

MACHEnergy

Mount Pleasant Operation

A JOINT VENTURE WITH
JCDA
Japan Coal Development Australia



Appendix C

Groundwater Impact Assessment

Modification 8



Australasian
Groundwater
& Environmental
Consultants

Report on

Mount Pleasant Operation Modification 8 Groundwater Impact Assessment

Prepared for
MACH Energy Australia Pty Ltd

Project No. 20250079.MPO5009.001
December 2025

ageconsultants.com.au

ABN 64 080 238 642

Document details and history



Document details

Project number	MPO5009.001
Document title	MPO MOD 8 Life of Mine Extension
File name	MPO5009.001_MPO_MOD8_Life_of_Mine_Extension_v05.01.docx

Document status and review

Edition	Comments	Author	Authorised by	Date
v01.01	Draft one	AJ/RSM	BM	17/10/2025
v02.01	Draft two	AJ	BM	29/10/2025
v03.01	Draft three	AJ/BM	BM	18/11/2025
v04.01	Draft four	BM	BM	03/12/2025
v05.01	Final	BM	BM	04/12/2025

This document is and remains the property of AGE and may only be used for the purpose for which it was commissioned and in accordance with the Terms of Engagement for the commission. Unauthorised use of this document in any form whatsoever is prohibited.

Australasian Groundwater and Environmental Consultants Pty Ltd

Brisbane (Head Office)
Level 2, 15 Mallon Street
Bowen Hills QLD 4006
t: (07) 3257 2055

Adelaide
Office 13, 62 Queen Street
Glenunga SA 5064
t: (07) 3257 2055

Newcastle
4 Hudson Street
Hamilton NSW 2303
t: (02) 4962 2091

Perth
46B Angove Street
North Perth WA 6006
t: (08) 6383 9970

Townsville
Unit 1, 60 Ingham Road
West End QLD 4810
t: (07) 4413 2020

Table of contents

1	Introduction.....	1
1.1	Original objectives and scope of work.....	1
1.2	Mining operations.....	4
1.2.1	Mount Pleasant Operation.....	4
1.2.2	Modification description.....	4
1.2.3	Adjacent mining operations.....	5
1.3	Report structure.....	6
2	Regulatory framework.....	7
2.1	NSW Water Management Act 2000.....	7
2.1.1	Water sharing plans.....	8
2.1.2	Water licensing.....	10
2.2	NSW Protection of the Environment Operations Act 1997.....	11
2.3	NSW Aquifer Interference Policy.....	11
2.4	Commonwealth Environment Protection and Biodiversity Conservation Act 1999.....	13
3	Environmental setting.....	14
3.1	Location.....	14
3.2	Climate.....	14
3.2.1	Rainfall.....	14
3.2.2	Evaporation and evapotranspiration.....	15
3.3	Topography.....	16
3.4	Drainage.....	18
3.4.1	Regional drainage.....	18
3.4.2	Local drainage.....	18
3.4.3	MPO area drainage.....	18
3.4.4	Streamflow and electrical conductivity.....	18
3.5	Land use.....	19
4	Geological setting.....	21
4.1	Regional geology.....	21
4.2	Local geology.....	26
4.2.1	Quaternary alluvium.....	26
4.2.2	Wittingham Coal Measures.....	29
4.2.3	Maitland Group.....	32
5	Hydrogeology.....	33
5.1	Hydrostratigraphic units.....	33
5.2	Groundwater monitoring network.....	33
5.3	Hydraulic properties.....	37
5.3.1	Hydraulic conductivity.....	37
5.3.2	Storage properties.....	39
5.4	Saturation and productivity.....	39
5.4.1	Hunter River alluvium.....	39
5.4.2	Permian sediments.....	41

Table of contents

5.5	Water levels	41
5.5.1	Hunter River alluvium	41
5.5.2	Permian sediments – Western Domain	41
5.5.3	Permian sediments – Central Domain	43
5.6	Groundwater flow	45
5.7	Groundwater quality and beneficial use	47
5.7.1	Salinity and pH	47
5.7.2	Major ions	49
5.7.3	Metals	50
5.7.4	Beneficial use	51
5.8	Groundwater dependent assets	51
5.8.1	Bioregional Assessment – Hunter subregion water dependent assets	51
5.8.2	Private water users	56
5.8.3	Groundwater dependent ecosystems	59
5.8.4	Stygofauna	63
5.9	Conceptual model	64
5.10	Potential impact causal pathways	66
6	Numerical groundwater model	69
7	Groundwater model predictions	73
7.1	During mining	73
7.1.1	Groundwater inflows to mining areas	73
7.1.2	Drawdown during mining operations	74
7.2	Post-mining recovery conditions	78
8	Groundwater impact assessment	81
8.1	Incidental take of water from the alluvium and stream flow effects	81
8.1.1	Indirect take from alluvium	81
8.1.2	Indirect take from surface water	81
8.1.3	Post-mining changes in alluvial and surface water fluxes	81
8.1.4	Water licensing requirements	83
8.2	Water supply bores	83
8.3	Groundwater dependent ecosystems	85
8.4	Groundwater quality	85
9	Uncertainty analysis	87
9.1	Overview	87
9.2	Mine inflow rate	88
9.3	Baseflow reduction in Hunter River, Sandy Creek and Dart Brook	88
9.4	Indirect take from the Hunter River alluvium, Sandy Creek alluvium and Dart Brook alluvium	88
9.5	Zone of 2 m drawdown	88
10	Groundwater monitoring and management	96
10.1	Groundwater Management Plan	96
10.1.1	Water level monitoring	97

Table of contents

10.1.2	Water quality monitoring	97
10.1.3	Groundwater inflows	98
10.1.4	Annual Review and improvement of environmental performance	99
10.1.5	Management and mitigation strategies	99
10.2	Additional monitoring and management	99
11	Summary and conclusions	100
12	References	102
13	Glossary and acronyms	106
A1	Model objectives	1
A2	Model details	1
A2.1	Model software and complexity	1
A2.2	Model grid	2
A2.2.1	Model layers	4
A2.2.2	Timing	5
A2.3	System stresses	5
A2.3.1	Recharge	5
A2.3.2	Evapotranspiration	7
A2.3.3	Water courses and surface drainage	9
A2.3.4	Mining	9
A2.3.5	Depth dependence of hydraulic conductivity	11
A3	Model calibration	13
A3.1	Calibration targets	13
A3.1.1	Heads	13
A3.1.2	Fluxes	14
A3.2	Calibration results	17
A3.2.1	Calibration heads	20
A3.2.2	Hydraulic parameters	23
A3.2.3	Storage properties	25
A3.2.4	Water budget	26
A3.2.5	Mine inflow	27
A4	Predictive and recovery simulations	30
A4.1	Predictive simulations	30
A4.2	Recovery simulations	32
A5	Uncertainty analysis	35
A5.1	Methodology	35
A6	Climate sensitivity analysis	39
A7	Groundwater model validation	42
A8	References	45

Table of contents

List of figures

Figure 1.1	Regional Location	2
Figure 1.2	Modified MPO General Arrangement.....	3
Figure 2.1	Water sharing plan areas and subordinate management units relevant to the MPO	9
Figure 2.2	“Highly productive” groundwater sources (NSW Government, 2012).....	12
Figure 3.1	Cumulative Rainfall Departure and monthly rainfall (SILO).....	15
Figure 3.2	Monthly average SILO rainfall, evaporation and evapotranspiration	16
Figure 3.3	Terrain and drainage	17
Figure 3.4	Flow duration and electrical conductivity at WaterNSW stream gauges.....	20
Figure 4.1	Surface geology	22
Figure 4.2	Conceptualised north – south geological cross section	24
Figure 4.3	Conceptualised west – east geological cross section	25
Figure 4.4	Hunter River alluvium thickness in bores	27
Figure 4.5	Interpreted extents of the Hunter River alluvium.....	28
Figure 4.6	MPO typical stratigraphic section.....	31
Figure 4.7	MPO open cut pit face – looking south-west	32
Figure 4.8	MPO open cut pit face – looking north-west.....	32
Figure 5.1	MPO groundwater monitoring network.....	36
Figure 5.2	Hydraulic conductivity vs depth – Permian coal.....	38
Figure 5.3	Hydraulic conductivity vs depth – Permian interburden	39
Figure 5.4	Saturated thickness – Hunter River alluvium.....	40
Figure 5.5	Water levels – Hunter River alluvium and Hunter River	40
Figure 5.6	Water levels – MPO Western Domain regolith	42
Figure 5.7	Water levels – MPO Western Domain Permian sediments	43
Figure 5.8	Water levels – MPO Central Domain Permian sediments.....	44
Figure 5.9	Water table contours interpolated from 2023 observations	46
Figure 5.10	Electrical conductivity – Hunter River alluvium and Hunter River	48
Figure 5.11	Electrical conductivity – MPO Western Domain regolith	48
Figure 5.12	Electrical conductivity – MPO Central Domain Permian sediments.....	49
Figure 5.13	Piper plot of groundwater composition at the MPO (Hydrosimulations, 2019).....	50
Figure 5.14	Metal and metalloid ion concentrations in alluvium and Permian strata at the MPO (Hydrosimulations, 2019).....	51
Figure 5.15	Bioregional assessment – Hydrogeological assets (Macfarlane <i>et al.</i> , 2016)	53
Figure 5.16	Bioregional assessment – Ecological groundwater-dependent ecosystem assets (Macfarlane <i>et al.</i> , 2016).....	54
Figure 5.17	Bioregional assessment – Economic groundwater-dependent assets (Macfarlane <i>et al.</i> , 2016)	55
Figure 5.18	Land ownership overview	58

Table of contents

Figure 5.19	Potential aquatic GDEs in the vicinity of the MPO	60
Figure 5.20	Potential terrestrial GDEs in the vicinity of the MPO	62
Figure 5.21	Conceptual model	65
Figure 6.1	Model extent and mesh	70
Figure 6.2	Scatter diagram with verification	72
Figure 7.1	Predicted groundwater inflows for the modified MPO (up to December 2032)	73
Figure 7.2	Predicted drawdown in alluvium/regolith (Layers 1 and 2) at end of mining for modified MPO (up to December 2032).....	75
Figure 7.3	Predicted drawdown in Edderton seam (Layer 18) at end of mining for modified MPO (up to December 2032)	76
Figure 7.4	Predicted incremental drawdown due to only the Modification (up to December 2032).....	77
Figure 7.5	Predicted maximum drawdown during and post-mining attributed to the modified MPO	79
Figure 7.6	Predicted particle pathlines post-mining.....	80
Figure 8.1	Indirect take from alluvium bodies due to the modified MPO	82
Figure 8.2	Reduction in baseflow due to the modified MPO	82
Figure 9.1	Probability distribution for MPO mine inflow rate	89
Figure 9.2	Probability distribution for rate of baseflow decline in Hunter River.....	90
Figure 9.3	Probability distribution for rate of baseflow decline in Sandy Creek	90
Figure 9.4	Probability distribution for rate of baseflow decline in Dart Brook.....	91
Figure 9.5	Probability distribution for indirect alluvial take from Hunter River alluvium	91
Figure 9.6	Probability distribution for indirect take from Sandy Creek alluvium	92
Figure 9.7	Probability distribution for indirect take from Dart Brook alluvium	92
Figure 9.8	Likelihood of 2 m drawdown at end of mining for modified MPO (up to December 2032) – Alluvium (Layers 1 and 2).....	93
Figure 9.9	Likelihood of 2 m drawdown at end of mining for modified MPO (up to December 2032) – Edderton Seam (Layer 18)	94
Figure 9.10	Evidence of uncertainty analysis convergence – maximum mine inflow.....	95

List of tables

Table 2.1	Water sharing plans relevant to the MPO.....	8
Table 2.2	Details of MACH held WALs – groundwater sources.....	10
Table 3.1	Average monthly rainfall (mm).....	14
Table 3.2	Average monthly evaporation and evapotranspiration (mm).....	16
Table 3.3	WaterNSW stream gauges in vicinity of the MPO	19
Table 4.1	Summary of regional geological units	23
Table 4.2	Wittingham Coal Measures indicative thickness.....	30
Table 5.1	MPO groundwater monitoring network.....	34
Table 5.2	Hydraulic conductivity packer test data	37

Table of contents

Table 5.3	Private bores in the vicinity of the MPO	56
Table 5.4	WALs in the vicinity of the MPO.....	57
Table 5.5	Causal pathways with a groundwater component	67
Table 8.1	Water licensing requirements for the modified MPO.....	83
Table 8.2	Drawdown in private bores	84
Table 9.1	Calibrated uncertainty modelling language	87
Table 10.1	Parameters for annual groundwater laboratory analysis.....	98

List of appendices

Appendix A	Numerical modelling report
Appendix B	Compliance with government policy

Mount Pleasant Operation Modification 8

Groundwater Impact Assessment

1 Introduction

The Mount Pleasant Operation (MPO) is located approximately three kilometres (km) north-west of Muswellbrook in the Upper Hunter Valley of New South Wales (NSW) (Figure 1.1). The Mount Pleasant Operation Development Consent DA 92/97 was granted on 22 December 1999 under the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act). The MPO was also approved under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) in 2012 (EPBC 2011/5795).

MACH Energy Australia Pty Ltd (MACH Energy) acquired the MPO from Coal and Allied Operations Pty Ltd on 4 August 2016. MACH Energy commenced construction activities at the MPO in November 2016 and commenced mining operations in October 2017, in accordance with Development Consent DA 92/97 and EPBC 2011/5795.

MACH Mount Pleasant Operations Pty Ltd manages the MPO as agent for and on behalf of the unincorporated Mount Pleasant Joint Venture between MACH Energy (95% owner) and J.C.D. Australia Pty Ltd (5% owner). Throughout this report, MACH Mount Pleasant Operations Pty Ltd and the unincorporated Mount Pleasant Joint Venture will be referred to as MACH.

The MPO as currently approved under Development Consent DA 92/97 (as most recently modified by Modification 6) includes a Coal Handling and Preparation Plant (CHPP) and a rail loop and spur, conveyor and load-out facility connecting the mine to the Muswellbrook-Ulan Rail Line.

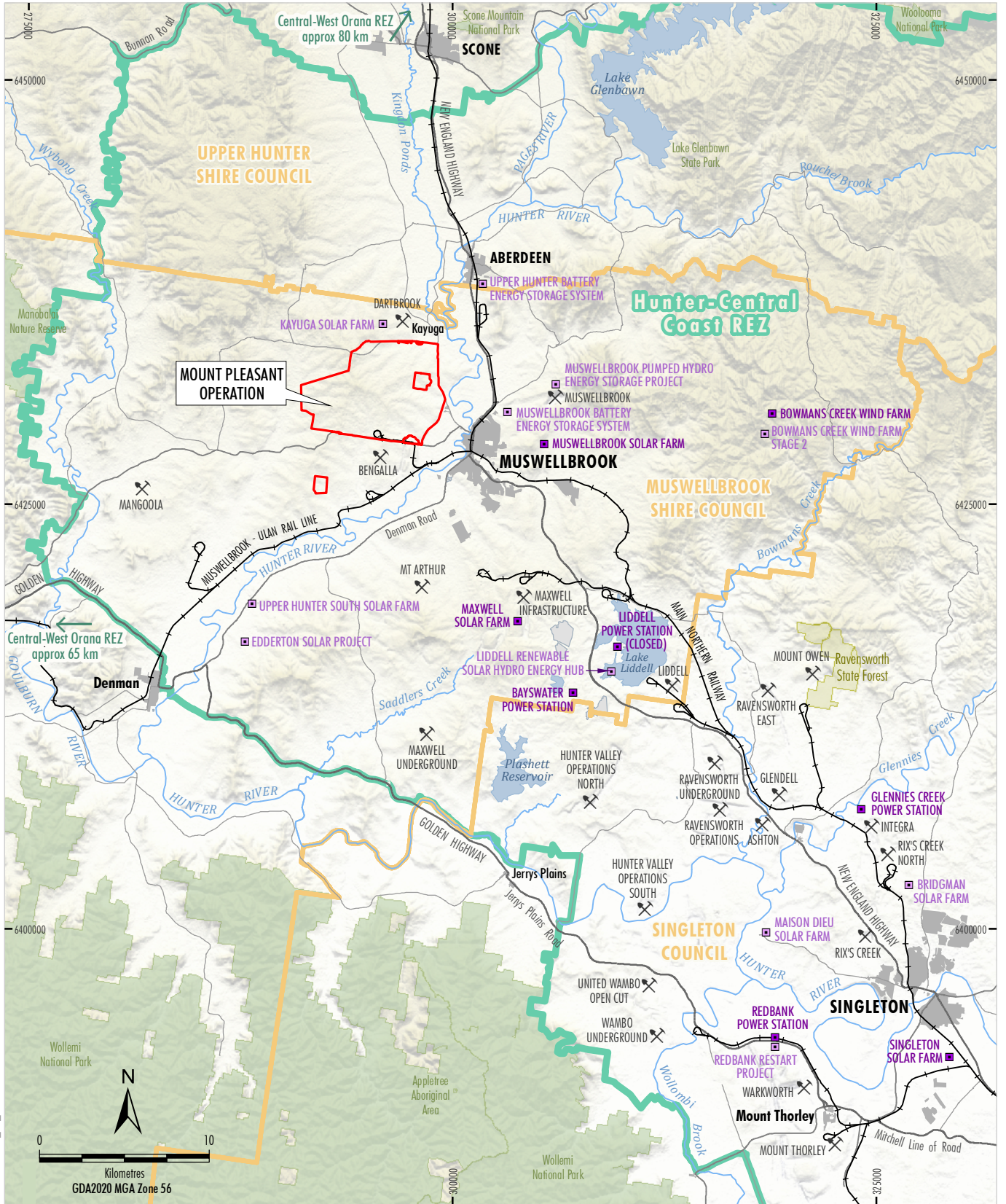
MACH is proposing an extension of life to the existing mining operations approved under Development Consent DA 92/97 to create greater certainty for the Mount Pleasant Operation and an increase in extraction rate due to operational efficiencies identified (the Modification) (Figure 1.2).

MACH engaged Australasian Groundwater and Environmental Consultants Pty Ltd (AGE) to complete a Groundwater Impact Assessment (GIA) to support the Modification Report, which has been prepared to accompany the Modification application.

1.1 Original objectives and scope of work

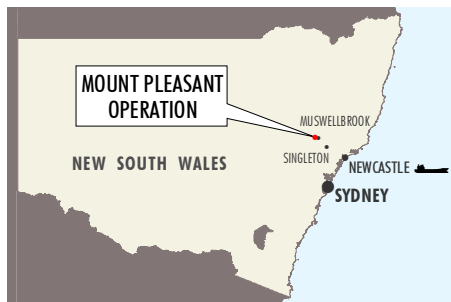
The objective of the GIA was to assess the potential impacts of the Modification on the groundwater regime, in consideration of the requirements of relevant NSW and Federal Government policies and guidelines. This GIA comprises two parts, a description of the existing hydrogeological environment, and an assessment of the impacts of the Modification on that environment. This GIA includes:

- review of existing background data and previous hydrogeological investigations;
- modelling of the potential impacts resulting from the Modification on:
 - regional groundwater levels in aquifers and aquitards during and post-mining;
 - rates of baseflow to surface waters;
 - groundwater quality during and post-mining; and
 - take of water under applicable water sharing plans.
- comparison of predicted impacts against the requirements of the *NSW Aquifer Interference Policy* (AIP);
- assessment of the potential for impacts upon water dependent assets via causal pathways including:
 - potential groundwater dependent ecosystems (GDEs); and
 - third party water users (i.e. private bores).
- assessment of risks to groundwater systems and consideration of appropriate mitigation, management and monitoring measures.



MACH-18-02A-MOD9_GW_2014

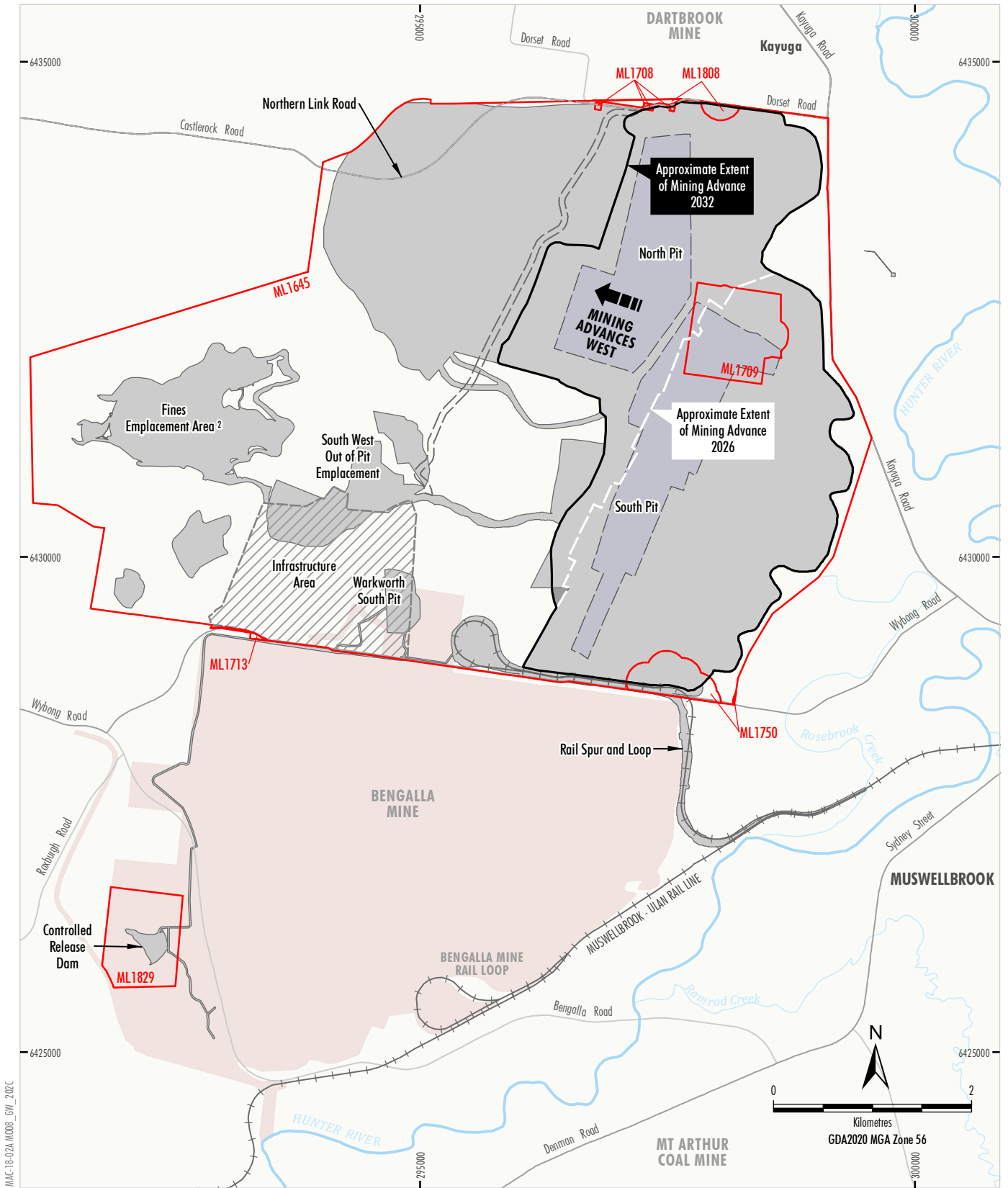
Source: NSW Spatial Services (2025); EnergyCo (2024)



- LEGEND**
- Mining Operation
 - Existing/Approved Major Energy Generation Site
 - Proposed Major Energy Generation Site
 - Railway
 - National Parks and Wildlife Estate
 - State Forest/Reserve
 - Local Government Boundary
 - Hunter-Central Coast Renewable Energy Zone (REZ)
 - Mining Lease Boundary (Mount Pleasant Operation)

MACHEnergy
MOUNT PLEASANT OPERATION
Regional Location

Figure 1.1



Source: MACH (2025); NSW Spatial Services (2025); Department of Planning and Environment (2016)

LEGEND

- Mining Lease Boundary (Mount Pleasant Operation)
- Approved Surface Disturbance Plan - DA 92/97 ¹
- Extension of Open Cut Mining and Emplacement Area (Land Lawfully Disturbed under SSD-10418)
- Indicative Pit Floor Footprint
- Services Corridor Being Developed Under SSD-10418 to be Used Under the Modification
- Revised Infrastructure Area Envelope
- Bengalla Mine Approved Disturbance Boundary (SSD-5170)

¹ Excludes some incidental Project components such as water management infrastructure, access tracks, topsoil stockpiles, power supply, temporary offices, other ancillary works and construction disturbance.

² The general arrangement of the Fines Emplacement Area has been amended from the area shown in DA 92/97 to reflect as-built structures.

MACHEnergy

MOUNT PLEASANT OPERATION

Modified Mount Pleasant Operation

General Arrangement

Figure 1.2

1.2 Mining operations

1.2.1 Mount Pleasant Operation

The MPO is an existing open cut coal mine and associated infrastructure located approximately 3 km north-west of Muswellbrook in the Upper Hunter Valley of NSW (refer Figure 1.1).

The MPO currently operates under Development Consent DA 92/97, which was originally granted under the EP&A Act on 22 December 1999 and has been subsequently modified on six occasions. Under Development Consent DA 92/97, the MPO is approved to produce up to 10.5 Mtpa of ROM coal and MACH can undertake mining operations on the site until 22 December 2026.

The MPO is carried out generally in accordance with the surface disturbance area depicted and described in Appendix 2 of Development Consent DA 92/97. Condition 2 of Schedule 2 of Development Consent DA 92/97 (as modified) states the following (emphasis added):

2. *The Applicant must carry out the development:*

- a) *generally, in accordance with the EIS, EA (MOD 1), EA (MOD 2), EA (MOD 3), EA (MOD 4), EA (MOD 6) and project layout plans; and*
- b) *in accordance with the Statement of Commitments and conditions of this consent.*

Notes:

- The project layout plans are Figures 1, 2, 3 and 4 shown in Appendix 2.
- The Applicant may carry out development in the surface disturbance area depicted and described in Figure 3 in Appendix 2 to the extent authorised by the terms of this consent.
- *The Applicant may lodge an application under section 4.55 of the Environmental Planning and Assessment Act 1979 to modify this consent, including to modify condition 5 in Schedule 2 to extend the period of mining operations beyond 22 December 2026 in respect of all or any part of the surface disturbance area depicted and described in Figure 3 in Appendix 2.*
- *The Statement of Commitments is reproduced in Appendix 3.*

It is noted that MACH holds a separate consent for the Mount Pleasant Optimisation Project (SSD 10418) granted on 6 September 2022. As described in the Modification Report, this Modification application is to Development Consent DA 92/97 and does not affect the separately approved Mount Pleasant Optimisation Project under SSD 10418.

1.2.2 Modification description

The Modification would include the following key changes to the approved Mount Pleasant Operation:

- a six-year extension of permitted (ROM coal) mining operations to 31 December 2032; and
- an increase in the approved ROM coal extraction rate from 10.5 to 12.5 million Mtpa (metric tonnes per annum).

The Modification would involve no material changes to existing:

- mining tenements;
- mining methods;
- primary site access;
- electricity supply and distribution;
- Mine Infrastructure Area;
- Coal Handling and Preparation Plant, coal stockpile and rail loading facilities;
- rehabilitation objectives and methods; and
- the existing hours of operation and key on-site activities.

The Modification would involve the continuation of the MPO until the end of 2032 under Development Consent DA 92/97 (referred to as the 'modified MPO'), with open cut mining proposed to recover a total of 142 million tonnes (Mt) of ROM coal across the life of mine and a maximum of 12.5 million tonnes per annum (Mtpa) extracted in any calendar year (Figure 1.2).

Coal will be extracted from two pits, South Pit and North Pit. Under Development Consent DA 92/97, mining in North Pit is depth-limited to the Vaux Seam. The target seams for the MPO within the Wittingham Coal Measures would continue to be extracted within the modified MPO, with North Pit continuing to be depth-limited to the Vaux Seam.

Mining activities for the modified MPO would be undertaken within currently held MPO mining leases and mining would target the same coal seams within the Wittingham Coal Measures as the approved MPO.

1.2.3 Adjacent mining operations

The Hunter Coalfield has a number of approved coal mining operations in addition to the approved operation at MPO. The nearest active mines within approximately 10 km of the MPO are Bengalla Mine, Muswellbrook Coal Mine, Dartbrook Mine, Mt Arthur Coal Mine and Mangoola Coal. With the exception of Muswellbrook Coal Mine and Mangoola Coal, each of these mines extract from the Wittingham Coal Measures. The AIP requires that an assessment of groundwater drawdown, including capture of groundwater via inflow, and any changes in water quality as the result of aquifer interference activities (such as open cut mining), considers the cumulative influence of nearby mines. A brief summary of these approved operations is provided below:

- Bengalla Mine (Bengalla Mining Company) extracts from the Wittingham Coal Measures using open cut methods. Mining operations commenced in 1998 and are approved to extract up to 15 Mtpa until 2039. The Bengalla Mine open cut progresses from east to west and is located immediately south of the MPO.
- Dartbrook Mine (Australian Pacific Coal) is located immediately north of the MPO and has previously extracted coal from the Wittingham Coal Measures using underground methods. Dartbrook Mine had been under care and maintenance since 2007. In March 2022, the recommencement of bord and pillar mining in the Kayuga Seam of the Wittingham Coal Measures until December 2027 was approved. Mining operations (bord and pillar only) at Dartbrook Mine recommenced in 2024. Dartbrook Mine went into external administration and receivership in July 2025, and operations wound down but continue to operate at the time of writing.
- Muswellbrook Coal Mine (Muswellbrook Coal Company) is located approximately 6 km east of the MPO and extracted from the Greta Coal Measures to the Loder Seam using open cut methods. Coal was extracted at Muswellbrook Coal Mine from 1907, with open cut operations ceasing in 2022.
- Mt Arthur Coal Mine (BHP) is located approximately 8 km south of the MPO and currently extracts from the Ramrod Creek Seam of the Wittingham Coal Measures using open cut methods at two locations. Mining operations commenced in 2008 and are currently approved to 30 June 2030.
- Mangoola Coal (Glencore) is located approximately 15 km west of the MPO and extracts from the Newcastle Coal Measures to the Pilot Seam using open cut methods. Open cut operations are approved until 2030.

Mangoola Coal targets seams that are separated by a significant thickness of strata above the target seams of MPO. In addition, Mangoola Coal is on the western side of the Mt Ogilvie Thrust Fault. The Mt Ogilvie fault is a significant structural feature that offsets the coal seams against lower permeability interburden units, forming a barrier to the expansion of drawdown beyond the fault and limiting the potential for the groundwater impacts of the two operations to overlap.

Muswellbrook Coal Mine is closer to the MPO, being 6 km east of MPO, and targets older seams in the Greta Coal Measures exposed in the Muswellbrook Anticline. Because of the stratigraphic separation, Mangoola Coal and Muswellbrook Coal Mine would not be considered in the cumulative impact assessment.

West Muswellbrook is a proposed open cut development about 3 km to the west of the MPO. The West Muswellbrook Project proposes to target the shallow seams within the Jerrys Plains Subgroup of the Wittingham Coal Measures, being the Blakefield seam and above. These seams do not occur at the MPO site and therefore cumulative impacts are unlikely.

Historically there has been an additional mining proposal, the Spur Hill Underground Coking Coal Project. However, it is noted that the Gateway Certificate for the Spur Hill Underground Coking Coal Project has lapsed and the proponent of the Spur Hill Underground Coking Coal Project has indicated that they do not anticipate it will proceed as proposed in previous documentation (Malabar Coal Limited, 2019). It is noted that should any future development application be made for the Spur Hill Underground Coking Coal Project, then this would need to consider cumulative impacts with the MPO at that time.

As a result, this assessment has considered the following approved mining operations as part of the cumulative assessment:

- The existing approved mining at the MPO up until 22 December 2026.
- Bengalla Mine.
- Mt Arthur Coal Mine.
- Dartbrook Mine.

1.3 Report structure

This report is structured as follows:

- Section 1 – Introduction: provides an overview of the modified MPO, scope of the report and objectives.
- Section 2 – Regulatory framework: describes the NSW and Commonwealth regulatory framework relating to groundwater and relevant to the modified MPO.
- Section 3 – Environmental setting: describes the environmental setting of the modified MPO, including the climate, terrain, land uses and other environmental features.
- Section 4 – Geological setting: describes the regional geology and local stratigraphy.
- Section 5 – Hydrogeology: describes the existing local groundwater regime within the modified MPO and surrounds.
- Section 6 – Numerical groundwater model: describes the application of modelling to assess the impacts associated with the modified MPO.
- Section 7 – Groundwater model predictions: presents the numerical model predictions during mining and for the post-mining recovery phase.
- Section 8 – Impact assessment: describes the predicted impacts of the modified MPO on the groundwater regime and water dependent assets.
- Section 9 – Sensitivity and uncertainty analysis: summarises the uncertainty and sensitivity analysis undertaken on the numerical groundwater model, including details about the purpose and methodology of the assessment.
- Section 10 – Groundwater monitoring and management: describes the proposed measures for mitigation, management and monitoring of the groundwater regime and potential impacts.

Appendix A provides a detailed description of the numerical modelling undertaken for the modified MPO, including details on model construction, calibration and validation. Appendix B provides a summary of compliance against the AIP.

2 Regulatory framework

This GIA has considered the requirements of the following legislation, policies and guidelines relevant for groundwater:

- NSW Government guidance, policies and legislation:
 - *Groundwater assessment toolbox for major projects in NSW* (DPE, 2022a).
 - *Minimum Groundwater Modelling Requirements for SSD/SSI Projects* (DPE, 2022b).
 - *Guidelines for Groundwater Documentation for SSD/SSI Projects* (DPE, 2022c).
 - *Cumulative Groundwater Impact Assessment Approaches* (DPE, 2022d).
 - *Water Management Act 2000* (WM Act) and the associated water sharing plans.
 - the AIP.
 - *Protection of the Environment Operations Act 1997* (POEO Act).
- Commonwealth Government guidance:
 - Significant Impact Guidelines 1.3: Coal seam gas and large coal mining developments - impacts on water resources (Commonwealth Department of Climate Change, Energy, the Environment and Water, 2022).
 - Information Guidelines for Proponents preparing Coal Seam Gas and Large Coal Mining Development Proposals (Independent Expert Scientific Committee on Unconventional Gas Development and Large Coal Mining Development [IESC], 2024a).
 - Information Guidelines Explanatory Note: Using impact pathway diagrams based on ecohydrological conceptualisation in environmental impact assessment (IESC, 2024b).
 - IESC Explanatory Note on Uncertainty Analysis in Groundwater Modelling (Peeters and Middlemis, 2023).

The following sections identify the relevant NSW Government legislative instruments, regulations and policies that are applicable to the management of groundwater at the MPO. This section also presents information on the licences (water access and environmental) currently held by MACH.

2.1 NSW Water Management Act 2000

The WM Act manages NSW water resources via the regulation of access rights through water licensing and approvals. The WM Act is administered by the NSW Department of Climate Change, Energy, the Environment and Water (NSW DCCEE) and WaterNSW via the following means:

- water access licence (WAL): which allows the holder access to a maximum volume or share component that may be drawn from a particular water source. A WAL may also specify a category and the conditions under which water may be taken from a particular water source;
- water use approval: which authorises the particular use of water taken under a WAL; and
- water supply work approval: which states the nature, type and location of infrastructure by which water may be taken from a water source.

As Development Consent DA 92/97 (including the Modification) is not a SSD, under the EP&A Act, relevant water use approvals and a water supply work approvals would be required.

MACH is also to obtain WALs to account for the maximum annual predicted inflows to the open cut at the MPO (refer Section 2.1.1 and 2.1.2).

2.1.1 Water sharing plans

Under the WM Act, water sharing plans have been developed for certain river and aquifer systems to regulate access rights in a manner that protects dependent ecosystems.

Due to areal and geological heterogeneity, the management of water resources under a water sharing plan can be sub-divided to provide scope for further refinement in water resource allocation such as:

- extraction management units which assign resource allocations via long-term, average annual extraction limits; and
- management areas or management zones which assign various rules on water trading and WAL dealings.

Table 2.1 presents the relevant surface water and groundwater water sharing plans, including the relevant sub-divisions (where applicable), relevant to the MPO.

The boundaries of the respective water sharing plans and sub-divisions are shown in Figure 2.1.

Table 2.1 Water sharing plans relevant to the MPO

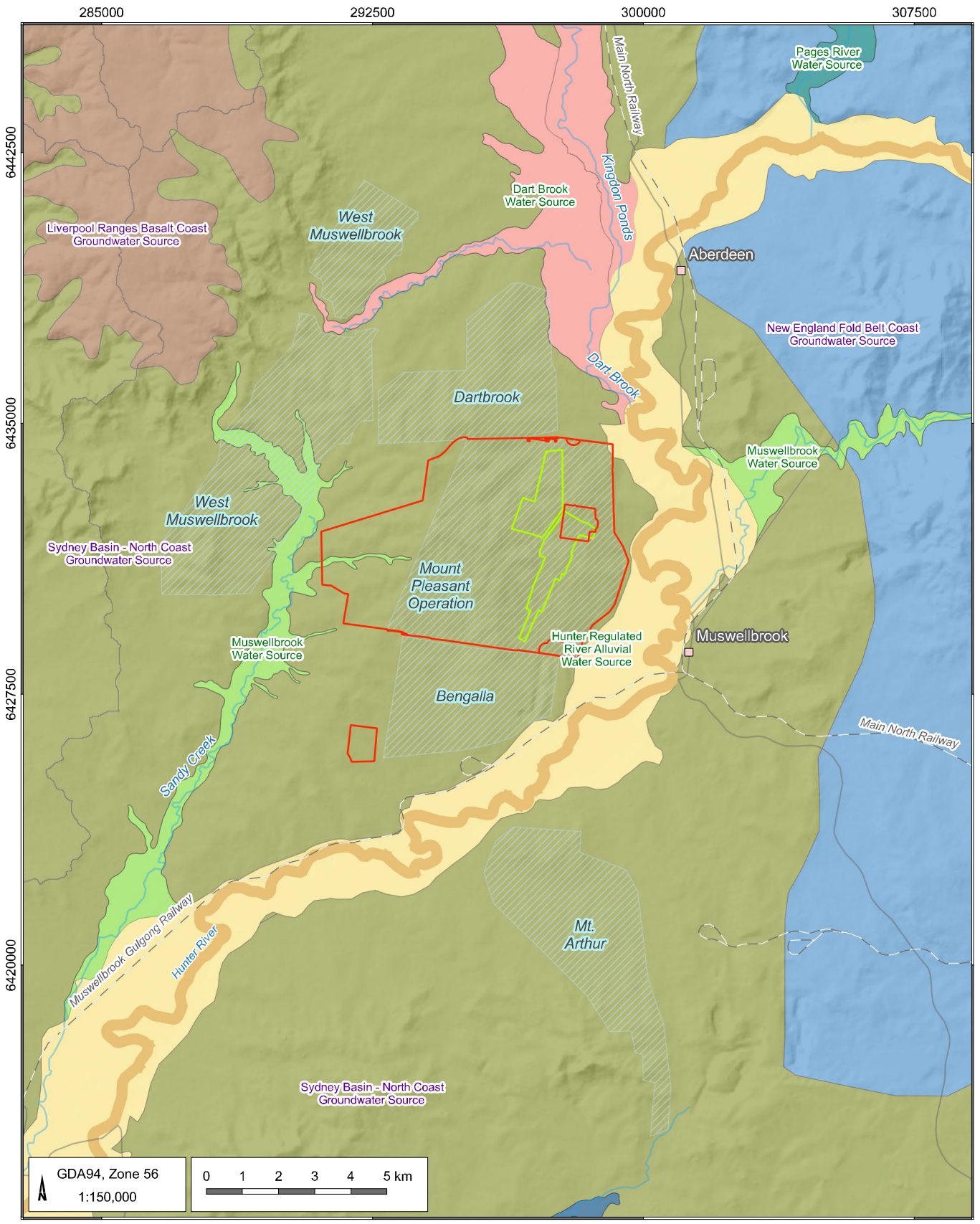
Water sharing plan	Groundwater management area	Extraction management unit	Water source	Groundwater management zone
<i>Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources 2022</i>	Hunter River Alluvium	Hunter Regulated River Alluvium	Hunter Regulated River Alluvial Water Source	Upstream (u/s) Glennies Creek
		Greater Hunter	Unnamed Upriver Alluvium in the Muswellbrook Water Source	-
			Dart Brook Water Source	Lower Dart Brook
	Not applicable (surface water)	-	Muswellbrook Water Source	-
<i>Water Sharing Plan for the Hunter Regulated River Water Source 2016</i>	Management Zone 1A	-	Hunter Regulated River Water Source	Glenbawn Dam water storage and Hunter River to Goulburn River junction
<i>Water Sharing Plan for the North Coast Fractured and Porous Rock Groundwater Sources 2016</i>	Sydney Basin – North Coast	-	Sydney Basin – North Coast Groundwater Source	-

Further information relating to the water sharing plans identified in Table 2.1 and its relevance to the MPO is presented below.

The alluvial aquifers in the vicinity of the MPO are managed under the *Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources 2022*.

Within the vicinity of the MPO, the Hunter River Alluvium groundwater management area is placed into sub-divisions, which are as follows:

- Unnamed Upriver Alluvium in the Muswellbrook Water Source– groundwater associated with alluvium along Sandy Creek, in the western section of the MPO.
- Hunter Regulated River Alluvial Water Source (Upstream Glennies Creek Management Zone) - groundwater associated with alluvium present to the north-east and south-east of the MPO.
- Hunter Regulated River Water Source (Management Zone 1A) - Hunter River surface water and groundwater associated with alluvium located within 40 m of the top of the high bank of the Hunter River.



LEGEND

- Populated place
- Road
- Rail
- Drainage
- Mining lease
- Surrounding mines
- Pit Floor Extent

Hunter Unregulated and Alluvial Water Sources

- Hunter Regulated River Alluvial Water Source
- Dart Brook Water Source
- Jerrys Water Source
- Muswellbrook Water Source
- Pages River Water Source

North Coast Fractured and Porous Rock Groundwater Sources

- Liverpool Ranges Basalt Coast Groundwater Source
- New England Fold Belt Coast Groundwater Source
- Sydney Basin - North Coast Groundwater Source

MPO MOD 8 Life of Mine Extension (MPO5009.001)

Water sharing plan areas and subordinate management units relevant to MPO



DATE
13/10/2025

FIGURE No:
2.1

In the broader region, there are additional groundwater and surface water resources covered by the *Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources 2022* that may be relevant to the MPO. These are as follows:

- Dart Brook Water Source, situated to the north of the mine area and which falls within the bounds of the Lower Dart Brook Groundwater Management Zone; and
- Hunter Regulated River Alluvial Water Source (Upstream Glennies Creek Management Zone), situated east of the mine area.

No high priority GDEs listed in the *Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources 2022* are located within the MPO area. There are some mapped high priority GDEs located approximately 1 km to the west of the MPO as identified in the *Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources 2022*. These mapped high priority GDEs meet the criteria of the high ecological value aquatic ecosystem (HEVAE) framework outlined in Department of Industry (2018) and NSW Government (2024) (i.e. high and very high value groundwater dependent ecosystems).

Wappinguy Spring, approximately 40 km to the north-west of the mine area, is the closest high priority GDE listed in the *Water Sharing Plan for the North Coast Fractured and Porous Rock Groundwater Sources 2016*. No high priority GDEs are listed in the *Water Sharing Plan for the Hunter Regulated River Water Source 2016*.

The *Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources 2022* also addresses surface water within the catchment of the Hunter River, with MPO being situated within the boundaries of the Muswellbrook Water Source.

The MPO intercepts the groundwater resources managed under the *Water Sharing Plan for the North Coast Fractured and Porous Rock Groundwater Sources 2016*. The MPO would continue extraction from Permian aged coal measures that form part of the Sydney Basin – North Coast Groundwater Source. This groundwater source is not sub-divided into groundwater management zones, nor does it form part of an extraction management unit.

2.1.2 Water licensing

Where water sharing plans are in place, WALs permit their holder to take water from a specified water source. Open cut mining could result in a direct take from a water source for (i.e. pumping for dewatering or consumptive uses) or an incidental (indirect) take (i.e. induced groundwater inflow to open cut voids from a connected water source or evaporative losses where the void intersects the water table).

Table 2.2 summarises the WALs held by MACH relevant to groundwater (including inflow to mine workings) at the MPO and which are subsequently applicable to the modified MPO.

Table 2.2 Details of MACH held WALs – groundwater sources

WAL Number	WAL category	Water source	Groundwater management Zone	Share components [Units]
18253, 18266, 18206, 18199, 18122, 18131, 21503, 18154, 18177	Aquifer	Hunter Regulated River Alluvial	Upstream Glennies Creek	295
Various	High Security	Hunter Regulated River	Management Zone 1A	961
Various	General Security	Hunter Regulated River	Management Zone 1A	2,947
23935	Aquifer	Muswellbrook	None	41
18836*	Unregulated River	Krui River	None	12
44101	Aquifer	Dart Brook	Lower Dart Brook Management Zone	20
41437, 40298	Aquifer	Sydney Basin	None	730

Note: * associated with a MACH biodiversity offset property, and not related to the mining operation.

2.2 NSW Protection of the Environment Operations Act 1997

The POEO Act provides the framework for the regulation and reduction of pollution and waste in NSW. The POEO Act is administered by the NSW Environment Protection Authority (NSW EPA), which issues environment protection licences (EPLs) for certain activities scheduled in the POEO Act, including those that may impact on groundwater quality.

MACH holds EPL 20850 which permits activities scheduled under the POEO Act (coal works and mining for coal) at MPO. The POEO Act also requires immediate reporting of pollution incidents which cause or threaten to cause material harm to the environment.

2.3 NSW Aquifer Interference Policy

Proponents of aquifer interference activities are required to provide predictions of the volume of water to be taken from a water source(s) as a result of the activity. These predictions need to occur prior to project approval. After approval and during operations, these volumes need to be measured and reported in an annual return or environmental management report. The water user must hold sufficient share component and water allocation to account for the take of water from the relevant water source when the take occurs (refer Section 8.1).

The AIP states that a water licence is required for the aquifer interference activity regardless of whether water is taken directly for consumptive use or incidentally. In the case of the modified MPO the take of water occurs incidentally during the mining process. This incidental take of groundwater can induce flow from adjacent groundwater sources or connected surface water, which constitutes take of water under the AIP. In all cases, separate WALs are required to account for the take from all individual water sources (refer Section 8.1 for predicted takes).

The AIP also describes minimal impact considerations for aquifer interference activities which are a series of acceptable thresholds for water level and quality changes. The minimal impact consideration thresholds depend upon whether the water source is “highly productive” or “less productive” and whether the water source is alluvial or porous/fractured rock in nature.

A “highly productive” groundwater source is defined by the AIP as a groundwater source which has been declared in regulations and datasets, based on the following criteria:

- a) has a Total Dissolved Solids (TDS) concentration less than 1,500 milligrams per litre (mg/L); and
- b) contains water supply works that can yield water at a rate greater than 5 litres per second.

“Highly productive” groundwater sources are further grouped by geology into alluvial, coastal sands, porous rock, and fractured rock. “Less productive” groundwater sources are all other aquifers that do not satisfy the “highly productive” criteria for yield and water quality.

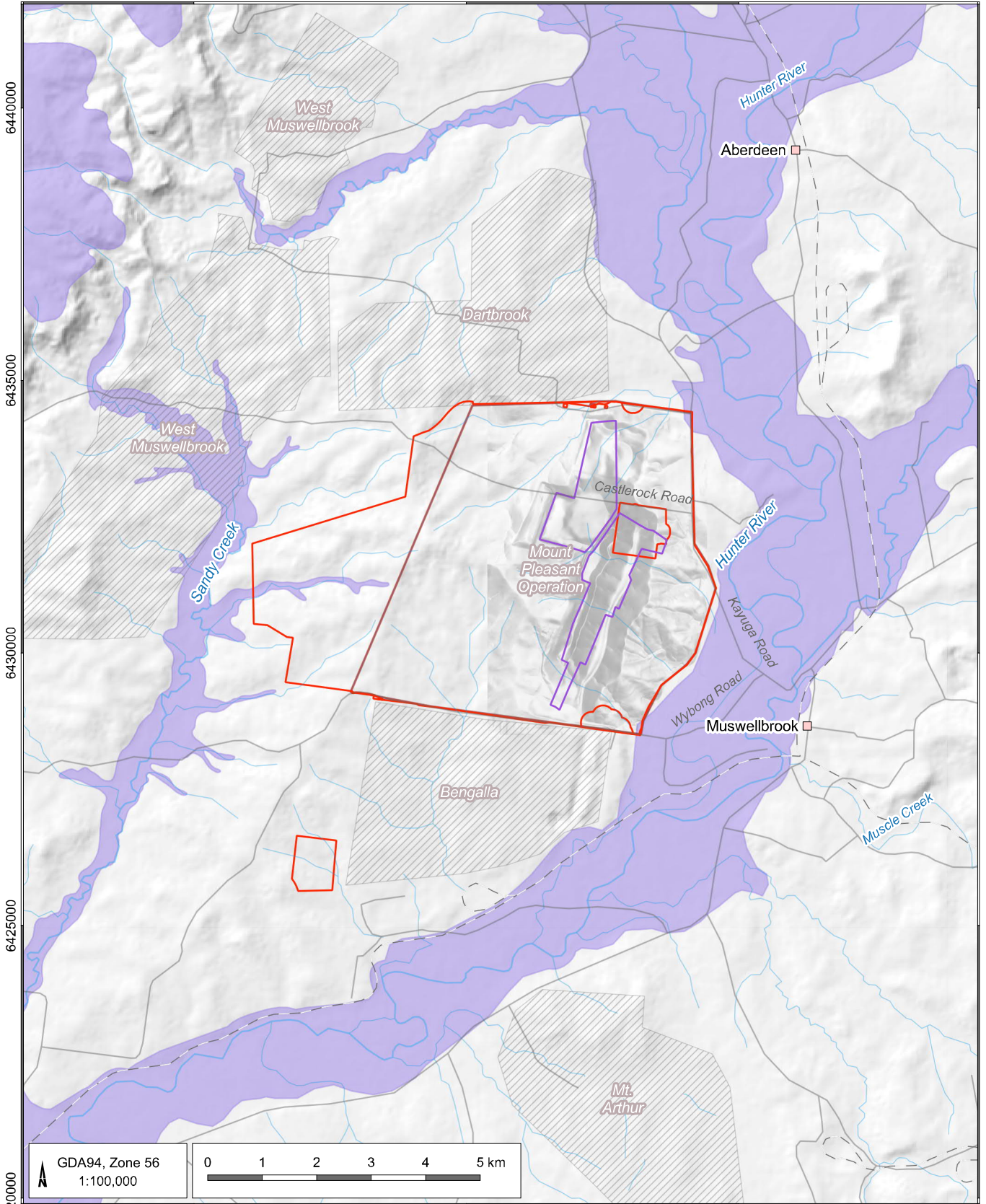
The AIP requires that impacts on “highly productive” and “less productive” water sources need to be assessed and accounted for. In 2012, the then NSW Government produced a map of groundwater productivity across NSW, showing those areas classified as either “highly productive” or “less productive”. The groundwater productivity map has been produced based on regional scale geological maps. Figure 2.2 shows the groundwater productivity map, which indicates the alluvium along Sandy Creek and the Hunter River has been classified as “highly productive”. Neither of these classified “highly productive” groundwater sources would be intersected by the modified MPO open cut mining activities. The extent and characteristics of the Quaternary alluvium is further discussed in Section 4.2.1. Section 5 provides further information on the properties of the alluvial and Permian aquifers. The Permian coal measures (porous and fractured rock) are categorised as “less productive” (NSW Government, 2012).

The minimal impact considerations are a series of threshold levels defining minimal impact on groundwater sources, connected water sources, GDEs, culturally significant sites and water users. The thresholds specify water table and groundwater pressure drawdown as well as groundwater and surface water quality changes. Section 8 presents the predicted impacts of the modified MPO and provides a comparison to the AIP thresholds.

290000

295000

300000



LEGEND

- Populated place
- Road
- Rail
- Drainage
- Pit Floor Extent
- Mining lease
- Mount Pleasant Operation
- Surrounding mines
- Highly productive groundwater

MPO MOD 8 Life of Mine Extension (MPO5009.001)

“Highly productive” groundwater sources (NSW Government, 2012)



DATE
13/10/2025

FIGURE No:
2.2

2.4 Commonwealth Environment Protection and Biodiversity Conservation Act 1999

The MPO was also approved under the EPBC Act in 2012 (EPBC 2011/5795). This approval, which is related to Development Consent DA 92/97, authorises land clearance within a 'Project area boundary'. A separate approved action for the Continuation of the Bengalla Mine (EPBC 2012/6378) authorises potential impacts associated with the construction of the MPO Controlled Release System. A separate action for the Mount Pleasant Optimisation Project was referred in July 2020 (EPBC 2020/8735). The EPBC 2020/8735 action was approved with conditions on 24 September 2024 under section 133(1) of the EPBC Act.

As all aspects of the proposed modified development would be carried out pursuant to the existing EPBC 2011/5795 and EPBC 2020/8735 approvals and there would be no further aspect of the proposed modified development requiring approval under the EPBC Act, this GIA does not assess the potential for the proposed modified development to have a significant impact on any matters of national environmental significance under the EPBC Act, nor consider the requirement for any further approval under the EPBC Act.

3 Environmental setting

3.1 Location

MPO is situated in the Hunter Coalfields of the Sydney Basin and is entirely within the Muswellbrook Local Government Area. The mine is situated approximately 3 km north-west of Muswellbrook.

3.2 Climate

3.2.1 Rainfall

The climate in the Muswellbrook area is temperate and is characterised by hot summers with intermittent thunderstorms and mild dry winters. The Bureau of Meteorology (BoM) operates a number of rainfall stations in the vicinity of MPO. The nearest rainfall station, situated approximately 6 km north-east of the MPO, is Muswellbrook (St Heliers) (BoM station 061374). This station commenced operation in 1992 and was closed in March 2022. Therefore, data from the nearby Muswellbrook (Spring Creek, Castle Vale) (BoM station 061192), was used in order obtain the most recent rainfall data. The average (mean) annual rainfall at Muswellbrook (Spring Creek, Castle Vale) is approximately 683.7 millimetres (mm).

In order to obtain longer term climate information, data was sourced from the Scientific Information for Land Owners (SILO) database. SILO is operated by the Queensland Department of Environment, Science and Innovation (DESI), with data contributions from BoM. SILO generates a climate dataset via interpolation between neighbouring BoM stations to produce a continuous daily time series. The SILO dataset obtained for this assessment (latitude -32.25, longitude 150.85) included long-term rainfall, temperature, and evaporation information from 1889 to present (DESI, 2024).

A comparison of SILO average monthly rainfall and that recorded at Muswellbrook (Spring Creek, Castle Vale) is shown in Table 3.1. This comparison of longer-term SILO climate data identifies slightly lower annual average rainfall (613.5 mm) to that recorded at Muswellbrook (Spring Creek, Castle Vale).

Table 3.1 Average monthly rainfall (mm)

Source	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Muswellbrook (Spring Creek, Castle Vale) 061192	87.5	68.6	77.8	46.6	47.7	43.2	35.2	39.0	38.2	55.7	69.1	75.1
	Average Annual 683.7 mm (1960 – September 2025)											
SILO	73.2	63.2	58.5	42.2	40.1	47.8	41.9	38.5	40.3	48.9	55.1	63.8
	Average Annual 613.5 mm (1889-2025)											

Long-term rainfall trends are provided by the cumulative rainfall departure (CRD). A CRD is generated by cumulatively summing the residuals between actual monthly rainfall and the long-term average monthly rainfall with a rising CRD correlating with above average rainfall and a falling CRD indicating the reverse. CRD trends are relevant as groundwater hydrographs, particularly for shallow aquifers, tend to reflect similar trends, with declining groundwater levels during a period of below average rainfall and rising trends in periods of above average rainfall.

Figure 3.1 shows the CRD calculated using the SILO rainfall data for the period 1889 to October 2025.

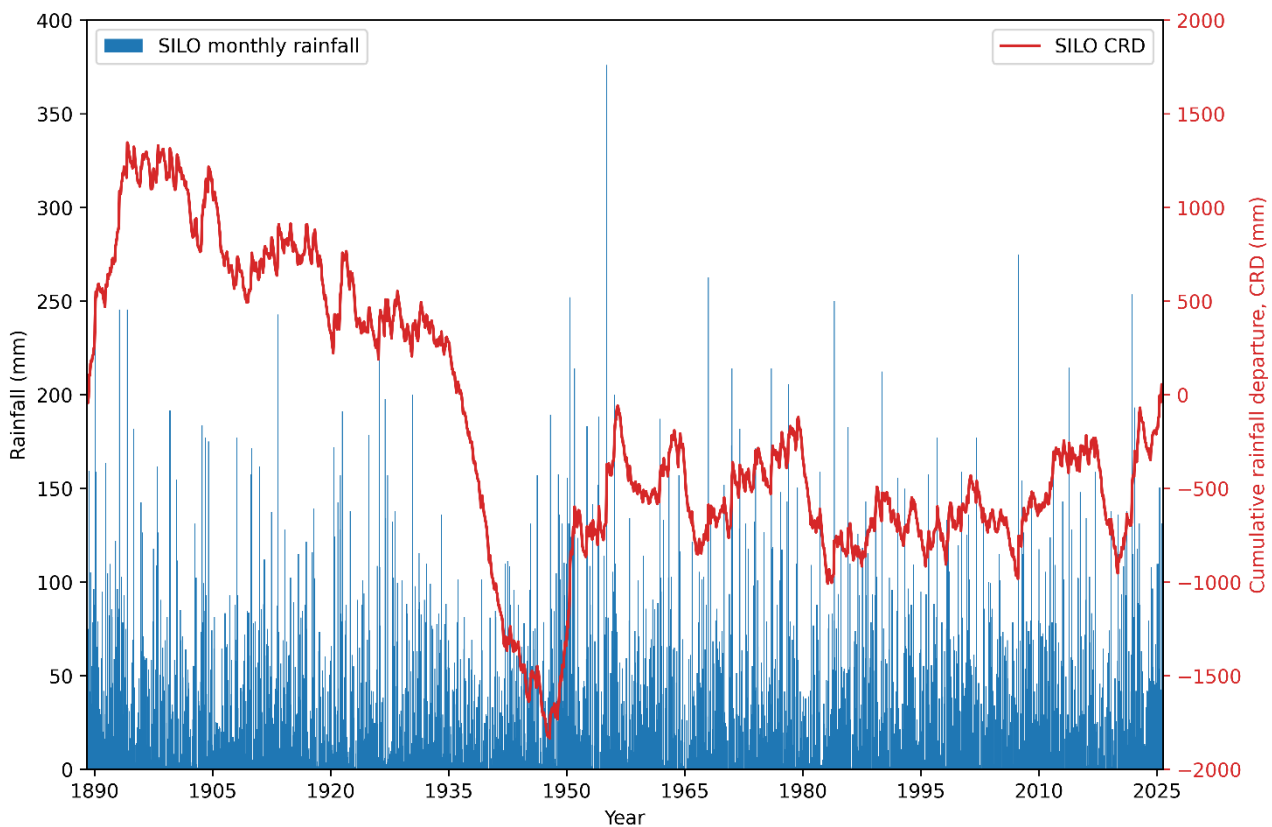


Figure 3.1 Cumulative Rainfall Departure and monthly rainfall (SILO)

Figure 3.1 indicates that the long-term rainfall trend in the upper Hunter catchment comprises a long period of below average rainfall between around 1900-1950, with multiple year droughts such as the 1937 – 1946 “WWII Drought”. The period following 1946 was characterised by a (generally) sustained period of above average rainfall until the early 1990s. Whilst this period indicates that conditions were generally wetter, it was periodically interspersed with short-lived droughts, including the 1982-83 drought.

Figure 3.1 also indicates wetter episodes in the early- and mid-1950s, mid-1970s, early-1990s and 2010 – 12. Notably, below-average rainfall from early 2023 led to a sharp decline, followed by generally above-average rainfall up to October 2025 as shown in Figure 3.1. Groundwater levels and the response to climate and mining activities are discussed further in Section 5.

3.2.2 Evaporation and evapotranspiration

Evaporation data was obtained from Scone SCS station 061089, located approximately 20 km north-east of MPO and SILO potential evaporation. Scone SCS was decommissioned from January 2019. Table 3.2 summarises monthly averages for evaporation from Scone SCS and SILO, and monthly averages for evapotranspiration from SILO.

A summary of SILO average monthly rainfall, evaporation and evapotranspiration is shown on Figure 3.2.

Table 3.2 Average monthly evaporation and evapotranspiration (mm)

Source	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Scone SCS (61089) Evaporation	217	175.2	151.9	108	71.3	48	58.9	86.8	120	158.1	186	223.2
	Average Annual 1,604 mm (1992 – 2019)											
SILO Evaporation	209.1	164.2	145.4	102.8	70.8	52.2	60.7	84.6	116.9	155.0	179.8	212.6
	Average Annual 1,554.1 mm (1889-2025)											
SILO Evapotranspiration (Morton)	238.3	238.3	238.3	238.3	238.3	238.3	238.3	238.3	238.3	238.3	238.3	238.3
	Average Annual 1,791.5 (1889-2025)											

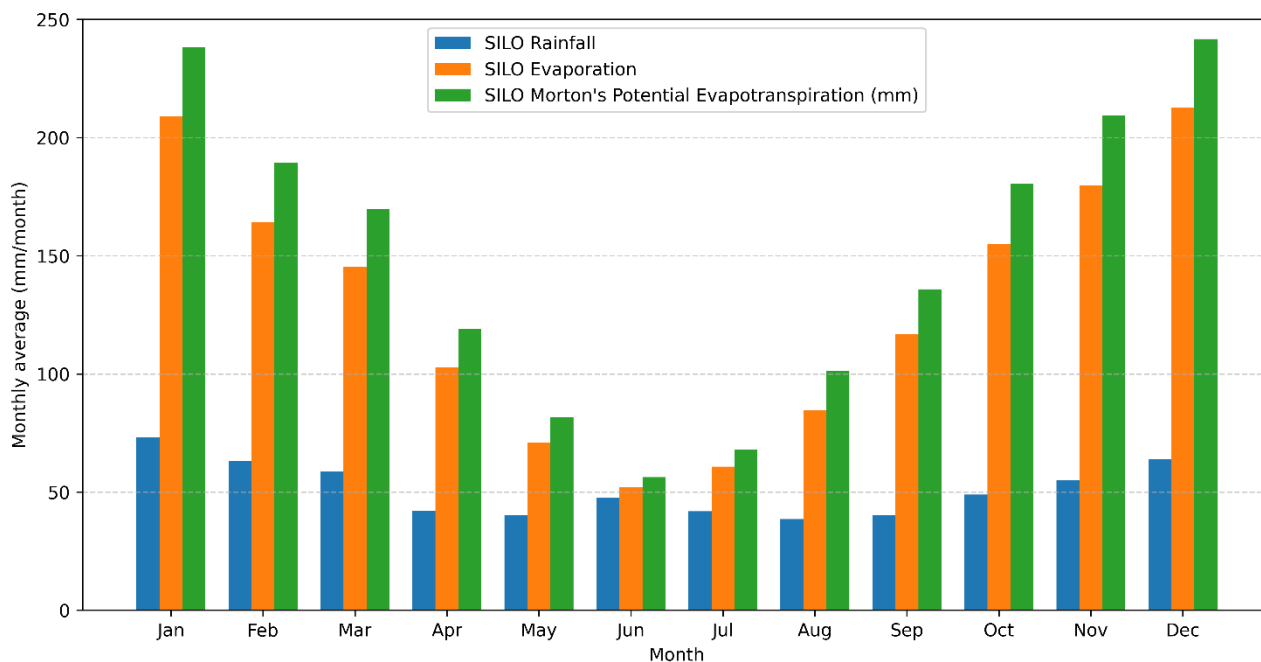


Figure 3.2 Monthly average SILO rainfall, evaporation and evapotranspiration

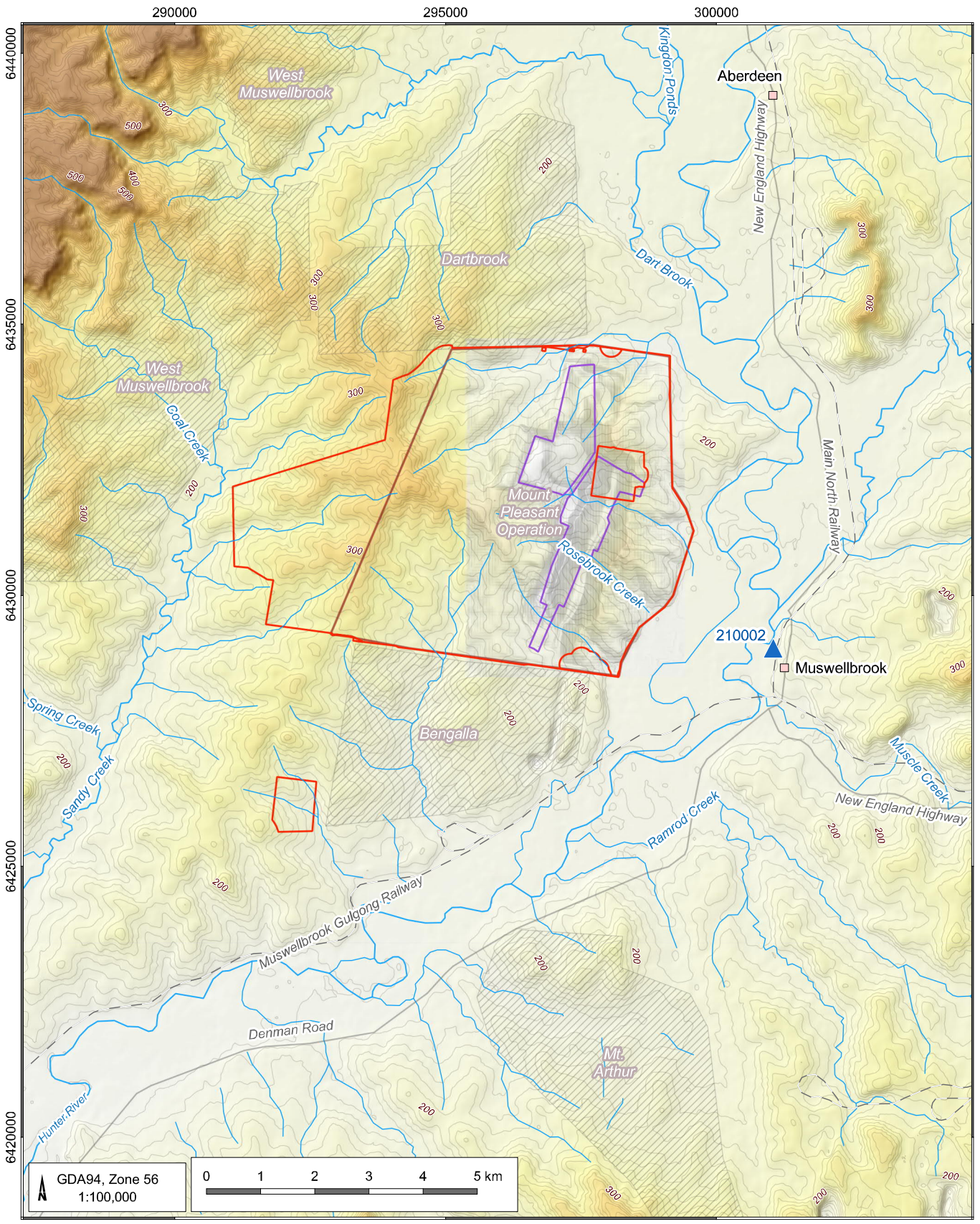
Figure 3.2 indicates that groundwater recharge is unlikely to be high due to the high evaporation rates relative to rainfall. Recharge rates depend on a range of factors including soil type, geology, topography, vegetation and dominant land use. Despite the high average evaporation rates recharge will occur sporadically when rainfall activity promotes saturation of the soil profile and evaporation is insufficient to remove the soil moisture. During these periods there is potential for deep drainage of water to underlying groundwater systems.

3.3 Topography

MPO and much of its surrounds exhibits high topographic relief relative to the floodplain area of the Hunter River, which is relatively flat lying with minor incised drainages.

Data from the NSW Spatial Services Unit of the Department of Finance, Services and Innovation has been combined with site-specific LiDAR data to generate the Digital Elevation Model (DEM) shown on Figure 3.3.

As shown on Figure 3.3, ground elevation across the mine area ranges from approximately 150 metres above Australian Height Datum (mAHD) to 350 mAHD. Lower elevations are typically associated with the Hunter River floodplain (at about 140 mAHD to 160 mAHD) to the east of the mine area.



LEGEND

- Populated place
- ▲ Water NSW stream gauge
- Road
- Rail
- Drainage
- Mining lease
- Mount Pleasant Operation
- Surrounding mines
- Pit Floor Extent

- Elevation contour (mAHD)
- Elevation (mAHD)**
- 100
 - 200
 - 250
 - 300
 - 400
 - 500
 - 600

MPO MOD 8 Life of Mine Extension
(MPO5009.001)

Terrain and drainage



DATE
13/10/2025

FIGURE No:
3.3

3.4 Drainage

Whilst drainage nearby MPO is characterised by lower order, unnamed ephemeral watercourses, there are a number of local and regional drainage features present in the vicinity of the MPO (refer Figure 3.3). A brief description of regional, local and site specific drainage is presented below.

3.4.1 Regional drainage

The Hunter River, with a catchment of 22,000 square kilometres (km²) is the principal regional drainage feature. In the vicinity of MPO it flows from the north-east to the south and then south-west before reaching its confluence with the Goulburn River, 20 km south of the MPO. Glenbawn Dam is a major hydraulic control regulating the flow of the Hunter River and is situated 15 km upstream of MPO.

MPO is situated in the 'Upper Sector' of the Hunter River Salinity Trading Scheme, as managed by the NSW EPA.

3.4.2 Local drainage

In the vicinity of MPO, there are a number of local drainage features that are tributaries of the Hunter River (refer Figure 3.3).

MPO is located approximately 1 km south of the confluence of Dart Brook and the Hunter River. Dart Brook is a perennial watercourse that is characterised by a broad alluvial plain (1 to 2 km wide). Dart Brook is a major tributary of the Hunter River with headwaters approximately 50 km to the north of MPO.

Kingdon Ponds, another perennial watercourse is the main tributary to Dart Brook, with the confluence located 3 km upstream from where Dart Brook joins the Hunter River.

Sandy Creek, a non-perennial watercourse, originates 7 km north-west of MPO and flows south, within 1 km of MPO mining leases, before joining the Hunter River in the town of Denman, south-west of MPO. Sandy Creek is fed by several lower order watercourses including Coal Creek, and Spring Creek. A number of first and second order unnamed watercourses occur within vicinity of MPO, and subsequently drain west to Sandy Creek.

For clarity, 'Sandy Creek' will be used to refer to Sandy Creek within the Muswellbrook Water Source (refer Section 2.1.1), which flows north to south up to 3 km west of the mine area. This distinction is considered necessary as there are two other watercourses also locally known as 'Sandy Creek' in the area. The first of which is the southernmost tributary of Dart Brook and which lies approximately 4 km to 5 km north of MPO. The second enters the Hunter River from the east of Muswellbrook, approximately 3 km east of MPO.

3.4.3 MPO area drainage

There are a number of ephemerally discharging first and second order named and unnamed watercourses occurring within MPO (refer Figure 3.3). These watercourses drain either west to Sandy Creek or east to the Hunter River.

The small catchments in the southeast of the MPO area discharge directly east onto the alluvial plain. The eastward draining second order watercourse known as Rosebrook Creek connects with a secondary or relict channel of the Hunter River that is situated to the west of the main trunk of the river. Review of aerial photography indicates that drainage lines from the eastward draining catchments have been overprinted or altered by agricultural activities. In addition, drainage from two small catchments in the northern section of the mine area drain to the north before turning east and joining the Hunter River.

3.4.4 Streamflow and electrical conductivity

WaterNSW operates a number of stream gauges in the vicinity of MPO. These gauges measure streamflow and electrical conductivity (EC) and are listed in Table 3.3 from upstream to downstream (Kingdon Ponds Creek, Dart Brook, and Hunter River).

Table 3.3 WaterNSW stream gauges in vicinity of the MPO

Station	Name	Status	Monitoring period	Area (km ²)
210093	Kingdon Ponds Creek (near Parkville)	Active	1972 – current	177
210124	Dart Brook at Yarrandi Bridge	Active	1991 – current	233
210015	Hunter D/S Glenbawn	Active	1940 – current	1,295
210056	Hunter River at Aberdeen	Active	1959 – current	3,090
210002	Hunter River at Muswellbrook Bridge	Active	1906 – current	4,220
210055	Hunter River Denman	Active	1908 – current	4,530

Figure 3.4 presents flow duration curves determined from streamflow measured at the stream gauges listed in Table 3.3. The flow duration curves on Figure 3.4 show that flow in the regulated Hunter River downstream of Glenbawn Dam is reliable as a result of this dam being in place. Flow in the Hunter River tributaries Dart Brook and Kingdon Ponds is lower as the result of smaller catchment size and no hydraulic controls to regulate discharge.

Available stream gauge EC data is also presented on Figure 3.4. Data is not recorded at all stream gauges (e.g. Dart Brook) or across the entire period shown at all gauging stations. However, Figure 3.4 shows that EC is relatively fresh, generally between 100 and 1,000 microSiemens per centimetre ($\mu\text{S}/\text{cm}$), along the Hunter River, with the mean (at Muswellbrook) being 503 $\mu\text{S}/\text{cm}$. The summary shows that there is a slight increase in EC from upstream to downstream.

3.5 Land use

According to NSW Land Use Mapping, MPO and surrounds is predominantly cleared with unimproved agricultural land utilised primarily for grazing. Areas of arable land exist to the east of MPO on the floodplain of the Hunter River. Residential and industrial land uses are present as part of the township of Muswellbrook (1 km east), the rural locality of Kayuga, as well as there being some improved pasture.

Mining is a major land use in the immediate surrounds of MPO. As noted in Section 1.2, Bengalla Mine is situated immediately south of MPO and Dartbrook Mine is immediately north. In addition, Mangoola Coal, Mt Arthur Coal Mine, and Muswellbrook Coal Mine are also located in the vicinity of MPO.

MACH is the major landholder within the modified MPO boundary and has historically leased most of the relevant landholdings for ongoing agricultural production.

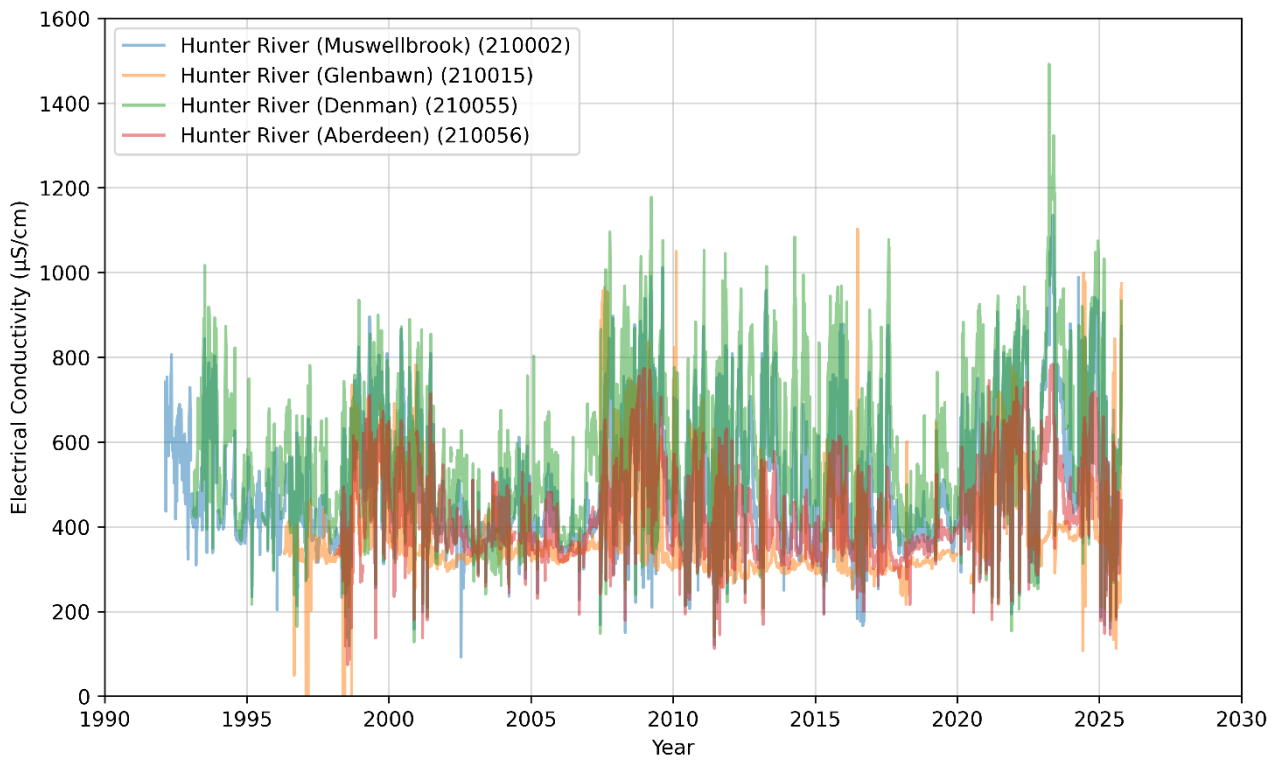
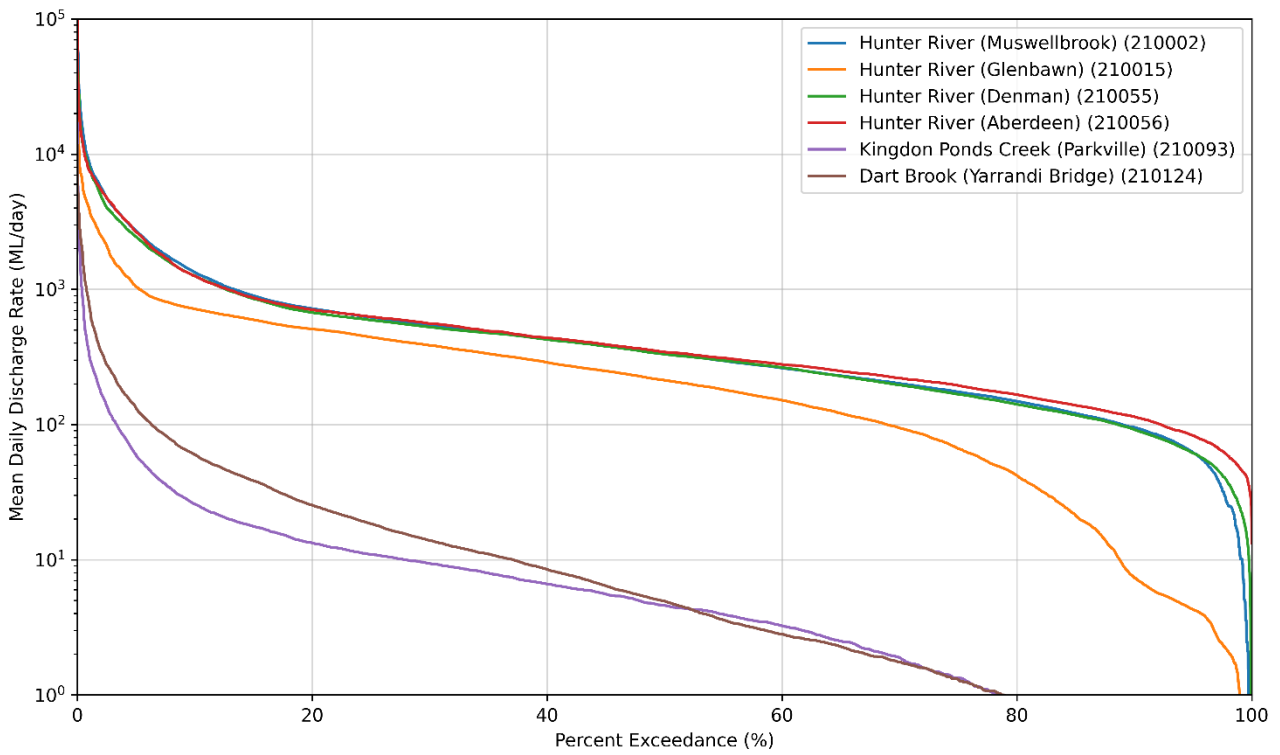


Figure 3.4 Flow duration and electrical conductivity at WaterNSW stream gauges

4 Geological setting

The geological setting has been informed by the following data sources:

- publicly available geological maps (Hunter Coalfields map sheets) and reports;
- hydrogeological reports and geological datasets prepared for MPO and surrounding mines; and
- hydrogeological data held on the NSW DCCEEW groundwater database.

The information provided was used to develop a 3D numerical groundwater model for the modified MPO. Appendix A describes the approach to the groundwater modelling in detail.

4.1 Regional geology

MPO is located along the western outcrop of the Permian coal measures, as shown on the 1:100,000 scale Hunter Coalfield Regional Geology Map (Glen & Beckett, 1993) (Figure 4.1). The Hunter Coalfield forms part of the Permian and Triassic Sydney Basin that was formed during a period of crustal thinning and igneous rifting in the Late Carboniferous to Early Permian. The basin was subsequently infilled with Permian and Triassic aged sediments.

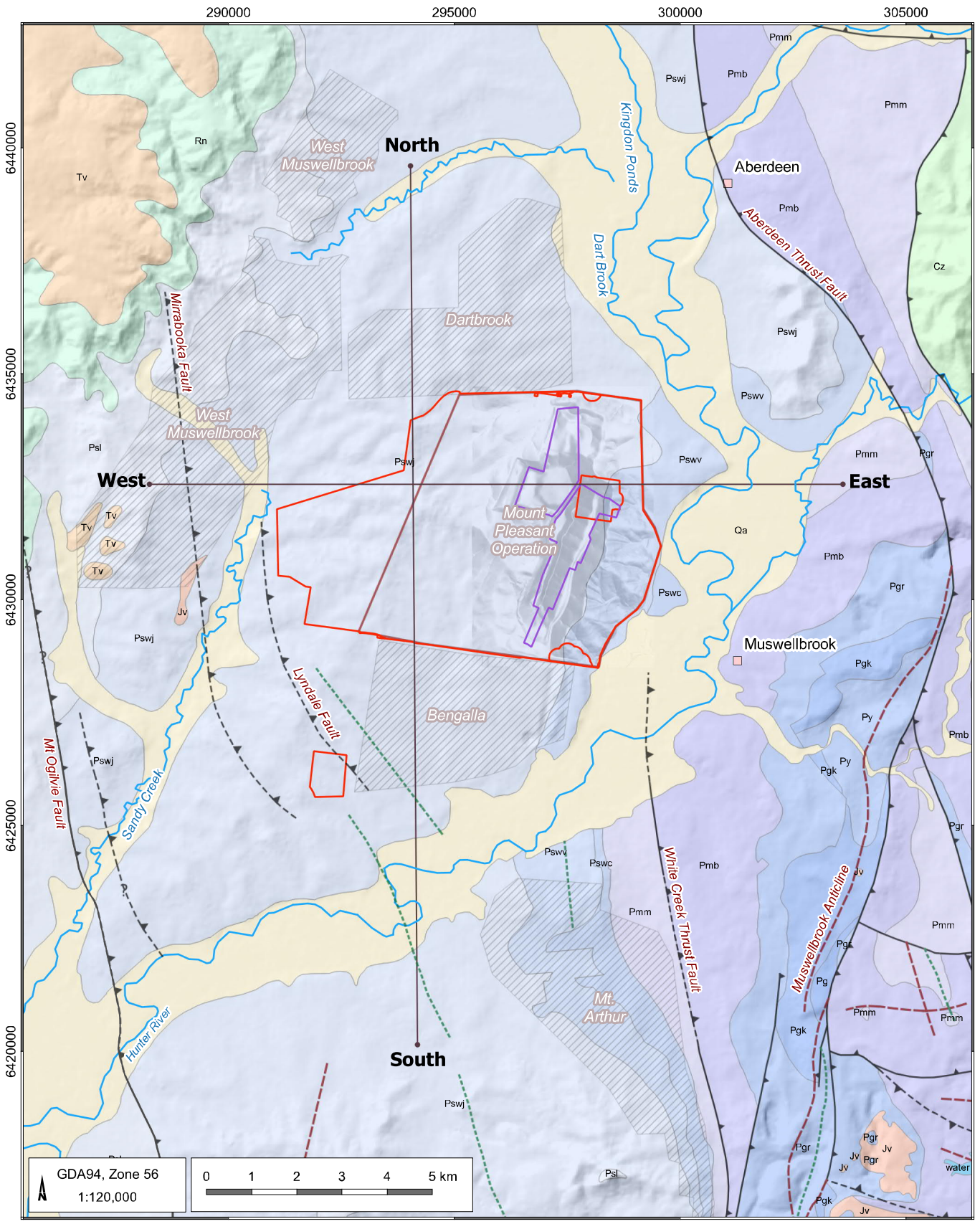
Regional geology is comprised of the Late Permian Wittingham Coal Measures, a sequence of coal seams interbedded with claystone, tuff, siltstone, sandstone, and conglomerate. The Wittingham Coal Measures are divided into two subgroups, the Jerrys Plains Subgroup and the Vane Subgroup. The Jerrys Plains Subgroup comprises a sequence of coal seams interbedded with claystone, tuff, siltstone, sandstone, and conglomerate. Within the Jerrys Plains Subgroup there are 15 main coal seams that are mined across the Hunter Valley. In stratigraphic order (youngest to oldest) these coal seams include Whybrow seam, Redbank Creek seam, Wambo seam, Whynot seam, Blakefield seam, Glen Munro seam, Woodlands Hill seam, Arrowfield seam, Bowfield seam, Warkworth seam, Mount Arthur seam, Piercefield seam, Vaux seam, Broonie seam and Bayswater seam. The Vane Subgroup includes the Wynn seam and Edderton seam.

The Wittingham Coal Measures conformably underlie the Newcastle Coal Measures. Together the Wittingham and Newcastle Coal Measures form the Singleton Supergroup. The Singleton Supergroup overlies the marine sequences of the Maitland Group (sandstones, siltstones and conglomerates) that in turn overlies the Early Permian Greta Coal Measures.

The Permian sediments are unconformably overlain by a thin capping of Quaternary alluvial sediments deposited along drainage lines and forming flood plains. The alluvial deposits near MPO comprise silt, sand, and gravel along the present-day alignments of the Hunter River and Sandy Creek. A weathering profile is typically present as a thin heterogeneous layer of unconsolidated weathered material (regolith) grading to fresh bedrock.

The coal measures are influenced by a series of fold structures and thrust faults (Hunter and Aberdeen) that trend in a north-west to south-east direction. The Hunter thrust fault and Aberdeen thrust fault, are located approximately 6 km to the east of MPO. In this vicinity, these faults generally trend parallel to each other with an approximately north to south/south-east trace. The Aberdeen fault is almost coincident with the Muswellbrook Anticline, the axis of which has been eroded away, exposing older units including the Maitland Group and the Greta Coal Measures. The Hunter thrust forms the boundary between the Carboniferous New England Block which has been thrust over Permian Sydney Basin sediments. Regionally, the Permian coal measures outcrop between older Carboniferous units to the east and younger Triassic sandstones and conglomerates of the Sydney Basin to the west.

The main structural feature west of MPO is the Mt Ogilvie thrust fault. This structure, approximately 10 km west of MPO trends north to south. Throw along the fault has forced the Wittingham Coal Measures up where they now lie adjacent to the younger Newcastle Coal Measures. Throw along the Mt Ogilvie fault has led to a maximum displacement of 100 to 200 m beneath Sandy Creek (HydroSimulations, 2013; Mackie Environmental Research Pty Ltd [MER], 2006). Further south this structure weakens, with the throw declining so that the fault/structure forms a roll-over or monocline (HydroSimulations, 2013 and 2015). Smaller, but similarly north-south oriented faults are mapped by Glenn and Beckett (1993) between the MPO and Mt Ogilvie Fault. These are the Mirrabooka and Lyndale Faults, and are indicated to exhibit smaller throw.



LEGEND

- Populated place
- Drainage
- Cross section lines
- Thrust fault
- Thrust fault (approximate)
- Anticline
- Syncline
- Mining lease
- Pit Floor Extent
- Mount Pleasant Operation
- Surrounding mines

Surface geology

- Qa - Quaternary Alluvium
- Tv - Tertiary Basalt
- Jv - Jurassic Volcanics
- Rn - Hawkesbury Sandstone, Narrabeen G.
- Psl - Wollombi Coal Measures
- Pswj - Denman Fmt, Jerrys Plains Subgroup
- Pswv - Archerfield Ss., Vane Subgroup
- Pswc - Saltwater Creek Formation
- Pmm - Mulbring Siltstone
- Pmb - Braxton Formation
- Pg - Greta Coal Measures
- Pgr - Greta Coal Measures
- Pgc - Greta Coal Measures
- Py - Gyarran Volcanics
- Cz - Carboniferous tuff and ignimbrite
- water

MPO MOD 8 Life of Mine Extension
(MPO5009.001)

Surface geology



AGE

DATE
14/10/2025

FIGURE No:
4.1

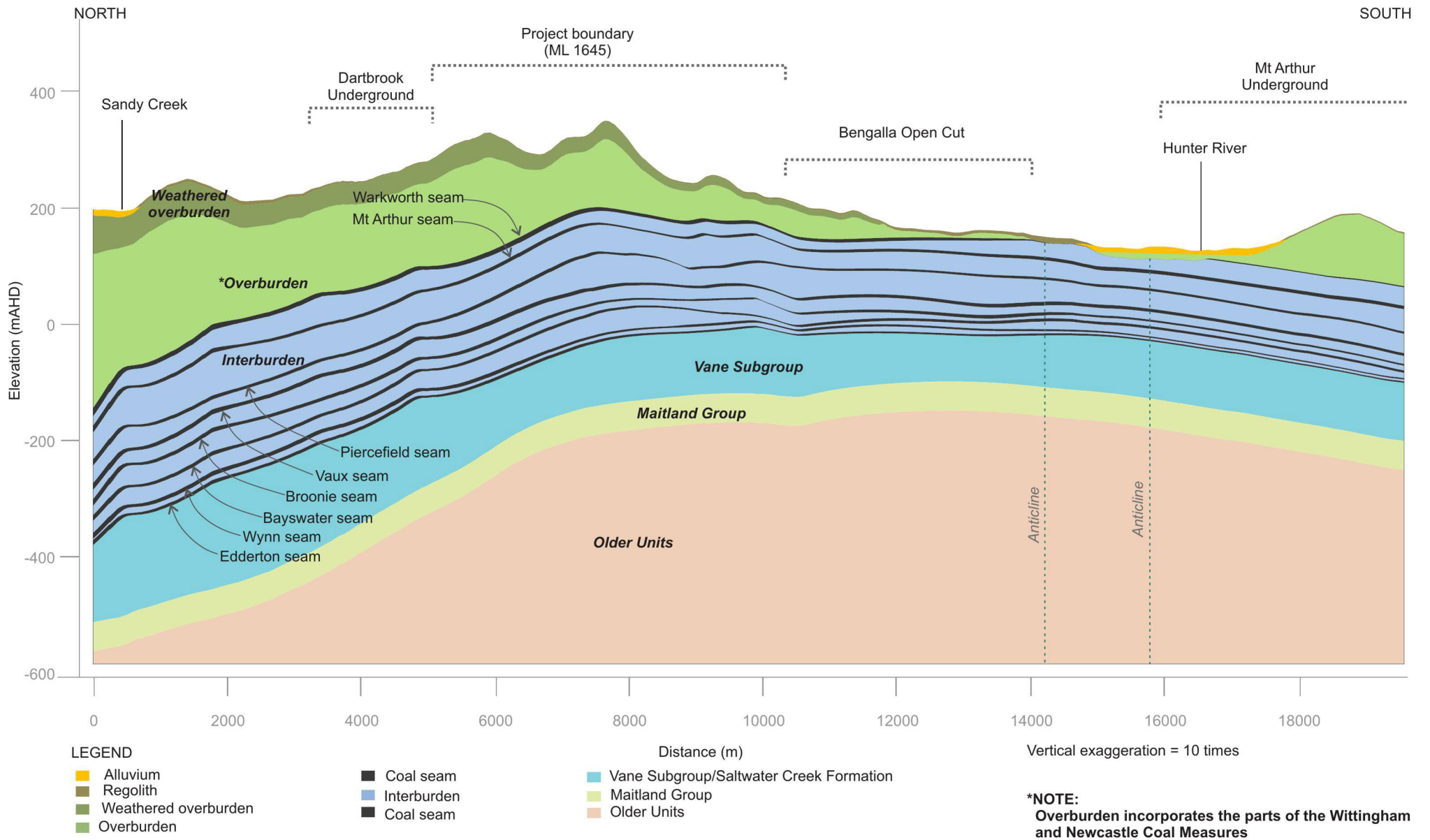
Table 4.1 provides a summary of the regional geology shown on Figure 4.3, including the stratigraphic units and coal measures relevant to MPO and surrounding area. Figure 4.2 and Figure 4.3 provide conceptual geological cross-sections showing the occurrence of key stratigraphic units across MPO.

Table 4.1 Summary of regional geological units

Age	Stratigraphic unit		Description*	
Quaternary	Quaternary sediments – alluvium (Qa)		Clay, silt, and sand overlying basal clayey sands and gravels in places.	
Tertiary and Jurassic	Basalt (Tv or Jv)		Flows, sills and dykes	
Triassic	Narrabeen Group (Rn)		Interbedded fine to medium-grained sandstone and siltstone, claystone and conglomerate.	
Permian	Newcastle Coal Measures		Numerous coal seams; claystone, tuff, siltstone, sandstone, conglomerate	
	Wittingham Coal Measures	Watts Sandstone	Well-sorted quartz lithic sandstone	
		Denman Formation	Dark grey striped sandstone-siltstone laminite with abundant burrows	
		Jerrys Plains Subgroup (Pswj)	Bowfield seam	Numerous coal seams; claystone, tuff, siltstone, sandstone, conglomerate
			Warkworth seams (A and E)	
			Mt Arthur seams	
			Piercefield seam	
			Vaux seam	
			Broonie seams	
		Bayswater seam		
		Archerfield Sandstone	Bronze-coloured, well-sorted quartz lithic sandstone	
	Vane Subgroup (Pswv)	Wynn seam	Coal bearing sequences with wedges of sandstone and siltstone.	
		Edderton seam		
Clanricard				
Bengalla				
Edinglassie				
Ramrod Creek				
Saltwater Creek Formation (Pswc)	Sandstone and siltstone, minor coaly bands, siltstone towards base.			
Permian	Maitland Group	Mulbring Siltstone (Pmm)	Fine-grained offshore sediments: siltstone, claystone, minor fine sandstone.	
		Muree Sandstone (Pms)	Fine to coarse sandstone, conglomerate, and minor clay	
		Branxton Formation (Pmb)	Conglomerate, sandstone, and siltstone	

Notes: *Descriptions predominantly from the Australian Stratigraphic Units Database (Geoscience Australia, 2017).

Seams highlighted in **bold** are the MPO target coal seams (noting that North Pit is depth-limited to Vaux Seam under Development Consent DA92/97).

