

## Advice to decision maker on coal mining project

### Proposed action: Carmichael Coal Mine and Rail Project, Queensland (EPBC 2010/5736) – New Development

<b>Requesting agency</b>	Department of the Environment, and  The Office of the Coordinator-General, Queensland Department of State Development, Infrastructure and Planning
<b>Date of request</b>	06 November 2013
<b>Date request accepted</b>	07 November 2013
<b>Advice stage</b>	Assessment (draft Supplementary Environmental Impact Statement)

#### Advice

The Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development (the Committee) was requested to provide advice on the Carmichael Coal Mine and Rail Project in Queensland which is being assessed by the Department of the Environment (the Department) in accordance with the provisions of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and the Office of the Coordinator-General, Queensland Department of State Development, Infrastructure and Planning (the Coordinator-General), in accordance with Part 4 of the *State Development and Public Works Organisation Act 1971* (SDPWO Act).

This advice has been based on the draft Supplementary Environmental Impact Statement (draft SEIS) provided by the regulators. However, the Committee is aware that in the process of finalising its advice, a final version of the SEIS was publically released on 25<sup>th</sup> November 2013. The respective joint referral regulators both confirmed that the Committee should base its advice on the draft SEIS.

The Carmichael Coal Mine and Rail Project is a greenfield coal mine in the Galilee Basin located approximately 160 km north-west of Clermont in Central Queensland. The mine proposes six open cut pits and five multi-seam underground mines producing up to 74 million tonnes per annum (Mtpa) of raw coal, equating to up to 60 Mtpa of thermal coal for export over a 60 year mine life. The mine footprint is over 200 km<sup>2</sup>. Additional infrastructure includes a rail line and associated facilities connecting with the existing Goonyella and Newlands rail systems; an airport; an offsite workers accommodation village for up to 3500 employees; a heavy industrial area; and offsite raw water supply infrastructure. The Carmichael River bisects the mine site and a single crossing is proposed to connect the northern and southern mine areas. Six voids are expected to remain after closure of the mine with possible depths up to 300m below pre-development ground surface.

The Committee, in line with its Information Guidelines<sup>1</sup>, has considered whether the proposed project assessment has used the following:

Relevant data and information: key conclusions

Groundwater flow conceptualisation: There are important data gaps, especially in the deeper groundwater systems, most notably hydraulic head information, which bring into question the conclusions being drawn about groundwater flow directions. The groundwater flow interpretation contained within the draft SEIS appears to be based primarily on shallow groundwater monitoring. This interpretation is not considered to be consistent with expected groundwater flow for deeper formations, given regional geology and accepted regional groundwater flow directions within the Great Artesian Basin (GAB).

There is insufficient data provided in the draft SEIS to substantiate the proponent's groundwater flow conceptualisation.

Rewan Formation: The current groundwater model assumes the Rewan Formation will respond uniformly as an aquitard. However, the Committee questions this assumption based on variability in the hydraulic conductivity field data. Further data collection and assessment of the Rewan Formation is necessary. In addition, more data is needed to predict the effect of potential subsidence induced fracturing in the Rewan Formation on leakage rates from the GAB to the coal seam. Information on the degree of groundwater connectivity between the coal seams and the GAB is essential to understand the potential impacts of this project.

Springs: The source aquifer for the Mellaluka Springs Complex has not been determined, and as such it is not possible to accurately predict impacts from mining on these Springs. For both the Mellaluka and Doongmabulla Springs Complexes there is insufficient information on ecology and water chemistry, particularly in relation to potential seasonal variability, to design scientifically appropriate management and mitigation strategies. The Committee has little confidence in the capacity of the groundwater flow conceptualisation and groundwater flow model to predict the impact on these Spring Complexes.

Ecological Impacts: Additional information to quantify the likelihood and extent of ecological impacts e.g. to riparian vegetation, as a result of changes to surface and groundwater systems would be beneficial to inform the development of mitigation and management measures.

