILLMB4 bore at the northeastern part of Project area, doesn’t show as much discrepancy as bore MILLMB4, which reports a good model prediction at the depth of this bore. Modelled water level matches closely with measured water level at the beginning and the end of the monitoring period which has been ongoing since 2014 to the present time. However, the model does not manage to replicate seasonal groundwater level variation and underpredicts the maximum levels observed.

Calibration validation hydrographs for the full calibration dataset are presented in **Appendix A**. While water levels at some Millennium site bores are not well matched by the model (i.e., 20 m discrepancy), the observed water level trends for these bores are reflected well in modelled water level trends. The Australian Groundwater Modelling Guidelines (Barnett *et al.*, 2012) suggest that model outputs obtained by calculating the difference between a stressed and unstressed or ‘null mining’ scenario can minimise the predictive uncertainty associated with model outcomes.

As drawdown predictions are obtained by calculating the difference in predicted aquifer groundwater levels between two model scenarios, the absolute error associated with predicted groundwater levels is negated and the model is considered fit for the purpose of this assessment.

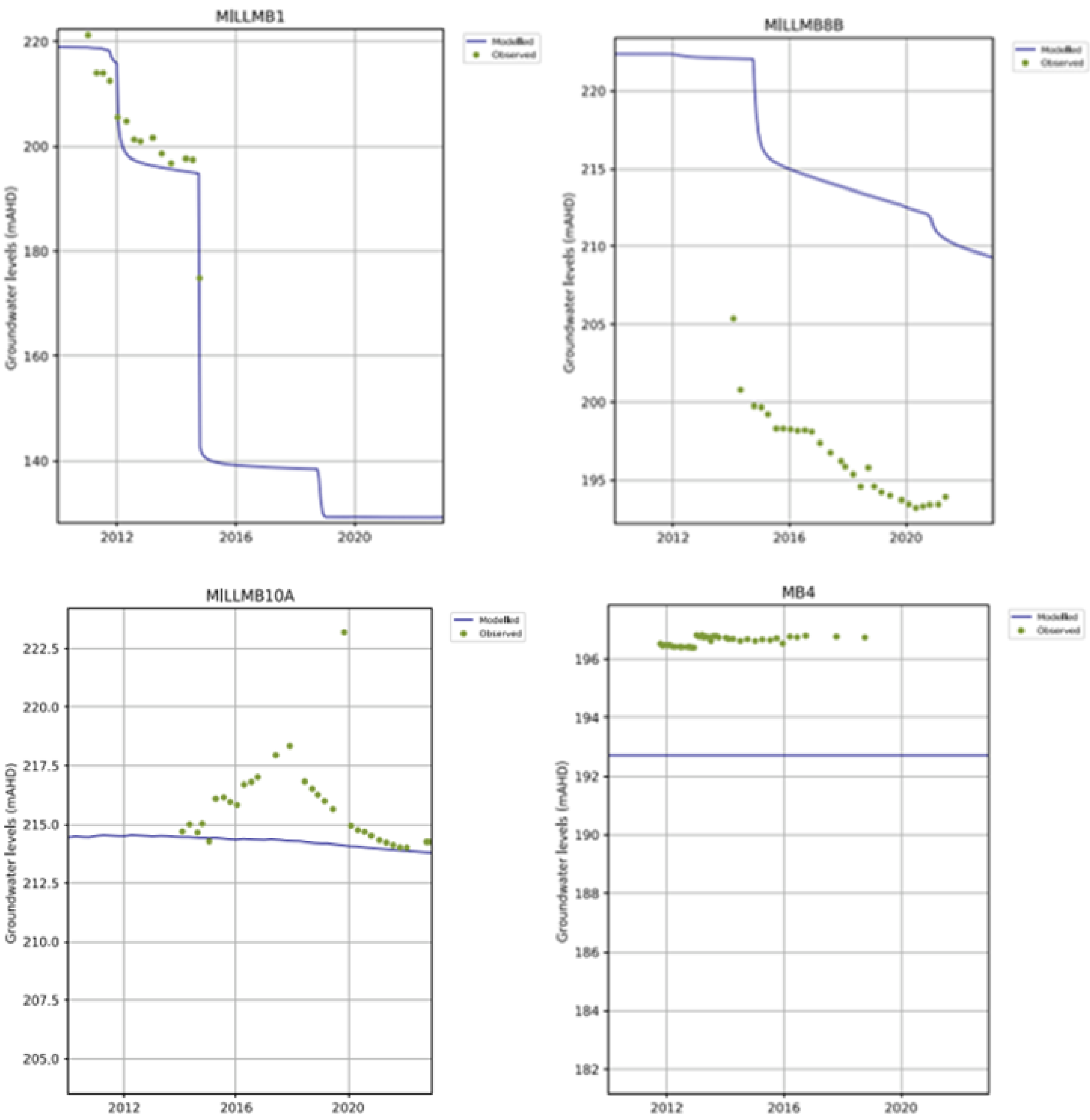


Figure 2-9 Calibration Fit for Millennium Site Bores MB1, MB4, MB8B, and MB10A

2.5.3 Model Water Balance

2.5.3.1 Steady State Calibration

The water balance for the steady state model calibration is shown in **Table 2-6**. 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 2.63 and 1.71 ML/d respectively, indicating that groundwater enters the model domain through this boundary.

A net outflow of 3.13 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 (1.99 ML/d outflow). The mass balance error for the steady state calibration is 0.00 %, 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 2-6 Steady-State Model Water Balance

Component	Inflow (ML/d)	Percent of Total Inflow (%)	Outflow (ML/d)	Percent of Total Inflow (%)
Recharge (RCH)	4.20	25.82	0.00	0.00
ET (from GW) (EVT)	0.00	0.00	1.99	12.26
SW-GW Interaction Isaac River (RIV)	9.43*	58.00	12.56	77.24
Regional GW Flow (GHB)	2.63	16.18	1.71	10.50
Mines (DRN)	0.00	0.00	0.00	0.00
Storage	0.00	0.00	0.00	0.00
Total	16.26	100.00	16.26	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.

2.5.3.2 Transient Calibration

The model water balance for the transient simulation averaged over the duration of the calibration period is presented in **Table 2-7**. 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 2-7** shows 2.01 ML/d is lost to evapotranspiration in areas where the water table is within 2 m of the land surface. In total 3.08 ML/d is discharged via surface drainages, with the vast majority of that attributed to the Isaac River, a net gaining condition in the river in the calibration period.

Table 2-7 Transient Model Water Balance*

Component	Inflow (ML/d)	Percent of Total Inflow (%)	Outflow (ML/d)	Percent of Total Inflow (%)
Recharge (RCH)	4.26	14.35	0.00	0.00
ET (from GW) (EVT)	0.00	0.00	2.01	6.76
SW-GW Interaction Isaac River (RIV)	9.77**	32.92	12.85	43.31
Regional GW Flow (GHB)	2.72	9.17	1.74	5.88
Mines (DRN)	0.00	0.00	7.78	26.24
Storage	12.92	43.56	5.29	17.82
Total	29.67	100.00	29.67	100.00

** Values in table are average values over the transient calibration period.

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

A net inflow of 0.98 ML/d occurs due to the GHB component. This indicates that a small volume of water (approximately 3% of total flow) enters the model domain through this boundary and therefore, this boundary condition does not have a significant influence on the model predictions. A total of 7.78 ML/d is removed from the model by the Drain boundary condition that represents historical mining (1988-2022) in the model.

2.5.4 Calibrated Hydraulic Parameters

Table 2-8 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 2-8 Hydraulic Conductivity – Best Calibrated Model

Model Layer	Formation	Unit	Horizontal Hydraulic Conductivity (m/day)	Anisotropy Kz/Kx
1	Alluvium	Surface cover	12.0	0.200
1	Regolith	Surface cover	1.0	0.100
1	Weathered Permian	Surface cover	0.6	0.060
1	Duaringa Formation	Surface cover	0.5	0.050
1 & 2	Tertiary Basalt	Tertiary basalt	3.2	0.100
2	Regolith	Surface cover	1.0	0.030
3	Rewan Group	Triassic	2.0×10^{-3}	0.070
4	Rangal Coal Measures	Leichhardt overburden	1.0×10^{-5} to 6.0×10^{-3}	0.090
5		Leichhardt seam	1.0×10^{-4} to 9.0×10^{-2}	0.002
6		Interburden	5.0×10^{-5} to 1.0×10^{-3}	0.100
7		Vermont seam	1.0×10^{-4} to 1.0×10^{-2}	0.030
8		Vermont underburden	5.0×10^{-5} to 1.0×10^{-3}	0.002
9	Fort Cooper Coal Measures	Fort Cooper overburden	5.0×10^{-5} to 1.0×10^{-3}	0.100
10		Fort Cooper seam	$1.0 \times 10^{-4}$to 1.0×10^{-3}	0.100
11		Fort Cooper underburden	5.0×10^{-5} to 4.0×10^{-1}	0.005
12	Moranbah Coal Measures	Q Seam	$1.0 \times 10^{-4}$to 1.0×10^{-1}	0.200
13		Interburden	$5.0 \times 10^{-5}$to 5.0	0.200
14		P Seam	$1.0 \times 10^{-4}$to 5.0	0.050
15		Interburden	5.0×10^{-5} to 3.0×10^{-1}	0.040

Model Layer	Formation	Unit	Horizontal Hydraulic Conductivity (m/day)	Anisotropy Kz/Kx
16		H Seam	$1.0 \times 10^{-4}$to 1.0×10^{-1}	0.007
17		Interburden	$5.0 \times 10^{-5}$to 2.0×10^{-1}	0.060
18		D Seam	$1.0 \times 10^{-4}$to 1.0×10^{-1}	0.030
19		Interburden	1.0×10^{-5} to 2.0×10^{-1}	0.005
	Faults		5.0×10^{-5} to 1.0×10^{-2}	0.100
-	Spoil		3.0×10^{-1}	0.200

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 5.0×10^{-5} m/day and the hydraulic conductivity of the coal seams is capped at a minimum of 1.0×10^{-4} m/day.

The hydraulic conductivity of the interburden/overburden and coal seam layers decreases with depth according to Equations 1, 2 (exponential) and Equation 3 (power). Equations 1 and 2 were adopted from the existing model (SLR, 2021d). With regards to the faults, an exponential equation (Equation 3) was used to replicate changes in hydraulic conductivities of fault at depth.

Coal: HC = HC0 × e(-0.015×depth)
(Eq. 1)

Interburden (RCM and FCCM): HC = HC0 × e(-0.018×depth)
(Eq. 2)

Fault: HC = HC0 × e(-0.018×depth)
(Eq. 3)

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).

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 2-10**, while the calibrated relationships for coal units, specifically the Leichardt and Vermont Seams as relevant to the Project, are presented in **Figure 2-11**. The observation data in the figures present the Olive Downs site data (2018), Winchester South site data, Lake Vermont North site data and Coffey (2014) Bowen Basin data.

Figure 2-12 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 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 2-12**, the calibrated (modelled) horizontal hydraulic conductivity values are all within the range of field data.

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 shown in **Table 2-9**.

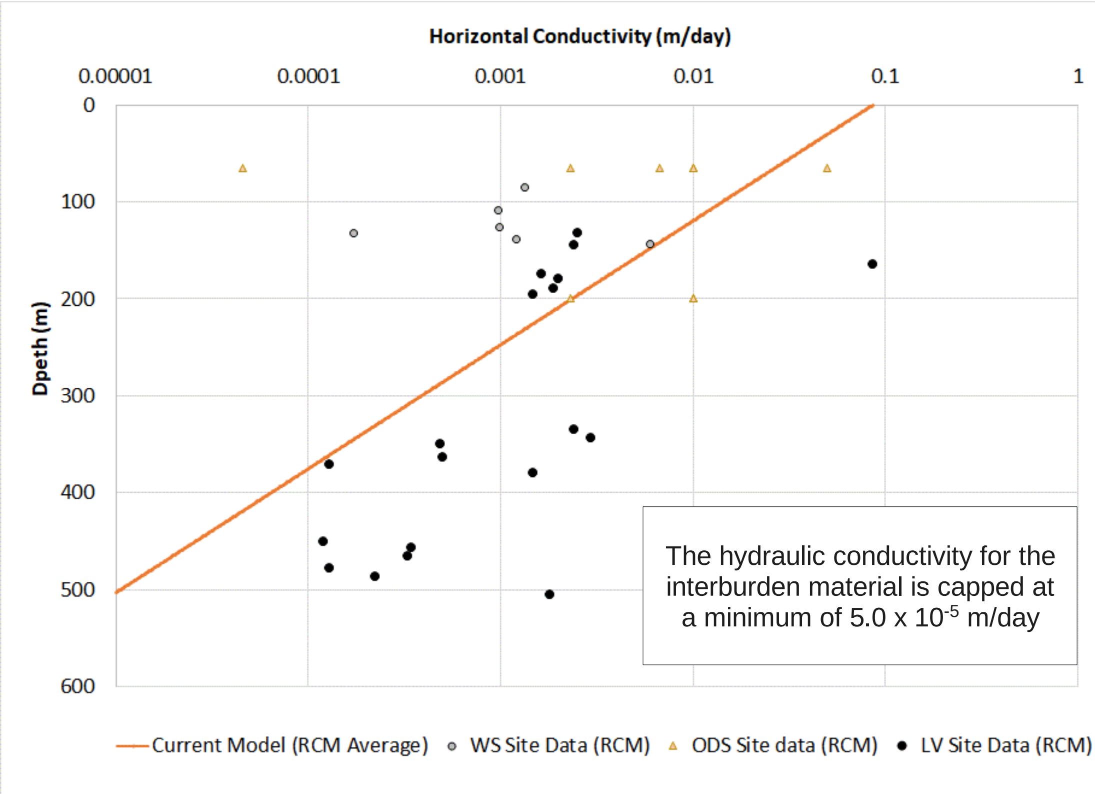


Figure 2-10 Hydraulic Conductivity vs Depth – Interburden/Overburden

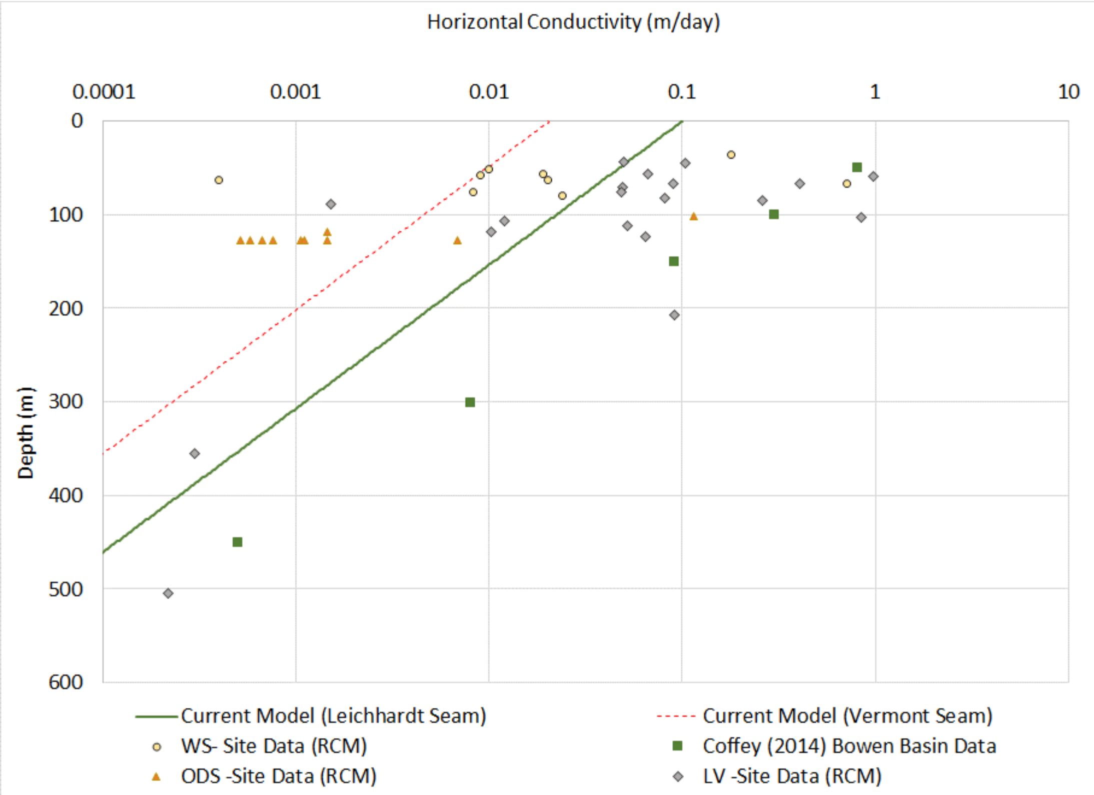


Figure 2-11 Hydraulic Conductivity vs Depth – Coal

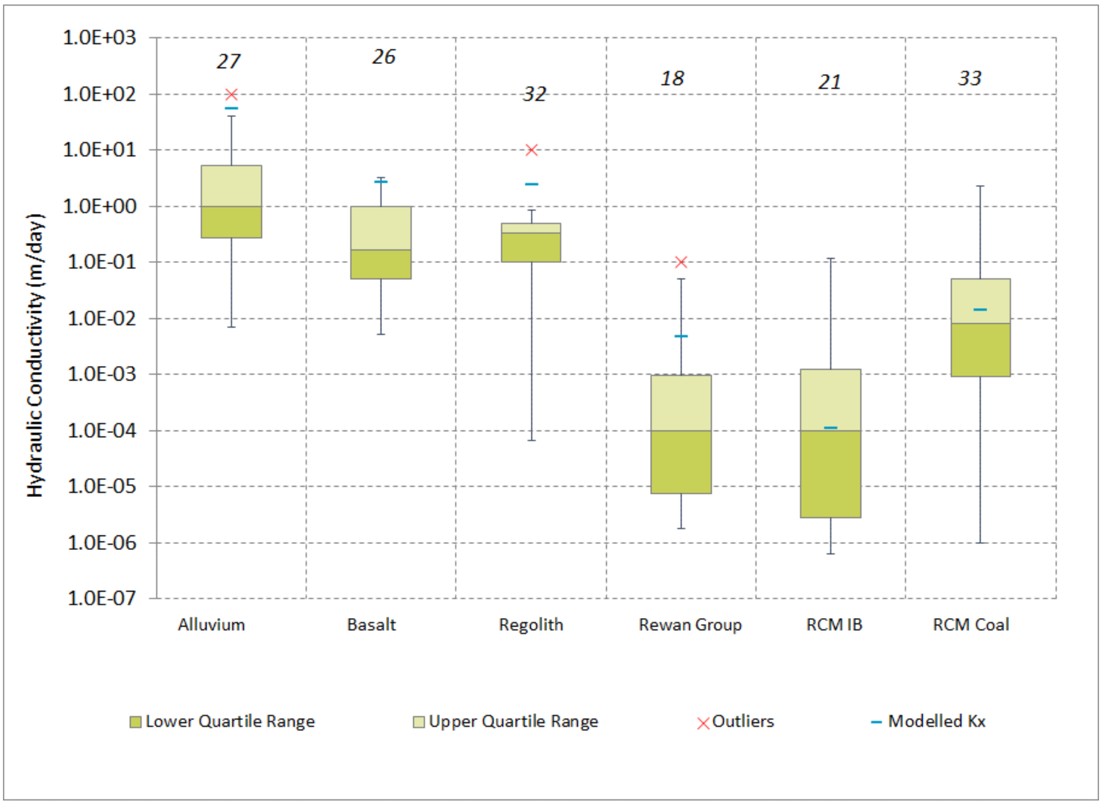


Figure 2-12 Hydraulic Parameters Estimates vs Best Calibrated Hydraulic Parameters

Table 2-9 Hydraulic Conductivity of Faults – Best Calibrated Model

Model Layer	Formation	Unit	Average Horizontal Hydraulic Conductivity (m/day)	Anisotropy Kv/Kx
3	Rewan Group		9.8×10^{-3}	0.35
4	Rangal Coal Measures	Leichhardt overburden	9.1×10^{-3}	0.34
5		Leichhardt seam	9.0×10^{-3}	0.32
6		Interburden	8.5×10^{-3}	0.30
7		Vermont seam	8.0×10^{-3}	0.29
8		Vermont underburden	7.7×10^{-3}	0.27
9	Fort Cooper Coal Measures	Fort Cooper overburden	7.3×10^{-3}	0.35
10		Fort Cooper seam	6.3×10^{-3}	0.18
11		Fort Cooper underburden	4.9×10^{-3}	0.12
12	Moranbah Coal Measures	Q Seam	4.3×10^{-3}	0.17
13		Interburden	4.1×10^{-3}	0.19
14		P Seam	3.8×10^{-3}	0.19
15		Interburden	3.7×10^{-3}	0.23
16		H Seam	3.3×10^{-3}	0.21
17		Interburden	3.0×10^{-3}	0.22
18		D Seam	2.6×10^{-3}	0.21
19		Interburden	1.9×10^{-3}	0.18

2.5.5 Calibrated Storage Properties

Table 2-10 summarises the calibrated values of specific storage and specific yield for the hydrostratigraphic units.

Table 2-10 Calibrated Storage Parameters – Best Calibrated Model

Model Layer	Formation	Unit	Specific Yield Sy (%)	Specific Storage Ss (m-1)
1	Alluvium	Surface cover	4.20	1.0×10^{-5}
1	Regolith	Surface cover	3.60	5.5×10^{-6}
1	Weathered Permian	Surface cover	1.00	1.0×10^{-6}
1	Duaringa Formation	Surface cover	2.10	1.0×10^{-6}
1 & 2	Tertiary Basalt	Tertiary basalt	3.40	1.2×10^{-6}
2	Regolith	Surface cover	2.80	1.0×10^{-6}
3	Rewan Group	Triassic	4.20	7.0×10^{-7}

Model Layer	Formation	Unit	Specific Yield Sy (%)	Specific Storage Ss (m-1)
4	Rangal Coal Measures	Leichhardt overburden	2.80	4.7×10^{-6}
5		Leichhardt Seam	0.80	9.0×10^{-7}
6		Interburden	0.10	7.0×10^{-7}
7		Vermont Seam	0.20	3.1×10^{-6}
8		Vermont underburden	0.20	1.6×10^{-6}
9	Fort Cooper Coal Measures	Fort Cooper overburden	0.10	7.0×10^{-7}
10		Fort Cooper seam	0.50	3.2×10^{-6}
11		Fort Cooper underburden	0.60	1.9×10^{-6}
12	Moranbah Coal Measures	Q Seam	0.10	4.8×10^{-6}
13		Interburden	0.40	1.7×10^{-6}
14		P Seam	0.10	9.0×10^{-6}
15		Interburden	0.13	1.4×10^{-6}
16		H Seam	0.10	9.0×10^{-6}
17		Interburden	0.32	3.4×10^{-6}
18		D Seam	0.10	9.7×10^{-6}
19		Interburden	0.39	3.5×10^{-6}
	Fault		0.20 to 3.90	7.0×10^{-7} to 6.3×10^{-6}
	Spoil		5.00	1.0×10^{-5}

2.5.6 Calibrated Recharge

Table 2-11 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 595.7 mm/year.

Table 2-11 Calibrated Rainfall Recharge – Best Calibrated Model

Model Geology Zone	(mm/year)	% Mean annual rainfall
Isaac River Channel Alluvium	3.2	0.53
Isaac River Flood Plain Alluvium	1.4	0.23
Other Alluvium	1.4	0.23
Duaringa Formation	0.1	0.01
Tertiary basalts	1.9	0.32
Weathered Permian	0.4	0.06

Model Geology Zone	(mm/year)	% Mean annual rainfall
Regolith	0.1	0.01

Figure 2-13 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.

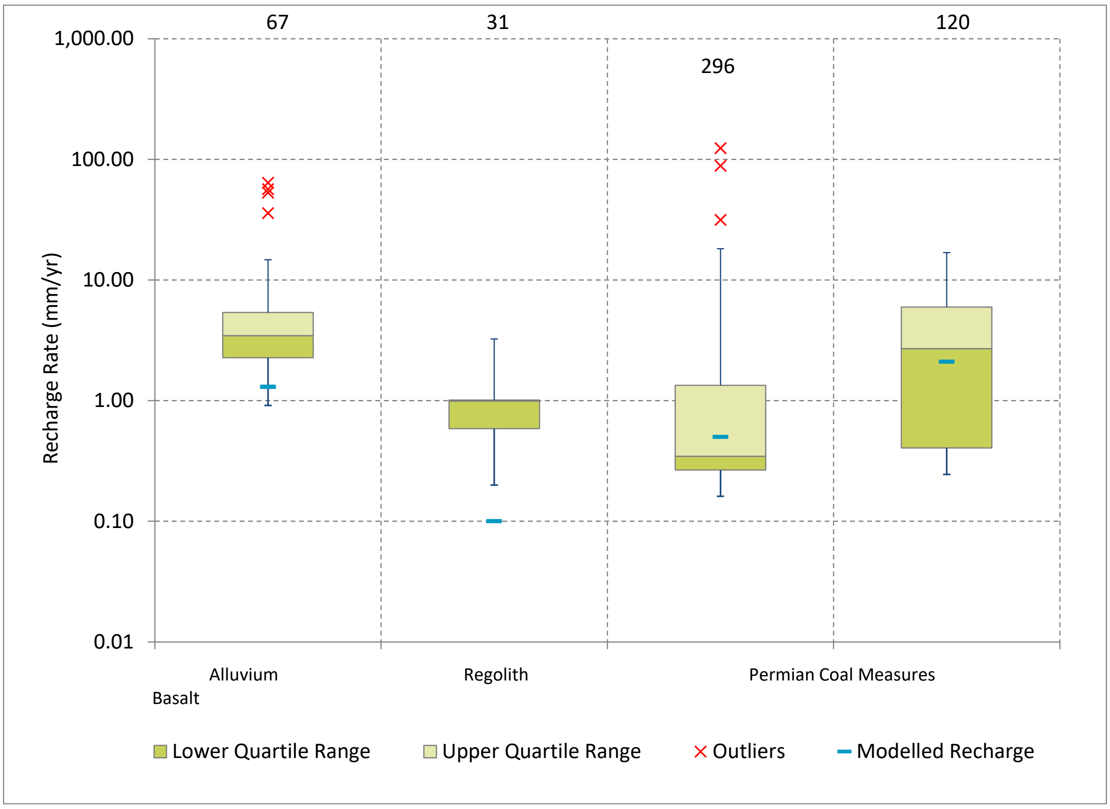


Figure 2-13 **CMB Recharge Estimates vs Modelled Recharge**

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 model stress period setup is detailed in **Appendix D**, alongside simulated mine timings.

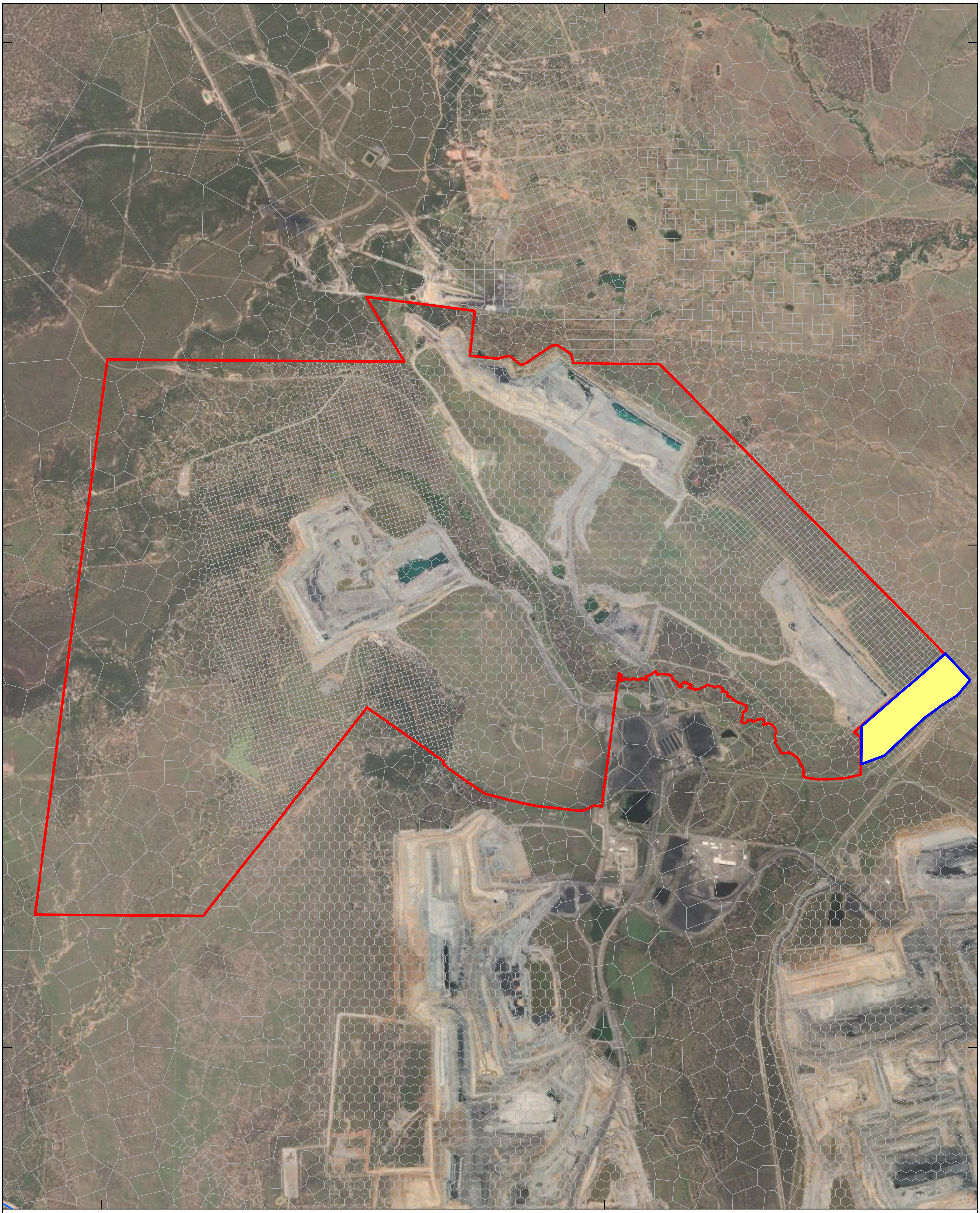
Transient predictive models have been developed for three model scenarios, from July 2021 to December 2021 with quarterly time intervals followed by bi-annual time intervals from January 2022 to December 2042:

- Null Run – no mining within region from January 2008 (end of transient warmup).
- Approved– all approved and foreseeable mining in region excluding underground mining at the Project.
- Project– all approved and foreseeable mining in region including the proposed mining at the Project.

A three-year operational window was assumed for mine cells at any Millennium open cut areas, after which time the drains were removed and the MODFLOW Time Variant Materials (TVM) package was used to assign spoil properties to the cells. The drains at the Project remain active during active mining and one year following the completion of the bord and pillar mining.

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. The simulated predictive mine progression for the Project is presented in **Figure 3-1**.

Predictive modelling results presented in this report section are based on the single model (i.e., best calibrated model realisation discussed in **Section 2.5**) and uncertainty with respect to the model predictions is investigated in detail in **Section 6.0**.



0 0.5 1 km

Coordinate System: GDA 1994 MGA Zone 55
Scale: 1:50,000 at A4
Project Number: 620.031508
Date: 27-Oct-2023
Drawn by: AS

SLR

Major Drainage System
Project Boundary
Project Mining Lease Boundary
Model Boundary
Model Grid

Mine Progression

FY2024/25 (July 24-June 25)

MAVIS SOUTH UNDERGROUND EXTENSION GROUNDWATER MODELLING REPORT

MINE PROGRESSION FOR THE MAVIS SOUTH

FIGURE 3-1

H:\Projects-SLR\620-BNE\620-BNE\620.031508.00001 Millennium Mine - Mavis South\06 SLR Data\01 CADGIS\GIS\Modelling Report\620031508 MOD F3-01 Mine Progression for the Mavis South.mxd

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 for the three model scenarios. The mass balance error for three scenarios was 0.0 % 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).

Table 3-1 to **Table 3-3** show in all the three model scenarios, groundwater enters the model through regional groundwater flow (GHB). The GHB net flow is approximately 3% of the total flow in water balance for all the scenarios indicating the model boundary conditions do not influence the model predictions.

Evapotranspiration for the predictive models is approximately 1.85 ML/d for the Project and Approved scenarios and 2.00 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 (-3.12 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 Approved scenario the net river exchange flux (RIV) is positive (4.49 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 2021, 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 Project scenario creates the same river loss as Approved scenario, indicating that the proposed mining activities do not impact the flow out of the Isaac River.

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 Project scenario resulted in an increase in the average drain outflow (15.32 ML/d from 15.18 ML/d predicted for the Approved scenario) (i.e., 0.14 ML/d or 52 ML/yr).

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

Component	Inflow (ML/d)	Percent of Total Inflow (%)	Outflow (ML/d)	Percent of Total Inflow (%)
Recharge (direct rainfall)	4.22	10.21	0.00	0.00
Evapotranspiration (ET)	0.00	0.00	1.85	4.49
SW/GW Interaction Isaac River (RIV)**	13.69	33.14	9.23	22.36
Regional GW flow (GHB)	3.02	7.30	1.70	4.12
Drains (Mine inflows)	0.00	0.00	15.32	37.12
Storage	20.39	49.35	13.17	31.91
Total	41.31	100.00	41.28	100.00

* Values in table are average values over the transient prediction period.

** 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)	4.22	10.24	0.00	0.00
Evapotranspiration (ET)	0.00	0.00	1.85	4.51
SW/GW Interaction Isaac River (RIV)**	13.71	33.29	9.22	22.40
Regional GW flow (GHB)	3.01	7.32	1.70	4.13
Drains (Mine inflows)	0.00	0.00	15.18	36.88
Storage	20.24	49.15	13.19	32.07
Total	41.18	100.00	41.14	100.00

* Values in table are average values over the transient prediction period.

** 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)	4.22	23.90	0.00	0.00
Evapotranspiration (ET)	0.00	0.00	2.00	11.32
SW/GW Interaction Isaac River (RIV)**	9.54	54.04	12.66	71.77
Regional GW flow (GHB)	2.65	15.00	1.72	9.74
Drains (Mine inflows)	0.00	0.00	0.00	0.00

Component	Inflow (ML/d)	Percent of Total Inflow (%)	Outflow (ML/d)	Percent of Total Inflow (%)
Storage	1.25	7.06	1.26	7.16
Total	17.65	100.00	17.64	100.00

* Values in table are average values over the transient prediction period.

** 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

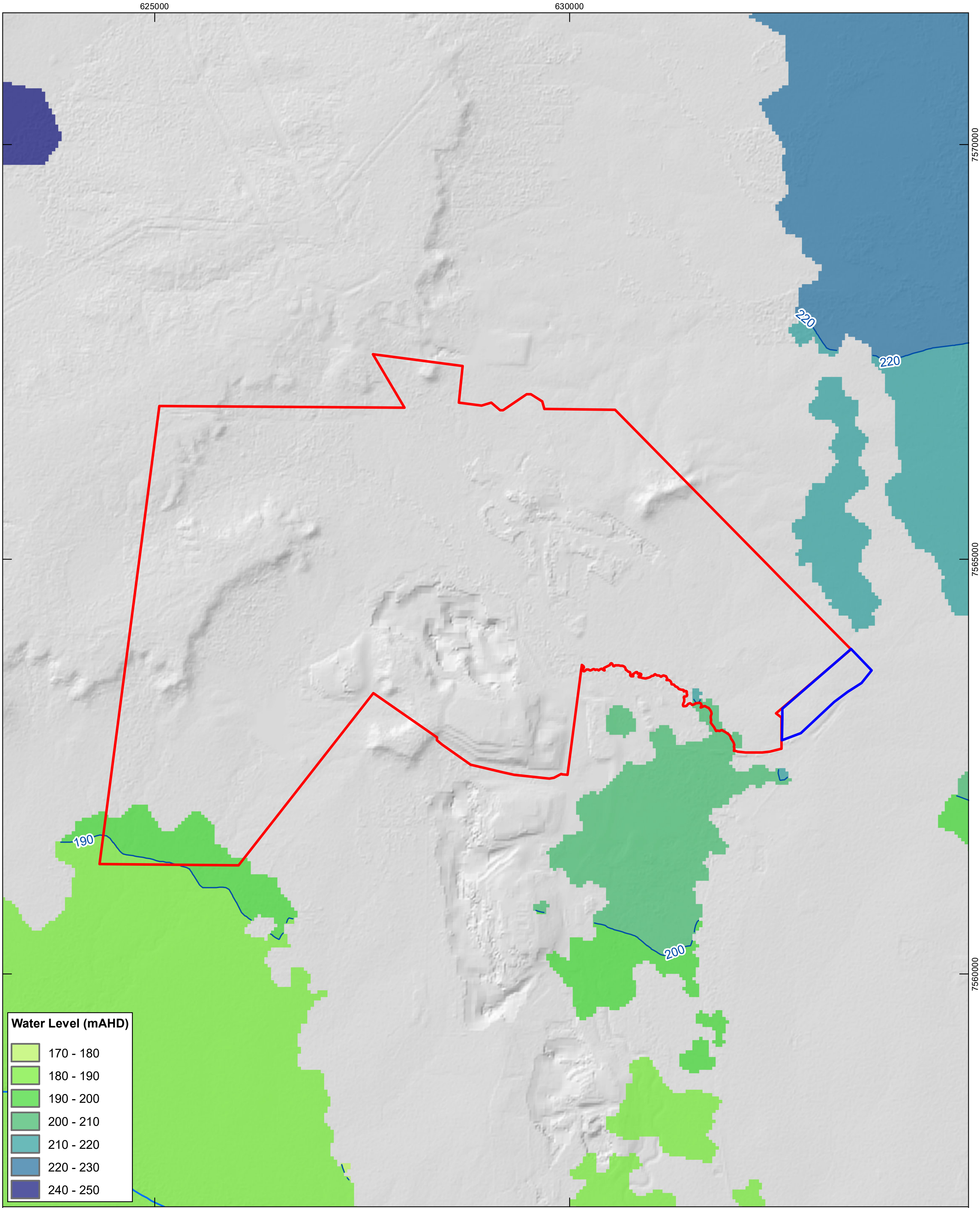
Predicted groundwater levels at the end of mining operations for the Approved Scenario (Figure 3-4) and Project Scenario (Figure 3-7)are provided in **Figure 3-2** to **Figure 3-7**. The gaps in the water level grids represent unsaturated areas (i.e., where the simulated water level elevation is below the base of cell).

These predicted groundwater levels indicate that there is no change to alluvial groundwater levels when comparing the Project 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 (2027) for the Project and Approved mining scenarios. No change to Regolith groundwater levels is observed within the Project area for the Project 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 Leichardt Seam (Layer 5) at the end of mining for Approved and Project mining scenarios, and additional depressurisation within in the Leichardt Seam is observed for the Project mining scenario only (**Figure 3-7)**.

No change in the regional hydraulic gradient was observed in the alluvium and regolith, indicating that Mavis South has a negligible incremental impact on the shallow groundwater system. A discussion on groundwater drawdown within the Permian units including Leichardt Seam are included in **Section 3.4**.



0 0.5 1 km

Coordinate System:	GDA 1994 MGA Zone 55
Scale:	1:60,000 at A4
Project Number:	620.031508
Date:	30-Oct-2023
Drawn by:	AS

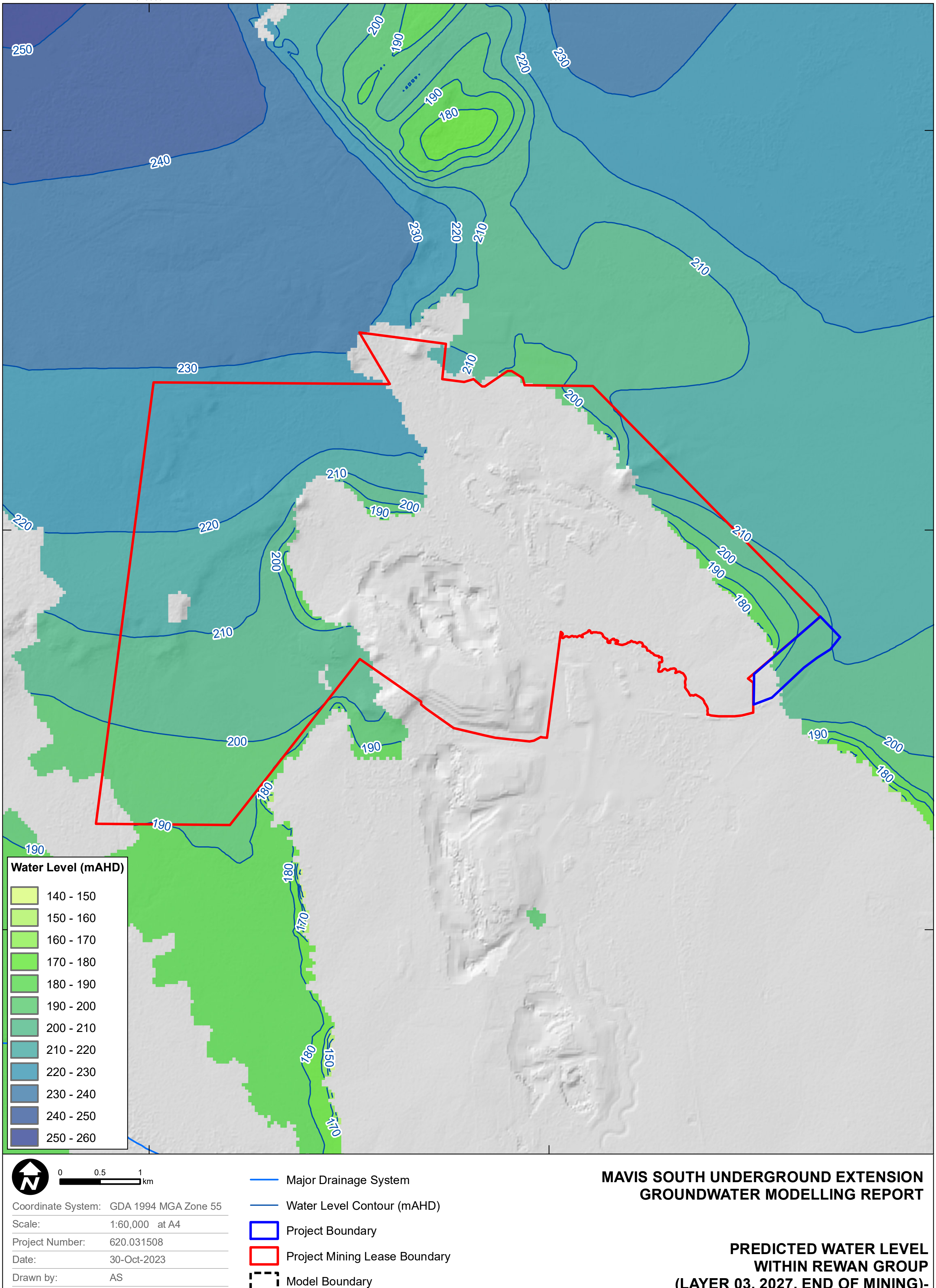
Major Drainage System
Water Level Contour (mAHD)
Project Boundary
Project Mining Lease Boundary
Model Boundary

MAVIS SOUTH UNDERGROUND EXTENSION GROUNDWATER MODELLING REPORT

PREDICTED WATER LEVEL WITHIN REGOLITH (LAYER 02, 2027, END OF MINING)- APPROVED SCENARIO

SLR

FIGURE 3-2

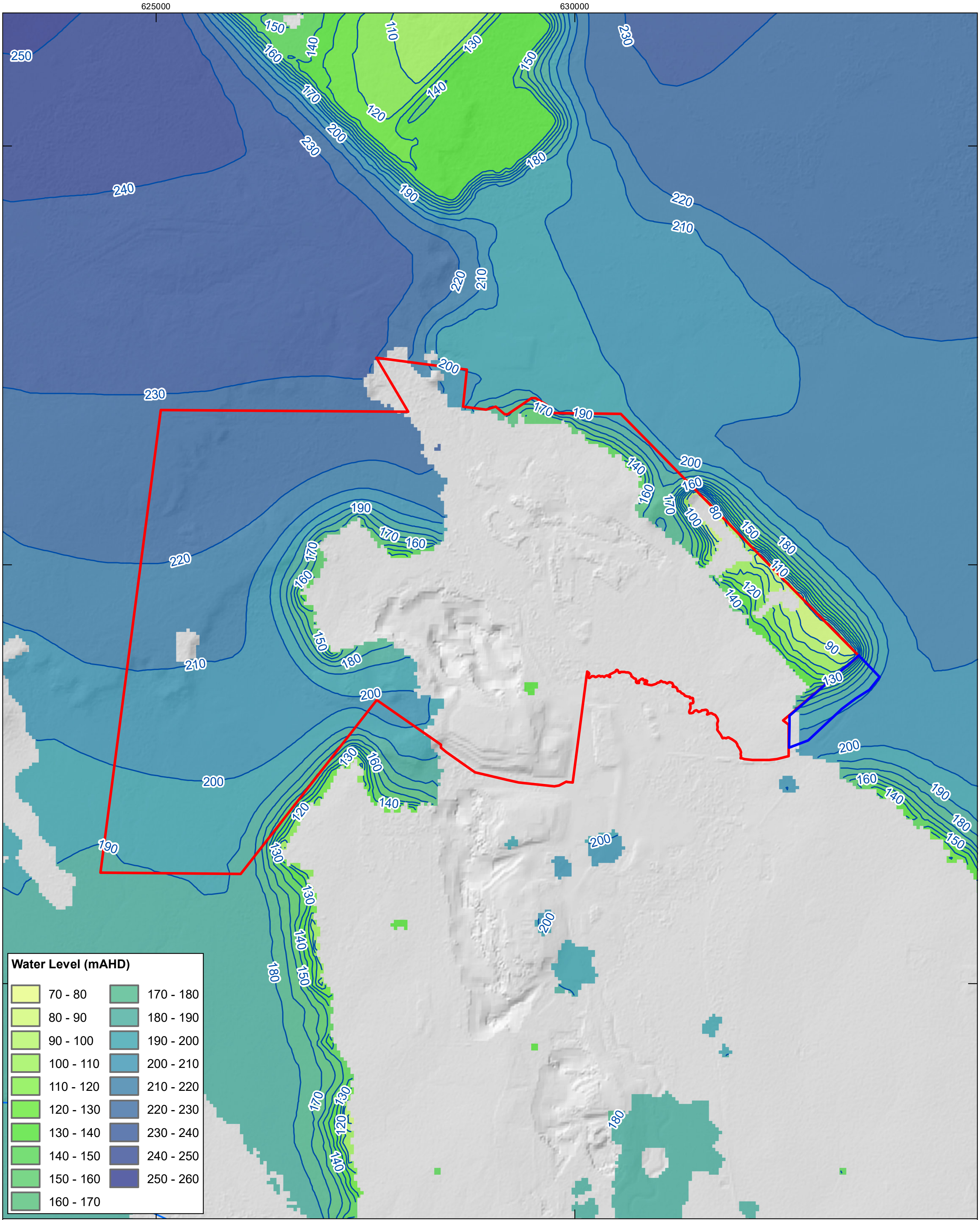


MAVIS SOUTH UNDERGROUND EXTENSION GROUNDWATER MODELLING REPORT

PREDICTED WATER LEVEL WITHIN REWAN GROUP (LAYER 03, 2027, END OF MINING)- APPROVED SCENARIO

FIGURE 3-3

H:\Projects-SLR\620-BNE\620-BNE\620.031508.00001 Millennium Mine - Mavis South\06 SLR Data\01 CADGIS\GIS\Modelling Report\620031508 MOD F3-03 Predicted Water Level within Rewan Group (Layer 3, 2027, EoM) – AS.mxd



H:\Projects-SLR\620-BNE\620-BNE\620.031508.00001 Millennium Mine - Mavis South\06 SLR Data\01 CADGIS\GIS\Modelling Report\620031508 MOD F3-04 Predicted Water Level within Leichardt Seam (Layer 5, 2027, EoM) – AS.mxd

Coordinate System:	GDA 1994 MGA Zone 55
Scale:	1:60,000 at A4
Project Number:	620.031508
Date:	30-Oct-2023
Drawn by:	AS

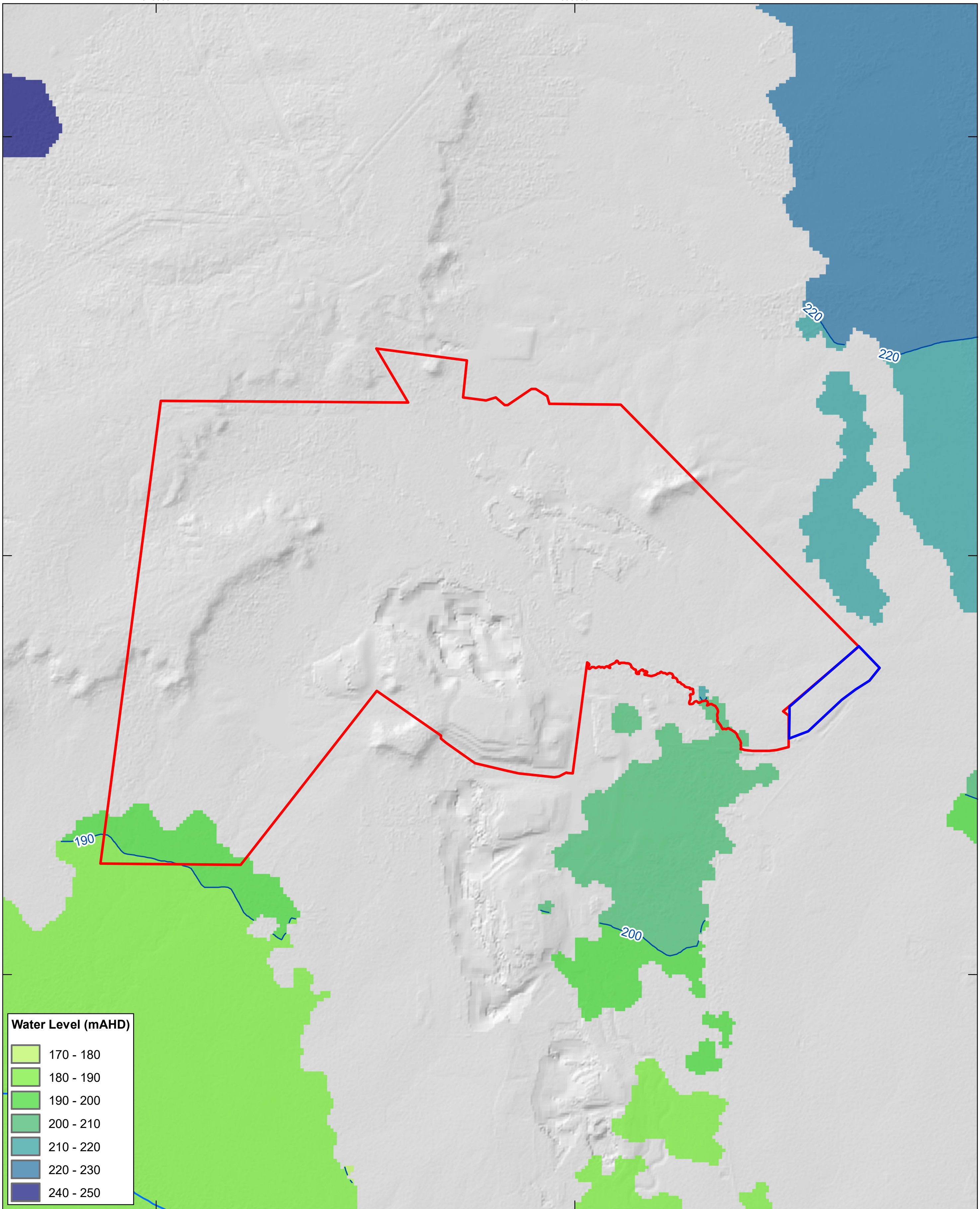
- Major Drainage System
- Water Level Contour (mAHD)
- Project Boundary
- Project Mining Lease Boundary
- Model Boundary

SLR

MAVIS SOUTH UNDERGROUND EXTENSION GROUNDWATER MODELLING REPORT

PREDICTED WATER LEVEL WITHIN LEICHARDT SEAM (LAYER 05, 2027, END OF MINING)- APPROVED SCENARIO

FIGURE 3-4



0 0.5 1 km

Coordinate System: GDA 1994 MGA Zone 55
Scale: 1:60,000 at A4
Project Number: 620.031508
Date: 30-Oct-2023
Drawn by: AS

Major Drainage System
Water Level Contour (mAHD)
Project Boundary
Project Mining Lease Boundary
Model Boundary

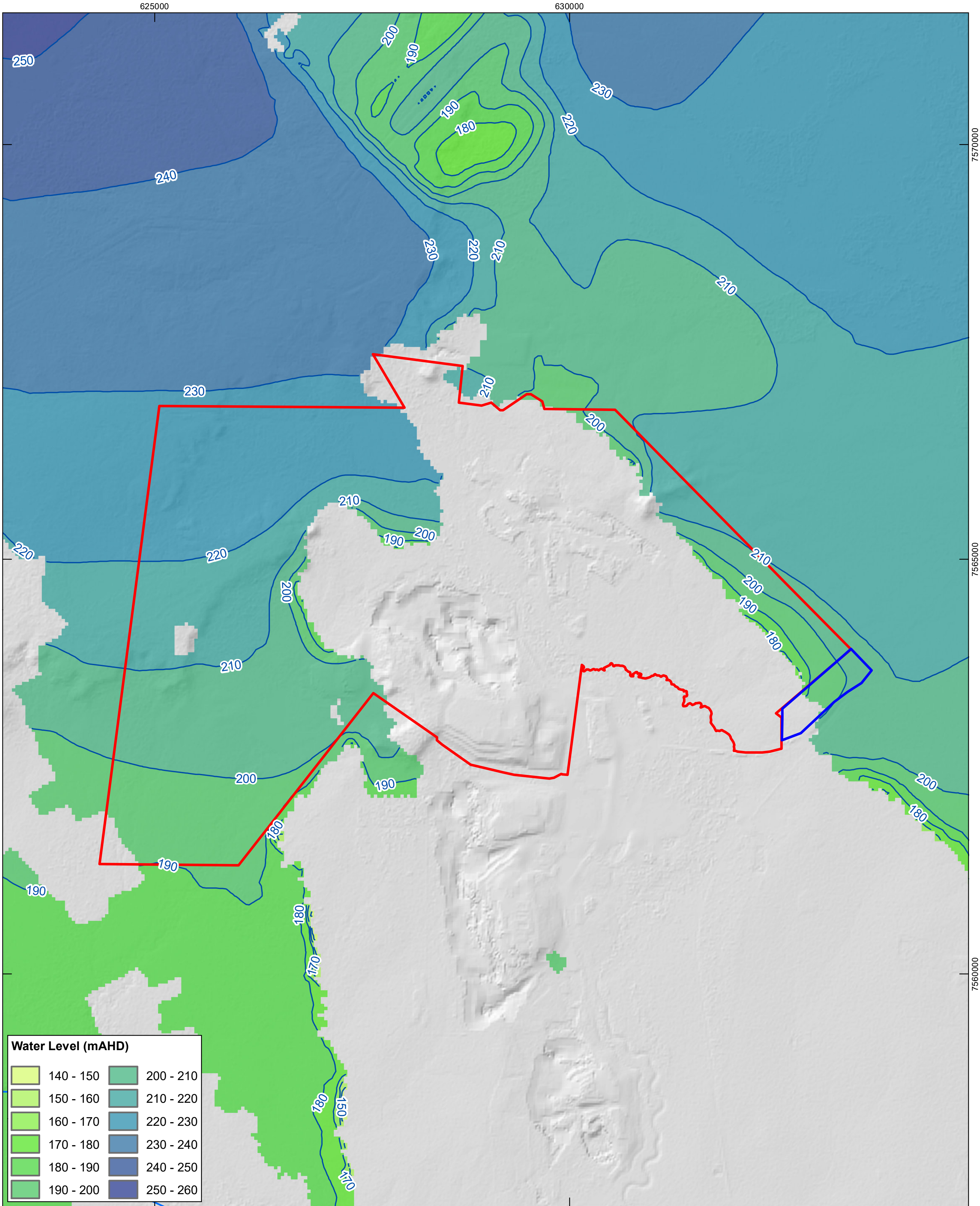
MAVIS SOUTH UNDERGROUND EXTENSION GROUNDWATER MODELLING REPORT

PREDICTED WATER LEVEL WITHIN REGOLITH (LAYER 02, 2027, END OF MINING)- PROJECT SCENARIO

SLR

FIGURE 3-5

H:\Projects-SLR\620-BNE\620-BNE\620.031508.00001 Millennium Mine - Mavis South\06 SLR Data\01 CADGIS\GIS\Modelling Report\620031508 MOD F3-05 Predicted Water Level within Regolith (Layer 2, 2027, EoM) – PS.mxd



N

0 0.5 1 km

Coordinate System:	GDA 1994 MGA Zone 55
Scale:	1:60,000 at A4
Project Number:	620.031508
Date:	30-Oct-2023
Drawn by:	AS

- Major Drainage System
- Water Level Contour (mAHD)
- Project Boundary
- Project Mining Lease Boundary
- Model Boundary

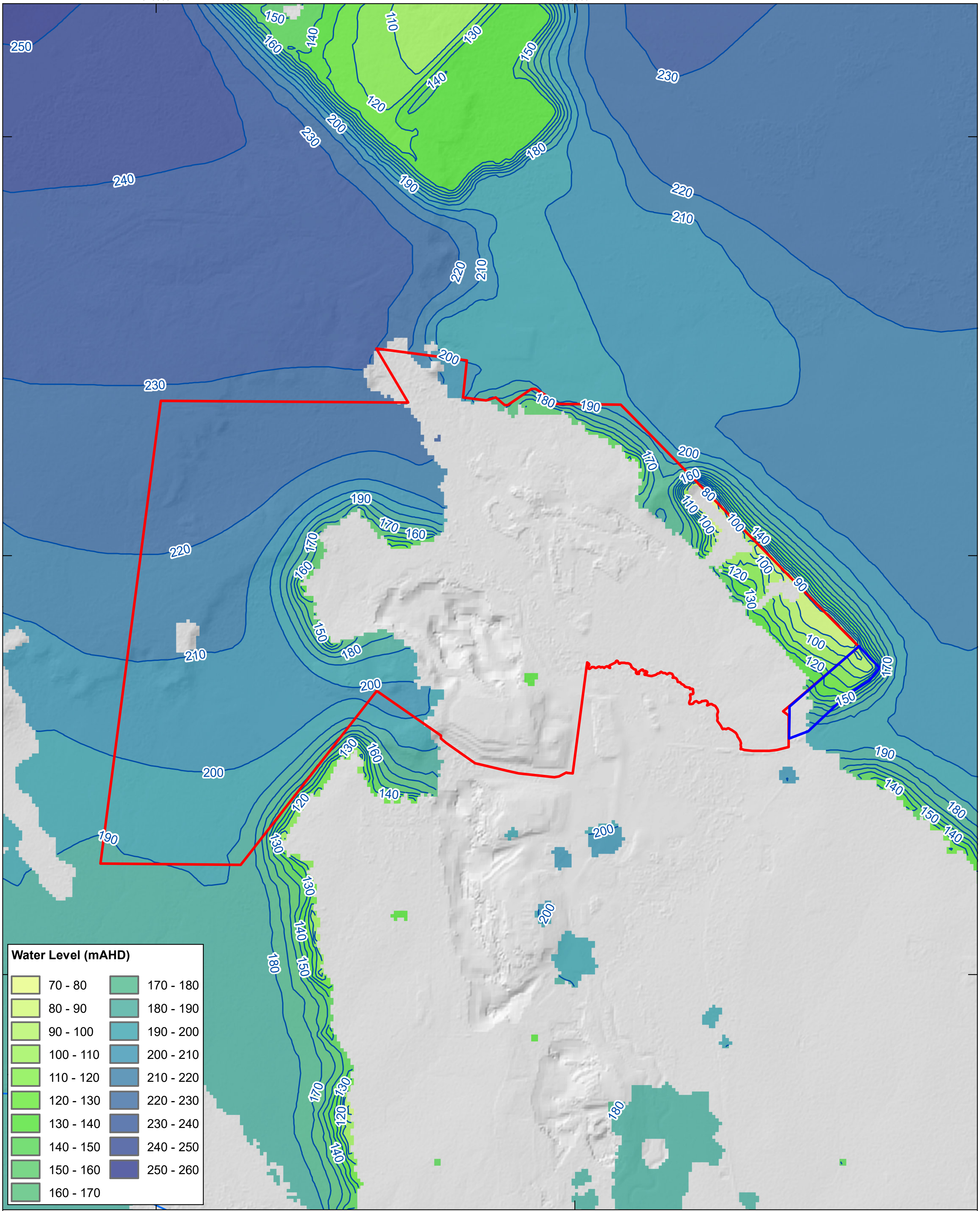
MAVIS SOUTH UNDERGROUND EXTENSION GROUNDWATER MODELLING REPORT

PREDICTED WATER LEVEL WITHIN REWAN GROUP (LAYER 03, 2027, END OF MINING)- PROJECT SCENARIO

SLR

FIGURE 3-6

H:\Projects-SLR\620-BNE\620.031508.00001 Millennium Mine - Mavis South\06 SLR Data\01 CADGIS\GIS\Modelling Report\620031508 MOD F3-06 Predicted Water Level within Rewan Group (Layer 3, 2027, EoM) – PS.mxd



0 0.5 1 km

Coordinate System:	GDA 1994 MGA Zone 55
Scale:	1:60,000 at A4
Project Number:	620.031508
Date:	30-Oct-2023
Drawn by:	AS

Major Drainage System
Water Level Contour (mAHD)
Project Boundary
Project Mining Lease Boundary
Model Boundary

SLR

MAVIS SOUTH UNDERGROUND EXTENSION GROUNDWATER MODELLING REPORT

PREDICTED WATER LEVEL WITHIN LEICHARDT SEAM (LAYER 05, 2027, END OF MINING)- PROJECT SCENARIO

FIGURE 3-7

H:\Projects-SLR\620-BNE\620.031508.00001 Millennium Mine - Mavis South\06 SLR Data\01 CADGIS\GIS\Modelling Report\620031508 MOD F3-07 Predicted Water Level within Leichardt Seam (Layer 5, 2027, EoM) – PS.mxd

3.4 Maximum Predicted Drawdowns

3.4.1 Incremental Drawdown

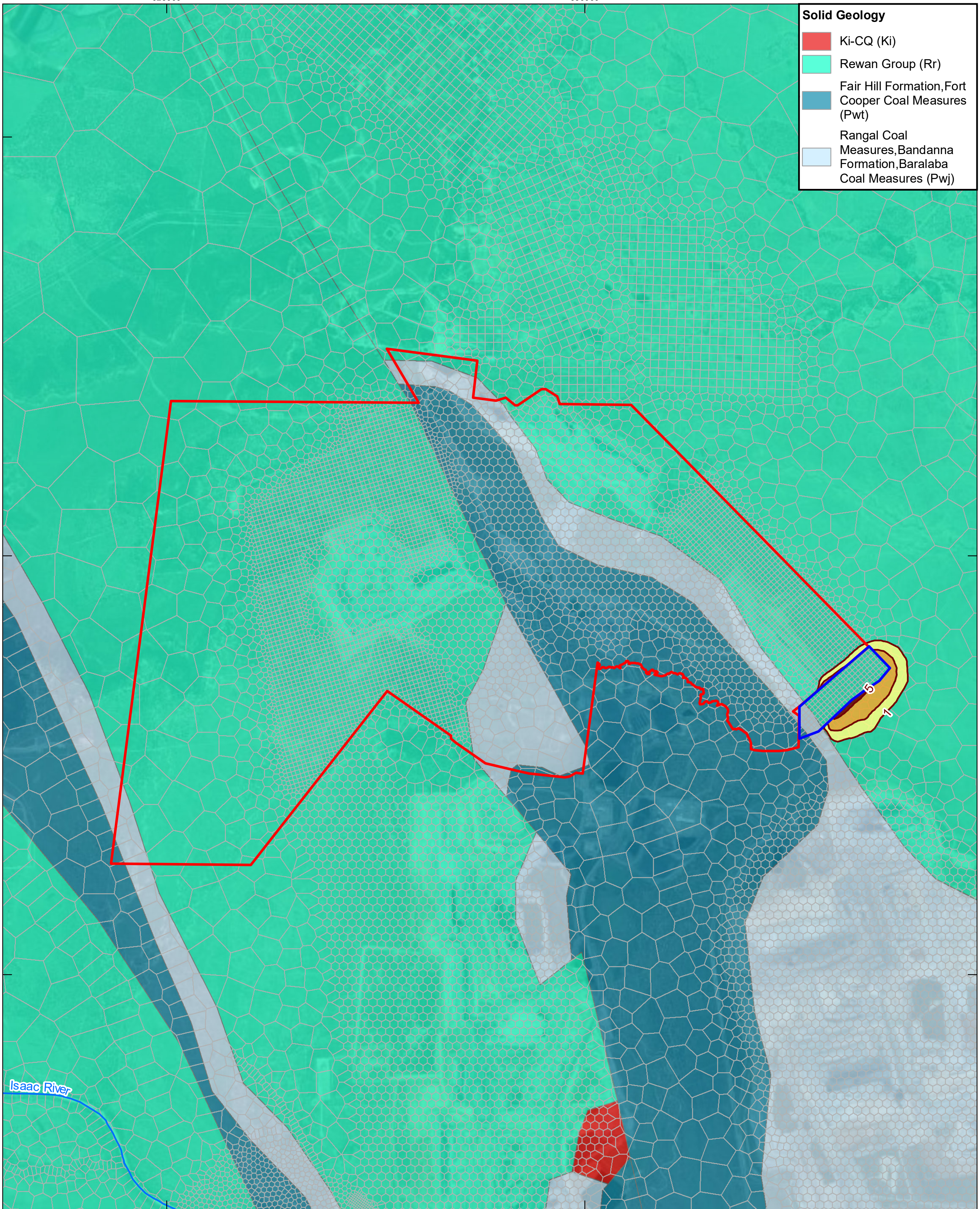
The process of mining directly removes water from the groundwater system and reduces water levels in surrounding groundwater units. The extent of the zone affected is dependent on the properties of the aquifers/aquitards and is referred to as the zone of drawdown. Groundwater drawdown is greatest at 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.

In this report, maximum incremental drawdown refers to the drawdown impact associated with the underground mining at Mavis South only and is obtained by comparing the difference in predicted aquifer groundwater levels for the Approved scenario and the Project 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 3-9**) show where maximum incremental drawdown impacts are predicted to exceed 1 m.

There model did not predict any incremental drawdown in the Quaternary Alluvium and in the regolith due to the Mavis South Underground mining. Maximum predicted incremental drawdowns in the Rewan Group and Leichardt Coal Seam are shown in **Figure 3-8** and **Figure 3-9**, respectively.

Figure 3-8 shows maximum predicted incremental drawdown in the Rewan Group due to the Mavis South Underground mining is up to 10 m at the working coal face. The predicted incremental drawdown in the Rewan Group extends 400 m to the south-east of the Mavis South Underground Mine footprint.

Figure 3-9 shows the predicted incremental drawdown in the Leichardt Seam due to the Project. The Leichardt Seam is the target coal seam at the Project and maximum predicted drawdown reaches to 95 m in this layer. As shown in **Figure 3-9**, it is predicted that the drawdown due to Mavis South Underground mining extends approximately 950 m towards east and southeast from the mine footprint.



Coordinate System:	GDA 1994 MGA Zone 55
Scale:	1:60,000 at A4
Project Number:	620.031508
Date:	27-Oct-2023
Drawn by:	AS

Major Drainage System
Drawn Contour (m)
Project Boundary
Project Mining Lease Boundary
Model Grid

Maximum Drawdown (m)

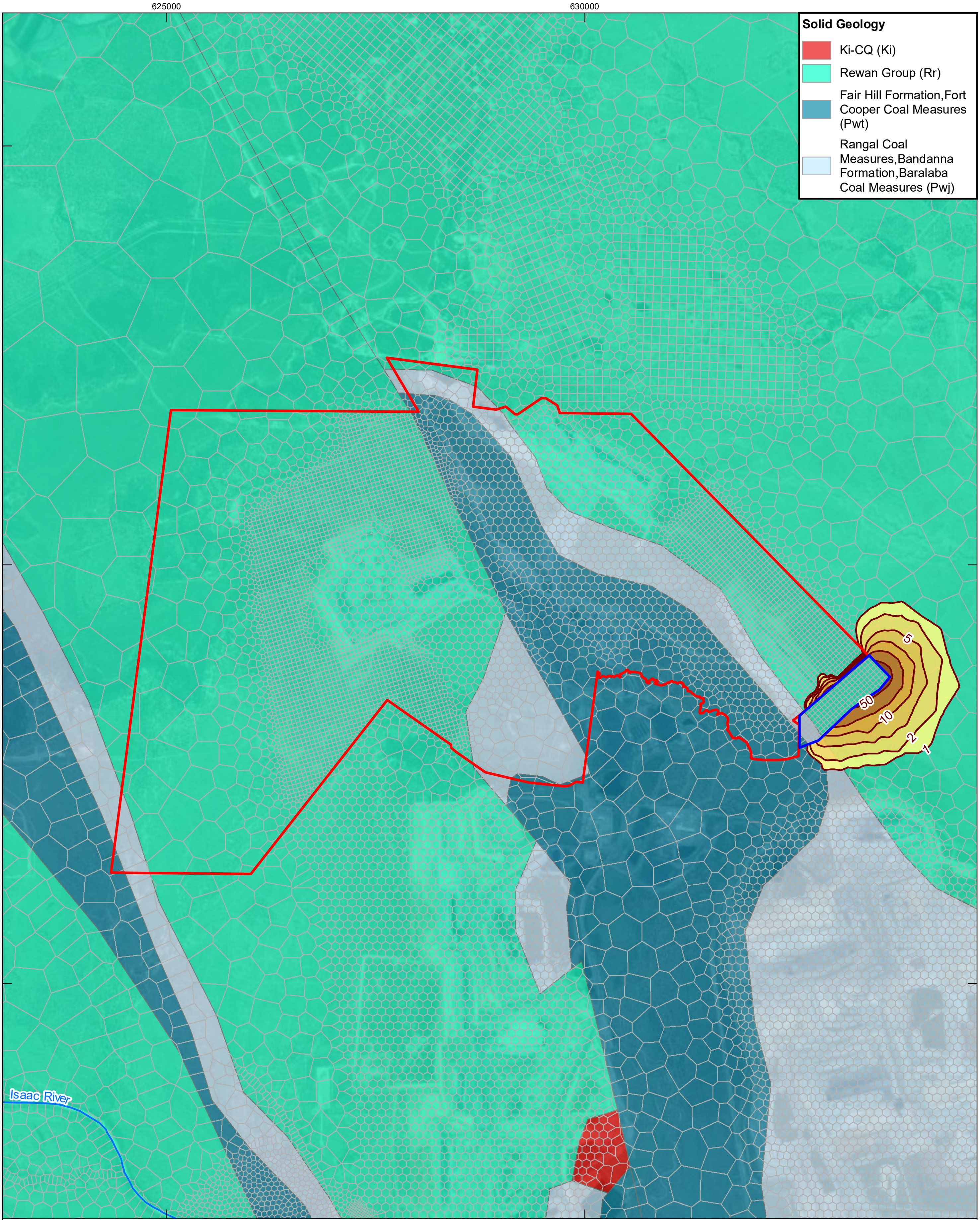
1 - 2
2 - 5
5 - 10

MAVIS SOUTH UNDERGROUND EXTENSION GROUNDWATER MODELLING REPORT

MAXIMUM PREDICTED INCREMENTAL DRAWDOWN IN REWAN GROUP (2027, END OF MINING)

FIGURE 3-8

SLR



H:\Projects-SLR\620-BNE\620-BNE\620.031508.00001 Millennium Mine - Mavis South\06 SLR Data\01 CADGIS\GIS\Modelling Report\620031508 MOD F3-9 Maximum Predicted Incremental Drawdown in Leichardt Seam (2027 End of Mining).mxd

0 1 2 km

Coordinate System:	GDA 1994 MGA Zone 55
Scale:	1:60,000 at A4
Project Number:	620.031508
Date:	27-Oct-2023
Drawn by:	AS

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

Maximum Drawdown (m)

- 1 - 2
- 2 - 5
- 5 - 10
- 10 - 20
- 20 - 50
- 50 - 100
- 100 - 200

MAVIS SOUTH UNDERGROUND EXTENSION GROUNDWATER MODELLING REPORT

MAXIMUM PREDICTED INCREMENTAL DRAWDOWN IN LEICHARDT SEAM (2027, END OF MINING)

FIGURE 3-9

3.4.2 Cumulative Drawdown

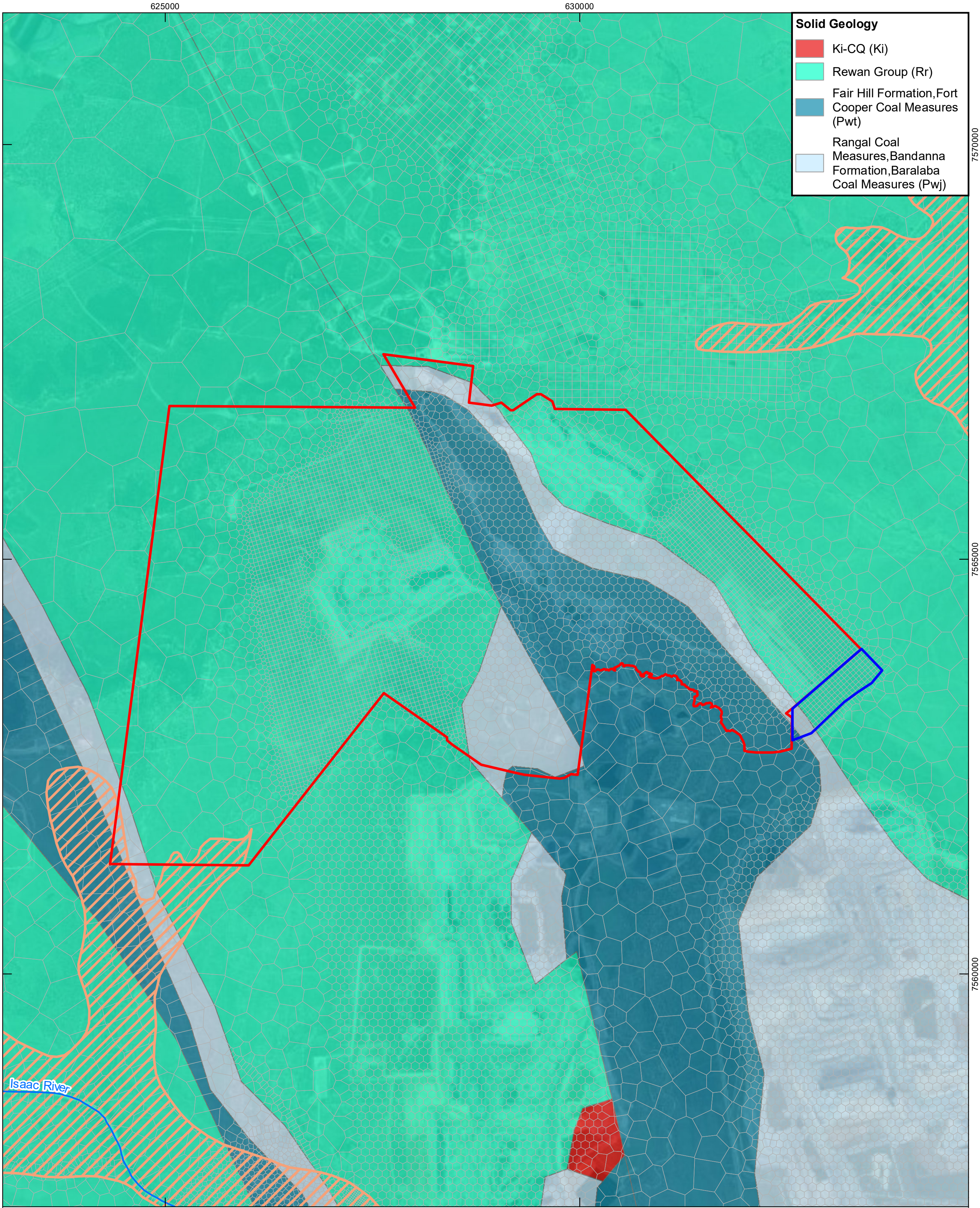
The simulated cumulative drawdown presented in this section show the impacts on different hydrostratigraphic units due to the existing approved mining within the model domain. The simulated cumulative drawdown shows whether the zone of impact from the neighbouring operations is predicted to interact with the zone of impact predicted for the mining at Mavis South Underground in different aquifers.

Maximum predicted cumulative drawdowns in the Quaternary alluvium, regolith, Rewan Group, and Leichardt Seam are shown in **Figure 3-10** to **Figure 3-13**. These drawdowns represent the total impact of mining by all current mining in addition to the Project. They show the difference in the groundwater levels between the Project Scenario and the theoretical "no-mining" or null run scenario.

There is no predicted incremental drawdown impacts in the Quaternary alluvium or the Tertiary regolith sediments as a result of the Mavis South Underground (**Figure 3-10**and **Figure 3-11**).

Maximum predicted cumulative drawdown in the Rewan Group is mainly between 10 to 20 m which covers the significant part of the project site except the northeastern part that shows less drawdown ranging 5 to 10 m (**Figure 3-12**). Cumulative drawdown in the surrounding mines is mostly around 20 to 50 m range with a very small region that drawdown reaches to 100 m in this layer.

Maximum predicted cumulative drawdown in Leichardt Seam increases from south-west to the north-east direction ranging from 20 to 50 m drawdown up to 200 m in the Mavis South Project area. **Figure 3-13** presents the drawdown within the Project site and the surrounding mines in Leichardt Seam unit.



