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

Advice to decision maker on coal mining project

IESC 2020-111: Glendell Continued Operations Project (EPBC 2019/8409 and SSD 9349) – Expansion

Requesting agency	The Australian Government Department of the Environment and Energy (now the Australian Government Department of Agriculture, Water and the Environment) The New South Wales Department of Planning, Industry and Environment
Date of request	17 January 2020
Date request accepted	22 January 2020
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 then Australian Government Department of the Environment and Energy and the New South Wales Department of Planning, Industry and Environment to provide advice on the Glendell Tenements Pty Ltd's Glendell Continued Operations Project in New South Wales. 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 Glendell Continued Operations Project is a proposed open-cut extension of the existing Glendell Mine. The project is in the New South Wales Hunter Valley in an area with considerable historical and current mining. Although the project will utilise existing infrastructure, major changes will be required including diverting Yorks Creek and moving its confluence with Bowmans Creek approximately 4 km upstream. A single final void will be left by the project.

Key potential impacts from this project are:

- the Yorks Creek diversion which will result in the loss of existing aquatic, riparian and subsurface habitat within Yorks Creek, and potentially alter flows and habitat in the 4-km reach of Bowmans Creek which will now receive higher flows due to relocation of its confluence with the diverted Yorks Creek. The proposed diversion may be unable to recreate the lost habitat or continue to provide habitat which is characteristic of lower stream reaches in the region;
- the proposed final void which may be a source of evapo-concentrated recharge to the hard rock aquifers;
- changes to baseflows due to groundwater drawdown and altered catchment areas. This will in turn affect the persistence of, and water quality within, refugial pools;
- additional drawdown in the alluvial aquifers which will impact groundwater-dependent ecosystems including riparian vegetation, aquatic biota and stygofauna; and,
- additional cumulative impacts to surface water, groundwater and biota.

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

- Further work is required to increase confidence in the groundwater model simulation of the alluvium as this has important implications for assessing impacts on groundwater-dependent ecosystems.
- Further modelling and detailed design work for the proposed Yorks Creek diversion is required to justify the proposed design and to assess whether suitable habitat, that is consistent with that in the lower reaches of creeks in the project region, can be reproduced within and alongside the diverted channel.
- Further explanation and potentially modelling of the proposed final void and pit lake are required. It is currently unclear whether the pit lake will be a permanent groundwater sink, a flow-through system or vary over time. Also, clarification is required of how salinity will change over time within the pit lake.
- Additional discussion of how water quality changes in Bowmans Creek may impact aquatic biota within refugial pools is needed to fully understand potential impacts.
- Clarification is required as to where the rehabilitated Swamp Creek catchment will be diverted in the final landform. Information provided is currently contradictory. Confirmation that modelling of streamflows and flooding has used the correct diversion is also needed.

Context

The Glendell Continued Operations Project (the ‘project’) is a proposed extension of the existing Glendell Mine located approximately 20 km northwest of Singleton in the New South Wales Hunter Valley. Mining has occurred at the Glendell Mine since 2008. The project proposes to extend the existing Glendell Pit in a northerly direction to access an additional 135 Mt run-of-mine coal until 2044. The project will disturb an additional 750 ha of land outside already approved disturbance areas, including some 540 ha of native grassland, woodland and forest. The project will use existing coal handling, processing and transportation facilities, with tailings to be placed within existing approved tailings storage facilities. Parts of Yorks Creek will be mined through, necessitating diversion of approximately 2 km of its lower reaches. Additional water management infrastructure will be developed and integrated with the Mount Owen Complex Water Management System and the Greater Ravensworth Area Water and Tailings Scheme (GRAWTS). The project will also require realignment of Hebden Road and the demolition and relocation of the existing Glendell Mine Infrastructure Area (MIA).

Glendell Mine and the project are part of the Mount Owen Complex which also includes Mount Owen Mine and Ravensworth East Mine. Water and tailings at the Mount Owen Complex are managed through the GRAWTS which incorporates Integra Underground Mine, Liddell Coal Operations and Ravensworth Operations. All mines of the GRAWTS are operated by subsidiaries of Glencore or their joint venture partners. The GRAWTS allows integrated water management across all member mines with water transferred between mines as demand or storage capacity requires. Only Liddell Coal Operations and Ravensworth Operations have licensed discharge points which means that water requiring discharge must be transferred through the GRAWTS to these mines. Discharges are governed by the relevant Environment Protection Licence (EPL) operating at each mine.

The IESC previously reviewed this project in June 2019 when it was being assessed by the New South Wales Mining and Petroleum Gateway Panel.

Response to questions

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

General
Question 1: Do the groundwater and surface water assessments in the EIS provide adequate mapping and delineation of surface and groundwater resources?

1. The Environmental Impact Statement (EIS) generally provides adequate mapping and delineation of surface water and groundwater resources at a broad scale.

2. Modelling of a 'unit' pool to predict potential impacts on refugial pools has limited value given each refugial pool will have unique characteristics that cannot be captured by modelling of a single 'representative' pool. The IESC instead suggests the proponent undertake further field studies to map refugial pools and determine their characteristics including groundwater connectivity. This information should be obtained for all refugial pools in potentially affected creeks, particularly those within Yorks Creek that will likely be lost and which should, ideally, be recreated within the diversion.

