
Annexure F

Peer review reports

F.1 Flood model peer review (BMT 2022 and BMT 2023)

Our ref: L.A11137.002.Peer_Review.docx

5 October 2022

EMM
Level 4, 74 Pirie Street
Adelaide SA 5000
Attention: Kate Holder

Dear Kate,

RE: FLOOD MODELLING PEER REVIEW

BMT was engaged by Glencore through EMM to undertake a peer review of flood modelling undertaken by Engeny in support of Glencore's Hunter Valley Operations (HVO) Continuation Project near Singleton NSW. Peer review of flood models and outputs was undertaken by BMT at key stages throughout the assessment.

This letter documents the outcomes of the peer review and is structured in two parts:

- Part 1 documents the peer review process involving BMT along with BMT's recommendations and the outcomes from those recommendations.
- Part 2 lists the SEARs requirements along with BMT's advice on if those requirements have been satisfied through the modelling.

Part 1: Peer Review Process, Recommendations and Outcomes

The peer review process has involved BMT at two key stages of the modelling assessment to review the flood modelling and make recommendations where appropriate. These two stages of review were as follows:

- March 2020 – Review of Baseline flood model
- August 2021 – Review of updated flood model (updated in response to BMT's March 2020 review and to include more current data). Models reviewed also included an 'existing case' and an 'operational case'.

When required, meetings were held between Engeny, Glencore and BMT to discuss BMT's flood model recommendations and Engeny's proposed approach for addressing the recommendations.

Table 1.1 sets out the key recommendations made by BMT against issues identified in the initial March 2020 review of the flood modelling.

Table 1.1 Summary of March 2020 Review Recommendations

ID	BMT Recommendation	Engeny Action/Outcome
1	Apply scaling of peak flows from Singleton to Liddell using full equation	Model updated
2	Revise design tributary inflows due to revised scaling	Model updated
3	Extend 2D model code to allow Hunter River backwater propagation into key tributaries	Model updated
4	Improve representation of key levees in area of interest using breaklines	Model updated

Table 1.2 lists a summary of BMT’s recommendations from the August 2021 model review. An updated set of models were supplied to BMT in September 2022. These models have been reviewed to check that the BMT recommendations from the August 2021 review have been addressed. Table 1.2 also lists the outcome of these checks.

Table 1.2 Summary of August 2021 Review Recommendations

ID	BMT Recommendation	Engeny Action/Outcome
1	Review modelled schematisation of the two bridges which form part of the operational case. Bridge deck elevations should tie in with adjoining road/embankment elevations and sub-structure form loss calculations should be revisited to account for all bridge piers.	Deck elevations have been amended and sub structure form loss calculations have been updated to account for all piers.
2	Review the initial water levels applied in the North Void and amend if warranted.	A DEM is now applied representing a future landform in the operational case.
3	Improve modelled representation of causeway river crossing, changing from layered flow constriction to a 1D culvert.	After further discussion with BMT it was agreed to model this as a conservative case with the minor culverts in the causeway effectively blocked.
4	Use results to produce relevant mapping output required by SEARs requirements, including impact mapping for the Extreme Event.	Additional mapping provided – see section below with regards to SEARs.
5	When documenting the modelling, it should be made clear that the modelling is of regional Hunter River flood events and that modelled flows on the tributaries are not representative of design flows on those tributaries. Likewise, reporting should make clear that the modelling does not assess impacts due to the levees interfering with local runoff.	Supplied reporting includes a statement that the modelling is for Hunter River ‘regional’ floods.

Limitations of Review

In undertaking the peer review, BMT has relied upon, and presumed accurate, information (or absence thereof) provided by Engeny. Except as otherwise stated in this review, BMT has not attempted to

verify the accuracy or completeness of any such information. If the information is subsequently determined to be false, inaccurate or incomplete, then it is possible that our observations and conclusions as expressed in this review may change.

The focus of the peer review is on the flood model set up and ability of the model to satisfactorily determine flood impacts. Aspects such as the design/feasibility of the proposed infrastructure have not been assessed as part of this review.

Part 2: SEARs Requirements

The HVO Continuation Project is to comply with the NSW Planning Secretary's Environmental Assessment Requirements (SEARs) for the preparation of an Environmental Impact Statement (EIS). SEARs have been issued separately for the HVO North and HVO South projects, however the requirements are the same for both projects and the two projects are treated as one for the purposes of this review.

BMT has reviewed the flooding specific SEARs requirements against the flood modelling and reporting and our opinion on whether these recommendations have been satisfied is documented below.

Requirement 9

The EIS must map the following features relevant to flooding as described in the Floodplain Development Manual 2005 (NSW Government 2005) including:

- a) *Flood prone land*
- b) *Flood planning area, the area below the flood planning level*
- c) *Hydraulic categorisation (floodways and flood storage areas)*

BMT Comment

Engeny has supplied to BMT a draft of the Surface Water Impact Assessment. This includes the following relevant maps:

- A map showing flood prone land and the area below the flood planning level (the flood planning area)
- A map showing the hydraulic categorisation of the floodplain into floodway, flood fringe and flood storage

The report does not detail the criteria used to determine the hydraulic categorisation, noting that the Floodplain Development Manual also does not include a prescriptive method for determining these categories. It is recommended that additional detail is provided in how the categories have been determined. Notwithstanding this, the relevant maps requested by the SEARs requirement are included and so this requirement has been met.

Requirement 10

The EIS must describe flood assessment and modelling undertaken in determining the design flood levels for events, including a minimum of the 1 in 10 year, 1 in 100 year flood levels and the probable maximum flood or an equivalent extreme event.

BMT Comment

A flood model technical report 'Hunter River Flood Assessment' (ref N1000_067-REP-004) was provided to BMT and provides sufficient detail of the hydrologic and hydraulic flood modelling

assessments. The report includes a range of design events which include the 1 in 10 AEP, 1 in 100 AEP and an extreme event. BMT considers that this SEARs requirement has been fully met.

Requirement 11

The EIS must model the effect of the proposed development (including fill) on the flood behaviour under the following scenarios:

- a) *Current flood behaviour for a range of design events identified in 10 above. This includes the 1 in 200 and 1 in 500 year flood events as proxies for assessing sensitivity to an increase in rainfall intensity of flood producing rainfall events due to climate change.*

BMT Comment

The events assessed as part of the flood assessment are the 1 in 10; 1 in 20; 1 in 50; 1 in 100; 1 in 200; 1 in 500 and 1 in 1000 AEP events along with an extreme event.

Whilst the 1 in 200 and 1 in 500 events have been modelled, they are presented and commented on in the Engeny report in terms of changes in flood extent and the report concludes that climate change impacts on Hunter River flooding are not expected to have a significant impact on the flood outcomes for the project.

In our opinion the SEARs requirement is requesting that the 1 in 200 and 1 in 500 are used as a proxy for the 1 in 100 AEP under a future climate and that the effect of the proposed development on the flood behaviour under a climate change (proxy) scenario is assessed. The mapping output for the 1 in 200 and 1 in 500 AEP events should therefore be equivalent to the content presented for the 1 in 100 AEP under an existing climate i.e. peak flood level and peak flood velocity impact maps.

As such BMT considers that this SEARs recommendation is only partially met.

Requirement 12

Modelling in the EIS must consider and document:

- a) *The impact on existing flood behaviour for a full range of flood events up to and including the probable maximum flood.*
- b) *Impacts of the development on flood behaviour resulting in detrimental changes in potential flood affection of other developments or land. This may include redirection of flow, flow velocities, flood levels, hazards and hydraulic categories.*
- c) *Relevant provisions of the NSW Floodplain Development Manual*

BMT Comment

The events assessed as part of the flood assessment are the 1 in 10; 1 in 20; 1 in 50; 1 in 100; 1 in 200; 1 in 500 and 1 in 1000 AEP events along with an extreme event.

Engeny has presented impacts (change in peak level and velocity) for events up to and including the 1 in 100 AEP event. For larger (rarer) events, Engeny has stated the focus is on emergency management with a focus on issues of access and flood hazard. To this end, impact maps for the 1 in 100 and 1 in 1000 AEPs along with the extreme event present changes in AEM flood hazard rating. BMT agrees with this approach.

The impact mapping is sufficient to be able to identify any impacts on flood behaviour in terms of redirection of flow, changes in peak velocity, changes in peak level and changes to categorised flood hazard. Any changes to hydraulic categories (floodway, flood fringe and flood storage) are not shown,

however we consider that this would not provide any additional insight into changes in flood behaviour from that already provided by impact mapping.

The flood modelling is based on the similar techniques as those undertaken for Singleton Council's Flood Study, which itself is undertaken in accordance with the principles of the Floodplain Development Manual. As such, the flood modelling is considered to account for relevant provisions in the Floodplain Development Manual.

BMT considers that this SEARs requirement has been met.

Requirement 13

The EIS must assess the impacts of the proposed development on flood behaviour, including:

- a) Whether there will be detrimental increases in the potential flood affectation of other properties, assets and infrastructure.*
- b) Consistency with Council floodplain risk management plans*
- c) Compatibility with the flood hazard of the land*
- d) Compatibility with the hydraulic functions of flood conveyance in floodways and storage in flood storage areas of the land.*
- e) Whether there will be adverse effect to beneficial inundation of the floodplain environment, on, adjacent to or downstream of the site*
- f) Whether there will be direct or indirect increase in erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses.*
- g) Any impacts the development may have upon existing community emergency management arrangements for flooding. These matters are to be discussed with the SES and Council.*
- h) Whether the proposal incorporates specific measures to manage risk to life from flood. These matters are to be discussed with the SES and Council.*
- i) Emergency management, evacuation and access, and contingency measures for the development considering the full range of flood risk (based upon the probable maximum flood or an equivalent extreme flood event). These matters are to be discussed with and have the support of Council and the SES.*
- j) Any impacts the development may have on the social and economic costs to the community as consequence of flooding.*

BMT Comment

BMT's peer review has been undertaken on the hydrologic and hydraulic modelling and the ability of that modelling to adequately define project related flood impacts. Many of the items listed under Requirement 13 relate to further investigation of any identified impacts including discussions with the SES and Council.

BMT has been supplied with a draft copy of a surface water impact assessment and we have provided commentary on relevant aspects of the report which fall within this requirement. We cannot conclude that requirement 13 has been met as, for example, there would need to be documented evidence of discussions with Council and the SES, which there is not. Limited BMT commentary is provided below listed under items a) to j) to match those of the requirement.

- a. The supplied report includes an analysis of third party property which is impacted by increased flood levels in the 1 in 100 AEP event (as used for the flood planning level).
- b. The report does not make reference to existing floodplain risk management plans

- c. The report does not make reference to the compatibility of the development with the flood hazard of the land.
- d. The flood assessment defines the hydraulic functions of the land but does not make reference to the compatibility of the development to these hydraulic functions.
- e. The report does not refer to adverse impacts to beneficial inundation of the floodplain
- f. The report considers channel stability and notes that velocity changes are localised around the project infrastructure and that there remains a low likelihood of scour.
- g. An analysis of potential changes to hazard and inundation times on primary transport routes has been undertaken. Any discussion with the SES and Council has not been documented.
- h. This is not documented.
- i. Emergency management and associated measures for the development itself are not discussed in the report.
- j. Flood impacts in terms of social and economic costs to the community are not discussed

Not all items in Requirement 13 a) to j) may be relevant for this assessment. Where not relevant, for example where the impacts are minimal and additional analysis is not warranted, this should be discussed in the report.

Table 1.3 provides a summary of the SEARs relevant to flooding and BMT’s opinion on whether these requirements have been satisfied.

Table 1.3 SEARs Summary

SEARs Requirement ID	Requirement Met	Comment
9	Yes	
10	Yes	
11	No	Partially met. Flood impacts should be presented for climate change proxy events.
12	Yes	
13	No	Some items of the requirement are not discussed in the supplied reporting. Report commentary should be made against each item stated in the SEARs requirement – even if that commentary is to justify those requirements not being relevant

Yours Sincerely,

BMT

Barry Rodgers
Principal Scientist

Our ref: L.A11137.003.01.Peer_Review.docx

4 July 2023

EMM

Level 4, 74 Pirie Street
Adelaide SA 5000

Attention: Kate Holder

Dear Kate,

RE: FLOOD MODELLING PEER REVIEW

Between March 2020 and October 2022 BMT was engaged by HV Operations Pty Limited (HVO) through EMM to undertake a peer review of flood modelling undertaken by Engeny in support of HVO's Continuation Project near Singleton NSW. Peer review of flood models and outputs was undertaken by BMT at key stages throughout the assessment.

Following HVO's submission of the flood modelling as part of the Environmental Impact Statement (EIS), comments have been provided back from Biodiversity and Conservation Division (BCD) of the Department of Planning and Environment (DPE) on the adequacy of the flood modelling. BMT has been requested by EMM to provide additional comment on the flood modelling aspects raised by BCD.

This letter provides an overall summary of the peer review process along with specific commentary on the aspects raised by BCD. For a detailed account of peer review findings and recommendations, reference should be made to the BMT peer review (contained within Appendix K of the EIS) .

Peer Review Process

The peer review process has involved BMT at three key stages of the modelling assessment to review the flood modelling and make recommendations where appropriate. These three stages of review were as follows:

- March 2020 – Review of baseline flood model
- August 2021 – Review of updated flood model (updated in response to BMT's March 2020 review and to include more current data). Models reviewed also included an 'existing case' and an 'operational case'.
- September 2022 – Review of updated flood model (updated in response to BMT's August 2021 review)

When required, meetings were held between Engeny, Glencore and BMT to discuss flood model recommendations made by BMT and Engeny's proposed approach for addressing the recommendations.

BMT Comment on BCD Recommendations

In a letter dated 13 March 2023, BCD identified 23 issues of which 6 related to flooding and flood risk. A recommendation was provided by BCD for each identified issue. The issues and recommendations pertaining to flooding and flood risk are numbered 18 to 23 and are summarised in Table 1.1 below. For detailed descriptions of the issues and associated recommendations, reference should be made to BCD's letter.