Coordinate System:	GDA 1994 MGA Zone 55
Scale:	1:60,000 at A4
Project Number:	620.031508
Date:	27-Oct-2023
Drawn by:	AS

SLR

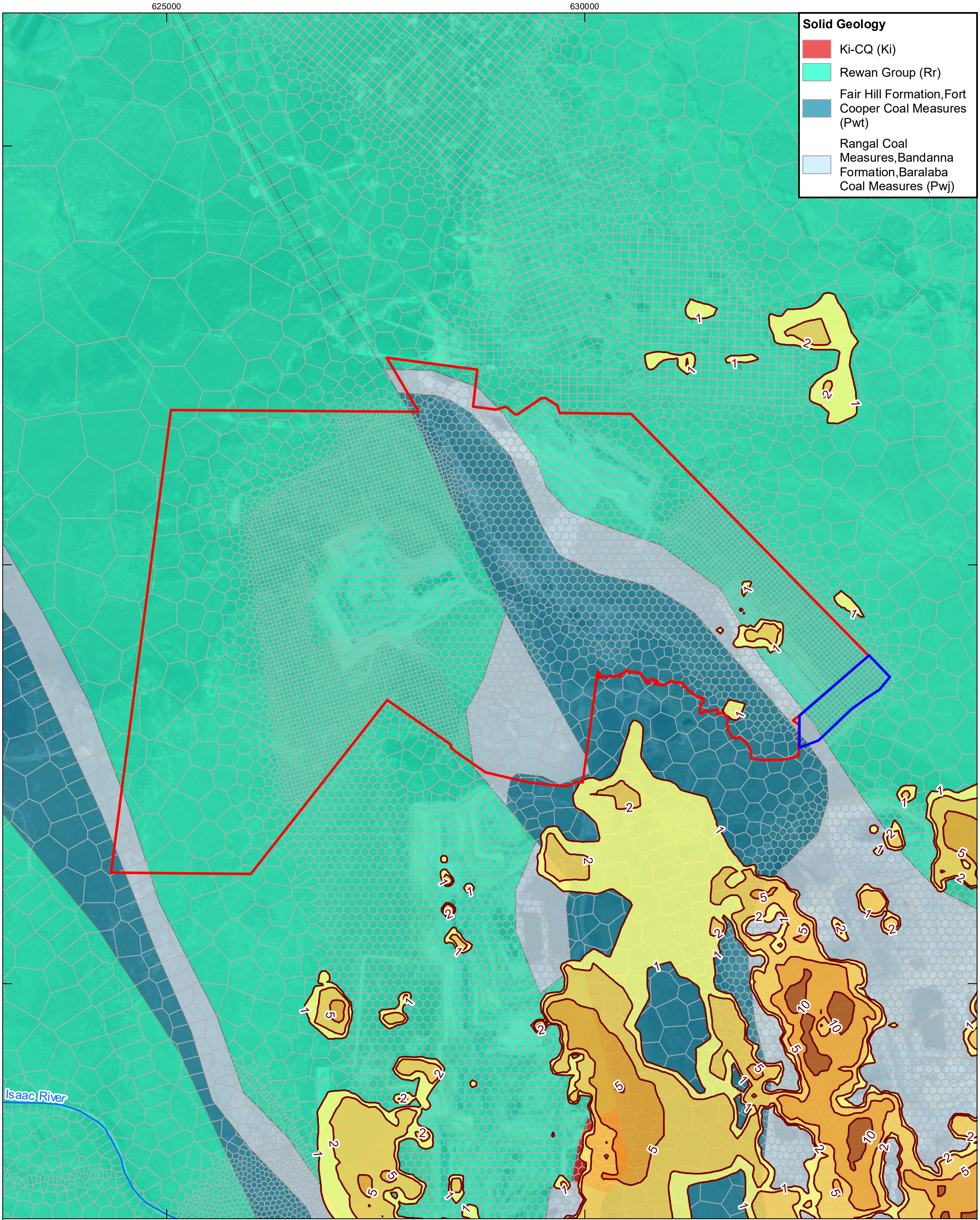
- Major Drainage System
- Project Boundary
- Project Mining Lease Boundary
- Model Grid
- Alluvium Extent

MAVIS SOUTH UNDERGROUND EXTENSION GROUNDWATER MODELLING REPORT

MAXIMUM PREDICTED CUMULATIVE DRAWDOW IN QUATERNARY ALLUVIUM (2027, END OF MINING)

FIGURE 3-10

H:\Projects-SLR\620-BNE\620-BNE\620.031508.00001 Millennium Mine - Mavis South\06 SLR Data\01 CADGIS\GIS\Modelling Report\620031508 MOD F3-10 Maximum Predicted Cumulative Drawdown in Quaternary Alluvium (2027 End of Mining).mxd



Coordinate System:	GDA 1994 MGA Zone 55
Scale:	1:60,000 at A4
Project Number:	620.031508
Date:	27-Oct-2023
Drawn by:	AS

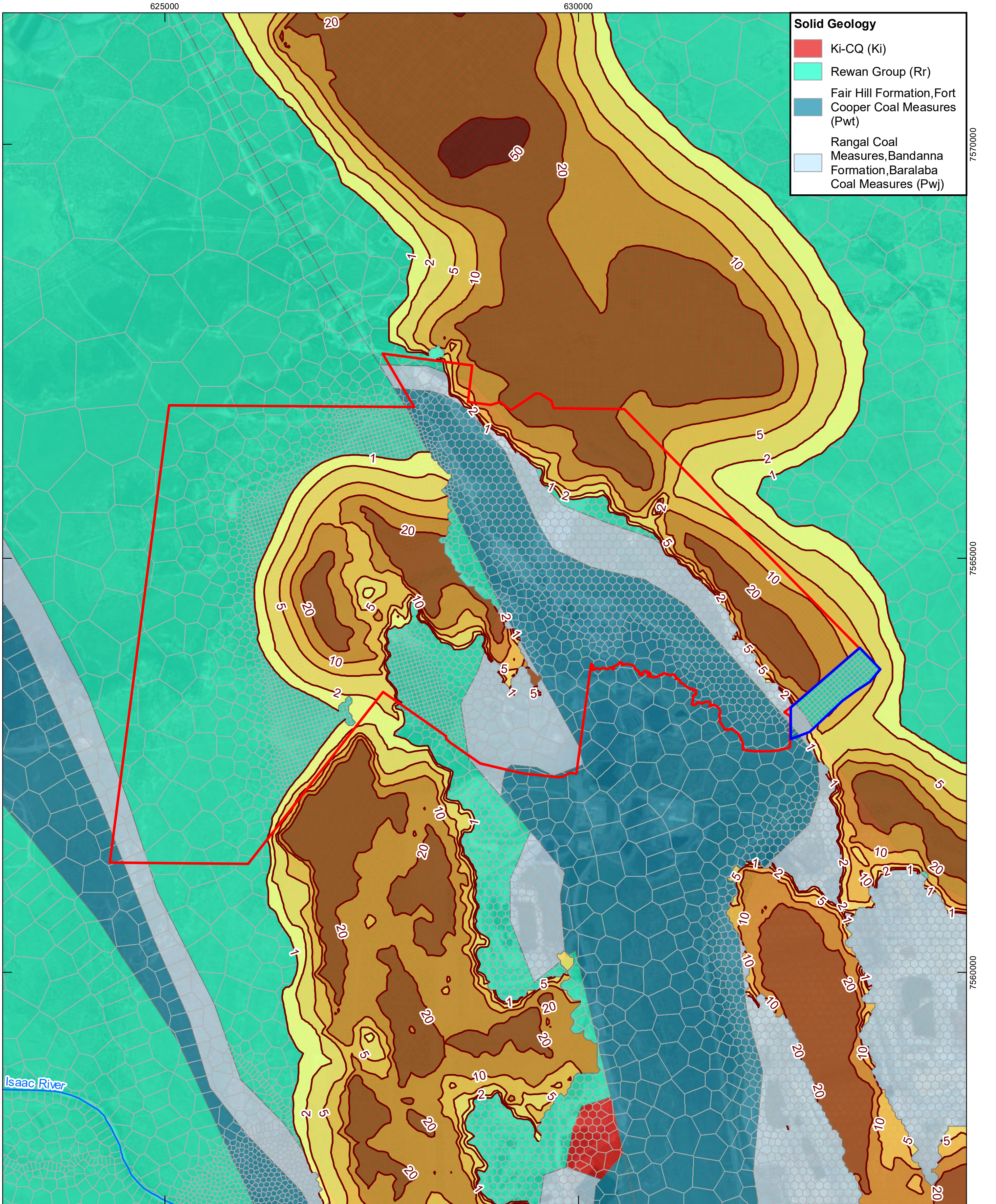
SLR

MAVIS SOUTH UNDERGROUND EXTENSION GROUNDWATER MODELLING REPORT

MAXIMUM PREDICTED CUMULATIVE DRAWDOW IN REGOLITH (2027, END OF MINING)

FIGURE 3-11

H:\Projects-SLR\620-BNE\620-BNE\620.031508.00001 Millennium Mine - Mavis South\06 SLR Data\01 CADGIS\GIS\Modelling Report\620031508 MOD F3-11 Maximum Predicted Cumulative Drawdown in Regolith(2027 End of Mining).mxd



H:\Projects-SLR\620-BNE\620-BNE\620.031508.00001 Millennium Mine - Mavis South\06 SLR Data\01 CADGIS\GIS\Modelling Report\620031508 MOD F3-12 Maximum Predicted Cumulative Drawdown in Rewan Group (2027 End of Mining).mxd

0 1 2 km

Coordinate System:	GDA 1994 MGA Zone 55
Scale:	1:60,000 at A4
Project Number:	620.031508
Date:	27-Oct-2023
Drawn by:	AS

Major Drainage System

Maximum Drawdown Contour (m)

Project Boundary

Project Mining Lease Boundary

Model Grid

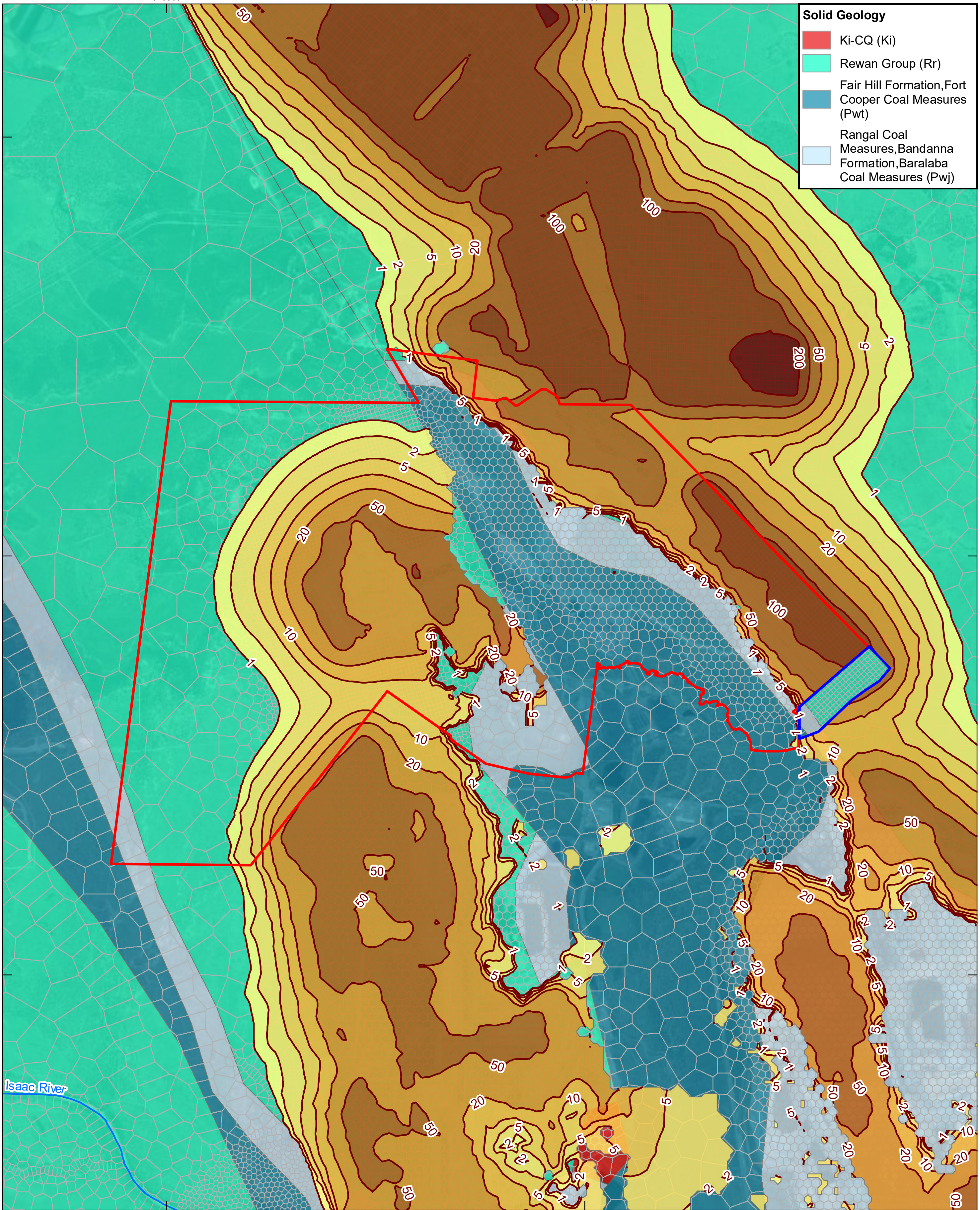
Maximum Drawdown (m)

- 1 - 2
- 2 - 5
- 5 - 10
- 10 - 20
- 20 - 50
- 50 - 100

MAVIS SOUTH UNDERGROUND EXTENSION GROUNDWATER MODELLING REPORT

MAXIMUM PREDICTED CUMULATIVE DRAWDOW IN REWAN GROUP (2027, END OF MINING)

FIGURE 3-12



0 1 2 km

Coordinate System: GDA 1994 MGA Zone 55

Scale: 1:60,000 at A4

Project Number: 620.031508

Date: 27-Oct-2023

Drawn by: AS

SLR

Major Drainage System

Maximum Drawdown Contour (m)

Project Boundary

Project Mining Lease Boundary

Model Grid

Maximum Drawdown (m)

- 1 - 2
- 2 - 5
- 5 - 10
- 10 - 20
- 20 - 50
- 50 - 100
- 100 - 200
- 200 - 500

MAVIS SOUTH UNDERGROUND EXTENSION GROUNDWATER MODELLING REPORT

MAXIMUM PREDICTED CUMULATIVE DRAWDOW IN LEICHARDT SEAM (2027, END OF MINING)

FIGURE 3-13

H:\Projects-SLR\620-BNE\620-BNE\620.031508.00001 Millennium Mine - Mavis South\06 SLR Data\01 CADGIS\GIS\Modelling Report\620031508 MOD F3-13 Maximum Predicted Cumulative Drawdown in Leichardt Seam (2027 End of Mining).mxd

3.5 Predicted Groundwater Inflow

Mine inflow volumes for Millennium Mine have been calculated as time weighted averages of the outflow reported by ZoneBudget software for Millennium drain cells. The predicted groundwater inflows to Mavis South Pit from 2023 to the end of mining are presented in **Figure 3-14**.

The inflow due to the proposed Mavis South Underground is predicted to occur in 2025 and 2026. The maximum predicted inflow in this period is 71.5 ML/year for year 2026. The inflow due to the Mavis Approved underground mining fluctuates throughout these years with an overall increase from 32.9 ML/year in 2023 to 131.4 ML/year in 2027. The figure also shows the totals for both the Mavis Approved and Mavis South underground mines, which has a maximum in 2026 with approximately 150 ML/year.

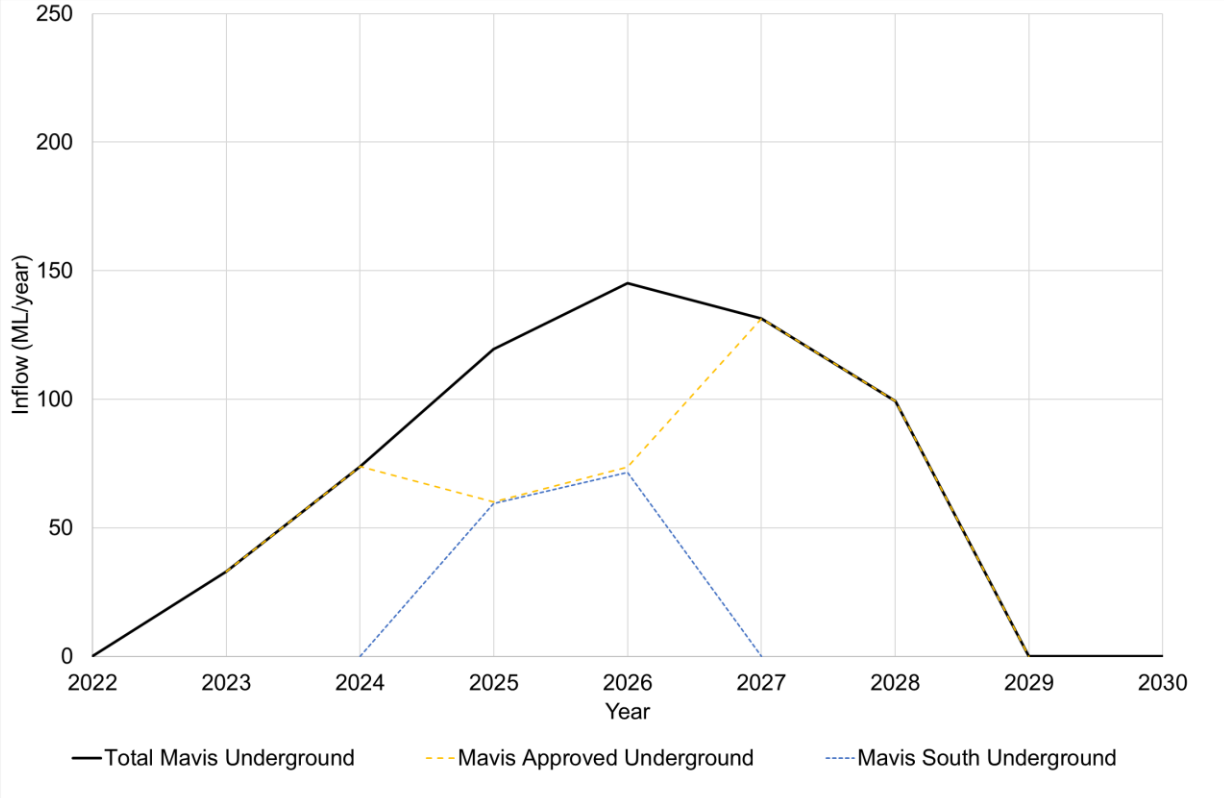


Figure 3-14 Predicted Groundwater Inflows

4.0 Recovery Model

The post-mining recovery modelling included simulation of groundwater level recovery in the Mavis South Underground workings as well as the Millennium open cuts. A 456-year transient model was created to ascertain post-mining recovery.

All drain cells representing the Millennium open cut, Mavis Approved, and Project mining were removed at the start of the recovery period to allow groundwater levels in the underground workings and the overlying water-bearing strata to recover.

In the Millennium open cut pits, all the mine areas changed to spoil and only the sections of open cut near the Project (known as E Pit) mined at the final year were not backfilled and remained as a void. The void cells were assigned high horizontal and vertical hydraulic conductivities (1,000 m/day) and storage parameters based on the compressibility of water (specific yield of 1.0, storage coefficient of 5.0 x 10^{-6} m^{-1}), to simulate free water movement within the cells. No extra recharge or evapotranspiration are applied to the voids, and it was assumed that it will be filled through groundwater recovery. With regards to the spoil, the 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 specific storage of 1.0 x 10^{-5} m^{-1}.

In the Mavis Approved and Project area, the parameters adopted in the model cells to reflect mined-out areas were consistent with the properties at the end the prediction model (**Section 2.3.6.2**).

Figure 4-1 shows the recovered groundwater levels of monitoring bores located at Millennium Mine area. The model predicts that the groundwater system at Project area is being influenced by the mining activities at the neighbour mining tenements, during the recovery period. The model predicted that groundwater levels in monitoring bore MILLCSMB2, located close to Mavis Approved area will reach equilibrium approximately 420 years post-mining.

Figure 4-2 shows the modelled groundwater table at the end of the recovery model. The figure shows flat gradients around the Millennium mine and some flow towards neighbouring mines, which may be associated with their final void locations.

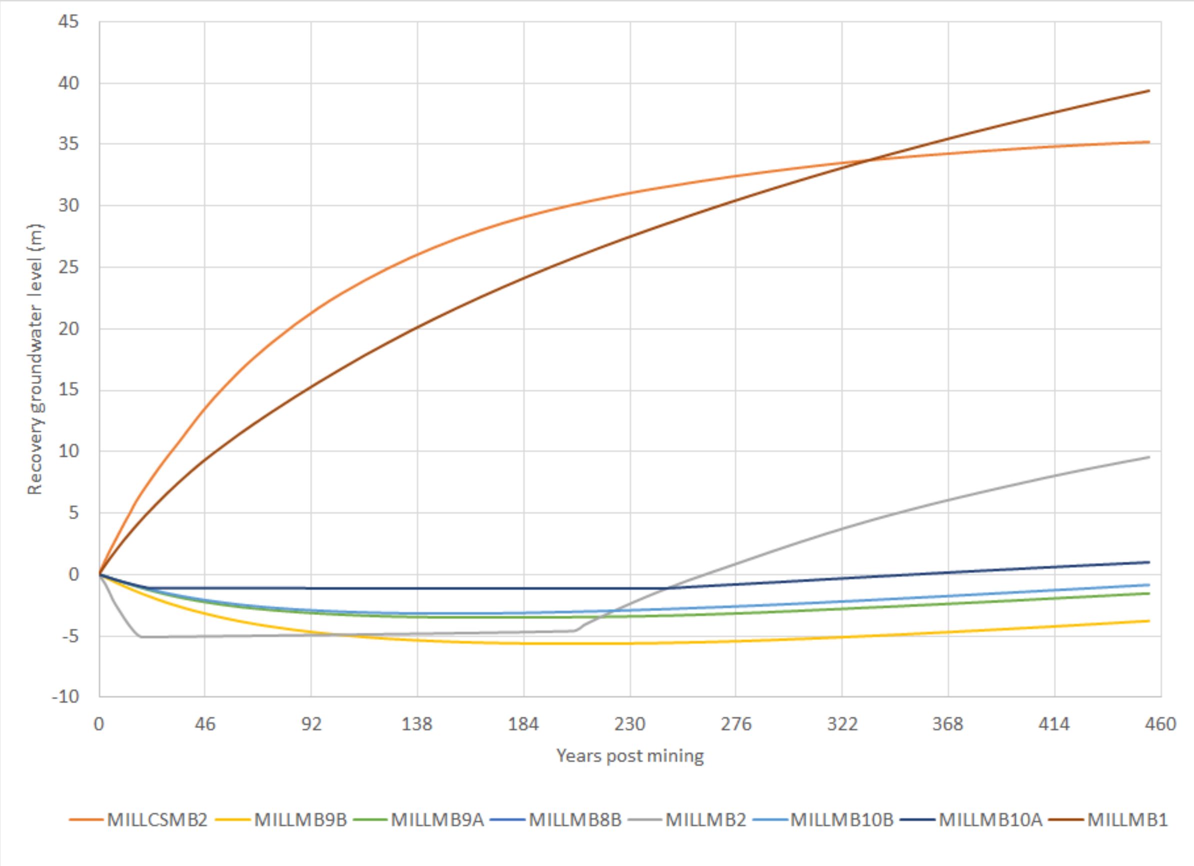
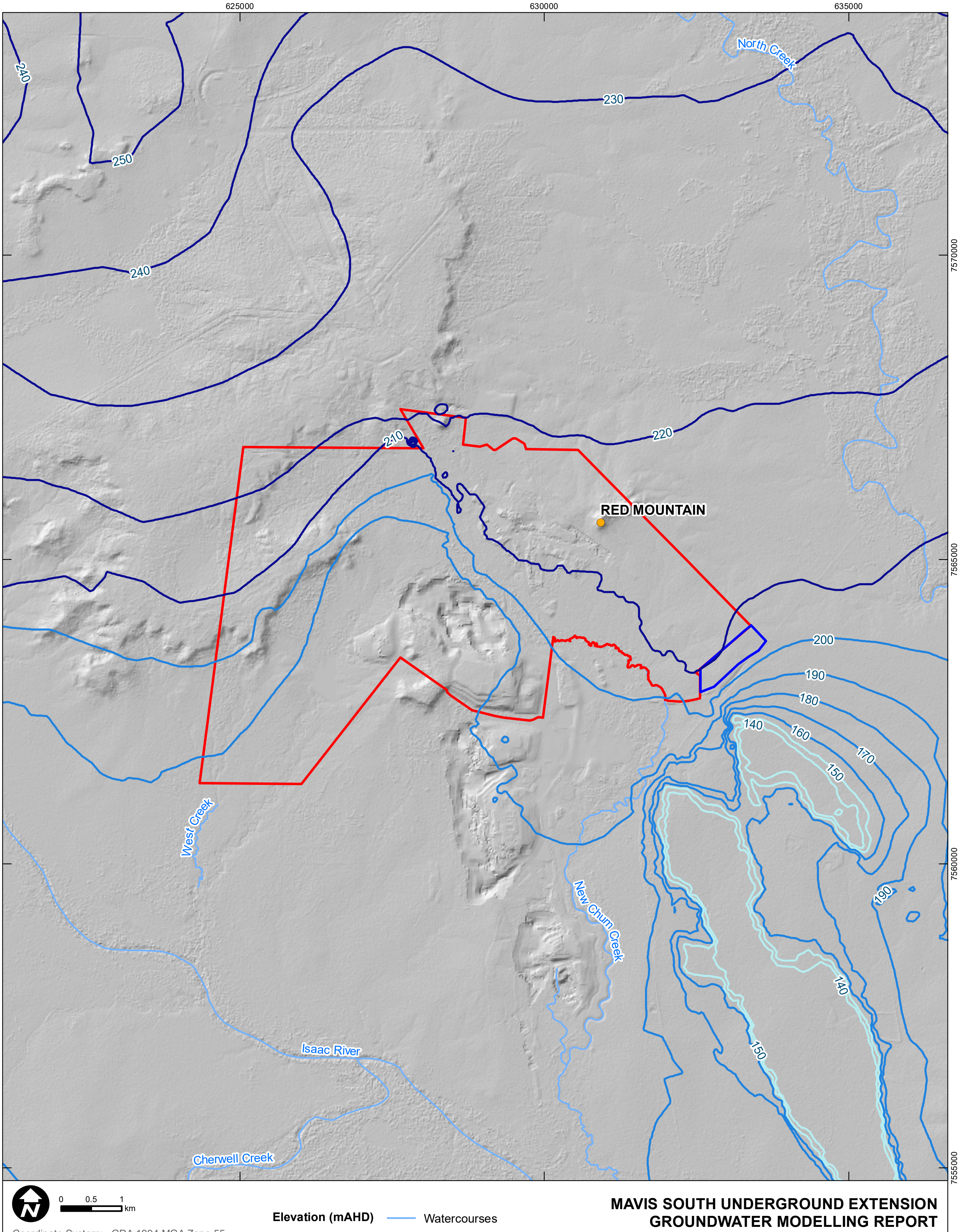


Figure 4-1 Predicted Groundwater Recovery within the Millennium Mine Area



Coordinate System:	GDA 1994 MGA Zone 55
Scale:	1:80,000 at A4
Project Number:	620.031508
Date:	07-Nov-2023
Drawn by:	AS

SLR

MAVIS SOUTH UNDERGROUND EXTENSION GROUNDWATER MODELLING REPORT

GROUNDWATER TABLE AT THE END OF RECOVERY RUN

FIGURE 4-2

H:\Projects-SLR\620-BNE\620-BNE\620.031508.00001 Millennium Mine - Mavis South\06 SLR Data\01 CADGIS\GIS\Modelling Report\620031508 MOD F4-2 Table at the End of Recovery Run.mxd

5.0 Sensitivity Analysis

5.1 Calibration Identifiability

As reported by the PEST Uncertainty User Guide (Doherty., 2011); “Identifiability is defined here as the capability of model calibration to constrain parameters used by a model.” and “Where this value is zero for a particular parameter, the calibration dataset possesses no information with respect to that parameter. Where it is 1, the parameter is completely identifiable on the basis of the current calibration dataset (though cannot be estimated without error because its estimation takes place on a dataset that contains measurement noise).

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 and vertical hydraulic conductivity, specific yield, specific storage and recharge are summarised in **Figure 5-1** through **Figure 5-5**.

Figure 5-1 indicates that in that the modelled water levels are highly sensitive to the horizontal conductivity of Rewan Group, Leichhardt Seam, Vermont Seam, MCM D Seam and Q Seam units and therefore are ‘identifiable’.

The identifiability of horizontal hydraulic conductivity of most of the faults are generally less than 0.5 indicating the modelled water level are not very sensitive to these parameters.

Identifiability of vertical hydraulic conductivity is presented in **Figure 5-2**. Vertical hydraulic conductivity of Rewan, Rewan Coal Measure interburden (Layer 4 and Layer 8), Leichhardt Seam, Fort Cooper Coal Measures interburden and Moranbah Coal Measures interburden have high identifiability values indicating these parameters can be estimated using the calibration data set. All other zones feature low values (equal to and below 0.40) and are not sensitive.

Figure 5-3 shows that specific yield of Alluvium, Regolith, Tertiary Basalt, Rewan Group, Isaac fault zone and Moranbah Coal Measures interburden have high identifiability values (>0.7) which means the can be estimated during the calibration.

Figure 5-4 shows that the specific storage of Rewan interburden and Moranbah Coal Measures interburden seam have high identifiability indicating the modelled water levels are highly sensitive to these parameters in the model.

Figure 5-5 shows that the recharge rates for all the zones except the Isaac River Channel and Duaringa Formation have high identifiability values (>0.7), are estimable during the calibration process.

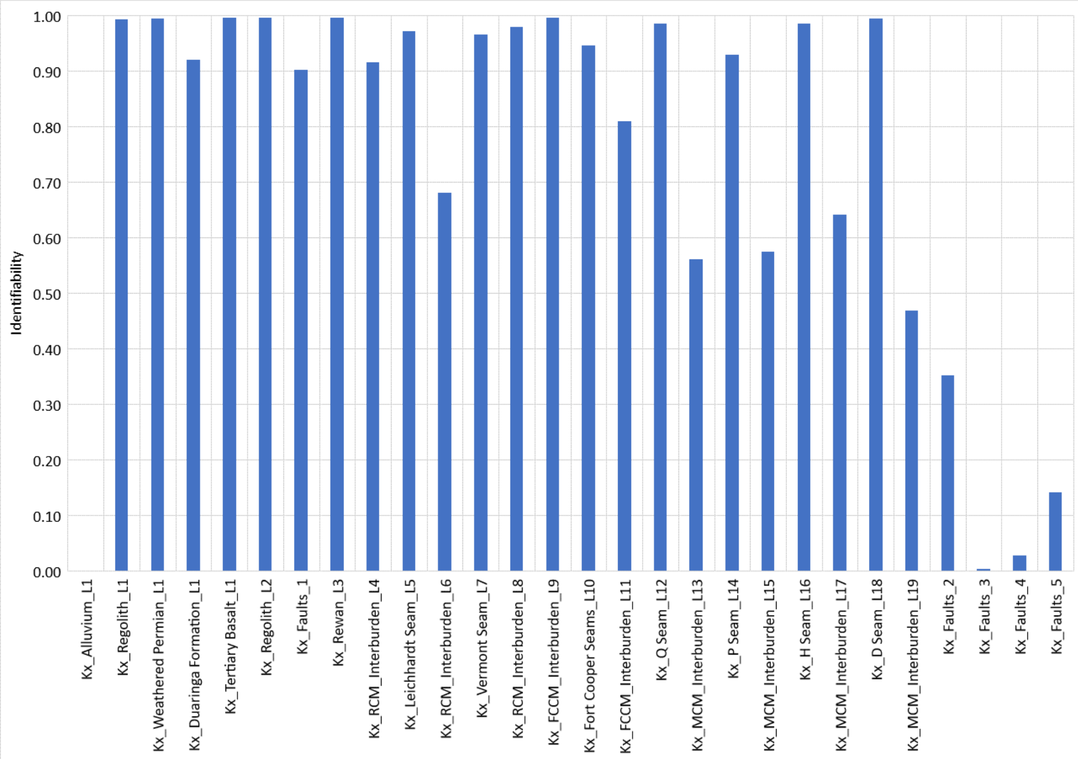


Figure 5-1 Identifiability – Horizontal Hydraulic Conductivity (Kx)

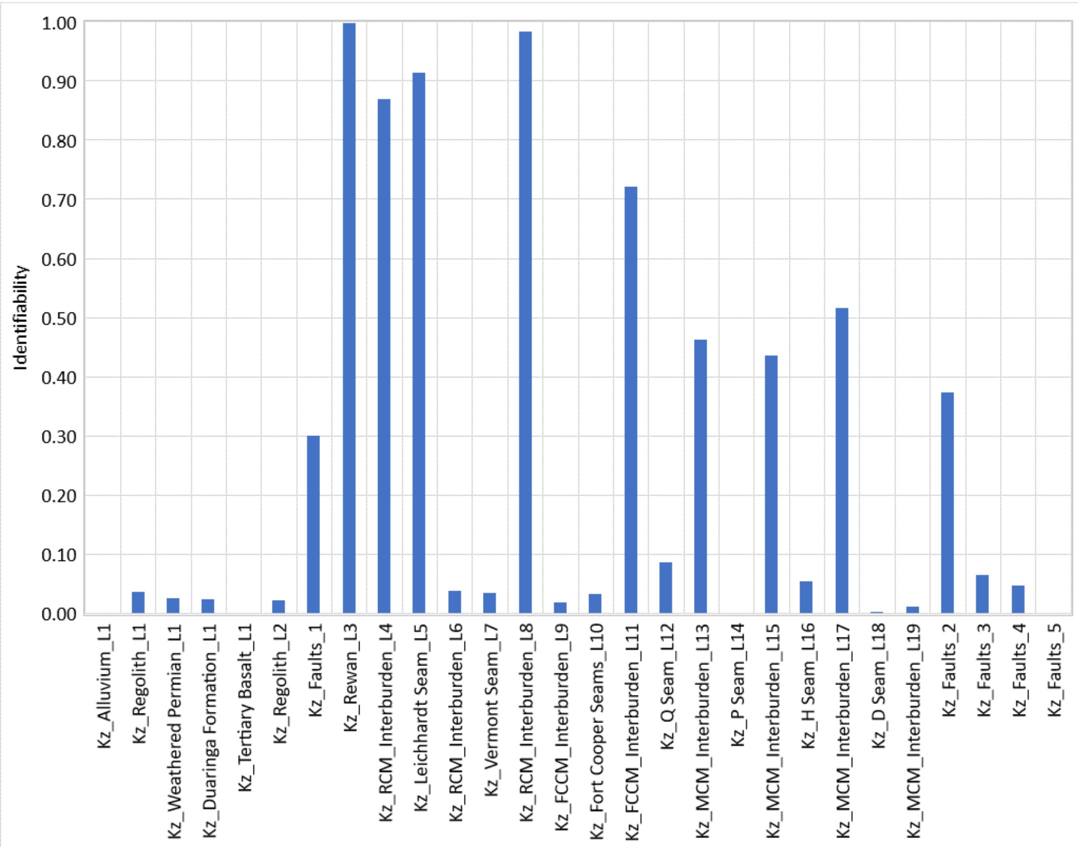


Figure 5-2 Identifiability – Vertical Hydraulic Conductivity (Kz)

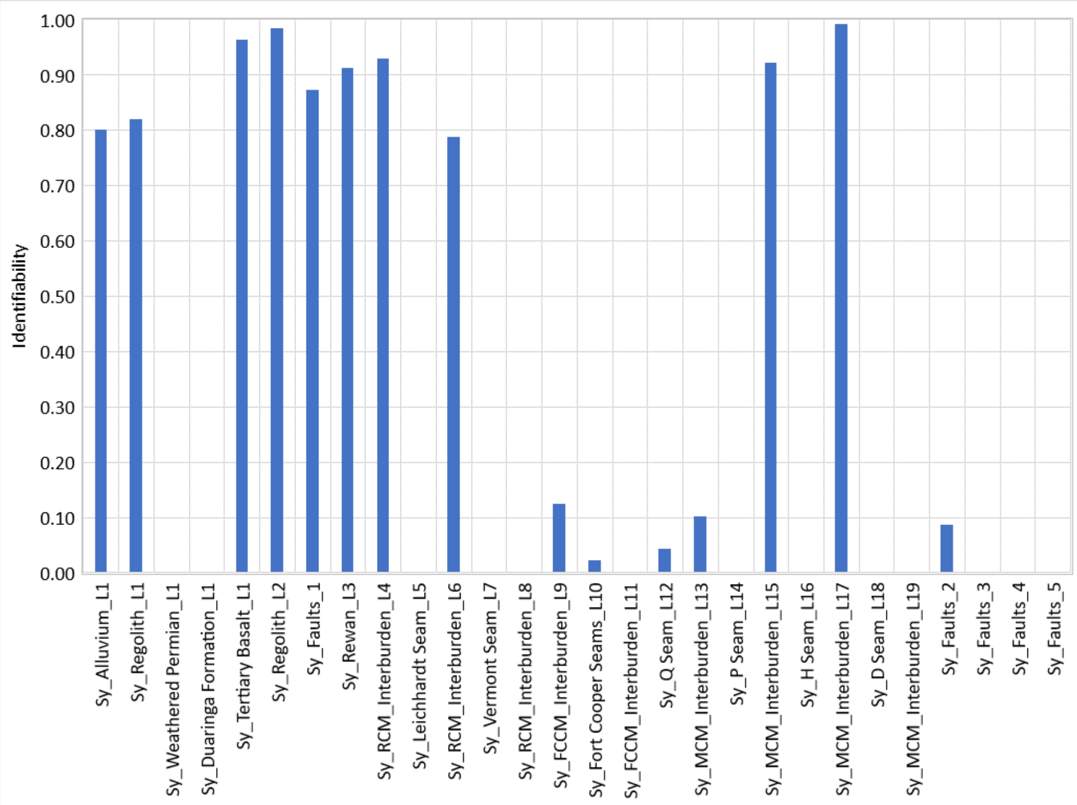


Figure 5-3 Identifiability – Specific Yield (Sy)

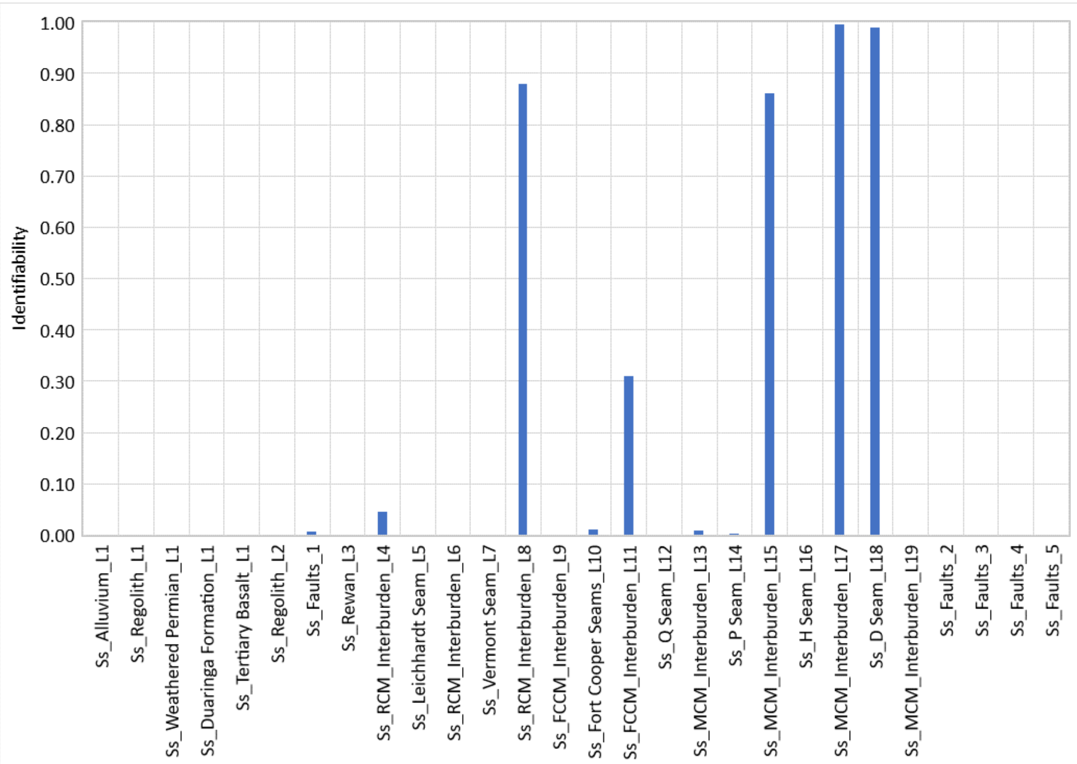


Figure 5-4 Identifiability – Specific Storage (SS)

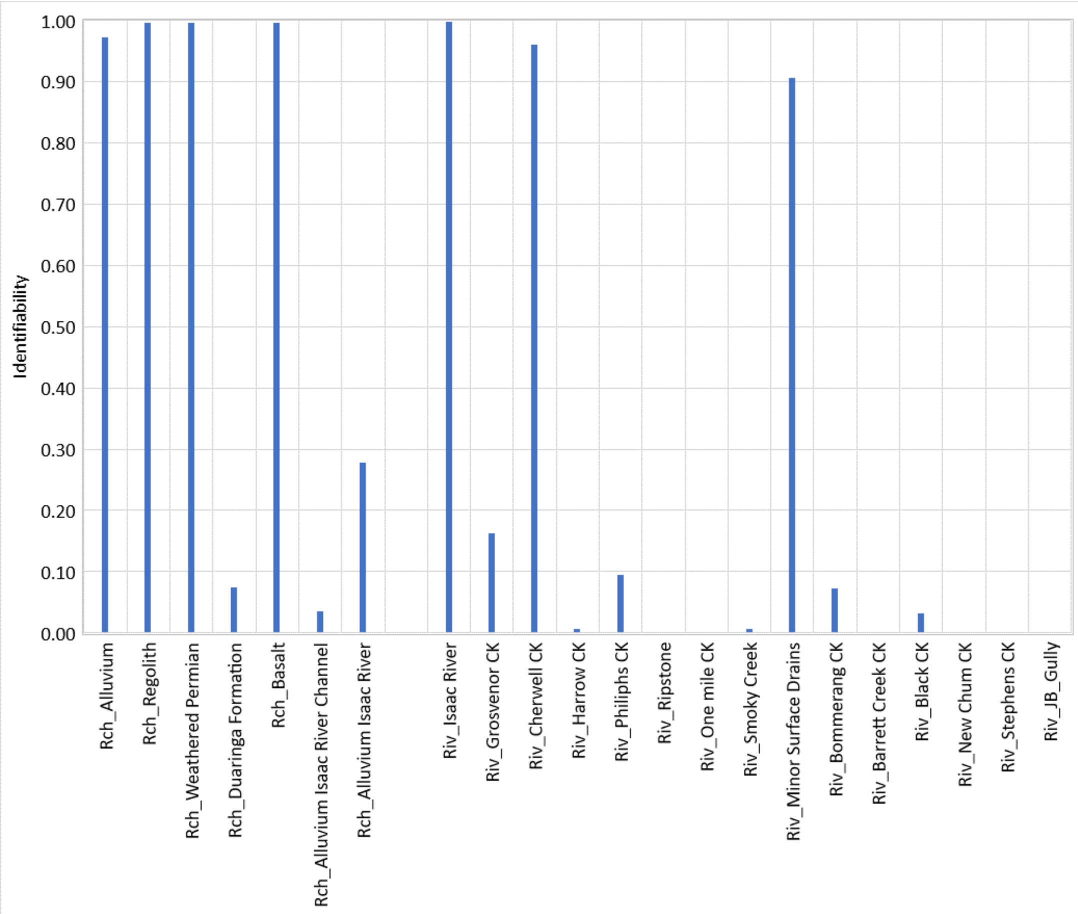


Figure 5-5 Identifiability – Recharge (RCH) and River Vertical Conductivity

5.2 Prediction Identifiability

Prediction identifiability describes parameters capability on influencing 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 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 5-6 presents the relationship between the identifiability of the Project 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 parameter that require further work to reduce their influence on predictive uncertainty in relation to groundwater inflows include the vertical hydraulic conductivity of the H seam (Layer 16).

Figure 5-7 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 requires further work to reduce its influence on predictive uncertainty in relation to the maximum drawdown extent is vertical hydraulic conductivity of the RCM interburden (Layer 6).

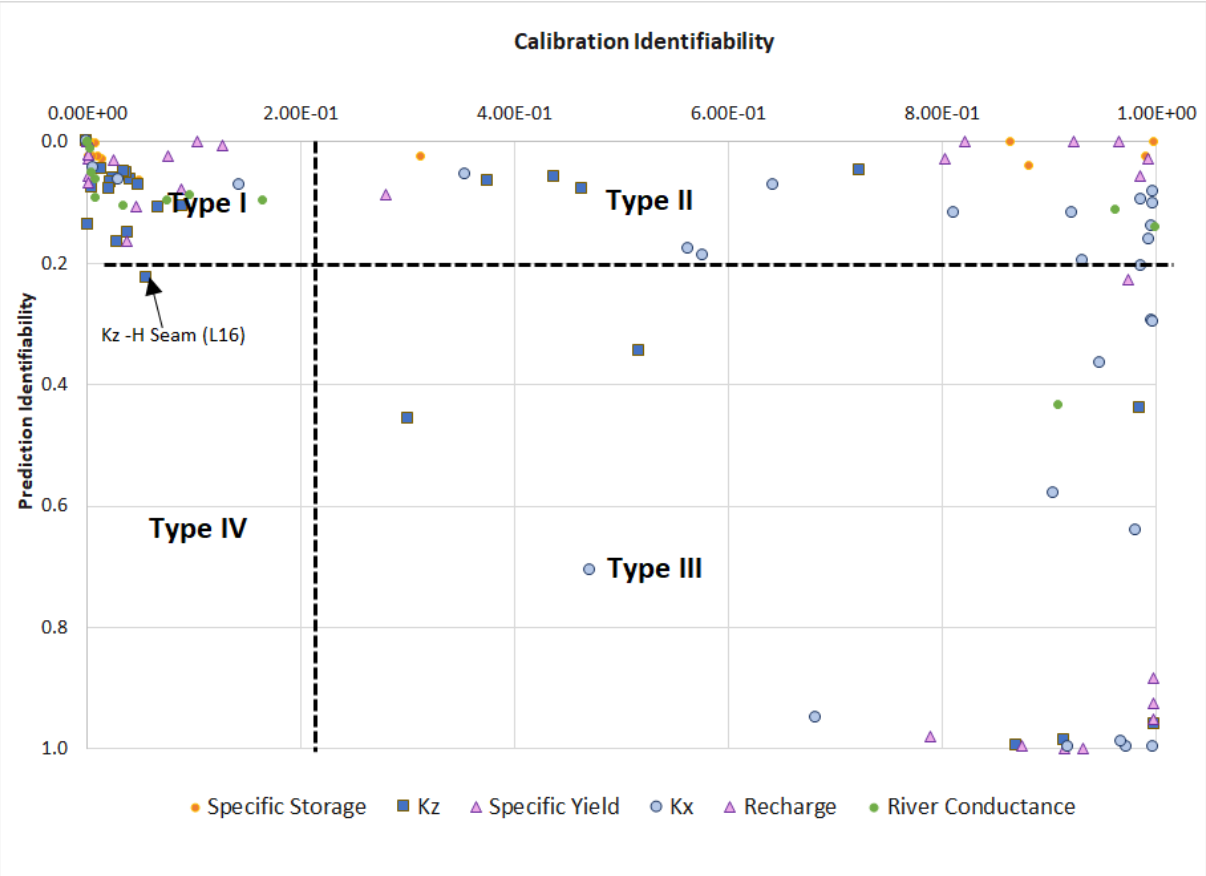


Figure 5-6 Uncertainty Contribution (Predicted Mine Inflow) versus Identifiability

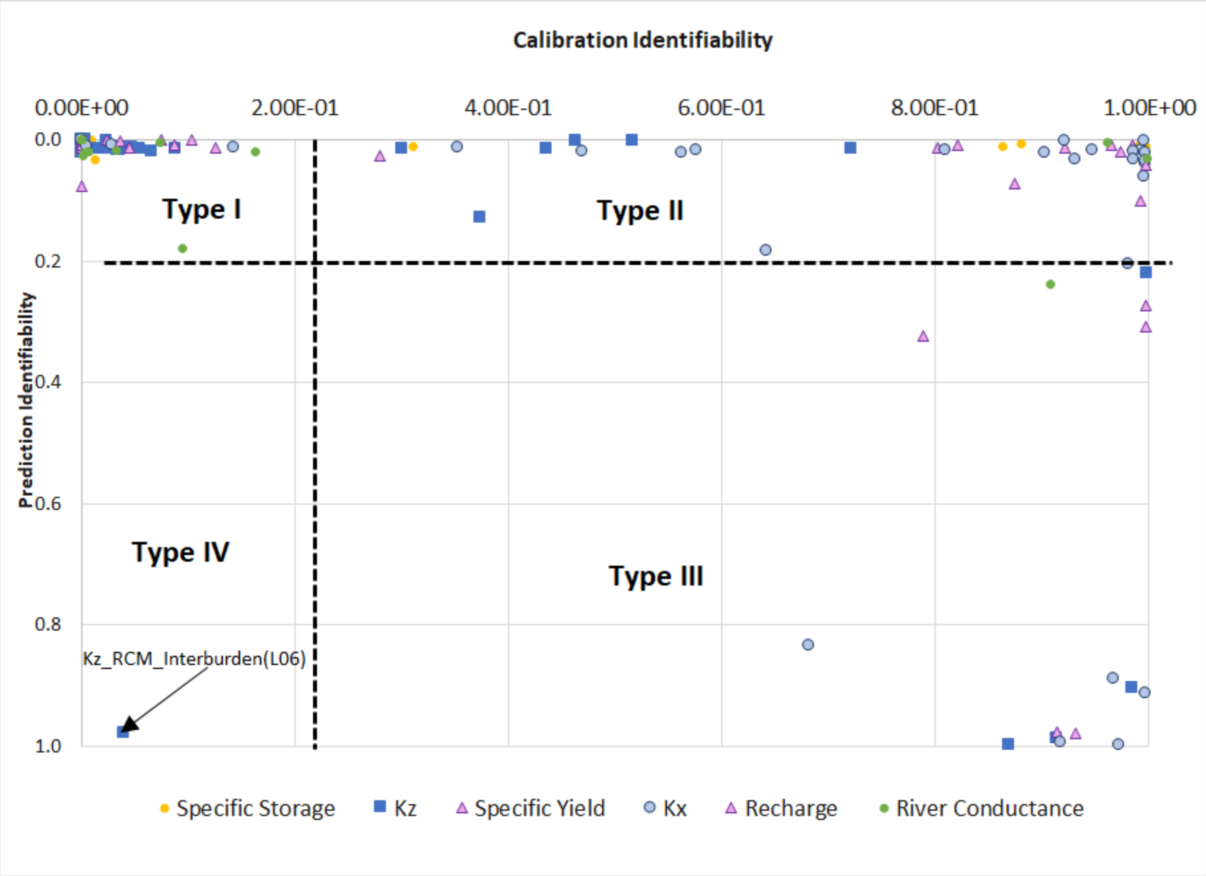


Figure 5-7 **Uncertainty Contribution (Maximum Incremental Drawdown) versus Identifiability**

6.0 Uncertainty Analysis

A Type 3 Monte Carlo uncertainty analysis 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. For Millennium South, 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. 550 model realisations were generated, each having differing values of key parameters. The realisations were run, and calibration quality was assessed.

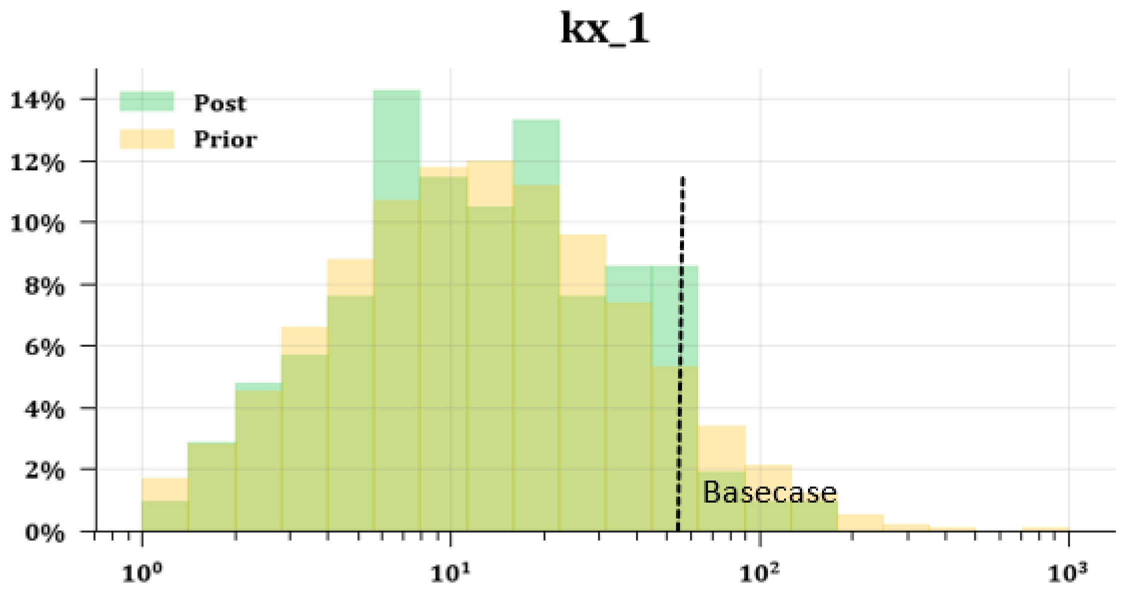
Of the 550 model runs, 73 model runs were accepted as sufficiently calibrated (with SRMS less or equal to calibration SRMS of 8%). These were used in all model scenarios (Project Mining, Approved Mining) and statistically analysed for uncertainty analysis.

6.1 Parameter Distribution

Table 6-1 to **Table 6-5** 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 550 model realisations) and posterior (i.e., from 73 accepted realisations) are provided as **Appendix E**.

Upon review of parameter distributions, it was noted that the horizontal hydraulic conductivity for the Alluvium for the calibrated prediction model (i.e., the one used in **Section 2.6**) is at the upper range of parameter distribution. **Figure 6-1** presents the parameter distribution of horizontal hydraulic conductivity of Alluvium from the uncertainty analyses and the value used in the calibrated prediction model scenario. As **Figure 6-1** shows, the majority of realisations are centred around the 10 m/day with a few of realisations up to 50 m/day. This indicates that although 54 m/day used in the calibrated prediction model is considered to be extreme, the uncertainty analysis results are based on a more probable value (i.e., 10 m/day). In addition, the sensitivity analysis in **Section 5** indicates the horizontal hydraulic conductivity of alluvium is considered to be type 2 meaning that it will not have significant influence on the modelling predictions. Note that this assessment is valid for the entire regional model and that there is no alluvium around Millennium mine that will be affected by this.



Prior : Prior distribution from 550 realisations. Post : Posterior distribution from 73 accepted realisations

Figure 6-1 Horizontal Hydraulic Conductivity of Alluvium Parameter Distribution

Table 6-1 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
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

Zone	Layer - Unit	Horizontal Hydraulic Conductivity (m/day)	
		Mean (Log10)	Constraint
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 6-2 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
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 6-3 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
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 6-4 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 x 10^{-5}
2	Layer 1 - Regolith	-5.55	< SS_Alluvium;< 1 x 10^{-5}
3	Layer 1 - Weathered Permian	-6.99	< SS_Alluvium;< 1 x 10^{-5}
4	Layer 1 - Duaringa Formation	-6.49	< SS_Alluvium;< 1 x 10^{-5}
5	Layer 1/2 - Tertiary Basalt	-6.17	< SS_Alluvium;< 1 x 10^{-5}
6	Layer 2 - Regolith	-6.75	< SS_Alluvium;< 1 x 10^{-5}
7	Layer 3-19- Faults zone1	-5.52	< SS_Alluvium;< 1 x 10^{-5}
8	Layer 3-Rewan	-6.25	< SS_Alluvium;< 1 x 10^{-5}
9	Layer 4 - RCM O/B	-5.48	< SS_Alluvium;< 1 x 10^{-5}
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 6-5 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.

6.2 Uncertainty Results

6.2.1 Number of Realisations

73 realisations were selected as calibrated realisations and used for uncertainty analysis. The predictive model was run using the 139 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 6-2 and **Figure 6-3** show the 95 % confidence intervals of the median and maximum drawdown and predicted inflows, as well as the variance of the median and maximum drawdown and predicted inflows 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 realisation is added to the dataset. As shown in **Figure 6-2** and **Figure 6-3**, additional realisations will not significantly increase or decrease the confidence intervals of predictions of mine inflows and maximum drawdowns. Therefore, the results from the 73 realisations are considered sufficient for the estimation of uncertainty with respect to inflows and other prediction variables.

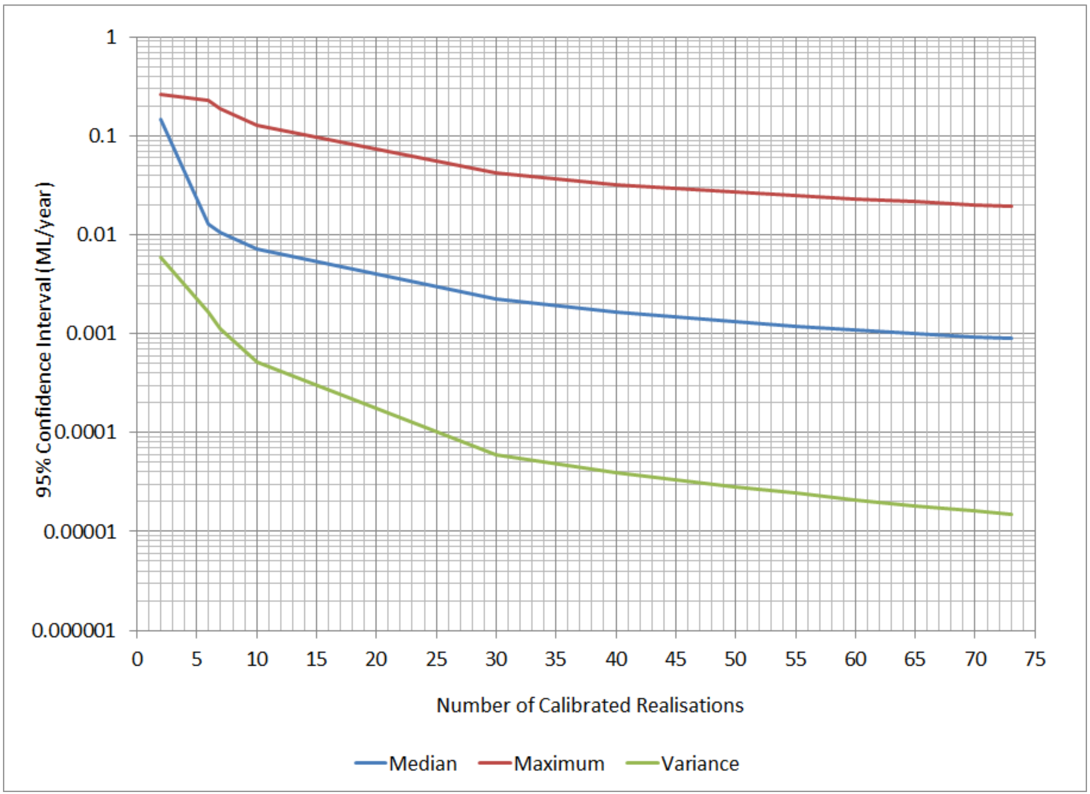


Figure 6-2 95 % Confidence Interval for Pit Inflows

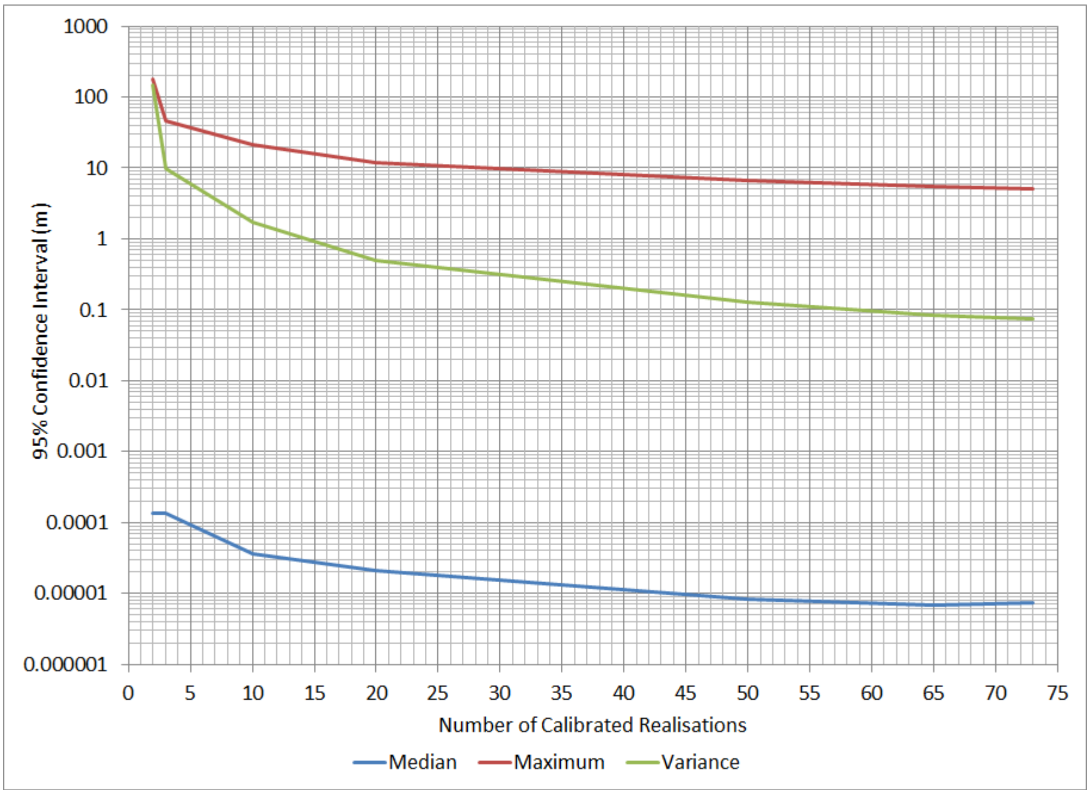


Figure 6-3 95 % Confidence Interval for Maximum Drawdowns

6.2.2 Uncertainty of Mine Inflows

Figure 6-4 shows the predicted inflows for the combined Approved Mavis and Mavis South Underground Mine and different percentiles including 10th, 33rd, 50th, 67th and 90th prediction bounds. Based on the IESC (2018) guidelines these percentiles represent:

- 10th 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 - 90th indicates it is unlikely that the outcome is larger than this value, and
- 90th percentile indicates it is very unlikely the outcome is larger than this value.

The bounds in the figure demonstrate the uncertainty within the predicted inflow rate. The bounds show that the calibrated model generally match the 50th percentile.

As shown in **Figure 6-4**, the maximum mine inflow in the uncertainty analysis was 638 ML/year (1.75 ML/d) (i.e., very unlikely that the outcome is larger than this value). The average inflows for the 10th to 90th percentiles are 15.5 ML/year (0.04 ML/d) and 127.1 ML/year (0.35 ML/day) respectively. The estimated inflows from the calibrated prediction model are following the 67th percentile lines, which means that the best calibrated model is slightly overpredicting the groundwater inflows.

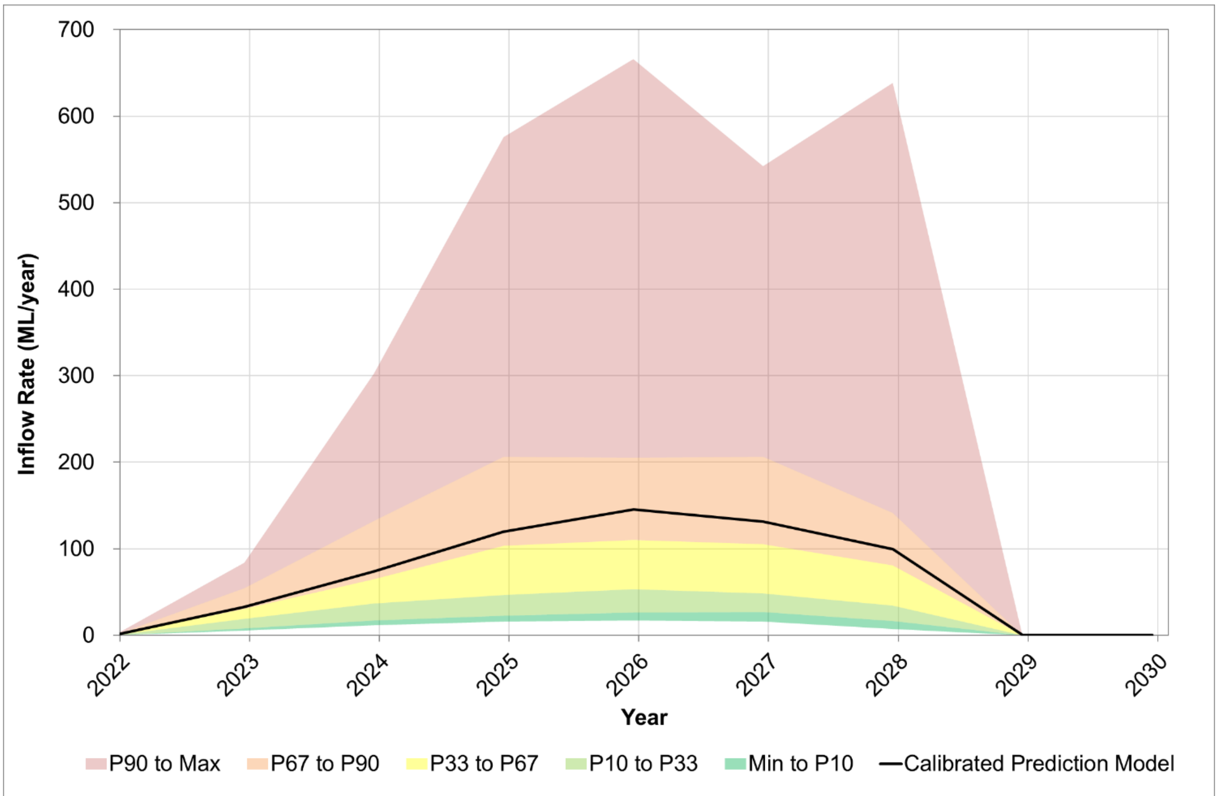


Figure 6-4 Mine Inflow Uncertainty

6.2.3 Groundwater Drawdowns

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

The 95th percentile lines show the predicted maximum drawdown extent exceeded by 5% of tested realisations. Therefore, drawdown extent greater than the 95th percentile area is an unlikely outcome. The 5th percentile lines in the figures show the predicted maximum drawdown extent exceeded by 95% of tested realisations. Therefore, it is highly likely that the actual extent will be greater than that shown for the 5th percentile. The 50th percentile lines show the predicted maximum drawdown extent exceeded 50% of tested realisations. Therefore, these predictions are considered as likely outcomes.

The uncertainty results for the 95th percentile indicate that it is highly unlikely the Mavis South Underground project will result in additional impacts on the alluvium and regolith, and hence no maps are shown for those two layers.

Figure 6-5 shows the uncertainty in the extent of predicted 1 m maximum incremental drawdown in Rewan formation. As shown in this figure, the 95th percentile maximum drawdowns in the Rewan extends approximately between 0.8 km to the east and 10 km to the south of the Project area.

Figure 6-6 shows the uncertainty in the extent of predicted 1 m maximum incremental drawdown in the Leichhardt Seam. The figures show that the 95th percentile drawdown in Leichhardt Seam extends between 2.6 and 2.1 km to the northeast and southeast of the Project area, whereas the calibrated prediction model extends approximately between 0.84 and 0.92 km to the northeast and southeast of the Project area.

0 0.5 1 km

Coordinate System: GDA 1994 MGA Zone 55
Scale: 1:80,000 at A4
Project Number: 620.031508
Date: 07-Nov-2023
Drawn by: AS

Watercourses
Project Boundary
Mining Lease Boundary

1m Drawdown
5th Percentile
50th Percentile
95th Percentile
Basecase

MAVIS SOUTH UNDERGROUND EXTENSION GROUNDWATER MODELLING REPORT

UNCERTAINTY IN PREDICTED 1 M MAXIMUM INCREMENTAL DRAWDOWN IN REWAN GROUP (LAYER 3)

SLR

FIGURE 6-5

H:\Projects-SLR\620-BNE\620-BNE\620.031508.00001 Millennium Mine - Mavis South\06 SLR Data\01 CADGIS\GIS\Modelling Report\620031508 MOD F6-05 Uncertainty in Predicted 1 m Maximum Incremental Drawdown in Rewan Group.mxd

0 0.5 1 km

Coordinate System:	GDA 1994 MGA Zone 55
Scale:	1:80,000 at A4
Project Number:	620.031508
Date:	07-Nov-2023
Drawn by:	AS

SLR

Watercourses
Project Boundary
Mining Lease Boundary

1m Drawdown
5th Percentile
50th Percentile
95th Percentile
Basecase

MAVIS SOUTH UNDERGROUND EXTENSION GROUNDWATER MODELLING REPORT

UNCERTAINTY IN PREDICTED 1 M MAXIMUM INCREMENTAL DRAWDOWN IN LEICHARDT SEAM (LAYER 5)

FIGURE 6-6

H:\Projects-SLR\620-BNE\620-BNE\620.031508.00001 Millennium Mine - Mavis South\06 SLR Data\01 CADGIS\GIS\Modelling Report\62003150B MOD F6-06 Uncertainty in Predicted 1 m Maximum Incremental Drawdown in Leichardt Seam.mxd

7.0 Model Confidence and Limitations

The groundwater modelling was conducted in accordance with the Australian Groundwater Modelling Guidelines (Barnett et al. 2012), the MDBC Groundwater Flow Modelling Guideline (MDBC 2001) and the released IESC Explanatory Note for Uncertainty Analysis (Peeters and Middlemis, 2023).

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. 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 on bores.
- 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 2021 model variation, which shows that there are several model revisions and the latest data has been included. The model has been peer reviewed for each revision. This model build and associated review process is deemed commensurate with the Project related risk to the groundwater environment.

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 Bowen Basin Regional 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 good fit between observed and modelled groundwater levels (**Section 2.5.2**). A depth dependence function was used for hydraulic conductivity, with the calibrated values showing a good fit to observed data as presented in **Section 2.5.4**. Overall, the model is considered fit for purpose to achieve the objectives outlined in **Section 1.2** based on the data provided and the Project timeframe. Updates could be conducted in future to further refine the model, but this would be dependent on the purpose of the modelling and availability of data to inform future changes.

The model sensitivity was explored for an array of parameters. This showed that these parameters were generally well constrained by the calibration. For the predictions, two parameters fell into the type 4 error, which has low identifiability, but high predictive uncertainty.

The uncertainty analysis was undertaken to add a likelihood estimate to the prediction for the main two quantities of interest, the groundwater inflows and predicted drawdowns in a multitude of relevant geological formations.

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 Millennium South and neighbouring mines.
		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. Geophysical surveys across the Project Area have identified minor faulting in the Project 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.
	Conceptualisation – Surface Water Groundwater Interactions	Fit for purpose	Groundwater – Surface water interactions were conceptualised as being limited due to the ephemeral nature of the local creeks. Larger surface water features have a higher likelihood of interacting with groundwater. The interaction is likely a discharge of surface water into groundwater during flow events.
	Conceptualisation – Saturated Extent of Alluvium and Regolith	Fit for purpose	The regional model captures the alluvium where it occurs based on the relevant site data. There is no significant alluvium around Millennium mine. Any additional data or study on alluvium extent and thickness at Project area 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 model 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. Watercourses within and in the vicinity of the Project Area such as Boomerang Creek are ephemeral and only flow briefly after rainfall. Therefore, river stage height of zero was assigned to these watercourses in the model. 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 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 underground at Mavis South. The surrounding mines (Daunia and Poitrel) have been included based on the data sharing agreement (i.e most

Type	Part	Status	Comment
			recent mine plans). Mining at Carborough Downs was implemented based on publicly available data.
	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 and mine inflows.

8.0 Conclusions

A numerical groundwater model for the proposed Mavis South Underground Mine was developed using an existing SLR model (SLR, 2021c) as the foundation. The numerical groundwater model developed for the Project has successfully achieved the modelling objectives, as outlined in **Section 1.2**.

The numerical groundwater model covered a large domain due to extensive historic and approved mining within the region to allow for a cumulative assessment. Existing and approved mines are represented in the model.

A calibration validation was undertaken to match the latest observation datasets. In doing so, new observation data was included in the calibration data set where it was available. The calibrated validation model showed a reasonable match between simulated and observed water levels across the model domain and therefore the model remained calibrated.

Model calibration statistics are within suggested guidelines (Barnett et al., 2012) and mass balance errors remain low, through the model calibration and predictive modelling. Model construction considers all available data, including the current site mine plan and site geological model for the Project area. The uncertainty analysis has demonstrated no impact on alluvial water levels for the Project, with Project related drawdown primarily contained within the Project area. The model serves as a suitable representation of possible transient groundwater conditions within the Study Area, over the life of the Project, however, the uncertainty in predictions should be acknowledged.

As more site-specific hydraulic data becomes available, new data should be compared with the calibrated parameters achieved and the validity of the model calibration should be assessed. Additional site-specific data is expected to “tighten” uncertainty bounds for model prediction results.

Predictive sensitivity indicates that mine inflows are most sensitive to the hydraulic conductivity values of the Rewan group units. However, calibration sensitivity to these parameters is relatively low. Future work should consider opportunities to further constrain values of these parameters.

