INDEPENDENT ADVISORY PANEL FOR UNDERGROUND MINING

ADVICE RE:

METROPOLITAN MINE

LONGWALLS 308 - 310

EXTRACTION PLAN

September 2022

EXECUTIVE SUMMARY

The Metropolitan Coal Mine is an underground coal mine located adjacent to the town of Helensburgh, approximately 30 kilometres (km) north of Wollongong in the Southern Coalfield of NSW.

Mining at the site has occurred historically since the 1880s. The mine is owned and operated by Metropolitan Coal Pty Ltd, a wholly owned subsidiary of Peabody Energy Australia Pty Ltd. The current mining operations, under Project Approval MP08_0149 were approved by the then NSW Minister of Planning on 22 June 2009 and have subsequently been modified on three occasions.

Condition 6 of Schedule 3 of the Project Approval requires the preparation of an Extraction Plan prior to the commencement of second workings. The Extraction Plan must demonstrate that mining operations do not cause exceedances of the performance measures identified in Condition 1 of Schedule 3 of the Project Approval.

Metropolitan Coal is currently extracting coal from Longwall 307 under an Extraction Plan approval for Longwalls 305-307 granted by the Department in March 2020.

On 12 July 2022, the NSW Department of Planning and Environment (DPE) requested the Independent Advisory Panel for Underground Mining (the Panel) to provide advice in relation to the Extraction Plan for Longwalls 308 to 310 at the Metropolitan Colliery.

Specifically, the DPE requested advice on:

1. The Groundwater, Biodiversity and Heritage monitoring programs and whether:
    - *there is an adequate network of monitoring stations in representative locations, especially the T-series of groundwater monitoring bores;*
    - *the frequency of monitoring is sufficient to identify and therefore limit any potential exceedances of performance indicators and/or performance measures; and*
    - *allows for adequate baseline data for future EPs, particularly for swamps S76, S77 and S92.*
2. Subsidence Assessment and whether subsidence predictions and interactions with geological structures are accurately presented.
3. The Groundwater, Biodiversity and Heritage TARPs and whether they:
    - *enable measurement of compliance with the performance measures; and*
    - *have triggers (and associated performance indicators) that adequately inform the mine's overall performance with respect to subsidence impact and environmental consequences.*

The Panel reviewed a range of documents in preparing its advice, met on multiple occasions via videoconference and requested supplementary information from the Applicant. The Panel also undertook a site inspection of Metropolitan Coal Mine and relevant significant surrounding surface features. The Panel's findings include a number of key conclusions and recommendations in relation to the Extraction Plan. These include:

1. <u>Mine Plan and Subsidence Implications</u>

    The Panel concludes that:

(i) the methodologies used to predict conventional and non-conventional subsidence effects are appropriate and the levels of confidence in the predictions have been adequately presented.
(ii) the subsequent extraction of LW311 to LW313 will result in increased subsidence over LW308 to LW310 to that reported in the Extraction Plan. However, although vertical displacement is predicted to almost double over LW310, the conservative nature of the mine layout results in minor corresponding increases in strain and tilt and, therefore, is unlikely to result in significant increases in impacts over LW308 to LW310.

The Panel recommends that the Extraction Plan be updated to include:
(i) incremental, transient and cumulative predictions of both conventional and non-conventional surface subsidence parameters for LW308 to LW310 over the projected life of the mine;
(ii) a reassessment of the impacts and consequences associated with these revised subsidence predictions.

2. Geological Structures

The Panel recommends that, notwithstanding any in-principle endorsement of the Extraction Plan for LW308 to LW310, extraction of these panels should not commence until the Woronora Impact Strategy Review Panel confirms that geological structures have not acted as conduits for abnormal or higher than predicted water inflow to mine workings from Woronora Reservoir following the extraction of LWs 305, 306 and 307.

3. Heritage Management Plan

The Panel's advice on the management of Aboriginal heritage is on hold pending ongoing inquiries being made by DPE. In the interests of time, advice on the Heritage Management Plan will be provided in a supplementary report when the outstanding information becomes available to the Panel.

4. Surface Water

The Panel concludes that:

(i) Type 3 fracture impacts to Waratah Rivulet due to the proposed LW308 to LW310 are unlikely. However, the valley closure triggers in the proposed Waratah Rivulet TARP are not likely to indicate increasing likelihood of a Type 3 fracture before the fracture occurs and these triggers are not sufficiently justified in the Extraction Plan or in supplementary information provided to the Panel.

(ii) Aside from the Panel's preceding conclusion about the Waratah Rivulet TARP and the Panel's conclusions related to how geological structures might impact surface water, the Panel has no significant concerns regarding the surface water management plan in this Extraction Plan.

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.

5. Groundwater

The Panel recommends that:

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. 10m 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.

6. Swamps

Monitoring

The Panel concludes for the swamps relevant to LW308 to LW310 that the network and frequency of monitoring is adequate.

The Panel recommends 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.

TARPS

The Panel recommends that the following revisions to the upland swamp vegetation TARP:

- 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.
- 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 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 joints, rather than fracturing of intact sandstone.
- *'Surface cracking within upland swamps resulting from mine subsidence is..'* should be replaced with *'Subsidence impacts are..'*.
- The large swamps S76, 77 and 92 should be added to this TARP.

Swamps 76, 77 and 92

The Panel concludes that mining of LW308 to LW310 is unlikely to impact Swamps 76, 77 and 92 but mining of subsequent panels may do so.

The Panel recommends that:

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 sinclude:
    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.

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1.0 SCOPE OF WORKS

The Metropolitan Coal Mine is an underground coal mine owned and operated by Metropolitan Coal Pty Ltd, a wholly owned subsidiary of Peabody Energy Australia Pty Ltd. The mine is located adjacent to the town of Helensburgh, approximately 30 kilometres (km) north of Wollongong in the Southern Coalfield of NSW. Mining at the site has occurred historically since the 1880s.

The current mining operations, under Project Approval MP08_0149 were approved by the then NSW Minister of Planning on 22 June 2009 and have subsequently been modified on three occasions.

Conditions 6 and 7 of Schedule 3 of the Project Approval require the preparation of an Extraction Plan prior to the commencement of second workings. The Extraction Plan must demonstrate that mining operations do not cause exceedances of the performance measures identified in Condition 1 of Schedule 3 of the Project Approval.

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Specifically, the DPE requested advice on:

1. The Groundwater, Biodiversity and Heritage monitoring programs and whether:
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3. The Groundwater, Biodiversity and Heritage TARPs and whether they:
    - *enable measurement of compliance with the performance measures; and*
    - *have triggers (and associated performance indicators) that adequately inform the mine's overall performance with respect to subsidence impact and environmental consequences.*

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

- Em. Professor Jim Galvin – Chair – Subsidence and Mining
- Professor Neil McIntyre – Surface Water
- Dr Ann Young – Swamps and Ecology
- Em. Professor Rae Mackay – Groundwater

2.0 METHOD OF OPERATION

The Panel convened by videoconferences throughout the preparation of its advice and was administratively supported by Secretariat staff provided by the DPE's Major Project and Resource Assessment Teams. Three members of the Panel also undertook a site inspection on 10 August 2022.[1]

A wide range of documents were reviewed by the Panel in preparing this review. The principal documents are summarised in Table 1.

Table 1: Key documents reviewed by the Panel

Document Reference	Document Name
Extraction Plan	Extraction Plan – Metropolitan Coal Mine LW 308-310, including the following addendums/volumes: • Extraction Plan: Main Document • Response to Agency Submissions (May 2022) • Appendix A - Water Management Plan • Appendix B - Land Management Plan • Appendix C - Biodiversity Management Plan • Appendix D - Heritage Management Plan • Appendix E - Built Features Management Plan • Appendix F - Public Safety management Plan • Appendix G - Subsidence Management Plan • Appendix H - Coal Resource Recovery Plan • Appendix I – Subsidence Report
The Applicant's Response to Additional Information Requests	• SLR Consulting Australia Pty Ltd (2020) Metropolitan Coal Groundwater: Model Calibration Report. • SLR Consulting Australia Pty Ltd (2021) Metropolitan Coal Groundwater Monitoring Report – 1 January – 30 June 2021. • RM (2021) Metropolitan Collieries Pty Ltd–Longwalls 308-310 Environmental Risk Assessment Report – 26 November 2021. • Appendix B1 - Hydro Engineering & Consulting Pty Ltd (2021) Metropolitan Coal Surface Water Review 1 January to 30 June 2021 • Appendix B2 - Hydro Engineering & Consulting Pty Ltd (2021) Surface Water Review 1 January to 31 December 2021 • SLR Consulting Australia Pty Ltd (2021) Groundwater Investigation November 2021 - Appendix G Groundwater Investigation Bores T3-T5 – 2021 Annual Review • SLR Consulting Australia Pty Ltd (2022) Groundwater Investigation June 2022 – Transect Bores T2, T3 and T5 • MSEC (2022) Subsidence Predictions including attachments 1-4 for Longwalls 301-317 as specified in email dated 7 September 2022

[1] Dr Ann Young, Professor Neil McIntyre and Em. Professor Rae Mackay.

