NARRABRI MINE

EXTRACTION PLAN
WATER MANAGEMENT PLAN

LW 203 – LW 206

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Acronyms and abbreviations

Acronym	Description
µS/cm	microSiemens per centimetre
AHD	Australian Height Datum
AIP	NSW Aquifer Interference Policy
ANZECC	Australia and New Zealand Environment and Conservation Council
ANZG	Australia and New Zealand Guidelines for Fresh and Marine Water Quality
ARMCANZ	Agricultural and Resources Management Council of Australia & New Zealand
AoD	Angle of Draw
CF	Cut and flit
Cwlth	Commonwealth
DCCEEW	The NSW Department of Climate Change, Energy, the Environment and Water
DCCEEW Water Group	The Water Group within the NSW Department of Climate Change, Energy, the Environment and Water
DES	QLD Department of Environment and Science (now QLD Department of Environment, Science and Innovation)
DGS	Ditton Geotechnical Services
DPE	The NSW Department of Planning and Environment
DPE Water	The former Water group within DPE (now DCCEEW Water Group)
DPHI	The NSW Department of Planning, Housing and Infrastructure
EA	Environmental assessment
EC	electrical conductivity
EIS	Environmental Impact Statement
EP 203-206	Extraction Plan for LW 203 to LW 206
EP-BMP	Extraction Plan – Biodiversity Management Plan
EP-WMP	Extraction Plan - Water Management Plan (this document)
EP&A Act	*Environmental Planning and Assessment Act 1979*
EPA	Environment Protection Authority
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Cwlth)
EPL	Environment Protection License
GAB	Great Artesian Basin
GDE	groundwater dependent ecosystem
ha	hectare
IEA	Independent Environmental Audit
IEAPM	Independent Expert Advisory Panel for Mining
km	kilometre
LiDAR	light detection and ranging
LW	longwall panel

Acronym	Description
m	metre
mbgl	metres below ground level
MDB	Murray Darling Basin
mg/L	milligram per litre
Mining Act	*Mining Act 1992* (NSW)
ML	mining lease; megalitre
mm	millimetre
mm/m	millimetre per metre
MOD 5	Modification 5
MOD 7	Modification 7
Mtpa	million tonnes per annum
NCOPL	Narrabri Coal Operations Pty Ltd
NDVI	Normalised difference vegetation index
PED	personal emergency device (communications system)
pH	potential of hydrogen
POEO Act	*Protection of the Environment Operations Act 1997*
QA/QC	Quality assurance / quality control
ROM	run of mine
SoC	Statement of Commitment
SSGV	Site specific guideline value
TARP	trigger action response plan
TDS	total dissolved solids
TOC	total organic carbon
TSS	total suspended solids
U95%CL	upper 95 % confidence level
UAL	Upper Allowable Limit
UCL	Lower Allowable Limit
VI	visual inspection
VWP	vibrating wire piezometer
WAL	water access licence
WHC	Whitehaven Coal Limited
WM Act	*Water Management Act 2000*
WSP	water sharing plans
XL	Cross section cross-line across the longwall panels

Table of contents

Tables

Figures

1. Introduction

1.1 Background

The Narrabri Mine is an existing underground coal mining operation situated in the Gunnedah Coalfield. It is located approximately 25 kilometres (**km**) south-east of Narrabri and approximately 60 km north-west of Gunnedah, within the Narrabri Shire Council Local Government Area in New South Wales (**NSW**). The Narrabri Mine includes an underground coal mine, a coal handling and preparation plant and associated rail siding and surface infrastructure.

The Narrabri Mine is operated by Narrabri Coal Operations Pty Ltd (**NCOPL**), on behalf of the Narrabri Mine Joint Venture, which consists of two Whitehaven Coal Limited (**WHC**) wholly owned subsidiaries, and other joint-venture partners[1]. The underground mine is covered by Mining Lease (**ML**) 1609 which covers an area of 5,298 hectares (**ha**) for the predominant purpose of mining for coal from the Hoskissons Coal Seam.

Stage 1 of the Narrabri Mine was approved in November 2007 under Part 3A of the *Environmental Planning and Assessment Act 1979* (**EP&A Act**). Construction of the mine and supporting infrastructure commenced in 2008, with production using a continuous miner commencing in 2010. Following the approval of the Stage 2 Environmental Assessment (R.W Corkery & Co., 2009) (the **EA**) and the issue of the Stage 2 Project Approval 08_0144 (**Project Approval**) in July 2010, and *Environmental Protection and Biodiversity Conservation Act 1999* (**EPBC Act**) approval (**2009/5003**) in January 2011, the Narrabri Mine was converted to an 8 million tonnes per annum (**Mtpa**) run of mine (**ROM**) longwall mining operation, which commenced in 2012.

The Project Approval has subsequently been modified on a number of occasions. The environmental assessment for Modification 5 (Resource Strategies, 2015) (**MOD 5**), approved in December 2015, changed the mine geometry by reducing the number of longwall (**LW**) panels from 26 to 20, increased some LW panel widths and increased the production to 11 Mtpa of ROM coal until July 2031.

Modification 7, the most recent modification of the Project Approval, was approved on 23 November 2021. The environmental assessment for Modification 7 (Resource Strategies, 2021) (**MOD 7**) describes the change in mining method within the extent of the previously approved LW 201 and LW 202 and allows for up to 0.7 Mtpa via bord and pillar extraction at pillar reduction panels Cut and Flit (**CF**) 201 to CF 205. There is no change to the previously approved longwall panels LW 203 to LW 209. The bord and pillar mining will occur concurrently with existing longwall operations for a period of approximately five years, with the maximum ROM coal production rate remaining within the approved limit of 11 Mtpa.

1.2 Purpose and scope

This Extraction Plan - Water Management Plan (**EP-WMP** or **Plan**) for Longwall (**LW**) 203 to LW 206 has been prepared in accordance with Schedule 3 Condition 4(h) of the Project Approval and the Department of Planning, Housing and Infrastructure (**DPHI**) (formerly the Department of Planning and Environment [**DPE**] *Extraction Plan Guideline* (DPE, 2022).

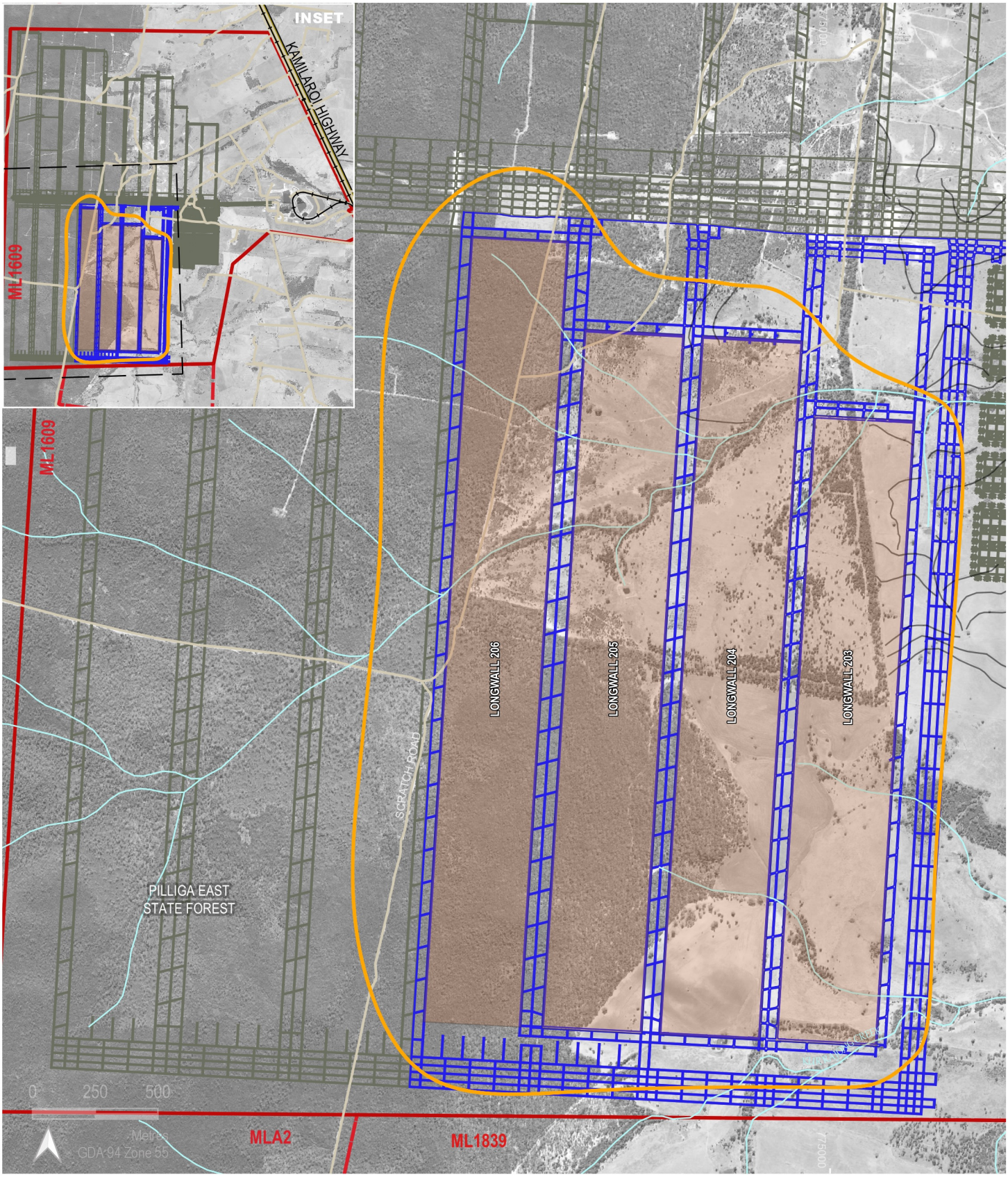
The EP-WMP sets out the objectives, performance measures and management actions required to manage the potential impacts from subsidence on watercourses and aquifers above LW 203 to LW 206 (the **Extraction Plan Area**[2]). This Plan forms Appendix A of the Extraction Plan for LW 203 to LW 206 (**EP 203-206**).

[1] For full details on the joint venture ownership, refer to the introduction of the Extraction Plan.

[2] The area located within the 45° Angle of Draw (**AoD**) as shown on Figure 1-1.

The Ditton Geotechnical Services Pty Ltd (**DGS**) *Mine Subsidence Assessment Report for LW 203 to LW 206* (DGS, 2022) (**Mine Subsidence Assessment Report**) has been used as a basis for developing the performance measures and management actions in response to the predicted impacts on watercourses and aquifers within the Extraction Plan Area. The Mine Subsidence Assessment Report is presented in full as Appendix J to EP 203-206.

The Extraction Plan Area and underground mining layout for LW 203 to LW 206 is presented in Figure 1-1. A detailed description of the underground mining method is provided within EP 203-206.



WHITEHAVEN COAL

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LEGEND

- ML1609
- ML1839
- MLA2
- Underground mining layout
- Longwalls 203 to 206
- Proposed longwall voids (LW203-206)
- 45 degree angle of draw
- Road
- Watercourse
- Contour bank

NARRABRI MINE

FIGURE 1-1

Extraction Plan Area and Underground Mining Layout for LW 203 to LW 206

1.3 Objectives

The objectives of this EP-WMP are to:

- provide details of the relevant statutory requirements, including any relevant approval, licence or lease conditions;
- provide baseline data for surface water flows and quality in watercourses and other water bodies, groundwater levels, yield and quality in the Extraction Plan Area;
- provide a description of the management of potential impacts and/or environmental consequences of the proposed second workings on watercourses and aquifers;
- provide a surface water monitoring program that:
  - monitors for potential impacts to surface water take, stream flows and quality, riparian vegetation health and channel stability; and
  - evaluates the effectiveness of management actions.
- provide a groundwater monitoring program that:
  - monitors for potential impacts to groundwater resources or quality, groundwater bores on privately-owned land, groundwater inflows to underground workings and groundwater dependent ecosystems (**GDEs**); and
  - evaluates the effectiveness of management actions.
- provide triggers to inform additional and/or adaptive management actions;
- describe the protocol for managing and reporting any incident, non-compliance or exceedance of any impact assessment criteria or performance criteria, complaint, or failure to comply with other statutory requirements;
- detail the regulatory reporting requirements;
- describe the protocol for periodic review of this Plan; and
- identify the roles and responsibilities for implementation of this Plan.

1.4 Statutory requirements

1.4.1 Relevant legislation

Environmental Planning and Assessment Act 1979

The EP&A Act provides the statutory basis and framework for planning and environmental assessment in NSW. The EP&A Act includes provisions to ensure that the potential environmental impacts of a development are assessed and considered by consent authorities prior to granting development approval. The original approvals for the Narrabri Mine were obtained under the Part 3A, 'Major Projects' provisions of the EP&A Act. While Part 3A has since been repealed, it remains applicable to NCOPL under transitionary provisions.

Protection of the Environment Operations Act 1997

The *Protection of the Environment Operations Act 1997* (**POEO Act**) regulates pollution from a facility or activity through the placement of conditions in an environment protection licence (**EPL**). Activities requiring an EPL are listed in Schedule 1 of the POEO Act and include mining for coal and coal works.

The POEO Act provides the statutory framework for managing water pollution in NSW. It is supported by the *Protection of the Environment Operations (General) Regulation 2021,* which among other functions prescribes certain matters for the purposes of the definition of water pollution.

It is an offence under section 120 of the POEO Act to pollute waters. However, section 121 and section 122 of the POEO Act provides a defence against prosecution under section 120 where the pollution was regulated by an EPL or regulation which was not contravened.

Environment Protection and Biodiversity Conservation Act 1999 (Cwlth)

The EPBC Act is designed to protect national environmental assets, known as Matters of National Environmental Significance, which include a water resource associated with a large coal mining development (the water trigger).

Mining Act 1992

The *Mining Act 1992* (**Mining Act**) regulates the licensing, land access, and operations for coal mines operating in NSW. Under the Mining Act, all resource activities must be licensed, including exploration activities.

Water Management Act 2000

The NSW *Water Management Act 2000* (**WM Act**) provides for the protection, conservation and ecologically sustainable development of the water sources of the State. The WM Act includes the concept of “no more than minimal harm” for both the granting of water access licences (**WALs**) and the granting of approvals. The WM Act licensing regimes for the management of water resources apply to water sources that are the subject of a Water Sharing Plan (**WSP**).

All surface water and groundwater associated with the Narrabri Mine, including extraction from the Namoi River, is governed by the WM Act. The following WSPs are relevant to the Narrabri Mine:

- Water Sharing Plan for the Upper Namoi and Lower Namoi Regulated River Water Sources 2016 (Lower Namoi Regulated River Water Source);
- Water Sharing Plan for the Namoi and Peel Unregulated Rivers Water Sources 2012;
- Water Sharing Plan for the NSW Murray Darling Basin (**MDB**) Porous Rock Groundwater Sources 2020 – Gunnedah-Oxley Basin MDB Groundwater Source (Gunnedah Oxley Basin MDB [Other] Management Zone);
- Water Sharing Plan for the NSW Great Artesian Basin (**GAB**) Groundwater Sources 2020 – Southern Recharge Groundwater Source; and
- Water Sharing Plan for the Namoi Alluvial Groundwater Sources 2020 – Upper Namoi Zones 2, 4 and 5 and the Lower Namoi Groundwater Sources.

The current WALs held by NCOPL for surface water and groundwater sources are listed in Table 1-1.

Table 1-1 Existing surface and groundwater licences

Works approval	WAL	Water source	Nominal allocation (units/yr)
Surface water			
90CA802130	6762	Lower Namoi Regulated River Water Source (high security)	20
90CA802130	2728	Lower Namoi Regulated River Water Source (general security)	10
90CA802130	20152		600
90MW833069[1]	2671		48
90MW833092[2]	44965	Namoi and Peel Unregulated Rivers Water Sources 2012 (Eulah Creek Water Source)	40
Groundwater			
90WA81289	12833	Upper Namoi Zone 5 Namoi Valley (Gins Leap to Narrabri) Groundwater Source	67
90WA81289	20131		150
90MW833065[3]	12822		43
90MW833064	29549	Gunnedah - Oxley Basin Murray Darling Basin Groundwater Source	1,468
90MW833064[4]	43017		403
90MW833068[5]	15922	GAB Southern Recharge Groundwater Source	248

Note:

[1] Pending approval of application to Water NSW to change the nominated works to miscellaneous work number 90MW833069 (currently 90CA802130).

[2] Pending approval of application to Water NSW to change the nominated works to miscellaneous work number 90MW833092.

[3] Pending approval of application to Water NSW to change the nominated works to miscellaneous work number 90MW833065 (currently 90WA812891).

[4] Pending approval of application to Water NSW to change the nominated works to miscellaneous work number 90MW833064.

[5] Pending approval of application to Water NSW to change the nominated works to miscellaneous work number 90MW833068 (currently 90WA822539).

1.4.2 Statutory approvals

Project Approval

This Plan has been developed in accordance with Schedule 3 Condition 4 of the Project Approval which requires NCOPL to prepare an Extraction Plan for all second workings within the area of the Approved Mine Plan (Appendix H to EP 203-206) to the satisfaction of the Secretary.

In accordance with Schedule 4 Condition 4(h), the Extraction Plan must include a Water Management Plan that has been prepared in consultation with the Environment Protection Authority (**EPA**) and the Water Group within the NSW Department of Climate Change, Energy, the Environment and Water (**DCCEEW Water Group**), which provides for the management of potential environmental consequences of the proposed second workings on watercourses and aquifers.

Schedule 3 Condition 4(b) of the Project Approval requires the Extraction Plan and its sub plans to be approved by the Secretary prior to NCOPL carrying out any of the second workings covered by EP 203-206.

The EP-WMP must include detailed performance indicators for each relevant performance measure conditioned under Schedule 3 Condition 1. In accordance with Schedule 3 Condition 1, NCOPL must ensure that the development does not cause any exceedances of the performance measures detailed in Table 1-2.

Project Approval Schedule 6 Condition 2 lists the requirements for the preparation of management plans which must be prepared in accordance with any relevant guidelines and include details of the relevant approval, licence or lease conditions. Attachment 1, Table A1-1 provides a summary of the Project Approval conditions relevant to this Plan and outlines the section of the EP-WMP in which each of these conditions have been addressed. Table A1-2 provides the relevant Statement of Commitments (**SoCs**) and a cross reference table to where these commitments have been addressed.

Table 1-2 Subsidence impact performance measures

Feature	Performance Measures
Water Resources	
Great Artesian Basin	The Proponent shall ensure that, within 5 years of the date of this approval, any loss of water flow into the Great Artesian Basin aquifers (equal to the maximum predicted impact, or the measured impact of the project, whichever is the greater), is managed, licensed or offset (including the possibility of injection of raffinate) to the satisfaction of DPIE Water.
Biodiversity	
Flora and Fauna	The Proponent shall ensure that clearing and disturbance of vegetation above the mining area is minimised, to the satisfaction of the Secretary.

Environment protection licence

NCOPL is the holder of EPL 12789, which includes conditions relating to surface water, groundwater, erosion and sediment control and associated water management infrastructure.

EPBC Act Approval

The Narrabri Mine was granted EPBC 2009/5003 in 2011 issued under the EPBC Act (last varied on 24 March 2021).

EPBC 2009/5003 prescribes conditions to minimise potential impacts on EPBC Act listed threatened species and communities within the mine site. Condition 3 of EPBC 2009/5003 states that in order to minimise potential impacts on EPBC Act listed threatened species and communities within the mine site, prior to any Works commencing and in accordance with the NSW Director General's Assessment Report and approval conditions (26 July 2010), the person undertaking the action must develop and implement an Extraction Plan.

Mining lease

NCOPL are the holder of ML 1609 (issued in January 2008 and varied 19 August 2022).

1.5 Risk assessment

A subsidence risk assessment has been undertaken to identify the risks associated with subsidence at the Narrabri Mine. It builds on previous risk assessments completed for LW 101 to LW 110 and Panels 201 to 202 and is presented as Appendix I to EP 203-206. The updated risk assessment for LW 203 to LW 206 assessed all risks identified within the Extraction Plan Area as either low or moderate.

The potential environmental impacts and consequences relevant to surface water and groundwater management are further discussed in section 3 and section 5.

1.6 Preparation and consultation

Consultation with the EPA and the DCCEEW Water Group (formerly DPE Water) was undertaken for the preparation of this EP-WMP in accordance with Schedule 3 Condition 4(h) of the Project Approval. The draft EP-WMP (Revision A) was provided to the EPA and DPE Water on 8 November 2022. Attachment 2 provides evidence of the consultation process, including a cross reference table addressing the comments received, and detailing the section of the Plan where these comments have been addressed (Table A2-1).

The EP 203-206 (Revision 0) was submitted to DPE for approval on 13 February 2023. NCOPL received post submission recommendations from the Independent Expert Advisory Panel for Mining (IEAPM [formerly IAPUM]) on 14 February 2023 and 30 March 2023 and from DPE Water on 30 March 2023, 7 September 2023 and 17 November 2023.

Due to the timeframe required for NCOPL to adequately respond to the post submission recommendations from IEAPM and DPE Water, and to prevent a discontinuation of mining, NCOPL submitted a request to obtain progressive approval in accordance with Schedule 2 Condition 11 of the Project Approval. NCOPL received progressive approval from DPE on 7 May 2023 to continue mining in LW 203 only subject to conditions.

Revision 0B of EP-WMP has been revised in accordance with Condition 6 of the progressive approval to consolidate responses to IEAPM and DPE Water (now DCCEEW Water Group) recommendations.

Revision 0C (this Plan) has been revised in accordance with further commentary from IEAPM and DCCEEW Water Group.

Attachment 4 of the EP 203-206 provides cross referencing tables detailing the section of the EP 203-206 or it's sub-plans where each of IEAPM and DCCEEW Water Group recommendations have been addressed.

1.7 Access to information

In accordance with Schedule 6 Condition 10 of the Project Approval, the approved Extraction Plan and all appendices, audits and reports, and summaries of all monitoring data (where relevant) will be made publicly available on the WHC website. All information will be kept up to date.

Note that any printed copies of this EP-WMP are uncontrolled.

2. Baseline surface water and groundwater data

2.1 Surface water

2.1.1 Surface water resources

LW 203 to LW 206 are primarily located in the Kurrajong Creek catchment which is a sub-catchment of the Namoi River as shown in Figure 2-1. The Namoi River flows in a north-westerly direction and is located approximately 5 km north and east of the Extraction Plan Area.

The headwaters of Kurrajong Creek and Kurrajong Creek Tributary 1 rise in the Pilliga East State Forest to the west of the Extraction Plan Area. The watercourses travel north-east towards the Namoi River, converging downstream of the Narrabri Mine Pit Top. Kurrajong Creek discharges to Tulla Mullen Creek, a tributary of the Namoi River, approximately 5 km downstream (north-east) of the Narrabri Mine Pit Top.

Kurrajong Creek traverses the southern boundary of LW 203 and is a third order stream[3] within the vicinity of LW 203 to LW 206. The Kurrajong Creek catchment area to the eastern extent of LW 203 is approximately 21.9 km^2. Kurrajong Creek Tributary 1, a third order stream, flows south-west to north-east above LW 203 to LW 206. The catchment area of Kurrajong Creek Tributary 1 to the eastern extent of the Extraction Plan Area is approximately 12.6 km^2.

Kurrajong Creek has an average gradient of 1.2 % to the eastern extent of LW 203 while Kurrajong Creek Tributary 1 has an average gradient of 0.97 %.

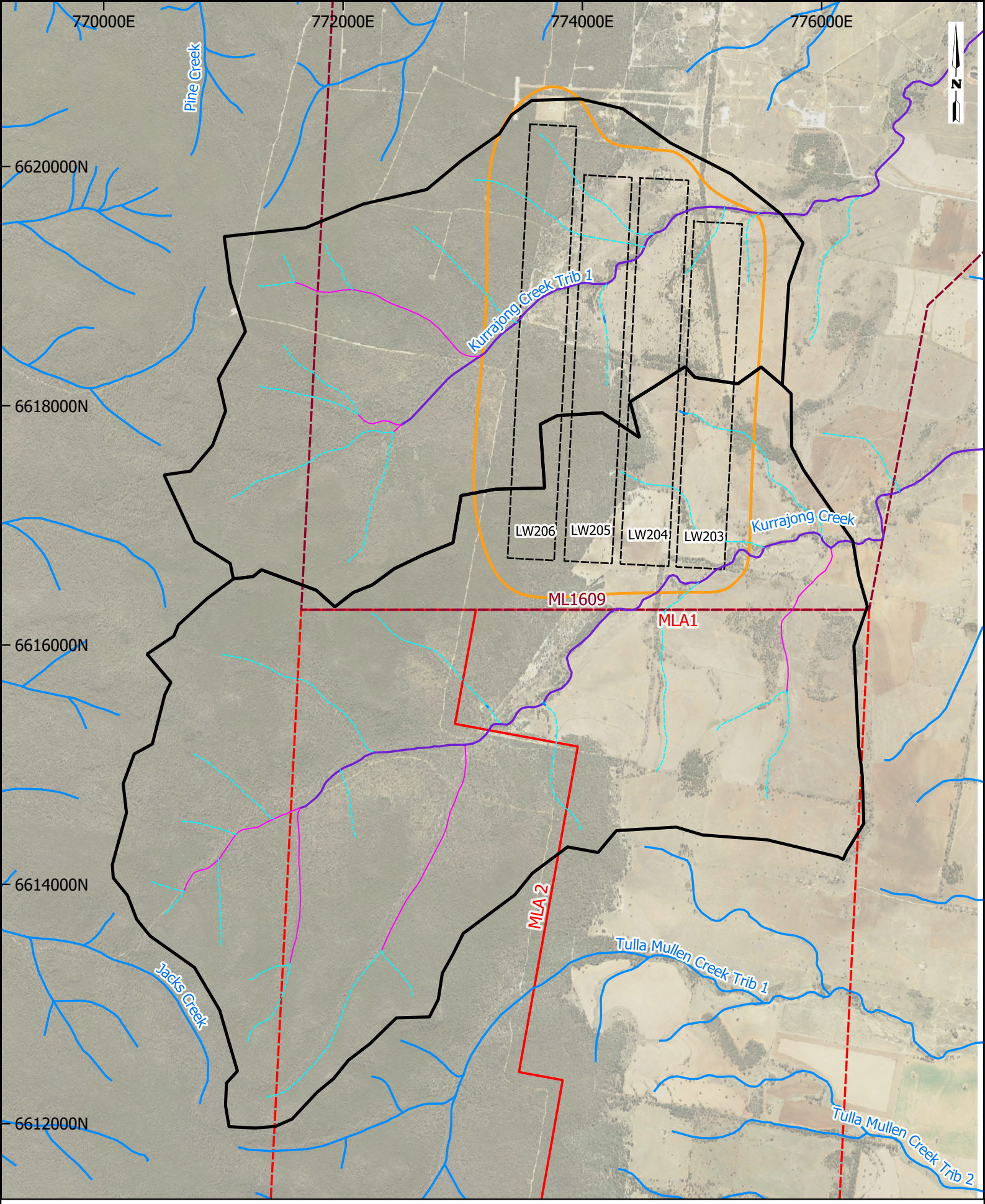
Kurrajong Creek is ill-defined to the downstream boundary of LW 203, consisting of a broad flow path with minor low flow channel. The bed material is comprised of sandy loam with scattered dryland vegetation. Immediately downstream of the eastern extent of LW 203, the watercourse is comprised of a broad flow path with no evident low flow channel. The bed material consists of sandy loam with intermittent sand deposition. Scouring was evident on some outside bends of the watercourse in this reach (WRM, 2020).

A four metre (**m**) high headcut is located downstream of the eastern extent of LW 203, separating the downstream incised channel and the upstream ill-defined channel. The headcut is the result of historical headwater erosion of the channel bed rather than a result of Narrabri Mine activities and will likely to progress further upstream with successive flood events unless otherwise appropriately managed (WRM, 2020).

Downstream of the headcut, Kurrajong Creek is incised with a channel width of approximately 10 m wide and vertical banks approximately 0.8 m deep. The bed material in this reach consists of coarse sand with no in-stream vegetation (WRM, 2020).

Several minor (first and second order) watercourses drain to Kurrajong Creek and Kurrajong Creek Tributary 1 (Figure 2-1). These watercourses are generally steeper than the main channel of Kurrajong Creek and drain as broad overland flow or broad v-shaped valleys with no incised channel. Contour banks have been constructed at a number of these minor watercourses to minimise surface erosion and to direct rainfall runoff to agricultural farm dams (WRM, 2020).

[3] Strahler stream order classification scheme (Strahler, 1952).



LEGEND

- LW203-206 (Proposed)
- Extraction Plan Area
- First Order Stream
- Second Order Stream
- Third Order Stream
- Minor Watercourse
- Catchment Boundary
- Mining Lease
- Mining Lease Application

FIGURE 2-1: Extraction Plan Area surface water resources

ATC WILLIAMS

0 500 1000 1500 2000

Metres

CRS: GDA94 / MGA Zone 55
Aerial: Google 2018

File: Synergy\116100\06\Data and Calcs\Baseplan_116100-06.qgz

2.1.2 Surface water flows

Based on the period of monitoring and the number of event-based samples collected during this period, the percentage of time for which there was ponded water and/or surface water flow at each monitoring site shown in Figure 2-2 has been estimated. It is noted that other factors may have prohibited event-based sampling i.e., access restrictions. As such, the number of samples collected may not accurately represent the number of flow events during the monitoring period. Table 2-1 presents the period of monitoring, number of sampling events and estimated frequency of ponded water and/or surface water flow over the period of monitoring at each site.

