

Advice to decision maker on coal mining project

IESC 2021-122: Saraji East Mining Lease Project (EPBC No. 2016/7791) – Expansion

Requesting agency	The Australian Government Department of Agriculture, Water and the Environment (DAWE) The Queensland Department of Environment and Science (DES)
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Advice stage	Assessment

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 Agriculture, Water and the Environment and the Queensland Department of Environment and Science to provide advice on the BM Alliance Coal Operations Pty Ltd's Saraji East Mining Lease Project in Queensland. This document provides the IESC's advice in response to the requesting agencies' questions. These questions are directed at matters specific to the project to be considered during the requesting agencies' 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 Saraji East Mining Lease Project (the 'project') is a single-seam underground mine development located within the Bowen Basin, Queensland. The project is expected to produce up to eight million tonnes per year of metallurgical product coal over a production schedule of approximately 20 years, from 2023 to 2042. The project is adjacent to (and in some areas overlaps) the existing open-cut mine and will require the construction of supporting infrastructure, including a Coal Handling Preparation Plant (CHPP), a Mine Infrastructure Area (MIA), a conveyor system, rail spur and balloon loop, water pipelines, dams and powerlines.

Subsidence above longwalls is predicted to affect the Brigalow (*Acacia harpophylla* dominant and codominant) Threatened Ecological Community (TEC) located within the underground mine footprint as well as Hughes, Plumtree and Boomerang creeks where the proponent predicts reduced surface water flows and increased sedimentation downstream. These changes will likely affect areas identified as providing potential habitat for the Ornamental Snake (*Denisonia maculata*), Greater Glider (*Petauroides volans*) and Koala (*Phascolarctos cinereus*) which are listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The project will also contribute to groundwater drawdown, primarily within Tertiary and Permian aquifers in the area; however, impacts to groundwater users in the area are expected to be limited.

Key potential impacts from this project are detailed below.

- Altered flow and sediment regimes in Plumtree, Boomerang and Hughes creeks, potentially affecting aquatic and riparian habitats and their biota, water quality (especially suspended sediments) and fish passage. In some areas, surface cracking and subsidence-induced changes to the stream profile may reduce surface flows by altering surface water-groundwater interactions. Subsidence may destabilise creek banks, promote erosion and impact on riparian vegetation that provides vital ecological corridors along watercourses in the project area.
- Altered surface runoff, flooding patterns and groundwater recharge due to predicted subsidence of 1.4 – 2.5 m across much of the undermined area (and up to 3.5 m predicted above a single southern longwall) and associated surface cracking. These alterations in surface runoff and flooding will likely change flow regimes of ephemeral streams, impact riparian and floodplain vegetation, and alter water regimes of oxbow lakes and other standing wetlands in the project area. Cracking and localised changes in topography may also impact on the approximately 246 ha of Brigalow (*Acacia harpophylla* dominant and codominant) TEC and associated Ornamental Snake habitat (e.g. gilgai).
- Groundwater drawdown within the alluvium may impact the condition of riparian vegetation (potentially including terrestrial groundwater-dependent ecosystems (GDEs)) that has been identified as likely habitat for Greater Gliders and Koalas in the project area.
- Incremental contribution to cumulative impacts of other land-uses, including nearby mines, on water quality and water-dependent ecosystems in the project area and downstream.

The IESC has identified several areas in which additional work is required to address the key potential impacts, as detailed in this advice. These are summarised below.

- Quantify the magnitude and extent of surface cracking induced by ground movement to improve estimates of groundwater recharge. The assumption of the 150 m vertical extent of the fracturing above the coal seam should be justified and compared with empirical data for sites in the Bowen Basin. A peer review of the geomechanical model is required.
- Further groundwater modelling is required to increase confidence in the model calibration, sensitivity and uncertainty analyses, and model predictions. Quantification of the groundwater-surface water interactions should be improved by better characterisation of the alluvium, Quaternary and Tertiary sediments. This would improve representation of groundwater drawdown and groundwater-surface water interactions. Sensitivity analysis is also required. These will clarify potential impacts to water assets and GDEs in the region, and the development of appropriate Trigger-Action Response Plans (TARPs). A peer review of the groundwater model is required.
- Quantitative estimates of all potential surface water losses resulting from subsidence should be provided. This should include analysis of the impacts of likely changes to flow regimes, including increases in the duration and number of low- and zero-flow days, as these changes are likely to

affect instream and riparian biota within Hughes, Plumtree and Boomerang creeks. The additional work should also consider how the predicted changes to water regimes will alter water quality.