The Applicants response to questions raised during site visit	• Email from Metropolitan Coal (2022) in response to IAPUM Questions arising from site visit to Metropolitan – 12 August 2022 • Email from Metropolitan Coal (2022) in response to IAPUM Questions arising from site visit to Metropolitan – 17 August 2022 • Email from Metropolitan Coal (2022) in response to IAPUM queries regarding Definition of Aboriginal Heritage (25/7/22 email from IAPUM) – 27/7/22 • Email from Metropolitan Coal (2022) in response to IAPUM queries regarding predictions of cumulative subsidence after completion of LW 313 (IAPUM email of 6/9/22) – 7/9/22
Agency Advice	• DPE Biodiversity and Conservation Division • Dam Safety • DPE Water • Heritage NSW • Mining Exploration and Geoscience • Resource Regulator • Subsidence Advisory • Water NSW

2.1. SITE VISIT, SUBSEQUENT INFORMATION AND MEETINGS

Site Visit

The site inspection by three members of the Panel took place on 10 August 2022.[2] It involved a briefing at Metropolitan Coal Mine by the Applicant, followed by an inspection of key surface features including Swamp 92, Swamp 89, local streams, pools and an Aboriginal cultural heritage site, FRC 68.

The Panel was accompanied by the Applicant and its relevant consultants, the DPE's Secretariat for the Panel and a member from the DPE's Resource Assessments team.

Subsequent Information

The Panel sourced additional reports from the Applicant, as outlined in Table 1.

Meetings

The Panel convened several times over the course of preparing its advice. Table 2 summarises the schedule of meetings held in chronological order.

Table 2: Schedule of meetings held

Meeting Date	Meeting Information
22 July 2022	Panel Meeting – Initial Briefing by DPE
28 July 2022	Panel Approach Discussion
3 August 2022	Panel Progress Update
10 August 2022	Site Inspection – Visit to Metropolitan Coal Mine and Surface sites
26 August 2022	Site inspection recap, update on final report, discussion of remaining issues
2 September 2022	Discussion with DPE
21 September 2022	Discussion with DPE followed by Panel meeting

[2] While the Panel Chair, Em. Prof Jim Galvin, could not participate in the site visit, he had an overall appreciation of the site and issues from his previous roles that include undertaking an independent risk study and assessment of mining impacts on Waratah Rivulet for the Department of Primary Industry in 2005; as a member of the 2007/08 Inquiry Panel that undertook the Strategic Review of Impacts of Underground Coal Mining on Natural Features in the Southern Coalfield; as a member of the 2009 Planning Assessment Commission Panel for the Metropolitan Coal Project; and as Chair of the 2018/19 Independent Expert Panel for Mining in the Catchment.

3.0 LW308 TO 310 FOUNDATION INFORMATION

3.1. SUBSIDENCE DEFINITIONS

This advice is premised on the following definitions as recommended by the 'Southern Coalfield Inquiry' (DoP, 2008):

- **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**.
- **Environmental Consequences:** the environmental consequences of **subsidence impacts**, including 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 on aquatic ecology, ponding, etc.

3.2. MINE PLAN AND SUBSIDENCE IMPLICATIONS

The mine plan is shown in Figure 1 and the associated Key Mining Parameters, as presented in the Extraction Plan, are reproduced in Table 3. The Panel notes, however, these parameters do not reflect the reduction in the width of the tailgate chain pillars of LW310 (from 70 to 45 m) that will occur over a significant length of LW310 once LW311 is developed.

Table 3: Key Mining Parameters for LW308 to LW310 as presented in the Extraction Plan.

Table 3
Key Mining Parameters

Parameter	Longwalls 308-310
ROM Coal Extracted (Mt)	Approx. 4.9
Gate Road Width (m)	5.2
Gate Road Height (m)	3.2
Maingate Chain Pillar Width (m)	70
Tailgate Chain Pillar Width (m)	70
Longwall Void Width (m) (ribline of goaf edge)	138
Longwall Void Length (m)	1,948 (LW308), 3,118 (LW309), 3,118 (LW310)
Seam Thickness (m)	2.6 – 2.9
Extraction Height (m)	Up to 3.2
Depth of Cover (m)	410 – 550

Mt = million tonnes.

Important points are the relatively narrow width of the longwall panels, the very wide chain pillars between LW306 to LW310, and the low to moderate range extraction height. These characteristics equate to a panel width-to-depth ratio range of ~0.25 to 0.34 and an interpanel pillar width-to-height ratio of ~22, both of which fall at the conservative end (least ground deformation) of the spectrum for longwall mining.

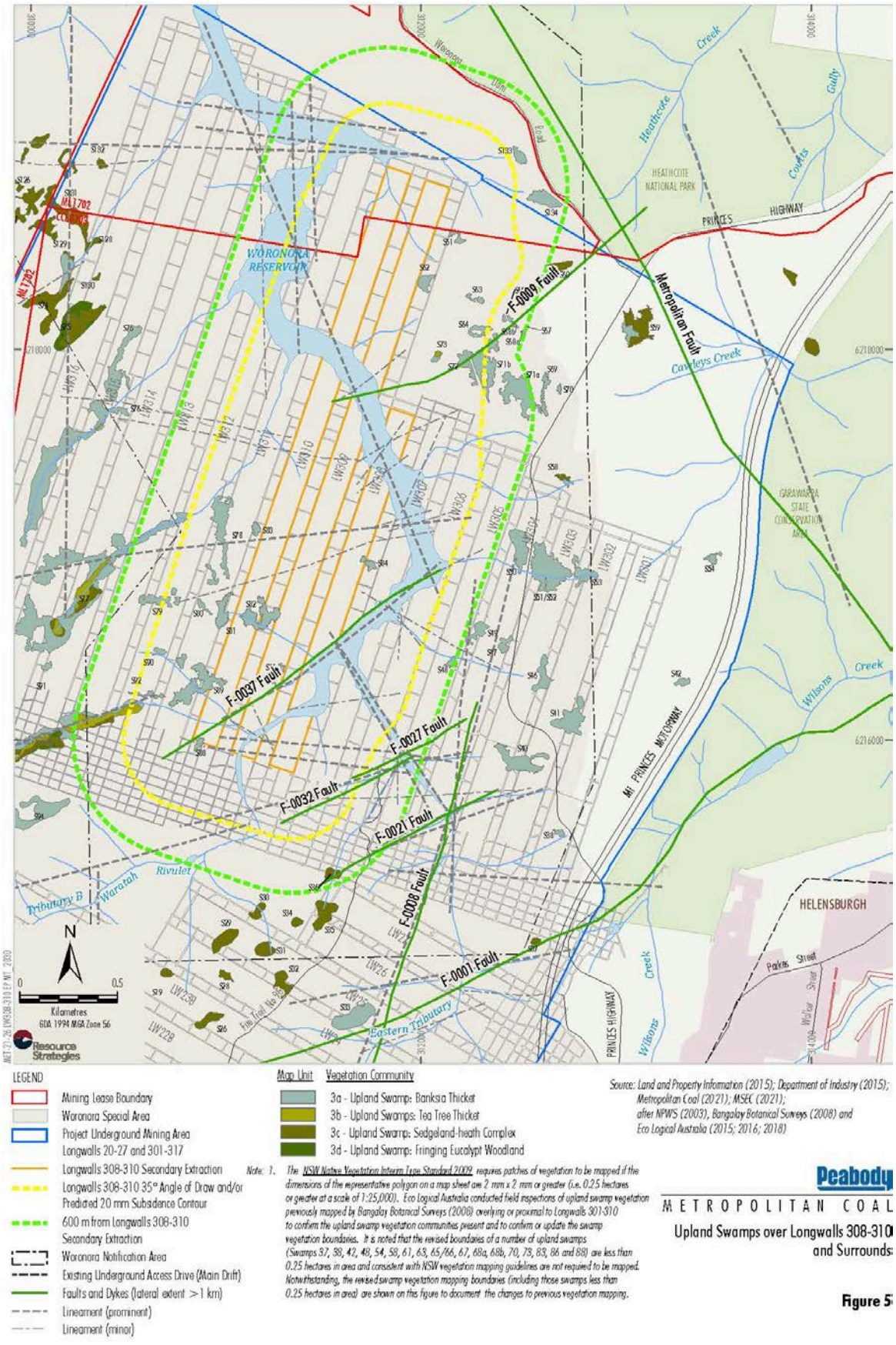

Figure 1: *Mine plan showing the proposed layout of LW308 to LW310*

The empirically based Incremental Profile Method (IPM) has been utilised by Mine Subsidence Engineering Consultants (MSEC, 2022) to predict conventional subsidence effects. This methodology is well established and has been utilised extensively at Metropolitan Mine and throughout the Southern Coalfield. It is supported by calibration to extensive site-specific performance data and supplemented with numerical modelling. The predictions of non-conventional subsidence effects, principally valley closure and upsidence, are derived from empirical models also developed by MSEC and based on extensive field performance data sourced from the Southern Coalfield. Predictions of both conventional and non-conventional subsidence effects are at least as good as alternative approaches and the order of accuracy and limitations associated with both methodologies are transparently identified.

Theoretically, the Key Mining Parameters presented in Table 3 could be expected to produce fairly benign conventional subsidence effects. This is supported by subsurface investigations, as reviewed by the Woronora Impact Strategy Review (WISR) Panel (Hebblewhite et al., 2017, 2019) and the Independent Expert Panel for Mining in the Catchment (IEPMC) (Galvin et al., 2018, 2019) and by surface subsidence monitoring over previous longwall panels as reported in the Subsidence Report for LW308-310 that comprises Appendix I of the Extraction Plan.

