

Advice to decision maker on Ensham Life of Mine Extension Project

IESC 2021-123: Ensham Life of Mine Extension Project (EPBC 2020/8669) - Expansion

Requesting agencies	The Australian Government Department of Agriculture, Water and the Environment and the Queensland Department of Environment and Science
Date of request	10/05/2021
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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 Ensham Resources Proprietary Limited's Ensham Life of Mine Extension Project in Queensland. This document provides the IESC's advice in response to the requesting agencies' questions. 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 Ensham Mine is an existing open-cut and underground bord-and-pillar coal mine, located 35 kilometres east of Emerald, Queensland. The mine is in the western part of the central Bowen Basin, and the Fitzroy Basin catchment. The proposed expansion (the 'project') will see the Ensham life-of-mine extended by nine years – up to 2037, requiring expansion of underground bord-and-pillar mining into three separate zones (the 'project area'): Zone 1, Zone 2, and Zone 3. Total project area is predicted to be approximately 2,737 ha; however, no surface construction, clearing, or disturbance outside of existing infrastructure will be required. Mining will progress into the three zones at different times, and it is expected that this will produce

up to 4.5 million tonnes of run-of-mine thermal coal per annum. Production at this rate will be within the current Environmental Authority (EA) limit of 12 million tonnes per annum.

The project is close to other existing or proposed mines in the Bowen Basin, including the Gregory-Crinum Coal Project, Kestrel Coal Project, Wilton and Fairhill Projects, and Curragh Project. Consequently, the project may contribute to the cumulative impacts of these mines and the current Ensham Mine.

Key potential impacts from this project are:

- drawdown of groundwater levels within the alluvium; and
- altered community composition and viability of groundwater-dependent ecosystems (GDEs) and aquatic and riparian ecosystems in and downstream of the project area.

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

- Elucidate and justify the hydrogeological conceptual models, particularly the nature of the groundwater-surface water interactions.
- Improve confidence in the groundwater modelling by expanding the sensitivity analysis for key hydrogeologic parameters.
- Assess groundwater dependency of riparian vegetation and Brigalow (*Acacia harpophylla*) on alluvial sediments by using direct techniques (e.g., stable isotopes, leaf water potential and soil water potential) as described in Doody *et al.* (2019) and Jones *et al.* (2019).

Context

The existing open-cut and underground bord-and-pillar operations of the Ensham Mine are currently extracting a portion of the various combined Aries and Castor seam and is authorised to continue until 2028 within Mining Lease (ML) 7459 and ML 70365. The proposed project is located in the central Bowen Basin within an existing mining precinct where other coal mines are operating. Much of the project area is cleared and now supports dryland and irrigated cropping and cattle grazing.

The project proposes extending the underground bord-and-pillar mine into the project area comprising Zones 1, 2 and 3. This expands the underground operation to the west of the existing approved underground operations. No additional surface infrastructure is proposed. The project has a surface area of approximately 2,737 ha: Zone 1 (2,134 ha); Zone 2 (394 ha); Zone 3 (209 ha).

The Nogoa River, an un-named southern anabranch and several minor tributaries traverse the project area. The Nogoa River is fed by the ephemeral Theresa Creek and releases from Fairbairn Dam upstream and flows 99% of the time. Controlled mine-water releases into the Nogoa River are currently authorised under EA EPML 00732813. No changes to the surface water mine infrastructure or flood protection levees will be required; mine waste-water will continue to be managed using the existing water management system for the project. Furthermore, no changes to the water licencing arrangements of the existing water supply surface infrastructure are required or expected for the project, as the current supply system at Ensham Mine will be utilised.

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.

Subsidence

1. Although the proponent has provided a subsidence assessment (Gordon Geotechniques 2020), there is little discussion of specific risks to water resources. This is presumably because subsidence is predicted to be limited to less than 40 mm within Zones 1, 2 and 3, which is within the range of natural variability of vertical soil movement within the region. Monitoring and mitigation of subsidence as a result of the proposed project is discussed in Paragraph 17.

