

## Advice to decision maker on coal mining project

### IESC 2018-093: Wallarah 2 Coal Project (EPBC 2012/6388) – New Development

<b>Requesting agency</b>	The Australian Government Department of the Environment and Energy
<b>Date of request</b>	11 April 2018
<b>Date request accepted</b>	11 April 2018
<b>Advice stage</b>	Approval

The Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development (the IESC) provides independent, expert, scientific advice to the Australian and state government regulators on the potential impacts of coal seam gas and large coal mining proposals on water resources. The advice is designed to ensure that decisions by regulators on coal seam gas or large coal mining developments are informed by the best available science.

The IESC was requested by the Australian Government Department of the Environment and Energy to provide advice on the Wyong Coal Pty Ltd's Wallarah 2 Coal Project in New South Wales (NSW). This document provides the IESC's advice in response to the requesting agency's questions. These questions are directed at matters specific to the project to be considered during the requesting agency's assessment process. This advice draws upon the available assessment documentation, data and methodologies, together with the expert deliberations of the IESC, and is assessed against the IESC Information Guidelines (IESC, 2018).

#### Summary

The Wallarah 2 Coal Mine (the proposed project) is a new underground coal mine, located approximately 25 km south-west of Newcastle, NSW. The proposed project will cover an area of approximately 3700 ha and extract 5 million tonnes per annum of run of mine coal over 25 years.

The proposed project's potential impacts would be primarily concentrated in the Jilliby Jilliby Creek Catchment area and would include subsidence related changes to the surface water and groundwater dynamics. Modelling undertaken by the proponent predicts a maximum 300 ML/year reduction in water from the drinking water catchment that supplies the Central Coast Water Supply Scheme (CCWSS). Of the 300 ML/year loss to the CCWSS, 270 ML/year is predicted to be lost from Jilliby Jilliby Creek and 30 ML/year from the Wyong River.

The proponent and the NSW Planning Assessment Commission (PAC) have identified the range of potential impacts to water resources.

In addition to the assessments undertaken by the NSW PAC and the proponent, the IESC has used the results from the Hunter Subregion of the Northern Sydney Basin Bioregional Assessment (BA) to inform this advice. The BA provides a regional-scale cumulative impact assessment that can be used to support the assessment of site-specific impacts undertaken by the proponent and the NSW PAC.

This advice does not provide comment on specific measures included within the range of strategies, plans or programs identified within the NSW Development Consent, because these were not available to the IESC. However, the IESC has identified a range of data acquisition, monitoring, mitigation and management measures that can be used to adaptively manage the residual risks to water resources that should be included within any plans to be prepared by the proponent. Measures are identified for:

- conventional and non-conventional subsidence impacts to Jilliby Jilliby Creek and its tributaries;
- the possibility of non-conventional subsidence impacts to the Wyong River;
- changes to water quality and quantity in Wallarah Creek and at the yet to be identified site of treated water discharge under the Central Coast Water Supply Compensatory Arrangement;
- potential impacts to groundwater-dependent ecosystems and water-dependent species; and,
- cumulative groundwater impacts.

### **Context**

The IESC previously provided advice to the former Commonwealth Department of Sustainability, Environment, Water, Population and Communities on the draft Environmental Impact Statement (EIS) for the proposed Wallarah 2 Coal Project, EPBC 2012/6388 (IESC 2013-026, dated 24 May 2013). The advice is available on the IESC 'Advice to regulators on development proposals' website at <http://iesc.environment.gov.au/committee-advice/proposals>.

On 16 January 2018, the NSW PAC determined that the proposed project be granted development consent and approved the project. The IESC has considered the various PAC reports and the conditions set out in the NSW regulator's instrument of approval.

The proposed project is located in the catchment for the CCWSS which provides drinking water for the Gosford-Wyong area of the Central Coast. The CCWSS encompasses the previous Gosford-Wyong Water Supply Scheme. In July 2012, the Mardi-Mangrove Link was officially completed enabling water to be transferred from the Wyong River and Ourimbah Creek during high flows – via Mardi Dam – to Mangrove Dam for storage. The Mardi-Mangrove Link aims to help prevent future low water supplies during extended periods of below-average rainfall (CCWSS, 2013).