Maximum predicted mining-induced conventional subsidence effects associated with the extraction of LW308 to LW310 as reported in the Extraction Plan are reproduced in Table 4 of this advice. The Extraction Plan predicts a maximum vertical displacement of 475 mm, a maximum tilt of 2.5 mm/m and maximum curvatures that equate to around 0.75 mm/m of tensile strain and 1.2 mm/m of compressive strain. These are quite low by longwall mining standards and can be expected to restrict subsidence impacts and environmental consequences. This is reflected in the reduced focus on mitigation of subsurface and surface impacts and consequences in some of the Management Plans for LW308 to LW310 in comparison to typical Extraction Plans (and Subsidence Management Plans) associated with longwall mining.

Table 4: Incremental and maximum predicted mining-induced conventional subsidence effects associated with LW308 to LW310 (sourced from Extraction Plan).

Maximum Predicted Subsidence, Tilt and Curvature for Longwalls 308-310

Subsidence Parameter	Incremental Subsidence Predictions			Total Subsidence Predictions (after LW308-310)
	Longwall 308	Longwall 309	Longwall 310	
Maximum Subsidence (mm)	300	300	300	475
Maximum Tilt (mm/m)	2.0	2.5	2.5	2.5
Maximum Hogging Curvature (km^{-1})	0.04	0.03	0.04	0.05
Maximum Sagging Curvature (km^{-1})	0.10	0.07	0.08	0.08

Source: after MSEC (2021) (Appendix I).

mm/m = millimetres per metre.

km^{-1} = 1/kilometres.

Note: For the Southern Coalfield, strain (mm/m) can be approximated by multiply curvature by a factor of 15. Hence, a maximum hogging curvature of 0.05 km^{-1} and a maximum sagging curvature of 0.08 km^{-1} can be equated, respectively, to a maximum tensile strain of 0.75 mm/m and a maximum compressive strain of 1.2 mm/m.

However, the Panel notes that the subsidence predictions presented in the Extraction Plan are incomplete in that they do not take account of the additional subsidence that may develop over LW308 to LW310 when subsequent longwall panels are extracted. In particular, the planned

reduction in chain pillar width over the southern half of all longwall panels after LW310 can be expected to result in a significant increase in vertical displacement over LW310.

Further information from the Applicant on this matter included Figure 2, which the Panel has annotated to show that the subsequent extraction of LW311 to LW313 is predicted to result over LW310 in around a doubling of maximum vertical surface displacement (from 475 mm to about 950mm), an increase of about 1.5 mm/m in maximum (transient) tilt to 4 mm/m and a marginal increase in permanent tilt, and a marginal increase of about 0.15 mm/m in maximum (transient) compressive strain. The additional information did not address non-conventional subsidence. For watercourses, the additional subsidence could possibly result in increases in valley closures and strains, thus increasing the risk of fracturing and, where the watercourses flow through swamps (e.g. Swamp 82), knock-on risks to swamps. However, the Extraction Plan already acknowledges that the watercourses overlying LW308 to LW310 will experience the full range of subsidence impacts.

The Panel concludes that:

1. the methodologies used to predict conventional and non-conventional subsidence effects are appropriate and the levels of confidence in the predictions have been adequately presented.
2. the subsequent extraction of LW311 to LW313 will result in increased subsidence over LW308 to LW310 to that reported in the Extraction Plan. However, although vertical displacement is predicted to almost double over LW310, the conservative nature of the mine layout results in minor corresponding increases in strain and tilt and, therefore, is unlikely to result in significant increases in impacts over LW308 to LW310.

The Panel recommends that the Extraction Plan be updated to include:

1. incremental, transient and cumulative predictions of both conventional and non-conventional surface subsidence parameters for LW308 to LW310 over the projected life of the mine;
2. a reassessment of the impacts and consequences associated with these revised subsidence predictions.

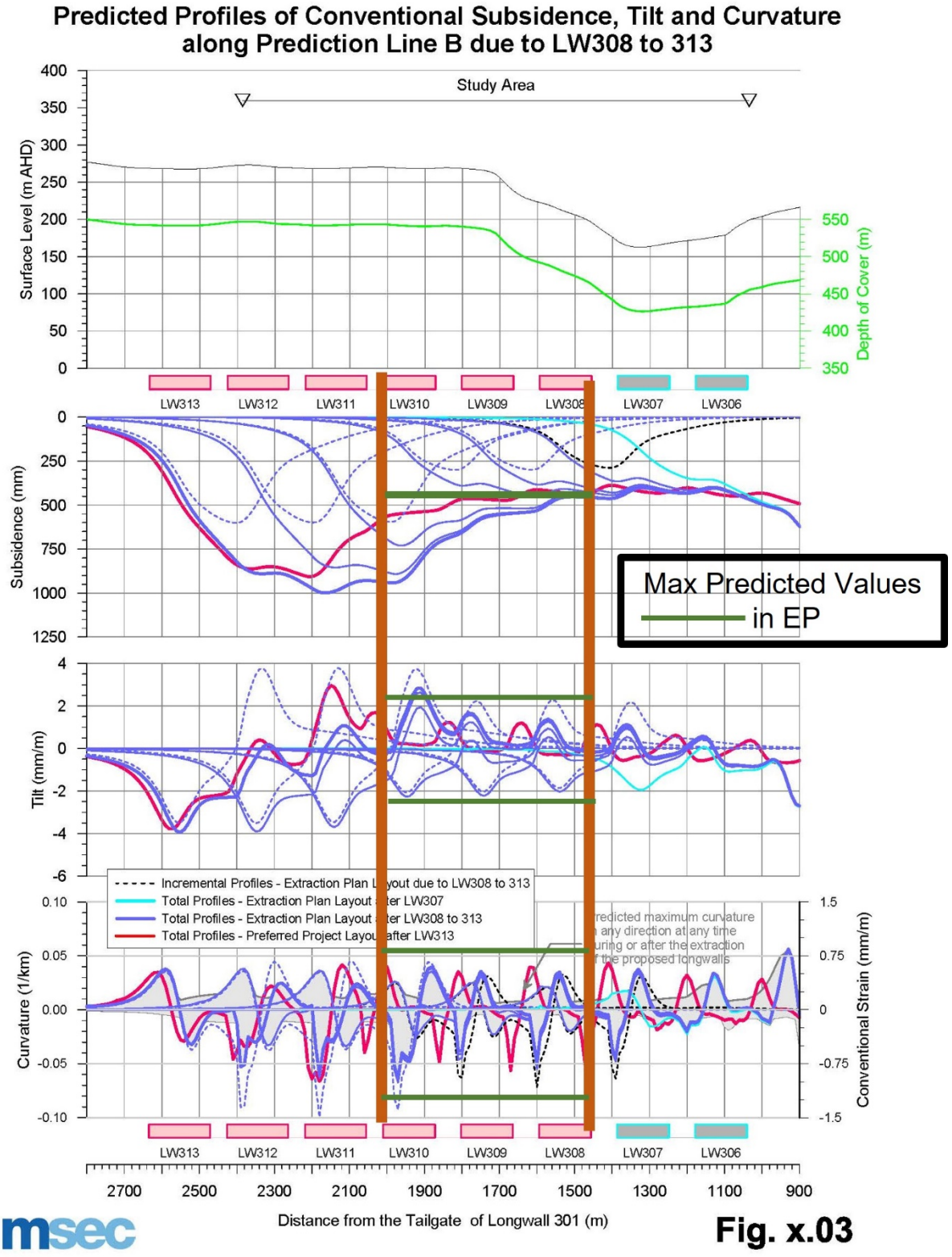

Figure 2: *Predicted conventional vertical displacements, tilts and strains over the southern portion of LW308 to LW310 after LW311 to LW313 have been extracted.*

4.0 GEOLOGICAL STRUCTURES

4.1. ANALYSIS AND ADVICE

Figure 1 shows the geological structures and lineaments[3] in the vicinity of LW308 to LW310. The Extraction Plan reports that lineaments have been examined for possible correlation to underground geological mapping in the study area of LW305 to LW307, including fault structure F-0027 which is coincident with a surface lineament passing through the body of Woronora Reservoir. It states that F-0027 was mined through by Maingate 305 and Maingate 306 without evidence of moisture.

Figure 1 also shows another fault structure, F-0037, which trends NE-SW and is coincident with a lineament that defines a significant drowned valley in the Woronora Reservoir. Both first workings (development roadways) and second workings (longwall mining) associated with LW306 to LW308 are planned under this section of Woronora Reservoir. This fault has surface expression as a sharp change of alignment in Stream P above LW310 (WMP Appendix A Figure 8).

The Extraction Plan also reports that the Stage 1 Report of the WISR Panel (Hebblewhite et al., 2017) included recommendations for further groundwater and surface water investigations and monitoring was approved by the Secretary for Planning in December 2017. The Stage 2 report of the WISR Panel (Hebblewhite et al., 2019) included 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. Amongst other things, WISR – Stage 2 concluded that based on the review of available data, analytical predictions and monitoring borehole 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.

The WISR provides a staged plan of action for further investigation into the impacts of mining near the reservoir. The Extraction Plan states that Metropolitan Coal has implemented a number of additional groundwater and surface water monitoring sites in response to the WISR Stage 1 and Stage 2 reports.