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Appendix A   Calibration Residuals

Mavis South Underground Extension Project

Groundwater Modelling Technical Report

MetRes Pty Ltd

SLR Project No.: 620.031508.00001

23 November 2023

Table A1: Calibration residuals

ID	Easting	Northing	Layer	Average Residual	Min	Max
141807	621693	7573807	2	-26.052	-28.908	-23.702
141864	621978	7572901	2	-20.028	-30.052	-11.747
141942	607531	7570131	1	-5.5191	-5.5191	-5.5191
162013	621998	7572002	2	-5.9171	-15.682	-2.0679
162041	622162	7573331	3	-21.157	-27.756	-15.141
162043	613496	7560208	2	12.3544	12.3544	12.3544
162044	615613	7560397	2	-8.1203	-8.1203	-8.1203
162048	613513	7557249	2	-3.5799	-3.5799	-3.5799
162068	605993	7571041	2	-10.09	-10.09	-10.09
162070	606033	7571055	2	-10.69	-10.69	-10.69
162071	605990	7571006	2	-10.337	-10.337	-10.337
162141	613846	7562175	2	-0.7323	-0.7323	-0.7323
162143	616018	7561336	2	2.75682	2.75682	2.75682
162164	608384	7558233	2	-5.7437	-5.7771	-5.7175
162165	608920	7556710	2	-2.1308	-7.4542	2.01196
162169	611129	7551675	2	0.47866	0.19193	1.06252
162171	612441	7550671	2	-0.8208	-0.8807	-0.7031
162173	611249	7549500	2	4.05382	1.45256	5.52871
162549	619260	7567365	2	6.22425	5.2104	6.57635
162550	620351	7567479	2	4.32936	3.66895	4.54911
162682	641152	7546517	2	-7.2562	-7.7882	-7.0479
162684	642471	7547492	2	-3.8952	-4.1644	-3.615
182078	620368	7568049	2	-6.9505	-15.675	-2.0462
182079	620368	7568046	2	-1.4178	-1.8768	-1.0363
182080	619740	7567253	2	3.34481	3.21617	3.44936
13040180	667824	7516333	1	-17.839	-19.606	-16.508
13040286	659983	7536966	2	-27.287	-27.796	-26.907
1238-MB1	650671	7522741	2	-10.797	-10.972	-10.582
1238-MB2	650670	7522744	7	-18.082	-18.377	-17.837
2218-MB2	645526	7522756	3	-4.5049	-5.3113	-3.6183
2218-MB3	645523	7522754	5	-4.86	-5.2829	-4.3353
2226-MB2	643134	7521947	4	3.21918	2.60811	3.79229
2226-MB3	643133	7521950	5	0.16733	-0.0877	0.36699
2372-MB1	647520	7526012	2	-10.435	-10.647	-10.263

ID	Easting	Northing	Layer	Average Residual	Min	Max
2372-MB2	647519	7526010	4	-10.142	-10.374	-9.9677
2372-MB3	647518	7526008	7	-9.4418	-9.585	-9.2797
2375-MB2	648042	7523874	9	-12.287	-12.399	-12.168
2393-MB1	645696	7523043	2	-2.2055	-2.7588	-1.7676
2393-MB2	645694	7523043	5	-4.3113	-4.7072	-3.8414
2393-MB3	645691	7523043	7	-4.5614	-5.0816	-3.7494
2394-MB1	644898	7522962	2	-6.5988	-6.724	-6.4773
2394-MB2	644895	7522962	3	-4.5302	-4.6963	-4.3747
C2105R	634650	7541857	5	-7.6816	-7.6816	-7.6816
C2136	631742	7547243	5	-15.575	-15.85	-15.341
CVMMB16_02	611248	7558493	16	-6.7287	-6.9042	-6.5857
CVMPB07_01	611565	7552523	2	6.4431	6.41383	6.47134
CVMPB07_02	611565	7552540	14	-6.408	-6.408	-6.408
CVMVWP01_3	610028	7560450	16	-8.5986	-9.1743	-7.8799
CVMVWP01_4	610028	7560450	18	-4.9242	-6.1225	-3.7848
DauniaPZ01	632534	7561905	8	-3.8395	-5.0826	-2.8959
DauniaPZ02	635300	7560237	6	-7.5569	-15.556	9.9436
DauniaPZ03	632332	7558326	8	-12.269	-13.104	-9.1004
DauniaPZ04	635531	7554554	8	-12.257	-12.928	-8.4046
DauniaPZ05	632576	7561914	8	-2.754	-4.7581	-1.0853
DauniaPZ06	631776	7561217	7	-4.0236	-11.83	-0.2616
DauniaPZ07	631627	7559539	10	-9.9018	-10.777	-8.8688
G2304R	633245	7543171	7	-13.279	-13.279	-13.279
G2307	630881	7547844	7	-15.004	-15.088	-14.769
GW01d_p1	642475	7547489	7	-8.2228	-9.374	-6.8841
GW01d_p2	642475	7547489	5	-12.136	-12.932	-10.769
GW01d_p3	642475	7547489	3	-6.6751	-6.9046	-6.2065
GW01d_p4	642475	7547489	3	-4.4918	-4.6425	-3.8065
GW01s	642471	7547492	2	-3.1853	-3.4605	-2.9088
GW02d	641148	7546512	7	-7.439	-7.5099	-7.404
GW02s	641152	7546517	2	-7.4509	-7.5424	-7.3664
GW06d_p1	639334	7542009	9	7.51692	7.1924	7.9026
GW06d_p2	639334	7542009	10	-1.5644	-2.0723	-1.1021
GW06d_p3	639334	7542009	9	-1.8742	-2.0976	-1.6774
GW06d_p4	639334	7542009	9	-6.3731	-7.1476	-4.2474
GW08d_p1	645312	7539846	5	-12.318	-15.112	-10.772

ID	Easting	Northing	Layer	Average Residual	Min	Max
GW08d_p2	645312	7539846	3	-6.6951	-6.9611	-6.4956
GW08d_p3	645312	7539846	3	-0.0951	-0.1611	0.00438
GW08d_p4	645312	7539846	3	-32.328	-38.276	-24.491
GW12d_p1	641492	7532790	5	1.35241	0.1868	5.8271
GW12d_p2	641492	7532790	5	-3.5443	-4.4234	-2.1829
GW12d_p3	641492	7532790	3	14.8373	11.9481	16.0378
GW12d_p4	641492	7532790	3	34.3073	33.3678	36.1881
GW12s	641498	7532791	2	-2.4265	-2.4408	-2.4105
GW16d_p1	660834	7525288	7	-27.223	-28.614	-23.333
GW16d_p2	660834	7525288	5	-15.253	-15.321	-15.162
GW16d_p3	660834	7525288	3	-14.899	-15.107	-14.668
GW16d_p4	660834	7525288	3	-14.204	-14.367	-14.028
GW18d	656891	7522809	7	-8.5329	-8.5494	-8.5125
GW18S	656885	7522810	1	-7.9942	-8.1192	-7.8974
GW21d	661580	7521648	10	-17.9	-17.919	-17.889
GW21s	661580	7521653	2	2.72385	2.5792	2.87484
GW8S	645323	7539847	1	-3.7415	-3.8209	-3.6685
KnobHill1	631005	7553874	1	-4.1051	-4.2391	-3.9863
KnobHill2	630431	7554061	1	-0.6232	-1.0863	0.49507
LH13	627200	7546952	9	12.8911	12.1606	13.766
LV2183_P2	644068	7520358	5	-4.304	-5.9304	-2.1643
LV2183_P3	644068	7520358	6	-23.14	-24.191	-22.08
LV2183_P4	644068	7520358	7	-15.915	-17.731	-13.397
LV2218_P1	645526	7522753	5	-6.0628	-7.4231	-5.5407
LV2218_P2	645526	7522753	6	-9.1676	-9.6342	-8.9056
LV2218_P3	645526	7522753	7	-8.327	-9.768	-7.6614
LV2226_P1	643129	7521950	4	4.62262	4.27984	4.90709
LV2226_P2	643129	7521950	5	-0.7621	-1.9654	0.14388
LV2226_P3	643129	7521950	6	-2.183	-2.8158	-1.5485
LV2226_P4	643129	7521950	7	-4.0417	-4.1511	-3.872
LV2370W	648037	7523878	2	-4.3399	-4.4844	-4.1879
LV2371W	643131	7521947	2	5.77166	5.10751	6.74113
LV2372R_P1	647515	7526007	6	-8.6922	-9.9147	-6.9392
LV2372R_P4	647515	7526007	7	-10.585	-11.115	-8.3673
MB08PZ4	615638	7559628	16	-14.619	-14.619	-14.619
MB1	623254	7551541	9	-3.6645	-5.6711	-2.0833

ID	Easting	Northing	Layer	Average Residual	Min	Max
MB13PZ4	615195	7551070	16	-10.859	-10.859	-10.859
MB15PZ4	620083	7547608	16	-1.1779	-1.1779	-1.1779
MB19CVM01A	610443	7548264	2	-2.1262	-2.4355	-1.7124
MB19CVM03T	610214	7551338	2	9.85401	7.47584	11.0717
MB19CVM04P	610215	7551344	18	23.9706	23.9706	23.9706
MB19CVM05T	611082	7551428	2	-9.8963	-12.018	-7.0874
MB19CVM06P	611075	7551429	16	-8.6271	-10.458	-5.6745
MB19CVM07T	611578	7552537	2	4.99099	4.71322	5.47103
MB19CVM08P	611579	7552526	16	-6.4371	-7.5204	-3.6046
MB19CVM09A	612560	7550879	2	1.79803	1.49263	2.24593
MB19CVM10P	613294	7549948	16	0.45601	-1.3955	3.30838
MB19SRM01A	640146	7516041	1	20.7839	20.7839	20.7839
MB19SRM02T	640140	7516048	2	10.7439	10.7439	10.7439
MB19SRM03P	640132	7516057	9	10.8382	10.8382	10.8382
MB19SRM04P	637174	7511222	2	1.87723	1.67339	2.15634
MB2	623684	7549391	9	1.66093	1.0549	2.1046
MB20CVM01A	610028	7560466	2	0.16502	-0.325	1.04119
MB20CVM04T	608307	7559829	2	2.60541	2.28169	3.42019
MB20CVM05P	608312	7559824	18	-8.255	-10.608	-5.9012
MB20CVM06T	610921	7549067	2	-2.3501	-4.1437	-1.8026
MB20PDM03P	621513	7548051	15	-4.8445	-5.6154	-4.1166
MB20PDM05P	630220	7533012	14	8.14749	6.92261	10.1688
MB20PDM06T	628976	7532808	2	20.4296	20.2759	20.6855
MB20PDM07T	621823	7538727	2	21.3623	21.1025	21.8753
MB20SRM02T	636028	7527850	9	-1.3542	-1.3542	-1.3542
MB20SRM03P	636021	7527857	18	-30.592	-30.592	-30.592
MB20SRM04A	631511	7530650	1	15.5718	15.5718	15.5718
MB20SRM06A	636596	7520189	2	16.9717	16.9717	16.9717
MB20SRM07P	641476	7508141	18	-2.6336	-2.6336	-2.6336
MB3	627240	7549946	3	-16.787	-17.397	-15.766
MB33	636754	7520380	12	3.88523	1.40987	7.49512
MB34	638040	7518450	14	-0.1304	-39.121	2.87751
MB35	642760	7520291	2	8.34915	6.80619	9.77529
MB36	640264	7514464	2	5.81409	3.98192	6.54461
MB39	640132	7516057	10	11.2715	10.3317	12.2351
MB4	626507	7544152	9	3.90201	3.66777	4.10773

ID	Easting	Northing	Layer	Average Residual	Min	Max
MB40	640140	7516048	2	10.8428	10.5287	11.0581
MB5	628491	7542693	9	4.98103	4.02347	5.39103
MillCSMB2	632916	7564461	5	-56.398	-63.851	-15.654
MillMB1	627785	7565127	5	1.75539	-5.5706	12.9948
MillMB10A	630730	7563772	9	1.5031	-0.1379	9.1095
MillMB10B	630730	7563772	11	7.30712	5.82179	9.5698
MillMB11A	631785	7562727	2	1.28112	-2.0907	3.60393
MillMB11B	631785	7562727	2	3.28862	1.88934	4.64023
MillMB2	627804	7563280	5	-25.236	-29.172	-1.7753
MillMB3A	630061	7562379	2	16.4423	7.86915	21.9069
MillMB3B	630061	7562379	2	10.8156	6.22915	15.5741
MillMB4	630428	7563387	2	4.18821	1.52922	6.61162
MillMB8B	627392	7565798	4	-17.916	-21.263	-16.376
MillMB9A	628539	7565789	10	6.71915	4.34138	8.19161
MillMB9B	628539	7565789	11	-5.9745	-38.385	2.63757
MOS_MB01	610570	7562897	2	3.25731	3.25731	3.25731
MOS_MB02	611777	7562388	15	-10.924	-10.924	-10.924
MOS_MB04	613961	7562355	2	-0.733	-0.733	-0.733
MOS_MB05	615206	7563212	2	3.7576	3.7576	3.7576
MOS_MB06	616017	7561336	2	2.74715	2.74715	2.74715
MOS_MB07	615613	7560398	2	-8.1203	-8.1203	-8.1203
MOS_MB08b	615638	7559628	11	-3.814	-3.814	-3.814
MOS_MB09b	618366	7558118	9	-0.2393	-0.2393	-0.2393
MOS_MB11	611617	7558367	15	-5.8882	-5.8882	-5.8882
MOS_MB12	613627	7557429	2	-3.5799	-3.5799	-3.5799
MOS_MB14	615195	7551070	11	-4.2299	-4.2299	-4.2299
MOS_MB16	620083	7547608	11	1.83827	1.83827	1.83827
OBS1	630111	7554627	2	-5.6888	-6.7223	-5.1229
OBS10	627784	7556229	5	-2.4821	-3.0325	-1.9994
OBS11	630313	7556960	2	12.1265	11.5973	13.0183
OBS12	626899	7559552	5	-23.709	-24.674	-22.609
OBS13	626891	7559550	7	-16.874	-16.902	-16.846
OBS14	629680	7560815	2	20.7504	20.7168	20.7749
OBS2	631341	7557693	9	0.2493	-0.8054	1.16921
OBS4	626685	7562094	4	-2.9488	-3.4912	-2.5991
OBS5	626050	7557202	2	-5.4001	-6.9664	-4.5841

ID	Easting	Northing	Layer	Average Residual	Min	Max
OBS6	628887	7556546	5	-11.185	-12.003	-10.387
OBS7	625570	7556820	1	-2.0498	-2.4497	-1.7063
OBS8	631867	7553655	1	2.54833	2.30054	2.97921
OBS9	627800	7556217	6	6.18482	5.46565	6.76208
ODN18MB1	640275	7547943	5	-8.9926	-9.0876	-8.8977
ODN18MB10	639451	7554580	10	-15.645	-15.645	-15.645
ODN18MB11	638599	7553465	10	-9.9367	-9.9367	-9.9367
ODN18MB12	640277	7547944	5	-1.1626	-1.4577	-0.8676
ODN18MB2	640263	7547944	1	1.28322	1.27307	1.29338
ODN18MB3	639750	7551426	5	-11.925	-11.926	-11.925
ODN18MB4	640684	7549869	2	-10.051	-10.465	-9.6371
ODN18MB6	639944	7551802	5	-10.891	-10.891	-10.891
ODN18MB7	640310	7554734	2	-5.7742	-5.7742	-5.7742
ODN18MB8	638921	7550183	2	-3.7664	-3.8313	-3.7015
ODN18MB9	640089	7557236	4	-1.5548	-1.5548	-1.5548
ODN18TB1	640318	7547935	5	-7.9076	-8.1776	-7.6377
ODN18TB2	640303	7547935	1	3.35306	3.14318	3.56294
PDMMB11_01	624187	7534394	17	-4.8394	-4.8394	-4.8394
PDMMB12_01	624324	7534454	17	-8.3044	-8.3044	-8.3044
PZ00B	632914	7529866	2	2.65089	2.59324	2.76041
PZ00C	632985	7529934	2	1.65743	1.60029	1.72849
PZ00D	631798	7530369	13	5.29807	4.93417	5.96267
PZ01	609954	7560323	18	-2.9245	-7.0491	-0.9237
PZ02	608553	7558420	2	-2.7976	-4.8991	-1.6544
PZ02A	632133	7530855	2	11.6373	11.204	12.0707
PZ02B	632133	7530855	15	-2.1868	-2.1973	-2.1764
PZ02C	632133	7530855	18	0.228	-6.8885	7.3445
PZ03-D	609029	7556890	18	-8.8346	-11.744	-7.4252
PZ03-S	609028	7556894	2	-7.1695	-11.955	-2.9789
PZ04	610844	7555504	12	-4.1577	-5.096	-3.4389
PZ04A	630356	7531133	2	15.3229	14.0994	16.7822
PZ04B	630356	7531133	16	14.1163	13.8709	14.3616
PZ04C	630356	7531133	18	13.8307	13.6104	14.051
PZ05	609030	7554296	18	-16.267	-18.839	-8.7636
PZ05A	642441	7509401	16	-1.4232	-1.4603	-1.386
PZ05B	642441	7509401	18	-6.3437	-6.3469	-6.3405

ID	Easting	Northing	Layer	Average Residual	Min	Max
PZ06A	639385	7513506	14	8.46266	8.42662	8.5299
PZ06B	639385	7513506	16	5.18822	5.0624	5.29578
PZ06C	639385	7513506	18	-4.1162	-4.5157	-3.6484
PZ06-S	611237	7551854	2	0.5389	0.06541	1.22472
PZ07-D	612578	7550882	12	-0.2611	-1.6221	0.93562
PZ07-S	612584	7550881	2	-0.0905	-0.8108	1.88961
PZ08A	634761	7523250	14	7.07255	6.77546	7.29153
PZ08B	634761	7523250	16	2.56888	2.49463	2.64313
PZ08-D	611526	7549891	17	-5.1042	-14.346	7.77012
PZ08-S	611524	7549887	2	5.31417	1.55762	6.39061
PZ09	614439	7549000	15	-12.011	-25.859	-3.9704
PZ09B	633026	7527959	16	-0.2567	-0.3103	-0.2031
PZ09C	633026	7527959	18	-0.1159	-0.8727	0.64098
PZ10B	634350	7524345	16	10.5384	9.06344	12.0134
PZ10C	634350	7524345	18	29.7541	28.0011	31.5071
PZ11-D	616904	7547778	14	-7.8118	-27.608	1.92425
PZ12-D	610834	7557342	13	-4.0113	-5.0682	-1.4077
PZ12-S	610825	7557397	2	-1.0579	-1.4063	-0.405
R2007	630448	7542330	7	-0.9	-0.9	-0.9
R2008	630879	7542573	5	-0.0607	-1.0057	0.14785
R2010	631743	7543062	5	-6.3759	-7.8279	-6.0561
R2010R	631730	7543070	5	-6.7391	-6.7391	-6.7391
R2032	630495	7545853	5	4.25636	1.12163	4.69133
R2035	629190	7545103	9	-0.6444	-0.913	-0.0537
R2054	629240	7548107	4	1.53097	-3.5614	2.67764
R2055	628798	7547863	7	3.3911	2.23038	3.64515
R2056	628364	7547623	9	6.17255	6.17255	6.17255
S10	642552	7546035	2	-3.6544	-3.661	-3.6478
S11	642455	7545332	1	-3.3425	-3.3425	-3.3425
S2	641386	7547617	1	-4.9939	-4.9939	-4.9939
S4	641567	7546845	1	-8.2781	-9.1201	-7.4361
S5	642239	7547332	2	-6.0686	-6.0828	-6.0544
S6	642054	7546721	1	-4.3682	-4.3718	-4.3645
S7	641443	7545828	2	-7.3634	-7.377	-7.3498
S8	642340	7546343	1	-2.2245	-2.322	-2.1271
S9	641767	7545426	2	-6.0835	-6.0871	-6.0798

ID	Easting	Northing	Layer	Average Residual	Min	Max
W1_MB1	637914	7531373	2	-1.2788	-1.2921	-1.272
W1_MB2	637916	7531372	5	-0.8289	-0.8954	-0.7655
W1_MB3	637919	7531372	7	-0.812	-0.8453	-0.7555
W10_MB1	641869	7524259	4	-10.18	-10.185	-10.175
W10_MB2	641869	7524259	7	-18.586	-18.786	-18.296
W10_MB3	641869	7524261	7	-14.782	-14.836	-14.726
W11_MB1	643941	7524860	3	-33.359	-67.309	-16.019
W11_MB2	643943	7524861	5	-13.788	-14.078	-13.618
W12_MB1	643268	7530165	2	-11.484	-11.601	-11.421
W13_MB1	645381	7530927	9	-8.7028	-8.7628	-8.6428
W14_MB1	645373	7528515	2	-4.6281	-4.8409	-4.422
W15_MB1	649009	7527504	2	5.16594	5.15458	5.18325
W15_MB2	649009	7527504	7	5.20633	5.17369	5.26693
W15_MB3	649009	7527504	7	5.22967	5.14369	5.33838
W2_MB1	637368	7531452	2	-0.6113	-0.6578	-0.5282
W2_MB2	637370	7531452	10	-0.7387	-0.7785	-0.7186
W3_MB1	640470	7529435	2	8.14054	7.42051	8.5805
W3_MB2	640468	7529435	2	-0.6695	-0.6994	-0.6395
W4_MB1	638172	7528735	2	6.30128	6.22152	6.42101
W4_MB2	638169	7528735	9	-1.0679	-1.3049	-0.9245
W5_MB1	638387	7527823	3	-0.7228	-0.7831	-0.6126
W5_MB2	638385	7527820	5	0.25008	0.22681	0.26694
W5_MB3	638384	7527817	7	-1.7105	-1.7205	-1.7006
W6_MB1	637758	7527892	9	-0.7702	-1.4298	-0.1107
W6_MB2	637761	7527893	10	0.34602	0.25634	0.50561
W7_MB1	637484	7526145	9	-0.8618	-0.8883	-0.8295
W8_MB1	639306	7523618	10	-4.1234	-4.2267	-3.9366
W9_MB1	640953	7524117	2	-4.8332	-4.9383	-4.7282
W9_MB2	640953	7524119	9	-12.5	-12.69	-12.22
W9_MB3	640952	7524121	9	-11.26	-11.31	-11.22
West-MB1	642872	7519929	2	4.0676	3.50277	4.76
West-MB2	642873	7519932	9	5.63431	5.23695	6.16434
WinnetBore	634791	7550023	1	-6.1713	-7.4118	-5.6352

Appendix B Hydrographs

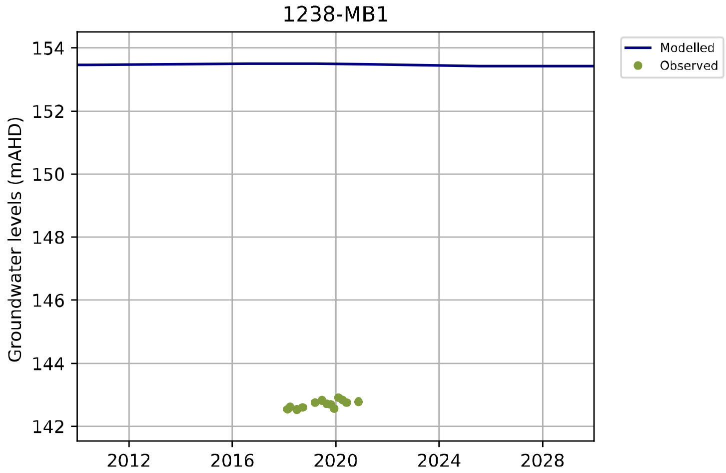
Mavis South Underground Extension Project

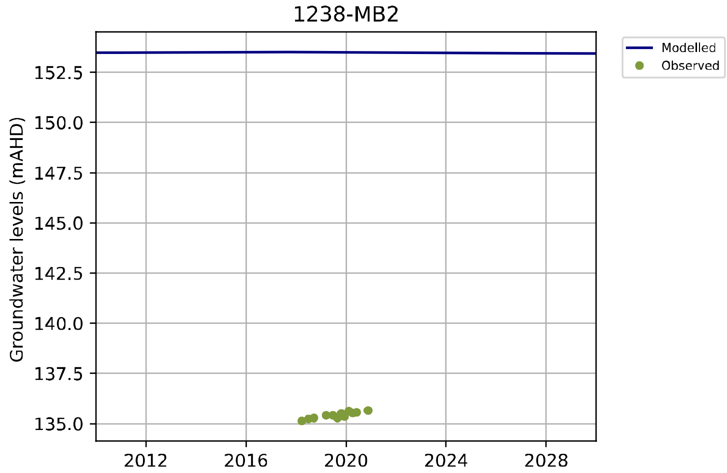
Groundwater Modelling Technical Report

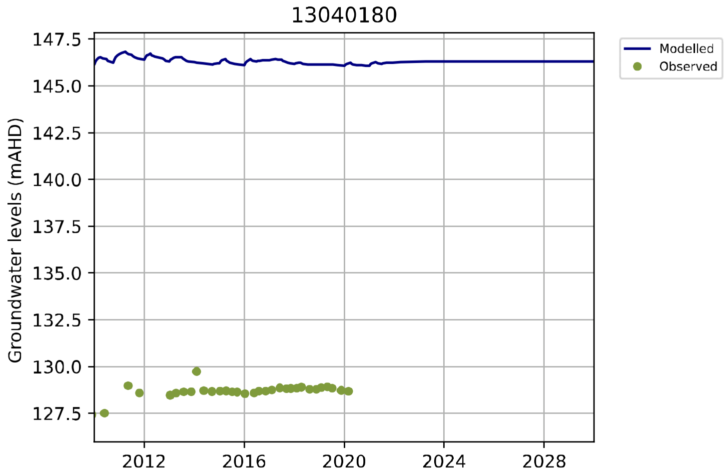
MetRes Pty Ltd

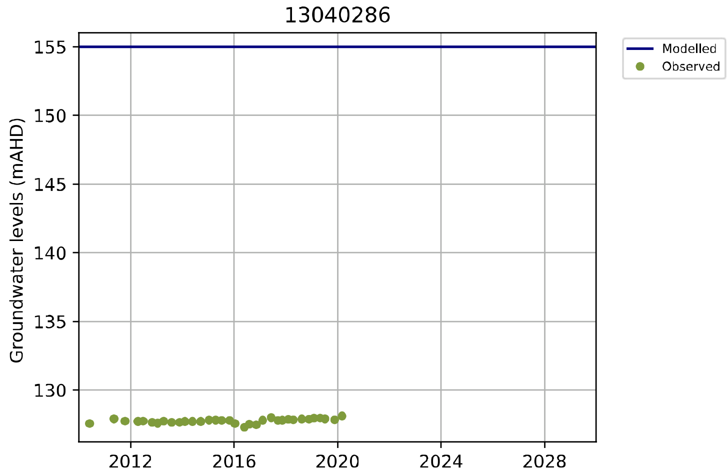
SLR Project No.: 620.031508.00001

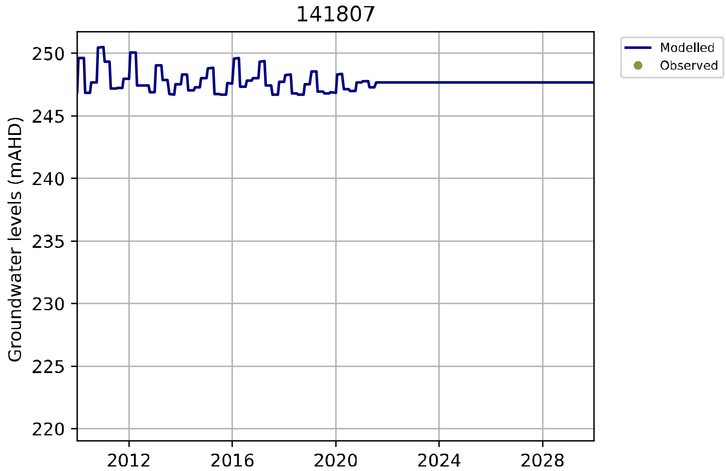
23 November 2023

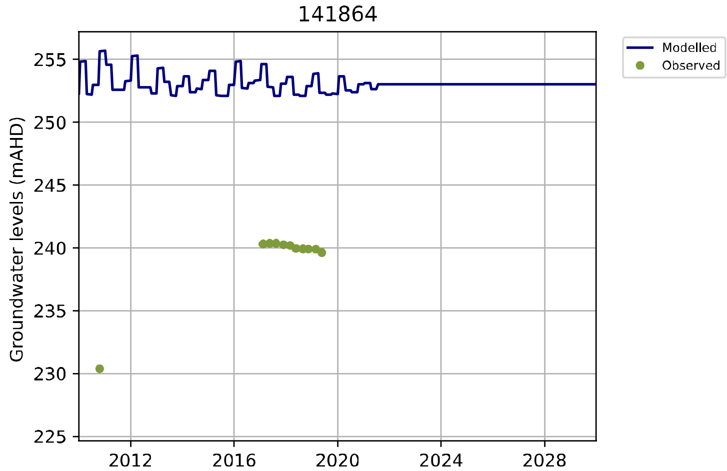

1238-MB1
Groundwater levels (mAHD)
154
152
150
148
146
144
142
2012
2016
2020
2024
2028
Modelled
Observed

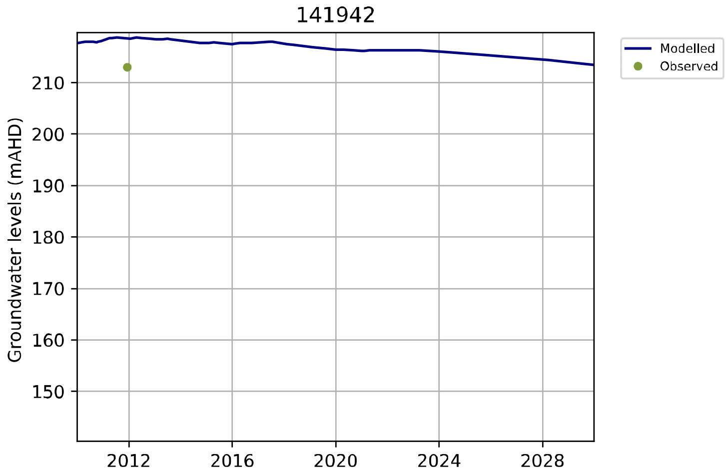

1238-MB2
Groundwater levels (mAHD)
152.5
150.0
147.5
145.0
142.5
140.0
137.5
135.0
2012
2016
2020
2024
2028
Modelled
Observed

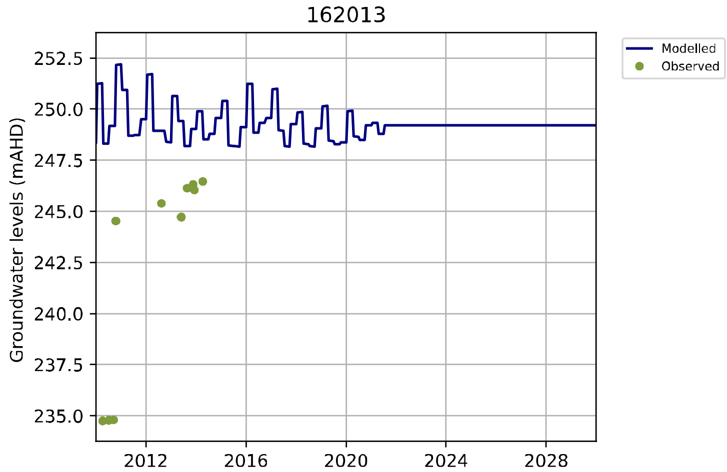

13040180
Groundwater levels (mAHD)
147.5
145.0
142.5
140.0
137.5
135.0
132.5
130.0
127.5
2012
2016
2020
2024
2028
Modelled
Observed

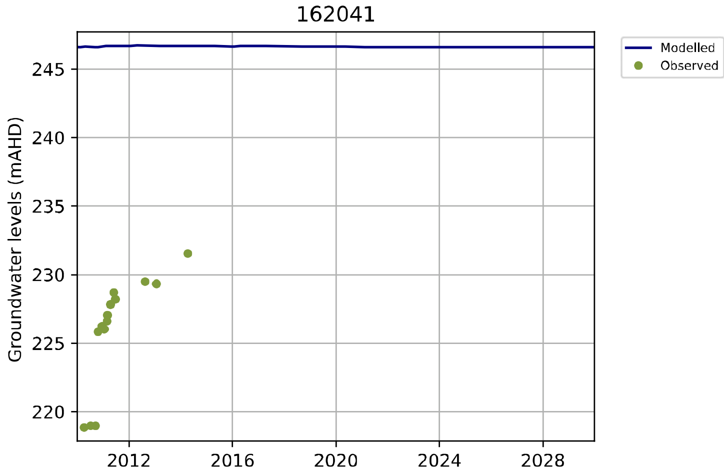

13040286
Groundwater levels (mAHD)
155
150
145
140
135
130
2012
2016
2020
2024
2028
Modelled
Observed

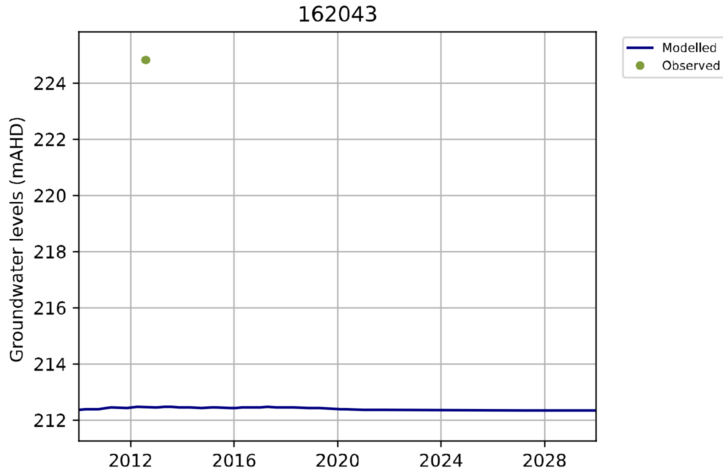

141807
Groundwater levels (mAHD)
250
245
240
235
230
225
220
2012
2016
2020
2024
2028
Modelled
Observed

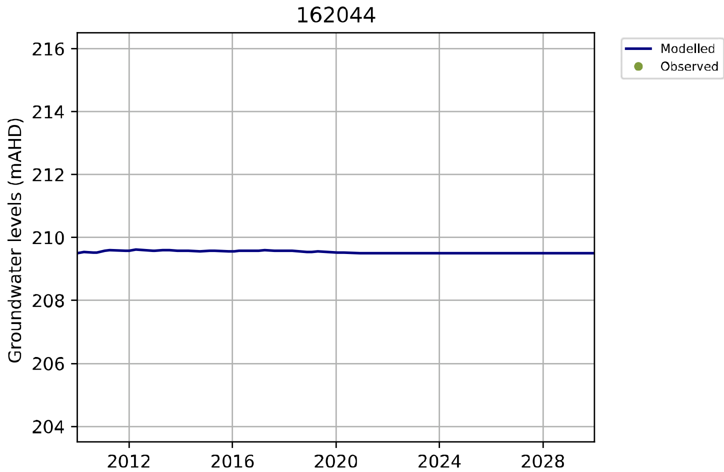

141864
Groundwater levels (mAHD)
255
250
245
240
235
230
225
2012
2016
2020
2024
2028
Modelled
Observed

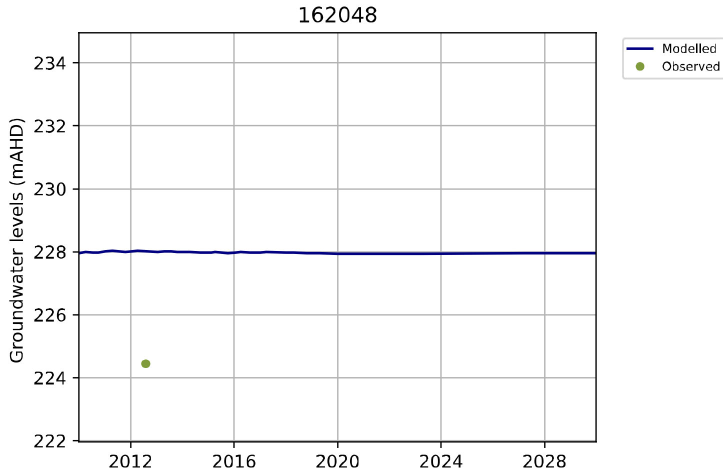

141942
Groundwater levels (mAHD)
210
200
190
180
170
160
150
2012
2016
2020
2024
2028
Modelled
Observed

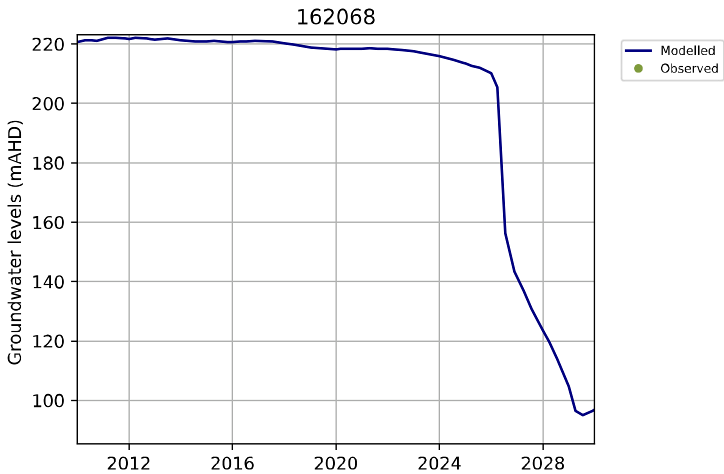

162013
Groundwater levels (mAHD)
252.5
250.0
247.5
245.0
242.5
240.0
237.5
235.0
2012
2016
2020
2024
2028
Modelled
Observed

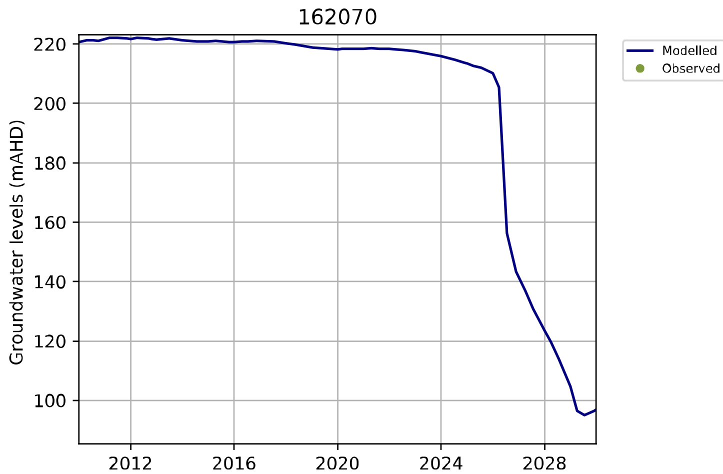

162041
Groundwater levels (mAHD)
220
225
230
235
240
245
2012
2016
2020
2024
2028
Modelled
Observed

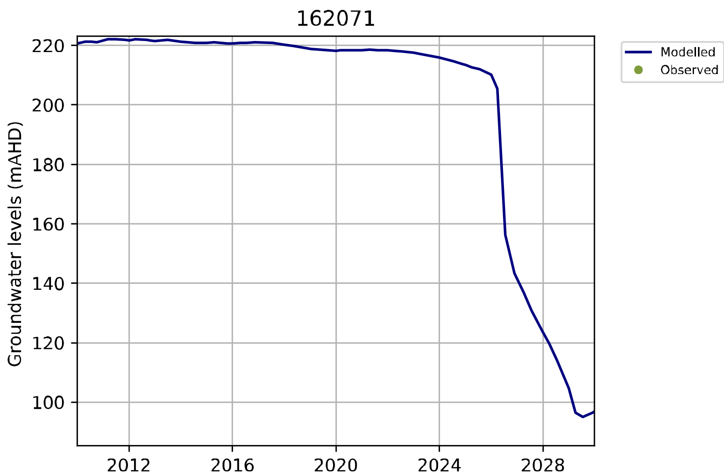

162043
Groundwater levels (mAHD)
212
214
216
218
220
222
224
2012
2016
2020
2024
2028
Modelled
Observed

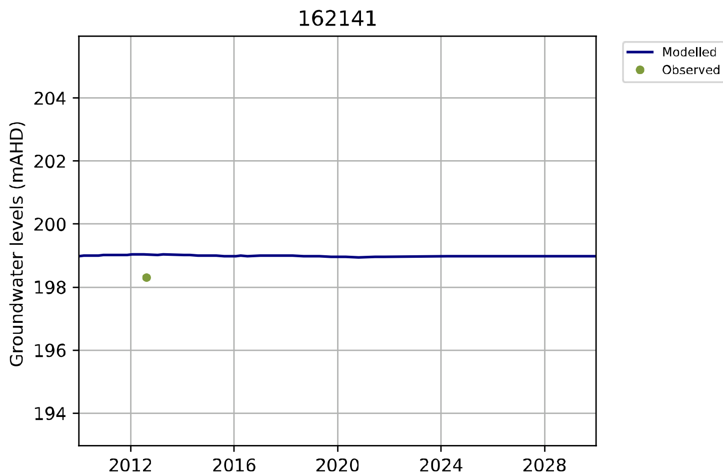

162044
Groundwater levels (mAHD)
204
206
208
210
212
214
216
2012
2016
2020
2024
2028
Modelled
Observed

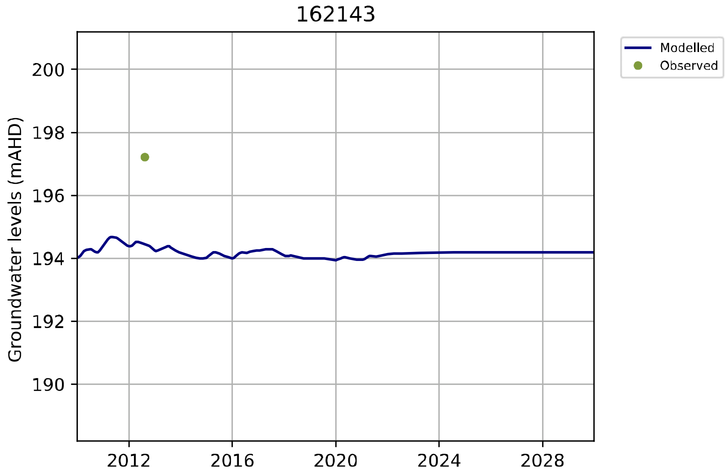

162048
Groundwater levels (mAHD)
222
224
226
228
230
232
234
2012
2016
2020
2024
2028
Modelled
Observed

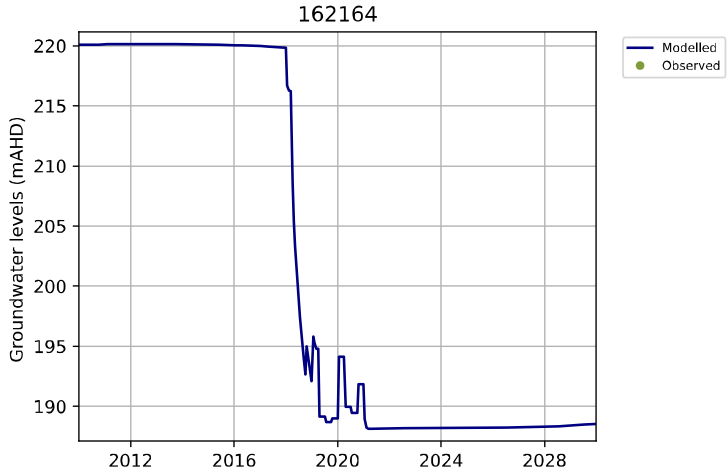

162068
Groundwater levels (mAHD)
100
120
140
160
180
200
220
2012
2016
2020
2024
2028
Modelled
Observed

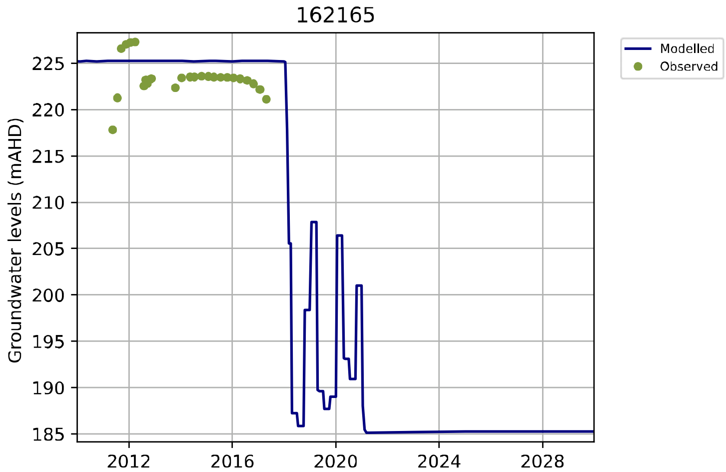

162070
Groundwater levels (mAHD)
100
120
140
160
180
200
220
2012
2016
2020
2024
2028
Modelled
Observed

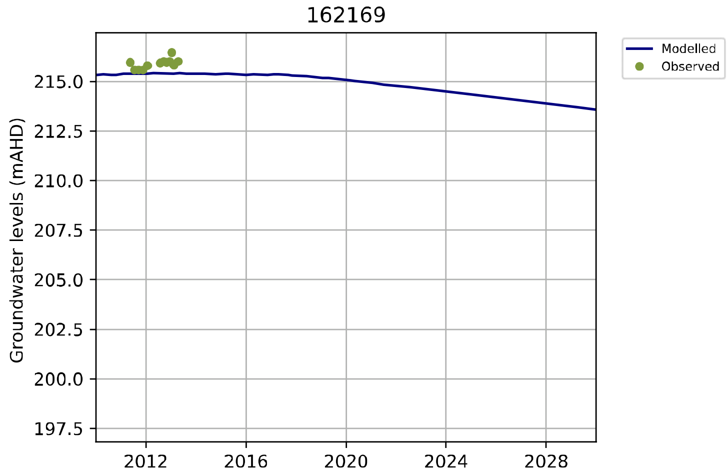

162071
Groundwater levels (mAHD)
100
120
140
160
180
200
220
2012
2016
2020
2024
2028
Modelled
Observed

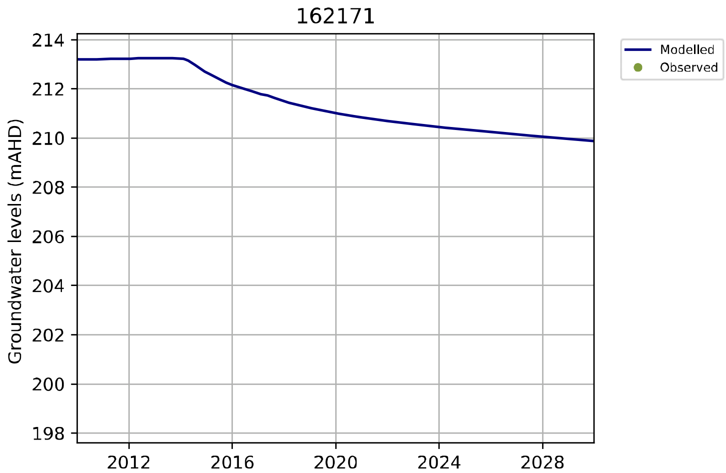

162141
Groundwater levels (mAHD)
194
196
198
200
202
204
2012
2016
2020
2024
2028
Modelled
Observed

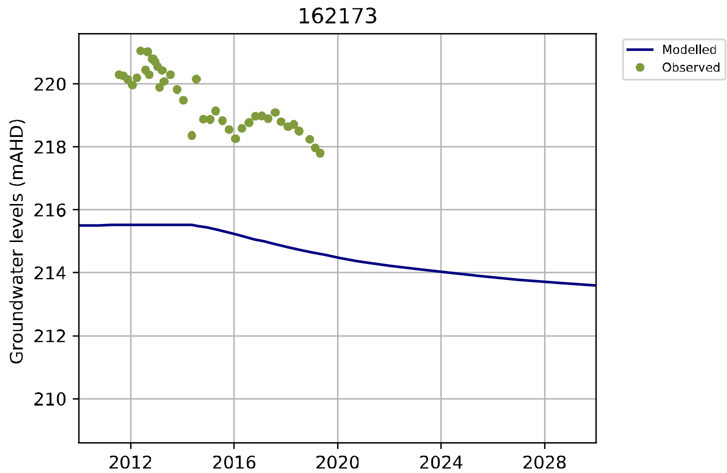

162143
Groundwater levels (mAHD)
200
198
196
194
192
190
2012
2016
2020
2024
2028
Modelled
Observed

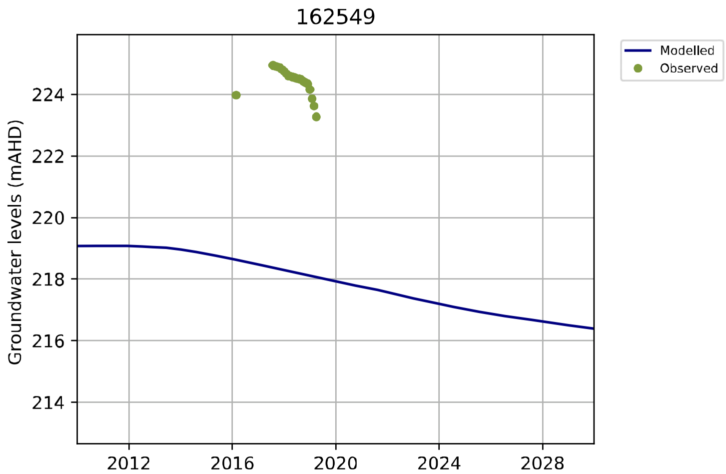

162164
Groundwater levels (mAHD)
220
215
210
205
200
195
190
2012
2016
2020
2024
2028
Modelled
Observed

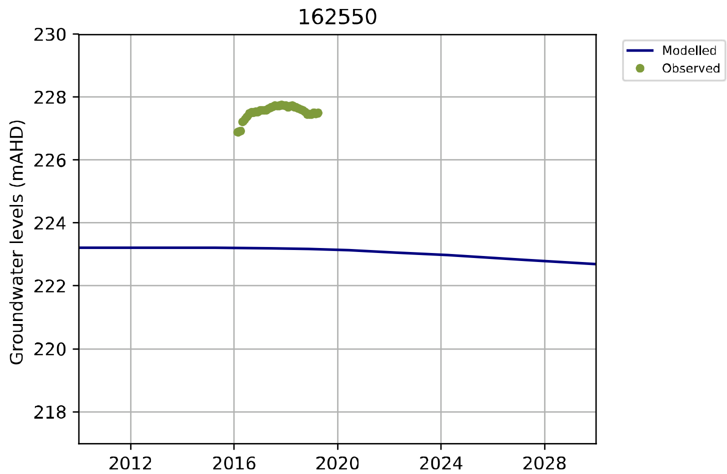

162165
Groundwater levels (mAHD)
225
220
215
210
205
200
195
190
185
2012
2016
2020
2024
2028
Modelled
Observed

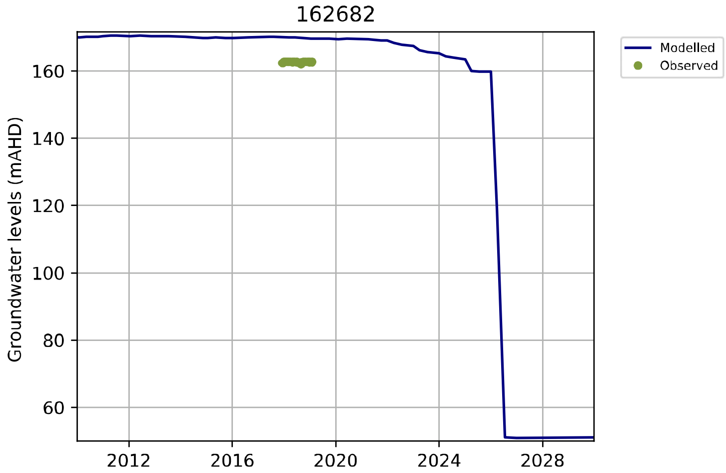

162169
Groundwater levels (mAHD)
215.0
212.5
210.0
207.5
205.0
202.5
200.0
197.5
2012
2016
2020
2024
2028
Modelled
Observed

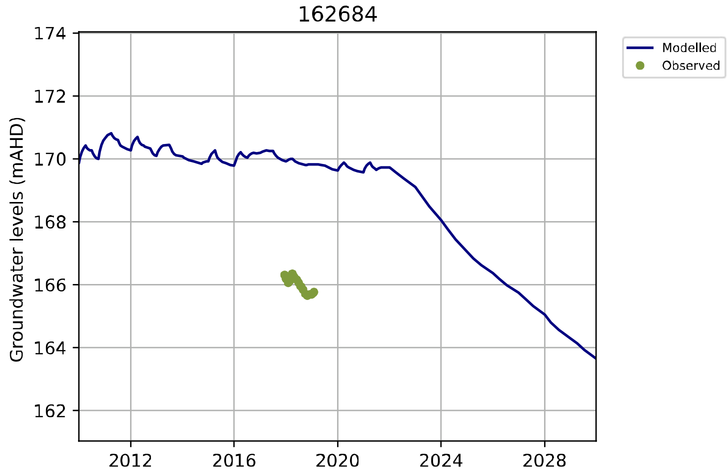

162171
Groundwater levels (mAHD)
214
212
210
208
206
204
202
200
198
2012
2016
2020
2024
2028
Modelled
Observed

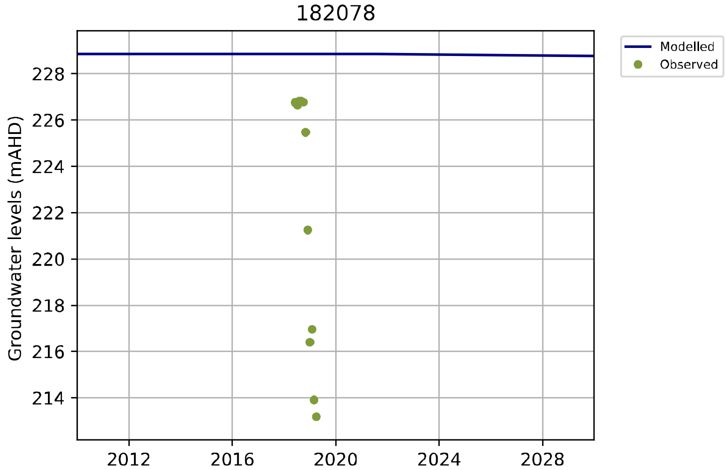

162173
Groundwater levels (mAHD)
220
218
216
214
212
210
2012
2016
2020
2024
2028
Modelled
Observed

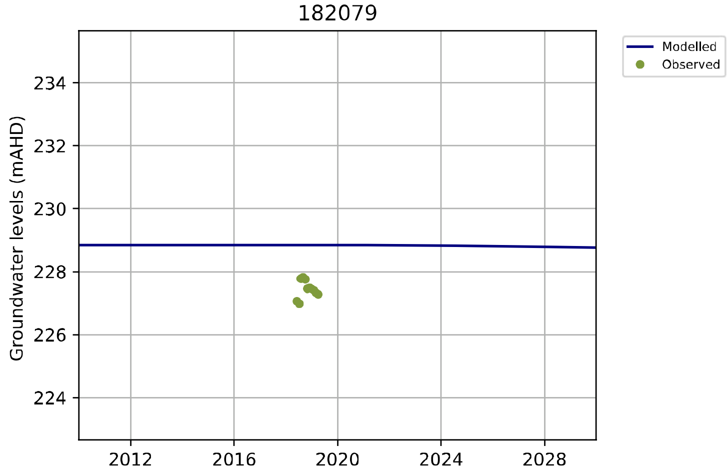

162549
Groundwater levels (mAHD)
224
222
220
218
216
214
2012
2016
2020
2024
2028
Modelled
Observed

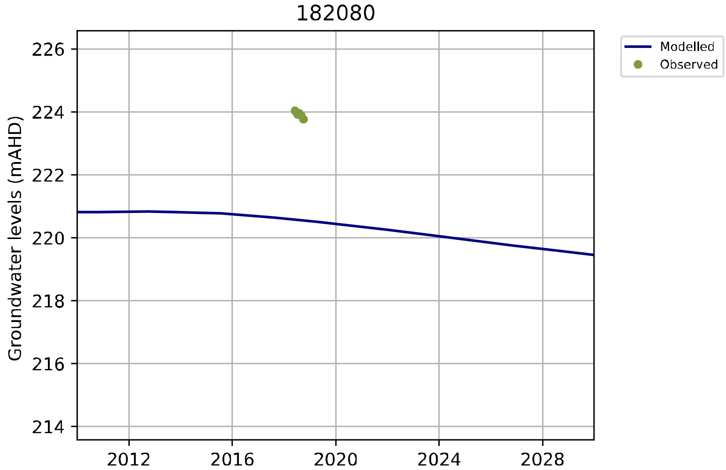

162550
Groundwater levels (mAHD)
230
228
226
224
222
220
218
2012
2016
2020
2024
2028
Modelled
Observed

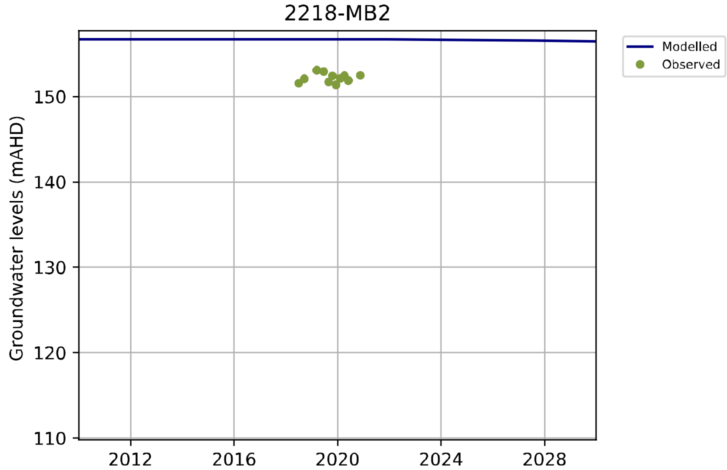

162682
Groundwater levels (mAHD)
160
140
120
100
80
60
2012
2016
2020
2024
2028
Modelled
Observed

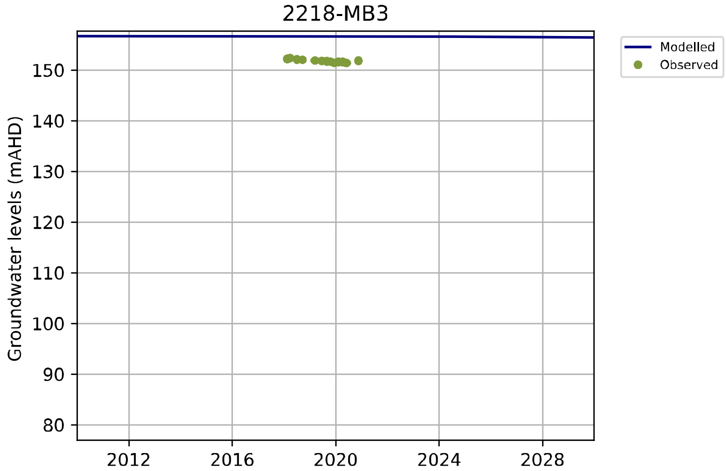

162684
Groundwater levels (mAHD)
174
172
170
168
166
164
162
2012
2016
2020
2024
2028
Modelled
Observed

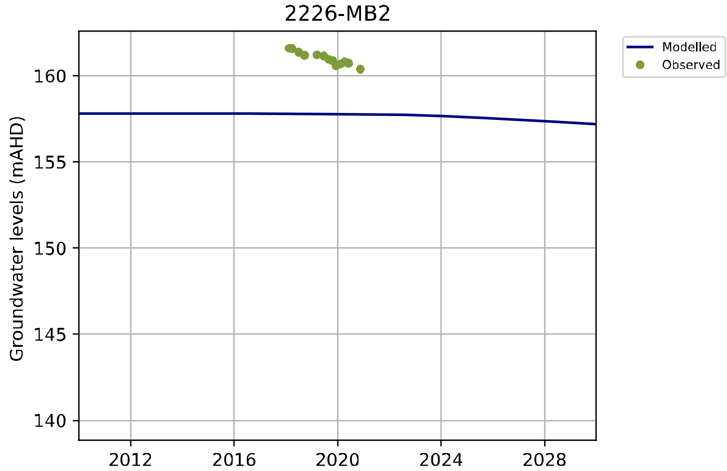

182078
Groundwater levels (mAHD)
228
226
224
222
220
218
216
214
2012
2016
2020
2024
2028
Modelled
Observed

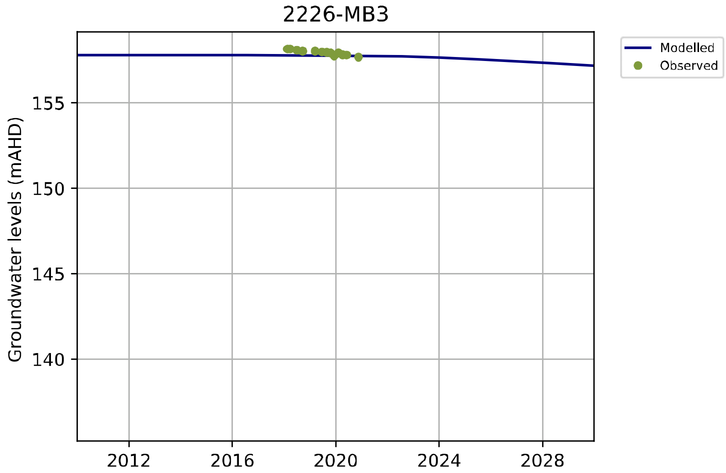

182079
Groundwater levels (mAHD)
234
232
230
228
226
224
2012
2016
2020
2024
2028
Modelled
Observed

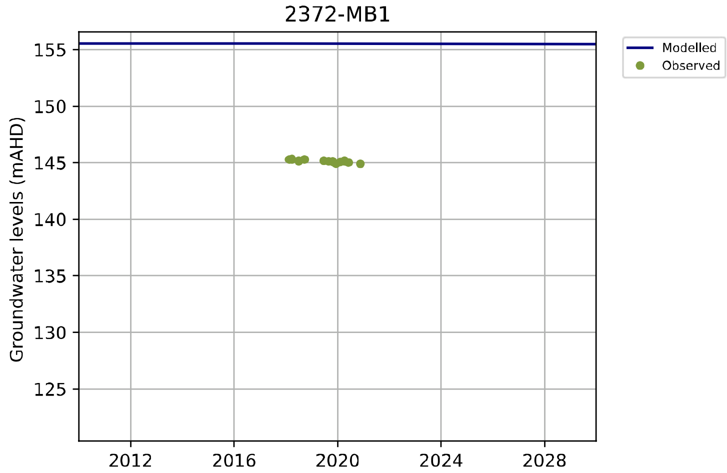

182080
Groundwater levels (mAHD)
226
224
222
220
218
216
214
2012
2016
2020
2024
2028
Modelled
Observed

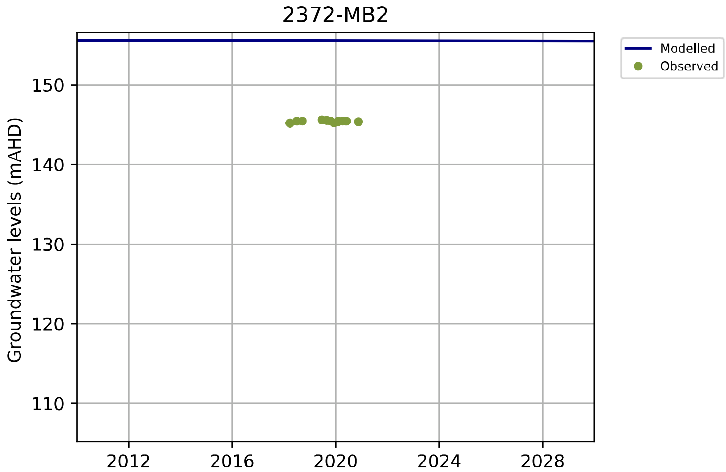

2218-MB2
Groundwater levels (mAHD)
150
140
130
120
110
2012
2016
2020
2024
2028
Modelled
Observed

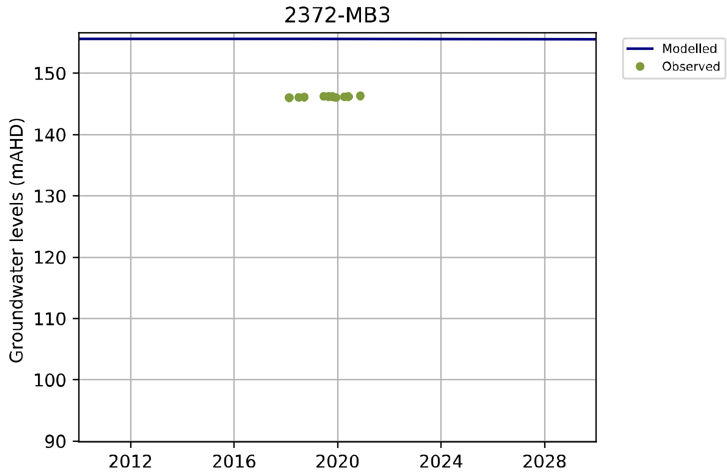

2218-MB3
Groundwater levels (mAHD)
150
140
130
120
110
100
90
80
2012
2016
2020
2024
2028
Modelled
Observed

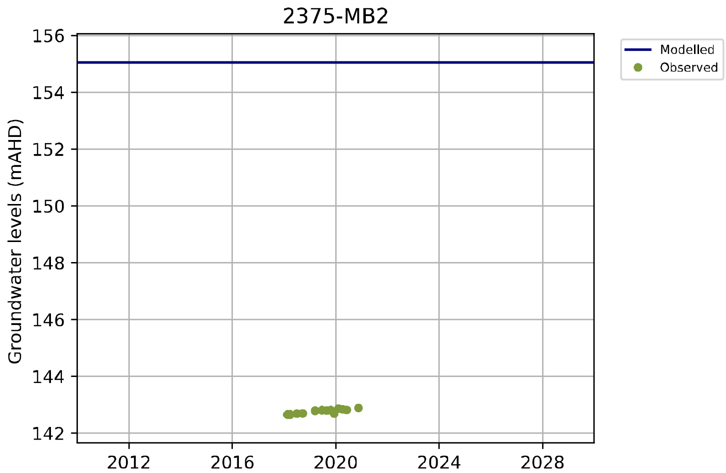

2226-MB2
Groundwater levels (mAHD)
160
155
150
145
140
2012
2016
2020
2024
2028
Modelled
Observed

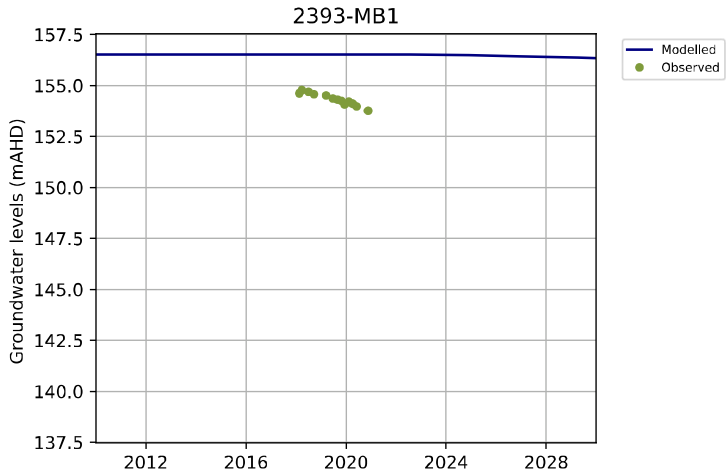

2226-MB3
Groundwater levels (mAHD)
155
150
145
140
2012
2016
2020
2024
2028
Modelled
Observed

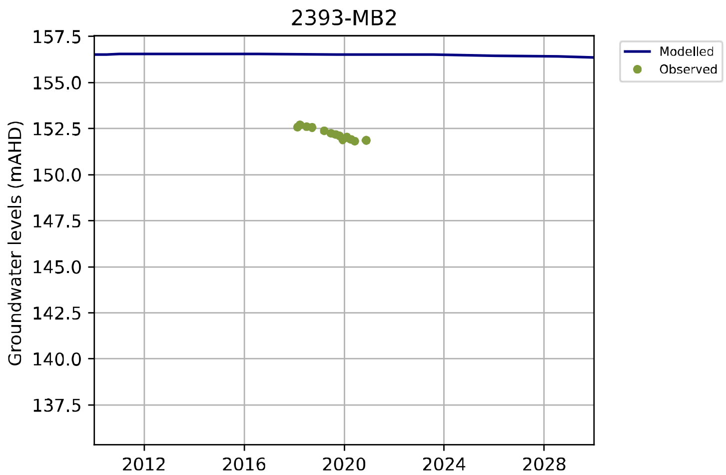

2372-MB1
Groundwater levels (mAHD)
155
150
145
140
135
130
125
2012
2016
2020
2024
2028
Modelled
Observed

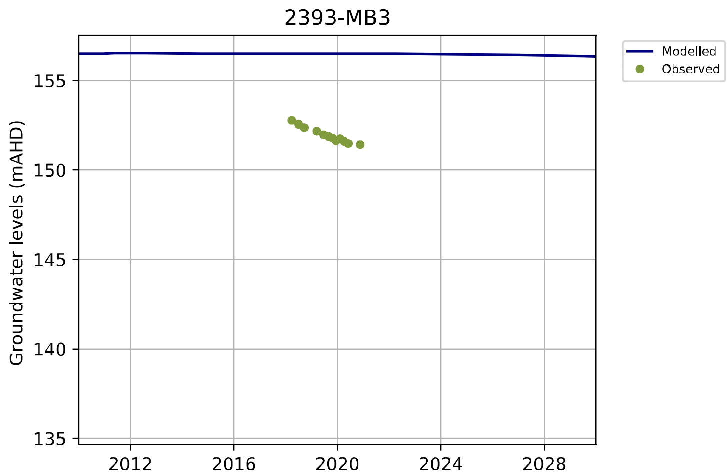

2372-MB2
Groundwater levels (mAHD)
150
140
130
120
110
2012
2016
2020
2024
2028
Modelled
Observed

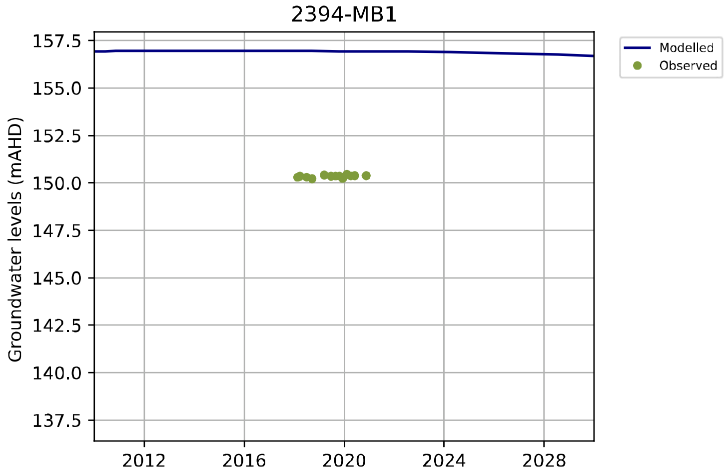

2372-MB3
Groundwater levels (mAHD)
150
140
130
120
110
100
90
2012
2016
2020
2024
2028
Modelled
Observed

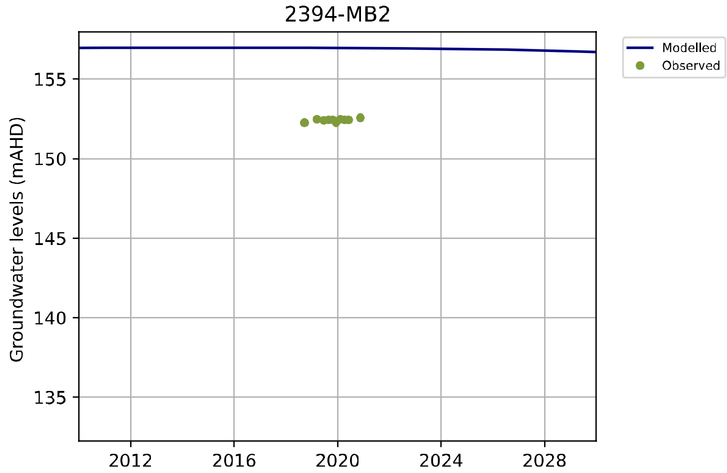

2375-MB2
Groundwater levels (mAHD)
156
154
152
150
148
146
144
142
2012
2016
2020
2024
2028
Modelled
Observed

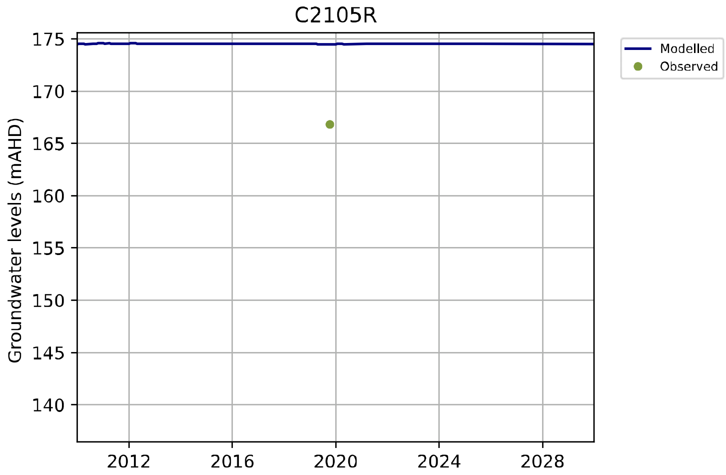

2393-MB1
Groundwater levels (mAHD)
157.5
155.0
152.5
150.0
147.5
145.0
142.5
140.0
137.5
2012
2016
2020
2024
2028
Modelled
Observed

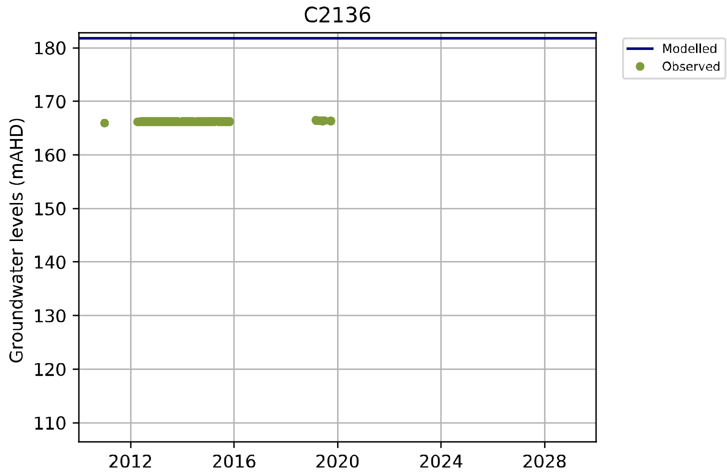

2393-MB2
Groundwater levels (mAHD)
157.5
155.0
152.5
150.0
147.5
145.0
142.5
140.0
137.5
2012
2016
2020
2024
2028
Modelled
Observed

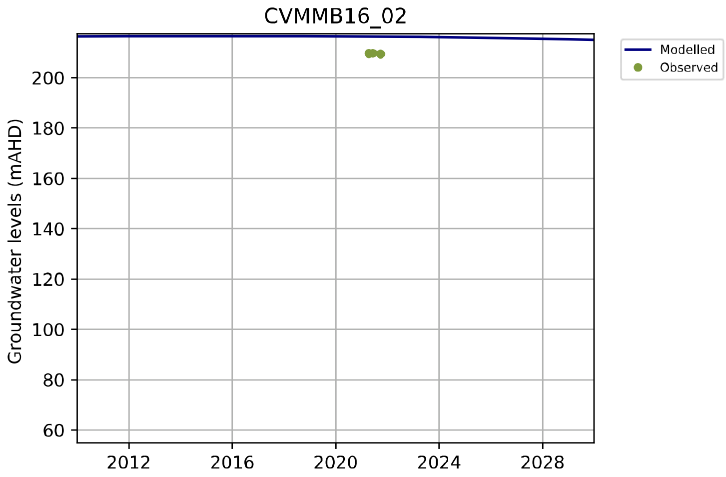

2393-MB3
Groundwater levels (mAHD)
155
150
145
140
135
2012
2016
2020
2024
2028
Modelled
Observed

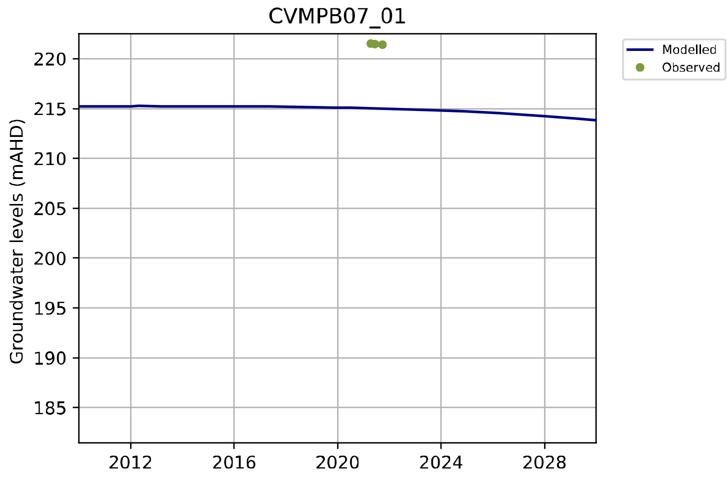

2394-MB1
Groundwater levels (mAHD)
157.5
155.0
152.5
150.0
147.5
145.0
142.5
140.0
137.5
2012
2016
2020
2024
2028
Modelled
Observed

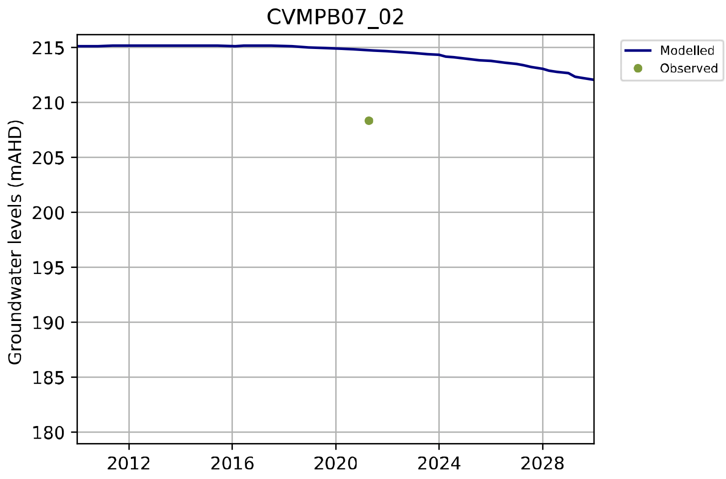

2394-MB2
Groundwater levels (mAHD)
155
150
145
140
135
2012
2016
2020
2024
2028
Modelled
Observed

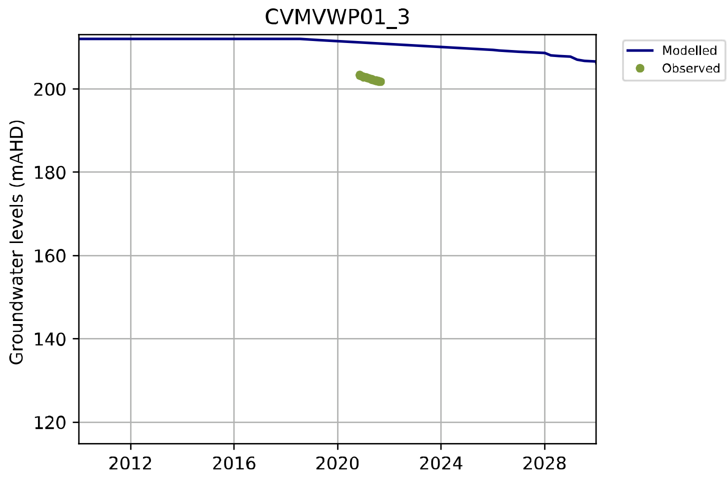

C2105R
Groundwater levels (mAHD)
175
170
165
160
155
150
145
140
2012
2016
2020
2024
2028
Modelled
Observed

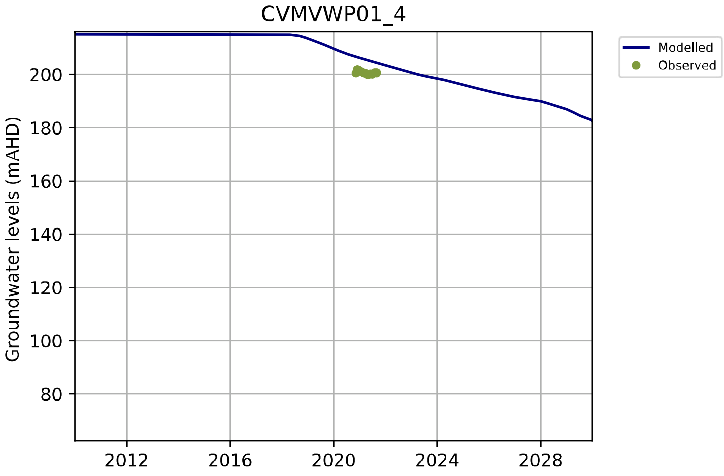

C2136
Groundwater levels (mAHD)
180
170
160
150
140
130
120
110
2012
2016
2020
2024
2028
Modelled
Observed

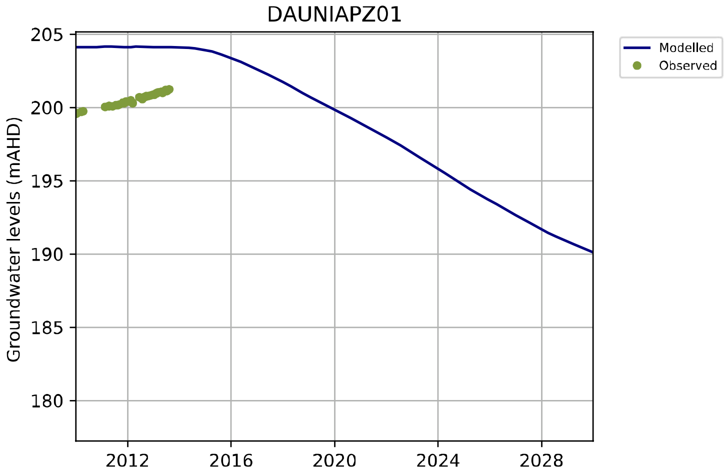

CVMMB16_02
Groundwater levels (mAHD)
200
180
160
140
120
100
80
60
2012
2016
2020
2024
2028
Modelled
Observed

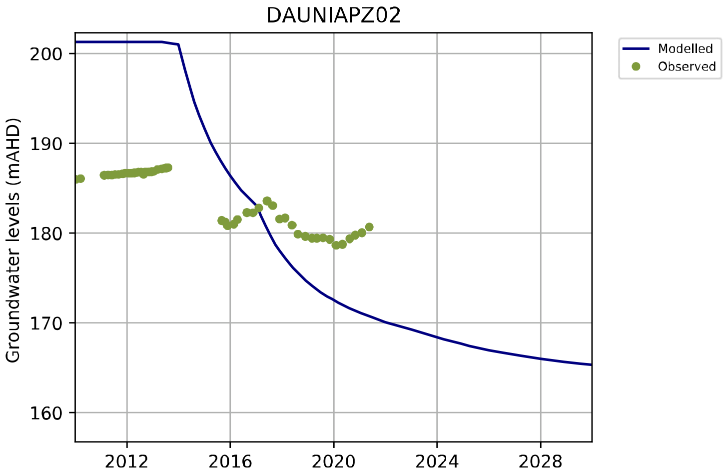

CVMPB07_01
Groundwater levels (mAHD)
220
215
210
205
200
195
190
185
2012
2016
2020
2024
2028
Modelled
Observed

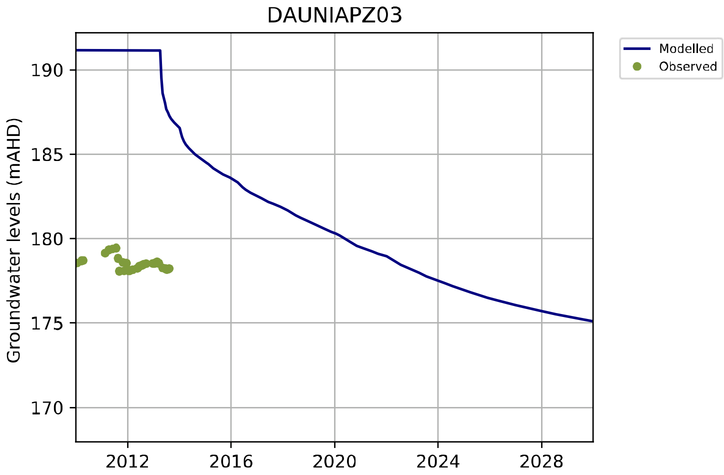

CVMPB07_02
Groundwater levels (mAHD)
215
210
205
200
195
190
185
180
2012
2016
2020
2024
2028
Modelled
Observed

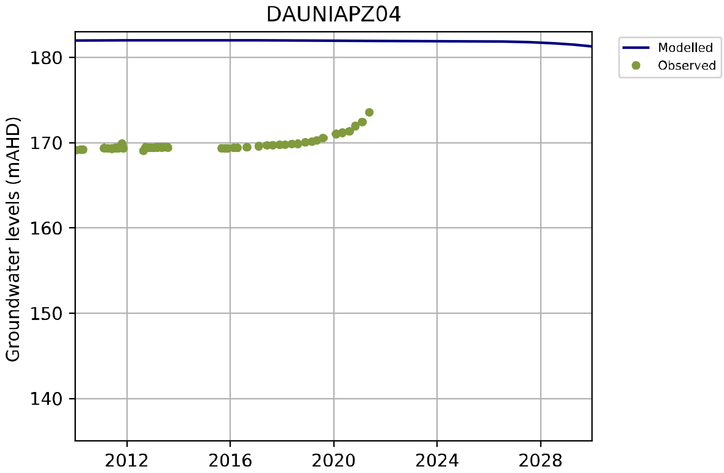

CVMVWP01_3
Groundwater levels (mAHD)
200
180
160
140
120
2012
2016
2020
2024
2028
Modelled
Observed

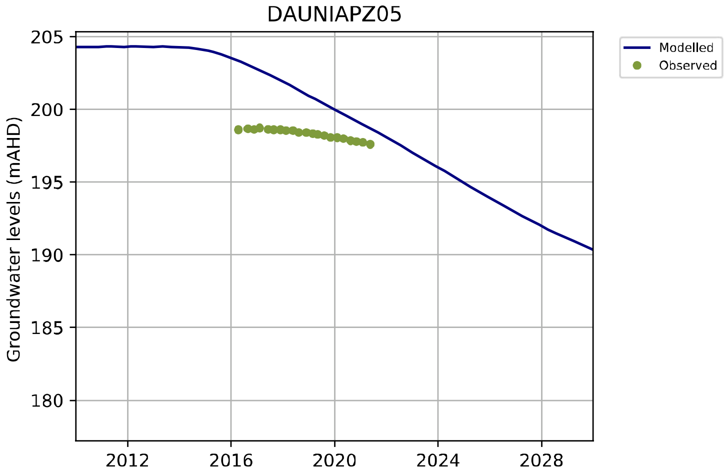

CVMVWP01_4
Groundwater levels (mAHD)
80
100
120
140
160
180
200
2012
2016
2020
2024
2028
Modelled
Observed

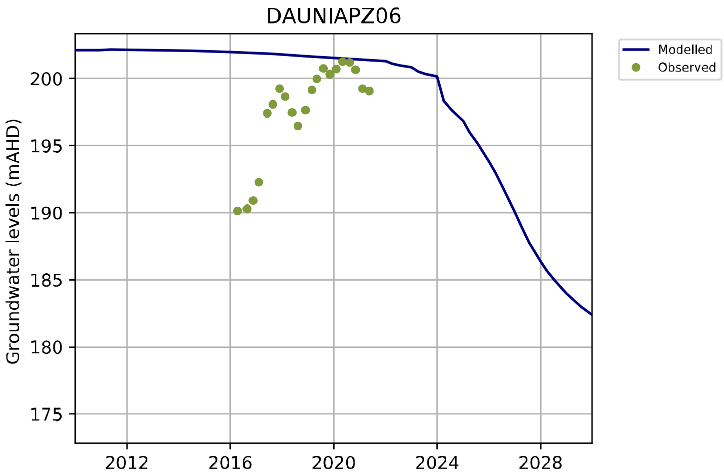

DAUNIAPZ01
Groundwater levels (mAHD)
180
185
190
195
200
205
2012
2016
2020
2024
2028
Modelled
Observed

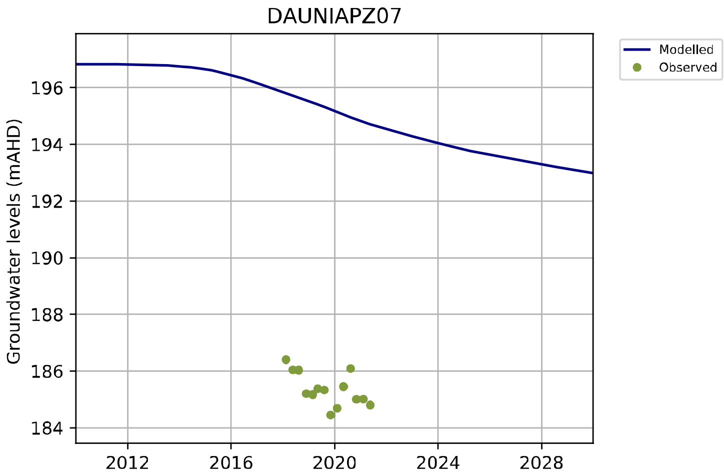

DAUNIAPZ02
Groundwater levels (mAHD)
160
170
180
190
200
2012
2016
2020
2024
2028
Modelled
Observed


