Metropolitan Coal Mine

Attachment 4
Groundwater Impact Assessment and Surface Water Assessment Peer Reviews

Peabody

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To:	Jon Degotardi (Metropolitan Coal)	cc:
From:	Stuart Brown (Principal Hydrogeologist, Hgeo Pty Ltd)	
Subject:	**Independent Peer Review: Metropolitan Coal Groundwater Impact Assessment**	
Date:	17/6/2025	**Ref:** D25279

Stuart Brown of HGEO Pty Ltd was engaged to provide an independent peer review of the Groundwater Impact Assessment (GIA) for a proposed modification to Metropolitan Colliery (Metropolitan Coal Mine). Metropolitan Collieries Pty Ltd (Metropolitan Coal) proposes to extend the life of the mine by reconfiguring Longwall 317 and adding an additional longwall (Longwall 318). This modification is subject to environmental assessment and approval processes, referred to as the Metropolitan Coal Mine Longwalls 317 and 318 Modification (the Modification).

The GIA was prepared by Australasian Groundwater and Environmental Consultants Pty Ltd (AGE) to support the Modification application, seeking approval under the NSW *Environmental Planning and Assessment Act 1979* and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*. This memo presents the findings of an independent peer review of the GIA Report, titled:

- AGE 2025. Metropolitan Mine Modification Groundwater Assessment, dated 13/6/2025, Project Number MTM5000.001, Version 05.01. (referred to as the "Main Report")

The report was provided as a Microsoft Word document. It presents an overview of the GIA findings. Details regarding the development and construction of the numerical groundwater model are contained in Appendix A: Numerical Modelling Report (referred to as the "Modelling Report").

Review scope and context

The review was carried out with reference to principles and concepts outlined in the Australian Groundwater modelling Guidelines (AGMG) (Barnett *et al.* 2012), Minimum Groundwater Modelling Requirements for SSD/SSI Projects (Department of Planning and Environment [DPE] 2022a), Guidelines on uncertainty analysis and decision support modelling (Middlemis and Peeters 2018; Doherty and Moore 2019) and Guidelines for Groundwater Documentation for SSD/SSI Projects (DPE 2022b).

The review was based on AGE's documentation and discussions with the modelling team during two online meetings where AGE presented the modelling approach and initial results. As a result, the report incorporates responses to comments raised during these discussions.; however, it did not include an independent verification of model input files or model execution.

1. Summary

An independent peer review was carried out of the GIA report for the proposed Modification. The review finds that the groundwater modelling methodology generally conforms to current best practice and is well supported by hydrogeological data. The numerical model is fit for purpose in assessing groundwater impacts associated with the Modification, with predictions considered plausible in terms of both magnitude and extent. The modelling report meets regulatory and industry standards, and no significant issues were identified that would affect the reliability of the assessment.

A number of minor comments and recommendations were communicated to AGE via email. Those recommendations were addressed and/or implemented in the final version of the report to the satisfaction of the reviewer and are not repeated here. Table 1 below summarises the findings of this review with respect to the AGMG and DPE (2022a) model compliance checklist.

Table 1. Numerical model compliance checklist summary (after DPE 2022a)

Item	Model aspect	Satisfied?	Comments
1	Are the modelling objectives clearly stated?	Yes	Page 1 of the Main Report.
2	Are the modelling objectives satisfied?	Yes	Section 7 of the Main Report.
3	Is the conceptual model consistent with the modelling objectives?	Yes	See comments below.
4	Is the conceptual model based on all available data, presented clearly?	Yes	See comments below.
5	Does the mathematical model design conform to best practice?	Yes	See comments below.
6	Is the model calibration satisfactorily addressed, including appropriate sensitivity analysis?	Yes	Model history matching using PEST-HP ENSI; Sensitivity analysis included.
7a	Are the calibrated parameter values plausible?	Yes	See comments below.
7b	Are the estimated effects (levels, fluxes) plausible?	Yes	See comments below.
8	Do the model predictions conform to best practice?	Yes	See comments below.
9	Is the uncertainty associated with the predictions reported?	Yes	UA ensemble approach using PEST tools.
10	Is the model fit for purpose?	Yes	

2. General comments

Reporting: The modelling report is well presented, with clear explanations of the conceptual model, modelling approach, and results. Maps, graphics, and data plots are of a very high standard and effectively support the analysis. The Main Report structure aligns with the recommendations of the AGMG. The separation of the assessment into a Main Report and a Modelling Report (as an appendix) is an effective approach, allowing the main assessment outcomes to be communicated clearly without being obscured by detailed technical content.