Appendix H of the Extraction Plan presents the outcomes of a risk assessment conducted in October 2021 on geological features with potential to affect water quantity available to Woronora Reservoir. The IAPUM Panel considers that the risk assessment team comprised an appropriate mix of internal and external expertise. The documentation does not provide insight into the technical aspects that informed the risk assessment. It records the need to address the following actions in respect of potential risk presented by lineaments, geological joints and faults:

- Targeted surface mapping above LW308-LW310.
- Review at end of panel the outcomes of LW306 when mining beneath lineaments for any evidence of water quantity available to Woronora Reservoir being affected.

[3] 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 (LW308-310 Extraction Plan, p. 9))

- Targeted post mining groundwater monitoring sites above LW305 to investigate height of fracture zone and presence of shear on bedding planes.

Control tools such as Trigger Action Response Plans (TARPs) are severely limited in their capacity to pre-empt and prevent inflow on geological structures. This is because water inflow is the only feasible parameter to monitor for and, even then, a lot of uncertainty can be associated with measured values and their source. Basically, inflow must already be occurring for a trigger to be activated.

The Panel notes that the extraction of LW 307 is well advanced. Accordingly:

The Panel recommends that, notwithstanding any in-principle endorsement of the Extraction Plan for LW308 to LW310, extraction of these panels should not commence until the WISR Panel confirms that geological structures have not acted as conduits for abnormal or higher than predicted water inflow to mine workings from Woronora Reservoir following the extraction of LWs 305, 306 and 307.

5.0 HERITAGE MANAGEMENT PLAN

5.1. THE ISSUES

The **Consent Conditions** include the following provisions:

Condition 6, Schedule 3 – A 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.

Condition 7, Schedule 3 – Management plans to include:

(a) a program to collect sufficient baseline data for future Extraction Plans
(b) a revised assessment of the potential environmental consequences
(c) a detailed description of the measures that would be implemented to remediate predicted impacts; and
(d) a contingency plan that expressly provides for adaptive management.

Subsidence Impact Performance Measures

Aboriginal heritage sites – Less than 10% of Aboriginal heritage sites within the mining area are affected by subsidence impacts.

Heritage NSW

Letter dated 7 March 2022:

"The HMP should clarify whether site specific management measures are needed to protect the Aboriginal cultural significance of particular sites detailed in the HMP." It is stated in the response that there are no site specific management measures proposed in the HMP. We do not consider this response to be sufficient because no information or clarification has been provided on whether or not site specific management measures are needed and, if so, what these should be. This information should be included in the HMP, as per our original advice.

5.2. ANALYSIS AND ADVICE

The Panel's advice on the management of Aboriginal heritage is on hold pending ongoing inquiries being made by DPE. In the interests of time, advice on the Heritage Management Plan will be provided in a supplementary report when the outstanding information becomes available to the Panel.

6.0 SURFACE WATER

6.1. THE ISSUES

- BCD has questioned the adequacy of the subsidence assessment for geological structures, especially those identified to underlie the Waratah Rivulet arm of Woronora reservoir and some major swamps (especially swamps S76 and S77).
- DPE is seeking advice from the Panel on Subsidence Assessment and whether subsidence predictions and interactions with geological structures are accurately presented.
- The IEPMC advised that:
    - it is important to confirm whether the presence of lineaments in the Southern Coalfield indicate heightened potential to impact on subsidence, groundwater and surface water in similar manners to those identified recently in the adjacent Western Coalfield;
    - faulting, basal shear planes and lineaments need to be very carefully considered and risk assessed 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 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;
    - the IEPMC was at that time relying on the WISR Stage 1 report (Hebblewhite et al., 2017) which stated that the area (around and under the Woronora Reservoir) appeared to be relatively clear of any high density or dominant fault structures and no dykes were known to be present in the area.

6.2. GENERALLY

The Department did not specifically request advice from the Panel on matters related to surface water impacts (flow, pool level or water quality), surface water TARPs or surface water monitoring. The surface water monitoring and impacts on water quantity and quality were addressed by the IEPMC (Galvin et al., 2018, 2019) and also by the WISR Reports – Stage 1 and Stage 2 (Hebblewhite et al., 2017, 2019). These studies concluded that there was no evidence that losses of water from the Woronora Special Area or impacts to reservoir water quality in relation to its use as a water supply were significant. While noting the need to address uncertainties regarding geological structures and the associated recommendation in Section 4 of this Advice, the Panel has no new concerns regarding quantity and quality of surface water in relation to LW308-310 and, hence, does not address these issues in detail in this advice.

During its field visit, the Panel visited the flow gauge at the outlet of Swamp 92 and from visual inspection is satisfied with the value of this gauge and its design. The Panel also visited stream P at pool SP1. Given the difficulty of access and the low order of this stream (1st to 2nd order), it has no concerns regarding this pool's sufficiency as the sole monitoring site in the downstream length of stream P. The Panel did not visit the other 1st and 2nd order streams above the proposed longwalls (streams Q and R and other small tributaries lying to the east of Woronora reservoir) due to difficulty of access.

The Panel notes that significant subsidence impacts are expected in these streams: "*The streams are located above Longwalls 308-310, and could experience the full range of predicted subsidence movements, with maximum predicted closure up to 700 mm"* (Peabody, 2021). The relevant performance measure presented in the EP is "*Negligible reduction to quantity or quality of water resources reaching Woronora Reservoir*" (Peabody 2022). Based on reported impacts (Peabody 2021) of LW301-306, including impacts on the small streams on the reservoir's eastern side (sub-catchments I and K), the Panel considers it unlikely that the impacts on the streams overlying LW308-310 will be considered significant with respect to the relevant performance measure. There is no pool level or water quality TARP for streams P and R even though these are being measured. The Panel agrees with this approach, considering that TARPs for these sites would have limited value aside from triggering increased reporting and considering that impacts at these sites can be effectively assessed by 6-monthly and annual reporting.

The Panel visited Waratah Rivulet at Cliff COH1 and noted that the stream was heavily iron stained, which was assumed to have arisen from enhanced up-flow of deep groundwater through fractured rock due to prolonged wet weather. This is not directly relevant for assessing the LW308-310 EP but it is relevant to the long-term outlook for iron staining in this and other watercourses.

6.3. WARATAH RIVULET

The Waratah Rivulet at the reservoir full supply level and northern end of rock bar W is located approximately 170 m from the proposed southern end of the LW308 and LW309. Pool W is approximately 70 m further away from the longwall end. The Performance Measure related to protection of Waratah Rivulet from subsidence impacts is "*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).*" Related Performance Indicators include "*No change to the natural drainage behaviour of Pools P, Q, R, S, T, U, V and W; Analysis of water level data for Pools P, T, U, V and W indicates the water level is at or above the pool's previous minimum.*"

The main basis for assessing potential subsidence consequences due to LW308-310 is predicted valley closure: "*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.*" At rockbar W the predicted valley closure is 200 mm (Table 7 of the Water Management Plan, Appendix A of the EP), which according to the Southern Coalfields rockbar model relates to less than 10% frequency in Type 3 fracturing (the incremental predicted valley closure due to LW308-310 at rockbar W is approximately 150 mm). Although exceeding the performance measure is considered unlikely on that basis, MSEC (Appendix I of the EP) recommend "*that a monitoring program be developed for the extraction of Longwalls 308 to 310 to identify and manage the development of valley closure and potential impacts within the Waratah Rivulet*".

Addressing this, in addition to the previously established TARPs (Table 27 of the Water Management Plan), Section 8.10 of the Water Management Plan states "*As described in Section 4.1, Metropolitan Coal has established a comprehensive monitoring and adaptive management program to identify subsidence related movements at the Waratah Rivulet to minimise the risk of exceedance of the Waratah Rivulet performance measure. A similar Valley Closure TARP*

has been successfully implemented by Metropolitan Coal at the Eastern Tributary for Longwalls 303 to 306." This Valley Closure TARP for the Eastern Tributary for Longwalls 303 to 306 is reproduced as Table 5 of this advice and the proposed corresponding TARP for the Waratah Rivulet (Table 29 of the Water Management Plan) as Table 6.

Table 5: LW305-LW307 Eastern Tributary Valley Closure TARP

Table 29
Longwalls 305-307 Eastern Tributary Valley Closure Trigger Action Response Plan

		Monitoring method	Measure	Frequency Based on length of void (m)		Level 1 Baseline condition	Level 2 Measurable change in observation from Level 1	Level 3 Measurable change in observation from Level 2
Monitoring	LW305	Closure prisms *Line A & B*	Closure high resolution		LW305	TARP commences at IEPMC 450m zone Incremental movements from extraction of Longwall 305, 306, 307[29]		
				Baseline data - fortnightly	0 m to 1181 m	No greater than **±1 mm**	Greater than Level 1 and no greater than **±2 mm**, measured in two consecutive epochs	Greater than Level 2 and no greater than **±4 mm**, measured in two consecutive epochs, or rate of change greater than 1.0 mm/week
				Zone 200 m prior to IEPMC – weekly	1181 m to 1381 m			
		Ground survey ETAU *U01P-U09P*	Relative 3D movement, closure and strain	*Within IEPMC Zone No greater than 3-day intervals*	1381 m to 1547 m	No greater than **±2 mm**	Greater than Level 1 and no greater than **±3 mm**, measured in two consecutive epochs	Greater than Level 2 and no greater than **±4 mm**, measured in two consecutive epochs
	LW306[30]	GNSS *# 21,22 # 32,42*	Absolute 3D movement and closure	LW306 1361 m to 1907 m		No greater than **±10 mm**	Greater than Level 1 and no greater than **±15 mm**, measured over three consecutive epochs (days)	Greater than Level 2 and no greater **±20 mm**, measured over three consecutive epochs (days), or rate of closure (as agreed by TC) greater than 2mm per week (*over a 7 day period*) when above the upper bound of the baseline period data.
				Real time data review weekly				
	LW307[30]	GNSS *# 21,22 # 32,42*	Absolute 3D movement and closure	LW307 1661 m to 2006 m		No greater than **±10 mm**	Greater than Level 1 and no greater than **±15 mm**, measured over three consecutive epochs(days)	Greater than Level 2 and no greater **±20 mm**, measured over three consecutive epochs (days)
				Real time data review weekly				
Reporting		Technical Committee meeting / review[31],[32]		Meeting/review at completion of baseline monitoring[33]		Meeting/review frequency: within 24 hours of closure prism ground survey (LW305) or, weekly within GNSS monitoring zone (LW's 306-307), or as otherwise determined by the Technical Committee		
		Key outcomes of Technical Committee[35]		Meeting/review data at commencement of TARP[34]		Reporting key outcomes within 24 hours of Technical Committee review		Immediate reporting to MC General Manager Increase data review frequency as determined by the Technical Committee Notification of the DPIE and WaterNSW of Level 3 status & associated actions MC to determine need to cease longwall mining operations at Level 3 status. Exceedance of Level 3 upper bound parameters over 2 consecutive survey measurements (measurements separated by a 3 day interval) would initiate cessation of mining by MC