Surface water
Question 2: To what extent can decision makers have confidence in the prediction of potential impacts on surface water resources provided in the EIS, including in regard to potential stream flow losses, water quality, uncontrolled discharges and flooding?

3. Stream flow losses have been predicted considering both changes in alluvial groundwater discharges and altered catchment areas. Results have been presented for each creek potentially impacted by the project. Predicted streamflow was provided for current, operational and post-mining (both proposed and approved final landforms) periods. Although only limited confidence can be given to the absolute estimates of existing streamflows, the changes to catchment areas are modest and thus it is reasonable to assume that the associated changes to flows are small compared to the natural variability of the system. However, considerably less confidence can be given to the impacts on baseflows given uncertainties concerning alluvium recharge behaviour, as discussed in Paragraphs 14-15. The proponent notes that they currently do not hold sufficient water access licences (WALs) for some water sources but has committed to obtaining any WALs required during operational and post-mining phases. It is currently unclear what volumes will require licensing in the post-mining phase. This information, determined from updated modelling, should be provided in the Rehabilitation Management Plan.

4. Potential water quality impacts have not been explored in detail as the proponent expects that the existing management strategies will be adequate to prevent impacts and no discharges are permitted from the project site. Further spatial and temporal detail of water quality data (e.g. plots of analytes at individual sites over time) could have been provided to improve the characterisation of historical conditions within water resources that may be impacted by the project. The IESC suggests some refinements of the current surface water and groundwater monitoring programs which are outlined in the response to Question 12.

5. The likelihood of uncontrolled discharges from water storages at the project site has not been reported. As the project will be part of the GRAWTS, the proponent will have considerable flexibility to move water across several mining operations to where storage capacity is available which will limit the likelihood of uncontrolled discharges. The water balance showed that forecast water inventory will be considerably less than available storage capacity across the GRAWTS, particularly from the early-2020s when mining will begin to cease at adjacent mines and their pits will be available for water storage (Umwelt 2019a, pp. 271-272). Should any of the adjacent mines be extended leading to an increase in the volume of produced water requiring management through the GRAWTS or a decrease in storage capacity, the proponent will need to update their water balance.

6. The proponent should clarify where the rehabilitated former Swamp Creek catchment will be routed in the final landscape. Gippel (2019, p. 21) suggested that it would be redirected upstream of the proposed Yorks Creek diversion which conflicts with GHD's (2019, p. 69) suggestion that flows in Bettys Creek would be increased by flows from the former Swamp Creek Catchment. Additionally, the proponent will need to confirm that flood modelling, diversion design, streamflow changes and catchment area changes have been determined appropriately for where Swamp Creek will be routed.

Surface water

Question 3: Are the assumptions used in the surface water models reasonable and justifiable, and have the respective models been validated with sufficient monitoring data to provide meaningful prediction, including worst-case impacts on surface water resources?

7. The limitations in available streamflow data and the large discrepancies between the observations and AWBM model outputs (in the case of Bowmans Creek) mean that little confidence can be given to the absolute estimates of streamflows. The assumptions used to assess the relative impacts of changed catchment areas on streamflows under final and worst-case conditions are reasonable. However, the surface water assessment of baseflow impacts is dependent on the defensibility of the alluvial groundwater behaviour as characterised by AGE (2019), and this is subject to the limitations and uncertainties discussed in Paragraphs 14-18.

Flooding

Question 4: Has the flood assessment undertaken in the EIS adequately assessed the flood risk profile of the Project and the impacts on the extent of flooding (flood depths and changes in velocity) and stability of downstream watercourses through changes in the landform (including the proposed realignments of Yorks Creek and Hebden Road) and the resulting changes to the catchment area?

8. The flood modelling and assessment provided in the EIS has considered changes to flood depths and velocities at several locations. Scenarios were modelled for different project stages (operational and final landform) and included changes to infrastructure relevant to that stage, including the realignment of Hebden Road. Changes in catchment areas were also considered. Changes in flood depth and velocity are clearly presented and allow comparison between different scenarios. Overall, it is considered that the adopted methodology is consistent with the most recent national flood guidance (Ball et al. 2019) and the assessment was undertaken to a good standard.

9. The flood modelling results have identified that the greatest increases in flood depths and velocities appear to occur in Bettys Creek. Cross-sectional shear stress within the Yorks Creek diversion for the

1% annual exceedance probability (AEP) event may exceed stability thresholds (GHD 2019, App. C, p. 29) although it is unclear where exactly within the Yorks Creek diversion this may occur. The proponent has stated that further detailed modelling is needed to identify appropriate mitigation measures. This modelling should be completed to inform the detailed design phase of the Yorks Creek diversion and development of the Rehabilitation Management Plan. If cross-sectional shear stresses are great enough to require rock armouring for channel stability, this will affect the habitat that can be produced in the diversion and potentially limit local riparian revegetation, disrupting its continuity along the diverted channel.

