

Advice to decision maker on coal mining project

IESC 2018-095: South Walker Creek Mulgrave Resource Access Stage 2C (MRA2C) Project (EPBC 2017/7957) – Expansion

Requesting agency	The Australian Government Department of the Environment and Energy
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Advice stage	Assessment

The Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development (the IESC) provides independent, expert, scientific advice to the Australian and state government regulators on the potential impacts of coal seam gas and large coal mining proposals on water resources. The advice is designed to ensure that decisions by regulators on coal seam gas or large coal mining developments are informed by the best available science.

The IESC was requested by the Australian Government Department of the Environment and Energy to provide advice on the BHP Billiton Mitsui Coal (BMC) Pty Ltd's South Walker Creek Mulgrave Resource Access Stage 2C Project in Queensland. 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 proposed South Walker Creek Mulgrave Resource Access Stage 2C (MRA2C) Project (proposed project) is approximately 25 km west-south-west of Nebo in the Bowen Basin, Qld. The target for production is the Permian Rangal Coal Measures. The proposed project is an expansion of the larger and operational South Walker Creek Mine (SWCM) within mining lease ML4750. From the information provided, the proposed project appears to almost double the rate of coal production to approximately 7.9 Mtpa. The expansion will include: extension of the existing Mulgrave Pit to the southwest; further diversion (approximately 8 km) of Walker Creek along the southern boundary of the project; construction of two additional water storages to the north (0.5 GL) and south (2 GL); and the development and rehabilitation of final void(s).

There are several key *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)-listed water-related assets within the project area and surrounds. The Vulnerable Black Ironbox (*Eucalyptus raveretiana*), Endangered Brigalow (*Acacia harpophylla* dominant and co-dominant) Threatened Ecological Community (TEC) and the Vulnerable Ornamental Snake (*Denisonia maculata*) occur within the project area. Several wetlands are located within or near the project. There are at least 15 unregistered landholder bores that are either owned by BMC or subject to existing agreement/compensation agreements.

The proposed expansion's key potential impacts and risks to water-related assets identified above include:

- direct impacts due to the removal of 8 km of Walker Creek and associated aquatic habitat, riparian vegetation and groundwater-dependent ecosystems (GDEs), with likely impacts on riverine ecosystem connectivity;
- direct and indirect impacts to downstream ecosystems from changes to surface water flow regimes as a result of the proposed diversion, including cumulative impacts associated with the doubling of the contributing catchment area and the potential for increased erosion and sedimentation;
- groundwater de-watering on nearby GDEs and connectivity between surface water and groundwater systems;
- intentional and unintentional untreated additional discharges to surface water and leakage to groundwater; and
- cumulative impacts (surface water and groundwater) with existing and proposed coal and coal seam gas (CSG) operations in the surrounding area. This includes cumulative groundwater impacts with nearby existing and proposed operational and final voids.

The large scale of historical and existing mining operations associated with the SWCM means that there are risks to several EPBC Act-listed species and TECs. These risks are associated with the proposed diversion and associated loss of 8km of Walker Creek and its riparian zone (to be cleared and mined), additional discharges, final landform and voids and cumulative impacts. The information presented in the draft Preliminary Documentation (PD) is ambiguous, inconsistent and incomplete in many areas. The draft PD refers to and relies on existing reports and historical data but does not provide adequate summary of information or data to support conclusions, assumptions and parameters used in this assessment. Historical groundwater and surface water information is limited spatially and temporally. Existing monitoring and management plans have not all been provided. Those that have been provided have not all been updated to include the proposed project expansion.

The hydrological models of surface and groundwater systems (including the water balance for the final void) are in general subject to large uncertainties, and their conceptualisation and parameterisation largely rely on untested assumptions which are not well supported by local observations or data on historical performance. Overall, the nature of the supporting evidence presented by the proponent makes it difficult to confidently assess potential impacts. The following advice highlights a large number of concerns raised by the IESC, and, until the deficiencies in the supporting information are addressed, it is difficult to provide further comment on the relative importance of some of the detailed concerns raised.

Context

The proposed project is an extension to the larger South Walker Creek Mine (SCWM) within mining lease ML4750. SWCM has been in operation for more than 20 years, with construction commencing in 1996. SWCM is stated to currently consist of 6 open cut pits: Toolah, Walker, Carborough, Mulgrave, Kemmis 1 and Kemmis 2 (BMC 2018b, p. 1). The proposed project is an extension of the Mulgrave Pit with a specific mine life extending to 2063.

The proposed expansion will use existing mine infrastructure. An 8-km diversion of Walker Creek and two surface water storages totalling 2.5 GL will be constructed. The SWCM is operating under an existing Environmental Authority (EPML00712313). Water Licences have been granted by the Queensland State government approving the existing and proposed diversion of Walker Creek. Carborough Creek (160 km² catchment) enters Walker Creek at the upper end of the proposed 8-km diversion. Walker Creek joins Bee Creek approximately 8 km downstream of the end of the proposed diversion. Dipperu National Park is approximately 18 km south-east of the SWCM along Bee Creek.

Key Potential Impacts

Key potential impacts on water resources and water-related assets are outlined below.

- Direct impacts to water-dependent ecosystems will occur through clearing and excavation within the mine boundary. These ecosystems include the EPBC Act-listed Black Ironbox and the Brigalow TEC which provides habitat for the Ornamental Snake. The Black Ironbox is mainly located along the riparian zone and is likely to be groundwater-dependent. Indirect impacts through groundwater drawdown and within the unconfined alluvium and regolith aquifers are likely to affect GDEs.
- The proposed diversion now includes flows from Carborough Creek, which doubles the area of the upstream contributing area compared to the existing diversion. The potential for increased groundwater recharge and increased erosion and sedimentation along the 8-km length of the diversion will likely alter the flow regime and in-stream habitat availability.
- The separation of the Carborough Creek riparian corridor and aquatic habitat from Walker Creek downstream of the proposed 8-km diversion will disrupt instream and riparian connectivity along Walker Creek to Bee Creek. These impacts are cumulative with those from the existing diversion.
- Impacts to downstream water quality and to ecosystems may occur through increased discharge volumes and potential leakage of contaminants (via groundwater) from proposed water storages to the north (0.5 GL) and south (2 GL). Elevated concentrations of contaminants in existing mine water storages and potentially in the new northern and southern dams suggest that there is a potential risk if these discharges are not appropriately managed.
- Final voids are a potential point source of poor quality water, which could impact nearby surface waters through overtopping and flooding, as well as impact groundwater through leakage of poor quality water. It is difficult to evaluate the magnitude and likelihood of these impacts from the current surface water and groundwater modelling.
- Groundwater drawdown from the proposed project, together with other local and regional operations, will extend the magnitude of groundwater drawdown in the region, potentially impacting surrounding groundwater-dependent ecosystems (GDEs). It could also result in extensive spatial and temporal disconnection of surface water and groundwater. This will likely change baseflow volumes, other components (e.g. duration, timing) of the flow regime, water quality and aquatic habitat availability. It could also result in further fragmentation or loss of riparian vegetation and ecological connectivity along the river network.
- Several wetlands may be impacted by groundwater drawdown or by surface water impacts. Two wetlands noted to be of high ecological significance (Queensland Globe 2018b) are to the west of the proposed project. Pink Lily Lagoon is stated to be a regionally significant wetland approximately 270 m to the east of the SWCM rail loop (BMC 2018b, p. 6). Bore 4, stated to be a spring sourced from the contact between the Rewan Formation and Clematis Group, is north-west of the project area (BMC 2018a, Figure 2, p. 3).

