OUT20/2603

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Dear Nagindar

Tahmoor South Coal Project (SSD 8445) -
Response to Submissions

I refer to your email of 4 March 2020 to the Department of Planning, Industry and Environment (DPIE) – Water about the above matter. DPIE - Water and the NSW Natural Resources Access Regulator (NRAR) provide advice and recommendations for the Response to Submissions (RtS) in Attachments A, B and C.

The amended project has addressed a number of our concerns including: the proponent's ability to obtain additional entitlement to account for the project's groundwater and surface water take, and the analysis and predictions of impacts by the groundwater model.

However the assessment of the amended project now indicates that there will be significant direct and cumulative impacts to groundwater bores in the vicinity as well as to Thirlmere Lakes. The proponent should be required to develop and implement prior to determination:

- a very rigorous bore census;
- make good provisions which are well understood, feasible and equitable;
- Thirlmere Lakes mitigation strategy, and
- Trigger Action Response Plan.

Any further referrals to DPIE - Water and NRAR regarding this matter can be sent by email to: landuse.enquiries@dpi.nsw.gov.au.

Yours sincerely

Mitchell Isaacs
Director, Office of the Deputy and Strategic Relations
Department of Planning, Industry and Environment: Water
4 June 2020

ATTACHMENT A

DPIE – Water and NRAR recommendations regarding the Response to Submissions for the Tahmoor South Coal Project (SSD 8445)

1. Water Licencing

Post Determination

1.1 Water Access Licences

The following recommendations are required as **conditions of consent**.

- The project must:
    - Obtain adequate Water Access Licences to account for both Surface and Groundwater take, prior to the take of any additional unlicensed water.
    - Provide evidence of the additional Water Access Licence shares obtained (in accordance with the predicted water) to the Natural Resources Access Regulator.

Explanation

The proponent will need to purchase sufficient additional volume of surface water and groundwater licences to account for the direct and indirect take generated by the project. The modelled maximum extraction volumes of incidental take from nearby water sources will need to be accounted for on Water Access Licences (WALs). A summary of the volumes follows:

- The project has been revised, and expected water take for surface water is predicted at 73.1ML/y. The existing surface water entitlement held by Tahmoor Mine is 5 ML/y. The project has reported that it would obtain the necessary water entitlements, and it is likely the project will be able to acquire the relevant WALs for surface water take.
- The maximum annual groundwater take predicted is 2,850 ML/year (7.8 ML/day). The existing groundwater entitlement held by Tahmoor Mine is 1,642 ML/y, meaning a shortfall of a maximum of 1,208 ML/y will need to be accounted for.

  Additional volumes may also need to be held if providing alternative water supplies to affected users (on the basis of volume flow provision) through Make Good is necessary (see **Recommendation 2.1** below).

The WALs can be obtained through water trade from the market or controlled allocation. The commitment by the proponent to obtaining additional entitlements is satisfactory provided the proponent understands the risks and uncertainty of both mechanisms.

Most deterministic uncertainty scenario runs consistently predict this or slightly lower volumes of take. However, the “Height of Connected Fracture (HoCF)” run yields an outlier of 20.5 ML/day or 7,482 ML/year, which is significantly higher. The probability of such an outcome is not clear, and the proponent does not offer any commentary on this aspect. We assume that this outcome is considered highly unlikely for the purpose of planning for water entitlements and hence do not require further advice from the proponent.

2. Groundwater

Prior to Determination

2.1 Groundwater drawdown / water user impacts – bore census, make good provisions, mitigation strategy and Trigger Action Response Plan

- As the project presents high impacts and risks to existing water users and groundwater dependent ecosystems in the area, approval requires: a very rigorous bore census; make good provisions; and Trigger Action Response Plan (TARP), as follows:

- Bore census - the proponent should clarify the proposed scope of its bore census, specifically whether this is to include bores outside the predicted direct impact of the proposal that are affected cumulatively.

  Please note that post determination **Recommendation 2.3** covers development of the detailed design of the bore census.

- Make good provisions - DPIE – Planning & Assessment (P&A) should ensure make good provisions are in place, well understood, feasible and equitably address the potential impacted users.
- Development of a strategy to mitigate or offset impacts to the high priority groundwater dependent ecosystem Thirlmere Lakes.
- A TARP in relation to groundwater impacts must be further developed in consultation with DPIE – Water, and DPIE – P&A should ensure that the conditions of consent have an appropriate approval pathway for the TARP.

DPIE – Water recommends that the proponent be held to the make good and TARP commitments through the **conditions of consent**.

Explanation

Summary of Impacts

The proponent has provided an Aquifer Interference Policy (AIP) impact summary in Table 6-6 from Appendix C of the Amendment Report which has been reproduced below. The affected water source is the Sydney Basin Porous Rock (Nepean Groundwater Source, Management Zone 2) which is categorised as a Highly Productive Groundwater source. The assessment concludes:

- **Water Table** – greater than 2 m water table decline cumulatively in the Permo-Trassic strata affecting water supply works – Level 2 impact classification
- **Water pressure** - greater than 2 m pressure decline cumulatively in the Permo-Trassic strata affecting water supply works – Level 2 impact classification
- **Water quality** – Level 1 impact classification

The amended project design yields predicted impacts that differ from the original project design considered in the EIS. The key water related changes in impacts are as follows:

- Average and peak mine inflows are predicted to be essentially the same (4.7 ML/day average and 7.5 – 8.0 ML/day peak for both designs)
- Groundwater drawdown at the Thirlmere lakes is predicted to be higher – from 0.02-0.05 m to 0.08 – 0.48 m
- More neighbouring bores will be affected (from 38 to 52 bores, excluding cumulative impacts)
- Similar surface water take
- Similar impacts on groundwater quality

Cumulative impacts increase the number of bores to experience Level 2 impacts – from 52 to 228 as explained under the bore census. Cumulative impacts also cause Level 2 impact thresholds to be breached at the high priority Groundwater Dependent Ecosystem Thirlmere Lakes. Project-specific groundwater drawdown is modelled to be less than 1% of water table fluctuation at the lakes. However cumulative impacts cause drawdowns of over 10% at two of the Thirlmere Lakes, triggering Level 2 impact consideration classification. No mitigation measure for this impact has been offered.

