Independent Expert Scientific Committee
on Coal Seam Gas and Large Coal Mining Development

Advice to decision maker on coal mining project

IESC 2015-071: Bylong Coal Project (EPBC 2014/7133) – New Development

Requesting agencies	The Australian Government Department of the Environment The New South Wales Department of Planning and Environment
Date of request	1 October 2015
Date request accepted	2 October 2015
Advice stage	Assessment

Context

The Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development (the IESC) was requested by the Australian Government Department of the Environment and the New South Wales Department of Planning and Environment to provide advice on KEPCO's Bylong Coal Project in New South Wales.

This advice draws upon aspects of information in the proposed project's 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 lies within the western coalfields of the Sydney-Gunnedah Basin in New South Wales. Approximately 6.5 million tonnes per annum of run of mine coal is proposed to be extracted via open cut and underground mining methods from the target Coggan and Ulan coal seams. The proposed project is located along the Bylong River, a tributary of the Goulburn River, which in turn is a tributary of the Hunter River. The closest large regional centre is Mudgee, located approximately 55 km south-west of the proposed project. The small settlement of Bylong Village is located to the north-west of the proposed project's boundary. The operational life of the mine is anticipated to be approximately 23 years.

The IESC previously provided advice (Attachment A) on the proposed project to the New South Wales Mining and Petroleum Gateway Panel on 14 March 2014 (IESC 2013-040). The IESC recognises the effort undertaken to address recommendations identified in its previous advice. Outstanding matters are noted herein.

Key potential impacts

Key potential impacts to water resources resulting from the proposed project are associated with groundwater drawdown, subsidence and changes to water quality. Groundwater drawdown is predicted to result in reduced water availability to groundwater dependent ecosystems (GDEs) associated with Dry Creek, Lee Creek and the Bylong River (i.e. vegetation, stygofaunal communities,

surface water including persistent groundwater-fed pools and associated ecosystems). Potential subsidence impacts to the Dry Creek catchment include fracturing through to the surface and drainage of groundwater from perched alluvial aquifers that may affect GDEs, surface flows and water quality. There is also potential for contamination of alluvial groundwater and surface water due to leaching from reject materials within the overburden emplacement areas and backfilled pits.

Assessment against information guidelines

The IESC, in line with its Information Guidelines (IESC, 2015), has considered whether the proposed project assessment has used the following:

Relevant data and information: key conclusions

With the exception of the assessment of potential impacts to ecological water-related assets, relevant data and information have been used to support the assessment of impacts to water resources. Values and parameters used in hydrological and hydrogeological calculations are consistently justified (based on measured data) or referenced, however, baseline aquatic ecological data is inadequate due to the limited survey effort and inappropriate survey design. Many statements within the ecological impact assessment regarding the susceptibility or tolerance of biota to impacts lack adequate supporting evidence.

Appropriate methodologies and interpreted model outputs in a logical and reasonable way: key conclusions

The assessment documentation presents a range of studies. In some cases the IESC considers alternative studies or interpretations are warranted to support the assessment of potential impacts to water resources. These include the approach to identifying GDEs, consideration of impacts to surface water (e.g. the combined impact of factors such as the loss of baseflows, reduction in catchment area and effects of large flood events).

Advice

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

Question 1: Do the groundwater, surface water and subsidence assessments, including the numerical models within, provide reasonable estimations of the likely impacts to water resources (including water quality or water quantity) and groundwater dependent ecosystems (GDEs), with particular reference to the Bylong River, Lee Creek and Dry Creek catchments and any woodland or forest communities located over the proposed underground works. In particular, provide advice on the robustness of the groundwater and surface water models to provide suitable quantitative predictions for the project.

Response

1. Although the groundwater, surface water and subsidence assessments provide estimations of most of the likely impacts to water resources, some gaps have been identified. Key gaps include: descriptions of boundary conditions for the numerical groundwater model; consideration of impacts to the Goulburn River; identification and assessment of GDEs; details of the proposed borefield; consideration of the combined impacts to surface water; and a thorough assessment of potential subsidence impacts.