- As much of the water quality data is over a decade old, contemporary water quality data (ideally, for at least two years from multiple sites) should be collected for all creeks draining the project area to provide a more robust baseline against which to judge any impacts of the project on water quality. These more recent data should be combined with the data already collected to optimise the derivation of site-specific water quality guidelines, especially where background levels of some parameters (e.g. turbidity) are elevated. This is especially relevant for Boomerang Creek where mine-affected water (MAW) is to be released.
- Further geochemical characterisation of composite samples collected from areas intersecting the project's longwalls across the entire area to be mined is needed to better represent potential leachate concentrations of contaminants across the site.
- More recent ecological data on the distribution and abundance of aquatic biota, terrestrial GDEs and stygofauna in the project area and downstream are required to better characterise the potential impacts of the project.
- The cumulative impacts on groundwater, surface water, water quality and water-dependent ecosystems requires further investigation. Other mines in the area, such as the Lake Vermont Mine and Bowen Gas Project, should be considered in the cumulative impact assessment. The cumulative impact of total flow reductions, altered flow regimes and water quality decline on riverine and riparian biota should be assessed. This should include consideration of historic as well as proposed impacts in the region.
- As the final landform of the undermined project area is likely to have a substantially altered topography (e.g. multiple parallel troughs up to 2.5 m deep) that will have long-term effects on runoff, flooding patterns and groundwater recharge (especially where cracking occurs), more details are required about how this final landform will be remediated to minimise any legacy impacts.

Context

The project is a proposed single-seam underground mine development within the Bowen Basin, Queensland. It is located within the Isaac Regional Council, approximately 30 km north of Dysart and approximately 167 km south-west of Mackay. The project is expected to produce up to eight million tonnes per year of metallurgical (coking and pulverised coal injection) product coal over a production schedule of approximately 20 years, from 2023 to 2042.

The project is next to (and in some areas overlaps) the existing Saraji open-cut mine. The proposal is to extract the Dysart Lower (D14/D24) seam using the Longwall Top Coal Caving method, in longwalls of up to 320 m wide and 5,335 m long. The project also requires the construction of supporting infrastructure, including a CHPP, a MIA, a conveyor system, rail spur and balloon loop, water pipelines, dams and powerlines.

Response to questions

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

Question 1: Advice is sought on whether the proponent has adequately characterised surface and groundwater resources and related assets, and identified and assessed the key risks and impacts to water resources and related assets as a result of the project, in particular identification of, and risks and impacts to:

- a. groundwaters, surface waters and groundwater-surface water interactions; and
- b. water-dependent ecosystems.

1. The IESC recognises that BM Alliance Coal Operations Pty Ltd (BMA) has a long association with the site, where the existing Saraji Mine has been in operation since the early 1970s. Associated with this history is an in-depth understanding of environmental assets in the region. Noting this, the IESC considers that additional justification and evidence is required to validate a number of assertions made within the Environmental Impact Statement (EIS) as outlined below.

Groundwater

2. Key risks from the proposed project primarily relate to mining-induced ground movement, which is predicted to cause surface cracking and near-surface ground movement, increased regional groundwater drawdown, as well as potentially alter groundwater-surface water interactions.
3. To assess subsidence impacts on water resources, the proponent has developed a geomechanical model, extending from the surface to 800 m below ground level (mbgl), over a 5-km east-west and 11-km north-south domain. While this general approach appears appropriate, due to the nature of the modelling, the IESC considers the predictions to be of relatively low confidence. It is unclear whether model predictions have been compared with empirical data from other sites in the Bowen Basin and alternative predictive methods. A peer review of this additional work should be undertaken.
4. The extent and degree of interactions between surface water and *shallow* groundwater are poorly understood for the creeks in the project area and downstream. In part this is due to the characterisation of the alluvium appearing inconsistent within the documentation. Specifically, Quaternary sediments are noted within the current groundwater assessment as being associated with the Isaac River and Phillips Creek; however, little or no alluvium is mapped adjacent to Hughes Creek (AECOM 2019, p. 63 – 68). Justification for this assertion is required, as alluvial sands are noted by the proponent as also being associated with Hughes Creek in AGE (2012a, p. 6) and Alluvium (2019, p. 22). Ground-truthing of the extent of Quaternary sediments should be completed. The existing hydraulic characteristics of Quaternary and Tertiary sediments in the project area should be investigated. Additionally, the proponent should evaluate the potential for loss of surface flows associated with cracking and subsidence-related alteration of hydrological connectivity.
5. The proponent has undertaken an assessment to characterise groundwater resources within the area, primarily through the development of a MODFLOW SURFACT groundwater model. This model is a refined version of the previous AECOM (2016) model, which was based on the AGE (2012a) finite difference numerical groundwater model. The calibration data are sparse and only very limited sensitivity analysis has been completed. Accordingly, there can be little confidence in model predictions of drawdown in all areas, especially in high-risk areas such as alluvium and Tertiary sediments associated with Phillips and Hughes creeks and oxbow wetlands.
6. Cracking associated with subsidence is a primary uncertainty and the IESC notes use of geomechanical modelling results, Minserve (2017), to inform their assessment. The assumed height of fracturing 150 m above the mined panel should be justified. This assumption is particularly

important closer to the open cut where the D24 seam depth is shallower. The impact of this assumption should be explored in model sensitivity analysis.

