WHITEHAVEN COAL

8 December 2020

Stephen O'Donoghue
Director Resource Assessments
Energy, Resources and Compliance – Planning and Assessment
Department of Planning, Industry & Environment

Dear Stephen,

TARRAWONGA LIFE OF MINE MODIFICATION – RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

Please find enclosed a response to the request for additional information received from the Department of Planning, Industry & Environment in relation to the Tarrawonga Coal Mine Life of Mine Modification 7 (refer Table 1).

If you wish to discuss or require any further information to progress the assessment of the Modification 7 application, please do not hesitate to contact Tony Dwyer on (02) 6741 9316.

Yours sincerely

Tony Dwyer

Group Manager - Approvals and Environment

Table 1 – Response to Response to Supplementary DPIE Request for Additional Information

Comment	TCPL Response
After careful consideration, the Department requests that you provide the following additional information. • *clarification of the alignments/setbacks of the pit crest from the mapped alluvium and flood bund;*	The alignment of the modified Open Cut pit extent sought under the Modification 7 application is shown as the "Modification Open Cut Extent" on Figure 1-3 of the Modification Report (refer to the dashed black line) (Whitehaven Coal Limited, 2020). This line is consistent with the Open Cut extent shown on Figure 5-2 of the Modification Report. Figure 5-2 shows that the Open Cut pit crest does <u>not</u> intercept the alluvial boundary mapped by SLR Consulting (2019) (i.e. the Modification will avoid mining the Upper Namoi alluvium).
• *consideration of the potential for leakage towards the pit and/or post mining void via the alluvium due to floodwater ponding against the flood bund and/or mapped alluvium;*	This comment has been considered by Dr Noel Merrick of Hydrosimulations and a response is provided in Attachment 1. In summary, for a probable maximum flood (PMF) event, the magnitudes are estimated to be in the order of 20 megalitres (ML) for vertical recharge from floodwaters and about 2 ML for lateral flow of flood water beneath the flood bund towards the backfilled pit. Dr Merrick considers the potential risk associated with these scenarios to be very low. It is also noted that Tarrawonga Coal Pty Ltd (TCPL) holds 36 ML of licences in the Upper Namoi Zone 4 Namoi Valley (Keepit Dam to Gin's Leap) Groundwater Source under WAL36548.
• *consideration of potential pathways via fractured rock from blasting; and*	This comment has been considered by Dr Merrick of Hydrosimulations and a response is provided in Attachment 1. In summary, for enhanced fracturing due to blasting or stress relief, the extra lateral flow through the near-surface basement rocks is estimated to be in the order of 1 ML during a PMF flood event.
• *consideration of any additional reasonable and feasible mitigation measures (such as keying the flood bund into the bedrock where it is located on the alluvium).*	As described in the Modification Report, 1-dimensional flood modelling was completed that indicates a flood bund <u>may</u> be required for the modified landform. TCPL committed to completing an assessment of potential flooding in the eastern area of the Modification using 2-dimensional modelling. If the 2-dimensional modelling indicates that flood bunding is required to protect against a probable maximum flood event, detailed designs of the flood bund would be prepared to the satisfaction of the Secretary with consideration given to keying the flood bund into the bedrock where it is located on the alluvium along the extent of the bund.

REFERENCES

Whitehaven Coal Limited (2020) *Tarrawonga Life of Mine Modification – Modification Report.*

ATTACHMENT 1

HYDROSIMULATIONS RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

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Date: 7 December 2020

To: Mr Tony Dwyer
Group Manager
Tarrawonga Coal Pty Ltd
PO Box 600
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From: Dr Noel Merrick

Re: **Tarrawonga Coal Mine MOD 7 (PA11_0047 Mod 7) Request for Additional Information**

Our Ref: HS2020/03b

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1 Introduction

On 3 December 2020, the Department of Planning, Industry and Environment (DPIE) requested additional information from Tarrawonga Coal Pty Ltd with respect to the Tarrawonga Coal Mine (TCM) MOD 7 currently under consideration. This request followed a videoconference on 2 December 2020 involving representatives of DPIE, TCM and Resource Strategies as well as Mr Hugh Middlemis (HydroGeoLogic) and Dr Noel Merrick (HydroSimulations/SLR Consulting Australia).