DAUNIAPZ03
Groundwater levels (mAHD)
170
175
180
185
190
2012
2016
2020
2024
2028
Modelled
Observed

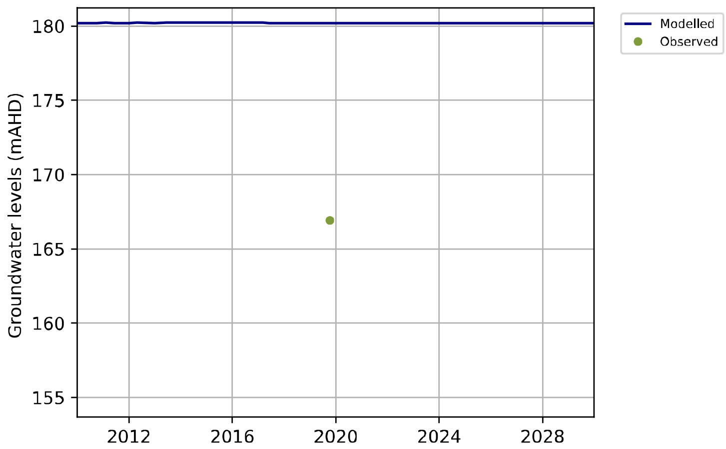

DAUNIAPZ04
Groundwater levels (mAHD)
140
150
160
170
180
2012
2016
2020
2024
2028
Modelled
Observed


DAUNIAPZ05
Groundwater levels (mAHD)
180
185
190
195
200
205
2012
2016
2020
2024
2028
Modelled
Observed

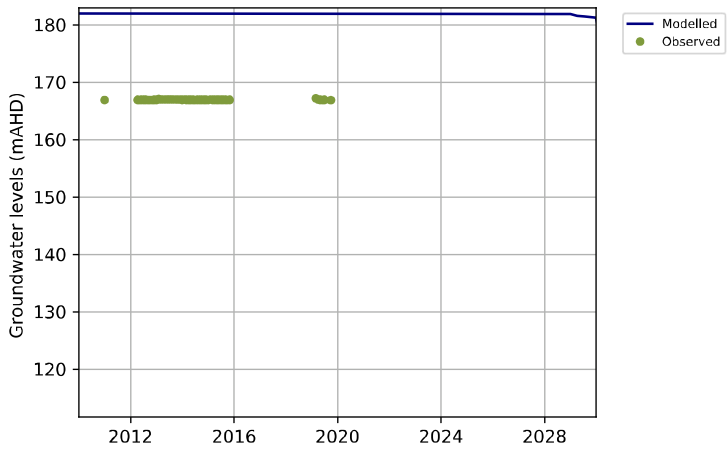

DAUNIAPZ06
Groundwater levels (mAHD)
175
180
185
190
195
200
2012
2016
2020
2024
2028
Modelled
Observed


DAUNIAPZ07
Groundwater levels (mAHD)
184
186
188
190
192
194
196
2012
2016
2020
2024
2028
Modelled
Observed

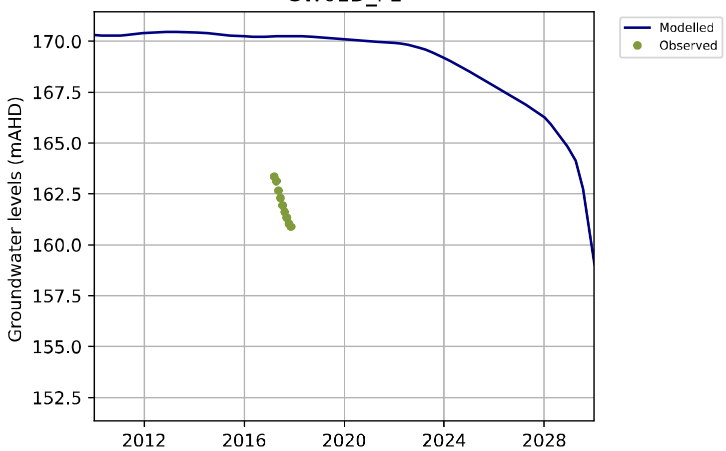
G2304R



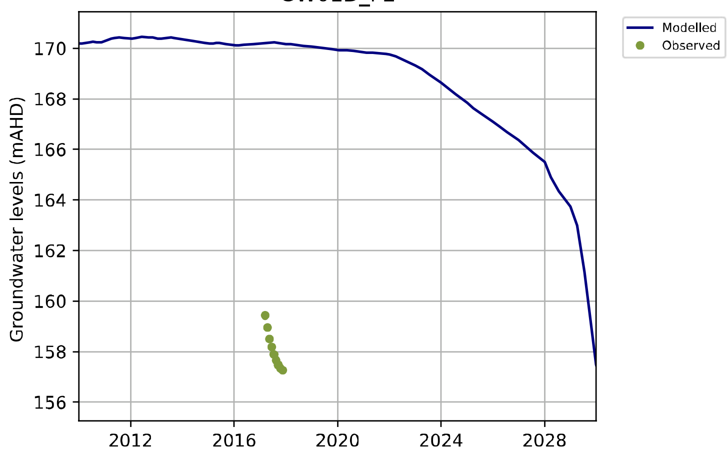
G2307



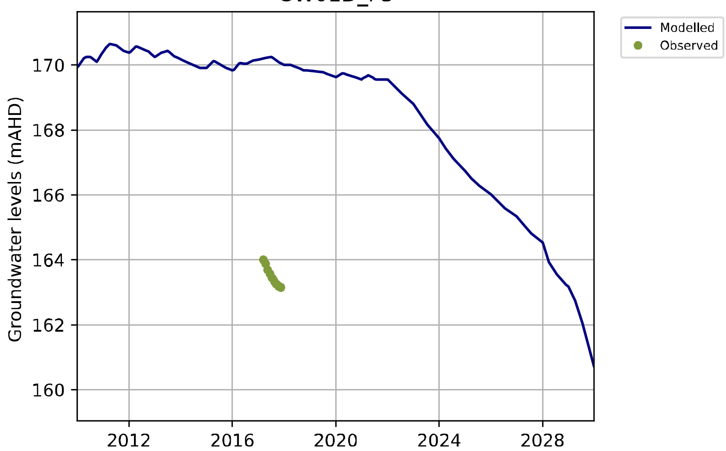
GW01D_P1



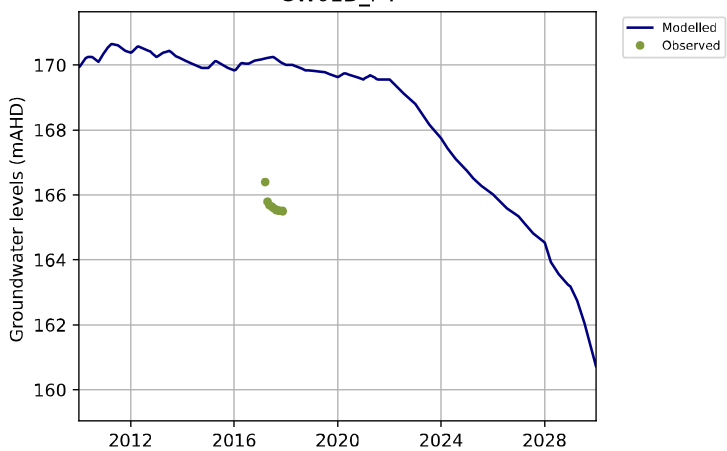
GW01D_P2



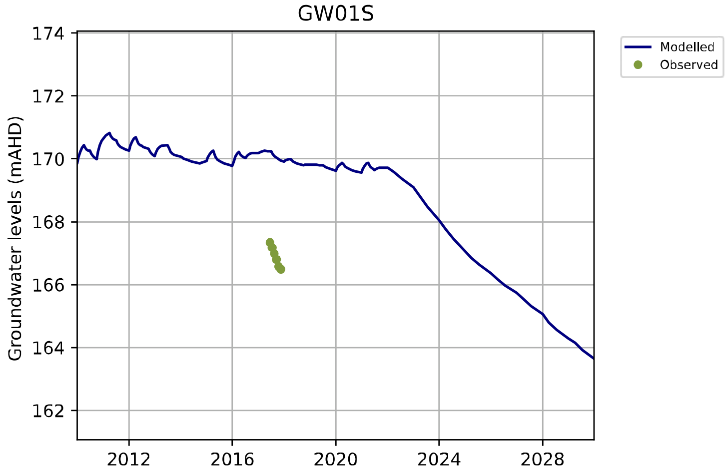
GW01D_P3



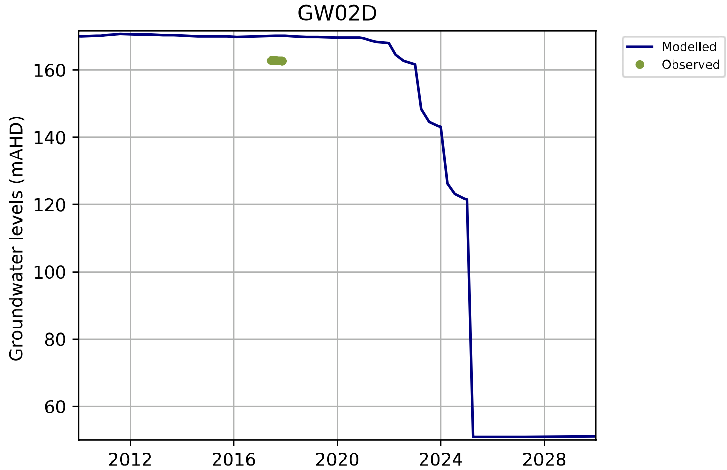
GW01D_P4

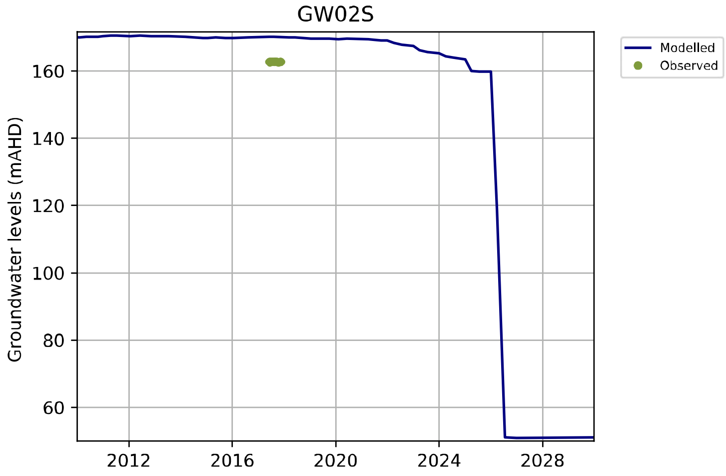


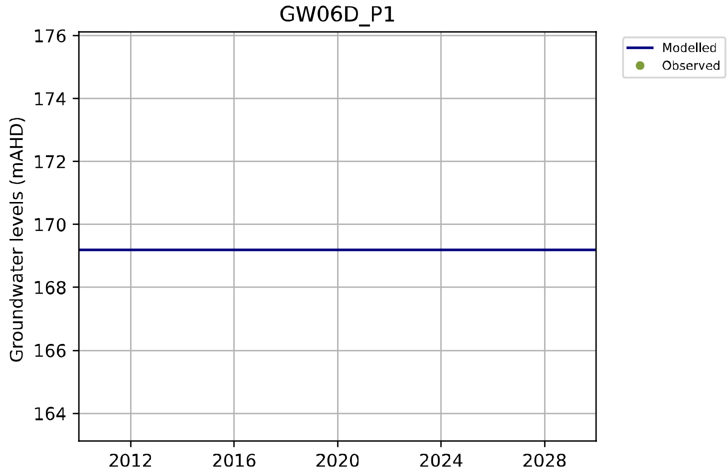
GW01S

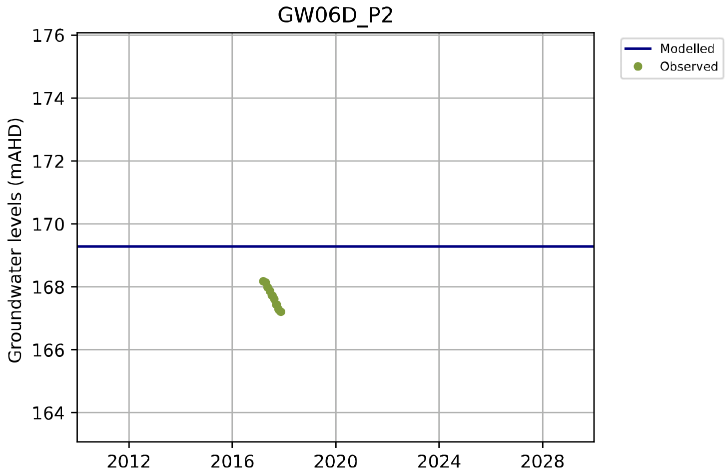


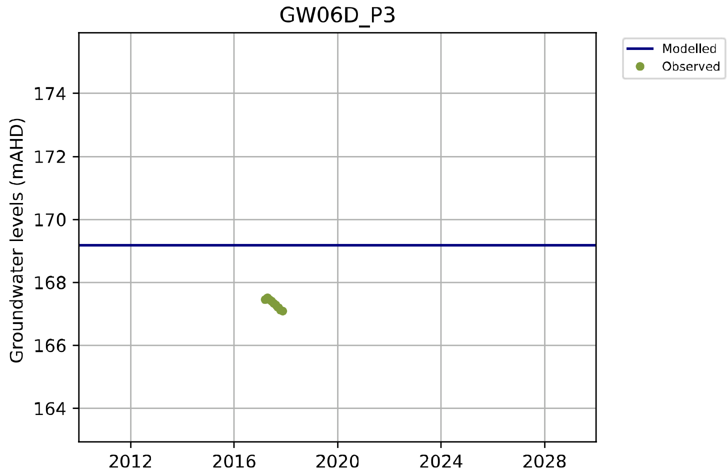
GW02D

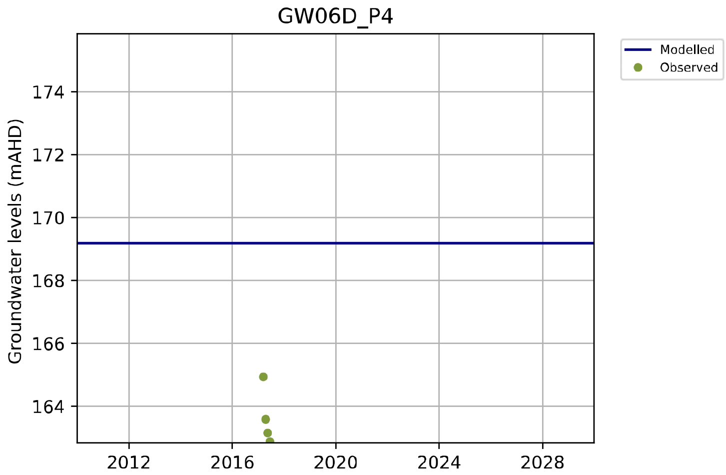


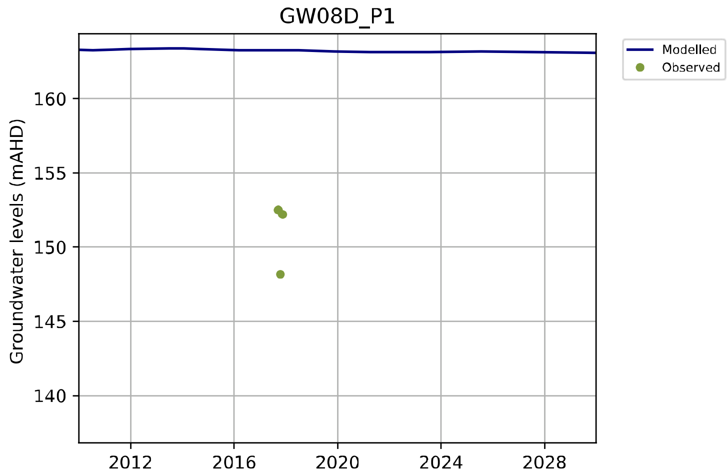

GW02S
Groundwater levels (mAHD)
160
140
120
100
80
60
2012
2016
2020
2024
2028
Modelled
Observed

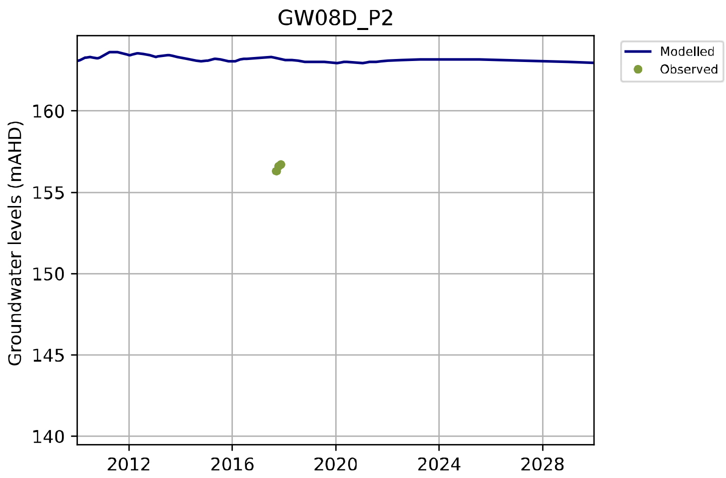

GW06D_P1
Groundwater levels (mAHD)
176
174
172
170
168
166
164
2012
2016
2020
2024
2028
Modelled
Observed

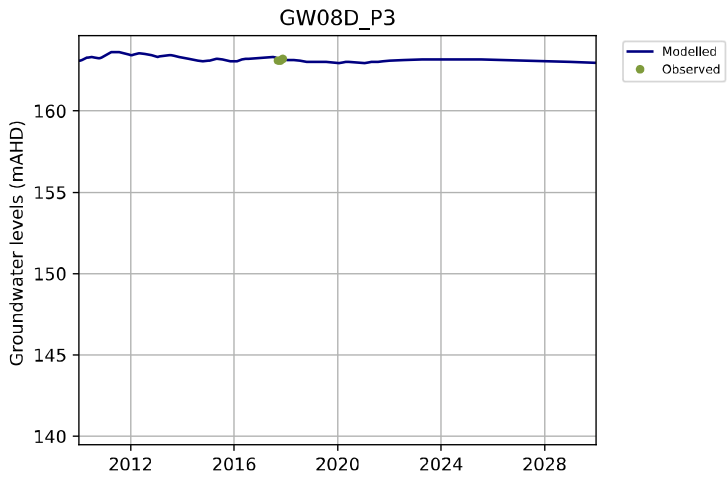

GW06D_P2
Groundwater levels (mAHD)
176
174
172
170
168
166
164
2012
2016
2020
2024
2028
Modelled
Observed


GW06D_P3
Groundwater levels (mAHD)
174
172
170
168
166
164
2012
2016
2020
2024
2028
Modelled
Observed

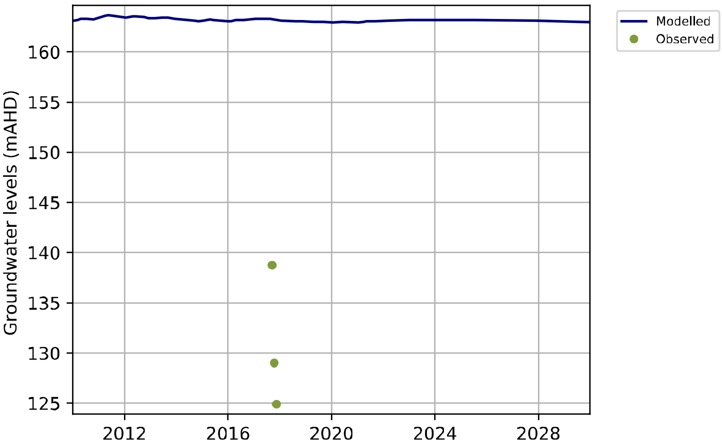

GW06D_P4
Groundwater levels (mAHD)
174
172
170
168
166
164
2012
2016
2020
2024
2028
Modelled
Observed


GW08D_P1
Groundwater levels (mAHD)
160
155
150
145
140
2012
2016
2020
2024
2028
Modelled
Observed

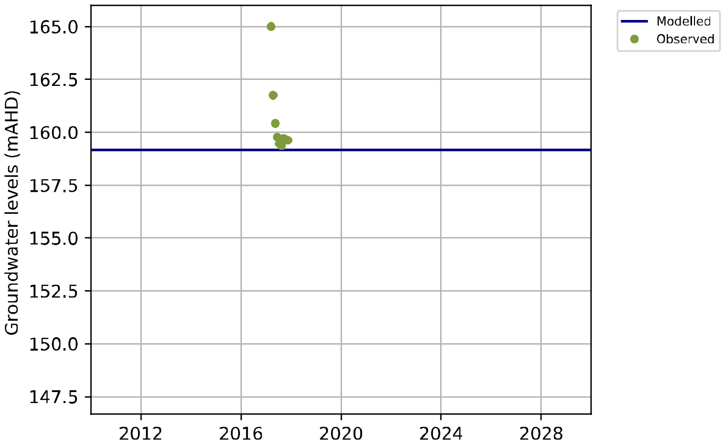

GW08D_P2
Groundwater levels (mAHD)
160
155
150
145
140
2012
2016
2020
2024
2028
Modelled
Observed


GW08D_P3
Groundwater levels (mAHD)
160
155
150
145
140
2012
2016
2020
2024
2028
Modelled
Observed

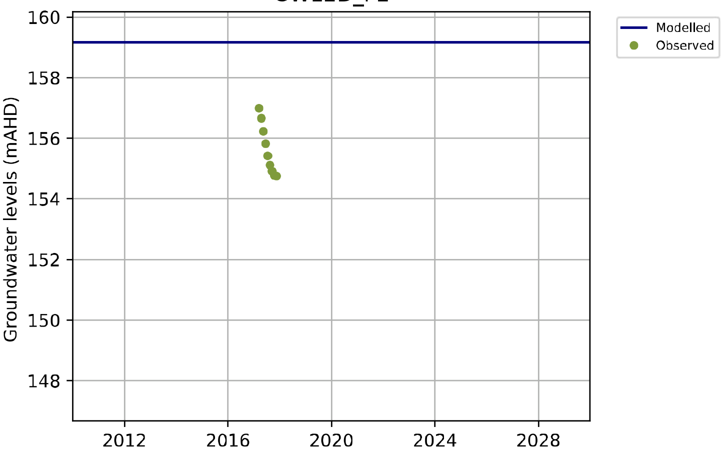
GW08D_P4



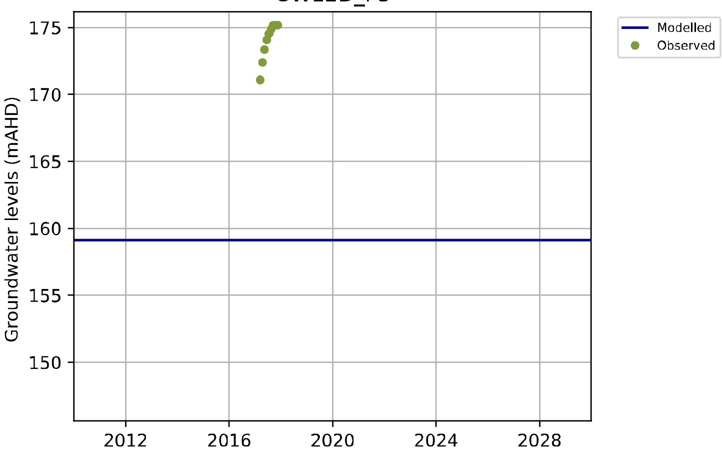
GW12D_P1



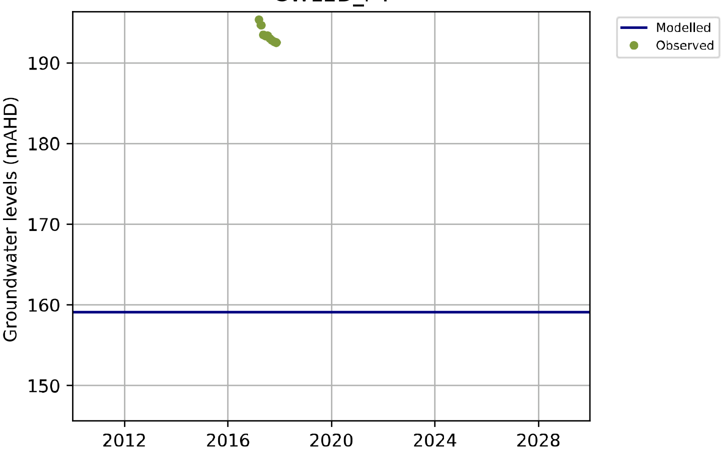
GW12D_P2



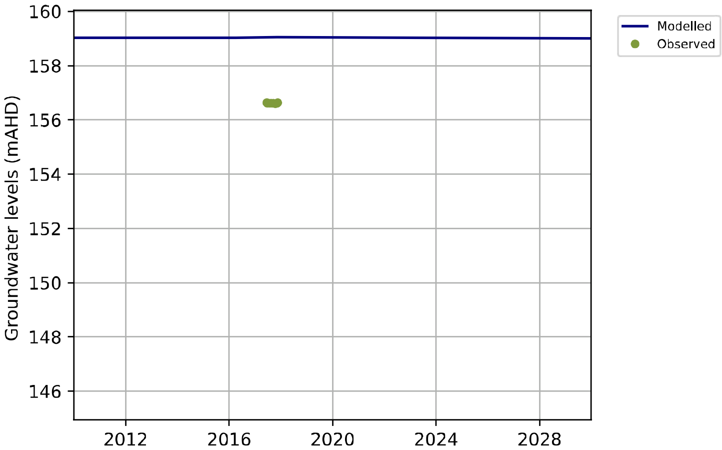
GW12D_P3



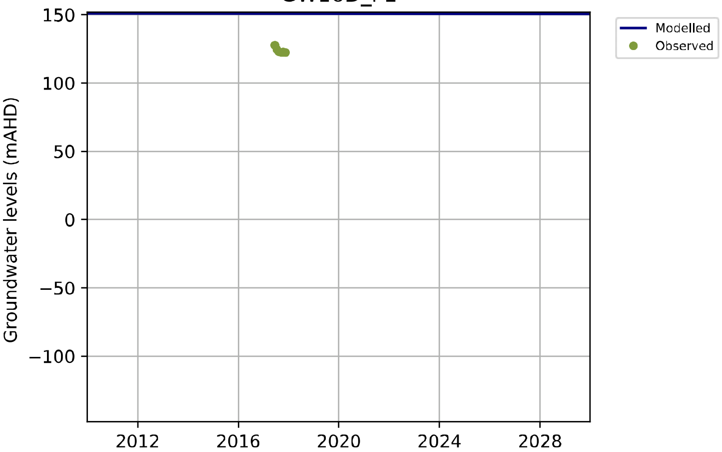
GW12D_P4



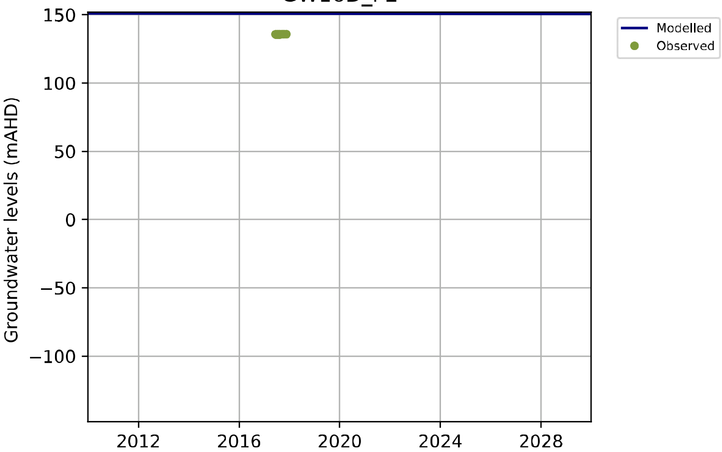
GW12S

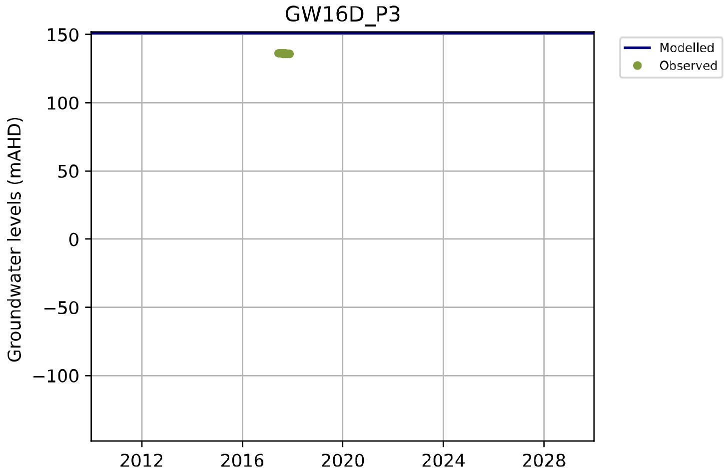


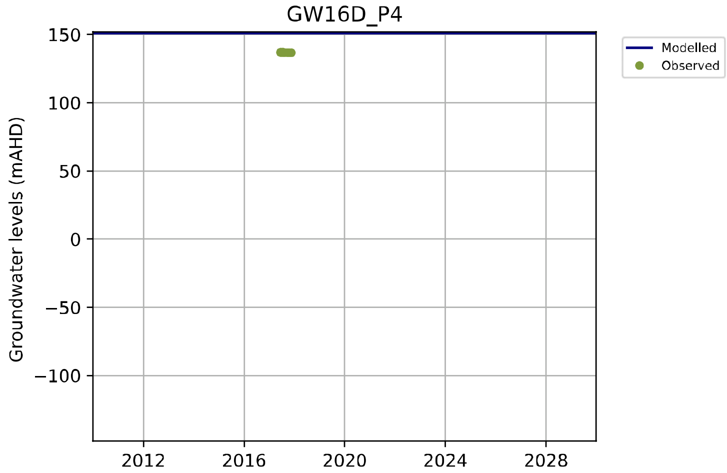
GW16D_P1

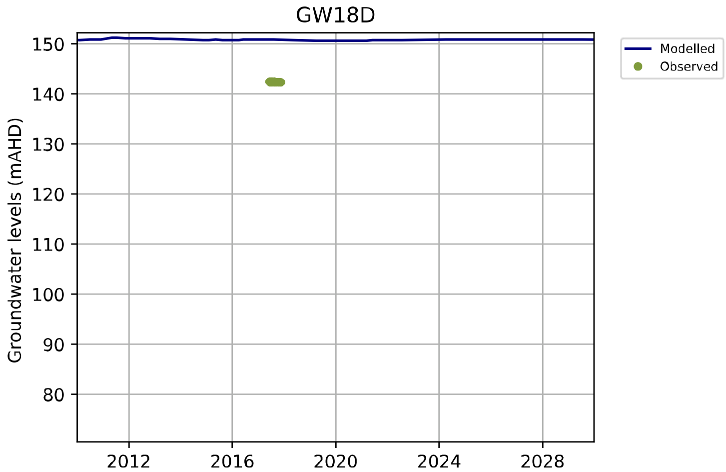


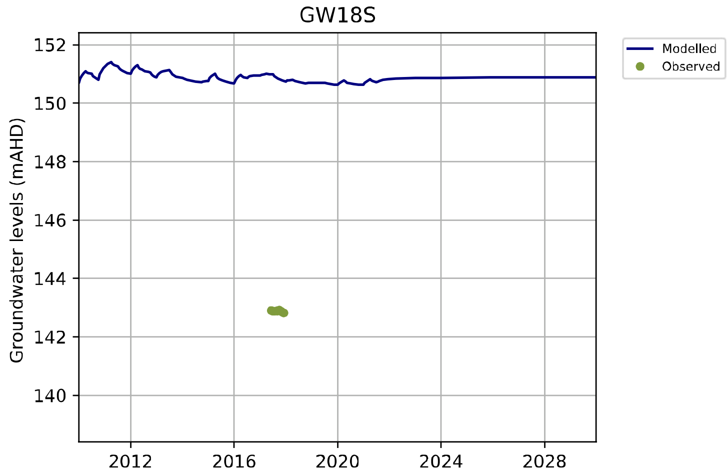
GW16D_P2

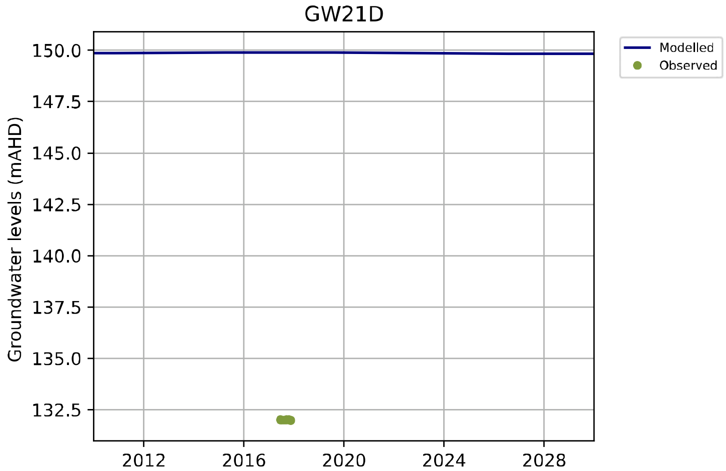


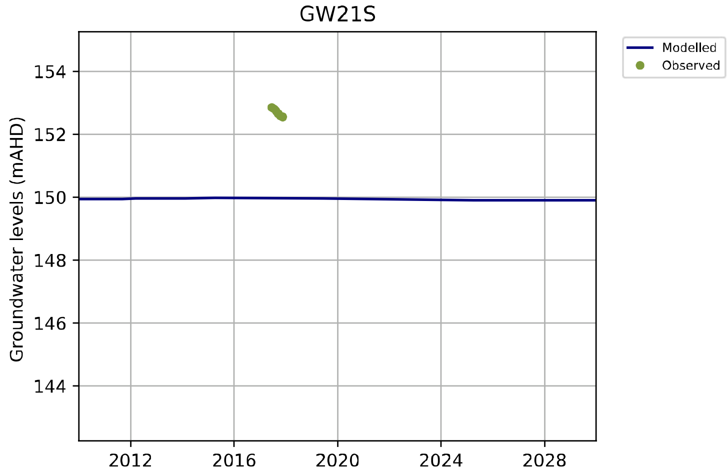

GW16D_P3
Groundwater levels (mAHD)
150
100
50
0
−50
−100
2012
2016
2020
2024
2028
Modelled
Observed

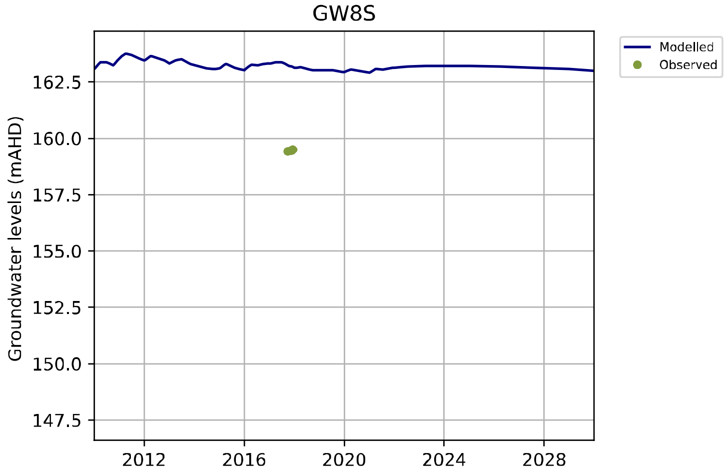

GW16D_P4
Groundwater levels (mAHD)
150
100
50
0
−50
−100
2012
2016
2020
2024
2028
Modelled
Observed

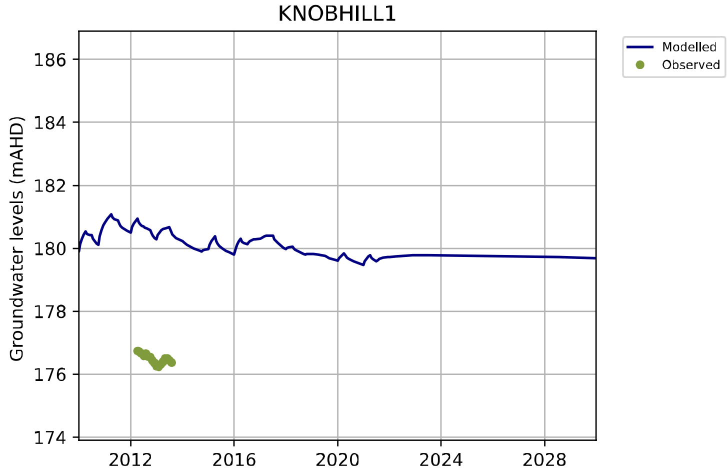

GW18D
Groundwater levels (mAHD)
150
140
130
120
110
100
90
80
2012
2016
2020
2024
2028
Modelled
Observed

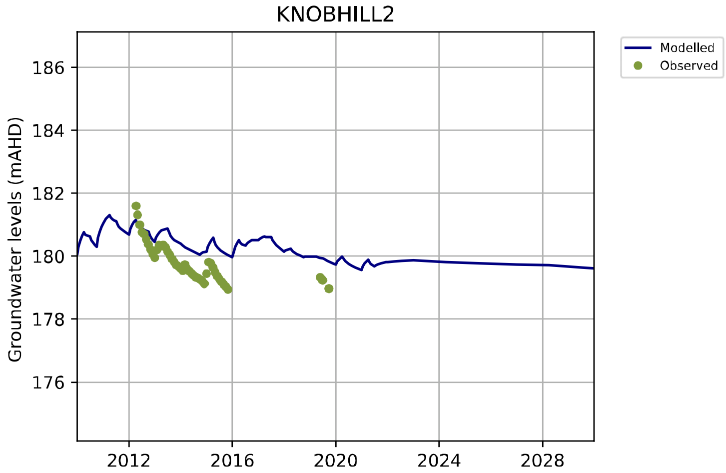

GW18S
Groundwater levels (mAHD)
152
150
148
146
144
142
140
2012
2016
2020
2024
2028
Modelled
Observed

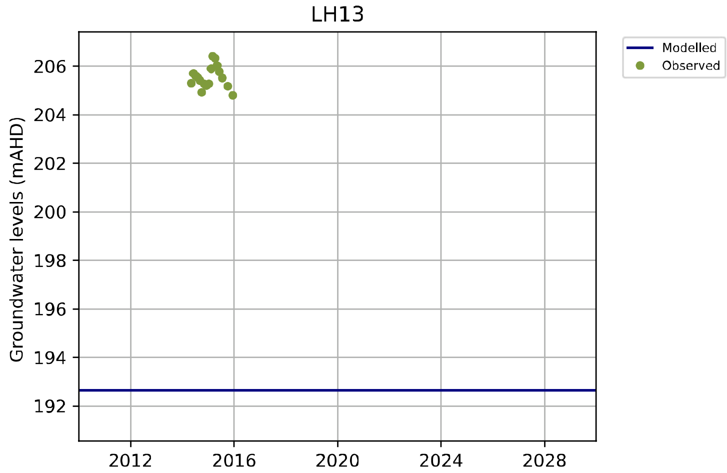

GW21D
Groundwater levels (mAHD)
150.0
147.5
145.0
142.5
140.0
137.5
135.0
132.5
2012
2016
2020
2024
2028
Modelled
Observed

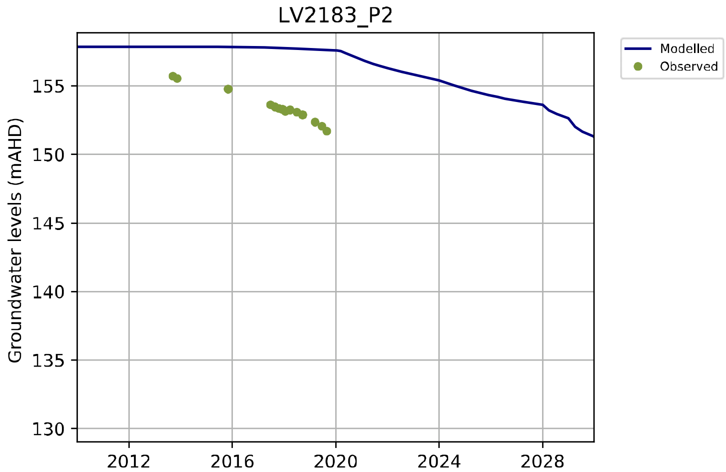

GW21S
Groundwater levels (mAHD)
154
152
150
148
146
144
2012
2016
2020
2024
2028
Modelled
Observed

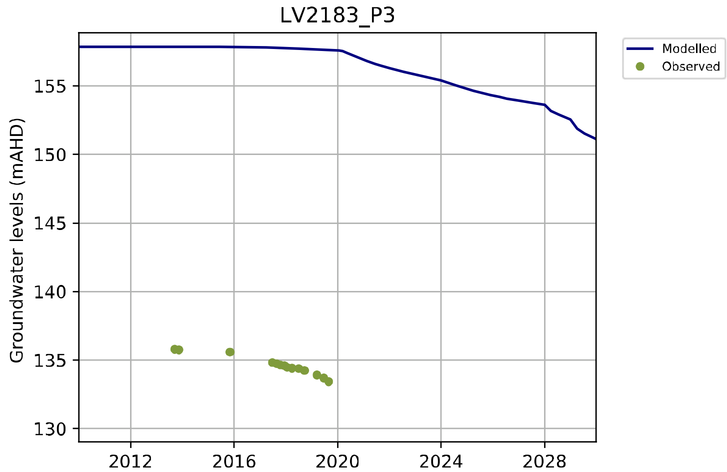

GW8S
Groundwater levels (mAHD)
162.5
160.0
157.5
155.0
152.5
150.0
147.5
2012
2016
2020
2024
2028
Modelled
Observed

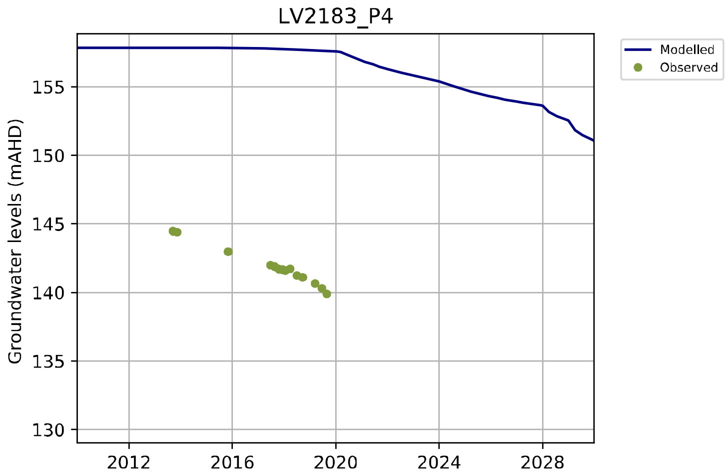

KNOBHILL1
Groundwater levels (mAHD)
186
184
182
180
178
176
174
2012
2016
2020
2024
2028
Modelled
Observed

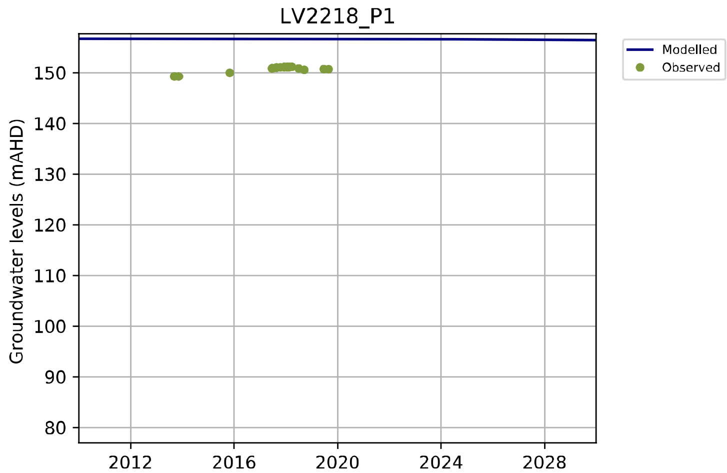

KNOBHILL2
Groundwater levels (mAHD)
Modelled
Observed
186
184
182
180
178
176
2012
2016
2020
2024
2028

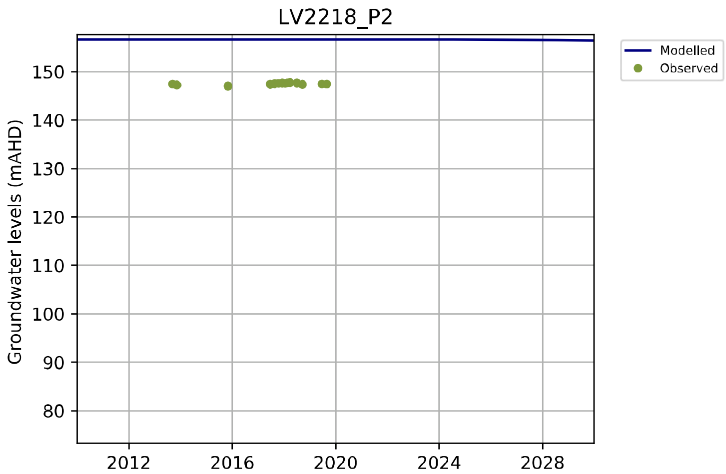

LH13
Groundwater levels (mAHD)
Modelled
Observed
206
204
202
200
198
196
194
192
2012
2016
2020
2024
2028

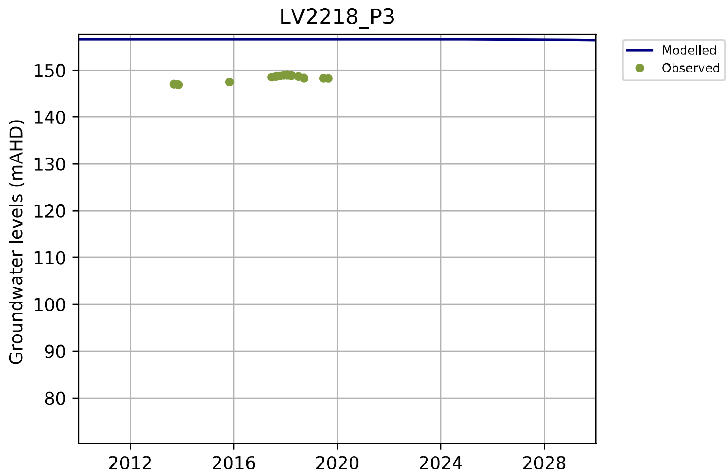

LV2183_P2
Groundwater levels (mAHD)
Modelled
Observed
155
150
145
140
135
130
2012
2016
2020
2024
2028

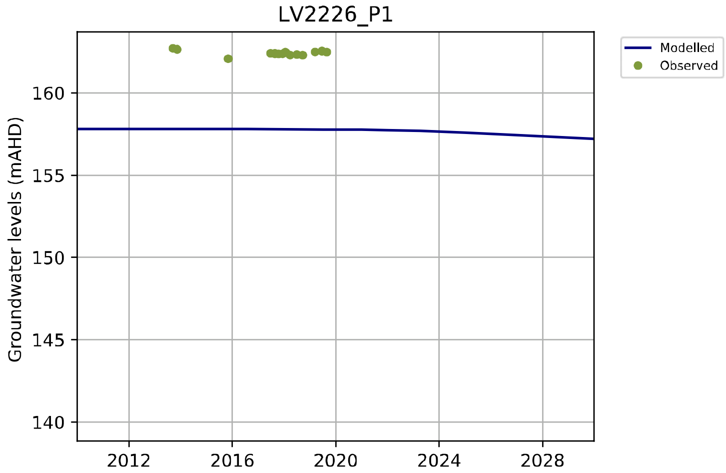

LV2183_P3
Groundwater levels (mAHD)
Modelled
Observed
155
150
145
140
135
130
2012
2016
2020
2024
2028

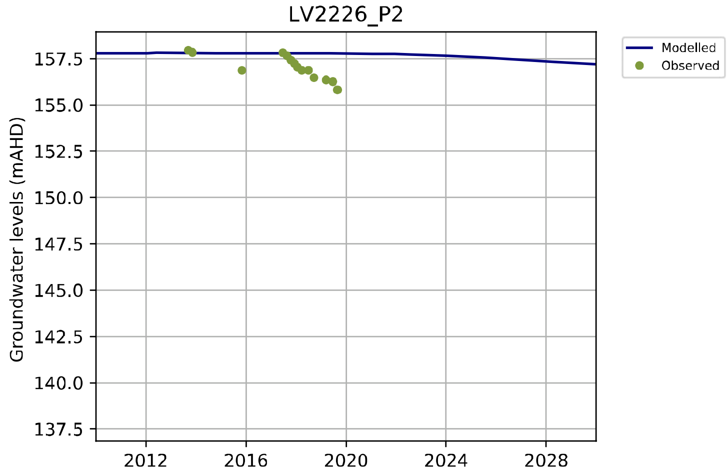

LV2183_P4
Groundwater levels (mAHD)
Modelled
Observed
155
150
145
140
135
130
2012
2016
2020
2024
2028

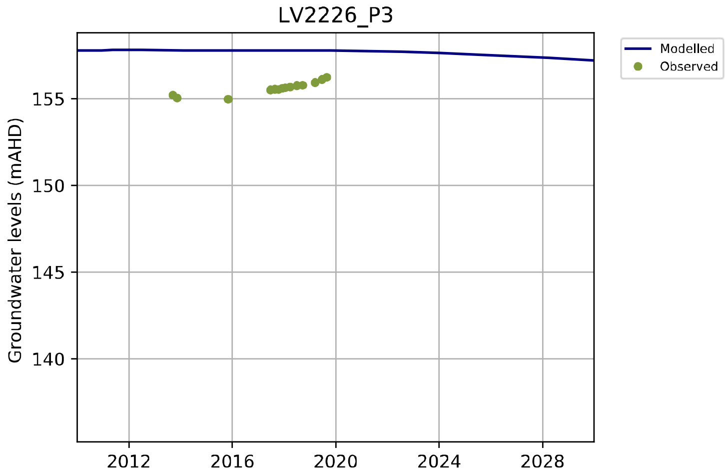

LV2218_P1
Groundwater levels (mAHD)
Modelled
Observed
150
140
130
120
110
100
90
80
2012
2016
2020
2024
2028

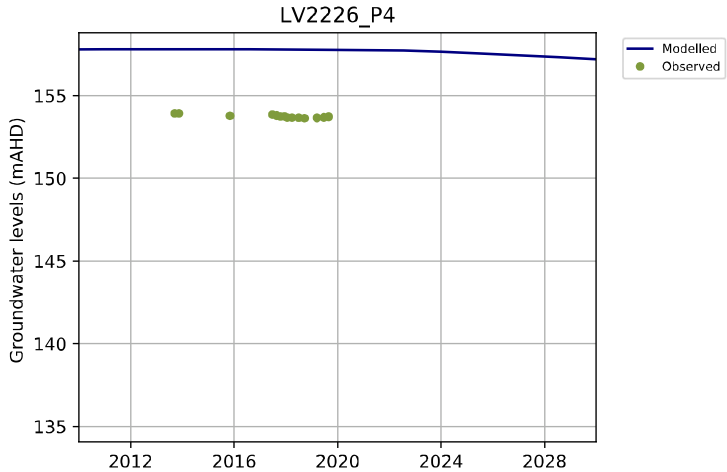

LV2218_P2
Groundwater levels (mAHD)
Modelled
Observed
150
140
130
120
110
100
90
80
2012
2016
2020
2024
2028

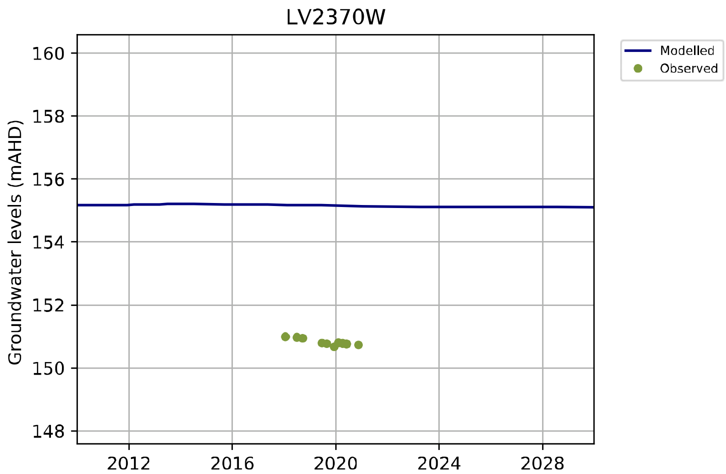

LV2218_P3
Groundwater levels (mAHD)
Modelled
Observed
150
140
130
120
110
100
90
80
2012
2016
2020
2024
2028

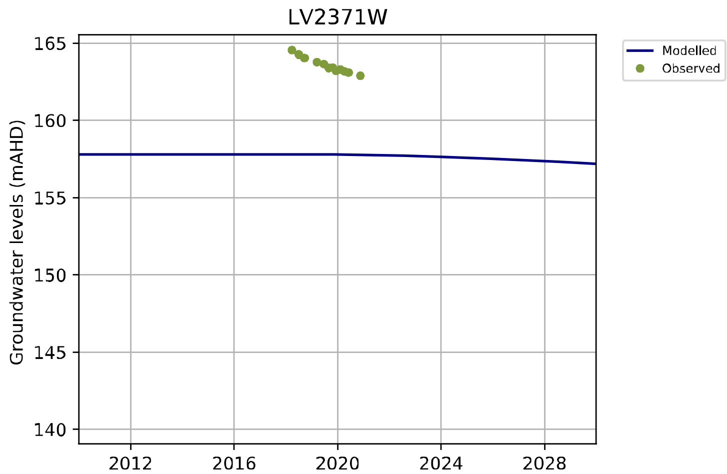

LV2226_P1
Modelled
Observed
Groundwater levels (mAHD)
160
155
150
145
140
2012
2016
2020
2024
2028

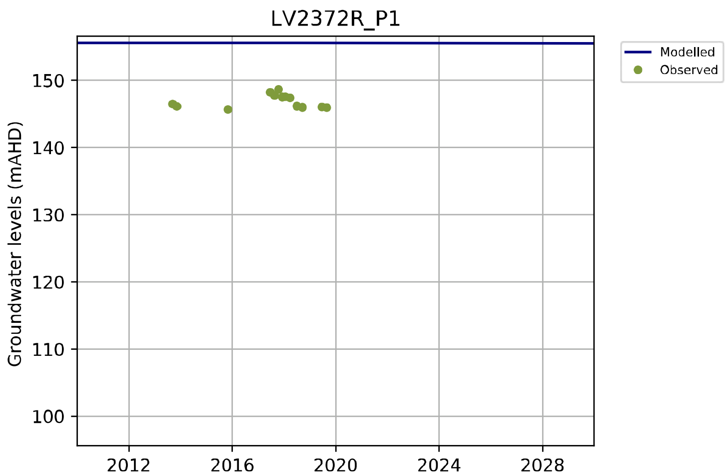

LV2226_P2
Modelled
Observed
Groundwater levels (mAHD)
157.5
155.0
152.5
150.0
147.5
145.0
142.5
140.0
137.5
2012
2016
2020
2024
2028

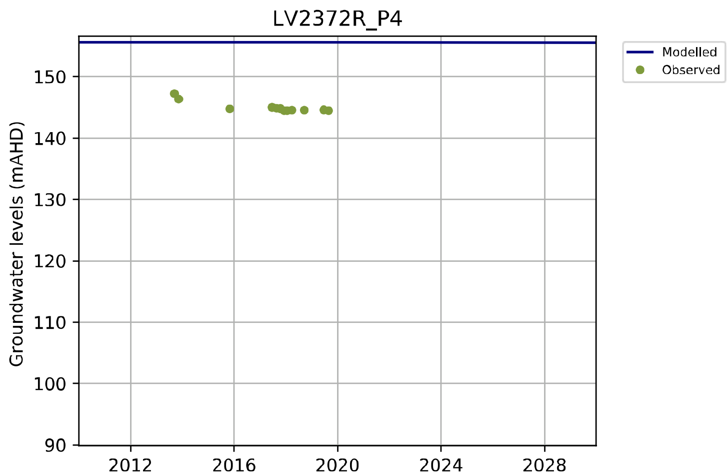

LV2226_P3
Modelled
Observed
Groundwater levels (mAHD)
155
150
145
140
2012
2016
2020
2024
2028

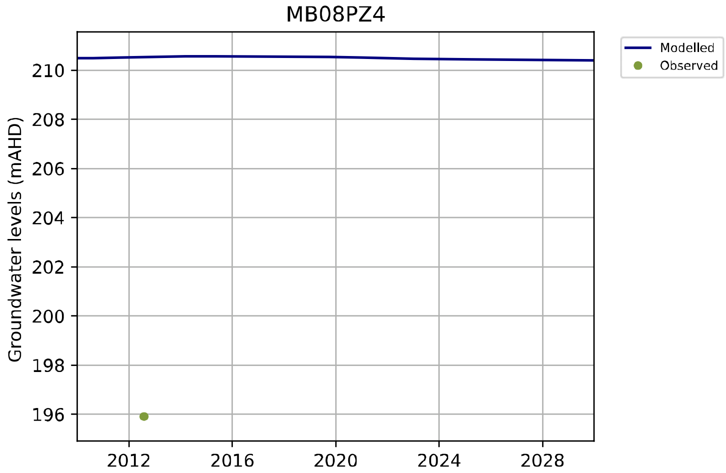

LV2226_P4
Modelled
Observed
Groundwater levels (mAHD)
155
150
145
140
135
2012
2016
2020
2024
2028

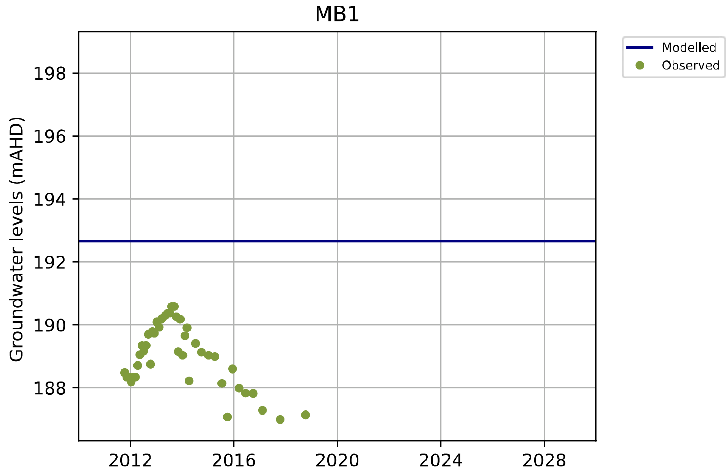

LV2370W
Modelled
Observed
Groundwater levels (mAHD)
160
158
156
154
152
150
148
2012
2016
2020
2024
2028

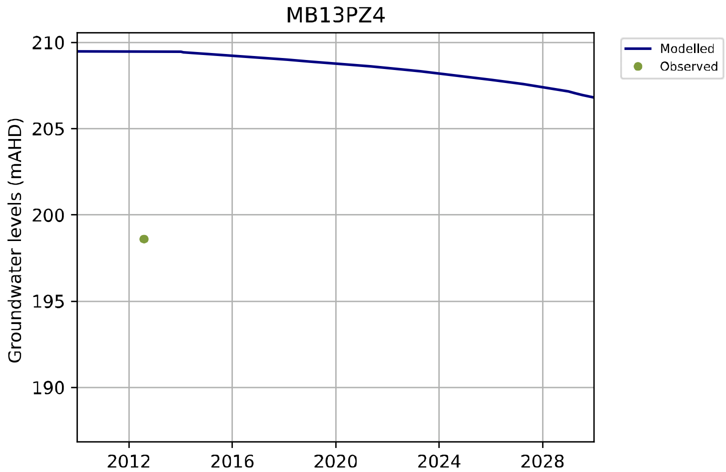

LV2371W
Modelled
Observed
Groundwater levels (mAHD)
165
160
155
150
145
140
2012
2016
2020
2024
2028

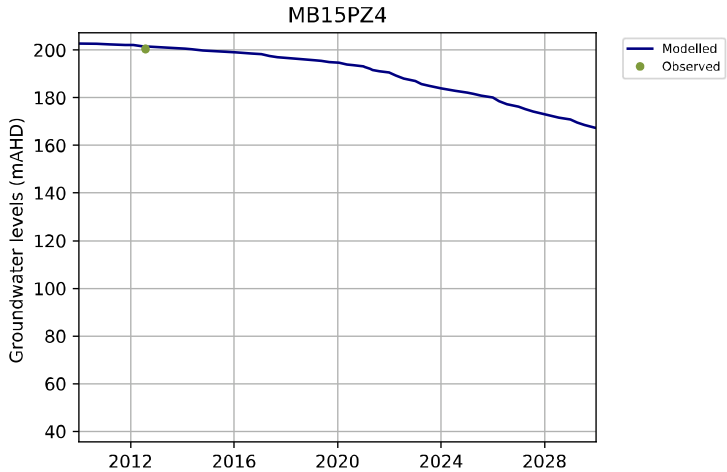

LV2372R_P1
Modelled
Observed
Groundwater levels (mAHD)
150
140
130
120
110
100
2012
2016
2020
2024
2028

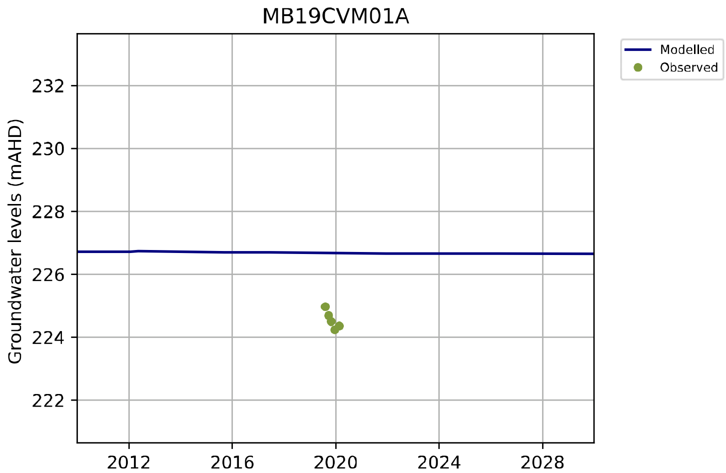

LV2372R_P4
Modelled
Observed
Groundwater levels (mAHD)
150
140
130
120
110
100
90
2012
2016
2020
2024
2028

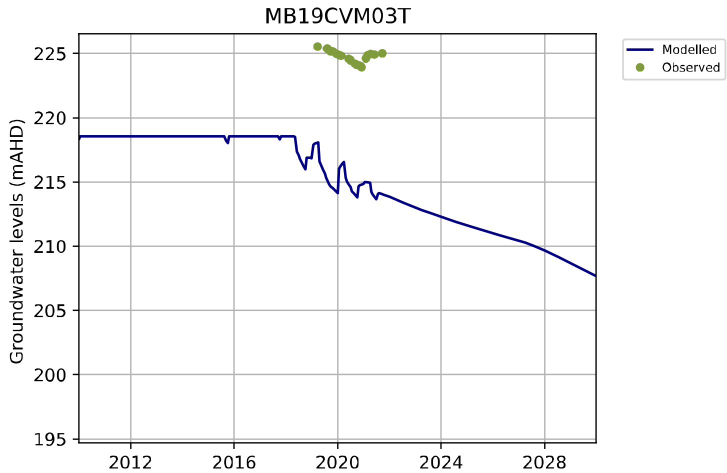

MB08PZ4
Groundwater levels (mAHD)
210
208
206
204
202
200
198
196
2012
2016
2020
2024
2028
Modelled
Observed

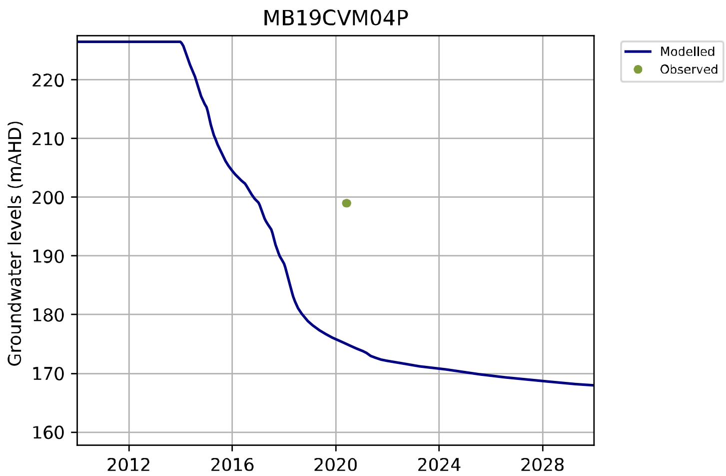

MB1
Groundwater levels (mAHD)
198
196
194
192
190
188
2012
2016
2020
2024
2028
Modelled
Observed

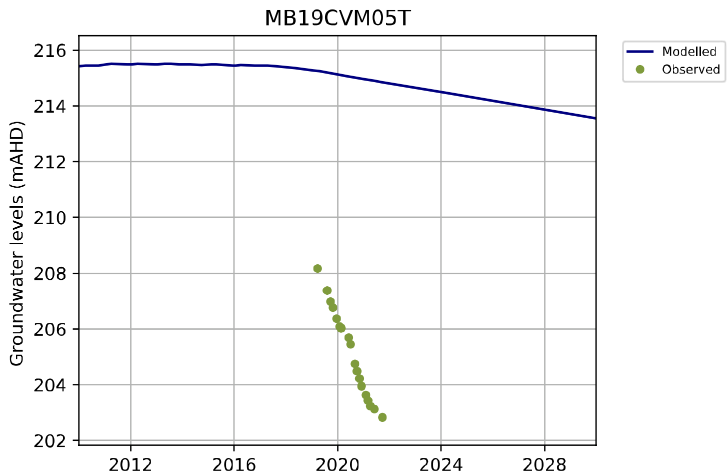

MB13PZ4
Groundwater levels (mAHD)
210
205
200
195
190
2012
2016
2020
2024
2028
Modelled
Observed

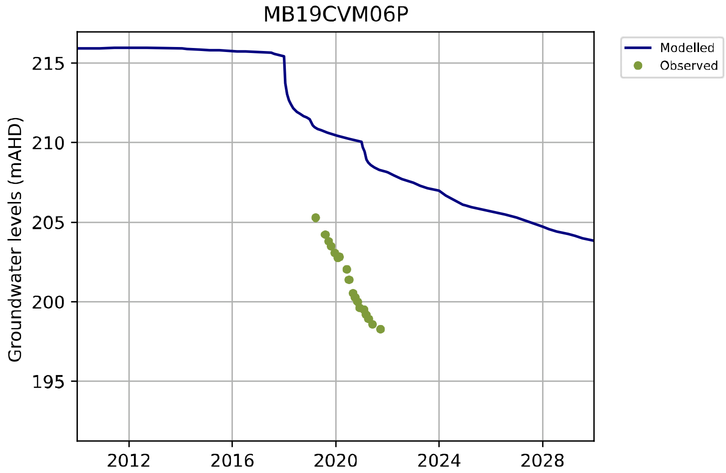

MB15PZ4
Groundwater levels (mAHD)
200
180
160
140
120
100
80
60
40
2012
2016
2020
2024
2028
Modelled
Observed

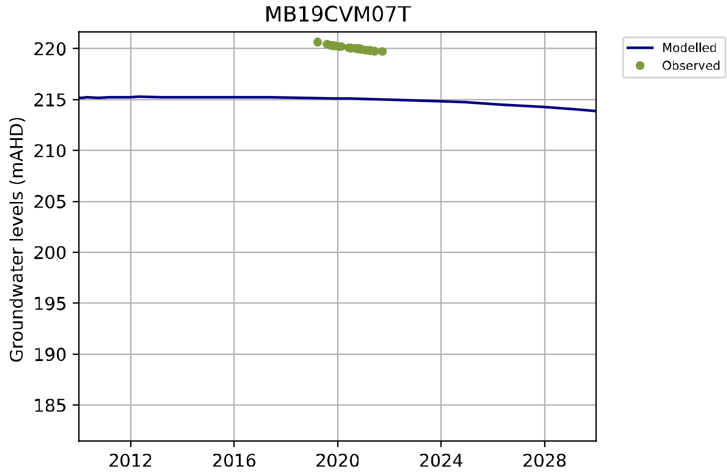

MB19CVM01A
Groundwater levels (mAHD)
232
230
228
226
224
222
2012
2016
2020
2024
2028
Modelled
Observed

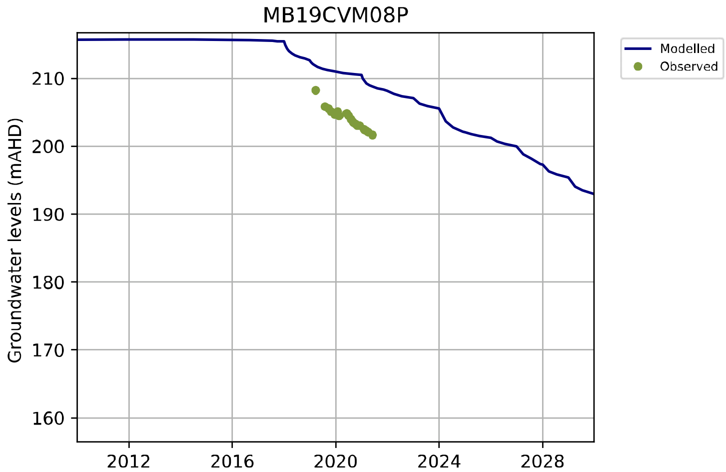

MB19CVM03T
Groundwater levels (mAHD)
225
220
215
210
205
200
195
2012
2016
2020
2024
2028
Modelled
Observed

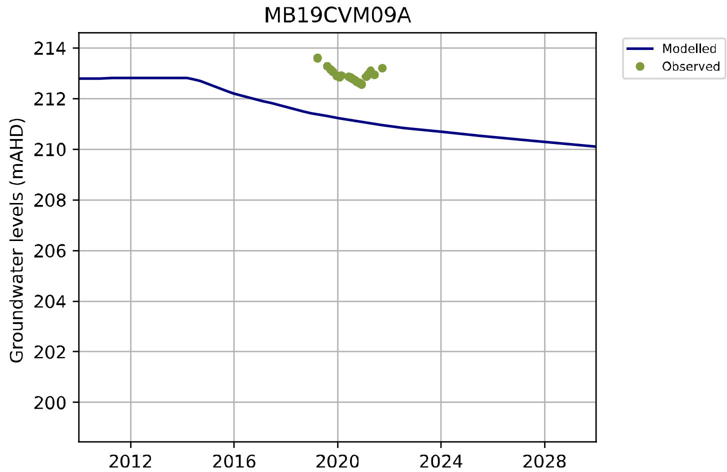

MB19CVM04P
Groundwater levels (mAHD)
220
210
200
190
180
170
160
2012
2016
2020
2024
2028
Modelled
Observed

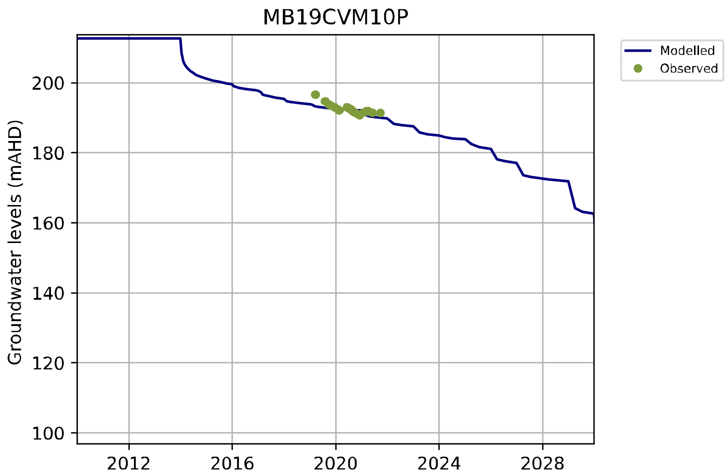

MB19CVM05T
Groundwater levels (mAHD)
216
214
212
210
208
206
204
202
2012
2016
2020
2024
2028
Modelled
Observed

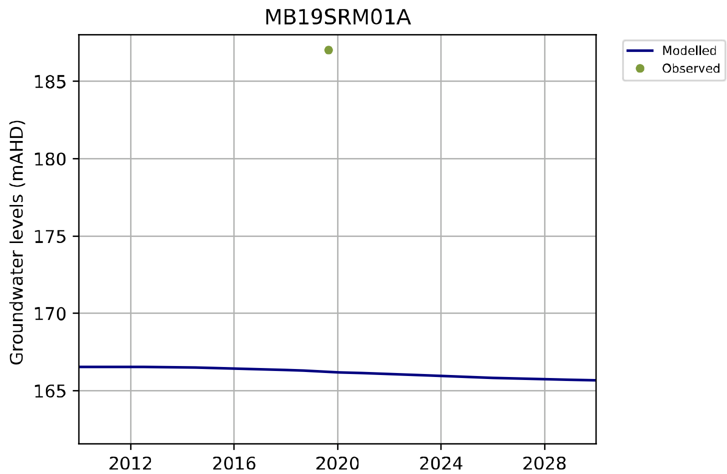

MB19CVM06P
Groundwater levels (mAHD)
215
210
205
200
195
2012
2016
2020
2024
2028
Modelled
Observed

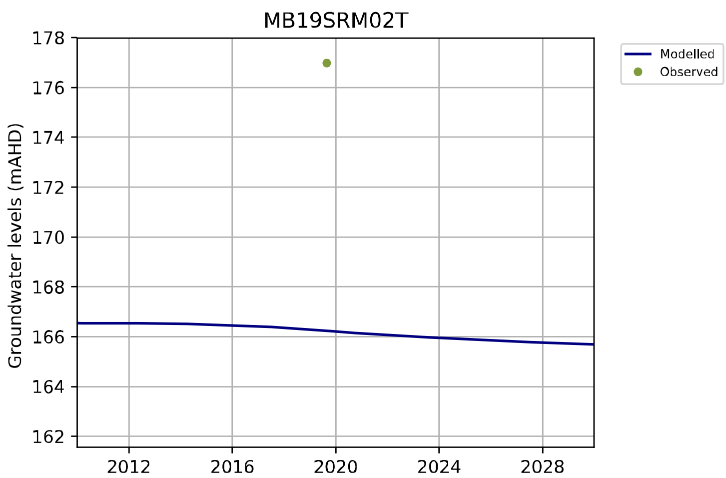

MB19CVM07T
Groundwater levels (mAHD)
220
215
210
205
200
195
190
185
2012
2016
2020
2024
2028
Modelled
Observed

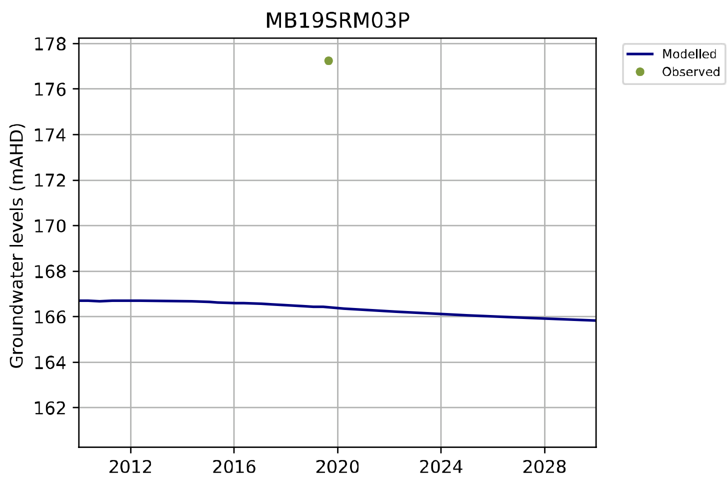

MB19CVM08P
Groundwater levels (mAHD)
210
200
190
180
170
160
2012
2016
2020
2024
2028
Modelled
Observed

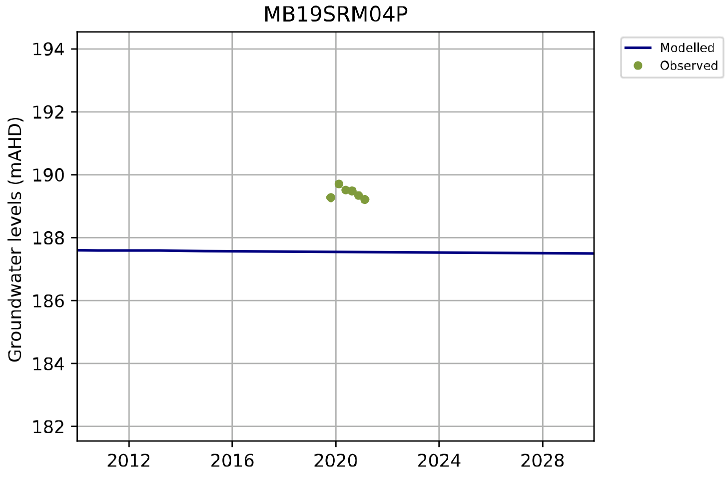

MB19CVM09A
Groundwater levels (mAHD)
214
212
210
208
206
204
202
200
2012
2016
2020
2024
2028
Modelled
Observed

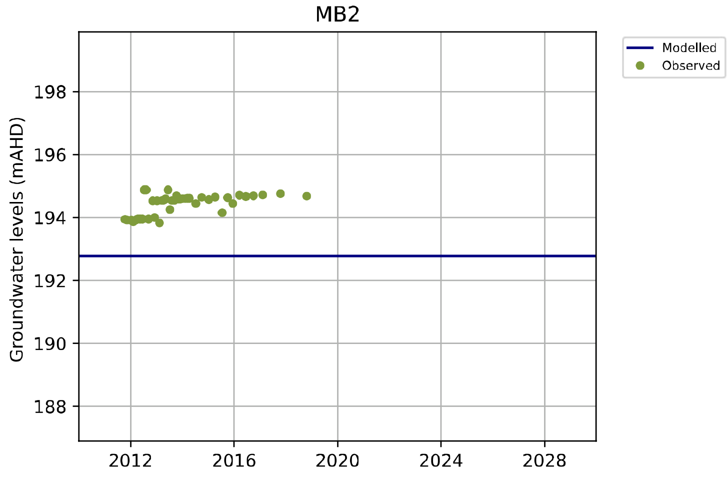

MB19CVM10P
Groundwater levels (mAHD)
200
180
160
140
120
100
2012
2016
2020
2024
2028
Modelled
Observed

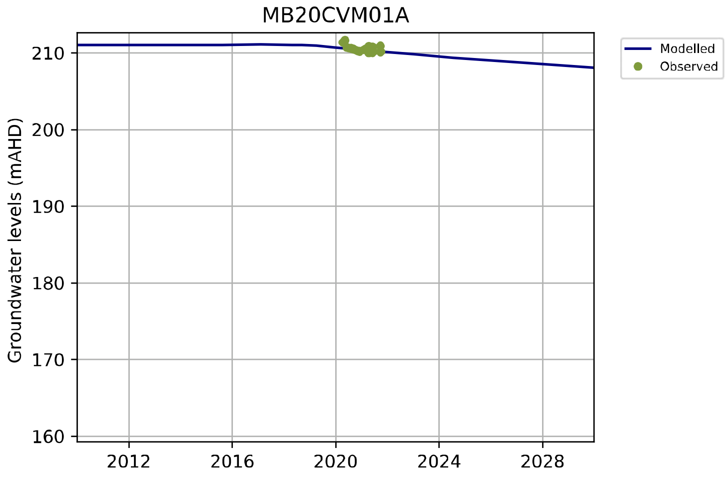

MB19SRM01A
Groundwater levels (mAHD)
185
180
175
170
165
2012
2016
2020
2024
2028
Modelled
Observed

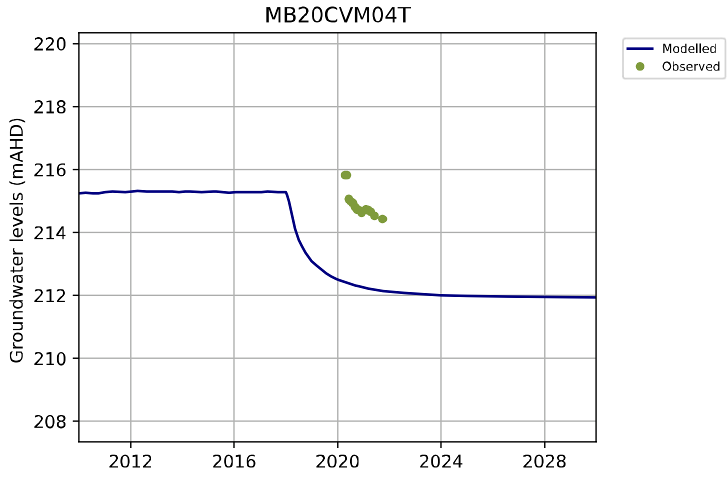

MB19SRM02T
Groundwater levels (mAHD)
178
176
174
172
170
168
166
164
162
2012
2016
2020
2024
2028
Modelled
Observed