Table 1.1 Recommendations

BCD Issue/Recommendation ID	Summary of Issue
18	The proponent has not demonstrated that there will be no adverse flood impacts to the township of Singleton
19	Flood impacts less than 20 mm have not been assessed
20	The flood impact mapping does not show private properties where impacts are predicted to occur
21	Changes in the frequency and duration of flooding has not been assessed
22	Insufficient information has been provided to determine the extent of flooding impacts on private property
23	Appropriate conditions of consent are required to ensure that adversely impacted landowners are equitably compensated

This letter only discusses issues 18 and 19 as items 20 to 23 are being addressed by others.

Issue 18 - Impacts in Singleton

During the peer review process discussion was had between Engeny and BMT on whether to include mapping within Singleton. Key concerns in showing project flood mapping within Singleton were in relation to the flood levels and extents within Singleton differing by an unknown amount from those shown in Singleton Council's (Council) modelling, which was still being prepared at the time and was not available for use. This would be due to factors such as different design event assumptions which tended towards conservative assumptions, proximity of downstream model boundary to Singleton and lack of modelled detail within Singleton given that the area of interest is located a significant distance (approximately 30km) upstream of the township.

The potential for design flood levels/extents to be greater in Singleton than those shown on Council mapping may give the perception that the project has resulted in these higher levels and greater extents rather than the different modelling techniques applied. Given that peak flood level impacts from the project (mapped down to within 20mm) were located a significant distance upstream of the mapping limit, we agreed with Engeny's approach and considered this downstream mapping limit acceptable. We requested that a plot of the flow hydrograph was included near the downstream limit of mapping to demonstrate that there was insignificant increase in downstream flow beyond the mapping limit.

BCD's recommendation makes note of the need to identify the cause of boundary condition instabilities and assess the model's suitability for assessing flood impacts. Based on our review of the model, there was not an issue with boundary stability. The suitability of assessing impacts within Singleton related more to the close proximity of the boundary to Singleton and the absolute flood levels that would result from this.

BCD's recommendation also mentions the potential for the assessment to use the TUFLOW model developed for the 2022 Singleton Flood Study. We note that Council's model would have been used at the outset of the project if available at the time but as it was not, Engeny developed their own model which was subject to BMT's peer review. Given that the Engeny model has been peer reviewed and assesses flood impacts for a range of event magnitudes, we do not consider it necessary to repeat the assessment in an alternative model.

Issue 19 - Impacts less than 20mm

BCD recommends that peak flood level impacts are mapped to 10mm. The HVO mapping shows impacts to a 20mm threshold. In our opinion an impact of 20mm is sufficient as almost all of the modelled and impacted area is rural (Primary Production RU1). The following additional points are noted:

- The Singleton Bypass project, which is currently underway, also involves modelling on the Hunter River although this project is focussed on the Singleton area. In its environmental assessment, set out within a Review of Environmental Factors (REF), a peak flood level impact threshold of 20mm was applied for mapping purposes. The HVO assessment is consistent with this.
- Whilst there is little to no published guidance on acceptable flood level impacts, a recent guideline by Austroads¹ assumes a 25mm change in peak flood level at residential buildings is generally acceptable with greater tolerances for non-residential uses.

In conclusion we consider that a 20mm threshold is sufficient for the project.

Remaining Issues

Issues 20 to 22 relate to requests for provision of additional mapping and modelling outputs to further understand the flood impacts. BMT's review was focussed on the hydrologic and hydraulic modelling and the ability of that modelling to adequately define project related flood impacts. As such, we consider these additional mapping requests outside our scope of review and are matters for Engeny/HVO.

Issue 23 relates to compensation for adversely impacted landowners. This is also a matter which is outside the scope of BMT's peer review engagement.

Limitations of Review

In undertaking the peer review, BMT has relied upon, and presumed accurate, information (or absence thereof) provided by Engeny. Except as otherwise stated in this review, BMT has not attempted to verify the accuracy or completeness of any such information. If the information is subsequently determined to be false, inaccurate or incomplete, then it is possible that our observations and conclusions as expressed in this review may change.

¹ Guide to Road Design Part 5: Drainage – General and Hydrology Considerations, Austroads, Sydney, 2023.

The focus of the peer review is on the flood model set up and ability of the model to satisfactorily determine flood impacts. Aspects such as the design/feasibility of the proposed infrastructure have not been assessed as part of this review.

Yours Sincerely,

BMT

A handwritten signature in blue ink, appearing to read 'Barry Rodgers', with a stylized flourish at the end.

Barry Rodgers
Principal Scientist

F.2 Engeny response to BMT (2022) review comments

28 November 2022

HV Operations Pty Ltd
Sent by email

Attention: Jason Martin, Approvals Manager HVOCP

Dear Jason

RE: Response to Flooding Peer Review Letter (BMT 5 October 2022)

BMT was engaged by HV Operations through EMM to undertake a peer review of the flood modelling and assessment undertaken by Engeny in support of the Hunter Valley Operations (HVO) Continuation Project (HVOCP). BMT provided a letter dated 5 October 2022 documenting the outcomes of the peer review and is structured in two parts.

Part 1 of the letter provides a summary of the peer review process that was undertaken, including BMT's progressive findings and recommendations dating back to March 2020 and the subsequent actions implemented by Engeny. Part 2 of the letter provides an opinion on whether the requirements of the SEARs have been satisfied by the Surface Water Impact Assessment (SWIA).

Two potential gaps in the flood impact assessment were identified in the letter from BMT relating to the SEARs requirements. Extracts from the BMT letter describing the potential gaps are provided below.

Requirement 11

- Wording of the SEARs

The EIS must model the effect of the proposed development (including fill) on the flood behaviour under the following scenarios:

 - a) *Current flood behaviour for a range of design events identified in 10 above. This includes the 1 in 200 and 1 in 500 year flood events as proxies for assessing sensitivity to an increase in rainfall intensity of flood producing rainfall events due to climate change.*
- Peer Reviewer findings (BMT)
 - *In our opinion the SEARs requirement is requesting that the 1 in 200 and 1 in 500 are used as a proxy for the 1 in 100 AEP under a future climate and that the effect of the proposed development on the flood behaviour under a climate change (proxy) scenario is assessed. The mapping output for the 1 in 200 and 1 in 500 AEP events should therefore be equivalent to the content presented for the 1 in 100 AEP under an existing climate i.e. peak flood level and peak flood velocity impact maps.*
 - *Partially met. Flood impacts should be presented for climate change proxy events.*

Requirement 13

- Wording of the SEARs

The EIS must assess the impacts on the proposed development on flood behaviour, including:

 - a. *Whether there will be detrimental increases in the potential flood affectation of other properties, assets and infrastructure.*
 - b. *Consistency with Council floodplain risk management plans.*
 - c. *Compatibility with the flood hazard of the land.*
 - d. *Compatibility with the hydraulic functions of flow conveyance in floodways and storage in flood storage areas of the land.*

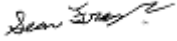
- e. Whether there will be adverse effect to beneficial inundation of the floodplain environment, on, adjacent to or downstream of the site.
 - f. Whether there will be direct or indirect increase in erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses.
 - g. Any impacts the development may have upon existing community emergency management arrangements for flooding. These matters are to be discussed with the SES and Council.
 - h. Whether the proposal incorporates specific measures to manage risk to life from flood. These matters are to be discussed with the SES and Council.
 - i. Emergency management, evacuation and access, and contingency measures for the development considering the full range or flood risk (based upon the probable maximum flood or an equivalent extreme flood event). These matters are to be discussed with and have the support of Council and the SES.
 - j. Any impacts the development may have on the social and economic costs to the community as consequence of flooding.
- Peer reviewer findings (BMT)
 - Not all items in Requirement 13 a) to j) may be relevant for this assessment. Where not relevant, for example where the impacts are minimal and additional analysis is not warranted, this should be discussed in the report.
 - Some items of the requirement are not discussed in the supplied reporting. Report commentary should be made against each item stated in the SEARs requirement – even if that commentary is to justify those requirements not being relevant

Following provision of the peer review findings, Engeny has engaged with the Project team including EMM and the Glencore Water Infrastructure Manager to determine the best approach to resolve the gaps in the SEARs identified by BMT. This letter provides a response documenting the adopted approach. It is noted that the flood event terminology used by Engeny below is the AEP (%) consistent with the latest version of the SWIA. This terminology is interchangeable with the 1:X AEP referred to above for the events under discussion.

- Requirement 11:
 - The climate change assessment has been updated to include commentary on both the flood immunity of Project infrastructure under the climate change scenarios as well as to describe the Project impacts that would occur under the climate change scenarios. This is described in Section 6.2.6 of the SWIA including:
 - How the change in flood level from climate change compares to the current Singleton Council flood planning level and freeboard allowances.
 - The incremental change in flood regime (i.e., flood level or extent) due to the Project on properties not owned by the JV partners under climate change scenarios.
 - Interpretation of the above incremental changes due to the Project and assessment of any resulting potential impact on the use of the land or additional inundation of dwellings under climate change scenarios.
 - We note that flood impact maps have been targeted at their intended function (i.e., flood planning or emergency management). Flood level and velocity impact mapping has been provided up to and including the 1% AEP flood, which is the event adopted by Singleton Council to determine the flood planning level. Events larger than the 1% AEP flood are not utilised for flood planning purposes and, accordingly, flood level and velocity impact maps are not provided for those events (including the 0.5% and 0.2% AEP climate change proxies). By contrast, the larger flood events are utilised for assessment of hazard and emergency management. For this reason, hazard impact maps have been included for a range of larger floods (1% AEP, 0.1% AEP and Extreme Event).
- Requirement 13:
 - Additional text has been added to the report to address each sub-item of Requirement 13 more specifically. In addition, Section 6.2.7 and Table 6-4 have been added to clearly demonstrate how and where each aspect of the SEARs has been addressed.

Based on the above adjustments, we believe the flooding requirements of the SEARs have now been fully met by the SWIA. Please don't hesitate to contact the undersigned if you'd like to discuss any aspect in further detail.

Regards,



Sean Frazer

Principal Engineer (CPEng, RPEQ)

Water Management

Associate

DISCLAIMER

This letter has been prepared on behalf of and for the exclusive use of HV Operations Pty Ltd and is subject to and issued in accordance with HV Operations Pty Ltd instruction to Engeny Water Management (Engeny). The content of this letter was based on previous information and studies supplied by HV Operations Pty Ltd

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F.3 Flood risk assessment peer review (Torrent 2024)

Our Ref: DJL: L.T2522.003

12 July 2024

Joe Fittell

Energy and Resource Assessments | Planning and Assessment
Department of Planning and Environment

joe.fittell@planning.nsw.gov.au

Attention: Joe Fittell

Dear Joe

RE: PEER REVIEW OF FLOOD RISK ASSESSMENT FOR HVO CONTINUATION PROJECT

Torrent Consulting was engaged by NSW Department of Planning and Environment (DPE) to undertake a peer review of the of the of the Hunter River Flood Assessment for the Hunter Valley Operations Continuation Project (SSD 11826681 and SSD 11826621) (the Project).

The focus of the review is to assess the appropriateness of the developed models and design flood assessment, and general consistency with respect to industry best practice.

Scope of Review

The general scope of works for the review as defined by DPE is expected to cover the following elements (as a minimum).

1. Undertake a comprehensive review of the flood modelling and flood assessment completed for the Hunter Valley Operations Continuation Project EIS including:

- a. whether the assumptions used are reasonable, appropriate and suitably justified;
- b. the adequacy of the methodology, analysis and assessment presented in evaluating the flood impacts of the proposed development;
- c. the identification of any areas of deficiency and recommendations to improve or resolve these issues in the assessment;
- d. the significance of impacts, key environmental risks and issues for consideration during the assessment process;
- e. suitability of the proposed mitigation and/or management and/or protection measures; and
- f. any recommendations (if required) for additional information to inform the assessment of the project.

2. Consultation with relevant NSW Government personnel, the Applicant and its experts if required, to be co-ordinated through the Department.

To facilitate the review, the following relevant documents and files were provided:

- Hunter River Flood Assessment (Engeny, 2023)
- TUFLOW model files
- BCD - Advice on EIS
- Muswellbrook SC - Advice on EIS

- Singleton Council Advice on EIS

Model Review

The detailed review of the model configuration is documented in Appendix A. The following represent the most pertinent comments from the review:

- Model extent, resolution and topography – the model extent covers the Hunter River floodplain extending from Jerrys Plains to ~6km downstream of Singleton. The model extents appear adequate to simulate flood flow distributions in the potential area of influence of the proposed works, extending sufficiently upstream and downstream along the Hunter River and into backwater reaches of significant tributaries.

The adopted TUFLOW model grid resolution of 8m is generally appropriate to resolve flow distribution in the channel and floodplain. The baseline model topography uses LiDAR data from various sources with underlying grid resolutions of 1 to 2m. Accordingly, the underlying topographical data resolution supports the adopted model grid resolution. Note that the review assumes the underlying LiDAR data sets are of appropriate accuracy in representing ground levels.

- Boundary conditions – design inflows to the TULFOW model have been derived from Flood Frequency Analysis (FFA) at relevant gauging stations including Hunter River at Liddell and Hunter River at Singleton.

The methodology employed for the FFA is generally appropriate. However, it is recognised there is considerable uncertainty with some of the historical events in the annual series, particularly some high flow events that have a significant influence on the frequency distributions and peak flow estimates. The assumptions made in formulating the annual series and distribution fitting (e.g. stage-discharge relationships, outlier treatment) impacts on the design peak flood estimation for specified design flood magnitudes. This is evident in comparison of design flow estimates derived in other studies such as WBM Oceanics (2007), BMT (2016) and BMT (2021). Accordingly, there is variation in design flood estimates across the studies including the current assessment. Notwithstanding, the derived FFA in the current assessment is suitable for the investigation of the relative impacts of the proposed works.

