HydroGeoLogic

HydroGeoLogic Pty Ltd (ABN 51 877 660 235)
PO Box 383, Highgate 5063, South Australia
0438 983 005 hugh@hydrogeologic.com.au

PEER REVIEW STATEMENT

ATTENTION:	Tegan Cole, NSW Dept of Planning Industry and Environment (DPIE)	
FROM:	Hugh Middlemis, Principal Groundwater Engineer, HydroGeoLogic (HGL)	
REFERENCES:	**7 October 2021**	Mount Pleasant Optimisation Project (SSD 10418)(EPBC 2020/8735)
SUBJECT:	**Mount Pleasant Optimisation Project Rehabilitation and Mine Closure.** **Targeted Peer Review of the Groundwater Impact Assessment Final Void Issues.**	

Dear Tegan

This brief report presents the outcomes of a targeted peer review on the post-mining final void issues described in the Groundwater Impact Assessment ('GIA'; AGE 2020a), presented as Appendix C to the Mount Pleasant Optimisation Project EIS (SSD 10418) (MACH Energy 2020a).

1. SOPE OF WORK AND PEER REVIEWER

The scope of work comprises the provision of technical advice to the Department regarding the post-mining Groundwater Impact Assessment ('GIA') of the final void/landform options (approved voids versus one large void, and proposed void versus no void), including:

- whether the assumptions used are reasonable, appropriate and suitably justified;
- identification of any areas of deficiency and recommendations to improve or resolve these issues in the assessment;
- the significance of impacts, issues for consideration for the assessment, key environmental and contamination risks;
- suitability and adequacy of the proposed measures to avoid, mitigate or minimise the likelihood, extent and significance of impacts;
- consideration and recommendation of any additional measures to further avoid, minimise and/or mitigate any identified impacts of the project;
- advice as to whether the groundwater modelling for the proposed final landform options is adequate to inform the Department's assessment of the likely impacts;
- whether the conclusions reached in the project's Rehabilitation and Mine Closure Addendum are reasonable, appropriate and suitably justified.

Technical advice was also requested in relation to the appropriateness of the proposed final landform options (approved void vs one large void, proposed void vs no void) and the post-mining groundwater impacts:

- long term residual drawdown;
- potential throughflow / pollutant migration risks (ie. changes to groundwater and surface water quality);
- changes to flow regimes, groundwater systems and flooding; and
- the timing and rate of recovery for water levels reaching equilibrium.

The review was conducted by Hugh Middlemis, who has relevant skills and experience, notably:

- Independent expert reviews of the groundwater assessments for several NSW coal mining and other projects; Boggabri Mod 8, Bowdens Silver, Cowal Gold, Tarrawonga LoM Mods, Vickery Extension, Tahmoor South and Hume Coal (for DPIE 2018-2021).
- Appointed by the NSW Independent Planning Commission as a member of the Mining and Petroleum Gateway Panel (2021-2024).

We assert no conflict of interest issues in relation to this work. Mr Middlemis has not worked on the Mt Pleasant project, nor for the principal MACH Energy, nor for their consultants AGE and HEC.

2. PEER REVIEW FINDINGS

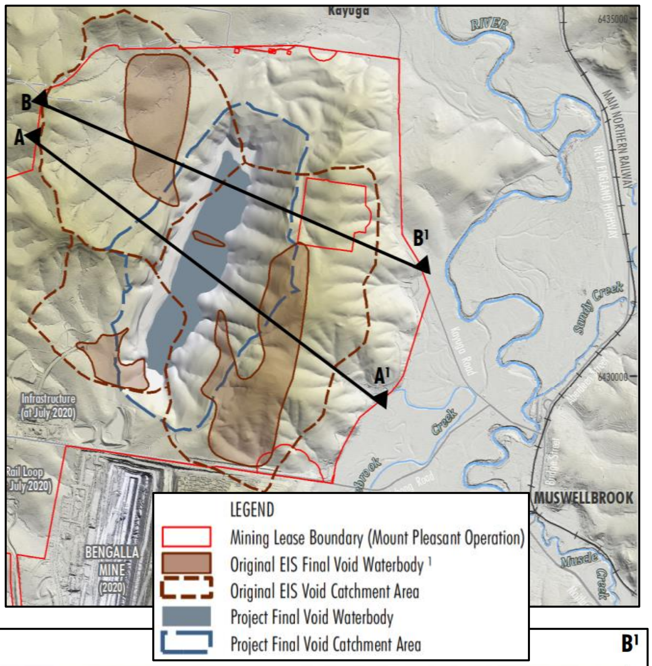
The Mount Pleasant groundwater model (AGE 2020a) is fundamentally fit for the purpose of simulations to inform the Department's assessment of the likely impacts, and it has been independently peer reviewed by Dr Brian Barnett, a highly skilled and experienced expert and principal author of the best practice guidelines (Barnett et al. 2012).