[29] TARP Level 1, 2 and 3 data are based on additional movements due to extraction of each longwall. The Technical Committee will be presented with incremental data due to each longwall and cumulative monitoring data due to all longwalls from 303 onwards.
[30] For LW306 and LW307 and where catchment access permits, supplementary high-resolution surveys will occur at monthly intervals (0 m to 1400 m), fortnightly intervals (1400 m-1650 m) and weekly intervals (1650 m-to finish point). These high-resolution surveys will complement the primacy of the GNSS assessment to provide information to the Technical Committee.
[31] Members of the Technical Committee may attend a meeting in person or remotely via screen sharing. Where this is not possible, the Committee member will be provided with the information presented in the meeting and outcomes of the meeting for review and comment. Participation will be noted in the key outcomes reporting to the DPIE and WaterNSW.
[32] The Technical Committee will be informed at a weekly frequency with ETAU pool water level monitoring and visual inspections.
[33] Distance marking 2 x depth away from Eastern Tributary
[34] Commencement of IEPMC 450 m zone + extra 200 m, or for LW307 as per GNSS monitoring zone.
[35] The key outcomes of the Technical Committee Meeting will be reported to the DPIE, WaterNSW and Metropolitan Coal (MC) General Manager.

Table 6: LW308-LW310 Waratah Rivulet Valley Closure TARP

Table 29
Longwalls 308-310 Waratah Rivulet Valley Closure Trigger Action Response Plan
TARP Zone – extraction within 450 m of Waratah Rivulet

Valley Closure[1] (*Total Closure*)	Monitoring Method and Measure		TARP Level			
			Level 1 up to 50% of design criteria – low probability of type 3 impact (*loss of pool water level*).	**Level 2** up to 75% of design criteria[2]– low probability of type 3 impact (*loss of pool water level*).	**Level 3** Greater than Level 2 and no type 3 impact (loss of pool water level).	**Level 4** Type 3 impact confirmed
Longwalls 308-310	Telemetered real time data GNSS *# 43,44* Absolute 3D movement and closure	***Trigger***	Baseline to no greater than **100 mm**	Greater than Level 1 and no greater than **150 mm**. Measurements over three consecutive epochs (days)	Greater than Level 2 (**150 mm)** and no type 3 impact (loss of pool water level). Measurements over three consecutive epochs (days).	Diversion of flows or change in natural drainage behaviour of pools in performance measure zone.
		Action	Monthly monitoring[3] • GNSS data[4] • Pool level data[5] • Visual inspections End of Panel • Rock bar closure survey[6]	Monthly monitoring • As per Level 1, and • Rock bar closure survey within 2 weeks.	Weekly monitoring • All data gathering increased to weekly frequency • Weekly review of GNSS and rock bar closure line data[7]	Immediate action • Metropolitan Coal to initiate procedures to cease extraction of current longwall panel at next available cut through
		Response and Reporting	Reporting: • Monthly to Technical Committee Technical Committee: • End of panel meeting • Key outcomes reported to DPIE and WaterNSW	Reporting: • Monthly to Technical Committee Technical Committee: • Monthly meeting • Key outcomes reported to DPIE and WaterNSW	Reporting: • Weekly to Technical Committee Technical Committee: • Weekly meeting • Metropolitan Coal to determine need to cease longwall mining operations at Level 3 in consultation with Technical Committee • Key outcomes of Technical Committee reported to DPIE and WaterNSW following each meeting • Notify DPIE and WaterNSW of Level 3 status and associated actions	Response: • Immediate Technical Committee meeting and reporting to review all relevant data (within 24hrs) • Immediate reporting (24hrs) to Metropolitan Coal General Manager • Immediate notification (24hrs) of the Level 4 status and associated actions to DPIE and WaterNSW • Commence Stream Remediation Plan.

[1] Waratah Rivulet will be monitored for total closure (cumulative value) as measured from the commencement of Longwall 307 (i.e. the "baseline" period) to the completion of Longwall 310.

[2] A predicted total valley closure of 200 mm has been successfully used as a design tool for mining in the vicinity of the Waratah Rivulet from Pool P to Rock bar W. Type 3 Impacts to pools along the Waratah Rivulet have not occurred at predicted total valley closure of less than 200 mm. Impacts that have occurred along the Waratah Rivulet have been the result of mining directly beneath the Waratah Rivulet or in close proximity (< 100 m) to the rock bars with predicted total valley closure greater than 200 mm. Some pools along the Waratah Rivulet have also been mined directly beneath without impact with predicted total closure up to 800 mm.

[3] Monitoring and review frequency can be increased at any time as determined by the Technical Committee.

[4] GNSS valley closure monitoring is representative of closure at Rock Bars U, V and W that are within 450 m of extraction of Longwalls 308-310.

[5] Pool water level monitoring equipment and loggers are installed at Pools P, Q, R, S, T, U, V and W.

[6] Rock bars to be monitored (located within 450 m of extraction) are T, U, V and W for Longwall 308, and U, V and W for Longwalls 309 and 310. Each rock bar has a terrestrial survey closure line.

[7] Weekly review to include observations of closure, strain, vertical subsidence, horizontal movement.

In the proposed Waratah Rivulet TARP, level 1, 2 and 3 triggers are based on measured valley closures of 100 mm and 150 mm (50 and 75% of the predicted valley closure of 200 mm that is associated with no previous impacts to the Waratah Rivulet). As recognised by the Extraction Plan ("*With the conservative nature of valley closure predictions, observed valley closure is typically lower than predicted valley closure*") the 100 mm and 150 mm triggers are likely to translate to higher values of predicted valley closure. Supplementary information provided by Peabody[4], Figure 3 in this advice, shows that for Waratah Rivulet, observed valley closures have in all plotted cases been below 80 mm, but with corresponding predicted valley closure up to approximately 390 mm. Therefore, based on the available information including that contained in Figure 3, the proposed 100 mm and 150 mm observed valley closure trigger values are unlikely to be surpassed but if they are surpassed this presents a moderate to high risk of a Type 3 fracture. The Eastern Tributary TARP was based on considerably more sophisticated monitoring and assessment and relatively risk-averse observed valley closure values. Its success should not be used to justify the proposed Waratah Rivulet TARP. Against this background, the Panel does not concur with WaterNSW's view that the proposed trigger levels are appropriate for performance assessment.

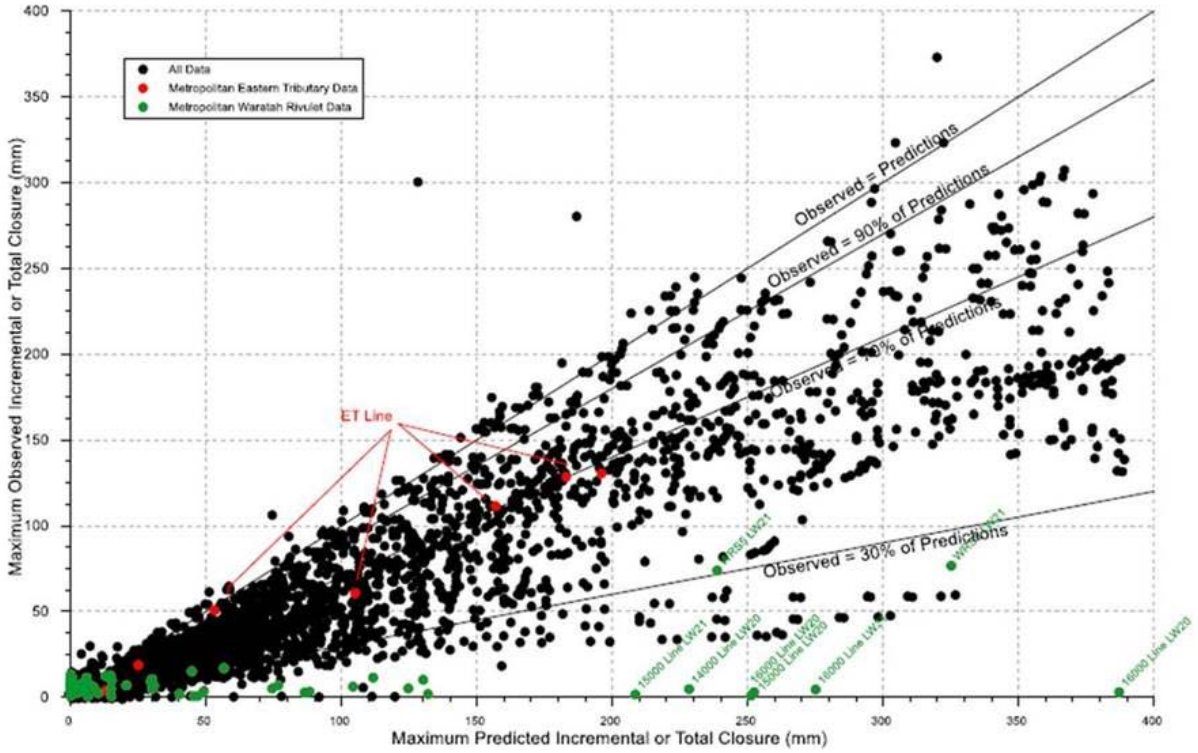

Figure 3: *Predicted Versus Observed Valley Closure at Metropolitan Coal and other Southern Coalfield Mines (copied from supplementary information provided by Peabody to DPE 17/08/22).*