- At least 15 unregistered landholder bores are likely to be impacted by groundwater drawdown. These bores are either owned by BMC or subject to existing agistment / compensation agreements.

Response to questions

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

Question 1: Can the Committee provide comment on whether the information provided in the assessment documentation (including baseline and modelled data), and the conclusions drawn by the proponent, is adequate to assess the project's impacts on water resources, including impacts on GDEs and impacts on surface water from creek diversions?

1. The information provided in the draft preliminary documentation (PD) is not adequate to inform the project's impacts on water resources, including GDEs and surface waters potentially affected by the creek diversion. Presented baseline information and modelling should be considered preliminary and need to be supplemented through additional specific groundwater, surface water and ecological data collection and assessment.
2. There are inconsistencies in the information and data presented throughout the draft PD. Several references to existing and historical reports and data are not provided or adequately summarised to provide sufficient context for assessment of the proposed project. In addition, project boundaries are not clearly and consistently defined in maps in the draft PD. For example, many figures show the location and extent of the "MRA2C proposed pit area" (BMC 2018a, Figure 3, p. 4) and not the entire project area (BMC 2018a, Figure 4, p. 7). The figures showing just the footprint of the proposed pit area could be misinterpreted to indicate the full project boundary, but do not capture the proposed diversion and the two proposed water storages to the north and south. In addition, the size of the proposed southern dam is not consistent across diagrams.
3. The proponent's summary risk assessment is not adequate as it has not considered all potential impacts and risks from the proposed project. Details on how risk ratings were derived and evaluated based on likelihood and consequence were not provided.
4. To improve the assessment of impacts to water resources, issues raised in the following sections need to be addressed. Clarification on particular information requirements is provided in response to Question 2.

Surface Water

5. Information on the proposed site water management is incomplete and unclear. The proponent does not provide details of how their site water balance modelling was configured or critically review the assumptions used. The information in the Water Management Plan has not been updated to reflect changes required to accommodate the proposed project. In particular, it is unclear how the proposed new 0.5-GL northern dam and 2-GL southern dam would be managed and what measures will be put in place to minimise impacts, including seepage of mine-affected water. Seepage from the northern dam in particular could affect water quality in Walker Creek and its associated alluvium, impacting groundwater-dependent riparian vegetation and associated biota.
6. The volumes and management of intentional releases (presumably untreated) are not clear. The Receiving Environment Management Plan (REMP) has not been fully updated to account for the proposed expansion. The locations of proposed discharge sites associated with the proposed expansion are not clear. While some water quality data and discharge water quality limits have been presented, the impacts on water quality of discharges into creeks have not been assessed. The proponent has not used knowledge of historical impacts or gauged observations to help assess the nature of the impacts on streamflow regimes and downstream biota.

7. Surface water flow data for Walker Creek and Carborough Creek, which have not been presented, are essential to assess the proposed expansion's potential impacts on downstream ecosystems, especially aquatic biota and riparian zone vegetation. It would also give greater confidence in the proponent's diversion plans if these were based on actual flow data. It is stated in the Diversion Monitoring Plan (Alluvium 2017) that a gauging station was installed on Walker Creek associated with the existing diversion although other documentation (Alluvium 2018) states that there is no gauging on Walker Creek.
8. Insufficient information on the proposed diversion and associated levees has been provided to determine the likelihood of them meeting their management aims. Reports on the detailed design of the diversion are cited, but not provided¹.
 - a. The proponent has not provided detail of revegetation other than planting with the EPBC Act-listed Black Ironbox. Information on other species to be planted and revegetation methods would aid in understanding the likelihood of providing and maintaining a stable and self-sustaining landform and the degree to which it will provide an effective habitat corridor for flora and fauna. This revegetation strategy should specify the expected trajectory of vegetation response (White et al. 2014). It should also predict when riparian structure will resemble that of undiverted reaches of Walker Creek.
 - b. The ability of the design to be self-sustaining in terms of sediment control and ecological function is critically dependent on the estimates of flood behaviour and streamflow regime. With respect to flood behaviour, the Alluvium (2014, 2015) reports were not included in the submission, and it is unclear to what degree these estimates are consistent with the procedures included in the national guidelines (Ball et al. 2016), which were released after these reports were produced. While it would appear that the changes to the mine site will minimally impact on the contributing upstream area, no quantitative information is presented on the flow regime on the basis of gauged or derived streamflows. No assessment has been made on how the flow regime affects habitat availability to aquatic and terrestrial biota along the length of the diversion.
 - c. While a typical cross-section of the diversion has been provided (Alluvium 2016, p. 32), there is little information on how or whether this would be varied to provide geomorphic complexity to support habitat diversity.
 - d. The diversion is expected to experience in-filling with sediment (aggradation). The proponent has not examined the impact this may have on flood protection in the long term. This is particularly relevant for the flood protection of the final void and for the extent of the new floodplain created by the diversion. The IESC also notes that data for sediment characteristics were taken from Bee Creek. Sediment characteristics may be different for Walker Creek along the diverted part, affecting the reliability of modelling.
 - e. Information on the success of the existing stream diversion has not been provided. This information would increase confidence in predictions of the likely success of the proposed diversion – including its capacity to mimic the natural channel and provide ecologically appropriate habitat – or point to ways in which the design could be improved.

¹ *Mulgrave Resources Access Walker Creek Diversion – Stage 2C Detailed Design and Mulgrave Resources Access Walker Creek Diversion – Stage 2C revegetation plan*, cited in State of Queensland 2016b.

- f. The proponent notes that geotechnical assessment for the diversion and bunds will be required, including identifying suitable material for levee construction. The proponent has not outlined the specification for appropriate material for these levees.
 - g. The diversion has been designed to incorporate a hyporheic zone. However, the proponent provides no evidence in the draft PD that groundwater drawdown has been considered in the design of the hyporheic zone. This information is important given the diversion has been designed with a 70-m horizontal standoff from the active pits, which may affect the likely success of rehabilitation. It is also unclear how closely this constructed hyporheic zone would resemble that of the existing watercourse or mimic its ecological function.
 - h. Approximately 3.5 km of levee banks are proposed, but no information is provided on how these may alter floodplain inundation patterns and associated ecological processes (e.g. seed set and tree recruitment, organic matter breakdown).
9. The sodic soils on site present a risk to downstream water quality if not appropriately managed. Information on site management to address this risk has not been provided.