7. The IESC considers the model to be largely uncalibrated due to the lack of observations in coal seam layers 6, 8, 10 and 11 and only a single observation in layers 4, 5 and 9. Only a single recharge sensitivity scenario is presented. The proponent should demonstrate the sensitivity and uncertainty of the extent and magnitude of drawdown predictions to:
 - a. assumptions in the height of vertical fracturing (after comparative studies and geomechanical model peer review);
 - b. the horizontal and vertical hydraulic conductivity of coal seams, interburden and Quaternary and Tertiary sediments; and
 - c. other model parameters (e.g. recharge, storativity).
8. The proponent has mapped several faults east of the site, with the Isaac Fault separating the relatively undisturbed sediments to the west from faulted sediments to the east. Whilst no known faults are mapped within the project area, the IESC notes that Boomerang and Hughes creeks appear to be located above a fault located approximately 1 km to the north-east. A site-specific assessment should be undertaken to determine whether this fault could act as a conduit to groundwater drawdown.
9. The IESC does not have confidence in predicted changes to water quality of the partially backfilled final voids. During the post-closure phase, groundwater levels are predicted to recover within the underground workings, up into the partially backfilled final voids. The proponent considers that there are likely to be limited impacts to groundwater quality but does not provide evidence to support this assertion. The proponent should assess the quality and quantity of groundwater that may enter the final voids from recovering underground workings and how this may impact on water quality and levels within partially backfilled voids.
10. An independent peer review to evaluate the groundwater model has not been provided and should be undertaken as a priority in future revisions of the model.

Surface water

11. Limited information regarding calibration, validation, sensitivity analysis and uncertainty analysis has been provided for the surface water models, especially the 1D and 2D hydrological models and the sediment transport model. This is particularly paramount to the water balance model in which MAW storage capacities have been estimated (refer also to Paragraph 13a). Although calibration may not be possible due to insufficient data, uncertainty and sensitivity analyses should be undertaken to indicate the level of confidence in the model's predictions. As part of future updates, the IESC considers that the proponent should refer to the methodology provided by Viney et al. (2021) for modelling impacts on surface water due to coal mining.
12. Limited streamflow data have been provided by the proponent. Streamflow data were recorded between mid to late 2010 and June 2013 in Hughes, One Mile, Spring and Phillips creeks as part of monitoring for the existing Saraji Mine (AECOM 2021a, App. A, pp. 24 – 30). One gauging station was installed downstream of release points in each of these creeks. The IESC recommends that the proponent collect daily streamflow data for Phillips, Hughes, One Mile, Boomerang (where the MAW release point is proposed), Plumtree and Spring creeks for at least two years prior to construction to obtain an understanding of the flow regimes and baseline conditions of these creeks as well as the likely extent of groundwater-surface water interactions (refer to Paragraphs 4 and 14). These data can then be used to calibrate and verify surface water models, such as the hydrological model which cannot currently be directly calibrated due to the lack of streamflow data (Alluvium 2019, p. 12). The

streamflow data will also enable the proponent to identify how each creek's flow regime may be altered by the project and more reliably predict the repercussions on aquatic and other biota (refer to Paragraph 15).