Further to above, the FFA confirms some inconsistency between estimated design flows at Liddell and Singleton for major design flood events. The inflow derivation for the assessment utilised a scaling method to derive the inflow distributions between Liddel (U/S model inflow), Singleton (D/S model boundary) and the intermediate tributary flows of Bowmans Creek, Glennies Creek and Wollombi Brook. Whilst the methodology can be justified, particularly in the context of the uncertainty around the FFA design flood estimates, the adopted inflows at the upstream model boundary may be considered on the low side. This is borne out of a greater weighting to tributary inflows providing the gap flow between Liddell and Singleton, rather than higher flows adopted at Liddell for the upstream model boundary.

- Hydraulic Roughness – the development of the TUFLOW model requires the assignment of different hydraulic roughness zones. These zones are typically delineated from aerial photography and cadastral data identifying different land-uses for modelling the variation in flow resistance. The spatial distribution of land-use type and adopted hydraulic roughness coefficient (Manning's 'n' value) is considered fit for purpose.

- Development representation – the existing conditions (base) model was modified to represent the post-development design (operations) condition. Changes to the TUFLOW model incorporated various bulk earthworks design surfaces representing modifications to working/void areas, levees, ancillary works (roads and bridges).

Figure 1 presents the difference in model topography from existing to design conditions. The DEM modifications appear to appropriately represent the scale and nature of the proposed works. However, it is noted that the adopted model grid resolution of 8m may not explicitly define the contiguous crest levels of narrow linear features such as levees and road embankment where they are read into the model directly via a DEM surface (1 or 2m resolution) and have not been reinforced by other 2d_shape layers.

- Design Flood Results – the design flood results have been independently reproduced with the TUFLOW model files provided for the review. The design flood mapping and impact assessment of post-development conditions is consistent with the reported outcomes and analysis.

Response to SEARS

A peer review of the flood impact assessment for the proposed development has been undertaken including detailed technical review of developed models.

The developed models are considered fit for purpose in the model construction and adopted parameters. The model development and design flood assessment methodology is considered consistent with industry standard practice. The application of the models, assessment of flood impacts, and proposed design demonstrate that flood risk has been appropriately considered in accordance with the SEARS (refer to Appendix B).

Conclusions and Recommendations

The flood impact assessment and supporting modelling is found to generally be fit for purpose and suitable for assessment of the proposal on design flood conditions. The following represent the key limitations of the assessment undertaken, and recommendation for further consideration:

- The methodology employed for design inflow derivation potentially underestimates peak design flows at the upstream model boundary. This may provide for a lower peak flood condition in the upstream reach of the Hunter River between Liddell and the Glennies Creek confluence. The potential for higher design flows for a given flood magnitude may warrant consideration of potential impact on design flood immunity for proposed infrastructure. However, it is not expected that inflow refinement would change the overall findings of the impact assessment, being a relative condition. The potential variation in design flow may be considered by undertaking further sensitivity testing or reviewing change in flood condition with higher order events already established.
- A number of the topographical modifications for the proposed works are defined by direct import of design DEMs of 1 and 2m grid resolution. The underlying TUFLOW model resolution of 8m may not provide for adequate representation of the design in the modelled topography. It is recommended these be reviewed to consider impacts on design flood behaviour and potential localised impacts. It is noted any refinement in this regard is not expected to fundamentally change the flood assessment, but confirm local conditions.

Notwithstanding these limitations, the modelling, impact assessment and design are considered to appropriately consider and address flood risk for the proposed development in accordance within industry practice and requirements of the SEARS.

We trust that this review meets your requirements. For further information or clarification please contact the undersigned. The CV of the reviewer is attached at Appendix C.

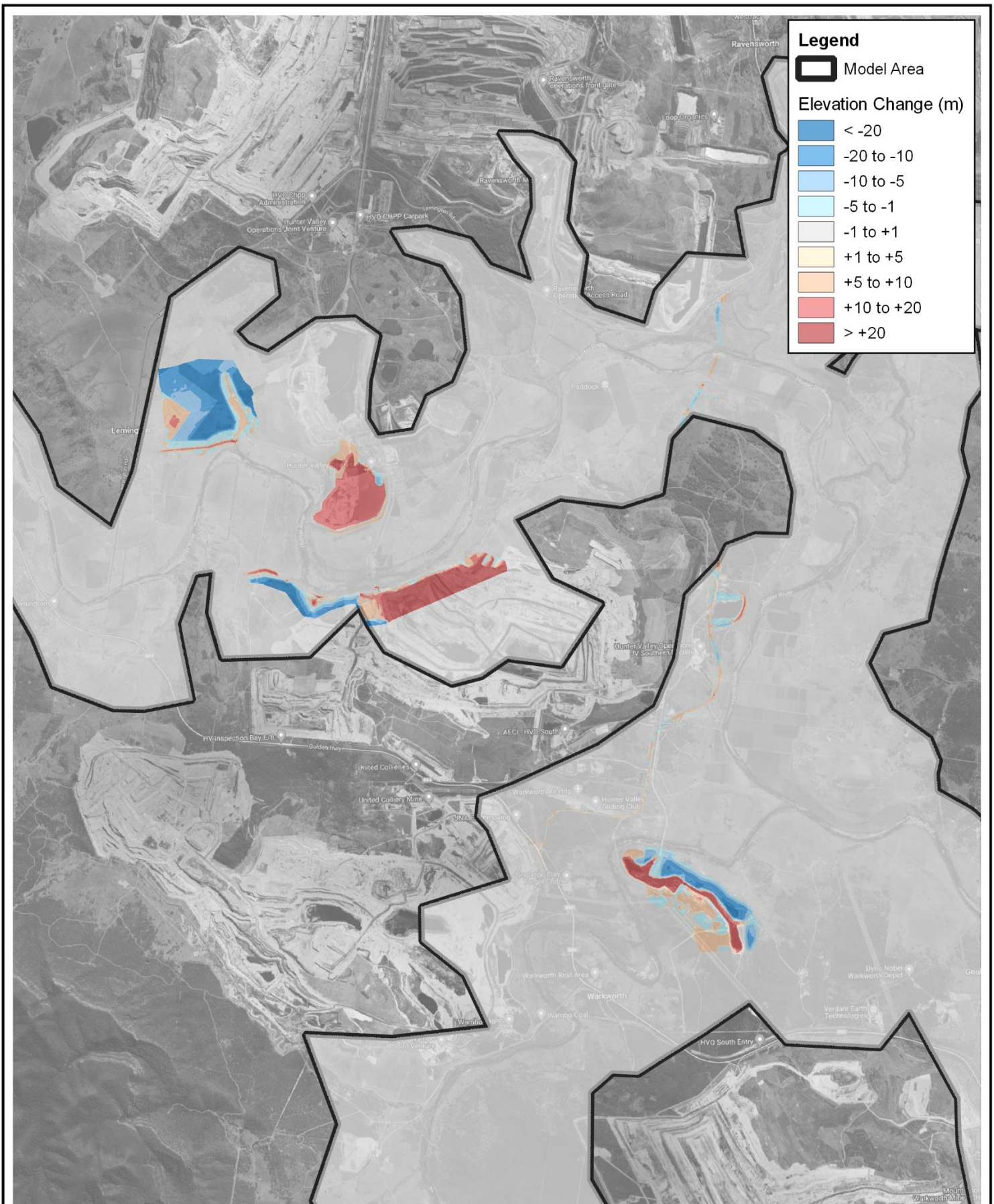
Yours faithfully

Torrent Consulting

A handwritten signature in black ink, appearing to read 'DL', is positioned below the company name.

Darren Lyons
Principal Water Resources Engineer

CPEng MIEAust





Title: Change in Model Topography		0 2 4 km approx. scale	
Figure:	1	<i>Information shown on this figure is compiled from numerous sources and may not be complete or accurate. Torrent Consulting cannot be held responsible for the misuse or misinterpretation of any information and offers no warranty guarantees or representations of any kind in connection to its accuracy or completeness. Torrent Consulting accepts no liability for any loss, damage or inconvenience caused as a result of reliance on the information.</i>	
Revision:	A		
Filepath: Z:\Projects\T2522_HVO_Flood_Review\GIS\T2522_002_Topography.gqz			

APPENDIX A – Detailed Model Review

Table A1 – Model Audit of TUFLOW Run File HVO_~e1~_~e2~_~s1~_113.tcf

Item	Configuration	Comment	Action
Software	TUFLOW Version	<ul style="list-style-type: none"> TUFLOW_2020-01-AB-iSP-w64- build indicated in model copy handover, suitable for assessment 	Nil
Control Files	File Structure	<ul style="list-style-type: none"> Standard folder structure used. Processed results files (maximum ascii grids) used in mapping provided. No raw TUFLOW results provided. Simulation of models in review process reproduced results consistent with mapping. 	Nil
Simulation Commands	Solution Scheme	<ul style="list-style-type: none"> HPC solution scheme utilising GPU hardware. 	Nil
	Timestep	<ul style="list-style-type: none"> 2D Model timestep = 0.4 seconds (sets initial timestep value) HPC uses adaptive time stepping No 1D Timestep (noting no 1D domain) 	Nil
Model Extent	2D Domain	<ul style="list-style-type: none"> Model grid size 8m - suitable for broad Hunter River floodplain environment, typical channel width >40m) No SGS mode – would provide better conveyance representation and utilise available DEM resolution, but no major benefit at scale of modelling Active 2D domain set by 2d_code_HVO_105_R.shp – model extent covers Hunter River floodplain from Jerrys Plains to downstream of Singleton, including reaches on tributaries capturing backwater influence (e.g. Farrells Creek, Bayswater Creek, Bowmans Creek, Glennies Creek, Wollombi Brook, Rixs Creek) Domain sufficiently covers proposed works extent and potential impact area, extends sufficiently downstream to consider impacts. 	Nil
	1D Domain	<ul style="list-style-type: none"> No 1D elements 	Nil
Model Topography	Base DEM	<ul style="list-style-type: none"> Built from multiple sources with following hierarchy (in order of use where coverage overlaps): <ul style="list-style-type: none"> LiDAR 2020 1m.dem (1m grid resolution) sry egl lidar 161123.txt (2m grid resolution) Cessnock201110_Wollombi.txt (1m grid resolution) Camberwell201705-Glennies.txt (1m grid resolution) Cessnock201110_Additional_Singleton.txt (1m grid resolution) Cessnock201110-LID1-AHD_Spliced.txt (1m grid resolution) General consistency found at boundaries, no significant edge effects 	Nil


	<p>Base DEM Modifications</p>	<ul style="list-style-type: none"> 210413 1m Flood Data Levee Raise 2021 Surface_trim.asc (1m grid resolution) - Cheshunt Haul Road description in report)  <ul style="list-style-type: none"> 20201207 WSP Des NV Levee 1 DEM 1m.dem (1m grid resolution) - West portion of North Void TSF Levee 	<p>Nil</p>
	<p>BASE Z shape modifications</p>	<ul style="list-style-type: none"> 2d_zsh_HVO_101_P.shp 2d_zsh_HVO_101_L.shp – localised lowering and widening of Bowmans Creek near Hunter River confluence 	<p>Nil</p>



- 2d_zsh_ExLevee_103_P.shp | 2d_zsh_ExLevee_101_L.shp – reinforcement of existing levee crest (multiple levees including works area and Singleton township)



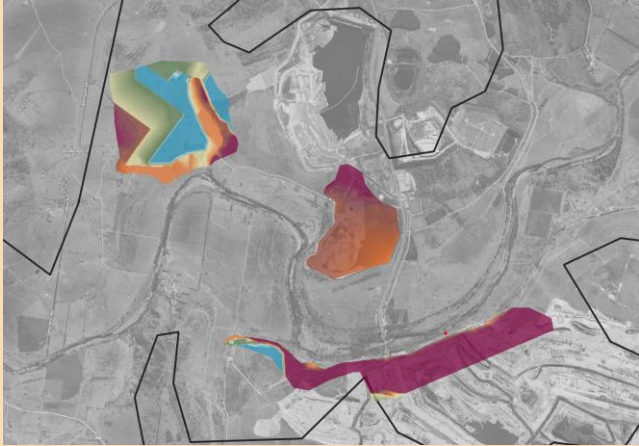
- 2d_zsh_South_Lemington_Levee_107_P.shp | 2d_zsh_South_Lemington_Levee_107_L.shp – reinforcement of existing levee crest

			
Hydraulic Structures	Base model (2d representation)	<ul style="list-style-type: none"> • 2d_lfcsh_HVO_112_R.shp – layered flow constriction representing haul road bridge crossing of Wollombi Brook • No survey review, broad parametrisation looks appropriate 	Nil
Hydraulic Roughness	Materials Layers	<ul style="list-style-type: none"> • Materials layer defined by 2d_mat_HVO_001_R.shp and 2d_mat_HVO_Channel_101_R.shp • Default material set to “Grazing/Grassland”. Digitised polygons generally reflective of land use as defined in materials file (tmf) • Same roughness distribution adopted for existing and design condition. 	Nil
	Manning’s ‘n’ values	<ul style="list-style-type: none"> • Values applied as per input file HVO_105.tmf • Adopted values within appropriate ranges for land use types. • It is noted the “Riverbank” and “Cleared Riverbank” land use types digitised separately have adopted the same Manning’s ‘n’ value. Not expected to have significant influence on broader floodplain levels and flow distribution. 	Nil
Boundary Conditions	Inflow Boundaries	<ul style="list-style-type: none"> • Upstream inflow defined as QT (hydrograph) inflow boundary (2d_bc_HVO_102_L.shp) for mainstream Hunter River • Tributary inflows applied to 2D domain via source area (2d_sa_HVO_101_R.shp) hydrographs for Bowmans Creek, Glennie Creek and Wollombi Brook. • Inflow hydrographs correctly reference via boundary condition database (bc_dbase_HVO_106.csv) • Derivation of hydrographs discussed in main body of report. 	Refer to report body
	Downstream Boundary	<ul style="list-style-type: none"> • Model outflow boundary D/S of Singleton represented by TUFLOW HQ boundary (2d_bc_HVO_102_L.shp) • Adopted boundary slope of 0.0005 - this appears to be consistent with modelled profiles though region in other studies. 	Nil

