

Advice to decision maker on coal mining project

IESC 2015-070: China Stone Coal Project (EPBC 2014/7353) – New Development

Requesting agencies	The Australian Government Department of the Environment and The Queensland Office of the Coordinator-General
Date of request	24 August 2015
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Advice stage	Assessment

Context

The Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development (the IESC) was requested by the Australian Government Department of the Environment and the Queensland Office of the Coordinator-General to provide advice on the MacMines Austasia's China Stone Coal project in Queensland.

This advice draws upon aspects of information in the draft Environmental Impact Statement (EIS) together with the expert deliberations of the IESC. The project documentation and information accessed by the IESC are listed in the source documentation at the end of this advice.

The China Stone Coal Project is a new open cut and underground coal mine, located in Central Queensland, approximately 270 km southwest of Townsville and 300 km west of Mackay, in the northern Galilee Basin. The project will target the A, B, C and D coal seams of the Permian Betts Creek Beds. The proposed project will cover an area of approximately 20,000 ha and extract up to 38 million tonnes per year of product (thermal) coal, over the 50-year life of the project. Associated proposed infrastructure includes: workshop/buildings; coal covered storage areas and access roads; dragline and equipment laydown areas; coal handling and preparation plants; tailings dam; waste and water management infrastructure, dams and treatment facilities; conveyors, rail loop and train-loading facilities; and a power station.

Key potential impacts

Key potential impacts include drawdown of groundwater and reduced pressure and flow within Great Artesian Basin (GAB) aquifers (i.e. the Clematis Sandstone), and subsequent reduced supply to the Doongmabulla Springs Complex and private bores. Potential subsidence impacts include alteration of surface features including development of ground surface depressions, enhancement of inter-aquifer connectivity, and cracking of the bed of the Northern Seasonal Wetland. Potential hydrological and ecological impacts may arise from mine water discharges. There is uncertainty regarding the potential impacts both from this mine and cumulatively from the adjacent Carmichael Coal Mine (CCM) project

to groundwater dependent ecosystems (GDEs) including the Doongmabulla Springs Complex. The proposed project and the CCM project both require a large external water supply (up to approximately 12 GL/year each) however the potential impacts of sourcing this supply on surface water or groundwater resources have not been assessed.

The IESC recognises the proposed project is a greenfield site with a lack of representative spatial, temporal and hydrostratigraphic variation in data available for the area. This lack of data results in uncertainty in the hydrogeological conceptualisation and subsequent numerical groundwater modelling predictions. This uncertainty leads to low confidence in the potential impacts predicted by the proponent, and makes tenuous any comment on the appropriateness of mitigation and management measures. The advice, therefore, necessarily identifies further information and data that is needed to address the questions raised.

Assessment against information guidelines

The IESC, consistent with its Information Guidelines (IESC, 2014), has considered whether the proposed project assessment has used the following:

Relevant data and information: key conclusions

The proponent's groundwater monitoring data was collected over a limited timeframe, does not provide a regional context for, and is inadequate to assess spatial and temporal variability of groundwater flows,. The data provided is insufficient to confirm the presence and hydrogeological influences of a posited fault in the proposed Northern underground mining area. Available data from shallow bores indicate that the majority of the Clematis Sandstone is dry or unsaturated in much of the project area, which limits prediction of impacts. Ecological attributes onsite and offsite were inadequately assessed, with survey locations only visited on one occasion, or surveys only being undertaken at the beginning and end of the dry season. Baseline surface water quality and quantity data is insufficient to establish environmental management objectives for the project.

Application of appropriate methodologies: key conclusions

The groundwater model is classified as Class 1 (Barnett, et al., 2012), which is inappropriate for an impact and assessment model at the project scale. There was no transient calibration, uncertainty analysis or peer review undertaken. Sensitivity analyses were undertaken on the numerical groundwater model to determine the influence of the fault and potential subsidence impacts. However, an uncertainty analysis was not undertaken on the numerical groundwater model predictions. Subsidence modelling used an acceptable empirical method. The fault was not considered as part of predicting subsidence impacts and no justification of the extent of connective cracking above the dual seam longwall mining area was provided. A simplistic cumulative impact assessment of the CCM project and China Stone project was undertaken by superimposing maximum predicted groundwater drawdown contours for each project on a map and not through appropriate calculations. Other reasonably foreseeable coal projects, such as Hyde Park Coal Project, were not considered. The full extent of potential cumulative impacts has not been considered, including to the Doongmabulla Springs Complex and to sources of water supply for the mines.

