

## Advice to decision maker on coal mining project

### IESC 2023-142: Lake Vermont Meadowbrook Project (EPBC 2019/8485) – Expansion

<b>Requesting agency</b>	The Australian Government Department of Climate Change, Energy, the Environment and Water and The Queensland Department of Environment and Science
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<b>Advice stage</b>	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 Climate Change, Energy, the Environment and Water and the Queensland Department of Environment and Science to provide advice on the Bowen Basin Coal Pty Ltd's Lake Vermont Meadowbrook Coal Mine 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 Lake Vermont Meadowbrook Coal Mine Project ('the project') is a proposed expansion of open-cut and longwall operations north of the existing approved operations located 25 km north of Dysart, Queensland. The project will mine 108.6 million tonnes (Mt) of metallurgical coal from underground operations targeting the Vermont Lower Seam and Leichhardt Lower Seam and 13.3 Mt from open-cut operations until 2055 (AARC 2023a, Executive Summary, p. 3).

The project will consist of underground single- and dual-seam longwall mining, open-cut mining and construction of supporting infrastructure which includes an electrical substation, underground portal, drifts and shafts, boreholes and gas drainage bores (AARC 2023a, Executive Summary, p. 3).

The project area falls within the Isaac-Connors sub-catchment of the Fitzroy Basin. Boomerang Creek, One Mile Creek and Phillips Creek are within the project site where underground operations will occur (AARC 2023a, Ch 8, p. 8-8). Subsidence-induced ground movements of up to 5 m are predicted in the catchments of Boomerang and One Mile creeks.

The project is located within the Bowen Basin where considerable mining activity occurs. The impacts from the project will contribute to the cumulative impacts to groundwater, surface water and ecosystems and biota across the basin.

Key potential impacts from this project are:

- ground movements including predicted vertical subsidence of up to 5.0 m (Gordon 2022, p. 33), including up to 4.0 m beneath Boomerang Creek (AARC 2023a, Ch. 5, p. 5-26). This subsidence is likely to affect groundwater dynamics, surface runoff, stream flows and water-dependent biota and ecosystems;
- possible connected fracturing (surface to seam), which could result in the loss of surface water flows to the subsurface and potentially the goaf areas. This process could influence groundwater level recovery, alter groundwater flow paths and change surface water flow regimes permanently;
- drawdown within the alluvial system that will likely impact stygofauna and other groundwater-dependent ecosystems (GDEs) including riparian vegetation along One Mile, Phillips and Boomerang creeks which may use groundwater during low-rainfall periods;
- direct clearing of 247.7 ha of habitat used by species listed by the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act);
- impairment of aquatic ecosystems and landforms during operations and post mine closure due to erosion and sediment transport;
- collective effects and interactions among two or more of the above individual impacts (e.g., between drawdown and subsidence) that combine to affect, for example, alluvial recharge, stream flow and GDE condition along Boomerang and One Mile creeks; and
- contribution to cumulative impacts to groundwater levels, surface water regimes and ecosystems and biota.

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

- Further analysis is needed to understand the areas where possible connected fracturing may occur and its potential impacts on surface water-groundwater connectivity (e.g., alluvial fluxes), ecologically important components of the surface water flow regime, and biota dependent on surface water and groundwater.
- Additional information is required to better understand the potential impacts of surface cracking on surface water systems and alluvial groundwater, including changes to quantity of runoff, and to the frequency of low- and zero-flow days and other ecologically important components of the flow regime.
- Additional information is required to demonstrate how the final landform and stream channels will stabilise, including how dispersive soils and erosion will be monitored and managed.
- Additional hydrogeological and ecological studies are required to characterise potential GDEs, including several wetlands (e.g., Wetland 8). This should include:

- field surveys and ground-truthing to establish groundwater dependence of the Brigalow Threatened Ecological Community (TEC) along One Mile Creek, Poplar Box TEC on alluvial plains and remnant River Red Gum woodlands fringing drainage lines and lacustrine wetlands.
- further sampling for stygofauna within alluvial sediments, especially along One Mile Creek.
- Improvements are required to the groundwater modelling at the local scale to increase confidence in the predicted impacts and their nature and magnitude. These include the influence of the Isaac Fault, gas drainage, recharge rates, representation of surface and groundwater interactions, local-scale calibration, mine inflows, groundwater mounding post-mining, alluvial fluxes and climate change.
- Monitoring of contaminants in the proposed sediment dams is needed to determine if there is a risk of increasing contaminants in the surface water system from overflow during large flood events (e.g., those with a 1% Annual Exceedance Probability (AEP)).
- One or more impact pathway diagrams (IPDs) derived from an evidence-based ecohydrological conceptualisation should be developed to illustrate the collective and interacting impacts that may arise from this project. These IPDs should link predicted drawdown, subsidence, erosion and other impacts to potential ecological outcomes such as adverse effects on GDEs, riparian vegetation and aquatic biota and ecosystems.
- Further information is needed about timeframes and the potential cumulative impacts of allowing the natural sediment load of creeks to infill subsidence troughs.