Cumulative Impacts: The proponent undertook a limited cumulative impact assessment including four other proposed projects in the region. There are, however, additional relevant proposed projects which should be included in the cumulative impacts assessment, including the China Stone Coal Project. These proposed developments extend over 300 km in length within the Galilee Basin and comprise some of the largest coal mines in Australia. On this basis, the Committee considers that information on cumulative impacts should be commensurate with the scale of all proposed developments.

Application of appropriate methodologies: key conclusions

Numerical Groundwater Model: The Committee is not confident that the proponent's groundwater model will be able to accurately predict responses to perturbation of the groundwater system arising from the proposed mine. The Committee does not have confidence in the model's predictions for the potential groundwater impacts to the Doongmabulla and Mellaluka Spring Complexes and the Carmichael River.

The Committee has significant concerns in relation to the use of no flow boundaries at most of the edges of the model domain and the truncation of the Clematis Sandstone (and other geological formations) on the western side in the numerical model. It appears that surface water catchment

boundaries have been used to define the overall model domain, for both shallow and deeper groundwater systems. It is not good practice to employ model boundary conditions such as no flow boundaries without justification and validation. The use of no flow boundary conditions in a groundwater flow model can have profound effects on its predictions. Due to these unjustified and unvalidated assumptions, the Committee does not consider that the numerical model provides a reasonable prediction of the impacts of the development.

**Regional Faults:** The conceptual model would benefit from an assessment of regional faults. The proponent's groundwater model does not take into consideration the influence of faulting within the Rewan Formation. The Committee notes that faults have been identified on the eastern boundary of the Galilee Basin within the Rewan Formation in other project proposals, but their potential role on groundwater flow processes has not been considered in this project.

**Subsidence Fracturing:** The assessment of the height of the subsidence fracture zone above longwall mining was not based on local site data nor with due consideration of multi-seam mining. The draft SEIS notes that these factors are significant and may result in underestimation of the fracture zone height above longwall mining. Likewise the connectivity of the fracture network and the relative increase in hydraulic conductivity of strata within this zone needs verification. Subsidence fracture zone height and hydraulic connectivity could have implications for the GAB and surface water resources.

#### Reasonable values and parameters in calculation: key conclusions

The Committee supports URS's peer review recommendation on the need to *"validate the location and type of boundaries in the model, emphasising suitability, impact on model results/predictions, and assumptions used when selecting the model boundaries."*

The proponent's field data needs to be further integrated into the groundwater model to establish an appropriate set of values and ranges for model layers, in particular, hydraulic conductivity parameters for the Rewan Formation. Sensitivity analysis of the groundwater model confirms that the integrity of the Rewan Formation plays a critical role in controlling impacts to the GAB and the Doongmabulla Springs Complex. This role may also extend to include ecological communities supported by discharge from the GAB, the groundwater dependent Waxy Cabbage Palm and other threatened species in the region.

**Rewan Formation:** On-site measurements of hydraulic conductivity values for the Rewan Formation ranged across several orders of magnitude, consistent with the variable lithology presented from drilling logs. These variations in local geology, including the potential for faulting, deep weathering or lateral gradation into the Warang Sandstone, may increase the permeability of the Rewan Formation. The implications of this contrasting behaviour for regional groundwater processes need to be further explored.

The Committee's advice, in response to the Department's specific questions is provided below.

#### ***Question 1: To what extent has the revised information provided by the proponent addressed the Interim Committee's advice?***

1. The revised information has filled a number of data gaps identified by the Interim Committee. Notwithstanding, there remain important data gaps and modelling inaccuracies which bring into question the hydraulic conductivity values employed by the model, the results of the groundwater model and conclusions being drawn about groundwater flow which directly affect the predicted impacts and proposed mitigation strategies.
2. The Committee acknowledges the Queensland Department of Natural Resources and Mines' preliminary work on a regional scale water balance assessment for the eastern edge of the

Galilee Basin. The water balance work is to now include a regional groundwater and surface water quality monitoring program. This information is not yet available to the Committee.