The proposed project lies within the Hunter Subregion BA (Herron et al., 2018c). The Hunter subregion BA groundwater model provides a range of potential cumulative impacts from coal mining to water resources in the region. Hydrological changes were predicted along the Wyong River that are attributed to the Wallarah 2 project. To further assess these hydrological changes, the Hunter subregion BA obtained local-scale information from the Wallarah 2 project to constrain the regional groundwater model within that area. The Hunter Subregion BA constrained model predicts groundwater drawdown extents associated with the proposed project to be less than the regional model predictions.

It should be noted that the proponent's model and the Hunter subregion BA model are constructed differently and serve different purposes. Given the presence and significance of the CCWSS within the area of potential impact, the range of impacts predicted by the regional BA model to groundwater and surface water provides the conservative bounds upon which monitoring and management measures can be developed. This example shows the importance of using local scale information to constrain model predictions. The joint use of both models provides greater confidence in determining impacts.

## Key Potential Impacts

The key potential impacts of the proposed project have been identified by the proponent and the NSW regulator. Key potential impacts identified through the NSW assessment of the proposed project are consistent with those identified in the 2013 IESC advice and include:

- changes to surface water and groundwater hydrology and water quality due to subsidence;
- a maximum 300 ML/year reduction in water from the drinking water catchment for the CCWSS, including:
  - 270 ML/year from Jilliby Jilliby Creek;
  - 30 ML/year from the Wyong River;
- impacts to groundwater-dependent ecosystems (GDEs) and other water-dependent species, particularly within the Jilliby Jilliby Creek catchment; and,
- cumulative impacts associated with current and future mining within the area.

## Response to questions

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

Question 1: Is the supplementary data and information sufficient to assess and monitor the potential impacts to water resources including the Gosford-Wyong Water Supply Scheme?

1. Since the IESC provided its advice in 2013, the proponent and the PAC have undertaken a range of studies and assessments. The documentation available to the IESC included PAC assessments, the proponent's responses to submissions and to the PAC, as well as reporting and monitoring provided in 2018 to support the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) assessment. The IESC has used this information as the 'supplementary data and information' to support the formation of this advice.
2. The proposed project's key potential impacts, including those previously identified by the IESC (IESC, 2013), are mostly related to impacts caused by subsidence and strata collapse above the proposed longwalls. The IESC advice of 2013 identified a number of risks that needed to be further assessed. Broadly, these matters were:
  - a. flow reductions in surface water systems due to a reduction in surface runoff and reduced baseflow provision to the Wyong River and its tributaries;
  - b. potential ecological impacts from changes to the water table, flooding regime, increased sedimentation and nutrient loading (particularly from the steep slopes) and reduced surface water flows;
  - c. groundwater impacts from subsidence fracturing and induced drainage from aquifers;
  - d. potential impacts of discharges into Wallarah Creek; and,
  - e. groundwater quality impacts from underground storage of brine and salt concentrate within the extracted longwalls.
3. The supplementary assessments undertaken by the NSW regulator and the proponent have satisfactorily addressed the potential impacts, including those to the CCWSS (which encompasses the Gosford-Wyong Water Supply Scheme) and those identified in the 2013 IESC advice, to a level where any residual matters can be addressed using the monitoring and management measures outlined in the response to Question 2. Further consideration of potential cumulative impacts has

been supplemented by modelling and assessments undertaken through the Hunter Subregion BA (Herron et al., 2018a).

Question 2: In consideration of the NSW conditions and the Hunter Bioregional Assessment does the IESC suggest any specific data collection, monitoring and controls to manage the impacts of the project? Could the IESC give an indication of timing for these?

4. The conditions in the NSW Development Consent for the proposed project are substantial and robust. However, the IESC cannot comment on specific measures within each of the required monitoring, mitigation and management plans because they were not available to the IESC for review. The range of measures provided in response to Question 2 are designed to support the development and review of strategies, plans or programs still to be prepared by the proponent.
5. Groundwater modelling undertaken through the Hunter subregion BA (Herron et al., 2018a) indicates impacts are primarily groundwater drawdown and reductions in baseflow, which have associated impacts on surface water flow and aquatic ecosystems. The BA regional model indicates the possibility of drawdown to extend beyond the predictions obtained using the locally constrained BA modelling and the proponent's site-specific groundwater model. However, ongoing monitoring and regular (e.g. 3 yearly) re-evaluation of the proponent's numerical groundwater model will help constrain the range of predictions and inform ongoing monitoring and management measures. In consideration of the results of the Hunter subregion BA, the proponent's assessments and modelling and the conditions within the NSW Development Consent, the IESC has identified a range of measures to monitor, mitigate and adaptively manage potential impacts to water resources.