The videoconference was held to discuss the draft peer review report by Hugh Middlemis:

> Middlemis H (2020). Tarrawonga Coal Mine LoM Mod. 7 Groundwater Assessment Peer Review. HydroGeoLogic Pty Ltd report prepared for NSW DPIE, 30 November 2020.

Subsequently, DPIE requested the following information by letter:

1. clarification of the alignments/setbacks of the pit crest from the mapped alluvium and flood bund;
2. consideration of the potential for leakage towards the pit and/or post mining void via the alluvium due to floodwater ponding against the flood bund and/or mapped alluvium;
3. consideration of potential pathways via fractured rock from blasting; and
4. consideration of any additional reasonable and feasible mitigation measures (such as keying the flood bund into the bedrock where it is located on the alluvium).

This report addresses items 2 and 3.

2 Context for Potential Leakage Risk

The issues raised in items 1 to 4 in Section 1 should be viewed in the context of their effect on final void water levels, as the final void would be the destination of extra groundwater recharge occasioned by rare flood events.

HydroSimulations (2019) notes that "The final water level in the void is expected to be approximately 260 m AHD, which is approximately 15 m lower than current levels in the alluvium". HEC (2019) notes "an average equilibrium level approximately 22 m below the spill level", which is 280 mAHD, with a minimum headspace of 20 m. For a final void area of about 45 hectares, the air space between the equilibrium water surface and the spill point would be about 9,000 ML. It follows that flood recharge volumes much less than this would not pose a risk of spillage from the final void lake, with associated water quality effects.

3 Potential Leakage from Floodwater

The HydroGeoLogic report notes:

- "…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…"
- "…the leakage potential is probably low…"
- "...there is no flow path from saturated alluvium towards the pit or final void under normal conditions."
- "…the source of leakage would have to be from any floodwater that might pond against the flood bund…"
- There is "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.

The design flood bund has a length of about 750 m where it overlies mapped alluvium (Figure 1).

