

# Advice to decision maker on coal mining project

IESC 2018-098: Maxwell Project – Expansion

Requesting agency	The New South Wales Mining and Petroleum Gateway Panel
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Advice stage	Gateway Application

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 New South Wales Mining and Petroleum Gateway Panel to provide advice on Malabar Coal Limited's Maxwell Project in 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 proposed Maxwell project is an underground coal mine extension to be developed in the Hunter Valley, NSW. The project involves underground mining of four coal seams, the shallowest seam to be mined using bord and pillar methods with the deeper three coal seams to be longwall-mined. Coal will be handled at the existing Maxwell infrastructure site with coal rejects, tailings and brine to be deposited within the existing open cut East Void.

Key potential impacts from this project are:

• long-term changes, which are severe and irreversible, to Permian hard rock aquifers and surface watercourses, due to subsidence fracturing;

- changes to groundwater levels in alluvial aquifers due to leakage through shallow, hard rock fractures into hard rock aquifers;
- changes to surface water flow regimes and an increase in sediment deposition (particularly in Saddlers Creek and its tributaries) due to surface effects of subsidence, the extent of which is unable to be determined as a surface water assessment was not included in the Gateway Certificate Application;
- groundwater drawdown impacts to groundwater-dependent ecosystems (GDEs), the extent of both are uncertain due to the limited information; and,
- decreased groundwater and surface water quality should seepage occur from the rejects, tailings and brine in the East Void.

Understandably, the documentation provided by the proponent is targeted at assessing impacts to important agricultural land, as is required by the Gateway Certificate Application process, and does not include the full range of information outlined in the IESC Information Guidelines for proponents preparing coal seam gas and large coal mining development proposals (Information Guidelines) (IESC 2018). Should this project proceed to a more detailed environmental assessment, the IESC would expect the documentation provide further detail on key risks relevant to ecological assets, water management, final landform management, geochemical characteristics, and related mitigation measures.

The IESC is concerned that the inherent uncertainty involved in model conceptualisation and parameterisation does not warrant the unrealistically high confidence with which subsidence and groundwater impacts are presented. The key areas in which additional work is required to address the potential impacts are summarised below.

- Given the potentially irreversible and severe impacts to groundwater resources (and surface watercourses), explicit consideration of the uncertainty involved in predicting subsidence and ground movements is needed. This should include greater transparency on how these uncertainties transfer to groundwater impact predictions using traditional equivalent porous media groundwater models (such as MODFLOW).
- Provision of geological modelling of the interburden, distribution of lithologies and process deposition that will influence vertical subsidence and fracture heights above each mined seam and their impact on groundwater predictions.
- Provision of site-specific information or relevant peer-reviewed case studies that address the general lack of understanding on how best to quantify the effects of ground movement, subsidence and fracturing on water movement and storage.
- Collection of groundwater observation data and relevant down-borehole information to verify empirical approaches used to estimate the height of fracturing above extracted seams.
- An assessment that gives due consideration to the large inherent uncertainties in the potential impacts (e.g. through subsidence fracturing, ponding and/or erosion) on flow regimes, water quality and instream biota in surface water systems such as Saddlers Creek and its tributaries that drain the region of predicted subsidence. This should include long-term case studies for comparison.
- Baseline (pre-mining) information on surface water quantity and quality (e.g. suspended solids), channel geomorphology and aquatic biota is needed to inform risk assessments and, if needed, suitable mitigation strategies.

- An assessment of the extent and condition of relevant groundwater-dependent ecosystems and their biota, complemented with an appropriate risk assessment, monitoring program and feasible mitigation strategies for those impacts that cannot be avoided.
- Provision of site-specific surface water, geochemical and risk assessments supported by a site-specific water balance and cumulative impact assessment, the latter to include relevant reaches of the Hunter River.

### Context

The proposed Maxwell project has been referred to the IESC at the 'Gateway' stage due to its location partly on identified Biophysical Strategic Agricultural Land (BSAL) as legislated under the NSW *Environmental Planning and Assessment Act 1979*.

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 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. This information includes that outlined in the IESC Information Guidelines (IESC 2018) as well as in IESC Explanatory Notes as they become available.