#### Subsidence

6. Jilliby Jilliby Creek and its tributaries overlie the majority of the proposed northern longwalls. Subsidence within the Jilliby Jilliby Creek catchment is predicted to include both conventional and non-conventional subsidence effects. The NSW Development Consent contains a robust array of conditions to monitor and adaptively manage subsidence impacts, including the development of Longwall Extraction Plans (Schedule 3, Condition 7). The IESC considers the following subsidence monitoring and management measures would support Schedule 3, Condition 7 of the NSW Development Consent and could be implemented to prevent or reduce potential impacts to water resources:
  - a. The proponent should consider using a range of subsidence monitoring measures, such as remote sensing (e.g. inSAR or Lidar) before and after each longwall's extraction, to compare the data with predictions and subsidence monitoring points.
  - b. All subsidence monitoring points (as per Schedule 3, Condition 7 (h)(i) of the NSW Development Consent) should be installed before any mining of second workings for all longwalls in each Extraction Plan. That is, for an Extraction Plan that covers five longwalls, all monitoring points for all five longwalls should be identified and installed prior to any second workings being undertaken on the first longwall to be extracted.
  - c. Data from subsidence monitoring needs to be used to provide better calibrated predictions of subsidence within each consecutive Extraction Plan.
  - d. Each Extraction Plan after the first needs to report on the success or failure of chain pillar yielding resulting in a change to the predicted differential subsidence. Reporting needs to consider yielding of chain pillars detailed in previous Extraction Plans as yielding may vary over time. Surface impacts need to be reported if chain pillars remained intact following longwall

extraction as this may result in greater than predicted subsidence effects, such as strain, tilt and curvature.

- e. Monitoring should be undertaken to determine if leakage from shallow near-surface fractures occurs and if the flows through fractures are returning to the watercourses. This monitoring could occur through methods identified in paragraph 18 and be supported by Schedule 3, Condition 9(f) of the NSW Development Consent. Such monitoring should be undertaken before mining commences to gather the baseline conditions above each longwall and include:
    - i. Detailed monitoring to determine baseline geomorphological conditions including creek mapping and high-resolution photography (before, during and after undermining of each longwall) of any rock bars, shallow alluvium (e.g. less than 2 m deep) and permanent or semi-permanent pools within the subsidence impact area.
    - ii. Geophysical logging of boreholes that allow changes in groundwater storage, fracture apertures to be quantified and depth of rock deformation to be identified. Both open rock and multi-level piezometers will support assessment of changes to hydraulic gradients between different hydrogeological units (such as between alluvium and the underlying sequences).
    - iii. Time series cross-sections (before, during and after undermining of each longwall) using suitable geophysical techniques. This should include profiles across the creek channel and either side of the flood plain, with depth penetration exceeding the depth of alluvium to bedrock, but with meter or sub-metre scale resolution of data in at least 10 – 30 m of the surface.
  - f. If water travels through a tortuous network of near-surface fractures it may return to surface water courses containing different water quality parameters. Groundwater quality monitoring is needed to determine whether groundwater that has travelled through shallow subsidence fractures (see measures described in paragraphs 6e and 18) contains metals or other contaminants. This monitoring should be compared to groundwater monitoring from a reference site upstream and outside of the subsidence impact zone.
  - g. The proponent should install of a number of nested multi-level piezometer monitoring sites in locations matching the cases described in the EIS (Appendix G, 2013, pp. 22 – 42) to verify the depth and thickness of the constrained zone that develops in strata above the longwalls. The depth and thickness of the constrained zone should be compared with the results of the numerical subsidence modelling (EIS, Appendix G, 2013). The observed base of the constrained zone should also be compared with and with other analytical methods (e.g. the Ditton method (Ditton and Merrick, 2014) and the Tametta (2013) method) to estimate the height of caving above the coal seam.
7. Conventional subsidence impacts largely represent a low risk to the Wyong River. However, longwalls 2S to 4S and 1SW to 5SW are close to the Wyong River and are the longwalls most likely to cause non-conventional subsidence impacts. Given the importance of the Wyong River to the CCWSS, the following measures are needed as a component of the Extraction Plans for these longwalls:
- a. Updated subsidence predictions using data from the northern longwall panels.
  - b. Use of data from the northern panels to identify any adaptive management strategies that may be needed (e.g. shortening of longwalls) should updated predictions of conventional or non-conventional subsidence exceed the limits identified in the EIS.