The Panel concludes that:

1. Type 3 fracture impacts to Waratah Rivulet due to the proposed LW308 to LW310 are unlikely. However, the valley closure triggers in the proposed Waratah Rivulet TARP

[4] Email from Peabody to DPE ,17/08/22

are unlikely to indicate increasing likelihood of a Type 3 fracture before the fracture occurs and these triggers are not sufficiently justified in the Extraction Plan or in supplementary information provided to the Panel.

2. Aside from the Panel's preceding conclusion about the Waratah Rivulet TARP and the Panel conclusions related to how geological structures might impact surface water, the Panel has no significant concerns regarding surface water management plan in this Extraction Plan.

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.

7.0 GROUNDWATER MONITORING

7.1. THE ISSUES

The request for advice raises five questions in relation to groundwater:

1. Is there an adequate network of monitoring stations in representative locations, especially the T-series of groundwater monitoring bores?

2. Is the frequency of monitoring sufficient to identify and therefore limit any potential exceedances of performance indicators and/or performance measures?

3. Will there be adequate baseline data for future Extraction Plans, particularly for swamps S76, S77 and S92?

4. Do the TARPs enable measurement of compliance with the performance measures?

5. Do the TARPs have triggers (and associated performance indicators) that adequately inform the mine's overall performance with respect to subsidence impact and environmental consequences?

7.2. ANALYSIS AND ADVICE

7.2.1. Purposes of Groundwater Monitoring

In order to address these questions, it is worth unpacking the purposes of the groundwater monitoring, which are largely driven by the performance measures that have been established for the Consent Area. The relevant performance measures are:

1. Negligible reduction to the quantity of water resources reaching the Woronora Reservoir

2. Negligible leakage from the Woronora Reservoir

3. Negligible reduction to the quality of water resources reaching the Woronora Reservoir

4. Negligible reduction in the water quality of Woronora Reservoir

5. Negligible impact to threatened species, populations, or ecological communities

6. Swamps 76, 77 and 92 shall not be undermined without prior written approval of the Director General

Groundwater monitoring is not in itself a means of mitigating impacts. Rather, its primary purpose is to allow assessment of the occurrence and scale of impacts. Therefore, the Panel does not consider that groundwater related TARPs are applicable to the avoidance of impacts but only to identifying and managing the associated environmental consequences.

Prior to mining, groundwater flows locally would have been towards the rivers and reservoir. This essentially remains the situation at present. Extraction of LW308 to LW310, because of the location of the longwalls, is unlikely to change this condition unless there are significant

diversions of flows into the mine that cause increased leakage from the reservoir and/or potential reductions to lateral groundwater flows to the reservoir through diversion of groundwater towards the mine. Therefore, flows into the mine are an important consideration in terms of flow performance measures for Woronora Reservoir. Water quality related to Woronora Reservoir is unlikely to be significantly impacted by increased leakage from the reservoir or reductions in groundwater inflows. The change in chemical contributions to the reservoir from loss of groundwater inflows does not appear to be a significant cause for concern. Near-surface subsidence impacts may affect the ease with which groundwater flows to the rivers and reservoir and they may affect the total groundwater flows by changing the magnitude of groundwater recharge. Changes in groundwater flows may also impact chemical contributions to the reservoir through the creation of new groundwater pathways (cracking) with the resulting changes to water-rock interactions and the release of chemicals from fresh rock surfaces. Changes in groundwater recharge are likely to be a primary cause of impacts to the upland swamps and any important species within the swamps that rely on the natural water balance of the swamps.

Groundwater monitoring generally serves little purpose as an early warning system for changes to mine inflows or evidence of inflow rate. As noted in Section 5.2, inflow to the mine must already be occurring for it to be detected. Groundwater monitoring can provide some evidence of the regional response to mine inflows. Groundwater monitoring is unlikely to provide evidence of the location of leakage from the reservoir to the mine.

Given the nature of the changes to shallow groundwater and surface water quality due to subsidence, groundwater quality monitoring is unlikely to be particularly effective at increasing knowledge of water quality changes relevant to the reservoir beyond those that would be available by direct measures of water quality changes in surface flows.

Groundwater monitoring to observe changes in regional flows during mining is potentially valuable but it is important to consider the groundwater flow system not as a two-dimensional system but as a three-dimensional system, where variations of groundwater heads with depth are as important as variations laterally when quantifying the changes to the flow system. The development of the T series of boreholes suggests that the borehole designs and interpretations of the monitoring results have been largely driven by two-dimensional assumptions. This issue is considered in more detail below.

Groundwater monitoring in swamp substrate and at shallow depth (typically 10m bgl[5]) has been shown to be effective at Metropolitan Mine for highlighting mining induced changes to swamp groundwater hydrology. Evidence of mining impacts is observed for the swamps overlying the 20 series longwalls. Additionally, two of the seven swamps monitored above LW301 to LW304 show changes to shallow groundwater that were probably induced by mining. However, for the swamps above LW301 to LW304 there is no clear evidence of an impact on the substrate groundwater. There are no swamps above longwalls LW305 to LW307. Due to the interpanel (chain) pillars being wider, surface subsidence over these longwalls is lower than over earlier longwalls. Swamps adjacent to LW305 to LW307 show no evidence of impacts from mining.

Practically all swamps at Metropolitan Mine show that the groundwater in the substrate is perched above the base of the swamp with the shallow groundwater table lying below the

[5] bgl – below ground level

swamp substrate base. There is the potential for downflow to the underlying shallow groundwater but the rate of downflow is unknown and may be negligible. The majority of the swamps appear to be sustained by surface water and rainfall rather than by groundwater. For many of the monitored swamps, groundwater heads in the substrate fall below the measurement level, under natural conditions, indicating no saturated zone in the swamp for periods of time. This has implications for the swamp groundwater TARPs and is discussed in more detail below.

There are no significant swamps overlying LW308 and LW309 and those swamps that are adjacent to these longwalls are not likely to be significantly affected by mining, given the low levels of predicted surface subsidence.

Longwall panels from LW310 onwards are predicted to induce subsidence magnitudes that are similar to those over LW301 to LW304. Based on the evidence from LW301 to LW304, it may be expected that some mining impacts on the shallow groundwater will occur below swamps above these longwalls. However, it is not clear that the swamp substrate groundwater and moisture conditions will be affected or that the swamp's ecological conditions will be changed because of mining. Monitoring of the swamps will provide evidence of hydrological change. The groundwater TARPs can then be used to determine the actions to be undertaken if changes are observed. The recommendations for suggested changes to the groundwater TARPs include a requirement to update the planned actions in the event of impacts from mining on swamp hydrology.

7.2.2. T-Series Monitoring Bores

The T series monitoring bores provide a transect essentially at right angles to the alignment of Woronora Reservoir and therefore provide some evidence of the lateral groundwater flow conditions to the reservoir. A single groundwater head is monitored in each bore at the base of the bores (and groundwater monitoring levels), and are all approximately at the same level as the nominal minimum reservoir level at the transect location established by the old weir that exists in the reservoir. The most recent replacement to T3 has been drilled to be below this level. This configuration of measurements, given the lack of measurements below the reservoir level, implies that the transect only meaningfully assesses flows to the reservoir and not away from the reservoir and can only be interpreted through two-dimensional assumptions of lateral flow.

The head measurements are not consistent with two-dimensional flow behaviour. Intriguingly, reviews of the monitoring data by the applicant's consultants largely force a two-dimensional interpretation of flows to the reservoir without clear justification. Boreholes T1 and T3 show groundwater levels that mirror the reservoir level, while Bores T2, T4, T5 and T6 show heads significantly above the reservoir level but are not all consistent with continuous lateral flow to the reservoir. The measurements do not guarantee that lateral flows are to the reservoir, even though this would be expected. Neither do they allow quantification of lateral flows. They do show the difficulty of using groundwater borehole data to assess regional flows. They also show the potential for groundwater data to identify temporal changes to groundwater conditions, though interpretation of the temporal changes is probably only likely to be indicative of groundwater responses regionally.

At this stage of mine development, it is probably not worth modifying the transect array. However, a more appropriate design would have included multiple (3 or 4 elevation) level

monitoring in each bore with the lower two levels occurring below the minimum reservoir level.