## Context

The project is a proposed expansion of existing approved operations at Lake Vermont and will consist of one open-cut pit and two areas of longwall operations. The project is located 25 km north of Dysart, Queensland within the Bowen Basin and will mine approximately 122 Mt until 2055.

The project area covers 8,238 ha and will directly disturb 827.8 ha. The disturbance arises from open-cut operations (666.4 ha), infrastructure development (15.3 ha) and indirect disturbance through subsidence-induced ponding and mitigation measures (214 ha) (AARC 2023a, Executive Summary, p. 3). The proponent plans to expand the water management system within the project area by constructing three new sediment dams and one mine infrastructure area dam (WRM 2023b, p. 6). All mine-affected water will be collected from both operations and managed within the existing approved water management system at Lake Vermont Mine. The proponent is not proposing additional mine-affected water release points and all releases will be managed through currently approved release points (AARC 2023a, Ch. 8, p. 8-17).

In the project area, Boomerang Creek, One Mile Creek and Phillips Creek are ephemeral streams which recharge the alluvial groundwater system during rainfall events. Groundwater-dependent ecosystems (GDEs) possibly rely on these shallow groundwater systems during periods of low surface water flow. Four species listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) occur in the project area: Ornamental Snake (*Denisonia maculata*), Squatter Pigeon (*Geophaps scripta scripta*), Koala (*Phascolarctos cinereus*) and Greater Glider (*Petauroides volans*), along with two TECs (Brigalow and Poplar Box). The proponent plans to directly clear 0.9 ha of Brigalow TEC, 207.1 ha of Ornamental Snake habitat, 15.6 ha of Squatter Pigeon habitat, 12.3 ha of Koala habitat and 11.8 ha of Greater Glider habitat (AARC 2023b, p. 107).

Other mining projects surrounding the proposed project include Saraji Mine, Saraji East Project, Olive Downs, Winchester South Project, Eagle Downs, Vulcan Complex, Peak Downs, Daunia, Caval Ridge, Poitrel, Millennium, Isaac Downs, Moranbah South and Isaac Plains East (AARC 2023a, Ch. 3, p. 3-11). This proposed project will likely contribute to cumulative impacts, especially water and sediment movements.

## Response to questions

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

### Water resources and assets

Question 1: Advice is sought on whether the proponent has adequately characterised surface and groundwater resources and related assets, including those related to the use of adjacent existing Lake Vermont Mine's pits.

#### Groundwater

1. Geology (drill holes and geophysical surveys), groundwater levels and groundwater quality (regular monitoring at 32 bores at the project site (see AARC 2023a, Ch. 7, pp. 7-39 to 7-41)) have been used to assist characterisation of groundwater resources, and conceptualisation is adequate at the regional scale. This also includes recent groundwater level and quality data that are discussed for the adjacent mining area of Lake Vermont (for 26 monitoring sites identified in AARC 2023a, Ch. 7, Table 7.10, p. 7-42). However, at the local scale, information pertinent to potential impact pathways from underground operations via subsidence and faulting to receptors (e.g., creeks and GDEs) has not adequately informed the assessment.
2. It is unclear from the information provided how the pits at the adjacent Lake Vermont Mine are, or will, affect the groundwater systems at the project site. Although these pits are assumed to be included in the groundwater modelling, limited discussion has been provided on how these pits will be used post-mining and how this could affect the groundwater resources of the project area.

#### Surface Water

3. The proponent has provided limited information about the surface water resources potentially impacted by the proposed project and limited detail has been provided to characterise the surface water resources affected by the previously approved project. No quantitative information has been provided on stream flows or on ecologically important components of the flow regime for watercourses that may be impacted by the proposed project.
4. In terms of characterising mine water management, it is not possible to assess the defensibility of the parameters used in the rainfall-runoff model (AWBM) as no information is provided on its calibration (WRM 2023b, Section 3.4.2, p. 27), and no discussion is provided on whether the estimates are consistent with regional and other sources of information. Accordingly, it is not possible to have confidence in the estimates of storage behaviour, the risk of unregulated spills from the dams, annual volume estimates of required raw water supplies or the transfers to Lake Vermont.

#### Ecology

5. The characterisation of in-stream aquatic ecosystems and terrestrial ecology is sufficient; however, characterisation of the stygofauna and other GDEs is limited.
  - a. The IESC commends the proponent for using multiple lines of evidence to evaluate the presence of terrestrial GDEs. However, the assessment is limited by the timing (surveying in August yet

November and December have the highest pan evaporations) and lack of temporal variation accounted for in the surveys. This means that not all potential terrestrial GDEs may have been characterised because they were not accessing the groundwater during the period of sampling.