- c. To support the conditions in the NSW Development Consent, determination of baseline geomorphological conditions (e.g. slope, rate of erosion, flow rates, location of any important rock bars or semi-permanent/permanent pools) of the Wyong River within the areas at risk from subsidence associated with longwalls 2S to 4S and 1SW to 5SW. These baseline parameters can then be used to compare conditions in the Wyong River, during and after the longwall extraction. The baseline monitoring should also be used to identify areas at risk of impact and identify site-specific management measures such as those identified in paragraph 6.

#### Wyong River and the Central Coast Water Supply Scheme

8. The Wyong River is located within the area of the Water Sharing Plan for the Central Coast Unregulated Water Sources. Total surface water entitlement within the Wyong River is 38,782 ML/year and is 99 per cent allocated with approximately 89 per cent for town water supplies and 10 per cent for irrigation (NSW Department of Water and Energy, 2009). The predicted peak loss of 300 ML/year due to the project would result in removal of less than 1 per cent of the surface water entitlement for the Central Coast Unregulated Water Sources, but this will be compensated for as part of the mine operations (see paragraph 9).
9. Surface water modelling undertaken by the Hunter subregion BA identifies a potential risk, with a low probability of occurring, to the number of flow days in the Wyong River (Herron et al., 2018b, p. 15). Groundwater and surface water monitoring should be used to validate groundwater and surface water modelling results to confirm the quantity of water lost from the Wyong River and Central Coast Unregulated Water Sources. According to the proponent's modelling, peak water loss would not be likely to eventuate until approximately year 11 of the proposed project. To address the risk identified by the BA, the proponent could release the Water Treatment Plant's additional capacity (predicted to be a maximum of 500 ML/year) as a contingency to the CCWSS until such time as the quantity of water lost due to the project is confirmed to be within the range predicted by the site-specific groundwater or surface water model/s (i.e. 300 ML/year).
10. The NSW Development Consent (Schedule 4, Condition 17) requires the proponent to release 300 ML/year of treated water back to the CCWSS at a location mutually agreed with the local Council. An assessment of the potential impacts to surface watercourses and GDEs associated with this condition has not been provided to the IESC. The potential impacts of discharging 300 ML/year will depend on a range of parameters, such as the flow regime, water quality and geomorphology of the watercourse or water body being discharged into. The proponent will need to develop water monitoring and management measures to address any risks associated with the release once the location of the discharge point into the CCWSS is confirmed. These should be provided prior to the release of any treated water and should include:
  - a. the location of the discharge point, the location of monitoring points (including upstream reference sites) and the frequency of water quantity and quality monitoring;
  - b. water quality parameters, including metals and other contaminants, of the released treated water to be compared to those in the receiving environment, such as using ANZECC/ARMCANZ Guidelines for 95 per cent aquatic ecosystem protection;
  - c. if discharging into a creek or river, inclusion of the discharge site into a Site Water Balance and Sediment and Erosion Control Plan (e.g. Schedule 4, Condition 19 of the NSW Development Consent);
  - d. consideration of pre-release natural flow regimes and climatic extremes, for both dry and wet seasons. In particular the potential to alter habitat and flow requirements for in-stream biota, such as the Australian Grayling (*Prototroctes maraena*) and Macquarie Perch (*Macquaria australasica*); and,

- e. a comprehensive risk assessment of potential impacts on in-stream, riparian and associated GDEs downstream of the release point. This risk assessment should include an ecohydrological conceptual model illustrating potential pathways and mechanisms of effects of altered surface flows, groundwater exchanges and in-stream water quality. This conceptual model would help the proponent justify strategies proposed to manage and mitigate potential impacts.

These measures could be used to support Schedule 4, Condition 17 of the NSW Development Consent relating to the CCWSS Compensatory Arrangement.