However, as described in the sections below, the application of the model to some scenarios and/or the documentation of some results does not always meet best practice guidelines.

This review finds that, while many aspects of the final void water level, water balance and water quality assessments of the various options have been conducted competently, the analysis of some key aspects is deficient and/or not adequately documented, as discussed below.

2.1 Proposed Single Final Void

It is understood that the existing approval is based on a final landform with multiple voids, whereas the proposed final landform for the Mt Pleasant Optimisation involves a single void (Figure 1). The final void will receive groundwater and surface water inflows and will develop into a final void lake with a predicted water level of 80 or 90 mAHD. Predictions indicate that a final equilibrium would be achieved after around 300 years once there is a balance between the groundwater and surface water inputs and the lake evaporation output.



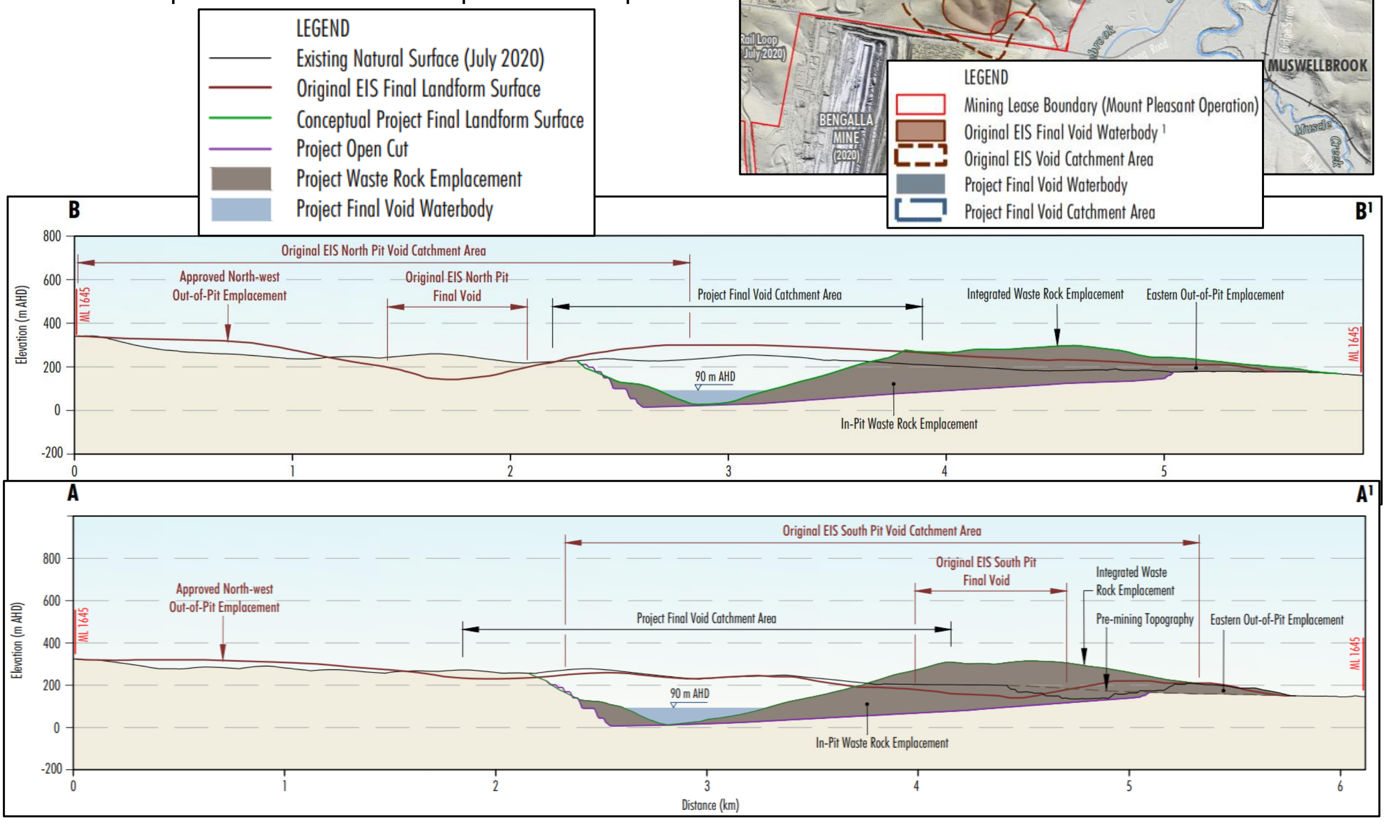


Figure 1 - Mt Pleasant conceptual final landform plan and section (after MACH 2021b, Figs. 7 & 8)

