METROPOLITAN COAL LONGWALLS 311-316

EXTRACTION PLAN




MAIN TEXT

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LONGWALLS 311-316

EXTRACTION PLAN

Revision Status Register

Section/Page/ Annexure	Revision Number	Amendment/Addition	Distribution	DPHI Approval Date
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November 2024

TITLE BLOCK

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Mine	Metropolitan Colliery
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Title	Metropolitan Coal Longwalls 311-316 Extraction Plan
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Signature of Authorised Representative	
Name of Authorised Representative	Jon Degotardi
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Date of Signatures	**15 November 2024**

OVERVIEW AND SUMMARY OF COMMITMENTS

This document is an Extraction Plan that outlines the proposed management, mitigation, monitoring and reporting of potential subsidence impacts and environmental consequences from the secondary extraction of Longwalls 311 to 316 at the Metropolitan Colliery (Metropolitan Coal Mine).

The table on page iii summarises the surface and sub-surface features within the vicinity of Longwalls 311-316 and the relevant section of this Extraction Plan that details the management measures and monitoring for each feature.

The Trigger Action Response Plans (TARPs) provided in the component management plans will be further developed as this Extraction Plan is reviewed and revised. Table 18 of this Extraction Plan is designed to support both the TARPs in the component management plans and clearly outline actions and levels of responsibility within Metropolitan Collieries Pty Ltd (Metropolitan Coal).

In accordance with the Development Consent, Metropolitan Coal must ensure that underground mining complies with the subsidence impact performance measures outlined below. This Extraction Plan has been developed to meet these subsidence impact performance measures.

Subsidence Impact Performance Measures

Water Resources	
Catchment yield to the Woronora Reservoir	*Negligible reduction to the quality or quantity of water resources reaching the Woronora Reservoir* *No connective cracking between the surface and the mine*
Woronora Reservoir	*Negligible leakage from the Woronora Reservoir* *Negligible reduction in the water quality of Woronora Reservoir*
Watercourses	
Waratah Rivulet between the full supply level of the Woronora Reservoir and the maingate of Longwall 23 (upstream of Pool P)	*Negligible environmental consequences (that is, no diversion of flows, no change in the natural drainage behaviour of pools, minimal iron staining, and minimal gas releases)*
Eastern Tributary between the full supply level of the Woronora Reservoir and the maingate of Longwall 26	*Negligible environmental consequences over at least 70% of the stream length (that is no diversion of flows, no change in the natural drainage behaviour of pools, minimal iron staining and minimal gas releases)*
Biodiversity	
Threatened species, populations, or ecological communities	*Negligible impact*
Swamps 76, 77 and 92	*Set through condition 4 below*
Land	
Cliffs	*Less than 3% of the total length of cliffs (and associated overhangs) within the mining area experience mining-induced rock fall*
Heritage	
Aboriginal heritage sites	*Less than 10% of Aboriginal heritage sites within the mining area are affected by subsidence impacts*
Items of historical or heritage significance at the Garrawarra Centre	*Negligible damage (that is fine or hairline cracks that do not require repair), unless the owner of the item and the appropriate heritage authority agree otherwise in writing*
Built Features	
Built features	*Safe, serviceable and repairable, unless the owner agrees otherwise in writing*

Source: After Table 1 of the Project Approval (PA 08_0149).

Summary of Surface and Sub-surface Features and Relevant Extraction Plan Reference

Feature	Section/Management Plan Reference
Natural Features	
Streams	Section 4.2.1 and WMP (Appendix A)
Cliffs and overhangs, Steep Slopes and Land in General (including rock ledges and outcrops)	Section 4.2.2 and LMP (Appendix B)
Upland Swamps	Section 4.2.3 and BMP (Appendix C)
Natural Vegetation	
Public Utilities and Other Infrastructure	
Woronora Reservoir	Section 4.2.1 and WMP (Appendix A)
Exploration Boreholes	Section 4.1.1 and Subsidence Report (Appendix H)
Survey Control Marks	
Fire Trails and Vehicular Tracks	Sections 4.2.2 and LMP (Appendix B)
Areas of Archaeological and/or Heritage Significance	
Known Aboriginal Heritage Sites	Section 4.2.4 and HMP (Appendix D)

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1 INTRODUCTION

The Metropolitan Colliery (**Metropolitan Coal Mine**) is owned and operated by Metropolitan Collieries Pty Ltd (**Metropolitan Coal**) which is a wholly owned subsidiary of Peabody Energy Australia Pty Ltd (**Peabody**). It is located adjacent to the township of Helensburgh (Figure 1) and approximately 30 kilometres (**km**) north of Wollongong in New South Wales (**NSW**). Metropolitan Coal is located within Consolidated Coal Lease (**CCL**) 703, Mining Lease (**ML**) 1610 and ML 1702. Metropolitan Coal is one of the earliest established and longest continually running coal mining operations in Australia, with a history dating back to the 1880s.

Metropolitan Coal was granted approval for the Metropolitan Coal Project (the **Project**) by the Minister for Planning under section 75J of the NSW *Environmental Planning and Assessment Act 1979* (**EP&A Act**) on 22 June 2009. A copy of the Project Approval is available on the Peabody website (http://www.peabodyenergy.com). The Project comprises the continuation, upgrade and extension of underground coal mining operations and surface facilities at Metropolitan Coal.

The Project involves the extraction of coal by longwall mining methods from the Bulli Seam. The potential environmental consequences of the Project were assessed in the *Metropolitan Coal Project Environmental Assessment* (the **Project EA**) (Helensburgh Coal Pty Ltd [HCPL], 2008) and the *Metropolitan Coal Project Preferred Project Report* (the **Preferred Project Report**) (HCPL, 2009).

Longwalls 311-316 are situated to the west of Longwalls 301-310 and define the next mining sub-domain within the Project underground mining area (Figures 1 and 2).

Following the submission of the March 2024 version of the Longwalls 311-316 Extraction Plan, additional in-seam exploration drilling ahead of first workings and development of first workings have proven further adverse gas and geological conditions such that would necessitate a variation to the installation face for Longwalls 311, 312 and 313 (i.e. a shortening of the longwalls). In addition, Longwalls 314, 315 and 316 have been shortened consistent with Longwalls 301 to 310 and in keeping with an observed degradation of the geological resource trending in a north-west orientation.

The revised longwall layout would reduce the secondary extraction area and, therefore, would reduce subsidence effects compared to the March 2024 version of the Longwalls 311-316 Extraction Plan. No additional subsidence or environmental impacts are anticipated due to the revised longwall layout, and in some cases, environmental impacts would be avoided or reduced.

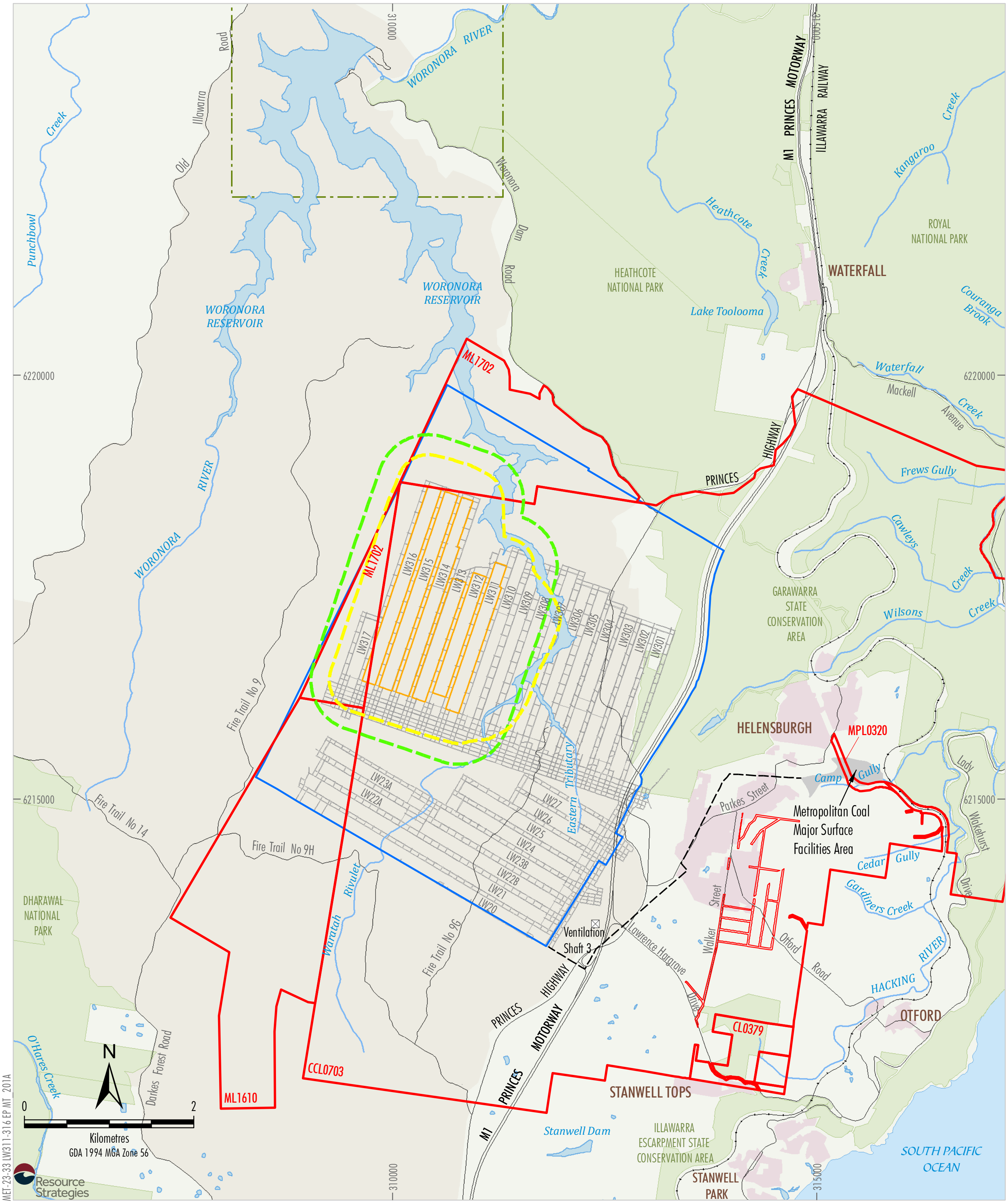
The Longwalls 311-316 layout has been revised since the preparation of the March 2024 Subsidence Report. The updated subsidence predictions are provided in an Addendum Letter prepared by Mine Subsidence Engineering Consultants Pty Ltd (MSEC), which is provided in Appendix H.

1.1 PURPOSE AND SCOPE

This Extraction Plan outlines the proposed management, mitigation, monitoring and reporting of potential subsidence impacts and environmental consequences in the Project underground mining area during the secondary extraction of Longwalls 311-316 at Metropolitan Coal.

This Extraction Plan has been prepared in consideration of the NSW Department of Planning and Environment (DPE) (now known as the Department of Planning, Housing and Infrastructure[1]) (2022) *Extraction Plan Guideline*.

[1] The former Department of Planning and Environment (DPE) was renamed to the Department of Planning, Housing and Infrastructure (DPHI) on 1 January 2024. References to DPE have been retained throughout the remainder of this document.



LEGEND

- Mining Lease Boundary
- Woronora Special Area
- Railway
- Project Underground Mining Area
- Longwalls 20-27 and 301-317
- Longwalls 311-316 Secondary Extraction
- Longwalls 311-316 35° Angle of Draw and/or Predicted 20 mm Subsidence Contour
- 600 m from Longwalls 311-316 Secondary Extraction
- Woronora Notification Area
- Existing Underground Access Drive (Main Drift)

Source: Land and Property Information (2015); Department of Industry (2015); Metropolitan Coal (2023); MSEC (2024)

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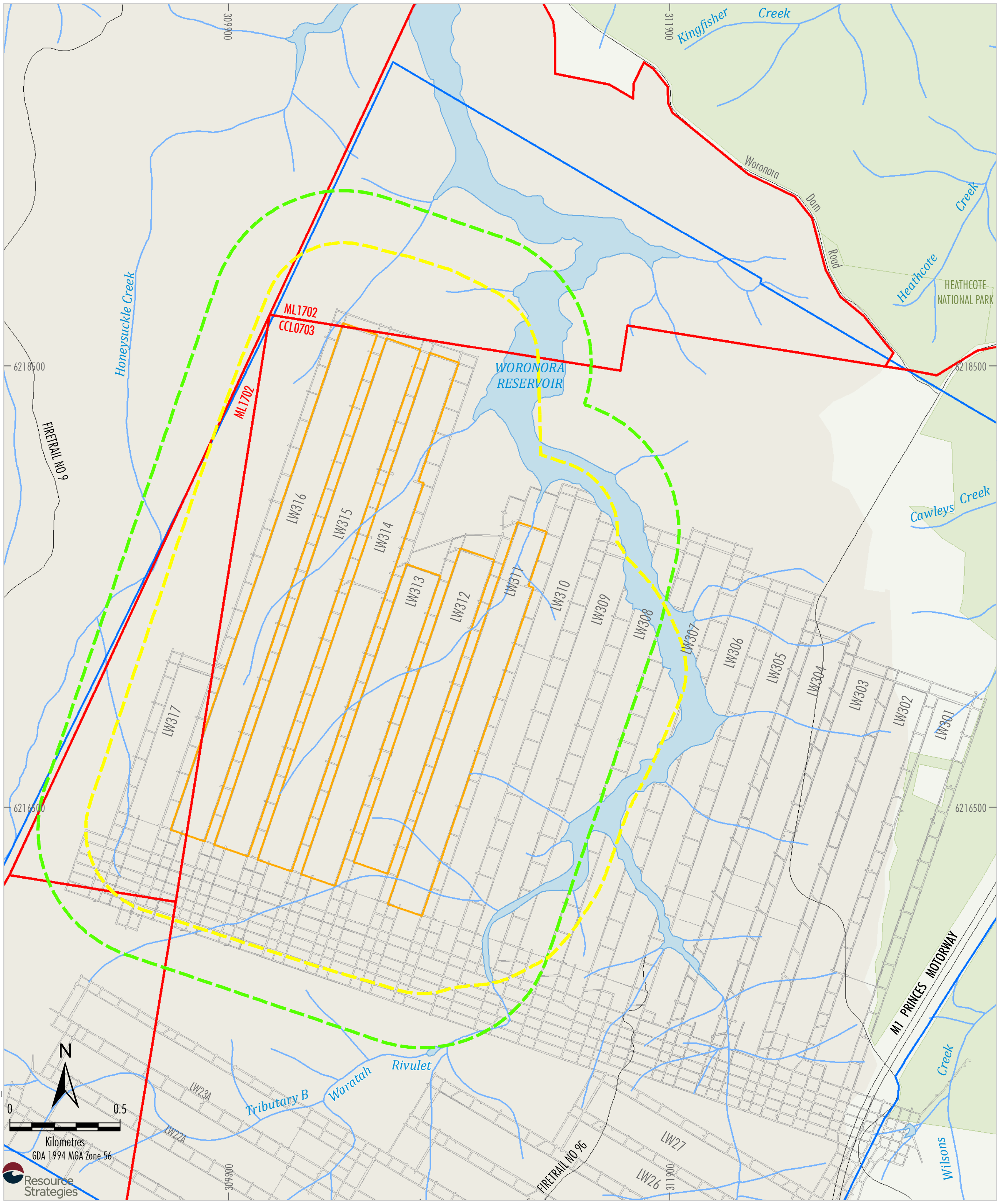
Longwalls 311-316 and Project Underground Mining Area

Figure 1



LEGEND

- Mining Lease Boundary
- Woronora Special Area
- Project Underground Mining Area Longwalls 20-27 and 301-317
- Longwalls 311-316 Secondary Extraction
- Longwalls 311-316 35° Angle of Draw and/or Predicted 20 mm Subsidence Contour
- 600 m from Longwalls 311-316 Secondary Extraction

Source: Land and Property Information (2015); Department of Industry (2015); Metropolitan Coal (2023); MSEC (2024)

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Longwalls 311-316 Layout

Figure 2

This Extraction Plan includes post-mining monitoring and management of potential subsidence impacts and environmental consequences for Longwalls 20-22, 23-27, 301-303, 304, 305-307 and 308-310. This Extraction Plan will supersede the previously approved Metropolitan Coal Longwalls 308-310 Extraction Plans consistent with the recommended approach in the DPE (2022) *Extraction Plan Guideline*.

The objectives of this Extraction Plan are to:

- provide detailed plans of Longwalls 311-316;
- outline potential subsidence effects, subsidence impacts and environmental consequences of Longwalls 311-316;
- provide a comprehensive assessment of potential subsidence impacts to Swamps 76. 77, and 92;
- describe the measures that will be implemented to manage, mitigate and remediate potential subsidence impacts and environmental consequences during the mining of Longwalls 311-316;
- detail the monitoring of subsidence effects, subsidence impacts and environmental consequences during the mining of Longwalls 311-316; and
- provide a contingency plan for subsidence impacts and environmental consequences in relation to the Project's subsidence impact performance measures.

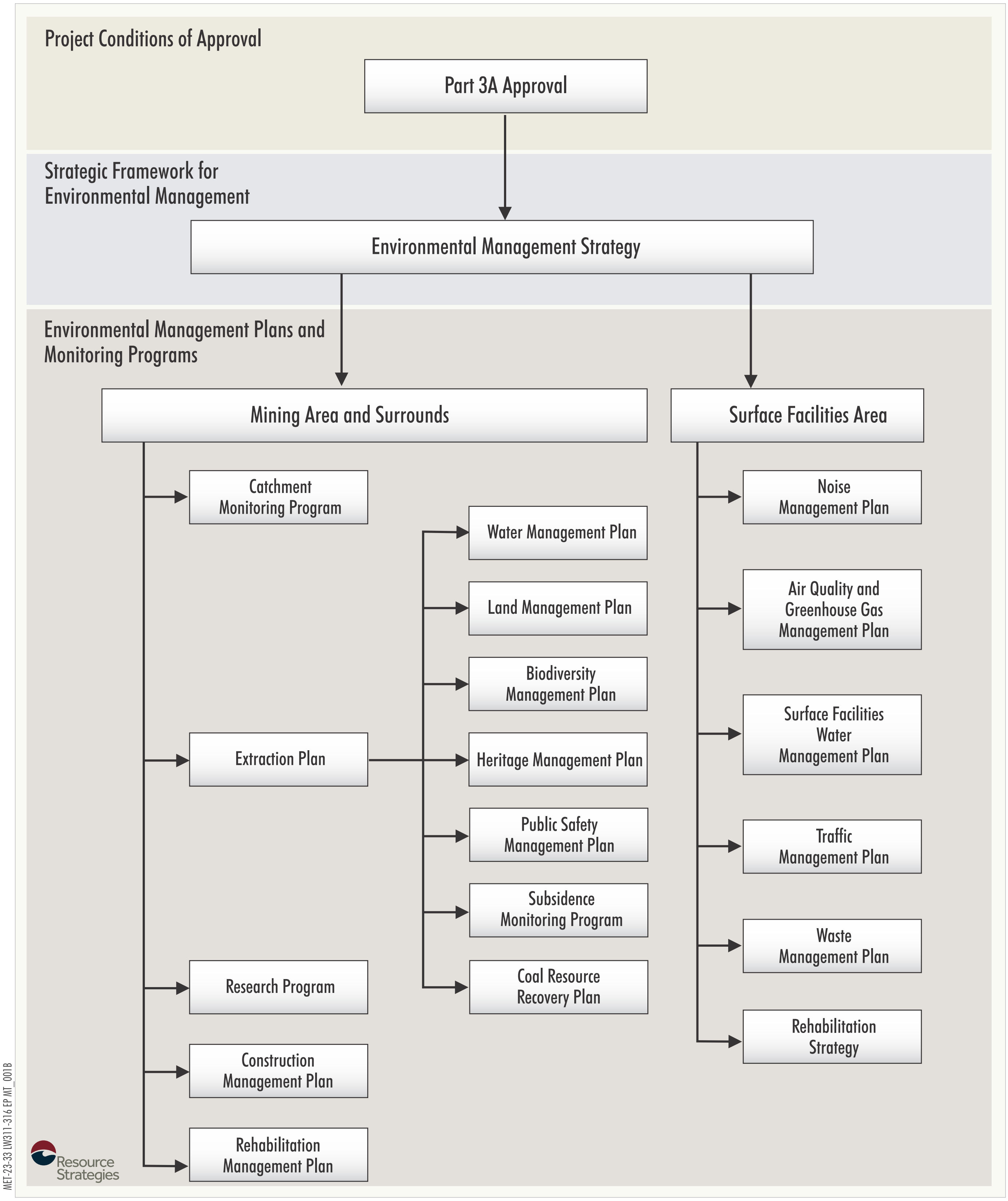
The Extraction Plan area for Longwalls 311-316, based on a 35 degree (°) angle of draw and/or predicted 20 millimetre (mm) subsidence contour, is shown on Figures 1 and 2.

This Extraction Plan forms part of Metropolitan Coal's Environmental Management Strategy. The relationship of this Extraction Plan to the Metropolitan Coal Environmental Management Structure is shown on Figure 3.

1.2 STRUCTURE OF THE EXTRACTION PLAN

This Extraction Plan comprises a main text component (with Attachments) and supporting management plans and studies, which include Appendices A through to H. An overview of the Extraction Plan main text sections and Attachments is presented below:

Section 1	Provides an introduction to the Extraction Plan, including a description of the purpose and scope of the Extraction Plan and a summary of the mine plan and design.
Section 2	Describes the process of development of the Extraction Plan, including the conduct of risk assessments, the review of relevant information obtained since Project Approval and a summary of consultation conducted with key stakeholders.
Section 3	Provides a short overview of the subsidence impact assessment undertaken including the update and review of predicted subsidence effects and potential subsidence impacts and environmental consequences, subsidence predictions, subsidence impact performance measures and subsidence management approach.
Section 4	Details all of the monitoring methods proposed to support the assessment of subsidence effects, impacts and environmental consequences.
Section 5	Describes the measures that will be implemented to manage, mitigate, remediate and monitor potential subsidence impacts and environmental consequences on natural and built features.
Section 6	Outlines the key elements of plan implementation, detailing the review protocol of the Extraction Plan and associated management plans, alongside reporting, regular review and key responsibilities.
Section 7	Lists the references cited in Sections 1 to 6 of this Extraction Plan.



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Environmental Management Structure

Figure 3

Attachment 1	Outlines the relevant requirements under the Project Approval and provides the relevant section of this Extraction Plan where the requirements are addressed.
Attachment 2	Provides details of a program to collect baseline data for the next Extraction Plan.
Attachment 3	Relevant Consultation Records.
Attachment 4	Provides a key contact register for the Extraction Plan.

Appendices A to G contain component management and monitoring plans of the Extraction Plan. The Longwalls 311-316 layout has been revised since the preparation of the March 2024 Subsidence Report. The updated subsidence predictions are provided in Appendix H. Appendices A to H are listed below:

Appendix A	Water Management Plan (WMP).
Appendix B	Land Management Plan (LMP).
Appendix C	Biodiversity Management Plan (BMP).
Appendix D	Heritage Management Plan (HMP).
Appendix E	Public Safety Management Plan (PSMP).
Appendix F	Subsidence Monitoring Program (SMP).
Appendix G	Coal Resource Recovery Plan (CRRP).
Appendix H	Subsidence Report.

The following graphical plans have been prepared in accordance with the DPE (2022) *Extraction Plan Guideline*:

Plan 1	Existing, Proposed and Future Workings.
Plan 2	Longwalls 311-316 Surface Features.
Plan 3	Geological and Seam Data.
Plan 5	Mining Titles and Land Ownership.
Plan 6	Geological Section and Geotechnical Logs.
Plan 7	Subsidence Monitoring Locations.

Plans 1, 2, 3, 5 and 6 are provided in Attachment 1 of the CRRP (Appendix G).

As there are currently no existing and/or planned future workings in seams above and/or below the proposed workings, Plan 4 (referred to in the DPE [2022] *Extraction Plan Guideline*) has not been prepared.

Plan 7 is provided in Attachment 1 of the SMP (Appendix F).

1.3 MINE PLANNING AND DESIGN

1.3.1 Geology and Stratigraphy

Metropolitan Coal is located within the Southern Coalfield, within the southern part of the Sydney Basin, which is infilled with sedimentary rocks of Permian age (<270 million years ago) and of Triassic age (<225 million years ago) (HCPL, 2008).

Three formally named coal seams of the Illawarra Coal Measures are present in the Southern Coalfield, namely the Bulli, Balgownie and Wongawilli Seams (HCPL, 2008).

Immediately overlying the Bulli Coal unit of the Illawarra Coal Measures are sandstones and claystones of the Narrabeen Group. The Narrabeen Group contains the Newport Formation (sometimes referred to as the Gosford Formation), the Bald Hill Claystone (also referred to as Chocolate Shale and formed as a result of laterite weathering Gerringong Volcanics), the Bulgo Sandstone, the Stanwell Park Claystone/Shale, the Scarborough Sandstone, the Wombarra Shale and the Coal Cliff Sandstone. At the top of the sequence in the area of interest is the Hawkesbury Sandstone (HCPL, 2008).

The Independent Expert Panel for Mining in the Catchment (IEPMC)[2] *Initial Report on Specific Mining Activities at the Metropolitan and Dendrobium Coal Mines* (IEPMC, 2018) (herein referred to as the IEPMC Initial Report) indicates that in recent years it has been identified in the Western Coalfield that surface subsidence, groundwater and surface water responses to longwall mining can be significantly modified in the vicinity of lineaments. Metropolitan Coal is unable to draw comparisons of lineament behaviour between the two geographically separated regions given the degree of variables potentially present. Metropolitan Coal believes that the depth to the basement rock is a key variable with likely substantive influence on behaviour of lineaments and markedly different between the shallow Western coalfields and deeper sedimentation of the Southern Coalfields (Appendix G).

Many features of the NSW Coalfields surface topography are directly correlated to the basement structure, the depth of the basement from the surface through many sedimentary epochs and the deformational episodes of the basement rock. The Palaeozoic granite basement rock underlies the Sydney Basin sedimentary rocks. At Metropolitan Coal the total depth of Sydney Basin sedimentation is 2.3 km (Appendix G). The major geological features mapped at seam level are shown on Figure 4[3].

Surface lineaments are linear features in the surface landscape, preferentially eroded, that may be the surface expression of an underlying geological structure, fault or dyke or simply a result of surface joint sets. Lineaments are identified from aerial photography, LiDAR and from digital topographic sets.

Lineaments mapped by Metropolitan Coal are shown on Figure 5. Additional LiDAR mapping was conducted by Metropolitan Coal in January and July 2023 to identify any new linear features within the Longwalls 311-316 35° angle of draw and/or predicted 20 mm subsidence contour. The 2023 LiDAR review confirmed the existing lineament mapping analysis with additional lineaments added to the dataset. Lineaments were examined for possible correlation to underground geological mapping in the study area of Longwalls 311-316.

Longwalls 311-316 are located approximately 1,280 metres (**m**) south-west of the Metropolitan Fault, at its closest point. The Metropolitan Fault has a north-northwest to south-southeast strike and dips to the south-west (Appendix G).

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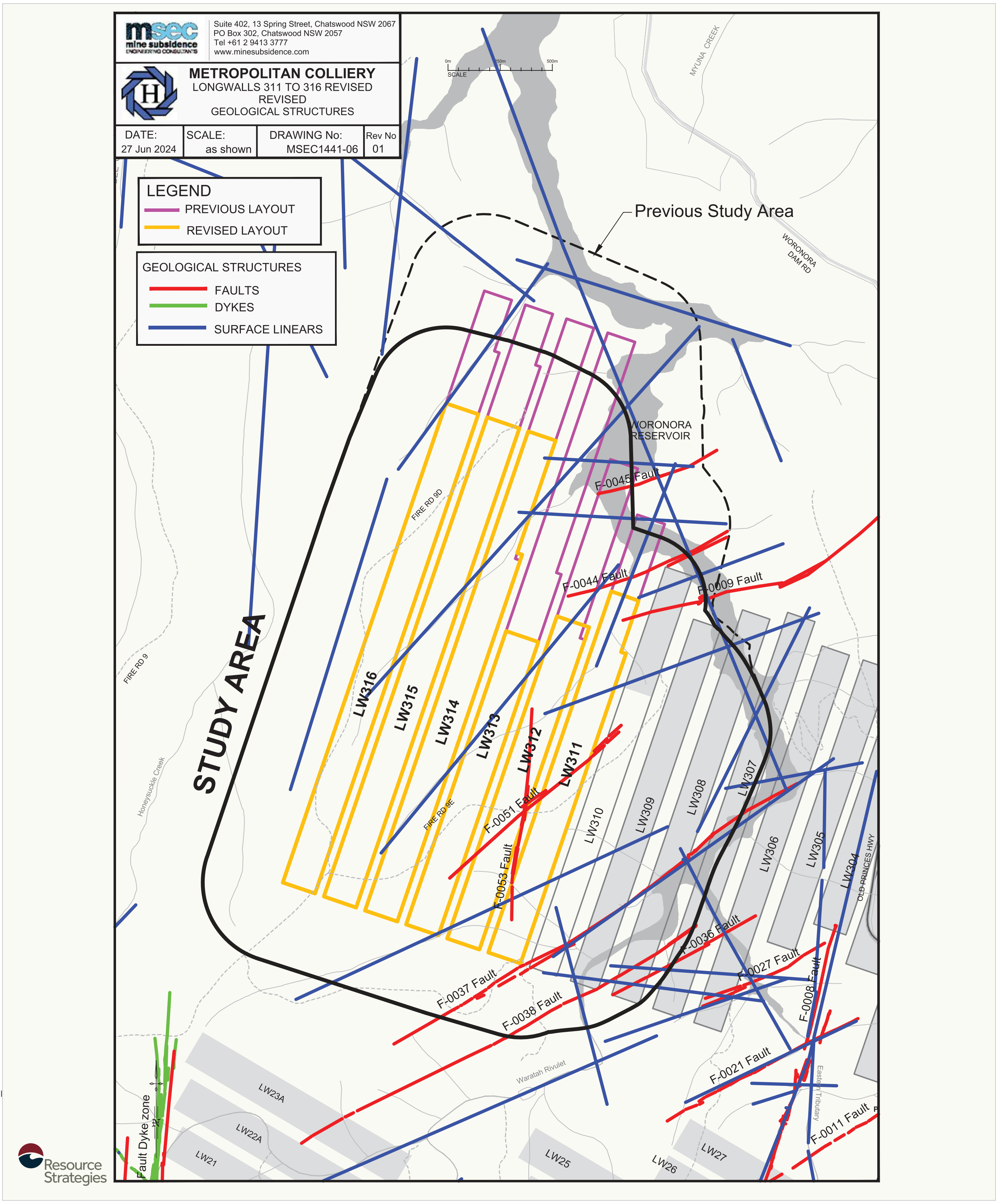
[2] The IEPMC was established in November 2017 by the NSW Government to provide expert advice to the DPE on the impact of mining activities in the Greater Sydney Water Catchment Special Areas, with a focus on risks to the quantity of water in the catchment.

[3] Figure 4 presents the July 2024 longwall layout. The revised longwall layout as of October 2024 are shown in Figure 2.



Source: MSEC (2024)

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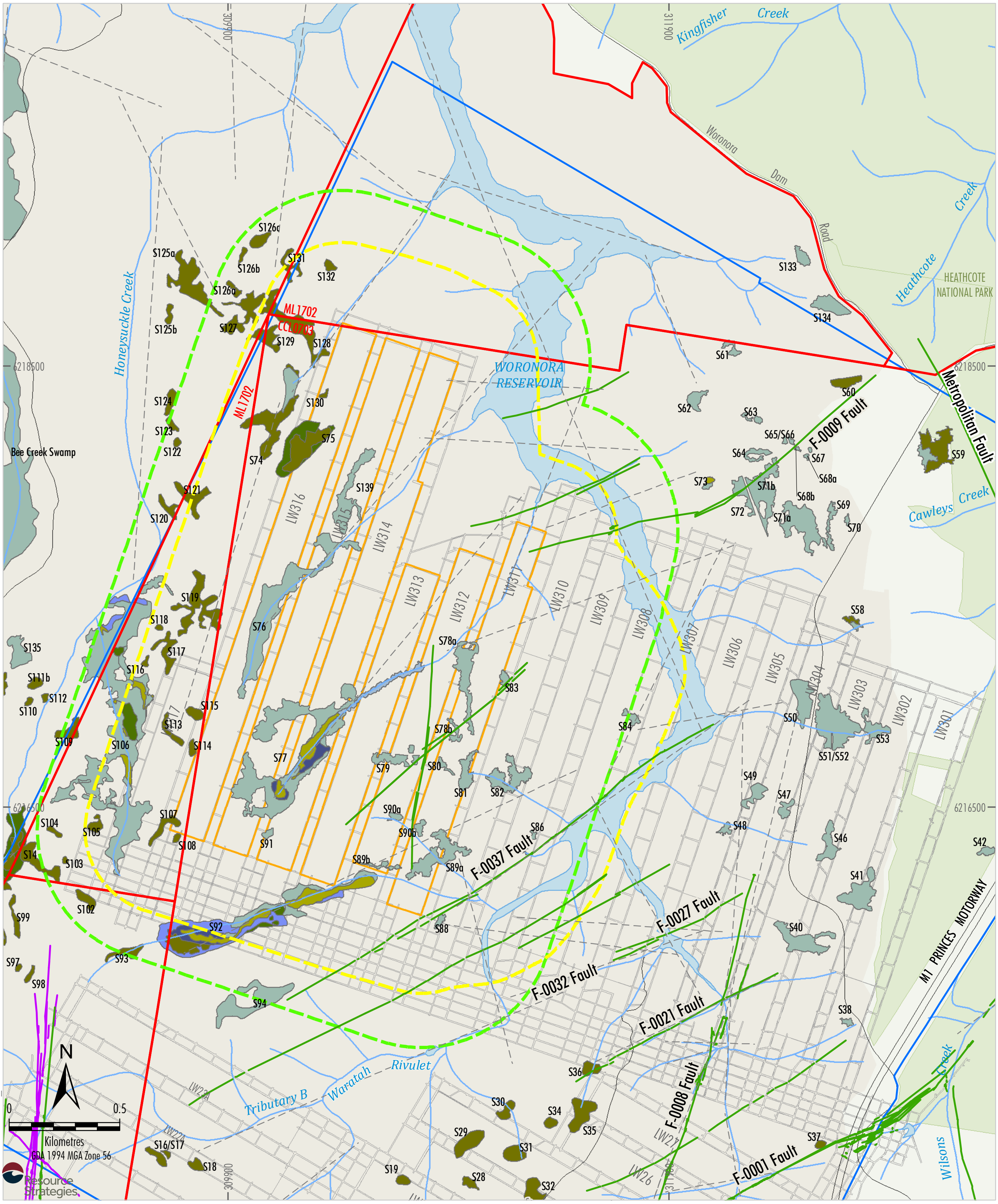
Longwalls 311-316 Geological Structures Identified at Seam Level

Figure 4



LEGEND

- Mining Lease Boundary
- Woronora Special Area
- Project Underground Mining Area Longwalls 20-27 and 301-317
- Longwalls 311-316 Secondary Extraction
- Longwalls 311-316 35° Angle of Draw and/or Predicted 20 mm Subsidence Contour
- 600 m from Longwalls 311-316 Secondary Extraction
- Faults (of note or greater than 1 km strike)
- Dykes
- Lineament

Map Unit	Vegetation Community
3a	Upland Swamp: Banksia Thicket
3b	Upland Swamps: Tea Tree Thicket
3c	Upland Swamp: Sedgeland-heath Complex
3d	Upland Swamp: Fringing Eucalypt Woodland
3e	Upland Swamp: Banksia / Tea Tree Thicket
3f	Upland Swamp: Restioid Heath
3g	Upland Swamp: Cyperoid Heath

Note: *The NSW Native Vegetation Interim Type Standard 2009 requires patches of vegetation to be mapped if the dimensions of the representative polygon on a map sheet are 2 mm x 2 mm or greater (i.e. 0.25 hectares or greater at a scale of 1:25,000). Eco Logical Australia conducted field inspections of upland swamp vegetation previously mapped by Bangalay Botanical Surveys (2008) overlying or proximal to Longwalls 301-310 to confirm the upland swamp vegetation communities present and to confirm or update the swamp vegetation boundaries. It is noted that the revised boundaries of a number of upland swamps (Swamps 37, 38, 42, 48, 54, 58, 61, 63, 65/66, 67, 68a, 68b, 70, 73, 83, 86 and 88) are less than 0.25 hectares in area and consistent with NSW vegetation mapping guidelines are not required to be mapped. Notwithstanding, the revised swamp vegetation mapping boundaries (including those swamps less than 0.25 hectares in area) are shown on this figure to document the changes to previous vegetation mapping.*

Source: Land and Property Information (2015); Department of Industry (2015); Metropolitan Coal (2023); MSEC (2024); after NPWS (2003), Bangalay Botanical Surveys (2008); Eco Logical Australia (2015; 2016; 2018) and Ecoplanning (2021; 2023)

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Known Lineaments over Longwalls 311-316 and Surrounds

Figure 5

A strike slip fault, F0008 (Figure 4), with up to 1.2 m vertical displacement occurs over Longwalls 20-27, and this fault extended partially through Longwall 304. This fault is associated with a surface linear that aligns with the Eastern Tributary and then passes east of the Woronora Reservoir full supply level dissipating into the landscape (Figure 5). Longwalls 20-27 and Longwall 304 were extracted through this feature directly under the Eastern Tributary with no moisture evident at seam level and no change in mine water balance during the several years of extraction in the area.

A strike slip fault, F0027, with zero vertical displacement, has been mapped in the gate roads leading into Longwall 304 and 305. The associated surface linear is located approximately 250 m west of the end of the Eastern Tributary arm of Woronora Reservoir full supply level. No moisture has been evident where the F0027 structure intersects the seam.

A strike slip fault, F0037, with zero vertical displacement, has been mapped in the gate roads and the three longwalls extracted through this feature, being Longwalls 306, 307 and 308. The associated surface linear is aligned with the Waratah Rivulet arm of Woronora Reservoir. Similar to previous experience of mining through these features no moisture has been evident from F0037 structure in the seam. The Longwalls 311-316 Geological Features Risk Assessment participants were shown images of F0037 during longwall extraction with the structure displaying dry and dusty conditions.

F0009 is a normal fault with a displacement of 0 m - 18 m located north of Longwall 308 and with a south-west strike bisecting Longwall 309 and diminishing to 0 m displacement at Longwall 310. The displacement of F0009 combined with coal quality north of the structure led to an economic decision to reposition the Longwall 308 and 309 face line from the Preferred Project Layout to the Extraction Plan Layout. Longwall 310 is anticipated to be able to ramp through the structure.

A detailed seismic assessment of F0009 was commissioned to determine the vertical extent of the structure with multiple dedicated seismic lines installed to provide a suitable resolution throughout the stratigraphy. The Velseis (2018) report concluded:

> *The large normal fault F0009 can be seen to impact the Bulli Seam only, and there is no evidence from available seismic data that this normal fault extends to the shallower Bald Hill Claystone level in the stratigraphy.*

From the detailed seismic report, the fault is not vertically extensive, residing at depth about the Illawarra Coal Measures. Whilst not vertically extensive, horizontally the structure extends north-west away from the extraction area towards the Metropolitan Fault. From the point where F0009 bisects Longwall 309 to the Metropolitan fault, the horizontal distance is approximately 1.5 km.

To demonstrate the structure poses negligible effects to the groundwater systems, a surface to seam borehole (2020EX02) was approved and installed in 2020. This hole, located along strike, approximately 700 m north-west of the intercept with Longwall 310, was designed to measure the horizontal permeability characteristics of F0009 by coring through the structure at depth. An assessment of the permeability characteristics found (Golder Associates Pty Ltd, 2020):

> *Hydraulic conductivities measured across the fault were comparable to those recorded for the unfractured host rock… there is negligible variance in horizontal flow characteristics associated with the fault measured at this location.*

Detailed surface mapping has not identified any associated surface linear with F0009. The Longwalls 311-316 Geological Features Risk Assessment participants were shown images of F0009 during development mining with the structure displaying dry and dusty conditions and a tight unbroken contact with the surrounding rock. Given the available data, it is highly unlikely that this feature would provide hydraulic connectivity either vertically or horizontally as a result of the extraction of Longwalls 311-316, similar to previous experiences of mining through other structures such as F0008, F0021, F0027 and F0037. The risk posed by F0009 was carefully considered and reviewed during the Longwalls 311-316 Geological Features Risk Assessment, with the continuation of a control to visually monitor F0009 for signs of moisture and further delineation to occur on roadway advancement (similar to controls previously used for structures passed through by mining).

A risk assessment workshop was held on 25 July 2023 to assess the potential for mining effects on geological features to impact on the quantity of water available to the Woronora Reservoir. The outcomes of the risk assessment are described in Section 2.2.2 and provided in Appendix G.

1.3.2 Mining Geometry

During the NSW Government's assessment phase of the Project EA (HCPL, 2008), and in recognition of concerns raised by key stakeholders during the formal PAC assessment process, Metropolitan Coal considered it appropriate to reduce the proposed extent of the original Project longwall mining area (i.e. Longwalls 20-44).

The Project Approval granted by the Minister for Planning in June 2009 included a layout for Longwalls 20-27 and 301-317 referred to as the Preferred Project Layout (as described in the Preferred Project Report [HCPL, 2009]). Longwalls 301-317 included in the Preferred Project Layout comprised 163 m panel widths (void) with 45 m pillars (solid) beyond the 35° angle of draw from the full supply level of Woronora Reservoir, and 138 m panel widths (void) with 70 m pillars (solid) when mining beneath or within the angle of draw of the Woronora Reservoir.

Following further mine planning investigations, Metropolitan Coal identified that significant operational efficiencies and consequently a significant economic benefit would be achieved by rotating the first workings of Longwalls 301-317 to be square with the 300 Mains (a rotation of approximately six degrees). The Secretary of the DPE approved the revised first workings in accordance with Condition 5, Schedule 3 of the Project Approval in April 2015.

Subsequently, Metropolitan Coal proposed to consolidate the panel and chain pillar widths of Longwalls 301-304 to 163 m (void) panel widths and 45 m wide pillars (solid). Changes to the first workings of Longwalls 301-303 and Longwall 304 were approved by the DPE in May 2016 and November 2018, respectively.

Following submission of the Longwalls 305-307 Extraction Plan in October 2019, Metropolitan Coal requested approval from the Secretary of the NSW Department of Planning, Industry and Environment (DPIE) for a revision of the Longwalls 305 and 306 first workings layout. The revised layout included a reduction to the panel (void) lengths of Longwall 305 (from 1,596 m to 1,547 m) and Longwall 306 (from 1,956 m to 1,907 m) and associated changes to the cut-through positions for the Longwalls 305 and 306 maingates. The revised layout of Longwalls 305 and 306 did not change the panel widths, pillar widths or panel orientation.

In January 2021, Metropolitan Coal submitted an application to the DPIE requesting a 50 m extension to the panel (void) length of Longwall 307 at the commencing end (from 1,956 m to 2,006 m). The 50 m extension of Longwall 307 was approved by the DPIE in August 2021.

With the submission of Longwalls 308-310 Extraction Plan in February 2022, Metropolitan Coal requested approval from the Secretary of the DPE for a revision to the first workings of Longwall 310 maingate and a reduction in extraction length of Longwall 308 from 3,110 m to 1,948 m, a reduction of 1,162 m. Approximately 1,568 m of the maingate pillar of Longwall 310 from the commencing end was decreased in width from 70 m to 45 m. The commencing positions (i.e. the northern end) of Longwall 309 and Longwall 310 were requested consistent with the Preferred Project Layout. Subsequent to the submission and during the assessment process, Metropolitan Coal requested to vary the first working layout of Longwall 309. The revised layout included a reduction of 1,288 m to the panel (void) length (from 3,118 m to 1,948 m). The revised layout of Longwall 309 was approved by the Secretary of the DPE on 15 November 2022. The Longwalls 308-310 Extraction Plan was approved by the Secretary of the DPE on 12 December 2022.

In November 2023, Metropolitan Coal requested approval from the Secretary of the DPE to vary the first working layout of Longwall 310 to reduce the extraction length from 3,118 m to 2,089 m (a reduction of 1,029 m). The revised layout of Longwall 310 was approved by the Secretary of the DPE on 27 November 2023.

Relevant to the Longwalls 311-316 Extraction Plan, the commencing positions (i.e. the northern end) of Longwalls 311-316 are by 1,495 m, 1,727 m, 1,904 m, 1,047 m, 1,079 m and 1,161 m shorter than the Preferred Project Layout (respectively). The finishing positions (i.e. the southern end) of Longwalls 311-316 are consistent with the Preferred Project Layout.

Following the submission of the Revised Longwalls 311-316 Layout Extraction Plan in July 2024, Metropolitan Coal proposes to reduce the length of Longwall 312 by 130 m at the finishing (southern) end of the longwall. (Figure 2).

A summary of the longwall dimensions for Longwalls 311-316 is provided in Table 1. The layout of Longwalls 311-316 includes both 163 m and 138 m panel widths (void) and 45 m and 70 m pillar widths (solid), consistent with the Preferred Project Layout (Figure 2). As the mine progresses west of the reservoir it will transition to 163 m panel widths, with 138 m panel widths remaining at the northern commencing ends beneath the reservoir.

Table 1
Summary of Longwall Dimensions for Longwalls 311-316

Longwall	Longwall Length (m)	Total Void Width (m)	Tailgate Chain Pillar Width (m)
LW311	1,829	138 / 163	45 / 70
LW312	1,502	138 / 163	45 / 70
LW313	1,487	138 / 163	45 / 70
LW314	2,427	138 / 163	45 / 70
LW315	2,427	138 / 163	45 / 70
LW316	2,427	138 / 163	45 / 70

1.3.3 Mining Method

Longwalls 311-316 extraction will occur from north to south. Longwalls 311-316 will be extracted using retreating longwall mining methods for secondary extraction. The longwall panel will be formed by driving two sets of gate roads (the tailgate and maingate roads). Each gate road requires two roadways (headings) to be driven parallel to each other. The two roadways will be used for ventilation purposes, with one of the roadways utilised as a transport road and the other roadway used to convey the coal that will be mined back to the main conveyors. Construction of development main headings and gate roads are mined using continuous miners.

The dimensions of the headings will be approximately 5.2 m wide and 3.2 m in height. The headings are connected approximately every 130 m by driving a cut-through from one heading to another which forms pillars of coal along the length of the gate road. The tailgate and maingate roads are separated by the longwall panel, initially 138 m void width in the north and increasing to 163 m void width in the south. The maingate roads and tailgate roads are then linked together by driving an installation road and bleeder road at the top end of the longwall panels. Run-of-mine (ROM) coal will be conveyed by the maingate conveyor to the main conveyor which will carry coal to the surface of the mine.

1.3.4 Mining Parameters

The Extraction Plan area and proposed mine plan is shown on Plan 1 of Attachment 1 in Appendix G and key dimensions are summarised in Table 2.

Table 2
Key Mining Parameters

Parameter	Longwalls 311-316
ROM Coal Extracted (Mt)	Approximately 9.0
Gate Road Width (m)	5.2
Gate Road Height (m)	3.2
Maingate Chain Pillar Width (m)	45 or 70
Tailgate Chain Pillar Width (m)	45 or 70
Longwall Void Width (m) (ribline of goaf edge)	138 or 163
Longwall Void Length (m)	1,487 to 2,427
Seam Thickness (m)	2.5 to 2.65
Extraction Height (m)	2.8
Depth of Cover (m)	405 to 555

Mt = million tonnes.

1.3.5 Mining Schedule

Metropolitan Coal operates seven days a week, 24 hours a day on a rotating shift basis. The extraction of Longwalls 1 to 308 is complete, with extraction of Longwall 309 underway.

The provisional extraction schedule for Longwalls 311-316 is provided in Table 3.

Table 3
Provisional Extraction Schedule

Longwall	Estimated Start Date	Estimated Duration	Estimated Completion Date
Longwall 311	October 2024	8 Months	June 2025
Longwall 312	July 2025	6 Months	December 2025
Longwall 313	January 2026	5 Months	June 2026
Longwall 314	August 2026	9 Months	June 2027
Longwall 315	July 2027	8 Months	March 2028
Longwall 316	April 2028	8 Months	December 2028

The future Extraction Plans will consider the cumulative subsidence effects, subsidence impacts and/or environmental consequences. Note that the total cumulative predicted subsidence effects, subsidence impacts and/or environmental consequences at the completion of the Project are considered in the Project EA (HCPL, 2008) and the Preferred Project Report (HCPL, 2009).

1.3.6 Previous and Future Mining

Mining at the Metropolitan Coal Mine commenced in the 1880s after the Bulli Seam was identified during exploration in 1884. Prior to the commencement of longwall mining in 1995, bord and pillar underground mining methods were primarily employed.

Currently there are no plans for mining other coal seams (i.e. other than the Bulli Seam) at the Metropolitan Coal Mine.

Previous longwall mining areas at the Metropolitan Coal Mine are located to the east and south of Longwalls 311-316 and include Longwalls 1-18, Longwalls 20-27, and Longwalls 301-310. Extraction of Longwalls 1-18 commenced in 1995 and was completed in 2009. Extraction of Longwalls 20-27 commenced in 2010 and was completed in early 2017. Extraction of Longwalls 301-310 commenced in mid-2017. Extraction of Longwall 309 commenced in August 2023 and is scheduled to be completed in February 2024 followed by Longwall 310. The location of historic and previous mining at the Metropolitan Coal Mine is shown on Plan 1 in Attachment 1 of the CRRP (Appendix G).

The current layout of Longwalls 311-316 is shown on Figure 1 in this document, and on Plan 1 in Attachment 1 of the CRRP (Appendix G) and includes narrow longwalls (138 m wide) beneath and within angle of draw of the full supply level of the Woronora Reservoir. The layout of Longwall 317 will however be subject to further review for future Extraction Plans in consideration of potential subsidence impacts and environmental consequences.

2 DEVELOPMENT OF THE EXTRACTION PLAN

2.1 PLAN DEVELOPMENT

This Extraction Plan has been prepared by Metropolitan Coal with assistance from a team of suitably qualified and experienced persons including MSEC, SLR Consulting Australia Pty Ltd (SLR Consulting), ATC Williams Pty Ltd (ATC Williams), Associate Professor Barry Noller, Ecoplanning Pty Ltd (Ecoplanning), Bio-Analysis Ptd Ltd (Bio-Analysis), Niche Environment and Heritage Pty Ltd (Niche), and Resource Strategies Pty Ltd (Resource Strategies).

Metropolitan Coal has engaged specialists to provide input into the Extraction Plan and provide a review on the predicted subsidence effects, subsidence impacts and environmental consequences of mining Longwalls 311-316.

Subsidence predictions of mining Longwalls 311-316 was undertaken by MSEC within *Metropolitan Coal Mine – Longwalls 311-316 Subsidence Predictions and Impact Assessments for the Natural and Built Features in Support of the Extraction Plan* (Attachment 1 of Appendix H). These subsidence predictions have been reviewed alongside recent subsidence monitoring data with the report provided by MSEC (2024). The Longwalls 311-316 layout has been revised since the preparation of the March 2024 Subsidence Report. The revisions to the layout involved a reduction of longwall panels. The updated subsidence predictions are provided in Appendix H.

2.1.1 Statutory Requirements

This Extraction Plan has been prepared in accordance with the conditions of the Project Approval (08_0149) and in consideration of the DPE (2022) *Extraction Plans Guideline.*

The statutory requirements relevant to this Extraction Plan are summarised below.

Project Approval (08_0149)

This Extraction Plan has been prepared in accordance with Conditions 6 and 7, Schedule 3 of the Project Approval. The requirements of Conditions 6 and 7, Schedule 3 of the Project Approval are summarised in Table 4, along with the relevant section of this Extraction Plan in which the requirements are addressed.

Further detail on the requirements of the Project Approval is provided in Attachment 1.

Table 4
Extraction Plan Requirements

Project Approval (08_0149) Condition	Extraction Plan Reference
Condition 6, Schedule 3	
6. The Proponent shall prepare and implement an Extraction Plan for all second workings in the mining area to the satisfaction of the Director-General[1]. This plan must:	This document
(a) be prepared by a team of suitably qualified experts whose appointment has been endorsed by the Director-General;	Section 2.1 and Attachment 3
(b) be approved by the Director-General before the Proponent is allowed to carry out the second workings covered by the Extraction Plan;	This Application
(c) include a detailed plan for the second workings, which has been prepared to the satisfaction of DRE[2], and provides for adaptive management (from Longwall 23 onwards);	Section 1.3 and Appendix G
(d) include detailed plans of any associated surface construction works;	N/A

Table 4 (Continued)
Extraction Plan Requirements

Project Approval (08_0149) Condition	Extraction Plan Reference
Condition 6, Schedule 3 (Continued)	
(e) include the following to the satisfaction of DRE[2]:	
• a coal resource recovery plan that demonstrates effective recovery of the available resource;	Appendix G
• revised predictions of the conventional and non-conventional subsidence effects and subsidence impacts of the extraction plan, incorporating any relevant information that has been obtained since this approval; and	Appendix H
• a Subsidence Monitoring Program to: - validate the subsidence predictions; and - analyse the relationship between the subsidence effects and subsidence impacts of the Extraction Plan and any ensuing environmental consequences;	Section 4.1 and Appendix F
(f) include a:	
• Water Management Plan, which has been prepared in consultation with OEH, SCA[3] and NOW[4], to manage the environmental consequences of the Extraction Plan on watercourses (including the Woronora Reservoir), aquifers and catchment yield;	Appendix A
• Biodiversity Management Plan, which has been prepared in consultation with OEH and DRE (Fisheries)[5], to manage the potential environmental consequences of the Extraction Plan on aquatic and terrestrial flora and fauna, with a specific focus on swamps;	Appendix C
• Land Management Plan, which has been prepared in consultation with SCA[3], to manage the potential environmental consequences of the Extraction Plan on cliffs, overhangs, steep slopes and land in general;	Appendix B
• Heritage Management Plan, which has been prepared in consultation with OEH and the relevant Aboriginal groups, to manage the potential environmental consequences of the Extraction Plan on heritage sites or values; and	Appendix D
• Built Features Management Plan, which has been prepared in consultation with the owner of the relevant feature, to manage the potential environmental consequences of the Extraction Plan on any built features; and	Section 4.2.5
(g) include a Public Safety Management Plan, which has been prepared in consultation with DRE[2] (for any mining within the DSC notification area), to ensure public safety in the mining area.	Appendix E
Note: In accordance with condition 12 of schedule 2, the preparation and implementation of Extraction Plans for second workings may be staged, with each plan covering a defined area of second workings. In addition, these plans are only required to contain management plans that are relevant to the specific second workings that are being carried out.	
Condition 7, Schedule 3	
7. In addition to standard requirements for management plans (see condition 2 of schedule 7), the Proponent shall ensure that the management plans required under condition 6(f) above include:	
(a) a program to collect sufficient baseline data for future Extraction Plans;	Appendices A to E, Attachment 2
(b) a revised assessment of the potential environmental consequences of the Extraction Plan, incorporating any relevant information that has been obtained since this approval;	Appendices A to E, Section 3.1
(c) a detailed description of the measures that would be implemented to remediate predicted impacts; and	Appendices A to E, Section 4
(d) a contingency plan that expressly provides for adaptive management.	Appendices A to E, Section 5.1

1 The Director-General of the DPE is now the Secretary of the DPE.

2 The NSW Division of Resources and Energy (DRE) is now the NSW Resource Regulator.

3 The Sydney Catchment Authority (SCA) is now WaterNSW.

4 The NSW Office of Water (NOW) is now the Department of Planning and Environment – Water (DPE – Water).

5 DRE (Fisheries) is now the Department of Primary Industries – Fisheries (DPI-Fisheries).

Condition 4, Schedule 3 of the Project Approval relating to the undermining of the Swamps 76, 77 and 92 is addressed in the Large Swamp Assessment (Metropolitan Coal, 2024).

Licences, Permits and Leases

In addition to the Project Approval, all activities at or in association with Metropolitan Coal will be undertaken in accordance with the following licences, permits and leases which have been issued or are pending.

- The conditions of mining leases issued by the NSW Division of Resources and Geoscience (now Mining, Exploration and Geoscience), under the NSW *Mining Act 1992* (e.g. CCL 703, ML 1610, ML 1702, Coal Lease [**CL**] 379 and Mining Purpose Lease [**MPL**] 320).
- The conditions of Environment Protection Licence (**EPL**) No. 767 issued by the NSW Environment Protection Authority (**EPA**) under the NSW *Protection of the Environment Operations Act 1997*. Revision of the EPL will be required prior to the commencement of Metropolitan Coal activities that differ from those currently licensed.
- The prescribed conditions of specific surface access leases within CCL 703 for the installation of surface facilities as required.
- Water Access Licences (**WALs**) issued by the NSW Department of Industry – Water (now DPE – Water) under the NSW *Water Management Act 2000*, including WAL 36475 under the *Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources 2023* and WAL 25410 under the *Water Sharing Plan for the Greater Metropolitan Region Unregulated River Water Sources 2023.*
- Mining and workplace health and safety related approvals granted by the NSW Resources Regulator and WorkCover NSW.
- Supplementary approvals obtained from WaterNSW for surface activities within the Woronora Special Area (e.g. fire road maintenance activities).

2.2 RISK ASSESSMENTS

In accordance with the DPE (2022) *Extraction Plan Guideline*, a number of risk assessments have been undertaken for the Metropolitan Coal Longwalls 311-316 Extraction Plan to ensure that appropriate consideration was given to risk assessment and risk management in each component management plan.

2.2.1 Environmental Risk Assessment

An Environmental Risk Assessment (**ERA**) was conducted for four of the key component plans of this Extraction Plan *viz.* WMP, LMP, BMP and LMP.

The suitably qualified and experienced experts endorsed by the Secretary of the DPE for the preparation of the Metropolitan Coal Longwalls 311-316 Extraction Plan participated in the ERA[4]. The ERA process involved the key steps described below.

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[4] Participants included Mr Peter DeBono (MSEC, Subsidence and Land), Ms Ines Epari (SLR Consulting, Groundwater), Mr Anthony Marszalek and Dr Camilla West (ATC Williams, Surface Water), Associate Professor Barry Noller (The University of Queensland, Surface Water Quality), Dr Sharon Cummins (Bio-Analysis, Aquatic Fauna), Ms Elizabeth Norris (Ecoplanning, Flora), Mr Jamie Reeves (Niche Environment and Heritage, Heritage), Mr Jon Degotardi (Metropolitan Coal), Mr Stephen Love (Metropolitan Coal), Mr Nicolas Tucker (Metropolitan Coal), Mr Jamie Warwick (Resource Strategies), Ms Harper Mulloy (Resource Strategies) and Ms Abigail Ashford (Resource Strategies).

Review of Relevant Documentation and Risk Identification

In preparation for the ERA workshop, the ERA participants reviewed a number of documents relevant to the risk assessment. This included (but was not limited to):

- The 2008 *Environmental Risk Analysis* (SP Solutions, 2008) conducted for the Project EA (Appendix O of the Project EA).
- The Preferred Project Report (HCPL, 2009). During the NSW Government's assessment phase of the Project EA, and in recognition of concerns raised by key stakeholders during the formal PAC assessment process, HCPL considered it appropriate to reduce the proposed extent of the original Project longwall mining area (i.e. Longwalls 20-44). This reduction in the extent of longwall mining resulted in a significant reduction to the extent of potential subsidence effects to the Waratah Rivulet and the Eastern Tributary and a reduction in the consequential potential environmental impacts.
- The Longwall 308-310 Environmental Risk Assessment Report (Risk Mentor, 2021) (which included consideration of the Longwalls 301-303, Longwall 304 and Longwalls 305-307 Environmental Risk Assessment Report).
- Figures showing the Longwalls 311-316 layout in relation to key surface features.
- Subsidence predictions for Longwalls 311-316 (including subsidence contours, Eastern Tributary, Waratah Rivulet, Woronora Reservoir, other streams, cliff sites, upland swamps and Aboriginal heritage sites).

The participants were asked to identify any additional (specific) issues/risks and/or changes to previously assessed levels of risk in preparation for the ERA workshop.

ERA Workshop

The ERA workshop for Longwalls 311-316 was conducted on 18 August 2023, with all participants attending via video conferencing. The ERA workshop was facilitated by an independent specialist, Dr Peter Standish of Risk Mentor and conducted in accordance with AS/NZS ISO 31000: *2009 Risk Management – Principles and Guidelines.*

The general consensus of the workshop participants was the additional (specific) issues/risks identified for Longwalls 311-316 were broadly assessed and ranked as part of the 2008 Environmental Risk Analysis, Longwalls 301-303 ERA, Longwall 304 ERA, Longwalls 305-307 ERA and/or Longwalls 308-310 ERA. However, additional (specific) issues were identified by the workshop participants relevant to Longwalls 311-316. Each of the issues/risks were explained systematically by the relevant workshop participants and each carefully reviewed.

Loss scenarios for the key potential environmental issues were identified for upland swamps, aquatic biota, threatened amphibians, Waratah Rivulet and the Woronora Reservoir. The risk rankings are within the "low-medium" range and consequently the potential outcomes can be integrated into the existing management systems for effective review and monitoring.

ERA Report Review

All ERA participants were asked to review the draft Longwalls 311-316 ERA report that was prepared to summarise the outcomes of the risk assessment. Participants' comments were incorporated into the final Risk Mentor (2023) report.

The WMP, LMP, BMP and HMP have been prepared to provide for effective management of the identified subsidence risks.

2.2.2 Risk Assessment on Geological Features with Potential to Affect Water Quantity Available to Woronora Reservoir and Aboriginal Heritage

The IEPMC Initial Report recommended that the potential implications for water quantity of faulting, basal shear planes and lineaments be carefully considered and risk assessed at all mining operations in the Catchment Special Areas (IEPMC, 2018).

In relation to the Metropolitan Coal Mine, the IEPMC Initial Report concluded (p. 127):

> *In the case of Metropolitan Mine:*
>
> - *…..*
> - *the potential for water be diverted out of Woronora Reservoir and into other catchments through valley closure shear planes and geological structures including lineaments will require careful assessment in the future because it is planned that most of the remaining longwall panels in the approved mining area will pass beneath the reservoir.*

A risk assessment workshop was held on 25 July 2023 to assess the potential for Longwalls 311-316 mining effects on geological features to impact on the quantity of water available to the Woronora Reservoir. The workshop participants identified and assessed the potential for mining effects on lineaments, joints, faulting, basal shear planes and dykes to impact on the quantity of water to the Woronora Reservoir, including the potential for water to be diverted out of Woronora Reservoir and into other catchments. Participants also assessed the impacts to Aboriginal heritage sites as a result of mining effects on geological features.

The participants considered the risk control measures and procedures to be reasonable to manage the identified risks. The risk assessment is provided in Attachment 2 of the CRRP (Appendix G).

Further information on the risk assessment is provided in the Longwalls 311-316 CRRP (Appendix G).

2.2.3 Public Safety Management Plan Risk Assessment

A risk assessment was held on 5 December 2023 for the Longwalls 311-316 PSMP (Appendix E) to identify and address potential safety hazards to the public, including:

- potential subsidence impacts on built features;
- potential instability of cliff formations or steep slopes caused by subsidence;
- deformations or fracturing of any land caused by subsidence; and
- any other impacts of subsidence.

Risk assessment attendees included representatives from Metropolitan Coal (Approvals Manager, Technical Services Manager, Environment & Community Superintendent, Environment and Community Coordinator and Senior Mining Engineer / Facilitator), MSEC and Resource Strategies.

Several risk control and management measures were identified during the risk assessment which considered the extraction of coal beneath land and infrastructure.

Metropolitan Coal considers all risk control measures and procedures to be feasible to manage all identified risks.

2.3 REVIEW OF RELEVANT INFORMATION OBTAINED SINCE PROJECT APPROVAL

The five management plans of this Extraction Plan (i.e. the WMP [Appendix A], LMP [Appendix B], BMP [Appendix C], HMP [Appendix D], and PSMP [Appendix E]) have been prepared in consideration of the information obtained since Project Approval (i.e. the results of monitoring of subsidence impacts and environmental consequences).

In particular, Appendices A to D provide a detailed summary of the information obtained since Project Approval by the Water, Land, Biodiversity and Heritage Management Plans, respectively.

A summary of the information obtained since the Project Approval most relevant to the Longwalls 311-316 Extraction Plan has been provided below.

Eastern Tributary and Waratah Rivulet

The Preferred Project Report (HCPL, 2009) indicated that valley closure values of greater than 200 mm were predicted for a number of pools/rock bars on the Waratah Rivulet, Eastern Tributary and other streams. 'Negligible consequence' for a watercourse was considered by the Project Approval to mean, *'no diversion of flows, no change in the natural drainage behaviour of pools, minimal iron staining, and minimal gas releases'*, and was assumed to be achieved in circumstances where predicted valley closure was less than 200 mm. Subsidence impacts to a number of pools on the Eastern Tributary occurred during the mining of Longwalls 26 and 27 at predicted total valley closure values of less than 200 mm and resulted in the exceedance of the negligible environmental consequences performance measure for the Eastern Tributary.

The IEPMC Initial Report recommended that the concept of restricting predicted valley closure to a maximum of 200 mm to avoid significant environmental consequences be revised for watercourses (IEPMC, 2018). Metropolitan Coal agreed that the 200 mm valley closure concept required revision in relation to the Eastern Tributary, noting that the unexpected impacts are particular to the Eastern Tributary and not the Waratah Rivulet. Restricting predicted valley closure to 200 mm has been a successful design tool for mining in the vicinity of the Waratah Rivulet.

The negligible environmental consequences performance measure for watercourses as described above applied specifically for the Waratah Rivulet along the portion of the '*Waratah Rivulet between the full supply level of the Woronora Reservoir and the maingate of Longwall 23 (upstream of Pool P)'.* This section of the Waratah Rivulet includes Pool T to Rock Bar W, located to the south-east of Longwalls 311-316.

The restriction of predicted valley closure to 200 mm has been a successful design tool on the Waratah Rivulet, with no impacts to pools and rock bars along the Waratah Rivulet at predicted total valley closure of less than 200 mm. Pool P to Rock Bar W have not exceeded the negligible environmental consequence performance measure for the Waratah Rivulet. Predicted total valley closure for Pool P to Rock Bar W was less than 200 mm for the extraction of Longwalls 20-27, 301-303, 304, 305-307 and did not increase for Longwalls 308-310.

Pool A to Pool O (a total of 16 pools) are located upstream of Pool P, and are therefore not subject to the Waratah Rivulet negligible environmental impact performance measure. It is noted that the majority of these pools were predicted to experience maximum predicted total closure of greater than 200 mm. However, of these pools, only two (Pools G1 and N) have experienced subsidence impacts that would have resulted in an exceedance of the negligible environmental impact performance measure. Impacts that have occurred at these pools have been the result of mining directly beneath the Waratah Rivulet or in close proximity (< 100 m) to the rock bars, at predicted total valley closure greater than 200 mm.

Although subsidence impacts were observed at a number of pools on the Eastern Tributary at predicted total valley closure values of less than 200 mm during the mining of Longwalls 26 and 27, restricting predicted total valley closure to 200 mm is no longer applied for the Eastern Tributary.

A geotechnical study of the Waratah Rivulet investigated the geological characteristics of the stream bed, with the aim of identifying any characteristics that would make the Waratah Rivulet more susceptible to subsidence movements (similar to the Eastern Tributary). The study focussed on Pool P to Rock Bar W on the Waratah Rivulet, and compared these sites to Pool ETAM on the Eastern Tributary, which has experienced subsidence movements due to historical mining.

The geotechnical study identified a thick unit (approximately 25 m) of thinly bedded sandstone along the Eastern Tributary at the location of Pool ETAM. The thinly bedded sandstone is considered to be of lower strength, and more weathered than adjoining thickly bedded sandstone units and therefore more prone to impact from valley closure movements. In addition, a higher frequency of seam level faults and surface lineaments have been identified in the vicinity of the Eastern Tributary. The thinly bedded units identified along the along Waratah Rivulet were limited to less than 5 m thickness and the frequency of seam level faults and surface lineaments was considerably less.

Based on the results of the assessment, the geological features identified along the Eastern Tributary are considered to be unique, compared to the Waratah Rivulet. The Eastern Tributary is therefore more likely to be susceptible to subsidence movements. Restricting valley closure to 200 mm therefore continues to be an appropriate design tool for the Waratah Rivulet. Further discussion on the subsidence predictions and 200 mm valley closure design tool for Longwalls 311-316 is provided in the WMP (Appendix A).

Metropolitan Coal developed a monitoring and adaptive management approach to the mining of Longwall 303 towards the Eastern Tributary. As Longwall 303 mined towards the Eastern Tributary, Metropolitan Coal used a Trigger Action Response Plan (TARP) designed to monitor valley closure movements on the Eastern Tributary. The Eastern Tributary Valley Closure TARP has been successfully implemented by Metropolitan Coal for Longwalls 303, 304 and 305. The Waratah Rivulet is monitored by the same Global Navigation Satellite System (GNSS) valley closure monitoring methods used for the Eastern Tributary with consideration of the 200 mm valley closure design tool (as described in the Longwalls 308-310 Extraction Plan) (Appendix A).

Woronora Reservoir

Condition 2 of the Longwalls 301 and 302 approval required Metropolitan Coal to conduct further investigation into potential impacts on the Woronora Reservoir. Metropolitan Coal engaged independent experts to prepare a Woronora Reservoir Impact Strategy to provide a staged plan of action for further investigations and a report into the impacts of mining near the reservoir. Professor Bruce Hebblewhite (B. K. Hebblewhite Consulting), Dr Frans Kalf (Kalf and Associates Pty Ltd) and Emeritus Professor Thomas McMahon (University of Melbourne) were endorsed by the DPIE for the Woronora Reservoir Impact Strategy in May 2017.

The *Woronora Reservoir Strategy Report – Stage 1* (Hebblewhite *et al.,* 2017) was provided by the independent experts to the DP&E in September 2017. The Stage 1 report included recommendations for further groundwater and surface water investigations and monitoring and was approved by the Secretary for Planning in December 2017.

The *Woronora Reservoir Strategy Report – Stage 2* (Hebblewhite *et al.,* 2019) was provided by the independent experts to the DPIE in June 2019. The Stage 2 report includes additional recommendations in regard to groundwater and surface water investigations and monitoring, based on further data and analysis arising from the ongoing monitoring programs, including those recommended in the original Stage 1 report.

The Stage 1 report included recommendations for further groundwater and surface water investigations and monitoring. The key outcomes and recommendations of the Stage 1 report were considered in the Longwall 304 Extraction Plan.

The Stage 2 report represents the second stage of the Woronora Reservoir Impact Strategy, based on further data and analysis arising from the ongoing monitoring programs, including those recommended in the Stage 1 report.

The surface water and groundwater monitoring locations that have been installed as a component of the Woronora Reservoir Impact Strategy are described in the WMP (Appendix A).

The additional monitoring sites and environmental investigations for the Woronora Reservoir Impact Strategy included the installation of two streamflow monitoring stations in sub-catchments I and K to the west of Longwalls 301-303 and the installation of a pluviometer in the vicinity of the northern end of Longwall 307. The Stage 2 report recommended that further analysis of the data obtained from these monitoring sites (that covers at a minimum the initial 12-month period) be conducted. A summary of the outcomes of this assessment is provided below.

Data collected from the flumes on sub-catchments I and K commenced on 31 May 2018 and 3 June 2018, respectively (the flumes were installed on 17 May 2018 and 16 May 2018, respectively). Secondary extraction from Longwall 302 was occurring at the commencement of monitoring. Sub-catchment I overlies Longwall 301 to Longwall 305 while Sub-Catchment K predominately overlies Longwall 306 and Longwall 307. Sub-Catchment K formed a control for the assessment of potential impacts to streamflow in Sub-Catchment I associated with secondary extraction from Longwall 301 to Longwall 304.

Streamflow monitoring in sub-catchments I and K is proposed to continue up to the completion of Longwall 310.

Assessments of the dry weather recessions recorded at the flumes on sub-catchments I and K show consistent behaviour with time, although the recorded streamflow recession during low flow periods appears to be more rapid at the gauging station on Sub-Catchment K than on Sub-Catchment I. There is no visual indication of a change in recessionary behaviour (i.e. rate of recession) for Sub-Catchment I and no indication from the recorded stage and streamflow data that mining of Longwall 301 to Longwall 305 has impacted streamflow at the Sub-Catchment I gauging station. Additionally, there is no visual indication of a change in recessionary behaviour (i.e. rate of recession) for Sub-Catchment K and no indication from the recorded data that mining of Longwall 306 or Longwall 307 has impacted streamflow at the Sub-Catchment K gauging station (to June 2023), noting the Sub-Catchment K gauging was inundated by backwater from the Woronora Reservoir for periods of 2023. This is consistent with the results of monitoring of the quantity of water resources reaching the Woronora Reservoir for the Waratah Rivulet and Eastern Tributary.

A preliminary water balance of the Woronora Reservoir has been developed as a component of the Woronora Reservoir Impact Strategy. The primary purpose of the water balance analysis was to establish whether the inputs to and outputs from the Woronora Reservoir could be measured sufficiently and accurately to estimate a loss through the bed of the reservoir because of longwall mining being undertaken in the catchment and/or from other activities that may affect the water balance. The issues identified in the water balance suggest that the magnitude of bias and uncertainty in the data used in the analysis is such that it is doubtful that the water balance values provide a satisfactory baseline for assessing the potential loss of reservoir water through the bed and it was recommended that a Stage 2 water balance study be undertaken.

The Stage 2 report recommended groundwater model-derived cross sections be generated to display the pressure head profiles before and after mining specific panels with the zero pressure heads clearly displayed. Representative north-south and east-west cross sections have been prepared for Longwalls 311-316 using the re-calibrated model with stacked drains (Appendix 6 of the WMP).

In December 2019, the WRIS Panel prepared a letter report which provides a summary of the key conclusions from the Stage 1 and Stage 2 reports and considers the IEPMC *Report on Coal Mining Impacts in the Special Areas of the Greater Sydney Water Catchment* (dated 14 October 2019). It also considers feedback from the WRIS Panel's meeting with the DPIE, Water NSW and Metropolitan Coal on 11 November 2019. The key findings of this report were:

1. *Connective fracturing/depressurisation and depressurisation alone extends up to approximately 195 m above the current 163 m wide longwall extraction zone (Figure 1).*
2. *There is virtually no pressure head propagation (i.e. depressurisation), that is pressure head loss, extending upwards beyond about 80 m from the surface and very little above 150 m from the surface (Figure 1). The depressurisation zone below 150m is recovering due to lateral groundwater flow.*
3. *There is no evidence of surface to longwall panel connectivity at the Metropolitan Mine, with inflows averaging 0.01 ML/day between January 2009 and April 2019.*
4. *There is a clear benefit in using narrower panels and wider chain pillars near and beneath the Woronora Reservoir as it substantially reduces subsidence predictions.*
5. *The ratios of 'width of panel' and 'depth of cover' at the Metropolitan Mine proposed for mining under the Woronora Reservoir (0.32 to 0.35) are similar to those used for the previously successful mining conducted with very low inflow reported at the South Bulli Mine and Bellambi West Colliery below the Cataract Reservoir (0.34 to 0.41).*
6. *Mining in the upper reaches of sub-catchment I has not impacted on flows recorded at the flume further downstream, consistent with the results of monitoring of the quantity of water resources reaching the Woronora Reservoir for the Waratah Rivulet and Eastern Tributary.*
7. *Water balance modelling of inputs to and outputs from the Woronora Reservoir indicates that the combined average loss from groundwater outflow under the dam wall and loss through the bed of the Woronora Reservoir is 2.9 ML/day with a 95% uncertainty band between 0.4 ML/day to 5.4 ML/day, in which ungauged inflows to the reservoir and reservoir evaporation are the major contributors to the uncertainty. The 2.9 ML/day equates to 3.6% of the total outputs modelled from the Woronora Reservoir. Taking into account the facts that groundwater outflow under than dam wall could not be adequately modelled, that there are problems in stream gauging a large proportion of the current ungauged area, and there are difficulties in estimating reservoir evaporation, it is recommended that a Stage 2 water balance study be not undertaken.*
8. *Based on the review of available data, analytical predictions and monitoring bore evidence at LW302, together with the use of narrower panels and wider chain pillars beneath the reservoir, the proposed longwall mining is not expected to result in connective cracking between the longwalls and surface or significant inflows from Woronora Reservoir to the mine extraction zone.*
9. *The existing monitoring regime should be continued, together with the additional monitoring recommended above. All monitoring results should be regularly reviewed against predicted values to provide ongoing confidence in the performance of the mining operation and its impacts.*

Metropolitan Coal understands that the WRIS Panel is no longer required to conduct investigations into potential impacts on the Woronora Reservoir and that these investigations will instead be conducted by the Independent Expert Advisory Panel for Mining (IEAPM).

2.4 CONSULTATION

Metropolitan Coal was granted Project Approval (08_0149) for the Project in June 2009. Since then, extensive consultation with stakeholders has been undertaken in relation to the Extraction Plans and component management plans prepared for Longwalls 20-22, 23-27, 301-303, 304, 305-307 and 308-310 in accordance with Condition 6, Schedule 3 of the Project Approval. This consultation has informed the development of the Longwalls 311-316 Extraction Plan and component management plans.

Consultation undertaken with stakeholders to date in relation to the Longwalls 311-316 Extraction Plan is described below and provided in Attachment 3.

2.4.1 NSW Government Agencies

Metropolitan Coal requested the endorsement of the Extraction Plan team as suitably qualified and experienced experts on 21 July 2023. The Extraction Plan team was endorsed by the DPE on 31 July 2023.

During the preparation of previous Metropolitan Coal extraction plans (i.e. the Longwalls 20-22, 23-27, 301-303, 304, 305-307 Extraction Plans), component management plans were distributed to stakeholders for comment prior to submission to the DPE. To allow for the timely assessment of the Longwalls 311-316 Extraction Plan by the DPE, and to ensure continuation of mining at the Metropolitan Coal Mine, stakeholder consultation will be conducted in parallel with the DPE's assessment of the Longwalls 311-316 Extraction Plan, similarly to the process undertaken for the Longwalls 308-310 Extraction Plan.

During the preparation of this Extraction Plan, Metropolitan Coal consulted the following NSW government agencies and independent bodies in regard to the Large Swamp Assessment (Metropolitan Coal, 2024):

- DPE;
- WaterNSW; and
- IEAPM.

In June 2023, Metropolitan Coal provided the DPE with a briefing paper titled *Large Swamp Assessment – Metropolitan Coal Longwalls 311-316 Extraction Plan* (the Briefing Paper). The Briefing Paper outlined existing monitoring programs and the proposed environmental assessments to be included in the Large Swamp Assessment, which will address Condition 4, Schedule 3 of the Project Approval.

Following the receipt of the Briefing Paper, DPE consulted the IEAPM and sought advice on whether the proposed scope of the Large Swamp Assessment demonstrates an appropriate array of environmental assessment, an adequate network of monitors in representative locations and there is sufficient baseline data.

The IEAPM undertook a site inspection, alongside WaterNSW, Metropolitan Coal and consultants, to inspect the Large Swamps 76, 77 and 92, gauging stations downstream of Swamps 76 and 92 and groundwater monitoring locations on 23 October 2023.

On 23 November 2023, the DPE provided IEAPM's advice to Metropolitan Coal regarding the Longwalls 311-316 Extraction Plan and scope of the Large Swamp Assessment. The *Metropolitan Coal Mine: High Level Review - Large swamp environmental assessment requirements for the Extraction Plan for Longwalls 311 to 316* (IEAPM, 2023) included a total of 26 recommendations, pertaining to a variety of environmental aspects, including subsidence, surface water, groundwater and biodiversity.

On 29 March 2024, Metropolitan Coal distributed the Longwalls 311-316 Extraction Plan for comment to the following agencies:

- WaterNSW.
- Heritage NSW.
- DPI-Fisheries.
- Mining, Exploration and Geoscience.
- Department of Climate Change, Energy, the Environment and Water – Water Group.
- Dam Safety NSW.
- Subsidence Advisory NSW.
- Biodiversity, Conservation and Science Group.
- Wollongong City Council.

Comments received from the above NSW government agencies were incorporated into the revised Longwalls 311-316 Extraction Plan in July 2024.

Further comments were provided by NSW Government agencies on the revised Longwalls 311-316 Extraction Plan. The majority of issues raised in the comments were the same or similar to those previously provided by the agencies and considered by Metropolitan Coal in the preparation of the revised Extraction Plan (July 2024 version). A response to new issues raised in the NSW Government agencies comments were provided to the DPHI on 19 August 2024.

On 9 September 2024, the DPHI provided IEAPM's advice to Metropolitan Coal regarding the Longwalls 311-316 Extraction Plan. The Metropolitan Coal Mine: Stage 1: Longwalls 311 312 included a total of 42 recommendations regarding the Longwalls 311-316 Extraction Plan (IEAPM 2024). The advice received has been incorporated into this revised Longwalls 311-316 Extraction Plan.

A nominee of the Planning Secretary approved the secondary extraction of Longwall 311 on 19 October 2024. Further advice is expected from the IEAPM on the proposed secondary extraction of Longwalls 312-316. Metropolitan Coal will update this Extraction Plan in response to this advice, as necessary.

2.4.2 Landholders

A land ownership plan is provided on Figure 6. In summary, one lot is located within 600 m of Longwalls 311-316, and is owned by WaterNSW.

As described in Section 2.4.1, stakeholder consultation will be conducted in parallel with the DPE's assessment of the Longwalls 311-316 Extraction Plan. Metropolitan Coal will provide a copy of the Longwalls 311-316 Extraction Plan to WaterNSW on submission of the Extraction Plan.

2.4.3 Aboriginal Groups

As described in Section 2.4.1, stakeholder consultation will be conducted in parallel with the DPE's assessment of the Longwalls 311-316 Extraction Plan. A draft of the Longwalls 311-316 HMP was provided to the Aboriginal stakeholders registered at Metropolitan Coal on 19 April 2024 for their review and comment. Comments received from Aboriginal stakeholders were incorporated into the revised Longwalls 311-316 HMP.

2.4.4 Infrastructure Owners

Extensive consultation with each infrastructure owner/manager was conducted for the Longwalls 301-303, Longwall 304, Longwalls 305-307 and Longwalls 308-310 Extraction Plans.

No built features are located within the Longwalls 311-316 35º angle of draw and/or 20 mm subsidence contour or in the vicinity the Longwalls 311-316 35º angle of draw and/or 20 mm subsidence contour that necessitate a Built Features Management Plan (BFMP). As extraction is moving away from previously considered built features, the number of BFMPs has been reduced over time as monitoring indicates the reduction of subsidence to negligible levels post mining.

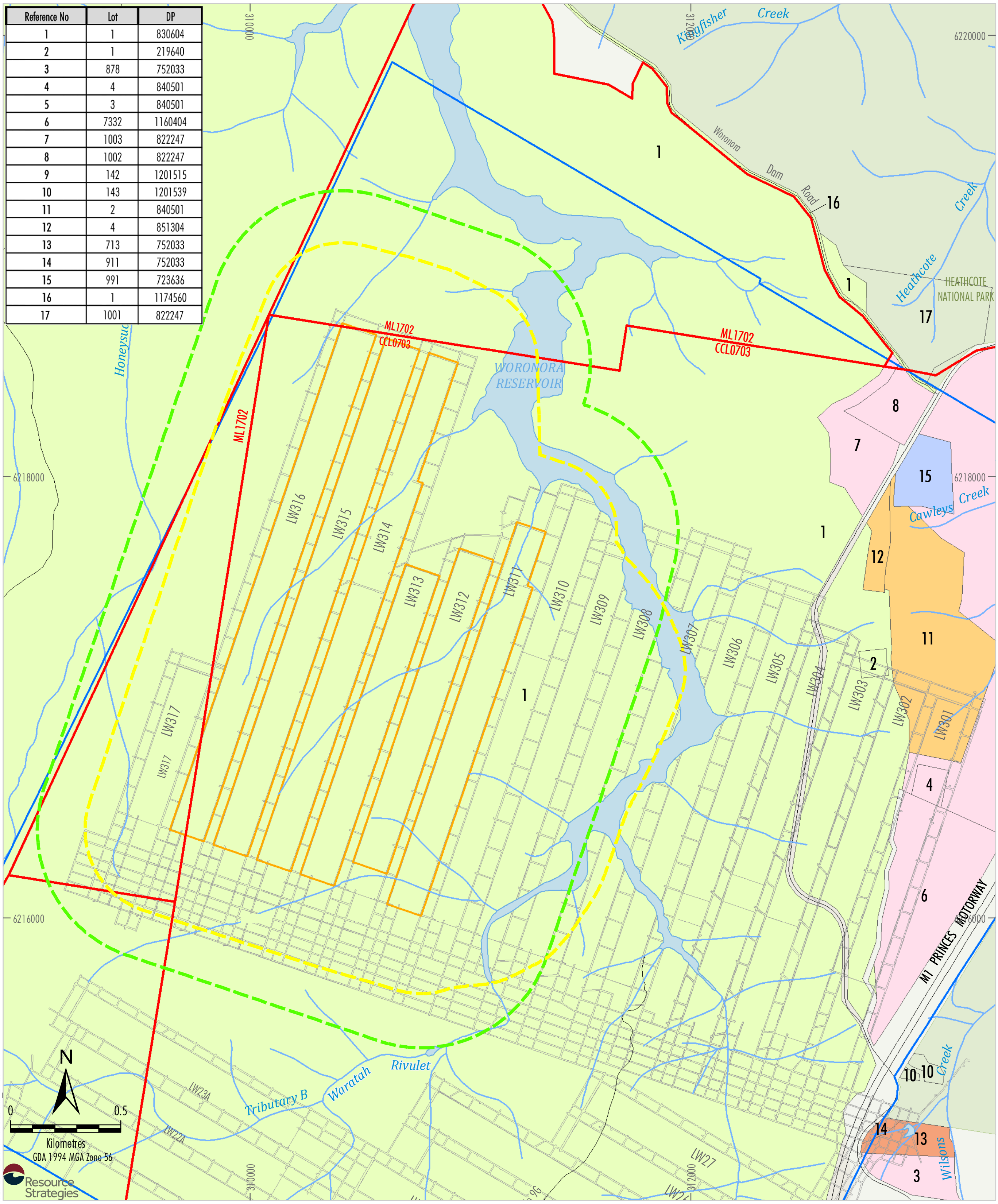
The final Transport for NSW (TfNSW) BFMP will be concluded at the end of Longwall 310 which is expected to be four consecutive longwalls recording negligible subsidence.

TfNSW were consulted on this approach and endorsed the discontinuation of the Metropolitan Coal BFMP after the conclusion of Longwall 310 (Appendix 1 of the PSMP).

2.4.5 Public Consultation

The Metropolitan Coal Community Consultative Committee (CCC) was advised of the development of the Extraction Plan at a meeting on 21 November 2023. The CCC was informed that submission of the Extraction Plan was anticipated in Quarter 1, 2024 and received regular updates at subsequent meetings.

Reference No	Lot	DP
1	1	830604
2	1	219640
3	878	752033
4	4	840501
5	3	840501
6	7332	1160404
7	1003	822247
8	1002	822247
9	142	1201515
10	143	1201539
11	2	840501
12	4	851304
13	713	752033
14	911	752033
15	991	723636
16	1	1174560
17	1001	822247



LEGEND

- Mining Lease Boundary
- Woronora Special Area
- Project Underground Mining Area Longwalls 20-27 and 301-317
- Longwalls 311-316 Secondary Extraction
- Longwalls 311-316 35° Angle of Draw and/or Predicted 20 mm Subsidence Contour
- 600 m from Longwalls 311-316 Secondary Extraction

Landholder

- WaterNSW
- The State of New South Wales (Crown Land)
- The State of New South Wales (National Parks and Wildlife Service Estate)
- Health Administration Corporation
- The Trustees of the Macedonian Orthodox Monastery
- R & C Stewart

Source: Land and Property Information (2015); Department of Industry (2015); (DPE 2023); Metropolitan Coal (2023); MSEC (2024)

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Land Ownership within 600 m of Longwalls 311-316

Figure 6

3 SUBSIDENCE ASSESSMENT

3.1 SUBSIDENCE PREDICTIONS

Revised predictions of subsidence effects for Longwalls 311-316 were developed by MSEC (2024) (Appendix H). The process for the development of these predictions is described below.

Predicted Conventional Subsidence Movements

MSEC (2024) provides a detailed description of the development of mine subsidence and the method used to predict the mine subsidence movements resulting from the extraction of Longwalls 311-316. The report includes the maximum predicted conventional subsidence parameters for Longwalls 311-316 including:

- Incremental Subsidence Parameters, which are the predicted subsidence parameters due to the extraction of Longwalls 311-316.
- Total Subsidence Parameters, which include the accumulated subsidence parameters after the completion of a series of longwalls.

The maximum predicted incremental and total subsidence, tilt and curvatures for Longwalls 311-316 are summarised in Table 5. Figure 7 provides the predicted total subsidence contours after Longwalls 311-316 extraction[5].

Table 5
Maximum Predicted Subsidence, Tilt and Curvature for Longwalls 311-316

Subsidence Parameter	Incremental Subsidence Predictions						Total Subsidence Predictions (after LW311-316)
	Longwall 311	Longwall 312	Longwall 313	Longwall 314	Longwall 315	Longwall 316	
Maximum Subsidence (mm)	600	600	600	600	600	600	1,500
Maximum Tilt (mm/m)	3.0	3.0	3.0	4.5	4.5	4.5	7.0
Maximum Hogging Curvature (km^{-1})	0.02	0.02	0.02	0.05	0.05	0.04	0.08
Maximum Sagging Curvature (km^{-1})	0.04	0.04	0.04	0.08	0.08	0.08	0.09

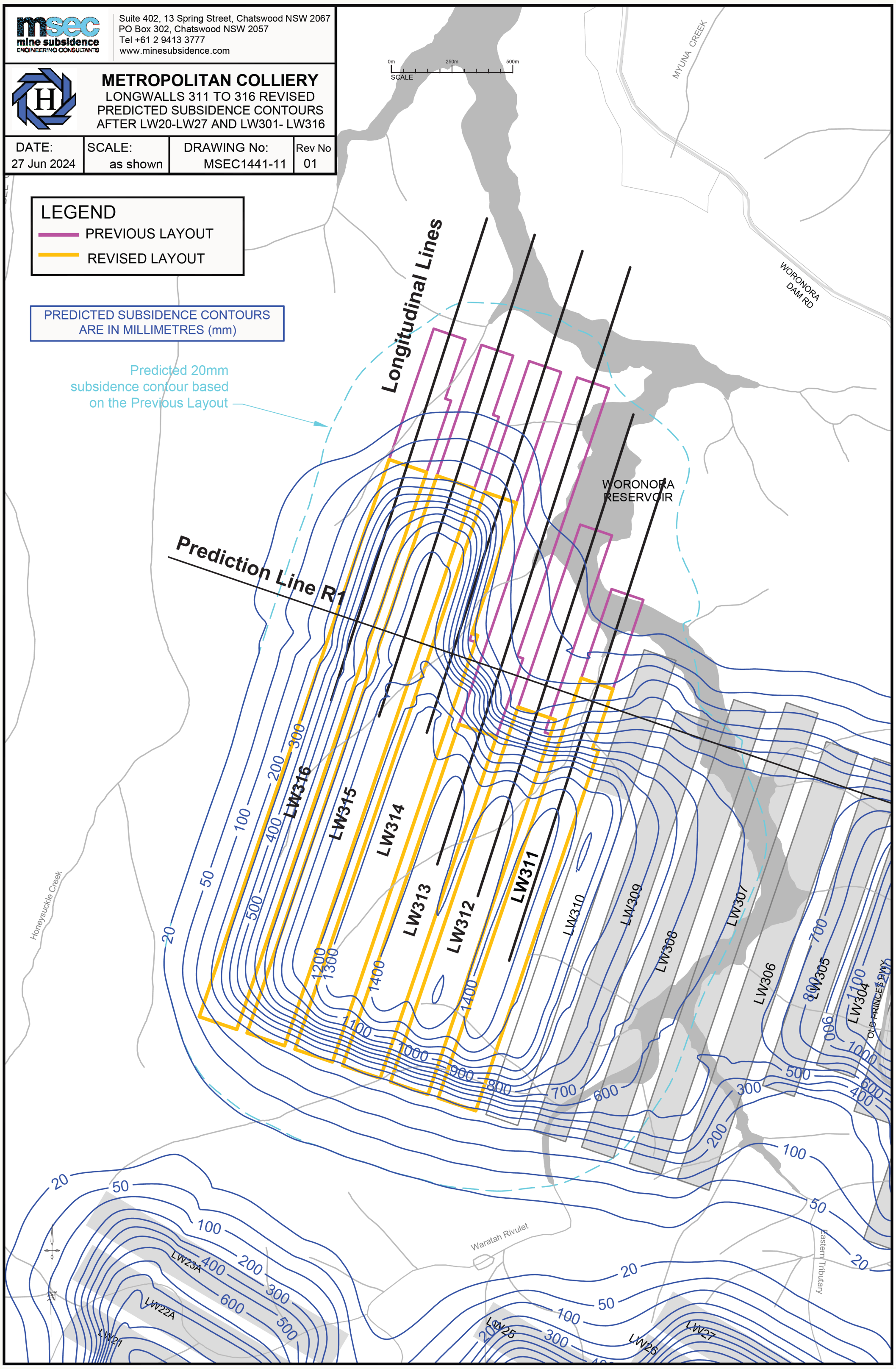
Source: after MSEC (2024) (Appendix H).
mm/m = millimetres per metre.
km^{-1} = 1/kilometres.

The predictions of conventional subsidence parameters do not include the valley related upsidence and closure movements.

Non-Conventional Ground Movements

MSEC (2024) (Appendix H) considers it likely that non-conventional ground movements will occur due to near surface geological conditions, steep topography and valley related movements, which are often accompanied by elevated tilts and curvatures. The potential subsidence impacts from non-conventional subsidence movements are described for natural and built features in Appendix H.

5 Predicted subsidence contours are based on the July 2024 longwall layout. Refer to Appendix H for more details.



Source: MSEC (2024)

MET-23-33 LW311-316 EP MT_003A

Resource Strategies

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Predicted Total Subsidence Contours after Longwalls 311-316

Figure 7

In most cases, it is not possible to predict the exact locations or magnitudes of the non-conventional anomalous movements due to near surface geological conditions. For this reason, the strain predictions provided in Appendix H are based on a statistical analysis of measured strains in the Southern Coalfield, including both conventional and non-conventional anomalous strains.

Predicted Far-Field Movements

Based on an empirical model for the Southern Coalfield, MSEC (2024) (Appendix H) concluded that the predicted far-field horizontal movements resulting from Longwalls 311-316 extraction are very small and could only be detected by precise surveys. While the impacts of far-field horizontal movements on natural and built features within the vicinity of Longwalls 311-316 are not expected to be significant, there are structures which are sensitive to small differential movements, including roads and road bridges to the east of Longwall 301 (Appendix H).

3.1.1 Review Of Predictions

The predicted subsidence effects, subsidence impacts and environmental consequences of the Project were assessed in the Project EA and Preferred Project Report. This section describes the process of reviewing and updating these predictions to consider the Extraction Plan Layout.