Groundwater

2. The proponent has provided geological and hydrogeological conceptual models to inform the design of the numerical groundwater water model (SLR 2020, Appendix A, Figure 14, p. 44 and SLR 2020, Appendix A, Figure 38, p. 74). However, the IESC is concerned that these conceptual models are not broadly representative of the region and do not adequately capture the heterogeneity of the underlying geology. Furthermore, the spatial variability of the interactions of flows between the alluvium and Nogoa River is poorly represented. For example, although the proponent has described the Nogoa River as broadly disconnected from the underlying alluvium, several groundwater expressions discharging into the Nogoa River have been observed, which have been assessed by the proponent as being caused by irrigation (SLR 2020, Appendix A, p. 51). The IESC also notes that the Rangal Coal Measures subcrop in localised zones beneath the alluvium (SLR 2020, p. 19) and so may have some intermittent connection with the Nogoa River, its tributaries and other surface water systems in the project area. However, these potential groundwater-surface water interactions and groundwater expressions are not depicted in the conceptual models of the project area used to inform the numerical groundwater model. The proponent should provide additional conceptual model cross-sections within the project area that show the locations of these groundwater expressions and subcropping Rewan Group and Rangal Coal Measures. These conceptual cross-sections should be used to ensure that the numerical groundwater model is consistent with these hydrogeological and groundwater-surface water conceptual models.
3. The numerical groundwater model should be updated to ensure consistency with these conceptual models. Furthermore, the locations of potential drawdown within the alluvium in relation to potential GDEs, including the ecologically important riparian corridors within and surrounding the project area, should be provided as part of the predictions of the groundwater model. Additional work that should be undertaken to increase confidence in the predictions of the numerical groundwater model is outlined below.
 - a. The sensitivity and uncertainty analyses for the groundwater model did not consider an increase in the horizontal hydraulic conductivity of the Rewan Group, which acts as a hydraulic barrier between the underlying Rangal Coal Measures and overlying alluvium (SLR 2020, Appendix A, Table 22, p. 101). As the Rewan Group is likely to be the main hydraulic control on incremental drawdown within the alluvium, and given its lateral connection geologically and hydraulically, to both the Rangal Coal Measures and the alluvium (SLR 2020, Appendix A, Figure 38, p. 74), the horizontal hydraulic conductivity of the Rewan Group should be varied within a plausible range of

values as part of the groundwater model sensitivity analysis. Predicted drawdown contours within the alluvium in relation to potential GDEs, including riparian corridors within and surrounding the project area should also be provided as part of these sensitivity and uncertainty analyses. This would increase confidence in the proponent's prediction of negligible drawdown within the alluvium, and predicted lack of impacts to potential GDEs including riparian corridors along the Nogoa River and its tributaries.

- b. Predicted drawdown contours suggest that drawdown impacts within the Rangal Coal Measures may reach or exceed model boundaries (e.g. SLR 2020, Appendix A, Figure 45, p. 93). Given that the Rangal Coal Measures subcrop in localised zones beneath the alluvium (Paragraph 2), model boundary conditions should be varied within a plausible range of locations, types and values as part of the sensitivity analysis. This would increase confidence in the predicted range and magnitude of groundwater drawdown within the Rangal Coal Measures and overlying alluvium.
4. The proponent has stated that discharge of mine-affected water will be undertaken in accordance with the existing approved discharge criteria for Ensham Mine (Idemitsu 2021, Chapter 25, p. 87). Analytical results of bores screened within the Rangal Coal Measures indicate that EC values are between 4,000 and 12,000 $\mu\text{S}/\text{cm}$ and median concentrations of dissolved metals, except arsenic and silver, are generally below the Australian and New Zealand Guidelines (ANZG) (2018) for the protection of 95% of aquatic species. It is therefore unlikely that discharge of underground mine inflows, which are likely to be dominated by leakage from the Rangal Coal Measures, will threaten the ecological values of the Nogoa River.