Explanation

Groundwater assessment

2. The numerical groundwater model is adequate to predict the range of potential impacts to groundwater resources associated with the proposed project. Recommendations made in the previous IESC advice (IESC 2013-040) in relation to the numerical groundwater model have been addressed, with the exception of testing the sensitivity of the fluxes to the Goulburn River to changes in a range of model parameter values. Undertaking the following activities would improve confidence in the model's performance:

    a. Interrogation and sensitivity analysis of the predicted groundwater-surface water exchange fluxes associated with the Goulburn River including pre, during and post mining. This is of particular importance given the stated significant flow through the alluvium to the Goulburn River.

    b. Further explanation and justification of all boundary conditions used in the groundwater model.

3. The groundwater impact assessment indicates riparian vegetation GDEs associated with Bylong River, Lee Creek and Dry Creek will experience groundwater drawdown as a result of the proposed project. However, GDEs have not been identified using the methodology identified in the previous IESC advice (IESC 2013-040). Consistent with that advice, GDEs should be identified using a systematic approach in which:

    a. the hydrogeological conceptualisation identifies areas of shallow groundwater (less than 20 metres below ground level) and groundwater discharge,

    b. vegetation and wetland mapping is overlaid to identify areas of potential GDEs, and

    c. techniques from the Australian GDE Toolbox (Richardson et al., 2011) are applied to confirm groundwater use by vegetation and groundwater discharge to surface water bodies.

4. The ecological impacts of the predicted groundwater drawdown have not been adequately assessed. In particular the assessment needs to consider how groundwater drawdown, including associated changes to the groundwater gaining/losing nature of watercourses, may affect recruitment and survival of groundwater-dependent riparian vegetation and the condition and permanence of groundwater-fed pools. Monitoring of GDEs is discussed further in Paragraph 39 and 40.

5. Water requirements for mine operations are proposed to be met through groundwater inflows to mining areas and a borefield in the Bylong River alluvium. Numerical groundwater model predictions suggest that if dry conditions occurred in years 3 to 10 of the proposed project, the borefield (15 bores) would yield insufficient water and a further 25 to 31 bores would be necessary. The number and distribution of these bores will affect groundwater drawdown predictions. The alluvial drawdown predictions should be updated to include this increased borefield, with the risks to GDEs, including surface water baseflow and groundwater users re-assessed.

Surface water assessment

6. The results from the proponent's surface water modelling studies should be used to assess the integrated impact on surface water resources as a result of the proposed project (i.e. the combined impact of the loss of catchment area, altered surface water-groundwater interactions, loss of baseflow and subsidence-related surface cracking, streambed cracking and ponding). A

subsequent assessment of the potential for impacts to water-related assets should be undertaken.

7. The 1000 year average recurrence interval design event should be modelled to inform the assessment the flooding risk to mine infrastructure and potential mobilisation of contaminants from coal stockpiles and reject emplacement areas. Further recommendations regarding the assessment of potential impacts to surface water quality are discussed in response to Question 2.

Subsidence assessment

8. The subsidence modelling provides a conservative assessment of the potential extent and severity of subsidence effects likely to be caused by the proposed project (i.e. the model is likely to overestimate the impacts of subsidence).

9. The potential impacts of severe subsidence have been identified (e.g. connective cracking to the surface, root shear and reduction in length of water residence time in perched aquifers) but the implications of these impacts and associated mitigation and management measures have not been adequately assessed. Further consideration of potential impacts to GDEs, aquifer storage and critically endangered ecological communities within the subsidence area is needed. This assessment should inform estimates of the value and future persistence of the proposed offset site located above the proposed longwall mining area.

Question 2: Does the EIS provide a reasonable consideration of the potential for discharges (including long term salt migration from backfilled open cut pits including reject emplacement) to nearby watercourses and alluvial groundwater systems and the significance of any resulting impacts to water quality and the downstream environment? If not, how could the assessment be improved?

Response

10. No. While a variety of studies, including water and salt balances and geochemical analyses, have been undertaken to assess the likelihood and potential impact of discharges, the full range of potential impacts of these discharges have not been considered. The assessment should consider potential impacts in the context of seasonal and climatic variability and uncertainty associated with predictions. The impact assessment should explicitly consider the value, condition and objectives for downstream environments (e.g. Goulburn River National Park).

Explanation

11. Increased concentrations of salts and other contaminants may enter the alluvial and surface water systems via the following pathways:

    a. discharges from the water management system and

    b. surface runoff and seepage from overburden emplacement areas and backfilled pits.