The proponent should formulate a strategy to mitigate or off-set those impacts. An off-set strategy could be modelled on, for example, actions taken by another mine with Level 2 GDE impacts that proposes to implement a Biodiversity Management Plan and Swamp Offset Strategy under the NSW Biodiversity Offset Scheme and the Environmental Protection and Biodiversity Conservation Act 1999. Such a strategy should be prepared in consultation with the NSW National Parks and Wildlife Service, being the custodian of the asset affected.

As noted under the bore census, the apportionment of responsibility for those impacts and what regulatory controls may apply to whom present challenges to regulators and the mines.

Bore census

The proponent has identified groundwater users and bores potentially affected (incrementally) by the Tahmoor proposal itself, and total cumulative impacts due to all mining in the area (largely Bulli Seams Operations). The potential impacts are considerable with multiple bores predicted to exceed the Level 2 minimal impact consideration classification under the AIP (2 m decline), as follows (as shown in Table 6-4 from Appendix C in the Amended Report):

- 52 bores > 2 m - Tahmoor-only impact
- 228 bores > 2 m - all cumulative impact

Accounting for further model uncertainty (considering all deterministic scenarios):

- 73 bores > 2 m - Tahmoor-only impact
- 264 bores > 2 m - all cumulative impact

The distribution of the affected bores is shown in Figures 6-1 and 6-2 of Appendix C in the Amended Report.

The potential combined impacts on third parties from all mining operations in the area (i.e. the cumulative impacts) are considerably higher than those of individual mines like the Tahmoor South project. The apportionment of responsibility for those impacts and what regulatory controls may apply to whom present challenges to the regulators and mines.

The details of the updated bore census is not given – only that it has commenced (November 2019) and would establish baseline conditions.

It is proposed that the pre-mining bore census would be limited to bores predicted to be affected – implemented progressively as mining proceeds and amended according Extraction Plans. It is not clear whether the proponent is identifying bores affected by this proposal only or all the bores affected cumulatively.

Furthermore, the number of bores potentially impacted are considerable, and although it is difficult to see with the maps presented, predicted water table drawdowns greater than 10 m could affect numerous bores. Modelled impacts on bores from the project bore census is provided in Table 6-5 which shows numerous instances of impacts greater than 10 m due to the Tahmoor activity itself, and cumulatively.

Make good provisions

The applicant identifies the impact of the proposal independently of existing impact in the "cumulative impact area", as well total cumulative impacts. In principle when DPIE - Water authorises the take of groundwater through trades, it places the responsibility of the impact on the latest applicant and may thus refuse or restrict a groundwater trade. In this mining scenario it seems unclear:

- whether bores impacted as a result of cumulative impact were already impacted above the 2m trigger and are the object of existing make good arrangements by other mines; and
- whether the added impact from Tahmoor increases significantly the pre-existing impact scenario to a degree that warrants further make good provisions.

There are several ways to define through modelling a proponent's responsibility for bore impacts. DPIE - Water suggests care be taken to ensure all users have access to make good proportionate to their water availability losses. In the case where Tahmoor is the operation triggering the 2m impact drawdown threshold, Tahmoor Coal should carry responsibility for make good regardless of the magnitude of their own impact.

DPIE - P&A should also consider whether proponents should cover an affected registered bore owner's legal fees. As a point of principle, those impacted should not need to engage in multiple processes with various companies to gain compensation of impact.

DPIE – Water also strongly recommends that the proponent be held to this commitment through conditions of consent.

Trigger Action Response Plan (TARP)

Although making a firm commitment to a TARP, the proponent is deferring the development of the details to the Extraction Plan process, post-determination. The proponent notes this will be done in consultation with DPIE - Water.

Given the identified significance of evident risk to existing water users, further development of the details of this plan is warranted in consultation with DPIE - Water.

DPIE – Water also strongly recommends that the proponent be held to this commitment through conditions of consent.

2.2 Groundwater Assessment report and model plan

- The proponent should:
    - Update the Groundwater Assessment report (Appendix C of the Amended Report).
    - Provide a clear plan for a groundwater model re-build and calibration.

      Note: DPIE – Water's model rebuild recommendation in **Recommendation 2.4** (below), with specific details provided in **Attachment B**.

  These recommendations should be developed in consultation with DPIE - Water.

Explanation

Groundwater Assessment report

There is noticeable inconsistency between the Tahmoor South - Response to Submissions - Feb 2020 (RtS) and the revised Groundwater Assessment Report that should be addressed.

In some cases, there are clear, adequate responses in the RtS to certain issues raised by DPIE – Water. For example, the RtS provides the required steady-state water balance, but this information is not included in the report despite being readily available to the report authors.

Conversely, the revised Groundwater Assessment Report responds positively to issues raised by DPIE – Water such as the recommendations to rebuild the model using unstructured grid and parametrising and calibrating it using the pilot point approach. However, the RtS states that these enhancements to the model are unwarranted.