- b. Baseline stygofauna sampling at nine bores was conducted in May and September 2021 and two sites were confirmed to contain stygofauna (Stygoecologia 2022, p. 21). Under the DSITIA (2015) *Guideline for the Environmental Assessment of Subterranean Aquatic Fauna*, this sampling constitutes a pilot study. As stygofauna were detected within the Tertiary alluvium, further comprehensive sampling should be conducted to characterise this GDE. The IESC suggests the following:
  - i. groundwater pumping techniques for stygofauna sampling should be considered in addition to netting to increase the likelihood of stygofauna detection and detection of species representative of the aquifer environment; and
  - ii. shallow monitoring bores (<30 m) close to One Mile Creek should be added to the sampling regime and installed if necessary. This area was not adequately investigated in the pilot study but is within both subsidence and drawdown zones.

Question 2: Advise whether the EIS has identified and assessed the key risks and impacts to water resources and related assets as a result of the proposed project, in particular to:

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

### Groundwater

6. The proponent's assessment of ecological impacts at receptors via potential links to the proposed underground mining via pathways such as surface and groundwater interactions, subsidence, and induced fracturing and faults is siloed and not integrated. The hydrogeological investigations are more general and have not targeted potential receptors and pathways. Impact assessment relies on a regional-scale model that is acknowledged (JBT 2023, Att. A, Sections 3.1-3.2, pp. 20-33; HydroAlgorithmics 2022, Table 2, pp. 8-9) not to capture important local-scale detail and processes including groundwater/surface water interactions and the local-scale influence of faults.
7. Although faulting has been mapped across the project site (e.g., AARC 2023a, Ch. 3, Figure 3.15, p. 3-30 and Gordon 2022, Figure 19, p. 18), there is a lack of field data to clearly understand the effect of faults, particularly the Isaac Fault, on groundwater flows and impact predictions.
  - a. The groundwater model tends to overpredict groundwater levels which is more apparent in the areas near the Isaac Fault (JBT 2023, Att. A, Figure 3-4, p. 24).
  - b. The assumption of compartmentalisation by the Isaac Fault limits the extent of predicted drawdown. Future work should provide evidence for compartmentalisation (e.g., Murray and Power 2021). For example, drilling and monitoring bores through and either side of the fault zone, hydraulic testing and suitable environmental water tracers are required to evaluate the influence of faults on groundwater flow and vertical hydraulic connectivity. If drawdown in the Permian Coal Measures and the overlying Rewan Formation is not compartmentalised by the Isaac Fault, then there may be potential for increased drawdown in the overlying unconsolidated formations including the Isaac River alluvium.
8. The proponent proposes to pre-drain gas from the underground panels in advance of mining using 'surface-to-seam' and 'underground in-seam' boreholes and pumps (AARC 2023a, Ch. 3, p. 3-65). It is vital that hydraulic isolation across strata is maintained to ensure these gas boreholes do not become pathways for impact propagation, which may be challenging when goafing occurs (AARC

2023a, Ch. 3, Figure 3.41, p. 3-69). These boreholes are not included in the groundwater modelling assessment.

9. Although some estimates for recharge rates were determined from field data (JBT 2023, Table 4-12, p. 66), the calibrated groundwater model recharge rates were substantially different for some geological formations (JBT 2023, Att. A, Table 3-9, p. 42). The IESC suggests that:
  - a. the differences between field data and calibrated recharge rates be discussed and justified.
  - b. uncertainty in recharge rates be explored further and clearly reported. This should include an analysis of how different rates could affect the extent and magnitude of groundwater drawdown, surface water-groundwater connectivity and future predicted groundwater mounding.
  - c. the effect of climate change on future recharge rates be considered.
  - d. further discussion and justification be provided of the proposed spoil recharge rate. A recharge rate of 1% of annual rainfall has been adopted for backfilled spoil (JBT 2023, Att. A, p. 9). This rate may be low depending on the properties of the backfilled spoil (e.g., particle size), thus predictions of groundwater level recovery times and mounding may not be accurate.
10. The water balance is dominated by flows between groundwater and the Isaac River. To support this, evidence should be provided on baseflow estimates and riverbed conductance should be included in the uncertainty analysis.
11. The groundwater model is a regional-scale model, and calibration results at the local scale suggest that there are issues with conceptualisation or data assimilation in the project area. This is shown by a scattergram of calibration residuals (JBT 2023, Att. A, Figure 3-1, p. 21) with predicted water levels at the site forming a horizontal line, suggesting that most groundwater level predictions are near-identical. Although this may be a function of the limited variation in topography across the site, further explanation is required, especially the implications of the model's inability to replicate vertical head differences (JBT 2023, Att. A, p. 32).
12. Two different approaches to predicting the groundwater inflows to the underground workings were provided (JBT 2023, Figure 5-11, p. 90). There is considerable difference in the total predicted inflows (5,110 ML versus 17,948 ML, JBT 2023, Table 5-2, p. 91). The IESC considers that:
  - a. further discussion on the suitability of the assumptions used in the reduced inflow case should be provided. This should be supported by field observations if possible.
  - b. uncertainty in the predictions for both approaches should be further explored and contextualised. This should include an analysis of potential impacts to surface water-groundwater interactions, surface water flow regimes and water-dependent ecosystems. The likely source of the additional water under the 'base case' approach should be explained.
  - c. discussion is needed on how the 'base case' water volumes would affect the site water inventory and how the excess water would be managed.
  - d. monitoring of inflows during operations will be essential to confirm the reduced inflow case. The data should be used to trigger timely updates to the groundwater modelling if inflow observations are greater than predictions. Additionally, management plans will also require updating if greater inflows are observed because the predicted impacts may increase.
13. The timing of the maximum extent of groundwater drawdown is unclear from the information provided and may not coincide with the end of mining, particularly in the case of cumulative drawdown predictions. Additionally, there should be further discussion of the predicted groundwater mounding,

and why 4 m of mounding appears to be predicted in most groundwater sources (JBT 2023, pp. 78-79).

