

Advice to decision maker on coal mining project

IESC 2014/041: Teresa Coal Mine (EPBC 2011/6094) – New Development

Requesting agency	The Australian Government Department of the Environment The Queensland Department of Environment and Heritage Protection
Date of request	05 February 2014
Date request accepted	05 February 2014
Advice stage	Assessment

Advice

The Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development (IESC) was requested by the Australian Government Department of the Environment and the Queensland Department of Environment and Heritage Protection to provide advice on the Teresa Coal Project in Queensland.

This advice draws upon aspects of information in the Draft Environmental Impact Statement (EIS), together with the expert deliberations of the IESC. The project documentation and information accessed by the IESC are listed in the source documentation at the end of this advice.

The proposed project is located approximately 17km north of Emerald and 70km south of Clermont in the Bowen Basin, Central Queensland. The project area is defined by two Mining Lease Application areas (MLA). MLA 70405 is approximately 7,000 hectares and covers the southern part of the project area while MLA 70442 is approximately 3,000 hectares and covers the northern part of the project area.

The proposed project is targeting the Corvus II coal seam within the German Creek Coal Formation of the Blackwater Group in the Bowen Basin. The proposed new underground coal mine and associated above ground infrastructure would produce up to eight million tonnes of run-of-mine (ROM) coal per year. The principal method of mining would be retreat longwall extraction, with a small section by partial block extraction. The life of the mine is anticipated to be up to 30 years. The current coal resource within the Corvus II coal seam is estimated at 310 million tonnes. The MLA is bound to the south and west by Theresa Creek and Gordonstone Creek to the northeast; tributaries of the Nogoa River, located to the south. Construction of the proposed project is anticipated to commence in late 2014 subject to mining lease and environmental approvals. The majority of construction works are anticipated to be completed by 2017, with full operation to commence in 2019.

The IESC would like to highlight that there are factual inconsistencies and key findings within chapters of this EIS that are not consolidated or considered within other chapters. For example conclusions and scenarios from one report (e.g. geotechnical findings of subsidence fracturing into the Tertiary formations) have not been considered in other reports (e.g. the hydrogeological model). This leads to uncertainty regarding the impacts as predicted by the proponent. Notably the IESC considers the following to be key impacts of concern for the proposal:

- Exclusion of subsidence induced fracturing into the Tertiary sands in the numerical groundwater model may under-predict mine water inflows and groundwater drawdown in this important regional aquifer.
- Given there may be an underestimate of mine water inflows, discharge volumes would also be underestimated. A potential increase in this volume of water has not been assessed for impacts to flow regimes, geomorphology, water quality and consequential impacts on water related assets.
- The impact of fracturing on water quality from the mixing of surface water and water drained from overlying aquifers has not been assessed nor has potential generation of acidic water from water percolation through potentially acid forming material above the goaf. This water will need to be removed from the mine and discharged to surface watercourses.

The IESC, in line with its Information Guidelines¹, has considered whether the proposed project assessment has used the following:

Relevant data and information: The following pieces of relevant data and information are needed for potential impacts arising from proposal to be assessed:

- Expanded spatial and temporal groundwater monitoring data to determine the behaviour of groundwater levels;
- Analysis of subsidence fracturing impacts to surface watercourses, groundwater drawdown and mine inflows;
- Data characterising the geomorphology of surface watercourses and surface water-groundwater interaction;
- Data on the timing, location and water quality of surface water discharges;
- Information related to water-related ecological values; and
- A quantitative assessment of the proposal's contribution to cumulative impacts within the region.

Appropriate methodologies which have been applied correctly: Clarification and justification of the methods and approaches used to predict potential impacts are needed, particularly in relation to:

- The conceptual and numerical groundwater models not sufficiently identifying impacts on water resources or other matters of national environmental significance. Notably this includes the exclusion of a model scenario where subsidence fracturing is present in the Tertiary units;
- Incorporation of Tertiary sands into the subsidence modelling;
- While flood modelling techniques are sound, accuracy and confidence in the model would be improved by adopting more recent analytical methods and providing further information to clarify and justify model inputs and results. The flood model, as compiled, is not suitable for assessing water quality impacts;

- Inclusion of changes to floodplain flow distributions and velocities, and consequential impacts, on the rising and falling limbs of flood events; and
- The use of mean monthly discharges to assess allowable water discharges implies that Theresa Creek is a perennial rather than ephemeral watercourse.

Reasonable values and parameters in calculations: Justification and/or further information is needed to support the proponent's approach or conclusions in relation to:

- The extent of subsidence fracture height and enhanced permeability causing an underestimation of ground and surface water impacts;
- The selection of watercourse model boundaries in the groundwater model used to represent surface water-groundwater connectivity in the proposal;
- The absence of formations in the subsidence model; and
- Exclusion of faulting from the groundwater model.

The IESC's advice, in response to the requesting agencies' specific questions is provided below.

Question 1: The proponent states in Volume 1; Chapter 13 of the EIS (Attachment A), that given the distance from mines in the region and relative geological isolation from these mines (except via the basalt strata), significant cumulative impacts are unlikely. Taking into account the information provided in the EIS regarding other groundwater users in the area, does the Committee agree that significant cumulative impacts are unlikely? If not, what information is needed from the proponent to support their claim?