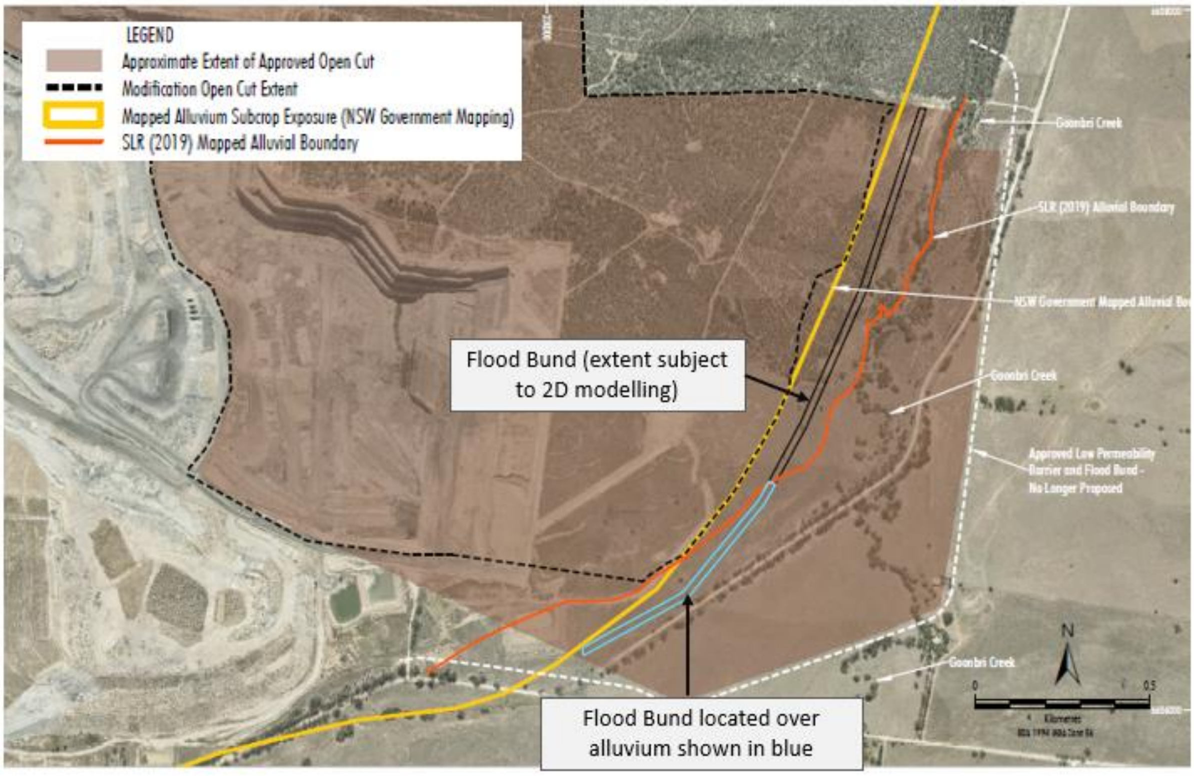

Figure 1. Location of flood bund relative to pit extent and alluvial boundary

The potential for floodwater to abut the flood bund or escape around its southern toe is indicated in **Figure 2** for 1% AEP and PMF events. It is noted that the Modification Report states that the final flood bund design, including its extent, would be subject to 2-dimensional modelling (Whitehaven, 2020).

A **1**% **AEP** (Annual Exceedance Probability) flood is an event that has a **1**% chance of occurring or being exceeded in any **one** year; statistically, such a flood would be expected to occur once every 100 years. The probable maximum flood (PMF) is a worst-case event that could occur when extreme hydrological and meteorological conditions coincide; such an event is generally considered to be equivalent to 0.01 – 0.001 %AEP, and would be expected to occur only once in more than 10,000 years.

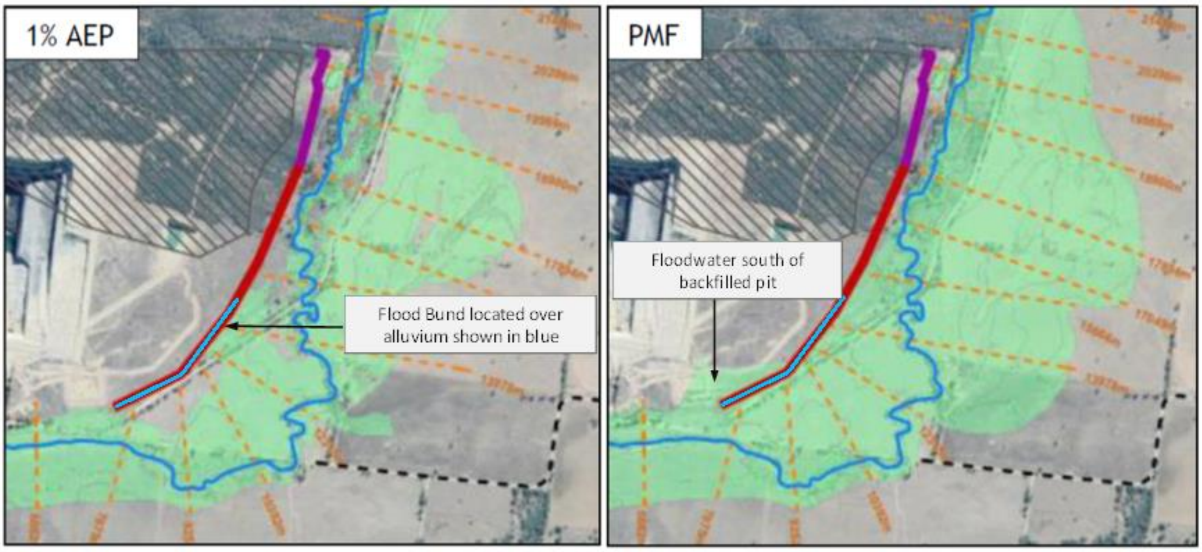

Figure 2. Predicted flood extents [after HEC (2019), Figures 29 & 30]