14. The proponent's analysis has identified considerable uncertainty associated with the predictions of groundwater fluxes from the alluvium (JBT 2023, Att. A, Figure 6-4, p. 90). The effect of the predicted losses on the surface water flow regimes, including potential changes to ecologically relevant components such as the duration and timing frequency of low and zero flows, is not discussed. Further analysis and interpretation of these predictions is required to understand the range of potential impacts to surface water-groundwater interactions and ecological processes which rely on these interactions.
15. It is unclear how the groundwater modelling incorporates climate change. Recharge in the model is based on different historic rainfall datasets, generally using data from 1990-2020 (JBT 2023, Att. A, p. 9). Given the project extends to 2055 and groundwater drawdown recovery is predicted to take over 270 years (AARC 2023a, Ch. 7, p. 7-29), climate-change scenarios, including RCP8.5, should be discussed, including an analysis of impacts on drawdown, groundwater recovery times, the pit lake and potential mounding.
16. Potential for seepage through the Tertiary sediments once groundwater levels have recovered was identified by the proponent (JBT 2023, p. 98) but its likely effects on groundwater and surface water features are not discussed. The water quality of this seepage is unclear, although it will contact backfilled materials. From Figure 6-2 (JBT 2023, p. 104), it appears that one pathway for this seepage is towards Phillips Creek.

#### Surface Water

17. The analysis undertaken to characterise flood risks in the project area has made good use of available information and the adopted procedures are consistent with guidance detailed in the national flood guidelines (Ball et al., 2019).
18. The proponent has not adequately identified and assessed two key potential risks to surface water systems:
  - a. assessment is limited of the potential impacts on the surface water flows from possible surface cracking associated with underground mining. Further assessment is needed of how ecologically relevant components of the flow regime (e.g., the duration of low-flow and no-flow periods) may be altered and could affect aquatic biota and riparian vegetation.
  - b. the project's risks to local-scale sediment regimes (e.g., sediment sources, amounts and transfer pathways) are unclear. For example, the proposed mitigation measure for subsidence-induced ponding is for the natural sediment load of the creeks to infill the subsided areas. However, there is no discussion on the timeframes required for this to occur or how the potential reduction of creek sediment loads due to subsidence at the Saraji East Project may affect sediment dynamics in the project area.
19. A qualitative risk assessment is required of the likely collective impacts of the two risks identified above (Paragraph 18) with potential impacts of altered runoff caused by ponding and the effects of drawdown. As these impacts are likely to occur concurrently, their combined effects on receptors such as aquatic biota and ecosystems, riparian vegetation and terrestrial GDEs should be considered, guided by an appropriate IPD (Paragraph 26).

#### Ecology

20. To improve assessment of the risks of project-related drawdown, the proponent should extend the ground-truthing of terrestrial GDEs along One Mile Creek. Only one site was surveyed along this

creek despite the presence of riparian vegetation along its length, and no groundwater bores were sampled within the area to determine accurate groundwater levels (3D Environmental 2022, p. 23). Brigalow TEC is also present along One Mile Creek. As Brigalow may be groundwater dependent (Doody et al., 2019) the proponent should investigate whether trees within this TEC are accessing groundwater and may be at risk from the predicted drawdown.