1. The IESC notes the absence of data presented in the EIS to enable an assessment of the likelihood of significant cumulative impacts to ground and surface water resources including the following:
 - a. There are three mines located 30-50km east of the proposed project. A qualitative approach was adopted to assess cumulative groundwater impacts in the region. The IESC considers that this qualitative approach contains assumptions, regarding the size of the projects, drawdown impacts, timing of mining and drawdown, that may result in an underestimation of the impacts. The IESC recommends that the numerical groundwater model be updated to address the matters discussed in question 2 and that the results be used in the cumulative impact assessment.
 - b. For groundwater users, the numerical model estimates extraction for irrigation as 2 ML/year for both stock and domestic bores and apportions all licensed extraction volumes equally across all bores associated with any given licence. If the actual extraction volumes vary across the model areas, then this assumption may underestimate drawdown associated with groundwater user bores and Groundwater Dependent Ecosystems (GDEs) mapped in those specific areas.
 - c. Prior to construction, properties with potential drawdown of greater than 1m will have a baseline assessment undertaken at each of the active bores to establish pre-operational condition. As the current model may be underestimating groundwater drawdown and groundwater impacts may be greater than those currently predicted, baseline monitoring should be extended to include those groundwater bores affected.
 - d. The following features would enable a comprehensive assessment of the cumulative impacts on surface water resources in the Nogoia River catchment:
 - i. Identification and sensitivity of potentially impacted ecological and human assets;

- ii. The quality, timing and volume of water discharges for the proposal, and other mines operating in the Nogoja River catchment;
- iii. Effect of cumulative water discharges on watercourse flow regimes and volumetric discharges, water quality, geomorphology, aquatic biota and ecosystems;
- iv. Effects of cumulative groundwater drawdown on surface water hydrology and water quality;
- v. Information on increased surface water-groundwater connectivity as a result of subsidence-induced fracturing and cracking, and the consequential effect on regional surface water hydrology;
- vi. Regional changes to floodplain storage and/or flood behaviour, and;
- vii. Impacts of the proposed haul roads on overland flow paths, flood behaviour and water quality.

Question 2: The EIS (Attachment A), Volume 1; Chapter 13 and Appendix I presents information regarding groundwater impacts, studies and mitigations. Please advise if: a. The numerical and conceptual groundwater models presented are adequate to predict the impacts on groundwater. If not discuss what information would address this. b. The numerical and conceptual groundwater models are adequate or do they present any concerns that may impact upon water resources or any other matters of national environmental significance? c. The Committee agrees with the groundwater level recovery time predicted by the proponent?

2. The conceptual and numerical groundwater models do not sufficiently identify impacts on water resources or other matters of national environmental significance. There are a number of inconsistencies noted in the numerical and conceptual groundwater model which reduce confidence in the predicted impacts on groundwater. These include:
 - a. Modelled scenarios and rationale: The groundwater model does not incorporate zones of enhanced permeability in the Tertiary sediments which would be consistent with the subsidence predictions presented in the subsidence report. Groundwater modelling results are only presented for fracturing in the overburden material. Constraining enhanced permeability may further underestimate mine water inflows and subsequent drawdown of groundwater. This could result in loss of surface water to groundwater and volumes of water for surface water discharge. Results of a modelled scenario consistent with the subsidence modelling should be presented to allow for a better estimate of the potential groundwater drawdown and discharge volumes.
 - b. The Emerald Formation is noted to comprise undifferentiated deposits of several sediments (gravels, sand, sandstone etc), though the proponent states that the plasticity of the Emerald Formation is likely to provide mitigation against increased permeability. However, if subsidence impacts propagate through the overburden, groundwater impacts will be larger than currently predicted which would need to be considered given significance of the alluvium, Tertiary Basalt and Tertiary sands as a water resource in the region.
 - c. Boundaries: The river bed has been set equal to the river stage, meaning that the river boundaries allow baseflow out of the aquifer, but do not allow leakage from the watercourse to the aquifer. This constraint does not provide for times between seasonal flows in the watercourses where groundwater may be recharged. Further, the numerical model sets alluvium discharges predominately into creeks. Given the project area's climate, the ephemeral nature of watercourses and groundwater monitoring bore levels in the alluvium adjacent to the creeks, these constraints result in an inaccurate representation of natural

ground and surface water interactions. Characterisation of seasonal trends in groundwater levels and interactions with surface water would provide a more adequate assessment.