Surface water

5. The Nogoa River is classified as a perennial system with flows dominated by releases from Fairbairn Dam. To predict licensed takes and discharges to and from the Nogoa River, HEC (n.d. -a) developed a Water and Salt Balance Model (WSBM) using 131 historical climate realisations to simulate predicted volumes up to the 95th percentile. In summary, 95th percentile release volumes ranged between approximately 4,000 ML and 10,000 ML a year (HEC n.d. -a, Figure 21, p. 31), while predicted annual extraction volumes at the 95th percentile ranged between 600 ML and 700 ML (HEC n.d. -a, Figure 25, p. 35). The IESC notes that this predicted extraction rate is less than the current annual extraction allocation from the Nogoa River of 1,500 ML/year. Although this model is considered by the IESC to be generally fit for purpose, the following recommendations would increase confidence in the proponent's predictions.
 - a. The WSBM has not been calibrated to historical data. Although the IESC notes that the project's catchment area is small and so the lack of calibration may not be significant, calibration to historical data would increase confidence in the WSBM's ability to accurately predict future takes and discharges.
 - b. The proponent has not completed a climate change sensitivity analysis for the WSBM. Although the 131 realisations of historical climate data that have been used by HEC (n.d. -a) to inform modelling are likely to be an adequate representation of how climate change may alter the water and salt balance throughout the life of the project, greater confidence would be achieved if the proponent undertook a sensitivity analysis using a 'worst-case' climate scenario because current carbon emissions are still tracking the Representative Concentration Pathway (RCP) 8.5 projection (Schwalm *et al.* 2020).
6. Results of the groundwater model sensitivity analysis indicated that predicted underground mine inflows, which were integrated within the site water balance model, were most sensitive to an increase in target coal seam horizontal hydraulic conductivity. These results indicated that peak mine inflows of approximately 26 ML/day (9,500 ML/year) may occur between 2031 and 2032, compared to a 'base case' scenario of approximately 10 ML/day (3,600 ML/year) (SLR 2020, Appendix A, Figure 53, p. 104).

Should underground mine inflows exceed predicted 'base case' volumes, the IESC recommends that the proponent predict the incremental impact of these flows on projected discharge volumes, including the incremental impact of potential discharge into the Nogoia River during low flows.

7. The EA for extraction from the Nogoia River does not include a minimum flow trigger level for extraction which can occur as long as the annual allocation is not reached (HEC n.d. -a, p. 20). Furthermore, the upstream Fairbairn Dam can release flows to the river when required so that water demands of the proposed project would be able to be supplied during periods of low- or no-flow. The proponent should clarify the minimum flow within the Nogoia River that would require releases from Fairbairn Dam to supplement mine water demand for the proposed project. This would ensure that extraction during low-flow periods does not materially impact downstream biota, including the EPBC-listed White-throated snapping turtle and Fitzroy River turtle.

Flooding

8. Flooding of underground workings will occur post closure when water is no longer pumped from the underground mine and the groundwater rebounds. The subsidence study undertaken by Gordon Geotechniques (2020) assessed that flooding of mine workings could influence pillar load in two ways. Water pressure acting on the roof of the workings may act as a hydraulic jack to unload the pillars or, in the case of overburden being fully saturated over the full water head, result in higher loads on the pillars. Flooding of overburden has the effect of temporarily decreasing the factor of safety (FoS) of the pillars. During an AEP 0.1 flood event, a 10-m flood depth is predicted within the Nogoia River channel above the Zone 1 bord-and-pillar mining area. The proponent has committed to increasing the pillar size to 26 m x 30 m from the standard 24 x 28 m configuration or reducing the mining height to approximately 3.87 m to ensure that a minimum FoS of 1.6 is maintained (Idemitsu 2021, Chapter 12, p. 14). The IESC agrees with these measures as they will reduce the probability of catastrophic consequences due to failure of the bord-and-pillar system during extreme flooding events.