	Initial Water Levels	<ul style="list-style-type: none"> Initialisation of IWL=-120m AHD (no initial storage) Initial water level in HVO pit defined at 64.5m AHD via 2d_IWL_HVO_106_R.shp. 	Nil
Model Scenarios	Design Events	<ul style="list-style-type: none"> Historical calibration events identified as 1955 and 2007 with hydrographs included in event file (HVO_001.tef) and bc_dbase references Note no calibration results provided – refer to main body of review Design events identified as 10yr, 20yr, 50yr, 100yr, 200yr, 500yr, 10-00yr and PMF with hydrographs included in event file (HVO_001.tef) and bc_dbase references Peak ascii grid results provided for design event scenarios and reproduced in review process 	Nil
	Development Scenario	<ul style="list-style-type: none"> “Base” scenario representing existing/pre-development conditions “Op” scenario representing operations/post-development condition Scenario references used in various control file commands as appropriate 	Nil
Errors, checks and warnings	Output Files	<ul style="list-style-type: none"> No issues with model stability, time-stepping 	Nil

Table A2 – Model Audit of TUFLOW Run File HVO_~e1~_~e2~_~s1~_113.tcf

(NB: only changes from HVO_~e1~_~e2~_~s1~_113.tcf documented to compare pre- and post-development condition)

Item	Configuration	Comment	Action
Model Topography	Base DEM Modifications	<ul style="list-style-type: none"> 2044 Landform DEM.asc (2m grid resolution) – HVO final landform description in report  <ul style="list-style-type: none"> 201207 1m HVO CONTINUATION MITCHELL LEVEE.dem (1m grid resolution) – Mitchell levee design 	Suggest confirm crest appropriately represented with respect to model grid size and DEM sampling, and potential impact on assessment



- WSP DES NV LEVEE 2 DEM 1m.dem (1m grid resolution) – Southern portion of North Void TSF Levee



- 20201207 WSP DES CH LEVEE DEM 1m.dem (1m grid resolution) – Cheshunt Levee




- 201207 1m HVO CONTINUATION RIVERVIEW LEVEE.dem (1m grid resolution) – Riverview Levee



- LAKE JAMES 1m.dem (1m grid resolution) – Lake James

		 <ul style="list-style-type: none"> • 210414 1m HVO LEMINGTON ROAD DESIGN.dem (1m grid resolution) – Lemington Road 	
	<p>BASE Z shape modifications</p>	<ul style="list-style-type: none"> • 2d_zsh_South_Lemington_Levee_107_P.shp 2d_zsh_South_Lemington_Levee_107_L.shp (reinforcement of existing levee crest). • Note not referenced in “Ops” model geometry (HVO_8m_113.tgc but covered by final landform DEM (2044 Landform DEM.asc) 	<p>Nil</p>

			
Hydraulic Structures	Operations model (2d representation)	<ul style="list-style-type: none"> • 2d_lfcsh_HVO_DEV_113_R.shp 2d_lfcsh_pts_HVO_Dev_113_P.shp – layered flow constriction representing proposed Lemington bridge crossing of Hunter River (north bridge section on main river alignment and south bridge section on southern flood runner) • No survey review, broad parametrisation looks appropriate 	Nil
Boundary Conditions	Outflow Boundary	<ul style="list-style-type: none"> • Ingress to pit behind Mitchell Levee defined as represented by TUFLOW HQ boundary (2d_bc_HVO_ext_DEV_106_L.shp) with nominal slope 0.05 • Levee overflow extracted from model, assume for mapping purposes 	Nil
	Initial Water Levels	<ul style="list-style-type: none"> • Initial water level in HVO pit defined at 70.0m AHD via 2d_IWL_HVO_Fin_106_R.shp. 	Nil
Errors, checks and warnings	Output Files	<ul style="list-style-type: none"> • No issues with model stability, time-stepping 	Nil

APPENDIX B – Response to SEARS

Hunter River Flood Assessment (Engeny, 2023)

Table 6-4: Summary of Response to Flooding SEARs

SEARs - Requirement 13	Response	Relevant Section
<p>9. The EIS must map the following features relevant to flooding as described in the Floodplain Development Manual 2005 (NSW Government 2005) including:</p> <ul style="list-style-type: none"> Flood prone land. Flood planning area, the area below the flood planning level. Hydraulic categorisation (floodways and flood storage areas). 	All items mapped	Section 2.4
<p>10. The EIS must describe flood assessment and modelling undertaken in determining the design flood levels for events, including a minimum of the 1 in 10 year/ 1 in 100 year flood levels and the probable maximum flood, or an equivalent extreme event.</p>	Flood model technical report	Appendix C
<p>11. The EIS must model the effect of the proposed development (including fill) on the flood behaviour under the following scenarios:</p> <ul style="list-style-type: none"> Current flood behaviour for a range of design events as identified in 11 above. This includes the 1 in 200 and 1 in 500 year flood events as proxies for assessing sensitivity to an increase in rainfall intensity of flood producing rainfall events due to climate change. 	Flood impact mapping and detailed assessment including climate change assessment	Section 6.2 (including Section 6.2.6) and Appendix C
<p>12. Modelling in the EIS must consider and document:</p> <ul style="list-style-type: none"> The impact on existing flood behaviour for a full range of flood events including up to the probable maximum flood. Impacts of the development on flood behaviour resulting in detrimental changes in potential flood affection of other developments or land. This may include redirection of flow, flow velocities, flood levels, hazards and hydraulic categories. Relevant provisions of the NSW Floodplain Development Manual 2005. 	Flood impact mapping and detailed assessment	Section 6.2 and Appendix C
<p>13. The EIS must assess the impacts on the proposed development on flood behaviour, including:</p> <ul style="list-style-type: none"> Whether there will be detrimental increases in the potential flood affection of other properties, assets and infrastructure. 	Detailed mapping of flood impacts (level and velocity) and discussion focused on the 1% AEP used for flood planning	Section 6.2
<ul style="list-style-type: none"> Consistency with Council floodplain risk management plans 	Consistent with current plan	Section 6.2.4
<ul style="list-style-type: none"> Compatibility with the flood hazard of the land 	Compatible with flood hazard	Section 6.2.4

SEARs - Requirement 13	Response	Relevant Section
<ul style="list-style-type: none"> Compatibility with the hydraulic functions of flood conveyance in floodways and storage in flood storage areas of the land. 	Compatible with hydraulic functions	Section 6.2.4
<ul style="list-style-type: none"> Whether there will be adverse effect to beneficial inundation of the floodplain environment, on, adjacent to or downstream of the site 	No impact on beneficial inundation as level changes are minimal for the range of flood events assessed. Refer ecology assessment for further detail.	Section 6.2
<ul style="list-style-type: none"> Whether there will be direct or indirect increase in erosion, siltation, destruction of riparian vegetation or a reduction in the stability of riverbanks or watercourses. 	Assessment of channel stability indicates velocity changes are localised around the project infrastructure and that there remains a low likelihood of scour.	Section 6.4
<ul style="list-style-type: none"> Any impacts the development may have upon existing community emergency management arrangements for flooding. These matters are to be discussed with the SES and Council. 	An analysis of potential changes to emergency management, hazard and inundation times on primary transport routes has been undertaken.	Section 6.2.4
<ul style="list-style-type: none"> Whether the proposal incorporates specific measures to manage risk to life from flood. These matters are to be discussed with the SES and Council. 	Impact assessment indicates minimal change in flood behaviour and therefore no further specific measures to manage risk to life are required. Improved immunity of the Lemington Road crossing will reduce risk exposure for road users.	Section 6.2.4
<ul style="list-style-type: none"> Emergency management, evacuation and access, and contingency measures for the development considering the full range of flood risk (based upon the probable maximum flood or an equivalent extreme flood event). These matters are to be discussed with and have the support of Council and the SES. 	Impact assessment indicates minimal change in flood behaviour and therefore no changes are required to existing site emergency management, evacuation and access, and contingency measures. Improved immunity of the Lemington Road crossing will reduce risk exposure for road users.	Section 6.2.4
<ul style="list-style-type: none"> Any impacts the development may have on the social and economic costs to the community as consequence of flooding. 	Impact assessment indicates minimal change in flood behaviour and therefore no change in existing social and economic costs to the community. Social and economic impacts of the Project are discussed in more detail elsewhere in the EIS.	Section 6.2

APPENDIX C – Reviewer CV

Position

Principal Water Resources Engineer

Experience

25+ years

Qualifications

Bachelor of Engineering Civil (BE Hons1), University of Technology, Sydney (1996)
Chartered Professional Engineer (CPEng), Member Institution of Engineers (MIEAust), Registered Professional Engineer of Queensland (RPEQ)

Recent Employment

2023 to present

Torrent Consulting - Principal Water Resources Engineer

2021 to 2023

Umwelt Australia - National Water & Catchments Lead

2006 to 2020

BMT - NSW/Vic Business Unit Manager (2012 to 2020), NSW Flood Lead (2006-2016)

2001 to 2005

Mott MacDonald, Cambridge (UK) - Senior Water Resources Engineer

Career Overview

Darren is a Principal Water Resources Engineer with extensive consulting engineering experience in Australia and overseas. Darren has a specialised background in both the development and application of numerical models for hydraulic, water quality and sediment transport studies. This has provided for extensive experience in investigating natural resource processes across catchment, fluvial, estuarine and coastal environs.

Through the senior management role of multi-disciplinary teams, Darren has extensive experience in managing and directing a wide range of specialist water and environmental projects including coastal processes and coastal zone management, stormwater management and Water Sensitive Urban Design, climate change risk and adaptation, water conservation and planning studies. This has provided him a sound knowledge of a wide range of natural resource management issues and the skills required to investigate, interrogate and provide quality outcomes to address Client's needs in these areas.



Darren Lyons

Skillset

Hydrodynamic, water quality and sediment transport modelling and investigations

Hydrological catchment and receiving water processes

Flood studies and floodplain risk management

Impact assessments for infrastructure and land development

Design and performance of hydraulic structures

Flood emergency response management

Community engagement

Expert witness and peer review services

Project Experience

Flood Studies and Floodplain Risk Management Studies (FRMS)

- Ungarie Flood Study and FRMS (2017 and 2020)
- Lake Illawarra, Mt Warrigal, Oak Flats Flood Study (2020)
- Emu Plains Flood Study (2020)
- Waverley LGA Overland Flood Study (2019)
- Georges River Flood Study Review (2019)
- Mullet Creek/West Dapto Flood Study Update and Flood Planning Assessment (2017)
- Mid-Georges River Sub-Catchments FRMS (2017)
- Jewells Wetland Flood Study and FRMS (2013 and 2018)
- Fairfield CBD FRMS (2018)
- Williamstown-Salt FRMS (2017)
- Lower Wollombi Brook Flood Study (2016)
- Griffith Main Drain J and Mirrool Creek Flood Study and FRMS (2015)
- Botany Bay Foreshore Flood Study (2015)
- Lower Myall River and Myall Lakes Flood Study (2015)
- Alexandra Canal Catchment Flood Model Conversion (2015)
- Clarence Town Flood Study and FRMS (2011 and 2014)
- Darling Harbour Catchment Flood Study (2014)
- City of Sydney CBD Flood (2014)
- Wyong River Flood Study (2013)
- Narrabeen Lagoon Flood Study (2013)
- Manly Lagoon Flood Study (2013)
- Lake Conjola FRMS (2013)
- Burrill Lake FRMS (2013)
- Liverpool Overland Flow FRMS (2013)
- Lake Wyangan Flood Study and FRMS (2012 and 2013)
- Wollombi Brook Flood Study and FRMS (2012)
- Duck Creek Flood Study (2012)
- Coogee Bay Flood Study (2012)

- LT Creek Flood Study (2011)
- Tabourie Lake Flood Study (2010)
- Liverpool Overland Flow Flood Study Stage 2 and 3 (2008 and 2010)
- Bomaderry Creek Flood Study (2010)
- Moore Reserve Overland Flow Study (2009)
- Coffs Creek Flood Study Review (2008)
- Anzac Creek FRMS (2007)

Flood/Water Resources Impact Assessments

- Kurri Kurri Lateral Gas Pipeline WRIA (2023)
- Jingi Jingi Solar Farm FIA (2023)
- Goulburn River Solar Farm WRIA (2023)
- Broken Hill Energy Storage WRIA (2023)
- Olympic Hwy Interswection Upgrades (2022)
- Moah Creek Wind and Solar Farm FIA (2022)
- Tallawang Solar Farm WRIA (2022)
- Warragamba Dam Raising Project EIS (2020)
- Hawthorn Rowing Club Floating Pontoon FIA (2020)
- Nelson Bay Road Upgrade Concept Options Flood Constraints (2020)
- Penway Place Penrith Flood Emergency Management Plan (2020)
- Light Horse Interchange Hub FIA (2019)
- Surry Hills Shopping Village Drainage and Flooding (2019)
- Old Cooma Road Upgrade FIA (2018)
- Lower Hunter Freight Corridor Surface Water Constraints (2017)
- Newcastle Rezoning of Surplus Rail Corridor Lands FIA (2016)
- Singleton Bypass Route Options Investigation (2014)
- Hexham Train Support Facility FIA (2013)
- Hexham Relief Roads Project FIA (2013)
- Northbank Enterprise Hub FIA (2013)
- Newline Road Levee Assessment FIA (2012)
- Country Regional Network Culvert Upgrade Investigations (2012)
- Burrill Bridge Upgrade Options FIA (2012)