- d. Recharge: Groundwater recharge is reported to be minimal, with the evidence for this statement based on limited monitoring data collected over a period of below average rainfall. An estimate of groundwater recharge was undertaken using the water table fluctuation method. The model utilises parameters at the low end of recharge values. Given the relatively high hydraulic conductivity in the Tertiary sequences, recharge rates may be considerably higher, particularly within the alluvium and basalt.
 - e. Conceptualisation: The region's geological and hydrogeological characteristics have been represented as seven layers in the proponent's conceptual groundwater model. While the main water resource units (alluvium, Tertiary basalt and Tertiary sands) have been presented as distinct hydrostratigraphic units, it was noted that several formations were combined, in particular the Emerald Formation and Permo-Triassic overburden. This may result in an over simplification of the hydrogeological regime, in particular the characterisation of the Permo-Triassic overburden and its role in mitigating potential subsidence impacts to shallower Tertiary aquifers.
 - f. The proponent notes the existence of a fault at the western edge of the longwall panels in the Permian strata, but this fault is not included in the model. Given the fault's proximity to the subsided area and Theresa Creek, the fault should be characterised so as to minimise uncertainty of its role in groundwater connectivity.
 - g. The proponent notes the likely variability in extent of the Tertiary sands. The distribution, extent and hydraulic connectivity with units above the Tertiary sands need to be characterised, as it has been identified as a significant water resource in the region. Subsidence fracturing propagated through the Permo-Triassic overburden is likely to significantly impact on the Tertiary sands. Should subsidence fracturing induce flow from the Tertiary Sands, mine inflow will increase and there may also be a reduction in groundwater levels. This will impact users of this resource, particularly when recharge is not sufficient to offset the effects of drawdown.
 - h. The proponent's interpretation of groundwater flow in the Permian strata does not appear consistent with conceptualised geology in the area. Groundwater flow is depicted to the north in the Permian, which is noted to be opposite to the dip of the Corvus 2 seam. This finding should be interpreted with caution due to vast spacing of the monitoring bores. Further monitoring bores could provide clarification and justification of these interpreted contours.
 - i. Model prediction: There was insufficient data to undertake transient model calibration. As the model is only calibrated in steady state it is likely to produce transient predictions of low confidence. The predictive model includes stresses that are outside the range included in calibration, such as the fracturing and dewatering due to subsidence. As such, the reliability of and confidence in the model's predictions is likely to be low.
3. For these reasons, the IESC considers that there is uncertainty in the current model's conceptualisation, numerical construction and predictions, which may significantly underestimate groundwater impacts and volumes of surface water discharge due to mine water inflows.
 4. The proponent states "a period of approximately 15 to 20 years after closure is required for water levels to return to within 1m of final static levels". Given the concerns relating to the model, the IESC considers that there is low confidence in the predicted groundwater level recovery.

Question 3: Does the Committee agree with the findings in Volume 1, Chapter 6 and Chapter 9 and Volume 2, Appendix F1 to F5 of the EIS (Attachment A) that changes to topography and hydrology as a result of subsidence to the west of the Blair Athol railway line are not likely to result in significant impacts during flooding from Teresa Creek? Does the committee find the proposed subsidence mitigation and management measures suitable to protect downstream surface water quality and quantity?

5. The proponent's flood study refers to a 'TC5' subsidence scenario; however, this scenario is not discussed in the EIS or supporting technical subsidence report. The flood study may be based on an earlier, and possibly different, prediction of subsidence effects. Confidence would be improved by confirmation that the flood study is based on the most recent subsidence predictions.
6. Changes in peak flood surface levels will be accompanied by a change in flow volume, timing, extent, and/or depth entering and leaving the floodplain. Such a change has not been quantified. Alterations to flood volume could impact environmental assets or other beneficial uses downstream of the proposed development. Presenting and comparing the pre- and post-development flow hydrograph would inform the assessment of potential impacts on sensitive assets.
7. The modelling techniques used to assess flood impacts appear to be sound; however the accuracy of the model and design outcomes would be improved by using more recent flood frequency analysis techniques, such as those developed by Rahman et al (2012) and Kuczera & Frank (2006), to reduce uncertainty in design flood flow estimation.
8. Confidence in the flood models and the conclusions of the flood study would be enhanced by:
 - a. Providing a comparison of pre- and post-development flood hydrographs and longitudinal profiles of peak flood surface along the floodplain within the mining lease;
 - b. Providing the rationale for the use of the CRC Forge method to estimate design rainfall for flood levels greater than the 100 year average reoccurrence interval (ARI), rather than the Bureau of Meteorology's Intensity-Duration-Frequency data;
 - c. Resolving the discrepancy between the different peak flow rates generated for the 100 year ARI event and describing the method used to derive the adopted peak flow rate of 8,521 m³/s;
 - d. Plotting measured annual series stream gauge data against the adopted flood frequency distribution to demonstrate the 'goodness of fit' of the adopted probability distribution;
 - e. Undertaking and documenting a quality assurance process for model inputs, particularly in relation to the light detection and ranging (LIDAR) dataset;
 - f. Quantifying the overall uncertainty in the model results. The models in their current form cannot be considered as calibrated to historical data. The sensitivity analysis should be expanded to include hydrological (initial loss, continuing loss, routing parameters, rainfall volume) and hydraulic (roughness and head loss coefficients) parameters that elucidate the uncertainty range in the flood behaviour.
9. The potential for increased surface water-groundwater connectivity in the Theresa Creek floodplain overlying the underground mine has not been considered. While subsidence-induced fracturing in the Theresa Creek floodplain is not expected to significantly impact peak flood conditions for 50 year ARI, or larger, flood events, the influence of fracturing on smaller floods may be more significant. Expansion of the flood study to incorporate groundwater flux and a broader range of flood events would enable the impact of groundwater drawdown on peak flood levels and flood volumes to be more comprehensively assessed and quantified.