The proposed Maxwell project is an underground coal mine to be developed within Mining Lease Area EL 5460 in the Hunter Valley, New South Wales. The Maxwell project involves underground mining within four coal seams including (in order of shallowest to deepest): bord and pillar mining of the Whynot Seam and longwall mining of the Woodland Hill Seam, Arrowfield Seam and Bowfield Seam. Coal is proposed to be mined at a rate of up to 8 million tonnes per annum for a total of approximately 150 million tonnes of run-of-mine coal over a 26-year operational period. The coal product would be a mixture of metallurgical coal and thermal coal.

Upgrades to the coal handling and preparation plant (CHPP) and coal transportation infrastructure will be required to allow coal to be managed using the existing Maxwell infrastructure. Coal will either be exported via the existing Maxwell rail facilities or transported via conveyor to the Bayswater and/or Liddell Coal Power Stations. Coal rejects, tailings and brine will be deposited within the existing East Void located near the existing Maxwell CHPP facility. The rehabilitation of the East Void following completion of tailings deposition is a component of the proposed Maxwell project.

#### **Response to questions**

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

Question 1: It would be appreciated if the IESC could advise on the potential likelihood and significance of any impacts of the proposal on water resources.

- The limited level of detail in the project documentation at the Gateway stage restricts the ability of the IESC to assess the extent and likelihood of most of the proposed project's potential impacts to water resources. Consequently, this advice is only able to provide general advice on the potential likelihood and significance of impacts of the proposed project, a number of which have been identified in the documentation accompanying the Agricultural Impact Assessment (AIA).
- 2. Key potential impacts include those caused by subsidence and groundwater dewatering. A detailed subsidence assessment has been provided which provides adequate consideration of physical subsidence impacts, while the Preliminary Groundwater Assessment (AIA, Attachment C) provides an indication of the potential groundwater drawdown impacts. However, limited information is available on surface water impacts, ecological impacts (including to groundwater-dependent ecosystems (GDEs)) and potential impacts associated with the proposed final landform and backfilled

East Void. Several strategies and assessments to address these identified information gaps are provided in response to Question 4.

### <u>Subsidence</u>

- 3. Given the number of vertically successive coal seams to be mined, the proposed Maxwell Project will result in a range of potential subsidence-related impacts to water resources. These would include changes to surface watercourse gradients, flows and erosion, and surface ponding as well as surface and shallow fracturing. The maximum conventional vertical subsidence is predicted to be 5.8 m where all four coal seams are proposed to be extracted. However, conventional vertical subsidence will occur progressively as each subsequently deeper coal seam is mined. The seam with the greatest individual contribution to subsidence is predicted to be the Woodlands Hill Seam (AIA, Attachment B, p. 27), which is the second to be mined, is the first series of longwalls and the first to undermine the bord and pillar workings within the Whynot Seam. The extraction of three underlying coal seams beneath the Whynot Seam will likely result in the collapse of retained coal pillars, which would likely result in increased subsidence evident at the surface. The IESC notes that elsewhere in the Hunter Valley (North Wambo Underground Mine, see AIA, Attachment B, pp. 23 24) the extraction of longwalls beneath bord and pillar mined seams has resulted in localised subsidence in excess of 100 per cent of the total mining height.
- 4. While the subsidence assessment utilises an appropriate methodology for both single- and double-seam subsidence predictions, there is a higher level of uncertainty regarding the predictions for subsidence from the mining of the third and fourth seams. This uncertainty is due to empirical evidence not being available to support model calibration for the mining of three and four vertically successive seams. Given this uncertainty, the IESC considers a risk-based, or precautionary, approach should be used when interpreting total cumulative subsidence, particularly in proximity to geological features (see paragraph 5 below) and important water resources (e.g. the Hunter River and its alluvium).
- 5. A number of structural features (igneous sills and fault zones, including the East Graben Fault) have been identified that may result in non-conventional, anomalous or irregular subsidence. These various types of subsidence potentially pose a higher risk to water resources outside of the conventional subsidence (26.5 degree angle of draw) impact zone. The resulting impacts at the surface from these subsidence episodes could be severe where the structural features are associated with water resources such as surface watercourses, alluvial aquifers and other GDEs or groundwater infrastructure (e.g. monitoring bores).