10. Additional discussion of predicted flood depths and velocities at the confluence of Bowmans Creek and the Yorks Creek diversion, and within the lower reaches of the Yorks Creek diversion (up to at least the Hebden Road crossing) should be provided. Current predictions show that the lateral extent of flooding within Bowmans Creek at the confluence is less than in many other parts of Bowmans Creek and that ponding in the lower reaches of Yorks Creek diversion is not expected. Given the significant change in bed slope from 0.04 m/m to relatively flat conditions that occurs 150 m before the confluence (Gippel 2019, p. 37), further assessment of the stability of the watercourse (see Paragraph 36) is required.

11. The proponent has considered the potential worst-case scenario for flooding through the probable maximum flood (PMF) event, which is an indication of the upper limiting flood magnitude with an annual exceedance probability that is notionally less than 10^{-6}.

12. The proponent has used modelling of the 0.2% and 0.5% AEP flood events as a proxy for assessing the effects of potential climate change. It is not clear from the documentation why this approach was used in lieu of the simple temperature-scaling approach recommended in the national guidance (Ball et al. 2019); however, it is assumed that the results are intended to represent the impacts of climate change on the 1% AEP event. While unconventional, this is a reasonable approach that is notionally indicative of the impacts on rainfall intensities under climate change.

13. The stability of downstream watercourses beyond Bowmans Creek has not been discussed in detail. As limited erosional changes are predicted within Bowmans Creek downstream of the diversion (Gippel 2019, p. 47), changes further downstream are likely to be also minimal but this prediction should be confirmed with additional monitoring (see Paragraphs 49 and 51).

Groundwater

Question 5: Is the conceptual regional groundwater model developed based on a sound understanding of the altered hydrogeological environment of the area due to historical open cut and underground mining, including the alluvial aquifers within the Project's zone of influence?

14. The qualitative conceptual model provided (Umwelt 2019b, App. B) shows expected changes to the hydrogeological regime at the site as the project progresses. However, the magnitudes of changes, particularly those relating to changes in upward leakage from the Permian aquifer and downward leakage from the alluvial aquifers are not quantified. Recharge rates to the shallow alluvium aquifer are also not quantified. As the water balance for the alluvial aquifers has not been adequately quantified, it is not possible to evaluate whether the conceptual model is based on a sound understanding of the current and likely future hydrogeological environment of the area. The proponent should provide further quantitative information on leakage and recharge rates and on the interaction of groundwater in the alluvium and along the watercourses. Additionally, the conceptual uncertainties of the water balance fluxes should be explored further in the uncertainty analysis (see Paragraph 18).

15. The proponent has provided monitoring data from several sites to demonstrate that depressurisation of the Permian groundwater system has not propagated into the alluvial groundwater system during approved mining at Glendell Mine. Within the Bowmans Creek alluvium, they have conceptualised

that fresh recharge to the aquifer is greater than the prior upward leakage from the Permian groundwater system (AGE 2019, p. 58). However, the proponent noted that within other alluvial groundwater systems, water quality data suggested fresh recharge was less than upward leakage (AGE 2019, p. 70). It is unclear how this conceptualisation has been considered in the groundwater model as calibrated rainfall recharge to the alluvium is stated to exceed downward losses (AGE 2019, p. 96). Also, it is unclear whether groundwater drawdown within the Permian groundwater system could also propagate into overlying alluvial aquifers associated with creeks other than Bowmans Creek, and how this is likely to change over decades. The proponent should further evaluate this potential impact, particularly for Swamp Creek where project-specific drawdown is already predicted but could potentially be greater if upward leakage is a larger portion of inflows to the alluvial aquifer than currently modelled.

Groundwater
Question 6: Has the numerical groundwater model been calibrated with sufficient monitoring data to provide meaningful model outputs, including worst-case impacts on groundwater resources?

16. All available monitoring data appear to have been used to history match (calibrate) the groundwater model. However, the history-matched model does not replicate observations closely for several history-matching target locations. Additionally, multiple history-matched hydrographs provided show that the observed groundwater levels are not within the 95% confidence interval of the prediction hydrographs (AGE 2019, App. B2 of App. B). Examples include DDH223-120 (observed head approximately 50 m lower than predicted head), CS4658-BRT (observed head almost 50 m lower than predicted head) and GCP34 (observed head approximately 30 m lower than predicted head). The IESC considers that while it is important that sufficient monitoring data are used to history match groundwater models, the ability of the model to replicate observed data is crucial for providing confidence in the model predictions.

17. The IESC notes that residuals are greater in the 0-50 m AHD range meaning that the model is not replicating observations in this depth range, which the proponent has acknowledged (AGE 2019, App. B, p. 38). Further information is required on which strata and model layers occur within the 0-50 mAHD range including clearly identifying these on the conceptual model graphics. Additionally, an analysis of spatial history-matching trends is needed. History-matched results should be provided showing residuals by model layer and location. This information is needed to understand the predictive scenarios for which the model should be used. For example, it currently appears that the model may not be fit for predicting potential impacts to the alluvium and within the 0-50 mAHD depth range. Figure B 30 (AGE 2019, App. B, p. 59) highlights the inability of the model to replicate inferred baseflows by up to two orders of magnitude. Such comparisons are particularly relevant to the predictions of impact on baseflows.