3. Changes in the draft SEIS addressing some of the Interim Committee's comments include:
  - a. An updated groundwater model which was independently reviewed, however, the peer review highlights inconsistencies with the modelling with which the Committee agrees. The review recommendations do not appear to have been addressed or rectified in the draft SEIS.
  - b. Additional subsidence modelling and sensitivity analysis of groundwater modelling parameters, with the notable exception of flow boundaries. However due to uncertainty around model parameters for hydraulic conductivity and the characterisation of the Rewan Formation, conclusions on impacts to the GAB and springs need to be reconsidered.
  - c. Assessment of the overburden materials for the potential to produce acidity and salinity in the final void has only partially been addressed.
  - d. Additional studies on GAB impacts and on the Doongmabulla Springs and, to a lesser extent, Mellaluka Spring complex sites have been undertaken.
4. Areas not fully addressed in the draft SEIS in response to the Interim Committee comments include:
  - a. Revision of the groundwater model and more in-depth spring surveys to enable a more rigorous assessment of potential impacts on the Doongmabulla and Mellaluka Springs Complexes, along with the development of appropriate and better aligned mitigation measures.
  - b. The development of an appropriately scaled regional groundwater model and water balance, commensurate to the size of the development, to reduce uncertainty in regard to cumulative impacts.
  - c. Ecological issues associated with a range of threatened species including the Waxy Cabbage Palm, Black Throated Finch and groundwater dependent vegetation.

*Question 2: Is the conceptual groundwater model adequate, or what changes should [be made] to the conceptual groundwater model?*

*Question 3: Are the revised groundwater models and the relevant data and analyses adequate to assess the potential impacts to groundwater?*

5. A combined answer to question two and three are provided below as they are interrelated.
6. The conceptual groundwater model is not adequate nor underpinned by sufficient representative data. There is insufficient hydraulic head information, particularly in the deeper geological units, to justify the groundwater flow predictions made by the groundwater flow model. Further hydraulic head information, especially in the deeper geologic units, and at a regional scale both within and beyond the mine site is required in order to better constrain the groundwater model.
7. The Committee considers that the revised groundwater model is not adequate to assess the potential impacts on groundwater, including springs, groundwater dependent ecosystems and the Carmichael River. Due to inappropriate boundary conditions the Committee has no confidence in the results of the groundwater model.

