Independent Expert Scientific Committee
on Coal Seam Gas and Large Coal Mining Development

Advice to decision maker on gold mining project

IESC 2021-127: Tomingley Gold Extension Project (GA-15823373) – Expansion

Requesting agency	Mining and Petroleum Gateway Panel on behalf of the Independent Planning Commission NSW
Date of request	3 September 2021
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Advice stage	Gateway Application

The Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development (the IESC) provides independent, expert, scientific advice to the Australian and state government regulators on the potential impacts of coal seam gas and large coal mining proposals on water resources. Under section 505D (2) (b) of the *Environment Protection and Biodiversity Conservation Act 1999,* the IESC may also provide scientific advice on matters specified at the request of a Minister of a State or Territory with the agreement of the Commonwealth Environment Minister. The advice is designed to ensure that decisions by regulators on these mining developments are informed by the best available science.

The IESC was requested by the Mining and Petroleum Gateway Panel to provide advice on the Tomingley Gold Extension Project in New South Wales. This document provides the IESC's advice in response to the requesting agency's questions. These questions are directed at matters specific to the project to be considered during the requesting agency's assessment process. This advice draws upon the available assessment documentation, data and methodologies, together with the expert deliberations of the IESC, and is assessed against the IESC Information Guidelines (IESC 2018).

Summary

The Tomingley Gold Extension Project seeks to expand its current gold mine operations approximately 4 km south of the village of Tomingley, in central western NSW. The project includes both the existing mine, which comprises four open-cut pits with underground mines under three of the areas (Wyoming 1, Caloma 1 and Caloma 2), as well as an open-cut and underground mining extension to target the San Antonio and Roswell deposits. The existing operations are referred to as the Tomingley Gold Operations (TGO) and the extension as the San Antonio and Roswell deposits (SAR) mine. The project is expected to extend the mine life by seven years (from 2025 to 2032) and increase ore production from 1.5 million tonnes per annum (Mtpa) to 1.75 Mtpa. The proposal also includes an expansion and upgrade of existing

surface infrastructure, including relocating a section of the Newell Highway (R.W. Corkery & Co. Pty Ltd 2021, pp. 8 – 10).

The project is at the Gateway stage under the *NSW State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007* (the Mining SEPP) for approval, prior to lodging a development application and environmental impact statement. Consequently, the documentation provided focusses on potential Biophysical Strategic Agricultural Land (BSAL) and is supplemented with preliminary assessments of how the proposed activities may affect groundwater, surface water hydrology and water quality.

Key potential impacts from this project are:

- the loss of 207 ha of BSAL identified at the project site. This land would be directly cleared for the mine development;
- short- and long-term (legacy) effects arising from contamination of surface water and groundwater near Residue Storage Facilities (RSF) which is likely to contain saline and moderately alkaline water with elevated concentrations of, for example, ammonia, arsenic, copper, cyanide and nickel;
- post mining, final void water quality is predicted to gradually degrade over time due to ongoing evaporative loss from the voids, eventuating in saline water potentially contaminated with high concentrations of dissolved metals and other toxicants. Some migration and throughflow is likely to occur in the final voids, but poor-quality water is primarily expected by the proponent to remain constrained to the voids where they are likely to pose risks to bats and birds that can access the contaminated pit lakes; and
- changes to groundwater availability and quality in the perched alluvial aquifers associated with Gundong and Bulldog creeks caused by mining activities and alterations of topographic relief (e.g., road realignment). Altered alluvial groundwater availability and surface water-groundwater interactions may impact the condition and persistence of terrestrial and subterranean groundwater-dependent ecosystems (GDEs) associated with these creeks. These GDEs may include threatened ecological communities, as well as remnant riparian vegetation used transiently by species listed under the *Environment Protection and Biodiversity Conservation Act 1999 Cth* (EPBC Act) and the NSW *Biodiversity Conservation Act 2016* (BC Act).

In the responses to the questions posed below, the IESC has identified several areas in which additional work is required for a future Environmental Impact Statement (EIS) that would help address the key potential impacts. These are summarised below.

- Further information is required to confirm the site's groundwater conceptualisation. Field data are particularly required to establish the extent of the perched alluvial aquifers, their degree of hydraulic connection with the Bogan River and Gundong and Bulldog creeks and verify the claim that there is no connection between the perched alluvial aquifers and the deeper regional fractured rock aquifer in the vicinity of the mapped GDEs. Based on this assessment, further groundwater modelling may be required to fully understand the magnitude and extent of drawdown and associated impacts.
- The order-of-magnitude uncertainties of aquifer hydraulic parameters should be addressed by the model uncertainty analysis to capture plausible ranges of these parameters in the project area. Drawdown impacts may extend further than presently predicted.