Table 2-1 Frequency of ponded/flowing water

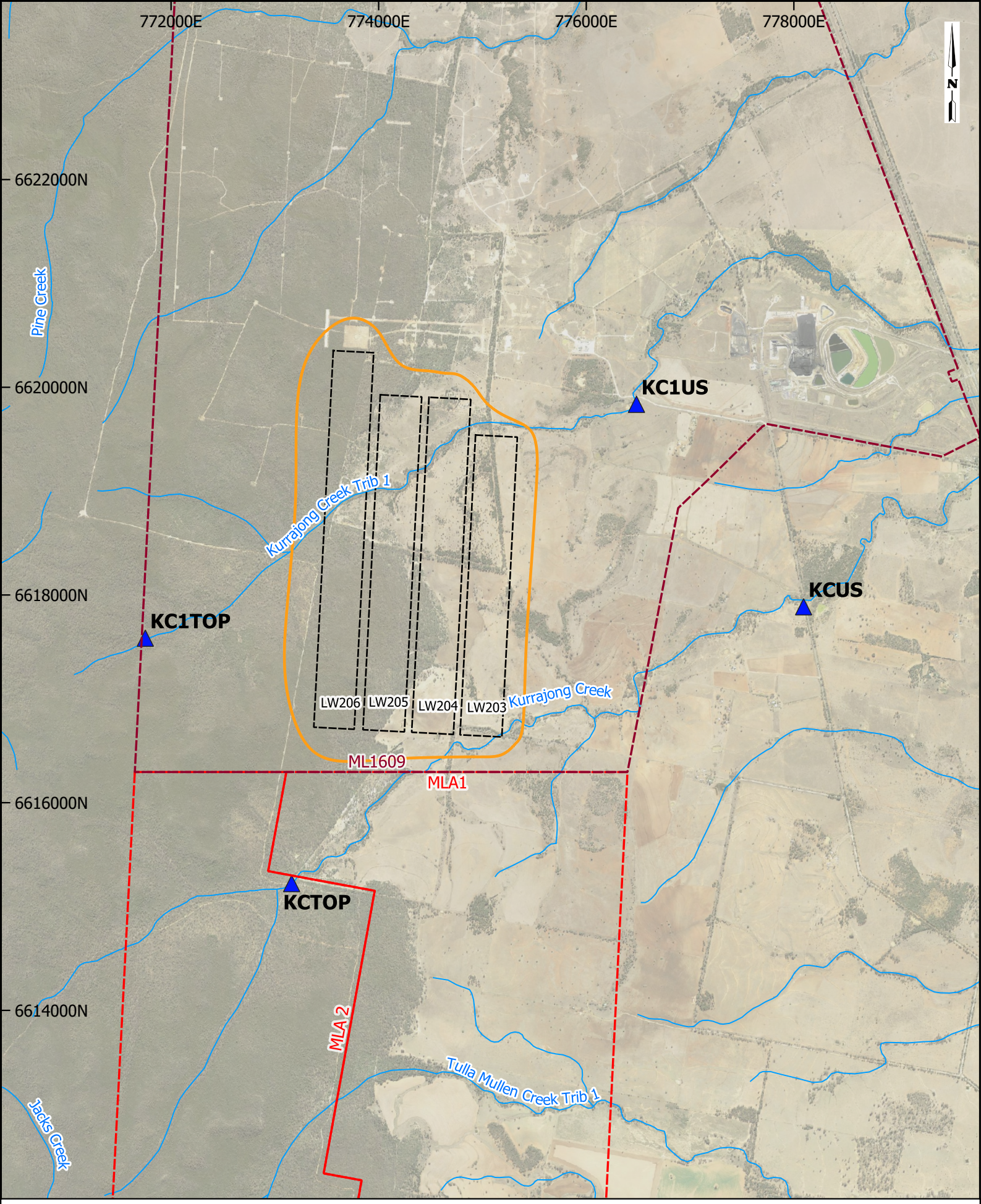
Watercourse	Site	Monitoring period (No. of days)	Number of days samples collected	Frequency of days with ponded/flowing water
Kurrajong Creek	KCTOP	1,625	0	0%
	KCUS	5,246	63	1.2%
Kurrajong Creek Tributary 1	KC1TOP	5,246	0	0%
	KC1US	5,246	41	0.8%

The data presented in Table 2-1 indicates that the watercourses within and adjacent to the Extraction Plan Area are highly ephemeral, particularly at headwater sites. Ponded and/or flowing water was present at downstream monitoring sites on Kurrajong Creek and Kurrajong Creek Tributary 1 approximately 1.2% and 0.8% of sampling occasions respectively over the duration of monitoring.

2.1.3 Surface water quality

Baseline surface water quality monitoring has been undertaken by NCOPL at sites within and adjacent to the Extraction Plan Area since July 2007. The locations of the monitoring sites relevant to the Extraction Plan Area are shown in Figure 2-2.

To provide an indication of baseline water quality conditions within and adjacent to the Extraction Plan Area, water quality data for the period of record has been compared to the ANZECC & ARMCANZ (2000) and ANZG (2018) default trigger guidelines for the protection of aquatic ecosystems, consistent with the Namoi River catchment water quality objectives (NSW Government, 2006). Additionally, the Namoi River catchment water quality objectives for visual amenity have been considered. The default guideline values and water quality objectives are summarised in Table 2-2.



LEGEND

- LW203-206 (Proposed)
- Mining Lease
- Mining Lease Application
- Extraction Plan Area
- Watercourse
- Water Quality Monitoring Site

FIGURE 2-2: Surface water quality monitoring sites

ATC WILLIAMS

0 500 1000 1500 2000

Metres

CRS: GDA94 / MGA Zone 55
Aerial: Google 2018

File: Synergy\116100\06\Data and Calcs\Baseplan_116100-06.qgz

Table 2-2 Kurrajong Creek (KCUS) water quality default values and objectives

Parameter	ANZECC & ARMCANZ (2000) and ANZG (2018) Default Guideline Values		Namoi River Catchment Water Quality Objectives (NSW Government, 2006)
	Aquatic Ecosystems (95%ile level of species protection)	Upland Rivers (NSW)	Visual amenity
pH (pH units)	-	6.5 - 8	-
EC (µS/cm)	-	350	-
TSS (mg/L)	-	-	-
Grease and Oil (mg/L)	-	-	Oils and petrochemicals will not be noticeable as a visible film on the water, nor will they be detectable by odour.
TOC (mg/L)	-	-	-

Table 2-3 and Table 2-4 present a summary of the water quality monitoring data recorded at KCUS in Kurrajong Creek and KC1US in Kurrajong Creek Tributary 1.

Where default guideline values for aquatic ecosystems and/or upland rivers were available, the monitoring results were compared with these default guideline values, and the percentage of exceedances reported.

Table 2-3 Kurrajong Creek (KCUS) water quality summary

Parameter (mg/L unless otherwise stated))	Default guideline value	KCUS*				Exceedances %
		No. of samples	Min	Median	Max	
pH	6.5 - 8.0	84	6.59	7.36	8.18	2%
EC (µS/cm)	350	84	33	208	1,280	29%
TSS	-	84	2	93	2,180	-
Grease & Oil	-	82	<2	<5	27	-
TOC	-	81	5	11	23	-

**July 2007 to December 2024*

Table 2-4 Kurrajong Creek Tributary 1 (KC1US) water quality summary

Parameter (mg/L unless otherwise stated)	Default guideline value	KC1US*				Exceedances %
		No. of samples	Min	Median	Max	
pH	6.5 - 8.0	53	6.7	7.35	8.27	6%
EC (µS/cm)	350	53	54	109	1,300	2%
TSS	-	53	8	71	2,760	-
Grease & Oil	-	51	<2	<5	12	-
TOC	-	51	5	11	21	-

**July 2007 to December 2024*

The data presented in Table 2-3 and Table 2-4 show that the default guideline values for pH and EC are, at times, naturally exceeded at monitoring sites KCUS and KC1US in Kurrajong Creek and Kurrajong Creek Tributary 1 respectively. Site specific guideline values (**SSGVs**) have been derived for KCUS and KC1US as detailed in section 6.1.2.

2.1.4 Other water users

A total of 17 farm dams used for livestock watering are located within or directly adjacent to the Extraction Plan Area (DGS, 2022). The farm dams are mostly less than 1 ML in capacity and have not been declared as dams under the Dams Safety Act (WRM, 2020).

2.2 Groundwater

2.2.1 Groundwater regime

The Narrabri Mine is located within the Mullaley Sub-basin, which forms part of the larger Gunnedah Basin. The western half of the mining lease is also located on the eastern margin of the Surat Basin[4]. In general, the Surat and Gunnedah Basin stratigraphic units are characterised by a dip to the west at an angle of less than 10 degrees and outcrops along the Namoi River valley.

The main stratigraphic units occurring in the vicinity of the Narrabri Mine are the:

- Gunnedah Basin Units inclusive of:
  - the Napperby Formation and Digby Formations of Triassic age; and
  - Permian coal measures within the Black Jack Group, including the Hoskissons Coal Seam, Arkarula Formation and Pamboola Formations (which are locally characterised by an east [shallowest] to west [deepest] dip).
- Surat Basin Units of Jurassic age, which include the Pilliga Sandstone, Purlawaugh Formation and Garrawilla Volcanics; and
- Quaternary alluvium which consists of unconsolidated clays, silts, sands and gravels associated with the Namoi River and its associated tributaries.

Of the units listed above, only the Namoi River alluvium and Pilliga Sandstone are considered regionally significant aquifers ("highly productive" under the Aquifer Interference Policy [**AIP**][5]). The Namoi River alluvium is present at outcrop approximately 5.5 km east of the Extraction Plan Area and not present within the Extraction Plan Area. Whilst the remaining units may support minor extractions for stock and domestic purposes, they are relatively low-yielding aquifers ("less productive" unit under the AIP). A conceptual

[4] The Surat Basin of northern New South Wales is part of the Great Artesian Basin, a large Jurassic–Cretaceous intra-cratonic basin that covers 1.7 million km^2 of eastern Australia. In NSW, the Surat Basin covers an area of 270 000 km^2 and has a maximum thickness of approximately 1.8 km in northern NSW. The basin unconformably overlies the early to late Palaeozoic Lachlan Orogen in the western to central part of the basin, and in the east overlies the Permian to Triassic Sydney–Gunnedah–Bowen Basin system.

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

- has a total dissolved solids (**TDS**) concentration less than 1,500 milligrams per litre (mg/L); and
- contains water supply works that can yield water at a rate greater than 5 litres per second (L/s).

geological cross-section showing the main stratigraphic units occurring in the vicinity of the mine is provided in Figure 2-3.

Only the Pilliga Sandstone, Purlawaugh Formation and occasionally the Garrawilla Volcanics outcrop or sub-outcrop above the Extraction Plan Area (i.e. LW 203-206).

2.2.2 Groundwater levels

NCOPL has historically undertaken monitoring of groundwater levels in the Namoi Alluvium, Pilliga Sandstone, Purlawaugh Formation, Garrawilla Volcanics, Napperby Formation, Digby Formation, Hoskissons Coal Seam, Arkarula Formation, Pamboola Formation and various older units.

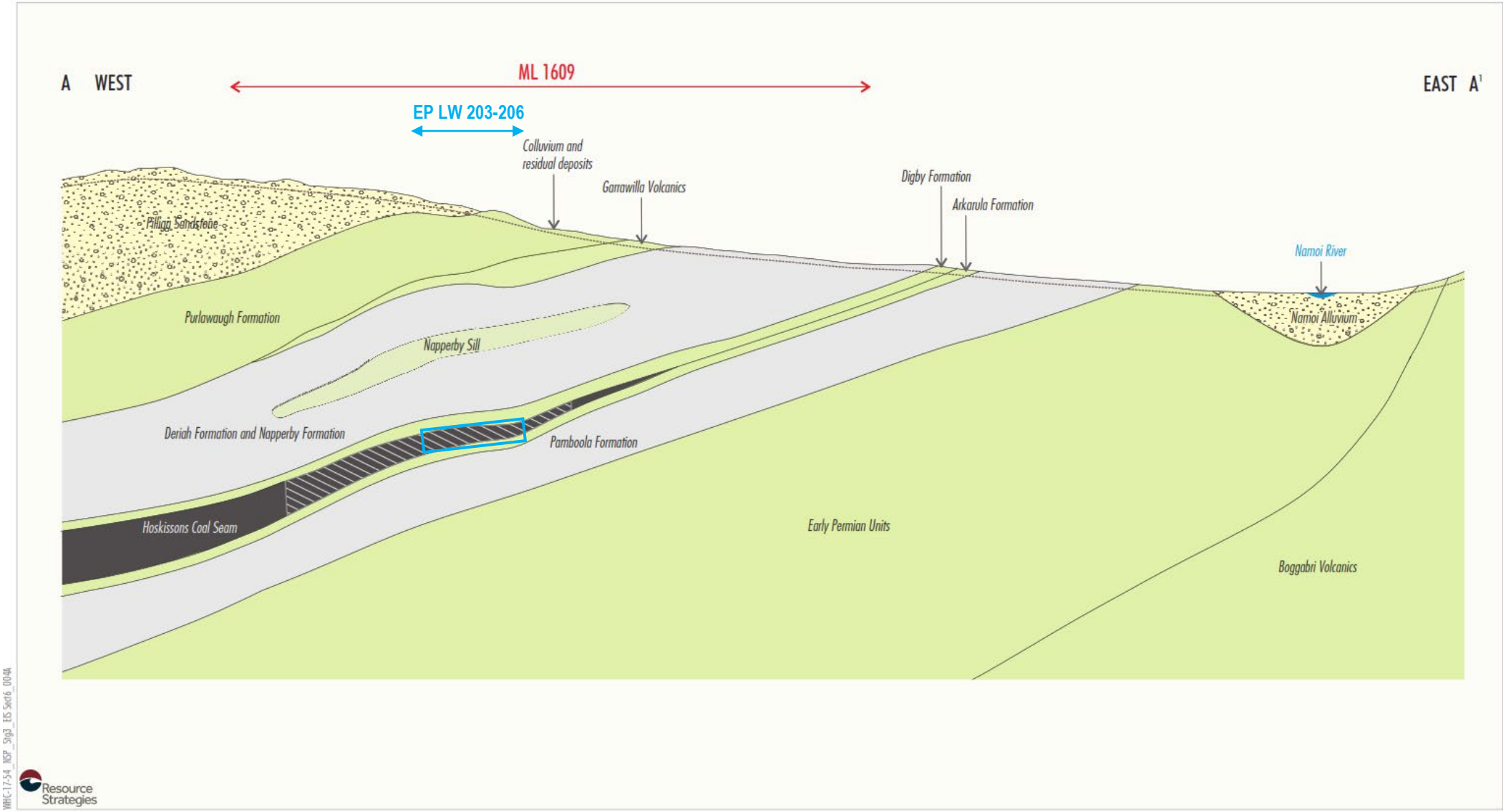
Regional groundwater level contours for the Namoi Alluvium indicate that groundwater flows generally south to north along the Namoi River, consistent with topography and flow direction of the river. Intensive groundwater use for irrigation results in seasonal water table drawdown in excess of 15 m in areas of the Namoi Alluvium.

Regional groundwater flow directions in the Pilliga Sandstone are towards the north-west, show little or no temporal variation, and do not appear to be affected by climate, Narrabri Mine dewatering and other extraction.

Deeper units show varying levels of response to the Narrabri Mine operations, from little or no response in the Purlawaugh Formation, to substantial depressurisation in the Hoskissons Coal Seam, as should be expected given the nature of mining operations.

Recharge to the hydrostratigraphic units occurs through diffuse rainfall recharge and limited seepage through the non-perennial Kurrajong Creek and its tributaries when flowing. No aquifer discharge occurs above the Extraction Plan Area related to baseflow since groundwater levels are generally deep and well below the non-perennial tributaries associated with the Extraction Plan Area. Accordingly, no alluvium is present along these creeks and are either entirely disconnected (or possibly only very occasionally connected) to the Namoi Alluvium.

No high priority GDEs occur within ML 1609 as described in the Stage 3 Groundwater Impact Assessment (AGE, 2020a). The Mayfield Spring (a potential groundwater feature) occurs approximately 1 km south of the Extraction Plan Area.



Source: AGE (2020)

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FIGURE 2-3
Conceptual Geological Cross-Section and Approximate Extraction Plan Area

2.2.3 Groundwater quality

Both the Namoi Alluvium and the Pilliga Sandstone are characterised by relatively low salinity and variability. The median electrical conductivity (**EC**) for both aquifers is less than 700 microSiemens per centimetre (**µS/cm**), suggesting the water is relatively fresh.

The Garrawilla Volcanics has an EC of approximately 2,630 µS/cm, suggesting brackish to moderately saline groundwater. In addition, median EC values for the Purlawaugh and Napperby Formations suggest moderately saline conditions on average but show a high degree of variability and relatively fresh water in some cases, suggesting that potentially useful freshwater aquifers can be encountered within these formations.

Data for the Hoskissons Coal Seam suggest moderately saline conditions based on the median EC value of 6,180 µS/cm, whilst data for the two deepest units monitored within the mining lease, the Arkarula and Pamboola Formations, suggest median EC values in excess of 15,000 µS/cm. The relatively high salinity values recorded in samples taken from the Arkarula Formation may reflect the depth of this unit and the lack of any known outcrop areas. Residence times with the strata may therefore be substantial resulting in relatively high salinity groundwater.

Table 2-5 provides a summary of the field EC data by hydrostatic unit.

Table 2-5 Summary statistics, field EC data by hydrostratigraphic unit

Formation	No. bores	No. tests	Field EC (µS/cm)					
			Mean	Min	25%	50%	75%	Max
Alluvium	9	92	2,292	597	704	853	5,860	7,050
Pilliga Sandstone	4	93	1,410	129	256	393	2,900	5,440
Purlawaugh Formation	4	181	8,343	293	674	4,880	18,960	34,900
Garrawilla Volcanics	9	360	4,606	274	1379	2,630	4,158	20,200
Napperby Formation	9	438	9,632	1,020	3,083	7,040	17,628	33,100
Hoskissons Coal Seam	1	5	5,580	1,410	4,070	6,180	7,490	8,750
Arkarula Formation	1	15	19,230	1,140	15,915	23,770	25,015	25,420
Pamboola Formation	3	174	14,785	1,050	3,468	17,175	25,025	27,340

2.2.4 Groundwater yields

The Narrabri Hydrogeological Sheet (1:250 000) (NSW Water Resources Commission) indicates that the site is mapped primarily as Jurassic sediments (Purlawaugh Formation), which are rarely considered as aquifers and have yields generally less than 0.5 Litres per second (L/s). This map also identifies a small area in the south-east portion of ML 1609 as part of the Gunnedah Basin sequence, with low yields similar to the Purlawaugh Formation. The geological unit in the Narrabri area with the highest potential yields is the Garrawilla Volcanics of the *NSW GAB Groundwater Sources Southern Recharge Groundwater Source*. However, this formation is not regionally extensive and not considered a highly productive groundwater source.

2.2.5 Groundwater use

There are more than 2,200 bores in the regional context, comprising approximately 1,500 water supply bores and approximately 700 bores drilled for non-water supply purposes (e.g. monitoring, exploration or dewatering). Registered water supply bores in the broader region are located predominantly within the Namoi alluvium and include a number of bores used for irrigation purposes that tap into the 'highly productive' Namoi Alluvium aquifer.

Closer to the site, however, groundwater use is less prevalent and less intensive. Privately-owned registered water supply bores in the immediate vicinity of the mine are predominantly used for stock and domestic purposes, which reflects the lack of highly productive formations immediately to the east (outside the extent of Namoi alluvium), and lack of development to the west (i.e. within the Pilliga East State Forest).

Groundwater is also extracted from NCOPL's existing alluvial bore located adjacent to the Namoi River when required (e.g. when supply from the underground mining area is insufficient to meet water demands, and sufficient allocation from the Namoi River [i.e. utilising NCOPL's existing Namoi River pump] is unavailable).

The existing alluvial bore is located within the Upper Namoi Zone 5 groundwater source (within the *WSP for the Namoi Alluvial Groundwater Sources 2012*), and water is extracted in accordance with the relevant Water Access Licence (**WAL**) (Table 1-1) held by NCOPL and the rules prescribed in the WSP.

3. Subsidence impacts and potential environmental consequences

3.1 Subsidence predictions

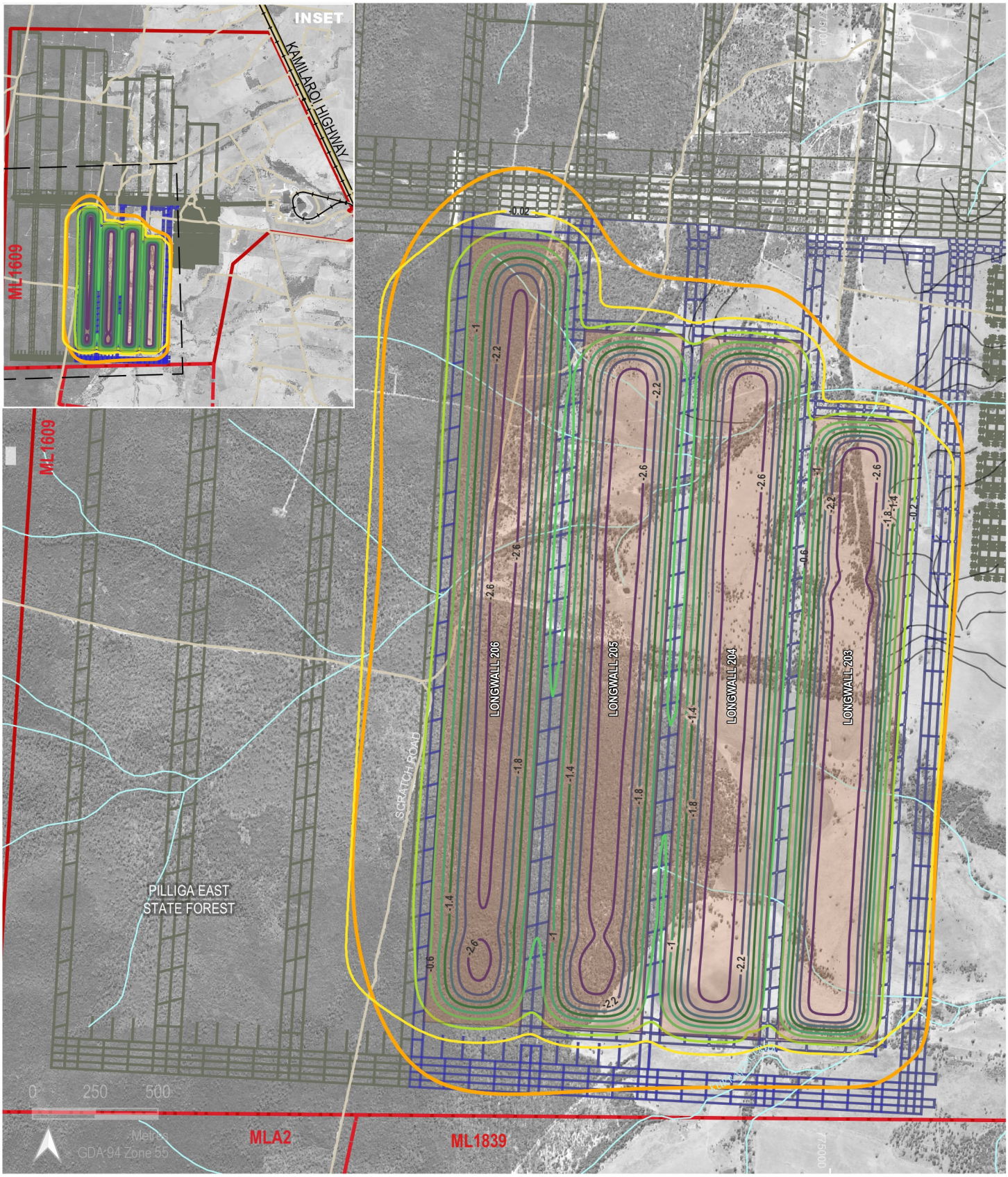
Subsidence predictions for the Extraction Plan Area were assessed and are presented in the Mine Subsidence Assessment Report. The Mine Subsidence Assessment Report details the potential impacts to natural, man-made and Aboriginal heritage features within the Extraction Plan Area based on the predictions of conventional and non-conventional subsidence. The predictions include a review of the subsidence effects measured above previously mined LW 101 to LW 109.

The predicted maximum subsidence estimates for the Extraction Plan Area are summarised in Table 3-1 and shown on Figure 3-1.

Table 3-1 Maximum final subsidence effect predictions

LW	Cover depth (m)	Subsidence (m)	Tilt (mm/m)	Tensile strain (mm/m)	Compressive strain (mm/m)
203	200-208	2.63 - 2.80	34 - 54	15 - 32	16 - 35
204	230-242	2.72 - 2.80	29 - 47	11 - 26	12 - 27
205	248-282	2.75 - 2.80	24 - 39	9 - 19	9 - 21
206	280-311	2.75 - 2.80	20 - 33	7 - 15	7 - 16

Source: adapted from Table 4 (DGS, 2021)



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LEGEND

- ML1609
- ML1839
- MLA2
- Underground mining layout
- Longwalls 203 to 206
- Proposed longwall voids (LW203-206)
- 45 degree angle of draw
- Roads
- Watercourse
- Contour bank

Subsidence contours (m)

- -0.02
- -0.2
- -0.6
- -1
- -1.4
- -1.8
- -2.2
- -2.6

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FIGURE 3-1

Predicted Subsidence Contours
for LW 203 to LW 206

3.1.1 Subsidence cracking

Based on the predicted range of maximum transverse tensile strains for the proposed longwall panels (i.e. 7 mm/m to 32 mm/m), surface crack widths are estimated to range from approximately 210 millimetres (**mm**) to 330 mm in cohesionless soils and from approximately 420 mm to 650 mm in cohesive soils or shallow rock (Table 3-2). Cracks usually develop within several days after a longwall face has retreated beneath a given location, with some of the cracks closing in the compression zone in the middle of the fully developed subsidence trough, together with new cracks developing in the tensile zones along and inside the panel sides approximately two to three weeks later.

Surface crack widths are upper 95% confidence level (**U95%CL**) values (to the nearest 10 mm), which means they may be exceeded 5% of the time (by definition) due to adverse topographic or geological conditions. Whilst this effect is unlikely to occur above LW 203 to LW 206 generally, crack widths may exceed the predicted range near the crests of steep creek banks or elevated ridges. The steep rocky slopes above LW 204 and LW 205 are considered likely to be impacted by surface cracking more than 300 mm wide. Based on the above, it is estimated that approximately 0.02 km^2 to 0.04 km^2 of the surface will be crack affected. This represents 0.13% to 0.27% of the extracted longwall area.

Based on reference to the Australian Coal Industry's Research Program (2003), surface cracks will likely develop by the time the longwall face has retreated past a given location for a distance equal to one to two times the cover depth (i.e. ranging from 170 m to 840 m, based on cover depths at the Narrabri Mine).

Table 3-2 Predicted maximum crack width in flat terrain

LW	Cross section cross-line (XL)	Panel width [W] (m)	Cover depth [H] (m)	Panel W/H	Effective bay length* (m)	Predicted maximum tensile strain (mm/m)		Predicted U95%CL crack width (mm)	
						Mean	U95%	Sand or Loam	Clay or Rock
203	6	402.8	208	1.94	10.4	15	29	300	600
	7	402.8	200	2.01	10.0	15	31	310	620
	8	402.8	204	1.97	10.2	16	32	330	650
204	6	402.8	232	1.74	11.6	12	24	280	560
	7	402.8	242	1.66	12.1	11	23	280	560
	8	402.8	230	1.75	11.5	13	26	300	600
205	6	399.7	248	1.61	12.4	10	20	250	500
	7	399.7	282	1.42	14.1	9	17	240	480
	8	399.7	275	1.45	13.8	9	19	260	520
206	6	395.3	280	1.41	14.0	8	15	210	420
	7	395.3	311	1.27	15.6	7	14	220	440
	8	395.3	304	1.3	15.2	8	15	230	460

Source: DGS, 2022 (Table 7)
* - max (H/20, 10m)

3.1.2 Ponding

The Mine Subsidence Assessment Report predicts a maximum panel subsidence of up to 2.8 m, which may result in closed form depressions forming in some of the central areas of the longwall panels with flatter surface gradients and disrupt natural drainage pathways to watercourses and farm dams. Analysis of the pre- and post-mining surface levels suggests that ponding (if it occurs) is likely to develop along Kurrajong Creek and its tributaries.

A total of six potential ponding locations have been assessed within the Extraction Plan Area. Five of the potential ponding areas already exist along the watercourses and dams. Existing (pre-mining) and post-mining pond depths are estimated to range from 0.1 m to 4.7 m. Pond depths are estimated to increase by up to 1.3 m or decrease by up to 0.04 m.

The maximum changes in pond area (where positive represents an increase in pond area) are estimated to range from -0.42 ha to 2.92 ha. The maximum changes in pond volume (where positive represents an increase in pond volume) are estimated to range from -0.23 megalitres (**ML**) to 20.6 ML[6]. The largest ponding increases are estimated over LW 203 and LW 205.