8. Groundwater Flow: The contour maps (based on limited regional bore data in some formations) depict (pre mining) groundwater flow towards the Carmichael River in each of the formations. For the shallow tertiary and alluvial aquifers the flow direction is conceivable and may be consistent with topographically driven flow. However the Committee questions the application of this flow direction to deeper formations in the absence of substantiating information, noting theoretical research in this regard. Geological cross sections of Permian and GAB Formations indicate, as expected, a general dip to the west. As such groundwater flow in deeper aquifers would be anticipated to conform to the generally recognised regional westerly flow within the GAB from the eastern recharge zone towards the centre of the basin. Furthermore, the groundwater contours are based on point measurements from bores that are in a relatively straight line (trending north-south), which leads to multiple interpretations and may introduce bias when determining groundwater flow direction. The independent peer review of the groundwater model undertaken by URS also notes that the model flow direction is at odds, and is not consistent, with the regional flow direction and geology.
9. Model extent and boundary conditions: The URS review of a draft version of the groundwater model recommends that the proponents “*validate the location and type of boundaries in the model, emphasising suitability, impact on model results / predictions, and assumptions used when selecting the model boundaries.*” This recommendation has not been adequately addressed in the draft SEIS.
10. The Committee can find no evidence in the documentation provided to substantiate the truncation of the Clematis Sandstone (and other geological units) on the western side in the numerical model. This truncation and the no flow boundary condition employed forces the numerical model to indicate groundwater flow towards the Carmichael River based on limited available bore data (noting that the proponent raises doubts as to whether some of these bores are in fact completed in the Clematis Sandstone). As all the information presented indicates that the Clematis Sandstone extends to the west of this truncation in the numerical model, the Committee cannot accept that such a truncation is valid. As a result, impacts on the Clematis Sandstone, or its dependent ecosystems including the Doongmabulla Springs Complex, cannot be inferred from the numerical model predictions.
11. Further, the Committee can find no justification in the documentation provided, for the apparent delineation of ‘no flow’ boundaries in the numerical model based on surface water catchments particularly for the Triassic and Permian hydrogeological units. As depicted in the geological cross-section, both the GAB and Permian Formations extend well to the west of the proposed mine area and beyond the numerical model boundary. As a consequence the Committee has no confidence in the predicted groundwater flows in the Permian and Triassic Formations.
12. The Committee recommends that the western truncation of the Clematis Sandstone and the ‘no flow’ boundaries be removed, unless adequate justification is provided, so that the numerical model better reflects the known geology and groundwater flow of the region to allow a better assessment of the potential impacts of the proposed development. Further the model domain should be extended, especially to the west, and additional groundwater levels for the Clematis Sandstone and Permian Formations be added to both better constrain the model as well as to validate groundwater flow conceptualisation and groundwater model results. Once these adjustments have been made the model should be re-run with methods and results provided to the regulators.
13. Rewan Formation: There is uncertainty around the capacity of the Rewan Formation to act as an aquitard to limit vertical leakage between adjacent formations, with consequent uncertainty on potential impacts to the GAB and Doongmabulla Springs Complex. There is a wide range of horizontal hydraulic conductivity (ranging from  $1.0 \times 10^{-1}$  m/d and  $9.5 \times 10^{-5}$  m/d) and limited vertical conductivity data. The Committee notes other evidence that suggests that north of this proposal

the Rewan Formation appears to grade laterally into the Warang Sandstone, which is described as an aquifer; implying that in this region literature values for the Rewan Formation conductivity may not be appropriate. The numerical model used a 'blanket' figure for hydraulic connectivity which was lower than the mean of the field values. Given that the sensitivity analysis indicated the significance of the Rewan Formation in mitigating impacts on the Doongmabulla Springs and the GAB, the Committee recommends that as part of the revised model the mean of the measured hydraulic conductivity values be used.

14. The proponent's groundwater model does not take into consideration the potential of faulting within the Rewan Formation. The extent of faulting in the Rewan Formation should be determined in order to inform the connectivity assessment. The conceptual model would benefit from an assessment of regional faults to enable greater certainty on the scale of impacts possible from this proposal.
15. The Committee highlights the importance of ongoing monitoring and assessment of hydrogeological field data (using appropriate sampling methods) to update and improve the conceptualisation of the system and its parameters prior to and during the operation of the mine, particularly in light of the 60 year life of the mine.

*Question 4: What are the key uncertainties and risks of the project and/or potential impacts on groundwater and surface water resources, and other water dependent matters of national environmental significance?*

16. Key risks and uncertainties in relation to understanding potential impacts are:
  - a. The characterisation and role of the Rewan Formation, given its importance as a barrier to groundwater flow and minimising drawdown impacts on the overlying GAB Formations;
  - b. Very limited understanding of regional faults in the area;
  - c. The lack of confidence in the interpretation of groundwater flow direction;
  - d. The limited extent of the model domain and the use of no flow boundaries in the groundwater model; and
  - e. The adequacy of hydrogeological values used in the groundwater model.
17. The potential impacts to groundwater and surface water resources as drawn from the proponent's draft SEIS documentation include;
  - a. The Doongmabulla Spring Complex<sup>i</sup> is an EPBC Act listed endangered ecological community which will be impacted by groundwater drawdown and is assigned to the highest conservation ranking under the recovery plan for the springs community;
  - b. Significant impacts to Mellaluka Springs, (located four to ten kilometres south of the project site) have been predicted;
  - c. Potential impacts to terrestrial vegetation communities that may rely on shallow groundwater (<20 meters below ground level), for example along watercourses;

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<sup>i</sup> These springs are located 8 km west from the project site and sourced by water from the Clematis Sandstone. It provides habitat for a number of endemic fauna and flora species and contains the larger of two known populations of the EPBC-listed species *Eryngium fontanum* (blue devil). The Doongmabulla Springs Complex is also considered to be critical habitat for the survival of this EPBC-listed community.