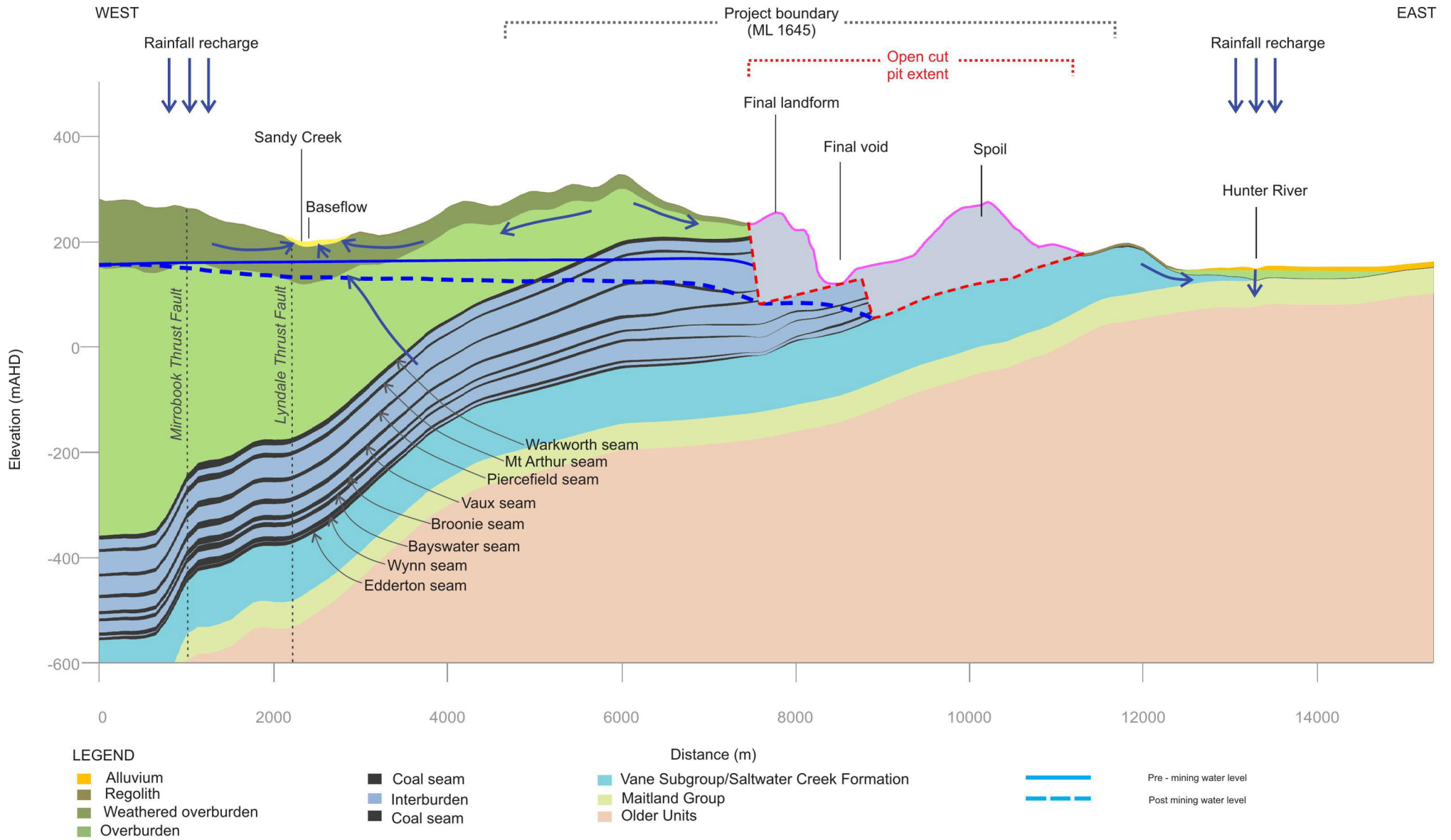


Conceptualised north - south geological cross section

Figure 4.2

MPO MOD 8 Life of Mine Extension (MPO5009.001)





Conceptualised east-west geological cross section

Figure 4.3

MPO MOD 8 Life of Mine Extension (MPO5009.001)



4.2 Local geology

At a local scale, the following stratigraphic units occur within, or adjacent to MPO (from youngest to oldest):

- Quaternary alluvium;
- Permian sediments (Wittingham Coal Measures):
 - Jerrys Plains Subgroup; and
 - Vane Subgroup (including Saltwater Creek Formation).
- Maitland Group.

Each of the main stratigraphic units is discussed in further detail below in order of increasing depth from ground surface and increasing geologic age.

4.2.1 Quaternary alluvium

Figure 4.1 shows areas of alluvium as mapped by Glenn and Beckett (1993) for the Hunter Coalfield Map. Near MPO alluvial sediments are mapped along the Hunter River floodplain to the north, east and south, as well as along Sandy Creek to the west.

The alluvial aquifer associated with the Hunter River (referred to as 'Hunter River alluvium') near MPO is typical of that deposited by a partially confined meandering river system that is characterised by a sedimentary sequence which fines upward. These sequences are commonly less than 20 m thick. MPO monitors six bores (MPBH1, MPBH2, MPBH3b, MPBH4, MPBH5 and MPBH6) located within the Hunter River alluvium along the eastern boundary of the MPO (i.e. west of Hunter River main channel). Lithology logs for a selection of these bores are presented in Figure 4.4.

These logs serve to classify the typical properties of the alluvial aquifer system in the vicinity of MPO as follows:

- Silty sand in the (approximately) upper 6 m, representing either overbank deposition or colluvial material transported from areas of higher topography;
- Gravel beds progressively overlain by sediments of decreasing size (coarse sand to fine sands and clays), indicating a reduction in stream power at that location over time; and
- Poorly graded gravel beds 5-10 m thick, representing paleochannel deposits (from historical river meandering).

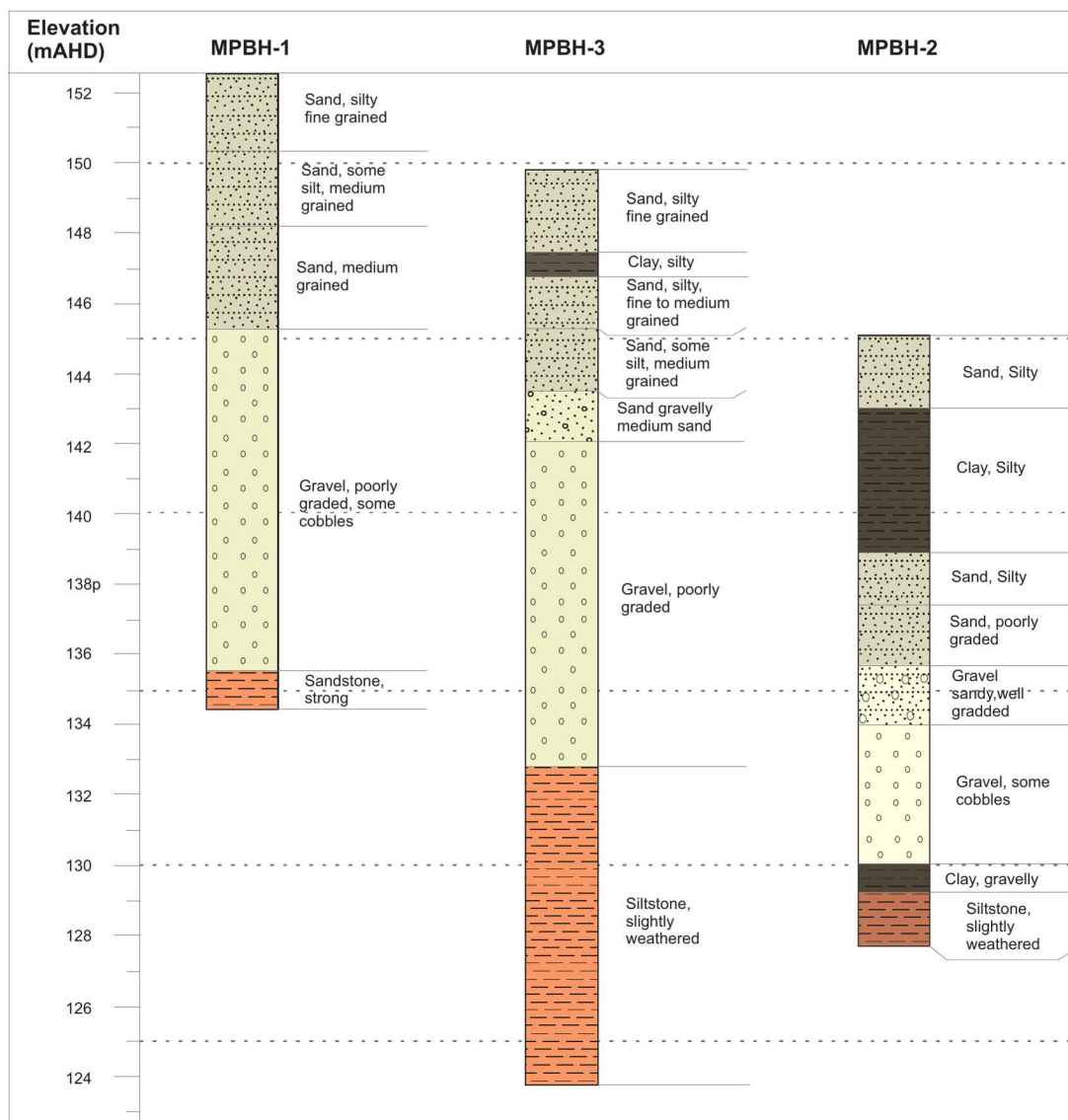
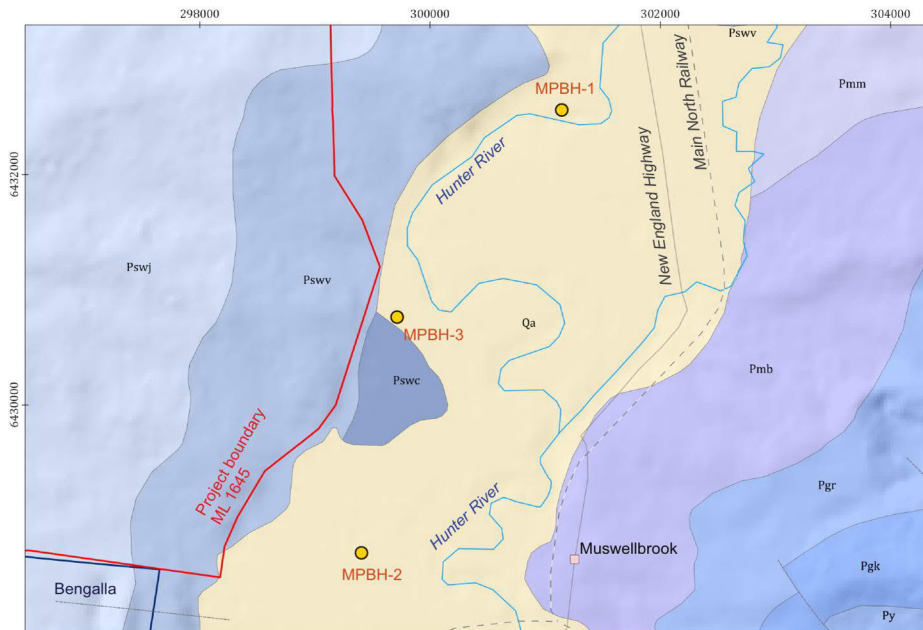
Similar stratigraphic sequences are described for the Hunter River alluvium in the groundwater assessments for Mt Arthur Coal Mine and Bengalla Mine (AGE, 2013a, 2013b), with sand and silt overlying the basal gravels that exhibit higher groundwater productivity.

MPO has previously commissioned investigations to better understand the nature and extent of alluvium in the vicinity of the mine, these investigations included:

- Geophysical investigation (Groundwater Imaging, 2016) using transient electromagnetic (TEM) survey. The survey was undertaken along the eastern edge of the approved MPO boundary to assist in identifying unconsolidated sediments, including alluvium in this area.
- Investigative drilling (ENRS, 2018) in a number of locations selected based on the results of the geophysical survey and desktop analysis. Drilling was undertaken to confirm the presence or absence of alluvium in these locations to inform where MPO infrastructure and waste dumps might be situated.

Based on a review of topography data, geological mapping, MPO drilling data and registered groundwater works (bores) from the NSW government database to provide a refined understanding of the nature and extent of the alluvium in the vicinity of the MPO it was identified that:

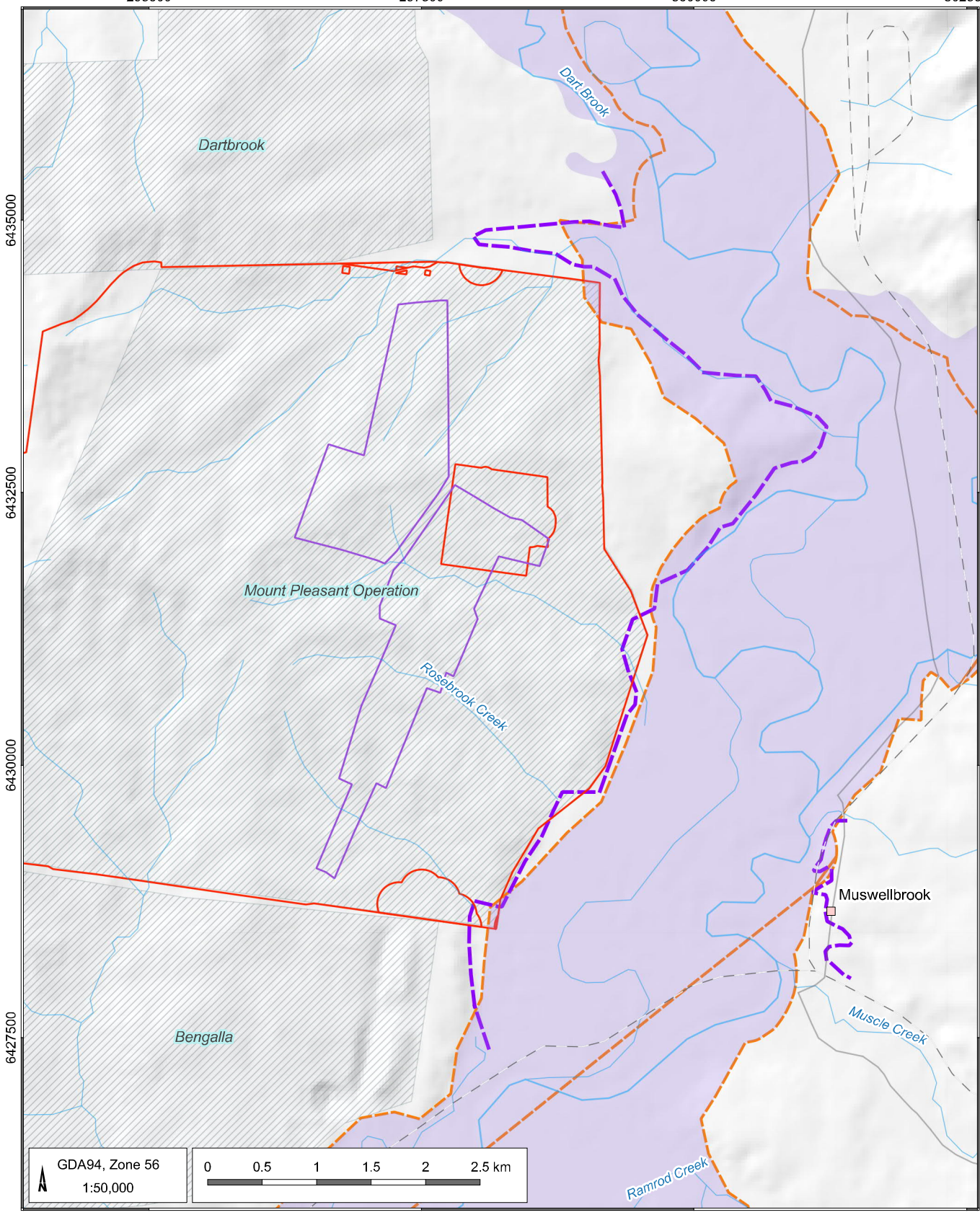
- Much of the unconsolidated material in many drillholes within the MPO boundary was weathered strata (regolith) dominated by fine-grained lithologies.
- Adjacent to the MPO boundary, alluvium broadly corresponds with mapped geology (Glenn and Beckett, 1993), the Hunter Regulated River Alluvial Water Source (refer Figure 2.1) and "highly productive" groundwater source mapping (refer Figure 2.2).
- Based on bore logs and the TEM survey, some local modifications to mapped alluvial boundaries was required to either extend or reduce its extent (refer Figure 4.5).



Hunter alluvium thickness in bores

Figure 4.4

MPO MOD 8 Life of Mine Extension (MPO5009.001)



LEGEND

- Populated place
- Road
- Rail
- Drainage
- Interpreted alluvial boundary
- Mining lease
- Pit Floor Extent
- Surrounding mines
- Hunter Regulated River Alluvial Water Source
- Highly productive groundwater (DPI Water)

MPO MOD 8 Life of Mine Extension (MPO5009.001)

Interpreted extents of the Hunter River alluvium

AGE DATE 13/10/2025 FIGURE No: **4.5**

4.2.2 Wittingham Coal Measures

The Permian sediments of the Wittingham Coal Measures outcrop and subcrop beneath and to the west of the Hunter River. Further west, away from major drainage lines, the Wittingham Coal Measures are conformably overlain by the Newcastle Coal Measures, and to the north, unconformably by the Triassic sediments of the Narrabeen Group.

The target coal resources for MPO occurs within the Permian sediments of the Wittingham Coal Measures; and include the Warkworth, Mt Arthur, Piercefield, Vaux, Broonie and Bayswater seams of the Jerrys Plains Subgroup; and the Wynn and Edderton seams of the Vane Subgroup. Under Development Consent DA 92/97, mining in North Pit is depth-limited to the Vaux Seam. The modified MPO target seams within the Wittingham Coal Measures would continue to be mined, with North Pit continuing to be depth-limited to the Vaux Seam. The coal seams within the Wittingham Coal Measures vary in thickness at the MPO, and are summarised in Table 4.2.

Interburden between the coal seams of the Wittingham Coal Measures consists of interbedded lithic sandstone, siltstone, tuffaceous claystone and mudstone units which are a result of variable depositional environments. Figure 4.6 presents the typical stratigraphy at the MPO whilst Figure 4.7 and Figure 4.8 provide imagery of stratigraphy in the MPO open cut face.

The youngest of the Permian sediments within the MPO and surrounds are the Jerrys Plains Subgroup (Pswj on Figure 4.1). As shown on Figure 4.6, coal seams of the Jerrys Plains Subgroup above the Bowfield seam are not present at the MPO.

The late Permian Vane Subgroup (Pswv on Figure 4.1) conformably underlies the Jerrys Plains Subgroup and is subdivided into the Foybrook Formation and the Archerfield Sandstone. The uppermost unit is the Archerfield Sandstone which comprises well-sorted quartz lithic sandstone deposited in a wave or current dominated lower deltaic plain depositional setting. The Archerfield Sandstone occurs at the base of the Bayswater seam, and is distinguishable as a massive, light brown or honey coloured sandstone.

The Foybrook Formation comprises coal bearing sequences with wedges of siltstone and sandstone. There are six main coal seams within the Foybrook Formation; in stratigraphic order (youngest to oldest) coal seams include Wynn, Edderton, Clanricard, Bengalla, Edinglassie and Ramrod Creek seams. Locally to the MPO area, the Vane Subgroup outcrops east of the Jerrys Plains Subgroup, adjacent to the Hunter River alluvium. The Vane Subgroup, including the Saltwater Creek Formation are also inferred to subcrop beneath the veneer of the Hunter River alluvium.

Generally, the Permian coal measures at the MPO are stratified (layered) sequences that have undergone deformation resulting in strata dipping at an approximate 4% gradient to the west. This dip locally increases in proximity to some of the faults noted above.

Table 4.2 Wittingham Coal Measures indicative thickness

Seam	10 th percentile thickness (m)	90 th percentile thickness (m)	Average thickness (m)
Bowfield	0.8	3.4	1.8
Warkworth	2.4	7.8	6.5
Mt Arthur	3.6	11.7	6.8
Piercefield	1.9	8.1	5.8
Vaux	3.7	37.1	17.0
Broonie	1.9	6.3	4.5
Bayswater	1.9	10.7	6.0
Wynn	3.2	7.7	5.1
Edderton	3.2	4.8	4.2
Clanricard	1.1	3.8	2.5
Bengalla	2.1	4.6	2.9
Edinglassie	3.7	6.3	5.8
Ramrod Creek	0.5 (20 th percentile)	20.4 (80 th percentile)	6.0

Note: Seams highlighted in **bold** are the MPO target coal seams (noting that North Pit is depth-limited to Vaux Seam under Development Consent DA92/97).

Figure 4.2 and Figure 4.3 show the surface and depth of the coal seams and interburden units in cross section. Figure 4.2 also indicates the Muswellbrook anticline and the strata dipping away from the fold axis and plunging to the west.

Locally there are two west-to-east trending faults within the MPO, as mapped by MACH. These are known as the 'North Fault' and 'South Fault' respectively, and have a small degree of displacement, up to 15 and 20 m respectively but generally much less. The orientations of these local faults are consistent with the group of faults mapped by Glenn and Beckett (1993) in the Bengalla area.

As noted in 4.2.1, a thin weathered profile occurs across the Permian sediments within the MPO. Figure 4.7 and Figure 4.8 show the MPO open cut face looking south-west and north-east respectively. Figure 4.7 provides an indication of coal seam dip and the depth of the weathered profile at the MPO whilst Figure 4.8 shows some local deformation above the coal seam. Of note in both figures is the absence of a saturated section in the exposed strata (i.e. no seepage face).

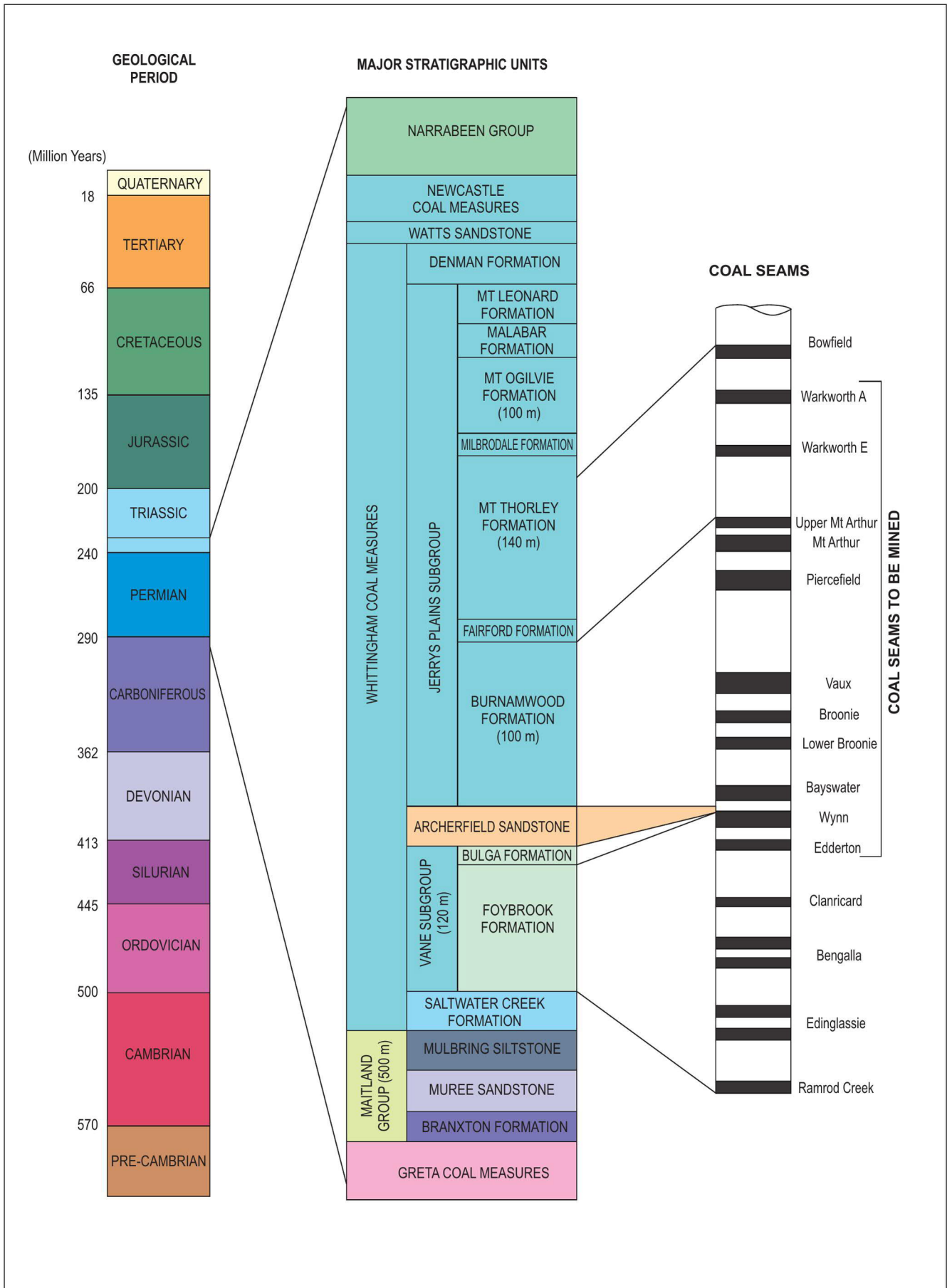


Figure reference: MACH Energy (2017)

Mount Pleasant typical stratigraphic section

Figure 4.6

MPO MOD 8 Life of Mine Extension (MPO5009.001)





Figure 4.7 MPO open cut pit face – looking south-west



Figure 4.8 MPO open cut pit face – looking north-west

4.2.3 Maitland Group

The Maitland Group is a sedimentary sequence from the basal Branxton Formation (conglomerate), the Muree Sandstone, and the finer-grained Mulbring Siltstone. Review of cross-sections in Glenn and Beckett (1993), indicates that the thickness of the Branxton Formation is approximately 150 m near Muswellbrook (maximum reported thickness is >1,000 m) whilst the Mulbring Siltstone is approximately 300 m (maximum reported thickness is 393 m).

The alluvial or deltaic Muree Sandstone is absent from this part of the Hunter Coalfield.

5 Hydrogeology

5.1 Hydrostratigraphic units

The geological units described previously can be grouped into the following 'hydrostratigraphic units' based on their ability to transmit groundwater:

- Quaternary alluvium – forms a relatively extensive alluvial aquifer system within the flood plains of the Hunter River and Sandy Creek; and
- Permian sediments that can be divided into:
 - thin, generally dry and variably permeable weathered rock (regolith);
 - non coal interburden such as conglomerates, claystones, siltstones and sandstones that forms aquitards; and
 - low to moderately permeable coal seams that act as the most transmissive strata within the coal measures sequence.

The sections below describe the hydrogeological properties of each of the hydrostratigraphic units and present a conceptual model for the groundwater regime.

5.2 Groundwater monitoring network

MPO currently monitors groundwater levels and quality using a network of monitoring bores. The monitoring network covers the Hunter River alluvium, regolith and the Permian interburden/coal seams within the MPO. Monitoring bores within the Hunter River alluvium are typically shallow (<20 m) owing to the shallow nature of the local alluvial deposits. The Permian strata are also monitored using bores installed in the shallow and deeper strata within the geological sequence. The locations of the existing MPO monitoring bores and additional bores to be installed are shown on Figure 5.1. The adjacent Bengalla Mine also operates a groundwater monitoring network with both operations sharing the groundwater information collected. Summary details of the existing and historical MPO groundwater monitoring network are provided in Table 5.1, as well as the additional monitoring bore to be installed by MACH (2025).

In summary the key aspects of the MPO monitoring network (shown on Figure 5.1) are as follows:

- the network is comprised of three areas: Eastern, Western and Central;
- the eastern network monitors groundwater in the alluvial aquifer associated with the Hunter River via six bores (MPBH1 through MPBH6);
- the western network monitors groundwater in the alluvium/ regolith and underlying Permian strata in drainage lines that discharge to the west (i.e. Sandy Creek); and
- the central network monitors groundwater in the coal seams and interburden units proximal to open cut pits.

Table 5.1 MPO groundwater monitoring network

Bore ID	General Location	Easting (GDA94)	Northing (GDA94)	Elevation# (mAHD)	Total Depth (m)	Aquifer/Unit
MPBH1	Eastern	301151	6432563	152.54	18	Alluvium
MPBH1-C	Eastern	301140	6432567	153.57	77	Coal
MPBH1-HR	Eastern	301134	6432573	153.51	50	Interburden
MPBH2	Eastern	299403	6428716	145.03	17.4	Alluvium
MPBH2-C	Eastern	299383	6428748	146.15	80	Coal
MPBH2-HR	Eastern	299385	6428746	146.10	50.5	Interburden
MPBH3* [^]	Eastern	299700	6430710	-	14	Alluvium
MPBH3b	Eastern	299481	6431354	149.98	14	Alluvium
MPBH4	Eastern	299477	6431036	148.07	15	Alluvium
MPBH4-C	Eastern	299489	6431035	149.89	81	Coal
MPBH4-HR	Eastern	299500	6431033	149.62	50.5	Interburden
MPBH5	Eastern	298875	6429486	144.25	10	Alluvium
MPBH5-C	Eastern	298881	6429491	145.92	33.2	Coal
MPBH5-HR	Eastern	298889	6429495	146.02	22	Interburden
MPBH6	Eastern	300032	6434294	157.85	17	Alluvium
MPBH6-C	Eastern	300034	6434303	157.87	115	Coal
MPBH6-HR	Eastern	300033	6434298	157.83	65	Interburden
MPBH7	Western	290737	6430821	196.41	11	Regolith ¹
MPBH7-C	Western	290729	6430820	195.65	75	Coal
Melody Bore	Central	297623	6434011	192.73	43.8	Coal
3500B500S* [^]	Central	295194	6429840	-	21.43	Interburden #1
3500B500L* [^]	Central	295194	6429840	-	175.36	Bayswater Seam
3500C500S	Central	295177	6430846	239.80	28.48	Interburden #1
3500C500L	Central	295177	6430846	239.80	86.77	Mt Arthur Seam
4500F000	Central	296128	6433364	217.20	121.24	Vaux Seam
5000A500* [^]	Central	296709	6428864	-	65	Vaux Seam
5000D000	Central	296667	6431369	241.10	171.35	Wynn and Edderton Seams
5000D000R	Central	294029 ^β	6430490 ^β	-	278	Wynn and Edderton Seams
5500D000*	Central	297167	6431378	222.00	136	Interburden #7 & Wynn Seam
6000C000S* ^{^+}	Central	295737 ^β	6428921 ^β	-	51.27	Wynn Seam

Bore ID	General Location	Easting (GDA94)	Northing (GDA94)	Elevation# (mAHD)	Total Depth (m)	Aquifer/Unit
6000C000L* ^{A+}	Central	295737 ^β	6428921 ^β	-	20.69	Interburden#2
6500F500U	Central	298120	6433894	189.00	35.1	Interburden #4/Broonie Seam
6500F500M	Central	298120	6433894	189.00	77.3	Interburden #6/Wynn Seam
6500F500L	Central	298120	6433894	189.00	115.2	Maitland Group
6500F625	Central	297644	6433996	194.10	36.3	Permian – unknown
7000D000U*	Central	298669	6431394	162.40	12.89	Interburden #7/Edderton Seam
7000D000L*	Central	298669	6431394	162.40	98.73	Maitland Group
7500F000	Central	299088	6433423	183.70	182.8	Edderton Seam
WRA1U	Western	292118	6429657	218.04	6.5	Regolith
WRA1L	Western	292121	6429650	217.80	19.4	Warkworth seam
WRA2U*	Western	292907	6431864	261.65	5.5	Regolith
WRA2L*	Western	292908	6431867	261.50	18.95	Warkworth seam
WRA3U**	Western	293075	6431276	258.07	6.75	Regolith
WRA3L**	Western	293074	6431275	257.67	22.19	Warkworth seam
WRA5U**	Western	291980	6431370	-	7.64	Alluvium/Regolith
WRA5L**	Western	291980	6431370	-	19.30	Warkworth/Permian
WRA6U	Western	291354	6431233	212.13	9.27	Regolith
WRA6L	Western	291359	6431231	211.67	18.98	Warkworth seam
Proposed GDE bore (shallow) ^α	Central	-	-	-	-	Alluvium/weathered regolith
Proposed GDE bore (deep) ^α	Central	-	-	-	-	Mount Arthur Seam
VWP ^α	Central	-	-	-	-	Multiple
Proposed NE Alluvium ^α	Eastern	-	-	-	-	Alluvium
Proposed East Alluvium ^α	Eastern	-	-	-	-	Alluvium

Notes: * = decommissioned.

= ground level.

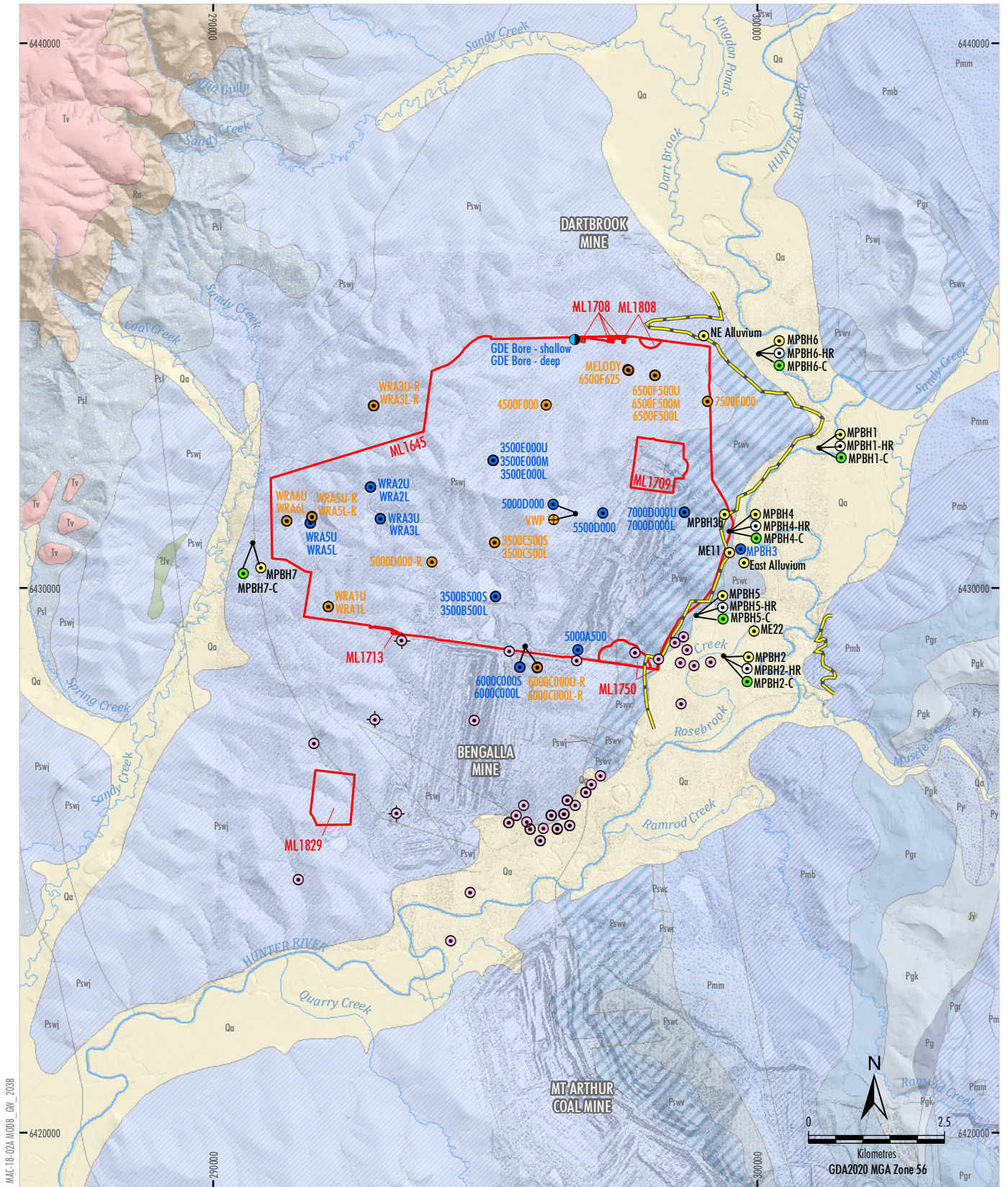
^ = not found or destroyed in latest survey.

+ = replacement bore proposed (MACH, 2025).

α = details to be confirmed.

β = coordinates presented in GDA2020 MGA56.

1= aquifer unit incorrectly listed as Hunter River Alluvium in WMP.



Source: MACH (2025); Bengalla Mine (2015); WaterNSW (2020, 2025); NSW Spatial Services (2025)

- LEGEND**
- Mining Lease Boundary (Mount Pleasant Operation)
 - Interpreted Extent of Alluvium
 - Mount Pleasant Monitoring
 - GDE Bore
 - ⊕ Vibrating Wire Piezometer
 - Standpipe
 - Standpipe - Alluvium
 - ⊕ Standpipe - Coal Seam
 - ⊗ Standpipe - Interburden
 - Standpipe - Historical
 - ⊕ Bengalla Monitoring
 - ⊗ Bengalla Standpipe
 - ⊕ Bengalla Vibrating Wire Piezometer

- Quaternary
- Qa: Alluvium
- Tertiary
- Tv: Basalt
- Jurassic
- Jv: Volcanics
- Triassic
- Rn: Hawkesbury Sandstone and Narrabeen Group
- Permian
- Pswj: Denman Formation and Jerry Plains Subgroup
- Pswv: Archerfield Sandstone and Vane Subgroup
- Pswc: Saltwater Creek Formation
- Pmm: Mulbring Siltstone
- Pmb: Branxton Formation
- Pg: Greta Coal
- Pgr: Greta Coal Measures (coal seams, siltstone and sandstone)
- Ppk: Greta Coal measures (pellet claystone, siltstone and chert)
- Psl: Wollombi Coal Measures
- Py: Gyarran Volcanics

MACHEnergy
MOUNT PLEASANT OPERATION
Mount Pleasant Operation
Groundwater Monitoring Locations

Figure 5.1

5.3 Hydraulic properties

The hydraulic properties that govern groundwater storage and flow across the broader region vary considerably between the unconsolidated Quaternary alluvial systems and the confined hard rock Permian groundwater system associated with the coal measures. Details of the hydraulic properties in the aquifers associated with MPO are presented below.

5.3.1 Hydraulic conductivity

Hydraulic property data within the MPO area has historically been collected at the MPO, much of it during the original approvals process in the 1990s. Results of slug, packer and core testing were presented in the original Environmental Impact Statement (ERM Mitchell McCotter, 1997) and a supplementary submission to the Commission of Inquiry (ERM Mitchell McCotter, 1999).

The results of the packer testing program are presented in Table 5.2.

Table 5.2 Hydraulic conductivity packer test data

Bore ID	Test zone	Test depth (m)	Hydraulic conductivity (m/day)
575OD750	Broonie seam	56–59	3.7×10^{-2}
	interburden	72–75	6.2×10^{-3}
	interburden/coal	83–86	5.3×10^{-3}
	interburden	87–90	1.0×10^{-4}
	Bayswater seam	91–94	1.1×10^{-1}
	Wynn seam	106–109	1.0×10^{-1}
	interburden	113–116	3.2×10^{-3}
	interburden	124–127	6.4×10^{-3}
	Wynn seam	133–136	8.0×10^{-2}
	Edderton seam	141–144	6.3×10^{-2}
4750C000	interburden	52–55	1.1×10^{-3}
	Piercefield seam	70.5–73.5	1.4×10^{-1}
	interburden	77–80	8.0×10^{-4}
	interburden	97.5–100.5	1.1×10^{-3}
	interburden	111–114	3.0×10^{-3}
	Broonie seam	135–138	3.4×10^{-2}
	interburden	153.5–156.5	3.3×10^{-3}
	interburden	164.5–167.5	1.7×10^{-3}
4250F250	Piercefield seam	86–89	1.5×10^{-2}
	Vaux seam	150–153	1.5×10^{-1}
	Bayswater seam	191.5–194.5	9.6×10^{-2}
	interburden	127–130	2.6×10^{-3}
	interburden/coal	173.5–176.5	3.0×10^{-3}
	interburden	211–214	2.4×10^{-3}

ERM Mitchell McCotter (1997) stated that testing (unknown method, assumed to be pumping tests) had been undertaken at three locations in the Hunter River alluvium. The results of these tests produced estimates of hydraulic conductivity of 8.8, 18.9 and 33.2 m/day (harmonic mean = 15.3 m/d). AGE (2013b) reported results in the range 5-40 m/day for Hunter River alluvium, as did Aquaterra (2009), who reported 50 m/day. These reported values for hydraulic conductivity are relatively high and likely associated with underlying gravel at the base of the alluvium, as observed in the bore logs shown on Figure 4.4.

To supplement the MPO data, horizontal hydraulic conductivity values for the coal seams and interburden units determined from field testing at other mine sites in the vicinity of the MPO were compiled (AGE, 2013a, 2013b, 2014; MER, 2006, 2007). The results of this compilation are presented graphically in Figure 5.2 (coal) and Figure 5.3 (interburden). Average horizontal conductivity for the coal seams is 7.5×10^{-2} m/day and for the interburden is 7.0×10^{-2} m/day.

As shown on Figure 5.2, testing results indicate that horizontal hydraulic conductivity values in the coal seams are in the range between 1×10^{-5} to 1 m/day. Similar testing conducted in the Permian interburden units returned lower values, ranging from predominantly between 1×10^{-6} to 1×10^{-2} m/day (i.e. hydraulic conductivity was generally two orders of magnitude lower than the coals).

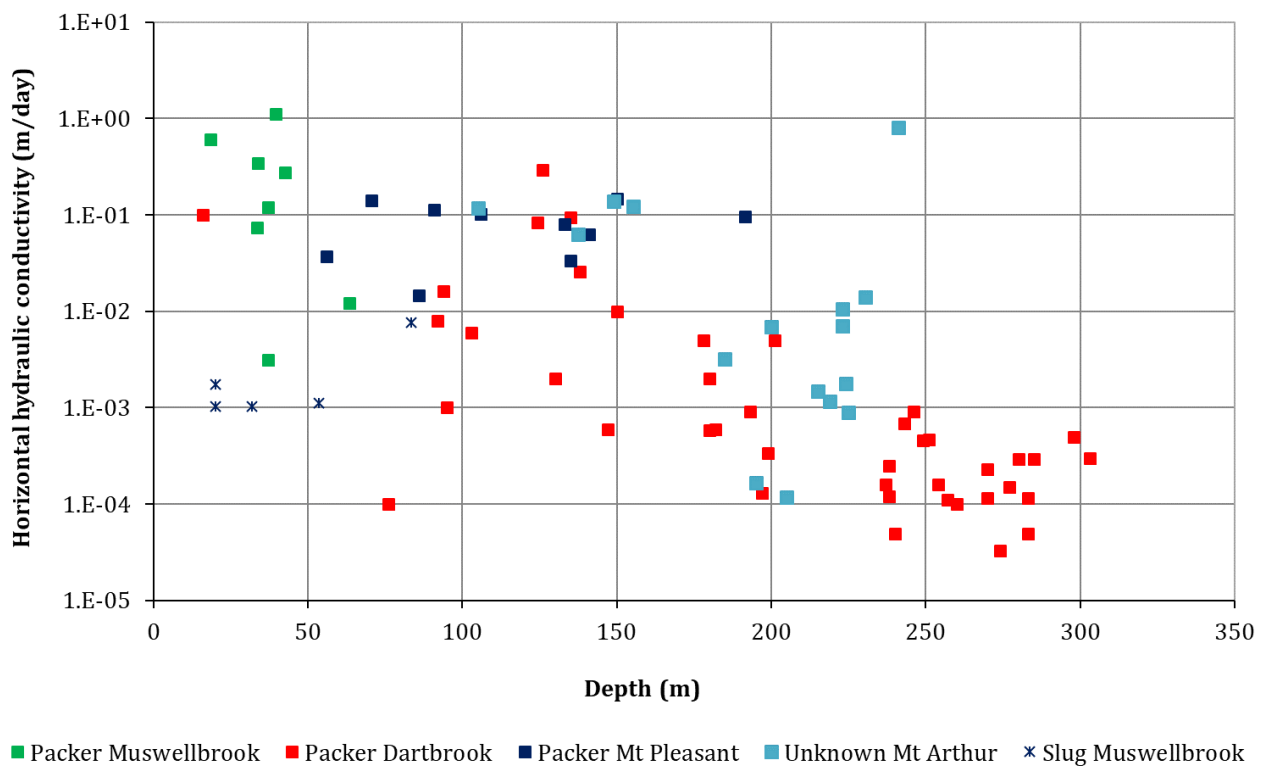


Figure 5.2 Hydraulic conductivity vs depth – Permian coal

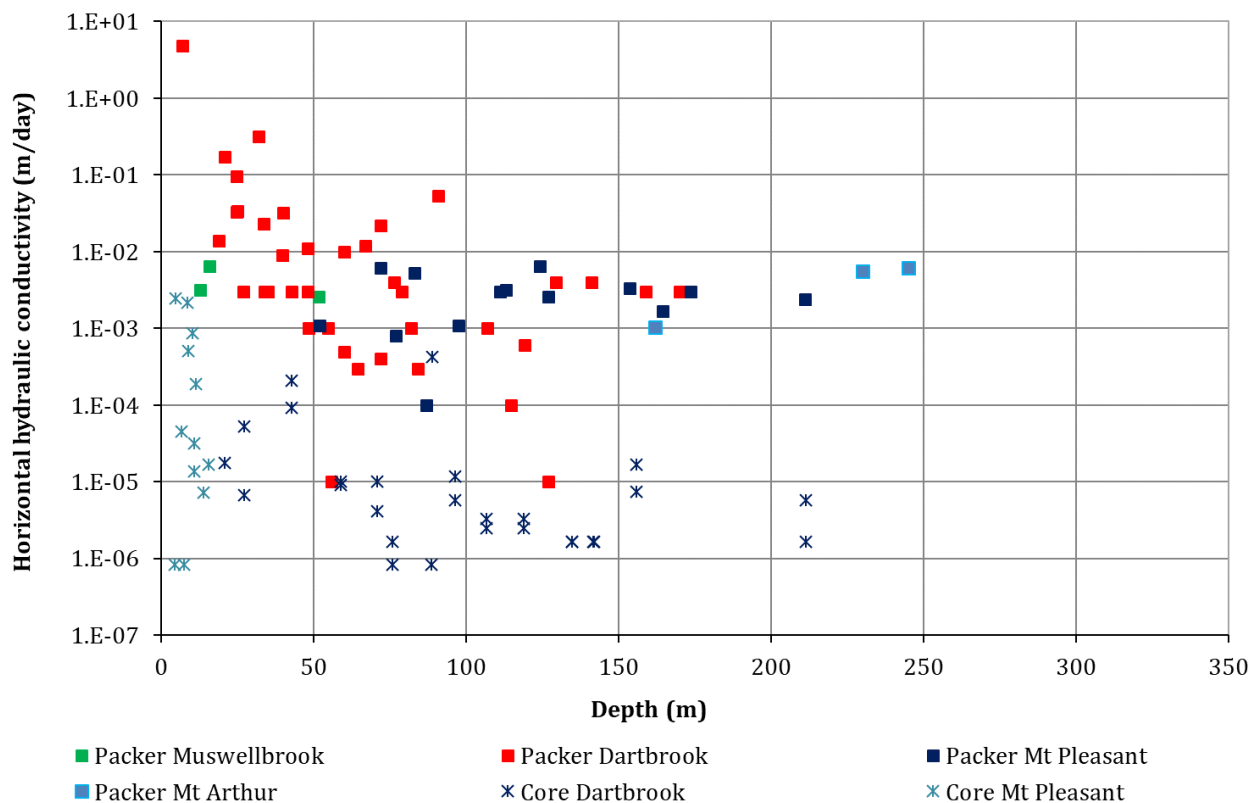


Figure 5.3 Hydraulic conductivity vs depth – Permian interburden

5.3.2 Storage properties

A number of measurements of total porosity from Bulga exploration core samples vary between 4.3 to 10.7% for those interburden units that correspond with the target sequence at MPO (MER, 2013). Total porosity is a theoretical upper limit for the groundwater held in a volume of rock or soil and is significantly higher than the porosity that would be drained under gravity (Specific yield [Sy]). It is noted that Sy together with porosity (n) and specific storage (Ss), usually decreases with depth.

5.4 Saturation and productivity

5.4.1 Hunter River alluvium

As noted in Section 2.3, the Quaternary alluvium associated with the Hunter River is recognised as a “highly productive” groundwater source. The alluvial material typically offers significantly increased groundwater storage when compared to the underlying Permian coal seams, through higher interstitial porosity.

Figure 5.4 below shows the saturated thickness of the Hunter River alluvium measured between 2003 and 2025 in the monitoring bores with extensive historical monitoring records. Review of the borehole logs for these bores (refer Figure 4.4) indicates that groundwater occurs within the gravels at the base of the alluvial sequence. This is further supported by water level observations, shown in Figure 5.5 which identifies that water levels in the monitoring bores correspond with the top of the gravels noted in the borehole logs.

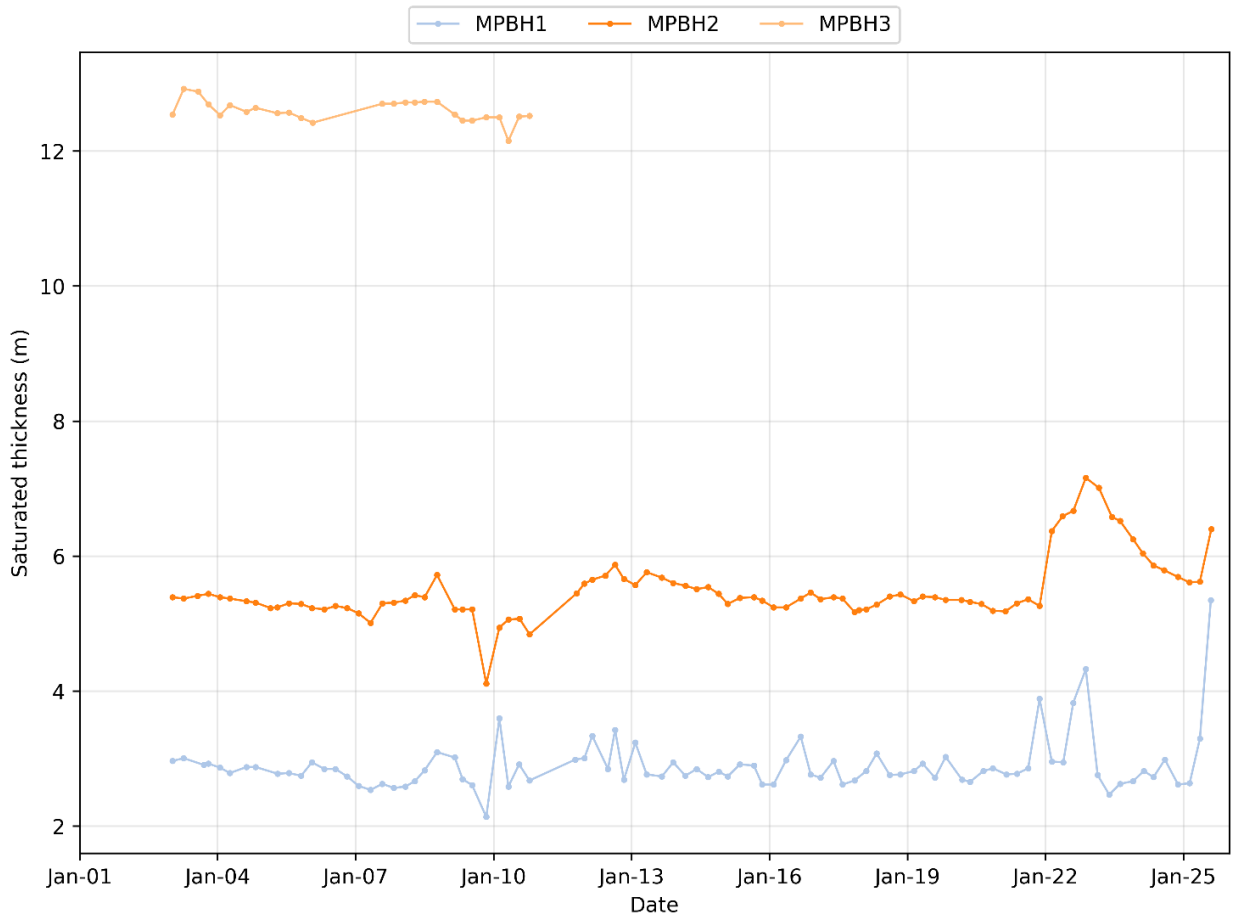


Figure 5.4 Saturated thickness – Hunter River alluvium

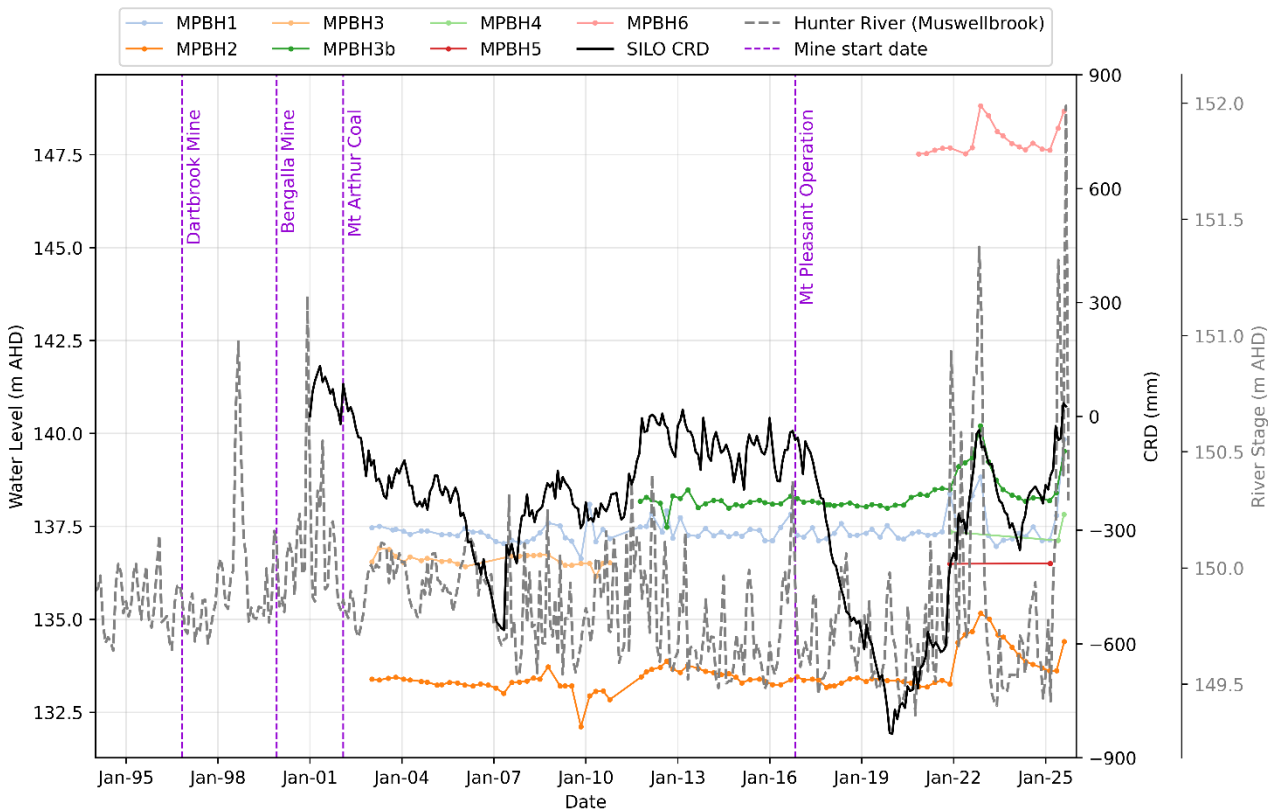


Figure 5.5 Water levels – Hunter River alluvium and Hunter River

5.4.2 Permian sediments

Saturation of the Permian strata occurs in both the coal seams and interburden. The ability to yield water is limited to the coal seams, as the interburden does not transmit significant volumes of groundwater, instead acting as an aquitard confining the coal seams. The coal seams are comprised of multiple plies with intervening non-coal interburden. When the plies and non-coal layers are combined each seam can range from 2.5 m to 10 m in thickness and is generally fully saturated with groundwater. The yield from the coal seams is also relatively low due to limited permeability and thickness, meaning they cannot be classified as "highly productive", and are considered "less productive". Figure 4.7 and Figure 4.8 show the coal seams intersected in MPO open cuts and illustrate the lack of significant seepage from the interburden rock units and the coal seams. This limited seepage from the coal seams is typical of Hunter Valley mines, which do not commonly need to remove significant volumes of groundwater from the mining face/pit as the volumes of seepage are low and readily evaporate from the pit face.

5.5 Water levels

5.5.1 Hunter River alluvium

Figure 5.5 presents water levels in the Hunter River alluvium measured between 2003 and 2025 in seven monitoring bores, MPBH1 to MPBH6 and MPBH3b (refer Figure 4.4). This figure also presents water levels compared to the average monthly stream water level in the Hunter River and the CRD, as derived from SILO data (refer Section 3.2.1). The average monthly stream water level shown was calculated using the stage record for WaterNSW gauge 210002, located due east of MPBH5 and MPBH2 (Hunter River at Muswellbrook) (Figure 5.1). The water level was then adjusted using the zero-gauge elevation.

Figure 5.5 shows a clear head separation between the nearest bore to the gauge (MPBH2, 980 m from the gauge). The significantly lower water level of the bore compared to the river level suggests losing surface water conditions in this reach of the river. Review of LiDAR data and water levels at MPBH1 and MPBH3, both upstream of the gauge, indicate levels are below the invert of the river channel. This also suggests losing surface water conditions in the vicinity of these bores. To further support this conclusion, Hunter River elevations were extrapolated from gauge 210002 to a location adjacent MPBH1 (refer Figure 5.5), with the results further indicating losing surface water conditions at this location.

The conclusion drawn from the baseline monitoring conducted within the Hunter River alluvium is that water levels in the alluvium are generally stable and do not exhibit a marked response to rainfall. Whilst this indicates that losses from the surface water system largely maintain the alluvial aquifer in this area, it is worth noting that Hunter River water levels are significantly affected by controlled releases from Glenbawn Dam, and discharge volumes from the dam are generally reduced during significant rainfall events. Two such events can be clearly seen in the water levels record in 2022, and more recently in 2025 (refer to Figure 5.5).

5.5.2 Permian sediments – Western Domain

Monitoring bores in the Western Domain of the MPO (WRA1, WRA2, WRA3, WRA5, WRA6) (see Figure 5.6) are all located within shallow Permian sediments. These are nested monitoring bores with separate piezometers within the regolith and underlying unweathered Permian strata. The upper piezometer (U) is screened in regolith (i.e. weathered rock [WRA3, WRA5 and WRA6 only]), with the lower piezometer (L) screened in either Permian interburden or coal seams, below the depth of weathering (refer Table 5.1). The readings shown on Figure 5.6 and Figure 5.7 indicate similar water levels at some sites, such as WRA5, suggesting hydraulic connection between the Permian and shallower units at these locations. Other sites, such as WRA3, have divergent water levels between the Warkworth seam and the regolith, suggesting a comparative reduction in hydraulic connectivity at these locations. Figure 5.6 and Figure 5.7 also show the CRD (refer Section 3.2.1 for the period shown). Comparison with the CRD indicates that water levels in the monitored strata exhibit a muted response to rainfall. Moderate groundwater flow is expected through the relatively permeable regolith and is expected to follow topography. Whilst the regolith has the potential to hydraulically connect the alluvium to the mine workings, this unit is typically dry, thin (refer Figure 4.7 and Figure 4.8) and topographically separated from the open cut pits (i.e. drainage divide).

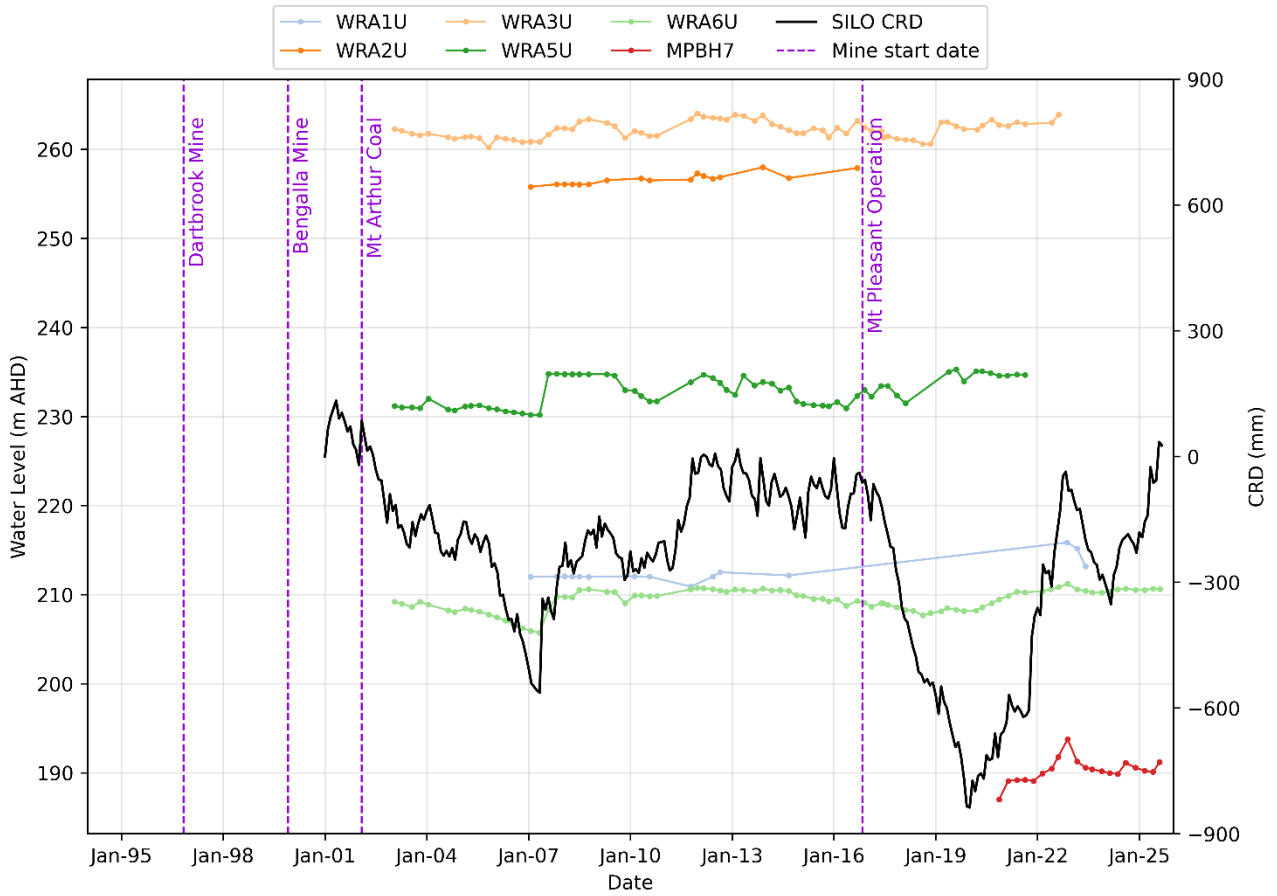


Figure 5.6 Water levels – MPO Western Domain regolith

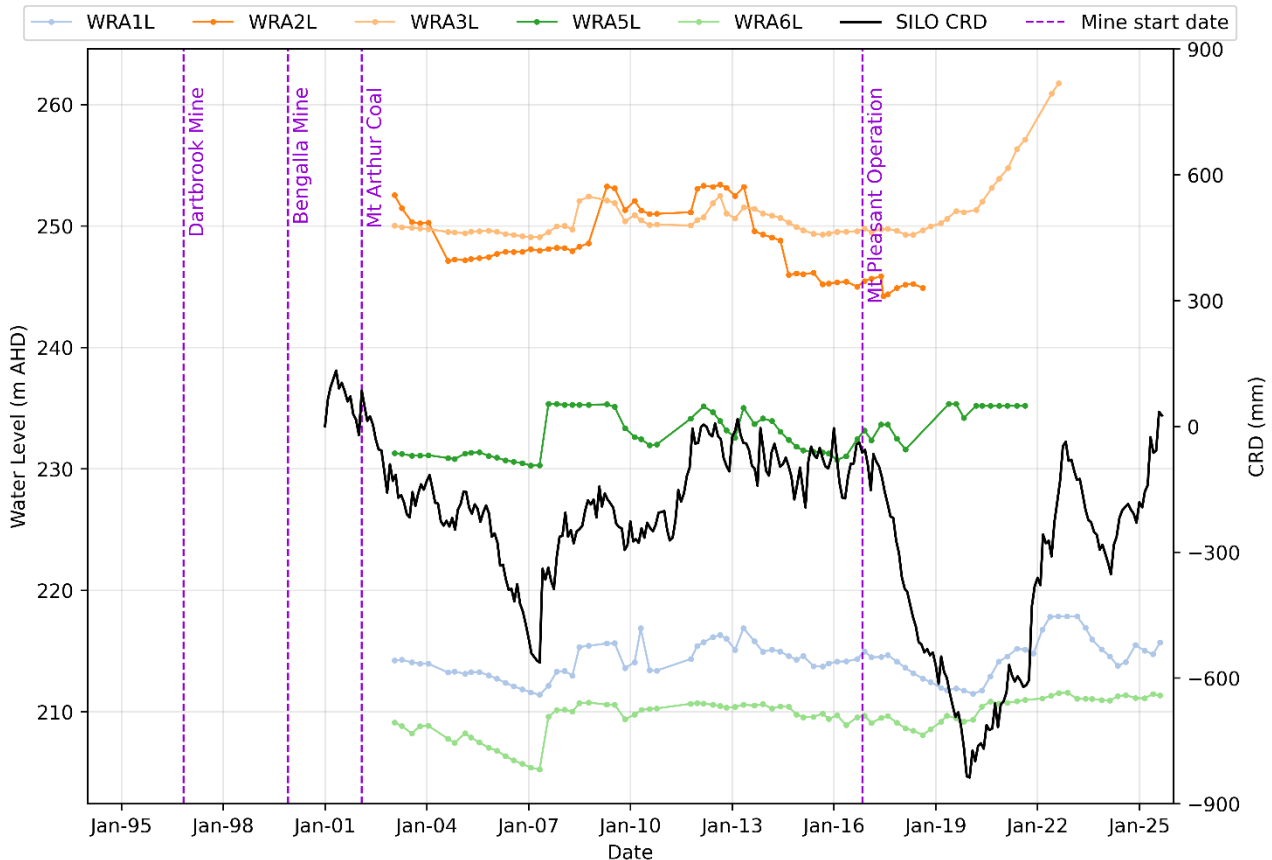


Figure 5.7 Water levels – MPO Western Domain Permian sediments

5.5.3 Permian sediments – Central Domain

Groundwater in the central section of the MPO, north and west of the open cut pits, is monitored via a network of eleven monitoring bores (refer Figure 5.1). The central network targets Permian sediments, including interburden, coal seams, and the underlying Maitland Group (6500F500L and 7000D000U). Table 5.1 presents information on the Permian strata in which these bores are screened. Three locations (6500F500, 3500C500, and 7000D000) are nested monitoring bores with an upper piezometer (U) and lower piezometer (L). Water level observations for these bores are shown in Figure 5.8.

Figure 5.8 indicates that water levels within the upper interburden units (3500C500L and 3500C500S) are generally stable over the period of record, apart from a gradual decline at 3500C500L. These bores show limited short-term response to rainfall variation, as indicated by the CRD. There are notable water level changes including the sharp declines in 5000D000 and 5500D000 from mid-January 2019, and temporary fluctuations in 6500F500U, which includes long periods of missing data. The decline in 6500F500U and 5500D000 may be partly associated with a period of below-average rainfall that started in 2017. Abrupt fluctuations in 5500D000 from 2021 onward may indicate localised disturbances, potential operational activity, or logger / transcription errors.

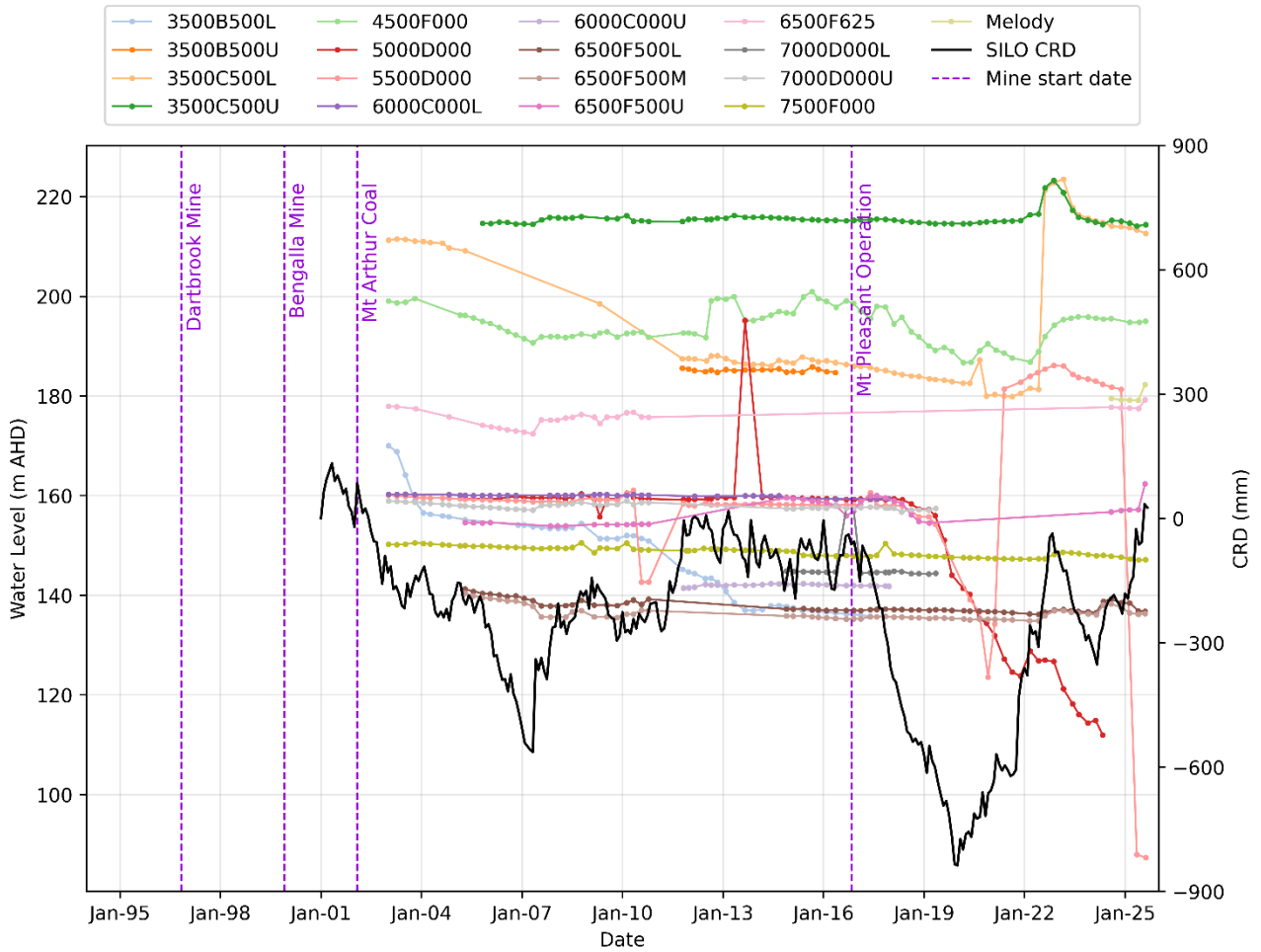


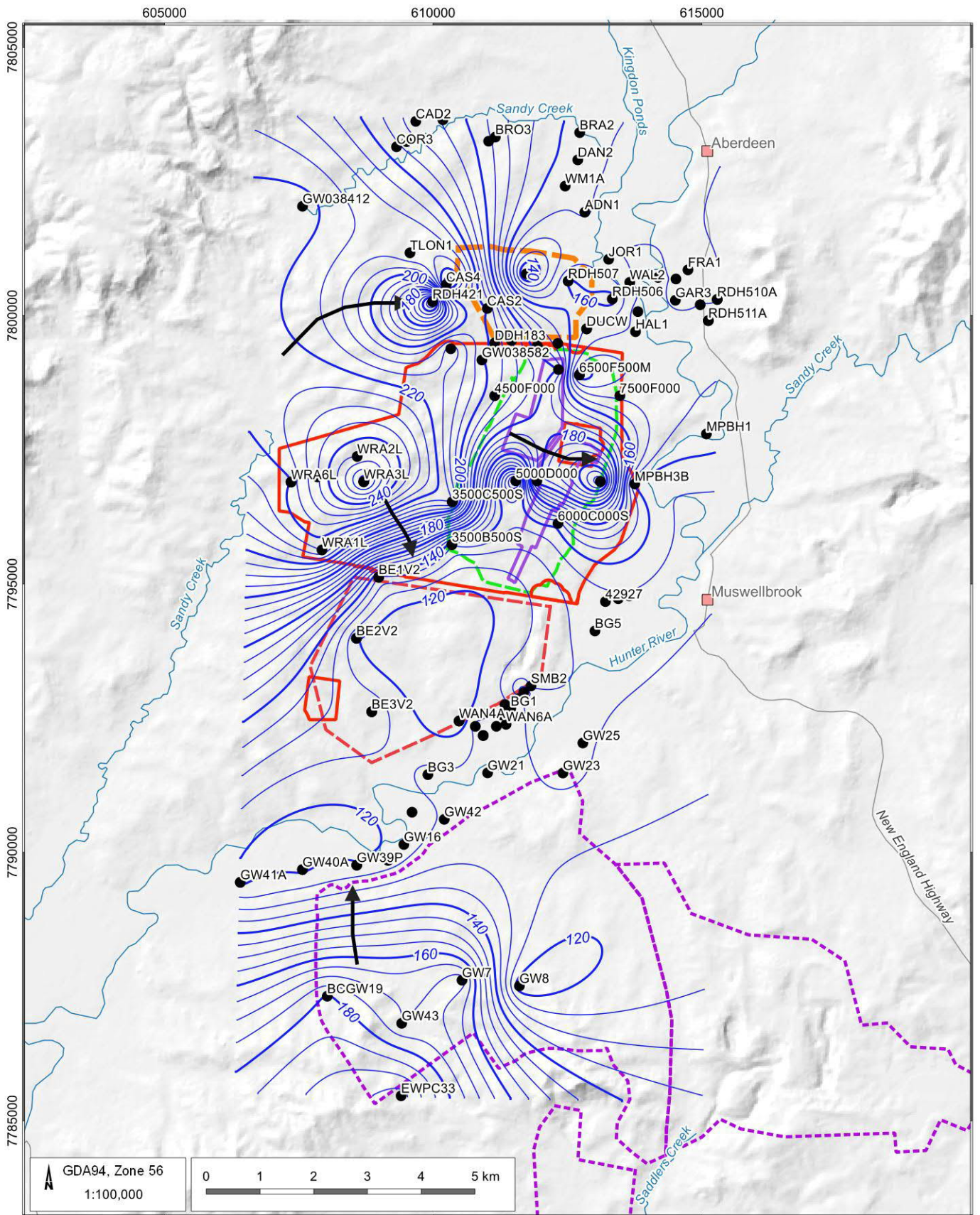
Figure 5.8 Water levels – MPO Central Domain Permian sediments

5.6 Groundwater flow

Regionally, groundwater flow is directed from the elevated areas in the west and northwest toward the Hunter River floodplain in the east and southeast. Within the MPO, the inferred groundwater gradient is relatively steep on the western side, indicating flow toward the east and northeast from higher elevations. Gentler gradients are evident to the east, where groundwater flow converges toward the Hunter River and its associated alluvium.

Groundwater levels within the Hunter River alluvium indicate flow generally aligned with the river channel, suggesting strong hydraulic connection and local exchange between surface water and groundwater. As noted in Section 5.5.1, monitoring bore data show that the Hunter River locally recharges the adjacent alluvium. A map of water table contours is presented in Figure 5.9. A local groundwater divide is inferred across the elevated terrain in the western part of the MPO, with:

- westward and southward flow toward Sandy Creek; and
- eastward and southeastward flow toward the Hunter River and Dart Brook.



GDA94, Zone 56
1:100,000



LEGEND

- Populated place
- Drainage
- Road
- 2023 regional bore contours**
- Major
- Minor
- Bengalla Project Extent
- Dartbrook Project Extent
- MPO Pit Extent
- Mt Arthur Pit Extent
- Mining lease
- Pit Floor Extent
- Flow direction

MPO MOD 8 Life of Mine Extension
(MPO5009.001)

Water table contours interpolated from 2023 observations

©2024 Australasian Groundwater and Environmental Consultants Pty Ltd (AGE) - www.ageconsultants.com.au
 Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011 ; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006 ;
 G:\Projects\MPO5004.001 Mt Pleasant MOD7 Groundwater Assessment\GIS\Workspaces\001_Deliverable\105.08_MPO5004_Water table contours interpolated from 2023 observations.gzg

5.7 Groundwater quality and beneficial use

5.7.1 Salinity and pH

This section describes the water quality and beneficial use of groundwater within the Quaternary alluvium and Permian sediments. Salinity is the key constraint to groundwater use and can be described by TDS concentrations. TDS concentrations are commonly classified on a scale ranging from fresh to extremely saline. Food and Agriculture Organization of the United Nations ('FAO') (2013) provide a useful set of categories for assessing salinity based on TDS concentrations as follows:

- Fresh water: <500 mg/L (approximately 750 $\mu\text{S}/\text{cm}$).
- Brackish (slightly saline): 500 to 1,500 mg/L (approximately 750 to 2,250 $\mu\text{S}/\text{cm}$).
- Moderately saline: 1,500 to 7,000 mg/L (approximately 2,250 to 10,500 $\mu\text{S}/\text{cm}$).
- Saline: 7,000 to 15,000 mg/L (approximately 10,500 to 22,400 $\mu\text{S}/\text{cm}$).
- Highly saline: 15,000 to 35,000 mg/L (approximately 22,400 to 55,250 $\mu\text{S}/\text{cm}$).
- Brine: >35,000 mg/L (approximately 55,250 $\mu\text{S}/\text{cm}$).

As noted in Section 5.2, MACH operates a groundwater monitoring network at the MPO, as shown in Figure 5.1 and detailed in Table 5.1. Each of the monitoring bores identified in Table 5.1 is monitored quarterly for measurement of field parameters (pH and EC). As EC is proportional to the total dissolved ions in a water sample it can be used to estimate TDS concentrations by multiplying by 0.67 (ANZG, 2019).

Figure 5.10, Figure 5.11 and Figure 5.12 show the ranges in groundwater EC ($\mu\text{S}/\text{cm}$) collected across the MPO monitoring bore network. These figures also show the FAO classifications that have been derived from the 0.67 EC to TDS multiplier.

Figure 5.10 presents the EC measured at monitoring bores within the Hunter River alluvium adjacent to the MPO and the Hunter River, measured at WaterNSW gauge 210002. Measured EC at MPBH1 (mean 561 $\mu\text{S}/\text{cm}$) is consistent with the Hunter River (mean EC 503 $\mu\text{S}/\text{cm}$) and can be considered as fresh water. When compared to the Hunter River, measured EC at MPBH2 (mean 891 $\mu\text{S}/\text{cm}$) is slightly higher and within lower bound of the "brackish" water category. Groundwater at MPBH3b (mean 4,392 $\mu\text{S}/\text{cm}$) has notably higher EC than the other alluvial bores and considered to be "moderately saline". Application of the EC to TDS multiplier identifies that groundwater in MPBH1 and MPBH2 falls within the "highly productive" category (TDS <1,500 mg/L) of the AIP whilst that in MPBH3b does not.

Measured groundwater EC in the western monitoring network (regolith) is shown on Figure 5.11. This network is comprised of bores situated adjacent to minor drainage features which discharge into Sandy Creek. Notably, groundwater in this network exhibits the highest EC for all MPO monitoring bores. Groundwater in this network sits within the moderately saline to saline classification with a range between 3,288 $\mu\text{S}/\text{cm}$ (mean EC for WRA5U) and 11,320 $\mu\text{S}/\text{cm}$ (mean EC for MPBH7). With the exception of MPBH7 (mean EC of 11,320 $\mu\text{S}/\text{cm}$) and WRA6U (mean EC of 10,227 $\mu\text{S}/\text{cm}$), the EC in regolith is within the ANZG (2019) recommended range for livestock drinking water (EC 7,463 $\mu\text{S}/\text{cm}$ [TDS < 5,000 mg/L]). Groundwater EC in the deeper bores within Permian (i.e., WRA1L to WRA6L) near Sandy Creek ranged from 3,581 $\mu\text{S}/\text{cm}$ (mean EC for WRA1L) to 15,607 $\mu\text{S}/\text{cm}$ (mean EC for WRA3L).

Measurement of groundwater EC in the central monitoring bores has not been continuous, as shown on Figure 5.12. EC in these bores is variable, with sudden changes in EC recorded over the period of record. Mean EC in the coal seams 4,060 $\mu\text{S}/\text{cm}$ (moderately saline); interburden 3,898 $\mu\text{S}/\text{cm}$ (moderately saline); mixed interburden and coal 3,601 $\mu\text{S}/\text{cm}$ (moderately saline) and the underlying Maitland Group 1,650 $\mu\text{S}/\text{cm}$ (brackish).

Whilst not shown on figures, calculated mean pH for groundwater in each of the networks (eastern, western and central) was ~ 7.0 , indicating generally neutral groundwater conditions. However, pH values vary significantly from 5.7 (slightly acidic) at WRA5U to 12.4 (highly alkaline) at 7000D000U reflecting the heterogeneity of the units monitored in this network.

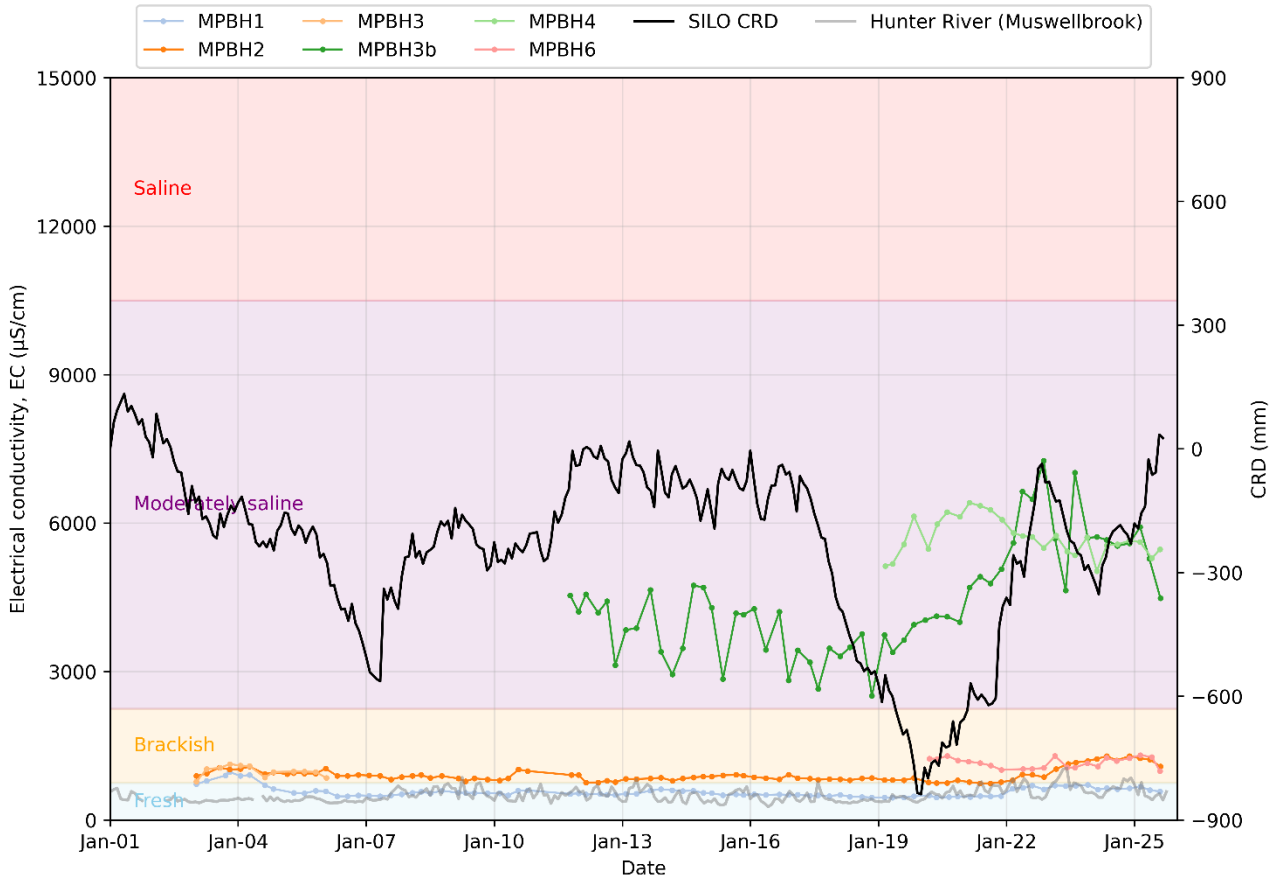


Figure 5.10 Electrical conductivity – Hunter River alluvium and Hunter River

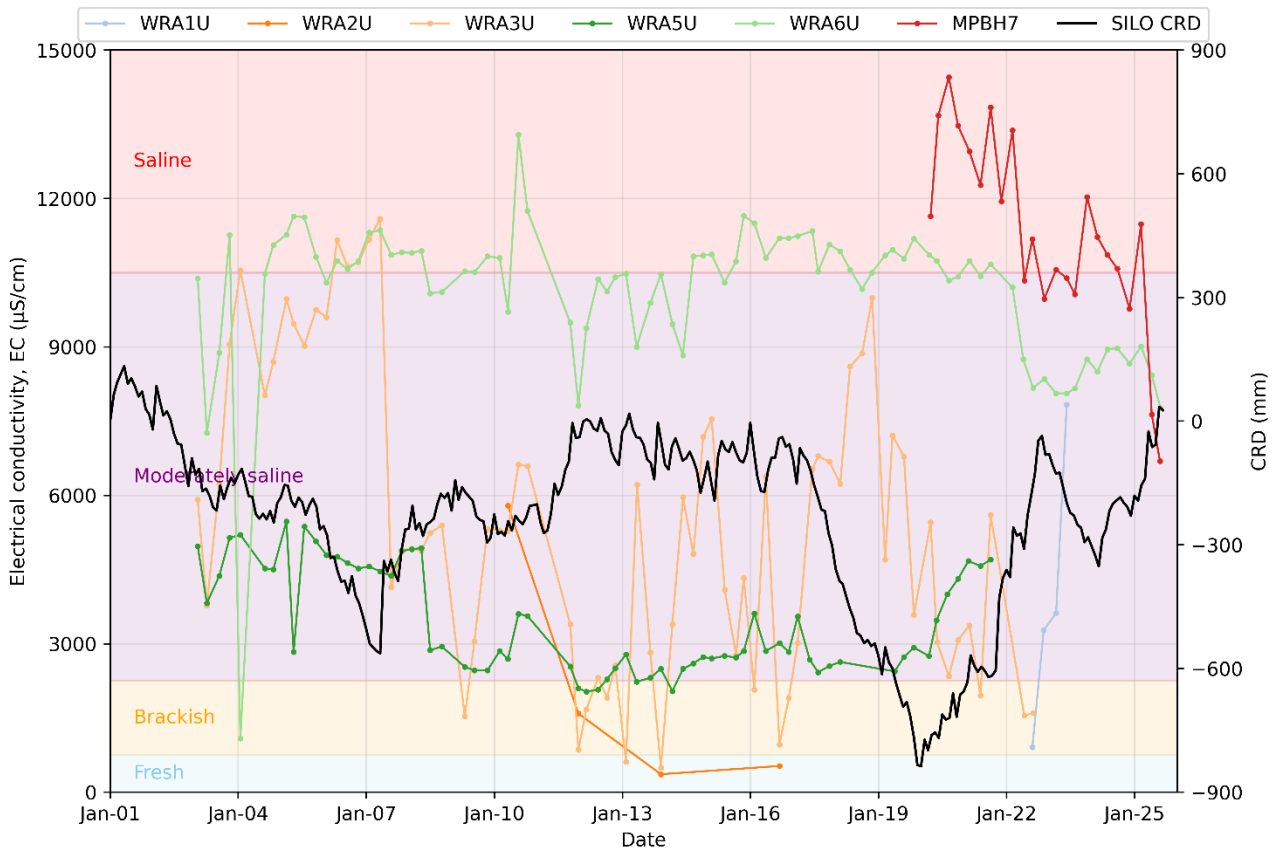


Figure 5.11 Electrical conductivity – MPO Western Domain regolith

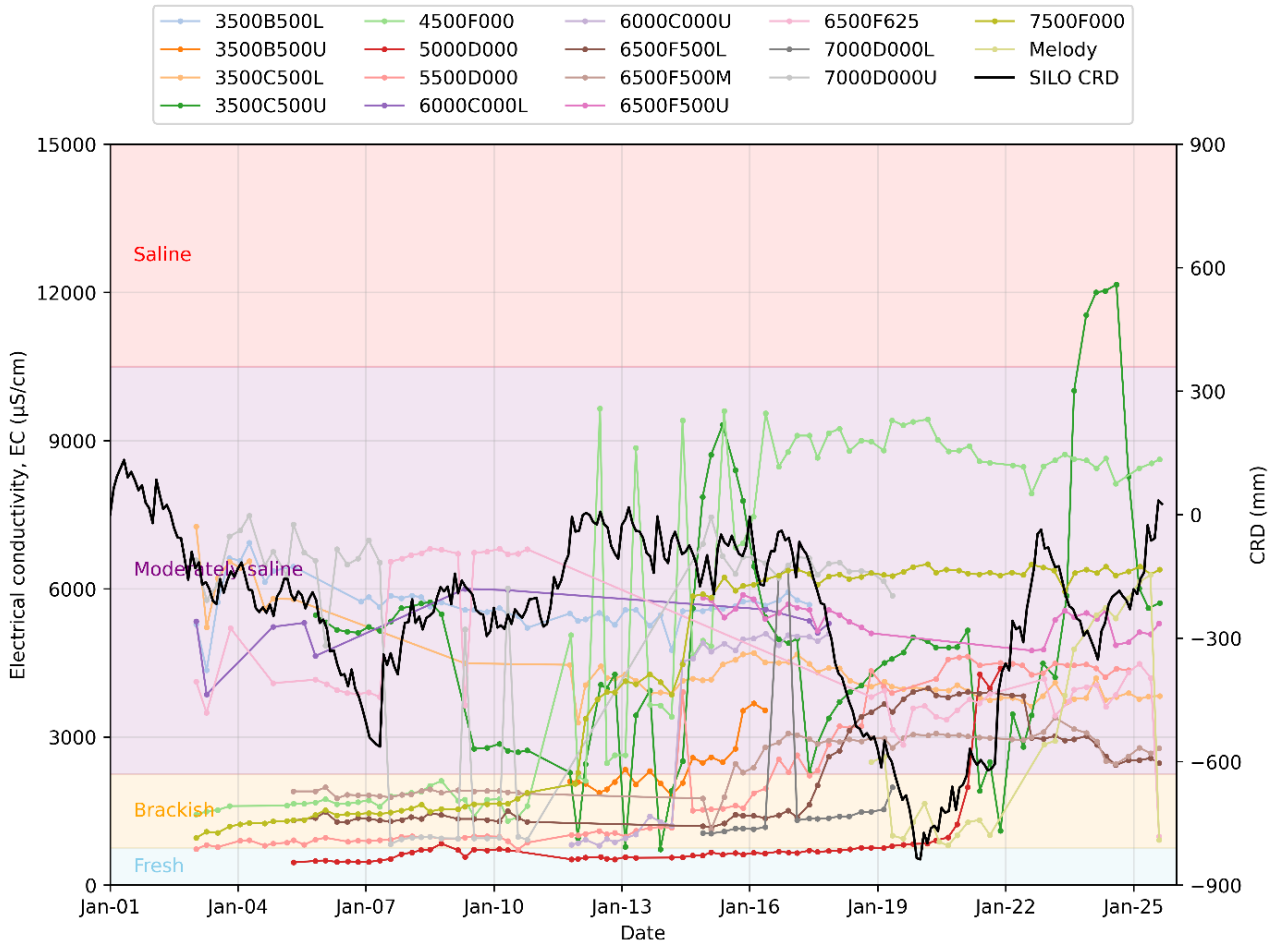


Figure 5.12 Electrical conductivity – MPO Central Domain Permian sediments

5.7.2 Major ions

Analysis of the varying abundances and types of dissolved ions present in a sample can be used to classify groundwater. The chemical composition of a groundwater often reflects its origin and interactions with the host aquifer materials, including the dissolution and precipitation of minerals. Subsequently, the chemical classification of groundwater via major ion composition is a useful method to develop conceptual models of groundwater systems.

The major ion chemistry of 129 groundwater samples collected at the MPO is shown as a Piper plot on Figure 5.13. A Piper plot uses two tri-linear plots to represent the proportions of major cations (lower-left: $\text{Na}^+ + \text{K}^+$, Ca^{2+} , Mg^{2+}) and anions (lower-right: $\text{HCO}_3^- + \text{CO}_3^{2-}$, Cl , SO_4^{2-}) that are measured in a groundwater sample. Each analysis is then projected onto a third rhombohedral (upper) plot illustrating the overall water type.

Review of the Piper plot indicates that whilst the results for the Permian strata, including the coal measures, are variable, they are generally dominated by sodium, potassium and chloride resulting in classification as a sodium chloride type water. Groundwater in the alluvium could principally be classified as a magnesium carbonate type water with predominantly calcium and bicarbonate ions present in samples.

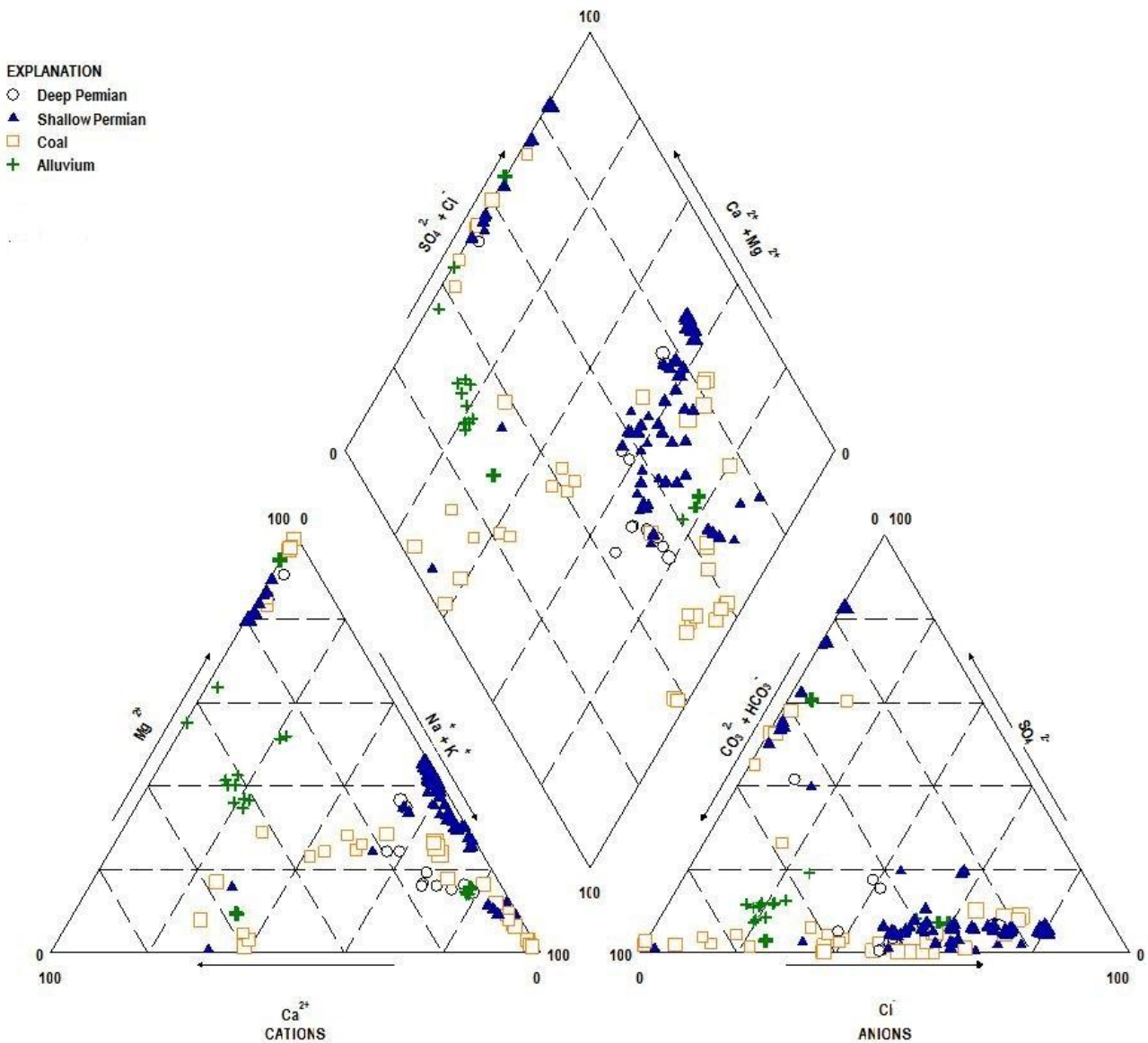


Figure 5.13 Piper plot of groundwater composition at the MPO (Hydrosimulations, 2019)

5.7.3 Metals

Metals and metalloids are trace elements that naturally occur in the Earth's crust. Trace elements are considered essential for many organisms in low quantities, however harmful if in high uptake. Inherently, the presence of trace elements in the subsurface results in the suspension and dissolution of these species in groundwater.

The Australian Drinking Water Guidelines (National Health and Medical Research Council [NHMRC], 2011) and ANZECC & ARMCANZ (2000) water quality guidelines outline standard concentrations that indicate when trace elements become harmful in water. The concentrations of trace metals in 131 groundwater samples from the Quaternary alluvium and Permian aquifers at the site are summarised in Figure 5.14. Comparison to the ANZECC & ARMCANZ framework illustrates that most trace element quantities measured at the site fall within acceptable limits for irrigation and livestock use in both the alluvial and Permian systems. Groundwater sourced from the alluvium demonstrates generally lower ion and trace concentrations and as such meets the stricter acceptable limits for human drinking water for more of the analytes (e.g. aluminium, arsenic, lead) than does the Permian sourced groundwater (NHMRC, 2011).