## Groundwater

- 6. The potential impacts to groundwater resources (and surface water drainage) are highly likely to be severe and irreversible. Given the lack of adequate methods to assess the potentially severe and irreversible impacts to groundwater (and surface water resources) from subsidence, the current groundwater modelling approach has potentially understated the impacts of the proposed project and overstated the certainty with which the impacts can be predicted.
- 7. The IESC acknowledges the efforts made by the proponent to model the complex subsidence fracturing and groundwater impacts potentially caused by the proposed multi-seam mining method. However, the traditional porous media groundwater model used (MODFLOW-USG) is incapable of realistically simulating groundwater responses to ground movement of strata. This ground movement could include, but is not limited to, bed separation and subsidence-induced fracturing (which could extend to the ground surface). This is compounded by the limited options available to couple geotechnical and groundwater models and also the limited amount of data available to support the modelling of fracturing for multi-seam extraction. While the groundwater model report has utilised the best available methods to estimate fracture propagation above extracted coal seams, both the

Tammetta (2013) and Ditton equations contain a number of assumptions that may not be appropriate to inform groundwater modelling in multi-seam mining operations. The IESC acknowledges that work to review and verify these methods is needed to expand the empirical data on which these methods rely.

- 8. The IESC considers that the groundwater model predictions contain a high degree of uncertainty for the following reasons.
  - a. The extent of ground movement (e.g. subsidence, fracturing, bedding shear) above any longwall panel is uncertain and difficult to identify and predict (see Galvin 2017). The uncertainties are compounded by multi-seam extraction. The impacts on groundwater are even more uncertain given the likely tortuous flow paths through various fracture networks. Evidence from a number of other longwall mines (e.g. in the Southern and Western Coalfields of NSW; PSM 2017) shows that groundwater responses to the extent of subsidence fracturing cannot be accurately predicted.
  - b. Limited detail has been provided to describe how the stacked drain process determines changes to hydrogeological parameters within the different fracture zones above extracted coal seams. Further, the groundwater model is highly sensitive to the vertical hydraulic conductivity through the fractured zones above (and between) each of the mined seams and no empirical evidence or data has been provided to support the application of this method.
- 9. The groundwater model results appear to contain some systematic bias whereby groundwater levels are overpredicted compared to observed groundwater levels. For example, the calibration and verification of water level data points presented in Figures 36 to 39 of the AIA (Attachment C) are consistently at a higher elevation compared to the observed water levels, many by more than 50 m.
- 10. The uncertainties identified in paragraphs 6 to 9 above make it difficult for the IESC to confidently determine the likelihood and significance of potential impacts. However, the IESC considers it is reasonable to conclude that long-term hydrogeological changes would be likely to the North Coast Fractured and Porous Rock aquifers (as defined by NSW Government 2016) between the Bowfield seam and the surface within the mining area, given the magnitude of the predicted subsidence and subsurface deformation, and the number of vertically consecutive coal seams to be mined.
- 11. The predicted impact to the alluvium over the entire model domain is the loss of approximately 0.28 ML/day (98.8 ML/year) (AIA, Attachment C, Figure 43 and p. 65). Given the uncertainty in the magnitude and hydrogeological effect of shallow hard rock and surficial fracturing, and the above noted sensitivity of the model to the vertical conductance of the fractured zone above each of the extracted seams, the potential impacts to alluvial aquifers may well be greater than predicted. Finer-scale modelling of alluvium and detailed representation of alluvial impacts will be needed in future modelling. Further, confirmation of alluvium extent (e.g. using geophysics), will be particularly important where the Hunter River Alluvium is close to the southern edge of the proposed mining area.
- 12. The groundwater model predicts significant depressurisation and dewatering of the Permian coal seams, extending for up to 9 km to the west, south and north. Vertical propagation of this depressurisation is predicted to result in a maximum predicted water table drawdown of approximately 20 m but the two-metre drawdown contour is not predicted to extend beyond the mining lease.
- 13. The preliminary groundwater model predicts groundwater drawdown impacts to 29 existing groundwater user bores within the model domain, two of which are within the mining lease area. Of the 29 bores, only one is predicted to experience drawdown impacts greater than two metres due to the proposed Maxwell project. The potential impacts to landholder bores will need to be re-assessed following more detailed groundwater modelling and cumulative impact assessment. The IESC

considers that the process to determine 'make good' arrangements for cumulative impacts shared between mine sites needs to be established and documented.