Water quality

9. The proponent has provided baseline surface water quality data that are generally sufficient (HEC n.d. -b) and will assist with quantifying the incremental impacts of the proposed project on surrounding watercourses. However, monitoring in some locations of the mine site has been sporadic. Furthermore, water quality objectives (WQOs) have been exceeded at a number of sites. To ensure that seasonal changes in water quality, including these recorded exceedances, are accurately captured, the proponent should ensure that monitoring rounds are undertaken systematically under the approved EA (Condition 25). The IESC recommends that downstream monitoring of metals be included in the water quality monitoring program.

Water-dependent ecosystems

10. The aquatic ecological value of the Nogoia River and its tributaries is assessed as 'high' by the proponent (Idemitsu 2021, Chapter 14, p. 25) because the main channel provides favourable habitat for foraging and potential habitat for breeding for aquatic biota, including two EPBC-Act listed turtles (White-throated snapping turtle (*Elseya albagula*) and the Fitzroy River turtle (*Rheodytes leukops*)). Although the aquatic ecological values of ephemeral watercourses in the project area are rated lower, remnant pools along these watercourses may be important aquatic refuges. The proponent has not assessed whether water and sediment regimes of these refugial pools may be altered by the project, potentially affecting their ecological significance for aquatic and riparian biota. For example, mobilised sediment may fill pools and reduce their permanence. Ephemeral streams are water-dependent ecosystems whose biota and biogeochemical processes contribute to the ecological integrity of adjacent riparian and terrestrial ecosystems (Datry *et al.* 2017).
11. The proponent highlights the significance of riparian zone vegetation along the Nogoia River and other watercourses in the project area to ecological connectivity and faunal movement in this largely cleared

landscape (Idemitsu 2021, Chapter 13, p. 29). The project area also supports patches of Brigalow community (*Acacia harpophylla*), an EPBC Act-listed threatened ecological community (TEC) as well as stands of Coolibah (*Eucalyptus coolabah*) and Red Gum (*Eucalyptus camaldulensis*). Field surveys undertaken in 2019 and 2020 suggested that, based on a lack of floristic indicators and observed water stress, these species were not GDEs (AECOM 2020, p. 53). Based on this indirect evidence, the proponent assumes that vegetation on alluvial sediments and along the watercourses is not using groundwater and therefore would not be affected by any drawdown in the alluvium. The IESC recommends that the proponent confirms the validity of this important assumption by using direct techniques (e.g., stable isotopes, leaf water potential and soil water potential) as suggested by Doody *et al.* (2019) and Jones *et al.* (2019) to assess potential groundwater use by Brigalow, Coolibah and Red Gums. These investigations could focus on vegetation communities near the confluence of Mosquito Creek and the Nogoia River, along the un-named southern anabranch, and in patches of Brigalow on alluvial sediments where groundwater occurs near the surface. There would be merit in pairing these investigation sites with the intended locations for the proposed alluvial monitoring bores (Paragraph 18).

12. A stygofauna assessment, comprising a single round of sampling in November 2019, was undertaken by frc environmental (2020, p. 9). This GDE was characterised as being of low environmental value within the proposed project area because of the limited occurrence of stygofauna (found in only two of the 15 surveyed bores), and because groundwater quality was classified as only potentially suitable for stygofauna (on the basis of high EC and high depth to water table). The Guideline for the Environmental Assessment of Subterranean Aquatic Fauna (DSITI 2015) recommends that when a one-off pilot survey confirms the presence of subterranean aquatic fauna, a comprehensive survey of bores sampled over at least two seasons is required. Results of this comprehensive survey would increase confidence in the proponent's claims that the stygofauna of the project area are naturally depauperate, that this GDE is of low environmental value in the project area, and that it is unlikely to be significantly impacted by the proposed project.