Reasonable values and parameters in calculations: key conclusions

Modelled hydrograph data presented provides consistently poor matches to observed head levels. For surface flows, the Australian Water Balance Model runoff modelling parameters were appropriately selected based on experience and a review of comparable mining operations in central Queensland and the Galilee Basin. Water quality guidelines (ANZECC & ARMCANZ, 2000) are incorrectly quoted as mg/L rather than µg/L (EIS Appendix G, Table D1), leading to incorrect conclusions about potential exceedences within the project site.

Advice

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

Question 1: What are the key uncertainties, risks and potential impacts on water resources? Are there additional measures and commitments required to adequately mitigate, monitor and manage potential risks and impacts to water resources?

Response

1. There are numerous uncertainties associated with this project due to insufficient hydrogeological, hydrological and ecological data presented both within and surrounding the project area. This lack of data results in uncertainty in the hydrogeological conceptualisation and subsequent numerical groundwater modelling predictions. This uncertainty leads to a lack of confidence in the potential impacts predicted by the proponent, and makes tenuous any comment on the appropriateness of mitigation and management measures.
2. The key uncertainties arise from the lack of monitoring data to provide any meaningful interpretation of baseline conditions. These impact on:
 - a. the appropriateness of the hydrogeological conceptualisation (including the fault and associated strata in the Northern underground mining area and the relationship between surface water and groundwater systems, such as the Doongmabulla Springs Complex and Lake Buchanan); and
 - b. the reliability of the numerical groundwater model and its predicted impacts.
3. No environmental risk assessment was undertaken for water resources or water-related assets. The key uncertainties above lead to the risk that the potential impacts on water resources have not been identified. For example, there is the risk that cumulative depressurisation effects may extend to key water-related assets, such as the Doongmabulla Springs Complex.
4. As a consequence a number of key potential impacts are identified but are not sufficiently quantified. These include:
 - a. drawdown of groundwater and reduced pressure and flow within GAB aquifers (i.e. the Clematis Sandstone) and reduced supply to private bores;
 - b. alteration of surface features including development of ground surface depressions, expansion of inter-aquifer connectivity, and cracking of the bed of the Northern Seasonal Wetland from subsidence;
 - c. changes to the flow regime in Tomahawk Creek and North Creek catchments;
 - d. mine water releases with contaminants potentially exceeding guidelines for the protection of aquatic ecosystems across large floodplain areas downstream of the project area; and
 - e. potential cumulative impacts to the Belyando River catchment and GDEs including the Doongmabulla Springs Complex.

5. Further baseline and time-series monitoring data needs to be collected from within and beyond the project area on surface water and groundwater quantity and quality, especially groundwater levels within the Clematis Sandstone and Moolayember Formation. Data should be collected to ensure that seasonal variability and the relationship between surface water and groundwater systems are captured. This data should be utilised to further assess potential impacts to water resources and water-related assets. An appropriate monitoring programme should be designed to reduce uncertainty associated with predictions and quantify potential impacts. This should be used to inform the design of a follow-up monitoring programme to assess impacts and the effectiveness of mitigation or management strategies during and after mining.

Explanation

Groundwater

6. The Clematis Sandstone is reported as being unsaturated or dry in the project area based on the bore data presented. However, this same unit is considered to be the source aquifer for the Doongmabulla Springs Complex (e.g. Bradley, 2015).
7. Given the inconsistency between project site and other regional information, it is unclear how depressurisation from the proposed project would impact on the Clematis Sandstone.