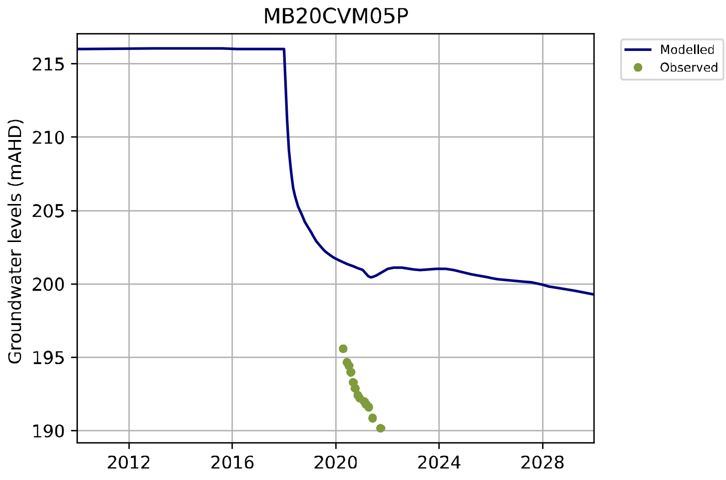

MB19SRM03P
Groundwater levels (mAHD)
178
176
174
172
170
168
166
164
162
2012
2016
2020
2024
2028
Modelled
Observed

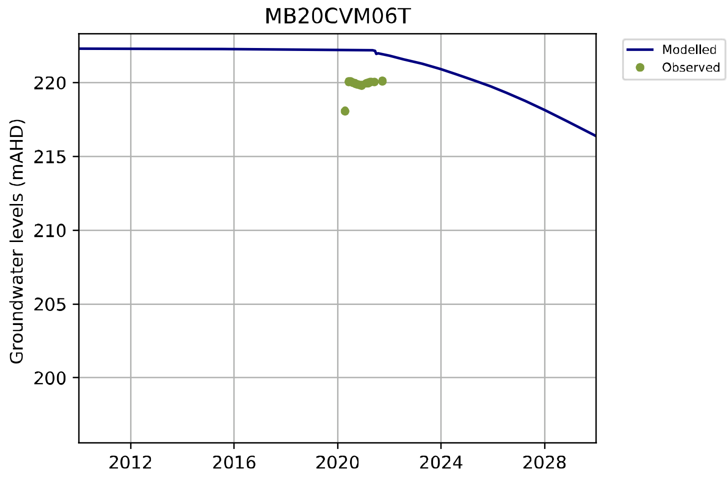

MB19SRM04P
Groundwater levels (mAHD)
194
192
190
188
186
184
182
2012
2016
2020
2024
2028
Modelled
Observed

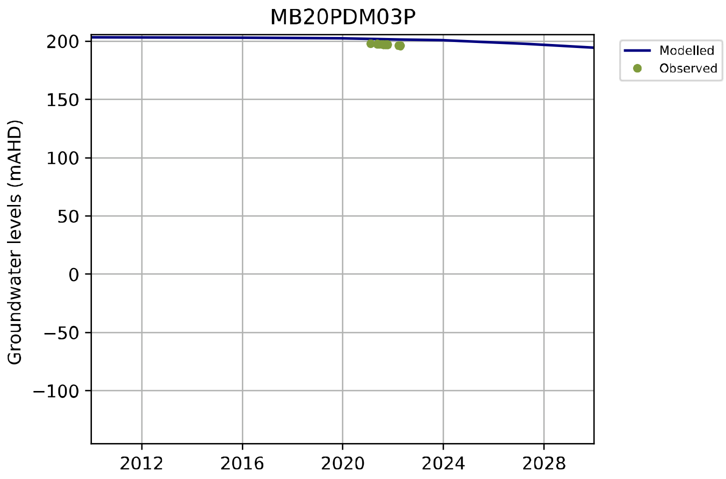

MB2
Groundwater levels (mAHD)
198
196
194
192
190
188
2012
2016
2020
2024
2028
Modelled
Observed

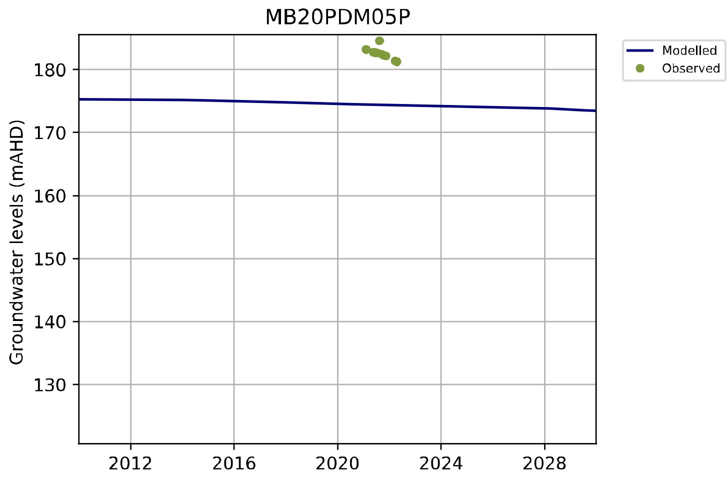

MB20CVM01A
Groundwater levels (mAHD)
210
200
190
180
170
160
2012
2016
2020
2024
2028
Modelled
Observed

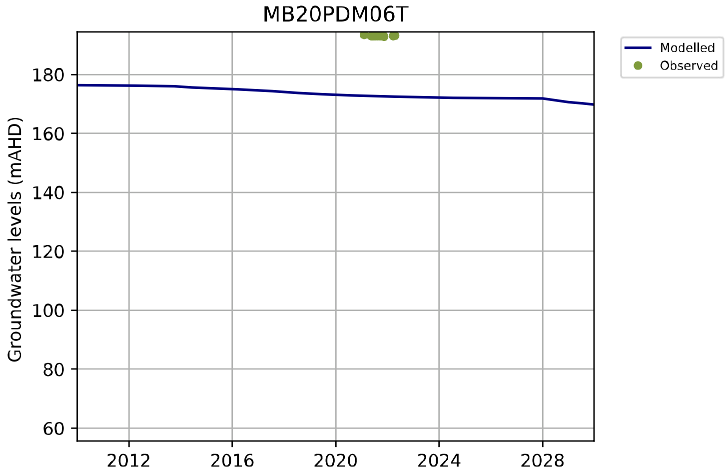

MB20CVM04T
Groundwater levels (mAHD)
220
218
216
214
212
210
208
2012
2016
2020
2024
2028
Modelled
Observed

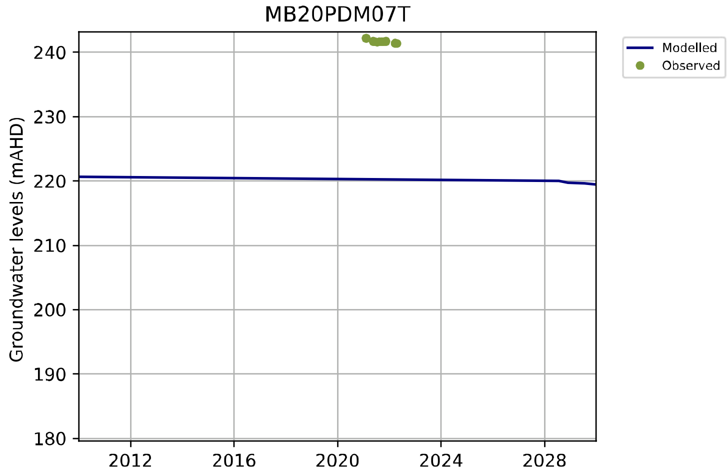

MB20CVM05P
Groundwater levels (mAHD)
215
210
205
200
195
190
2012
2016
2020
2024
2028
Modelled
Observed

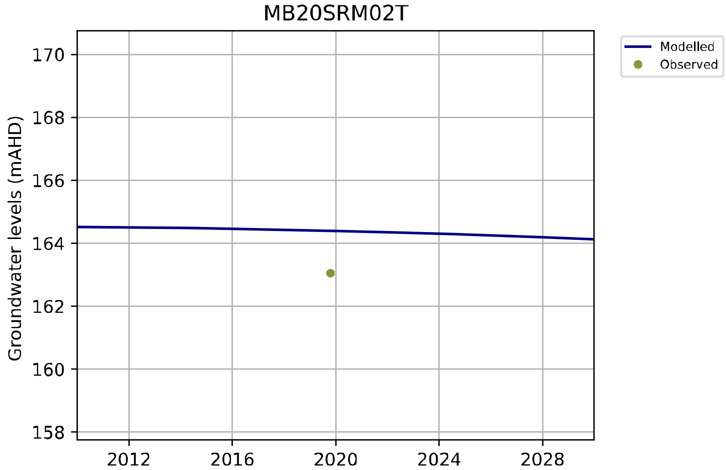

MB20CVM06T
Groundwater levels (mAHD)
220
215
210
205
200
2012
2016
2020
2024
2028
Modelled
Observed

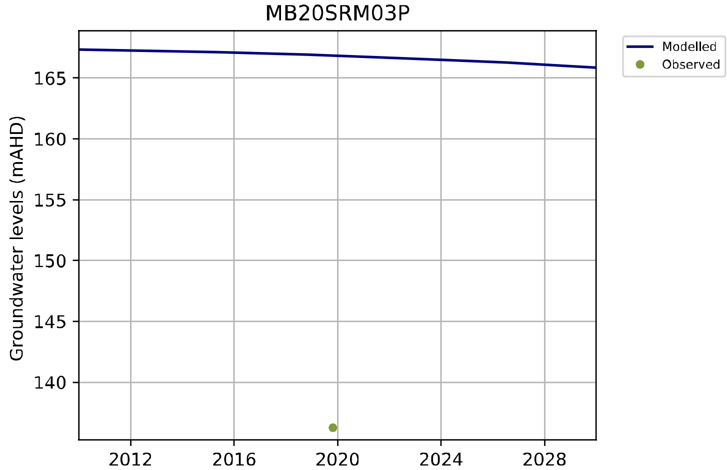

MB20PDM03P
Groundwater levels (mAHD)
200
150
100
50
0
−50
−100
2012
2016
2020
2024
2028
Modelled
Observed

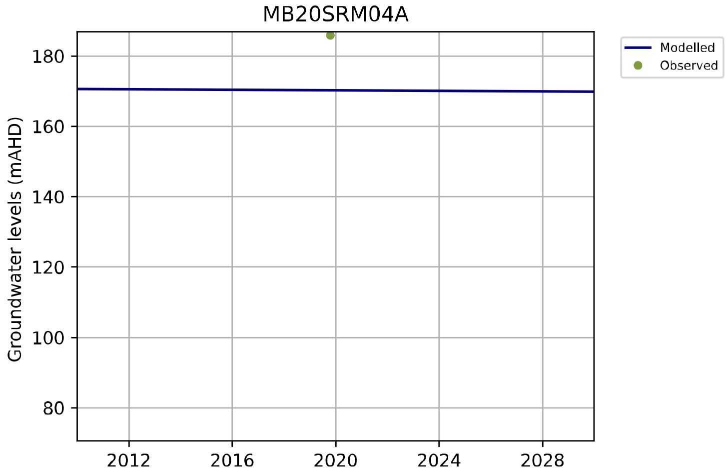

MB20PDM05P
Groundwater levels (mAHD)
180
170
160
150
140
130
2012
2016
2020
2024
2028
Modelled
Observed

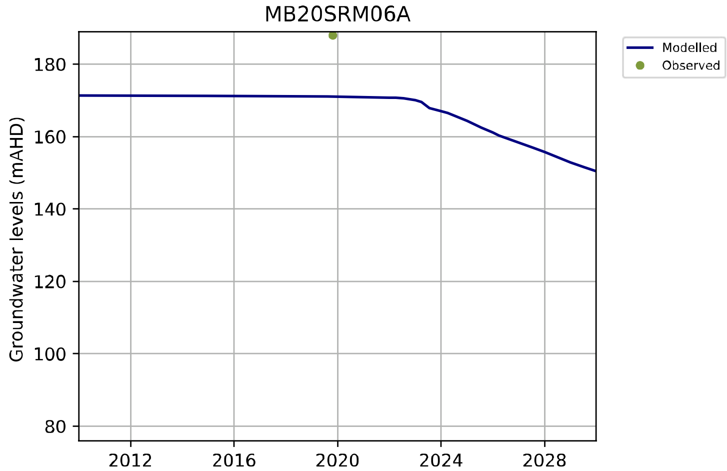

MB20PDM06T
Groundwater levels (mAHD)
60
80
100
120
140
160
180
2012
2016
2020
2024
2028
Modelled
Observed

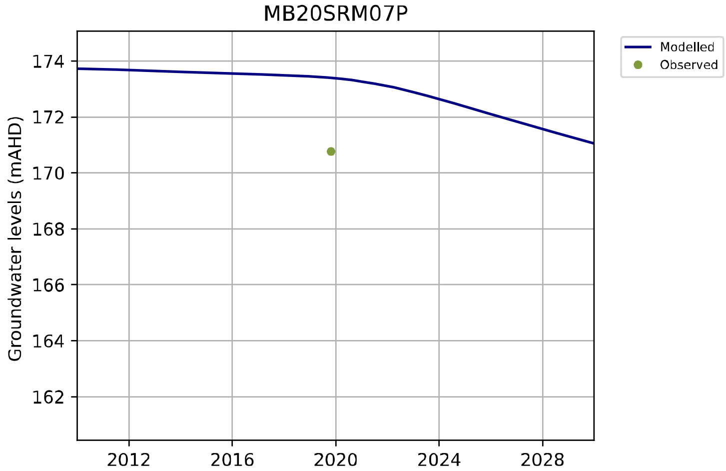

MB20PDM07T
Groundwater levels (mAHD)
180
190
200
210
220
230
240
2012
2016
2020
2024
2028
Modelled
Observed

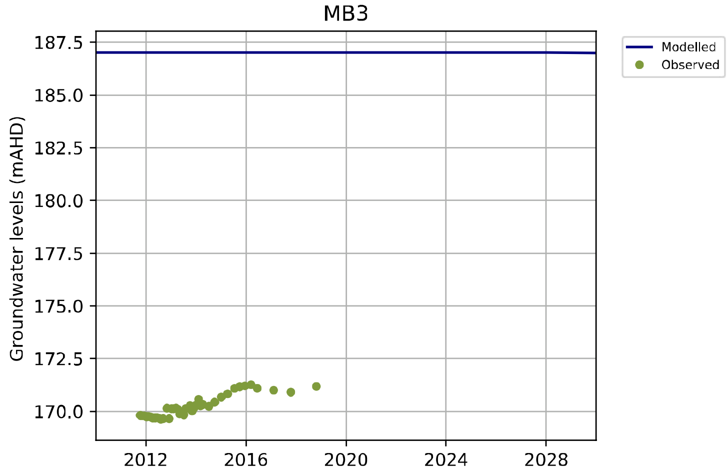

MB20SRM02T
Groundwater levels (mAHD)
158
160
162
164
166
168
170
2012
2016
2020
2024
2028
Modelled
Observed

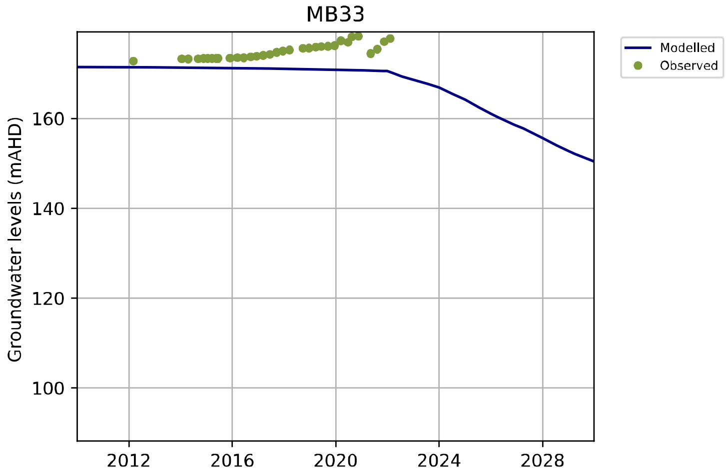

MB20SRM03P
Groundwater levels (mAHD)
140
145
150
155
160
165
2012
2016
2020
2024
2028
Modelled
Observed

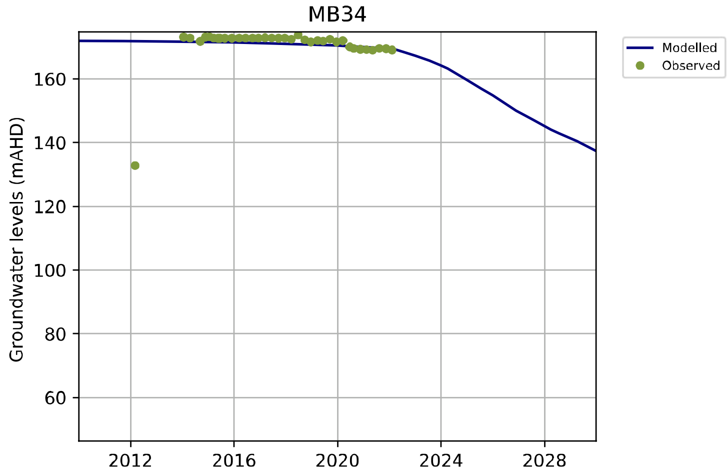

MB20SRM04A
Groundwater levels (mAHD)
80
100
120
140
160
180
2012
2016
2020
2024
2028
Modelled
Observed

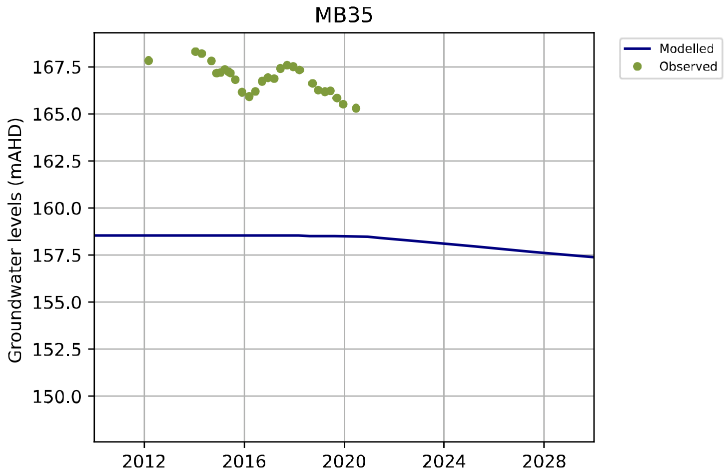

MB20SRM06A
Groundwater levels (mAHD)
80
100
120
140
160
180
2012
2016
2020
2024
2028
Modelled
Observed

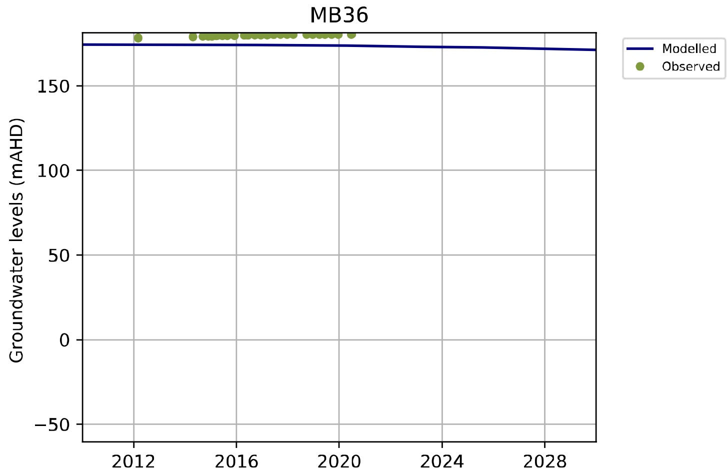

MB20SRM07P
Groundwater levels (mAHD)
162
164
166
168
170
172
174
2012
2016
2020
2024
2028
Modelled
Observed

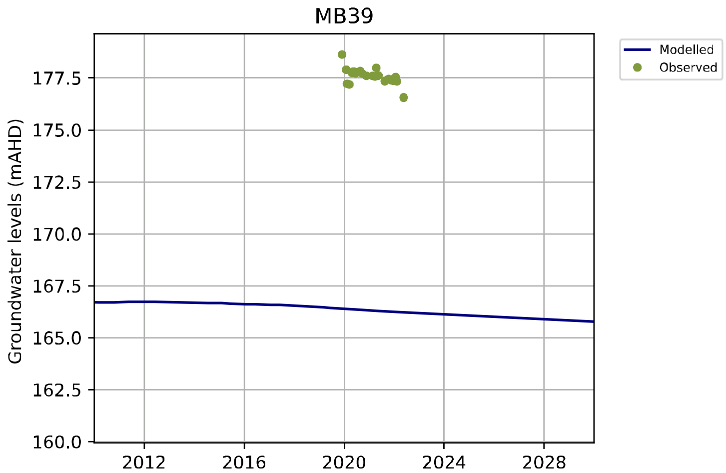

MB3
Groundwater levels (mAHD)
170.0
172.5
175.0
177.5
180.0
182.5
185.0
187.5
2012
2016
2020
2024
2028
Modelled
Observed

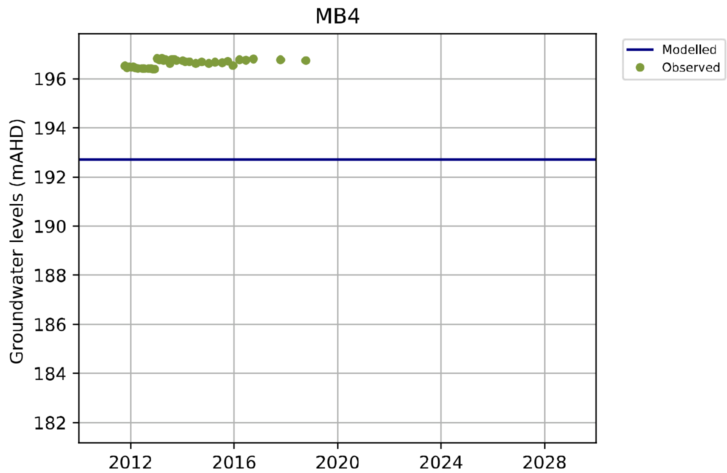

MB33
Groundwater levels (mAHD)
160
140
120
100
2012
2016
2020
2024
2028
Modelled
Observed

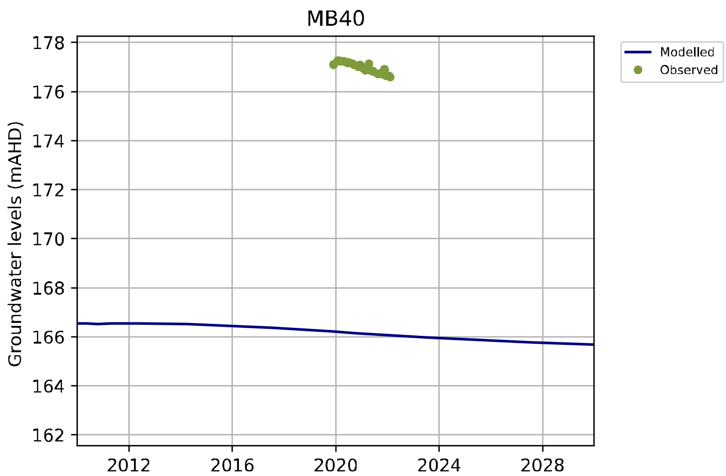

MB34
Groundwater levels (mAHD)
160
140
120
100
80
60
2012
2016
2020
2024
2028
Modelled
Observed

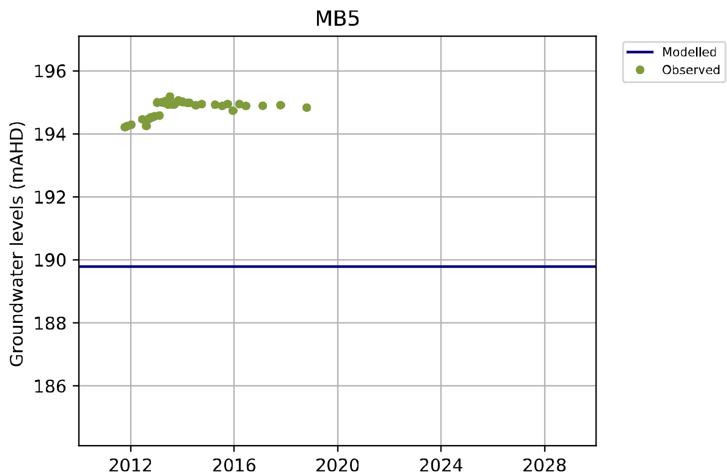

MB35
Groundwater levels (mAHD)
167.5
165.0
162.5
160.0
157.5
155.0
152.5
150.0
2012
2016
2020
2024
2028
Modelled
Observed

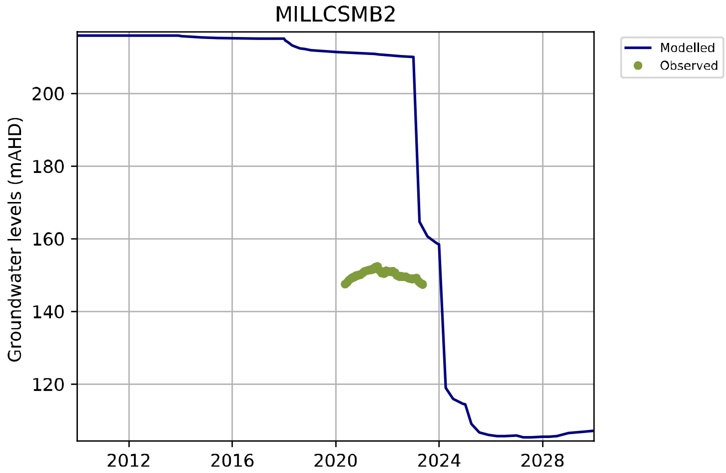

MB36
Groundwater levels (mAHD)
150
100
50
0
−50
2012
2016
2020
2024
2028
Modelled
Observed

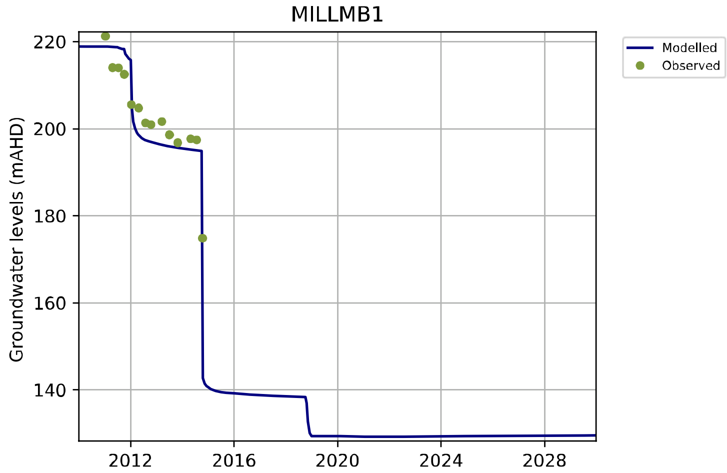

MB39
Groundwater levels (mAHD)
177.5
175.0
172.5
170.0
167.5
165.0
162.5
160.0
2012
2016
2020
2024
2028
Modelled
Observed

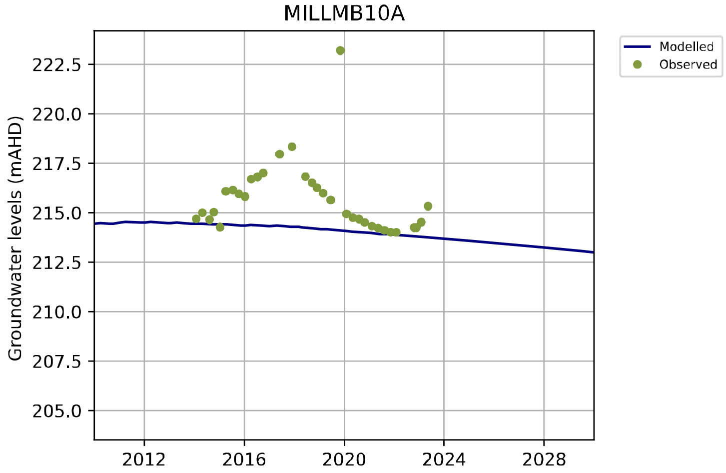

MB4
Groundwater levels (mAHD)
196
194
192
190
188
186
184
182
2012
2016
2020
2024
2028
Modelled
Observed

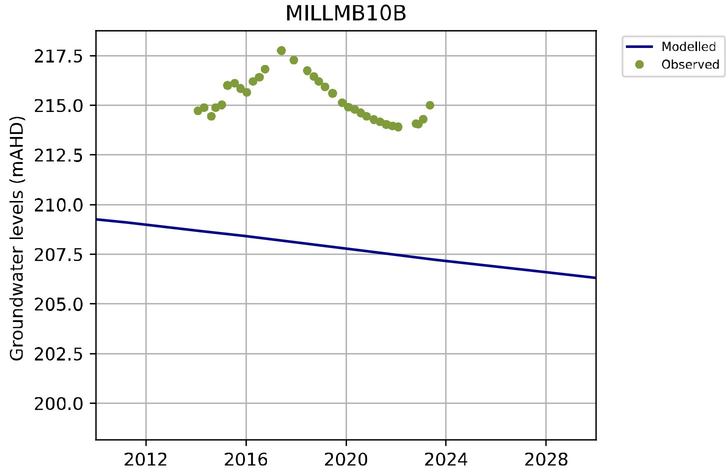

MB40
Groundwater levels (mAHD)
178
176
174
172
170
168
166
164
162
2012
2016
2020
2024
2028
Modelled
Observed

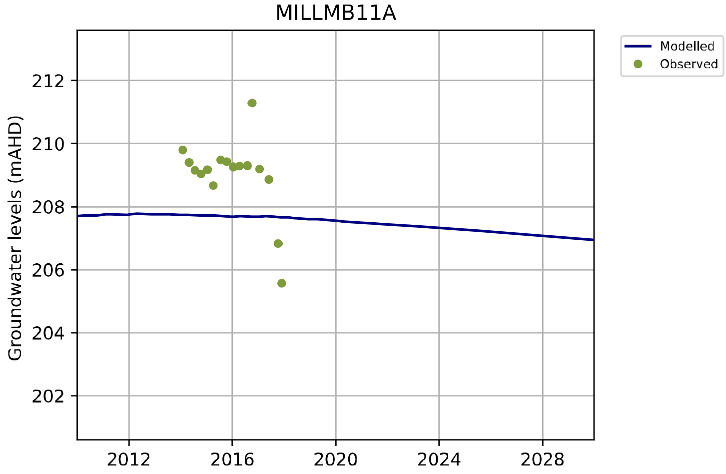

MB5
Groundwater levels (mAHD)
196
194
192
190
188
186
2012
2016
2020
2024
2028
Modelled
Observed

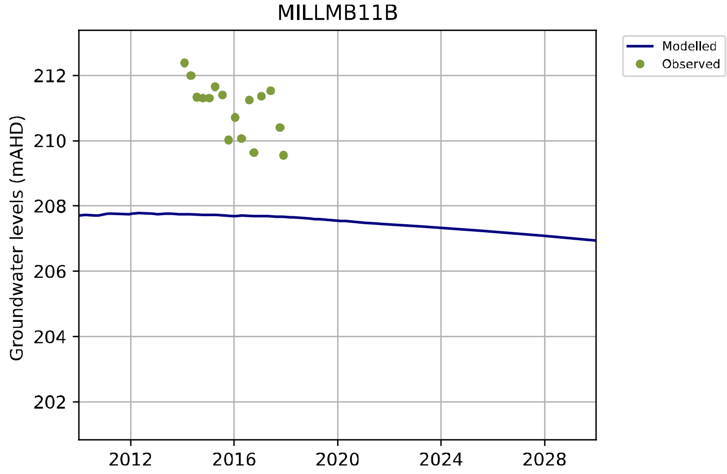

MILLCSMB2
Groundwater levels (mAHD)
Modelled
Observed
200
180
160
140
120
2012
2016
2020
2024
2028

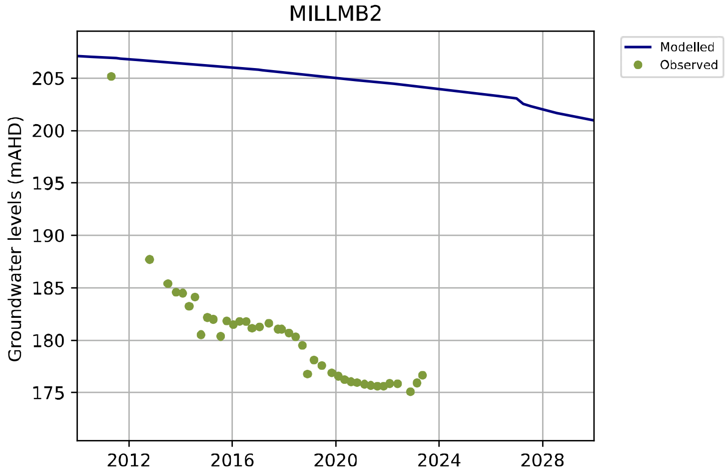

MILLMB1
Groundwater levels (mAHD)
Modelled
Observed
220
200
180
160
140
2012
2016
2020
2024
2028

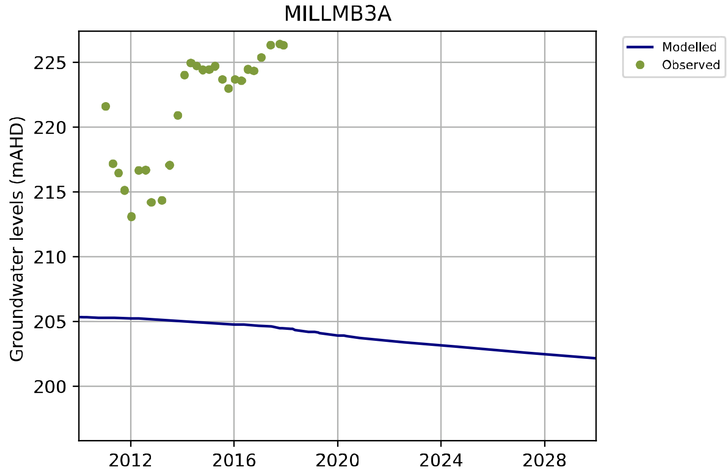

MILLMB10A
Groundwater levels (mAHD)
Modelled
Observed
222.5
220.0
217.5
215.0
212.5
210.0
207.5
205.0
2012
2016
2020
2024
2028

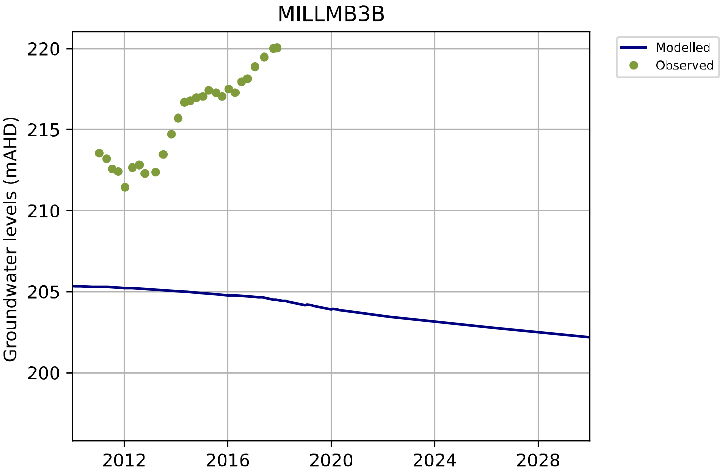

MILLMB10B
Groundwater levels (mAHD)
Modelled
Observed
217.5
215.0
212.5
210.0
207.5
205.0
202.5
200.0
2012
2016
2020
2024
2028

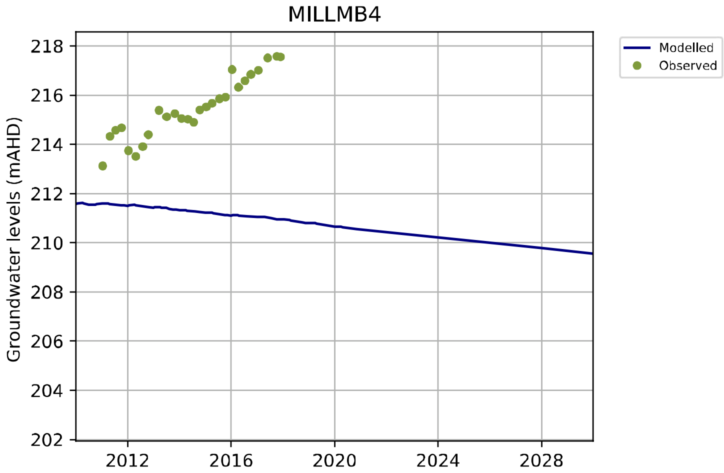

MILLMB11A
Groundwater levels (mAHD)
Modelled
Observed
212
210
208
206
204
202
2012
2016
2020
2024
2028

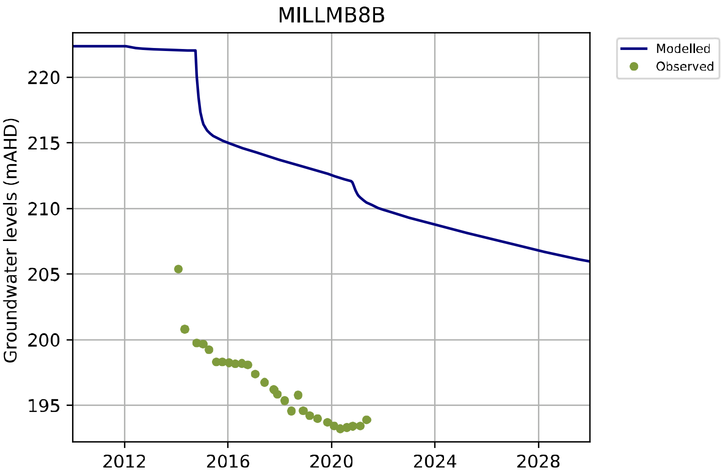

MILLMB11B
Groundwater levels (mAHD)
Modelled
Observed
212
210
208
206
204
202
2012
2016
2020
2024
2028

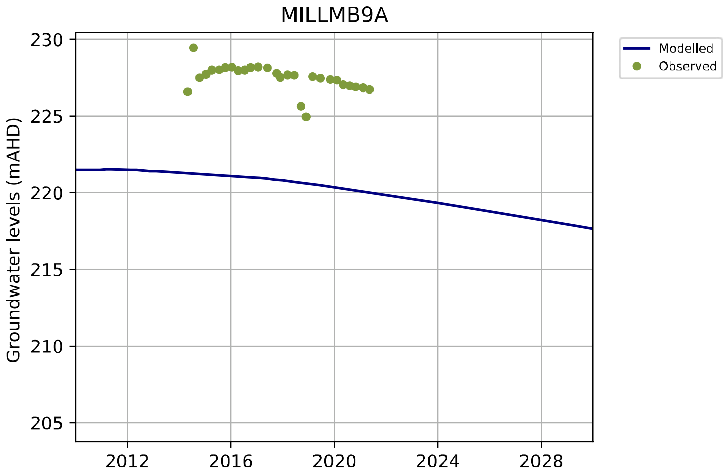

MILLMB2
Groundwater levels (mAHD)
Modelled
Observed
205
200
195
190
185
180
175
2012
2016
2020
2024
2028

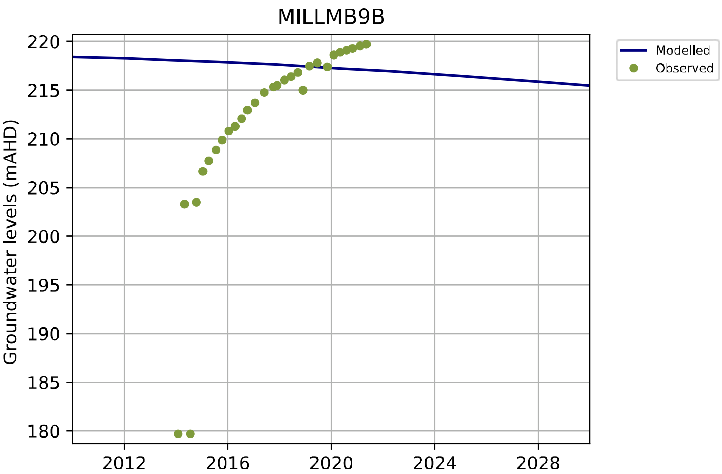

MILLMB3A
Groundwater levels (mAHD)
Modelled
Observed
225
220
215
210
205
200
2012
2016
2020
2024
2028

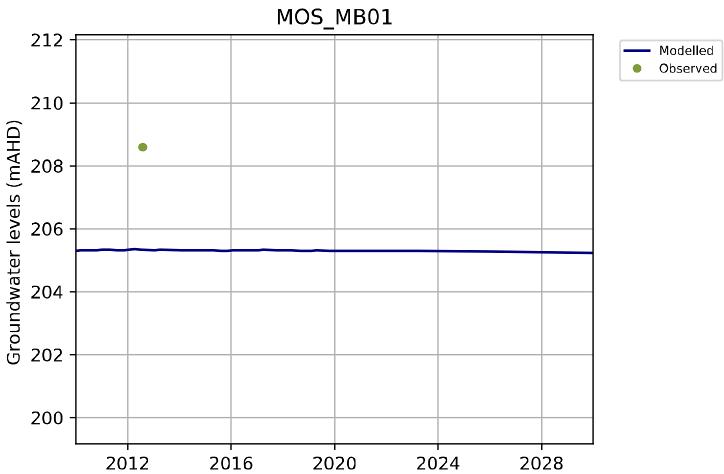

MILLMB3B
Groundwater levels (mAHD)
220
215
210
205
200
2012
2016
2020
2024
2028
Modelled
Observed

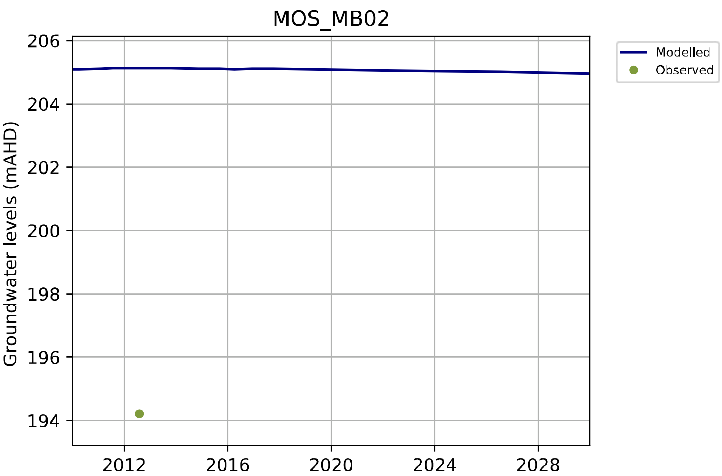

MILLMB4
Groundwater levels (mAHD)
218
216
214
212
210
208
206
204
202
2012
2016
2020
2024
2028
Modelled
Observed

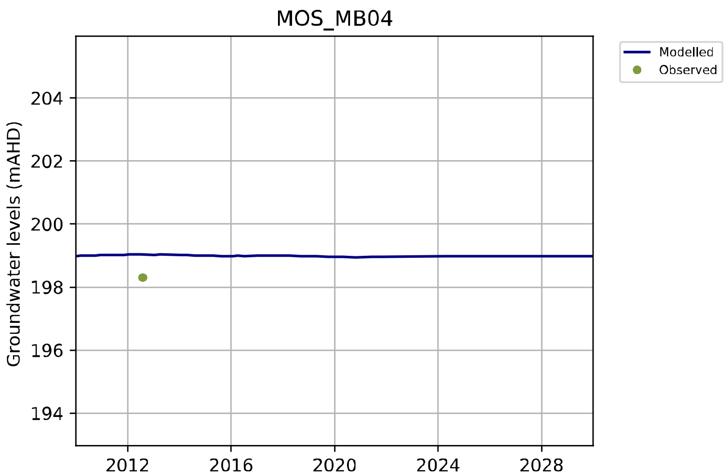

MILLMB8B
Groundwater levels (mAHD)
220
215
210
205
200
195
2012
2016
2020
2024
2028
Modelled
Observed

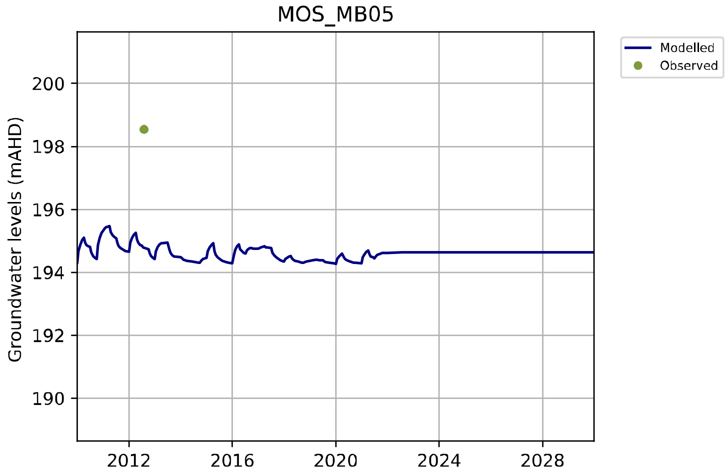

MILLMB9A
Groundwater levels (mAHD)
230
225
220
215
210
205
2012
2016
2020
2024
2028
Modelled
Observed

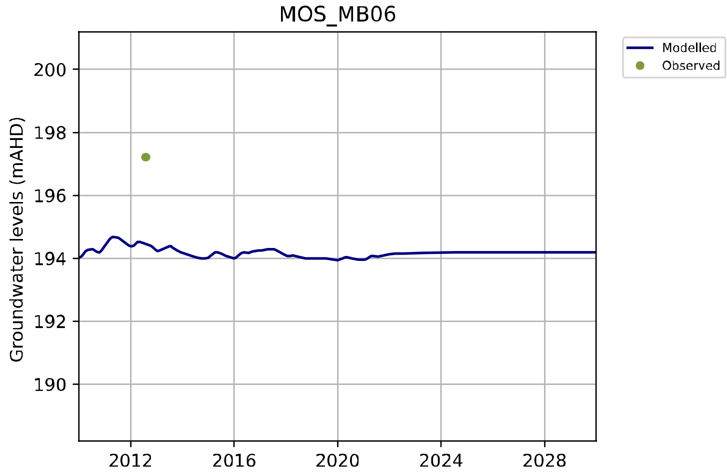

MILLMB9B
Groundwater levels (mAHD)
220
215
210
205
200
195
190
185
180
2012
2016
2020
2024
2028
Modelled
Observed

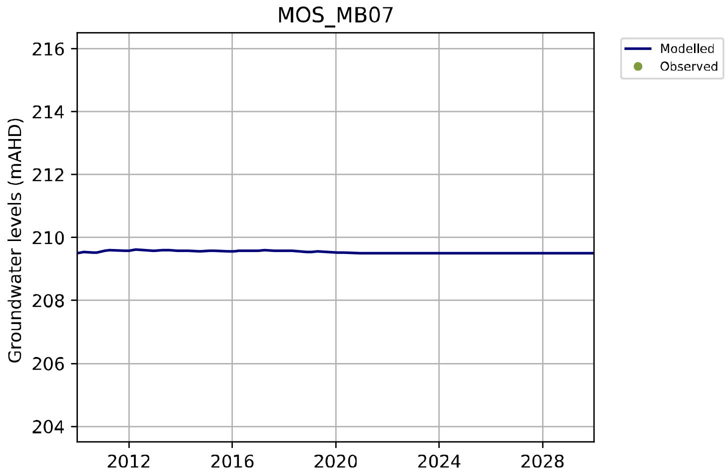

MOS_MB01
Groundwater levels (mAHD)
212
210
208
206
204
202
200
2012
2016
2020
2024
2028
Modelled
Observed

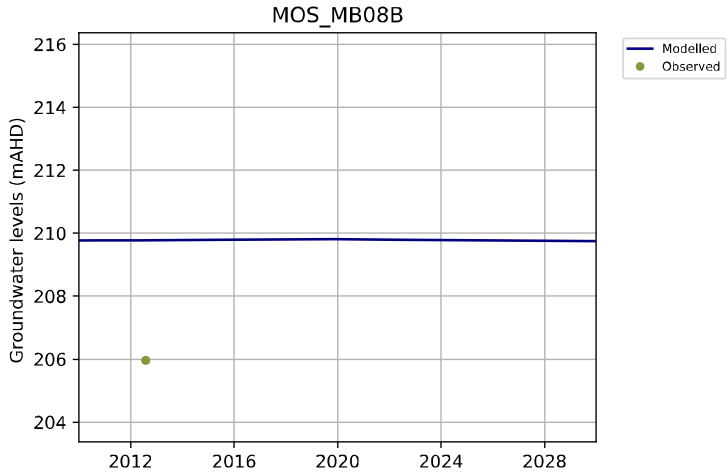

MOS_MB02
Groundwater levels (mAHD)
206
204
202
200
198
196
194
2012
2016
2020
2024
2028
Modelled
Observed

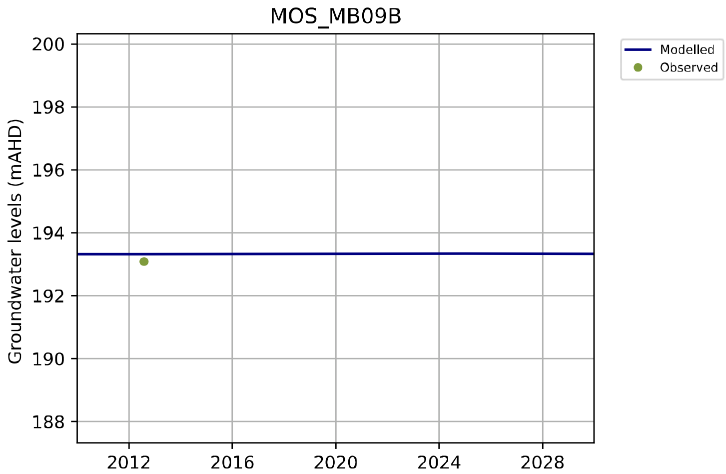

MOS_MB04
Groundwater levels (mAHD)
204
202
200
198
196
194
2012
2016
2020
2024
2028
Modelled
Observed

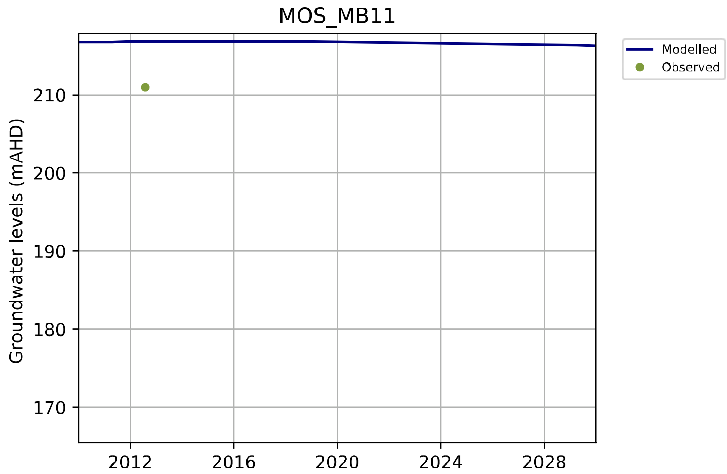

MOS_MB05
Groundwater levels (mAHD)
190
192
194
196
198
200
2012
2016
2020
2024
2028
Modelled
Observed

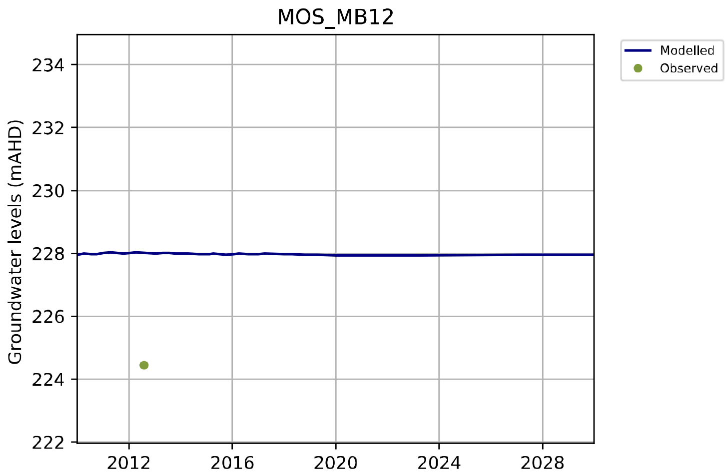

MOS_MB06
Groundwater levels (mAHD)
190
192
194
196
198
200
2012
2016
2020
2024
2028
Modelled
Observed

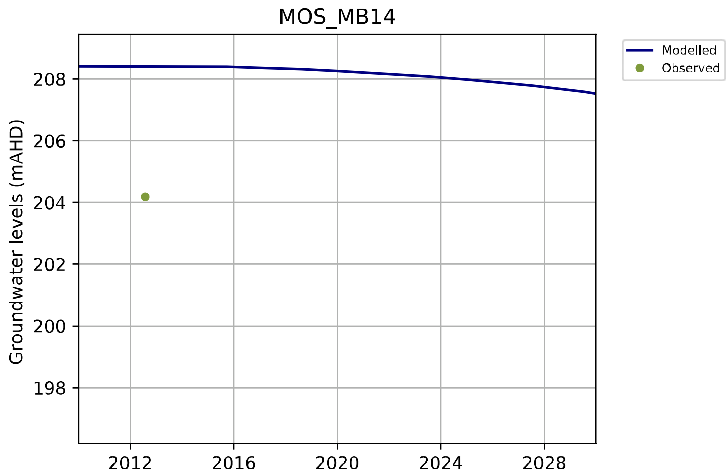

MOS_MB07
Groundwater levels (mAHD)
204
206
208
210
212
214
216
2012
2016
2020
2024
2028
Modelled
Observed

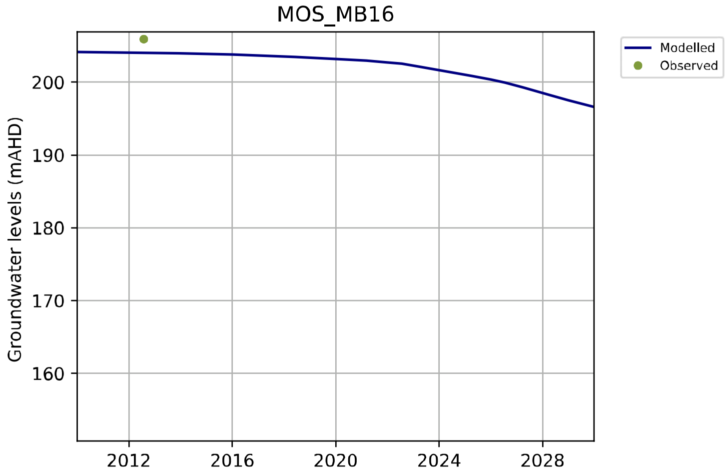

MOS_MB08B
Groundwater levels (mAHD)
204
206
208
210
212
214
216
2012
2016
2020
2024
2028
Modelled
Observed

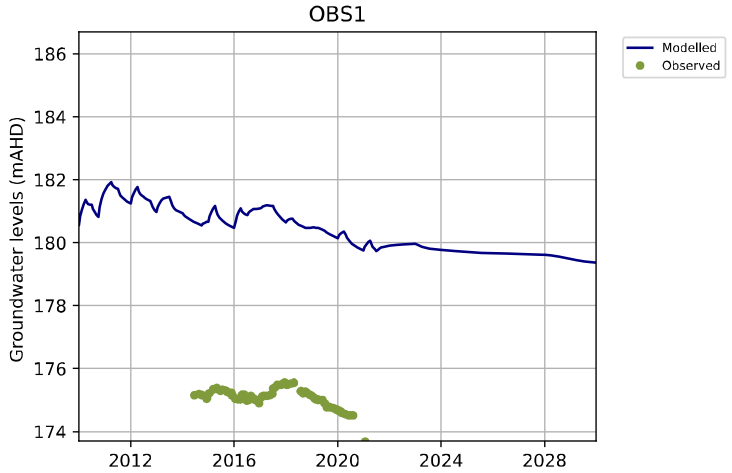

MOS_MB09B
Groundwater levels (mAHD)
188
190
192
194
196
198
200
2012
2016
2020
2024
2028
Modelled
Observed

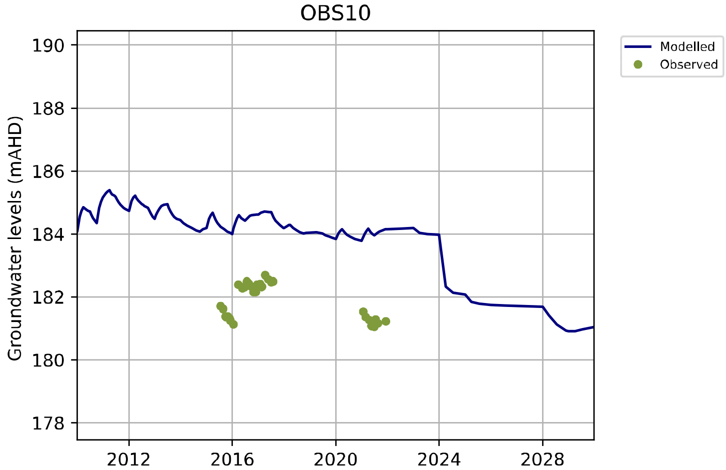

MOS_MB11
Groundwater levels (mAHD)
170
180
190
200
210
2012
2016
2020
2024
2028
Modelled
Observed

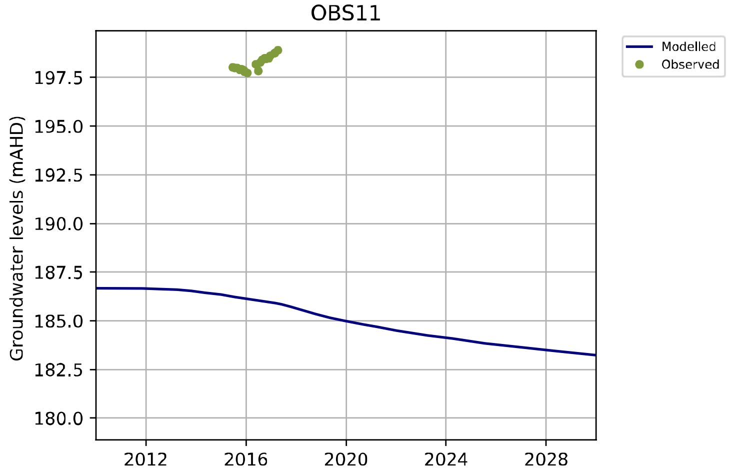

MOS_MB12
Groundwater levels (mAHD)
222
224
226
228
230
232
234
2012
2016
2020
2024
2028
Modelled
Observed

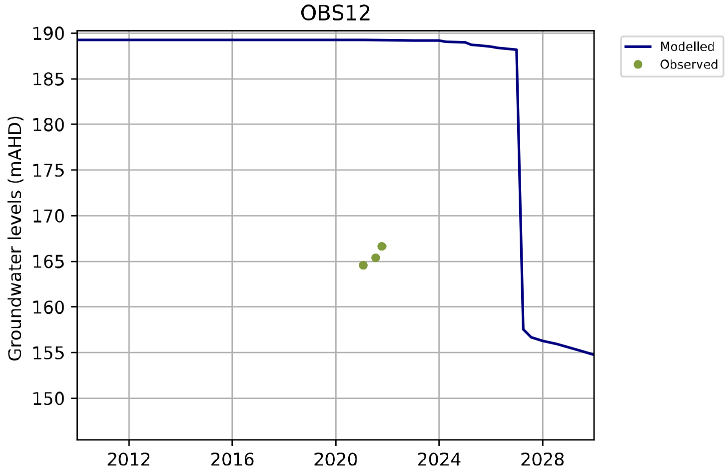

MOS_MB14
Groundwater levels (mAHD)
198
200
202
204
206
208
2012
2016
2020
2024
2028
Modelled
Observed

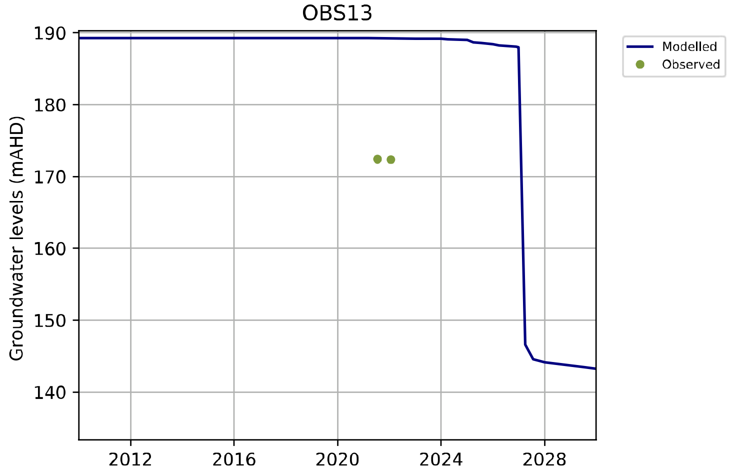

MOS_MB16
Groundwater levels (mAHD)
Modelled
Observed

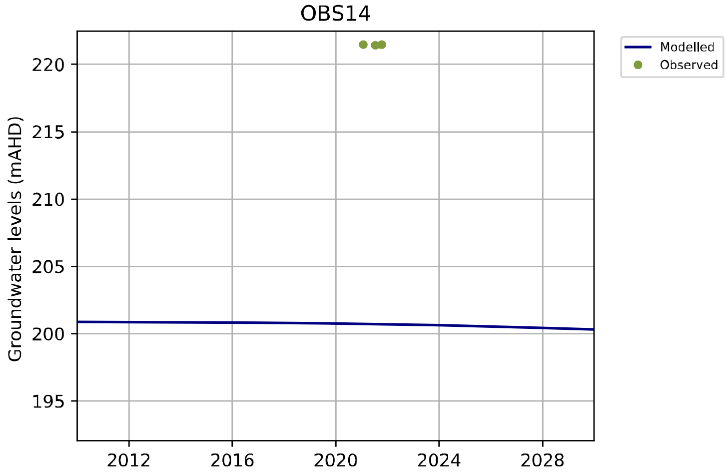

OBS1
Groundwater levels (mAHD)
Modelled
Observed

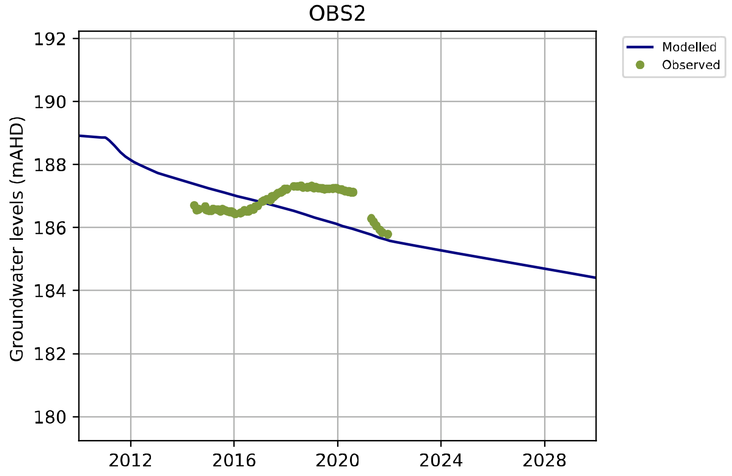

OBS10
Groundwater levels (mAHD)
Modelled
Observed

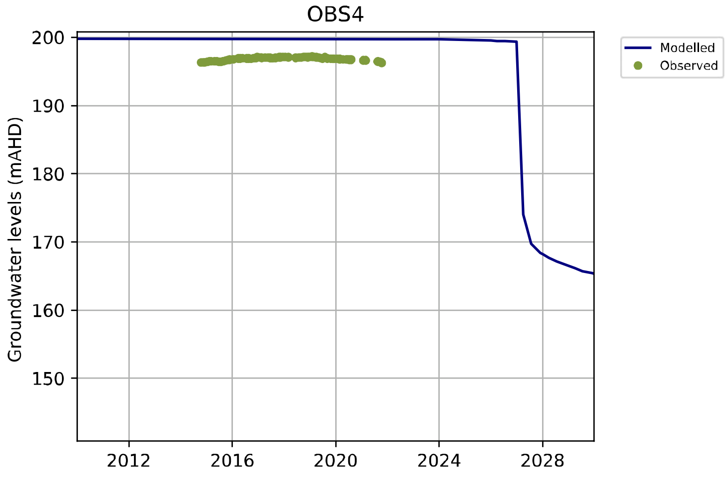

OBS11
Groundwater levels (mAHD)
Modelled
Observed

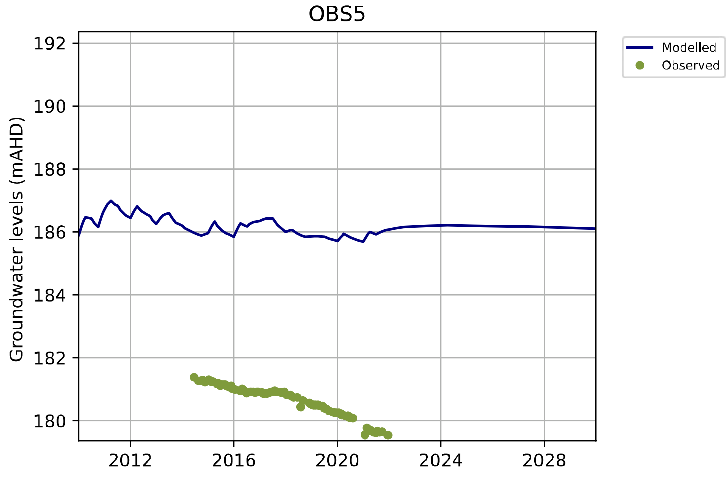

OBS12
Groundwater levels (mAHD)
Modelled
Observed

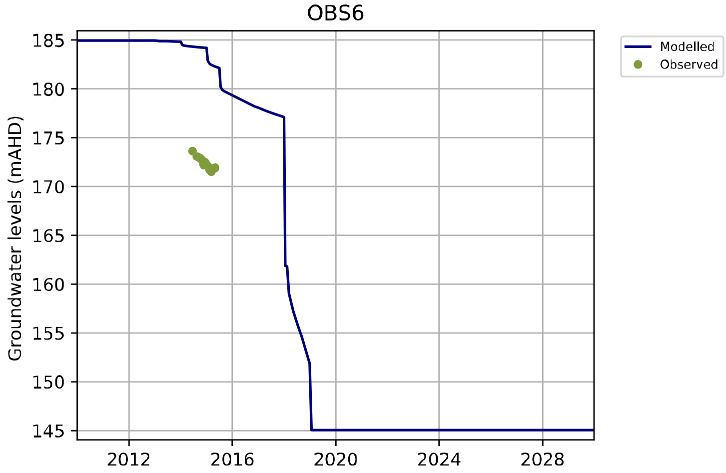

OBS13
Groundwater levels (mAHD)
Modelled
Observed

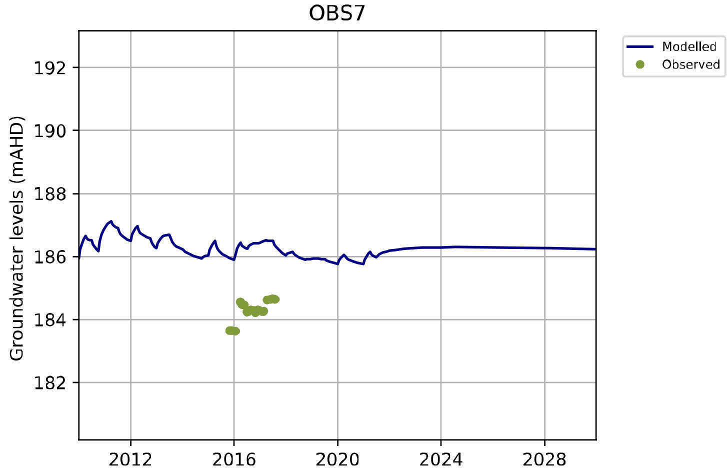

OBS14
Groundwater levels (mAHD)
Modelled
Observed

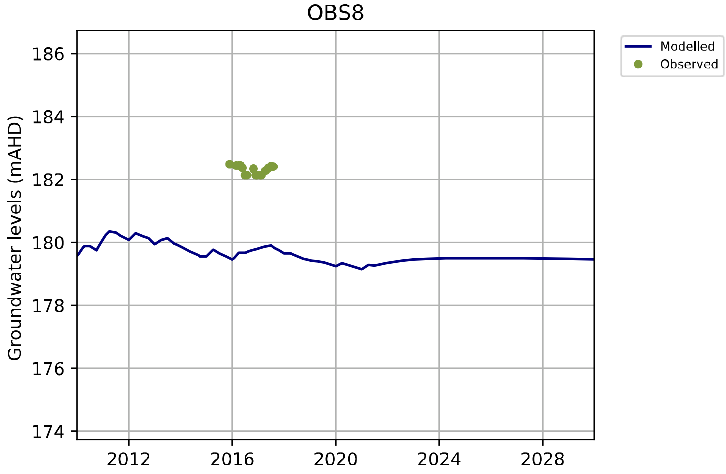

OBS2
Groundwater levels (mAHD)
Modelled
Observed

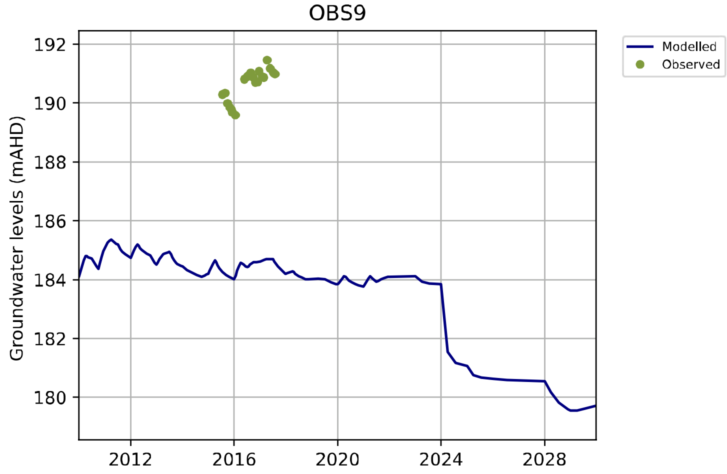

OBS4
Groundwater levels (mAHD)
200
190
180
170
160
150
2012
2016
2020
2024
2028
Modelled
Observed

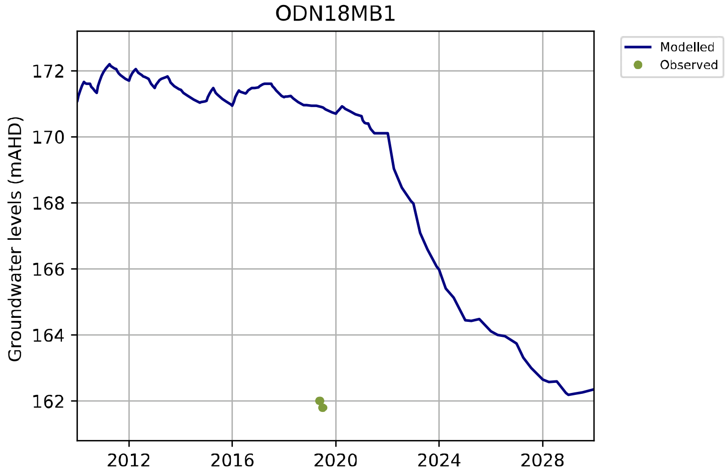

OBS5
Groundwater levels (mAHD)
192
190
188
186
184
182
180
2012
2016
2020
2024
2028
Modelled
Observed

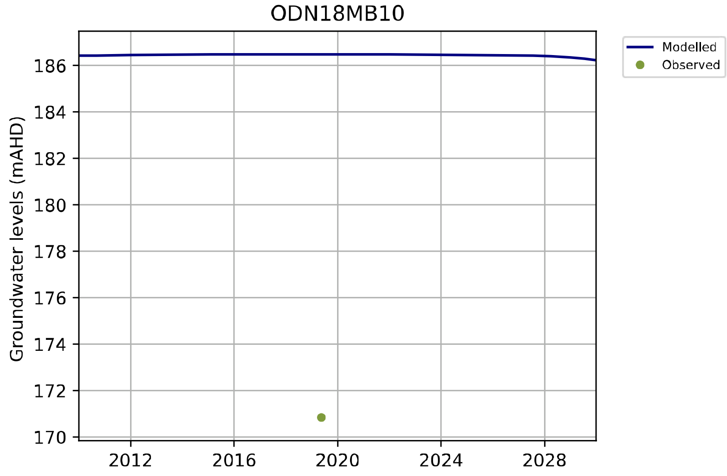

OBS6
Groundwater levels (mAHD)
185
180
175
170
165
160
155
150
145
2012
2016
2020
2024
2028
Modelled
Observed

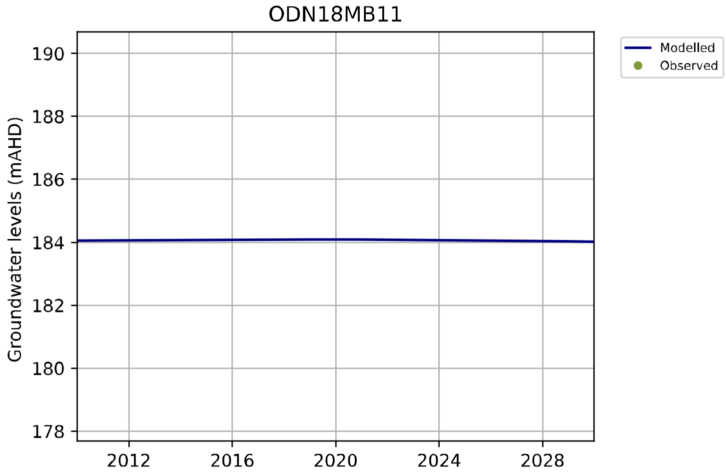

OBS7
Groundwater levels (mAHD)
192
190
188
186
184
182
2012
2016
2020
2024
2028
Modelled
Observed

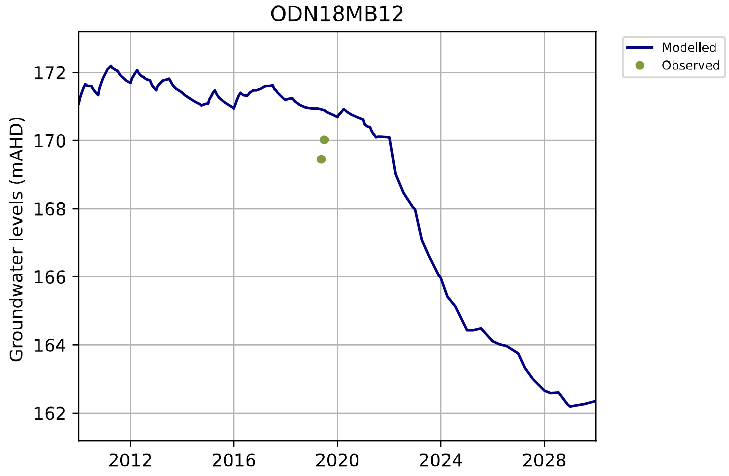

OBS8
Groundwater levels (mAHD)
186
184
182
180
178
176
174
2012
2016
2020
2024
2028
Modelled
Observed

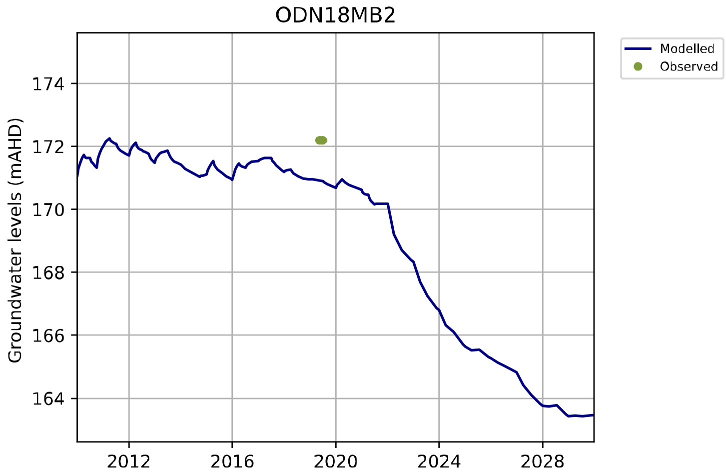

OBS9
Groundwater levels (mAHD)
192
190
188
186
184
182
180
2012
2016
2020
2024
2028
Modelled
Observed

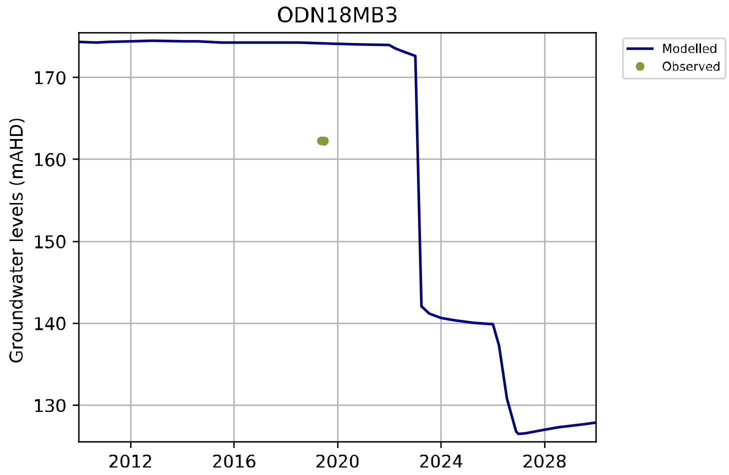

ODN18MB1
Groundwater levels (mAHD)
172
170
168
166
164
162
2012
2016
2020
2024
2028
Modelled
Observed

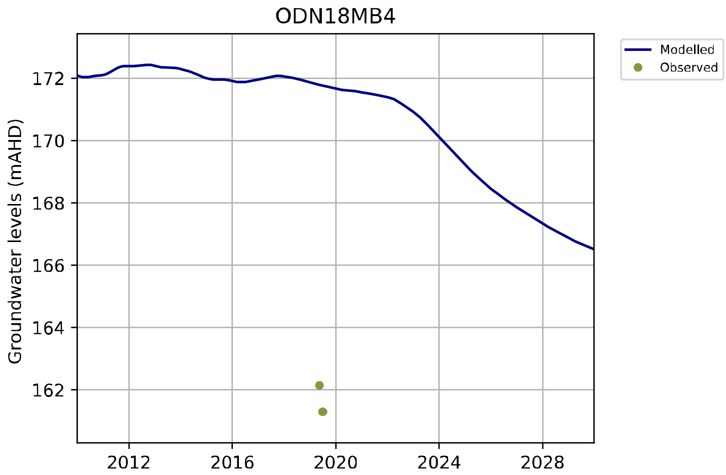

ODN18MB10
Groundwater levels (mAHD)
186
184
182
180
178
176
174
172
170
2012
2016
2020
2024
2028
Modelled
Observed

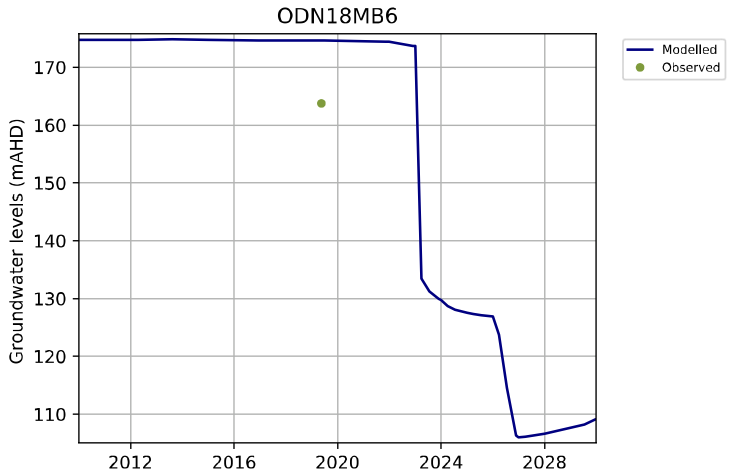

ODN18MB11
Groundwater levels (mAHD)
190
188
186
184
182
180
178
2012
2016
2020
2024
2028
Modelled
Observed