Final landform

13. It is understood that reject material from the proposed project, which will be generated at an annual volume of 18,000 m³ (225,000 m³ lifetime total) will be stored in Pit C and Pit D, which are predicted to become regional groundwater sinks in perpetuity. Although the geochemical studies suggest that overburden and waste rock are not acid-forming, have a high degree of buffering capacity and are not highly enriched in metals, the sodic nature of the material may generate levels of salinity or sedimentation runoff above applicable guidelines and existing EA conditions. The proponent should ensure that any reject material temporarily stockpiled on site from the proposed project is managed in accordance with the existing sediment and erosion management plan.

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, other mining activities and coal seam gas projects) are appropriate and supported.

Groundwater

14. Assessment of cumulative drawdown impacts beyond the existing operations at Ensham has been done only qualitatively on the basis that surrounding coal mines within a 30-km radius of the proposed project (i.e., Gregory Crinum, Kestrel, and the proposed Wilton and Fairhill coal projects) are targeting different coal seams and that cumulative impacts are not expected due to the interbedded low-permeability layers separating the coal seams (SLR 2020, Appendix A, p. 32). However, the IESC would expect that the cumulative drawdown impacts of surrounding mines be determined quantitatively. The groundwater model uncertainty analysis (Paragraph 3a-b) suggests that groundwater drawdown extent within the coal seams is sensitive to the modelled horizontal hydraulic conductivity of the coal

seams. To increase confidence in the predicted lack of cumulative groundwater drawdown impacts of the project, the proponent should quantify the difference in predicted groundwater drawdowns between the incremental and cumulative drawdown scenarios.

Surface water

15. The proponent predicts no cumulative impacts to water quality or quantities within the Nogoia River compared to already approved operations. This is presumably because predicted median takes and releases to and from the Nogoia River are less than, or only marginally greater than, those from existing operations at Ensham Mine. Furthermore, surface water modelling suggests that releases will maintain already approved water quality limits (i.e., EC values below 12,500 $\mu\text{S}/\text{cm}$, pH between 6.5 and 9.0, sulfate less than 1,000 mg/L and turbidity less than 360 NTU). The IESC notes that there are sufficient surface water monitoring baseline data available from both upstream and downstream sites which could be used to inform the frequency, timing and volumes of releases from the proposed project. This information would be useful to guide strategic releases to reduce the potential for downstream cumulative impacts on flows of the Nogoia River.

Water-dependent ecosystems

16. Potential cumulative impacts to GDEs are largely informed by groundwater drawdown predictions. To the extent that the current groundwater model can provide a reliable estimate of the lack of groundwater drawdown within the alluvium, it appears that the project is unlikely to contribute materially to cumulative impacts to GDEs. However, the lack of uncertainty analysis of the horizontal hydraulic conductivity of the Rewan Group, which may act as the main hydraulic control on drawdown within the alluvium (Paragraph 3a), makes it difficult to assess the materiality of predicted drawdown within the alluvium. Reassessment of cumulative impacts on potential GDEs is needed if uncertainty analysis of the groundwater model indicates a greater extent and magnitude of drawdown compared to current predictions, and groundwater dependence is demonstrated by the suggested field studies (Paragraph 11).

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

17. An independent expert review of the subsidence report (Gordon Geotechniques 2020), commissioned by the IESC, was conducted by Emeritus Professor Bruce Hebblewhite (Hebblewhite 2021). In summary, the review concluded that the proposed bord-and-pillar mining layout was a generally appropriate and well-developed geotechnical design. However, it was noted by Hebblewhite (2021) that the accuracy of subsidence monitoring is likely to be limited by LiDAR, quoted as being ± 50 mm, which is accepted as reasonable for such technology. Given this accuracy is higher than the range of subsidence predicted by the proposed project, the proponent should consider using a more accurate survey technique as recommended by Hebblewhite (2021). The IESC supports all of the other recommendations by Hebblewhite (2021, Section 4) and these should be addressed within the project's subsidence management plan. The IESC cannot comment on the adequacy of the proposed mitigation, management and monitoring measures without access to the subsidence management plan.