Water Quality

10. The proponent provides a REMP dated September 2016 but it is unclear whether this plan has been updated to account for this proposed expansion. The REMP provides water quality objectives for a number of parameters, mostly based on the Model Water Conditions for aquatic ecosystems. Not all values align with the 95% species protection Guideline Values for slightly to moderately disturbed aquatic ecosystems in ANZECC/ARMCANZ (2000)². Most notably silver, cobalt and beryllium objective concentrations are more than 10 times the ANZECC/ARMCANZ (2000)² guideline values.
- a. Reference sites (located upstream of discharge locations) show exceedances of ANZECC² Guideline Values for a number of metals (e.g. aluminium, chromium, copper, iron and lead) (FRC 2016, Table 2.1). It is unclear how many samples this monitoring data is based on, especially as only annual sampling is outlined in the REMP. Annual sampling is inadequate to characterise the natural variation in water quality at these reference sites. The intermittency of the flow regime suggests that natural variation in water quality is likely to be high. There is little interpretation of why reference sites show high metal concentrations or the implications for mine water management.
 - b. The proponent provides water quality data on mine-affected water contained in storages, but does not provide information on the actual quality of discharge water. It is unclear whether water undergoes any treatment prior to discharge. This water contains high concentrations of a number of metals, sulfate and salinity. No assessment of the environmental impacts of this discharge has been provided.
11. There is little information on how the proposed new northern and southern dams would be managed or the environmental risks associated with these. It is implied in the assessment documentation that these would contain mine-affected water. There may be environmental risks associated with dam management, including from seepage.

² A new version of these guidelines has recently been released. The *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* are available at <http://www.waterquality.gov.au/anz-guidelines>.

Groundwater

12. Adequate baseline information and groundwater data from current SWCM operations are not provided. This information is crucial in assessing the potential behaviour and response of confined and unconfined groundwater to proposed expansion activities. This information is likely to be available in existing reports (e.g. Annual Groundwater Reviews dated 2012, 2013, 2014), which have not been adequately summarised or provided. It is not clear whether this information, if available, has been used to inform the conceptualisation and construction of the numerical groundwater model and so improve its ability to predict project and cumulative impacts with any confidence.
13. Predictions from the groundwater model are important to inform potential impacts to GDEs utilising shallow groundwater (e.g. EPBC Act-listed Black Ironbox) and changes to groundwater and surface water connectivity. From the information provided and the numerical modelling undertaken, there is significant uncertainty in relation to the predicted magnitude and extent of groundwater drawdown. Available groundwater monitoring locations and associated data are limited spatially, hydrostratigraphically and temporally, further restricting adequate characterisation of the groundwater system.
14. There are several issues with the numerical groundwater model that would need to be addressed to improve the transparency of the assessment and certainty around project and cumulative impacts. These issues are associated with the model's construction, hydraulic parameterisation, boundary conditions, water balance, calibration, predictive simulations (steady state and transient) and the modelling of voids. The sensitivity and uncertainty analysis of the model also does not appear to appropriately test a range of realistic variations of hydraulic parameters to capture natural variability, nor the effect of changes to the model's boundary conditions and their influence on predictions. The current uncertainty analysis does not adequately vary values for recharge and hydraulic conductivity. Specific storage values and variation are not reported. The small variations in recharge and hydraulic conductivity employed in the current analysis leads to small variations in drawdown. The uncertainty analysis scenarios are also biased by the combination of recharge and hydraulic conductivity values used. The recharge values are largely higher compared to baseline values. The hydraulic conductivity values are largely lower compared to baseline values. This combination leads to smaller drawdown predictions. The uncertainty analysis leads to both smaller drawdown predictions and smaller ranges in drawdown predictions than might be expected. The parameters employed in the uncertainty analysis require physical justification.
15. The IESC commends the provision of an independent review of the groundwater model. The peer review noted the lack of detail and information provided in the draft PD on aspects of the modelling that are needed to adequately assess the modelling approach and outcomes. The peer review also identified a number of issues in model files that are not reported or discussed in the draft PD. Consistent with this IESC advice, the peer review also noted issues around the depth of mining, model construction and layering, hydraulic parameterisation, boundary conditions, water balance, and the representation and modelling of operational and final voids.
16. Several bores have elevated concentrations of iron, including MB10 and MB11. MB10 and MB11 were sampled monthly between early 2015 to mid-2016, with reported total iron concentrations increasing over this period and then falling sharply. For example, MB10 recorded total iron concentrations of 550 µg/L in Aug 2016 and then 0.09 µg/L in Sept 2016. Similar trends are also noted in MB11. No interpretation of these results is provided.
17. The IESC note that the Groundwater Contaminant Trigger Levels (Table 11) in the EA are not specified. Condition W52 states that the trigger levels in Table 11 must be determined and submitted to the administering authority by 1 March 2016.

Water-dependent ecosystems

18. The proponent has not provided any information from field surveys or other assessments to determine the community composition of aquatic biota or ecological health of the drainage networks that may be affected by the proposed expansion. South Walker Creek is an ephemeral stream that frequently lacks surface flow. Ephemeral and intermittent streams provide habitat for a range of aquatic species (review in Stubbington et al. 2017) and provide important ecosystem services (Datry et al. 2018). Without information from appropriate aquatic assessments (as outlined in response to Question 2), it is not possible to assess the potential for impacts to water-dependent species that use the surface water resources within the proposed expansion area.
- Given the length of the proposed diversion (approximately 8 km), stream velocities, availability of pools and substrate heterogeneity are key considerations. Alluvium's "design principles" (Sec 3.1 of App B Attach C) specify the need to include "habitat features", but it is not evident whether this has been explicitly considered.
 - The diverted channel will alter local recharge of the water table in that area and alter patterns of floodplain inundation from pre-diversion conditions. The proponent has not predicted how these alterations will affect water-dependent ecosystems, including GDEs and riparian and floodplain biota.
 - The 8-km diversion will disconnect the riparian corridor and aquatic habitats of Carborough Creek from those of Walker Creek downstream of the diversion. Recovery, especially of riparian trees, may take at least a decade.
19. There are three wetlands identified in the surrounding area: Pink Lily Lagoon (stated to be a regionally significant wetland) and two unnamed wetlands to the west. Wetland fauna, notably waterbirds and aerial aquatic insects (e.g. dragonflies, mayflies) are likely to move between the wetlands, water storages and final voids that contain water. Additional ecological information on the standing waters (both isolated and riverine) associated with the proposal should be gathered to ensure a broader understanding of the ecological connectivity and potential impacts on surface water-dependent ecosystems.
20. Black Ironbox (*Eucalyptus raveretiana* – EPBC Act-listed as Vulnerable) and the Brigalow (*Acacia harpophylla* dominant and co-dominant) Threatened Ecological Community (EPBC Act-listed as Endangered) have been identified within the project area. The proponent's assessment notes that Black Ironbox is likely to opportunistically ('intermittently') access groundwater (BMC 2018a, p. 23) and therefore this species is, by definition, a Type 3 GDE (Richardson et al. 2011). The proponent states that Brigalow is not considered to be a GDE, because it "...is generally found to rely on trapped surface water or water stored in the unsaturated zone rather than groundwater" (BMC 2018a, p. 23). Water trapped above a low-permeability zone and stored within the unsaturated zone would meet the definition of a perched aquifer in Richardson et al. (2011) and therefore Brigalow may also be considered groundwater-dependent. Clarification of the groundwater dependence and ecological water requirements of these vegetation types in the area of predicted groundwater drawdown is needed. Some potential ways to measure these requirements are identified in the response to Question 2. Within the proposed expansion area, Black Ironbox (and the associated riparian vegetation) and the Brigalow TEC are important habitat types for a number of threatened species.
- Black Ironbox occupies the riparian fringe along Walker Creek. This riparian vegetation containing Black Ironbox is considered to be high quality potential habitat for the Greater Glider (*Petauroides volans*) and the Koala (*Phascolarctos cinereus*), both listed as Vulnerable under the EPBC Act.