13. The proponent has not considered climate change impacts on rainfall events and evaporation in the surface water modelling provided. Input climate data for the water balance model consisted of a synthetic data set of daily rainfall and evaporation data obtained from SILO gridded data over the period 1889 to 2017 (AECOM 2021b, p. 26). Although this approach takes historical extremes into account, it does not account for future extremes, such as increased rainfall intensity and altered rainfall frequency and duration. To model a worst-case scenario, it would be prudent to consider the impacts of a Representative Concentration Pathway (RCP) 8.5 emissions scenario because carbon emissions are currently tracking those modelled in this projection (Schwalm et al. 2020). In particular:
 - a. to increase confidence in predicted water storage capacities, the proponent should consider a 'worst case' scenario incorporating higher-than-expected rainfall intensity, duration and frequency. The proponent states that there is sufficient capacity to contain all mine-affected water (MAW) and that uncontrolled releases are only likely to occur as a result of extreme rainfall events (BHP 2021a, 8-33). However, given that climate change scenarios have not been considered, the likelihood of releases is uncertain; and
 - b. evaluation of the difference between the probable maximum flood (PMF) and the 1000-year ARI event would provide further assurance regarding the impacts of flooding.
14. Subsidence of 1.4 – 2.5 m across much of the undermined area (and up to 3.5 m predicted above a single southern longwall) is likely to cause surface cracks and alter infiltration and surface runoff. In addition, increased hydraulic connectivity between the ground surface and goafs could potentially occur where the height of fracturing above the seam is greater than the depth of cover. Although Tertiary sediments are predicted to develop cracks to a depth of approximately 10 – 15 m below ground, these cracks are expected to self-seal (Minserve 2017, p. 6.2). Justification is required to support this conclusion given the depth of this cracking, and that cracks are likely to provide preferential flow paths even after they are 'visually' sealed. The proponent should provide evidence to demonstrate the capability of such systems to self-seal in the project area.
15. Surface water modelling predicts a reduction in total flow volumes from upstream to downstream of the mining area, hydraulic behaviour will be altered, and sediment transport reduced by subsidence troughs (Alluvium 2019, pp. 43 – 63). These potential changes require additional evaluation as described below.
 - a. Reductions in total flow have been estimated from upstream to downstream of the project area (e.g. 11.4% for 2-year ARI events (Alluvium 2019, p. 63)). As cracking is predicted above longwalls below Hughes, Plumtree and Boomerang creeks, the IESC considers that a quantitative assessment of stream flow loss in each creek should be undertaken, including whether the number of low- and no-flow days will be reduced. Changes in flow regimes (e.g. flow duration, timing of onset of flow) in ephemeral creeks can have major repercussions for biodiversity and the composition of their aquatic and riparian communities (Datry et al. 2017), and are also likely to affect fish passage.
 - b. Approximately 5.6 km of Hughes Creek is predicted to be impacted by subsidence, particularly along a 1.35-km diversion of the channel. Channel bed deepening is predicted to propagate upstream and increase bank erosion, which may also impact on riparian vegetation and the ecological connectivity it provides. Given that Boomerang Creek is already transport-limited (Alluvium 2019, p. 18), it is recommended that the cumulative effects of subsidence on sediment transport beyond the project area is quantified. An assessment of the impacts on water quality

and water-dependent ecosystems due to reduced total flow and altered flow and sediment regimes should also be provided.

16. Although the proponent has undertaken sampling to characterise water quality for five watercourses (Hughes, One Mile, Phillips and Boomerang creeks, and the Isaac River), the data are insufficient to provide reliable baseline conditions for assessing environmental impacts, such as those from reduced streamflows or potential spills of MAW. The IESC considers that the water quality monitoring program should be expanded prior to mining so that current site-specific objectives can be determined (as outlined in Huynh and Hobbs (2019)). Limitations of the current data set are as follows.
 - a. Data have only been collected for Hughes, One Mile and Phillips creeks between 2010 and mid-2013 (AECOM 2021a, p. 13). It cannot be assessed whether there have been any changes in water quality in these creeks in the last decade and the lack of recent baseline water quality data prevents reliable assessment of any changes that may arise from the project. The proponent should collect contemporary data from these three creeks to provide a more robust baseline against which to judge any impacts of the project on water quality in the creeks. These more recent data could be combined with those already collected to optimise the derivation of site-specific water quality objectives for each creek.
 - b. The proponent stated that data were collected for Boomerang Creek and Isaac River between 2010 and 2020. However, these raw data are not provided and fewer than eight sampling events occurred for many of the parameters tested (AECOM 2021a, Tab. 15, p. 36). Given the likely high variability in water quality data (e.g. from high flow variability), more data on many parameters are needed to provide an adequate baseline against which to assess potential impacts of the project. As a controlled MAW release site is proposed for Boomerang Creek (BHP 2021a, p. 8-33), an adequate baseline data set is especially important for this creek and should be collected from the two proposed monitoring points shown in Figure 8-6 (BHP 2021a).
 - c. No water quality data have been provided for Plumtree Creek. The IESC considers that baseline data should be collected for this watercourse so that likely impacts of the project on this creek can be assessed.
17. The proponent provided a summary table of the water quality data in the downstream locations of each of the watercourses (BHP 2021a, Tab. 8.5, p. 8-17). The IESC notes that there are inconsistencies in the 95th percentile values reported in Table 8.5 compared with the individual watercourse data provided in Tables 6 – 14 in AECOM (2021, pp. 25 – 32). For example, several of the 95th percentile values reported in Table 8.5 are higher than the maximum values listed in Tables 6 – 14 (e.g. chromium, selenium, uranium and zinc in Phillips Creek; chromium and selenium in One Mile Creek; and molybdenum, selenium and zinc in Hughes Creek). Thus, it is unclear whether additional data have been included in the calculations for the summary table which were not presented elsewhere in the AECOM (2021a) water quality report. The proponent should clarify the water quality data sources used and confirm whether these calculations are correct.
18. The water quality objectives for physico-chemical parameters were obtained from the Environmental Protection (Water and Wetland Biodiversity) Policy 2019 (EPP (Water)) specific to the upper Isaac River catchment. The objectives for dissolved metals were obtained from both the EPP (Water) stock watering values as well as the ANZG (2018) guidelines. The values obtained in the statistical analyses for dissolved metals were compared against the ANZG (2018) objectives for all the metals except selenium, where the EPP (Water) stock water objective was used (20 µg/L). Selenium concentrations were 10 µg/L in four of the five watercourses (BHP 2021a, Tab. 8.5, p. 8-17), exceeding the ANZG (2018) objective (5 µg/L). The proponent should justify the use of the EPP (Water) stock water objective in this instance.