When a flood occurs, some of the floodwater will infiltrate the soil and replenish soil moisture and raise the water table.

The direction of groundwater flow in the subject area is indicated in **Figure 3** by arrows perpendicular to groundwater head contours. Most flood-induced groundwater would continue downgradient in a south-westerly direction. However, floodwater close to the flood bund would generate groundwater that would head towards the backfilled pit, and from there move towards the final void.

Figure 2 shows that, for the 1% AEP flood event, floodwater is predicted to abut the flood bund for less than 50% of its length overlying alluvium (about 350 m of 750 m). For the PMF event, floodwater would abut the entire 750 m length and would pass around the toe of the bund (as backwater) and abut the mapped edge of alluvium, but would not abut the backfilled pit.

Floodwater recharge would occur to alluvial soils that are mapped dry at soil sites 9, 11 and 13 by SLR (2019):

- Site 9: grey/brown sodosol, clay to 0.70m, then weathered sandstone.
- Site 11: brown sodosol, clay to 0.85m, then weathered sandstone.
- Site 13: brown sodosol, clay to 0.75m, then weathered sandstone and gravelly clay.

These descriptions suggest low lateral permeability when saturated by floodwaters. The clayey nature of the alluvial flank material is supported by transient electromagnetic (TEM) mapping shown in **Figure 4** for depths from 1 m to 12 m, indicating that similar low lateral permeability would hold in the weathered bedrock which hosts the local water table. The natural depth to the water table is about 5 to 7 m, measured at the nearby alluvial bore MW5 which has fluctuated historically between 267.5 m AHD and 270 m AHD.