- b. Brigalow is primarily associated with potential habitat for the Ornamental Snake (*Denisonia maculata* – EPBC Act-listed as Vulnerable) such as gilgai and cracking clay depressions that are intermittently filled with water.
- 21. The proponent has not assessed the likely presence of Type 1 GDEs (stygo fauna) with a pilot study following an appropriate desktop review as per DSITI guidelines (DSITI, 2015). Several studies elsewhere in the Fitzroy Basin (e.g. upper Dawson River, upper Connors River) have reported stygo fauna within alluvial aquifers (Hose et al. 2015). Based on depth to groundwater and groundwater quality, it is reasonable to conclude that stygo fauna would be present in this part of Queensland (Glanville et al. 2016). Pilot sampling for stygo fauna should include bores, especially Bore 4 which is stated to be a spring.
- 22. Vegetation surveys have only been provided for the proposed expansion area. To determine the range of potential impacts to GDEs, the proponent needs to undertake vegetation surveys and identify the location of all Type 3 GDEs within the predicted extent of groundwater drawdown. Implications of predicted drawdown on these GDEs should be assessed.
- 23. Determining water requirements for the EPBC Act-listed vegetation (Black Ironbox and Brigalow) is important as these will directly influence the success of revegetation along the proposed Walker Creek diversion; the likelihood of impacts beyond the area studied (i.e. within the predicted extent of groundwater drawdown); and inform the mitigation, management and offsetting strategies required by the proponent. It will also be important to assess the likelihood, extent and severity of impacts to the species (especially threatened ones) that potentially depend on Black Ironbox and Brigalow and their associated vegetation communities.
- 24. The proponent identified that significant impacts were likely for the Brigalow TEC and the Ornamental Snake, and that even after mitigation measures, residual impacts on these EPBC Act-listed species and TECs would remain significant (p vii, Eco Logical 2017).

Final landform and voids

- 25. Very little information has been provided on the proposed final landform. A map of the proposed final void(s) has not been provided.
- 26. The proponent has undertaken water balance modelling for a final void. The void level and salinity are modelled. This modelling is unrealistic in that it assumes the void is full of water immediately post closure. Modelling shows water levels decline from the initial (arbitrary and unrealistic) full level, which is inconsistent with groundwater model predictions, for the whole of the 117-year period modelled. It is not clear how groundwater inflows have been accounted for, and it does not appear that groundwater model outputs have been used. Salt concentrations are noted to increase for the whole period. It would also appear that the same runoff coefficient has been adopted for the whole site, although higher runoff ratios would be associated with highly disturbed and compacted areas. Given this, it is unclear whether any inferences can meaningfully be drawn from the modelling results.
- 27. Further information is needed on how groundwater inflows have been modelled in the numerical groundwater model. The final void elevations are represented directly in the groundwater model, with the model grid distorted in layers 1 to 5 to bring the top elevation of the model down to the level of the base of the pit where voids will be present. This distortion may influence the estimation of lateral groundwater flow into the pit, restricting flows to vertical only. It is unclear what these results mean for the likely behaviour and equilibrium level for the final void(s) and how these have been used to inform water balance modelling discussed in the paragraph above.
- 28. Direct rainfall of 604 mm/year is applied to the final voids. This value is substantially lower than the annual rainfall of 731 mm calculated from SILO (Scientific Information for Land Owners) patch point datasets for Queensland for station 033054. This may reflect differences between the raw data record

for the gauge and the interpolated SILO data (which may indicate different lengths of record in climatic data). This difference should be explained given its importance in modelling water levels in the final voids.

Question 2: Can the Committee identify and discuss what additional information could be provided by the proponent to assist in the assessment of impacts on water resources, including impacts on GDEs and impacts from creek diversions?

29. To address the information deficiencies described in response to Question 1, the proponent should provide the following additional information which would assist assessment of impacts on surface water, water quality, water-dependent ecosystems and groundwater.

Surface water

30. To improve the assessment of impacts to surface water, the following should be provided:

- a. Any available surface water flow data for Walker Creek (or similar local streams) to help validate estimates of stream flows and flood risks.
- b. An assessment of the changes in flow regime (duration, timing and other ecologically important flow components) and instream habitat availability as a result of the proposed diversion.
- c. Details of how the proposed northern and southern dams will be managed to minimise unintentional discharges and to detect any potential impacts (such as seepage of contaminated water).
- d. Details of site water management and the site water balance modelling associated with the proposed expansion. Estimated water discharge volumes across the proposed project's life and an assessment of the environmental impacts of these releases should be provided.
- e. Additional information on the design of the proposed diversion and levees. The IESC notes that some of this information may already exist in reports cited in the draft PD but was not provided (see response to Question 1). This should include:
 - i. summary of successes and failings in the existing Walker Creek diversion and how the planned design could be altered as result of this information;
 - ii. details of proposed revegetation (e.g. species, provenance, maintenance and watering, weed control) and evidence of the likelihood of success. This should include the predicted "vegetation trajectories" (White et al. 2014), especially where early succession species are used to facilitate establishment of longer-lived species;
 - iii. details of if and how the cross-section of the diversion will be varied along its length to provide habitat heterogeneity, in accordance with principles outlined in an ACARP report cited in the PD (White et al. 2014). The IESC notes that refugial pools along the channel would provide especially valuable habitat if they could be designed in such a way that they did not quickly fill with sediment;
 - iv. analysis of the long-term impacts of infilling of the diversion with sediment, the stability of the diversion and the level of flood protection afforded to the final void. This analysis should be undertaken using data on sediment composition taken from the likely sources of sediment in the diversion from all disturbed contributing areas. Information from Bee Creek should not be used as a proxy;

- v. material specification for the flood bunds associated with the diversion and for material used in the diversion and to fill tributaries (Golder 2018, p. 34); and
 - vi. the earlier Alluvium (2014, 2015) reports which detail how the hydrological analyses were undertaken, and information on the extent to which the flood estimates are consistent with current national guidelines published subsequent to the reports being prepared.
- f. Alluvium (2016) suggests four diversion ‘principles’, including development of a diversion that “promotes nutrient processing, ecological connectivity, and facilitate sediment storage and transport”. No information is provided on the first two of these aspects for Walker Creek pre-diversion, nor is it clear whether these principles will be tested in the proposed diversion. This is crucial to assessing the success of the diversion in replacing ecological features lost from the original creek.
 - g. An analysis of the potential for groundwater drawdown from mining to increase leakage from the diversion and implications for the functions of the planned hyporheic zone of the diversion. This should also account for the expected composition and bedform of the diversion and how they will vary over time.
 - h. Information on how sodic soils will be managed on site should consider the framework for management of dispersive soils presented in Dale et al. (2018).
 - i. A plan for the final landform, including a map that clearly defines the location of final void(s). The water balance, groundwater model and salinity modelling for the final void(s) should be updated and all key assumptions justified.
 - j. Baseline data on ecological function and water quality upstream and downstream of the proposed and existing diversions against which to measure recovery of ecological habitat connectivity provided by the proposed diversion.
31. Information on the final landform should include discussion of appropriate management of sodic soils on site. The IESC notes that the nearby Coppabella mine has experienced challenges in remediating the dispersive soils on site (Dale et al. 2018).