Discharges from the water management system

12. The proposed project's water balance modelling predicts:

    a. controlled discharges from the water management system to surface waters are not needed,

    b. uncontrolled releases from sediment dams will occur, and

    c. no uncontrolled spills of mine-affected water will occur.

13. While the water balance model does not model controlled discharges from sediment dams, this is a proposed mechanism for dewatering following rainfall events (page 194 of EIS). The assessment should consider potential impacts to water quality and quantity associated with these releases, and derive local water quality objectives to permit releases for turbidity, salinity and other contaminants.

14. To provide greater assurance that the proposed project's water management system will adequately minimise impacts to downstream water quality and quantity, sensitivity and uncertainty analysis, including consideration of future climate variability, should be undertaken on the water balance model. Once operations commence and additional data are collected, the water balance model should be revised and rerun and action taken, as required, to ensure the water management system's performance measures can be satisfied.

Surface runoff and seepage from the overburden emplacement areas and backfilled pits

15. The proposed topography of the backfilled pits along with the predicted rise in the groundwater level at equilibrium may result in areas of groundwater seepage at the surface. Seepages to the surface may transport contaminants and contribute to reductions in surface water quality in the long term. This potential discharge pathway has not been assessed.

16. The assessment documentation acknowledges the potential for seepage through backfilled pits to have some impact on the salinity of water in the alluvial aquifers adjacent to open cut mining areas, and to the surface waters of the Bylong River and Lee Creek. The assessment:

    a. considers impacts on an average annual basis only,

    b. assumes no parallel reduction in surface water quality, and

    c. does not consider other contaminant transport pathways, such as the potential for seepage from overburden emplacements, via the weathered colluvium, to alluvial aquifers.

17. The assessment documentation states that if saline leachate enters the alluvial groundwater it is likely to be heavily diluted and that contaminants would be removed by natural filtration processes (EIS, Appendix J, p. 6.66). Limited evidence is presented to support these claims, whilst no data is presented to show that the predicted concentrations of contaminants are within safe limits for GDEs or aquatic biota.

Further improvements

18. The assessment would benefit from consideration of the proposed project's potential combined impact to surface water quality and alluvial groundwater quality and the associated impacts to biota. All components of this assessment should consider how changing conditions (as a result of seasonal or future climatic change) may affect predicted impacts. For example during periods of low surface flows where watercourses retract to groundwater-fed pools that are subject to evaporation, impacts are likely to be more severe. Uncertainty associated with the leaching potential and contaminant load from infill materials should also be considered.

19. In relation to the geochemical impact assessment, the concentrations of contaminants in the leachate (e.g. metals) should be compared to guidelines for aquatic ecosystem protection. For example, if a metal exceeds the guideline (allowing for dilution and attenuation in the environment), then implementation of the tiered approach in the National Water Quality Management Strategy (refer to the decision tree at Figure 3.4.2 of ANZECC and ARMCANZ, 2000) may be useful to assess impacts on biota from the leachate mixture.

20. Local water quality objectives should be derived from the over two year's of baseline data collected at the proposed project's site. Potential impacts in the immediate vicinity and downstream environments (e.g. within the Goulburn River National Park) should be considered.

Question 3: Has the Applicant provided reasonable strategies to avoid, mitigate or reduce the likelihood, extent and significance of impacts?

Response

21. No. Many of the potential impacts to water resources, for example impacts associated with groundwater drawdown and subsidence, cannot be avoided or reduced without changes to the proposed operations and/or mine layout. Many of the mitigation or remediation measures proposed are to be detailed and implemented through a variety of plans that are not part of the assessment documentation. The consideration of strategies to avoid, mitigate or reduce impacts is limited due to the:

    a. insufficient identification of potential impacts (as noted in Paragraphs 16.c and 25),

    b. discounting of potential impacts without supporting evidence (as noted in Paragraph 17),

    c. unproven nature of proposed mitigation measures (as described in Paragraph 23), and

    d. lack of a quantitative risk assessment (as noted in Paragraph 24).

Explanation

Subsidence

22. There is a risk that the predicted subsidence impacts may not be fully remediated with the proposed measures given the magnitude of predicted impacts (as noted in Paragraph 9). It is also possible that fracturing could lead to changes that cannot be remediated (e.g. ongoing drainage of perched alluvial groundwater reducing groundwater availability for dependent vegetation and root shear). These impacts may reduce the viability of GDEs and/or critically endangered ecological communities.