While the groundwater modelling details presented in the Groundwater Impact Assessment ('GIA'; AGE 2020a) are adequate and demonstrate consistency with best practice guidelines in general, the EIS report (MACH 2020a) and the supporting technical appendices present conflicting information on the long term lake level. The EIS states at section 7.8.3 (p.7-59) that the final void lake level is predicted to be 90 mAHD and illustrates this at Figure 7-16 (consistent with Figure 1 above). Figure A4.2 of the GIA also shows the final void lake level at 90 mAHD, but the similar Figure 30 in the Surface Water Impact Assessment ('SWIA'; HEC 2020) shows the predicted final void lake level at 80 mAHD (Figure 2). This inconsistency should be resolved.

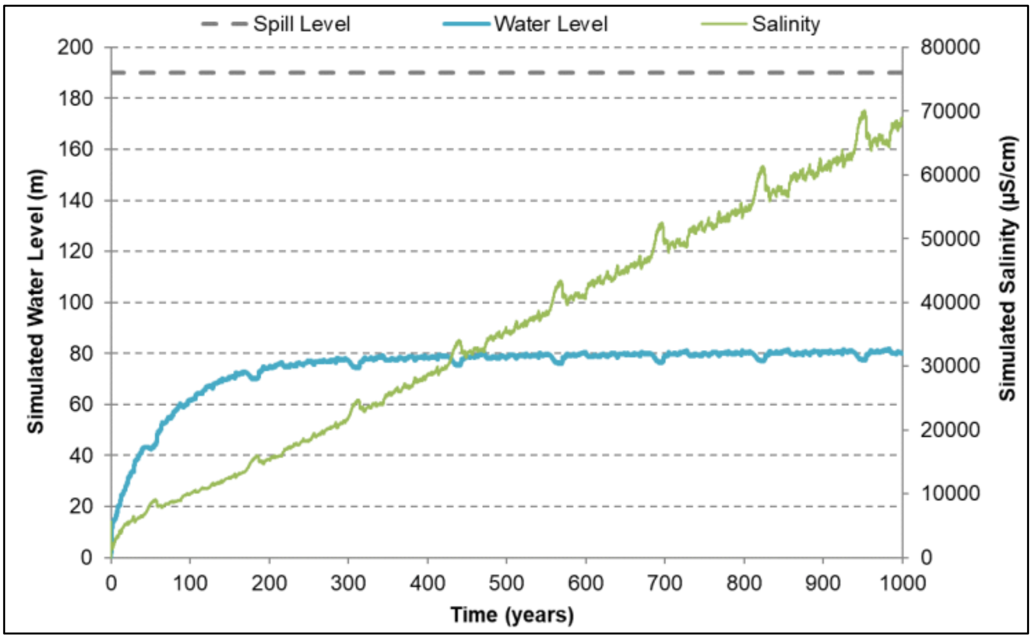


Figure 2 - Predicted final void lake level and salinity (after HEC 2020, Fig. 30)

In any event, the final void lake level is predicted to be well below the final void spill level at about 190 mAHD. Although a parameter sensitivity analysis has not been presented for this analytical GoldSim water and salt balance model (HEC 2020), it is very likely that the level of the long term final void lake (as configured) would remain a groundwater sink well below the spill level, mainly due to the large area of the lake water surface and the relatively low inflows.