10. Flood flow velocity impacts have not been assessed by the proponent. Subsidence within the Theresa Creek floodplain is unlikely to significantly alter peak flood flow velocities during the 100 year ARI, or greater, flood event. Floodplain flow distributions and velocities are likely to be impacted on the rising and falling limbs of the flood, particularly as the flood wave tracks across the floodplain on the rising limb of the flood hydrograph. The potential impacts of changes to flood flow velocity are likely to be limited to changes in the mobilisation of sediments. Quantification of changes to flood flow velocities, incorporating rising and falling limbs of the flood event, as well as peak flows, would enable the full range of potential flood impacts to be identified and assessed.
11. Due to the low gradient of the floodplain and relative depth of the subsided panels, the proponent has assessed that mitigation measures to prevent flooding of subsided parts of the floodplain, or drain ponded water from the floodplain, are not feasible. Although the construction of levees and diversion channels and drainage of ponded areas is possible, the impacts of implementing these mitigation measures may include changes to flood behaviour, geomorphology, and water quality, with consequential impacts on downstream water-related assets. An assessment of the benefits and potential impacts of flood mitigation measures is needed.
12. The flood models, as compiled, are not suitable to directly assess water quality impacts. Water quality modelling would assess changes to water quality components. A finer scale grid resolution would be needed in the model to assess effects of micro scale surface erosion issues, such as subsidence-induced surface cracking or changes to velocity profiles in the subsided areas.

Question 4: Is flood modelling presented in the EIS (Attachment A), Volume 1, Chapter 9 and Volume 2, Appendices F1 and F3 sufficient to determine if flood mitigations and water management systems will be effective to prevent downstream impacts on water quality and quantity? If not can you recommend any improvements?

13. Decisions regarding flood protection should be informed by local and regional flood models. While the regional flood model indicates mine infrastructure will not be affected by flooding, the local flood model indicates that the Mine Affected Water (MAW) dam and parts of the Rejects Emplacement Area (REA) will be impacted. This infrastructure may contain contaminants that could degrade water quality and as such, they should be protected from flood water. A specific mitigation plan describing how local drainage infrastructure will be designed, so as to avoid erosion of the REA, and inundation and overtopping of the MAW dam, is warranted.
14. The influence of groundwater drawdown has not been considered in the flood study. While groundwater drawdown is not expected to significantly impact flood levels during 50 year, or larger ARI events, expansion of the flood study to incorporate groundwater flux and a broader range of flood events would enable the effect of groundwater drawdown on peak flood levels and flood volumes to be more comprehensively assessed and quantified.
15. The flood models as compiled are not suitable for predicting impacts on water quality.

Question 5: The EIS (Attachment A), at Volume 2, Sections 9.12 (surface water), 12.6 (Matters of National Environmental Significance) and 13.5 (groundwater), describes mitigations in regards to the construction of the haul road. Does the Committee consider there are any significant risks from haul road construction in relation to water resources? If significant risks are identified, please discuss information that could reduce uncertainty and mitigation measures to reduce risks.

16. While the proponent has identified the majority of risks arising from construction and operation of the haul road; the following risks to water quality are not considered:
 - a. Post-mining and decommissioning;
 - b. The potential use of untreated mine-affected water for dust suppression for the haul road may result in salt and metal build up in the surface layer of the haul road, which could be eroded

during rainfall events. While sediment basins are likely to retain and settle sediments, dissolved salts may be released when the basins overflow. Untreated mine-affected water should not be used for dust suppression unless it can be demonstrated that receiving waterways will not be adversely affected; and

- c. Flood water overtopping the unsealed haul roads during flood events, potentially resulting in increased scouring and/or sedimentation in downstream terrestrial lands and/or watercourses. Under the current proposal, culverts are sized to accommodate the 5 year ARI flood event. If erosion risks are significant and cannot be adequately mitigated, culvert sizing may need to be reconsidered.
17. Development of the alternative southern haul road route within the floodplain of the Nogoa River may affect flood behaviour during significant flood events. Detailed flood modelling will evaluate this impact. Assessment of water quality impacts from scouring during significant flooding in the Nogoa River is also needed.
 18. The southern haul road corridor is likely to traverse and potentially impact multiple waterways. It therefore is likely to have greater impact on water resources than the northern haul road option.

Question 6: Are there any likely impacts, not considered in the EIS (Attachment A), that might lead to changes in surface and/or groundwater dynamics, quality or quantity. What impacts are these changes likely to have on other water users (human and ecological)?