3.1.1.1 Predicted Subsidence Effects and Subsidence Impacts

A detailed subsidence assessment for Longwalls 311-316 has been prepared in support of this Extraction Plan by MSEC (2024), with the outcomes of this assessment incorporated into the management plans in Appendices A to E. The Subsidence Report by MSEC (2024) is provided in Appendix H.

Review of Subsidence Prediction Methodology

The predictions of subsidence effects for Longwalls 311-316 were developed by MSEC (2024) using the Incremental Profile Method, calibrated using observed monitoring data above the previously extracted longwalls at Metropolitan Coal (Appendix H). The Incremental Profile Method is based on a large database of observed subsidence movements in the Southern Coalfield and has been found, in most cases, to give reasonable, if not conservative, predictions of maximum subsidence, tilt and curvature.

Based on monitoring data from the Southern Coalfield, there is an approximate 90 percent (**%**) confidence level that the maximum observed incremental subsidence will be less than the maximum predicted incremental subsidence using the standard model (Appendix H).

Comparison with Previous Predictions of Subsidence Effects

MSEC (2024) (Appendix H) provides a comparison of the maximum predicted conventional total subsidence parameters for the Extraction Plan Layout and the Preferred Project Layout for Longwalls 311-316. The values are the maxima anywhere above the longwall layouts. The maximum predicted total subsidence and tilt based on the Extraction Plan Layout for Longwalls 311-316 are greater than the maxima predicted based on the Preferred Project Layout. The increased subsidence is the result of calibration of the Incremental Profile Method model (MSEC, 2024). The predicted tilt based on the Extraction Plan Layout is greater than the Preferred Project Layout near the finishing ends of Longwalls 311-316 but is similar to the predicted tilt based on the Preferred Project Layout elsewhere. The maximum predicted total hogging and sagging curvature for the Extraction Plan Layout are similar to the predicted based on the Preferred Project Layout (Appendix H).

A feature of the Preferred Project Layout is increased pillar widths beneath and in close proximity to the Woronora Reservoir. As a result, the maxima based on the Preferred Project Layout occurred in the north-east and west of the Longwalls 311-316 35° angle of draw and/or predicted 20 mm subsidence contour, however, the area in the north-east have been left unmined by the shortening of Longwalls 311-316 for the Extraction Plan Layout (Appendix H).

The Woronora Reservoir full supply level is located above the commending ends Longwalls 311-313. The maximum predicted vertical subsidence based on the Extraction Plan Layout, is greater than the maximum predicted based on the Preferred Project Layout. The increased subsidence is the result of calibration of the Incremental Profile Method model (MSEC, 2024). The maximum predicted upsidence and closure for the Woronora Reservoir full supply level, based on the Extraction Plan Layout, are less than the maxima predicted based on the Preferred Project Layout (Appendix H).

The Eastern Tributary flows in a northerly direction into the full supply level of the Woronora Reservoir approximately 1.4 km (at the full supply level) to the east of Longwall 311 (Figure 2). The Eastern Tributary is not predicted to experience measurable valley related movements and conventional subsidence movements during the extraction of Longwalls 311-316 (Appendix H).

The Waratah Rivulet flows to the north-east and into the full supply level of the Woronora Reservoir, approximately 550 m (at the full supply level) to the south-east of Longwalls 311-316 (Figure 2). The maximum predicted vertical subsidence, upsidence and closure for the Waratah Rivulet, based on the Extraction Plan Layout, are similar to or less than the maxima predicted based on the Preferred Project Layout (Appendix H).

Predicted Subsidence Impacts

MSEC (2024) (Appendix H) has conducted a detailed assessment of potential subsidence impacts for each of the natural and built features identified in the vicinity of Longwalls 311-316. Potential subsidence impacts identified by MSEC (2024) are consistent with those identified in the Project EA and Preferred Project Report and include:

- surface cracking, heaving, buckling, humping and stepping;
- sub-surface fracturing;
- changes in gradients, ponding, scouring/erosion and changes in stream alignment; and
- instability of land features, including rock falls.

Potential impacts with respect to structures include cracking of road surfaces, opening of joints in pipelines, alteration of tension of electricity transmission lines and cracks in masonry.

The revised subsidence predictions for the Extraction Plan Layout do not change the subsidence impact assessments provided in the Project EA and Preferred Project Report (Appendix H).

3.1.1.2 Potential Environmental Consequences

Detailed discussion of potential environmental consequences is provided in the management plans in Appendices A to F. The suitably qualified experts conducted a review of the potential environmental consequences due to Longwalls 311-316 extraction for the preparation of each management plan.

The IEPMC Initial Report indicates that in recent years it has been identified in the Western Coalfield that surface subsidence, groundwater and surface water responses to longwall mining can be significantly modified in the vicinity of lineaments. Further to advice from the IEPMC, the DPIE requested that specific regard be given to the potential impacts of mining near and under lineaments on surface water features, including swamps and waterfalls. This consideration of lineaments is included in the BMP (Appendix C) and WMP (Appendix A), respectively.

The potential impacts of mining effects on geological features on the quantity of water resources to the reservoir are assessed in the CRRP (Appendix G).

3.2 SUBSIDENCE IMPACT PERFORMANCE MEASURES

The Project Approval requires Metropolitan Coal not to exceed the subsidence impact performance measures outlined in Table 1 of Condition 1, Schedule 3 of the Project Approval. The subsidence impact performance measures are detailed in Table 6.

Table 6
Subsidence Impact Performance Measures

Water Resources	
Catchment yield to the Woronora Reservoir	*Negligible reduction to the quality or quantity of water resources reaching the Woronora Reservoir* *No connective cracking between the surface and the mine*
Woronora Reservoir	*Negligible leakage from the Woronora Reservoir* *Negligible reduction in the water quality of Woronora Reservoir*
Watercourses	
Waratah Rivulet between the full supply level of the Woronora Reservoir and the maingate of Longwall 23 (upstream of Pool P)	*Negligible environmental consequences (that is, no diversion of flows, no change in the natural drainage behaviour of pools, minimal iron staining, and minimal gas releases)*
Eastern Tributary between the full supply level of the Woronora Reservoir and the maingate of Longwall 26	*Negligible environmental consequences over at least 70% of the stream length (that is no diversion of flows, no change in the natural drainage behaviour of pools, minimal iron staining and minimal gas releases)*
Biodiversity	
Threatened species, populations, or ecological communities	*Negligible impact*
Swamps 76, 77 and 92	*Set through condition 4 below*
Land	
Cliffs	*Less than 3% of the total length of cliffs (and associated overhangs) within the mining area experience mining-induced rock fall*
Heritage	
Aboriginal heritage sites	*Less than 10% of Aboriginal heritage sites within the mining area are affected by subsidence impacts*
Items of historical or heritage significance at the Garrawarra Centre	*Negligible damage (that is fine or hairline cracks that do not require repair), unless the owner of the item and the appropriate heritage authority agree otherwise in writing*
Built Features	
Built features	*Safe, serviceable and repairable, unless the owner agrees otherwise in writing*

3.3 SUBSIDENCE MANAGEMENT APPROACH

Potential environmental consequences during the mining of Longwalls 311-316 will be managed in accordance with the relevant requirements of the Project Approval and other approvals, through:

- **Mine Planning and Design** – The design of the mine, including avoidance and subsidence mitigation measures (Section 1.3).
- **Subsidence Monitoring** – Monitoring to confirm predictions of subsidence effects and potential subsidence impacts and environmental consequences (Section 4.1).
- **Management Measures and Remediation** – Implementation of management measures and/or remediation, as required, to address subsidence impacts and/or environmental consequences.
- **Adaptive Management** – The implementation of adaptive management where appropriate (Section 5.1.1).
- **Contingency Plans** – Implementation of Contingency Plans in the event an exceedance of a subsidence impact performance measure or an unexpected impact is detected (Section 5.1.2), including consideration of identified potential contingency measures (Sections 4.2.1 to 4.2.8).

Surface and sub-surface features within the vicinity of Longwalls 311-316 are listed in Table 7. Features within the Longwalls 311-316 35° angle of draw and/or 20 mm predicted subsidence contour may potentially be impacted by the secondary extraction of Longwalls 311-316. There are also features that lie outside the Longwalls 311-316 35° angle of draw and/or 20 mm predicted subsidence contour that may experience either far-field movements, or valley related movements. The surface features which are sensitive to such movements have been identified and have been included in the subsidence assessments provided in MSEC (2024) (Appendix H).

The location of natural features and known Aboriginal heritage sites within 600 m of Longwalls 311-316 and surrounds are shown on Figures 8, 9 and 10. The locations of surface infrastructure/built features over and adjacent to Longwalls 311-316 are shown on Figures 11a and 11b[6]. Descriptions of each of these features are contained within the relevant management plan referenced in Table 7.

Subsidence predictions and potential impacts to surface and sub-surface features are provided and described in MSEC (2024) (Appendix H).

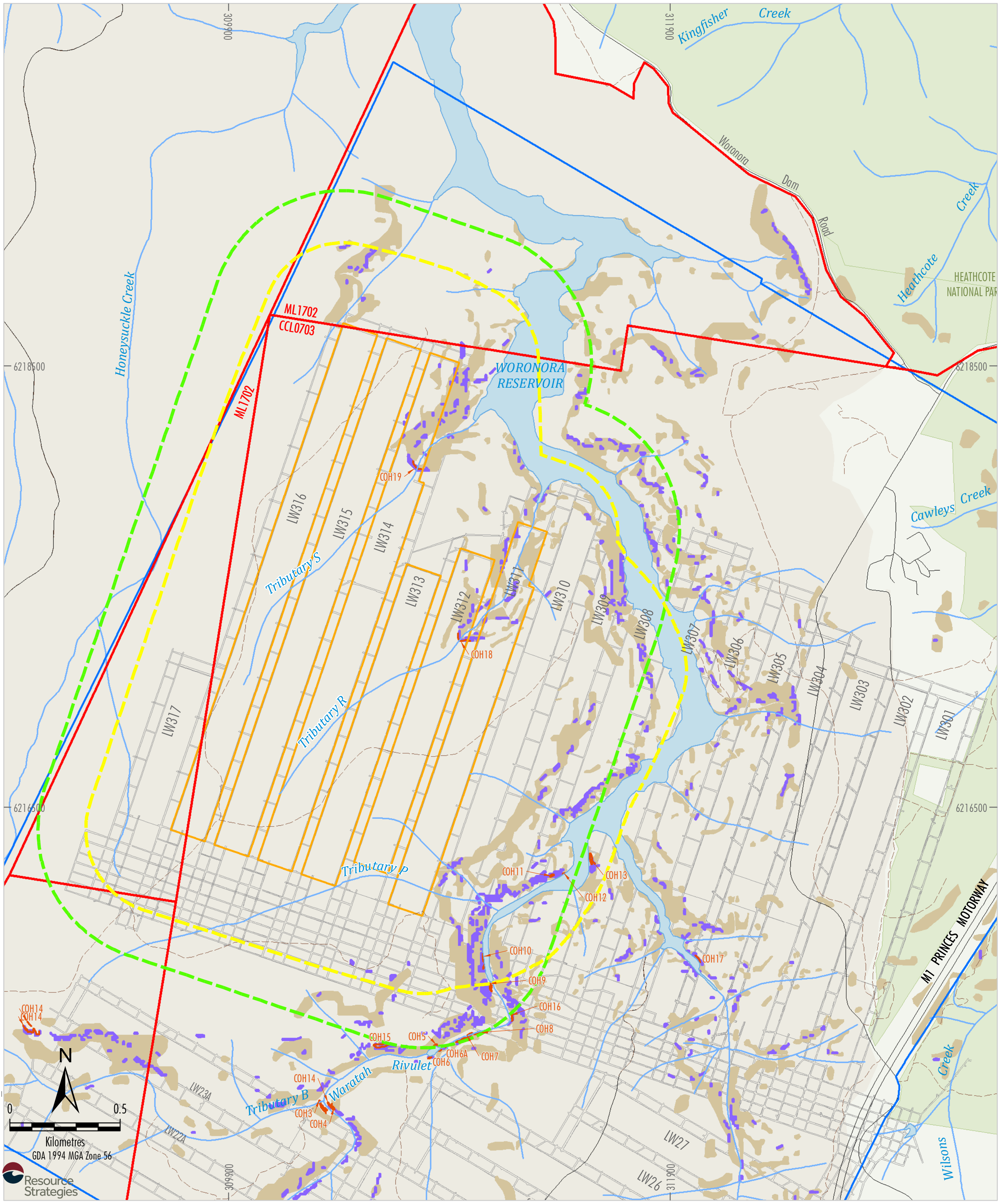
Management measures and monitoring for each feature are included in each of the management plans as indicated in Table 7 and summarised in Sections 4.2.1 to 4.2.8.

The SMP (Appendix F) has been prepared to validate the subsidence predictions and analyse the relationship between the subsidence effects and subsidence impacts of the Extraction Plan and any ensuing environmental consequences. A summary of the proposed monitoring for the Extraction Plan is provided in Section 4.1.

[6] Figures 11a and 11b show the July 2024 longwall layout. The revised longwall layout as of October 2024 are shown in Figure 2.

Table 7
Surface and Sub-surface Features

Feature	Section/Management Plan Reference
Natural Features	
Streams	Section 4.2.1 and WMP (Appendix A)
Cliffs and overhangs, Steep Slopes and Land in General (including rock ledges and outcrops)	Section 4.2.2 and LMP (Appendix B)
Upland Swamps	Section 4.2.3 and BMP (Appendix C)
Natural Vegetation	
Public Utilities and Other Infrastructure	
Woronora Reservoir	Section 4.2.1 and WMP (Appendix A)
Exploration Boreholes	Section 4.1.1 and Subsidence Report (Appendix H)
Survey Control Marks	
Fire Trails and Vehicular Tracks	Sections 4.2.2 and LMP (Appendix B)
Areas of Archaeological and/or Heritage Significance	
Known Aboriginal Heritage Sites	Section 4.2.4 and HMP (Appendix D)



LEGEND

- Mining Lease Boundary
- Woronora Special Area
- Project Underground Mining Area Longwalls 20-27 and 301-317
- Longwalls 311-316 Secondary Extraction
- Longwalls 311-316 35° Angle of Draw and/or Predicted 20 mm Subsidence Contour
- 600 m from Longwalls 311-316 Secondary Extraction
- Road
- Vehicular Track
- Streams
- Cliffs and Overhangs
- Steep Slopes (Project Approval)
- Steep Slopes (Project Environmental Assessment)

Source: Land and Property Information (2015); Department of Industry (2015); Metropolitan Coal (2023); MSEC (2008; 2018; 2023; 2024)

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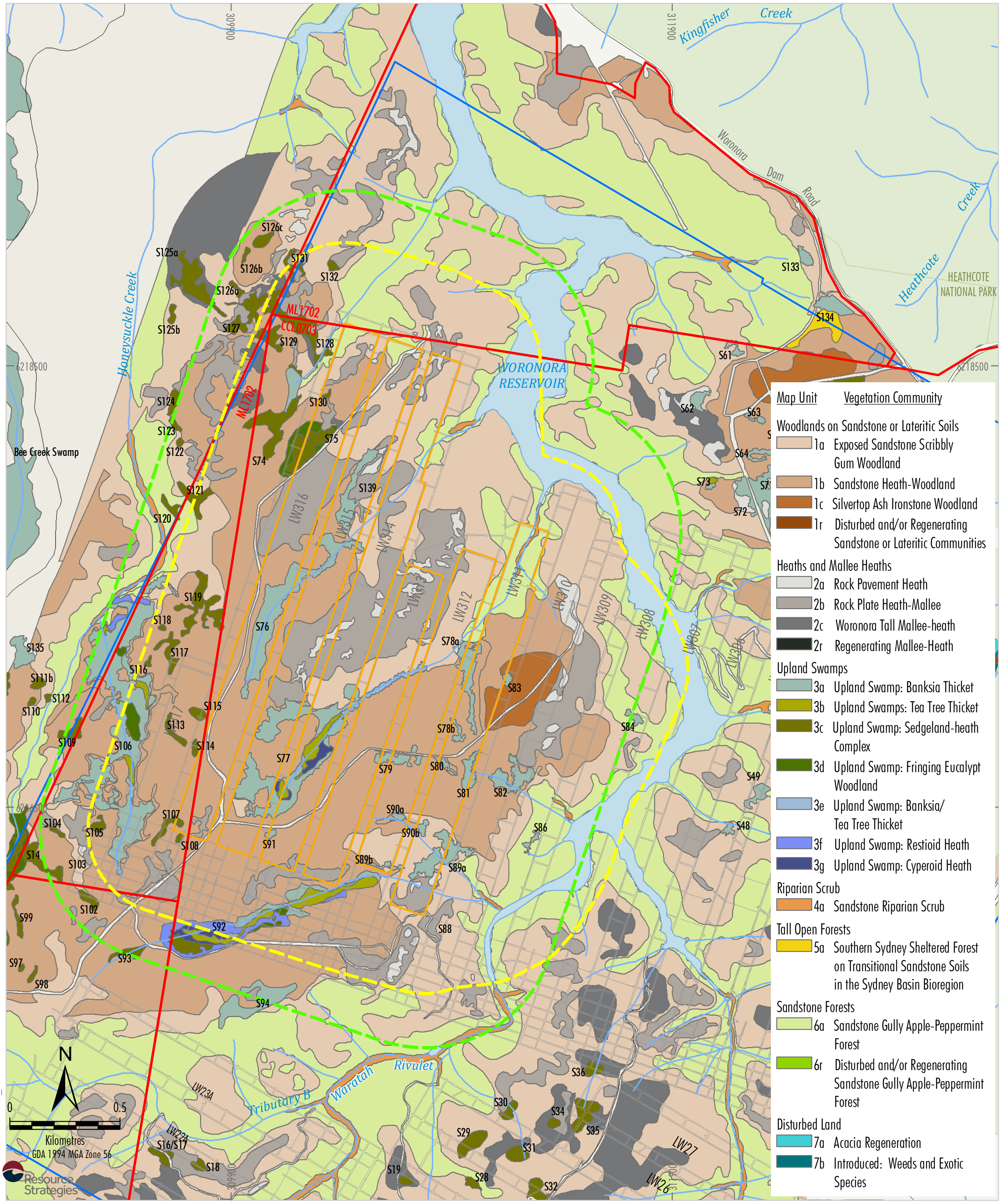
Cliffs and Overhangs, Steep Slopes and Land in General within 600 m of Longwalls 311-316 and Surrounds

Figure 8



LEGEND

- Mining Lease Boundary
- Woronora Special Area
- Project Underground Mining Area Longwalls 20-27 and 301-317
- Longwalls 311-316 Secondary Extraction
- Longwalls 311-316 35° Angle of Draw and/or Predicted 20 mm Subsidence Contour
- 600 m from Longwalls 311-316 Secondary Extraction

Note: *The NSW Native Vegetation Interim Type Standard 2009 requires patches of vegetation to be mapped if the dimensions of the representative polygon on a map sheet are 2 mm x 2 mm or greater (i.e. 0.25 hectares or greater at a scale of 1:25,000). Eco Logical Australia conducted field inspections of upland swamp vegetation previously mapped by Bangalay Botanical Surveys (2008) overlying or proximal to Longwalls 301-310 to confirm the upland swamp vegetation communities present and to confirm or update the swamp vegetation boundaries. It is noted that the revised boundaries of a number of upland swamps (Swamps 37, 38, 42, 48, 54, 58, 61, 63, 65/66, 67, 68a, 68b, 70, 73, 83, 86 and 88) are less than 0.25 hectares in area and consistent with NSW vegetation mapping guidelines are not required to be mapped. Notwithstanding, the revised swamp vegetation mapping boundaries (including those swamps less than 0.25 hectares in area) are shown on this figure to document the changes to previous vegetation mapping.*

Source: *Land and Property Information (2015); Department of Industry (2015); Metropolitan Coal (2023); MSEC (2024); after NPWS (2003), Bangalay Botanical Surveys (2008); Eco Logical Australia (2015; 2016; 2018) and Ecoplanning (2021; 2023)*

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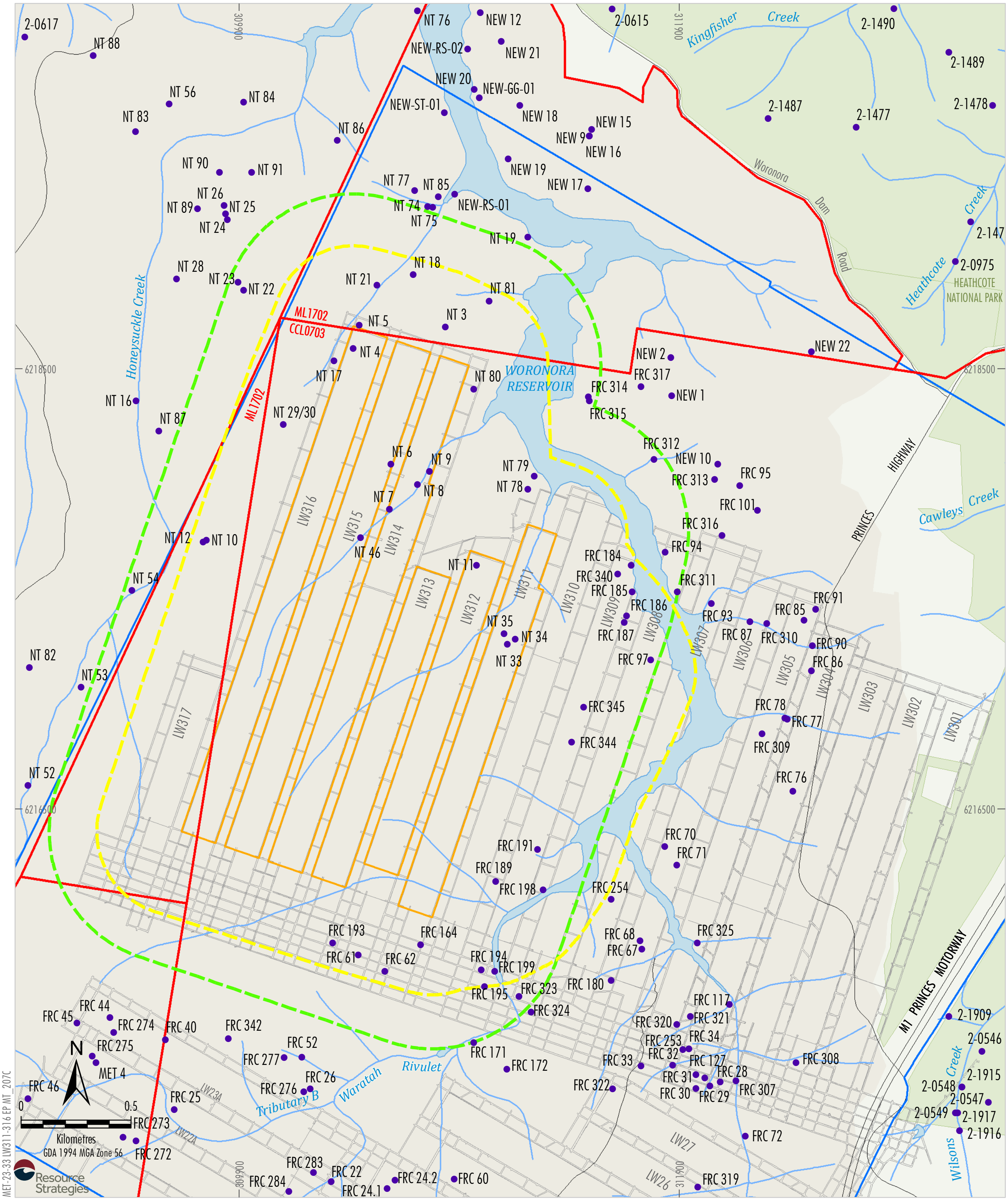
Longwalls 311-316 Vegetation Mapping

Figure 9



LEGEND

- Mining Lease Boundary
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- Longwalls 311-316 Secondary Extraction
- Longwalls 311-316 35° Angle of Draw and/or Predicted 20 mm Subsidence Contour
- 600 m from Longwalls 311-316 Secondary Extraction
- Aboriginal Heritage Site

Source: Land and Property Information (2015); Department of Industry (2015); Metropolitan Coal (2023); MSEC (2024); Niche Heritage and Environment (2024)

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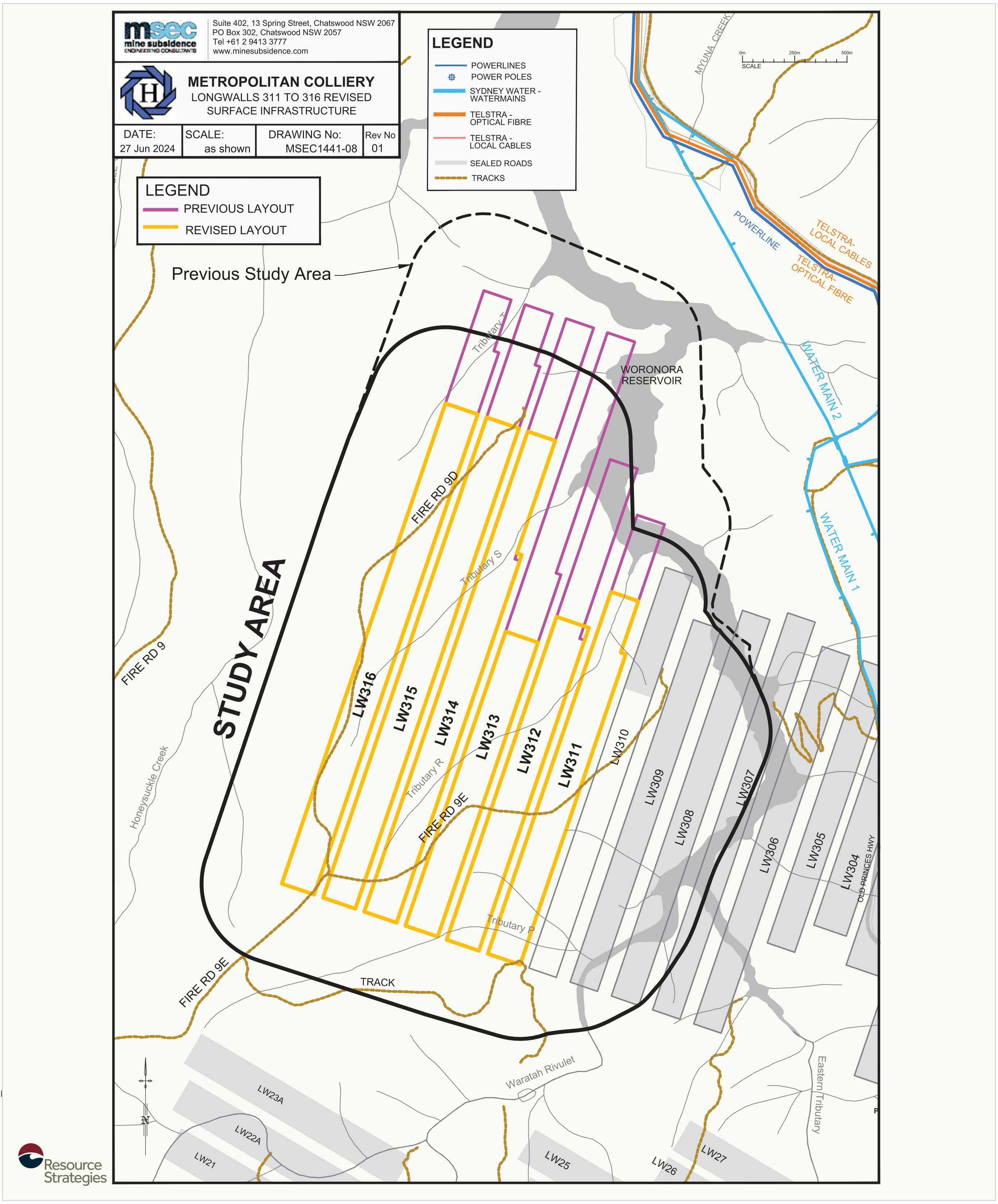
Longwalls 311-316
Known Aboriginal Heritage Sites

Figure 10



Source: MSEC (2024)

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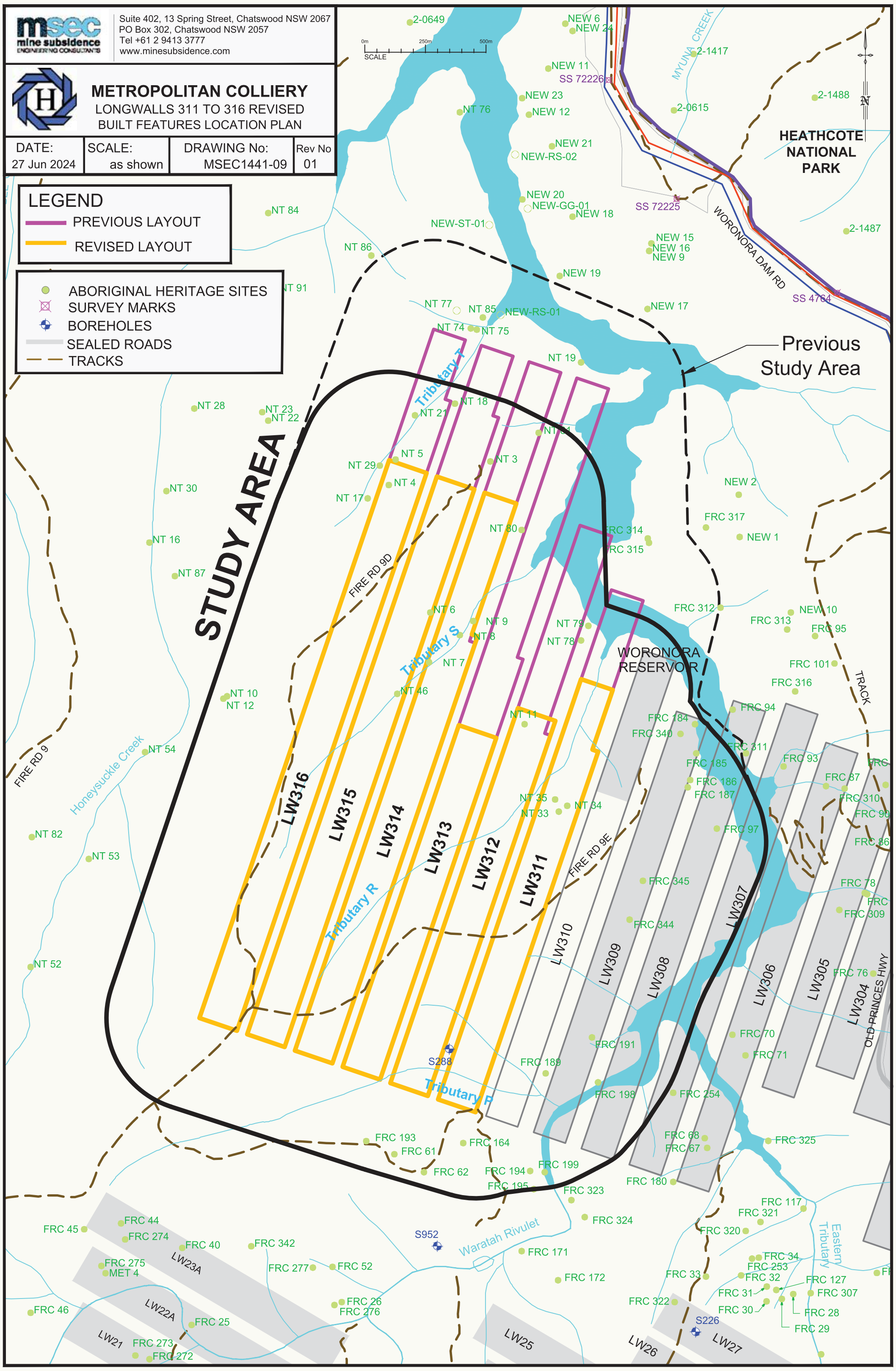
Surface Infrastructure Over and Adjacent to the Longwalls 311-316 Study Area

Figure 11a



MET-23-33 LW311-316 EP MT_005B

Source: MSEC (2024)

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Surface Infrastructure Over and Adjacent to the Longwalls 311-316 Study Area

Figure 11b

4 MONITORING PROGRAMS

Surface and sub-surface features within, or in the vicinity of, the Longwalls 311-316 are listed in Table 7. These features may be potentially impacted by the secondary extraction of Longwalls 311-316. Descriptions of each of these features are contained within the relevant management plan referenced in Table 7.

The Longwalls 311-316 35º angle of draw and/or 20 mm subsidence contour is wholly within land owned by the WaterNSW and there are no relevant proposed developments within 600 m of Longwalls 311-316 proposed by other parties.

Subsidence predictions and impact assessments for surface and sub-surface features have been provided in Appendix H. Management and monitoring actions for each feature are included in management plans as indicated in Table 7 and summarised in Sections 4.2.1 to 4.2.7.

The component management plans to this Extraction Plan form part of Metropolitan Coal's Environmental Management System for the Metropolitan Coal Mine as shown on Figure 3.

4.1 SUBSIDENCE MONITORING PROGRAM

4.1.1 Subsidence Monitoring

The SMP is provided in Appendix F.

The objectives of the monitoring program are:

- To monitor the subsidence effects associated with Longwalls 311-316 extraction and where relevant, previous Longwalls 308-310, Longwalls 301-307 and Longwalls 20-27.
- To summarise and consolidate the various environmental monitoring programs presented in each of the key component plans of the Longwalls 311-316 Extraction Plan which focus on the monitoring of subsidence impacts and environmental consequences of mine subsidence. These include:
  - the WMP (Appendix A);
  - the LMP (Appendix B);
  - the BMP (Appendix C);
  - the HMP (Appendix D); and
  - the PSMP (Appendix E).
- To analyse the relationship between the subsidence effects and subsidence impacts of the Extraction Plan and any ensuing environmental consequences.
- To validate subsidence predictions.
- To provide subsidence data to improve the predictive methods and provide a better understanding of the underlying factors contributing to ground movement.

The SMP is composed of subsidence parameter monitoring that is summarised in Table 8.

Table 8
Subsidence Parameter Monitoring Components

Monitoring Component	Description	Frequency	Relevant Management Plan
300 XL Line.	Monitoring line traversing approximately perpendicular across 300 series longwalls.	• Prior to Longwall 311. • Within 3 months following completion of each longwall.	General – all plans
Waratah Rivulet.	Cross Line Q (WaterNSW gauging station). Cross Line at rock bars R, S, T, U and V. Realtime absolute monitoring sites 43 and 44.	• Prior to Longwall 311. • Following the completion of Longwall 311.	WMP Rock Bars Q, R, S, T, U, V
Valley Closure monitoring.	Realtime absolute 3D monitoring sites as per subsidence monitoring figure (Figure 5 of Appendix F).	• Prior to Longwall 311. • Continuous (downloaded monthly). • Real-time (continuous) absolute 3D monitoring. • Following the completion of each longwall.	General
Large Swamps (76, 77 and 92) valley closure monitoring.	Realtime absolute 3D monitoring sites as per subsidence monitoring figure (Figure 5 of Appendix F).	• Prior to Longwall 311. • Real time (continuous) absolute 3D monitoring. • Following the completion of each longwall.	WMP BMP Large Swamps 76, 77 and 92

Surveys will measure subsidence movements in three dimensions using a total station survey instrument.

Real-time (continuous) absolute 3D monitors will measure subsidence movements in three dimensions using GNSS survey methods.

Plan 7 in Attachment 1 of Appendix F shows the subsidence monitoring locations during the mining of Longwalls 311-316.

4.1.2 Survey Accuracy and Frequency

Longwall subsidence measurements will be surveyed in accordance with the relevant specifications and legislation as applied in NSW. These include:

- *Survey and Drafting Directions for Mining Surveyors 2020 (NSW Mines)* (Department of Customer Service – Spatial Service); and
- *Inter-governmental Committee on Surveying and Mapping Standards and Practices for Control Surveys (SP1) Version 1.7 Sept 2007* ICSM Publication No.1 (ICSM SP1).

The Survey and Drafting Directions for Mine Surveyors 2020 Section *3.4 Correlation of Surface and Underground Surveys* will be consistent with Class 'D' survey as prescribed in ICSM SP1. It is intended that all Control Surveys for mine subsidence of the Longwalls 311-316 to be surveyed to Class 'D' using prescribed methods as described in ICSM SP1.

Subsidence monitoring would be undertaken by a suitably qualified person.

The prescribed accuracy, as defined by the ICSM SP1 and the required frequency of the surveys can be seen in the SMP (Appendix F).

4.1.3 Subsidence Effects Recording and Reporting

Analysis of the relationship between subsidence effects, subsidence impacts and environmental consequences will be reported annually in the Annual Review. The analysis will include:

- comparison of predicted subsidence effects and measured parameters;
- comparison of predicted subsidence impacts and measured impacts;
- analysis of any variations between predicted and measured conventional subsidence effects and impacts (e.g. consideration of underlying parameters such as distance functions, etc. used to determine the predicted subsidence profile);
- analysis of variations between predicted and measured far-field movements and non-conventional subsidence effects (e.g. effects of geological structures and valley closure) and impacts; and
- analysis of the 3D movement about longwall extraction with particular reference to the transverse and longitudinal movements versus distance in advance of the longwall panel.

The analyses will be used to assess the validity of the subsidence predictions and to refine the predictive methods where appropriate.

The relationship between subsidence effects, impacts and environmental consequences will be determined through review and reporting of each environmental management plan (e.g. LMP, WMP, BMP and HMP) in accordance with Condition 3, Schedule 7 of the Project Approval.

4.2 ENVIRONMENTAL MONITORING PROGRAM

4.2.1 Water Management

4.2.1.1 Overview

The WMP is provided in Appendix A. The purpose and scope of the WMP are summarised below:

Purpose: To manage the potential environmental consequences of the Extraction Plan on watercourses (including the Woronora Reservoir), aquifers and catchment yield.

Scope: Surface water and groundwater resources during the mining of Longwalls 311-316.

4.2.1.2 Key Water Issues, Monitoring and Management Measures

There are a number of tributaries located within the Longwalls 311-316 35° angle of draw and/or predicted 20 mm subsidence contour (Figure 8). These streams consist of shallow drainage lines from the topographical high points, forming tributaries where valley heights increase and drain into the Woronora Reservoir. The streams are located above Longwalls 311-316, and could experience the full range of predicted subsidence movements, with maximum predicted closure up to 675 mm (MSEC, 2024) (Appendix H).

Three larger tributaries are located within the Longwalls 311-316 35° angle of draw and/or predicted 20 mm subsidence contour (Figure 8). These tributaries are identified as Tributary P (through Swamp 92), Tributary R (through Swamp 77) and Tributary S (through Swamp 76).

The Woronora Reservoir full supply level is located above Longwalls 311-316 and within the Longwalls 311-316 35° angle of draw and/or predicted 20 mm subsidence contour (Figure 8). As described in Section 3.1 and the WMP (Appendix A), the potential impacts on the Woronora Reservoir based on the Extraction Plan Layout are predicted to be consistent with those based on the Preferred Project Layout.

The Woronora Reservoir Impact Strategy, developed by the Independent Experts, provides a staged plan of action for further investigation into the impacts of mining near the reservoir. Metropolitan Coal have implemented a number of additional groundwater and surface water monitoring sites in response to the Stage 1 and Stage 2 reports. The Woronora Reservoir Impact Strategy is described in Section 2.3 and the WMP (Appendix A).

The Eastern Tributary flows in a northerly direction into the full supply level of the Woronora Reservoir approximately 1.4 km (at the full supply level) to the east of Longwall 311. The Eastern Tributary is not predicted to experience measurable valley related movements and conventional subsidence movements during the extraction of Longwalls 311 to 316 (Appendix H).

Metropolitan Coal established a comprehensive monitoring and adaptive management program to identify subsidence related movements at the Eastern Tributary to minimise the risk of further exceedance of the Eastern Tributary performance measure. The Eastern Tributary Valley Closure TARP has been successfully implemented by Metropolitan Coal for Longwalls 303, 304 and 305. Consistent with the TARP, the decision to cease mining of Longwalls 303, 304 and 305 was made at a very low magnitude of valley closure. The same monitoring and adaptive management program were used for the extraction of Longwalls 306, 307, 308 and 309 (as described in the Longwalls 308-310 Extraction Plan).

For Longwalls 311-316, the Waratah Rivulet will be monitored by the same Global Navigation Satellite System (GNSS) valley closure monitoring methods used for the Eastern Tributary with consideration of the 200 mm valley closure design tool (Appendix A).

As described in Section 2.3, restricting predicted valley closure to 200 mm has been a successful design tool to date for mining in the vicinity of the Waratah Rivulet and Metropolitan Coal has developed a TARP for Waratah Rivulet closure based on this principal as well as monitoring data from the previous extraction underneath and adjacent to the Waratah Rivulet.

The intent of the Waratah Rivulet Valley Closure TARP is to identify the initial development of valley closure prior to an impact occurring. The adaptive management approach is based on Metropolitan Coal conducting GNSS monitoring of the Waratah Rivulet to detect mining-induced effects, allowing the cessation of mining prior to mining resulting in any unacceptable or adverse impacts on the Waratah Rivulet. The monitoring provides the earliest possible indicator for development of valley closure. The development of valley closure is recognised as the dominant mechanism that results in impact to a rockbar.

The geotechnical study of the Waratah Rivulet stream bed investigated the geological characteristics of the stream bed, with the aim of identifying any characteristics that would make the Waratah Rivulet more susceptible to subsidence movements (similar to the Eastern Tributary). The study focussed on Pool P to Rock Bar W on the Waratah Rivulet, and compared these sites to Pool ETAM on the Eastern Tributary, which has experienced subsidence movements due to historical mining. Based on the results of the assessment, the geological features identified along the Eastern Tributary are considered to be unique, compared to the Waratah Rivulet. The Eastern Tributary is therefore more likely to be susceptible to subsidence movements. Restricting valley closure to 200 mm therefore continues to be an appropriate design tool for the Waratah Rivulet. Further discussion on the subsidence predictions and 200 mm valley closure design tool for Longwalls 311-316 is provided in the WMP (Appendix A).

Notwithstanding, the potential impacts of mining near and under lineaments on surface water features has been assessed. Hydraulic connectivity via lineaments to the waterfall at rock bar ETAU on the Eastern Tributary is considered to be highly unlikely as a result of the extraction of Longwalls 311-316 (Appendix A).

A risk assessment workshop was held on 25 July 2023. The workshop participants identified and assessed the potential for mining effects on lineaments, joints, faulting, basal shear planes and dykes to impact on the quantity of water to the Woronora Reservoir, including the potential for water to be diverted out of Woronora Reservoir and into other catchments. The participants considered the risk control measures and procedures to be reasonable to manage the identified risks. Further information on the risk assessment is provided in the CRRP (Appendix G).

The key issues relating to subsidence impacts on surface water and groundwater resources are described in the WMP and the relevant monitoring and management measures are summarised in Table 9 and Section 4.1.

4.2.1.3 Assessment of Performance Indicators and Measures

Performance indicators developed for the subsidence impact performance measures relating to water resources and watercourses are presented in the WMP and are summarised in Table 10.

Table 9
Management Issues for Water Resources and Watercourses during Longwalls 311-316 Extraction

<table>
<tr><th>Issue</th><th>Approved Impact</th><th>Monitoring</th><th>Management</th></tr>
<tr><td>Catchment yield to the Woronora Reservoir</td><td>• Negligible reduction to the quality or quantity of water resources reaching the Woronora Reservoir.
• No connective cracking between the surface and the mine.</td><td rowspan="4">Monitoring in accordance with the WMP, including:
• Surface water quality.
• Surface water flow.
• Groundwater pressure/level.
• Inspections of underground workings for water accumulation.
• Mine water make.
• Woronora Reservoir water quality.
• Visual inspections of stream cracking, gas releases, iron staining and drainage behaviour.
• Gas releases.
• Pool water levels.
• Groundwater quality.
Subsidence monitoring at Waratah Rivulet gauging station.
Subsidence monitoring for the Waratah Rivulet Valley Closure TARP.
Subsidence monitoring in accordance with the SMP.</td><td rowspan="4">• Mine planning and design:
- Conservative mining geometry.
- Shortening of Longwalls 303, 304, 305, 306, 308, 309 and 310.
• Adaptive management – Waratah Rivulet Valley Closure TARP.
• Risk assessments.
• Additional monitoring (e.g. increase in monitoring frequency or additional sampling).
• Stream remediation.
• Revegetation measures.
• Offsets.</td></tr>
<tr><td>Woronora Reservoir</td><td>• Negligible leakage from the Woronora Reservoir.
• Negligible reduction in water quality of Woronora Reservoir.</td></tr>
<tr><td>Waratah Rivulet between the full supply level of the Woronora Reservoir and the maingate of Longwall 23 (upstream of Pool P)</td><td>• Negligible environmental consequences (that is, no diversion of flows, no change in the natural drainage behaviour of pools, minimal iron staining, and minimal gas releases).</td></tr>
<tr><td>Eastern Tributary between the full supply level of the Woronora Reservoir and the maingate of Longwall 26</td><td>• Negligible environmental consequences over at least 70% of the stream length (that is no diversion of flows, no change in the natural drainage behaviour of pools, minimal iron staining and minimal gas releases).</td></tr>
</table>

Table 10
Summary of Water Resources and Watercourses Performance Measures and Performance Indicators

Performance Measure	Performance Indicator(s)
Negligible reduction to the quantity of water resources reaching the Woronora Reservoir.	• *Changes in the quantity of water entering Woronora Reservoir are not significantly different post-mining compared to pre-mining, that are not also occurring in the control catchment.*
Negligible reduction to the quality of water resources reaching the Woronora Reservoir.	• *Changes in the quality of water entering Woronora Reservoir are not significantly different post-mining compared to pre-mining concentrations that are not also occurring at control site WOWQ2.*
No connective cracking between the surface and the mine.	• *Visual inspection does not identify abnormal water flow from the goaf, geological structure, or the strata generally.* • *The 20-day average mine water make does not exceed 1 ML/day.* • *Significant departure from the predicted envelope of the vertical potentiometric head profile at Bore PM02 does not occur.* • *Significant departure from the predicted envelope of the vertical potentiometric head profile at Bore PM01 does not occur.*
No connective cracking between the surface and the mine. Negligible leakage from the Woronora Reservoir.	• *The hydraulic gradient to the Woronora Reservoir at full supply level from Bore PHGW2A is reduced by no more than 40% from that measured to 30 June 2017.*
Negligible leakage from the Woronora Reservoir.	• *The hydraulic gradient to the Woronora Reservoir at full supply level from Bore 9EGW2A is reduced by no more than 40% from that measured to 30 June 2017.* • *The hydraulic gradient to the Woronora Reservoir at full supply level from Bore PM02 is reduced by no more than 40% from that measured to 30 June 2017.* • *The hydraulic gradient from transect bore T5 to bore T2-R (or Woronora Lake Level) is reduced by no more than 20% from that measured on 11 December 2022.*
	• *The hydraulic gradient from transect bore T2 to the Woronora Reservoir remains positive (towards the Reservoir).*
Negligible reduction in the water quality of Woronora Reservoir.	• *Changes in the quality of water in the Woronora Reservoir are not significantly different post-mining compared to pre-mining concentrations.*
Negligible environmental consequences (that is, no diversion of flows, no change in the natural drainage behaviour of pools, minimal iron staining, and minimal gas releases) on the Waratah Rivulet between the full supply level of the Woronora Reservoir and the maingate of Longwall 23 (upstream of Pool P).	• *No change to the natural drainage behaviour of Pools T, U, V and W.* • *Analysis of water level data for Pools, T, U,, V and W indicates the water level is at or above the pool's previous minimum.* • *Visual inspection of the Waratah Rivulet from Pool T to the full supply level of the Woronora Reservoir does not show significant changes in the extent or nature of iron staining that isn't also occurring in the Woronora River (control site).* • *Gas releases in Waratah Rivulet from Pool T to the full supply level of the Woronora Reservoir have not increased beyond those observed up to the commencement of Longwall 301 extraction.*
Negligible environmental consequences over at least 70% of the stream length (that is no diversion of flows, no change in the natural drainage behaviour of pools, minimal iron staining and minimal gas releases) of the Eastern Tributary between the full supply level of the Woronora Reservoir and the maingate of Longwall 26.	• *No change to the natural drainage behaviour of Pools ETAS, ETAT and ETAU.* • *Analysis of water level data for Pools ETAS/ETAT and ETAU indicates the water levels are above that required to maintain water over the downstream rock bars.* • *Gas releases in Eastern Tributary between the full supply level of the Woronora Reservoir and the maingate of Longwall 26 have not increased beyond those observed up to the commencement of Longwall 301 extraction.*

Monitoring against these performance indicators during the mining of Longwalls 311-316 is summarised in Table 9 and Section 4.1 and described in detail in Appendix A. The procedure that will be followed to assess the extraction of Longwalls 311-316 against the performance indicators and performance measures is outlined in Figure 12 and described in detail in the WMP (Appendix A).

Monitoring conducted in accordance with the Metropolitan Coal Longwalls 23-27 WMP identified that the following watercourse impact performance measure for the Eastern Tributary between the full supply level of the Woronora Reservoir and the maingate of Longwall 26 had been exceeded in relation to *minimal iron staining* and *no diversion of flows/no change in the natural drainage behaviour of pools.* (emphasis added):

*Negligible environmental consequences over at least 70% of the stream length (that is **no diversion of flows, no change in the natural drainage behaviour of pools, minimal iron staining** and minimal gas releases)*

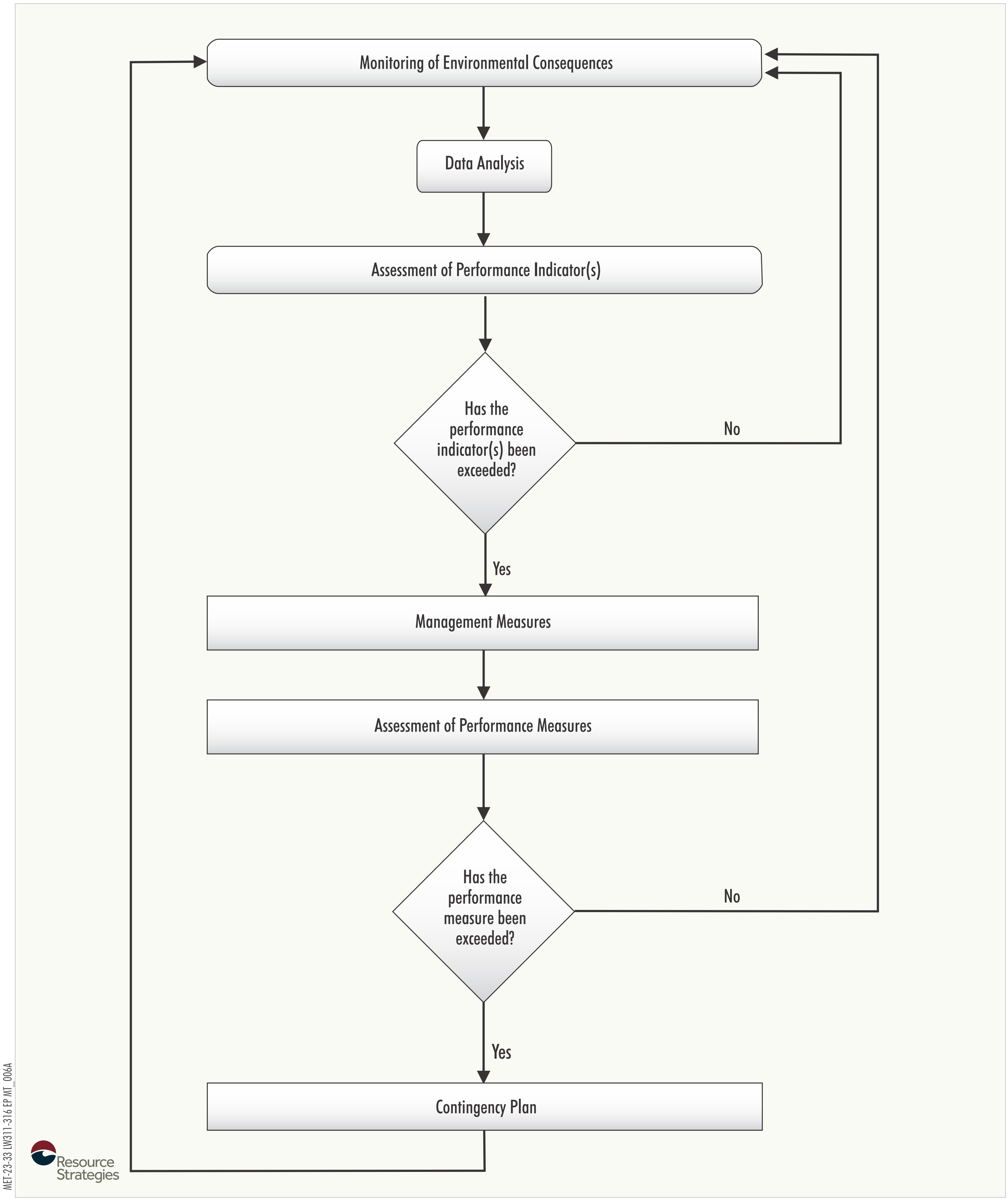
Metropolitan Coal provided the DPE with a proposed course of action in relation to the exceedance of the Eastern Tributary subsidence impact performance measure, focused on the implementation of stream remediation measures. In accordance with Condition 1, Schedule 6 of the Project Approval, Metropolitan Coal is required to restore surface flow and pool holding capacity on the Eastern Tributary between the full supply level of the Woronora Reservoir and the maingate of Longwall 26. Metropolitan Coal is committed to the remediation of pools on the Eastern Tributary.

4.2.1.4 Contingency Plan

In the event that a water resource or watercourse subsidence impact performance measure is exceeded, Metropolitan Coal will implement a Contingency Plan as described in the WMP and summarised in Section 5.1.2. Potential contingency measures for an exceedance of the water resource or watercourse performance measures include:

- The conduct of additional monitoring (e.g. increase in monitoring frequency or additional sampling) to inform the proposed contingency measures.
- The implementation of stream remediation measures to restore surface water flow/pool holding capacity.
- The implementation of revegetation measures to remediate impacts of gas releases on riparian vegetation.
- The purchase of water from Sydney Water in accordance with a license agreement established to the satisfaction of WaterNSW and the DPE.
- The provision of a suitable offset(s) to compensate for the reduction in the quantity of water resources reaching the Woronora Reservoir. Examples of potential offsets include improvement works in the Woronora Reservoir water supply catchment.
- The implementation of adaptive management measures. Examples of adaptive management measures include stepping-around a longwall, the use of stand-offs (environmental pillar) from a particular location, or increasing the setback of the longwalls already subject to stand-off.

As indicated in Section 4.2.1.1 above, Metropolitan Coal will conduct stream remediation on the Eastern Tributary in response to the exceedance of the Eastern Tributary watercourse subsidence impact performance measure during the mining of Longwalls 23-27.



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Monitoring of Environmental Consequences against Performance Indicators and Measures

Figure 12

4.2.2 Land Management

4.2.2.1 Overview

The LMP is provided in Appendix B. The purpose and scope of the LMP are summarised below:

Purpose: To manage the potential environmental consequences of the Extraction Plan on cliffs and overhangs, steep slopes and land in general.

Scope: Cliffs and overhangs, steep slopes and land in general during the mining of Longwalls 311-316.

4.2.2.2 Key Land Issues, Monitoring and Management Measures

Cliffs are defined as a continuous rock face, including overhangs, having a minimum height of 10 m and a slope of greater than 66º. Overhangs associated with cliffs and/or considered sensitive to potential mine subsidence movements (due to their location relative to the Waratah Rivulet) were also identified within the Project underground mining area (Figure 8).

Six cliff and overhang sites are located within the Longwalls 311-316 35° angle of draw and/or predicted 20 mm subsidence contour (sites COH10, COH11, COH12, COH13, COH18 and COH19) while an additional four cliff and overhang sites (sites COH5, COH7, COH8 and COH09) are outside the Longwalls 311-316 35° angle of draw and/or predicted 20 mm subsidence contour and within 600 m of Longwalls 311-316. These four cliff and overhang sites were included in the Extraction Plans.

Detailed baseline recording for four cliffs and overhang sites located within the Longwalls 311-316 35º angle of draw and/or predicted 20 mm subsidence contours (COH10, COH11, COH12 and COH13) has been conducted and is included in Appendix B. Baseline recording of the remaining two cliffs, COH18 and COH19, within the 35° angle of draw and/or predicted 20 mm subsidence contour will be carried out prior to the commencement of Longwall 311, subject to logistics and site access including obtaining any necessary approvals.

Visual inspections for subsidence impacts on cliff site COH17 were conducted following the completion of Longwalls 303 and 304. The visual inspections did not record any subsidence impacts. For Longwalls 311-316, visual inspections for subsidence impacts will be conducted at sites COH10, COH11, COH12, COH13, COH18 and COH19:

- prior to the commencement of Longwall 311 extraction;
- monthly at cliff site(s) located within 400 m of longwall extraction; and
- within three months of the completion of Longwall 311, Longwall 312 and Longwall 313 at all identified sites (i.e. sites COH10, COH11, COH12, COH13, COH18 and COH19) and within three months of the completion of Longwall 314, Longwall 315 and Longwall 316 at sites COH18 and COH19.

The cliffs located outside of the Longwalls 311-316 35° angle of draw and/or predicted 20 mm subsidence contour and within 600 m of Longwalls 311-316 are not expected to experience any measurable vertical subsidence resulting from the extraction of Longwalls 311-316 (Appendix B).

Consistent with the Project Approval, steep slopes are defined as an area of land having a natural gradient of between 33° and 66° (Figure 8). Steep slopes have been identified to highlight areas where existing ground slopes may be marginally stable. However, no significant slope failures have been observed in the Southern Coalfield as a result of longwall mining.

Land in general refers to the general landscape other than cliffs and steep slopes. There are rock ledges, also called rock outcrops and minor cliffs, which occur within 600 m of Longwalls 311-316 (Appendix B). Land in general includes other land features such as fire trails and vehicular tracks, however excludes surface features such as streams and upland swamps which are addressed in the WMP and BMP, respectively.

The key issues relating to subsidence impacts on land are described in the LMP and the relevant monitoring and management measures are summarised in Table 11 and Section 4.1.

4.2.2.3 Assessment of Performance Indicators and Measures

The Project Approval requires Metropolitan Coal not to exceed the subsidence impact performance measure relating to land, outlined in Table 1 of Condition 1, Schedule 3:

> *Less than 3% of the total length of cliffs (and associated overhangs) within the mining area experience mining-induced rock fall.*

Metropolitan Coal will assess the Project against the following performance indicator:

> *Cliff sites COH10, COH11, COH12, COH13, COH18 and/or COH19 experience cliff instabilities that do not require management measures to be implemented.*

Metropolitan Coal will assess steep slopes and land in general against the following performance indicator:

> *Steep slopes and land in general experience sandstone fracturing/cracking and rock falls that do not require management measures to be implemented.*

Monitoring against the performance indicators and performance measure during the mining of Longwalls 311-316 is summarised in Table 11 and Section 4.1 and described in detail in Appendix B. The procedure that will be followed to assess the extraction of Longwalls 311-316 against the performance indicators and performance measure is outlined in Figure 12 and described in detail in the LMP (Appendix B).

4.2.2.4 Contingency Plan

In the event the subsidence impacts observed exceed the land subsidence impact performance measure, Metropolitan Coal will implement a Contingency Plan as described in the LMP and summarised in Section 5.1.2.

Table 11
Management Issues for Land during Longwalls 311-316 Extraction

<table>
<tr><th>Issue</th><th>Approved Impact</th><th>Monitoring</th><th>Management</th></tr>
<tr><td>Cliffs and overhangs</td><td>• Less than 3% of the total length of cliffs (and associated overhangs) within the mining area experience mining-induced rock fall.</td><td rowspan="2">Monitoring in accordance with the LMP, including visual observations of:
• Cliff instabilities or cracking.
• Sandstone fracturing.
• Rock falls.
Subsidence monitoring in accordance with the SMP.</td><td rowspan="2">• Stabilisation techniques including:
– Installation of artificial rock support.
– Installation of standing supports.
• Improvement of appearance including:
– Application of product to enhance the weathered appearance of a cliff face.
– Planting of endemic native vegetation.
• Implementation of erosion and sediment controls.
• Permanent filling of surface tension cracks.
• Measures to address safety hazards.</td></tr>
<tr><td>Steep slopes and land in general</td><td>• Sandstone fracturing (including surface tension cracking) and subsequent rock falls consistent with that observed during the extraction of previous longwalls at Metropolitan Coal.</td></tr>
</table>

4.2.3 Biodiversity Management

4.2.3.1 Overview

The BMP is provided in Appendix C. The purpose and scope of the BMP are summarised below:

Purpose: To manage the potential environmental consequences of the Extraction Plan on aquatic and terrestrial flora and fauna, with a specific focus on swamps.

Scope: Aquatic and terrestrial flora and fauna (including swamps) during the mining of Longwalls 311-316.

4.2.3.2 Key Biodiversity Issues, Monitoring and Management Measures

Thirty nine upland swamps are located within the Longwalls 311-316 35° angle of draw and/or predicted 20 mm subsidence contour (Swamps 74, 75, 76, 77, 78a, 78b, 79, 80, 81, 82, 83, 84, 86, 88, 89a, 89b, 90a, 90b, 91, 92, 105, 106, 107, 108, 113, 114, 115, 116, 117, 118, 119, 121, 127 128, 129, 130, 131, 132 and 139) and an additional fifteen swamps (Swamps 14, 93, 94, 102, 103, 104, 109, 120, 122, 123, 124, 125a, 126a, 126b and 126c) are located within 600 m of Longwalls 311-316 (Figures 5 and 8).

Riparian vegetation and habitats for aquatic biota occur along streams which flow to the Woronora Reservoir (including the Waratah Rivulet and Eastern Tributary), and some of their tributaries (Figure 9). No threatened aquatic biota listed under the *Fisheries Management Act 1994*, NSW *Biodiversity Conservation Act 2016* (BC Act) or Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) has been recorded within the Project underground mining area or in the Woronora Reservoir.

Vegetation communities mapped on slopes and ridgetops within 600 m of Longwalls 311-316 secondary extraction include woodlands on sandstone or lateritic soils, heaths and mallee heaths, sandstone forests and disturbed land (Figure 9).

The cliffs and overhangs, steep slopes, and land in general described in Section 4.2.2 also provide habitat for aquatic and terrestrial flora and fauna.

A number of threatened terrestrial flora and fauna species listed under the BC Act or EPBC Act are known to occur, or have the potential to occur within the Project underground mining area or surrounds. No endangered flora or fauna populations that were listed under the *Threatened Species Conservation Act 1995* (TSC Act) at the time of Project Approval occur within the Project underground mining area or surrounds.

Endangered Ecological Communities (EECs) listed under the TSC Act at the time of Project Approval and identified as occurring in the Project underground mining area or surrounds includes the Southern Sydney Sheltered Forest on Transitional Sandstone Soils in the Sydney Basin Bioregion EEC and the O'Hares Creek Shale Forest EEC.

The key issues relating to subsidence impacts on biodiversity are described in the BMP and the relevant monitoring and management measures are summarised in Table 12 and Section 4.1.

Other subsidence impact performance measures and indicators of relevance to biodiversity include the water resource and watercourse performance measures detailed in the WMP and the land subsidence impact performance measure detailed in the LMP.

Table 12
Management Issues for Biodiversity during Longwalls 311-316 Extraction

Issue	Approved Impact	Monitoring	Management
Threatened species, populations, or ecological communities	Negligible impact	***Upland Swamps*** • Vegetation monitoring: - Visual inspections. - Transect/quadrat monitoring. - Indicator species. • Groundwater monitoring.	• Swamp remediation techniques. • Additional monitoring (e.g. increase in monitoring frequency or additional sampling). • Adaptive management – Large Swamp Valley Closure TARP. • Mine planning and design: - Conservative mining geometry. - Shortening of Longwall 312.
		Riparian Vegetation • Vegetation monitoring: - Visual inspections. - Quadrat monitoring. - Indicator species.	• Stream remediation. • Weed control measures. • Planting of endemic species. • Stream bank erosion control measures in accordance with the WMP. • Management measures for impacts associated with cliffs and overhang sites include: – the implementation of erosion and sediment control measures; and – stabilisation techniques; in accordance with the LMP. • Additional monitoring (e.g. increase in monitoring frequency or additional sampling).
		Slopes and Ridgetops • Visual inspections of cliffs and overhangs, steep slopes and land in general.	• Management measures for impacts associated with cliffs and overhang sites include: – the implementation of erosion and sediment control measures; and – stabilisation techniques; in accordance with the LMP. • Filling of surface tension cracks in accordance with the LMP.
		Aquatic Biota and their Habitats • Watercourses (i.e. aquatic habitats) in accordance with WMP. • Aquatic biota stream monitoring. • Aquatic biota pool monitoring.	• Mine planning and design: - Conservative mining geometry. - Shortening of Longwalls 303, 304, 305, 306, 308, 309 and 310. • Adaptive management – Waratah Rivulet Valley Closure TARP. • Stream remediation. • Additional monitoring (e.g. increase in monitoring frequency or additional sampling).

Table 12 (Continued)
Management Issues for Biodiversity during Longwalls 311-316 Extraction

Issue	Approved Impact	Monitoring	Management
Threatened species, populations, or ecological communities (Cont.)	Negligible impact (Cont.)	***Terrestrial Fauna and their Habitats*** • Terrestrial fauna habitats, as discussed for upland swamps, riparian vegetation, slopes and ridgetops and aquatic habitats above. • Threatened amphibian monitoring.	• Mine planning and design: - Conservative mining geometry. - Shortening of Longwalls 303, 304, 305, 306, 308, 309, 310 and 312. • Adaptive management – Waratah Rivulet Valley Closure TARP. • Adaptive management – Large Swamp Amphibian Monitoring TARP. • Swamp remediation techniques. • Stream remediation. • Weed control measures. • Planting of endemic species. • Stream bank erosion control measures in accordance with the WMP. • Management measures for impacts associated with cliffs and overhang sites include: – the implementation of erosion and sediment control measures; and – stabilisation techniques; in accordance with the LMP. • Filling of surface tension cracks in accordance with the LMP. • Additional monitoring (e.g. increase in monitoring frequency or additional sampling).

4.2.3.3 Assessment of Performance Indicators and Measure

Performance indicators developed for the subsidence impact performance measure relating to biodiversity are presented in the BMP and are summarised in Table 13.

Table 13
Biodiversity Performance Measure and Performance Indicators

Performance Measure	Performance Indicators
Negligible impact to threatened species, populations, or ecological communities.	**Upland Swamps** • Subsidence impacts are not expected to result in measurable changes to swamp groundwater levels when compared to control swamps or seasonal variations in water levels experienced by upland swamps prior to mining. **Large Swamps Valley Closure** • That the specified Large Swamps 76, 77 and 92 are not expected to experience valley closure greater than predicted for the Preferred Project Layout. **Riparian Vegetation** • Impacts to riparian vegetation are expected to be localised and limited in extent, similar to the impacts previously experienced at Metropolitan Coal. **Aquatic Biota** • The aquatic macroinvertebrate and macrophyte assemblages in streams are not expected to experience long-term impacts as a result of mine subsidence. **Terrestrial Fauna** • The amphibian assemblage is not expected to experience changes significantly different to the amphibian assemblage at control sites (for Longwalls 20-27 and 301-310). • The threatened amphibian abundance with the Large Swamp Transects is not expected to experience a decline compared to previous years, due to groundwater substrate or pool water level impacts, significantly different to the threatened amphibian abundance trends at control sites (for Longwalls 311-316).

Monitoring against these performance indicators during the mining of Longwalls 311-316 is summarised in Table 12 and Section 4.1. and described in detail in the BMP (Appendix C). The procedure that will be followed to assess the extraction of Longwalls 311-316 against the performance indicators and performance measures is outlined in Figure 12 and described in detail in the BMP.

4.2.3.4 Contingency Plan

In the event the subsidence impact performance measure for threatened species, populations or ecological communities is considered to have been exceeded, Metropolitan Coal will implement a Contingency Plan as described in the BMP and summarised in Section 5.1.2.

4.2.4 Heritage Management

4.2.4.1 Overview

The HMP is provided in Appendix D. The purpose and scope of the HMP are summarised below:

Purpose: To manage the potential environmental consequences of the Extraction Plan on Aboriginal heritage sites or values.

Scope: Aboriginal heritage sites or values that could experience subsidence effects during the mining of Longwalls 311-316.

4.2.4.2 Key Aboriginal Heritage Issues, Monitoring and Management Measures

Thirty-one (31) known sandstone overhang sites are located within the 35° angle of draw and/or predicted 20 mm subsidence contour of Longwalls 311-316. Of the 31 sites with overhangs, 12 have art only and five have art and/or artefacts and/or a deposit/PAD. Nine open sites are located within the Longwalls 311-316 35° angle of draw and/or predicted 20 mm subsidence contour, namely sites FRC 164, FRC 193, NT, 7, NT 8, NT 12, NT 17, NT 21, NT 29/30 and NT 46.

Eight (8) Aboriginal heritage sites of high scientific (archaeological) significance and/or particular cultural significance are located within the Longwalls 311-316 35° angle of draw and/or predicted 20 mm subsidence contour (Figure 4). Sites FRC 62 and FRC 185 are of high scientific (archaeological) significance and particular cultural significance. Sites FRC 62, FRC 185, and FRC 191 and FRC 195 are of high scientific (archaeological) significance, and sites FRC 198, FRC 340, NT 8, NT 9, NT 35 and NT 46 are of particular cultural significance.

A geotechnical risk assessment report was prepared for the sites of high scientific (archaeological) significance and/or particular cultural significance within the Longwalls 311-316 35º angle of draw and/or predicted 20 mm subsidence contour, provided as Appendix 4 of the HMP (Appendix D).

Metropolitan Coal acknowledges that all Aboriginal heritage sites are of cultural significance to the Aboriginal people who have a traditional connection to Country.

The key issues relating to subsidence impacts on Aboriginal heritage sites and values are described in the HMP and the relevant monitoring and management measures are summarised in Table 14 and Section 4.1.

Table 14
Management Issues for Aboriginal Heritage during Longwalls 311-316 Extraction

Issue	Approved Impact	Monitoring	Management
Aboriginal heritage sites	Less than 10% of Aboriginal heritage sites within the mining area are affected by subsidence impacts.	• Aboriginal heritage sites.	• Installation of an artificial dripline (e.g. silicone dripline) to direct increased moisture/water seepage away from art panels. • Installation of artificial rock support (e.g. rock bolts, cable bolts, cement sprays [e.g. shotcrete], injections of a binding agent [PUR or similar]). • Installation of standing supports (e.g. timber props, timber cogs, sandbags and metal [hydraulic] props). • Scaling/dislodgement/removal of remaining loose rock. • Salvage of artefacts for safekeeping and storage and/or display at a suitable location in consultation with the Aboriginal community. • Use of cosmetic treatments (e.g. in the form of coloured grout or similar) to restore aesthetic values. • Installation of a stress relief slot or stress focus notch.

4.2.4.3 Assessment of Performance Indicators and Measure

The Project Approval requires Metropolitan Coal not to exceed the subsidence impact performance measure relating to Aboriginal heritage sites, as specified in Table 1 of Condition 1, Schedule 3:

> *Less than 10% of Aboriginal Heritage sites within the mining area are affected by subsidence impacts.*

The performance indicator developed for the subsidence impact performance measure relating to Aboriginal heritage sites is presented in the HMP and is summarised in Table 15.

Monitoring against the performance indicator during the mining of Longwalls 311-316 is summarised in Table 14 and Section 4.1 and described in detail in the HMP (Appendix D). The procedure that will be followed to assess the extraction of Longwalls 311-316 against the performance indicator and performance measure is outlined in Figure 12 and described in detail in the HMP (Appendix D).

Table 15
Heritage Performance Measure and Performance Indicator

Performance Measure	Performance Indicator
Less than 10% of Aboriginal heritage sites within the mining area are affected by subsidence impacts.	Metropolitan Coal will assess the Project against the following performance indicator to allow early recognition of mining impacts: *Less than 7% of Aboriginal heritage sites within the mining area are affected by subsidence impacts.* Sites are considered to be "affected by subsidence impacts" if they exhibit one or more the following consequences that cannot be attributed to natural weathering or deterioration: • overhang collapse; • cracking of sandstone that coincides with Aboriginal art or grinding grooves; and • rock fall that damages Aboriginal art.

4.2.4.4 Contingency Plan

In the event the Aboriginal heritage sites subsidence impact performance measure has been exceeded, Metropolitan Coal will implement a Contingency Plan as described in the HMP and summarised in Section 5.1.2.

4.2.5 Built Features Management

No built features are located within the Longwalls 311-316 35º angle of draw and/or 20 mm subsidence contour or in the vicinity of the Longwalls 311-316 35º angle of draw and/or 20 mm subsidence contour that necessitate a BFMP. As extraction is moving away from previously considered built features, the number of BFMPs has been reduced over time as monitoring indicates subsidence is negligible post-mining.

The final TfNSW BFMP will be concluded at the end of Longwall 310 which is expected to be four consecutive longwalls recording negligible subsidence.

As described in Section 2.4.4, TfNSW were consulted on this approach and endorsed the discontinuation of the Metropolitan Coal BFMP after the conclusion of Longwall 310 (Appendix 1 of the PSMP).

4.2.6 Public Safety Management

4.2.6.1 Overview

The PSMP is provided in Appendix E. The purpose and scope of the PSMP are summarised below:

Purpose: To manage the potential consequences of the Extraction Plan on public safety within the mining area.

Scope: Land within the mining area where potential risks to the public could be encountered.

4.2.6.2 Key Public Safety Issues, Monitoring and Management Measures

The primary hazards associated with the extraction of Longwalls 311-316 include:

- potential subsidence impacts on built features;
- potential instability of cliff formations or steep slopes caused by subsidence;
- deformations or fracturing of any land caused by subsidence; and
- any other impacts of subsidence.

A large proportion of the land within 600 m of Longwalls 311-316 is owned and/or managed by WaterNSW or The State of NSW (Crown Land), and therefore accessibility to the general public is restricted (Figure 6). The general public are not allowed in the Woronora Special Area for any recreational or other purpose. Access restrictions are also applicable to some of the identified built features in the vicinity of Longwalls 311-316.

Longwalls 311-316 are located outside the Woronora Notification Area[7], (Figure 1). At its closest point to Longwalls 311-316, the Woronora Dam wall and the labyrinth spillway is located more than 4.5 km from the commencing end of Longwall 316 (Figure 1). The dam wall and spillway are located at large distances from Longwalls 311-316. It is not expected that measurable conventional subsidence movements would occur at the dam wall and spillway (MSEC, 2024) (Appendix H). In addition, it is unlikely that non-conventional subsidence movements would be observed at the distances of the dam wall and spillway from Longwalls 311-316 (Appendix H).

Metropolitan Coal is required to obtain all necessary approvals from the Minister administering the *Mining Act 1992* in accordance with the requirements of the *Dams Safety Act 2015* and the Dams Safety Committee.

The key issues relating to potential risks to public safety during the extraction of Longwalls 311-316 are described in the PSMP (Appendix E). The relevant monitoring and management measures are summarised in Table 16 and Section 4.1.

[7] The Woronora Notification area was amended on 1 July 2022 to an area 1.5 km around the Woronora Dam wall which is outside or beyond the mining lease.

Table 16
Management Issues for Public Safety during Longwalls 311-316 Extraction

Issue	Approved Impact	Monitoring	Management
Public Safety	• Public safety to be ensured within the mining area. • Built features – Safe, serviceable and repairable, unless the owner and the MSB agree otherwise in writing.	• Monitoring in accordance with the LMP.	• Restricted access. • Woronora Special Areas Consent. • Woronora Special Area Catchment Induction. • Management of roads/tracks (including fire trails and vehicular tracks) in accordance with the LMP. • Consultation with landowners and infrastructure owners. • Other management measures in relation to public safety may include: - traffic control including diversion of traffic; - temporary speed restrictions; - warning signs/lights; - restriction of public access; - erection of barriers; - implementation of security services; and - use of emergency services for public control.

4.2.6.3 Assessment of Performance Indicators and Measures

The Project Approval requires Metropolitan Coal not to exceed the subsidence impact performance measure relating to built features, as specified in Table 1 of Condition 1, Schedule 3:

> *Safe, serviceable and repairable, unless the owner and the MSB agree otherwise in writing.*

Metropolitan Coal will also assess the Project against the following public safety performance indicator:

> *Public safety will be ensured in the event that any hazard to the general public arising from subsidence effects becomes evident.*

Monitoring against the performance indicator and performance measure during the mining of Longwalls 311-316 is summarised in Table 16 and Section 4.1 and described in detail in Appendix E. The procedure that will be followed to assess the extraction of Longwalls 311-316 against the performance indicator and performance measure is outlined in Figure 12 and described in detail in the PSMP (Appendix E).

4.2.6.4 Contingency Plan

In the event the built features subsidence impact performance measure of 'safe' is considered to have been exceeded or is likely to be exceeded, Metropolitan Coal will implement a Contingency Plan as described in the PSMP and summarised in Section 5.1.2.

4.2.7 Rehabilitation Management

Rehabilitation associated with subsidence impacts from the extraction Longwalls 311-316 will be undertaken in accordance with the Forward Program, Rehabilitation Management Plan and the management and mitigation measures outlined in this Extraction Plan and relevant component plans.

The Metropolitan Coal Rehabilitation Management Plan details the rehabilitation of surface disturbance areas (including those associated with surface exploration activities, vehicular access tracks, environmental monitoring activities and other minor Project-related surface activities).

In accordance with Condition 4, Schedule 6 and Condition 12, Schedule 2 of the Project Approval (08_0149), rehabilitation and remediation measures for impacts to other natural or built surface features resulting from subsidence are described in detailed in each of the management plans (Appendices A to E).

The overriding objective for subsidence management is to minimise the potential for, or extent of, the predicted subsidence impacts. The key issues relating to subsidence impacts on rehabilitation, surface water and groundwater resources, land resources and agricultural activities, biodiversity, built features, heritage sites and values and public safety are described in in detailed in each of the management plans (Appendices A to E).

This Extraction Plan also details relevant monitoring and management measures that are undertaken relevant to each identified impact. Metropolitan Coal has also prepared a SMP (Appendix F) to validate subsidence predictions and analyse the effects and impacts of subsidence and any ensuing environmental consequences.

As required by this Extraction Plan, remediation of subsidence impacts or environmental consequences detected by subsidence monitoring are conducted where required in consideration of the unmitigated impact (including potential risks to safety and the potential for self-healing or long-term degradation) and the potential impacts of the remediation (including site accessibility).

A number of potential management measures are available to mitigate/remediate subsidence impacts on land in general resulting from underground mining operations. Remediation of subsidence impacts may be required in stream pools, rock bars and other natural or built features. It is anticipated that remediation activities would generally follow mining in a downstream direction, however as indicated previously, additional remediation measures may be required in some areas.

The specific timing of stream remediation activities will also be influenced by practical considerations, such as the amount of stream flow and safe access to remediation areas. Generally, the volume of stream flow is required to be such that surface flow over the respective rock bar is absent.

The rehabilitation objective for Waratah Rivulet (between the downstream edge of Flat Rock Swamp and the full supply level of the Woronora Reservoir) and the Eastern Tributary (between the full supply level of the Woronora Reservoir and the maingate of Longwall 26), viz. *Restore surface flow and pool holding capacity as soon as reasonably practicable*, is addressed in the Metropolitan Coal Stream Remediation Plan (Appendix 7 of the WMP).

Metropolitan Coal will assess the progress of the stream remediation measures in achieving the rehabilitation objective for Waratah Rivulet and the Eastern Tributary against the performance indicators detailed in the Stream Remediation Plan: The rehabilitation objective are considered to have been met if surface flow and pool holding capacity has been restored in the impacted pool.

The Metropolitan Coal Stream Remediation Plan details the stream remediation measures to be implemented for the Metropolitan Coal Mine. In summary, the Stream Remediation Plan:

- describes the vegetation and Aboriginal heritage management measures that are implemented at a stream remediation site prior to the commencement of remediation activities;
- describes the fracture characterisation and stream remediation that are conducted on the Waratah Rivulet and Eastern Tributary;
- provides a description of the stream grouting techniques that are used;
- outlines the site layout of stream remediation activities at each rock bar; and
- details the environmental management measures that are implemented during the conduct of the stream remediation activities.

Subsidence monitoring and remediation undertaken each year are reported in the Annual Review.

4.2.8 Monitoring Program Summary

The various monitoring programs that are detailed in each of the management plans (Appendices A to E) are summarised in Table 17. The monitoring programs may be expanded as a result of the investigation to be undertaken in response to comments from the IEAPM. The location of environmental monitoring sites included in Metropolitan Coal's various environmental monitoring programs detailed in Table 17, are shown on Figure 8, and Figures 13 to 21.

Figure 13 presents the locations of air quality, noise and dust monitoring sites. Figures 14 to 18 presents the location of surface water and groundwater monitoring sites. Figures 19 to 21 presents the location of biodiversity monitoring sites.

Details of any subsidence impacts observed will be recorded in the Subsidence Impact Register with visual observations documented in the Subsidence Impact Register Assessment Form. Visual inspections will be undertaken in accordance with the inspection checklist. The Subsidence Impact Register will be maintained as an electronic spreadsheet on-site, with hard copies of assessment forms filed in a folder.

Table 17
Longwalls 311-316 Environmental Monitoring Program Summary

Management Plan	Monitoring Component	Sites	Monitoring Parameter/Analysis	Monitoring Frequency
WMP	Stream Features	• The Waratah Rivulet from Pool P to the full supply level of the Woronora Reservoir.	• Location, approximate dimensions (length, width and depth), and orientation of surface cracks (specifically whether cracks are developed perpendicular to the stream flow or are controlled by rock joints or other factors, etc.). • Nature of iron staining (e.g. whether isolated or across the entire streambed). • Extent of iron staining (e.g. the length of stream affected). • Description of gas release (e.g. isolated bubbles or continuous stream, and type of gas [methane or carbon dioxide]). • Nature of scouring, for example the depth of scouring, type of soil exposed, any obvious vegetation impact, potential for severe erosion, etc. • Water discoloration or opacity if present. • Rock bar characteristics such as extent of cracking, seepage, underflow.	• Visual inspection and photographic survey of Eastern Tributary at annual intervals. • Visual inspection and photographic survey of Waratah Rivulet monthly when longwall extraction is within 450 m of the stream and within 3 months of the completion of each longwall. • Weekly monitoring at pools observed with gas releases until no gas releases have been observed at the pool for three consecutive weeks.
	Surface Water Flow	• Eastern Tributary (GS 300078). • Waratah Rivulet (GS 2132102). • Swamp 92 Flume (GS 300143). • Swamp 76 Flume (GS 300142). • Woronora River (GS 2132101). • Honeysuckle Creek (GS 300077). • O'Hares Creek (GS 213200).	• Stream flow data.	• Continuous (downloaded monthly).

Table 17 (Continued)
Longwalls 311-316 Environmental Monitoring Program Summary

Management Plan	Monitoring Component	Sites	Monitoring Parameter/Analysis	Monitoring Frequency
WMP (Cont.)	Pool Water Levels and Drainage Behaviour	• Eastern Tributary Pools ETG, ETJ, ETM, ETO, ETU, ETW, ETAF, ETAG, ETAH, ETAI/ETAJ/ETAK, ETAL, ETAM, ETAN, ETAO, ETAP, ETAQ, ETAR, ETAS/ETAT7[1] and ETAU. • Waratah Rivulet Pools A, F, J, K, L, M, N, O, P, Q, R, S, T, U, V and W. • Pools SR1, SR2 and SP1 on tributaries of the Woronora Reservoir. • Woronora River Control Pools WRP1, WRP2, WRP3 and WRP4.	• Pool water levels.	• Continuous water level sensor and logger (downloaded monthly at all sites).
		• Waratah Rivulet Pools B, C, E, G, G1, H and I.	• Pool water levels.	• Manually monitored daily, until such time that continuous sensors are installed.
		• Pools ETAS, ETAT and ETAU on the Eastern Tributary.	• Evidence of new cracking within the stream bed or rock bar. • Whether the pools continue to flow over, through and/or below the rock bars (where relevant). • Whether surface flow is evident along the length of the pools prior to flowing over/through/below the rock bars or boulder fields.	• Visual inspections conducted at the completion of each longwall.
		• Pools on the Waratah Rivulet from Pool P to the full supply level of the Woronora Reservoir.		• Visual inspections conducted monthly when longwall extraction is within 450 m of the stream and at the completion of each longwall.

Table 17 (Continued)
Longwalls 311-316 Environmental Monitoring Program Summary

Management Plan	Monitoring Component	Sites	Monitoring Parameter/Analysis	Monitoring Frequency
WMP (Cont.)	Stream Water Quality	• Eastern Tributary sites ETWQ F, ETWQ J, ETWQ N, ETWQ U, ETWQ W, ETWQ AF, ETWQ AH, ETWQ AQ and ETWQ AU. • Waratah Rivulet sites WRWQ 2, WRWQ 6, WRWQ 8, WRWQ 9, WRWQ M, WRWQ N, WRWQ P, WRWQ R, WRWQ T, WRWQ U, WRWQ V, and WRWQ W. • Woronora Reservoir tributaries at sites SR1, SR2 and SP1. • Tributary B site RTWQ 1. • Tributary D site UTWQ 1. • Far Eastern Tributary site FEWQ 1. • Honeysuckle Creek site HCWQ 1. • Bee Creek site BCWQ1. • Woronora River sites WOWQ1 and WOWQ 2.	• Water quality parameters as described in the WMP (samples collected for metal analysis to be field filtered).	• Monthly.
		• Eastern Tributary sites ETWQ F, ETWQ J, ETWQ N, ETWQ AF and ETWQ AQ. • Waratah Rivulet sites WRWQ 2, WRWQ 6, WRWQ 8, WRWQ 9, WRWQ M, WRWQ N and WRWQ P. • Woronora River control site WOWQ 2. • Bee Creek control site BCWQ 1. • Honeysuckle Creek control site HCWQ 1. • Woronora Reservoir tributaries at sites SR1, SR2, S92-GS and SP1.	• Unfiltered water quality samples analysed for total iron, total aluminium and total manganese.	• Monthly.

Table 17 (Continued)
Longwalls 311-316 Environmental Monitoring Program Summary

Management Plan	Monitoring Component	Sites	Monitoring Parameter/Analysis	Monitoring Frequency
WMP (Cont.)	Stream Water Quality (Cont.)	• Site ETAU, and at a minimum of three downstream sites (site ETFSL 0, site ETFSL 100, ETFSL 200, site ETFSL 300, site ETFSL 400, site ETFSL 500, site CONFLU1, site WDFS1 and/or site WDFS1+100). • Site WARARM5.	• Water quality parameters as described in the WMP (samples collected for metal analysis to be field filtered). • Unfiltered water quality samples analysed for total iron and total manganese.	• Site ETAU, and at a minimum of three downstream sites - weekly (until the site ETWQ AU monitoring results are at Level 1 or Level 2 of the WMP TARP for the quality of water resources reaching the Woronora Reservoir for four consecutive assessment periods. • Site ETAU, and at a minimum of three downstream sites - fortnightly (once the site ETWQ AU monitoring results have returned to Level 1 or Level 2 TARP levels for four consecutive assessment periods, unless the TARP level returns to Level 3). • Site WARARM5 - at the same frequency described above when the sites downstream of site CONFLU1 can be accessed for sampling (i.e. when the Woronora Reservoir water levels are suitably low).
	Woronora, Nepean and Cataract Reservoir Water Quality	• Woronora Reservoir (site DW01). • Nepean Reservoir. • Cataract Reservoir.	• Total iron, total manganese and total aluminium.	• As made available by WaterNSW.
	Shallow Groundwater Levels Near Streams	• Site ETO1, ETO2, ETO3 and ETO4 (adjacent to Pool ETO). • Waratah Rivulet sites WRGW1, WRGW2, WRGW3, WRGW5, WRGW6 and WRGW7. • Eastern Tributary site ETGW1.	• Groundwater levels.	• Data downloaded monthly at all sites.

Table 17 (Continued)
Longwalls 311-316 Environmental Monitoring Program Summary

Management Plan	Monitoring Component	Sites	Monitoring Parameter/Analysis	Monitoring Frequency
WMP (Cont.)	Groundwater Levels/Pressures	• Transect sites T1, T2, T3-R, T5 and T6. • Groundwater standpipes TBS02-90 and TBS02-190. • Site 9HGW0 (Longwall 10 post-mining). • Site 9EGW1B. • Site 9FGW1A. • Site 9GGW2B. • Site 9HGW1B. • Site PM02. • Site 9GGW1-3. • Site 9GGW1-80. • Site PM01 (9DGW1B). • Site 9EGW2A and Site 9EGW2-4 (redrill). • Site PM03. • Site PHGW1B. • Site PHGW2A. • Site F6GW3A. • Site F6GW4A. • site TBS02-90. • site TBS02-190. • Site TBS02-250R. • Site LW305GW (Longwall 305 post-mining).	• Groundwater levels.	• Data downloaded/reading monthly. • Analysis at the frequency described in the WMP.
	Groundwater Quality	• Waratah Rivulet sites WRGW1, WRGW2, WRGW3, WRGW5, WRGW6 and WRGW7.	• Water quality parameters as described in the WMP.	• Monthly.
	Mine Water Make	• Underground.	• Groundwater inflow to the mine (20-day average).	• Mine water balance inputs (as described in the WMP). • Weekly statutory inspections.

Table 17 (Continued)
Longwalls 311-316 Environmental Monitoring Program Summary

Management Plan	Monitoring Component	Sites	Monitoring Parameter/Analysis	Monitoring Frequency
LMP	Cliffs and overhangs	• Cliff sites COH10, COH11, COH12, COH13, COH18 and COH19.	• Cliff instabilities – length of cliff/overhang that experiences mining-induced rock fall (i.e. the exposure of a fresh face of rock and debris scattered around the base of the cliff or overhang), compared against the land subsidence impact performance indicator and subsidence impact performance measure.	• Visual inspection prior to Longwall 311 extraction. • Monthly when longwall extraction is within 400 m of each site. • Following the completion of Longwall 311, Longwall 312 and Longwall 313 for all sites and following completion at Longwall 314, Longwall 315 and Longwall 316 at sites COH18 and COH19.
	Steep slopes and land in general	• Steep slopes and other land within 600 m of Longwalls 20-27 and Longwalls 301-316 secondary extraction.	• Sandstone fracturing and rock falls (nature and extent of surface tension cracks and rock ledge collapse, compared against the land subsidence impact performance indicator).	• Visual inspections as part of routine works conducted in the catchment.
BMP	Upland Swamps – Vegetation	• Swamps 16, 17, 18, 19, 20, 24, 25, 28, 30, 31, 32, 33, 34, 35, 36 and 94 (overlying or adjacent to Longwalls 20-27). • Swamps 40, 41, 46, 47, 48, 49, 50, 51/52, 53 and 58 (overlying or adjacent to Longwalls 301-304). • Swamps 69, 70, 71a, 71b, 72 and 73 (overlying or adjacent to Longwalls 305-307). • Swamps 61, 62, 63, 64, 78, 79, 80, 81, 82, 83, 88, 89, 90 and 92 within the Longwalls 308-310 35° angle of draw and/or predicted 20 mm subsidence contour. • Swamps 74, 75, 76, 77, 92, 106, 119, 128 and 139 within Longwalls 311-316 35° angle of draw and/or predicted 20 mm subsidence contour[1]. • Control Swamps 101, 111a, 125, 135, 136, 137a, 137b, 138, Bee Creek Swamp, Woronora River 1, Woronora River south arm and Dahlia Swamp.	• Cracking of exposed bedrock areas and/or swamp substrate. • Areas of increased erosion, particularly along any existing drainage line. • Any changes in water colour, particularly evidence of iron precipitation. • Changes in vegetation condition, including areas of stressed vegetation (i.e. plants that demonstrate symptoms of stress) and dead/dying plants that appear unusual. • Whether the amount of seepage (at the terminal step/over exposed surfaces of the swamp) at the time of inspection appears unusual (relative to recent rainfall).	• Visual inspections bi-annually in spring and autumn for swamps overlying or adjacent to Longwalls 301-316. • Every third year, in autumn and spring for swamps overlying or adjacent to Longwalls 20-27.

Table 17 (Continued)
Longwalls 311-316 Environmental Monitoring Program Summary

Management Plan	Monitoring Component	Sites	Monitoring Parameter/Analysis	Monitoring Frequency
BMP (Cont.)	Upland Swamps – Vegetation (Cont.)	• Swamps 28, 30, 33, 35 and 94 Swamps 28, 30, 33, 35 and 94 (Longwalls 23-27). • Swamps 40, 41, 46, 48, 50 51/52 and 53 (Longwalls 301-304). • Swamp 71a (Longwalls 305-307). • Swamps 62, 64, 78, 79, 80, 81, 82, 83, 89, 90 and 92 within the Longwalls 308-310 35° angle of draw and/or predicted 20 mm subsidence contour. • Swamps 76 and 77 within the Longwalls 311-316 35° angle of draw and/or predicted 20 mm subsidence contour. • Control Swamps 101, 111a, 125, 135, 136, 137a, 137b, 138, Bee Creek Swamp, Woronora River 1, Woronora River south arm and Dahlia Swamp.	• Vegetation structure. • Dominant species. • Estimated cover and height for each stratum. • Full floristics. • Estimated cover abundance for each species using seven point Braun-Blanquet scale. • Condition/health rating for each species in the quadrat.	• Transect and quadrat monitoring bi-annually in spring and autumn for swamps overlying or adjacent to Longwalls 301-316. • Every third year, in autumn and spring for swamps overlying or adjacent to Longwalls 23-27.
		• Twenty tagged individuals (*Epacris obtusifolia*) in each of Swamps 18 and 24 (Longwalls 20-22) and Control Swamps 101, 111a and 125. • Twenty tagged individuals (*Epacris obtusifolia*) in each of Swamps 35 and 94 (Longwalls 23-27) and Control Swamps 137a, 137b and 138. • Twenty tagged individuals (*Epacris obtusifolia*) in each of Swamps 40 and 53 (Longwalls 301-304) and Control Swamps 101, 136 and 137a. • Twenty tagged individuals (*Pultenaea aristata*) in each of Swamps 19, 30, 33, 35 and 94 (Longwalls 23-27) and Control Swamps 135, 136, 137a and 138. • Twenty tagged individuals (*Banksia robur, Callistemon citrinus* and *Leptospermum juniperinum*) in each of Swamps 20 (Longwalls 20-22) and Control Swamps Woronora River 1, Woronora River south arm and Dahlia Swamp. • Twenty tagged individuals (*Callistemon citrinus*) in each of Swamps 28 (Longwalls 23-27) and Control Swamps Woronora River 1, Woronora River south arm and Dahlia Swamp.	• Population monitoring data including condition/health rating for each plant and reproductive rating.	• Indicator species monitoring bi-annually in spring and autumn for swamps overlying or adjacent to Longwalls 301-316. • Every third year, in autumn and spring for swamps overlying or adjacent to Longwalls 20-27.