Please note that many of DPIE Water's comments in this RtS advice seek improvements in the reporting of the current model and do not require any further work on the model itself. These improvements will enhance the readability and completeness of the document and give the reader greater confidence in the product. Overall, the report is required to be a standalone documentation of all aspects relating to the undertaken modelling work with minimal referencing to other information sources.

Model Plan

The proponent is required to provide a clear plan for model re-build and calibration. This plan should be in line with the specific recommendations made by DPIE - Water (refer to **Recommendation 2.4** and **Attachment B**), other submitters, the revised report and the latest independent review.

DPIE Water notes that the revised groundwater model (and report) have already addressed many of the issues raised by DPIE - Water (and other submitters). The model revision has lowered the mean absolute error from c. 21 m to c. 11 m and the Scaled Root Mean Square SRMS from 3.7% to 2.8%, and includes additional improvements to the model and report. As such, DPIE - Water has a higher level of confidence in the provided analysis and results, but there are still issues that must be addressed in future editions of the model (and associated reporting).

Post Determination Recommendations

2.3 Groundwater drawdown/water user impacts – bore census development

- The detailed design of the bores census is to be developed in consultation with DPIE – Water and to the satisfaction of the DPIE Secretary.

Explanation

As explained in **Recommendation 2.1**, the project presents high risks to existing water users in the area, so a very rigorous bore census is required, and DPIE – Water involvement will assist in the adequate development of this.

2.4 Groundwater model

- The proponent should rebuild the model within two years of project determination.

  This should be in accordance with the model rebuild plan (required prior to determination – see **Recommendation 2.2** above).

Explanation

Attachment B provides further detailed recommendations regarding the model rebuild.

2.5 Water Monitoring Plan

The proponent should develop its Water Monitoring Plan in consultation with DPIE - Water and to the satisfaction of the DPIE Secretary.

Explanation

The proponent's commitments in relation to groundwater monitoring substantially address the recommendations made by DPIE - Water in its review of the EIS, with the omission of some details. These can be addressed during the consultation process for the development of the plan.

3. Surface Water

Post Determination Recommendations

Please note explanation comments for Recommendations 3.1, 3.2 and 3.3 are provided in Attachment C.

3.1 Geomorphology Survey

- The proponent should undertake a geomorphology survey (baseline and post mining) of waterways overlying and within the 20mm line of subsidence for each longwall to complement monitoring of subsidence at each longwall, in consultation with DPIE – Water.

3.2 Trigger Action Response Plans

- Trigger Action Response Plans (TARPS) are to be developed in consultation with DPIE – Water:
  - to develop risk assessments and appropriate management responses, including any necessary remediation and rehabilitation of impacts to overlying or adjacent watercourses or floodplain pockets;
  - for unexpected flow loss based on analysis of baseline (i.e. pre-subsidence) streamflow data, post-subsidence streamflow data and contemporaneous data from control sites.

    This is to apply catchment flow modelling to form baseline and variability in flow stage from rainfall events during and following mining subsidence; and
  - for unexpected loss of pool water holding capacity based on analysis of baseline (i.e. pre-subsidence) pool water level data, post-subsidence pool water level data and contemporaneous data from control pool sites. Pool water balance modelling should be developed in the analysis particularly during unusual climatic/hydrological conditions.

3.3 Monitoring

- Monitoring of streamflow, pool water levels and water quality should continue for a minimum two years following cessation of longwall subsidence related movement in a watercourse or following completion of any stream/pool remediation. Monitoring data would be reviewed at regular periods over this period. Reviews would involve assessment against long term performance objectives which would be based on the pre-mine baseline conditions or an approved departure from these objectives.

END ATTACHMENT A

ATTACHMENT B

Recommendations 2.2 and 2.4 - Groundwater Model – Specific Comments and Recommendations RtS for the Tahmoor South Coal Project (SSD 8445)

DPIE – Water Groundwater Model recommendations as part of this submission (see **Attachment A**) are:

- **Recommendation 2.2** (prior to determination) - Provide a clear plan for a groundwater model re-build and calibration
- **Recommendation 2.4** (post determination) - The proponent should rebuild the model within two years of project determination.

The following table provides specific RtS Comments and Recommendations from DPIE – Water related to these two overarching recommendations. It also tabulates the specific recommendations provided (in its 5 March 2019 submission to the EIS) and the proponent's RtS response.

DPIE - Water EIS Recommendations	Proponent RtS Response	DPIE – Water RtS Comments and Recommendations
a. A detailed list of the limitations and assumptions in the techniques used to inform the modelling should be provided.	a. Model assumptions are included in discussion in relevant subsections in Section 4, and limitations discussed in Section 4.11 of the revised Groundwater Assessment (Appendix C of Project Amendment Report). Refer to the opinion of the Independent Reviewer (HydroGeoLogic, 2019) about the standard of reporting and documentation of modelling.	Section 4.11 describes some of the model limitations in terms of data (geological layer elevations and groundwater levels). The quality of VWP data has also been identified as a limiting factor. The section highlights that despite having a substantial dataset of hydraulic properties, single values of hydraulic properties have been adopted for each layer (i.e. layers have been assumed to be homogeneous). Model limitations also include uncertainty associated with the degree of enhancement of permeabilities (mostly vertical) in the underground fractured zone due to mining. The model's lateral discretisation (100x 100 m laterally is considered a limiting factor to the model's ability to simulate some. The section is incomplete and relevant information is provided in other sections, e.g. the high level of uncertainty in the groundwater abstraction dataset discussed in Section 3.8.1 and other sections. Further improvements are required as follows: - Completion of list of limitation (some items are missing). - Discussion of implications on the model's ability to make reliable predictions, particularly with regards to the Thirlmere Lakes and groundwater users (bores).