18. The proponent has provided a Null-space Monte Carlo uncertainty analysis to examine a range of plausible model parameterisations. The probabilities of drawdown exceeding 2 m within the alluvium are presented graphically (AGE 2019, App. B, p. 72). Worst-case take predictions are also explored as part of the uncertainty analysis, and predictions are stated to be within licence volumes except for the Jerrys and Glennies Water Sources (AGE 2019, p. 114). The proponent notes that “Extreme combinations of high recharge, low permeability and low storage promotes groundwater decant through the spoil into surrounding strata” (AGE 2019, p. 114). Further discussion of this should be provided so that the likelihood of these extreme parameterisations (i.e. is this the potential worst-case scenario?) can be assessed, and potential impacts identified and managed. Further discussion is also required to understand how the predictive uncertainty analysis has incorporated the large degree of model-to-observation misfit and whether there are systematic biases at different calibration target locations that need to be accounted for in the predictive uncertainty analysis.

19. A peer review of the groundwater modelling was provided. The reviewer noted that reporting of history-matching performance and changes to the magnitude of model outputs when sensitive parameters were varied would be useful (AGE 2019, App. F, pp. 5-6). The IESC agrees that this information should be provided.

20. Post-mining recovery predictions have not considered the impacts of climate change when assessing rates of groundwater recovery and long-term impacts on GDEs. This should be discussed further by the proponent and be addressed in the Rehabilitation Management Plan.

Groundwater

Question 7: To what extent can decision makers have confidence in the predictions of potential impacts on groundwater resources provided in the EIS, with regard to groundwater inflows, drawdowns in aquifers and potential impacts on private bores and groundwater dependent ecosystems?

21. The proponent notes that groundwater inflows to the Glendell Pit only result in very limited 'free flowing' groundwater which is generally removed via evaporation with insufficient volumes entering sumps for quantification (AGE 2019, p. 84). Estimates of inflows are less than 1 ML/day (AGE 2019, p. 84). Decision makers can be confident in this prediction based on the understanding that the Glendell Pit is a relatively dry pit.

22. Two privately owned bores are predicted to be impacted by less than 0.2 m due to the project and less than 0.5 m due to cumulative impacts, leaving approximately 4 m of saturated aquifer still accessible (Umwelt 2019a, p. 270). This level of impact is well within the limits permitted under the New South Wales Aquifer Interference Policy and will be managed under make good provisions. The IESC agrees with the peer reviewer that this level of accuracy could not be expected from the groundwater model (AGE 2019, App, F, p. 6).

23. Groundwater take from some water sources is predicted to increase post-mining (Umwelt 2019a, p. 264 and 284). The proponent has committed to obtaining the required licences for any take; however, they should further explain why takes will increase post-mining, and when and at what volume takes are expected to peak and equilibrate.

24. Further discussion of the predicted impacts and the confidence in those predictions for GDEs is provided in the response to Question 10.

Final void and pit lake

Question 8: Has the EIS adequately analysed the evolution of change in water quality and level in the Glendell Mine final void pit lake in the proposed final landform, any potential risk of spills or leaching on downstream environments, and cumulative impacts due to multiple voids across the Mount Owen Complex due to groundwater flowpath interactions?

25. The proponent has stated that the final void pit lake will be a groundwater sink (Umwelt 2019a, p. 270). However, they also stated that the pit lake was predicted to "be a source of water to the hard rock aquifers in strata sub-cropping below the water level of the pit lakes" (Umwelt 2019c, p. 23). The proponent needs to provide further discussion to reconcile these statements (e.g. will the void be a sink for one aquifer and a flow-through system for a different aquifer?) and clearly identify whether and when the pit lake will be a groundwater sink or a flow-through system. This should include clearly depicting the processes on the conceptual model graphics so that the connectivity of the final void pit lake with all aquifers over time is better explained (especially for the post mining phase shown in Figure 4 (Umwelt 2019b, App. B, p. 6)). If the pit lake is identified as a flow-through system, the proponent must identify the flowpath and endpoints of the final void's potentially contaminated water and any groundwater and surface water resources that could be impacted. Additionally, a monitoring plan should be developed that includes monitoring for metals which have been identified as characteristic of seepage from waste material (see Paragraph 45) within the pit lake, particularly if

flow-through conditions will occur. This plan should clearly outline the proposed sampling locations, frequency and the period over which monitoring will occur post mining.

26. Evaporation is predicted to exceed inflows to the pit lake and also exceed rainfall; however, the proponent has stated that salinity is not predicted to increase above the concentration of the most saline input (groundwater) (Umwelt 2019a, p. 270). Detailed temporal information of the estimated proportional contribution of various water sources, salinity changes over time of the water sources and applied evaporation rates are required to understand how the pit lake salinity evolves and to explain how the pit lake will not become more saline given the predicted evapo-concentration. This discussion should also address why predicted pit lake salinity in the vicinity of the Mount Owen Complex is generally lower than at other Hunter Valley Mines (see GHD 2019, Table 8-3, p. 60).