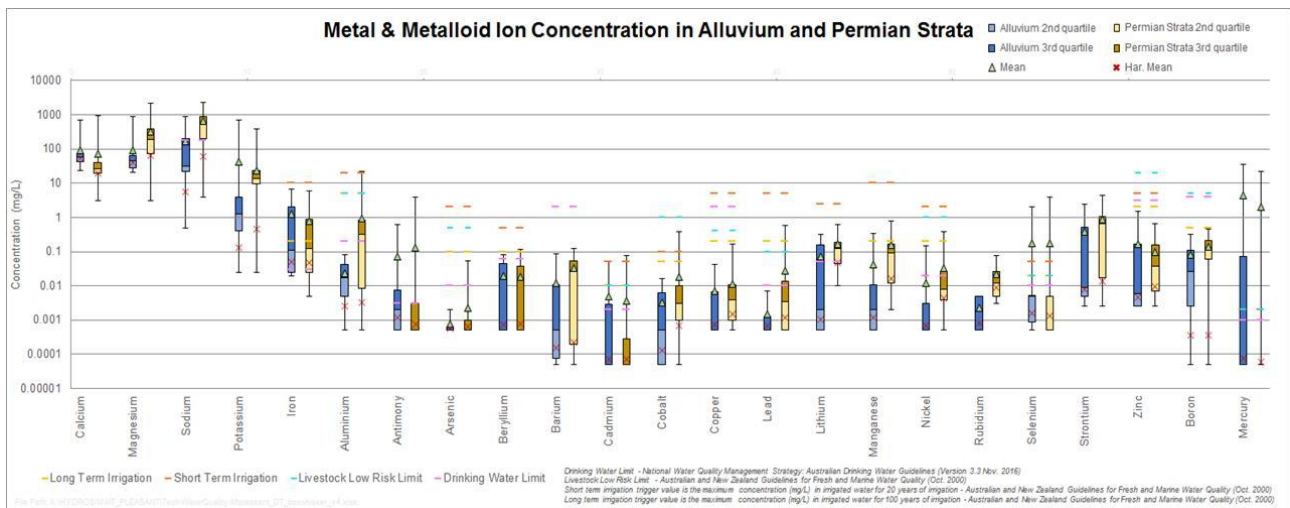


Figure 5.14 Metal and metalloid ion concentrations in alluvium and Permian strata at the MPO (Hydrosimulations, 2019)

5.7.4 Beneficial use

As noted above, salinity is the key restriction on beneficial use of groundwater at the MPO. Groundwater at the MPO falls between the brackish and saline classification. This means that much of this groundwater (brackish to saline) is unsuitable for more sensitive uses such as human consumption and irrigation. The data does indicate that some MPO groundwater has salinity levels that could be tolerated by stock or used to irrigate salt tolerant crops.

Due to its lower EC, (fresh water), groundwater measured in much of the Hunter River alluvium (e.g. MPBH1 and MPBH2) could be applied to a broader range of beneficial uses. These may include a larger range of crops under irrigation, livestock fodder or, dependent on additional parameters, this groundwater may be utilised as potable water.

5.8 Groundwater dependent assets

The IESC information guidelines require the identification of water-dependent assets with potential to be impacted by large coal mines. Information on potentially groundwater dependent assets from a number of different sources is summarised below.

5.8.1 Bioregional Assessment – Hunter subregion water dependent assets

In the context of Bioregional Assessments water-dependent assets are defined as ‘an asset potentially impacted by changes in groundwater and/or surface water due to coal or coal seam gas development. Some ecological assets solely depend on rainfall and will not be considered as water dependent if evidence does not support a linkage to groundwater or surface water’ (Macfarlane *et al.*, 2016). Assets can be classified for economic, ecological, or sociocultural.

In the Hunter sub-region ecological water dependent assets are classified into three subgroups:

- ‘Surface water feature’ – 205 assets;
- ‘Groundwater feature (subsurface)’ – 24 assets; and
- ‘Vegetation’ – 1,422 assets, of which:
 - Groundwater-dependent ecosystems – 587 assets; and
 - Habitat (potential species distribution) – 835 assets.

The Hunter River alluvium is noted as alluvial aquifer assets within the 'Groundwater feature (subsurface)' subgroup (refer Figure 5.15) The alluvium along Sandy Creek is not differentiated from the bedrock groundwater units in terms of the asset groupings. There are no groundwater springs identified close to MPO.

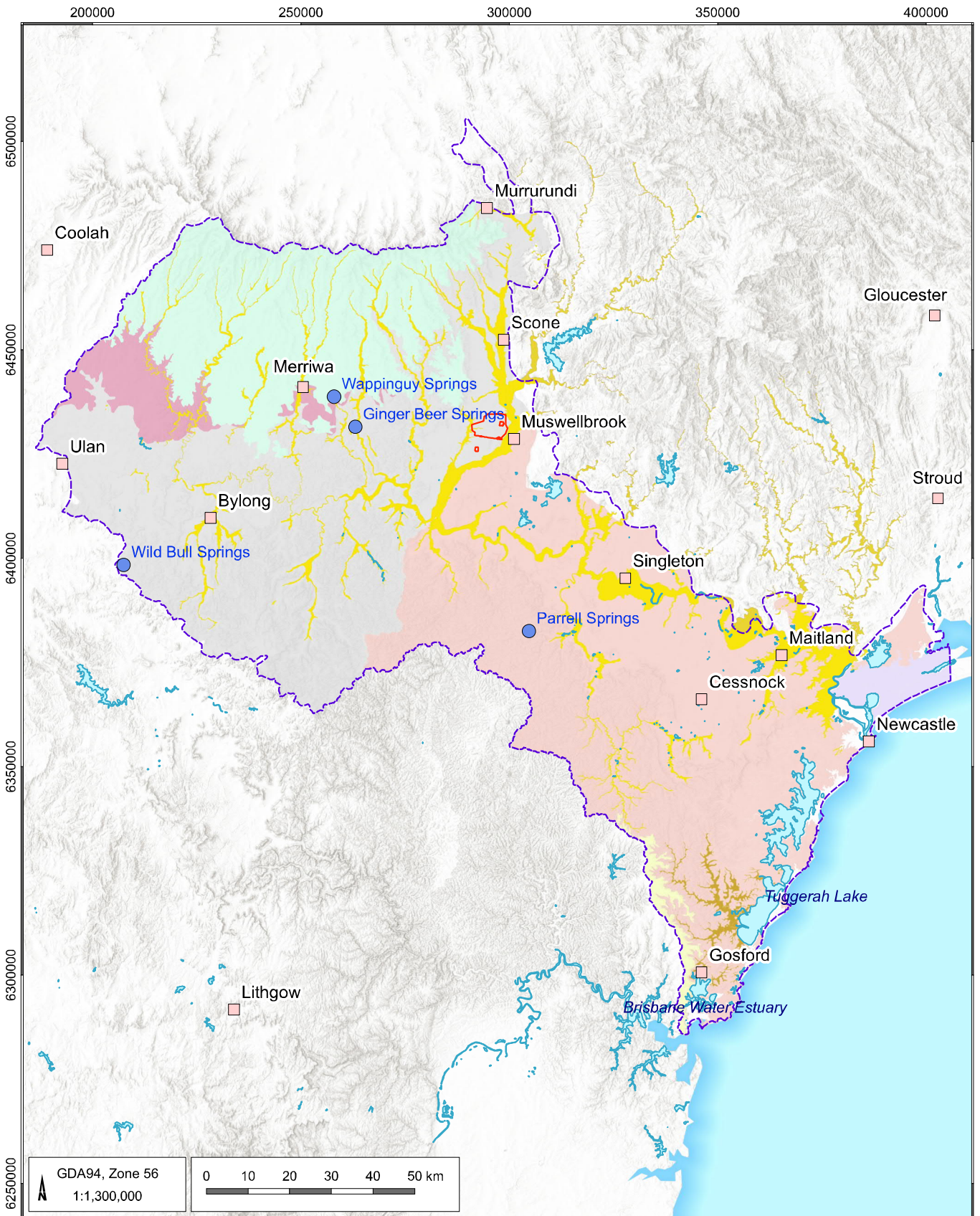
Assets within the 'Vegetation' subgroup and classified as 'Groundwater-dependent ecosystems' assets are shown on Figure 5.16. The closest assets to MPO are riverine forests located along the Hunter River. There are no vegetation assets identified along Sandy Creek.

Economic water dependent assets represent WALs, basic water rights, water source areas, water supply infrastructure, and regulated rivers. Within the Hunter subregion there are 108 surface water economic assets and 141 groundwater economic assets. The assets identified represent groups of smaller elements, e.g. in the Hunter region the 141 groundwater assets account for 5,463 individual elements as shown on Figure 5.17. The map identifies a number of potential groundwater elements with basic water rights (stock and domestic) or water access rights in the vicinity of the MPO. Bores that are classified as exploratory or monitoring bores and which do not have associated water access rights are not included in the asset register (Macfarlane *et al.*, 2016). Registered water bores within the vicinity of the MPO are discussed further in Section 5.8.2.

There were 307 sociocultural water dependent assets identified within the Hunter subregion. These were judged to be water dependent based on their proximity to other surface water or groundwater features. The assets can be classified as:

- Cultural:
 - heritage site – 275 assets; and
 - indigenous site – 9 sites.
- Social:
 - recreational – 23 sites.

There are no maps within the bioregional assessment showing the locations of the sociocultural water dependent assets within the Hunter subregion (Macfarlane *et al.*, 2016).



LEGEND

- Locality
- Springs
- Mining lease
- Hunter subregion

- Hunter River Alluvium
- Liverpool Ranges Basalt
- Oxley Basin
- Sydney Basin - Mangrove Mountain Sandstone
- Sydney Basin - Upper Hunter
- Sydney Sandstone Central Coast
- Sydney Sandstone Central Coast Alluvium
- Tomago-Tomaree-Stockton Sandbeds

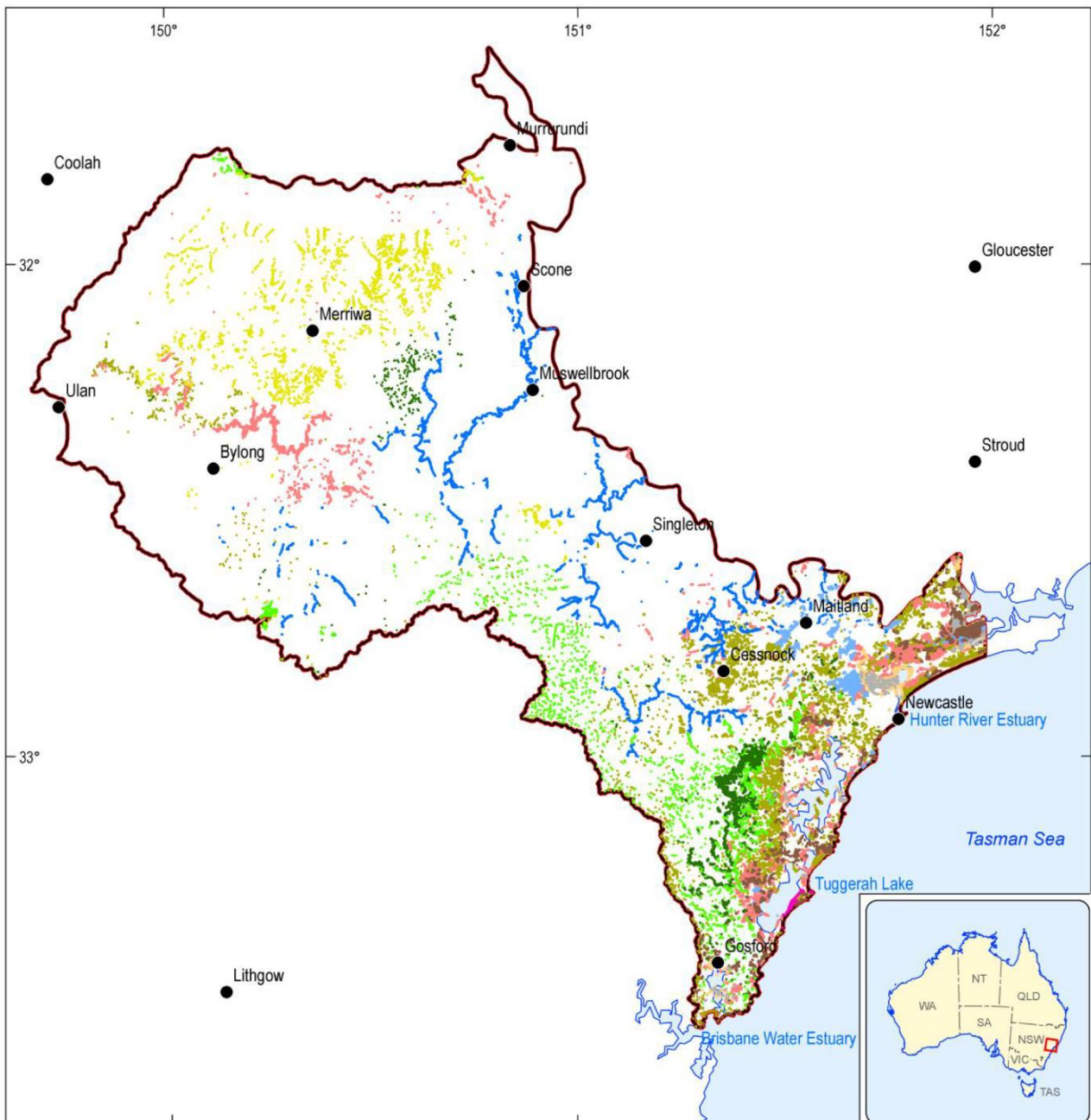
MPO MOD 8 Life of Mine Extension
(MPO5009.001)

**Bioregional assessment –
Hydrogeological assets (Macfarlane et al., 2016)**

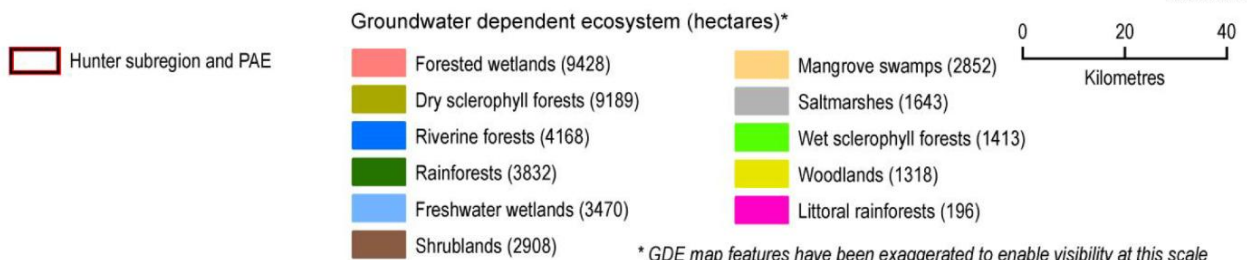


DATE
13/10/2025

FIGURE No:
5.15



HUN-132-003



* GDE map features have been exaggerated to enable visibility at this scale

Figure 7 Location of assets in the ‘Vegetation’ subgroup in the ‘Groundwater-dependent ecosystems’ asset class of the Hunter subregion

Vegetation types are grouped according to vegetation formation (Keith 2006). Note that within this classification the formation ‘Forested wetlands’ includes Eastern riverine forests.

Data: NSW Department of Primary Industries (Office of Water) (Dataset 2)

Figure 5.16 Bioregional assessment – Ecological groundwater-dependent ecosystem assets (Macfarlane et al., 2016)

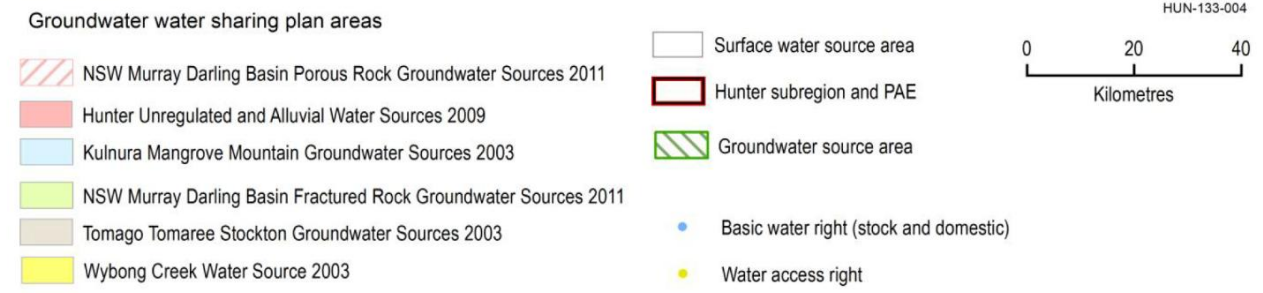
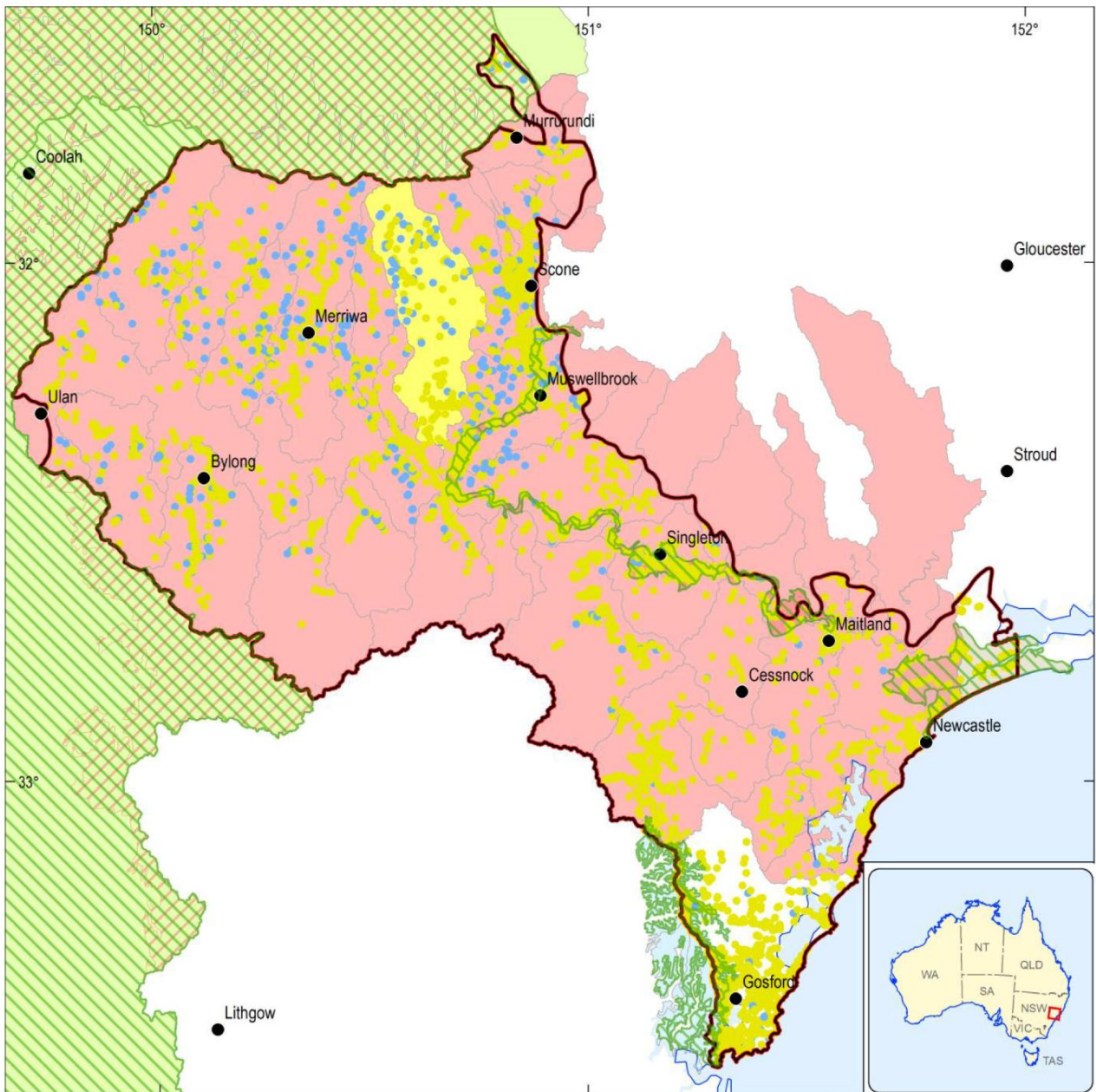


Figure 10 Location of groundwater elements within the preliminary assessment extent (PAE) of the Hunter subregion

Data: NSW Department of Primary Industries, NSW Office of Water (Dataset 2), NSW Office of Water (Dataset 4)

Figure 5.17 Bioregional assessment – Economic groundwater-dependent assets (Macfarlane *et al.*, 2016)

5.8.2 Private water users

In 2017, MACH commissioned a bore census of privately held bores and spring discharges at or near to the MPO (MACH, 2017). MACH subsequently wrote to each landholder that participated in the bore census in May 2020 to confirm the outcomes of the bore census remained correct.

The census identifies seven bores on land within the approved MPO boundary. Figure 5.18 presents an overview of land ownership in the vicinity of the project.

The census also identified 39 bores, wells and springs that are located on privately owned land and used for irrigation, stock watering and domestic purposes. Some bores also form part of the current and historical monitoring networks at surrounding coal mining operations. Details of the bores and their purpose are provided in Table 5.3.

Table 5.3 Private bores in the vicinity of the MPO

Bore	Easting	Northing	Year drilled	Depth (mTOC)	Type
ADNUM1	300521	6429434	N/A	13	Well – Domestic
ASHFIELD1	289344	6428899	<50-60 (years)	5.75	Well – Stock
BARRY1	299564	6430431	N/A	13.56	Well – Stock & Domestic
BELGRAVE	295085	6434438	N/A	23.85	Well – Stock & Monitoring
COWTIME1	300330	6429753	N/A	-	Bore – Stock
CAS1_G	296503	6434654	1964	28.23	Bore – Not Used
CAS2_G	295914	6435419	<1950s	65	Bore – Monitoring
CAS3_G	295821	6435484	1957	76.7	Bore – Dry
CAS4_G	294928	6435957	NA	34.8	Bore – Monitoring
GRAY1	299882	6430334	N/A	-	Bore – Domestic
GRAY2	299856	6430316	N/A	-	Bore – Stock & Domestic
GW038412	291568	6437714	<1950s	7.7	Well – Stock & Domestic and Monitoring
HAYES1	299582	6430624	1930s	15.2	Well – Irrigation
HAYES2	299681	6430616	1950s-60s	15.5	Well – Stock & Domestic
JLON.1	292407	6434333	1971	57.9	Bore – Not in use (windmill not functioning)
JLON.2	292320	6434393	1965	37.4	Bore – Not Used
JLON1	298194	6434785	1979	6	Well & Bore – Monitoring
JLON2	300044	6434608	~1965-80s	82	Bore – Never used
JLON3	299887	6434455	<1961	12.83	Well – Domestic
JLON4	299404	6434623	1932	12.5	Well – Stock
JLON5	299629	6434796	1954	11.7	Well – Irrigation
KELMAN1	300925	6429305	N/A	12.4	Well – Domestic
MATHER1	299814	6430440	>40 years	13.08	Well – Domestic

Bore	Easting	Northing	Year drilled	Depth (mTOC)	Type
MITCHELL1	299860	6430413	N/A	-	Well – Domestic
MOORE1	299668	6430812	1958	52-56FT	Well – Domestic
MOORE1S	291441	6429318	N/A	NA	Spring – Stock
MOORE2	299720	6430762	2003	Blocked	Bore – Not Used (previously monitoring)
MOORE2S	291427	6429323	N/A	NA	Spring – Stock
MOORE3S	290851	6429236	N/A	NA	Spring – Stock
MOORE4	290139	6430000	< 60 years	4.5	Well – Stock
MP-BH1	301149	6432563	2003	18	Bore- Monitoring
MP-BH3	299481	6431354	N/A	14	Well – Stock
PARKINSON1	288944	6427796	N/A	4.7	Well – Stock
PITMAN1	300806	6429378	1991	-	Bore – Domestic
RDH76	296343	6435365	1982	49.4	Bore -Monitoring
SIMPSON1	299906	6429198	>50 years	11.6	Well – Stock & Domestic
SORMAZ1	300010	6429263	1992	11.61	Bore – Not Used
WALTON1	290331	6428144	N/A	90	Bore – Stock
WICKS1	300534	6429472	N/A	12.5	Well – Domestic

Note: mTOC = metres below top of casing.

With the exception of the BELGRAVE bore, that is located in the northwestern section of the MPO, none of the bores within the approved MPO boundary are privately operated. The BELGRAVE bore is also monitored as part of the Dartbrook Mine monitoring program.

Whilst the majority of the bores in Table 5.3 are authorised to take water under the basic landholder rights provisions of the WM Act, two of the bores identified in Table 5.3, JLON5 and HAYES1 are associated with WALs issued for the purpose of irrigation. Details of WALs issued in the vicinity of the MPO and are presented in Table 5.4

Table 5.4 WALs in the vicinity of the MPO

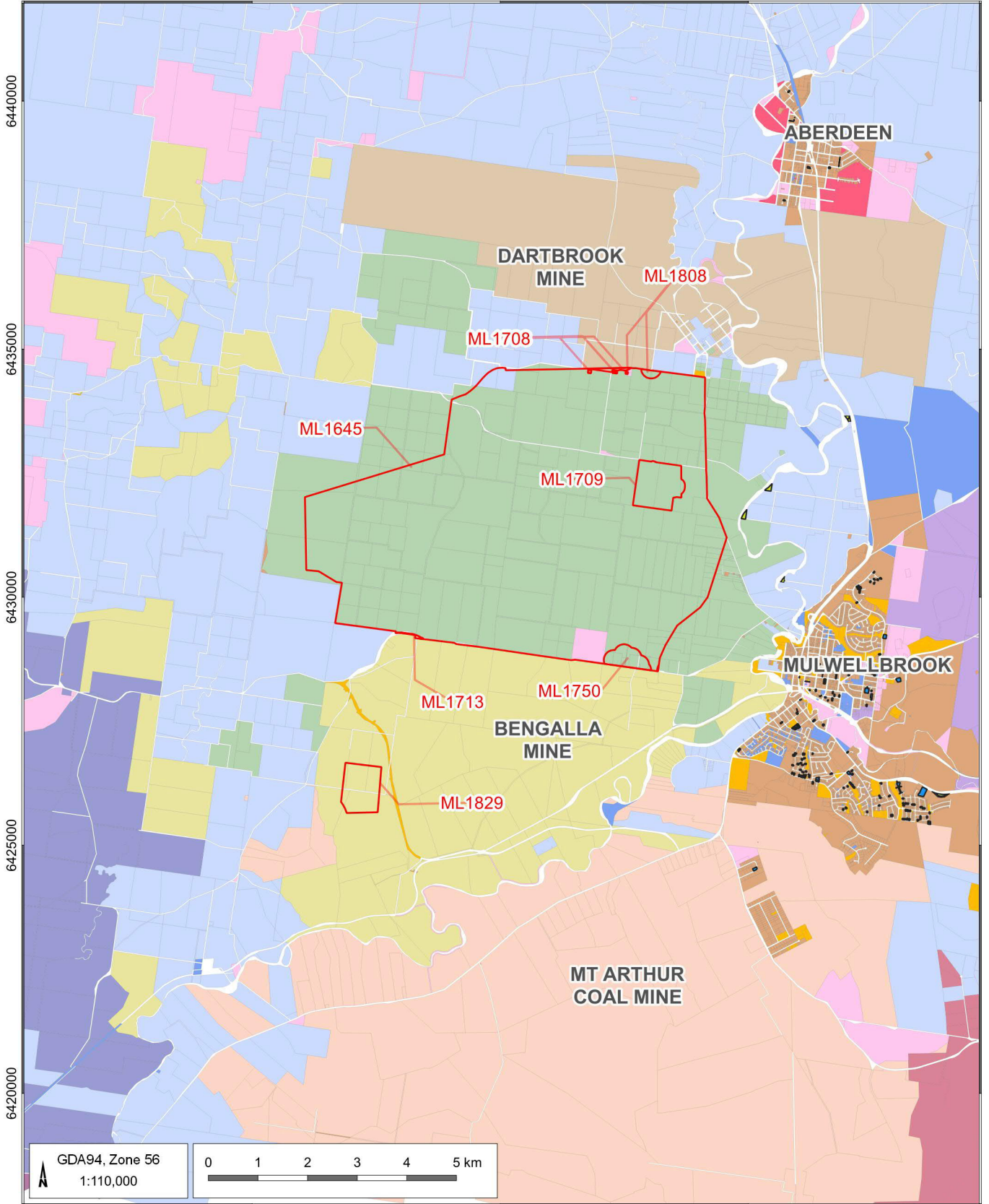
WAL number	Water source	Share components
18131*	Hunter Regulated Alluvial Water Source (U/S Glennies Creek Management Zone)	60
18224		22
18177*		5

Note: * = MACH held.

290000

295000

300000



LEGEND

- Mining Lease Boundary
- (Mount Pleasant Operation) Mount Pleasant-controlled
- Bengalla-controlled
- Dartbrook-controlled
- Mangoola-controlled
- Muswellbrook Coal-controlled
- Mt Arthur-controlled
- Other Mining/Resource-controlled
- Other Mining/Resource Company-controlled
- Crown
- The State of NSW
- Muswellbrook Shire Council
- Upper Hunter Shire Council
- Privately-owned Land
- Muswellbrook and Upper Hunter LEP Zones B2, B5, R1, R5
- Mine-owned
- Privately-owned - Acquisition on Request
- Privately-owned - Mitigation on Request
- Privately-owned - Mitigation/Acquisition on Request*
- Other Privately-owned

MPO MOD 8 Life of Mine Extension (MPO5009.001)

Land Ownership Overview



DATE 30/10/2025

FIGURE No: 5.18

5.8.3 Groundwater dependent ecosystems

GDEs are ecosystems that rely upon groundwater for their continued existence. GDEs may be completely dependent on groundwater, such as aquifer GDEs, or may utilise groundwater intermittently when it is available as a component of its lifecycle water requirements, such as riparian tree species in arid and semi-arid areas (Doody, Hancock and Pritchard, 2018).

The Australian Groundwater-Dependent Ecosystems Toolbox (Richardson *et al.*, 2011) defines three main types of GDEs:

- Type 1: Subterranean ecosystems, including cave and aquifer ecosystems (refer Section 5.8.4).
- Type 2: Aquatic ecosystems that rely on the surface expression of groundwater, including surface water ecosystems which may have a groundwater component, such as rivers, wetlands and springs.
- Type 3: Terrestrial ecosystems that rely on the subsurface presence of groundwater.

GDEs can require access to groundwater on a permanent (obligate) or intermittent (facultative) basis to meet all or some of their water requirements so as to maintain their communities of plants and animals, ecological processes and ecosystem services (Doody, Hancock and Pritchard, 2018).

No high priority GDEs listed in the *Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources 2022* are located within the MPO area. There are some mapped high priority GDEs located approximately 1 km to the west of the MPO as identified in the *Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources 2022*. These mapped high priority GDEs meet the criteria of the HEVAE framework outlined in Department of Industry (2018) and NSW Government (2024) (i.e. high and very high value groundwater dependent ecosystems).

Wappinguy Spring, approximately 40 km to the north-west of the mine area, is the closest high priority GDE listed in the *Water Sharing Plan for the North Coast Fractured and Porous Rock Groundwater Sources 2016*. No high priority GDEs are listed in the *Water Sharing Plan for the Hunter Regulated River Water Source 2016*. The *Groundwater Dependent Ecosystem Atlas* (GDE Atlas) was developed by the BoM as a national dataset of Australian GDEs to inform groundwater planning and management (BoM, 2024). The Atlas contains information about three types of ecosystems defined in the Australian Groundwater-Dependent Ecosystems Toolbox.

GDEs derived in the GDE Atlas are mapped according to the following classifications:

- High potential for groundwater interaction.
- Moderate potential for groundwater interaction.
- Low potential for groundwater interaction.

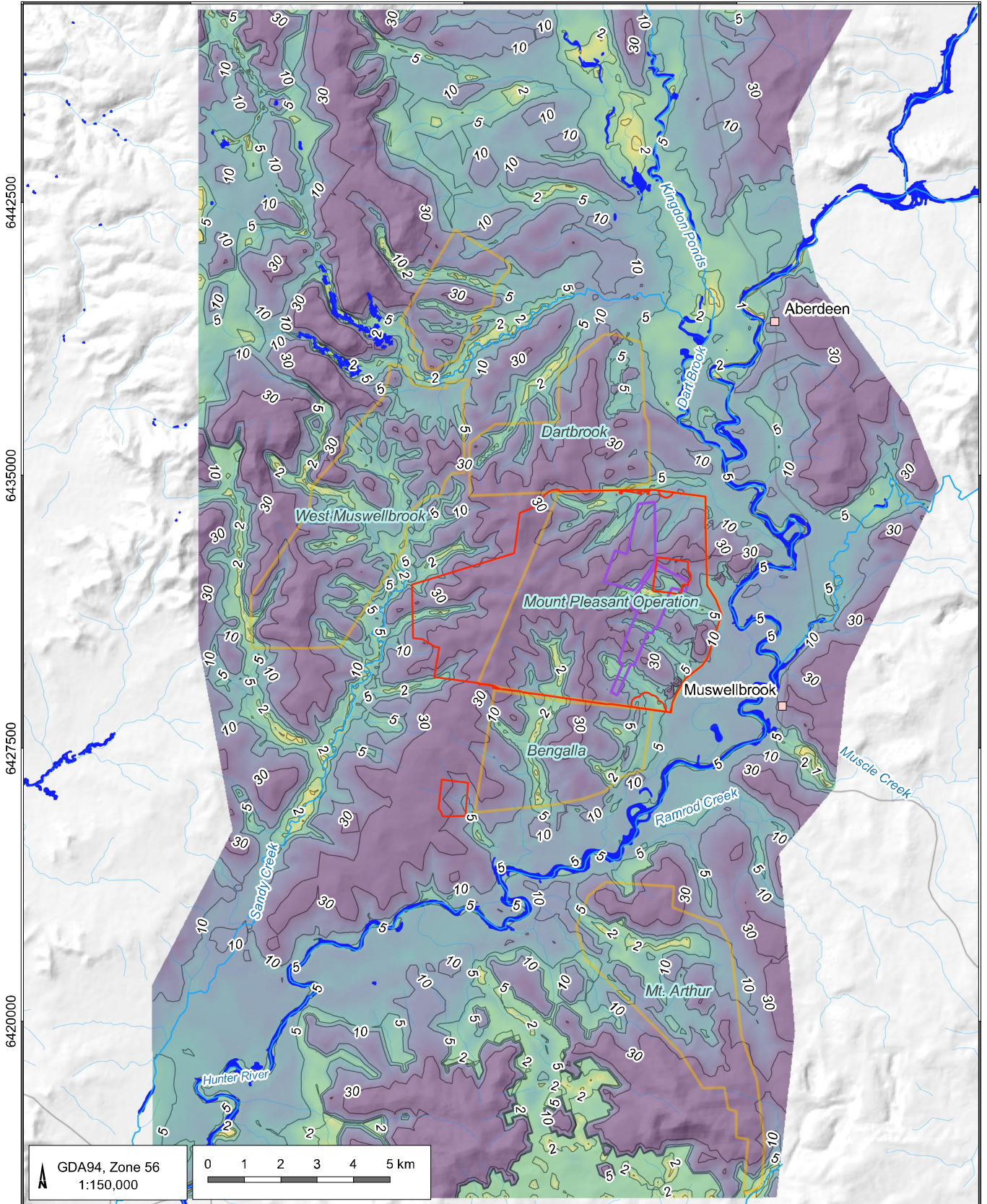
The GDE Atlas identifies the following potential GDEs in the vicinity of the MPO (Figure 5.19):

- Aquatic habitat within the Hunter River is mapped as having high potential for groundwater interaction.
- The majority of remnant terrestrial vegetation in the vicinity of the MPO is mapped as having low potential for groundwater interaction.

285000

292500

300000



LEGEND

- Populated place
- Road
- Drainage
- Mining lease
- Surrounding mines
- Pit Floor Extent
- High potential terrestrial GDE

— Modelled depth to water table contour

Modelled depth to water table (m)

- 1
- 2
- 5
- 10
- 30

MPO MOD 8 Life of Mine Extension (MPO5009.001)

Potential aquatic GDEs in the vicinity of the MPO



AGE

DATE
13/10/2025

FIGURE No:
5.19

Hunter River vegetation mapping was not undertaken for the Modification. Notwithstanding, given the Hunter River is mapped as having high potential for groundwater interaction and groundwater levels in the Hunter River alluvium are typically 5 to 10 m below land surface and 2 m below the stream bed, aquatic vegetation along the Hunter River has been assessed as a potential GDE (Section 8.3).

The Permian sediments within the MPO area are not considered to be a significant aquifer. The regolith (weathered bedrock) directly below the ground surface may have a higher hydraulic conductivity, compared to the deeper interburden, owing to weathering effects. The depth to groundwater in the Permian sediments typically ranges from 50 m to greater than 100 metres below ground level (mbgl). There are isolated areas of shallower groundwater associated with regolith material present in ephemeral drainage lines, however these are a less significant water source than the Hunter River alluvial aquifer in terms of both water volume and quality.

Hunter Eco (2025) has mapped the vegetation communities relevant to the modified MPO as part of the BDAR. Hunter Eco (2025) has also reviewed mapped vegetation communities for species that could be potential Type 3 (terrestrial) GDEs. This review determined that some small patches of the *White Box-Narrow-leaved Ironbark-Blakley's Red Gum* vegetation community (PCT 3396) could potentially be a facultative groundwater user. The location of some small patches of the potentially groundwater dependent *White Box-Narrow-leaved Ironbark-Blakley's Red Gum* vegetation community (PCT 3396) is shown on Figure 5.20.

The depth to groundwater in the vicinity of this vegetation community typically ranges from 2 to 10 mbgl. Water levels at monitoring bore 4500F000, which is located approximately 100 m from some small patches of the *White Box-Narrow-leaved Ironbark-Blakley's Red Gum* vegetation community (PCT 3396), have historically fluctuated by approximately 6 m (Section 5.9).

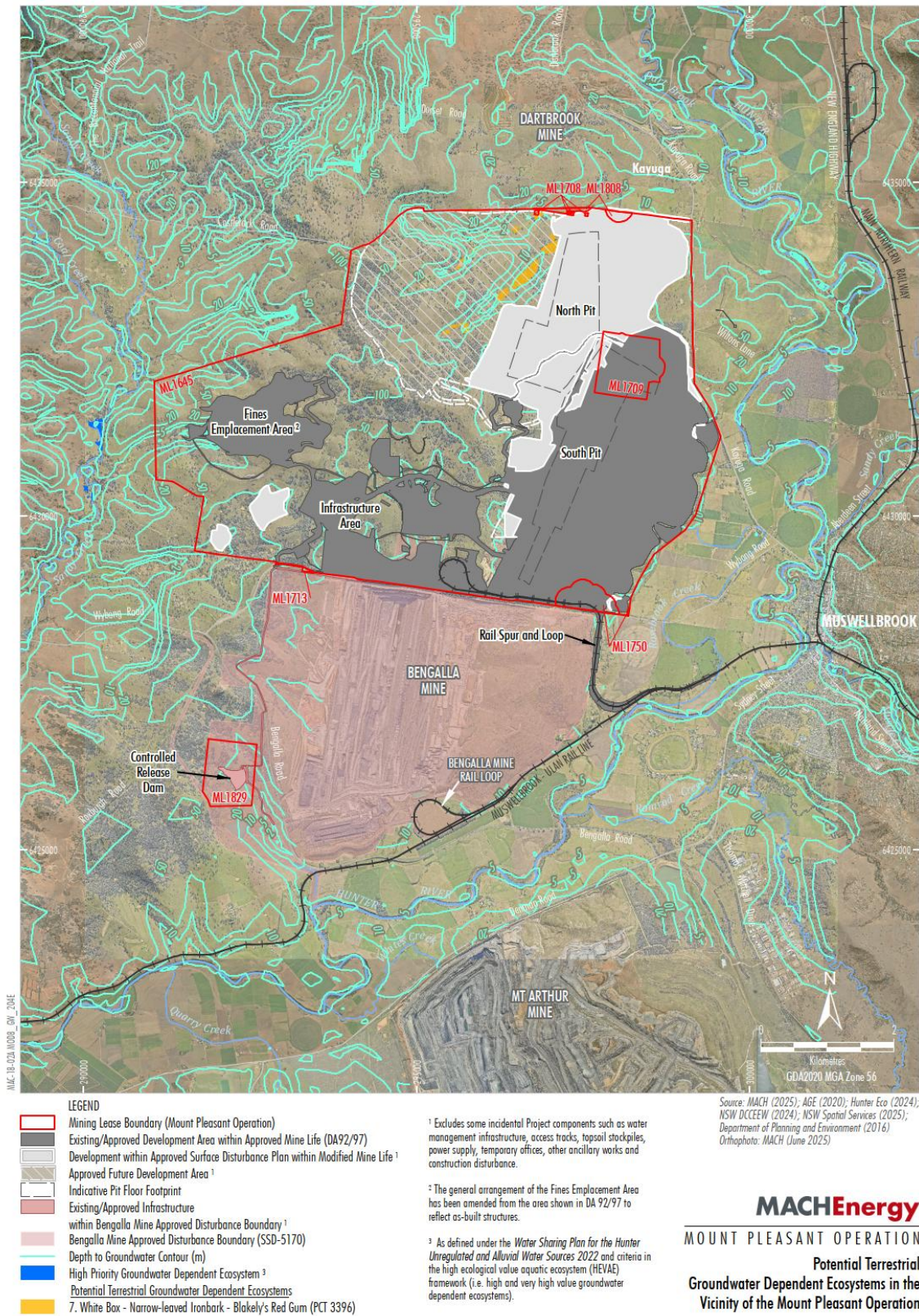


Figure 5.2

Figure 5.20 Potential terrestrial GDEs in the vicinity of the MPO

5.8.4 Stygofauna

Stygofauna are small specialised subterranean aquatic invertebrates that are found in aquifers across Australia and the rest of the world. Stygofauna are predominantly found in aquifers with large (mm or greater) pore spaces, especially alluvial aquifers, and less frequently fractured rock aquifers (Hose *et al.*, 2004). Stygofauna have occasionally been recorded in coal seam aquifers, especially those which are hydraulically connected to a shallow alluvial aquifer.

The majority of stygofauna are found in locations where food supply and oxygen are more plentiful. The optimal conditions for stygofauna have been identified as:

- alluvial systems with large pore spaces;
- water levels within 20 mbgl;
- EC of less than 5,000 $\mu\text{S/cm}$ (TDS \sim 3,350 mg/L); and
- pH of approximately 6.5 to 7.5.

There is the potential for mining activities to impact on stygofauna habitats if they are present in the aquifer units near to the mines.

Several studies in eastern Australia have identified relatively diverse stygofauna in alluvial groundwater systems, including sites in the Hunter Region of NSW (Hancock and Boulton, 2008 and 2009; Tomlinson and Boulton, 2010). The greatest number of taxa appear to occur in boreholes with low conductivities (i.e. $< 1,500 \mu\text{S/cm}$) and where the water table was < 10 metres (m) deep, associated with the alluvium of larger river systems and trees with deep roots penetrating the saturated water of groundwater systems (Hancock and Boulton, 2008).

Between 2004 and 2008, 26 stygofauna taxa were identified in samples from 40 bores situated throughout the Hunter Valley, with this number expected to rise if samples were identified to species level (Hancock and Boulton, 2008 and 2009; Watts *et al.*, 2007). Twenty taxa were recorded from the Hunter River alluvial aquifer near Denman and the Pages Creek alluvial aquifer. A total of 21 taxa were identified from bores sampled at Dart Brook, 18 taxa at Kingdon Ponds and eight taxa from the Hunter River alluvial aquifer near Muswellbrook (Hancock and Boulton, 2008 and 2009; Watts *et al.*, 2007). None of the taxa collected were listed under the NSW *Threatened Species Conservation Act, 1995* or EPBC Act (Eco Logical Australia [ELA], 2013).

In 2012, ELA sampled thirteen bores and wells within the vicinity of the Bengalla Mine (ELA, 2013). Eight samples were collected from the Hunter River Alluvial Aquifer and five from the Permian rock aquifers in July 2012. Ten of the bores were re-sampled in September 2012. No new taxa were collected during the second round of sampling however, fauna were collected from three bores that did not yield any fauna in the first round, indicating that the distribution of stygofauna can vary temporally (ELA, 2013).

Six stygofauna taxa were collected from the two surveys (ELA, 2013). Cyclopoid crustaceans were the most numerous and frequently encountered taxon. Other taxa were *Notobathynella* sp. 1, *Bathynella* sp. 1, *Chillagoe* sp. 1, *Ostracoda* and *Oligochaeta* (ELA, 2013). All of the taxa collected at Bengalla Mine were known from other parts of the Hunter Valley (see Hancock and Boulton, 2009).

Bio-analysis (2020) undertook sampling for stygofauna in the vicinity of MPO. Sample sites were selected based on the likelihood of having suitable stygofauna habitat. Selection was based on available hydrogeological information and an attempt was made to choose bores or wells spread over the Study Area. Seven bores were visited on 27 and 28 November 2018 comprising five alluvial bores, one interburden bore (7000D000) and one Permian bore (WRA1L).

Six invertebrate taxa were collected from four of the alluvial bores, with three of those taxa considered likely to be stygofauna: *Cyclopidae*, *Ostracoda* and *Isotomidae*. All taxa were also present in bores sampled within the alluvial aquifer for the *Continuation of the Bengalla Mine – Stygofauna Assessment 2013* (Bio-analysis, 2020).

No stygofauna were collected from bore 18298, which is situated in the alluvial aquifer on the southern side of the Hunter River. Similarly, no stygofauna were collected from this bore by ELA (2013) in July 2012 and relatively low numbers (four *Cyclopidae* and six *Ostracods*) were collected in September 2012 (Bio-analysis, 2020).

No stygofauna were collected from the bore sampled within the interburden aquifer (7000D000) or the Permian aquifer (WRA1L), which is consistent with expectations given that EC in both bores was well above 1,500 $\mu\text{S}/\text{cm}$ (Bio-analysis, 2020).

5.9 Conceptual model

Conceptual models are abstractions or simplifications of reality. During development of conceptual models, the essence of how the key system components operate and interact is distilled. This section describes the processes that control and influence the storage and movement of groundwater in the hydrogeological systems occurring in vicinity to the MPO and the broader region around MPO.

The conceptual groundwater model for the MPO is presented graphically in Figure 5.21. The conceptual groundwater model section graphically illustrates the main hydrogeological features and processes occurring at the MPO, including recharge, discharge, and anthropogenic activities (i.e. landholder pumping and mine dewatering).

Two aquifer systems occur in the MPO, namely:

- alluvium along the Hunter River; and
- Permian sediments including:
 - weathered bedrock (regolith);
 - unweathered bedrock (overburden and interburden); and
 - the coal seams of the Wittingham Coal Measures.

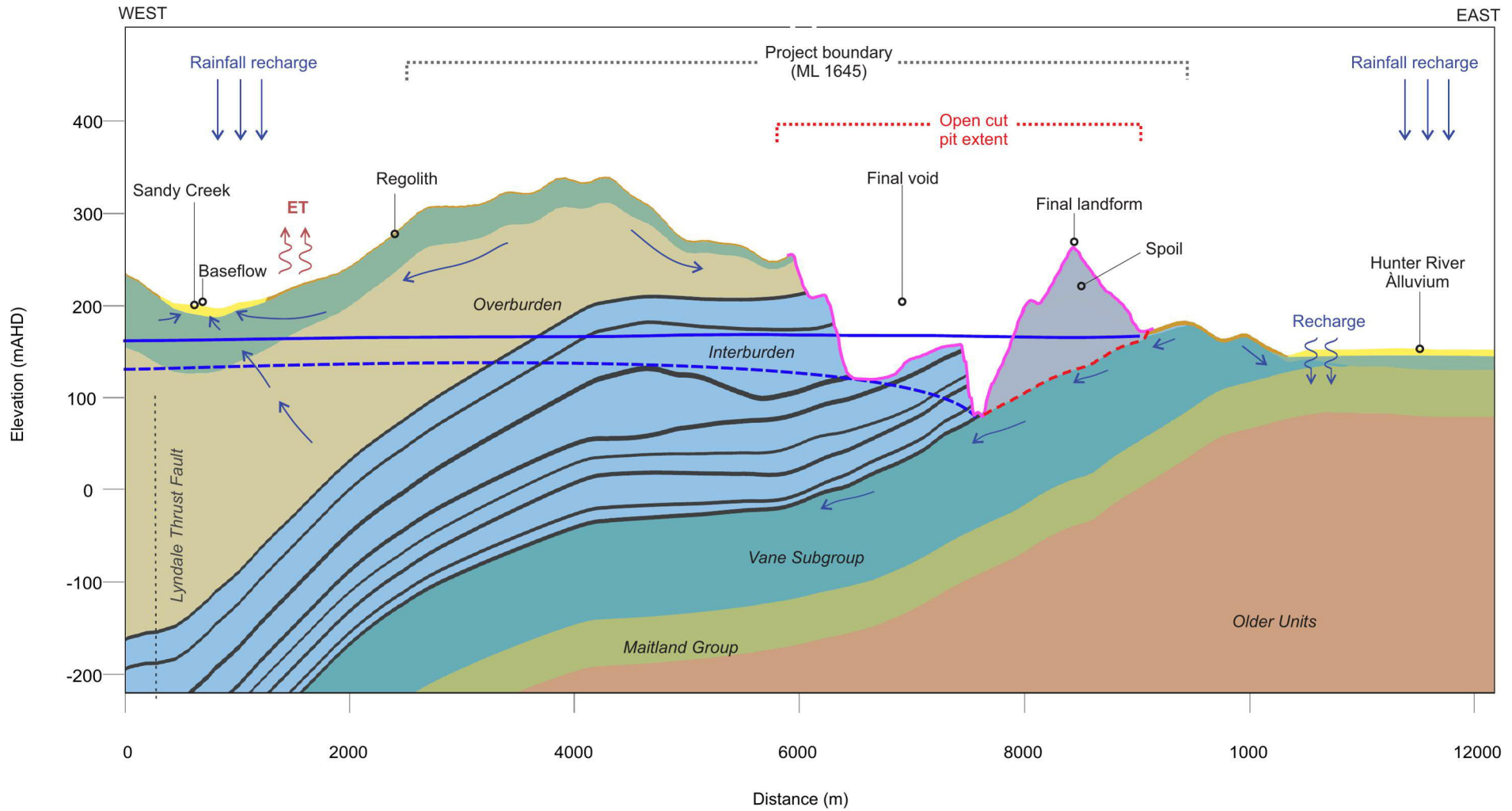
Alluvial deposits are present along the Hunter River to the east and along Sandy Creek to the west of the MPO. The main groundwater bearing units occur in the Hunter River flood plain due to greater saturated thickness and lower salinity. Groundwater levels in the Hunter River alluvium are usually 5 to 10 m below land surface and 2 m below the stream bed, meaning the Hunter River is generally a recharge source (i.e. losing stream) to the alluvial groundwater system. While there is less data available for Sandy Creek west of the MPO, based on nearby groundwater levels and topography it is considered a gaining system.

The regolith (weathered bedrock) directly below the ground surface may have a higher hydraulic conductivity, compared to the deeper interburden, owing to weathering effects. The regolith aquifer represents a less significant water source than the alluvial aquifers in terms of both water volume and quality but is the most readily accessible unit for landholders outside the flood plain.

The Wittingham Coal Measures are not considered to be a significant aquifer. While some coal seams may show an elevated hydraulic conductivity, the dominant interburden sections are of very low hydraulic conductivity. Occurrence and flow of groundwater are governed by the presence of micro faults, joints, fractures, and bedding planes which are often locally discontinuous. Previous investigations have conceptualised large scale structures nearby MPO, such as the Mt Ogilvie Fault, to likely be barriers, rather than conduits to fluid flow (AGE, 2013a). The Wittingham Coal Measures are also relatively deep, which along with low yield volumes and variable salinity limits groundwater usage.

The generally lower salinity occurring within the Quaternary alluvium indicates more significant recharge rates that can occur via:

- diffuse rainfall and deep drainage through the flood plain soils;
- seepage of river and creek flows through the stream bed;
- runoff from the topographically higher bedrock hills and subsequent deep drainage through the soil profile at the fringes of the alluvium; and
- the Permian coal measures in places where higher heads in the coal seams cause upward discharge into the overlying alluvium.



LEGEND

- | | | | | | | |
|----------------------|----------------|------------------|----------------|---------------|---|--------------------------|
| Alluvium | Warkworth seam | Piercefield seam | Broonie seam | Wynn seam | Vane Subgroup/Saltwater Creek Formation | Pre - mining water level |
| Regolith | Interburden 1 | Interburden 3 | Interburden 5 | Interburden 7 | Maitland Group | Post mining water level |
| Weathered overburden | Mt Arthur seam | Vaux seam | Bayswater seam | Edderton seam | Older Units | |
| Overburden | Interburden 2 | Interburden 4 | Interburden 6 | Interburden 8 | | |

Conceptual model

Figure 5.21

MPO MOD 8 Life of Mine Extension (MPO5009.001)



Recharge to the regolith, which includes areas of spoil emplacement nearby MPO, is via direct infiltration of rainfall. The regolith in turn provides recharge to the Wittingham Coal Measures through areas of either coal seam or interburden sub crop.

The potentiometric surface and flow directions in both the regolith and the Wittingham Coal Measures reflect topography, with flow to the south-east towards the low-lying alluvial flood plain. The flow within the alluvium is aligned with the direction of flow within the streams to the south and south-west.

In addition to natural groundwater systems, anthropogenic activities also influence groundwater flow in the vicinity of the MPO and across the broader region, with nearby mining activities having the largest impact.

Landholders preferentially extract groundwater from the alluvial aquifers in the region, compared to the adjacent elevated hills (Permian sediments). Within the hills, most bores/wells are situated near drainages where recharge to regolith and shallow unweathered bedrock is expected to be enhanced. Evapotranspiration will also contribute to the discharge of groundwater in areas where the water table is sufficiently close to the land surface and where the vegetation can access it.

Groundwater quality across the hydrostratigraphic units is highly variable, ranging from fresh to saline. Groundwater quality is best within the alluvial aquifers, but still variable in quality based on location. Groundwater within the regolith, unweathered bedrock and coal seams is variable but can be suitable for stock and domestic purposes, where salinities are lowest.

5.10 Potential impact causal pathways

For the purposes of Bioregional Assessments, causal pathways are defined as ‘the logical chains of events – either planned or unplanned – that link coal resource development and potential impacts on water resources and water dependent assets’ (Dawes *et al.*, 2018). Water dependent assets can be impacted by changes to quantity, quality or timing of surface water or groundwater or both. Water dependent assets in the vicinity of the MPO were identified in Section 5.8.

The identification of causal pathways between the proposed development and the water-dependent assets is an important part of the impact assessment process. Causal pathways are initiated by an activity associated with the coal resource development. In the case of the Modification, this is the extension of mining life within the existing approved MPO area, and it is the incremental increase in potential impacts that requires assessment. It is also important to note surrounding areas and water-dependent assets that are unlikely to be impacted by the proposed development.

There are four main causal pathway groups associated with coal mining, although there is commonly overlap or linkage between them:

- ‘subsurface depressurisation and dewatering’;
- ‘subsurface physical flow paths’;
- ‘surface water drainage’; and
- ‘operational water management’.

This report focusses on those causal groups primarily related to groundwater, that is ‘subsurface depressurisation and dewatering’, and ‘subsurface physical flow paths’. ‘Surface water drainage’ is also briefly discussed in relation to groundwater-surface water interactions.

The ‘subsurface depressurisation and dewatering’ group of causal pathways occurs when coal mines intentionally dewater the subsurface so that open-cut and underground mining operations can occur safely. The pre-existing hydraulic gradients are disrupted, usually causing changes to groundwater levels and pressures, and occasionally altering groundwater quality. Pumping from conventional bores extracting groundwater to support mining activities is also part of this causal group. However, the scale of the effects from conventional bores is typically less than those associated with open cut mine dewatering. Groundwater extraction for open cut mine development can unintentionally affect non-target strata in situations where direct hydraulic connections exist. The connections could be diffuse, such as connections between adjacent geological layers, or more focussed via structures such as faults.

The region surrounding MPO has significant disturbance of groundwater levels from historical mining. Dartbrook Mine to the north and Bengalla Mine to the south both show mine related drawdown in their groundwater level monitoring data. These can be noted in the observation data points in the calibration hydrographs in Appendix A1. Notably, the bores responding to mining and subsequent care and maintenance at Dartbrook Mine are CAS_2, CAS_4, DDH193, and Kayuga1, and likewise at Bengalla Mine the bores showing direct influence from mining are BE2, REP21, WAN2, WAN4, WAN8, WAN10.

The 'subsurface physical flow paths' causal pathway group involves activities that physically modify the rock mass, creating new pathways that water may flow along. Long term the replacement of pre-mining bedrock by spoil or a final void lake would alter the physical properties of the subsurface compared to pre-mining conditions.

Example causal pathway diagrams for open cut coal mining developments are presented in Henderson *et al.* (2016). The groundwater components that are potentially relevant to mining at the MPO are summarised in Table 5.5. The table outlines the most likely pathways, impact causes, impact modes and activities to generate the impacts. The potential hydrological effects on the groundwater system are noted in the final column. Those components that are most likely to produce the greatest changes to the groundwater system, or which have been identified as occurring within the MPO area are highlighted bold.

Many of the smaller scale issues can be managed by following current best practices to reduce the likelihood of them occurring e.g. those activities caused by equipment failure or poor component design.

The potential activities that are most likely to produce impacts over a large area relate to the effects of open cut mining below the groundwater table, and backfilling of the resulting mining void with spoil.

Potential disruption to rivers has also been included as a high potential causal pathway, due to the proximity of the Hunter River alluvium to the east and Sandy Creek to the west.

The most likely potential causal pathways identified have been considered when designing the numerical groundwater model to ensure that they are suitably represented.

Table 5.5 Causal pathways with a groundwater component¹

Pathway	Cause	Mode and activity	Hydrological effect
Aquifer outcrop areas – deep soil drainage	Coal characteristics	Fire in stockpiles, fire in the pit from excavation or blasting, fire in stockpiles	Quality
	Incomplete rehabilitation	Negligence during post-closure mine decontamination	Quality
	Consolidation of loose backfill	Compaction or settlement of backfill over time	Direction
	Diverting site drain line	Changes to natural surface drainage through diverting creeks or for rainfall and runoff diversion Disruption of natural surface drainage via dam construction, site preparation, topsoil and spoil preparation Disruption of natural surface drainage by excavation of the pit	Quality, Direction, Volume/ quantity
	Inevitable, deliberate	Deliberate pit wall dewatering Leaching of spoil dumps or coal stockpiles Runoff changes via topsoil excavation and storage	Quality, Flow (reduction), Pressure, Volume/ quantity
	Poor handling/management	Excessive runoff during closure from water management structures	Quality

¹ After Henderson *et al.*, 2016.

Pathway	Cause	Mode and activity	Hydrological effect
Aquifer outcrop areas – SW-GW interactions	Human error, accident	Equipment (pipe) failure leading to containment failure for dewatering water, waste streams, mine dewatering, treatment, re-use, disposal Substantial spillage from on-site mine equipment or on-site coal transport Treatment plant failure during mine water treatment, re-use, disposal	Quality
	Containment failure, leaching, flooding	Groundwater or surface water contamination from drill cutting disposal Increased inflow from natural events during dewatering, treatment, reuse and disposal processes Overflow and/or loss of containment of surface water Treatment plant failure during mine water treatment, re-use, disposal Leaching of fine rejects water decant dam	Quality
	Physical disruption of river boundary or channel	Linking aquifers via preferential drainage if mine expansion too close to river/lake	Flow (reduction), Pressure, Volume/ quantity
Aquifers – Groundwater conditions	Drilling control issues	Pressure imbalance and localised water table changes	Quality, Level
	Incomplete grouting	Incomplete/compromised cementing leading to linking of aquifers within groundwater bores	Quality, Composition
	Poor design, construction	Bore leakage between aquifers following abandonment Linking aquifers in groundwater supply bores with long screens	Quality, Composition
Aquifers – Groundwater conditions post-mining	Inevitable, deliberate	Artificial point of recharge, enhanced aquifer interconnectivity, groundwater source/sink – post-closure water filling the pit Leaching from in-pit backfill/spoil dump Groundwater extraction from groundwater supply bores	Quality, Direction, Pressure, Volume/ quantity Pressure

Note: Bold highlighting indicates those causes and activities that are likely to cause the greatest changes at the MPO.

6 Numerical groundwater model

The previous 3D numerical groundwater flow model (referred to as the 'model') developed for the GIA for the Mount Pleasant Optimisation Project (AGE 2020) was verified and then adopted to assess the potential impacts of the modified MPO (e.g. extension of mine life to December 2032). The objective of the modelling was to identify the potential impacts of the approved MPO at December 2026 and from the modified MPO on the groundwater system and the identified water dependent assets. The model mesh was developed using Algomesh software, and this mesh was imported into MODFLOW-USG, which employs an unstructured grid and Newton Solver to simulate complex stratigraphy, hydraulic conductivity distribution, and mine geometries. A detailed description of the numerical model development is provided in Appendix A.

The model simplifies the geology identified in the conceptual model into 20 key representative layers, which are based on the site geological model and extrapolated over the model domain following validation against the drill hole database. The model domain covers an area of approximately 19 km from west to east, and 30 km from north to south (Figure 6.1), centred on the MPO to limit boundary condition impacts, and encompasses adjacent mines to represent cumulative impacts. These extents provide a model domain sufficient for the objectives of assessing the impacts to the surrounding groundwater system. The model domain is discretised into 32,915 Voronoi cells per layer of varying sizes to represent different environmental and mining features throughout the model domain. The model mesh is shown in Figure 6.1. The specific features where cells were refined to smaller sizes are listed below:

- open cut and underground mining areas – 100 m x 100 m to 300 m x 100 m;
- streams and alluvial flood plains – from 100 m x 100 m to 200 m x 200 m cells;
- Dartbrook Mine Hunter Tunnel (under Hunter River) – 100 m x 100 m; and
- up to 700 m cell sizes in more peripheral areas.

The extent of the mining areas shown on figures in Sections 6 to 9 are based on the areas where drain cells were progressively applied. These areas are broadly representative of the mine extraction areas at these sites but may not necessarily represent the full mine surface footprints or tenure.

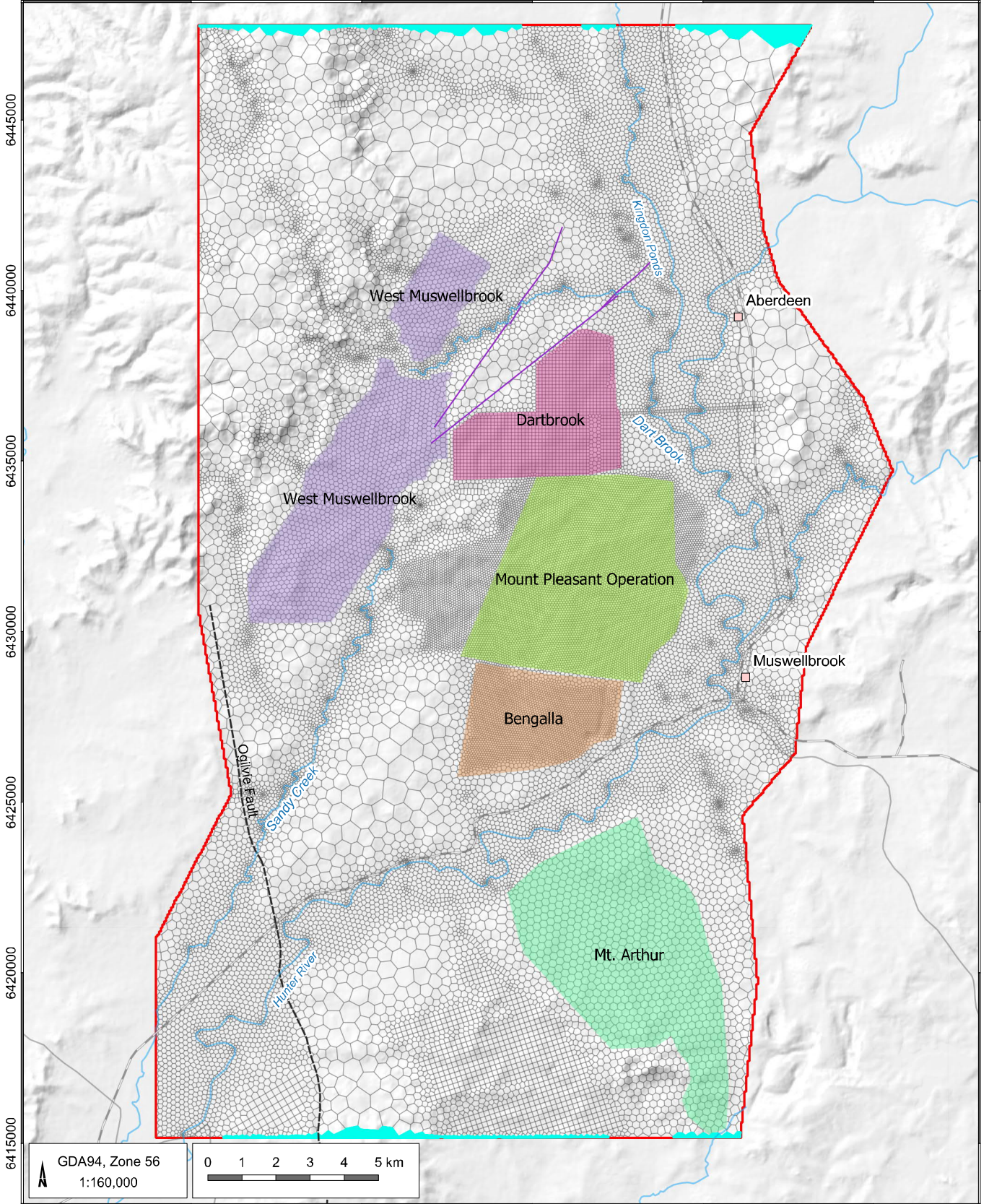
The model layers represent the major hydrostratigraphic units including shallow geological units as well as the major coal seams and interburden. All model cells within each layer are active and assigned to one hydrostratigraphic unit.

The groundwater model was calibrated to a pre-mining steady state water level dataset and then to transient water level and Bengalla Mine, Dartbrook Mine and Mt Arthur Coal Mine inflow datasets (1991 to 2017). The calibration was achieved by adjusting aquifer parameters and stresses to produce the best match between the observed and simulated water levels and mine inflows (history matching). Manual testing, automated parameterisation software (PEST) (Doherty, 2010) and pilot points were used to guide the model towards a set of hydraulic parameters and recharge rates that provided the best history matching result.

The dewatering of groundwater within mining areas are represented in the model by the drain boundary condition. In open cut pits, the model layers within the pit shell have drain elevations set to dewater those model cells. Underground mining is represented by the drain package as well but only applied in the coal seams being mined. The fracture zone above the longwall panels is simulated through hydraulic property changes representing the disturbance.

The match between the measured and modelled water levels is measured at the model scale by a Scaled Root Mean Square error (SRMS). Calibration to the original dataset (up to September 2018) in 2019 produced a SRMS statistic of 4.1% (weighted with increased weights on nested bores where vertical gradient information was available) or SRMS of 2.83% with a weighting of one for each observation point. This indicates the model provides a sufficient match to measured water levels. Adding the additional monitoring data up to August 2025 increases the SRMS from 2.83% to 5.37%, which is less than the 10% threshold listed as significant in the national modelling guidelines (Barnett et al., 2012). The primary cause of the increased SRMS is the inclusion of newly drilled bores and additional measurements (603 head data points) in the validation dataset. The updated dataset also covers a broader range of observed head values (87.35 m AHD to 263.9 m AHD) compared with the dataset used in the 2019 calibration. Mine inflow rates were also compared where available and shown to provide a reasonable match to four surrounding locations (Dartbrook Wynn Seam, Dartbrook Mine Hunter Tunnel, Bengalla Mine and Mt Arthur Coal Mine).

285000 290000 295000 300000 305000



LEGEND

- Populated place
- Road
- Rail
- Ogilvie Fault
- Major Dyke
- Drainage
- Grid
- Bengalla
- Dartbrook
- Mount Pleasant Operation
- Mt. Arthur
- West Muswellbrook
- General head boundary
- No-Flow Boundary

MPO MOD 8 Life of Mine Extension
(MPO5009.001)

Model extent and mesh



AGE

DATE
13/10/2025

FIGURE No:
6.1

Following verification, the model was used to estimate potential changes in the alluvial water table (e.g. drawdown) and the Permian groundwater pressure (e.g. depressurisation), as well as the volume of groundwater intercepted by the modified MPO, in accordance with the modified MPO mine plan up to December 2032. The model impact predictions are derived from the difference between the following model simulations:

- a model simulation representing no mining for the assessment of cumulative impacts of all mines;
- a model simulation representing the approved MPO at December 2026 and surrounding approved mining operations (e.g. Bengalla Mine, Dartbrook Mine, Mt Arthur Coal Mine);
- a model simulation representing the modified MPO (up to December 2032) and surrounding approved mining operations (e.g. Bengalla Mine, Dartbrook Mine, Mt Arthur Coal Mine); and
- a model simulation representing only the surrounding approved mining operation (excluding the approved and modified MPO).

This approach provides an assessment of the overall cumulative impact of the modified MPO, as well as the incremental impact of the Modification.

The MPO is currently approved to undertake mining operations until December 2026. The modified MPO would extend the mining operations until December 2032, incorporating an increase in the production rate and mining of additional coal reserves within the extended mine life. To contextualise the incremental impact of the Modification beyond the approved MPO in December 2026, a model iteration with mine progression ceasing at the end of 2026 was prepared for comparison against the full proposed mine life.

The residual impacts to the groundwater system post-mining have also been assessed, with the water level in the void determined from interactions with the surface water models (ATC Williams, 2025).

The uncertainty of the model predictions, resulting from initial uncertainty in the assumptions and input parameters, was analysed. The analysis focussed on varying model parameters and design features that have the most influence on model predictions, particularly where those values have not been informed by the calibration process. The model parameters were adjusted to encompass the expected range of uncertainty. Appendix A provides a detailed discussion of the uncertainty analyses. Where possible the uncertainty analyses followed the process recommended in the IESC's draft explanatory note on uncertainty analysis (Middlemis and Peeters, 2018), and the updated version (Peeters and Middlemis, 2023).

Figure 6.2 shows the scatter diagram that compares the water level observations with the corresponding predicted water levels from the model. The verification dataset shows that the model is performing similarly to the calibration period, albeit some locations where the predicted water level is much lower than the observed, as denoted by the verification points below the line of best fit in Figure 6.2.

It should be noted that Figure 6.2 presents the model–data comparison used for calibration of the (AGE, 2020) model. As discussed in detail in Section A7, the calibrated model was validated using water level measurements collected up to August 2025 from monitoring bores within the MPO to evaluate its ability to reproduce regional groundwater behaviour and mine-related impacts, thereby supporting decision-making within the MPO and surrounding areas.

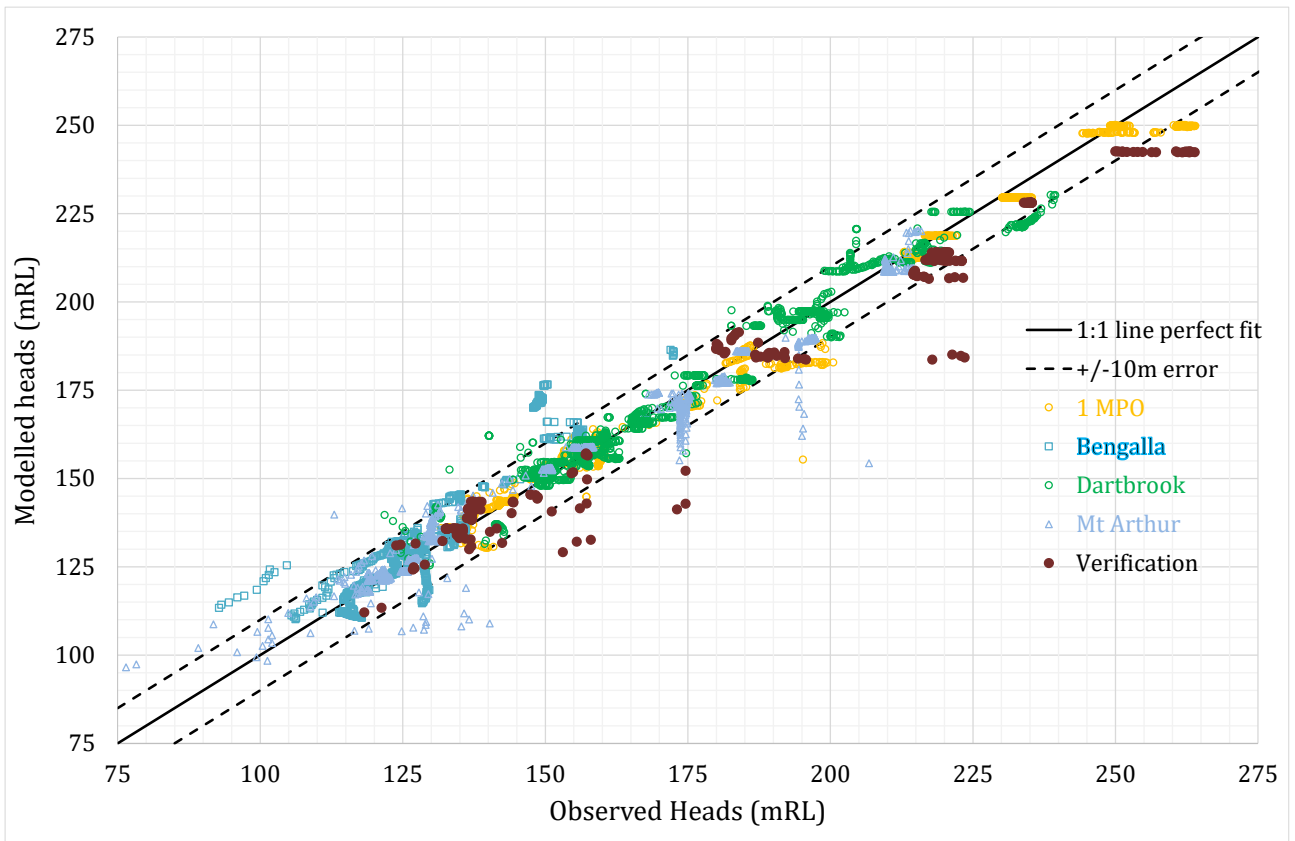


Figure 6.2 Scatter diagram with verification

7 Groundwater model predictions

The following subsections describe the model predictions during mining operations and for the post-mining recovery phase.

7.1 During mining

7.1.1 Groundwater inflows to mining areas

The groundwater inflows were calculated based on the modified MPO mine plan up to December 2032. Mining commenced in 2017 (with inflows occurring in the 2018-19 water year) at the MPO and are proposed to continue until the end of 2032 for the modified MPO. The total predicted groundwater inflows for the modified MPO are shown in Figure 7.1.

The maximum predicted inflow is 148 megalitres (ML) in the 2029-2030 water year. The peak inflow is well within the 730 ML of WAL allocations currently held by MACH for the Sydney Basin – North Coast Groundwater Source (WALs 41437 and 40298).

The maximum predicted inflow for the modified MPO is less than the maximum predicted inflow predicted for the original approved MPO of 1.9 megalitres per day (ML/day) or 690 megalitres per year (ML/year) (PPK, 1997) (Original 1997 EIS). This is considered to be due to material desaturation of the Permian strata by the neighbouring Dartbrook and Bengalla Mines, the extent of mining operations for the modified MPO mine plan in December 2032 compared to the original approved MPO, as well as improvements in groundwater modelling since the original water management study was prepared in 1997.

The maximum predicted inflow for the modified MPO up to December 2032 (approximately 148 ML in the 2029-2030 water year) is an increase on the maximum predicted inflow that would occur during the approved mine life for the MPO up to December 2026 (approximately 97 ML in the 2025-2026 water year).

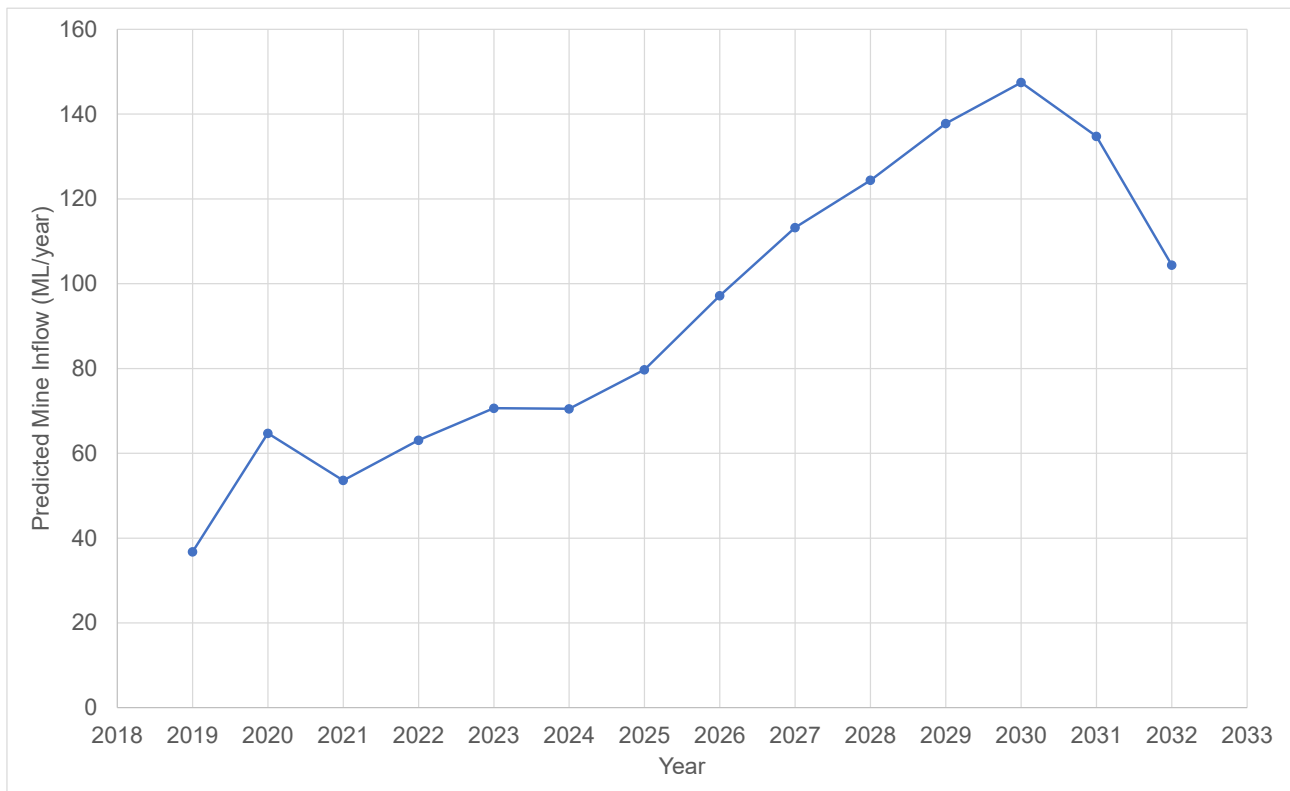


Figure 7.1 Predicted groundwater inflows for the modified MPO (up to December 2032)

7.1.2 Drawdown during mining operations

Predictions of maximum groundwater drawdown during mining have been completed using the numerical groundwater model described in Section 6 and Appendix A. This model is termed the 'base case' model as it represents the best match to historical data and is the basis of the uncertainty analysis presented in Section 9. The predicted drawdown contours are a composite of the maximum values predicted at each cell at any time over the operational period of mining. The actual duration and timing of the maximum predicted drawdown within each cell varies depending on the proximity of mining over the life of the MPO.

Drawdown maps are presented for the alluvium and regolith (Layers 1 and 2) and Edderton seam (Layer 18) at the end of mining for the modified MPO in Figure 7.2 and Figure 7.3. Each figure is split to show outputs for two different scenarios:

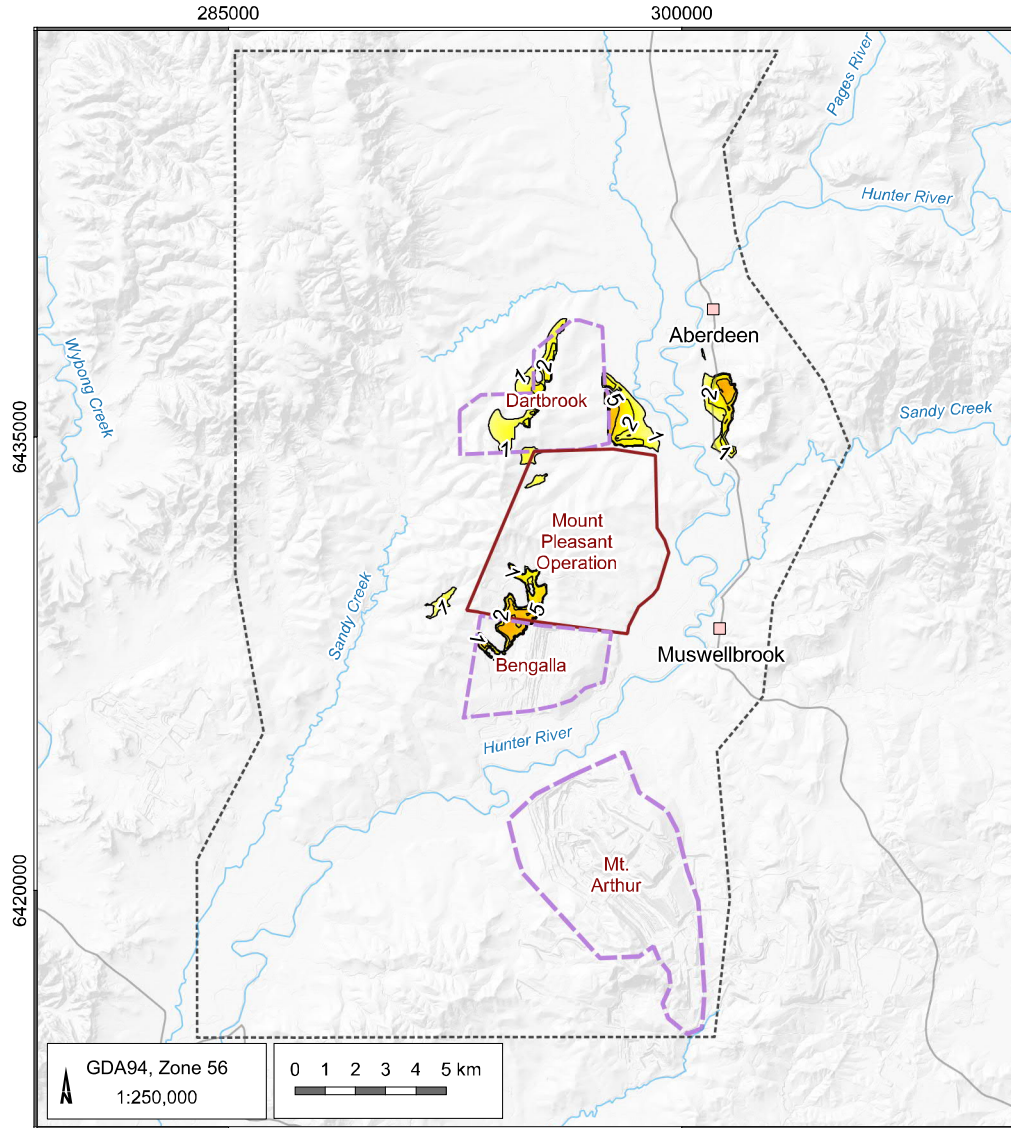
- predicted cumulative drawdown – where drawdown occurs from the modified MPO up to December 2032 and approved neighbouring mines (Dartbrook Mine, Bengalla Mine, and Mt Arthur Coal Mine); and
- predicted drawdown attributed to the modified MPO only (up to December 2032).

The modified MPO up to December 2032 is predicted to result in only limited drawdown in the alluvium to the north of the MPO, near the existing Dartbrook Mine (Figure 7.2b). Limited drawdown is predicted in the Hunter River alluvium as the majority of the target seams subcrop west of the alluvium extent. At the northern boundary of the MPO, the Edderton seam subcrop extends closer to and then under the alluvium associated with the Hunter River, resulting in the minor predicted drawdown to the north of the MPO.

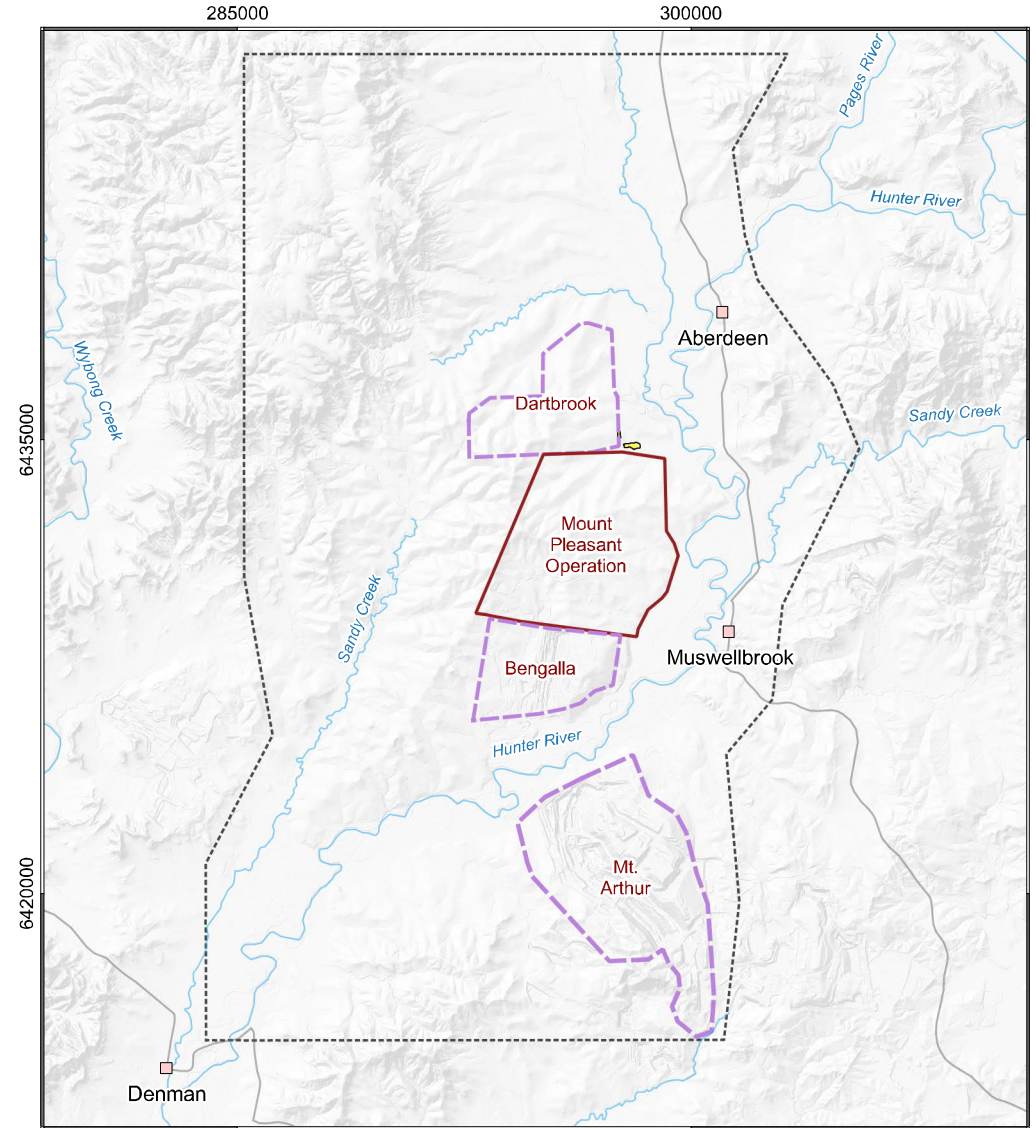
The drawdown predicted in the Edderton seam is constrained to the north and south by the concurrent drawdowns occurring due to the neighbouring mines. Drawdown is constrained by the subcrop in the east (evident in the contours), and the subcrop extending under the alluvium to the north-east of the modified MPO can also be observed in the extent of the drawdown contours.

The incremental predicted drawdown attributed to the Modification only (i.e. modified MPO up to December 2032 excluding the approved mine life for the MPO ceasing in December 2026) is shown on Figure 7.4. The simulation for the Modification only (up to December 2032) is predicted to result in an increase in drawdown in the alluvium immediately north of the MPO, due to the pit advancing further north.

a) Predicted cumulative drawdown

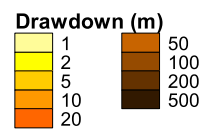


b) Predicted drawdown attributed to MPO



LEGEND

- Populated place
- Drainage
- Road
- Drawdown contour (m)
- Mount Pleasant Operation
- Surrounding mines
- Model boundary



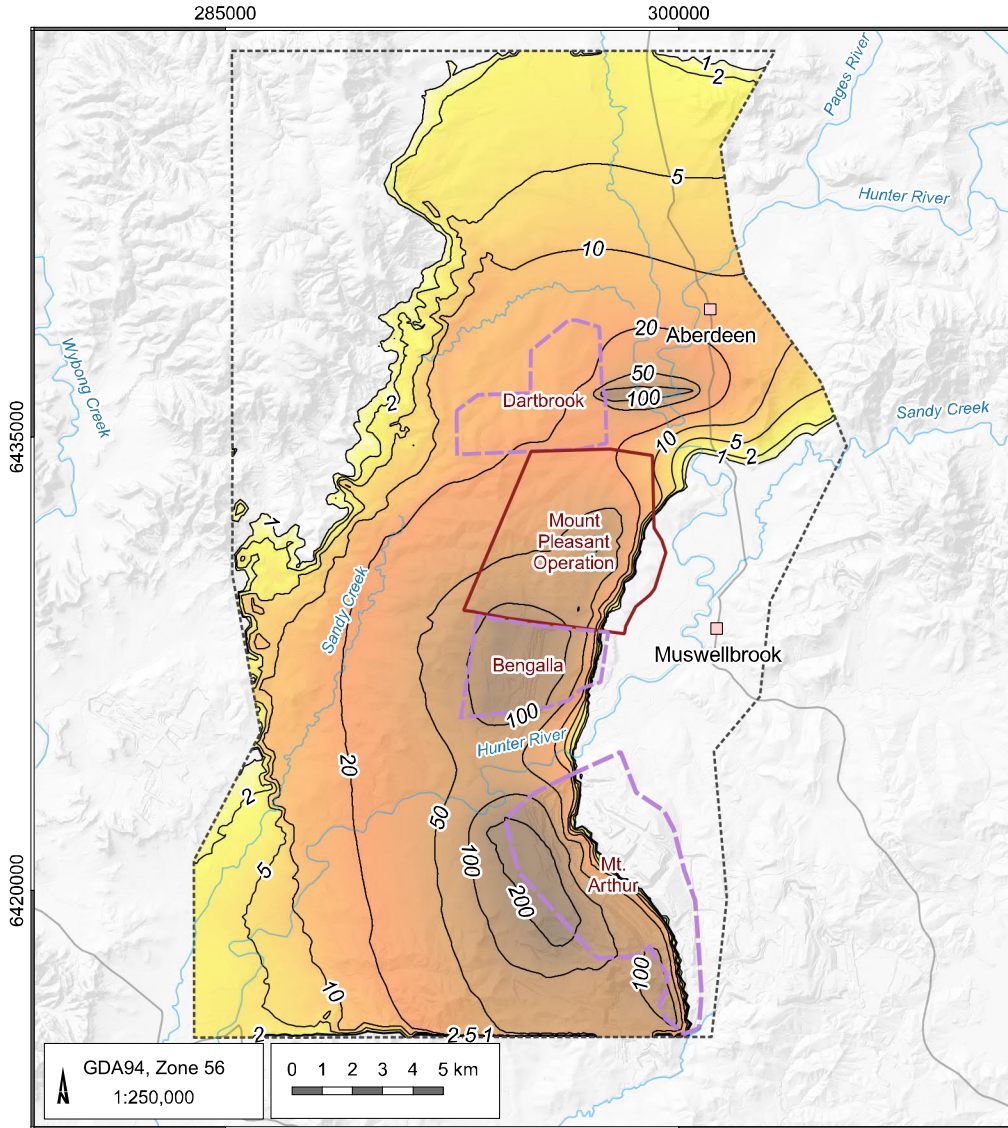
MPO MOD 8 Life of Mine Extension (MPO5009.001)

Predicted drawdown in alluvium/regolith (Layers 1 and 2) at end of mining for modified MPO (up to December 2032)

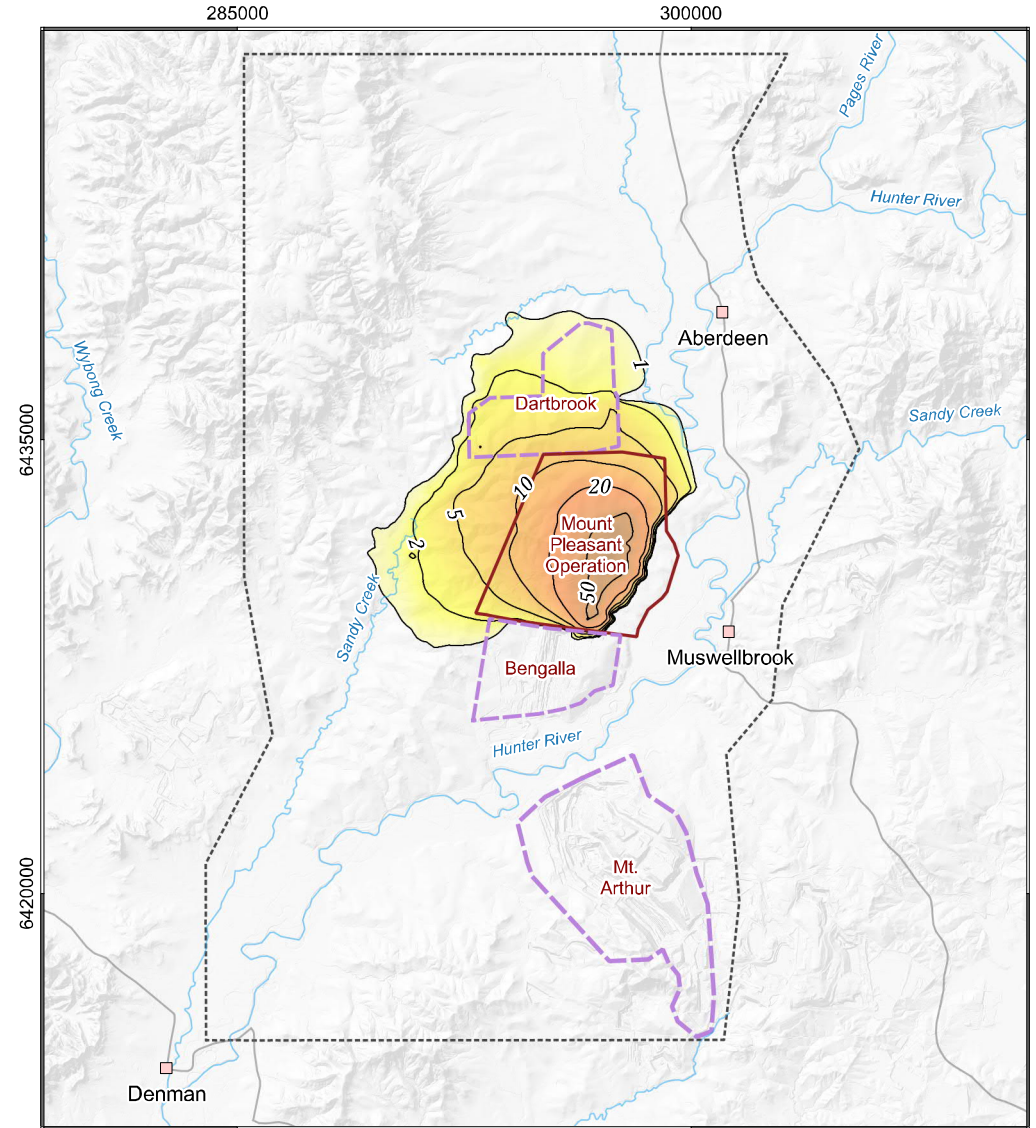
DATE
13/10/2025

FIGURE No:
7.2

a) Predicted cumulative drawdown

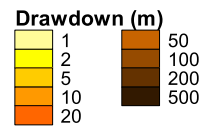


b) Predicted drawdown attributed to MPO



LEGEND

- Populated place
- Drainage
- Road
- Drawdown contour (m)
- Mount Pleasant Operation
- Surrounding mines
- Model boundary



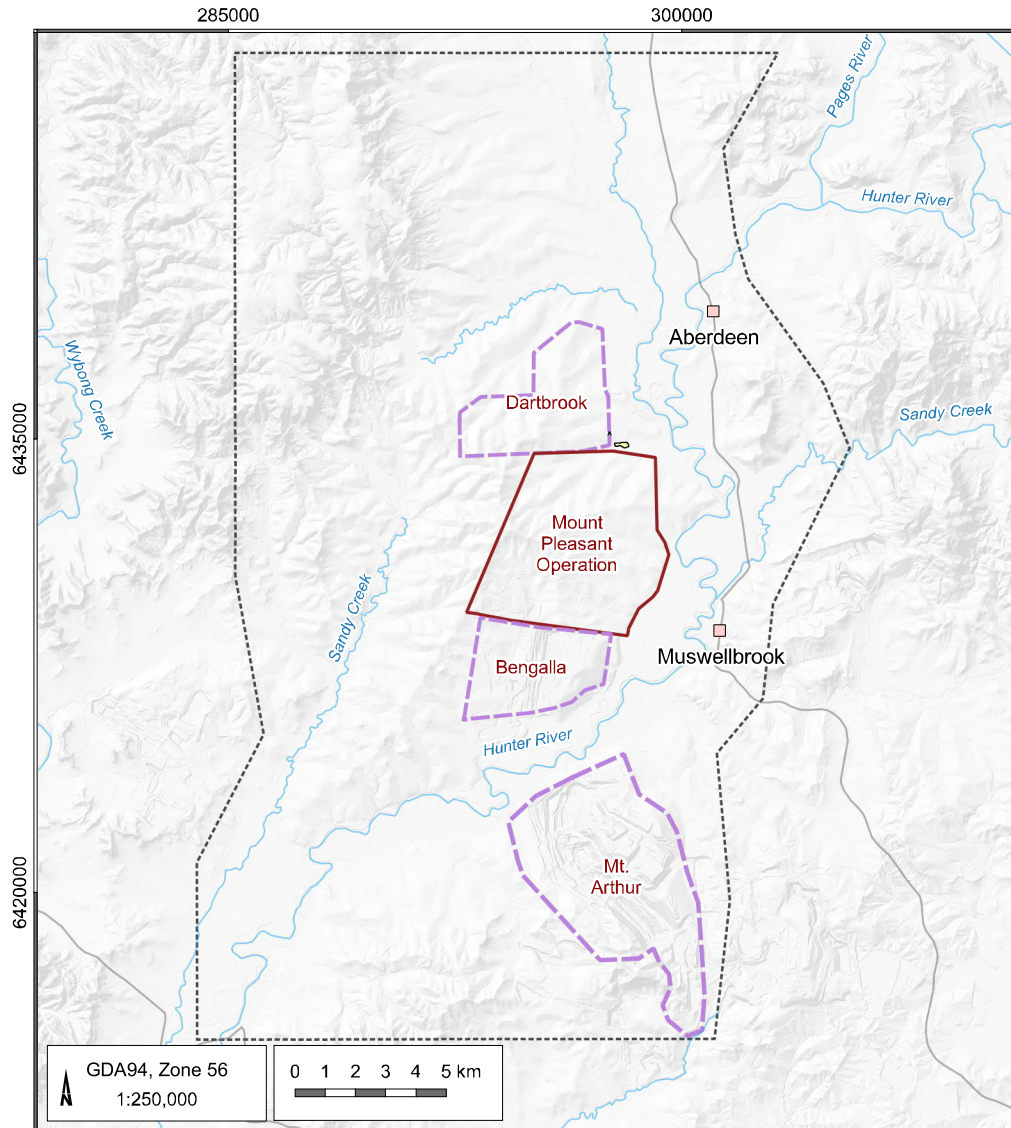
MPO MOD 8 Life of Mine Extension
(MPO5009.001)

**Predicted drawdown in Edderton
seam (Layer 18) at end of mining
for modified MPO (up to December
2032)**

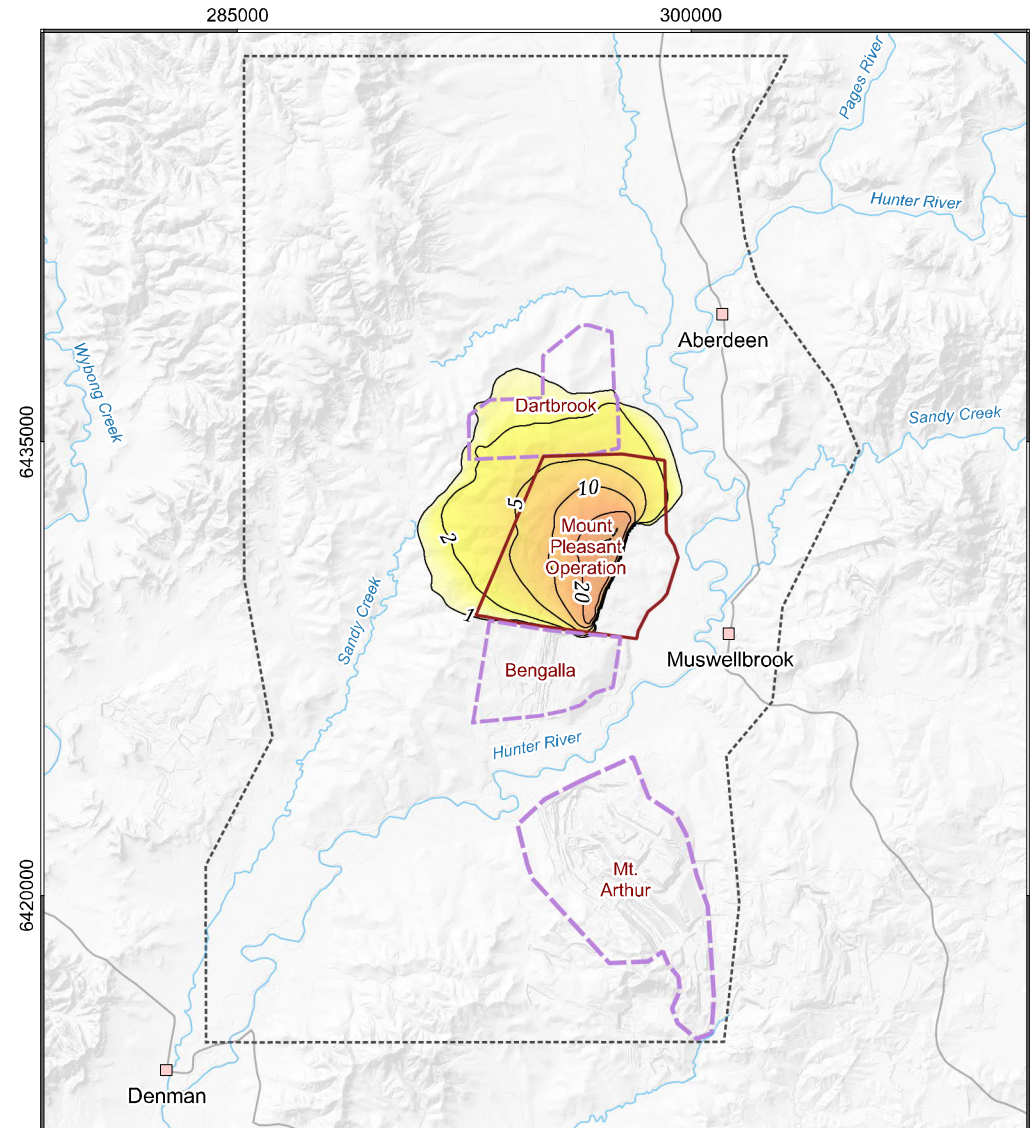
DATE
13/10/2025

FIGURE No:
7.3

a) Incremental increase in predicted drawdown due to the Project relative to the approved mine life (2026) in alluvium/regolith (Layer 2)

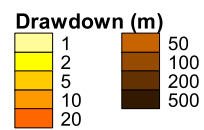


b) Incremental increase in predicted drawdown due to the Project relative to the approved mine life (2026) in Edderton Seam (Layer 18)



LEGEND

- Populated place
- Drainage
- Road
- Drawdown contour (m)
- Mount Pleasant Operation
- Surrounding mines
- Model boundary



MPO MOD 8 Life of Mine Extension (MPO5009.001).