#### Surface Water

- 14. The preliminary groundwater model predicts leakage from the Hunter River and Saddlers Creek to peak at approximately 50.0 ML/year and 45.4 ML/year respectively approximately 80 100 years post mining (AIA, Attachment C, pp. 64 65). The volume of water lost from surface watercourses will be highly dependent on whether non-conventional, anomalous or irregular subsidence occurs. Fracturing of rock bars due to valley closure and upsidence may also exacerbate the potential impacts to surface watercourses and waterbodies. No consideration has been given to the sensitivity of key assumptions on the estimated leakage rates. Accordingly the IESC has little confidence in the estimated likelihood and significance of the impacts on surface water resources.
- 15. Subsidence fracturing within the shallow substrate beneath alluvial sediments will be less readily detectable than surface cracks or cracks in rock bars in drainage lines. Fracturing under alluvial sediments, particularly deep sediments associated with the Hunter River, are likely to be irreversible and could result in substantial losses of surface water flows via the alluvial aquifers.
- 16. The proponent has not provided any information on the project's mine water management measures or whether controlled releases to surface watercourses will be required. Coal mines in the Hunter Valley are required to discharge mine water in accordance with the Hunter River Salinity Trading Scheme (HRSTS). While the HRSTS is designed to minimise salt loads in the Hunter River, it does not prevent discharges of water high in other contaminants and toxicants. Controlled and uncontrolled (spills) releases have the potential to impact the downstream environment. However, it is not possible to determine the potential likelihood and significance of downstream surface water impacts without a site-specific water balance and a surface water quantity and quality assessment.

## Groundwater-dependent ecosystems (GDEs)

- 17. A detailed assessment of ecological assets and GDEs has not been provided. However, the proponent (AIA, Attachment C, p. 68) acknowledges the water-dependent asset register for the Hunter subregion (Macfarlane et al. 2016) of the Northern Sydney Basin Bioregional Assessment for providing guidance for identification of various GDEs including surface and subsurface waters and groundwater-dependent vegetation. Based on the results of the preliminary groundwater modelling, shallow groundwater exists near Saddlers Creek, Saltwater Creek, the Hunter River and a number of minor drainages and tributaries. At least two types of GDEs are potentially impacted:
  - a. <u>Type 1 Aquifer and cave ecosystems.</u> Stygofauna are known from the alluvial aquifers and hyporheic zones of the Hunter River and its tributaries (Hancock 2006; Hancock and Boulton 2009) and may be affected by altered groundwater regimes. Surveys (Eco Logical 2015 and 2018 cited in Attachment C, pp. 32 33) for stygofauna in the Hunter River alluvium and Saddlers Creek alluvium near the proposed project found one known stygofaunal taxon (Syncarida, *Notobathynella* sp.) from the Hunter River alluvium and two likely stygofaunal taxa (Cyclopoida and Ostracoda) in the Hunter River and Saddlers Creek alluvium.
  - b. <u>Type 3 Ecosystems dependent on subsurface presence of groundwater.</u> Groundwaterdependent vegetation is likely to occur, especially along riparian zones and on floodplains of Saddlers Creek, Saltwater Creek, the Hunter River and other relevant tributaries in the predicted areas of groundwater drawdown. Further assessment is needed to determine which vegetation in these areas is dependent on groundwater (see response to Question 4, paragraph 39), and how it may be affected by the proposed mining and associated drawdown. In particular, assessments are needed on the possible impacts to EPBC Act-listed critically endangered ecological communities (e.g. White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived

Native Grassland, Central Hunter Valley eucalypt forest and woodland) which may contain species that are opportunistically dependent on groundwater.

#### Final Landform

18. Rejects, tailings and brine are proposed to be deposited in the East Void at the existing Maxwell mine. While the IESC considers that this is an appropriate way to handle coal waste for the proposed project, the waste-filled void may pose a long-term legacy risk to both surface water and groundwater quality if appropriate monitoring and management measures are not implemented.

Question 2: It would be appreciated if the IESC could advise on the boundary conditions used in the groundwater model.