Assessment objectives:

Objectives of the Main Report (page 1): "*to assess the impact of the Modification on the groundwater regime, and address the requirements of relevant NSW and Commonwealth government legislation and policies.*".

Key objective in the Modelling Report (page 1): "*to assess risks to the groundwater regime using a groundwater model to systematically investigate the causal pathways for potential impacts on water resources and water-dependent assets.*".

Furthermore, regarding the specific objectives of the numerical modelling assessment, the quantities of interest (QoI) are identified in Section 5.10.3 of the Main Report. These were appropriately determined based on the Minimal Harm Criteria of the *NSW Aquifer Interference Policy* (DPI 2012) and an analysis of impact propagation mechanisms (impact propagation diagram [IPD], presented in Figure 5.31 of the Main Report). The QoI are:

- *"change in groundwater levels in the Bulgo and Hawkesbury sandstones; and*
- *change in groundwater flux from/to the Woronora Reservoir, local water courses (i.e. Honeysuckle Creek, Woronora River and Waratah Rivulet) and upland swamp areas."*

These objectives were met. Key outcomes of the assessment are presented in Section 7 of the Main Report.

3. Groundwater model

Model class. Note that the current guidelines on uncertainty analysis (e.g. Middlemis and Peeters, 2023) no longer promote the concept of model confidence or complexity classification as a measure of model adequacy. Instead, model confidence is best represented quantitatively through appropriate uncertainty analysis methods.

Conceptualisation: Background to the assessment is provided in Sections 3 (Environmental setting), 4 (Geological setting), and 5 (Conceptual model). These sections review background information on the climate, drainage, geology and hydrogeology of the region. The hydrogeology of the area is relatively well known from mining and exploration over many years, which is reflected in the material presented. Aquifer properties and parameters are also well constrained from testing and monitoring over many decades. These data provide a sound basis for the model structure and parameterisation presented later in the report and in the appendix. Of particular importance is the analysis of piezometric levels and gradients near and beneath Upland Swamps, demonstrating that most are likely perched systems ("losing" via downward seepage and disconnected from regional groundwater). This has implications in relation to potential impacts to swamp hydrology and justifies the separate assessment of swamp impacts by ATC Williams Pty Ltd (ATCW).

Section 5.9 reviews major regional geological faults that pass near the existing mine, but do not intersect current future planned workings, including the Modification. The section considers aspects of faulting that are potentially relevant to propagation of drawdown impacts as highlighted in the Independent Expert Scientific Committee on Unconventional Gas Development and Large Coal Mining Development (IESC) guidance on faults in groundwater impact assessment. The section lays the conceptual framework for numerical representation of the faults where they may offset strata, form stratigraphic "windows", and or transverse boundaries to groundwater flow.

The conceptual model and potential impact pathways are well described and illustrated using hydrogeological cross sections in Figures 5.27 to 5.30 and the IPD in Figure 5.31.

Model approach and design: Model design and approach are presented in Section 6 of the Main Report with more detail presented in the Modelling Report appendix.

The numerical model is developed using MODFLOW-USG which is a control-volume finite difference code which allows for unstructured grids. The code is widely used for groundwater modelling and favoured for its stability and flexibility. The code is considered appropriate for this application.