Water quality

32. The proponent should provide an assessment of the likely impacts of additional discharges from this project on the receiving environment. This should include:
- a. discussion of the causes of elevated concentrations of metals in reference sites, including seasonal and event-based variability (noting that additional data collection may be necessary to do this);
 - b. provision of data on the actual water quality of releases and of timing and quantities of releases expected to arise during the life of this project; and
 - c. discussion of the expected impacts of changes in downstream water quality on ecological health. This should include an analysis of the potential for, and likely impacts from, first-flush pulses of water with potentially elevated contaminant concentrations (e.g. Whittle and Leggett 2016).
33. The proponent should provide information on how the proposed northern and southern dams will be managed, including whether any measures will be implemented to limit seepage of mine-affected water. The potential environmental impacts of the dams, including seepage, should be assessed.

Water-dependent ecosystems

34. The challenges of using standard methods to sample the aquatic biota of ephemeral and intermittent streams are well-documented (review in Chiu et al. 2017), and conventional indices of Australian river condition (e.g. Chessman 1995) are of limited value in assessing stream health in these systems. Nonetheless, if during the flowing phase, replicate quantitative benthic samples or qualitative sweep-net samples of aquatic macroinvertebrates are collected using standard methods from equivalent habitats along Walker Creek upstream (within and downstream of the diversion during flow), their assemblage composition and relative abundance can be compared. This will ascertain whether key taxa are missing or unusually uncommon. Often, knowledge of the ecological traits of these key taxa indicate potential impacts of sedimentation or high concentrations of contaminants, even in ephemeral or intermittent streams. The proponent may wish to consider methods documented in Steward et al. (2018) to assess the ecological health of rivers when they are dry.
35. As mentioned in the response to Question 1, the proponent should supplement a desktop review with a pilot survey of stygofauna, especially in saturated alluvial sediments and groundwater bores in areas where groundwater drawdown is predicted. Appropriate sampling methods are described in the Queensland guidelines by DSITI (2015). The results will allow the proponent to judge whether there will be any potential impacts on Type 1 GDEs and, if so, develop a suitable monitoring program to inform an effective trigger-action-response plan.
36. The proponent's assessment of groundwater dependence of vegetation needs to quantify the water requirements of potential GDEs within the project area and predicted extent of groundwater drawdown, particularly riparian vegetation (including Black Ironbox) and the Brigalow TEC. This assessment should include:
- a. application of techniques from, for example, the Australian GDE Toolbox (Richardson et al. 2011) and Eamus et al. (2015) to assess groundwater use by vegetation (especially during dry periods) and to identify groundwater discharge to surface water bodies;
 - b. analysis and presentation of multiple lines of evidence using onsite monitoring and appropriate literature and supported by available tools (e.g. the Bureau of Meteorology's GDE Atlas (2018) and the State of Queensland's (2018a) WetlandInfo mapping;
 - c. development of maps that show seasonal depths to groundwater within the area inhabited by threatened flora and GDEs. These maps need to be supported by groundwater monitoring data gathered from within the area inhabited by threatened flora and GDEs. Monitoring data presented in the assessment have not been gathered in some representative locations (e.g. west of the project boundary and along the southern section of Walker Creek within the project area. These maps and monitoring data should then be used to develop hydrogeological conceptualisations to identify areas of shallow groundwater that may be accessible by GDEs. These will help target specific areas for groundwater monitoring and will also help guide the design of programs to assess the effect of diversion on groundwater;
 - d. development of ecohydrological conceptualisations that integrate results from hydrogeological, hydrological, geomorphological and ecological investigations at a spatial and temporal scale that is suitable for predicting potential impacts to GDEs and pathways of likely effects and for justifying proposed mitigation strategies;
 - e. site-specific soil assessments detailing relevant edaphic conditions to promote persistence of Black Ironbox and Brigalow and to facilitate their revegetation; and
 - f. tolerances of Type 3 GDEs and other riparian and floodplain vegetation in the project area to the possible concentrations of contaminants (including pulses carried when flow resumes) that may be released intentionally or unintentionally during and after mining.

Groundwater

37. To support the assessment of groundwater impacts, the draft PD should be updated with adequate baseline information and groundwater data from current SWCM operations to inform potential project-related impacts.
38. All issues raised under Question 1 of this advice and in the peer review in relation to the groundwater model need to be addressed and adequately discussed and reported. These include:
- a. discussion and justification for model boundary conditions and construction, including layer thicknesses. Model boundary conditions need to be adequately discussed and justified, particularly model boundaries to the west as the current boundary appears to influence predictions within the confined aquifer. Values for river conductance need to be provided and justified. The depth of mining needs to be clarified. Golder (2018, Figure 36) shows predicted drawdown within the confined aquifer extending beyond the model boundary to the west. Also, contours on the figure are noted as maximum drawdown, but the legend incorrectly notes contours to be m AHD.
 - b. further discussion and justification on model parameterisation, in particular realistic specific storage values for each hydrostratigraphic unit, need to be provided.
 - c. further discussion and justification for evapotranspiration (ET) and extinction depths. There appear to be inconsistencies in conceptualisation and reporting between ET and groundwater recharge, discharge and depth. It is noted in the peer review that model input files suggest that the explanation of the evapotranspiration package is incomplete. Further, that '[a] different extinction depth was assigned in the steady state model (12 m) and the transient calibration, operational and closure models (3 m)' (Rozlapa 2018, p. 3). Incomplete explanation of the modelling approach limits the ability of a reader to understand how the modelling approach will affect impact predictions. The unexplained discrepancy between the steady state model and the transient calibration, operational and closure models further undermines the IESC's confidence in the modelling. The proponent should provide a thorough justification for the way evapotranspiration has been modelled, including the different approach between the steady state and transient models.
 - d. further discussion on model calibration, including steady state and transient calibration. Justification for adjusting parameters between predictive runs needs to be provided. Large differences between measured and modelled hydraulic head (Golder 2018, Figures 30 and 31, and Appendix B) need to be explained, discussed and revised as appropriate.
 - e. further discussion and detail on the representation of void(s) (e.g. geometry, depth, parameters) in the model. In particular, model layering (from the peer review) needs to be addressed as the current configuration restricts the assessment of void behaviour and its water balance as it essentially limits groundwater flow into the void.
 - f. groundwater flow paths for the unconfined and confined aquifers need to be re-assessed and adequately presented. For example, modelled groundwater contours in the confined aquifer (Golder 2018, Figure 33, p. 67) appear to be incorrect as they predict contours in areas to the east where the coal seam aquifer is not present. Also groundwater contours within the coal seam aquifer indicate flow to the south-east which is inconsistent with the proponent's conceptual representation (Golder 2018, Figure 10) of groundwater flow within the confined aquifer.
 - g. Coppabella Mine is located 4 km to the south-west and its mining operations are simulated using drain cells, using the maximum depth of mining across the entire footprint of the mine. Predicted groundwater drawdown associated with Coppabella Mine within the confined

aquifer is limited in extent, which may not represent actual groundwater drawdown associated with the operation of the mine. Further information and discussion are needed to determine the adequacy of how the model represents drawdown interdependencies and interactions with other mines.

