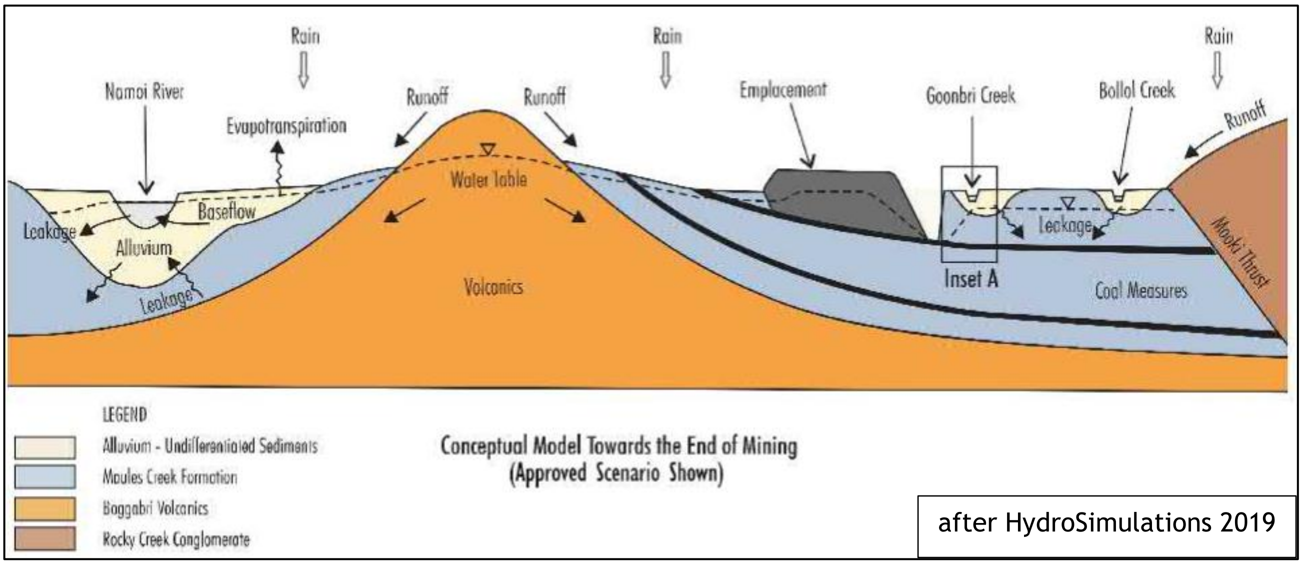
Tarrawonga Coal Mine LoM Mod. 7 Groundwater Assessment Peer Review

Prepared for:	NSW Department of Planning Industry and Environment	10 December 2020



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Middlemis H (2020). Tarrawonga Coal Mine LoM Mod. 7 Groundwater Assessment Peer Review. Prepared by HydroGeoLogic for NSW Department of Planning, Industry and Environment. 10 December 2020.

1. Introduction

1.1 Tarrawonga Coal Mine Life of Mine Modification 7

The Tarrawonga Coal Mine is about 12 km north-west of Boggabri in the Maules Creek sub-basin of the Gunnedah Basin of New South Wales (Figure 1), which has a long history of coal mining. The Tarrawonga Coal Mine open cut has been in operation since 2006, owned and operated by Tarrawonga Coal P/L (TCPL), a wholly owned subsidiary of Whitehaven Coal Ltd. Whitehaven has also developed other coal mines in the area including Maules Creek to the north and Rocglen, Vickery and the former Canyon Coal Mine to the south. The Boggabri Coal Mine immediately north of Tarrawonga has been operated by Idemitsu since 2006.

A key aspect of the proposed Tarrawonga Life of Mine Modification 7 is the reduction to the previously approved open cut pit extent to the east to avoid mining the Upper Namoi alluvium. This also removes the requirement for a diversion of Goonbri Creek, and for a low permeability barrier to reduce leakage from the alluvium towards the mine.