19. Subsidence related water impacts: The proponent's subsidence model predicts that fractures will propagate from the mining level through the overlying Permian rockmass and into overlying aquifers such as the Tertiary sands and overlying basalt. Furthermore, there will be contiguous fracture connection between the surface and underground mine workings above most mining areas, and connection of this contiguous fracture with the surface may develop. Potential subsidence impacts include:
 - a. Subsidence cracking that could affect the integrity of the raw water dam north of LW 202 and represents a significant operational and environmental hazard, particularly if dam failure occurred; however, mitigation measures are not discussed. Other sensitive mine infrastructure is within the same distance from longwall mining as the raw water dam, including the MAW dam, the MIA and potentially, flood protection infrastructure. Risks to such infrastructure are not discussed.
 - b. Reduced integrity of the capping layer over the REA material, the possible clay lining at the base of the REA, and the encapsulation of potential acid forming (PAF) material within the REA. The proponent should discuss proposed mitigation for subsidence impacts on the REA to increase confidence that acid mine drainage (AMD) impacts to surface and groundwater will not occur.
 - c. Creation of a series of depressions across the landscape, particularly in the area of the unnamed tributary of Theresa Creek and the Theresa Creek floodplain, with up to 2.6m of subsidence predicted. Changes in topography will restrict water flow, alter the natural direction of drainage, cause ponding within subsidence troughs and reduce floodplain connectivity. Subsidence is likely to result in the disconnection of the headwater end of the waterways from Theresa Creek. The impact from subsidence on vegetation communities, particularly coolabah woodland, and on aquatic ecosystems, is predicted to be high.
 - d. Subsidence fracturing may reduce ponding duration within the Theresa Creek floodplain and increase the volume of water to be managed within, and discharged from, the mine water management system.
20. Subsidence modelling: The hydrogeological study identified a thick layer of Tertiary sands (up to 30m thick within the mining area) with flowing or drifting tendencies when encountered during

drilling. These properties are described as “limited matrix support or consolidation”. This layer is not discussed in similar terms in the geological conceptualisation for the subsidence model. Although a 20cm sand layer was identified, it appears to not be included in the model. Further, cross sections depict the Tertiary sands as sitting directly on top of the coal measures, raising uncertainty of the geological conceptualisation included in the subsidence model and the confidence in the model's predictions.

21. The subsidence model indicates that up to 64 different modes of yield or stress state will occur in the strata above longwall mining, however subsequent discussion describes these states as shear or tensile cracking at surface. Longwall subsidence can cause a variety of surface impacts and deformation effects, in addition to tensile cracking, and given the detail provided by the model simulation, it is unclear why such impacts are not included in the discussion. Consideration of potential subsidence impacts to surface features and water resources would improve understanding of impacts to surface water resources, and provide certainty that the proposed mitigation measures address all relevant impacts.
22. Surface and groundwater connectivity: As a result of mine dewatering, predicted groundwater drawdown within the unconfined alluvium beneath Theresa and Gordonstone Creeks may alter the hydrology and water quality of these watercourses, potentially increasing the duration of no-flow events and reducing the volume of surface water discharged from these creeks. Groundwater drawdown may also reduce or remove water from the persistent waterholes in these watercourses. Dry season sampling reveals that persistent pools in Theresa Creek and Gordonstone Creek provide refugia for fish and macroinvertebrates.
23. Surface water: The Environmental Management Plan (EMP) suggests that one of the release point options for mine-affected water discharges is the subsidence impacted tributary of Theresa Creek. The large volume of water proposed for discharge and the ponding effect caused by subsidence is likely to exacerbate geomorphic issues such as water-logging, erosion and flooding of this part of the Theresa Creek floodplain. Selection of water release points that do not significantly alter baseline flow regimes, or exacerbate erosion or flooding, could minimise the impacts of mine-affected water discharges.
24. The proponent states that discharges of mine-affected water will meet the requirements of an Environmental Authority (EA); however, discharge scenarios, release points, discharge water quality, and water quality investigation trigger values have not been proposed in the draft EMP. This information would inform an assessment of the impacts of mine affected water discharges on the hydrology and water quality of Theresa Creek, Gordonstone Creek and the Nogoia River, as well as subsequent impacts on dependent ecosystems and other downstream users of surface water resources.
25. A limited assessment of impacts on surface water resources within the Nogoia River catchment concludes that the proposal will not contribute to cumulative impacts. However, the exclusion of several important causes of potential impacts to surface water resources, as outlined elsewhere in this advice, increases the likelihood that cumulative impacts have been underestimated.
26. The proponent has based their estimate of allowable mine affected water discharge volumes on an interpretation of Theresa Creek stream gauge data that is inconsistent with the ephemeral flow regime classification of this waterway. Under this interpretation, discharges of mine-affected water may be permitted in the dry season. Discharges that change flow regimes from ephemeral to perennial have the potential to significantly alter aquatic ecosystem function and species composition, and facilitate introduction and colonisation of pest species in watercourses.
27. Water Quality: A preliminary geochemical assessment of lithologies comprising waste rock from mining has been undertaken but a number of uncertainties regarding impacts to water resources remain. These pertain to:

- a. Static testing undertaken for limited lithologies (Corvus I seam, roof & floor; Corvus II seam, roof & floor) with the proponent noting that sampling is not statistically representative. Given the wide range of values between individual samples and the associated standard deviation for the data provided, the assessment of risk associated with acid drainage is uncertain.
 - b. No testing of metals in potential leachate from the REA has yet been undertaken; instead whole-rock assays have been performed and elemental abundance measurements have been compared to a published geochemical abundance index. This analysis may not adequately identify risks to surface or groundwater as it does not distinguish the chemical form of metals in the REA and hence the solubility of key water quality constituents likely to be present. The analysis also does not account for the effect of contaminants in the environment, where soluble metals below average global abundance may exceed local water quality objectives and be harmful to aquatic ecosystems, or affect suitability for stock or agriculture.
28. Given the 7-10m vertical separation between the Corvus I and the underlying Corvus II seam, goafing effects may lead to in-situ dewatering and oxidation of PAF materials in the Corvus I seam and floor. Discussion of potential impacts and mitigation is limited to the following: no calculations (or kinetic testing) are provided to demonstrate that natural groundwater pH will be sufficient to buffer acid forming potential; the level of increased salinity due to neutralisation of acid groundwater is not discussed, nor is potential mobilisation of contaminants and metals in aquifers. Risks to surface water resources due to mine dewatering of poor quality or acid groundwater are not discussed.
29. Rehabilitation and decommissioning of the REA does not address whether the final landform may continue to release leachate post mining or at what quantity or quality. While the proponent proposes to capture leachate and runoff from the REA in a sediment dam during operation, it is unclear whether this will continue post mining or if potential leachate from the REA will discharge directly into local drainage channels.
30. Water balance: The catch dams for the REA have been designed with the assumption that the primary pollutants entrained in runoff from the waste rock stockpile and MIA are sediments. This is inconsistent with the waste rock geochemical assessment results that indicate waste coal and coal rejects are present and potentially acid forming, and that surface runoff from the REA may be of low pH and contain elevated concentrations of salts and/or dissolved metals. Discharge of potentially contaminated runoff from REA increases risks to downstream water resources, aquatic ecosystems and town water supplies. The proposed management of runoff from the REA and the design of dams to manage this runoff should be revised with consideration of the preliminary geochemistry results. Considering the potential contamination risks and the uncertainties presented in the preliminary geochemistry assessment, the runoff from the REA would be more appropriately managed as mine-affected water.
31. The volumetric catchment runoff input to the site water balance is not presented in the water balance modelling results. Further, surface runoff from the REA, which comprises 72% of the surface infrastructure area, has been excluded from the site water balance. There is an increased risk that the water surplus simulated from the model is underestimated, and the discharge requirements are potentially higher than predicted. In order to more accurately predict the volume of water to be managed in the mine water management system, the volume of surface water and REA runoff should be included in the water balance model.
32. Use of water from Fairbairn Dam for dust suppression along the haul roads is likely to result in the need to discharge a larger volume of mine affected water than is currently proposed in the Site Water Management Strategy. The source of water for dust suppression should be clarified and the water balance updated, if necessary.
33. Water-dependent ecosystems: There is insufficient groundwater level data to determine the scale and extent of surface water-groundwater connectivity or the use of groundwater by vegetation. In

particular, there is insufficient evidence to support the prediction that groundwater drawdown will not significantly affect the baseflow in Theresa or Gordonstone Creeks or the condition of any groundwater dependent vegetation.

34. The proponent has identified eight springs in two clusters in areas of outcropping Tertiary basalts. Predicted drawdown indicates that all springs will be impacted, with four of the springs, those within and adjacent to the mine footprint, expected to dry up. The proponent suggests that these springs may represent localised perched groundwater discharge, but this requires confirmation. In addition, subsidence and associated deformation to geological structures associated with the mine are likely to have a “longer-lasting” hydrological impact on all springs. No ecological surveys have been carried out at the spring sites so ecological impacts have not been considered in the EIS.
35. The proponent identifies three vegetation communities as GDEs. The proponent suggests that groundwater levels are too deep (14m) to be accessed by these communities and that impacts from predicted minor drawdown in the shallow alluvium due to mining operations are low. However, 14m is within the range at which groundwater use by trees is possible (Eamus, Froend, Loomes, Hose & Murray 2006). Further, monitoring of groundwater levels on site was only carried out for a few months over a period with negligible rainfall. Groundwater levels following periods of recharge may be shallower and therefore more likely to be accessed by vegetation.
36. The desktop review identified the Fitzroy River turtle as having been recorded within 100 km of the Project Area. The Fitzroy River turtle is listed as vulnerable under the EPBC Act and is endemic to the Fitzroy Basin. This species was not observed during the field surveys, but was not specifically targeted. Its presence during the dry season is considered unlikely due to the lack of suitable habitat. It prefers fast-flowing riverine habitat which is not permanently available within the project area. However, this species has the potential to disperse some distance upstream from the Nogoia River into the project area during the wet season.

Question 7: What monitoring and management practices could be used to address the impacts identified in response to the questions above that will ensure that suitable outcomes for water-related assets are achieved?

Subsidence: Robust approaches for estimating the permeability caused by fracturing are available but have not been adopted by the proponent. These approaches include geotechnical and hydrogeological modelling that incorporates the effect of subsidence induced fractures and the degree of connectivity throughout the fracture network over time using the FLAC and MODFLOW – SURFACT modelling platforms. Such techniques have been used in the Hunter Valley in NSW (SCT, 2008). Given the significant potential impacts to mine inflows and impacts to groundwater and surface water resources, additional information regarding potential flow rates through the fracture network would allow impacts to groundwater and surface water resources.