2.2 Multiple or Single Final Voids

It is noted that a key issue stated in the SEARs under 'Rehabilitation and Final Landform' is to achieve a '*final landform that is safe, stable and non-polluting*' (MACH 2020b, Table 1), and this is also included in the stated rehabilitation objectives (MACH 2020b, Table 6). The final landform is reported to be designed on geomorphic principles to meet the SEARs requirements in terms of safety and stability (although that is outside this reviewer's expertise and not within this review scope).

The issue of a non-polluting final void is problematic because there appears to be no definition of 'non-polluting' as such. However, this review considers that it should be analysed in terms of the final void lake equilibrium between the groundwater and surface water inputs and the lake evaporation output, and the predicted water quality in relation to the existing beneficial use status of the groundwater quality (stock quality, in broad terms), and surface water quality where that needs consideration.

The catchment areas and final void water bodies for the multiple voids under the existing approval and the single void now proposed are shown in Figures 5 and 6 of the Request for Information report (MACH 2021b); similar to the plan view in Figure 1 above.

The single void appears to be an improvement in terms of a simple comparison of reduced footprint, which has implications for the final void lake equilibrium water level and water quality:

- reduced surface area of the void waterbody (162 ha compared to 435 ha)
- reduced catchment area (810 ha compared to 2050 ha).

The proposed single final void is deeper because the mining extends to deeper coal seams, which is more likely to result in a long term groundwater sink, as is reasonably predicted. Whether or not the proposed single final void will result in an improvement in water quality terms, compared to the multiple voids, is a complex question. It is not possible for this review to provide a definitive comparison, as that requires assessment of the catchment runoff inputs as well as the groundwater inputs and the evaporation effects, and a geochemical assessment. Nonetheless, this review considers that the final void lake water quality and geochemistry assessment is deficient in the sense that comprehensive details are not provided to clearly establish whether or not the final void lake would form a long term 'non-polluting' landform.

The assessment reports have not provided detailed evaluations that clearly identify the impacts and/or benefits of the final void options in water quality terms. For example, the assessment reports have not presented clear and comprehensive water quality predictions, other than in the simple terms of the final void lake salinity (Figure 2 above). The Geochemistry Assessment (RGS Environmental, 2020) identified that the Archerfield sandstone interburden is potentially acid forming (PAF) and may have the potential to generate elevated metals concentrations. The waste rock management strategy is designed to blend or encapsulate any PAF rock with other rock to produce an overall non-acid forming (NAF) emplacement material. However, there is no delineation of where any PAF material may be exposed in the pit wall, so that risks could be assessed in relation to the predicted final void lake configuration, and there appear to be no details provided on the treatment of any PAF material that may be exposed in the pit walls, which could significantly affect the final void lake water quality (Jones et al. 2016).

Given these gaps, the assessment cannot and does not present a comprehensive hydrogeochemical analysis of the final void lake water quality. There is also a gap in the assessment as to whether or not a plume of poor quality groundwater may develop below and adjacent to the final void lake, whether that would remain stable around the final void lake, how far it may extend laterally and vertically, and any associated plume transport and fate implications. This could/should have been assessed more thoroughly, at least via the simple method of particle tracking, augmenting the analysis already presented for shallow flowpaths towards the proposed single final void lake (Figure 7.6 of AGE 2020a).

2.3 Proposed Single Void

It is reasonable to conclude from the information presented that the proposed single final void prediction of a long term groundwater sink appears to be valid, and the assessment reports have presented adequate but not comprehensive evidence to confirm this outcome (eg. sensitivity analyses on the analytical GoldSim water balance analysis have not been conducted).

For example, the GIA presents contour plans of drawdown and particle tracking plots, which help demonstrate the groundwater sink outcome, and confirm that post-mining groundwater flowpaths within the mine lease migrate mainly towards the final void lake at Mt Pleasant, with some migration towards the final voids at Bengalla and Dartbrook. However, there are gaps in the information presented, notably the lack of prediction plots in terms of post-mining groundwater levels (not simply drawdown) in the form of time series and contour plans.