Surface Water

8. Potential impacts to the surface water flow regime include:
 - a. Projected reductions in catchment area of Tomahawk and North creeks by approximately 2% and 7% over the life of the project (and reductions of 2% for both catchments post mining).
 - b. Subsidence impacts resulting in surface cracking, ponding, impacts to residual pools and subsequent loss of catchment yield.
 - c. Change in the inundation regime for floodplain habitat, ephemeral drainages and creeks downstream of the project area, and drainage corridors onsite.
9. Investigation and assessment into surface water flow regimes should be undertaken for creeks downstream of the project area, such as Pigeonhole Creek, North Creek and the “major waterway” identified (under the Department of Agriculture Forestry and Fisheries’ mapping system) in the Tomahawk Creek catchment.
10. The release of large volumes of mine-affected water from mining pits across a 64 km length of relatively flat ground with small drainage lines. Mine water releases can be expected to have increased turbidity, salinity, contaminants (e.g. metals) that are likely to exceed aquatic ecosystem protection limits. Subsidence may also increase erosion leading to water quality impacts in downstream areas.

Surface water-groundwater interaction

11. There is a lack of monitoring data to inform the understanding and assessment of potential impacts to sites with groundwater-surface water interaction, which include the Doongmabulla Springs Complex and Lake Buchanan and smaller scale GDEs on drainage lines or seasonal perched aquifers.
12. A monitoring programme should be developed that allows for the assessment of groundwater-surface water systems. This programme could include an early warning methodology to ensure mine-induced depressurisation does not impact the Doongmabulla Springs Complex, Lake Buchanan and the Caikingburra Swamp.

Ecology

13. Ecological impacts are uncertain as there is no mapping of ecological attributes and no ecological survey effort outside the project boundary. Surveys are expected to extend to (at least) the predicted extent of groundwater drawdown (IESC, 2014).
14. Aquatic surveying was inadequate with locations visited on one occasion or only undertaken at the beginning and end of the dry season. For example, only one round of sampling for stygofauna was undertaken within the project area, with only two Tertiary bores sampled. Best practice guidelines (WA EPA, 2007) state that sampling should be done across the zone of impact and at least twice. Dr Grant Hose, the expert who examined the samples, mentioned the need for multiple sampling events in his letter attached to the EIS assessment documentation (EIS, Appendix E of Appendix G).
15. The proponent considers there is no shallow groundwater onsite to support GDEs. Water levels in the Tertiary sediments below North Creek are 15-20 metres below ground level suggesting that potential GDEs should be considered in the assessment.
16. The project area contains two seasonal wetlands, and a series of residual pools within the drainage lines which are generally considered of less value by the proponent due to the non-permanence of their water supply. The Southern Seasonal Wetland will be removed by open cut mining, and the Northern Seasonal Wetland will be undermined by longwall mining.
 - a. The proponent's claim that these wetlands do not provide important habitat for a number of waterbirds (including migratory species) due to their seasonal nature is not supported by sufficient evidence, due to the lack of survey effort.
 - b. The proponent considers the Northern Seasonal Wetland is not dependent on, nor interacts with, groundwater due to the large depth to groundwater in this area. The potential for dependence on the role of perched groundwater was not considered.
 - c. Subsidence may result in potential impacts to the Northern Seasonal Wetland including:
 - i. a loss in storage capacity as perched groundwater and surface water are lost to the fracture zone, particularly if impacts occur during the period the wetland holds water;
 - ii. ponding and increased areas of inundation; and
 - iii. habitat disturbance during surface subsidence remediation activities.
17. The proponent defined high value habitat for a number of threatened bird species (squatter pigeon and black throated finch) based on distance to permanent water sources. The loss of residual pools, riparian habitat, and the Southern Seasonal Wetland may decrease the suitability of surrounding habitat for species reliant on water. Many species records for the black throated finch are some distance from mapped permanent water sources, and not within high value habitat. The black throated finch may require a greater mosaic of habitat (see DECC NSW, 2007) than the high value habitat identified by the proponent.

Water resources

18. The mine water management system is predicted to have a water deficit throughout the proposed operations. The annual external water requirement over the life of the mine is predicted to range from approximately 903 ML/year under wettest modelled conditions to 12,300 ML/year under driest modelled conditions.