- Geochemical characterisation of waste rock and tailings is needed to differentiate anthropogenic contamination from the natural environment and for the assessment of disposal and storage options, cumulative impacts, and other potential impacts to the environment.

- Whilst the proponent has committed to adherence to the Cyanide Code (R.W. Corkery & Co. Pty Ltd 2011, p. A3-13), further information is required to characterise the chemistry of the Residue Storage Facility (RSF) and assess the associated risks to wildlife.

- Further information is required regarding the proponent's plan to mitigate potential risks associated with the RSF, including embankment failure, poor foundation conditions, overtopping and seepage leading to groundwater contamination. Additional climatic stresses, such as extreme rainfalls and fluctuating wet and dry conditions, should also be considered.

- Contemporary water quality data (ideally, for at least two years from multiple sites and including suitable reference sites) should be collected for potentially impacted creeks to provide a more robust baseline against which to judge any impacts of the project.

- A water balance assessment to investigate the potential for sediment-laden water discharges and overflows, as these could reduce water quality and impact the condition of water-dependent ecosystems downstream (e.g., Gundong and Bulldog creeks and the Bogan River).

- A field assessment of groundwater use (which is likely to be opportunistic) by terrestrial GDEs (e.g., riparian vegetation) along Gundong and Bulldog creeks is necessary to better characterise and assess potential impacts to these ecosystems.

- Additional data are required on the distribution and abundance of aquatic biota, terrestrial GDEs and stygofauna (if present) to better characterise the potential impacts of the project. These data will assist with assessing the risks to biota and/or ecological communities protected under the EPBC Act and/or the BC Act.

- Whilst an updated monitoring plan is proposed to be developed following project approval but prior to commencement, trigger action response plans (TARPs) should also be developed to detect and mitigate potential impacts of the project and include specific timeframes for implementation.

Context

The project occurs within the Lachlan Fold Belt (LFB), a fractured rock system that lies under several surface water catchments and shallow alluvial aquifers, spanning the width of the Murray-Darling Basin from Albury to Bourke in NSW (MDBA 2020). The project area has been conceptualised as having three groundwater systems: a shallow localized perched aquifer associated with larger watercourses (e.g., Gundong Creek), a generally unsaturated Cenozoic alluvium, and a fractured rock groundwater system which contains the regional water table. This last system generally has low permeability but there may be areas where permeability is enhanced by structural deformation and discontinuities, zones of mineralisation and chemical weathering. Groundwater is stored and moves through fractures, joints, bedding planes, faults and cavities within the rock mass (NSW DPIE 2019a; NSW DPIE 2019b). Aquifers in the drier western regions of the LFB are typically deep and not linked to surface water flow (NSW DPIE 2019b).

The existing operations are referred to as the Tomingley Gold Operations (TGO). The project has operated since 2012 and includes the current extraction of ore and waste rock from four open-cut mines, underground mining underneath three of those open-cut pits (Wyoming 1, Caloma 1 and Caloma 2), the construction of three out-of-pit waste rock emplacements and two in-pit waste rock emplacements, and construction and use of a processing plant and residue storage facilities (RSFs).

The proposed extension is referred to as the San Antonio and Roswell deposits (SAR) mine. The SAR operations and modified TGO operations, include the development of the SAR open-cut and underground mine, an additional open-cut and underground mining extension to target the San Antonio and Roswell deposits, construction of the SAR Amenity Bund, modifications to the current processing plant, increases in the capacity of RSF 2, and the construction of two waste rock emplacements (the Caloma Waste Rock Emplacement within the Caloma 1 and Caloma 2 open-cut pits, and SAR Waste Rock Emplacement, within the southern and central sections of the SAR open-cut pit). Water use is predicted to increase from 220 ML/yr to 896 ML/yr (maximum volume). The proposal also includes expansion and upgrades of existing surface infrastructure, including relocating a section of the Newell Highway (R.W. Corkery & Co. Pty Ltd 2021, pp. 8 – 10).