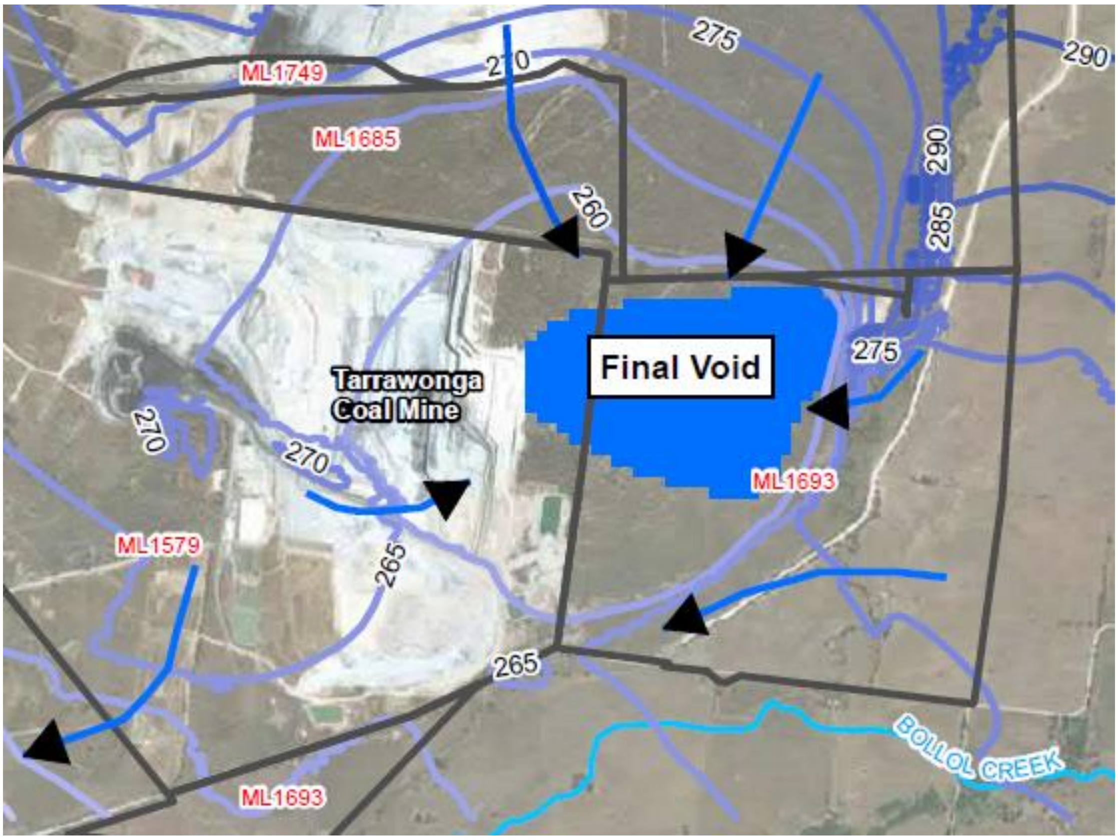

Figure 3. Predicted recovered groundwater levels and flow directions after 100 years [from HydroSimulations (2019), Figure 43]