- d. Reduced baseflows and groundwater drawdown are predicted to result in up to 100% canopy dieback of riparian tree cover in the worst affected area involving the River Red Gum, Paper Bark and the EPBC Act listed Waxy Cabbage Palm;
  - e. Permanent changes to the flow regimes, stream morphology and water quality;
  - f. Permanent reduction in the Carmichael River base flows after mine closure of 31% of the long term average pre-development baseflow due to reduced groundwater baseflow and discharge from the Doongmabulla Springs Complex, and a local reduction of surface water flows of 21.5% flows; and
  - g. The proposed extraction of up to 12,500 ML per annum from the Belyando sub-catchment, together with the predicted reduction of flow from the upstream Carmichael River sub-catchment, and a range of changes to surface water flow (i.e. flood patterns, stream morphology), has the potential to contribute to downstream impacts.
18. The Committee considered the following risks and uncertainties from the proposal:
- a. The Committee is not confident that the proponent's groundwater model, based on the current conceptualisation will be able to accurately predict responses to perturbation of the groundwater system arising from the proposed mine;
  - b. There is unresolved uncertainty about the potential impacts on GAB groundwater resources, given that the groundwater model does not consider flow to the GAB outside the model domain.
  - c. There is unresolved uncertainty around the impacts that reduced flow will have on riparian ecosystems and individual species, with the proposal information providing a generalised discussion on the impacts to terrestrial and aquatic ecosystems and does not identify or consider species' tolerances to predicted changes in flow regimes;
  - d. There is a degree of uncertainty in the flood model predictions due to the paucity of temporal and spatial gauging data;
  - e. The source aquifer for the Mellaluka Springs Complex has not been identified and as such it is not possible to accurately predict impacts from mining on these springs;
  - f. The proposal assumes that that the six post mining voids are expected to remain dry (assuming that evaporation will exceed groundwater inflow) but the Committee considers that there is still potential for the voids to gradually fill with water, particularly after prolonged heavy rainfall events, and as such there could be potential risks to nearby surface water and groundwater resources as a result of degraded water quality; and
  - g. A discharge strategy containing sufficient information to understand the risks to aquatic ecology and water quality has been not provided in the draft SEIS.

*Question 5: Are there additional measures and commitments required to monitor, mitigate and manage impacts resulting from changes to surface or groundwater resources?*

- 19. Although a number of management strategies are proposed to minimise the impacts of the proposal, due to the scale of this project, there will be both unavoidable and permanent impacts that are unlikely to be adequately mitigated.
- 20. Groundwater Modelling: Due to the lack of confidence in the current groundwater model predictions, the model needs to be revised, as discussed in paragraph 12, to adequately inform

understanding of the proposal's impacts to groundwater and inform appropriate mitigation and management measures.