Predicted incremental drawdown due to only MOD 7 (up to December 2023)

DATE
13/10/2025

FIGURE No:
7.4

7.2 Post-mining recovery conditions

At the end of mining, a large proportion of the open cut mining area would have been backfilled with spoil and recontoured to simulate more natural landforms in accordance with the proposed modified final landform at December 2032. On completion of mining for the modified MPO (i.e. December 2032), the modified final landform would include two inter-connected pit voids (i.e. the final void). Approved final voids at the neighbouring Bengalla Mine and Mt Arthur Coal Mine would also remain in the post-mining phase. The deepest areas of the final void would be similar to the maximum depths mined.

Post-mining conditions were simulated using the numerical model to determine and assess the changes to the groundwater system associated with the modified final landform in December 2032. Appendix A (Section A4.2) provides details of the model set up and the representation of post-mining conditions.

Post-mining conditions were simulated by extending the model run to cover a period of 1,000 years after mining ceases and then adding a steady state stress period to simulate equilibrium conditions. Groundwater levels from the end of mining are adopted for the starting heads of the recovery period. Removal of all remaining mine 'drain cells' in the model and switching to the final landform in the backfilled mining areas also occurs at the start of this recovery period.

When interpreting the post-mining results, it is important to note that the long modelling period (1,000+ years) reduces the confidence in the forecast of post-mining predictions. The post-mining predictions should therefore be considered an early indicator of potential post-mining impacts that should be reviewed and updated as part of post-closure planning for the MPO (e.g. as part of a mine closure plan).

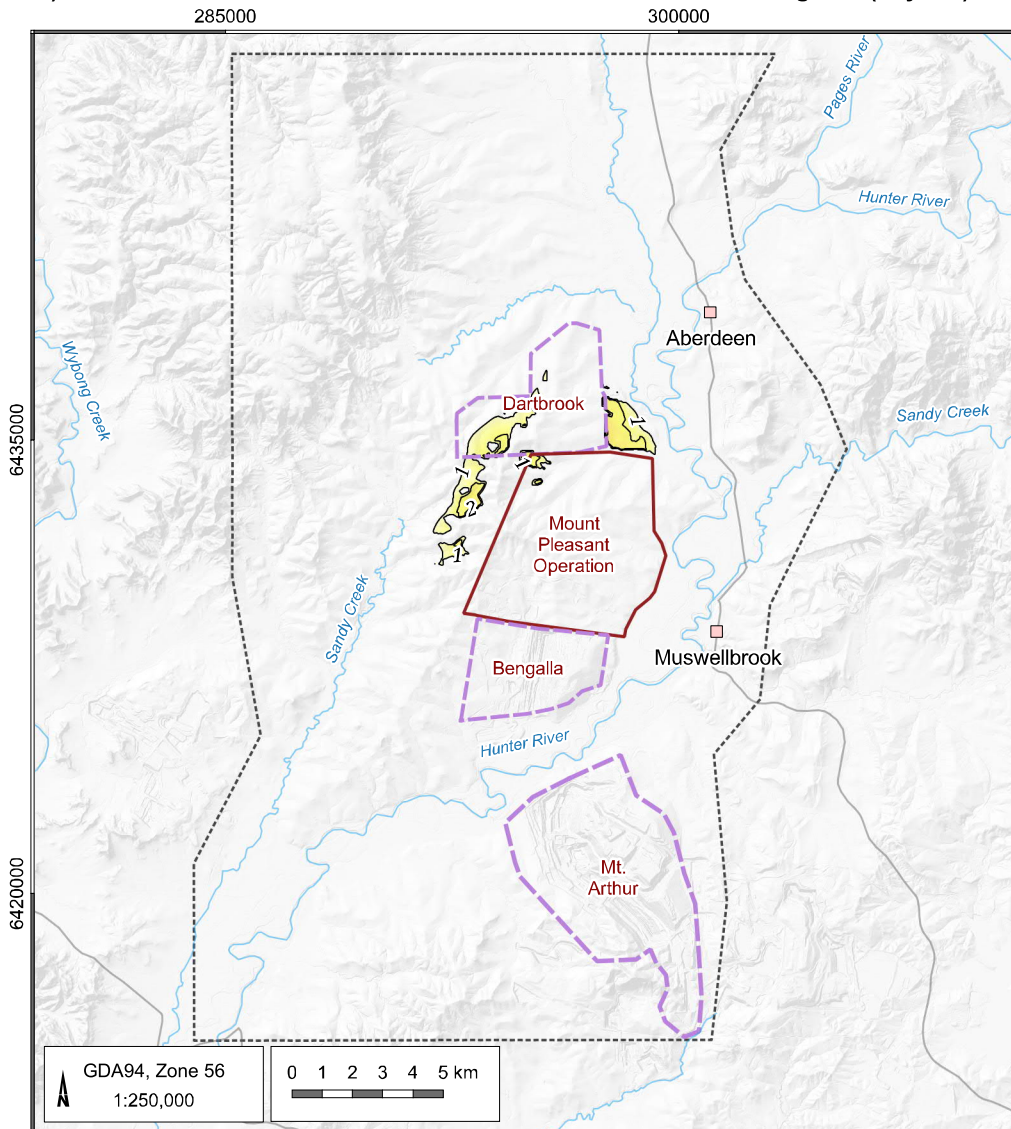
The model results indicate that groundwater levels would gradually recover in some places close to the MPO, however the drawdown extent would continue to grow with time until an equilibrium state is reached. In all mining areas for the MPO, the long-term groundwater levels are predicted to equilibrate at a lower level than under pre-mining conditions, with the final void acting as a long-term groundwater sink.

The predicted long-term residual drawdown due to the final void for the modified MPO at December 2032 is presented in Figure 7.5 for the alluvium and regolith (Layers 1 and 2) and in the Edderton Seam (Layer 18). These drawdowns are determined by the same differencing approach to determine the maximum drawdown due to the modified MPO.

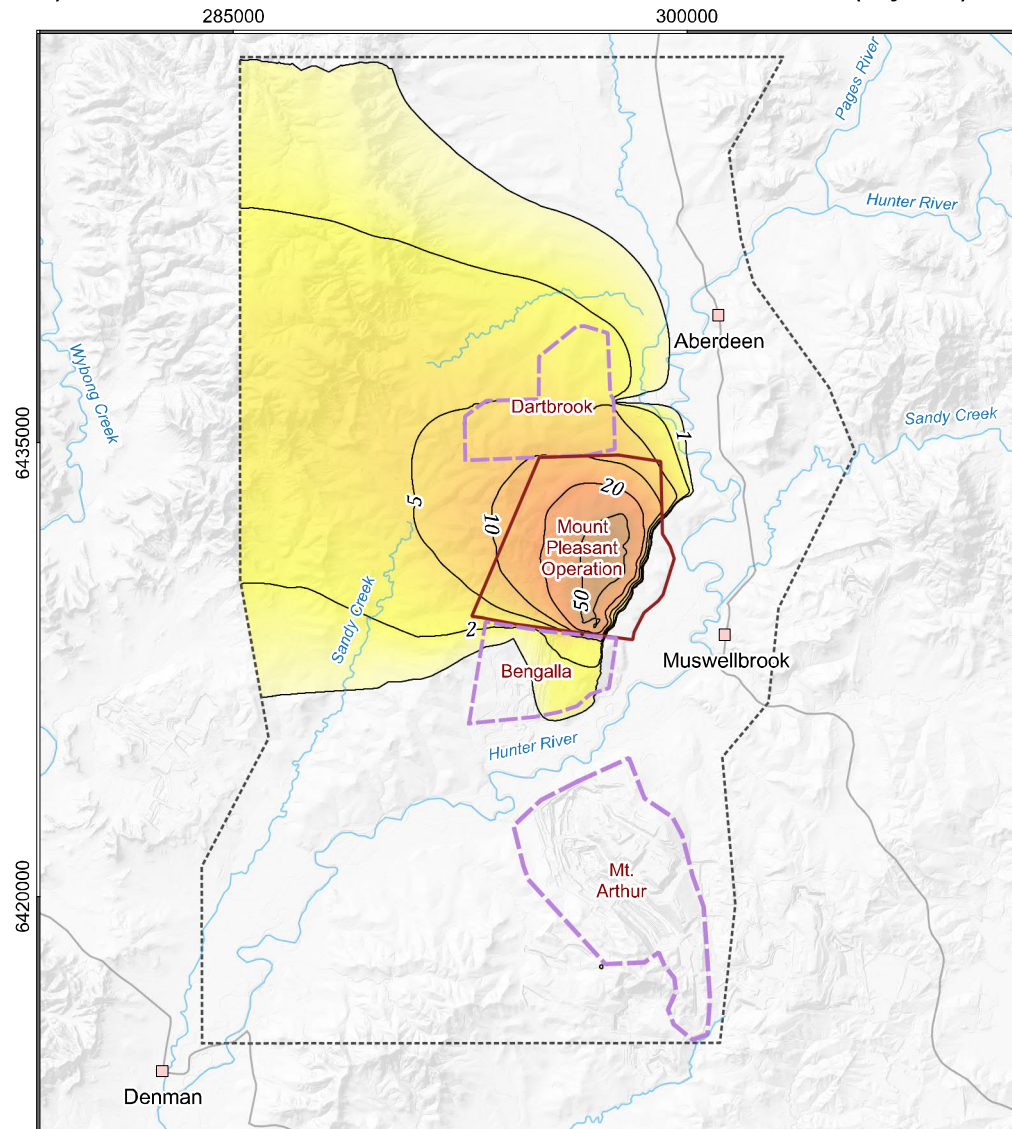
Predicted flow paths for water originating from the out-of-pit waste emplacement were derived using the groundwater model predicted equilibrium water table contours. Figure 7.6 demonstrates flow migration from the out-of-pit emplacement would be directed predominantly towards the final void for the modified MPO (at December 2032) and Bengalla Mine final void. All eastern origin points tracked down towards the final void for the modified MPO (at December 2032), while contours in the western parts of the MPO area show groundwater flow towards either the final void for the modified MPO (at December 2032) or Bengalla Mine final void.

As such, the final void for the modified MPO (at December 2032) and Bengalla Mine final void act to largely restrict potential for seepage downstream to the Sandy Creek catchment.

a) Predicted maximum drawdown attributed to MPO in alluvium/regolith (Layer 2)



b) Predicted maximum drawdown attributed to MPO in Edderton Seam (Layer 18)



- LEGEND
- Populated place
 - Drainage
 - Road
 - Drawdown contour (m)
 - Mount Pleasant Operation
 - Surrounding mines
 - Model boundary

Drawdown (m)	
	1
	2
	5
	10
	20
	50
	100
	200
	500

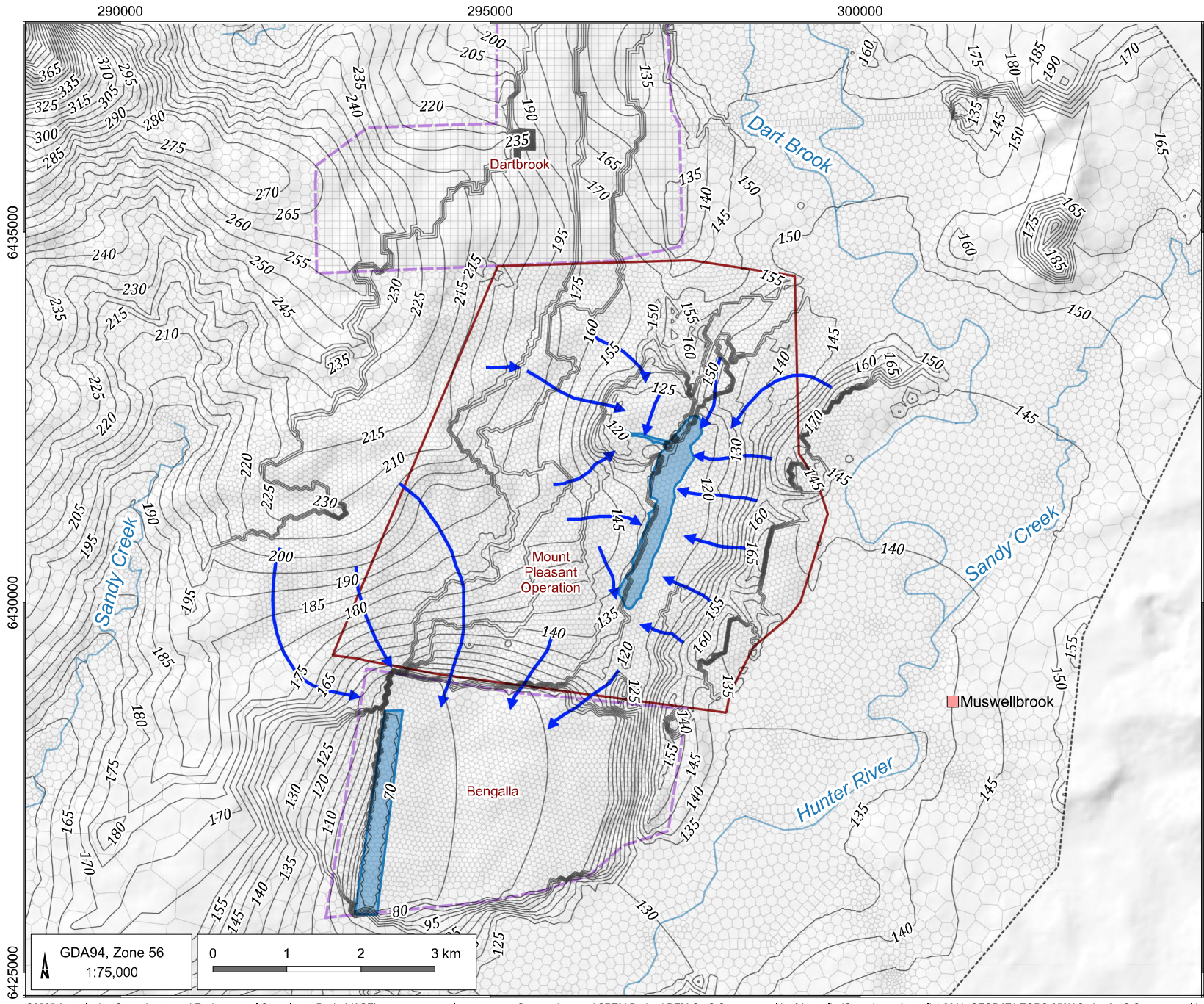


MPO MOD 8 Life of Mine Extension
(MPO5009.001)

**Predicted maximum drawdown
during and post-mining attributed
to the modified MPO**

DATE
13/10/2025

FIGURE No:
7.5



- LEGEND
- Populated place
 - Drainage
 - Head contour (5m)
 - Direction of groundwater flow
 - ▭ MPO/Bengalla void
 - ▭ Mount Pleasant Operation
 - ▭ Surrounding mines
 - Model boundary
 - Grid

MPO MOD 8 Life of Mine Extension
(MPO5009.001)

Predicted particle pathlines post-mining

DATE
13/10/2025



FIGURE No:
7.6

GDA94, Zone 56
1:75,000

0 1 2 3 km

8 Groundwater impact assessment

8.1 Incidental take of water from the alluvium and stream flow effects

The model was used to determine the potential for mining to interfere with the alluvial groundwater systems and to provide estimates of indirect 'water take' in accordance with the AIP. Mining would not directly intercept alluvial aquifers, however, an indirect impact or 'water take' occurs as the Permian strata become depressurised and the volume of groundwater flowing from the Permian to the Quaternary alluvium progressively reduces. The change in alluvial water resources was determined by comparing water budgets for alluvial zones using versions of the numerical model that contained and excluded MPO (both approved MPO in December 2026 and modified MPO).

8.1.1 Indirect take from alluvium

The indirect take from the Hunter River, Sandy Creek and Dart Brook alluvium is presented in Figure 8.1. In accordance with the AIP, the predicted change in baseflow has been subtracted from the change in alluvial flow to prevent double accounting.

The unadjusted indirect take (i.e. including the predicted change in baseflow) from the Hunter River alluvium due to the modified MPO peaks at 29.3 ML/year by the end of mining. The incremental change in adjusted indirect take from the alluvium due to the modified MPO (i.e. excluding the predicted change in baseflow) is predicted to peak at be 1.8 ML/year during the life of the modified MPO (up to December 2032) and post-mining.

The adjusted indirect take from the Sandy Creek alluvium (i.e. excluding the predicted change in baseflow) increases over time, with a predicted take of up to 0.2 ML/year during the life of the modified MPO (up to December 2032), rising to a peak of 0.7 ML/year post-mining (predicted at the end of the recovery stress period in the model). Similarly, indirect take from the Dart Brook alluvium (i.e. excluding the predicted change in baseflow) increases over time up to approximately 0.4 ML/year during the life of the modified MPO (up to December 2032), rising to a peak of approximately 1 ML/year post-mining.

8.1.2 Indirect take from surface water

Baseflow to the streams in the vicinity of MPO is reduced as mining draws down the water table, influencing the magnitude and direction of surface water-groundwater exchange. It is important to note that throughout this report the terms 'baseflow reduction' and 'leakage' are used interchangeably to describe a net water loss from the surface water system.

The predicted reduction of baseflow due to the modified MPO in each of the Hunter River, Sandy Creek and Dart Brook is shown on Figure 8.2.

The predicted reduction in baseflow to the Hunter River due to the modified MPO is 27.5 ML/year in 2032 (the end of the mine life for the modified MPO), rising to a peak of 42 ML/year post-mining. Potential impacts to baseflow in Sandy Creek and Dart Brook are predicted to be negligible during the mine life of the modified MPO (i.e. peak reduction in baseflow of 0.2 ML/year and 1 ML/year, respectively) and post-mining at equilibrium recovery conditions (i.e. peak reduction in baseflow of 1.6 ML/year and 5.5 ML/year, respectively).

8.1.3 Post-mining changes in alluvial and surface water fluxes

The equilibrium water level in the final void is predicted to be significantly lower than the pre-mining water level. 'Water take' from the groundwater systems would continue post-mining due to the continued flow of groundwater to the final void.

The long-term peak indirect take from each water source is considered in the water licensing requirements for the modified MPO (Section 8.1.4).

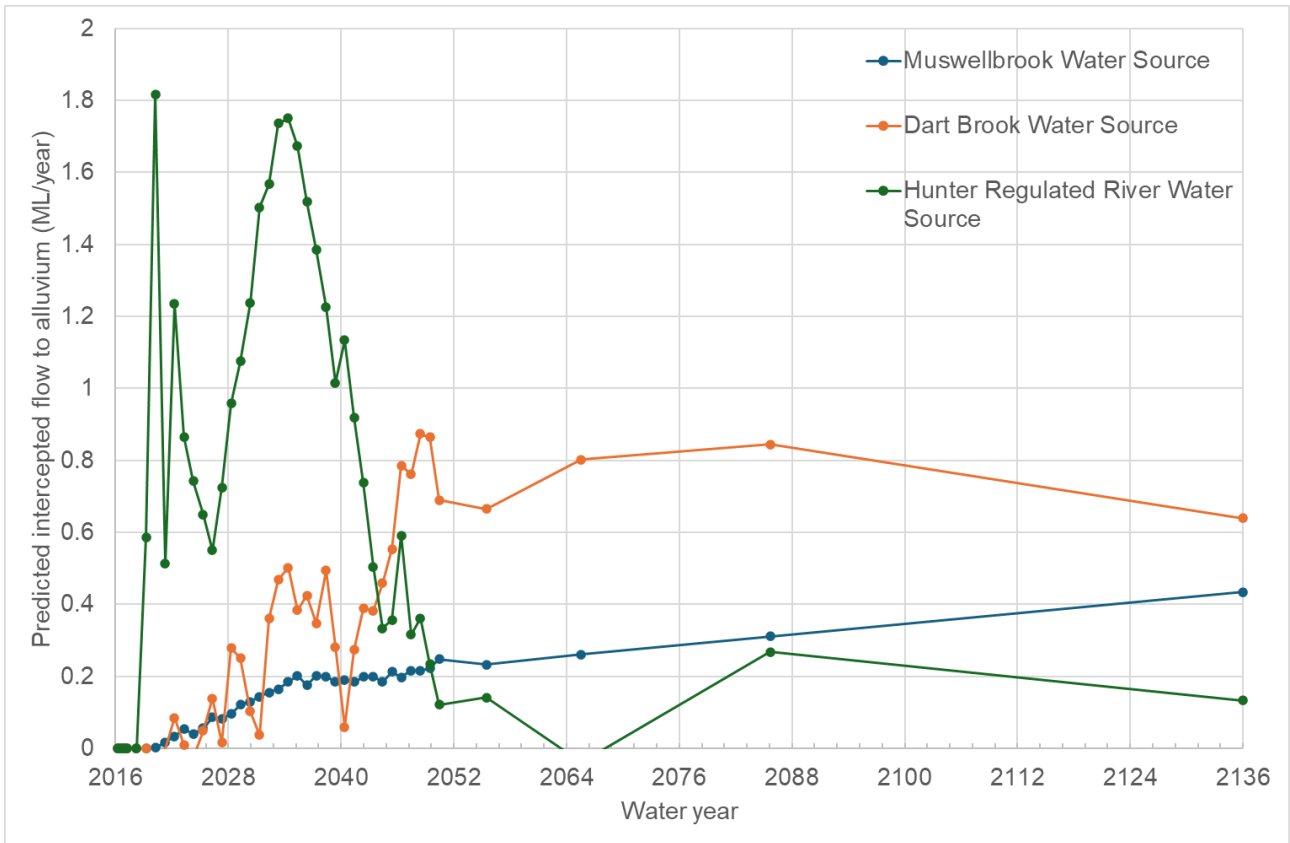


Figure 8.1 Indirect take from alluvium bodies due to the modified MPO

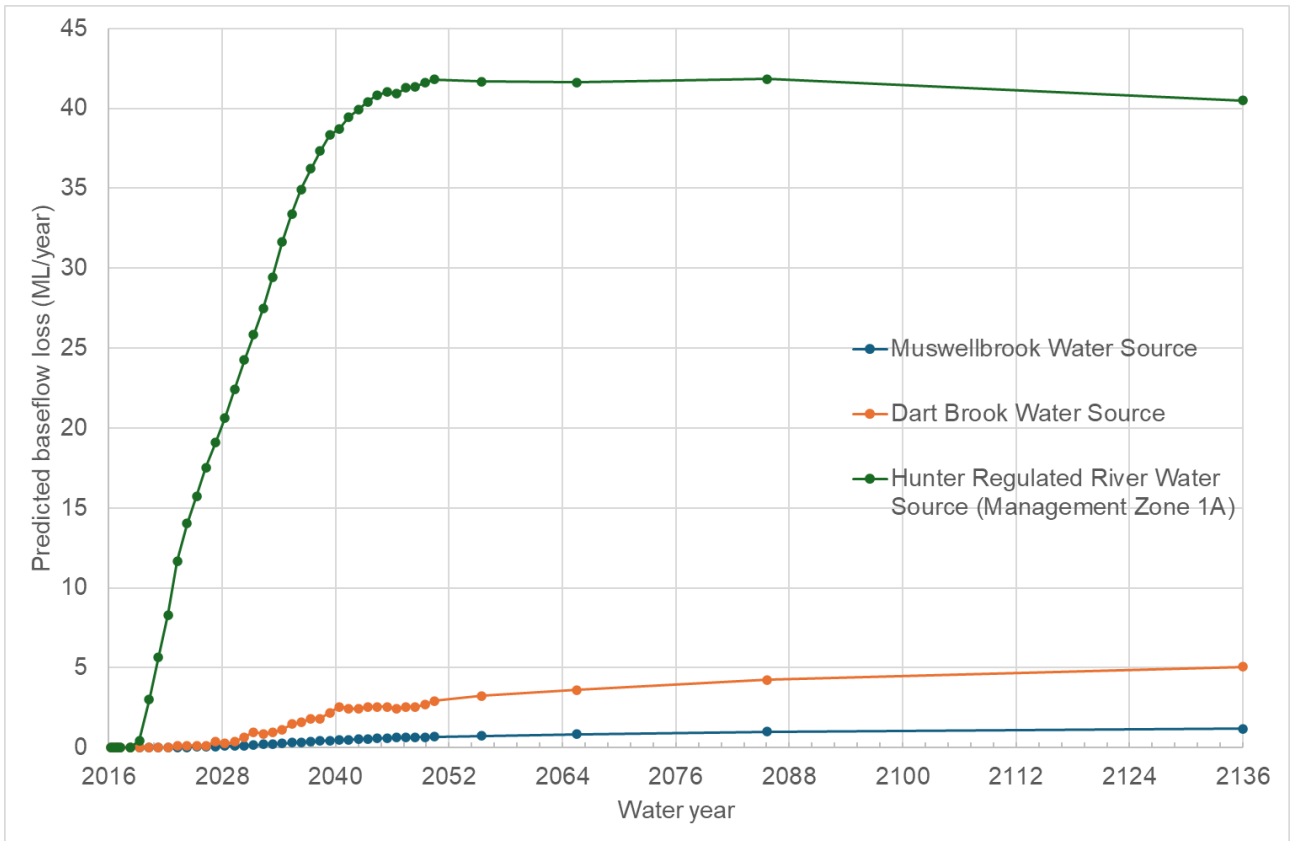


Figure 8.2 Reduction in baseflow due to the modified MPO

8.1.4 Water licensing requirements

The WM Act and AIP require that all groundwater taken, either directly or indirectly, is accounted for via WALs. Groundwater intercepted from the mining area is considered a direct take from the Permian groundwater system, whilst the changes in flow occurring within the Quaternary alluvium and rivers resulting from depressurisation of the underlying Permian is considered an indirect take.

A summary of the water licensing requirements for the modified MPO is provided in Table 8.1. MACH holds sufficient WALs to account for the take from each water source.

The proportion of inflows from the various water sources is summarised in Table 8.1. The post-mining take from the Sydney Basin – North Coast Groundwater Source in the *Water Sharing Plan for the North Coast Fractured and Porous Rock Groundwater Sources 2016* is 61 ML/year from the perspective of flow from host rock into the mined area to the pit void. Within the mined area, the additional recharge on the spoil also flows to the void, which increases the total groundwater inflows to the void to 175 ML/year.

Under *Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources 2022*, the Muswellbrook Water Source and Dart Brook Water Source comprise aquifer licences and unregulated river licences, therefore, Table 8.1 provides the peak water licensing requirement predicted over a year for these water sources based on the indirect take from both the alluvium and surface water (i.e. adjusted baseflow loss).

Table 8.1 Water licensing requirements for the modified MPO

Water Sharing Plan	Water Source	Share Components (Units)	During Mining Water Licensing Requirements (ML/year)	Post-mining Water Licensing Requirements (ML/year)
<i>Water Sharing Plan for the Hunter Regulated River Water Source 2016</i>	Hunter Regulated River Water Source (Management Zone 1A)	961 (High) 2,947 (General)	28	42
<i>Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources 2022</i>	Hunter Regulated River Alluvial Water Source	295	2	2
	Muswellbrook Water Source	41	1	2
	Dart Brook Water Source	20	1	6
<i>Water Sharing Plan for the North Coast Fractured and Porous Rock Groundwater Sources 2016</i>	North Coast – Sydney Basin Groundwater Source	730	148	61*

Note: * 175 ML/year would be required to be licensed for the North Coast – Sydney Basin Groundwater Source if including groundwater inflows from spoil (rather than just the host-rock aquifer).

8.2 Water supply bores

Section 5.8.2 described potential groundwater users based on the private bores in proximity of the MPO. A bore census was previously undertaken for the Mount Pleasant Optimisation Project and identified 39 bores, wells and springs on privately owned land used for irrigation, stock watering and domestic purposes in the proximity of the MPO. Several bores identified in this bore census also form part of the current and historic monitoring networks at surrounding coal mining operations.

An assessment of drawdown predicted at private bores was conducted and considered both the impacts of the modified MPO up to December 2032 and cumulative mining including the modified MPO up to December 2032 and the surrounding Dartbrook Mine, Bengalla Mine and Mt Arthur Coal Mine. Of the 39 bores, wells and springs identified in the bore census, 35 were included in this assessment as the remainder were abandoned (e.g. not in use by private owner). Where bores lacked a record of depth, it was assumed that the bore accessed the most productive layer in that location (e.g. bores located within the extent of the Hunter River alluvium were assumed to access the alluvial layers). The BELGRAVE bore is accessing regolith material associated with the "less productive" Sydney Basin – North Coast Groundwater Source.

A total of six bores on private property were predicted to experience drawdown exceeding 2 m due to cumulative impacts from the modified MPO up to December 2032 and surrounding mining operations. Details of the bores and the predicted drawdown are summarised in Table 8.2. Only two of these private bores, CAS1_G and JLON1, are predicted to experience greater than 2 m drawdown as a result of the modified MPO only. CAS1_G is described as being not in use and JLON1 is understood to be dry.

The remaining private bores are either dry (i.e. CAS3_G), not in use (i.e. CAS2_G and CAS4_G) and/or are predicted to not experience drawdown due to the modified MPO only, and therefore, would already be subject to mitigation measures.

Existing monitoring undertaken at CAS1_G and CAS4_G as part of the Dartbrook Mine groundwater monitoring programme indicates these bores have already experienced approximately 15 m drawdown due to the operation of the Dartbrook Mine.

Table 8.2 Drawdown in private bores

Bore ID	Depth (mTOC)	Groundwater level (mBGL)	Electrical Conductivity (µS/cm)	Maximum Cumulative Drawdown (m)	Maximum Drawdown for Modified MPO Only (m)	Type
BELGRAVE	23.85	7.16	6,280	7.1	0	Well – Stock & Monitoring
CAS1_G	28.23	11.73	8,040	9.1	3.3	Bore – Not in Use
CAS2_G	65	39.71	13,045	22.3	0	Bore – Monitoring (Not in Use)
CAS3_G	76.7	Dry	Dry	25.8	0	Bore – Not in Use*
CAS4_G	34.8	27.89	10,585	32	0	Bore – Monitoring (Not in Use)
JLON1	52	Dry	Dry	4.2	2.4	Well & Bore – Monitoring*

Notes: Groundwater level & EC data for all bores is sourced from regional monitoring/MPO bore census data from 2016-2020.

* Bore observed to be dry.

8.3 Groundwater dependent ecosystems

The following potential GDEs have been identified in the vicinity of the MPO (Sections 5.8.3 and 5.8.4):

- the Hunter River is identified as a potential Type 2 aquatic GDE based on the GDE Atlas;
- some small patches of the *White Box-Narrow-leaved Ironbark-Blakley's Red Gum* vegetation community (PCT 3396) have been identified as a potential Type 3 terrestrial GDE (Hunter Eco, 2025);
- some mapped high priority GDEs located approximately 1 km to the west of the MPO as identified in the *Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources 2022*; and
- stygofauna collected from bores accessing the Hunter River alluvium.

The impacts to the Hunter River were evaluated through assessment of the drawdown extent in the nearby alluvium. The areas of predicted drawdown from the modified MPO up to December 2032 in the Hunter River alluvium are limited, being located primarily to the north of MPO and east of Dartbrook Mine (Figure 7.2). The predicted peak reduction in baseflow to the Hunter River due to the modified MPO is 41.8 ML/year, which is negligible relative to the total flows in the Hunter River (greater than 100,000 ML/year on average).

As described in Section 5.8, there are some mapped high priority GDEs located approximately 1 km to the west of the MPO as identified in the *Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources 2022*. No drawdown is predicted to be experienced at these high priority GDEs as a result of the modified MPO (or cumulatively) during mining or post-mining (Figure 7.2).

The patches of the *White Box-Narrow-leaved Ironbark-Blakley's Red Gum* vegetation community (PCT 3396) identified by Hunter Eco (2025) are predicted to experience negligible drawdown as a result of the modified MPO (or cumulatively) during mining or post-mining (Figure 7.2).

All of the stygofauna taxa collected in the vicinity of the MPO are prevalent elsewhere in the Hunter Valley (Section 5.8.4). There is no significant drawdown predicted along the Hunter River alluvium and therefore potential impacts to these stygofauna populations are predicted to be negligible.

Three spring locations were previously identified south-west of the MPO, and have been labelled Moore1S, Moore2S, and Moore3S. As part of the approved MPO, these locations are predicted to experience a maximum drawdown exceeding 2 m. Moore3S is predicted to experience an incremental increase in drawdown of approximately 0.3 m from the modified MPO (approved MPO drawdown predicted to be 2.3 m). Moore1S and Moore2S are predicted to experience incremental drawdowns of approximately 1.1 m at both of these locations (approved MPO drawdowns predicted to be 12.9 m and 12.5 m, respectively). As such, the modified MPO would only result in a minor increase in drawdown in comparison to the impacts predicted for the approved MPO (in December 2026) (e.g. may already be dry as a result of approved MPO at December 2026).

8.4 Groundwater quality

Key components of the modified MPO that could affect groundwater quality are as follows:

- mine life extension allowing continuation of open cut mining and development of a final void at the end of the mine life for the modified MPO (at December 2032);
- mine life extension allowing co-disposal of coarse rejects with waste rock as part of ROM waste rock operations;
- mine life extension allowing continued development of the waste rock emplacements; and
- mine life extension allowing continued development of the Fines Emplacement Area, including the construction of additional embankment raises (lifts).

As mining progresses, the final void for the modified MPO (at December 2032) would act as a groundwater sink, preventing interaction between the final void water and the surrounding natural groundwater systems. Therefore, there would be no groundwater quality impact associated with the final void for the modified MPO (at December 2032).

The original water management study prepared for the approved MPO as presented in the original 1997 EIS (PPK, 1997) predicted some seepage of water from the approved final landform to the surrounding natural groundwater system, including:

- seepage from the Fines Emplacement Area towards the Sandy Creek alluvium; and
- seepage from the out-of-pit emplacement eastwards to the adjacent Hunter River alluvium.

During operations, the Fines Emplacement Area would be managed in accordance with the Fines Emplacement Plan (ATC Williams, 2017) for the MPO. The plan provides for the management of seepage from the Fines Emplacement Area as follows:

- establishment of a foundation drain to manage potential seepage through the embankment;
- a clay fill cut-off key is constructed into the bedrock underlying the embankment footprint to minimise the potential for shallow seepage beneath the Fines Emplacement Area;
- seepage water is collected, tested and recovered using a pump back system as required; and
- prioritising the return of decant water to the water management system, thereby minimising the decant pond volume and seepage potential of the Fines Emplacement Area.

With the implementation of the above measures, the potential impacts on groundwater quality during the operation of the Fines Emplacement Area is predicted to be negligible.

The modified MPO involves a mine life extension allowing continuation of the open cut pit progression in a westerly direction. As a result, the modified MPO final void would be located closer to the Fines Emplacement Area (compared to the final voids for the approved MPO in December 2026), drawing more seepage towards the final void as opposed to the Sandy Creek alluvium. The continuation of open cut pit progression in a western direction also increases the distance between the modified MPO final void and the Hunter River alluvium, reducing the potential for seepage towards the Hunter River alluvium.

The potential for seepage from the proposed final landform for the modified MPO in December 2032 has been assessed using groundwater model predicted water table levels. The analysis of flow directions derived from the water table contours demonstrates that seepage is predicted to primarily occur to the final voids for the modified MPO and Bengalla Mine.

Based on the above, the modified MPO is considered to have a negligible impact on groundwater quality.

9 Uncertainty analysis

9.1 Overview

The IESC's Explanatory Note on Uncertainty Analysis in Groundwater Modelling (Peeters and Middlemis, 2023) outlines that the uncertainty analysis has to be undertaken based on the risk and consequences of a project. Most coal mines are considered to be in the high risk and high consequence category and would likely warrant a quantitative assessment of the uncertainty. The IESC's guidelines define key model outcomes or predictions as a quantity of interest (QoI). QoI's are defined as a model outcome from a specified model scenario, with a predefined spatial and temporal setting, that is relevant to assess the likelihood and consequence of a causal pathway element representing a hazard. In the case of the modelling undertaken for MPO, the QoI's relate to take from the groundwater system resulting from dewatering activities, which includes impact predictions for private bores and GDEs.

In this case, a Monte Carlo (MC) uncertainty analysis was undertaken to quantify the magnitude of uncertainty in the future impacts predicted by the model. This type of analysis produces probability distributions for predictive impacts by assessing a composite likelihood of an impact occurring through assessing and ranking the predictions from hundreds of model 'realisations'.

Each model realisation is informed by the observation dataset by using the relationship between the observation statistics to perturbations of each parameter in the groundwater model.

This uncertainty analysis was essentially undertaken as a three-part process. Firstly, a valid range for each parameter (i.e. pre-calibration range) was determined, and then 300 model realisations were created, each with varied values of model parameters. The pre-calibration range used was identical to that used previously in the base case model calibration (Appendix A).

The constrained realisations were tested and the models that failed to converge or could not achieve adequate calibration were rejected, leaving the output from 196 successful models. Models were considered to have an acceptable calibration if SRMS (heads) $\leq 10\%$. The outputs were analysed to provide a statistical distribution of the predictive impacts.

Outputs from the uncertainty modelling were processed in accordance with the risk-based probability ranking. The ranges adopted are shown in Table 9.1.

Table 9.1 Calibrated uncertainty modelling language

Narrative descriptor	Probability class	Description	Colour code
Very likely	0-10%	Very likely that the outcome is larger than this value	Green
Likely	10-33%	Likely that the outcome is larger than this value	Light Green
About as likely as not	33-67%	As likely as not that the outcome is larger than this value	Yellow
Unlikely	67-90%	Unlikely that the outcome is larger than this value	Orange
Very unlikely	90-100%	Very unlikely that the outcome is larger than this value	Red

9.2 Mine inflow rate

The range of possible inflow volumes from the base case parameter set (Figure 9.1) indicate that despite calibration, uncertainty in model parameters results in variation in the simulated inflows. The predicted peak inflows range from 148 ML/year (10%) to 507 ML/year (90%), compared to the predicted inflow for the base case of 148 ML/year during the mine life of the modified MPO (up to December 2032), with the difference between the base case and the median (267 ML/year) uncertainty analysis results being largely a function of the calibrated model storage values tending towards the lower end of their ranges. This provides a conservative prediction of the extent of potential groundwater impacts, with the uncertainty analysis able to explore the potential direct take for the higher storage values. The 90th percentile model case (507 ML/year) remains within MACH's existing water licensing entitlement (730 units).

9.3 Baseflow reduction in Hunter River, Sandy Creek and Dart Brook

Figure 9.2 shows the variability of take from the Hunter River resulting from the uncertainty in model parameters. Despite the range of inflows, even the unlikely upper take of 42 ML/year for the modified MPO (up to December 2032) is well within the MACH's existing share components for the Hunter Regulated River Water Source (e.g. 961 units from High Security WALs and 2,947 units from General Security WALs). Note, the terms 'baseflow reduction' and 'leakage' are used interchangeably to describe a net water loss from the surface water system.

The unlikely upper estimates of baseflow reduction for Sandy Creek and Dart Brook remain negligible (up to approximately 3 ML/year and 6 ML/year, respectively) (Figure 9.3 and Figure 9.4) and within MACH's existing share components for these water sources.

9.4 Indirect take from the Hunter River alluvium, Sandy Creek alluvium and Dart Brook alluvium

The range of predicted volumes of incremental indirect take for the Hunter River alluvium (i.e. excluding the predicted change in baseflow), can be seen in Figure 9.5. MACH existing share components for the Hunter River Regulated Alluvial Water Source (295 units) is greater than the unlikely scenario (5.3 ML/year), indicating that MACH would remain well within its licencing limits for the modified MPO up to December 2032.

The unlikely upper estimates of alluvial take for Sandy Creek and Dart Brook remain negligible (up to approximately 1.5 ML/year and 3 ML/year, respectively) (Figure 9.6 and Figure 9.7) and within MACH's existing share components of these water sources.

9.5 Zone of 2 m drawdown

The extent of 2 m drawdown at the end of the mine life for the modified MPO (up to December 2032) was assessed for each of the 196 model runs. The total number of times a model cell had drawdown >2 m was tallied and converted to a percentile. The resulting contours for each percentile are shown on Figure 9.8 and Figure 9.9. The greater the extent of the drawdown away from the modified MPO, the less likely it is to occur.

Please note that the colour ramp for Figure 9.8 and Figure 9.9 is reversed compared to the calibrated model language presented in Table 9.1. It is logical for the drawdown regions that fewer occurrences of 2 m drawdown in a model cell results in less chance of that drawdown being exceeded, whereas for the inflows there was greater chance of the inflow rate being exceeded if the percentile was low.

In the alluvium (Layers 1 and 2), it is very unlikely (0.1-10%) that any areas would incur 2 m drawdown as a result of modified MPO only (up to December 2032), with only the area immediately north of the MPO, adjacent to where Dart Brook and the Hunter River join, showing any potential. It is worth noting that these impacts are only relevant where a sensitive receptor exists (such as a private bore) that is screened in the relevant layer. Within the area of predicted drawdown that exceeds 2 m, one private bore (JLON1) is present, however, this bore is approximately 52 m deep, is not screened in the alluvium, and has been recorded as being dry for several years.

In the Edderton Seam (Layer 18), it is unlikely (10-33%) to very unlikely (0-10%) that the predicted base case model extent of 2 m drawdown would be exceeded. Minor reaches to the west and to the north of MPO demonstrate areas about as likely as not (33-67%) to experience 2 m drawdown outside the predicted range of the base case model. This result reflects the conservatism that is built into the model assumptions.

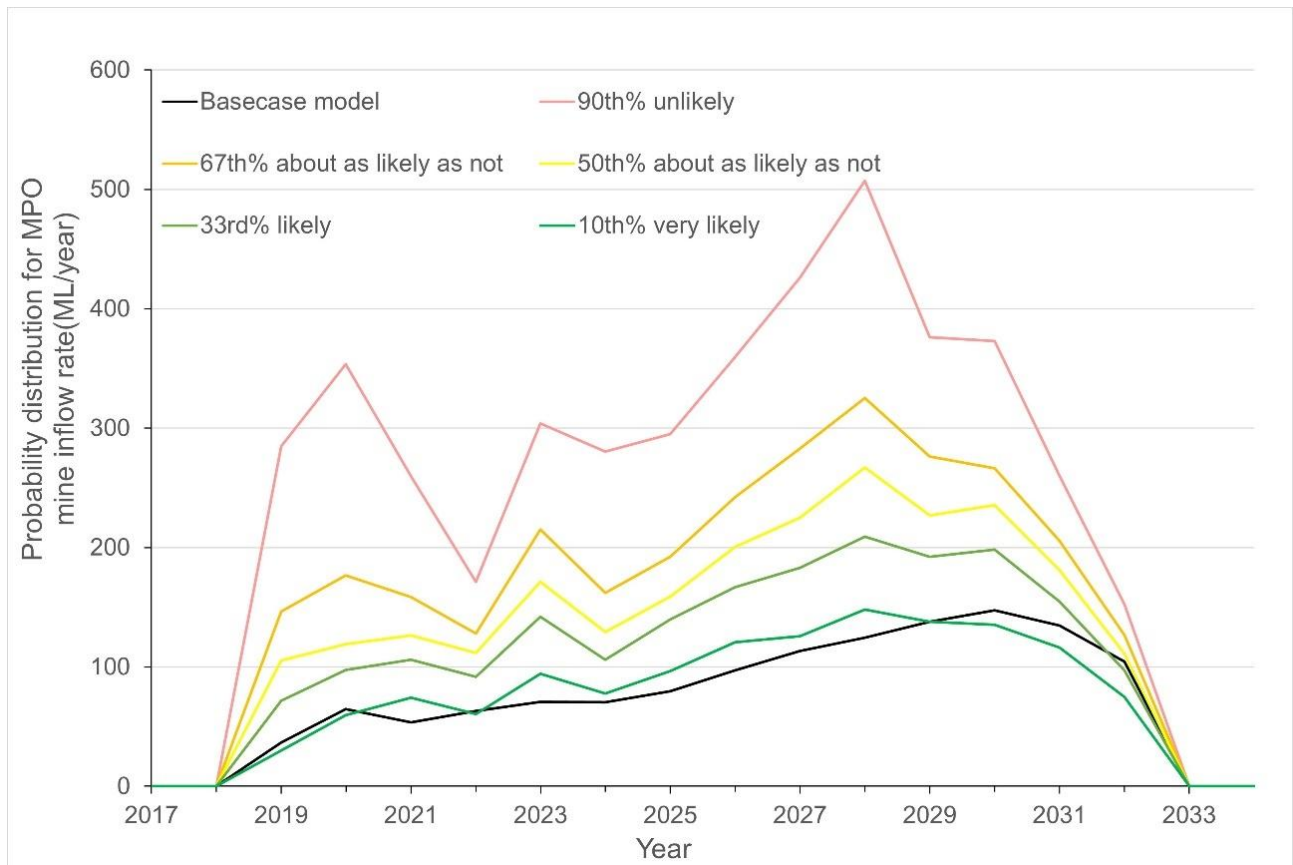


Figure 9.1 Probability distribution for MPO mine inflow rate

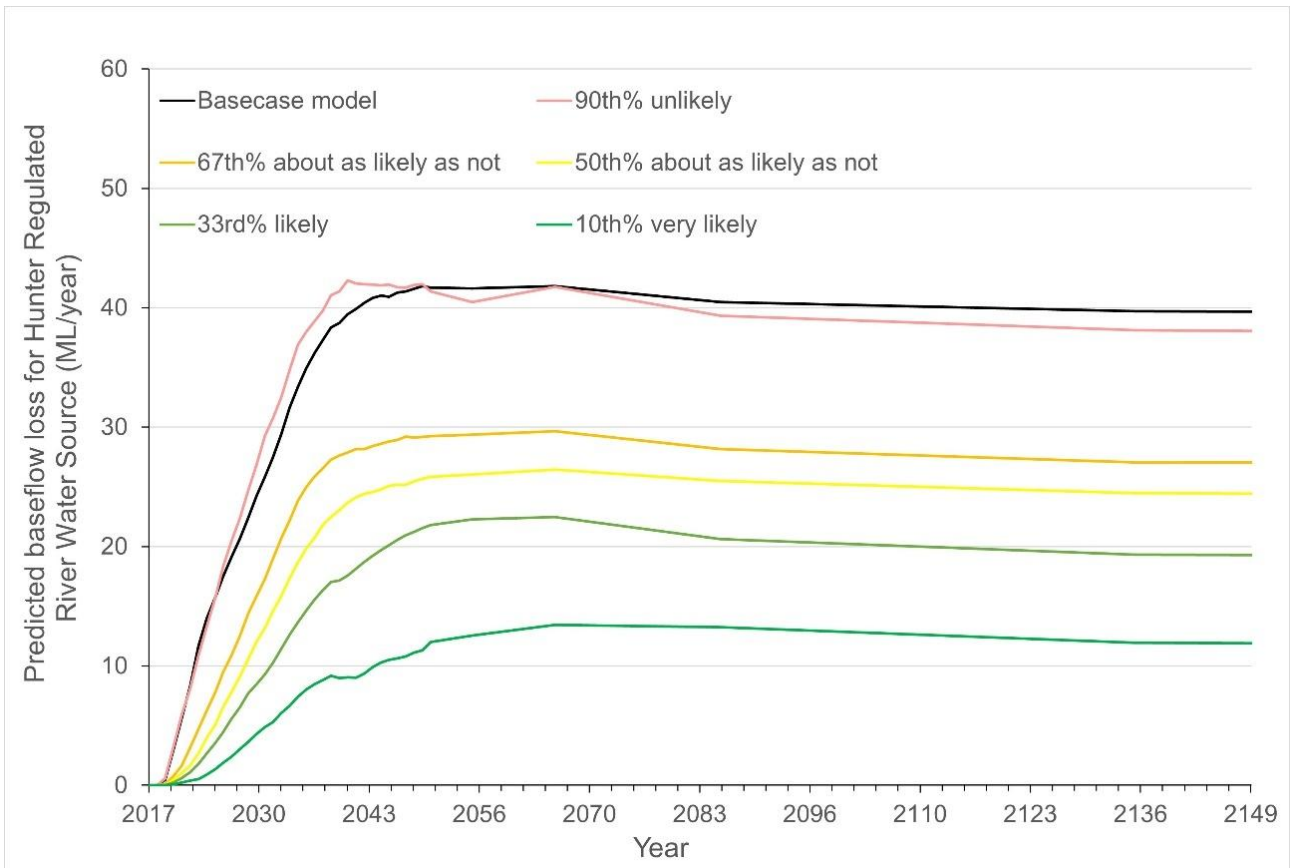


Figure 9.2 Probability distribution for rate of baseflow decline in Hunter River

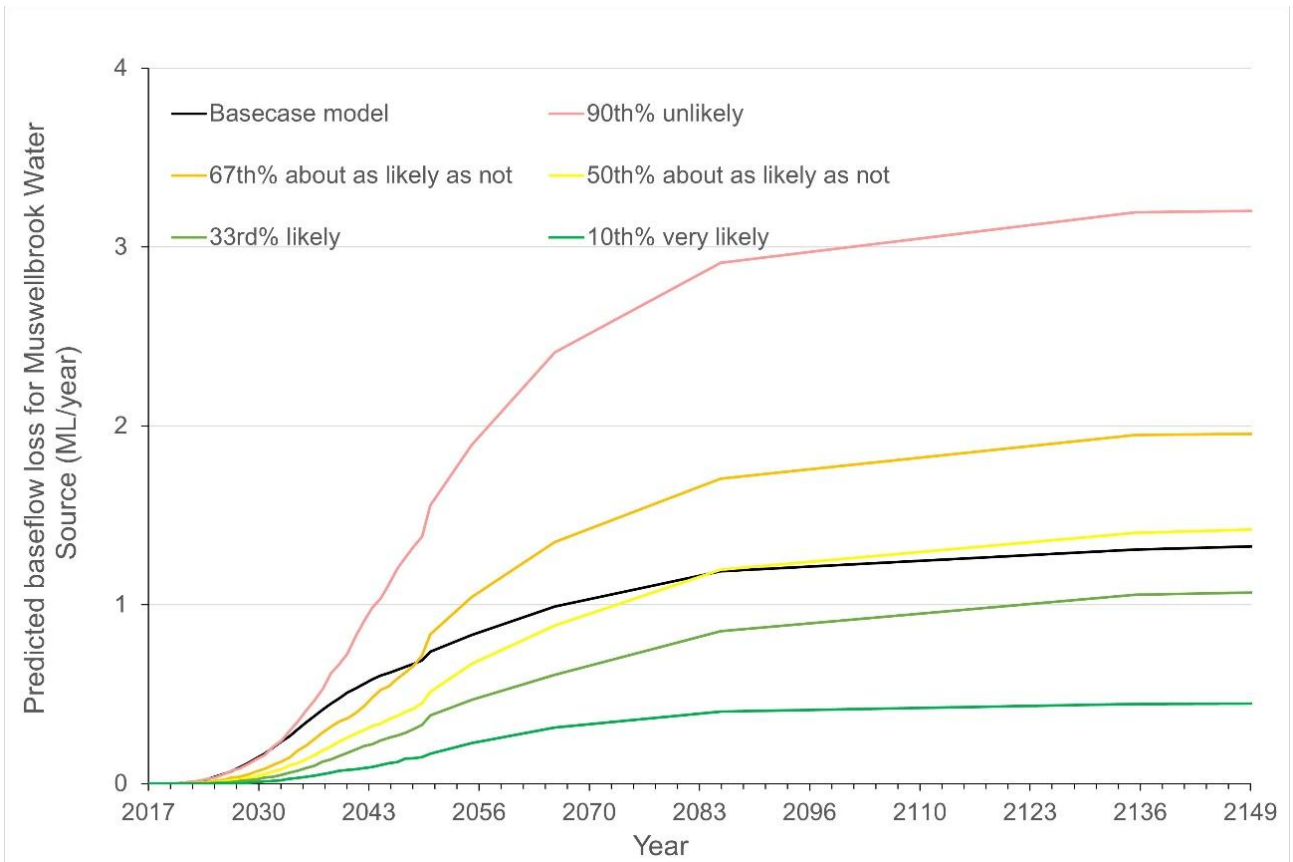


Figure 9.3 Probability distribution for rate of baseflow decline in Sandy Creek

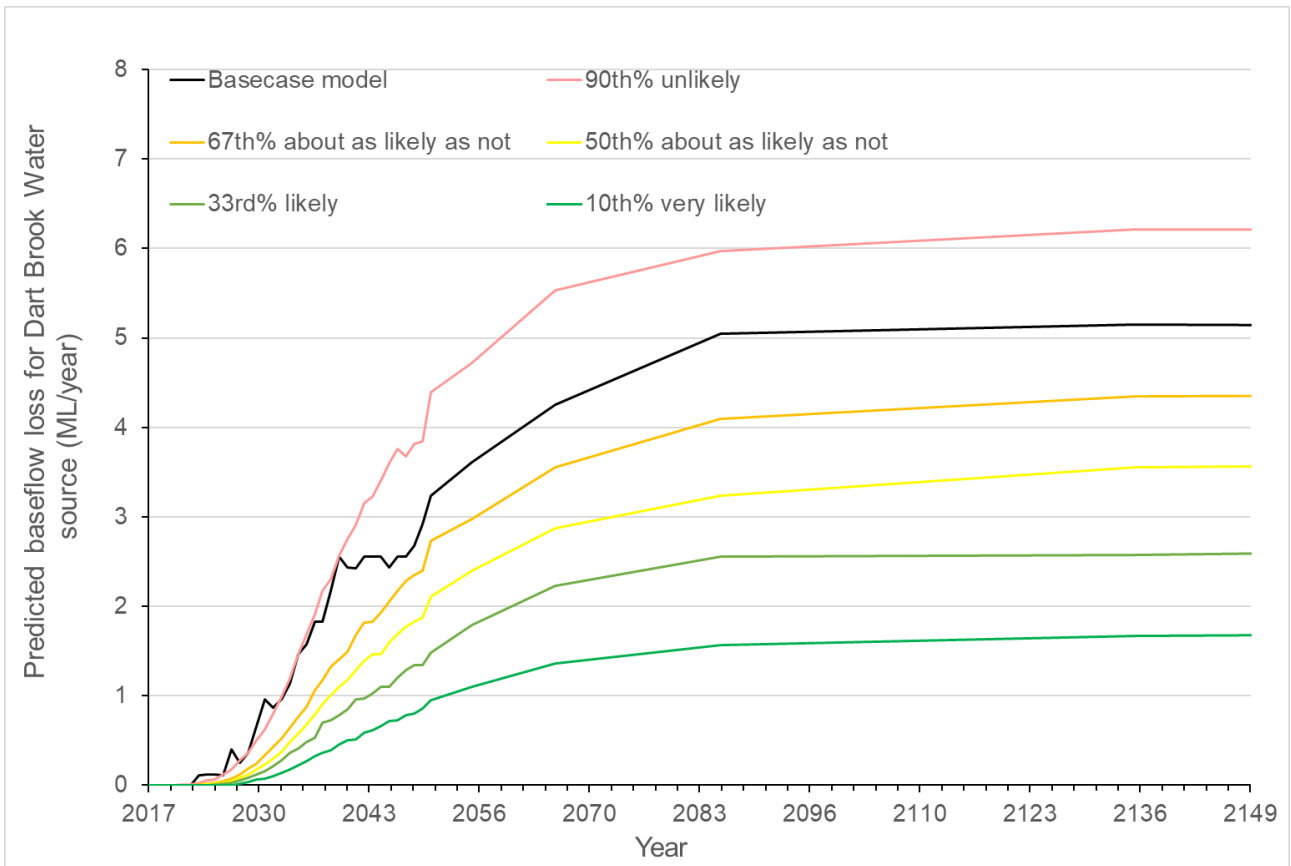


Figure 9.4 Probability distribution for rate of baseflow decline in Dart Brook

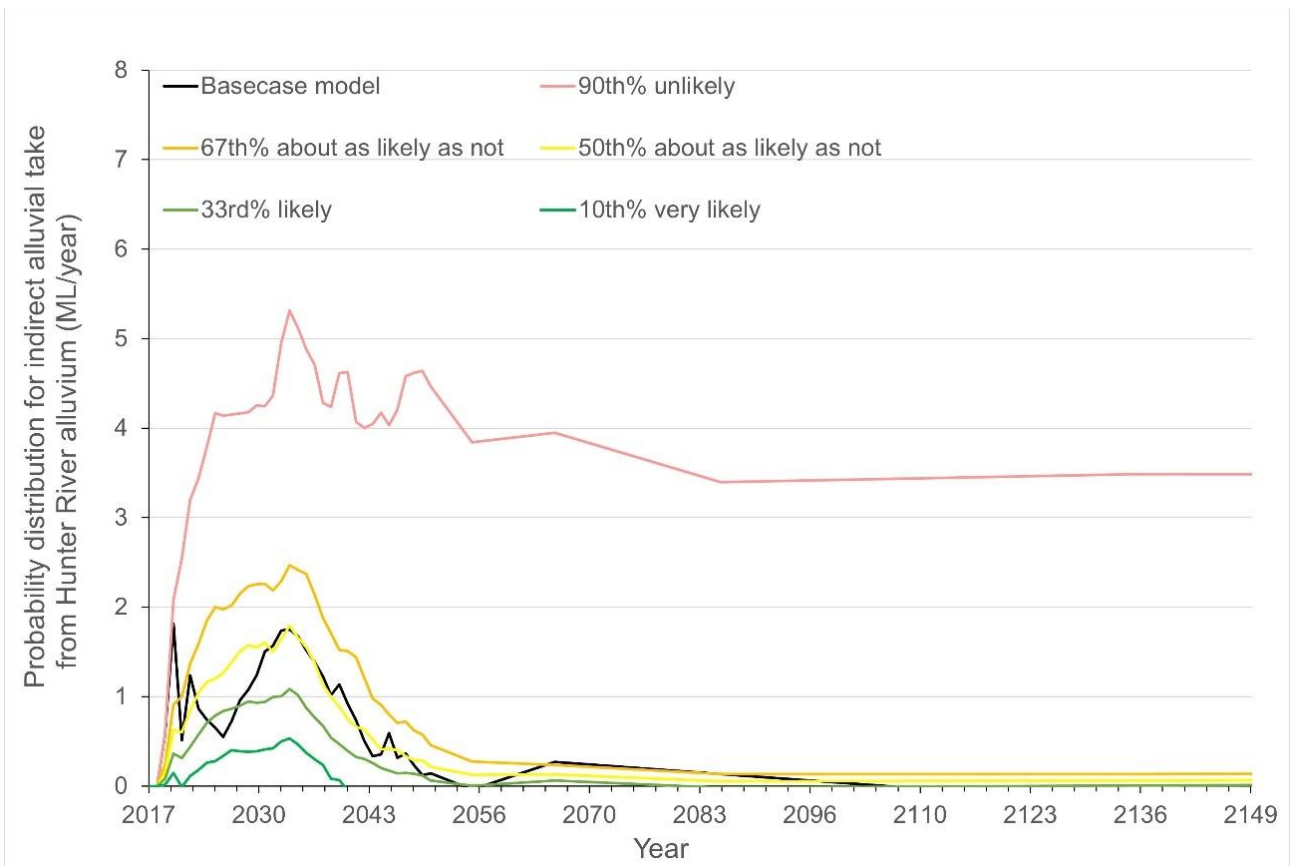


Figure 9.5 Probability distribution for indirect alluvial take from Hunter River alluvium

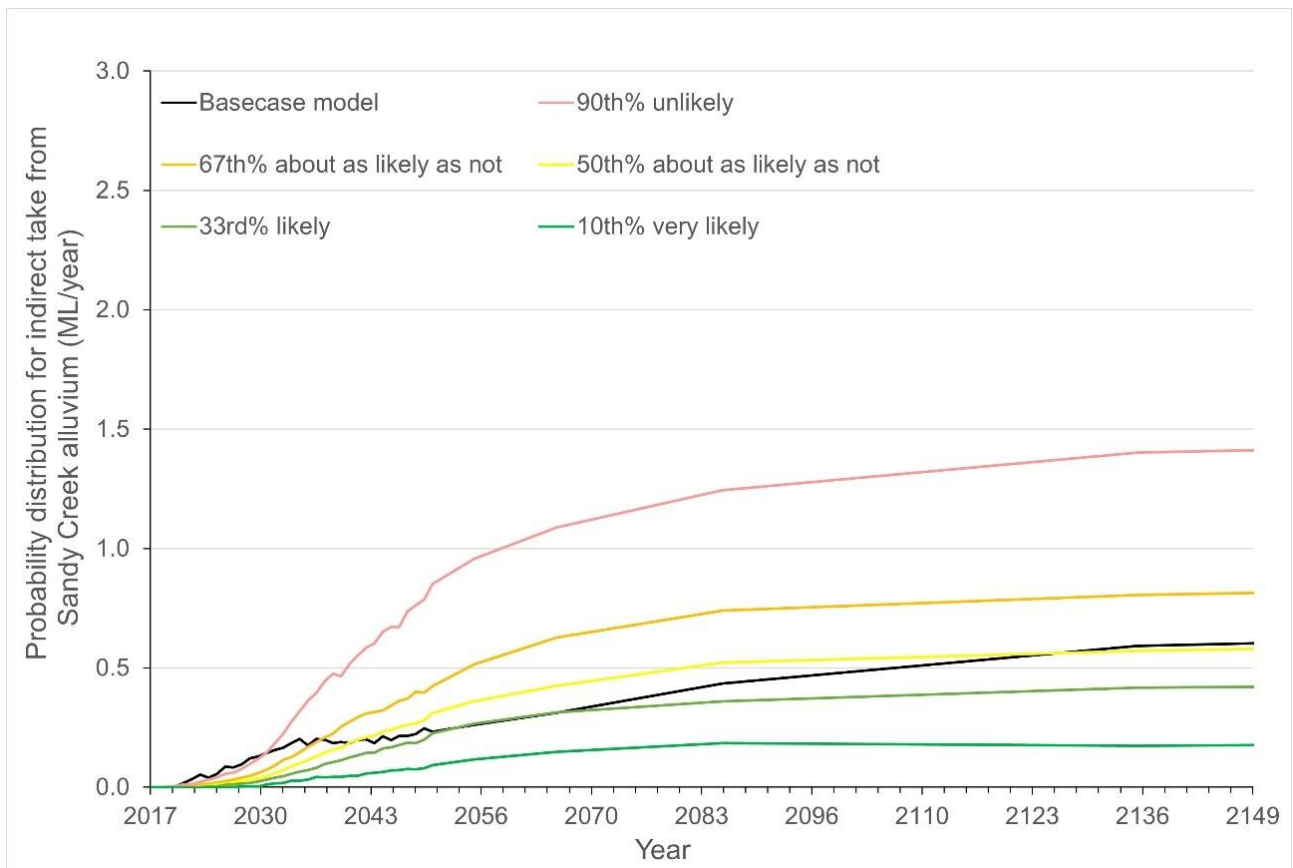


Figure 9.6 Probability distribution for indirect take from Sandy Creek alluvium

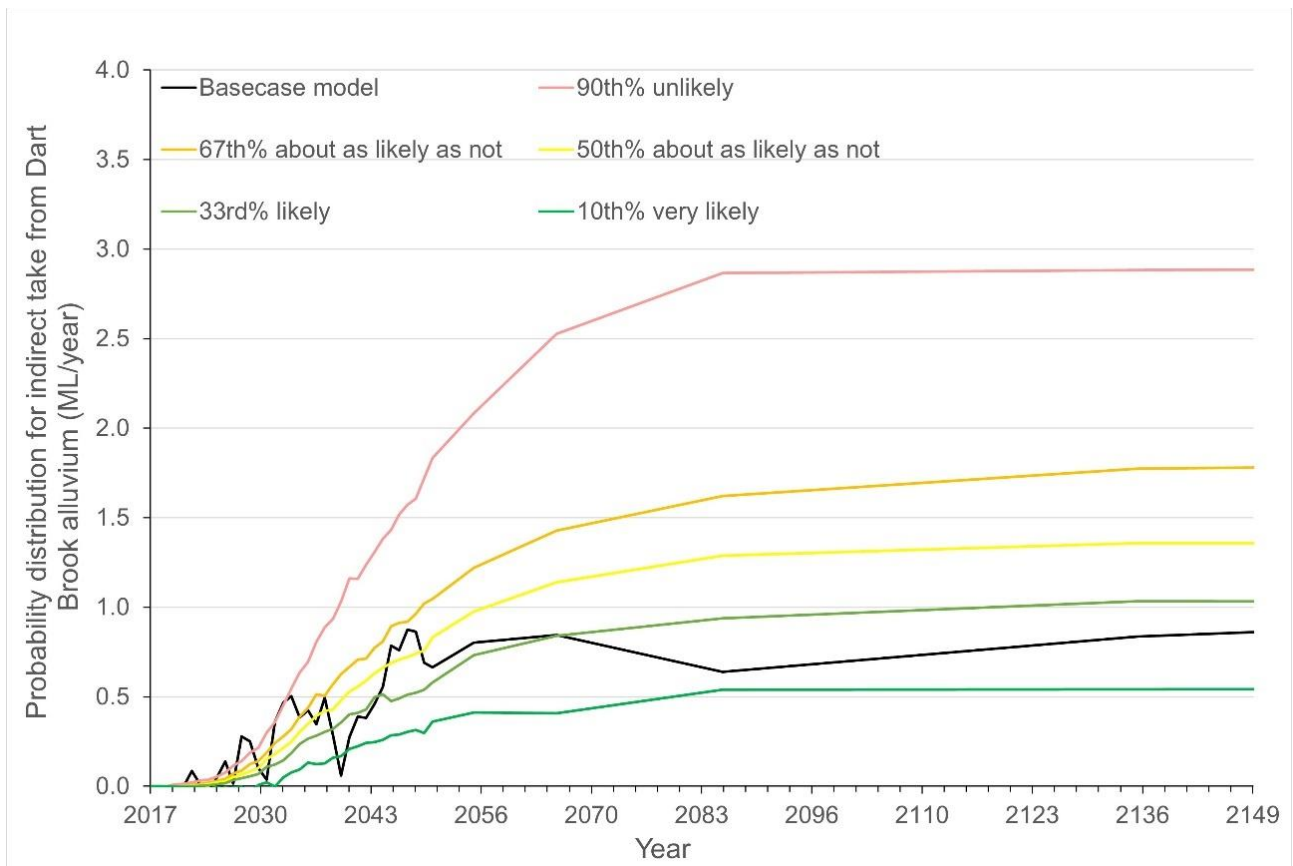
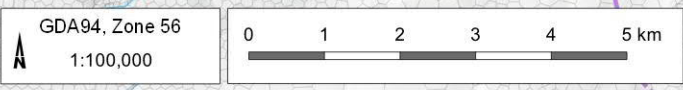
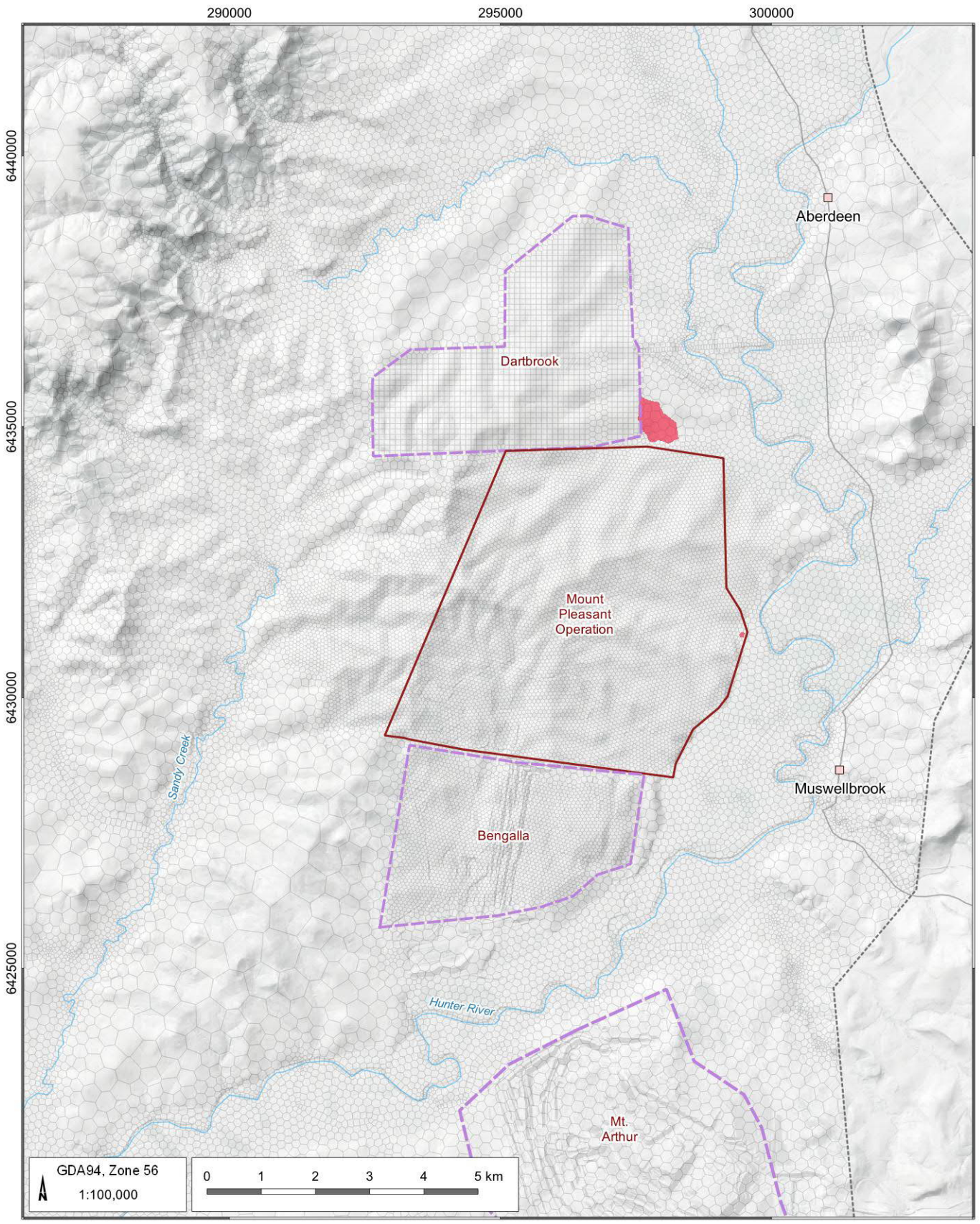


Figure 9.7 Probability distribution for indirect take from Dart Brook alluvium



- LEGEND
- Populated place
 - Drainage
 - Road
 - Basecase 2m drawdown contour
 - Mount Pleasant Operation
 - Surrounding mines
 - Model boundary
 - Grid

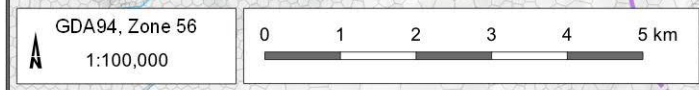
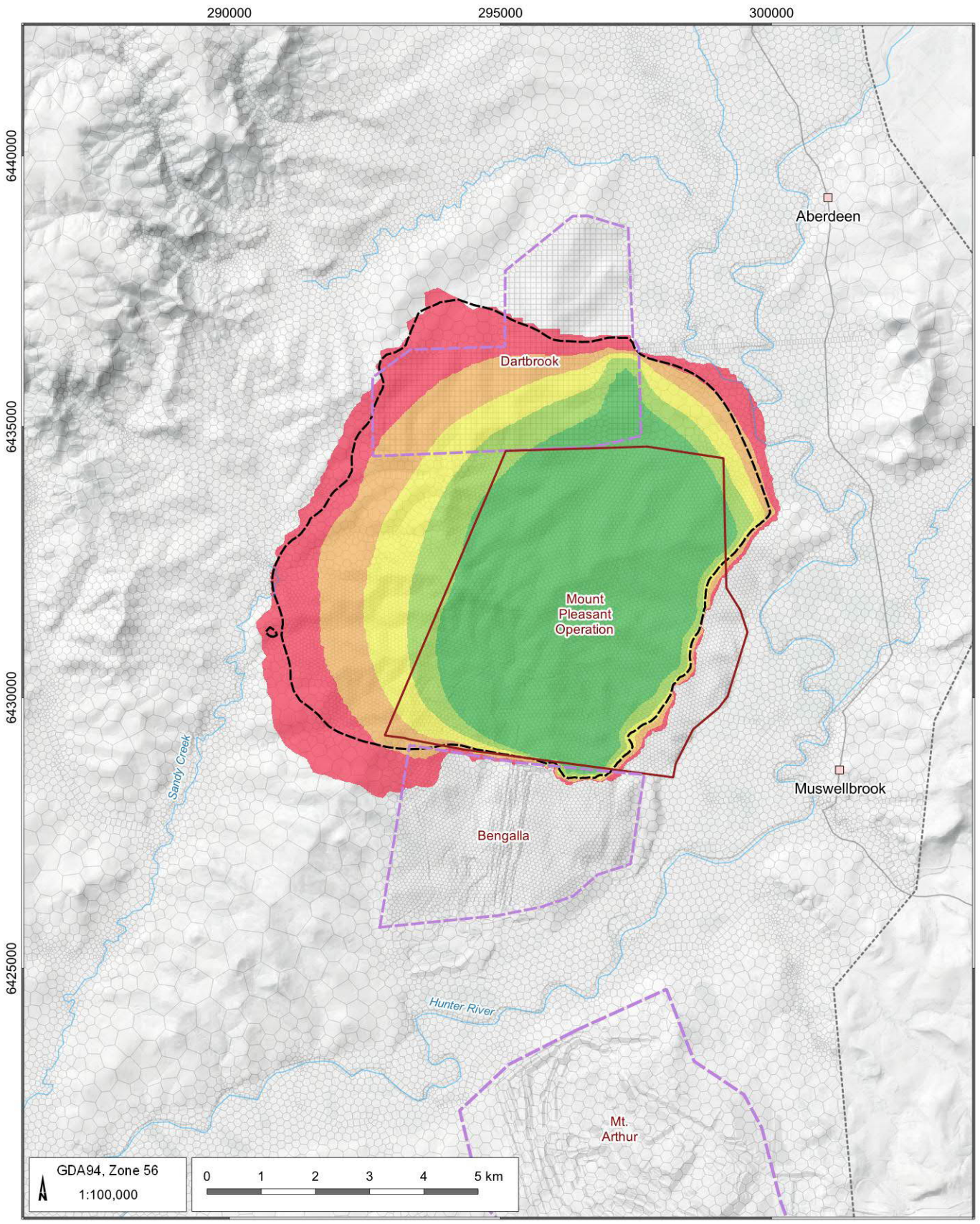
- Likelihood of 2 m drawdown**
- 0 - 10% (Very likely)
 - 10 - 33% (Likely)
 - 33 - 67% (About as likely as not)
 - 67 - 90% (Unlikely)
 - 90 - 100% (Very unlikely)

MPO MOD 8 Life of Mine Extension
(MPO5009.001)

Likelihood of 2 m drawdown at end of mining for modified MPO (up to December 2032) – Alluvium (Layers 1 and 2)

DATE: 04/07/2024

FIGURE No.: **9.8**



LEGEND

- Populated place
- Drainage
- Road
- - - Basecase 2m drawdown contour
- Mount Pleasant Operation
- - - Surrounding mines
- - - Model boundary
- Grid

- Likelihood of 2 m drawdown**
- 0 - 10% (Very likely)
 - 10 - 33% (Likely)
 - 33 - 67% (About as likely as not)
 - 67 - 90% (Unlikely)
 - 90 - 100% (Very unlikely)

MPO MOD 8 Life of Mine Extension
(MPO5009.001)

Likelihood of 2 m drawdown at end of mining for modified MPO (up to December 2032) – Edderton Seam (Layer 18)

AGE DATE: 04/07/2024 FIGURE No.: **9.9**

Convergence of the uncertainty analysis is shown below in Figure 9.10, which demonstrates that the 196 model runs that comprise the converged and calibrated models from the original 300 realisations, are enough to describe the uncertainty, and adding more runs is unlikely to change the conclusions from the analysis.

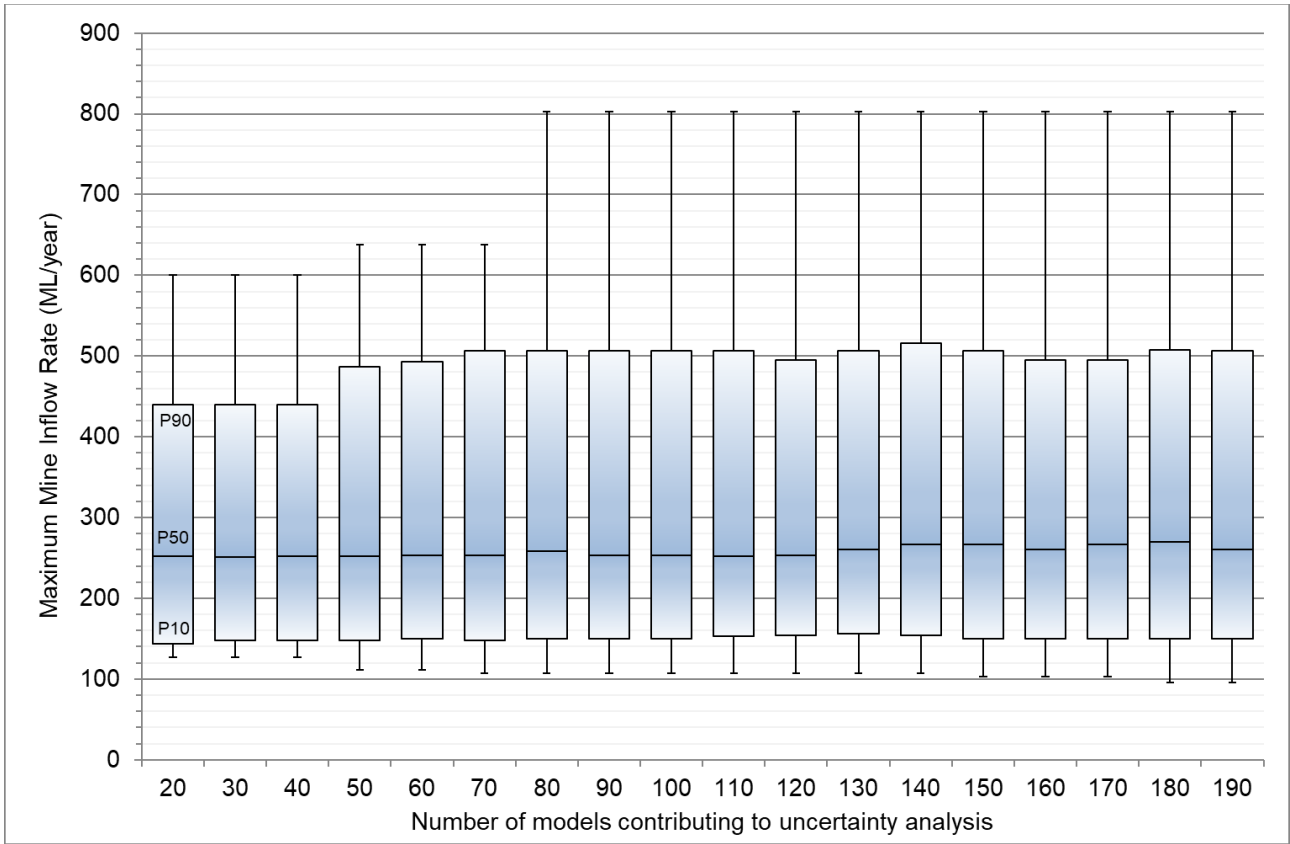


Figure 9.10 Evidence of uncertainty analysis convergence – maximum mine inflow

10 Groundwater monitoring and management

MACH currently operates the MPO in accordance with the Water Management Plan (WMP), which was prepared in consultation with NSW government agencies, updated and approved in 2025 (MACH, 2025) by the NSW Department of Planning, Housing and Infrastructure (DPHI). The WMP describes the management of environmental and community aspects, impacts and performance relevant to the site's water management system and also includes a Groundwater Management Plan (GWMP). The existing groundwater monitoring program would be continued so the potential impacts of the MPO are monitored and managed. The sections below outline aspects of the current WMP, and recommended updates (should MACH proceed with the Modification) to monitor the potential impacts of the modified MPO.

10.1 Groundwater Management Plan

The approved GWMP for the MPO outlines a monitoring program to collect groundwater levels and quality measurements and allow actual impacts to the local groundwater system to be compared against those identified in the environmental assessments. The groundwater monitoring program focusses on collecting information on potential impacts to:

- groundwater levels on neighbouring properties and any beneficial groundwater users;
- groundwater quality; and
- WAL compliance.

The approved GWMP identifies 34 active monitoring bores as shown in Figure 5.1. These 34 locations comprise monitoring bores completed in alluvial, Permian, coal seam, and older formations (Maitland Group). These bores are measured quarterly for manual water levels and in-situ pH and EC (MACH, 2025). Groundwater samples are collected annually for laboratory analysis of various parameters including physicochemical parameters, major ions, alkalinity, select nutrients, and dissolved and total metals.

In addition to the monitoring conducted for the approved WMP (MACH, 2025), MACH reviewed the groundwater monitoring program at the MPO as a part of the assessment for the Mount Pleasant Optimisation Project (SSD 10418). Following this review, MACH established additional groundwater monitoring sites in November 2019 and January 2020 and committed to further additions as outlined in the WMP (Figure 5.1) (MACH, 2025). MACH (2025) describes the following bores that were established in November 2019 and January 2020:

- a new nested site (MPBH6) to the north-east of the MPO that includes an alluvial and hard rock monitoring bore;
- two additional sites to the east of the MPO (MPBH4 and MPBH5), drilled as part of an alluvial investigation program by ENRS in February 2018 (ENRS, 2018);
- new hard rock monitoring bores at two of the existing alluvial sites to the east of the MPO (MPBH1 and MPBH2); and
- a new site to the west of the MPO (MPBH7).

MACH (2025) also describes the following bores will be added to the monitoring network:

- replacement bores:
 - paired set of bores on the south side of the tributary to Sandy Creek on the western side of the MPO near the perimeter of the dam work to replace WRA5U and WRA5L, which were removed during the construction of a dam; and
 - paired set of bores to the west of the south-west corner of the current mine pit with depths for the two bores targeting the Mount Arthur and Vaux Seams to replace 6000C000S and 6000C000L, which were destroyed in the course of mining activity.
- additional alluvial bores to monitor for drawdown in the alluvium and potential seepage:
 - one to the north-east of the MPO; and
 - one to the east of the MPO;
- paired set of bores (shallow and deep) in the vicinity of the Type 3 terrestrial GDEs identified during the assessment for the Mount Pleasant Optimisation Project (SSD 10418), targeting the overburden and the Mount Arthur Seam (the shallowest coal seam);
- a set of three vibrating wire piezometer arrays located along Wybong Road between the MPO and Bengalla Mine;
- a vibrating wire piezometer array to the west of the MPO to capture pressure changes in relevant Permian units; and
- Fines Emplacement Area bores including:
 - a paired set of bores located in the drainage just north of the Fines Emplacement Area and targeting the same strata as WRA3U/L to replace WRA3U/L; and
 - WRA2U/L, which intersect the same strata and would therefore become obsolete.

As outlined in the WMP (MACH, 2025), trigger levels will be established for the new monitoring bores when sufficient monitoring data, with a minimum of two years, is available. The following sub-sections provide details on the groundwater monitoring program for the MPO as outlined in the WMP (MACH, 2025).

10.1.1 Water level monitoring

Ongoing monitoring of groundwater bores enables natural groundwater level fluctuations (such as responses to rainfall) to be distinguished from potential groundwater level impacts due to depressurisation resulting from mining activities. Ongoing monitoring of groundwater levels can also be used to assess the extent and rate of depressurisation against model predictions.

All active existing and proposed bores would be monitored manually on a quarterly basis. Monitoring at bore locations within the mining areas for the MPO would be discontinued when those sites are destroyed by the advancing open cut.

Data from the MPO monitoring program will be supplemented with data available from the Bengalla Mine monitoring bores in the region, as required for comparison.

10.1.2 Water quality monitoring

All active existing and proposed bores would be sampled quarterly for in situ pH and EC, with samples being collected for laboratory analysis on an annual basis to test for the parameters outlined in Table 10.1.

Groundwater quality analysis will continue in order to detect any changes in groundwater quality during mining. The current quarterly monitoring frequency for pH and EC is considered adequate to monitor the potential impacts of the modified MPO on groundwater quality. In addition, the locations for annual groundwater quality suite sampling will be adjusted in future iterations of the WMP to account for mined out sites and provide adequate spatial coverage to detect the cumulative mining impacts.

Table 10.1 Parameters for annual groundwater laboratory analysis

Parameters			
General			
pH	EC	TDS	-
Major Cations and Anions			
Sodium	Potassium	Calcium	Chloride
Sulfate as SO ₄	Total Phosphorus as P	Nitrate as N	Nitrite as N
Nitrate & Nitrite as N	Ammonia as N	Total Cations	Total Anions
Ionic Balance	Acidity as CaCO ₃	Bicarbonate Alkalinity as CaCO ₃	Hydroxide Alkalinity as CaCO ₃
Total alkalinity as CaCO ₃	Carbonate alkalinity as CaCO ₃	Total Hardness as CaCO ₃	Magnesium
Trace Metals and Other			
Aluminium	Antimony	Arsenic	Barium
Beryllium	Boron	Cadmium	Chromium
Cobalt	Copper	Fluoride	Iron
Lead	Manganese	Mercury	Molybdenum
Nickel	Selenium	Silver	Strontium
Vanadium	Zinc	Reactive Silica	-

10.1.3 Groundwater inflows

Groundwater extraction for mining activities from all pumping bores would be measured by means of a flow meter attached to the bore headworks or installed in the discharge pipeline as required under the conditions of the relevant water licences.

Volumes of water pumped directly from the open cut pits would be measured by means of flow meters fitted to pipelines or recording of pumping times and rates. Water reporting to the open cut pits may include both groundwater seepage inflows and incident rainfall and runoff.

Where accurate data are available for comparison, estimates of seepage inflows to the open cut would be compared to the modelled groundwater inflows. The rainfall runoff component estimates would also be determined, where appropriate for comparison, using the rainfall records and the existing site water balance model.

Operational water balance reviews would be conducted regularly, as described in the Site Water Balance.

The model developed and used for the MPO would be used as a management tool for the periodic review and calibration of predicted groundwater impacts through the life of the MPO. The model would be progressively refined, with refinements informed by the results of the groundwater monitoring program. Revised outputs from the model would be reported in the Annual Review, as relevant over the life of the MPO, and used to inform regular site water balance reviews. The model will be peer reviewed every three years.

The observed groundwater levels would be reviewed against the model predictions on an annual basis. A suitably qualified hydrogeologist would determine when groundwater levels deviate significantly from those predicted by the model and devise potential causes for the deviations. The review will consider the impacts of mining, along with other factors that could produce the groundwater level behaviour including climatic conditions, rainfall recharge, pumping from privately-owned bores, and other mining operations.

10.1.4 Annual Review and improvement of environmental performance

In accordance with Condition 3, Schedule 5 of Development Consent DA 92/97, MACH would review and evaluate the environmental performance of the MPO for the previous calendar year by the end of March each year. The report will be submitted to the DPHI, to the satisfaction of the Planning Secretary. In relation to water, the MPO Annual Review would:

- include a comprehensive review of the groundwater monitoring results at the MPO over the past year, which includes a comparison of the results against:
 - compliance with relevant statutory requirements, limits, or performance measures/criteria;
 - monitoring results of the previous years;
 - relevant predictions in the approval documentation for the MPO; and
- identify any groundwater-related non-compliance over the past year, and describe what actions were (or are being) taken to ensure compliance;
- identify any trends in the groundwater monitoring data over the life of the MPO;
- identify any discrepancies between the predicted and actual groundwater impacts of the MPO and analyse the potential cause of any significant discrepancies; and
- describe what groundwater-related measures will be implemented over the next year to improve the environmental performance of the MPO.

The model developed and used for the MPO would be used as a management tool for the periodic review and calibration of predicted groundwater impacts through the life of the MPO. The model would be progressively refined, with refinements informed by the results of the groundwater monitoring program. Revised outputs from the model would be reported in the Annual Review, as relevant over the life of the MPO, and used to inform regular site water balance reviews. The model would also be peer reviewed every three years.

The observed groundwater levels would be reviewed against the model predictions on an annual basis. A suitably qualified hydrogeologist would determine when groundwater levels deviate significantly from those predicted by the model and the reason for this deviation. The review would consider the impact of mining, and other factors that could result in varying water levels including climatic conditions, rainfall recharge, pumping from privately-owned bores, and other mining operations.

10.1.5 Management and mitigation strategies

The WMP includes a Trigger Action Response Protocols (TARP) plan for groundwater to be implemented in the event of groundwater monitoring results being detected outside the groundwater trigger value range. The TARP also includes actions to be implemented in the event of groundwater levels in relevant alluvial monitoring bores falling below the specified trigger values, three consecutive water quality results outside of the adopted trigger values, or landholder complaints.

10.2 Additional monitoring and management

The potential groundwater impacts from the modified MPO (up to December 2032) are predicted to influence a larger area than the approved MPO at December 2026. However, the impacts would be less than those described by the MPO in the original 1997 EIS.

A number of groundwater monitoring sites already exist due to the existing mining operations at the MPO and proximity of surrounding mines, and there are additional proposed monitoring sites based on the WMP (MACH, 2025). Based on the data reviewed as part of this document, and predicted impacts of the modified MPO, the existing groundwater monitoring network, with the addition of the proposed changes outlined in MACH (2025), would be sufficient to monitor and manage the potential impacts of the modified MPO.