Table 17 (Continued)
Longwalls 311-316 Environmental Monitoring Program Summary

Management Plan	Monitoring Component	Sites	Monitoring Parameter/Analysis	Monitoring Frequency
BMP (Cont.)	Upland Swamps - Groundwater	Includes paired piezometers (i.e. one swamp substrate piezometer to a depth of approximately 1 m and one sandstone piezometer to a depth of approximately 10 m). • Swamps 20 and 25 (Longwalls 20-22). • Swamps 28, 30, 33 and 35 (Longwalls 23-27). • Swamps 40, 41, 46, 51, 52 and 53 (Longwalls 301-303). • Swamp 50 (Longwall 304). • Swamps 71a and 72 (Longwalls 305-307). • Swamps 62, 64 and 82 (Longwalls 308-310). • Swamps 74, 75, 76[2], 77, 81, 89, 92, 106[2], 113, 115 and 119 (Longwalls 311-316). • Control Swamps 101, 137a, 137b, Bee Creek Swamp and Woronora River 1.	• Groundwater levels.	• Datalogger (continuous).
	Riparian Vegetation	• sites MRIP01, MRIP02, MRIP05, MRIP06 and MRIP09 (Longwalls 20-22). • sites MRIP11 and MRIP12 overlying (Longwalls 23-27). • sites MRIP07 and MRIP08 (Longwalls 23-27). • control sites MRIP03, MRIP04 and MRIP10 (Longwall 23A).	• Areas of new water ponding. • Any cracking or rock displacement. • Changes in vegetation condition, including areas of stressed vegetation that appear unusual.	• Visual inspections bi-annually in spring and autumn.
		• sites MRIP01, MRIP05, MRIP06 and MRIP09 (Longwalls 20-22). • sites MRIP11 and MRIP12 (Longwalls 23-27) • sites MRIP03 and MRIP10 (Longwall 23A) • sites MRIP07 and MRIP08 (Longwalls 23-27).	• Vegetation structure. • Dominant species. • Estimated cover and height for each stratum. • Full floristics. • Estimated cover abundance for each species using seven point Braun-Blanquet scale. • Condition/health rating for each species in the quadrat.	• Permanent quadrat (20 m x 2 m) monitoring bi-annually in spring and autumn.

Table 17 (Continued)
Longwalls 311-316 Environmental Monitoring Program Summary

Management Plan	Monitoring Component	Sites	Monitoring Parameter/Analysis	Monitoring Frequency
BMP (Cont.)	Riparian Vegetation (cont.)	• Existing tagged individuals (*Prostanthera linearis*, *Schoenus melanostachys* and *Lomatia myricoides*) at sites MRIP01, MRIP03, MRIP05, MRIP06, MRIP07, MRIP08, MRIP09, MRIP10, MRIP11, MRIP12. • Existing tagged individuals (*Lomatia myricoides*) at site MRIP02. • Existing tagged individuals (*Schoenus melanostachys* and *Lomatia myricoides*) at site MRIP04.	• Population monitoring data including condition/health rating for each plant and reproductive rating.	• Indicator species monitoring bi-annually in spring and autumn.
	Aquatic Biota and their Habitats	• Surface water resources and watercourses in accordance with the WMP.	• Monitoring of aquatic habitats in accordance with the WMP.	• In accordance with the WMP.
		• Stream monitoring at following Locations (if sufficient aquatic habitat is available for sampling); – WT3, WT4, WT5, ET1, ET2, ET3 and ET4. – Control Locations: WR1 and OC.	Impacts on aquatic ecology: • Habitat Characteristics. • Water Quality. • Aquatic Macroinvertebrates. • Aquatic Macrophytes.	• Biannually in spring (15 September to 15 December) and autumn (15 March to 15 June).
		• Larger pools ETAH on the Eastern Tributary and control Pool WP on the Woronora River and Pool OC on O'Hares Creek. • Smaller pools ETAG, ETAI and ETAK on the Eastern Tributary and control Pools WP-A, WP-B and WP-C on the Woronora River and Pools OC-A, OC-B and OC-C on O'Hares Creek.	The response of aquatic ecosystems to the implementation of stream remediation works: • Habitat Characteristics. • Water Quality. • Aquatic Macroinvertebrates. • Aquatic Macrophytes.	• Monitoring of Pools ETAG and ETAH will recommence subsequent to the conduct of stream remediation activities at Pool ETAH and will be conducted bi-annually in spring (15 September to 15 December) and autumn (15 March to 15 June). • Monitoring of Pools ETAI and ETAK will recommence subsequent to the conduct of stream remediation activities at Pool ETAK and will be conducted bi-annually in spring (15 September to 15 December) and autumn (15 March to 15 June).

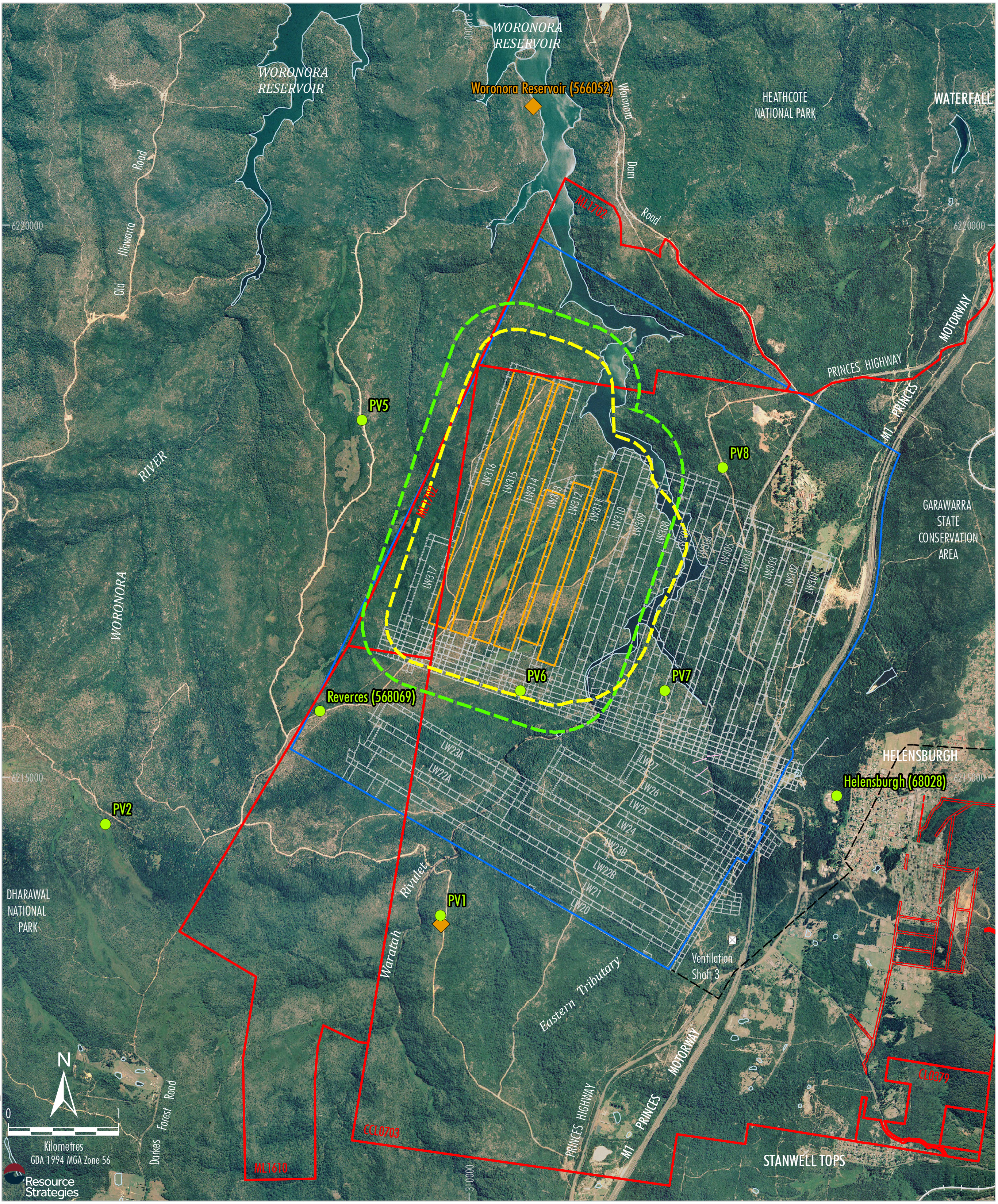
Table 17 (Continued)
Longwalls 311-316 Environmental Monitoring Program Summary

Management Plan	Monitoring Component	Sites	Monitoring Parameter/Analysis	Monitoring Frequency
BMP (Cont.)	Amphibian Monitoring	• Sites 25-28 (Longwalls 301-303). • Sites 29 and 30 (Longwalls 305-307). • Sites 31, 33, 34 and 39 (Longwalls 308-310). • Transects Sites S76, S77 and S92 (Longwalls 311-316). • Control Sites 7 to 12 and 18 to 22. • Control Transects Sites S14, S106[2], Bee Creek Swamp and S76[2].	• Multivariate analysis of threatened amphibian species relative abundance. • Non-threatened amphibian species relative abundance. • Species richness (diversity) to be monitored.	• Survey biannually in spring/summer (i.e. October to February) during suitable weather conditions.
HMP	Aboriginal Heritage	• All sites within the Longwall 311 35° angle of draw and/or predicted 20 mm subsidence contour, namely Sites NT 11, NT 33, NT 34, NT 35, NT 78, NT 79, FRC 97, FRC 185, FRC 186, FRC 187, FRC 189, FRC 191, FRC 193, FRC 194, FRC 196, FRC 198, FRC 199, FRC 340, FRC 344 and FRC 345.	• Inspections of rock surfaces for cracking and/or exfoliation and/or blockfall. • Inspection of art motifs for damage or deterioration. • Identification of any natural weathering processes that may result in deterioration (e.g. fire, vegetation growth and water seepage). • Comparison of the physical characteristics of the site at the time of monitoring against the previous monitoring and the baseline record.	• Within three months following the completion of Longwall 311.
		• All sites within the Longwalls 312 35° angle of draw and/or predicted 20 mm subsidence contour, namely Sites NT 11, NT 33, NT 34, NT 35, NT 78, NT 79, FRC 97, FRC 185, FRC 186, FRC 187, FRC 189, FRC 191, FRC 193, FRC 194, FRC 196, FRC 198, FRC 199, FRC 340, FRC 344 and FRC 345.		• Within three months following the completion of Longwall 312.
		• All sites within the Longwalls 313 35° angle of draw and/or predicted 20 mm subsidence contour, namely Sites NT 3, NT 7, NT 8, NT 9, NT 11, NT 18, NT 33, NT 34, NT 35, NT 78, NT 79, FRC 61, FRC 62, FRC 97, FRC 185, FRC 186, FRC 187, FRC 189, FRC 191, FRC 193, FRC 194, FRC 195, FRC 196, FRC 198, FRC 199, FRC 340, FRC 344 and FRC 345.		• Within three months following the completion of Longwall 313.

Table 17 (Continued)
Longwalls 311-316 Environmental Monitoring Program Summary

Management Plan	Monitoring Component	Sites	Monitoring Parameter/Analysis	Monitoring Frequency
HMP (Continued)	Aboriginal Heritage (Continued)	• All sites within the Longwalls 314 35° angle of draw and/or predicted 20 mm subsidence contour, namely sites NT 3, NT 5, NT 6, NT 7, NT 8, NT 9, NT 11, NT 18, NT 21, NT 33, NT 34, NT 35, NT 46, NT 78, NT 79, FRC 61, FRC 62, FRC 97, FRC 185, FRC 186, FRC 187, FRC 189, FRC 191, FRC 193, FRC 194, FRC 195, FRC 196, FRC 198, FRC 199, FRC 340, FRC 344 and FRC 345.	As above.	• Within three months following the completion of Longwall 314.
		• All sites within the Longwalls 315 35° angle of draw and/or predicted 20 mm subsidence contour, namely sites NT 3, NT 4, NT 5, NT 6, NT 7, NT 8, NT 9, NT 11, NT 18, NT 21, NT 33, NT 34, NT 35, NT 46, NT 78, NT 79, FRC 61, FRC 62, FRC 97, FRC 185, FRC 186, FRC 187, FRC 189, FRC 191, FRC 193, FRC 194, FRC 195, FRC 196, FRC 198, FRC 199, FRC 340, FRC 344 and FRC 345.		• Within three months following the completion of Longwall 315.
		• All sites within the Longwalls 316 35° angle of draw and/or predicted 20 mm subsidence contour, namely sites NT 3, NT 4, NT 5, NT 6, NT 7, NT 8, NT 9, NT 10, NT 11, NT 12, NT 17, NT 18, NT 29/30, NT 33, NT 34, NT 35, NT 46, NT 78, NT 79, FRC 61, FRC 62, FRC 97, FRC 185, FRC 186, FRC 187, FRC 189, FRC 191, FRC 193, FRC 194, FRC 195, FRC 196, FRC 198, FRC 199, FRC 340, FRC 344 and FRC 345.		• Within three months following the completion of Longwall 316.

[1] Due to the nature of rock bar ETAS, Pool ETAS and Pool ETAT typically sit at the same level.
[2] Swamp 76 and 106 would be used as a control swamp until such time that subsidence effects are greater than negligible (to be determined by MSEC), at which time, it would become a test (impact) site.



LEGEND

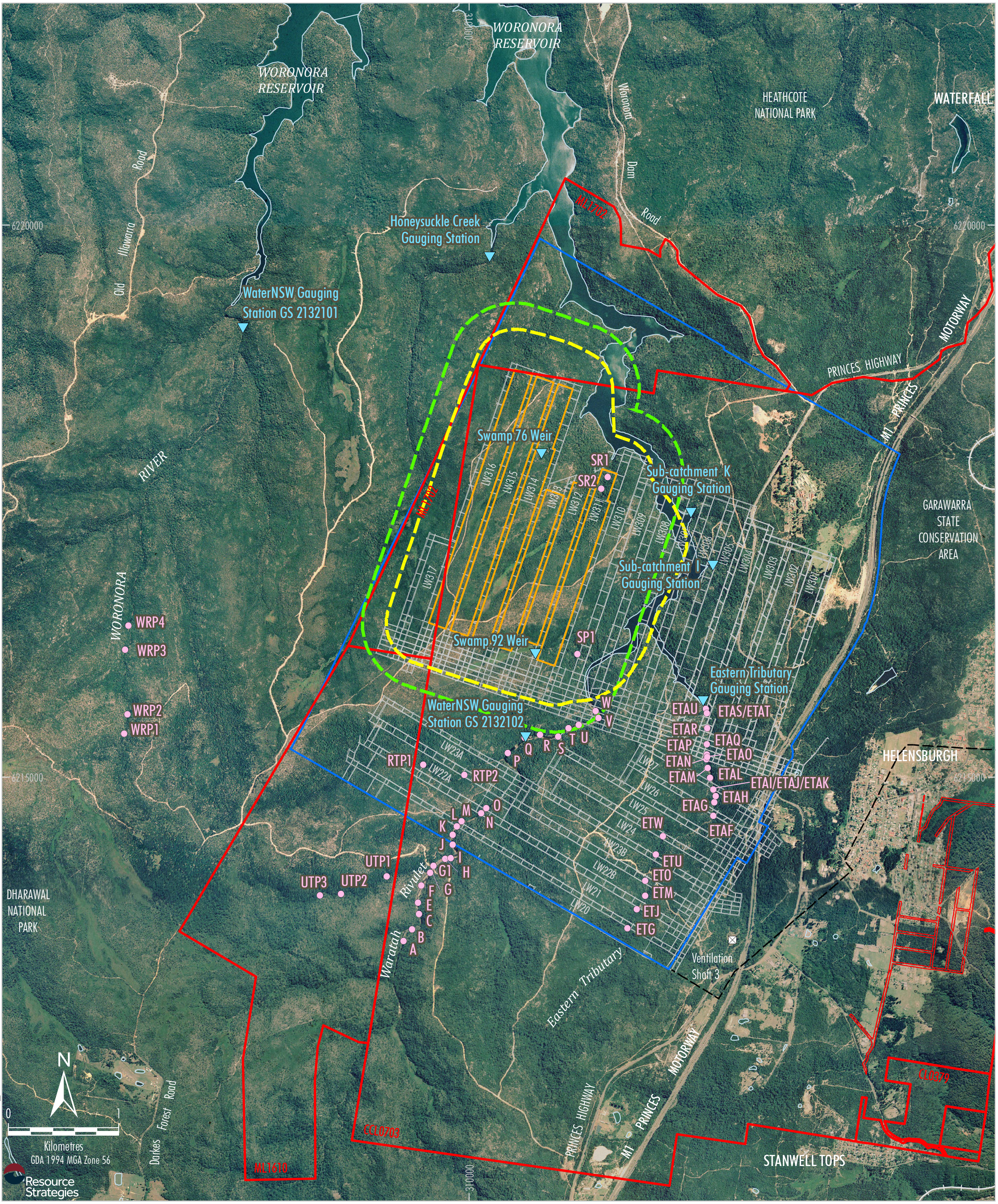
- Mining Lease Boundary
- Railway
- Project Underground Mining Area Longwalls 20-27 and 301-317
- Longwalls 311-316 Secondary Extraction
- Longwalls 311-316 35° Angle of Draw and/or Predicted 20 mm Subsidence Contour
- 600 m from Longwalls 311-316 Secondary Extraction
- Existing Underground Access Drive (Main Drift)
- Evaporimeter
- Pluviometer

Notes:
1. The Bureau of Meteorology pluviometer at Darkes Forest (68024) is not shown. It is located approximately 3.75 km south of the Metropolitan Coal pluviometer (PV2).
2. The Bureau of Meteorology pluviometer at Lucas Heights (66078) is not shown. It is located approximately 12.5 km north of the Metropolitan Coal pluviometer (PV8).

Source: Land and Property Information (2015); Date of Aerial Photography 1998; Department of Industry (2015); Metropolitan Coal (2023); MSEC (2024)

Peabody
METROPOLITAN COAL
Meteorological Sites

Figure 13



LEGEND

- Mining Lease Boundary
- Railway
- Project Underground Mining Area Longwalls 20-27 and 301-317
- Longwalls 311-316 Secondary Extraction
- Longwalls 311-316 35° Angle of Draw and/or Predicted 20 mm Subsidence Contour
- 600 m from Longwalls 311-316 Secondary Extraction
- Existing Underground Access Drive (Main Drift)
- Gauging Station
- Pool Water Level Site

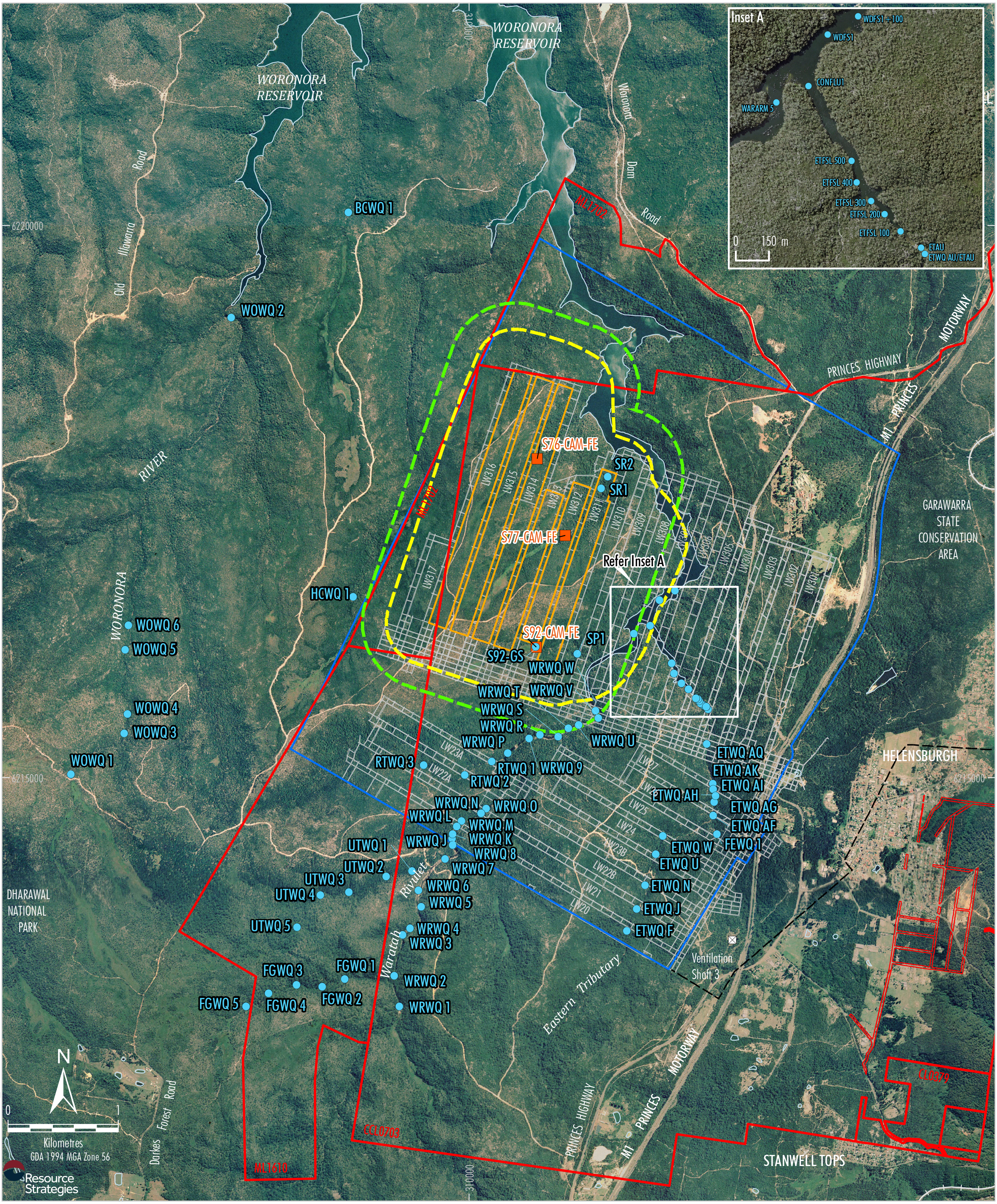
Source: Land and Property Information (2015); Date of Aerial Photography 1998; Department of Industry (2015); Metropolitan Coal (2023); MSEC (2024)

Peabody

METROPOLITAN COAL

Surface Water Quantity Sites

Figure 14



LEGEND

- Mining Lease Boundary
- Railway
- Project Underground Mining Area Longwalls 20-27 and 301-317
- Longwalls 311-316 Secondary Extraction
- Longwalls 311-316 35° Angle of Draw and/or Predicted 20 mm Subsidence Contour
- 600 m from Longwalls 311-316 Secondary Extraction
- Existing Underground Access Drive (Main Drift)
- Surface Water Quality Site
- Proposed Iron Staining Camera

Source: Land and Property Information (2015); Date of Aerial Photography 1998; Department of Industry (2015); Metropolitan Coal (2023); MSEC (2024)

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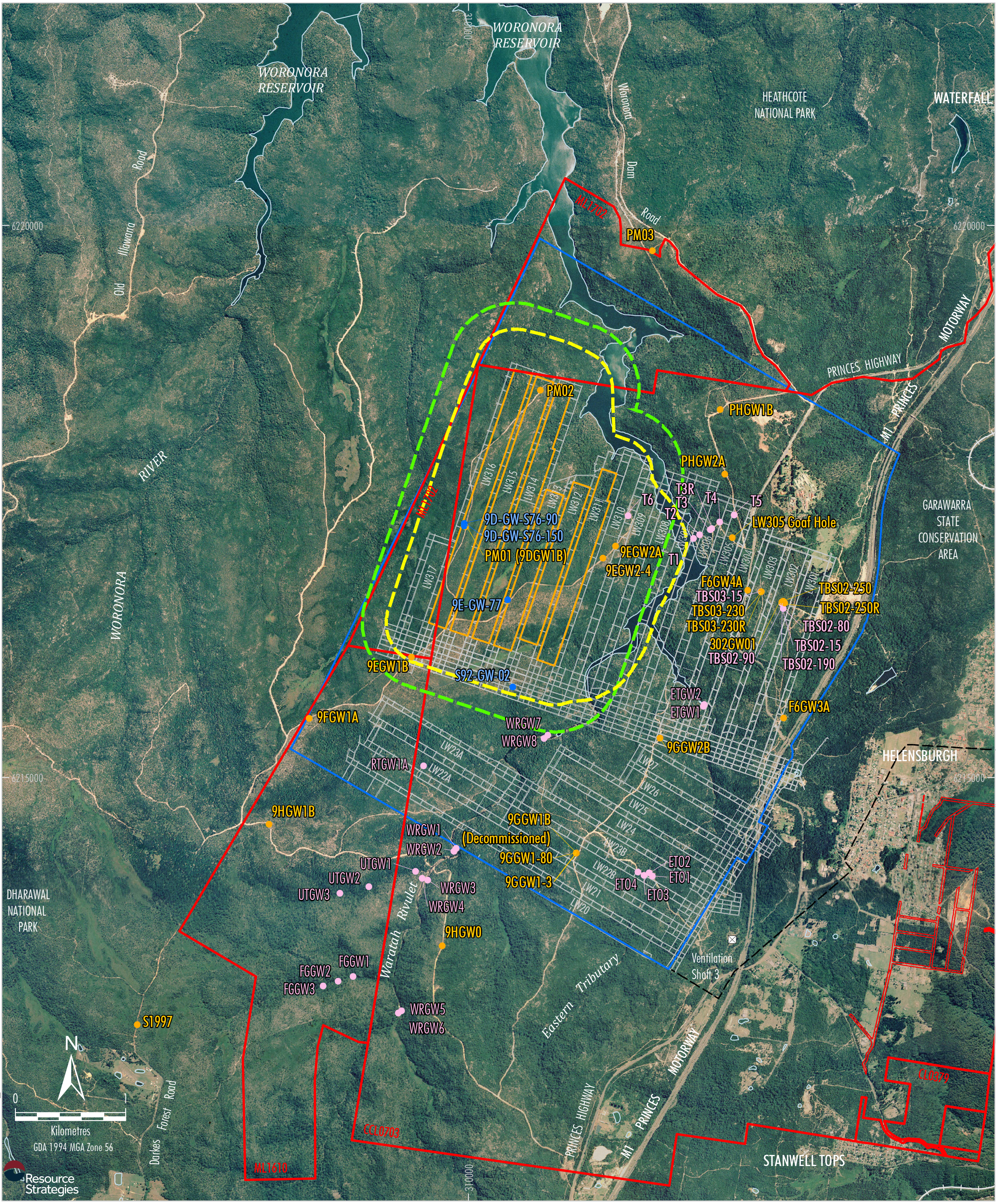
METROPOLITAN COAL

Surface Water Quality Sites

Figure 15



LEGEND

- Mining Lease Boundary
- Railway
- Project Underground Mining Area Longwalls 20-27 and 301-317
- Longwalls 311-316 Secondary Extraction
- Longwalls 311-316 35° Angle of Draw and/or Predicted 20 mm Subsidence Contour
- 600 m from Longwalls 311-316 Secondary Extraction
- Existing Underground Access Drive (Main Drift)
- Groundwater Level Bore
- Groundwater Level/Pressure Bore
- Proposed Groundwater Monitoring Site

Source: Land and Property Information (2015); Date of Aerial Photography 1998; Department of Industry (2015); Metropolitan Coal (2023); MSEC (2024)

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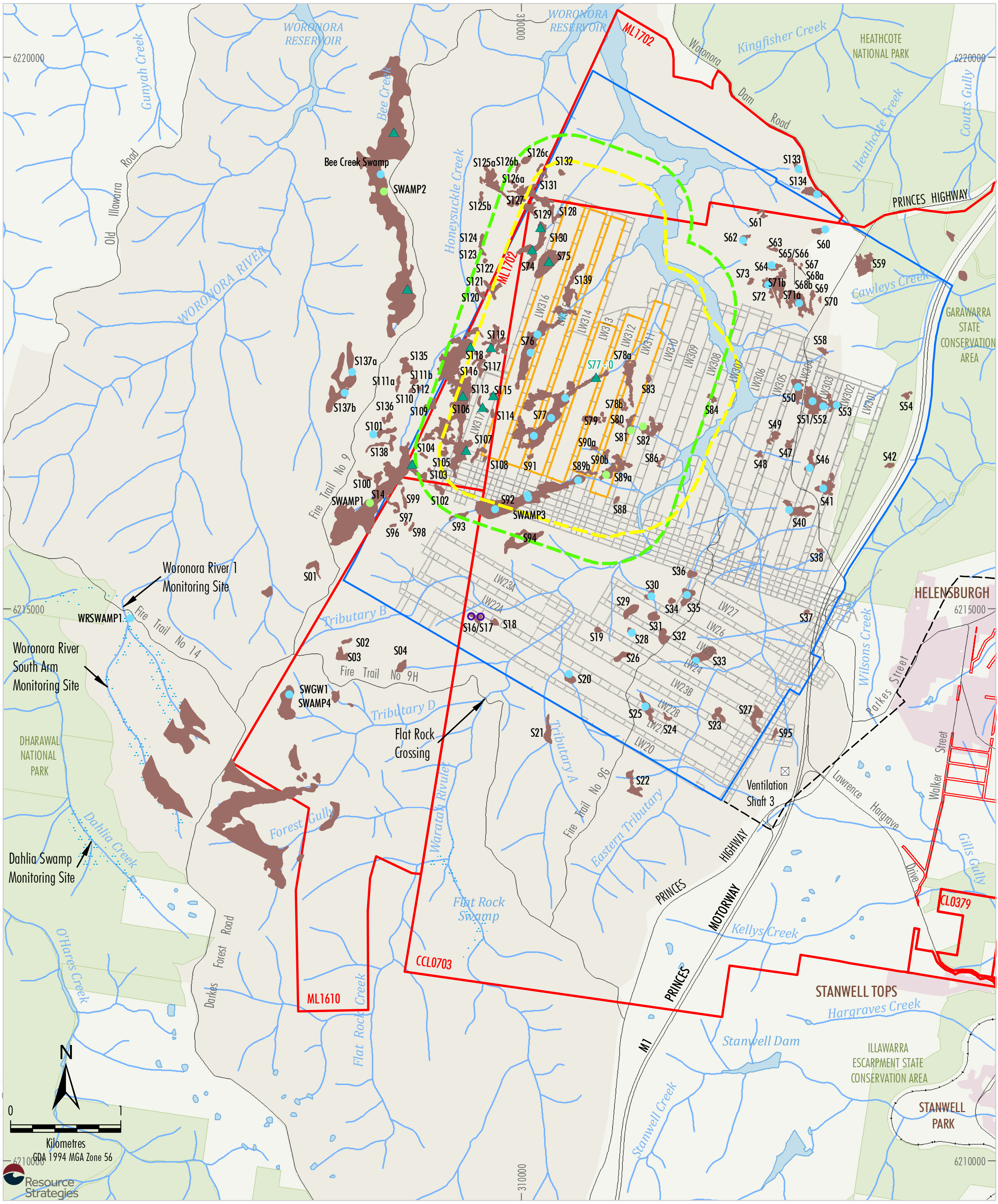
METROPOLITAN COAL

Groundwater Level and/or Pressure Bore Locations

Figure 16



LEGEND

- Mining Lease Boundary
- Woronora Special Area
- Railway
- Project Underground Mining Area Longwalls 20-27 and 301-317
- Longwalls 311-316 Secondary Extraction
- Longwalls 311-316 35° Angle of Draw and/or Predicted 20 mm Subsidence Contour
- 600 m from Longwalls 311-316 Secondary Extraction
- Existing Underground Access Drive (Main Drift)
- Upland Swamp
- Swamp Substrate and Shallow Groundwater Piezometer
- Swamp Substrate Groundwater Piezometer
- Swamp Shallow Groundwater Piezometer
- Swamp Soil Moisture Probe
- Proposed Future Monitoring Sites

Note: Shallow Groundwater Piezometers at swamp monitoring site 92-1 is planned for installation by November 2024. Installation would be subject to suitable weather conditions and access to the Woronora Special Area. The future monitoring site locations in Bee Creek are indicative only and subject to change based on site access and swamp field investigations.

Source: Land and Property Information (2015); Department of Industry (2015); Metropolitan Coal (2023); MSEC (2024); after NPWS (2003), Bangalay Botanical Surveys (2008); Eco Logical Australia (2015; 2016; 2018) and Ecoplanning (2021; 2023)

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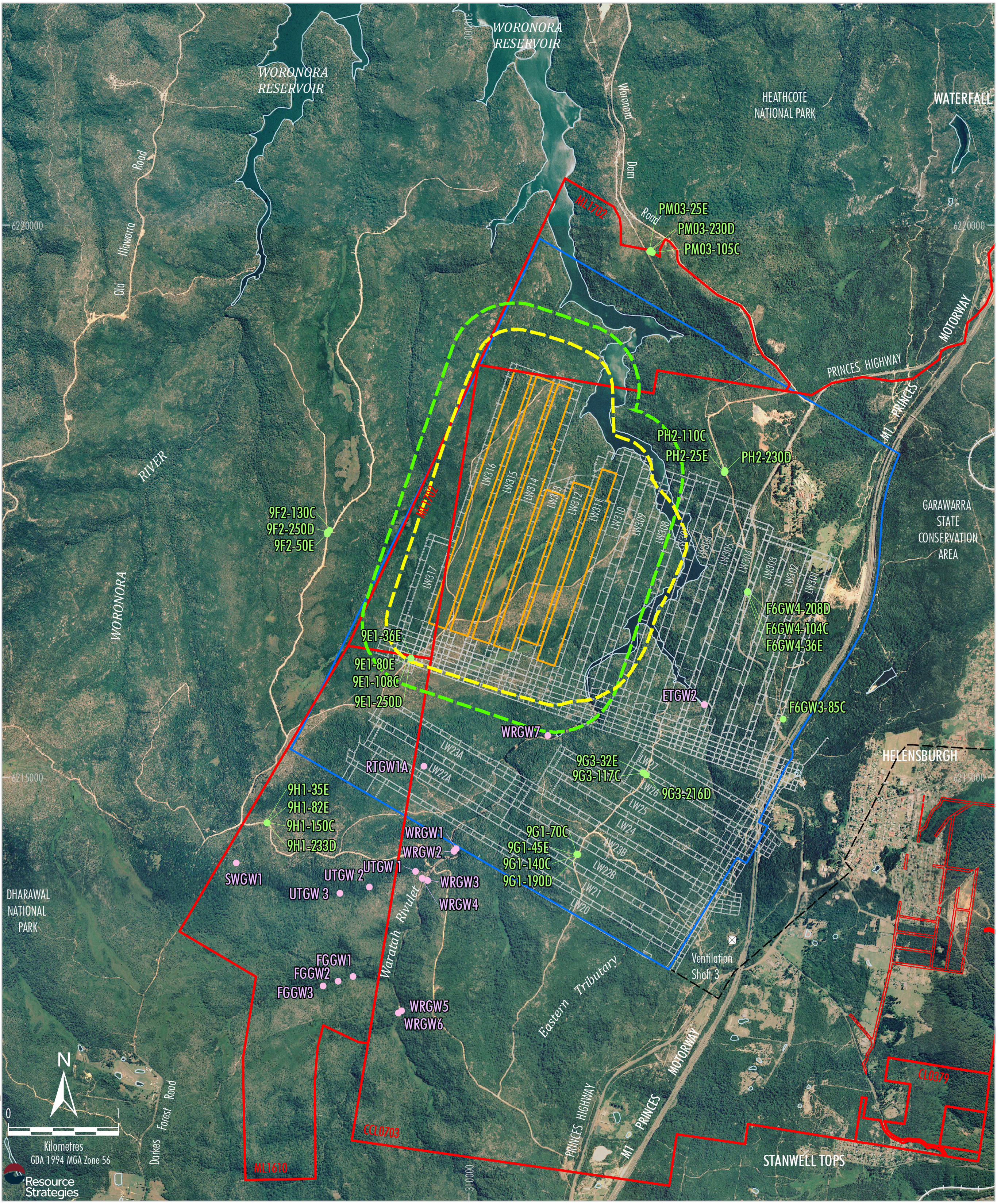
METROPOLITAN COAL

Upland Swamps Groundwater Piezometer Locations

Figure 17



LEGEND

- Mining Lease Boundary
- Railway
- Project Underground Mining Area Longwalls 20-27 and 301-317
- Longwalls 311-316 Secondary Extraction
- Longwalls 311-316 35° Angle of Draw and/or Predicted 20 mm Subsidence Contour
- 600 m from Longwalls 311-316 Secondary Extraction
- Existing Underground Access Drive (Main Drift)
- Deep Groundwater Chemistry Monitoring Site
- Stream Shallow Groundwater Quality Monitoring Site

Source: Land and Property Information (2015); Date of Aerial Photography 1998; Department of Industry (2015); Metropolitan Coal (2023); MSEC (2024)

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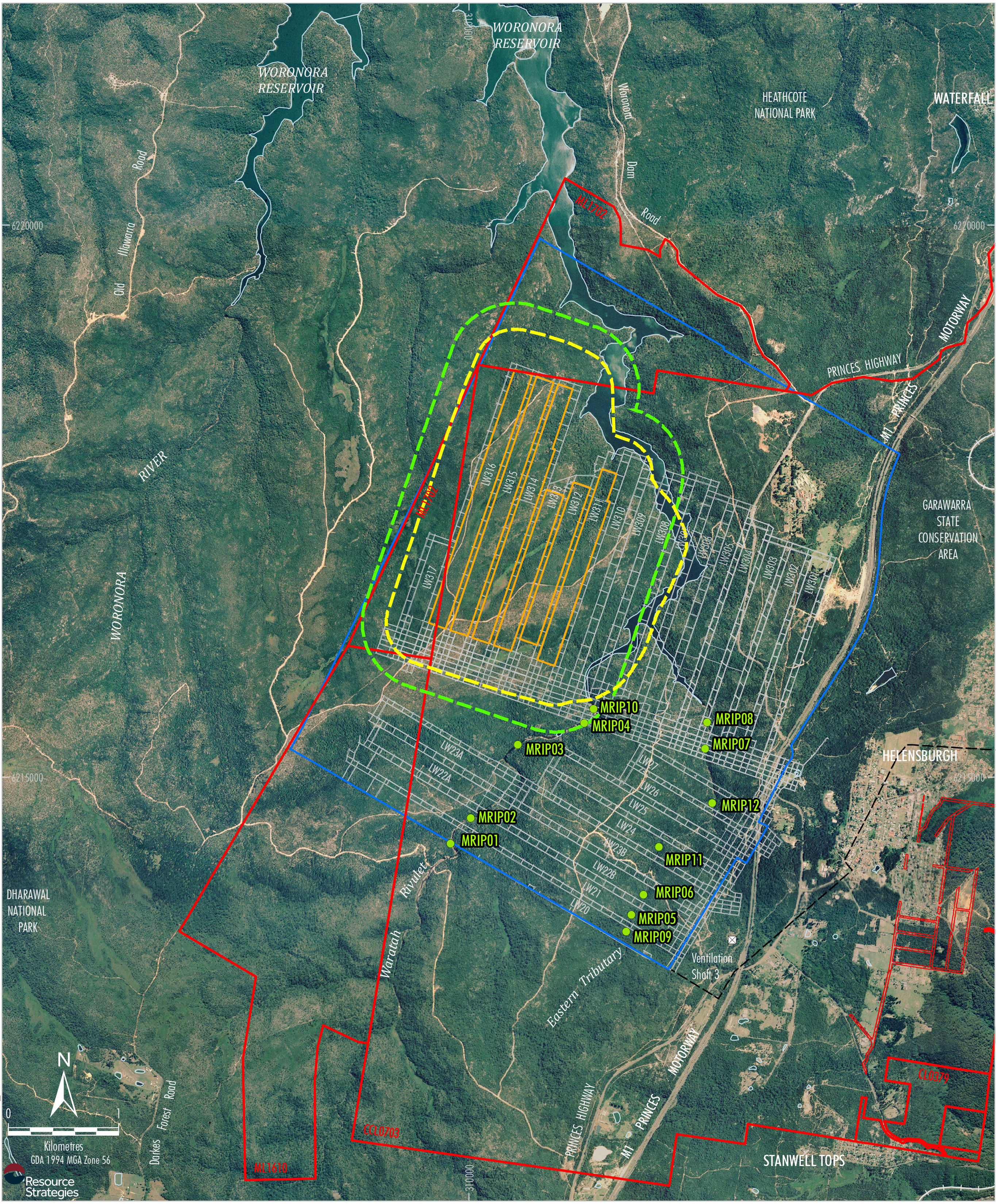
METROPOLITAN COAL

Groundwater Quality Sites

Figure 18



LEGEND

Mining Lease Boundary
Railway
Project Underground Mining Area Longwalls 20-27 and 301-317
Longwalls 311-316 Secondary Extraction
Longwalls 311-316 35° Angle of Draw and/or Predicted 20 mm Subsidence Contour
600 m from Longwalls 311-316 Secondary Extraction
Existing Underground Access Drive (Main Drift)

Monitoring Site
Riparian Vegetation Monitoring Site

Source: Land and Property Information (2015); Date of Aerial Photography 1998; Department of Industry (2015); Metropolitan Coal (2023); MSEC (2024)

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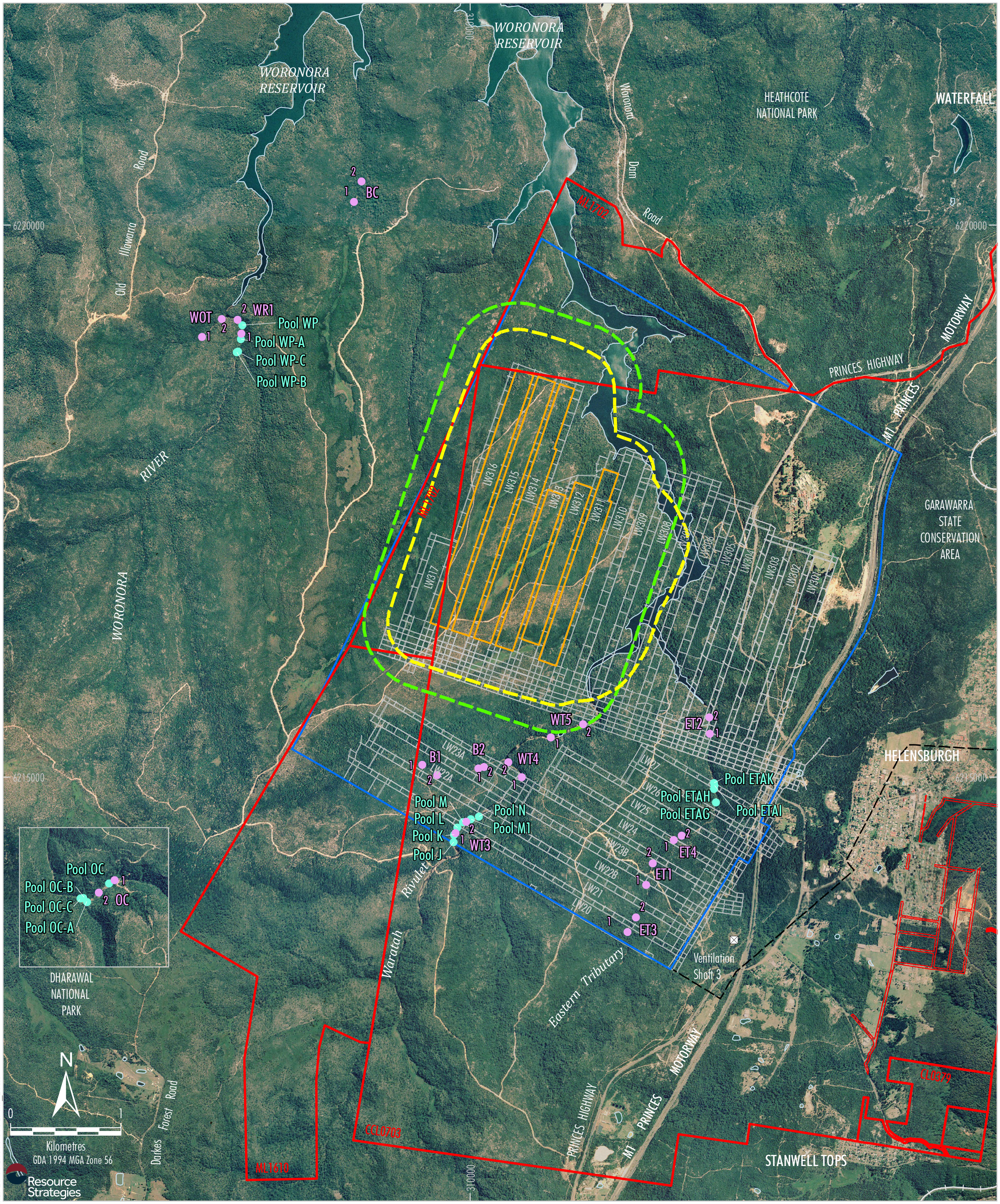
METROPOLITAN COAL

Riparian Vegetation Monitoring Locations

Figure 19



LEGEND

- Mining Lease Boundary
- Railway
- Project Underground Mining Area Longwalls 20-27 and 301-317
- Longwalls 311-316 Secondary Extraction
- Longwalls 311-316 35° Angle of Draw and/or Predicted 20 mm Subsidence Contour
- 600 m from Longwalls 311-316 Secondary Extraction
- Existing Underground Access Drive (Main Drift)

Monitoring

- Pool Aquatic Ecology Sampling Site
- Stream Aquatic Ecology Sampling Site

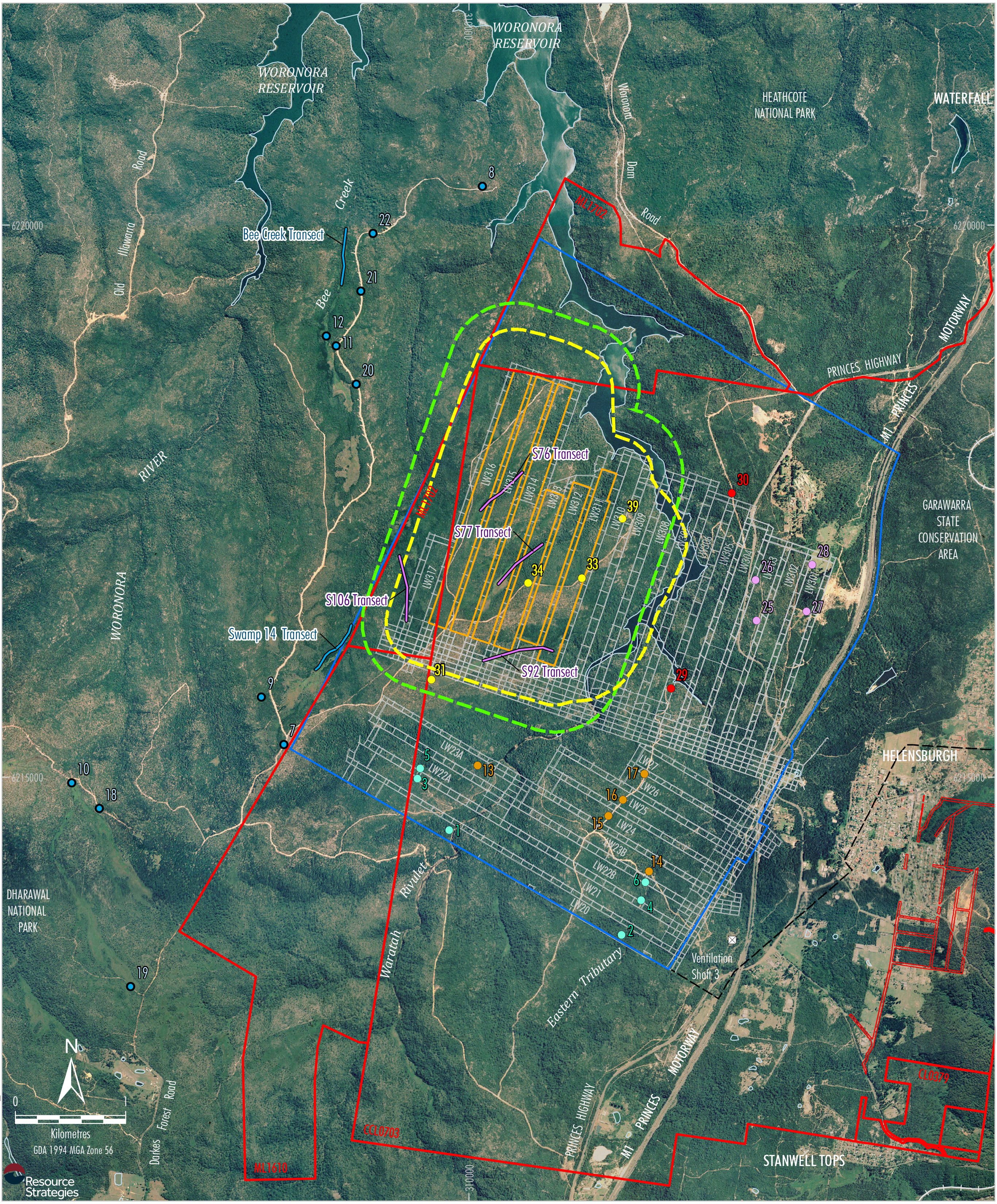
Source: Land and Property Information (2015); Date of Aerial Photography 1998; Department of Industry (2015); Metropolitan Coal (2023); MSEC (2024)

Peabody

METROPOLITAN COAL

Aquatic Ecology Sampling Locations

Figure 20



LEGEND

- Mining Lease Boundary
- Railway
- Project Underground Mining Area Longwalls 20-27 and 301-317
- Longwalls 311-316 Secondary Extraction
- Longwalls 311-316 35° Angle of Draw and/or Predicted 20 mm Subsidence Contour
- 600 m from Longwalls 311-316 Secondary Extraction
- Existing Underground Access Drive (Main Drift)

Monitoring Sites

- Longwalls 20-22 Amphibian Monitoring Site
- Longwalls 23-27 Amphibian Monitoring Site
- Longwalls 301-303 Amphibian Monitoring Site
- Longwalls 305-307 Amphibian Monitoring Site
- Longwalls 308-317 Amphibian Monitoring Site
- Longwalls 311-316 Amphibian Monitoring Transect
- Control Site
- Control Transect

Note: Swamp 76 and 106 would be used as a control swamp until such time that subsidence effects are greater than negligible (to be determined by MSEC), at which time, it would become a test (impact) site

Source: Land and Property Information (2015); Date of Aerial Photography 1998; Department of Industry (2015); Metropolitan Coal (2023); MSEC (2024)

Peabody

METROPOLITAN COAL

Amphibian Monitoring Locations

Figure 21

5 MANAGEMENT, MITIGATION, REMEDIATION AND REPORTING MEASURES

5.1 ADAPTIVE MANAGEMENT AND CONTINGENCY PLANNING

5.1.1 Adaptive Management

Metropolitan Coal will implement an adaptive management approach for the Project. Adaptive management will involve:

- Planning – developing management strategies to meet performance measures; identifying performance indicators to assess performance; and establishing monitoring programs to monitor against the performance measures.
- Implementation – implementing management strategies and monitoring impacts against performance indicators.
- Review – reviewing and evaluating the effectiveness of management strategies by analysis of monitoring data against predicted impacts, performance indicators and performance measures in accordance with the schematic presented in Figure 12.
- Contingency Response – implementing contingency plans where an exceedance of a subsidence impact performance measure or an unexpected impact is detected (Section 5.1.2).
- Adjustment – adjusting management strategies to improve performance.

5.1.2 Contingency Response

In the event a subsidence impact performance measure described in Sections 4.2.1 to 4.2.6 has been exceeded as a result of Longwalls 311-316 extraction, Metropolitan Coal will implement the relevant Contingency Plan detailed in the WMP (Appendix A), LMP (Appendix B), BMP (Appendix C), HMP (Appendix D) or the PSMP (Appendix E). In general, the Contingency Plans include the following:

- The likely exceedance will be reported to the Technical Services Manager and/or the Environment & Community Superintendent within 24 hours.
- The Technical Services Manager or the Environment & Community Superintendent will report the likely exceedance to the General Manager as soon as practicable after becoming aware of the exceedance.
- Metropolitan Coal will report the exceedance to the DPE, relevant agencies and relevant stakeholders as soon as practicable after Metropolitan Coal becomes aware of the exceedance.
- Metropolitan Coal will conduct an investigation to evaluate the potential contributing factors.
- Metropolitan Coal will identify an appropriate course of action with respect to the identified impact(s), in consultation with specialists, relevant agencies and relevant stakeholders as necessary. For example:
  - proposed management and/or mitigation measures (Section 4);
  - a program to review the effectiveness of the management and/or mitigation measures; and
  - consideration of offsets or adaptive management.

  Contingency measures will be developed in consideration of the specific circumstances of the exceedance and the assessment of environmental consequences.
- Metropolitan Coal will submit the proposed course of action to the DPE for approval.
- Metropolitan Coal will implement the approved course of action to the satisfaction of the DPE.

In accordance with Condition 6, Schedule 6 of the Project Approval, Metropolitan Coal will provide a suitable offset to compensate for the impact to the satisfaction of the Secretary of the DPE if either the contingency measures implemented by Metropolitan Coal have failed to remediate the impact or the Secretary of the DPE determines that it is not reasonable or feasible to remediate the impact.

Relevant management and contingency measures are summarised in Section 4.2 and outlined in the component management plans (Appendices A to E).

Responsibilities during the contingency response are outlined in Section 6.4, which is designed to clearly outline actions, levels of responsibility within Metropolitan Coal and reporting requirements where monitoring results indicate that impacts are exceeding (or likely to exceed) predicted or approved limits. Section 6.4 will further describe key responsibilities to support the TARPs provided in the component management plans (Appendices A to E).

5.2 INCIDENTS, COMPLAINTS, EXCEEDANCES AND NON-COMPLIANCES

Metropolitan Coal has developed a reporting framework for the Extraction Plan based on the nature of the predicted subsidence impacts and consequences and streamlining of reporting requirements.

Table 18 provides a summary of the proposed reporting framework, including which stakeholders will receive copies of each report and the distribution method. The subsections below provide further detail on the contents of each reporting mechanism.

5.2.1 Incident Report

An incident is defined as a set of circumstances that causes or threatens to cause material harm to the environment, and/or breaches or exceeds the limits or performance measures/criteria in the Project Approval.

The reporting of incidents will be conducted in accordance with Condition 6, Schedule 7 of the Project Approval. Metropolitan Coal will notify the Secretary of the DPE and any other relevant agencies (Table 18) of any incident associated with the Project as soon as practicable after Metropolitan Coal becomes aware of the incident. Within seven days of the date of the incident, Metropolitan Coal will provide the Secretary of the DPE and relevant agencies with a detailed report on the incident.

An Incident Report will include the following:

- details on the nature of the incident (including survey results, photographs and date of the incident);
- results of investigation(s) to identify/evaluate the contributing factors to the incident;
- proposed course of action and development of contingency measures; and
- relevant Metropolitan Coal contact details to obtain further information on the incident.

Table 18
Summary of Reporting Framework

Report	Frequency	Distribution	Distribution Method[1]	Responsibility for Data Collation and Preparation	Responsibility for Submission
Incident Report	As required	DPE (Secretary of the DPE, c/- Executive Director) RR (Manager and Principal Inspector, Environment) Other regulators as specified in management plans	Email	Technical Services Manager or Environment & Community Superintendent	Technical Services Manager, Environment & Community Superintendent or General Manager
Six Monthly Report	Six monthly	Internal Metropolitan Coal Document	Email	Technical Services Manager or Environment & Community Superintendent	Technical Services Manager or Environment & Community Superintendent
Annual Review	Annually	DPE (Director, Resource Assessments) RR (Manager and Principal Inspector, Environment) Other regulators as specified in management plans Metropolitan Coal website	Email and Website	Technical Services Manager or Environment & Community Superintendent	Technical Services Manager or Environment & Community Superintendent
Complaints Register	Updated following receipt of complaints	Metropolitan Coal website	Website	Environment & Community Superintendent	Environment & Community Superintendent

1 See Attachment 4 for distribution details.

5.2.2 Six Monthly Reporting

A six monthly report (**Six Monthly Report**) will be prepared to report on subsidence impacts and environmental consequences associated with the Longwalls 311-316 Extraction Plan. The Six Monthly Report will be used by Metropolitan Coal to verify environmental performance (including assessing against TARP Performance Indicators and Performance Measures, and to identify whether further management and/or monitoring is required).

The Six Monthly Reports will be prepared with input from suitability qualified specialists. This document will not be distributed externally.

5.2.3 Annual Review

An Annual Review will be prepared and submitted in accordance with Condition 3, Schedule 7 of the Project Approval. The Annual Review will review the performance of the Project to the satisfaction of the Secretary of the DPE and will:

- describe the works that were carried out in the past calendar year, and the works that are proposed to be carried out over the current calendar year;
- include a comprehensive review of the monitoring results and complaints records of the Project over the past calendar year, which includes a comparison of these results against:
  - the relevant statutory requirements, limits or performance measures/criteria;
  - the monitoring results of previous years; and
  - the relevant predictions in the Project EA, Preferred Project Report and Extraction Plan.
- identify any non-compliance over the last year, and describe what actions were (or are being) taken to ensure compliance;
- identify any trends in the monitoring data over the life of the Project;
- identify any discrepancies between the predicted and actual impacts of the Project, and analyse the potential cause of any significant discrepancies; and
- describe what measures will be implemented over the next year to improve the environmental performance of the Project.

5.2.4 Complaints

The Environment & Community Superintendent is responsible for maintaining a system for recording complaints.

Metropolitan Coal will maintain public signage advertising the telephone number on which environmental complaints can be made. The Environment & Community Superintendent is responsible for ensuring that the currency and effectiveness of the service is maintained. Notifications of complaints received are to be provided as quickly as practicable to the Environment & Community Superintendent.

Complaints and enquiries do not have to be received via the telephone line and may be received in any other form. Any complaint or enquiry relating to environmental management or performance is to be relayed to the Environment & Community Superintendent as soon as practicable. All employees are responsible for ensuring the prompt relaying of complaints. All complaints will be recorded in a complaints register.

For each complaint, the following information will be recorded in the complaints register:

- date and time of complaint;
- method by which the complaint was made;
- personal details of the complainant which were provided by the complainant or, if no such details were provided, a note to that effect;
- nature of the complaint;
- the action(s) taken by Metropolitan Coal in relation to the complaint, including any follow-up contact with the complainant; and
- if no action was taken by Metropolitan Coal, the reason why no action was taken.

The Environment & Community Superintendent is responsible for ensuring that all complaints are appropriately investigated, actioned and that information is fed back to the complainant, unless requested to the contrary.

In accordance with Condition 10, Schedule 7 of the Project Approval, the complaints register will be made publicly available on the website and updated on a monthly basis. A summary of complaints received and actions taken will be presented to the CCC as part of the operational performance review.

6 PLAN ADMINISTRATION AND RESPONSIBILITIES

6.1 REVIEW OF OTHER MANAGEMENT PLANS

In accordance with Condition 4, Schedule 7 of the Project Approval, the strategies, plans and programs required under The Project Approval will be reviewed within three months of the submission of:

(a) an audit under Condition 8, Schedule 7;

(b) an incident report under Condition 6, Schedule 7;

(c) an annual review under Condition 3, Schedule 7; and

if necessary, revised to the satisfaction of the Secretary of the DPE, to ensure the strategies, plans and programs are updated on a regular basis and to incorporate any recommended measures to improve environmental performance.

The strategies, plans and programs will also be reviewed within three months of approval of any Project modification and if necessary, revised to the satisfaction of the DPE. The revision status of the strategies, plans and programs is indicated on the title page of each copy.

6.2 REVIEW OF THE EXTRACTION PLAN

This Extraction Plan and its component management plans will be reviewed in detail, and revised if necessary, in the following circumstances:

- during Metropolitan Coal preparing subsequent Extraction Plans for Longwalls 311-316, or for other Longwalls being mined within the Metropolitan Coal Mine;
- within 3 months of the submission of an Incident Report relating to a subsidence impact (Section 5.2.1) taking into consideration any contingency response implemented following submission of the Incident Report (Section 5.1.2); and/or
- where there is a significant change in operation that may affect the environment or the community.

In addition to the above, this Extraction Plan will also be reviewed within 3 months of:

- the submission of an Annual Review;
- the submission of an audit report; or
- any modification to the conditions of the Project Approval.

The component management plans of this Extraction Plan reference components of a number of existing Environmental Management Plans to avoid duplication (Section 4). If these Environmental Management Plans are revised separately in accordance with the Project Approval the management plans will be updated accordingly.

If the review determines updates are required, this would be reported to DPE.

6.3 DISTRIBUTION

In accordance with Condition 10, Schedule 7 of the Project Approval 'Access to Information', Metropolitan Coal will make the Extraction Plan publicly available on the Peabody website.

Metropolitan Coal recognises that various regulators have different distribution requirements, both in relation to whom documents should be sent and in what format. An Environmental Management Plan and Monitoring Program Distribution Register has been established in consultation with the relevant agencies and infrastructure owners that indicates:

- to whom the Metropolitan Coal plans and programs, such as the Extraction Plan, will be distributed;
- the format (i.e. electronic or hard copy) of distribution; and
- the format of revision notification.

Metropolitan Coal will make the Distribution Register publicly available on the Peabody website. Metropolitan Coal will be responsible for maintaining the Distribution Register and for ensuring that notification of revisions is sent by email or post as appropriate.

In addition, Metropolitan Coal employees with local computer network access will be able to view the controlled electronic version of this Extraction Plan on the Metropolitan Coal local area network. Metropolitan Coal will not be responsible for maintaining uncontrolled copies beyond ensuring the most recent version is maintained on Metropolitan Coal's computer system and the Peabody website.

6.4 KEY RESPONSIBILITIES

Key responsibilities under this Extraction Plan are summarised in Table 19. The component management plans provide additional responsibilities under the plans.

Table 19
Key Extraction Plan Responsibilities

Responsibility	Task
General Manager	• Ensure resources are available to Metropolitan Coal personnel to facilitate the completion of responsibilities under this Extraction Plan. • Ensure the safety of Metropolitan Coal employees and the public in relation to Metropolitan Coal operations. • Approve and instruct implementation of remediation/corrective action/compensation, if necessary.
Mining Engineering Manager	• Ensure the safety of Metropolitan Coal employees and the public in relation to Metropolitan Coal operations through oversight of mining activities conducted in accordance with the Safety Management System. • Ensure adequate resources are available for implementation of remediation/corrective actions.
Technical Services Manager	• Liaise with relevant stakeholders regarding environmental management. • Ensure monitoring and reporting required in accordance with this Extraction Plan are carried out within specified timeframes, are adequately checked and processed and are prepared to the required standard. • Ensure that any Incident Reports are lodged in a timely manner with all available information. • Ensure that reviews of the strategies, plans and programs are conducted as described in Sections 6.1 and 6.2. • Liaise with relevant stakeholders regarding subsidence impact management and related public safety hazards.
Environment & Community Superintendent	• Liaise with relevant stakeholders regarding environmental management. • Ensure monitoring and reporting required in accordance with this Extraction Plan are carried out within specified timeframes, are adequately checked and processed and are prepared to the required standard. • Ensure that any Incident Reports are lodged in a timely manner with all available information. • Ensure that reviews of the strategies, plans and programs are conducted as described in Sections 6.1 and 6.2.
Registered Mine Surveyor	• Undertake all subsidence monitoring to the required standard within the specified timeframes and ensure data is adequately checked, processed and recorded.

7 REFERENCES

Department of Planning and Environment (2022) *Extraction Plan Guideline*.

Golder Associates Pty Ltd (2020) *2020 EX02 Summary Report*.

Hebblewhite, B., Kalf, F. and McMahon T. (2017) *Woronora Reservoir Strategy Report – Stage 1 Report - Metropolitan Coal – Longwall mining near and beneath Woronora Reservoir.*

Hebblewhite, B., Kalf, F. and McMahon T. (2019) *Woronora Reservoir Strategy Report – Stage 2 Report - Metropolitan Coal – Longwall mining near and beneath Woronora Reservoir.*

Helensburgh Coal Pty Ltd (2008) *Metropolitan Coal Project Environmental Assessment.*

Helensburgh Coal Pty Ltd (2009) *Metropolitan Coal Project Preferred Project Report.*

Independent Expert Advisory Panel for Mining (2023) *Metropolitan Coal Mine: High Level Review – Large swamp environmental assessment requirements for the Extraction Plan for Longwalls 311-316.*

Independent Expert Advisory Panel for Mining (2024) *Metropolitan Coal Mine: Stage 1: Longwalls 311-312.*

Independent Expert Panel for Mining in the Catchment (2018) *Initial Report on Specific Mining Activities at the Metropolitan and Dendrobium Coal Mines.* 12 November 2018.

Mine Subsidence Engineering Consultants (2024) *Metropolitan Coal Mine – Longwalls 312 Modified Finishing End Mine Subsidence Overview (MSEC Report 1141-100 Revision A).*

Metropolitan Collieries Pty Ltd (2024) *Longwalls 311-316 Large Swamp Assessment.*

Risk Mentor (2021) *Metropolitan Coal Longwalls 308-310 Subsidence Environmental Risk Assessment Report.*

Risk Mentor (2023) *Metropolitan Collieries Pty Ltd – Longwalls 311-316 Environmental Risk Assessment Report.*

SP Solutions (2008) *Metropolitan Coal Project Environmental Risk Analysis*. Appendix O in the Helensburgh Coal Pty Ltd (2008) *Metropolitan Coal Project Environmental Assessment*.

Velscis (2018) *Metropolitan 2D repro. Processing and Interpretation report*.

ATTACHMENT 1

STATUTORY REQUIREMENTS

METROPOLITAN COAL LONGWALLS 311-316

EXTRACTION PLAN

ATTACHMENT 1

STATUTORY REQUIREMENTS

Peabody

ATTACHMENT 1
STATUTORY REQUIREMENTS

This Attachment outlines relevant statutory requirements within Project Approval (08_0149) and provides the relevant section of the Metropolitan Coal Longwalls 311-316 Extraction Plan where the requirements are addressed.

Table A1-1
Project Approval (08_0149) Requirements

Condition Number (Schedule 3)	Condition		Document Reference/Comment
Performance Measures			
1.	The Proponent shall ensure that the project does not cause any exceedances of the performance measures in Table 1.		
	Table 1: Subsidence Impact Performance Measures		
	Water Resources		
	Catchment yield to the Woronora Reservoir	Negligible reduction to the quality or quantity of water resources reaching the Woronora Reservoir No connective cracking between the surface and the mine	Section 4.2.1 and Appendix A (Water Management Plan)
	Woronora Reservoir	Negligible leakage from the Woronora Reservoir Negligible reduction in the water quality of Woronora Reservoir	
	Watercourses		
	Waratah Rivulet between the full supply level of the Woronora Reservoir and the maingate of Longwall 23 (upstream of Pool P).	Negligible environmental consequences (that is, no diversion of flows, no change in the natural drainage behaviour of pools, minimal iron staining, and minimal gas releases)	Section 4.2.1 and Appendix A (Water Management Plan)
	Eastern Tributary between the full supply level of the Woronora Reservoir and the maingate of Longwall 26	Negligible environmental consequences over at least 70% of the stream length (that is no diversion of flows, no change in the natural drainage behaviour of pools, minimal iron staining and minimal gas releases)	
	Biodiversity		
	Threatened species, populations, or ecological communities	Negligible impact	Section 4.2.3 and Appendix C (Biodiversity Management Plan)
	Swamps 76, 77 and 92	Set through condition 4 below	

Table A1-1 (Continued)
Project Approval (08_0149) Requirements

Condition Number (Schedule 3)	Condition		Document Reference/Comment
1 (cont.).	*Table 1: Subsidence Impact Performance Measures (Continued)*		
	Land		
	Cliffs	Less than 3% of the total length of cliffs (and associated overhangs) within the mining area experience mining-induced rock fall	Section 4.2.2 and Appendix B (Land Management Plan)
	Heritage		
	Aboriginal heritage sites	Less than 10% of Aboriginal heritage sites within the mining area are affected by subsidence impacts	Section 4.2.4 and Appendix D (Heritage Management Plan)
	Items of historical or heritage significance at the Garrawarra Centre	Negligible damage (that is fine or hairline cracks that do not require repair), unless the owner of the item and the appropriate heritage authority agree otherwise in writing	
	Built Features		
	Built features	Safe, serviceable and repairable, unless the owner and the MSB agree otherwise in writing	Section 4.2.5
	Note: The proponent will be required to define more detailed performance indicators for each of these performance measures in the various management plans that are required under this approval (see condition 6 below).		

Table A1-1 (Continued)
Project Approval (08_0149) Requirements

Condition Number (Schedule 3)	Condition	Document Reference/Comment
Extraction Plan		
4.	The Proponent shall not undermine Swamps 76, 77 and 92 without the written approval of the Director-General. In seeking this approval, the Proponent shall submit the following information with the relevant Extraction Plan (see condition 6 below): (a) a comprehensive environmental assessment of the: • potential subsidence impacts and environmental consequences of the proposed Extraction Plan; • potential risks of adverse environmental consequences; and • options for managing these risks; (b) a description of the proposed performance measures and indicators for these swamps; and (c) a description of the measures that would be implemented to manage the potential environmental consequences of the Extraction Plan on these swamps (to be included in the Biodiversity Management Plan – see condition 6(f) below), and comply with the proposed performance measures and indicators.	Large Swamps Assessment (Metropolitan Coal, 2024)

Table A1-1 (Continued)
Project Approval (08_0149) Requirements

Condition Number (Schedule 3)	Condition	Document Reference/Comment
Extraction Plan		
6.	The Proponent shall prepare and implement an Extraction Plan for all second workings in the mining area to the satisfaction of the Director-General. The plan must:	
	(a) be prepared by a team of suitably qualified and experienced experts whose appointment has been endorsed by the Director-General[1];	Section 2.1 and Attachment 3
	(b) be approved by the Director-General before the Proponent is allowed to carry out the second workings covered by the Extraction Plan;	This Application
	(c) include a detailed plan for the second workings, which has been prepared to the satisfaction of DRE, and provides for adaptive management (from Longwall 23 onwards);	Section 1.3 and Appendix G (Coal Resource Recovery Plan)
	(d) include detailed plans of any associated surface construction works;	N/A
	(e) include the following to the satisfaction of DRE[2]:	
	• a coal resource recovery plan that demonstrates effective recovery of the available resource;	Appendix G (Coal Resource Recovery Plan)
	• revised predictions of the conventional and non-conventional subsidence effects and subsidence impacts of the extraction plan, incorporating any relevant information that has been obtained since this approval; and	Appendix H (Subsidence Report)
	• a Subsidence Monitoring Program to: – validate the subsidence predictions; and – analyse the relationship between the subsidence effects and subsidence impacts of the Extraction Plan and any ensuing environmental consequences;	Section 4.1 and Appendix F (Subsidence Monitoring Program)

1 The Director-General of the DP&E is now the Secretary of the Department of Planning and Environment (DPE).

2 The Division of Resources and Energy (DRE) is now the Resources Regulator.

Table A1-1 (Continued)
Project Approval (08_0149) Requirements

Condition Number (Schedule 3)	Condition	Document Reference/Comment
Extraction Plan (Continued)		
6 (cont.).	(f) include a;	
	• Water Management Plan, which has been prepared in consultation with OEH, SCA[3] and NOW[4], to manage the environmental consequences of the Extraction Plan on watercourses (including the Woronora Reservoir), aquifers and catchment yield;	Section 2.4, Section 4.2.1 and Appendix A (Water Management Plan).
	• Biodiversity Management Plan, which has been prepared in consultation with OEH and DPI (Fisheries)[5], to manage the potential environmental consequences of the Extraction Plan on aquatic and terrestrial flora and fauna, with a specific focus on swamps;	Section 2.4, Section 4.2.3 and Appendix C (Biodiversity Management Plan).
	• Land Management Plan, which has been prepared in consultation with SCA, to manage the potential environmental consequences of the Extraction Plan on cliffs, overhangs, steep slopes and land in general;	Section 2.4, Section 4.2.2 and Appendix B (Land Management Plan).
	• Heritage Management Plan, which has been prepared in consultation with the OEH and the relevant Aboriginal groups, to manage the potential environmental consequences of the Extraction Plan on heritage sites or values;	Section 2.4, Section 4.2.4 and Appendix D (Heritage Management Plan).
	• Built Features Management Plan, which has been prepared in consultation with the owner of the relevant feature, to manage the potential environmental consequences of the Extraction Plan on any built features; and	Section 2.4 and Section 4.2.5
	(g) include a Public Safety Management Plan, which has been prepared in consultation with DRE[2] and the DSC (for any Mining within the DSC notification area), to ensure public safety in the mining area.	Section 2.4, Section 4.2.6 and Appendix E (Public Safety Management Plan).
	Note: In accordance with condition 12 of schedule 2, the preparation and implementation of Extraction Plans for second workings may be staged, with each plan covering a defined area of second workings. In addition, these plans are only required to contain management plans that are relevant to the specific second workings that are being carried out.	

[3] The Sydney Catchment Authority (SCA) is now WaterNSW.

[4] The NSW Office of Water (NOW) is now the Department of Planning, Industry and Environment – Water (DPIE – Water).

[5] DRE (Fisheries) is now the Department of Primary Industries – Fisheries (DPI – Fisheries).

[6] Dams Safety Committee (DSC) is now Dams Safety NSW.

Table A1-1 (Continued)
Project Approval (08_0149) Requirements

Condition Number (Schedule 3)	Condition	Document Reference/Comment
Extraction Plan (Continued)		
7.	In addition to standard requirements for management plans (see condition 2 of schedule 7), the Proponent shall ensure that the management plans required under condition 6(f) above include:	
	(a) a program to collect sufficient baseline data for future Extraction Plans;	Appendices A to E and Attachment 2
	(b) a revised assessment of the potential environmental consequences of the Extraction Plan, incorporating any relevant information that has been obtained since this approval;	Section 3.1 and Appendices A to E
	(c) a detailed description of the measures that would be implemented to remediate predicted impacts; and	Section 4 and Appendices A to E
	(d) a contingency plan that expressly provides for adaptive management.	Section 5.1 and Appendices A to E
Condition Number (Schedule 7)	**Condition**	**Document Reference/Comment**
Management Plan Requirements		
2.	The Proponent shall ensure that the management plans required under this approval are prepared in accordance with any relevant guidelines, and include:	
	(a) detailed baseline data;	Appendices A to E
	(b) a description of:	
	• the relevant statutory requirements (including and relevant approval, licence or lease conditions);	Section 2.1.1, Appendices A to E and Attachment 1
	• any relevant limits or performances measures/criteria;	Section 3, Section 4 and Appendices A to E
	• 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 and Appendices A to E
	(c) a description of the measures that would be implemented to comply with the relevant statutory requirements, limits, or performances measures/criteria;	Section 4 and Appendices A to E
	(d) a program to monitor and report on the:	Section 4.2, Section 5.2 and Appendices A to F
	• impacts and environmental performance of the project;	
	• effectiveness of any management measures (see c above);	

Table A1-1 (Continued)
Project Approval (08_0149) Requirements

Condition Number (Schedule 7)	Condition	Document Reference/Comment
Management Plan Requirements (Continued)		
2. (Cont.)	(e) a contingency plan to manage any unpredicted impacts and their consequences;	Section 5.1.2 and Appendices A to E
	(f) a program to investigate and implement ways to improve the environmental performance of the project over time;	Sections 5.1 and 6 and Appendices A to E
	(g) a protocol for managing and reporting any: • incidents; • complaints; • non-compliances with statutory requirements; and • exceedances of the impact assessment criteria; and/or performance criteria and	Sections 6 and Appendices A to E
	(h) a protocol for review of the plan.	Sections 6.1 and 6.2 and Appendices A to G

ATTACHMENT 2

PROGRAM TO COLLECT BASELINE DATA FOR FUTURE EXTRACTION PLANS

METROPOLITAN COAL LONGWALLS 311-316

EXTRACTION PLAN




ATTACHMENT 2

PROGRAM TO COLLECT BASELINE DATA FOR FUTURE EXTRACTION PLANS

Peabody

ATTACHMENT 2
PROGRAM TO COLLECT BASELINE DATA FOR FUTURE EXTRACTION PLANS

Longwalls 311-316 (the subject of this Extraction Plan) are the eleventh, twelfth, thirteenth, fourteenth, fifteenth and sixteenth longwalls within the 300 longwall series. Longwall 317 is located to the west of Longwall 316.

In accordance with Condition 7, Schedule 3 of the Project Approval (08_0149), Metropolitan Coal is required to collect baseline data for the next Extraction Plan. However, the currently approved Longwall 317 is too short to economically mine and, therefore, Metropolitan Coal is seeking to modify Project Approval (08_0149) to extend Longwall 317 and add a new Longwall 318. Metropolitan Coal will collect baseline data for upland swamps, riparian vegetation, slopes and ridgetops, aquatic biota and their habitats, and terrestrial fauna and their habitats as part of the Modification process to inform the impact assessment and for use in future Extraction Plans.

ATTACHMENT 3

RELEVANT CONSULTATION RECORDS

METROPOLITAN COAL LONGWALLS 311-316

EXTRACTION PLAN




ATTACHMENT 3

RELEVANT CONSULTATION RECORDS

Peabody

Department of Planning and Environment

NSW GOVERNMENT

Our ref: MP 08_0149-PA-89

Mr Jon Degotardi
Manager – Project Approvals
Metropolitan Colleries Pty Ltd
PO Box 402
Helensburgh NSW 2508

31 July 2023

Subject: Appointment of Experts – Extraction Plan for Longwalls 311 to 316

Dear Mr Degotardi

I refer to your request dated 21 July 2023 for the Planning Secretary's approval of the following experts to prepare the Extraction Plan for Longwalls 311 to 316 under Condition 6, Schedule 3 of MP 08_0149.

The Department has reviewed the information you have provided and is satisfied that nominated experts are suitably qualified and experienced.

Accordingly, I can advise that the Planning Secretary approves the following experts to prepare the Extraction Plan for Longwalls 311 to 316:

- Mr Peter DeBono of Mine Subsidence Engineering Consultants - Subsidence;
- Ms Ines Epari of SLR Consulting - Groundwater;
- Mr Anthony Marszalek and Dr Camilla West of ATC Williams – Surface Water;
- Associate Professor Barry Noller of The University of Queensland – Water quality;
- Ms Elizabeth Norris of Ecoplanning – Flora ecology;
- Dr Sharon Cummins of Bio-Analysis Pty Ltd – Fauna ecology
- Mr Jamie Reeves of Niche Environment and Heritage – Aboriginal Cultural Heritage;
- Mr Jamie Warwick of Resource Strategies – Environmental Planning

If you wish to discuss the matter further, please contact Melanie Hollis on 8217 2043.

Yours sincerely

Gabrielle Allan
A/Director Energy and Resource Asessments

As nominee of the Planning Secretary

INDEPENDENT EXPERT ADVISORY PANEL FOR MINING

ADVICE RE:

REPORT TITLED:

Metropolitan Coal Mine:

Independent review of environmental performance to 2022

(Dupen, 2023)

September 2023

Report No: IEAPM 202309-2

EXECUTIVE SUMMARY

In March 2023, a report titled *'Metropolitan Coal Mine – independent review of environmental performance to 2022'* was prepared by consulting company H2onestly Pty Ltd on behalf of the Nature Conservation Council of NSW (NCC), a community-based organisation. The author of the report is Mr Peter Dupen and it is referred to as the 'Dupen Report' in this Executive Summary.

The Dupen Report is founded on the hypothesis by its author that higher than expected flows measured during 2020 in the Eastern Tributary, which feeds Woronora Reservoir, can be attributed to surface flows and shallow groundwater being widely diverted and drained as a result of mining-induced fracturing on each side of and beneath the valley hosting the Eastern Tributary. This fracturing is hypothesised to comprise an interconnected network of sub-vertical surface fractures and sub-horizontal bedding plane shears that Dupen refers to as a *new subsidence mechanism.* He associates this mechanism, which he has termed *'ridge fracture drainage'*, with the *unexpected and unpredicted formation of large-scale shear planes opening up* at the base of aquifers. This forms the basis for Dupen's conclusions that:

- *The aquifers which sit above and feed the incised valley streams are draining at rates measurably higher than pre-mining, in places rapidly and completely, due to unexpected and unpredicted formation of large-scale shear planes opening up at their base.*

- *If this new subsidence mechanism is indeed widespread, a likely outcome is that a range of protected Special Area ecosystems overlying the mine will dry and change. The other major risk from widespread basal shear formation is that it will cause the water quality in the Woronora drinking water reservoir to become increasingly degraded by metal-laden discharges from unmeasured shear plane vents.*

In May 2023, the NSW Department of Planning and Environment (DPE) requested the following advice from the Independent Expert Advisory Panel for Mining (IEAPM) in relation to the Dupen Report.

- *Identify and comment on the elements of the Report that are relevant to the operation and environmental performance of Metropolitan Coal;*
- *Provide advice as to what actions or further investigations would be required to test or confirm the hypothesis put forward in the Report; and*
- *Any other significant advice that the Panel may wish to provide concerning this issue.*

The Panel overlapped with another IEAPM Panel established to provide DPE with a range of advice relating to water quality performance measures for Woronora Reservoir specified in Consent Conditions for Metropolitan Coal Mine. Matters of significance raised in the Dupen Report in relation to potential mining impacts on water quality fall within the brief of the other Panel and the reader is referred to the advice of that Panel (IEAPM**,** 2023).

The nature of the structure and content of the Dupen Report results in a range of conclusions and recommendations being developed progressively throughout the Panel's advice report. The reader is referred to these for further insight into the following summary advice:

Identify and comment on the elements of the Report that are relevant to the operation and environmental performance of Metropolitan Coal

Subsidence Focussed

1. The two basic mining-induced elements that constitute Dupen's hypothesised *ridge fracture drainage* model are sub-vertical surface fractures and sub-horizontal bedding plane shears. Both elements are well established in subsidence engineering and, individually and collectively, have been the subject of a number of detailed subsidence and hydrogeological studies in the Southern Coalfield over recent decades for the purpose of detecting and monitoring their formation, including at the Eastern Tributary. Hence, ridge fracture drainage cannot be considered a *new subsidence mechanism.*
2. If the Dupen hypothesis concerning surface flows and shallow groundwater being widely diverted and drained as a result of mining-induced fracturing is validated then ridge fracture drainage could, arguably, be considered to be a *new subsidence consequence*. This depends on the spatial scale and the magnitude and distribution of shear displacement on what Dupen refers to as *large scale shear planes opening up at their base,* in comparison to documented past experience. The term *large scale* is not defined in the Dupen Report.
3. The Dupen Report does not provide sufficient evidence to cause the Panel to believe that the scale of bedding plane shears in the vicinity of the Eastern Tributary might be materially different to that of other shear planes detected and studied in the Southern Coalfield.
4. Due to the low values of predicted incremental valley closures during the 300 series of longwalls, it is unlikely that ground movements were significant enough to increase the hydraulic conductivity of shear planes in the Eastern Tributary during the period of flow anomalies.

Groundwater Focussed

5. Perched water in swamp colluvium and very shallow weathered Hawkesbury Sandstone is hydraulically disconnected from the deeper regional groundwater systems and will not drain unless near surface fracturing intersects these features. There is no clear evidence of drainage of these shallow groundwater systems in the available monitoring records.
6. There is no evidence from Metropolitan Coal's groundwater monitoring network (except at the transect bore locations overlying LW305 and LW306) that water levels in the Hawkesbury Sandstone aquifers across the Eastern Tributary catchment have fallen and desaturated the ridgelines. In fact, most monitored regional water table levels have stabilised or risen in recent years.
7. Alternative explanations of the increased surface flows at the Eastern Tributary gauging station observed since August 2020 (which corresponds with the commencement of an above average rainfall period) include:
    i. underflow that previously discharged to Woronora Reservoir downstream of the Eastern Tributary gauging station is now reporting as surface water flow upstream of the gauging station; and

ii. larger volumes of (natural) interflow and regional groundwater are discharging and contributing to surface water flows across the whole catchment.

8. Increased groundwater discharge is potentially consistent with the Dupen hypothesis of sub-vertical fractures and shears with enhanced hydraulic connection connecting regional groundwater to the Eastern Tributary. However, there is no widespread evidence of a reduction in water levels or groundwater storage volumes across the catchment in the Hawkesbury Sandstone aquifer, which is contrary to the Dupen hypothesis.
9. Beneath ridgelines and hillslopes, the absence of permanent springs and any obvious perched groundwater (apart from in the vicinity of swamps) suggests most rainfall recharge (apart from that portion that is lost to evapo-transpiration and via interflow after rain) drains vertically to the regional water table and then moves laterally to emerge in the base of the valleys as baseflow.
10. The shallow perched water table in colluvium and underlying/adjacent weathered sandstone supports upland swamps. The upland swamps will not drain and will not be impacted unless near surface fracturing intersects and drains these features.
11. The regional water table occurs at depth beneath the ridgelines, and naturally discharges to permanent streams. Regional groundwater does not discharge at elevated sites and does not support ridgeline and hillside terrestrial ecosystems, however it may contribute to some riparian communities.

Surface Water Focussed

12. Metropolitan Coal (through consultants) has undertaken a detailed analysis of potential reasons for the Eastern Tributary flow anomalies that Dupen uses to support the ridge fracture drainage hypothesis. The Panel agrees with main conclusions and recommendations from that analysis, being:
    i. There are serious errors in the flow data used by Dupen but this is not the reason for the anomalies. To address these errors the rating curve for the Eastern Tributary should be extended to improve high flow measurement accuracy.
    ii. The flow anomalies are unlikely to be due to subsidence movements of the flume.
    iii. The controlled burn conducted from September 2021 to March 2022 in the Eastern Tributary catchment has likely contributed but, by itself, is unlikely to fully explain the flow anomalies.
    iv. The flow anomalies may be related to mining-induced increases in the hydraulic conductivity of the creek bed.
13. Additional to the considerations in the consultant's analysis, the Panel concludes that:
    i. While blockage of the flume by debris is another potential reason for the flow anomalies, regular inspection and clearance of the flume makes this unlikely.
    ii. Errors in the rainfall-runoff modelling may also contribute to flow anomalies, including non-linearity in the groundwater storage-discharge relation and non-stationarity in hydrological processes related to drought. This has not been assessed by Metropolitan Coal.
14. Contrary to the observation by Dupen that "*Since 2017, the previously permanent Pools ETAG to ETAR have been dry except for short periods following major rainfall events*", these pools were generally flowing during 2017-2022 except during prolonged dry weather.

15. The reason for the Eastern Tributary flow anomalies remains unknown, and the Dupen hypothesis cannot be discounted based on the flow data.
16. The status of the pools and whether remediation improves the status of the pools, while important for assessing the environmental performance of the mine, will not be a decisive factor regarding the Dupen hypothesis.

Overarching Conclusions

17. Previous studies and investigations have been undertaken of basal shears and the magnitude of associated impacts on the groundwater system and these do not provide evidence supporting major impacts of the style and magnitude suggested in the Dupen Report.
18. The evidence that Dupen has used for the development of his hypothesis is limited (as acknowledged by Dupen) and incomplete and additional evidence sourced by the Panel confirms that this data contained errors, in some cases of a serious nature.
19. A wider assessment of the groundwater data, including more recent data than that available to Dupen, has not provided evidence of the widespread dewatering of the regional groundwater system predicted by Dupen's hypothesis.
20. Dupen's interpretation of the impacts of changing groundwater baseflow contributions to Woronora Reservoir arising from his hypothesis is also not consistent with enhanced basal shears and the dewatering of the Hawkesbury Sandstone aquifer beneath the ridgelines.
21. Consideration by the Panel of a wider set of data indicates that the inferences made by Dupen about the scale of impacts unfolding on the regional ecology and the Woronora reservoir are likely overstated. For this reason, the Panel does not support the Dupen Report's primary recommendation *"that further undermining of the Woronora Reservoir should be halted until the implications of these unexpected changes now unfolding in Woronora Reservoir Catchment can be urgently evaluated"*.
22. Even though the scale of impacts suggested by Dupen are not expected by the Panel to be as large as Dupen predicts, the Panel accepts that components of Dupen's hypothesis should be evaluated through new data collection and further interpretation to build confidence in Metropolitan Coal's assessment of the long-term impacts of mining under the catchment.
23. If the drainage mechanism hypothesised by Dupen has merit, it should be able to be validated by field experience at other sites above mine workings at Metropolitan Coal Mine and at other mines operating in similar topography in the Southern and Western Coalfields of NSW.

Provide advice as to what actions or further investigations would be required to test or confirm the hypothesis put forward in the Report

The Panel recommends (from a groundwater perspective) that:

1. Additional bores (standpipes) be established at the T5 monitoring location to monitor the vertical piezometry in the Hawkesbury Sandstone and to establish whether extensive basal shears occur at depth below this eastern ridgeline area.
2. Additional bores (standpipes) be established at the T6 monitoring location and at other accessible locations overlying the proposed LW311 to LW316 panels as soon as

practicable to monitor the natural vertical piezometry in the Hawkesbury Sandstone below this western ridgeline area.

The Panel recommends (from a surface water perspective):

3. Extension of the Eastern Tributary flow gauge rating curve as recommended by Metropolitan Coal's consultant (HEC, 2022); also spot measurements of flow covering flow rates as high as safely practicable; and urgent repair of the weir. Revised rating curves and the spot measurements of flow should be published in annual reports.
4. Re-analysis of the flow data including the most recent data. This analysis should be of the nature of HEC (2022) but also consider the possibility of increased flows being related to high groundwater or reservoir levels or errors in the modified AWBM model (Australian Water Balance Model).
5. Further reporting of the modelling in annual report appendices should contain details of the modified AWBM model and parameter values needed to allow independent assessment.
6. If it is concluded after review and extension of the rating curve and analysis using the most recent flow data that baseflows may have substantially increased due to subsidence effects, further investigation should be undertaken regarding the source of the increased baseflow and its significance for aquatic ecology and water quality entering the Woronora Reservoir.
7. Metropolitan Coal's 2023 Annual Report should provide information on the success of the Eastern Tributary remediation program.

Any other significant advice that the Panel may wish to provide concerning this issue

1. The Panel recommends for the purpose of developing a better understanding of valley closure impacts to inform mine design that, if it has not already done so, Metropolitan Coal undertakes and makes available to the Department, an investigation of mining impacts on the Eastern Tributary that includes an evaluation of:
   i. How predicted valley closure developed incrementally along the Eastern Tributary.
   ii. How well incremental and total predicted valley closure correlated with measured incremental and total measured closure.
   iii. The nature and extent of natural and mining-induced fracturing to a depth of at least 20 m along the Eastern Tributary downstream from the maingate of LW26 to the Full Supply Level (FSL) of Woronora Reservoir (noting that some of these investigations may have already been undertaken).
   iv. How well mining-induced environmental impacts along the Eastern Tributary correlate to both predicted valley closure and to measured valley closure.
   v. The hydraulic characterisation of the fracture system and the underflows that are taking place along that portion of the Eastern Tributary between the maingate of LW26 and the Eastern Tributary gauging station. This could include establishing new shallow groundwater bores in a longitudinal section to assist in better assessing long term water level and water quality behaviour.

TABLE OF CONTENTS

1.0 INTRODUCTION

In March 2023, a report titled *'Metropolitan Coal Mine – independent review of environmental performance to 2022'* was prepared by consulting company H2onestly Pty Ltd on behalf of the Nature Conservation Council of NSW (NCC), a community-based organisation. The author of the report was Mr Peter Dupen and, henceforth, that report is referred to as the 'Dupen Report' and referenced as Dupen (2023).

The Dupen Report is founded on the hypothesis by its author that higher than expected flows recently measured during 2020 in the Eastern Tributary, which feeds Woronora Reservoir, may be attributed to surface flows and shallow groundwater being widely diverted and drained through shear zones and fractures at the base of valleys because of a previously unidentified subsidence mechanism. Dupen refers to this new mechanism as *'ridge fracture drainage'*. Dupen is of the view that:

- *The aquifers which sit above and feed the incised valley streams are draining at rates measurably higher than pre-mining, in places rapidly and completely, due to unexpected and unpredicted formation of large-scale shear planes opening up at their base.*

- *If this new subsidence mechanism is indeed widespread, a likely outcome is that a range of protected Special Area ecosystems overlying the mine will dry and change. The other major risk from widespread basal shear formation is that it will cause the water quality in the Woronora drinking water reservoir to become increasingly degraded by metal-laden discharges from unmeasured shear plane vents.*

On 16 May 2023, the NSW Department of Planning and Environment (DPE) requested the following advice from the Independent Expert Advisory Panel for Mining (IEAPM) in relation to the Dupen Report.

- *Identify and comment on the elements of the Report that are relevant to the operation and environmental performance of Metropolitan Coal;*
- *Provide advice as to what actions or further investigations would be required to test or confirm the hypothesis put forward in the Report; and*
- *Any other significant advice that the Panel may wish to provide concerning this issue.*

The Chair of the IEAPM (Em. Professor Jim Galvin) convened the following Panel to prepare the advice:

- Em. Professor Jim Galvin – Chair – Subsidence and Mining
- Professor Neil McIntyre – Surface Water
- Mr John Ross – Groundwater
- Em. Professor Rae Mackay – Groundwater

All four Panel members have experience in the Southern Coalfield that is relevant to addressing DPE's brief.

The Panel overlapped with another IEAPM Panel established to provide DPE with a range of advice relating to water quality performance measures for Woronora Reservoir specified in Consent Conditions for Metropolitan Coal Mine. Matters of significance raised in the Dupen Report in relation to potential mining impacts on water quality fall within the brief of this other Panel and the reader is referred to the advice of that Panel (IEAPM, 2023).

The topics of mining subsidence and associated impacts and consequences for water resources in the Southern Coalfield are complex and have been the subject of many studies over the last 50 years. To assist the non-technical specialist in understanding the hypotheses and propositions put forward in the Dupen Report and the Panel's assessment of them, this current advice report is structured around first providing a summary of Dupen's hypotheses and associated concerns (Section 3.0), followed by a summary of the evolution of the local knowledge base and some relevant foundation principles relating to mining impacts on groundwater and surface water at Metropolitan Coal Mine (Section 4.0). A detailed critique of the Dupen Report is then presented in Section 5.0, which forms the basis of the Panel's advice in Section 6.0.

2.0 METHOD OF OPERATION

The Panel convened by videoconference during the preparation of its advice and was administratively supported by Secretariat staff provided by the DPE's Major Projects and Resource Assessments teams.

A wide range of documents was provided through DPE to support the Panel in preparing this advice. The principal documents are summarised in Table 1.

Table 1: Key documents reviewed by the Panel

Document Reference	Document Name
Documents provided by DPE	• DPE Request for Advice – Water Quality Performance Measures for Metropolitan Coal Mine – 6 April 2023 • Metropolitan Coal Consolidated Project Approval 08_0149 • Metropolitan Coal Mine – Independent review of environmental performance to 2022, Peter Dupen, March 2023
Additional documents provided by Metropolitan Coal	• Metropolitan Coal Review of Recorded Streamflow – Eastern Tributary, Hydro Engineering & Consulting, November 2022

2.1.1.Site Visit

On 10 May 2023, the Panel undertook a site inspection in the Woronora Catchment under the guidance of WaterNSW and in the company of DPE officers. It inspected the valley sides and valley floor area of the Eastern Tributary between Fire Trail 9J crossing and the Eastern Tributary Gauging Station (at the end of Fire Trail 9G), and the Flat Rock Crossing area of Waratah Rivulet.

2.1.2.Meetings

The Panel convened multiple times over the course of preparing its advice. The Department's Resource Assessments team was invited to several of these meetings on an as-needed basis. to provide technical briefings and updates to the Panel. Table 2 summarises in chronological order the schedule of formal meetings that involved the Panel. A number of meetings restricted to Panel members also took place.

Table 2: Schedule of formal meetings involving the Panel.