21. Water Balance: To assess the impacts of the proposed water management strategy on receiving environments, future iterations of the site water balance model should assess all changes to stores and flows of water in the system, with consideration to seasonal variation, longer-term climatic scenarios and the staged project plan. The Committee recommends the following refinements to the model input parameters:
  - a. Parameters assigned for the runoff model should be calibrated using regional stream gauging data if there is limited stream flow data available for the site;
  - b. The total for runoff, seepage losses, and water demand for dust suppression should be presented with consideration of seasonal and long-term climate variations;
  - c. The volume of evaporation losses from the mine should be presented with consideration of storage characteristics (storage size and water depth), and seasonal and long-term climate variations;
  - d. The total water demand for the mine water operation rather than the net demand should be estimated;
  - e. Other internal water movements, such as return water from the tailing facilities, need to be taken into account;
  - f. External water demands and discharge requirements should be presented with consideration of seasonal variations and long-term climatic scenarios to provide an understanding of the potential magnitude of water demand in dry seasons, and release and overflow scenario during high rainfall wet seasons; and
  - g. For significant mining horizons, information should be presented to provide an understanding of the relative magnitude of water demands and discharge requirements during various mining stages.
22. Springs: The proposal indicates that any impacts to the Doongmabulla Springs Complex are likely to fall within the range of seasonal fluctuations to which the springs are already adapted. Based on the previously covered lack of confidence in the groundwater model to predict impacts, and the ecological significance of the Doongmabulla Spring Complex there is the need to put in place more than just monitoring, but also mitigation strategies to manage potential impacts to the springs should these be greater than currently predicted. Once the groundwater model has been revised (as recommended in point 12) the proponent should revise the impacts analysis and proposed mitigation.
23. The proposal has predicted adverse impacts at the Mellaluka Spring Complex, including loss of all ecological function due to a maximum predicted drawdown of up to 8.22m during the mine's operational phase and up to 25.6m post-closure. Proposed mitigation measures include the manual pumping of groundwater to the surface to offset the loss of flows to spring-fed wetlands. The proponent also proposes to prepare a wetland remediation and management plan when drawdown commences. The Committee considers that detailed consideration of mitigation and management measures at the Mellaluka Springs Complex should be carried out prior to the commencement of mine operations and include comprehensive ecological and water quality studies. It would be important to determine and characterise the source aquifer for the Mellaluka Springs Complex to determine the effectiveness of mitigation measures.
24. Further mitigation actions for both springs complexes could include:



- a. Identifying suitable trigger levels, the rationale for deriving the trigger levels and a response strategy for managing the resultant impacts; and
  - b. Reference and adopt the monitoring and mitigation measures applied in conditions for the three previously Commonwealth approved coal seam gas to liquefied natural gas projects in the Surat Basin.
25. Groundwater: The development of a Groundwater Monitoring Plan to build and update information on the current monitoring network would be beneficial. This Plan would need to address the significant uncertainties that exist within the groundwater model (discussed in responses to Question 2 and 3). The Plan should consider the inclusion of additional groundwater monitoring locations to the west of the mine site to specifically monitor the drawdown in the GAB units (including the Rewan Formation) and the Doongmabulla Springs Complex. Should drawdown levels alter from the predicted levels the potential impacts and required mitigation measures should be reassessed.
26. Groundwater Dependent Ecosystems (GDE): The proponent intends to provide a GDE Management Plan prior to commencement of mine operations. The Plan should determine the efficacy of mitigation and management options proposed to reduce impacts on the 831 EPBC-listed Waxy Cabbage Palms.
27. The proponent intends to monitor the health of the riparian vegetation, including groundwater-dependent ecosystems such as the River Red Gums and Paper Bark. The proponent has provided limited management measures in the event that the health of these species declines as a result of the permanent reduction in groundwater discharge to the Carmichael River. The proposed management measures should address the impacts arising from predicted dieback of riparian vegetation.
28. Water Quality: The following management plans would further improve the development of appropriate mitigation and management measures:
- a. To ensure effective and environmentally sustainable outcomes from controlled and uncontrolled mine releases, it would be expected that the proponent would develop a mine water Discharge Strategy, which would take account of the volume and timing of controlled and uncontrolled discharges, specific discharge scenarios and seasonal variations. Management measures within site specific Management Plans will need to reflect the risks identified within the Discharge Strategy and the site water balance should also be updated to account for both controlled and uncontrolled releases;
  - b. The proponent commits to providing a Site Water Management Plan and Receiving Environment Management Plan. The project would benefit from a surface water monitoring program to assess background hydrological and water quality conditions, inter-annual and seasonal variation, and the effectiveness of mitigation and management measures. The monitoring program should be robust to enable early detection of impacts arising from mine operations and identification of the cause of any change from baseline conditions or water quality / hydrological objectives and be consistent with the National Water Quality Management Strategy;
  - c. Revise the site specific Water Quality Objectives (WQOs) for the sub-catchment with additional seasonal data to meet a minimum of two years' contiguous monthly data and give consideration to developing trigger values that represent the strong dry and wet seasonal periods. The four sampling locations used to derive the WQOs are largely within (or very close to) the project boundaries. The Committee considers that additional upstream and

downstream sampling along the Carmichael River would strengthen the effectiveness of the monitoring network.