11 Summary and conclusions

The Mount Pleasant Operation (MPO) is an open-cut coal mine located approximately 3 km northwest of Muswellbrook in the Upper Hunter Valley, NSW. The operation is managed by MACH Mount Pleasant Operations Pty Ltd, on behalf of the Mount Pleasant Joint Venture (95% MACH Energy Australia Pty Ltd and 5% J.C.D. Australia Pty Ltd). The project operates under Development Consent DA 92/97 (granted 1999) and EPBC 2011/5795 (approved 2012). MACH Energy is seeking approval to extend the operational life of the MPO to December 2032 and to increase annual ROM coal production through operational efficiencies within the existing surface disturbance boundary. As part of the Modification application, AGE completed a GIA to evaluate potential effects of the proposed modification on groundwater levels, hydraulic connectivity, GDEs, private bores, and surface water–groundwater interactions.

A three-dimensional transient numerical groundwater flow model was developed and applied using MODFLOW-USG, employing an unstructured grid and Newton Solver to simulate complex stratigraphy, hydraulic conductivity distribution, and mine geometries. The model domain extends approximately 19 km (north–south) by 30 km (east–west), encompassing key hydrogeological units including the Permian coal measures, Triassic Narrabeen Group, and Quaternary alluvium associated with the Hunter River, Sandy Creek, and Dart Brook. The model also includes adjacent mining operations (Bengalla, Dartbrook, and Mt Arthur) to evaluate cumulative groundwater impacts.

The model was calibrated and validated against an extensive monitoring dataset. The initial calibration was undertaken by AGE (2020) and verified against over 3,700 groundwater level observations from 125 monitoring bores, achieving a Scaled Root Mean Square (SRMS) error of approximately 5%, consistent with national modelling guidelines (Barnett et al., 2012). The model was validated in March 2025 and subsequently updated to August 2025 using recent data from the MPO monitoring bore network. Validation was based on groundwater level data from 45 monitoring bores within the MPO area, spanning 2003–2025, thereby extending the temporal coverage beyond the 2020 calibration dataset.

Statistical analysis of pre-2020, post-2020, and combined datasets shows the combined RMS error of 9.5 m and SRMS of 5.7%, which is below the 10% benchmark recommended by the Australian Groundwater Modelling Guidelines (Barnett et al., 2012). While the RMS increased slightly compared to the 2020 calibration (8.4 m), the expanded dataset incorporated a broader range of groundwater levels (87.35–263.9 m AHD) due to newly established monitoring bores. Validation hydrographs demonstrate that the model successfully reproduces observed groundwater level trends and spatial drawdown patterns. Localised deviations are within acceptable limits and largely attributed to conservative assumptions and simplified vertical layering, which tend to overestimate vertical hydraulic connectivity. Overall, the model remains robust, well-calibrated, and reliable for impact prediction and groundwater management within the MPO domain.

Predictive simulations were undertaken for both the Approved Project and Modified Project scenarios for the period 1990–3049, with mining commencing in 1995 (start of mining at Dartbrook Mine) and concluding in the MPO in 2032. Post mining recovery simulations extend though to 3049. Model outputs indicate that:

- Additional drawdown due to the Modification is spatially limited, typically <2 m beyond the existing area of influence, with cumulative drawdown largely driven by regional mining activities.
- Indirect take from alluvial aquifers is minimal, peaking at 1.8 ML/year (Hunter River alluvium) and <1 ML/year (Sandy Creek and Dart Brook) post-mining.
- Baseflow reduction to/from the Hunter River is predicted to peak at approximately 42 ML/year, which is <0.05% of mean annual flow and therefore hydrologically insignificant.
- Six registered private bores are predicted to experience drawdown >2 m under the cumulative scenario; of these, only two (CAS1_G and JLON1) are attributable to the Modified MPO, both of which are low-yield or inactive.
- Groundwater-dependent ecosystems (GDEs) are predicted not to experience measurable drawdown impacts.
- Groundwater quality impacts are expected to remain negligible, with seepage and salinity managed under the existing Fines Emplacement and water management framework.
- MACH Energy holds sufficient Water Access Licences (WALs) under the Water Management Act 2000 (NSW) to account for all direct and indirect groundwater take consistent with the NSW Aquifer Interference Policy (AIP).

A Monte Carlo uncertainty analysis (n = 300 realisations) was conducted to assess the propagation of hydraulic property uncertainty. The results indicate that predicted mine inflows (mean 507 ML/year) and drawdown extents remain within conservative bounds and below licensing entitlements under all realisations.

MACH operates the MPO under the 2025 Water Management Plan (WMP), including the Groundwater Management Plan (GWMP), which establishes the framework for monitoring and managing environmental and water-related impacts. The groundwater monitoring program, comprising 34 active bores across alluvial, coal seam, and Permian formations, includes quarterly water level measurements, annual water quality sampling, and comparison of extraction/inflows against model predictions. A Trigger Action Response Protocol (TARP) ensures timely management of any deviations or water quality exceedances.

Overall, the modified MPO is predicted to cause only a slight expansion of the drawdown area compared to the approved project, with impacts remaining well below those predicted in the 1997 EIS. With the current and planned monitoring program, potential groundwater impacts are considered effectively managed, ensuring ongoing protection of the regional groundwater system and associated ecosystems.

12 References

- Australasian Groundwater and Environmental Consultants Pty Ltd (AGE), 2013a. "Continuation of Bengalla Mine Groundwater Impact Assessment". Prepared for Hansen Bailey Pty Ltd June 2013.
- Australasian Groundwater and Environmental Consultants Pty Ltd (AGE), 2013b. Bylong Coal Project Gateway Certificate Application Supporting Document, Appendix E Groundwater Impact Assessment. Prepared for Bylong Coal Pty Ltd. January 2014.
- Australasian Groundwater and Environmental Consultants Pty Ltd (AGE), 2014. "Report on West Muswellbrook Project gateway application. Highly Productive aquifer groundwater impact assessment". Prepared for Muswellbrook Coal Company Limited.
- Australasian Groundwater and Environmental Consultants Pty Ltd (AGE), 2020. "Report on Mount Pleasant Optimisation Project Groundwater Impact Assessment" Prepared for Mach Energy Australia Pty Ltd, Project G1970A, December 2020.
- ANZECC/ARMCANZ, 2000. "Australian and New Zealand Guidelines for Fresh and Marine Water Quality". Australian and New Zealand Governments and Australian state and territory governments, Canberra ACT, Australia. Revised in 2018, with data available at www.waterquality.gov.au/anz-guidelines.
- ANZG, 2019. "Australian and New Zealand Guidelines for Fresh and Marine Water Quality". Australian and New Zealand Governments and Australian state and territory governments, Canberra ACT, Australia. Available at www.waterquality.gov.au/anz-guidelines.
- Aquaterra, 2009. "Ashton South East Open Cut Project Hydrogeological Impact Assessment". Prepared for Ashton Coal Operations Pty Limited 2013.
- ATC Williams, 2017. Mount Pleasant Operation Fines Emplacement Plan. Prepared for MACH Energy Australia Pty Ltd.
- ATC Williams, 2025. "Mount Pleasant Operation Modification 8 Surface Water Assessment".
- Barnett, B, Townley, LR, Post, V, Evans, RE, Hunt, RJ, Peeters, L Richardson, S, Werner, AD, Knapton, A, & Boronkay, A, 2012. "Australian groundwater modelling guidelines", Waterlines report, National Water Commission, Canberra.
- Bio-Analysis, 2020. "Mount Pleasant Optimisation Project Aquatic Ecology Report". Prepared for MACH Energy Australia Pty Ltd.
- Commonwealth Bureau of Meteorology, 2024. "Groundwater Dependent Ecosystem Atlas".
- Commonwealth Department of Climate Change, Energy, the Environment and Water, 2022. "Significant Impact Guidelines 1.3: Coal seam gas and large coal mining developments - impacts on water resources".
- Dawes WR, Herron NF, Macfarlane C, Rachakonda PK, Henderson BL, Ford JH, Wilkes PG, Marvanek SP & Ramage A, 2018. "Conceptual modelling for the Hunter subregion. Product 2.3 for the Hunter subregion". Prepared for the Northern Sydney Basin Bioregional Assessment. Department of the Environment and Energy, Bureau of Meteorology, CSIRO and Geoscience Australia, Australia. <http://data.bioregionalassessments.gov.au/product/NSB/HUN/2.3>.
- Department of Industry, 2018. "Applying the High Ecological Value Aquatic Ecosystem (HEVAE) Framework to Riverine Ecosystems".
- Department Planning and Environment, 2022a. "Groundwater Assessment Toolbox for Major Projects in NSW - Overview Document".

- Department Planning and Environment, 2022b. "Minimum Groundwater Modelling Requirements for SSD/SSI Projects".
- Department Planning and Environment, 2022c. "Guidelines for Groundwater Documentation for SSD/SSI Projects. Technical Guideline".
- Department Planning and Environment, 2022d. "Cumulative Groundwater Impact Assessment Approaches".
- Doherty, J, 2010. "PEST – Model independent parameter estimation user manual: 5th edition", Watermark Numerical Computing, Corinda, Australia.
- Doody TM, Hancock PJ, & Pritchard JL, 2018. "Assessing Groundwater-Dependent Ecosystems: IESC Information Guidelines Explanatory Note". A report prepared for the Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development through the Department of the Environment and Energy.
- Eco Logical Australia, 2013. "Continuation of the Bengalla Mine – Stygofauna Assessment 2013".
- ENRS, 2018. "Alluvial Drilling Report - Mount Pleasant Operation, report number ENRS0653". Prepared for MACH Energy Australia Pty Ltd, March 2018.
- ERM Mitchell McCotter, 1997. "Mount Pleasant Mine Environmental Impact Statement". Prepared for Coal & Allied Operations Pty Ltd. September 1997.
- ERM Mitchell McCotter, 1999. "Mount Pleasant Mine Commission of Inquiry – Submission in Reply". For Office of the Commissioners of Inquiry for Environment and Planning. February 1999.
- FAO, 2013. Food and Agricultural Organisation of the United Nations: <http://www.fao.org/docrep/t0667e/t0667e05.htm>.
- Geoscience Australia, 2019. Australian Stratigraphic Units Database. http://dbforms.ga.gov.au/pls/www/geodx.strat_units.int, accessed March 2019.
- Glen RA, & Beckett J, 1993. "Hunter Coalfield Regional Geology 1:100 000, 2nd edition". Geological Survey of New South Wales, Sydney.
- Groundwater Imaging, 2016. "AgTEM Alluvium and Subcrop Investigation at Mount Pleasant". Report for MACH Energy Australia Pty Ltd. December 2016.
- Hancock, P. J. and Boulton, A. J., 2008. "Stygofauna biodiversity and endemism in four alluvial aquifers in eastern Australia". *Invertebrate Systematics* 22: 117-126.
- Hancock, P. J. and Boulton, A. J., 2009. "Sampling groundwater fauna: efficiency of rapid assessment methods tested in monitoring wells in eastern Australia". *Freshwater Biology* 54: 902-917.
- Henderson BL, Hayes KR, Mount R, Schmidt RK, O'Grady A, Lewis S, Holland K, Dambacher J, Barry S & Raiber M, 2016. "Developing the conceptual model of causal pathways. Submethodology M05 from the Bioregional Assessment Technical Programme". Department of the Environment and Energy, Bureau of Meteorology, CSIRO and Geoscience Australia, Australia.
- Hose, G. and Turak, E, 2004. "River Health in the New South Wales Lower North Coast, Hunter and Central Coast Catchments". Report prepared for the New South Wales Environment Protection Authority.
- Hunter Eco, 2025. "Mount Pleasant Operation Modification 8 Groundwater Dependent Ecosystems Assessment".
- HydroSimulations, 2013. "Spur Hill Underground – Gateway Application: Preliminary Groundwater Assessment". Report for Spur Hill Management, document HC2013-14, November 2013.

- HydroSimulations, 2015. "Spur Hill Underground – Groundwater Assessment for Gateway Application Presentation to CCC". June 2015. <http://www.spurhillunderground.com.au/images/pdfs/Groundwater%20CCC%20Presentation.pdf>.
- HydroSimulations, 2019. "Mount Pleasant Project – Groundwater Assessment". Report HS2017/27a. August 2019.
- Independent Expert Scientific Committee on Unconventional Gas Development and Large Coal Mining Development, 2024a. "Information Guidelines for Proponents preparing Coal Seam Gas and Large Coal Mining Development Proposals".
- Independent Expert Scientific Committee on Unconventional Gas Development and Large Coal Mining Development, 2024b. "Information Guidelines Explanatory Note: Using impact pathway diagrams based on ecohydrological conceptualisation in environmental impact assessment".
- Macfarlane C, Rachakonda PK, Herron NF, Marvanek SP, Wang J, Moore B, Bell J, Slegers S, Mount RE and McVicar TR, 2016. "Description of the water-dependent asset register for the Hunter subregion. Product 1.3 for the Hunter subregion". Prepared for the Northern Sydney Basin Bioregional Assessment. Department of the Environment, Bureau of Meteorology, CSIRO and Geoscience Australia, Australia. <http://data.bioregionalassessments.gov.au/product/NSB/HUN/1.3>.
- MACH Energy, 2017. "Mount Pleasant Operation Bore Census Report". April 2017.
- MACH Energy, 2025. "Mount Pleasant Operation Water Management Plan". Prepared by MACH Energy Australia Pty Ltd.
- Mackie Environmental Research, 2006. "Mt Arthur Underground Project Environmental Assessment - Groundwater Management". Prepared for BHP Billiton Pty Ltd, 2007.
- Mackie Environmental Research, 2007. "Anvil Hill Project: Groundwater Management Studies". Report for Centennial Hunter Pty Ltd, May 2006.
- Mackie Environmental Research, 2013. "Assessment of Groundwater Related Impacts Arising from the Proposed Bulga Optimisation Project". Report for Bulga Coal Management, April 2013.
- Malabar Coal Limited, 2019. "Maxwell Project Environmental Impact Statement". <https://majorprojects.planningportal.nsw.gov.au/prweb/PRRestService/mp/01/getContent?AttachRef=SSD-9526%2120190808T070743.846%20GMT>.
- Middlemis H & Peeters LJM, 2018. "Explanatory Note, Uncertainty Analysis in Groundwater Modelling". A report prepared for the Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development through the Department of the Environment and Energy.
- National Health and Medical Research Council, 2011. "Australian Drinking Water Guidelines 6 2011". Version 3.5, Updated August 2018.
- New South Wales Government, 2012. "Aquifer Interference Policy", NSW Government policy for the licensing and assessment of aquifer interference activities. Department of Primary Industries.
- New South Wales Government, 2024. "Groundwater and the environment: Groundwater dependent ecosystems. Assessing the ecological value of groundwater dependent ecosystems". Website: <https://water.dpie.nsw.gov.au/our-work/science-data-and-modelling/groundwater-management-and-science/groundwater-and-the-environment>.
- Papadopoulos SS, 2022. "User guide for mod-PATH3DU", S.S. Papadopoulos and Associates, Bethesda, Maryland Waterloo, Ontario, October 2022.
- PPK, 1997. Mount Pleasant Mine Environmental Impact Statement. Prepared for Coal & Allied Operations Pty Ltd.

- Peeters LJM, and Middlemis H, 2023. "Information Guidelines Explanatory Note: Uncertainty analysis for groundwater modelling". A report prepared for the Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development through the Department of Climate Change, Energy, the Environment and Water.
- Queensland Department of Environment, Science and Innovation, 2024. "SILO Climate Data", accessed at <https://www.longpaddock.qld.gov.au/silo/>, January 1889 to January 2024.
- Richardson S, Irvine E, Foend R, Boon P, Barber S, and Bonneville B, 2011. "Australian groundwater-dependent ecosystems toolbox part 1: Assessment framework". Waterlines Report 69. Canberra, Australia: Waterlines.
- Tomlinson and Boulton, 2010. Ecology and management of subsurface groundwater dependent ecosystems in Australia – a review. *Marine and Freshwater Research*, 61(9), 936–949.
- Watts, C. H. S., Hancock, P. J. and Leys, R., 2007. "A stygobitic *Carabhydrus* Watts (Dytiscidae, Coleoptera) from the Hunter Valley in New South Wales, Australia". *Australian Journal of Entomology* 46: 56-59.

13 Glossary and acronyms

AGE	Australasian Groundwater and Environmental Consultants Pty Ltd
AHD	Australian Height Datum
AIP	Aquifer Interference Policy
CRD	Cumulative Rainfall Departure
GDE	Groundwater Dependent Ecosystem
IESC	Independent Expert Scientific Committee on Unconventional Gas Development and Large Coal Mining Development
MPO	Mount Pleasant Operation
MACH	MACH Energy Australia Pty Ltd
ML	Megalitres
MNES	Matters of National Environmental Significance
Mtpa	Million tonnes per annum
TDS	Total Dissolved Solids
VWP	Vibrating wire piezometer

Appendix A

Numerical modelling report

A1 Model objectives

The model has been developed to address the following objectives of this GIA:

- replicate the historical behaviour of the groundwater regime;
- predict the changes in groundwater levels and flows due to the proposed mining at the modified MPO;
- predict the cumulative changes to groundwater levels and flows due to the modified MPO and surrounding mining operations;
- predict potential impacts of the modified MPO to existing users including GDEs; and
- predict take from various water sources for estimating licence requirements.

A2 Model details

A2.1 Model software and complexity

Groundwater modelling has taken into account the Murray-Darling Basin Commission (MDBC) Groundwater Flow Modelling Guideline (MDBC, 2001) as well as the Australian Groundwater Modelling Guidelines (Barnett *et al.*, 2012). Under the earlier MDBC modelling guideline, the model is best categorised as an Impact Assessment Model of medium complexity. That earlier guide (MDBC, 2001) describes this model type as follows:

“Impact Assessment model – a moderate complexity model, requiring more data and a better understanding of the groundwater system dynamics, and suitable for predicting the impacts of proposed developments or management policies.”

Under the more recent (Barnett *et al.*, 2012) guidelines, this model would be classified as a Confidence Level 2 groundwater model, with the following key indicators (based on Table 2-1 of Barnett *et al.*, 2012):

- rainfall and evaporation data are available for the site (Level 3);
- groundwater head observations and bore logs are available and with a good coverage around the MPO and relevant nearby mines, but without spatial coverage throughout the model domain (Level 2);
- streamflow data and baseflow estimates available at a few points (Level 2);
- seasonal fluctuations reasonably replicated in many parts of the model domain (Level 2, possibly 3);
- scaled RMS error and other calibration statistics, e.g. mean residual, are acceptable (Level 3); and
- suggested use is for prediction of impacts of proposed developments in aquifers with a medium to high value (Level 2).

Numerical modelling has been undertaken using the MODFLOW-USG code (Panday *et al.* 2015). MODFLOW-USG is widely used code for groundwater modelling and is presently considered an industry standard.

A2.2 Model grid

The model grid covers the MPO and surrounding mining operations (e.g. Bengalla Mine, Dartbrook Mine, Mt Arthur Coal Mine). The model domain is approximately 19 km wide (west to east direction) and 30 km long (north to south direction) as shown in Figure A2.1. The active model extent is limited by the outcrop of Maitland Group units to the east. The Maitland Group is the unit below the deepest seam at the MPO. The Mount Ogilvie fault is used as a model boundary in the south-west of the model domain and is simulated as a no-flow boundary. The nearest model edge to the MPO is 9 km which is considered sufficient to avoid the boundary condition assigned at the model extent affecting the key predicted impacts.

The boundary conditions assigned at the model extents are also presented in Figure A2.1. The General Head Boundary (GHB) is assigned to model layers representing coal seams at the northern and southern model extents and allows for the transfer of water into and out of the model domain. The remaining model extents are considered no flow boundaries.

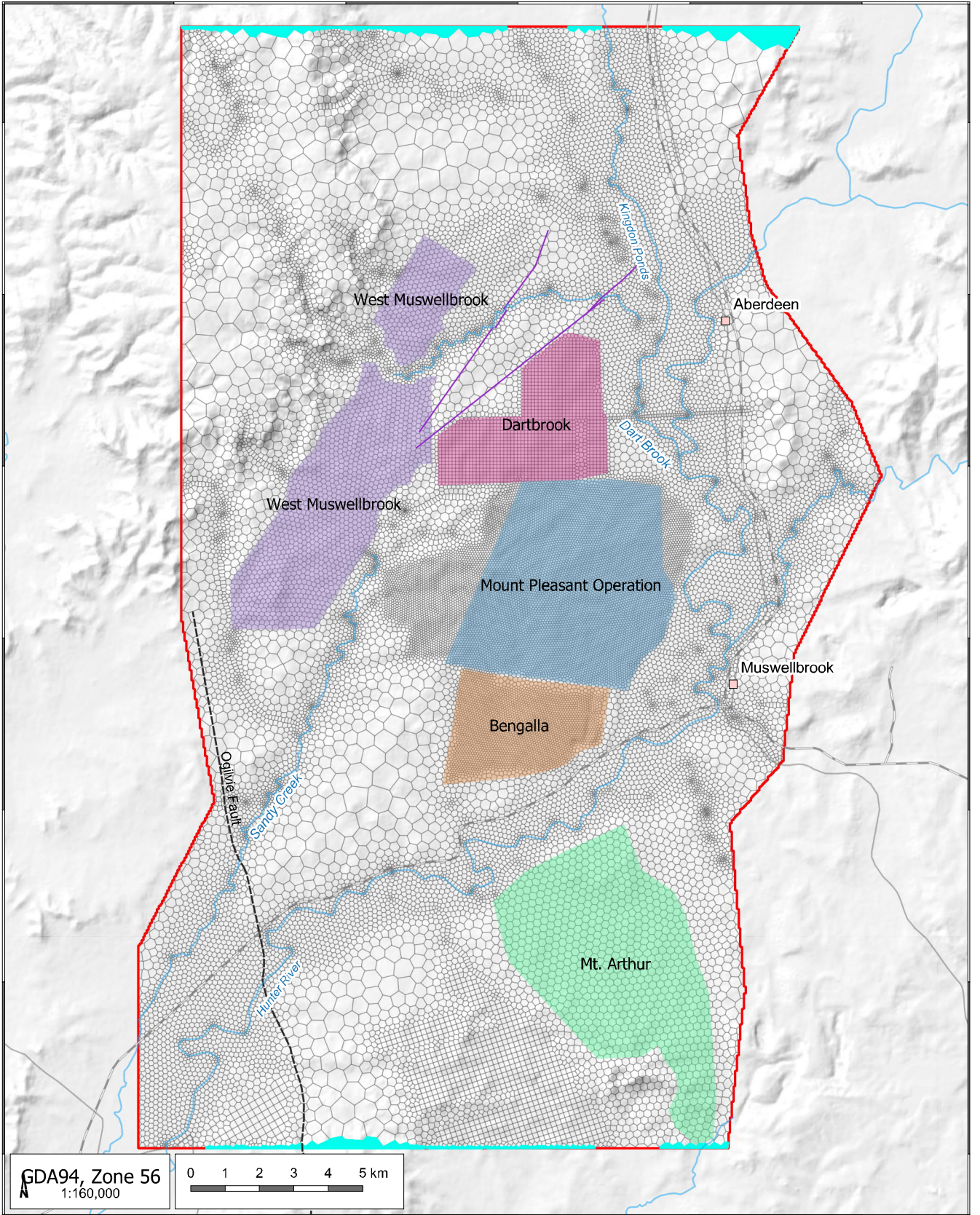
The model domain is discretised and arranged into 20 layers comprising 32,915 cell nodes in each layer. The dimensions of the cells have been varied to represent different levels of detail throughout the model domain. The specific features where cells were refined to smaller sizes are listed below:

- open cut and underground mining areas – 100 m x 100 m to 300 m x 100 m;
- streams and alluvial flood plains – from 100 m x 100 m to 200 m x 200 m cells;
- Dartbrook Mine Hunter Tunnel (under Hunter River) – 100 m x 100 m; and
- up to 700 m cell sizes in more peripheral areas.

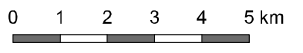
The model layers represent the major hydrostratigraphic units including shallow geological units as well as the major coal seams and interburden.

285000 290000 295000 300000 305000

6445000
6440000
6435000
6430000
6425000
6420000
6415000



GDA94, Zone 56
1:160,000



LEGEND

- Populated place
- Road
- Rail
- Olgilvie Fault
- Major Dyke
- Drainage
- Grid
- Bengalla
- Dartbrook
- Mount Pleasant Operation
- Mt. Arthur
- West Muswellbrook
- General head boundary
- No-Flow Boundary

MPO MOD 8 Life of Mine Extension
(MPO5009.001)

Model extent and mesh



AGE

DATE
13/10/202

FIGURE
A 2.1

A2.2.1 Model layers

The model uses 20 layers to represent the key hydrostratigraphic horizons from the Quaternary alluvium down to deeper Permian formations. The layers were based on horizons in available from the MPO site geological model based on drill hole data from exploration drilling and extrapolated beyond the limit of geological model using publicly available data and experience. AGE considers this to be adequate to meet the model objectives. The model layering is summarised in Table A2.1.

It should be noted that all model cells within each layer are active and assigned to one hydrostratigraphic unit. Where the hydrostratigraphic unit sub-crops and effectively disappears, the assigned thickness is reduced to 5 cm. To make the model more representative of the geology, hydraulic properties have been assigned from the major unit beneath these areas where the hydrostratigraphic unit being represented by the model layer does not exist.

Table A2.1 Model layers

Layer	Represents
1 and 2	Surficial alluvium and weathered zone/regolith
2	Weathered overburden
3	Overburden
4	Warkworth Seam
5	Interburden 1
6	Mount Arthur Seam (and Kayuga Seam at Dartbrook Mine)
7	Interburden 2
8	Piercefield Seam
9	Interburden 3
10	Vaux Seam
11	Interburden 4
12	Broonie Seam
13	Interburden 5
14	Bayswater Seam
15	Interburden 6
16	Wynn Seam
17	Interburden 7
18	Edderton Seam
19	Vane Subgroup/Saltwater Creek Formation
20	Maitland Group and older units

A2.2.2 Timing

The numerical groundwater model simulates groundwater flow from 1990 to 3049 as follows:

- Last day of 1990 – steady state stress period;
- 1991 to the end of 2010 – 21 x annual stress periods;
- 2011 to the end of 2017 – 24 x quarterly stress periods;
- 2018 to the end of 2048 – 31 x annual stress periods;
- 2049 to 3049 – recovery stress periods of variable increasing length; and
- Last stress period is a steady state stress period representing post-mining equilibrium conditions.

Quarterly stress periods are introduced to the model so that seasonal variability in recharge and mine progression in Bengalla Mine and Mt Arthur Coal Mine could be better represented.

A2.3 System stresses

A2.3.1 Recharge

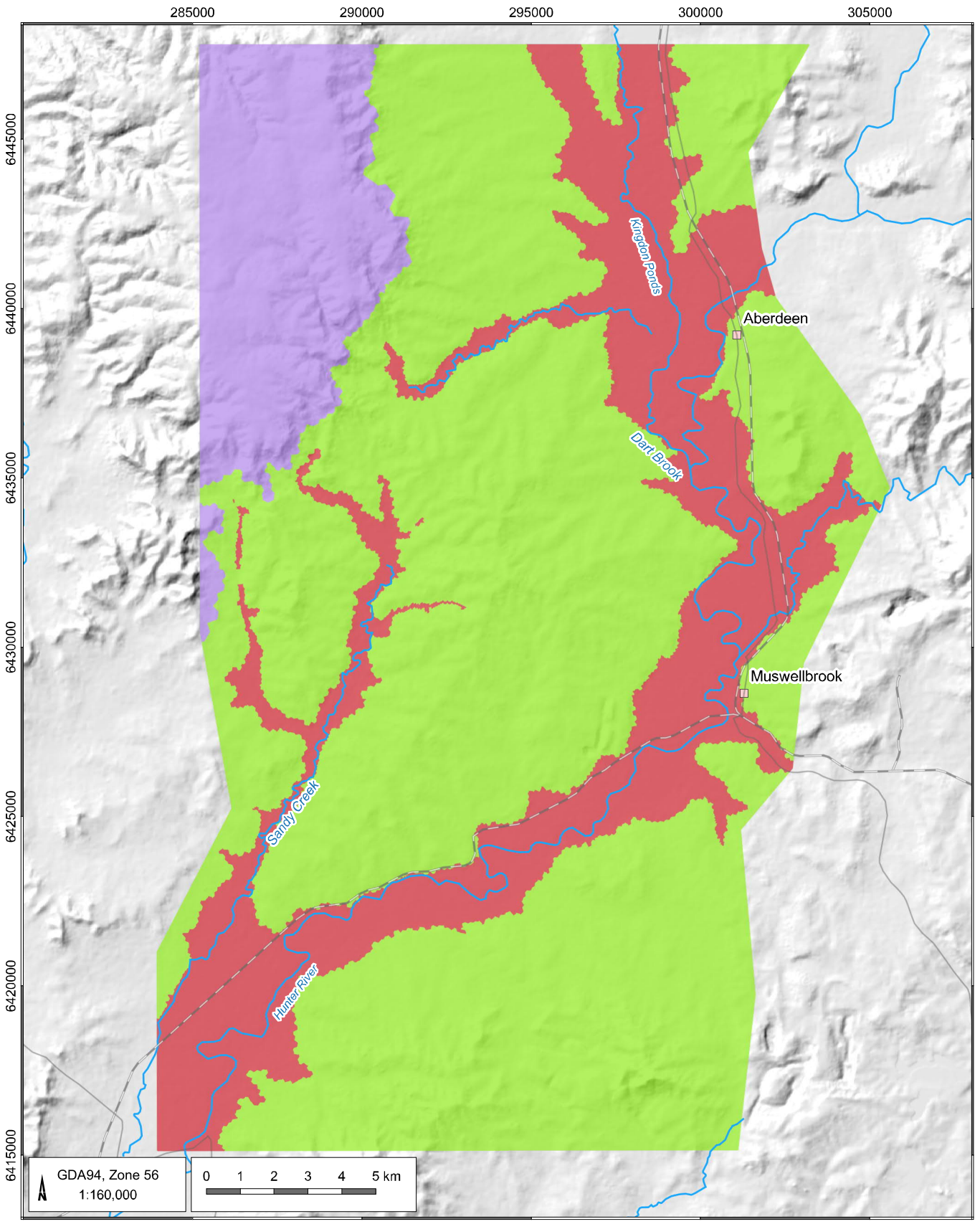
The MODFLOW USG recharge package (RCH) was used to represent deep drainage from diffuse rainfall. The dominant mechanism for recharge to the groundwater system is through diffuse infiltration of rainfall through the soil profile and subsequent deep drainage to underlying groundwater systems. Options within MODFLOW USG were selected to ensure flow through the vadose zone was not represented, due to a lack of available parameters to represent unsaturated flow. The closest BoM meteorological station to the MPO is Muswellbrook (St Heliers) (BoM station 061374). This station commenced operation in 1992 and was closed in March 2022. Therefore, data from the nearby Muswellbrook (Spring Creek, Castle Vale) (BoM station 061192), was used in order obtain the most recent rainfall data. The average (mean) annual rainfall at Muswellbrook (Spring Creek, Castle Vale) is approximately 678.5 mm.

The model domain was divided into three zones within which the factors affecting recharge were thought to be consistent. This was largely driven by the locations where various geologies outcrop and the recharge could be received. Figure A2.2 shows the recharge distribution zones. Table A2.2 represents the calibrated rate of recharge for each geological unit.

Table A2.2 Recharge rate and percentage for each zone

Zone	Diffuse recharge rate— transient			
	% of annual rainfall	Min (mm/year)	Mean (mm/year)	Max (mm/year)
Alluvium	3.20	12.4	23.9	28.4
Triassic Sandstone	2.80	10.9	20.9	24.8
Permian	0.5	1.9	3.7	4.4

Note: mm/year = millimetres per year.



LEGEND

- Populated place
- Road
- Rail
- Drainage
- Recharge zones**
- Alluvium
- Triassic
- Permian

MPO MOD 8 Life of Mine Extension
(MPO5009.001)

Model recharge zones



AGE

DATE
13/10/2025

FIGURE No:
A 2.2

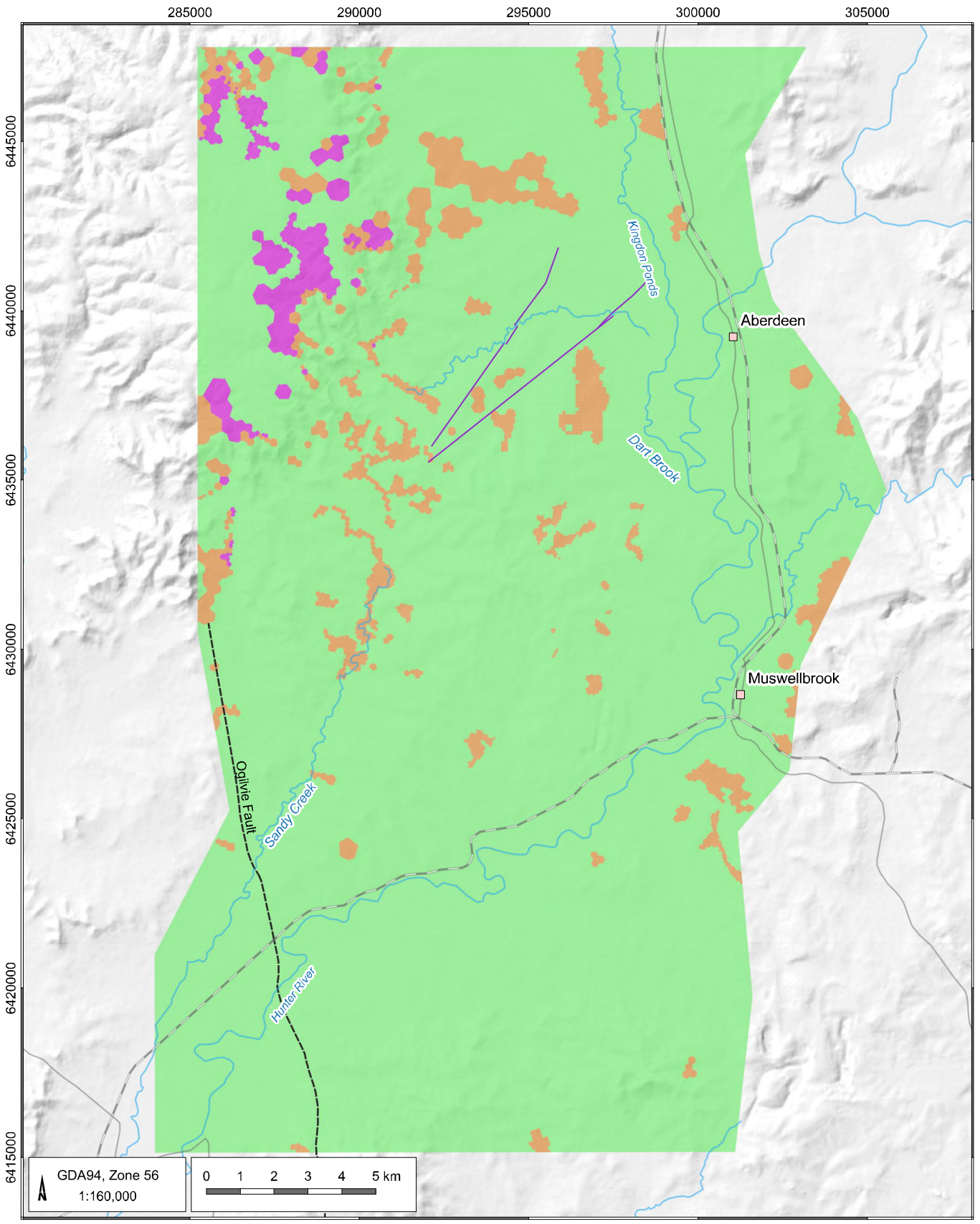
A2.3.2 Evapotranspiration

Evapotranspiration from shallow water tables was represented with the evapotranspiration package (EVT). The evapotranspiration boundary condition was assigned to the uppermost model cells across the model domain (i.e. Layer 1). Evapotranspiration will only occur when the water table depth is close enough to the natural surface to be within the extinction depth (below which no evapotranspiration takes place). Evapotranspiration has been accounted for in the net calibrated recharge rate that represents water infiltration beyond the root zone. Use of the EVT package in this instance is to remove groundwater that comes close to the surface and does not have the nearby minor surface drainage lines represented in the model to remove it. An evaporation rate of 600 mm/year is assigned at the surface representing a maximum rate of evapotranspiration. Below ground this rate decreases linearly until reaching zero at the extinction depth. Extinction depths have been derived from the plant rooting depths of the dominant species in the various vegetation communities across the model domain (Canadell *et al.* 1996). Table A2.3 shows the extinction depth for each vegetation zone and Figure A2.3 shows the evapotranspiration zones.

Table A2.3 Evapotranspiration rooting zones

Vegetation zone	Rooting depth (m)
Open grassland	1
Open/grassy woodland	2.5
Forest	5

Note: m = metres.



LEGEND

- Populated place
- Road
- Rail
- Olgivie Fault
- Major Dyke
- Drainage
- Evapotranspiration zones**
- Open grassland
- Open/grassy woodland
- Forest

MPO MOD 8 Life of Mine Extension
(MPO5009.001)

Model evapotranspiration zones



AGE

DATE
13/10/2025

FIGURE No:
A 2.3

A2.3.3 Water courses and surface drainage

Groundwater interaction with surface drainage was modelled using the river package (RIV) of the MODFLOW USG. The major streams in the vicinity of the MPO are the Hunter River, Dart Brook, and Sandy Creek. For the major watercourses, river stage elevations are interpolated between gauging stations to assign a depth or water in the respective river. This replicates the generally consistent flow in these streams and provides opportunity for recharge from the stream. Minor watercourses are ephemeral and only flow for short periods after rainfall events and are therefore simulated with a river depth set to zero. This means that groundwater is only removed from these features as baseflow when groundwater levels are high enough (i.e. above the bed of the river). The location of the river cells in the groundwater model were assigned to either Layer 1 where alluvium exists or Layer 2 where Layer 1 is not present. Table A2.4 summarises the river cell parameters in the model.

Table A2.4 River (RIV) bed parameters

River No	River name	Vertical hydraulic conductivity Kv (m/day)	Width (m)	Water depth (m)	Bed thickness (m)
1	Hunter River	0.05	20	Steady state (1 – 2 m) Transient (historical monthly average)	1
2	Dart Brook	0.05	10	Steady state (0.7 m) Transient (historical monthly average)	1
3	Sandy Creek	1	5	0	1
4	Other creeks	1	5	0	1

A2.3.4 Mining

The Hunter region has a number of coal mining operations. The MPO is situated between a number of mines, therefore cumulative impacts must be considered. The neighbouring mines include Bengalla Mine and Mt Arthur Coal Mine to the south and Dartbrook Mine to the north. Mangoola Coal is located on the western side of the Mount Ogilvie Thrust Fault. The Mount Ogilvie Fault is a significant structural feature in the region which fully offsets the coal seams against lower permeability interburden in the vicinity of the MPO. This means potential cumulative impacts between the MPO and Mangoola Coal are significantly reduced.

A2.3.4.1 Bengalla Mine and Mt Arthur Coal Mine open cut

The model represented open cut mining using the drain (DRN) package. For the other open cut mines (i.e. Bengalla Mine and Mt Arthur Coal Mine), publicly available data (AGE, 2013a/2013b/2014, and HydroSimulations 2015) was used to represent the progression of mining and the drain cells were set for all model cells within the pit shell extent (i.e. all layers from the lower most mined seam to the surface). The reference elevations for each drain cell was set to the bottom of the corresponding layer assuming that the layer becomes dry and the water stored in each layer is removed by the drain. The volume of water removed via the DRN package is a function of the head difference (between the predicted groundwater level in the model cell and the reference level assigned to the drain) and a conductance term. Initial estimates of drain conductance were calculated layer-by-layer using model cell dimensions and vertical hydraulic conductivity values.

Open-cut mining is followed by the progression of backfilling with spoil. The higher permeability of mining spoil was simulated by changing the permeability and storage properties of model cells containing spoil using the MODFLOW-USG Time-Variant Materials package (TVM). The higher recharge within the spoil was simulated using the MODFLOW USG RCH package.

Table A2.5 shows the hydraulic properties and recharge rate applied to simulate the spoil in the groundwater model.

Table A2.5 Hydraulic properties applied to spoil

Kh (m/day)	Kv (m/day)	Sy	Ss (m-1)	Recharge
0.3	0.1	0.1	1E-05	2% rainfall

Notes: Kh = Horizontal Hydraulic Conductivity. Kv = Vertical Hydraulic Conductivity. Sy = Specific Yield. Ss = Specific Storage.

A2.3.4.2 Dartbrook Mine

Like the open cut mines, the underground mining at Dartbrook Mine was simulated using the MODFLOW USG DRN package. The drain boundary condition was set within the Dartbrook Mine target coal seams (i.e. Wynn and Kayuga / Mt Arthur seams). The drain cells were gradually added to the model to replicate the development of the roadways and the extraction of panels over time. The model also simulated the gradual changes to aquifer properties in response to longwall mining such as goaf and fracture zone development, using the MODFLOW USG Time Varying Materials (TVM) package. This was achieved by changing the parameters within the coal seam and overlying strata as the longwall panel was developed. In doing so, a series of multipliers were used to enhance hydraulic conductivities within the deformation zone overlying coal extraction areas. The multipliers are dependent on height above the coal seam, with the highest values applied to the units closest to the mined seam and then a gradual reduction as the units near the maximum height of connective cracking. The maximum height of connective cracking was derived using the Ditton/Merrick equation (Ditton and Merrick, 2014) and are calculated on a cell-by-cell basis for panel width and overburden thickness, with t' assumed to be 20 m and mined thickness 3.4 m. Changes to hydraulic parameters used a logarithmic stepping function across stress periods. The typical fractured zone multipliers are presented in Table A2.6 and Table A2.7 for Wynn Seam longwall mining and for Kayuga Seam longwall mining, respectively for mean heights above the coal seam.

Table A2.6 Fracture zone multipliers for Wynn seam longwall mining at Dartbrook Mine

Lithology	Layer	Mean height above seam (m)	Kh multiplier	Kv multiplier	
Alluvium and Regolith	1	285	2	3	
Alluvium and Weathered Overburden	2	283			
Overburden	3	283			
Warkworth Seam	4	283		2	3
Interburden 1	5	260			
Kayuga / Mount Arthur Seam	6	234			
Interburden 2	7	190			5
Piercefield Seam	8	145			
Interburden 3	9	127			
Vaux Seam	10	109		6	20
Interburden 4	11	82			
Broonie Seam	12	56			
Interburden 5	13	48			
Bayswater Seam	14	39	68		
Interburden 6	15	19			
Wynn Seam	16	0		83	152

Table A2.7 Fracture zone multipliers for Kayuga seam longwall mining at Dartbrook Mine

Lithology	Layer	Mean height above seam (m)	Kh multiplier	Kv multiplier
Alluvium and Regolith	1	2	2	3
Alluvium and Weathered Overburden	2	0		
Overburden	3	0		
Warkworth Seam	4	23		47
Interburden 1	5	24	3	73
Kayuga / Mount Arthur Seam	6	0	10	115

A2.3.5 Depth dependence of hydraulic conductivity

Figure A2.4 and Figure A2.5 summarise the available hydraulic conductivity measurements derived from different tests at the MPO against depth. There are two types of hydraulic tests shown in the figures, known as the packer and core permeability tests. The core test values are generally lower than the packet test. This is expected given that the core test represents the centimetre-scale sample and does not consider the joints/fractures and hydraulically conductive structures within the formations.

Figure A2.4 and Figure A2.5 show that the Kh declines with depth as overburden pressure increases. To reflect this, an exponential equation that fits the packer test data was adopted in the model, simulating the reduced Kh with depth. The equation is as follows:

- Coal and interburden: $Kh = HC0 \times \exp(\text{slope} \times \text{depth})$

Where:

- Kh is horizontal hydraulic conductivity at specific depth.
- HC0 is horizontal hydraulic conductivity at depth of 0m (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).

Values of 'slope' and HC0 were derived such that the equations provided the line of best fit for the measured hydraulic test data. Given the focus is mainly on the MPO, the lines of best fit were weighted more towards the MPO test data. With regards to the type of hydraulic test, the packer test data was preferred over the core permeability test. As mentioned, this is mainly because the packer test generally provides the bulk representative value of interburden and coal seam hydraulic properties.

The fit of equations are shown as the black lines in Figure A2.4 and Figure A2.5 for the coal and interburden. These equations have been used to assign the initial permeability values in the model. During the calibration, the slope is fixed and the HC0 can vary based on the upper and lower ranges specified as dash blue and yellow lines in Figure A2.4 and Figure A2.5. The horizontal and vertical conductivity were capped to ensure maximum and minimum values did not exceed literature ranges for their respective units. Table A2.8 presents the additional parameter constraints applied to coal and Permian units.

Table A2.8 Additional parameter constraints

Unit	Min Kh (m/day)	Max Kh (m/day)	Min Kv (m/day)	Max Kv (m/day)
Coal and interburden	1.0E-06	1.0E-01	1.0E-09	1.0E-01

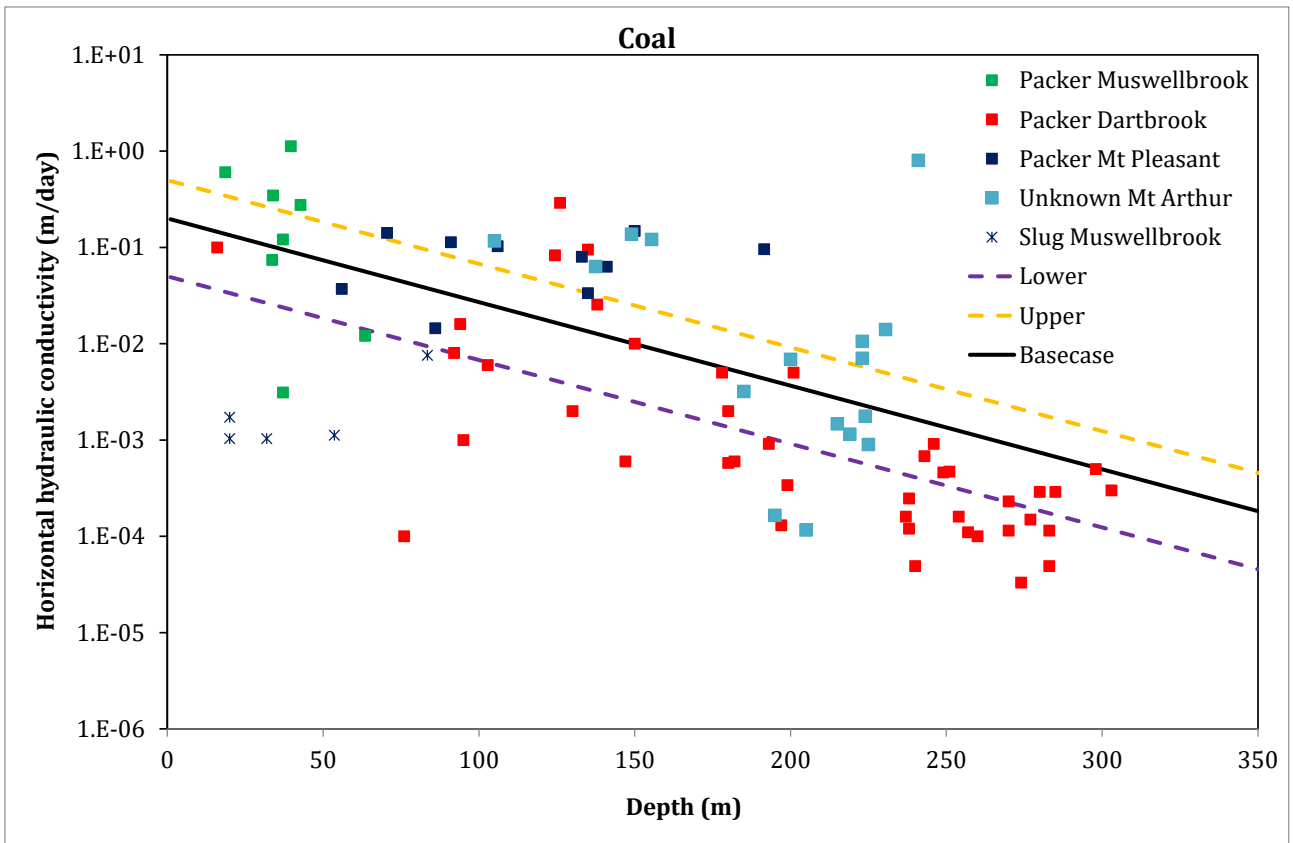


Figure A2.4 Horizontal hydraulic conductivity for coal seam measures

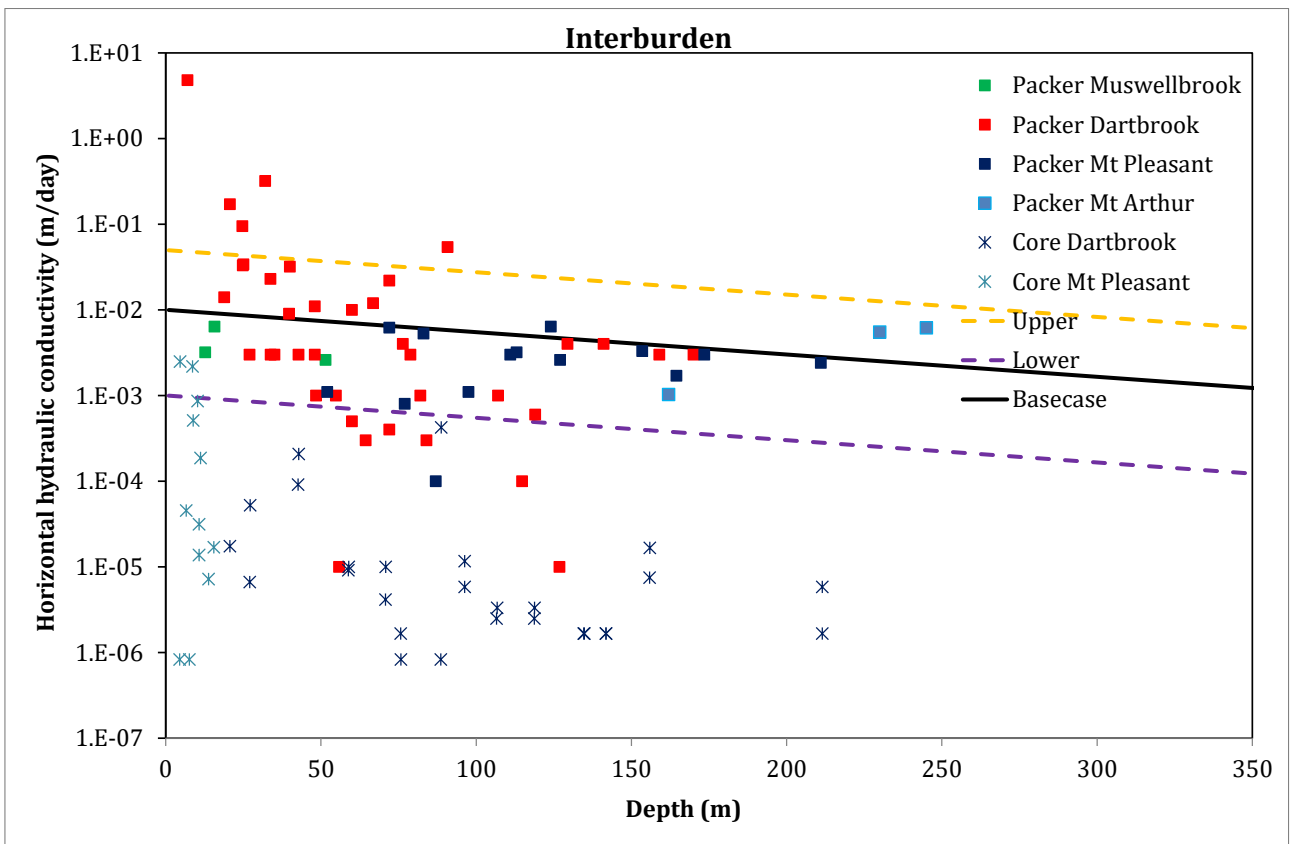


Figure A2.5 Horizontal hydraulic conductivity for interburden

A3 Model calibration

The groundwater model was calibrated to a pre-mining steady state water level set and then to transient water level and mine inflow datasets (1991 to September 2018) as part of the GIA for the Mount Pleasant Optimisation Project (AGE, 2020), using available groundwater level data and documented mine inflows. The model was calibrated by adjusting aquifer parameters and stresses to produce the best match between the observed and simulated water levels and mine inflows. Manual testing, automated parameterisation software (PEST) (Doherty, 2010) and pilot points were used to determine optimal hydraulic parameters and recharge rates to achieve the most representative calibration of the groundwater model.

The calibrated parameters have been assessed through a verification of the previous calibration (AGE, 2020), and this verification has demonstrated that the model remains sufficiently calibrated and it remains an appropriate tool to undertake the assessment of impacts from the modified MPO.

A3.1 Calibration targets

A3.1.1 Heads

The steady state and transient model simulated water levels at all available monitoring bores with reliable datasets. A total of 114 monitoring sites were available to calibrate the model, comprising:

- 87 monitoring bores; and
- 27 monitoring points with vibrating wire piezometers.

Figure A3.1 shows the locations of the monitoring bores. As the frequency and amount of data varies from monitoring location to monitoring location, the bore water level records were weighted as follows:

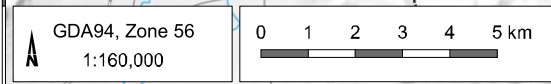
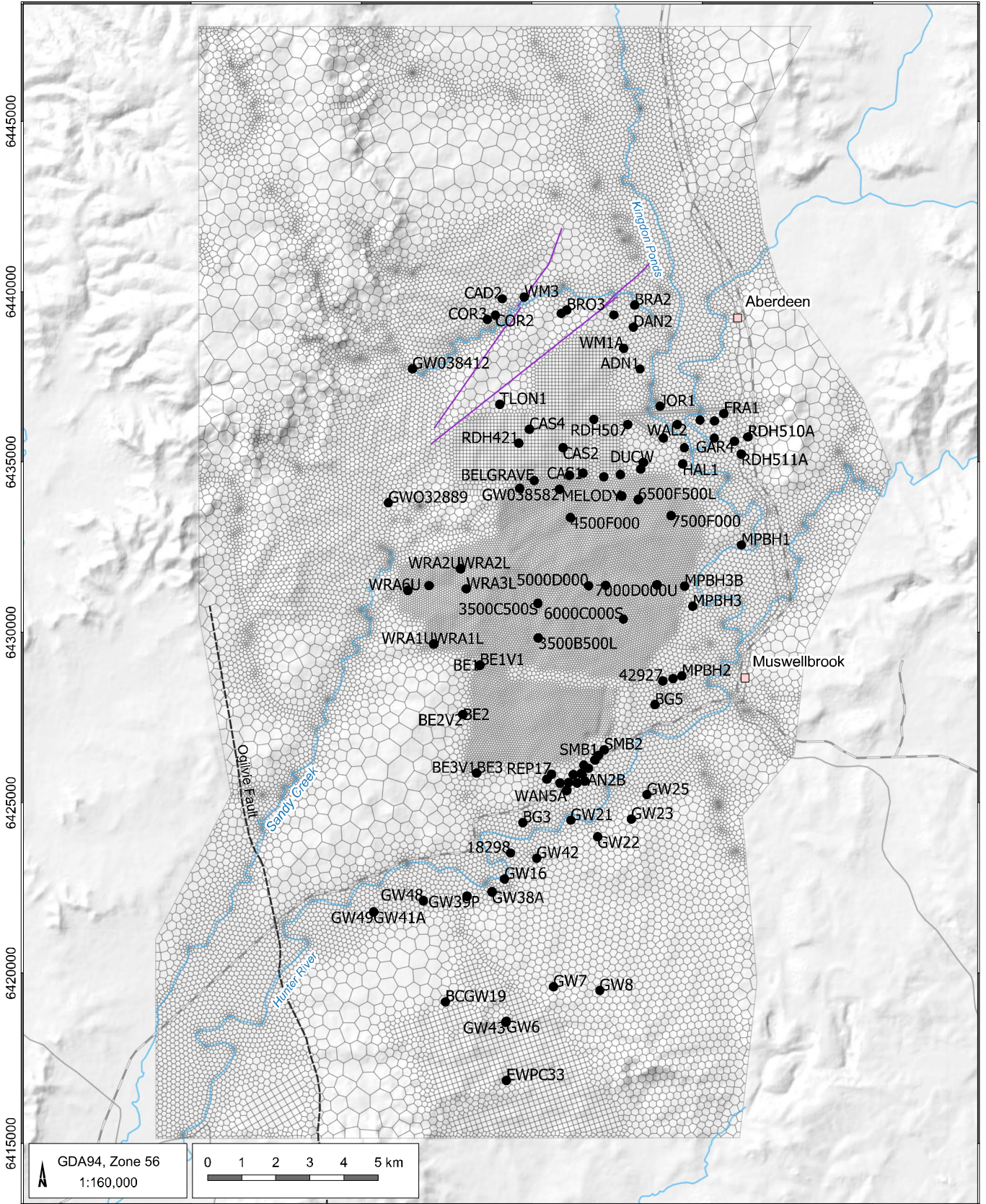
- obviously anomalous results were removed;
- datalogger data was reduced to a monthly frequency; and
- datapoints for each location were weighted according to the formula:
 - Weight of datapoint = $1/\sqrt{\text{(number of points for that site)}}$.

Using this method, bores with longer records have a lower weighting per datapoint, but the overall weighting of each bore in the combined dataset is equal to 1. The model was calibrated to the 5,604 observed water level observations available in September 2018, with the 'best calibrated' model returning the lowest objective function (ϕ) value (i.e. the sum of the squares of the residuals between observed and modelled water levels across the chosen dataset).

A3.1.2 Fluxes

The MPO started operations in October 2017 and so only the initial mining activities at the MPO up to September 2018 are simulated during the calibration period and the model predicts unsaturated conditions for the shallow material mined during this period. However, groundwater inflows to other mines in this area are available. As mentioned in Section A2.3.4, the neighbouring mines include open cut mining at the Bengalla Mine, Mt Arthur Coal Mine, and the underground extraction at Dartbrook Mine. Data and records for inflow has been derived from the Annual Reviews and used for calibration. Responses of observation bore water levels to advancing mining suggested that there was a degree of heterogeneity present within several geological layers. This became more apparent during initial model calibration, when not all bores within a layer would calibrate using uniform hydraulic parameters.

To explore the heterogeneity within the model domain and provide a degree of flexibility during the calibration, a series of pilot points were added to the top three model layers. The locations of the pilot points in each model layer are consistent between the layers and are shown in Figure A3.2. The pilot points were interpolated across the model domain in each layer of the model using ordinary automatic Kriging through PLPROC (Watermark Numerical Computing, 2015). Horizontal and vertical conductivity were then derived based on the interpolated values at each cell centre. To calibrate the model, the pilot point multipliers were allowed to vary \pm two orders of magnitude from the starting point. The starting point for all multipliers was assumed to be 1. For Permian units (coal and interburden) there was additional constraints applied to cap the upper and lower values (as presented in Table A2.8).



- LEGEND
- Populated place
 - Observations
 - Road
 - Rail
 - Ogilvie Fault
 - Major Dyke
 - Drainage
 - Grid

MPO MOD 8 Life of Mine Extension
(MPO5009.001)

Observation target locations



DATE
13/10/2025

FIGURE No:
A 3.1

285000

290000

295000

300000

305000

6445000

6440000

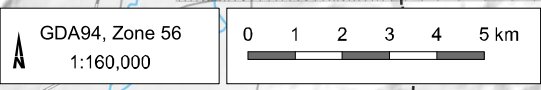
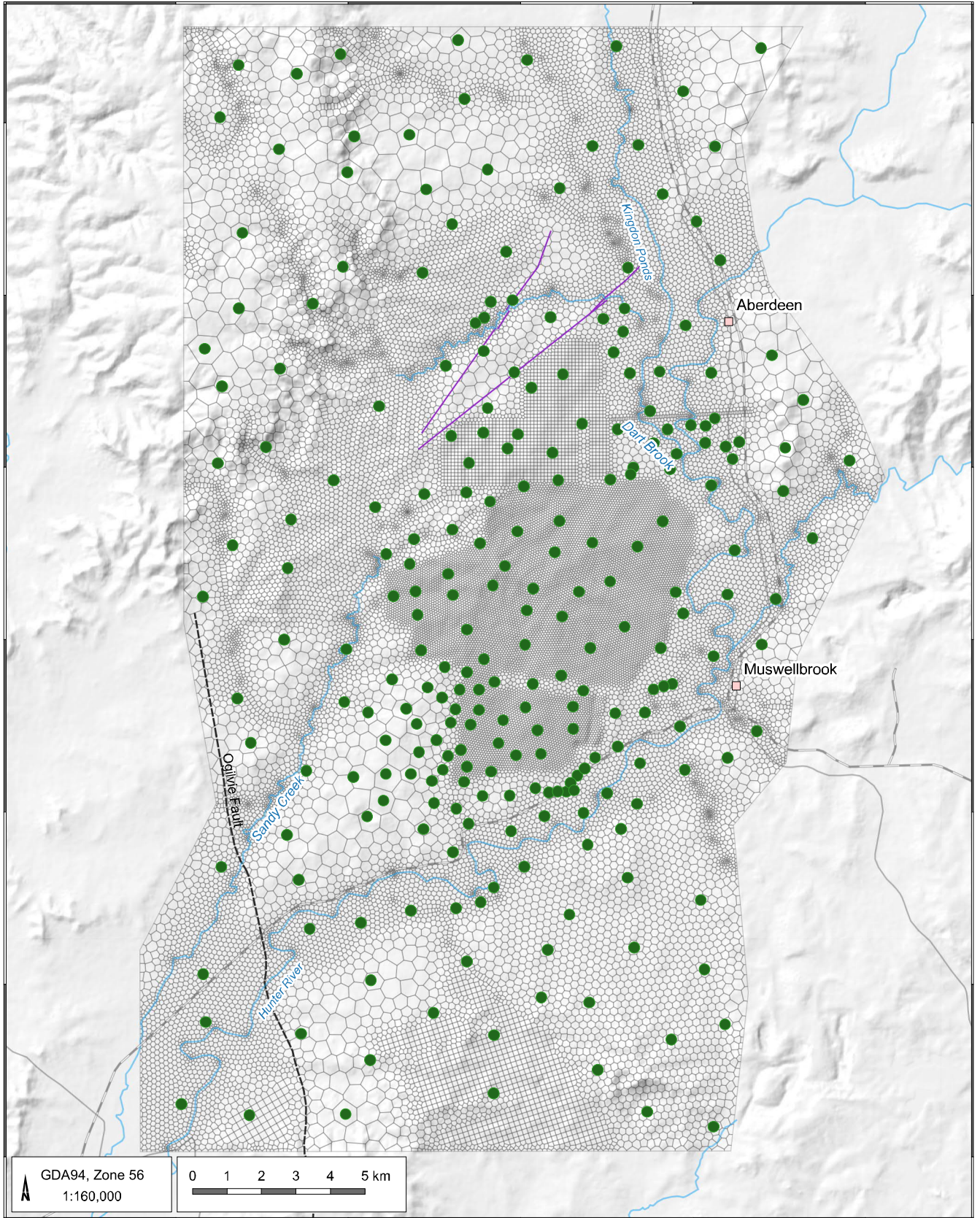
6435000

6430000

6425000

6420000

6415000



LEGEND

- Populated place
- Pilot points
- Road
- Rail
- Olgilvie Fault
- Major Dyke
- Drainage
- Grid

MPO MOD 8 Life of Mine Extension (MPO5009.001)

Location of pilot points



AGE

DATE
13/10/2025

FIGURE No:
A 3.2

A3.2 Calibration results

Figure A3.3 presents the observed and simulated groundwater levels graphically as a scattergram for the historical transient calibration, with the verification results added for comparison. The points in the scatter are grouped by the various mines the data is sourced from. Overall, there is a good fit between the modelled and observe datasets in all mines, particularly at the MPO. It appears that there is some variability in the Mt Arthur Coal Mine monitoring bores, which may be due to not replicating all the interburden and target coal seams within Mt Arthur Coal Mine. Appendix A1 shows the simulated hydrographs for each observation bore.

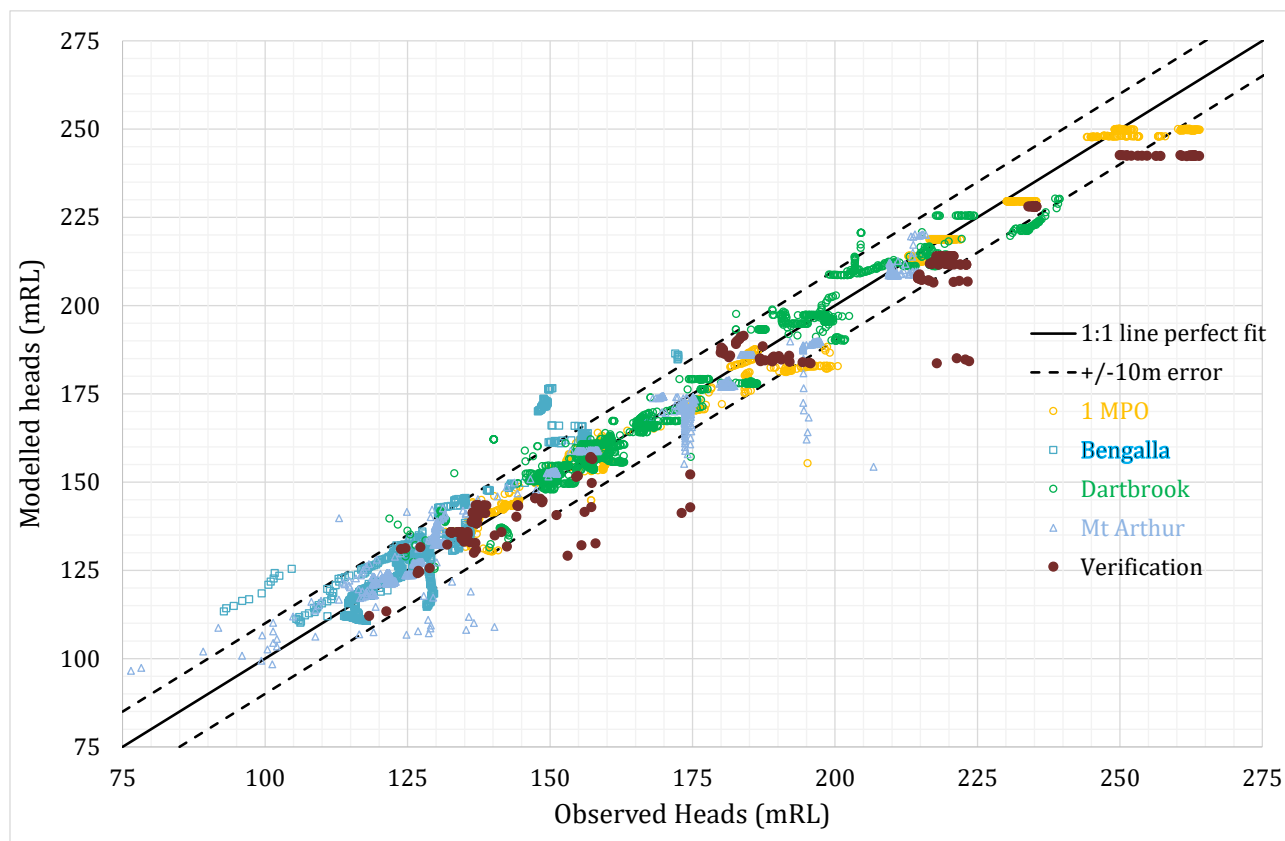
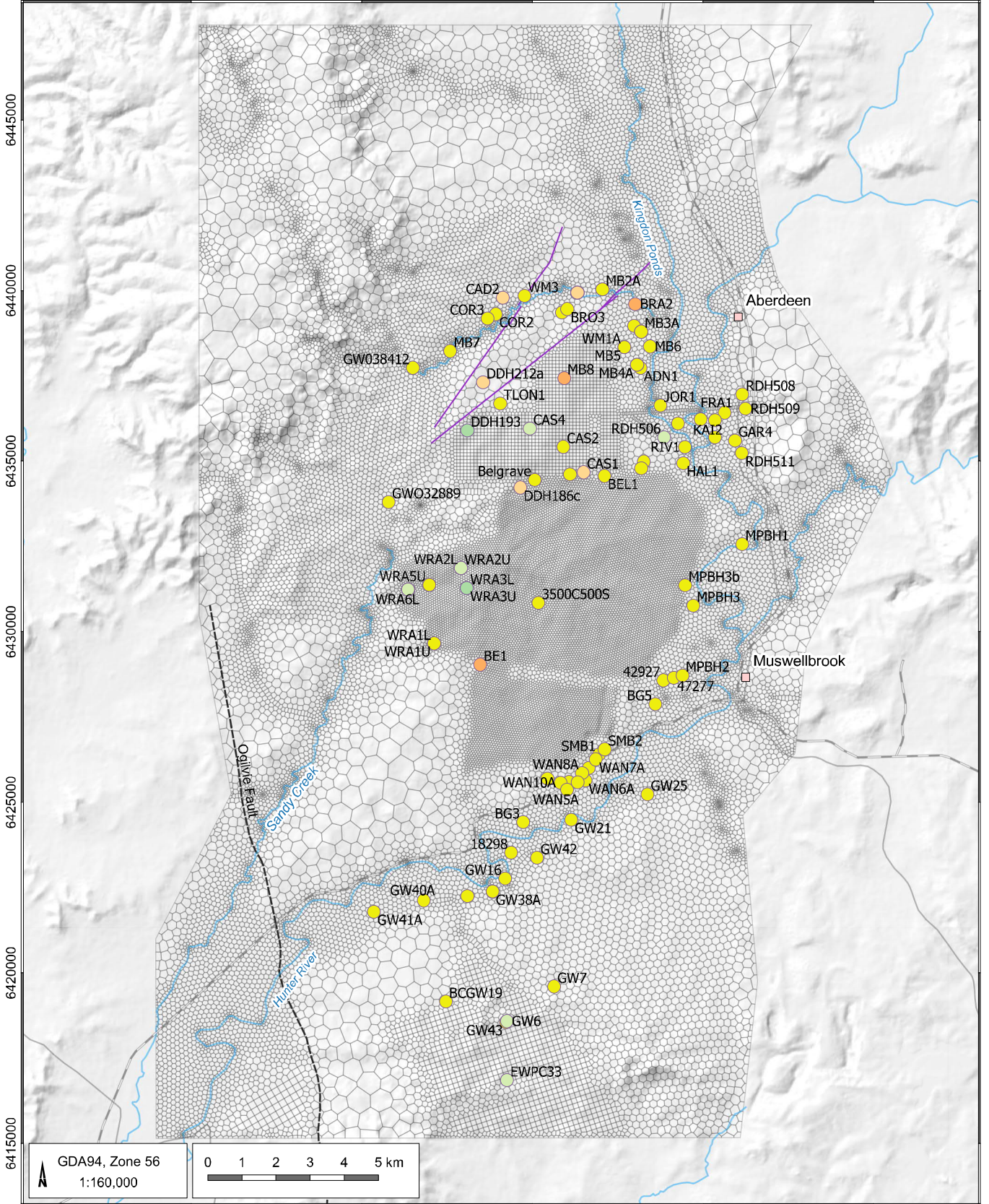


Figure A3.3 Transient calibration – modelled vs observed groundwater levels

Figure A3.4 shows the spatial distribution of residuals at shallow groundwater observation sites (i.e. Layers 1 to 3). This figure indicates that the shallow bores are replicated reasonably well across the model domain. Figure A3.5 shows the spatial distribution of residuals within deeper units (i.e. Layers 4 to 20) and indicates the deep bores are generally well represented across the model domain. The largest residuals are shown as dark orange points in Figure A3.5 and includes the nested piezometer BE1 located west of Bengalla Mine. Further inspection of hydrographs for BE1 and surrounding nested bores (i.e. BE2 and BE3) in Appendix A1 indicates that the model has been able to simulate the pressure difference from shallow to deep piezometers, but the heads appear to be overestimated in V1 and V2 piezometers in BE1 and BE2. This overestimation does not appear to be significant and may be due to heterogeneity and assumed thickness of the interburden units.

The root mean square (RMS) error calculated for the calibrated model was 5.4 m. The total measured head change across the model domain was 190.2 m, with a standardised weighted SRMS of 4.1%, and an unweighted SRMS of 2.83%. Adding the verification observations up to August 2025 increased the RMS to 9.49 m and the SRMS to 5.37 % and is well within the recommended SRMS of 10% in Barnett *et al.* (2012). The primary cause of the increased SRMS is due to the addition of newly drilled bores into the validation dataset. With these results the model as a whole can be considered calibrated.

285000 290000 295000 300000 305000



LEGEND

- Populated place
- Road
- Rail
- Olgilvie Fault
- Major Dyke
- Drainage
- Grid

Average residuals (m)

- 40.0 - -30.0
- 30.0 - -20.0
- 20.0 - -10.0
- 10.0 - -5.0
- 5.0 - 5.0
- 5.0 - 10.0
- 10.0 - 20.0
- 20.0 - 30.0
- 30.0 - 40.0

MPO MOD 8 Life of Mine Extension
(MPO5009.001)

Average residuals for shallow bores in layers 1 to 3

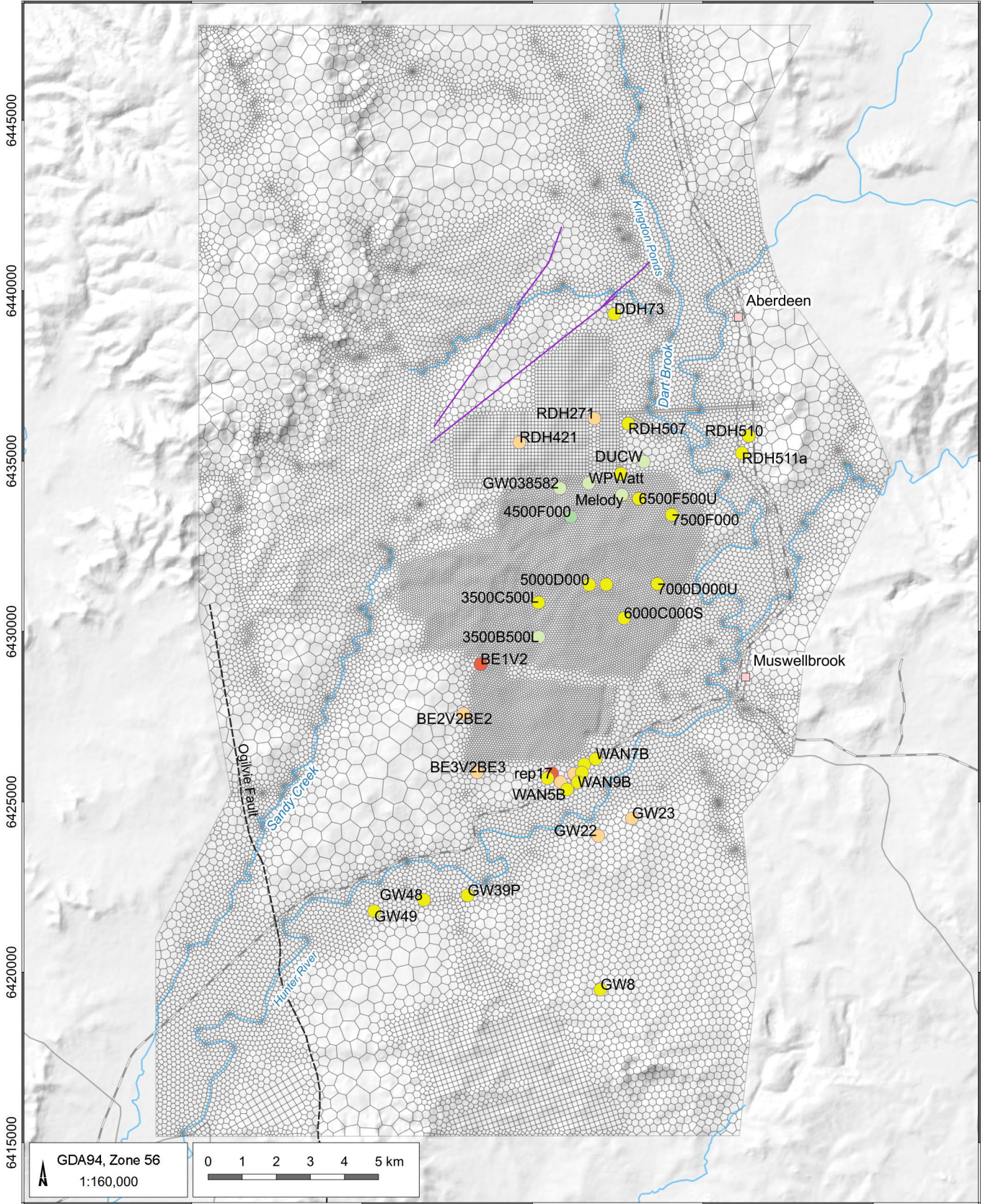


AGE

DATE
13/10/2025

FIGURE No:
A 3.4

285000 290000 295000 300000 305000



LEGEND

- Populated place
- Road
- Rail
- Olgivie Fault
- Major Dyke
- Drainage
- Grid

Average residuals (m)

- 40.0 - -30.0
- 30.0 - -20.0
- 20.0 - -10.0
- 10.0 - -5.0
- 5.0 - 5.0
- 5.0 - 10.0
- 10.0 - 20.0
- 20.0 - 30.0
- 30.0 - 40.0

MPO MOD 8 Life of Mine Extension
(MPO5009.001)

**Average residual for deep bores in
Layers 4 to 20**



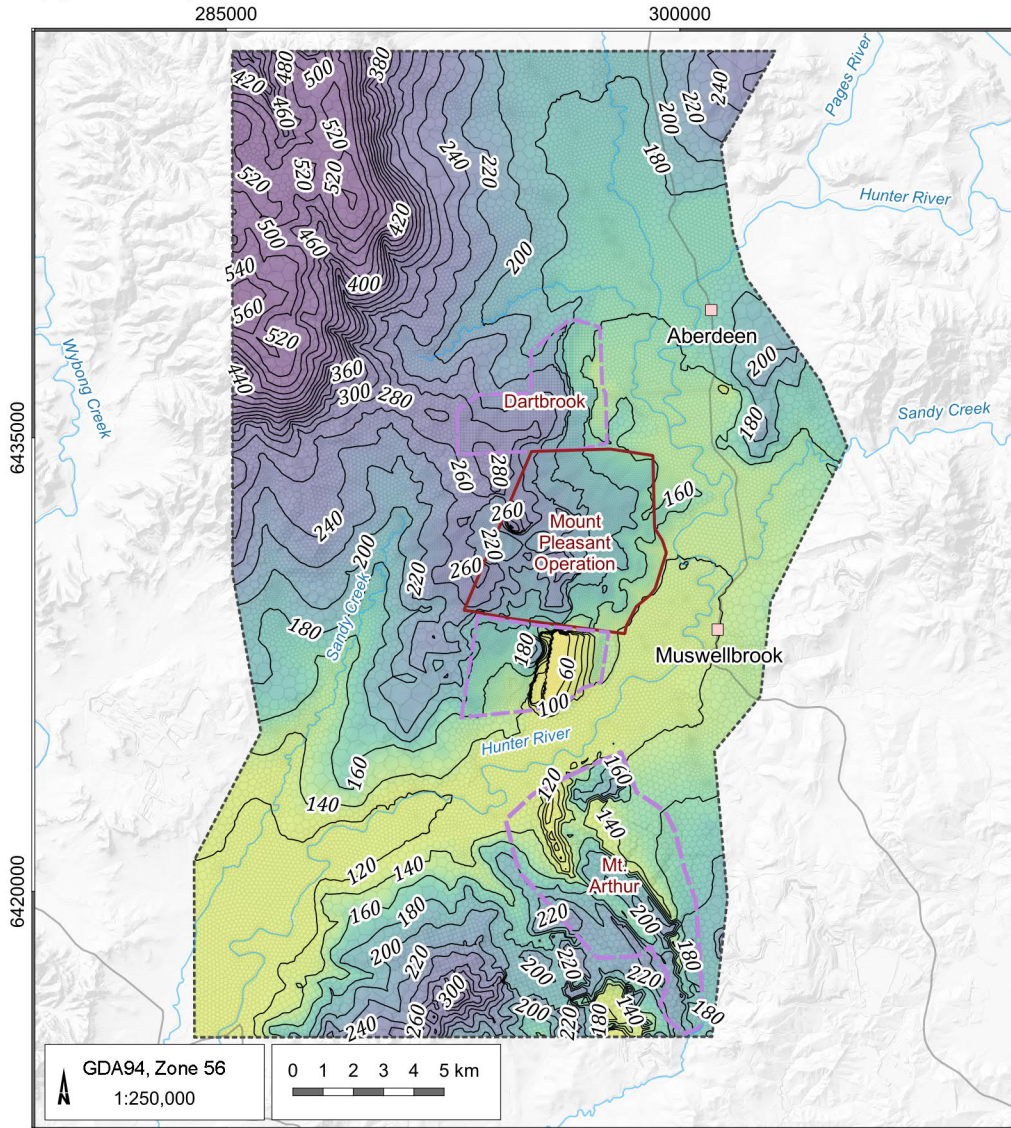
DATE
13/10/2025

FIGURE No:
A 3.5

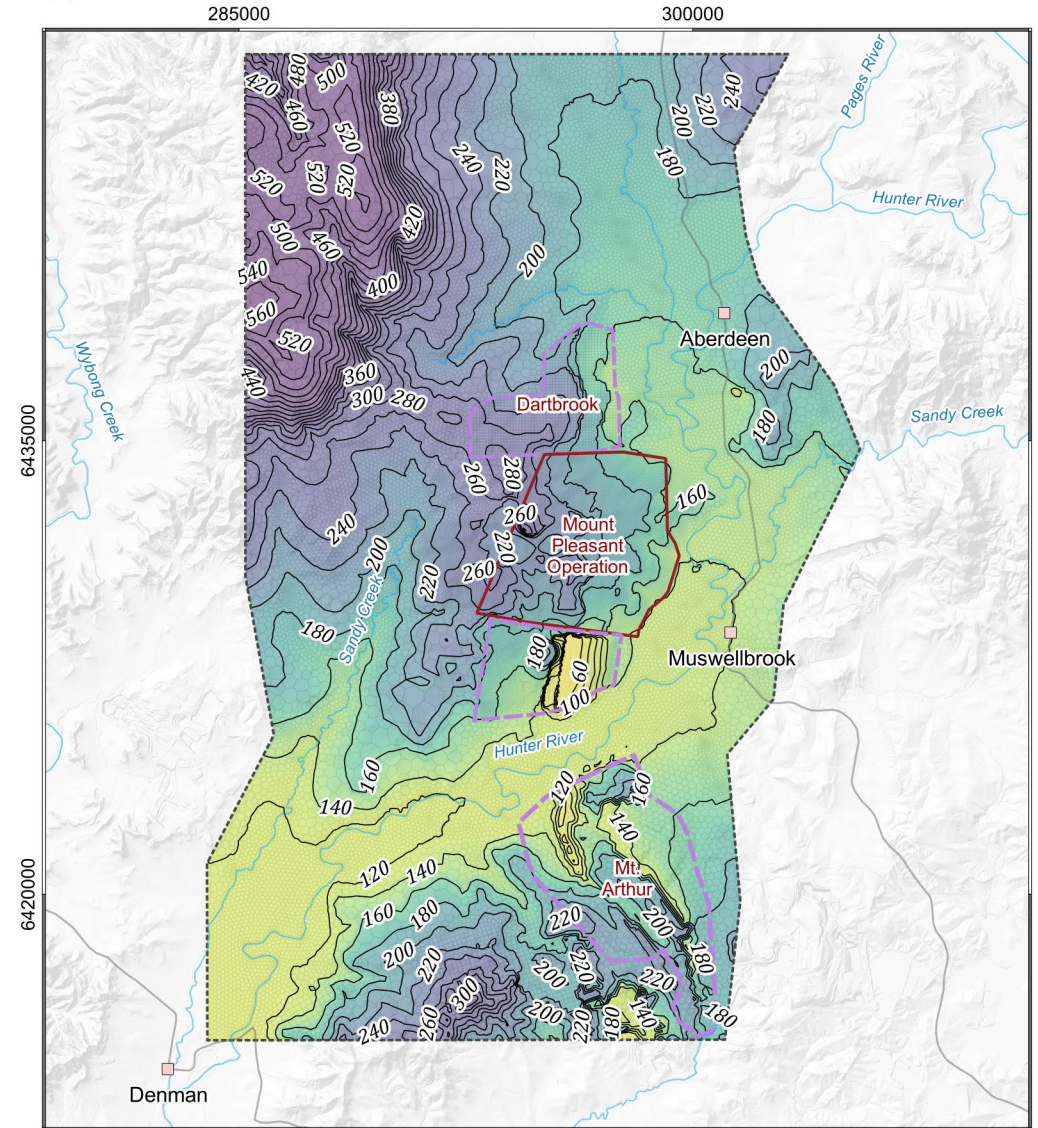
A3.2.1 Calibration heads

The calibrated heads from the pre-mining steady state model are presented for Layers 1 and 2 (alluvium and regolith) and Layer 16 (Wynn seam) in Figure A3.6(a) and Figure A3.7(a), respectively. The calibrated heads at the end of the transient model (2017) are presented for Layers 1 and 2 (alluvium and regolith) and Layer 16 (Wynn seam) in Figure A3.6(b) and Figure A3.7(b), respectively. Groundwater levels representing 2017 conditions show the depressurised zones within the potentiometric surface caused by the advancement of mining at Bengalla Mine, and Mt Arthur Coal Mine and Dartbrook Mine.

(a) Pre mining

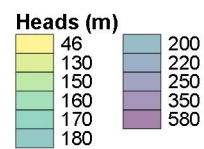


(b) 2017



LEGEND

- Populated place
- Drainage
- Road
- Head contours (mAHD)
- Mount Pleasant Operation
- Surrounding mines
- Model boundary



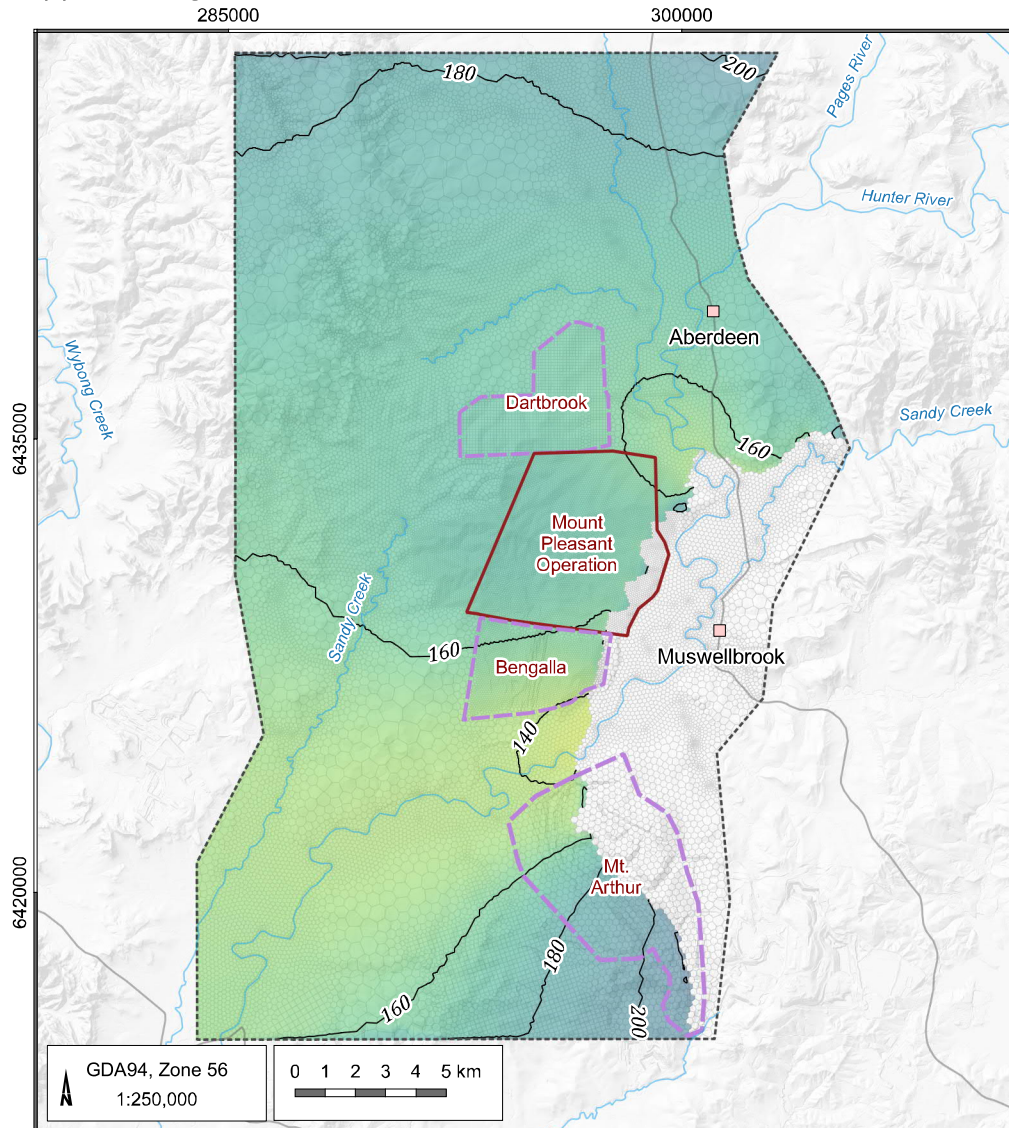
MPO MOD 8 Life of Mine Extension
(MPO5009.001)

**Modelled groundwater levels –
Layers 1 and 2 (Alluvium and
Regolith)**

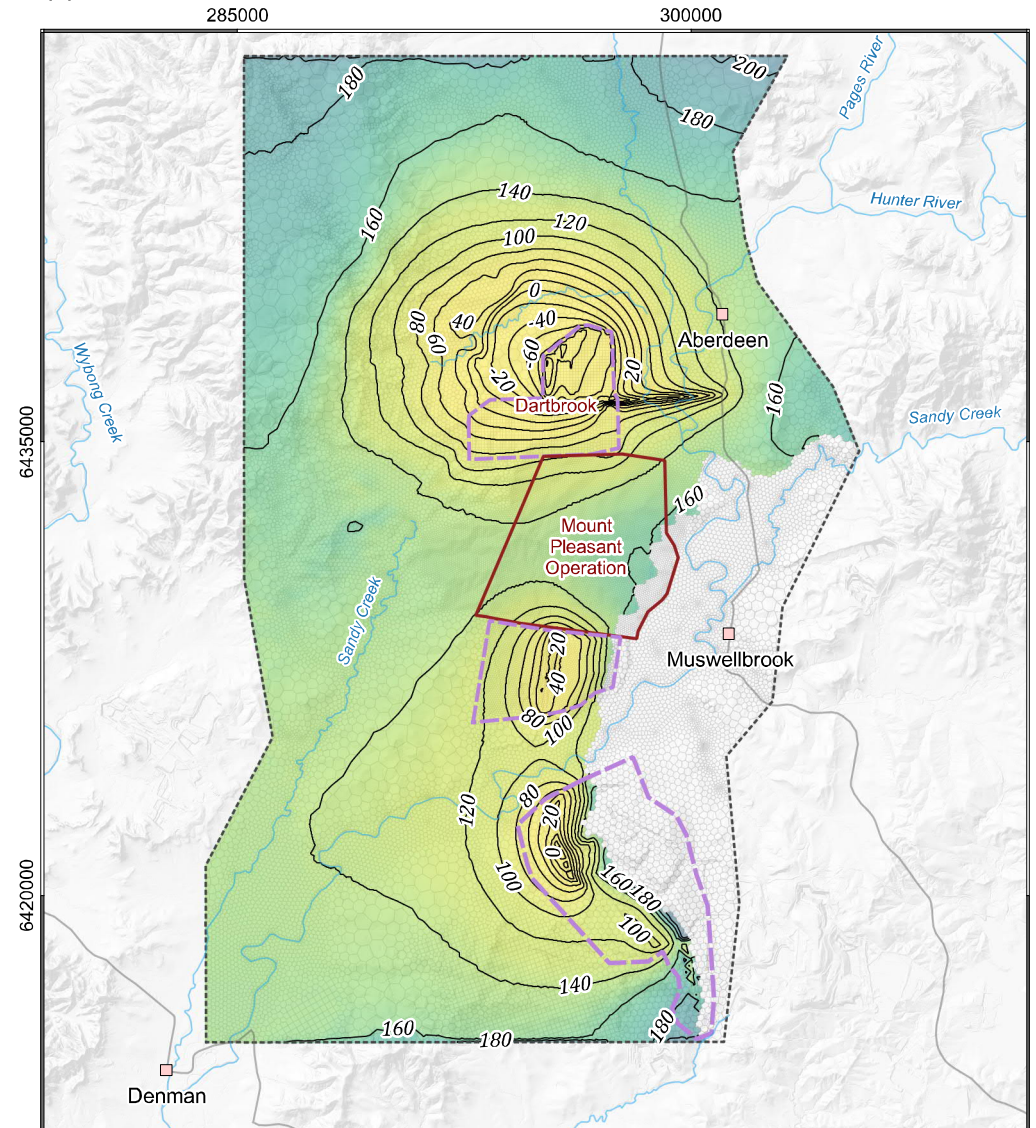
DATE
13/10/2025

FIGURE No:
A 3.6

(a) Pre mining



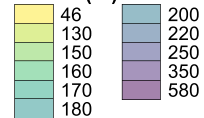
(b) 2017



LEGEND

- Populated place
- Drainage
- Road
- Head contours (mAHD)
- Mount Pleasant Operation
- Surrounding mines
- Model boundary

Heads (m)



MPO MOD 8 Life of Mine Extension
(MPO5009.001)

**Modelled groundwater levels –
Layer 16 (Wynn seam)**

DATE
13/10/2025

FIGURE No:
A 3.7

A3.2.2 Hydraulic parameters

Table A3.1 summarises the calibrated hydraulic conductivity (or in many cases HC0) for each of the hydrostratigraphic units within the model domain. The values presented are the base case value for each layer. It should be noted that hydraulic properties in Layers 1 to 3 are adjusted based on the pilot points shown in Figure A3.2. Appendix A2 shows the resulting hydraulic conductivity from this pilot point adjustment process for model Layers 1 to 3. The HC0 that is listed in Table A3.1 refers to the calibrated hydraulic conductivity at a depth of zero metres as utilised in the equation presented in Section A2.3.5.

The values in Table A3.1 are further refined by the constraints listed in Table A2.8 before being written to model input files. Percentile plots of the calibrated ranges in hydraulic conductivity that are written to model files are shown in Figure A3.8 and Figure A3.9. The plots use data from a regularised 200 m grid covering the model domain rather than model cell centres. This approach has been used to remove the effect of different cell sizes, which could bias the outputs. The notable steps in values in Layers 1 and 2 represent the different stratigraphic zones present within that layer (e.g. alluvium and regolith).