DPIE - Water EIS Recommendations	Proponent RtS Response	DPIE – Water RtS Comments and Recommendations
		- Require: USG-MODFLOW see justification in Sec 4.11 and add lakes - Better representation of heterogeneity (e.g. pilot point calibration) - List additional actions to address each limitation in future versions of the model.
b. Once the model is redeveloped, the sensitivity and uncertainty of the model should be characterised in line with the Explanatory Note, Uncertainty Analysis in Groundwater Modelling, Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining, 2018.	b. A set of deterministic scenarios has been carried out, focussing on major conceptual processes and impact pathways. Refer to the opinion of the Independent Reviewer (HydroGeoLogic, 2019) about the deterministic scenarios carried out. The Groundwater Assessment recommends that the model undergo revision only once the findings of the OEH Research Program are available for incorporation. At that time, additional uncertainty analysis can be carried out.	The numerical model presented in the EIS (HS, 2018) was updated to incorporate a number of items raised by IESC, local councils, DPIE/DPE, DPIE (DoI) Water and DPIE's Independent Reviewer following the public exhibition of the EIS and following a further meeting with these groups in early 2019. There are enhancements to the model that are required to be made regardless of other data becoming available, e.g. better representation of heterogeneity (use available data and pilot point model parametrisation and calibration technique) and refinement of the model grid (e.g. by using unstructured grid). Further enhancement of the model are required when additional data become available, e.g. data from the OEH Research Program.
c. Impact predictions should be given using the P90 of the outcome of the sensitivity and uncertainty analysis.	c. Characterisation of 90%ile is useful at greenfield sites where the hydrology of the system in response to stresses are not well understood. Tahmoor Mine has been operating for almost 40 years, and the groundwater model is calibrated against groundwater levels and inflow. Refer to the opinion of the Independent Reviewer (HydroGeoLogic, 2019) about the deterministic scenarios carried out.	Noted. It is also noted that the worse-case deterministic scenario for mine in-flows is characterised by the proponent as unreasonably high.
d. Justification should be provided as to why bore abstraction was not included in the model, including detailed sensitivity and uncertainty analysis of the inclusion or exclusion of the effects of pumping.	d. There is significant uncertainty in the groundwater abstraction dataset, and this remains. Refer to Section 3.8.1 of the revised Groundwater Assessment (Appendix C of Project Amendment Report) for discussion of the available data, and Section 5.2.1 for discussion of how this process is incorporated into a single predictive scenario.	This has been adequately addressed. This is a reasonable argument. Groundwater use data is very uncertain and its inclusion in the model would be very problematic.
e. Steady-state results and	e.This issue was discussed with DoI – W, NRAR and DoI	This being the case, the proponent is required to include this information in

DPIE - Water EIS Recommendations	Proponent RtS Response	DPIE – Water RtS Comments and Recommendations
calibration data should be provided to identify the transient model sensitivity to initial conditions and compare how the model behaves without storage terms.	Water staff in the April 2019 meeting. An appropriate steady state calibration, using the same model parameters as the transient model, was presented and discussed with attendees at the meeting.	the report to address the Department's requirement, help understand the system's behaviour, give confidence in the steady-state and transient model, and enhance the quality of model documentation.
f. Explanation of why the surface water stage (elevation) was not used in calibration.	f. The representation of surface water stage was deficient in the EIS groundwater model. Surface water stages for watercourses have been modified in the revised Groundwater Model (Section 4.4.4 of Appendix C of the Project Amendment Report). Lake stages for Thirlmere lakes have been modified in the revised Groundwater Model (Section 4.4.5).	This issue has been adequately addressed.
g. Clarification of the effects of weights that were assigned to observations on transient model performance.	g. Discussion of target weightings is provided in Section 4.8.2 of the revised Groundwater Assessment (Appendix C of Project Amendment Report).	This issue has been adequately addressed. The weighting applied for calculating assessing model performance has been provided and is based on perceived data reliability. See item (r) below for further discussion on performance statistics.
h. Justification of the overestimated evapotranspiration (ET) from the water table (e.g. 40%, Table 5-2) despite this effect being included in the recharge (RCH) component (which represents a form of double counting). Sensitivity and uncertainty analyses for this parameter should be provided.	h. Evapotranspiration (ET) occurs above the land surface, at the land surface, within the soil zone, and also from shallow water tables. The first three of those components are considered when making estimates of recharge, as per Doble and Crosbie (2016). If the water table is within ~20cm of bare soil or within the root zone of plants, it can be subject to evapotranspiration, as such modelling is considered to be appropriate in relation to this parameter.	1. Clarification is required to whether evapotranspiration took place in lakes and surface water areas. In such cases, water will evaporate from the surface water feature rather than evapotranspire from the underlying water table. 2, Model sensitivity to this parameter is required 3. Maps showing the distribution of this parameter in the steady-state model and the average values in the transient model are required. 4. The same is required for recharge. 5. Confirmation is required to that there is no double counting of evapotranspiration between the groundwater and the GoldSim models.
i. Justification of the potentially underestimated recharge. Sensitivity and uncertainty analyses for this parameter	i. Refer to detailed review and analysis of recharge in Section 3.8.4 of the revised Groundwater Assessment (Appendix C of Project Amendment Report). The Nepean Sandstone GW Source extends from areas of rain ~1800	This issue has been adequately addressed.