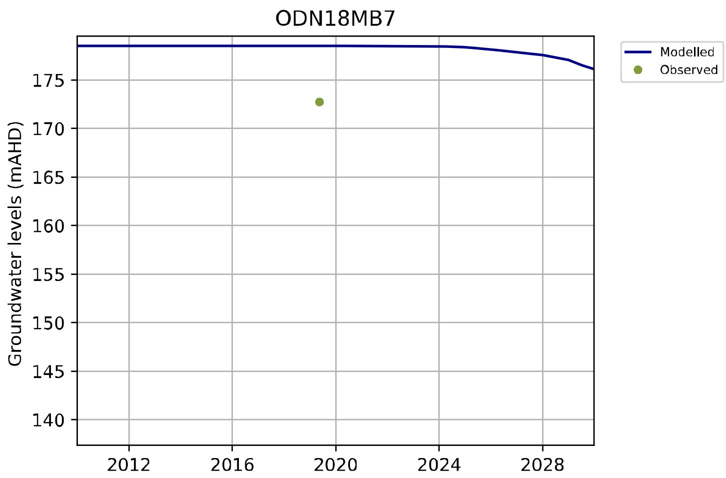

ODN18MB12
Groundwater levels (mAHD)
172
170
168
166
164
162
2012
2016
2020
2024
2028
Modelled
Observed

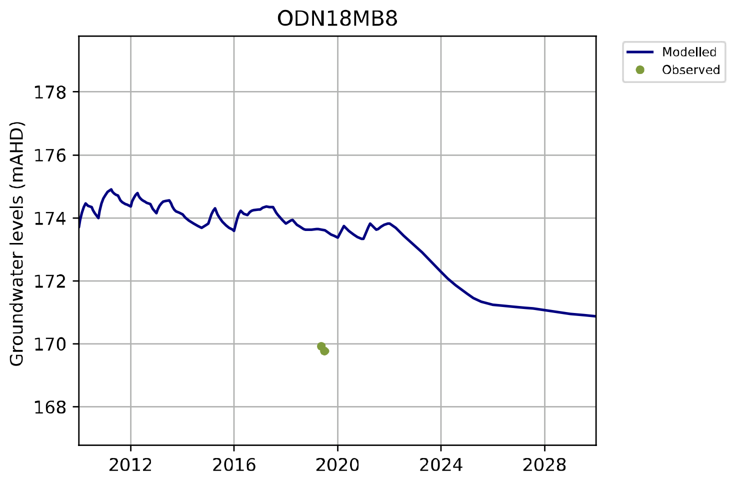

ODN18MB2
Groundwater levels (mAHD)
174
172
170
168
166
164
2012
2016
2020
2024
2028
Modelled
Observed

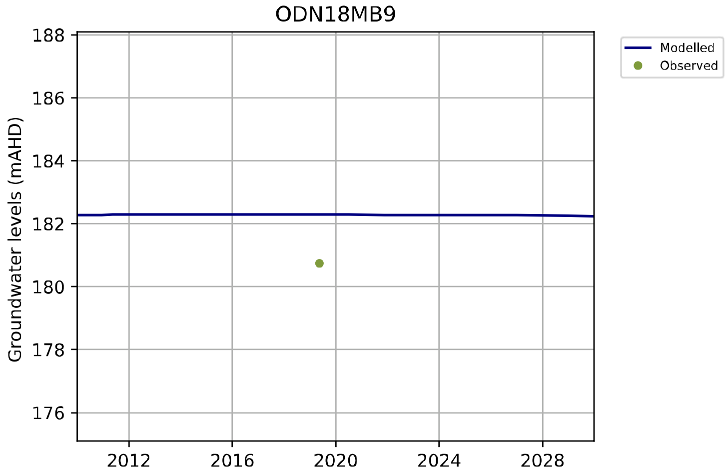

ODN18MB3
Groundwater levels (mAHD)
170
160
150
140
130
2012
2016
2020
2024
2028
Modelled
Observed

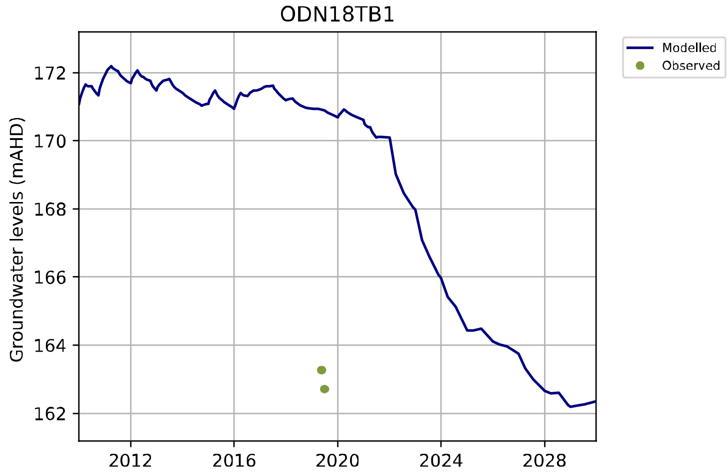

ODN18MB4
Groundwater levels (mAHD)
172
170
168
166
164
162
2012
2016
2020
2024
2028
Modelled
Observed

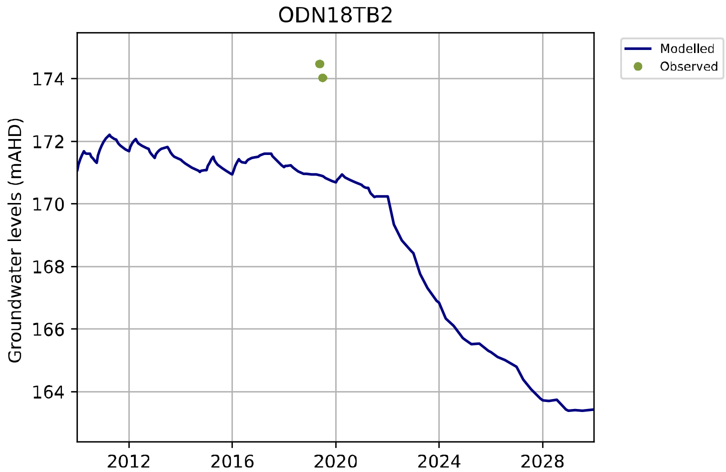

ODN18MB6
Groundwater levels (mAHD)
170
160
150
140
130
120
110
2012
2016
2020
2024
2028
Modelled
Observed

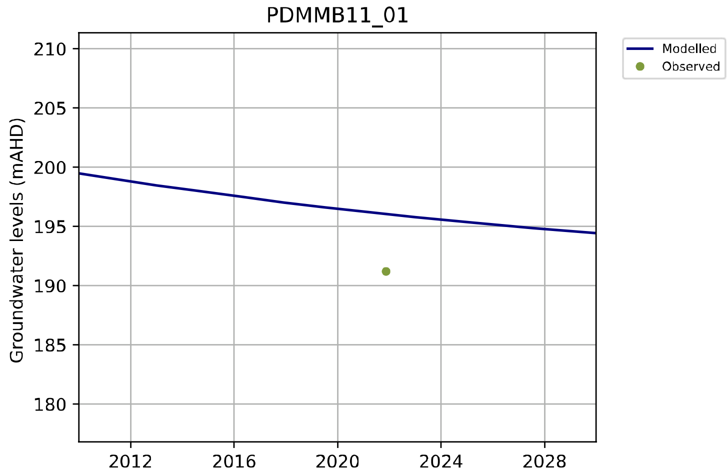

ODN18MB7
Groundwater levels (mAHD)
175
170
165
160
155
150
145
140
2012
2016
2020
2024
2028
Modelled
Observed

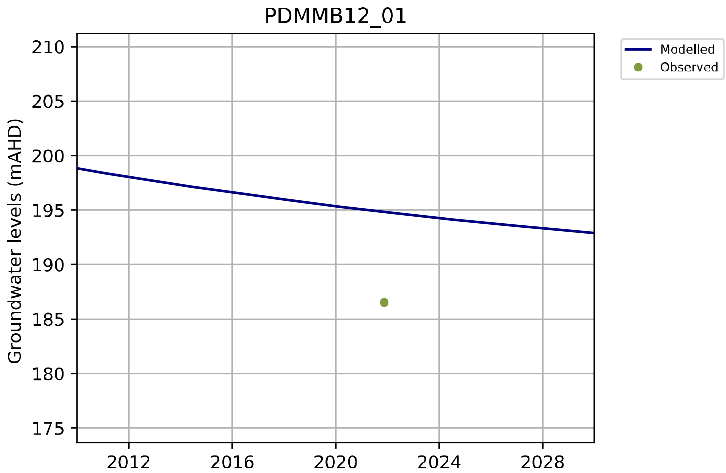

ODN18MB8
Groundwater levels (mAHD)
178
176
174
172
170
168
2012
2016
2020
2024
2028
Modelled
Observed

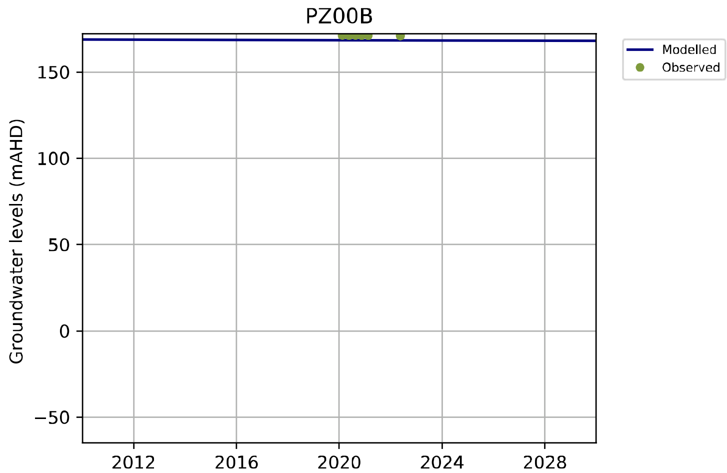

ODN18MB9
Groundwater levels (mAHD)
188
186
184
182
180
178
176
2012
2016
2020
2024
2028
Modelled
Observed

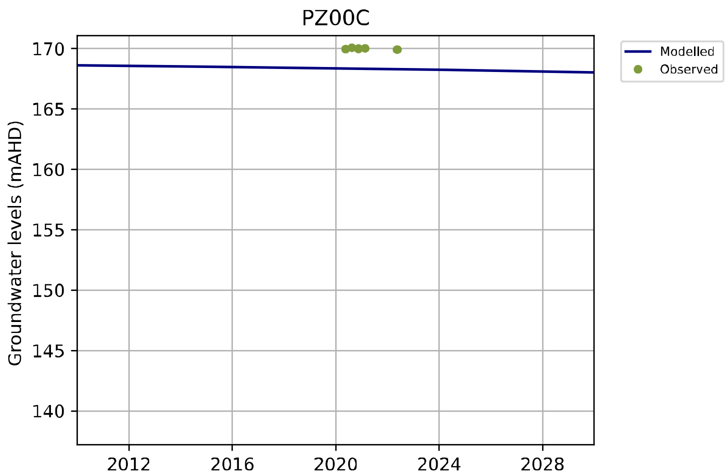

ODN18TB1
Groundwater levels (mAHD)
172
170
168
166
164
162
2012
2016
2020
2024
2028
Modelled
Observed

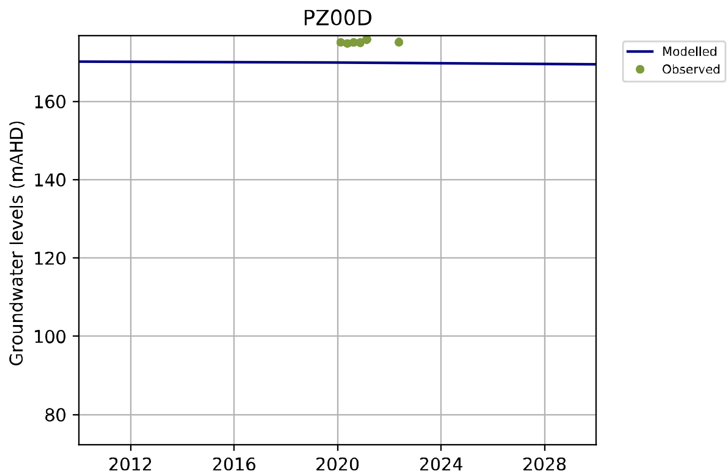

ODN18TB2
Groundwater levels (mAHD)
174
172
170
168
166
164
2012
2016
2020
2024
2028
Modelled
Observed

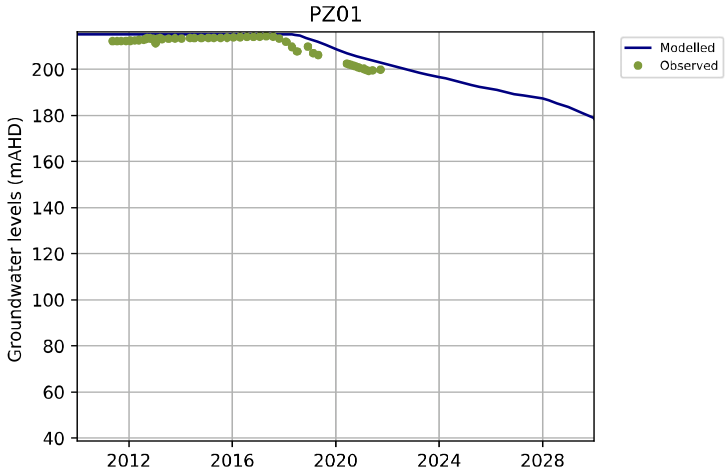

PDMMB11_01
Groundwater levels (mAHD)
210
205
200
195
190
185
180
2012
2016
2020
2024
2028
Modelled
Observed

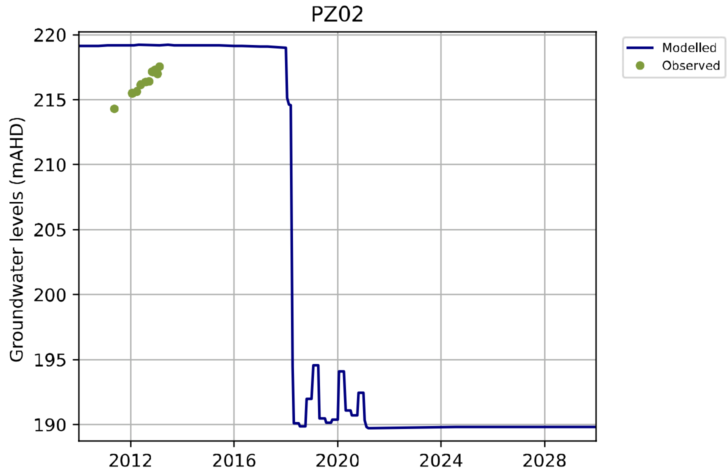

PDMMB12_01
Groundwater levels (mAHD)
210
205
200
195
190
185
180
175
2012
2016
2020
2024
2028
Modelled
Observed

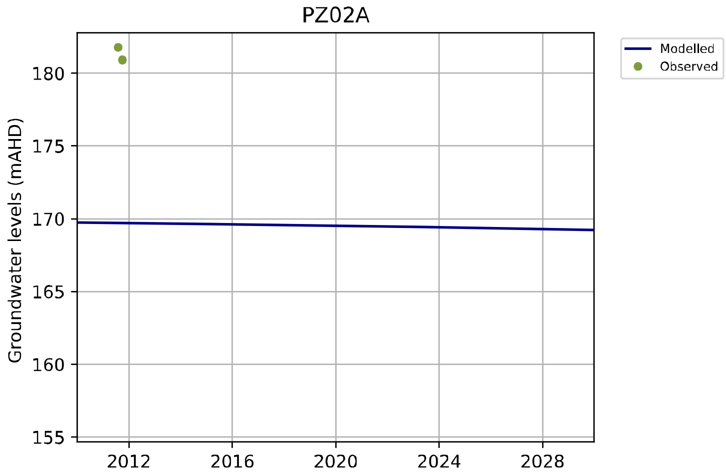

PZ00B
Groundwater levels (mAHD)
150
100
50
0
−50
2012
2016
2020
2024
2028
Modelled
Observed

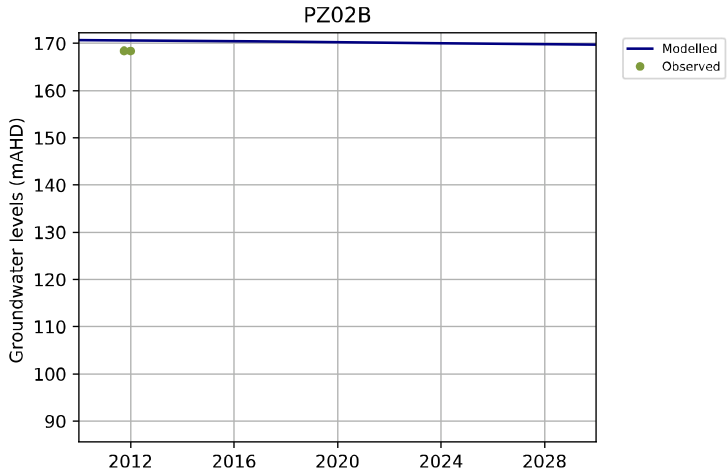

PZ00C
Groundwater levels (mAHD)
170
165
160
155
150
145
140
2012
2016
2020
2024
2028
Modelled
Observed

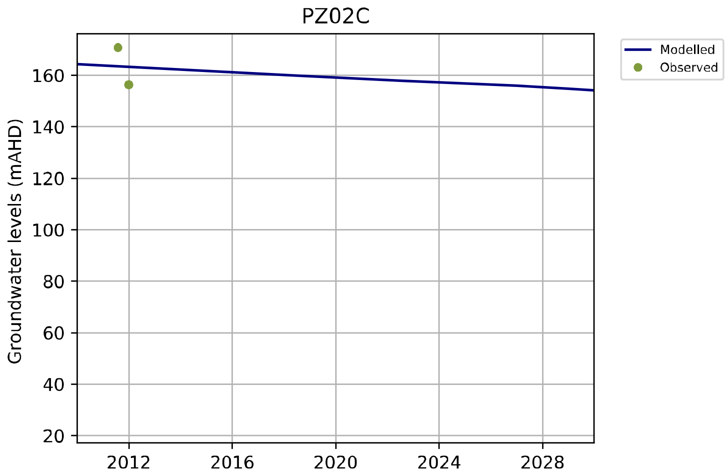

PZ00D
Groundwater levels (mAHD)
160
140
120
100
80
2012
2016
2020
2024
2028
Modelled
Observed

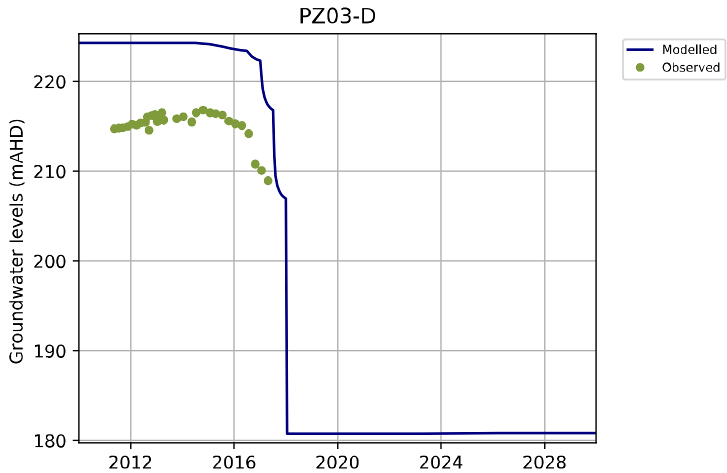

PZ01
Groundwater levels (mAHD)
40
60
80
100
120
140
160
180
200
2012
2016
2020
2024
2028
Modelled
Observed

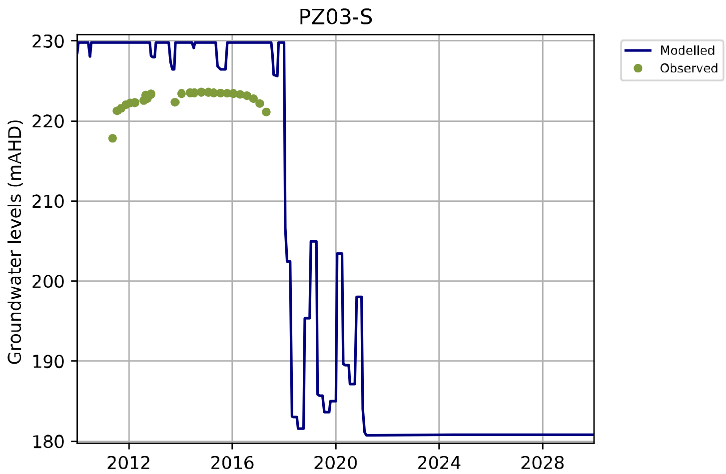

PZ02
Groundwater levels (mAHD)
190
195
200
205
210
215
220
2012
2016
2020
2024
2028
Modelled
Observed

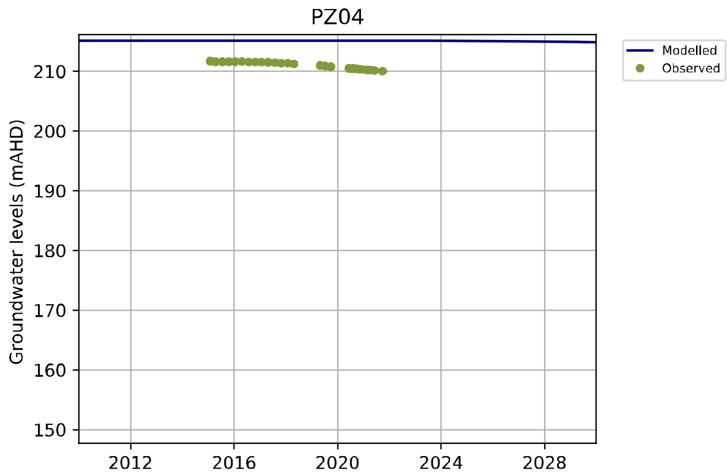

PZ02A
Groundwater levels (mAHD)
155
160
165
170
175
180
2012
2016
2020
2024
2028
Modelled
Observed

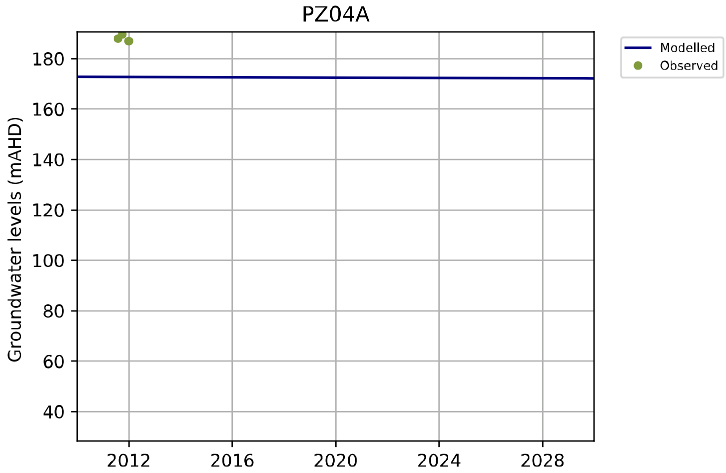

PZ02B
Groundwater levels (mAHD)
90
100
110
120
130
140
150
160
170
2012
2016
2020
2024
2028
Modelled
Observed

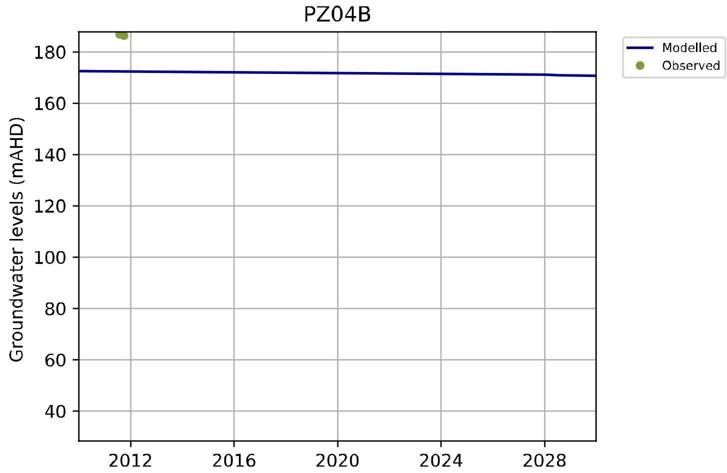

PZ02C
Groundwater levels (mAHD)
20
40
60
80
100
120
140
160
2012
2016
2020
2024
2028
Modelled
Observed

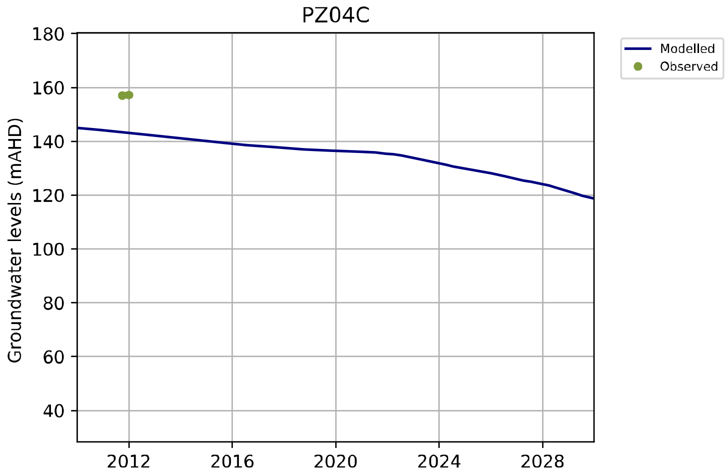

PZ03-D
Groundwater levels (mAHD)
180
190
200
210
220
2012
2016
2020
2024
2028
Modelled
Observed

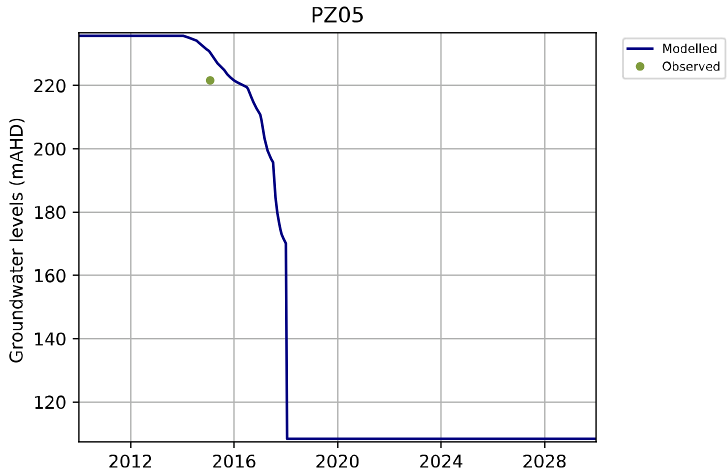

PZ03-S
Groundwater levels (mAHD)
180
190
200
210
220
230
2012
2016
2020
2024
2028
Modelled
Observed

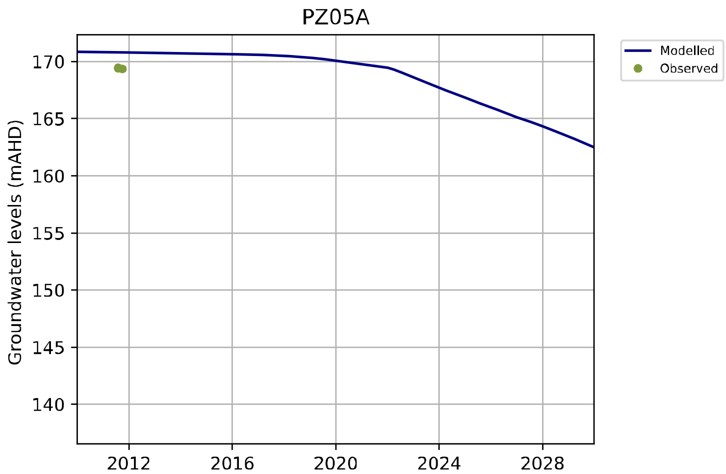

PZ04
Groundwater levels (mAHD)
150
160
170
180
190
200
210
2012
2016
2020
2024
2028
Modelled
Observed

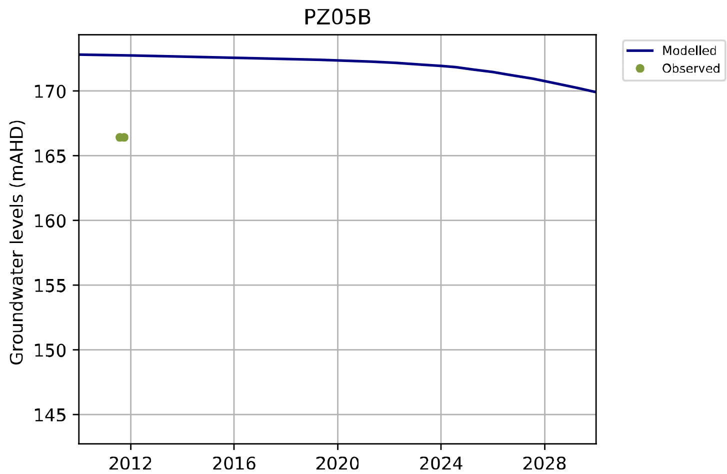

PZ04A
Groundwater levels (mAHD)
Modelled
Observed

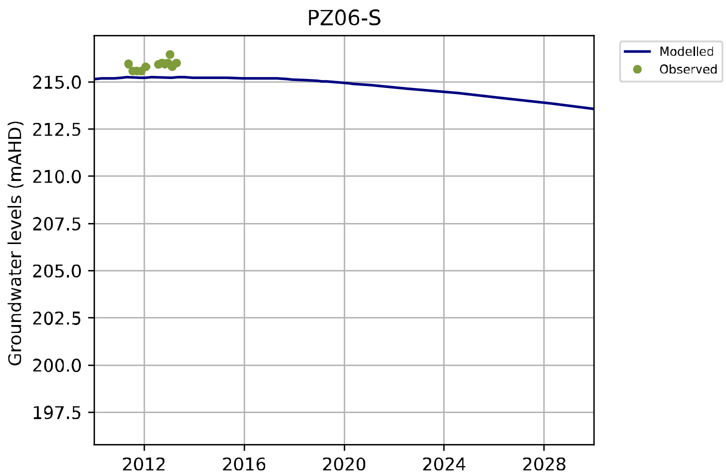

PZ04B
Groundwater levels (mAHD)
Modelled
Observed

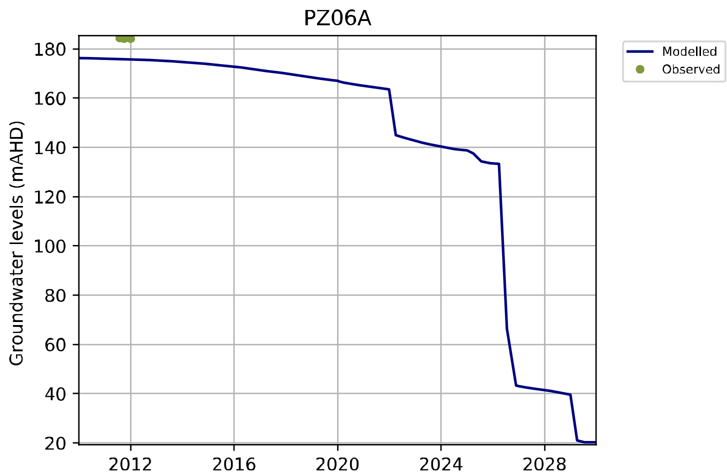

PZ04C
Groundwater levels (mAHD)
Modelled
Observed

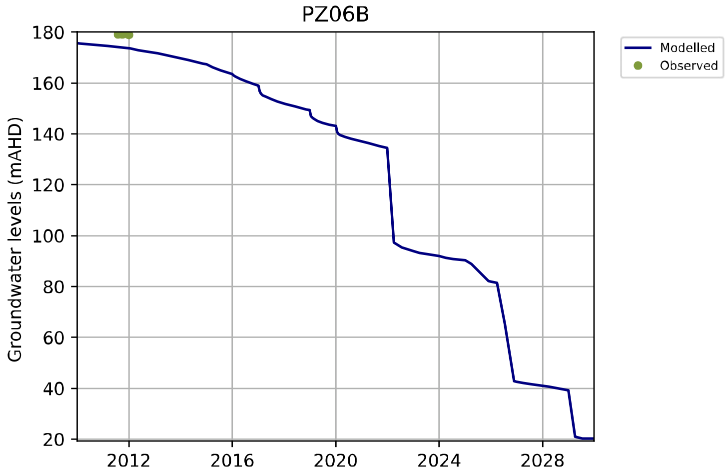

PZ05
Groundwater levels (mAHD)
Modelled
Observed

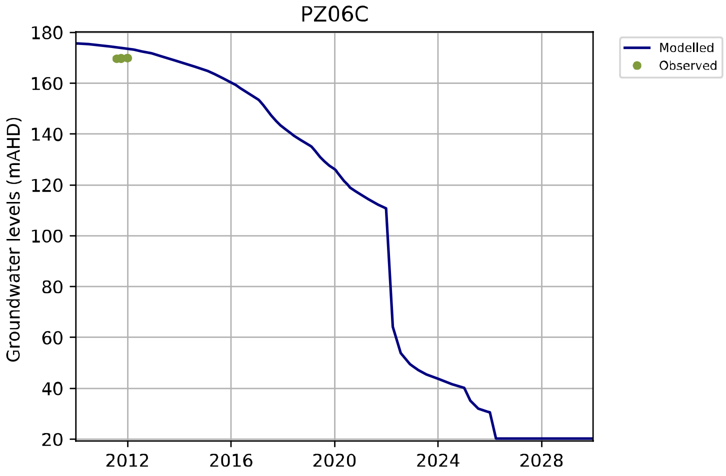

PZ05A
Groundwater levels (mAHD)
Modelled
Observed

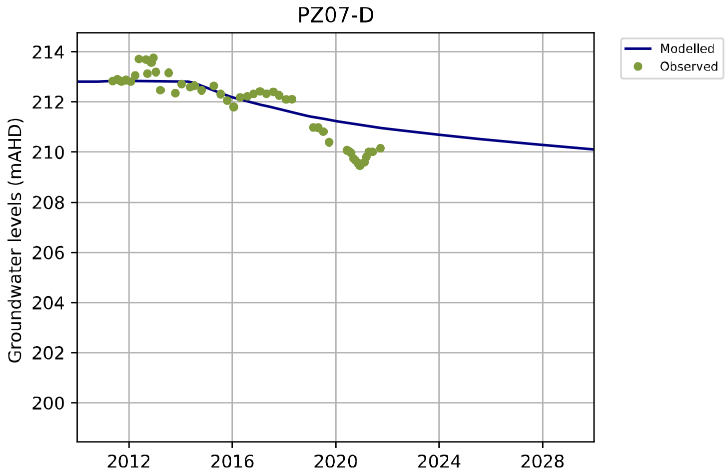

PZ05B
Groundwater levels (mAHD)
Modelled
Observed

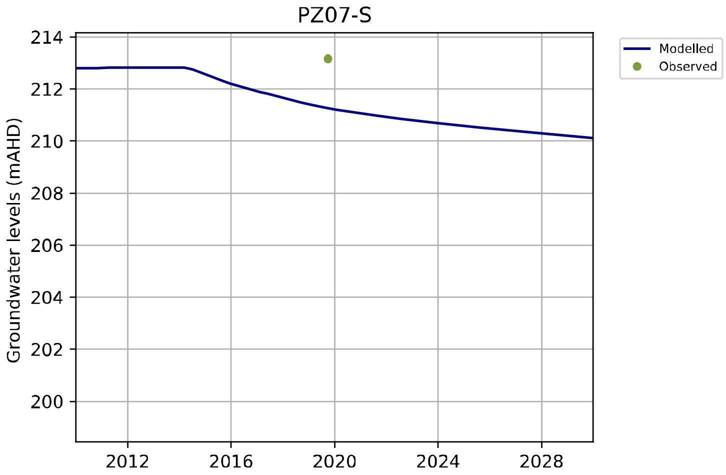

PZ06-S
Groundwater levels (mAHD)
Modelled
Observed

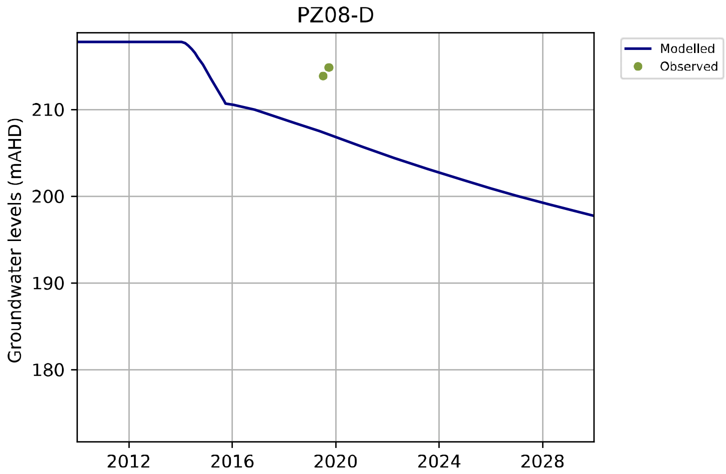

PZ06A
Groundwater levels (mAHD)
Modelled
Observed

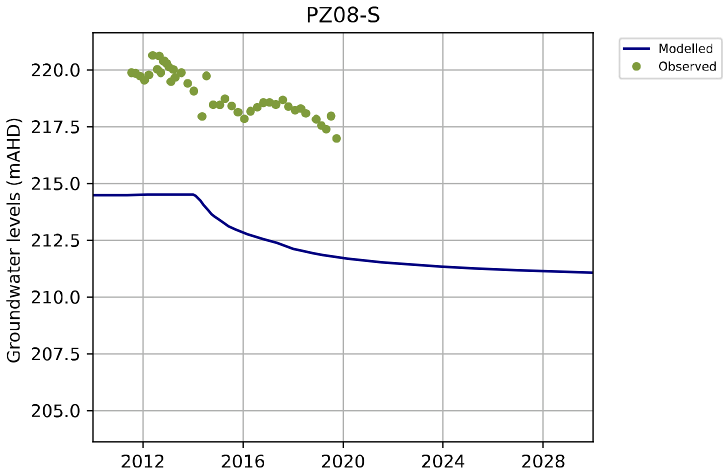

PZ06B
Groundwater levels (mAHD)
Modelled
Observed

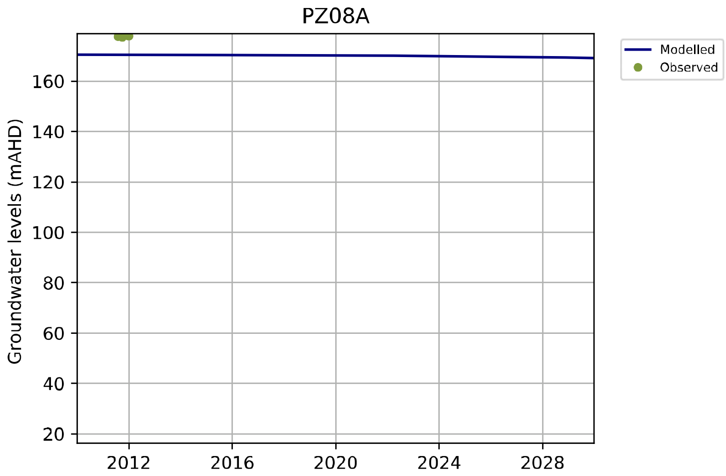

PZ06C
Groundwater levels (mAHD)
Modelled
Observed

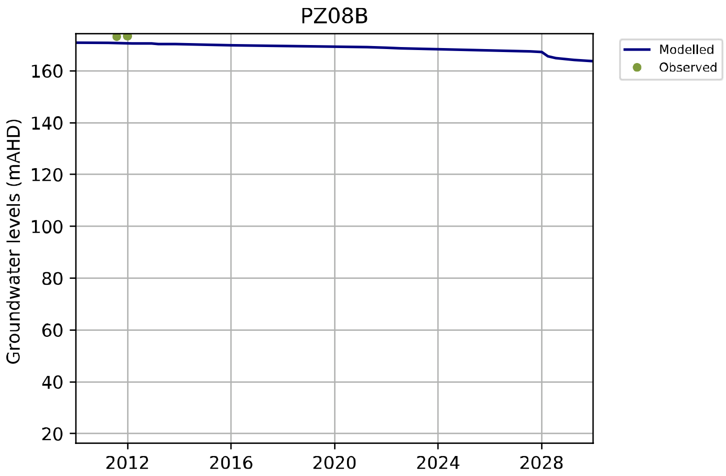

PZ07-D
Groundwater levels (mAHD)
Modelled
Observed

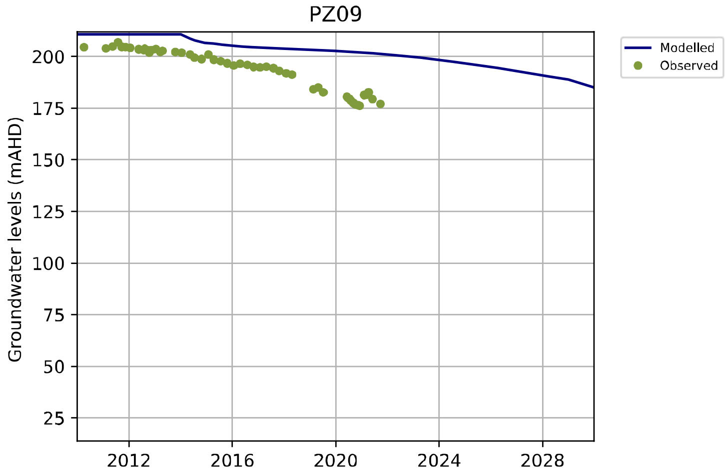

PZ07-S
Groundwater levels (mAHD)
Modelled
Observed

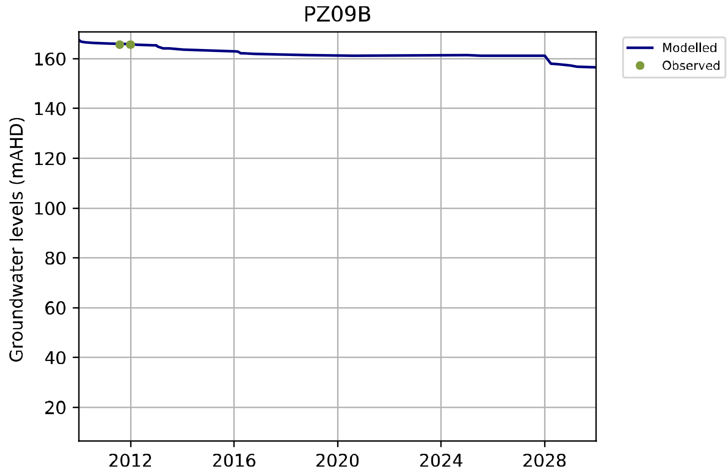

PZ08-D
Groundwater levels (mAHD)
Modelled
Observed

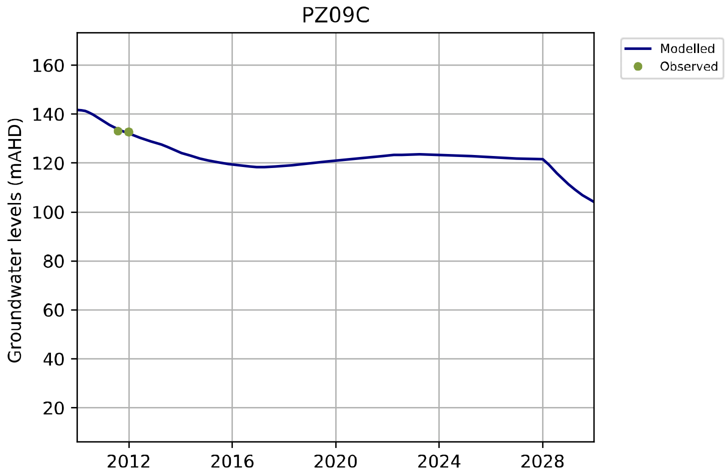

PZ08-S
Groundwater levels (mAHD)
Modelled
Observed

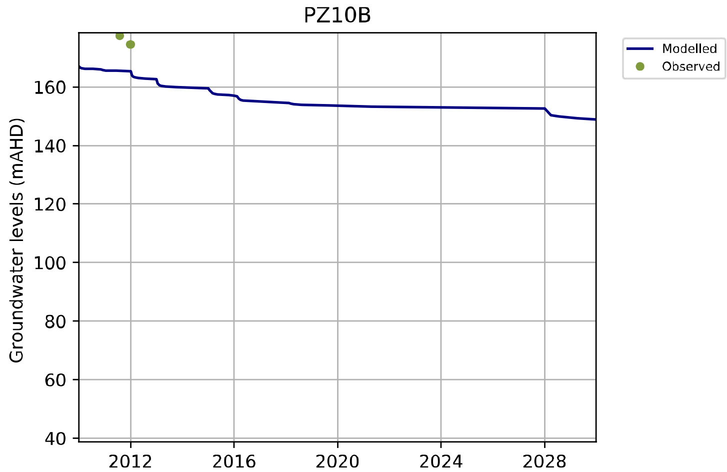

PZ08A
Groundwater levels (mAHD)
Modelled
Observed

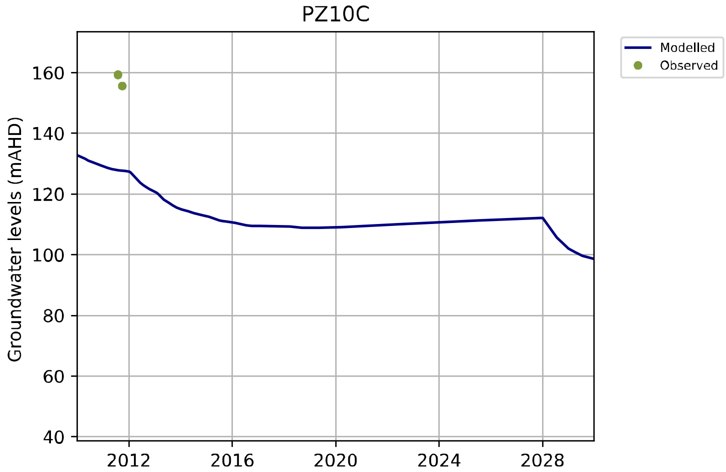

PZ08B
Groundwater levels (mAHD)
Modelled
Observed

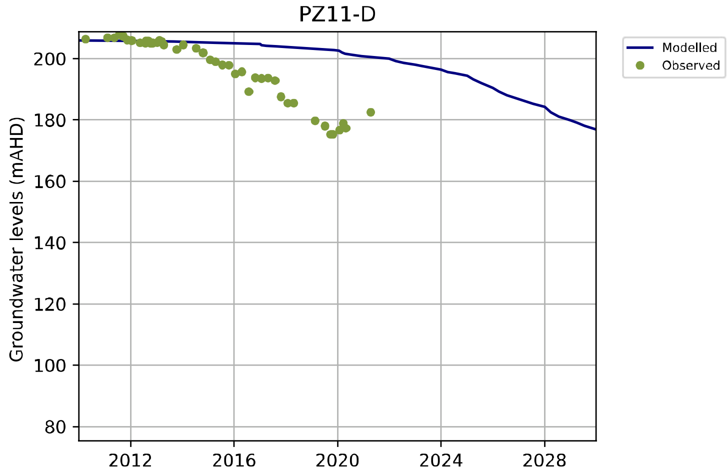

PZ09
Groundwater levels (mAHD)
200
175
150
125
100
75
50
25
2012
2016
2020
2024
2028
Modelled
Observed

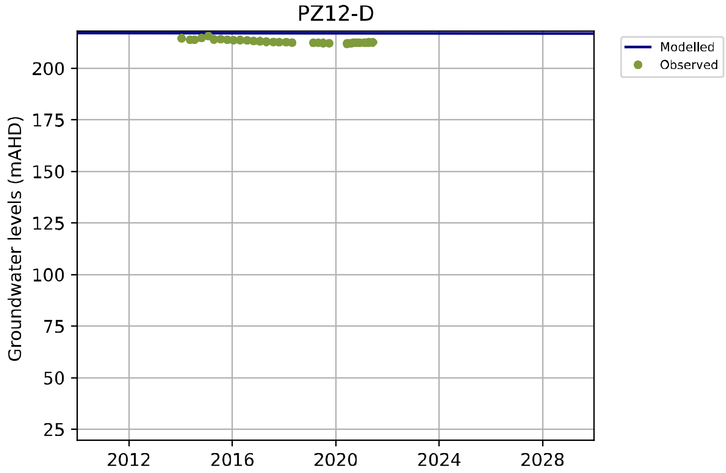

PZ09B
Groundwater levels (mAHD)
160
140
120
100
80
60
40
20
2012
2016
2020
2024
2028
Modelled
Observed

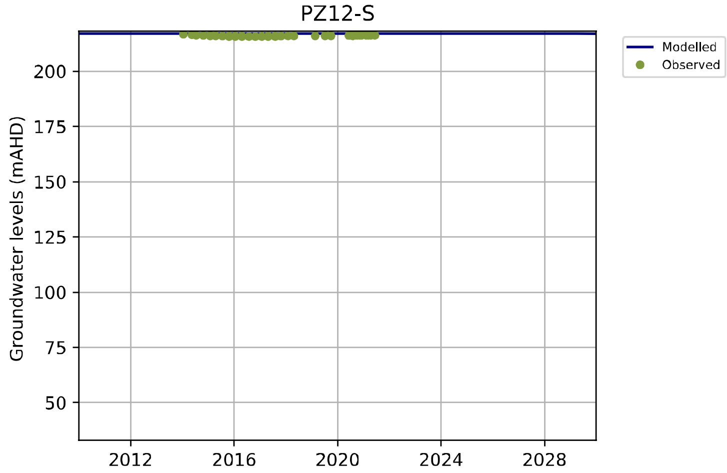

PZ09C
Groundwater levels (mAHD)
160
140
120
100
80
60
40
20
2012
2016
2020
2024
2028
Modelled
Observed

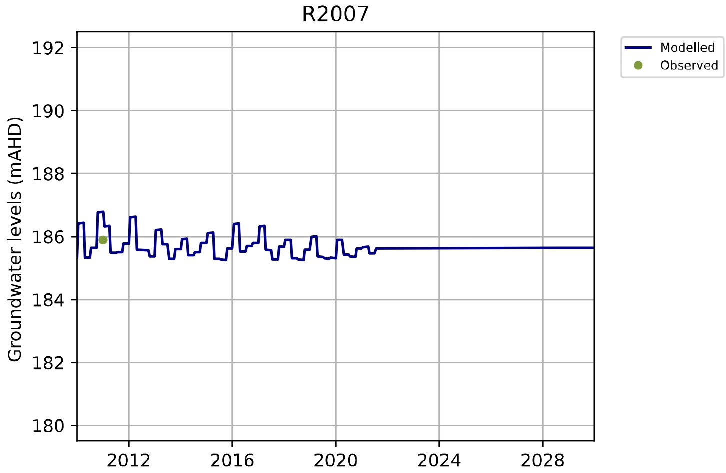

PZ10B
Groundwater levels (mAHD)
160
140
120
100
80
60
40
2012
2016
2020
2024
2028
Modelled
Observed

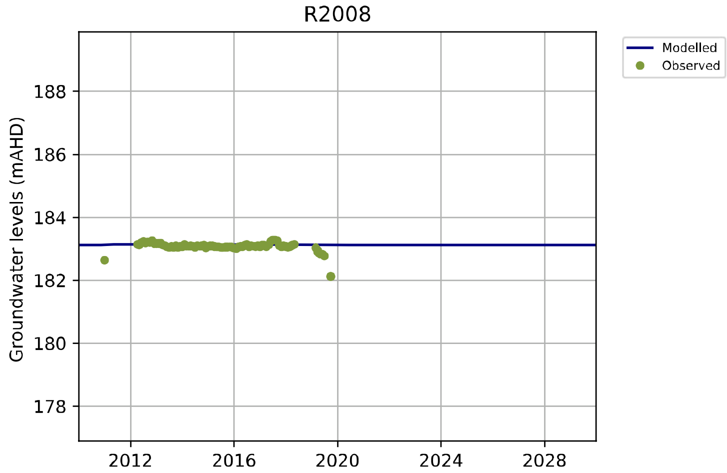

PZ10C
Groundwater levels (mAHD)
160
140
120
100
80
60
40
2012
2016
2020
2024
2028
Modelled
Observed

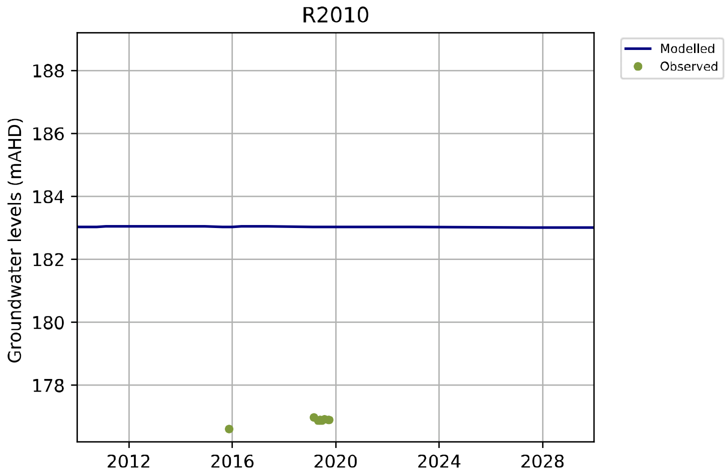

PZ11-D
Groundwater levels (mAHD)
200
180
160
140
120
100
80
2012
2016
2020
2024
2028
Modelled
Observed

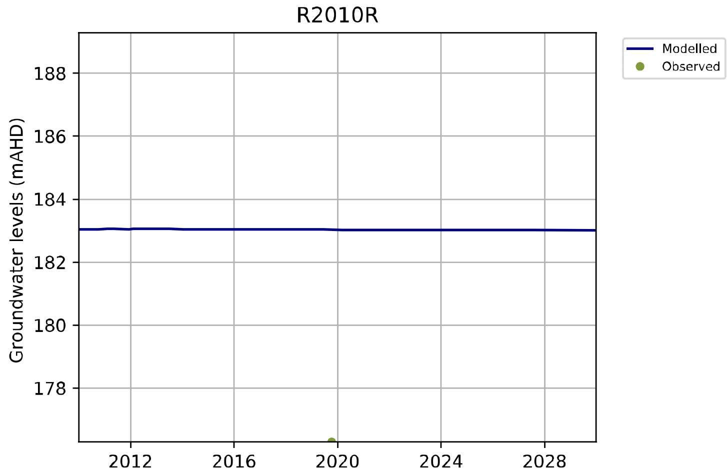

PZ12-D
Groundwater levels (mAHD)
200
175
150
125
100
75
50
25
2012
2016
2020
2024
2028
Modelled
Observed

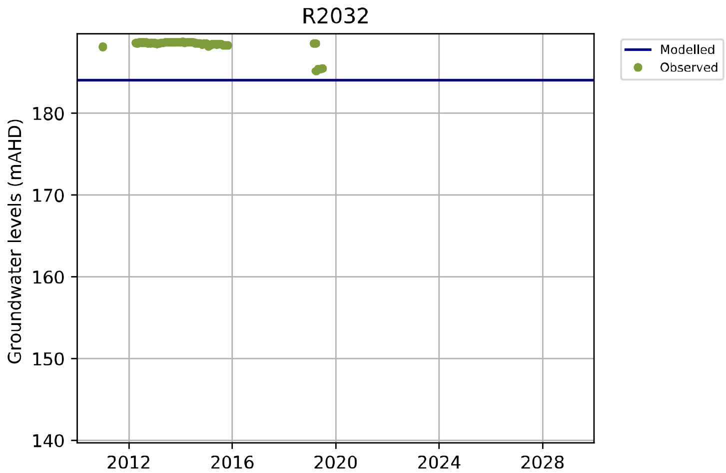

PZ12-S
Groundwater levels (mAHD)
200
175
150
125
100
75
50
2012
2016
2020
2024
2028
Modelled
Observed

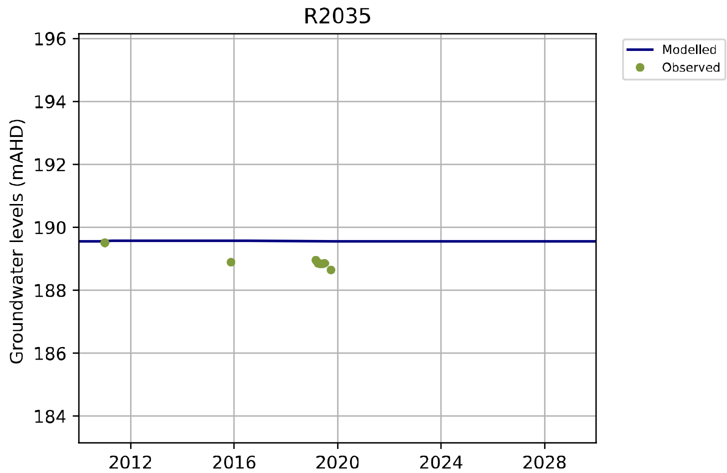

R2007
Groundwater levels (mAHD)
192
190
188
186
184
182
180
2012
2016
2020
2024
2028
Modelled
Observed

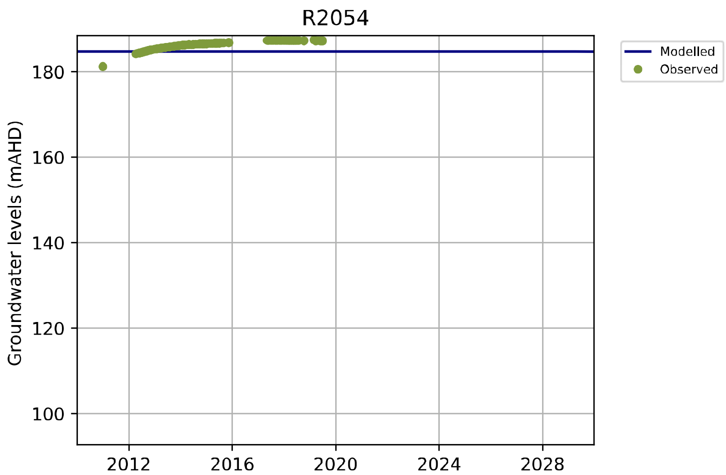

R2008
Groundwater levels (mAHD)
188
186
184
182
180
178
2012
2016
2020
2024
2028
Modelled
Observed

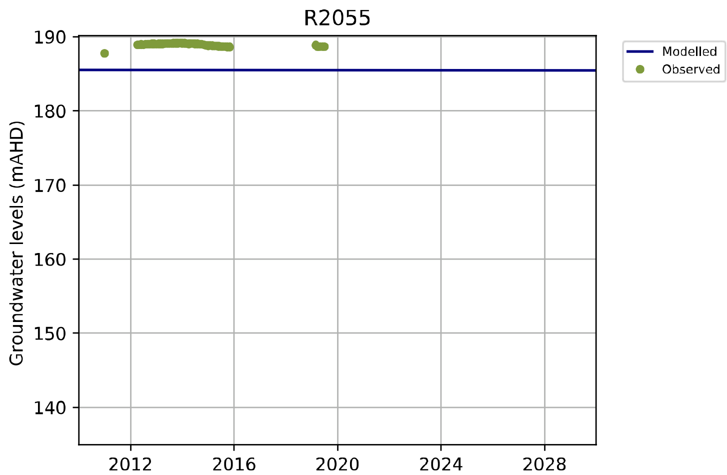

R2010
Groundwater levels (mAHD)
188
186
184
182
180
178
2012
2016
2020
2024
2028
Modelled
Observed

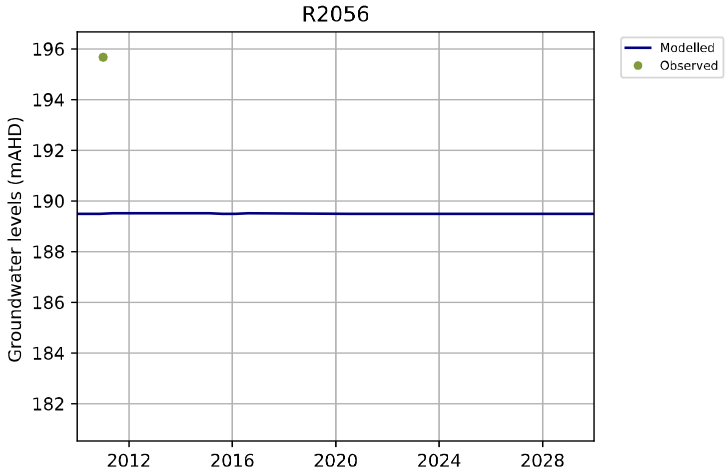

R2010R
Groundwater levels (mAHD)
188
186
184
182
180
178
2012
2016
2020
2024
2028
Modelled
Observed

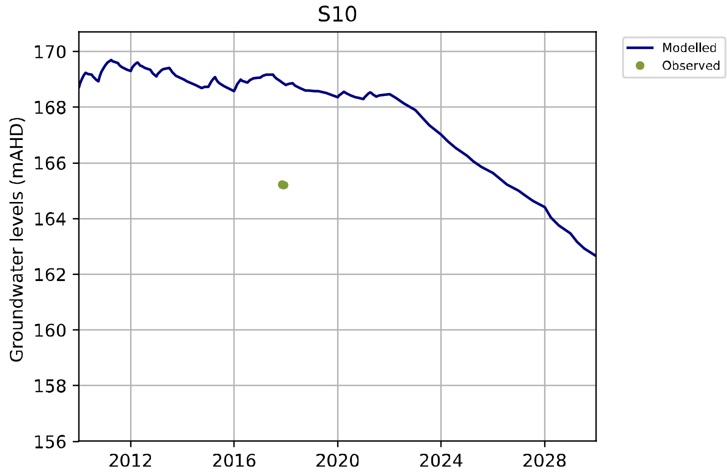

R2032
Groundwater levels (mAHD)
180
170
160
150
140
2012
2016
2020
2024
2028
Modelled
Observed

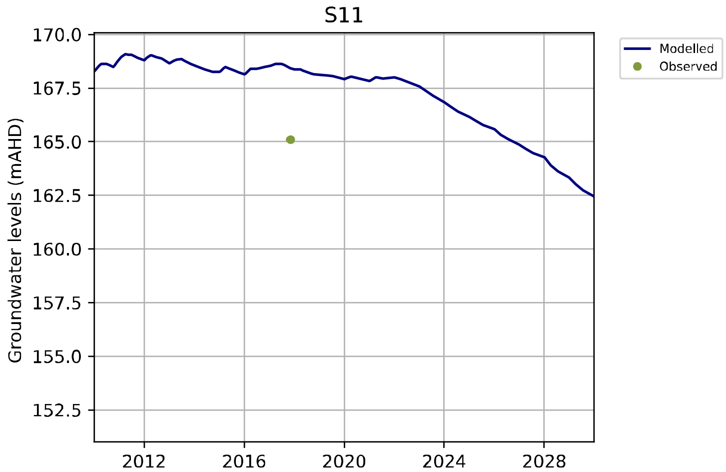

R2035
Groundwater levels (mAHD)
196
194
192
190
188
186
184
2012
2016
2020
2024
2028
Modelled
Observed

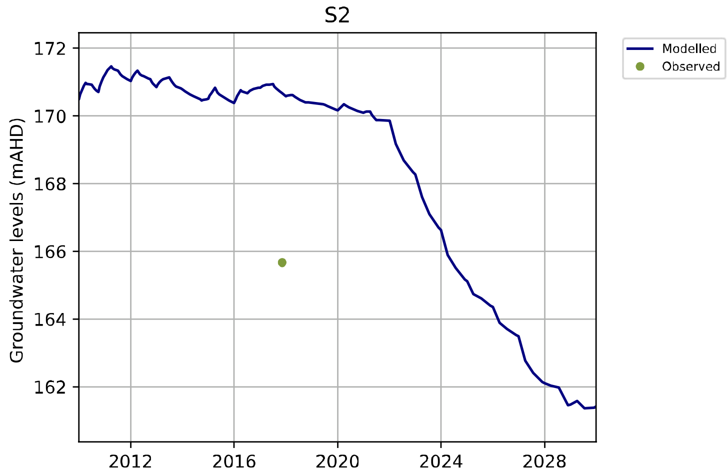

R2054
Groundwater levels (mAHD)
180
160
140
120
100
2012
2016
2020
2024
2028
Modelled
Observed

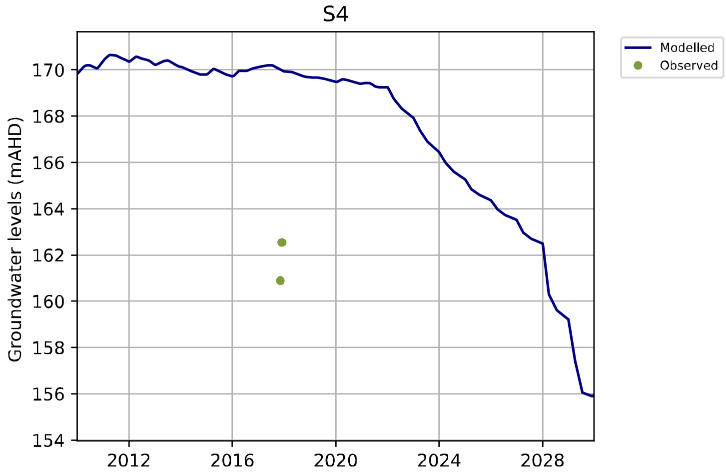

R2055
Groundwater levels (mAHD)
190
180
170
160
150
140
2012
2016
2020
2024
2028
Modelled
Observed

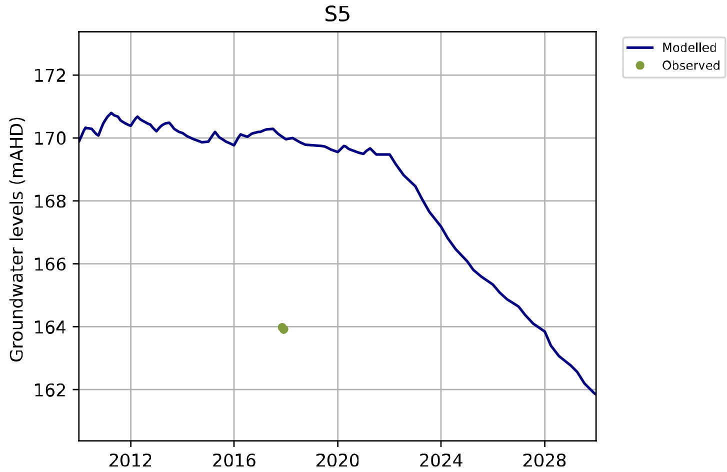

R2056
Groundwater levels (mAHD)
196
194
192
190
188
186
184
182
2012
2016
2020
2024
2028
Modelled
Observed

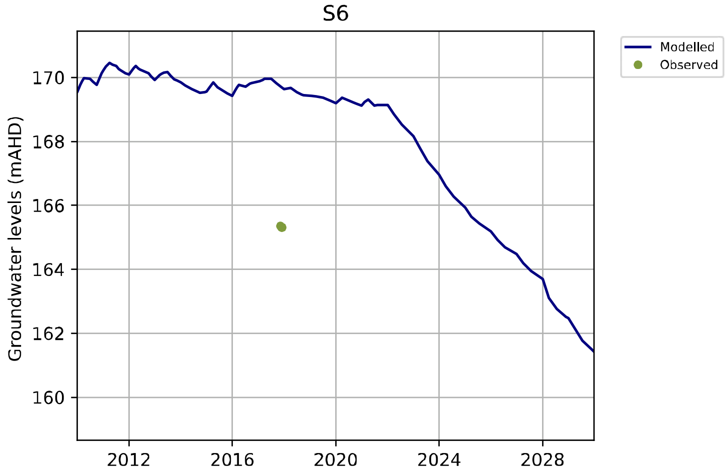

S10
Groundwater levels (mAHD)
170
168
166
164
162
160
158
156
2012
2016
2020
2024
2028
Modelled
Observed

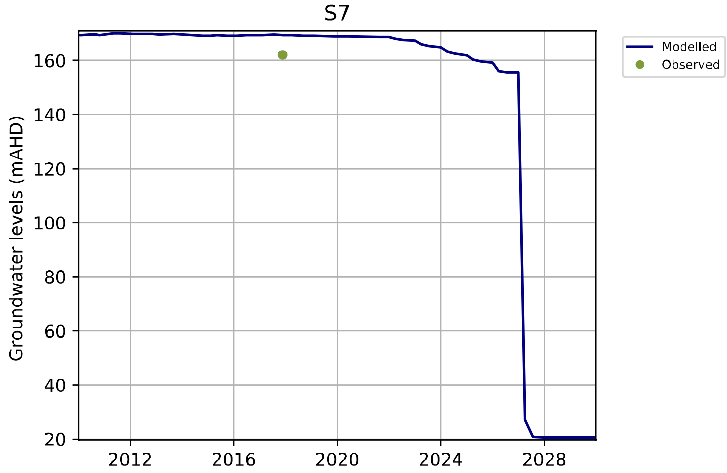

S11
Groundwater levels (mAHD)
170.0
167.5
165.0
162.5
160.0
157.5
155.0
152.5
2012
2016
2020
2024
2028
Modelled
Observed

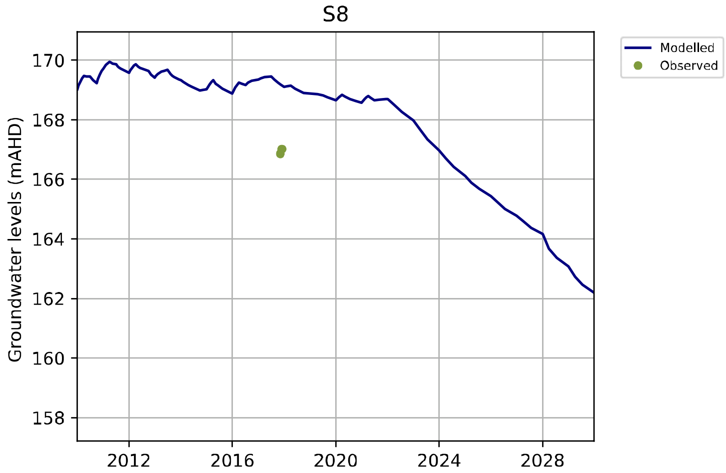

S2
Groundwater levels (mAHD)
172
170
168
166
164
162
2012
2016
2020
2024
2028
Modelled
Observed

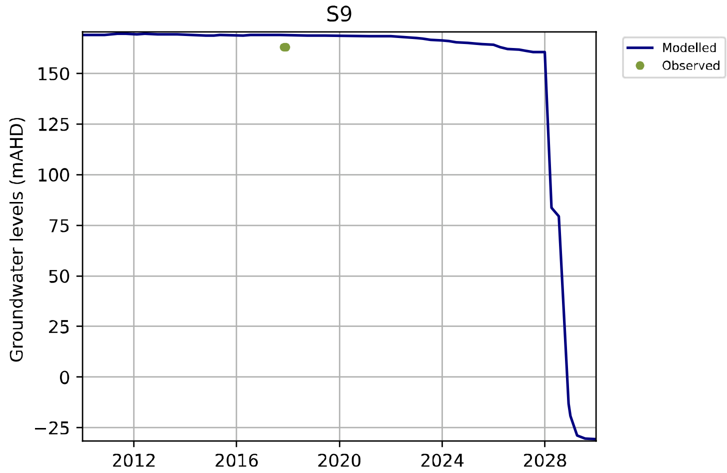

S4
Groundwater levels (mAHD)
170
168
166
164
162
160
158
156
154
2012
2016
2020
2024
2028
Modelled
Observed

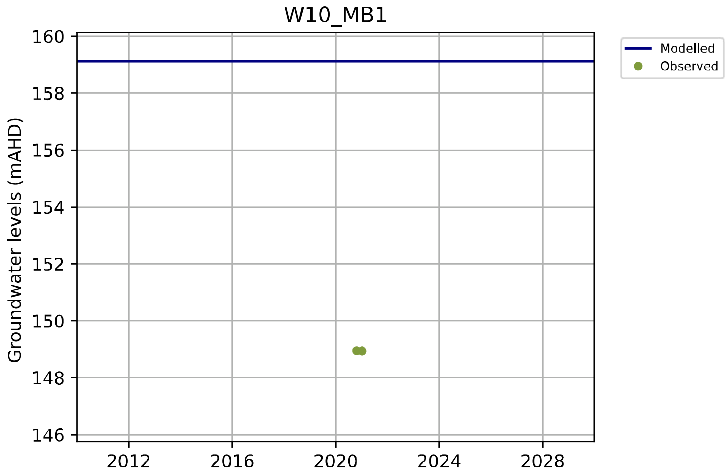

S5
Groundwater levels (mAHD)
172
170
168
166
164
162
2012
2016
2020
2024
2028
Modelled
Observed

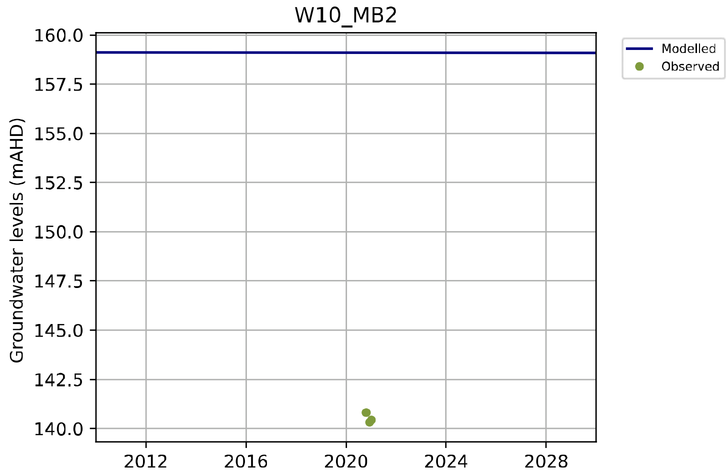

S6
Groundwater levels (mAHD)
170
168
166
164
162
160
2012
2016
2020
2024
2028
Modelled
Observed

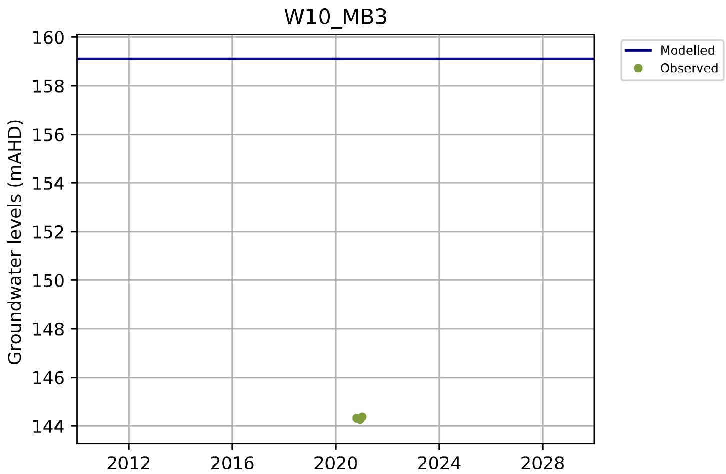

S7
Groundwater levels (mAHD)
160
140
120
100
80
60
40
20
2012
2016
2020
2024
2028
Modelled
Observed

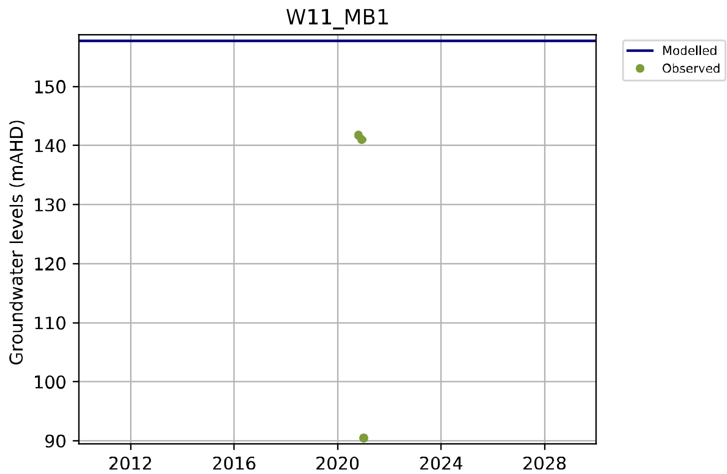

S8
Groundwater levels (mAHD)
170
168
166
164
162
160
158
2012
2016
2020
2024
2028
Modelled
Observed

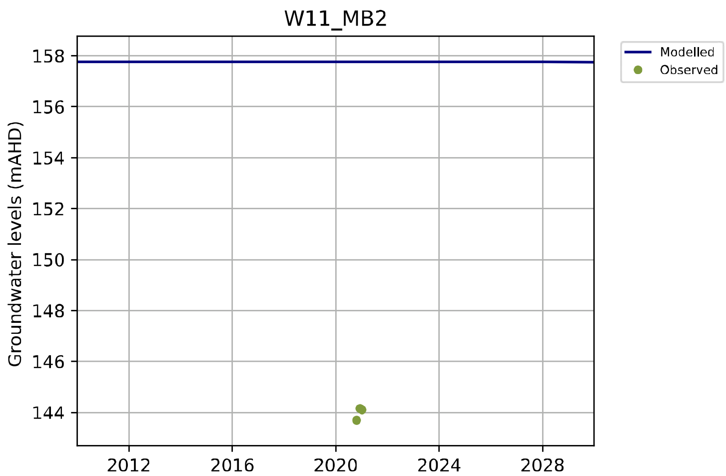

S9
Groundwater levels (mAHD)
150
125
100
75
50
25
0
−25
2012
2016
2020
2024
2028
Modelled
Observed

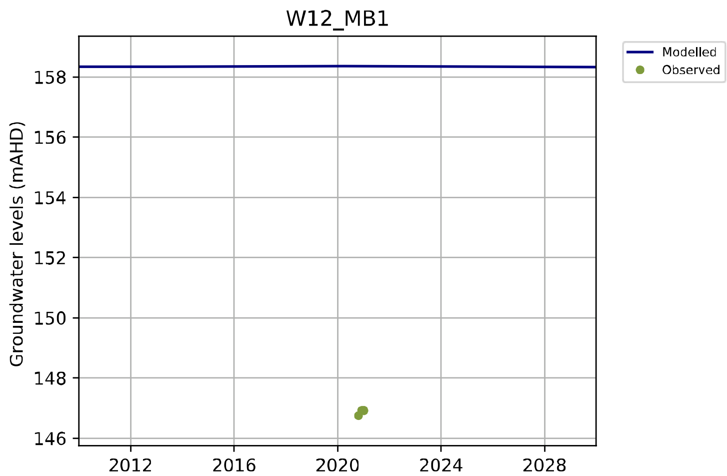

W10_MB1
Groundwater levels (mAHD)
160
158
156
154
152
150
148
146
2012
2016
2020
2024
2028
Modelled
Observed

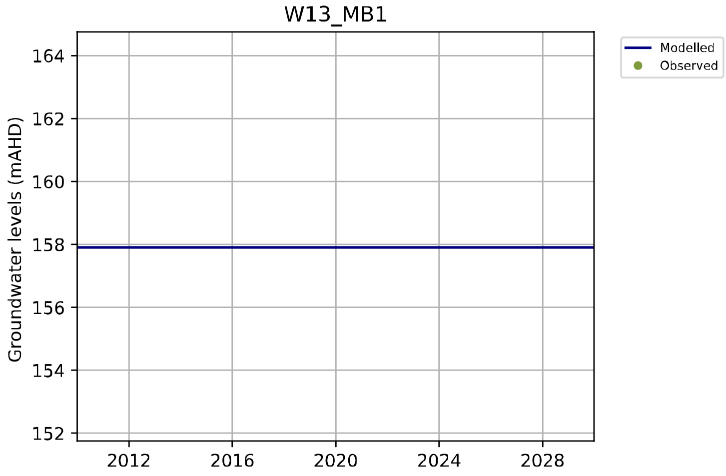

W10_MB2
Groundwater levels (mAHD)
160.0
157.5
155.0
152.5
150.0
147.5
145.0
142.5
140.0
2012
2016
2020
2024
2028
Modelled
Observed