Overall, the existing ponds are expected to extend laterally from the watercourses for distances ranging from 50 m to 410 m. Existing ponded areas extend up to 270 m, indicating a potential lateral increase of up to 140 m.

3.2 Predicted subsidence impacts on water resources

3.2.1 Surface water flows

River flow objectives

The Kurrajong Creek and Kurrajong Creek Tributary 1 are classified as uncontrolled streams of the Namoi River catchment (NSW Government, 2006). The NSW Government (2006) defines uncontrolled streams as largely natural and typically ephemeral. The River Flow Objectives for uncontrolled streams in the Namoi River catchment (NSW Government, 2006), which are applicable to watercourses within and adjacent to LW203-206, are to:

- protect pools in dry times;
- protect natural low flows;
- maintain natural rates of change in water levels;
- maintain wetland and floodplain inundation;
- maintain natural flow variability; and
- manage groundwater for ecosystems.

These objectives have been considered in the development of the Trigger Action Response Plan (**TARP**) detailed in section 7. The TARP has been designed to assess performance against the prescribed watercourse performance measures for Kurrajong Creek and Kurrajong Creek Tributary 1.

[6] The actual ponding depths, areas and volumes will also depend upon several other factors, such as rain duration, surface cracking and effective percolation rates of the surface soils along the creeks/drainage lines.

Potential impacts on streamflow due to surface cracking

The watercourses within the Extraction Plan Area are ephemeral and are likely to only flow during periods of high or extended rainfall. During high rainfall periods, the majority of surface water runoff will flow as streamflow within the watercourse, with negligible flow diverted to the underlying strata. During periods of low flow, a portion of surface water flow is expected to be diverted to the underlying strata. However, given the highly ephemeral nature of the watercourses, low flow periods are expected to be rare. As such, redirection of surface flow within the Extraction Plan Area is expected to have negligible effect on local watercourses and is unlikely to have discernible impacts on catchment-wide surface water resources and ecosystems.

Cracking of a watercourse bed will likely result in redirection of surface flow to the underlying strata. Where surface flow is diverted to the subsurface fracture network, there is potential that the redirected flow will re-emerge further downstream of the longwall panels. Fracturing within the Extraction Plan Area is expected to be discontinuous and unlikely to result in direct hydraulic connection to the underground mine workings. Additionally, there is potential that, following major flow events, cracks in watercourses with cohesionless bed material (i.e., sand) may self-seal due to sediment deposition (DGS, 2022).

The maximum annual volume of surface water take due to subsidence related surface cracks across the southern longwall panels (200 series) has been estimated to be 4.2 ML from all watercourses (i.e. 3.5 ML for the first and second order watercourses and 0.7 ML for the third order watercourses [WRM, 2023]).

A monitoring method has been developed to calculate the actual annual take for the purpose of complying with water licensing requirements (section 6.1.3).

Potential impacts on streamflow due to groundwater drawdown and baseflow reduction

Baseflow contribution to the watercourses within the Extraction Plan Area has not been observed. Given the highly ephemeral nature of the watercourses, it is expected that baseflow contribution will be negligible.

Additionally, the groundwater model (AGE, 2024) predicts a negligible impact to baseflow in the Namoi River and associated tributaries due to mining. As such, groundwater drawdown associated with mining of LW 203 to LW 206 is not expected to result in an impact to surface water flow within the Extraction Plan Area.

3.2.2 Overland flow, ponding and flooding

The predicted maximum panel subsidence of up to 2.8 m may result in notable depressions forming in areas of naturally low gradients. These depressions are likely to result in a reduction in overland flow to downstream watercourses and farm dams. Where surface depressions naturally exist along Kurrajong Creek and Kurrajong Creek Tributary 1, there is potential for increased ponding and further reduction in streamflow to downstream reaches.

DGS (2022) identified 5 existing (P13, P14.1, P14.2, P14.3, P15) and 1 potential (P16) ponding locations within and adjacent to Kurrajong Creek Tributary 1. These ponds have the potential to increase in dimension as a result of subsidence, further disrupting flows to natural drainage channels and/or dams located downstream. Existing and post-mining pond depths are estimated to range from 0.1 to 4.7 m. The maximum changes in pond area (where positive represents an increase in pond area) are estimated to range from -0.42 ha to 2.92 ha. The changes in pond volume (where positive represents an increase in pond volume) are estimated to range from -0.23 to 20.6 ML.

It is noted that the ponded areas are expected to accumulate sediment over time thereby reducing, to some extent, impacts to overland flow (DGS, 2022).

While subsidence associated with mining of LW 203 to LW 206 may result in localised areas of increased ponding, due to the ephemeral nature of the watercourses it is unlikely to result in significant changes to flooding in the Extraction Plan Area.

Water captured in the in-stream surface depressions associated with subsidence is not considered to be a take of water, as the ponded water remains in-stream. This position was accepted by DPE Water (now DCCEEW Water Group) in an extraction plan technical matters meeting chaired by the DPE on 29 June 2023.

3.2.3 Farm dams and contour banks

There are 17 farm dams used for livestock watering located within or directly adjacent to the Extraction Plan Area. The farm dams are predicted to be impacted by tensile and compressive strains ranging from 3 mm/m to 20 mm/m (DGS, 2022). Based on the predicted phases of tensile and compressive strain development, the Mine Subsidence Assessment Report estimates that breaching of the dam walls or water storage areas may occur. For all farm dams located within the Extraction Plan Area, a loss or increase of water storage area may occur as a result of the predicted mining-induced tilt. The Mine Subsidence Assessment Report estimates that maximum tensile crack widths of 30 mm to 400 mm may occur within the base or walls of the farm dams.

A number of contour banks, constructed to manage overland flow and reduce erosion and sedimentation transport, are present in the Extraction Plan Area. The contour banks are typically constructed with low longitudinal gradients (i.e., less than 0.5 %). Based on the subsidence predictions associated with mining LW 203 to LW 206, impacts to contour banks may occur resulting in the contour banks no longer performing as designed. Where impacts to contour banks occur, there is potential for re-direction of overland flow, concentration of overland flow and increased erosion (WRM, 2020).

Where required, remediation of farm dams and contour banks will be undertaken by NCOPL as described in the Extraction Plan - Built Features Management Plan.

3.2.4 Slope instability and erosion

Based on the subsidence predictions associated with mining LW 203 to LW 206, differential ground movement and/or instability may occur resulting in an increase in the gradients of local watercourses and overbank areas. This may result in increased flow velocity and subsequently influence rates of erosion and sediment transport. The effects of differential ground movement or instability are most likely to be observed immediately downstream of the chain pillars. Where increased erosion and sediment transport occurs, there is potential that downstream landforms/geomorphology and surface water quality may be affected.

3.2.5 Surface water quality

Increased erosion due to subsidence effects has the potential to result in sediment transport and increased total suspended solids (**TSS**) and turbidity concentrations in downstream watercourses. Where increased ponding occurs as a result of subsidence, the ponded water that resides on or flows over saline soils may result in an increase in salinity concentrations in downstream watercourses.

Where surface cracking occurs, diverted flow may be conveyed via the dilated strata and remerge further downstream in the watercourse as surface flow. This may result in isolated, episodic increases in salinity and dissolved metals at locations in Kurrajong Creek and Kurrajong Creek Tributary 1 where flow re-emergence occurs.

3.2.6 Groundwater inflows

The predicted annual groundwater volumes (water take) for each water source over the life of mine are based on the most recent groundwater model re calibration (AGE, 2024) and are presented in Table 3-3. The peak mine inflow is predicted to be 1,252 ML/year occurring in the year 2030 (Table 3-3). The period of mining LW 203 to LW 206 is marked in bold in Table 3-3. It is important to note that the predicted inflows for this period represents the total predicted mine inflow to all panels, whilst the majority of this inflow will be to panels currently under production (i.e. LW 203 to LW 206) some inflow will also be derived from previously mined areas and pre-drainage of areas yet to be mined.

Details of the current groundwater allocations held by NCOPL are summarised in Table 1-1.

3.2.7 Groundwater impacts

The assessment of groundwater impacts for the approved mine plan (MOD 7) is primarily based on predictions from the groundwater model re-calibration (AGE, 2024) and predicted impacts as outlined in the Mine Subsidence Assessment Report.

The following impacts have been predicted in association with mining LW 203 to LW 206:

- connective cracking is estimated to range from 151 m to 257 m above panels LW 203 to LW 206, which equates to 64% to 87% of the overlying cover depth;
- direct hydraulic connection to the mine workings due to sub-surface fracturing is estimated to encroach within 27 m to 55 m depth below the surface, with the closest value occurring above the proposed LW 203;
- overall groundwater inflow predictions as presented in Table 3-3;
- drawdown at two privately owned stock and domestic bores;
- dewatering leading to drawdown in overlying strata above the LW 203 to LW 206 exacerbated by fracturing due to collapse into the goaf; and
- dewatering impacts will continue to develop in each of the “less productive” hydrostratigraphic units in which impacts have already been observed namely the Digby Formation, Napperby Formation, Garrawilla Volcanics and Purlawaugh Formation.

Table 3-3 Revised predicted annual groundwater take per water source (AGE, 2024)

Water Year	Total (ML/year)	*NSW Murray-Darling Basin Porous Rock Groundwater Sources Order 2020*	*NSW Great Artesian Basin Groundwater Sources 2020*	*Namoi Alluvial Groundwater Sources Order 2020 (Upper Namoi Zone 5)*	*Upper and Lower Namoi Regulated River Water Source*
2023	**511**	**504**	**6**	**0**	**0**
2024	**558**	**549**	**9**	**0**	**0**
2025	**625**	**616**	**9**	**0**	**0**
2026	**763**	**753**	**9**	**0**	**0**
2027	934	927	7	0	0
2028	1,058	1,046	10	0	2
2029	1,166	1,153	12	0	1
2030	1,252	1,236	15	0	2
2031	1,238	1,215	21	0	2

Source: Table 6.2 of *Narrabri Coal Mine Groundwater Model - Re-calibration Stage 2 MOD 7– v02.01* (AGE, 2024)

3.2.8 Groundwater dependant ecosystems

The relevant WSPs identify high priority GDEs within the predicted zone of influence of the Stage 2 Project (located in proximity to VI1 and VI2 – see section 6.2.2). These GDEs are understood to be based on 'high potential' GDE areas identified in the National Groundwater Dependent Ecosystem Atlas (GDE Atlas, Bureau of Meteorology [**BoM**], 2018). Recent modelling completed for the Stage 3 EIS (AGE, 2020) suggests that the mapped GDE areas are unlikely to be actual GDE areas since regional groundwater levels are thought to be more than 10 m below ground.

The Hardys and Eather Springs which are located approximately 13 km and 15 km south of ML 1609, respectively, are also listed as high priority spring GDE sites in the latest revision of the WSP for the GAB Southern Recharge Source. A third potential spring feature, the Mayfield Spring has also been identified close to the southern boundary of the mining lease. This spring is not mapped in the GDE Atlas (BoM, 2018) or listed as a high priority GDE in the relevant WSPs. Maximum drawdowns of less than 5 cm are predicted at all three potential spring sites. As such, it is considered unlikely that discharge from these springs would be significantly affected.

All potential GDEs in the area, including the three springs, and Blairmore Feature 1 and 2, are thought to be sourced from shallow groundwater systems and/or perched surface water dominated systems. Drawdown at the water table (i.e. within the surficial alluvium / regolith deposits) is therefore the critical factor in determining whether any impact could occur.

Drawdown in excess of the relevant AIP thresholds is predicted at a number of potential terrestrial GDE areas (VI1 and VI2 in Figure 6-1). These areas are predominantly located within the Gunnedah Oxley Basin MDB Groundwater Source and include areas which are mapped as being dominated by Red Gum, River Red Gum, shallow freshwater wetland sedgeland with smaller areas of Ironbark and Box grassy woodland. However, the predicted water table drawdown is unlikely to affect the long-term viability of any facultative[7] groundwater dependent vegetation mapped as a 'high priority' GDE in the WSPs (Resource Strategies, 2020). Given that the GDEs were assessed utilising the Stage 3 mine plan, any potential impact to these GDEs is expected to

[7] GDEs that utilise groundwater as required (i.e. opportunistically)

be less due to the smaller Stage 2 mine plan. Section 6.2.2 details the monitoring method for the identified GDE sites.

4. Performance measures and indicators

Performance measures for watercourses are listed in Schedule 3 Condition 1 of the Project Approval and are presented in Table 4-1.

Table 4-1 Subsidence performance measures and performance indicators for water resources

Feature	Subsidence performance measures	Subsidence performance indicators
Great Artesian Basin	The Proponent shall ensure that, within 5 years of the date of this approval, any loss of water flow into the Great Artesian Basin aquifers (equal to the maximum predicted impact, or the measured impact of the project, whichever is the greater), is managed, licensed or offset (including the possibility of injection of raffinate) to the satisfaction of DPIE Water.	Groundwater volumes extracted from Great Artesian Basin water source are measured and reported annually against licensed groundwater extraction volume.

NCOPL will ensure sufficient water entitlements are held in WALs to account for the maximum predicted take for each water source, including the associated WAL dealings prior to take occurring.

Based on the predicted subsidence impacts in the Mine Subsidence Assessment Report and the proposed remediation measures, it is considered that the performance measures for water resources within the Extraction Plan Area will be achieved during and following mining of LW 203 to LW 206.

NCOPL has established additional performance measures and indicators for the management of water resources as detailed in Table 4-2.

Table 4-2 Performance measures and performance indicators

Feature	Performance measures	Performance indicators
Surface water	Surface water quality does not exceed the SSGVs.	Monitoring demonstrates surface water quality is within or below the SSGVs and TARPs are adhered to where required.
Pilliga Sandstone	Subsidence impact or environmental consequences is not to exceed that predicted in the EIS	Monitoring demonstrates groundwater quality and levels of the Pilliga Sandstone are consistent with predictions and trigger levels.
Ponding	Surface water ponding does not result in adverse impacts to vegetation health.	Monitoring demonstrates no adverse impact to vegetation health as a result of subsidence induced ponding and TARPs are adhered to where required.
Surface water take	Sufficient water entitlement is available for the operation of the Narrabri Mine and water is extracted in accordance with the Eulah Creek WAL held by NCOPL, and the rules prescribed in the WSP.	Calculation of surface water take indicates sufficient water entitlement is available and TARPs are adhered to where required.

Feature	Performance measures	Performance indicators
Water course morphology	Subsidence due to mining does not impact on the morphology of creeks.	Monitoring demonstrates no impact to water course morphology as a result of subsidence and TARPs are adhered to where required.
Groundwater levels (non-Pilliga bores)	Impacts on aquifers are consistent with model predictions.	Monitoring demonstrates groundwater levels remain above the adopted trigger levels and TARPs are adhered to where required.
Groundwater levels (Pilliga bores)	Impacts on the Pilliga Sandstone aquifer are consistent with model predictions.	Monitoring demonstrates groundwater levels remain above the adopted trigger levels and TARPs are adhered to where required.
Groundwater quality	Groundwater quality does not exceed trigger values.	Monitoring demonstrates groundwater quality is within or below the adopted trigger values and TARPs are adhered to where required.
Groundwater inflows	Groundwater inflows are consistent with model predictions.	Weekly review of water take against predicted water take demonstrates groundwater inflows are consistent with model predictions and TARPs are adhered to where required.
GDEs	Impacts on alluvium aquifer are consistent with model predictions.	Monitoring demonstrates groundwater levels remain above the adopted trigger levels and TARPs are adhered to where required.
	Groundwater quality does not exceed trigger values.	Monitoring demonstrates groundwater quality is within or below the adopted trigger values and TARPs are adhered to where required.
	No adverse impacts to vegetation health (considering natural variation).	Monitoring demonstrates no adverse impact to vegetation health and TARPs are adhered to where required.

5. Management measures

In accordance with Schedule 2 Condition 1 of the Project Approval, NCOPL will implement all practicable measures to prevent and/or minimise any harm to the environment that may result from the construction, operation, or rehabilitation activities at the Narrabri Mine.

NCOPL will implement the management measures detailed in the following sections to ensure compliance with the performance measures listed in Table 4-1, Table 4-2 and the TARP (Table 7-1).

5.1 Surface cracking

The surface cracking associated with mine subsidence will expose soils to short term erosion during the first flush, which may temporarily increase turbidity and TSS in the local watercourse. It is expected that turbidity and TSS would revert back to background conditions for subsequent flow events as the cracks fill in and repair. As a result, water quality impacts associated with mine subsidence is not expected to be long term or significant.

General measures for remediation of surface cracks are:

- Conduct visual inspections of the surface during active subsidence in accordance with section 4.5; and
- Repair larger surface cracks (more than 50 mm) following active subsidence (rip or grade where necessary).

Minor cracks (i.e. less than 50 mm wide) are not expected to require remediation as geomorphological processes will likely result in these cracks filling naturally over time. However, if larger surface cracks (i.e. more than 50 mm wide) have not self-corrected within two months, remediation will be required. Remediation of larger surface cracks will generally be undertaken using conventional earthmoving equipment (such as backhoe or grader) and will involve ground disturbance associated with in-filling by cultivation of the ground surface or in-filling with suitable soil or other material obtained from stockpiles at nearby gas drainage or ventilation sites, or material from within the footprint of the Reject Emplacement Area.

Prior to any remediation, NCOPL will undertake a review of environmental impacts that may result from the remediation at the specific location and consider whether remediation will create an increased impact (e.g. clearing native vegetation to enable machinery access or major drainage works that will cause a greater impact from excavation). If the assessment concludes that there may be the potential to increase impacts on watercourses or biodiversity, alternative methods of remediating the crack are warranted (e.g. without machinery).

After surface cracks have been remediated, NCOPL will conduct an inspection within three months to identify if further remediation is required. Refer to the TARP in section 7.

Surface cracking associated with mine subsidence and the implementation of remedial measures will be monitored to minimise potential impacts of short-term erosion during first flush events.

5.2 Sub-surface cracking

The management measures for controlling sub-surface fracturing include (in order of increasing impact to mining):

- Monitoring rainfall deficit and underground water during longwall mining to detect surface to seam connectivity.
- Repairing surface cracks following active subsidence in accordance with section 5.1.
- Decrease mining height and/or panel width to limit continuous fracture heights.
- Leave a barrier pillar beneath a sensitive area or limit mining to first workings.

A borehole extensometer and vibrating wire piezometer has been installed above LW 203 to monitor the height of fracturing development after supercritical conditions develop. Inspections and monitoring of underground workings and groundwater make will also be recorded and plotted against rainfall deficit data to detect surface to seam connectivity. Monitoring details are provided in section 6.2.7.

5.3 Ponding

A set of criteria to determine the most suitable option for the management and remediation of ponding is presented in Table 5-1.

Table 5-1 Criteria for subsidence pond management and remediation

Type of impact	Severity	Description of severity	Management / remediation measures
Creation of subsidence pond(s) in floodplain areas isolated from the main stream drainage path	Low	Small shallow ephemeral pond which may serve a useful ecological and/or agricultural function	Re-establish any affected contour banks and revegetate
	Moderate to High	Large semi-permanent or permanent pond with the potential to impact ecological and/or agricultural function	• Construct drainage channels to create free draining areas • Restore affected contour banks • Revegetate fringing areas around residual pond • Exclude stock access from riparian areas
Creation of in-stream pond(s) or changes to length, depth and/or shape of existing in-stream pond(s)	Low	• Creation of similarly sized in-stream pond(s) as existed prior to subsidence effects • Changes to existing pond(s) resulting in similar size and distribution of in-stream pond(s)	Stabilise pond inlet and outlet using graded rock and vegetation enhancement

Type of impact	Severity	Description of severity	Management / remediation measures
	Moderate	Moderate increase or decrease in size and distribution of in-stream pond(s) with the potential to impact ecological and/or agricultural function	• Construct in-stream barriers or drainage channels to reduce or increase the effective size and spatial distribution of pond(s) • Stabilise pond inlet and outlet using graded rock and vegetation enhancement
	High	Significant increase in size of in-stream pond(s) with high potential for impact to ecological and/or agricultural function	• Dewater ponded area • Reshape surface and infill pond • Re-establish natural drainage channel

Remediation of ponded areas will consider the following:

- ponding located in areas where vegetation is not affected, will be allowed to self-correct;
- ponding located in areas with affected vegetation, or if ponding significantly alters or affects flows, will be assessed and remedial actions (that present the lowest environmental impact) developed in consultation with a geomorphologist; and/or
- if downstream water quality analysis indicates a change in EC trends, the ponding will be assessed, and remediation options will be developed to afford the maximum practical protection to the affected feature.

Remediation works within a watercourse will be undertaken in consideration of the *Guidelines for Controlled Activities on Waterfront Land* (NRAR, 2018).

5.4 Steep slopes

Appropriate impact management strategies for steep slope instability and soil contour banks are described in section 5.3 of the Extraction Plan – Land Management Plan.

5.5 Erosion

Management measures for gully erosion are commensurate with the measures for surface crack remediation as detailed in section 5.1.

For significant gully erosion, the following measures may be considered:

- grade banks to stop the upslope concentration of flow and stabilise through revegetation:
  - graded bank diversionary structures may need to be installed on a suitable grade to ensure flows that are diverted away from the gullies with consideration of ground surface, soil type and design flows; and
  - sow perennial pasture species in accordance with the Rehabilitation Management Plan.

- fill using rocks or rubble sourced from site or reshape using an excavator, or a combination of both. After filling, it is recommended that they be dressed with topsoil to encourage rapid establishment of vegetation; or
- diversion banks to convey flows to a safe disposal area where water will naturally spread and not concentrate into erosive volumes and velocities. Where safe disposal areas are not available, the construction of a suitable drop structure to safely convey diverted flows into creek lines will need to be considered.

Depending on the nature of the soils and the availability and quality of topsoil, consideration will be given to the use of soil ameliorants to improve the soil structural stability. This will improve rehabilitation and revegetation outcomes. Soils may respond particularly well to the use of gypsum to address the highly dispersible soils. Temporary sediment fencing will be installed below any areas to be disturbed and be maintained until such time as disturbed areas have revegetated.

5.6 Groundwater monitoring bores

The monitoring locations located over the proposed longwall limits (P9, P10, P11, P80, P81 [wireline extensometer], P90, and the two old production wells) may be subject to failure due to subsidence and fracturing (DGS, 2022). Where groundwater monitoring points are identified as having been impacted by subsidence, NCOPL will undertake to reinstate or correct the monitoring point where possible. The DCCEEW Water Group will be notified within two weeks of identification of detection of the impacted bore. A determination of the appropriate action for reinstatement or correction of the groundwater bore will be determined in consultation DCCEEW Water Group. Impacted monitoring locations will be rectified within three months of detection (where possible).

Additional monitoring bores may be required to replace the function of impacted monitoring bores, if necessary. Groundwater monitoring bore P8 is located 1.2 km outside the limits of longwall mining (3.75 times the cover depth) and has a ‘low’ risk of being impacted by horizontal bedding shear movements.

6. Subsidence impact monitoring

6.1 Surface water monitoring

6.1.1 Monitoring standards

Surface water monitoring at Narrabri Mine will be undertaken in accordance with the Australian Standard for Water Quality Sampling *AS/NZS 5667.1:1998* and the *Approved Methods for the Sampling and Analysis of Water Pollutants in NSW* (EPA, 2022). Laboratory analysis will be undertaken by a laboratory which has the relevant accreditation by the National Association of Testing Authorities (**NATA**). Quality assurance and quality control (**QA/QC**) for water quality monitoring will be undertaken in accordance with the *Australian and New Zealand Guidelines for Fresh & Marine Water Quality* (ANZG, 2018).

6.1.2 Site-specific guideline values

In order to reflect local conditions, SSGVs have been derived from historical data for monitoring sites KCUS and KC1US, located downstream of the Extraction Plan Area and upstream of the Narrabri Mine. The SSGVs have been defined as the 90th (referred to as Stage 1) and 95th percentile (referred to as Stage 2) of the baseline water quality data recorded at these sites. As limited water quality data is available for monitoring sites KC1TOP and KCTOP, SSGVs were unable to be derived for these sites. These sites will continue to be monitored when feasible in order to provide reference site data for comparison to KCUS and KC1US data in the event of a trigger exceedance.

As constituent values may at times naturally exceed the derived SSGV of the baseline water quality data, an exceedance of a SSGV is not considered as immediate evidence of an impact, rather the SSGVs are proposed as performance indicators to initiate investigation into potential changes in water quality characteristics which may result in impacts to aquatic ecosystems at monitored surface water sites.

Table 6-1 presents the SSGVs derived for KCUS and KC1US. It is noted that KC1US overlies the eastern edge of CF 201 (cut and flit panel) and therefore may be impacted by mining related effects associated with CF 201. Potential subsidence effects related to mining of CF 201 and associated monitoring and management measures are described in the *Panels 201 – 202 Extraction Plan Water Management Plan* (WHC, 2022).

Table 6-1 Site specific guideline values – surface water quality

Parameter (mg/L unless otherwise stated)	KCUS		KC1US	
	Stage 1	Stage 2	Stage 1	Stage 2
pH (pH units)	6.5 - 8	6.5 - 8	6.5 - 8	6.5 - 8
EC (µS/cm)	649	798	207	217
TSS	652	870	479	957
TOC	15	17	16	17

Note: a minimum of 81 baseline values were used to derive the SSGVs for KCUS and a minimum of 51 baseline values for KC1US

If the SSGVs are exceeded (Table 6-1), the TARP (section 7) will be initiated.

6.1.3 Streamflow monitoring

Visual inspections will be undertaken at surface water monitoring sites in Kurrajong Creek and Kurrajong Creek Tributary 1 in order to record the presence of ponded water and surface water flow at each monitoring site. This will aid in providing an improved understanding of watercourse hydrology within the Extraction Plan Area and in interpreting water quality and erosional effects.

An approach for quantifying losses of stream flow from surface cracking and ponding for a range of climatic scenarios has been established. The aim of this monitoring is to determine the requirement for a WAL under the *WSP for the Namoi and Peel Unregulated Rivers Water Sources 2012*.

Water take due to subsidence induced surface cracking will be calculated based on the volume of water retained in each crack in accordance with the following calculation:

Captured water in each surface crack = (crack width x crack depth x crack length)/2.

The width, depth, and length of each surface crack will be recorded as part of the ongoing subsidence monitoring program as described in section 6.1.5, Table 6-3. NCOPL will review rainfall data and subsidence monitoring data annually to calculate the volume of water captured following each runoff event[8]. If a second runoff event occurs prior to surface crack repair, then a subsequent calculation will be required[9]. NCOPL will then assess potential water take against the licensed volume obtained from the Eulah Creek Water Source as part of the annual WAL reporting.

If surface cracks are repaired prior to a runoff event, then a water volume calculation is not required.

Attachment 3 provides a schematic of the calculation method described above, including the approach for deriving an estimate of crack length.

It is to be noted that surface cracks are likely to occur along the perimeter of the longwall panel and, as such, more than one crack is to be expected.

[8] A run off event is defined as a rainfall event >38.4 mm over 5 consecutive days

[9] The recommended monitoring method is based on surface cracks being filled with water by a maximum of two run off events per water take calculation (WRM, 2023).

6.1.4 Surface water monitoring program

A surface water monitoring program will be implemented to monitor the impacts of subsidence effects during the extraction of LW 203 to LW 206. The surface water monitoring program is summarised in Table 6-2.

Table 6-2 Surface water monitoring program

Location	Parameters	Monitoring frequency
KC1TOP, KC1US, KCTOP, KCUS	Field analysis: • pH • EC • turbidity • DO • temperature Laboratory analysis: • pH • EC • TDS • TSS • turbidity • TOC • Oil & grease • Metals and metalloids: aluminium, arsenic, cadmium, chromium, copper, lead, nickel, selenium, zinc, iron, molybdenum, antimony, mercury, cobalt	Quarterly, in the event of flow during the quarter
	Visual inspection to record streamflow characteristics: • no ponding/flow • ponded water • trickle flow • flowing water	

6.1.5 Channel geomorphology and riparian vegetation

6.1.5.1 Visual inspections

Visual inspections will be performed:

- monthly behind the longwall face (i.e. during active subsidence) and
- quarterly at watercourses within the active subsidence zone

to determine surface crack locations (including width, depth, length), extent of ponding and if there is significant vegetation that may require monitoring of vegetation health.

Observations of any subsidence effects such as surface cracks, ponding, and erosion will be recorded and reported to the Environment Manager as they are identified, and appropriate management measures will be implemented as detailed in the relevant Extraction Plan/s.

6.1.5.2 Remote sensing

Baseline surveys will be conducted via remote sensing (multi-spectral image and LiDAR) prior to longwall mining to record vegetation health, creek bank condition and natural drainage patterns. Annual remote sensing will then be utilised during and following mining to determine any changes. Monitoring results and any remediation works will be reported in the annual review.

6.1.5.3 Field survey

Where visual inspections or remote sensing identify significant changes in channel geomorphology that are not consistent with predicted impacts (section 3.2), NCOPL will conduct a field survey to ground truth and develop an appropriate monitoring regime and/or remediation measures. Parameters may include surveying on ground channel cross sections, bankfull level and wetted permitter.

Table 6-3 summarises the channel geomorphology and riparian vegetation monitoring program.