21. Depressurisation within the Tertiary aquifer could result in increased downward drainage of Quaternary alluvium (3D Environmental 2022, pp. 80-81). The IESC agrees with the recommendation (3D Environmental 2022, pp. 87-88) to further investigate and quantify drawdown-related impacts to Wetland 8, a wetland of High Ecological Significance mapped as a Type 2 GDE.
22. Additional field data and ground truthing are required to quantify the probability and extent of increased infiltration along Boomerang and Phillips creeks arising from depressurisation within the Tertiary aquifer that leads to increased downward drainage of Quaternary aquifers. Reduced capacity of Quaternary and Tertiary aquifers could pose a threat for terrestrial GDEs that periodically rely on this resource.
23. Changes induced by ponding may pose risks (e.g., waterlogging) to vegetation, some of which are species listed by the EPBC Act. These risks should be assessed in more detail, especially for arboreal fauna because much of the surrounding landscape has been cleared and is already fragmented.
24. Drawdown beneath Boomerang Creek could significantly change water levels and dewater the aquifer at the locations where stygofauna were observed (Stygoecologia 2022, p. 36). This magnitude of drawdown is also likely to reduce stygofauna habitat and sever subsurface movement pathways critical for recolonisation of newly saturated sediments. Given the results of the pilot study (Paragraph 5), a comprehensive survey is needed of more bores, sampled more frequently, to better document stygofauna composition and abundance and improve predictions and monitoring of impacts associated with prolonged drawdown. This additional sampling should focus on alluvial sediments and include suitable reference sites where no project-related drawdown is predicted.
25. Site surveys identified evidence of Koalas and Greater Gliders along Boomerang and Hughes creeks (AARC 2023b, pp.183, 197). Impairment or loss of this vegetation due to groundwater drawdown may have repercussions for these two species which are both listed as Endangered under EPBC Act, as well as other native wildlife. More details on the likely impacts of groundwater drawdown to vegetation that supports arboreal and other fauna, and provides ecological connectivity within the area, are needed.
26. The EIS's identification and assessment of the project's risks to water resources needs to include one or more IPDs, derived from an evidence-based ecohydrological conceptualisation, to illustrate all the potential direct and indirect impact pathways and their interactions during and after mining. Much of the current EIS treats each potential impact (e.g., drawdown, subsidence) individually but does not clearly describe their likely collective impacts and how these may vary. As project-related drawdown, subsidence, erosion and other processes will occur concurrently, the combined effects of these in different parts of the project area should be explored. For example, ponding in the catchment caused by subsidence may interact with spatially variable drawdown to affect groundwater dynamics in the alluvium along Boomerang and One Mile creeks and alter groundwater availability for terrestrial and aquatic GDEs. Drawing up the IPDs will better integrate the different sections of the EIS, illustrate interacting impact pathways, and help identify and justify where further data, monitoring and mitigation measures are required (see response to Question 4).



## Cumulative impacts

Question 3: Advice is sought on whether the EIS has sufficiently addressed the cumulative impacts on water resources and related assets (including within the project area, other mining activities and coal seam gas projects) and whether the conclusions on cumulative impacts are appropriately supported.

### Groundwater

27. Cumulative impacts have been examined in the groundwater modelling. Due to the large number of mining activities operating in the area, considerable cumulative drawdown of groundwater is predicted. The IESC notes the following limitations of the provided assessment.
- a. It is unclear whether the potential impacts from the Bowen Gas Project are included in the cumulative groundwater drawdown predictions provided. Although it is stated that the Bowen Gas Project was included in a sensitivity analysis (AARC 2023a, Ch. 7, p. 7-19), the Bowen Gas Project is not clearly discussed, and it appears the results may not have been provided within the documentation of this project.
  - b. As discussed in Paragraphs 7 and 9, further work is required to parameterise the groundwater model to increase confidence in impact predictions. Similarly, more work is needed to justify the predictions of inflows to underground mining areas (Paragraph 12) and to clarify post-mining impact predictions (Paragraph 13). Once the suggested additional works are completed, updated cumulative impacts predictions should be provided.

### Surface water

28. The proponent discussed cumulative impacts to water quality and reduced surface water runoff due to capture by different mine water management systems. However, there is no information about the potential cumulative impacts to Boomerang Creek and downstream to the Isaac River from the combined subsidence predicted for the project and the Saraji East Project.

### Ecology

29. The proponent has not discussed potential cumulative impacts arising from habitat fragmentation and modification to remnant floodplain vegetation and riparian corridors along ephemeral streams in the project area which are potentially important habitats for a range of EPBC Act-listed species such as the Koala and Greater Glider. This may be especially important in areas where drawdown and subsidence affect the condition and persistence of this vegetation.
30. The proponent acknowledges that impacts of the Saraji East Project are likely to contribute to the cumulative ecological impacts of the project on Type 1 GDEs associated with Boomerang Creek (3D Environmental 2022, pp. 85-86). However, the potential impacts from these combined with subsidence, drawdown, erosion and alterations to flow regimes within the project area have not been adequately considered and are likely to contribute to cumulative impacts on regional GDEs and their associated biota.
31. While potential climate-change impacts have been well described in Katestone (2022), their implications have not been considered in the cumulative effects on terrestrial GDEs and aquatic ecosystems. Climate-change scenarios should be incorporated into the assessment of potential cumulative impacts on GDEs and other water resources.

## Mitigation and management

Question 4: Advice is sought on whether the proposed monitoring, mitigation and management measures are specific enough to adequately identify, mitigate and manage impacts from the proposed project on water resources and related assets.