27. Flood modelling results are stated to indicate that while flood water would enter the pit lake during a PMF event, over 100 m of freeboard would remain which means that spillage would not occur (Umwelt 2019a, p. 281). Additionally, the proponent identified that a relatively minor change to the proposed final landform would prevent flood water from entering the pit lake even during the PMF event. The proponent should provide further information on what constitutes this relatively minor change. If no adverse impacts to landform stability and biota are identified, then the proponent should consider making the design change.

28. The proponent has stated that the additional mining proposed and the changed location of the final void (compared to the approved final void) may affect the recovery timing of the North Pit and Bayswater North Pit final voids (Umwelt 2019a, p. 242). This potential impact should be discussed further so it can be identified whether it will affect groundwater flow paths or ecological assets and, if so, how.

29. It is unclear from modelling whether climate change has been accounted for in the post-mining phase. Given the predicted recovery period of approximately 450 years for groundwater levels (AGE 2019, p. 105) following mining, climate change should be considered as it may affect the time taken for recovery which could result in impacts to water resources occurring over longer periods and affect rates of possible post-mining recovery of water resources.

30. The influence of all voids remaining in the final landform on groundwater flowpaths is captured within the groundwater modelling of the post-mining phase as nearby voids have been incorporated in the groundwater model.

Cumulative impacts

Question 9: Does the EIS provide an adequate assessment of cumulative impacts to surface and groundwater resources during the mining operations and during the recovery phase post mining including changes in catchment areas, the rate of recovery of groundwater levels and saturation of alluvial aquifers? Do these assessments adequately differentiate impacts due to the Project, historical mining already undertaken and currently approved operations (i.e. mining yet to occur)?

31. Cumulative surface water and groundwater impacts have been assessed at a range of scales (including project-specific) for the expanded Glendell Mine and for the entire Mount Owen Complex. Impact predictions are provided at multiple time-points including during operations and post mining. Changes to catchment areas over time are considered. Although the rate of groundwater recovery is not clear, the proponent discusses when groundwater levels are likely to be similar to current levels. The saturated thickness of alluvium is provided for operational and end-of-mining time-points although again the rate of recovery and hence the length of time during which impacts may be occurring to GDEs and surface waters is not clear. Further discussion is needed of rates of recovery under different cumulative scenarios that differentiate impacts due solely to the project, historic mining, current mining, and approved mining likely to occur, and include potential effects of predicted climate change during the recovery period.

32. Desaturation of a section of the Bowmans Creek alluvium to the west of the project is predicted to occur due to cumulative impacts (Umwelt 2019a, p. 266). Although modelling suggests that the project will not cause this desaturation, the proponent notes that the project appears to increase the time taken post mining for the alluvial groundwater levels to recover (Umwelt 2019a, p. 266). Further discussion of how the project causes this delay, what the additional recovery time is, and if it is likely to impact GDEs (including stygofauna) should be provided.

33. The proponent states that post mining, the project will result in up to 1 m of depressurisation to the north of the mine which is not expected to have a material effect on the alluvium (Umwelt 2019a, p. 265) although this is subject to the uncertainties discussed in Paragraphs 14-18.

34. The predicted impacts of the project are differentiated from those of historic and existing mining. However, the future potential impacts from approved but yet-to-commence operations are not clearly identified.

Water-dependent ecosystems
Question 10: Have the surface and groundwater impacts of the Project on the local and regional aquatic ecological values (aquatic biota and riparian habitat) and groundwater dependent ecosystems (including stygofauna) been adequately described and assessed?

35. Yorks Creek diversion will be partially located in fill (upper reaches) and partially cut into bedrock (lower reaches) (Gippel 2019, p. 37). The proponent acknowledges that this will present geochemical and geotechnical challenges. However, these challenges have not been fully discussed nor have design, mitigation and management options that could address these challenges. The IESC notes that the current design presents further challenges with recreating existing habitats, especially floodplain terraces and refugial pools. During the detailed design phase, the proponent needs to consider the geochemical and geotechnical challenges that they have identified and:

    a. whether the proposed diversion will provide suitable instream habitat that is consistent with that occurring within the lower reaches of a creek in this region;

    b. how riparian habitat and alluvial terraces comparable to those along the existing Yorks Creek will be recreated, especially in the reach which is to be cut into bedrock; and,

    c. how the subsurface alluvial and hyporheic ecosystems present within the current Yorks Creek can be recreated in the diverted channel.

36. The proposed Yorks Creek diversion will include a reach with a bed slope of 0.04 m/m commencing 150 m upstream of its confluence with Bowmans Creek (Gippel 2019, p. 37). The proponent notes that bed slopes this steep are not common along lower reaches of streams (GHD 2019, p. 83). Further consideration of options to decrease the steepness of the bed slope or detailed information on proposed management of this reach is required to ensure that the reach will provide habitat that is suitable for biota currently living in the lower reaches of Yorks Creek. The proponent should also discuss whether sediment could accumulate in the relatively flat reach which is proposed immediately downstream of the steep reach and upstream of the confluence with Bowmans Creek, and how this would affect surface and subsurface hydrological and ecological connectivity between Yorks Creek and Bowmans Creek. The likelihood of deposited sediment partially or completely infilling refugial pools in the lower reaches of the diverted channel should be assessed and if necessary mitigated.