- h. drawdown associated with proposed Arrow operations are stated to not reach the South Walker Creek Mine or MRA2C Project area, primarily because there are no production wells planned for the eastern part of ATP 1103 closest to South Walker Creek. While the closest area of planned high-density CSG production wells are more than 10 km west of the ATP 1103 boundary, any potential impacts associated with CSG projects should be considered and, if required, incorporated into the MRA2C Project cumulative impact assessment.
 - i. The Leichhardt Seam within the Rangal Coal Measures is a CSG target for the Arrow Bowen Gas Project. Given the proximity of the CSG development, cumulative impacts need to be considered. The water table has a downward gradient in some areas (Golder 2018, Section 4.1.4 p. 19), which suggests that drawdown within the confined aquifer may induce leakage from the shallow water table. This could impact wetlands and other GDEs recorded in the area, and Bore 4.
39. Once the groundwater model has been updated to address all issues (including those raised in paragraph 38 above) a thorough sensitivity and uncertainty analysis will be needed. This should include model boundary conditions and conceptualisation. Parameters should be varied to ensure that the uncertainty analysis captures the likely extent, magnitude and range of drawdown behaviours in an unbiased fashion. Parameter choices should be physically justified and evidence-based.

Final landform and voids

40. Information on the final void(s) should include, but not be limited to:
- a. void location and geometry;
 - b. improved water balance modelling;
 - c. predicted changes in water quality over time (paragraph 26); and
 - d. further discussion on how the groundwater model has been set up to account for pit inflow.
41. Information on the final landform should include landform design and how sodic soils will be managed on site.

Question 3: Can the Committee provide comment on whether the proposed management and mitigation measures are adequate? What additional measures, if any, should be taken to monitor, mitigate and manage impacts on resources, including impacts on GDEs and impacts from creek diversions?

42. The IESC considers that evidence presented in the draft PD is inadequate to justify proposed management and mitigation measures to protect EPBC Act-listed species and TECs, GDEs and other water-related resources. Potential impacts of the project are stated to be managed through existing Management Frameworks that exist for the broader SWCM. It is not clear if and how these plans have been updated to include impacts associated with the proposed expansion.
43. Data relating to the performance of existing operations, especially the current diversion, should be used to inform proposed management and mitigation measures.
44. A comprehensive risk assessment is needed, appraising and prioritising all material risks of the proposed project and potential cumulative impacts. This risk assessment would indicate which risks

should be avoided and would inform mitigation strategies for unavoidable impacts. Additional measures to monitor, mitigate and manage impacts are described below.

Surface water

45. The proponent proposes to monitor surface water once a year. This is not sufficient to assess seasonal and flow-related variability in water quality in the upstream reference sites or to detect potential downstream impacts from mine discharges.
46. To detect impacts to water quality from discharges and from the diversion, event-based water quality monitoring should be undertaken at several points along Walker Creek (including upstream and downstream of the diversion and mining activity) and at sites upstream and downstream of discharge locations. The list of parameters to be analysed should be determined based on a scoping study in which a broad range of parameters are measured. Given that the 8-km diversion will be largely unshaded, especially after construction, the proponent should continually monitor water temperature downstream of the diversion.
47. The proponent should ensure that their water discharges do not cause substantial impacts to receiving environments, including cumulatively with other developments in the area. Little information has been provided on the downstream aquatic ecosystems and biota, although it is noted that the Southern Snapping Turtle potentially occurs in this area (Eco Logical 2017). Mitigation strategies may require treatment of water prior to discharge to bring metal concentrations below levels specified in the ANZECC/ARMCANZ (2000)² Guidelines for protection of slightly-to-moderately-disturbed systems. This is particularly important as the proponent does not appear to propose any treatment of mine-affected water prior to release or any measures to protect downstream water quality, beyond release conditions specified in the Environmental Authority. It is also unclear how the proponent plans to dispose of water currently stored in F Pit. If this is to be released without treatment, elevated concentrations of a number of parameters may pose risks to the downstream environment.
48. The information presented on the diversion does not give the IESC confidence that the diversion will result in a system that replicates the ecological diversity and ecosystem function of the existing stream, even in the long term. Such an outcome is important to maintain habitat connectivity and is specified as part of the four diversion design principles (Alluvium 2016).
49. From the information presented, it appears that much of the length of the diversion will have a uniform profile, particularly over the diverted reach that does not follow the existing drainage line. This does not accord with the principle of habitat heterogeneity for stream diversions discussed in the ACARP report (White et al. 2014) cited by the proponent. The proponent should design the diversion to incorporate in-stream habitat heterogeneity, especially considering that deeper sections might hold water longer after flow ceases and therefore act as refugial pools. In-stream bed heterogeneity also increases habitat diversity for benthic biota and promotes hyporheic exchange (Boulton et al. 2014).
50. The proponent is required under their water licence amendment (Queensland Government 2017) to monitor the success of the diversion, in accordance with the ACARP report by Hardie and White (2001). The proponent has not detailed their approach to meeting this requirement. The proponent should outline how they will monitor the success of the diversion and their management responses if the diversion is not performing as expected. This should form a trigger-action-response plan (TARP). In particular, monitoring is required to assess how vertical (e.g. hyporheic, alluvial sediments) and lateral (e.g. riparian, floodplain) connectivity has been achieved along the diverted section.
51. As discussed in response to Question 2, the proponent should provide additional information on the potential environmental impacts of water discharges. If these environmental impacts are not acceptable, additional treatment of water prior to discharge will be necessary.