- 19. The IESC has noted a number of sources of uncertainty in the preliminary groundwater model in response to Question 1 (paragraphs 6 to 9). These sources of uncertainty have a more profound influence on groundwater modelling predictions than the adopted groundwater boundary conditions. Nevertheless, the groundwater model's boundary conditions are also subject to multiple sources of uncertainty due to model non-uniqueness. Insufficient justification is provided for the selection and location of general head boundaries, particularly to describe their sporadic or patchy placement around the model domain. Moreover, it is stated that the groundwater model lateral boundary conditions are sufficiently far from the mine to have no impact on model predictions. It is therefore unclear why the applied general head boundary conditions are even needed.
- 20. Boundary conditions identified within the preliminary groundwater impact assessment include general head boundaries, no flow boundaries (prescribed by inactive cells), river boundaries and drains as well as recharge and evapotranspiration (AIA, Attachment C, pp 42 45).
- 21. The IESC notes that the groundwater model is preliminary and agrees with the recommended improvements listed in the AIA (Attachment C, p. 83). In addition to these recommendations, future models that are produced should provide the following details to support the prescription of boundary conditions.
  - a. Further detail on the location and parameterisation of general head boundaries (or other boundary conditions if used). This should include which bore/s or datasets (e.g. predicted groundwater levels from other groundwater models and the associated data used to generate the predictions) are used to determine appropriate boundary conductance and to provide the water level data from that bore.
  - b. Confirmation of geological outcrop and strata pinch-out to inform the location of no-flow boundaries and inactive groundwater model cells. While the preliminary groundwater assessment appears to have followed geological and exploration mapping, a dedicated geological assessment is needed (as detailed in paragraph 29) to confirm the hydrogeological conceptualisation, the representation of interburdens and the geological structures using no-flow boundaries that prevent the lateral flow of groundwater.
  - c. Information on recharge rates as a proportion of rainfall (particularly for the alluvium) that are independent of the groundwater model. This information should be compared to, if possible, other studies that consider environmental tracers or soil water balance modelling and consider a range of evaporation extinction depths greater than two metres.
  - d. Detailed river reach and geophysics mapping that identifies river bed materials. This information should support the chosen river bed conductance values applied in the groundwater model. River boundary conditions can also be compared to surface water runoff-flow models and baseflow calculations to justify the choice of conductance.

22. It is recommended that both sensitivity and uncertainty analysis should be undertaken for the parameterisation of boundary conditions including, for example, recharge, evapotranspiration (including extinction depth), river bed conductance (including representation of natural heterogeneity along the river), drain conductance and strata conductance at general head boundaries. These analyses should prioritise examination of the relative importance of general head boundaries, recharge and drain conductance to the overall water balance to identify values that significantly influence drawdown distribution in all hydrogeological units in the groundwater model.

Question 3: It would be appreciated if the IESC could advise on the appropriateness of the proposed mitigation measures.

- 23. Given the preliminary nature of the water resource assessments provided to satisfy the Gateway Certificate process, the mitigation measures detailed are mostly high level and lack the specificity needed for the IESC to determine their appropriateness.
- The available documentation (Malabar Coal, 2018, pp. 17 20; AIA, pp. 58 59) describes preliminary monitoring and management measures for subsidence but provides limited information on most other mitigation measures.
- 25. It is probably not feasible to successfully mitigate ground movement impacts that are at depth or that are not visible or accessible at the surface (e.g. below alluvium associated with surface watercourses).
- 26. Subsidence mitigation measures are to be detailed within a subsidence management plan and implemented following impact identification through site-specific monitoring. At this stage the identified potential mitigation measures for subsidence-induced surface cracking include ripping, re-grading or in-filling of large to medium surface cracks, re-grading and erosion controls in surface drainage lines and repairing or reinstating damaged groundwater bores. However, the IESC would expect to see more detail on the specific monitoring, management and mitigation measures included within a full environmental assessment. Detailed, long-term and peer-reviewed case studies on successful use of these measures at equivalent locations are essential. Studies should be provided on the relative impacts from grading surface water drainage channels versus letting them "self-heal" after subsidence.

Question 4: The IESC may also recommend further studies that should be undertaken if relevant.

27. Given the preliminary state of water resource assessments within the AIA and Gateway Certificate Application, the IESC recommends a number of further studies below that should be completed as a component of any future assessments. While some of the following studies may not be relevant at the Gateway stage, the IESC considers that they would be critical to inform any future environmental assessment processes. The recommended studies and methods described are based on current understanding and should not be considered exhaustive. When undertaking further studies, the proponent should consider the information needs outlined in the IESC's Information Guidelines (IESC 2018) and relevant IESC Explanatory Notes as they become available.

#### Groundwater assessment and groundwater modelling

28. The preliminary groundwater impact assessment identified a high-level scope for groundwater modelling to inform future environmental assessment (AIA, Attachment C, p. 83). The IESC is generally supportive of the identified future groundwater modelling scope, but recognises the inherent complexities of modelling fracture flow through porous media (see paragraphs 6 to 9). Where justified by monitoring data, consideration should be given to incorporating structural geological features (e.g. faults, dykes, sills, lithological variations in geology) in groundwater modelling undertaken to inform the next stage of environmental assessment.