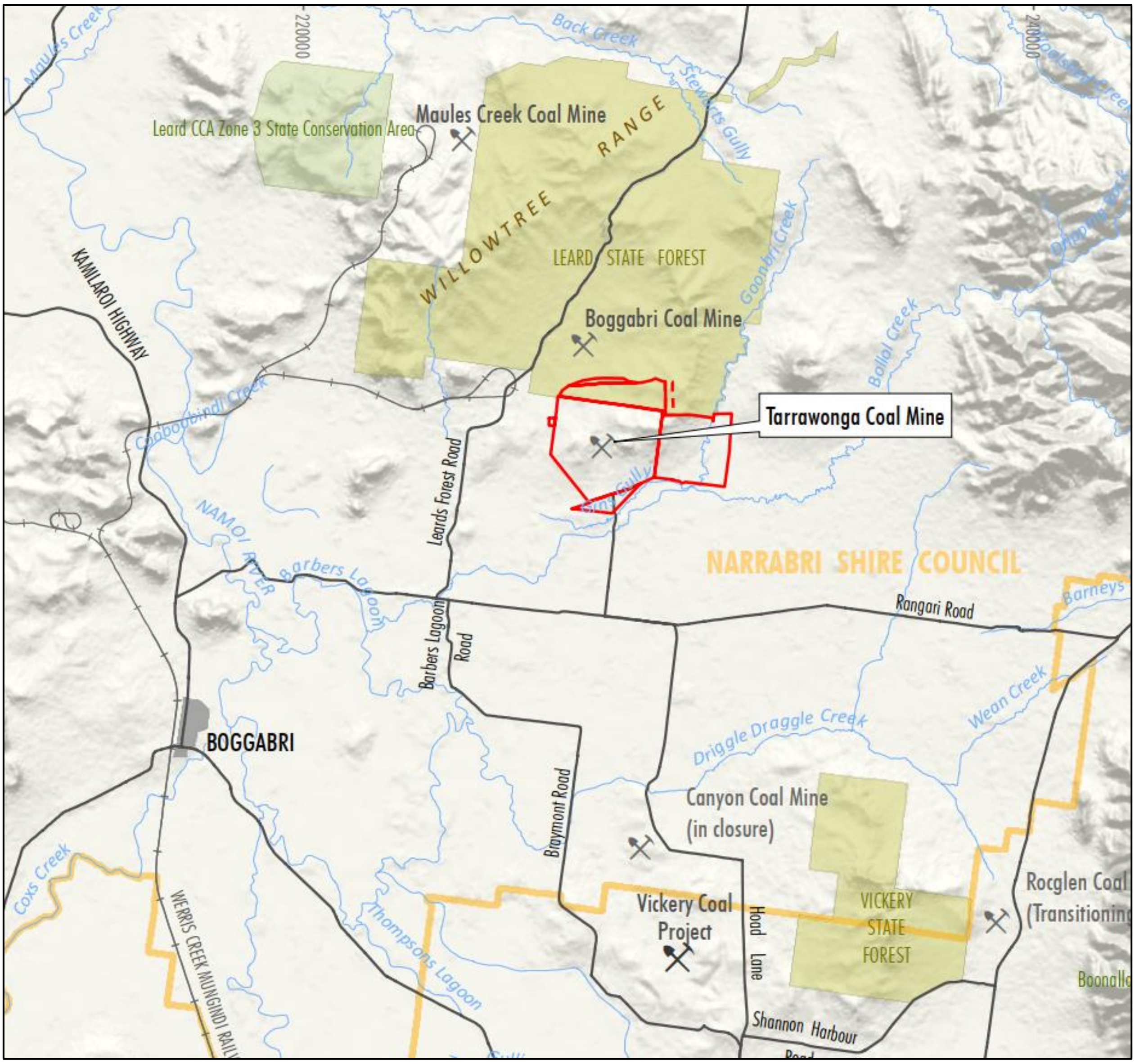

Figure 1 -- Tarrawonga Coal Mine regional location (after Whitehaven Coal)

1.2 Peer Review

This report presents the findings of an independent peer review of the groundwater and modelling investigations that form the quantitative basis for the Tarrawonga Coal Mine Life of Mine (LoM) Modification 7 groundwater assessment (HydroSimulations 2019) that supports the LoM Modifications Report (Whitehaven Coal, undated). This independent review effectively forms advice to the NSW Department of Planning, Industry and Environment (DPIE) on whether the groundwater assessments made, or conclusions reached, are supported by the evidence presented, and/or whether additional information, monitoring, assessment and/or modelling may be required to inform the assessment.

The best practice principles and procedures of the Australian Groundwater Modelling Guideline (Barnett et al. 2012) were applied to conduct this review, as there are no standard procedures for peer reviews of groundwater investigations and impact assessments as such. Consideration was also given to recent guidance on uncertainty analysis (eg. Middlemis and Peeters, 2018, regarding coal mines and CSG; and Middlemis et al. 2019, which is more generally applicable and actually was the basis for the former).

This desktop review was conducted in November-December 2020 by Hugh Middlemis of HydroGeoLogic; brief bio information is provided in section 5. A video conference discussion on 3 December was facilitated by the DPIE with representatives from Whitehaven Coal and their consultants HydroSimulations (groundwater) and Resource Strategies (assessment). The main topic discussed was the potential for leakage towards the mine from floodwaters that may pond against the flood bund in the area of mapped Namoi alluvium near the south-east corner of the open pit and the Goonbri Road alignment. Subsequently, Whitehaven provided additional documentation on this topic. Refer to section 3.6 for more information.

1.3 Evidentiary Basis

The main evidentiary basis for this peer review is the groundwater assessment report (listed as Appendix A to the Modification Report):

- HydroSimulations (2019). Tarrawonga Coal Mine Life of Mine Modification Groundwater Assessment. Prepared for Whitehaven Coal, 30 September 2019.

Groundwater-related aspects of other reports on the Tarrawonga Coal Mine LoM Modification assessment were considered, notably:

- LoM Modification Report, providing an overview of the project and its assessment.
- LoM Modification Appendix B Surface Water Assessment (HEC 2019), mainly in relation to the post-mining final void lake water balance modelling.
- LoM Modification Submissions Report, outlining responses by Whitehaven Coal to submissions from various parties.

Reports relating to the Vickery Extension project groundwater assessment were also considered, mainly in relation to the potential effects of the proposed Vickery/Extension dewatering effects and the water supply borefield that were not included in the Tarrawonga Mod 7 assessment:

- HydroSimulations (2018). Vickery Extension Project Groundwater Assessment. Prepared for Whitehaven Coal. August 2018. Presented as Appendix A to the Vickery Extension Project Environmental Impact Statement.
- Middlemis H (2018). Vickery Extension Groundwater Assessment Independent Review. Prepared by HydroGeoLogic for NSW Department of Planning and Environment. 9 November 2018.

2. Review Outcome Summary

A summary statement of the findings of this peer review is presented below, followed by the compliance checklist (Table 1) based on the best practice guidelines.

The Tarrawonga Coal Mine Life of Mine Modifications groundwater modelling and assessment (HydroSimulations, 2019) is a sound example of best practice. It is fit for the purpose of groundwater-related impact assessment arising from the Tarrawonga LoM Modification activities (Mod. 7), including the cumulative impacts of the Boggabri, Tarrawonga and Maules Creek (BTM) complex activities, and the Tarrawonga post-mining pit void, and for informing related management and mitigation strategies, licensing and monitoring.