19. In all watercourses draining the project area, turbidity far exceeded the water quality objective (50 NTU) (BHP 2021a, Tab. 8.5, p. 8-17). As subsidence-related mobilisation of sediments is likely to further elevate these already high levels of turbidity, the IESC considers that the proponent should provide more information regarding the potential impacts of the project on turbidity, including predictions of likely ecological and cumulative impacts (refer to Paragraphs 22, 27 and 38).
20. The proponent states that discharges of MAW will only occur during extreme rainfall events when the released water would be subject to dilution (AECOM 2021a, p. 49) and residual impacts on surface waters are predicted to be minor (BHP 2021a, p. 8-57). However, given that subsidence is predicted to reduce total flow, alter hydraulic parameters and cause ponding, the amount of dilution that could occur is uncertain. The proponent should provide a thorough assessment of the impact of discharges and runoff to surface water quality in all creeks whose flow may be affected by subsidence and/or groundwater drawdown.
21. The proponent asserts that there will be negligible impacts to surface water quality due to the project. However, the potential impacts from erosion, sedimentation and releases of MAW have not been adequately considered by the proponent. The proponent should supply sufficient baseline data (refer to Paragraph 16) from appropriately designed monitoring of the surface waters of all potentially impacted creeks to confirm that water quality and erosion management measures are effective.

Water-dependent ecosystems

22. The IESC considers that the effort to identify and characterise all aquatic, terrestrial and subterranean GDEs likely to occur in the project area is not commensurate with the potential impacts of the project. Additional sampling is required to confirm current site conditions and address the following limitations.
 - a. Aquatic baseline ecology surveys appear to be limited to two sampling events undertaken in December 2007 and April 2010 (FRC Environmental 2018, pp. 7 – 8). Only three sites in the project area were surveyed, with no samples collected from Hughes Creek. Further, the three creeks to be undermined in the area have been identified as important corridors for fish passage (BHP 2021a, p. 7-11). The IESC recommends that the proponent conduct detailed aquatic surveys (water quality, habitat availability and structure, turtles, fish, aquatic macroinvertebrates and relevant riparian biota) at several sites on each of the three creeks to be undermined as well as suitable reference sites where impacts are not predicted. These surveys should coincide with a period of flow as well as a period soon after flow has ceased so that remnant pools can also be assessed. Without this more recent and spatially comprehensive baseline dataset, the proponent is unable to assess whether there have been any changes in composition of the aquatic biota in these creeks in the last decade or reliably predict likely impacts of the project (e.g. altered flow regimes) on aquatic and riparian biota.
 - b. The presence of terrestrial GDEs, such as groundwater-dependent vegetation within wetlands and along watercourses and on floodplains, has not been ground-truthed in the project area or where groundwater drawdown may occur. Instead, indirect evidence is used to infer that vegetation in the project area is not groundwater-dependent. Field assessments (see Doody et al. 2019) of the extent of groundwater dependence by vegetation in wetlands, along creeks and on floodplains where drawdown is predicted would enable a more robust evaluation of the likely impacts on terrestrial GDEs in the project area. It is unclear from the proponent's desktop evaluation of subterranean GDEs, and limited sampling of bores in 2011, whether stygofauna are currently present, especially in alluvial sediments where drawdown is predicted. The IESC recommends field sampling for stygofauna, especially in alluvial sediments, to provide a more reliable baseline for assessing potential impacts of the project on this obligate GDE (Paragraph 38).

23. Although the site is characterised by intermittent flows and it is assumed that the alluvial sediments associated with the creeks do not contain permanent groundwater (BHP 2020a, p. 21-93), drawdown within alluvial sediments associated with Boomerang, Plumtree and Hughes creeks could lead to long-term impacts to GDEs and agricultural water resources. Site surveys identified widespread evidence of Greater Gliders and Koalas in these areas, particularly areas containing Forest Red Gums, taller trees or trees with hollows. Impairment or loss of this vegetation due to groundwater drawdown is likely to have repercussions for these two arboreal species, both listed as Vulnerable under the EPBC Act, as well as other native wildlife. The proponent needs to provide more detail on the likely impacts of limited access to shallow groundwater for the vegetation that supports arboreal and other fauna and provides ecological connectivity within the area.
24. Localised changes in topography, including tension cracking and ponding in the channel and along riparian corridors of Boomerang, Plumtree and Hughes creeks, will result in changes to riparian vegetation because species intolerant to ponding will die back in the subsided areas, potentially being replaced by vegetation more tolerant to inundation (BHP 2020a, p. 6-46). Fauna reliant on the local riparian vegetation are likely to be impacted by loss of habitat. In addition, localised changes may affect terrestrial vegetation including regional ecosystems (REs) listed as 'endangered' or 'of concern' as well as 246 ha of Brigalow (*Acacia harpophylla* dominant and codominant) TEC (out of 418 ha within the Project Area). Changes to Brigalow vegetation may impact the threatened Ornamental Snake (*Denisonia maculata*), which has been recorded in the project area on multiple occasions (BHP 2020a, p. 6-45). The proponent needs to provide more detail on the likely impacts of changes in surface water flows and flooding on the habitats and biota that will be affected, including gilgai and oxbow lakes.