Meeting Date	Meeting Information
14 April 2023	Panel - DPE Briefing
10 May 2023	Site Visit
11 May 2023	Site Visit Debrief and meeting at DPE Offices

31 May 2023	Panel Meeting Discussion
14 June 2023	Panel Meeting Discussion
30 June 2023	Panel Meeting Discussion
18 August 2023	Panel Meeting Discussion
24 August 2023	Panel Meeting Discussion
1 September 2023	Panel Meeting Discussion

3.0 DUPEN HYPOTHESIS AND CONCERNS

3.1. LOCATION MAPS

Figure 1 is reproduced from the Dupen Report and shows the near east-west layout of longwall panels LW20 to LW27 (the '20 Series') in the lower section of the figure and the near north-south layout of LW301 to LW316 (the '300 Series') in the upper section of the figure. The 20 Series longwall panels are separated from the 300 Series by main development roadways. Extraction of LW309 commenced shortly before finalising this advice report. The Panel has added the blue text boxes in Figure 1 to identify Waratah Rivulet, Woronora Reservoir, and the point (X) marking the start of the downstream section of the Eastern Tributary that is the subject of a Performance Measure of particular relevance in this matter.

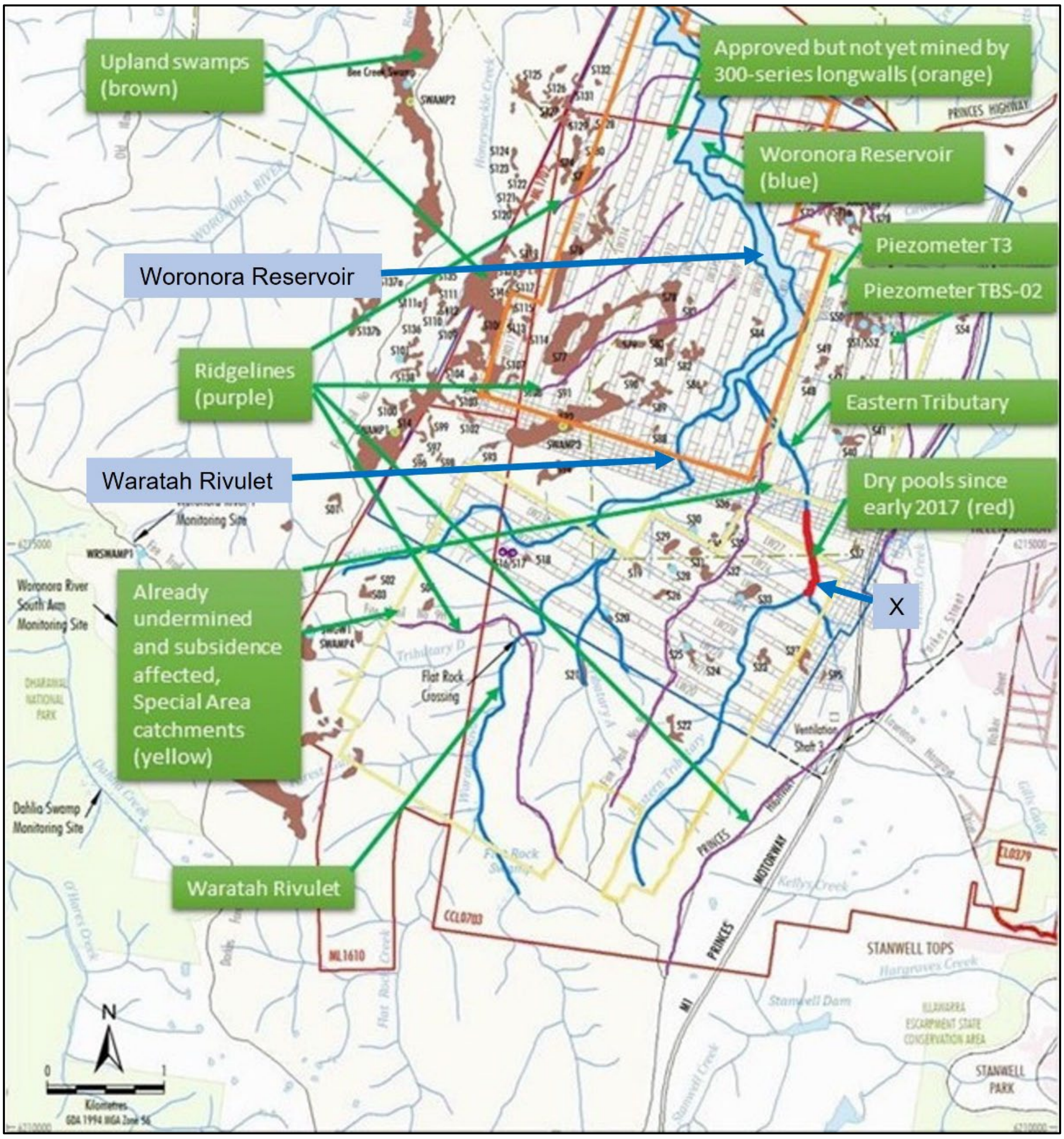


Figure 1: Reproduction of Figure 1 of the Dupen Report in which it is captioned as *Key features discussed in this report, annotated in green over base figure reproduced from Metropolitan Coal 2021 Annual Report,* with the blue text boxes being added by the Panel.

Figure 2 shows the naming and location of pools on Waratah Rivulet and the Eastern Tributary and surface water monitoring sites over Metropolitan Coal Mine. Note that rock bars WRS1 and WRS3 referred to in this Panel advice report control, respectively, Pools E and F on Waratah Rivulet.

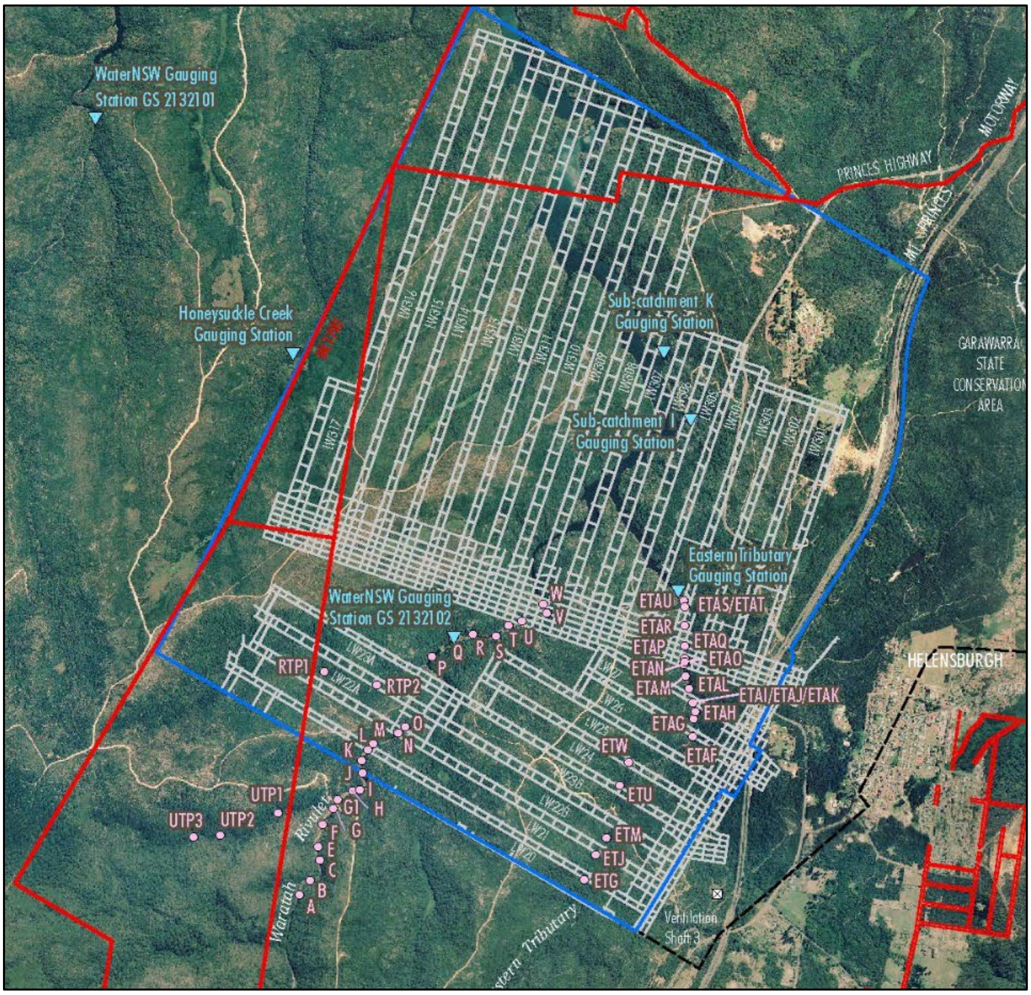


Figure 2: Plan showing the naming and location of rock pools on Waratah Rivulet and Eastern Tributary and surface water monitoring sites over Metropolitan Coal Mine. Note that rock bars WRS1 and WRS3 referred to in this Panel advice control, respectively, Pools E and F on Waratah Rivulet (extract from Figure 7 of Peabody, 2022b)

3.2. THE DUPEN HYPOTHESIS

The Dupen Hypothesis[1] has its primary basis in Figure 3, which is Chart 3 of the Metropolitan Coal 2021 Annual Review (Peabody, 2022b). Dupen has concluded on the basis of this chart that during the reporting period (1/1/21 to 31/12/21), flow in Eastern Tributary has been increasingly higher than model predictions [2].

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[1] Dupen invokes the term ‘hypotheses’ for addressing the evidence he believes supports his central hypothesis noted in Section 1.0 of this Panel Advice report. The Panel’s use of the term ‘hypothesis’ refers to Dupen’s central hypothesis.

[2] p19 of Dupen, 2023a

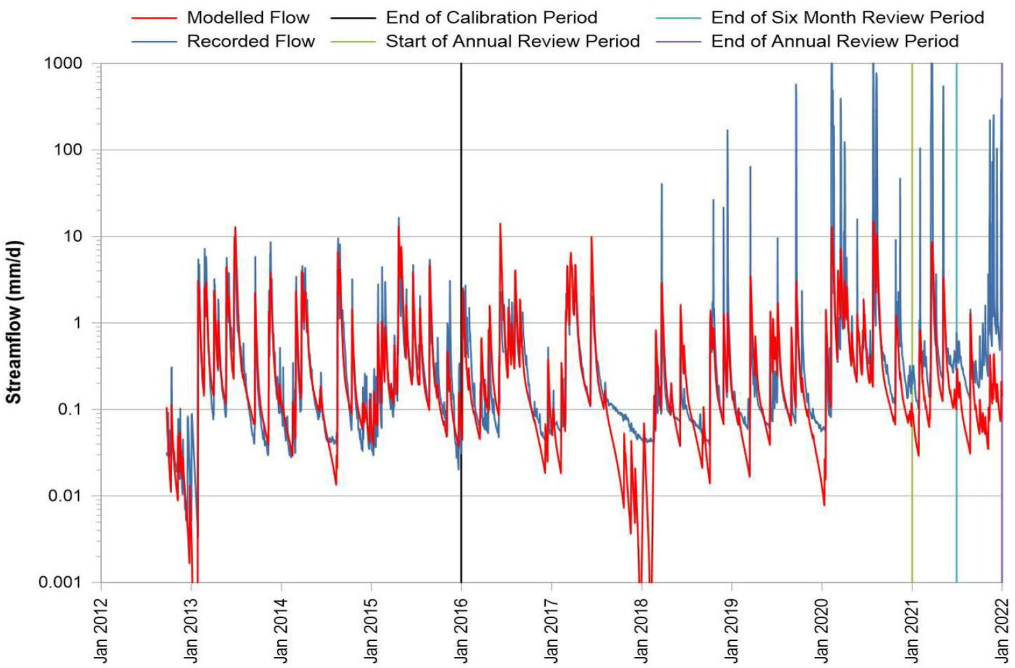

Figure 3: Reproduction of Figure 12 of Dupen Report where it is described as *monitored and model-predicted flows – Eastern Tributary upstream of Woronora Reservoir.* The figure is originally Chart 3 from Peabody (2022b). The y-axis scale (mm/day) is the flow volume rate in mm^3/day divided by the catchment area in mm^2. 1 mm/day = 67 L/s, equating to almost 5.8 ML/d.)

Dupen introduces other lines of evidence for his hypothesis. Of particular significance are the changes in piezometry observed in the transect boreholes T1 – T6, shown in Figure 4. The location of the transect can be identified from Figure 1 by the positioning of piezometer T3.

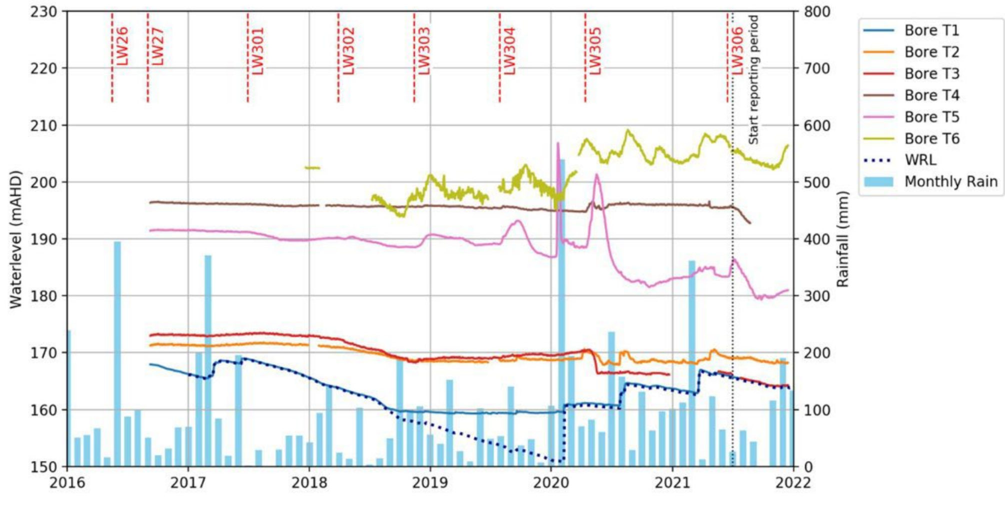

Chart 52 Groundwater Level in Bores T1 to T6

Figure 4: Piezometric data for Boreholes T1 to T6 extending from the reservoir along a transect approximately at right angles to the reservoir. (Reproduction of Figure 9 in the Dupen Report)[3]

A cross section showing the elevations of the Boreholes T1-T5 is shown in Figure 5 (Figure 2 in SLR, 2023a which is an updated version of Figure 8 in the Dupen Report)

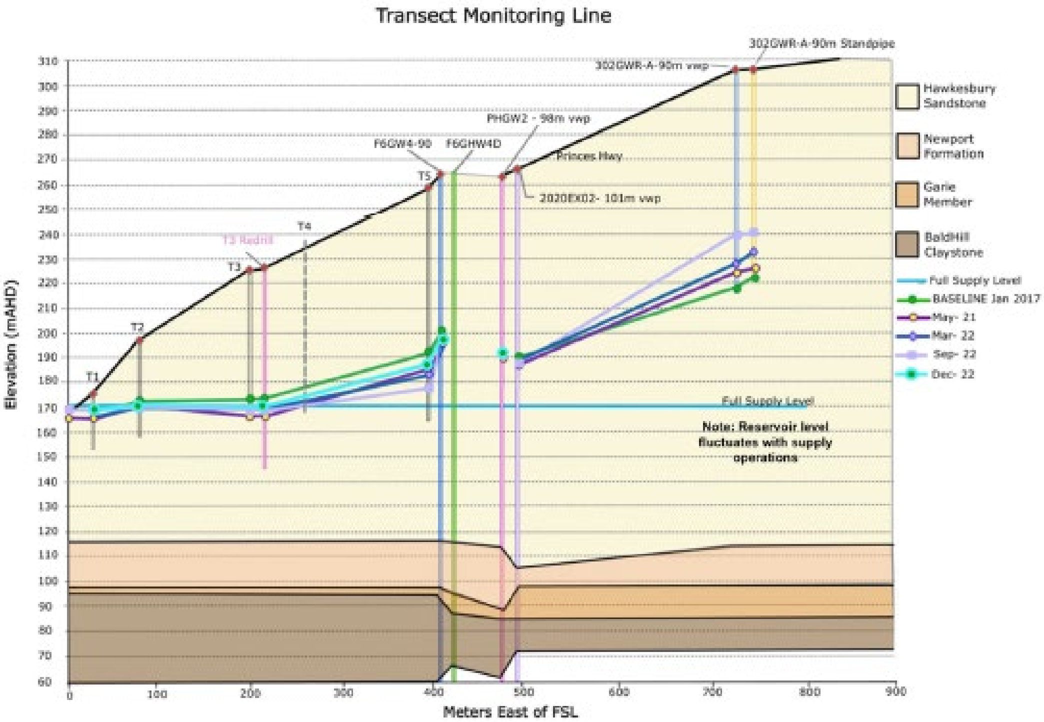

Figure 5: Cross section along the line of Boreholes T1 to T5 showing the elevation of the monitoring bores and the observed water levels at the end of 2022 (reproduction of Figure 2 in SLR, 2023a).

Based on the author's interpretation of the data, the Dupen Report states:

> *There are numerous concerning aspects of the post-mining groundwater conditions revealed by the transect piezometers. These include the long-term anomalously low water table in T5 (Figure 8 and Figure 9) and recent drops in T4 and T5 levels. Another surprising feature are the three large (+10 m) observed level surges in T5 between mid-2019 and mid-2020 (Figure 9), which are reasonably attributed by Peabody's consultants to pressure waves affecting the aquifer as the longwalls progress beneath. If present however, any pressure waves felt at T5 should intuitively have been observed at all of the nearby wells, especially the adjacent T4 piezometer (Figure 3). The reason for this contrast in pressure wave response through the*

[3] The actual water level in T1 during 2018 and 2019 when reservoir levels are low is not known. It would drop and not flatline as shown in this hydrograph

transect is not clear, but suggests a high degree of structural heterogeneity in the aquifer.

The most disturbing trend however, is that the levels in T3 dropped below its base 17 days after the commencement of Longwall 305 (Figure 3), and then sheared in December 2020 (Figure 9). The piezometer was replaced in 2021 by a deeper one at the same location (T3-R). As can be observed by the red trace in Figure 9, groundwater responses in T3/T3-R appeared sensible for its ridge position prior to mining but now the water table closely mimics the reservoir level.

Dupen is also of the view that a number of unpredicted mining-induced environmental consequences have appeared in the catchments, including:

The perennial Eastern Tributary has unexpectedly gone dry for a 500 m length since the end of 2016 as a result of undermining.[4]

This 500 m section of the Eastern Tributary is the section that has been marked in 'red' by Dupen in Figure 1.

Dupen offers what he describes as being *the only two hydrogeologically plausible hypotheses that I can think of which could account for the …behaviours in streamflow affected by subsidence.* The first of these, stated below, is reported by Dupen to be difficult to comprehend.

1. *The bedrock base of Eastern Tributary has been crushed by "non-conventional" subsidence effects (particularly the subsidence-induced valley closure mechanism) resulting in a relatively small (say 50-100 m in cross-section) "tunnel" of shallow fractures induced along and below the valley axis between Pools ETAG to ETAR. This conceptual model (summarised in Section 5.3.2) was the same one employed to explain the sub-surface diversion of flows in Waratah Rivulet, as well as WC21 and some other streams over the Dendrobium Mine nearby.*

   It is difficult to comprehend using this conceptual model however, how sub-surface flows through a 500 m long, poorly interconnected "crush zone" of compressive fractures can have mimicked above-ground catchment flow responses as closely as shown in Figure 12[5] *since the desiccation event in 2016/2017. I also struggle to identify a plausible mechanism for the increasing flows observed since about October 2021 using this conceptual model.*

The second conceptual model is Dupen's preferred explanation for the increased flow and is stated as:

2. *Whilst some non-conventional valley closure effects may well have contributed, the primary cause of flow diversion is the impositions of a mechanism termed here as "ridge fracture drainage" (Figure 4)*[6]*; the opening of widespread and interconnected basal shear planes beneath the base of the valley between Pools ETAG to ETAR*[7]*, combined with sub-vertical drainage along and below the ridge surfaces. If these subsidence effects are indeed substantial, ridge fracture*

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[4] ES1
[5] Reproduced in this advice report as Figure 3
[6] Reproduced in this advice report as Figure 6
[7] See Figure 2 of this advice report

drainage presents a risk to the catchments that has not previously been recognised, and the implications for future longwalls should be urgently re-considered.

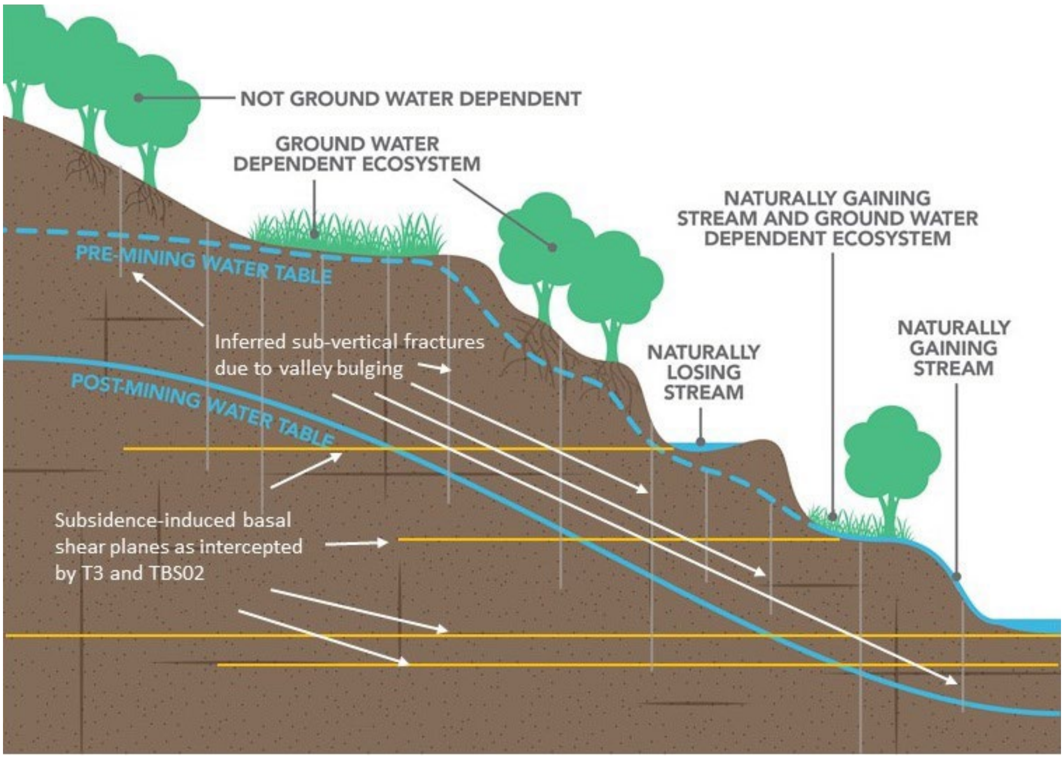

Figure 6. Reproduction of Figure 4 of the Dupen Report where it is described as *Schematic showing the hypothesised causes of "ridge fracture drainage", annotated here as basal shear planes (yellow) and sub-vertical stress relief fractures (grey). Base figure reproduced from Advisian, 2016*

In view of the ridge fracture drainage hypothesis, the Dupen Report goes on to state in the conclusions and recommendations that:

- *There is considerable evidence….that shear planes developed beneath the stream and reservoir base are leading to unpredicted and substantial subsidence impacts and environmental consequences. If the hypotheses presented in Section 5 are correct, surface flows and shallow groundwater are being widely diverted and drained by expanding shear and fracture systems in a mechanism termed here as ridge fracture drainage (Figure 1)*[8]*. If this new subsidence mechanism is indeed widespread, a likely outcome is that a range of protected Special Area ecosystems overlying the mine will dry and change. The other major risk from widespread basal shear formation is that it will cause the water quality in the Woronora drinking water reservoir to become increasingly degraded by metal-laden discharges from unmeasured shear plane vents.*[9]

[8] This Figure number appears to be incorrect and, presumably, should read *Figure 4*, being Figure 6 of this Panel advice report

[9] p32

with the primary recommendation arising from Dupen's report being:

- *…that further undermining of the Woronora Reservoir should be halted until the implications of these unexpected changes now unfolding in Woronora Reservoir catchment can be urgently evaluated.*

The Dupen Report acknowledges that the concerns raised in it are based on hypotheses and inferences, stating:

- *….this report has not followed a causally sound epistemology because I am not enumerating all hypotheses for all dimensions of the catchments nor impacts, nor rigorously falsifying any of the hypotheses against evidence - unfortunately there has not been an opportunity to use causal science directly in the time and budget allocated for this report.*[10]

[10] p24 – last paragraph

4.0 HISTORICAL BACKGROUND AND CONTEXT

4.1. SUBSIDENCE KNOWLEDGE BASE

Over the past 50 years, a range of public inquiries, studies and independent assessments have been undertaken into mining in the Southern Coalfield. A number of these are particularly relevant to the mining operations of Metropolitan Coal Mine and to reviewing aspects of the Dupen Report.

In the mid-1970s, the NSW Government commissioned Mr Justice Reynolds to conduct an inquiry into coal mining under stored waters in the Southern Coalfield, including beneath Woronora Reservoir. The Reynolds Inquiry (Reynolds, 1976) made a number of recommendations relating to the design of underground mine workings in the vicinity of stored waters. Subsequently, the guidelines have been the subject of theoretical and applied research and field investigations (for example, Byrnes, 1999; Singh & Jakeman, 1999, 2001) that have informed the design of longwall panels beneath Cataract Reservoir at South Bulli Colliery and beneath Woronora Reservoir at Metropolitan Coal Mine.

During the early 1990's, it began to be recognised that surface subsidence behaviour in the Southern Coalfield of NSW was more complex than predicted by conventional methodologies. Large areas of both the Southern Coalfield and the Western Coalfield in NSW are characterised by steep, incised topography with valleys and gorges that align with natural joint systems in the host rock. The incised topography naturally interrupts the transmission of horizontal tectonic stresses and causes them to be re-directed from the hills and into the floor of valleys and gorges. This process can lead to overstressing of valley floors, causing the rock mass to shear on bedding planes at or just below the floors of valleys. This movement, in turn, can result in the near surface rock strata bending and buckling upwards. This natural process is known as *'valley bulging'* and is sustained over time by weathering, leading to a progressive deepening of valleys. The planes on which the shear displacement occurs progressively daylight in the sides of a valley as it deepens.

Field investigations dating back well before the assessment of the Metropolitan Coal Project in 2009 confirmed that valley bulging can result in the creation of voids beneath watercourses, often in the form of open bedding planes which can act as underground flow paths for groundwater and stream water (Patton & Hendren, 1972; Fell et al., 1992; Everett et al., 1998; and Waddington & Kay, 2002a). Subsurface stream flow, commonly referred to as *'underflow',* can occur independently of the surface flow or the two flow paths may intermittently connect.

During the late 1990s the unpredicted severity of mining-induced subsidence impacts on natural and man-made surface features associated with valleys in the Southern Coalfield and the Western Coalfield became of increasing concern and prompted a range of investigations. These established that underground mining has the potential to grossly increase both the rate and magnitude of valley bulging. Underground mining layouts involving the formation of excavations, or panels, of sufficient width to induced fracturing, caving and subsidence of the overlying strata can cause significant changes on a regional scale in the pre-mining stress field. These changes to the stress field can significantly accelerate the rate and magnitude of valley bulging and result in significant uplift of valley floors and lateral movement of valley sides. This lateral movement is referred to as *'valley closure'*.

The mining-induced component of valley closure develops incrementally as panels are extracted, can extend well beyond the mining footprint and can be up to the order of 800 mm in the Southern Coalfield. The mining-induced subsidence effects on valley floors are due to a combination of conventional subsidence involving bending and sag of the bedded strata above excavations and non-conventional subsidence involving valley closure, with both behaviours inducing (basal) shearing along bedding planes[11]. The subsidence effects are variable because they are a function of the location and direction of mining panels relative to that of the valleys. Depending on the relative locations of these two sources of mining-induced surface strain, surface strains associated with strata sag over each longwall panel may increase or reduce surface strains associated with valley closure. This is one reason why the prediction of mining-induced valley closure effects and impacts is an imprecise process.

One of the earliest and more detailed investigations into mining-induced valley closure involved monitoring the development of ground deformation along Waratah Rivulet at Metropolitan Coal Mine. This watercourse runs approximately parallel to and about 1400 m west of the Eastern Tributary, as shown in Figure 1. Mining-induced impacts on the Waratah Rivulet were a significant catalyst for establishing the *Strategic Review – Impacts of Underground Mining on Natural Features in the Southern Coalfield* (often referred to as the Southern Coalfield Inquiry) (DoP, 2008). Publications relating to valley closure which informed that Inquiry included Waddington and Kay (2002b), Mills and Huuskes (2004), Galvin (2005) and Mills (2007).

The PAC Panel for the Metropolitan Coal Project was required to have regard to the findings of the Southern Coalfield Inquiry. The PAC's report included the following Figure 7, sourced from Mills, 2007. The figure summarises its author's understanding of subsidence and valley closure impacts on watercourses based on the investigations conducted at Waratah Rivulet and shows the activation of bedding plane shears both in the sides and floors of a valley. Since 2009, additional detailed field investigations into the development and permeability of basal shear planes have been undertaken at a number of other sites in the Southern Coalfield, in particular at Dendrobium Mine in similar topography to that at Metropolitan Colliery.

Notable studies at Dendrobium Mine relate to setback distance of the finishing ends of LW6 to LW8 from Sandy Creek Waterfall (Walsh et al., 2014) and setback distance of the starting ends of longwalls LW12 to LW18 from Avon Reservoir (SCT, 2015, 2016, 2017; HGEO, 2020). Basal shear plane locations and mining-induced displacements were determined from borehole monitoring at both sites. HGEO (2020) reported that at Sandy Creek Waterfall, packer testing indicated these bedding plane shear horizons have a hydraulic conductivity within the normal range of naturally jointed rock at shallow depth. It reported that a comprehensive program of groundwater monitoring between Avon Reservoir and the western end of longwalls LW12 to LW18 indicated that the measured hydraulic conductivity on a bedding plane shear increases two to three orders of magnitude to 1×10^{-6} m/s because of mining-induced initiation and/or remobilisation of shear plane displacement. This change in hydraulic conductivity was observed in five boreholes. The report concluded that the two to three orders of magnitude change in hydraulic conductivity had the effect of bringing the hydraulic conductivity of the bedding plane shear to a hydraulic conductivity similar to that of the surrounding strata.

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[11] This Advice report is premised on the following definitions as recommended by the Southern Coalfield Inquiry:

- Subsidence Effects: the deformation of the ground mass surrounding a mine due to the mining activity. The term is a broad one and includes all mining-induced movements, including both vertical and horizontal displacement, tilt, strain and curvature.
- Subsidence Impacts: the physical changes to the ground and its surface caused by subsidence effects. These impacts are principally tensile and shear cracking of the rock mass and localised buckling of strata caused by valley closure and upsidence but also include subsidence depressions or troughs.
- 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.

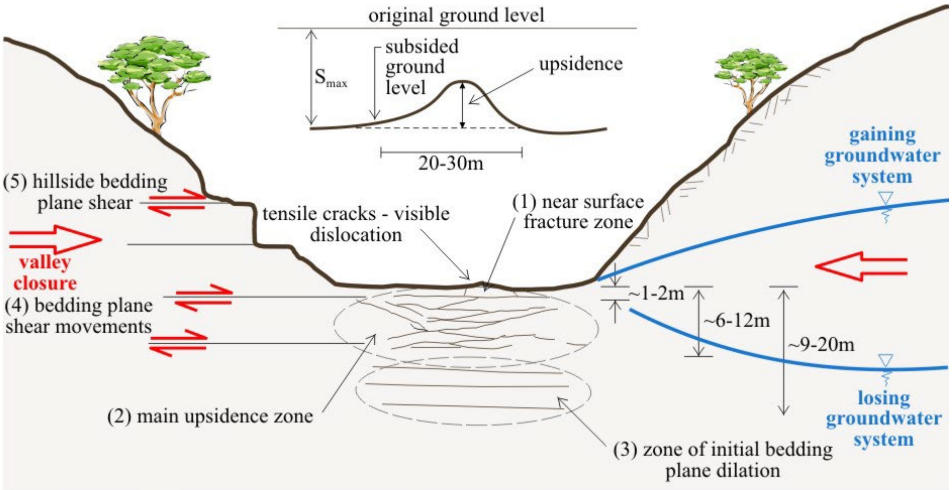

Figure 7: Cross section showing nature of rock fracturing observed due to valley closure in river channels in the Southern Coalfields (Mills, 2007)[12].

In 2017, DPE placed a condition of approval on Metropolitan Coal Mine that required it to engage independent experts endorsed by DPE to prepare a Woronora Reservoir Impact Strategy (WRIS). The WRIS Panel comprised three experts covering the discipline areas of mining and subsidence, groundwater and surface water[13]. The issues that DPE requested the WRIS Panel to address included *probable leakage rates* and *characterization of fractures (pre and post mining) including shear planes* (WRIS**,** 2017) The first report of the WRIS concluded that since 2009 water make into mine workings had averaged 0.09 ML/day and the 20-day average make had been below 0.5 ML/d. It also concluded that the then current debate around whether mining-activated shear planes would extend to the base of the Woronora Reservoir when the 300 Series of longwall panels were extracted needed to be informed by more detailed monitoring and review. The WRIS's recommendations included the drilling of additional boreholes for the purpose of monitoring the development of shear planes and groundwater pressures in response to mining.

The second report of the WRIS concluded that bedding plane shear monitoring had been very successful and clearly identified multiple planes of shear that initiated at a distance of less than 400 m from the approaching longwall face (WRIS**,** 2019). The report concluded that not all shear planes demonstrate increased conductivity, even though they have exhibited significant shear displacement (20 mm – 50 mm).[14]

In 2018, the NSW Department of Planning commissioned the Office of the Chief Scientist and Engineer to convene an *Independent Expert Panel for Mining in the Catchment* (IEPMC) to undertake a Scope of Works that included a specific focus on past and future mining activities at Metropolitan Coal Mine. The IEPMC concluded in its first report (OCSE**,** 2018) that losses of water from the catchment into the mine workings were negligible and that, going forward, the potential for water to be diverted out of Woronora Reservoir and into other catchments through valley closure shear planes and geological structures including

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[12] Gaining groundwater system means groundwater baseflow to a gaining stream; Losing groundwater system means surface water loss from a losing stream

[13] The Chair of the WRIS Panel was Professor Bruce Hebblewhite, who is Deputy Chair of the IEAPM and not involved in the preparation of this advice report.

[14] p92, WRIS**,** 2019

lineaments would require careful assessment because the remaining longwall panels in the approved area passed beneath the reservoir[15],[16].

The IEPMC also produced three advice reports for DPE regarding the Extraction Plans for LW303, LW304 and LW305 to LW307, respectively. These reports were concerned with limiting further impacts of valley closure on the lower reaches of the Eastern Tributary, including part of the area of particular concern to Dupen shown in red in Figure 1.

4.2. GROUNDWATER AND SURFACE WATER

4.2.1. Groundwater Characteristics

The geological unit of primary interest, with respect to the impacts of mining on groundwater systems and baseflows to surface water and the Woronora Reservoir, is the Hawkesbury Sandstone, shown in Figure 8.

The shallow groundwater system in this sandstone unit comprises:

- Localised perched groundwater associated with swamp colluvium and shallow sandstone (predominantly in the weathered zone); and
- Regional groundwater comprising saturated porous and fractured sandstone below the regional water table.

Rainfall infiltration over the catchment area and surface water losses from losing stream sections are the only groundwater recharge characteristics. Evapo-transpiration, baseflow discharges and leakage to deeper aquifers in the Narrabeen Group rocks are the primary discharge characteristics.

The Panel's site inspection on the 10 May 2023 (after an extended dry period) did not identify any other groundwater discharge features in the landscape apart from one seepage area in a depression towards the northern end of Fire Trail 9G. There were no obvious spring discharge areas and no evidence of basal shear zones (above stream level) that were discharging mineralised groundwater. There was no evidence of any terrestrial GDEs tapping shallow groundwater. However, the Panel recognises that during and just after rain, ephemeral springs and seeps could occur through interflow where cross bedded sandstone and bedding plane partings daylight in the valley sides.

Perched groundwater derived from rainfall occurs in colluvium beneath ridgelines and valley sides, and also in the weathered Hawkesbury Sandstone underlying swamp sites (Figure 8). Perched groundwater sits above the regional groundwater leading to different water tables at different depths. Typically, perched groundwater occurs within 10 m of surface with the water table potentially ranging from at surface during wet periods to being absent during severe droughts. The absence of permanent springs and any obvious perched groundwater in the upper Hawkesbury Sandstone (apart from in the vicinity of swamps) suggests most rainfall recharge (apart from that portion that is lost to evapo-transpiration and via interflow after rain) drains vertically to the regional water table and then moves laterally to emerge in the base of the valleys as baseflow.

[15] piii, OCSE (2018)

[16] The Panel notes that the Dupen Report also states that there is no concrete evidence that there is a substantial net loss of water volumes from the Woronora Reservoir catchment into underlying workings.

Groundwater flow in the Hawkesbury Sandstone in areas unaffected by mining occurs mainly through natural fractures and to a lesser extent through porous layers. The natural fracture system is complex and flow paths are tortuous from recharge zones to discharge zones. The depth to the regional water table (based on limited data) varies between 70 m below ground level (mbgl) below the major ridgelines to less than 3 mbgl near the permanent streams and Woronora Reservoir (see Figure 5). From the ridgelines, there is both lateral flow to permanent streams and vertical flow to deeper aquifers. A downward hydraulic gradient typically exists, even to the deeper strata in the Narrabeen Group and Illawarra Coal Measures underlying the Hawkesbury Sandstone. This is the case before and after mining, although downward flows are small due to the limited hydraulic conductivity of the low permeability siltstone and claystone formations.

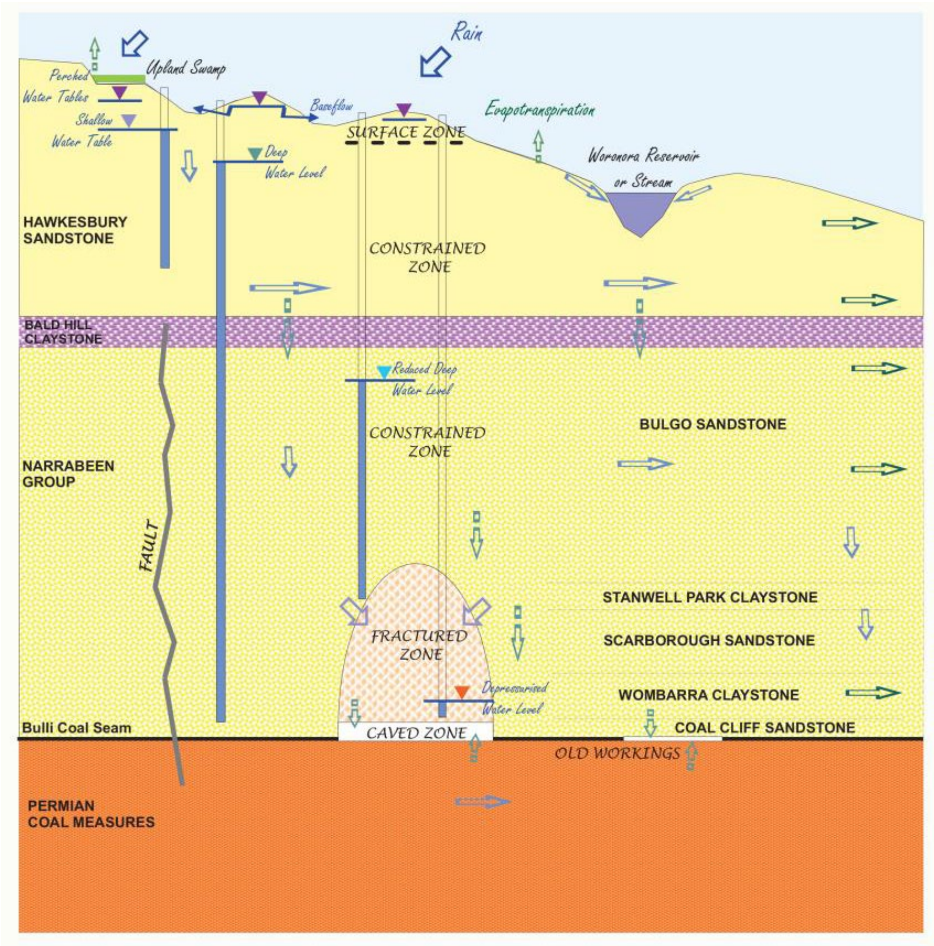

Figure 8: Conceptual groundwater system proposed by the WRIS for Metropolitan Coal Mine (Figure 3-1 from WRIS, 2017).

Longwall mining changes the groundwater flow geometry within the regional groundwater system in the Hawkesbury Sandstone above longwall panels as groundwater depressurisation occurs in deeper formations and as enhanced fracturing propagates through portions of the upper formations including the sandstone. These changes generally result in lowering of the regional water table due to:

- release of pressurised groundwater into dilated fractures;
- increased flow of groundwater to surface water due to enhanced fracturing and dilated bedding planes; and

- increased flow into the mine void.

Due to the significant depth (435 to 550 m) and relatively conservative geometry of the workings at Metropolitan Coal Mine and the hydrogeological conditions, the latter contribution is recognised as not presently significant.

Where subsidence-induced fracture systems increase the hydraulic connection of groundwater to surface watercourses, mining can result in increased surface water flows. Conversely, the possibility of surface flows being diverted to underflow due to subsidence effects, means that surface water flows may be seen to reduce over some lengths of creeks. The Dupen report refers to these potential changes as "changed baseflow patterns". Currently the magnitude and location of net baseflow gains or losses to Waratah Rivulet, Eastern Tributary and other Woronora tributaries are uncertain.

Measurement of groundwater levels is generally undertaken using piezometers. A piezometer measures a groundwater level or pressure at a specific areal location and depth. Because fractures dominate flow paths in the Hawkesbury Sandstone, and installed piezometers in this formation may or may not coincide with fracture locations, measurements cannot be interpreted as measuring the precise response of the regional groundwater system to natural recharge, flow, and any mining induced subsidence. It is not uncommon that groundwater levels and their responses to mining vary between nearby piezometers.

Care is required in attributing the cause of piezometric changes above longwall panels. Strata relaxation associated with overburden strata sagging and subsiding above a longwall excavation can result in delamination and the creation of partings (voids) between stratum, which a piezometer can report as depressurisation. Water pressure may be recovered once sufficient time has elapsed for groundwater to fill this new void space. This behaviour can be largely site specific because the sag component of total vertical displacement is site specific and has minimal interaction with sag over adjacent panels.

4.2.2. Surface Water Characteristics

The Eastern Tributary consists of a series of pools, rock bars and boulder fields, which are mapped and photographed in detail in Peabody, 2022a). The Metropolitan Coal 2021 Annual Report (Peabody, 2022b) acknowledges subsidence effects and consequences on pool drainage behaviour over a ~ 2 km length of the creek overlying LW20 to LW27 and further downstream towards the Woronora Reservoir (Pools ETAG, ETAH, ETAI, ETAJ, ETAK, ETAL, ETAM, ETAN, ETAO, ETAQ and ETAR). This has led to an ongoing program of grouting in an attempt to seal surface and near-surface fractures and recover pool water levels and continuity of surface flows. Subsidence has not visibly affected pool drainage behaviour further downstream at Pools ETAS, ETAT and ETAU (Peabody, 2022b).

The Eastern Tributary hydrology is consistent with 2nd and 3rd order creeks generally in the Southern Coalfield, with sources dominated by surface runoff, interflow, discharge from shallow aquifers, and exchanges of flow between surface and subsurface zones of the creek. The potentially significant sources of water are:

- Surface water discharges. During rainfall, the rainfall in some areas of the catchment will exceed the infiltration capacity of the soil, and overland flow will be generated. This flows into the creek within a few minutes to hours, creating rapid increases in flows and being the main contributor to flood flows. A proportion of this overland flow will infiltrate as it moves over the soil surface and then migrate as interflow or evaporate or recharge the perched or regional groundwater. Disturbances to vegetation and soil such as fire can change the balance of overland flow, interflow, recharge and evaporation, although any change should recover quickly in the case of controlled burns.

- Interflow. During and after high rainfall events, interflow occurs where water infiltrates the unsaturated zone and moves laterally to then return to the surface as an ephemeral spring or enter a nearby stream. Interflow is fast flow that occurs in the subsurface after a few hours and can last for days and weeks depending on the nature of the rainfall event and the available storage in the unsaturated zone.
- Perched groundwater discharges. Perched groundwater is recharged by rainfall and interflow and remains in the subsurface for long periods. This groundwater is localised and sits on shallow impermeable layers above the regional groundwater system (not shown in Figure 7). It can discharge slowly laterally (potentially as interflow) depending on the geometry of the impermeable layer but otherwise will remain as a localised pocket of shallow groundwater in the landscape subject to evapo-transpiration.
- Regional groundwater discharges. This discharge occurs in creek lengths where the regional water table sits above the creek level; i.e. a gaining system shown in Figure 7. This source of flow can be sustained for weeks to months over prolonged periods of dry weather and is commonly considered to be the major component of "baseflow". The low flows during prolonged dry weather (Figure 3) reflect a limited sustained contribution of regional groundwater in the Eastern Tributary catchment, although what lengths of creek this applies to is not well understood.

  The baseflow rate depends on the hydraulic connectivity between the regional groundwater system and the creek, among other factors. In principle, mining can decrease baseflow rates due to lowering of the groundwater levels or increase baseflow rates if subsidence leads to an increase in the hydraulic connectivity[17]. Either can be a temporary or permanent effect.

The main potential mechanisms for loss of water from the Eastern Tributary are:

- Loss of water to the regional groundwater system (the losing system in Figure 7). The available groundwater data does not indicate this mechanism is widespread along the lower portion of the Eastern Tributary.
- Diversion of water through fractures to the shallow subsurface (underflow), where it flows downstream in the near-surface fracture zone (Figure 7). This water generally re-appears further downstream in the creek, where the near surface fracture flow paths reconnect with the surface. The surface and near-surface fracture zone may be natural or mining-enhanced. Exchanges between the visible surface flows and the near-surface fracture zone mean that flow may appear absent from considerable lengths of the creek during dry weather.

Measuring and modelling creek flow rates is a common approach to measuring the consequences of mining for water resources. For example, the comparison of modelled flow (representing pre-mining conditions) and measured flow (representing mining conditions) near the Waratah Rivulet inlet to the Woronora Reservoir is the basis for a flow performance indicator for Metropolitan Coal Mine. A comparison of modelled and measured flows is also reported in Peabody (2021, 2022) at the Eastern Tributary flow gauge location (Figure 3). The flow gauge consists of a prefabricated flume set into a concrete wall, the latter acting as a weir when overflow occurs. Measurements and modelling of the Eastern Tributary flows

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[17] Flow gauging in the Eastern Tributary (Figure 3) began in 2012 while longwall mining in the area dates back to 1995, including the LW20 series from 2010, so there is no pre-mining baseline data for this catchment that would allow an assessment of long-term cumulative consequences on baseflows.

are prone to errors especially at high flows: the flume is designed to accurately measure flows up to approximately 235 L/s (3.5 mm/day in Figure 3) (HEC, 2022). Any flows above this value are estimated using a rating curve (a curve showing the relationship between water level and stream flow rate), which has been approximately estimated and lacks validation (HEC, 2022). The Panel's field inspection on 10 May 2023 noted that the concrete weir stops short of the bank, which may contribute to errors at low to medium flow rates due to water escaping around the flume and weir.

The Eastern Tributary surface flow model employs the industry-standard AWBM model, which has been adjusted specifically for the Woronora catchments and peer-reviewed (Gilbert & Associates, 2015). The Panel has not undertaken an in-depth technical review of the model. The Panel's review of the model is based on the figures and commentary in Peabody (2022b) and HEC (2022). The model does not (and was not designed to) estimate high flows accurately for a number of reasons, including the reliance on daily rather than peak rainfall data, and absence of accurate high flow calibration data. The model also has some errors at medium to low flows (as can be seen in the calibration period in Figure 3). These types of errors are generally considered acceptable for this type of model application. The assessment looks for changes in errors between the calibration and the mining period and considers whether they should be attributed to mining or other effects. Further review of Figure 3 and its interpretation by the Dupen Report is in Section 5 of this advice report.

4.3. PERFORMANCE MEASURES AND INDICATORS

Performance measures are set as part of the Project Approval conditions (DoP, 2009b). The performance measures most relevant for the scope of this advice report are:

- *Catchment yield to the Woronora Reservoir:*
  - *Negligible reduction in the quality or quantity of water resources reaching the Woronora Reservoir*
  - *No connective cracking between the surface and the mine*
- *Woronora Reservoir:*
  - *Negligible leakage from the Woronora Reservoir*
  - *Negligible reduction in the water quality of Woronora Reservoir*
- *Eastern Tributary between the full supply level of the Woronora Reservoir and the maingate of Longwall 26[18]:*
  - *Negligible environmental consequences over at least 70% of the stream length (that is no diversion of flows, no change in the natural drainage behaviour of pools, minimal iron staining and minimal gas releases)*
- *Upland swamps, riparian vegetation and aquatic biota:*
  - *Negligible impact on Threatened Species, Populations, or Ecological Communities*

The performance measures related to water flow are relevant to this current advice report in light of the potential significance of matters raised in the Dupen Report and arising out of the Panel's review of the Dupen Report. Specific areas of relevance for the current advice report

[18] The location of the maingate of Longwall 26 is approximated by the blue cross in Figure 1.

relate to potential changes over time to flows into the Woronora Reservoir and to changes to the environmental conditions along the Eastern Tributary due to diversion of flows. The performance measures related to upland swamps, riparian vegetation and aquatic biota are relevant to the comments in the Dupen report that ecosystems will inevitably degrade due to the diversion of surface and near-surface flows.

As previously noted, matters of significance raised in the Dupen Report in relation to potential mining impacts on water quality fall within the brief of another IEAPM Panel and the reader is referred to IEAPM (2023).

5.0 DUPEN REPORT ASSESSMENT

5.1. APPROACH

This section first focusses on overviewing the primary hypothesis of the Dupen Report and key supporting statements, then identifies other key statements made in the report related to the implications of the hypothesis. The Panel has not assessed Section 3.8 (Volumetric loss calculations) of the report as it is considered to be outside of the scope of the Department's request for advice from the IEAPM.

5.2. PRIMARY HYPOTHESIS AND STATEMENTS – OVERVIEW AND EVALUATION

5.2.1. Prediction and appearance of impacts on Eastern Tributary

Dupen states that:

> *Such widespread fracturing and surface flow water diversions* [on the Eastern Tributary] *were not anticipated in the planning application documents (Helensburgh Coal, 2008; 2009), and their implications are not acknowledged by the mining company nor the regulators and their expert committees, based on the documentation reviewed.*

It is correct that the planning application documents lodged by Helensburgh Coal for assessment by the Planning Assessment Commission (PAC) made no provision for limiting subsidence impacts on the Eastern Tributary. However, the PAC and subsequent expert panels (IEPMC and the IEAPM) did anticipate and/or acknowledge the potential for widespread subsurface fracturing.

The Eastern Tributary was designated as a significant natural feature by the PAC after it conducted a field inspection. The draft Preferred Project Report (PPR) lodged by Helensburgh Coal in the final stages of the PAC's assessment included a revised mine layout that was based on preventing fracturing and drainage of any more rock bars on Waratah Rivulet, downstream of pool L shown on Figure 2. Helensburgh Coal proposed to achieve this with a revised mine layout designed to limit predicted valley closure to no more than 200 mm downstream of pool L.

This criterion was based on minimising the potential for draining of pools due to cracking of rockbars, which had not been recorded on watercourses up to that time at sites for which predicted total closure was less than 200 mm[19],[20]. The PAC concluded that:

> "*Because the 200 mm closure limit is an outcome of a prediction methodology that is under development, it is subject to change as the prediction methodology evolves* (DoP, 2009a).

The PAC questioned whether closure and upsidence behaviour in the Project Area could be presumed to conform to past Southern Coalfield experience, given that conventional subsidence effects were greater in the Project Area than recorded elsewhere in the Southern Coalfield. It was advised by Helensburgh Coal that:

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[19] Note, as explained in Part 1 of the IEPMC's report (OCSE, 2018) that mine design criterion was (and still is) based, unusually so, on predicted values of valley closure and not on measured values (because measured values did not correlate as well with subsidence impacts)

[20] Reference MSEC, 2007

"*There is some probability, regardless of the approach, that potential impacts could occur at predicted closure values less than the minimum predicted total closure of 200 mm that has been identified to date*".[8]

The revised mine layout was based on limiting predicted valley closure along Waratah Rivulet to less than 200 mm. However, this in turn did result in a reduction in predicted valley closure along the Eastern Tributary, as shown in Figure 9.

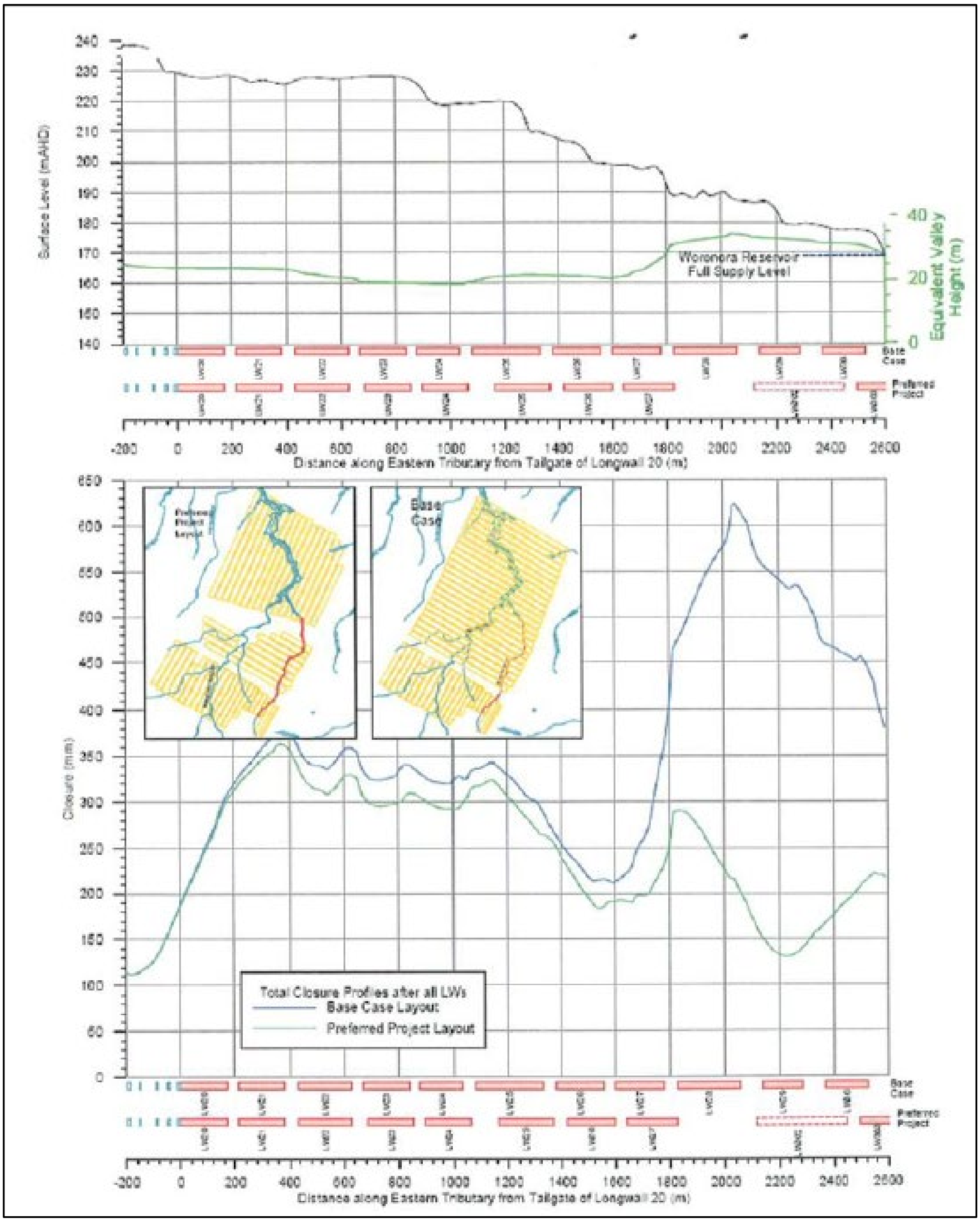

Figure 9: Profiles of predicted valley closure along the Eastern Tributary associated with both the mine layout proposed in the EIS for the Metropolitan Coal Project and the modified layout presented to the PAC during its assessment process (Peabody, 2009).

The PAC foresaw that the levels of valley closure predicted in the draft PPR were still sufficient to result in significant impacts to Eastern Tributary. Accordingly, the PAC recommended that the environmental *outcome for the reach of the Eastern Tributary between the junction of the two tributaries at approximately 6214600N and 312200E and the full storage level be set at negligible consequences (i.e. no diversion of flows, no change in the natural drainage behaviour of pools, and minimal iron staining)*. These coordinates correspond closely to the position of the maingate of LW26 at the eastern (outbye) end of this longwall panel, marked by 'X' in Figure 1. Notwithstanding the changes to the original mine plan, the PAC did not endorse the modified mine plan nor was it required to. In fact, the PAC concluded that[21]:

> *The main problems* [with the revised mine plan] *appear to be:*
>
> - *The predicted impacts associated with the southern ends of Longwalls 30 and 31* [since renumbered LW301 and LW302]*; and*
> - *The predicted impact associated with Longwall 27.*

An expanded version of the PPR was submitted to the Department of Planning (DoP) after the PAC had concluded its review (as reported in the Department's 'Reasons for Approval'). However, the mine plan and predictions of valley closure were basically unchanged from that shown in Figure 9. DoP stated in its assessment of the PPR that:

> *It is generally accepted that the figure* [of 200 mm of predicted valley closure] *is far from established. It must be seen as indicative, rather than determinate. There remains a possibility, particularly for fragile rock types, that significant buckling and shearing of stream beds will eventually be observed where predicted valley closure is less than 200 mm.*[22]

Subsequently, DoP relaxed the PAC's recommended Performance Measure for the lower end of the Eastern Tributary, stating:

> 1. *HCPL has made a convincing case that reducing valley closure to 200 mm over this stretch of the Tributary* [midway across Longwall 26 to the Reservoir] *would cause it to be unable to extract Longwall 27*[23]*;* and
> 2. *The Department has therefore recommended a condition that the environmental outcome for the lower length of the Eastern Tributary be set at "negligible consequences" for at least 70% of the stream downstream of the maingate of Longwall 26 to full storage level.*[24]

The Panel is unaware of the basis for determining a figure of 70% and what sections of the Eastern Tributary downstream of the maingate of LW26 were expected make up this accumulated proportion of unimpacted stream length.

Within 12 months of the PAC's assessment, it was established that some 10% of those rock bars that had been monitored in the Southern Coalfield had been impacted at predicted valley closure levels of less than 200 mm to the extent that '*pool water levels were observed to drop more than was expected after considering the rainfall and groundwater flow conditions*'. This level of impact was classified as a 'Type 3' impact. On that basis, based on the mine layout as approved, the full extent of the Eastern Tributary between the maingate of LW26 and the

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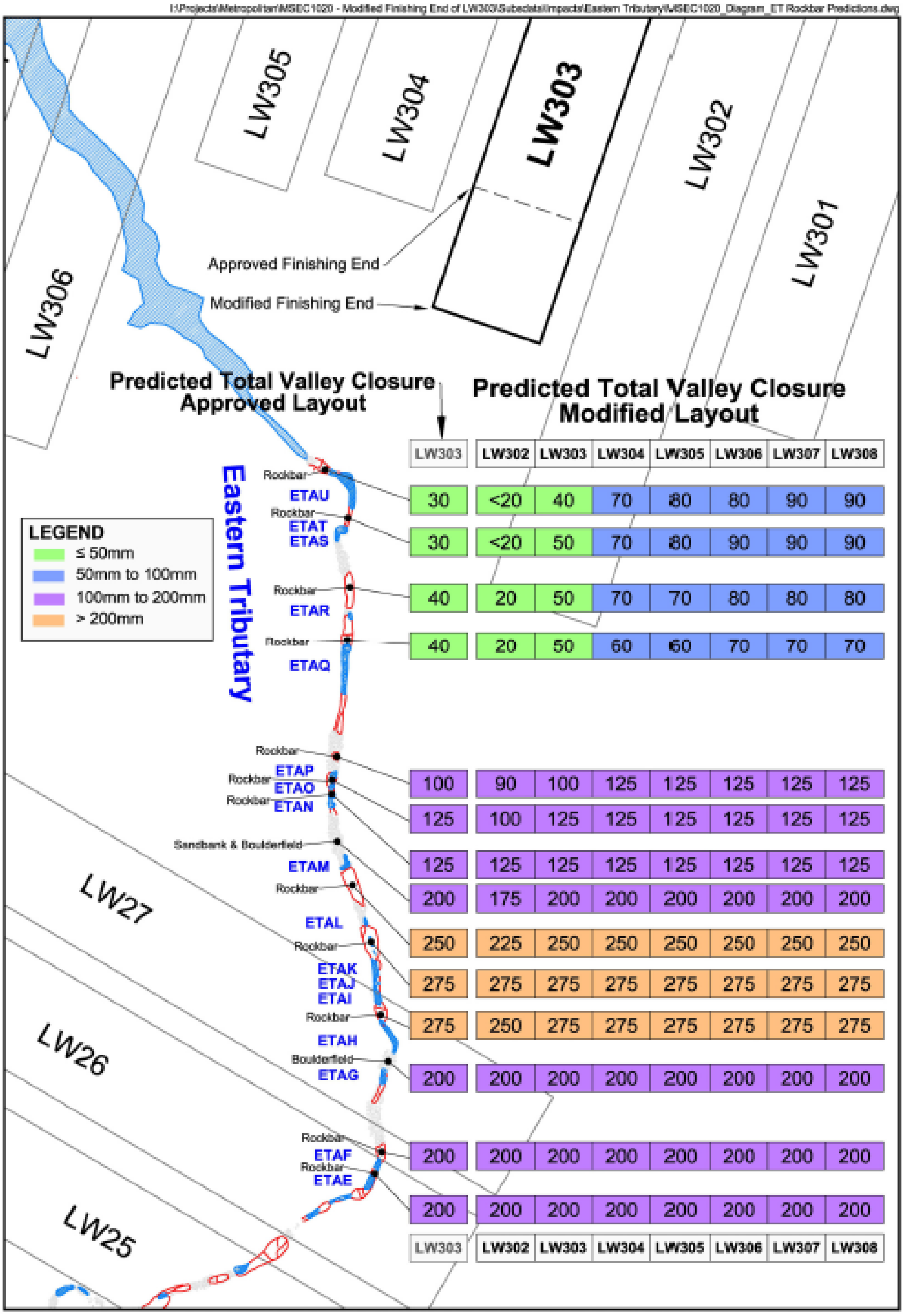
[21] P126 of DoP, 2009a
[22] p21 of DoP, 2009b
[23] p25 of DoP, 2009b
[24] p 26 of DoP, 2009b

full supply level of Woronora Reservoir was vulnerable to environmental impacts that exceeded a performance measure of *negligible.* This always included that section of the Eastern Tributary located over the 'pillar' zone since predicted valley closure over this area still ranged up to almost 300 mm.

LW27 was completed in March 2017 and mining of LW301 commenced in June 2017. This panel was shortened for operational reasons and, as shown in Figure 10, stopped over 350 m short of its planned finish point. Hence, the contribution of this panel to cumulative valley closure along the Eastern Tributary could be expected to be minimal. LW302 was extracted to its originally planned and finished in February 2018. Soon after, it was recognised that the Performance Measure of negligible for 70% of the length of Eastern Tributary downstream of Point X had been exceeded, resulting in LW303 to LW305 being setback from Eastern Tributary substantially greater distances than planned at the time of project approval. The modified layout, shown in Figure 10, resulted in moderate to very large decreases in predicted valley closure downstream of about pool ETAM[25], as evidenced by comparing predictions plotted (in green) in Figure 9 with those tabulated in Figure 10.

Nevertheless, although the actual mine layout was predicted to result in valley closure of only 125 mm at rockbar ETAO, it appears that subsidence effects were sufficient to cause subsurface flow at this rockbar. Figure 11 shows the appearance of 10 m of core recovered to one side of Rockbar ETAO. This photograph was taken during the Panel's site inspection on 20 May 2023. Drilling was in progress and the core had still to be geotechnically logged. However, the photograph clearly shows a high density of iron-stained fractures, especially in the upper 5 m of the core. No information was available at the time on the in-situ aperture of these fracture planes and how fracture density and aperture compared with that towards the centre of the watercourse. Grouting was also in progress to remediate the fracture network at the rock bar. Field observations and discussions with operators made a compelling case that subsurface flow is occurring at this location.

[25] This is an informed estimate by the Panel and should be confirmed by more detailed information and analysis by Metropolitan Coal



LW303	LW302	LW303	LW304	LW305	LW306	LW307	LW308
30	<20	40	70	80	80	90	90
30	<20	50	70	80	90	90	90
40	20	50	70	70	80	80	80
40	20	50	60	60	70	70	70
100	90	100	125	125	125	125	125
125	100	125	125	125	125	125	125
125	125	125	125	125	125	125	125
200	175	200	200	200	200	200	200
250	225	250	250	250	250	250	250
275	275	275	275	275	275	275	275
275	250	275	275	275	275	275	275
200	200	200	200	200	200	200	200
200	200	200	200	200	200	200	200
200	200	200	200	200	200	200	200
LW303	LW302	LW303	LW304	LW305	LW306	LW307	LW308

Figure 3 Predicted total valley closure after LW303 to 308 at Eastern Tributary rock bars

Figure 10: Predicted cumulative valley closure at the Eastern Tributary for LW302 to LW308 (Peabody, 2019).

Figure 11: Core observed during the Panel's site visit on 10/5/23, the core having been recovered to a depth of 10 m from one side of Rockbar ETAO on the Eastern Tributary and showing a series of iron-stained partings indicative of subsurface flowpaths.

Other subsidence related statements in Dupen (2023) relevant to the Panel's advice are:

- *Again unlike the Waratah Rivulet impacts (and WC21 over Dendrobium Mine), the desiccation event occurred not gradually and progressively following undermining, but over a relatively short time period after most of the 20 series longwalls had already been mined. The wholly unpredicted drying event was first reported in November 2016 and by February 2017, over 500 m of the previously permanently flowing creek was frequently or permanently dry.*

  The Panel notes that the Eastern Tributary was undermined by LW27 in November and December 2017 and remained within the area of influence of active mining until the panel was completed in March 2017. The tabulations of predicted valley closure presented in Figure 10 show that after the completion of LW302, predicted valley closure plateaued at 200 mm on the southern flank and at the centre of LW27 and at 275 mm on the northern flank of LW27 and downstream to rockbar ETAL. It then progressively reduced and plateaued at 200 mm at ETAM and 125 mm at ETAN, ETAO and ETAP.

Based on the predictions of valley closure for both the original approved mine layout and the actual mine layout, it appears likely that the extraction of subsequent longwalls after LW27 would have resulted in minimal additional (incremental) predicted valley closure at rockbars upstream from ETAP; that is, the values of predicted valley closure tabulated for these rockbars in Figure 10 are likely to be close to those at the time that the Eastern Tributary was being undermined by LW27. This being the case and given the magnitudes of the predicted cumulative valley closures at that stage, it is quite plausible that the incremental increase in valley closure over not only LW27 but also over previously extracted longwalls in its vicinity was a trigger for a significant mining-induced ground deformation event beneath the Eastern Tributary, at least downstream to ETAP.

Buckling is a form of structural failure due to deflection initiated by load acting through the long axis of a structure (as opposed to bending initiated by load acting at right angles to the structure). Step increases in deflection can be initiated by very small increases in load or, in this case, valley closure. Once a threshold value is exceeded, deflection can develop rapidly. In the case of valley closure, one is dealing with high stresses on a regional basis that act on natural material that is of variable composition and contains defects. Hence, it is quite conceivable that sometime around or just after the completion of LW27 a large area that had appeared relatively benign could deform quickly as a result of incremental increases in valley closure over LW27 and earlier panels. The total valley closure at that point in the mining process had been predicted to reach a level known to result in fracturing of rock bars.

The Panel recommends for the purpose of developing a better understanding of valley closure impacts to inform mine design that, if it has not already done so, Metropolitan Coal undertake an investigation of mining impacts on the Eastern Tributary that includes an evaluation of:

1. How predicted valley closure developed incrementally along the Eastern Tributary.
2. How well incremental and total predicted valley closure correlated with measured incremental and total measured closure.
3. The nature and extent of natural and mining-induced fracturing to a depth of at least 20 m along the Eastern Tributary downstream from the maingate of LW26 (point 'X') to the FSL of Woronora Reservoir (noting that some of these investigations may have already been undertaken).
4. How well mining-induced environmental impacts along the Eastern Tributary correlate to both predicted valley closure and to measured valley closure.

- *Another unexpected feature of the Eastern Tributary pool drying event is that much of it has occurred over areas in which very little subsidence occurred as they lie over unsubsided "first workings" or unmined rock (Figure 11).*

  Valley closure is not confined to above mine workings. It can develop at considerable distances beyond the mining footprint.

- *There is little evidence that the Eastern Tributary pool drying event may be attributed to "rock-bar throughflow", as envisaged by Peabody's consultants (Figure 14). ...This mechanism, in which water in an upstream pool is able to seep through the fractured fabric of the intervening rock bar ………. It is worth noting* *that, if shear planes have indeed been widely developed beneath the valley axis as hypothesised in Section 3.2, the remedial design that was used with considerable success at Waratah Rivulet may not be successful in restoring surface flows to Eastern Tributary.*

As noted earlier, drilling being undertaken at the time of the Panel's site visit in May 2023 provides evidence that subsurface flow had occurred at Rockbar ETAO, well downstream of the footprint of LW27.

- *Subsidence monitoring showed that valley closure effects in the area of the dried pools were mostly within the "conservative" valley closure threshold hypothesised by subsidence consultants MSEC (2008). MSEC's subsidence impact predictions suggest that no more than 10% of stream beds should be cracked as long as valley closure is less than 200 mm, measured across the axis of a valley). On this basis, the widespread flow diversions experienced in Waratah Rivulet were not expected to be repeated in Eastern Tributary (Metropolitan Coal, 2022b).*

  The mine design procedures and subsidence impact assessments were based on predicted valley closure, not measured valley closure, because measured valley closure did not produce as good a correlation with impact outcomes as did predicted valley closures (see OCSE, 2018 for a more detailed discussion on this matter). As reflected in Figure 9 and Figure 10, valley closure for Rockbar ETAI to ETAM was always predicted to be greater than 200 mm.

5.2.2. Flow measurements

Dupen suggests that the anomalously high flows recently measured at the Eastern Tributary gauge (see Figure 3) may be explained by the Dupen Report's main hypothesis, being:

> *My interpretation of the reported trends (Section 3.5) is that flows in Eastern Tributary and probably other undermined streams are currently being affected by increased draining of the undermined ridges through basal shear planes. Once a new equilibrium is established, quicker and smaller baseflows may reduce overall flows to the Reservoir.*[26]

For high flows, from January 2019, Figure 3 includes several incidences of the flow rate measured at the Eastern Tributary weir being well above the rainfall rate at the nearby Darkes Forest gauge, Figure 12, which is implausible.[27] Following Metropolitan Coal's investigation into the flow anomalies (HEC, 2022), the rating curve (i.e. the calibration of the flow-depth relation at the flow measurement flume and weir) was updated to give the data in Peabody (2022b) reproduced as Figure 13 in this advice report. Figure 14 (Figure 8 from HEC, 2022) is the same plot, zooming in on the period 1-Jan-2020 to 1-Sept-2022.

[26] p28 of Dupen, 2023a.

[27] Groundwater contributions to the flow hydrograph, derived from prior rainfall events, would not be sufficient to allow the peaks in measured surface flows to exceed the rainfall rate for these incidences.

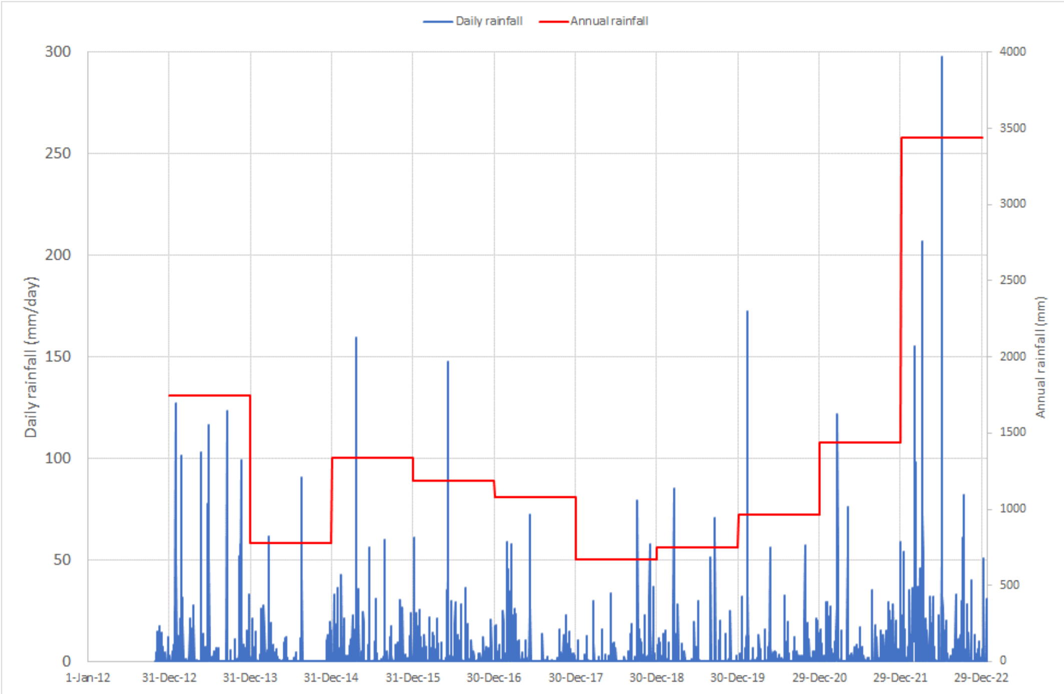


Figure 12: Daily and annual rainfall at the Darkes Forest gauge (approximately 5 km south-west of the Eastern Tributary flow gauge). Data sourced from https://www.longpaddock.qld.gov.au/silo/ .

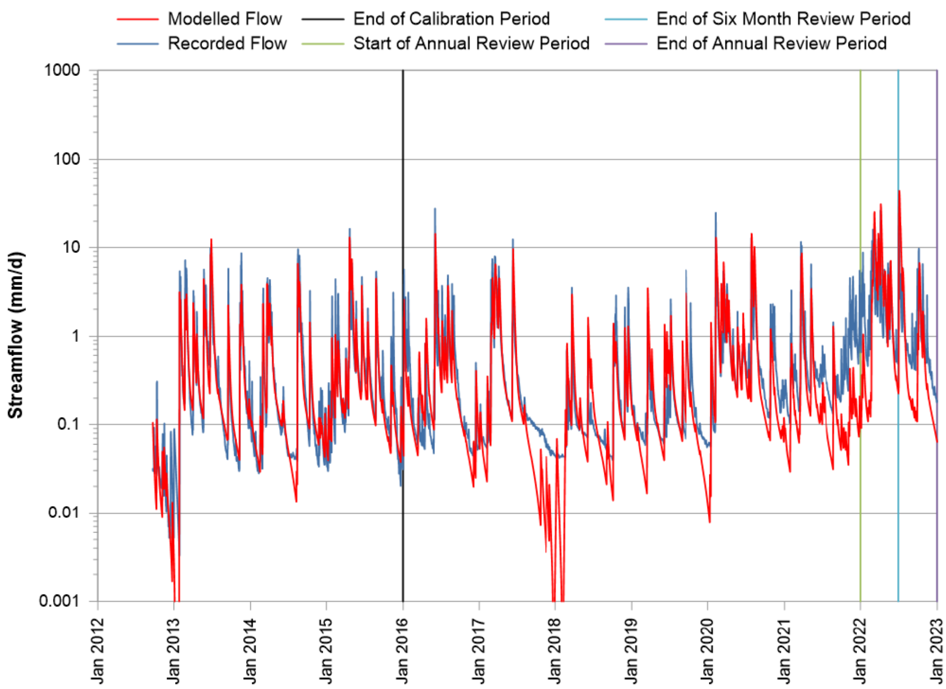


Figure 13: Flow data from the Eastern Tributary gauge. Originally Chart 4 in Peabody (2023). (The y-axis scale (mm/day) is the flow volume rate in mm^3/day divided by the catchment area in mm^2. 1 mm/day = 67 L/s.)

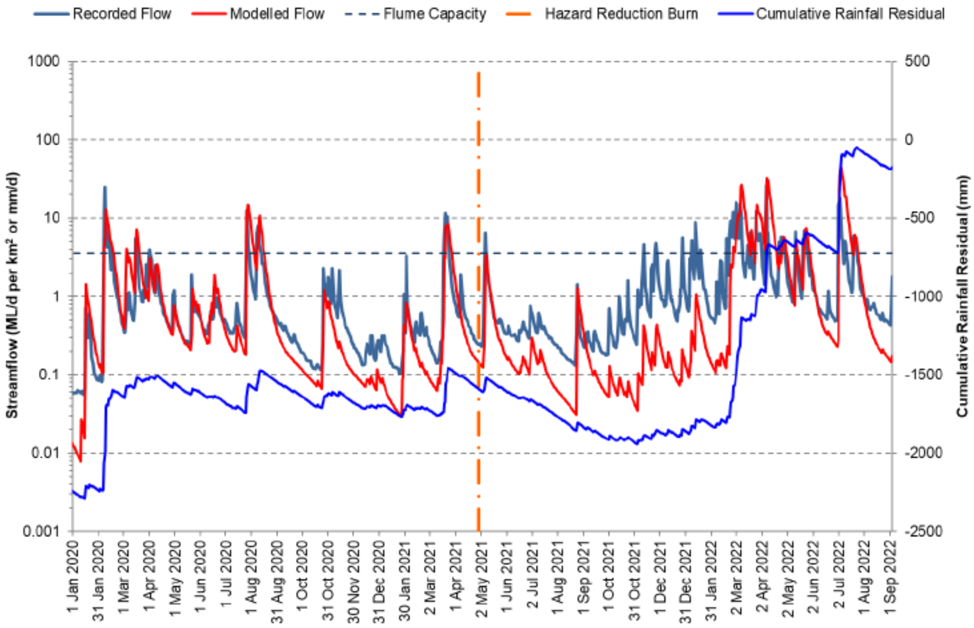


Figure 14: Flow data from the Eastern Tributary gauge between 1 January 2020 and 1 September 2022. Originally Figure 8 from HEC (2022).

HEC (2022) explores the following potential reasons for the higher-than-predicted flows during the period early 2017 to late 2022:

1. Flow measurement errors due to subsidence effects on the flume and weir.
2. Changes in catchment hydrology due to a controlled burn in the catchment on 29 April 2021.
3. Increased baseflow due to subsidence-induced stream bed fracturing.

The relevant conclusions and recommendations of HEC (2022) are:

1. *It is apparent that flume movement could not conceivably lead to significant changes in monitored flow rates.*
2. *A controlled hazard reduction burn was conducted within the Metropolitan Special Area and the catchment of GS 300078 on 29 April 2021. For a period of approximately 10 months following, the divergence between the hydrographs increases and this behaviour is considered related to the effects of the burn, which likely increased the rate of catchment runoff. However, this behaviour appears to have diminished since the onset of higher rainfall in approximately March 2022.*

   and

   the hazard reduction burn alone could not have resulted in the significant divergence between modelled and recorded streamflow
3. *During periods of flow recession dating back to spring 2017, the modified streamflow record somewhat exceeds modelled flow. It is considered that this may be related to increased baseflow occurring due to subsidence-induced stream bed fracturing upstream of GS 300078 leading to flow diversion through the fracture network which increases flow routing.*
4. *It is recommended that Metropolitan Coal conduct high resolution survey of the stream bed and banks (including the concrete weir either side of the flume) for a*

distance upstream and downstream of the flume and that this data be used as input to a numerical hydraulic model of the stream at GS 300078. The model should then be used to extend the gauging station rating relationship beyond the capacity of the flume. In the interim, streamflow in excess of flume capacity should be estimated using the quadratic extrapolation of the flume rating curve.

The Panel's comments on each of these are:

1. The first conclusion was based on a field survey of the flume to estimate possible movements since installation, and then testing sensitivity of the flow estimates to a revision of the flume rating curve that accounts for these movements (HEC, 2022). The level of detail provided in HEC (2022) about the nature of the movements of the flume and the rating curve revision approach is not sufficient to critically review this conclusion; nevertheless, from the information provided, the Panel considers that movement of the flume is unlikely to have caused the observed flow anomalies.

   The HEC (2022) investigation did not consider the possibility of measurement errors due to the presence of flood debris behind the flume, which could create the types of flow anomaly observed. However, if the flume is regularly inspected and cleared, which is normal good practice, and is implemented in this case according to Peabody staff[28], this could not be a reason for the prolonged flow anomalies.

2. Regarding the second conclusion, the increased flow rates from April 2021 are consistent with what might be expected due to partial clearance of vegetation due to the hazard control burn combined with the relatively persistent rainfall that occurred from September 2021 to March 2022. The modelling conducted in HEC (2022) is simplistic regarding the potential effects of fire (e.g. see Bren, 2023) and it is possible that it significantly underestimates the effect of the fire. Nevertheless, considering the presence of anomalous flows even before the burn, the Panel agrees with conclusion that the burn has likely had an effect but, by itself, is unlikely to fully explain the flow anomaly.

3. The substantially increased flows since August 2020, which is before the burn event, suggest larger volumes of groundwater release following rainfall events. Higher infiltration rates would be reflected in increased interflow volumes and potentially increased regional groundwater levels and discharges. While the AWBM model used to produce the red lines in Figure 13 and Figure 14 will translate high rainfall to groundwater storage and flows, it is possible there are non-linear responses to high rainfall that the model does not account for, which could create the flow anomalies in Figure 13 and Figure 14.

   Drought conditions such as those experienced from early 2017 to early 2020 are capable in some situations of changing the nature of flow responses in a way that simple models, such as the AWBM model used in Peabody (2022) and HEC (2022), cannot replicate. The hydrological modelling literature has examples of higher than predicted flows following dry years (for example, Deb & Kiem, 2020). However, the magnitude of flows observed from August 2020 relative to the rainfall are probably too high to be explained by the limitations of the model.

   Increased groundwater discharge is potentially consistent with the hypothesis in the Dupen report of sub-vertical fractures connecting the surface with groundwater stores combined with enhanced hydraulic connection of these stores to the creek. However, as suggested in the conclusion of HEC (2022) "*It is considered that this may be related to increased baseflow occurring due to subsidence-induced stream bed*

[28] As indicated to Professor McIntyre during a field visit on 19/07/2023.

fracturing", this may be related to increased connectivity between the creek and regional groundwater due to creek bed fracturing and does not necessarily mean enhanced flow through basal shear planes as proposed in the Dupen Report. The clear divergence in model and recorded flows commences in August 2020 during the extraction of LW305 (the closest longwall to the Eastern Tributary gauging station).

Another possible explanation for increased surface flows is the recent rise in reservoir levels. There has likely been underflow beneath the flow gauge that has not been recorded via the flume while the reservoir levels are low. As the reservoir level began to rise in early 2020, the piezometric head of the underflow and regional groundwater may have risen forcing the underflow to become surface flow captured by the flume.

4. Regarding the recommendation under HEC (2022) point 4 above, the Panel agrees. The Panel also recommends that:

    i. Spot flow measurements are taken and used to validate the rating curve for the flume, to further check whether subsidence of the flume or damage to the weir has caused flow estimation errors.

    ii. Repairs to the weir are carried out.

In summary, the Panel concludes that HEC (2022) has undertaken a detailed analysis of potential reasons for the apparent flow anomalies. While there remain questions about the sufficiency of both the flow measurements and the model used for that analysis, the Panel agrees with the main conclusions and recommendations of that report, including that the flow anomalies observed may be partially due to enhanced release of groundwater due to subsidence effects. However, there are additional hypotheses for the flow anomalies that should be explored.

Regarding the timing of the flow anomaly in relation to mining, the clear flow anomaly in Figure 13 and Figure 14 begins in August 2020, whereas mining of LW27 ceased in early 2017, so it seems unlikely that this change in flow response is associated with basal shear plane movement as a result of mining, unless this happened during the 300 longwall series. Predicted valley closure due to cumulative effects of LW302 to LW308 are shown in Figure 10. This shows a small increase in predicted closure from rockbars ETAU to ETAM due to the extraction of LW302 and LW303, being a maximum 25 mm in the vicinity of ETAM. Subsequent longwalls do not result in any increases in predicted valley closure. Where there are closure increments due to LW302 and LW303, it is only in the vicinity of ETAM that the predicted cumulative closure reaches above 125 mm. The Panel concludes it is conceivable but unlikely that ground movements upstream of the Eastern Tributary flow gauge since 2017 were significant enough to increase hydraulic conductivity of shear planes. The Panel recommends that available measurements and predictions of ground movements due to the 300 series of longwalls, including measured valley closures, are reviewed to determine if ground deformation might be responsible for changes in flow responses observed since August 2020.

In summary, the Panel recommends:

1. Extension of the Eastern Tributary flow gauge rating curve as recommended in HEC (2022); also spot measurements of flow covering flow rates as high as safely practicable; and urgent repair of the weir. Revised rating curves and the spot measurements of flow should be published in annual reports.

2. Re-analysis of the flow data including the most recent data. This analysis should be of the nature of HEC (2022) but also consider the possibility of increased flows being related to high groundwater or reservoir levels or errors in the modified AWBM model.

3. Further reporting of the modelling in annual report appendices should contain details of the modified AWBM model and parameter values needed to allow independent assessment.
4. If it is concluded after review and extension of the rating curve and analysis using the most recent flow data that baseflows may have substantially increased due to subsidence effects, further investigation should be undertaken regarding the source of the increased baseflow and its significance for aquatic ecology and water quality entering the Woronora Reservoir.
5. The Metropolitan Coal 2023 Annual Report should provide information on the success of the Eastern Tributary remediation program.

5.2.3. Pool levels

The Dupen Report proposes that the drying of pools over a 500 m length of the Eastern Tributary (Figure 1) supports the ridge fracture drainage hypothesis [29]. This is based on the concept in Figure 6 that water is diverted from the ridges and hillsides through vertical fractures and shear planes into the fractured zone below the creek. The Report includes the statements *'This evidence includes the unpredicted drying of all pools along a partly undermined section of Eastern Tributary'*[30] and '*Since 2017, the previously permanent Pools ETAG to ETAR (Figure 11) have been dry except for short periods following major rainfall events'*[31].

The latter statement does not accurately reflect the data, which shows that outside the period of unusually dry weather from 2017-2019 (see Figure 12), the pools were generally flowing in the reported period (2017-2022). This is illustrated in Figure 15 for pool ETAI, which is generally representative of the data for other pools from ETAG to ETAR (as shown in Peabody (2023), Charts 5-12) although pools ETAM to ETAR are less frequently dry during the dry weather of 2017-2019. This shows that weather is the dominant control on pool levels. Nevertheless, mining subsidence consequences on pool levels and drainage at pools ETAG-ETAR have been acknowledged (Peabody, 2023)

In order to support the hypothesis that ridge fracture drainage and pool drying in the Eastern Tributary during 2017-2019 are connected, the Dupen Report proposes that loss of pool water due to fracturing of rock-bars, which has been widely observed in the Waratah Rivulet, is an unlikely reason for dry pools in the Eastern Tributary. The Panel does not accept the reasons behind this argument, as explained in Section 5.2.1 of this advice report.

The Dupen report states[32]:

> *"It is worth noting that, if shear planes have indeed been widely developed beneath the valley axis as hypothesised in Section 3.2, the remedial design that was used with considerable success at Waratah Rivulet may not be successful in restoring surface flows to Eastern Tributary".*

This is yet to be tested: the remediation, which started in the Eastern Tributary in 2020-2021, was not assessed by Peabody in the Metropolitan Coal 2022 Annual Report. The Panel assumes this lack of assessment was due to lack of pool level data during 2022 and anticipates

[29] p22 of Dupen, 2023b
[30] pES1 of Dupen, 2023b
[31] p18 of Dupen, 2023b
[32] p21 of Dupen, 2023b

an assessment in the 2023 Annual Report. However, this is unlikely to provide definitive further evidence regarding the hypothesis. If assessments of pool levels show that remediation has not been successful, this indicates that flow is being diverted downstream by fractures deeper or wider than the influence of the remediation, possibly but not necessarily including shear planes. Therefore, while the assessment of the outcome of the remediation of the Eastern Tributary is essential, it is not critical to testing the hypothesis.

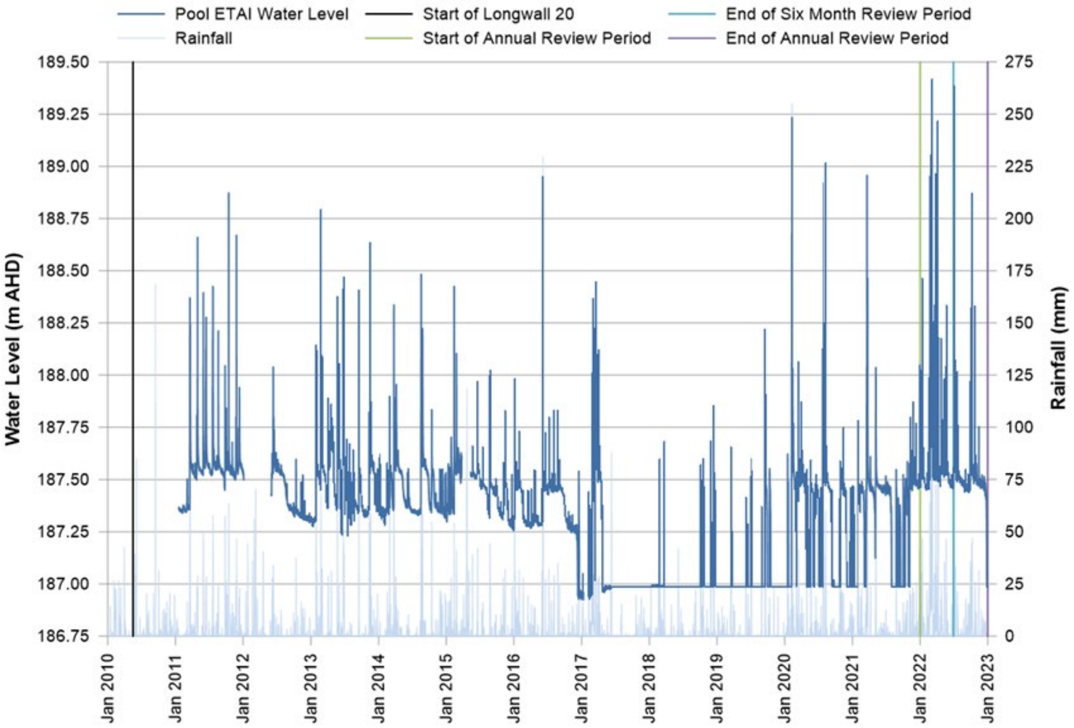


Figure 15: Chart 7 from Peabody (2022) showing recorded water levels at Pool ETAI

5.2.4. Bedding planes shears

The Dupen hypothesis lacks clarity as to the criteria used by Dupen to define shear planes as *'large-scale'*. The Panel considers that these criteria should at least include the regional extent of a shear plane and the magnitude of shear displacement that it has undergone. The magnitude of shear displacement is not considered in the Dupen Report.

Figure 4 of the Dupen Report (reproduced as Figure 6 of this advice report) is a schematic that represents most of the perched and regional groundwater flow and discharge processes that occur in the Hawkesbury Sandstone landscape across the Southern Coalfields. However, the schematic is not representative of the specific groundwater processes that are occurring in the Eastern Tributary catchment. The schematic shows:

- bedding shear planes daylighting on the valley side and labelled *'Subsidence-induced basal shear planes as intercepted by T3 and TBS02*.

  These are shown as both linear and extensive beneath both the valley sides and valley floor. The Panel believes that the nature of the valley side shears is exaggerated in this schematic. The Panel's visit to the Eastern Tributary area on the

10 May 2023 did not locate any valley side shears that were actively discharging regional groundwater.[33]

TBS02 is located over the centreline of LW302 and TBS03 is located over the centreline of LW303, both adjacent to the Eastern Tributary. WRIS (2019) reported that bedding plane shear movement occurred at depths of 105 m, 114 m, 162 m and 202 m below surface, with the deeper bedding plane being at approximately the top interface of the Bald Hill Claystone. The WRIS Panel reported that the extent of shear movement at each horizon differed slightly but was in the range of at least 20 mm – 50 mm and that there were only very small differences in hydraulic conductivity for the 105 m, 114 m and 162 m horizons, but a dramatic increase in hydraulic conductivity for the 202 m shear horizon at the top of the Bald Hill Claystone (shown in Figure 5 to be some 70 m below the Eastern Tributary). It concluded that the results confirm the view that whilst shears can occur on multiple horizons, not all horizons represent increased flow paths.

- *'inferred sub-vertical fractures due to valley bulging'.*

  The caption to Figure 4 of Dupen (2023) refers to the inferred sub-vertical fractures as being *stress relief fractures.* As the valley sides are not subjected to lateral stress, stress relief is not a plausible mechanism for inducing vertical cracking. However, sub-vertical fracturing can be associated with conventional subsidence (subsidence troughs) and with unravelling of slope material caused by subsidence movement, although these fractures tend to close. This is because surface alluvium and rock displace downhill under the effect of gravity, resulting in tensile strains accumulating towards ridge tops and being expressed as wide, open cracks. For example, Galvin (2005) reported the presence of a +200 mm wide crack on a fire trail at the top of the ridge above Waratah Rivulet.

Against this background, subsidence can be expected to increase the capacity of the surface to absorb rainfall, however, the distributions and depth of the inferred subvertical fracturing shown in Figure 4 of the Dupen Report (Figure 6 of this Panel Advice report) is considered highly conceptual and very unlikely to represent the situation in the field.

The Panel concludes that the subsidence environment and ground response to subsidence is not unique to Eastern Tributary and, therefore, if the drainage mechanism hypothesised by Dupen has merit, it should be able to be validated by field evidence at other sites above mine workings at Metropolitan Coal Mine and at other mines operating in similar topography in the Southern and Western Coalfields of NSW. The Panel is unaware of any other such evidence.

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[33] The Panel does not consider the photo of the bedding plane shear shown in Figure 6 of the Dupen report to be representative of the process being hypothesised by Dupen. The photograph has appeared in multiple publications, including as Figure 10B in the first report of the IEPMC (OCSE**,** 2018) where it was captioned:

> *"Photographs taken in a railway cutting undermined by approximately 150 m wide longwall panels at an approximate depth of 300 m (W/H ~0.5) in the Southern Coalfield showing the development of vertical fractures and shear displacement on bedding planes in response to mining-induced subsidence.*"

5.2.5. Hydrogeological behaviour

Figure 4 in the Dupen Report, reproduced as Figure 6 of this advice report, and associated explanations in Sections 3.2 and 3.3 of the Dupen Report are an over-simplification of the groundwater flow processes in the Waratah Rivulet and Eastern Tributary catchments.