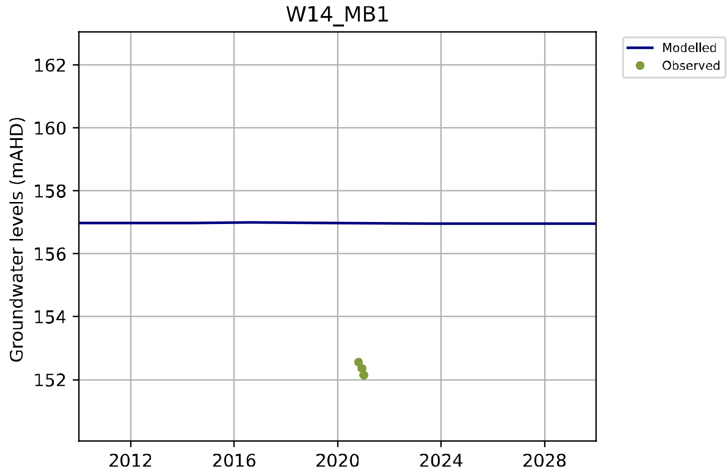

W10_MB3
Groundwater levels (mAHD)
160
158
156
154
152
150
148
146
144
2012
2016
2020
2024
2028
Modelled
Observed

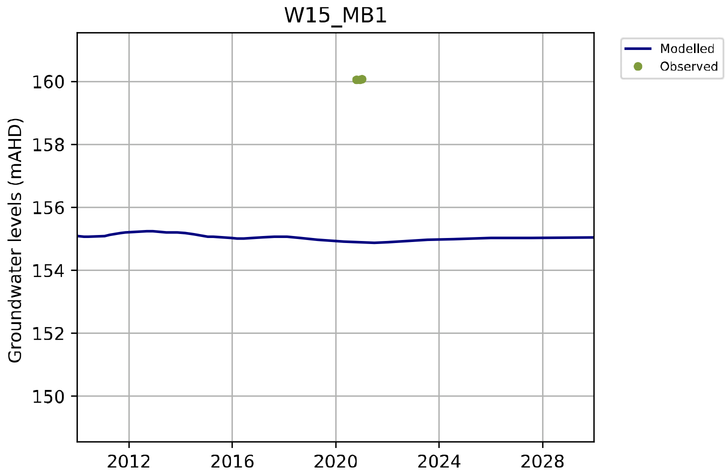

W11_MB1
Groundwater levels (mAHD)
150
140
130
120
110
100
90
2012
2016
2020
2024
2028
Modelled
Observed

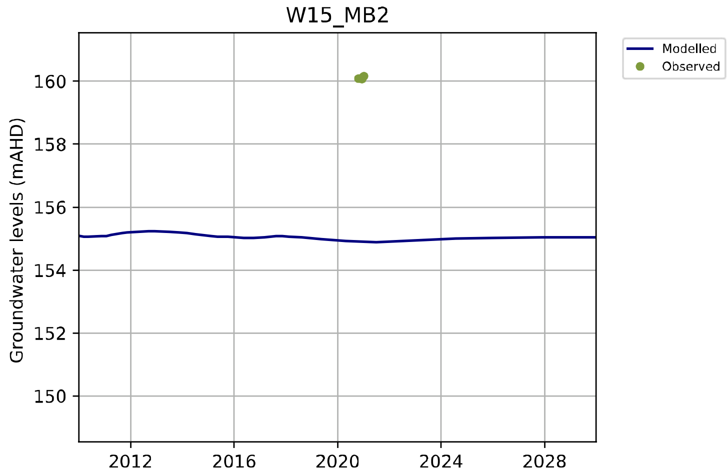

W11_MB2
Groundwater levels (mAHD)
158
156
154
152
150
148
146
144
2012
2016
2020
2024
2028
Modelled
Observed

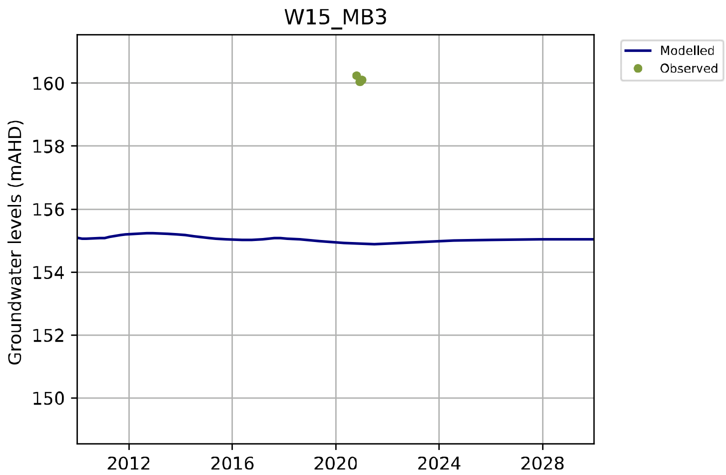

W12_MB1
Groundwater levels (mAHD)
158
156
154
152
150
148
146
2012
2016
2020
2024
2028
Modelled
Observed

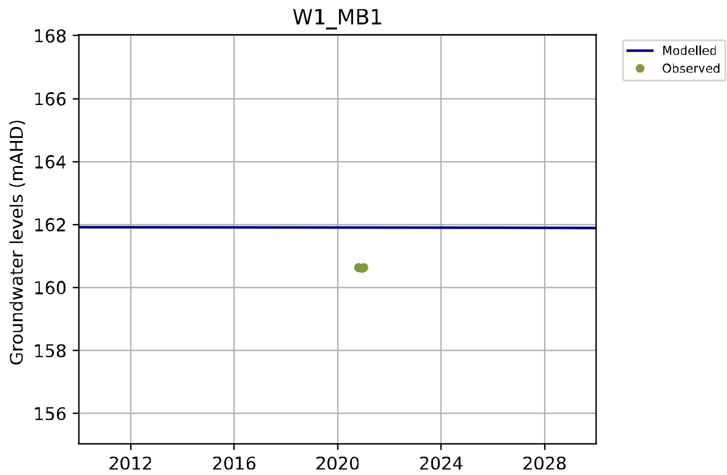

W13_MB1
Groundwater levels (mAHD)
164
162
160
158
156
154
152
2012
2016
2020
2024
2028
Modelled
Observed

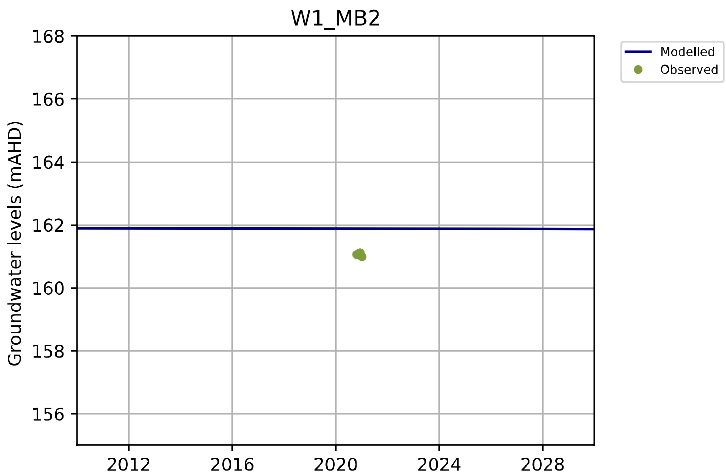

W14_MB1
Groundwater levels (mAHD)
162
160
158
156
154
152
2012
2016
2020
2024
2028
Modelled
Observed

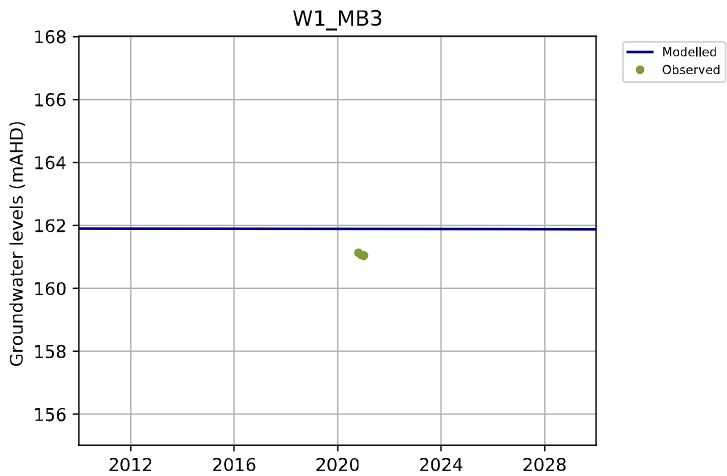

W15_MB1
Groundwater levels (mAHD)
160
158
156
154
152
150
2012
2016
2020
2024
2028
Modelled
Observed

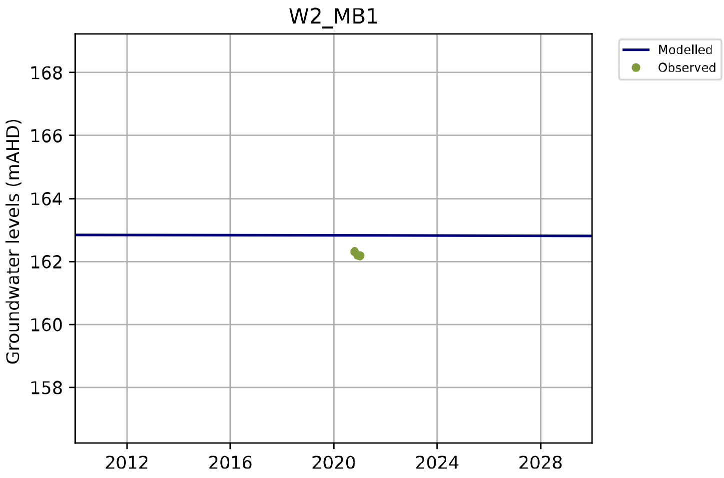

W15_MB2
Groundwater levels (mAHD)
160
158
156
154
152
150
2012
2016
2020
2024
2028
Modelled
Observed

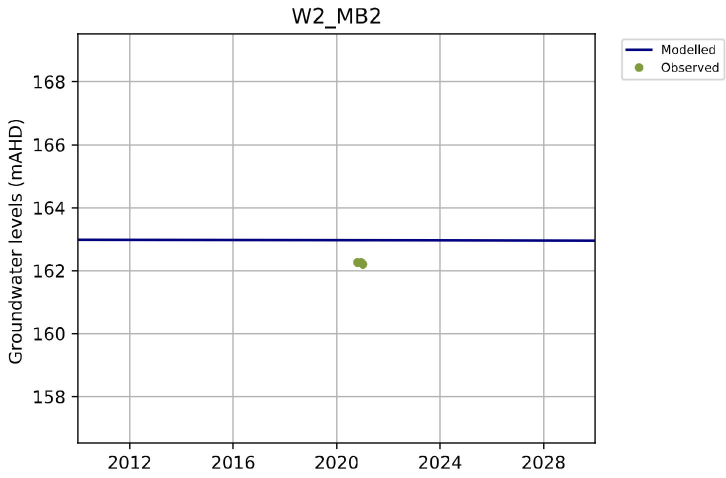

W15_MB3
Groundwater levels (mAHD)
160
158
156
154
152
150
2012
2016
2020
2024
2028
Modelled
Observed

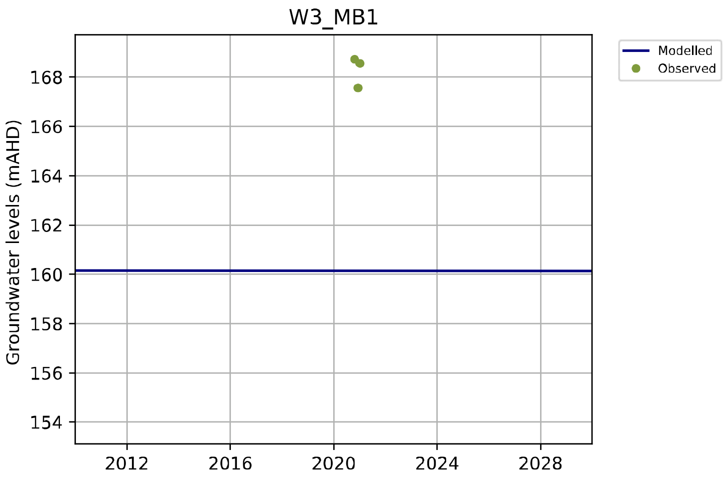

W1_MB1
Groundwater levels (mAHD)
168
166
164
162
160
158
156
2012
2016
2020
2024
2028
Modelled
Observed

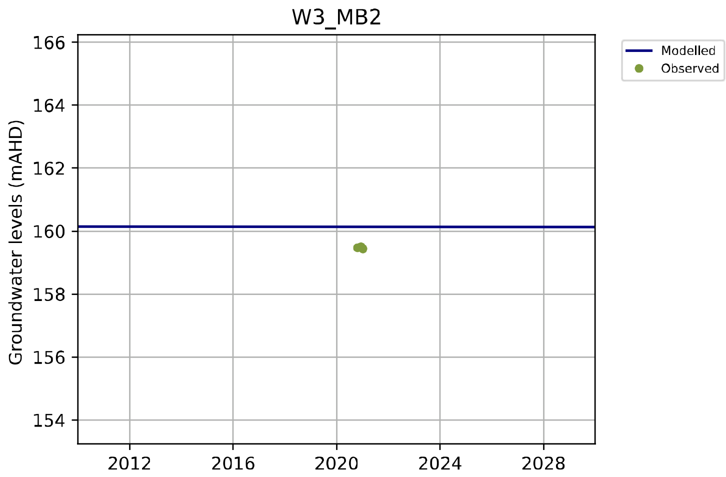

W1_MB2
Groundwater levels (mAHD)
168
166
164
162
160
158
156
2012
2016
2020
2024
2028
Modelled
Observed

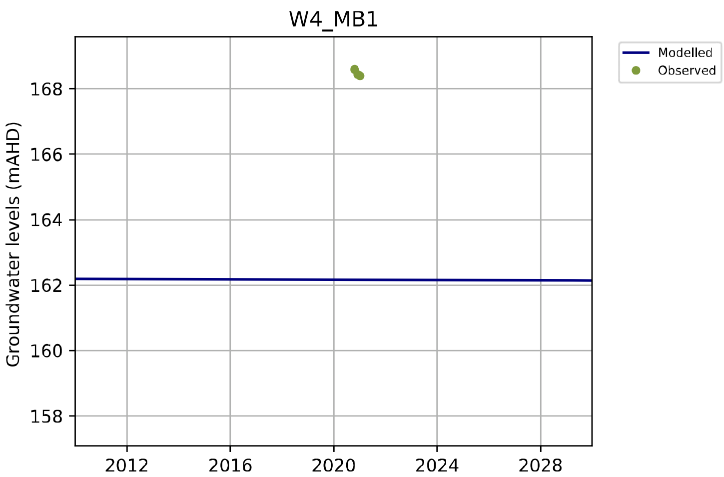

W1_MB3
Groundwater levels (mAHD)
168
166
164
162
160
158
156
2012
2016
2020
2024
2028
Modelled
Observed

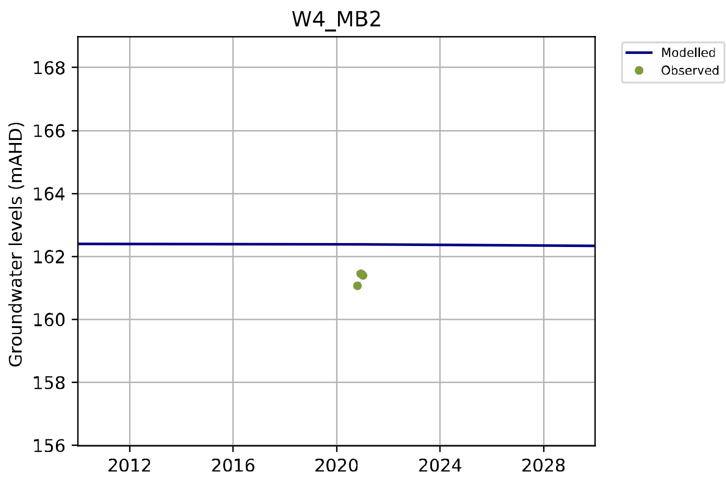

W2_MB1
Groundwater levels (mAHD)
168
166
164
162
160
158
2012
2016
2020
2024
2028
Modelled
Observed

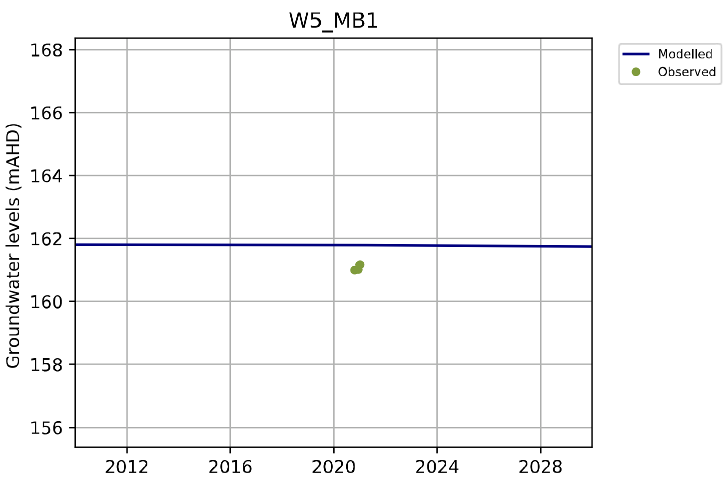

W2_MB2
Groundwater levels (mAHD)
168
166
164
162
160
158
2012
2016
2020
2024
2028
Modelled
Observed

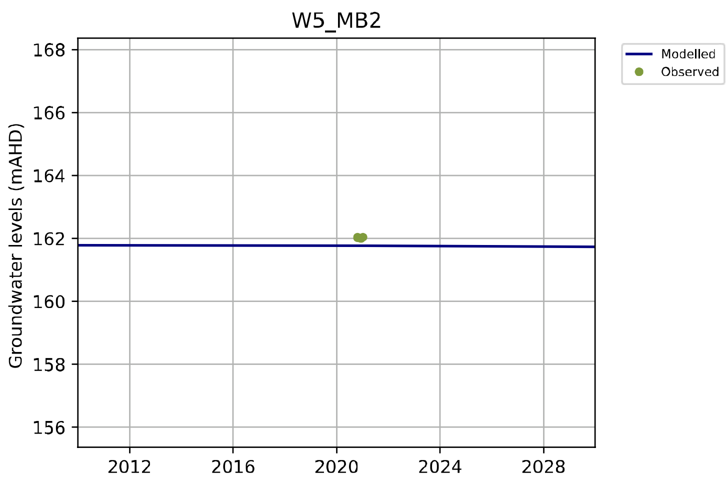

W3_MB1
Groundwater levels (mAHD)
168
166
164
162
160
158
156
154
2012
2016
2020
2024
2028
Modelled
Observed

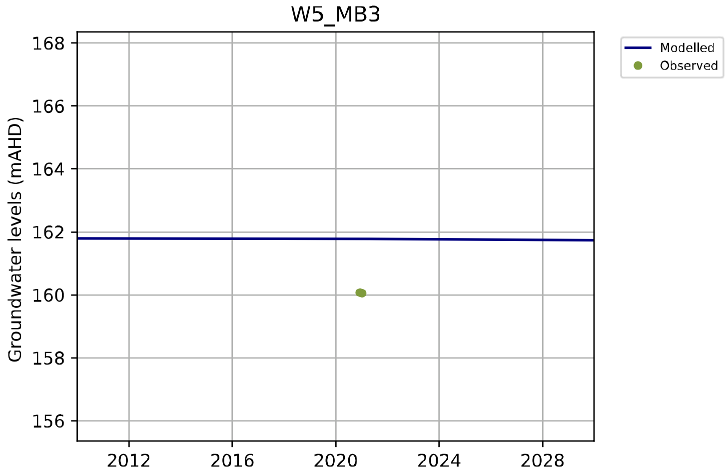

W3_MB2
Groundwater levels (mAHD)
166
164
162
160
158
156
154
2012
2016
2020
2024
2028
Modelled
Observed

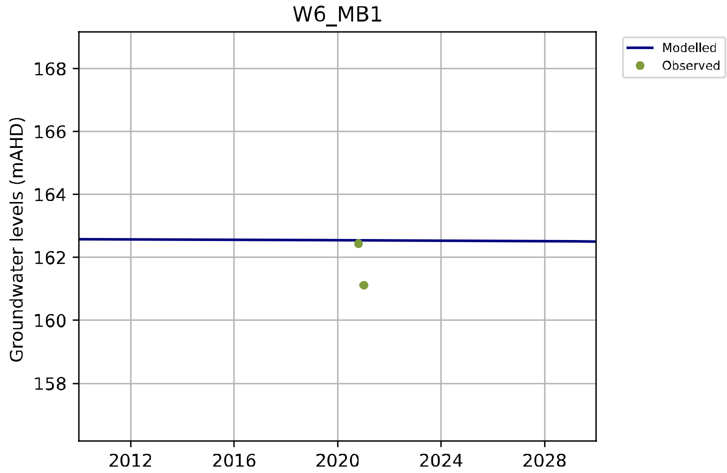

W4_MB1
Groundwater levels (mAHD)
168
166
164
162
160
158
2012
2016
2020
2024
2028
Modelled
Observed

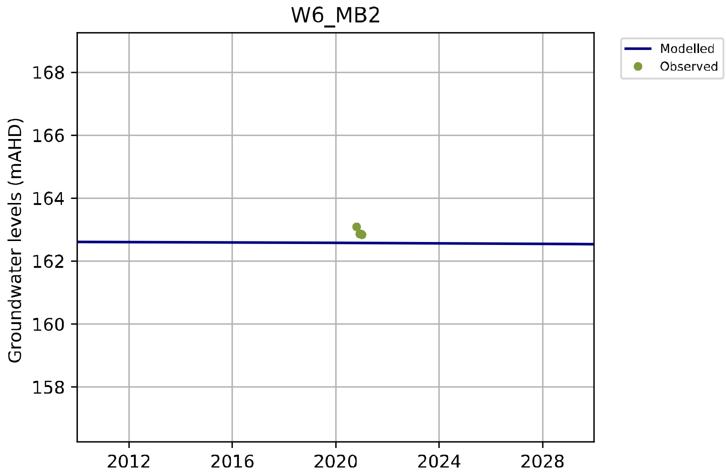

W4_MB2
Groundwater levels (mAHD)
168
166
164
162
160
158
156
2012
2016
2020
2024
2028
Modelled
Observed

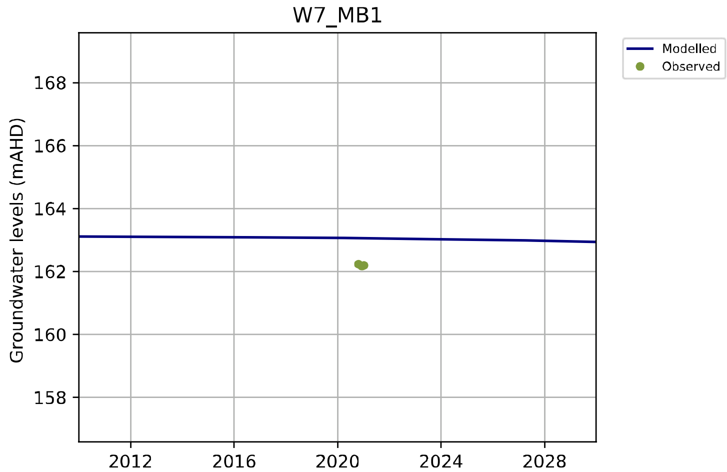

W5_MB1
Groundwater levels (mAHD)
168
166
164
162
160
158
156
2012
2016
2020
2024
2028
Modelled
Observed

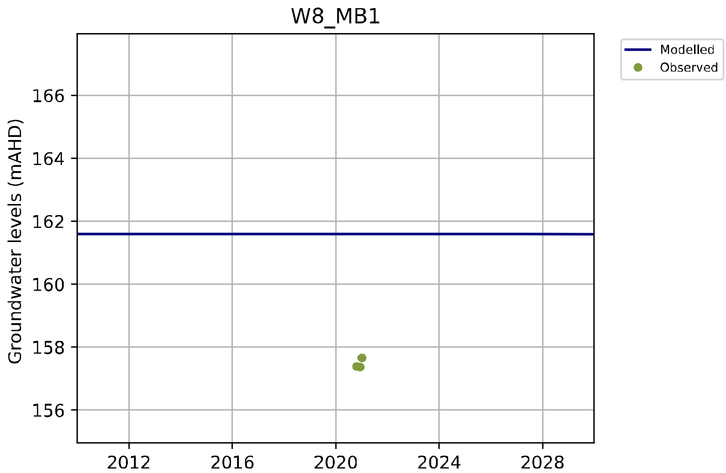

W5_MB2
Groundwater levels (mAHD)
168
166
164
162
160
158
156
2012
2016
2020
2024
2028
Modelled
Observed

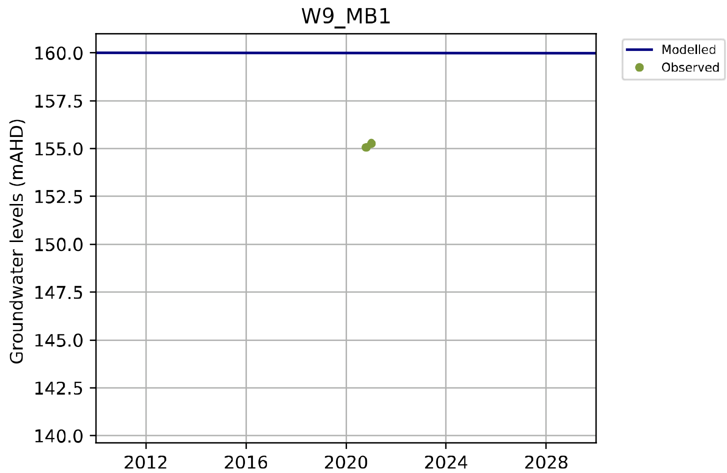

W5_MB3
Groundwater levels (mAHD)
168
166
164
162
160
158
156
2012
2016
2020
2024
2028
Modelled
Observed

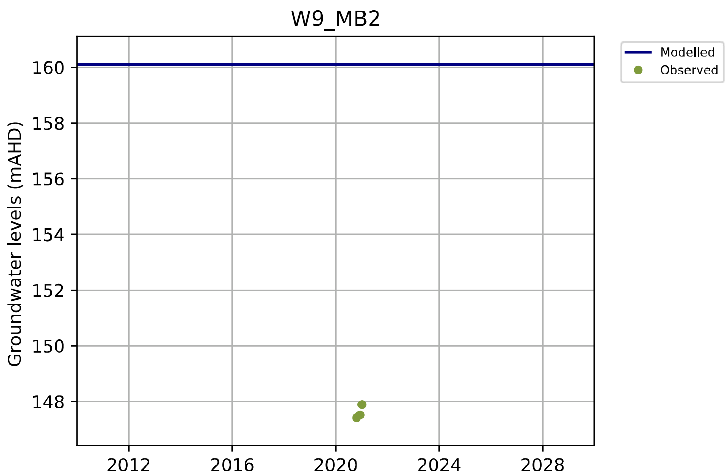

W6_MB1
Groundwater levels (mAHD)
168
166
164
162
160
158
2012
2016
2020
2024
2028
Modelled
Observed

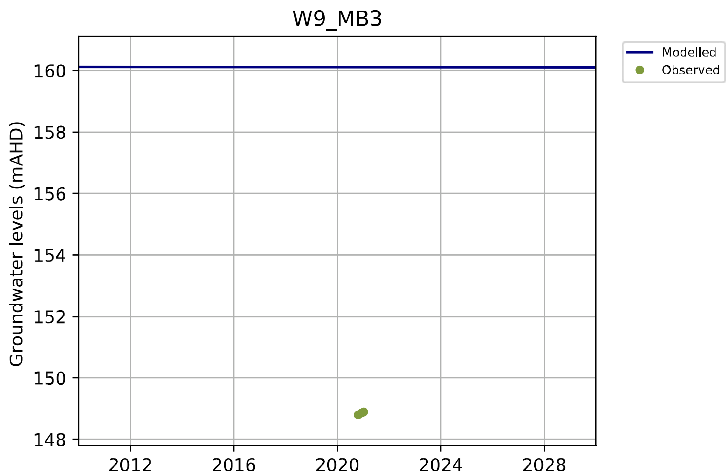

W6_MB2
Groundwater levels (mAHD)
168
166
164
162
160
158
2012
2016
2020
2024
2028
Modelled
Observed

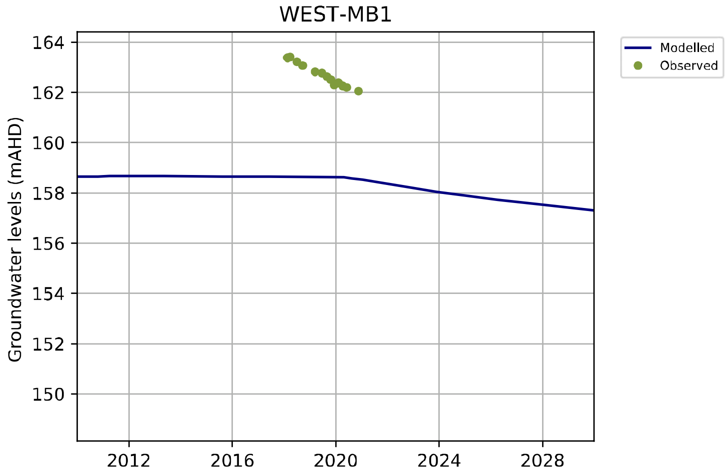

W7_MB1
Groundwater levels (mAHD)
168
166
164
162
160
158
2012
2016
2020
2024
2028
Modelled
Observed

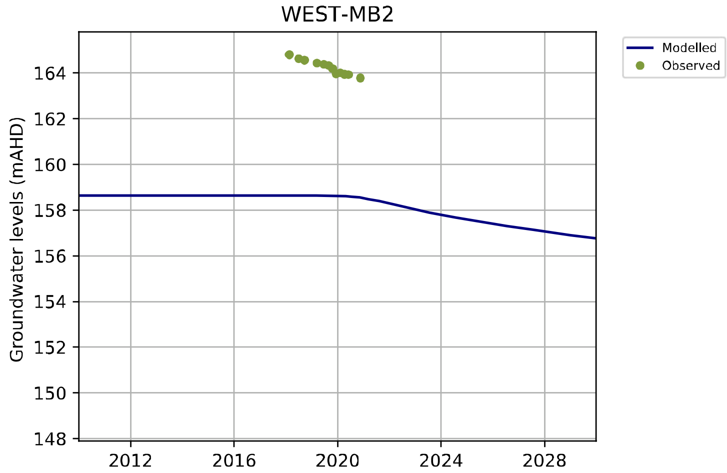

W8_MB1
Groundwater levels (mAHD)
166
164
162
160
158
156
2012
2016
2020
2024
2028
Modelled
Observed


W9_MB1
Groundwater levels (mAHD)
160.0
157.5
155.0
152.5
150.0
147.5
145.0
142.5
140.0
2012
2016
2020
2024
2028
Modelled
Observed


W9_MB2
Groundwater levels (mAHD)
160
158
156
154
152
150
148
2012
2016
2020
2024
2028
Modelled
Observed


W9_MB3
Groundwater levels (mAHD)
160
158
156
154
152
150
148
2012
2016
2020
2024
2028
Modelled
Observed


WEST-MB1
Groundwater levels (mAHD)
164
162
160
158
156
154
152
150
2012
2016
2020
2024
2028
Modelled
Observed


WEST-MB2
Groundwater levels (mAHD)
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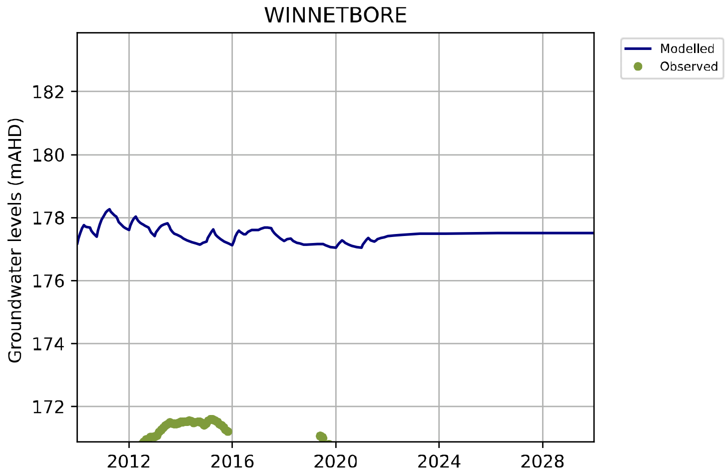
162
160
158
156
154
152
150
148
2012
2016
2020
2024
2028
Modelled
Observed


WINNETBORE
Groundwater levels (mAHD)
182
180
178
176
174
172
2012
2016
2020
2024
2028
Modelled
Observed

Appendix C Hydraulic Parameters and Recharge Zone Distribution

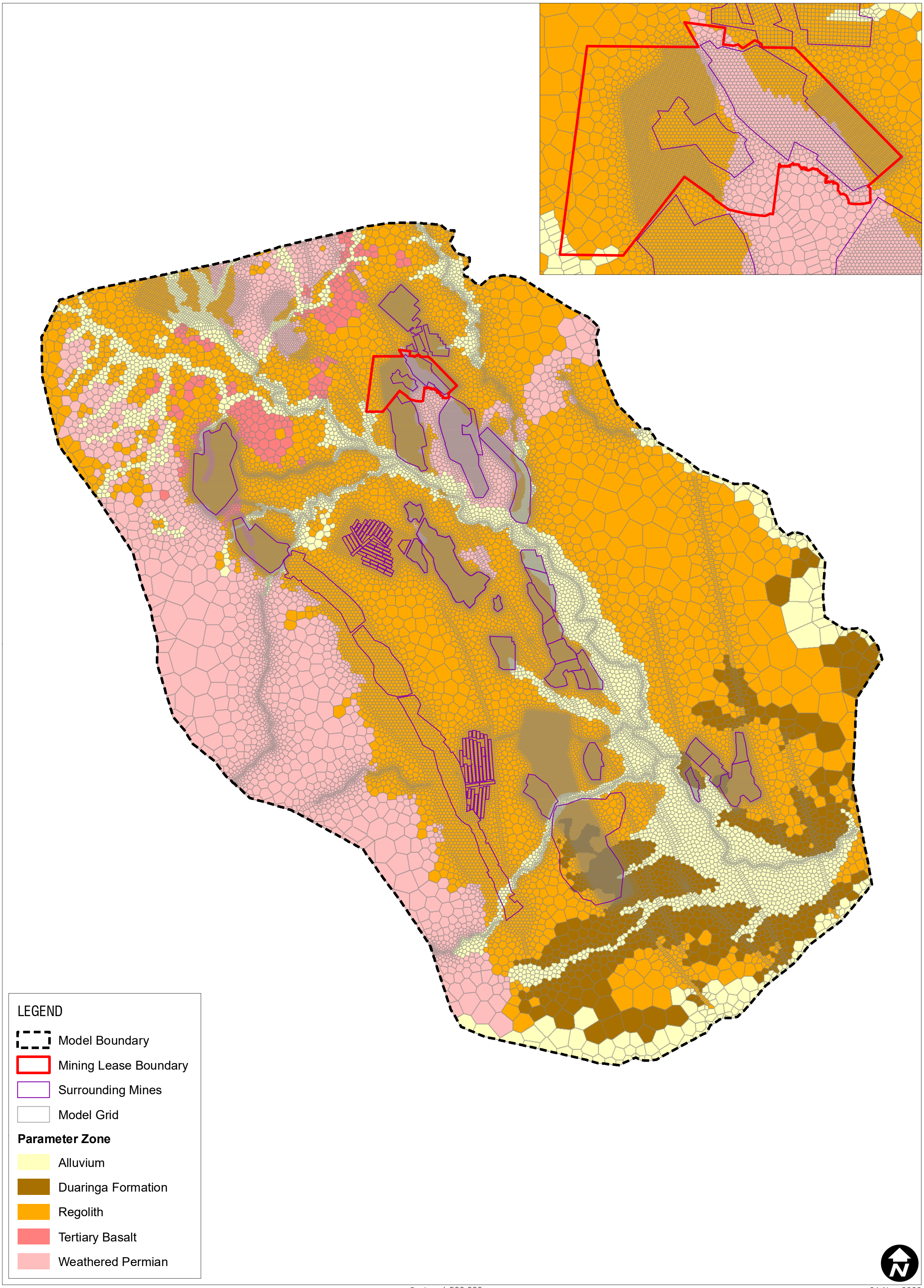
Mavis South Underground Extension Project

Groundwater Modelling Technical Report

MetRes Pty Ltd

SLR Project No.: 620.031508.00001

23 November 2023



0 10 km

Scale: 1:500,000
GDA 1994 MGA Zone 55

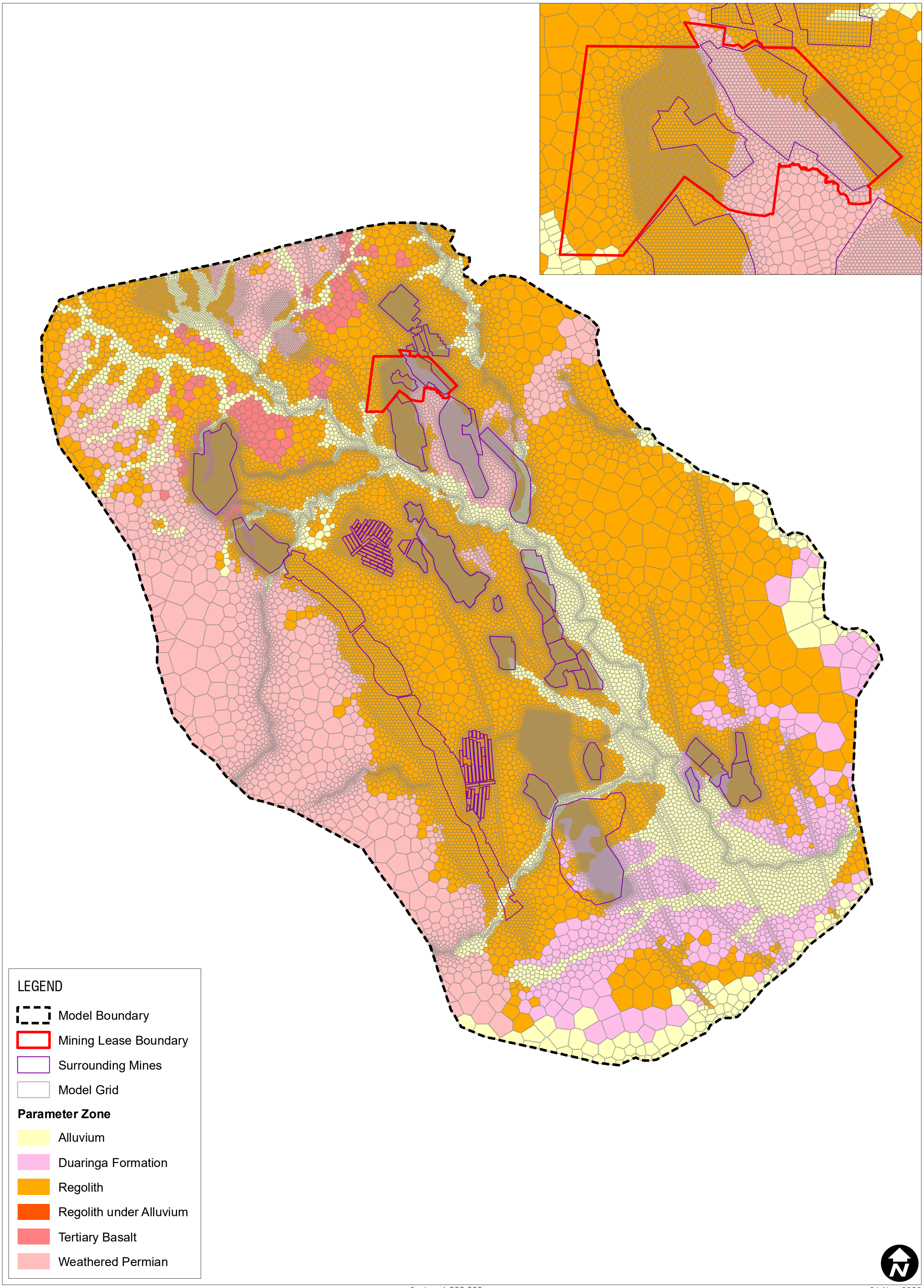
01-Nov-2023
620.031508

H:\Projects-SLR\620-BNE\620-BNE\620.031508.00001 Millennium Mine - Mavis South\06 SLR Data\01 CADGIS\GIS\Modelling Report\Appendix C\620031508 C-1 Modelled hydraulic conductivity zones.mxd

SLR

Hydraulic Parameter Zone Distribution Layer 1

APPENDIX C-1



Scale: 1:500,000
GDA 1994 MGA Zone 55

01-Nov-2023
620.031508

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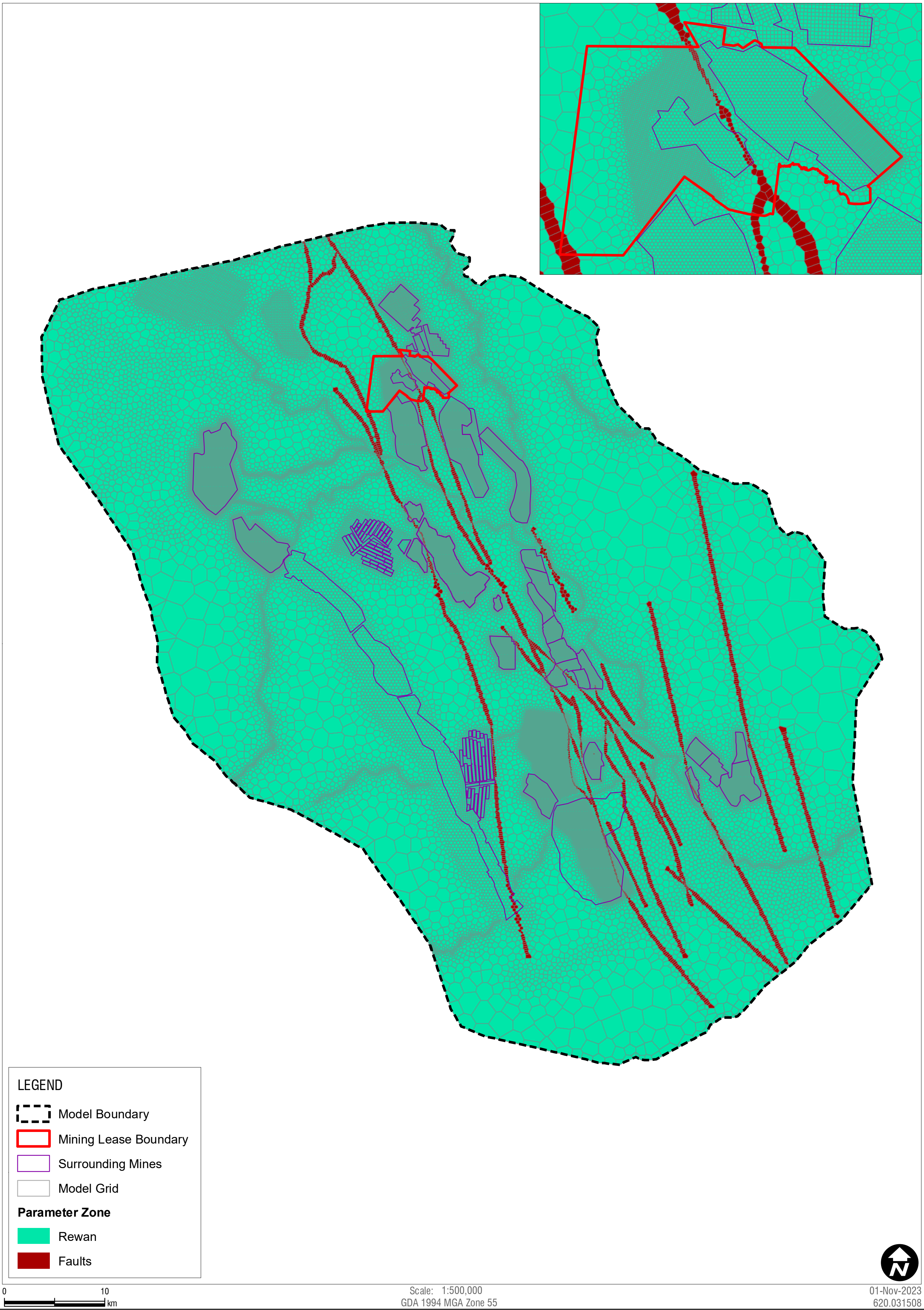
SLR

Hydraulic Parameter Zone Distribution Layer 2

APPENDIX C-2



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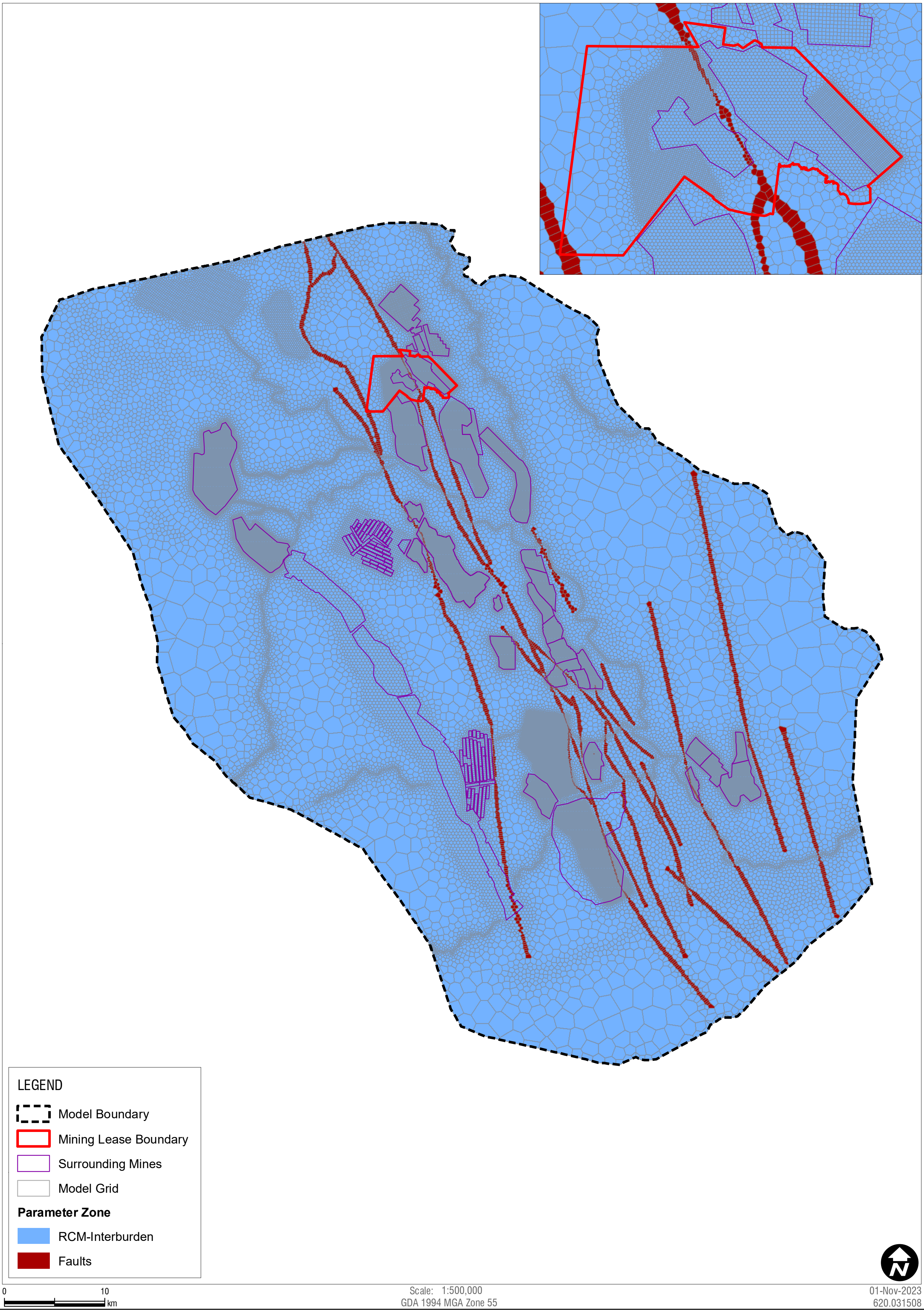
Scale: 1:500,000
GDA 1994 MGA Zone 55

01-Nov-2023
620.031508

SLR

Hydraulic Parameter Zone Distribution Layer 3

APPENDIX C-3



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SLR

Hydraulic Parameter Zone Distribution Layer 4

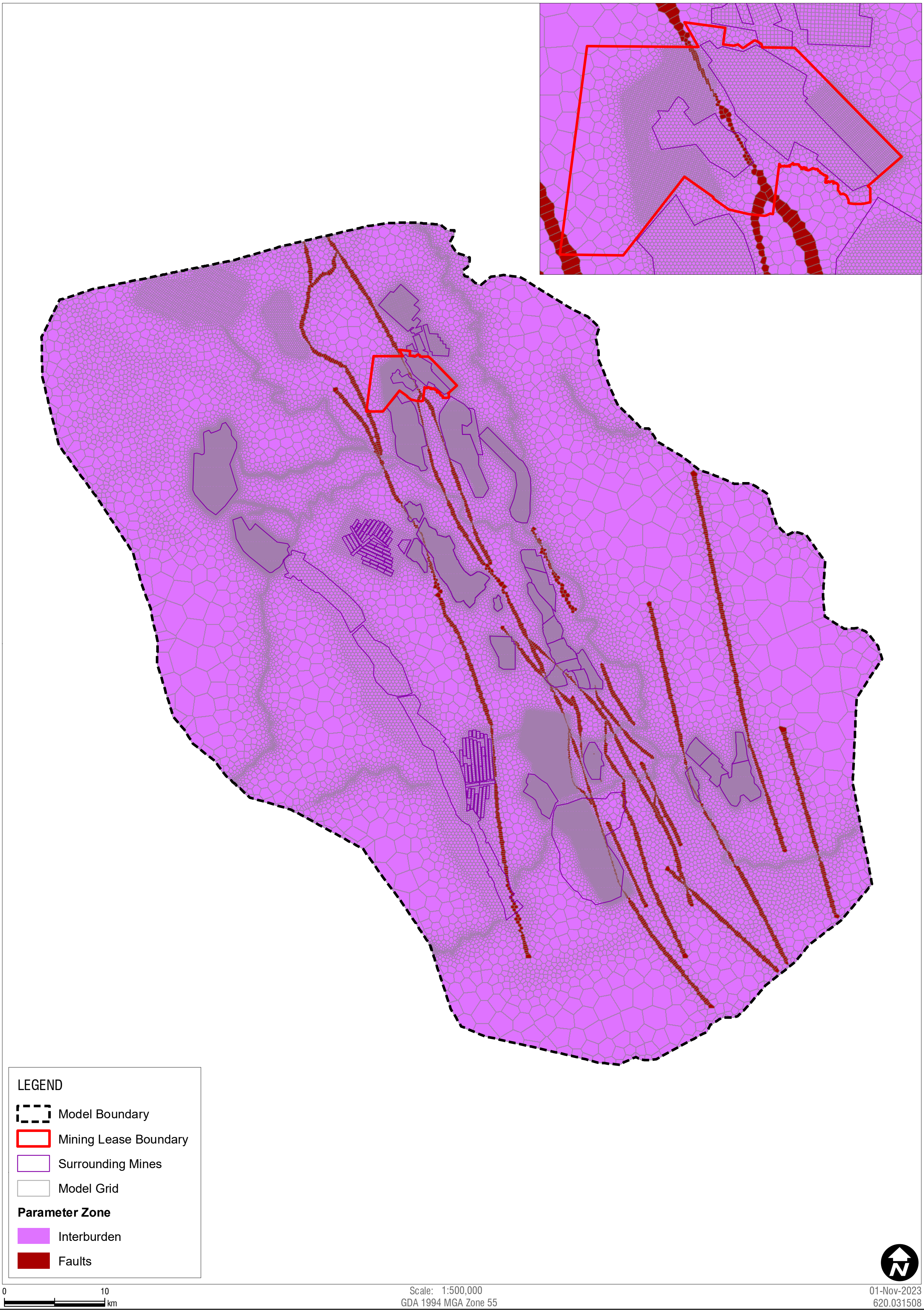
APPENDIX C-4

H:\Projects-SLR\620-BNE\620-BNE\620.031508.00001 Millennium Mine - Mavis South\06 SLR Data\01 CADGIS\GIS\Modelling Report\Appendix C\620031508 C-5 Modelled hydraulic conductivity zones.mxd

SLR

Hydraulic Parameter Zone Distribution Layer 5

APPENDIX C-5



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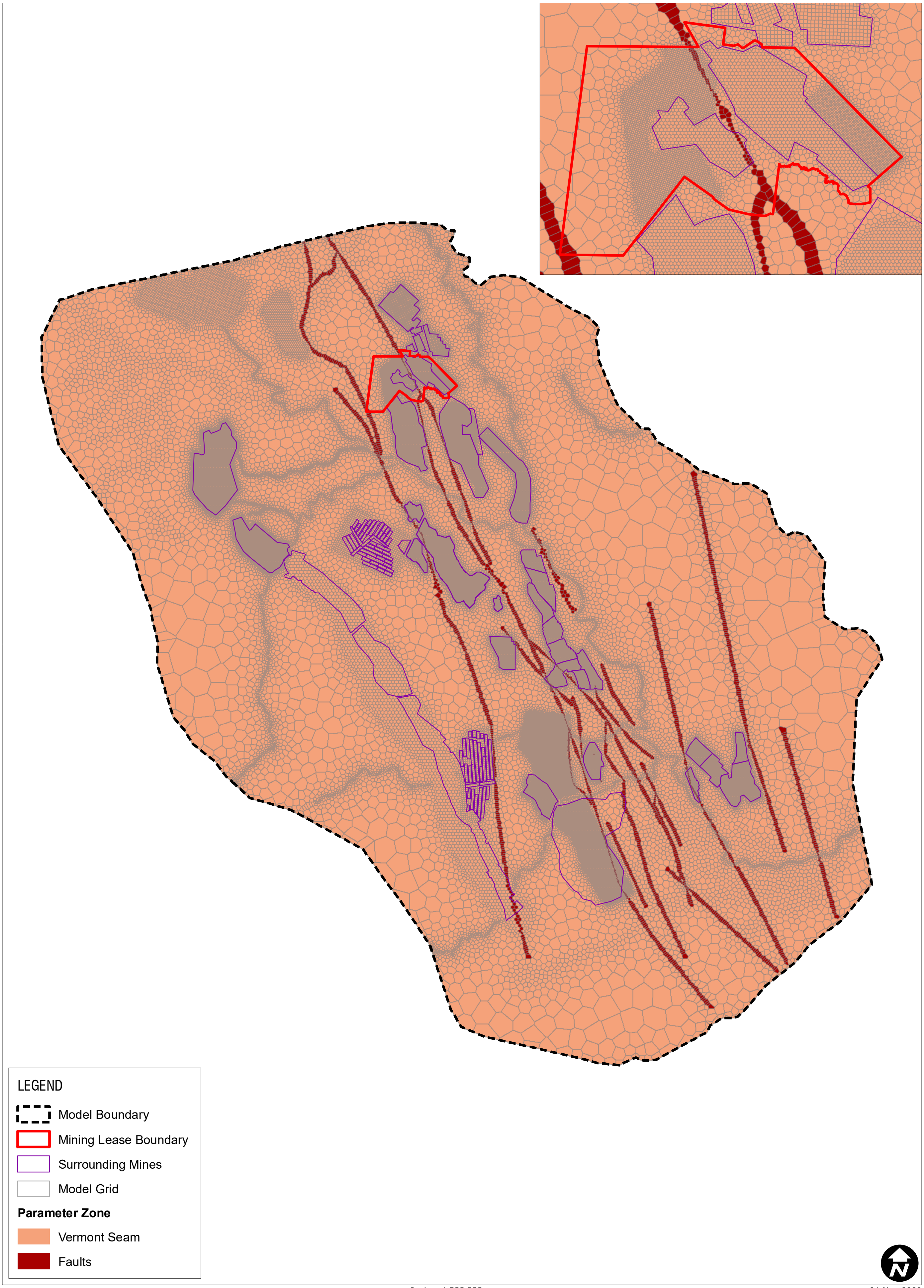
01-Nov-2023
620.031508

SLR

Hydraulic Parameter Zone Distribution Layer 6

APPENDIX C-6



0 10 km

Scale: 1:500,000
GDA 1994 MGA Zone 55

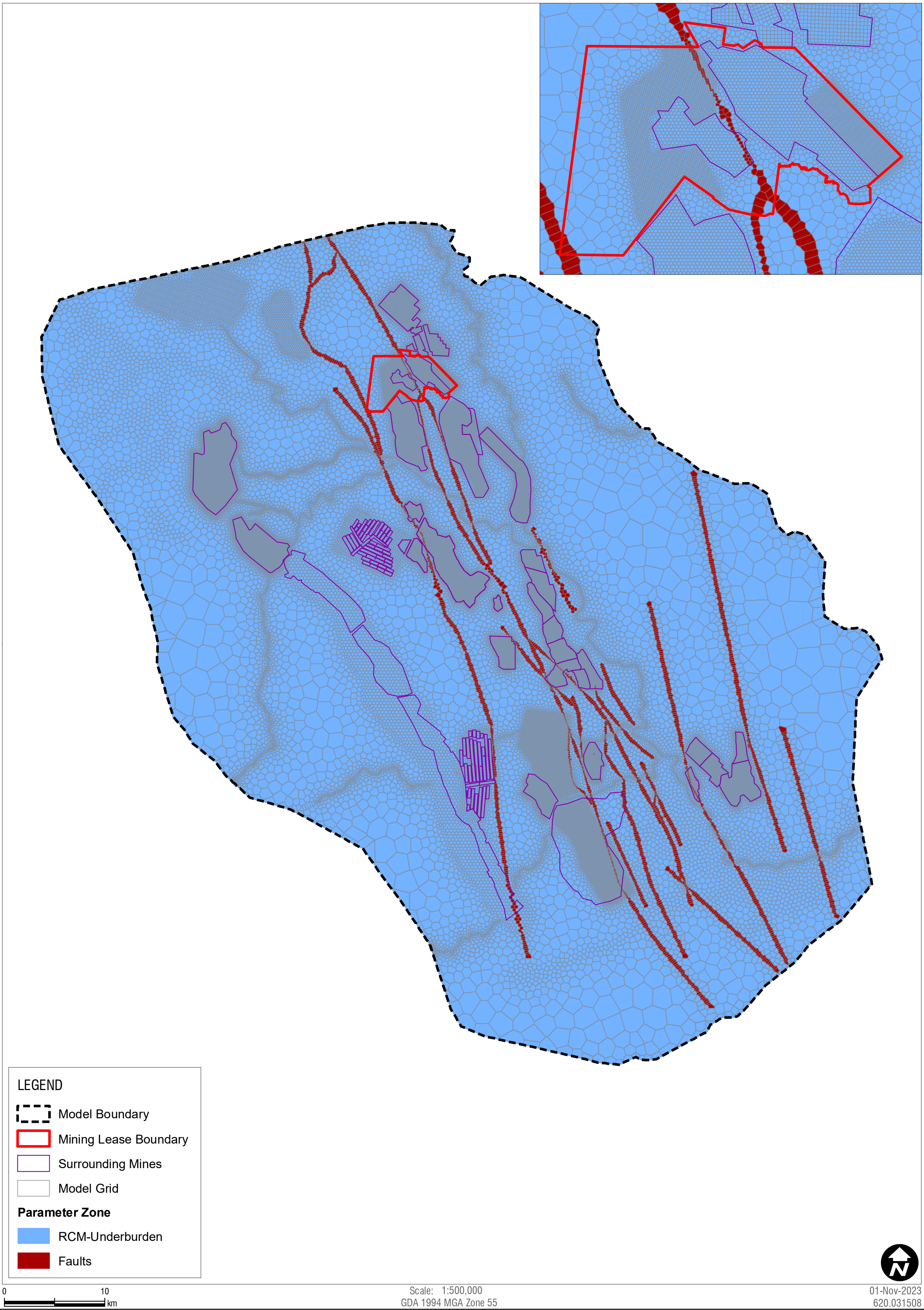
01-Nov-2023
620.031508

H:\Projects-SLR\620-BNE\620-BNE\620.031508.00001 Millennium Mine - Mavis South\06 SLR Data\01 CADGIS\GIS\Modelling Report\Appendix C\620031508 C-7 Modelled hydraulic conductivity zones.mxd

SLR

Hydraulic Parameter Zone Distribution Layer 7

APPENDIX C-7



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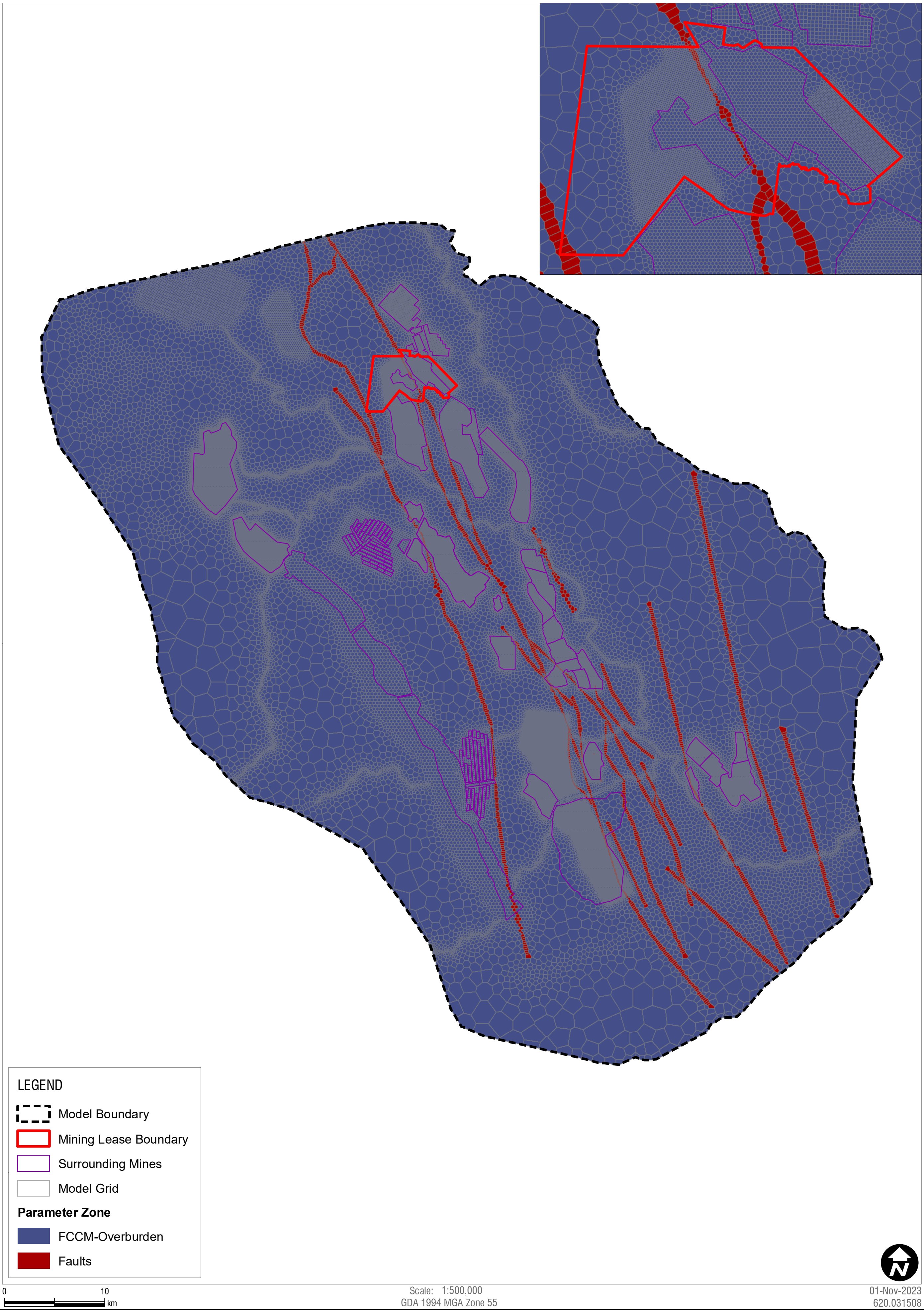
SLR

Hydraulic Parameter Zone Distribution Layer 8

APPENDIX C-8



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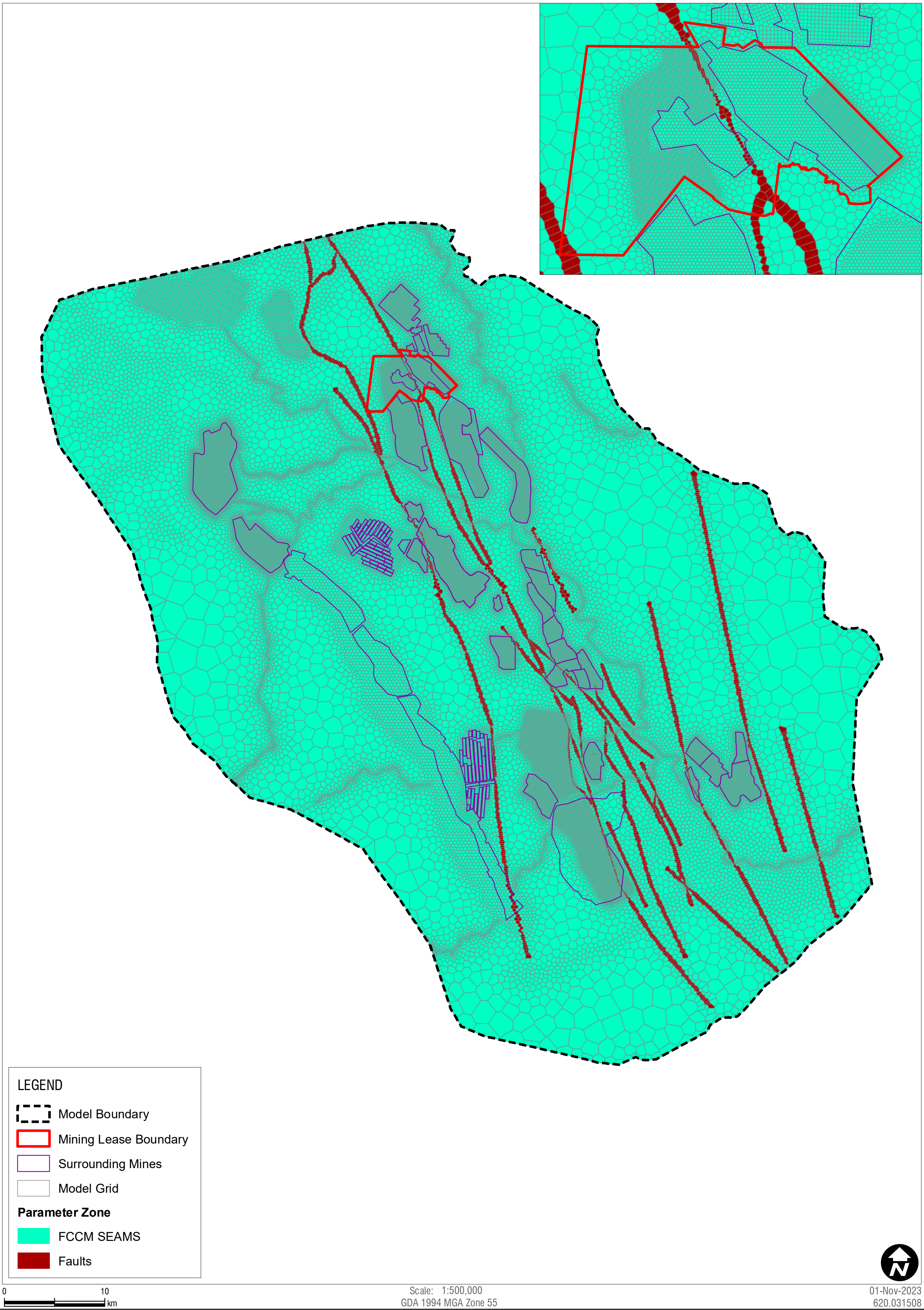
Scale: 1:500,000
GDA 1994 MGA Zone 55

01-Nov-2023
620.031508

SLR

Hydraulic Parameter Zone Distribution Layer 9

APPENDIX C-9



Scale: 1:500,000
GDA 1994 MGA Zone 55

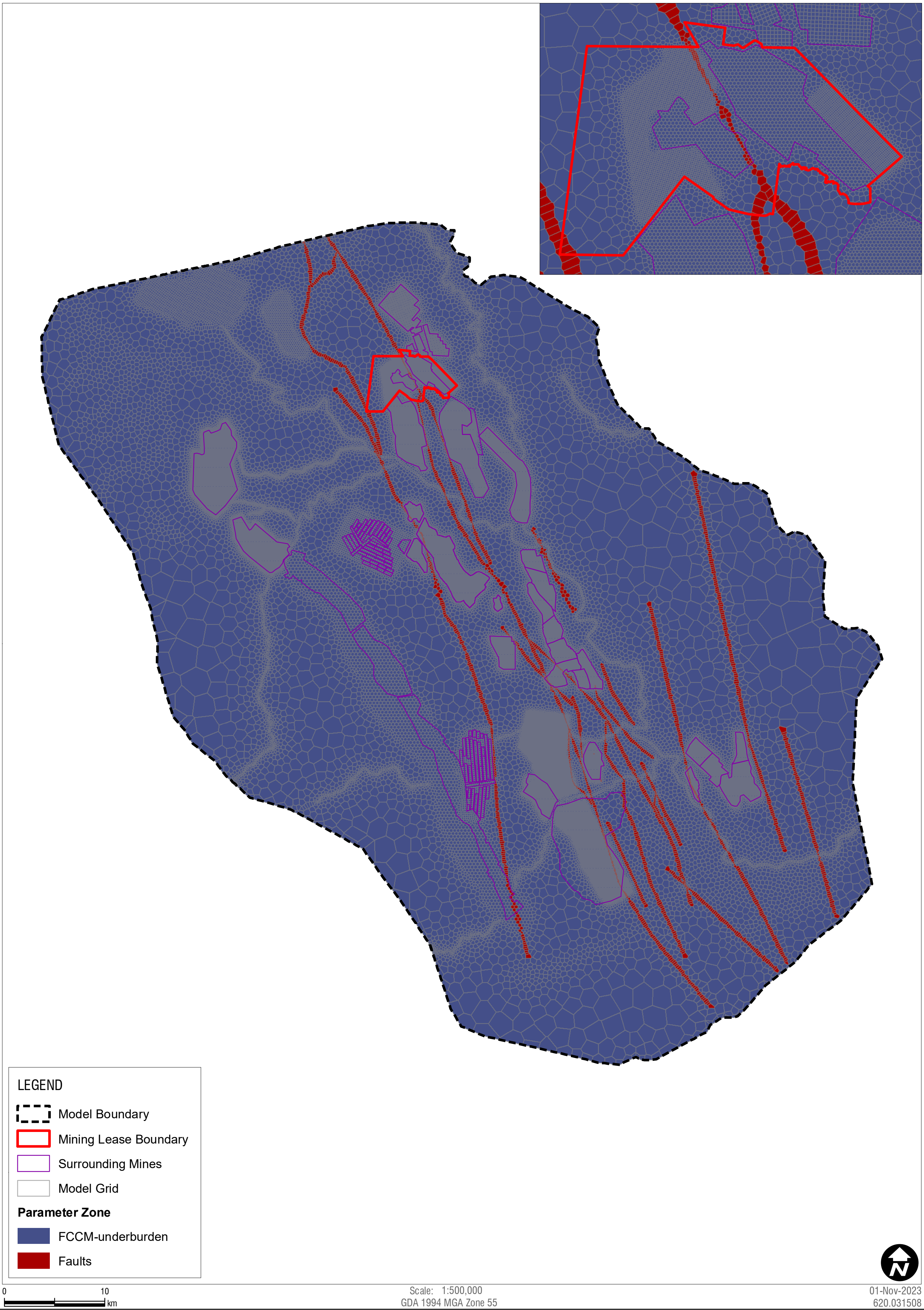
01-Nov-2023
620.031508

H:\Projects-SLR\620-BNE\620-BNE\620.031508.00001 Millennium Mine - Mavis South\06 SLR Data\01 CADGIS\GIS\Modelling Report\Appendix C\620031508 C-10 Modelled hydraulic conductivity zones.mxd

SLR

Hydraulic Parameter Zone Distribution Layer 10

APPENDIX C-10



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Scale: 1:500,000
GDA 1994 MGA Zone 55

01-Nov-2023
620.031508

SLR

Hydraulic Parameter Zone Distribution Layer 11

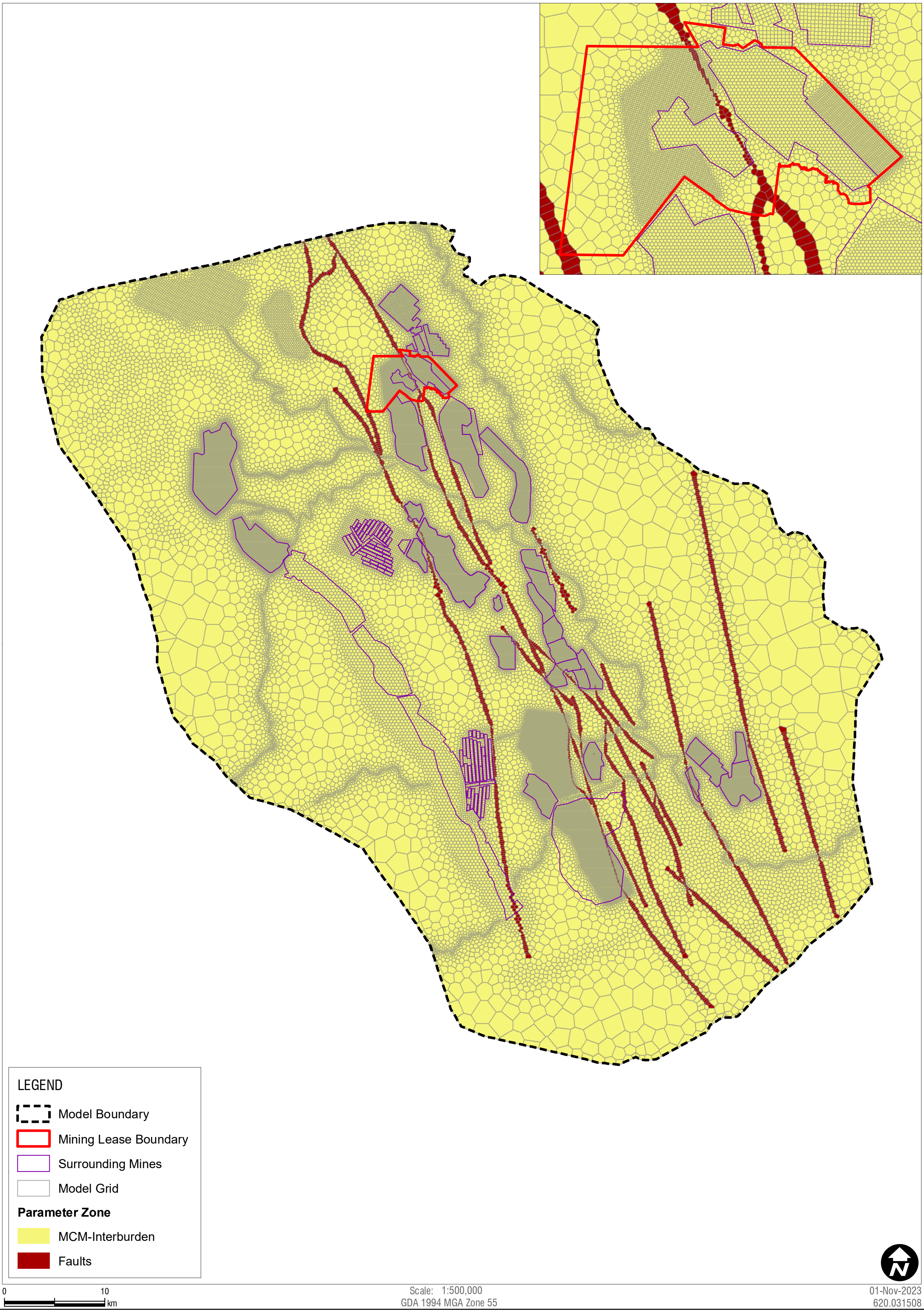
APPENDIX C-11

H:\Projects-SLR\620-BNE\620-BNE\620.031508.00001 Millennium Mine - Mavis South\06 SLR Data\01 CADGIS\GIS\Modelling Report\Appendix C\620031508 C-12 Modelled hydraulic conductivity zones.mxd

SLR

Hydraulic Parameter Zone Distribution Layer 12

APPENDIX C-12



Scale: 1:500,000
GDA 1994 MGA Zone 55

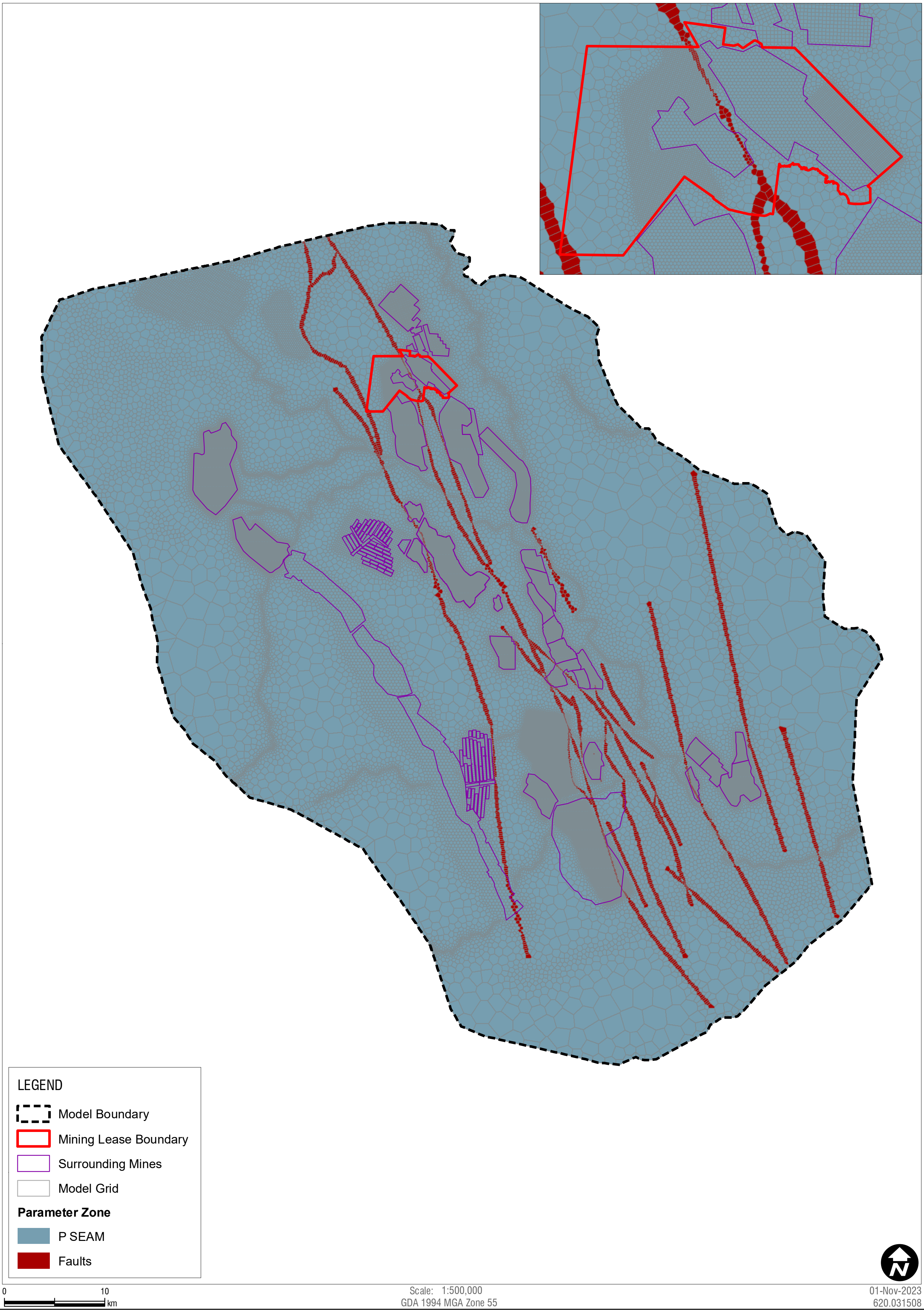
01-Nov-2023
620.031508

H:\Projects-SLR\620-BNE\620-BNE\620.031508.00001 Millennium Mine - Mavis South\06 SLR Data\01 CADGIS\GIS\Modelling Report\Appendix C\620031508 C-13 Modelled hydraulic conductivity zones.mxd