Water-dependent ecosystems

52. The management of GDEs (e.g. EPBC Act-listed Brigalow) that are not proposed to be cleared should include monitoring GDEs in reference sites outside the groundwater-drawdown zone to provide comparative baseline data. In addition, Type 1 GDEs should be monitored if the pilot survey reveals the presence of stygofauna in the alluvial sediments and other aquifers in the proposed expansion area within the predicted zone of groundwater drawdown (see Paragraph 36).
53. The proponent's primary mitigation strategy for impacts to the riparian habitat (including removal of 525 EPBC Act-listed Black Ironbox trees) is to revegetate the proposed Walker Creek Diversion. The IESC agrees this is a valuable measure to reduce impacts to the riparian zone vegetation and associated biota (including all threatened species). However, the likely benefits of the proposed mitigation are limited by the following.
- a. The proponent has not provided evidence of successful establishment of tree species (particularly Black Ironbox) along the existing diversion or from similarly constructed diversions in equivalent landforms elsewhere.
 - b. The riparian habitat to be removed is the best quality habitat on site for a number of threatened species (Greater Glider and Koala) (Eco Logical 2018, pp. 20 – 21) due to the number of tree hollows and particular vegetation inhabiting these areas. According to the draft PD (Appendix C, Fig. 3, p. 4), pit expansion through Walker Creek is proposed to occur between 2023 and 2037 and removal of the riparian habitat will need to occur before this. If revegetation is successful, it will take the revegetated diversion significantly longer than 20 years to reach a forest structure comparable to the current natural habitat. The delay between removal of the natural habitat and regrowth to an equivalent condition is likely to fragment the local population of mobile threatened species dependent on the riparian vegetation, and complete recovery may not be possible. It will also substantially disrupt the instream habitat use and ecological connectivity of the riparian zone corridors along Walker Creek, including to Carborough Creek, which enters near the upper end of the proposed 8-km diversion.
 - c. It takes more than 100 years for eucalypts to develop hollows suitable for small vertebrates and potentially more than 200 years for eucalypts to develop hollows suitable for larger animals such as the Greater Glider (Wormington et al. 2003; Wormington and Lamb 2013). There is little research on the effectiveness of nest boxes for the Greater Glider to mitigate the loss of natural hollows.
 - d. As proposed (and noting the limitations in the assessment documentation identified in paragraph 8), the diversion's steep banks, potential high erosion capacity and limited availability of alluvium when compared to the natural Walker Creek limit the IESC's confidence in the capacity of the banks, benches and floodplain of the diversion to support a self-sustaining population of Black Ironbox and potentially other riparian species.
54. To optimise successful establishment of Black Ironbox along the proposed diversion, the proponent should apply the findings from the assessments identified in paragraph 36 in the diversion's design and construction.
55. The IESC notes with concern that the proponent does not consider that the proposed clearing of Black Ironbox and riparian vegetation, that provides habitat for the EPBC Act-listed Greater Glider and Koala, requires offsetting (Eco Logical 2018, p. 60). The IESC lists significant reservations about the adequacy of the proposed ecological mitigation strategy and no potential avoidance measures such as changes to the mine plan have been proposed.

Groundwater

56. The locations of the two compliance monitoring points should be explicitly defined. Groundwater quality trigger levels have not yet been specified in the EA. The IESC notes that the Queensland Government (2011) provides groundwater quality objectives for aquatic ecosystem protection for catchments within the Fitzroy Basin, which could be a suitable starting point for defining trigger levels.
57. To improve the spatial coverage of groundwater monitoring within the project area and surrounds, additional groundwater monitoring should be considered, such as:
- a. nested bores to the west to monitor groundwater levels within the alluvium and regolith, and confined aquifers associated with the coal seam;
 - b. specific monitoring around the proposed northern and southern surface water storages to monitor potential leakage; and
 - c. specific monitoring along the proposed diversion to assess influence on groundwater within the alluvium/regolith and potential effects on nearby GDE vegetation.
58. The groundwater model should be updated periodically (e.g. every 3 years) as the data are collected to assess and inform ongoing project and cumulative impacts. Updated modelling should also continue to inform mitigation, monitoring and management strategies.

Final voids and landform

59. The information on the final landform and voids described in response to Question 2 should include measures to monitor progress on construction and stabilisation of the final landform and voids, and measures to remediate impacts. In particular, monitoring and mitigation should focus on managing sodic soils, erosion and water quality in the final void(s).

Question 4: Can the Committee provide comment on whether the potential cumulative impacts on water resources from the current mining operation, proposed expansion, and other existing and proposed mining projects in the region have been adequately addressed?

60. Cumulative impacts on water resources are partially addressed. The draft PD provides an indication of potential cumulative impacts associated with the diversion of Walker Creek and groundwater drawdown only. Given the amount of historical mining within the SWCM and the potential for future expansions within SWCM lease and other projects, including CSG development, the assessment of cumulative impacts would further need to consider:
- a. the potential for future diversion and realignment of Walker Creek to the north. Figure 3 (BMC 2018a, p. 4) suggests a future realignment to the north to potentially contain a sharp angle, which would be prone to erosion and instability;
 - b. monitoring of water quality of existing and proposed storages and releases of mine-affected water;
 - c. operational and post-closure management of final voids within the project area, SWCM and the Coppabella Mine to the south. These features introduce long-term issues that require careful consideration and planning. These issues include altered water quality and flows, influences on local groundwater flow paths and GDE persistence or recovery, and flood management. Cumulative impacts on ecological connectivity in the Walker Creek network, especially along creek lines down to Dipperu National Park, must also be considered; and
 - d. long-term regional groundwater drawdown. Deficiencies in the current groundwater model prevent an adequate assessment of cumulative impacts. Drawdown interactions and

interdependencies between the existing and proposed mine are not adequately discussed or modelled, which introduces uncertainty around the magnitude and extent of cumulative groundwater impacts. The assessment should give further consideration to existing and potential future extensions to the SWCM; the presence of the Coppabella Mine to the south; and the Arrow Bowen Gas Project in the area. In particular:

- i. future extensions of the SWCM, particular in the north section of the mining lease will contribute to cumulative impacts. Future extensions in this direction have the potential to impact on Bore 4 which is a spring located at the contact between the Rewan Formation and Clematis Group to the west.
- ii. the proximity of the Coppabella Mine suggests drawdown extents have the potential to intersect. However, there is limited monitoring between the two projects to adequately characterise this interaction.
- e. the direct removal of an 8-km section of Walker Creek and its implications for further fragmentation and loss of riparian vegetation, aquatic habitat and ecological connectivity along the river network. The proposed diversion is unlikely to replace the habitats and ecological processes provided by the current Walker Creek, especially in the short term (<10 years), with cumulative impacts potentially propagating upstream and downstream.
- f. potential reductions in surface flow caused by increased infiltration and enhanced evaporation in the (at least initially) unshaded diversion may also affect water quality and ecosystem health downstream of the diversion.

Date of advice	11 September 2018
Source documentation available to the IESC in the formulation of this advice	<p>Alluvium 2016. <i>Functional design report: Mulgrave Resource Access Walker Creek Diversion – Stage 2C</i>, May 2016. Provided as Attachment C to Appendix B to the draft Preliminary Documentation.</p> <p>Alluvium 2017. <i>Monitoring program: Mulgrave Resource Access Walker Creek Diversion Stage C</i>, February 2017. Report prepared on behalf of BHP Billiton Mitsui Coal. Provided as Attachment E to Appendix B of the draft Preliminary Documentation.</p> <p>Alluvium 2018. <i>South Walker Creek Mine Mulgrave Resources Access 2C Project – Surface Water Impact Assessment</i>, June 2018. Report prepared on behalf of BHP Billiton Mitsui Coal. Provided as Appendix B to the draft Preliminary Documentation.</p> <p>BMC 2018a. <i>MRA2C Project EPBC 2017-7957 Water Assessment</i>, 16 July 2018. Provided as the draft Preliminary Documentation.</p> <p>BMC 2018b. <i>South Walker Creek Water Management Plan</i>, 1 April 2018. Provided as Appendix D to the draft Preliminary Documentation.</p> <p>EcoLogical 2017. <i>Mulgrave Stage 2C Ecological Impact Study, Assessment of Matters of National Environmental Significance</i>. Prepared for BHP Billiton, 05 May 2017. Provided as Appendix E to the draft Preliminary Documentation</p> <p>Footprints Environmental Consultants (FEC) 2013. <i>Threatened Terrestrial Fauna Species Assessment Report for Mulgrave Pit Expansion Project, South Walker Creek Mine</i>. Prepared for BHP Billiton Mitsui Coal Pty Ltd. June 2013. Provided as part of the draft Preliminary Documentation.</p> <p>FRC Environmental 2016 <i>South Walker Creek Receiving Environment Monitoring Program Design</i>. Prepared for BMC South Walker Creek Mine, 16 September 2016. Provided as Attachment F to Appendix B of the draft Preliminary Documentation.</p>