Expert Witness and Peer Review

- Astoria Developments vs Coffs Harbour City Council NSW L&E Court - Statement of Evidence flooding matters (2022)
- HB&B Property vs Parramatta City Council NSW L&E Court - Expert Witness on Flooding Matters including Court Evidence (2021)
- McBride vs Great Lakes Council NSW L&E Court -Flooding Matters including Court Evidence (2020)
- Hernes Investment vs Insurance Australia Group - Statement of Evidence flooding matters (2020)
- Colac Otway Planning Scheme Amendment C90 VCAT Hearing Colac Shire Council (2020)
- Jenman & White vs Sydney Water Corporation Council NSW L&E Court -Flooding Matters (2019)
- Gardener vs Central Coast Council NSW L&E Court -Flooding Matters (2019)
- Scott v Singleton Council NSW L&E Court -Flooding Matters including Court Evidence (2017)
- Paper Trade Processing (Aust) vs Liverpool City Council - Flooding and Stormwater Matters (2017)
- Gili vs City of Greater Geelong VCAT -Flooding Matters including Court Evidence (2017)
- Kenneth William Allport v Lismore City Council NSW L&E Court -Drainage Matters (2017)
- Pridel Investments vs Coffs Harbour City Council NSW L&E Court - Expert Witness on Flooding Matters incl. Court Evidence (2016)
- Sunland Developments vs Pittwater Council NSW L&E Court - Flooding Matters including Court Evidence (2016)
- Sketch Design Studio vs Manly Council NSW L&E Court -Flooding Matters including Court Evidence (2015)
- Trinvas and Kelaron vs City of Sydney NSW L&E Court- Flooding Matters (2015)

Papers and Presentations

- Williams, D., Lyons, D. and Asquith, B. “Improving the Rigour of Catchment-wide Hydrodynamic Modelling of the Rainfall-runoff Process”. Hydrology and Water Resources Symposium, Sydney 2023
- Leister, J., Lyons, D., South, M., and Newby M. “Best Practice Planning for Residual Risk Behind Levees: The Launceston Experience”. Floodplain Management Australia National Conference, Canberra 2019
- Williams, D., Lyons, D., Eggleton, J. and Lyons, S. “Predicting the Next Major Flood on the Hunter River”. Floodplain Management Australia National Conference, Newcastle 2017
- Lyons, D. and Williams, D. “Entrance Modelling and the Influence on ICOLL Flood Behaviour” Presented at the 52nd NSW Floodplain Management Association Conference, Batemans Bay 2012
- Lyons, D.J. and Jennings, P. “Flooding in the Wollombi Valley - Learning from Experience”. Presented at the 51st NSW Floodplain Management Association Conference, Tamworth 2011
- Guganesharajah, K., Pavey, J.F., van Wonderen, J., Khasankhanova, G.M, Lyons, D.J. and Lloyd, B.J. |2007| Simulation of Processes Involved in Soil Salinization to Guide Soil Remediation. Journal of Irrigation and Drainage Engineering, ASCE, 133|2|, 131-139
- Guganesharajah, K., Lyons, D.J., Parsons, S.B., and Lloyd, B.J. |2006|. Influence of Uncertainties in the Estimation Procedure of Flood Water Level. Journal of Hydraulic Engineering, ASCE, 132|10|, 1052-1060

F.4 SWIA peer review

6 October 2022

Hunter Valley Operations
PO Box 315
Singleton NSW 2230

Re: HVO Continuation Project - Surface Water Peer Review

1 Introduction

1.1 Background and Project Details

Hunter Valley Operations (HVO) is a multi-pit open cut mining complex approximately 24 kilometres (km) north-west of Singleton in the Hunter Valley of New South Wales (NSW). HVO comprises two mine sites separated by the Hunter River, HVO North and HVO South. While the two mine sites are approved under separate development consents, they are operated as one complex with fully integrated environmental management systems, including an integrated Water Management System (WMS).

The HVO Continuation Project (the Project) broadly comprises the continuation of the life of HVO North and HVO South, from the current approved mining completion dates of 2025 and 2030 respectively, to the end of 2050 at HVO North and 2045 at HVO South. The continuation of mining across the HVO Complex will increase resource recovery from the existing operation, predominantly by mining through previously mined areas and to the extent of existing mining tenements and extracting coal from deeper seams at HVO North.

To enable the Project to proceed, two new State significant development (SSD) consents are required; one for HVO North and one for HVO South, under Part 4, Division 4.1 of the *NSW Environmental Planning and Assessment Act 1979* (EP&A Act). The Project will seek to maintain separate development consents for HVO North and South, as is currently the case. However, given that the two mine sites operate as one complex with fully integrated environmental management systems, one Environmental Impact Statement (EIS) is being prepared to support the two development applications required for the Project.

HVO is owned by subsidiary companies of Yancoal and Glencore, as participants in the unincorporated HVO Joint Venture (JV). HV Operations Pty Ltd (HV Operations) is the appointed manager of the JV.

The surface water impact assessment (SWIA) forms part of the EIS and provides an assessment of the potential impacts to surface water associated with the Project. The SWIA documents the assessment methods and results, initiatives to avoid and minimise surface water impacts and additional mitigation and management measures proposed to address residual impacts not able to be avoided.

The EIS is being prepared by EMM Consulting Pty Ltd (EMM) with assistance from several specialist sub-consultants, including Engeny Water Management (Engeny), who prepared the SWIA and supporting technical appendices. The technical appendices included the streamflow assessment, water quality assessment, water balance modelling, final voids assessment and flood modelling.

1.2 Scope of independent peer review

I have been engaged by HV Operations to undertake an independent peer review of the SWIA and technical appendices prepared by Engeny. The peer review covered the stream flow assessment, water quality assessment, water balance modelling and final voids assessment; but not the flood modelling, which has been reviewed by BMT Commercial Australia Pty Ltd (BMT).

Although EMM is engaged by HV Operations as the principal author preparing the EIS, I have worked independently from the main EIS project team and have acted to avoid any conflicts of interest.

The Secretary's Environmental Assessment Requirements (SEARs) did not specifically require the engagement of an independent peer reviewer to address the adequacy of the SWIA, however HV Operations thought it prudent given the scale and complexity of the Project.

1.3 Credentials as independent peer reviewer

I am a Fellow of Engineers Australia, currently employed as an Associate Director, Water Resources with EMM.

I am a Civil Engineer with a Master of Engineering Science degree in Water Resources, with 40 years' experience in water engineering. My technical skills include surface water impact assessment, mine water management, water resource management, hydrologic and hydraulic analysis, urban and rural floodplain management, environmental impact assessment and civil design; working both in Australia and internationally.

I have also provided Expert Evidence for several Supreme Court cases and Land and Environment Court proceedings, dealing with flooding and stormwater management issues, and was the Project Engineer on the 1987 revision of Australian Rainfall and Runoff.

2 SWIA requirements

The SWIA was prepared by Engeny in accordance with requirements of the NSW Department of Planning and Environment (DPE) (formerly NSW Department of Planning, Industry and Environment (DPIE)), which were set out in the Secretary's Environmental Assessment Requirements (SEARs) for the Project, issued on 11 March 2021. In terms of the SWIA, the SEARs for HVO North and HVO South are the same.

During preparation of the SEARs, DPE invited other government agencies to identify matters to be addressed in the EIS. Matters relevant to potential surface water impacts have also been addressed in preparing the SWIA and technical appendices.

3 Peer review tasks

My peer review included a review of the draft SWIA report and supporting technical appendices, as well as involvement in a series of peer review workshops and other technical meetings held throughout the assessment period. I also provided ad-hoc technical advice to the EIS project team related to the SWIA.

My on-going involvement throughout the assessment period is summarised in the following sections.

3.1 Inception meeting and risk workshop

An inception meeting and risk workshop was held in Newcastle on 16 March 2020. The purpose of the workshop was to provide an overview of the Project and undertake a risk review of the Project from a water perspective. Key surface water related issues and potential risks identified at the workshop (excluding issues and risks related to flooding) included the following:

- potential impacts to the water balance;
- loss of baseflow and potential ecological impacts;
- final void(s) characteristics (levels and salinity) and potential stratification;
- controlled releases and compliance with the Hunter River Salinity Trading Scheme (HRSTS);
- incremental impacts, beyond what has already been approved for the existing mining operation;
- cumulative impacts to streamflow and water quality; and
- potential impacts of future climate change, especially on the characteristics of the final voids.

The workshop included representatives from Glencore, HV Operations, EMM and specialist sub-consultants preparing technical input for the EIS.

3.2 Peer review workshops and conference calls

Peer review workshops were held at key decision points throughout the assessment period to discuss and confirm the proposed SWIA methodologies (ie what is being assessed and why), background data, proposed modelling framework, model calibration and model results. Additional conference calls were also held, as required, to discuss aspects related to the SWIA, mainly related to the water balance modelling.

I was involved in the following conference calls and peer review workshops (the scope of the conference calls and/or workshops are noted in brackets).

Conference calls:

- September 2020 – Water Balance Model (appropriate operational base model to adopt).
- October 2020 – Water Balance Model (preliminary model parameters and assumptions).
- April 2021 – Water Balance Model (review preliminary model parameters and assumptions).
- May 2021 – Final Voids Modelling (scoping of stratification modelling for the final voids).
- August 2021 – Water Quality Assessment (available water quality data and impact assessment).
- September 2021 – Water Balance Model (review of baseline model calibration).

Peer review workshops:

- June 2021 – Water Balance Model (review model assumptions, model parameters and initial model calibration).
- October 2021 – Water Balance Model (discuss water management schematics, model updates, model assumptions, model parameters, revised model calibration and preliminary model results).

- November 2021 – Water Balance Model (follow up to October 2021 workshop to discuss model updates, assumptions, parameters, revised calibration and updated model results).
- January 2022 – Final Void Modelling (review model assumptions, model parameters and preliminary model results for fully mixed scenario).
- February 2022 – Final Void Climate Change and Sensitivity Assessment (review model assumptions, model parameters and preliminary model results for different climate change scenarios).
- March 2022 – Water Balance Model (follow up to November 2021 workshop to discuss final water management schematics, model updates, assumptions, parameters and updated model results).
- June 2022 – Streamflow, Water Quality and Cumulative Assessment (review preliminary assessment results for streamflow, water quality and cumulative impacts).

Due to COVID travel/meeting restrictions, the peer review workshops were held as conference calls rather than face-to-face meetings. Findings and actions from the peer review workshops were documented and distributed to workshop attendees. Actions from the workshops were discussed during subsequent workshops to enable closure of any outstanding items.

In addition to myself, the workshops and conference calls were also attended by representatives from Glencore, HV Operations, EMM and Engeny.

3.3 Draft SWIA reports

I have peer reviewed the following draft reports and supporting technical appendices:

- Surface Water Impact Assessment Report (14 Sept 2022)
- Appendix B – Streamflow Assessment
- Appendix F – Water Quality Assessment
- Appendix G – Water Balance Modelling
- Appendix H – Final Void Assessment

Based on my review of the draft reports and supporting technical appendices, I can confirm that the stream flow assessment, water quality assessment, water balance modelling and final voids assessment are consistent with the discussions and findings from the peer review workshops and conference calls.

In my opinion the assessment methodology and approach adopted by Engeny are appropriate to assess the potential impact of the Project and to satisfy the requirements of the SEARs and other matters related to surface water raised by various government agencies.

The assessment is based on comprehensive baseline water quality and streamflow data, which was used to characterise the existing environment. The assessment is further supported by appropriate rainfall-runoff and water balance modelling, which was used to simulate water management performance over the life of the mine.

This has enabled potential impacts associated with the Project to be identified, and appropriate management and mitigation measures to be formulated to minimise impacts. The performance of the WMS will be monitored during mining and rehabilitation phases to ensure that it complies with the required objectives.

4 Methodology and approach

The overall objectives and general methodology followed by Engeny in preparing the SWIA (related to my peer review scope) is summarised in the following sub-sections.

4.1 Streamflow Assessment

The objective of the streamflow assessment was to:

- assess potential impacts to the volume and frequency of flows in nearby streams; and
- inform potential ecological impacts resulting from increased dry periods (frequency and duration).

This involved the following tasks:

- identify streams of interest, based on potential changes to surface catchments or baseflow/leakage;
- develop long term flow series and flow duration curves, based on:
 - gauged flow data for the Hunter River and Wollombi Brook; and
 - rainfall-runoff modelling for the ungauged ephemeral streams;
- adjust long term flow series to reflect changes to surface catchment or baseflow/leakage; and
- assess change in the volume of streamflow and the occurrence and duration of dry days.

The surface water assessment included a baseline characterisation of existing catchment areas and associated watercourses, as well as existing water quality and downstream water users.

4.2 Water Quality Assessment

The objective of the water quality assessment was to:

- assess the potential impact of the project on receiving water quality and ecological values; and
- identify any necessary management and/or mitigation measures.

This involved the following tasks:

- define baseline water quality characteristics based on historical monitoring data;
- identify sensitive receptors and Environmental Values for receiving waters;
- define water quality targets based on ANZG guideline values and “Blue Book” values; and
- assess potential impacts to receiving water quality based on water balance modelling results.

Sufficient water quality data (more than two years of monthly sampling) and corresponding flow data are available to assess potential water quality impacts associated with the Project (both spatially and temporally). Water quality monitoring data are available for the Hunter River, Wollombi Brook and some of the ephemeral streams as well as for the clean, sediment and mine water systems for the existing mine.

Historical water quality data includes pH, electrical conductivity (EC), total suspended solids (TSS) and total dissolved solids (TDS), as well as nutrients and a range of metals/metalloids.

4.3 Water Management System performance

The objective of the water balance modelling was to:

- document the existing integrated WMS (for the HVO Complex);
- identify water management infrastructure required for the Project; and
- assess the performance of the WMS, in terms of:
 - containment of surface runoff;
 - mine water storage (clean, sediment and mine water);
 - water supply reliability (in terms of available water licences) and
 - utilisation of the available HRSTS discharge.

This involved the following tasks:

- develop basis of design for the WMS (including levees, diversions and storages);
- review mine plan progression to identify water management infrastructure requirements;
- determine site water demands over the life of the mine;
- develop and calibrate site water balance model (GoldSIM model); and
- simulate the Project WMS and assess performance over the life of the mine.