Extent and discretisation: The model comprises 15 layers to represent the layered stratigraphy with some layers being pinched out top reflect geological discontinuation. The extent of the model is 23 km wide by 19 km long and centred on existing and proposed mining operations. Maps of modelled drawdown show that the 1 m drawdown contours (in upper stratigraphic units) associated with the Metropolitan Coal Mine incorporating the Modification do not impinge on the model boundaries, indicating that the model domain is sufficiently large. Spatial discretisation is via a voronoi mesh which is optimised so that cells are refined at, and aligned with, key surface water features, faults and mine operations. The total number of model cells (nodes) is around 188,600 excluding inactive or pinched out nodes. This is a moderate sized numerical model (although quite a large area), and it has been optimised to allow relatively fast runtimes (30 mins), while representing important aspects of the hydrogeological conceptual model. Temporal discretisation ranges from multiple years to monthly stress periods. This model structure and discretisation is considered appropriate and conforms to current best practice.

Boundary conditions are appropriate for the scale of the model and model objectives. Model boundaries are represented by General Head Boundaries (GHB) which allow for movement of groundwater across those boundaries and to some extent mitigate boundary effects. Cumulative effects from the neighbouring Appin Colliery located to the west is simulated using GHB and Constant Head Cells, based on nearby monitoring. **Reservoirs and major watercourses** are represented as River boundaries. Given the vertical scale of the model, the use of average river stage elevations and variable reservoir stage elevations is appropriate. **Major faults** are represented by assigning non-neighbour node connections to represent potential stratigraphic windows, and Horizontal Flow Boundaries (HFB) to represent possible transverse barriers to flow. This approach simulates the main potential hydrogeological characteristics of the fault, with HFB permeability allowed to vary in calibration.

Mining parameters. The representation of mining effects, including subsidence fracturing of strata above the goaf is a key consideration (and source of uncertainty) in the assessment of impacts from Longwall mines. This aspect is discussed in some detail in Section A2.7.5. The Ditton formula (Ditton and Merrick 2014) predicts that vertically connected fracturing (A-zone) likely extends from the coal seam into the lower Bulgo Sandstone. The hydraulic characteristics of the fracture network is simulated using drain boundaries within the affected strata, followed by modification of aquifer properties. This approach captures the main features and effects of the subsidence fracturing and has been used by other consultants. Drain conductance and fracture network hydraulic properties are estimated using a modified form of the Thiem equation (after Panday *et al.* 2013) which requires estimates of fracture density as a parameter. The reviewer has not independently verified the formulae nor the initial parameter values. However, it is noted that the fracture density parameters were allowed to vary during calibration and in uncertainty analysis, making the initial values less critical.

Hydrogeological parameters applied to geological strata are well constrained from numerous packer tests, bore permeability tests and previous modelling studies. The values and ranges applied are considered appropriate based on the reviewer's experience. Sufficiently wide parameter bounds were applied such that parameters values can be optimised during the history matching process.

History matching (model calibration). Model parameter values were optimised through a history matching process using PEST-HP ENSI (ensemble space inversion) (Doherty 2025). ENSI is a flexible and efficient method designed for complex and highly parameterised models. History matching used a range of observation targets, including groundwater heads, drawdown, vertical head gradients, surface water baseflows and mine inflow. This helps to reduce non-uniqueness and bias during calibration. The calibration process involved varying multiple parameters related to aquifer characteristics, recharge and evapotranspiration, boundary conditions, surface water features, fault permeability, and mining parameters. A pilot point approach was used to account for spatial variability in certain parameters (e.g., aquifer properties, recharge). The overall methodology aligns with current best practice.

History matching resulted in an acceptable fit between model results and monitoring observations, with a Scaled root mean square of 5%. Hydrographs presented in Appendix A1 show a reasonable fit in terms of trends. Some misfit in absolute heads is expected due to measurement uncertainty and local-scale effects that may not be fully captured at the resolution of a regional numerical model.

Sensitivity analysis. Parameter sensitivity in discussed in Section 6.2 of the Modelling Report. The analysis draws on the Jacobian Matrix which represents the local partial derivatives of model outputs with respect to model parameters (or parameter groups). This is appropriate given that the model has been calibrated using 15 years of monitoring data, and that the predictive period is both of similar nature to the previous mining and of shorter duration. The analysis showed that the groundwater drawdown (and therefore stream baseflow loss) is most sensitive to the values of horizontal hydraulic conductivity (Kh), vertical hydraulic conductivity (Kv) and storage values in the Hawkesbury Sandstone (HBSS) (model layers 3, 4 and 5) and Bulgo Sandstone (layers 8 and 9). Mine inflow is most sensitive to Kh, Kv and storage values in those layers which sit partially within the modelled A-Zone (in layers 9 to 13).