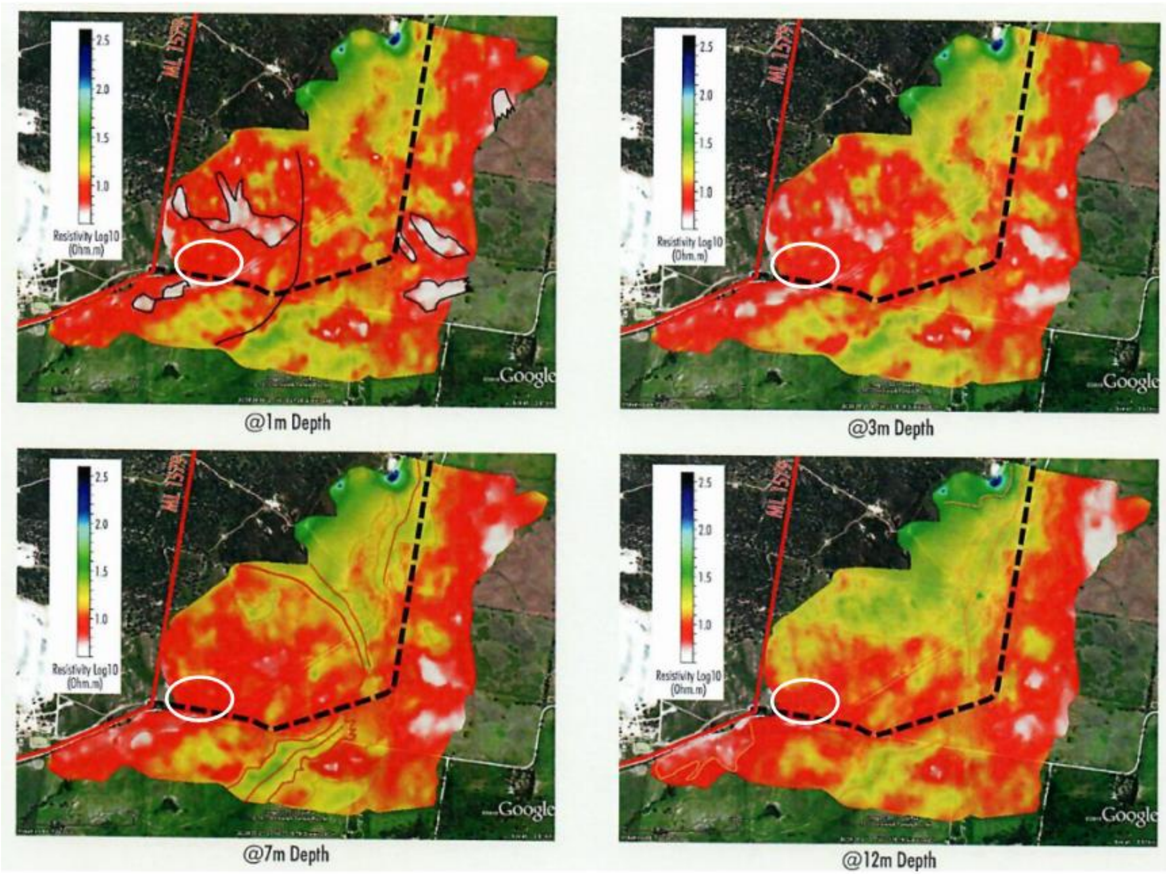

Figure 4. TEM maps of electrical resistivity [after Heritage Computing (2011)]

3.1 Calculation of vertical leakage from floodwater

As shown on **Figure 2**, there would be an opportunity for PMF flood recharge between the pit extent and the southern flood bund, although floodwater would not be in direct contact with spoil. There is negligible opportunity for the 1% AEP flood event.

HEC (2019; Table 33) calculated PMF flood heights along Goonbri Creek. Between the toe of the flood bund and the lease boundary, the predicted flood height would drop from about 1.7 m to about 0.5 m. The area of inundation on the western side of the flood bund has been calculated to be about 63,000 m^2. For flood heights taken to range from 0.5 m on the lease boundary to 1.8 m on the western side of the flood bund, the volume of pooled water would be about 70 ML. This floodwater pool would dissipate by downgradient flow, evaporation and subsurface infiltration. The relatively high salinity of alluvial groundwater (mean 2,260 µS/cm at MW5) suggests infrequent inputs of fresh floodwater.

Given the clayey nature of alluvium, the recharge from diffuse rainfall was estimated by model calibration to be only 1.3% of rainfall. Recharge would be higher from a flood event, but the precise fraction is not known; however, it is unlikely to be higher than about 10% in my opinion.

Full saturation of the subsurface soil depends on the porosity of the soil and the duration of a flood, both of which are not known precisely. As the depth to water (in the PMF inundated area) is about 6 m normally, the subsurface to be saturated would consist of about 1 m of clayey alluvium and 5 m of weathered sandstone. For the purpose of estimation, the porosities are assumed to be 5% for clayey alluvium and 1-5% for weathered sandstone. The soil air space capable of saturation would be about 6 to 19 ML, say 20 ML maximum. With 70 ML of ponded water available at ground surface, full saturation would be possible. With a pond depth of about 1.5 m and an infiltration rate of 10%, saturation would occur in 1 or 2 days. Persistence of a peak flood for a longer duration would add to the 20 ML flood recharge but the extra amount would be limited by the capacity of the subsurface to discharge the groundwater laterally to provide space for the uptake of additional flood recharge.

In summary, a volume of about 20 ML could arrive at the water table after a PMF event and most of this would migrate laterally through weathered sandstone towards the backfilled pit and ultimately to the final void. The model simulation for post-mining recovery has estimated initial groundwater inflow to the final void of about 270 ML/year and an ultimate inflow of about 240 ML/year, due mostly to flow through spoil (HydroSimulations, 2019). An increase of about 20 ML in one of these years would be an increase of about 7% in the year of occurrence. This would add about 0.05 m to the height of water in the void lake.

As noted above, there is negligible opportunity for the 1% AEP flood event recharge to reach the pit via vertical leakage.

3.2 Calculation of lateral leakage from floodwater

Lateral leakage from the east of the flood bund to the west of the flood bund could occur via alluvium if the flood bund is not keyed into hard rock. It can also occur through the weathered rock that underlies the alluvium, negating the benefit of keying, but the volumes of transfer would be lower due to reduced permeability.