37. The risks to the MAW dam and other infrastructure due to subsidence cracking should be clarified. To minimise the risk of impacts to downstream water users, mitigation measures, including relocation of sensitive infrastructure such as the MAW dam to areas unlikely to be affected by subsidence should be considered.
38. Surface Water: To inform the extent and scale of potential impacts, the baseline geomorphology, hydrology and water quality studies should incorporate the following matters:
 - a. Comprehensive characterisation and quantification of existing surface water-groundwater dynamics in Theresa Creek and Gordonstone Creek, including within the waterholes that persist during the dry season;
 - b. Incorporation of longitudinal and cross section profiles of potentially affected watercourses, which indicate the relative position of the water table to creek beds in the wet and dry season;

- c. Inclusion of an additional monitoring site at the southern limit of the unnamed tributary of Theresa Creek to the west of the Blair Athol railway line, particularly in light of the anticipated subsidence impacts on this tributary and its possible use as a receiving waterway for mine-affected water; and
 - d. Given the high flow variability within the Theresa and Gordonstone Creeks, sampling over several years would inform the development of local water quality objectives and trigger values.
39. In order to provide an accurate and consistent understanding of watercourse hydrology that informs the development of discharge scenarios and minimises impacts on water-dependent ecosystems, it is suggested that:
- a. Classification of flow regimes be based on published literature, such as Kennard *et al* (2010) or Mackay *et al* (2012) and consistently applied across the proponent's technical studies;
 - b. Flow duration curves be developed for the Theresa Creek stream gauges and calculation of allowable mine site discharges be based on these rather than 'mean' monthly flow; and
 - c. Proposed discharge scenarios should not change the flow regime of receiving watercourses.
40. The definition and quantification of discharge scenarios, water release points, on site contaminant and end of pipe water quality limits and flow, and the investigation of trigger levels, would allow for re-evaluation of the scale and extent of potential impacts. A revised impact assessment, proposed monitoring, mitigation and management measures may be needed.
41. At a minimum, the discharge scenarios and trigger values should consider the Model Water Conditions for Coal Mines in the Fitzroy Basin (DEHP, 2013), the National Water Quality Management Strategy (ANZECC and ARMCANZ, 2000) and the water quality objectives for the Nogoa River (DEHP, 2011).
42. The proposed operational water monitoring program would be strengthened by including reference condition monitoring sites, as well as additional impact monitoring sites to verify the conclusions of the assessment documentation and detect any additional impacts from:
- a. Proposed water discharges, including from the REA;
 - b. Groundwater drawdown, including impacts on watercourse hydrology and water quality;
 - c. Loss of surface water due to subsidence-induced fracturing and cracking; and
 - d. Changes to the Theresa Creek floodplain, including quantifying the extent and duration of subsidence-induced ponding in the unnamed Theresa Creek tributary to the west of the Blair Athol railway line, and subsidence-induced erosion and sedimentation.
43. Surface and groundwater connectivity: Incorporation of the potential increase in surface water-groundwater connectivity due to subsidence-induced fracturing would ensure that the full range of impacts on surface water hydrology and water quality is evaluated.
44. Water balance: It is suggested that the mine water balance, discharge scenarios and impacts on receiving watercourses are re-evaluated if further studies proposed in the response to question 6 indicate that subsidence-induced fracturing will increase surface water-groundwater connectivity across the mine lease.
45. Water Quality: Given the elevated electrical conductivity and concentrations of dissolved metals likely to be present in abstracted groundwater, mine-affected water may require treatment prior to discharge. Water quality modelling would inform the need for water treatment facilities, and the design of these facilities if they are needed.

46. The proponent has identified that a second phase of geochemical assessment will be undertaken for the supplementary EIS. The following additional measures should be considered to address and mitigate risks to surface and groundwater resources due to AMD:
- a. The proposed sampling and testing should be expanded to provide volumetric estimates of PAF material likely to be excavated. The assessment should also consider spatial variability, including the possibility that acid forming mineralisation may be associated with the fault running to the west of longwall panels LW101 – LW116.
 - b. Immediate element solubility and leach testing of REA materials should inform the design of appropriate site water management strategies. As discharge of runoff and leachate from the REA is proposed, the quality of water discharged from the site should meet water quality objectives without treatment, or further details on treatment/water management should be provided.
 - c. Kinetic testing for overburden materials likely to be dewatered and oxidised in situ during mine operations should also be undertaken to improve understanding of risks to groundwater resources. Neutralisation capacity of groundwater and surrounding rock should be assessed against the results of the kinetic tests. The design of groundwater monitoring networks should address potential contamination from salinity and mobilisation of metals in the context of post-mining groundwater flow paths created due to subsidence fracturing.
 - d. Detailed assessment of the source of REA capping material and relevant properties (e.g. dispersivity or cracking clay) would improve confidence of adequate mitigation against AMD.
 - e. Lining the base of the REA with suitable low-permeability material to minimise groundwater infiltration and hence potential contamination with acid, saline or metaliferous leachate. Given the limited thickness of stored REA materials, details on the effectiveness of the proposed encapsulation techniques would improve confidence in the conceptual REA design for containing and minimising AMD.
 - f. Provide discussion of proposed mitigation for subsidence impacts on the REA (including consideration of alternative locations for the REA not subject to subsidence) to increase confidence that AMD impacts to surface and groundwater will not occur.
 - g. The appropriateness of the proponent's proposal to capture runoff from the REA in a sediment basin is discussed in question 6. While the location of such a sediment basin, or other collection basins, has not yet been determined, it is likely that it would be located within the area subject to subsidence. The proponent should therefore address likely subsidence impacts on a sediment collection basin, in particular:
 - i. Design of appropriate mitigation strategies to ensure that infiltration due to surface cracking does not lead to contamination of groundwater resources;
 - ii. Ensure, with appropriate design, monitoring and management that the integrity of containment structures not be impacted due to subsidence effects; and,
 - iii. Consider alternative locations for the REA and runoff collection basins which will not be affected by subsidence.
47. Water-dependent ecosystems: Groundwater level data of appropriate duration would determine seasonal variation in groundwater levels and assess potential groundwater-surface water interactions. Details of the location and frequency of monitoring in the proposed Environmental Authority (EA) are not provided. Monitoring locations should include the Theresa Creek alluvium and the vicinity of the identified GDEs including springs.
48. More detail is needed on the proposed investigations and monitoring to establish baseline data for the hydrogeology and ecology of the identified springs. Investigations would confirm whether they are sourced from perched groundwater and ecological surveys would determine the ecological