It is important to recognise that for these two catchments:

- There are localised shallow perched water tables in upland swamp colluvium and underlying/adjacent weathered sandstones;
- The regional water table occurs at depth beneath the ridgelines, and naturally discharges to permanent streams. Regional groundwater does not present or discharge at elevated sites on the valley sides;
- The regional water table is a subdued reflection of the topography and in these catchments does not support the upland swamps or terrestrial vegetation on ridgelines and steep hillslopes; and
- The post mining water table does not always occur at depth below previously gaining streams – the current conceptualisation suggests there are most likely connected gaining and losing sections along Waratah Rivulet and the Eastern Tributary (Peabody, 2022a) but that overall regional groundwater continues to flow to these streams.

Dupen argues that the transect boreholes T1 - T6 (located above the northern portion of LW305 and LW306 adjacent to Woronora Reservoir) provide a good profile of aquifer levels through the upper aquifer (Hawkesbury Sandstone) within the ridge immediately east and west of the reservoir.

While the Panel agrees that these monitoring bores are useful to assess the regional water table elevation and level variations between the ridgeline and the reservoir, these locations do not provide any vertical piezometry data to better understand lateral and vertical flows, and the potential for deep drainage. Ideally, to better understand groundwater flow in the fracture network, a more appropriate design would have included multiple (3 or 4 elevation) level monitoring in separate monitoring bores with the lower two intervals occurring below the minimum reservoir level.

Two of the five transect boreholes (T3R and T1) confirm the intersection of a fracture zone that is hydraulically connected to the Woronora Reservoir. Water levels at these two sites rise and fall with reservoir levels. The latest published trends for all six transect bores are shown in Figure 16.

Dupen states:

> *The aquifers which sit above and feed the incised valley streams are draining at rates measurably higher than pre-mining, in places rapidly and completely, due to unexpected and unpredicted formation of large-scale shear planes opening up at their base. These shear zones are inferred to be 500 m long in one location and over 250 m wide at another. Where they are developed they appear to be acting as drains centred on the undermined valley centers which now accommodate creeks and Sydney's stored drinking water (Figure 4)* [Figure 6 of this advice report].

Dupen does not provide corroborating evidence of substantial aquifer drainage. The groundwater data provided by Metropolitan (SLR, 2023b) show no large scale groundwater drainage in the near surface environment. Only one borehole over the 300 series longwalls shows any near surface impact from mining, namely: Swamp 50 10m Piezometer where the perched water level fell by 6.5 m (SLR, 2023b). The sharp decline occurred during the passage of LW304 followed by stabilisation and some recovery.

For the Hawkesbury Sandstone aquifer, there are many monitoring sites at ridgeline locations with multiple depth sensors that show no evidence of aquifer depressurisation or drainage (SLR, 2023b). Many sites show subtle increases in water table levels during recent years as a result of increased rainfall recharge and/or an increase in the Woronora reservoir level. However, the borehole T1 to T5 transect does show some evidence of mining-induced water level declines (Figure 14 in this report taken from SLR, 2023a):

- Water level in Borehole T5 has declined by 10-12 m since the commencement of LW305;
- Water level in Borehole T4 (inoperable since August 2021) declined by approx. 5 m at the commencement of LW306; and
- Water level in the original Borehole T3 declined by approx. 5 m at the commencement of LW305 but has since risen in the deeper replacement bore T3-R with the increase in the reservoir storage levels.

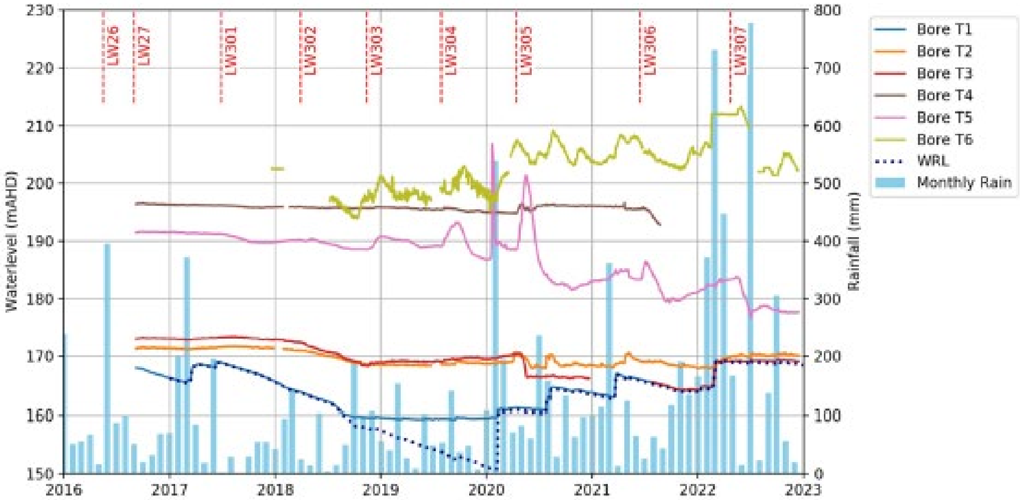

Figure 3 Groundwater hydrographs for bores T1 to T6 compared with reservoir water level and rainfall

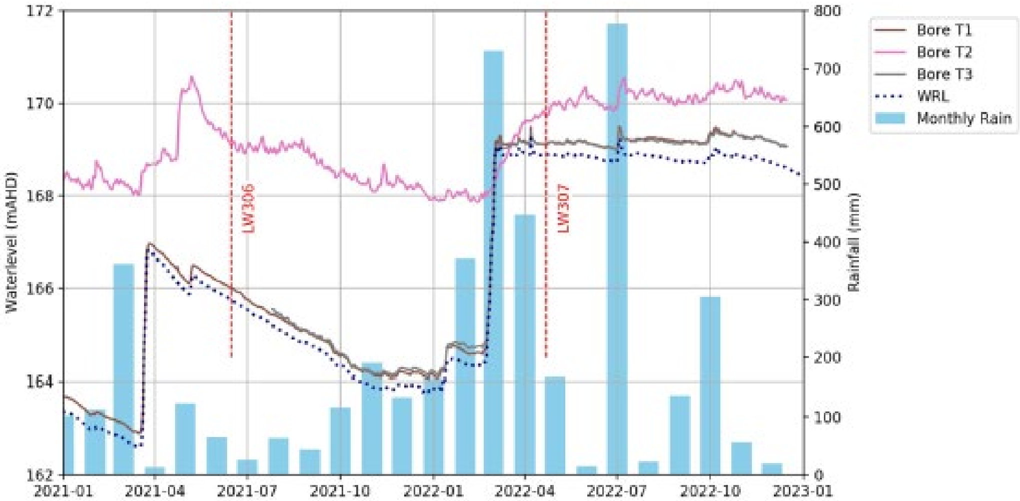

Figure 4 Groundwater hydrographs for bores T1 to T3 compared with reservoir water level and rainfall

Figure 16: Groundwater hydrographs for transect boreholes T1 to T6. (Figures 3 and 4 from SLR, 2023a)

Gradients are still towards the reservoir and the observed declines at just one transect cannot be considered sufficient evidence of substantial aquifer drainage to creek lines and the reservoir through the ridge fracture drainage mechanism without a better understanding of the vertical piezometry and spatial/temporal variations in the Hawkesbury Sandstone groundwater system.

The inferred sizes of the basal shear with increased transmissivity due to mining associated with the Eastern Tributary seems to be solely inferred from the length of the 'dry' section of Eastern Tributary and the position of Borehole T3 lower in the catchment. As noted in Sections 5.2.1 and 5.2.3, there is evidence that the 500 m dry section identified by Dupen is not completely dry and surface flows do occur. Underflow is apparent for the section but the connection to a large-scale basal shear extending along the full length of the 'dry' tributary cannot be confirmed by the available observations. It is clear that the groundwater at Borehole location T3 has a strong connection to the reservoir and while this indicates how far away from the reservoir a high conductivity connection can extend, it also cannot define the length of tributary or reservoir section that it connects to. Without further observations these data do not provide strong support to the ridge fracture drainage hypothesis.

There are several hypotheses that can explain the drop in water level at Borehole T3 including by fracturing connecting the borehole to an existing basal shear that has already been identified in Borehole T1. The Panel is of the view that the change in conditions in May 2020 at Borehole T3 is most likely due to local ground movements forming a connection between the local groundwater at the measurement depth in Borehole T3 with an existing underlying fracture or basal shear that is also identified in Borehole T1. The fracture permeability is sufficiently high to bring the hydraulic head at location T3 close to the reservoir water level.

As noted in Section 3.0, Dupen states that there are only two hydrogeologically plausible hypotheses that he can think of which could account for behaviours in streamflow affected by subsidence, the first of which is related to crushing of bedrock due to non-conventional subsidence impacts to create a 'tunnel' of shallow fractures. He states that *'it is difficult to comprehend using this conceptual model, how sub-surface flows through a 500 m long, poorly interconnected "crush zone" of compressive fractures can have mimicked above-ground catchment flow responses as closely as shown in Figure 12 since the desiccation event in 2016/2017'.*

The Panel does not agree with the reasoning presented by Dupen because the comparisons of catchment flow responses in his Figure 12, reproduced as Figure 3 of this advice report, are based on observed and modelled daily flows. The modelled flows are derived using the Australian Water Balance Model (AWBM), which is a spatially lumped catchment model. Neither this model nor the use of daily flows are designed to simulate local (500 m scale) effects on flow travel times, and so Figure 12 in the Dupen Report should not be used to support or challenge the "tunnel" concept. The Report goes on to state "*I also struggle to identify a plausible mechanism for the increasing flows observed since about October 2021 using this conceptual model*". While other mechanisms can be identified to explain the increasing flows, no mechanism has been validated to explain the increased flows at this stage. The increased flows need to be better understood, as has been partly addressed by HEC (2022) and commented on by the Panel in Section 5.2.2.

5.2.6. Evaluation summary

The Panel's findings from its evaluation of the primary Dupen hypothesis and statements can be summarised as follows.

An important initial observation is that the subsidence mechanism underpinning Dupen's hypothesis is not new. However, Dupen has placed new emphasis on the significance of this mechanism for the long-term behaviour of the regional groundwater system and the resulting downstream impacts on the quantity and quality of water entering Woronora Reservoir and upstream impacts on the hydrology and ecology of ridge line ecosystems. Previous studies and investigations have addressed ground movements on basal shears and have assessed the magnitude of associated impacts on the groundwater system. These studies do not provide evidence supporting major impacts of the style and magnitude suggested in the Dupen report.

Dupen's hypothesis was developed through assessment of several features of the data collected from monitoring of surface and groundwater conditions in and around the Eastern Tributary. The data relied upon by Dupen has been reviewed by the Panel as well as that derived from additional studies undertaken by Metropolitan Coal's consultants. While corrections to the stream flow data have been made by the consultants, these have not removed the anomalies used by Dupen to build his hypothesis. Nevertheless, the further review has offered up viable alternative explanations for the anomalies. Neither Dupen's hypothesis nor the alternative explanations can be validated at this time based on the available evidence. For this reason, a range of additional work is recommended to provide the necessary field evidence to support or reject each of these explanations for the mining-induced impacts on both groundwater and surface water.

A wider assessment of the groundwater data, including more recent data than that available to Dupen, has not provided evidence of the widespread dewatering of the regional groundwater system predicted by Dupen's hypothesis. Dupen's interpretation of the impacts of changing groundwater baseflow contributions to Woronora Reservoir arising from his hypothesis is also not consistent with enhanced basal shears and the dewatering of the Hawkesbury Sandstone aquifer beneath the ridgelines.

The Dupen Report recommends stopping mining until the validity of the Dupen hypothesis has been adequately tested and the long-term implications of groundwater dewatering are fully assessed. As noted above, consideration by the Panel of a wider set of data, notably of groundwater responses to mining, indicates that the inferences made by Dupen about the scale of impacts unfolding on the regional ecology and the Woronora Reservoir are likely overstated. For this reason, the Panel does not agree with this recommendation.

Even though the scale of impacts suggested by Dupen are not expected by the Panel to be as large as Dupen predicts, the Panel accepts that components of Dupen's hypothesis should be evaluated through new data collection and further interpretation to build confidence in Metropolitan Coal's assessment of the long-term impacts of mining under the catchment.

If the drainage mechanism hypothesised by Dupen has merit, it should be able to be validated by field experience at other sites above mine workings at Metropolitan Coal Mine and at other mines operating in similar topography in the Southern and Western Coalfields of NSW.

5.3. EVALUATION OF OTHER DUPEN STATEMENTS

5.3.1. Implications for aquifer storage and baseflows

> *The aquifers which sit above and feed the incised valley streams are draining at rates measurably higher than pre-mining, in places rapidly and completely, due to unexpected and unpredicted formation of large-scale shear planes opening up at their base.*
>
> *The desaturation of the undermined ridges hypothesised in Section 3 is likely to continue for some years or decades to come even if mining is stopped at this point.*
>
> *My interpretation of the reported trends (Section 3.5) is that flows in Eastern Tributary and probably other undermined streams are currently being affected by increased draining of the undermined ridges through basal shear planes. Once a new equilibrium is established, quicker and smaller baseflows may reduce overall flows to the Reservoir.*

The Panel is of the opinion that apart from the water level declines observed at three bores along the T1-T5 transect, there is no evidence of widespread desaturation of the ridges around the reservoir from monitoring groundwater levels in the shallow Hawkesbury Sandstone aquifers at any other locations across the catchment. If the Dupen hypothesis is correct, then there should be evidence of regional groundwater depletion within days to weeks based on the apparent increased flows in the Eastern Tributary. The observed localised declines at the transect bores cannot be considered sufficient evidence of substantial aquifer drainage beneath the catchment ridgelines.

If ridge fracture drainage were occurring, it is unlikely that "*Once a new equilibrium is established, quicker and smaller baseflows may reduce overall flows to the Reservoir.*" Indeed, any lowering of groundwater levels would likely increase overall flows due to accelerated drainage and reduced evapotranspiration. Overall flows could reduce if the changes in hydraulic conductivity of the shear planes meant that water was being diverted to outside the Woronora catchment, but there is no evidence to suggest that inter-catchment diversions of flow is happening. In summary, the Panel is of the view that the ridge fracture drainage hypothesis has no bearing on overall flow volumes into the reservoir.

> *The mining-induced shear planes and fractures are causing the drainage of the sandstone aquifers within the ridges that lie above the undermined creeks and stored waters. The desaturation of the aquifers through the newly imposed fracture system would permanently change the hydrological ecological and geochemical nature of the drinking water catchment.*

The current 300 series longwall designs have been adopted to minimise the risk of hydrological impacts to the Woronora Reservoir by minimising the likelihood of vertical leakage. The available field observations are consistent with the adopted design aims. The historical and current longwall design also appear to have limited impact on the regional groundwater system based on the available evidence, however additional monitoring of the piezometry within the Hawkesbury Sandstone aquifer for the remaining longwalls in the current 300 series is required to confirm any long-term drainage impacts.

The ecological and geochemical implications are reviewed below.

5.3.2. Implications for water quality

> *Formation of rapid subsurface flowpaths through fractures are expected to add a substantial but as yet unquantified addition of metal and salt (drinking water contaminants) discharged into this drinking water via subsurface springs created by basal shear planes*
>
> *The discharges of water diverted through these new fracture systems are emerging with high concentrations of iron, manganese, aluminium and other metals and salts. The sampled discharges to the reservoir from Eastern Tributary already appear to be breaching performance measures, and these effects can be expected to worsen significantly as unmeasurable discharges from aquifer drainage emerge at or below the axis of the valley. The long-term fate of these additional contaminants in the reservoir is currently unknown, but so far the dissolved metal concentrations have not been greatly elevated at the drinking water off-take at the northern end of the reservoir near the Woronora Dam wall.*

The quantity of natural contaminants that will enter the reservoir will be directly related to the size and density of fracture/shear zone that has occurred. If the fracture zone due to valley closure is restricted to the tributary floor and neighbouring rock then the total contaminant mass may be quite limited. However, it is not immediately possible to determine the size or density.

The question of water quality is out of scope of the current Panel and the reader is referred to IEAPM (2023).

5.3.3. Implications for ecosystems/swamps

> *A likely result of these changed baseflow patterns is that a large proportion (potentially all) of the riparian, swamp and forest ecosystems on the undermined ridges will become drier and presumably less capable of filtering surface flows entering the reservoir (ES2)*

The regional groundwater table under the ridgelines (between 50 and 70mbgl based on available piezometric data) is well below the limit of groundwater extraction by terrestrial ecosystems. There is no evidence to suggest that these terrestrial ecosystems on the ridgelines and steep slopes will become drier.

The riparian, swamp and forest ecosystems all rely on the moisture in the shallow soils and any perched groundwater at shallow depth. The upland swamps in these catchments are maintained by perched groundwater that is not in hydraulic connection with the regional water table. Provided there is no fracturing of the base of swamps that causes accelerated drainage of perched groundwater, then these terrestrial ecosystems should continue to survive. They are maintained by rainfall, interflow and runoff from adjacent sideslope areas and should continue to filter runoff that enters the permanent streams and the reservoir.

All available borehole data indicate that there has yet to be any significant impact to the shallow perched groundwater systems other than the weathered sandstone underlying Swamp 50 and here the impact of the groundwater decline is not likely to be sufficient to impact the near surface hydrology or ecological functioning of the swamp.

> *Extensive fracturing in the Hawkesbury Sandstone aquifer is leading to desaturation of the ridges around the reservoir, as well as the possibly permanent loss of ecologically important surface flows*

The lack of evidence for desaturation of shallow groundwater beneath the ridgelines is discussed in Section 5.3.1.

There is no evidence for the permanent loss of baseflows that help to sustain surface flows. In fact, stream flow data primarily since August 2020, suggest an increase in flows compared to model predictions (Section 5.2.2)

5.3.4. Implications for performance measures and indicators

> *Contrary to Peabody's interpretation, my conclusion from the review reported herein is that a diversion of around 500 m of virtually all surface water flows via subsurface channels (Figure 1) constitutes more than a negligible environmental consequence, and therefore an exceedance of the Performance Measure*
>
> *The Performance Indicators now used to enable evaluation of Performance Measure success in respect to Eastern Tributary are unfortunately not useful for evaluating the environmental consequences of basal shear planes developing beneath the stream surface, a mechanism which was not predicted nor yet publicly recognised. The Environmental Indicators provided in the 2021 Annual Review are focused instead entirely on the important role of protecting the integrity of the flow gauge at Rockbar ETAU*

Diversion of nearly all surface water into the subsurface is not correct based on observations of flow and pooling in the tributary.

It is acknowledged by Peabody (2022a) that mining has resulted in environmental consequences in regards to the drainage behaviour of the rock pools ETAG, ETAH, ETAI, ETAJ, ETAK, ETAL, ETAM, ETAN, ETAO, ETAQ and ETAR along the tributary (although the performance indicator relates only to pools ETAS, ETAT and ETAU, which are not reported to be impacted and the Panel has no reason to suggest that they have been). Current understanding is that these exceedances are due to surface fractures in the creek, and remedial measures are being employed with the aim of restoring the affected pools and surface water flows (see comments in Sections 5.2.1 and 5.2.2). The observations in the Dupen Report regarding diversions of flow from the ~500 m length of Eastern Tributary has no new implications for whether the performance measures are being met.

The unexpected increase in flows that is seen in Figure 13 does not breach the quantity component of the performance measure "*negligible reduction in the quantity and quality of water resources reaching the Woronora Reservoir*" as the flows to the reservoir are higher than expected. The Dupen Report considers long term changes to the flows by suggesting that *"Once a new equilibrium is established, quicker and smaller baseflows may reduce overall flows to the Reservoir"*[34] but does not present the basis for this suggestion. The Panel agrees that the pattern of baseflows to Woronora Reservoir would change if the Dupen hypothesis is correct. This is because of the more rapid transit of water through the groundwater system leading to quicker rises and falls in the baseflow component of the reservoir inflows. However, the Panel does not agree with the suggestion that the baseflows would be smaller. The total volume of baseflow would only reduce if groundwater recharge is reduced or if groundwater is diverted out of the reservoir catchment. The Dupen Report identifies higher groundwater recharge conditions as *"stress relief fractures are expected to result in increased infiltration of rainfall runoff from undermined ridge surfaces and soil-rock interfaces"*[35]. No mechanism is presented in the report that indicates that groundwater is likely to be diverted away from the reservoir catchment. In these circumstances, inflows to the reservoir are not expected to reduce unless the climate changes. This is contrary to Dupen's assertion.

Of greater significance for catchment yield to the Woronora reservoir is the potential impact of subsidence on the quality of flows reaching the reservoir. This is an issue associated with mining subsidence impacts whether or not the Dupen hypothesis is accepted. The monitoring and assessment of water quality in the Eastern Tributary has been considered by a separate IEAPM panel (IEAPM**,** 2023).

As covered in Section 5.3.3 the Panel considers that the Dupen Report has no implications for performance measure *Negligible impact on Threatened Species, Populations, or Ecological Communities* in relation to riparian and swamp ecosystems. If long-term changes to baseflow regimes are confirmed by the further analysis, the potential implications for that performance measure in relation to aquatic biota will need to be considered.

5.3.5. Dupen Report recommendations

> *Consideration should be given to applying causal science to the analysis of volumetric and water quality changes discussed in this report, in order to truly understand the*

[34] p28 Dupen (2023)
[35] p26 Dupen (2023)

impacts of what is now unfolding in the catchments of Sydney's water supply due to Metropolitan's proposed progress towards the deepest parts of the catchment.

Data collection to date at the mine has not been focussed on developing statistical models to examine the linkages between cause and effect. Consequently, new data plans would be needed to underpin a causal science assessment based on statistical approaches. New statistical techniques would be required to accompany the new data that would be difficult to explain and demonstrate to both mine owners and the regulators. This would take considerable time given the complexity of the natural environment applicable to hydrology and hydrogeology and the limitations of modern data collection methods. It would not be guaranteed to add new knowledge in time to be effective.

At this point in time, the Panel considers that stage assessing causal relationships through traditional modelling using deterministic flow models combined with careful sensitivity studies that are implemented by experts and rigorously peer reviewed represents the most effective means of eliciting the necessary knowledge about the system responses given current practices. It will also be the most easily understood by the operators, regulators and the wider community.

As the Dupen Report demonstrates, inferences about hydrogeological processes based on sparse data sets with unrecognised errors are fraught with difficulties. These difficulties are not likely to be reduced by adopting a new paradigm for their analysis.

6.0 SUMMARY PANEL ADVICE

The nature of the structure and content of the Dupen Report results in a range of conclusions and recommendations being developed progressively throughout the Panel's advice report. The reader is referred to these for further insight into the following summary advice:

Identify and comment on the elements of the Report that are relevant to the operation and environmental performance of Metropolitan Coal

Subsidence Focussed

1. The two basic mining-induced elements that constitute Dupen's hypothesised *ridge fracture drainage* model are sub-vertical surface fractures and sub-horizontal bedding plane shears. Both elements are well established in subsidence engineering and, individually and collectively, have been the subject of a number of detailed subsidence and hydrogeological studies in the Southern Coalfield over recent decades for the purpose of detecting and monitoring their formation, including at the Eastern Tributary. Hence, ridge fracture drainage cannot be considered a *new subsidence mechanism.*
2. If the Dupen hypothesis concerning surface flows and shallow groundwater being widely diverted and drained as a result of mining-induced fracturing is validated then ridge fracture drainage could, arguably, be considered to be a *new subsidence consequence*. This depends on the spatial scale and the magnitude and distribution of shear displacement on what Dupen refers to as *large scale shear planes opening up at their base,* in comparison to documented past experience. The term *large scale* is not defined in the Dupen Report.
3. The Dupen Report does not provide sufficient evidence to cause the Panel to believe that the scale of bedding plane shears in the vicinity of the Eastern Tributary might be materially different to that of other shear planes detected and studied in the Southern Coalfield.
4. Due to the low values of predicted incremental valley closures during the 300 series of longwalls, it is unlikely that ground movements were significant enough to increase the hydraulic conductivity of shear planes in the Eastern Tributary during the period of flow anomalies.

Groundwater Focussed

5. Perched water in swamp colluvium and very shallow weathered Hawkesbury Sandstone is hydraulically disconnected from the deeper regional groundwater systems and will not drain unless near surface fracturing intersects these features. There is no clear evidence of drainage of these shallow groundwater systems in the available monitoring records.
6. There is no evidence from Metropolitan Coal's groundwater monitoring network (except at the transect bore locations overlying LW305 and LW306) that water levels in the Hawkesbury Sandstone aquifers across the Eastern Tributary catchment have fallen and desaturated the ridgelines. In fact, most monitored regional water table levels have stabilised or risen in recent years.
7. Alternative explanations of the increased surface flows at the Eastern Tributary gauging station observed since August 2020 (which corresponds with the commencement of an above average rainfall period) include:
   i. underflow that previously discharged to Woronora Reservoir downstream of the Eastern Tributary gauging station is now reporting as surface water flow upstream of the gauging station; and

ii. larger volumes of (natural) interflow and regional groundwater are discharging and contributing to surface water flows across the whole catchment.

8. Increased groundwater discharge is potentially consistent with the Dupen hypothesis of sub-vertical fractures and shears with enhanced hydraulic connection connecting regional groundwater to the Eastern Tributary. However, there is no widespread evidence of a reduction in water levels or groundwater storage volumes across the catchment in the Hawkesbury Sandstone aquifer, which is contrary to the Dupen hypothesis.
9. Beneath ridgelines and hillslopes, the absence of permanent springs and any obvious perched groundwater (apart from in the vicinity of swamps) suggests most rainfall recharge (apart from that portion that is lost to evapo-transpiration and via interflow after rain) drains vertically to the regional water table and then moves laterally to emerge in the base of the valleys as baseflow.
10. The shallow perched water table in colluvium and underlying/adjacent weathered sandstone supports upland swamps. The upland swamps will not drain and will not be impacted unless near surface fracturing intersects and drains these features.
11. The regional water table occurs at depth beneath the ridgelines, and naturally discharges to permanent streams. Regional groundwater does not discharge at elevated sites and does not support ridgeline and hillside terrestrial ecosystems, however it may contribute to some riparian communities.

Surface Water Focussed

12. Metropolitan Coal (through consultants) has undertaken a detailed analysis of potential reasons for the Eastern Tributary flow anomalies that Dupen uses to support the ridge fracture drainage hypothesis. The Panel agrees with main conclusions and recommendations from that analysis, being:
    i. There are serious errors in the flow data used by Dupen but this is not the reason for the anomalies. To address these errors the rating curve for the Eastern Tributary should be extended to improve high flow measurement accuracy.
    ii. The flow anomalies are unlikely to be due to subsidence movements of the flume.
    iii. The controlled burn conducted from September 2021 to March 2022 in the Eastern Tributary catchment has likely contributed but, by itself, is unlikely to fully explain the flow anomalies.
    iv. The flow anomalies may be related to mining-induced increases in the hydraulic conductivity of the creek bed.
13. Additional to the considerations in the consultant's analysis, the Panel concludes that:
    i. While blockage of the flume by debris is another potential reason for the flow anomalies, regular inspection and clearance of the flume makes this unlikely.
    ii. Errors in the rainfall-runoff modelling may also contribute to flow anomalies, including non-linearity in the groundwater storage-discharge relation and non-stationarity in hydrological processes related to drought. This has not been assessed by Metropolitan Coal.
14. Contrary to the observation by Dupen that "*Since 2017, the previously permanent Pools ETAG to ETAR have been dry except for short periods following major*

rainfall events", these pools were generally flowing during 2017-2022 except during prolonged dry weather.

15. The reason for the Eastern Tributary flow anomalies remains unknown, and the Dupen hypothesis cannot be discounted based on the flow data.
16. The status of the pools and whether remediation improves the status of the pools, while important for assessing the environmental performance of the mine, will not be a decisive factor regarding the Dupen hypothesis.

Overarching Conclusions

17. Previous studies and investigations have been undertaken of basal shears and the magnitude of associated impacts on the groundwater system and these do not provide evidence supporting major impacts of the style and magnitude suggested in the Dupen Report.
18. The evidence that Dupen has used for the development of his hypothesis is limited (as acknowledged by Dupen) and incomplete and additional evidence sourced by the Panel confirms that this data contained errors, in some cases of a serious nature.
19. A wider assessment of the groundwater data, including more recent data than that available to Dupen, has not provided evidence of the widespread dewatering of the regional groundwater system predicted by Dupen's hypothesis.
20. Dupen's interpretation of the impacts of changing groundwater baseflow contributions to Woronora Reservoir arising from his hypothesis is also not consistent with enhanced basal shears and the dewatering of the Hawkesbury Sandstone aquifer beneath the ridgelines.
21. Consideration by the Panel of a wider set of data indicates that the inferences made by Dupen about the scale of impacts unfolding on the regional ecology and the Woronora reservoir are likely overstated. For this reason, the Panel does not support the Dupen Report's primary recommendation *"that further undermining of the Woronora Reservoir should be halted until the implications of these unexpected changes now unfolding in Woronora Reservoir Catchment can be urgently evaluated"*.
22. Even though the scale of impacts suggested by Dupen are not expected by the Panel to be as large as Dupen predicts, the Panel accepts that components of Dupen's hypothesis should be evaluated through new data collection and further interpretation to build confidence in Metropolitan Coal's assessment of the long-term impacts of mining under the catchment.
23. If the drainage mechanism hypothesised by Dupen has merit, it should be able to be validated by field experience at other sites above mine workings at Metropolitan Coal Mine and at other mines operating in similar topography in the Southern and Western Coalfields of NSW.

*Provide advice as to what actions or further investigations would be required to test or confirm the hypothesis put forward in the Report*

The Panel recommends (from a groundwater perspective) that:

1. Additional bores (standpipes) be established at the T5 monitoring location to monitor the vertical piezometry in the Hawkesbury Sandstone and to establish whether extensive basal shears occur at depth below this eastern ridgeline area.

2. Additional bores (standpipes) be established at the T6 monitoring location and at other accessible locations overlying the proposed LW311 to LW316 panels as soon as practicable to monitor the natural vertical piezometry in the Hawkesbury Sandstone below this western ridgeline area.

The Panel recommends (from a surface water perspective):

3. Extension of the Eastern Tributary flow gauge rating curve as recommended by Metropolitan Coal's consultant (HEC, 2022); also spot measurements of flow covering flow rates as high as safely practicable; and urgent repair of the weir. Revised rating curves and the spot measurements of flow should be published in annual reports.
4. Re-analysis of the flow data including the most recent data. This analysis should be of the nature of HEC (2022) but also consider the possibility of increased flows being related to high groundwater or reservoir levels or errors in the modified AWBM model (Australian Water Balance Model).
5. Further reporting of the modelling in annual report appendices should contain details of the modified AWBM model and parameter values needed to allow independent assessment.
6. If it is concluded after review and extension of the rating curve and analysis using the most recent flow data that baseflows may have substantially increased due to subsidence effects, further investigation should be undertaken regarding the source of the increased baseflow and its significance for aquatic ecology and water quality entering the Woronora Reservoir.
7. Metropolitan Coal's 2023 Annual Report should provide information on the success of the Eastern Tributary remediation program.

Any other significant advice that the Panel may wish to provide concerning this issue

8. The Panel recommends for the purpose of developing a better understanding of valley closure impacts to inform mine design that, if it has not already done so, Metropolitan Coal undertakes and makes available to the Department, an investigation of mining impacts on the Eastern Tributary that includes an evaluation of:
    i. How predicted valley closure developed incrementally along the Eastern Tributary.
    ii. How well incremental and total predicted valley closure correlated with measured incremental and total measured closure.
    iii. The nature and extent of natural and mining-induced fracturing to a depth of at least 20 m along the Eastern Tributary downstream from the maingate of LW26 to the Full Supply Level (FSL) of Woronora Reservoir (noting that some of these investigations may have already been undertaken).
    iv. How well mining-induced environmental impacts along the Eastern Tributary correlate to both predicted valley closure and to measured valley closure.
    v. The hydraulic characterisation of the fracture system and the underflows that are taking place along that portion of the Eastern Tributary between the maingate of LW26 and the Eastern Tributary gauging station. This could include establishing new shallow groundwater bores in a longitudinal section to assist in better assessing long term water level and water quality behaviour.

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INDEPENDENT EXPERT ADVISORY PANEL FOR MINING

ADVICE RE:

Water Quality Performance Measures for Metropolitan Coal Mine

October 2023

Report No: IEAPM 202310-1(R1)

EXECUTIVE SUMMARY

Overview

On 4 April 2023 the Department of Planning and Environment wrote to the Chair of the Independent Advisory Panel for Underground Mining (IAPUM), which is now the Independent Expert Advisory Panel for Mining (IEAPM, referred to as "the Panel" here on), requesting advice on Water Quality Performance Measures for Metropolitan Coal Mine.

The Metropolitan Coal Project Approval (08_0149) requires Metropolitan Coal to ensure that its mining activities do not cause any exceedance of subsidence impact performance measures that include "*negligible reduction to the quality or quantity of water resources reaching the Woronora Reservoir*" and "*negligible reduction in the water quality of Woronora Reservoir*". While there has been a succession of triggers in recent years indicating a degradation of water quality reaching the reservoir and water quality in the reservoir, Peabody has consistently concluded that the impacts of the Metropolitan Mine have been negligible.

In this context, advice was requested on:

1. *The Assessments Against Water Quality Performance Measures, and whether the justifications and conclusion that the water quality performance measure for Woronora Reservoir have not been exceeded are reasonable.*

2. *Whether the performance indicator for negligible reduction to the quality of water resources reaching the Woronora Reservoir defined in WMPs is appropriate.*

3. *Whether additional water quality monitoring, analysis and/or assessment is required to further determine compliance with the water quality performance measure for Woronora Reservoir.*

4. *Whether any further reasonable and feasible actions to mitigate and manage water quality impacts are considered necessary, beyond the existing requirements to continue implementing monitoring and management programs.*

5. *Whether a cumulative impact assessment study is considered necessary to review water quality trends and potential impacts on drinking water supply from increased metals loads from the catchments impacted by mine subsidence at Metropolitan Mine.*

The Department also noted that it would welcome any other significant advice that the Panel may wish to provide concerning this issue.

This is the first advice provided by the Panel or IAPUM that focusses on water quality, which the Panel views as a topic relevant not only for the Woronora Reservoir but also for the other water bodies subject to mining impacts in the Special Areas. Understanding the advice requires background knowledge of the relations between subsidence, tributary water quality, reservoir water quality and the operational targets of the reservoir. This report provides this basic knowledge, prior to addressing the five items of advice listed above.

Conclusions

The quality of the Woronora Reservoir has been poor during 2022-2023 (and during other periods historically) and has led to significant complications for water treatment and water supply. Although there are natural influences on water quality that might explain the observed variations in water quality, the Panel cannot rule out the possibility that the Metropolitan Mine has had a non-negligible adverse impact.

While dissolved forms of iron, manganese and aluminium (Fe, Mn and Al) are of primary relevance to raw water quality, there is potential for particulate forms to be transported from the catchment into the reservoir and thereafter, in the case of Fe and Mn, be transformed into dissolved forms. Hence, total (dissolved plus particulate) Fe, Mn and Al concentrations are relevant and the reliance on dissolved Fe, Mn and Al concentrations in the Metropolitan Mine performance indicators for water quality reaching the reservoir is unsatisfactory.

The assessments of the quality of water reaching the Woronora Reservoir presented by Peabody in response to level 3 triggers are not based on sufficient data and analysis and therefore do not provide sufficient justification and reasonable conclusions. The assessments do not adequately consider the potential significance of the impaired water quality for the WaterNSW Raw Water Supply Agreement and Water Quality Incident Management trigger levels.

The assessments of the quality of water in the Woronora Reservoir are not based on sufficient data and analysis and therefore do not provide sufficient justification and reasonable conclusions. The Panel considers that the depth of analysis provided in the annual and six-monthly reports, while significant, is incommensurate with the uncertainty regarding mining's potential contribution to the degraded water quality and incommensurate with the consequences of the degradation in terms of the ability of WaterNSW to meet the Raw Water Supply Agreement and in terms of the disruption to operation of the Water Filtration Plant (WFP).

Aside from the need to transition to the use of total metals, the existing descriptions of the performance indicators and trigger levels for the Eastern Tributary and Waratah Rivulet are satisfactory. They will need to be reviewed when and where performance indicators are changed to the use of total metals concentrations.

The performance indicators and trigger levels for the reservoir (which use total Fe, Mn and Al concentrations) are appropriate, although should be subject to annual review.

The significance of the impaired water quality reaching the reservoir can only be fully determined using contaminant loads (concentration x flow rate) as well as concentrations because high loads can coincide with low concentrations and vice-versa. Improved high flow data and flow event water quality is required to understand water quality impacts and to estimate contaminant loads.

Due to data constraints and monitoring practicalities, analysis of contaminant loads will have limited applicability to determining cumulative impacts of mining in the Eastern Tributary and Waratah Rivulets and other catchments that are being undermined as part of the 300 longwall series. Nevertheless, approximate estimates of loads from these catchments will support scenario analysis to assess whether water quality risks from mining are potentially significant for the operation of the reservoir and WFP. Application of contaminant load estimates to future mining areas including baseline periods and control sites will allow a complete Before-After-Control-Impact (BACI) analysis based on loads as well as concentrations.

An appropriate hydrodynamic and contaminant transport model can support determination of whether a measured or estimated increase in metal loads due to mining affects the current or future ability of WaterNSW to meet raw water supply agreements. It can also allow testing of hypotheses that measured changes in water quality in the reservoir are attributable partially to mining. WaterNSW is planning to implement such a model for the Woronora Reservoir in the 2023-2024 financial year. Due to the catchment and reservoir data sets required, and knowledge of reservoir operations required, it is unlikely to be sensible for Peabody to undertake an independent hydrodynamic and contaminant transport analysis.

Temperature and water quality data obtained at various depths through the water column in the upper reservoir would capture both the temperature stratification behaviour and the water quality at this point. As well as supporting assessments of whether changes in the water quality reaching the reservoir due to mining have been non-negligible, these data will be of value in calibrating and validating a hydrodynamic and contaminant transport model of the reservoir.

There would be value in improved understanding of the extent of any increase in iron and manganese concentrations in reservoir sediments. Sediment cores can provide a historical record of changes to inputs to the reservoir though it should be recognised that increased inputs are likely to be associated with both high rainfall events and, possibly, increased loads of iron and manganese as a result of mining.

The program of remediation (grouting of fractures) in the Waratah Rivulet and Eastern Tributary has contributed and continues to contribute to the sealing of fractures and reducing subsidence-induced contamination. The Panel expects this program to continue to have positive impacts on contaminant loads to the reservoir. However, because the grouting cannot and does not aim to seal all fractures that interact with the surface flows, the Panel does not expect the remediation to return contaminant concentrations or loads to pre-mining values.

At this time, the Panel does not advise additional mitigation and management measures (aside from the monitoring and analysis recommended above) beyond the ongoing grouting program.

Long-term risks to water quality in the Special Areas arise from:

- The potential for cumulative consequences of historical, current and future mining areas on reservoir water and sediment composition and quality.

- The potential for widespread mobilisation of contaminants from subsidence fractures if regional groundwater levels and pressures rebound.

The current advice partially addresses these concerns for the Woronora reservoir by recommending monitoring and analysis that supports a better understanding of the contaminant loads from longwall mining areas of the catchment, improved capability to predict the consequences for water quality supplied to the WFP and better baseline data and modelling capability for assessing future mining proposals.

If the unexpectedly high flow rates that have been measured at the Eastern Tributary from early 2020 to late 2022, which are assessed in detail in IEAPM (2023), are due to increased groundwater discharge through subsidence fractures or shear planes, they may be associated with highly elevated contaminant loads. This illustrates the need for reporting of contaminant loads wherever possible with available data. Furthermore, measurement of water chemistry can assist in determining the source of these unexpectedly high flows.

Recommendations

Performance indicators and associated trigger levels for water reaching the Woronora Reservoir should be assessed using total Fe, Mn and Al where sufficient baseline data exist. Both total and dissolved Fe, Mn and Al concentrations should be reported in six-month and annual reports.

Contaminant loads as well as concentrations should be considered in performance measure assessments and six-monthly and annual reporting as far as data allow. Current data limitations mean that reliance on concentrations for monthly assessment of performance indicators is appropriate for the current series of longwalls.

Flow event water quality (including dissolved and total Fe, Mn and Al concentrations) using automatic samplers at ETWQ AU, WQWQ9 and WOWO2 should be obtained to support analysis of contaminant loads. At the same sites, continuous measurements of electrical conductivity, pH, redox potential, and turbidity should also be obtained.

After a database of flow and concentration measurements has been built up, analysis should be conducted towards generalisation of flow-concentration relationships, and approximation of loads, and whether these have changed as mining has progressed. Initial results including total Fe, Al and Mn loads at ETWQ AU, WQWQ9 and WOWO2 should be reported in the 2024 Annual Report and updates provided in subsequent annual reports.

For future mining areas, flow and contaminant concentrations should be measured and loads estimated at least two years in advance of mining at impact and control sites to allow BACI analysis.

Suitable methods for improving the extension of the Eastern Tributary rating curves to improve high flow measurement accuracy should be undertaken by Peabody. WaterNSW should review whether the extension of the rating curve at the Waratah Rivulet could be improved. Selected watercourses in future mining areas should have flow gauges installed with validated rating curves. Where it is impractical to extend rating curves to high flows, alternative methods of high flow estimation should be considered.

Temperature and water quality data should be obtained at various depths through the water column in the upper reservoir (at a location such as WDFS1 that is downstream of the entry of both the Waratah Rivulet and Eastern Tributary) to capture both the temperature stratification behaviour and the water quality at this point. Frequency of data collection should increase following significant flow events and following level 3 triggers for water quality reaching the reservoir.

It is recommended that an agreement be reached whereby a hydrodynamic and contaminant transport model set-up is designed to support assessments of potential mining impacts. Consideration should be given as to how the responsibility for the modelling is shared between WaterNSW and Peabody.

Peabody should procure sediment cores at selected locations downstream of the confluence of Waratah Rivulet and Eastern Tributary with the reservoir and at control sites in the reservoir in order to assess the possible impacts of mining on alterations to sediment composition (with implications to possible mobilisation of Fe and Mn should these sediments become anoxic).

When quality of water reaching the reservoir at performance indicator sites surpasses a level 3 trigger, analysis should be extended to:

- once installed, water quality data collected at various depths at WDFS1 or similar site representing the confluence of the Eastern Tributary and Waratah Rivulet arms of the reservoir,
- if available, contaminant load estimates,
- if available, reference to results of a lake hydrodynamic and contaminant transport model run using relevant scenarios of increased contaminant loads.

In any future mining areas, performance indicators and triggers should be based on loads as well as concentrations.

When reservoir water quality passes a level 3 trigger, more detailed analysis of the reservoir water quality should be undertaken including:

- data collected at various depths at DW01 (i.e., at the vertical profiler),
- data collected at various depths at Woronora Reservoir at DWO_THMD (Honeysuckle Creek Junction),
- once installed, data collected at various depths at WDFS1 (Figure 3) (or similar site representing the confluence of the Eastern Tributary and Waratah Rivulet arms of the reservoir),

- once available, iron and manganese concentrations in reservoir sediments.

Irrespective of these recommendations for further analysis in response to triggers, the Panel recommends that a more detailed analysis be undertaken of historical reservoir water quality and sediment cores in order to analyse potential trends and relations with mining development. This should be included in the 2023 Annual Review and updated in subsequent annual reviews.

Following the conclusions in IEPMC (2019), it is recommended that a broader study of potential long-term cumulative impacts of mining on water quality in the Special Areas is needed.

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1.0 SCOPE OF WORKS

On 4 April 2023, the Department of Planning and Environment wrote to the Chair of the Independent Advisory Panel for Underground Mining (now the Independent Expert Advisory Panel for Mining, referred to as "the Panel" here on) requesting advice on Water Quality Performance Measures for Metropolitan Coal Mine. Specifically, advice was requested on:

1. *The Assessments Against Water Quality Performance Measures*[1]*, and whether the justifications and conclusion that the water quality performance measure for Woronora Reservoir have not been exceeded are reasonable.*

2. *Whether the performance indicator for negligible reduction to the quality of water resources reaching the Woronora Reservoir defined in WMPs is appropriate.*

3. *Whether additional water quality monitoring, analysis and/or assessment is required to further determine compliance with the water quality performance measure for Woronora Reservoir.*

4. *Whether any further reasonable and feasible actions to mitigate and manage water quality impacts are considered necessary, beyond the existing requirements to continue implementing monitoring and management programs.*

5. *Whether a cumulative impact assessment study is considered necessary to review water quality trends and potential impacts on drinking water supply from increased metals loads from the catchments impacted by mine subsidence at Metropolitan Mine.*

The Department also noted that it would welcome any other significant advice that the Panel may wish to provide concerning this issue.

The Chair of the IEAPM (Em. Professor Jim Galvin) nominated the following members of the Panel to prepare the advice:

- Professor Neil McIntyre – Surface water (and Chair of the Panel for this advice)
- Mr John Ross – Groundwater
- Professor David Waite – Water quality

2.0 METHOD OF OPERATION

As part of developing its advice, the Panel undertook the following activities:

- Online meeting with WaterNSW on 12 July

- Field visit on 19 July to Eastern Tributary, Waratah Rivulet and Woronora dam attended by Neil McIntyre and David Waite of the Panel and representatives of DPE, WaterNSW and Peabody.

- Online meeting with Sydney Water and WaterNSW on 26 July

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[1] The Assessments Against Water Quality Performance Measures are primarily a series of assessments from 2018 to 2022 conducted for Peabody by Associate Professor Barry Noller of The University of Queensland that followed exceedances of performance indicators for water quality reaching the Woronora Reservoir.

- Online meetings of Panel members on 5 July, 7 August and 28 August.

The following primary documentation was referred to by the Panel:

- HEC (2023) Metropolitan Coal - Surface Water Review 1 July to 31 December 2022 (App B2 of Metropolitan Coal Annual Review 2022)

- Peabody (2022) Metropolitan Coal Water Management Plan for Longwalls 308-310

- The University of Queensland (2018-2022), Assessments Against Water Quality Performances. A series of 25 letters from Associate Professor Barry Noller of The University of Queensland to Peabody between November 2018 to December 2022.

- Peabody (2023) Assessment Against The Water Resources Subsidence Impact Performance Measure, Letter of 10 January 2023 to NSW Department of Planning and Environment

- Metropolitan Coal Project Approval (08_0149)

- WaterNSW letter to Peabody in response to Annual Review Report 2021 (dated 31 August 2022)

- WaterNSW letter to Peabody in response to Assessment against Water Quality Performance Measure - April 2022 (dated 26 September 2022)

- WaterNSW letter to Peabody in response to Assessment against Water Quality Performance Measure - April, May and June 2022 (dated 15 February 2023)

- WaterNSW Annual Water Quality Monitoring Reports 2020-2021, 2021-2022

- WaterNSW Greater Sydney Destratification Systems Operating Considerations, March 2023

- WaterNSW Water Quality Incident Response Protocol, June 2021

- Independent Expert Panel for Mining in the Catchment (IEPMC), 2018, Initial report on specific mining activities at the Metropolitan and Dendrobium coal mines, Prepared for the NSW Department of Planning and Environment

- Independent Expert Panel for Mining in the Catchment (IEPMC), 2019, Independent Expert Panel for Mining in the Catchment Report: Part 2. Coal Mining Impacts in the Special Areas of the Greater Sydney Water Catchment, Prepared for the NSW Department of Planning, Industry and Environment

- Responses to Panel's request for information provided by WaterNSW on 14 July, 1 August and 1 September (emails).

- Responses to Panel's request for information provided by Sydney Water on 4 September (email).

3.0 BACKGROUND

3.1. WORONORA RESERVOIR AND MINING IN THE CATCHMENT

Woronora Reservoir (Figure 1) is one of the raw water storages that serves the Sydney area. Its capacity is 71.79 GL with catchment area 74.1 km^2 and surface area 3.996 km^2 when at capacity. The average total inflow over 2012-2017 was estimated to be approximately 28,000 ML/year or 900 L/s (WRIS 2019). The Eastern Tributary and Waratah Rivulet, which are the main tributaries affected by mining (Figure 1 and Figure 2), enter the reservoir approximately 10 km upstream of the dam. The catchment areas of these tributaries are 6.7 km^2 and 20.2 km^2 respectively (at flow gauge station numbers GS2132102 and GS300078).

Metropolitan Coal has undertaken longwall mining within the Woronora Reservoir catchment boundaries since mining of Longwall 1 in 1995 (Figure 2). Mining of longwalls 1-27 was complete in 2017 and, following mining of longwalls 301-308 from 2017 to 2023, mining of longwall 309 (immediately to the west of the reservoir in Figure 2) commenced in August 2023 (Peabody 2023).

The presence of mining subsidence-induced fractures and dilated bedding planes at locations in the Eastern Tributary and Waratah Rivulet and changes in pool drainage behaviour have been the subject of previous assessments (IEPMC 2018) and are summarised in Peabody's annual reports (e.g. Tables 7-9 of Peabody 2023). Further assessment of the subsidence effects, impacts and environmental consequences[2] for the Eastern Tributary catchment is provided in concurrent Panel advice (IEAPM 2023) whereas the current advice focusses on the potential consequences for water quality.

3.2. WORONORA RESERVOIR – WATER QUALITY CRITERIA

The Woronora Reservoir supplies raw water to the Woronora Water Filtration Plant (WFP), situated at Woronora Dam and operated for Sydney Water by Veolia. The design capacity of the WFP is approximately 160 ML/day and its minimum output in order to prevent shut-down and to maintain a minimum supply is approximately 40 ML/day.

WaterNSW also has a Water Quality Incident Management protocol based on trigger levels and associated responses. The responses include notifying WFP operators when delivered raw water quality exceeds specified trigger levels (Table 1). The WFP operation, including its output rate, are adjusted when the input water quality reduces below specified limits. These limits are aligned with the trigger levels in Table 1.

The raw water supply agreement (RWSA) standards for Woronora Reservoir for total iron, total manganese and total aluminium (WaterNSW 2022a, Table 4.2) correspond to the major incident levels

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[2] The advice is premised on the following definitions as recommended by the Southern Coalfield Inquiry:

- Subsidence Effects: the deformation of the ground mass surrounding a mine due to the mining activity. The term is a broad one and includes all mining-induced movements, including both vertical and horizontal displacement, tilt, strain and curvature.
- Subsidence Impacts: the physical changes to the ground and its surface caused by subsidence effects. These impacts are principally tensile and shear cracking of the rock mass and localised buckling of strata caused by valley closure and upsidence but also include subsidence depressions or troughs.
- 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

in Table 1. The significance of the RWSA standards is described by WaterNSW (2022a) as "*WaterNSW has established terms and conditions of supply with wholesale customers to ensure treated water is not harmful to consumers' health. ... These standards are based on the treatment capabilities of the plants and the natural characteristics of the catchment. This ensures that raw water can be treated to meet ADWG requirements*". WaterNSW (2021a, p19) further explains "*These RWSAs include site specific water quality standards applicable for each Water Filtration Plant (WFP) based on typical historical raw water quality and plant capabilities".*

The ADWG requirements referred to above and also referred to in the Peabody assessments (e.g., The University of Queensland 2022) are the Australian Drinking Water Guidelines published by the National Health and Medical Research Council and National Resource Management Ministerial Council (NHMRC & NRMMC, 2011). The ADWG requirements include maximum concentrations of metals in drinking water following treatment in a WFP. While the ADWG requirement for total manganese is 0.5 mg/L, the ADWG also indicate that some nuisance microorganisms can concentrate manganese and give rise to taste, odour and turbidity problems in distribution systems. A discretionary target of 0.01 mg/L is suggested by the ADWG for waters leaving a WFP. High filterable manganese concentrations in raw waters necessitate use of permanganate dosing to ensure treated waters contain less than 0.02 mg/L, above which manganese will form a coating on pipes that can slough off as a black ooze.

Another water quality guideline, which is referred to in the Peabody assessments (e.g., The University of Queensland 2022), is the Australian and New Zealand Guidelines for fresh and marine water quality (ANZG 2018), which includes guidelines for protection of aquatic species.

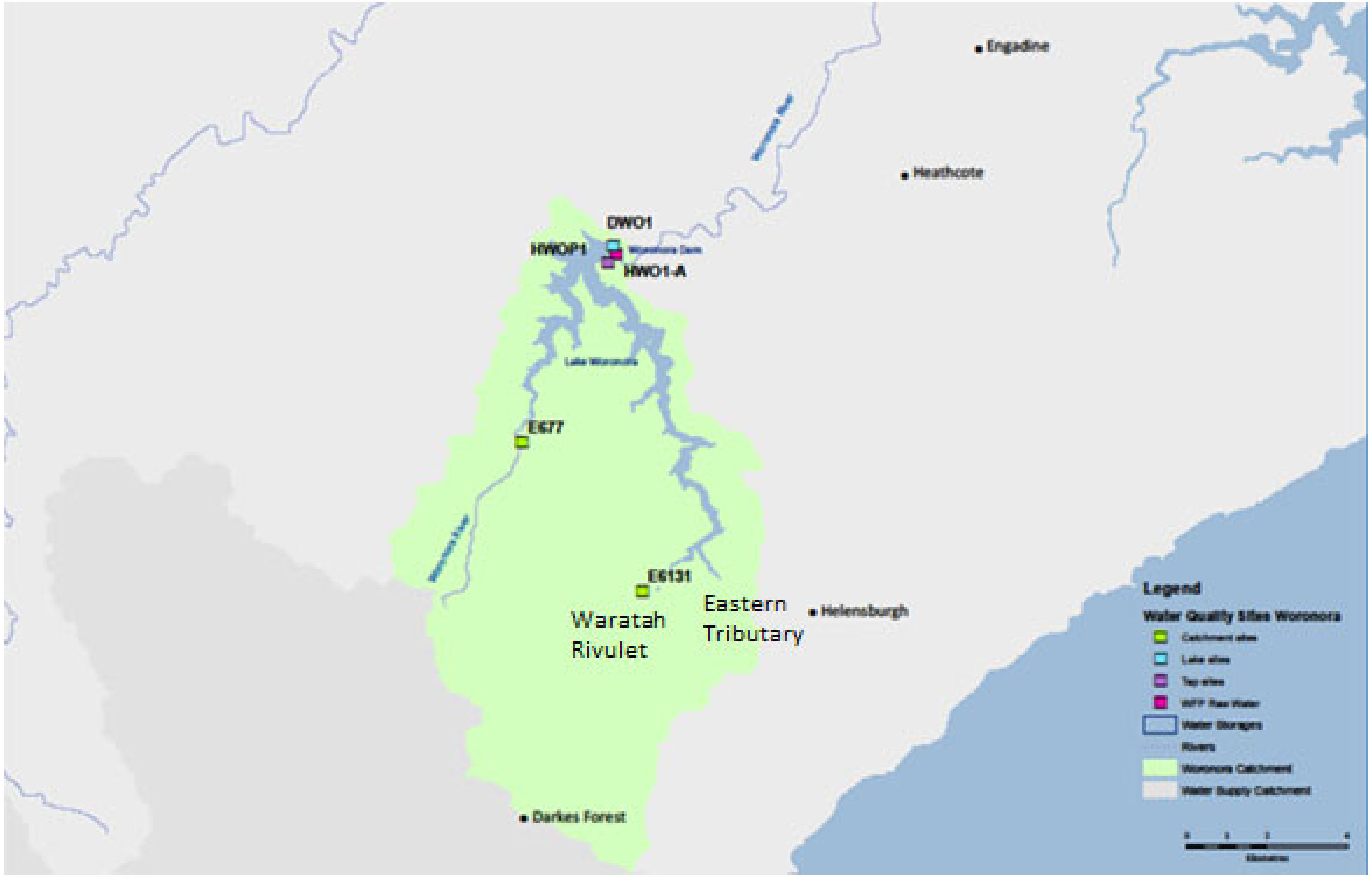

Figure 1. The Woronora Reservoir and its catchment (Figure 5.3 from WaterNSW 2021b, with the Eastern Tributary and Waratah Rivulet labels added to indicate their locations). HWOP1 is the picnic ground drinking water tap (and is not referred to again in this advice); DW01, HW01-A, E677 and E6131 are other WaterNSW monitoring points referred to in Section 3.3 below.

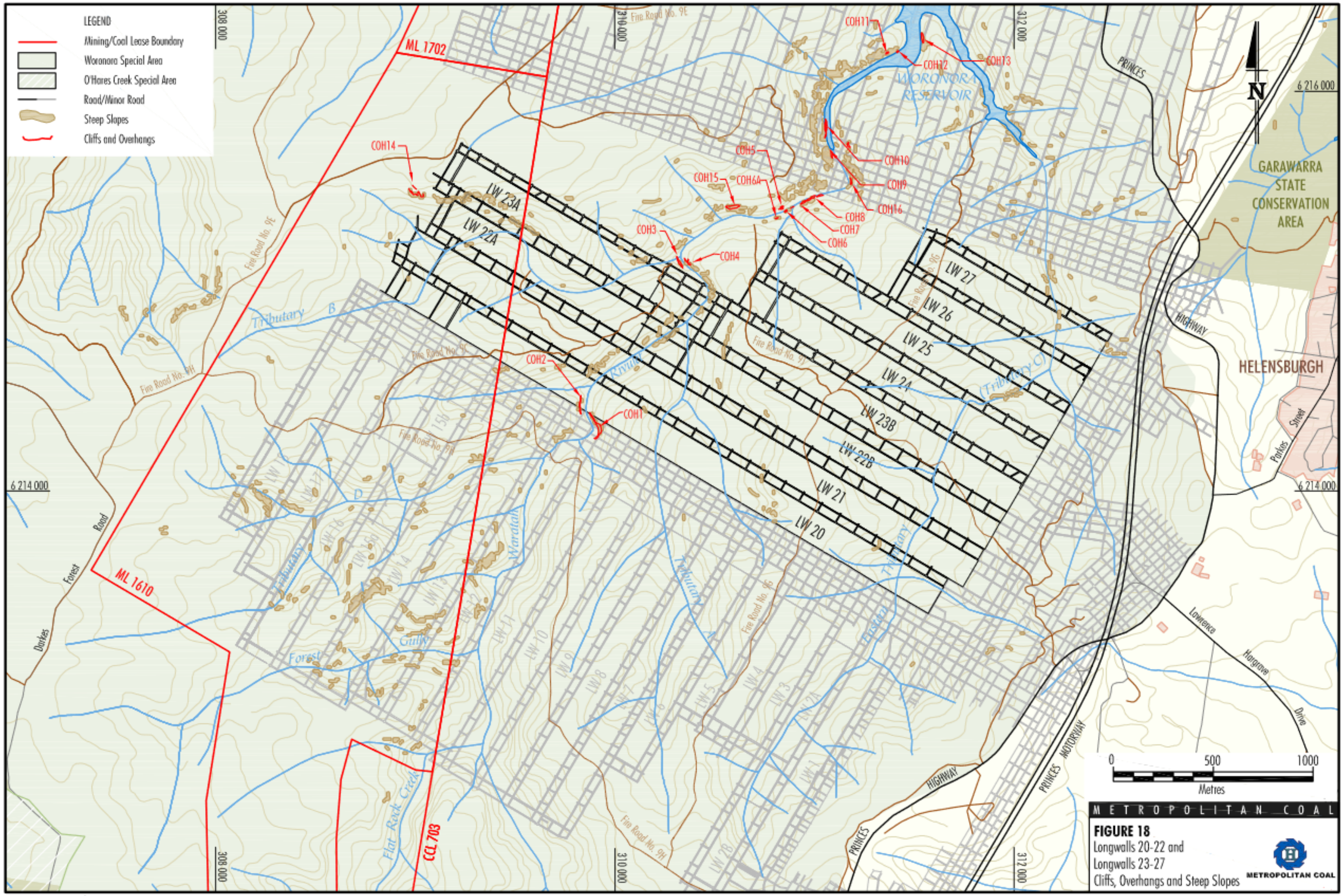

Figure 2. Longwalls 1-27 overlying the Waratah Rivulet and Eastern Tributary catchments (Figure 18 from Peabody, 2016)

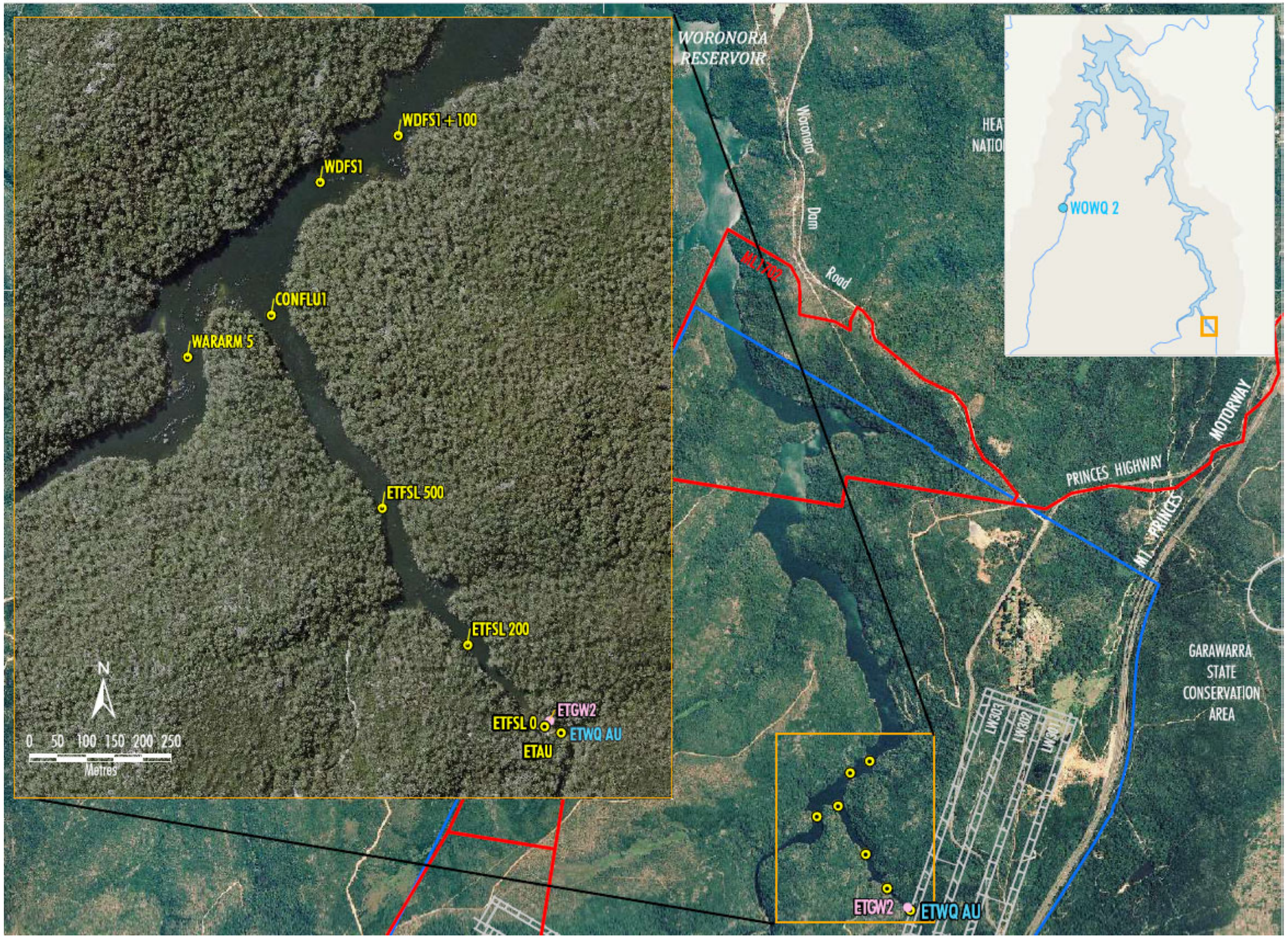

Figure 3. Peabody's monitoring locations at ETWQ AU and below the Full Supply Level of the Woronora Reservoir (copied from Figure 1 of The University of Queensland 2022)

Table 1 Water Quality Incident Management trigger levels for selected parameters at point of supply to Woronora Water Filtration Plant (from Table 7 of WaterNSW 2021)

Parameter	**Alert level**	**Minor incident level**	**Major incident level[1]**
Turbidity (NTU)	>3-11	>11-20	>20
True Colour @ 400 nm (CU)	>6 – 52.5	>52.5-70	>70
Filterable Iron (mg/L)	>0.1		
Total Iron (mg/L)	>0.5-0.75	>0.75-1.0	>1.0
Filterable Manganese (mg/L)	>0.02		
Total Manganese (mg/L)	>0.03-0.07	>0.07-0.1	>0.1
Total Aluminium (mg/L)		>0.3-0.4	>0.4
Total Organic Carbon (mg/L)	>4		

[1] The major incident level corresponds to the Raw Water Supply Agreement (RWSA) for Total Iron, Total Manganese and Total Aluminium (Table 4.2 of WaterNSW 2022a)

3.3. RAW WATER QUALITY MONITORING

As well as at the point of supply to the water filtration plant (HW01-A in Figure 1), raw (i.e., untreated) water quality is regularly monitored by WaterNSW near to the dam wall (DWO1) and at the junction of the reservoir and Honeysuckle Creek (DWO_THMD) (Figure 1). DW01 has long-term data (e.g., total iron since 1953, total manganese since 1986 and total aluminium since 1990) while water quality monitoring at DWO_THMD began in 2012. The frequency of monitoring varies, typically 1 to 2 weeks at DWO1. DWO1 and DWO_THMD samples are taken over a range of depths from the surface down to near the bed of the reservoir (at up to 59.5 m depth). Water quality has been sampled by WaterNSW at six other sites in the reservoir over the decades. Three reservoir sites are currently operational: DWO1, DWO_THMD and a new site downstream of Bee Creek that was added in 2023[3]. WaterNSW routinely monitor the Waratah Rivulet and Woronora River (E6131 and E677 in Figure 1). The WaterNSW monitoring results are reported in WaterNSW annual reports and, for DWO1, in Metropolitan Mine annual and six-month reviews.

Peabody monitors water quality at many locations in the Metropolitan mining areas and control sites to inform performance assessments and to contribute to six-monthly and annual reporting (e.g., see locations of sites in Figure 7 of Peabody 2022). For performance assessments, the key sites are ETWQ AU, WRWQ9 and WOWQ2 (ETWQ AU is shown in Figure 3, while WRWQ9 and WOWQ2 are co-located with E6131 and E677 in Figure 1). ETWQ AU is co-located with the Eastern Tributary Gauging station immediately upstream of the reservoir at its Full Supply Level, WRWQ9 is co-located with the WaterNSW flow gauge on the Waratah Rivulet, approximately 700 m upstream of the Full Supply Level, and WOWQ2 is the Woronora River control site, unaffected by mining. Measurement of water quality at site ETWQ AU commenced in 2010, while at WQWQ9 it commenced in 2006 though measurements elsewhere in the Waratah Rivulet date back to 2001 (Parsons Brinckerhoff 2010). Additionally, monitoring has been undertaken by Peabody at sites in the reservoir downstream of the Full Supply Level at the Eastern Tributary and Waratah Rivulet (ETFSL (x3), WDFS (x2), CONFLU1

[3] This summary of water quality monitoring is based on a spreadsheet provided to the Panel by WaterNSW

and WARARM 5 sites in Figure 2), which allow sampling from the "mixing zone" (The University of Queensland 2022) where the incoming contaminants are mixed with the upper reservoir water.

3.4. WATER QUALITY INCIDENTS AND TRENDS

Historically and most recently in July 2022, the Woronora reservoir water quality reduces during and after floods. This is illustrated here in Figure 4 and Figure 5 replicated from HEC (2022), showing that iron (Fe), aluminium (Al) and manganese (Mn) concentrations were unusually high during 2022 at DWO1[4] (i.e., all consistently above the 10 year Average Recurrence Interval curves and often above the 20 year Average Recurrence Interval curves). Sediment (turbidity) and Natural Organic Matter (NOM) concentrations were also elevated. Twelve months after the July 2022 flood event, the Woronora reservoir water quality had not recovered to average historical concentrations.

High sediment and Natural Organic Matter (NOM) concentrations necessitate the use of high coagulant dosages and frequent filter backwash with resultant high sludge loads and thus greater difficulty and increased cost in treating these waters compared to waters of lower turbidity and NOM content. For this reason, the WFP is currently operating at its minimum operational flow of 40 ML/day. This has financial implications for Sydney Water related to the contractual arrangements with the water treatment provider and the need to provide alternative drinking water sources including running the Kurnell desalination plant. While the principal operational challenges with the WFP are due to increased organic matter concentrations and increased turbidity associated with flood events (which result in the need for increased addition of coagulants, increased sludge loads and decreased filter run times), the challenges due to elevated metal concentrations cannot be ignored with high total iron concentrations contributing to high turbidity and high manganese concentrations requiring treatment to meet the 0.01 mg/L discretionary guideline referred to previously.

The quality of feed waters to the Woronora WFP is monitored by WaterNSW. WaterNSW has provided details of exceedances of the alert and incident levels (Table 1) since 2013 with a tabulation of numbers of exceedances (and severity of the exceedance) per year for particular parameters provided in Table 2 below.

Woronora Reservoir is artificially mixed by aerators deployed at the base of the reservoir near the dam wall with the injection of air preventing stratification and potential subsequent development of anoxic (low oxygen) conditions at depth. This aims to avoid the development of poor water quality at depth, including preventing the release of iron and manganese and associated nutrients (particularly phosphorus) from the sediments that can occur in anoxic conditions. The aerators are operated when temperature differences between deep and shallow water indicates the potential for stratification. The aerators destratify the reservoir in the vicinity of the dam wall but are unlikely to prevent stratification in the upper reaches of the reservoir, meaning that any redox-active metals (particularly iron and manganese) accumulated in the sediments of the upper reaches due to mining may be prone to release during anoxic conditions and potentially transported downstream towards the dam.

[4] Trends and variations in reservoir water quality are assessed only at DWO1 due to relatively short lengths of record at all other monitoring stations

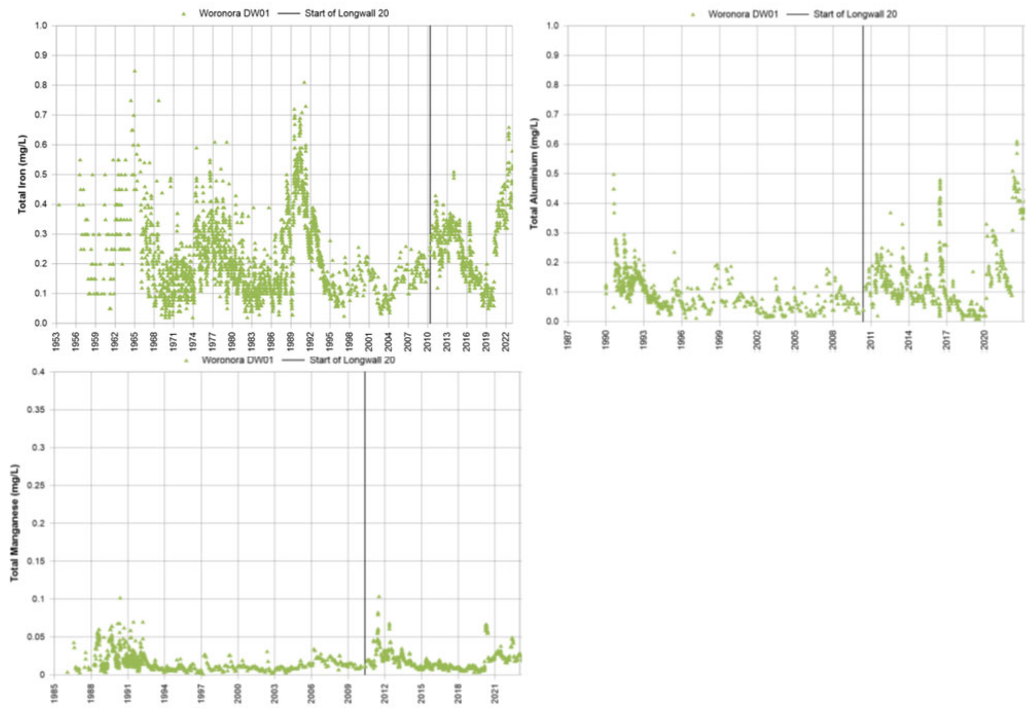

Figure 4. Time-series of total iron, aluminium and manganese at set DWO1 (Charts 42-44 of Peabody 2023). The far right-hand side of each plot shows the spike in July 2022.

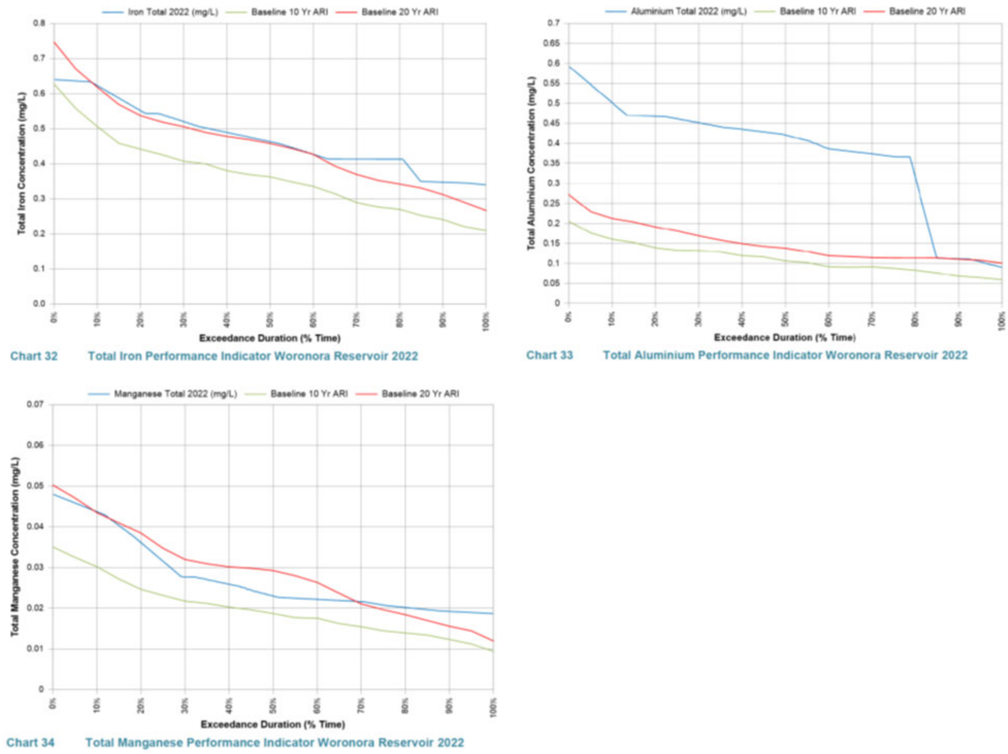

Figure 5. Exceedance durations of concentrations of total iron, aluminium and manganese at DWO1 during 2022, compared with exceedance durations in two historical years with poor quality water (10 Yr and 20 Yr ARI years) (Charts 45-47 of Peabody 2023).

Table 2 Number of exceedances at alert, minor and major levels per year for water quality parameters listed in Table 1. Data provided to Panel by WaterNSW based on monitoring data from HW01-A (location in Figure 1).

Year	Turbidity	Colour	TOC	Al tot	Fe tot	Fe filt	Mn filt
2023 (to end June)	0	6	6	2 (minor)	4 (alert)	0	6 (alert)
2022	36 (alert)	40 (alert)	41 (alert)	5 (minor) 33 (major)	26 (alert)	41 (alert)	27 (alert)
2021	2 (alert)	23 (alert)	23 (alert)	1 (minor)	2 (alert)	23 (alert)	10 (alert)
2020	6 (alert)	11 (alert)	22 (alert)	6 (minor) 1 (major)	0	22 (alert)	5 (alert)
2019	1 (alert)	0	2 (alert)	0	0	0	0
2018	0	0	0	0	0	0	0
2017	0	0	12 (alert)	0	0	0	0
2016	11 (alert)	0	26 (alert)	2 (minor) 6 (major)	0	0	0
2015	6 (alert)	0	20 (alert)	0	0	0	0
2014	1 (alert)	0	9 (alert)	0	0	0	0
2013	0	0	6 (alert)	0	0	0	0

3.5. SUBSIDENCE IMPACTS ON WATER QUALITY – MECHANISMS

The mechanisms of mining subsidence impacts and effects as relevant to the watercourses in the Metropolitan mining area are described in IEPMC (2018), WRIS (2017, 2019) and IEAPM (2023). Previous studies by and for the Sydney Catchment Authority have investigated in detail the mechanisms and evidence of the consequences of subsidence for water quality in the Waratah Rivulet, and reviewed water quality consequences of mining in other watercourses of the Southern Coalfield (Parsons Brinckerhoff 2007, 2010, Jankowsi 2010, Jankowsi and Knights 2010). Here, a summary of the mechanisms is given.

Of primary relevance here is the diversion of surface water and groundwater through mining-induced rock fractures and subsequent discharge of contaminated water into creeks and then into the reservoir. A variety of physicochemical processes influence the particular forms of iron, aluminium and manganese likely to be present. Under anoxic conditions, as is typical in subsurface environments, iron and manganese will be present predominantly in their soluble ferrous (Fe(II)) and manganous (Mn(II)) forms. On exposure to oxygen-containing water, the reduced forms of these redox-active elements should, thermodynamically, be transformed to their oxidised ferric (Fe(III)) and manganic (Mn(IV)) forms. Given the tendency of these oxidised forms to hydrolyse and precipitate, these elements will eventually be present, under oxic conditions, principally as particulate iron and manganese oxyhydroxides (typically represented as FeOOH(s) and MnOOH(s)). The rates of Fe(II) and Mn(II) oxidation by oxygen however differ markedly and are strongly pH dependent with Fe(II) expected to transform to particulate FeOOH(s) within minutes at circumneutral pH while Mn(II) transformation may take many days or even weeks to reach its preferred MnOOH(s) form. The oxidised forms of these elements will initially form nanosized particulates that may aggregate to micron-sized assemblages that will be trapped on the 0.45 μm membrane filters used to separate the "dissolved" (filterable) fraction from the total metal oxyhydroxide present though a portion of the particulates may remain in fine colloidal form and pass through the membrane filters (and appear in the "dissolved" fraction)[5].

The presence of natural organic matter (NOM) in oxic waters may inhibit the aggregation process (as a result of adsorption of this organic matter to particulates and imposition of negative surface charge) with resultant increase in proportion of the metal oxyhydroxide present in colloidal form. Unlike redox active iron and manganese, aluminium occurs only in the trivalent (Al(III)) form and will be present either as aluminium oxyhydroxides (AlOOH(s)) or, more likely, as aluminosilicate clays. Like FeOOH(s), these particulate forms of aluminium may be retained by the 0.45 µm membrane filters or, if sufficient NOM is present, a portion of the particulate aluminium may remain in colloidal form and pass through the filters into the filterable fraction. High concentrations of total aluminium are often observed together with high turbidity as suspended aluminosilicate clays are typically the cause of high turbidity.

In summary,

- The mass of iron, aluminium and manganese transported from rock fractures to the reservoir depends on the degree and location of fracturing, properties of the rock, chemistry of the water, and flow pathways, flow rates, and the interactions of all these.

- If baseflow discharges from regional groundwater increase after a high rainfall event, or if regional water table levels recover post mining, then increased loads of iron, aluminium and manganese transported from rock fractures could be expected.

- The physicochemical processes influencing the forms of iron, aluminium and manganese result in iron and aluminium being present in streams flowing into Woronora Reservoir predominantly in particulate form and manganese being present predominantly in filterable ("dissolved") form.

- Iron, aluminium and any particulate manganese present in streams flowing into Woronora Reservoir would be expected to deposit, for the most part, to the sediments in solid oxyhydroxide form though a portion may remain in suspension if stabilised in colloidal form by adsorbed natural organic matter.

- Dissolved manganous (Mn(II)) manganese, the predominant form of manganese in streams flowing into Woronora Reservoir, is likely to remain in this form for some time (days-weeks) though would be expected to eventually oxidise to manganic (Mn(III)) form and deposit to the sediments as particulate oxyhydroxide (MnOOH(s)).

The eventual fate of the redox active elements iron and manganese that are deposited to benthic Woronora Reservoir sediments will be dependent on the oxidation state of the sediments. In winter, the reservoir will typically be well-mixed with sufficient oxygen through the water column to maintain iron and manganese in their oxidised particulate forms within the benthic sediments. In summer, when the reservoir naturally thermally stratifies (i.e., separates into a higher temperature well-mixed oxic surface layer (the epilimnion) and a lower temperature anoxic deeper layer (the hypolimnion)), the particulate forms of iron and manganese are likely to be transformed, to some extent, to filterable ("dissolved")

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[5] While the word "dissolved" has been consistently used in the Metropolitan Water Management Plan, it should be recognised that "dissolved" concentrations may also include colloidal materials that may have passed through the 0.45 µm filter used in field sampling. In this advice, "filterable" is used to include both dissolved and colloidal forms.

forms that, subsequently, may be transported through the reservoir and, potentially, to the raw water offtake near the dam wall.

As noted above, the reservoir is artificially destratified (by injection of air) near the dam wall during summer to reduce the extent of release of iron and manganese from the sediments and to minimise the likelihood of high concentrations of iron and manganese being present in raw waters supplied to the WFP. This destratification process is effective in preventing formation of an anoxic zone in the vicinity of the aerator but is unlikely to break the stratification that will occur in summer in the upper reservoir. It is possible that natural convective forces and/or the aeration process could result in the transport of high iron and manganese content waters from the upper reaches of the reservoir toward the dam wall though hydrodynamic and contaminant transport modelling of the reservoir would be required to assess the likelihood of this occurring.

While the diversion of surface water and groundwater through mining-induced rock fractures and subsequent discharge of contaminated water into creeks and then into the reservoir is evident, the extent to which the increased loads of iron, aluminium and manganese transported to reservoir benthic sediments as a result of mining subsequently impacts reservoir water quality is uncertain given that these elements occur naturally in the runoff from non-mined catchments and in the benthic sediments. It should be noted however that freshly deposited particulate oxyhydroxides of these elements are likely to be more reactive and more readily mobilised on onset of low oxygen conditions than the more crystalline (and thus less reactive) forms of these elements that are intrinsically present naturally in the sediments.

Aside from metals leaching from rock fractures, potential consequences of mine subsidence on water quality include:

- Physical drying of affected swamps and subsequent increase risk of erosion of swamp organic material, and reduced capacity of the swamp to moderate contaminant export.
- Changes to slopes of watercourses and associated soil erosion.
- Accidental spills of contaminants from surface operations within the catchment.

These mechanisms, if and when they exist in this catchment, could affect reservoir water quality, particularly during and after flood events. However, these mechanisms are relatively localised and the diversion of surface water and groundwater through mining-induced rock fractures is considered to be the more relevant mechanism for the purpose of this advice.

3.6. SUBSIDENCE IMPACTS MANAGEMENT AND PERFORMANCE MEASURES

The Metropolitan Coal Project Approval (08_0149) requires Metropolitan Coal to ensure that its mining activities do not cause any exceedance of subsidence impact performance measures outlined in Table 1 of Condition 1, Schedule 3 of the Approval, which includes:

- *Negligible reduction to the quality or quantity of water resources reaching the Woronora Reservoir*
- *Negligible reduction in the water quality of Woronora Reservoir*

The associated Performance Indicators (Peabody's proposed measure of whether the performance measure in being met) are:

- *Changes in the quality of water entering Woronora Reservoir are not significantly different post-mining compared to pre-mining concentrations that are not also occurring at control site WOWQ2*

- *Changes in the quality of water in the Woronora Reservoir are not significantly different post-mining compared to pre-mining concentrations.*

The first of these is based on comparing pre-mining baseline with post-mining measurements of water quality on the Eastern Tributary (site ETWQ AU) and Waratah Rivulet (WRWQ9), taking into account variations at the control site on the Woronora River (WOWQ2). The parameters considered for the creek water quality performance indicators are filterable (field filtered using 0.45 µm filter) iron, filterable manganese and filterable aluminium.

The second of these performance indicators – that focusses on Woronora Reservoir water quality - is based on comparing pre-mining baseline and post-mining measurements of water quality at site DWO1 in the reservoir without use of a control site (although variations in water quality in other reservoirs have been considered in the analysis of results). In this case the parameters are total iron, total manganese and total aluminium.

A series of three water quality triggers (defined in Table 24-a, 24-b and 26 of Peabody 2022, copied as Tables 3, 4 and 5 below) are used to escalate management actions based on the degree of difference between pre-mining and post-mining water quality. If trigger level 3 for creek sites ETWQ AU or WRWQ9 is surpassed for any of the three parameters this is treated by Peabody as requiring an investigation to determine if it should be regarded as a non-negligible impact that would constitute an exceedance of the performance measure related to the quality of water resources entering the Woronora Reservoir. This investigation has been provided by Associate Professor Barry Noller of The University of Queensland resulting in a series of reports from November 2018 to December 2022 (and earlier assessments are referred to in Peabody 2022), which concluded that the performance measure has not been exceeded. The rationale of that conclusion is reviewed as part of Section 4 of this advice. If the trigger level 3 for reservoir water quality at site DWO1 (Table 5 below) is triggered, then an investigation is also required. The Panel has not seen specific reports associated with the reservoir water quality triggers except those in the 6-month and annual reports, which have concluded that the level 3 triggers during 2022 were not associated with mining. This conclusion is also reviewed in Section 4 of this advice.

Table 24-A
Trigger Action Response Plan – Negligible Reduction to the Quality of Water Resources Reaching the Woronora Reservoir

Performance Measure	Performance Indicator	Monitoring Site(s)	Parameters	Frequency/ Sample Size	Analysis Methodology	Error Types	Baseline	Significance Levels/Triggers		Action/Response
Negligible reduction to the quality of water resources reaching the Woronora Reservoir.	*Changes in the quality of water entering Woronora Reservoir are not significantly different post-mining compared to pre-mining concentrations that are not also occurring at control site WOWQ2.*	Site WRWQ9 on the Waratah Rivulet. Site ETWQ AU on the Eastern Tributary. Control site WOWQ2 on the Woronora River.	Iron (Fe). Manganese (Mn). Aluminium (Al). [Field filtered].	Monthly.	Water quality data analysed quarterly, following the receipt of laboratory data[1]: • Adjusted baseline mean plus two standard deviations[2, 3] have been calculated for each water quality parameter and are provided in Table 24-B. • Adjusted baseline mean plus one standard deviation[4, 5] has been calculated for each water quality parameter and are provided in Table 24-B. The six month mean metal concentration will also be calculated at the end of each six month review period.	Potential for sampling, laboratory and data management errors.	<u>WRWQ9</u> • Fe (0.03 to 0.39 mg/L). • Mn (0.01[6] to 0.069 mg/L). • Al (0.001[6] to 0.15 mg/L). <u>ETWQ AU</u> • Fe (0.1 to 0.5 mg/L). • Mn (0.005[6] to 0.033 mg/L). • Al (0.03 to 0.11 mg/L). <u>WOWQ2</u> • Fe (0.05[6] to 1.3 mg/L). • Mn (0.01[6] to 0.1 mg/L). • Al (0.0005[6] to 0.11 mg/L).	Level 1	Data analysis indicates no water quality parameter exceeds the adjusted baseline mean plus two standard deviations.	Continue monitoring. Six monthly reporting.
								Level 2	Data analysis indicates any water quality parameter exceeds the adjusted baseline mean plus two standard deviations for one month.	Increase the frequency of data analysis to monthly (until such time that data analysis indicates a return to Level 1). Six monthly reporting.
								Level 3	Data analysis indicates: • any water quality parameter exceeds the adjusted baseline mean plus two standard deviations for two consecutive months; or • over a three month period the water quality parameter exceeds the adjusted mean plus two standard deviations in the first month, the adjusted mean plus one standard deviation in the next month and the adjusted mean plus two standard deviations in the third month; or • the six month mean exceeds the adjusted baseline mean plus one standard deviation for two consecutive assessment periods (i.e. over two six monthly reports); and • there was not a similar exceedance of the trigger at the control site.	Increase the frequency of data analysis to monthly (until such time that data analysis indicates a return to Level 1). If the water quality parameter is greater than the historical maximum, then undertake an investigation and assess against the performance measure. If the water quality parameter is less than the historical maximum, then undertake an investigation and assess against the performance measure at the end of the quarter[7]. Report to DPE, WaterNSW, DPE – Water and BCS within one month of assessment completion. Consider the need for management measures, in accordance with Sections 8 and 9.

Table 3 Trigger Action Response Plan for water quality entering the Woronora Reservoir (Table 24-A of Peabody 2022).

Table 24-B
Adjusted Baseline Mean plus Standard Deviations for Sites WRWQ9, ETWQ AU and WOWQ2

Assessment	Site	Water Quality Indicator	Baseline Mean Plus Two Standard Deviations (mg/L)	Adjusted Baseline Mean Plus Two Standard Deviations (mg/L)	Baseline Mean Plus One Standard Deviation (mg/L)	Adjusted Baseline Mean Plus One Standard Deviation (mg/L)
Waratah Rivulet water quality post-mining versus baseline, and compared to control site WOWQ2	**WRWQ9**	Dissolved Iron	0.544	0.706	0.284	0.337
		Dissolved Aluminium	0.097	0.100	0.041	0.047
		Dissolved Manganese	0.092	0.117	0.055	0.066
	WOWQ2 (using same baseline period as WRWQ9 to allow comparison)	Dissolved Iron	0.741	0.961	0.324	0.385
		Dissolved Aluminium	0.244	0.250	0.094	0.109
		Dissolved Manganese	0.064	0.082	0.042	0.051
Eastern Tributary water quality post-mining versus baseline, and compared to control site WOWQ2	**ETWQ AU**	Dissolved Iron	0.543	0.543	0.336	0.336
		Dissolved Aluminium	0.094	0.188	0.065	0.106
		Dissolved Manganese	0.029	0.030	0.017	0.020
	WOWQ2 (using same baseline period as ETWQ AU to allow comparison)	Dissolved Iron	1.657	1.657	0.555	0.555
		Dissolved Aluminium	0.075	0.151	0.061	0.100
		Dissolved Manganese	0.090	0.094	0.052	0.058

Table 4 Water quality criteria that define the water quality trigger levels referred to in Table 3 (Table 24-B of Peabody 2022).

Table 26
Trigger Action Response Plan – Negligible Reduction to the Quality of Water Resources in the Woronora Reservoir

Performance Measure	Performance Indicator	Monitoring Site(s)	Parameters	Frequency/ Sample Size	Analysis Methodology	Error Types	Baseline	Significance Levels/ Triggers		Action/Response
Negligible reduction in the water quality of Woronora Reservoir.	*Changes in the quality of water in the Woronora Reservoir are not significantly different post-mining compared to pre-mining concentrations.*	Woronora Reservoir (site DW01) (subject to data availability from WaterNSW) Nepean Reservoir (subject to data availability from WaterNSW) Cataract Reservoir (subject to data availability from WaterNSW)	Total Iron (Fe). Total Manganese (Mn). Total Aluminium (Al).	Sampling frequency is variable.	Water quality data analysed annually, following the receipt of data from WaterNSW. Water quality parameters, measured in the same location on the same day will be geometrically averaged. The parameter records will be interpolated to provide daily records. Concentration exceedance duration curves will be calculated for each parameter by determining the concentration exceeded at each location by percentages of days of the year covering the full range from 0% to 100%, at 5% intervals. Baseline data[1] will be analysed in an annual format to determine concentration exceeded with an estimated average recurrence interval (ARI[2]) curve of 20 years by percentages of days in the year from 0% to 100%. For each percentage of time selected from this range, an ARI curve will be calculated by fitting a log Generalised Extreme Value distribution to the concentration exceeded each year of the baseline record by that percentage of days. For each water quality parameter, the concentration exceedance curve for the current year of monitoring and the 20 year ARI exceedance curve calculated from the baseline records will be plotted on a graph.	Potential for sampling, laboratory and data management errors.	Baseline 10 and 20 year ARI exceedance curve	Level 1	The current year's duration exceedance curve for a water quality parameter in Woronora Reservoir (total iron, total manganese and total aluminium) is below the baseline 10 year ARI exceedance curve for any range of the duration percentages from 0% to 75%.	Continue monitoring. Annual reporting.
								Level 2	The current year's duration exceedance curve for a water quality parameter in Woronora Reservoir (total iron, total manganese and total aluminium) is above the baseline 10 year ARI but below the baseline 20 year ARI exceedance curve for any range of the duration percentages from 0% to 75%.	Plot and qualitatively assess the Woronora Reservoir, Nepean Reservoir and Cataract Reservoir water quality data every six months (until such time that data analysis indicates a return to Level 1). Annual reporting.
								Level 3	The current year's duration exceedance curve for a water quality parameter in Woronora Reservoir (total iron, total manganese and total aluminium) is above the baseline 20 year ARI exceedance curve for any range of the duration percentages from 0% to 75%.	Plot and qualitatively assess the data from the Nepean Reservoir and Cataract Reservoir. Undertake investigation and assess against the performance measure. Report to DPE, WaterNSW, DPE – Water and BCS within one month of assessment completion. Consider the need for management measures, in accordance with Sections 8 and 9.

[1] Baseline data includes data prior to 19 May 2010 (i.e. prior to the commencement of Longwall 20).

[2] Average Recurrence Interval. This term has been used here for consistency with previous Annual Reviews and Water Management Plans. Based on recommendations by the Institution of Engineers Australia, the preferred terminology now involves the term Annual Exceedance Probability (AEP) expressed as a percentage probability. This is to avoid confusion that the term ARI has caused within the industry, community and other stakeholders. A 20 year ARI is equivalent to a 5% AEP.

Table 5 Trigger Action Response Plan for Woronora Reservoir water quality (Table 26 of Peabody 2022).

3.7. PREVIOUS INVESTIGATIONS AND ADVICE RELATING TO MINING IMPACTS ON THE WATER QUALITY OF THE WORONORA RESERVOIR

Parsons Brinckerhoff (2010) conducted a study for the Sydney Catchment Authority that included understanding the consequences of subsidence for water quality of the Waratah Rivulet. Relevant conclusions were:

- *The effects of longwall mining induced subsidence on surface water quality were most apparent under low flow conditions. During low flow conditions EC, major ion concentrations, dissolved manganese, barium and strontium concentrations were elevated. In addition, dissolved iron readily oxidised to form orange/brown precipitates of iron oxides and hydroxides on the creek bed and thick bacterial mats flourished under the low flow conditions.*

- *The long term impacts on surface water in Waratah Rivulet are difficult to assess due to lack of baseline (pre-mining) data. During the study period [2006-2009], there was no significant increase in major ion or metal concentrations over time. However a comparison of the current data with the only available historical water quality data (from 2001) does show an increase in salinity, and some major ions and metals in Waratah Rivulet at Flat Rock Crossing.*

Although assessing in some detail the water quality of the Waratah Rivulet, which accounts for 29% of the Woronora Reservoir catchment, Parsons Brinckerhoff (2010) did not quantify or comment in any detail on the implications of modifications to the Waratah Rivulet water quality for the Woronora Reservoir. The WaterNSW annual reviews include a data summary and brief commentary on water quality at a site on Waratah Rivulet (downstream of Flat Rock Crossing, near where Fire Road 9H crosses the Waratah Rivulet on Figure 1), with WaterNSW (2022) stating "*Aluminium and indices reflecting increases in organic loading (pH and dissolved oxygen) showed increased exceedances mainly due to increased inflows*". Trends are assessed biannually by WaterNSW, with the last assessment in WaterNSW (2021) (Table 9.3 of that document) showing statistically significant negative trends (reducing concentrations) at DW01 during 2011-2021 for total and filterable manganese, total aluminium, and total and filterable iron.