The groundwater model has calibrated lateral hydraulic conductivity (K) values of 1-10 m/day in alluvium (Layer 1) and 0.0001-0.0006 m/day in overburden (Layer 3), although the clayey nature of the alluvium as indicated on **Figure 4** would favour a local alluvium value of 0.1 m/day or less.

Figure 2 shows that floodwater is predicted to abut the flood bund for a length of about 350 m for the 1% AEP flood event and for 750 m for the PMF event. Where floodwater abuts the bund, the flood heights calculated by HEC (2019; Table 33) range from 1.4 to 1.5 m for the 1% AEP event and 1.7 to 3.4 m for the PMF event (average 2.3 m).

Estimates of lateral flow beneath the bund, after the subsurface soils are saturated, can be made using Darcy's Law for flow through a 1 m thickness of clayey alluvium and 5 m thickness of weathered sandstone:

$$Q = K\,A\,(dh/dx)$$

where A is cross-sectional area and (dh/dx) is the initial hydraulic gradient from the eastern side to the western side of the bund.

The *dh* component of the initial hydraulic gradient is taken to be the flood height plus 6 m (the normal depth to water). The *dx* component of the hydraulic gradient is taken to be 10 m representing the assumed width of the bund (subject to final design). The initial hydraulic gradients are 0.74 for the 1% AEP event and 0.83 for the PMF event.

The cross-section areas for the 1% AEP event are 350 m^2 for the clayey alluvium and 1,750 m^2 for the weathered sandstone. Noting that the lower 350 m of the bund is flanked by backwater, and the soil on the western side is already taken to be saturated by vertical flood recharge, the remaining cross-section areas for the PMF event are 400 m^2 for the clayey alluvium and 2,000 m^2 for the weathered sandstone.

The initial lateral flows for the 1% AEP event are:

- 0.26 ML/day for clayey alluvium (assuming K = 1 m/day) or 1.8 ML for a flood duration of 7 days
- 0.0013 ML/day for weathered sandstone (assuming K = 0.001 m/day) or 0.009 ML for a flood duration of 7 days

The initial lateral flows for the PMF event are:

- 0.33 ML/day for clayey alluvium (assuming K = 1 m/day) or 2.3 ML for a flood duration of 7 days
- 0.0017 ML/day for weathered sandstone (assuming K = 0.001 m/day) or 0.012 ML for a flood duration of 7 days

The lateral flow rates would reduce as the water table west of the bund rises.

In summary, lateral leakage beneath the flood bund due to floodwater is negligible, being no more than 2 or 3 ML.

4 Potential Leakage Pathways

The HydroGeoLogic report notes:

- "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' …"
- The proponent should "include an assessment of the potential for groundwater seepage from floodwaters ponding against the bund, via fracture propagation laterally from the pit and under the mapped alluvium…"

DPIE-Water, in a letter to DPIE dated 21 July 2020, expressed the view that "a zone of structural deformation typically extends out from the highwall due to blasting and stress release leading to an increase in Kx/Kv permeability conceptually considered to extend within the porous rock underlying the Namoi Valley".

The zone of structural deformation is considered to extend within the porous rock to a very limited lateral distance, within one model cell width, as indicated by the typical close spacing of blast holes which are designed to produce minimal interference of the lateral fracturing extents. A rule of thumb is that blast holes should be spaced no farther apart than half the depth of the holes[1]. At the joint videoconference on 2 December 2020, Mr Tony Dwyer of Whitehaven Coal explained that blasting adjacent to the pit wall follows an initiation sequence that focuses energy *away* from the wall so as not to disturb the integrity of the wall.

Apart from the effect of blasting, there will be a stress relaxation effect due to lithostatic unloading. Based on preliminary two-dimensional modelling, Foster *et al.* (2018) concluded that "any new fractures would tend to be sub-parallel to the excavation face and floor", which would promote development of flow paths around the edge of the pit rather than towards the pit. They also noted that "enhanced fracture connection with surface recharge sources may lead to increased recharge", for example from a flood event.