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- Garrahy M 2018. *BMC South Walker Creek Mine Mulgrave Resource Area Stage 2C (MRA2C)*, 12 June 2018. Cover letter to the Department of the Environment and Energy. Provided as part of the draft Preliminary Documentation.
- Golder 2018. *Groundwater Impact Assessment for the South Walker Creek Mine MRA2C project*. Prepared on behalf of BHP Billiton Mitsui Coal, 11 June 2018. Provided as Appendix C to the draft Preliminary Documentation.
- Rozlapa K and Jolly J 2018. *Updated South Walker Creek Model Review*. AQ2 Pty Ltd, 16 July 2018. Provided as part of the draft Preliminary Documentation.
- State of Queensland 2016. *Environmental Authority EPML00712313 – South Walker Creek Mine*. Department of Environment and Heritage Protection, 13 September 2016. Provided as Attachment A to Appendix B of the draft Preliminary Documentation.
- State of Queensland 2017. *Application for Amendment of Water Licence: Reference 613491, application reference 582179*. Department of Natural Resources and Mines, 11 July 2017. Letter to BHP Billiton Mitsui Coal. Provided as Attachment D to Appendix B of the draft Preliminary Documentation.

**References
cited within the
IESC's advice**

- Ball J, Babister M, Nathan R, Weeks W, Weinmann PE, Retallick M and Testoni I (editors) 2016: *Australian Rainfall and Runoff: A Guide to Flood Estimation*. Geoscience Australia, Commonwealth of Australia. ISBN 978-1-925297-07-2.
- Boulton AJ, Brock MA, Robson BJ, Ryder DS, Chambers JM and Davis JA 2014. *Australian Freshwater Ecology: Processes and Management*. 2nd edition, Wiley, Chichester.
- Bureau of Meteorology 2018. *Groundwater Dependent Ecosystems Atlas*. Available: <http://www.bom.gov.au/water/groundwater/gde/index.shtml>.
- Chessman BC 1995. Rapid assessment of rivers using macroinvertebrates: A procedure based on habitat-specific sampling, family level identification and a biotic index. *Australian Journal of Ecology*, 20, 122-129.
- Chiu MC, Leigh C, Mazor R, Cid N and Resh V 2017. Chapter 5.1 Anthropogenic threats to intermittent rivers and ephemeral streams. In: *Intermittent Rivers and Ephemeral Streams: Ecology and Management*. (Editors: T Datry, N Bonada and AJ Boulton), pp. 433-454. Academic Press, London.
- Dale G, Thomas E, McCallum L, Raine S, Bennet J and Reardon-Smith K 2018. *Applying risk-based principles of dispersive mine spoil behaviour to facilitate development of cost-effective best management practices*. ACARP Project C24033.
- Datry T, Boulton AJ, Bonada N, Fritz K, Leigh C, Sauquet E, Tockner K, Hugueny B and Dahm CN 2018. Flow intermittence and ecosystem services in rivers of the Anthropocene. *Journal of Applied Ecology*, 55, 353-364.
- DSITI 2015. Guideline for the Environmental Assessment of Subterranean Aquatic Fauna. Available: <https://publications.qld.gov.au/dataset/f7e68ccd-8c13-422f-bd46-1b391500423f/resource/ba880910-5117-433a-b90d-2c131874a8e6/download/guideline-subterranean-aquatic-fauna.pdf>.
- Eamus D, Zolfaghar S, Villalobos-Vega R, Cleverly J and Huete A 2015. Groundwater-dependent ecosystems: recent insights from satellite and field-based studies. *Hydrology and Earth System Sciences*, 19, 4229-4256.
-

-
- Fisher Stewart 2002. *Bowen Basin river diversions: design and rehabilitation criteria*. ACARP Project C9068.
- Jeston P. 2011 *South Walker Creek Mine Environmental Water Management Plan*. Report SWC-ENV-PRO-5912952 v7, October 2011. Available: <http://www.environment.gov.au/epbc/notices/assessments/2013/7025/2013-7025-south-walker-creek-mine-water-mgmt-plan.pdf>.
- Glanville K, Schulz C, Tomlinson M and Butler D 2016. Biodiversity and biogeography of groundwater invertebrates in Queensland, Australia. *Subterranean Biology*, 17: 55–76.
- Hardie R and White K 2001. *Monitoring geomorphic processes in Bowen Basin river diversions*. ID&A. Report for ACARP project C9068.
- Hose GC, J Sreekanth, Barron O, Pollino C 2015. *Stygofauna in Australian groundwater systems: Extent of knowledge*. CSIRO, Australia.
- IESC 2018. *Information Guidelines for proponents preparing coal seam gas and large coal mining development proposals*. Available: <http://www.iesc.environment.gov.au/system/files/resources/012fa918-ee79-4131-9c8d-02c9b2de65cf/files/iesc-information-guidelines-may-2018.pdf>.
- Richardson S, Irvine E, Froend R, Boon P, Barber S and Bonnerville B 2011. *Australian groundwater-dependent ecosystems toolbox part 1: assessment framework*. Waterlines report, National Water Commission, Canberra.
- State of Queensland (Department of Environment and Heritage Protection) 2011. Environmental Protection (Water) Policy 2009. Available: <https://www.ehp.qld.gov.au/water/policy/fitzroy-basin.html>
- State of Queensland (Department of Environment and Science) 2018a. *WetlandInfo*. Available: <https://wetlandinfo.ehp.qld.gov.au/wetlands/>.
- State of Queensland (Department of Natural Resources, Mines and Energy) 2018b. *Queensland Globe*. Available: <https://qldglobe.information.qld.gov.au/>
- Steward AL, Negus P, Marshall JC, Clifford SE and Dent C 2018. Assessing the ecological health of rivers when they are dry. *Ecological Indicators* 85:537-547.
- Stubbingon R, Bogan MT, Bonada N, Boulton AJ, Datry T, Leigh C and 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.
- White K, Moar D, Hardie R, Blackham D and Lucas R 2014. *Criteria for functioning river landscape units in mining and post mining landscapes*. Alluvium. Final report for ACARP Project C20017.
- Whittle PL and Leggett AM 2016. *Establishing closure targets for discharge to temporary waters — a review*. 'Mine Closure 2016' Edited by AB Fourie and M Tibbett, Australian Centre for Geomechanics, Perth, pp. 495-503. Available: https://papers.acg.uwa.edu.au/d/1608_36_Whittle/36_Whittle.pdf.
- Wormington K and Lamb D 2013. Tree hollow development in wet and dry sclerophyll eucalypt forest in south-east Queensland, Australia. *Australian Forestry*, 62, 336-345.
- Wormington KR, Lamb D, McCallum HI and Moloney DJ 2003. The characteristics of six species of living hollow-bearing trees and their importance for arboreal marsupials
-

in the dry sclerophyll forests of southeast Queensland, Australia. *Forest Ecology and Management*, 182, 75-92.