32. Limited information on mitigation and management measures has been provided. There are existing monitoring and management plans for the currently approved areas of the Lake Vermont Complex which will be updated and extended to cover the project (e.g., AARC 2023a, Ch. 7, p. 7-43). However, details of the existing plans and proposed updates are not fully discussed. The proponent should address the following when updating monitoring, mitigation and management plans:
- a. site-specific water quality objectives (WQOs) and groundwater level triggers are required and can be derived from groundwater quality monitoring that has occurred monthly since October 2020. It is unclear whether the WQOs and groundwater level triggers will be site-specific or only aquifer-specific. Site-specific values are preferable as these will consider the variability across the project site and provide an improved level of protection over objectives derived across an entire water source.
  - b. although the groundwater monitoring network will be expanded, it is unclear how many of the additional bores will be compliance bores. Justification should be provided for why monitoring bores will not be compliance bores.
  - c. the IESC agrees with the recommendation (RGS 2021, p. 28) that further monitoring should be conducted to ensure that any contaminant accumulation in the proposed three sediment dams does not lead to contamination of One Mile Creek and a tributary of Phillips Creek due to dam overflow (WRM 2023b, pp. 15-17).
  - d. monitoring of wetlands for potential impacts from groundwater drawdown is planned (JBT 2023, p. 106) but more details (e.g., sampling locations, parameters, predicted responses) are needed. If the additional work suggested in Paragraph 5 identifies that any of the wetlands are groundwater-dependent, these areas should be included in the planned GDE Monitoring and Management Plan (GDEMMP).
  - e. any areas of Brignalow TEC or other vegetation identified as groundwater-dependent (see Paragraph 20) should also be included in the GDEMMP.
  - f. a monitoring and management plan is needed to address subsidence. There is considerable uncertainty about the magnitude of subsidence-induced land movements likely to occur above the areas of dual-seam extraction as there are no basin-specific field data for dual-seam extraction available. Impact predictions will require verification with data from elevation surveys to enable appropriate management measures to be implemented.
  - g. erosion management should specifically consider the increased risks posed by dispersive soils found in some parts of the project area.
  - h. all management plans should include trigger action response plans (TARPs) that incorporate sufficiently frequent monitoring and timely actions to detect impending impacts and allow appropriate mitigation and management actions to be implemented.
33. Adaptive management options such as modified design of longwall panels in areas where subsidence predictions are exceeded were not considered in the provided documentation. The IESC suggest that the proponent discuss these adaptive management options.

34. The design and likely effectiveness of the mitigation measures proposed for subsidence troughs within the catchments of Boomerang and One Mile creeks are not adequately discussed (see Paragraph 18b). Further information is needed about the mitigation measures and potential cumulative impacts with subsidence associated with the Saraji East Project.
35. The proponent proposes channels as mitigation measures on some areas of the floodplain to manage ponding from subsidence, and the surface water course is expected to naturally recover through erosion and sedimentation over time. Further information is needed on how this will result in a stable landform, particularly given the presence of dispersive soils on site. Details should include any post-mining monitoring and how this will be used to inform mitigation or management measures. The proponent needs to also consider the risk of channel avulsion across the floodplain between Boomerang and One Mile creeks, especially in subsided areas and their mitigation channels, and how this risk might be managed.
36. The proposed offset area (AARC 2023a, Ch. 10, Figure 10.25, p. 10-136) within the mining lease application coincides with areas indicated to have potential groundwater drawdown. Baseline condition surveys should be conducted, and further information should be provided on how this will be managed and mitigated if maximum drawdown is reached, and the vegetation community is adversely affected. The proponent may need to reconsider the offset's location to one where the offset will not be affected by nearby activities.
37. As many impacts discussed individually in the EIS will occur concurrently and are likely to interact, mitigation and management measures should explicitly address these collective impacts, illustrated using one or more IPDs (Paragraph 26). Identification of specific impact pathways and their interactions would help target the most effective mitigation measures in a given area (e.g., placement of mitigation channels to minimise undesired impacts of gully erosion and sedimentation).

### **Subsidence**

Question 5: Advice is sought on whether the EIS has provided justification and evidence to support the claim that subsidence will have no significant impacts to surface and groundwater resources and assets.

38. The IESC does not consider that adequate explanation and evidence have been provided to justify the proponent's conclusion that subsidence will have no significant impacts to surface and groundwater resources and assets. The limited data and information available to predict potential subsidence movements in dual-seam extraction areas (Gordon 2022, pp. 23-24) increases uncertainty in the predictions of subsidence-induced land movements and resulting impacts to surface waters and their biota and ecosystems. The following additional information is also required.
  - a. Impact predictions and uncertainty in these predictions are based on the assumptions that connected fracturing will only occur up to 120 m above areas of single-seam extraction and 180 m above dual-seam extraction areas (AARC 2023a, Ch. 7, p. 7-32). However, recent advances in quantifying subsidence above longwalls indicates that an enhanced fracture zone connecting surface to seam is plausible in cases that were previously not considered to be hydraulically connected to surface (Seedsman 2020, Byrnes 2022, p. 1). A more thorough assessment is required that compares various approaches to predicted height of fracturing and hydraulic connectivity with the surface. This revised assessment should include vertical profiles and maps of areas where surface-to-seam hydraulic connectivity is plausible under different approaches in the context of surface features and processes that could be impacted.
  - b. The groundwater modelling assumes and uses equivalent porous media (EPM) conditions. This approach is unable to explicitly simulate the impacts of surface cracking and fracturing of deeper strata. The IESC does not believe that an EPM-based groundwater model can adequately address the main impact pathways or worst-case scenarios. The limitations of this modelling

approach should be discussed in detail and further inform the risk assessment, monitoring and adaptive management of the impacts of subsidence.