23. To improve confidence that the proposed remediation measures may be effective, further evidence, including case studies of the successful application of the proposed measures in a similar context, should be provided. While this was raised by the IESC in its previous advice (IESC 2013-040), evidence has not been provided.

Risk assessment

24. Consistent with the previous IESC advice (IESC 2013-040), the risk assessment should quantitatively assess the likelihood and consequence of identified impacts and justify the residual risk following application of proposed mitigation measures.

Water-related assets

25. The single, spatially-limited aquatic ecology survey is insufficient to identify values that may be impacted by the project, and hence inform mitigation measures. If additional water-related assets are identified as a result of further surveys (as recommended in Paragraphs 3 and 40), predicted impacts should be reassessed in light of the additional data collected, and appropriate avoidance and mitigation strategies proposed.

Question 4: Are there further strategies the IESC would recommend to avoid, mitigate or reduce the likelihood, extent and significance of impacts on water resources or groundwater dependent ecosystems? And if so, why?

Response

26. Yes, there are a number of further strategies available that could be employed by the proponent. Additional strategies are recommended to:

    a. manage waste materials to reduce the long-term risk of contamination of water resources,

    b. manage water on site to reduce the need for external release, and

    c. reduce subsidence impacts due to the difficulty in remediating severe subsidence impacts noted in Paragraphs 8 and 22 and 23.

27. Additional monitoring is recommended in Question 5 to inform the assessment of potential impacts and therefore selection of appropriate strategies for the site.

Explanation

Waste material management

28. Adoption of the full suite of recommendations relating to the management of potentially acid-forming materials proposed within the Geochemical Impact Assessment (EIS, Appendix AB) would further reduce the likelihood of and uncertainty associated with predicted impacts to water resources.

29. Given the final landform of the backfilled open cut pits is proposed to extend above the surrounding and existing landform, placement of potentially acid-forming materials should take into account the risk of erosion and exposure of waste materials, and prediction of equilibrium groundwater levels within the backfilled pits, as well as the uncertainty associated with groundwater modelling predictions.

Water management

30. Management triggers and associated responses for key storages within the water management system (e.g. sediment dams) should be developed and described in the Water Management Plan. Management responses could include increasing the pumping capacity to divert water to the mine water management system (instead of being released from site), resizing/introducing additional temporary sediment dams, use of flocculating agents or other treatment as necessary.

Subsidence

31. Subsidence impacts can be reduced through a number of engineering techniques including reducing the widths of longwall panels, increasing tailgate/chain pillar widths or a combination of both and reducing the height of coal extracted (Commonwealth of Australia, 2015). These techniques could be applied to longwalls underlying sensitive surface features or to longwalls that have a large width to depth of cover ratio.

Question 5: In addition to the proposed monitoring and management regime recommendations in the EIS, does the IESC recommend additional monitoring and management measures to minimise the risks of the project to water-related assets, including groundwater dependent ecosystems?

Response

32. Expansions to surface water and groundwater monitoring networks to minimise the risks of the project to water-related assets are suggested below. Where additional sites have been identified, monitoring should begin immediately to establish baseline conditions. Surface water and groundwater monitoring presented as part of the Water Management Plan should be consistent with the National Water Quality Management Strategy (ANZECC and ARMCANZ, 2000), which should include determination of appropriate local water quality objectives and guideline values.

33. Appropriate management and mitigation measures should be defined as part of the Water Management Plan in the event that guideline values are exceeded. Management triggers and subsequent responses should be defined before mining commences and should utilise the proponent's existing water monitoring dataset.

Explanation

Groundwater and final landform

34. The groundwater monitoring network can be improved by the inclusion of additional sites in the Lee Creek alluvium to identify potential impacts of leachate from the adjacent overburden emplacement areas. Groundwater monitoring points should also be established in the backfilled pits to monitor water quality as the groundwater level re-equilibrates, and provide an early indication of potential water quality impacts to alluvium groundwater and associated surface waters.

35. The Water Management Plan should describe how the groundwater monitoring programme will provide assurance that observed groundwater drawdown is consistent with predictions, and in cases where groundwater drawdown exceeds predictions, describe how potential impacts will be mitigated. The Water Management Plan should also describe the management of long-term impacts to water resources once mining is complete, including measures to assess the effectiveness of remediation.