Table 6-3 Summary of channel geomorphology and riparian vegetation monitoring program

Aspect/feature	Frequency	Method and analysis	Parameters
Visual inspections			
Active subsidence directly behind longwall face	During active subsidence, monthly and following a significant rainfall event (defined as a rainfall event >38.4 mm over 5 consecutive days).	Visual inspections to: • Identify areas of surface cracking. • Identify erosion/potential erosion. • Determine appropriate management response.	• Surface crack GPS location, depth, width and length. • Erosion and potential for erosion (e.g., knickpoints, head cuts).
Watercourses in active subsidence zone	Baseline and then quarterly during active subsidence	Visual inspection and photographs to: • Identify areas of ponding, including vegetation. • Identify erosion/potential erosion. • Identify sedimentation. • Determine appropriate management response.	• Ponding GPS location, width, depth, area, presence of vegetation. • Bed and bank stability. • Watercourse erosion and potential for erosion (e.g., knickpoints, head cuts). • Sedimentation
Direct field survey	Following changes detected during monitoring.	• Field inspection and survey • Sampling/testing as required.	• Determined during field survey.
Remote sensing			
Topography and landscape morphology and erosion monitoring	Baseline and then annually.	Baseline LiDAR comparison with annual LiDAR	• High resolution topography. • Changes in creek cross-sections. • Areas with increased erosion.

Aspect/feature	Frequency	Method and analysis	Parameters
Vegetative cover characteristics	Baseline and then annually.	• Satellite imagery • Multi-spectral imaging (NDVI)	• Vegetative biomass and cover changes

6.2 Groundwater monitoring

The Narrabri Mine groundwater monitoring program provides for the collection of water quality and water level data. As groundwater monitoring considers local variations whenever possible, NCOPL utilises an analysis of historical data to determine the suitability of groundwater for a particular purpose at a monitoring location. Continued monitoring also provides for the ongoing collection of data to inform management decisions in relation to potential groundwater impacts arising from operations.

Key components of the groundwater monitoring program include:

- measurement of water levels in seepage, standpipe, and production bores;
- water quality sampling of seepage, standpipe, and production bores;
- continuous measurement of water levels at the VWPs;
- continuous monitoring of water quality entering the underground mine workings;
- manual reading of the volume of groundwater pumped to surface from the box cut;
- water level and quality analysis at two private landholder bores; and
- photographs and site observations at identified springs and high priority GDE sites.

6.2.1 Monitoring network

The NCOPL groundwater monitoring network includes groundwater quality sampling, groundwater level sampling and field data collection from 85 individual monitoring locations. Utilising this data, impact assessment criteria (trigger values) have been adopted (section 6.2.7) for:

- mine water inflow volume/rate;
- groundwater quality;
- groundwater levels; and
- groundwater dependant ecosystems.

In 2023, NCOPL significantly expanded its groundwater monitoring network. The locations for each monitoring point are included in Figure 6-1 and are described in Attachment 4, Table A4-1. The entire network now comprises:

- 53 standpipes of which:
  - 40 are for general water quality and water level monitoring purposes; and
  - 13 are for monitoring of seepage around the water management infrastructure.
- 15 VWPs with sensors in multiple formations per location for water level monitoring;
- Two private landholder bores;
- One wireline extensometer;

- Three water production bores; and
- 14 surface water locations including high priority terrestrial and spring GDE sites and standing pools associated with shallow strata monitoring bores.

Four monitoring bores targeting the Pilliga Sandstone, operated as part of the Narrabri Gas Project (Santos), are also reviewed as part of the network.

6.2.2 Groundwater dependent ecosystems

NCOPL will conduct monitoring at visual inspection (**VI**) sites of potential 'high priority' GDEs and identified springs/features (Figure 6-1), to establish baseline data and identify trends in surface conditions and/or water quality. The corresponding TARP is provided in section 7.

The VI sites are referenced as follows:

- VI1: GDEs to the northeast of ML 1609 comprising shallow freshwater wetland sedgeland, River Red Gum and Box Grassy Woodland;
- VI2: a small River Red Gum location southeast of ML 1609;
- VI3: Mayfield Spring
- VI4: Hardy's Spring
- VI5: Eather Dam 1
- VI6: Eather Dam 2
- VI7: Blairmore Feature 1
- VI8: Blairmore Feature 2

No dedicated groundwater monitoring bores are proposed in proximity to the GDEs within the zone of influence (VI1 and VI2). Monitoring bores P3, P4, P5, P39B, P62, P63, P68, P69 are located between the underground workings and the GDEs.

Monitoring bore P39B is the closest alluvial bore to the mine and is not predicted to be impacted. A groundwater level trigger has been derived for this bore as drawdown within the alluvium/regolith deposits is the critical factor in determining whether impacts to GDEs could occur (Table 6-5).

Monitoring bores P3, P4 and P5 constructed in deeper geological formations, located between the mine and the Namoi Alluvium, also have groundwater level triggers (Table 6-5).

The Mayfield Spring (VI3) will be monitored by upstream and downstream alluvial monitoring bores (P91 and P92).

Quaternary Alluvium monitoring bores P71, P72, P74 and P75 are located within, or in close proximity to, the GDEs associated with Sandy Creek and its tributaries (VI4-VI6). These monitoring bores will provide additional data on ground water level and quality for assessment of potential impacts.

Surface water levels and field water quality parameters in any standing pools at alluvial monitoring bore locations will also be monitored (Table 6-6).

Monitoring bore results will be compared with VI data to determine any correlations between any observed anomalies. The comparison will occur twice per year and be recorded in the annual review. Additionally, a

suitably qualified hydrogeologist is engaged to undertake quarterly groundwater data reviews that cover results from all monitoring bores, including those without triggers.

6.2.3 Privately-owned bores

NCOPL will conduct annual groundwater level and quality monitoring at two privately owned bores (WB12 and WB18). Monitoring will include water level and water quality analysis for EC and pH and an annual laboratory analysis for physical parameters, cations, anions, dissolved metals, and nutrients.

Groundwater level and quality monitoring will be conducted in accordance with the monitoring program summary provided in section 6.2.7.

If monitoring detects the water supply at private landholder bores (WB12 and WB18) is adversely and directly impacted as a result of mining, NCOPL will provide compensatory measures in accordance with Schedule 4, Condition 9B of the Project Approval.

The adopted yearly water level triggers for private landholder bores are presented in Table 6-5 and water quality triggers are presented in Attachment 5

6.2.4 Relationship between measured EC and TDS

NCOPL will conduct EC and TDS monitoring to identify relationships between measured EC and TDS in mine water and groundwater in the Hoskissons Seam and adjoining aquifers.
EC and TDS will be monitored via:

- routine monitoring data from the box-cut;
- groundwater collected within the longwall panels i.e. targeting the Hoskissons Seam; and
- monitoring bores associated in adjoining aquifers i.e. Garrawilla, Napperby, Purlawaugh and Watermark.

The groundwater collected within the longwall panels will be sampled monthly for an initial 6-month period to collect adequate baseline data. Following this, the groundwater collected within the longwall panels will be sampled annually.

The relationship between EC and TDS will be analysed during the annual Hydrogeologist review (refer to section 9.3).

6.2.5 Mine inflow rates and quality

Daily recording of mine water inflows and outflows will be conducted to record potential sudden inflows as subsidence develops (as a result of groundwater inflow or connection to surface water flows). An observed inflow rate 100% in excess[10] of the predicted base case mean weekly equivalent inflow rate at any stage during the EP 203-206 operational period sustained for three consecutive weeks, will trigger an investigation and preparation of a response plan as detailed in section 7. The investigation into a significant increase in mine

[10] Day to day inflow rates may be highly variable as the longwall retreats and subsidence develops. A fracture zone may be intercepted which contributes increased inflow for a short period of time (days to weeks), but then inflow would be expected to return to the long term average. The groundwater model also assessed variability in parameters, including hydraulic conductivity, to examine potential variability in impact on groundwater (groundwater level drawdown and inflow rate) compared to the base case. The adoption of a 100% trigger level for variation in inflow rates is based on these two considerations.

inflows to the mine workings will include comparison to and updating of the groundwater model as detailed in section 9.2 and section 9.3.

The volumes extracted from the LW 203 to LW 206 mine workings will be transferred through the box cut sump and pumped flows measured from this location. These volumes are included as part of the monitoring network and are reported in the Annual Review. This forms the largest portion of flow that contributes to Narrabri Mine's licenced groundwater extraction volume.

6.2.6 Groundwater impact assessment criteria

Groundwater quality triggers

Water quality trigger values (Attachment 5) have been developed for EC based on an assessment of historical data (AGE, 2021a) and utilising the methodology described in the Queensland Department of Science, Information Technology, and Innovation guidelines "*Using monitoring data to assess groundwater quality and potential environmental impacts*" (DSITI, 2017). The monitoring locations have been selected based on the suitability of the water quality (e.g. irrigation or stock [beef cattle] drinking) and monitoring purpose.

The pH trigger values (Attachment 5) have been derived from the Australian and New Zealand Guidelines (**ANZG**) (2018) recommended irrigation long term application pH range.

Since no significant drawdown and hence no significant water quality impacts are anticipated in the Namoi Alluvium and/or the Pilliga Sandstone, triggers have only been derived in a single monitoring bore in each of these aquifers until sufficient baseline data is collected in the newly constructed bores within these formations.

Triggers for EC and pH

If pH is outside the range of 6.0 – 8.5 for three consecutive readings or the EC trigger value of 5,970 (µS/cm) is exceeded for three consecutive readings, the TARP (Level 2) will be initiated.

Two tiered triggers for EC

For those monitoring locations where water quality is unsuitable for use as irrigation/stock watering or where the intended purpose is seepage monitoring, two tiered EC triggers will be utilised. These triggers are not static values and are derived using the rolling median calculated from the eight most recent data points and plotted on a time series chart (control chart) that includes:

- individual data points;
- the 80th percentile calculated from the long-term dataset; and
- the 95th percentile calculated from the long-term dataset.

Two triggers are then identified as follows:

- Tier 1 – where the rolling median exceeds the 80th percentile of long-term data; and
- Tier 2 – where three consecutive exceedances of the 95th percentile of the long-term data occur. If this occurs, the TARP (Level 2) will be initiated.

The Tier 1 trigger provides a method for assessing a gradual change in groundwater quality over the medium term via use of the rolling median, whilst the Tier 2 trigger is intended to detect an event related change over the short term.

Trigger criteria will be established for the newly constructed bores following the collection of sufficient baseline data over six to eight monitoring events.

Bore specific EC trigger values are presented in Attachment 5.

Groundwater level triggers

Method

Water level trigger values for NCOPL monitoring bores have been developed in accordance with the method detailed in Table 6-4.

Table 6-4 Tiered trigger level description

Tier	Description	Trigger
Tier 1	Upper allowable limit (UAL): • Indicates trend is towards an unacceptable level but is still within reasonable expected levels.	5th percentile of baseline data
Tier 2	Upper cut-off limit (UCL): • A detailed investigation is required for three consecutive exceedances. Model predicts yearly triggers to 2031.	Model prediction + 2 m (subtract predicted drawdown from selected baseline groundwater level and add 2 m to allow for model uncertainty).
Tier 3	Applies to Pilliga Sandstone monitoring bore P7 only	Greater than 4m drawdown
Tier 4	Applies to Pilliga Sandstone monitoring bore P7 only	Greater than 10m drawdown

The adopted yearly triggers for monitoring bores with sufficient historical data are presented in Table 6-5. Should observed water levels fall below the adopted trigger levels, the TARP (section 7) will be initiated.

In determining trigger levels for new bores (no prior-to-mining baseline), the ‘baseline’ period will be adjusted based on climate and mining operational considerations and the expert opinion of the hydrogeologist. Monitoring bore P42_90, that was drilled post-mining in 2018, is an example of an existing trigger bore that does not have pre-mining baseline data. The P42_90 trigger level is based on the 5th percentile of the available data.

Pilliga Sandstone monitoring bores

Groundwater level triggers apply to P7, P42_90, and P54_30, with P7 subject to additional trigger levels (i.e. Tier 3 and Tier 4 [Table 6-5]).

The newly constructed monitoring bores P6B, P60, P66, P77-1, P82, and P90, and the Santos monitoring bores (Attachment 4) provide further monitoring of the Pilliga Sandstone. Trigger levels will be established for the newly constructed bores following the collection of sufficient baseline data over six to eight quarterly monitoring events.

A suitably qualified hydrogeologist will review data for each monitoring bore on a quarterly basis as part of the existing routine quarterly data reviews. The review will determine whether enough data has been gathered to define trigger levels. Once sufficient data is available, appropriate trigger thresholds will be identified following the methodology outlined above.

Trigger levels for the new bores (P6B, P60, P66, P77-1, P82, and P90) will be developed as soon as possible. However, it is not possible to predict in advance how much monitoring data will be required. This is because initial readings at monitoring points can be influenced by drilling operations, and it may take time for groundwater levels to stabilize and accurately reflect actual conditions.

Ongoing monitoring is required to confirm a stable level and will also provide information on the significance of any seasonal fluctuations on level. Ideally, at least 12 monthly readings following stabilisation would be available for each monitoring point to allow appropriate trigger levels to be set. Once additional triggers have been determined then a revised EP-WMP including any additional trigger bores would be submitted to the Secretary within three months of receipt of the hydrogeologist's trigger setting report.

Table 6-5 Groundwater level triggers (m AHD)

ID	Geology	Tier 1	Tier 2								Tier 3	Tier 4
			2024	2025	2026	2027	2028	2029	2030	2031		
P1	Garrawilla Volcanics	291.6	291.6	291.5	291.5	291.5	291.5	291.4	291.4	291.3	n/a	n/a
P2	Napperby Formation	242.4	238.4	236.8	235.4	234.2	233.1	232.1	231.2	230.3	n/a	n/a
P3	Pamboola Formation	222.3	221.6	221.4	221.2	221.0	220.8	220.6	220.4	220.2	n/a	n/a
P4	Napperby Formation	226.7	225.8	225.7	225.5	225.4	225.2	225.1	225.0	224.8	n/a	n/a
P5	Pamboola Formation	207.7	206.8	206.6	206.4	206.2	206.0	205.8	205.6	205.4	n/a	n/a
P7	Pilliga Sandstone	224.4	224.4	224.4	224.4	224.4	224.4	224.4	224.4	224.4	222.4	216.4
P8	Purlawaugh Formation	269.6	269.6	269.6	269.6	269.6	269.5	268.4	267.2	266.6	n/a	n/a
P9	Purlawaugh Formation	264.2	260.8	260.6	260.3	259.4	258.9	258.6	258.4	258.2	n/a	n/a
P10	Napperby Formation	275.2	273.9	272.4	270.9	269.8	267.3	263.9	260.9	258.7	n/a	n/a
P11	Purlawaugh Formation	270.4	270.1	269.8	267.8	267.4	262.5	262.8	262.8	263.4	n/a	n/a
P12	Napperby Formation	199.0	210.0	208.8	207.7	206.3	205.0	203.9	203.1	202.5	n/a	n/a
P13	Garrawilla Volcanics	264.7	262.6	262.5	262.4	262.3	262.3	262.2	262.1	262.0	n/a	n/a
P39B	Alluvium	220.3	219.6	219.6	219.6	219.6	219.6	219.6	219.6	219.6	n/a	n/a
P42_90	Pilliga Sandstone	244.7	244.2	244.2	244.2	244.2	244.2	244.2	244.2	244.2	n/a	n/a
P47	Garrawilla Volcanics	262.4	261.3	261.1	261.0	260.9	260.8	260.7	260.7	260.6	n/a	n/a
P53	Garrawilla Volcanics	254.8	253.5	253.5	253.5	253.4	253.4	253.4	253.3	253.3	n/a	n/a
P54_30	Pilliga Sandstone	332.4	332.3	332.3	332.3	332.2	332.1	332.0	332.0	332.0	n/a	n/a
WB12	Arkarula and Pamboola Formations	208.3	208.6	208.6	208.6	208.6	208.6	208.6	208.6	208.6	n/a	n/a
WB18	Napperby Formation	214.2	213.2	213.0	212.9	212.7	212.6	212.5	212.3	212.2	n/a	n/a

6.2.7 Groundwater monitoring program summary

The Narrabri Mine groundwater monitoring program is summarised in Table 6-6 and monitoring locations are shown on Figure 6-1. A detailed list of all monitoring locations and the type of monitoring conducted at each location is provided in Table A4-1, Attachment 4.

Table 6-6 Groundwater monitoring program

Monitoring focus	Monitoring type/location	Monitoring parameters	Frequency
Groundwater	**VWPs (Pilliga Sandstone sensors)** P42, P54, P77 **VWPs (all formations)** P42, P44, P45, P46, P54, P55, P56, P76(b), P77, P80	• Pressure data	**Pilliga Sandstone sensors** • Continuous with monthly download of data **All formations** • Continuous with quarterly download of data
	Standpipes (Pilliga Sandstone) P6B, P7, P60, P66, P82, P90 **Standpipes (other formations)** P1, P2, P3, P4, P5, P8, P9, P10, P11, P12, P13, P16, P17, P19, P39A, P39B, P43, P47, P51, P52, P53, P59, P62, P65, P68, P71, P74, P75, P91, P92, WB2	• Water level • Field EC and pH • Laboratory analysis: ▪ physical parameters (e.g. alkalinity, EC, TDS, total suspended solids [TSS] and pH); ▪ cations (e.g. calcium, magnesium, sodium, and potassium); ▪ anions (e.g. carbonate, bicarbonate, sulphate, chloride, and fluoride); ▪ dissolved metals (e.g. aluminium, antimony, arsenic, boron, cobalt, cadmium, chromium, copper, iron, lead, manganese, mercury, molybdenum, nickel, silver, selenium, and zinc); and ▪ nutrients (e.g. ammonia, nitrate, phosphorous and reactive phosphorous).	**Pilliga Sandstone** • Monthly for water level • Quarterly for water quality (EC and pH) • Annually for all other parameters **Other formations** • Quarterly for water level and water quality (EC and pH) • Annually for all other parameters
	Seepage bores P28, P29, P30, P31, P32, P33, P34, P58, P83, P84, P85, P88, P89	• Water level • Field EC and pH • Laboratory analysis: ▪ physical parameters (e.g. alkalinity, EC, TDS, TSS and pH); ▪ cations (e.g. calcium, magnesium, sodium, and potassium); ▪ anions (e.g. carbonate, bicarbonate, sulphate, chloride, and	Quarterly (in accordance with Condition M2.3, U2.1 and U3.1 of EPL 12789)

Monitoring focus	Monitoring type/location	Monitoring parameters	Frequency
		fluoride); ▪ dissolved metals (e.g. aluminium, antimony, arsenic, boron, cobalt, cadmium, chromium, copper, iron, lead, manganese, mercury, molybdenum, nickel, silver, selenium, and zinc); and ▪ nutrients (e.g. ammonia, nitrate, phosphorous and reactive phosphorous).	
	Water quality entering the underground mine workings (i.e. within longwall panels).	• EC • TDS	Monthly for an initial 6-month period and annually thereafter.
	Mine water pumping inflow and outflow.	• Discharge rate	Weekly meter read
	Private landholder bores WB12 and WB18	• Water level • Field EC and pH • Laboratory analysis: ▪ physical parameters (e.g. alkalinity, ED, TDS, TSS and pH); ▪ cations (e.g. calcium, magnesium, sodium, and potassium); ▪ anions (e.g. carbonate, bicarbonate, sulphate, chloride, and fluoride); ▪ dissolved metals (e.g. aluminium, antimony, arsenic, boron, cobalt, cadmium, chromium, copper, iron, lead, manganese, mercury, molybdenum, nickel, silver, selenium, and zinc); and ▪ nutrients (e.g. ammonia, nitrate, phosphorous and reactive phosphorous).	Annually
Subsidence (subsurface cracking)	Subsidence calibration borehole P80 and geotechnical borehole P81 above LW 203 – deep borehole piezometers, shallow standpipe piezometers and deep wireline extensometers.	• Water level • Displacement.	Continuous

Monitoring focus	Monitoring type/location	Monitoring parameters	Frequency
GDEs	**VI sites 1-8** Hardy's, Mayfield, and Eather springs, Blairmore Feature 1 and 2, and mapped high priority GDEs.	• Four site photographs (upstream, downstream, at the left bank and at the right bank) and observations of: ▪ flow rates (no, low, or high flow); ▪ surface water levels (water present, low, high); ▪ field water quality (EC and pH) in any standing pools; and ▪ vegetation health.	Quarterly
Surface water quality (Quaternary alluvial bores)	P59/P60/P61 (PCUS in SWMP), P62/P63/P64 (Pca in SWMP), P65/P66/P67 (P65-P67 SW[1]), P68/P69/P70 (P68-P70 SW[2]), P71/P72/P73 (P71-P73 S[3]), P74/P75/P76 (P74-P76 SW[4])	• Field water level (water present, low/high) and quality (EC and pH) in any standing pools.	Quarterly
Research sampling program Also refer to Section 9.7.1	Sampling to be undertaken at selected monitoring bores in the Surat Basin and Gunnedah Basin as well as mine inflow (Permian associated with the Gunnedah Basin): <u>Near surface strata:</u> P91 and P92 (at Mayfield Spring) <u>Surat Basin:</u> Pilliga Sandstone: P7 and P90 Purlawaugh Formation: P8, P9, P11, P72 Garrawilla Volcanics: P13 and P16. Gunnedah Basin: Napperby Formation: P10 and P12 Hoskissons Coal Seam: Mine water (4 samples)	• methane • radiocarbon dating (^{14}C and ^{36}CL).	Once off [5]

Note:

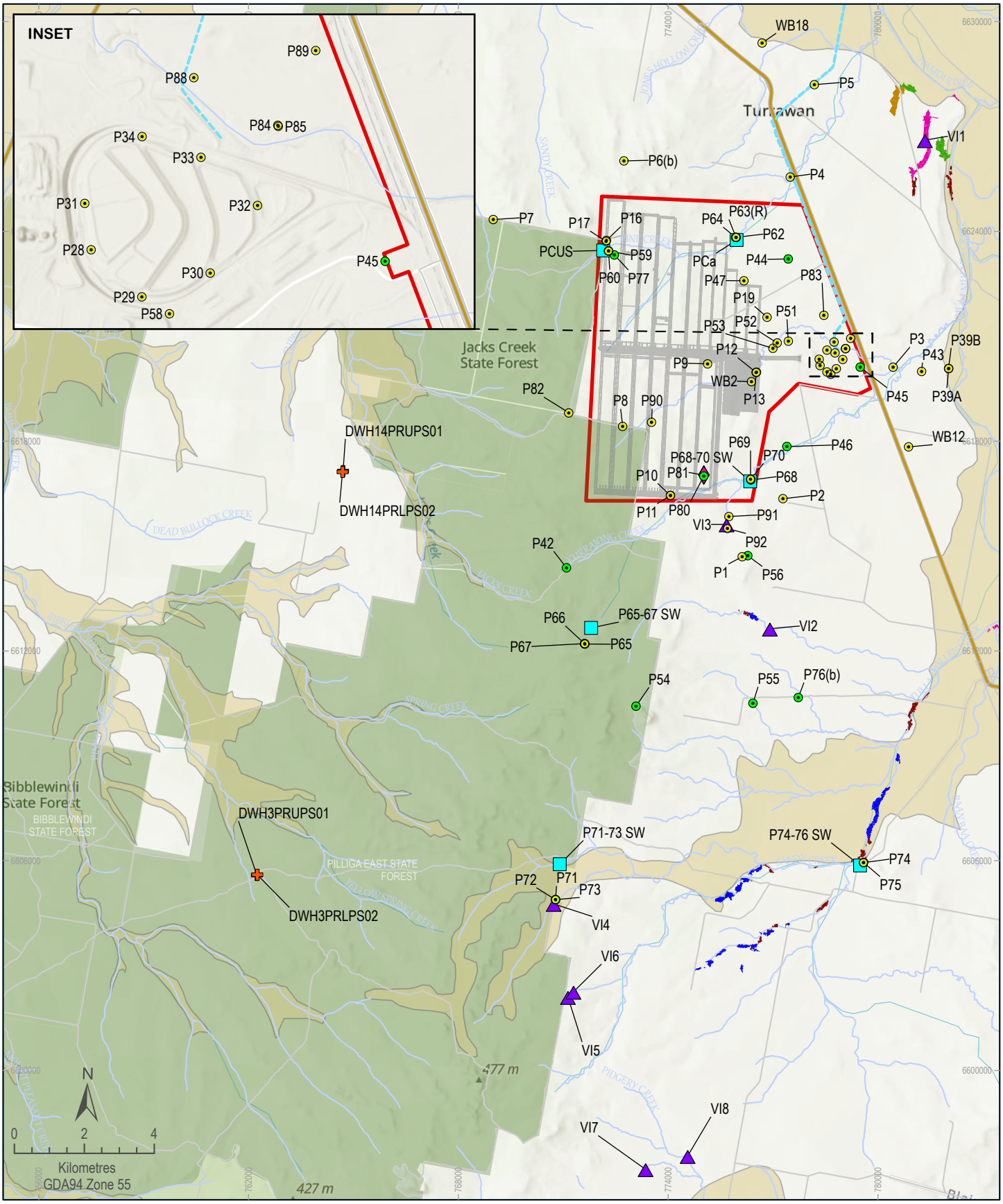
[1] No standing water on inspection. Site would only have flow during heavy rainfall.

[2] Standing pool of water in minor watercourse.

[3] Ponded area upstream of road crossing in minor watercourse.

[4] Small dam downstream of well pad.

[5] As part of the research assessment discussed in Section 9.7.1. From this assessment, the need any further/routine methane and radiocarbon dating work to be confirmed.



WHITEHAVEN COAL

ONWARD CONSULTING

LEGEND

- ML1609
- Alluvium
- State forest
- Namoi River pipeline (buried)
- Stage 2 underground longwall panels
- Highway
- Roads
- Watercourses

Groundwater monitoring sites

- Alluvial surface water monitoring
- GDE monitoring location
- Santos monitoring location
- Standpipe
- VWP
- Wireline extensometer

Groundwater Dependent Ecosystems (GDE)

- Box grassy woodland
- Narrow-leaved Ironbark
- Red Gum
- River Red Gum
- Shallow freshwater wetland sedgeland

NARRABRI MINE

Figure 6-1

Groundwater Monitoring Locations

7. Contingency response

In the event that a non-compliance against a performance measure and/or impact assessment criteria has occurred, or is likely to occur, NCOPL will:

1. Report the non-compliance as soon as practicable to the relevant agencies as required under the Project Approval and relevant legislation in accordance with section 8.
2. Identify and implement an appropriate course of action with respect to the non-compliance in consultation with a suitably qualified person/s and relevant agencies.
3. Review the effectiveness of the EP-WMP management measures in accordance with section 9.6.

In addition, a TARP (Table 7-1) has been developed to identify, assess and respond to triggers and to manage risks associated with meeting the water performance measures and/or impact assessment criteria.

Table 7-1 Trigger action response plan

<table>
<tr><th>Performance measure</th><th>Status</th><th>Trigger</th><th>Action</th><th>Response</th></tr>
<tr><td colspan="5">Water quality watercourse</td></tr>
<tr><td rowspan="2">Surface water quality does not exceed the SSGVs
Sites:
• KC1TOP, KC1US, KCTOP, KCUS.

Parameters:
• Field - EC, pH
• Laboratory - TSS, TOC

Frequency:
• Quarterly.
• During flow event (as practical).

Analysis:
• Comparison of water quality records during operations with the SSGVs for KCUS and KC1US.</td><td>Normal</td><td>The water quality trigger levels are not exceeded and performance measures met.</td><td>None required.</td><td>• Continue to implement surface water management measures in accordance with this Plan.
• Continue routine surface water monitoring and evaluation of results.</td></tr>
<tr><td>Level 1</td><td>• Less than pH 6.5 or greater than pH 8.0 for one monitoring event.
• EC, TSS and TOC exceeding Stage 1 trigger for one monitoring event.
<table>
<tr><th rowspan="2">Parameter</th><th rowspan="2">Trigger</th><th colspan="4">Monitoring location</th></tr>
<tr><th>KCUS</th><th>KC1US</th><th>KCTOP</th><th>KC1TOP</th></tr>
<tr><td>EC (µs/cm)</td><td>Stage 1</td><td>649</td><td>207</td><td rowspan="3">N/A</td><td rowspan="3">N/A</td></tr>
<tr><td>Total suspended solids (mg/L)</td><td>Stage 1</td><td>652</td><td>479</td></tr>
<tr><td>Total organic carbon (TOC)</td><td>Stage 1</td><td>15</td><td>16</td></tr>
</table>
Note:
The TSS concentration limit may be exceeded for water discharged provided that:
• the discharge occurs solely as a result of rainfall measured at the premises that exceeds 38.4 mm over any consecutive 5-day period immediately prior to the discharge occurring; and
• all practical measures have been implemented to dewater all sediment dams within 5 days of rainfall such that they have sufficient capacity to store run off from a 38.4 mm, 5-day rainfall event.</td><td>Conduct preliminary quality assurance of data to confirm an exceedance.</td><td>For a single exceedance, the exceedance will be recorded, with no further contingency or notification measures required. If pH or a Stage 1 trigger is exceeded at the same location for three consecutive sampling events, then the actions required for Level 2 will be implemented.</td></tr>
</table>

<table>
<tr><th>Performance measure</th><th>Status</th><th>Trigger</th><th>Action</th><th>Response</th></tr>
<tr><td></td><td>Level 2</td><td>

Less than pH 6.5 or greater than pH 8.0 for three consecutive monitoring events.
EC, TSS and TOC exceeding Stage 1 trigger for the same parameter exceeded at the same location for three consecutive monitoring events.
EC, TSS and TOC exceeding Stage 2 trigger for one monitoring event.