SLR

Hydraulic Parameter Zone Distribution Layer 13

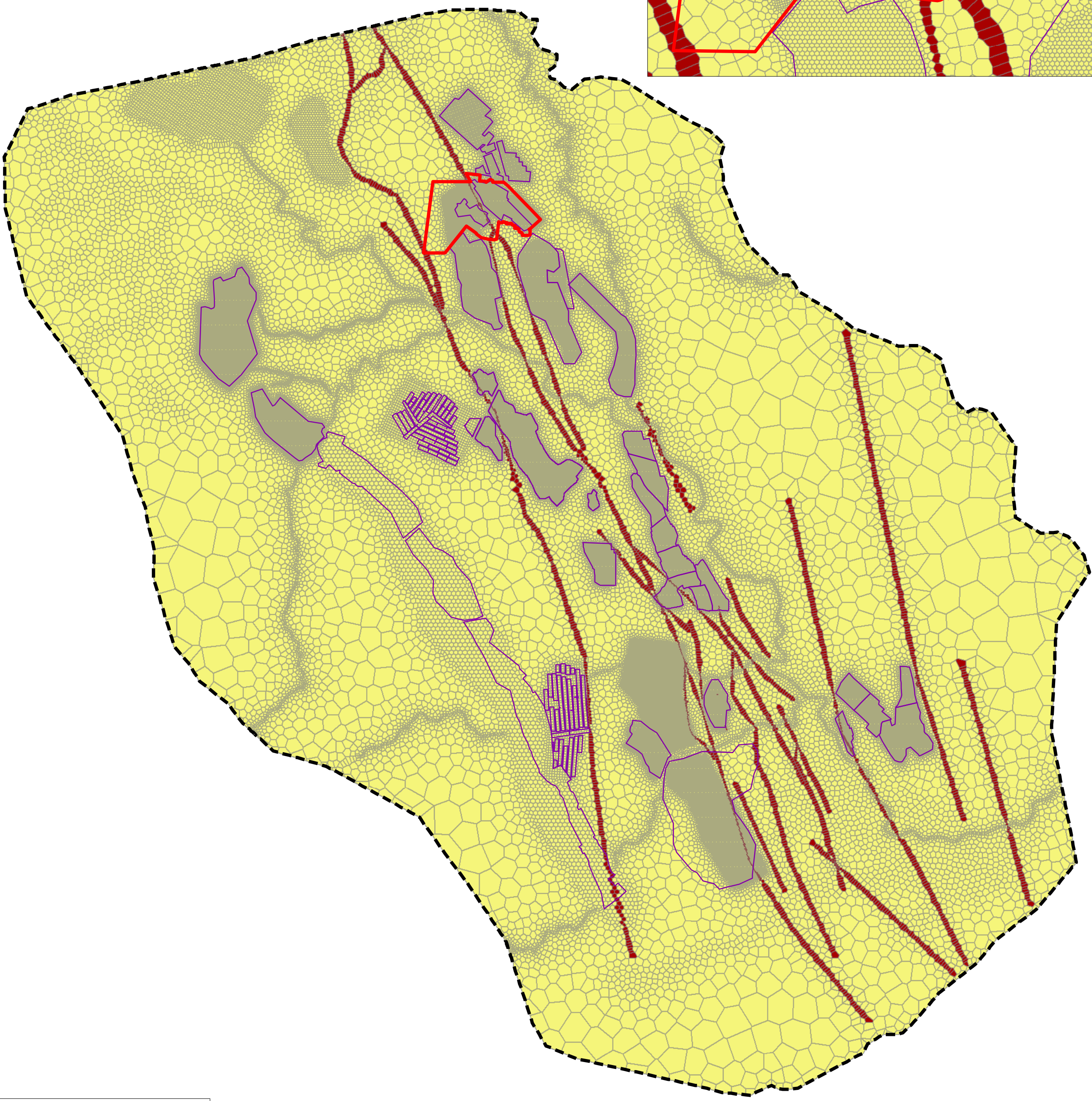
APPENDIX C-13

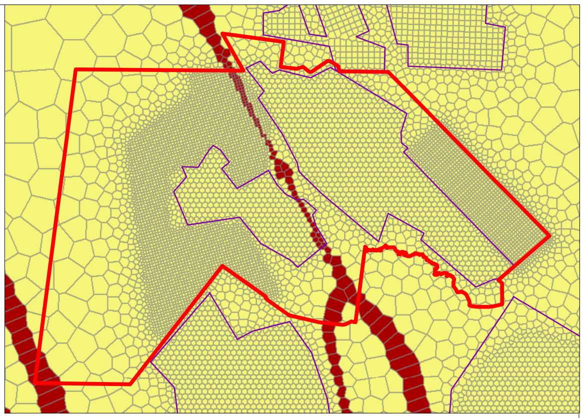


SLR

Hydraulic Parameter Zone Distribution Layer 14

APPENDIX C-14





LEGEND

Model Boundary

Mining Lease Boundary

Surrounding Mines

Model Grid

Parameter Zone

MCM-Interburden

Faults

0 10 km

Scale: 1:500,000
GDA 1994 MGA Zone 55

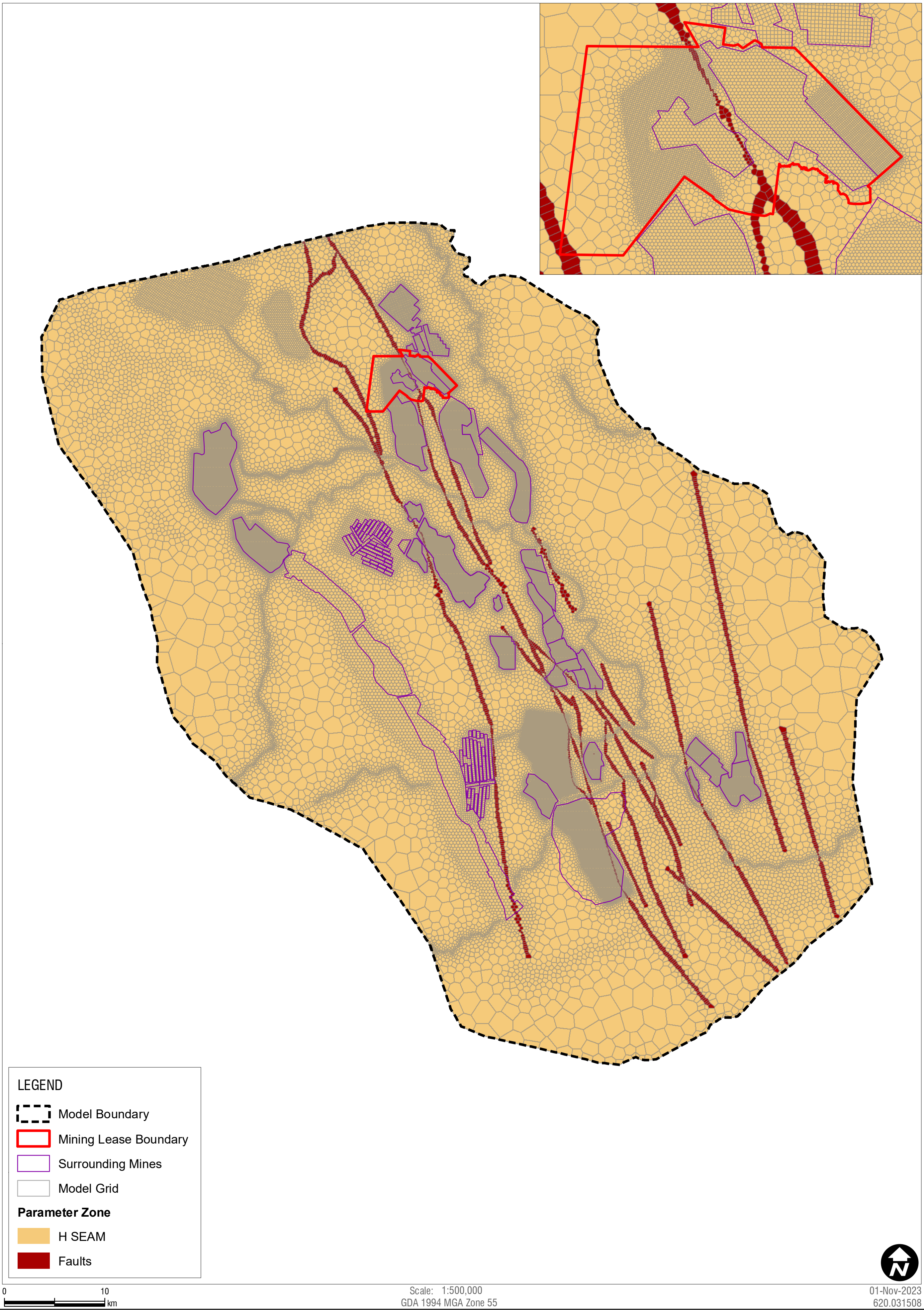
01-Nov-2023
620.031508

H:\Projects-SLR\620-BNE\620-BNE\620.031508.00001 Millennium Mine - Mavis South\06 SLR Data\01 CADGIS\GIS\Modelling Report\Appendix C\620031508 C-15 Modelled hydraulic conductivity zones.mxd

SLR

Hydraulic Parameter Zone Distribution Layer 15

APPENDIX C-15



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GDA 1994 MGA Zone 55

01-Nov-2023
620.031508

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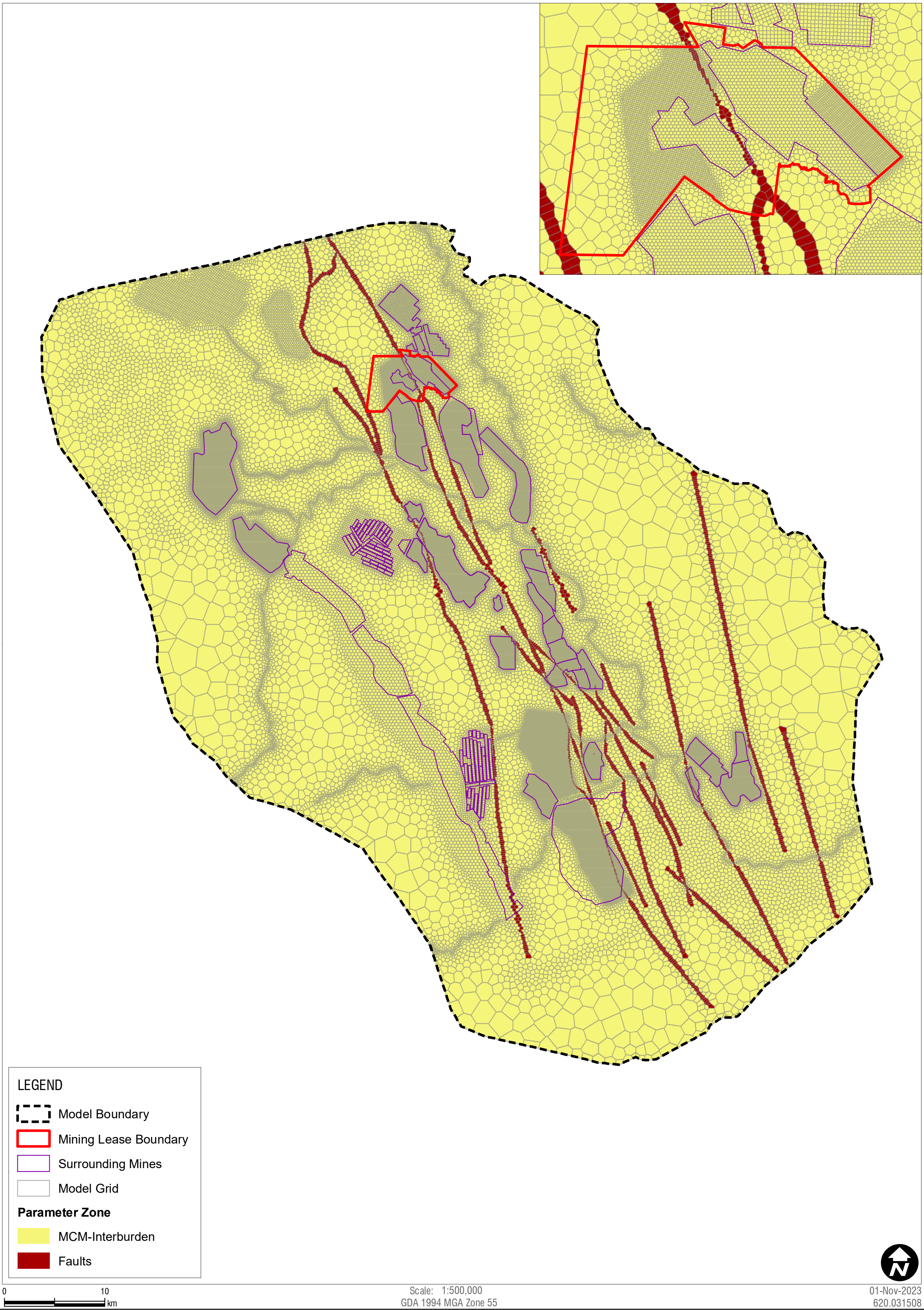
SLR

Hydraulic Parameter Zone Distribution Layer 16

APPENDIX C-16

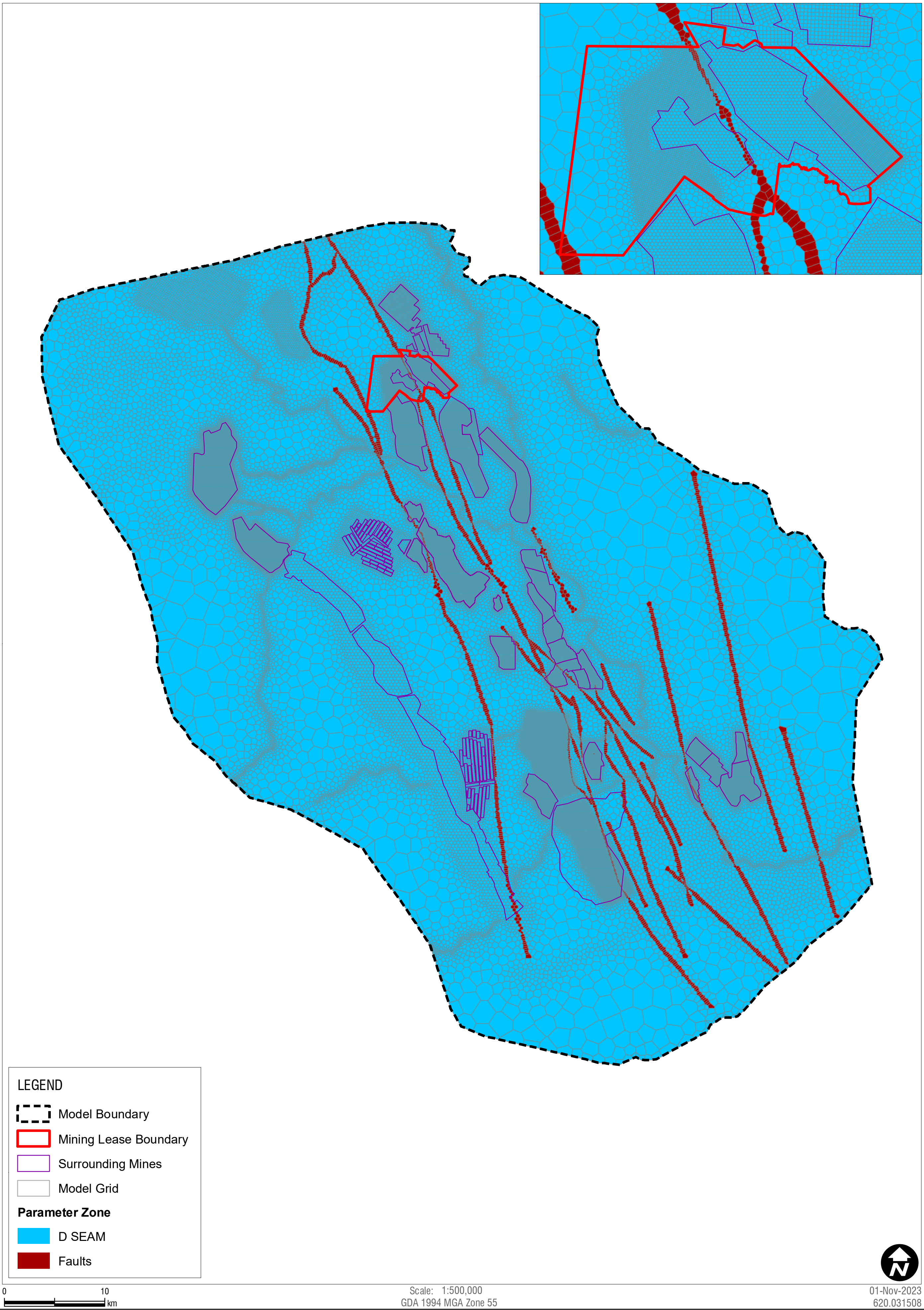


H:\Projects-SLR\620-BNE\620-BNE\620.031508.00001 Millennium Mine - Mavis South\06 SLR Data\01 CADGIS\GIS\Modelling Report\Appendix C\620031508 C-17 Modelled hydraulic conductivity zones.mxd

SLR

Hydraulic Parameter Zone Distribution Layer 17

APPENDIX C-17



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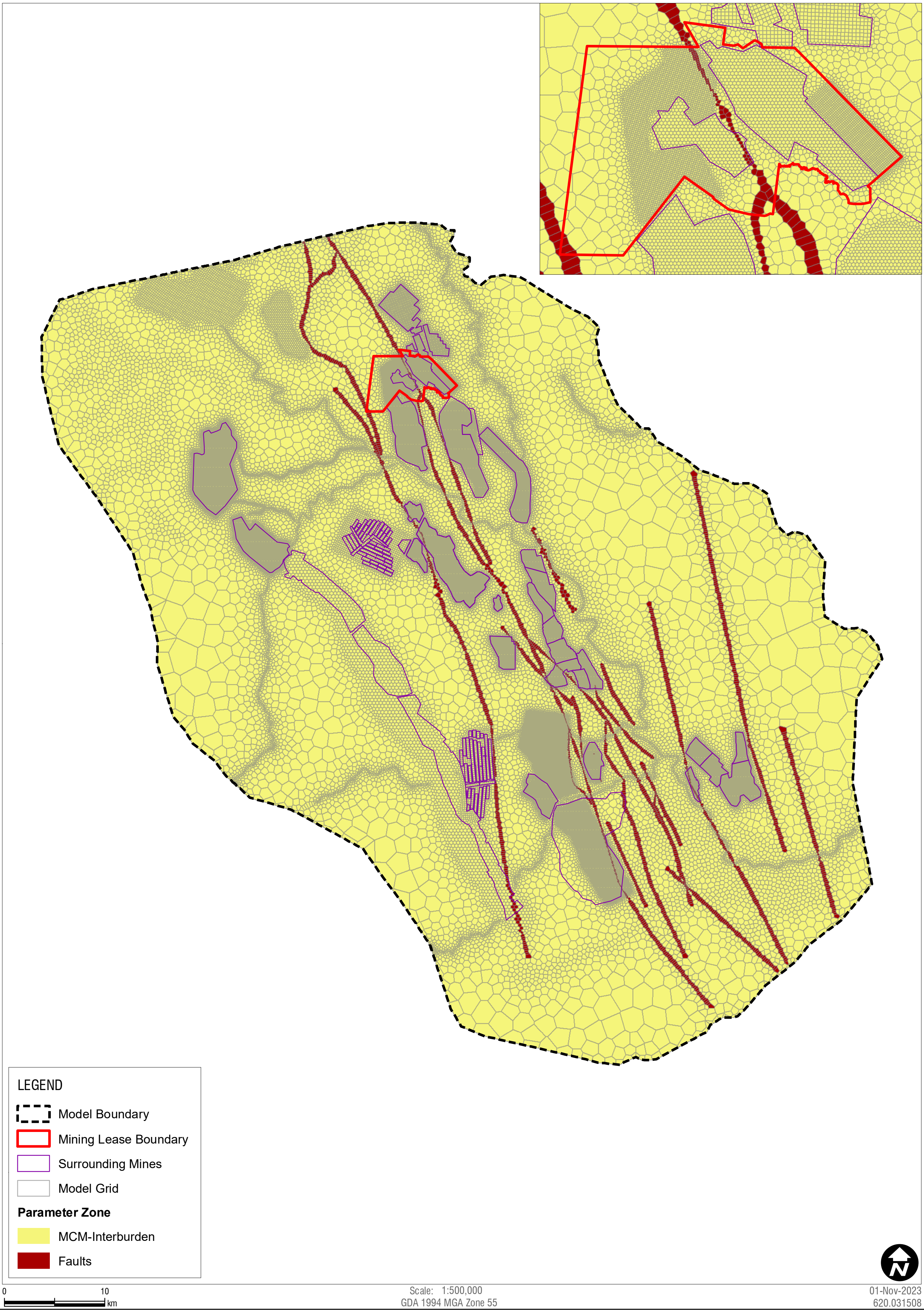
Scale: 1:500,000
GDA 1994 MGA Zone 55

01-Nov-2023
620.031508

SLR

Hydraulic Parameter Zone Distribution Layer 18

APPENDIX C-18



Scale: 1:500,000
GDA 1994 MGA Zone 55

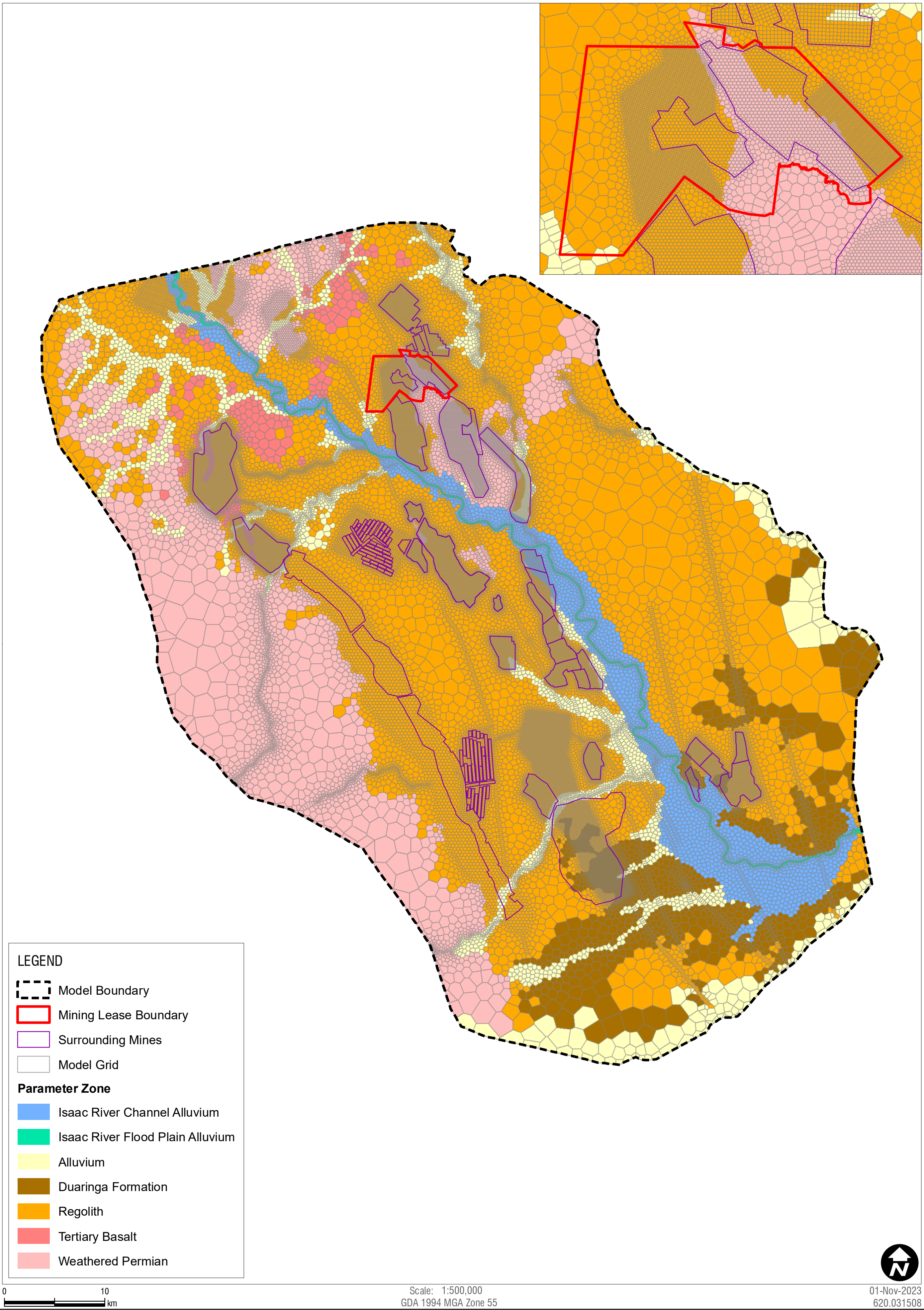
01-Nov-2023
620.031508

H:\Projects-SLR\620-BNE\620-BNE\620.031508.00001 Millennium Mine - Mavis South\06 SLR Data\01 CADGIS\GIS\Modelling Report\Appendix C\620031508 C-19 Modelled hydraulic conductivity zones.mxd

SLR

Hydraulic Parameter Zone Distribution Layer 19

APPENDIX C-19



Scale: 1:500,000
GDA 1994 MGA Zone 55

01-Nov-2023
620.031508

H:\Projects-SLR\620-BNE\620-BNE\620.031508.00001 Millennium Mine - Mavis South\06 SLR Data\01 CADGIS\GIS\Modelling Report\Appendix C\620031508 C-20 Recharge Zone Distribution.mxd

Recharge Zone Distribution

APPENDIX C-20

Appendix D Stress Periods and Simulated Active Mine Timings

Mavis South Underground Extension Project

Groundwater Modelling Technical Report

MetRes Pty Ltd

SLR Project No.: 620.031508.00001

23 November 2023

Calibration Period	Interval	Stress Period	From	to	MSM (OC)	CVM (OC)	PDM (OC)	SRM (OC)	SRM (UG)	Gr (UG)	Poi (OC)	WS (OC)	DM (OC)	Mill (OC)	Mill (UG)	IP (OC)	OD (OC)	ED (UG)	LV (OC)	LVN (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	

Calibration Period	Interval	Stress Period	From	to	MSM (OC)	CVM (OC)	PDM (OC)	SRM (OC)	SRM (UG)	Gr (UG)	Poi (OC)	WS (OC)	DM (OC)	Mill (OC)	Mill (UG)	IP (OC)	OD (OC)	ED (UG)	LV (OC)	LVN (OC)
	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	From	to	MSM (OC)	CVM (OC)	PDM (OC)	SRM (OC)	SRM (UG)	Gr (UG)	Poi (OC)	WS (OC)	DM (OC)	Mill (OC)	Mill (UG)	IP (OC)	OD (OC)	ED (UG)	LV (OC)	LVN (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	

Calibration Period	Interval	Stress Period	From	to	MSM (OC)	CVM (OC)	PDM (OC)	SRM (OC)	SRM (UG)	Gr (UG)	Poi (OC)	WS (OC)	DM (OC)	Mill (OC)	Mill (UG)	IP (OC)	OD (OC)	ED (UG)	LV (OC)	LVN (OC)
	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	

Calibration Period	Interval	Stress Period	From	to	MSM (OC)	CVM (OC)	PDM (OC)	SRM (OC)	SRM (UG)	Gr (UG)	Poi (OC)	WS (OC)	DM (OC)	Mill (OC)	Mill (UG)	IP (OC)	OD (OC)	ED (UG)	LV (OC)	LVN (OC)
	Quarterly	42	01-10-2017	31-12-2017		x	x	x		x	x		x	x		x			x	
	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	

Calibration Period	Interval	Stress Period	From	to	MSM (OC)	CVM (OC)	PDM (OC)	SRM (OC)	SRM (UG)	Gr (UG)	Poi (OC)	WS (OC)	DM (OC)	Mill (OC)	Mill (UG)	IP (OC)	OD (OC)	ED (UG)	LV (OC)	LVN (OC)
	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	x
	Annual	60	30-12-2022	30-12-2023	x	x	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		x	x

Calibration Period	Interval	Stress Period	From	to	MSM (OC)	CVM (OC)	PDM (OC)	SRM (OC)	SRM (UG)	Gr (UG)	Poi (OC)	WS (OC)	DM (OC)	Mill (OC)	Mill (UG)	IP (OC)	OD (OC)	ED (UG)	LV (OC)	LVN (OC)
	Annual	62	29-12-2024	30-12-2025	x	x	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	x
	Annual	64	30-12-2026	30-12-2027	x	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

Calibration Period	Interval	Stress Period	From	to	MSM (OC)	CVM (OC)	PDM (OC)	SRM (OC)	SRM (UG)	Gr (UG)	Poi (OC)	WS (OC)	DM (OC)	Mill (OC)	Mill (UG)	IP (OC)	OD (OC)	ED (UG)	LV (OC)	LVN (OC)
	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

Calibration Period	Interval	Stress Period	From	to	MSM (OC)	CVM (OC)	PDM (OC)	SRM (OC)	SRM (UG)	Gr (UG)	Poi (OC)	WS (OC)	DM (OC)	Mill (OC)	Mill (UG)	IP (OC)	OD (OC)	ED (UG)	LV (OC)	LVN (OC)
	Annual	82	31-12-2044	31-12-2045		x	x			x		x					x	x		x
	Annual	83	01-01-2046	31-12-2046		x	x			x		x					x	x		x
	Annual	84	01-01-2047	31-12-2047		x	x			x		x					x	x		x
	Annual	85	01-01-2048	30-12-2048		x	x			x		x					x	x		x
	Annual	86	31-12-2048	31-12-2049		x	x					x					x	x		x
	Annual	87	01-01-2050	31-12-2050		x	x					x					x	x		x
	Annual	88	01-01-2051	31-12-2051		x	x					x					x	x		x
	Annual	89	01-01-2052	30-12-2052			x					x					x	x		x
	Annual	90	31-12-2052	31-12-2053			x										x	x		x
	Annual	91	01-01-2054	31-12-2054			x										x	x		x

Calibration Period	Interval	Stress Period	From	to	MSM (OC)	CVM (OC)	PDM (OC)	SRM (OC)	SRM (UG)	Gr (UG)	Poi (OC)	WS (OC)	DM (OC)	Mill (OC)	Mill (UG)	IP (OC)	OD (OC)	ED (UG)	LV (OC)	LVN (OC)
	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		

Note:

MSM: Moorval South; CVM: CVM; PDM: Peak Downs; SRM: Saraji; Gr: Grosvenor; Poi: Poitrel; WS: Winchester South; DM: Daunia Mine; Mill South: Millennium South; IP: Isaac Plains; OD: Olive Downs; ED: Eagle Downs; LV: Lake Vermont; LVN: Lake Vermont North; OC: Open Cut Mine; UG: Underground Mine;

Appendix E Uncertainty Analysis Parameter Distribution

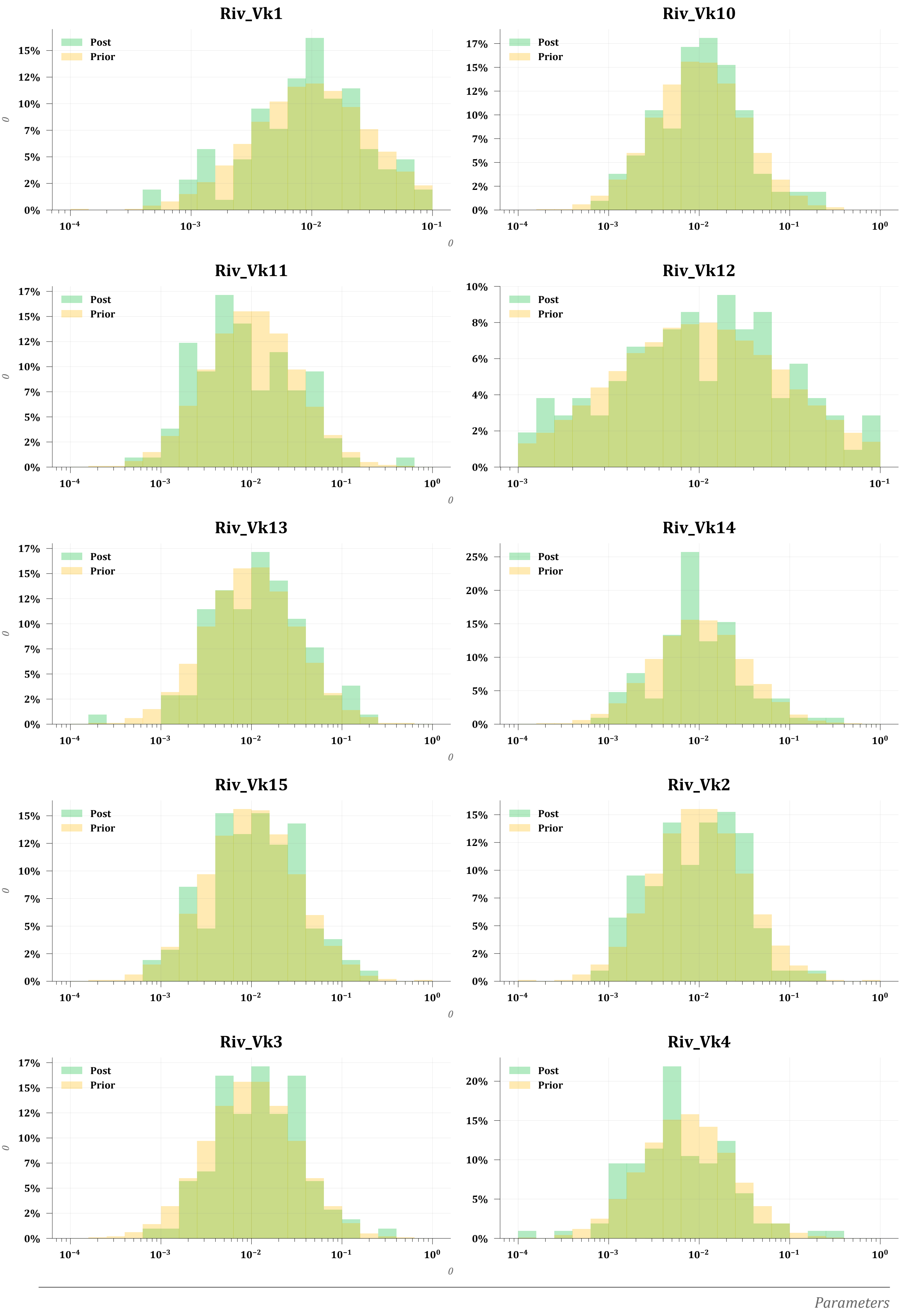
Mavis South Underground Extension Project

Groundwater Modelling Technical Report

MetRes Pty Ltd

SLR Project No.: 620.031508.00001

23 November 2023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Riv_Vk11
Riv_Vk12
Riv_Vk13
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Riv_Vk2
Riv_Vk3
Riv_Vk4
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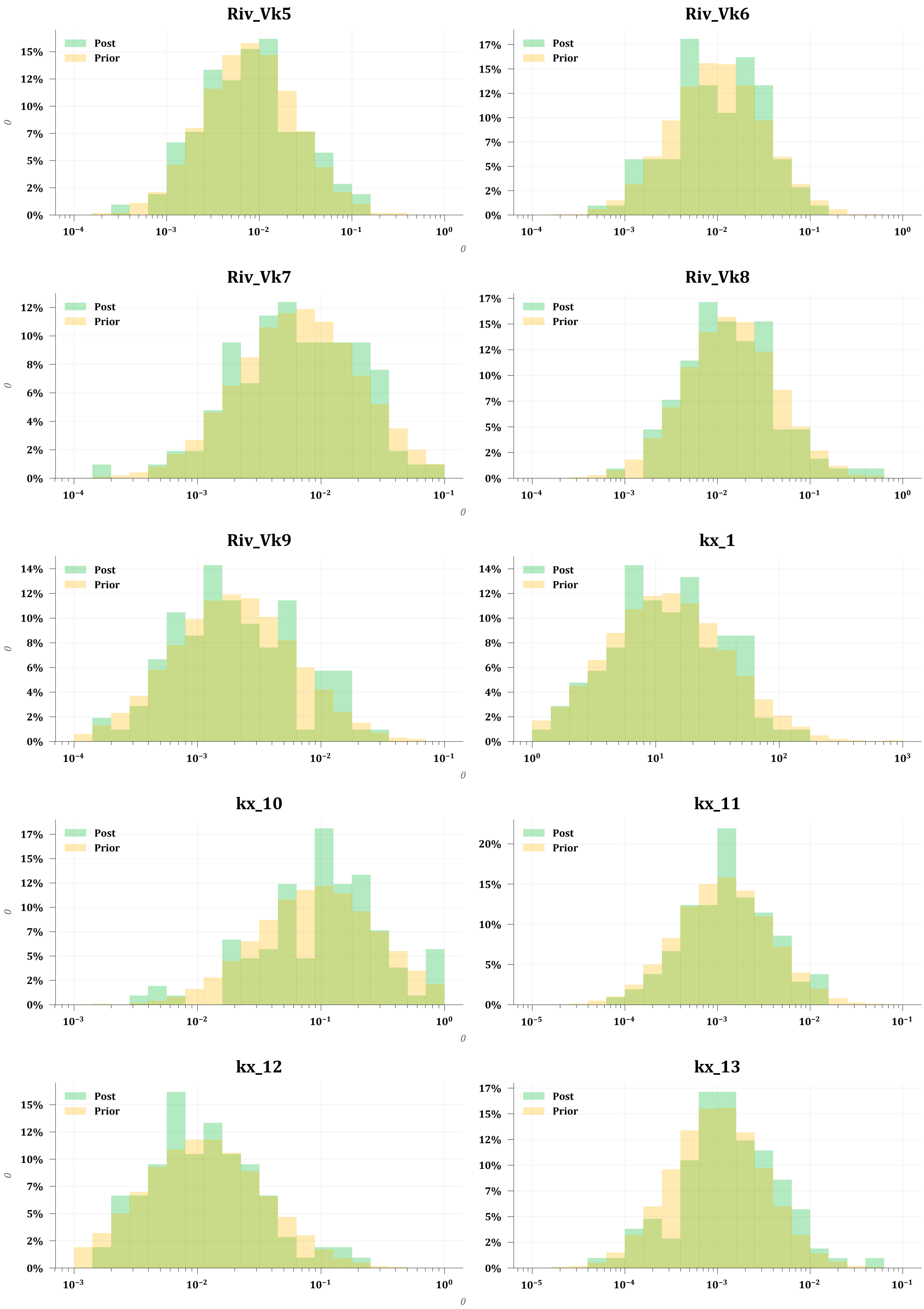
Prior
Parameters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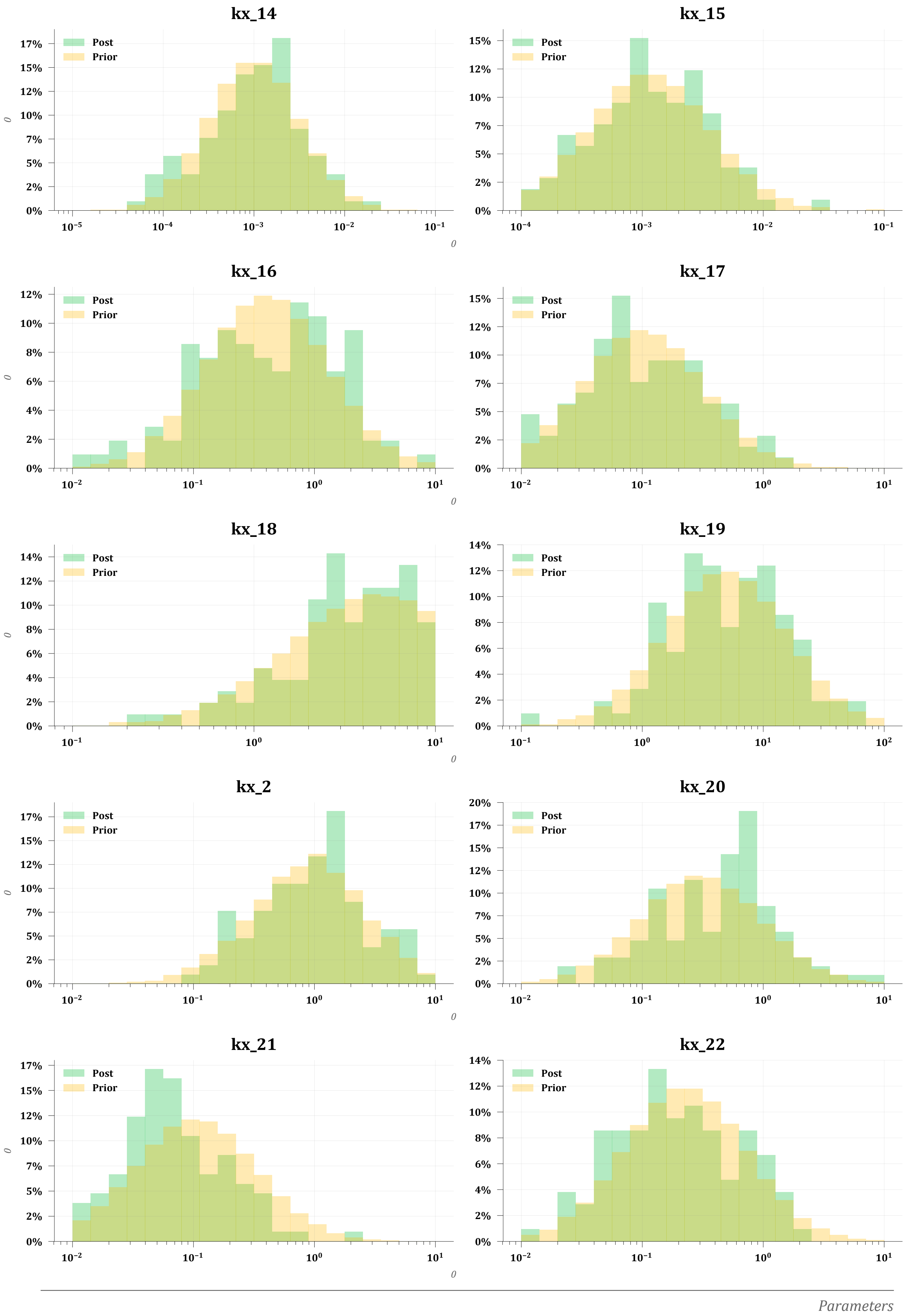
Parameters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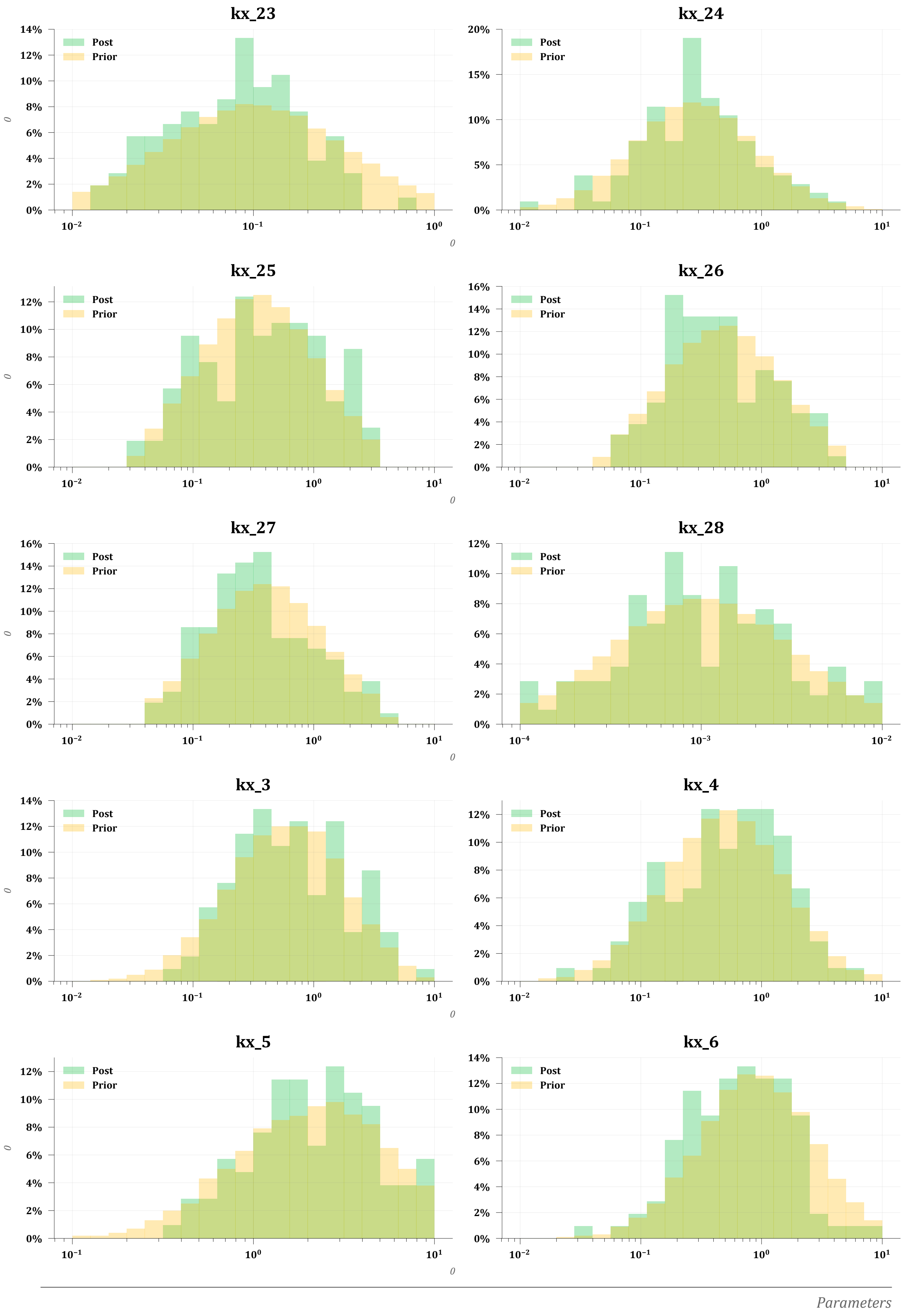
kx_22
Post
Prior
Parameters



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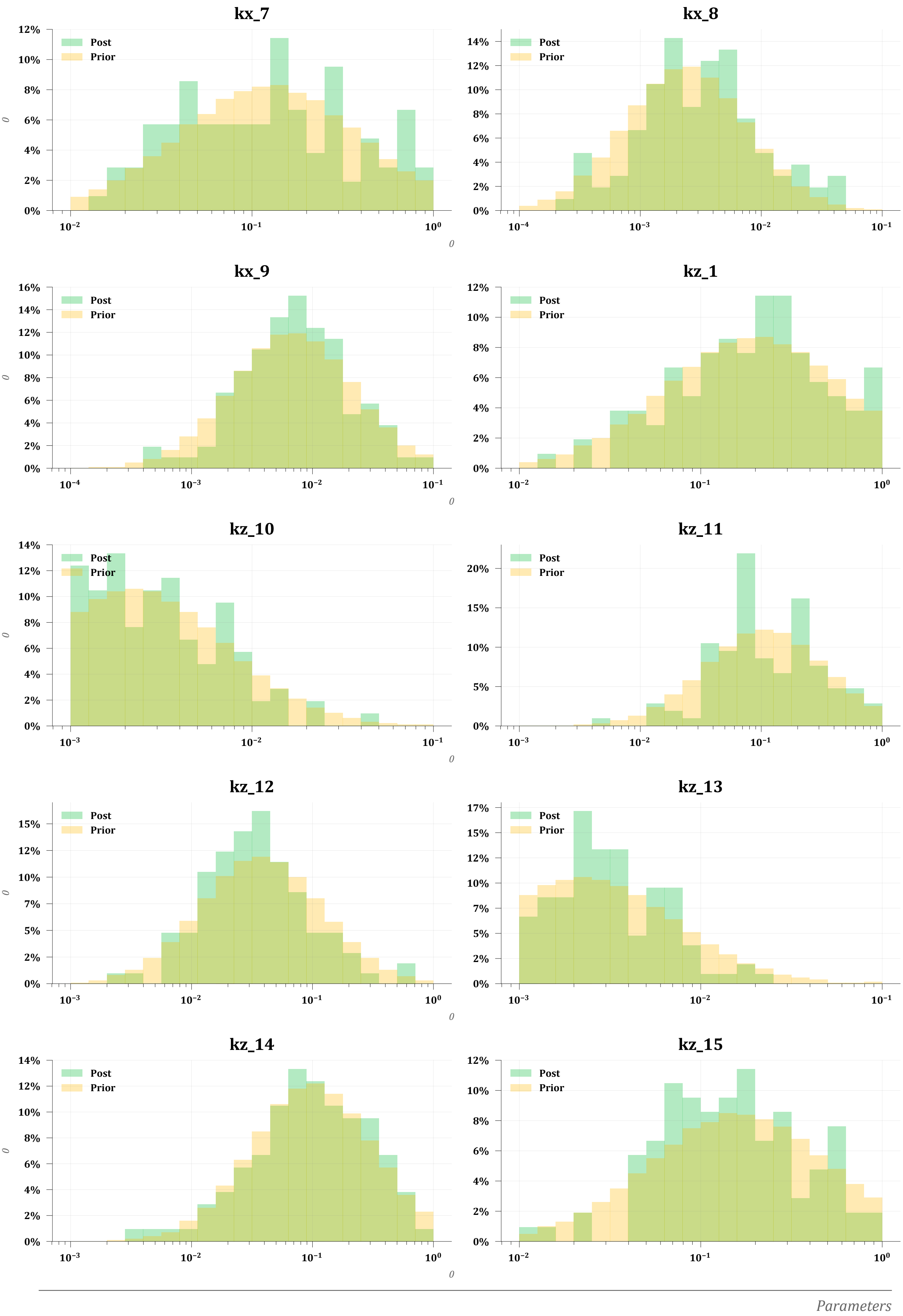
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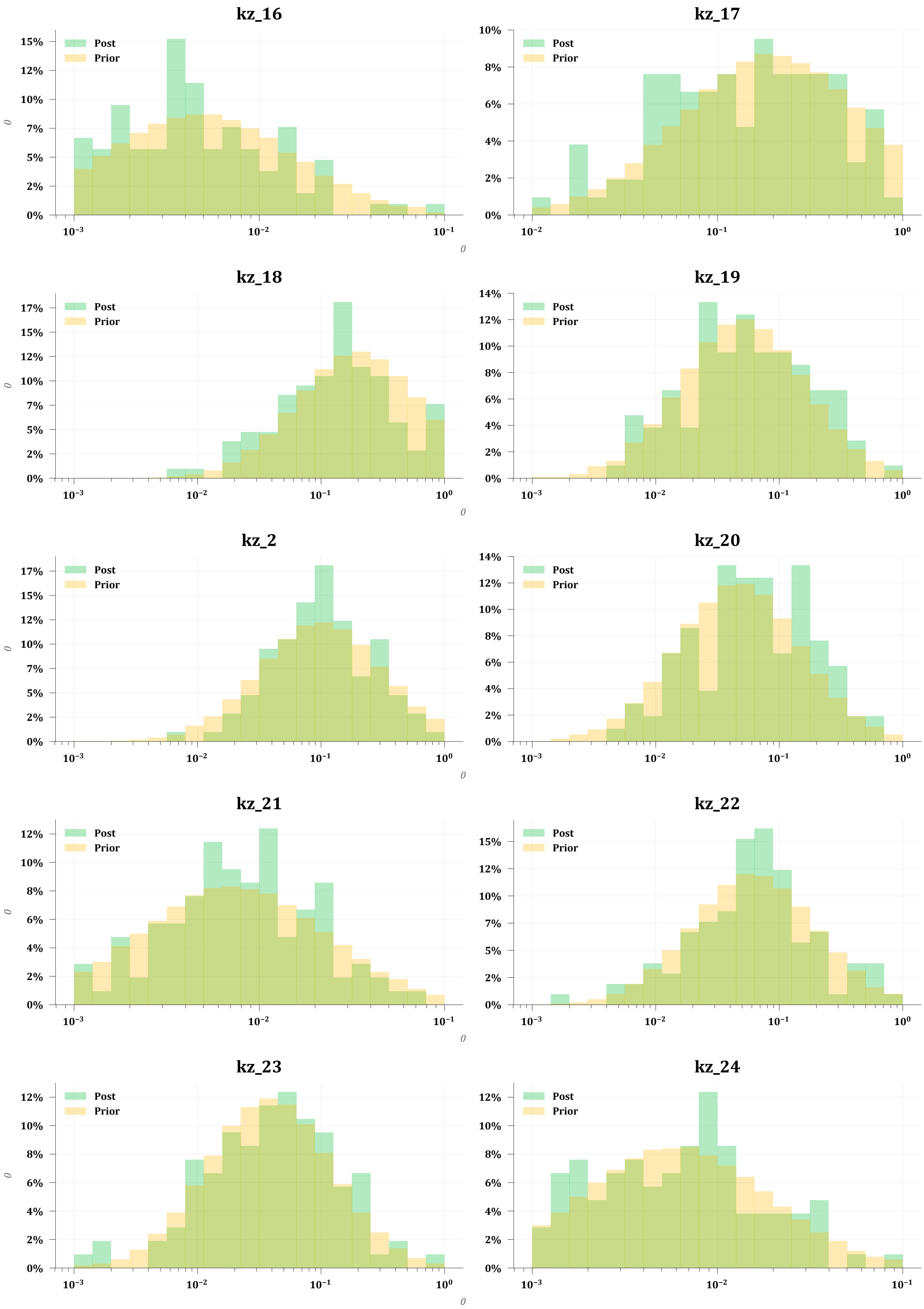
Parameters



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Prior
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10%
7%
5%
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10⁻²
10⁻¹
0
kz_17
10%
8%
6%
4%
2%
0%
10⁻²
10⁻¹
10⁰
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kz_19
14%
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kz_20
kz_21
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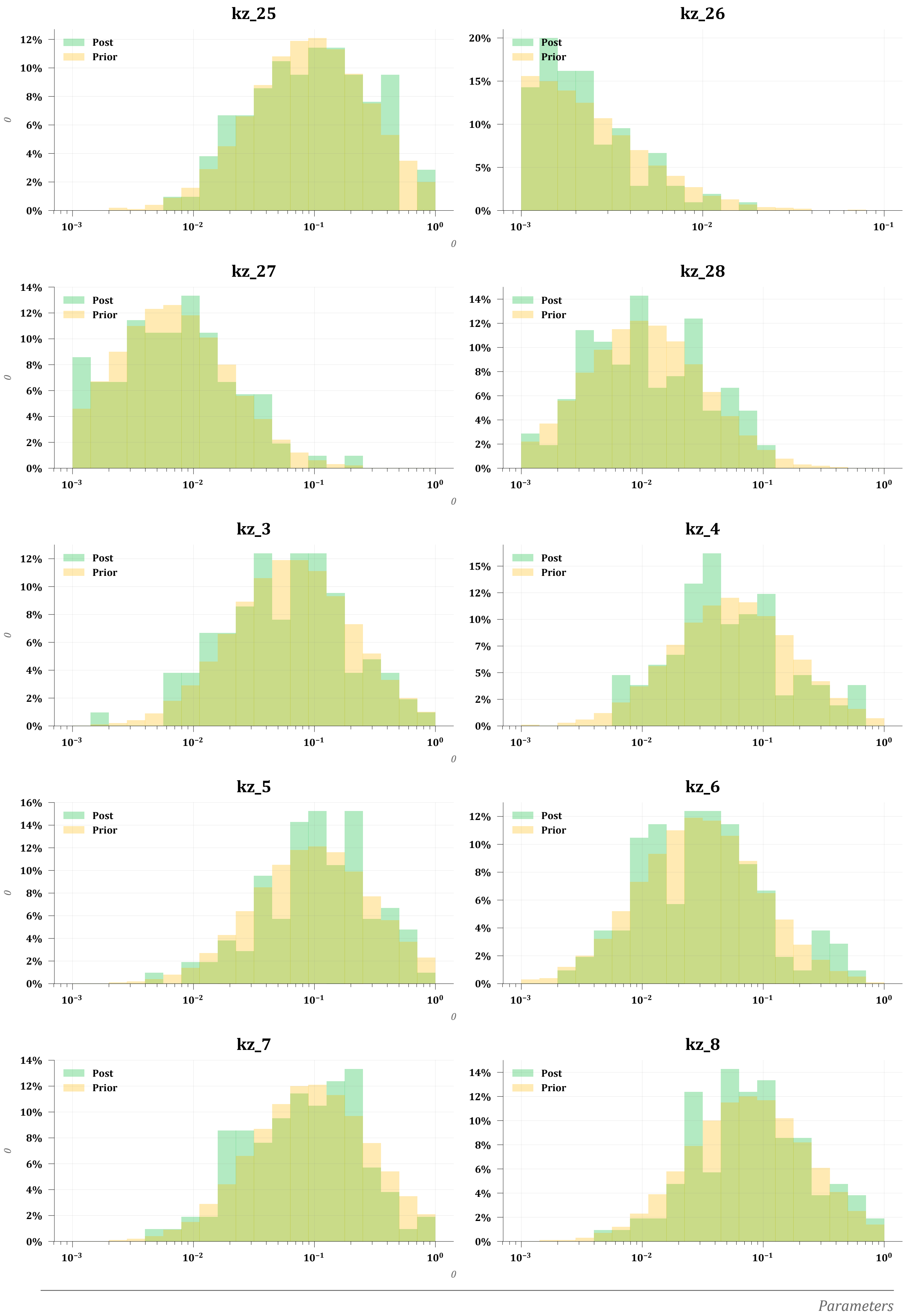
kz_23
kz_24

Parameters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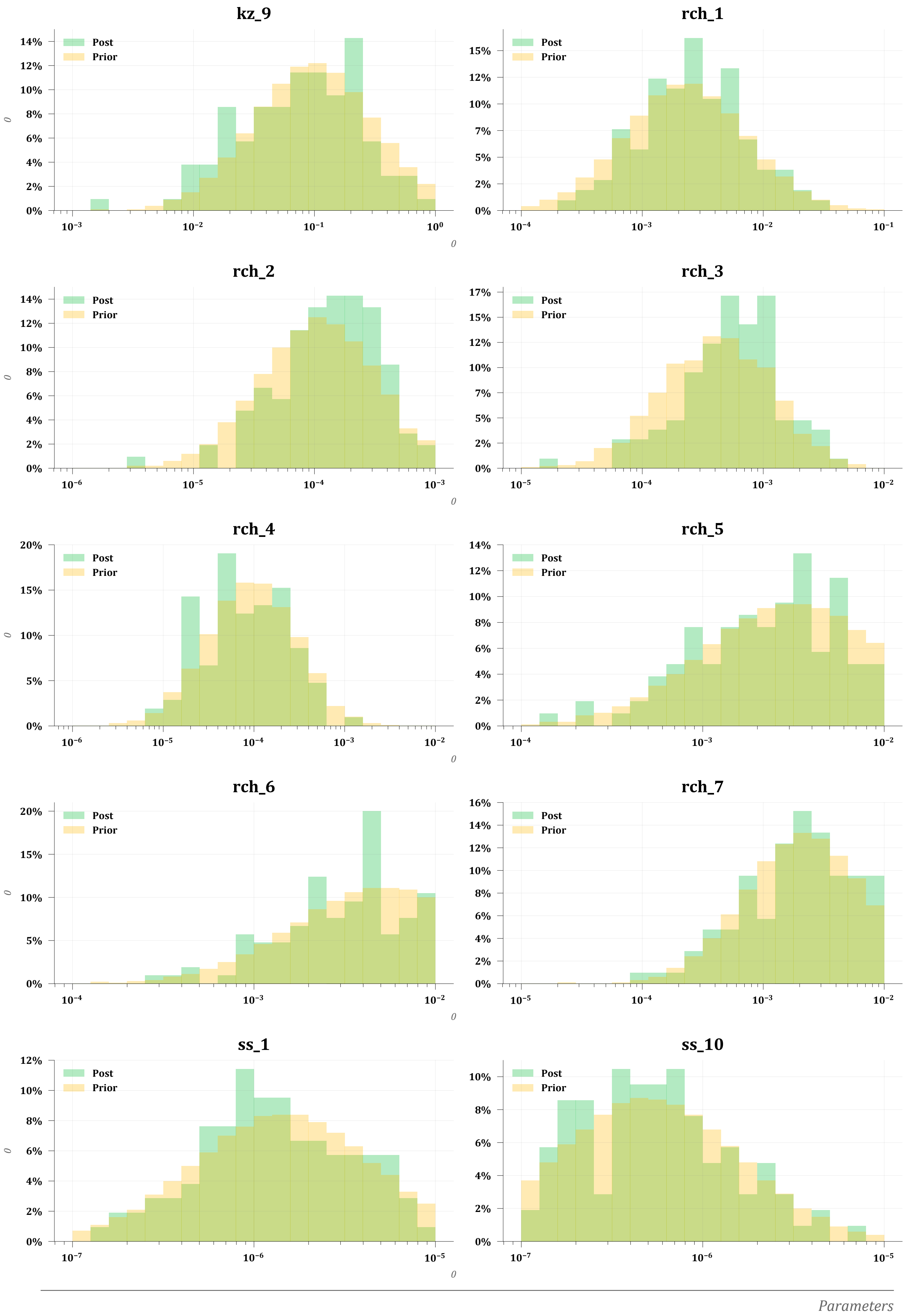
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rch_4
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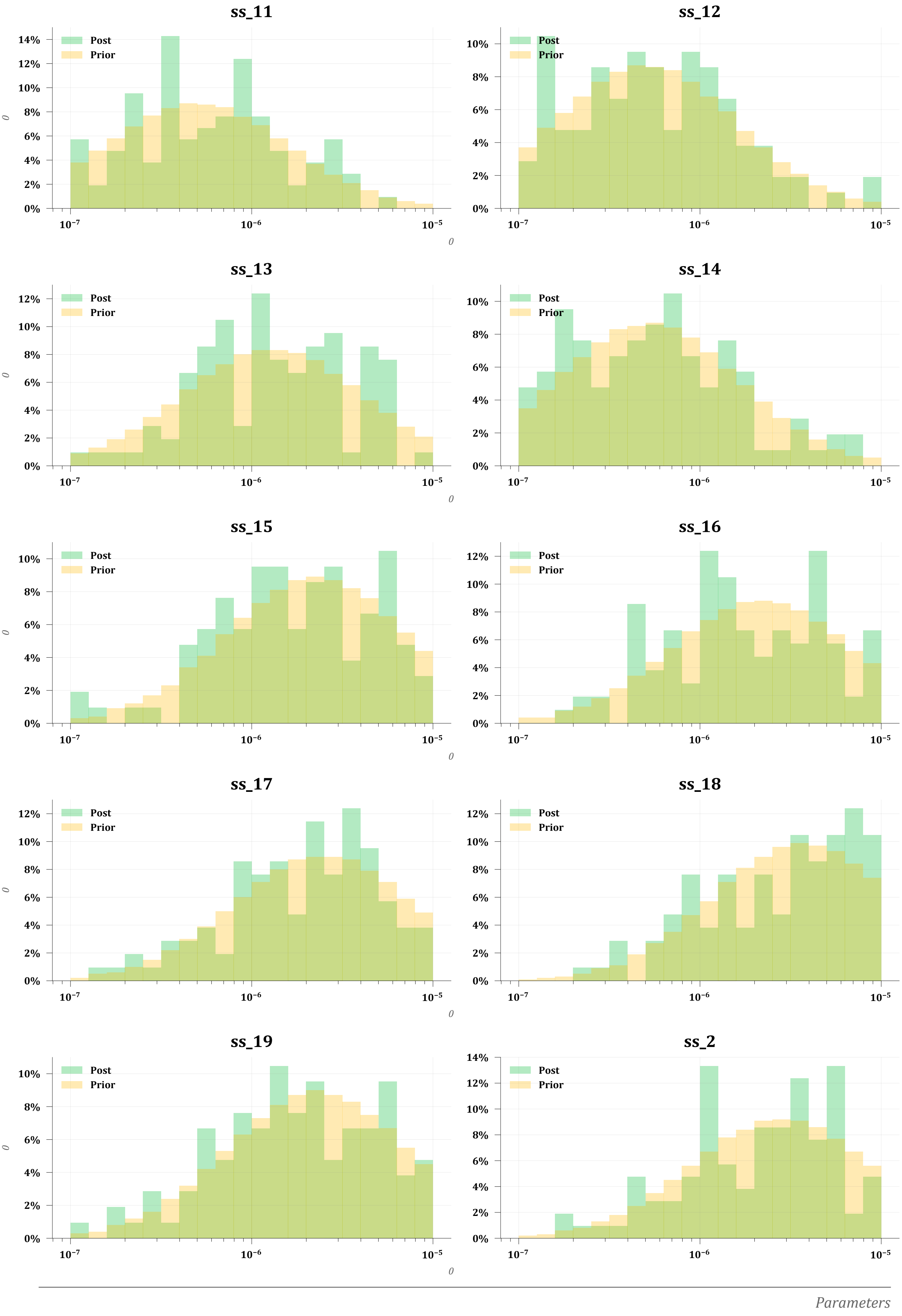
rch_6
rch_7
ss_1
ss_10
Post
Prior
Parameters



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ss_12
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ss_16
ss_17
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ss_19
ss_2
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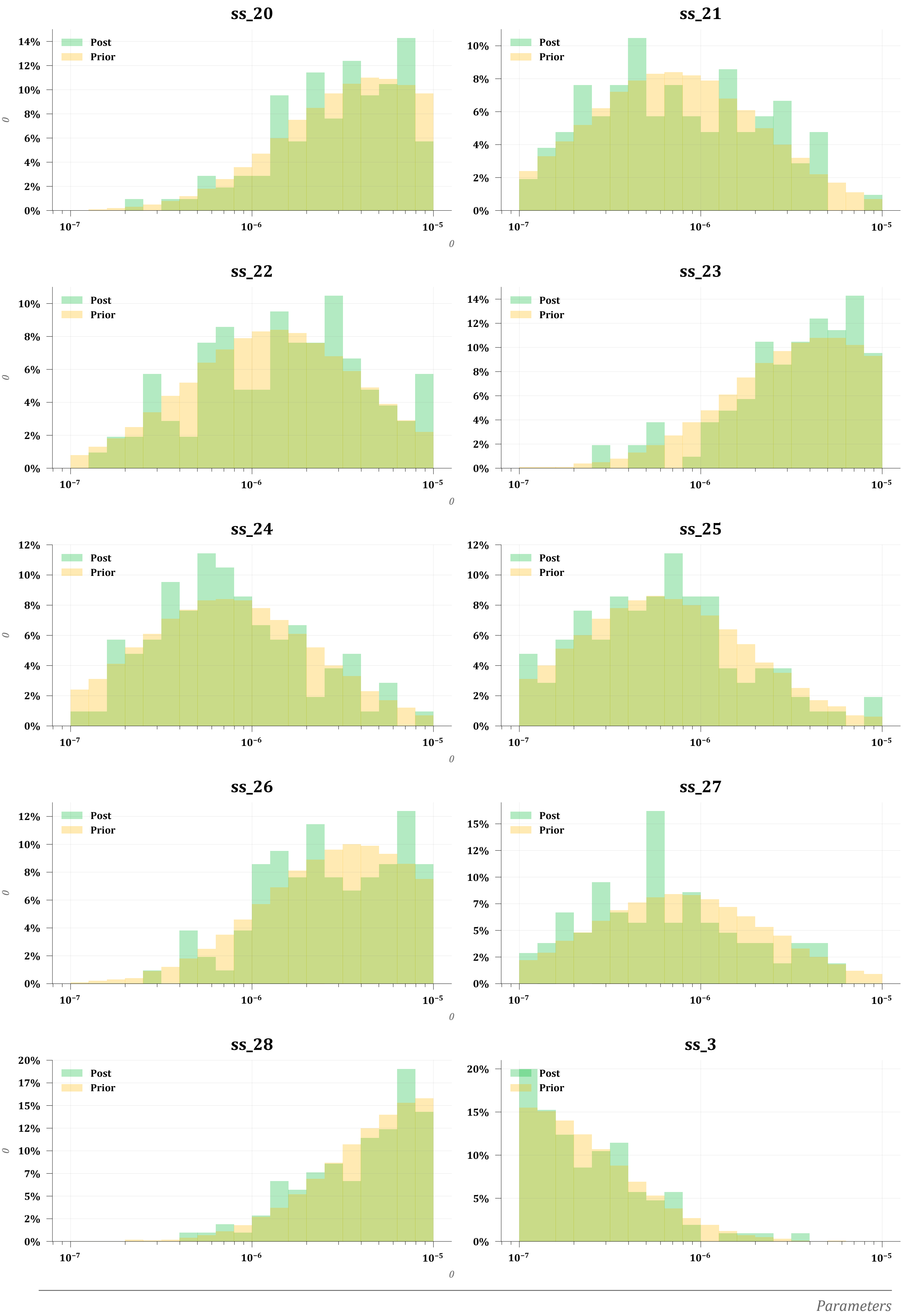
4%
6%
8%
10%
12%
14%
10^{-7}
10^{-6}
10^{-5}
0
Parameters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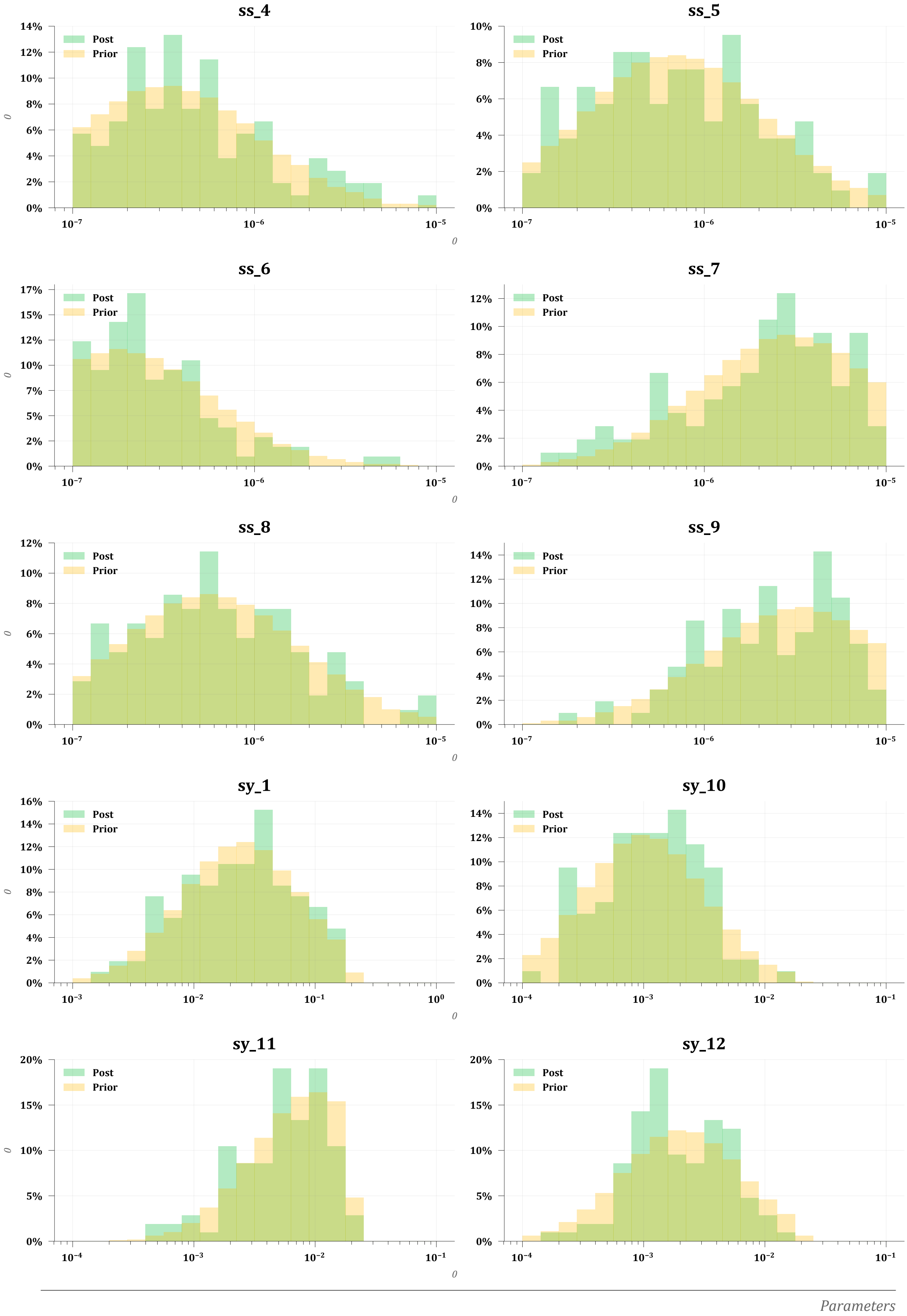

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Prior
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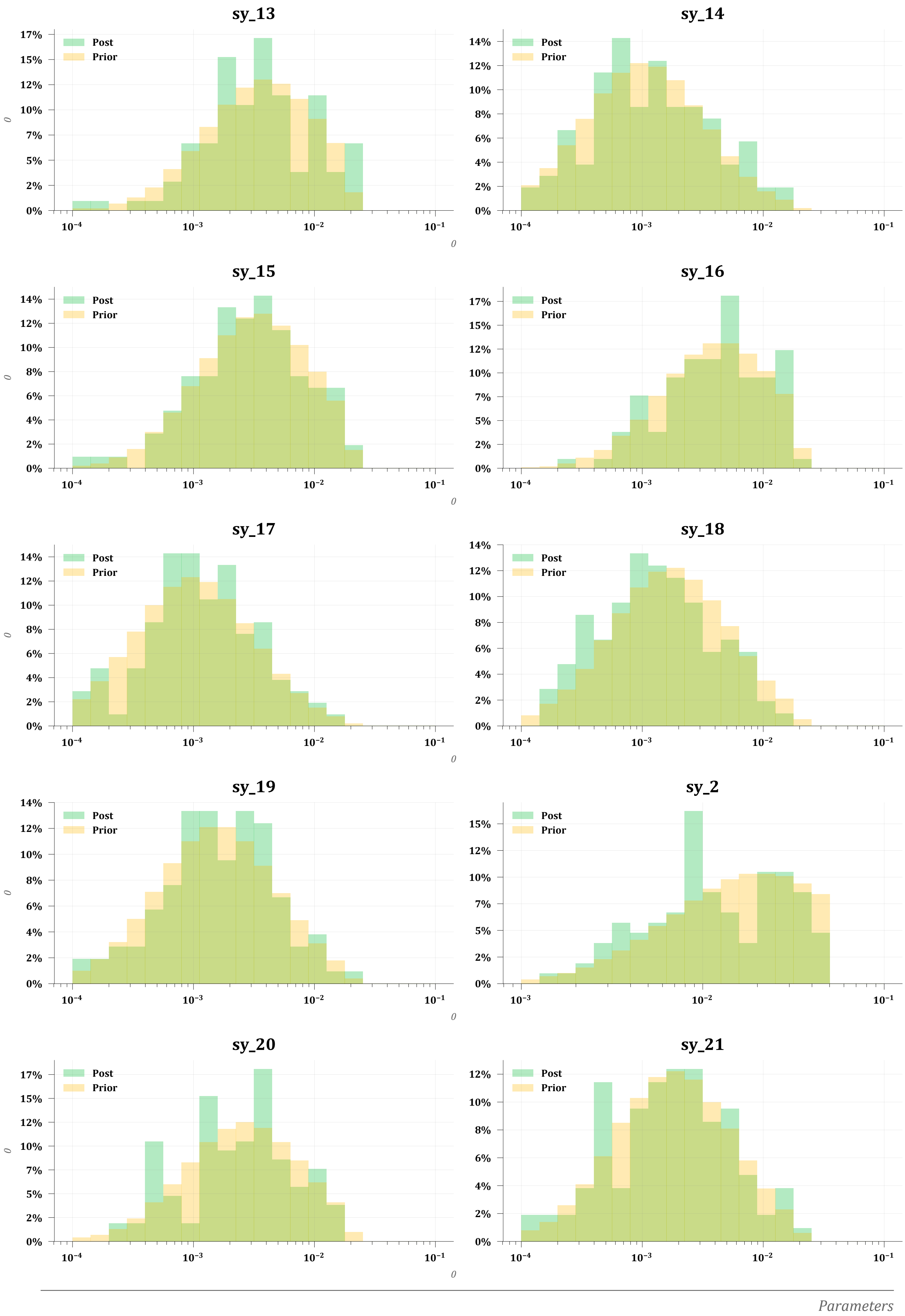
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sy_2
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sy_21
Post
Prior
Parameters


sy_22
sy_23
sy_24
sy_25
sy_26
sy_27
sy_28
sy_3
sy_4
sy_5
Post
Prior
0
0%
2%
4%
5%
6%
7%
8%
10%
12%
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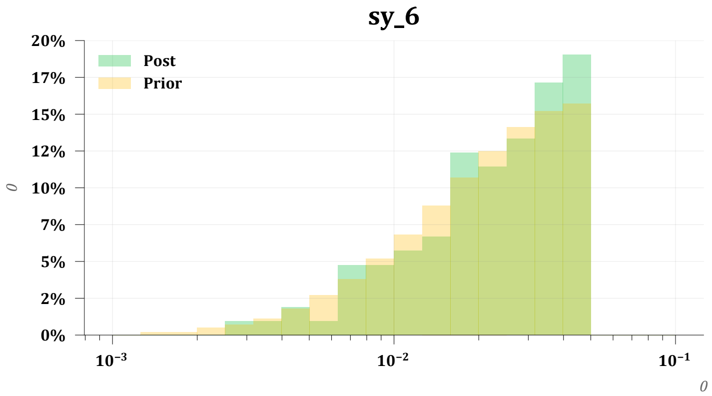
15%
20%
10⁻⁴
10⁻³
10⁻²
10⁻¹
Parameters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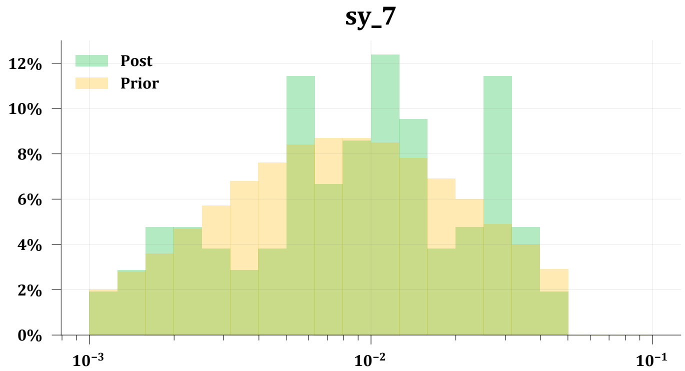
10⁻²
10⁻¹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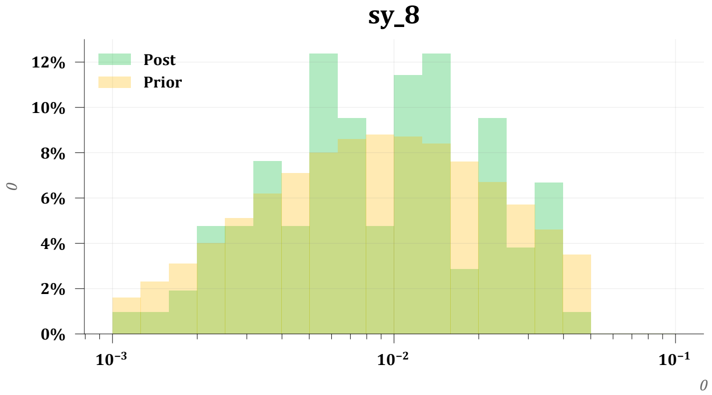
10⁻²
10⁻¹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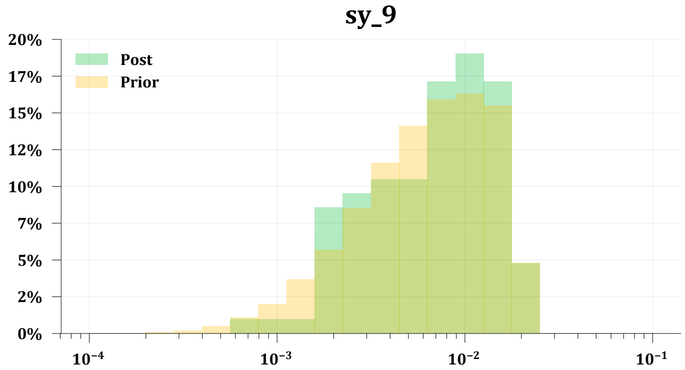
10⁻¹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Prior
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10⁻⁴
10⁻³
10⁻²
10⁻¹

Making Sustainability Happen