Table A3.1 Calibrated base hydraulic conductivity values (HC0)

Model layer	Lithology	Horizontal hydraulic conductivity Kh (m/day)	Vertical hydraulic conductivity factor (Kv:Kh)
1 and 2	Alluvium and regolith	4.61	0.2
2	Weathered overburden (HC0 in Kh-depth equation)	0.01	0.6
3	Overburden (HC0 in Kh-depth equation)	0.01	0.003
4	Warkworth Seam (HC0 in Kh-depth equation)	0.28	0.005
5	Interburden 1 (HC0 in Kh-depth equation)	0.03	0.001
6	Mount Arthur Seam (HC0 in Kh-depth equation)	0.05	0.006
7	Interburden 2 (HC0 in Kh-depth equation)	0.02	0.008
8	Piercefield Seam (HC0 in Kh-depth equation)	0.05	0.003
9	Interburden 3 (HC0 in Kh-depth equation)	0.01	0.008
10	Vaux Seam (HC0 in Kh-depth equation)	0.05	0.008
11	Interburden 4 (HC0 in Kh-depth equation)	0.003	0.003
12	Broonie Seam (HC0 in Kh-depth equation)	0.14	0.005
13	Interburden 5 (HC0 in Kh-depth equation)	0.02	0.005
14	Bayswater Seam (HC0 in Kh-depth equation)	0.05	0.002
15	Interburden 6 (HC0 in Kh-depth equation)	0.03	0.003
16	Wynn Seam (HC0 in Kh-depth equation)	0.14	0.002
17	Interburden 7 (HC0 in Kh-depth equation)	0.05	0.001
18	Edderton Seam (HC0 in Kh-depth equation)	0.06	0.001
19	Vane Subgroup/Saltwater Creek Formation (HC0 in Kh-depth equation)	0.02	0.001
20	Maitland Group and older units (HC0 in Kh-depth equation)	0.06	0.03

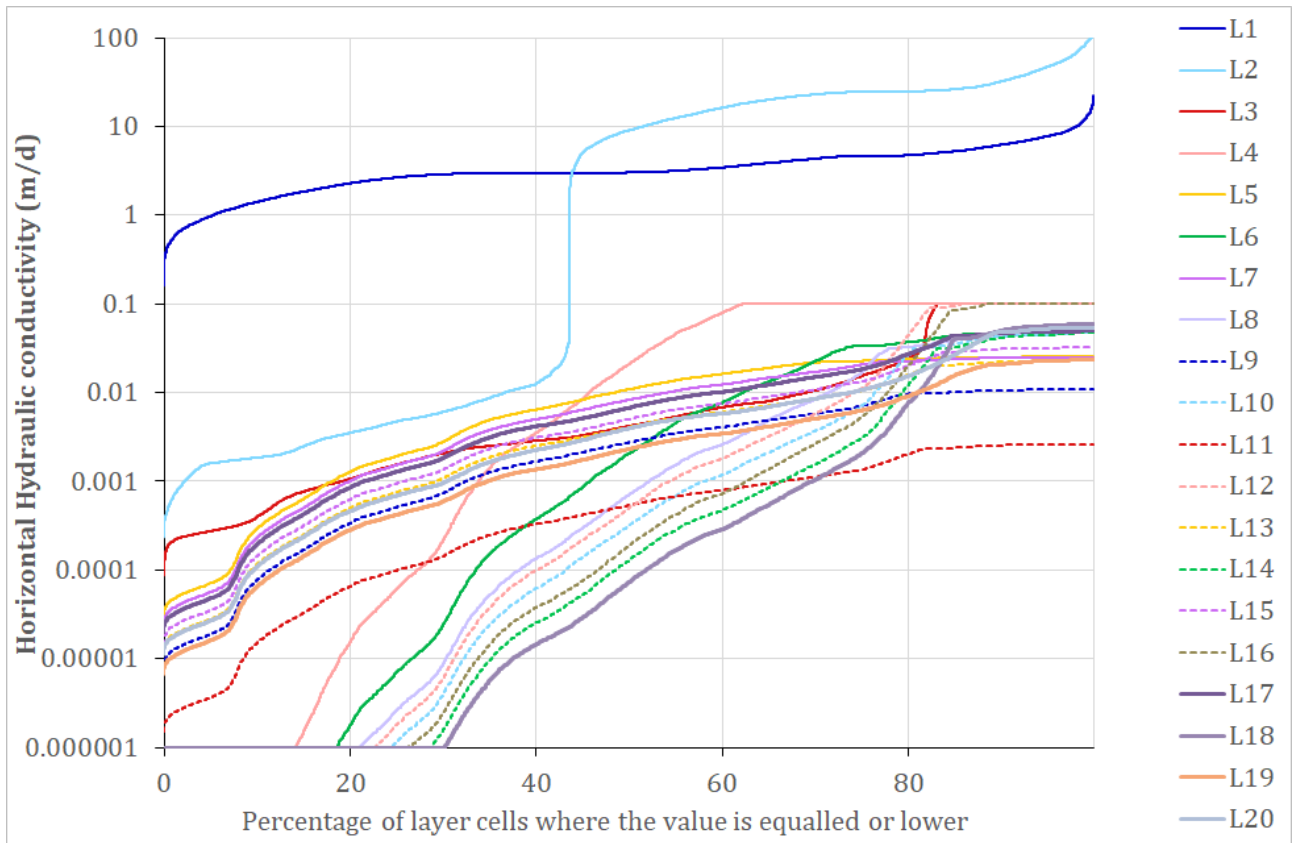


Figure A3.8 Horizontal hydraulic conductivity ranges in each model layer

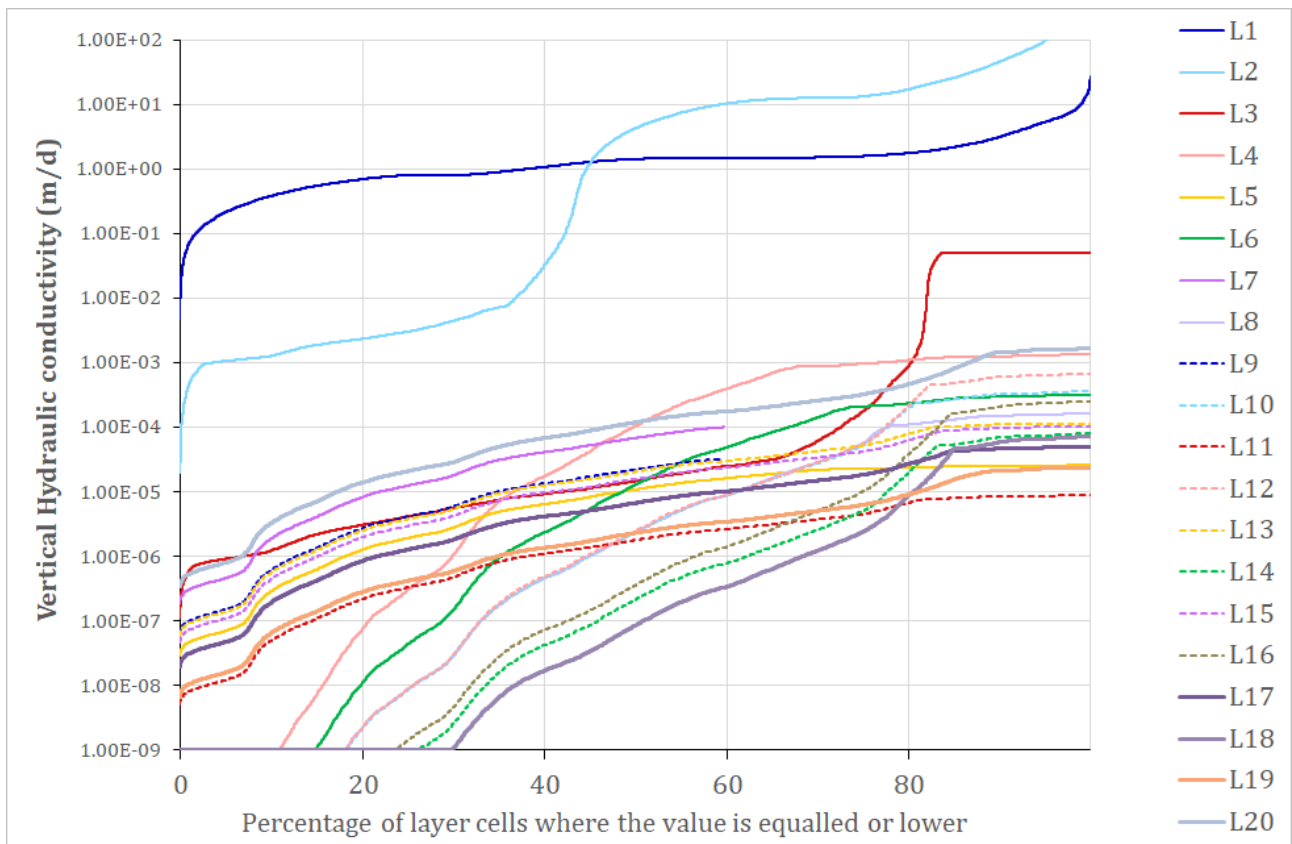


Figure A3.9 Vertical hydraulic conductivity ranges in each model layer

A3.2.3 Storage properties

Table A3.2 summarises the calibrated values for specific storage and specific yield. Unlike hydraulic conductivities, the storage parameters are uniform across the whole model domain at each layer. Specific yield is only relevant in the model where the layers become unconfined, so the parameter is not necessarily utilised in the deeper model layers. Specific storage is only applied where the model layers are confined.

Table A3.2 Calibrated base storage values

Model layer	Lithology	Specific yield Sy (-)	Model layer Ss (m ⁻¹)
1 and 2	Alluvium and regolith	7.0E-02	1.3E-05
2	Weathered overburden	3.2E-02	3.3E-06
3	Overburden	1.7E-03	2.3E-07
4	Warkworth Seam	3.8E-03	5.0E-06
5	Interburden 1	1.1E-02	7.6E-07
6	Mount Arthur Seam	1.1E-03	5.0E-06
7	Interburden 2	1.3E-03	6.7E-07
8	Piercefield Seam	1.6E-04	2.3E-07
9	Interburden 3	1.3E-04	3.0E-06
10	Vaux Seam	1.3E-04	2.2E-06
11	Interburden 4	1.6E-04	1.1E-06
12	Broonie Seam	1.0E-04	1.8E-06
13	Interburden 5	2.1E-04	2.8E-07
14	Bayswater Seam	1.2E-04	2.3E-07
15	Interburden 6	1.0E-04	2.3E-07
16	Wynn Seam	2.4E-03	3.1E-07
17	Interburden 7	1.0E-04	2.3E-07
18	Edderton Seam	6.3E-03	2.3E-07
19	Vane Subgroup/Saltwater Creek Formation	1.0E-04	2.5E-06
20	Maitland Group and older units	4.6E-04	2.7E-06

A3.2.4 Water budget

The mass balance error (i.e. the difference between calculated model inflows and outflows at the completion of the steady state calibration) was 0.00%. The maximum percent discrepancy at any time step in the simulation was also 0.01%. This value indicates that the model is stable and achieves an accurate numerical solution. Table A3.3 shows the water budget for the steady state (pre-mining) model.

Table A3.3 Model budgets – steady state

Parameter	In (ML/day)	Out (ML/day)	In - Out (ML/day)
Rainfall	15.6	-	15.6
River	5.6	17.9	-12.3
Evapotranspiration	-	3.4	-3.4
General head boundary	0.1	0.02	0.08
Total	21.3	21.32	-0.02

The water budget indicates that recharge (rainfall and river leakage) to the groundwater system within the model averages 21.3 ML/day, with approximately 17.9 ML/day being discharged via surface drainage, and 3.4 ML/day lost to evapotranspiration in areas where the water table is close to the land surface. The model indicates that the Hunter River is losing on average 6 ML/day to seepage to the groundwater system which is around 0.6% of total average flow of ~1000 ML/day. Regional through flow from the general head boundary is negligible and contributes only 0.5% of the total input to the groundwater model.

Table A3.4 shows the average component water budget for the transient calibration (1991 to 2017). The model converged to a satisfactory level with 0.0 percent discrepancy reported. This is confirmed by the numerical accounting terms of 'storage in' (3.46 ML/day) and 'storage out' (1.49 ML/day) providing the balance to Table A3.4.

Table A3.4 Model budgets – transient calibration

Parameter	In (ML/day)	Out (ML/day)
Rainfall	13.28	-
River	6.76	17.36
Evapotranspiration	-	2.97
General head boundary	0.1	0
Drains	-	1.78
Total	20.14	22.11

The transient water budget indicates that the groundwater system varies slightly from steady state conditions due to expanding mining represented in the model. Recharge (rainfall and river leakage) within the model averages 20.14 ML/day, with approximately 17.36 ML/day being discharged via surface drainage. The differences between the steady state and transient recharge rates are due to different climatic conditions during the transient calibration period (1991 to 2017) when compared to the annual average that was adopted for the steady state simulation. The transient budget also shows that, on average, drains (mining) take out an average of 1.78 ML/day, which is relatively small component of the overall water budget.

A3.2.5 Mine inflow

Figure A3.10 to Figure A3.13 show the simulated versus observed annual groundwater inflows to open cut pits and underground workings at mines within the model domain used in the calibration. Figure A3.10 to Figure A3.13 shows generally a good match between observed and simulated inflows.

The model slightly overestimates the inflows, particularly for Bengalla Mine. This is acceptable given that the model predicted inflows have not been adjusted for evaporative loss, nor for moisture that has been removed with the mined coal.

The key aspect of the level of match to the measured mine inflows is that the modelled inflows are in the same order of magnitude. Because of the simplified mine plans that have been adopted for the neighbouring mines, there is no expectation that all nuances in the inflow observations would be recreated.

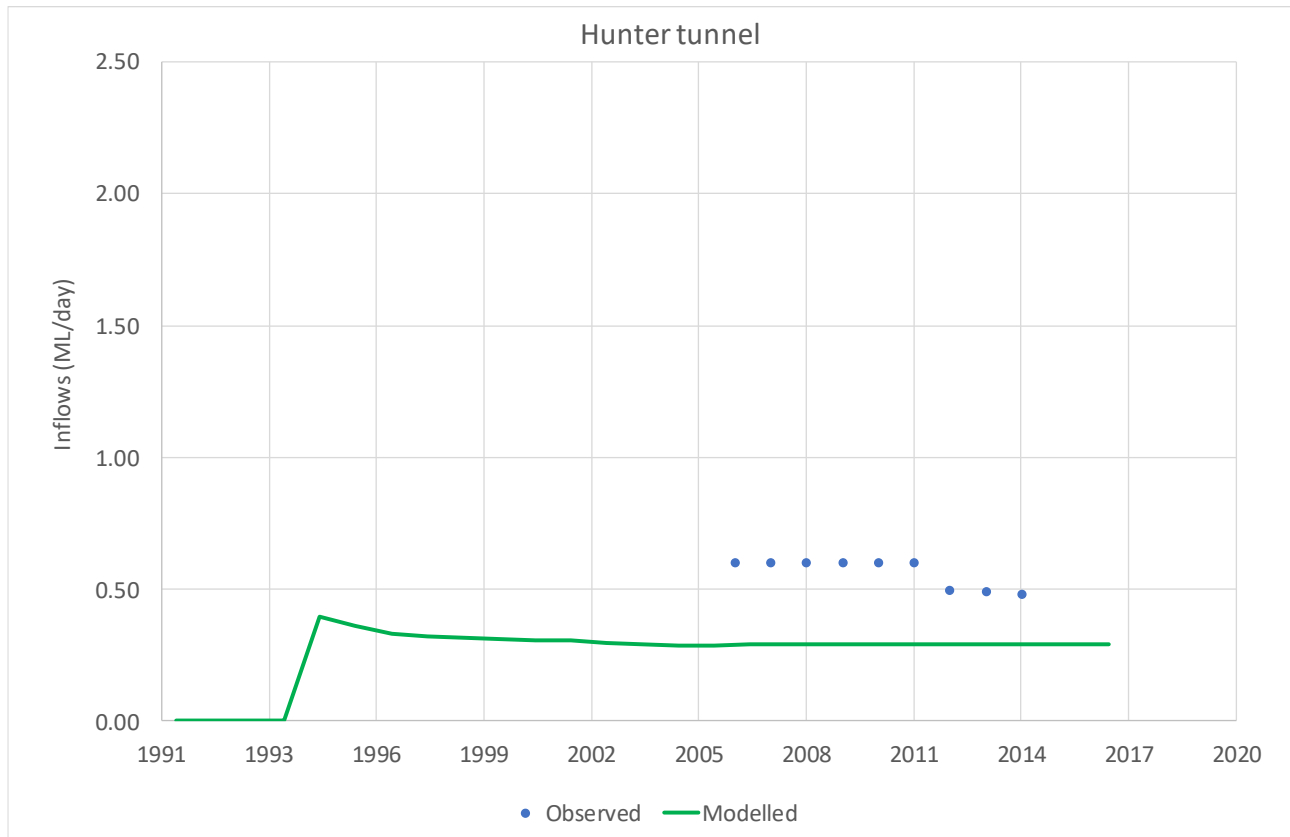


Figure A3.10 Simulated and observed inflows – Dartbrook Mine Hunter Tunnel

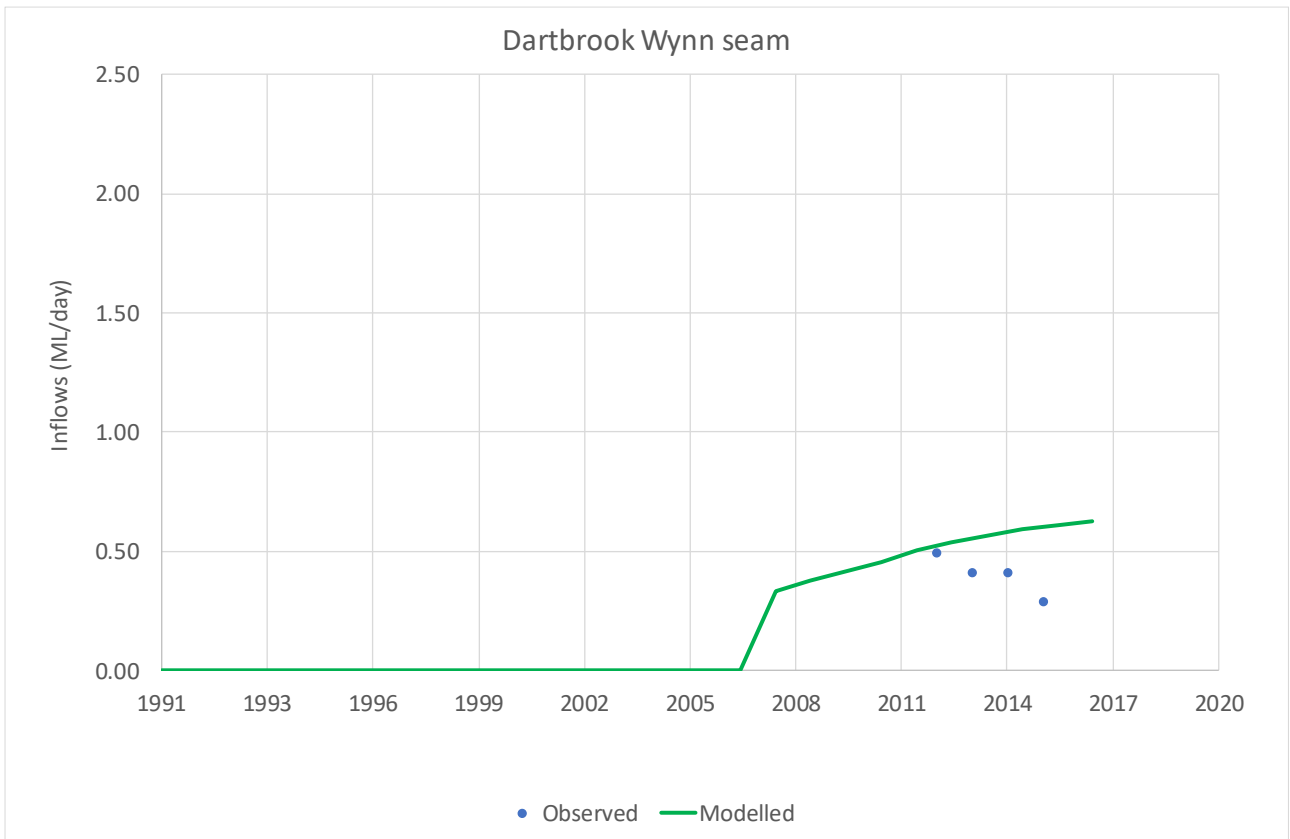


Figure A3.11 Simulated and observed inflows – Dartbrook Wynn Seam

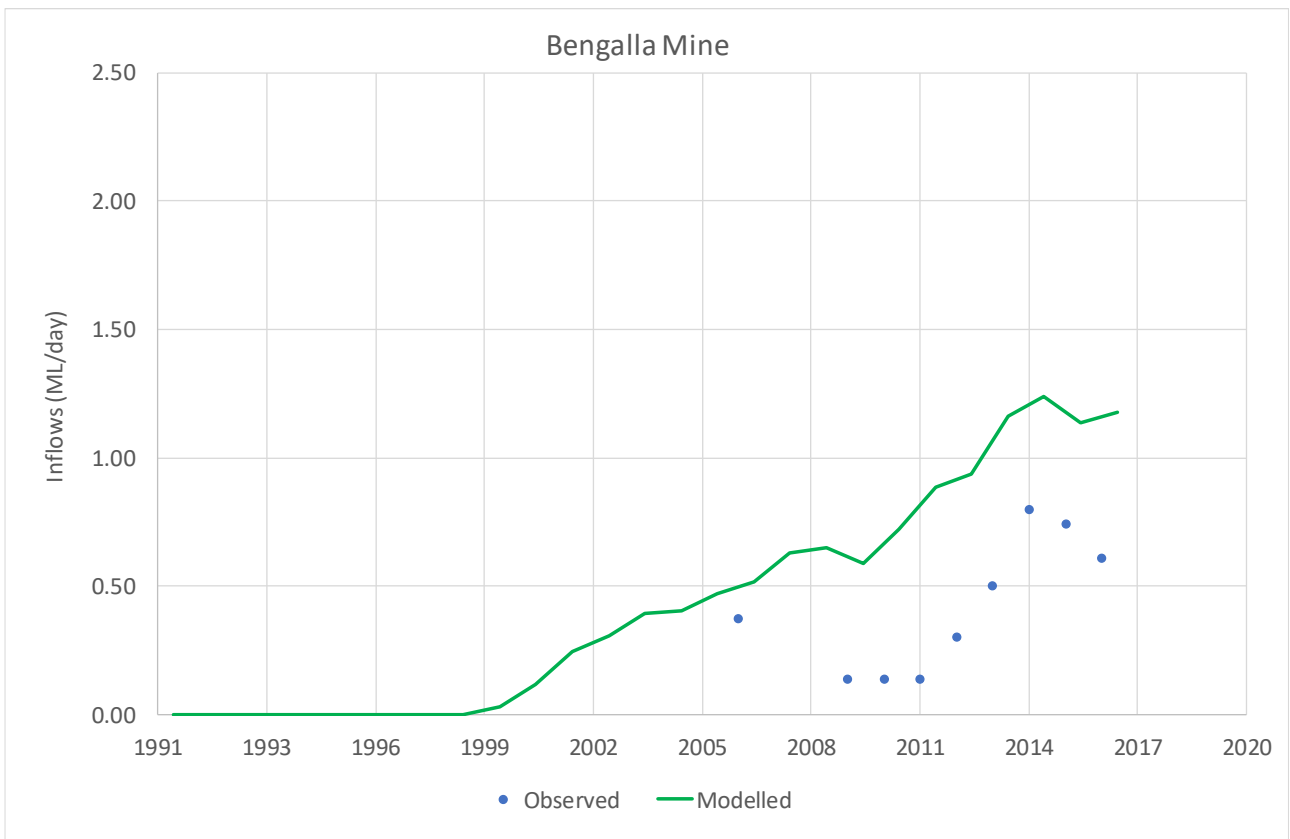


Figure A3.12 Simulated and observed inflows – Bengalla Mine

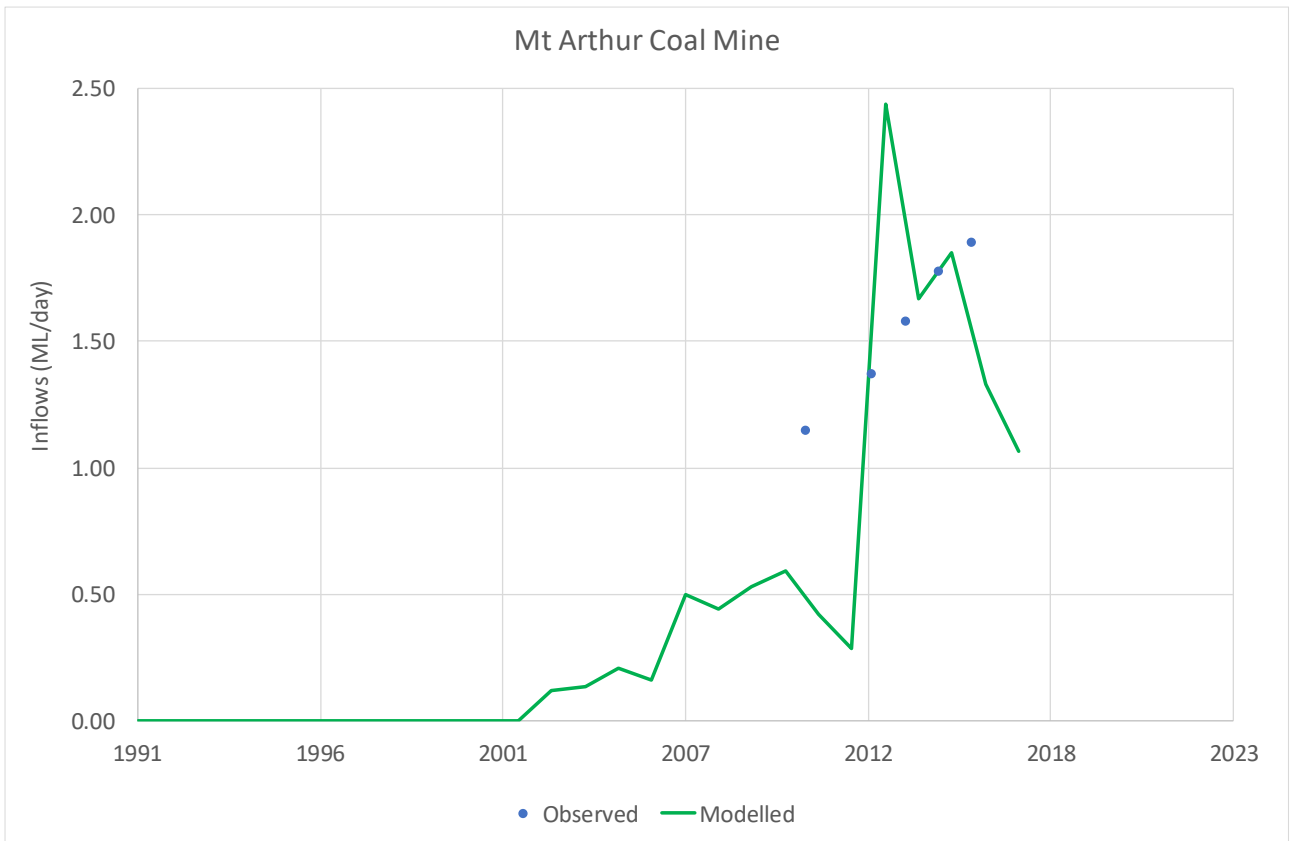


Figure A3.13 Simulated and observed inflows – Mt Arthur Coal Mine

A4 Predictive and recovery simulations

A4.1 Predictive simulations

Four models were run for the predictive simulations (Section 7). These were:

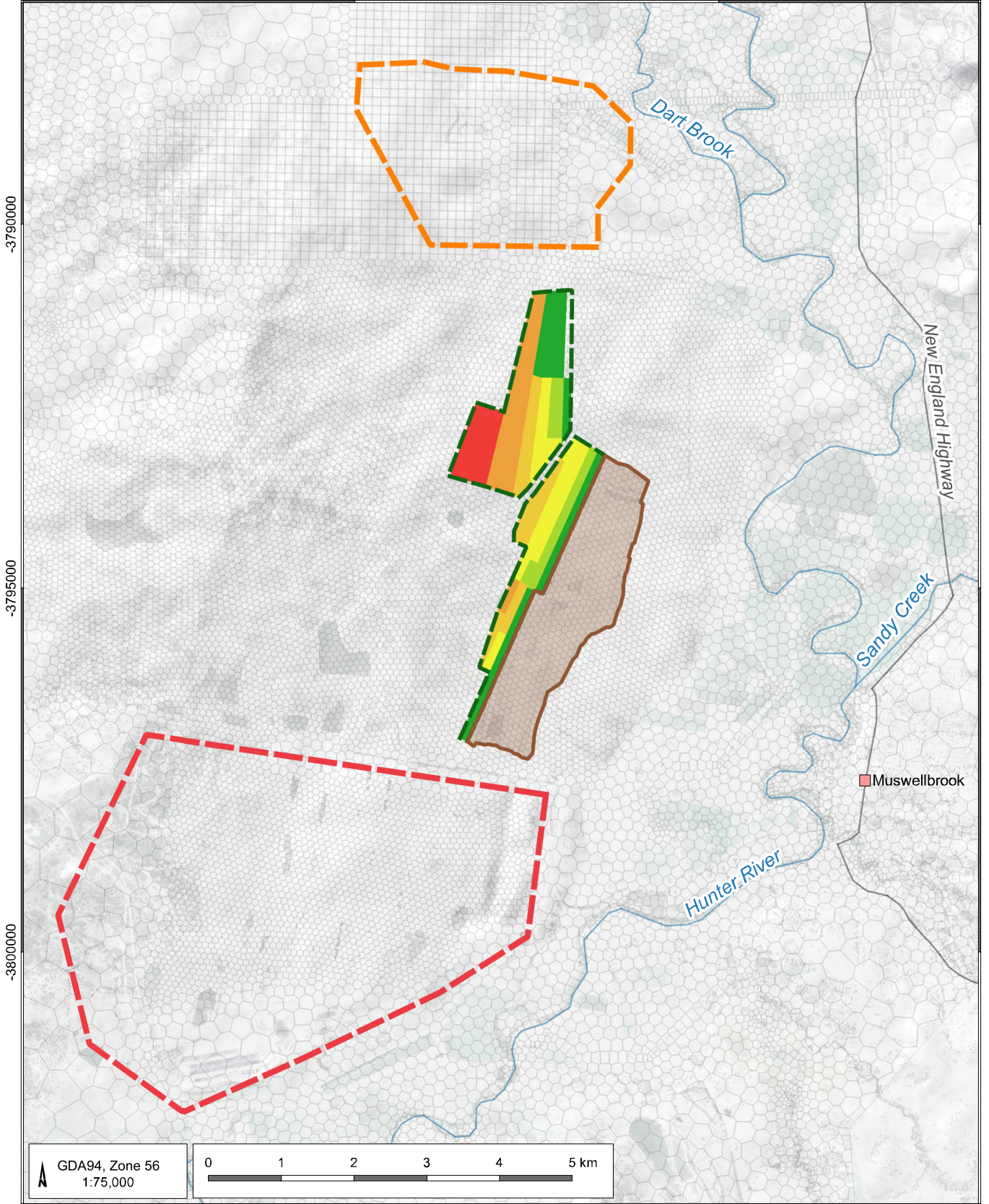
- a model simulation representing no mining for the assessment of cumulative impacts of all mines;
- a model simulation representing the approved MPO at December 2026 and surrounding approved mining operations (e.g. Bengalla Mine, Dartbrook Mine, Mt Arthur Coal Mine);
- a model simulation representing the modified MPO (up to December 2032) and surrounding approved mining operations (e.g. Bengalla Mine, Dartbrook Mine, Mt Arthur Coal Mine); and
- a model simulation representing only the surrounding approved mining operation (excluding the approved and modified MPO).

By comparing the outputs from these four model simulations the cumulative impacts from all mining areas, and the impacts from only the modified MPO can be predicted. The mine plan for the approved MPO (mining up to 2026) and modified MPO (up to 2032) is presented in Figure A4.1. This mine plan was provided by MACH and indicates when mining begins at the locations shown. Outputs from the predictive models are presented in Sections 7 and 8 of the main report.

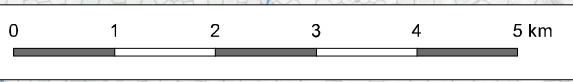
Further to the above model runs, a model run was also undertaken that simulates the approved mining up to December 2026 based on the mine life of the approved MPO. This model run was used to isolate the approved mining impacts up to December 2026 from the proposed mine life extension to December 2032 for the modified MPO to contextualise the overall MPO impacts reported.

16790000

16795000



GDA94, Zone 56
1:75,000



LEGEND

- Populated place
- Road
- Drainage
- Bengalla
- Dartbrook
- MOD7 Pit Extent
- Approved mining area
- Grid
- MOD8 mine progression (Year)**
- 2027
- 2028
- 2029
- 2030
- 2031
- 2032

MPO MOD 8 Life of Mine Extension
(MPO5009.001)

MPO Simulated Mine Plan



AGE

DATE
13/10/2025

FIGURE No:
A 4.1

A4.2 Recovery simulations

The transient model was extended by one stress period to simulate recovery of the groundwater system once all mining is complete. At the completion of mining, any remaining boundary conditions representing dewatering were removed, and the model was adjusted to simulate post-mining conditions. This included an increase in permeability in the mining areas to represent the more permeable spoil, and enhanced recharge rates to the spoil to simulate their enhanced recharge capacity. In addition, an evaporative boundary condition was applied over the final landform with the exception of the pit lake areas. Final voids are expected to remain for Mt Arthur Coal Mine and Bengalla Mine, as well as the final void proposed for the modified MPO (at December 2032).

The water level for the modified MPO final void (in December 2032) post-mining has been determined by ATC Williams (2025), and their predicted water level recovery is presented in Figure A4.2. This assessment has used steady state groundwater inflow predictions linked to stage elevation in the void from the groundwater model, within the overall void water balance to determine the predicted final void water level. This was the same approach as previously requested by the regulators for the SSD EIS.

The void footprints for all the mines are presented in Figure A4.3. Equilibrium void levels in the neighbouring mines have been sourced from corresponding assessments in the public domain.

The recovery simulation was run for 1,000 years, thus allowing the groundwater levels in the backfilled spoil, final void lake, unmined coal seams, and the overlying water-bearing strata to recover to a long term post-mining equilibrium.

The general head boundary (GHB) package was used to simulate the pit water level in the modified MPO final void (at December 2032) with the reference general head value assigned to the target water level. Voids at the neighbouring mine sites (Bengalla and Mt Arthur Mines) were simulated using the time variant constant head package (CHD).

Model cells representing backfilled spoil were assigned a higher horizontal (0.3 m/day) and vertical (0.1 m/day) conductivity than the bedrock units, and a porosity (specific yield) of 0.1. There are few reported measurements of hydraulic properties of backfilled mining spoil, therefore these parameters are estimated based on experience. Recharge rates to the spoil were also increased to 6% of average annual rainfall.

Despite the final void lake being represented by the general head boundary condition, the model cells located within the final voids were also assigned a high K_h and K_v (1,000 m/day) and storage parameters (S_y of 1.0, S_s of 5.0×10^{-6} m⁻¹), to simulate free water movement within the void. This approach is often referred to as a 'high-k' lake. This allowed free movement of seepage into the upper parts of the void space to migrate down to the boundary condition (GHB) representing the pit lake.

Outputs from the recovery modelling are presented in Section 7.2 of the main report.

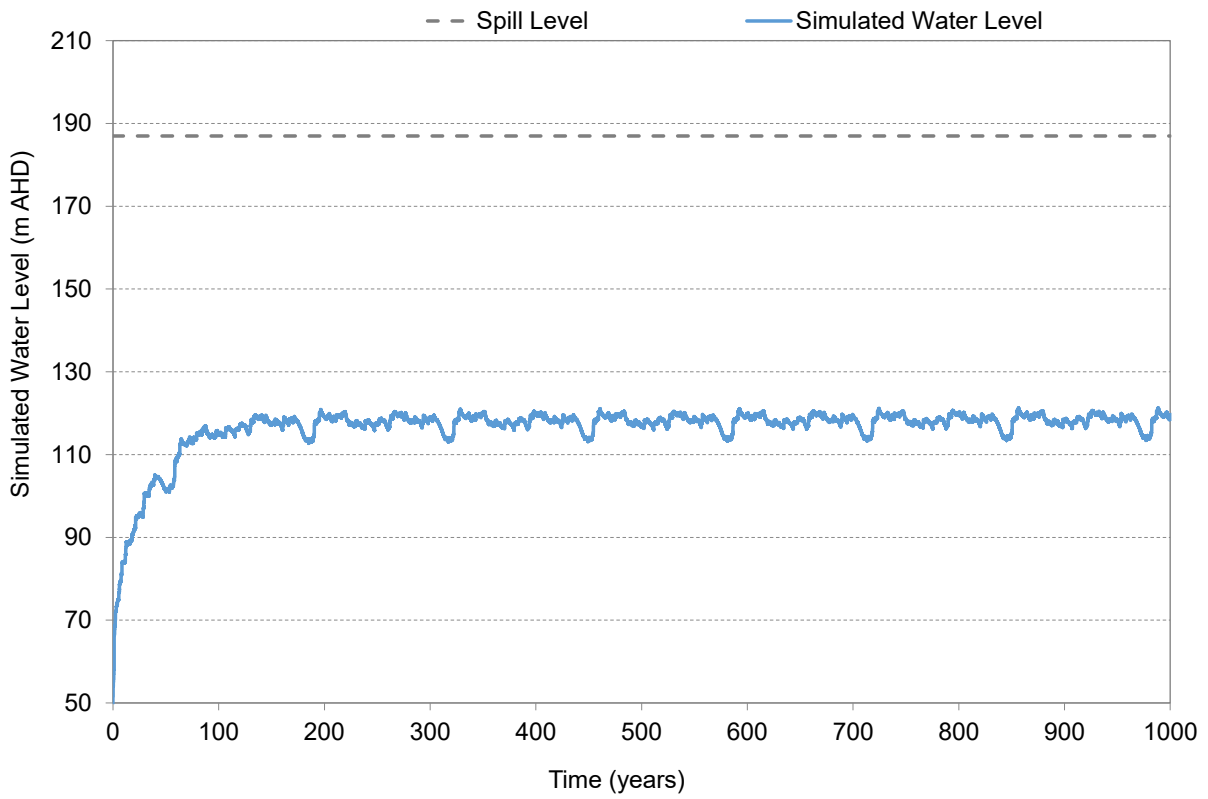


Figure A4.2 Modified MPO (at December 2032) simulated final void water level (ATC Williams, 2025)

290000

300000

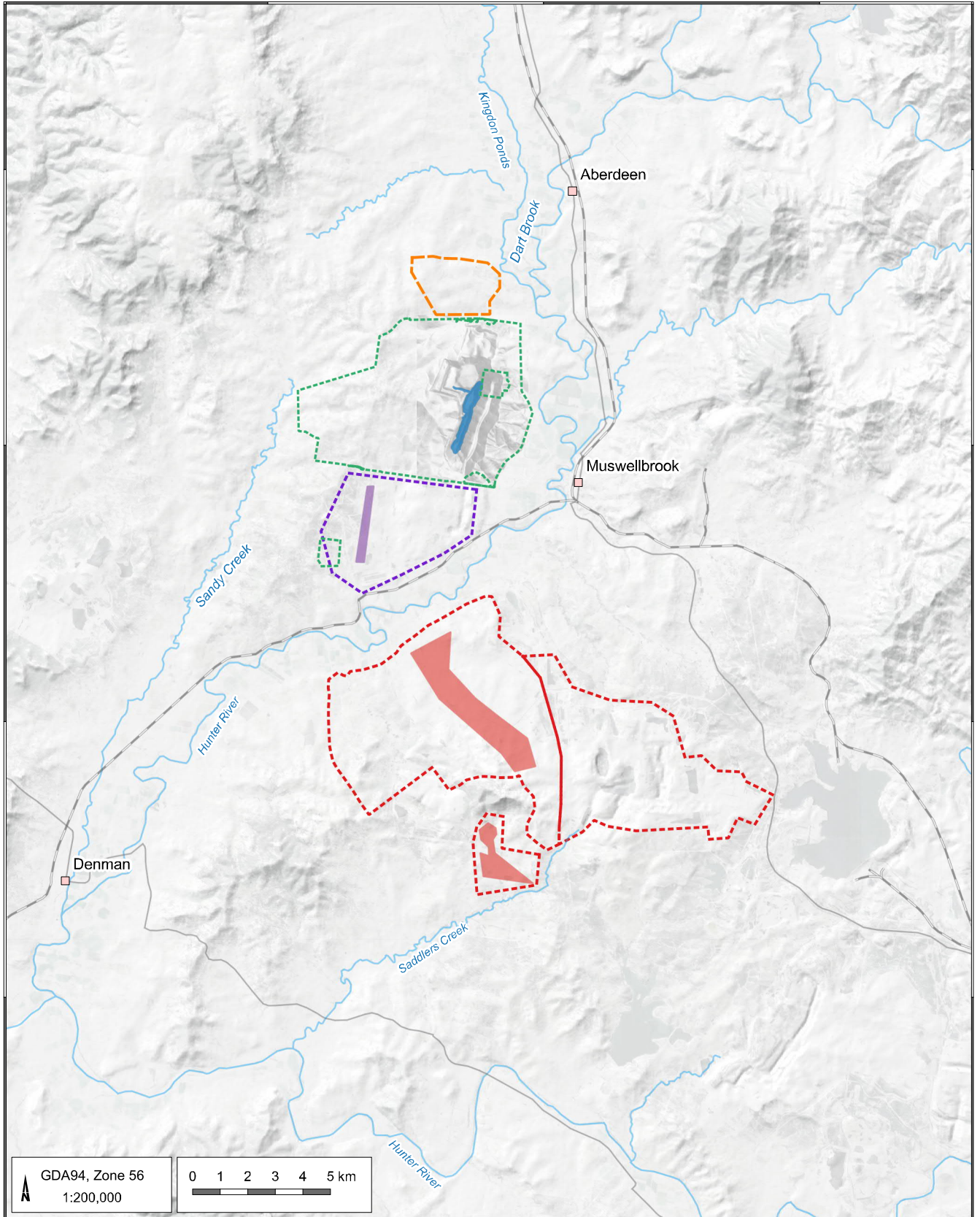
310000

6440000

6430000

6420000

6410000



GDA94, Zone 56
1:200,000



LEGEND

- Populated place
- Road
- Rail
- Drainage
- Dartbrook Project Extent
- Bengalla Project Extent
- Mt Arthur Project Extent
- MPO Project Extent
- Bengalla final void
- Mt Arthur final voids
- MPO void

MPO MOD 8 Life of Mine Extension
(MPO5009.001)

**Simulated final void for modified MPO
(at December 2032) and final voids for
neighbouring mines**



DATE
13/10/2025

FIGURE No:
A 4.3

©2025 Australasian Groundwater and Environmental Consultants Pty Ltd (AGE) - www.ageconsultants.com.au
Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
G:\Projects\MPO5004.001 Mt Pleasant MOD7 Groundwater Assessment3_GIS\Workspaces\001_Deliverable\1A.04.03_MPO5004_Simulated final void for modified MPO (at December 2032) and final voids for
neighbouring mines.gqz

A5 Uncertainty analysis

Groundwater models represent complex environmental systems and processes in a simplified manner. This means that predictions from groundwater models, like so many other environmental models, are inherently uncertain. When considered in a risk management context, a single calibrated model is insufficient to fully predict the range of potential impacts and their likelihood. A robust uncertainty analysis is therefore important for regulatory decision-making to ensure management options and approaches are appropriate to the level of risk and its likelihood for any particular impact.

The sections below describe the methodology and results of the uncertainty analysis completed for the modified MPO numerical model.

A5.1 Methodology

A calibration constrained uncertainty analysis was undertaken to quantify the magnitude of uncertainty in the future impacts predicted by the model in relation to QoIs. This type of analysis produces probability distributions for predictive impacts by assessing a composite likelihood of an impact occurring through assessing and ranking the predictions from hundreds of models 'realisations'. Each model realisation is informed by the observation dataset by using the relationship between the observations statistics to perturbations of each parameter in the groundwater model.

This uncertainty analysis was essentially a three-part process. Firstly, the valid range for the parameters (i.e. pre-calibration range) was determined, and then 300 model realisations were created, each having differing values of key parameters. Hydraulic properties in the model were log-transformed and log-normal distributions were assumed in generating the random parameters for the realisations. Realisations were then constrained using calibration datasets.

The constrained realisations were tested and the models that failed to converge or could not achieve adequate calibration were rejected, leaving only the output from 196 successful models. Models were considered to have an acceptable calibration of SRMS (heads) $\leq 10\%$. This output was analysed to provide a statistical distribution of the predictive impacts.

Outputs from the uncertainty modelling were processed in accordance with the risk-based probability ranking. The ranges adopted are shown in Table A5.1.

It is important to note that the ranges include outputs from all model runs that are deemed to be within an acceptable calibration. There may be one outlier model run within the dataset that produces the extremities of the ranges on the charts. Table A5.2 through to Table A5.6 present the prior and posterior parameter summary statistics for the distinct geological zones in the model domain.

Table A5.1 Calibrated uncertainty modelling language






Narrative descriptor	Probability class	Description	Colour code
Very likely	0 – 10	Very likely that the outcome is larger than this value	
Likely	10 – 33	Likely that the outcome is larger than this value	
About as likely as not	33 – 67	As likely as not that the outcome is larger than this value	
Unlikely	67 – 90	Unlikely that the outcome is larger than this value	
Very unlikely	90 – 100	Very unlikely that the outcome is larger than this value	

Table A5.2 Prior and posterior statistics of horizontal hydraulic conductivity

Group (layers)	Prior (m/d)				Posterior (m/d)				Difference (%)			
	Min	Max	Mean	Std	Min	Max	Mean	Std	Min	Max	Mean	Std
Alluvium (Layer 1)	5.5E-03	9.2E+01	4.8E+00	9.0E+00	5.5E-03	9.2E+01	5.0E+00	9.3E+00	0.0	0.0	-3.7	-2.8
Regolith (Layer 1)	5.0E-03	2.1E+02	3.4E+00	9.3E+00	5.0E-03	1.8E+02	3.9E+00	1.0E+01	0.0	19.6	-14.5	-8.3
Alluvium (Layer 2)	5.8E-03	2.6E+02	1.1E+01	2.2E+01	5.8E-03	2.6E+02	1.1E+01	2.1E+01	0.0	0.0	5.5	5.0
Regolith (Layer 2, including weathered overburden)	4.5E-04	8.4E+00	1.6E-01	4.2E-01	4.5E-04	8.4E+00	1.4E-01	3.5E-01	0.0	0.0	19.6	19.8
Permian interburden (Layer 3, 5, 7, 9, 11, 13, 15, and 17)	3.3E-04	8.6E+01	1.8E-01	5.0E-01	3.8E-04	8.6E+01	1.8E-01	5.1E-01	-14.7	0.0	1.0	-2.2
Permian coal (Layer 4, 6, 8, 10, 12, 14, 16, and 18)	1.1E-03	4.9E+00	2.2E-01	3.3E-01	1.1E-03	4.9E+00	2.2E-01	3.3E-01	-1.4	0.0	0.1	0.6
Permian underburden (Layer 19 & 20)	1.0E-03	5.0E-01	7.7E-02	5.1E-02	1.1E-03	5.0E-01	8.2E-02	5.4E-02	-7.7	0.0	-5.3	-5.3

Table A5.3 Prior and posterior statistics of vertical hydraulic conductivity

Group (layers)	Prior (m/d)				Posterior (m/d)				Difference (%)			
	Min	Max	Mean	Std	Min	Max	Mean	Std	Min	Max	Mean	Std
Alluvium (Layer 1)	4.3E-03	8.6E+00	4.7E-01	7.3E-01	4.3E-03	8.6E+00	4.9E-01	7.7E-01	0.0	0.0	-4.8	-5.5
Regolith (Layer 1)	2.5E-03	5.0E+00	3.9E-01	5.6E-01	2.5E-03	5.0E+00	3.9E-01	5.5E-01	0.0	0.0	0.0	0.4
Alluvium (Layer 2)	4.5E-03	9.7E+01	3.7E+00	8.8E+00	4.5E-03	9.4E+01	3.6E+00	8.6E+00	0.0	2.9	2.2	2.0
Regolith (Layer 2, including weathered overburden)	4.5E-03	9.8E+01	4.4E+00	1.0E+01	4.7E-03	9.7E+01	4.4E+00	9.9E+00	-2.7	1.2	1.0	1.0
Permian interburden (Layer 3, 5, 7, 9, 11, 13, 15, and 17)	4.1E-05	8.9E+01	4.2E-01	1.0E+00	4.5E-05	8.9E+01	4.0E-01	1.0E+00	-8.7	0.0	4.1	4.5
Permian coal (Layer 4, 6, 8, 10, 12, 14, 16, and 18)	1.0E-03	9.9E-02	1.2E-02	1.6E-02	1.0E-03	9.7E-02	1.2E-02	1.6E-02	0.0	1.5	1.3	2.6
Permian underburden (Layer 19 & 20)	8.0E-04	9.8E-02	1.7E-02	1.9E-02	8.0E-04	9.8E-02	1.7E-02	1.8E-02	0.0	0.0	1.2	2.3

Table A5.4 Prior and posterior statistics of specific yield

Group (layers)	Prior (m/d)				Posterior (m/d)				Difference (%)			
	Min	Max	Mean	Std	Min	Max	Mean	Std	Min	Max	Mean	Std
Alluvium (Layer 1)	1.0E-03	9.9E-02	3.2E-02	2.7E-02	1.0E-03	9.9E-02	3.1E-02	2.6E-02	-0.1	0.0	2.7	2.3
Regolith (Layer 1)	1.0E-02	1.0E-01	5.0E-02	2.5E-02	1.0E-02	1.0E-01	4.9E-02	2.6E-02	-1.8	0.2	2.5	-1.5
Alluvium (Layer 2)	1.1E-03	4.9E-01	1.0E-01	1.2E-01	1.1E-03	4.9E-01	1.1E-01	1.2E-01	0.0	0.0	-8.3	-4.8
Regolith (Layer 2, including weathered overburden)	1.0E-04	1.0E-01	2.1E-02	2.6E-02	1.1E-04	1.0E-01	2.4E-02	2.7E-02	-1.6	0.0	-11.1	-4.8
Permian interburden (Layer 3, 5, 7, 9, 11, 13, 15, and 17)	8.1E-05	4.9E-02	5.1E-03	6.0E-03	8.1E-05	4.9E-02	5.0E-03	6.0E-03	0.0	0.0	1.9	-0.1
Permian coal (Layer 4, 6, 8, 10, 12, 14, 16, and 18)	8.0E-05	2.0E-02	2.7E-03	3.5E-03	8.0E-05	2.0E-02	2.7E-03	3.5E-03	0.0	0.0	0.0	0.4
Permian underburden (Layer 19 & 20)	8.2E-05	1.9E-02	1.7E-03	2.9E-03	8.2E-05	1.9E-02	1.7E-03	2.8E-03	0.0	0.0	3.7	6.7

Table A5.5 Prior and posterior statistics of specific storage

Group (layers)	Prior (m/d)				Posterior (m/d)				Difference (%)			
	Min	Max	Mean	Std	Min	Max	Mean	Std	Min	Max	Mean	Std
Alluvium (Layer 1)	2.3E-07	2.3E-05	7.0E-06	6.2E-06	2.3E-07	2.3E-05	6.9E-06	6.2E-06	0.0	0.0	1.3	0.1
Regolith (Layer 1)	2.4E-07	2.3E-05	7.4E-06	6.3E-06	2.4E-07	2.3E-05	7.2E-06	6.3E-06	0.0	0.0	1.9	-0.4
Alluvium (Layer 2)	2.3E-07	2.3E-05	6.8E-06	6.5E-06	2.7E-07	2.3E-05	6.8E-06	6.4E-06	-13.2	0.0	0.2	1.2
Regolith (Layer 2, including weathered overburden)	2.4E-07	2.3E-05	4.7E-06	5.0E-06	3.1E-07	2.3E-05	5.3E-06	5.4E-06	-22.3	0.0	-11.1	-7.0
Permian interburden (Layer 3, 5, 7, 9, 11, 13, 15, and 17)	2.3E-07	2.3E-05	3.2E-06	4.0E-06	2.3E-07	2.2E-05	3.1E-06	3.9E-06	0.0	2.7	1.3	1.2
Permian coal (Layer 4, 6, 8, 10, 12, 14, 16, and 18)	2.3E-07	2.3E-05	3.5E-06	4.1E-06	2.3E-07	2.3E-05	3.5E-06	4.1E-06	0.0	0.0	0.0	-0.2
Permian underburden (Layer 19 & 20)	2.3E-07	2.2E-05	4.0E-06	4.2E-06	2.3E-07	2.2E-05	4.3E-06	4.5E-06	0.0	0.0	-5.8	-6.7

Table A5.6 Prior and posterior statistics of recharge

Group	Prior (m/d)				Posterior (m/d)				Difference (%)			
	Min	Max	Mean	Std	Min	Max	Mean	Std	Min	Max	Mean	Std
Alluvium	9.8E-02	3.0E-02	4.9E-02	1.7E-02	9.6E-02	3.0E-02	4.8E-02	1.7E-02	1.3	0.0	1.6	-1.6
Triassic sandstone	3.0E-02	5.0E-03	1.8E-02	6.8E-03	3.0E-02	5.0E-03	1.8E-02	6.8E-03	0.0	0.0	0.5	-1.0
Premian	9.9E-03	1.0E-03	4.7E-03	2.2E-03	9.9E-03	1.4E-03	5.1E-03	2.2E-03	0.0	-25.8	-8.1	4.2

A6 Climate sensitivity analysis

In addition to the uncertainty analysis, the predictions have also looked at the potential impacts from long-term climate change. The potential change to rainfall volume and distribution resulting from climate change will have impacts on recharge rates to the groundwater system.

The Climate Futures tool projections builder (<https://www.climatechangeinaustralia.gov.au/en/projections-tools/climate-futures-tool/projections-builder/>) has been used to generate three scenarios that the projections builder has labelled 'Best case', 'Maximum Consensus', and 'Worst case'. Due to uncertainty in changes to rainfall, the modelling has looked at both an increase and a decrease in rainfall volumes annually. The projections also use the Representative Concentration Pathway (RCP) of 8.5 which represents the highest baseline emissions scenario where emissions continue to rise throughout the twenty-first century, and the predictions were provided for 2090. The predicted changes to rainfall and evapotranspiration for the three scenarios are provided in Table A6.1.

Table A6.1 RCP8.5 projected change in annual rainfall and evapotranspiration at 2090

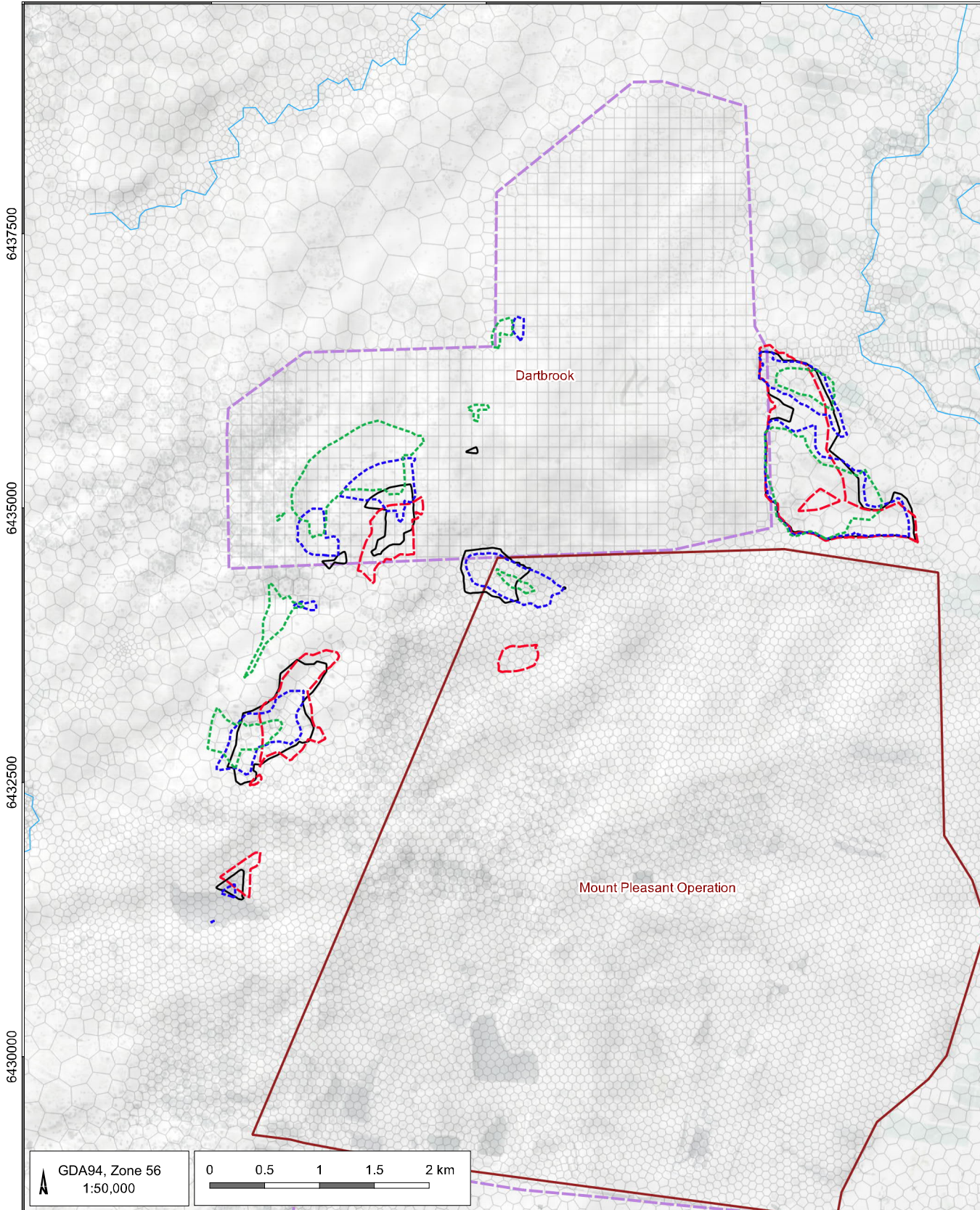
Scenario	Climate model	Annual change	
		Rainfall	Evapotranspiration
Best case (largest reduction in rainfall)	GFDL-ESM2M	-34.0%	14.5%
Maximum Consensus (highest agreement between different climate models)	ACCESS1-0	-15.4%	15.2%
Worst case (largest increase in rainfall)	NorESM1-M	19.1%	8.3%

Impacts to the groundwater system considering the three scenarios can be seen in a comparison of the base case and climate change predicted 2 m drawdown on the alluvium (and regolith) and the deeper Edderton Seam. The 2 m drawdown extent for both shallow and deep groundwaters is not predicted to significantly vary in any of the simulated scenarios as shown in Figure A6.1 and Figure A6.2.

292500

295000

297500



LEGEND

- Populated place
- Drainage
- Road
- Mount Pleasant Operation
- Surrounding mines
- Grid

2m drawdown contours

- Basecase
- Best
- Maximum Consensus
- Worst

MPO MOD 8 Life of Mine Extension (MPO5009.001)

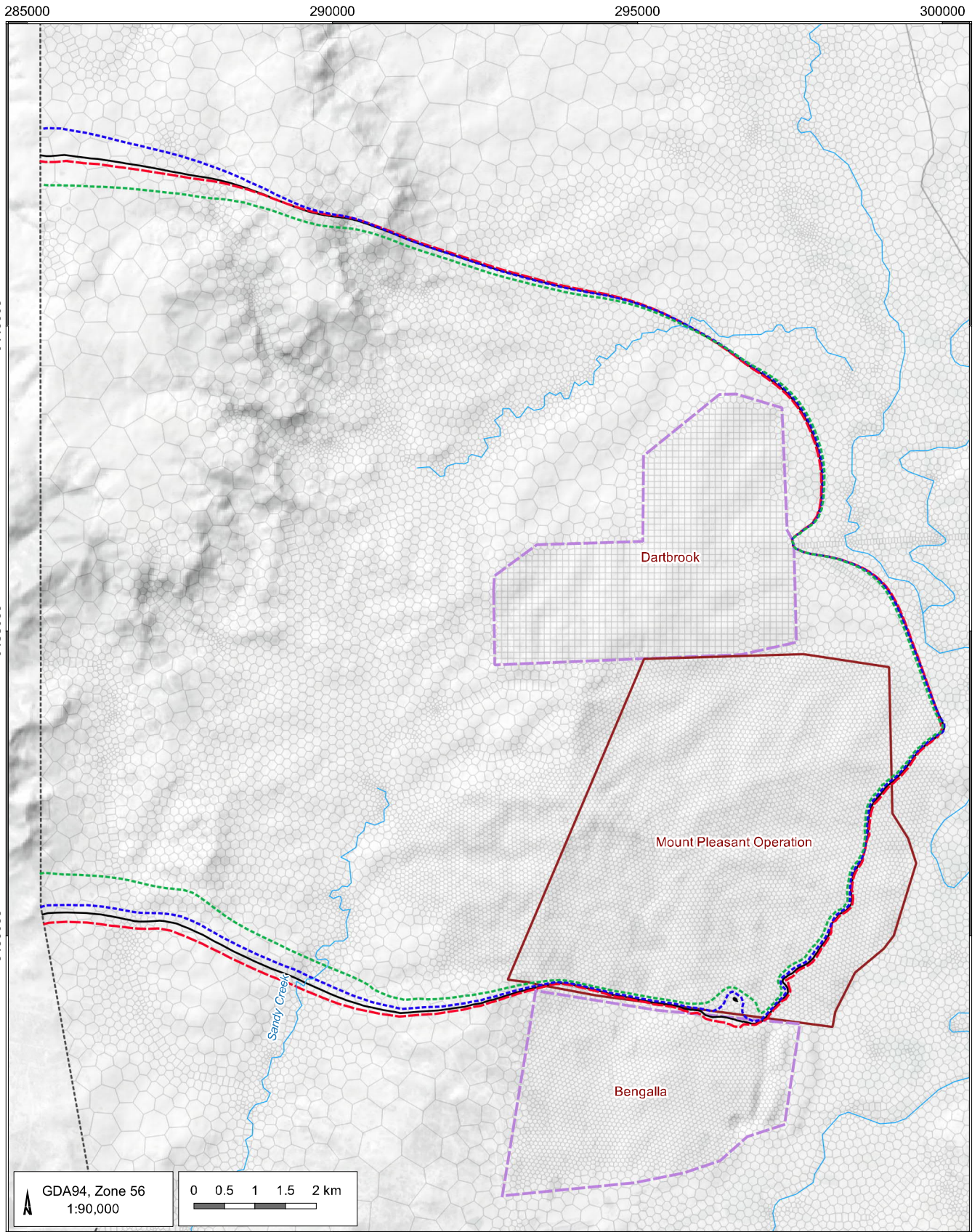
Simulated 2 m drawdown in alluvium/regolith (Layers 1 and 2) for the climate change scenarios at equilibrium post mining conditions



AGE

DATE
13/10/2025

FIGURE No:
A 6.1



LEGEND

- Populated place
- Drainage
- Road
- Mount Pleasant Operation
- Surrounding mines
- Grid

2m drawdown contours

- Basecase
- - - Best
- . . . Maximum Consensus
- - - Worst

MPO MOD 8 Life of Mine Extension
(MPO5009.001)

Simulated 2 m drawdown in Edderton seam (Layer 18) for climate change scenarios at equilibrium post mining conditions



AGE

DATE
13/10/2025

FIGURE No:
A 6.2

A7 Groundwater model validation

The groundwater model was validated in March 2025. This validation was then updated in August 2025 based on data to that time. Updated validation hydrographs are provided in Appendix A3.

It is important to note that only the data from the MPO monitoring bore network was used for this model validation, and not all the data used in the AGE 2020 model calibration (i.e., Bengalla, Dartbrook, Mt. Arthur data). The full dataset can be used for the comprehensive peer review required every three years under the Development Consent DA 92/97.

To validate the model, a comprehensive comparison was conducted using newly collected monitoring data obtained since the previous model calibration in 2020. The validation process involved assessing water level measurements from 45 monitoring bores located within the MPO, as detailed in Appendix A3. This dataset spans from 2003 to 2025, providing an extended timeframe beyond the data utilised in the 2020 model calibration. By incorporating more recent observations and updates to mine progression, the validation aimed to assess the model's accuracy in simulating groundwater conditions and identifying any deviations or trends that may have emerged since the last calibration. Figure A7.1 compares simulated and observed heads using data from 2003 to 2025.

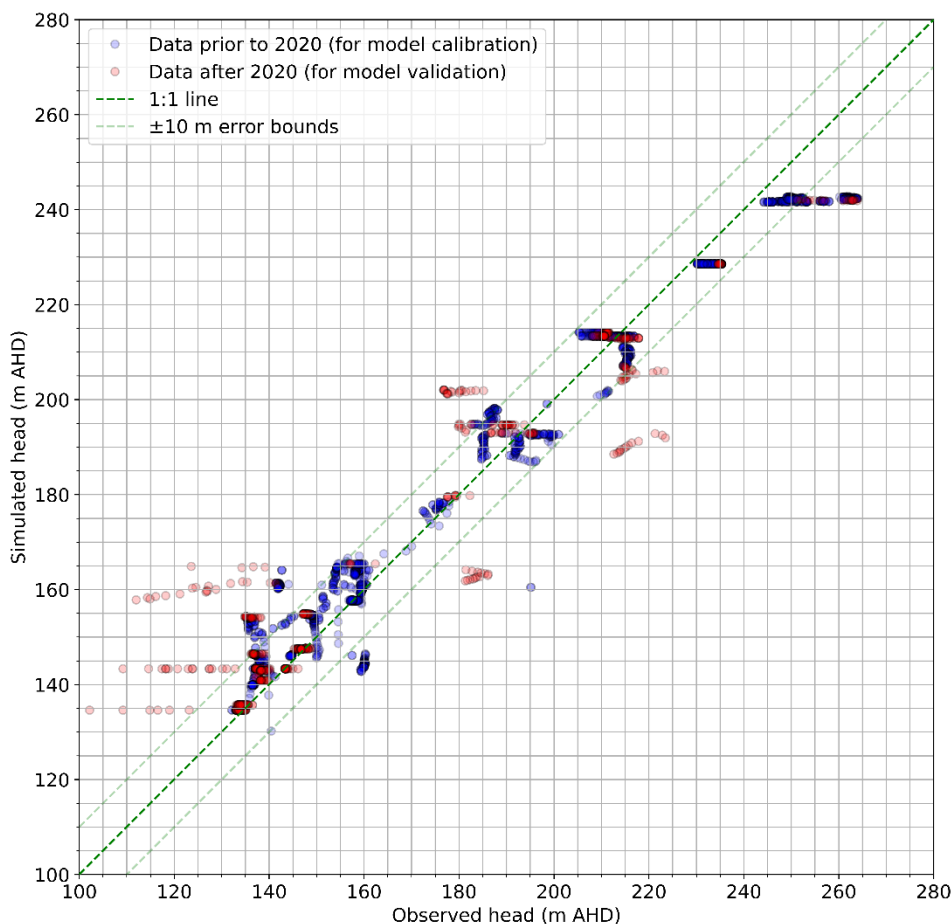


Figure A 7.1 Simulated-observed head comparison

The deviation of data points from an exact match between modelled and observed heads is represented by the root mean squared (RMS) error, calculated as follows:

$$RMS = \sqrt{\frac{1}{n} \sum_{i=1}^n (h_o - h_s)^2}$$

Where h_o and h_s represent the observed and simulated heads at n different locations and times, respectively.

Calculating the RMS error allows for the derivation of the scaled RMS (SRMS) error, which serves as a measure of goodness of fit in evaluating the quality of model predictions (Barnett *et al.*, 2012). The SRMS is defined as the RMS error divided by the range of observed groundwater levels, calculated as follows:

$$SRMS = \frac{100}{\Delta h} \sqrt{\frac{1}{n} \sum_{i=1}^n (w_i (h_o - h_s))^2}$$

Where Δh represents the range of measured heads across the model domain, and w_i is a weighting factor between 0 and 1, calculated at each location by $1/\sqrt{m}$, with m being the number of data points for that location. However, a weighting factor of 1 was assumed here to calculate the natural (unweighted) residual.

Table A 7.1 provides a summary of the statistical measurements, including number of data point, range of observation head, RMS and SRMS errors. These measurements are evaluated based on three data sets: the previous data, the new data, and a combined dataset incorporating both the old and new data. This comparison helps assess the impact of the updated data on overall statistical accuracy.

Table A 7.1 Summary of statistical measures for data before and after 2020

Dataset	Number of data points	Min observed head (m AHD)	Max observed head (m AHD)	RMS (m)	SRMS (%)
Prior 2020	2,180	132.1	264.0	8.41	6.38
After 2020	603	87.35	263.9	12.6	7.15
All	2,783	87.35	264.0	9.49	5.37

Notes: Min = minimum; Max = maximum; m AHD = metres Australian Height Datum; RMS = root mean squared error; SRMS = scaled root mean squared error.

According to Table A 7.1 the number of data points used for calculating statistical measures in the model-data comparison for this study is one-fifth of that used in the previous model calibration (AGE, 2020). However, the updated dataset covers a wider range of observed head values, from 87.35 m AHD to 263.9 m AHD, whereas the observed head range in the 2020 dataset was between 132.1 m AHD and 264.0 m AHD. The RMS and SRMS values for the post-2020 dataset were 12.6 m and 7.15%, respectively, compared to 8.41 m and 6.38% for the pre-2020 dataset, indicating a slight reduction in model accuracy for the post-2020 dataset.

Globally, considering both the pre- and post-2020 datasets, the RMS value was 9.49 m, showing a slight increase compared to the RMS of the pre-2020 dataset (8.41 m), which represents a 13% increase. Meanwhile, the global SRMS value was 5.73%, reflecting a 10% reduction compared to the SRMS of the pre-2020 dataset (6.38%). This SRMS value falls below the 10% benchmark recommended in the Australian Groundwater Modelling Guidelines (Barnett *et al.*, 2012), indicating that the model calibration meets acceptable standards. The primary cause of the increased SRMS is due to the addition of newly drilled bores into the validation dataset, and these results suggest that the model, derived from the AGE 2020 model, remains adequately calibrated for its intended purpose, and further calibration is not necessary at this stage.

Additional validation of the model's performance was conducted by analysing hydrographs, provided in Appendix A3, which illustrate both model-predicted and observed groundwater levels at monitoring points within the model domain. While some discrepancies exist between the predicted and observed values, the model effectively captures the overall groundwater level trends, particularly in areas where monitoring data indicates significant drawdown due to mine dewatering. In cases where deviations are observed, the model tends to predict a greater decline in groundwater levels than what has been measured. This is likely due to the use of conservative assumptions in the model, as well as the simplified model layering, which may overestimate vertical hydraulic connectivity compared to actual site conditions.

Overall, the model demonstrates a robust capacity to simulate regional groundwater behaviour and mine-related impacts. While some localised differences between observed and simulated values exist, these are within acceptable limits given the inherent uncertainties in groundwater modelling. The model is therefore deemed reliable for decision-making and impact assessments within the MPO and surrounding areas.

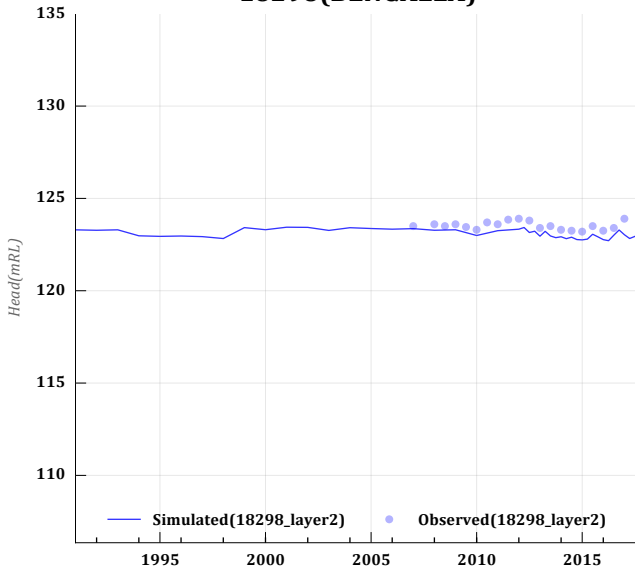
A8 References

- Australasian Groundwater and Environmental Consultants Pty Ltd (AGE), 2013a. "Continuation of Bengalla Mine Groundwater Impact Assessment". Prepared for Hansen Bailey Pty Ltd June 2013.
- Australasian Groundwater and Environmental Consultants Pty Ltd (AGE), 2014. "Report on West Muswellbrook Project gateway application. Highly Productive aquifer groundwater impact assessment". Prepared for Muswellbrook Coal Company Limited.
- Australasian Groundwater and Environmental Consultants Pty Ltd (AGE), 2014. "Report on West Muswellbrook Project gateway application. Highly Productive aquifer groundwater impact assessment". Prepared for Muswellbrook Coal Company Limited.
- Australasian Groundwater and Environmental Consultants Pty Ltd (AGE), 2020. "Report on Mount Pleasant Optimisation Project Groundwater Impact Assessment" Prepared for Mach Energy Australia Pty Ltd, Project G1970A, December 2020.
- Australasian Groundwater and Environmental Consultants Pty Ltd (AGE), 2025. "MPO MOD7" Prepared for Mach Energy Australia Pty Ltd, Project MPO5004.001, August 2024.
- ATC Williams, 2025. "Mount Pleasant Operation Modification 8 Surface Water Assessment".
- Barnett, B, Townley, LR, Post, V, Evans, RE, Hunt, RJ, Peeters, L Richardson, S, Werner, AD, Knapton, A, & Boronkay, A, 2012. "Australian groundwater modelling guidelines", Waterlines report, National Water Commission, Canberra.
- Canadell, J., Jackson, R.B., Ehleringer, J. B., Mooney, H. A., Sala, O. E., & Schulze, E.-D. 1996. Maximum rooting depth of vegetation types at the global scale. *Oecologia*, 108(4): 583–595.
- Ditton, S., and Merrick, N.P., 2014. A new sub-surface fracture height prediction model for longwall mines in the NSW coalfields. Paper presented at the Australian Earth Science Convention, Newcastle NSW.
- Doherty, J, 2010. "PEST – Model independent parameter estimation user manual: 5th edition", Watermark Numerical Computing, Corinda, Australia.
- HydroSimulations, 2015. "Spur Hill Underground – Groundwater Assessment for Gateway Application-Presentation to CCC". June 2015.
- Murray-Darling Basin Commission, 2001. Groundwater Flow Modelling Guideline retrieved from https://www.mdba.gov.au/sites/default/files/archived/mbdc_GW_reports/2175_GW_flow_modelling_guideline.pdf.
- Panday, S, Langevin, CD, Niswonger, RG, Ibaraki, M & Hughes, JD, 2015. "MODFLOW-USG version 1: An unstructured grid version of MODFLOW for simulating groundwater flow and tightly coupled processes using a control volume finite-difference formulation"; U.S. Geological Survey Techniques and Methods, book 6, chap. A45, 66 p.
- Peeters LJM and Middlemis H, 2023. "Information Guidelines Explanatory Note: Uncertainty analysis for groundwater modelling". A report prepared for the Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development through the Department of Climate Change, Energy, the Environment and Water.
- Tomlinson, M, Boulton, A. "Ecology and Management of Subsurface Groundwater Dependent Ecosystems in Australia". *Journal of Environmental Science - Marine and Freshwater Research*. Published 3 September, 2010.
- Watermark Numerical Computing, 2015. "Watermark Numerical Computing, Calibration and Uncertainty Analysis for Complex Environmental Models".
- Whetton P, Hennessy K, Clarke J, McInnes K, Kent D, 2012. 'Use of Representative Climate Futures in impact and adaptation assessment.' *Climatic Change* 115, 433-442. 10.1007/s10584-012-0471-z.

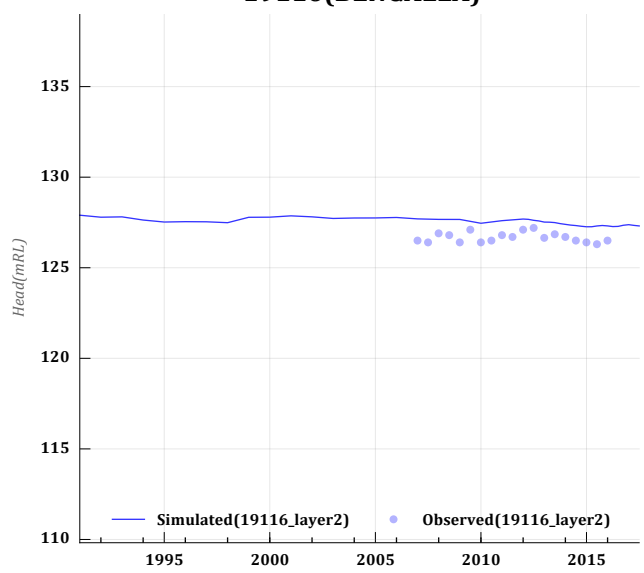
Appendix A1

Calibration details and hydrographs

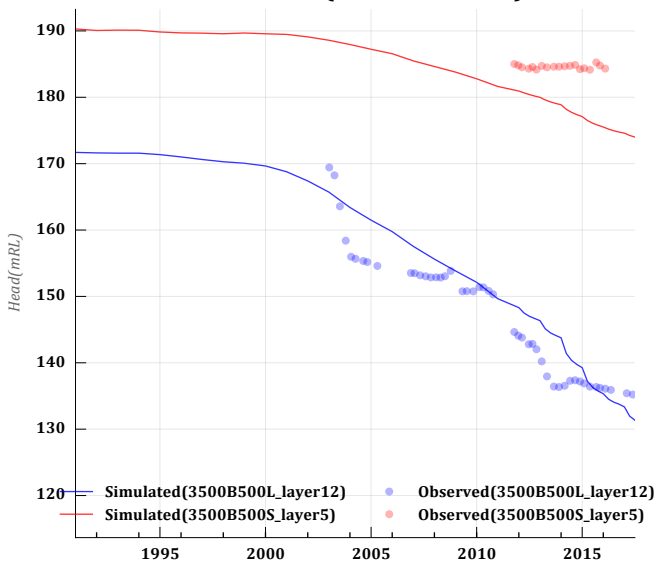
18298(BENGALLA)



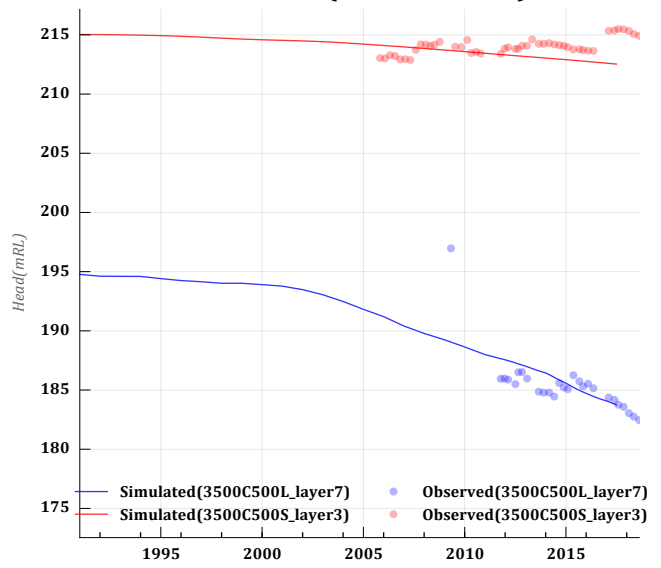
19116(BENGALLA)



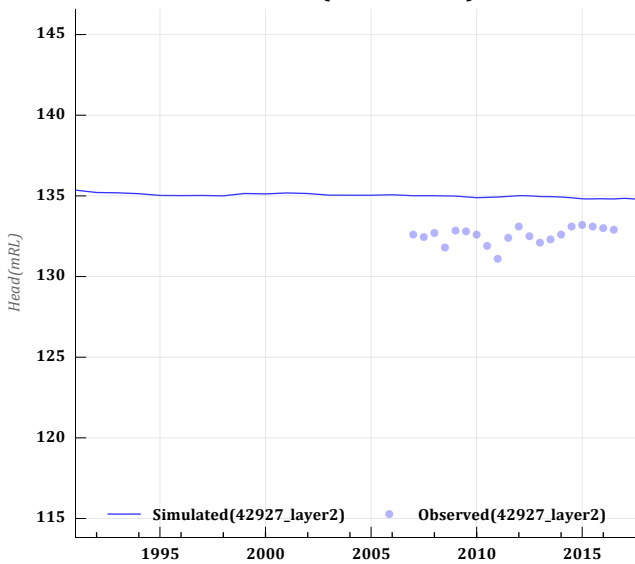
3500B500(MT PLEASANT)



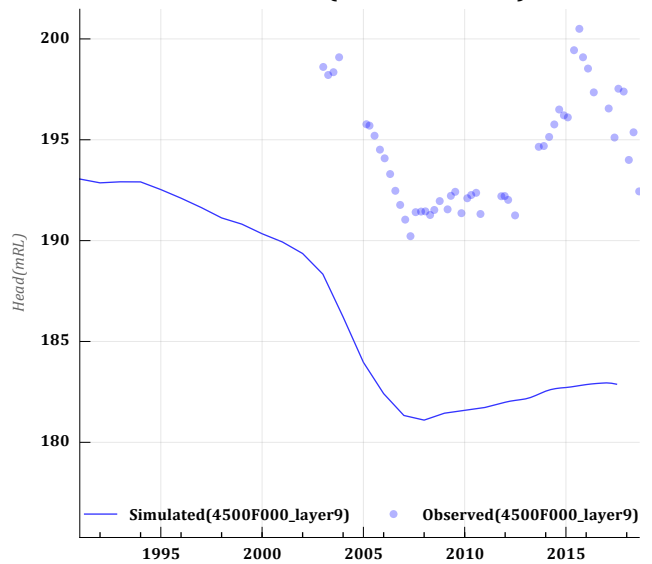
3500C500(MT PLEASANT)



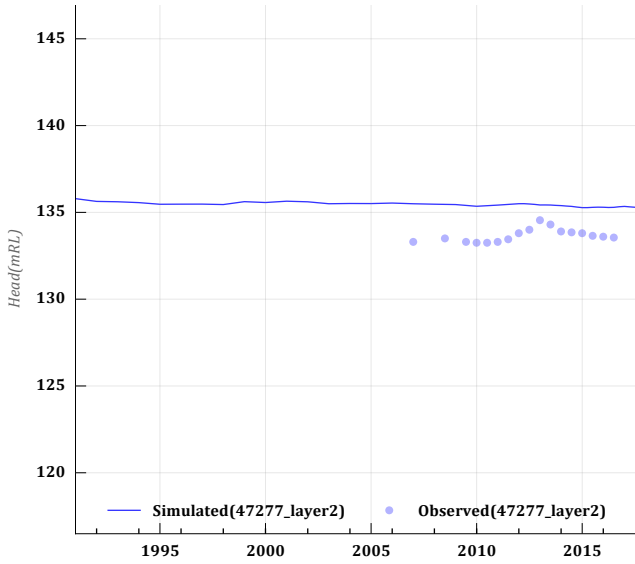
42927(BENGALLA)



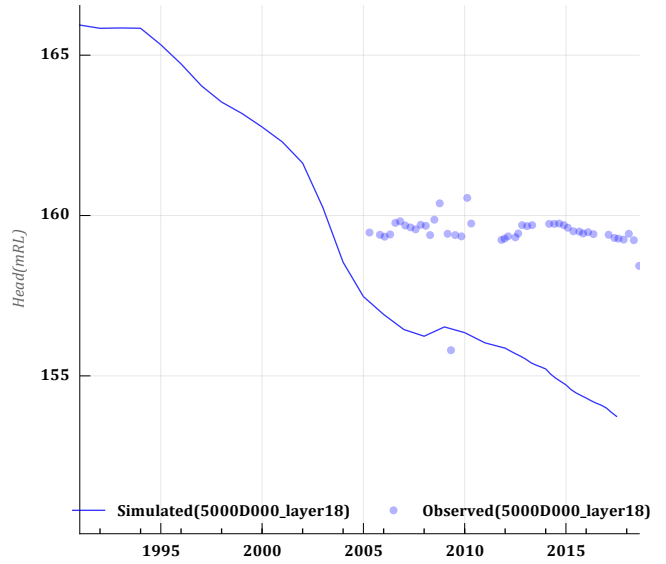
4500F000(MT PLEASANT)



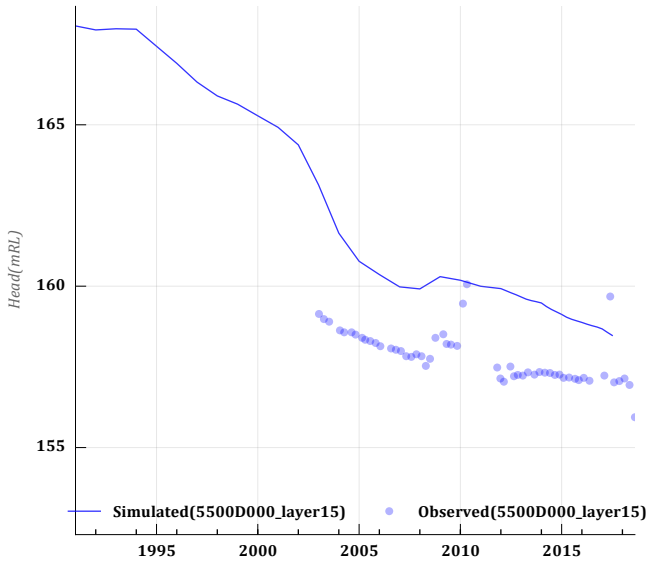
47277(BENGALLA)



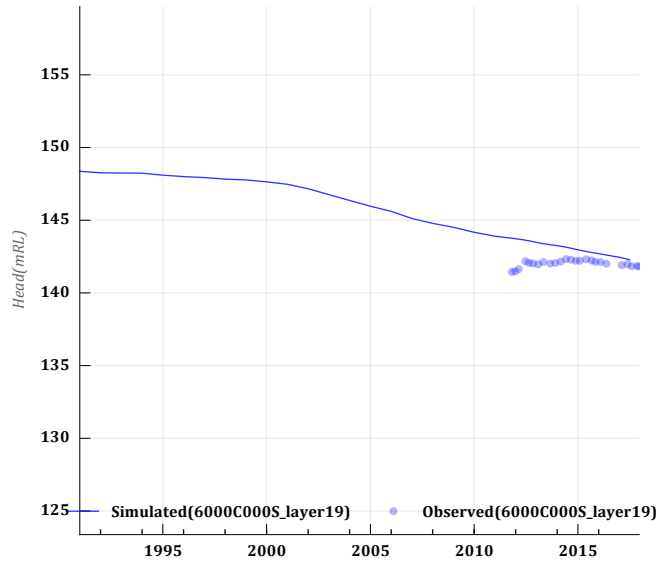
5000D000(MT PLEASANT)



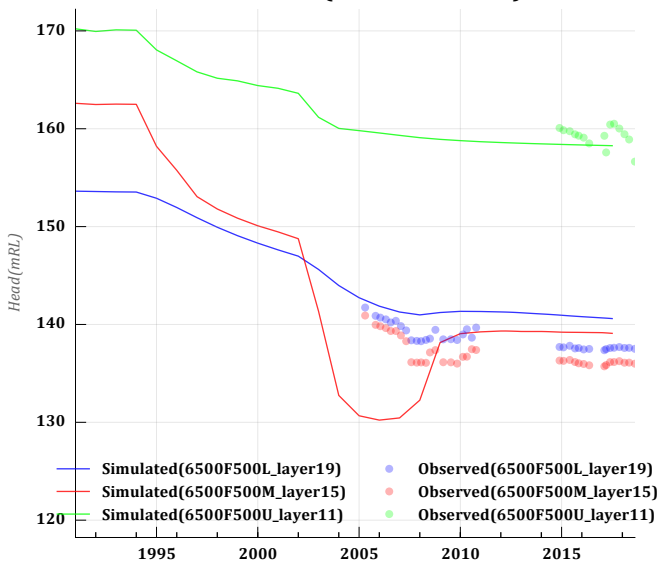
5500D000(MT PLEASANT)



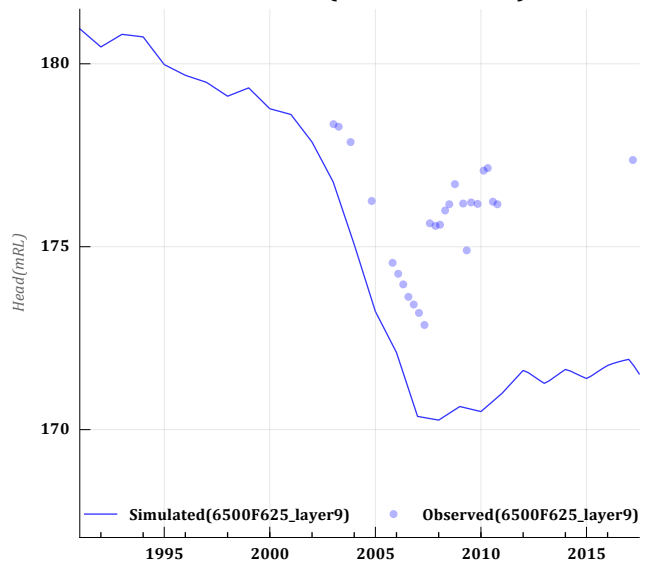
6000C000S(MT PLEASANT)

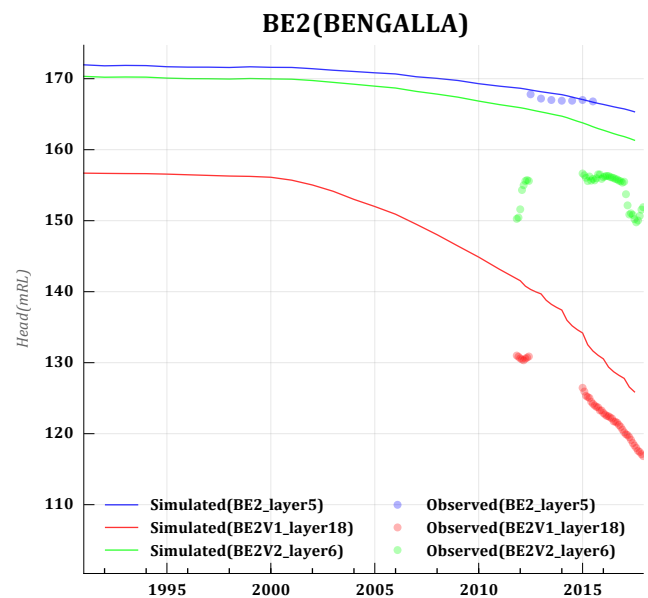
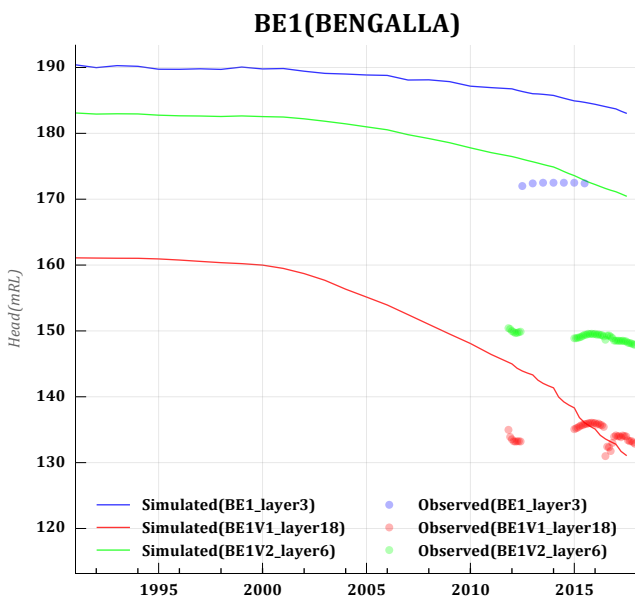
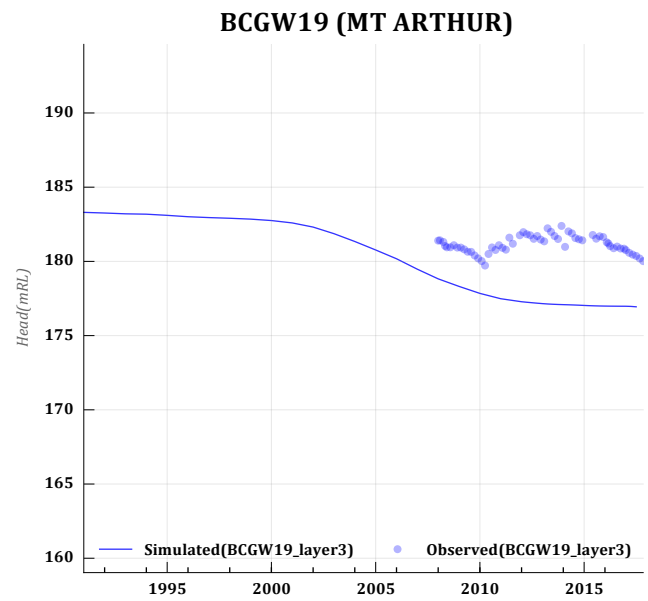
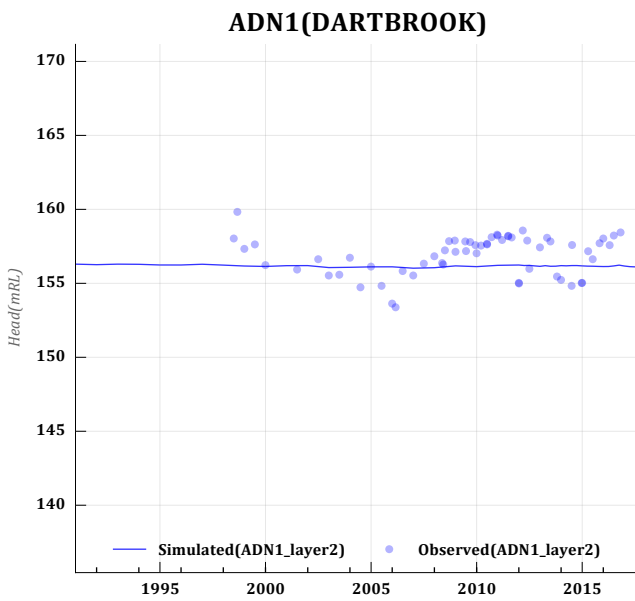
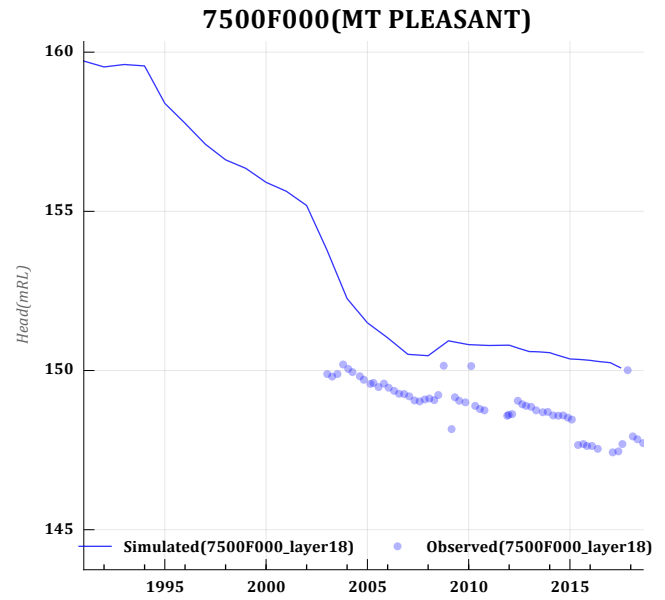
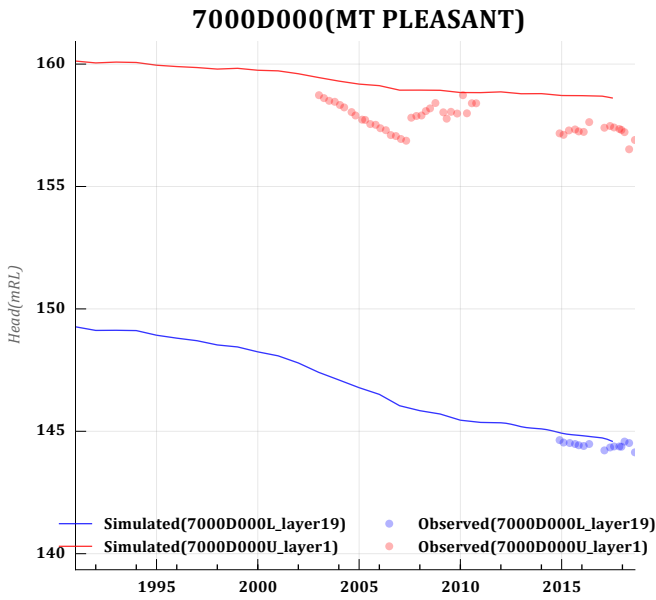