- c. Although the proponent considered a scenario in the groundwater model which includes connected fracturing from seam to surface, no clear evaluation of the potential impacts of the predicted additional drawdown on surface water systems, including wetlands, and their dependent ecology was provided. Considerable additional drawdown (up to approximately 25 m) is predicted within the Tertiary Sediments beneath Boomerang Creek (JBT 2023, Figure 5-8, p. 86) which may have significant impacts on surface water flow regimes and the frequency and duration of intermittent wetting of the alluvium associated with this creek. Given this uncertainty and that drawdown may actually exceed 25 m, there is a risk of long-term desaturation of the alluvium below parts of Boomerang Creek.

Question 6: Advice is sought on whether the impacts to the GDEs due to subsidence are negligible and acceptable.

39. The IESC does not consider that the information provided by the proponent is sufficient to determine that potential impacts of subsidence on GDEs are negligible (Paragraphs 40-41). The IESC does not comment on acceptability of potential impacts as that is a regulatory decision; the IESC's advice is solely scientific.
40. Localised changes in topography and stream morphology, including tension cracking and ponding in the channels and along riparian corridors of Boomerang and One Mile Creek, are predicted as a result of underground mining. A series of six small troughs in the channel bed of Boomerang Creek and eight main troughs in the channel bed of One Mile Creek are expected to develop (Gordon 2022, Figures 35 and 36, p. 34). These troughs are also predicted across the alluvial floodplains where tension cracking could potentially reach the Quaternary and Tertiary sediments, causing leakage through to deeper aquifers. As these alluvial aquifers may support GDEs, more detailed discussion is required about potential impacts to GDEs from changes in groundwater recharge to the Quaternary and Tertiary sediments arising from subsidence and ponding.
41. Additional data are also required to provide a reliable baseline for assessing potential impacts of subsidence and ponding on GDEs 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).

Question 7: Advice is sought on whether the EIS has provided sufficient justification and evidence to support conclusions that impacts from subsidence on creek hydraulics and hydrology are likely to be temporary or minor and manageable.

42. The subsidence assessment did not fully assess potential impacts to creek hydraulics, surface water flow regimes or surface water-groundwater connectivity and, as such, there is insufficient justification provided to support the proponent's conclusions. Additional analysis is needed as outlined below.
  - a. Areas of ponding arising from subsidence impacts were presented (AARC 2023a, Ch. 6, Figure 6.8, p. 6-18) as were cross-sections of likely changes to the bed of Boomerang and One Mile creeks (Gordon 2022, Figures 35-36, p. 34). However, there is no discussion of the potential impacts of these changes on ecologically relevant components of the flow regimes of these creeks or how potential impacts of grade reversals such as limiting the spatial extent of low flows could impact aquatic and riparian ecosystems and biota.
  - b. Impact predictions of groundwater drawdown including changes in flux from the alluvial aquifers appear to be based on the 'base case' which does not include connected fracturing reaching the

surface in any location. Given connected fracturing is possible (Paragraph 38), further analysis and assessment is needed of how connected fracturing would alter the potential impacts currently predicted, including on creek hydraulics and hydrology.

- c. Potential impacts from surface cracking (not connected fracturing) such as the diversion of surface flows (including temporarily) and changes to water quality (e.g., increased turbidity) should be assessed, along with feasible mitigation options.
- d. Sediment accumulation in subsided areas is seen as a positive outcome as it will reduce ponding but these sediments will be eroded from other parts of the catchment. More information is needed on the hydraulic and ecological impacts of these changes to the sediment regime in the affected creeks and their receiving waters. Given the identification and nature of dispersive soils in the project area (WRM 2023a, Section 2.3.3, p. 34), it can be expected that management of sediment will require ongoing monitoring.
- e. A reduction of sedimentation in the system due to the Saraji East Project's predicted subsidence troughs causing less sediment to be available for mitigation of the proposed project subsidence is likely. Discussion of potential project-specific and cumulative impacts on creek hydraulics and hydrology has not been provided.
- f. Drainage channels are proposed to manage ponding (AARC 2023a, Ch. 6, p. 6-17). The potential impacts on creek hydraulics and hydrology arising from these drainage channels are not discussed, especially where they may interact with other impact pathways such as drawdown.

Question 8: Advice is sought on whether the EIS has sufficiently addressed impacts on aquatic and terrestrial fauna due to subsidence, and whether the proposed mitigation measures are sufficient to manage the potential impacts.