Predictive uncertainty analysis was carried out using an ensemble approach and is presented in Section A6 of the Modelling Report. The PEST suite tools PREDUNC7 and RANDPAR2 (Doherty 2018) were used to generate an ensemble of 260 parameter realisations based on the calibrated parameter estimates (i.e. posterior parameter distributions). The results of the analysis were presented effectively, including as drawdown probability maps in Figures A6.8 to A6.13. The approach is appropriate for a complex and highly parameterised model and is consistent with the IESC guidance on uncertainty analysis (Peeters and Middlemis 2023).

Model predictions and impact assessment are presented in Section 7 of the Main Report. Groundwater inflow estimates are plausible and match estimates of actual inflow reasonably well, if inflows from the A-zone fracture network are excluded. While mine inflow is not a stated QoI, the observation further supports the idea that subsidence fracturing above the goaf is of limited extent and/or transmissivity at Metropolitan Colliery. Maps of groundwater head drawdown are presented in Figures 7.2 to 7.8, for the Modification only, and the project including the Modification. The results are plausible based on the information provided and the reviewers experience. The relatively minor drawdown impacts in the mid to upper HBSS for the Modification scenario are consistent with the relatively incremental expansion of the Modification (4-5%) compared with the approved mine plan. Changes to groundwater discharge to the Woronora Reservoir and local watercourses are also minor which is in keeping with the minor drawdown in the HBSS which provides most of the baseflow to those watercourses. The report presents estimates of drawdown in the regolith beneath the mapped Upland Swamps. A drawdown of up to 2.2 m is predicted in the regolith beneath Swamp 106 which directly overlies the Longwalls within the Modification. A separate assessment of impacts was carried out by ATCW based on those estimates.

Overall, this review finds that the groundwater modelling methodology is in keeping with current best practice, is well supported by hydrogeological observations and is fit for the purpose of hydrological impact assessment. The resulting predictions of potential groundwater and surface water impacts are considered to be plausible in terms of magnitude and extent, based on the information provided and monitoring of previous mining effects.

I hope you find these comments useful. If you have any further questions, please contact me using the details above.

Regards

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4. References

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To:	Jon Degotardi (Metropolitan Coal)	cc:
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Subject:	**Independent Peer Review: Metropolitan Coal Swamp Impact Assessment**	
Date:	17/6/2025	**Ref:** D25286

Stuart Brown of HGEO Pty Ltd was engaged to provide an independent peer review of the Swamp Impact Assessment for a proposed modification to Metropolitan Colliery (Metropolitan Coal Mine). Metropolitan Collieries Pty Ltd (Metropolitan Coal) proposes to extend the life of the mine by reconfiguring Longwall 317 and adding an additional longwall (Longwall 318). This modification is subject to environmental assessment and approval processes, referred to as the Metropolitan Coal Mine Longwalls 317 and 318 Modification (the Modification).

The Surface Water Assessment was prepared by ATC Williams Pty Ltd (ATCW) to support the Modification application. The report is entitled:

- Metropolitan Coal Longwalls 317-318 Modification Surface Water Assessment, dated 11/6/2025, Document No: 240208R002-revD. (referred to here as "the report")

The report was provided as a Microsoft Word document and this review focussed on aspects of the Swamp assessment in Sections 1 to 8. This memo presents the findings of an independent peer review of the report, specifically in relation to the Swamp Impact Assessment, including conceptualisation, numerical modelling approach, and results as presented in those sections. The review included two meetings conducted online where ATCW presented the proposed model approach and preliminary findings. The review did not include verification of numerical model input files. Preliminary comments were sent to ATCW by email on 2/5/2025; issues that were addressed beforehand are not repeated in this review.