29. Void Management: The management of the voids could be further strengthened by providing a Mine Void Management Plan, which would be expected to be developed prior to completion of mining in the first pit. This Plan should consider aspects such as groundwater hydrology and properties, surface water hydrology and include measures to minimise potential impacts associated with the final void. In the Final Void Management Plan, the proponent should demonstrate that impacts to water resources are mitigated and managed in perpetuity where backfilled voids are not part of the final landform and consider options for the post-mine use.
30. Further assessment, taking into account seasonal and climatic variations (i.e. high rainfall and flooding) would be beneficial to assess final void water levels and the likelihood of the final voids to discharge water into surface water and groundwater system. Given the scale of the project, the accumulation of salt and other potentially harmful constituents identified in the final voids should be modelled to inform adequate mitigation and management measures.
31. Mine waste management plan: Future revisions to the mine waste management plan should be undertaken to take into consideration the management and handling of overburden material, soil testing to characterise overburden and a robust monitoring network for migration of acid, saline or metaliferous drainage.
32. Flood modelling data: Utilise additional data from the two new monitoring stations installed within the Carmichael River as it becomes available, to update/validate the flood model predictions. The flood model should be updated prior to the final design of the flood levees to ensure that the planned height remains sufficient to protect mining areas from a 1:1000 ARI event. This is particularly important given the significant seasonal and climatic variability in the region.
33. Water Supply: In future planning and design the proponent could investigate the feasibility of onsite treatment and reuse of 'mine affected water' to reduce the volumes required to be harvested from the downstream Belyando River and to reduce the need to discharge 'mine affected water' during high flows.

*Question 6: Given the impacts to the Carmichael River identified by the Interim Committee, are the proposed mitigation and management measures adequate?*

34. The Carmichael River will be adversely affected by a reduction in catchment size and reduced groundwater discharge to the river due to drawdown, and this is predicted to increase no-flow periods and compromise the ecosystem health in the riparian zone. Reduced groundwater discharge and water table drawdown will also adversely affect groundwater dependent ecosystems and species, and is predicted to lead to mortality and decreased spatial extent of the vulnerable Waxy Cabbage Palm.
35. Management measures that address the risks (i.e. changes to spawning, feeding, and breeding) to individual species as a result of predicted reduction of flows to the Carmichael River, and the predicted increase in flood levels, would better mitigate impacts. These management measures should take into consideration any uncertainties within the hydrological and flood modelling.
36. The Carmichael River is the southern limit of the Waxy Cabbage Palm. All populations of this species occur in areas of remnant vegetation (Vegetation Management Act 1999 Qld) and are therefore currently protected from broad scale clearing. The proponent intends to monitor the health of riparian vegetation, and limited management measures have been provided in the event of decline in vegetation health. Translocation of the Waxy Cabbage Palms is mentioned but this may not be feasible and is an unproven technique. The Committee recommends

investigation of the water requirements of this species, and monitoring of changes to groundwater and baseflow in the Carmichael River, with consideration of management options.

37. The draft SEIS states that water may be pumped to the Carmichael River channel near the upstream mine area boundary during dry periods to mitigate the impact of drawdown on the Carmichael River. Proposed mitigation measures could be further improved by better understanding aspects of natural flow regimes and ecological water requirements. Specific water quality standards and potential water treatment of discharge should also be considered when baseflows are likely to be low or nil, as this can lead to reduced dilution factors. Given that groundwater drawdown impacts are generally predicted to increase post closure, options for post-closure flow supplementation should also be taken into consideration.