Table 1 - Groundwater Model Compliance: 10-point summary – Tarrawonga LoM Mod 7

Question	Y/N	Comments re Tarrawonga LoM Mod.7
1. Are the model objectives and model confidence level classification clearly stated?	Yes	Mod. 7 context well described. Modelling to assess potential impacts on groundwater resources clearly stated. Class 2-3 model confidence level is claimed; endorsed by this peer review.
2. Are the objectives satisfied?	Yes	Method and results suitable for groundwater impact assessment purposes. 3D model design and execution consistent with best practice. Steady state and transient calibration to datasets 2006-2018, plus sensitivity/uncertainty analyses. Sound application to mining, cumulative impact and post-mining final void. Sensitivity and uncertainty analysis conducted. Fit for purpose. Some assumptions/limitations re simulation of proposed Vickery/Extension activities, but adequately justified.
3. Is the conceptual model consistent with objectives and confidence level?	Yes	Conceptualisation is mature (ie. 2011 model is validated), consistent with data, objectives and Class 2-3 confidence level for mining impact assessment and licensing purposes.
4. Is the conceptual model based on all available data, presented clearly and reviewed by an appropriate reviewer?	Yes	Many studies in the area, including on mines, all carefully considered to develop a sound conceptual model, validating the 2011 conceptual model. Competent and experienced hydrogeologists, modellers and reviewers have evaluated the data, conceptualisation, models and results/outcomes across many studies over many years in this area.
5. Does the model design conform to best practice?	Yes	The model software (Modflow-USG and Vistas), model design, extent (102 x 33 km), layers (12), grid (50-500m), boundaries, parameters and methodology (section 6) are consistent with best practice design and execution. Modelling approach accounts for Boggabri, Maules Creek and Rocglen mine activities. Does not include Vickery/Extension, as Tarrawonga coal seams reportedly do not extend south to Vickery.

6. Is the model calibration satisfactory?	Yes	Model calibration performance is acceptable (SRMS error 7.6% for steady state, 7.1% for transient 2006-2018). Time series matches mostly good, some poor performances justified ok.
7. Are the calibrated parameter values and estimated fluxes plausible?	Yes	Model parameter values are consistent with drilling, testing and modelling information. Inflow rates at Tarrawonga and Boggabri and Maules Creek mines in low permeability Maules Creek Formation are low (combined <0.8 ML/day), but help constrain potential model flux non-uniqueness.
8. Do the model predictions conform to best practice?	Yes	Overall methodology is consistent with best practice and is suitable for guiding dewatering impact assessment and management plans and for decision making on licensing. Cumulative impacts adequately considered, including Boggabri, Maules Creek, Rocglen mines nearby. Post-mining scenario did not include Vickery final void (justified ok due to truncated coal seams), or Vickery water supply borefield. However, Vickery Extension assessment considered cumulative impact including Tarrawonga, Boggabri, Vickery and Rocglen, showing incremental borefield drawdown of around 1m near Tarrawonga, so Vickery borefield impacts arguably not material. More rigorous assessment may not be warranted if current plans for Vickery borefield involve lower extraction volumes. Existing Tarrawonga approval includes final void lake. Mod 7 post-mining water balance modelling is well-executed, informed by inflow-level relationship from groundwater model results. Not reported whether there was groundwater modelling to explore Tarrawonga mine closure options or to justify the final void adopted. Leachate potential issues not assessed in detail. Additional information (Whitehaven 2020) assesses potential for leakage towards pit and/or post-mining void via the alluvium due to floodwater ponding against flood bund and/or mapped alluvium, which has low probability of occurrence – see section 3.6 below for detail.
9. Is the uncertainty associated with the simulations/predictions reported?	Yes	Quantitative uncertainty analysis conducted using stochastic Monte Carlo method, consistent with best practice guidance, noting relatively low risk context (brownfields site, low permeability coal measures, low inflows and limited regional drawdown extent). Uncertainty analysis considered key parameters; Kx, Kz, Ss, Sy and recharge, and implications are well documented.
10. Is the model fit for purpose?	Yes	Tarrawonga hydrogeological and groundwater modelling assessment is fit for the purpose of mine dewatering environmental impact assessment (including cumulative impacts) and informing management strategies and licensing. Post-mining final void lake allowed for under existing Tarrawonga approval, and Mod 7 final void water balance assessment is adequate. However, application of groundwater model to investigate closure options and related uncertainties, including leachate potential, is less than one would expect in terms of best practice (see section 3.7 for more discussion). This is not a limitation of the model, as it is fit for this purpose, but it reflects limitations in the overall assessment.

3. Discussion

3.1 Model Confidence Level Classification

The Australian Groundwater Modelling Guidelines (Barnett et al. 2012) present a schema for model confidence level classifications. The schema is based on considerations underpinning the hydrogeological conceptual model (HCM) and the data available, especially aquifer responses to hydrological stresses, as well as the model design, construction and performance. It is expected that any model will have attributes that fall into more than one 'class', with the overall 'confidence level' indicated from the weight of criteria that are met. The groundwater assessment report claims a Class 2-3 model confidence level classification. This peer review concurs with that assessment, confirming the Tarrawonga model as fit for purpose and suitable for impact assessment scenario modelling purposes.

3.2 Fitness for Purpose

The report (HydroSimulations 2019) is very well-written and provides detailed explanations of the conceptual model and the numerical model design and execution.

The 3D model domain, layer setup, grid design, boundary conditions and parameters applied are all consistent with the available information and conceptualisation, and apply up-to-date MODFLOW-USG software and modelling methods.

The conceptualisation is sound, based on a range of investigations over many years, and has been implemented aptly in the model. The model calibration performance is adequate statistically, benchmarked against operational mine dewatering stresses and aquifer responses. The time series matches to monitoring data are mostly good, and the simulated groundwater flow patterns reflect the hydrogeological conceptualisation.

The impact assessments and interpretations are supported by the data available and the evidence presented, and the ongoing monitoring and other investigations will provide additional data for future model refinements and improvements in performance and for further uncertainty analysis to help guide future monitoring and management programs.