36. Groundwater quality is proposed to be sampled quarterly or annually. Monthly sampling would increase the likelihood of more rapid detection of exceedences of guideline values and therefore potential contamination. More frequent monitoring would also better reveal patterns associated with seasonal climatic variations.

Surface water

37. To enable more timely detection of surface water impacts and isolation of sources of contamination to inform management measures, the surface water monitoring programme should incorporate:

    a. Additional monitoring stations located closer to the downstream confluence of Bylong River and Dry Creek, and adjacent to open cut pits along Lee Creek.

    b. Event-based water quality monitoring downstream, especially downstream of the proposed overburden emplacement areas and continuous monitoring of electrical conductivity to detect pulses of salts arising from altered groundwater inputs or potentially contaminated run-off.

c. Additional monitoring sites on the Goulburn River upstream and downstream of the confluence of the Bylong River to provide further certainty that impacts to downstream water quality will be detected.

38. Appropriate local water quality objectives and guideline values should also be determined, particularly for intermittent streams. Further collection of surface water quality data at high and low flows to support characterisation of baseline water quality in Dry Creek and Lee Creek is needed.

Water-related assets

39. Aquatic surveys should include fish, as suggested in IESC 2013-040. While the IESC accepts the use of the AusRivAs method to assess the macroinvertebrate community composition, the data set is currently too limited to draw conclusions regarding the condition of aquatic habitat. To maximise the effectiveness of the AusRivAs method, sampling in two seasons (i.e. spring and autumn) is recommended to enable use of the more powerful combined season AusRivAs models against which to test the results (Coysh *et al*., 2000). If the techniques employed to date (i.e. AusRivAs and SIGNAL) are adopted for ongoing aquatic surveys, the inclusion of additional monitoring sites downstream of the project area is recommended.

40. The proponent's proposed monitoring of riparian vegetation GDEs should commence immediately to establish baseline conditions. This programme should be expanded to include additional GDEs identified (refer to Paragraph 3) and stygofauna, and include sites predicted to be impacted by groundwater drawdown, as well as reference sites.

    a. Condition monitoring of vegetation GDEs should assess tree health and population condition (e.g. recruitment success and seed set).

    b. For surface water GDEs (e.g. groundwater-fed pools) condition monitoring should measure consistency of water supply and water quality and aquatic ecology survey sites (part of the proposed ecological monitoring programme) should coincide with these areas.

    c. The GDE represented by stygofauna in the alluvium of Lee Creek and Bylong River should also be monitored to detect responses to altered groundwater flows and water quality. Experiential evidence shows that stygofauna can be stranded by declines in the groundwater table (Stumpp and Hose, 2013).

41. Consideration should be given to the coordinated sampling (where possible) of the same set of monitoring sites for water quality and aquatic ecology to improve the information base with which to interpret any observed changes in condition of surface-water GDEs.

Subsidence

42. To inform ongoing management of subsidence impacts, subsidence predictions and the effectiveness of proposed remediation measures should be reviewed and updated as new information is available. Extraction plans will describe how subsidence impacts will be managed. These plans could be prepared for sections of the underground operations to enable new information to be adopted and management activities modified as mining progresses.

Date of advice	16 November 2015
Source documentation available to the IESC in the formulation of this advice	IESC 2014-040: Bylong Coal Project – New Development. Available: http://iesc.environment.gov.au/committee-advice/proposals/bylong-coal-project-new-development-project-advice Hansen and Bailey, 2015. Bylong Coal Project Environmental Impact Statement, 2015.
References cited within the IESC's advice	ANZECC and ARMCANZ, 2000. *Australian guidelines for water quality monitoring and reporting* [Online]. Available: http://www.environment.gov.au/system/files/resources/0b71dfb9-8fea-44c7-a908-826118d403c8/files/nwqms-monitoring-reporting.pdf Commonwealth of Australia, 2015. *Management and monitoring of subsidence induced by longwall coal mining activity*, prepared by Jacobs Group (Australia) for the Department of the Environment, Commonwealth of Australia, Canberra. Available: http://ausrivas.ewater.org.au/ausrivas/index.php/resources2/category/2-pdfs?download=8:predictive-modeling-manual Coysh, J., Nichols, S., Ransom, G., Simpson, J., Norris, R., Barmuta, L., Chessman, B., 2000. *AUSRIVAS Macroinvertebrate Bioassessment Predictive Modelling Manual.* CRC for Freshwater Ecology, Canberra. Available: http://ausrivas.ewater.org.au/ausrivas/index.php/resources2/category/2-pdfs?download=8:predictive-modeling-manual IESC, 2015. *Information Guidelines for Independent Expert Scientific Committee advice on coal seam gas and large coal mining development proposals* [Online]. Available: http://www.iesc.environment.gov.au/publications/information-guidelines-independent-expert-scientific-committee-advice-coal-seam-gas Richardson, S., et al., 2011. *Australian groundwater dependent ecosystems toolbox part 2: assessment tools*, National Water Commission, Canberra. Stumpp, C. and Hose, G., 2013. *The Impact of Water Table Drawdown and Drying on Subterranean Aquatic Fauna in In-Vitro Experiments*. *Plos One*, 8, e78502.

Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development

Advice to decision maker on coal mining project

IESC 2013-040: Bylong Coal Project – New Development

Requesting agency	The New South Wales Mining and Petroleum Gateway Panel
Date of request	15 January 2014
Date request accepted	17 January 2014
Advice stage	Gateway Application

Advice

The Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development (the IESC) was requested by the New South Wales Mining and Petroleum Gateway Panel to provide advice on the Bylong Coal Project in New South Wales. The proposed project has been referred to the IESC at the 'Gateway' Stage due to its location on identified Biophysical Strategic Agricultural Land (BSAL) as legislated under the NSW *Environmental Planning and Assessment Act 1979*.

This advice draws upon aspects of information in the Gateway Certificate Application, including the Preliminary Groundwater Assessment, 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 lies within the Western Coalfields of the Sydney-Gunnedah Basin in New South Wales. Approximately six million tonnes per annum of run of mine coal is proposed to be extracted via open cut and underground mining methods from the target Coggan and Ulan coal seams. The proposed project is located along the Bylong River, a tributary of the Goulburn River, which in turn is a tributary of the Hunter River. The closest large regional centre is Mudgee, located approximately 55 km south-west of the proposed project. The small settlement of Bylong Village is located within the proposed project boundary. The mine life is anticipated to be approximately 29 years.

The IESC recognises that the Gateway Certificate Application has been designed to address the criteria specified as part of the Gateway process, which differs in scale and detail and does not contain the level of analysis expected for a development application and accompanying environmental assessment. The IESC recommends that any further project assessment documentation includes the type of information that enables a robust assessment of impacts on water resources such as that outlined in the Information Guidelines[1].

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

Question 1: The potential likelihood and extent of any impacts of the proposal on water resources, as well as the appropriateness of the proposed mitigation measures.

1. The limited level of detail in project documentation at the Gateway stage restricts the ability of the IESC to assess the extent and likelihood of impacts to water resources as a result of the proposed project. Consequently, this advice is only able to describe broadly the potential impacts of the proposed project, many of which have been identified in the documentation accompanying the Gateway Certificate Application.

2. Key issues include surface-groundwater interactions, impacts as a result of subsidence and potential contamination of water resources following mining. Limited information is available on surface water and ecological impacts at this stage. Potential impacts to water resources, as well as the scientific adequacy of proposed mitigation measures are discussed under the headings below.

Subsidence

3. Subsidence of up to 3.4 m above the proposed longwalls is predicted. Subsequent impacts to water resources include ponding, changes to flood paths, erosion and scouring along drainage lines and loss of surface flows as a result of fracturing of bedrock and surface cracking. Proposed mitigation and remediation methods for subsidence include infilling of surface cracks, regrading and compacting the surface, planting of vegetation for stabilisation and constructing bunds adjacent to drainage lines to control flooding. There is limited information provided at this stage about the effectiveness of proposed stream remediation measures, such as the proposed reinstatement of stream beds with highly cohesive soils or grouting of bedrock. Documentation provided with the development application would benefit from evidence of success of the proposed subsidence remediation methods, including case studies.

4. The proponent has designed the mine layout to maintain buffer distances from most alluvial aquifers, with the exception of the Dry Creek alluvium. Longwall mining in proximity to streams and associated alluvium has the potential to fracture the confining hard rock layers, providing direct conduits from surface waters to coal seams. Future iterations of the project assessment documentation should clearly define alluvial extents along Dry Creek and specify buffer distances from proposed longwalls.