Groundwater

18. The proponent has committed to maintain the current groundwater monitoring network, sampling frequency and analytical schedule for the proposed project, in accordance with the current EA (Schedule C). Furthermore, four new monitoring bores will be installed (Idemitsu 2021, Chapter 25, Table 25-21, p. 92). Three bores will be screened within the Nogoia River alluvium and one will be

screened in the Rangal Coal Measures. The proponent also notes that one vibrating wire piezometer, which was installed in November 2019, is screened within the lower alluvium, Rewan Group, overburden, target coal seams and underburden. The IESC recommends that further bores be included in areas of alluvium to the west of the mine area to provide reference data where drawdown is not predicted. Groundwater level thresholds will be developed after two years of monitoring, while groundwater quality triggers will be developed for each bore using a minimum of 18 samples taken over two years (Idemitsu 2021, Chapter 25, p. 93). The proponent notes that during this two-year period, interim groundwater quality limits will be used in accordance with existing EA Condition C48, Table C10. The IESC supports these measures as they will provide further confidence that the proposed action will not materially impact on drawdown within the alluvium or flows within the Nogoia River. These monitoring bores will also assist with groundwater model validation.

Surface water

19. Surface water monitoring is outlined in the proponent's Receiving Environment Monitoring Program (REMP), the requirements of which have been guided by the EA. As the REMP was not provided to the IESC by the proponent, commentary on this document is not possible.
20. Controlled releases will be done in accordance with the proponent's existing EA which defines salinity and flow requirements of releases. Controlled releases have been incorporated into the WSBM, and modelling suggests that the proponent will be able to meet EA requirements. However, there are numerous factors that may alter the proponent's ability to meet the requirements of the EA which have been discussed throughout this advice (Paragraph 6 and Paragraph 7). The proponent should explain how they intend to manage mine-affected water when they are unable to undertake controlled releases (e.g., during periods of low flows within the Nogoia River).

Water-dependent ecosystems

21. The IESC recommends that additional stygofauna sampling be undertaken for the reasons described in Paragraph 12. All collected specimens should be identified as far as practical (e.g., beyond 'Oligochaeta') to ensure that endemic species are not being overlooked because of coarse taxonomic assessment. If further stygofauna are found, the proponent should assess potential impacts of drawdown on their community composition and ecosystem services and propose suitable mitigation measures to reduce these potential impacts. The IESC considers that the monitoring, management, and mitigation measures under the current EA are sufficient to detect and mitigate potential impacts from the project on other GDEs and aquatic biota. However, there is still uncertainty about whether riparian vegetation along watercourses draining the project area may be influenced by drawdown, altered flooding regimes and/or reduced water quality. If the further field investigation recommended in Paragraph 11 indicates that riparian or other vegetation on alluvial sediments is perennially or intermittently groundwater-dependent, a GDE management plan should be developed which outlines suitable mitigation and monitoring strategies for this vegetation.

Date of advice 29 June 2021

Source documentation provided to the IESC for the formulation of this advice	<p>Gordon Geotechniques 2021. <i>Discussion of Sinkhole Subsidence</i>. Addendum to Gordon Geotechniques Pty Ltd 2020. 10 May 2021.</p> <p>Gough G 2021. <i>Ensham Life of Mine Extension Project Water Resources Cumulative Impacts Report Letter</i>. 6 May 2021.</p> <p>Hebblewhite, B 2021. <i>Subsidence Report for the Ensham Life of Mine Project (Report No. 2105/01.1)</i>. 4 June 2021.</p>
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