There is some discussion in submissions from several organisations (eg. Country Women's Association, Leard Forest Research Node, Maules Creek Community Council, People for the Plains) that the groundwater modelling conducted for the Tarrawonga Mod 7 differs from another groundwater modelling project of the Boggabri, Tarrawonga and Maules Creek (BTM) complex currently being conducted by others. These submissions have voiced concerns about whether the modelling conducted for the Tarrawonga Mod 7 assessment is 'adequate to inform decision-making' as it has 'not been provided for public review' and it is 'out of date', not 'the latest' or 'not up to date', as it was published in 2019 and uses data available up to 2018.

Whether or not another BTM modelling investigation may be in progress by others, the Tarrawonga BTM modelling report is publicly available on the DPIE website and this peer review has concluded that it is a sound example of best practice in design and execution and it is fit for purpose to inform decision-making. The Tarrawonga modelling report describes its development in terms of an update to the previous BTM model developed in 2011 for TCPL by HydroSimulations, which was peer reviewed by Dr Frans Kalf, a very highly respected and independent hydrogeologist and modeller. The Tarrawonga model uses up to date modelling software and uncertainty methods, although the latest data used is from 2018. Nevertheless, the 2019 modelling program effectively forms a successful post-audit of the 2011 model version, and includes an uncertainty analysis that helps address data limitations, both key principles recommended by best practice guidance (Barnett et al. 2012), confirming the fitness for purpose of the Tarrawonga BTM model.

3.3 Calibration and Prediction

The model has a good history match calibration in steady state and transient modes to the data record 2006-2018, good water balance performance, and aquifer parameters that are adequately benchmarked, confirming the model as a sound predictive tool.

Model calibration performance is acceptable in that it is within the guideline statistical criterion of 5-10% scaled RMS (sRMS is 7.6% for steady state, and 7.1% for the transient 2006-2018 history match simulation).

The time series plots (Attachment D to HydroSimulations 2019) show generally good agreement between modelled and measured groundwater levels, with reasonable justifications provided for the few exceptions, as expected for the regional modelling approach that is not designed with local scale detail at every point.

The overall prediction scenario methodology and results presentations are consistent with best practice and are suitable for guiding impact assessment, mitigation and management planning and licensing. The modelling assessments provide good detail on water balance issues and drawdown impacts on third party bores, with consideration of impacts on stream leakage, baseflows and groundwater dependent ecosystems. The analysis quantifies the volumes involved in terms of the Aquifer Interference Policy and groundwater management zones, including interactions with the important Namoi alluvium, such that the results should be adequate for licensing purposes. This peer review concurs with the conclusion that the Tarrawonga Coal Mine Life of Mine Modifications groundwater assessment meets the Aquifer Interference Policy (AIP) Level 1 Minimal Impact Consideration Classifications.

Importantly, the groundwater assessment demonstrates that the impact associated with the Tarrawonga LoM Modification would be lower than the already-approved impacts, and the uncertainty assessment supports reasonable confidence in the predictions.

3.4 Sensitivity and Uncertainty

A basic prediction sensitivity analysis was conducted into the key parameters relating to the spoil (waste rock emplacement) properties, in terms of the horizontal and vertical hydraulic conductivity and the recharge rate. This is important for the post-mining scenario, and the results showed low sensitivity in terms of predicted mine inflows.

More importantly, a quantitative uncertainty analysis was conducted using a stochastic Monte Carlo method, consistent with recommendations in recent guidance on uncertainty methods (Middlemis and Peeters, 2018). The method investigated uncertainties relating to the key parameters of horizontal and vertical hydraulic conductivity (Kx and Kz), specific storage (Ss), specific yield (Sy) and recharge (RCH).

The uncertainty analysis results showed little variability in predicted mine inflows (±20% compared to the base case of around 90 ML/year), while the predicted change in leakage from Goonbri and Bollol Creeks showed more variability (±50%), but of a small amount (25 ML/year) in relation to the base case of around 1000 ML/year (combined). Uncertainty analysis methods and results are difficult topics to explain, but the assessment has done so with clarity in its presentation and discussion of results.

In its current form, the groundwater assessment provides information that is suitable for impact assessments and management plan development, and for licensing decisions, including on the uncertainties that may influence decisions. However, it is noted that even the most comprehensive modelling and uncertainty analysis cannot completely rule out the potential for unwanted outcomes (Middlemis and Peeters 2018). The Tarrawonga BTM model is assessed as fit for purpose, and the ongoing monitoring program is well-designed to provide the data for model improvements.

3.5 Cumulative Impacts

In terms of cumulative impacts, the Tarrawonga model incorporates the groundwater effects of mining activities at Tarrawonga (obviously), and the Boggabri and Maules Creek coal mines north of Tarrawonga, effectively representing the BTM complex. It also includes the Rocglen mine further south, which is currently transitioning to closure. The Tarrawonga BTM model does not include the mining activities at Vickery or Vickery Extension. This is justified by noting that the target coal seams at Tarrawonga are truncated either by faulting or erosion, so they do not persist to the south or to the east of the Modification area, and thus there is no potential for hydraulic interaction.

It is noted that the Vickery Extension assessment (HydroSimulations 2018), included in its modelling the proposed Vickery water supply borefield that is sited between Tarrawonga and Vickery. The Vickery Extension modelling predicted that the cumulative drawdown extents between these projects would coalesce to a very minor degree (order of one metre near Bollol Creek – see Figure 2), and even then, only due to the assumed (conservatively high) Vickery borefield extraction, which may not be realistic for current borefield plans.

In summary, although the Tarrawonga cumulative impacts assessment did not specifically include extractions for the Vickery Extension mine and water supply borefield, it is reasonable to infer that including those effects would not materially change the Tarrawonga predictions of BTM complex cumulative impacts.