<table>
<tr><th rowspan="2">Parameter</th><th rowspan="2">Trigger</th><th colspan="4">Monitoring location</th></tr>
<tr><th>KCUS</th><th>KC1US</th><th>KCTOP</th><th>KC1TOP</th></tr>
<tr><td rowspan="2">EC (µs/cm)</td><td>Stage 1</td><td>649</td><td>207</td><td rowspan="6">N/A</td><td rowspan="6">N/A</td></tr>
<tr><td>Stage 2</td><td>798</td><td>217</td></tr>
<tr><td rowspan="2">Total suspended solids (mg/L)</td><td>Stage 1</td><td>652</td><td>479</td></tr>
<tr><td>Stage 2</td><td>870</td><td>957</td></tr>
<tr><td rowspan="2">Total organic carbon (TOC)</td><td>Stage 1</td><td>15</td><td>16</td></tr>
<tr><td>Stage 2</td><td>17</td><td>17</td></tr>
</table>
Note:

The TSS concentration limit may be exceeded for water discharged provided that:
the discharge occurs solely as a result of rainfall measured at the premises that exceeds 38.4 mm over any consecutive 5-day period immediately prior to the discharge occurring; and
all practical measures have been implemented to dewater all sediment dams within 5 days of rainfall such that they have sufficient capacity to store run off from a 38.4 mm, 5-day rainfall event.

</td><td>

Conduct preliminary quality assurance of data to confirm an exceedance.
Environmental Manager to implement contingency and notification measures as per section 8.

</td><td>

Hydrologist (or similar specialist) to review sampling and climate data and compare to upstream value to confirm likely mining impact or otherwise. If mine related, undertake physical inspection of affected surface and creeks to identify potential source of water quality degradation.
Implement appropriate management or contingency response (i.e. repair of subsidence cracking, remediation of ponding, erosion control works and rehabilitation).

</td></tr>
<tr><td colspan="5">Vegetation health (ponding)</td></tr>
<tr><td rowspan="2">Surface water ponding does not result in adverse impacts to vegetation of significance.
Sites:

Ponded areas identified above LW203-206, as necessary (identified through visual inspection and survey, see ‘Changes to Watercourse Morphology’ TARP).

Parameters:

Changes in topography
Riparian vegetation health.

Frequency:

Quarterly watercourse visual inspections
Annual remote sensing

Analysis:

Comparison to baseline.

</td><td>Normal</td><td>No adverse impacts on vegetation observed.</td><td>None required.</td><td>

Continue to implement surface water management measures in accordance with this Plan.
Continue routine surface water ponding monitoring and evaluation of results.

</td></tr>
<tr><td>Level 1</td><td>Identified minor impacts to vegetation due to creation of small ephemeral ponds or minor increase or decrease in size and distribution of in-stream ponds.</td><td>Record visual observations, including photographs.</td><td>Investigate options to remediate based on risk assessment (low risk to ecological and/or agricultural function). Remediation options may include:

Re-establish any affected contour banks and revegetate.
Stabilise pond inlet and outlet using graded rock and vegetation enhancement.

</td></tr>
</table>

Performance measure	Status	Trigger	Action	Response
	Level 2	Significant impacts to vegetation identified (e.g. canopy dieback, tree death) due to creation of large semi-permanent ponds or moderate to significant increase or decrease in size and/or distribution of in-stream ponds.	Record visual observations, including photographs.	Investigate options to remediate based on risk assessment (moderate to high risk to ecological and/or agricultural function). Remediation options may include: • Construct drainage channels to create free draining areas and restore affected contour banks • Revegetate fringing areas around residual pond • Exclude stock access from riparian areas • Construct in-stream barriers or drainage channels to reduce or increase the effective size and spatial distribution of pond(s) • Stabilise pond inlet and outlet using graded rock and vegetation enhancement • Dewater ponded area • Reshape surface and infill pond • Re-establish natural drainage channel
Changes in watercourse morphology				
Subsidence due to mining does not impact on the morphology of creeks. **Sites:** • Reaches of Kurrajong Creek Tributary 1 and Kurrajong Creek which traverse the Extraction Plan Area. **Parameters:** • Identification of changes in vegetation, creek grade, bank erosion and sedimentation. **Frequency**: • Monthly visual inspections (monthly subsidence inspections) • Quarterly watercourse visual inspections • Annual remote sensing **Analysis**: • Comparison to baseline.	**Normal**	No identified impacts on water course morphology.	None required.	• Continue to implement surface water management measures in accordance with this Plan. • Continue routine creek line monitoring program and evaluation of results.
	Level 1	Changes in channel cross-section, bed erosion, incision and deposition identified	Record observations, including photographs.	• A qualified geomorphologist will be consulted to develop an action plan which may involve further monitoring or remediation (with consideration given to application of the River Style Framework for classifying channel condition and recovery). • Implement geomorphologists action plan. • Implement contingency and notification measures as per section 8.
	Level 2	Further monitoring identifies remediation works are not performing (i.e. ineffective control measure).	Record observations, including photographs.	• As for Level 1 • If implemented erosion control measures are found to be failing, review causes and replace with like or better. Continue monitoring.
Water take				
Sufficient water entitlement is available for the operation of the Narrabri Mine and water is extracted in accordance with the Eulah Creek WAL held by NCOPL, and the rules prescribed in the WSP.	**Normal**	Annual water take indicates sufficient water entitlement (licensed take) is available.	None required.	Continue subsidence monitoring program.

Performance measure	Status	Trigger	Action	Response
Sites: • Subsidence induced surface cracks. **Parameters:** • Surface crack width, depth, and length **Frequency:** • Monthly and following a significant rainfall event*. **Analysis:** • Calculation of water volume within each crack (W x D x L / 2)	**Level 1**	Cumulative water take for the current water year reaches 95% of water entitlement (licensed take).	Develop plan to complete additional surface cracking repairs, supplementary to the existing planned rehabilitation program, with priority given to zones of surface cracking most likely to be subject to occurrence of stream flow.	• Implement supplementary surface cracking repair plan to accelerate rehabilitation in priority zones of surface cracking. • Transfer additional entitlements from other Whitehaven operations (where feasible) or obtain additional allocation on the open market in accordance with the appropriate trading rules of the relevant WSP.
Groundwater levels – non-Pilliga bores				
Impacts on aquifers are consistent with model predictions. **Sites:** • P1, P2, P3, P4, P5, P8, P9, P10, P11, P12, P13, P39B, P47, P53, WB12, and WB18. **Parameters:** • Water level. **Frequency:** • Standpipe bores - Quarterly manual monitoring of groundwater levels. • VWP bores - automatic groundwater level monitoring via telemetry – reviewed quarterly. **Analysis:** • Review of groundwater level monitoring data. Note: as baseline data is established for additional monitoring bores, where relevant, triggers will be derived and incorporated into the TARP.	**Normal**	Quarterly data review indicates no exceedances of the Tier 1 to Tier 2 trigger levels. OR Quarterly data review indicates one single exceedance of the Tier 1 trigger level. **Trigger levels are provided in Table 6-5.**	Nil	Continue quarterly review of data including assurance and analysis. For a single exceedance of the Tier 1 trigger, the exceedance will be recorded, with no further contingency or notification measures required. If a water level trigger is exceeded at the same location for three consecutive sampling events, then the actions required for Level 1 will be implemented.
	Level 1	Quarterly data review indicates one single exceedance of the Tier 2 trigger level. OR Quarterly data review indicates three consecutive exceedances of the Tier 1 trigger level. **Trigger levels are provided in Table 6-5.**	Conduct preliminary quality assurance and analysis of data to confirm exceedance.	For a single exceedance of the Tier 2 trigger, the exceedance will be recorded, with no further contingency or notification measures required. If a water level trigger is exceeded at the same location for three consecutive sampling events, then the actions required for Level 2 will be implemented. OR Following three consecutive exceedances of the Tier 1 trigger: • Conduct internal investigation on possible links to operational activities and external influences (e.g. climatic data) and report outcomes in the Annual Review. • Seek advice from a suitably qualified hydrogeologist as required. • Monitoring data and review outcomes to be considered in the groundwater model recalibration in accordance with Schedule 4, Condition 9 of the Project Approval.
	Level 2	Quarterly data review indicates three consecutive exceedances of the Tier 2 trigger level. **Trigger levels are provided in Table 6-5.**	• Conduct and internal review of data quality assurance and analysis to confirm exceedance. • Implement contingency and notification measures as per section 8. • Increase monitoring	• Conduct an investigation, including involvement of a suitably qualified hydrogeologist to: ▪ assess historical data and perform statistical trend procedure to remove natural variations; ▪ review groundwater model predictions and assumptions;

Performance measure	Status	Trigger	Action	Response
			frequency to monthly for initial period of up to three months.	▪ assess water level in nearby bores within the same aquifer; ▪ investigate links to operational activities and external influences (e.g. climatic data); ▪ review water takes against licensed allocation; ▪ investigate conceptual model for fracturing and interconnectivity between formations due to subsidence; and ▪ assess potential risk of environmental impacts to sensitive receptors. • Implement reasonable and feasible remediation measures in accordance with hydrogeologist recommendations and in consultation with DPHI. • Monitoring data and outcomes from the investigation to be considered in the groundwater model recalibration in accordance with Schedule 4, Condition 9 of the Project Approval.
Groundwater levels – Pilliga bores				
Impacts on the Pilliga Sandstone aquifer are consistent with model predictions. **Sites:** • P7, P42_90, P54_30. **Parameters:** • Water level. **Monitoring frequency:** • Standpipe bores – monthly manual monitoring of groundwater levels. • VWP bores – automatic groundwater level monitoring via telemetry – reviewed monthly. Note: as baseline data is established for additional monitoring bores, where relevant, triggers will be derived, and bores incorporated into the TARP.	**Normal**	Monthly data review indicates no exceedances of the Tier 1 to Tier 4 trigger levels. OR Monthly data review indicates one single exceedance of the Tier 1 trigger level. **Trigger levels are provided in Table 6-5.**	Nil	Continue quarterly review of data including assurance and analysis. For a single exceedance of the Tier 1 trigger, the exceedance will be recorded, with no further contingency or notification measures required. If a water level trigger is exceeded at the same location for two consecutive sampling events, then the actions required for Level 1 will be implemented.
	Level 1	Monthly data review indicates one single exceedance of the Tier 2 trigger level. OR Monthly data review indicates two consecutive exceedances of the Tier 1 trigger level. **Trigger levels are provided in Table 6-5.**	Conduct and internal review of data quality assurance and analysis to confirm exceedance. AND For two consecutive exceedances of the Tier 1 trigger: • Implement contingency and notification measures as per section 8.	For a single exceedance of the Tier 2 trigger, the exceedance will be recorded, with no further contingency or notification measures required. If a water level trigger is exceeded at the same location for three consecutive sampling events, then the actions required for Level 2 will be implemented. OR Following two consecutive exceedances of the Tier 1 trigger: • Conduct internal investigation on possible links to operational activities and external influences (e.g. climatic data) and report outcomes in the Annual Review. • Seek advice from a suitably qualified hydrogeologist as required. • Monitoring data and review outcomes to be considered in the groundwater model recalibration in accordance with Schedule 4, Condition 9 of the Project Approval.

Performance measure	Status	Trigger	Action	Response
	Level 2	Monthly data review indicates one single exceedance of the Tier 3 trigger level. OR Monthly data review indicates two consecutive exceedances of the Tier 2 trigger level. **Trigger levels are provided in Table 6-5.**	Conduct preliminary quality assurance and analysis of data to confirm exceedance. AND For two consecutive exceedances of the Tier 2 trigger: • Implement contingency and notification measures as per section 8. • Increase monitoring frequency to monthly for initial period of up to three months.	Following two consecutive exceedances of the Tier 2 trigger: • Conduct an investigation, including involvement of a suitably qualified hydrogeologist to: ▪ assess historical data and perform statistical trend procedure to remove natural variations; ▪ review groundwater model predictions and assumptions; ▪ assess water level in nearby bores within the same aquifer; ▪ investigate links to operational activities and external influences (e.g. climatic data); ▪ review water takes against licensed allocation; ▪ investigate conceptual model for fracturing and interconnectivity between formations due to subsidence; and ▪ assess potential risk of environmental impacts to sensitive receptors. If the investigation concludes that the potential risk of environmental impact/s is high, NCOPL will: • conduct technical feasibility reviews to assess potential remediation measures (including establishment of provisional performance measures) in consultation with DPHI, which may include but not be limited to: ▪ reduction in cutting height to limit subsidence; ▪ narrowing panel widths; or ▪ limiting mining to first workings. • Assess approval pathways and considerations for the potential remediation options. • Investigations, technical feasibility, and approval reviews would be targeted for completion within a six-month period (based on an appropriate timeframe for reviewing the groundwater model) in preparation for potential deployment should a Tier 3 trigger be activated. If the investigation concludes that the risk of environmental impacts is low: • monitoring will continue in accordance with Table 6-6 and results reported in the Annual Review.

Performance measure	Status	Trigger	Action	Response
	Level 3	Two consecutive exceedances of the Tier 3 trigger level. **Trigger levels are provided in Table 6-5.**	Conduct preliminary quality assurance and analysis of data to confirm exceedance/s. AND For two consecutive exceedances of the Tier 2 trigger: • Implement contingency and notification measures as per section 8. • Increase monitoring frequency to monthly for initial period of up to three months.	Responses required for Level 2. AND • Revisit and validate investigations completed at Level 2 and assess risk of environmental impact/s to sensitive receptors. • If assessed risk of environmental impact is high, implement reasonable and feasible remediation measures (as assessed at Level 2) in consultation with DPHI. • Review implementation of remediation measures against performance measures to monitor the progress and success of implementation.
	Level 4	Two consecutive exceedances of the Tier 4 trigger level. **Trigger levels are provided in Table 6-5.**	Conduct preliminary quality assurance and analysis of data to confirm exceedance/s. AND For two consecutive exceedances of the Tier 2 trigger: • Implement contingency and notification measures as per section 8. • Increase monitoring frequency to monthly for initial period of up to three months.	Responses required for Level 3. AND Modify remediation and mitigation measures commenced at Level 3 and implement additional mitigation as required in consultation with DPHI.
Groundwater quality				
• Groundwater quality does not exceed trigger values **Sites:** • P1, P2, P3, P4, P7, P8, P9, P10, P11, P12, P13, P16, P19, P29, P31, P32, P39A, P39B, P43, P47, P51, P52, P53, WB2, WB12, and WB18. **Parameters:** • EC and pH. **Monitoring Frequency:** • Quarterly. Note: as baseline data is established for additional monitoring bores, where relevant, triggers will be derived, and bores incorporated into the TARP.	**Normal**	Routine monitoring indicates water quality does not exceed the EC or pH trigger values.	Nil	Continue routine groundwater monitoring and evaluation of results including quality assurance.
	Level 1	Routine monitoring indicates water quality exceeds the EC or pH trigger value (single exceedance). **Trigger values are provided in Attachment 5.**	Conduct preliminary quality assurance and analysis of data to confirm exceedance.	For a single exceedance, the exceedance will be recorded, with no further contingency or notification measures required. If a water level trigger is exceeded at the same location for three consecutive sampling events, then the actions required for Level 2 will be implemented.
	Level 2	Routine monitoring indicates water quality exceeds the EC or pH trigger value over three consecutive monitoring events. **Trigger values are provided in Attachment 5.**	• Conduct preliminary quality assurance and analysis of data to confirm exceedance. • Implement contingency and notification measures as per section 8.	• Engage a suitably qualified hydrogeologist to undertake an assessment and report on any identified changes/likely causes and recommendations. • Implement reasonable and feasible remediation measures in accordance with hydrogeologist recommendations and in consultation with DPHI.

Performance measure	Status	Trigger	Action	Response
Groundwater dependent ecosystem – groundwater level and quality				
• Impacts on alluvium aquifer are consistent with model predictions. • Groundwater quality does not exceed trigger values. **Sites:** • Alluvium monitoring bores (P4, P5 and P39B) **Parameters:** • Water level • pH and EC **Monitoring frequency:** • Quarterly Note: as baseline data is established for the newly constructed bores, trigger levels will be derived (including trigger levels for 10% cumulative variation in water table associated with bores within 40m of a GDE) and relevant bores incorporated into the TARP.	**Normal** **Level 1** **Level 2**	Refer to trigger levels in Groundwater levels – non-Pilliga bores and groundwater water quality TARP components.	Refer to actions in Groundwater levels – non-Pilliga bores and groundwater quality TARP components.	Refer to responses in Groundwater levels – non-Pilliga bores and groundwater quality TARP components.
Groundwater dependent ecosystem – surface conditions				
No adverse impacts to vegetation health (considering natural variation). **Sites:** • Visual inspection sites (VI1-VI8) **Parameters:** • Vegetation health; • Flow rates; • Water level; and • pH and EC. **Monitoring frequency:** • Quarterly	**Normal**	No adverse impacts on vegetation observed.	Nil.	Continue routine visual inspections and evaluation of results.
	Level 1	Quarterly inspection identifies adverse impacts on vegetation.	Record visual observations, including photographs.	• Continue routine visual inspections and evaluation of results. • Review nearby shallow strata monitoring bore data to determine groundwater level trends.
	Level 2	Quarterly inspection identifies significant impacts to vegetation (e.g. canopy dieback, tree death).	• Record visual observations, including photographs. • Implement contingency and notification measures as per section 8.	Engage a suitably qualified hydrogeologist to assess potential risks of environmental impacts and provide contingency responses through investigation of: • historical monitoring data and trends; and • model predictions. Implement reasonable and feasible remediation measures in accordance with hydrogeologist recommendations and in consultation with DPHI

<table>
<tr><th>Performance measure</th><th>Status</th><th>Trigger</th><th>Action</th><th>Response</th></tr>
<tr><td colspan="5">Groundwater inflows</td></tr>
<tr><td rowspan="3">Groundwater inflows are consistent with model predictions.

Sites:
• Underground workings

Parameter:
• Total passive intake of aquifer water

Analysis:
• Annual groundwater forecast modelling.
• Weekly review of actual water take against the predicted water take.</td><td>Normal</td><td>No exceedance of groundwater inflows against model predictions</td><td>Nil</td><td>Continue routine groundwater monitoring and evaluation of results including quality assurance.</td></tr>
<tr><td>Level 1</td><td>Groundwater inflow exceeds predicted water take for two consecutive quarters.</td><td>Conduct preliminary quality assurance and analysis of data to confirm exceedance.</td><td>• Conduct internal investigation on possible links to operational activities and external influences (e.g. climatic data) and report outcomes in the Annual Review.
• Seek advice from a suitably qualified hydrogeologist as required.
• Monitoring data and review outcomes to be considered in the groundwater model recalibration in accordance with Schedule 4, Condition 9 of the Project Approval.</td></tr>
<tr><td>Level 2</td><td>Groundwater inflow rate 100% in excess of the predicted base case mean weekly equivalent inflow rate sustained for three consecutive weeks.

Predicted groundwater take triggers
<table><tr><th>Water year</th><th>TARP Trigger 1 [a]</th><th>TARP Trigger 2 [b]</th></tr><tr><td>2024</td><td>139.5</td><td>21.5</td></tr><tr><td>2025</td><td>156.3</td><td>24.0</td></tr><tr><td>2026</td><td>190.8</td><td>29.3</td></tr><tr><td>2027</td><td>233.5</td><td>35.9</td></tr><tr><td>2028</td><td>264.5</td><td>40.7</td></tr><tr><td>2029</td><td>291.5</td><td>44.8</td></tr><tr><td>2030</td><td>313.0</td><td>48.2</td></tr><tr><td>2031</td><td>309.5</td><td>47.6</td></tr></table>Notes: a = total predicted volume (ML/year) divided by 4 to present average quarterly threshold.
b = total predicted volume (ML/year) divided by 52 to present average weekly threshold and multiplied by 2 to represent 100 % of predicted weekly average</td><td>• Conduct and internal review of data quality assurance and analysis to confirm exceedance.
• Implement contingency and notification measures as per section 8.</td><td>• Conduct an investigation, including involvement of a suitably qualified hydrogeologist to:
▪ assess historical data and perform statistical trend procedure to remove natural variations;
▪ review groundwater model predictions and assumptions;
▪ assess water level in nearby bores;
▪ investigate links to operational activities and external influences (e.g. climatic data);
▪ review water takes against licensed allocation;
▪ investigate conceptual model for fracturing and interconnectivity between formations due to subsidence; and
▪ assess potential risk of environmental impacts to sensitive receptors.
• Implement reasonable and feasible remediation measures in accordance with hydrogeologist recommendations and in consultation with DPHI.
• Monitoring data and outcomes from the investigation to be considered in the groundwater model recalibration in accordance with Schedule 4, Condition 9 of the Project Approval.</td></tr>
</table>

Note:
*Significant rainfall event defined as a rainfall event >38.4 mm over 5 consecutive days.

8. Incidents and non-compliance

8.1 Incident notification

An incident is defined under the Project Approval as *a set of circumstances that causes or threatens to cause material harm, and/or breaches or exceeds the limits of performance measures/criteria*. Material harm to the environment is defined under the Project Approval as *involving actual or potential harm to the health or safety of human beings or to the environment that is not trivial.* This definition excludes "harm" that is authorised under the Project Approval or any other statutory approval (e.g., the Environmental Protection License [**EPL**]).

In the event of any exceedance of the performance criteria, NCOPL will advise the Secretary and any other relevant agencies as soon as practicable after becoming aware of the incident, in accordance with Schedule 6 Condition 4. Within 7 days of the event, NCOPL will also provide the Secretary and any relevant agencies a detailed report which will:

- describe the date, time and nature of the exceedance/incident;
- identify the cause (or likely cause) of the exceedance/incident;
- describe what action has been taken to date; and
- describe the proposed measures to address the exceedance/incident.

Notifications to the EPA will be made by contacting the Environment Line on 131 555 and written details of the notification will be provided within 7 days of the date on which the incident occurred.

Incident reporting and emergency response is further described in NCOPLs Environmental Management Strategy.

8.2 Non-compliance notification

In accordance with Schedule 6 Condition 2, where a non-compliance with a statutory requirement/s or an exceedance of the relevant criteria or performance measures has occurred, NCOPL will, at the earliest opportunity, take all reasonable and feasible steps to ensure that the exceedance ceases and does not recur. Once this has been achieved, all reasonable and feasible options for remediation (where relevant) will be considered.

In accordance with Schedule 6 Condition 4, within seven days of becoming aware of a non-compliance, NCOPL will notify DPHI of the non-compliance[11]. The notification will be made in writing via the Major Projects website and identify the development (including the development application number and name), set out the condition or requirement that the development is non-compliant with, why it does not comply and the reasons for the non-compliance (if known) and what actions have been, or will be, undertaken to address the non-compliance.

NCOPL will implement any reasonable remediation measures as directed by the Secretary, to the satisfaction of the Secretary.

[11] A non-compliance which has been notified as an incident under section 8.1 does not need to also be notified as a non-compliance under section 8.2.

9. Reporting, evaluation and review

Monitoring results will be reviewed against the impact assessment criteria detailed in section 6 and Attachment 5. Where an exceedance of the relevant criteria or performance measure has occurred, NCOPL will implement the actions outlined in the TARP (Table 7-1) and the procedures outlined in section 8. NCOPL will notify potentially affected water users when an elevated monitoring result becomes known and provide updates throughout any investigation or assessment.

Reporting of the water level results from the monitoring network will be included in the Annual Review. The reporting will include a comparison to climate trends and surface water monitoring results to identify changes in the surface water and groundwater interactions (e.g. comparison of groundwater levels to rainfall and estimated recharge).

9.1 Data quality assurance plan

9.1.1 Data collection

The following data quality assurance/quality control (**QA/QC**) procedures will be followed during groundwater level, groundwater quality, and mine inflow data collection.

Groundwater level monitoring

- The primary instrumentation that requires QA/QC checks include steel tapes and electric tapes used to measure groundwater levels. These are to be checked for any faults before every monitoring event. Maintain the tape in good working condition by periodically checking the tape for breaks, kinks, and possible stretch.
- The electric tape is to be recalibrated annually (or more frequently if it is used often) or if the tape has been subjected to abnormal stress that may have caused it to stretch. Cunningham and Schalk (2011) provides more guidance on the use of electrical measuring tapes.
- Pressure transducers used to monitor water levels will be assessed by QA/QC procedures as specified by the vendor and as described in Cunningham and Schalk (2011). Additionally, calibration and maintenance information of specific brands of pressure transducers are provided by the manufacturers and will be consulted.
- The procedure to identify any anomalies and/or outliers is to be followed to validate and justify abnormal data entries. Continuous decline in levels is to be validated against potential equipment faults, changes in monitoring bore construction due to subsidence, changes in levels due to climate, changes in level due to mining and changes in level due to agricultural use. Groundwater level hydrographs will be developed for each monitoring point to identify any outliers in the data collected. If such outliers are identified in the monitoring data, these will be highlighted appropriately and excluded from comparisons with trigger elevations.
- The methods for analysis of groundwater level data are summarised in Figure 9-1. The flowchart outlines the pre-processing steps, including QA/QC undertaken for groundwater level data analysis.
- As indicated in Figure 9-1, manual standing water levels and electronic pressure logger/VWP data will be converted to a reduced water level with respect to Australian Height Datum (**m AHD**). Pressure logger data will be adjusted to remove the effects of barometric pressure changes where required.

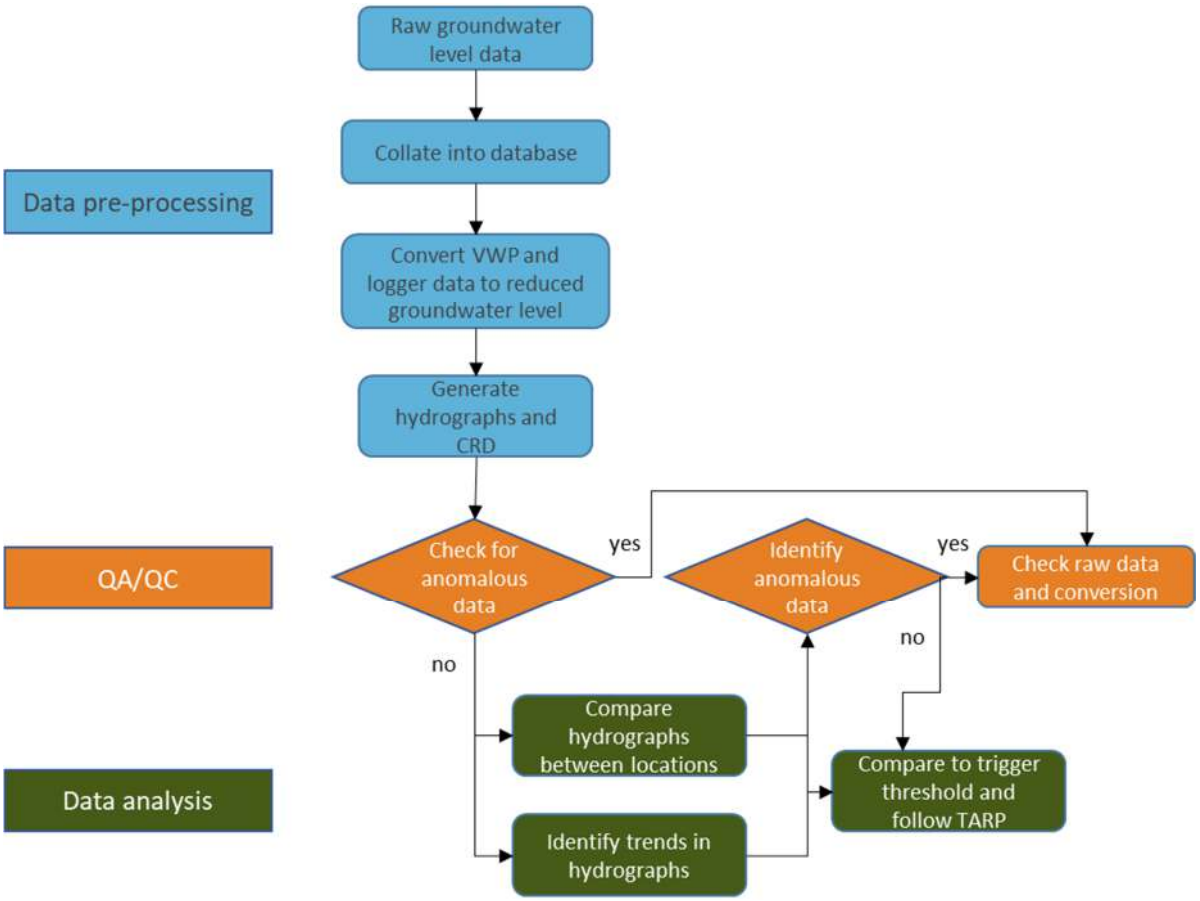


Figure 9-1 Groundwater level data pre-processing and analysis flowchart

Groundwater quality monitoring

Field:

The following field sampling QA/QC procedures will be applied in order to prevent cross-contamination and preserve sample integrity:

- samples are to be collected in clearly labelled bottles with appropriate preservation solutions;
- samples are to be delivered to the laboratories within the specified holding times; and
- pH and EC/TDS (salinity are also measured in the field with calibrated field measurement equipment and then compared against laboratory data).