A detailed water balance model (ie GoldSIM) was developed to simulate the performance of the WMS over the life of the Project (ie 2023 to 2050). The model was also used to estimate the characteristics of the final voids (refer to Section 4.4 below).

The GoldSIM model was based on existing operational information provided by HV Operations, which was revised to include future water management infrastructure and operational procedures at several timeframes based on the progressive mine plans developed by HV Operations. The model conceptualisation, model assumptions, model parameters, calibration and model results were discussed during the peer review workshops. The model was progressively updated based on matters raised during the workshops and other conference calls.

The calibrated water balance model provides a reliable framework to assess water management performance of the Project over the simulation period (ie 2023 to 2050).

4.4 Final voids assessment

The objective of the final voids assessment was to:

- assess the recovery level of the final void lakes;
- assess time to recover to equilibrium levels; and
- assess fully mixed water quality trends, in terms of salinity.

This involved the following tasks:

- determine the physical characteristics of the final voids, including catchment areas and storage curves;
- develop a water balance model for the final voids (GoldSIM) to model volume and salinity;
- incorporate groundwater fluxes, based on groundwater model results (from Australasian Groundwater & Environmental Consultants Pty Ltd (AGE)); and
- simulate the void lake recovery and equilibrium characteristics, including potential climate change.

The final voids model was used to estimate the long-term water level and salinity in the HVO North Void and HVO South Void, under both existing and future climate change scenarios. The model assumptions, model parameters and model results were discussed during the peer review workshops. Several changes were made based on the workshop discussion.

5 Conclusion

I have been involved in review of the SWIA for the Project from the initial inception meeting and risk workshop in March 2020 up until my review of the final draft SWIA report (Engeny, 14 Sept 2022).

The independent peer review involved participation in several peer review workshops and conference calls to discuss the surface water assessment methodology, adopted water management schematics, modelling assumptions and parameters, model calibration and modelling results. The water balance model and rainfall-runoff models were progressively revised and updated as the assessment progressed, based on feedback from the peer review workshops and conference calls.

In my opinion the assessment methodology and approach adopted by Engeny are appropriate to assess the potential impact of the Project and to define the management and mitigation measures required to minimise potential impacts associated with the Project.

The draft SWIA report and supporting technical appendices is consistent with the requirements of the SEARs and the Information Guidelines developed by the Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Developments (IESC).

Yours sincerely



Ian Rowbottom

Associate Director - Water Resources

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F.5 Groundwater model peer review

26 September 2025

EMM Consulting Pty Limited
Email delivery: kholder@emmconsulting.com.au

Kate Holder
Associate Director (Hydrogeologist) / Groundwater Team Manager

Dear Kate:

HVO Continuation Project
Groundwater Assessment Independent Review

1 INTRODUCTION

KCB Australia Pty Ltd (KCB) was commissioned by EMM Consulting Pty Limited (EMM), to conduct an independent review of the groundwater assessment for Hunter Valley Operations (HVO) Continuation Project (the project).

1.1 Project Description

HVO is a well-established multi-pit open cut coal mining complex in the Hunter Valley of New South Wales (NSW). HVO comprises two mine sites separated by the Hunter River; HVO North and HVO South (Figure 1 and Figure 2). While the two mine sites are separated by the Hunter River, they are operated as one complex with fully integrated environmental management systems. The HVO Complex is illustrated at a local scale in Figure 3.

The HVO Continuation Project broadly comprises the continuation of the life of HVO North and HVO South, from the current approved mining completion dates of 2026 and 2030 respectively, to the end of 2045 and 2042, respectively. The continuation of mining across the HVO Complex will increase resource recovery from the existing operation. This will be predominantly by mining through previously mined areas, mining to the extent of existing mining tenements and extracting coal from deeper seams at HVO North (excluding Carrington West Wing extension area where mining depth is proposed to occur as approved).

At HVO South an extension to the life of the mine is proposed to facilitate improved mine sequencing outcomes and reduction in mining rate. The Project proposes a reduced mining footprint at HVO South compared to what is approved for extraction, with the previously approved coal extraction in the Riverview South East Extension area and South Lamington Pits (SLP) 1 and 2 areas proposed to be removed from mine plan (and future approvals) for the Project. However, some rehabilitation works will be required to be undertaken in the SLP 1 area, as part of the mine closure process. The approved construction and operation of the Lemington Coal Preparation Plant and associated rail facilities, which is currently approved, but not constructed, under the HVO South Project Approval has also been removed from the Project.

A number of infrastructure upgrades and changes are also required to facilitate the Project (and are included as part of it), including:

- realignment of part of Lemington Road to enable the continuation of mining at HVO North;
- relocation of transmission and telecommunication lines;
- an upgrade of the Newdell LP including construction of a new product stockpile and train loading bin;
- an upgrade of the Hunter Valley Load Point product stockpile including an extension to the existing coal stockpile;
- expansion of the HVO North ROM coal stockpile; and,
- improvements to Lake James (Dam 15S) and Parnells Dam (Dam 9W).

A groundwater assessment was undertaken to support the Public Environment Report (PER) submissions for the Project. The assessment supports the overarching water resources impact assessment which provides an assessment of the potential impacts of the Project on water resources including water-dependent assets.

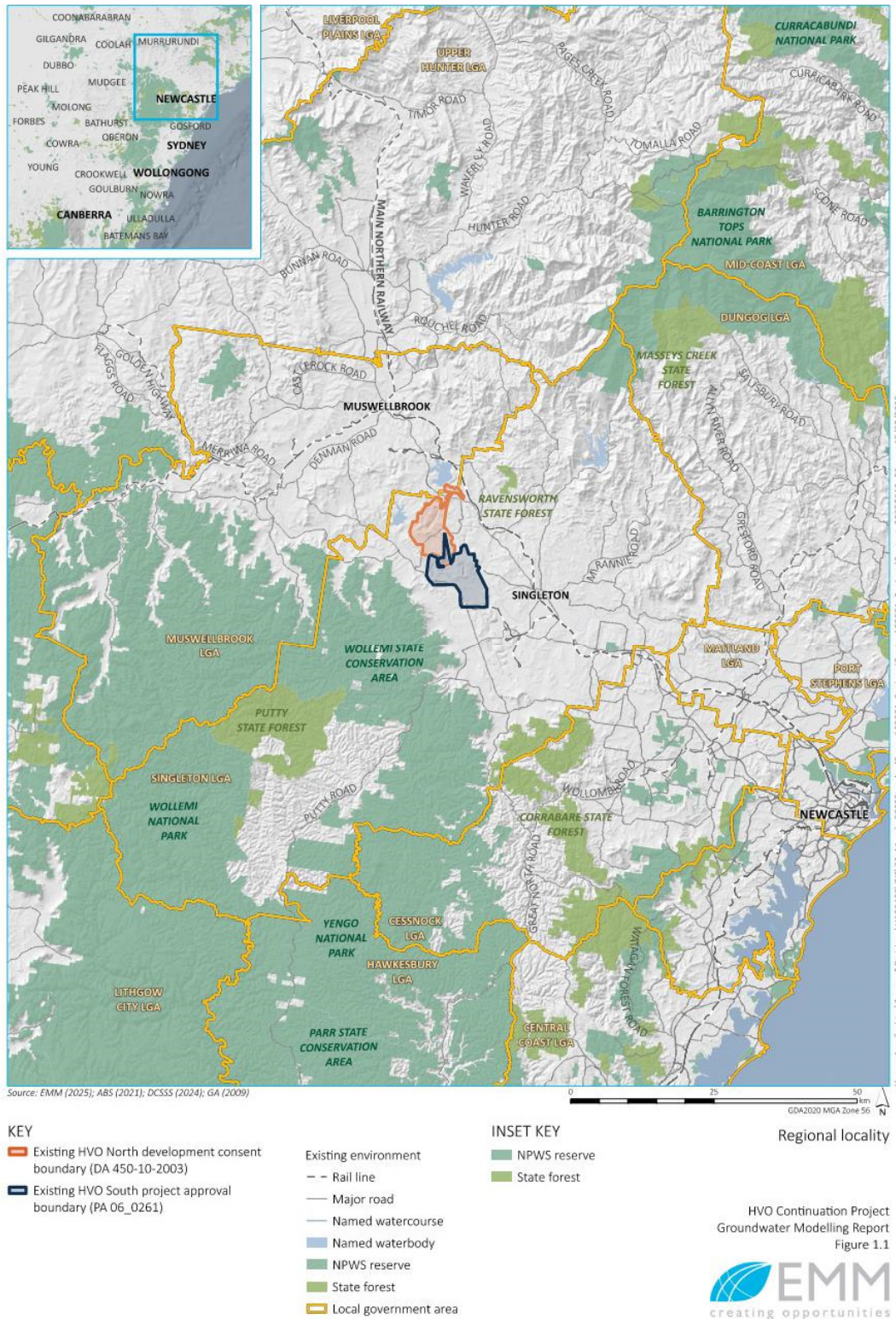


Figure 1 Project Location Plan (from EMM (2025))

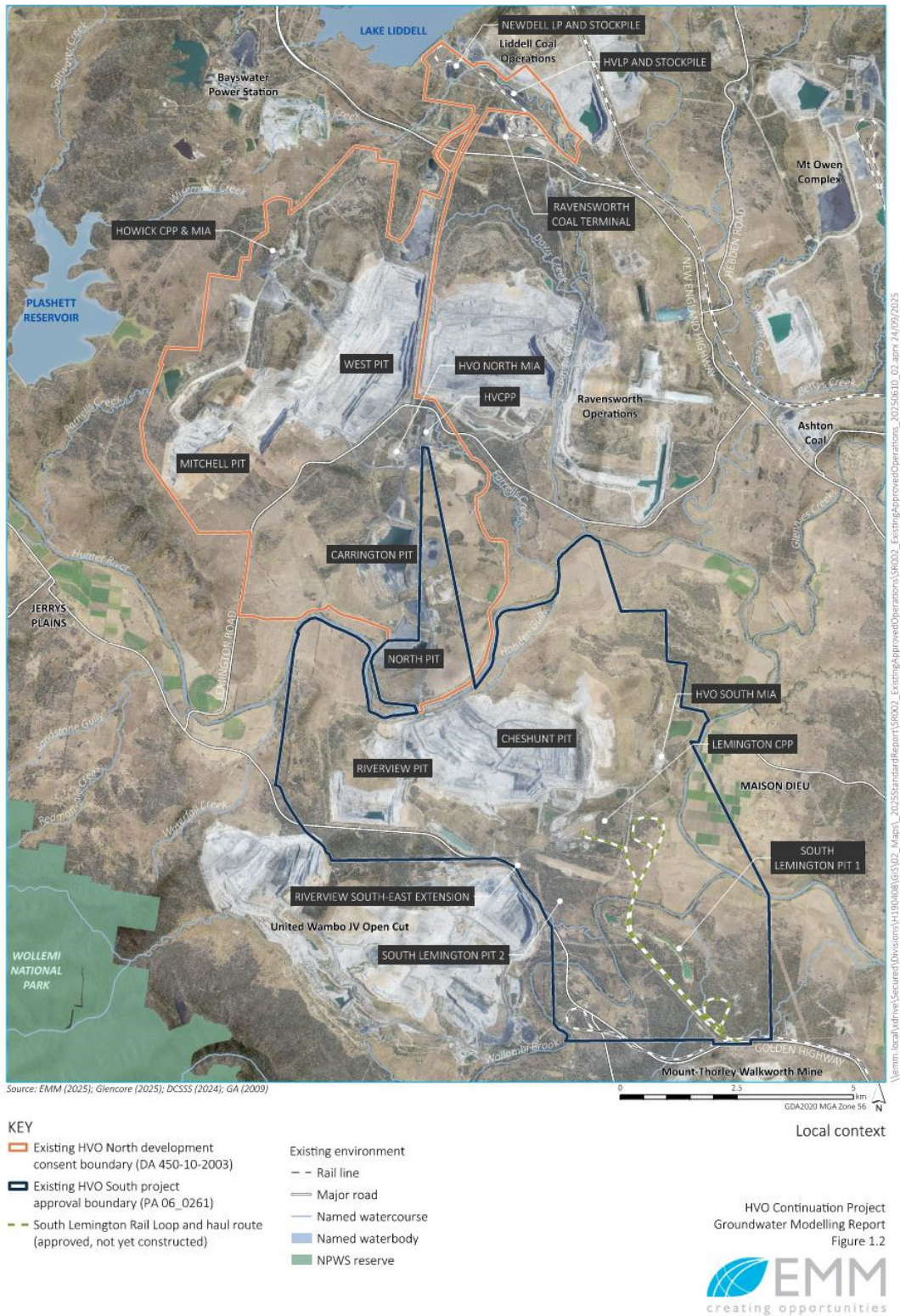


Figure 2 Project Layout (from EMM (2025))