7.2.3. Regional Groundwater Monitoring

There are relatively small numbers of groundwater monitoring points across the remaining mine footprint still to be mined. This may be due in part to access and in part due to disturbance of land; however, there is justification to include 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. This would provide a better means of interpreting the shallow responses to mining affecting the swamps as well as providing a more complete interpretation of the interactions between the mine and the overlying groundwater regime for the purposes of understanding long term recovery of groundwater levels post mining.

7.2.4. Swamp Hydrology

Swamps 76, 77 and 92 will not be undermined by LWs 308-310. There is a possibility that Swamps 77 and 92 will be affected by completion of LW310 and therefore establishment of monitoring well in advance of commencement of LW310 is required. Monitoring at three locations at each of these swamps has commenced and daily water levels in the substrate, with soil moisture monitoring also taking place at the same locations. Only the central location includes a 10 m deep piezometer. It would have been beneficial for each site to have included a 10 m piezometer. A suitably long record of monitoring substrate conditions seems likely to be available at these sites prior to commencement of LW310. Even though the record would be less for 10 m deep piezometers, it would be beneficial and is recommended for all three sites in each swamp to include a 10 m deep record.

It appears that the number and location of monitoring points on each swamp were decided based on a trade-off between the density of measurements and the degree of disturbance to the swamps. Panel members were advised during the field visit that the locations of the monitoring points were set to achieve a wide geographical spread as well as to place bores in areas of significant substrate depths. It is not possible to confirm the latter constraint. It is also not possible to confirm that responses to mining at these locations will be representative of the full areas of the swamps.

It is apparent that given a suitably long record prior to mining, swamp monitoring can provide evidence of changes to swamp hydrology based on previous results from Metropolitan mine's monitoring program. It seems likely, therefore, that the current monitoring will provide some assurance that any significant impacts on groundwater and, hence, on swamp ecology will be identified. Information from the swamps overlying the first 300 series longwalls suggests that the lower subsidence levels predicted and occurring due to current mining are not significantly altering swamp groundwater conditions. It therefore seems reasonable to assume that if the mining configuration does not change, this trend towards impacts lesser than those under the 20 series longwalls will continue for the current longwalls. At this stage, there does not appear to be any reason for not continuing to undermine the major swamps through the development of LW311 onwards, but this should be reviewed regularly during the extraction of LW308 to LW310 and by a detailed review of subsidence impacts occurring at these swamps immediately after extraction of LW309 and again after extraction of LW310.

7.2.5. Undermining of Woronora Reservoir

This issue has already been considered under subsidence impacts and is not considered further here.

7.2.6. TARPs

TARPs presently used at Metropolitan Mine are less about identifying potential requirements for mitigation of impacts prior to occurrence and more about identifying impacts that are taking place for the purposes of assessing the scale of impact and environmental consequences for future mining. The trigger levels adopted for different performance measures are focussed only on increasing levels of data acquisition and reporting for wider management considerations.

Table 15 of the Biodiversity Management Plan (BMP) presents the TARP for swamp groundwater monitoring. The Panel has the following concerns regarding this TARP:

- Level 1 is effectively business as usual. It therefore has no value as a trigger. If it is appropriate to include a statement on the basic monitoring and processing of data that occurs routinely for monitoring the hydrology of the swamp, then this should be identified not as a trigger level but as a baseline from which triggers can be assessed.
- There are typically three sets of subsurface water measurements that are taken routinely for the swamps overlying Metropolitan Mine; these are substrate moisture content, substrate water level and shallow groundwater level. The current triggers only concern substrate water level. The triggers should also consider the other two measurements as these are potentially as important as substrate water level in determining the potential impacts on the swamp ecology.
- The parameter adopted for substrate water level is groundwater level and it is presented as a level against Australian Height Datum (AHD). As a swamp is undermined, the swamp will subside. This means that the same water conditions in the substrate will be represented by changing values of water level measured against AHD over time. It is not appropriate to adopt water level AHD as a baseline. It would be better to adopt either water height above substrate base or water height below casing top. This would also be applicable for observations of the shallow water level as it is the separation between the substrate water level and the shallow groundwater level that has potential significance for drainage of a swamp.
- Swamps above LWs 20-27 and above LWs 301-310 adopt groundwater height above AHD as the baseline. However, the Level 2 Trigger for Swamps above LWs 20-27 is that the seven day moving average is above the minimum, while the Level 2 Trigger for Swamps above LWs 301-310 is that seven day moving average is below the minimum. This is inconsistent and suggests that for LWs 20-27, the measurements are reported as depth to water table and not water level above AHD. Consistency is required. There is very little reason for swamps overlying different longwalls to be treated differently.
- Seven day average water level below the full length of record minimum is used as the measure of potential dry swamp conditions. The same measure is adopted for both Level 2 and Level 3 Triggers, the difference being that Level 3 is deemed to have been reached if the analysis of the record indicates that the dry conditions are not natural. This would be acceptable, except that the Action response for both Levels 2 and 3 allows that as wetter conditions return (i.e. water level above the minimum for more than 7 days) there can be a return to Level 1. The problem here is the lack of clarity

around when a return to Level 1 is justified. A return to Level 1 may be justified after analysis of the record identifies that the dry conditions are normal; essentially then it would be possible to return to Level 1 from Level 2. A return to Level 1 is not justified if the record identifies that dry conditions are not normal, and then it should not be possible to return to Level 1 from Level 2 or 3. It is theoretically possible to return to Level 2 from Level 3 if the conditions that caused the hydrology of the swamp to behave unnaturally no longer pertain, and then to return to Level 1 once Level 2 has been demonstrated. In order to resolve this, there needs to be a definition of how long a data record is required to identify normal or abnormal conditions and a requirement that it is only possible to return to Level 1 once normal hydrological conditions within the swamp have been demonstrated.

In respect of groundwater levels in general, TARPs for groundwater levels that may be impacted by leakage to the mine or by higher or lower groundwater flows to the reservoir or streams have little obvious value as noted earlier. Mine inflow should be the measure of effectiveness of the constrained zone above the mine at controlling deep percolation of groundwater. Groundwater level changes that are not due to increased discharge to the mine provide limited to no evidence of the scale or directions of changes to flow to the streams or reservoir. This is because they can be a product of changes to recharge, storage or hydraulic conductivity, which may all be subject to variation as a consequence of ground movements due to mining. While knowledge of groundwater level changes may be helpful for recalibration of the groundwater model for the area and for performing sensitivity analysis to assess the most likely regional impacts, they are not likely to have immediate value for management of the mine or the environment. Water quality TARPs for the streams are most likely to provide better measures of groundwater quality impacts on surface waters than groundwater quality measurements.

7.2.7. Recommendations

The Panel recommends that:

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 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.

8.0 SWAMPS

8.1. THE ISSUES

Schedule 3 of the **Consent Conditions** include the following provisions:

> **Condition 1** – negligible impact on threatened species, populations, or ecological communities
>
> **Condition 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:
>
> (a) a comprehensive environmental assessment
>
> **Condition 6(f) –** Preparation of a Biodiversity Management Plan….., to manage the potential environmental consequences of the Extraction Plan on aquatic and terrestrial flora and fauna, with a specific focus on swamps;
>
> **Condition 7** - Management plans to include:
>
> (a) a program to collect sufficient baseline data for future Extraction Plans
>
> (b)……

The Request for Advice raised four issues relevant to upland swamps:

1. Is the network of monitoring adequate in representative locations for:
    a. Swamp and shallow groundwater; and
    b. Biodiversity
2. Is the frequency of monitoring adequate to identify and therefore limit any potential exceedances of performance indicators and/or performance measures?
3. Does monitoring allow for adequate baseline data for future Extraction Plans particularly for Swamps 76, 77, 92
4. Do the TARPS
    a. enable measurement of compliance with PMs; and
    b. have triggers and associated PMs that inform the overall performance with respect to subsidence impacts and environmental consequences.

8.2. ADEQUACY OF MONITORING

In recent advice to DPE, the Panel has challenged the assumption that the ecology of 1st and 2nd order streams is not significant and, therefore, the Panel had concerns about the absence of monitoring of other aspects of biodiversity such as aquatic ecology and riparian vegetation. Following field inspection, it accepts the difficulty of monitoring these within steep and densely vegetated terrain without creating undue disturbance of the sites.

Recommendations concerning additional monitoring for Swamps 76, 77 and 92 are given in Section 7.

Otherwise:

The Panel concludes for the swamps relevant to LW308 to LW310 that the network and frequency of monitoring is adequate.

BCD (2022, Table A1.1) has drawn attention to the full range of data not being available *inter alia* for swamps above or closely adjacent to LW303 to LW306.

The Panel recommends that 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.

8.3. TARPS

TARPS for upland swamp vegetation (Table 14) and swamp groundwater (Table 15) of the Biodiversity Management Plan are relevant to this matter. The need to redevelop the swamp groundwater TARP has already been articulated in Section 7 of this advice.

The Panel recommends that the following revisions to the upland swamp vegetation TARP:

- 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.
- 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.

The Panel recommends that in redrafting the swamp groundwater TARP (see Section 7):

- 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.
- *'Surface cracking within upland swamps resulting from mine subsidence is..'* should be replaced with *'Subsidence impacts are..'*.
- The large swamps S76, 77 and 92 should be added to this TARP.