Final landform

25. Kinetic Leach Column (KLC) tests conducted on composite samples demonstrated that leachate concentrations of aluminium, arsenic, copper, nickel, selenium, and zinc exceeded ANZG (2018) guidelines for the 95% species protection level. However, many of the drill-hole samples comprising the composite samples were taken from north-west of the proposed longwalls. The IESC recommends that the proponent do further geochemical characterisation of composite samples collected from areas intersecting the project's longwalls across the entire area to be mined to better represent potential leachate concentrations of contaminants across the site.

Question 2: Advice is sought on whether the EIS conclusions on the cumulative impacts on water resources and related assets (including within the Project Area and also associated with other mining activities and coal seam gas projects) are appropriately supported?

26. The proponent's assessment of cumulative impacts to water resources is limited in its scope and detail. Specifically, the proponent has confined the investigation of cumulative impacts on groundwater to those associated with the approved Saraji Mine as well as the proposed underground extraction. This assessment predicts additional drawdown to extend approximately 2 km and 3 km further east than under approved operations in the unconfined and confined units, respectively, and connect two previously distinct drawdown zones within each of these units (AECOM 2019, p. 97). The IESC does not have confidence in these predictions of cumulative impacts because they are likely to be underestimates if they omit potential impacts from nearby approved projects such as the Lake Vermont Mine and Bowen Gas Project.
27. The proponent has identified surrounding land uses which have the potential to contribute to sediment loads and turbidity. However, the proponent should elaborate on the contribution that the project will have on cumulative impacts and justify their claim that significant regional cumulative impacts on surface water are not expected to occur (BHP 2021a, p. 22-7).

28. The potential cumulative impact of total flow reductions, altered flow regimes and water quality decline on riverine and riparian biota has not been adequately assessed. Assertions that the project is unlikely to cause significant cumulative impacts because the existing riparian vegetation is already highly disturbed (BHP 2021a, p. 22-7) and that all aquatic species recorded in watercourses in and around the project area are tolerant of ephemeral flow and variable water quality (BHP 2021a, p. 22-7) lack adequate justification. Further, without recent and reliable ecological and water quality baseline data (refer to Paragraphs 16, 22 and 38), the proponent is unable to properly assess potential cumulative impacts of the project and all other nearby land-uses and mining operations. The IESC also recommends that the proponent consider historical (legacy) impacts in the region to provide a greater understanding of potential cumulative impacts from the project.

Question 3: Advice is sought on whether the proposed monitoring, mitigation and management measures are specific enough to adequately identify, mitigate and manage impacts from the Project including to water resources and related assets?

Subsidence

29. Although the proponent describes some aspects of subsidence monitoring (BHP 2021b, Tab. 2, pp. 19 – 20), justification to support the effectiveness of proposed mitigation measures is not presented in detail. Additional suggestions to improve subsidence monitoring and mitigation measures follow.
- a. Both multi-level pore pressure (e.g. using vibrating wire piezometers) and open rock bores that are suitable for downhole geophysics monitoring are required. These can be used to verify changes in the depth of surface cracks, and height of fracturing above longwalls with relatively shallow overburden. Results should be incorporated into future revisions of the groundwater modelling program to verify predictions.
 - b. Infilling cracks, grading or channel re-profiling are the main mitigation measures that have been identified (BHP 2021c, Tab. 5, pp. 15 – 17; BHP 2021b, Tab. 3, p. 21). Larger cracks (> 50 mm) are proposed to be remediated where monitoring of waterways within the subsidence zone indicates cracks fail to self-seal within 12 months of detection. Justification for not remediating smaller cracks which fail to self-seal is required. The IESC also notes that the proponent has not explained how they propose to locate or remediate cracks that are obscured by alluvial sediment or provided convincing evidence from independent studies to demonstrate the success of grouting and other remediation measures. The proponent should justify the effectiveness of the proposed remediation options in a revised subsidence management plan.