- 43. The IESC considers that the EIS has not sufficiently addressed impacts on aquatic and terrestrial fauna due to subsidence. Insufficient evidence is presented to demonstrate that the proposed mitigation measures will effectively manage the potential impacts.
- 44. Subsidence-induced ponding may result in the following impacts that require further discussion and justification that proposed mitigation measures are sufficient to manage the potential impacts:
  - a. die-back of vegetation that is intolerant of inundation. This may affect Brigalow TEC and Poplar Box TEC, especially recruitment and seedling growth.
  - b. loss or impairment of habitat for EPBC Act-listed species that utilise the riparian corridor.
  - c. disconnection and alteration of surface water habitats through changed flow regimes arising from ponding from subsidence and changes in sedimentation.
  - d. increased erosion and scouring which will likely increase turbidity and alter instream habitat availability and stability.
- 45. The proponent proposes to monitor ponding-induced changes to vegetation (AARC 2023a, Ch. 6, p. 6-17). However, no details of the monitoring program are provided to enable assessment of its likely effectiveness. Impacted vegetation is to be replaced with native species adapted to ponding; thus, the management measures will facilitate ecosystem changes rather than attempting to mitigate these first. The proponent should explain how this species replacement might alter runoff from the catchment and habitat availability for native fauna.
- 46. The aquatic ecology assessment states that impacts to fish passage due to subsidence will be monitored and remediated (AARC 2022, p. 107). However, this is not extended to other aquatic flora

or fauna. Further investigation is suggested to evaluate subsidence-related impacts on instream biota, in conjunction with annual assessments of stream habitat condition and aquatic flora and fauna. There should also be evidence presented that the proposed mitigation measures are feasible and will maintain instream ecological connectivity and aquatic habitat availability.

47. Gilgai were identified in some areas overlying longwall panels (AARC 2023a, Ch. 7, Figure 7.5, p. 7-16). Subsidence of these gilgai is likely to affect their structure and ability to hold water, impacting their suitability as habitat for EPBC Act-listed species such as the Ornamental Snake. This should be discussed, along with feasible mitigation measures.
48. Stabilisation of the channel system proposed to mitigate subsidence-induced ponding is not discussed or demonstrated for post-mining scenarios. Given the presence of dispersive soils and the low gradient of the area, it is unclear that the proposed channels have a high likelihood of success. Construction of the mitigative channels may increase erosion (e.g., creating gullies that need management) and decrease water quality. The proponent needs to further justify this proposed mitigation measure and provide examples of its effectiveness in similar environmental settings.

<b>Date of advice</b>	23 May 2023
<b>Source documentation provided to the IESC for the formulation of this advice</b>	AARC 2023. <i>Lake Vermont Meadowbrook Extension Project Environmental Impact Statement</i> . AARC Environmental Solutions. Prepared for Bowen Basin Coal Pty Ltd. 2023.
<b>References cited within the IESC's advice</b>	<p>AARC 2023a. <i>Lake Vermont Meadowbrook Extension Project Environmental Impact Statement</i>. AARC Environmental Solutions. Prepared for Bowen Basin Coal Pty Ltd. 2023.</p> <p>AARC 2023b. <i>Lake Vermont Meadowbrook Project Terrestrial Ecology Assessment</i>. AARC Environmental Solutions. Prepared for Bowen Basin Coal Pty Ltd. January 2023. (Appendix G of the Lake Vermont Meadowbrook EIS)</p> <p>AARC 2022. <i>Lake Vermont Meadowbrook Project Aquatic Ecology Assessment</i>. AARC Environmental Solutions. Prepared for Bowen Basin Pty Ltd. November 2022. (Appendix H of the Lake Vermont Meadowbrook EIS)</p> <p>Ball J, Weinmann E, Kuczera G 2019. <i>Book 3 of Australian Rainfall and Runoff Peak Flow Estimation</i>. Australian Rainfall and Runoff A Guide to Flood Estimation. Available: ARR: A guide to flood estimation (au.s3-website-ap-southeast-2.amazonaws.com).</p> <p>Byrnes 2022. <i>Lake Vermont Meadowbrook EIS Peer Review Subsidence</i>. Byrnes Geotechnical Pty Ltd. Prepared for Bowen Basin Coal Pty Ltd. March 2022. (Attachment 5 of the Lake Vermont Meadowbrook EIS)</p> <p>Doody TM, Hancock PJ, Pritchard JL 2019. <i>Information Guidelines Explanatory Note: Assessing groundwater-dependent ecosystems</i>. Report prepared for the Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development through the Department of the Environment and Energy, Commonwealth of Australia 2019. Available [online]: <a href="#">Information Guidelines Explanatory Note - Assessing groundwater-dependent ecosystems   iesc</a> accessed 18 May 2023.</p> <p>DSITIA 2015. <i>Guideline for the environmental assessment of subterranean aquatic fauna</i>. Department of Science, Information Technology, Innovation and the Arts, Queensland Government. Available [online]:</p>

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- WRM 2023b. *Lake Vermont Meadowbrook Project EIS Site Water Balance and Water Management System Report*. WRM Water & Environment Pty Ltd. Prepared for Bowen Basin Coal Pty Ltd. February 2023. (Appendix Y of the Lake Vermont Meadowbrook EIS)
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