37. The proponent has identified and investigated potential impacts at three persistent pools within Bowmans Creek that they consider likely to be groundwater-dependent. The analyses identified that complete drying of these groundwater-dependent pools was unlikely (see GHD 2019, Figures 9-10 and 9-11, pp. 73-74) though this assessment is subject to the uncertainties in baseflow contribution as predicted by the groundwater model (see Paragraphs 7 and 14-18). Further consideration of how

decreases in pool depth would impact water quality, including dissolved oxygen and water temperature, should be provided to fully understand potential impacts to aquatic biota.

38. The predicted drawdown resulting from the project is greatest in Bowmans Creek and what will be the remnant downstream reach of Yorks Creek (AGE 2019, Figure 7-2, p. 92). It is unclear whether the drawdown prediction for the remnant downstream reach of Yorks Creek has considered the impact that greatly reduced surface water flows (due to diversion of the upstream reaches) will have on groundwater levels through reduced recharge. The IESC notes that this reach of Yorks Creek will be severely impacted by the Yorks Creek diversion. However, further discussion should be provided including predictions of how the current water-dependent biota in this reach will respond to lowered groundwater levels and reduced stream flows, whether any post-mining recovery is expected, and whether the recreated habitat in the diverted channel is intended to replace that lost habitat, including associated GDEs.

39. The proponent has predicted drawdown and changes to the saturated thickness of the alluvium. Project-specific potential drawdown beneath terrestrial GDEs that do not overlie alluvium is less clearly identified. Figure 7-10 (AGE 2019, p. 103) shows cumulative water table drawdown. To the north of the project and immediately adjacent to the project boundary, drawdown of up to 50 m is predicted beneath an area identified as having a high potential to be a terrestrial GDE. Given the proximity to the project and the magnitude of the predicted drawdown which will disconnect the GDE from the water table, the proponent should discuss the proportion of predicted water table drawdown that is caused by the project. If the project is causing or contributing substantially to the disconnection, then mitigation and management options should be developed.

40. Sampling of alluvial bores in the project area yielded seven stygofaunal taxa that, at the broad taxonomic level routinely used in these surveys, have been collected throughout the Hunter River alluvial aquifer and aquifers of tributary streams such as Pages River, Kingdon Ponds and Dart Brook (Eco Logical 2019, p. 15). Groundwater modelling indicates that drawdown due to nearby mines will desaturate two sections of the Bowmans Creek alluvium, fragmenting this aquifer and constituting a significant threat to the local stygofauna. Although the proponent acknowledges that drawdown associated with the project will delay reconnection of the fragmented aquifer, it is asserted that this impact on the regional stygofauna community is negligible (Eco Logical 2019, p. 31). The IESC considers that this community and the potential impact of the project has been adequately described and assessed, but recommends that stygofaunal monitoring of the isolated 5.5-km fragment of alluvial aquifer of Bowmans Creek should be done during and after mining to confirm that reconnection occurs and the stygofaunal community recovers as predicted.

41. The diversion of Yorks Creek will remove approximately 2 km of riparian habitat in its lower reaches (Umwelt 2019a, p. 279). There will also be impacts on riparian habitat along parts of Swamp Creek and at the proposed confluence of Bowmans Creek and the diverted channel of Yorks Creek (Umwelt 2019a, p. 311). A section of River Oak Riparian Grassy Tall Woodland of the Western Hunter Valley along Bowmans Creek outside the development area will be affected by groundwater drawdown (Umwelt 2019a, p. 316). Although the proponent acknowledges that loss of riparian habitat may disrupt fauna moving between habitats in the area, it is considered that these impacts will be minor given the existing disturbed and fragmented landscape (Umwelt 2019d, pp. 82-83). More evidence is needed to support this assertion of minimal impacts, especially as the current riparian vegetation is likely to be disproportionately important because of the existing landscape-level fragmentation. The proponent should also assess the significance of other roles (e.g. organic matter contribution, shading, bank stability) of the riparian vegetation that will be temporarily lost or impaired so that appropriate plans for mitigation of these impacts can be developed.

42. Modelling indicates that the number of zero-flow days in Bowmans Creek will increase, resulting in declines in pool depth and water quality (GHD 2019, pp. 73-74). Although the proponent has surveyed aquatic biota at multiple locations along Bowmans Creek and other creeks in the project

area in 2018 (Umwelt 2019d, App. F, pp. 13-16), there does not appear to have been a survey of potential refugial pools and their biota along each of these creeks during a low-flow period or shortly after flow ceased. This lack of data severely limits predictions of how alterations in depth, water quality and persistence might affect aquatic fauna (e.g. macroinvertebrates, tadpoles) seeking refuge in these pools. Given that reductions in flow duration and pool persistence in ephemeral streams can have major effects on aquatic biota (Stubbington et al. 2017), the IESC recommends targeted sampling of persistent pools during a low-flow period or shortly after flow ceases so that the proponent can better assess the potential impacts on surface water biota of the predicted changes in hydrology, especially in Bowmans Creek.