There is some confusing information presented in the reports. For example, the numerical groundwater model was used to define the relationship between groundwater level and inflow to the pit void, which was applied as one key input to the analytical GoldSim water balance, consistent with best practice. However, the plot of groundwater level versus inflow (Figure 3) exhibits a strange and unexplained relationship of increasing inflow between zero and about 50 mAHD (more than half-way up to the final equilibrium level shown in Figure 2 above), under conditions when the driving head for inflow is falling and thus inflows should be reducing (ie. as shown for the inflows below 2.5 ML/d on Figure 3 below, but also noting the maximum inflow during mining is about 1.6 ML/d; AGE 202a, Figure 9.1). The post-mining final void lake is not predicted to reach 50 mAHD until after about 60 years, which is a very long time for inflows to be increasing under some as yet unexplained process or undocumented modelling method.

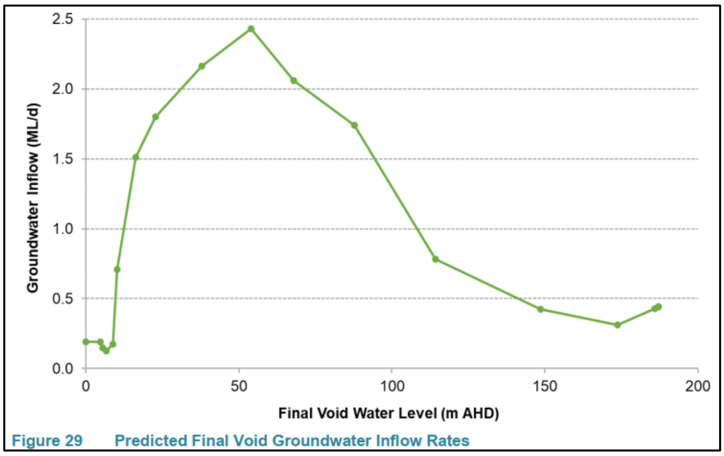


Figure 3 - groundwater level and void inflow relationship (after HEC 2020, Fig. 29)

2.4 Non-polluting Final Landform

The Surface Water Impact Assessment ('SWIA'; HEC 2020) applies a GoldSim analytical water and salt balance model to predict that the final void lake salinity will increase linearly to about 70,000 EC after about 1000 years (see Figure 2 above). The existing groundwater quality is characterised by the inflow to the existing pit, which reportedly averages 5522 EC, and yet the post-mining final void lake salinity is predicted to be more than double that salinity after about 50 years, and to continue increasing to 70,000 EC (more than seawater) with no sign of abatement at 1000 years. This review finds it unreasonable to characterise the post-mining final void lake water quality as 'non-polluting', at least in the sense of it forming a potential source of poor quality water that is effectively a 'window' into the post-mining watertable.

Accepted best practice and risk-based methods for mining project impact assessment apply the source-pathway-receptor framework (eg. Howe et al. 2010, curated by the National Water Commission; Howe, Moran and Vink, 2010). These methods are also consistent with the risk-based causal impact pathway aspects of the best practice groundwater modelling guidelines (Barnett et al. 2012) and the recent uncertainty analysis guidance (Middlemis et al. 2018). A common principle is that (paraphrasing): *without the presence of a pathway to a receptor there is no possibility of an effect from a source*.

The characterisation of the proposed single final void lake as a long term groundwater sink appears to be justified (notwithstanding the issues raised herein). This may tend to suggest that there is no groundwater pathway for impacts away from the void, but only if a simplistic assessment of potential causal pathways for impacts has been considered. It is recommended that the proponent should present a more comprehensive assessment that considers the potential range of pathways for impacts from the final void lake source, consistent with best practice methods (eg. Howe et al. 2010; Barnett et al. 2012; Middlemis and Peeters 2018).

It is noted that the SEARs also require '*an analysis of final landform options, including the short and long-term cost and benefits, constraints and opportunities of each, and detailed justification for the preferred option*.' It is recognised that the assessment reports present some information on the closure options that appear to have been carefully considered, inclusive of stakeholder feedback, and which has resulted in significant reductions in the final void footprint (eg. about 1.5 km of the northern part of the final void will be backfilled). However, the reader is left with the impression that there is a preferred scenario for a final void lake, given a range of assertions, for example, that:

- it would be '*uneconomic'* to fully backfill
- '*partial backfilling of the final void would not eliminate the final void water body'*
- the 'no void' option would drive '*increased seepage of water from the backfilled waste rock material to the Hunter River alluvium*', and would be '*inconsistent with the rehabilitation objectives for final voids*' of the existing approval, which reportedly require the final voids '*to be designed as long term groundwater sinks to maximise ground water flows across backfilled pits to the final void*.'