DPIE - Water EIS Recommendations	Proponent RtS Response	DPIE – Water RtS Comments and Recommendations
should be provided.	mm/yr and PE 1500 mm/yr in the south/east to rain 800-850 and PE 1400 mm/yr in the north and west. LTA rainfall at Tahmoor is 1000 mm/yr. Crosbie (2015) includes estimate of average recharge around Tahmoor of 5-21 mm/a, higher (20-100 mm/a near escarpment/Dendrobium). Therefore, it is reasonable to expect lower recharge at Tahmoor than the average 6% estimated by NOW (2011). The model uses recharge zones (Figure 4-3 within Section 4.8.2 of the revised Groundwater Assessment in Appendix C of the Project Amendment Report) applied consistent with broad rainfall zones and consistent with Crosbie estimates (i.e. higher at the escarpment, lower in the north and west).	
j. Clarification of the calibration targets for steady-state modelling.	j.Steady state simulation was used for initialising the transient simulation. Mining has occurred since ~1980 at this site, while the first available groundwater level from a monitoring bore is from 2005 (and from 2008 in VWPs), so calibration to 'steady state' groundwater levels is not viewed as critical. However, model calibration to 'steady state' water levels was presented at the meeting in April 2019 and considered satisfactory.	1. model calibration to steady-state is only critical in this case because transient models are sensitive to initial conditions. 2. Assessment of model sensitivity to initial conditions is recommended. 3. As indicated in the Department's comment on evapotranspiration above (**point h**), maps showing the distribution of this parameter in the steady-state model and the average values in the transient model are required.
k. Provision of the steady-state simulation water balance is required.	k. steady state mass balance was presented at the meeting in March 2019, noting 0.04% mass balance error. Tah_045 (SS Sp1) Units: m3 **Component** **IN** **OUT** RECHARGE 182,768 0 RLEAKAGE 39,086 54,884 DRAINS 0 0 ET 0 163,006 HDBOUNDS 757 4,640 STORAGE 0 0 TOTAL 222,611 222,531	Please include this response and discuss in the report. Also please refer to the Department's comment on **point e** above.

DPIE - Water EIS Recommendations	Proponent RtS Response	DPIE – Water RtS Comments and Recommendations
l. Provision of the relative parameter sensitivity assessments is needed for both the steady-state and transient models.	l. Refer Figure 5-1 (Transient Sensitivities) below. This was discussed at the meeting in April 2019. Kh parameters generally more sensitive, as well as some like Sy6 (Bulgo Sandstone) in response to fracturing and drawdown (and observations) in that unit.	Please include figure and adequate discussion in the report, including used methodology. This section may need to be changed following better representation of heterogeneity using pilot point or similar parameterisation and calibration techniques.
m. Documentation of the hydraulic conductivity anisotropy (KH/KV) data based on project domain field data and discussion of the significance of this characteristic is required.	m. The field data is presented alongside modelled results in the assessment. The model has been parameterised via independent inputs of Kh and Kv, rather than relying on anisotropy ratios. Packer and core testing results are summarised for each stratigraphic unit on Figure 4-6 of the Project Amendment Report revised Groundwater Assessment (Appendix C of the Project Amendment Report). The modelled parameters are well constrained by field data.	This is noted. The Department required this information to help the readers/reviews of the report to readily understand the difference between the various layers as well as between field and model calculated data, i.e. to make the report more user-friendly. Inclusion of this data is still strongly recommended.
n. Verification of the geological layering uncertainty noted in Section 4.11 is required based on borehole logs and other project intrusive investigation data.	n. In accordance with the recommendations in the revised Groundwater Assessment (Appendix C of the Project Amendment Report), the geological model and groundwater model would be revised to into account any developments from the OEH Thirlmere Lakes research program once detailed findings are available. This would include more detailed assessment of geological structure around Tahmoor South – something best achieved once development begins underground on site.	This issue has been adequately addressed.
o. Discussion of the consequences of changes in aquifer storage presented in the water balance accounts for surface water and groundwater systems around the project domain is required.	o. The storage components reported in Table 4-6 of the revised Groundwater Assessment are representative of lowering or increasing groundwater levels through time across the model domain. These changes in groundwater levels are a response to recharge, evapotranspiration, baseflow, mine inflow. There is an imbalance between the IN and OUT between 1980-2019 (an overall decline in groundwater level), related to generally dry conditions in the second half of that period, as well as an increasing amount of mining across the model domain.	1. Please include response in a relevant section in the report including a discussion of the “consequences” to the model and hydrological system.