The IESC acknowledges that this project is at the Gateway Certificate Application stage, where the proponent must demonstrate that the proposal will not significantly reduce the agricultural productivity of any BSAL. Consequently, the documentation provided by the proponent is limited in scope and the IESC, in responding to the requesting agency's questions, can provide only general guidance on potential impacts, as well as suggest additional information required if the proposal proceeds to the EIS stage.

Response to questions

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

Question 1: Whether the conceptual understanding of the surface water and groundwater resources and dependent ecosystems have been adequately described, including their interactions, and especially regarding the 'perched' alluvial system and dependent ecosystems (including riparian vegetation), and the nature of its hydraulic connection with the underlying fractured rock aquifer system and dependent ecosystems (including any stygofauna)?

Groundwater

1. Given the nature of the Gateway Certificate Application process, the documentation provided to the IESC focusses on identifying potential BSAL and how it may be affected by the proposed project, assessing possible groundwater and surface water impacts and proposing feasible mitigation measures. This documentation relies on a qualitative conceptual understanding of surface water and groundwater resources and their dependent ecosystems to infer potential impacts of the proposed project. For groundwater resources, the assessment aims to address the requirements of the *NSW Aquifer Interference Policy*. Although the IESC notes that the conceptual model is supported by regional information and site-specific monitoring, further information is required to improve its adequacy in portraying likely interactions and connectivity between 'perched' groundwater in the alluvium, associated water-dependent ecosystems and the underlying fractured rock aquifer system.

2. The project occurs within the Lachlan Fold Belt (LFB), a fractured rock system that lies under several surface water catchments and shallow alluvial aquifers. Although the Murray-Darling Basin Fractured Rock Water Resource Plan indicates that, at a regional level, there is very little connectivity between aquifers and surface water at the western end of the LFB, the level of connectivity is less clear around the project location as much of the current groundwater monitoring has been undertaken some 250 km to the south (MDB 2019; NSW DPIE 2019b). To better understand site-specific connectivity and improve certainty regarding potential impacts of the proposed project on groundwater levels, quality and associated GDEs, further monitoring and sampling (Paragraphs 3 and 6) need to be undertaken in and near the project area.

3. Site-specific groundwater monitoring included an analysis of water strike data, and monitoring data available from bores located at the TGO (seven), SAR (four, recently installed) and RSF 1. The IESC notes that the drilling program and SAR bores are limited to the vicinity of the proposed mining area

and considers that additional monitoring is required to confirm the conceptualisation, particularly the depth to water and dynamics of surface water-groundwater interactions below and near the Bogan River and Gundong and Bulldog creeks.

a. The potential for perched aquifers has primarily been assessed through bore GDCMB01, as well as registered bores GW037395, GW803148 and GW045135 located within the Gundong Creek alluvium. The proponent acknowledges that perched aquifers are expected along larger current or ancient watercourses, primarily characterised as disconnected losing streams with short periods when groundwater contributes to baseflows after rainfall events (Jacobs 2021a, p. 47). The IESC suggests that additional information is required to confirm the spatial extent of perched aquifers as it relates to potential GDEs.

b. The potential for deeper alluvial aquifers has been assessed through the installation of only one bore - RWWB004. The proponent notes that whilst bore RWWB004 is dry, deeper aquifers may exist as paleochannels below the regional water table (Jacobs 2021a, p. 45). The IESC considers that the current bore coverage is not sufficient to characterise the extent of deeper alluvial aquifers in the project area and suggests that additional investigation (using multi-level monitoring bores) should be undertaken within and beyond the area of predicted drawdown. Drilling methods should be suitable to identify first-strike water, to confirm whether or not alluvium is unsaturated, with testing to confirm the hydraulic properties of the deeper regional alluvium, the weathered boundary and the fractured rock groundwater system.

Surface water

4. The IESC considers that insufficient information is provided to support the conceptualisation of the site, particularly surface water-groundwater fluxes. The proponent concludes that changes to surface water hydrological characteristics are predicted to be minor and largely associated with construction of diversion structures and the realignment of the Newell Highway (Jacobs 2021b, pp. 47 – 48). Further investigation is needed on the likelihood of changes to surface-groundwater interactions and the potential impacts on ecologically important flow components. This should include characterisation of Tomingley Creek, beneath which drawdown is predicted to occur (Jacobs 2021a, Fig. 6.22, p. 100).