In addition, a duplicate sample is collected in the field to assess sampling and laboratory analysis accuracy.

Laboratory:

The laboratories conduct their own internal QA/QC program to assess the repeatability of the analytical procedures and instrument accuracy. These programs include analysis of laboratory sample duplicates, spike samples, certified reference standards, surrogate standards/spikes, and laboratory blanks.

Data:

The selected groundwater monitoring bores will have water samples collected for water quality analysis and field pH and EC measurements. The methodology for analysis of groundwater quality data is summarised in Figure 9-2. Similar to the water level flowchart (Figure 9-1), this flowchart outlines the pre-processing, including QA/QC, as well as the steps that will be undertaken for groundwater quality data analysis.

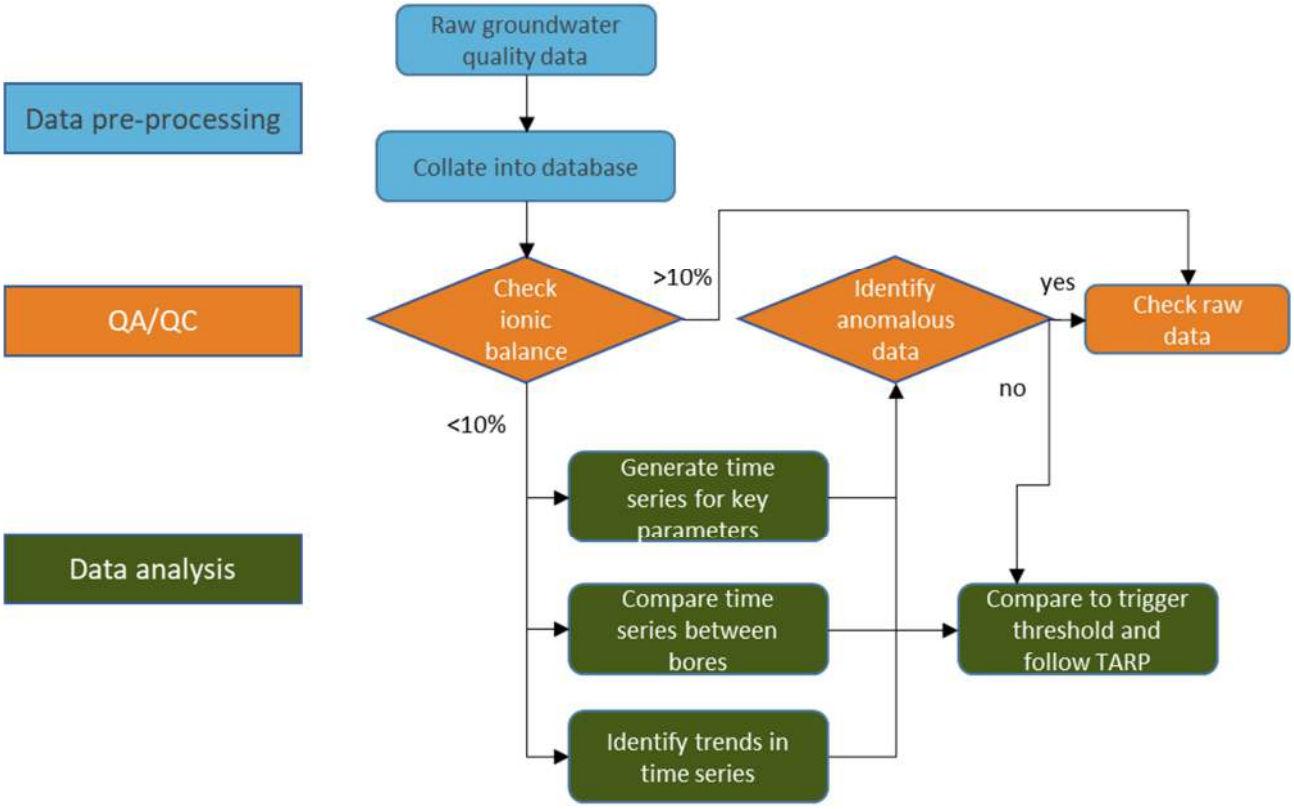


Figure 9-2 Groundwater quality data pre-processing and analysis procedures

9.1.2 Data analysis

All data on groundwater levels, groundwater quality, and data quality control is to be provided in a csv format to accompany the release of Annual Reviews.

9.1.3 Maintenance strategy

Narrabri Mine's maintenance strategy and philosophy is based on planned preventative maintenance principles. The Maintenance Strategy is a program of planned maintenance tasks that consider statutory obligations and is designed to maximise the reliability and availability of the equipment.

The Maintenance Strategy separates equipment types and breaks the equipment into components for the allocation of specific maintenance tasks at the necessary frequency. These maintenance tasks are managed using a Computerised Maintenance Management System (CMMS). The system generates the planned work schedule.

Work order schedules and supporting documentation are periodically reviewed (maximum 3 years) for adequacy and accuracy. Defect work orders are raised through the defect management process and are scheduled for completion based on priority.

9.2 Groundwater model

The groundwater model (AGE, 2024) will be used as a management tool for the periodic review and validation of predicted groundwater impacts throughout the life of mine. NCOPL will update the model every five years in accordance with Schedule 4, Condition 9 of the Project Approval and in consultation with DCCEEW Water Group. If significant impacts on groundwater above the mine are identified, then NCOPL will reduce the period from five years to three years for at least the next update to capture new knowledge acquired.

The results of the groundwater monitoring program will assist to refine the numerical model, having regard to any impacts that may be occurring at the time due to the cumulative operation of the Narrabri Mine and the Narrabri Gas Project. Model calibration will predominantly use the available groundwater level data, estimated actual mine inflows and estimated baseflows in major local water courses. The re-calibration will include forward impact predictions of brine re-injection to the mine's goaf at the conclusion of mining operations.

Other circumstances which may trigger further development or refinement of the groundwater model include:

- a significant change to the mine plan and/or sequence;
- acquisition of new hydrogeological information, such as groundwater levels and aquifer properties (i.e. hydraulic conductivity) which are different to calibrated values used in the model; and
- groundwater drawdown and inflows which significantly exceed model predictions for that stage of mining.

Revised outputs from the numerical model will be reported periodically over the life of mine.

Should any review or post-audit indicate a significant variance from the model predictions with respect to either water quality or groundwater levels, then the implications of such variance will be assessed, and appropriate response actions implemented in consultation with DCCEEW Water Group as appropriate. This may also include an independent peer review as requested by the Secretary.

9.3 Annual hydrogeologist review

As part of the annual monitoring program, NCOPL will commission an experienced hydrogeologist to collate and review the monitoring data collected. The hydrogeologist will provide the findings in an Annual Hydrogeologists Report, including a summary of the mine's environmental performance over the preceding year in relation to groundwater inflows, groundwater levels and groundwater quality (e.g. the EC Tier 1 trigger 80th percentile rolling median as described in section 6.2.6), and compare observed groundwater quality and groundwater levels to the trigger values presented in section 6.2.7 and Attachment 5.

The review will also:

- compare any observed impacts with those predicted in the groundwater modelling and, if significant variation is found between predicted impacts and observed operational monitoring data, then notification of proposed remediation will be submitted to DPHI;
- revise trigger levels as additional monitoring information becomes available and, if required, the EP-WMP will be updated to reflect any changes to site-specific trigger levels listed in Table 6-5;

- assess if available drawdown attributable to the mine for the existing groundwater users is reduced by over 15%;
- identify relationships between measured EC and TDS in mine water and groundwater in the Hoskissons Seam and adjoining aquifers from the collection of adequate samples over time and evaluating this data for comparison (i.e. trends);
- assess trends in water level and quality data at standing pools with comparison to associated shallow aquifer water level and quality data to determine possible connectivity;
- implement procedures from ANZG (2018) to establish, update and report on site-specific baseline status, variability and the early detection of state trends and change against trigger values for each water-quality objective using control charts and with uncertainty estimated from quality control measures;
- establish and assess the ongoing suitability of appropriate factors for converting EC to TDS for each sampling site with consideration of the influence of major ionic composition; and
- Report/present groundwater inflow data at a monthly timescale (not annual).

9.4 Annual Review

In accordance with Schedule 6 Condition 6, NCOPL will review the performance of its environmental management for the previous calendar year and report the relevant results within the Annual Review, to the satisfaction of the Secretary. The Annual Review will at minimum provide information regarding the effectiveness of the management measures to prevent, and if prevention is not reasonable and feasible, to minimise any impact on water.

Further, the Annual Review requires a number of items to be reviewed or assessed. In summary these are:

- monitoring results and complaints;
- non-compliances and incidents;
- compliance with performance measures;
- discrepancies between predicted and actual impacts; and
- measures to be implemented to improve environmental performance.

NCOPL will include maps, hydrographs, and/or other visual tools within the Annual Review to present the groundwater monitoring results with reference to the NSW Government *Guidelines for Groundwater Documentation for SSD/SSI Projects. Technical guideline.* (DPE, 2022). The results will display both recent and historical datasets (including baseline). In addition, all data on groundwater levels, quality, and data quality control will be provided separately to DCCEEW Water Group in csv format to accompany the Annual Review.

The Annual Review may also make recommendations for any additions, changes, or improvements to NCOPLs environmental management procedures.

The Annual Review will be made available on the WHC website.

9.5 Independent environmental audits

Prior to 13 September 2010, and every 3 years thereafter, unless the Secretary directs otherwise, NCOPL will commission and pay the full cost of an Independent Environmental Audit (**IEA**) of the development (Stages 1 and 2), to be conducted in accordance with the requirements of Schedule 6 Condition 7.

The audit team will be led by a suitably qualified auditor and the IEA will be conducted by suitably qualified, experienced and independent team of experts whose appointment has been endorsed by the Secretary.

9.6 Management plan review and evaluation

As required by Schedule 6 Condition 3 of the Project Approval, within three months of any of the following:

- completion of an IEA (as required by Schedule 6 Condition 7);
- submission of an Incident Report (as required by Schedule 6 Condition 4);
- submission of an Annual Review (as required by Schedule 6 Condition 6); and
- any modification to the conditions of the Project Approval (unless the conditions require otherwise).

NCOPL will then review, and if necessary, revise this EP-WMP. This is to ensure that the strategies, plans and programs are updated on a regular basis, and incorporate any recommended measures to improve the environmental performance of the Narrabri Mine operations.

Condition 3 of Schedule 6 further states that if the review determines that this EP-WMP requires revision, then this will be completed to the satisfaction of the Secretary. A dedicated review register will be maintained which will provide the details of the review of all relevant strategies, plans and programs that need to be reviewed as required by Schedule 6 Condition 3 of the Project Approval. The revision status of this EP-WMP is indicated in section 14.

9.7 Improvement measures

Project Approval Schedule 6 Condition 2(f) requires this Plan to include a program to investigate and implement ways to improve the environmental performance of the development over time. Improvement measures may be investigated through review of the following:

- monitoring data, and any assessment of trends;
- audit outcomes, including audits of water management measures; and
- incident reports, including any community complaints.

Reasonable and feasible improvement measures will be implemented and documented as a management measure in a revision to the Plan as described above.

9.7.1 Research sampling program

The DCCEEW Water group, in correspondence OUT24/17840 dated 15 November 2024, recommended that the EP-WMP include *'Age dating isotopes and methane in the groundwater quality sampling suite for a selection of bore monitoring sites and passive mine inflow to evaluate cross-connectivity and changes over time.'*

Work recently undertaken by CSIRO (Raiber et al, 2022) focusses on the adjacent Narrabri Gas Project lease area. Based on analysis of electrical conductivity, methane and radiocarbon data, CSIRO concluded that there is "no or only very limited hydrogeological connectivity between the Pilliga Sandstone and underlying Gunnedah Basin formations" in the southern and eastern part of the Narrabri Gas Project area (i.e. adjacent to the Narrabri Coal Mine lease area; Raiber et al, 2022). This conclusion is based on the finding that the Gunnedah Basin strata contains significantly more saline groundwater with higher methane concentrations

and lower radiocarbon such that even a small volume of inflow into the overlying Pilliga Sandstone would be "readily noticeable within the Pilliga Sandstone" (Raiber et al, 2022).

NCOPL proposes to undertake a sampling program for methane (CH_4) and radiocarbon dating (^{14}C and ^{36}CL) to further support the conclusions made by CSIRO. A hydrogeologist will be engaged in 2025 to undertake this work.

The scope of works is expected to include the following:

- initial study design;
- consultation with CSIRO;
- sampling;
- data analysis, interpretation and reporting; and
- provision for re-assessment every 5 years over the life of the project.

The proposed scope of work includes consultation with CSIRO to confirm that similar sampling and other methodologies are applied to ensure that the findings are robust and comparable to the existing work.

The sampling program will include sixteen (16) groundwater monitoring points, the majority of which are located towards the west of the mining lease in areas where both the Gunnedah Basin strata and Pilliga Sandstone are present:

- Near surface strata:
  - P91 and P92 (at Mayfield Spring)
- Surat Basin:
  - Pilliga Sandstone: P7 and P90
  - Purlawaugh Formation: P8, P9, P11, P72
  - Garrawilla Volcanics: P13 and P16.
- Gunnedah Basin:
  - Napperby Formation: P10 and P12
  - Hoskissons Coal Seam: Mine water (4 samples)

Consistent with previous work undertaken by CSIRO (Raiber et al, 2022), the data analysis stage of this study will likely also include detailed analyses of temporal, historical hydrochemical datasets from NCOPL's groundwater monitoring database including:

- hierarchical clustered analysis (HCA) using available datasets of pH, Ca, Mg, Na, K, HCO_3, Cl, F, SO_4;
- EC and spatial distribution of salinity (i.e. EC and Chloride/bromide ratios); and
- spatial distribution of bicarbonate.

10. Complaints management

Any complaints received in relation to water will be managed in accordance with the complaints management protocol as follows:

- Publicly advertised telephone complaints line, 1800WHAVEN, will be in place to receive complaints.
- Each complaint received will be recorded in a Complaints Register, which will include the following details:
  - date and time of complaint;
  - method by which a complaint was made;
  - personal details the complainant wishes to provide or, if no such details are provided, a note to that effect;
  - nature of the incident that led to the complaint;
  - action taken by NCOPL in relation to the complaint (i.e., any required remedial actions), including any follow-up contact with the complainant; and
  - if no action was taken, the reason why no action was taken.
- The Environmental Superintendent will be responsible for ensuring that an initial response is provided within 24 hours of receipt of a complaint (except in the event of complaints recorded when the mine is not operational or outside of usual business hours).
- Once the identified measures are undertaken, the Environmental Superintendent will sign off on the relevant complaint within the Complaints Register.
- If necessary, follow-up monitoring will take place to confirm the source of the complaint is adequately mitigated.
- A summary of the complaints will be maintained by NCOPL and made available to the Community Consultative Committee, the complainant (on request) and on the WHC website. A summary of complaints received every 12 months will be provided in the Annual Review.

In the event that any complainant considers that NCOPL has not adequately addressed their concerns, the NCOPL representative will convene additional meetings with the complainant.

11. Plan implementation

11.1 Roles and responsibilities

During the operational phases of the development, the Narrabri Mine will be managed by the General Manager who will have overall responsibility for ensuring contractors, employees and service providers comply with all laws, regulations, licences, and approvals. Table 11-1 outlines the roles and responsibilities applicable to this EP-WMP.

Table 11-1 Roles and responsibilities

Roles	Responsibilities
General Manager	• Ensure that adequate resources are available to NCOPL personnel to facilitate the completion of their responsibilities under this EP 203-206.
Mining Engineering Manager	• Ensure all contractors, sub-contractors and service-personnel are appropriately qualified, competent, and licensed to undertake the required work under this EP 203-206.
Environmental Manager	• Review and authorisation of changes to this EP 203-206 • Responsible for decision making in relation to the activation of TARP responses and/or contingency planning. • Manage incident, non-compliance and other reporting requirements. • Communicate with statutory agencies and departments, public authorities, and the community.
Environmental Superintendent	• Ensure that all environmental monitoring and reporting is undertaken in accordance with this EP 203-206 and various approval requirements, and is checked, processed, and filed appropriately. • Advise on matters identified in all approval, permit, licence, and consent documents and ensure all operations are conducted in compliance with those conditions, and all other environmental obligations.
Surface Operations Manager	• Provides notification to all mine personnel advising of potential subsidence hazards and impacts. • Maintains access to critical surface infrastructure and facilitates inspections and remedial works.
Civil Services Coordinator	• Inspect and monitor the condition and safety of roads and tracks around the mine site. • Remediates subsidence impacts to maintain trafficability of access roads and tracks.
Technical Services Manager	• Provide technical advice to support decision making in relation to the activation of TARP responses and/or contingency planning. • Liaise with stakeholders regarding subsidence impact management. • Decommission mining infrastructure prior to subsidence impacts.
Registered Mine Surveyor	• Ensure the subsidence monitoring program is implemented and adhered to.

12. References

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Whitehaven (2022). *Narrabri Mine Extraction Plan Water Management Plan Panels 201 – 202*.

13. Glossary

Term	Definition
Active subsidence	The period of time that movement of the ground can occur after underground mining.
Angle of Draw (AoD)	The angle with the vertical, made by a straight line extending away from the limits of extraction at seam level to the ground surface, spanning the horizontal distance in which subsidence may occur.
Chain pillar	The pillar(s) of coal left between adjacent longwall panels. This forms a barrier that allows the goaf to be sealed off and facilitates tailgate roof stability.
Compressive strain	A decrease in the distance between two points on the surface. This can cause shear cracking or steps at the surface if > 3 millimetres per metre (mm/m).
Cover depth	The depth of coal seam from the ground surface (metres).
Department	Planning and Assessment Group within the NSW Department of Planning, Housing and Infrastructure (formerly the NSW Department of Planning and Environment [DPE]).
Development	The Stage 2 development described in the EA as modified by the Project Approval.
Environmental consequences	The environmental consequences of subsidence impacts including: damage to built features; loss of surface flows to the subsurface; loss of standing pools; adverse water quality impacts; development of iron bacterial mats; cliff falls; rock falls; damage to Aboriginal heritage sites; impacts to aquatic ecology; ponding.
Extraction Plan Area	The area predicted to be affected by the proposed secondary extraction of the approved longwall panels LW 203 to LW 206.
First workings	Development of the main headings and gate roads to establish access to the coal in the mining area.
Goaf	The mined-out area into which the immediate roof strata breaks.
Groundwater	Water contained in the interconnected pore spaces and voids of the saturated zone of sediments and rocks.
Incident	A set of circumstances that causes or threatens to cause material harm to the environment, and/or breaches or exceeds the limits of performance measures/criteria in the Project Approval.
Material harm	Material harm to the environment is defined in section 147 of the POEO Act.
Mining Operations	The extraction, processing, and transportation of coal on the site, including the formation of mine access drifts and associated surface infrastructure such as gas and water drainage facilities.
MOD 5	Reduced the number of longwall panels from 26 to 20; increased the longwall panel widths for LW 107 to LW 120 from approximately 295 m to approximately 400 m; extended the western footprint approximately 60 m; and increased the maximum ROM coal processing rate from 8 Mtpa to 11 Mtpa.
MOD 7	Describes the change in mining method within the extent of the previously approved LW 201 and LW 202 and allows for up to 0.7 Mtpa via bord and pillar extraction at pillar reduction panels CF 201 to CF 205.
Narrabri Mine	The development approved under Project Approval 05_0102 and Project Approval 08_0144.
Pollution incident	Has the same meaning as in the POEO Act.
Project Approval	Development consent (PA 08_0144) issued on 26th July 2010 under Section 75J of *the Environmental Planning and Assessment Act 1979* by the Department of Planning & Infrastructure (as modified).
Raffinate	Treated process water from the Water Conditioning Plant.

Term	Definition
Rehabilitation	The treatment or management of land disturbed by the project for the purpose of establishing a safe, stable and non-polluting environment including the remediation of impacts.
Remediation	Activities associated with partially or fully repairing or rehabilitating the impacts of the project or controlling the environmental consequences of this impact.
Second workings	Extraction of coal from longwall panels, mini-wall panels, or pillar extraction.
Secretary	Planning Secretary under the EP&A Act, or nominee
Stage 1	The project approval granted by the Minister Planning for the Narrabri Coal Project, dated 14 November 2007.
Stage 2	Narrabri Mine Stage 2 approved under Project Approval 08_0144.
Statement of Commitments	The Proponent's revised commitments in Appendix 3 of the Project Approval, dated May 2010.
Subsidence	The totality of subsidence effects, subsidence impacts and environmental consequences of subsidence impacts.
Subsidence effects	Deformation of the ground mass due to mining, including all mining-induced ground movements, such as vertical and horizontal displacement, tilt, strain and curvature.
Subsidence impacts	Physical changes to the ground and its surface caused by subsidence effects, including tensile and shear cracking of the rock mass, localised buckling of strata caused by valley closure and upsidence and surface depressions or troughs.
Tailgate	Refers to the tunnels or roadways down the side of a longwall block which provides a ventilation pathway for bad or dusty air away from the longwall face. It is usually located on the side of the longwall panel adjacent to extracted panels or goaf.
Tensile strain	An increase in the distance between two points on the surface. This is likely to cause cracking at the surface if it exceeds 2 mm/m. Tensile strains are usually associated with convex (hogging) curvatures near the sides (or ends) of the panels.
the Proponent	Narrabri Coal Operations Pty Ltd
Tilt	The rate of change of subsidence between two points (A and B), measured at set distances apart (usually 10m). Tilt is plotted at the mid-point between the points and is a measure of the amount of differential subsidence.
Upsidence	Relative vertical upward movements of the ground surface associated with subsidence.
Vertical subsidence	Vertical downward movements of the ground surface caused by underground coal mining.
Watercourse	A river, creek or other stream, including a stream in the form of an anabranch or tributary, in which water flows permanently or intermittently, regardless of the frequency of flow events: In a natural channel, whether artificially modified or not, or in an artificial channel that has changed the course of the stream. It also includes weirs, lakes and dams.

14. Review history

Revision	Comments	Author	Authorised by	Date
0B	Issued for approval	Onward Consulting	B. Baker	21 August 2024
0C	Amended based on agency review	Onward Consulting	B. Baker	24 January 2024

Attachment 1 Compliance conditions relevant to this Plan

Table A1-1 Project Approval conditions relevant to this Plan

Project Approval 08_0144 conditions		Document reference
Condition	**Requirement**	
Schedule 2 Condition 1	The Proponent shall implement all practicable measures to prevent and/or minimise any harm to the environment that may result from the construction, operation, or rehabilitation of the project.	Section 5
Schedule 2 Condition 11	With the approval of the Secretary, the Proponent may submit any management plan or monitoring program required by this approval on a progressive basis. ***Note**: The conditions of this approval require certain strategies, plans, and programs to be prepared for the project. They also require these documents to be reviewed and audited on a regular basis to ensure they remain effective. However, in some instances, it will not be necessary or practicable to prepare these documents for the whole project at any one time, particularly as these documents are intended to be dynamic and improved over time. Consequently, the documents may be prepared and implemented on a progressive basis, subject to the conditions of this approval. In doing this however, the Proponent will need to demonstrate that it has suitable documents in place to manage the existing operations of the project.*	There is no staging of the EP-WMP
Schedule 3, Condition 4 (h)	The Proponent shall prepare and implement Extraction Plans for any second workings to be mined to the satisfaction of the Secretary. Each Extraction Plan must: include a: • Water Management Plan, which has been prepared in consultation with EPA and DPIE Water, which provides for the management of the potential impacts and/or environmental consequences of the proposed second workings on surface water resources, groundwater resources and flooding, and which includes:	Section 1.4.2 Section 1.6
	▪ surface and groundwater impact assessment criteria, including trigger levels for investigating any potentially adverse impacts on water resources or water quality;	Section 6.1.2 Section 6.2.6 Section 6.2.7
	▪ a program to monitor and report groundwater inflows to underground workings; and	Section 6.2.5
	▪ a program to manage and monitor impacts on groundwater bores on privately-owned land;	Section 6.2.3
	***Notes**:* *Management plans prepared under condition 4(h) should address all potential impacts of proposed underground coal extraction on the relevant features. Other similar management plans required under this approval (eg under conditions 13 and 23 of schedule 4 or condition 3 of schedule 5) are not required to duplicate these plans or to otherwise address the impacts associated with underground coal extraction.*	
Schedule 3 Condition 5	The Proponent shall ensure that the management plans required under condition 4(h) above include:	
	(a) an assessment of the potential environmental consequences of the Extraction Plan, incorporating any relevant information that has been obtained since this approval;	Section 3

Project Approval 08_0144 conditions		Document reference
Condition	**Requirement**	
	(b) a detailed description of the measures that would be implemented to remediate predicted impacts; and	Section 5
	(c) a contingency plan that expressly provides for adaptive management.	Section 7
Schedule 6, Condition 2	The Proponent shall ensure that the management plans required under this approval are prepared in accordance with any relevant guidelines, and include:	
	(d) detailed baseline data;	Section 2
	(e) a description of:	
	• the relevant statutory requirements (including any relevant approval, licence or lease conditions);	Section 1.4
	• any relevant limits or performance measures/criteria;	Section 4 Section 6.1.2 Section 6.2.6 Section 6.2.7
	• the specific performance indicators that are proposed to be used to judge the performance of, or guide the implementation of, the project or any management measures	Section 4
	(f) a description of the measures that would be implemented to comply with the relevant statutory requirements, limits, or performance measures/criteria:	Section 5 Section 6
	(g) a program to monitor and report on the:	
	• impacts and environmental performance of the project;	Section 6
	• effectiveness of any management measures (see (c) above);	
	(h) a contingency plan to manage any unpredicted impacts and their consequences;	Section 7
	(i) a program to investigate and implement ways to improve the environmental performance of the project over time;	Section 9.6
	(j) a protocol for managing and reporting any;	
	• incidents;	Section 8.1
	• complaints;	Section 10
	• non-compliances with statutory requirements; and	Section 8.2
	• exceedances of the impact assessment criteria and/or performance criteria; and	
	(k) a protocol for periodic review of the plan.	Section 9.6
Schedule 6 Condition 3	Within 3 months of the submission of an:	Section 9.6
	(a) audit under condition 7 of Schedule 6;	
	(b) incident report under condition 4 of Schedule 6; and	
	(c) annual review under condition 5 of Schedule 6; and	

Project Approval 08_0144 conditions		Document reference
Condition	**Requirement**	
	(d) any modification to the conditions of this approval (unless the conditions require otherwise),	
	the Proponent shall review, and if necessary revise, the strategies, plans, and programs required under this approval to the satisfaction of the Secretary.	
Schedule 6 Condition 4	The Proponent shall notify the Secretary in writing via the Major Projects website and any other relevant agencies of any incident associated with the project as soon as practicable after the Proponent becomes aware of the incident. Within 7 days of the date of the incident, the Proponent shall provide the Secretary and any relevant agencies with a detailed report on the incident.	Section 8
Schedule 6 Condition 5	The Proponent shall provide regular reporting on the environmental performance of the project on its website, in accordance with the reporting arrangements in any plans or programs approved under the conditions of this approval, and to the satisfaction of the Secretary.	Section 1.7 Section 9.3
Schedule 6 Condition 6	By the end of March each year, the Proponent must submit a review of the environmental performance of the project for the previous calendar year to the satisfaction of the Secretary.	Section 9.4
Schedule 6 Condition 7	Prior to 13 September 2010, and every 3 years thereafter, unless the Secretary directs otherwise, the Proponent shall commission and pay the full cost of an Independent Environmental Audit of the project (Stages 1 and 2).	Section 9.5
Schedule 6 Condition 10	The Proponent shall: (a) make copies of the following publicly available on its website: • the documents referred to in Condition 2 of Schedule 2; • all current statutory approvals for the project; • all approved strategies, plans and programs required under the conditions of this approval; • a comprehensive summary of the monitoring results of the project, reported in accordance with the specifications in any conditions of this approval, or any approved plans and programs; • a complaints register, updated on a monthly basis; • minutes of CCC meetings; • the annual reviews of the project; • any independent environmental audit of the project, and the Proponent's response to the recommendations in any audit; • any other matter required by the Secretary; and	Section 1.7 Section 9.4 Section 9.5 Section 10
	(b) keep this information up-to-date, to the satisfaction of the Secretary.	Section 1.7

Table A1-2 Relevant SoCs

SoC requirements		WMP reference
SoC	**Summary of the requirement**	
5.4	Undertake a detailed condition assessment of the 3rd order waterways within the predicted subsidence zone to enable assessment of changes post mining.	Section 2.1.1
5.5	Inspect local drainage lines above the active and completed longwall panels. Monitoring should assess any restriction of flows and hence restriction of fish passage to facilitate appropriate restorative measures.	Section 6.1 Section 6.1.5
5.6	Undertake water quality sampling from watercourses within the impact zone to determine any impacts on sediment loading and other parameters including salt loads	Section 6.1.3
5.10	In the event of erosion within Mine Site watercourses, stabilise the damaged or eroded banks in accordance with an Erosion and Sediment Control Plan.	Section 5.5
5.11	Establish survey lines along ephemeral drainage gullies and along gully crests and monitor during and after mining of each longwall panel to identify any signs of cracking or ‘upsidence’.	Section 6.1.5
5.15	Inspect the watercourses over the subsidence zone to identify the location and extent of ponding.	Section 6.1.5
5.16	For ponding where there is little or no vegetation of conservation significance, monitor the location and extent of ponding.	Section 6.1.5
6.17	Undertake remedial action if the available drawdown attributable to the mine for the existing groundwater users is reduced by over 15%. In the event that an existing water supply is deemed (by the hydrogeologist) to be adversely affected by the Longwall Project, the Proponent will mitigate, or compensate for this impact through the provision of a replacement water supply.	Section 9.3
12.12	Minimise erosion on the Mine Site as a consequence of subsidence.	Section 5.5

Attachment 2 Consultation records

DOC22/989569-5
15 November 2022

Mr Brent Baker
Manager HSE – Narrabri Coal Operations
Whitehaven Coal Limited
10 Kurrajong Creek Rd,
Baan Baa NSW 2390
Email: BrentBaker@whitehavencoal.com.au

No Comment to Post Approval Advice Request

Dear Mr Baker

Thank you for the request for advice from Public Authority Consultation (PAE-50414707), requesting input from the NSW Environment Protection Authority (EPA) on the draft (Revision A) Extraction Plan - Water Management Plan for the Narrabri Coal Mine Stage 2 Project (PA 08_0144) at 10 Kuarrjong Creek Road, Baan Baa NSW 2390.