- 29. A geological assessment is needed to confirm the hydrogeological conceptualisation. The geological assessment should include detailed geological maps of outcrop, subcrop, alluvial extent and regolith extent, bore logs and any geophysical assessments (such as electromagnetic surveys) undertaken to confirm the geological features within the project's impact area.
- 30. A detailed, independent and peer reviewed assessment of the potential surface-to-seam fracturing with an integrated hazard map (c.f. Herron et. al. 2018) overlaying the GDEs, BSAL areas, geological structures and drainage lines close to the Hunter River alluvium is needed.
- 31. There is a high degree of uncertainty associated with the groundwater modelling, including the stacked drain VCOND method used to estimate the influence of the fractured zone on groundwater. This method is unable to directly simulate fracturing to the surface (AIA, Attachment C, p. 47) and is not supported by any case-study evidence (because there are no detailed groundwater case studies for the effects of the extraction of more than three coal seams) (see also paragraph 4). Given the lack of evidence or case studies for this number of consecutive seam extractions, it is critical that appropriate monitoring and investigative down-borehole information data should be collected to reduce uncertainty in future predictions.
- 32. Confirmation of the depth and extent of the Hunter River alluvium and its associated groundwater levels are needed as its alluvial material is near the predicted watertable drawdown extent as well as along Saddlers Creek and a tributary of Saltwater Creek. This assessment could occur using the methods described in paragraph 29 and should be accompanied by finer-scale groundwater modelling. Confirming the alluvial extent and water levels will be particularly important given the uncertainty in the magnitude of surficial and shallow hard rock fracturing caused by subsidence and the sensitivity of the groundwater model to the vertical hydraulic conductivity within fractured zones of the deeper geology.
- 33. Future groundwater impact assessments should provide greater transparency around the source hydrogeological data used to parameterise the groundwater model including, but not limited to, the boundary conditions (see response to Question 2), the hydrogeological conceptualisation and hydrogeological parameters. This should include clearly presenting the hydrogeological data, the collection method (e.g. pump test, packer test) and any important information or statistics that inform how it was used in parameterisation of the groundwater model. Where sourced from existing studies, methods and data should be reproduced to justify their application in the future groundwater assessments.
- 34. Consideration should be given to using recently developed in-situ methods to measure specific storage (David et al. 2017; Rau et al. 2018) and applying the resulting values to better constrain the results of future groundwater models. There are multiple combinations of hydraulic conductivity and specific storage that could materially affect the modelled water balance and drawdown of a transient model.
- 35. The preliminary groundwater model only considered cumulative impacts from the Mt Arthur mine immediately to the north of the exploration lease. Although existing coal mines to the east are hydrogeologically separated by geological structure and outcropping, groundwater modelling to inform the next stage of assessment should include all mines within the model area unless exclusion is clearly justified and supported by geological and groundwater data. These mines include the proposed Spur Hill project, Mt Arthur (and extension) projects, Bengalla, Mangoola and the existing workings/voids within the Maxwell area. Cumulative impact assessment should also consider the results from the Bioregional Assessment for the Northern Sydney Basin, Hunter Subregion.
- 36. The proponent has committed to developing a groundwater management plan (including a groundwater monitoring programme) (Malabar Coal 2018 p. 19). Limited groundwater quality data (EC and pH), obtained from other reports and operations, have been provided for the Hunter River

Alluvium, Saddlers Creek alluvium and the Permian porous rock aquifers. A full range of parameters should be measured (beyond EC and pH) and included in the proposed groundwater monitoring program to be included in the groundwater management plan. This plan should be presented as a component of any future environmental assessment.

#### Surface water assessment

- 37. A surface water assessment is needed which:
  - uses a risk-based approach to identify key surface water systems with the potential to be impacted (e.g. through subsidence fracturing, ponding or erosion), especially how this may alter the duration of periods of low and zero flow in Saddlers Creek and potentially impact on instream biota;
  - b. identifies the existing (baseline) hydrological regime of all watercourses within the potential zone of hydrological impacts;
  - c. uses appropriate surface water quantity and quality data to inform impacts and risks;
  - d. includes baseline monitoring data over a sufficient time period to enable the derivation of appropriate site-specific water quality guideline values;
  - e. considers geomorphology and the additional impacts potentially caused by the range of potential subsidence effects (e.g. sedimentation and erosion); and
  - f. informs appropriate mitigation strategies (e.g. timing and methods for re-establishing drainage lines to minimise erosion and vegetation damage).