This reviewer struggles to rationalise the tension between a requirement to apparently be consistent with the existing approvals around final void groundwater sinks on the one hand, and the SEARs requirement on the other, to apply groundwater modelling methods to identify a final landform option that that would avoid, mitigate or minimise groundwater-related impacts.

Nonetheless, it is again noted that the numerical groundwater model and the analytical GoldSim lake water balance model are both/together suitable for investigating alternative final void options. However, it is also noted that they have been applied to investigate only a single final void option, and even then with a limited range of backfill properties and void configurations. The numerical model has itself been applied to investigate one no void option. This review does not consider that to form a comprehensive investigation of a reasonable range of options.

It is recommended that the modelling tools be applied to investigate a comprehensive range of final void configurations to identify whether or not an alternative arrangement could result in post-mining groundwater levels, flows and water quality that would avoid, mitigate or minimise groundwater-related impacts, and to investigate key uncertainties (eg. evaporation rates, waste rock properties, mining and integrated backfill configurations, etc), in a manner consistent with best practice (eg. Jones et al. 2016, section 6.6; Lacy et al. 2016).

2.5 'No Void' Option

The assessment has provided information on the groundwater modelling scenario of adopting a 'no void' option (AGE 2020b), in response to feedback from Muswellbrook Shire Council. The groundwater model was set up for a 'no void' scenario by assuming reasonable values for spoil emplacement properties (Table A2.5; AGE 2020a) for the backfilled void in terms of recharge (2% of rainfall), permeability (Kh = 0.3 m/d, and Kv = 0.1 m/d) and specific yield (Sy = 0.1).

The 'no void' scenario predicts that the post-mining watertable would recover to about 180 mAHD, exceeding pre-mining groundwater levels, due mainly to the higher recharge rate of the backfilled landform than for pre-mining conditions. Such high groundwater levels result in the migration of groundwater flow away from the final landform and towards the nearby final voids at Bengalla and Dartbrook (eg. similar to predictions for the single void scenario), but also towards the Hunter River alluvium (not predicted for the single void case). This means that there is predicted to be increased flow of groundwater through the backfilled waste rock material towards the Hunter River alluvium. However, there is no accompanying analysis of potential changes to water quality.

The 'no void' option modelling is deficient by not investigating whether alternative recharge rates and/or aquifer properties could result in a reduced post-mining groundwater level that would avoid, mitigate or minimise groundwater migration through the waste rock emplacements and towards the Hunter River alluvium. The assessment also did not investigate the water quality implications, including taking account of the potential exposure of PAF material (in situ or in the final void wall). These deficiencies are not consistent with best practice (Barnett et al. 2012; Jones et al. 2016), but could be addressed with adequate consideration of the methods recommended therein, as recommended above.

2.6 Report and/or Model Issues

The points below discuss some inconsistencies between the assessment reports that warrant corrective action, and some questionable aspects of the groundwater model design:

i) The flow-duration curve for the Hunter River at Denman is inconsistent between the SIA (Figure 6) and the GIA (Figure 3.4). Flow-duration is an important consideration in terms of assessing the effect on low flow periods of the predicted baseflow reductions, but the assessment reports are currently deficient in that regard. The simple comparison of annual baseflow volumes to the total flow volume is inadequate in terms of evaluating hydrological and/or ecological impacts during low flow conditions. This issue was also raised by the IESC (MACH 2021b), but the response from the proponent does not provide the detail necessary to resolve the deficiency in the assessment. Given the presentation in the SIA and GIA of flow-duration curves that are based on measured data, the impact of baseflow changes on the flow-duration character should have been assessed with reference to that data, and it is recommended that improved documentation be provided.