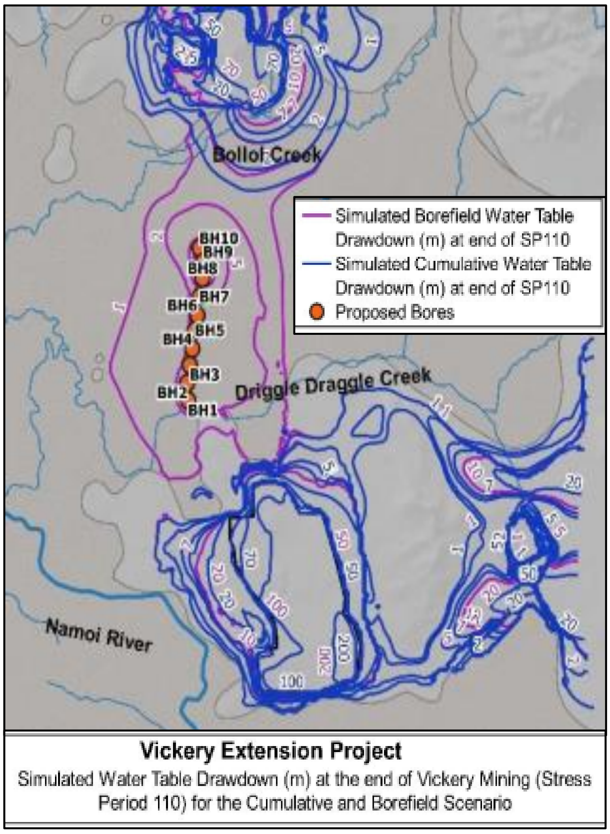

Figure 2 - minor Vickery borefield drawdown (after HydroSimulations 2018, Figure 62)

3.6 Namoi Alluvium

The Modification report (Whitehaven Coal, undated) makes two key statements about the Tarrawonga open cut extent in relation to the mapped Namoi alluvium:

- *'The modified open cut would be located within 200 m of the Upper Namoi alluvium, however, would remain at least 200 m from Goonbri Creek.'*
- *'The Modification open cut extent would not intercept the regionally mapped alluvials or alluvials mapped by SLR (2019) (Figure 5-2).'*

These statements appear to be in conflict with some key figures in the Modifications report that show the pit extent at its south-eastern corner. For example, Figure 3 below is based on Figure 5-2 of the Modification report, but is actually taken from page 5 of the submission by the People for the Plains. It shows that the pit crest extends up to the alignment of the NSW Government mapped alluvium (yellow line) along most of the eastern boundary. At its south-east corner, however, the pit crest aligns with the orange line that represents the alluvium mapped by SLR based on soil surveys and a topographical and geomorphological assessment (Attachment J of HydroSimulations 2019). In any case, it appears that the pit crest will extend up to the western-most alignment of the mapped alluvium, but would not actually 'intercept' the alluvium.

The problem is that the location of the pit crest is uncertain, based on the information presented. For example, Figure 3 below shows the south-east corner of the pit at about 150 metres from Goonbri Road. However, Figure 2-2 of the Modification report, shown below as Figure 4, shows this point at about 120 metres from Goonbri Road, and perhaps 80 metres from the nominal flood bund alignment (subject to detailed design). These distances have been scaled from the figures and are therefore approximate. It is not known whether the flood bund will be mostly aligned with the alluvium mapped SLR (2019), but indications are that may be the case along most of its alignment.

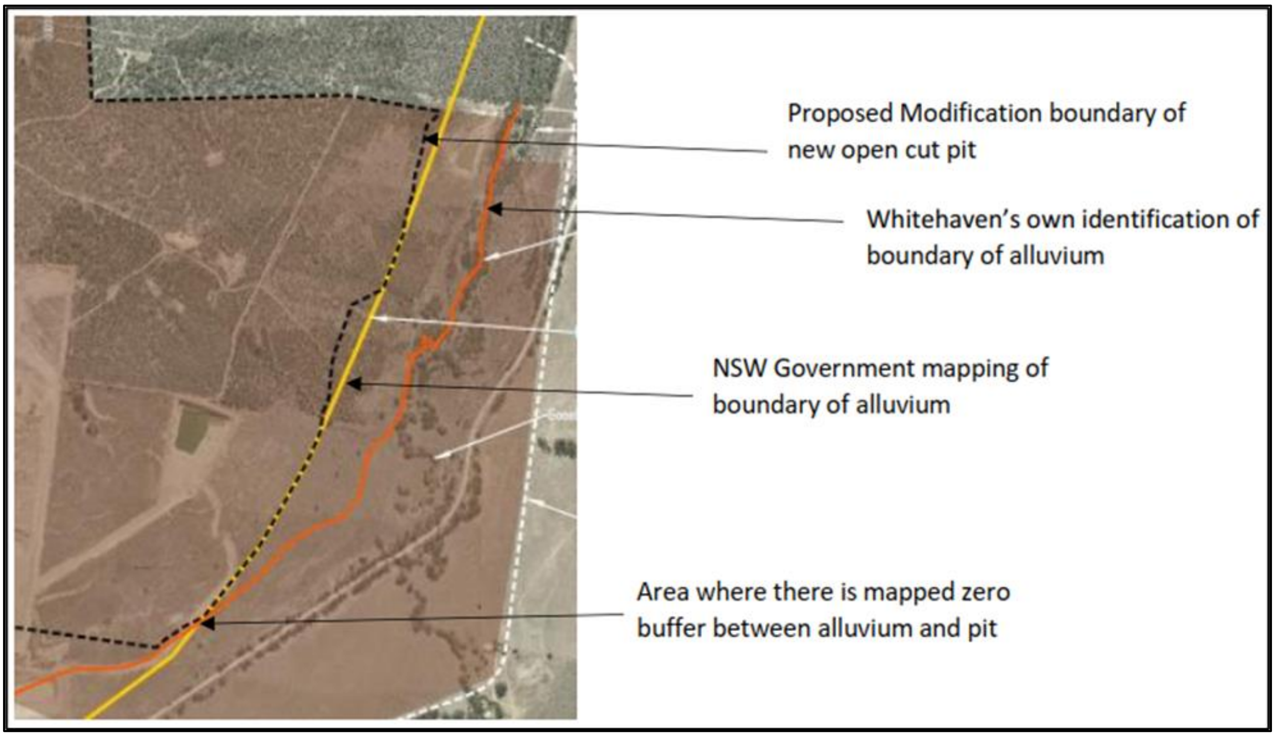

Figure 3 - mapped extent of alluvium and pit crest (after People for the Plains, 2020)