Groundwater

30. The proponent has committed to develop and establish a groundwater monitoring program (reviewed annually) prior to commencement (AECOM 2019, p. 116), which will primarily detect changes to groundwater levels and quality within the Quaternary and Tertiary aquifers and the Permian coal seam. Furthermore, the proponent has committed to develop a groundwater monitoring database based on the monitoring program and update this monthly. The IESC recommends that the groundwater model should be revised at regular intervals as additional relevant information becomes available.
31. The monitoring network is proposed to include existing bores (AECOM 2019, Tab. 13, pp. 57 – 58) and four new bores (one which is over the planned longwall panels) to augment the monitoring program as existing bores are lost (AECOM 2019, Tab. 30, p. 110; AECOM 2019, Fig. 30, p. 112). The IESC supports the additional monitoring for changes in groundwater level at the site, and recommends that these bores be installed as soon as possible.

32. The IESC notes that the proponent has not specifically provided triggers for groundwater level decline. The proponent should collect a minimum of two years of monitoring data to establish baseline conditions at the site and use this information to specify and justify triggers. Additionally, an explanation of potential mitigation actions is required if trigger levels are exceeded.
33. The IESC recommends that after mine closure, groundwater level data are compared to model predictions of long-term water recovery.
34. Recent additional groundwater quality data (i.e. collected within the last three years) are required to compare with earlier monitoring results undertaken in the project area. The IESC recommends that a specific groundwater quality TARP should be developed.
35. The EIS contains inconsistent information about the distribution of alluvium in the project area. The proponent should ground-truth the presence of Quaternary and Tertiary sediments along all watercourses draining the project area and measure depths to groundwater. Where saturated alluvium is identified along watercourses, appropriate groundwater monitoring and mitigation measures should be implemented. The groundwater monitoring network design should be reviewed once these studies are completed.

Surface water

36. The surface water monitoring plan and site-specific trigger values have not yet been developed. The proponent is required under the Environmental Authority to develop a Receiving Environment Monitoring Program (REMP), which the proponent has committed to develop and implement prior to construction (BHP 2021a, p. 8-51). The proponent has provided a preliminary response plan regarding exceedance of water quality objectives (BHP 2021a, Tab. 8.12, p. 8-55) and has committed to developing a TARP prior to construction (BHP 2021a, 8-54). Further information should be provided regarding site-specific water quality objectives, water quality monitoring locations and frequency, streamflow gauging and sediment sampling.
 - a. The proponent should follow the guidance provided in the IESC's explanatory note on deriving site-specific water quality guideline values (Huynh and Hobbs 2019) in addition to the EPP (Water) Isaac River Sub-basin Environmental Values and Water Quality Objectives (DEHP 2011) and the Deciding Aquatic Ecosystem Indicators and Local Water Quality Guidelines (DES 2018) (BHP 2021a, p. 8-18).
 - b. Although the proponent states that water will be monitored at upstream and downstream locations during emergency release events (BHP 2021a, p. 8-52), the frequency of monitoring during other times should also be specified. The IESC considers that regular and event-based water quality monitoring of the discharge water, upstream water and water immediately downstream of the licenced discharge points should occur to determine whether and when analytes exceed water quality guidelines.
 - c. The movement of sediment and attached metals is considered to be a potential impact to aquatic ecology (AECOM 2021a, p. 37). However, baseline monitoring of sediment quality does not appear to have been undertaken. The IESC recommends appropriate sediment monitoring to assess whether sedimentation and contamination may occur, especially in creeks deemed to be important for fish passage.
 - d. Little information is provided in the EIS regarding the frequency or location of streamflow monitoring during construction, operation and post-closure. The proponent states that additional baseline data on surface water flows and quality will be collected for the development of the REMP; however, no details are provided. The proponent should provide details on the ability (statistical power) of the proposed streamflow monitoring program to detect whether impacts on

streamflow are greater than predicted. The monitoring program should also be able to measure the effectiveness of any mitigation and management measures that are implemented.

37. The proponent has broadly outlined measures to mitigate impacts on surface water; however, specific details have not been provided in the EIS. Using more recent baseline data on water quality and the community composition and condition of riparian zone vegetation and aquatic biota, the proponent should propose appropriate mitigation and management strategies to minimise potential impacts of altered flow regimes and/or water quality on riparian vegetation and aquatic biota in Plumtree, Boomerang, Phillips, One Mile and Hughes creeks and further downstream in the Isaac River. A suitable monitoring strategy, including sampling appropriate reference sites, should be outlined that allows the proponent to demonstrate the effectiveness of these mitigation strategies in protecting the ecological integrity of the ephemeral streams and the Isaac River into which they flow.