1. Review comments

This review primarily focusses on the assessment of impacts to Upland Swamps as a result of the proposed Modification at Metropolitan Coal Mine as presented in the ATCW report. In the report, potential impacts swamps are assessed using a numerical modelling approach that is informed by a conceptual framework and observed impacts at swamps previously affected by mining.

The report is generally well structured and presented with effective use of maps and diagrams. The introductory sections provide a thorough overview of environmental settings such as regional geology, climate, drainage and water quality. Section 6 of the report presents a conceptual model whereby most swamps are perched systems within swamps sediments ("substrate"), overlying low permeability weathered Hawkesbury Sandstone (HBSS). The hydrological regime of an upland swamp system is described as reflecting a balance between water inputs and outputs. In the perched swamp systems, water inputs are rainfall infiltration, runoff from the upgradient slopes and lateral seepage from adjacent sandstone. Outflows are via lateral drainage to the downstream watercourse, vertical downwards seepage to the underlying sandstone, and evapotranspiration (EVT).

The report notes that analysis carried out by Australasian Groundwater and Environmental Consultants Pty Ltd (2025) in their Groundwater Impact Assessment identified that the water table within the HBSS may intersect with more incised lower reaches of some watercourses and valley infill swamps resulting in possible groundwater discharge (baseflow) to those systems. This is possibly the case for a small area of Swamp 106 near its outlet. However, most of Swamp 106 and all of

Swamp 74 is inferred to be perched (disconnected and losing) and this is an appropriate and conservative assumption for the approach used in this assessment.

Section 8 outlines the effects of past mining on the hydrological regime of swamps in the Metropolitan Coal Mine area, with persistent effects noted at Swamps 20 and 28. This provides important context for the numerical impact modelling.

Section 10 of the report describes the numerical model used for swamp impact assessment. For each target swamp, A 2D unsaturated zone model is developed in SEEP/W to simulate the water balance and water table fluctuations over time. The model comprises three layers: a base layer represents the HBSS and the upper two layers are the upper and lower clayey sand layers of the swamp sediments. The swamp water balance is stimulated by applying boundary conditions for rainfall infiltration and EVT. A perched water table can develop above the HBSS, with vertical downward seepage controlled by permeability parameters. The 2D slice model allows for accumulation of lateral groundwater flow from up-gradient of the observation site and swamp. The model includes a simplified representation of EVT compared with the 2024 model. The applied EVT varies according to the potential EVT (input timeseries), and as a function of the soil moisture content via a modifier function (represented as a characteristic curve). This is an improvement on the 2024 model in the reviewer's opinion. The model is calibrated by allowing the parameters controlling the characteristic curve to vary, while other parameters held constant. The approach is consistent with the conceptual model and achieves a reasonable fit between observed and simulated groundwater levels during the baseline periods.

Potential changes to swamp hydrological regime were assessed by applying a factor of increase of hydraulic conductivity (referred to hereafter as, K-factor) to each of the models and comparing the results against the "pre-mining" calibrated model results. ATCW determined from their 2024 assessment that observed impacts to Swamp 20 could be replicated using a K-factor of 2.0. However, the current assessment recognised that predicted subsidence effects at Swamp 106 and Swamp 76 are significantly less than those observed at Swamp 20 and therefore K-factors of 1.5 and 2.0 were used to represent likely and worst-case estimates. This is considered to be an appropriate and conservative approach, noting that the number of observations of previously impacted sites is limited.

Based on the model estimates of shallow groundwater levels at each swamp piezometer site. The tabulated results are presented in terms of the percentage of time that the swamp groundwater level is at or below a depth threshold, which are important metrics for swamp vegetation health. The report concluded that: "*Overall, under median and wet climatic conditions, the modelled impacts on S74 and S106 are considered minor. However, under dry climate scenarios, a modest increase in water level drawdown is predicted to occur*". This is a reasonable conclusion based on the results.

In conclusion, this review finds that the modelling methodology is appropriate for assessment of impacts to swamp hydrological regime and is well supported by hydrogeological data. The resulting predictions of potential changes in swamp shallow groundwater level are considered plausible in terms of magnitude.

I hope you find these comments useful. If you have any further questions, please contact me using the details above.

Regards

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