*Question 7: The proponent has concluded that there is a low risk of direct hydraulic connection between the surface and the coal seam as a result of subsidence, and has therefore concluded that the GAB will not be impacted. Does the Committee agree with this conclusion?*

38. Subsidence induced fracturing has the potential to impair the capacity of the Rewan Formation to present a barrier to groundwater flow from the GAB units to the underground workings.
39. The groundwater model predicts an increase in net leakage through the Rewan Formation post mining. Even a minor increase to vertical conductivity has the potential to affect post closure leakage rates and result in permanent impacts on groundwater resources and GDEs.
40. The Committee supports the recommendation outlined in the draft SEIS that a detailed assessment by an appropriate specialist groundwater consultant be undertaken on the potential hydraulic connectivity of the subsidence fracture networks. A monitoring program should consider sensitive ecological receptors and be established prior to mining in higher risk areas close to the GAB boundary or the Carmichael River riparian corridor. Additional monitoring bores should also be installed in the Clematis Sandstone.

*Question 8: Are the proposed management responses to subsidence adequate? If not, are there additional measures and commitments required to mitigate and manage impacts to listed threatened species and communities as a result of subsidence?*

41. The proponent acknowledges uncertainty in the predictions of the hydraulic conductivity of the subsidence induced fracture network, and the height above mining within which direct hydraulic connection with mine workings may occur, and this creates uncertainty in relation to the likelihood of direct hydraulic connectivity between the coal seam, GAB Formations, and the ground surface.
42. The project would benefit from additional consideration of ponding impacts to watercourses and proposed management responses. Significant areas of subsidence ponding are predicted and further consideration of the effects of ponding on post-mining stream catchment extent, on surface water flow, or on natural flooding regimes would be beneficial in identifying and managing potential impacts. The effectiveness of mitigation measures already proposed, including draining subsidence ponds, and in some cases, diversion of watercourses, should also be evaluated and demonstrated through surface water modelling.
43. A large portion of the area predicted to be subject to subsidence represents potentially suitable habitat for four threatened species confirmed present or likely to be present. These include the Black-Throated Finch, the Squatter Pigeon, the Yakka Skink and Little Pied Bat. Ecological impacts should be accurately assessed in important habitat areas where impacts to surface water resources may affect habitat stability and utilisation by these species.

44. The proposed application in the Galilee Basin of NSW and Bowen Basin parameters for subsidence in a different geological setting increases the level of uncertainty in relation to subsidence predictions.
45. Given the predicted impacts of the proposal on baseflows in the Carmichael River, and the uncertainty regarding the degree of hydraulic connectivity within the subsidence fracture zone, the Committee considers that an assessment of potential impacts of subsidence fracturing on groundwater-surface water interactions in the vicinity of Carmichael River is needed. The assessment should target potential impacts in the western portion of the mining lease where base flow contribution from groundwater is expected to be retained post mining.
46. Where impacts to threatened species and ecological communities are predicted, including communities supported by the natural discharge from springs, further mitigation options (including alternative mining methods) may need to be considered, such as narrower longwalls, or mining methods with lower subsidence impacts. Various studies and guidelines exist for mining under water resources.

The Galilee Basin has been identified as a priority region of the Lake Eyre Basin Bioregional Assessment. Data and relevant information from the proposed project should be made accessible for this Bioregional Assessment.

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<b>Date of advice</b>	<b>16 December 2013</b>
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<b>Source documentation available to the Committee in the formulation of this advice</b>	Adani Mining Pty Ltd, 2013. Carmichael Coal Mine and Rail Project Supplementary Environmental Impact Statement (draft). As available at 6 <sup>th</sup> November 2013.
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<b>References cited within the Committee's advice</b>	<sup>1</sup> 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: <a href="http://www.environment.gov.au/coal-seam-gas-mining/project-advice/pubs/iesc-information-guidelines.pdf">http://www.environment.gov.au/coal-seam-gas-mining/project-advice/pubs/iesc-information-guidelines.pdf</a>
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