DPIE - Water EIS Recommendations	Proponent RtS Response	DPIE – Water RtS Comments and Recommendations
p. Quantification of the error in the estimation of project area rainfall and subsequently recharge component of the groundwater model, as well as justification of the approach of combining the rainfall records from two separate weather stations. The data combination method is not described and the resultant synthetic rainfall estimates may not be realistic, particularly in representing the Millennium Drought.	p. As discussed at the meeting in April 2019, this was agreed to be a secondary issue. It was demonstrated that the rainfall records used in the EIS Groundwater Assessment were appropriate. The comparison of monthly total rainfall at the two sites is presented below, showing good correlation (R2 = 0.84). Rainfall totals vary by 7% at the two sites across months where records are available for both.	This issue has been adequately addressed. It is recommended that the proponent add this discussion into the groundwater report for completeness. The report reader should not be expected to refer to the RtS for information.
q. Inclusion of improved sensitivity and uncertainty analysis to clarify the representation of faults as either flow barriers or conduits within the model.	q. Broadly, the Nepean Fault zone is known to be more permeable, enhancing groundwater inflow to mine workings that intersect it. This is represented as such in the groundwater model. Other mapped faults are considered possible conduits, and this is investigated in deterministic scenarios. Parameterisation of faults is presented in Sections 4.5 and 5.2.1 of the revised Groundwater Model (Appendix C of the Project Amendment Report).	This issue has been adequately addressed. However we recommend the Groundwater report is improved to: 1. address a cross-reference error in the map legends Appendix G to Table 4-2, which should be Table 4-3 2. explain why Ss and Sy were kept undifferentiated from the host strata. 3. include fault parameters in Figure 5-1 (parameter sensitivity) which is provided only in the RtS but is required to be added to the revised model report.
r. Enhance the model to reduce SRMS (Scaled Root Mean Squared) error for all layers within the model to rectify the high values presented for the current version (Table 4-3 shows that SRMS>5% for all units except layer 1).	r. Model improvement is desirable; however, this point is not critical for current predictions. The “high values” include all layers above SBSS having SRMS <10%, with detailed discussion of model errors in Section 4.8 of the revised Groundwater Model (Appendix C of the Project Amendment Report). It is also unusual to report layer-by-layer sRMS –this was done on the request of the Independent Reviewer, who considered the reported statistics to be acceptable. The Australian Groundwater Monitoring Guidelines states: “a target SRMS of 5% or 10% is only meaningful when those setting the target know that it is achievable for a particular kind of problem	The calibration statistics for the calibrated transient model are 2.8% Scaled Root Mean Square (SRMS) and an absolute residual mean of 10.7 m. This is a significant improvement to the residual mean of 21 m presented in the EIS version of the model. The proponent has broken down the sources of error by stratigraphic unit showing the larger errors are found in the deeper units. The three shallow most layers above the confining Bald Hill Claystone have SRMS < 6%. Considerably higher SMRS and average residuals occur in the deeper layers below the Bald Hill Claystone. The better performance for the shallower layers provides better confidence in predicted impacts to third party bores in the vicinity of the mine as almost all water extraction is from the shallower Hawkesbury Sandstone units.

DPIE - Water EIS Recommendations	Proponent RtS Response	DPIE – Water RtS Comments and Recommendations
	and a particular environment with a known density of informative data."	Note: the layers described as "SBSS" in the proponent's response is a typo and should be HBSS – Hawkesbury Sandstone.
s. Reconstruct the model to address the model calibration error (21m absolute residual mean) and reduce the uncertainty in predicted outcomes.	s. See discussion of sources of error (Section 4.8.2 of revised Groundwater Assessment), which are dominantly in the coal seam and up to the lower Narrabeen Fm (Table 4-4). The model has overall sRMS <3% and is well calibrated to mine inflow. The mine inflow metric overrides the stated residual for an individual layer.	This issue has been adequately addressed. Whole of model average residual reduced from 21 m to 10.7 m. See (r) above for further discussion on performance statistics. By implementing the recommendations provided herein and by the independent reviewer, it is anticipated further improvements will be achieved.
t. Improve model zonation or undertake pilot point calibration to correct the single zone per layer representation of hydraulic properties and improve model calibration.	t. There is no basis for a more "advanced" calibration method when the %RMS metric conforms to Australian modelling guidelines. Uniform properties per lithology is standard practice for difficult mining models. Further, the AGMG states (p.74): "The number of parameters can be increased in such a way that calibration appears to be robust and the SRMS becomes negligibly small, but there may be no rational hydrogeological basis to support the degree of detail (the number of parameters) added to the model. This phenomenon is known as 'overfitting'. Overfitting should not be preferred relative to a larger SRMS with rational relationships between model parameters".	The Department still recommends more realistic representation of hydraulic layer heterogeneity in future versions (e.g. by using pilot point parameterisation), mainly to enhance inflow predictions. It is noted that the recommendation in Section 7.2 in the revised report recommends pilot point calibration following the re-implementation of the numerical model in unstructured grid environment (e.g. MODFLOW-USG). Both the EIS and RtS modelling reports highlighted pilot point calibration as a method to enhance the model. In addition, peer reviews of both models endorsed this recommendation. The latest peer review states: "*This review endorses the HS recommendation for future work (monitoring and modelling, plus research into Thirlmere Lakes) to further reduce the effects of uncertainty on simulations through pilot points and/or regularisation methods, which would require revisions to the model and refinement of the grid, reducing the number of cells.*"
u. Undertake and report on a detailed sensitivity and uncertainty analysis of the exclusion of the eastern area of the model domain resulting from the placement of a no flow boundary.	u. The area where the no flow boundary was extended occurs around MINE, which is located beyond Appin/West Cliff Mines, and approximately 15 km from Tahmoor South. Cumulative impact assessment of this area should be accounted for in Bulli Seam Operations modelling or Russell Vale modelling.	We require advice to explain the reasons for: 1. setting a 'no-flow' boundary as opposed to other types of boundaries? 2. "*Cumulative impact assessment of this area should be accounted for in Bulli Seam Operations modelling or Russell Vale modelling*" but not this model?
v. Explanation of the counter intuitive results obtained from running different lake level	v. An explanation was provided in the meeting in April 2019. The error occurred because of model numerical error (imprecision) when dealing with very small fluxes	This is a valid explanation. However could you please advise whether this has been resolved in the revised model and if yes, how? Are there any implications to this on the model predictions?