While provision for these two effects is not common modelling practice, the groundwater assessment has included the potential increase of Kx and/or Kv permeabilities, and rainfall recharge, within the *monte carlo* uncertainty analysis (UA). These parameters were altered to consider alternate parameter choices and as such the bounds for the UA results would capture a potential change in parameters due to blasting and stress relief effects.

Enhanced permeability in the weathered sandstone would affect the calculations made in **Section 3** for lateral flow beneath the flood bund. For a conservative increase in lateral hydraulic conductivity by two orders of magnitude, the resulting initial flows through the weathered sandstone would be:

- 0.13 ML/day for weathered sandstone (assuming K = 0.1 m/day) or 0.9 ML for a flood duration of 7 days for the 1% AEP event
- 0.17 ML/day for weathered sandstone (assuming K = 0.1 m/day) or 1.2 ML for a flood duration of 7 days for the PMF event

In summary, the lateral leakage beneath the flood bund due to floodwater would remain negligible.

5 Conclusion

This report has examined two issues:

1. Consideration of the potential for leakage towards the pit and/or post mining void via the alluvium due to floodwater ponding against the flood bund and/or mapped alluvium.

2. Consideration of potential pathways via fractured rock from blasting.

Estimates have been made for the magnitudes of vertical recharge from floodwaters and lateral movement of groundwater beneath a flood bund towards a backfilled pit, and ultimately to a final void. For a rare PMF flood event, the magnitudes are in the order of 20 ML for vertical recharge and about 2 ML for lateral flow. For enhanced fracturing due to blasting or stress relief, the extra lateral flow through the near-surface basement rocks is estimated to be in the order of 1 ML during the flood event. Such additional volumes of water would cause an imperceptible rise in the water level of the void lake.

Apart from the water volumes being very small, the considered flood events are roughly 1 in 100 years and 1 in 10,000 years. Apart from the likelihood of such an event being very low, the consequence also is immaterial. Therefore, the posed issues are very low risk.

[1] https://www.nps.gov/parkhistory/online_books/npsg/explosives/Chapter8.pdf

3 References

Foster SM, West LJ, Bottrell SH, and Hildyard MW (2018). A DFN Approach to Evaluating the Hydrogeological Significance of Lithostatic Unloading in Fractured Strata around Open-Pit Workings. In: Proceedings of 2nd International Discrete Fracture Network Engineering Conference, 20-22 June 2018, Seattle, WA, USA.

HEC (2019). Tarrawonga Coal Mine Life of Mine Modification Surface Water Assessment and Site Water Balance. Prepared for Whitehaven Coal Limited. October 2019.

Heritage Computing Pty Ltd (2011). A Hydrogeological Assessment in Support of the Tarrawonga Coal Project Environmental Assessment. Report HC2011/11 prepared for Tarrawonga Coal Pty Ltd.

HydroSimulations (2019). Tarrawonga Coal Mine Life of Mine Modification Groundwater Assessment. Report HS2019/19 prepared for Whitehaven Coal Limited, 30 September 2019.

Middlemis H (2018). Tarrawonga Coal Mine LoM Mod. 7 Groundwater Assessment Peer Review. Prepared by HydroGeoLogic for NSW Department of Planning and Environment. Draft, 30 November 2020.

SLR Consulting (2019). Alluvial Boundary Assessment - Tarrawonga Coal Mine. Appendix J in HydroSimulations (2019), Tarrawonga Coal Mine Life of Mine Modification Groundwater Assessment, Report HS2019/19 prepared for Whitehaven Coal Limited. July 2019.

Whitehaven Coal Limited (2020). Tarrawonga Coal Mine Life of Mine Modification – Modification Report. Report prepared by Whitehaven Coal Limited. May 2020.