#### Water balance modelling

- 38. A quantitative site-specific water balance is needed which accommodates various sources of uncertainty (e.g. using the Water Accounting Framework for the Australian minerals industry, Minerals Council of Australia 2014). This site-specific approach would describe:
  - a. the total water supply and demand under a range of rainfall, climatic and water demand scenarios to support the uncertainty analysis;
  - b. the required water infrastructure, including infrastructure capacity and transfers;
  - c. volumes of water needed to be discharged (if any), under a range of rainfall scenarios; and
  - d. quantitatively the potential water quality impacts due to the any of the above water management actions.

#### Groundwater-dependent ecosystems (GDEs)

- 39. An assessment of the extent and condition of GDEs and water-dependent flora and fauna is needed, followed by an appropriate risk assessment (e.g. Serov et al. 2012). These studies should consider the ecological water requirements for any water-dependent species and their habitat. The locations of any shallow groundwater discharge points and other GDEs should be included, especially in areas where drawdown is predicted. A systematic approach to the assessment of GDEs is recommended in which:
  - a. the methods from, for example, the Australian GDE Toolbox (Richardson et al. 2011) and Eamus et al. (2015) are used to assess groundwater use by vegetation (especially during dry periods).

- b. the hydrogeological conceptualisation is used to identify areas of shallow groundwater (less than 20 m below ground level) and potential areas of groundwater discharge.
- c. vegetation, seasonal depths to groundwater and shallow groundwater drawdown maps are overlaid to identify areas of potential GDEs. These maps should be supported by monitoring data gathered near the regions occupied by potential GDEs, with the shallow groundwater monitoring locations also plotted on the maps.
- d. ecohydrological conceptualisations are used that integrate results from hydrogeological, hydrological, geomorphological and ecological investigations at a spatial and temporal scale that is suitable for predicting potential impacts to GDEs and pathways of likely effects of the proposed development. The identified potential impact pathways should then be used to develop proposed mitigation strategies and to monitoring of these strategies' effectiveness.

### Final void management

- 40. Given the proponent proposes to dispose of coal rejects, tailings and brine in the existing East Void, early consideration of site-closure mitigation and management measures should be included in the form of a restoration plan in future assessment documentation. The restoration plan should include information on:
  - a. the proposed geomorphology and vegetation structure of the final landform, including whether the void will be completely backfilled (with tailings etc.) or will retain a final void.
  - b. long-term void water level and water quality modelling if a final void lake is predicted to remain. It is noted that groundwater modelling of the water flow directions from the post-closure East Void is proposed to occur as a component of future groundwater modelling (AIA, Attachment C, p. 83). This modelling should be used to inform restoration measures.
  - c. a final landform groundwater flow and groundwater quality monitoring network, capable of identifying seepage from the East Void following restoration. The post-closure East Void groundwater monitoring network should be installed during operations and be informed by the risk assessment and groundwater modelling described in paragraph 40b.
  - d. measures to ensure long-term landform stability, prevent erosion and ensure the final landform (including above the longwall mining area) does not pose a risk to surface water resources.

#### Geochemical assessment

- 41. The restoration plan should be informed by an assessment of the geochemical characteristics of the existing waste rock material, coal rejects, tailings and brine within the East Void and the potential for this material to be a contamination source to the surrounding environment.
- 42. The geochemical assessment should include soil chemistry analysis (e.g. sodicity, dispersivity, pH) to be used in covering or re-shaping of the East Void during restoration.

#### Risk assessment

43. Any future environmental assessments for the proposed project should include a stand-alone risk assessment that considers specific water-related risks to the environment, for example, using a methodology similar to that used in the Bioregional Assessments (Herron et. al. 2018). The risk assessment should be informed by the hazard risk mapping described in paragraph 30. This risk assessment should quantitatively assess the likelihood and consequence of identified impacts and the residual risk following application of proposed mitigation measures.

Date of advice	9 November 2018
Source documentation available to the IESC in the formulation of this advice	Malabar Coal 2018. Maxwell Project Technical Overview In Support of an Application for a Gateway Certificate, August 2018. Malabar Coal Limited.
	Malabar Coal 2018. Maxwell Project Agricultural Impact Assessment in Support of an Application for a Gateway Certificate, 19 August 2018. Report prepared for Malabar Coal Limited.
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