8.4. VEGETATION CHANGE AS A PERFORMANCE INDICATOR

The importance of the Coastal Upland Swamps on the Woronora Plateau was recognised by their declaration in 2012 as an Endangered Ecological Community under NSW legislation, and subsequently as a Threatened Ecological Community under Commonwealth legislation in 2014. However, as these declarations were made after the approval of the Metropolitan Coal Project, they do not apply retrospectively to the Consent Conditions. This is particularly relevant to the wording *'threatened species, populations, or ecological communities'* specified in the Performance Measure for swamps. Nevertheless, throughout the Project, this Performance Measure has been assessed by two Performance Indicators – one for vegetation change and one for groundwater change. The question is whether the Performance Measure is breached if there is a mining-related impact associated with vegetation only, or with groundwater only, or with both indicators.

The Panel was advised by the applicant[6] that:

> *The relevant Performance Measure for swamps is 'negligible impact to threatened species, populations or ecological communities'. Metropolitan Coal has not exceeded this Performance Measure, including for Swamps 20 and 28, and therefore has not had to implement any contingency measure for swamps. To this end, there is currently no biodiversity offset requirement for the Metropolitan Mine.*
>
> *Note that the Performance Indicator was previously exceeded for Swamps 20 and 28, however, further assessment found that the Performance Measure 'negligible impact to threatened species, populations or ecological communities' was not exceeded.*

It is the Panel's understanding that the applicant's view is based on the assessment of change in vegetation as mining-related changes in groundwater at these swamps are acknowledged. The Panel notes the following conclusions of the IEPMC in this regard:

- Changes in vegetation composition *'are consequences of impacts to the piezometric levels in the swamps and are therefore indirect indicators of the groundwater-dependency of these communities'*. They are '*changes that take years or decades to occur and to be clearly separable from natural changes'*.[7]
- '*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'*.[8]

The Biodiversity Management Plan (section 4.3.1) appears to acknowledge this situation, stating that '*The effects on vegetation of reductions in water levels in Swamp 20, if any, may take some years to be expressed in the absence of a catastrophic event such as extreme drought and/or a wildfire'*.

A large body of monitoring results and research has advanced the understanding of upland swamps since the approval of the Metropolitan Coal Project in 2009. The difficulties in identifying mining-induced changes in vegetation as opposed to climatic or other natural variations is well understood, and this casts doubt on the use of vegetation change as a measure of swamp ecosystem functionality. Recent analysis of the changes due to the Gospers Mountain fires on the swamps of the Newnes Plateau indicate that fires following dehydration due to hydrological changes in undermined swamps produce significant and long-lasting consequences for swamp vegetation.

Swamps are recognised as groundwater-dependent ecosystems and maintenance of the water table within the swamp sediments is part of their description as Coastal Upland Swamp EEC - *The Coastal Upland Swamp in the Sydney Basin Bioregion includes open graminiod heath, sedgeland and tall scrub associated with periodically waterlogged soils on the Hawkesbury sandstone plateaux*. This means that it is important to revise the TARPs to clarify what levels of change in groundwater may represent significant changes to the groundwater within the

[6] email via DPE on 28/07/2022
[7] section 5.5.1.2 of IEPMC Stage 1 report - Galvin et al. (2018)
[8] IEPMC Stage 2 report - Galvin et al. (2019)

swamps. It is particularly important with respect to Swamps 76, 77 and 92. Unlike the swamps over most of the Project Area, these are large swamps with diverse vegetation and they may be less rainfall-responsive and more groundwater-dependent than the smaller swamps dominated by Banksia thicket and sedgeland.

8.5. SWAMPS 76, 77, 92

Swamps 76, 77 and 92 are large swamps identified by the Planning Assessment Commission (2009) as requiring further studies prior to undertaking any mining operations that could impact them. Other swamps within the Project Area are small headwater swamps, associated with 1st order streams and lying near the ridgelines or on valley sides. Above the 300 series longwalls, their vegetation is Banksia thicket and above the 20 series longwalls, most are sedgeland-heath complex. These three swamps are significantly larger. Swamps 92 and 77 extend into 2nd order streams and include areas of tea tree thicket. All three are more accurately described as valley infill than headwater swamps.

The Director-General's Assessment Report (2009) stated that:

> *'the Department has recommended conditions to the effect that, prior to carrying out any underground mining operations that could cause subsidence impacts on Swamps 76, 77 and 92, HPCL must submit a revised and expanded impact assessment addressing both the subsidence impacts and environmental consequences. This assessment must include proposed performance measures and means to achieve them'.*

However, the Panel notes that the requirements of the Consent for Swamps 76, 77 and 92 as set out under Condition 4 are not entirely consistent with the above in that they only exclude undermining of the swamps without the written approval of the Director-General and not other mining that could impact the swamps.

The Director-General's Assessment Report also acknowledged the PAC's concern that '*the potential impact from non-conventional subsidence (ie valley closure and upsidence)*' was '*unclear*', as many of the swamps were not headwater swamps which '*are generally subject to minimal subsidence-related upsidence and closure'*. The Panel notes that Swamps 76, 77 and 92 are not headwater swamps but valley infill swamps and the understanding of the impacts of valley closure on valley infill swamps in the Southern Coalfield has progressed significantly in recent years.

At the time of assessment of the Metropolitan Coal Project (2009), the mining company (HPCL) anticipated that any '*changes in swamp moisture as a result of cracking are expected to be minor and immeasurable when compared to natural variability*'. Further, surface cracking was '*not expected to result in an increase in the vertical movement from the perched water table into the regional aquifer'*. HPCL argued that '*significant mine subsidence effects to upland swamps in elevated topography have not been observed at Metropolitan Colliery nor in similar circumstances (ie depth of mining, mine geometry and topographical aspects) across the Southern Coalfield.'*[9] Maximum closure strain values for Swamps 76, 77 and 92 were

[9] Metropolitan PPR 2009, section 6.2

predicted to range from 3.7-7.7 mm/m[10] but, nevertheless, negligible environmental impacts were predicted for upland swamps.

As shown in Figure 1, a small section of Swamp 92 falls with the angle of draw/20 mm subsidence limit zone of LW308-310 and a larger portion falls within the outer 600 m zone of LW308-310. A portion of Swamp 77 also falls within the outer 600 m zone. Stream P which is the exit stream from Swamp 92 will be undermined by LWs 309 and 310 and the exit stream from Swamp 77 lies within the 35º angle of draw.

The Panel concludes that mining of LW308 to LW310 is unlikely to impact Swamps 76, 77 and 92 but mining of subsequent panels may do so.

The Panel recommends that:

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.

[10] Metropolitan PPR 2009, section 6.4

9.0 SUMMARY CONCLUSIONS AND RECOMMENDATIONS

The Panel has reviewed the Extraction Plan submitted by the Applicant, including the addendum material. As a result of this review, the Panel offers the following summary conclusions and recommendations:

1. Mine Plan and Subsidence Implications

   The Panel concludes that:

   (i) the methodologies used to predict conventional and non-conventional subsidence effects are appropriate and the levels of confidence in the predictions have been adequately presented.

   (ii) the subsequent extraction of LW311 to LW313 will result in increased subsidence over LW308 to LW310 to that reported in the Extraction Plan. However, although vertical displacement is predicted to almost double over LW310, the conservative nature of the mine layout results in minor corresponding increases in strain and tilt and, therefore, is unlikely to result in significant increases in impacts over LW308 to LW310.

   The Panel recommends that the Extraction Plan be updated to include:

   (i) incremental, transient and cumulative predictions of both conventional and non-conventional surface subsidence parameters for LW308 to LW310 over the projected life of the mine;

   (ii) a reassessment of the impacts and consequences associated with these revised subsidence predictions.

2. Geological Structures

   The Panel recommends that, notwithstanding any in-principal endorsement of the Extraction Plan for LW308 to LW310, extraction of these panels should not commence until the WISR Panel confirms that geological structures have not acted as conduits for abnormal or higher than predicted water inflow to mine workings from Woronora Reservoir following the extraction of LWs 305, 306 and 307.

3. Heritage Management Plan

   The Panel's advice on the management of Aboriginal heritage is on hold pending ongoing inquiries being made by DPE. In the interests of time, advice on the Heritage Management Plan will be provided in a supplementary report when the outstanding information becomes available to the Panel.

4. Surface Water

   The Panel concludes that:

   (i) Type 3 fracture impacts to Waratah Rivulet due to the proposed LW308 to LW310 are unlikely. However, the valley closure triggers in the proposed Waratah Rivulet TARP are unlikely to indicate increasing likelihood of a Type 3 fracture before the fracture occurs and these triggers are not sufficiently justified in the Extraction Plan or in supplementary information provided to the Panel.

   (ii) Aside from the Panel's preceding conclusion about the Waratah Rivulet TARP and the Panel conclusions related to how geological structures might impact surface

water, the Panel has no significant concerns regarding surface water management plan in this Extraction Plan.

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.

5. Groundwater

The Panel recommends that:

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 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.

6. Swamps

Monitoring

The Panel concludes for the swamps relevant to LW308 to LW310 that the that network and frequency of monitoring is adequate.

The Panel recommends 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.

TARPS

The Panel recommends that the following revisions to the upland swamp vegetation TARP:

- 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.
- 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.

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 joints, rather than fracturing of intact sandstone.
- *'Surface cracking within upland swamps resulting from mine subsidence is..'* should be replaced with *'Subsidence impacts are..'*.
- The large swamps 76, 77 and 92 should be added to this TARP.

Swamps 76, 77 and 92

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