#### Jilliby Jilliby Creek

11. The proponent states that the maximum potential subsidence impact on water availability in the CCWSS equates to 300 ML/ year (Supplementary Information 2018, Appendix A, p. 31). The majority of this water loss is from the Jilliby Jilliby Creek catchment where a 270 ML/year reduction in water to the creek is predicted. The remaining 30 ML/year is predicted to be lost from the Wyong River (Supplementary Information 2018, Appendix A, p. 31). Subsidence beneath the alluvial floodplains of Jilliby Jilliby Creek and Little Jilliby Jilliby Creek has the potential to alter the erosion and sediment transport characteristics along these watercourses, cause minor “damming” of low flows and alter bed gradients. Therefore, the identified potential impacts to GDEs and surface water flows will be experienced mostly within the Jilliby Jilliby Creek catchment.
12. The IESC notes that the release of 300 ML/year into the CCWSS will not have any compensatory or mitigation benefits in the Jilliby Jilliby Creek Catchment for GDEs or private water extractors that are upstream of the release point. Further consideration of the GDEs and subsidence impacts in the Jilliby Jilliby Creek Catchment are discussed under paragraph 20 and 23.

#### Wallahah Creek

13. The proponent states that discharges into a tributary of Wallarah Creek of at least 3ML/d will result in a net increase in flow to Wallarah Creek (EIS, Appendix B, 2013, p. 52). It is noted that, should the 300 ML/year of water to be released to the CCWSS come from the Tooheys Road Water Treatment Plant (WTP) as was proposed, the volume of water to be discharged to Wallarah Creek will be lower than the volume that was assessed. It has not been clearly described how this change would affect the receiving environments. If the clean water from the WTP is not needed for water quality mixing (to improve water quality through dilution) the potential impacts of discharging to the Wallarah Creek tributary are likely to be less severe than the previous proposal. Given the predicted peak discharge from the WTP is 500 ML/year it is still likely that discharges will occur year round. Therefore the IESC considers that the development of a Surface Water Monitoring and Management Plan is needed to manage the potential impacts to Wallarah Creek. This plan should include:
  - a. Additional parameters beyond pH, EC and TSS for example metals.
  - b. Development of site-specific in-stream water quality objectives in accordance with ANZECC/ARMCANZ aquatic ecosystem protection guideline values as well as water quality monitoring for ecotoxic impacts, (i.e. undertaking a direct toxicity assessment using a range of fresh water species). Water quality measurements from monitoring point W6 have been used to set the water quality parameters of the treated water being discharged. However, the water quality from monitoring location W6, which is downstream of the discharge point location and exceeds the ANZECC/ARMCANZ Water Quality Guideline values for copper, cadmium and zinc. Consideration should be given to using the data from water quality monitoring location W12, noting this is also a disturbed site, which has lower EC, TDS, sulfate, chloride and iron.
  - c. Data and mitigation methods on potential changes to the total flow volumes and the frequencies of high, median and low flows in Wallarah Creek and the tributary being discharged into. If the

flow regime is changed from ephemeral to perennial, it is likely to alter the natural biota and ecosystem processes favoured by ephemeral flows and may provide habitat for unwanted exotic species such as Mosquito Fish (*Gambusia holbrooki*), which already exist in the downstream catchment area (EIS, Appendix O, 2013, p. 78). This will have a direct effect on potential breeding habitat of native fish and frogs in the receiving environment because *G. holbrooki* preys on native tadpoles and fingerlings. A potential mitigation method could be to release the treated water to recover the natural flow regime. Alternatively, the release of treated water into Jilliby Jilliby Creek (releasing into the CCWSS) would have proportionally less impact than if released into the smaller Wallarah Creek.

14. The quantity and quality of the discharged treated water will be managed through an Environmental Protection Licence (EPL) (Schedule 4, Condition 15 of the NSW Development Consent). The EPL has not yet been prepared. Water quality objectives should be applied to water released into Wallarah Creek from the WTP using the ANZECC/ARMCANZ 95th percentile aquatic ecosystem protection guideline values rather than recreational values (EIS, Appendix B, 2013, p. 59).
15. The barium concentration predicted in the treated water is higher than background water quality measurements. If these predictions are correct, discharged water could pose a potential risk to aquatic biota in Wallarah Creek when the majority of flow in the creek is made up of treated water. Because there is no ANZECC/ARMCANZ 95th percentile ecosystem protection guideline value for barium, the proponent should ensure that discharged treated water quality does not exceed the proposed EPL end-of-pipe limit for barium of 0.15 mg/L (Response to Submissions, 2013, p. 51) until site-specific guideline values for barium are derived. Site specific guideline values for barium should be derived using an upstream monitoring location that is representative of the existing water quality conditions in Wallarah Creek.