values likely to be impacted by groundwater drawdown. Following this, mitigation strategies need to be identified.

49. A pre and post-construction monitoring program would be needed to monitor potential changes of floodplain drainage, ponding and associated changes to aquatic ecosystems from subsidence. This plan should include monitoring of ecological condition of the aquatic and terrestrial ecosystems which may be affected by subsidence, identification of subsidence mitigation measures, and monitoring of the effectiveness of the proposed measures.
50. An assessment of altered aquatic habitat due to the proposed project on the Fitzroy River Turtle and the implications for habitat availability for this species during periods of high rainfall/flooding should be considered.

Question 8: Overall does the committee consider that the proponent has provided sufficient information on the water resources and its management to assess likely significant impacts from its proposed action? – If the information is considered insufficient for that purpose, what advice regarding areas of inadequacy can the committee provide?

51. Commitments to the mitigation and management of surface and groundwater water impacts in the EMP largely refer to the future development of management plans or high level descriptions of future data gathering exercises. The provision of mitigation and management measures would enable their adequacy to be assessed and increase confidence in the conclusions of the assessment documentation in relation to the proponent's assessment of the significance of residual impacts.
52. As documented above, the IESC considers that the proponent has not provided sufficient information on the water resources and their management to assess likely significant impacts from its proposed action. There are numerous conflicting pieces of evidence and omissions, which give rise to uncertainties in the proponent's evaluation of impacts.
53. The IESC recommends that once the issues raised in this advice are addressed by the proponent, an updated risk assessment be undertaken and documented.

Date of advice 14 March 2014

Source documentation available to the Committee in the formulation of this advice

Teresa Coal Project, December 2013, Environment Impact Statement

ANZECC and ARMCANZ (2000) Australian Guidelines for Water Quality Monitoring and Reporting. National Water Quality Management Strategy (NWQMS). Document 4 and 7. Australian and New Zealand Environment and Conservation Council & Agriculture and Resource Management Council for Australia and New Zealand, Canberra.

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Kennard, M.J., Pusey B.J., Olden, J.D., Mackay, S.J., Stein, J.L., & Marsh, N. (2010) Classification of Natural Flow Regimes in Australia to Support Environmental Flow Management, *Freshwater Biology*, 55:171-193

Kuczera G and Frank S, *Australian Rainfall and Runoff, Book IV, Estimation of Peak Discharge-Draft*, Engineers Australia, Jan 2006, downloaded 17 February 2014

Mackay, S., Marsh, N., Sheldon, F. & Kennard, M. (2013) *Low-flow Hydrological Classification of Australia*, National Water Commission, Canberra

Rahman, A., Haddad, K., Zaman, M., Ishak, E., Kuczera, G., and Weinman, E., *Australian Rainfall and Runoff, Revision Project 5: Regional Flood Methods*, ISBN 978-0-85825-908-

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Strata Control Technologies (2008) *Assessment of Longwall Panel Widths and Potential Hydraulic Connection to Bowmans Creek – Ashton Mine*. Report for Pikes Gully Seam Longwall 5-8 Subsidence Management Plan, Ashton Coal Mine, Ashton Coal Operations Ltd (available at <http://www.ashtoncoal.com.au/Resources/Reports--Publications/Subsidence-Management-Extraction-Plans/Pikes-Gully-Subsidence-Management-Extraction-Plans/Longwall-5-8/Appendix-B-Hydraulic-Connection-Assessment.pdf> accessed on 19/2/14).

**References
cited within the
Committee's
advice**

¹ Information Guidelines for Proposals Relating to the Development of Coal Seam Gas and Large Coal Mines where there is a Significant Impact on Water Resources available at: <http://www.environment.gov.au/coal-seam-gas-mining/project-advice/pubs/iesc-information-guidelines.pdf>