Avoidance, mitigation and monitoring
Question 11: Does the EIS provide reasonable strategies to effectively avoid, mitigate or minimise the likelihood, extent and significance of impacts, including cumulative impacts to significant water-related resources?

43. Proposed strategies for avoidance, mitigation and minimisation of impacts to water resources rely on updating existing management plans and continued implementation. Some summary information about proposed updates was provided but this was often limited because the proponent does not plan to update most plans until the project is approved. The IESC has not assessed the adequacy of existing management plans because these do not explicitly incorporate the project. Nonetheless, suggested improvements and required updates for relevant management plans are provided in the responses to Questions 12 and 13 below.

Avoidance, mitigation and monitoring
Question 12: Are the proposed updates to the surface water and groundwater monitoring proposed in the Mount Owen Complex WMS appropriate and adequate to capture the potential impacts of the Project on the significant water resources?

44. The groundwater and surface water monitoring networks provide adequate spatial coverage of the broader project area. However, as multiple maps have been provided for each network, it is unclear which sites will continue to be monitored during different project phases. When the relevant water management plans are updated, this information should be clearly outlined along with details of the monitoring programs (e.g. locations, sampling frequency and analyte suites) and site-specific guideline values for both water levels and quality.

45. The geochemical analysis has highlighted that waste material could potentially release cobalt, iron, manganese, nickel, zinc, aluminium, arsenic, copper, cadmium, chromium, barium, boron and molybdenum (Environmental Geochemistry International 2019, pp. 20-47). The groundwater and surface water monitoring suite of parameters should be expanded, particularly at sampling locations along and at the endpoints of these seepage pathways, to incorporate all analytes that may indicate seepage from waste material. This will allow potential seepage of contaminants to be identified early and appropriate mitigation and management measures to be implemented.

46. Recent groundwater quality data (AGE 2019, Table 5-3, pp. 75-76) show that the ANZG (2018) default guideline values for freshwater aquatic ecosystems (95% species protection level) are exceeded at multiple sites for many analytes, particularly those which could indicate seepage (e.g. aluminium, arsenic, chromium, copper, manganese, nickel, zinc, cadmium and selenium). The IESC recommends that the proponent characterise the typical concentrations of these analytes at relevant monitoring locations (as outlined in Paragraph 45) and develop site-specific guidelines from suitable reference sites that can be used within a trigger action response plan (TARP) for waste material seepage.

47. Site-specific surface water quality guideline values for electrical conductivity and total suspended solids have been developed for several sites within the clean water system (GHD 2019, Table 5-2,

p. 31). However, it appears that these site-specific guideline values have not been derived from reference sites and may have been determined from impacted sites as the values vary for each site. The IESC recommends that the proponent revises these site-specific guideline values to ensure that these are appropriately derived as outlined in ANZG (2018) and Huynh and Hobbs (2019). The proponent should also develop site-specific guideline values for a range of metals prior to commencing the project, particularly at sites where observed concentrations (e.g. copper, nickel, chromium, lead) commonly exceed default guideline values. Site-specific guideline values should also be developed for analytes that may be characteristic of seepage from waste material (see Paragraph 45) as part of a TARP. Suggested analytes include aluminium, copper, cobalt, iron, manganese, nickel, zinc, arsenic, cadmium and chromium.

48. Current surface water quality monitoring data from some sites (e.g. SC3, BC2, BC3, BC4 and BC5) show elevated salinity and total suspended solids. The cause of this is unclear. Further discussion should be provided which examines potential causes, including the potential for mine seepage particularly at SC3, BC2, BC3, BC4 and BC5.

Avoidance, mitigation and monitoring
Question 13: Are there any additional mitigation, monitoring, management or offsetting measures that should be considered by decision makers to address the residual impacts of the Project on water resources?

49. The proponent should install a flow gauge to measure flows through the Yorks Creek diversion. These monitoring data will provide useful information for assessing the hydrological and hydraulic performance of the diversion. Monitoring of the assemblage composition and condition of aquatic biota and riparian vegetation along the Yorks Creek diversion and in suitable reference sites is also recommended as this information will be needed as part of the proposed Before-After-Control-Impact (BACI) monitoring program (discussed below in Paragraph 51) to assess potential ecological impacts (including residual ones) of the diversion.

50. Continued monitoring of existing GDEs and riparian vegetation established along the Yorks Creek diversion is needed to identify potential impacts, assess rehabilitation progress and initiate mitigation programs if impacts are identified. Any TARPs developed should use baseline data collected during the recent drought period (2017-2019) cautiously, as ecological parameters such as species richness and community composition are likely to have been already impacted by reduced access to water, potentially resulting in a misleadingly conservative baseline.

51. A BACI-based monitoring program has been proposed to assess the impacts of the Yorks Creek diversion and the success of the constructed design in meeting the relevant design objectives (Umwelt 2019a, p. 262). The IESC agrees with this program design and that monitoring should rely on objectively measured data rather than rapid visual assessment approaches (Gippel 2019, p. 58). Further detail of the proposed monitoring program will need to be provided before its adequacy can be determined.