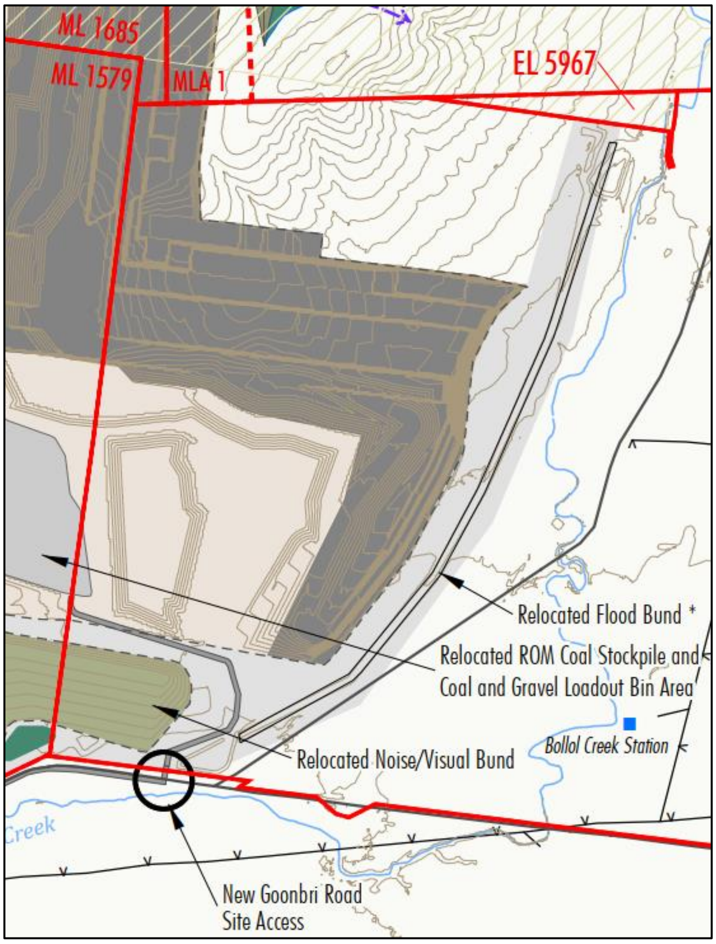

Figure 4 - pit crest general arrangement (Modification report, Figure 2-2)

With reference to Figure 5, it is important to define the exact location of the pit crest and the flood bund and the mapped alluvium in order to assess whether or not there may be the potential for leakage towards the pit and/or post-mining void via the alluvium and/or fractured rock basement due to flood inundation events, as several submissions have commented (eg. DPIE Water and People for the Plains).

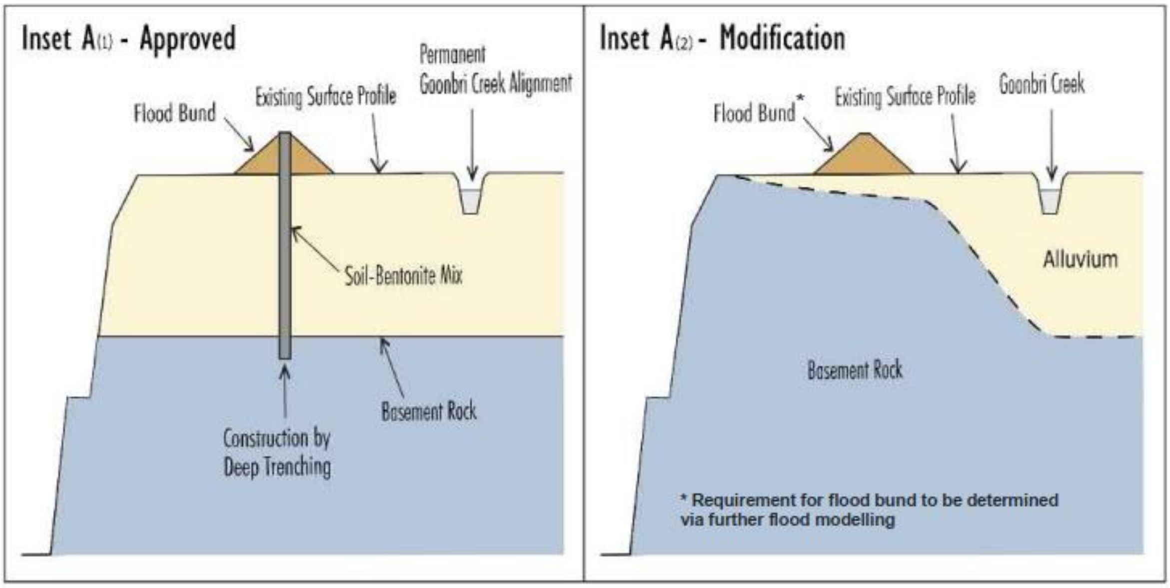

Figure 5 - alluvium and basement conceptual models (after HydroSimulations 2019, fig.16)

As the mapped alluvium is effectively unsaturated in this location, the pathway for leakage under the Mod 7 arrangement would be mainly via the fractured rock 'basement' of the Maules Creek Formation (Figure 5). This has arguably not been ignored in the Mod 7 reports, in that Hydrosimulations (2019) suggest on page 42 that the properties of the in situ 'basement' results in similar drawdown predictions under Mod 7 as for the approved case with a low permeability barrier under the flood bund (Figure 5).