Considering the implications of impaired water quality due to mining in the Special Areas, IEMPC (2019) cited a literature review prepared for WaterNSW (Advisian 2016):

> *"In summary, although some consequences on water quality within the watercourses in the study are documented in the literature, these consequences are likely to be short term, sporadic and localised… Any consequences on water quality at the reservoirs would be treatable by the existing Sydney Water treatment plants."*

The adequacy of relying on water treatment capacity in context of the relevant performance measures is considered in Section 4 of this advice.

IEMPC (2019) continued:

> *However, the literature review did not consider potential consequences of groundwater outflows from spill points following mine closure and groundwater repressurisation. This needs careful consideration because of the potential for the outflow to leach metals as it travels through the overburden fracture network. The total surface area of fractures in this network is orders of magnitude greater than that of local fracture networks that affect water quality in watercourses impacted by valley closure. This could have serious potential implications for both the volume of metals reporting to the Sydney water supply in the future and for the unknown but likely extremely long duration of these elevated metal loads, unless appropriately managed. As management options may be limited where spill points occur inside Special Areas, considerations arise as to whether it is feasible to restore water table in the long term.*

> *Better understanding of the potential long-term contaminant loads to reservoirs and other water supply works is essential. This should include integrating monitoring of contaminant concentrations with flow monitoring at operational mines so that contaminant loads*[6] *can be calculated and modelled at key locations. Relevant contaminants should be agreed between primary stakeholders.*

The Independent Advisory Panel for Underground Mining (IAPUM 2021) echoed that advice in the context of the Dendrobium mine:

> *The Panel regards contamination as a potential strategic concern if mining in the Special Areas is to continue long-term or if groundwater levels might recover and lead to increased discharge of contaminated water following the cessation of mining. If either scenario is possible, further consideration by stakeholders of the value and feasibility of estimating contaminant loads and their incorporation in TARPs is recommended.*

Where creeks enter a large reservoir such as the Woronora Reservoir, the creek's contaminant load over periods of days, weeks or months (depending on the flows and hydrodynamics) significantly influences the contaminant concentrations. Basing assessments only on concentrations has limited value, since high loads often coincide with low concentrations and vice versa.

The Woronora Reservoir Impact Strategy (WRIS) expert group was initiated in 2017 for "*Engagement of independent experts to prepare a Woronora Reservoir Impact Strategy, which provides a staged plan of action for further investigations and a report into the impacts of mining near the Reservoir*". Potential impacts on water quality were not considered in the WRIS reports (WRIS 2017, 2019).

3.8. WATERNSW COMMENTS

The Panel was provided by the Department with two documents (WaterNSW 2022b, 2023) in which WaterNSW comment on the water quality performance assessments undertaken by Associate Professor Barry Noller and one document (WaterNSW 2022c) that includes comments on the water quality results in the Metropolitan Coal 2021 Annual Review.

WaterNSW concerns of particular relevance to this advice are:

- Ongoing exceedances of filterable manganese performance indicators (Level 3) for water reaching the reservoir
- 2021 exceedances (Level 3) of water quality indicators for total aluminium, manganese and iron in the Woronora Reservoir (following the WaterNSW letter of 31 Aug 2021 these exceedances have been repeated during 2022)
- Lack of assessment of water quality trends and the impacts of mining on loads
- The potential for more frequent impacts from extreme events as mining footprint increases
- Monitoring and assessment is not rigorous enough to evaluate cumulative impacts on water quality in Woronora Reservoir

[6] Load rate = concentration x flow. This needs to be calculated continuously over time in order to determine loads, which requires methods of measuring or estimating flow and water quality continuously over time. Lack of measurement or estimation of flows and concentrations at high flows currently precludes the estimation of loads in the mine-impacted areas of the Woronora Reservoir catchment (and other mining-impacted catchments in the Special Areas).

- The inadequacy of performance indicators based on filterable metals
- The potential for water quality impacts beyond the upper reservoir due to reservoir flood hydrodynamics.

3.9. CUMULATIVE IMPACTS ASSESSMENT USING NUMERICAL MODELS

In the current context, cumulative impact assessment can include: 1) analysis of historical trends in water quality to assess whether there is a relation with the development of mining, 2) numerical modelling of historical and future impacts of mining on water quality at the reservoir dam wall, and 3) examination of sediment cores to assess the change in nature of benthic sediments. The need for and applicability of these assessments is addressed in Section 4 of this advice. Some introduction to numerical modelling is given here as background.

Modelling potential impacts of mining on water quality at the reservoir dam wall would require a hydrodynamic and contaminant transport numerical model of the Woronora Reservoir. Such models are widely used to support understanding of water quality variability over time and space, to predict risks from environmental changes, and to help identify sediment and water quality management options. A hydrodynamic model simulates the details of how flow moves through the reservoir over time, including the effects of incoming surface and groundwater flows, wind effects and vertical stratification. A contaminant transport model simulates how the relevant contaminants are carried with the flow and their physical and chemical transformations, including transformations between dissolved and particulate states and exchanges between the water and the sediments. The validation of such a model, which is essential to have good confidence in its results, generally requires specific monitoring of reservoir flows, temperature and water chemistry in addition to the routine monitoring that has been undertaken historically. The modelling would also require estimates of flow and contaminant loads at all inflow points.

A hydrodynamic and contaminant transport model does not exist for Woronora although WaterNSW advised that such models exist or are under development for a number of the water supply reservoirs and one is planned for Woronora, with its development underway in the current financial year (2023-2024). WaterNSW has the capacity to employ these models for operational and strategic purposes, including predicting spatial and temporal variations of contaminants in response to loading events, with a recent example in Rumman et al. (2023). These models, if developed considering the relevant physical and chemical processes (including storage and release of metals from sediments under anoxic conditions), have the capacity to estimate how loads of metals associated with mining are translated to the concentrations of metals and other contaminants at the drinking water off-take. They do not have the capacity to estimate the input loads, which must be based on measurements and scenarios.

4.0 PANEL ADVICE

4.1. ASSESSMENTS AGAINST WATER QUALITY PERFORMANCE MEASURES

The Assessments Against Water Quality Performance Measures, and whether the justifications and conclusion that the water quality performance measure for Woronora Reservoir have not been exceeded are reasonable

There are two relevant water quality performance measures to consider: 1) *Negligible reduction to the quality or quantity of water resources reaching the Woronora Reservoir*; 2) *Negligible reduction in the water quality of Woronora Reservoir*. The associated performance indicators are listed in Section 3.6 of this advice.

Assessment against the performance measure for water reaching the reservoir

To assess whether *the justifications and conclusion that the water quality performance measures for Woronora Reservoir have not been exceeded are reasonable* requires careful consideration of both the performance indicators used and the criteria used to assess whether *reduction to the quality of water resources reaching the Woronora Reservoir* is "negligible". The definition of "negligible" in the Project Approval is "*Small and unimportant, such as not to be worth considering*".

The parameters considered for the creek water quality performance indicators are filterable (field filtered using 0.45 µm filter) iron, manganese and aluminium.

The case of manganese is considered first. While the Panel has not re-analysed the extensive water quality data set that is now available for sites ETWQ AU, WRWQ9 and control site WOWQ2, HEC (2022) and previous assessments concluded that exceedances in filterable manganese concentrations at site ETWQ AU and the lack of exceedances at the control site equated to a Level 3 trigger. This triggered the assessment against the performance measure conducted by Associate Professor Barry Noller of The University of Queensland.

In his reports regarding manganese (e.g. The University of Queensland 2022), Associate Professor Noller notes that low levels of filterable manganese, e.g. <0.1 mg/L, exist in the natural creek water but comments that, while increases in manganese concentrations in the Eastern Tributary have been observed as a result of the transfer of soluble manganese from groundwater to surface water through mine-induced subsidence and cracking, values at ETWQ AU and at the various monitoring sites in the mixing zone[7] have been below the ADWG health limit of 0.5 mg/L except for occasional observations above this ADWG value. In drier years prior to 2022, in particular 2018, manganese concentrations at ETWQ AU were considerably higher, up to approximately 2.8 mg/L (Figure 6 below); nevertheless, manganese concentrations in the mixing zone have been, with some exceptions, below 0.5 mg/L. The dilution of high concentrations as the flow moves from the Eastern Tributary at ETWQ AU to the mixing zone at ETFSL 100 and ETFSL 200 is illustrated in Figure 7 below.

The series of assessments from 2018 to 2022 (e.g. The University of Queensland 2018, 2022) consistently conclude that "*Manganese concentrations are easily diluted by freshwater flow to low levels when higher creek flows occur*" and "*The watercourse performance measure, Negligible reduction to the quality of water resources reaching the Woronora Reservoir, is not considered to have been exceeded*".

Regarding whether or not the justifications and conclusions presented in the performance assessments are reasonable for manganese, the Panel has considered the following issues.

[7] The mixing zone is where the creek water is mixed with the upper reservoir water represented by Peabody monitoring sites ETFSL 0, ETFSL 200, ETFSL 500, WDFS1, WDFS1 +100, CONFLU1 and WARARM5 in Figure 2

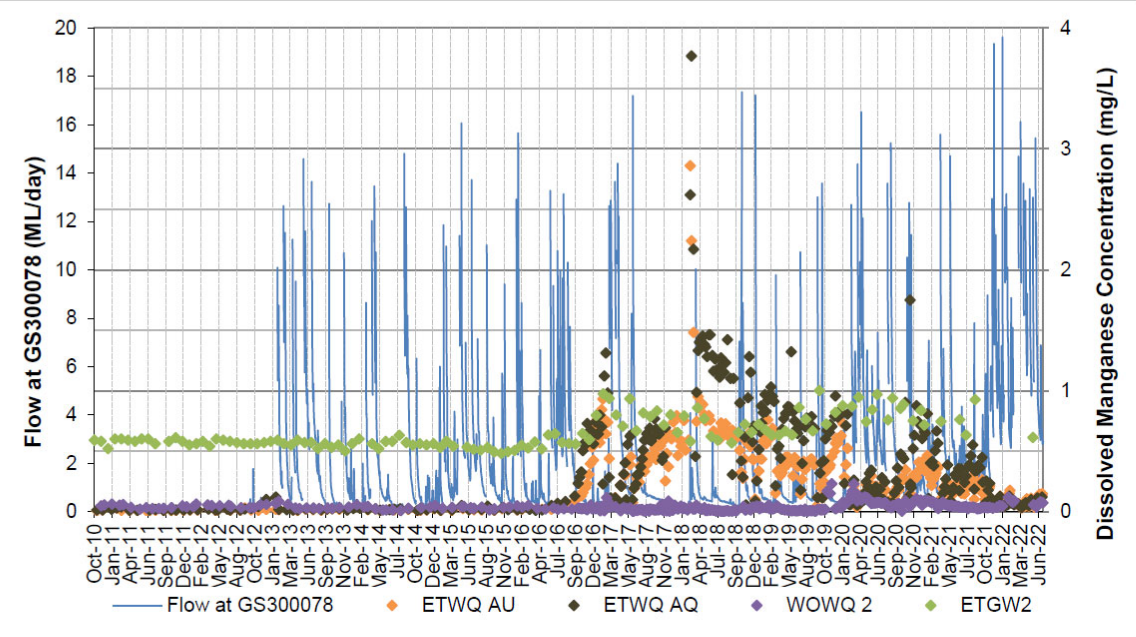

Figure 6. Chart 2 from The University of Queensland (2022): Dissolved Manganese Concentrations at Surface Water Quality Sites ETWQ AU, ETWQ AQ and WOWQ 2 and Groundwater Quality Site ETGW2, and Stream Flow at ETWQ AU (to 30 June 2022)

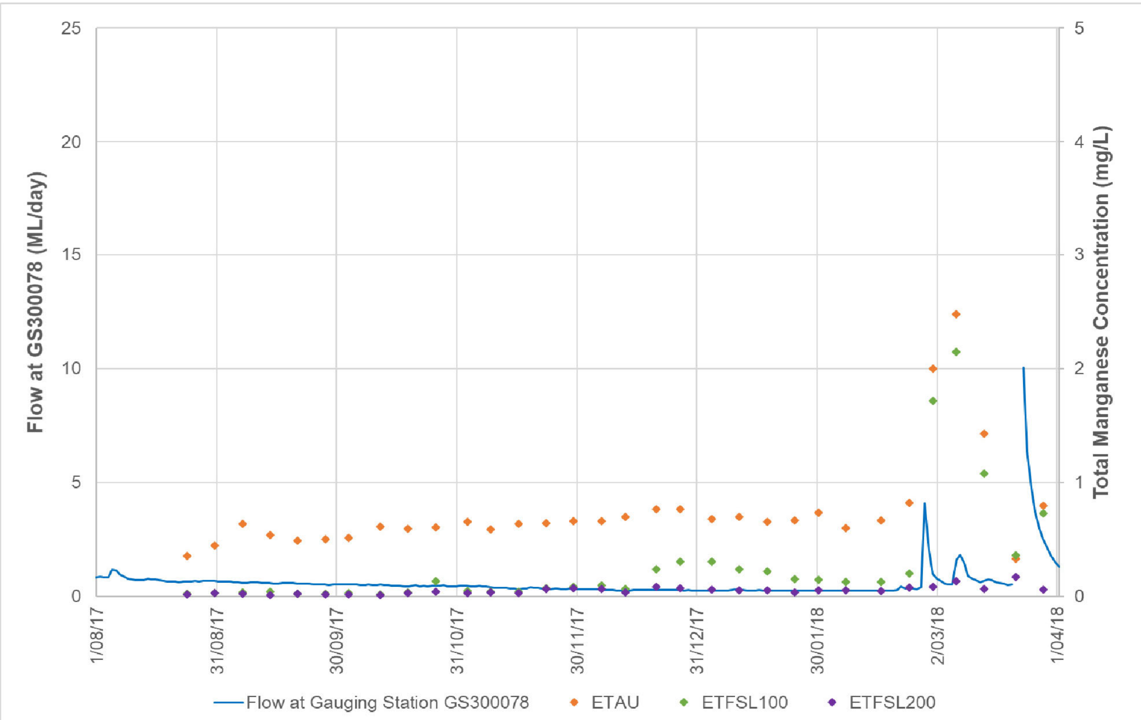

Figure 7. Chart 4 of The University of Queensland (2018): Total Manganese Concentrations at Surface Water Quality Sites ETWQ AU, ETFSL 100 and ETFSL 200 and Stream Flow at ETWQ AU (August 2017 to 31 March 2018)

1. The Water Quality Incident Management protocols and RWSA that define the operational targets and trigger levels of WaterNSW are relevant to the operation of the WFP, and therefore the Panel considers them to be relevant to determining the significance of mining impacts. In particular, the Panel considers that any impact that contributes to concentrations at the off-take point (i.e., at the dam) rising above the alert levels should be treated as a non-negligible impact. The main criterion used in the assessment reports (e.g. The University of Queensland 2022) for manganese is the ADWG limit of 0.5 mg/L, which is considerably higher than the alert level of 0.02 mg/L for filterable manganese.

2. It is unknown how a concentration measured near the entrance to the reservoir (i.e., ETWQ AU, WRWQ9 and the sites in the mixing zone), and the potential accumulation of contaminants in the reservoir sediments, can translate to raw water supply quality at the Woronora dam off-take point some 10 km further downstream. The ADWG criterion applied in the assessment reports for determining a negligible impact might be conservative due to the large potential for dispersion and dilution of manganese between the mixing zone and the dam; on the other hand, it does not consider the potential for manganese to accumulate in the reservoir sediments and subsequently to be released from the sediments and contribute to disruptive events such as that beginning in July 2022.

3. The significance of the impaired water quality reaching the reservoir can only be fully determined using loads as well as concentrations, together with an appropriate hydrodynamic and contaminant transport model to calculate how loads propagate to concentrations at the off-take point, including consideration of cumulative impacts.

4. The persistence of elevated manganese concentrations entering the Woronora Reservoir since, at least, 2017 raises concerns about cumulative impacts, which requires improvement of the assessment approach as addressed in Sections 4.2-4.5 of this advice.

The Panel concludes that the assessment reports presented by Peabody from 2018-2022 and the Peabody Annual Reviews are not based on sufficient data and analysis and therefore do not provide sufficient justification and reasonable conclusions. The assessments do not adequately consider the significance of the impaired water quality (including cumulative impacts) to the ability of WaterNSW to meet the RWSA and Water Quality Incident Management trigger levels. The Panel recognises the significant additional monitoring and modelling that would be required for a fuller assessment and there are associated challenges and uncertainties, which are addressed in Sections 4.2-4.5.

Each of the four points and the conclusion above also apply, in general terms, to aluminium and iron. For these two parameters, there have been occasional level 3 triggers at either ETWQ AU or WRWQ9 during the period 2018-2022 (e.g. HEC 2022, The University of Queensland 2018). These triggers have been based on measurements of filterable iron and filterable manganese although the subsequent assessments of concentrations in the mixing zone sites have included total as well as filterable iron (e.g. The University of Queensland 2018). The Panel emphasises the need for measurement and assessment of both total and filterable concentrations of these elements at all water quality sites (as addressed further in Section 4.2 below). This is particularly the case for iron in view of the possibility that particulate iron oxyhydroxides, the major form of iron present in waters reaching the reservoir, may subsequently undergo reductive dissolution if/when reservoir sediments experience low oxygen conditions (as is likely under thermally stratified conditions in summer) and contribute to an increase in iron concentrations within the reservoir. As emphasised in Section 4.2 below, the measurement of total concentrations of iron, aluminium and manganese will also be critical to obtaining a reliable estimate of total loads of these elements transported to the reservoir.

Assessment against performance measure for the reservoir

The water quality performance measure for Woronora Reservoir is that *changes in the quality of water in the Woronora Reservoir are not significantly different post-mining compared to pre-mining concentrations*. As prescribed in Table 26 of Peabody (2022) (reproduced in Table 5 above), the water quality performance measure for Woronora Reservoir is quantified by determination of the percentage of time that total concentrations of iron, aluminium and manganese for any particular year are above the 10 and 20 year average recurrence interval (ARI) exceedance curves with increasing incidence of exceedances defining the Levels 1, 2 and 3 triggers. Exceedances of these triggers results in the requirement for particular actions by Peabody as described in Table 26 of Peabody (2022). Assessment against this water quality performance measure for Woronora Reservoir is presented in the six-monthly and annual surface water review reports (e.g. HEC 2022). HEC (2022) states that "*Total iron exceeded the baseline 10 Year exceedance curve for 100% of the review period and marginally exceeded the baseline 20 Year ARI exceedance curve for approximately 92% of the review period (refer Chart 32). Total aluminium exceeded the baseline 10 Year and 20 Year ARI exceedance curves for 100% and 85% of the review period respectively (Chart 33). Total manganese exceeded the baseline 10 Year exceedance curve for 100% of the review period and marginally exceeded the baseline 20 Year ARI exceedance curve for approximately 31% of the review period (Chart 34). The results for total iron, total aluminium and total manganese equate to a Level 3 significance*."

Implementing the Level 3 exceedance actions (listed in Table 5 above), HEC (2022) concluded that reasonably similar trends in total iron, aluminium and manganese concentrations were observed in Woronora, Nepean and Cataract Reservoirs through 2022. HEC also compared total aluminium, iron and manganese concentrations with the Water Quality Incident Management trigger levels (Table 1 above) and concluded that:

- The water quality standard applicable for (total) aluminium of 0.4 mg/L was slightly exceeded from March to October 2022
- The water quality standard applicable for (total) iron of 1.0 mg/L was not exceeded during 2022
- The water quality standard applicable for (total) manganese of 0.1 mg/L was not exceeded during 2022.

On the basis of these analyses, HEC advised that the Performance Measure of "*Negligible reduction in the water quality of Woronora Reservoir*" had not been exceeded.

In providing advice on compliance with this Performance Measure, the Panel has taken into account the advice from Sydney Water Corporation that operators of the Woronora Filtration Plant have experienced difficulty in operating the plant at outputs above the minimum of 40 ML/day since mid-2022 with this difficulty associated with the high sediment and natural organic matter (NOM) content of incoming raw water from Woronora Reservoir.

In assessing the extent of potential challenges associated with maintenance of water of good quality in Woronora Reservoir, the Panel has considered WaterNSW's Water Quality Incident Response Protocol (WaterNSW 2021a) (a partial list of incident trigger levels is provided in Table 1). Increased incidence of exceedances of the alert, minor or major response levels provides a clear indication of deterioration of reservoir water quality as a result of either natural or man-made phenomena or both.

While it is likely that high rainfall in the Woronora Reservoir catchment and resultant increase in transport of sediment and dissolved materials (such as natural organic matter and manganese) has contributed to the increase in number of water quality exceedances in recent years, the Panel is unable to rule out the possibility, on the basis of the information provided, that mining-related activity may have also been a contributing factor.

In summary, the assessment of HEC (2022) is not sufficient in that water quality during 2022-2023 (and during other periods historically) has been poor and caused significant water treatment and water supply operational complications, and the contribution of mining to this is yet to be determined. The Panel considers that the depth of analysis provided in the annual and six-monthly reports (e.g. HEC 2022), while significant, is incommensurate with the impacts and the uncertainty regarding mining's potential contribution to these impacts and their consequences. Advice on further assessment is provided in Section 4.3.

4.2. PERFORMANCE INDICATORS

Whether the performance indicator for negligible reduction to the quality of water resources reaching the Woronora Reservoir defined in WMPs is appropriate

Due to the potential for particulate forms of Fe, Mn and Al to be transported into the reservoir and thereafter be transformed into filterable forms (see the description of mechanisms in Section 3.5 of this advice) and due to the relevance of total Fe, Mn and Al for the WaterNSW Water Quality Incident Response Protocol, the performance indicators and associated trigger levels should be assessed using <u>total</u> Fe, Mn and Al where sufficient baseline data exist. Sufficient baseline data should be ensured for future mining areas. Both total and filterable metals concentrations should be reported in six-month and annual reports.

The descriptions of the performance indicators and trigger levels for ETWQ AU and WRWQ9 in Table 24-A of Peabody (2022) (Table 3 above) are satisfactory, although will need to be reviewed where performance indicators are changed to use of total metals concentrations. The Panel emphasises the importance of also considering loads for impacts assessment and six-monthly and annual reporting when supporting data sets become available (see advice in 4.3); however, data limitations mean that the reliance on concentrations for monthly assessment of performance indicators and associated trigger levels is appropriate for the current series of longwalls.

The performance indicator for the reservoir (comparison of ARI curves for <u>total</u> Fe, Mn and Al) and associated trigger levels are appropriate. As noted above, the assessment of the performance indicators against the performance measures has not been sufficient.

4.3. MONITORING, ANALYSIS AND ASSESSMENT

Whether additional water quality monitoring, analysis and/or assessment is required to further determine compliance with the water quality performance measure for Woronora Reservoir

<u>Additional water quality monitoring</u>

Flow event water quality (including filterable and total Fe, Mn and Al) using automatic samplers at ETWQ AU, WQWQ9 and WOWO2 should be obtained to support analysis of loads. At the same sites, continuous measurements of electrical conductivity, pH, redox potential, and turbidity should be obtained. This is required to understand water quality impacts at high flows and to estimated metal loads. It is recommended that Peabody develop a monitoring plan in consultation with WaterNSW. The plan should include additional sites that will allow BACI (Before-After-Control-Impact) analysis of concentrations and loads to be applied to creek sites in potential future mining areas.

It is recommended that temperature and water quality data be obtained at various depths through the water column in the upper reservoir (at a location such as WDFS1 that is downstream of the entry of both the Waratah Rivulet and Eastern Tributary as shown in Figure 3) to capture both the temperature stratification behaviour and the water quality at this point. Time series analysis of this information should be used in assessing the possible impact of increased loads of metals resulting from mining on reservoir water quality at this location. These data will also be of value in calibrating and validating a hydrodynamic and contaminant transport model of the reservoir that would assist in assessing whether increased concentrations of filterable and particulate metals, that may arise as a result of mining, impact the quality of feed waters to the Woronora Filtration Plant (see Section 4.5).

<u>Reservoir sediment sampling</u>

Diversion of surface water and groundwater through mining-induced rock fractures and subsequent discharge of contaminated water containing elevated concentrations of iron and manganese into creeks and then into the reservoir would be expected to result in an accumulation of freshly deposited iron and manganese oxyhydroxides in benthic sediments in Woronora Reservoir. As noted earlier, freshly deposited particulate oxyhydroxides of iron and manganese are likely to be more reactive and more readily mobilised on onset of low oxygen conditions than the more crystalline (and thus less reactive) forms of these elements that are intrinsically present naturally in the sediments. While the iron and manganese minerals deposited to the sediments in the upper reaches of the reservoir may not necessarily lead to increased exceedances of alert levels for these elements at the offtake point to the WFP, the Panel is of the view that there would be value in improved understanding of the extent of any increase in iron and manganese concentrations in reservoir sediments as a result of mining through the procurement and subsequent analysis of sediment cores at selected locations downstream of the confluence of Waratah Rivulet and Eastern Tributary with the reservoir. An advantage of analysis of sediment cores is that it can provide a historical record of changes to inputs to the reservoir though it should be recognised that increased inputs are likely to be associated with both high rainfall events and, possibly, increased loads of iron and manganese as a result of mining.

Improved high flow estimation

A constraint in estimating loads is the uncertainty in high flow rates measured at the Eastern Tributary and Waratah Rivulet flow gauges. For example, the rating curve for the Waratah Rivulet indicates that maximum accurately measured flow (approximately 17,000 L/s) is less that the maximum estimated flow (230,000 L/s)[8]. The Eastern Tributary flow gauge is accurate up to a flow rate of 235 L/s, while flows have been estimated up to approximately 2,000 L/s (see IEAPM 2023).

Suitable methods for improving the extension of the Eastern Tributary rating curves should be undertaken by Peabody. WaterNSW should review whether the extension of the rating curve at the Waratah Rivulet could be improved. Selected watercourses in future mining areas should have flow gauges installed with, as far as practicable, validated rating curves. For flow gauges in the small tributaries, it may be impractical to extend rating curves to high flows, and alternative methods of high flow estimation may be required (rainfall-runoff modelling).

Additional analysis and assessment

When reservoir water quality passes a level 3 trigger, more detailed analysis of the reservoir water quality should be undertaken to help determine whether the consequences of subsidence impacts have been negligible. This more detailed analysis should include:

i) data collected at various depths at DW01 (i.e., at the vertical profiler),

ii) data collected at various depths at Woronora Reservoir at DWO_THMD (Honeysuckle Creek Junction),

iii) once installed, data collected at various depths at WDFS1 (Figure 3) (or similar site representing the confluence of the Eastern Tributary and Waratah Rivulet arms of the reservoir),

iv) iron and manganese concentrations in reservoir sediments.

Similarly, when water quality reaching the reservoir at performance indicator sites surpasses a level 3 trigger, analysis should be extended to:

i) once installed, data collected at various depths at WDFS1 (Figure 3) (or similar site representing the confluence of the Eastern Tributary and Waratah Rivulet arms of the reservoir),

[8] Rating curve and maximum flow estimate is from the Waratah Rivulet entry on https://realtimedata.waternsw.com.au/

ii) if available, metal load estimates (see below).

iii) if available, reference to results of a lake hydrodynamic and contaminant transport model (see Section 4.5).

After a database of flow and concentration measurements has been built up, analysis should be conducted towards generalisation of flow-(total metal) concentration relationships, and approximation of loads, and whether these have changed as mining has progressed. Initial results including total Fe, Al and Mn loads at ETWQ AU, WQWQ9 and WOWO2 should be reported in the 2024 Annual Report, and updates provided in subsequent annual reports. The same reports should be provided for water quality performance indicator sites in future mining areas. BACI analysis should be undertaken as far as permitted by data.

For both flow and load estimation, the Panel acknowledges that high accuracy is not achievable for high flows; furthermore, there is a lack of baseline data covering historical longwall mining in the catchment, which started in 1995 (measurement of water quality at site ETWQ AU commenced in 2010, while at WQWQ9 it commenced in 2006 though measurements elsewhere in the Waratah Rivulet date back to 2001). For these reasons a BACI analysis will have limited applicability to determining cumulative impacts of mining in the Eastern Tributary and Waratah Rivulets, and smaller catchments being undermined as part of the 300 longwall series. Furthermore, estimation of loads from current mining areas will be limited by difficulty of monitoring flows and water quality in the smaller and less accessible tributaries of the reservoir. Nevertheless, approximate estimates of loads and mining impacts on loads from these catchments will support scenario analysis to assess whether water quality risks from mining are potentially significant for the operation of the reservoir and WFP. Application of load estimates to future mining areas including baseline periods and control sites will allow a complete BACI analysis based on loads as well as concentrations.

4.4. MITIGATION AND MANAGEMENT OF WATER QUALITY IMPACTS

Whether any further reasonable and feasible actions to mitigate and manage water quality impacts are considered necessary, beyond the existing requirements to continue implementing monitoring and management programs

A significant program of remediation (grouting of fractures) in the Waratah Rivulet and Eastern Tributary has contributed and continues to contribute to the sealing of fractures and reducing subsidence-induced contamination. The Panel expects this program to continue to have positive impacts on contaminant loads to the reservoir. However, because the grouting cannot and does not aim to seal all fractures that interact with the surface flows, the Panel does not expect the remediation to return concentrations or loads of metals to pre-mining values. Some fractures may self-seal due to accumulation of oxidised contaminants and other particles.

At this time, the Panel does not advise additional mitigation and management measures (aside from the monitoring and analysis recommended above) beyond the ongoing grouting plan. Depending on future water quality trends, there may be a need for mitigation and management measures by WaterNSW and Sydney Water, which might include expansion of reservoir de-stratification and adjustments to the WFP operation. Depending on future water quality trends and the degree of attribution to mining, there may also be a need for mitigation and management measures by Peabody in forms of changing the nature of water quality trigger levels, expansion of the remediation program, and changes to mine plans.

4.5. CUMULATIVE IMPACT ASSESSMENT

Whether a cumulative impact assessment study is considered necessary to review water quality trends and potential impacts on drinking water supply from increased metals loads from the catchments impacted by mine subsidence at Metropolitan Mine.

As previously noted, although there are natural influences on water quality that might explain the observed variations in water quality including the extreme event in July 2022, the Panel cannot rule out the possibility that the Metropolitan Mine has had a non-negligible adverse impact based on the existing analyses in Annual Reports. The Panel recommends that a more detailed analysis be undertaken of historical reservoir water quality (including control sites in reservoirs not affected by mining) in order to analyse potential trends and relations with mining development**.** This should be included in the 2023 Annual Review and updated in subsequent annual reviews.

As noted earlier, analysis of cores of reservoir benthic sediments can provide a historical record of changes to inputs to the reservoir and represents one of the few ways of assessing cumulative changes. It should be recognised however that increased inputs are likely to be associated with both high rainfall events and, possibly, increased loads of iron and manganese as a result of mining. Also, it should be emphasised that any increase in the extent of iron and manganese minerals deposited to the sediments in the upper reaches of the reservoir may not necessarily lead to increased exceedances of alert levels for these elements at the offtake point to the WFP. Despite this, the Panel is of the view that such information would add to general understanding of potential impacts of mining on reservoir water quality.

Development and application of a hydrodynamic and contaminant transport model may be useful to inform assessments required by level 3 trigger exceedances (either those for water entering the reservoir, or those for water in the reservoir). The model results could support determination of whether a measured or estimated increase in metal loads due to mining affects the current or future ability of WaterNSW to meet raw water supply agreements. It would also allow testing of hypotheses that measured changes in water quality in the reservoir are attributable partially to mining. The Panel understands that WaterNSW is commissioning a hydrodynamic and contaminant transport model for the Woronora Reservoir in the 2023-2024 financial year. Due to the catchment and reservoir data sets required, and knowledge of catchment and reservoir operations required, it is unlikely to be sensible for Peabody to undertake an independent hydrodynamic and contaminant transport analysis. It is recommended that a model set-up is designed to support assessments of potential mining impacts with consideration of how the responsibility for the modelling is shared between stakeholders. For example, the model may be run over a long time-frame to capture potential effects of historical, current and future mining, updated every year to allow for advances in data (in particular load estimates). Peabody could refer to the model results when assessments against performance measures are required.

4.6. OTHER MATTERS

Strategic water quality risks

As noted by the IEPMC (2019), there are strategic risks to water quality in the Special Areas related to the cumulative and long-term consequences of mining subsidence. These arise from:

- The potential for cumulative consequences of historical, current and future mining areas on reservoir water and sediment quality.

- The potential for widespread mobilisation of contaminants from subsidence-induced fractures if regional groundwater levels and pressures increase. This could occur if voids (such as roadways and adits) are sealed following mining, or due to wet weather increasing groundwater levels and pressures beyond those seen during the mining period. Increasing groundwater pressure has the potential to drive groundwater to surface water through fractures that have not previously been flushed of contaminants.

The current advice partially addresses these concerns for the Woronora reservoir by recommending monitoring and analysis that supports a better understanding of the contaminant loads from longwall mining areas of the catchment, improved capability to predict the consequences for water quality supplied to the WFP and better baseline data and modelling capability for assessing future mining proposals. The Panel emphasises the recommendation of the IEPMC (2019) that a broad study is needed of long-term cumulative impacts of mining on water quality in the Special Areas. While some elements of this are addressed in this advice, there are other considerations that may affect long-term water quality management that need considered for Metropolitan mine (including post-mining monitoring design, closure and post-closure planning, and groundwater and hydrogeochemical modelling).

<u>The Dupen (2023) report</u>

The Dupen (2023) report raises concerns that unforeseen impact mechanisms are having adverse consequences for hydrology, ecology and water quality in the Woronora catchment. In the IEAPM's advice to the Department on the Dupen (2023) report (IEAPM 2023), matters related specifically to water quality were deferred to this advice.

Dupen (2023) put forward the views that:

- *The aquifers which sit above and feed the incised valley streams are draining at rates measurably higher than pre-mining, in places rapidly and completely, due to unexpected and unpredicted formation of large-scale shear planes opening up at their base.*

- *If this new subsidence mechanism is indeed widespread, a likely outcome is that a range of protected Special Area ecosystems overlying the mine will dry and change. The other major risk from widespread basal shear formation is that it will cause the water quality in the Woronora drinking water reservoir to become increasingly degraded by metal- laden discharges from unmeasured shear plane vents.*

As discussed elsewhere in this advice, the Panel advises that there is a risk that mining-induced fracturing has and will continue to have adverse consequences for the quality of water entering the Woronora Reservoir from subsidence-affected creeks and therefore for the water quality of the reservoir. Further, the Panel considers that, if the increased flow rates associated with the Dupen hypothesis are due to the formation of large-scale shear planes then this is expected to result in an increased load of contaminants entering the Woronora reservoir. Indeed, the unexplained high flows from April 2020 to late 2022 (the latter being the end of the data period presented in Dupen 2023) combined with the elevated Mn concentrations in Figure 6 above raise concern and illustrate the need in future for loads to be assessed as well as concentrations. However, if contaminant load estimation at site ETAU WQ indicates an increased load of Mn, Fe or Al, this could be caused by increased flow though fractures underlying the creek or an increased discharge of regional groundwater by natural pathways and would not by itself confirm the Dupen hypothesis. If further investigation of the source of the increased flows is required (the reader is referred to the IEAPM (2023) for recommendations on this), the use of chemical and physical tracers of regional groundwater discharge should be considered as an element of that analysis.

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS

The quality of the Woronora Reservoir (and during other periods historically) has been poor during 2022-2023 and has led to significant complications for water treatment and water supply. Although there are natural influences on water quality that might explain the observed variations in water quality, the Panel cannot rule out the possibility that the Metropolitan Mine has had an adverse impact.

While dissolved forms of iron, manganese and aluminium (Fe, Mn and Al) are of primary relevance to raw water quality, there is potential for particulate forms to be transported from the catchment into the reservoir and thereafter, in the case of Fe and Mn, be transformed into dissolved forms. Hence, total (dissolved plus particulate) Fe, Mn and Al concentrations are relevant and the reliance on dissolved Fe, Mn and Al concentrations in the Metropolitan Mine performance indicators is unsatisfactory.

The assessments of the quality of water reaching the Woronora Reservoir presented by Peabody in response to level 3 triggers are not based on sufficient data and analysis and therefore do not provide sufficient justification and reasonable conclusions. The assessments do not adequately consider the potential significance of the impaired water quality for the WaterNSW Raw Water Supply Agreement and Water Quality Incident Management trigger levels.

The assessments of the quality of water in the Woronora Reservoir are not based on sufficient data and analysis and therefore do not provide sufficient justification and reasonable conclusions. The Panel considers that the depth of analysis provided in the annual and six-monthly reports, while significant, is incommensurate with the uncertainty regarding mining's potential contribution to the degraded water quality and incommensurate with the consequences of the degradation in terms of the ability of WaterNSW to meet the Raw Water Supply Agreement and in terms of the disruption to operation of the Water Filtration Plant (WFP).

Aside from the need to transition to the use of total metals, the existing descriptions of the performance indicators and trigger levels for the Eastern Tributary and Waratah Rivulet are satisfactory. They will need to be reviewed when and where performance indicators are changed to the use of total metals concentrations.

The performance indicators and trigger levels for the reservoir (which use total Fe, Mn and Al concentrations) are appropriate, although should be subject to annual review.

The significance of the impaired water quality reaching the reservoir can only be fully determined using contaminant loads (concentration x flow rate) as well as concentrations because high loads can coincide with low concentrations and vice-versa. Improved high flow data and flow event water quality is required to understand water quality impacts and to estimate contaminant loads.

Due to data constraints and monitoring practicalities, analysis of contaminant loads will have limited applicability to determining cumulative impacts of mining in the Eastern Tributary and Waratah Rivulets and other catchments that are being undermined as part of the 300 longwall series. Nevertheless, approximate estimates of loads from these catchments will support scenario analysis to assess whether water quality risks from mining are potentially significant for the operation of the reservoir and WFP. Application of contaminant load estimates to future mining areas including baseline periods and control sites will allow a complete Before-After-Control-Impact (BACI) analysis based on loads as well as concentrations.

An appropriate hydrodynamic and contaminant transport model will support determination of whether a measured or estimated increase in metal loads due to mining affects the current or future ability of WaterNSW to meet raw water supply agreements. It would also allow testing of hypotheses that measured changes in water quality in the reservoir are attributable partially to mining. WaterNSW is planning to implement such a model for the Woronora Reservoir in the 2023-2024 financial year. Due to the catchment and reservoir data sets required, and knowledge of reservoir operations required, it is unlikely to be sensible for Peabody to undertake an independent hydrodynamic and contaminant transport analysis.

Temperature and water quality data obtained at various depths through the water column in the upper reservoir would capture both the temperature stratification behaviour and the water quality at this point. As well as supporting assessments of whether changes in the water quality reaching the reservoir have been non-negligible, these data will be of value in calibrating and validating a hydrodynamic and contaminant transport model of the reservoir.

There would be value in improved understanding of the extent of any increase in iron and manganese concentrations in reservoir sediments. Sediment cores can provide a historical record of changes to inputs to the reservoir though it should be recognised that increased inputs are likely to be associated with both high rainfall events and, possibly, increased loads of iron and manganese as a result of mining.

The program of remediation (grouting of fractures) in the Waratah Rivulet and Eastern Tributary has contributed and continues to contribute to the sealing of fractures and reducing subsidence-induced contamination. The Panel expects this program to continue to have positive impacts on contaminant loads to the reservoir. However, because the grouting cannot and does not aim to seal all fractures that interact with the surface flows, the Panel does not expect the remediation to return contaminant concentrations or loads to pre-mining values.

At this time, the Panel does not advise additional mitigation and management measures (aside from the monitoring and analysis recommended above) beyond the ongoing grouting program.

Long-term risks to water quality in the Special Areas arise from:

- The potential for cumulative consequences of historical, current and future mining areas on reservoir water and sediment composition and quality.

- The potential for widespread mobilisation of contaminants from subsidence fractures if regional groundwater levels and pressures rebound.

The current advice partially addresses these concerns for the Woronora reservoir by recommending monitoring and analysis that supports a better understanding of the contaminant loads from longwall mining areas of the catchment, improved capability to predict the consequences for water quality supplied to the WFP and better baseline data and modelling capability for assessing future mining proposals.

If the unexpectedly high flow rates that have been measured at the Eastern Tributary from early 2020 to late 2022 (which are assessed in detail in a separate report by the IEAPM) are due to increased groundwater discharge through subsidence fractures or shear planes, they may be associated with highly elevated contaminant loads. This illustrates the need for reporting of contaminant loads wherever possible with available data. Furthermore, measurement of the water chemistry of these streams can assist in determining the source of these unexpectedly high flows.

5.2 RECOMMENDATIONS

Performance indicators and associated trigger levels for water reaching the Woronora Reservoir should be assessed using total Fe, Mn and Al where sufficient baseline data exist. Both total and dissolved Fe, Mn and Al concentrations should be reported in six-month and annual reports.

Contaminant loads as well as concentrations should be considered in performance measure assessments and six-monthly and annual reporting as far as data allow. Current data limitations mean that reliance on concentrations for monthly assessment of performance indicators is appropriate for the current series of longwalls.

Flow event water quality (including dissolved and total Fe, Mn and Al concentrations) using automatic samplers at ETWQ AU, WQWQ9 and WOWO2 should be obtained to support analysis of contaminant loads. At the same sites, continuous measurements of electrical conductivity, pH, redox potential, and turbidity should also be obtained.

After a database of flow and concentration measurements has been built up, analysis should be conducted towards generalisation of flow-concentration relationships, and approximation of loads, and whether these have changed as mining has progressed. Initial results including total Fe, Al and Mn loads at ETWQ AU, WQWQ9 and WOWO2 should be reported in the 2024 Annual Report and updates provided in subsequent annual reports. Load estimates should be provided in future Annual Reports for performance indicator sites in future mining areas.

For future mining areas, flow and contaminant concentrations should be measured at least two years in advance of mining at impact and control sites to allow BACI analysis.

Suitable methods for improving the extension of the Eastern Tributary rating curves to improve high flow measurement accuracy should be undertaken by Peabody. WaterNSW should review whether the extension of the rating curve at the Waratah Rivulet could be improved. Selected watercourses in future mining areas should have flow gauges installed with validated rating curves. Where it is impractical to extend rating curves to high flows, alternative methods of high flow estimation should be considered.

Temperature and water quality data should be obtained at various depths through the water column in the upper reservoir (at a location such as WDFS1 that is downstream of the entry of both the Waratah Rivulet and Eastern Tributary) to capture both the temperature stratification behaviour and the water quality at this point. Frequency of data collection should increase following significant flow events and following level 3 triggers for water quality reaching the reservoir.

It is recommended that an agreement be reached whereby a hydrodynamic and contaminant transport model set-up is designed to support assessments of potential mining impacts. Consideration should be given as to how the responsibility for the modelling is shared between WaterNSW and Peabody.

Peabody should procure sediment cores at selected locations downstream of the confluence of Waratah Rivulet and Eastern Tributary within the reservoir and at control sites in the reservoir in order to assess the possible impacts of mining on alterations to sediment composition (with implications to possible mobilisation of Fe and Mn should these sediments become anoxic).

When quality of water reaching the reservoir at performance indicator sites surpasses a level 3 trigger, analysis should be extended to:

- once installed, water quality data collected at various depths at WDFS1 or similar site representing the confluence of the Eastern Tributary and Waratah Rivulet arms of the reservoir,
- if available, contaminant load estimates,
- if available, reference to results of a lake hydrodynamic and contaminant transport model run using relevant scenarios of increased contaminant loads.

In any future mining areas, performance indicators and triggers should be based on loads as well as concentrations.

When reservoir water quality passes a level 3 trigger, more detailed analysis of the reservoir water quality should be undertaken including:

- data collected at various depths at DW01 (i.e., at the vertical profiler),
- data collected at various depths at Woronora Reservoir at DWO_THMD (Honeysuckle Creek Junction),
- once installed, data collected at various depths at WDFS1 (Figure 3) (or similar site representing the confluence of the Eastern Tributary and Waratah Rivulet arms of the reservoir),
- iron and manganese concentrations in reservoir sediments.

Irrespective of these recommendations for further analysis in response to triggers, the Panel recommends that a more detailed analysis be undertaken of historical reservoir water quality and sediment cores in order to analyse potential trends and relations with mining development. This should be included in the 2023 Annual Review and updated in subsequent annual reviews.

Following IEPMC (2019), it is recommended that a broader study of potential long-term cumulative impacts of mining on water quality in the Special Areas is needed.

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Large Swamp Assessment

Briefing Paper

Metropolitan Coal Longwalls 311-316 Extraction Plan

- Metropolitan Coal has commenced preparation of a new Extraction Plan for Longwalls 311-316.
- The primary assessment consideration for Longwalls 311-316 is expected to be impacts to the three large swamps (S76, S77 and S92) given the panels either directly undermine the swamps or are in close proximity.
- Therefore, approval for Longwalls 311-316 to be sought under a single extraction plan.

Large Swamps Background

- Metropolitan Coal Project Environment Assessment (EA) was lodged in July 2008. The EA did not consider the findings of the Southern Coalfield Inquiry Report released in the same month.
- Large Swamps S76, S77 and S92 were identified as being of "special concern" by the Planning Assessment Commission (PAC) in its 2009 Review Report.
- The PAC concluded these swamps should be subject to further attention primarily due to:
  - having their lower ends in valleys with moderate longitudinal slopes;
  - the EA describing them as terminating at rock bars;
  - increased vulnerability to the effects of valley closure and upsidence; and
  - potentially being exposed to non-conventional subsidence impact.
- Section 9.4.1 of the PAC Review Report sets out the assessment process to be followed for upland swamps – *Upland Swamp Risk Assessment Approach*.
- The application of this approach to Swamps S76, S77 and S92 would require consideration of several recommendations set out in section 9.4.2 of the PAC Review Report.
  - *"This approach is not designed to provide a higher level of protection to Swamps S76, S77 and S92 than that being afforded to other swamps in the Project Area."*

- These recommendations were reflected in Condition 4, Schedule 3 of Project Approval (08_0149):

> *The Proponent shall not undermine Swamps 76, 77 and 92 without the written approval of the Director General. In seeking this approval, the Proponent shall submit the following information with the relevant Extraction Plan (see condition 6 below):*
>
> *a) a comprehensive environmental assessment of the:*
> - *potential subsidence impacts and environmental consequences of the proposed Extraction Plan;*
> - *potential risks of adverse environmental consequences; and*
> - *options for managing these risks;*
>
> *b) a description of the proposed performance measures and indicators for these swamps; and*
>
> *c) a description of the measures that would be implemented to manage the potential environmental consequences of the Extraction Plan on these swamps (to be included in the Biodiversity Management Plan – see condition 6(f) below), and comply with the proposed performance measures and indicators.*

Metropolitan Coal proposes to address Condition 4 as part of the Longwalls 311-316 Extraction Plan.

Monitoring and Assessments Conducted to Date

Monitoring and impacts to date:

- Metropolitan has extracted 15 of 25 longwalls approved under the Project Approval (08_0149), these being LW20-27 and LW301-307 (2010 to 2022).
- To date a total of 33 swamps have been directly extracted beneath, with two having been determined to have attributable mining impacts from early longwalls.
- Longwall extraction geometries at Metropolitan are deliberately conservative to minimise the probability of impacts.

Assessments:

- Metropolitan Extraction Plans and environmental monitoring reports since the 2009 PAC Report have generally addressed the recommendations for swamp assessments as outlined in **Table 1**.

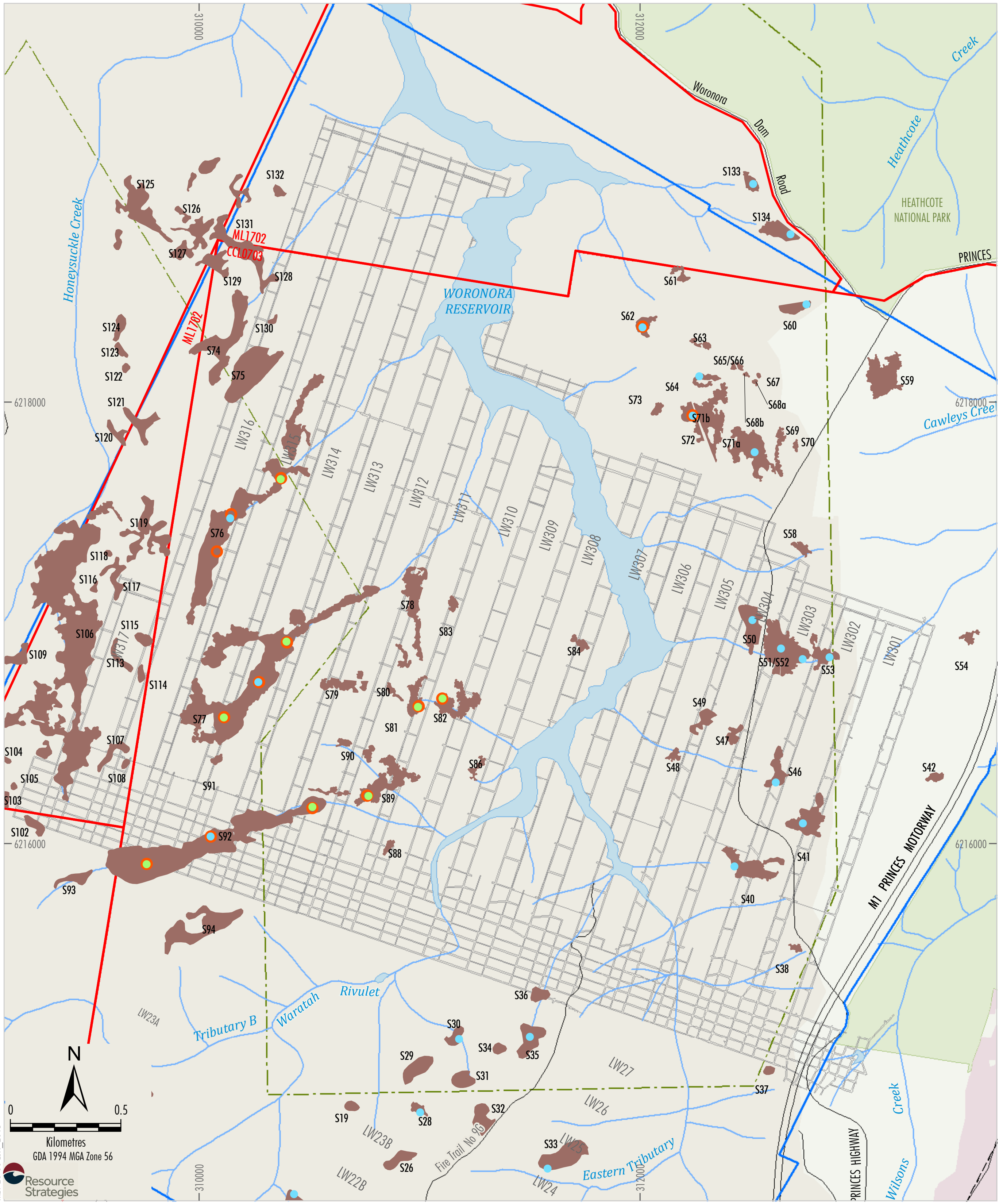
Table 1: 2009 PAC Report – Summary of Swamp Assessment Recommendations

Swamp Assessment Component
• Establishment of Risk Management Zones around swamps
• Prediction of conventional subsidence and impacts
• Prediction of non-conventional subsidence and impacts
• Establishment of strategies where outcomes are not achieved or predicted impacts are exceeded
• Utilise the Upland Swamp Risk Assessment Approach for assessing swamps
• Follow approach for assessing the acceptability of negative environmental consequences
• Monitoring of sample swamps previously undermined
• Monitoring of upsidence and valley-closure impacts
• Provision of net subsidence effects at significant features
• Implement groundwater monitoring regimes proposed by the Southern Coalfield Inquiry into Impacts on Swamps
• Vegetation mapping for classifying swamps
• Collection of baseline data necessary for assessing swamps

- Some recommendations of the PAC continue to be addressed through the ongoing fieldwork, monitoring, analysis and reporting implemented under the existing extraction plans:
  - Quarterly observation of previously undermined swamps for subsidence impacts (including upsidence and valley closure) as a part of Subsidence Monitoring Programs.
  - Groundwater and surface water monitoring programs (see below) implemented in accordance with Southern Coalfields Inquiry recommendations.
  - Ongoing vegetation monitoring and vegetation mapping for collection of baseline data – completed for swamps in 2016 and 2019.
- Other PAC recommendations outlined in **Table 1** have been incorporated into Extraction Plans since project approval.

Monitoring Programs:

- Swamp piezometers and moisture probes installed in Swamps S76, S77 and S92 in November 2020 including (**Figure 1 and Table 2**):
  - substrate groundwater piezometers installed approximately 10 m depth,
  - shallow groundwater piezometers installed at approximately 1 m depth, and
  - soil moisture probes.



LEGEND

Mining Lease Boundary
Woronora Special Area
Project Underground Mining Area Longwalls 20-27 and 301-317
Woronora Notification Area
Existing Underground Access Drive (Main Drift)
Upland Swamp
Swamp Substrate and Shallow Groundwater Piezometer
Swamp Substrate Groundwater Piezometer
Swamp Shallow Groundwater Piezometer
Swamp Soil Moisture Probe

Source: Land and Property Information (2015); Department of Industry (2015); Metropolitan Coal (2021); MSEC (2019)

Peabody
METROPOLITAN COAL

Upland Swamp Groundwater Monitoring Locations

Figure 1

Table 2. Groundwater Monitoring in Large Swamps

Swamp	Groundwater Monitoring Distribution
S76	• 1 substrate and shallow groundwater piezometer • 2 substrate piezometers • 3 soil moisture probes
S77	• 1 substrate and shallow groundwater piezometer • 2 substrate piezometers • 3 soil moisture probes
S92	• 1 substrate and shallow groundwater piezometer • 2 substrate piezometers • 3 soil moisture probes

- Flow measuring flumes installed downstream of Swamps S76 and S92.
- Additional Groundwater Monitoring shallow piezometers to be installed at the locations of substrate piezometers.

Swamp Remediation Measures

- Proposed swamp remediation measures are outlined in the approved Biodiversity Management Plan, including:
  - installation of coir log dams at knick points;
  - water spreading techniques using coir log and hessian ‘sausages’ such that water flow builds up behind them and slowly seeps through to maintain swamp moisture; and
  - injection grouting of rock substrate where fracturing has occurred.

Proposed Actions

Environmental Assessments

- Summary of swamp monitoring and impacts detected by the Project to date.
- Endorsement of suitably qualified experts to be sought.
- Field surveys to further characterise the large swamps.
- Ongoing collection of large swamp monitoring data necessary for establishing baseline conditions and assessing potential impacts on large swamps.

- Large Swamp Risk Assessment to be undertaken to resolve any outstanding uncertainty regarding impacts.
- Specialist studies to be completed as per **Table 3**.

Table 3: Proposed Assessment Scopes for Large Swamps

Assessment	Specialist	Scope
Subsidence	Mine Subsidence Engineering Consultant	• Site inspection of large swamps and recording of key features. • Subsidence predictions including non-conventional subsidence (closure and upsidence) and long-section profiles along each swamp. • Pre and predicted post mining topography. • Recommendation on high precision Global navigation satellite system monitoring sites specifically at key swamp rock bars along with subsidence predictions.
Groundwater	SLR Consulting	• Holistic review of monitoring data for previously undermined swamps. • Review of monitoring data for large swamps continue to validate data and assist with characterisation of the swamps. • Determine baseline groundwater conditions. • Conclude on the adequacy of the groundwater monitoring system as installed to identify any gaps.
Surface Water	ATC Williams	• Review of pre and predicted post-mining topography to aid assessment of potential for surface water impacts. • Produce updated flow path figures for large swamps.
Flora Survey	Ecoplanning / Eco Logical	• Baseline vegetation monitoring of large swamps. • Summary of impacts detected by Project to date • Produce updated flora mapping by species. • Review performance of undermined swamps east of the reservoir that were the subject of controlled burns to determine if changes evident may indicate less resilience to bushfire.
Fauna Survey	TBC	• Baseline surveys in large swamps. • Giant dragonfly surveys. • Amphibian species richness survey.
Upland Swamp Risk Assessment	All specialists	• Combine the relevant information from various specialists. • Assess the potential subsidence impacts and environmental consequences of the proposed extraction plan. • Consider potential risks of adverse environmental consequences. • Analyse options for managing these risks including analysis and costing of alternate mine plans (e.g. costs and benefits of avoidance).

INDEPENDENT EXPERT ADVISORY PANEL FOR MINING

ADVICE RE:

REPORT TITLED:

Metropolitan Coal Mine:

High Level Review - Large swamp environmental assessment requirements for the Extraction Plan for Longwalls 311 to 316

November 2023

Report No: IEAPM 202311-1

EXECUTIVE SUMMARY

On 23 August 2023, the NSW Department of Planning and Environment (DPE) requested advice from the Independent Expert Advisory Panel for Mining (IEAPM – the 'Panel') in relation to a Briefing Paper titled *Large Swamp Assessment – Metropolitan Coal Longwalls 311-316 Extraction Plan* (undated). The briefing paper was prepared by Resource Strategies, a consultant to Peabody Metropolitan Coal (Metropolitan Coal), in advance of preparing the Extraction Plan for LWs 311-316. It focuses on swamps S76, S77 and S92 that overlie longwalls (LW) 311 -316 and which were identified by the Planning Assessment Commission (PAC) as being of 'special concern' in its 2008 assessment of the Metropolitan Coal Project.

The Scope of Advice stated that:

> *The Department is seeking high-level advice from the Panel on Metropolitan Coal's proposed Large Swamp Assessment for swamps 76, 77, and 92, including whether it demonstrates that:*
> - *an appropriate array of environmental assessment is proposed;*
> - *there is an adequate network of monitors in representative locations; and*
> - *there is sufficient and adequate baseline data.*
>
> *The Department would also welcome any other relevant advice from the Panel, especially identification of any further investigations or assessments Metropolitan Coal should be undertaking in regards to these large swamps while preparing the Extraction Plan.*

The Briefing Paper is an outcome of Condition 4 of Schedule 3 of the Metropolitan Coal Project Approval (MP 08_0149), which states:

> *The Proponent shall not undermine Swamps 76, 77 and 92 without the written approval of the Director General. In seeking this approval, the Proponent shall submit the following information with the relevant Extraction Plan (see condition 6 below):*
>
> *a) a comprehensive environmental assessment of the:*
> - *potential subsidence impacts and environmental consequences of the proposed Extraction Plan;*
> - *potential risks of adverse environmental consequences; and*
> - *options for managing these risks;*
>
> *b) a description of the proposed performance measures and indicators for these swamps; and*
>
> *c) a description of the measures that would be implemented to manage the potential environmental consequences of the Extraction Plan on these swamps (to be included in the Biodiversity Management Plan – see condition 6(f) below) and comply with the proposed performance measures and indicators.*

The PAC Assessment Report gives context to these approval conditions. It noted under the heading of *Swamps* that:

> *There were significant deficiencies in the EA* (Environmental Assessment) *and the PPR* (Preferred Project Report) *in relation to prediction of non-conventional subsidence impacts at swamps. This led to concerns that a small number of swamps might be at risk from this source, and it was considered desirable that further work be undertaken to establish the nature and extent of any such risk before undermining of these swamps could proceed.*

The PAC specifically identified swamps S76, S77 and S92 as being three swamps of concern. The Briefing Paper acknowledges the assessment process for upland swamps suggested by the PAC for the Metropolitan Coal Project and outlines an approach for meeting the requirements of the above-mentioned Approval Condition 4. The Briefing Paper is high level and consequently does not go into detail on some aspects at this stage.

The setting of performance measures is a fundamental pre-requisite to finalising detailed advice on monitoring, identifying impacts, and addressing management responses. The Panel is particularly concerned that the development of LW311 is already well advanced even though the performance measures to be achieved by this mine layout are yet to be quantified and a full subsidence assessment is still a work in progress. The mining dimensions as determined by the location of development roadways is not only the primary control available for managing subsidence impacts and achieving environmental performance measures but virtually the only control available.

Against this background and conscious of time constraints (albeit that the need to specifically address mining in the vicinity of swamps S76, S77 and S92 was recognised over 13 years ago), the Panel has offered extended advice in some instances to facilitate the preparation of the Extraction Plan for LWs311 to LW312.

Based on the Briefing Paper and supplementary information supplied by Metropolitan Coal, the Panel has concluded that:

<u>Proposed environmental assessment</u>

- The subsidence information available to the Panel is not adequate to enable it to form a view on whether the current layout for LWs 311-316 could give rise to subsidence impacts affecting the primary swamps that overlie these panels.
- More detailed subsidence information is required before the Panel can more fully advise on the potential environmental consequences and therefore on the required level of monitoring and assessment.
- The available groundwater information and monitoring network is adequate (both spatially and with sufficient baseline) subject to the installation updates to characterise the shallow groundwater conditions within and immediately beneath each of the primary valley infill swamps (i.e. swamps S76, S77 and S92).
- For the western control swamps, there is one comparable valley infill swamp (Bee Creek Swamp) with only one paired groundwater monitoring site. The length of record is adequate but additional sites both within this swamp and swamp S14 would provide a better understanding of natural variability.
- The available groundwater information is inadequate to determine the regional water table depth in the Hawkesbury Sandstone and the connectivity (if any) with shallow perched groundwater across the ridgeline and near the primary swamps.
- The deep groundwater monitoring information is barely adequate to monitor regional depressurisation and the monitoring network would benefit from additional VWPs in both ridgeline areas and near swamps S77 and S92.
- The available surface water information is adequate subject to the concerns raised regarding potential subsidence impacts on the S92-GS flow gauge, recommendations for a detailed conceptualisation of the hydrology/hydrogeology, and the lack of information about surface water features within the swamps.
- The environmental assessment of the three valley infill swamps S76, S77 and S92 should be expanded to include swamp S106.

- The assessment scope for flora and fauna lacks key details in several areas (e.g. conceptualisation and reliance on groundwater and surface water, baseline mapping of flora and fauna).
- A comprehensive risk assessment is required that includes:
    - An integrated assessment of the risks arising from enhanced vertical drainage of groundwater, surface water losses and the potential changes to the biodiversity of the primary upland swamps.
    - Consideration of additional measures to potentially avoid or mitigate impacts to the threatened species and ecological communities within these swamps, particularly swamp S92.

<u>Adequacy of monitoring network</u>

- The shallow groundwater monitoring network for swamps S76, S77 and S92 is adequate subject to the proposed installation updates.
- The shallow groundwater monitoring network for the only valley infill control swamp to the west (Bee Creek Swamp) is inadequate.
- The regional water table monitoring network in the deep Hawkesbury Sandstone is inadequate and would benefit from additional monitoring locations near swamps.
- The deep groundwater monitoring information is barely adequate and would benefit from additional VWPs near swamps and early longwalls.
- The stream gauges located at the downstream locations within swamps S76 and S92 should be adequate to characterise the low flow discharges from these swamps, although no data from these gauges has been sighted by the Panel.
- The Briefing Paper provides little detail on the proposed flora and fauna monitoring surveys for these new longwalls, and the Panel is unable to form a view on whether a rigorous assessment is proposed, is in progress or is complete.

The Panel has provided recommendations to improve the information and assessment to be included in the preparation of the Extraction Plan for LWs 311-316. It has also listed recommendations for additional monitoring in advance of the commencement of mining LWs 311-316. These are quite detailed and are provided in Section 5 of this Advice. However, the following are of particular importance because of time considerations and potential consequences:

1. Given that the gateroads (which determine the dimensions of LW311) are already being driven:
    a. performance measures for swamp S92 need to be specified as a matter of priority
    b. the assessment of mining-induced impacts and consequences for swamps overlying LW311 should be undertaken as a priority to provide timely warning of any need to change the width and/or the totally extracted length of LW311.
2. Drivage of MG312 should be delayed until the large swamp impact assessment has been completed and the Extraction Plan for LW311 and LW312 has been endorsed by the Department.

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1.0 INTRODUCTION

On 23 August 2023, the NSW Department of Planning and Environment (DPE) requested advice from the Independent Expert Advisory Panel for Mining (IEAPM – the 'Panel') in relation to a briefing paper titled *Large Swamp Assessment – Metropolitan Coal Longwalls 311-316 Extraction Plan* (undated). The briefing paper was prepared by Resource Strategies, a consultant to Peabody Metropolitan Coal (Metropolitan Coal), in advance of preparing the Extraction Plan for LWs 311-316. It focuses on swamps S76, S77 and S92 that overlie longwalls (LW) 311 -316 and which were identified by the Planning Assessment Commission (PAC) as being of 'special concern' in its 2008 assessment of the Metropolitan Coal Project.

The required Scope of Advice stated that:

> *The Department is seeking high-level advice from the Panel on Metropolitan Coal's proposed Large Swamp Assessment for swamps 76, 77, and 92, including whether it demonstrates that:*
>
> - *an appropriate array of environmental assessment is proposed;*
> - *there is an adequate network of monitors in representative locations; and*
> - *there is sufficient and adequate baseline data.*
>
> *The Department would also welcome any other relevant advice from the Panel, especially identification of any further investigations or assessments Metropolitan Coal should be undertaking in regard to these large swamps while preparing the Extraction Plan.*

The Chair of the IEAPM (Em. Professor Jim Galvin) nominated the following Panel members to prepare the advice. Mr John Ross chaired the Panel:

- Em. Professor Jim Galvin – Subsidence and Mining
- Mr John Ross – Groundwater
- Professor Neil McIntyre – Surface Water
- Mr Nathan Garvey – Biodiversity
- Dr Ann Young – Swamps and Ecology

All five Panel members have experience in the Southern Coalfield that is relevant to addressing DPE's brief.

2.0 METHOD OF OPERATION

The Panel convened by videoconference during the preparation of its advice and was administratively supported by secretariat staff provided by the DPE's Major Projects and Resource Assessments teams.

Numerous key documents were provided through DPE to support the Panel in preparing this Advice. These documents are listed in Table 1. A range of documents that the Panel has had regard to in compiling this Advice are also recorded under References.

Table 1: Key documents provided to the Panel

Document Reference	Document Name

Documents provided by DPE	• Large Swamp Assessment – Briefing Paper (Resource Strategies)
	• Current Extraction Plan for LWs 308 to 310, Appendices and Attachments:
	  • 1. Extraction Plan: Main Document
	  • 2. Appendix A Water Management Plan
	  • 3. Appendix B Land Management Plan
	  • 4. Appendix C Biodiversity Management Plan
	  • 5. Appendix D Heritage Management Plan
	  • 6. Appendix E Built Features Management Plan
	  • 7. Appendix F Public Safety Management Plan
	  • 8. Appendix G Subsidence Monitoring Program
	  • 9. Appendix H Coal Resource Recovery Plan
	  • 10. Appendix I Subsidence Report
	• Project (MP 08-0149) Documentation
	• Agency Advice:
	  • Letter from WaterNSW, dated 24 June 2022
	  • Letters from BCD, dated 17 March 2022, and 7 July 2022
	• Panel Advice for Longwalls 308 to 310

Additional documents provided by Metropolitan Coal	• Draft swamps gradients and sections • Longwalls 311-317 Upland Swamp Vegetation Mapping and Characterisation (EcoPlanning 2019) • Maximum Predicted Subsidence Parameters for the Swamp Monitoring Sites • Groundwater monitoring network in the vicinity of swamps 76, 77 and 92 • Metropolitan Panel Visit Presentation - October 2023

2.1. SITE VISIT

On 23 October 2023, the Panel undertook a site inspection in the Woronora Catchment under the guidance of Peabody staff and in the company of DPE officers and staff from WaterNSW. The Panel inspected gauging stations and monitoring locations within swamps S76, S77 and S92.

2.2. MEETINGS

The Panel convened several times over the course of preparing its advice. The Department's Resource Assessments team was invited to several of these meetings on an as-needed basis. to provide technical briefings and updates to the Panel. Table 2 summarises in chronological order the schedule of formal meetings that involved the Panel. A number of meetings restricted to Panel members also took place.

Table 2: Schedule of formal meetings involving the Panel.

Meeting Date	Meeting Information
6 September 2023	Panel - DPE Briefing
20 October 2023	Panel catchup in advance of the site visit
23 October 2023	Presentation by Metropolitan Coal and its consultants on site followed by swamp inspections
2 November 2023	Panel meeting discussion
17 November 2023	Panel meeting discussion on final draft report

3.0 BACKGROUND CONSIDERATIONS

The Scope of Advice is focused on swamps S76, S77 and S92, the locations of which are shown in Figure 1**Error! Reference source not found.**. This section of the Panel's Advice R eport notes three earlier documents that have particular relevance to the Panel's advice, these being:

1. The PAC 2009 Review Report for the Metropolitan Coal Project (NSW Planning Assessment Commission 2009);
2. The Metropolitan Coal Project Approval (DoP 2009); and
3. The 2022 Advice Report of the Independent Advisory Panel for Underground Mining (IAPUM) in relation to the Extraction Plan for LWs 308-310 at Metropolitan Coal Mine (IAPUM 2022).

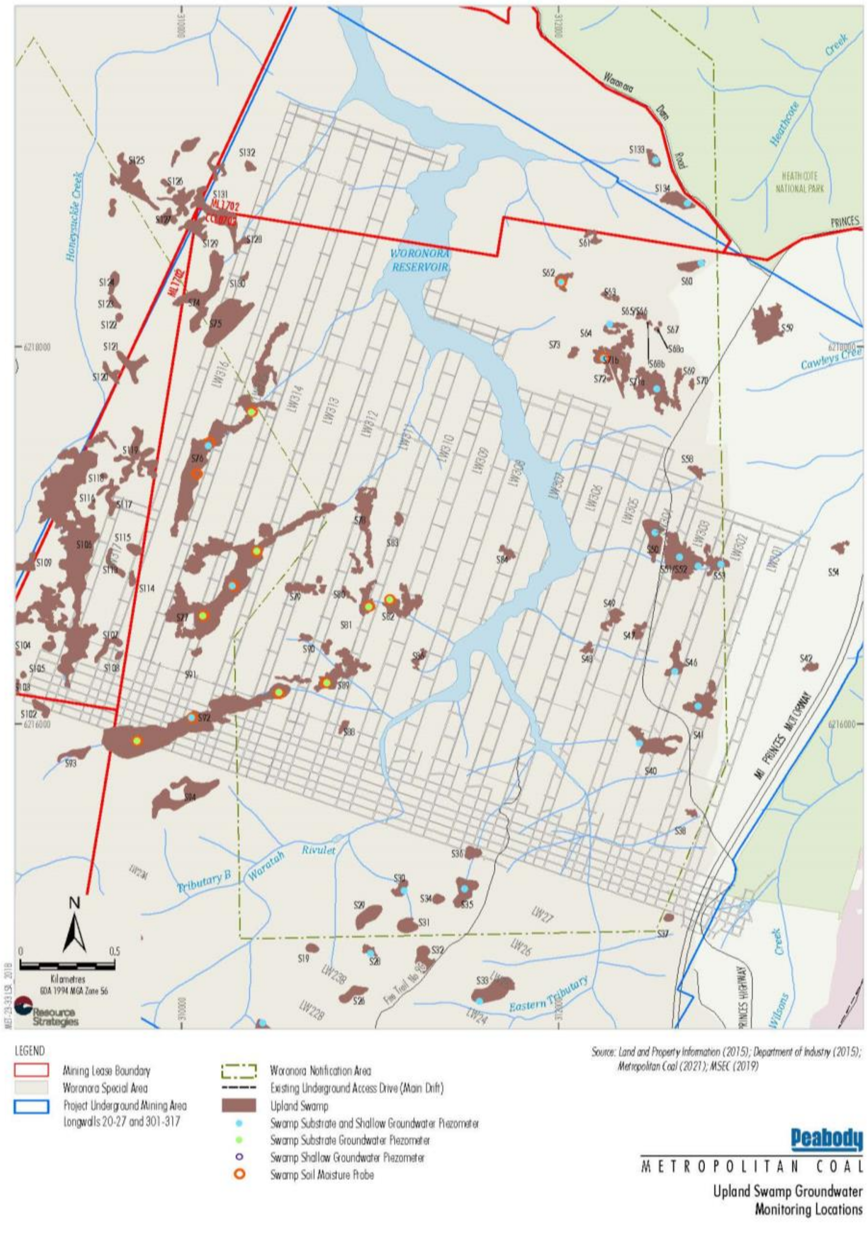

Figure 1

Figure 1: Location of swamps, proposed mine layout and established swamp groundwater monitoring locations in the vicinity of LWs 311 to 316.

3.1. 2009 PAC REVIEW REPORT

The Terms of Reference for the PAC's review of the Metropolitan Coal Project required it to have regard to the findings of a government commissioned review completed in 2008 titled *Impacts of Underground Coal Mining on Natural Features in the Southern Coalfield - Strategic Review* (DoP**,** 2008). That review, generally referred to the *Southern Coalfield Inquiry* (SCI), classified the upland swamps of the Southern Coalfield as falling into two categories, namely, *headwater* swamps and *valley infill* swamps. The SCI concluded that:

> *most known impacted swamps were valley infill swamps;*
>
> and
>
> *available evidence suggests a significant possibility that undermining of valley infill swamps could cause drainage, water table drop and consequent degradation to swamp water quality and associated vegetation. Further research was required before a definitive conclusion could be reached.*[1]

In its assessment of the Metropolitan Coal Project, the Planning Assessment Commission (PAC) questioned the validity of the Environmental Assessment (EA) in classifying all upland swamps as headwater swamps, thereby effectively quarantining them from the threat of non-conventional subsidence (valley closure and upsidence).

The PAC advised that:

> *if some swamps in the Project Area described as headwater swamps have predominantly valley infill characteristics at their lower ends and are thus potentially vulnerable to the effects of non-conventional subsidence, then a significantly greater level of assessment should have been applied to these swamps.*[2]

The PAC went on to conclude that:

> *at least three of the swamps identified as being exposed to non-conventional subsidence impacts should be the focus of further attention before undermining is allowed to proceed. These are swamps S76, S77 and S92.*[3]

3.2. METROPOLITAN COAL PROJECT APPROVAL

The PAC's recommendation for further assessment relating to swamps S76, S77 and S92 is reflected in Condition 4 of Schedule 3 of the Metropolitan Coal Project Approval (MP 08_0149), which states:

> *The Proponent shall not undermine Swamps 76, 77 and 92 without the written approval of the Director General. In seeking this approval, the Proponent shall submit the following information with the relevant Extraction Plan (see condition 6 below):*

---

[1] SCI Inquiry Report, p. 2
[2] PAC Review Report, p.85
[3] PAC Review Report, p. 87

a) a comprehensive environmental assessment of the:

- *potential subsidence impacts and environmental consequences of the proposed Extraction Plan;*
- *potential risks of adverse environmental consequences; and*
- *options for managing these risks;*

b) a description of the proposed performance measures and indicators for these swamps; and

c) a description of the measures that would be implemented to manage the potential environmental consequences of the Extraction Plan on these swamps (to be included in the Biodiversity Management Plan – see condition 6(f) below), and comply with the proposed performance measures and indicators.

The PAC for the Metropolitan Coal Project did not recommend performance measures explicitly for swamps, while the Metropolitan Coal Project Approval only refers generically to *proposed performance measures* and then only in relation to swamps S76, S77 and S92. Rather, both documents refer more generally to *threatened species and endangered ecological communities* (PAC) and to *threatened species, populations and ecological communities* (Project Approval). The Panel notes that at the time of the Project Approval, Temperate Highland Peat Swamps on Sandstone (THPSS) had not been listed as threatened under State or Federal legislation.

3.3. 2022 IAPUM ADVICE

In 2002, the IAPUM (the forerunner to the IEAPM) provided advice to the Department on the Extraction Plan for LW308-310 at Metropolitan Coal Mine in which it recommended the following for future Extraction Plans:

Swamps S76, S77 and S78

1. For all future approvals, Performance Measures (not only Performance Indicators) set for Swamps 76, 77 and 92 should include measures based on changes to groundwater in the swamp sediments and the underlying sandstone.

2. The Department should give clear guidance to the Applicant on its requirements for the Environmental Assessment prior to any mining activities that may cause more than negligible subsidence impacts on Swamps 76, 77 and 92. Requirements should include:

(a). analysis and presentation of all available groundwater data for 300 series longwalls with a focus on likely impacts and effects on Swamps 76, 77 and 92;

(b). analysis of the subsidence and groundwater implications for the large swamps of extending the mine layout for LWs 308-310 to LWs 311-316;

(c). assessment of potential changes in stream flow and stream water quality; and

(d). assessment of potential erosion and long-term vegetation changes particularly in relation to the risks posed by fire.

And that:

future Extraction Plans include tables of all parameters (such as period of record, depth to baseline, adjacent vegetation, graphical piezometric and soil moisture records for each site) relevant to all swamp monitoring sites within the project area.

Groundwater

1. Groundwater monitoring should be increased by adding two, and possibly three, additional multi-level VWP bores in the vicinity of Swamps 77 and 92 to monitor the deep groundwater behaviour above the predicted constrained zone.

2. 10 metre (m) deep bores should be added to each of the swamp monitoring points where this measurement depth is currently missing for swamps 76, 77 and 92.

3. The TARPs for Upland Swamp Groundwater monitoring should be redeveloped to employ consistent, time-independent parameter values for the triggers; adopt consistent TARPs across all longwalls; address the inadequacy of the triggers if historical substrate minimum groundwater levels are at the base of the substrate; review how lowering of trigger levels can occur and relate a lowering of a trigger level to assessment of impacts rather than climate variation; and increase the focus of the responses on assessing impacts of mining on the Swamps.

Upland Swamp Vegetation Mapping TARP

1. All sites within the large swamps 76, 77 and 92 should be added to monitoring sites in this TARP. The aim is to provide early warning of any changes in these swamps.

2. The Significance levels/Triggers should be re-drafted to specify quantitative values to the observed declines, the time periods over which they have occurred and the statistical difference to control swamps.

Upland Swamp Groundwater Monitoring TARP

1. The performance indicator should be re-worded as it implies that visible surface cracking must be the cause of changes in groundwater position within a swamp. It needs to recognise that cracking below swamp sediments is usually not discernible and that 'cracking' may include dilation of joints, rather than fracturing of intact sandstone.

2. 'Surface cracking within upland swamps resulting from mine subsidence is..' should be replaced with 'Subsidence impacts are..'.

3. The large swamps 76, 77 and 92 should be added to this TARP.

The DPE approved the LW308-310 Extraction Plan on the 12 December 2022 (DPE 2022). In the reasons for the approval of LW308-310 it is stated that *"... prior to undermining of Swamps 76, 77 and 92, the Department considers that the Panel recommendations provide additional guidance and targeted advice for development of future extraction plans*".

4.0 ADEQUACY REVIEW

4.1. CURRENT STATUS

The Briefing Paper acknowledges the assessment process for upland swamps suggested by the PAC for the Metropolitan Coal Project and outlines an approach for meeting the requirements of the above Approval Condition. The Briefing Paper is high level and consequently does not go into detail on some aspects at this stage.

The setting of performance measures is a fundamental pre-requisite to finalising detailed advice on monitoring, identifying impacts and addressing management responses. The Panel is particularly concerned that the development of LW311 is already well advanced even though the performance measures to be achieved by this mine layout are yet to be quantified and a full subsidence assessment is still a work in progress. The mining dimensions as determined by the location of development roadways is not only the primary control available for managing subsidence impacts and achieving environmental performance measures but virtually the only control.

Against this background and conscious of time constraints (albeit that the need to specifically address mining in the vicinity of swamps S76, S77 and S92 was recognised over 13 years ago), the Panel has offered extended advice in some instances to facilitate the preparation of the Extraction Plan for LWs311 to LW316.

4.2. SUBSIDENCE

The Panel has been advised that the assessment of mining-induced subsidence effects, impacts and consequences associated with the extraction of LWs 311-316 is still a work in progress. However, in response to its queries, on 3 November 2023 Metropolitan Coal provided the Panel with a summary tabulation of predicted maximum values for a range of subsidence parameters at specific monitoring locations in swamps S76, S77 and S92. This was followed up with advice on 6 November 2023 that:

- The maingate for LW310 (MG310) is nearing completion at 16c/t, with 4 pillars to go, plus development of the install and bleeder roadway for LW310.
- The maingate LW311 (MG311) is already at 7c/t, with completion of drivage at 21 c/t scheduled for around September 2024

The only information currently available to the Panel in relation to predicted maximum subsidence effects on swamps in the area of influence of LW311 is restricted to cumulative effects on swamp S92 after the completion of LW316, summarised in **Table** from the data provided on 6 November 2023.

Table 3: Summary information currently available in relation to predicted maximum subsidence effects on Swamp S92.

Site	Max Predicted Subsidence (mm)	Max Predicted Tilt (mm/m)	Predicted Conventional Tensile Strain after LW316 (mm/m)	Predicted Conventional Compressive Strain after LW316 (mm/m)	Max Predicted Upsidence after LW316 (mm)	Max Predicted Closure after LW316 (mm)
S92-1	700	6.5	1	<0.5	225	80
S92-2	70	0.5	<0.5	<0.5	30	<20
S92-3	<20	<0.5	<0.5	<0.5	<20	<20

In general, ground deformation towards the downstream end of a swamp has a higher potential to impact a swamp than ground deformation in the upstream portions. In the case of swamp S92, monitoring site S92-1 is both at the downstream end of the swamp and is predicted to experience higher subsidence effects than the upstream portions of the swamp.

Vertical displacement (subsidence) at S92-1 gives rise to the potential for ponding; the change in tilt (of 6.5 mm/m) is not insignificant, giving rise to the potential to change the drainage channel location and cause erosion; tensile strain may not be insignificant when it is appreciated that a tensile strain greater than 0.5 mm/m is sufficient to cause cracking of rock and that the prediction of 1 mm/m has been averaged over a 20 m distance (bay length) and so could correspond, for example, to one 20 mm wide crack every 20 m; and upsidence (differential subsidence) of 225 mm needs to also be factored into tilt predictions and subsurface flow considerations.

4.2.1. Summary

The Panel concludes that:

- The subsidence information available to the Panel is not adequate to enable it to form a view on whether the current layout for LWs 311-316 could give rise to unacceptable environmental consequences for the swamps that overlie these panels. This is because a full subsidence assessment is still a work in progress.
- More detailed subsidence information is required before the Panel can more fully advise on the potential environmental consequences and, therefore, on the required level of monitoring and assessment.
- Unforeseen environmental impacts are a concern since the development of gateroads that define the width of LW311 is already well advanced.

The Panel recommends that:

1. Given that the gateroads (which determine the dimensions of LW311) are already being driven:

a. performance measures for swamp S92 need to be specified as a matter of priority

b. the assessment of mining-induced impacts and consequences for swamps overlying LW311 should be undertaken as a priority to provide timely warning of any need to change the width and/or the totally extracted length of LW311.

2. Drivage of MG312 should be delayed until the large swamp impact assessment has been completed and the Extraction Plan for LW311 and LW312 has been endorsed by the Department.

4.3. GROUNDWATER

It is important to understand the natural (pre-mining) connectivity between perched and shallow groundwater systems in colluvium and the uppermost Hawkesbury Sandstone and deeper groundwater systems to manage any environmental consequences affecting swamps. Enhanced vertical fracturing, bedding dilation and horizontal shears caused by mining and the associated depressurisation of deeper strata creates the potential for accelerated drainage of shallow water tables. Loss of this shallow perched groundwater threatens the upland swamps that are dependent on this groundwater.

A broad coverage of shallow and deep groundwater monitoring sites is required to provide:

- Baseline data to understand the natural spatial and climatic variability of these systems.
- Early indications of impacts associated with subsidence and aquifer depressurisation and drainage.
- Appropriate triggers and management responses if impacts do occur.

4.3.1. Proposed environmental assessment

The groundwater systems overlying LWs 311 to 316 are similar to those overlying LWs 301 to 310 immediately to the east in the Waratah Rivulet and Eastern Tributary catchments. The key stratigraphic units that host the important groundwater systems are:

- Colluvium (silty and clayey sand) associated with the upland swamps, and regolith/weathered Hawkesbury Sandstone
- Hawkesbury Sandstone
- Narrabeen Group
    - sandstone and claystone
- Illawarra Coal Measures
    - shale, mudstone, claystone, minor sandstone and coal seams

The groundwater impact assessment that supports the Extraction Plan should contain a detailed conceptual model of the groundwater systems in these units including the natural connectivity between these systems, and their recharge, discharge and flow processes. For the shallower systems, it is important to describe the expected mining-induced changes to water levels arising from deep groundwater depressurisation, subsidence and enhanced fracturing that may extend into the Hawkesbury Sandstone. Descriptive text and informative conceptual cross-sections and/or long-sections are recommended.

The important groundwater systems that support the environmental assets across the catchment are:

- Localised perched groundwater associated with swamp colluvium and shallow sandstone (predominantly in the weathered zone) that contributes to the hydrology of swamps, springs and creeks in upper catchment areas.

- Regional shallow groundwater comprising saturated porous and fractured Hawkesbury Sandstone below the regional water table that sustains baseflows to permanent streams in lower catchment areas.

These systems should be the primary focus of the impact assessment and risk analysis.

The field visit on 23 October 2023 suggested that swamps S76 and S77 are probably largely dependent on rainfall and surface water run-on. Perched groundwater provides a lesser but important contribution to swamp hydrology because of the limited water storage in the thin colluvium and a spatially variable contribution from groundwater in the uppermost Hawkesbury Sandstone. Within these two swamps minimal surface water was evident; however, soil remained moist at depth and there was standing water over several metres above the gauging station at site S76. Perched groundwater in both the colluvium and weathered sandstone at these sites is recharged by rainfall. Saturated conditions are likely to prevail at lower elevations for long periods with less saturation and periodic drying at higher elevations and around the swamp edges.

At swamp S92, wetter conditions prevail across the whole swamp with surface water present in pools and drainage lines in the lower swamp area. At this site, there is likely to be greater dependence on perched groundwater for longer periods of time because the swamp is more extensive and is likely to have a larger water storage volume compared to the other two swamps.

The proposed groundwater assessment scope for large swamps (from Table 3 in Resource Strategies 2023), is quite generic and lacks explicit detail. For groundwater the scope is described as:

- *Holistic review of monitoring data for previously undermined swamps.*
- *Review of monitoring data for large swamps continue to validate data and assist with characterisation of the swamps.*
- *Determine baseline groundwater conditions.*
- *Conclude on the adequacy of the groundwater monitoring system as installed to identify any gaps.*

That part of the groundwater impact assessment that is devoted to upland swamps should be expanded to include:

- A detailed conceptualisation of the hydrology/hydrogeology of each of the listed swamps.
- Any updated groundwater model predictions that describe the impacts to these shallow groundwater systems, and their dependent environmental assets (i.e. stream baseflows and swamps).
- An integrated assessment of the risks arising from enhanced vertical drainage of groundwater, potential surface water losses and changes in the biodiversity of these upland swamps.

4.3.2. Adequacy of monitoring network

Metropolitan Coal has either already established or has committed to establishing the following groundwater monitoring network:

Localised perched groundwater

- Swamp piezometers and moisture probes installed in valley infill swamps S76, S77 and S92 including:
    - o shallow groundwater piezometers installed to approximately 10 m depth (one existing and an additional two proposed in each of the three swamps),
    - o swamp substrate groundwater piezometers installed to approximately 1 m depth (three existing within each of the three swamps), and
    - o soil moisture probes (three existing with multiple sensors within each of the three swamps).

  In addition to these three listed swamps, there are swamp substrate groundwater piezometers and soil moisture probes installed in swamps S81, S82 and S89 (one existing site within each of these three swamps), and

- Flow measuring flumes installed in the downstream drainage lines of swamps S76 and S92.

The Panel considers that the network and frequency of groundwater monitoring is adequate for swamps S76, S77 and S92. The Panel supports the updates to the monitoring network to include new 10 m shallow groundwater piezometers at two new sites in each of swamps S76, S77 and S92, noting that there is a risk that adequate baseline data will not be available at the S92-1 site prior to the proposed undermining of the northern portion of swamp S92 by LW312 in May 2025. For the other swamps there is likely to be a sufficient baseline database covering a range of seasonal conditions prior to the commencement of later longwall panels.

Swamp S106 is another large valley infill swamp located just to the west of LWs 316 and 317 that would benefit from a network of paired swamp substrate and shallow groundwater piezometers, and soil moisture probes. The Panel recommends a minimum of three sites be installed within this swamp as soon as practicable.

It is important that Metropolitan Coal nominate in the Extraction Plan appropriate control swamp/s in the unmined western Woronora River catchment against which water level trends pre and post mining can be compared. It is noted that western swamps S101, S137, and Bee Creek Swamp are currently tagged as control swamps and have established perched groundwater monitoring sites in both the swamp substrate and weathered/shallow sandstone. There is an additional swamp substrate piezometer in swamp S14. Bee Creek Swamp is the only comparable valley infill swamp to swamps S76, S77 and S92. The control swamps are shown in Figure 2.

The control swamps would benefit from:

- Additional paired piezometers upstream and downstream of the existing monitoring site in Bee Creek Swamp.
- Two paired piezometers site in swamp S14 at upstream and downstream locations.
- Soil moisture probes at all swamp substrate piezometer sites.

There is more than a decade of baseline data for the Bee Creek swamp site which is useful for comparison with similar data trends for swamps S92, S77 and S76, however additional sites are recommended to understand the natural variability of perched groundwater levels at different swamp elevations.

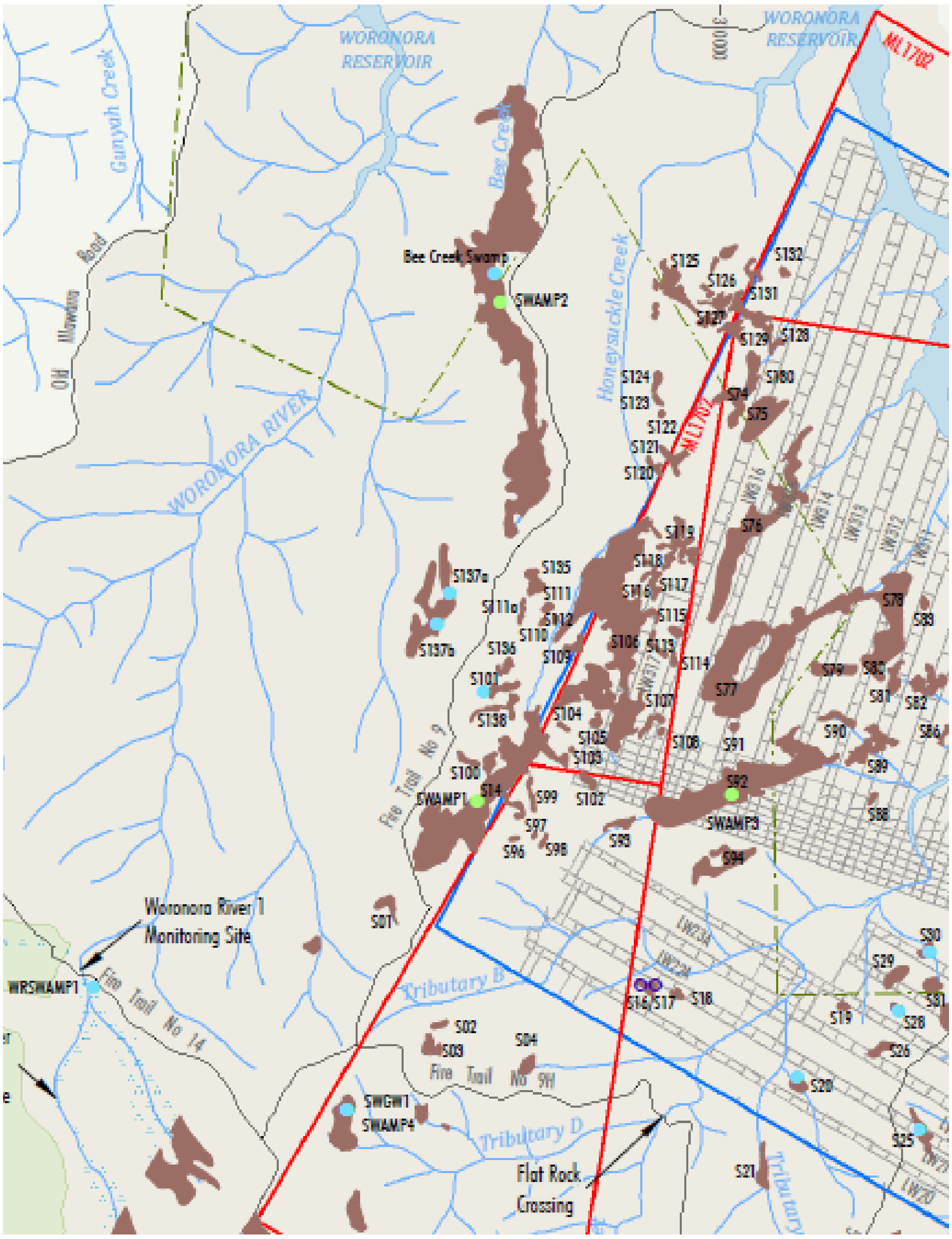

Figure 2: Location of control swamps and established swamp groundwater monitoring locations west of LW316-317.

Regional shallow groundwater in the Hawkesbury Sandstone

There is less extensive monitoring of the regional water table in the Hawkesbury Sandstone and very limited coverage near swamps. One standpipe and 14 sensors at five VWP sites have been installed across or adjacent to the proposed LW311-316 area. The VWP sites have been operational for more than a decade, although the status of each of the sensors is not known.

There are no sites overlying the early longwalls (LW311-313) and there is only one VWP site located near any of the listed swamps. This site is PM01 overlying LW316 located ~50m west of swamp S76 and swamp monitoring location S76-3. Data for the shallow sensor at

52m in Hawkesbury Sandstone at this site has been ‘missing’ since 2019 (Peabody 2022b, SLR 2023). The cause of this data loss should be investigated, and the sensor replaced with a standpipe if necessary.

The regional shallow groundwater monitoring network comprises:

- Standpipe
    - T6 (between LW309 and 310) – unknown monitoring depth interval
- VWP sites
    - PM01 (overlying LW316) – three sensors in Hawkesbury Sandstone
    - PM02 (overlying LW315) – two sensors in Hawkesbury Sandstone
    - PM03 (~600m north of LW312/313 on the northern side of the reservoir) – three sensors in Hawkesbury Sandstone
    - 9EGW1B (overlying roadways south of LW316/317) – three sensors in Hawkesbury Sandstone
    - 9EGW2A (overlying LW310) – three sensors in Hawkesbury Sandstone

There are no sites adjacent to swamps that confirm the lateral and vertical extent of localised perched groundwater and the connectivity with the regional water table at depth in the Hawkesbury Sandstone.

This network is inadequate for environmental assessment purposes and obtaining sufficient baseline data over a range of seasonal conditions prior to the commencement of LW311. At a minimum, the Panel recommends standpipes into the Hawkesbury Sandstone at the following locations near the primary LW311-316 swamps and adjacent to control swamps located to the west. Nested standpipes may be required if there is shallow perched groundwater and multiple aquifers in the Hawkesbury Sandstone at depth:

- A suitable location along the S92 access road, close to the entry to S92-2.
- A suitable location along Firetrail 9E overlying either LW311 or 312.
- Locations adjacent to at least two control swamps to the west (S137 and Bee Creek Swamp preferred).