5. Water quality monitoring has primarily been undertaken only at two sites along Gundong Creek (SW1 upstream and SW2 downstream of TGO) between July 2015 – December 2017. Water quality in Bulldog Creek was sampled once (June 2021) at three locations (Jacobs 2021b, pp. 28 – 30). The IESC considers that additional monitoring (Paragraph 4) is required to provide reliable baseline conditions for assessing environmental impacts and developing current site-specific objectives (Huynh and Hobbs 2019), such as those from reduced baseflows or potential spills of sediment-laden water.

Water-dependent ecosystems

6. As part of the proponent's groundwater assessment, potential terrestrial GDEs were identified using the Bureau of Meteorology GDE Atlas and mapping used in the Water Sharing Plan for the NSW MDB Fractured Rock Groundwater Sources (Jacobs 2021a, pp. 34 – 36). These GDEs were conceptualised as being associated with perched alluvial aquifers. However, a detailed assessment of GDEs was not provided as it is not required as part of the Gateway Certificate Application process. Nonetheless, without field data to help characterise key features (e.g., extent of dependence on groundwater, see Doody et al. 2019) of these potential GDEs, the IESC can have only limited confidence in the proponent's conceptualisation. Relevant field-verified data that are needed would include:

   a. the timing and contribution of groundwater to surface water flows (Paragraph 7);

b. the extent and water quality of the perched alluvial aquifers, along with temporal variations in depth to groundwater and storage volumes, particularly near the proposed open-cut pits;

c. the community composition, degree of groundwater dependence (which could be occasional) and condition of riparian vegetation, including whether this vegetation includes or supports species or ecological communities protected under the EPBC Act and/or the BC Act; and

d. the presence and composition of stygofaunal communities in areas of alluvium and fractured rock aquifers where drawdown is predicted.

7. The proponent conceptualises surface water resources in the project area as ephemeral losing streams primarily fed by surface runoff and sheet flow but occasionally fed briefly by groundwater from saturated alluvial sediments after heavy rain. No information is provided on the flow regimes of these ephemeral streams, especially the duration and timing of zero-flow periods which will dictate the occurrence and community composition of aquatic biota (Paragraph 30). Given the low gradient of much of their catchments, alterations to the topographic relief (e.g., bunds, realigned roads) are likely to change the flow regimes of these ephemeral streams, potentially impacting their aquatic biota as well as terrestrial and semi-aquatic biota that use surface water when it is available. The conceptualisation could be improved by incorporating field data to infer how the project might change flow regimes and water quality of ephemeral streams in and downstream of the project area, and what impacts these changes may have on communities and species protected under the EPBC and BC Acts.

Question 2: Whether the groundwater modelling is fit for purpose in terms of its design, execution and calibration performance, including representation of surface water interactions, and the time series matches to groundwater levels across a representative set of monitoring bores?

8. Further information (Paragraphs 3, 10 – 12) will be needed for assessing environmental impacts as part of an EIS. The IESC notes that as the project is currently at the Gateway Assessment stage, groundwater modelling is preliminary and has been designed to assess extraction rates and predict drawdown for informing licencing requirements and to infer impacts to existing bores only. Specifically, the model is not intended to predict drawdown at potential GDEs or quantify sources of baseflow (surface water-groundwater interactions), as these are conceptualised as not being associated with the fractured rock groundwater system (Jacobs 2021a, p. 70).

9. The transient calibration indicates there is a significant mismatch between observed and modelled hydraulic head data (systematically underpredicted) and an exploration of these mismatches is required across a representative set of monitoring bores.

Question 3: Whether the assumptions and the range of scenarios applied in the groundwater modelling are reasonable and there is sufficient data within the model to provide meaningful predictions, including an uncertainty assessment of the range impacts on productive groundwater resources within the meaning of the NSW Aquifer Interference Policy (AIP)?

10. The IESC has concerns about the validity of some of the assumptions and the range of scenarios applied in the groundwater modelling. Furthermore, there may not be sufficient data within the current model to enable meaningful predictions and uncertainty analyses of potential impacts on productive groundwater resources within the context of the AIP. Impact predictions could change when the model is updated and the IESC considers that addressing the issues outlined below would further increase confidence in the groundwater impact assessment and associated modelling and underlying assumptions.

a. The assumptions and assertions made in the hydrogeological conceptualisation require substantiation. For example, the assumption that all watercourses in the area are losing may not be valid in the upper reaches where the BOM Atlas identifies high-potential GDEs.