While this review considers that to be a perfunctory rather than comprehensive assessment, the leakage potential is probably low, based on the following reasoning:

- Firstly, based on statements in the Modifications report, it is assumed that the pit crest is aligned with the western-most mapped alluvium, and the flood bund will actually be located between the pit crest and Goonbri Road, as shown generally in Figure 4. The soil mapping shows that the alluvium is dry at its mapped extent (SLR 2019), so there is no flow path from saturated alluvium towards the pit or final void under normal conditions. This means that the source of leakage would have to be from any floodwater that might pond against the flood bund, which is some 100-200 metres from the pit crest generally, except near the south-east corner of the crest where it may be around 80 metres.
- Under those conditions, the 2D flood modelling prediction for the 1% annual exceedance probability (AEP) ('1 in 100 year' flood event), shows some ponding against the flood bund (Figure 6, after HEC 2019, Figure 29). The flooding assessment indicates that the ground level adjacent to the final void is at least 6 metres higher than the predicted flood level, which itself is lower than the flood bund crest by about 1 metre (HEC 2019, Table 33). Although the flooding assessment does not indicate the duration of such ponding, it does indicate that the 1% AEP critical storm duration is 2-3 hours, which implies that the flooding

duration would likely be in the order of days. This indicates little opportunity or potential for leakage from a 1% AEP flood event to adequately saturate the subsurface units and convey substantial volumes towards the pit or void. It is also noted that the probability of occurrence of a 1% AEP flood within the 10 year LoM period to 2030 is low at about 9.5%, while within a 100 year period it is about 63%, rising to about 85% within 200 years and 95% in a 300 year period (ie. it is likely during the closure period).

- Similarly, while the 2D flood modelling prediction of the larger event of the probable maximum flood (PMF; there is no established method of estimating its probability) shows some inundation on the western side of the indicative flood bund at its southern end (Figure 6), roadworks and pit crest bunding should apply adequate controls operationally to retain the floodwaters, and similarly for the post-mining landform.

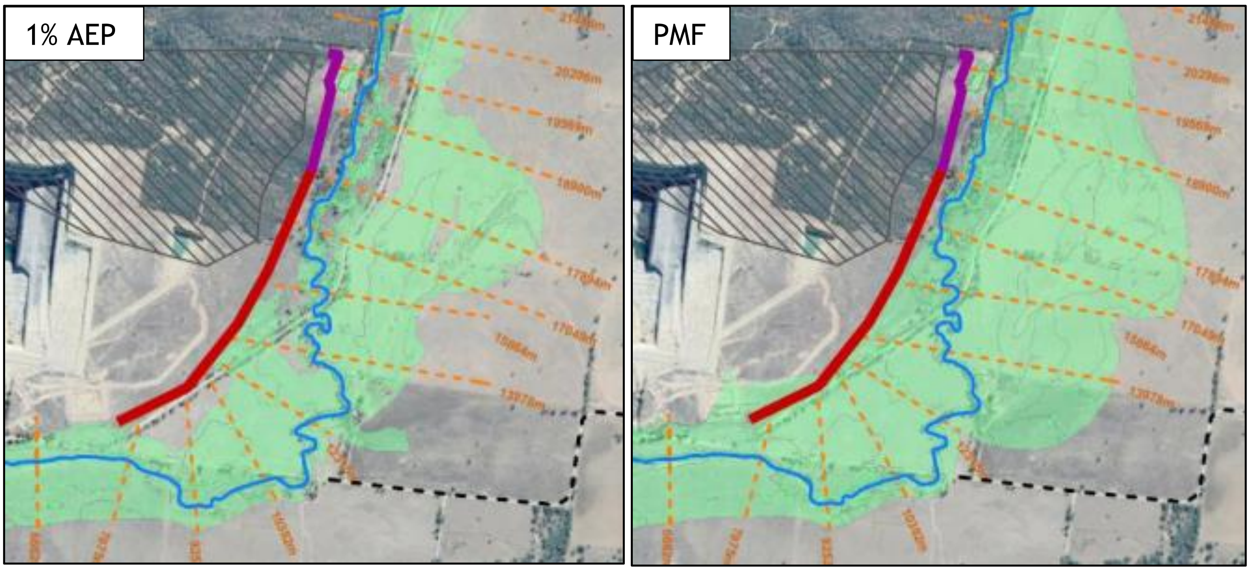

Figure 6 - Predicted 1% AEP and PMF flood extent (after HEC 2019, figs 29 & 30)

The DPIE facilitated a discussion of this issue on 2 December 2020 with the peer reviewer, Whitehaven Coal and their consultants. It was confirmed that the groundwater modelling assumptions of the pit excavation alignments were appropriate. A brief report was subsequently provided to document additional information to address the issues raised (Whitehaven 2020). That report confirmed the assumptions above about the alignments of the pit crest, mapped alluvium, and nominal flood bund (subject to further modelling). The additional information also estimated that the potential leakage volume is low (generally less than 20 ML), and that adequate air space is available in the final void above the final lake level (9000 ML).

In summary, there is a low probability of flood occurrence within the LoM period, the flood bunding and other earthworks will be designed to constrain floodwaters adequate distances from the operational or final voids, and any sub-surface leakage volumes would be low and could be accommodated during pit operations or by the final void.