These sites are in addition to the Panel’s previous advice (see Section 3). It appears that these previously recommended sites have not yet been constructed:

- Additional multi-level VWP bores (at two or three sites) in the vicinity of swamps S77 and S92 to monitor *(shallow and)*[4] deep groundwater behaviour above the predicted constrained zone, and
- Additional bores (standpipes) at the T6 monitoring location and at other accessible locations[5] overlying the proposed LW311-316 panels as soon as practicable to monitor the natural vertical piezometry in the Hawkesbury Sandstone.

[4] Additional clarification in this Panel advice.
[5] Two accessible locations are recommended in the dot points above.

Deep groundwater in the Narrabeen Group and Illawarra Coal Measures

Each of the five VWP sites listed above has sensors monitoring deep groundwater in the underlying Narrabeen Group sandstone aquifers. At least one additional VWP site (in addition to the two or three recommended above near swamps) located along Firetrail 9E at a suitable site overlying either LW311, 312 or 313 would assist in monitoring deep groundwater depressurisation and mining induced drawdown to shallow aquifers in the Hawkesbury Sandstone in this ridgeline area.

A slightly expanded deep groundwater monitoring network is recommended to monitor the lateral and vertical extent of depressurisation. These VWPs would be installed too late to obtain any worthwhile baseline data for the Extraction Plan but would be useful to understand future depressurisation and the potential for drainage of shallow groundwater in both upland swamp and ridgeline areas.

4.3.3. Summary

The Panel concludes that:

- The available information is adequate (both spatially and with sufficient baseline) subject to the installation updates to characterise the shallow groundwater conditions within and immediately beneath each of the primary swamps (i.e. swamps S76, S77 and S92).
- For the western control swamps, there is one comparable valley infill swamp (Bee Creek Swamp) with only one paired monitoring site. The length of record is adequate but additional sites both within this swamp and swamp S14 would provide a better understanding of natural variability.
- The available information is inadequate to determine the regional water table depth in the Hawkesbury Sandstone and the connectivity (if any) with shallow perched groundwater across the ridgeline and near the primary swamps.
- The deep groundwater monitoring information is barely adequate and the monitoring network would benefit from additional VWPs in both ridgeline areas and near swamps S77 and S92.

The Panel recommends that the assessment needs to include:

1. A detailed conceptualisation of the hydrology/hydrogeology of each of the listed swamps including groundwater-surface water interactions, and a holistic assessment of connectivity with regional groundwater and groundwater dependent assets.
2. Any updated groundwater model predictions that describe the impacts to these shallow groundwater systems, and their dependent environmental assets (i.e. stream baseflows and swamps).
3. An assessment of risk of subsidence impacts to upland swamps, including the risk of changes in groundwater levels and storage in swamp substrates and underlying weathered sandstone.
4. Detailed analysis of groundwater levels and soil moisture, using the existing monitoring network, and how this relates to swamp sub-communities.
5. A commitment that prior to the commencement of extraction of LW311, additional groundwater monitoring sites will be installed near the primary swamps, in Swamp S106 and within the western control swamps as recommended in Section 4.3.2.

6. Revised TARPs that encompass the recommendations made by the Panel in its advice on LW308-310 extraction plan, particularly improved time-independent water level parameters for the paired swamp groundwater monitoring locations.

4.4. SURFACE WATER

Overall the Briefing Paper proposes, at a high level, a satisfactory assessment of surface water subject to the recommendations made below and subject to the concerns raised earlier in this document regarding potential environmental consequences on swamp S92 surface water and recommendations for a detailed conceptualisation of the hydrology/hydrogeology.

Swamps S76, S77 and S92 are shown on the various available maps (e.g. Peabody 2022a, Figure 5) to have watercourses running within or closely alongside much or all of the swamp lengths. During the field visit on 23 October 2023, the swamp S92 watercourse was observed as flowing at the outlet flow gauge, with visible surface water within the swamp; while in swamps S76 and S77 there was evidence of surface water only near the S76 gauge site (noting that the preceding 5 months had been relatively dry, preceded by a wet year). A trickle of flow (<0.1 L/s) was observed during the field visit at the flume downstream of swamp S76. No flow was observed at the S92 gauge site in April 2018 (Appendix A of Peabody 2022b). The Panel was not able to observe distinct continuous stream channels in any of the swamps except for a few metres immediately upstream of the swamp S76 flow gauge and for some tens of metres upstream of the swamp S92 flow gauge. Drainage line and pool mapping using drones with selected ground-truthing would be useful to confirm the status of the surface hydrology in all three primary swamps.

From the Water Management Plan (Peabody 2022b) it is understood that the three tributaries of the Woronora Reservoir for which the swamps are headwaters, are named P, Q and R for swamps S92, S76 and S77 respectively. It would be beneficial for these tributaries to be named on relevant map(s) in the Extraction Plan.

4.4.1. Proposed environmental assessment

The assessment scope (as listed in Table 3 of the Briefing Paper) for surface water is:

- *Review of pre and predicted post-mining topography to aid assessment of potential for surface water impacts.*
- *Produce updated flow path figures for large swamps*

Additionally, Table 3 includes subsidence assessment including valley closure, which will inform surface water risk assessment. Furthermore, assessment of risks to surface waters and surface water-groundwater interactions may be assumed implicit to the Groundwater and Upland Swamp Risk parts of Table 3.

4.4.2. Adequacy of monitoring network

The surface water monitoring consists of two flow gauges: at the rock-bar downstream of swamp S76; and at the rock-bar at the outlet of swamp S92. Swamp S77 has no flow gauge because "*Stream specialist investigated and found not feasible to install a flow measuring flume downstream of Swamp 77*" (quoted from Peabody's presentation to the Panel prior to the field visit of 23 October 2023). The Panel agrees that the cost and environmental impacts of installing a flow gauge at Swamp S77 are unlikely to be justified.

The Panel notes that the swamp S76-GS and S92-GS flow gauges are designed to accurately measure low to medium flow rates, which is appropriate for assessing hydrological impacts of subsidence. The Panel notes the high potential for debris to accumulate in or upstream of the flumes and the need for regular maintenance; further, the likelihood of subsidence impacts at the flow gauge sites means that re-calibration and potentially repair to the flume/rockbar may be required. A camera that captures images every half-hour (or less) of flow and debris conditions at the S92-GS flow gauge would support data quality control, maintenance scheduling (if telemetry is possible), and record flow conditions during failures of the gauge.

There are no water quality gauges representing the swamps. There is a water quality site monitoring downstream of S92-GS (SP1 on Figure 7 of Peabody 2022b). Additional water quality data at the S92-GS flow gauge will allow any impacts within the swamp to be isolated from downstream impacts.

The period of baseline flow data at these two flow gauges is sufficient. These data should be presented alongside the piezometer and climate data in the Extraction Plan, and characterisation of flow rates and dynamics conducted.

There are no nominated control flow gauges and the Panel is not aware of established flow gauges that would make suitable controls, although the Honeysuckle Creek gauge might be useful for comparison with S92-GS. Swamp hydrology performance indicators should be designed taking the limited availability of controls into account.

4.4.3. Summary

The Panel concludes that:

- The available information and proposed approach are adequate subject to the recommendations made below and subject to the concerns raised earlier regarding potential subsidence impacts on S92 surface water and recommendations for a detailed conceptualisation of the hydrology/hydrogeology.

The Panel's recommendations for additional surface water assessment are:

1. Characterisation of baseline surface flow dynamics.
2. Characterisation of baseline water quality at the outlet of swamp S92.
3. Characterisation of the presence of drainage lines and major pools in swamp S92 to inform flora and fauna surveys, and as a baseline record of surface water storage features.

The Panel's recommendations for additional surface water monitoring are:

4. A camera that captures images every half-hour (or less) of flow and debris conditions at the swamp S92-GS flow gauge. This is common practice to support data quality control, maintenance (where telemetry is possible), and record flow conditions during failures of the gauge.
5. A baseline survey (potentially by drone) of major pools within swamps S76, S77 and S92.
6. Water quality monitoring at the swamp S92-GS site including a baseline period as far as practicable. The Panel acknowledges that there is a water quality site monitoring further downstream on this watercourse (SP1 on Figure 7 of Peabody 2022b). Additional water quality data at the flow gauge will allow any impacts within the swamp to be isolated from downstream impacts.

4.5. UPLAND SWAMP BIODIVERSITY

The information provided to the Panel to date lacks key details in several areas related to environmental assessment. This may impact the ability of the Panel and DPE to adequately assess the potential subsidence impacts and environmental consequences for upland swamps S76, S77 and S92. It is noted that a number of additional upland swamps are located within the angle of draw for LWs 311-316, including large valley infill swamp S106.

The site visit indicated that swamp S76 consisted of predominantly Banksia Thicket. Swamp S77 was slightly more diverse, consisting of predominantly Banksia Thicket with some areas of Tea-tree Thicket and Sedgeland-heath Complex. No evidence of water at the surface was observed in swamps S76 and S77, although swamp sediment was moist, sticky and darkened by organic matter to at least 0.5m depth. This aligns with swamp substrate piezometers which show the presence of a perched water table.

Swamp S92 was wet, with surface water present and the swamp supporting a diverse and complex range of vegetation communities including Tea-tree Thicket, Sedgeland-heath Complex and Banksia Thicket (Photo 4.1). This swamp is significant, showing a high degree of wetness and diversity, with potential to support a population of the Giant Dragonfly (*Petalura gigantea*).

Photo 4.1 – Upstream section of Swamp S92

Discussions with the Metropolitan Coal and their consultants indicated that environmental assessments, including surveys for frogs, the Giant Dragonfly and threatened flora were ongoing or about to be commenced at the time of the site visit.

4.5.1. Upland swamps

4.5.1.1. Proposed environmental assessment

The scope of the technical assessments for upland swamps is outlined in Table 3 of the Briefing Paper. Included is a swamp risk assessment scope which needs to be integrated and comprehensive. The Panel's comments on the proposed risk assessment are provided in Section 4.6.2.

The Panel recommends inclusion of the following in the environmental assessment for swamps S76, S77 and S92:

1. Development of a conceptual model (schematics) showing vegetation type, swamp gradients (including soil depths) and perched groundwater that sustains the primary swamps.
2. Revised baseline mapping of swamp sub-communities, using a replicable technique that will allow monitoring of changes in response to changes in hydrology. Comparison with previous mapping would be desirable.
3. If suitable access is possible, install a cross section of swamp substrate piezometers in the upper reaches of swamp S92. Piezometers should be representative of the vegetation communities, especially cyperoid heath/tea tree thicket v banksia heath v restioid sedgeland in S92.

Detailed assessment of the potential subsidence effects and associated impacts to swamp S92 are required given the significance of this swamp.

The Panel also flags the potential for impacts to swamp S106 from extraction of LWs 316 and 317. Similar to swamp S92, this swamp is large and is likely to support a diverse range of swamp sub-communities. The Panel recommends that Metropolitan Coal include an assessment of the potential impacts to swamp S106 in the impact assessment, and that monitoring of swamp S106 be included in the updated Biodiversity Management Plan that is included with the Extraction Plan.

Further west, large swamps S14 and Bee Creek Swamp appear similarly significant. Although not a part of this application, the Panel flags the need for the company to consider ongoing and expanded baseline monitoring of these swamps if future mining is planned for this area, particularly in light of the current use of these swamps as control sites.

4.5.1.2. Adequacy of monitoring network

There is a risk that extraction of LWs 316 and 317 will impact on swamp S106. The Panel recommends that a vegetation and flora monitoring transects be established in swamp S106, that complement the recommended shallow groundwater monitoring locations (see Section 4.3.2).

In line with the Panel's review of the LWs 308-310 Extraction Plan, it is recommended that the Extraction Plan include tables of all parameters (such as period of record, depth to baseline, adjacent vegetation, graphical piezometric and soil moisture records for each site) relevant to all swamp monitoring sites within the LWs 311-316 extraction area.

The Briefing Paper provides little detail on other monitoring proposed, including vegetation and flora monitoring. Current monitoring, outlined in the Biodiversity Management Plan (Peabody 2022c), includes transect/quadrat monitoring and indicator species monitoring (in addition to groundwater monitoring). The Panel anticipates that this is being expanded to include swamps S76, S77 and S92, and suitable additional control swamps. It is also recommended that ongoing mapping of swamp sub-communities, using a replicable technique that will allow monitoring of changes in response to changes in hydrology, be incorporated into the monitoring program.

Swamps S76, S77 and S92 are valley infill swamps and thus are different to the swamps previously undermined at the Metropolitan Coal Mine. In the area mined to date, only one valley infill swamp (S21) was identified in the 2008 Environmental Assessment and this was small and had already been undermined by LWs 7 and 8 (Florasearch and Western Research Institute (2008)). The Panel recommends that the company review its monitoring program and ensure comparable control sites are established, including piezometers, vegetation monitoring and threatened species monitoring. The expansion of these monitoring programs to include additional sites in Bee Creek Swamp and swamps S14 and S137 is recommended.

4.5.2. Flora and Fauna

4.5.2.1. Proposed environmental assessment

The scope of the assessment of flora and fauna is outlined in Table 3 of the Briefing Paper and includes:

- *Summary of impacts detected by Project to date*
- *Produce updated flora mapping by species.*
- *Review performance of undermined swamps east of the reservoir that were the subject of controlled burns to determine if changes evident may indicate less resilience to bushfire.*
- *Baseline surveys in large swamps.*
- *Giant dragonfly surveys.*
- *Amphibian species richness survey.*

Additionally, Table 3 includes subsidence assessment including closure, which will inform the risk assessment for habitat for flora and fauna species.

The Panel recommends inclusion of the following in the environmental assessment for LWs 311 to 316:

- Pool mapping within each primary swamp and their associated drainage lines to be undermined by LWs 311-316. Consideration could be given to remote fly-over investigation which could also provide useful data on vegetation distribution.
- Baseline surveys for fish species in defined drainage lines and pools downstream of the primary swamps using techniques such as trapping and backpack electrofishing.
- Baseline surveys for obligate swamp species, particularly the Giant Dragonfly (*Petalura gigantea*), with larval surveys recommended for this species, and for threatened flora species.
- Baseline surveys for Littlejohn's Tree Frog (*Litoria littlejohni*), Giant Burrowing (*Heleioporus australiacus*) and aquatic ecology, including upland swamps and also in large pools identified in the streams below the swamps.
- Baseline surveys for the Eastern Ground Parrot (*Pezoporus wallicus*). While not identified in this area since 2007, to the Panel's knowledge there has not been substantive survey undertaken and the possible presence of this species needs to be investigated.

4.5.2.2. Adequacy of monitoring network

The Briefing Paper provides little detail on flora and fauna monitoring proposed. Current monitoring, outlined in the Biodiversity Management Plan (Peabody 2022c), includes stream monitoring, pool monitoring and amphibian monitoring.

It is recommended that this monitoring program be reviewed subject to the findings of the current baseline surveys, with incorporation of the following elements considered:

- Incorporation of macroinvertebrate monitoring in pools into the ongoing program to document changes in macroinvertebrate assemblages as an indicator of water quality.
- Standardised monitoring of fish species in defined drainage lines and pools downstream of the primary swamps using techniques such as trapping and backpack electrofishing, if populations are identified during baseline assessment.
- Nocturnal surveys for threatened frog species using standardised transects, including comparison of abundance.
- Ongoing monitoring of the Ground Parrot if the species is detected during baseline surveys.

4.5.3. Summary

To summarise, the Panel's biodiversity recommendations for this Extraction Plan and subsequent primary swamps monitoring programs are:

1. Development of a conceptual model (schematics) showing vegetation type, swamp gradients (including soil depths) and perched groundwater that sustains the primary swamps.
2. Revised baseline mapping of swamp sub-communities, using a replicable technique that will allow monitoring of changes in response to changes in hydrology. Comparison with previous mapping would be desirable.
3. If suitable access is possible, install a cross section of swamp substrate piezometers in the upper reaches of swamp S92. Piezometers should be representative of the vegetation communities, especially cyperoid heath/tea tree thicket v banksia heath v restioid sedgeland in S92.
4. Include an assessment of the potential impacts to swamp S106 and include this swamp in other assessment and monitoring programs for biodiversity.
5. Baseline surveys for swamp related species, such as the Giant Dragonfly (*Petalura gigantea*), with larval surveys recommended for this species, and threatened flora species.
6. Baseline surveys for Littlejohn's Tree Frog (*Litoria littlejohni*), Giant Burrowing (*Heleioporus australiacus*) and aquatic ecology, including upland swamps and also in large pools identified in the streams below the swamps.
7. Baseline surveys for the Eastern Ground Parrot (*Pezoporus wallicus*).
8. Depending on the finding of the baseline surveys:
    - Incorporation of macroinvertebrate monitoring in pools into the program to document changes in macroinvertebrate assemblages as an indicator of water quality.
    - Nocturnal surveys for threatened frog species using standardised transects, including comparison of abundance.
    - Ongoing monitoring of the Ground Parrot if this species is detected.

4.6. OTHER ISSUES

4.6.1. Performance measures and indicators

The Briefing Paper does not mention the development of suitable performance measures and performance indicators as required under Condition 4 of Schedule 3 of the Metropolitan Coal Project Approval (MP 08_0149).

The development of new targeted, measurable and enforceable performance measures, performance indicators and triggers are required to account for new knowledge of potential environmental consequences since the original consent.

The Panel recommends that Metropolitan Coal draft new TARPs for inclusion in new Water Management and Biodiversity Management Plans that accompany the Extraction Plan to reflect the required performance measures and performance indicators to protect these swamps.

Previous advice provided by the Panel on the Extraction Plan for LWs 308-310 (IAPUM 2022) recommended revisions to the TARP for upland swamps; specifically:

- Rewording of the TARP to remove reference to the implication that surface cracking must be visible as the cause for changes in groundwater; and
- Due to the lag time between changes in groundwater and vegetation within upland swamps, Performance Measures (not only Performance Indicators) set for upland swamps must include measures based on changes to perched groundwater in the swamp sediments and the underlying weathered sandstone.

It is recommended that these changes are incorporated into the Extraction Plan and Biodiversity Management Plan.

The Panel's recommendations for improved performance measures and indicators are:

1. Reword the TARP to remove reference to the implication that surface cracking must be visible as the cause for changes in groundwater.
2. Revise the Performance Measures (not only Performance Indicators) set for upland swamps, and TARPS that include triggers based on temporal changes to perched groundwater in the swamp sediments and the underlying weathered sandstone.

4.6.2. Integrated risk assessment

The Briefing Paper outlines the proposed scope of a basic risk assessment that would:

- *Combine the relevant information from various specialists.*
- *Assess the potential subsidence impacts and environmental consequences of the proposed extraction plan.*
- *Consider potential risks of adverse environmental consequences.*
- *Analyse options for managing these risks including analysis and costing of alternate mine plans (e.g. costs and benefits of avoidance).*

The Panel advises that a detailed risk assessment is required and recommends that it includes:

- An integrated assessment of the risks arising from enhanced vertical drainage of groundwater, surface water losses and the potential changes to the biodiversity of the primary upland swamps.
- Consideration of additional measures to potentially avoid or mitigate impacts to the threatened species and ecological communities within these swamps, particularly swamp S92.

The Panel's recommendations are:

1. Prepare a comprehensive risk assessment that clearly articulates all the mining-induced risks to swamps S76, S77 and S92 including:
   - the risk of subsurface cracking and other bedrock structural changes likely to enhance vertical drainage extending beneath the swamps
   - the risk of accelerated drainage of shallow groundwater systems
   - the consequential impact to surface water and dependent ecosystems.
2. Identify appropriate actions to avoid, mitigate or manage the environmental risks.

5.0 RECOMMENDATIONS

Based on the content of the Briefing Paper and the additional information supplied by Metropolitan Coal for the technical scopes for the large swamp assessment, the Panel provides the following recommendations to improve the content in the Extraction Plan and recommendations for additional monitoring in advance of the commencement of extraction LWs 311-316. These recommendations have been aggregated from the main body of this Panel advice.

The Panel recommends:

Subsidence

1. Given that the gateroads (which determine the dimensions of LW311) are already being driven:
    a. performance measures for swamp S92 need to be specified as a matter of priority
    b. the assessment of mining-induced impacts and consequences for swamps overlying LW311 should be undertaken as a priority to provide timely warning of any need to change the width and/or the totally extracted length of LW311.
2. Drivage of MG312 should be delayed until the large swamp impact assessment has been completed and the Extraction Plan for LW311 and LW312 has been endorsed by the Department.

Groundwater

1. A detailed conceptualisation of the hydrology/hydrogeology of each of the listed swamps including groundwater-surface water interactions, and a holistic assessment of connectivity with regional groundwater and groundwater dependent assets.
2. Any updated groundwater model predictions that describe the impacts to these shallow groundwater systems, and their dependent environmental assets (i.e. stream baseflows and swamps).
3. An assessment of risk of subsidence impacts to upland swamps, including the risk of changes in groundwater levels and storage in swamp substrates and underlying weathered sandstone.
4. Detailed analysis of groundwater levels and soil moisture, using the existing monitoring network, and how this relates to swamp sub-communities.
5. A commitment that prior to the commencement of extraction of LW311, additional groundwater monitoring sites will be installed near the primary swamps, in Swamp S106 and within the western control swamps as recommended in Section 4.3.2.
6. Revised TARPs that encompass the recommendations made by the Panel in its advice on LW308-310 Extraction Plan, particularly improved time-independent water level parameters for the paired swamp groundwater monitoring locations.

Surface Water

1. Characterisation of baseline surface flow dynamics.
2. Characterisation of baseline water quality at the outlet of swamp S92.

3. Characterisation of the presence of drainage lines and major pools in swamp S92 to inform flora and fauna surveys, and as a baseline record of surface water storage features.
4. A camera that captures images every half-hour (or less) of flow and debris conditions at the swamp S92-GS flow gauge.
5. A baseline survey (potentially by drone) of major pools within swamps S76, S77 and S92.
6. Water quality monitoring at the swamp S92-GS site including a baseline period as far as practicable.

Upland Swamps and Biodiversity

1. Development of a conceptual model (schematics) showing vegetation type, swamp gradients (including soil depths) and perched groundwater that sustains the primary swamps.
2. Revised baseline mapping of swamp sub-communities, using a replicable technique that will allow monitoring of changes in response to changes in hydrology. Comparison with previous mapping would be desirable.
3. If suitable access is possible, install a cross section of swamp substrate piezometers in the upper reaches of swamp S92. Piezometers should be representative of the vegetation communities, especially cyperoid heath/tea tree thicket v banksia heath v restioid sedgeland in S92.
4. Include an assessment of the potential impacts to swamp S106 and include this swamp in other assessment and monitoring programs for biodiversity.
5. Baseline surveys for swamp related species, such as the Giant Dragonfly (*Petalura gigantea*), with larval surveys recommended for this species, and threatened flora species.
6. Baseline surveys for Littlejohn's Tree Frog (*Litoria littlejohni*), Giant Burrowing (*Heleioporus australiacus*) and aquatic ecology, including upland swamps and also in large pools identified in the streams below the swamps.
7. Baseline surveys for the Eastern Ground Parrot (*Pezoporus wallicus*).
8. Depending on the finding of the baseline surveys:
    - Incorporation of macroinvertebrate monitoring in pools into the program to document changes in macroinvertebrate assemblages as an indicator of water quality.
    - Nocturnal surveys for threatened frog species using standardised transects, including comparison of abundance.
    - Ongoing monitoring of the Ground Parrot if this species is detected.

Other issues

1. Reword the TARP to remove reference to the implication that surface cracking must be visible as the cause for changes in groundwater.
2. Revise the Performance Measures (not only Performance Indicators) set for upland swamps, and TARPS that include triggers based on temporal changes to perched groundwater in the swamp sediments and the underlying weathered sandstone.
3. Prepare a comprehensive risk assessment that clearly articulates all the mining-induced risks to swamps S76, S77 and S92 including:

- the risk of subsurface cracking and other bedrock structural changes likely to enhance vertical drainage extending beneath the swamps
- the risk of accelerated drainage of shallow groundwater systems
- the consequential impact to surface water and dependent ecosystems.

4. Identify appropriate actions to avoid, mitigate or manage the environmental risks.

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INDEPENDENT EXPERT ADVISORY PANEL FOR MINING

ADVICE RE:

METROPOLITAN COAL MINE

Stage 1: LONGWALLS 311-312

Date: 05/09/2024

Report No: IEAPM2024-9

EXECUTIVE SUMMARY

On 4 July 2024, the Director Resource Assessments, NSW Department of Planning, Housing and Infrastructure (DPHI) requested the Independent Expert Advisory Panel for Mining (IEAPM – "the Panel") to provide advice in relation to the proposed Extraction Plan (EP) for secondary coal extraction from Longwalls (LWs) 311-316 at the Metropolitan Coal Mine.

The scope of the Advice sought from the Panel on the following matters:

- *Whether the Panel's previous recommendations in the documents above have been adequately addressed, in particularly in relation to large swamps and water quality modelling and monitoring;*
- *The adequacy of large swamp impact predictions presented in the Large Swamp Assessment (Appendix H of the EP) and associated appendices;*
- *The adequacy of the proposed performance measures and indicators for large swamps required by condition 4(b) Schedule 3 of the consent and included in the Large Swamp Assessment (Section 7.2), and the need or otherwise to set more defined performance measures for large swamps beyond those related to threatened species, populations, or ecological communities;*
- *The need or otherwise to modify the mine plan to minimise/avoid impacts, particularly on large swamps, and ensure compliance with existing and proposed performance measures;*
- *The adequacy of the water and swamp monitoring programs;*
- *The water and swamp TARPs and whether they;*
    - *Enable measurement of compliance with existing and proposed performance measures established under the consent and proposed in the EP for large swamps; and*
    - *Have triggers (and associated performance indictors) that adequately reflect the existing and proposed performance measures.*

The Panel should feel free to provide any other advice it considers would assist the Department in reviewing the EP.

After the initial briefing by DPHI Assessments, preliminary review of information and Panel meetings; the IEAPM determined a staged approach is most suitable for this project. Stage 1 will consist of the following:

1. Reviewing whether the Panel's previous recommendations have been adequately addressed in relation to large swamps and water quality modelling and monitoring;
2. Restricting the Stage 1 advice to LW 311 and 312; and
3. Recommending clear and timely Performance Indicators that unambiguously define when impacts on biodiversity are greater than negligible.

The following sections of the report identify the following:

- Chapter 2 – Scope of works
- Chapter 3 – Method of Operation
- Chapter 4 – Background
- Chapter 5 – Metropolitan Coal's response to the Panel's previous recommendations
- Chapter 6 – Advice on LW 311 and 312 focussing on the large swamps
- Chapter 7 – Summary Conclusions
- Chapter 8 – Summary Recommendations

Based on the material presented to the Panel and the supplementary information supplied by Metropolitan Coal Pty Ltd, the Panel has made the following conclusions and recommendations for possible consideration in any Extraction Plan approval for Longwalls (LWs) 311 and 312:

CONCLUSIONS

Responses to previous Panel advice by Metropolitan Coal

- In relation to the Panel's previous advice *Water Quality Performance Measures for Metropolitan Coal Mine*, the responses by Metropolitan Coal indicate an intention to address the recommendations to some degree but in most cases lack information about timeframes and in some cases are vague or suggest an inadequate degree of commitment. These issues arising do not need to be urgently addressed in the context of Longwalls 311 and 312, except to ensure that total metals (rather than dissolved metals concentrations) are monitored at the outlet of Swamp 92.
- In relation to the Panel's previous advice *Large Swamp Environmental Assessment Requirements for the Extraction Plan for Longwalls 311 to 316*, most of the recommendations have not been addressed or have been addressed in a partial or unsatisfactory way. The major issues relevant to the consideration of Longwalls 311 and 312 are:
    - Due to the progression of Maingate 312 prior to assessment of the Extraction Plan the widths of Longwalls 311 and 312 are essentially fixed and reducing their width is now not a practical risk management option.
    - The large swamp TARPs remain unsatisfactory and need to be further refined in several aspects.
    - Aspects of the large swamp risk assessment are unsatisfactory, particularly for the downstream end of Swamp 77.
    - The baseline surveys of vegetation sub-communities are unsatisfactory.
    - The baseline surveys of threatened species are unsatisfactory.
    - Documented evidence of the absence of the Eastern Ground Parrot relied upon by the Extraction Plan is unavailable.
- In relation to the Panel's previous advice *Metropolitan Coal Mine: Independent Review of Environmental Performance to 2022*, plans are in place to install the recommended monitoring at site T6, but it was not yet in place at time of writing this advice.
- In relation to the Panel's previous advice *Metropolitan Coal Mine: Independent Review of Environmental Performance to 2022 and Metropolitan Mine Longwalls 308 – 310 Extraction Plan*, the recommended groundwater monitoring was not in place at time of writing this advice, limiting the value of that monitoring for understanding subsidence risks and for providing baseline data for assessing performance.

Significance of the large swamps

- For the purpose of assessing the Extraction Plan and considering suitable Performance Measures and Performance Indicators, Swamps 76, 77 and 92 are important upland swamps in terms of providing suitable habitat for threatened species and water supply protection, and because of their size and status as Threatened Ecological Communities. Swamps 77 and 92 meet criteria proposed by OEH (2016) for swamps of special significance on the Woronora Plateau.

The adequacy of large swamp impacts predictions

- The subsidence predictions for LWs 311-312 have been made using an appropriate method that has been reasonably applied; additionally, the subsidence reports are adequate when supported by the relevant management plans.
- The swamp groundwater modelling is useful and appropriate given its data constraints; however, due to the model uncertainty, little weight should be attached to the conclusion in the Large Swamp Assessment that "*The mining-related effects to Swamp 76 and Swamp 92 are expected to be minor with the water levels predicted to remain above the base of the substrate*".
- If subsidence impacts do occur along tributaries P, R and S, as predicted, this is likely to result in impacts to threatened species if and where they are present (presence is indicated in the BCS survey results presented to the Panel). If these impacts do occur, and result in loss of breeding habitat, they are unlikely to be considered negligible.
- The baseline surveys relied upon by the Extraction Plan for threatened frog species and for the Giant Dragonfly are inadequate. Therefore, the Panel lacks confidence in the impact predictions that there will be no significant impacts and that a negligible impact to threatened species can be achieved.
- The limitations in the baseline surveys cannot be properly addressed prior to the proposed commencing date of LW 311 or LW 312, but may be partially addressed prior to the proposed commencing date of LW 313.

The adequacy of the large swamp Performance Measures and Performance Indicators

- The proposed Performance Measure of "*Negligible impact on Threatened Species, Populations, or Ecological Communities*" is acceptable for the purpose of LWs 311 and 312 provided that this Performance Measure is supported by Performance Indicators that are relevant and have clear criteria that define when an impact is more than negligible.
- The proposed large swamp groundwater Performance Indicator "*Subsidence impacts are not expected to result in measurable changes to swamp groundwater levels when compared to control swamps or seasonal variations in water levels experienced by upland swamps prior to mining*" is acceptable for the purpose of LWs 311 and 312 if it is supported by triggers that clearly define when changes are significant enough to determine an exceedance of the Performance Measure.
- The large swamps warrant Performance Indicators and triggers that provide a higher level of confidence (than provided by those applied to previously undermined swamps) that impacts will be detected and managed appropriately.
- Increased groundwater recession rates leading to non-negligible loss of swamp groundwater is a sufficient and practical criterion for determining that the large swamp groundwater Performance Indicator has been exceeded. Due to the semi-quantitative assessment of recession rates, a technical document should clearly explain and demonstrate the method and criteria used. Any exceedance of this Performance Indicator should translate directly and irrespective of any subsequent assessment to an exceedance of the Performance Measure for the large swamps.
- Given the preceding conclusion, the Upland Swamp Vegetation Performance Indicator is unnecessary.
- The Performance Measure "*Negligible reduction to the quality or quantity of water resources reaching the Woronora Reservoir*" and associated Performance Indicators are acceptable.
- The Amphibian Performance Indicator should only refer to threatened species, with exceedance of the Performance Indicator reviewed by species and monitoring location (e.g. a transect) rather than the "*amphibian assemblage as a whole*".

The adequacy of the large swamp TARPs

- The closure thresholds used in the large swamp valley closure TARP are not sufficiently conservative for Swamp 77.
- The rationale for the location of closure lines in Swamps 76 and 77 requires clarification.
- There would be benefit in adding the shallow (~10m depth) HBSS groundwater into the upland swamp groundwater TARPs as an early warning of potential (short or long-term) impacts to swamp hydrology.
- The highest-level upland swamp groundwater trigger defines exceedance of the Performance Indicator and should define exceedance of the Performance Measure. It is appropriate for this to be based, as is proposed, on semi-quantitative analysis of groundwater levels including recessions that lead to non-negligible reductions in swamp groundwater levels. Better allowance needs to be made for baseline period levels that may be below the logger level.
- The proposed water quality TARPs are appropriate for LW 311-312.
- The Amphibian TARP is viewed by the Panel to have a number of limitations related to the lack of focus on abundance of individual species and availability of habitat (particularly breeding pools) along individual waterways, and other details.

The need or otherwise to modify the mine plan

- Of the three large swamps, Swamp 92 is the most significant. The proposed extent of LW 312 presents an unacceptable risk to Swamp 92, which could easily be addressed by shortening of that longwall.
- The downstream end of Swamp 77, including a controlling rockbar, is at high risk. If shortening of LWs 312 and 313 or reduction of (one or more of) LWs 313-316 panel widths by at least 60 m to protect Swamp 77 are not considered appropriate for economic or other reasons, then it is highly likely that the large swamp groundwater Performance Indicator will be exceeded at Swamp 77.
- Further consideration of risks to Swamp 76, Swamp 77 and tributaries that may host threatened species, and to management options including possible changes to the mine plan for LWs 313-316, should be given in Stage 2 of the Advice.

The adequacy of the water and swamp monitoring programs

- The proposed Subsidence Monitoring Program is adequate for the purpose of LWs 311 and 312, except that there is a need for a transverse subsidence monitoring line towards the northern end of LW 311, cutting across LW 311 towards the northern end of LW 316 to monitor subsidence behaviour within the zone of influence of Woronora Reservoir.
- The existing or proposed groundwater monitoring at the large swamps is adequate, except for the absence of any monitoring in the downstream area of Swamp 77, which the revised subsidence predictions show to be at high risk. Even if monitoring sites are established in this area, an unsatisfactory baseline period will be achievable if LWs 311 and 312 proceed as planned. Unless this can be resolved, it may be reasonable to assume (based on the subsidence predictions) that the groundwater Performance Indicator is exceeded at this location irrespective of measurements.
- The surface water monitoring for the large swamps has been implemented consistent with previous Panel recommendations. Where threatened frogs are identified, additional tributary pool level monitoring is appropriate.
- The Panel generally supports the swamp vegetation monitoring proposed but is unable to determine the suitability of quadrat/transect monitoring locations. The sites in Swamp 92 and Swamp 77 under-represent the lower reaches of the swamp.

RECOMMENDATIONS

Metropolitan Coal's response to the Panel's previous recommendations

1. The site S92-GS water quality monitoring should include measurement of total metals concentrations.
2. Peabody should proceed as soon as practicable with event sampling of water quality using automatic samplers irrespective of the outcomes of preliminary load assessments. This applies to ETWQ AU and also WQWQ9 and WOWQ2 if these are not covered by WaterNSW event sampling.
3. Peabody should commit, subject to access permission, to monitoring the depth profiles of water quality of the Woronora Reservoir at WDFS1 or other suitable site including regular (at least bi-annual) sampling throughout the remaining mining period, plus sampling following level 3 triggers for water quality reaching the reservoir.
4. An analysis of historical water quality trends in Woronora Reservoir and their relation to mining development should be included in the Metropolitan Coal 2024 Annual Review, and this should not be provisional on further suitable data becoming available.
5. The conceptual models of the large swamps should be reviewed in 6-monthly reporting in the light of new monitoring data, and updated to represent vegetation communities.
6. The T6 standpipes and the multi-level VWPs for Swamps 92 and 77 and standpipes at two sites in Swamp 76 should be installed as soon as practicable.

The adequacy of large swamp impact predictions

7. It is recommended that updates to the 1-dimensional and 2-dimensional models and their predictions should be undertaken in annual reviews to refine understanding of reasons for any observed subsidence consequences and to refine predictions for subsequent longwalls.
8. Further baseline surveys are required for threatened frog species, using appropriate survey methods and effort, conducted at a suitable time of year with survey locations targeting breeding habitat through the upland swamps (where present) and along suitable reaches of Tributaries P, R and S.
9. Additional surveys are required for Swamps 92, 77 and 76 using best practice methods. The Panel recommends the company engage with BCS in developing a suitable survey method.

The adequacy of the proposed performance measures and indicators for large swamps

10. The special significance of the large swamps should be managed by maintaining the proposed Performance Measure, and developing Performance Indicators and associated triggers that provide a high level of confidence that non-negligible impacts to the swamps will be detected and appropriately managed.
11. It is recommended that the action "*Initiate assessment against the performance measure for threatened species"* is removed from the highest-level Upland Swamp Groundwater TARP so that the trigger of this TARP defines an exceedance of both the Performance Indicator and the Performance Measure for the large swamps.
12. It is recommended that the Performance Indicator under Upland Swamp Vegetation Monitoring is removed (while maintaining the monitoring, annual reporting and TARP) and instead the groundwater Performance Indicator is relied upon to assess the Performance Measure for the large swamps.

The adequacy of the large swamp TARPs

13. The trigger for Swamp 92 should be reviewed by the Technical Committee following mining of LW 311 and submitted for approval prior to mining of LW 312.
14. To inform assessment of proposals for LW 313 to LW 316, the proposed large swamp valley closure TARP document should be revised to include a map showing closure line locations and additional justification of proposed locations, including consideration of any rockbar controls.
15. The large swamp groundwater level 2 TARP should include a trigger for potential impacts on HBSS shallow (~10m) groundwater levels, at which frequency of analysis of swamp groundwater levels should increase.
16. The large swamp groundwater triggers should allow for the possibility that the baseline period levels have been below the logger level.
17. The highest-level large swamp groundwater trigger action should include reviewing the mine plan for longwalls yet to be mined.
18. The large swamp groundwater TARP should explicitly state that a trigger at any one site constitutes a trigger for that swamp.
19. The large swamp groundwater TARP should include quarterly reporting of level 2 triggers and associated analysis.
20. A technical document, which clearly defines how the large swamp groundwater TARP triggers are assessed including examples, should be appended to the management plan.
21. The Biodiversity Management Plan should present a set of TARPs for the large swamps that separately from the TARPs for other swamps.
22. The Amphibian Performance Indicator and TARP should focus on abundance of individual species and availability of habitat (particularly breeding pools) along individual waterways.
23. The Amphibian TARP Level 2 trigger should assess if there has been a reduction in abundance of a threatened species (Red-crowned Toadlet, Littlejohn's Tree Frog or Giant Burrowing Frog) along an impacted waterway which has not been observed at control sites for one year. The Level 3 trigger should assess if there has been a reduction in abundance of a threatened species (Red-crowned Toadlet, Littlejohn's Tree Frog or Giant Burrowing Frog) along an impacted waterway which has not been observed at control sites for greater than one year.
24. Both Level 2 and 3 triggers should also include a trigger for drying of pools resulting in loss of habitat. It is recommended that periods align with the trigger levels above (i.e. loss of habitat for one year (Level 2) and greater than one year (Level 3)).
25. Further detail should be provided on the analysis to be conducted in relation to threatened species. The wording of the final action/response should make reference to implementation of appropriate mitigation/remediation or provisions of offsets, as per Sections 9 and 10. Remove the word "consider".
26. A reduction in a frog abundance at an impact site should translate directly to exceedance of the Performance Measure, hence the action "*Initiate assessment against the performance measure for threatened species*" should be deleted from the action/response. Table 19 of the Biodiversity Management Plan should be reviewed to determine if this is required.

The need or otherwise to modify the mine plan

27. It is recommended that the southern end of LW 312 is shortened by 260 m to minimise risks to Swamp 92.
28. It is recommended that Metropolitan Coal should provide DPHI, prior to a decision regarding approval of LW 311 and LW 312, further justification of why the predicted subsidence impacts in the downstream length of Swamp 77 may be considered acceptable, including evaluation of the feasibility of shortening of one or both of LWs 312 and 313.

29. It is recommended that, if the currently proposed layouts of LWs 311 and 312 are approved then, within 6 weeks of this Advice being submitted to DPHI (so that it can be considered by the Panel in Stage 2 of this Advice), Metropolitan Coal should submit to the DPHI a site-specific contingency plan that explains how non-minor fracturing in the downstream length of Swamp 77 (including its rockbar, base of tributary, and underneath the swamp soil) would be managed.

The adequacy of water and swamp monitoring programs

30. It is recommended that Metropolitan Coal should revise the Subsidence Management Plan to include a transverse subsidence monitoring line towards the northern end of LW 311, cutting across LW 311 towards the northern end of LW 316 monitor subsidence behaviour within the zone of influence of Woronora Reservoir.
31. It is recommended that Metropolitan Coal continues its endeavours to install the planned shallow and deep groundwater monitoring in/near the large swamps as soon as practicable and prior to commencement of LW 311.
32. It is recommended that a shallow swamp groundwater monitoring piezometer is installed near to the end of Swamp 77 at its downstream extent and, if safely accessible, rockbars and pools within the lower end of Swamp 77 should also be monitored for loss of water and visual impacts (fracturing and iron staining).
33. It is recommended that if no satisfactory monitoring, including baselines, can be installed to assess impacts to the downstream end of Swamp 77 and if the proposed longwall layout progresses then the large swamp groundwater Performance Indicator should be assumed to be exceeded over at least the valley infill area of Swamp 77.
34. Monitoring locations should target habitats at greatest risk of impacts from subsidence (breeding habitat) as identified during baseline surveys.
    - Monitoring locations should not be situated on access tracks. These locations are unsuitable for monitoring of threatened frog species.
    - Giant Dragonfly surveys should include targeted surveys for exuviae in wetter sections of the Swamps 77 and 92 (and Swamp 76).
35. Timing of monitoring should target key lifecycle stages of the species being monitored.
    - For threatened frogs, this should include the breeding periods, including calling and when tadpoles are present. This may require multiple surveys per year.
    - For the Giant Dragonfly, surveys should target the key emergence period between December and January.
36. Monitoring techniques should be targeted at, and suitable for, the species being monitored.
37. Surveys for threatened frogs must include nocturnal visual-aural surveys along monitoring transects. Use of 100 m x 100 m (1 ha) monitoring sites is not considered a suitable monitoring technique.
38. Instead of the measures of abundance outlined in the Biodiversity Management Plan, monitoring for threatened frogs should be undertaken to compare abundance along monitoring transects year-on-year.
39. Monitoring for threatened frogs should include monitoring of pool water levels at breeding locations identified during baseline surveys, including additional monitoring locations along Tributary P and Tributary R with sites informed by adequate baseline surveys.
40. If detected during baseline surveys, monitoring for the Giant Dragonfly should target exuviae in suitable habitat, as per recommendations of BCS. The company may also wish to considered use of eDNA surveys at the lower reaches of the swamps.

41. Surveys for threatened frogs must include nocturnal visual-aural surveys along monitoring transects. Use of 100 m x 100 m (1 ha) monitoring sites is not considered a suitable monitoring technique.

Other matters

42. Drivage of MG313 should be delayed until an Extraction Plan covering LW 313 has been endorsed by the Department.

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Glossary

BCS	Biodiversity, Conservation and Science Group of Department of Climate Change, Environment, Energy and Water
DCCEEW	Department of Climate Change, Environment, Energy and Water
DPHI	Department of Planning, Housing and Infrastructure
EEC	Endangered ecological community
EP	Extraction Plan
IEAPM, The Panel	Independent Expert Advisory Panel for Mining
IEAPUM	Independent Advisory Panel for Underground
LW	Long walls
TARPs	Trigger Action Response Plans
TSC	NSW *Threatened Species Conservation Act 1995*
EPBC Act	Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*
VWP	Vibrating Wire Piezometer

1.0 INTRODUCTION

The Metropolitan Coal Mine is an operating underground coal mine located approximately 30 kilometres (km) north of Wollongong. Development consent was granted in June 2009 and has been subsequently modified several times.

Metropolitan Coal Pty Ltd is seeking approval for an Extraction Plan (EP) for secondary coal extraction from Longwalls (LWs) 311-316. This advice will focus on evaluating the elements of the EP pertaining to LWs 311-312.

As part of the preparation of the EP, Metropolitan Coal Pty Ltd consulted with agencies to assist with the preparation of the report and the Large Swamp Assessment. The Independent Expert Advisory Panel for Mining (the Panel) was provided with the following agency advice post submission of the EP:

- Department of Planning, Housing and Infrastructure (DPHI) Resource Assessments
- WaterNSW
- Heritage NSW
- DPIRD-Fisheries
- Mining, Exploration and Geosciences
- DCCEEW (Water Group)
- DCCEEW - Biodiversity, Conservation and Science Group
- Wollongong City Council

The catalyst for requesting the Panel's advice is concerns raised by WaterNSW and BCS regarding potential impacts to swamps and water quality and the associated impacts to threatened species, watercourses and the Woronora Reservoir.

The below Figure 1 illustrates the location of the longwalls and the wider mining area.

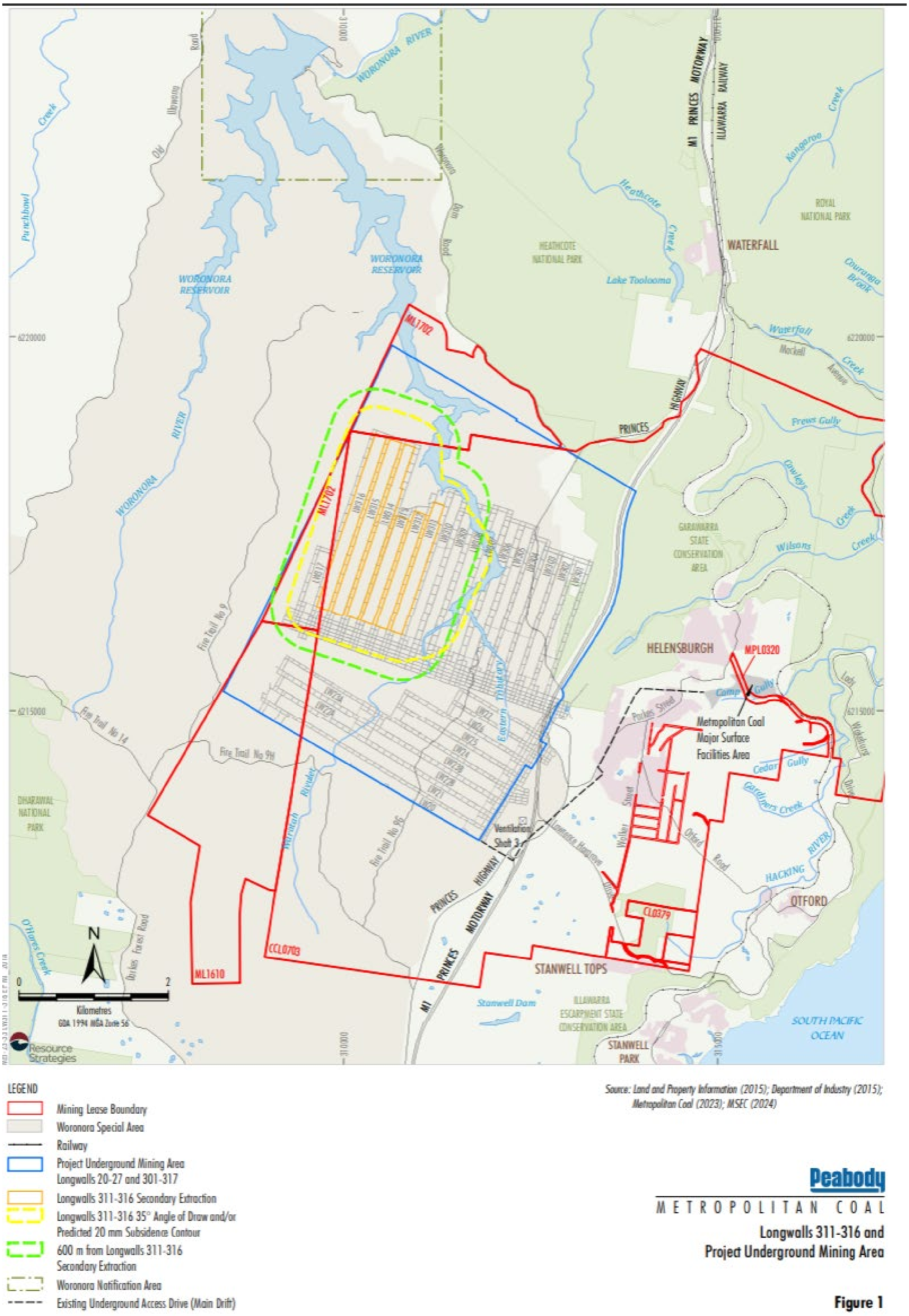

Figure 1: Map of Metropolitan Coal Longwall extraction areas

2.0 SCOPE OF WORKS

The NSW Department of Planning, Housing and Infrastructure (DPHI) established the Independent Expert Advisory Panel for Mining (the Panel). The Panel's purpose is to give DPHI and the Independent Planning Commission access to expert advice when assessing mining proposals under the *Environmental Planning and Assessment Act 1979*.

On 4 July 2024, the Director Resource Assessments, DPHI requested the Panel to provide advice in relation to the proposed EP for secondary coal extraction from LWs 311-316 at the Metropolitan Coal Mine (refer Appendix A). This follows four relevant previous sets of advice provided by the Panel and its predecessor, the Independent Advisory Panel for Underground Mining, on the Metropolitan Mine:

1. Advice Re: Water Quality Performance Measures for Metropolitan Coal Mine (IEAPM, 2023a)
2. Advice Re: Large Swamp Environmental Assessment Requirements for the Extraction Plan for Longwalls 311 to 316 (IEAPM, 2023b)
3. Advice Re: Metropolitan Coal Mine: Independent review of environmental performance to 2022 (IEAPM 2023c and IEAPM 2023d)
4. Advice Re: Metropolitan Mine Longwalls 308 – 310 Extraction Plan (IAPUM, 2022)

DPHI's Request for Advice sought advice from the Panel on the following matters:

- *Whether the Panel's previous recommendations in the documents above have been adequately addressed, in particularly in relation to large swamps and water quality modelling and monitoring;*
- *The adequacy of large swamp impact predictions presented in the Large Swamp Assessment (Appendix H of the EP) and associated appendices;*
- *The adequacy of the proposed performance measures and indicators for large swamps required by condition 4(b) Schedule 3 of the consent and included in the Large Swamp Assessment (Section 7.2), and the need or otherwise to set more defined performance measures for large swamps beyond those related to threatened species, populations, or ecological communities;*
- *The need or otherwise to modify the mine plan to minimise/avoid impacts, particularly on large swamps, and ensure compliance with existing and proposed performance measures;*
- *The adequacy of the water and swamp monitoring programs;*
- *The water and swamp TARPs and whether they;*
    - *Enable measurement of compliance with existing and proposed performance measures established under the consent and proposed in the EP for large swamps; and*
    - *Have triggers (and associated performance indictors) that adequately reflect the existing and proposed performance measures.*

The Panel should feel free to provide any other advice it considers would assist the Department in reviewing the EP.

After the initial briefing by DPHI Assessments, preliminary review of information and Panel meetings, the Panel determined a staged approach is most suitable for this project. As a result, DPHI requested that Stage 1 of the project provides the following advice:

1. Reviewing whether the Panel's previous recommendations have been adequately addressed in relation to large swamps and water quality modelling and monitoring;
2. Restricting the Stage 1 advice to LW 311 and 312; and
3. Recommending clear and timely Performance Indicators that unambiguously define when impacts on biodiversity are greater than negligible.

The Chair of the Panel (Em. Professor Jim Galvin) nominated the following members of the IEAPM to prepare the advice. Professor Neil McIntyre co-chaired this individual Panel and coordinated this advice report:

- Em. Professor Jim Galvin – Subsidence and Mining
- Mr John Ross – Groundwater
- Professor Neil McIntyre – Surface Water
- Dr Ann Young – Swamps
- Mr Nathan Garvey – Biodiversity and Ecology
- Professor David Waite – Water Quality

More background on the Panel can be viewed at Appendix B.

3.0 METHOD OF OPERATION

3.1. ACTIVITIES AND TIMELINE

The Panel convened by videoconference during the preparation of its advice and was administratively supported by the Panel Secretariat staff provided by DPHI – Major Projects Advisory.

The Panel convened on 23 July 2024 and received the supply of initial documentation and a virtual briefing. Additional information was then supplied to the Panel throughout August 2024 including a response to a further information request, post submission Agency Advice, and the Metropolitan Coal Mine response to Agency Advice.

The timeline relating to the IEAPM's assessment of the Metropolitan EP is summarised in Table 1.

Table 1: Timeline relating to IEAPM's assessment of Metropolitan Coal Mine EP.

Date	Milestone
4/7/2024	DPHI request for advice from IEAPM and supply of initial documentation
23/7/2024	Briefing from DPHI staff
23/7/2024	Panel teleconference to discuss issues and to resolve any advice queries
8/8/2024	IEAPM requested further information from Metropolitan Coal Mine
14/08/2024	Metropolitan Coal response to IEAPM questions and queries
16/08/2024	Panel teleconference to discuss issues and report structure
19/08/2024	Supply of additional information relating to response to agency advice.
23/08/2024	BCS briefing
27/08/2024	Panel teleconference to progress draft report
2/09/2024	Finalisation of IEAPM advice

3.2. REFERENCE DOCUMENTATION

Numerous key documents were provided through DPHI to support the Panel in preparing this Advice. These documents are listed in Table 2. A range of documents that the Panel has had regard to in compiling this advice are also recorded under References.

Table 2: Reference Documentation

Stage	Document Reference	Document Name
Initial documentation	Provided by DPHI	**Extraction Plan LW 311-316 including:** • Appendix 1 – Subsidence Report i. Appendix A Water Management Plan ii. Appendix B Land Management Plan iii. Appendix C Biodiversity Management Plan iv. Appendix D Heritage Management Plan v. Appendix E Public Safety Management Plan vi. Appendix F Subsidence Management Plan vii. Appendix G Coal Resource Recovery Plan viii. Appendix H Large Swamp Assessment • Appendix 2 – Subsidence Addendum Letter **Peabody Six Monthly Report** • Report and 10 attachments **Pre-submission Agency Advice** • DPI Fisheries • DCCEWW • BCS • BCS follow up • Heritage NSW • MEG • Subsidence Advisory • WaterNSW • Wollongong City Council **IEAPM High Level Review Report LW 311-316** **Metropolitan Coal Response to IEAPM Advice Report 2023** **LW 309 Waratah Rivulet TARP Results** **Metropolitan Coal Response to Submissions Letter**
Supplementary Documentation	Provided by DPHI	**Post Submission Agency Advice** • DCCEEW BCS • DCCEEW Heritage NSW • DPIRD Fisheries • DPIRD NSW Resources • WaterNSW • Wollongong City Council

Stage	Document Reference	Document Name
	Provided by Metropolitan Coal	**Response to Independent Expert Advisory for Mining Request for Information 14 August 2024** • Attachment 1 – Predicted Profiles of Subsidence, Upsidence and Closure along Tributaries • Attachment 2 - Eastern Tributary Water Levels Pre and Post Stream Remediation • Attachment 3 - Eastern Tributary Photography March 2024 • Attachment 4 – Fault Photos • Attachment 5 – Large Swamps Drone Survey **Response to Agency Advice Submissions 19 August 2024** • Appendix 1 Registered Aboriginal Parties Correspondence • Appendix 2 Subsidence Predictions based on Revised Layout, 30m and 60m Width Reductions • Appendix 3 Eastern Tributary Water Levels Pre and Post Stream Remediation Attachment 4 Metropolitan Coal Mine Eastern Tributary Stream Photos **Large Swamps and Adaptive Management** (issued 26 August 2024)

4.0 BACKGROUND

4.1. EXTRACTION PLAN AND ITS ENVIRONMENT

The proposed LWs 311 to 316 would undermine, either partially or fully, 19 Coastal Upland Swamps (Figure 2). Three of these, Swamps 76, 77 and 92 are the large swamps that are the subject of Metropolitan Coal's Large Swamp Assessment. A total of 39 swamps are located within the 35 degree angle of draw of the longwalls, including another large swamp, Swamp 106. The three main watercourses within the extraction plan area are tributaries P, R and S. These tributaries originate in Swamps 92, 77 and 76 respectively and drain to the Woronora Reservoir through the swamps and then through steep, incised valleys. The entry of Waratah Rivulet to Woronora Reservoir is just outside the subsidence-impacted area (as defined by the predicted 20 mm subsidence contour).

The groundwater system in the area may be considered, for the purpose of this advice, as having four components: the very shallow groundwater in the swamps that sits on the sandstone base of the swamps; the shallow groundwater in the sandstone underneath the swamp base which at some locations helps sustain swamp groundwater (i.e. has a hydraulic connection with the swamp groundwater); shallow groundwater in the slopes surrounding the swamps, which flows into the swamp; and deeper groundwater the surface of which is typically some tens of meters below the swamp base.

The layout of the mine and location of each longwall is shown in Figure 2 below. This shows the longwall outlines proposed in the Extraction Plan of July 2024 (Peabody 2024a), which are shortened from those proposed in the March 2024 Extraction Plan.

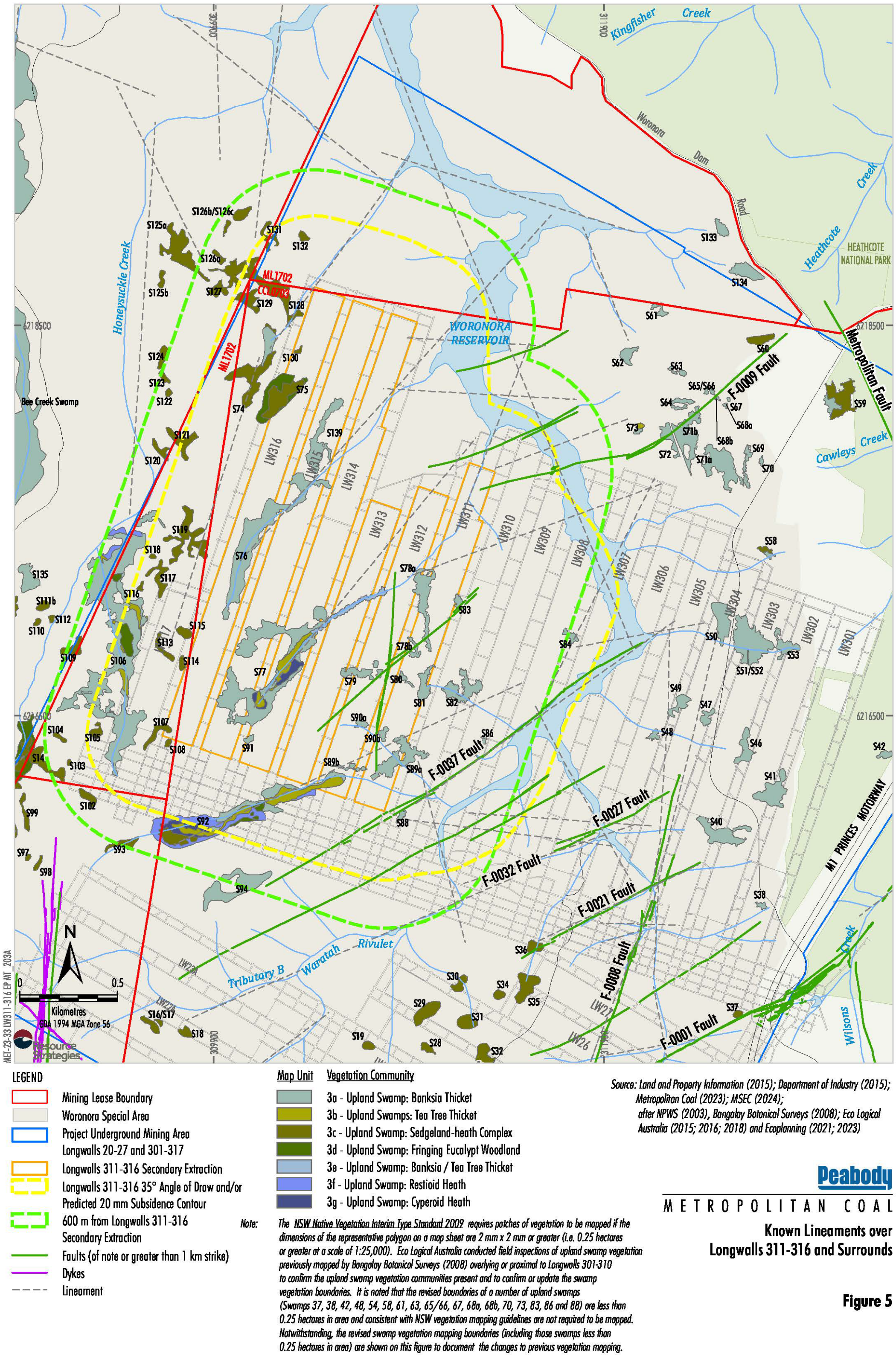

Figure 2 Longwalls 311-316 and upland swamp locations

4.2. Performance measures and Requirements of Condition Consent No. 4

The subsidence impact performance measures stated in the Consolidated Consent are described in Schedule 3 Condition 1 (Table 3).

Table 3: Subsidence impact performance measures (Table 6 of Peabody 2024a).

Water Resources	
Catchment yield to the Woronora Reservoir	Negligible reduction to the quality or quantity of water resources reaching the Woronora Reservoir No connective cracking between the surface and the mine
Woronora Reservoir	Negligible leakage from the Woronora Reservoir Negligible reduction in the water quality of Woronora Reservoir
Watercourses	
Waratah Rivulet between the full supply level of the Woronora Reservoir and the maingate of Longwall 23 (upstream of Pool P).	Negligible environmental consequences (that is, no diversion of flows, no change in the natural drainage behaviour of pools, minimal iron staining, and minimal gas releases)
Eastern Tributary between the full supply level of the Woronora Reservoir and the maingate of Longwall 26	Negligible environmental consequences over at least 70% of the stream length (that is no diversion of flows, no change in the natural drainage behaviour of pools, minimal iron staining and minimal gas releases)
Biodiversity	
Threatened species, populations, or ecological communities	Negligible impact
Swamps 76, 77 and 92	Set through condition 4 below
Land	
Cliffs	Less than 3% of the total length of cliffs (and associated overhangs) within the mining area experience mining-induced rock fall
Heritage	
Aboriginal heritage sites	Less than 10% of Aboriginal heritage sites within the mining area are affected by subsidence impacts
Items of historical or heritage significance at the Garrawarra Centre	Negligible damage (that is fine or hairline cracks that do not require repair), unless the owner of the item and the appropriate heritage authority agree otherwise in writing
Built Features	
Built features	Safe, serviceable and repairable, unless the owner and the MSB agree otherwise in writing

Note: The Proponent will be required to define more detailed performance indicators for each of these performance measures in the various management plans that are required under this approval (see condition 6 below).

Schedule 3 Condition 4 sets the following requirements for the large swamps (Swamps 76, 77 and 92) that are proposed to be undermined or partially undermined by LWs 311-316:

The Proponent shall not undermine Swamps 76, 77 and 92 without the written approval of the Director-General. In seeking this approval, the Proponent shall submit the following information with the relevant Extraction Plan (see condition 6 below):

(a) a comprehensive environmental assessment of the:

- *potential subsidence impacts and environmental consequences of the proposed Extraction Plan;*
- *potential risks of adverse environmental consequences; and*
- *options for managing these risks;*

(b) a description of the proposed performance measures and indicators for these swamps; and

(c) a description of the measures that would be implemented to manage the potential environmental consequences of the Extraction Plan on these swamps (to be included in the Biodiversity Management Plan – see condition 6(f) below), and comply with the proposed performance measures and indicators.

Schedule 6 Condition 6 states:

If the Proponent exceeds the performance measures in Table 1 of this approval and either

(a) the contingency measures implemented by the Proponent have failed to remediate the impact, or

(b) the Director-General determines that it is not reasonable or feasible to remediate the impact,

then the Proponent shall provide a suitable offset to compensate for the impact to the satisfaction of the Director-General.

Note: Any offsets required under this condition must be proportionate with the significance of the impact.

4.3. THE PANEL'S PREVIOUS RECOMMENDATIONS

The Panel and its predecessor, the Independent Advisory Panel for Underground Mining (IAPUM), have previously provided four sets of advice that are relevant to this current advice:

1. Water Quality Performance Measures for Metropolitan Coal Mine (IEAPM, 2023a)
2. Large Swamp Environmental Assessment Requirements for the Extraction Plan for Longwalls 311 to 316 (IEAPM, 2023b)
3. Metropolitan Coal Mine: Independent review of environmental performance to 2022 (IEAPM 2023c)
4. Metropolitan Mine Longwalls 308 – 310 Extraction Plan (IAPUM, 2022)

The recommendations from these four reports are listed in the tables in Section 5 of this Advice, along with the Panel's view on the adequacy of the Peabody responses[1].

[1] Only the responses to the second recommendation in *Metropolitan Coal Mine*: *Independent review of environmental performance to 2022* (IEAPM 2023c) is reviewed in Section 5.3; the other recommendations in IEAPM (2023c) are out of scope of this Advice.

5.0 METROPOLITAN COAL'S RESPONSE TO THE PANEL'S PREVIOUS RECOMMENDATIONS

Tables within Sections 5.1, 5.2, 5.3 and 5.4 provide an itemised review of Peabody's responses to the Panel's recommendations in IAPUM (2022) and IEAPM (2024 a,b,c).

5.1. WATER QUALITY PERFORMANCE MEASURES FOR METROPOLITAN COAL MINE (IEAPM, 2023A)

Ref	IEAPM (2023a) recommendation	Summary of Peabody response (Peabody 2024b)	Panel's comments, conclusions and recommendations
5.1.1	Performance indicators and associated trigger levels for water reaching the Woronora Reservoir should be assessed using total Fe, Mn and Al where sufficient baseline data exist. Both total and dissolved Fe, Mn and Al concentrations should be reported in six-month and annual reports.	It is proposed to monitor and report total metals as recommended at selected stream sites, noting that baseline data will not exist to allow Performance Indicators to feature total metals for LW 311-316 however total metals will be considered in cases where Performance Indicators are exceeded.	The site list for monitoring total metals (p104 of Peabody 2024a, Appendix A) is satisfactory, except that it should include the outlet of Swamp 92, site S92-GS. The approach to considering total metals for LW 311-316 is satisfactory given the lack of baseline data. Recommendation: site S92-GS water quality monitoring should include total metals.
5.1.2	Contaminant loads as well as concentrations should be considered in performance measure assessments and six-monthly and annual reporting as far as data allow. Current data limitations mean that reliance on concentrations for monthly assessment of Performance Indicators is appropriate for the current series of longwalls.	"*Metropolitan Coal will assist WaterNSW with the collection of data to undertake a Contaminant Load Assessment*". In the response to WaterNSW comments (Peabody 2024c): "*Metropolitan Coal agrees that it will take responsibility for the preparation of a contaminant load assessment. It is however noted that the contamination load assessment will be subject to the availability of suitable and complete data, which will include some WaterNSW data*".	Response satisfactory except that the time-frame for the contaminant load assessment is not necessarily satisfactory. The Panel notes that the 2024 Annual Review is not yet available on the Peabody Metropolitan Mine website, and so reliance on the 2023 Annual Review for reporting progress with the assessment (and other actions as a result of IEAPM 2023a) leaves doubt about timeliness. Reporting in a preceding six-monthly report is recommended. However, the Panel agrees that the assessment cannot reasonably be done in time to inform assessment of the LW 311-312 Extraction Plan. The Panel emphasises the importance of appropriate investment in obtaining the required data.

Ref	IEAPM (2023a) recommendation	Summary of Peabody response (Peabody 2024b)	Panel's comments, conclusions and recommendations
			Recommendation: Peabody should report progress in implementing recommendations of previous Panel advice *Re: Water Quality Performance Measures for Metropolitan Coal Mine* in six-monthly as well as annual reports.
5.1.3	Flow event water quality (including dissolved and total Fe, Mn and Al concentrations) using automatic samplers at ETWQ AU, WQWQ9 and WOWQ2 should be obtained to support analysis of contaminant loads. At the same sites, continuous measurements of electrical conductivity, pH, redox potential, and turbidity should also be obtained.	Peabody has committed to investigating the installation of an automatic sampler at site ETWQ AU. Peabody (2024c) states "*Following a meeting with WaterNSW to discuss available data, WaterNSW has provided Metropolitan Coal with a significant volume of water quality data collected by autosamplers on Waratah Rivulet and Woronora Reservoir. Metropolitan is currently reviewing this data to assess if any additional event-based water sampling is necessary to undertake a load assessment*".	The commitment implies that a preliminary investigation of loads will determine whether or not automatic samplers are needed. The Panel regards automatic sampling at all three sites as an urgent requirement for understanding loads of contaminants entering the Woronora Reservoir irrespective of outcomes of the data review or contaminant load assessment. Recommendation: Peabody proceeds as soon as practicable with event sampling of water quality using automatic samplers irrespective of the outcomes of preliminary load assessments. This applies to ETWQ AU; and also WQWQ9 and WOWQ2 if these are not covered by WaterNSW event sampling.
5.1.4	After a database of flow and concentration measurements has been built up, analysis should be conducted towards generalisation of flow-concentration relationships, and approximation of loads, and whether these have changed as mining has progressed. Initial results including total Fe, Al and Mn loads at	See above responses	See above responses

Ref	IEAPM (2023a) recommendation	Summary of Peabody response (Peabody 2024b)	Panel's comments, conclusions and recommendations
	ETWQ AU, WQWQ9 and WOWQ2 should be reported in the 2024 Annual Report and updates provided in subsequent annual reports. Load estimates should be provided in future Annual Reports for Performance Indicator sites in future mining areas.		
5.1.5	For future mining areas, flow and contaminant concentrations should be measured at least two years in advance of mining at impact and control sites to allow BACI analysis.	This will be considered for future mining areas	Response satisfactory.
5.1.6	Suitable methods for improving the extension of the Eastern Tributary rating curves to improve high flow measurement accuracy should be undertaken by Peabody. WaterNSW should review whether the extension of the rating curve at the Waratah Rivulet could be improved. Selected watercourses in future mining areas should have flow gauges installed with validated rating curves. Where it is impractical to extend rating curves to high flows, alternative methods of high flow estimation should be considered	A commitment is made to investigate revising the rating curve for Eastern Tributary in the LWs 311-316 Extraction Plan and for the investigation to the reported in the 2024 Annual Review; and to investigate flow gauges in future mining areas; and to report outcomes in the Annual Review.	Response satisfactory except that rather than waiting until the 2024 Annual Report, also reporting in a preceding six-monthly report is advised. Recommendation: As item 5.1.2.
5.1.7	Temperature and water quality data should be obtained at various depths through the water column in the upper reservoir (at a location such as WDFS1 that is downstream of the entry of both the Waratah Rivulet and Eastern	A commitment is made in the Extraction Plan (Section 11.1 of Appendix A, Peabody 2024a) to "*investigate introducing a short-term sampling program in the upper Woronora Reservoir to obtain temperature and water*	The Panel considers that a "*short-term program*" is insufficient. Repeated sampling is required, and frequency of data collection should increase following significant flow

Ref	IEAPM (2023a) recommendation	Summary of Peabody response (Peabody 2024b)	Panel's comments, conclusions and recommendations
	Tributary) to capture both the temperature stratification behaviour and the water quality at this point. Frequency of data collection should increase following significant flow events and following level 3 triggers for water quality reaching the reservoir.	*quality data at various depths through the water column*".	events and following level 3 triggers for water quality reaching the reservoir. Recommendation: Peabody should extend its commitment, subject to access permission, to monitoring the depth profiles of water quality of the Woronora Reservoir at WDFS1 or other suitable site to include regular (at least bi-annual) sampling throughout the remaining mining period, plus sampling following level 3 triggers for water quality reaching the reservoir.
5.1.8	An agreement be reached between WaterNSW and Peabody whereby a hydrodynamic and contaminant transport model set-up is designed to support assessments of potential mining impacts. Consideration should be given as to how the responsibility for the modelling is shared between WaterNSW and Peabody.	*Metropolitan Coal plans to work with WaterNSW regarding this recommendation. Development timing of the model to be agreed with WaterNSW and subject to collection of suitable data*.	Satisfactory. Progress should be reported in six-monthly reports and Annual Reports. Recommendation: As item 5.1.2.
5.1.9	Peabody should procure sediment cores at selected locations downstream of the confluence of Waratah Rivulet and Eastern Tributary within the reservoir and at control sites in the reservoir in order to assess the possible impacts of mining on alterations to sediment composition (with implications to	Peabody committed to investigating the suitability of gathering sediment cores in consultation with WaterNSW. Subject to consultation with WaterNSW, sediment cores will be collected at selected locations downstream of the confluence of Waratah Rivulet and Eastern Tributary within the reservoir and at control sites in the reservoir	Response satisfactory. The Panel notes importance of cores instead of grab samples for obtaining a historical record of past events and understanding its relation to mining development. While coring of soft sediments is non-trivial, it can be done using gravity or piston corers.

Ref	IEAPM (2023a) recommendation	Summary of Peabody response (Peabody 2024b)	Panel's comments, conclusions and recommendations
	possible mobilisation of Fe and Mn should these sediments become anoxic).	and assessed. Time-frame: December 2024 subject to access permission.	
5.1.10	In any future mining areas, Performance Indicators and triggers should be based on loads as well as concentrations	Peabody commit to assessing loads as per previous responses.	Response satisfactory.
5.1.11	IEAPM recommended that when quality of water reaching the reservoir at Performance Indicator sites surpasses a level 3 trigger, analysis should be extended to: • once installed, water quality data collected at various depths at WDFS1 or similar site representing the confluence of the Eastern Tributary and Waratah Rivulet arms of the reservoir • if available, contaminant load estimates • if available, reference to results of a lake hydrodynamic and contaminant transport model run using relevant scenarios of increased contaminant loads.	Peabody has updated the Level 3 trigger analysis to incorporate the recommendations, noting that the assessment is to be finalised without this information if it is unavailable.	Response satisfactory, noting the importance of developing the necessary information. Recommendation: As item 5.1.7.
5.1.12	Irrespective of these recommendations for further analysis in response to triggers, the Panel recommends that a more detailed analysis be undertaken of historical reservoir	Peabody commit to do so in 2024 Annual Review if suitable data are available.	An analysis of historical water quality trends in Woronora Reservoir and their relation to

Ref	IEAPM (2023a) recommendation	Summary of Peabody response (Peabody 2024b)	Panel's comments, conclusions and recommendations
	water quality and sediment cores in order to analyse potential trends and relations with mining development. This should be included in the 2023 Annual Review and updated in subsequent annual reviews		mining development would be useful even if further data cannot be obtained. Recommendation: An analysis of historical water quality trends in Woronora Reservoir and their relation to mining development should be included in the Metropolitan Coal 2024 Annual Review, and this should not be provisional on further suitable data becoming available.
5.1.13	Following IEPMC (2019), it is recommended that a broader study of potential long-term cumulative impacts of mining on water quality in the Special Areas is needed	Peabody committed to providing relevant data.	Response satisfactory.

5.2. LARGE SWAMP ENVIRONMENTAL ASSESSMENT REQUIREMENTS FOR THE EXTRACTION PLAN FOR LONGWALLS 311 TO 316 (IEAPM, 2023B)

Ref	IEAPM (2023b) recommendation	Summary of Peabody response (Peabody 2024b)	Panel's comments, conclusions and recommendations
5.2.1	Given that the gateroads (which determine the dimensions of LW 311) are already being driven: (a) performance measures for swamp S92 need to be specified as a matter of priority	Performance Measures for Swamp 92 and an assessment of mining-induced impacts and consequences from swamps overlying LWs 311-316 is included in the Large Swamp Assessment.	The recommendation has been met, noting item 5.2.2 below.

Ref	IEAPM (2023b) recommendation	Summary of Peabody response (Peabody 2024b)	Panel’s comments, conclusions and recommendations
	(b) the assessment of mining-induced impacts and consequences for swamps overlying LW 311 should be undertaken as a priority to provide timely warning of any need to change the width and/or the totally extracted length of LW 311	Based on the outcomes of the Large Swamp Assessment, there is no proposed change to the mining geometry of LW 311.	
5.2.2	Drivage of MG312 should be delayed until the large swamp impact assessment has been completed and the Extraction Plan for LW 311 and LW 312 has been endorsed by the Department	Metropolitan Coal has provided the Department of Planning, Housing and Infrastructure with a separate letter addressing this recommendation.	The Panel has not viewed the letter. MG312 had progressed to approximately one half the length of the proposed LW 312 by 19 July 2024 (DPHI 2024). The Panel considers that reducing the widths of the proposed LW 311 and LW 312 is not now a practical option.
5.2.3	A detailed conceptualisation of the hydrology/hydrogeology of each of the listed swamps including groundwater-surface water interactions, and a holistic assessment of connectivity with regional groundwater and groundwater dependent assets	Conceptualisation of the hydrology/hydrogeology of Large Swamps 76, 77 and 92 is included in the Large Swamp Assessment.	Satisfactory, noting that uncertainties in the conceptual model of interactions between shallow groundwater in the HBSS and swamp groundwater are yet to be addressed by additional monitoring. Recommendations related to this monitoring are in items 5.3.1 and 5.4.1 below.
5.2.4	Any updated groundwater model predictions that describe the impacts to these shallow groundwater systems, and their dependent environmental assets (i.e. stream baseflows and swamps)	Section 5.3 and Appendix B of the Large Swamp Assessment (Appendix H of Peabody 2024a) include 1D Water Balance Modelling and 2D SEEP-W modelling	The recommended modelling has been undertaken. The modelling is reviewed later in this Advice (Section 6.2) as relevant to LW 311-312.

Ref	IEAPM (2023b) recommendation	Summary of Peabody response (Peabody 2024b)	Panel's comments, conclusions and recommendations
5.2.5	An assessment of risk of subsidence impacts to upland swamps, including the risk of changes in groundwater levels and storage in swamp substrates and underlying weathered sandstone	A risk assessment has been undertaken for the LWs 311-316 Extraction Plan.	The relevant risks have been addressed in the Large Swamp Assessment (Section 6 and Appendix B of Appendix H of Peabody 2024a). The adequacy of the assessments is reviewed below in Section 6.2 of this Advice as relevant to LW 311-312.
5.2.6	Detailed analysis of groundwater levels and soil moisture, using the existing monitoring network, and how this relates to swamp sub-communities.	The Large Swamp Assessment will include detailed analysis of groundwater levels and soil moisture data using the existing monitoring network, and how this may relate to the mapped swamp sub-communities.	A detailed analysis of groundwater levels and soil moisture has been undertaken (Section 5.3.1 of the Large Swamp Assessment, which is Appendix H of Peabody 2024a). Monitoring data to relate to swamp vegetation sub-communities is not available
5.2.7	A commitment that prior to the commencement of extraction of LW 311, additional groundwater monitoring sites will be installed near the primary swamps, in Swamp S106 and within the western control swamps as recommended in Section 4.3.2	*Metropolitan Coal will investigate installation of additional groundwater monitoring sites near the Large Swamps, Swamp 106 and within the western control swamps.* *Where feasible, installations would be completed prior to Longwall mining within 400 metres of the site under the Longwalls 311-316 Extraction Plan.*	Response partially satisfactory. While a commitment has been made to further groundwater monitoring and a schedule provided (Peabody 2024c), this had not been implemented at time of writing this advice. Also, the subsidence predictions presented in the EP for Swamp 77 warrant additional swamp groundwater monitoring near its downstream end. Advice is provided in Sections 6.2, 6.5 and 6.6 below.
5.2.8	Revised TARPs that encompass the recommendations made by the Panel in its advice on LW 308-310 Extraction Plan, particularly improved time-independent	*It is not considered feasible to develop a workable TARP that would satisfy this recommendation. The existing upland swamp TARPs have been recommended with increased*	Not fully implemented – there are Performance Indicators and triggers nominated for swamp groundwater sites located within Swamp 76, Swamp 77 and

Ref	IEAPM (2023b) recommendation	Summary of Peabody response (Peabody 2024b)	Panel's comments, conclusions and recommendations
	water level parameters for the paired swamp groundwater monitoring locations.	*analysis and reporting requirements to the DPHI* (Section 7.2.1 and Appendix A of the Large Swamp Assessment, which is Appendix H of Peabody 2024a).	Swamp 92, but these do not incorporate the HBSS shallow groundwater. Advice is provided in Sections 6.2, 6.5 and 6.6 below.
5.2.9	Characterisation of baseline surface flow dynamics.	*The Large Swamp Assessment will include characterisation of baseline surface flow dynamics*	Satisfactory (Appendix B of Large Swamp Assessment, which is Appendix H of Peabody 2024a).
5.2.10	Characterisation of baseline water quality at the outlet of swamp S92.	*The Large Swamp Assessment will include characterisation of baseline water quality at the outlet of Swamp 92.*	Metropolitan Coal commenced monthly water quality sampling at Swamp 92 weir (S92-GS) in December 2023 (Peabody 2024d).
5.2.11	Characterisation of the presence of drainage lines and major pools in swamp S92 to inform flora and fauna surveys, and as a baseline record of surface water storage features.	*The Large Swamp Assessment will characterise existing drainage lines/paths within the Large Swamps. There are no mapped pools within the swamps based on numerous field investigations and review of high-resolution LiDAR and aerial imagery*	Satisfactory.
5.2.12	A camera that captures images every half-hour (or less) of flow and debris conditions at the swamp S92-GS flow gauge.	*Metropolitan Coal will install a camera that captures images at daily frequency will be installed at the Swamp 92 Gauging Station (S92-GS). Additionally, a second camera will be installed at the Swamp 76 Gauging Station (G76-GS).*	Satisfactory.

Ref	IEAPM (2023b) recommendation	Summary of Peabody response (Peabody 2024b)	Panel's comments, conclusions and recommendations
5.2.13	A baseline survey (potentially by drone) of major pools within swamps S76, S77 and S92.	The results of a drone survey have been provided and no pools are observed. A commitment has been made to *Drone surveys of Swamps 76, 77, 92, 106 and Bee Creek will be conducted annually starting from September 2024* (Peabody 2024d)	Satisfactory.
5.2.14	Water quality monitoring at the swamp S92-GS site including a baseline period as far as practicable.	*Water quality samples will be collected from the Swamp 92 Gauging Station (S92-GS) to allow for a comparison of data between S92-GS and the water quality data collected downstream at SP1. If data is comparable, then water quality data collected at SP1 will be used as a proxy for S92-GS*. Monitoring to commence at the beginning of LW 311.	Partially satisfactory. Because LW 311-LW 316 are all predicted to have subsidence impacts at Swamp 92, water quality monitoring at S92-GS should extend until at least 6 months beyond the end of LW 316 so that subsidence impacts can be properly assessed, including distinguishing water quality consequences for the swamp outlet to those further downstream. Analyses should include total as well as dissolved metals (Fe, Al and Mn) concentrations. Recommendation: Water quality monitoring at S92-GS should extend until at least 6 months beyond the end of LW 316.
5.2.15	Development of a conceptual model (schematics) showing vegetation type, swamp gradients (including soil depths) and perched groundwater that sustains the primary swamps.	*A second conceptual model focusing on the swamps and shallow groundwater system (to the upper Hawkesbury Sandstone) was prepared as part of the Unsaturated Zone Modelling*.	Partially satisfactory. Potential refinements to the conceptual model, including new knowledge about exchanges between swamp and shallow HBSS groundwater, should be included in annual reports. Vegetation

Ref	IEAPM (2023b) recommendation	Summary of Peabody response (Peabody 2024b)	Panel's comments, conclusions and recommendations
			communities should be incorporated into the model. Recommendation: The conceptual models of the large swamps should be reviewed in 6-monthly reporting in light of new monitoring data, and updated to represent vegetation communities.
5.2.16	Revised baseline mapping of swamp sub-communities, using a replicable technique that will allow monitoring of changes in response to changes in hydrology. Comparison with previous mapping would be desirable.	*Metropolitan Coal has engaged Ecoplanning to prepare revised baseline mapping of Large Swamps 76, 77 and 92 using high resolution LiDAR and aerial imagery. As per the response above, Metropolitan Coal is also investigating the use of drones to improve the regular monitoring of vegetation within the Large Swamps*.	Unsatisfactory. The method used by EcoPlanning to update the mapping of upland swamps did not use a replicable technique that will allow comparison over time in relation to mining. The Panel understands Metropolitan Coal intends to include drone surveys as a part of their regular monitoring. Recommendation: The Panel encourages the company to undertake this work prior to commencement of mining noting several years of baseline survey would be beneficial. At a minimum, baseline mapping must be prepared prior to commencement of any secondary extraction.
5.2.17	If suitable access is possible, install a cross section of swamp substrate piezometers in the upper reaches of swamp S92. Piezometers should be representative of the vegetation communities, especially	*The installation of additional monitoring sites within Swamp 92 would require additional clearing of vegetation for access and monitoring equipment. Given the upper reaches of Swamp 92 are away from the secondary*	Satisfactory with respect to the current application. The Panel believes that monitoring to investigate the link between water levels, vegetation sub-community mapping and refined water balance in line

Ref	IEAPM (2023b) recommendation	Summary of Peabody response (Peabody 2024b)	Panel's comments, conclusions and recommendations
	cyperoid heath/tea tree thicket v banksia heath v restioid sedgeland in S92.	*extraction area and that monitoring is being undertaken at three locations within the swamp, the additional impacts associated with further installations is not considered to be warranted.*	with Cairns et al. (2024) would be beneficial for future applications including Swamp 106.
5.2.18	Include an assessment of the potential impacts to swamp S106 and include this swamp in other assessment and monitoring programs for biodiversity.	*Predictions for Swamp 106 are included in Subsidence Report for the Longwalls 311-316 Extraction Plan… Metropolitan Coal will install additional groundwater monitoring sites west of the Longwalls 311-316 extraction area, including sites within Swamp 106. Baseline ecological surveys will also be conducted in Swamp 106 well prior to the commencement of Longwall 316.* Groundwater (~1 m and ~10 m depths) at three sites in S106 are planned are to be installed in 2024/2025	Satisfactory with respect to groundwater, pending confirmation of site locations and installation dates.
5.2.19	Baseline surveys for swamp related species, such as the Giant Dragonfly (Petalura gigantea), with larval surveys recommended for this species, and threatened flora species.	*Baseline surveys for the Giant Dragonfly in the Large Swamps have been undertaken by Dragonfly Environmental. No Giant Dragonflies were recorded during surveys in the large swamps. Further discussion on the surveys is included in the Large Swamp Assessment.*	Unsatisfactory. Baseline surveys for the Giant Dragonfly are considered inadequate for the purposes of providing revised impact predictions, as required by Schedule 3 Condition 6 and to inform locations of monitoring. Further detail is provided below in Section 6.
5.2.20	Baseline surveys for Littlejohn's Tree Frog (Litoria littlejohni), Giant Burrowing (Heleioporus australiacus) and aquatic	*Baseline surveys for the amphibians in the Large Swamps have been undertaken by Dragonfly Environmental. Little Johns Tree*	Unsatisfactory. Baseline surveys for the threatened amphibians are considered inadequate for the purposes of providing

Ref	IEAPM (2023b) recommendation	Summary of Peabody response (Peabody 2024b)	Panel's comments, conclusions and recommendations
	ecology, including upland swamps and also in large pools identified in the streams below the swamps.	*Frog was recorded at Swamp 92. Further discussion on the surveys is included in the Large Swamp Assessment.* *In addition, annual amphibian monitoring has been undertaken across the Metropolitan Coal Project since 2009. This includes sites within the Longwalls 311-316 extraction area since 2019.*	revised impact predictions, as required by Schedule 3 Condition 6 and to inform locations of monitoring. Further detail is provided below in Section 6.
5.2.21	Baseline surveys for the Eastern Ground Parrot (Pezoporus wallicus).	*A research program, Conservation of the Eastern Ground Parrot on the Woronora Plateau, funded by Metropolitan Coal was conducted by the Office of Environment and Heritage (OEH). The research program involved a targeted survey for the Eastern Ground Parrot (Pezoporus wallicus wallicus) (classified as Vulnerable under the Biodiversity Conservation Act 2016) and the establishment of a network of bio-acoustic monitoring stations (35 sites) in 2013. A total of 588 days and approximately 3,000 hours of data were recorded from the stations, however, no Eastern Ground Parrots were detected. Spot checks of recordings from a range of sites, confirmed the recogniser was performing accurately (i.e. no Eastern Ground Parrot calls*). *The results of the research program were considered by OEH to indicate that Eastern Ground Parrots are not likely to be resident on*	Given this report cannot be found the Panel recommends baseline surveys are undertaken using contemporary survey techniques as a priority. Further detail is provided below in Section 6.2 and 6.3.

Ref	IEAPM (2023b) recommendation	Summary of Peabody response (Peabody 2024b)	Panel's comments, conclusions and recommendations
		the Woronora Plateau. The occasional records of single parrots on the Woronora Plateau in the past ten years suggest isolated birds are dispersing through the area and are not part of a larger resident population.	
5.2.22	Depending on the finding of the baseline surveys: • Incorporation of macroinvertebrate monitoring in pools into the program to document changes in macroinvertebrate assemblages as an indicator of water quality. • Nocturnal surveys for threatened frog species using standardised transects, including comparison of abundance. • Ongoing monitoring of the Ground Parrot if this species is detected.	As noted above, no pools have been identified within the Large Swamps. Amphibian monitoring programs have been implemented annually in spring/summer for LWs 20-22 (2009 – 2022), LWs 23-27 (2010 – 2022), LWs 301-307 (2015 – 2022) LWs 308-317 (2019 – 2022). All sites are displayed in Attachment 1. Fifteen amphibian species have been monitored including three threatened species: the Giant Burrowing Frog (H*eleioporus australiacus*), Red crowned Toadlet (*Pseudophryne australis*) and Littlejohn's Tree Frog (*Litoria littlejohni*). Two six-day survey periods are utilised for each spring/summer survey, typically over the periods October to December and January to February. Each site is surveyed once during a standard 30-minute general area day search (early morning and late afternoon) supplemented by an evening 30-minute search/playback session using handheld spotlights and head lamps. Within Large Swamps 76, 77 and 92, one songmeter	Satisfactory for macroinvertebrates, given the absence of suitable pools within the large swamps Unsatisfactory for frogs and Ground Parrot. The monitoring proposed is not situated located in the in an appropriate location or to be conducted using best practice methods. Further detail is provided below in Section 6.

Ref	IEAPM (2023b) recommendation	Summary of Peabody response (Peabody 2024b)	Panel's comments, conclusions and recommendations
		will be deployed at each of the sites sampled for a minimum of one night. As noted above, the Eastern Ground Parrot has not been identified at the Metropolitan Coal Mine.	
5.2.23	Rewording of the TARP to remove reference to the implication that surface cracking must be visible as the cause for changes in groundwater.	This recommendation has been incorporated into the LWs 311-316 Extraction Plan TARP.	Satisfactory.
5.2.24	Revise the Performance Measures (not only Performance Indicators) set for upland swamps, and TARPs that include triggers based on temporal changes to perched groundwater in the swamp sediments and the underlying weathered sandstone.	*The Performance Measures are set in the Project Approval conditions and therefore it is proposed that they remain the same in the management plans (i.e. consistent with the Project Approval).* *Metropolitan Coal and specialist consultant are reviewing and revising the TARPs as part of the Longwalls 311-316 Extraction Plan. The groundwater related TARPs for the swamps include temporal based triggers*	Not satisfactory. The proposed TARPs omit shallow groundwater in the underlying sandstone. Advice on the adequacy of the proposed performance measures, indicators and TARPs is included in Sections 6.3 and 6.6 below.
5.2.25	Prepare a comprehensive risk assessment that clearly articulates all the mining-induced risks to swamps S76, S77 and S92 including:	*The Large Swamp Assessment was prepared in consideration of the risk identified during the environmental risk assessment for the Longwalls 311-316 Extraction Plan.*	Partially satisfactory. Comments and recommendations on the comprehensiveness and clarity of elements of the Large Swamp Assessment are addressed in Section 6 of this Advice.

Ref	IEAPM (2023b) recommendation	Summary of Peabody response (Peabody 2024b)	Panel's comments, conclusions and recommendations
	• the risk of subsurface cracking and other bedrock structural changes likely to enhance vertical drainage extending beneath the swamps • the risk of accelerated drainage of shallow groundwater systems • the consequential impact to surface water and dependent ecosystems.		
5.2.26	Identify appropriate actions to avoid, mitigate or manage the environmental risks.	The Large Swamp Assessment was prepared in consideration of the risk identified during the environmental risk assessment for the LWs 311-316 Extraction Plan. The Large Swamp Assessment will include actions to avoid, mitigate or manage the environmental risk.	Partially satisfactory. Advice on the adequacy of the mine planning considerations and proposed management actions (TARPs) is given in Sections 6.4 and 6.6 of this Advice.

5.3. Metropolitan Coal Mine: Independent review of environmental performance to 2022 (IEAPM, 2023c)[2]

Ref	IEAPM (2023c) recommendation	Summary of Peabody response (Peabody 2024b)	Panel's comments, conclusions and recommendations
5.3.1	Additional bores (standpipes) be established at the T6 monitoring location and at other	*Metropolitan Coal will investigate the installation of additional groundwater bores*	Satisfactory.

[2] Only the responses to the second recommendation in *Metropolitan Coal Mine*: *Independent review of environmental performance to 2022* (IEAPM 2023c) is reviewed in Section 5.3; the other recommendations in IEAPM (2023c) are out of scope of this Advice.

	accessible locations overlying the proposed LW 311 to LW 316 panels as soon as practicable to monitor the natural vertical piezometry in the Hawkesbury Sandstone below this western ridgeline area.	*at the T6 monitoring location … Investigation to be undertaken in 2024*	Recommendation: The T6 standpipes should be installed as soon as practicable to maximise their value for understanding groundwater response to mining.

5.4. METROPOLITAN MINE LONGWALLS 308 – 310 EXTRACTION PLAN (IAPUM, 2022)

Ref	IAPUM recommendation[3]	Summary of Peabody response (references listed below)	Panel's comments, conclusions and recommendations
5.4.1	Groundwater monitoring should be increased by adding two, and possibly three, additional multi-level VWP (Vibrating Wire Piezometer) bores in the vicinity of Swamps 77 and 92 to monitor the (shallow and) deep groundwater behaviour above the predicted constrained zone	VWP sites are proposed for Swamps 92 and 77 and standpipes at two sites in Swamp 76, all scheduled Q1 2025 subject to approval, weather and access (Peabody 2024c),	Partially satisfactory. Delays to installing these bores means a reduction in the baseline period and hence reduction in their value for understanding groundwater response to mining Recommendation: The proposed multi-level VWPs for Swamps 92 and 77 and standpipes at two sites in Swamp 76 should be installed as soon as practicable.
5.4.2	10 m deep bores should be added to each of the swamp monitoring points where this measurement depth is currently missing for Swamps 76, 77 and 92	Six new 10 m piezometers (two additional for each of the three swamps) are proposed to be installed in August 2024, ground conditions permitting (Peabody 2024c). The drilling for the additional monitoring bores is planned to resume 19 August 2024 (Peabody 2024d).	Satisfactory.

[3] Some of the recommendations in IAPUM (2022) are not covered here because they are not relevant to assessment of the current Extraction Plan.