Groundwater

5. The preliminary groundwater model predicts that once mining commences depressurisation of Permian strata occurs and the flow rate from the Permian strata to the alluvium (net 7.7 ML/day upward flow across the model domain) will be reduced. In some areas adjacent to the proposed open cut pits, this net upward flow is reversed to downward flow. Documentation provided with the development application should include groundwater recovery predictions across the model domain, including an assessment of whether groundwater flow from the Permian strata to the alluvium will return to pre-development levels and the time taken to reach equilibrium. Given the magnitude of the predicted alluvial drawdown, the potential for impacts to porosity and permeability and consequential implications for long-term flow storage and movement in the alluvium should be assessed.

6. Preliminary modelling indicates drawdown of up to 18.46 m for bores within the alluvium. Twenty three alluvial bores and one bore within the Permian hard rock are predicted to experience drawdown of greater than 2 m. Proposed mitigation measures include land acquisition, drilling deeper bores or supplementing water supplies.

7. Impacts of groundwater drawdown on ecological assets and associated mitigation measures have not been considered at this stage. The IESC recommends that impacts on water dependent assets (including aquatic ecosystems, terrestrial ecosystems, drinking water supply, irrigation water supply, surface infrastructure and other industries), should be assessed following updates to the groundwater model. Mitigation measures to address impacts on groundwater dependent assets should be included.

8. Contrary to the stated significant alluvial through-flow to the Goulburn River, the preliminary groundwater model predicts that the Goulburn River will not be impacted by the proposed project[2]. The representation of the Goulburn River as a constant head boundary within the model may be influencing this inconsistency. The IESC has included recommendations for further studies into the representation of streams in the groundwater model in response to Question 2.

Surface water

9. The steady state water budget indicates a net outflow of 3 ML/day from groundwater to the Bylong River and Lee Creek systems. As a result of the proposed project, there is predicted to be an average reduction in baseflow to these streams of 0.21 ML/day. Streamflow and rainfall data collected by the proponent show that the Bylong River maintains some baseflow through winter, but almost no flow between October and February. The spatial and seasonal variation in streamflow and the groundwater pumping regime should be reflected in future versions of the groundwater model. These modifications would more accurately represent current surface-groundwater flux and therefore improve confidence in the predictions of impacts.

10. The proponent intends to contain all mine-affected water on site, with no discharges, but does intend to use mine water for dust suppression. Sediment-affected water may be released from site, following treatment if necessary. Documentation provided with the development application should include:

    a. Assessment of potential for salinity to increase as a result of storing mine-affected water on site;

    b. Identification of contingency measures to ensure that mine water is not released from site;

    c. Measures to ensure stability of the landform and maintenance of water quality, given the potential for sodic soils across the proposed site;

    d. Assessment of the risks to surface and groundwater quality of using mine water for dust suppression; and

    e. Provision of details of the proposed treatment options for release of water of appropriate quality from sedimentation dams.

11. The proponent's documentation contains limited information about other impacts to surface water at the Gateway stage. The IESC has included recommendations for further studies into surface water impacts in response to Question 2.

Final landform

12. There is potential for contamination of the alluvium due to leaching from Coal Handling and Preparation Plant rejects and tailings within the backfilled pit, which may then flow into the adjacent surface water systems, in particular the Growee River and Lee Creek. Groundwater quality modelling of the final landform would be needed to accurately determine the potential transport of contaminants, including salts, to the alluvium and surface streams.

Question 2: The IESC may also recommend further studies that should be undertaken if relevant.

13. The IESC considers that any further studies in preparation for a development application should have reference to the type of information that enables a robust assessment of water resources such as those outlined in the Information Guidelines[1]. Specific recommendations for further work are made under the headings below.

Subsidence

14. Future iterations of the subsidence assessment should include a survey of the existing drainage lines and other surface water features and an assessment of their current condition, including associated vegetation, to provide a baseline against which the predicted changes to the landform can be assessed.

15. The monitoring and management programme for subsidence would benefit from further investigations on the height and impacts of connective cracking and the effectiveness of proposed mitigation and remediation measures.

Water balance

16. Studies are needed on the location and volumetric requirements of the proposed borefield to supplement mine water requirements. The proposed water take from this borefield should then be incorporated into the groundwater model.