DPIE - Water EIS Recommendations	Proponent RtS Response	DPIE – Water RtS Comments and Recommendations
scenarios, how this affects model confidence level and possible reasons (e.g: numerical instability) which can impact on model performance and predictions.	(typically 5-30 m3 at each lake), when the model solver tolerance is 4 cm and the area of a lake (e.g. Couridjah) is 15,000-45,000 m2.	3. This issue and the response should be addressed/described in the new model report.
w. Reconstruction of the model to utilise the unstructured grid capability of the Modflow USG platform to address the excessive run time and disk space requirements of the current version.	w. The model layering and extent were developed in response to the cumulative impact requirements of the Aquifer Interference Policy. That is, to represent mines and watercourses with relative detail, incorporate geomechanical changes, transient recharge and ET, carry out cumulative assessment in an area where there are not clear hydrological boundaries (to the north/south/east) and then have a model that runs quickly. Given the more contemporary focus on uncertainty, it is recommended that the model be revised (re-built) once the findings of the OEH Research Program are available and use this revised model to carry out more complete assessment of uncertainty.	The Department is satisfied with the proponent's understanding for the need to rebuild the model to enhance its performance and confidence in its predictions. However, this can be done independently of the new data becoming available from the OEH Research Program. A phased approach is recommended whereby the first phase will include a model rebuilt and the second phase will be updating the model with OEH research Program data.
x. Clarification of how the groundwater model has simulated changes in the lakes wetted area as a result of changes in water levels.	x. This was done via steady state models and passed to the Surface Water model. The open water area of each lake was estimated for a 4 or 5 specified water levels (as recommend by the Surface Water technical specialist - HEC). The wetted area was estimated from LiDAR data, and then translated into model cells.	This is proof that the steady-state model is important and must be included in the model report. The information provided in the RtS must be added into the model's report.
y. Explanation of the discrepancy between the surface water bodies mainly being conceptualised as losing whereas they are implemented as gaining features in the numerical model as suggested in the presented water	y. The main surface water features mentioned and conceptualised as being 'losing' are the Thirlmere Lakes and reservoirs. Thirlmere Lakes are small features on a regional scale or in water balance sense, although important ecologically. Baseflow to watercourses is analysed in the EIS Groundwater Assessment, and watercourses as described as losing or switching between gaining and losing. It was agreed that that the model could	This issue has been adequately addressed. However, DPIE Water requires that future versions of the model: 1. revise the adopted approach and consider alternatives 2. include bed conductance in the parametric sensitivity analysis (parameter identifiability).

DPIE - Water EIS Recommendations	Proponent RtS Response	DPIE – Water RtS Comments and Recommendations
budgets.	be modified to include an estimate of watercourse stage (transient or otherwise) applied to modelled watercourses to simulate variable or losing watercourses. This has occurred and is discussed in Section 4.4.4 and 4.4.5	
z. Undertake of particle tracking or another suitable method to define zones affected by mining activities (capture zone extent) for licencing purposes.	z. Particle tracking is not necessary nor is it appropriate for licensing. Zone budget has been used to partition the 'take' from different sources.	Zone budget approach is suitable to calculate inputs and outputs to [3D] zones. However, the report does not clarify how these zones were delineated. The Department requires clarification of the methodology used to define zones as errors in zone definition could render licensing requirements estimations invalid.
aa. Clarification of the drain cell inactivation to represent change from open space to goaf.	aa. Section 4.4.9 of the EIS Groundwater Assessment describes the activation and inactivation of MODFLOW Drains representing dewatering in the workings. It also states: "Hydraulic parameters were also changed with time in the goaf and surrounding enhanced permeability zone (EPZ) directly after mining of each longwall panel (see Section 4.6 for details)". Section 4.6 of the EIS Groundwater Assessment describes how K and Sy were changed in mine seam.	This issue has been adequately addressed.
bb. Discussion of the possibility that mine inflows (2.1% of water budget) may be an underestimation as a result of the overestimation of ET and discharge to surface water.	bb. See earlier discussion re: ET (point #h). See also discussion of recharge (point #i). 2.1% may be an underestimate or an overestimate. The actual value, be that 1-3%, is not the critical point. The water balance highlights that mine inflow has been a small part of the overall regional groundwater balance.	The water balance is important: to provide an understanding of the important processes in and controls over the system, and for licensing purposes An underestimation of a component in the water balance will necessarily mean overestimation in other component/s, and visa versa. Importantly, overestimation of ET could mean underestimation of mine inflows and/or depletion of the lakes. The report does not provide an analytical water balance for the modelled domain as part of the system conceptualisation. This is required to enable comparison with the numerical model results. It is noticed here that recharge has been varied through the model calibration process (Section 4.9.2), but evapotranspiration was kept constant. The proponent is required to justify these decisions. It is noted the model sensitivity is not assessed for recharge and evapotranspiration (Figure 5-1 in the RtS report).

DPIE - Water EIS Recommendations	Proponent RtS Response	DPIE – Water RtS Comments and Recommendations
cc. Justification of the adopted bed conductance (C) values (e.g. 100 m^2/d for drain cells representing longwalls).	cc. Conductance = k.x.y/t. Conductance of longwall Drains is difficult, and there is no clear calculation of what the the(thickness term) should be, i.e. vertical thickness or horizontal distance. In fact, it should be a combination of both. We applied k = 0.01 m/d for 100 x 100 m cells, and a thickness of 1 unit. This conductance has achieved desaturation of the mine workings, and the mine inflow is well calibrated.	This information is not presented in the report. It must be included so that the reader should not be left to speculate or be asked to refer to the RtS. In addition, the model sensitivity to this parameter is required to be assessed.
dd. As the effects on baseflow may be underestimated, especially in low flow conditions, transient analysis should be undertaken to identify the magnitude of depletion and possible length of dry periods.	dd. Regional groundwater models are not the tool for estimating change to length of dry periods – that is the role of the SWIA.	Noted and supported by surface water model assessment documented above.
ee. Justification for the use if the Modflow River Package rather than the MODFLOW lake package to represent the Thirlmere Lakes and use the most appropriate package based on the analysis.	ee. The RIV package is appropriate for use in the groundwater model. It would be ideal to use the Lake package in a local-scale model. The Surface Water model by HEC accounts for those processes, allowing the regional groundwater model to concentrate on simulating the ~40 years of historical mining and the proposed/future mining at appropriate scales while providing estimates of GW-SW flux to/from the lakes.	This issue has been adequately addressed.
ff. Provide more detailed information on the natural variability or a base case of ponded water levels in Thirlmere Lakes to justify the statements made within the EIS. A stochastic sensitivity analysis would allow the department to identify the uncertainty in the model used	ff. Detailed modelling of surface water stages (lake levels) is described in the Surface Water Assessment by HEC (Appendix D of Project Amendment Report). However, we note that Tahmoor South is >3.6 km from Thirlmere Lakes.	Refer to Surface Water Assessment comments in Attachment C.