52. The proponent has stated that an initial inspection will be undertaken to identify issues which may delay revegetation establishment; however, further monitoring may not commence until revegetation has demonstrated satisfactory growth (Umwelt 2019c, p. 59). It is unclear how 'demonstrated satisfactory growth' will be determined without regular monitoring following the initial inspection. When the Rehabilitation Management Plan is developed, a comprehensive monitoring plan to assess the success of rehabilitation will be required. Data on the current composition of riparian vegetation along Yorks Creek will provide a useful baseline to guide riparian rehabilitation.

53. It is unclear whether the potential impacts of groundwater drawdown on the likely groundwater-dependent state-listed threatened species *Acacia pendula* have been fully considered. A monitoring and management plan may be needed to detect and mitigate potential groundwater drawdown

impacts to this species. Alternatively, there may be a need for suitable offsets if effective mitigation is not feasible.

54. The IESC notes that the bushfires of the 2019/2020 Australian summer have impacted a considerable area of national parks within the project region. Vegetation across the project site, especially along unburnt riparian corridors, is likely to be providing crucial refuge habitat for a range of biota currently. Maintenance of this habitat will be particularly important until surrounding areas of burnt bushland have recovered adequately to provide suitable habitat again.

Date of advice	11 March 2020
Source documentation provided to the IESC for the formulation of this advice	Umwelt 2019. *Glendell Continued Operations Project Environmental Impact Statement.* November 2019. Final for submission. Prepared by Umwelt (Australia) Pty Limited on behalf of Glendell Tenements Pty Ltd.
References cited within the IESC's advice	AGE 2019. *Report on groundwater impact assessment Glendell Continued Operations Project.* Project No. G1874C, November 2019. Appendix 16 of the Glendell Continued Operations Project Environmental Impact Statement. ANZG 2018. *Australian and New Zealand guidelines for fresh and marine water quality.* Australian and New Zealand Governments and Australian state and territory governments, Canberra ACT. Available [online]: https://www.waterquality.gov.au/anz-guidelines accessed March 2020. Ball J, Babister M, Nathan R, Weeks W, Weinmann E, Retallick M, Testoni I, (Editors), 2019. *Australian Rainfall and Runoff: A Guide to Flood Estimation*. Commonwealth of Australia (Geoscience Australia), 2019. Available [online]: http://book.arr.org.au.s3-website-ap-southeast-2.amazonaws.com/ accessed March 2020. Eco Logical Australia 2019. *Glendell Continued Operations Project – Stygofauna Assessment.* Appendix 21 of the Glendell Continued Operations Project Environmental Impact Statement. Environmental Geochemistry International 2019. *Geochemical assessment of the Glendell Continued Operations Project.* Document No. 2356/1286. November 2019. Appendix 19 of the Glendell Continued Operations Project Environmental Impact Statement. GHD 2019. *Umwelt (Australia) Pty Ltd Glendell Continued Operations Project surface water impact assessment.* November 2019. Appendix 17 of the Glendell Continued Operations Project Environmental Impact Statement. Gippel CJ 2019. *Geomorphological assessment for Yorks Creek diversion constraints analysis. Glendell Continued Operations Project.* Prepared by Fluvial Systems Pty Ltd for Umwelt (Australia). Appendix 18 of the Glendell Continued Operations Project Environmental Impact Statement. Huynh T and Hobbs D 2019. *Deriving site-specific guideline values for physico-chemical parameters and toxicants.* 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. Available [online]: http://iesc.environment.gov.au/publications/information-guidelines-explanatory-note-deriving-site-specific-guidelines-values accessed March 2020.

IESC, 2018. Information Guidelines for proponents preparing coal seam gas and large coal mining development proposals. Available [online]: http://iesc.environment.gov.au/publications/information-guidelines-independent-expert-scientific-committee-advice-coal-seam-gas accessed March 2020.

Stubbington R, Bogan MT, Bonada N, Boulton AJ, Datry T, Leigh C & Vander Vorste R 2017. Chapter 4.3 The biota of intermittent rivers and ephemeral streams: aquatic invertebrates. In '*Intermittent Rivers and Ephemeral Streams: Ecology and Management*'. (Eds. T. Datry, N. Bonada and A.J. Boulton), pp. 217-243. Academic Press, London.

Umwelt 2019a. *Glendell Continued Operations Project Environmental Impact Statement – Main report.* November 2019. Final for submission. Prepared by Umwelt (Australia) Pty Limited on behalf of Glendell Tenements Pty Ltd.

Umwelt 2019b. *Glendell Continued Operations Project Assessment of Commonwealth matters – Final.* Appendix 10 of the Glendell Continued Operations Project Environmental Impact Statement.

Umwelt 2019c. *Glendell Continued Operations Project rehabilitation and mine closure strategy. Final.* November 2019. Appendix 24 of the Glendell Continued Operations Project Environmental Impact Statement.

Umwelt 2019d. *Glendell Continued Operations Project biodiversity development assessment report. Final.* November 2019. Appendix 20 of the Glendell Continued Operations Project Environmental Impact Statement.