#### Groundwater

16. Schedule 4, Condition 19 (d)(v) of the NSW Development Consent requires the proponent, as part of a groundwater management plan, to review and update the groundwater model every three years. To support that condition, the IESC considers that reviews and updates of this model should include sensitivity and uncertainty analyses. Such analyses support consideration of the full range of impacts, justify changes in model predictions over time and prioritise future data collection.
17. While the proponent noted that a number of operational issues hindered collection of hydraulic parameter measurements (2018 Supplementary Information, Appendix A, pp. 63 – 69), the IESC considers that ongoing collection of in situ hydrogeological parameters (hydraulic conductivity and storativity (e.g. using methods described by David et al., 2017)) should occur prior to the first update of the groundwater model. This data provides parameters at an appropriate scale to verify conceptual models and constrain the groundwater model.
18. Schedule 3, Condition 9(f) of the NSW Development Consent requires regular 'groundwater age dating' to identify downwards leakage from alluvial aquifers. While the IESC supports this approach, a broader group of environmental tracers should be considered to confirm the hydrogeological conceptualisation for subsidence-related downwards leakage through a porous matrix and fracture network. This should include a suite of suitable tracers that has distinctive end members from different hydrological zones and sources that could be indicative of mixing of different waters over time. Tracers should be used to inform groundwater flow rates and flow paths and to inform updates and reviews to the groundwater model.

#### Groundwater-Dependent Ecosystems

19. As identified by the IESC in 2013, in addition to the direct removal of remnant forest and woodland, groundwater drawdown and subsidence will potentially impact GDEs, especially those in the Jilliby



Jilliby Creek catchment. The main types of GDEs in the proposed project area are subterranean GDEs (e.g. alluvial aquifers), river base-flow GDEs (e.g. in-stream, hyporheic and riparian ecosystems) and terrestrial GDEs (e.g. groundwater-dependent vegetation and its associated biota). All three types occur in the Project area, and include habitat for several water-dependent species listed in the EPBC Act (see paragraph 22).

20. It is likely that alluvial and hyporheic sediments, especially those associated with third- and higher-order streams in the subsidence area (e.g. Jilliby Creek, Little Jilliby Creek and Wyong River), support groundwater-dependent biota (including hyporheic invertebrates and stygofauna) and fundamental ecosystem processes such as organic matter processing and nutrient transformation (e.g. Burrows et al., 2017). Data should be provided on the presence of stygofauna within alluvial sediments overlying the longwall panels, particularly in 3<sup>rd</sup> and higher-order streams. Stygofauna sampling could be repeated annually during the life of the project to detect potential effects of changes to groundwater levels. A monitoring program (e.g. Korbel and Hose, 2016) should be coupled with an appropriate management plan (e.g. required through Schedule 4, Condition 23 of the NSW Development Consent) to reduce or mitigate any detected impacts.
21. The Hunter Subregion BA has identified potential cumulative impacts, from Wallarah 2 and Mandalong, to riparian rainforests of the Wyong River catchment (e.g. Coachwood-crabapple warm temperate rainforest) (Herron et al. 2018c, p. v). This ecosystem is likely to have a dependence on streamflow and alluvial groundwater. Other potential GDE communities in the area include Woollybutt-Turpentine sedge forest and wetlands supporting *Phragmites australis* and *Typha orientalis*. The IESC considers a local-scale investigation of the subsidence impact zone is needed to provide data on the water dependence of these potential GDEs to inform management and mitigation measures. Data and investigations should begin prior to longwall extraction and include:
  - a. the depth to groundwater (from the surface) in areas inhabited by GDEs;
  - b. seasonal variations in depth to groundwater in areas inhabited by GDEs;
  - c. details of GDE extents incorporated into longwall Extraction Plans, including changes in extent since each previous Extraction Plan (e.g. could be achieved through remote sensing or aerial imagery);
  - d. identification of changes to GDE species composition, ecosystem health (e.g. reduced recruitment of young trees, loss of key species) or reductions in GDE extents; and,
  - e. an analysis of risk using the above data and groundwater monitoring data (e.g. gathered through Schedule 3, Condition 9 (g)(ii) of the NSW Development Consent) within each longwall Extraction Plan to identify potential management or mitigation measures.
22. The IESC notes that during extended dry periods, there may not be sufficient water supply to ensure the protection of GDEs in the areas affected by subsidence. Therefore, the Biodiversity Management Plan (Schedule 4, Condition 23 of the NSW Development Consent) could be supported by requirements to identify water needs of water-dependent species within the Jilliby Catchment Area, especially for the following species:
  - a. Macquarie Perch - *Macquaria australasica* (EPBC Act - Endangered);
  - b. Australian Grayling - *Prototroctes maraena* (EPBC Act - Vulnerable);
  - c. Giant Barred Frog - *Mixophyes iteratus* (EPBC Act - Endangered) (occur along permanent or semi-permanent streams, favour moist riparian habitats);