The NSW Environment Protection Authority (EPA) does not endorse or approve plans prepared for the purpose of project approvals and does not make representations in relation to the adequacy or completeness of any plans prepared for the purpose of project approval.

In view of these factors, the EPA has no comments to provide on this project and no follow-up consultation is required.

If you have any questions about this request, please contact Mr Lindsay Fulloon on (02) 6773 7000 or via email at info@epa.nsw.gov.au.

Yours sincerely

LINDSAY FULLOON
Manager Regulatory Operations

Department of Planning and Environment

Our ref: OUT23/150

Brent Baker
10 Kurrajong Creek Rd,
Baan Baa NSW 2390 Australia

Email: [redacted]

23 January 2023

Subject: **Narrabri Mine – Extraction Plan LW203-LW206 – Consultation Request**

Dear Brent Baker

I refer to your request for advice sent on 9 November 2022 to the Department of Planning and Environment (DPE) Water about the above matter.

The Department of Planning and Environment- Water makes a number of recommendations to improve the monitoring, management and reporting of surface and groundwater for the project. Further while it appears that groundwater triggers in the Water Management Plan (WMP) have been exceeded, we are not aware of the required responses being carried out.

Please note our detailed advice is in Attachment A.

Should you have any further queries in relation to this submission please do not hesitate to contact DPE Water Assessments at water.assessments@dpie.nsw.gov.au

Yours sincerely,

Mitchell Isaacs
Chief Knowledge Officer
Department of Planning and Environment: Water

Attachment A

Detailed advice regarding the Narrabri Mine - Extraction Plan LW203-LW206

1.0 Water Take and Licensing

1.1 Recommendation

That the proponent develops a methodology to determine surface water take due to subsidence related cracking prior to any surface cracking occurring.

1.2 Recommendation

That the proponent ensures sufficient water entitlement is held in a water access licence to account for the maximum water take for each water source prior to take occurring.

1.3 Explanation

Ensuring a suitable and approved methodology is in place to quantify surface water take prior to the take occurring is critical to inform water licence requirements at the site. It is understood the methodology is to be investigated within 12 months of the commencement of the Extraction Plan, however the proponent needs to ensure this is in place prior to any water take occurring.

2.0 Groundwater impact monitoring and management

2.1 Recommendation

That the Water Management Plan of the Extraction Plan be amended to:

- establish groundwater level triggers for monitoring bores of the GAB, including the Pilliga Sandstone within the GAB Southern Groundwater Recharge water source. This will require extending the monitoring network to more locations and requires consideration of timeline of impact through early indicators. A specific performance measure utilising a tiered approach is recommended for the Pilliga Sandstone as follows:
    - Tier 1 > 5m drawdown in the Pilliga Sandstone - all future westward panels revert back to original longwalls panels and reduce mining heights to that originally approved for Stage 2. This would reduce the vertical fracturing and extent of depressurisation into the Pilliga Sandstone.
    - Tier 2 at >10m drawdown in the Pilliga Sandstone - a cessation of mining further panels westward beneath the GAB or limit mining to first workings only. This would account for the fact that drawdown has doubled from that predicted for Stage 3 approval and that peak drawdowns are still yet to eventuate due to the lag in groundwater flow and any cumulative impact yet to be realised from other approved projects.
- establish performance targets to monitor, evaluate and report on high priority GDEs,
- ensure mitigation strategies for aquifer impacts are consistent with those approved in existing development consents, and
- modify the frequency of measuring the metered mining inflow and outflow from monthly to weekly and adjusting the response plan to excessive inflow from 3 consecutive months to 3 consecutive weeks.

2.2 Explanation

The Extraction Plan (EP) does not sufficiently define a process to manage and constrain groundwater related impacts to limits consistent with that presented at the approval assessment stage. This applies in particular to the protection of the Great Artesian Basin (GAB) and 'high priority' groundwater dependent ecosystems.

There is evidence of declining groundwater level trends in the aquifers of the GAB beyond that which was presented for the initial Stage 2 development consent and an increased risk that depressurisation impacts will exceed that presented for the Stage 3 approval. DPE Water seeks the establishment of thresholds, reporting processes and timeline development to ensure the project operates within impacts forecast at development consent, and the mitigation strategies put forward by the proponent will be enacted upon should impacts beyond that presented for approval eventuate.

The EP describes that CSIRO (2007), SCT (2008) and Tametta (2013) model results all indicate full depressurisation of the overburden, however the EP recommends the reader to consider these estimates as likely to give conservative results for estimating depressurisation. This indicates a potential for excessive aquifer depressurisation in the GAB Pilliga Sandstone both on and off lease.

Permitting excessive water level declines in the GAB conflicts with the Great Artesian Basin Strategic Management Plan 2019 to which the NSW Government is a signatory. This GAB Plan contains objectives for the protection of the GAB including:

> *" ...that industry measures are put in place to minimise impacts from mining and other resource extraction on groundwater recharge and Basin groundwater dependent ecosystems, including springs."*

Additionally, the NSW Aquifer Interference Policy (AIP) defines Level 1 impacts for the GAB Southern and Eastern Recharge Groundwater Sources including:

> *"a cumulative pressure level decline of not more than 15m, allowing for typical climatic "post-water sharing plan variations'.*

There are stratigraphic units that make up the GAB Southern Recharge Groundwater Source, where collectively the predicted drawdowns from the Narrabri Coal Project will exceed 15m (Purlawaugh Formation and Garrawalla Volcanics). However, it is the shallower Pilliga Sandstone that is the primary aquifer for management and protection and is the focus of this review. The groundwater impact assessment for the Stage 2 approval stated the Pilliga Sandstone would not be impacted by depressurisation. However, the assessment for the Stage 3 approval informed of cumulative drawdowns of up to 5m in two isolated sections of the Pilliga Sandstone. The stage 3 impacts are deemed to be appropriate to define trigger limits and response protocols.

The tiered performance measure approach recommended above was put forward by the proponent to address the uncertainty in subsidence related impacts when obtaining development consent but has not been carried forward into the Extraction Plan.

Mitigation strategies for impacts to aquifers greater than that predicted were presented in the EA that supported the Mod 5 application. Mitigation strategies were presented in a tiered order of increasing impact and included:

(i) grading of cracks;
(ii) decreasing mining widths and heights, and
(iii) leaving a barrier or limit mining to first working (ref: Mod 5 Appendix A Section 9.3.10).

However, the current Extraction Plan only brings forward the remediation option to remediate cracks and is silent on the other mitigation strategies to manage impacts as put forward for obtaining development consent.

2.3 Recommendation

That the Water Management Plan of the Extraction Plan be amended to include the requirement for regular InSAR subsidence reports and to interpret those in association with groundwater level monitoring.

2.4 Explanation

InSAR subsidence reports provide data to support subsidence impact interpretations.

2.5 Recommendation

That Annual Review reports prepared for this project be amended to:

- improve the presentation of the monitoring data and the use of maps, hydrographs and other visual tools reported in the Annual Review. The data should display recent and historical datasets (incl baseline).The SSD groundwater guidelines (https://water.dpie.nsw.gov.au/science-data-and-modelling/groundwater-management-and-science/groundwater-document-library) should be consulted to that effect.
- include documentation of quality assurance and controls.

2.6 Explanation

Comprehensive reporting and data presentation assists in ensuring information is available, accurate and easy to understand.

2.7 Recommendation

That the proponent ensures Trigger Action Response Plans are adhered to for groundwater drawdown limits.

2.8 Explanation

A comparison of groundwater levels reported in Narrabri Coals Annual Review documents against the groundwater level triggers shown in Table 6-5 of the WMP, indicates the occurrence of groundwater level declines below nominated trigger levels (see Table below). This included three consecutive readings which according to the WMP should include the following 2 actions:

- *engage hydrogeologist to undertake and report on any identified changes/likely causes and recommendations, and*
- *implement contingency responses as agreed with government agencies and in accordance with hydrogeologist recommendation.*

There is no evidence that these actions have occurred or been reported on.

Location ID	Bore depth (m bgl)	Screen Depth (m bgl)	Formation	Ground surface elevation (m AHD)	Sept 2008 water level (m bgl)	Aug 2021 water level (m bgl)	Oct 2021 water level (m bgl)	Jan 2022 water level (m bgl)	Sept 2008 water level (m AHD)	Aug 2021 water level (m AHD)	Oct 2021 water level (m AHD)	Jan 2022 water level (m AHD)	Extraction Plan 'Life of Mine' lowest groundwater level trigger (m AHD)
P8	65	57-63	Purlawaugh	322.09	50.53	50.78	50.8	50.75	271.56	271.31	271.29	271.34	269.6
P9	30	24-30	Purlawaugh	287.46	19.66	26.23	26.31	26.7	267.8	261.23	261.15	260.76	262.4
P10	130	118-130	Napperby	269.2	20.03	21.2	20.13	23.42	249.17	248	249.07	245.78	251.8
P11	50	44-50	Napperby	303.01	22.91	29.57	32.4	32.68	280.1	273.44	270.61	270.33	272.9

End Attachment A

Table A2-1 DPE Water consultation recommendations – 23 January 2023

Consultation feedback	Outcome	Document reference
1.0 Water Take and Licensing		
1.1 Recommendation That the proponent develops a methodology to determine surface water take due to subsidence related cracking prior to any surface cracking occurring.	Section 6.1.4 has been updated to state: "An assessment will be conducted by a surface water specialist prior to any surface cracking occurring within the Extraction Plan Area to consider alternative methodologies to measure and/or predict creek flows."	Section 6.1.4 of the EP-WMP **Response updated since Rev 0 – refer to section 6.1.3**
1.2 Recommendation That the proponent ensures sufficient water entitlement is held in a water access licence to account for the maximum water take for each water source prior to take occurring.	Noted. No update required as commitment has already been included in Section 4 of the Plan.	Section 4 of the EP-WMP **Section 1.4.1 of the EP-WMP details the WALs held by NCOPL**
2.0 Groundwater impact monitoring and management		
2.1 Recommendation That the Water Management Plan of the Extraction Plan be amended to: • Establish groundwater level triggers for monitoring bores of the GAB, including the Pilliga Sandstone within the GAB Southern Groundwater Recharge water source. This will require extending the monitoring network to more locations and requires consideration of timeline of impact through early indicators. A specific performance measure utilising a	As presented in Table 6-4 of the EP-WMP, four monitoring bores (P8, P9, P10 and P11) from the current Narrabri Mine groundwater monitoring network have been included in the EP-WMP monitoring program. In addition, the Subsidence Assessment Report (DGS, 2022) proposed an additional VWP (P80) and a wireline extensometer (P81) be installed above LW 203 at its southern limit. Given the Pilliga Sandstone Formation is not present above LW203 to LW206, monitoring locations in the Pilliga Sandstone were not included in Revision A of the EP-WMP. However, in response to DPE Water Recommendation 2.1, NCOPL propose to install an additional standpipe within the Pilliga Sandstone formation west of the planned longwall panels (P82) which has also been included in the EP-WMP monitoring program (Table 6-4). Furthermore, the revised Site WMP (which describes the overall site groundwater monitoring network) (not yet approved) includes two existing standpipes (P6 and P7) and two existing VWPs (P42_90 and P54_30) that are currently monitoring the Pilliga Sandstone. The	Section 6.2, Table 6-4, Table 6-5, Section 9.3 of the EP-WMP **Response updated since Rev 0 – refer to section 6.2 of the EP-WMP**

Consultation feedback	Outcome	Document reference
tiered approach is recommended for the Pilliga Sandstone as follows: ▪ Tier 1 >5 m drawdown in the Pilliga Sandstone – all future westward panels revert back to original longwalls panels and reduce mining heights to that originally approved for Stage 2. This would reduce the vertical fracturing and extent of depressurisation into the Pilliga Sandstone. ▪ Tier 2 at >10 m drawdown in the Pilliga Sandstone – a cessation of mining further panels westward beneath the GAB or limit mining to first workings only. This would account for the fact that drawdown has doubled from that predicted for Stage 3 approval and that peak drawdowns are still yet to eventuate due to the lag in groundwater flow and any cumulative impact yet to be realised from other approved projects.	existing monitoring bore P7 has also been in included in Revision 0 of the EP-WMP (Table 6-4 and Table 6-5). Stage 1 and Stage 2 groundwater level trigger criteria have been established for all monitoring bores (see Table 6-5 of EP-WMP) which require response actions to be undertaken in accordance with the TARP in section 7. The Stage 1 and Stage 2 triggers for the Pilliga Sandstone bores follow the tiered approach for trigger levels as recommended under Recommendation 2.1. However, the performance measures/response actions have not been adopted as they are not practicable. Refer to the TARP in section 7 for reasonable and feasible response actions. The method for deriving the Stage 1 and Stage 2 trigger criteria for all bores is documented in section 6.2 of the EP-WMP. In terms of the broader monitoring context, the revised Site WMP also recommends the drilling and installation of additional VWPs P61_1, P67_1, P70, P73_1 and P77_1. With the exception of P70, each of these VWPs are located to the west of the Pilliga Sandstone outcrop and include monitoring at shallow depths (including in the Pilliga Sandstone) to identify impacts through early indicators for groundwater drawdown. NCOPL are also proposing three additional standpipes (P68 shallow and P69 deep and P82 [mentioned above]). These standpipes have also been included in the EP-WMP groundwater monitoring program as well as VWPs P70 and P73 (Table 6-4). NCOPL will make use of the Santos Pilliga Sandstone monitoring data if the newly proposed P82 and the existing P7 monitoring bores exceed the trigger value/s. Detailed investigations will then be conducted as required. It is assumed that the Santos data will be readily available from their website. Note: Groundwater level triggers will not apply to the Santos bores, however the bores will provide background monitoring data for reference purposes only.	
• establish performance targets to monitor, evaluate and report on high priority GDEs,	As stated in section 3.2.7, no directly related impacts to GDEs from the Extraction Plan Area are expected and no high priority GDEs or alluvial aquifer systems occur within the Extraction Plan Area. Impacts on GDEs and other receptors outside of the mine footprint and Extraction Plan Area will be monitored and managed in accordance with the revised Stage 2 WMP (not yet approved). Notwithstanding the above, the groundwater monitoring program (Table 6-6) includes a commitment to conduct annual site visits to the Mayfield Spring which includes collecting data for the following parameters:	Section 3.2.8, Section 6.2.2, Section 6.2.7 of the EP-WMP **Response updated since Rev 0**

Consultation feedback	Outcome	Document reference

	• Site photographs (x4) and observations of:
	  ▪ Flow rates
	  ▪ Surface conditions
	  ▪ Surface water levels and field water quality (EC and pH) in any standing pools.
	
	Section 6.2.9 has been added to the EP-WMP which establishes performance criteria, monitoring and evaluation of Mayfield Spring.	

• ensure mitigation strategies for aquifer impacts are consistent with those approved in existing development consents, and	The revised subsidence predictions report for LW 203-206 (DGS, 2022) states the following mitigation strategies for sub-surface cracking: "The practical options available for controlling sub-surface fracturing are limited to: • Monitor rainfall deficit and underground water makes or changes to ventilation during longwall mining to detect surface to seam connectivity. • Repair surface cracks after active subsidence is complete. • Install further borehole extensometers and piezometers to monitor the height of fracturing development for multiple 400 m wide longwalls after supercritical conditions develop (most of the subsurface fracturing prediction models consider impacts due to one or two longwalls only)." Therefore, the above measures represent the most current and appropriate management strategies as recommended in the subsidence prediction report for LW 203-206 (DGS, 2022). These measures have been included in section 5.2 of the EP-Land Management Plan.	Section 5.2 **Response updated since Rev 0**
• modify frequency of measuring the metered mining inflow and outflow from monthly to weekly and adjusting the response plan to excessive inflow from 3 consecutive months to 3 consecutive weeks.	The monitoring frequency for mine water inflow and outflow in Table 6-6 (section 6.2.3) has been amended to state "weekly meter read". Section 6.2.5 has also been updated to state: "an observed inflow rate 100% in excess of the predicted base case mean monthly inflow rate at any stage during the EP 203-206 operational period sustained for three consecutive weeks where a significant rainfall event has occurred during this period, will trigger an investigation and preparation of a response plan as detailed in section 7." Note: a significant rainfall event is defined as a rainfall event >38.4 mm over 5 consecutive days.	Section 6.2.5, Section 6.2.7 of the EP-WMP

<table>
<tr><th>Consultation feedback</th><th>Outcome</th><th>Document reference</th></tr>
<tr><td></td><td>Response above has been superseded in Rev 0A (dated 9 May 2023) with the removal the rainfall condition from the trigger for mine inflows exceedance of a threshold increase.

Section 6.2.5 has been updated to state:
“an observed inflow rate 100% in excess of the predicted base case mean monthly equivalent inflow rate at any stage during the EP 203-206 operational period sustained for three consecutive weeks, will trigger an investigation and preparation of a response plan as detailed in section 7.”</td><td></td></tr>
<tr><td>2.3 Recommendation

That the Water Management Plan of the Extraction Plan be amended to include the requirements for regular InSAR subsidence reports and to interpret those in association with groundwater level monitoring.</td><td>NCOPL have an established remote sensing monitoring program in place which consists of annual multi spectral imaging and triennial LiDAR surveys to detect changes in landform. If changes in landform are detected, targeted field surveys will be conducted to examine the cause of change, followed by the implementation of appropriate management measures.

The surface zones subject to impact monitoring are described in the below table.
<table>
<tr><th>Surface zone</th><th colspan="2">Definition</th></tr>
<tr><td>Longwall</td><td>Zone of maximum subsidence.</td><td>>2 m predicted subsidence.</td></tr>
<tr><td>Transition</td><td>Zone of maximum stress and tilt.</td><td>0.1 – 1.5 m predicted subsidence.</td></tr>
<tr><td>Pillar</td><td colspan="2">Zone above the pillar with minimal subsidence.</td></tr>
<tr><td>Control</td><td colspan="2">Zones of no impact located outside of any predicted subsidence zone.</td></tr>
</table>
It would be very difficult to differentiate between ground deformation caused by subsidence and ground deformation caused by groundwater drawdown within the Extraction Plan Area (i.e. 45º AoD).

Section 6.2 of the EP-LMP describes the remote sensing monitoring program applicable to the entire mine site. Table 6-3 in the EP-WMP also describes the remote sensing monitoring program that is applicable to monitoring watercourses.</td><td>Table 6-3 of the EP-WMP</td></tr>
</table>

Consultation feedback	Outcome	Document reference
2.5 Recommendation That Annual Review reports prepared for this project be amended to: • improve the presentation of the monitoring data and the use of maps, hydrographs and other visual tools reported in the Annual Review. The data should display recent and historical datasets (incl baseline). The SSD groundwater guidelines (https://water.dpie.nsw.gov.au/science-data-and-modelling/groundwatermanagement-and-science/groundwater-document-library) should be consulted to that effect. • include documentation of quality assurance and controls.	NCOPL will include maps, hydrographs, and/or other visual tools within the Annual Review to present the groundwater monitoring results. The results will display both recent and historical datasets (including baseline). In addition, all data on groundwater levels, quality, and data quality control will be provided separately to DPE Water in csv format to accompany the Annual Review.	Section 9.4 of the EP-WMP
2.7 Recommendation That the proponent ensures Trigger Action Response Plans are adhered to for groundwater drawdown limits.	The Trigger Action Response Plan in section 7 (Table 7-2) details the monitoring bores that have a groundwater level trigger. If routine monitoring indicates the groundwater level exceeds the trigger level over three consecutive monitoring events (Level 2 trigger), NCOPL will ensure the actions of conducting preliminary quality assurance of data to confirm the exceedances and the implementation of the contingency and notification measures as per section 8 are executed. Responses to the exceedances include: • Engage hydrogeologist to undertake assessment and report on any identified changes/likely causes and recommendations. • Implement contingency responses as agreed with government agencies and in accordance with hydrogeologist recommendations. In addition, and in response to DPE Water Recommendation 2.1, an additional component has been included in the TARP specific to the Pilliga Sandstone monitoring bores.	Section 6.2.7 and Section 7 of the EP-WMP **Method for deriving trigger levels updated since Rev 0**

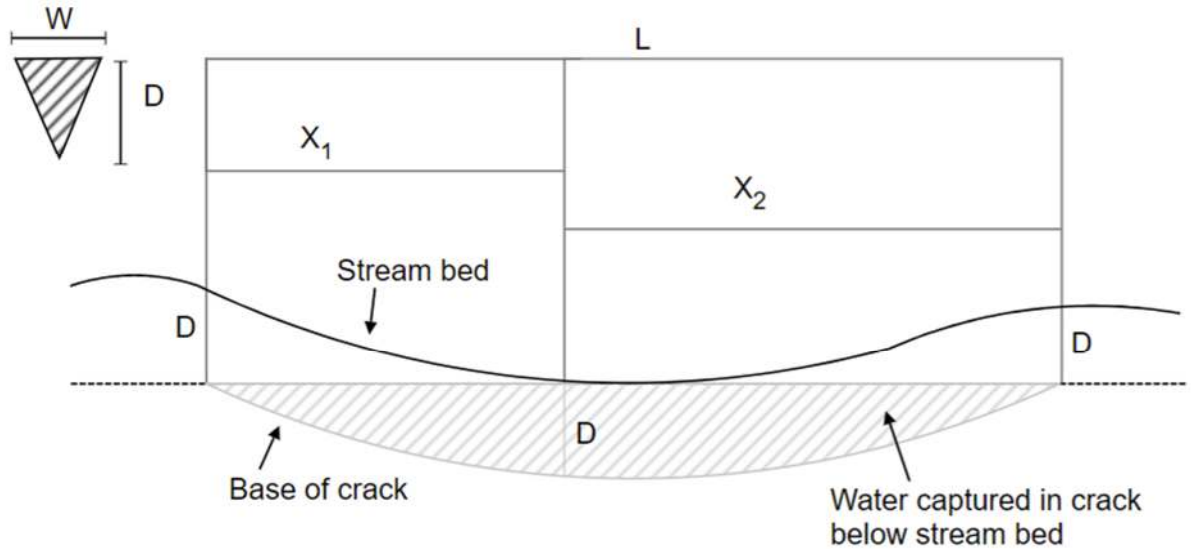
<table>
<tr><th>Consultation feedback</th><th>Outcome</th><th>Document reference</th></tr>
<tr><td></td><td>In response to DPE Water's 2.8 Explanation regarding historical groundwater level declines below the EP-WMP nominated trigger levels (for bores P9, P10 and P11), NCOPL have conducted a review of the trigger levels with a summary of the identified issues and recommendations presented in the below table.
<table>
<tr><th>Issue</th><th>Recommendations</th></tr>
<tr><td>The pre-mining baseline data used to derive groundwater level triggers, for some of the monitoring bores, (i.e. P10) shows fluctuating trends.</td><td>The pre-mining water level for P10 was adjusted from 278.1 mAHD to 271.99 mAHD using the average pre-mining data (i.e. pre-2012).</td></tr>
<tr><td>The heads predicted in the model simulations are regionally based, some discrepancies may occur due to the model grid construction process and real collar elevations.</td><td>The level trigger determination process should account for discrepancies. The drawdown will be subtracted from pre-mining baseline heads to derive triggers presented in the head (mAHD) and modelled predicted heads not used directly.</td></tr>
<tr><td>The numerical groundwater model derives regional impacts (as per the AIP), mine inflow rates, overall (regional) groundwater management options and model uncertainty. Not all observations applied in the numerical model calibrate 100%; some are slightly over-predicted, and some are slightly under-predicted but overall, the model achieved reasonable calibration targets in line with the Australian Model Guidelines[12].
The application of annual trigger levels was implemented following consultation with NRAR in 2021 regarding revision 3 of the Stage 2 WMP.</td><td>A single Stage 1 and Stage 2 trigger level for the life of mine period (i.e. 2031 for Stage 2) will be implemented. The proposed methodology is described in section 6.2 of the EP-WMP.</td></tr>
</table></td><td></td></tr>
</table>

[12] The objective of the calibration being to replicate observed groundwater levels, net baseflow gains and mine inflows in accordance with Australian Groundwater Modelling Guidelines (Barnett et al. 2012). The transient calibration achieved a 5.0% scaled root mean square (SRMS) error, which is well within acceptable limits (i.e. <10%), recommended by *the Australian Groundwater Modelling Guidelines* (Barnett et al., 2012). More importantly, the model was able to replicate the observed depressurisation of the Permian strata occurring above the existing underground mining area, and average inflows into the existing underground mining area (AGE, 2020b).

Consultation feedback	Outcome		Document reference
	However, monitoring and assessing against a yearly trigger has since been concluded by NCOPL to be impracticable based on the intent of the groundwater model and ability to calibrate to this accuracy (as stated above). In accordance with the Statement of Commitments within the Project Approval (PA 08_0144), the groundwater model will be recalibrated 12 months (2013), 3 years (2015) and 5 years (2017) after the commencement of longwall extraction. Recalibration will then occur every 5 years thereafter (2022, 2027 and 2032), and at least 12 to 18 months prior to the cessation of mining. The current recalibration time frame is 5 years; this means that small changes in mining may result in the over or under-prediction of groundwater levels in certain monitoring bores if the actual mining differs from the mine plan used in the preceding model calibration exercise. This is a further reason why annual trigger levels are difficult to manage, and exceedance of predicted levels may occur.		
	The NCO numerical groundwater model is currently in a recalibration stage (Nov 2022 to February 2023).	The objective is to adjust the groundwater level triggers to align with the 2023 calibrated numerical groundwater model where necessary. The Stage 1 and Stage 2 trigger levels for the EP-WMP monitoring bores have been derived from the 2023 recalibrated model (Table 6-5 of EP-WMP).	
	With consideration of the above, an adjustment of the trigger values has been conducted as part of the 2023 numerical groundwater model calibration. The method used to derive the trigger values is detailed in section 6.2 of the EP-WMP. The revised groundwater level trigger vales are presented in Table 6-5 of the EP-WMP.		

Attachment 3 Surface water take calculation method

Crack cross-section



W (m) = crack width
D (m) = crack depth
L (m) = crack length = $X_1 + X_2$

$$\text{Volume water} = \frac{W * D * L}{2}$$

Note:
to calculate X_1 and X_2 use LiDAR to determine distance away from each crack in watercourse where the subsided ground surface elevation reaches crack depth (D) above the bed of waterway at each crack (measured from ground level contours - LiDAR).