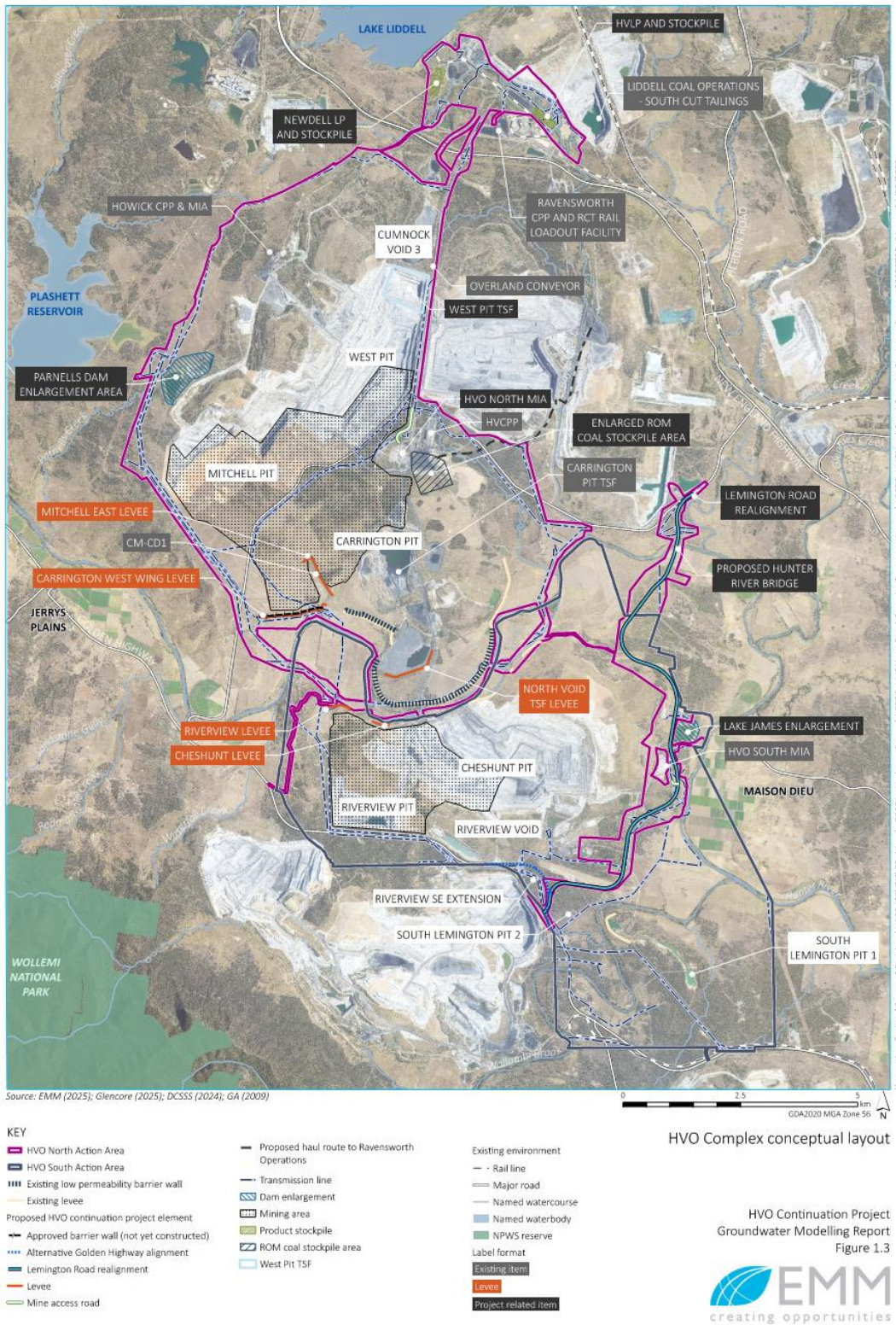


Figure 3 Project Conceptual Layout (from EMM (2025))

1.2 Review Background

EMM has undertaken a groundwater assessment for the Project. This assessment comprises a desktop review (including ongoing monitoring data), groundwater conceptualisation and numerical groundwater modelling to assess potential impacts on water resources as a result of the development of the Project.

EMM commissioned KCB to undertake an independent review of the groundwater assessment based on a staged approach to allow the review to be undertaken throughout key stages of the groundwater assessment, and in particular, the numerical modelling stage of the assessment.

The independent review process was undertaken in accordance with the relevant peer review requirements described in the *Australian Groundwater Modelling Guidelines* (Barnett et al. 2012) and with reference to relevant state and Australian guidelines. The purpose of the peer review is to assess the quality and validity of the groundwater assessment and its conclusions.

The review was conducted by Principal Hydrogeologist, Chris Strachotta. Chris has over 28 years of relevant experience as a hydrogeologist and is a Registered Professional Geoscientist (Hydrogeology) (Registration No. 10,151) with the Australian Institute of Geoscientists. Chris is a suitably qualified and experienced person for the purposes of undertaking this groundwater study peer review.

This report provides a description of the independent peer review and its findings.

1.3 Report Structure

This report comprises the following sections:

- Section 1 – Introduction
 - ◆ Provides an introduction to the document, summarises the project description, identifies the basis for the review and describes the review approach.
- Section 2 – Methodology
 - ◆ Provides a description of the adopted methodology for the review.
- Section 3 – Results
 - ◆ Describes the results of the review for each of the key components of the groundwater study.
- Section 4 – Conclusions

Appendix I presents the checklists for the review of the conceptual and numerical groundwater models, adopted from the *Australian Groundwater Modelling Guidelines* (Barnett et al. 2012).

2 METHODOLOGY

A staged approach has been adopted to undertake the independent review of the groundwater assessment, and the associated numerical groundwater model. The various stages of the review process include:

- Project background review – establishment of Project understanding including the conceptual hydrogeological setting;
- Numerical model validation criteria development and validation process review – review of EMM’s process of identifying if the existing model is “fit for intended purpose” to represent the Project current conditions and the proposed Project development;
- Numerical model update and historic-matching scenario review – review of refinements to the model domain and the model calibration process;
- Predictive simulation results review – review of the model results simulating the Project development, and the associated uncertainty analysis process; and,
- Groundwater modelling report review – review of the HVO Continuation Project Groundwater Modelling report (draft) (EMM, 2025).

The independent review methodology is consistent with the review process and checklists provided in Section 9 of the Australian Groundwater Modelling Guidelines (Barnett et al. 2012). The review checklists are reproduced in Appendix I.

3 RESULTS

The detailed findings of the independent review are presented in the review checklists provided in Appendix I (Table I.1 – Compliance Checklist and Table I.2 – Review Checklist).

A summary of the Project conceptual understanding review and the numerical groundwater model review is provided in the following sections.

3.1 Conceptual Groundwater Model

The independent review results of the conceptual groundwater model for the Project are provided as follows:

- A literature review and data collation process was undertaken to support the hydrogeological conceptualisation. The hydrogeological system was adequately described, including the various hydrostratigraphic units, aquifer extents and aquifer geometry (e.g. elevations, thickness) and geological structures (e.g. key faults adjacent to the Project).
- Groundwater fluxes for the aquifer system have been suitably defined, including natural recharge mechanisms (e.g. rainfall, watercourse infiltration), natural discharge mechanisms (e.g. evapotranspiration), interaction between hydrostratigraphic units and groundwater stresses (e.g. mine dewatering, post-closure pit lakes).

- Groundwater levels from the relevant hydrostratigraphic units, located across the Project and the surrounding area, have been compiled and analysed. This analysis provided a robust and representative understanding of groundwater levels, groundwater flow directions, vertical gradients between hydrostratigraphic units and temporal changes in water levels (e.g. seasonality).
- A review of the groundwater quality was not included as part of this assessment. The assessment of impacts to water resources from the proposed Project development was based on the reduction of water levels, and the interpreted reduction of dependency on groundwater.
- Existing stresses on the groundwater system from pre-Project mining activities have been conceptualised appropriately, as well as the stress from the proposed Project development.

3.2 Numerical Groundwater Model

3.2.1 Model Domain, Construction and Boundary Conditions

The model domain, construction and boundary conditions independent review findings are as follows:

- An appropriate model extent has been adopted for the numerical groundwater model. The model extent is consistent with the conceptual understanding of the hydrogeological system and is set at an adequate distance away from the Project development so as to not influence the model results.
- Model layering and layer morphology appropriately represents the hydrostratigraphic units and proposed Project mining activities.
- Applied boundary conditions are representative of the conceptual hydrogeological understanding:
 - ◆ Model edge – general head boundary (GHB) package adequately represents the regional groundwater flow gradient.
 - ◆ Recharge – recharge (RCH) package has been applied across model domain in accordance with the conceptual understanding of the recharge mechanisms to the groundwater system.
 - ◆ Evapotranspiration – evapotranspiration (EVT) package has been applied across the model domain and is based on estimated evapotranspiration rates and a variable extinction depth dependent on outcropping geology and mapped vegetation.
 - ◆ Surface water – groundwater interaction with surface water bodies have been represented in the model using a number of different boundary conditions. These include:
 - Constant Head (CHD) package – applied to Lake Liddell, Plashett Reservoir, Bayswater Power Station ash lake
 - Stream (STR) package – Hunter River, Bowmans Creek, Glennies Creek, Wollombi Brook

- River (RIV) package – minor drainage systems.
- ◆ Hydraulic barriers – conceptualized barriers to groundwater flow as a result of discrete structural geological features. Hydraulic barriers were represented using the Horizontal Flow Barrier (HFB) package; and were applied on the Hunter Valley dyke, Camberwell Anticline and the Davis Creek Fault.
- ◆ Mining Activities:
 - Project mine development, and development in the surrounding mining areas, has been represented by the Drain (DRN) package with the timing of the drain activation representing the progression of the open cut and underground mines. The Time-Variant Materials (TVM) package are also applied to the mine development areas following the application of the Drains to represent the condition of the post-mining residual void (e.g. open void, backfill etc). The Drain cell conductance adequately represents the characteristics of the proposed mine development. Goafing and fracturing above the underground mine, following mine development, have been appropriately simulated in the model.
 - Tailings and in-pit storages were simulated using the General Head (GHB) package.
 - Low permeability barrier walls in the Quaternary alluvium have been simulated using the TVM package, with the applied effective hydraulic conductivity adequately representing these barrier walls.

3.2.2 Model Calibration

The model calibration independent review results are as follows:

- Model calibration was completed with an automated approach using PESTPP-IES with an ensemble comprising 500 parameter realisations; allowing the assessment of uncertainties for the input parameters and prediction quantities of interest.
- Calibration was conducted against:
 - ◆ Observed groundwater levels from 365 monitoring points, across the various hydrostratigraphic units which provides adequate spatial coverage across the project area;
 - ◆ Vertical hydraulic head differences at 26 grouped monitoring locations four site; and,
 - ◆ Groundwater abstraction from the Lemington Underground development recorded from January 2020 to December 2023.
- Pilot points were applied in the model to support the parameterisation process and allow for the development of spatial heterogeneity of hydraulic parameters within the HSUs.
- The weighted Scaled Root Mean Squared (SRMS) statistical metric of the comparison between observed and simulated water levels for the transient calibration period was 7.9% for the Base realisation, 7.8% for the Ensemble P10 and 8.6% for the Ensemble P90; all of which are below the 10% trigger recommended by the Australian Groundwater Modelling Guidelines (Barnett 2012) and identifies the model calibration as adequate. The adequacy of the model calibration is further supported by the distribution of the calibration monitoring points across the model domain, both laterally and across the

model layers, and the correlation of water level trends between observed and simulated levels. Correlation between the observed and simulated vertical gradients, and Lemington Underground dewatering flux also support the adequacy of the model calibration.

- The water budget results for the calibration comprised a mass balance error of 0.00% for the overall transient calibration period for the Base realisation. These results support the adequacy of the model calibration.
- Hydraulic parameters were modified throughout the calibration process to allow the model to simulate groundwater levels over time, which are comparable to measured groundwater levels. The final calibrated hydraulic parameter values are within the range of hydraulic parameters identified across the Project area, and within the regional hydrogeological system. Application of a depth dependent hydraulic conductivity for the coal measures was undertaken to support the calibration process and represent the effects of increasing lithostatic pressure with depth. This application is considered appropriate for this setting and represents the conceptual understanding.
- A comparison of the model against performance indicators identified in the Australian Groundwater Modelling Guidelines for classifying the confidence level of groundwater models, indicates that the Project groundwater model is predominantly a Class 3 model, with minor performance indicators aligning with a Class 2 and Class 1 model.

3.2.3 Predictive Simulation

The predictive simulation independent review results are as follows:

- Predictive simulations were undertaken to assess potential changes to the groundwater regime as a result of the proposed Project open cut underground development activities.
- To assess the incremental changes to the groundwater system associated with the proposed underground development, three simulations were undertaken, comprising:
 - ◆ 1. “Baseline” – approved operations within the region, with all mining deactivated at the end of 2009, providing a ‘null’ scenario for assessment of cumulative effects.
 - ◆ 2. “Approve” – current approved operations at HVO North and HVO South, and approved foreseeable operations within the region; and,
 - ◆ 3. “Proposed” – approved and foreseeable operations within the region as well as the proposed mine development associated with the Project.

The difference in groundwater levels between the results of the “Proposed” simulation and the “Approved” simulation represents the incremental change in piezometric levels associated with the Project. The difference in groundwater levels between the results of the “Proposed” simulation and the “Baseline” simulation represents the cumulative change in piezometric levels from all mining activity within the region.

- Based on the adequacy of the model calibration, and the conceptual understanding of potential changes to the groundwater regime as a result of the Project, the predictive simulation results are considered to be an appropriate representation of potential changes to the groundwater regime and are suitable to be used for the interpretation of potential impacts to water resources as a result of the Project development.

3.2.4 Uncertainty Analysis

The uncertainty analysis independent review results are as follows:

- Quantitative uncertainty analysis was conducted using an industry-adopted and regulatory recommended mathematical and statistical approach. This approach evaluates the model inputs and outputs and assigns probability of occurrences to selected effects. The uncertainty analysis approach comprised two key steps:
 - ◆ Simulation of the calibration model using PESTPP-IES for 500 realisations to achieve better calibration results and optimised parameters; thereby refining the range of parameters for undertaking the uncertainty analysis of the predictive simulations.
 - ◆ Simulation of the three predictive simulations with the 500-realisation parameter ensemble to support calculation of probabilistic predictions. 414 realisations successfully converged and were used to assess the probabilistic outcomes.

The results from the converged 414 realisations were statistically analysed to provide the <P10, P10-P33, P33-P67, P67-P90 and >P90 percentile results. This range of results provided the uncertainty of drawdown/depressurisation for the Project development and cumulative change in groundwater; and is considered an appropriate level of uncertainty analysis for this assessment.