DPIE - Water EIS Recommendations	Proponent RtS Response	DPIE – Water RtS Comments and Recommendations
for Thirlmere Lakes.		

END ATTACHMENT B

ATTACHMENT C

Surface Water Assessment –

Explanatory Comments for Recommendations 3.1 to 3.3 (Post Determination)

RtS for the Tahmoor South Coal Project (SSD 8445)

Glencore (Tahmoor Coal) has engaged multiple modelling platforms to predict geo-mechanical response and resultant groundwater drawdown and loss of groundwater pressure. The geo-mechanical model incorporates some modelling of direct subsidence impact to undermined rivers. However, Tahmoor Coal has proposed additional setback distances from the Bargo River and removed a longwall block that would have directly subsided Dog Trap Creek, a tributary to the Bargo River.

The precautionary avoidance of direct subsidence impacts to the Bargo River gives greater confidence that direct connective pathways are avoided. The risk of far field alterations in flow regime in the Bargo River have not been fully investigated, due to limitations in the Incremental Profile Method to predict far field impacts.

The comparisons provided between the Incremental Profile Method (MSEC 1994) to predict likely and potential ground movements and the Tammetta model (SCT 2014) to predict height of fracture propagation provides additional confidence that predictions are valid for decision making purposes. That said, the local groundwater regime to east and west of the Bargo River is complex and makes precise predictions in groundwater levels, flux and pressure impossible. The combination of groundwater response to change in climatic conditions and mining-induced facture propagation requires detailed, long term validation of the two geo-mechanical models.

Tahmoor Coal has amended the mine plan to avoid the most significant impacts that are predicted to occur. These changes include:

- Removal of LW109 to avoid undermining Dog Trap Creek,
- Narrowing proposed longwall panel widths and extraction heights from the longwall blocks,
- Implementing a Trigger Action Response Program (TARP) to detect changes greater than predicted to the Bargo River or active bores in the Nepean sandstone between the longwall block layout and the Bargo River

The avoidance of direct subsidence to the Bargo River and Dog Trap Creek prevents major geomorphic impacts to these watercourses. As geo-mechanical and geomorphic effects can transmit for some distance from the end lines of longwall blocks, monitoring of actual subsidence and fracture development is required. Any monitoring program must identify likely risks and predicted effects to develop trigger levels for response and action.

The recommendations provided in Tahmoor South – Response to Submissions (RtS) – Feb 2020 in Table 7.2 (GE-1) include pre-mining geomorphic survey of watercourses within the direct subsidence zone. This is to form a basis for pre to post mining monitoring and establishment of triggers for remedial or other management action. The recommended identification of geomorphic risk by way of pre-mining survey requires explanation. The risk of geomorphic alteration following longwall passes involves identification of sensitivity and fragility of river features, and assessment of existing geomorphic state and likelihood of erosion risk or other alteration of channel form, channel complexity or geomorphic features.

Tahmoor Coal has made the following commitments regarding surface feature and geomorphological monitoring (s 5.1.33 of the RtS):

- A geomorphology survey (baseline and post mining) of waterways overlying each longwall would be undertaken to complement monitoring of subsidence at each longwall;

- Subsidence monitoring points would be installed before any mining of second workings for all longwalls in each Extraction Plan. The adaptive management plan for the Amended Project would include re-evaluation of the monitoring techniques for subsidence and biodiversity after mining of each longwall. This would then inform monitoring for subsequent longwall panels;
- Monitoring would be undertaken as part of the Extraction Plan to determine if leakage from shallow near-surface fractures is occurring and if the flows through fractures are returning to the watercourses. Monitoring would be undertaken before mining commences to assess the baseline conditions above each longwall, and would include:
    - detailed monitoring to determine geomorphological conditions, including creek mapping and high-resolution photography (before, during and after mining beneath each longwall) of any rock bars, shallow alluvium (i.e. less than 2 m deep) and permanent or semi-permanent pools within the subsidence impact area; and
    - geophysical logging of boreholes that allow changes in groundwater storage and fracture apertures to be quantified and depth of rock deformation to be identified (i.e. observations of non-deformed ground which could be at least 10- 30 m below surface). Both open-rock and multi-level piezometers will support assessment of changes to hydraulic gradients between different hydrogeological units (such as between alluvium and the underlying sequences); and would also be used for environmental water tracer studies to provide an additional line of evidence for hydraulic connection and disconnection.

These proposed measures should enable effective monitoring and response to risk of significant geomorphic alteration. The results of each round of monitoring should be accompanied by an assessment of specific stream power to the 1:5, 1:20, 1:50 and 1:100 year ARI flood events.

END ATTACHMENT C