3.7 Post-Mining Final Void

It is understood that the existing Tarrawonga approval allows for a post-mining final void lake. It is understood that the Boggabri mine groundwater assessment was based on the backfilling of the final void to the pre-mining water table. The Mod 7 groundwater assessment includes a final void lake in the final Tarrawonga landform, and the related modelling has been conducted consistent with best practice. While there has been no assessment of sensitivity, the results are considered to be a reasonable representation of the long term post-mining conditions for the assumptions involved.

The post-mining final void prediction and assessments reported are based largely on the water balance model (HEC 2019). This uses output from the groundwater model on the post-mining final void inflow-level relationship, combined with a 130-year rainfall dataset (1889-2018) and simulated runoff from catchments contributing to the final void lake, and reasonable assumptions for evaporation from the pit lake void. The results indicate a long term pit void lake and terminal sink at a level of about 260 mAHD (about 19 metres below spill level), with salinity predicted to increase steadily to 20,000 mg/L (more than half that of seawater and suitable for industrial purposes only) by 500 years post-mining, with no sign of a reduction in that trend.

The Mod 7 assessment cites cost as major factor to justify the backfill plans, along with the strategy of a final void water balance that is designed to achieve long term groundwater sink conditions as a means of 'containing' poor quality water to the void.

Without seeking to challenge existing approvals, this reviewer outlines below some post-mining groundwater issues that may be worthy of consideration by DPIE.

Best practice mine water management suggests that reduced long term risks to water resources could be achieved by backfilling the pit to the pre-mining groundwater level to minimise final void lake evaporation and salinisation impacts, subject to careful evaluation of potential leachate risks, along with consideration of community views (Johnson and Wright 2003; Younger and Wolkersdorfer, 2004).

While some international standards (eg. current South African legislation) require that pit lakes should be backfilled for the mine to achieve closure, this is can involve considerable financial liabilities, in comparison to environmentally stable pit lakes that can offer a sustainable closure option and may avoid the expense of continual water treatment (Johnstone 2019; McCullough et al. 2013).

These issues, and related uncertainties, do not appear to have been adequately explored to identify optimal closure options, and few details are provided to justify the position in environmental management terms for protecting regional groundwater environments from leachate risks. This is not a limitation of the model, as it is fit for this purpose, but it reflects limitations in the overall assessment.

The model is suitable for investigation of a range of closure options for the final void (from partial to total backfilling to none), to identify an optimum scenario to minimise risks to groundwater, and to evaluate how those predictions are affected by uncertainties. It is recommended that the model be applied to investigate closure options in order to provide quantitative information to justify the closure plans and to support decisions on licensing.

4. Conclusion

The Tarrawonga Coal Mine Life of Mine Modifications groundwater modelling and assessment (HydroSimulations, 2019) is a good example of best practice. It is fit for the purpose of groundwater-related impact assessment arising from the Tarrawonga Life of Mine Modification activities (Mod 7). That includes the cumulative impacts of the Boggabri, Tarrawonga and Maules Creek (BTM) complex activities, and the Tarrawonga post-mining pit void, and for informing related management and mitigation strategies, licensing and monitoring.

The recommended monitoring program and ongoing hydrogeological investigations are well-designed and will provide additional data for future model refinements and improvements in performance, and for comprehensive uncertainty analysis.

5. Declarations

For the record, the peer reviewer, Hugh Middlemis, is an independent consultant specialising in groundwater modelling. He has a degree in civil engineering and a master's degree in hydrology and hydrogeology, and 40 years' experience, and established the HydroGeoLogic independent consultancy in 2013. Hugh was principal author of the first Australian groundwater modelling guidelines (Middlemis et al. 2001) that formed the basis for the latest guidelines (Barnett et al. 2012) and was awarded a Churchill Fellowship in 2004 to benchmark groundwater modelling best practice. He is principal author on two recent guidance reports on modelling uncertainty (Middlemis and Peeters 2018; and Middlemis et al. 2019).

Hugh Middlemis has not worked on the Tarrawonga project nor for Whitehaven Coal, and we assert no conflict of interest issues in relation to this work.

We note the following in relation to previous interactions with Dr Noel Merrick (principal of HydroSimulations, the consultant acting for Tarrawonga Coal):

- Mr Middlemis has conducted reviews of investigations involving Dr Noel Merrick:
    - Vickery Extension Project groundwater assessment (2018-20; for DPE/DPIE).
    - Tahmoor South groundwater assessment (2018-20; for DPE/DPIE).
    - New Acland Coal Stage 3 Project Associated Water Licence (2019; for CSIRO under contract to QLD Dept of Natural Resources Mines and Energy).
    - Hume Coal Project groundwater assessment (2018-19; for DPE).
    - Wambo Longwall Panel 10A expansion studies (2015; for DPE).
    - HydroSimulations report on the Mulgrave River model in June 2016.
- More than 10 years ago, Mr Middlemis worked directly with Noel Merrick, notably:
    - to write the 2001 guidelines on groundwater modelling and prepare and deliver some related conference papers (Middlemis et al. 2001, 2004);
    - for a few semesters across about 1996-2005, Mr Middlemis worked as the distance education tutor for Dr Merrick's Groundwater Modelling subject at UTS (ie. marking assignments and helping students via email and telephone);

  - during parts of the period 1986-1989 when Mr Middlemis was at an early/mid-career stage at the NSW Department of Water Resources, he was seconded from the Hydrology unit to work in the Hydrogeology Unit on groundwater modelling projects, supervised directly by Mr Merrick.
- Dr Merrick is currently conducting an independent review of the Eastern Mallee EM1.3 model being developed for MDBA salinity management purposes by EMM Consulting, where Mr Middlemis is engaged as a sub-consultant. Historically, Dr Merrick has also completed independent reviews of groundwater models developed by Aquaterra for various purposes in SA and Victoria when Mr Middlemis was Aquaterra's Technical Director: Adelaide Plains solute transport model (2011); Padthaway solute transport model (2008); Eastern Mallee models EM2.1 (2008) and EM2.3 (2009).

6. References

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