4 CONCLUSION

The key conclusions of the independent review of the groundwater assessment are as follows:

- Conceptualisation of the hydrogeological system was conducted based on a detailed literature review and incorporating ongoing groundwater monitoring records. The conceptualisation appropriately defined the hydrogeological system and formed the basis for the numerical groundwater model.
- The collated baseline groundwater monitoring datasets developed for the groundwater assessment provide suitable spatial and temporal coverage to reliably characterise the local groundwater regime across each of the HSUs and seasonal variability.
- The groundwater regime conceptualisation and the subsequent numerical groundwater modelling have been undertaken in accordance with the *Australian Groundwater Modelling Guidelines* and with relevant aspects of the *IESC Information Guidelines Explanatory Notes on Uncertainty analysis for groundwater modelling and Characterisation and modelling of geological fault zones*, and provide a suitable, appropriate and well-supported representation of the groundwater regime as it relates to the Project mining area and its surrounds.
- The numerical modelling represents the Project and its groundwater effects at an appropriate level of detail, and specifically:
 - ◆ The model domain and associated boundary conditions have been established to appropriately represent the conceptual understanding of the hydrogeological system.

- ◆ Transient calibration (history-matching) was completed using recorded groundwater levels collected from across the Project area, both laterally and vertically. Calibration statistics from observed vs simulated groundwater level records are in accordance with recommended metrics from the Australian Groundwater Modelling Guidelines. The appropriateness of the calibration was further supported by comparable observed and simulated vertical gradients and groundwater abstraction during the calibration period.
- ◆ Proposed mining activities associated with the Project, and surrounding mining activities, have been appropriately incorporated and scheduled in the numerical model with the use of changing drain conditions and associated material properties.
- ◆ Comprehensive uncertainty analysis completed on the calibration and predictive simulations identifies that parameters adopted for the model predictions appropriately represent the hydrogeological conditions in the Project area and the changes to the groundwater regime as a result of the Project development.
- ◆ The numerical groundwater model has been constructed, calibrated and simulated in accordance with the Australian Groundwater Modelling Guidelines; and, the model is considered an appropriate tool for assessing potential groundwater impacts as a result of the Project development.

Yours truly,

Klohn Crippen Berger



Chris Strachotta
Principal Hydrogeologist

CS: CW

REFERENCES

EMM Consulting Pty Ltd 2025. *HVO Continuation Project Groundwater Modelling*. Report prepared for HV Operations Pty Ltd. August, 2025.

Barnett et al. 2012. "Australian Groundwater Modelling Guidelines." Waterlines Report. Canberra: National Water Commission.

APPENDIX I

Numerical Groundwater Model Review Checklists

Table I.1 Compliance Checklist

Question	Yes/No
1. Are the model objectives and model confidence level classification clearly stated?	Yes
2. Are the objectives satisfied?	Yes
3. Is the conceptual model consistent with objectives and confidence level classification?	Yes
4. Is the conceptual model based on all available data, presented clearly and reviewed by an appropriate reviewer?	Yes
5. Does the model design conform to best practice?	Yes
6. Is the model calibration satisfactory?	Yes
7. Are the calibrated parameter values and estimated fluxes plausible?	Yes
8. Do the model predictions conform to best practice?	Yes
9. Is the uncertainty associated with the predictions reported?	Yes
10. Is the model fit for purpose?	Yes

Table I.2 Review Checklist

Review Questions	Yes/No	Comments
1. Planning		
1.1 Are the project objectives stated?	Yes	
1.2 Are the model objectives stated?	Yes	
1.3 Is it clear how the model will contribute to meeting the project objectives?	Yes	
1.4 Is a groundwater model the best option to address the project and model objectives?	Yes	
1.5 Is the target model confidence-level classification stated and justified?	Yes	
1.6 Are the planned limitation and exclusions of the model stated?	Yes	
2. Conceptualisation		
2.1 Has a literature review been completed, including examination of prior investigations?	Yes	
2.2 Is the aquifer system adequately described?	Yes	
2.2.1 hydrostratigraphy including aquifer type (porous, fractured rock, etc)	Yes	
2.2.2 lateral extent, boundaries and significant internal features such as faults and regional folds	Yes	
2.2.3 aquifer geometry including layer elevations and thicknesses	Yes	
2.2.4 confined or unconfined flow and the variation of these conditions in space and time?	Yes	
2.3 Have data on groundwater stresses been collected and analysed?	Yes	
2.3.1 recharge from rainfall, irrigation, floods, lakes	Yes	
2.3.2 river or lake stage heights	Yes	
2.3.3 groundwater usage (pumping, returns etc)	Yes	
2.3.4 evapotranspiration	Yes	
2.3.5 other?	NA	
2.4 Have groundwater level observations been collected and analysed?	Yes	
2.4.1 selection of representative bore hydrographs	Yes	

Review Questions	Yes/No	Comments
2.4.2 comparison of hydrographs	Yes	
2.4.3 effect of stresses on hydrographs	Yes	
2.4.4 watertable maps/piezometric surfaces?	Yes	
2.4.5 If relevant, are density and barometric effects taken into account in the interpretation of groundwater head and flow data?	NA	
2.5 Have flow observations been collected and analysed?	Yes	
2.5.1 baseflow in rivers	Yes	
2.5.2 discharge in springs	NA	
2.5.3 location of diffuse discharge areas?	NA	
2.6 Is the measurement error or data uncertainty reported?	Yes	
2.6.1 measurement error directly measured quantities (e.g. piezometric level, concentration, flows)	NA	
2.6.2 spatial variability/heterogeneity of parameters	Yes	
2.6.3 interpolation algorithm(s) and uncertainty of gridded data?	Yes	
2.7 Have consistent data units and geometric datum been used?	Yes	
2.8 Is there a clear description of the conceptual model?	Yes	
2.8.1 Is there a graphical representation of the conceptual model?	Yes	
2.8.2 Is the conceptual model based on all available, relevant data?	Yes	
2.9 Is the conceptual model consistent with the model objectives and target model confidence level classification?	Yes	
2.9.1 Are the relevant processes identified?	Yes	
2.9.2 Is justification provided for omission or simplification of processes?	Yes	
2.10 Have alternative conceptual models been investigated?	NA	
3. Design and Construction		
3.1 Is the design consistent with the conceptual model?	Yes	
3.2 Is the choice of numerical method and software appropriate (Table 4-2 of Australian Groundwater Modelling Guidelines (Barnett et al. 2012))?	Yes	
3.2.1 Are the numerical and discretization methods appropriate?	Yes	
3.2.2 Is the software reputable?	Yes	
3.2.3 Is the software included in the archive or are references to the software provided?	Yes	
3.3 Are the spatial domain and discretization appropriate?	Yes	
3.3.1 1D/2D/3D	3D	
3.3.2 lateral extent	Yes	- adequately represented to not have the areas of interest be influenced by the model boundary, but also not be too large to influence model run times.
3.3.3 layer geometry?	Yes	- adequately applied to represent the key HSUs in the system

Review Questions	Yes/No	Comments
3.3.4 Is the horizontal discretisation appropriate for the objectives, problem setting, conceptual model and target confidence level classification?	Yes	
3.3.5 Is the vertical discretisation appropriate? Are aquitards divided in multiple layers to model time lags of propagation of responses in the vertical direction?	Yes	
3.4 Are the temporal domain and discretisation appropriate?	Yes	
3.4.1 steady state or transient	Yes	- both steady-state and transient simulations were undertaken to appropriately set-up and simulate the model to represent historical conditions and the proposed development
3.4.2 stress periods	Yes	
3.4.3 time steps?	Yes	
3.5 Are the boundary conditions plausible and sufficiently unrestrictive?	Yes	
3.5.1 Is the implementation of boundary conditions consistent with the conceptual model?	Yes	
3.5.2 Are the boundary conditions chosen to have a minimal impact on key model outcomes? How is this ascertained?	Yes	
3.5.3 Is the calculation of diffuse recharge consistent with model objectives and confidence level?	Yes	
3.5.4 Are lateral boundaries time-invariant?	Yes	
3.6 Are the initial conditions appropriate?	Yes	
3.6.1 Are the initial heads based on interpolation or on groundwater modelling?	Yes	
3.6.2 Is the effect of initial conditions on key model outcomes assessed?	Yes	
3.6.3 How is the initial concentration of solutes obtained (when relevant)?	NA	
3.7 Is the numerical solution of the model adequate?	Yes	
3.7.1 Solution method/solver	Yes	
3.7.2 Convergence criteria	Yes	
3.7.3 Numerical precision	Yes	
4. Calibration and Sensitivity		
4.1 Are all available types of observations used for calibration?	Yes	
4.1.1 Groundwater head data	Yes	
4.1.2 Flux observations	Yes	
4.1.3 Other: environmental tracers, gradients, age, temperature, concentrations etc.	NA	
4.2 Does the calibration methodology conform to best practice?	Yes	
4.2.1 Parameterisation	Yes	
4.2.2 Objective function	Yes	
4.2.3 Identifiability of parameters	Yes	
4.2.4 Which methodology is used for model calibration?	Yes	
4.3 Is a sensitivity of key model outcomes assessed against?	Yes	
4.3.1 parameters	Yes	

Review Questions	Yes/No	Comments
4.3.2 boundary conditions	Yes	
4.3.3 initial conditions	Yes	
4.3.4 stresses	Yes	
4.4 Have the calibration results been adequately reported?	Yes	
4.4.1 Are there graphs showing modelled and observed hydrographs at an appropriate scale?	Yes	
4.4.2 Is it clear whether observed or assumed vertical head gradients have been replicated by the model?	Yes	
4.4.3 Are calibration statistics reported and illustrated in a reasonable manner?	Yes	
4.5 Are multiple methods of plotting calibration results used to highlight goodness of fit robustly? Is the model sufficiently calibrated?	Yes	
4.5.1 spatially	Yes	
4.5.2 temporally	Yes	
4.6 Are the calibrated parameters plausible?	Yes	
4.7 Are the water volumes and fluxes in the water balance realistic?	Yes	
4.8 Has the model been verified?	NA	
5. Prediction		
5.1 Are the model predictions designed in a manner that meets the model objectives?	Yes	
5.2 Is predictive uncertainty acknowledged and addressed?	Yes	
5.3 Are the assumed climatic stresses appropriate?	Yes	
5.4 Is a null scenario defined?	Yes	
5.5 Are the scenarios defined in accordance with the model objectives and confidence level classification?	Yes	
5.5.1 Are the pumping stresses similar in magnitude to those of the calibrated model? If not, is there reference to the associated reduction in model confidence?	NA	
5.5.2 Are well losses accounted for when estimating maximum pumping rates per well?	NA	
5.5.3 Is the temporal scale of the predictions commensurate with the calibrated model? If not, is there reference to the associated reduction in model confidence?	Yes	
5.5.4 Are the assumed stresses and timescale appropriate for the stated objectives?	Yes	
5.6 Do the prediction results meet the stated objectives?	Yes	
5.7 Are the components of the predicted mass balance realistic?	Yes	
5.7.1 Are the pumping rates assigned in the input files equal to the modelled pumping rates?	NA	
5.7.2 Does the predicted seepage to or from a river exceed measured or expected river flow?	No	- Limited seepage from rivers / watercourses are predicted. The regional water table is below the base of the river and associated alluvium

Review Questions	Yes/No	Comments
5.7.3 Are there any anomalous boundary fluxes due to superposition of head dependent sinks (e.g. evapotranspiration) on head-dependent boundary cells (Type 1 or 3 boundary conditions)?	No	
5.7.4 Is diffuse recharge from rainfall smaller than rainfall?	Yes	
5.7.5 Are model storage changes dominated by anomalous head increases in isolated cells that receive recharge?	No	
5.8 Has particle tracking been considered as an alternative to solute transport modelling?	Yes	- particle tracking applied to assess post-closure groundwater flow conditions
6. Uncertainty		
6.1 Is some qualitative or quantitative measure of uncertainty associated with the prediction reported together with the prediction?	Yes	
6.2 Is the model with minimum prediction-error variance chosen for each prediction?	Yes	
6.3 Are the sources of uncertainty discussed?	Yes	
6.3.1 measurement of uncertainty of observations and parameters	Yes	
6.3.2 structural or model uncertainty	Yes	
6.4 Is the approach to estimation of uncertainty described and appropriate?	Yes	
6.5 Are there useful depictions of uncertainty?	Yes	
7. Solute Transport		
7.1 Has all available data on the solute distributions, sources and transport processes been collected and analysed?	NA	
7.2 Has the appropriate extent of the model domain been delineated and are the adopted solute concentration boundaries defensible?	NA	
7.3 Is the choice of numerical method and software appropriate?	NA	
7.4 Is the grid design and resolution adequate, and has the effect of the discretisation on the model outcomes been systematically evaluated?	NA	
7.5 Is there sufficient basis for the description and parameterisation of the solute transport processes?	NA	
7.6 Are the solver and its parameters appropriate for the problem under consideration?	NA	
7.7 Has the relative importance of advection, dispersion and diffusion been assessed?	NA	
7.8 Has an assessment been made of the need to consider variable density conditions?	NA	
7.9 Is the initial solute concentration distribution sufficiently well-known for transient problems and consistent with the initial conditions for head/pressure?	NA	
7.10 Is the initial solute concentration distribution stable and in equilibrium with the solute boundary conditions and stresses?	NA	
7.11 Is the calibration based on meaningful metrics?	NA	

Review Questions	Yes/No	Comments
7.12 Has the effect of spatial and temporal discretisation and solution method taken into account in the sensitivity analysis?	NA	
7.13 Has the effect of flow parameters on solute concentration predictions been evaluated, or have solute concentrations been used to constrain flow parameters?	NA	
7.14 Does the uncertainty analysis consider the effect of solute transport parameter uncertainty, grid design and solver selection/settings?	NA	
7.15 Does the report address the role of geologic heterogeneity on solute concentration distributions?	NA	
8. Surface water-Groundwater Interaction		
8.1 Is the conceptualisation of surface water-groundwater interaction in accordance with the model objectives?	Yes	
8.2 Is the implementation of surface water-groundwater interaction appropriate?	Yes	
8.3 Is the groundwater model coupled with a surface water model?	No	
8.3.1 Is the adopted approach appropriate?	Yes	
8.3.2 Have appropriate time steps and stress periods been adopted?	Yes	
8.3.3 Are the interface fluxes consistent between the groundwater and surface water models?	NA	