b. The model should be revised with additional surface water and groundwater data from outside the proposed mining area to investigate heterogeneity in geology and aquifer parameters and assess surface water-groundwater interactions (Paragraphs 3 and 6).

c. Discussion and justification of the type and location of modelled boundary conditions are needed, and their implications on model calibration and predictions should be rigorously assessed.

d. Additional recharge sources, including recharge associated with waste rock and final voids, should be included in the updated model. The results of the chloride mass balance were not provided in this assessment so the modelled recharge cannot be validated nor is it clear whether these results have been validated through other independent methods (Jacobs 2021a, p. 81).

e. The influence of faults has not been included in the model, despite the proponent acknowledging that subsurface features may act as barriers or conduits (Jacobs 2021a, p. 70). Groundwater modelling for the EIS should consider the behaviour of faults, including their potential to enhance connectivity between surface water and groundwater.

f. Evaluation of existing projects in the area is required to enable an assessment of potential cumulative impacts (e.g., on drawdown). Of particular concern are potential impacts associated with the historic Myalls United mine which is situated approximately 1.5 km south of the Wyoming One deposit, and mined to a depth of 200 m. The IESC also notes that the magnitude and extent of drawdown from Peak Hill Gold Mine, located approximately 10 km south of the proposed project area, do not appear to be discussed in the documentation provided.

g. Further sensitivity analyses should be undertaken as data become available to validate the site's conceptualisation (Paragraph 3).

h. Peer review of the model should be undertaken as a priority to provide confidence in predicted impacts.

Question 4: Noting that the project is predicted to exceed the Level 1 minimal impact considerations under the AIP at a limited number of groundwater bores, whether the impacts to these bores have been accurately modelled and assessed?

11. The IESC does not consider that the current modelling accurately assesses the potential impacts to these bores because of limitations identified in Paragraphs 3, 10 and 12. Modelling indicates that the 2-m groundwater drawdown contour will not encroach on any bores, other than TGO monitoring bores. All other bores that fall within the 2-m drawdown contour are stated by the proponent as unlikely to be impacted because they access the shallow alluvial groundwater system (Jacobs 2021a, p. 101). In addition to previous concerns regarding the extent of perched aquifers (Paragraph 3), the IESC notes that simulated groundwater levels are generally being underestimated, where there is a maximum error of approximately 14 m and 18 m in the TGO and SAR bores, respectively (Jacobs 2021a, pp. 86 – 88). Furthermore, modelling associated with bore WYMB002 does not appear to predict recharge events observed at the site.

Question 5: Whether the level of groundwater and water balance modelling uncertainty analysis conducted is commensurate with the risks?

12. The current uncertainty analysis is conducted on a poorly calibrated groundwater model (Paragraph 9) and may not be fit for purpose to appropriately assess the risks to water resources in the area. Crucially, the hydraulic conductivity (K) variation employed in the current analysis (by a modest 50%) is unrealistically small and does not reflect the natural variability observed at representative spatial scales. An updated uncertainty analysis should vary K by a larger amount that represents observed natural variability (at least one order of magnitude) each side of the calibrated baseline hydraulic conductivity value. In the current uncertainty analysis (Jacobs 2021a, App. D), K and recharge (R) are both varied concurrently by precisely the same amount (i.e., both R and K increased and reduced by 50% respectively). As hydraulic head solutions are controlled, in part, by the ratio of R/K, the resultant model non-uniqueness means that the current uncertainty analysis is likely to underestimate the true extent of uncertainty. R and K should be varied independently. The range of values employed in the uncertainty analysis should reflect natural variability, not mathematical sensitivity, and therefore R and K are unlikely to vary by the same amounts. This revised uncertainty analysis should also be conducted on a base model with significantly improved calibration.

13. A water balance was also developed to assess post-mining water level recovery and salt concentrations in the northern portion of the SAR open-cut and the TGO Wyoming 1 open-cut but no uncertainty analysis is provided. Limitations of the proponent's assessment are discussed in response to Question 7.

Question 6: Whether the predictions of impacts on long-term groundwater levels, flow and quality are acceptable?

14. The IESC considers that only limited information provided by the proponent is suited to assessing long-term environmental risks on long-term groundwater levels, flow and quality. Long-term changes to groundwater quality are most likely to relate to the proposed final landform and are discussed in response to Question 7.