- d. Giant Burrowing Frog - *Heleioporus australiacus* (EPBC Act - Vulnerable) (generally occur in permanent or semi-permanent pools in 1<sup>st</sup> or 2<sup>nd</sup> order streams, slow-growing, living up to 10 years);
  - e. Green and Gold Bell Frog - *Litoria aurea* (EPBC Act - Vulnerable, NSW Threatened Species Conservation Act - Endangered) (occurs in marshes and streams, especially those containing *Typha orientalis* and free of *Gambusia holbrooki*);
  - f. Stuttering Frog - *Mixophyes balbus* (EPBC Act - Vulnerable, NSW Threatened Species Conservation Act - Endangered) (riffle-breeding, breeds in summer during heavy rain, potentially impacted by a reduction in flow days);
  - g. Littlejohn's Tree Frog (*Litoria littlejohni*) (EPBC Act - Vulnerable) (breeds in upper reaches of permanent streams);
  - h. Green-thighed Frog (*Litoria brevipalmata*) (NSW Threatened Species Conservation Act - Vulnerable); and,
  - i. Wallum Froglet (*Crinia tinnula*) (NSW Threatened Species Conservation Act - Vulnerable) (breeds in permanent water and ephemeral pools).
23. The locations of aquatic ecological sampling sites provided by the proponent are not in the areas of the maximum predicted subsidence. This will likely hamper assessment of in-stream conditions before, during and after mining. The addition of further aquatic ecological sampling site locations in the maximum predicted subsidence areas for Jilliby Jilliby Creek and Little Jilliby Jilliby Creek should be used to support Schedule 4, Condition 20 and Condition 23 of the NSW Development Consent relating to the Frog Research Plan and the Biodiversity Management Plan.

#### Cumulative impacts

24. The bioregional assessment provides a cumulative impact assessment that includes the adjacent Mandalong Southern Extension Project. Predicted drawdown extents resulting from the two mines join when the regional parameters are used, but show a more limited connection when results are constrained using local hydrogeological data (Herron et. al., 2018a, pp. 124 – 126).
25. To monitor and manage cumulative impacts, the proponent should investigate and quantify the hydraulic connectivity on the north-east boundary of the project (including the use of, for example, environmental tracers and hydraulic testing). This should include the effects of geological structures (e.g. dykes) on connectivity between the Mandalong South Extension and the proposed project. This work should be incorporated into groundwater modelling reviews and updates of boundary conditions in the proponent's groundwater model.

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<b>Date of advice</b>	1 June 2018
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<b>Source documentation available to the IESC in the formulation of this advice</b>	<p>Environmental Impact Statement, 2013. <i>Main Report, Volume 1 and relevant water Appendices</i>. Report prepared by Hansen Bailey on behalf of Wyong Areas Coal Joint Venture, April 2013. Available:  <a href="http://majorprojects.planning.nsw.gov.au/index.pl?action=view_job&amp;job_id=4974">http://majorprojects.planning.nsw.gov.au/index.pl?action=view_job&amp;job_id=4974</a></p> <p>NSW Development Consent, 2018. <i>Schedule 1 – SSD 4974, Wyong Areas Coal Joint Venture</i>. Section 89E of the Environmental Planning and Assessment Act 1979. Minister for Planning. Available:  <a href="http://majorprojects.planning.nsw.gov.au/index.pl?action=view_job&amp;job_id=4974">http://majorprojects.planning.nsw.gov.au/index.pl?action=view_job&amp;job_id=4974</a></p>
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