ii) The western boundary of the numerical groundwater model is designed with a no flow condition that aligns partially with the Mt Ogilvie Fault, although the justification given is flawed, in that the Mt Ogilvie Fault is conceptually not a flow barrier as such, as evidenced by the GIA Figures 4.3 and 5.20 (AGE 2020a). The nearby Spur Hill groundwater assessment (HydroSimulations 2013) stated that '*The Mt Ogilvie structure is not considered to form a lateral barrier to groundwater flow*', mainly because the coal seams are not offset against low permeability interburden. It is noted that the predicted drawdown extends to the western boundary (eg. AGE 2020a, Figure 7.3), including the south-western corner where it diverges west from the Mt Ogilvie Fault. The IESC also raised this issue, and while the proponent's response presents an arguably reasonable argument (MACH 2021b), modelling best practice requires boundary conditions that unduly influence the simulation results to be investigated via sensitivity analysis (Barnett et al. 2012). This boundary condition issue was not mentioned in the peer review of the GIA, but it remains an open question that should be investigated via a sensitivity test using the groundwater model (eg. to quantify the effect on drawdowns and river-aquifer exchange fluxes due to an alternative boundary condition).

iii) The documentation of the groundwater modelling uncertainty analysis is perfunctory and not consistent with best practice, which requires reporting of methods and results that is open, transparent and open to scrutiny. The 'calibrated modelling language' (AGE

2020a, Table 9.1 and A5.1, and Figures 9.1 to 9.9) is not consistent with the recommendations in the guidance (Middlemis and Peeters 2018, Table 2), which specifies the colour coding in terms of the likelihood of exceedance (not the likelihood of occurrence as presented). These are not fatal flaws in the assessment as such, and it would be reasonable for a skilled reader to interpret the information, so corrective action is not crucial in this case.

3. SUMMARY AND RECOMMENDATIONS

The groundwater model is adequately fit for the purpose of simulations to inform the Department's assessment of the likely impacts, and it has been independently peer reviewed by Dr Brian Barnett, a highly skilled and experienced expert and principal author of the best practice guidelines (Barnett et al. 2012).

However, the application of the model to specific scenarios and/or the documentation of some results does not always meet best practice guidelines, particularly with regard to the documentation. Many aspects of the final void water level, water balance and water quality assessments of the various options have been conducted competently, but the analysis of some key aspects is deficient and/or not adequately documented. Nonetheless, it is reasonable to conclude from the information presented that the proposed single void prediction of a long term groundwater sink appears to be valid. However, this review finds it unreasonable to characterise the post-mining final void lake water quality as 'non-polluting' (ie. contrary to the SEARs), at least in the sense of it forming a potential source of poor quality water that is effectively a 'window' into the post-mining watertable.

The following corrective action is recommended:

- rationalise the conflicting information on the long term lake level (80 or 90 mAHD?);
- provide a sound explanation as to why the groundwater level versus inflow relationship that is used in the GoldSim analytical water and salt balance modelling (HEC 2020) is valid in showing increasing inflows between zero and about 50 mAHD, under conditions when the driving head for inflow is falling and thus inflows should be reducing; the explanation should also address why the maximum post-mining inflow is more than 1.5 times the maximum inflow predicted during mining;
- conduct sensitivity testing of the western 'no flow' numerical groundwater model boundary condition to quantify the effect on drawdowns and river-aquifer exchange fluxes associated with an adequately justified alternative boundary condition;
- apply the modelling tools to investigate a comprehensive range of final void and no void configurations in terms of recharge and evaporation rates and/or aquifer properties to identify whether or not an alternative arrangement could result in post-mining groundwater levels, flows and water quality that would avoid, mitigate or minimise groundwater-related impacts, including migration through the waste rock emplacements and towards the Hunter River alluvium, and investigate key uncertainties (eg. evaporation rates, waste rock properties, mining and integrated backfill configurations, etc).
- for selected/key final void scenarios investigated, analyse the water quality/geochemistry of the final void lake, including taking account of the potential exposure of PAF material (in situ or in the final void wall), and investigate whether a poor quality groundwater plume may develop under the final void lake and if so, investigate the transport and fate or stability of any plume;
- present a more comprehensive source-pathway-receptor impact assessment that considers the potential range of pathways for impacts from the final void lake source;
- assess the impact of predicted baseflow changes on the flow-duration character, and provide improved documentation.

Yours sincerely, HydroGeoLogic

Hugh

Hugh Middlemis

Principal Groundwater Engineer.

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