Question 7: Whether the assessment adequately analysed the evolution of change in water levels and quality in the final void pit lake(s) in the proposed final landform, any potential risk of spills or leaching on downstream environments, cumulative impacts due to multiple voids across the complex, and has adequately addressed water accounting requirements?

15. Modelling of void water-level recovery was performed using a "spreadsheet program" to determine the approximate equilibrium water levels and salt concentrations of post-mining voids (Jacobs 2021a, Fig. E.1, p. 152). No other information regarding this program is provided by the proponent, and without a clear description of the conceptual elements of the model it is not possible to assess its efficacy. This information is required as final void water quality is expected to gradually degrade over time due to ongoing evaporative loss from the voids and may present a material ongoing risk to the environment (Jacobs 2021a, p. 109). Continuous evaporation from an open pit that acts as a groundwater sink or partial sink (flow through system) may eventually lead to saline or hypersaline conditions in the open pit depending on overall water and salt balances. The potential for density-driven brine reflux and concomitant groundwater contamination, from the open pit to underlying groundwater, should be evaluated. This is in addition to advective-driven saline losses from the open pit in the case of flow through conditions.

16. The proponent has not modelled the final pit water quality (with the exception of salinity). Future modelling should assess potential changes in, for example, cyanide speciation, metals and metalloids, water hardness, alkalinity, pH, ammonia and major ions (including sulfate) over time. The proponent should provide information regarding the behaviour and any associated influences that

both the backfilled and open voids may have on the surrounding groundwater system (e.g., groundwater interactions, possible water quality characteristics of post-mining void water).

17. Orebodies within the project area comprise both oxide and sulfide zones beneath 20 – 60 m of Cenozoic alluvial deposits (Jacobs 2021a, p. 7). It is unclear whether waste rock and mine tailings are sulfidic and pose a risk of acid generation upon oxidation. If significant quantities of sulfide minerals are present in waste rock and tailings, exposure to the environment may produce acid mine drainage (AMD). The proponent should provide a comprehensive AMD assessment and management plan (if needed) following the guidelines provided by the Australian Government in Preventing Acid and Metalliferous Drainage Handbook (DFAT 2016a).

18. The proponent should provide a geochemical characterisation (static and kinetic tests) of waste rock and tailing materials. This information is critical to differentiate anthropogenic contaminants from background for the assessment of disposal and storage options, cumulative impacts, and other potential impacts to the environment. Furthermore, additional information on proposed closure and rehabilitation plans (e.g., capping material) is required to determine the potential impacts post mine closure of groundwater contamination from the RSF.

19. During and after the operational phase of the project, there is a risk of seepage from the RSFs into the surrounding Cenozoic alluvium. Seepage may result in the contamination of groundwater with alkaline RSF water, which may have elevated concentrations of ammonia, arsenic, copper, cyanide, nickel and salts similar to RSF 1 (Jacobs 2021a, p. 23). The IESC considers that the proponent should specify the concentrations of these contaminants in the RSF 1. This would allow a better assessment of the potential impacts and their extent in case of groundwater contamination.

20. Increasing the height of RSF 2 increases the potential severity of the environmental consequences of failure due to overtopping or internal erosion of the ~15 m high embankment. No discussion is provided on the approach taken to setting freeboard requirements to accommodate extreme rainfall, or to the additional failure pathways associated with raising the embankment. Considering the consequences of residue material overflowing from the storage facilities, due consideration will need to be given to the relevant leading practices (e.g., DFAT (2016b); ANCOLD (2019); NSW Resources Regulator (2020)) relevant to the planning, design and construction of tailings dams, dam safety management, and associated risk assessment. The IESC considers that the proponent should provide an analysis of the relevant factors to properly identify the potential impacts and severity of the consequences in the event of failure.

21. The proponent has stated that some migration and throughflow could occur in the final voids but expects poor-quality water to remain confined to the voids, providing the final void water levels remain below the regional fractured rock groundwater water table level (Jacobs 2021a, p. 109). Clarification on the predicted nature of the final voids (i.e., groundwater sink or throughflow system) is required to determine whether contaminated void water will stay in the voids or flow into the surrounding fractured rock groundwater system. The proponent should justify their claim that each void will behave as a groundwater sink and poor-quality water will remain confined to the voids.

22. The proponent has not provided sufficient information to enable the IESC to evaluate whether the water accounting requirements have been adequately assessed.

Question 8: Whether the assessment proposes reasonable strategies and measures to avoid, mitigate or reduce, to a practicable extent, the likelihood, extent and significance of impacts to significant water-related resources?