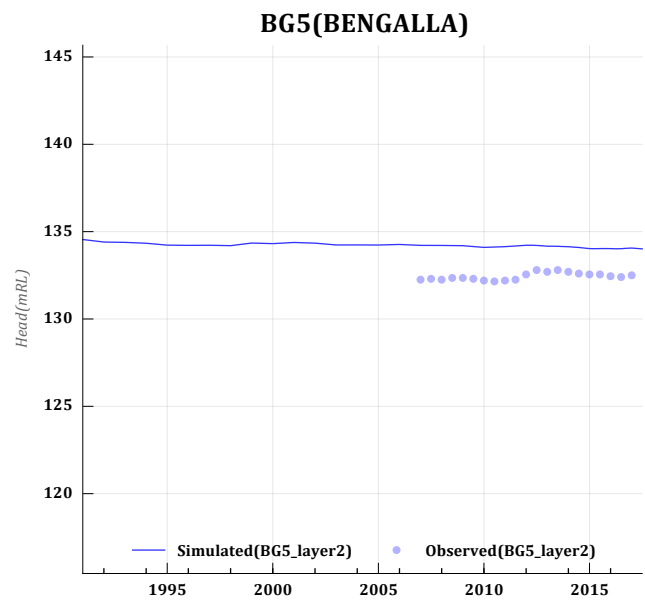
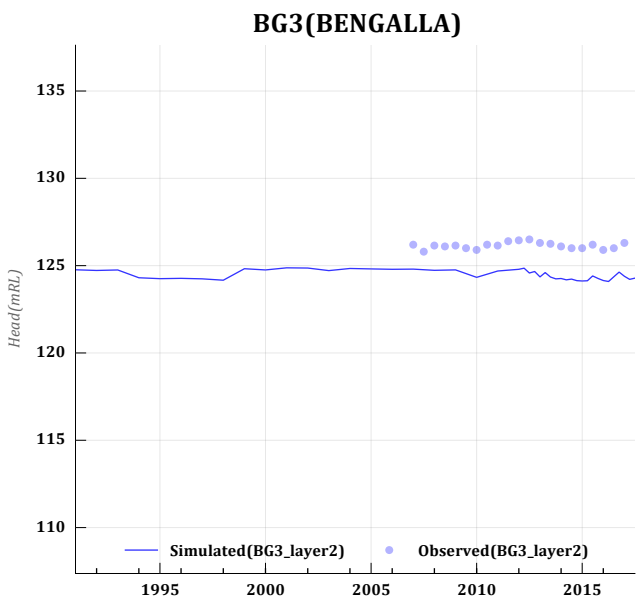
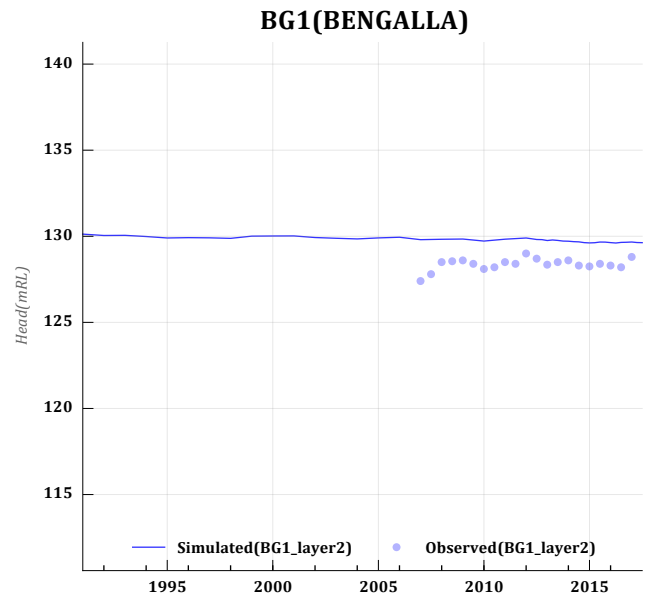
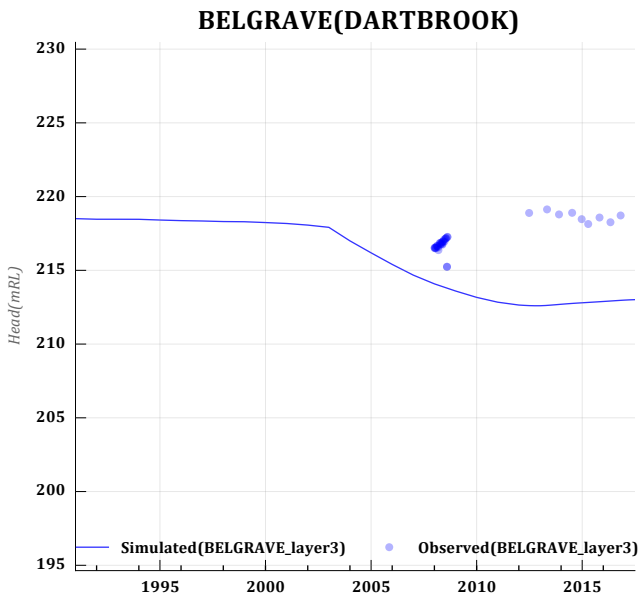
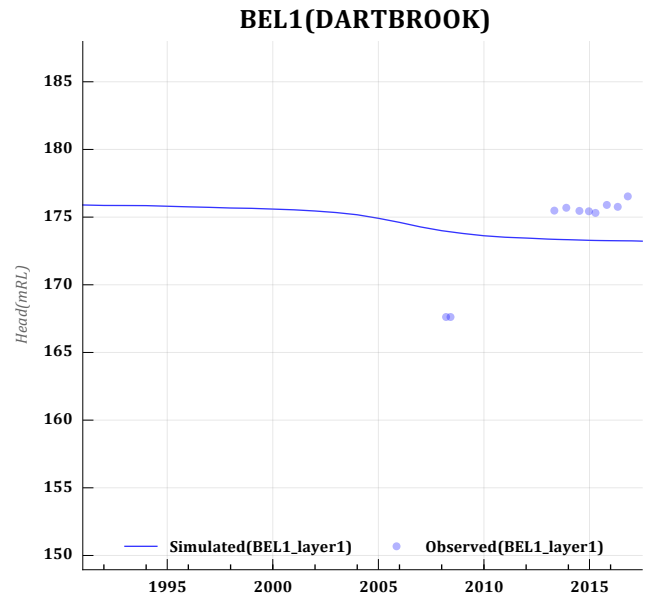
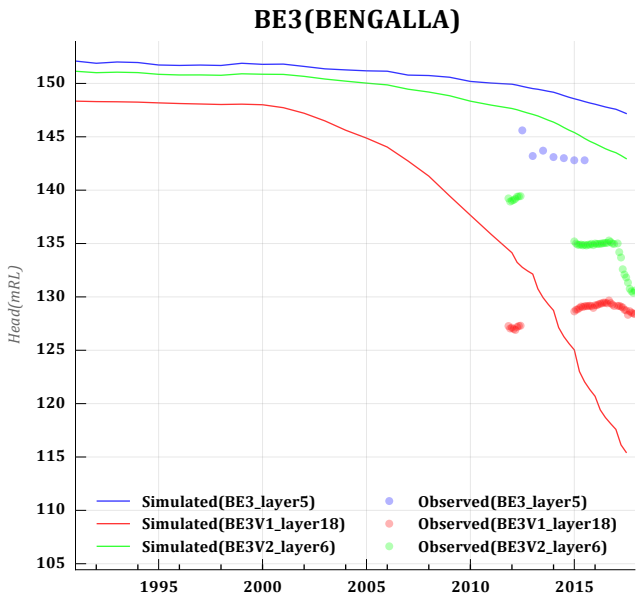
6500F500(MT PLEASANT)



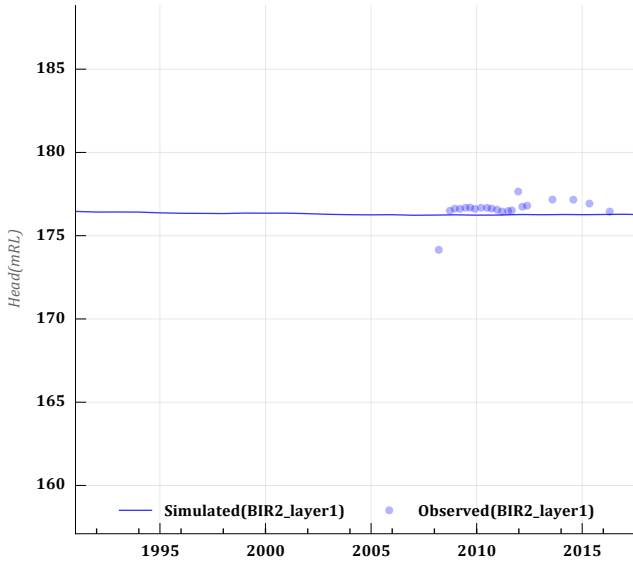
6500F625(MT PLEASANT)



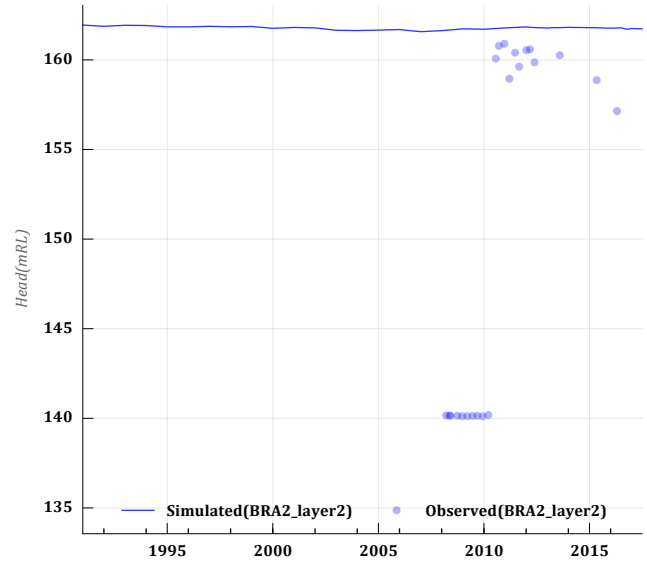




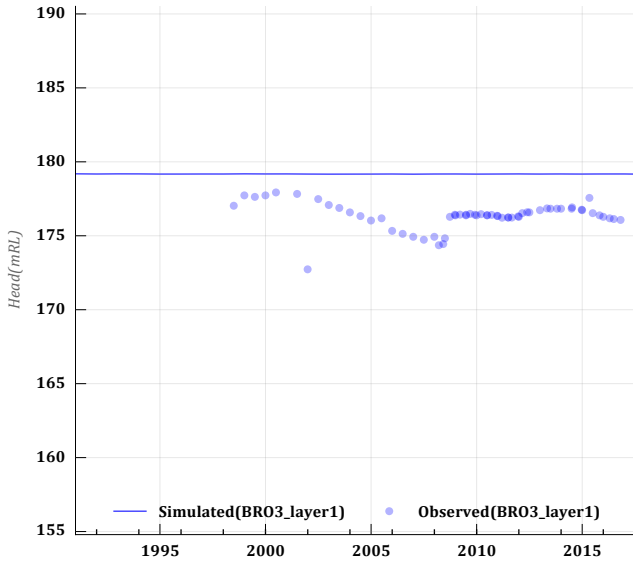
BIR2(DARTBROOK)



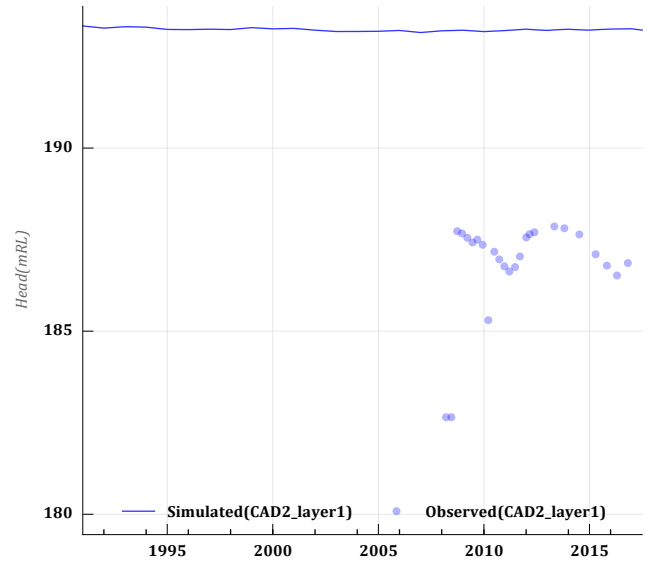
BRA2(DARTBROOK)



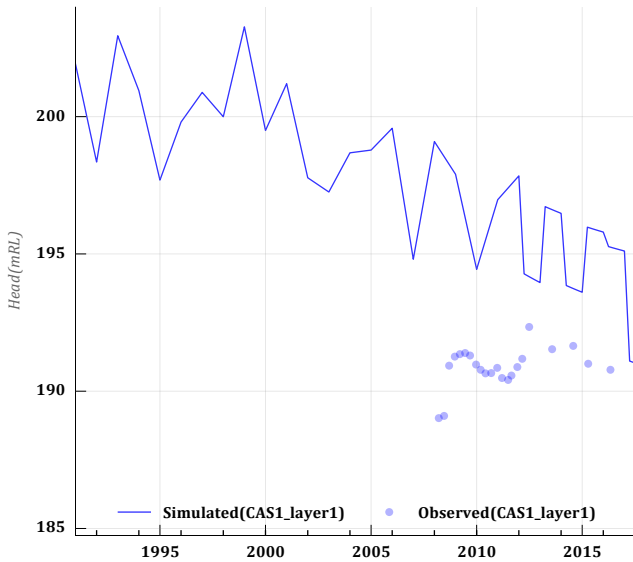
BRO3(DARTBROOK)



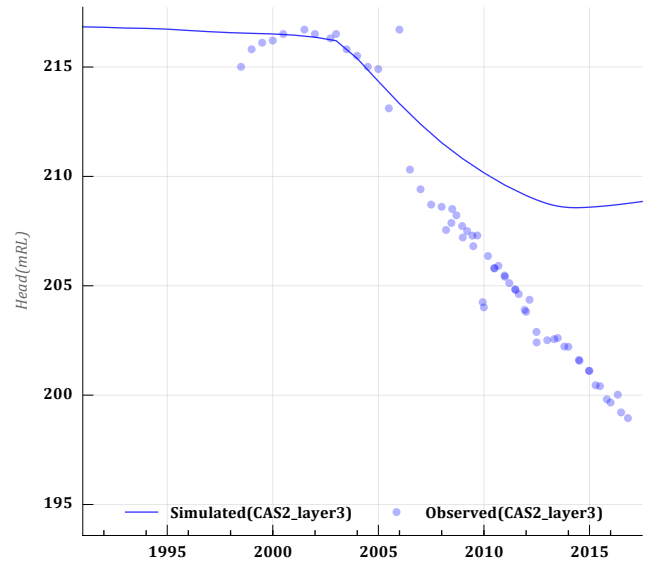
CAD2(DARTBROOK)

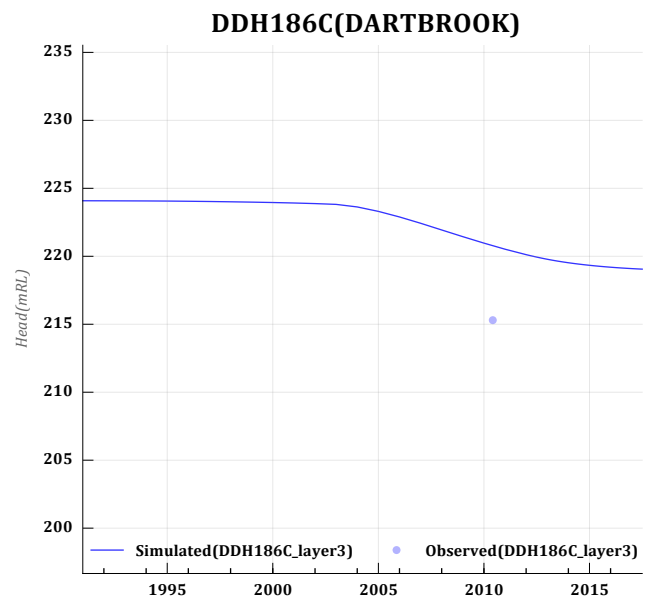
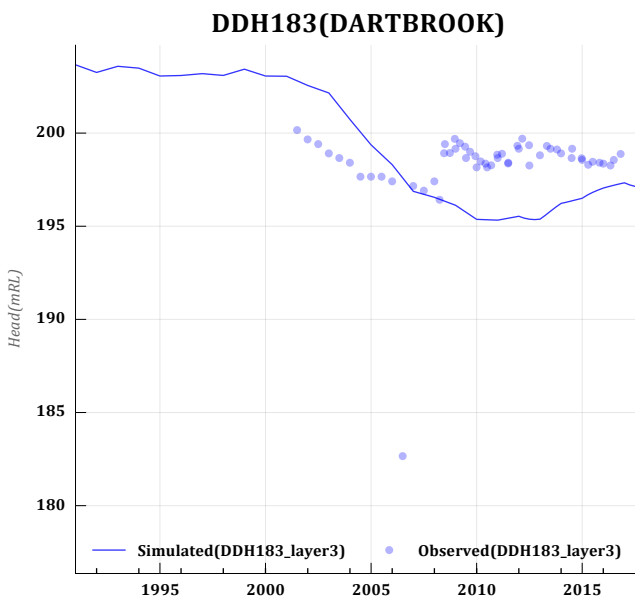
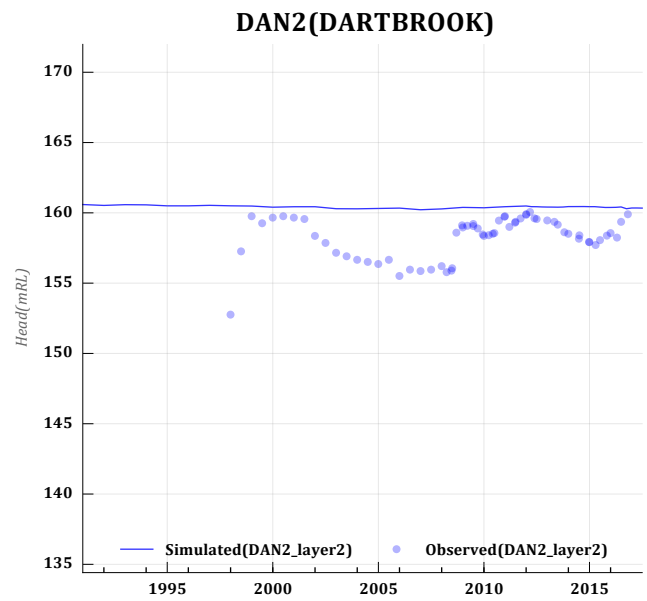
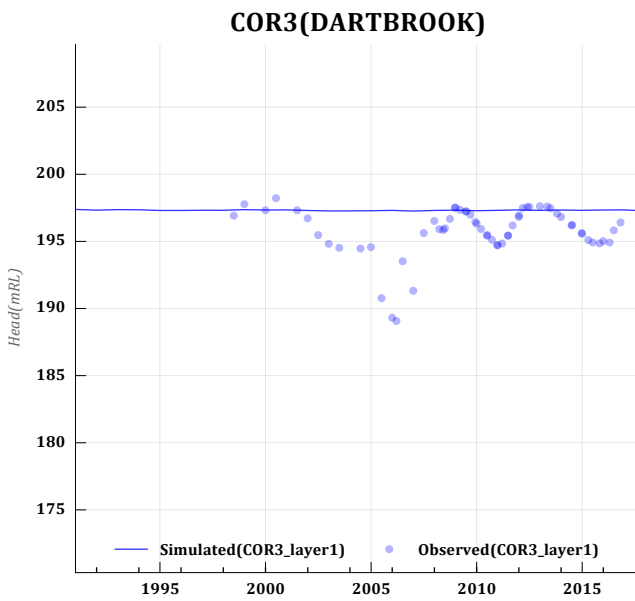
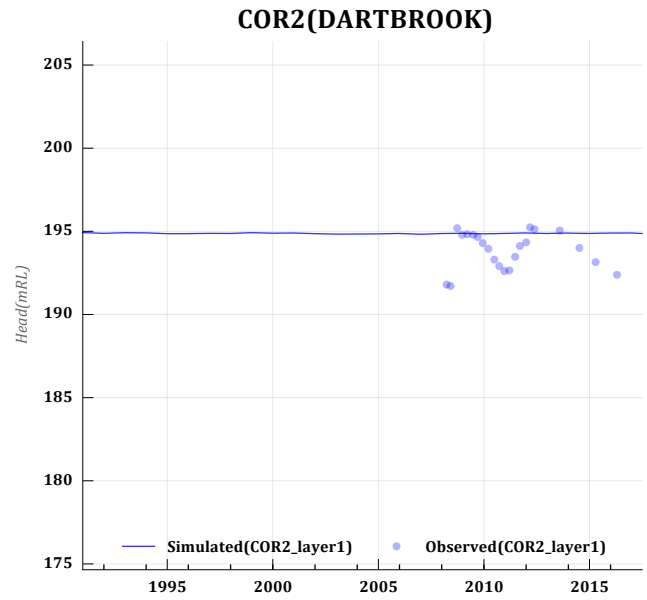
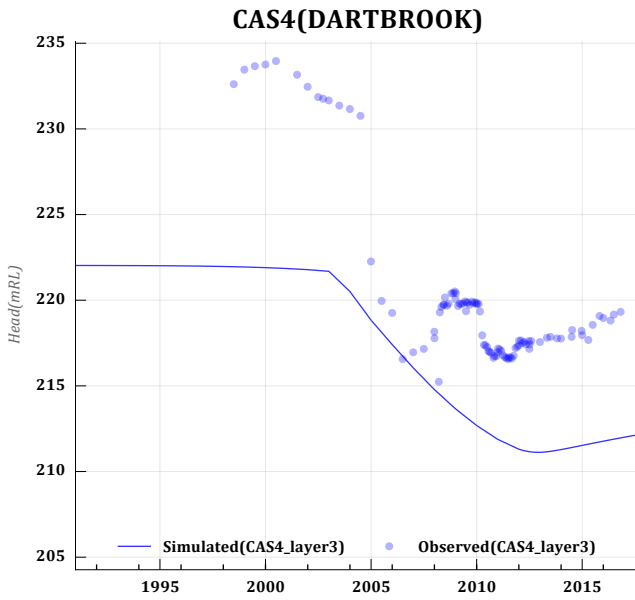


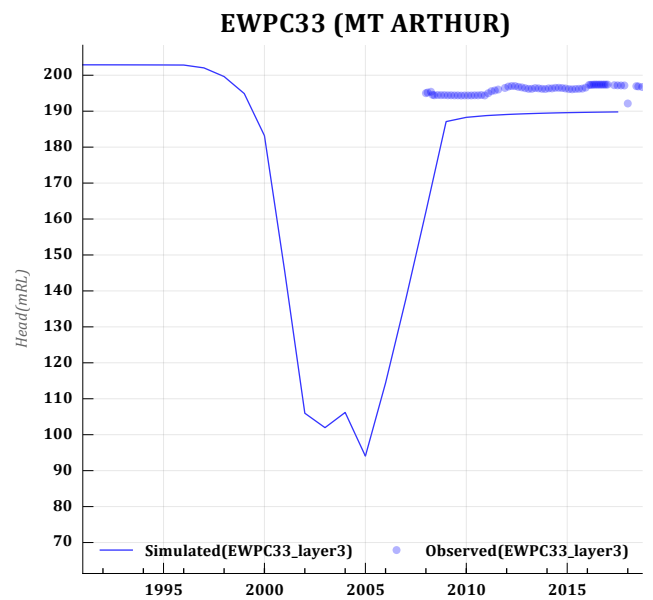
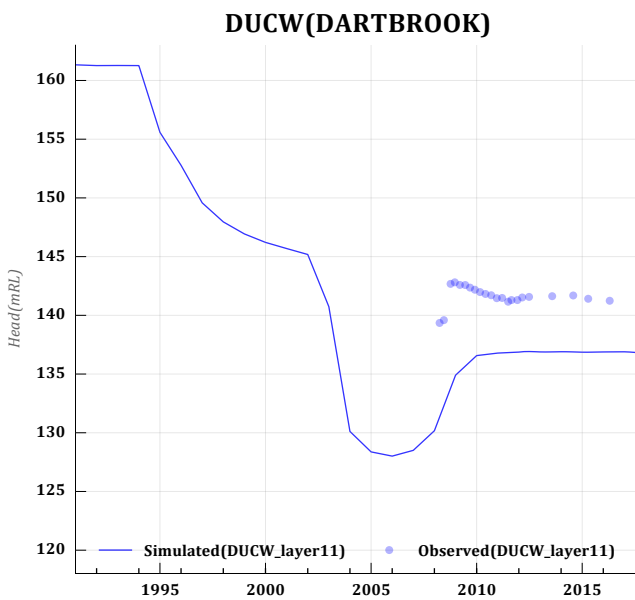
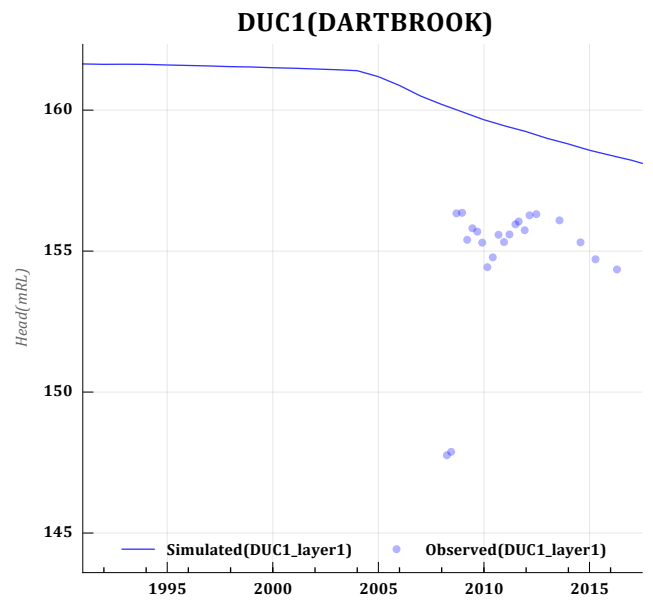
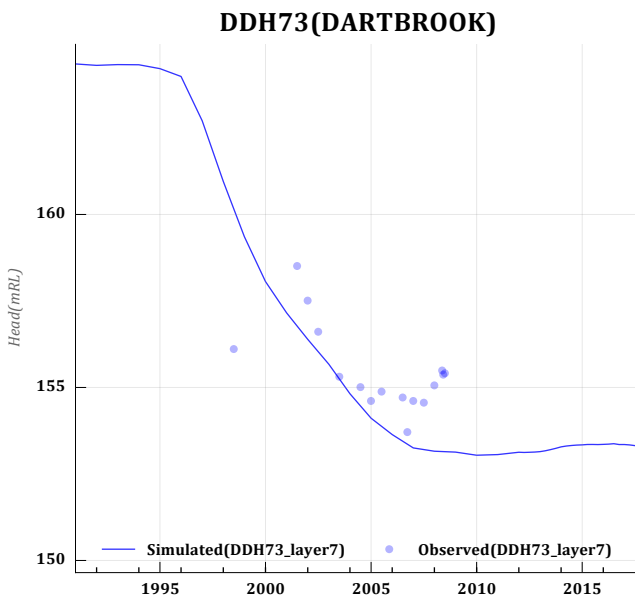
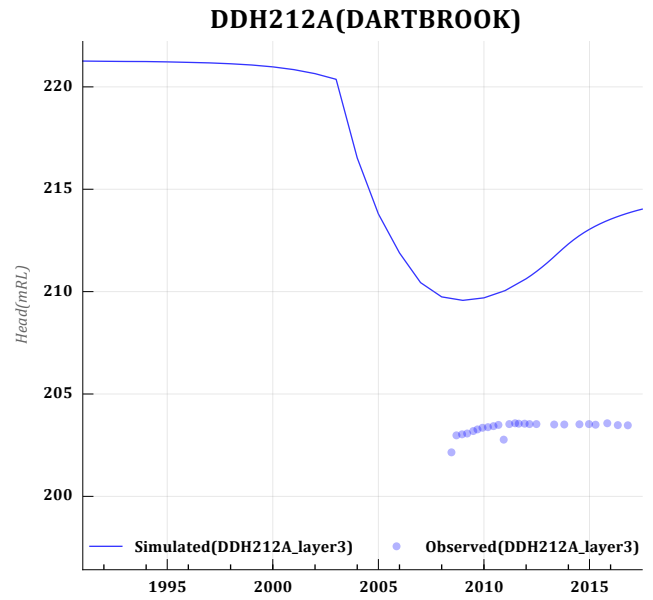
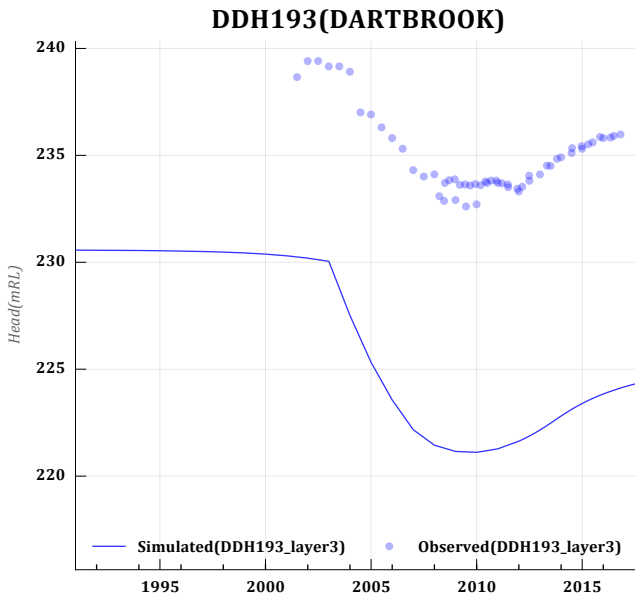
CAS1(DARTBROOK)



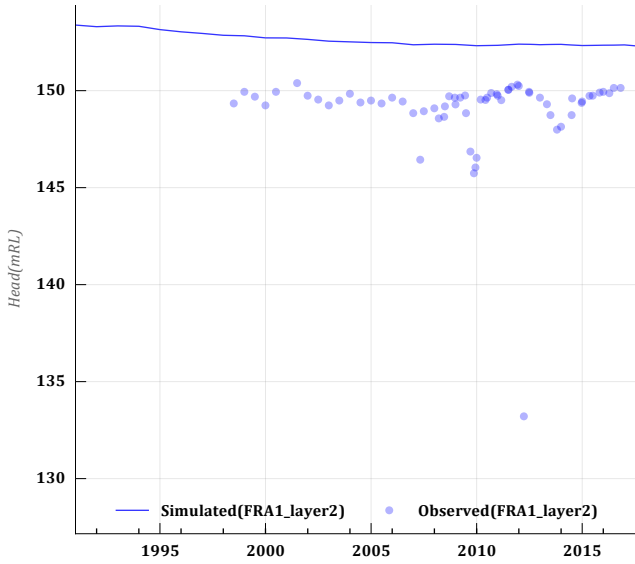
CAS2(DARTBROOK)



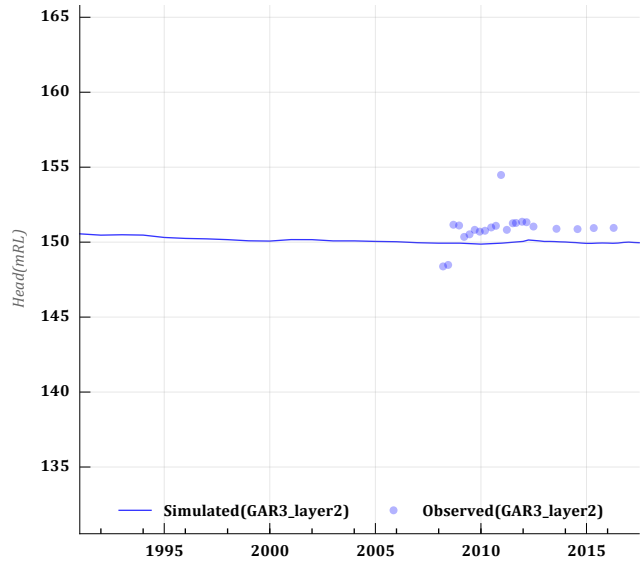




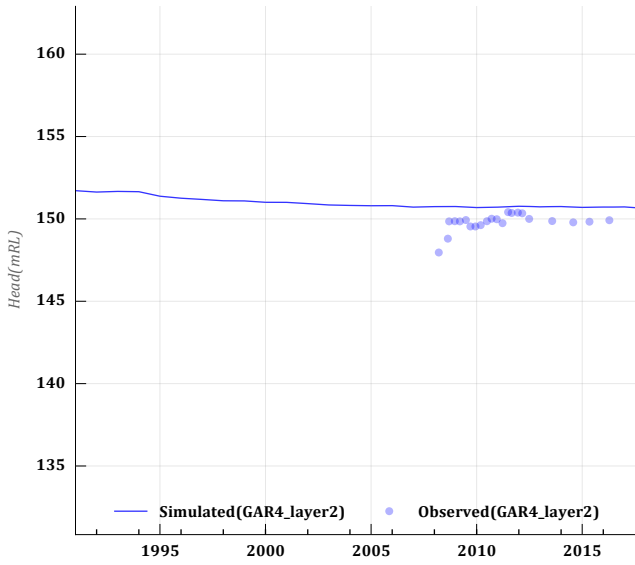
FRA1(DARTBROOK)



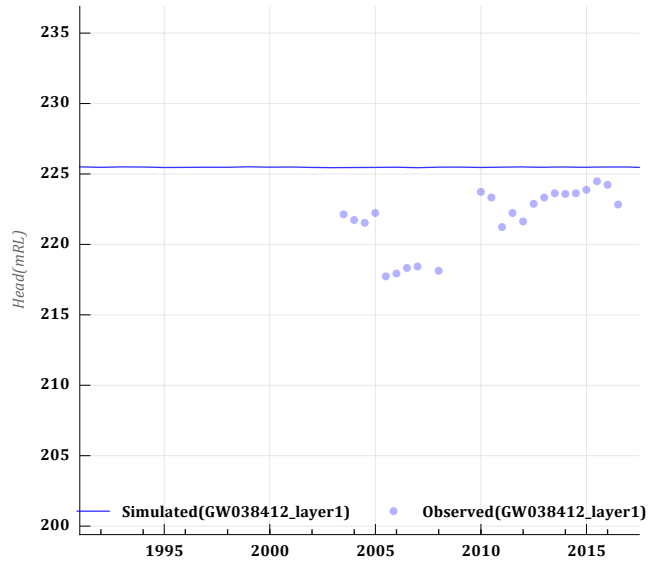
GAR3(DARTBROOK)



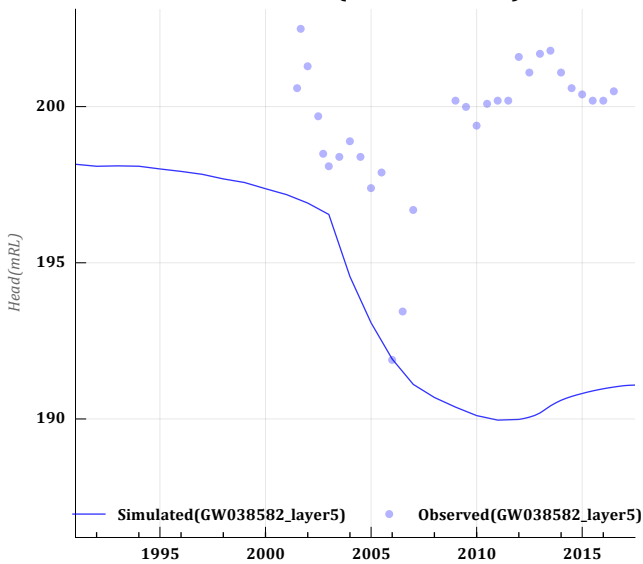
GAR4(DARTBROOK)



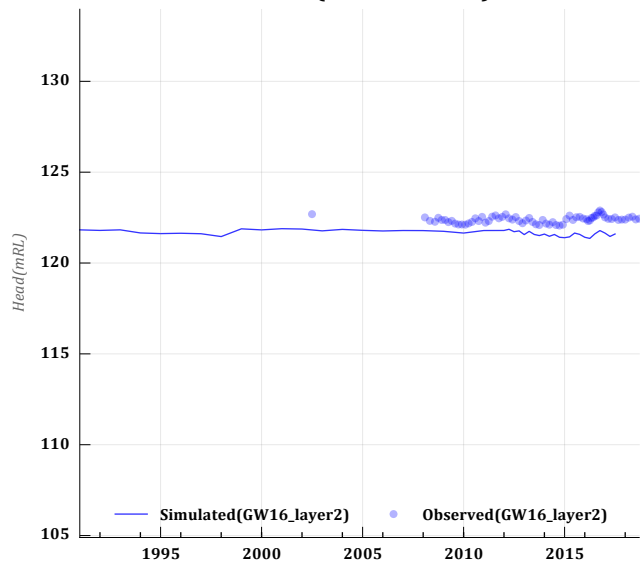
GW038412(DARTBROOK)



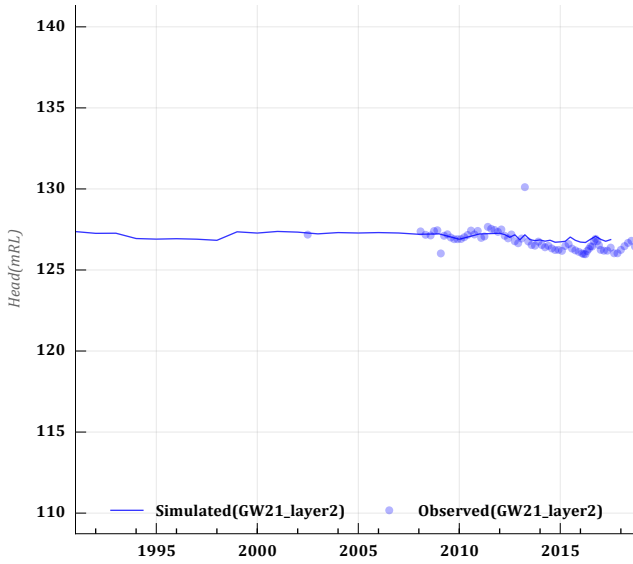
GW038582(DARTBROOK)



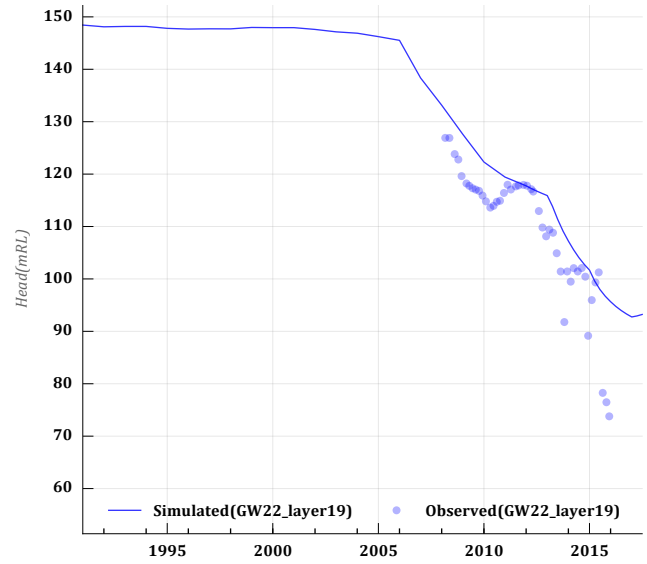
GW16 (MT ARTHUR)



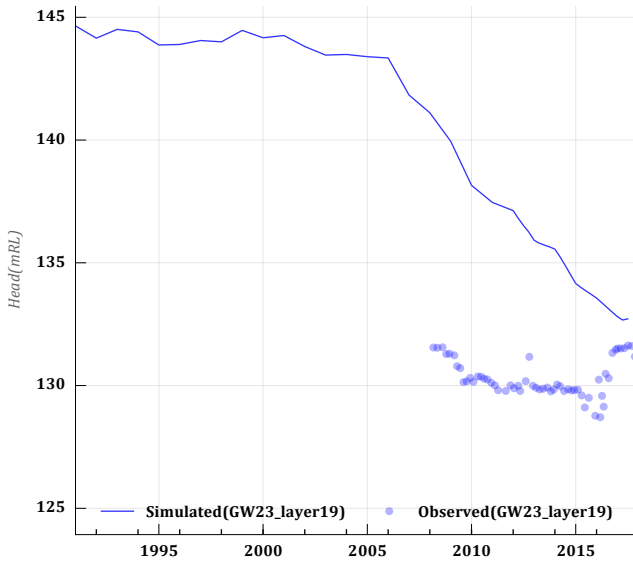
GW21 (MT ARTHUR)



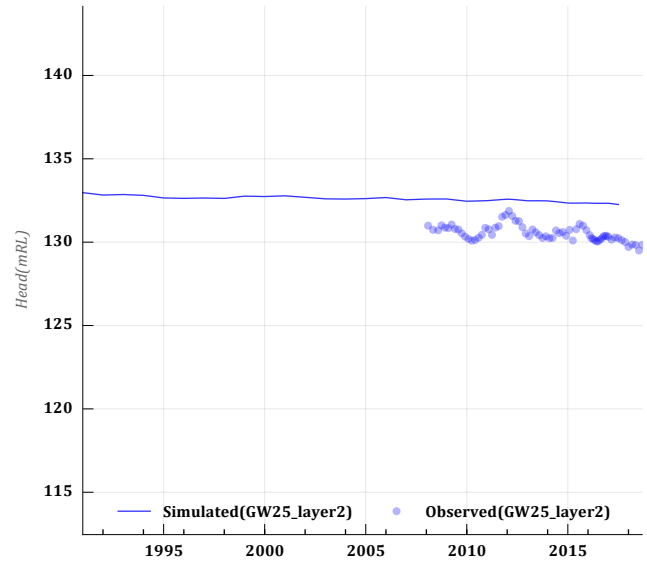
GW22 (MT ARTHUR)



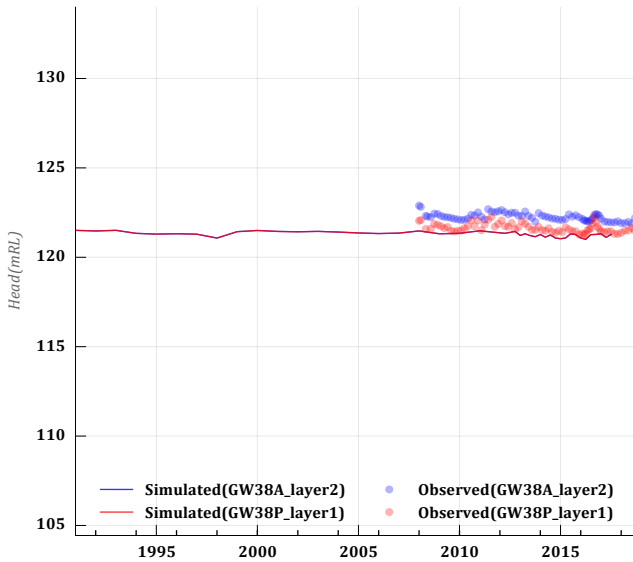
GW23 (MT ARTHUR)



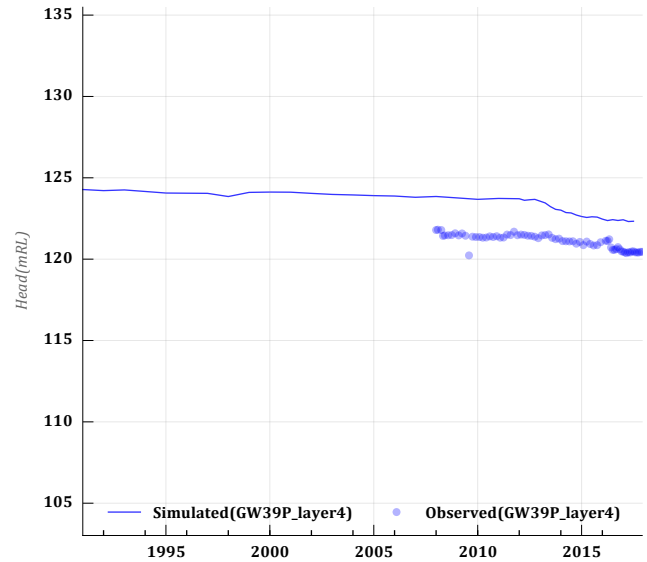
GW25 (MT ARTHUR)



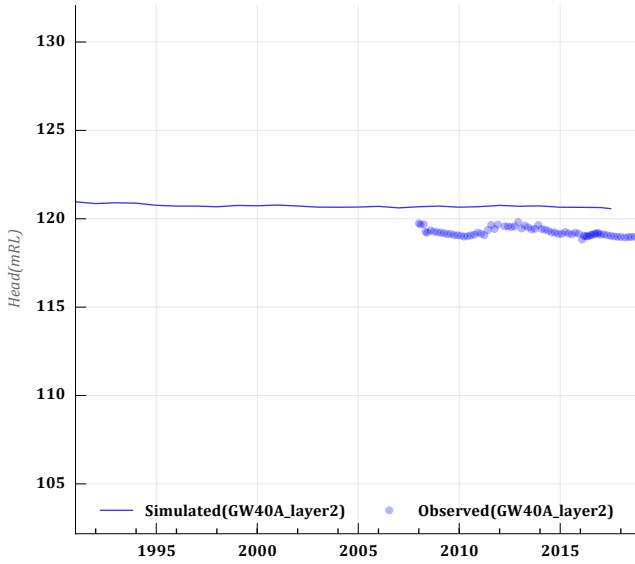
GW38 (MT ARTHUR)



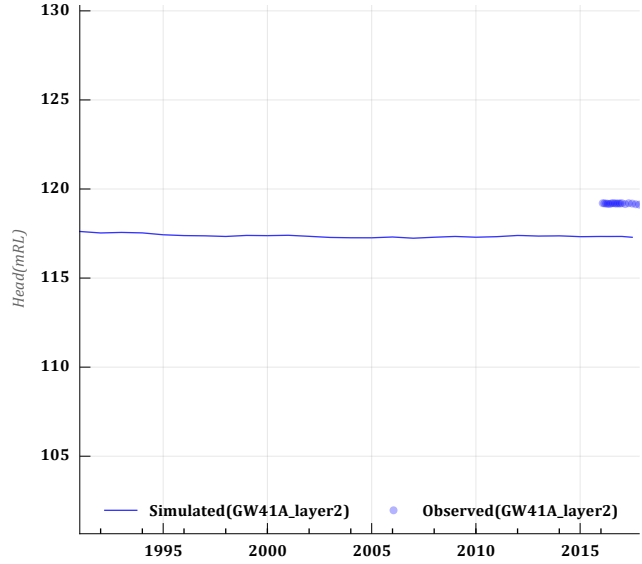
GW39 (MT ARTHUR)



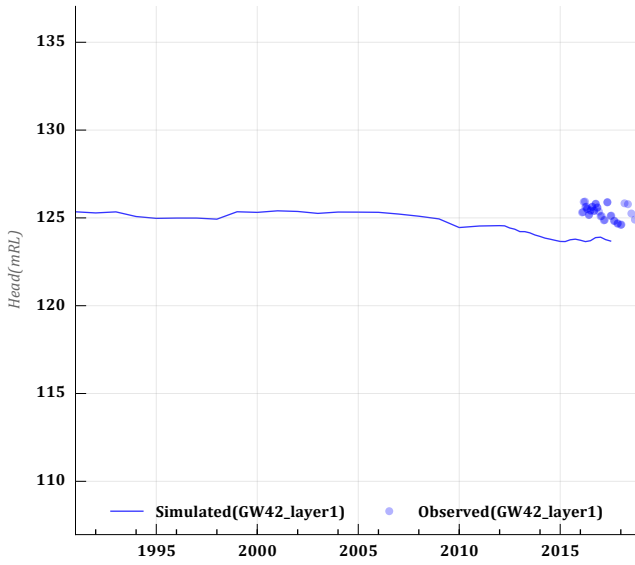
GW40A (MT ARTHUR)



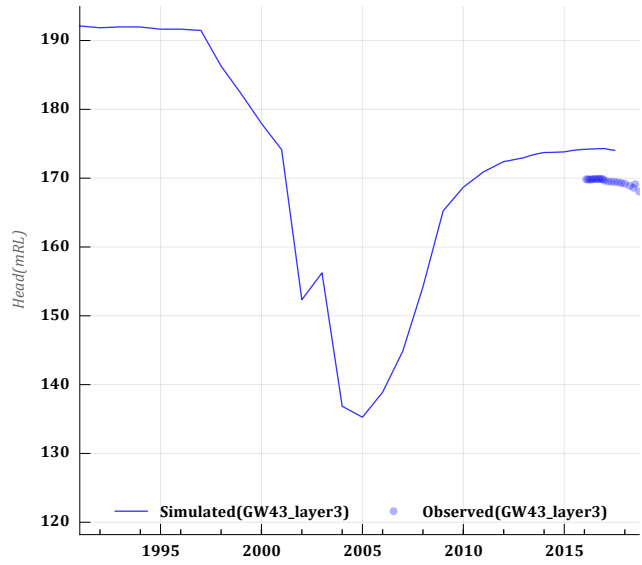
GW41A (MT ARTHUR)



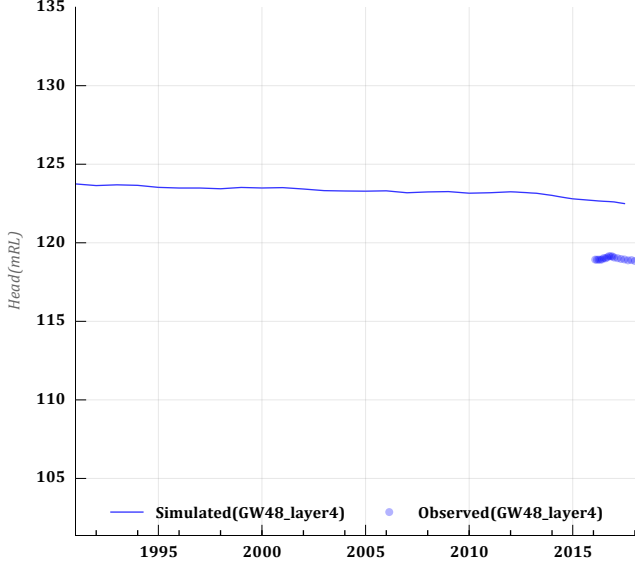
GW42 (MT ARTHUR)



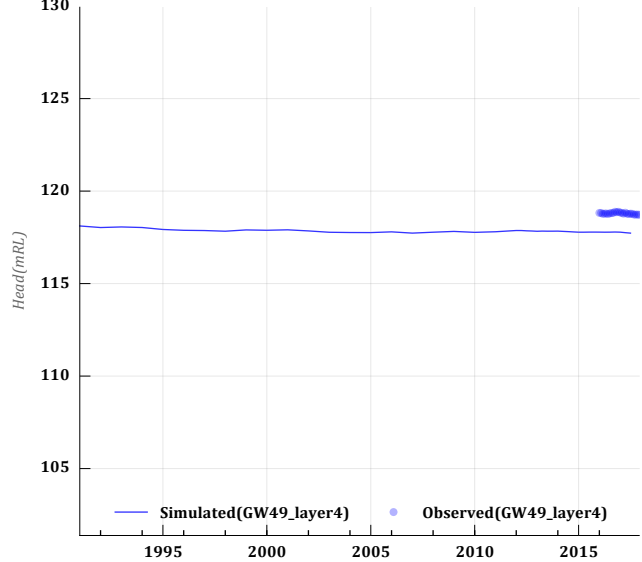
GW43 (MT ARTHUR)

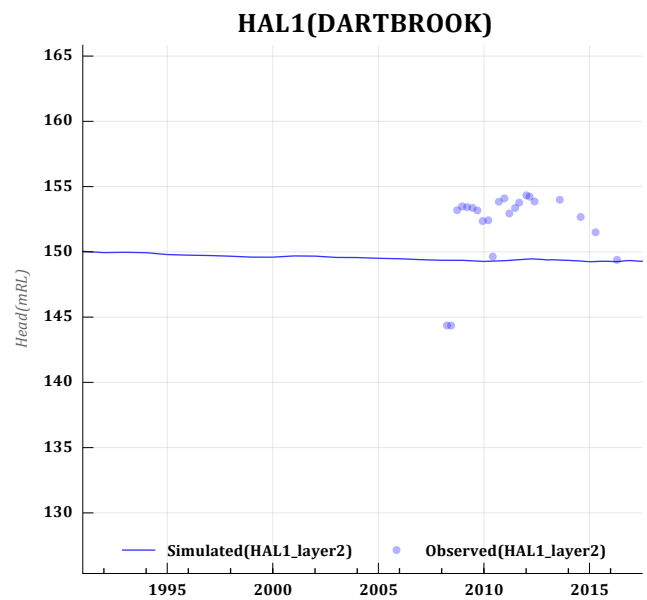
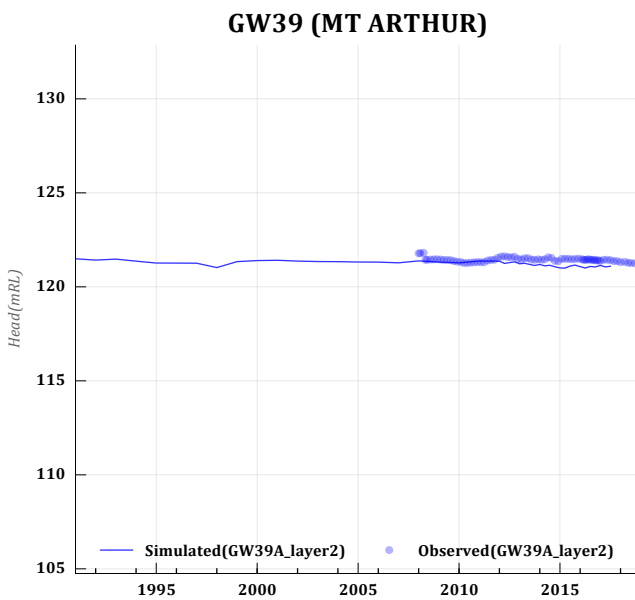
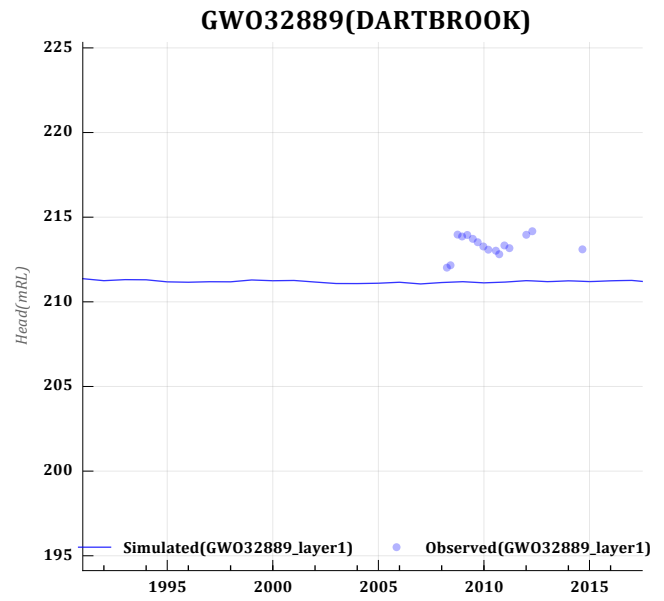
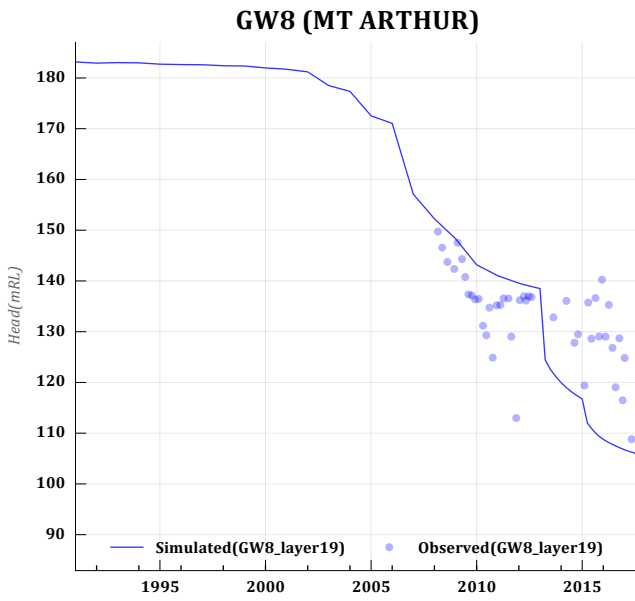
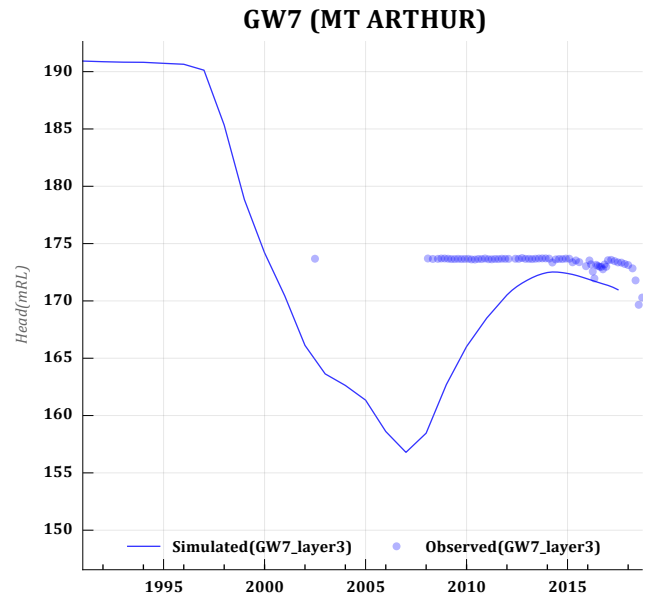
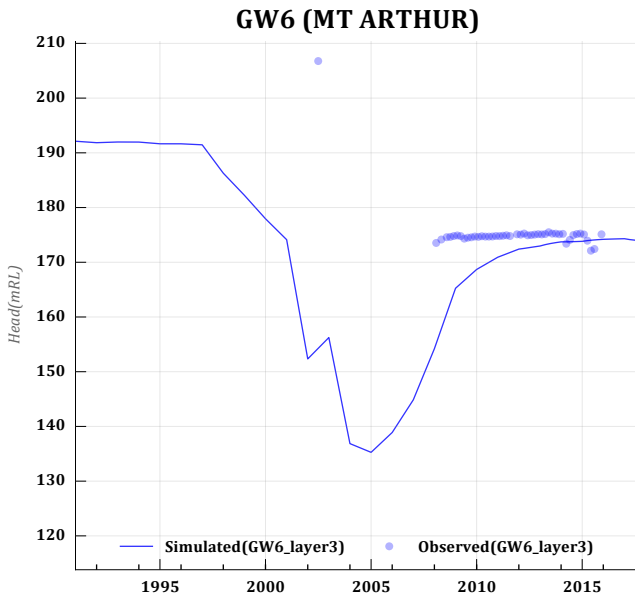


GW48 (MT ARTHUR)

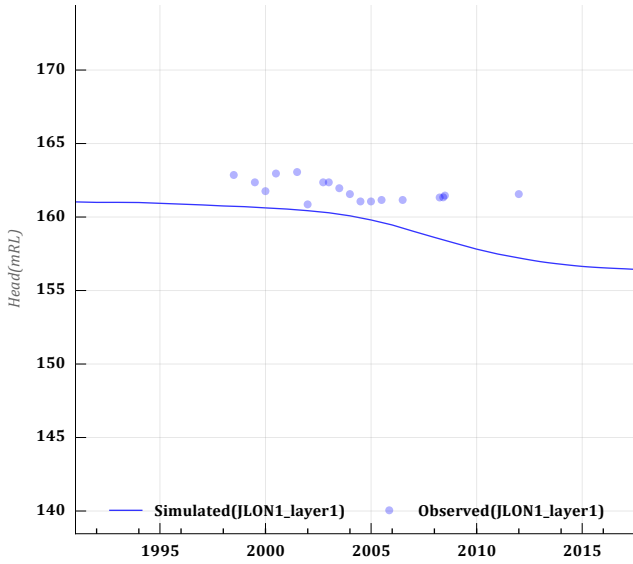


GW49 (MT ARTHUR)

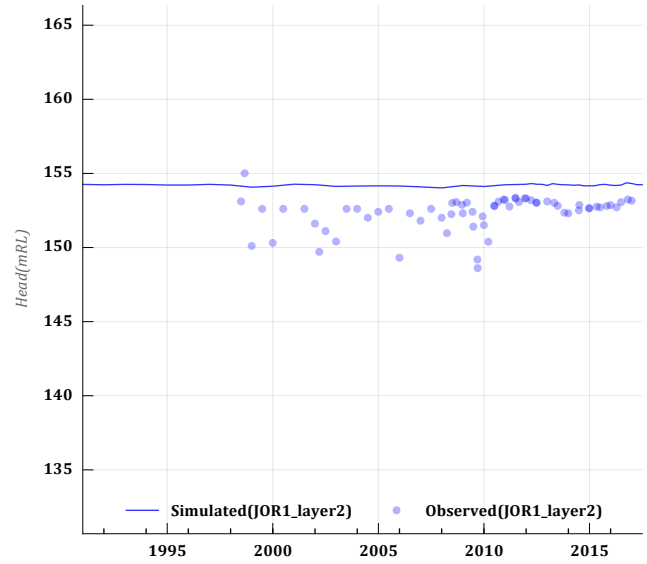




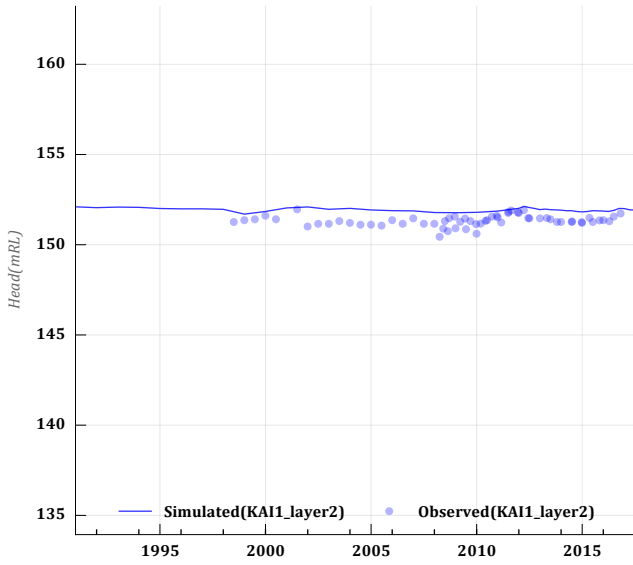
JLON1(DARTBROOK)



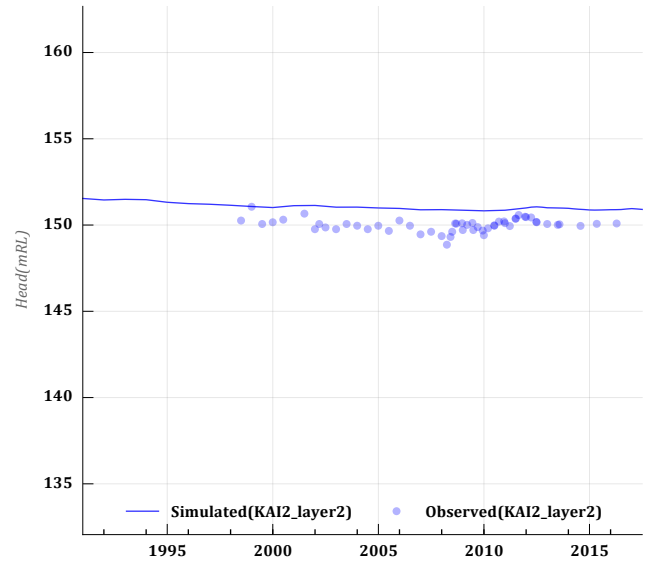
JOR1(DARTBROOK)



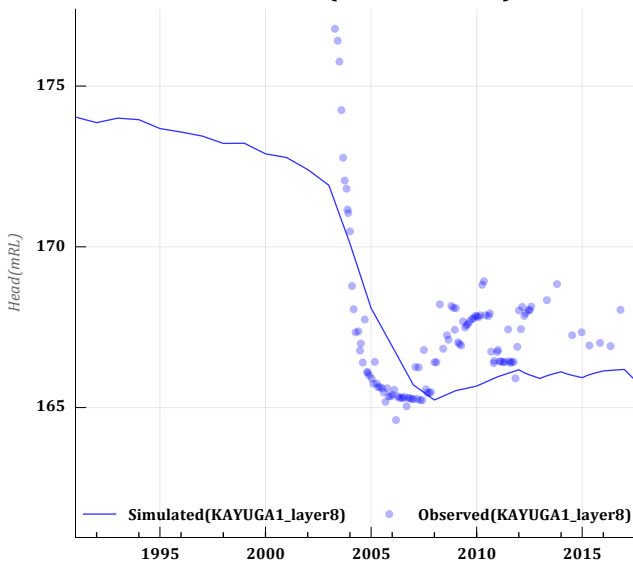
KAI1(DARTBROOK)



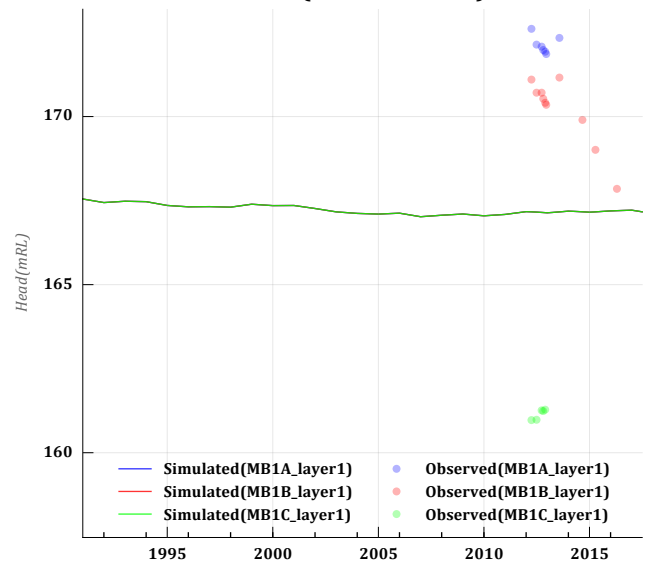
KAI2(DARTBROOK)



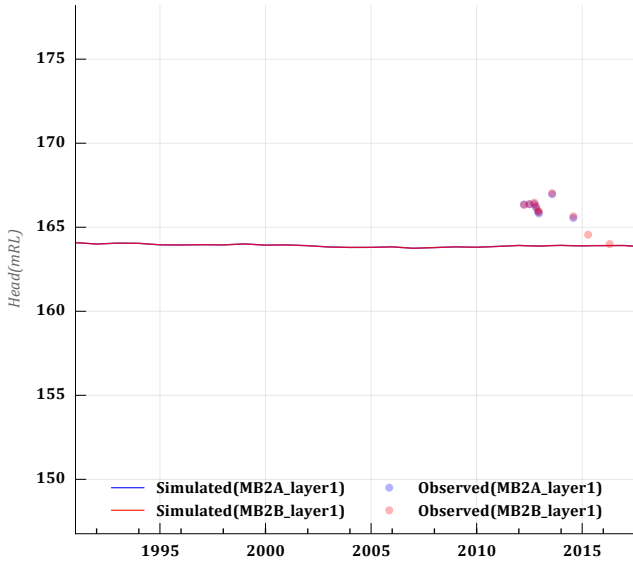
KAYUGA1(DARTBROOK)



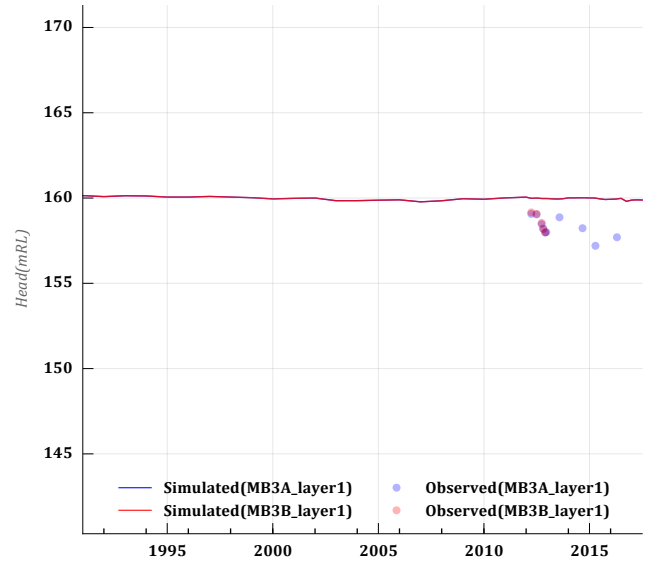
MB1(DARTBROOK)



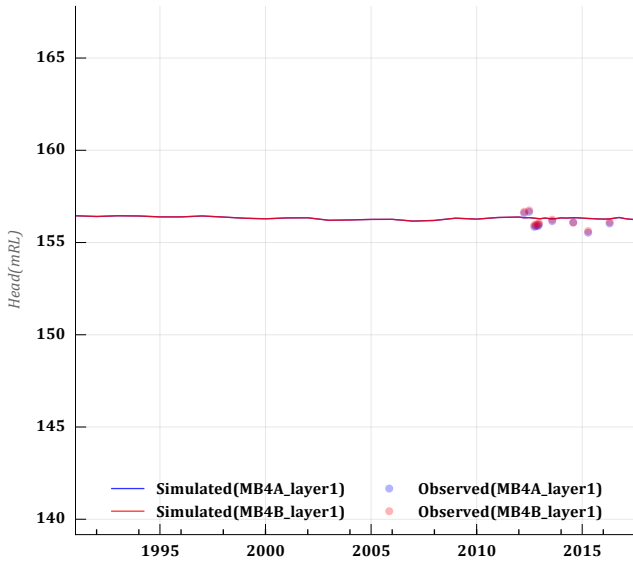
MB2(DARTBROOK)



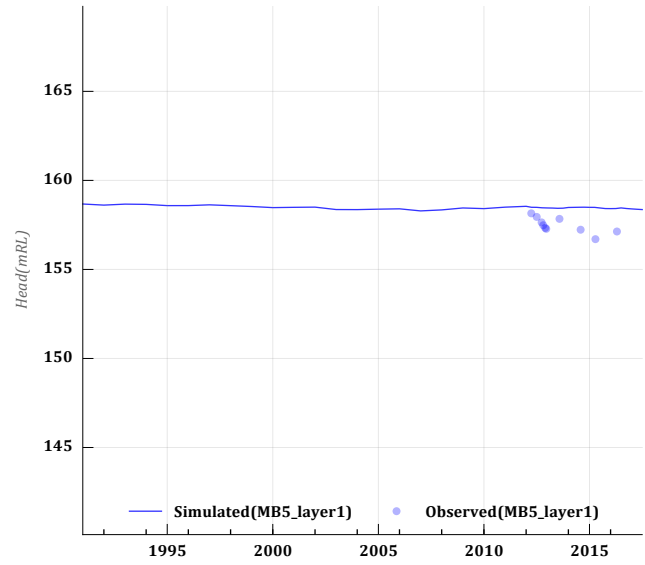
MB3(DARTBROOK)



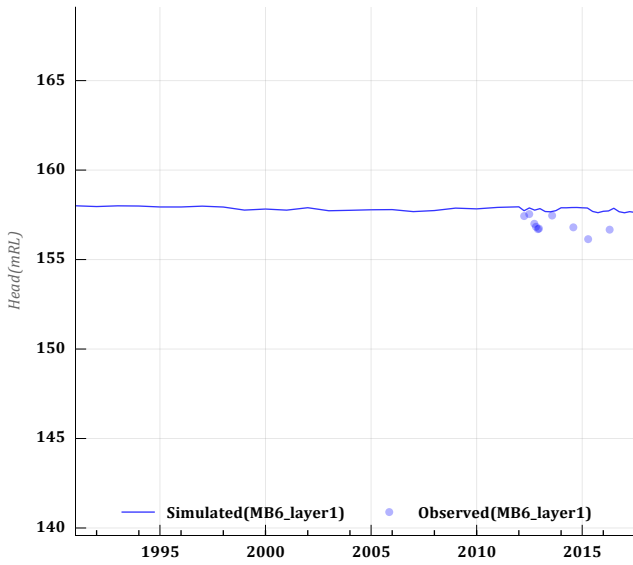
MB4(DARTBROOK)



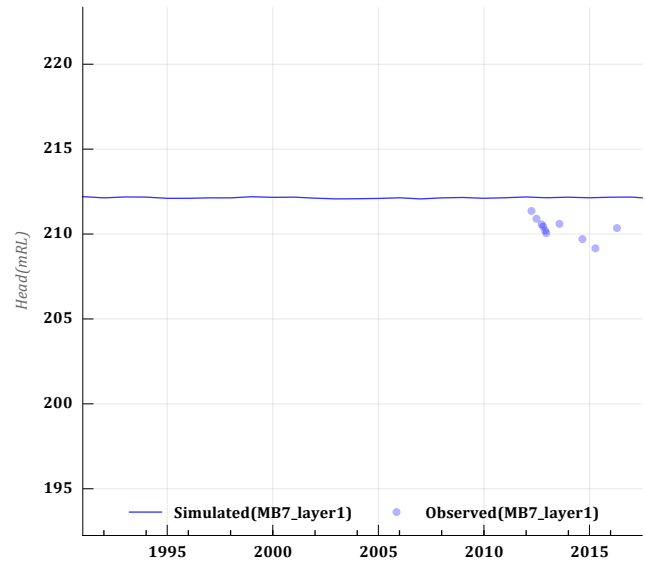
MB5(DARTBROOK)



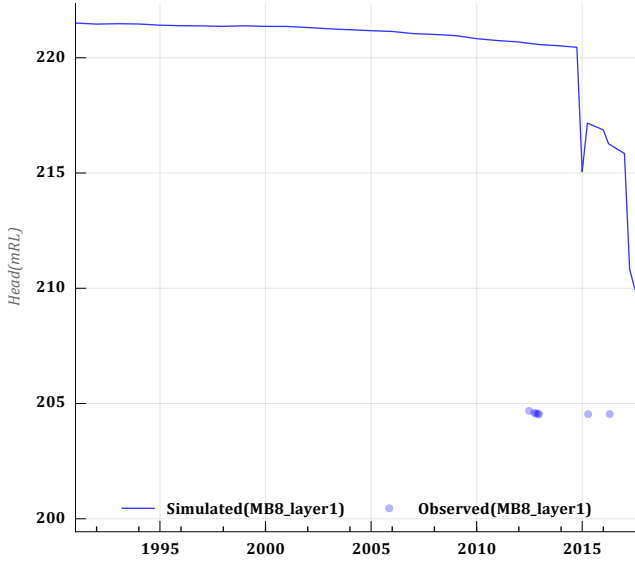
MB6(DARTBROOK)



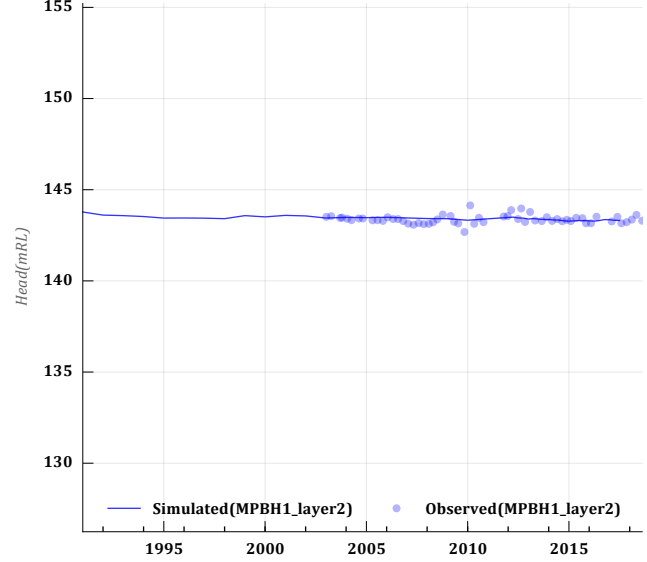
MB7(DARTBROOK)



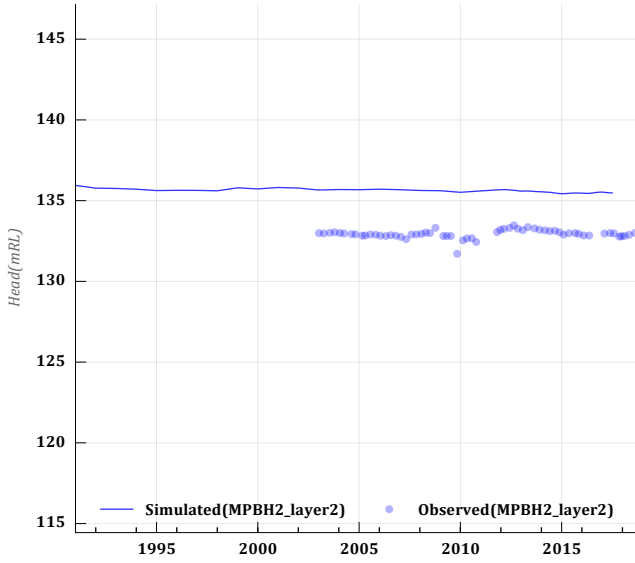
MB8(DARTBROOK)



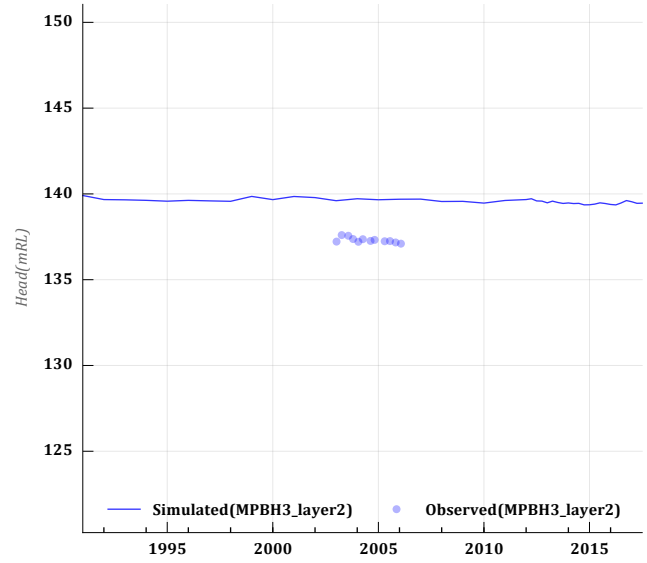
MPBH1(MT PLEASANT)



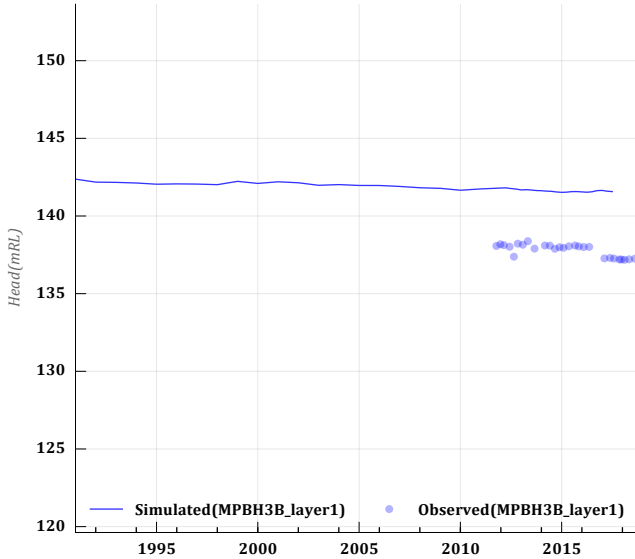
MPBH2(MT PLEASANT)



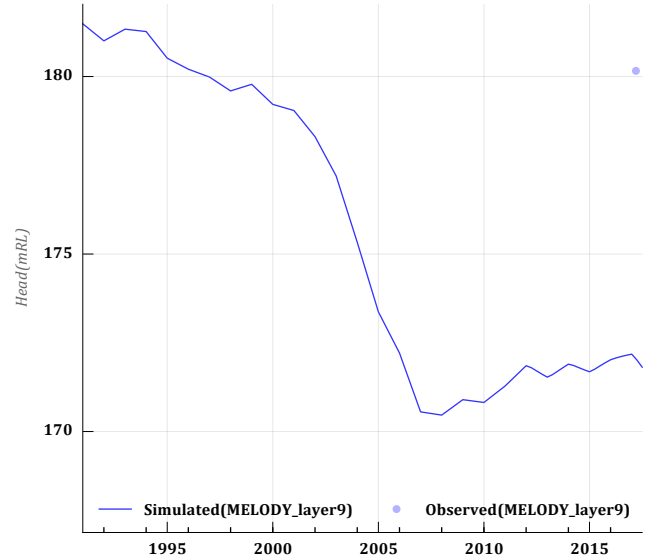
MPBH3(MT PLEASANT)



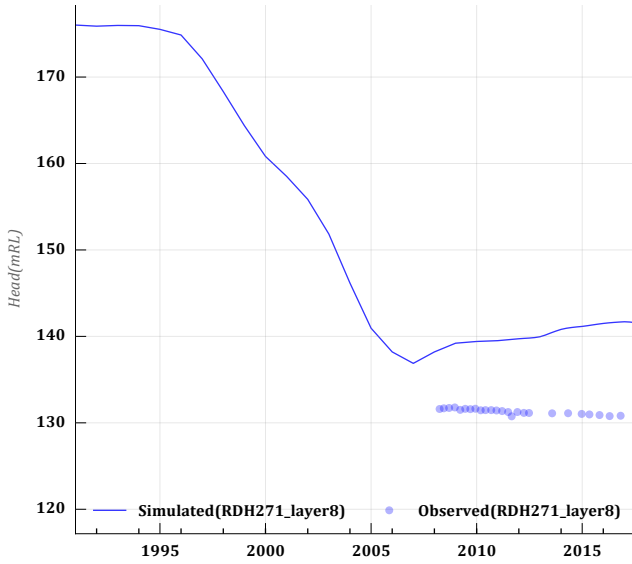
MPBH3B(MT PLEASANT)



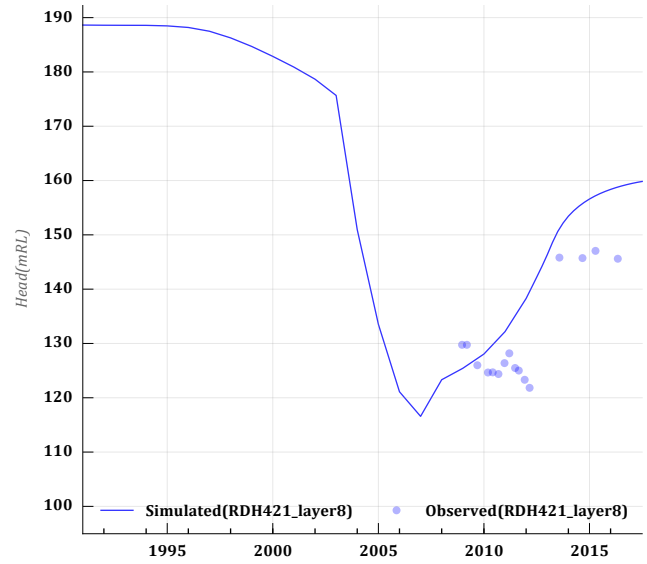
MELODY(MT PLEASANT)



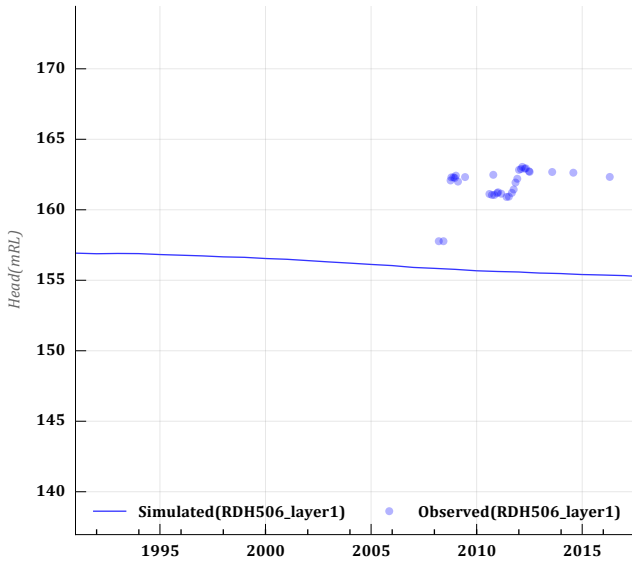
RDH271(DARTBROOK)



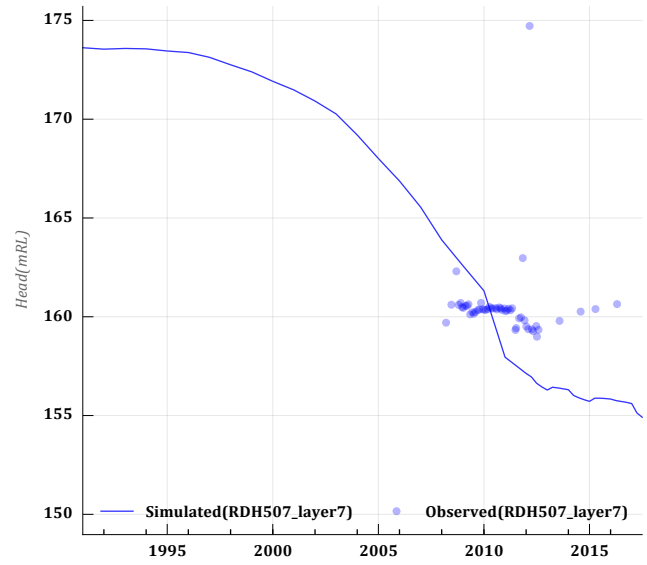
RDH421(DARTBROOK)



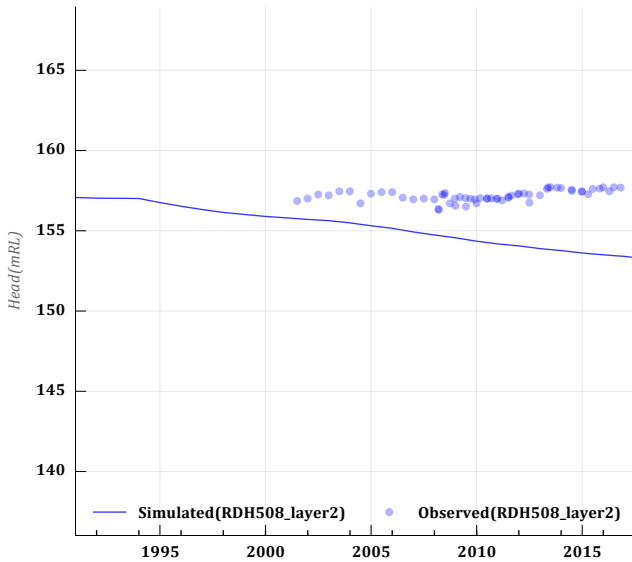
RDH506(DARTBROOK)



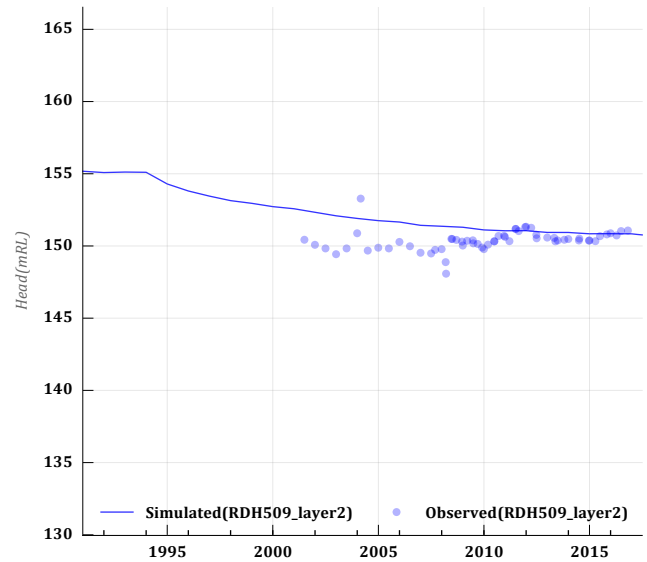
RDH507(DARTBROOK)



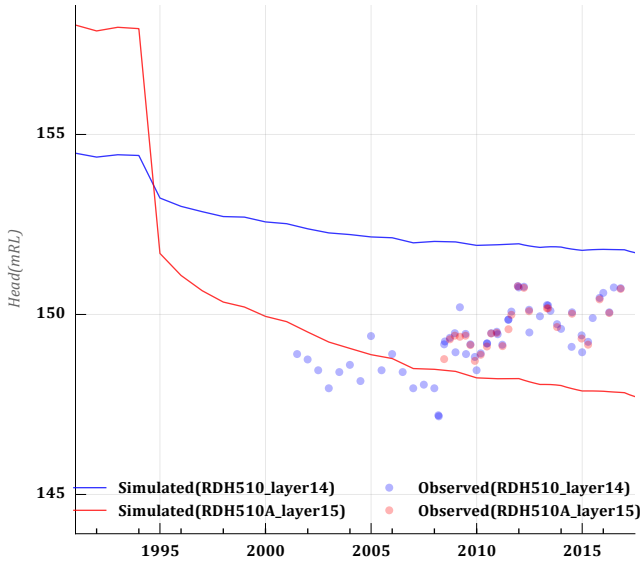
RDH508(DARTBROOK)



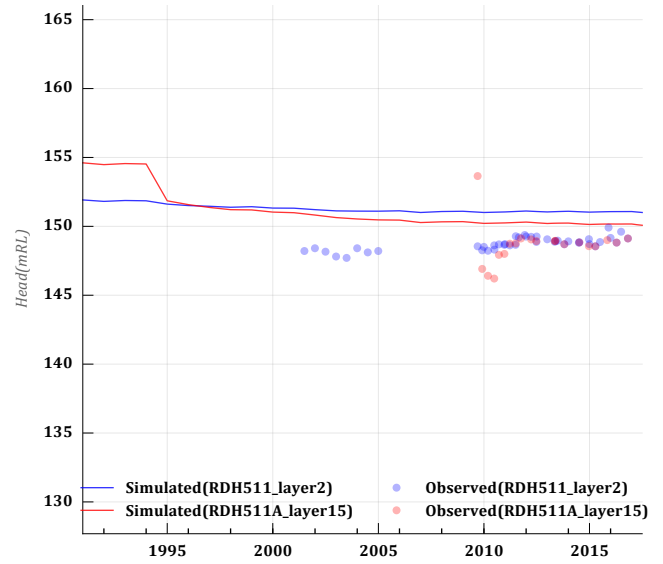
RDH509(DARTBROOK)



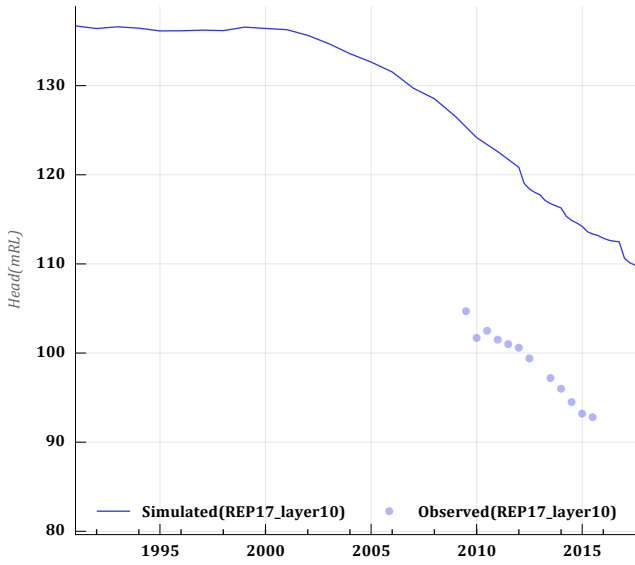
RDH510(DARTBROOK)



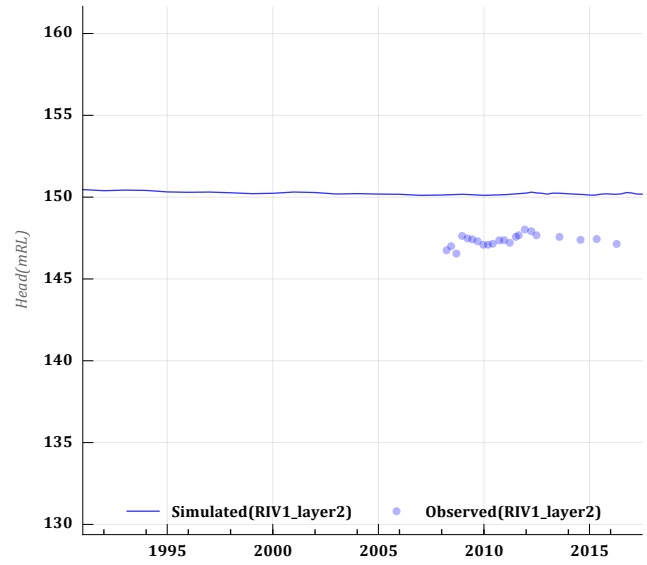
RDH511(DARTBROOK)



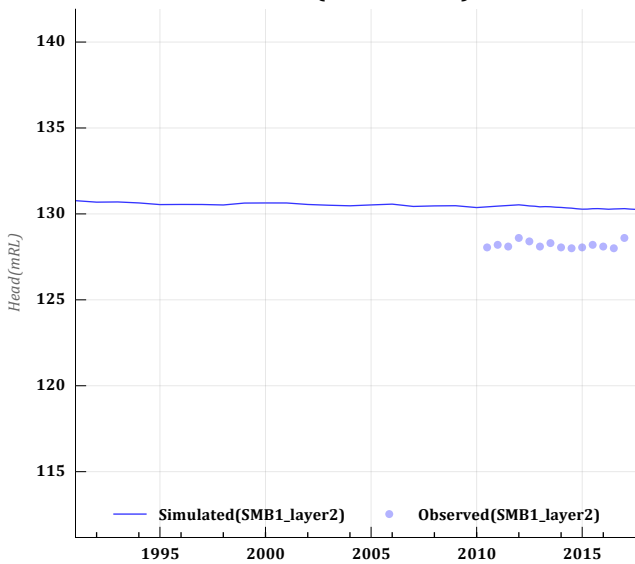
REP17(BENGALLA)



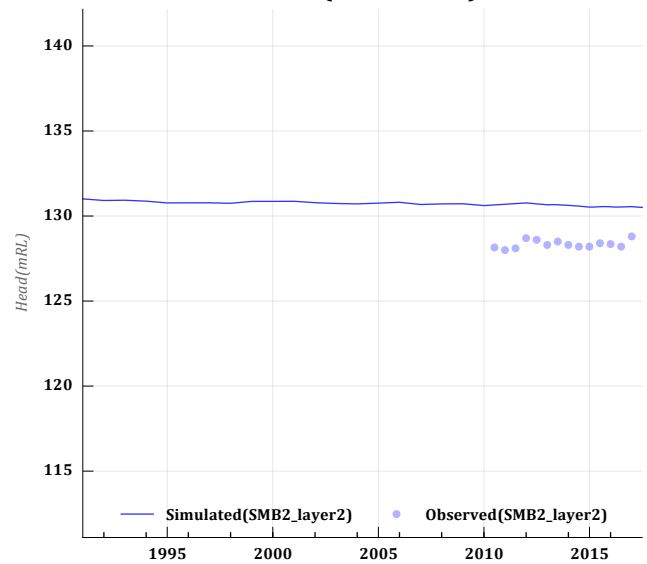
RIV1(DARTBROOK)

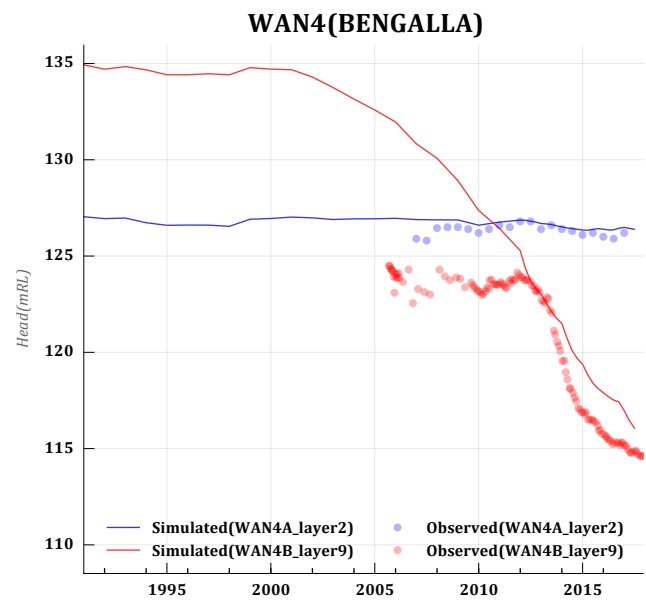
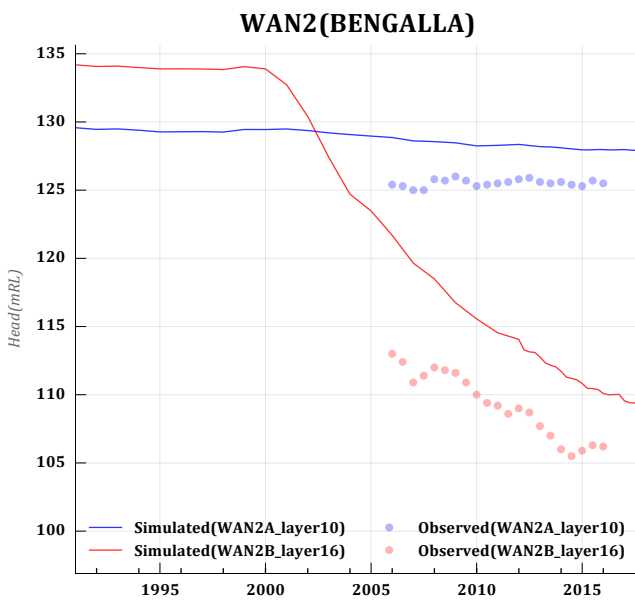
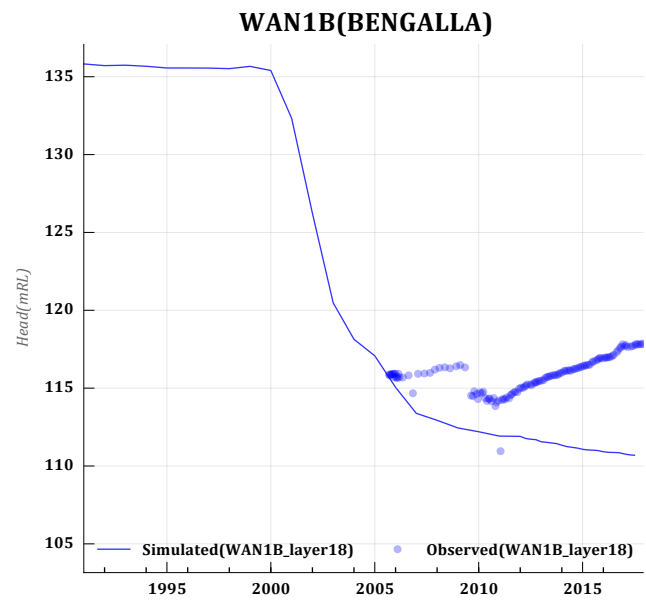
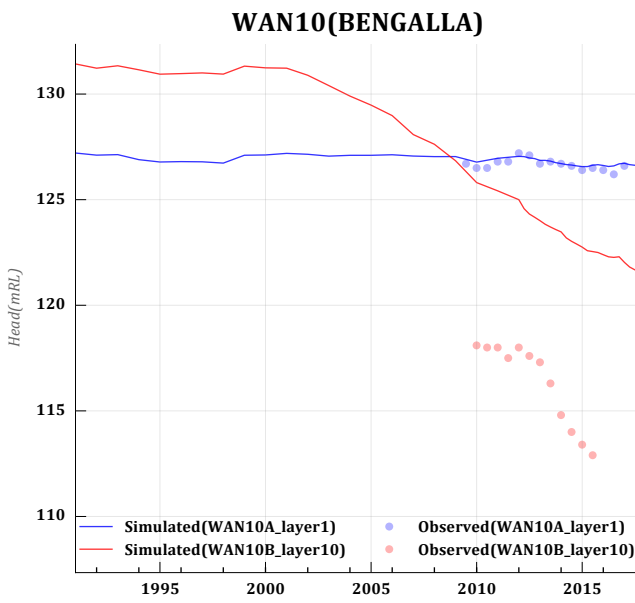
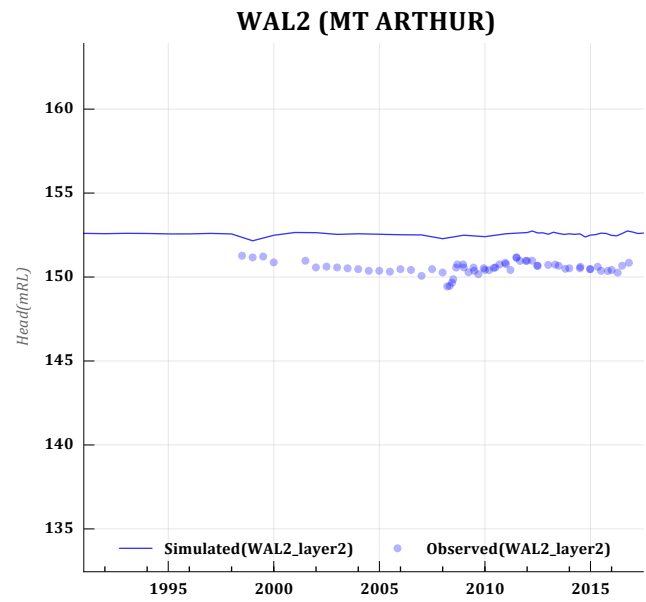
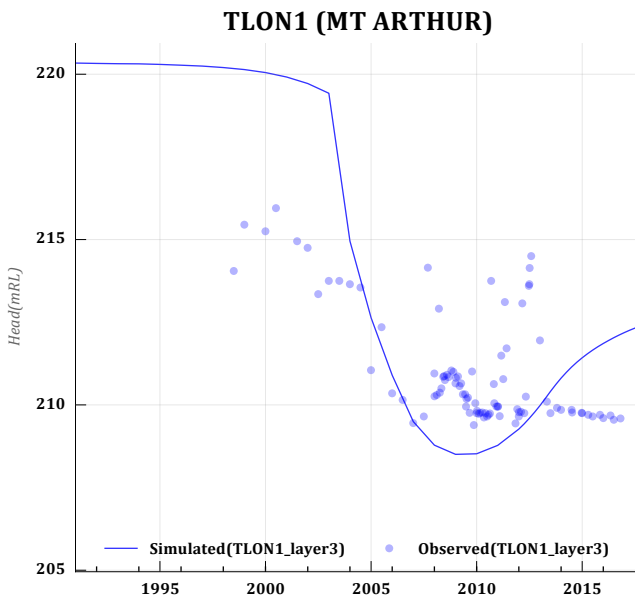