Ref	IAPUM recommendation[3]	Summary of Peabody response (references listed below)	Panel's comments, conclusions and recommendations
5.4.3	a) The TARPs for Upland Swamp Groundwater monitoring should be redeveloped to employ consistent, time-independent parameter values for the triggers; b) adopt consistent TARPs across all longwalls; c) address the inadequacy of the triggers if historical substrate minimum groundwater levels are at the base of the substrate; d) review how lowering of trigger levels can occur and relate a lowering of a trigger level to assessment of impacts rather than climate variation; and e) increase the focus of the responses on assessing impacts of mining on the Swamps	a) The "time independent" recommendation by the Panel has been addressed by a note in the TARP table explaining " *Post-subsidence substrate water levels are determined by measuring the water level above the logger such that any changes in relative saturation can be determined*". b) Revised TARP tables have been proposed in the relevant management plans (Appendix A, C and H of Peabody 2024a). c, d and e) Groundwater level triggers are proposed in Appendix C of Peabody (2024a).	a) Satisfactory, although the Panel suggests that a better and simpler way to communicate impacts to swamp groundwater levels is to report changes relative to the logger height. b) Satisfactory. c) Not satisfactory - see Section 6.6 of this Advice. d) Satisfactory subject to Section 6.6 of this Advice. e) Satisfactory subject to Section 6.6 of this Advice.
5.4.4	The Panel recommends that the Level 1, Level 2 and Level 3 observed valley closure trigger values are revised and justified based on re-consideration of the relationship between risk of Type 3 impacts and observed valley closure at the Waratah Rivulet.	Table 30 of Appendix A of Peabody (2024a) (LW 311 Waratah Rivulet Valley Closure Trigger Action Response Plan) has reduced the closure triggers compared to the corresponding table in the LW 308-310 EP (Table 29 of Appendix A of Peabody 2024a) to reasonable values and with reference to history of observed closures.	Satisfactory.
5.4.5	All sites within the large swamps S76, 77 and 92 should be added to monitoring sites in this TARP. The aim is to provide early warning of any changes in these swamps.	All three existing sites within each of S76, 77 and 92 have been included in the Upland Swamp Groundwater Monitoring TARP (Table 15 of Appendix C of Peabody 2024a).	Partially satisfactory. Although all sites are included, the TARP is not explicit about how many of the sites need to be impacted prior to a trigger.

Ref	IAPUM recommendation[3]	Summary of Peabody response (references listed below)	Panel’s comments, conclusions and recommendations
			Recommendation: Triggers in the Swamp Groundwater Monitoring TARP should clearly define that a trigger at any site is regarded as a trigger for that swamp.
5.4.6	The Significance levels/Triggers should be re-drafted to specify quantitative values for observed declines, the time periods over which they have occurred and the statistical difference to control swamps.	The response to a WaterNSW query regarding why the Panel’s recommendation has not been adopted (Peabody 2024c), states “*The introduction of more prescriptive and quantitative triggers (e.g. specific decline limits, time-periods or statistical differences) may produce false positive triggers due to the high climatic variability and may not provide any additional useful information to enable management decisions to be made*.” The Swamp Groundwater Monitoring TARP includes the footnote “*The semi-quantitative analysis includes analysis of the rate of recession from high to low water levels and analysis of rates of recovery from low to high water levels, compared to control swamps*”	Partially satisfactory. The Panel accepts that a semi-quantitative approach to assessing swamp groundwater level decline and recovery rates can be appropriate. The recession analysis method presented in Section 5.2 of Appendix B or Appendix H of Peabody (2024a), which is based mainly on visual comparison of pre- and post-mining and control site recessions is an appropriate element of the assessment. Similar approaches have worked well in mining impact assessment contexts. Because of the qualitative element: • A technical document, which clearly explains the approach and criteria used, with examples, should be referred to in the TARP and appended. This is not presently done. • TARP actions include prompter reporting of analysis results. Level 2 should lead to 6-monthly reporting and level 3 to immediate reporting. Section 5.2 of Appendix B or Appendix H of Peabody (2024a) somewhat explains and demonstrates the method; however, it mentions

Ref	IAPUM recommendation[3]	Summary of Peabody response (references listed below)	Panel's comments, conclusions and recommendations
			regression analysis but is unclear whether and how regression is incorporated and it is unclear what recovery criteria are applied and how. Recommendations: Swamp Groundwater Monitoring TARPs should include quarterly reporting of level 2 triggers and associated analysis. A stand-alone technical document, which defines how the Swamp Groundwater Monitoring TARP triggers are assessed including examples, is appended to the TARP. Further recommendations on the Swamp Groundwater Monitoring TARP are in Section 6.6 below.
5.4.7	The Panel recommends that in redrafting the swamp groundwater TARP: • The Performance Indicator should be re-worded as it implies that visible surface cracking must be the cause of changes in groundwater position within a swamp. It needs to recognise that cracking below swamp sediments is usually not discernible and that 'cracking' may include dilation of	*This recommendation has been incorporated into the Longwalls 311-316 Extraction Plan TARP*	Satisfactory.

Ref	IAPUM recommendation[3]	Summary of Peabody response (references listed below)	Panel's comments, conclusions and recommendations
	joints, rather than fracturing of intact sandstone. • '*Surface cracking within upland swamps resulting from mine subsidence is*..' should be replaced with '*Subsidence impacts are*..'.		
5.4.8	For all future approvals, Performance Measures (not only Performance Indicators) set for Swamps 76, 77 and 92 should include measures based on changes to groundwater in the swamp sediments and the underlying sandstone	*The Performance Measures are set in the Project Approval conditions and therefore it is proposed that they remain the same in the management plans (i.e. consistent with the Project Approval).* (Peabody 2024b)	Satisfactory, conditional on suitable definition of Performance Indicators and thresholds that unambiguously define a Performance Measure exceedance. Refer to Section 6.3 of this Advice.

6.0 ADVICE ON LW 311 AND 312 FOCUSSING ON THE LARGE SWAMPS

6.1. THE SIGNIFICANCE OF THE LARGE SWAMPS

BCS consider that the special significance of the swamps is "*Swamps 76, 77,92,106 (and other medium-large swamps) within the subject area have additional "significance", or "importance" which warrant special protection. This is reflected in the consent requirement for additional environmental assessment and written approval prior to undermining from the Director General (Consent authority)*" (BCS 2024b), while Peabody's view (Peabody 2024c) is "*...the identified Swamps 76, 77 and 92 are not considered to be of 'special significance' as defined by the Southern Coalfield Inquiry Report and this position has not changed as a result of the baseline data that has been collected since this report*", citing the NSW Planning Assessment Commission (2009) (PAC) conclusions that "*There is no convincing evidence before the Panel [the PAC] that identifies any individual swamp or group of swamps in the Project Area as being sufficiently unique or different so as to require identification as being of 'special significance' and thus requiring special consideration in a risk assessment framework*".

In their review of the Metropolitan Coal Project, the PAC recommended that the significance of upland swamps be reviewed on a case by case to determine whether individual upland swamps "*should be afforded 'special significance' status*" and recommended use of objective criteria, including "substantial size, unusual complexity, contiguous habitat, presence of endangered ecological community (EEC) or threatened species". In 2012 the (former) Office of Environment and Heritage (now BCS DCCEEW) drafted guidance for proponents when undertaking environmental impact assessment for upland swamps, including recommendations on interpretation of the criteria defined by the PAC. These Upland Swamp Environmental Assessment Guidelines (OEH 2012) were released in draft form. To the Panel's knowledge they were never finalised. However, it is the Panel's view that these guidelines provide a reasonable interpretation of the views of the PAC.

The Panel's assessment of Swamps 76, 77 and 92 against these guidelines is presented in Table 4 below and supports the view that two of the large swamps should be afforded 'special significance' status. Furthermore, the Panel views the intent of Schedule 3 Condition 4 as being that advances in knowledge (for example, of the large swamp hydrology and biodiversity, advances in knowledge about risks from mining, and developments in the protected status of the swamps) should be considered in setting Performance Measures and Performance Indicators for the large swamps. The Panel's view is that contemporary understanding has led to the view that the Coastal Upland Swamps in general are threatened ecological communities, as formalised under the NSW *Threatened Species Conservation Act 1995* (TSC Act) and Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) in 2012 and 2014 respectively. Further, the three large swamps have large areas and large catchment areas (Table 2 of Appendix B of Appendix H of Peabody 2024a) relative to upland swamps generally and therefore, as well as having high biodiversity value, have a relatively important role in regulating flows and sediments reaching Woronora Reservoir. The Panel therefore concurs with BCS's view that the large swamps above LWs 311-316 are swamps of special significance, with Swamps 77 and 92 meeting the criteria of OEH (2012) and Swamps 76 having records of threatened species.

Table 4: Assessment of Swamps 76, 77 and 92 against criteria of special significance (OEH 2012)[4]

Criterion	Swamp 76	Swamp 77	Swamp 92
Statutory thresholds	**Yes** Community listed as Coastal Upland Swamps endangered ecological community in 2012 (post approval of the Metropolitan Coal Project). Excluding this, the swamp is known to support records of threatened species including *Leucopogon exolasius*[1], the Giant Burrowing Frog[3], Littlejohn's Tree Frog[3] and Ground Parrot[1].	**Yes** Community listed as Coastal Upland Swamps endangered ecological community in 2012 (post approval of the Metropolitan Coal Project). Excluding this, the swamps is known to support records of threatened species including Giant Burrowing Frog [3].	**Yes** Community listed as Coastal Upland Swamps endangered ecological community in 2012 (post approval of the Metropolitan Coal Project). Excluding this, the swamps is known to support records of threatened species including the Leafless Tongue Orchid (*Cryptostylis hunteriana*)[2], Prickly Bush-pea (*Pultenaea aristata*)[1], the Red-crowned Toadlet[3], Littlejohn's Tree Frog[3] and Ground Parrot [3].
Swamp size	**No** Swamp 76 is 6.0 ha in size.	**Yes** Swamp 77 is 11.4 ha in size.	**Yes** Swamp 92 is 9.9 ha in size
Unusual complexity	**No** Swamp 76 is dominated by a single community – Banksia Thicket[2]. A total of 89 species have been recorded across Swamp 76 over all survey seasons and monitoring programs.	**Yes** Swamp 77 supports Banksia Thicket, Cyperoid Heath and Tea Tree Thicket[2]. A total of 69 species have been recorded from Swamp 77 over all survey seasons and monitoring programs.	**Yes** Swamp 92 supports Sedgeland-heath Complex, Restioid Heath, Cyperoid Heath, Banksia Thicket and Tea Tree Thicket[2]. Swamp 92 shows significant surface water and is "wet" when compared to other swamps. It is also the most floristically diverse. A total of 108 species have been recorded across

[4] OEH (2012) states that a swamp should be considered of special significance if it meets three of the following criteria:
- Statutory thresholds, indicated by the presence of threatened environmental communities (TECs) or threatened species
- Swamp size (greater than 7.4 ha)
- Unusual complexity (supporting tea-tree Thicket)
- Close proximate habitat (within one of the four key clusters of swamps)
- Importance for scientific research.

Criterion	Swamp 76	Swamp 77	Swamp 92
			Swamp 92 over all survey seasons and monitoring programs.
Close proximate habitat	**No** Swamp 76 is not located within one of the four key clusters of swamps identified in OEH (2012).	**No** Swamp 77 is not located within one of the four key clusters of swamps identified in OEH (2012).	**No** Swamp 92 is not located within one of the four key clusters of swamps identified in OEH (2012).
Importance for scientific research[4]	**No** Swamp 76 is not identified in OEH (2012) and is not currently used as a reference swamp.	**No** Swamp 76 is not identified in OEH (2012) and is not currently used as a reference swamp.	**No** Swamp 76 is not identified in OEH (2012) and is not currently used as a reference swamp.

1. BioNet Atlas of NSW Wildlife
2. EcoPlanning 2024, Appendix C in Appendix H of Peabody 2024a
3. BCS – data provided to the Panel, August 2024.
4. Since 2009, the scientific value of upland swamps has been more fully recognised. The three large swamps, and particularly S92, are repositories of significant volumes of organic sediments which may represent several thousand years of climatic record. Peat at the downstream end of Flat Rock Creek Swamp gave a radiocarbon age of 1500-2000 years CalBP (Tomkins and Humphreys 2006) and sediments that had been eroded from further upstream may have been older. Sediments in the large swamps, especially S92, are likely to be of similar ages.

6.2. THE ADEQUACY OF LARGE SWAMP IMPACT PREDICTIONS

Subsidence

The large swamp impact predictions are underpinned by the subsidence predictions (Appendix I of Peabody 2024a) and revised predictions (MSEC 2024) that allow for the shortened panel lengths proposed in the most recent Extraction Plan (Peabody 2024a). The proposed layout of the panels is in Figure 1 and 2 above.

The empirical based subsidence prediction methodology is established and fit-for-purpose. Consistent with previous approval conditions and good risk management when relying on empirically based procedures, predicted versus measured outcomes have been reviewed using subsidence measurements above previous longwalls and the methodology has been updated/recalibrated to better predict field outcomes. There is a sensible reason for this recalibration, being that the mining dimensions (depth, panel width, mining height, etc) and the lateral extent over which they extend is unique and, therefore, the database on which the previous predictions were based was not fully representative. This is a characteristic of using an empirical approach. Whilst the recalibration has resulted in an increase in predicted vertical subsidence, this has resulted in only a minimal increase in associated surface tilt and strain, too insignificant to form the basis for changing associated impact and consequence predictions.

The reduction in the proposed length of some longwall panels has resulted in localised minor increases in some subsidence effects in some areas and decreases in other areas. This is a reflection that subsidence behaviour at the starting and finishing ends of a longwall panel is slightly different to that along a panel and so the revised starting positions will result in increased subsidence effects at the new starting lines. However, these are of no greater magnitude than in some other areas.

In summary, the two relevant subsidence reports, being Appendix I of Peabody (2024a) and MSEC (2024), are adequate when supported by the relevant management plans.

Groundwater

The shallow groundwater in the swamp substrates has been modelled using 1-dimensional (vertical flow) and 2-dimensional (vertical and downslope flow) hydrological models as reported in Appendix B of Appendix H of Peabody (2024a). The models have been calibrated separately for Swamps 76, 77 and 92 using the baseline piezometer data from November 2020 to December 2023. The increase in sandstone hydraulic conductivity to represent the impacts of mining is calibrated on the Swamp 20 piezometer data. The modelling is useful for quantifying the possible response of the swamp groundwater levels to increased hydraulic conductivity of the underlying sandstone due to subsidence effects. The approach to the modelling is reasonable considering the limitations of input and calibration data.

The limitations to the modelling principally relate to:

- The twofold increase in hydraulic conductivity of the HBSS used to represent the potential subsidence effect is based on observations from one site (Swamp Substrate and Shallow Groundwater Piezometer) at Swamp 20. This is a reasonable approach although it may substantially underestimate or overestimate the effect at sites in Swamps 76, 77 and 92 due to differences in subsidence impacts, differences in swamp hydrology, differences in sandstone stratigraphy and differences in connectivity to the shallow HBSS groundwater.
- To account for the relatively high subsidence effects predicted at Swamp 77, a scenario of a five-fold increase in hydraulic conductivity of the HBSS has been applied. This is conservative in terms of the overall impact on Swamp 77; however, the high values of predicted valley closure at the downstream end of Swamp 77 may lead to much higher impacts in that area than predicted by the model. This includes a moderate likelihood of fracturing of the rock bar that is a downstream control on water levels in the lower swamp (the rockbar is mapped in Appendix 5 of Appendix A of Peabody 2024a).
- The 1-dimensional and 2-dimensional models do not aim to represent potential hydraulic connection between the shallow HBSS groundwater and the swamp groundwater and the potential consequences of mining-induced drawdown of that shallow groundwater. If that groundwater drains (horizontally and/or vertically) due to subsidence impacts, its contribution to the swamp inflow from sideslope areas or its role in preventing or reducing downward hydraulic gradients from the swamp will be adversely impacted.
- The 1-dimensional and 2-dimensional models do not aim to represent the propagation of loss of water at a rockbar control to further upstream in the swamp.
- Limitations in supporting data include lack of in-situ climate data, limited spatial coverage of swamp groundwater measurements in the large swamps, limited period of flow data for the large swamps, uncertainty in soil moisture data due to lack of calibration of sensors to local soils, and lack of soil property data to define hydraulic properties including the storage function.

In summary, the swamp water balance and swamp groundwater modelling is reasonable given the data available; however, due to its various limitations, little weight should be attached to the conclusion in the Large Swamp Assessment that "*The predictions of the large swamp unsaturated zone modelling* *indicate the following (ATC Williams, 2024): The mining-related effects to Swamp 76 and Swamp 92 are expected to be minor with the water levels predicted to remain above the base of the substrate*".

The possibility of leakage as mining intersects mapped faults was considered in Appendix G of Peabody (2024a). Three faults – F0037, F0051 and F0053 - are mapped intersecting LWs 311-316. No moisture had been evident in association with F0037 during mining of longwalls since LW 306 and photographs provided at seam level in LW 310 confirmed this (Peabody 2024e).

Surface water

The surface water predictions (Appendix B of Appendix H of Peabody 2024a) address potential water losses from within Swamps 76, 77 and 92 due to subsidence effects. These are modelled using the 2-dimensional swamp water balance model and impact scenarios as reviewed above. Based on the assumption that the basal seepage losses translate to baseflow losses at the swamp surface flow outlets, the modelling implies that the surface flow losses from swamps may be minor to negligible. This is possibly correct; however, given the preliminary state of the modelling as reviewed above, the predictions of potential surface water losses are not a strong basis for assessing environmental consequences.

It should also be noted that the hydrologic model does not include water quality aspects with increased penetration of surface waters to the subsurface and increased rate of groundwater transport in the subsurface as a result of fracturing almost certain to increase discharge of elements such as Fe, Mn and Al to surface streams and, eventually, Lake Woronora.

The Panel does not consider it necessary that additional surface water monitoring or modelling are undertaken prior to determination of the Extraction Plan for LW 311 and 312 because this would not achieve the level of accuracy required to instruct decisions within the relevant timeframe. Nevertheless, updating the models and their predictions annually is useful to refine understanding of reasons for any observed subsidence consequences and to refine predictions for subsequent longwalls.

It is recommended that updates to the 1-dimensional and 2-dimensional models and their predictions should be undertaken in annual reviews to refine understanding of reasons for any observed subsidence consequences and to refine predictions for subsequent longwalls.

Biodiversity

Impacts to biodiversity values are outlined in the Biodiversity Management Plan (Appendix C of Peabody 2024) and Large Swamp Assessment (Appendix H of Peabody 2024a).

The key impact to terrestrial biodiversity, particularly amphibians, will arise from reduced streamflow and/or reduction in pool water levels which provide habitat for breeding frogs. Subsidence impacts, including cracking of bedrock, leakage from pools and diversion of surface water flow, is predicted to occur along the lower lengths of Tributaries P, R and S given predicted valley closure levels (Appendix I of Peabody 2024a and MSEC 2024). If subsidence impacts do occur along these tributaries, this is highly likely to result in impacts to threatened species where they are present (presence is indicated in the BCS survey results presented to the Panel on 23 August 2024), particularly the Littlejohn's Tree Frog and Giant Burrowing Frog who both rely on pools for breeding. If these impacts do occur, and result in loss of breeding habitat, they are unlikely to be considered negligible.

The Biodiversity Management Plan (Appendix C of Peabody 2024a) predicts that while there may be subsidence impacts such as surface cracking, changes to hydrological impacts, localised impacts to riparian vegetation, reduction in quality of terrestrial habitat and potential for a reduction in pool water levels, this *"does not change the assessment of environmental consequences on terrestrial fauna and their habitats provided in the Project EA and Preferred Project Report"* (Appendix C of Peabody 2024a, p.91). It is the Panel's view that baseline surveys for threatened frogs are inadequate. As such, the Panel lacks confidence in the impact predictions that there will be no significant impacts and that a negligible impact to threatened species can be achieved. These baseline surveys are a key part of developing the impact predictions and would be used to design suitable mitigation strategies and inform ongoing monitoring. The following outlines the Panel's concerns.

- Survey locations are generally unsuitable and do not target key habitat at risk of impact. The majority of survey locations are located along access tracks; these areas provide minimal habitat for the threatened frog species targeted, other than habitat for the Red-crowned Toadlet in drainage channels. Survey locations in the upland swamps shown in the Large Swamp Amphibian Assessment (Appendix D to Appendix H of Peabody 2024a) are generally in the mid to upper reaches of the swamps and are less suitable. Surveys have not been undertaken along streams at the base of and below the upland swamps which include breeding habitat at greatest risk of impact. Additional survey locations are required.

- Surveys have generally not been conducted at an appropriate time of year for the Littlejohn's Tree Frog and Giant Burrowing Frog. Surveys for the Littlejohn's Tree Frog should be conducted between July and November. Surveys for Giant Burrowing Frog should be conducted between February and May to maximise detection of tadpoles and should be conducted within one week of heavy rainfall to maximise detection of adult frogs. Two survey periods are required.

- Survey methods are unsuitable for the species. Daytime searches for these frogs are unsuitable, with nocturnal surveys required. A single 30-minute search and call playback session is insufficient survey effort to reliably detect these species. The NSW Survey Guide for Threatened Frogs (NSW DPIE 2020) requires 480 minutes across four replicates (120 minutes per replicate) for every 500 m transect for Littlejohn's Tree Frog and 960 minutes across eight replicates (120 minutes per replicate) for every 500 m transect for the Giant Burrowing Frog. Acoustic recorders are not recommended for surveying for the Red-crowned Toadlet or Giant Burrowing Frog (DPIE 2020) and should be restricted to use for the Littlejohn's Tree Frog. As such, they cannot be used to replace other survey methods.

The inadequacy of surveys is demonstrated by surveys presented to the Panel by BCS at the meeting of 23rd August 2024. These surveys were undertaken by BCS over 5 days and 2 nights in September to November 2023 using a combination of aural visual surveys (2 nights in Swamp 92, no effort in Swamp 76 or 77), tadpole searches (3 half days in Swamp 92 and 3 days in Swamp 76, no effort in Swamp 77) and acoustic surveys (2 devices in Swamp 77 – yet to be retrieved). Littlejohn's Tree Frog and Red-crowned Toadlet were observed in Swamp 92 and Tributary P below Swamp 92. The Giant Burrowing Frog was recorded at the upstream extent of Swamp 77. Littlejohn's Tree Frog and Giant Burrowing Fog were observed in Swamp 76 and in Tributary S below Swamp 76.

Further baseline surveys are required for these threatened frog species, using appropriate survey methods and effort, conducted at a suitable time of year with survey locations targeting breeding habitat through the upland swamps (where present) and along suitable reaches of Tributaries P, R and S.

Impacts to upland swamps may arise from fracturing of bedrock below swamps and changes in groundwater within and below the swamps. The EP predicts that *"cracking of the bedrock beneath the swamps is expected to be isolated an of a minor nature"* (Appendix I of Peabody 2024a, p.49). At the Metropolitan Coal Mine, impacts to the shallow perched groundwater system in the upland swamps has been limited to observations in Swamps 20 and 28 to date with consequent changes in vegetation observed in Swamp 28 (Appendix A to Peabody 2024a). However, it is noted that the majority of swamps mapped over LWs 20-27 and 301-310 are valley side swamps, except for Swamp 20 which is a valley infill swamp (EcoPlanning 2024). Swamp 21, an unmonitored swamp, is also a valley infill swamp. In their submission, BCS (2024a) noted that '*no impacts... on upland swamps*' were predicted in the 2008 Environmental Assessment for the Metropolitan Coal Project, which was approved in 2009. BCS presented to the Panel the view that of the swamps above or to the side of Metropolitan Colliery longwalls, nine swamps (Flatrock Swamp, S16, S17, S20, S21, S25, S46, S51 and S50 have been hydrological impacted) while five monitored swamps (S35, S40, S52, S53 and S72) appear to not have been impacted. Flat Rock Swamp and Swamp 21 are relatively large valley infill swamps.

There are a number of threatened species with potential to rely on the upland swamps, including the Giant Dragonfly and Ground Parrot. The soil moisture profiles for Swamps 77 and 92, especially S92, show that high soil moisture conditions persisted at depths accessible by Giant Dragonfly larvae from November 2020 to November 2023, despite dry climatic conditions during this time. Hence these sites may provide important habitat for these species.

As for the threatened frogs, it is the Panel's view that baseline surveys for the Giant Dragonfly are inadequate. As such, the Panel lacks confidence in the impact predictions provided. Baseline surveys for the Giant Dragonfly were undertaken on three days in October 2023, November 2023 and January 2024. Of these dates, only January 2024 surveys were undertaken with the recognised survey period for the species (December to mid-January). Surveys across all three large swamps are limited to a single day. Review of survey effort (Figure 3.1 in Appendix D to Appendix H of Peabody 2024a) also indicates that surveys have sampled a very small portion of the upland swamps – it is unclear what survey effort was taken on which day. Surveys undertaken by BCS using eDNA sampling in Swamp 92 and Swamp 14 detected the Giant Dragonfly in Swamp 14. Swamp 14 is located less than one kilometre to the west of Swamp 92. No sampling by the company's consultants was undertaken in Swamps 76 or 77. Given these results, the Panel believes that additional surveys are required for Swamps 92 and 77 (and Swamp 76) using best practice methods. In their advice, BCS recommends systematic surveys are undertaken using a mix of surveys for exuviae and adults, with surveys to be undertaken in December and early-mid January. Given the limited expense and time involved, the company may wish to undertake eDNA surveys at the base of Swamps 77 and 92 (and Swamp 76) during an appropriate time of year to determine whether the species are present. If they are detected, additional surveys are recommended to understand the distribution of the species in these swamps. The Panel recommends the company engage with BCS in developing a suitable survey method.

No survey has been undertaken for the Ground Parrot, with Metropolitan Coal stating that extensive surveys were undertaken in 2013 as a part of the research project Conservation of the Eastern Ground Parrot on the Woronora Plateau. The Panel has been unable to sight this report and, as such, is unable to review the extent of surveys in relation to LWs 311 and 312 and is unable to determine whether surveys methods align with more contemporary techniques. It is the Panel's view that given this report cannot be found that baseline surveys are required to be undertaken as a priority using contemporary survey techniques.

6.3. THE ADEQUACY OF THE PROPOSED PERFORMANCE MEASURES AND INDICATORS FOR LARGE SWAMPS

Performance Measures

The Extraction Plan proposes that the Performance Measures relevant to the large swamps are unchanged from the those in preceding Extraction Plans, being:

- *Negligible impact on Threatened Species, Populations, or Ecological Communities*
- *Negligible reduction to the quality or quantity of water resources reaching the Woronora Reservoir*

The Panel notes that the Performance Measure for Negligible Impact on Threatened species, Populations and Ecological Communities is defined in the Extraction Plan as applying to '*Threatened species, populations and ecological communities include those listed under the TSC Act, EPBC Act or Fisheries Management Act 1994 at the time of Project Approval (i.e. the lists current as at 22 June 2009)*'. In that case, the Performance Measure would not apply to an Upland Swamps as an ecological community, because Upland Swamps were listed in 2012 and 2014 under the TSC Act and EPBC Act respectively.

However, the Panel interprets the intent of Schedule 3 Condition 4 as being that the Performance Measure may be revised or redefined in light of advances in knowledge (for example, of the large swamp hydrology and biodiversity, advances in knowledge about risks from mining) and the current status of Coastal Upland Swamps as threatened ecological communities. Therefore, the Panel's advice on Performance Measures and Performance Indicators is not constrained by the definition of threatened species, populations and ecological communities at the date of project approval.

Impacts to threatened species such as the Giant Burrowing Frog, Littlejohn's Tree Frog, Red-crowned Toadlet, Giant Dragonfly and Eastern Ground Parrot (which were listed under the TSC Act at the time of the project approval) can be assessed in accordance with the existing and company-proposed Performance Measure requiring negligible impact.

In its previous advice (IEAPM 2023b), the Panel advised "*Revise the Performance Measures (not only Performance Indicators) set for upland swamps, and TARPs that include triggers based on temporal changes to perched groundwater in the swamp sediments and the underlying weathered sandstone*." This advice was based on the view (IAPUM 2022, IEPMC 2019) that: *By definition, swamps are groundwater-dependent ecosystems. Therefore, a change in piezometric levels should be the primary gauge of impacts on the ecosystem. If maintenance of ecosystem functionality is to be mandated for any swamp, then piezometric variation must be used not only in the TARPs but also in performance measures.*

The current Panel maintains that view. If the Performance Measure is solely vegetation or biodiversity-based (rather than also groundwater-based), due to the long timescale (possibly decades) for biodiversity to react to groundwater changes, identification and management of a Performance Measure exceedance may be challenging and unsuccessful. This arguably applies to all the upland swamps that are subject to subsidence impacts, but particularly applies to the large swamps where a high level of confidence that impacts are detected and managed is warranted. To satisfy the Panel's concern, either the previous recommendation "*Revise the Performance Measures (not only Performance Indicators) set for upland swamps…*" should be applied to the large swamps 76, 77 and 92; or, accepting Peabody's proposed Performance Measure, the exceedance of an appropriately specified groundwater Performance Indicator and trigger should translate directly and irrespective of any subsequent vegetation or biodiversity assessment to an exceedance of the Performance Measure. The rest of this advice is based on the latter viewpoint, noting that new Performance Measures may be needed if suitable groundwater triggers cannot be developed. The proposed Performance Measure *Negligible impact on Threatened Species, Populations, or Ecological Communities* is considered acceptable by the Panel on that basis.

The Performance Measure *Negligible reduction to the quality or quantity of water resources reaching the Woronora Reservoir* is acceptable.

Large swamp groundwater Performance Indicators

The proposed groundwater Performance Indicator that addresses the Performance Measure *Negligible impact on Threatened Species, Populations, or Ecological Communities* for the large swamps is:

- *Subsidence impacts are not expected to result in measurable changes to swamp groundwater levels when compared to control swamps or seasonal variations in water levels experienced by upland swamps prior to mining.*

The Upland Swamp Groundwater TARP (Table 1 of Appendix A of Peabody 2024a) implies that a level 3 trigger of that TARP equates to the Performance Indicator being exceeded. Peabody's proposed actions following that trigger include increasing the frequency of data analysis, initiating assessment against the performance measure for threatened species, and considering the need for management measures. Hence, exceedance of the proposed Performance Indicator (i.e. thresholds defined in the level 3 trigger) would not directly define an exceedance of the Performance Measure. The Panel concludes that:

- Because of the potentially long time-delay between exceedance of the Performance Indicator and measurable impacts on biodiversity, for the large swamps, it is not suitable to rely on the action "*Initiate assessment against the performance measure for threatened species*" before determining an exceedance of the *Threatened Species, Populations, or Ecological Communities* Performance Measure.
- The groundwater trigger that defines an exceedance of the Performance Indicator (i.e. the highest-level trigger in the large swamp groundwater TARP) should translate directly to exceedance of the Performance Measure for the large swamps, hence the action "Initiate assessment against the performance measure for threatened species" should be deleted.
- The proposed Upland Swamp Groundwater Performance Indicator is adequate for the large swamps subject to a suitably defined trigger.
- Recommendations regarding the trigger are in Section 6.5 of this advice and include changes in groundwater levels and recession rates and at levels 2 and 3, changes to 10m groundwater levels and soil moisture changes.

It is recommended that the action "*Initiate assessment against the performance measure for threatened species"* is removed from the highest-level Upland Swamp Groundwater TARP so that the trigger of this TARP defines an exceedance of both the Performance Indicator and the Performance Measure for the large swamps without reliance on potential biodiversity changes.

Recommendations regarding the trigger are in Section 6.6 of this advice.

Surface water Performance Indicators

The proposed Performance Indicators that address the Performance Measure *Negligible reduction to the quality or quantity of water resources reaching the Woronora Reservoir* are adequate for the purpose of LW 311 and 312, with detailed advice on their longer-term applicability, including the need to move towards assessing loads of total metals, given in IEAPM (2023a).

Swamp vegetation Performance Indicators

In light of the recommendation above regarding the groundwater Performance Indicator, and subject to the recommendations around trigger levels and actions/response outlined in Section 6.6, the Panel is of the view that the Performance Indicator under Upland Swamp Vegetation Monitoring is unnecessary. It is recommended that the Performance Indicator under Upland Swamp Vegetation Monitoring is removed (while maintaining the monitoring, annual reporting and TARP).

Biodiversity Performance Indicators

For biodiversity, as for other issues, the performance measure, Performance Indicators and trigger levels proposed do not differ from those for LWs 308-310 and the current Performance Indicator is:

The amphibian assemblage is not expected to experience changes significantly different to the amphibian assemblage at control sites.

The Performance Indicator has been taken to refer to *"the amphibian assemblage (17 amphibian populations) as a whole"* (Appendix C of Peabody 2024a, p. 64). This interpretation does not represent the intent of the Performance Measure with the intended focus on threatened species. The Performance Indicator should only refer to threatened species, with exceedance of the Performance Indicator reviewed by species and monitoring location. For example, a greater than negligible impact on a threatened species along one tributary would represent an exceedance if control sites showed no change and the decline occurred over successive monitoring periods. The Panel recommends the Performance Indicator be refined to focus on reductions in frog populations along monitoring transects.

Performance Indicators may be required for additional threatened species if these species are detected during targeted surveys to recommended by the Panel.

Further detail is provided in Section 6.5.

6.4. THE NEED OR OTHERWISE TO MODIFY THE MINE PLAN

Constraints on modifying the mine plan for LW 311 and LW 312 related to the current status of mining

The maingate between LW 312 and LW 313 (MG312) had progressed to approximately one half the length of the proposed LW 312 by 19 July 2024 (DPHI 2024). The Panel understands that reducing the widths of the proposed LW 311 and LW 312 is now not a practical option; however, it does not constrain options for shortening LW 311 or LW 312.

Risks that might be managed by modifying the mine plan (LW 311 and LW 312) and assessment of options

Water quality. Risks to the quality of water reaching Woronora Reservoir stem from the potential generation of metal-rich runoff due to water diversions through subsidence-induced fractures both within and downstream of the swamps, and from potential erosion of the swamps. The predicted valley closures in the tributaries (P, R and S) downstream of the swamps following LW 311 and 312 are up to approximately 800 mm, which, based on previous experience in the Southern Coalfield (the "rockbar model”), will likely lead to extensive Type 3[5] fracturing of the tributary base and its rockbars. This is acknowledged in the Extraction Plan. This will lead to pulses of water of deteriorated quality and, additionally, may contribute to longer-term water quality consequences as explained in IEAPM (2023a). These potential consequences to Woronora Reservoir and recommendations on their management are covered in IEAPM (2023a).

Swamp 92. Following LW 312, maximum valley closure within Swamp 92 is predicted to be approximately 70 mm (Peabody 2024a and MSEC 2024). Following LW 316 this increases to 100 mm. Predicted compressive and tensile strains are up to approximately 1 mm/m after LW 316 (data not available for LW 312). Peabody (2024) includes an analysis of options for shortening LW 312 by 130 m or 260 m. The latter is predicted to halve maximum curvature to 0.03 that translates to halving tensile strains to less than 0.5 mm/m, which is considered by the Panel to equate to a very low risk of subsidence impact. The predicted valley closure for the original proposal and also for the two shortening options correspond to a near-zero likelihood of Type 3 fracturing.

The Panel considers that, of the three large swamps, Swamp 92 is the most significant. This swamp is of special significance, as it is large and highly complex, supporting all sub-communities within the Coastal Upland Swamp EEC. It has a significant perched groundwater system and stable high soil moisture levels from the surface to its base at approximately 1200 mm. Hence, it provides suitable habitat for a number of threatened species. Baseflow from this swamp also supports pools downstream which are habitat for Littlejohn’s tree frog, based on the BCS Survey (presentation to the Panel on 23 August 2024). Hence, Swamp 92 should be regarded as a priority for minimising risk. The proposed extent of LW 312 (i.e. with no shortening at southern end) leaves a low likelihood that conventional strains or valley closure will lead to fracturing with rapid consequences for swamp hydrology, ecology, and possibly sediments and water quality. Nevertheless, even if cracks are small, and even if they are infilled with fine colluvial sediments, this will not necessarily maintain in the long-term the perched groundwater in the swamp – infilled cracks are still higher permeability pathways than is naturally the case. Although the likelihood of impacts that would lead to exceedance of the Performance Indicators is low, the Panel considers the risk (likelihood x consequence) to be moderate and incommensurate with the high value of Swamp 92, and easily managed by shortening of LW 312 by 260 m.

It is recommended that the southern end of LW 312 is shortened by 260 m to minimise risks to Swamp 92.

Swamp 77. Following LW 312, the maximum valley closure within Swamp 77 is predicted in the Extraction Plan to be approximately 175 mm at the downstream end of the swamp, reducing rapidly in the upstream direction. Following LW 316 the predicted maximum valley closure is up to 325 mm. Tensile strains are predicted to be up to 0.5 mm/m after LW 316 (data not available for LW 312). LWs 312 and 313 have the greatest (both >100 mm) incremental effect on predicted valley closure at the downstream end of Swamp 77. It is likely that one or both of these longwall panels would need to be shortened to provide a high degree of protection to the swamp base and rockbar at the downstream end of Swamp 77 (i.e. the rockbar shown in Figure 14 of Appendix 5 of Appendix A of Peabody 2024a). A degree of protection would be provided by reducing panel widths of LWs 313 to 316 (Peabody 2024d). A 60 m reduction in the width of all these panels would reduce predicted valley closure at the downstream of Swamp 77 from 325 mm to approximately 180 mm. Generally, in the Southern Coalfields, 180 mm predicted valley closure has been associated with a low (< 10%) likelihood of Type 3 rockbar fracturing. If the currently proposed mine plan progresses and non-minor subsidence impacts to the Swamp 77 rockbar occur, consistent with the Panel’s advice on large swamp groundwater

[5] Type 3 fracturing is fracturing which has resulted in pool water levels dropping more than expected after considering the rainfall and surface and groundwater flow conditions. The Southern Coalfields “rockbar model” indicates that likelihood of Type 3 fracturing is zero when predicted valley closure is less than 80 mm, and less than 0.05 when predicted valley closure is less than 160 mm (IEPMC 2019).

Performance Indicators, this is likely to lead to the conclusion that the Performance Measure has been exceeded. While grouting of rockbar fractures has been a successful management measure at other locations for repair of rockbars, it is not useful if the bedrock below swamps has been cracked so the groundwater levels are compromised (IEPMC 2019). Also, the difficult accessibility of this part of Swamp 77 may discount grouting. The Panel concludes that, if shortening of LW 312 and LW 313 or reduction of (one or more of) LW 313-316 panel widths by at least 60 m to protect Swamp 77 are not considered appropriate for economic or other reasons, then it is highly likely that the large swamp groundwater Performance Indicator will be exceeded. As commented on below in this Advice, monitoring of groundwater levels, pool levels and rockbar fracturing in this area of Swamp 77, including a sufficient baseline period, would be required to assess impacts. The Panel is concerned also that impacts at the downstream end could lead to lowering of water levels, soil moisture and potentially gully erosion progressing upstream through the swamp.

It is recommended that Metropolitan Coal should provide DPHI, prior to a decision regarding approval of LW 311 and LW 312, further justification of why the predicted subsidence impacts in the downstream length of Swamp 77 may be considered acceptable, including evaluation of the feasibility of shortening of one or both longwalls.

It is recommended that, if the currently proposed layouts of LW 311 and LW 312 are approved, then within 6 weeks of this Advice being submitted to DPHI (so that it can be considered by the Panel in Stage 2 of this Advice), Metropolitan Coal should submit to the DPHI a site-specific contingency plan that explains how non-minor fracturing in the downstream length of Swamp 77 (including its rockbar, base of tributary, and underneath the swamp soil) would be managed.

<u>Swamp 76</u>. The maximum predicted valley closure is up to approximately 130 mm after LW 316. Tensile strain is up to 1.0 mm/m, which reduces to less than 0.5 mm/m under both (30 m and 60 m) scenarios of panel width reduction. For the proposed and reduced panel widths, the impacts of LW 311 and 312 on Swamp 76 are predicted to be negligible (i.e. indiscernible in the MSEC 2024 or Peabody 2024d results). Further, Table 4 concludes that this swamp does not meet the OEH (2012) criteria of special significance. The Panel concludes that further consideration of risks to Swamp 76 and management considerations should be given in Stage 2 of the Advice.

<u>Tributary S</u>. Recent surveys by BCS have identified a population of Littlejohn's Tree Frog and Giant Burrowing Frog in Tributary S, both within Swamp 76 and downstream of the swamp to the waterfall. The maximum predicted valley closure is less than 50 mm after LW 312 and up to approximately 250 mm after LW 316. For the proposed panel widths, the impacts of LW 311 and 312 on Tributary S are predicted to be negligible (i.e. indiscernible in the MSEC 2024 or Peabody 2024d results). The Panel concludes that further consideration of risks to threatened species habitat within Tributary S and management considerations should be given in Stage 2 of the Advice.

Further consideration of impacts to Tributary R may be required following completion of targeted surveys.

6.5. THE ADEQUACY OF THE WATER AND SWAMP MONITORING PROGRAMS

Subsidence

The proposed Subsidence Monitoring Program (Appendix F of Peabody 2024a) is adequate for the purpose of LW 311 ad LW 312, except that there is a need for a transverse subsidence monitoring line towards the northern end of LW 311, cutting across LW 311 towards the northern end of LW 316 to monitor subsidence behaviour within the zone of influence of Woronora Reservoir.

It is recommended that Metropolitan Coal should revise the Extraction Plan to include a transverse subsidence monitoring line towards the northern end of LW 311, cutting across LW 311 towards the northern end of LW 316 monitor subsidence behaviour within the zone of influence of Woronora Reservoir.

Groundwater

In a response to agency comments, Peabody (2024d) presents the status of groundwater monitoring in and under the swamps including a schedule for installing the remaining bores. As noted in Section 5.5 of this Advice, the proposed swamp and shallow HBSS groundwater monitoring meets the previous recommendations of the IAPUM (2022) and IEAPM (2023b) if it is installed prior to commencement of LW 311. There are three piezometers measuring shallow swamp groundwater levels in each of the three large swamps, all installed in November 2020. There is one HBSS (~10 m depth) piezometer already installed in each of the three swamps co-located with a swamp piezometer. Two further HBSS piezometers per swamp were proposed to be installed in mid-2024, but delays caused by adverse weather and ground conditions mean these were not installed (Peabody 2024d). The current absence of baseline data at these six proposed shallow HBSS (~10m) sites is not ideal with regards to the minimum baseline data recommended to support the Panel's advice regarding TARPs (see commentary in Section 6.6 below). These sites should be installed as soon as practicable, and the limited baseline period at these sites will need to be considered in the design of the TARPs if they are revised according to this Advice. The proposal for deeper groundwater monitoring at the large swamps (as in page 17 of Peabody 2024c and in Section 11.2 of Appendix A of Peabody 2024a) is satisfactory, noting that it should be installed as soon as practicable.

It is recommended that Metropolitan Coal continues its endeavours to install the planned shallow and deep groundwater monitoring in/near the large swamps as soon as practicable and prior to commencement of LW 311.

If the proposed layout of LW 311 and 312 is approved, given the likelihood of impacts at the lower end of Swamp 77 that might not be observed at the other Swamp 77 monitoring sites, a shallow swamp groundwater monitoring piezometer is needed near to the end of Swamp 77 at its downstream extent. If safely accessible, rockbars and pools within the lower end of Swamp 77 should also be monitored for loss of water and visual impacts (fracturing and iron staining). If the proposed mine plan is approved, an unsatisfactory baseline period will be achievable at the piezometer location (estimated as only 2 months – see Table 5). The Panel does not see any solutions to this. Unless a suitably designed TARP can be provided for this location that does not rely on a swamp groundwater baseline, or unless the mine plan is delayed to allow an adequate baseline (including a sample of swamp groundwater recessions and recoveries covering a range of dry and wet conditions prior to possible subsidence impacts), then based on the subsidence predictions it may be reasonable to assume that the groundwater Performance Indicator is exceeded at this location irrespective of measurements.

It is recommended that a shallow swamp groundwater monitoring piezometer is installed near to the end of Swamp 77 at its downstream extent; and, if safely accessible, rockbars and pools within the lower end of Swamp 77 should also be monitored for loss of water and visual impacts (fracturing and iron staining).

It is recommended that if no satisfactory monitoring, including baselines, can be installed to assess impacts to the downstream end of Swamp 77 and if the proposed layout of LW 311 and LW 312 progresses then the large swamp groundwater Performance Indicator should be assumed to be exceeded over at least the valley infill area of this swamp.

Table 5: The Panel's approximate estimates of achievable baseline periods at proposed/recommended swamp groundwater monitoring sites if the proposed mine plan schedule is approved.

Site	Start date of LW that will be within ~400 m of site	Assumed start of baseline period	Estimated baseline period (months)
Swamp 77 shallow piezometer (recommended site at lower end)	Nov 2024 (LW 311)	Sept 2024 (hypothetical earliest possible date)	2
S92-1 HBSS piezometer (southern)	March 2025 (LW 311)	Aug 2024 (assumed based on Peabody 2024e)	8
S77-1 HBSS piezometer	Feb 2025 (LW 311)	Aug 2024 (assumed based on Peabody 2024e)	6
S76-1 HBSS piezometer	Jul 2025 (LW 312)	Aug 2024 (assumed based on Peabody 2024e)	12

As mining progresses past faults F-0037, F-0053 and F-0051, monitoring of in-mine leakage and assessment of mine water balance should be continued and further risk analysis undertaken if required.

Surface water

The surface water monitoring for the large swamps has been implemented consistent with previous Panel recommendations. In light of new biodiversity information, recommendations are made below for additional tributary pool level monitoring where threatened frogs are identified. It is noted that a flow gauge at Swamp 77 was not installed due to accessibility challenges. Due to the importance of regular access to the flow gauges for maintenance, and because the two other large swamps have flow gauges downstream of their outlets, the Panel agrees that this is reasonable. Similarly, the monitoring of water quality downstream of two of the three swamps is reasonable, considering that these are minor (second order) tributaries of Woronora Reservoir.

Biodiversity

Swamps

Monitoring of upland swamp vegetation is outlined in Section 8.1 of the BMP (Appendix C to Peabody 2024) and includes a mix of visual inspections, transect/quadrat monitoring and indicator species monitoring, in addition to groundwater monitoring. The Panel generally supports the monitoring proposed, but is unable to determine the suitability of quadrat/transect monitoring locations. Section 8.1 refers to monitoring locations shown in Figure 9 and 14; however, monitoring locations are not shown on these maps. A review of Figure 2.1 of the EcoPlanning (2024) report (Appendix C in Appendix H of Peabody 2024a) appears to show just two monitoring locations in Swamp 92 (METH11 and METH12) and two in Swamp 77 (METH19 and METH20). Sites in Swamp 92 are in the upper reaches of the swamp, with no monitoring locations in the lower reaches with greatest potential for impact. Similarly, in Swamp 77 the two monitoring locations are in the upper reaches of the swamp. The Panel recommends addition of one additional site per swamp at the locations suggested.

As per our high-level review of the Large Swamp Environmental Assessment Requirements (IEAPM 2024b), the Panel would also recommend the company undertake revised baseline mapping of swamp sub-communities, using a replicable technique that will allow monitoring of changes in response to changes in hydrology. This will allow the company to undertake comparison with previous mapping to determine whether any changes in groundwater are resulting in changes in vegetation subcommunities. As outlined in Section 6.2, the Panel does not feel this recommendation has been adequately addressed.

Threatened species

As outlined in Section 6.2, the baseline surveys undertaken are considered inadequate for understanding the biodiversity values over LWs 311-312 (and 313-316) and characterising the potential impacts. Without adequate baseline data it is difficult for the Panel to comment on the monitoring proposed as the monitoring should be designed around the results of the baseline surveys to target known habitat for threatened species. As such, the Panel makes a number of high-level recommendations below:

- Monitoring locations should target habitats at greatest risk of impacts from subsidence (breeding habitat) as identified during baseline surveys.
    - The majority of threatened frog monitoring locations are situated on access tracks. These locations are unsuitable for monitoring of threatened frog species.
    - Giant Dragonfly surveys should include targeted surveys for exuviae in wetter sections of the Swamps 77 and 92 (and Swamp 76).
- Timing of monitoring should target key lifecycle stages of the species being monitored.
    - For threatened frogs, this should include the breeding periods, including calling and when tadpoles are present. This may require multiple surveys per year.
    - For the Giant Dragonfly, surveys should target the key emergence period between December and January.

Monitoring techniques should be targeted at and suitable for the species being monitored.

- As outlined above, Songmeters are not considered a suitable survey technique for the Giant Burrowing Frog or Red-crowned Toadlet. Surveys for threatened frogs must include nocturnal visual-aural surveys along monitoring transects. Use of 100 m x 100 m (1 ha) monitoring sites is not considered a suitable monitoring technique.
- The measures of abundance outlined in Section 8.6 of the BMP (Appendix C of Peabody 2024a) are considered unsuitable for species which are often detected in low numbers. It is the Panel's view that they are unnecessary and monitoring for threatened frogs should be undertaken to compare abundance along monitoring transects year-on-year.
- Monitoring for threatened frogs should include monitoring of pool water levels at breeding locations identified during baseline surveys. There is currently only one pool monitoring location along Tributary P and one along Tributary R. The Panel recommends additional monitoring locations with sites informed by adequate baseline surveys.
- If detected during baseline surveys, monitoring for the Giant Dragonfly should target exuviae in suitable habitat, as per recommendations of BCS. The company may also wish to considered use of eDNA surveys at the lower reaches of the swamps.

Following the completion of reliable targeted surveys, and an understanding of the baseline biodiversity values present over LWs 311 to 316, the Panel recommends the company undertake a review of monitoring locations and techniques to address the items raised above.

The Panel notes that the Biodiversity Monitoring Program is to be reviewed at the end of each longwall to identify potential impacts and consequences (Peabody 2024c, Section 8.8).

6.6. THE ADEQUACY OF THE LARGE SWAMP TARPS

The Panel notes the request for 'clear and timely performance indicators' and suggests the following principles be adopted in the definition of new TARPs, focussing on Swamps 92, 77 and 76 in particular. These TARPs may need to be revised in the future as the results of monitoring programs become available.

Subsidence

Peabody (2024e) presents a large swamp valley closure TARP, based on the closure lines shown in the subsidence monitoring plan (Figure 5 and Plan 7 of Appendix H of Peabody 2024a). The valley closure TARPs for Swamp 92/tributary P and Swamp 77/tributary R are relevant for LW 311 and LW 312. Valley closures will be measured using GNSS units across the three closure lines. The proposed level 2 and level 3 triggers are based on comparing measured valley closures with predicted valley closures. As the Panel has previously advised in context of Waratah Rivulet (IAPUM 2022), this is not necessarily a useful comparison because predicted valley closures tend to be higher (typically 0-200% higher based on the data shown in IAPUM 2022) than measured valley closures. Therefore, by the time a level 3 trigger for Swamp 77 of >325 mm observed closure has been activated, it is highly likely that a subsidence impact leading to drainage of Swamp 77 will already have occurred. Furthermore, the maximum closures in Swamp 77 are predicted to occur well downstream of the closure line. The Panel concludes that the trigger for Swamp 77 is not conservative enough. However, the predicted valley closure at the closure line for Swamp 77 is negligible for LW 311 and LW 312, and therefore further review of the Swamp 77 TARP is deferred to Stage 2 of this Advice.

The Panel recommends that the trigger for Swamp 92 be reviewed by the Technical Committee following mining of LW 311 and submitted for approval prior to mining of LW 312. The valley closure TARPs will be considered further in Stage 2 of this advice.

The TARP footnotes in Peabody (2024e) include "*Swamps 76, 77 and 92 are not rockbar controlled, rather they are valley infill swamps controlled by shallow gradient of the terrain*." While this may be correct for Swamp 76, and the majority of Swamps 77 and 92, it is not consistent with the reconnaissance of tributaries P and R in the Appendix A of Peabody (2024a), which notes controlling rockbars at the downstream ends of these swamps. The TARP also notes "*At each large swamp GNSS valley closure monitoring pairs will be established across the valleys at the furthest downstream groundwater monitoring point. This strategy will tie valley closure monitoring trends to the swamp groundwater monitoring occurring at the lower end of each large swamp*." This is difficult to reconcile with the large swamp closure line locations (Figure 5 or Plan 7 of Appendix H of Peabody 2024a), which for Swamps 76 and 77 seem to be well upstream of the most downstream piezometer locations.

It is recommended that, to inform assessment of proposals for LW 313 to LW 316, the proposed large swamp valley closure TARP document is revised to include a map showing closure line locations and additional justification of proposed locations, including consideration of any rockbar controls referred to in the stream reconnaissance that is included in the Extraction Plan.

Groundwater

The Panel has the following observations about the upland swamp groundwater TARPs (Appendix C of Peabody 2024a)[6]:

[6] The TARPs are different in Appendix C (Table 15) and Appendix H (Table 20) both dated July 2024 – the commentary here is for the more elaborate one from Appendix C.

- The TARP omits the HBSS shallow groundwater level, which if impacted could provide an early warning of groundwater impacts to the swamps.
- There may be cases where the 7-day minimum baseline period swamp groundwater level is not a useful benchmark, for example when that level is below the logger level or affected by extreme dry weather. This could be largely resolved by adding "OR the water level falls below the logger level".
- The water level recession rates and recovery rates are the most relevant and practical measures of impact. For the highest-level trigger to be activated, it is appropriate that changes in recessions should lead to significant changes in levels (as proposed, noting the previous point).
- The Level 3 Action includes "*Initiate assessment against the performance measure for threatened species*". The Panel considers that the highest-level trigger, i.e. exceedance of the swamp groundwater Performance Indicator, should directly translate to exceedance of the performance measure (as justified in Section 6.3 of this Advice).
- The Level 3 Action includes "*Consider the need for management measures, in accordance with Sections 9 and 10*". Section 9 (Appendix C of Peabody 2024a) describes remediation actions and Section 10 other management measures but excludes the possibility that the mine plan be reviewed and potentially adapted. In the Panel's opinion that possibility should be considered. For example, an exceedance of the Performance Indicator due to mining of LW 311 or LW 312 should warrant a review of the mine plan for LW 313 to LW 316.

The Panel recommends that:

- The upland swamp groundwater level 2 TARP includes a trigger for potential impacts on HBSS shallow (~10m) groundwater levels, at which frequency of analysis of swamp groundwater levels should increase, for example based on changes in recessions OR changes in swamp groundwater levels OR changes in HBSS shallow groundwater levels.
- The upland swamp groundwater levels 2 and 3 TARP includes a trigger for potential impacts on soil moisture, at which analysis of soil moisture changes in relation to recession rates and groundwater levels should be undertaken
- The upland swamp groundwater triggers should allow for the possibility that the baseline period levels have been below the logger level, for example based on the seven-day moving average being below the minimum established for the baseline period OR being below the logger level.
- The highest-level upland swamp groundwater trigger action should include a review of the mine plan for longwall panels yet to be mined that are predicted to potentially impact the large swamps.
- The upland swamp groundwater TARP should explicitly state that a trigger at any one site constitutes a trigger for that swamp.
- Like in the large swamp assessment document (Appendix H of Peabody 2024a), the BMP (Appendix C of Peabody 2024a) should have a separate set of TARPs for the large swamps.

Other recommendations on the upland swamp groundwater TARPs are in Section 6.6 of this Advice.

Surface water

There are no surface water flow TARPs applicable to LW 311 and LW 312. Consistent with previous mining areas, the small tributary flow gauges provide data for performance analysis in six-monthly and annual reporting rather than being used in TARPs. Although the surface flow monitoring data at outlets of Swamps 76 and 92 might be used to indicate changes to swamp storage, the flow gauges are prone to interference from debris and subsidence effects, and the piezometers provide a more direct and reliable measure of changes to swamp groundwater for the purpose of TARPs and Performance Indicators.

Advice regarding surface water quality TARPs is included in IEAPM (2023a). The proposed water quality TARPs are appropriate for LW 311-312. Review of total metal data in the 2024 annual report will be important for considering its potential inclusion in future TARPs.

Biodiversity

Threatened species

The Amphibian TARP is viewed by the Panel to have a number of limitations:

- There is inadequate baseline data (see above).
- Whilst the parameters to be measured (diversity and abundance) are considered suitable parameters, this should be focused on abundance of individual species and availability of habitat (particularly breeding pools) along individual waterways.
- The trigger levels are viewed as broadly suitable subject to some minor changes in wording.
    - The Level 2 trigger should assess if there has been a reduction in abundance of a threatened species (Red-crowned Toadlet, Littlejohn's Tree Frog or Giant Burrowing Frog) along an impacted waterway which has not been observed at control sites for one year.
    - The Level 3 trigger should assess if there has been a reduction in abundance of a threatened species (Red-crowned Toadlet, Littlejohn's Tree Frog or Giant Burrowing Frog) along an impacted waterway which has not been observed at control sites for greater than one year.
- For known breeding pools, both Level 2 and 3 triggers should also include a trigger for drying of pools resulting in loss of habitat. It is recommended that periods align with the trigger levels above (i.e. loss of habitat for one year (Level 2) and greater than one year (Level 3).
- The actions/response
    - Further detail should be provided on the analysis to be conducted in relation to threatened species. It is unclear what this refers to.
    - The wording of the final action/response should make reference to implementation of appropriate mitigation/remediation or provisions of offsets, as per Sections 9 and 10. Remove the word "consider".
    - A reduction in a frog abundance at an impact site should translate directly to exceedance of the Performance Measure, hence the action "Initiate assessment against the performance measure for threatened species" should be deleted from the action/response. Table 19 of the BMP (Appendix C of Peabody 2024a) should be reviewed to determine if this is required.

Further TARPS may be required for threatened species dependent on the outcomes of targe

6.7. OTHER MATTERS

Following its advice in IEAPM (2023b) the Panel remains concerned that panel widths are being effectively locked in prior to adequate assessments. It is recommended that drivage of MG313 should be delayed until an Extraction Plan covering LW 313 has been endorsed by the Department.

In light of the uncertainty around impacts to the large swamps, and to ensure offsets can be secured if Performance Measures are exceeded, the Panel recommends that further detail is provided on how an offset for the upland swamps can be secured with regard to the guidance in OEH (2016).

7.0 CONCLUSIONS

Responses to previous Panel advice by Metropolitan Coal

- In relation to the Panel's previous advice *Water Quality Performance Measures for Metropolitan Coal Mine*, the responses by Metropolitan Coal indicate an intention to address the recommendations to some degree but in most cases lack information about timeframes and in some cases are vague or suggest an inadequate degree of commitment. These issues arising do not need to be urgently addressed in the context of Longwalls 311 and 312, except to ensure that total metals (rather than dissolved metals concentrations) are monitored at the outlet of Swamp 92.
- In relation to the Panel's previous advice *Large Swamp Environmental Assessment Requirements for the Extraction Plan for Longwalls 311 to 316*, most of the recommendations have not been addressed or have been addressed in a partial or unsatisfactory way. The major issues relevant to the consideration of Longwalls 311 and 312 are:
  - Due to the progression of Maingate 312 prior to assessment of the Extraction Plan the widths of Longwalls 311 and 312 are essentially fixed and reducing their width is now not a practical risk management option.
  - The large swamp TARPs remain unsatisfactory and need to be further refined in several aspects.
  - Aspects of the large swamp risk assessment are unsatisfactory, particularly for the downstream end of Swamp 77.
  - The baseline surveys of vegetation sub-communities are unsatisfactory.
  - The baseline surveys of threatened species are unsatisfactory.
  - Documented evidence of the absence of the Eastern Ground Parrot relied upon by the Extraction Plan is unavailable.
- In relation to the Panel's previous advice *Metropolitan Coal Mine: Independent Review of Environmental Performance to 2022*, plans are in place to install the recommended monitoring at site T6, but it was not yet in place at time of writing this advice.
- In relation to the Panel's previous advice *Metropolitan Coal Mine: Independent Review of Environmental Performance to 2022 and Metropolitan Mine Longwalls 308 – 310 Extraction Plan*, the recommended groundwater monitoring was not in place at time of writing this advice, limiting the value of that monitoring for understanding subsidence risks and for providing baseline data for assessing performance.

Significance of the large swamps

- For the purpose of assessing the Extraction Plan and considering suitable Performance Measures and Performance Indicators, Swamps 76, 77 and 92 are important upland swamps in terms of providing suitable habitat for threatened species and water supply protection, and because of their size and status as Threatened Ecological Communities. Swamps 77 and 92 meet criteria proposed by OEH (2016) for swamps of special significance on the Woronora Plateau.

The adequacy of large swamp impacts predictions

- The subsidence predictions for LWs 311-312 have been made using an appropriate method that has been reasonably applied; additionally, the subsidence reports are adequate when supported by the relevant management plans.
- The swamp groundwater modelling is useful and appropriate given its data constraints; however, due to the model uncertainty, little weight should be attached to the conclusion in the Large Swamp Assessment that "*The mining-related effects to Swamp 76 and Swamp 92 are expected to be minor with the water levels predicted to remain above the base of the substrate*".

- If subsidence impacts do occur along tributaries P, R and S, as predicted, this is likely to result in impacts to threatened species if and where they are present (presence is indicated in the BCS survey results presented to the Panel). If these impacts do occur, and result in loss of breeding habitat, they are unlikely to be considered negligible.
- The baseline surveys relied upon by the Extraction Plan for threatened frog species and for the Giant Dragonfly are inadequate. Therefore, the Panel lacks confidence in the impact predictions that there will be no significant impacts and that a negligible impact to threatened species can be achieved.
- The limitations in the baseline surveys cannot be properly addressed prior to the proposed commencing date of LW 311 or LW 312, but may be partially addressed prior to the proposed commencing date of LW 313.

The adequacy of the large swamp Performance Measures and Performance Indicators

- The proposed Performance Measure of "*Negligible impact on Threatened Species, Populations, or Ecological Communities*" is acceptable for the purpose of LWs 311 and 312 provided that this Performance Measure is supported by Performance Indicators that are relevant and have clear criteria that define when an impact is more than negligible.
- The proposed large swamp groundwater Performance Indicator "*Subsidence impacts are not expected to result in measurable changes to swamp groundwater levels when compared to control swamps or seasonal variations in water levels experienced by upland swamps prior to mining*" is acceptable for the purpose of LWs 311 and 312 if it is supported by triggers that clearly define when changes are significant enough to determine an exceedance of the Performance Measure.
- The large swamps warrant Performance Indicators and triggers that provide a higher level of confidence (than provided by those applied to previously undermined swamps) that impacts will be detected and managed appropriately.
- Increased groundwater recession rates leading to non-negligible loss of swamp groundwater is a sufficient and practical criterion for determining that the large swamp groundwater Performance Indicator has been exceeded. Due to the semi-quantitative assessment of recession rates, a technical document should clearly explain and demonstrate the method and criteria used. Any exceedance of this Performance Indicator should translate directly and irrespective of any subsequent assessment to an exceedance of the Performance Measure for the large swamps.
- Given the preceding conclusion, the Upland Swamp Vegetation Performance Indicator is unnecessary.
- The Performance Measure "*Negligible reduction to the quality or quantity of water resources reaching the Woronora Reservoir*" and associated Performance Indicators are acceptable.
- The Amphibian Performance Indicator should only refer to threatened species, with exceedance of the Performance Indicator reviewed by species and monitoring location (e.g. a transect) rather than the "*amphibian assemblage as a whole*".

The adequacy of the large swamp TARPs

- The closure thresholds used in the large swamp valley closure TARP are not sufficiently conservative for Swamp 77.
- The rationale for the location of closure lines in Swamps 76 and 77 requires clarification.
- There would be benefit in adding the shallow (~10m depth) HBSS groundwater into the upland swamp groundwater TARPs as an early warning of potential (short or long-term) impacts to swamp hydrology.
- The highest-level upland swamp groundwater trigger defines exceedance of the Performance Indicator and should define exceedance of the Performance Measure. It is appropriate for this to

be based, as is proposed, on semi-quantitative analysis of groundwater levels including recessions that lead to non-negligible reductions in swamp groundwater levels. Better allowance needs to be made for baseline period levels that may be below the logger level.

- The proposed water quality TARPs are appropriate for LW 311-312.
- The Amphibian TARP is viewed by the Panel to have a number of limitations related to the lack of focus on abundance of individual species and availability of habitat (particularly breeding pools) along individual waterways, and other details.

The need or otherwise to modify the mine plan

- Of the three large swamps, Swamp 92 is the most significant. The proposed extent of LW 312 presents an unacceptable risk to Swamp 92, which could easily be addressed by shortening of that longwall.
- The downstream end of Swamp 77, including a controlling rockbar, is at high risk. If shortening of LWs 312 and 313 or reduction of (one or more of) LWs 313-316 panel widths by at least 60 m to protect Swamp 77 are not considered appropriate for economic or other reasons, then it is highly likely that the large swamp groundwater Performance Indicator will be exceeded at Swamp 77.
- Further consideration of risks to Swamp 76, Swamp 77 and tributaries that may host threatened species, and to management options including possible changes to the mine plan for LWs 313-316, should be given in Stage 2 of the Advice.

The adequacy of the water and swamp monitoring programs

- The proposed Subsidence Monitoring Program is adequate for the purpose of LWs 311 and 312, except that there is a need for a transverse subsidence monitoring line towards the northern end of LW 311, cutting across LW 311 towards the northern end of LW 316 to monitor subsidence behaviour within the zone of influence of Woronora Reservoir.
- The existing or proposed groundwater monitoring at the large swamps is adequate, except for the absence of any monitoring in the downstream area of Swamp 77, which the revised subsidence predictions show to be at high risk. Even if monitoring sites are established in this area, an unsatisfactory baseline period will be achievable if LWs 311 and 312 proceed as planned. Unless this can be resolved, it may be reasonable to assume (based on the subsidence predictions) that the groundwater Performance Indicator is exceeded at this location irrespective of measurements.
- The surface water monitoring for the large swamps has been implemented consistent with previous Panel recommendations. Where threatened frogs are identified, additional tributary pool level monitoring is appropriate.
- The Panel generally supports the swamp vegetation monitoring proposed but is unable to determine the suitability of quadrat/transect monitoring locations. The sites in Swamp 92 and Swamp 77 under-represent the lower reaches of the swamp.

8.0 RECOMMENDATIONS

Metropolitan Coal's response to the Panel's previous recommendations

1. The site S92-GS water quality monitoring should include measurement of total metals concentrations.
2. Peabody should proceed as soon as practicable with event sampling of water quality using automatic samplers irrespective of the outcomes of preliminary load assessments. This applies to ETWQ AU and also WQWQ9 and WOWQ2 if these are not covered by WaterNSW event sampling.
3. Peabody should commit, subject to access permission, to monitoring the depth profiles of water quality of the Woronora Reservoir at WDFS1 or other suitable site including regular (at least bi-annual) sampling throughout the remaining mining period, plus sampling following level 3 triggers for water quality reaching the reservoir.
4. An analysis of historical water quality trends in Woronora Reservoir and their relation to mining development should be included in the Metropolitan Coal 2024 Annual Review, and this should not be provisional on further suitable data becoming available.
5. The conceptual models of the large swamps should be reviewed in 6-monthly reporting in the light of new monitoring data, and updated to represent vegetation communities.
6. The T6 standpipes and the multi-level VWPs for Swamps 92 and 77 and standpipes at two sites in Swamp 76 should be installed as soon as practicable.

The adequacy of large swamp impact predictions

7. It is recommended that updates to the 1-dimensional and 2-dimensional models and their predictions should be undertaken in annual reviews to refine understanding of reasons for any observed subsidence consequences and to refine predictions for subsequent longwalls.
8. Further baseline surveys are required for threatened frog species, using appropriate survey methods and effort, conducted at a suitable time of year with survey locations targeting breeding habitat through the upland swamps (where present) and along suitable reaches of Tributaries P, R and S.
9. Additional surveys are required for Swamps 92, 77 and 76 using best practice methods. The Panel recommends the company engage with BCS in developing a suitable survey method.

The adequacy of the proposed performance measures and indicators for large swamps

10. The special significance of the large swamps should be managed by maintaining the proposed Performance Measure, and developing Performance Indicators and associated triggers that provide a high level of confidence that non-negligible impacts to the swamps will be detected and appropriately managed.
11. It is recommended that the action "Initiate assessment against the performance measure for threatened species" is removed from the highest-level Upland Swamp Groundwater TARP so that the trigger of this TARP defines an exceedance of both the Performance Indicator and the Performance Measure for the large swamps.
12. It is recommended that the Performance Indicator under Upland Swamp Vegetation Monitoring is removed (while maintaining the monitoring, annual reporting and TARP) and instead the groundwater Performance Indicator is relied upon to assess the Performance Measure for the large swamps.

The adequacy of the large swamp TARPs

13. The trigger for Swamp 92 should be reviewed by the Technical Committee following mining of LW 311 and submitted for approval prior to mining of LW 312.
14. To inform assessment of proposals for LW 313 to LW 316, the proposed large swamp valley closure TARP document should be revised to include a map showing closure line locations and additional justification of proposed locations, including consideration of any rockbar controls.
15. The large swamp groundwater level 2 TARP should include a trigger for potential impacts on HBSS shallow (~10m) groundwater levels, at which frequency of analysis of swamp groundwater levels should increase.
16. The large swamp groundwater triggers should allow for the possibility that the baseline period levels have been below the logger level.
17. The highest-level large swamp groundwater trigger action should include reviewing the mine plan for longwalls yet to be mined.
18. The large swamp groundwater TARP should explicitly state that a trigger at any one site constitutes a trigger for that swamp.
19. The large swamp groundwater TARP should include quarterly reporting of level 2 triggers and associated analysis.
20. A technical document, which clearly defines how the large swamp groundwater TARP triggers are assessed including examples, should be appended to the management plan.
21. The Biodiversity Management Plan should present a set of TARPs for the large swamps that separately from the TARPs for other swamps.
22. The Amphibian Performance Indicator and TARP should focus on abundance of individual species and availability of habitat (particularly breeding pools) along individual waterways.
23. The Amphibian TARP Level 2 trigger should assess if there has been a reduction in abundance of a threatened species (Red-crowned Toadlet, Littlejohn's Tree Frog or Giant Burrowing Frog) along an impacted waterway which has not been observed at control sites for one year. The Level 3 trigger should assess if there has been a reduction in abundance of a threatened species (Red-crowned Toadlet, Littlejohn's Tree Frog or Giant Burrowing Frog) along an impacted waterway which has not been observed at control sites for greater than one year.
24. Both Level 2 and 3 triggers should also include a trigger for drying of pools resulting in loss of habitat. It is recommended that periods align with the trigger levels above (i.e. loss of habitat for one year (Level 2) and greater than one year (Level 3)).
25. Further detail should be provided on the analysis to be conducted in relation to threatened species. The wording of the final action/response should make reference to implementation of appropriate mitigation/remediation or provisions of offsets, as per Sections 9 and 10. Remove the word "consider".
26. A reduction in a frog abundance at an impact site should translate directly to exceedance of the Performance Measure, hence the action "Initiate assessment against the performance measure for threatened species" should be deleted from the action/response. Table 19 of the Biodiversity Management Plan should be reviewed to determine if this is required.

The need or otherwise to modify the mine plan

27. It is recommended that the southern end of LW 312 is shortened by 260 m to minimise risks to Swamp 92.
28. It is recommended that Metropolitan Coal should provide DPHI, prior to a decision regarding approval of LW 311 and LW 312, further justification of why the predicted subsidence impacts in the downstream length of Swamp 77 may be considered acceptable, including evaluation of the feasibility of shortening of one or both of LWs 312 and 313.

29. It is recommended that, if the currently proposed layouts of LWs 311 and 312 are approved then, within 6 weeks of this Advice being submitted to DPHI (so that it can be considered by the Panel in Stage 2 of this Advice), Metropolitan Coal should submit to the DPHI a site-specific contingency plan that explains how non-minor fracturing in the downstream length of Swamp 77 (including its rockbar, base of tributary, and underneath the swamp soil) would be managed.

The adequacy of water and swamp monitoring programs

30. It is recommended that Metropolitan Coal should revise the Subsidence Management Plan to include a transverse subsidence monitoring line towards the northern end of LW 311, cutting across LW 311 towards the northern end of LW 316 monitor subsidence behaviour within the zone of influence of Woronora Reservoir.
31. It is recommended that Metropolitan Coal continues its endeavours to install the planned shallow and deep groundwater monitoring in/near the large swamps as soon as practicable and prior to commencement of LW 311.
32. It is recommended that a shallow swamp groundwater monitoring piezometer is installed near to the end of Swamp 77 at its downstream extent and, if safely accessible, rockbars and pools within the lower end of Swamp 77 should also be monitored for loss of water and visual impacts (fracturing and iron staining).
33. It is recommended that if no satisfactory monitoring, including baselines, can be installed to assess impacts to the downstream end of Swamp 77 and if the proposed longwall layout progresses then the large swamp groundwater Performance Indicator should be assumed to be exceeded over at least the valley infill area of Swamp 77.
34. Monitoring locations should target habitats at greatest risk of impacts from subsidence (breeding habitat) as identified during baseline surveys.
    - Monitoring locations should not be situated on access tracks. These locations are unsuitable for monitoring of threatened frog species.
    - Giant Dragonfly surveys should include targeted surveys for exuviae in wetter sections of the Swamps 77 and 92 (and Swamp 76).
35. Timing of monitoring should target key lifecycle stages of the species being monitored.
    - For threatened frogs, this should include the breeding periods, including calling and when tadpoles are present. This may require multiple surveys per year.
    - For the Giant Dragonfly, surveys should target the key emergence period between December and January.
36. Monitoring techniques should be targeted at, and suitable for, the species being monitored.
37. Surveys for threatened frogs must include nocturnal visual-aural surveys along monitoring transects. Use of 100 m x 100 m (1 ha) monitoring sites is not considered a suitable monitoring technique.
38. Instead of the measures of abundance outlined in the Biodiversity Management Plan, monitoring for threatened frogs should be undertaken to compare abundance along monitoring transects year-on-year.
39. Monitoring for threatened frogs should include monitoring of pool water levels at breeding locations identified during baseline surveys, including additional monitoring locations along Tributary P and Tributary R with sites informed by adequate baseline surveys.

40. If detected during baseline surveys, monitoring for the Giant Dragonfly should target exuviae in suitable habitat, as per recommendations of BCS. The company may also wish to considered use of eDNA surveys at the lower reaches of the swamps.
41. Surveys for threatened frogs must include nocturnal visual-aural surveys along monitoring transects. Use of 100 m x 100 m (1 ha) monitoring sites is not considered a suitable monitoring technique.

Other matters

42. Drivage of MG313 should be delayed until an Extraction Plan covering LW 313 has been endorsed by the Department.

REFERENCES

BCS 20/05/2024 [Biodiversity Conservation and Science Group, DPHI Resource Assessment], letter from Michael Saxon, BCS to Melanie Hollis, DPHI Resource Assessments

BCS 2024a. Re: Metropolitan Coal - Longwalls 311-316 Extraction Plan. Letter to the Department of Planning, Housing and Infrastructure, 20 May 2024. DOC24/348173.

BCS 2024b. Re: Metropolitan Coal Extraction Plan LW 311-316: Response to Agency Submissions . Letter to the Department of Planning, Housing and Infrastructure, 25 July 2024. DOC24/583146 .

DPHI 2024. Metropolitan Coal – Extraction Plan for Longwalls 311 to 316 Independent Expert Advisory Panel for Mining – Stage 1 Briefing, July 2024

IAPUM 2022. Advice Re: Metropolitan Mine Longwalls 308-310 Extraction Plan. dated September 2022

IEPMC 2019. Independent Expert Panel for Mining in the Catchment Report: Part 2. Coal Mining Impacts in the Special Areas of the Greater Sydney Water Catchment. Galvin, J.M., McIntyre, N., Young, A., Williams, R.M., Armstrong, C., Canbulat, I. Sydney: NSW Office of NSW Chief Scientist and Engineer

IEAPM 2023a. Advice Re: Water Quality Performance Measures for Metropolitan Coal Mine. Report IEAPM 202310-1(R1) dated October 2023

IEAPM 2023b. Advice Re: Metropolitan Coal Mine: High Level Review - Large swamp environmental assessment requirements for the Extraction Plan for Longwalls 311 to 316. Report IEAPM 202311-1 dated November 2023

IEAPM 2023c. Advice Re: Metropolitan Coal Mine: Independent review of environmental performance to 2022 (Dupen, 2023). Report IEAPM 202309-2 dated September 2023

MSEC 2024. Metropolitan Mine – Revised Layout for Longwalls 311 to 316 Mine Subsidence Overview. Letter to Jon Degotardi dated 2 June 2024.

NSW DPIE 2020. NSW Survey Guide for Threatened Frogs - A guide for the survey of threatened frogs and their habitats for the Biodiversity Assessment Method.

NSW Planning Assessment Commission (2009). The Metropolitan Coal Project Review Report, NSW Planning Assessment Commission, Sydney

OEH 2012, Upland Swamp Environmental Assessment Guidelines, Office of Environment and Heritage, Sydney.

Peabody 2024a. Metropolitan Coal Longwalls 311-316 Extraction Plan - Main Text

Peabody 2024b. File named “Metropolitan Coal - Response to IEAPM Recommendations LW 308-310”, Undated

Peabody 2024c. Letter to DPHI. Metropolitan Coal Longwalls 311-316 Extraction Plan – Response to Submissions, dated 3 July 2024

Peabody 2024d. Metropolitan Coal – Longwalls 311-316 Extraction Plan Response to Independent Expert Advisory for Mining Request for Information, Received by Panel 14 August 2024

Peabody 2024e. File named “LW311-316 EP - Large Swamps 76 77 92 - Proposed New TARP”, Received by Panel 26/08/2024

SLR (2023a) Groundwater Six-Monthly Report – 1 January to 30 June 2023. SLR Project No. 665.10000-R10 dated 3 October 2023

SLR (2023b) Groundwater Investigation 2023 Transect Bores T3-R and T5. Memo dated 27 November 2023

APPENDIX A – DPHI REQUEST FOR ADVICE AND REVISED REQUEST FOR ADVICE

Our ref: MP 08_0149

Emeritus Professor Jim Galvin
Chair - Independent Expert Advisory Panel for Mining

By email: j.galvin@bigpond.net.au

4 July 2024

Subject: Request for Advice – Metropolitan Coal Mine – Longwalls 311 to 316 Extraction Plan

Dear Prof Galvin

I am writing to you to request advice from the *Independent Expert Advisory Panel for Mining* (the Panel) in relation to the Metropolitan Coal Mine (MP 08_0149).

Metropolitan Coal is seeking approval for an Extraction Plan (EP) for secondary coal extraction from Longwalls (LW) 311 to 316 which are a continuation of the longwall series undermining the Woronora Reservoir. A copy of the EP application is provided as **Attachment 1**.

Metropolitan Coal has consulted with several agencies in the preparation of this EP. A copy of agency advice and Metropolitan Coal's response to this advice is attached for your consideration (see **Attachment 2**).

Further feedback is being sought from these agencies by the Department and will be provided to the Panel when received (to be provided as **Attachment 3**).

The Department considers the key technical issues for LWs 311 to 316 are the potential impacts to swamps and water quality, as raised in the advice from the Department of Climate Change, Energy, the Environment and Water (DCCEEW), Biodiversity, Conservation and Science (BCS) and WaterNSW. In particular, the impacts of mining on three large swamps (i.e. S76, S77 and S92) and their associated threatened species, and water quality of watercourses and the Woronora Reservoir, have been raised as specific concerns.

The Panel has previously provided advice on the Metropolitan Mine which included recommendations relevant to the LW 311 to 316 EP. This advice included:

- *Advice re: Metropolitan Mine Longwalls 308 – 310 Extraction Plan* (September 2022);

- *Independent review of environmental performance to 2022* (September 2023);
- *Water Quality Performance Measures for Metropolitan Coal Mine* (October 2023);
- *High Level Review – Large swamp environmental assessment requirements for the Extraction Plan for Longwalls 311 to 316* (November 2023).

Metropolitan Coal provided responses to recommendations made in these documents (see Attachments 4 and 5).

The Department is seeking advice from the Panel on the LW 311 to 316 EP, including:

- whether the Panel's previous recommendations in the documents above have been adequately addressed, particularly in relation to large swamps and water quality modelling and monitoring;
- the adequacy of the large swamp impact predictions presented in the *Large Swamp Assessment* (Appendix H of the EP) and associated appendices;
- the adequacy of the proposed performance measures and indicators for large swamps required by condition 4(b) Schedule 3 of the consent and included in the *Large Swamp Assessment* (Section 7.2), and the need or otherwise to set more defined performance measures for large swamps beyond those related to threatened species, populations, or ecological communities;
- the need or otherwise to modify the mine plan to minimise/avoid impacts, particularly on large swamps, and ensure compliance with existing and proposed performance measures;
- the adequacy of the water and swamp monitoring programs;
- the water and swamp TARPs and whether they:
  - enable measurement of compliance with existing and proposed performance measures established under the consent and proposed in the EP for large swamps; and
  - have triggers (and associated performance indicators) that adequately reflect the existing and proposed performance measures.

The Panel should feel free to provide any other advice it considers would assist the Department in reviewing the EP.

To assist the Panel, I have attached a copy of Metropolitan Coal's six-monthly report January to June 2023, and the most recent Waratah Rivulet Technical Committee Valley Closure Meeting for LW 309 (see **Attachment 6** and 7).

It would be appreciated if the Panel can provide advice on the EP by **16 August 2024.**

Please contact me on 8274 1274 or jessie.evans@dpie.nsw.gov.au if you have any questions or require additional information for your review.

Yours sincerely,

JEvans

Jessie Evans

Director
Energy and Resource Assessments

Attachments:

1. LW 311 to 316 EP
2. Agency Advice to Metropolitan Coal
3. Agency Advice to the Department
4. Metropolitan Coal's response to agency comments
5. Metropolitan Coal's responses to Panel recommendations on the EPs for LW 308-310 and LW 31-316
6. Metropolitan Coal Six Monthly Report January to June 2023
7. Waratah Rivulet Technical Committee Valley Closure Meeting for LW 309 – 1 March 2024

Department of Planning, Housing and Infrastructure

NSW GOVERNMENT

Our ref: MP 08_0149

Emeritus Professor Jim Galvin
Chair - Independent Expert Advisory Panel for Mining

By email: j.galvin@bigpond.net.au

2 August 2024

Subject: Request for Advice – Metropolitan Coal Mine – Longwalls 311 to 316 Extraction Plan

Dear Prof Galvin

Thank you for your letter dated 26 July 2024, outlining the Panel's staged approach for providing advice on the Metropolitan Coal Mine Extraction Plan for Longwalls 311 to 316 (Extraction Plan). I note the staged approach will comprise:

1. Reviewing whether the Panels' previous recommendations have been adequately addressed in relation to large swamps and water quality modelling and monitoring;
2. Restricting the Stage 1 advice to LW311 and 312; and
3. Recommending clear and timely performance indicators that unambiguously define when impacts on biodiversity are greater than negligible.

The Department accepts this staged approach.

As the Panel is aware, the Department has requested that government agencies provide advice on the Revised Extraction Plan. WaterNSW and BCS have requested additional information on performance measures and indicators and adequacy of monitoring programs.

The Department will request that Metropolitan Coal provides a response to agency comments for Stage 1. To aid in providing a timely response to the Panel, the Department will request that Metropolitan Coal's response is focused on proposed performance measures and indicators, and monitoring programs, for LWs 311 and 312.

It would be appreciated if the Panel can provide advice on the EP by **23 August 2024.**

Please contact me on 8274 1274 or jessie.evans@dpie.nsw.gov.au if you have any questions or require additional information for your review.

Yours sincerely,

JEvans

Jessie Evans

Director
Energy and Resource Assessments

APPENDIX B – PANEL BIOGRAPHY

Jim Galvin (Chair)

Professor Galvin is an Emeritus Professor (University of New South Wales) in Mining Engineering and former member of the NSW Planning Assessment Commission. Professor Galvin is one of the world's foremost experts on underground coal mining and subsidence and has extensive experience in geomechanics, mine management and risk management. He was a member of the Independent Panel for the Southern Coalfield Inquiry (2008), several subsequent reviews of mining projects in the Southern Coalfield and most recently, Chair of the Independent Expert Panel on Mining in the Catchment.

John Ross

John Ross is a Senior Principal Hydrogeologist with over 40 years' experience specialising in water resource, site contamination, infrastructure, mining and natural resource impact assessment and management. His specialty is sedimentary basin hydrogeology, particularly the Great Artesian Basin, Sydney-Gunnedah and Gloucester basins here in NSW. John has held specialist management roles in public and private corporations and environmental consultancies. He has a Bachelor of Science (Geology) and a Certificate in Engineering Hydrology and Groundwater Hydrology.

John provides technical hydrogeological expertise and advice across the spectrum of water resource development, environmental/water planning, assessment and management projects, including environmental impact assessments, environmental audits and technical peer reviews, monitoring programs, remedial action plans, modelling and groundwater licensing matters. John also has extensive experience in community and regulatory consultation across the eastern seaboard.

Neil McIntyre (co Chair for this Advice)

Neil McIntyre is Professor of Hydrology and Water Resources at The University of Queensland. He holds a BEng in Civil Engineering from Edinburgh University, and an MSc in Environmental Engineering and PhD in water quality modelling from Imperial College London. He is a Chartered Civil Engineer (UK Engineering Council), with expertise including surface water hydrology, water security assessments, and impacts of land use changes and mining on hydrology and water quality. His advisory roles have included serving on the Institution of Civil Engineer's Water Expert Panel (UK), the Steering Committee of the Commonwealth Leading Practice Sustainable Development Program, and the NSW Independent Expert Panel for Mining in the Catchments.

Ann Young

Dr Young is a retired academic who worked at the University of Wollongong's School of Earth and Environmental Sciences. Her PhD was a seminal study into the upland swamps on the Woronora Plateau. Between 2006 and 2017, she was a member of community consultative committees at two mines in the Southern Coalfield. She was involved with the Commonwealth Government's review of Temperate Highland Peat Swamps on Sandstone EEC and a member of the NSW Government's Independent Expert Panel for Mining in the Catchment.

Nathan Garvey

Nathan is an experienced ecologist with over 20 years' practice in biodiversity assessment and approvals across eastern Australia. Nathan holds a Bachelor of Science and Graduate Diploma in Biological Science from the University of NSW and is a Certified Environmental Practitioner and a Biodiversity Assessment Method (BAM) accredited assessor under the Biodiversity Conservation Act.

Nathan has experience across a diverse range of sectors including mining, oil and gas, linear infrastructure, renewable energy and residential development, including biodiversity assessment for major projects, offsetting and EPBC Act referrals. He has strong expertise and experience in the assessment of impacts to biodiversity arising from subsidence, as well as impacts to groundwater dependent ecosystems arising from groundwater drawdown. He is one of NSW's leading experts in biodiversity approvals and offsetting.

David Waite

David Waite is a Scientia Professor in the School of Civil and Environmental Engineering at the University of New South Wales. Professor Waite obtained his PhD from the Massachusetts Institute of Technology and has served as the Head of the Department of Water Engineering (1993-1999), Director of the Centre for Water and Waste Technology (1993-2006), Head of the School of Civil and Environmental Engineering (2007-2013) and Deputy Dean of the Faculty of Engineering (2013-2018) at UNSW. His principal research areas are that of investigation of physico-chemical processes in natural and engineered systems and biogeochemical transformation and fate of contaminants. Professor Waite is the CEO of the UNSW Centre for Transformational Environmental Technologies (CTET) and is an Associate Editor of the journal Environmental Science & Technology. He was honoured with international membership of the US National Academy of Engineering in 2018 for his distinguished service to engineering.

Department of Planning, Housing and Infrastructure

Our ref: MP08_0149-PA-103

Mr Jon Degotardi
Manager – Project Approvals
Metropolitan Collieries Pty Ltd

Via email: jdegotardi@peabodyenergy.com

19 October 2024

Subject: Approval for Extraction of Longwall 311

Dear Mr Degotardi

I refer to the Extraction Plan (EP) for Longwalls (LWs) 311-316 (dated 3 July 2024) submitted in accordance with condition 6, Schedule 3 of the Metropolitan Coal Project (MP08_0149). I also acknowledge the Independent Expert Advisory Panel for Mining (the Panel) advice on the EP (dated 5 September 2024 and 16 October 2024) and Metropolitan Collieries Pty Ltd (MC) response to this advice (dated 23 September 2024 and 2 October 2024).

Note that the Panel and Department have agreed that a staged approach to assessment and approval of LWs 311-316 is suitable. Consequently, consideration of the EP to date has been restricted to LWs 311 and 312 only.

I also note that in its most recent advice on the EP, the Panel determined that it is now in a position to support the EP for LW311 if the conditions of approval include provisions for additional surveying of threatened species and their environment in order to better inform conformance with the revised Performance Measures.

Accordingly, as nominee of the Planning Secretary, I approve the secondary extraction of LW 311 (only) as described in the EP, subject to the following conditions:

1. MC must complete the following surveys in accordance with the robust monitoring methods specified in Section 6 of the Panel advice (dated 5 September 2024):
    a. targeted surveys for Littlejohn's Tree Frog (Jul-Nov) and Giant Burrowing Frog (Feb- May) in Tributary P and Tributary R;
    b. suitable baseline surveys for pool and surface water levels, based on baseline frog surveys above, in Tributary P and Tributary R; and
    c. targeted surveys for the Giant Dragonfly (Dec-mid Jan) and Ground Parrot in Swamp 92.

2. MC must confirm the Performance Measures and Performance Indicators for threatened species in accordance with Sections 6.3 and 6.6 of the Panel advice (dated 5 September 2024).
3. MC must revise the monitoring program for all threatened species in accordance with Section 6.5 of the Panel advice (dated 5 September 2024).

I confirm that this approval does not extend to secondary extraction of LW 312. It is suggested that MC carefully consider the further Panel advice on LW 312, particularly in relation to potential impacts to Swamps 77 and 92, and implications to the longwall stand-off distances and proposed Trigger Action Reponses Plans.

You are reminded that if there are any inconsistencies between the EP and the conditions of approval, the conditions prevail. Please ensure you make the document publicly available on the project website at the earliest convenience.

If you wish to discuss the matter further, please contact Melanie Hollis on 02 8217 2043.

Yours sincerely,

JEvans

Jessie Evans

Director
Energy and Resource Assessments

As nominee of the Planning Secretary

ATTACHMENT 4

KEY CONTACT REGISTER

METROPOLITAN COAL LONGWALLS 311-316

EXTRACTION PLAN




ATTACHMENT 4

KEY CONTACT REGISTER

Peabody

ATTACHMENT 4
KEY CONTACT REGISTER

Table A4-1
Emergency Contacts

Organisation	Phone Number
Emergency Services (Police, Fire Ambulance)	000
NSW Environment Protection Authority	131 555
State Emergency Services	132 500
WorkCover Authority	13 10 50
Subsidence Advisory NSW (24-hour Emergency Service)	1800 248 083
Dams Safety NSW Executive Engineer (24-hour Emergency Contact)	(02) 9842 8070 0403 681 645
Wollongong City Council	(02) 4227 7111

Table A4-2
Internal Metropolitan Coal Contact Details

Position	Contact Name	Phone Number
Executive General Manager	James Hannigan	(02) 4294 7201
Mining Engineering Manager	Brenton Vermeulen	(02) 4294 7234
Approvals Manager	Jon Degotardi	(02) 4294 7233
Technical Services Manager	Nicolas Tucker	(02) 4294 7294
Environment & Community Superintendent	Stephen Love	(02) 4294 7384
Metropolitan Control Room (Manned 24 hours)	Control Operator	(02) 4294 7333
Community Hotline (24 hours)		1800 115 003

Table A4-3
Stakeholder Contact Details

Stakeholder	Position	Contact Name	Email/Contact Phone Number	Postal Address
NSW Government Agencies				
Department of Planning, Housing and Infrastructure (DPHI)	Director, Resource Assessments Principal Planning Officer, Resource Assessments	Jessie Evans Melanie Hollis	Jessie.Evans@planning.nsw.gov.au melanie.hollis@planning.nsw.gov.au	Locked Bag 5022 Paramatta NSW 2124
Resources Regulator	Project Coordinator, Royalties and Advisory Services Manager & Principal Inspector Environment	Alex Love Greg Kininmonth	industry.coordination@industry.nsw.gov.au Greg.Kininmonth@planning.nsw.gov.au	GPO Box 5477 Maitland NSW 2320 PO Box 674 Wollongong NSW 2520
Subsidence Advisory NSW	Manager, Claimant Outcomes - South	Matthew Montgomery	Matthew.Montgomery@customerservice.nsw.gov.au 24hr contact 1800 248 083	PO Box 488G, Newcastle 2300
Dams Safety NSW	Manager, Mining Projects	Heather Middleton	Heather.Middleton@dpie.nsw.gov.au dsc.mining@damsafety.nsw.gov.au (02) 9842 8077	Locked Bag 5123 Parramatta NSW 2124
WaterNSW	Manager, Environment & Catchment Protection	Camilla Edmunds	camilla.edmunds@waternsw.com.au	PO Box 398 Parramatta NSW 2124
Natural Resources Access Regulator	-	-	nrar.servicedesk@industry.nsw.gov.au	Locked Bag 5123 Parramatta NSW 2124
Biodiversity, Conservation and Science Directorate	Director, South-East Conservation and Regional Delivery Division Senior Team Leader, Ecosystems and Threatened Species	Michael Saxon James Dawson	Michael.Saxon@environment.nsw.gov.au James.Dawson@environment.nsw.gov.au (02) 4224 4125	Locked Bag 5022 Paramatta NSW 2124
Heritage NSW	Archaeologist (Illawarra)	Rose O'Sullivan	heritagemailbox@environment.nsw.gov.au	Locked Bag 5020 Paramatta NSW 2124
Department of Primary Industries – Fisheries	Regional Manager, Central/Metro Aquatic Ecosystems	Scott Carter	Scott.Carter@dpi.nsw.gov.au	Locked Bag 1 Nelson Bay NSW 2315
NSW Environment Protection Authority	Manager Regional Operations Illawarra Senior Operations Officer	Peter Bloem Andrew Couldridge	Andrew.Couldridge@epa.nsw.gov.au (02) 4224 4100	PO Box 513 Wollongong NSW 2520

Table A4-3 (Continued)
Stakeholder Contact Details

Stakeholder	Position	Contact Name	Email/Contact Phone Number	Postal Address
Aboriginal Groups				
Cubbitch Barta Native Title Claimants	-	Glenda Chalker	-	55 Nightingale Road Pheasants Nest NSW 2574
Korewal Elouera Jerrungurah Tribal Elders Corporation	-	Reuben Brown	-	86 Hertford Street Berkeley NSW 2506
Caines Family	-	Gary Caines	-	28 Gowan Brae Road Mount Ousley NSW 2519
La Perouse Botany Bay Aboriginal Corporation	-	Yvonne Simms	-	10 Murrong Place La Perouse NSW 2036
Woronora Plateau Gundungara Elders Councils	-	Paul Cummins	-	11 Garnett Grove Flinders NSW 2529
Tharawal Local Aboriginal Land Council	-	Rebecca Ede	-	PO Box 245 Thirlmere NSW 2572
Wodi Wodi Dharawal/Yuin Traditional Owners	-	James Davis	-	2 Poplar Avenue Unanderra NSW 2526
Illawarra Local Aboriginal Land Council	Chief Executive Officer	Adell Hyslop	-	PO Box 1306 Wollongong NSW 2500
Community				
Wollongong City Council	Development Project Officer	Nina Kent	nkent@wollongong.nsw.gov.au	Locked Bag 8821 Wollongong DC NSW 2500
Metropolitan Coal Community Consultative Committee	Independent Chair	Lisa Andrews	lisaandrews.ic@gmail.com	PO Box 6017 Lake Munmorah NSW 2259