Question 9: Whether there are any additional or varied strategies and/or mitigation, monitoring, management, or offsetting measures that should be considered by decision makers to address any

residual impacts of the project on water resources and related GDEs in conditions of consent, and if so, why.

23. Responses to Questions 8 and 9 are grouped below to avoid repetition.

Groundwater

24. The proponent proposes to continue their current monitoring program (described in Jacobs 2021a, App. G), with updates for the SAR mining component of the proposal. The updated monitoring plan is proposed to be developed following project approval, but prior to commencement. The IESC has the following concerns.

    a. Additions to the monitoring network appear to relate to the four SAR bores only. Additional bores and appropriate monitoring are required at both the TGO and SAR to confirm predicted changes to groundwater drawdown, water quality, depth to water and altered surface water-groundwater interactions outside of the proposed mining areas, particularly near the Bogan River and Gundong and Bulldog creeks (Paragraph 3), as well as RFS 2.

    b. The IESC considers that individual triggers are needed as part of a comprehensive TARP and should be developed based on appropriate baseline data, especially for new bores. The TARPs should clearly specify timeframes for implementation and potential mitigation measures and include examples of where these mitigation measures have been successfully applied in similar environments (Paragraph 33).

Surface water

25. The proponent has stated that appropriate surface water monitoring plans will be developed for the construction, operation and decommissioning of the proposed project. Specifically, the proponent has committed to develop a Construction Environment Management Plan, including a Construction Soil and Water Management Plan, an Erosion and Sediment Control Plan and an emergency spill response procedure. However, the proponent has not provided these plans at the time of this assessment. The following should be included within these plans.

    a. A map with information about the surface water monitoring locations. These locations should be upstream, within and downstream of the project site, and include reference locations where impacts are not predicted to compare results with potentially impacted locations.

    b. Information about the frequency of surface water monitoring, which should be consistent with Huynh and Hobbs (2019).

    c. Monitoring objectives and performance indicators should be clearly defined. These should include changes to water quality and volumes, timing and duration of flows.

    d. Trigger levels for contaminants should be defined. These thresholds should be derived from the default guideline values specified in the Australian New Zealand Guidelines for Fresh and Marine Water Quality (ANZG 2018).

    e. The proponent should also prepare a TARP for the trigger levels and responses to changes in water quality.

    f. Information about water reuse, treatment for water captured in the sediment-laden basins and voids, and disposal of sediment should be provided to assess potential impacts.

26. A water balance model has not been provided by the proponent that would help inform potential issues associated with mine water management. In addition to the proposed Construction Soil and Water Management Plan, a water balance model should be undertaken that incorporates water

storage capacities and estimates, historic daily rainfall and evaporation data, historical and future extremes, (e.g., increased rainfall intensity and altered rainfall frequency and duration). To increase the confidence in predicted water storage capacities, the proponent should consider a 'worst case' scenario that considers system performance under a wide range of extreme rainfalls and wet antecedent conditions, under current and future climate conditions.

27. More information is needed on any intended stream diversions (e.g., the southern tributaries of Bulldog Creek). The proponent may find the report by White et al. (2014) to be useful in designing diversions that incorporate in-stream habitat heterogeneity and promote natural rates of sediment transport.

28. The proponent has not provided a salt balance. Factors such as salt movement between stores, seasonal and long-term climate variation, concentration and mass of salt loads and possible changes to the properties of those stores arising during project development should be undertaken by the proponent (see IESC 2018).

Water-dependent ecosystems

29. The proponent has not proposed any strategies to avoid, mitigate or reduce potential impacts to water-dependent ecosystems such as GDEs and ephemeral streams. The IESC notes that GDEs have been only superficially conceptualised and considers that the potential for these impacts cannot be excluded based on the current information provided. In particular, the proponent's groundwater model has not been designed to assess impacts to GDEs quantitatively (Paragraph 8), and additional information is required to confirm how the predicted drawdown is likely to affect potential groundwater-dependent vegetation and stygofaunal communities, especially in alluvial sediments along Bulldog and Gundong creeks which lie within the predicted drawdown extent.