Attachment 4 Groundwater monitoring network

Table A4-1 Groundwater monitoring network

Location ID	Monitoring type	Owner	Coordinates (MGA55)		Bore depth (mbgl)	Screened interval / sensor depth (mbgl)	Formation	Monitoring purpose	Trigger criteria	
									Level	Quality
P1	Standpipe	Narrabri Coal Operations	776116	6614694	50	44-50	Garrawilla Volcanics	Level and quality	Predicted drawdown	ANZG (stock), bore specific
P2	Standpipe	Narrabri Coal Operations	777282	6616355	50	44-50	Napperby Formation	Level and quality	Predicted drawdown	EC two tiered
P3	Standpipe	Private	780433	6620115	45	34-40	Pamboola Formation	Level and quality	Predicted drawdown	EC two tiered
P4	Standpipe	Private	777490	6625553	30	24-30	Napperby Formation	Level and quality	Predicted drawdown	EC two tiered
P5	Standpipe	Stock Route	778180	6628195	30	24-30	Pamboola Formation	Level	Predicted drawdown	N/A
P6B	Standpipe	Narrabri Coal Operations	772735	6626015	108	93-102	Pilliga Sandstone	Level and quality	To be determined	To be determined
P7	Standpipe	State Forest	768998	6624338	90	78-90	Pilliga Sandstone	Level and quality	Predicted drawdown	ANZG (irrigation)
P8	Standpipe	State Forest	772697	6618421	65	57-63	Purlawaugh Formation	Level and quality	Predicted drawdown	ANZG (stock)
P9	Standpipe	State Forest	775127	6620209	30	24-30	Purlawaugh Formation	Level and quality	Predicted drawdown	EC two tiered
P10	Standpipe	State Forest	774063	6616444	130	118-130	Napperby Formation (no sill)	Level and quality	Predicted drawdown	EC two tiered
P11	Standpipe	Narrabri Coal Operations	774066	6616447	50	44-50	Purlawaugh Formation	Level and quality	Predicted drawdown	EC two tiered
P12	Standpipe	Narrabri Coal Operations	776513	6619964	90	84-90	Napperby Formation (above sill)	Level and quality	Predicted drawdown	ANZG (stock)
P13	Standpipe	Narrabri Coal Operations	776526	6619972	30	24-30	Garrawilla Volcanics/Napperby	Level and quality	Predicted drawdown	ANZG (stock)
P16	Standpipe	State Forest	772233	6623740	146	137-146	Garrawilla Volcanics	Level and quality	Predicted drawdown	ANZG (stock), bore specific
P17*	Standpipe	State Forest	772222	6623712	56	47-56	Purlawaugh Formation	Level and quality	N/A	N/A
P19	Standpipe	Narrabri Coal Operations	776827	6621543	187	184-187	Pamboola Formation	Level and quality	N/A	To be determined
P28*	Seepage bore	Narrabri Coal Operations	778343	6620162	25	19-25	Napperby Formation (above sill)	Level and quality	N/A	N/A
P29	Seepage bore	Narrabri Coal Operations	778541	6619978	25	19-25	Napperby Formation (above sill)	Level and quality	N/A	EC two tiered
P30	Seepage bore	Narrabri Coal Operations	778808	6620071	15	9-15	Napperby Formation (above sill)	Level and quality	N/A	N/A
P31	Seepage bore	Narrabri Coal Operations	778318	6620343	15	9-15	Napperby Formation (above sill)	Level and quality	N/A	EC two tiered
P32	Seepage bore	Narrabri Coal Operations	778993	6620335	15	9-15	Napperby Formation (above sill)	Level and quality	N/A	EC two tiered
P33*	Seepage bore	Narrabri Coal Operations	778772	6620523	15	9-15	Napperby Formation (above sill)	Level and quality	N/A	N/A
P34*	Seepage bore	Narrabri Coal Operations	778542	6620604	15	9-15	Napperby Formation (above sill)	Level and quality	N/A	N/A
P39A	Standpipe	Private	782024	6620076	80	72-78	Watermark Formation	Level and quality	N/A	ANZG (stock)
P39B	Standpipe	Private	782018	6620077	32	15-30	Tullamullen Alluvium	Level and quality	Predicted drawdown	ANZG (irrigation), bore specific

Location ID	Monitoring type	Owner	Coordinates (MGA55)		Bore depth (mbgl)	Screened interval / sensor depth (mbgl)	Formation	Monitoring purpose	Trigger criteria	
									Level	Quality
P42_90	VWP	Narrabri Coal Operations	771092	6614376	121	90	Pilliga Sandstone	Level	Predicted drawdown	N/A
P42_185	VWP	Narrabri Coal Operations	771092	6614376	427	185	Purlawaugh Formation	Level	N/A	N/A
P42_345	VWP	Narrabri Coal Operations	771092	6614376	427	345	Digby Formation	Level	N/A	N/A
P42_375	VWP	Narrabri Coal Operations	771092	6614376	427	375	Benelabri Formation	Level	N/A	N/A
P42_395	VWP	Narrabri Coal Operations	771092	6614376	427	395	Hoskissons Coal Seam	Level	N/A	N/A
P42_415	VWP	Narrabri Coal Operations	771092	6614376	427	415	Arkarula Formation	Level	N/A	N/A
P43	Standpipe	Private	781248	6619992	66	59-65	Watermark Formation	Level and quality	N/A	EC two tiered
P44_95	VWP	Narrabri Coal Operations	777433	6623210	98	95	Napperby Formation	Level	N/A	N/A
P44_134	VWP	Narrabri Coal Operations	777434	6623212	471	134	Digby Formation	Level	N/A	N/A
P44_245	VWP	Narrabri Coal Operations	777434	6623212	471	245	Arkarula Formation	Level	N/A	N/A
P44_330	VWP	Narrabri Coal Operations	777434	6623212	471	330	Arkarula Formation	Level	N/A	N/A
P44_375	VWP	Narrabri Coal Operations	777434	6623212	471	375	Arkarula Formation	Level	N/A	N/A
P44_445	VWP	Narrabri Coal Operations	777434	6623212	471	445	Arkarula Formation	Level	N/A	N/A
P45_42	VWP	Narrabri Coal Operations	779491	6620117	291	42.5	Digby Formation	Level	N/A	N/A
P45_80	VWP	Narrabri Coal Operations	779491	6620117	291	80	Arkarula Formation	Level	N/A	N/A
P45_150	VWP	Narrabri Coal Operations	779491	6620117	291	150	Watermark Formation	Level	N/A	N/A
P45_200	VWP	Narrabri Coal Operations	779491	6620117	291	200	Watermark Formation	Level	N/A	N/A
P45_240	VWP	Narrabri Coal Operations	779491	6620117	291	240	Watermark Formation	Level	N/A	N/A
P45_276	VWP	Narrabri Coal Operations	779491	6620117	291	276	Watermark Formation	Level	N/A	N/A
P46_34	VWP	Narrabri Coal Operations	777395	6617847	396	343	Leard Formation	Level	N/A	N/A
P46_70	VWP	Narrabri Coal Operations	777395	6617847	396	70	Napperby Formation	Level	N/A	N/A
P46_87	VWP	Narrabri Coal Operations	777395	6617847	396	87	Digby Formation	Level	N/A	N/A

Location ID	Monitoring type	Owner	Coordinates (MGA55)		Bore depth (mbgl)	Screened interval / sensor depth (mbgl)	Formation	Monitoring purpose	Trigger criteria	
									Level	Quality
P46_151	VWP	Narrabri Coal Operations	777395	6617847	396	151	Pamboola Formation	Level	N/A	N/A
P46_250	VWP	Narrabri Coal Operations	777395	6617847	396	250	Watermark Formation	Level	N/A	N/A
P46_308	VWP	Narrabri Coal Operations	777395	6617847	396	308	Porcupine Formation	Level	N/A	N/A
P47	Standpipe	Narrabri Coal Operations	776166	6622586	31	8-30.5	Garrawilla Volcanics	Level and quality	Predicted drawdown	ANZG (stock)
P51	Standpipe	Narrabri Coal Operations	777437	6620859	17	9-12	Garrawilla Volcanics	Level and quality	N/A	EC two tiered
P52	Standpipe	Narrabri Coal Operations	777118	6620808	24	18-21	Napperby Formation	Level and quality	N/A	EC two tiered
P53	Standpipe	Narrabri Coal Operations	776995	6620655	24	18-21	Garrawilla Volcanics	Level and quality	Predicted drawdown	EC two tiered
P54_30	VWP	State Forest	773079	6610419	348	30	Pilliga Sandstone	Level	Predicted drawdown	N/A
P54_60	VWP	State Forest	773079	6610419	348	60	Purlawaugh Formation	Level	N/A	N/A
P54_100	VWP	State Forest	773079	6610419	348	100	Purlawaugh Formation	Level	N/A	N/A
P54_140	VWP	State Forest	773079	6610419	348	140	Napperby Formation	Level	N/A	N/A
P54_180	VWP	State Forest	773079	6610419	348	180	Napperby Formation	Level	N/A	N/A
P54_220	VWP	State Forest	773079	6610419	348	220	Napperby Formation	Level	N/A	N/A
P54_260	VWP	State Forest	773079	6610419	348	260	Napperby Formation	Level	N/A	N/A
P54_300	VWP	State Forest	773079	6610419	348	300	Benelabri Formation	Level	N/A	N/A
P54_338	VWP	State Forest	773079	6610419	348	338	Arkarula Formation	Level	N/A	N/A
P55_91	VWP	Narrabri Coal Operations	776425	6610503	230	91	Napperby Formation	Level	N/A	N/A
P55_68	VWP	Narrabri Coal Operations	776425	6610503	230	68	Napperby Formation	Level	N/A	N/A
P55_103	VWP	Narrabri Coal Operations	776425	6610503	230	103	Digby Formation	Level	N/A	N/A
P55_128	VWP	Narrabri Coal Operations	776425	6610503	230	128	Arkarula Formation	Level	N/A	N/A
P55_152	VWP	Narrabri Coal Operations	776425	6610503	230	152	Pamboola Formation	Level	N/A	N/A
P55_188	VWP	Narrabri Coal Operations	776425	6610503	230	188	Pamboola Formation	Level	N/A	N/A
P55_221	VWP	Narrabri Coal Operations	776425	6610503	230	221	Pamboola Formation	Level	N/A	N/A
P56_55	VWP	Narrabri Coal Operations	776277	6614725	368	55	Napperby Formation	Level	N/A	N/A
P56_85	VWP	Narrabri Coal Operations	776277	6614725	368	85	Napperby Formation	Level	N/A	N/A

Location ID	Monitoring type	Owner	Coordinates (MGA55)		Bore depth (mbgl)	Screened interval / sensor depth (mbgl)	Formation	Monitoring purpose	Trigger criteria	
									Level	Quality
P56_115	VWP	Narrabri Coal Operations	776277	6614725	368	115	Napperby Formation	Level	N/A	N/A
P56_145	VWP	Narrabri Coal Operations	776277	6614725	368	145	Napperby Formation	Level	N/A	N/A
P56_175	VWP	Narrabri Coal Operations	776277	6614725	368	175	Arkarula Formation	Level	N/A	N/A
P56_205	VWP	Narrabri Coal Operations	776277	6614725	368	205	Pamboola Formation	Level	N/A	N/A
P56_235	VWP	Narrabri Coal Operations	776277	6614725	368	235	Pamboola Formation	Level	N/A	N/A
P56_265	VWP	Narrabri Coal Operations	776277	6614725	368	265	Watermark Formation	Level	N/A	N/A
P56_300	VWP	Narrabri Coal Operations	776277	6614725	368	300	Porcupine Formation	Level	N/A	N/A
P58	Seepage bore	Narrabri Coal Operations	778649	6619912	40	32-38	Napperby Formation	Level and quality	N/A	N/A
P59	Standpipe	Narrabri Coal Operations	772297	6623437	6	4-6	Alluvium/Colluvium	Level and quality	To be determined	To be determined
P60	Standpipe	Narrabri Coal Operations	772292	6623441	37.2	29-35	Pilliga Sandstone	Level and quality	To be determined	To be determined
P61-1	VWP	Narrabri Coal Operations	772295	6623438	93	92	Purlawaugh	Level	To be determined	N/A
P61-2	VWP	Narrabri Coal Operations	772295	6623438	147	138	Garawilla	Level	N/A	N/A
P61-3	VWP	Narrabri Coal Operations	772295	6623438	212	205	Napperby	Level	N/A	N/A
P61-4	VWP	Narrabri Coal Operations	772295	6623438	71	260	Basalt Sill	Level	N/A	N/A
P61-5	VWP	Narrabri Coal Operations	772295	6623438	24	300	Digby Formation	Level	N/A	N/A
P62	Standpipe	Narrabri Coal Operations	775947	6623827	6	4-6	Alluvium/Colluvium	Level and quality	To be determined	To be determined
P63(r)	Standpipe	Narrabri Coal Operations	775937	6623827	78.4	72-78	Napperby Formation	Level and quality	To be determined	To be determined
P64-1	VWP	Narrabri Coal Operations	775929	6623828	90	104	Napperby Formation (upper)	Level	N/A	N/A
P64-2	VWP	Narrabri Coal Operations	775929	6623828	114	120	Napperby Formation (lower)	Level	N/A	N/A
P64-3	VWP	Narrabri Coal Operations	775929	6623828	134	150	Digby Formation	Level	N/A	N/A
P64-4	VWP	Narrabri Coal Operations	775929	6623828	143	159	Hoskissons Coal Seam	Level	N/A	N/A

Location ID	Monitoring type	Owner	Coordinates (MGA55)		Bore depth (mbgl)	Screened interval / sensor depth (mbgl)	Formation	Monitoring purpose	Trigger criteria	
									Level	Quality
P65	Standpipe	Narrabri Coal Operations	771617	6612196	4.6	2.6-4.6	Alluvium/Colluvium	Level and quality	To be determined	To be determined
P66	Standpipe	Narrabri Coal Operations	771612	6612210	63	57-63	Pilliga Sandstone	Level and quality	To be determined	To be determined
P67-1	VWP	Narrabri Coal Operations	771607	6612207	30	115	Purlawaugh Formation (upper)	Level	To be determined	N/A
P67-2	VWP	Narrabri Coal Operations	771607	6612207	106	170	Purlawaugh Formation (lower)	Level	N/A	N/A
P67-3	VWP	Narrabri Coal Operations	771607	6612207	168	240	Napperby Formation (upper)	Level	N/A	N/A
P67-4	VWP	Narrabri Coal Operations	771607	6612207	243	300	Napperby Formation (lower)	Level	N/A	N/A
P67-5	VWP	Narrabri Coal Operations	771607	6612207	301	371	Digby Formation	Level	N/A	N/A
P68	Standpipe	Narrabri Coal Operations	776364	6616888	6	2-6	Alluvium/Colluvium	Level and quality	To be determined	To be determined
P69	Standpipe	Narrabri Coal Operations	776354	6616909	72.3	63.3-72.3	Napperby Formation	Level and quality	To be determined	To be determined
P70-1	VWP	Narrabri Coal Operations	776364	6616909	5	85	Napperby Formation	Level	To be determined	N/A
P70-2	VWP	Narrabri Coal Operations	776364	6616909	41	118	Digby Formation	Level	To be determined	N/A
P70-3	VWP	Narrabri Coal Operations	776364	6616909	83	124	Hoskissons coal seam	Level	To be determined	N/A
P71	Standpipe	Narrabri Coal Operations	770780	6604887	6	3-6	Alluvium/Colluvium	Level and quality	To be determined	To be determined
P72	Standpipe	Narrabri Coal Operations	770777	6604888	48	42-48	Purlawaugh Formation	Level and quality	To be determined	To be determined
P73-1	VWP	Narrabri Coal Operations	770782	6604886	22	90	Garrawilla Volcanics	Level	To be determined	N/A
P73-2	VWP	Narrabri Coal Operations	770782	6604886	41	175	Napperby Formation	Level	N/A	N/A
P73-3	VWP	Narrabri Coal Operations	770782	6604886	91	310	Digby Formation	Level	N/A	N/A
P73-4	VWP	Narrabri Coal Operations	770782	6604886	180	320	Arkarula Formation	Level	N/A	N/A
P74	Standpipe	Narrabri Coal Operations	779584	6605944	5.9	2.9-5.9	Alluvium/Colluvium	Level and quality	To be determined	To be determined
P75	Standpipe	Narrabri Coal Operations	779591	6605950	18.4	12.4-18.4	Napperby Formation	Level and quality	To be determined	To be determined
P76-1(b)	VWP	Narrabri Coal Operations	777720	6610667	4	11	Napperby Formation (upper)	Level	To be determined	N/A

Location ID	Monitoring type	Owner	Coordinates (MGA55)		Bore depth (mbgl)	Screened interval / sensor depth (mbgl)	Formation	Monitoring purpose	Trigger criteria	
									Level	Quality
P76-2(b)	VWP	Narrabri Coal Operations	777720	6610667	8	40	Napperby Formation (lower)	Level	To be determined	N/A
P76-3(b)	VWP	Narrabri Coal Operations	777720	6610667	21	81	Digby Formation	Level	To be determined	N/A
P76-4(b)	VWP	Narrabri Coal Operations	777720	6610667	43	105	-	Level	To be determined	N/A
P77-1	VWP	Narrabri Coal Operations	772459	6623324	24	40	Pilliga Sandstone	Level	To be determined	N/A
P77-2	VWP	Narrabri Coal Operations	772459	6623677	82	90	Purlawaugh Formation	Level	N/A	N/A
P77-3	VWP	Narrabri Coal Operations	772459	6623324	134	145	Garrawilla Volcanics	Level	N/A	N/A
P77-4	VWP	Narrabri Coal Operations	772459	6623324	198	205	Napperby Formation (upper)	Level	N/A	N/A
P77-5	VWP	Narrabri Coal Operations	772459	6623324	245	245	Napperby Formation (middle)	Level	N/A	N/A
P77-6	VWP	Narrabri Coal Operations	772459	6623324	261	265	Napperby Formation (lower)	Level	N/A	N/A
P77-7	VWP	Narrabri Coal Operations	772459	6623324	294	295	Digby Formation	Level	N/A	N/A
P80-1	VWP	Narrabri Coal Operations	775019	6616999	31.82	31.82	Garawilla Volcanics	Subsidence	To be determined	N/A
P80-2	VWP	Narrabri Coal Operations	775019	6616999	80.07	80.07	Napperby Formation	Subsidence	To be determined	N/A
P80-3	VWP	Narrabri Coal Operations	775019	6616999	132.32	132.32	Basalt Sill	Subsidence	To be determined	N/A
P80-4	VWP	Narrabri Coal Operations	775019	6616999	161.57	161.57	Napperby Base Sill	Subsidence	To be determined	N/A
P80-5	VWP	Narrabri Coal Operations	775019	6616999	188.11	188.11	Digby Formation	Subsidence	To be determined	N/A
P81	Wireline extensometer	Narrabri Coal Operations	775019	6617032	270	270	N/A	Displacement	N/A	N/A
P82	Standpipe	Narrabri Coal Operations	771156	6618806	110	104-110	Pilliga Sandstone	Level and quality	To be determined	To be determined
P83	Seepage bore	Narrabri Coal Operations	778452	6621599	39	36-39	Alluvium / near surface strata	Level and quality	N/A	In accordance with EPL
P84	Seepage bore	Narrabri Coal Operations	779072	6620648	24	21-24	Alluvium / near surface strata	Level and quality	N/A	In accordance with EPL
P85	Seepage bore	Narrabri Coal Operations	779074	6620644	10	7-10	Alluvium / near surface strata	Level and quality	N/A	In accordance with EPL
P88	Seepage bore	Narrabri Coal Operations	778744	6620834	11	7-11	Alluvium / near surface strata	Level and quality	N/A	In accordance with EPL

Location ID	Monitoring type	Owner	Coordinates (MGA55)		Bore depth (mbgl)	Screened interval / sensor depth (mbgl)	Formation	Monitoring purpose	Trigger criteria	
									Level	Quality
P89	Seepage bore	Narrabri Coal Operations	779220	6620940	11	7-11	Alluvium / near surface strata	Level and quality	N/A	In accordance with EPL
P90	Standpipe	Narrabri Coal Operations	773523	6618540	80	70-76	Pilliga Sandstone	Level and quality	To be determined	To be determined
P91	Standpipe	Narrabri Coal Operations	775736	6615843	15	9-15	Alluvium / near surface strata	Level and quality	To be determined	To be determined
P92	Standpipe	Narrabri Coal Operations	775694	6615503	15	9-15	Alluvium / near surface strata	Level and quality	To be determined	To be determined
DWH3PRUPS01	Santos	Santos	762239.7	6605589	-	-	Upper Pilliga Sandstone	Level	N/A	N/A
DWH3PRLPS02	Santos	Santos	762251.1	6605599	-	-	Lower Pilliga Sandstone	Level	N/A	N/A
DWH14PRUPS01	Santos	Santos	764703.3	6617145	-	-	Upper Pilliga Sandstone	Level	N/A	N/A
DWH14PRLPS02	Santos	Santos	764689.1	6617119	-	-	Lower Pilliga Sandstone	Level	N/A	N/A
WB2	Standpipe	Narrabri Coal Operations	776382	6619701	26	22-26	Garrawilla Volcanics	Level and quality	N/A	ANZG (stock)
WB12 (257_bore)	Standpipe	Private	780874	6617836	100	60-75	Arkarula Formation and Pamboola Formation	Level and quality	Predicted drawdown	ANZG (stock)
WB18 (Mentone Bore)	Standpipe (Stock and domestic)	Private	776686	6629386	16.69	Unknown	Napperby Formation	Level and quality	Predicted drawdown	ANZG (stock)
VI1 (NE GDE)	GDE	N/A	781341	6626607	N/A	N/A	N/A	Flow rate and surface conditions	N/A	To be determined
VI2 (E GDE) (TC1DS in SWMP)	GDE	N/A	776908	6612637	N/A	N/A	N/A	Flow rate and surface conditions	N/A	To be determined
VI3 (Mayfield)	GDE	N/A	775670	6615617	N/A	N/A	N/A	Flow rate and surface conditions	N/A	To be determined
VI4 (Hardy's)	GDE	N/A	770726	6604763	N/A	N/A	N/A	Flow rate and surface conditions	N/A	To be determined
VI5 (Eather 1)	GDE	N/A	771133	6602103	N/A	N/A	N/A	Flow rate and surface conditions	N/A	To be determined
VI6 (Eather 2)	GDE	N/A	771292	6602251	N/A	N/A	N/A	Flow rate and surface conditions	N/A	To be determined
VI7 (Blairmore 1)	GDE	N/A	773353	6597177	N/A	N/A	N/A	Flow rate and surface conditions	N/A	To be determined
VI8 (Blairmore 2)	GDE	N/A	774557	6597554	N/A	N/A	N/A	Flow rate and surface conditions	N/A	To be determined
P59/P60/P61 (PCUS in SWMP)	Surface water	N/A	772142	6623454	N/A	N/A	N/A	Quality	N/A	N/A
P62/P63/P64 (Pca in SWMP)	Surface water	N/A	775957	6623752	N/A	N/A	N/A	Quality	N/A	N/A
P65/P66/P67 (P65 - P67 SW)	Surface water	N/A	771796	6612659	N/A	N/A	N/A	Quality	N/A	N/A
P68/P69/P70 (P68-P70 SW)	Surface water	N/A	776346	6616850	N/A	N/A	N/A	Quality	N/A	N/A
P71/P72/P73 (P71-P73 SW)	Surface water	N/A	770899	6605900	N/A	N/A	N/A	Quality	N/A	N/A
P74/P75/P76 (P74-P76 SW)	Surface water	N/A	779487	6605864	N/A	N/A	N/A	Quality	N/A	N/A

Attachment 5 Groundwater quality trigger values

Groundwater quality – seepage monitoring bores

Derived trigger values for six shallow monitoring bores located around the mine brine storage points are summarised in Table D-1 and Table D-2 for bores completed into the Napperby Formation and Garrawilla Volcanics, respectively. Water quality impacts are considered likely at these locations, hence trigger values for these monitoring points have predominantly been derived using a control charting approach (DES, 2021).

Table D-1 Proposed trigger values for seepage monitoring bores situated in the Napperby Formation

Parameter	P29 [1]		P31 [1]		P32 [1]		P52 [1]	
	Tier 1 (80th)	Tier 2 (95th)	Tier 1 (80th)	Tier 2 (95th)	Tier 1 (80th)	Tier 2 (95th)	Tier 1 (80th)	Tier 2 (95th)
EC (µS/cm)	9,732	11,337	7,110	7,195	2,170	2,938	2,300	2,533
pH	**Min.**	**Max.**	**Min.**	**Max.**	**Min.**	**Max.**	**Min.**	**Max.**
	6.0^	8.5^	6.0^	8.5^	6.0^	8.5^	6.0^	8.5^

Notes:
[1] Tier 1 and Tier 2 control charting method (DES, 2021)
^ ANZG (2018) irrigation, long term application

Table D-2 Proposed trigger values for seepage monitoring bores situated in the Garrawilla Volcanics

Parameter	P51 [1]		P53 [1]	
	Tier 1 (80th)	Tier 2 (95th)	Tier 1 (80th)	Tier 2 (95th)
EC (µS/cm)	19,500	19,860	1,107	1,169
pH	**Min.**	**Max.**	**Min.**	**Max.**
	6.0^	8.5^	6.0^	8.5^

Notes:
[1] Tier 1 and Tier 2 control charting method (DES, 2021)
^ ANZG (2018) irrigation, long term application

Groundwater Quality Trigger Values – strata likely to experience drawdown impacts

Water quality triggers have been derived for a number of locations in each unit as summarised below in Table D-3, Table D-4, Table D-5, Table D-6, and Table D-7.

Table D-3 Garrawilla Volcanics monitoring locations and proposed trigger values

Parameter	WB2, P13, P47 [1]	P1 [1]	P16 [1]
EC (µS/cm)	5,970	5,970	5,970
pH	**Min.**		**Max.**
	6.0^		8.5^

Notes:
[1] ANZG (2018) livestock drinking water (beef cattle)
^ ANZG (2018) irrigation, long term application

Table D-4 Napperby Formation monitoring locations and proposed trigger values

Parameter	P2[3]		P4[3]		P10[3]		P12	
	Tier 1 (80th)	Tier 2 (95th)	Tier 1 (80th)	Tier 2 (95th)	Tier 1 (80th)	Tier 2 (95th)		
EC (µS/cm)	19,342[1]	19,731[1]	24,912[1]	25,610[1]	8,894[1]	9,426[1]	5,970[2]	
pH	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
	6.0^	8.5^	6.0^	8.5^	6.0^	8.5^	6.0^	8.5^

Notes:
[1] Tier 1 and Tier 2 control charting method (DES, 2021)
[2] ANZG (2018) livestock drinking water (beef cattle)
[3] Review of EC data for the Napperby Formation monitoring locations P2, P4 and P10 suggests that salinity (EC) values for groundwater at these locations is unsuitable for use as livestock drinking water. These locations are recommended for exclusion from ongoing assessment against the livestock drinking water trigger values.
^ ANZG (2018) irrigation, long term application

Table D-5 Purlawaugh Formation monitoring locations and proposed trigger values

Parameter	P8		P9 [1 3]		P11 [1 3]	
			Tier 1 (80th)	Tier 2 (95th)	Tier 1 (80th)	Tier 2 (95th)
EC (µS/cm)	5,970[2]		20,330[1]	21,190[1]	6,052[1]	6,546[1]
pH	Min.	Max.	Min.	Max.	Min.	Max.
	6.0^	8.5^	6.0^	8.5^	6.0^	8.5^

Notes:
[1] Tier 1 and Tier 2 control charting method (DES, 2021)
[2] ANZG (2018) livestock drinking water (beef cattle)
[3] Review of EC data for the Purlawaugh Formation monitoring locations P9 and P11 suggests that salinity (EC) values for groundwater at these locations is unsuitable for use as livestock drinking water. These locations are recommended for exclusion from ongoing assessment against the livestock drinking water trigger values.
^ ANZG (2018) irrigation, long term application

Table D-6 Watermark Formation monitoring locations and proposed trigger values

Parameter	Proposed trigger value (P39a)		P43 [1 3]	
			Tier 1 (80th)	Tier 2 (95th)
EC (µS/cm)	5,970[2]		11,162[1]	11,412[1]
pH	Min.	Max.	Min.	Max.
	6.0^	8.5^	6.0^	8.5^

Notes:
[1] Tier 1 and Tier 2 control charting method (DES, 2021)
[2] ANZG (2018) livestock drinking water (beef cattle)
[3] Review of EC data for the Watermark Formation monitoring location P43 suggests that salinity (EC) values for groundwater at these locations is unsuitable for use as livestock drinking water. These locations are recommended for exclusion from ongoing assessment against the livestock drinking water trigger values.
^ ANZG (2018) irrigation, long term application

Table D-7 Pamboola Formation monitoring locations and proposed trigger values

Parameter	P3 [1 2]	
	Tier 1 (80th)	Tier 2 (95th)
EC (µS/cm)	18,016[1]	18,564[1]
pH	Min.	Max.
	6.0^	8.5^

Notes:
[1] Tier 1 and Tier 2 control charting method (DSITI, 2017)
[2] Review of EC data for the Pamboola Formation monitoring location P3 suggests that salinity (EC) values for groundwater at these locations is unsuitable for use as livestock drinking water. These locations are recommended for exclusion from ongoing assessment against the livestock drinking water trigger values.
^ ANZG (2018) irrigation, long term application

Groundwater Quality Trigger Values – Strata unlikely to experience drawdown impacts

Consistent with the level of impact (i.e. no significant groundwater level or water quality impacts are predicted in the Pilliga Sandstone or the Namoi Alluvium), water quality triggers have been derived for at least one monitoring point in each aquifer. In each case, the closest monitoring point to the mine lease was selected. Adopted trigger values are summarised below in Table D-8 and Table D-9.

As shown for parameters where the historic baseline data suggest that the groundwater will not be suitable for long term irrigation (the dominant use of groundwater in these aquifers) then bore specific triggers, based on the 80th percentile of the observed data, have been developed. Trigger values for other parameters have been set based on ANZG guideline values (ANZG, 2018).

Table D-8 Alluvium monitoring locations and proposed trigger values

Parameter	P39b	
EC (µS/cm)	6,546 [1]	
pH	Min.	Max.
	6.0^	8.5^

Notes:
[1] Bore specific 80th percentile
^ ANZG (2018) irrigation, long term application.

Table D-9 Pilliga Sandstone monitoring locations and proposed trigger values

Parameter	P7	
EC (µS/cm)	2,327 [1]	
pH	Min.	Max.
	6.0^	8.5^

Notes:
[1] Converted from TDS trigger using equation 4.6 (ANZECC, 2000). ANZG (2018) Irrigation
^ ANZG (2018) irrigation, long term application

Groundwater Quality Trigger Values – Private Bores

As shown in Table D-10, groundwater trigger values have been derived for privately owned bores. The EC trigger value is based on the ANZG guideline values for beef cattle watering (ANZG, 2018).

Table D-10 Privately owned bores proposed trigger values

Parameter	Trigger values	
EC (µS/cm)	5,970[1]	
pH	**Min.**	**Max.**
	6.0^	8.5^

Notes:
[1] ANZG (2018) livestock drinking water (beef cattle)
^ ANZG (2018) irrigation, long term application