Water-dependent ecosystems

38. The IESC suggests that additional data are required to provide a reliable baseline for assessing potential impacts of the project on water-dependent ecosystems in the project area. These data should be collected from monitoring sites located in areas where impacts are predicted as well as appropriately dispersed reference sites where impacts of the project are unlikely (enabling the proponent to distinguish project-related impacts from background changes over time). In particular, the IESC recommends the following:
- a. An ecohydrological conceptual model is required that illustrates potential impact pathways and likely ecological responses by water-dependent ecosystems to predicted changes in surface water and groundwater quantity and quality in the project area and downstream. This model should specify pathways where mitigation measures are feasible for avoiding or reducing impacts of the project on water-dependent ecosystems, and could be used to identify relevant parameters and ecosystem components for targeted monitoring.
 - b. As the available data on aquatic biota are spatially restricted and over a decade old (refer to Paragraph 22), the IESC recommends that the proponent should survey habitat availability and structure, turtles, fish, aquatic macroinvertebrates and relevant riparian biota at several sites on each of the three creeks that are to be undermined as well as at suitable reference sites where impacts are not predicted. These surveys should be done during periods when the creeks are flowing and in remnant pools after flow ceases, and a monitoring regime should be established at these sites to detect any impacts on aquatic and riparian biota. There is merit in sampling some of the same sites where water quality is to be monitored. Where feasible, the biota of standing waters (e.g. oxbow lakes near Boomerang Creek) should also be surveyed as their water regime is likely to be altered by subsidence.
 - c. Based on indirect evidence, the proponent asserts that there are no GDEs in the project area (refer to Paragraph 22). However, Figure 37 (AECOM 2019, p. 87) shows the northern end of the project area has “moderate potential” for GDEs as shown in the GDE Atlas. It is plausible that some of the oxbow-lake, riparian and floodplain vegetation in the project area occasionally accesses groundwater and, therefore, is a terrestrial GDE. The IESC recommends that the proponent undertake field assessments of potential groundwater use (using methods described by Doody et al. 2019) by terrestrial vegetation, especially that growing in alluvial sediments or areas where the water table may be less than 10 mbgl. If areas of terrestrial GDEs are found where groundwater drawdown is predicted, offsets may be needed because of the lack of other mitigation options. Monitoring the response of terrestrial GDEs to drawdown in these locations will enable the proponent to identify what offsets will be required.

- d. Stygofauna, an obligate GDE, were sampled twice in 2011 in seven bores screened in Tertiary and Permian sediments. Alluvial sediments, where stygofauna are more likely (Glanville et al. 2016) were not sampled. The IESC recommends that more recent stygofaunal survey data be collected and include multiple samples from alluvial sediments in areas where drawdown is predicted as well as from reference bores where drawdown is not likely. If a pilot survey of ten bores yields any stygofauna, the proponent should collect a more comprehensive set of samples as recommended by DSITI (2015) so that potential impacts of the project on stygofauna can be assessed and, if necessary, monitored. If no stygofauna are collected, this increases confidence in the proponent's assertion that this GDE is not present in the project area.

Final landform

39. The proponent plans to refine the existing Saraji Mine mineral waste management strategy for in-pit spoil dumps to include waste from the proposed project. The IESC considers that specific details on the final landform and the updated management strategy should be included as part of this project.
40. The final landform of the undermined project area is likely to have a substantially altered topography (e.g. multiple parallel troughs up to 2.5 m deep) that will have lasting effects on runoff, flooding patterns and groundwater recharge, especially where cracking occurs. The proponent should provide details of how this final landform will be remediated, especially where native vegetation is likely to be established and where surface runoff contributes to streamflow in the creeks draining the project area.

Date of advice	30 June 2021
Source documentation provided to the IESC for the formulation of this advice	<p>AECOM 2016. Saraji Open Cut Extension Project, Groundwater Technical Report. Revision 1 – 7-Dec-2016. Prepared for BM Alliance Coal Operations Pty Ltd.</p> <p>AGE 2012a. Review of groundwater monitoring data. Saraji Mine. Project no. G1609. Prepared for BHP Billiton Mitsubishi Alliance.</p> <p>AGE 2012b. Predicted inflows and drawdown extents – Saraji East Underground Mine. Project no. G15494. Prepared for SKM.</p> <p>BHP 2021a. Saraji East Mining Lease Project, Environmental Impact Assessment. Prepared for BM Alliance Coal Operations Pty Ltd.</p>
References cited within the IESC's advice	<p>AECOM 2019. Saraji East Mining Lease Project Environmental Impact Statement Groundwater Technical Report. Revision 2 – 25-Feb-2019. Prepared for BM Alliance Coal Operations Pty Ltd.</p> <p>AECOM 2021a. Saraji East Mining Lease Project, Surface Water Quality Technical Report. Revision 5 – 15-Mar-2021. Prepared for BM Alliance Coal Operations Pty Ltd.</p> <p>AECOM 2021b. Saraji East Mining Lease Project, Environmental Impact Statement, Mine Water Balance Technical Report. Revision 4 – 15-Mar-2021. Prepared for BM Alliance Coal Operations Pty Ltd.</p> <p>Alluvium 2019. Technical Report: hydrology, hydraulics and geomorphology. Saraji East Mining Lease Project by Alluvium Consulting Australia for AECOM, QLD 4006.</p> <p>ANZECC/ARMCANZ 2000. Australian Guidelines for Water Quality Monitoring and Reporting. National Water Quality Management Strategy (NWQMS). Canberra: Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand.</p>

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