SMB1(BENGALLA)

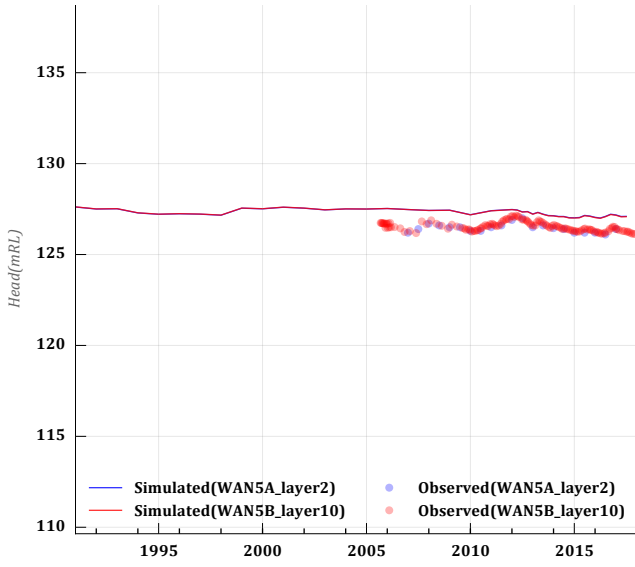


SMB2(BENGALLA)

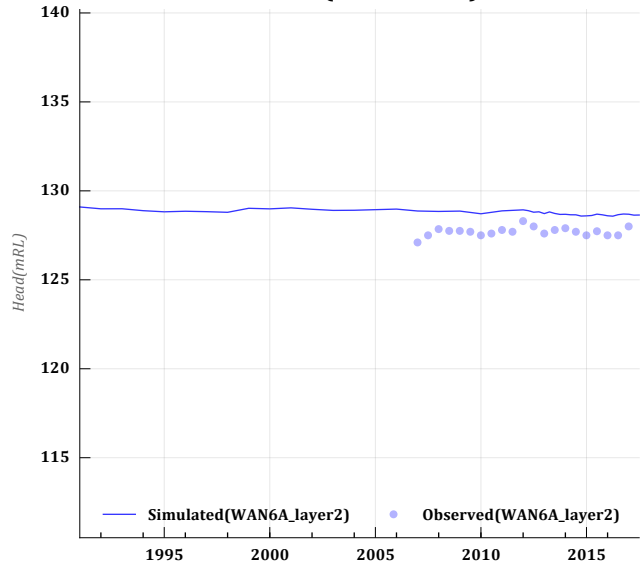




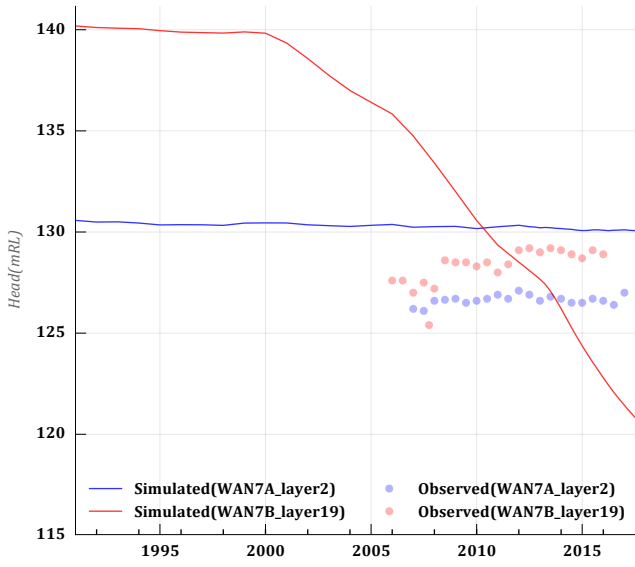
WAN5(BENGALLA)



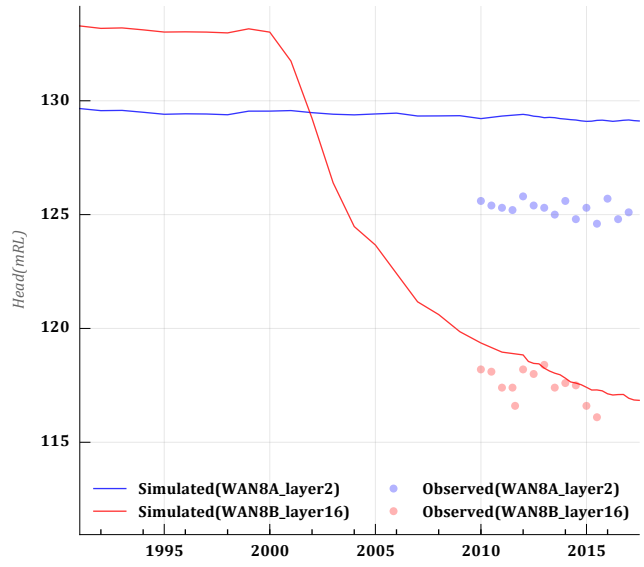
WAN6(BENGALLA)



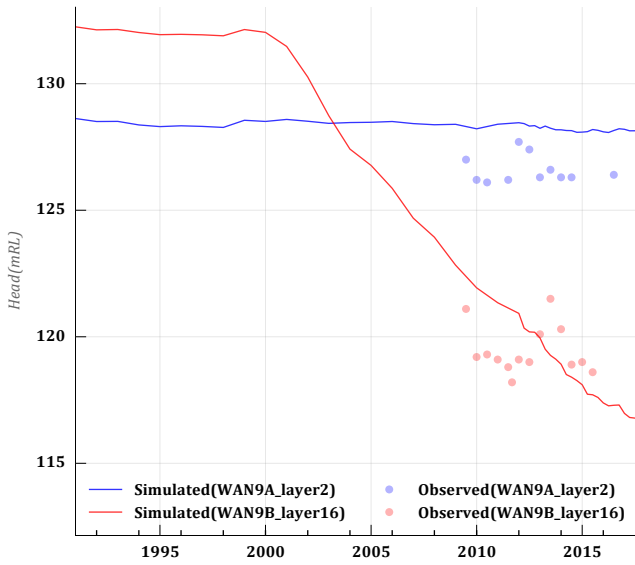
WAN7(BENGALLA)



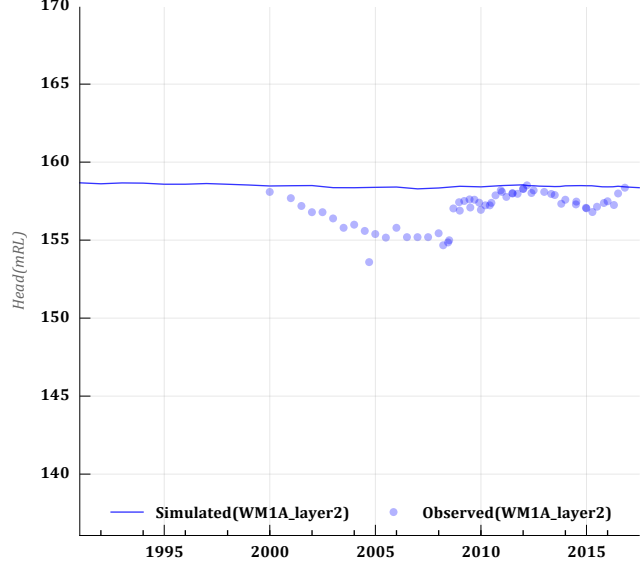
WAN8(BENGALLA)



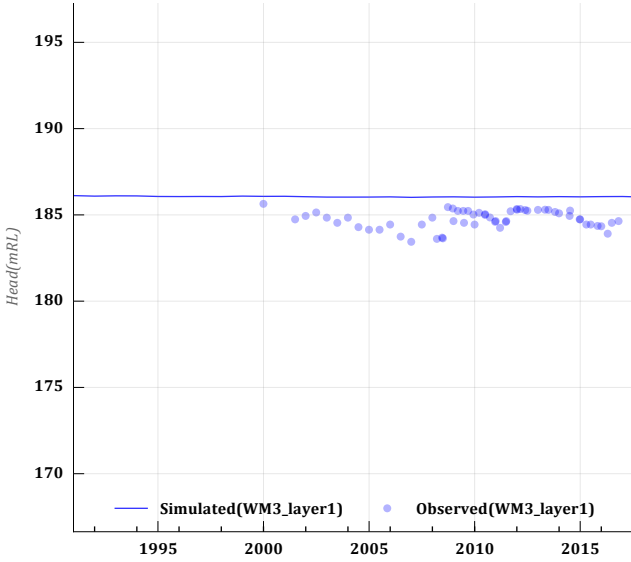
WAN9(BENGALLA)



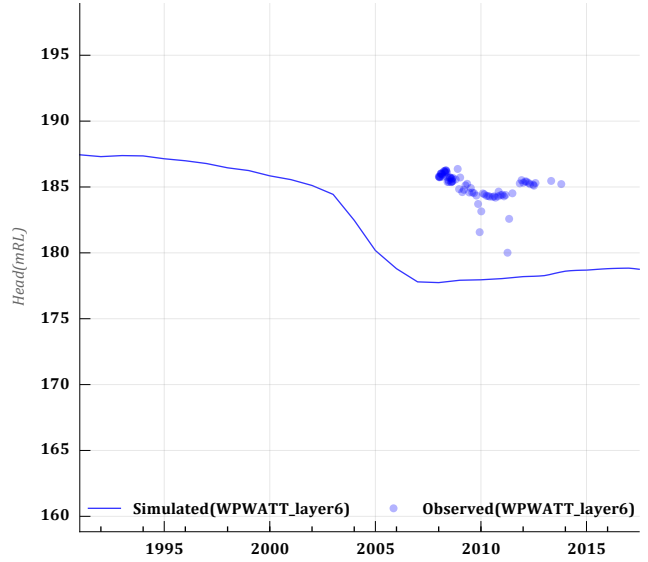
WM1 (MT ARTHUR)



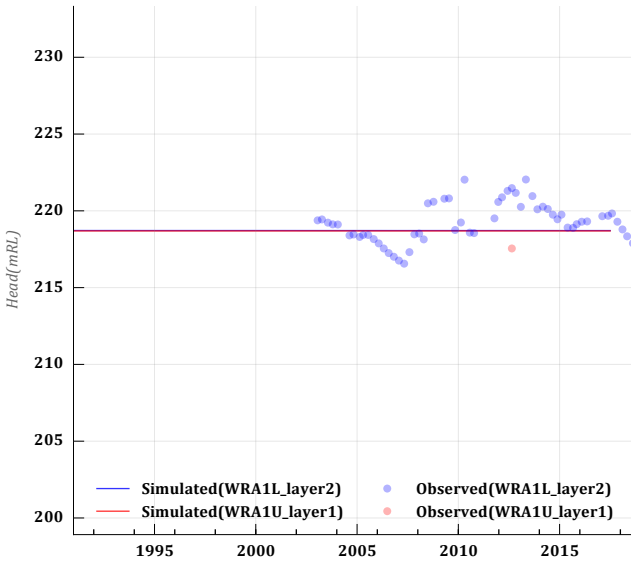
WM3 (MT ARTHUR)



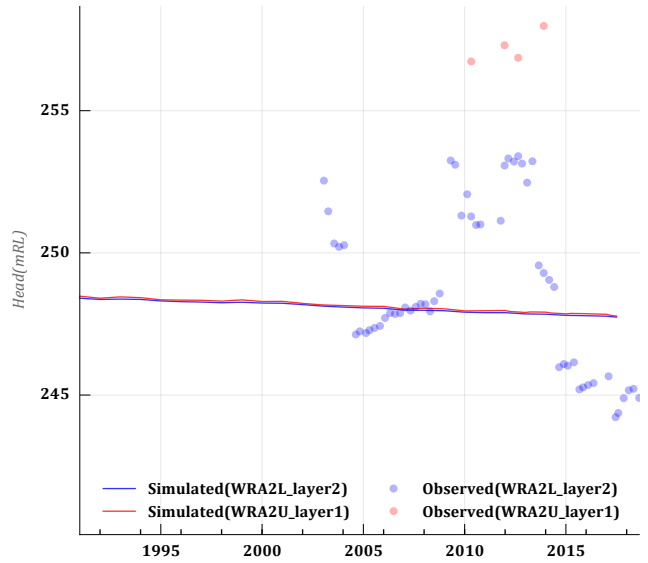
WPWATT(DARTBROOK)



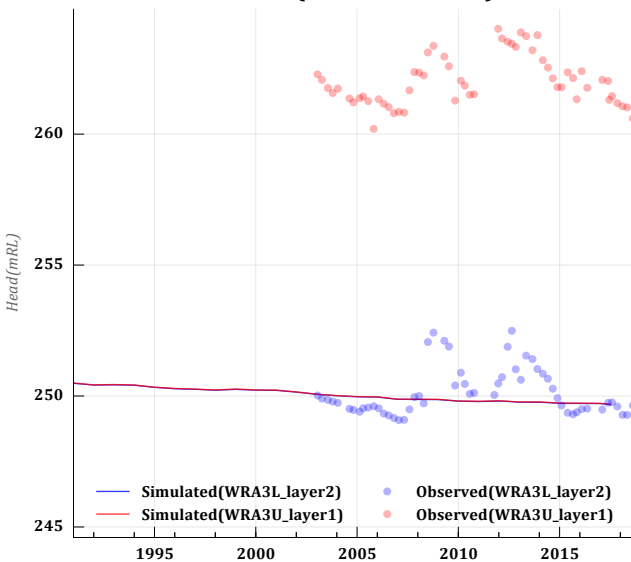
WRA1 (MT PLEASANT)



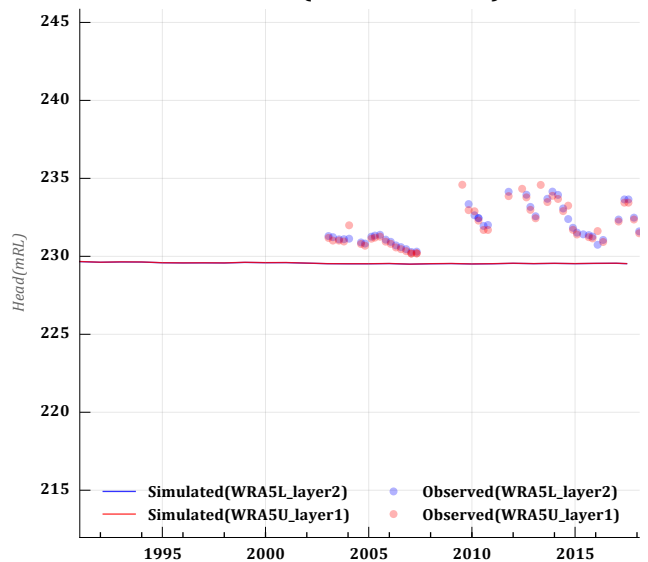
WRA2 (MT PLEASANT)



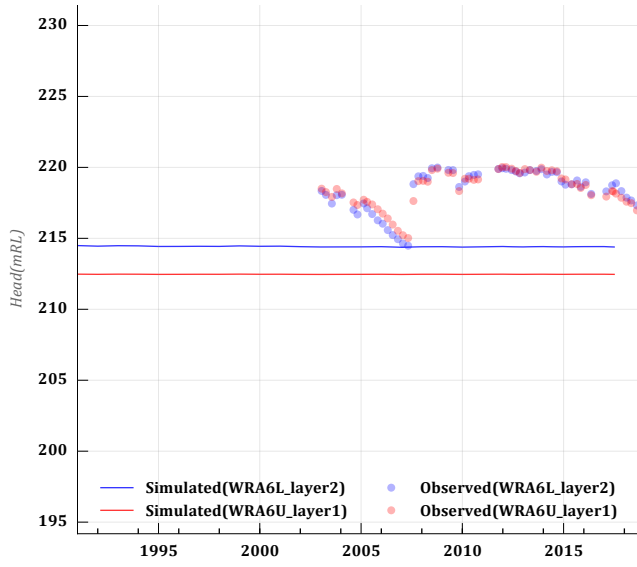
WRA3 (MT PLEASANT)



WRA5 (MT PLEASANT)

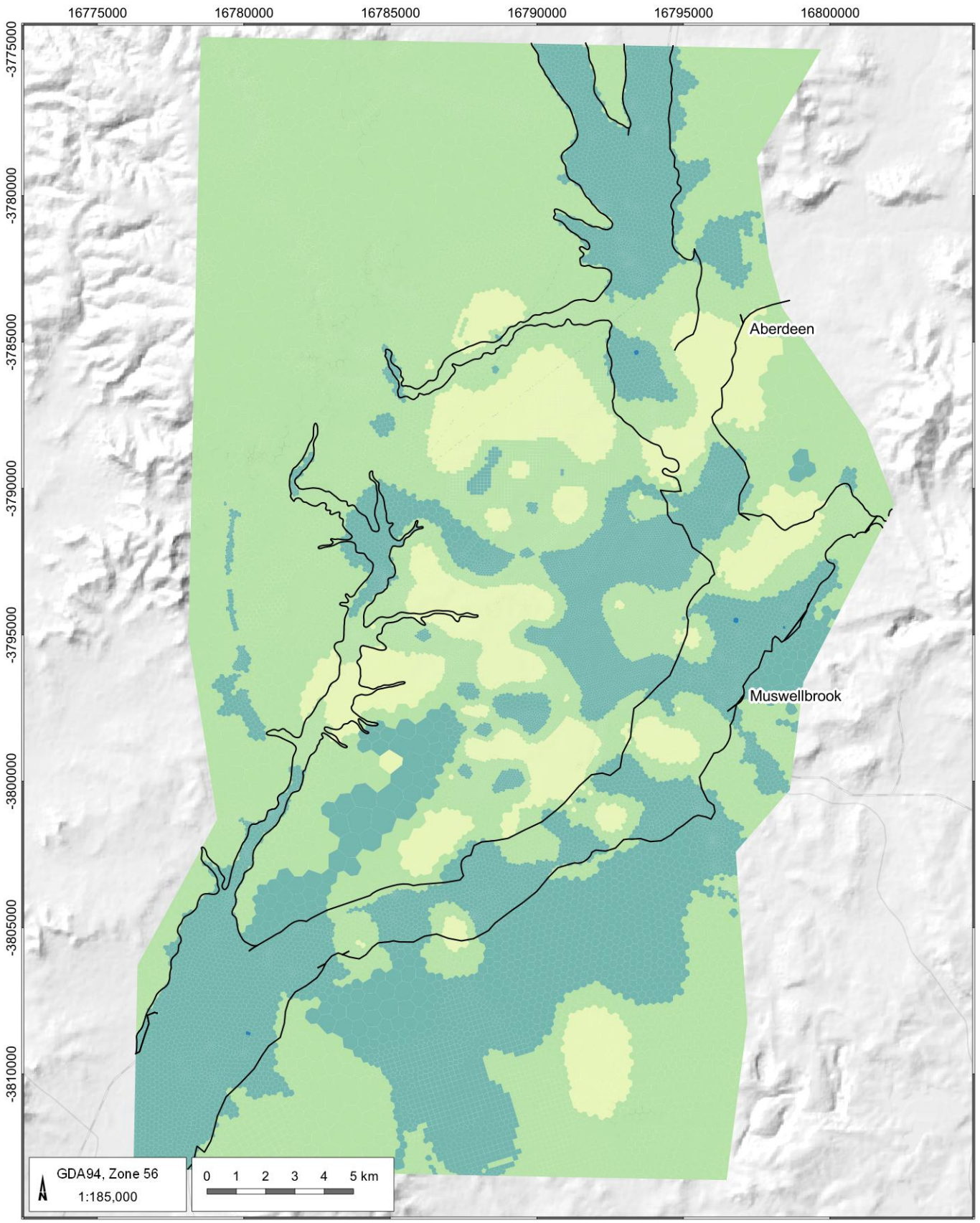


WRA6(MT PLEASANT)



Appendix A2

Spatial distribution of hydraulic parameters Layers 1 to 3



LEGEND

- Grid
- Road
- Rail
- Drainage
- Populated place
- Alluvium extent

Horizontal Hydraulic conductivity (m/day)

	0.0001 - 0.002
	0.002 - 0.005
	0.005 - 0.02
	0.02 - 0.05
	0.05 - 1.5
	1.5 - 4.0
	4.0 - 20.0
	20.0 - 120.0

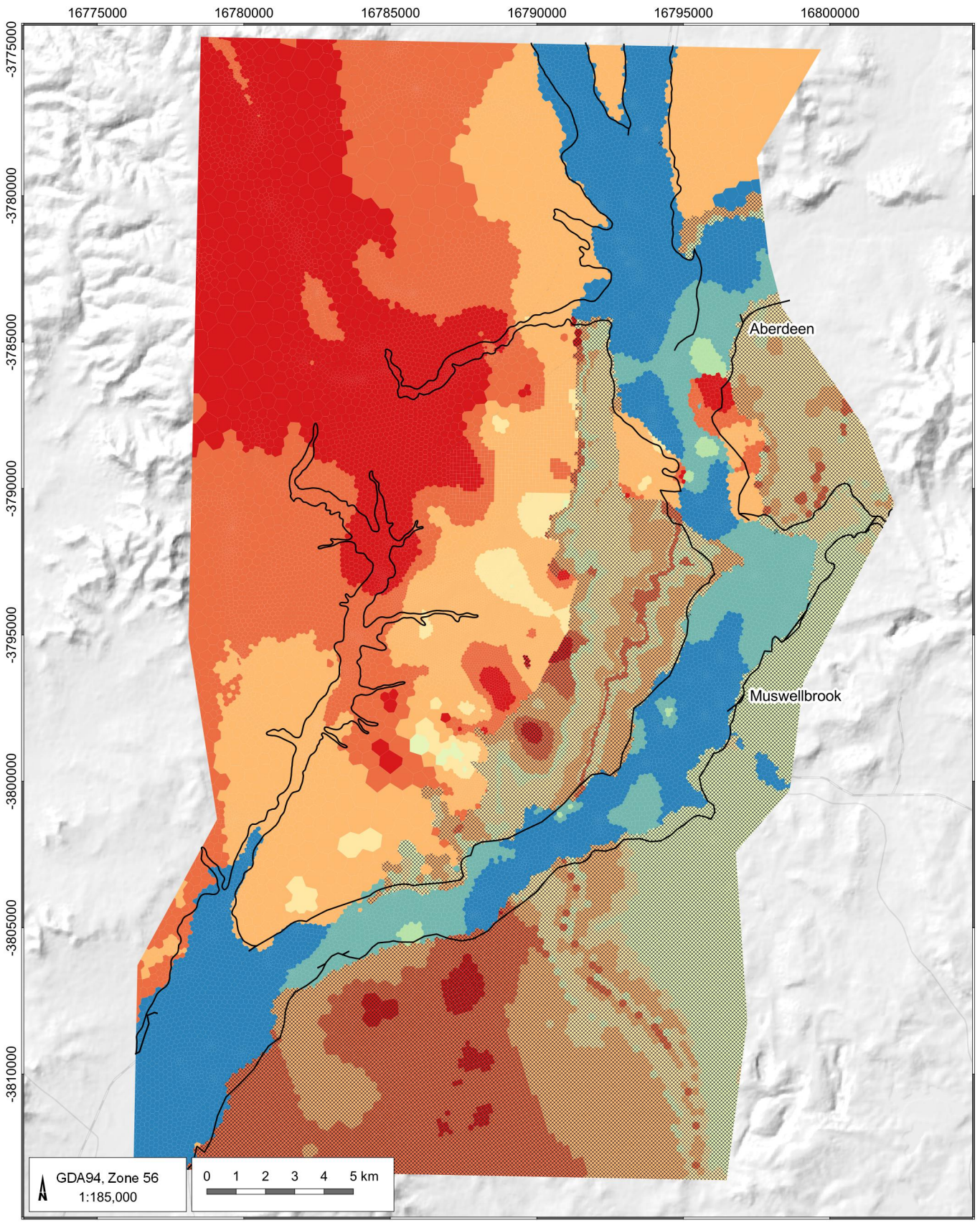
Mt Pleasant MOD7 Groundwater Assessment (MPO5004.001)

Spatial distribution of horizontal hydraulic conductivity (HK) layer 1



DATE
15/07/2024

FIGURE No:
A 2.1



LEGEND

- Grid
- Road
- Rail
- Drainage
- Populated place
- Alluvium extent
- Cells with thickness of less than 0.1m

Horizontal Hydraulic conductivity (m/day)

- 0.0001 - 0.002
- 0.002 - 0.005
- 0.005 - 0.02
- 0.02 - 0.05
- 0.05 - 1.5
- 1.5 - 4.0
- 4.0 - 20.0
- 20.0 - 120.0

Mt Pleasant MOD7 Groundwater Assessment (MPO5004.001)

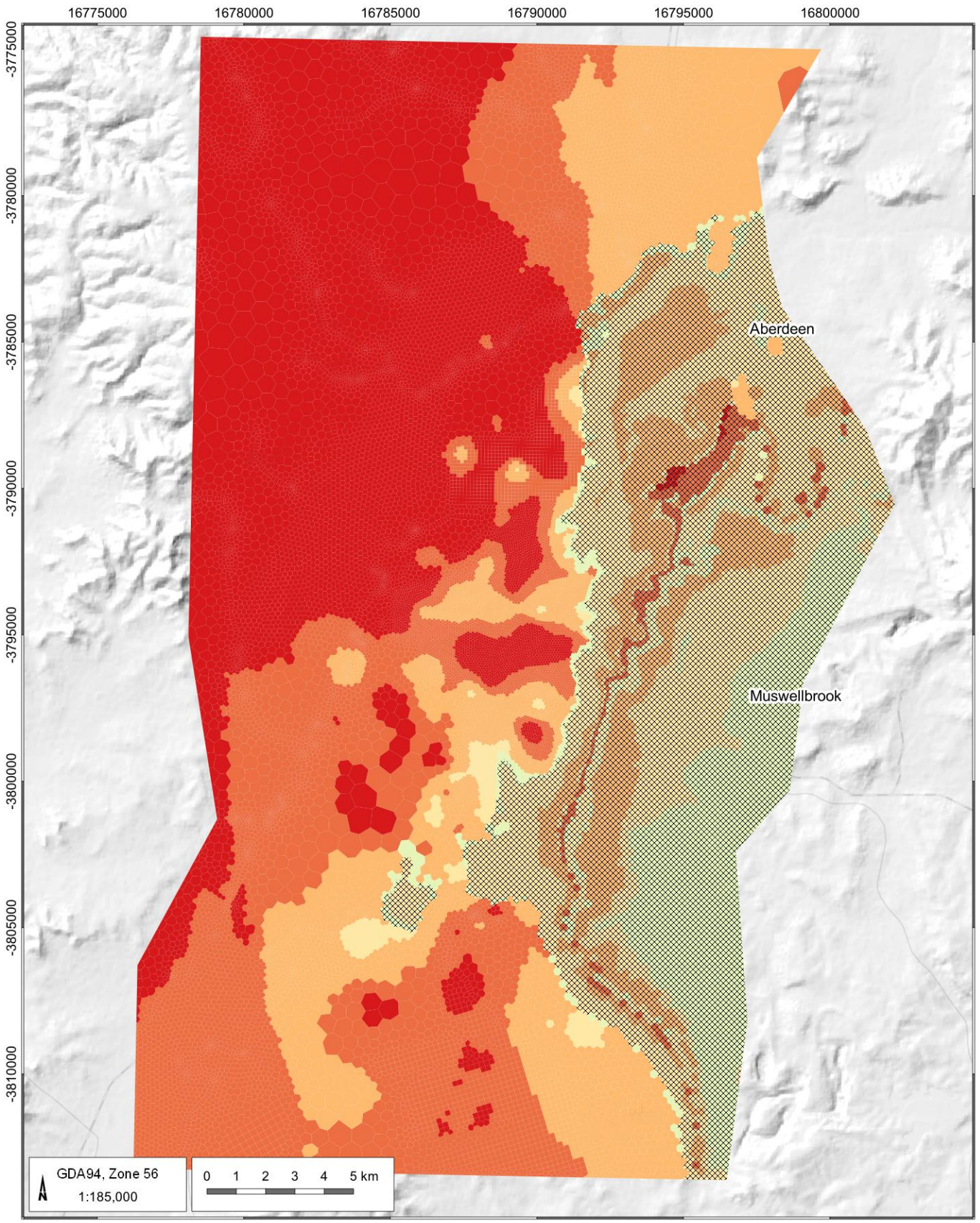
Spatial distribution of horizontal hydraulic conductivity (HK) layer 2



AGE

DATE
15/07/2024

FIGURE No:
A 2.2



LEGEND

- Grid
- Road
- Rail
- Drainage
- Populated place
- Cells with thickness of less than 0.1m

Horizontal Hydraulic conductivity (m/day)

- 0.0001 - 0.002
- 0.002 - 0.005
- 0.005 - 0.02
- 0.02 - 0.05
- 0.05 - 1.5
- 1.5 - 4.0
- 4.0 - 20.0
- 20.0 - 120.0

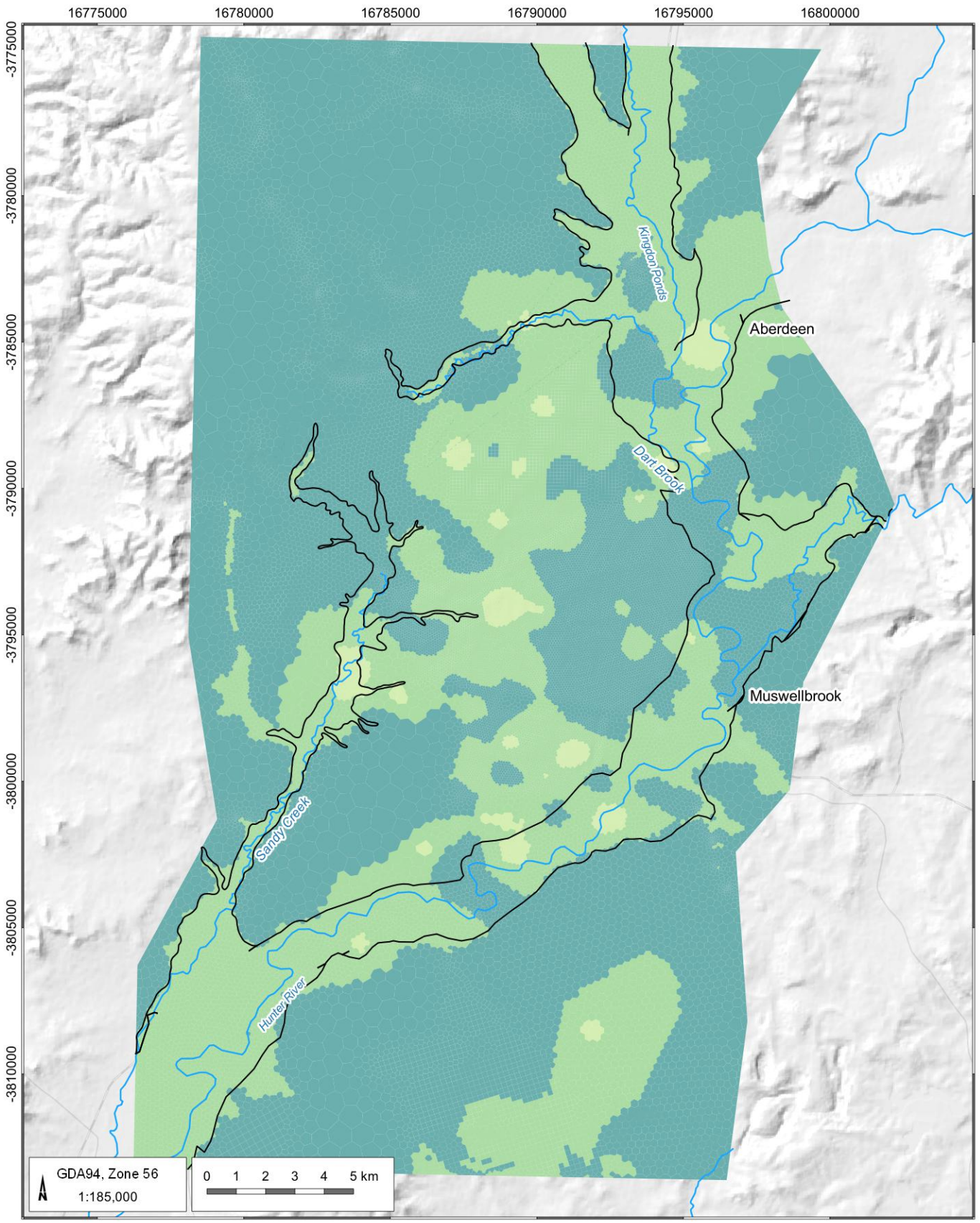
Mt Pleasant MOD7 Groundwater Assessment (MPO5004.001)

Spatial distribution of horizontal hydraulic conductivity (HK) layer 3



DATE
15/07/2024

FIGURE No:
A 2.3



LEGEND

- Grid
- Road
- Rail
- Drainage
- Populated place
- Alluvium extent
- Cells with thickness of less than 0.1m

Vertical hydraulic conductivity (m/day)

- 0.000000085 - 0.000008
- 0.000008 - 0.00001
- 0.00001 - 0.00002
- 0.00002 - 0.0001
- 0.0001 - 0.001
- 0.001 - 0.1
- 0.1 - 1.0
- 1.0 - 20.0
- 20.0 - 120.0

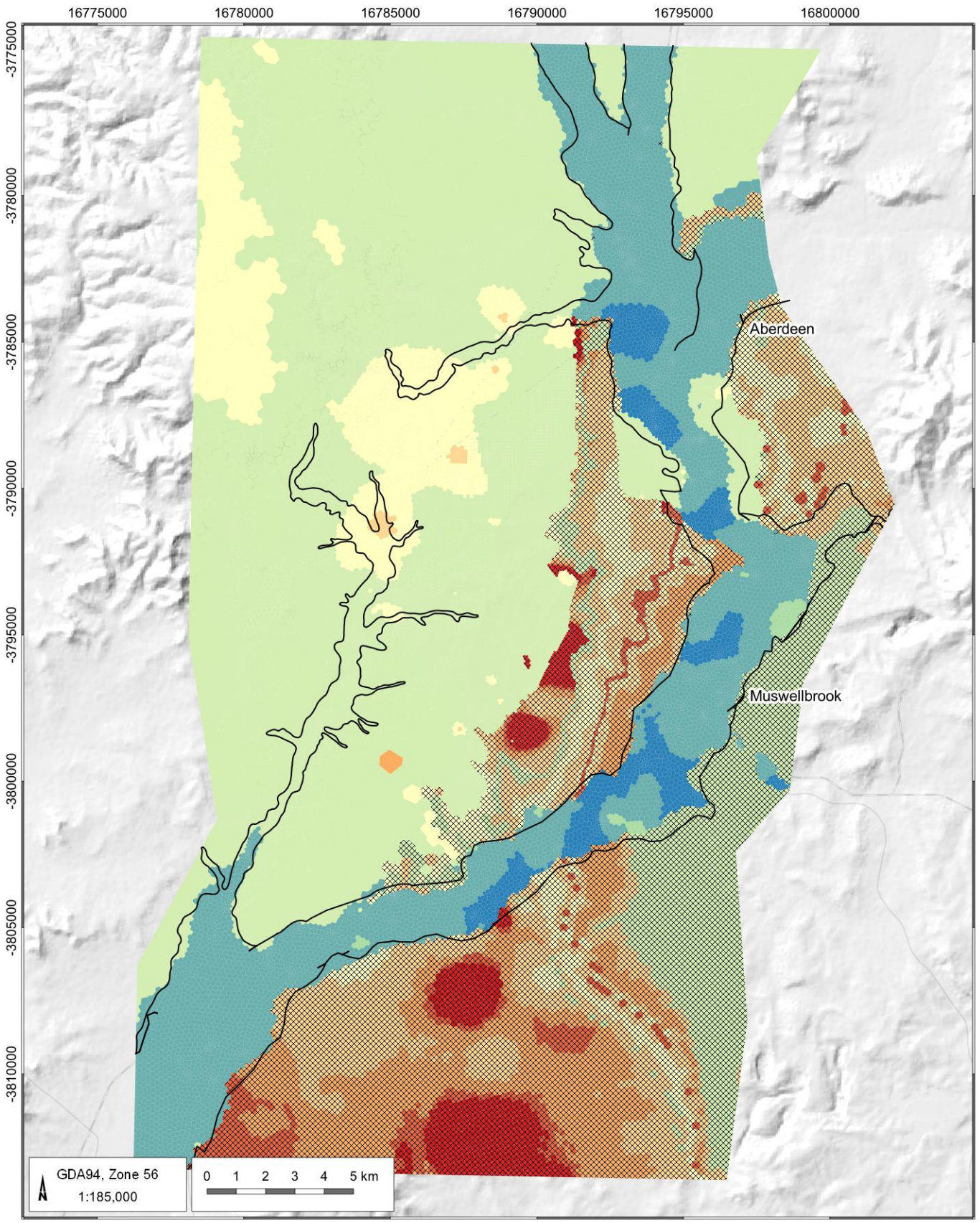
Mt Pleasant MOD7 Groundwater Assessment (MPO5004.001)

Spatial distribution of Vertical hydraulic conductivity (VK) layer 1



DATE
15/07/2024

FIGURE No:
A 2.4



LEGEND

- Grid
- Road
- Rail
- Drainage
- Populated place
- Alluvium extent
- Cells with thickness of less than 0.1m

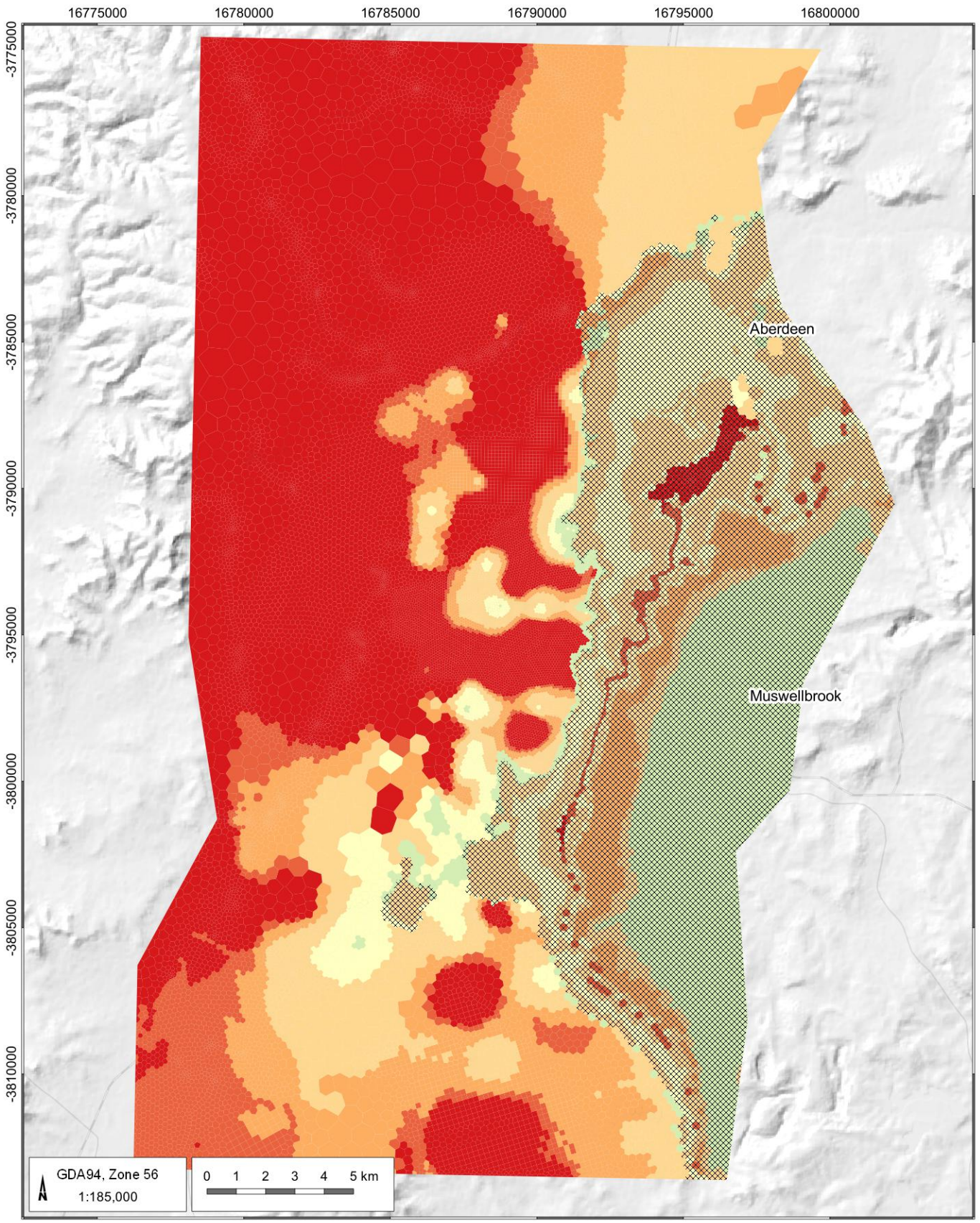
Vertical hydraulic conductivity (m/day)

- 0.000000085 - 0.000008
- 0.000008 - 0.00001
- 0.00001 - 0.00002
- 0.00002 - 0.0001
- 0.0001 - 0.001
- 0.001 - 0.1
- 0.1 - 1.0
- 1.0 - 20.0
- 20.0 - 120.0

Mt Pleasant MOD7 Groundwater Assessment (MPO5004.001)

Spatial distribution of Vertical hydraulic conductivity (VK) layer 2


 DATE 15/07/2024 FIGURE No: A 2.5



LEGEND

- Grid
- Road
- Rail
- Drainage
- Populated place
- Cells with thickness of less than 0.1m

Vertical hydraulic conductivity (m/day)

- 0.000000085 - 0.000008
- 0.000008 - 0.00001
- 0.00001 - 0.00002
- 0.00002 - 0.0001
- 0.0001 - 0.001
- 0.001 - 0.1
- 0.1 - 1.0
- 1.0 - 20.0
- 20.0 - 120.0

Mt Pleasant MOD7 Groundwater Assessment (MPO5004.001)

Spatial distribution of Vertical hydraulic conductivity (VK) layer 3



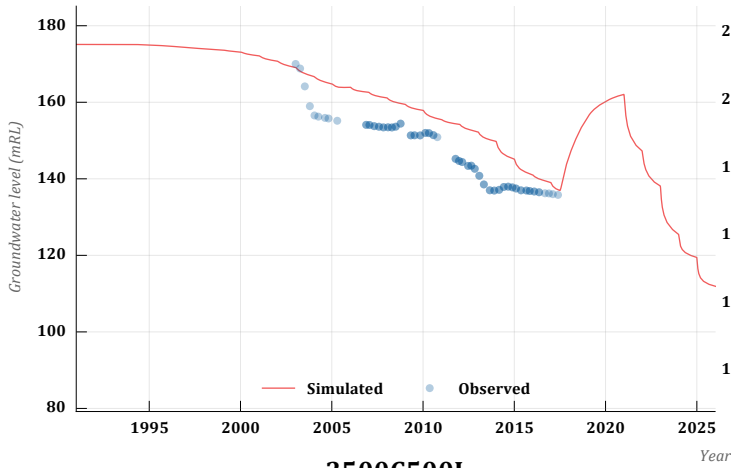
DATE
15/07/2024

FIGURE No:
A 2.6

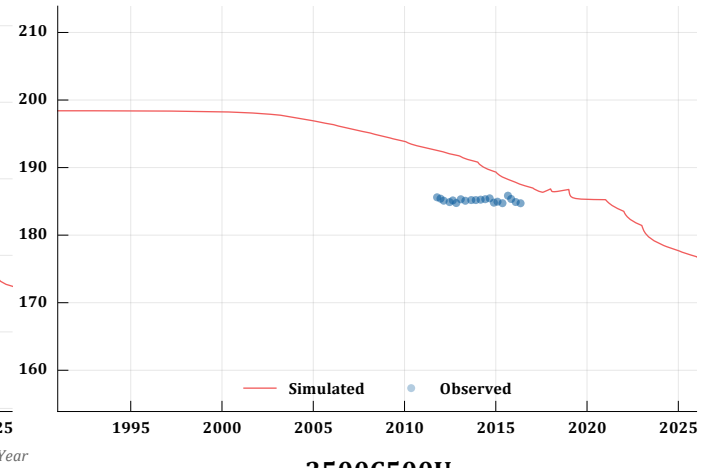
Appendix A3

Verification hydrographs

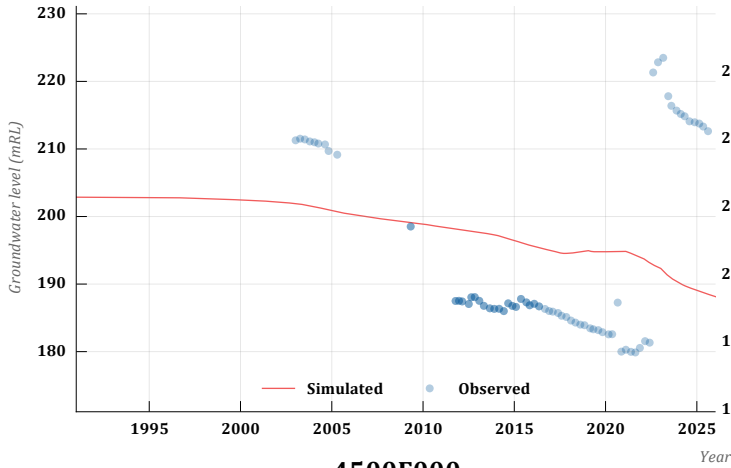
3500B500L



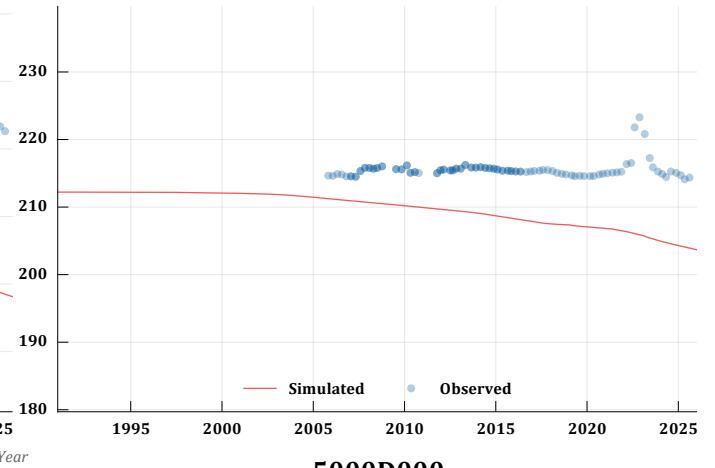
3500B500U



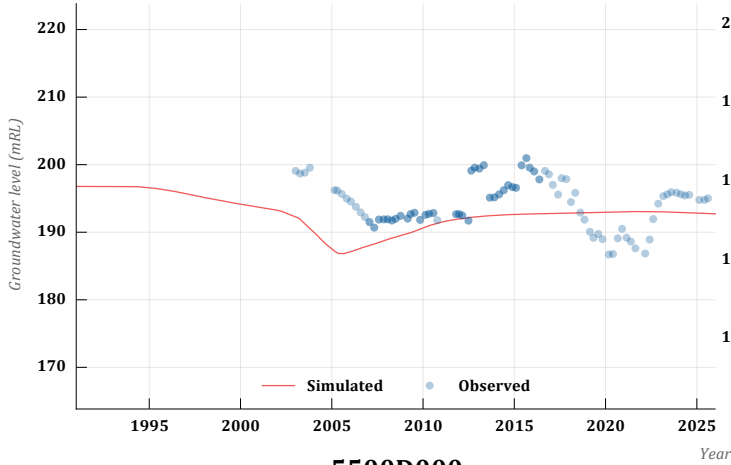
3500C500L



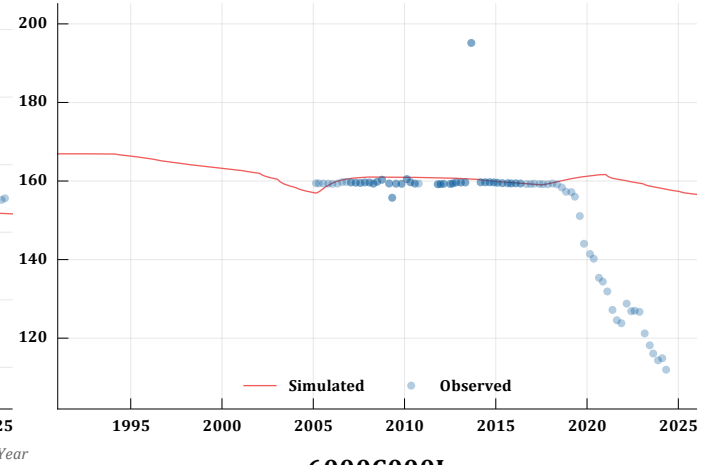
3500C500U



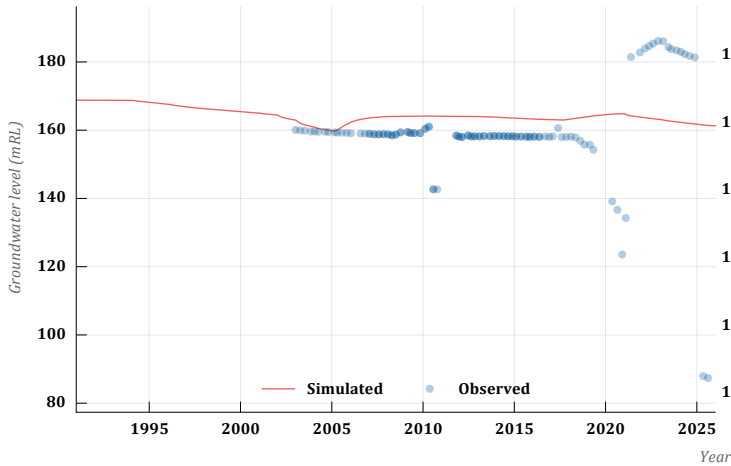
4500F000



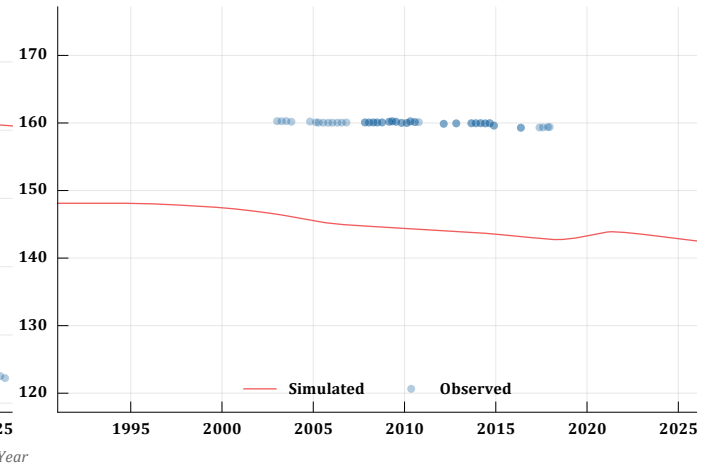
5000D000

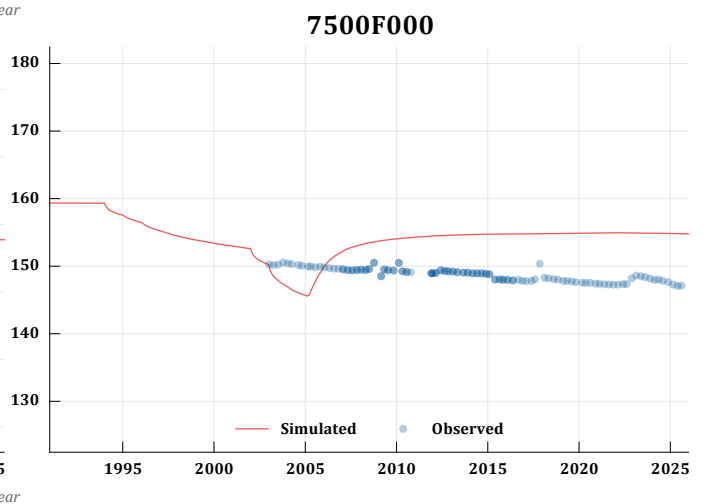
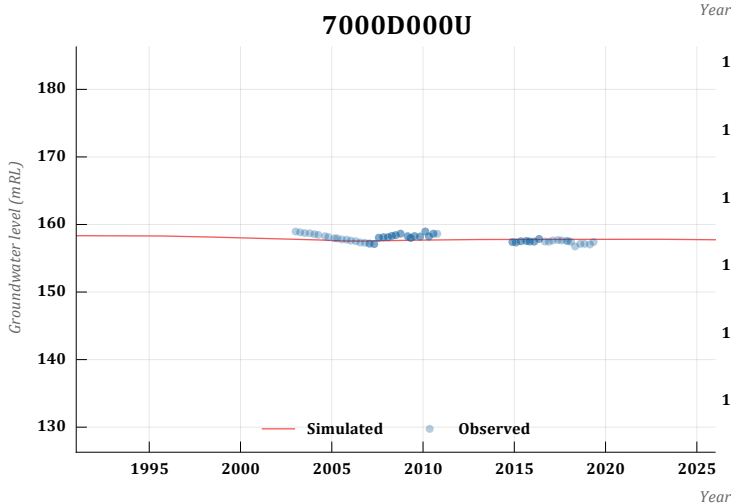
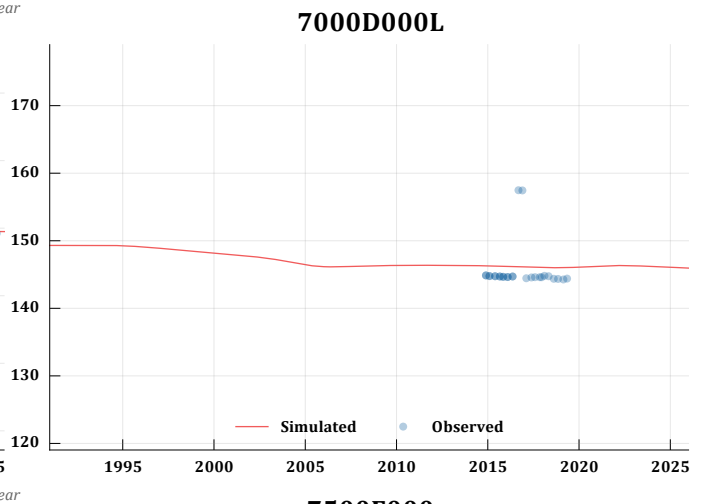
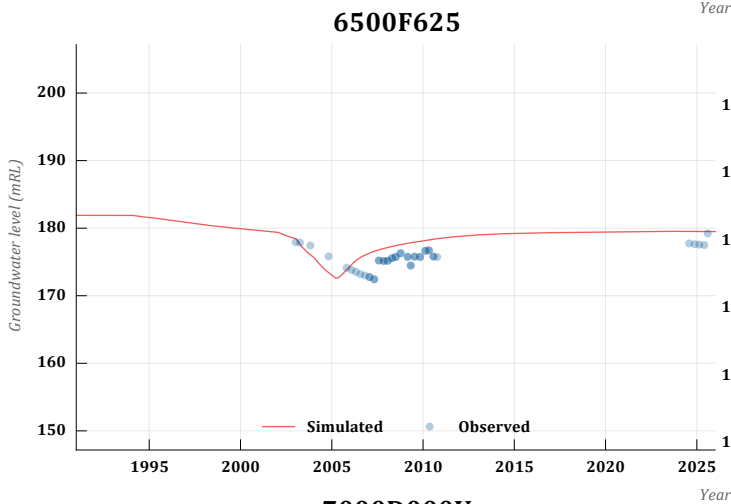
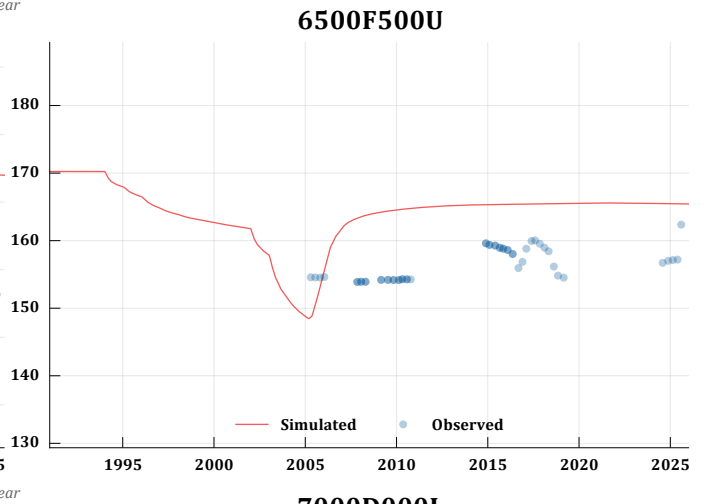
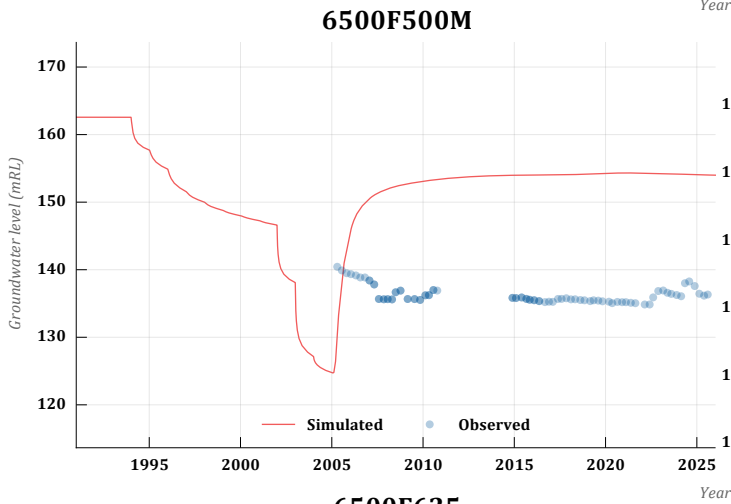
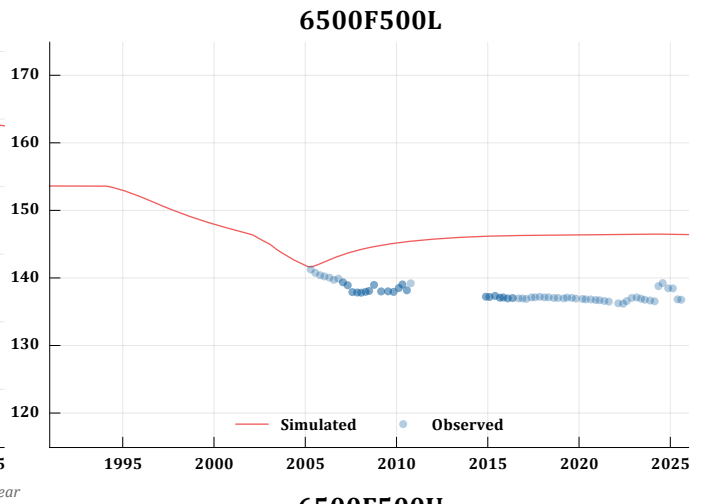
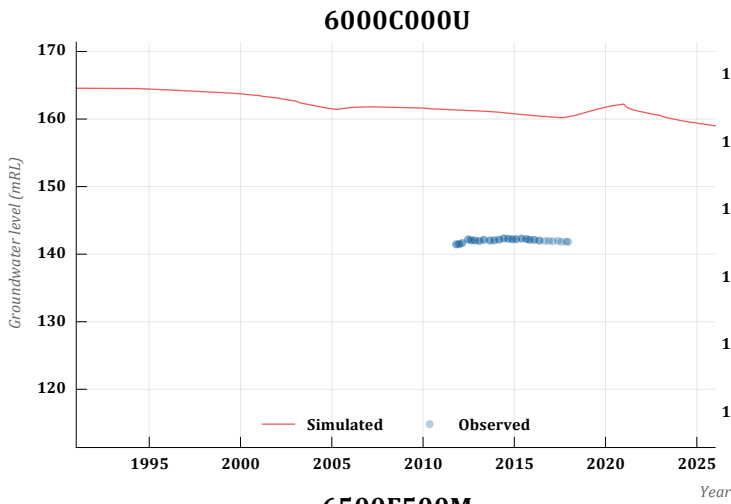


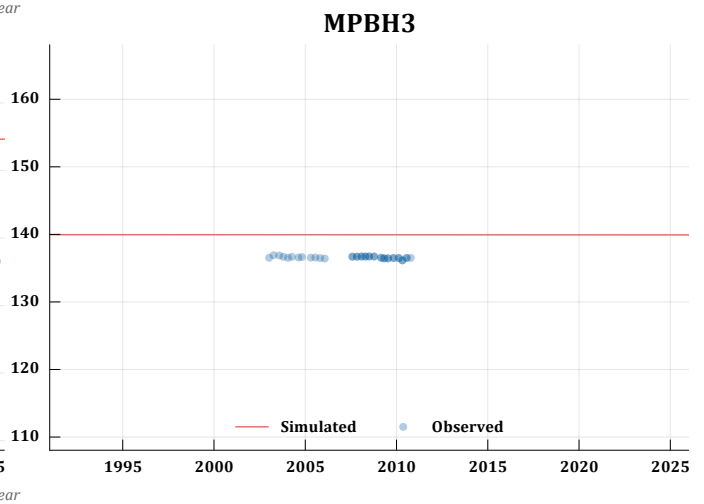
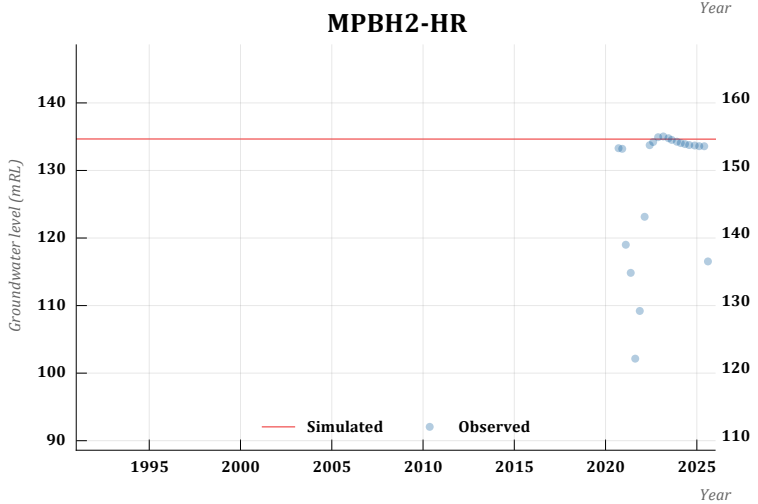
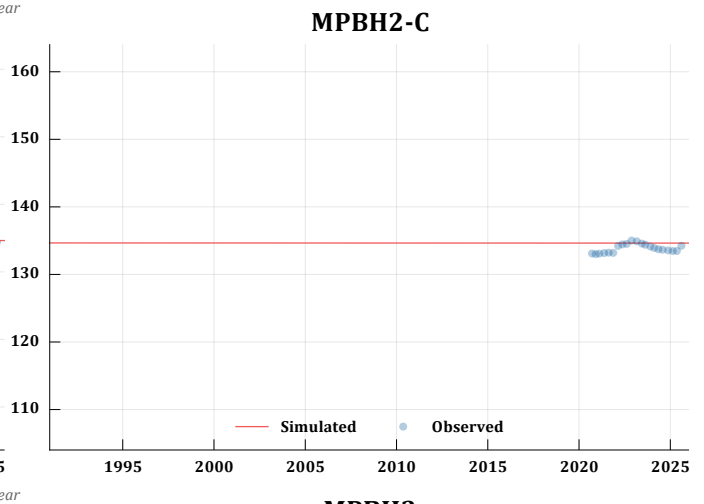
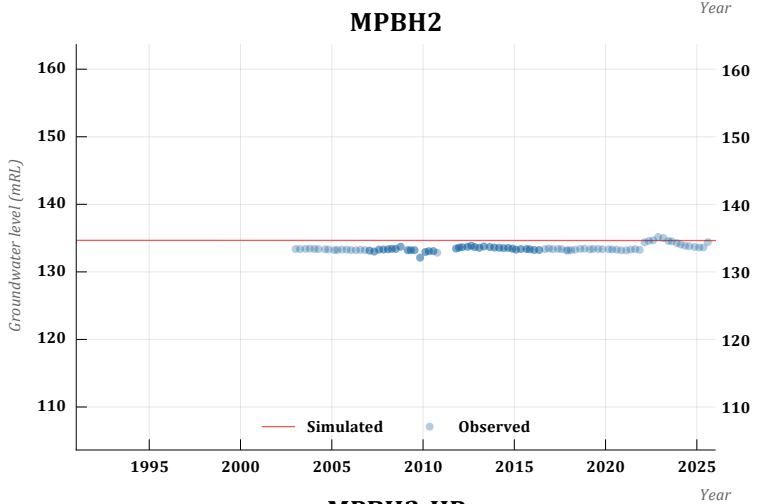
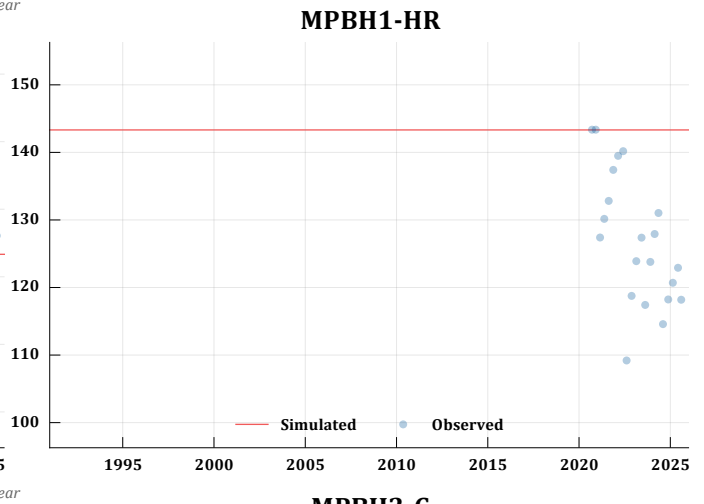
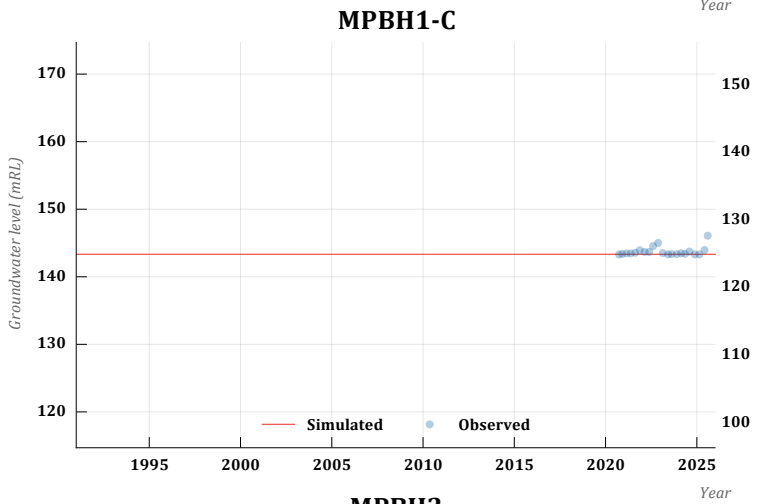
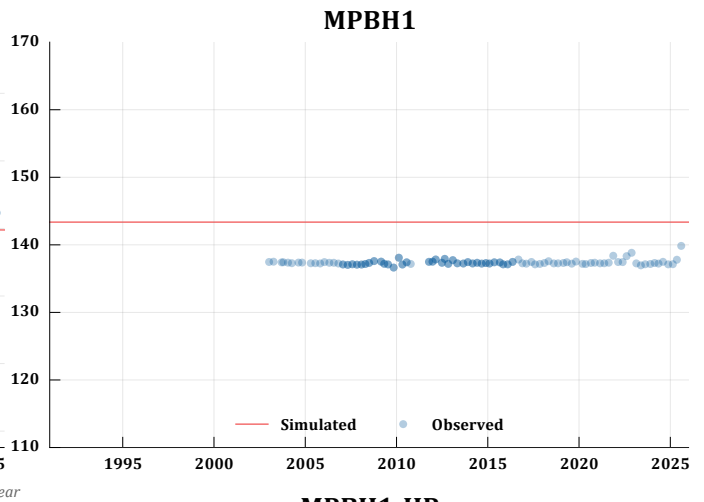
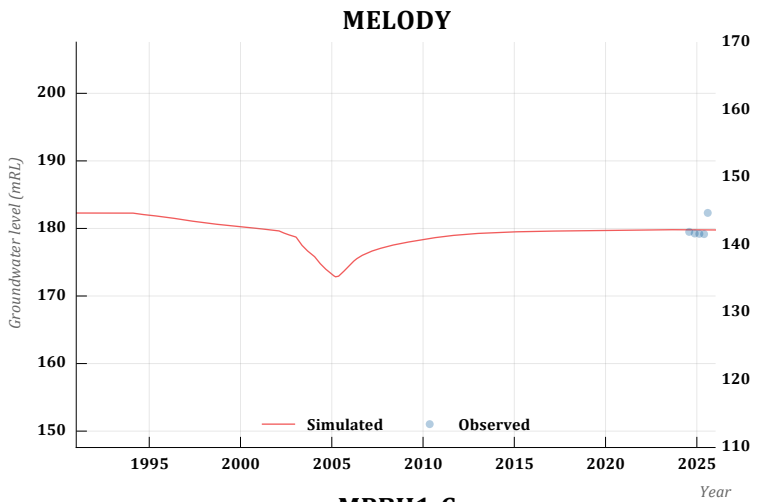
5500D000

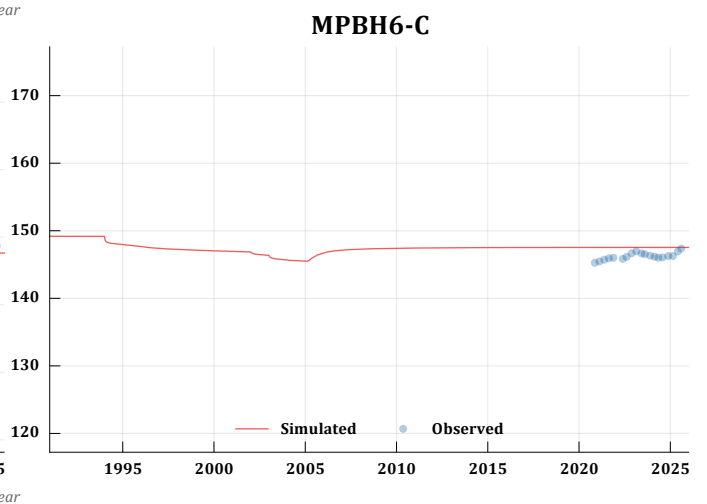
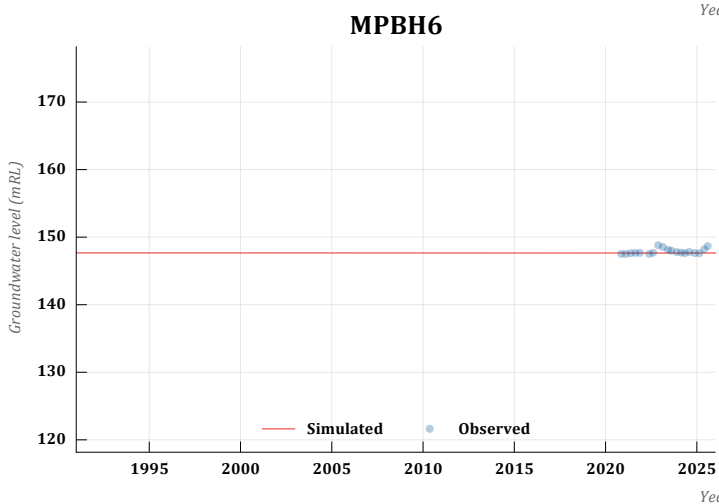
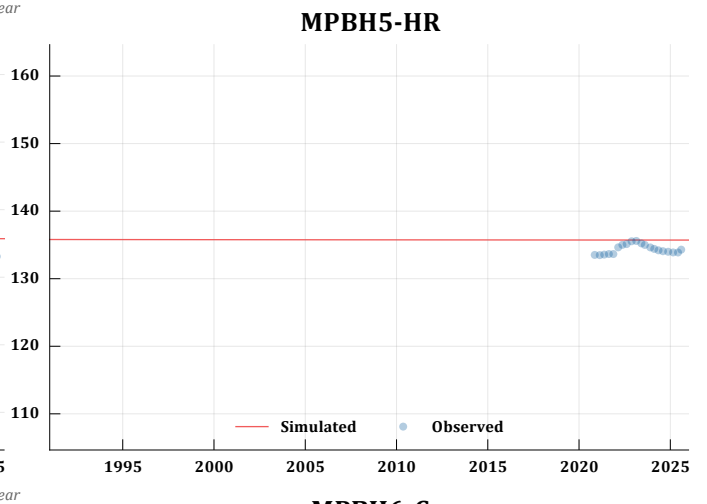
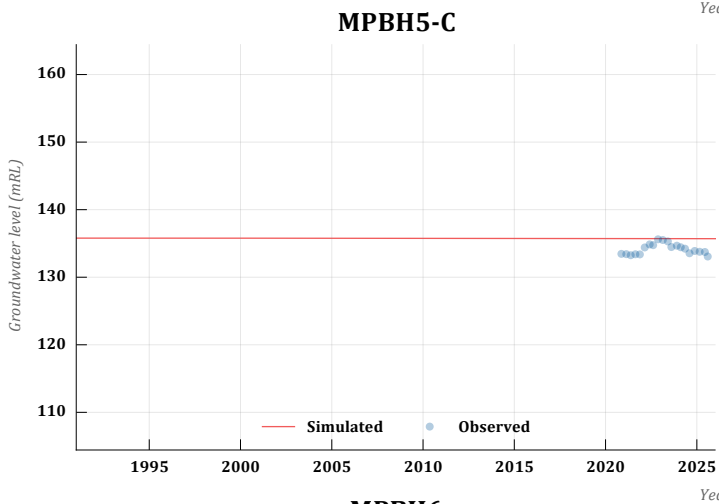
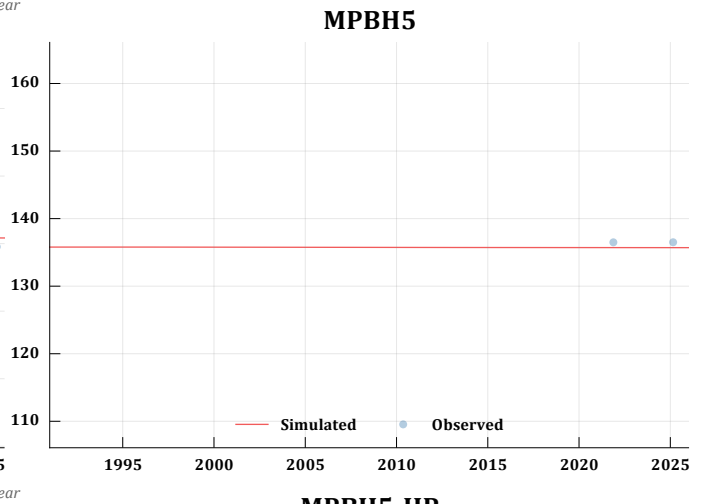
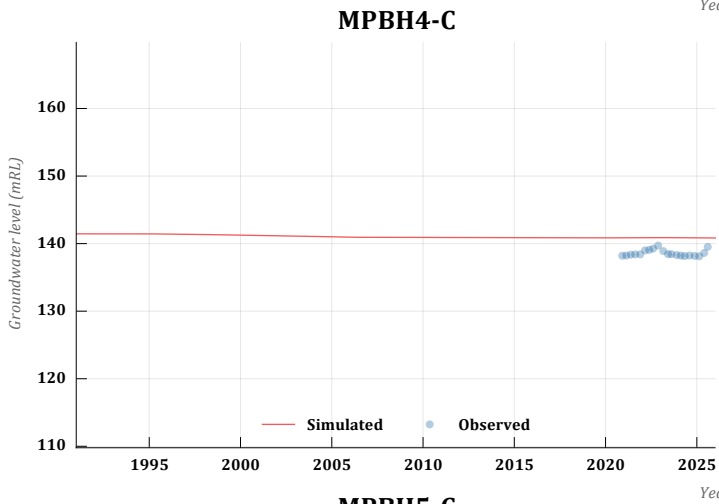
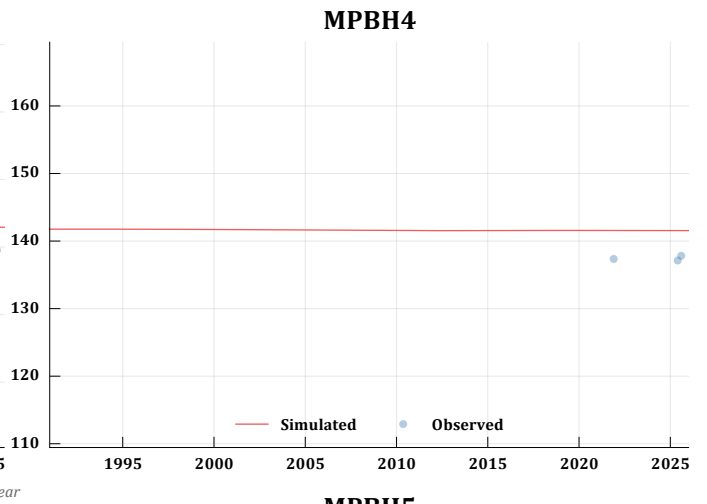
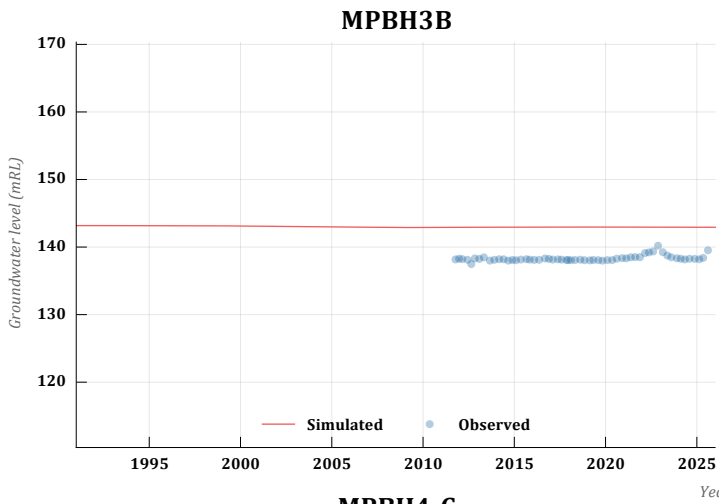


6000C000L

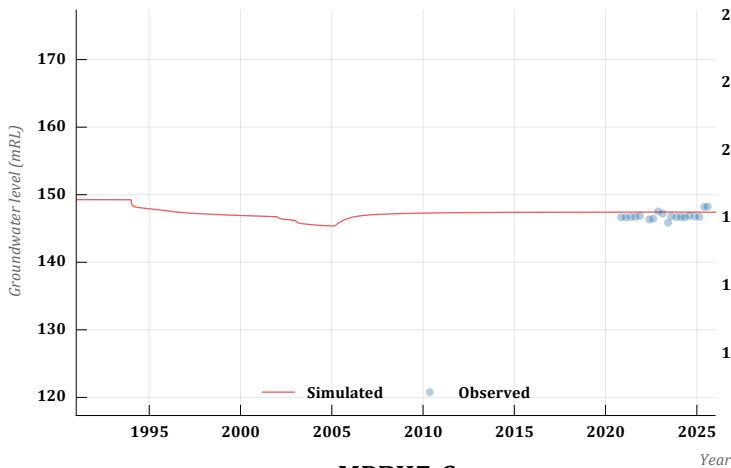




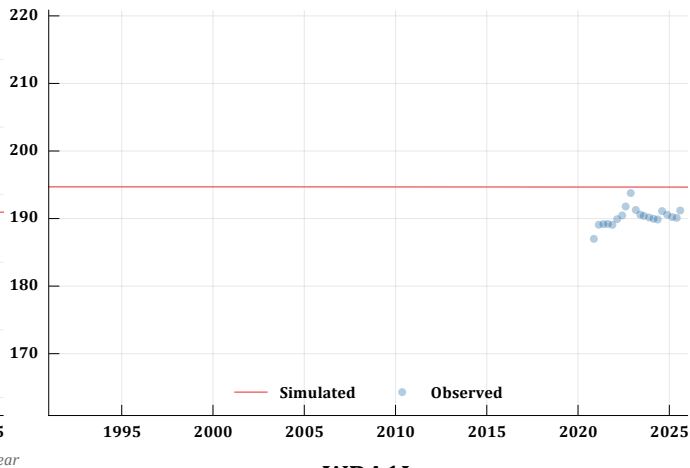




MPBH6-HR



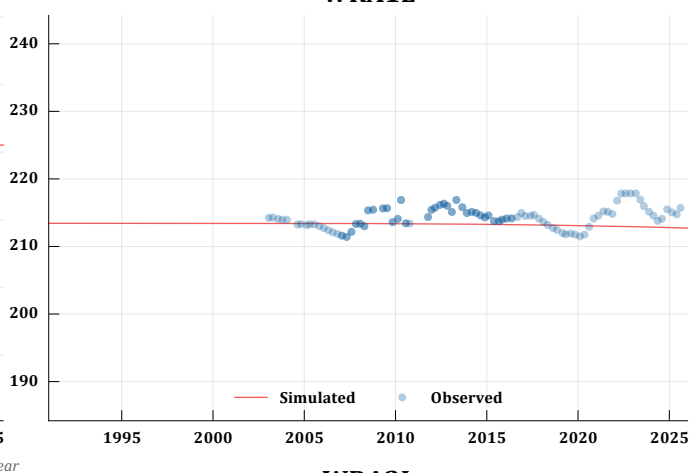
MPBH7



MPBH7-C



WRA1L



WRA1U



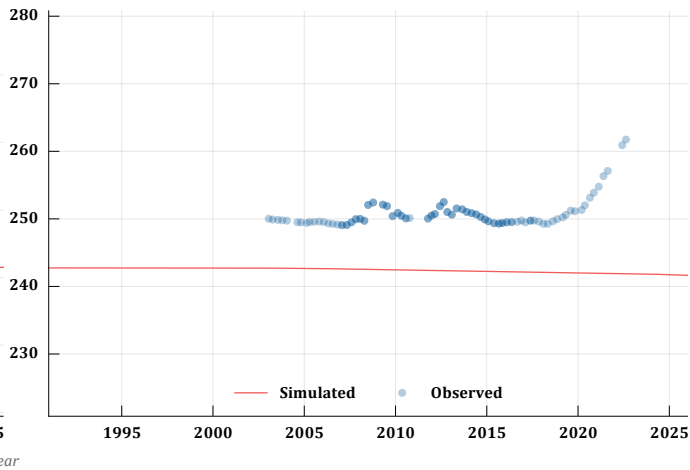
WRA2L



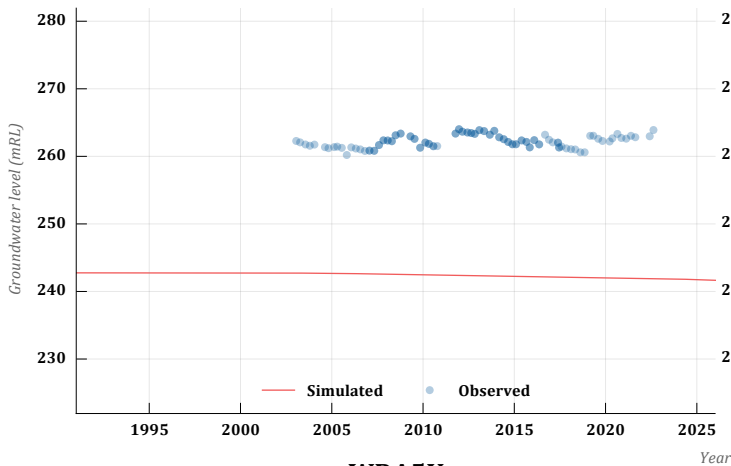
WRA2U



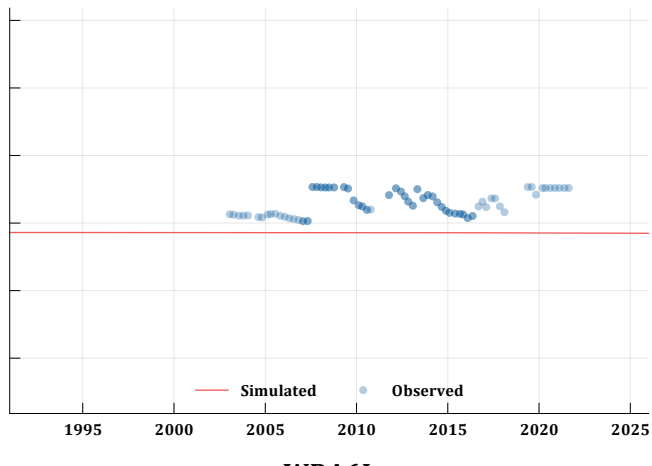
WRA3L



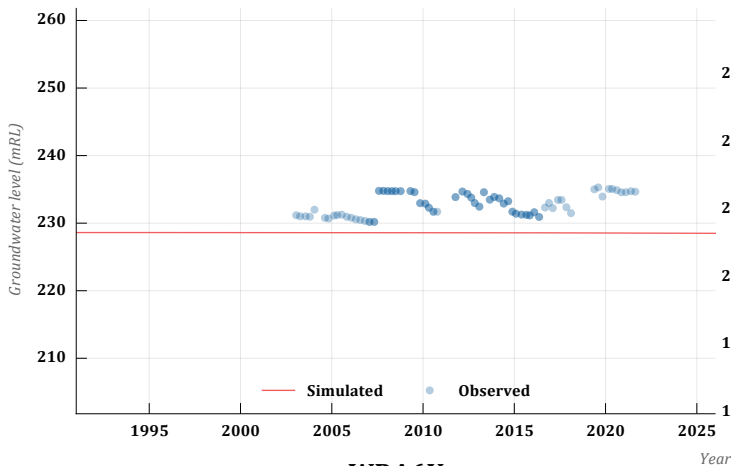
WRA3U



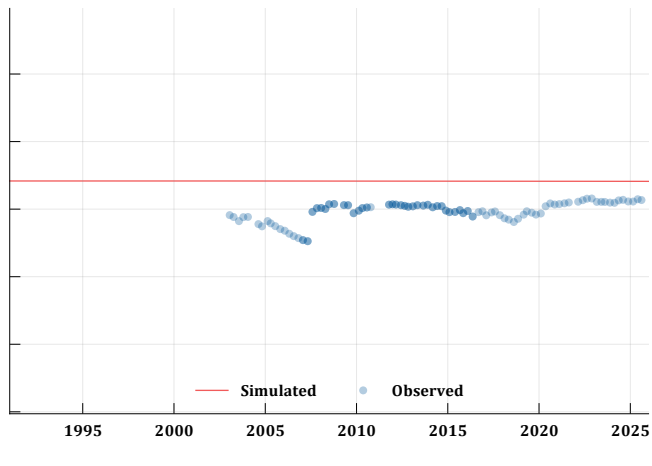
WRA5L



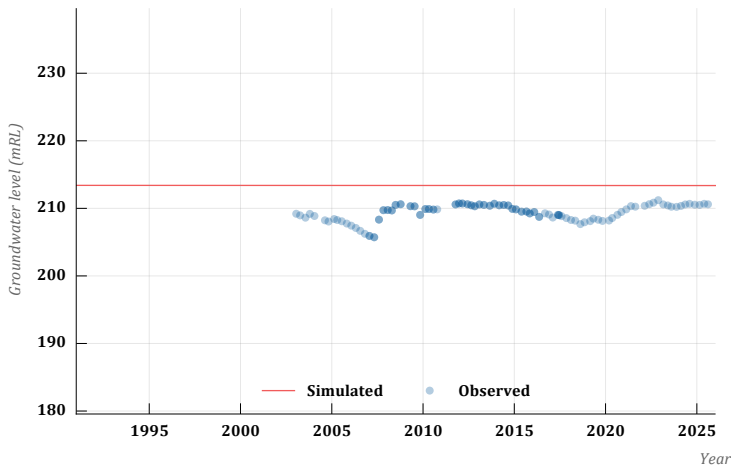
WRA5U



WRA6L



WRA6U



Appendix B

Compliance with government policy

B1 Compliance with New South Wales Policy

B1.1 Aquifer Interference Policy

This section discusses the ability of the MPO (incorporating the Modification) to comply with the AIP. Table B 1.1 to Table B 1.2 below compare the groundwater impact predictions for the MPO against the requirements under the AIP.

Table B 1.1 Accounting for or preventing the take of water

AIP requirement		Proponent response
1	Described the water source (s) the activity will take water from?	Section 2.1.1 describes the water sharing plans that the MPO will take water from, namely: <ul style="list-style-type: none"> • North Coast – Sydney Basin Groundwater Source from the <i>Water Sharing Plan for the North Coast Fractured and Porous Rock Groundwater Sources 2016</i>. • Hunter Regulated River Alluvial Water Source, Muswellbrook Water Source and Dart Brook Water Source from the <i>Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources 2022</i>. • Hunter Regulated River Water Source (Management Zone 1A) from the <i>Water Sharing Plan for the Hunter Regulated River Water Source 2016</i>.
2	Predict the total amount of water that will be taken from each connected groundwater or surface water source on an annual basis as a result of the activity?	Section 7.1.1 and Section 8.1 summarise the peak predicted take of groundwater and surface water from each water source due to the approved and modified MPO.
3	Predicted the total amount of water that will be taken from each connected groundwater or surface water source after the closure of the activity?	Section 8.1.3 describes the predicted post mining impacts.
4	Made these predictions in accordance with Section 3.2.3 of the AIP? (page 27)	Based on 3D numerical modelling as outlined in Section 6.
5	Described how and in what proportions this take will be assigned to the affected aquifers and connected surface water sources?	Table 8.1 summarises the peak take of surface water and groundwater from each water source due to mining at MPO (incorporating the Modification).
6	Described how any licence exemptions might apply?	Refer to the Surface Water Assessment (ATC Williams, 2024).
7	Described the characteristics of the water requirements?	Refer to the Surface Water Assessment (ATC Williams, 2024).
8	Determined if there are sufficient water entitlements and water allocations that are able to be obtained for the activity?	Section 2.1.2 describes the entitlements held by MACH and indicates these are sufficient to account for water taken from the potentially affected water sources. MACH will ensure all necessary water licences are obtained for the development.
9	Considered the rules of the relevant water sharing plan and if it can meet these rules?	Refer to Section 8.1.4.
10	Determined how it will obtain the required water?	Via seepage to the mine face (refer to Section 7.1.1). MPO also hold licences to take water from the regulated sections of the Hunter River.

AIP requirement		Proponent response
11	Considered the effect that activation of existing entitlement may have on future available water determinations?	Not applicable.
12	Considered actions required both during and post-closure to minimise the risk of inflows to a mine void as a result of flooding?	Refer to the Surface Water Assessment (ATC Williams, 2024).
13	Developed a strategy to account for any water taken beyond the life of the operation of the Project?	Refer to Section 8.1.3.
	Will uncertainty in the predicted inflows have a significant impact on the environment or other authorised water users?	Refer to Section 9.
14	Considered any potential for causing or enhancing hydraulic connections, and quantified the risk?	Open cut mining is not expected to generate significant changes in hydraulic connections beyond the pit shell.
15	Quantified any other uncertainties in the groundwater or surface water impact modelling conducted for the activity?	Refer to Section 9.
16	Considered strategies for monitoring actual and reassessing any predicted take of water throughout the life of the Project, and how these requirements will be accounted for?	Refer to Sections 8.1 and 10.

Table B 1.2 Determining water predictions

AIP requirement		Proponent response
1	Establishment of baseline groundwater conditions?	Refer to Section 3 and 5. Water quality and level data has been collected at MPO since 2003 for some of the key groundwater units and tested for a selection of water quality analytes. The monitoring network has been adapted over time to ensure that good spatial coverage is maintained.
2	A strategy for complying with any water access rules?	Refer to Section 8.1.
3	Potential water level, quality or pressure drawdown impacts on nearby basic landholder rights water users?	Refer to Section 8.2 (see Table 8.2).
4	Potential water level, quality or pressure drawdown impacts on nearby licensed water users in connected groundwater and surface water sources?	Refer to Section 8.1 to 8.4.
5	Potential water level, quality or pressure drawdown impacts on groundwater dependent ecosystems?	There are no high priority GDEs, as defined within WSPs, within the predicted area of drawdown.
6	Potential for increased saline or contaminated water inflows to aquifers and highly connected river systems?	The final void at MPO a will act as a 'groundwater sink' therefore no saline or contaminated water inflows to aquifers and highly connected river systems will occur.
7	Potential to cause or enhance hydraulic connection between aquifers?	Only open cut mining is proposed which is not expected to generate significant changes in hydraulic connection beyond the pit shell.
8	Potential for river bank instability, or high wall instability or failure to occur?	Refer to Surface Water Assessment (ATC Williams, 2024).
9	Details of the method for disposing of extracted activities (for CSG activities)?	N/A

There are two levels of minimal impact considerations specified in the AIP. If the predicted impacts are less than the Level 1 minimal impact considerations, then these impacts will be considered as acceptable. Where the predicted impacts are greater than the Level 1 minimal impact considerations then the AIP requires additional studies to fully assess these predicted impacts. If this assessment shows that the predicted impacts do not prevent the long-term viability of the relevant water-dependent asset, then the impacts will be considered to be acceptable. The modelling indicates the Level 1 minimal impact consideration thresholds could be exceeded for MPO (incorporating the Modification) in the form of greater than 2 m cumulative drawdown at six private bores. However, only two of these private bores are predicted to experience greater than 2 m drawdown as a result of the modified MPO only and are either not in use and/or understood to be dry.