Groundwater

17. The IESC agrees that improvements to the preliminary groundwater model are needed, consistent with the proponent's commitments. The IESC recommends that the updated numerical model should reflect the modifications and additions to the groundwater conceptualisation specified in Paragraphs 18-21.

18. Finer-scale understanding is needed of the spatial and temporal aspects of the existing connectivity regime between each of the hydrogeological units and surface water. In particular, the conceptualisation should include current groundwater extraction, streamflow, alluvial through-flow and discharge to the Goulburn River. In order to match the groundwater model outputs to seasonal field observations, consideration should be given to a variety of boundary conditions for streams across the model domain, including constant head or general head boundaries, river cells and drains. The project assessment documentation would benefit from sensitivity analysis of stream boundary conditions and justification for the conditions applied in the final groundwater model.

19. Studies should assess the predicted perturbations to, and recovery of, the hydrological regime resulting from the proposed project. In particular, the assessment should consider changes to hydraulic connectivity above shallow longwalls, where cracking is predicted to extend to the surface. Assessment of changes to interconnectivity between hydrogeological units and surface water would benefit from predictions at the sub-catchment level, including Lee Creek, Bylong River, Growee River and the Goulburn River.

20. Further evidence should be provided to confirm the extent of the alluvium associated with Dry Creek and buffer distances from the proposed longwalls. Any modifications needed to the mine layout to maintain the integrity of alluvial aquifers should be clearly described.

21. Water related assets should be identified. Studies relating to dependence on water resources for fauna (including stygofauna, macroinvertebrates, frogs and fish), flora and habitat, as well as the location of shallow groundwater discharge points and other groundwater dependent ecosystems (GDEs), should be included. A systematic approach to assessment of GDEs is recommended in which:

a. The hydrogeological conceptualisation identifies areas of shallow groundwater (less than 20 metres below ground level) and groundwater discharge.

b. Vegetation and wetland mapping is overlaid to identify areas of potential GDEs. Preliminary mapping should consider data sourced from the Vegetation Information System database, available from the NSW Office of Environment and Heritage.

c. Techniques from the Australian GDE Toolbox[3] may then be applied to confirm groundwater use by vegetation and groundwater discharge to surface water bodies.

Surface water

22. The IESC recommends that the baseline characterisation for the proposed project should include:

    a. Hydrogeochemical characterisation of the coal measures and overburden, including the potential for saline and acid forming material;

    b. The development of local water quality objectives; and

    c. Surveys of aquatic ecology in the Bylong River water source within and downstream of the mine lease.

23. Surface water studies would benefit from consideration of the combined impacts of loss of catchment area, loss of baseflow and surface cracking, streambed cracking and ponding as a result of subsidence. An assessment of the potential for impacts to water dependent assets should also be undertaken.

24. Documentation provided with the development application should include a flood assessment. The flood assessment should include the potential for:

    a. Subsidence to alter existing flood paths;

    b. Flooding of the mine pits;

    c. Erosion or destabilisation of overburden emplacement areas; and

    d. Impacts to in-stream and riparian vegetation, channel morphology, mine infrastructure or adjacent properties as a result of flooding.

Final landform

25. Geochemical characterisation of tailings and rejects should be undertaken to assess the potential contamination risk to the alluvium and surface waters.

Risk assessment

26. The documentation associated with the development application would benefit from inclusion of a stand-alone risk assessment considering specific water-related risks to the environment. This assessment should quantitatively assess the likelihood and consequence of identified impacts and the residual risk following application of proposed mitigation measures.

27. The Hunter Subregion within the Northern Sydney Basin has been identified for Bioregional Assessment. Data and relevant information from the proposed project should be made accessible to this Bioregional Assessment to assist the knowledge base for regional scale assessments.

Date of advice	14 March 2014
Source documentation available to the IESC in the formulation of this advice	Hansen Bailey, 2014. Bylong Coal Project – Gateway Certificate Application Supporting Document. Report prepared for KEPCO Bylong Australia
References cited within the IESC'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 [2] AGE, 2013. Bylong Coal Project – Groundwater Impact Assessment. Report prepared for KEPCO Bylong Australia. [3] Richardson, et al, 2011. The Australian Groundwater Dependent Ecosystems Toolbox. National Water Commission, Canberra.