30. The IESC considers it likely that surface-expression GDEs (e.g., riparian vegetation) within and near the project area may support threatened ecological communities or be used by species (e.g., Koala (*Phascolarctos cinereus*), birds and bats) that are protected under the EPBC Act and BC Act. Remnant vegetation, some of which may use groundwater from perched aquifers and alluvial sediments along watercourses in the area, is likely to be disproportionately important habitat in this largely cleared area. The IESC suggests that the proponent should investigate groundwater use by remnant vegetation in the area of predicted drawdown (especially along Bulldog and Gundong creeks) using approaches described in Doody et al. (2019) and Jones et al. (2019). If this vegetation is found to occasionally use groundwater, then the proponent should propose strategies to avoid or mitigate potential impacts of the project on groundwater dynamics and water quality, especially in the perched aquifers.

31. As subterranean GDEs (e.g., stygofauna and associated microbial assemblages) may mediate valuable ecosystem services such as nutrient cycling and groundwater filtration (Boulton et al. 2008), assessing their presence and potential vulnerability to impacts from the proposed project is relevant. The IESC recommends that the proponent conduct stygofauna surveys, especially within the perched alluvial aquifers, using methods described in Doody et al. (2019). The data collected from these surveys will help guide development of appropriate strategies to avoid, mitigate or reduce potential impacts on these subterranean GDEs. Monitoring of the effectiveness of these strategies is also recommended and could include sampling bores within and downgradient of the project area.

32. The proponent states that 'surface water quality and flooding objectives for downstream receivers are likely to be met and that the functionality [and] long-term viability of aquatic ecosystems would be maintained' (Jacobs 2021b, p. 3). To verify this statement, the proponent should sample aquatic biota (e.g., fish, invertebrates) in Gundong and Bulldog creeks and the Bogan River to provide baseline data to characterise this functionality and viability, and then should continue monitoring during and, for an appropriate time, after mining. Sampling strategies will need to be tailored to the ephemeral

flow regime of these waterways and could include bioindicators that can be sampled from dry riverbeds (e.g., Steward et al. 2018). Furthermore, the IESC notes that these 'downstream receivers' include Key Fish Habitat identified by DPIE (2021) in the Bogan River and lower reaches of Gundong and Bulldog creeks which may necessitate fish-habitat sampling as well.

33. The IESC recommends that the proponent provide TARPs to protect the functionality and long-term viability of aquatic ecosystems, including GDEs along Gundong and Bulldog creeks and the Bogan River. The TARPs should include appropriate trigger values and specific management actions for when trigger values are exceeded.

34. It is likely that the contaminated waters and tailings slurry of RSF 2 will be visited by birds and bats. Given the potential risks, especially of gold cyanide-bearing tailings solutions, to wildlife (reviewed in Donato et al. 2007), the proponent should detail how these risks will be avoided or mitigated during and after mining operations until restoration is complete.

Final landform

35. The proponent has not provided information about strategies and measures to avoid, mitigate or reduce potential impacts to water resources from the RSFs and waste rock. The IESC has recommended additional information (see response to Question 7) that would be needed for an assessment of the mitigation, monitoring and management plans.

36. No information is provided regarding management plans to reduce potential risks that could result in RSF embankment failure. More information regarding the proponent's plans to deal with seepage-induced instability, internal and external erosion, poor foundation conditions and overtopping should be provided. Additional climatic stresses, such as extreme rainfalls and fluctuating wet and dry conditions, should also be considered.

37. Pit lakes in the final voids are likely to attract birds and bats, some of which may include species protected under the EPBC and/or NSW BC Acts. As the water in these voids will be increasingly contaminated (e.g., through evapo-concentration, Paragraphs 15 – 16), it poses potential long-term legacy risks to wildlife that can access the pit lakes. The proponent should describe plans to avoid or mitigate these risks and, where possible, support these plans with evidence or examples of successful application of the intended measures.

New technology

38. The IESC notes currently approved operations include a carbon-in-leach processing plant with cyanide leaching circuits (R.W. Corkery & Co. Pty Ltd 2021, p. 5). The IESC is aware of commercial operations using thiosulfate rather than cyanide in the gold recovery process. The IESC recommends that the use of this new technology be considered to reduce the potential environmental impacts from the use of cyanide.

Date of advice	9 October 2021
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the IESC for the formulation of this advice	Jacobs Australia Pty Ltd (Jacobs) 2021b. Tomingley Gold Mine Expansion Project. Surface Water - EIS Technical Report. Doc no. IH191000-RP-001, dated September 2021. Prepared for R.W. Corkery & Co. Pty Ltd.
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