- a. The proponent is considering options for sourcing external water supplies. However, insufficient information has been provided to enable assessment of the viability of supply and impacts to other water users.
- b. Potential impacts on the surface water and groundwater resources from where this water is sourced from should be assessed, particularly when considering the impact of the external water requirements for the adjacent CCM project.

Mitigation, monitoring and management

- 19. A groundwater monitoring programme should be developed to reduce uncertainty associated with the current conceptualisation and associated model predictions (see response to Question 8 below).
- 20. Assessment of the potential impacts to surface water resources from the proposed project would be improved by:
 - a. Water quality objectives being established and justified for each relevant receiving water resource.
 - b. Contextual information about the surface water quality dataset, such as time, frequency and corresponding flow level, being provided to ensure that the data are representative of the existing condition and that the data set spans a suitable period of record, and relevant ANZECC & ARMCANZ (2000) guidelines are applied appropriately.
 - c. Installing monitoring stations immediately downstream of the project area (and the discharge point) to assess water quality changes to Pigeonhole Creek, North Creek, and downstream of the confluence of North Creek and the “major waterway” identified in the Tomahawk Creek catchment to detect any water quality change to the Belyando River.
- 21. The proponent notes a commitment to monitor ongoing health of flora and fauna retained in the project area, with details to be outlined in the biodiversity management plan which was not available in the assessment documentation, preventing assessment of the suitability of the proposed plan.
 - a. The provision of fauna watering points beyond the project area to mitigate for the loss of surface water sources should be considered.
 - b. Aquatic surveys were undertaken in May and October 2012 at 22 sites but not all sites could be resurveyed in October due to a lack of water. These sites should be re-surveyed to assess temporal variability particularly with regard to the wet and dry seasons.
 - c. Terrestrial surveys were generally undertaken at the beginning and end of the dry season, however it is important to conduct surveys during the wet season. If this is not possible, reasons should be stated and the precautionary principle applied.
 - d. Stygofauna surveys were limited to a single sampling occasion which is inadequate (see paragraph 13) and should be consistent with the best practice guidelines (WA EPA, 2007).

Question 2: Does the IESC agree with the proponent’s assessment that there is no direct groundwater – surface water interconnection within the predicted extents of groundwater drawdown?

Response

22. No. There are small areas within and outside the project area of potential and known groundwater-surface water interaction, including: seasonal perched aquifers along Bully Creek or drainage lines that support GDEs (e.g. River Red Gum), the Northern Seasonal Wetland, the Doongmabulla Springs Complex and Lake Buchanan.

Explanation

23. Groundwater is reported as typically being at depths in excess of 15 m below ground throughout the project area, and locally in excess of 100 m. Local topography in the area is dominated by the Darkies Range which forms an area of groundwater recharge and groundwater flow generally follows the topography to the east and west of the recharge zone.
24. Quaternary sediments (mud and gravel) can provide a water source supporting River Red Gum and Forest Red Gum along ephemeral drainage lines. Whilst the proponent found only thin (less than 1 m thick) patches of Quaternary sediments, there is insufficient evidence to confirm the broadscale absence of Quaternary sediments across the project area. As there is the potential for impacts to the water content of these sediments from subsidence or groundwater drawdown, their presence (or otherwise) and hydrology should be further investigated.
25. Lake Buchanan, listed on the Directory of Important Wetlands, has been inferred by the proponent as an indirect discharge zone for the Clematis Sandstone via the overlying Moolayember Formation due to the high saline water quality of the lake. There is insufficient groundwater monitoring data for the Clematis Sandstone, Rewan Formation or the underlying Permian Formation to the west of the project area. This limits understanding of Lake Buchanan groundwater-surface water dynamics and any potential future propagation of depressurisation towards Lake Buchanan. The 1 m drawdown contours provided by the proponent suggest that Lake Buchanan will not be impacted. However, it is important to note that given a steady state model has been used, some drawdown impact would be expected at the lake. Higher resolution model predictions, including a transient calibrated model and 0.2 m drawdown contours, would provide stronger evidence of potential drawdown impacts not reaching the lake.
26. The absence of shallow groundwater from the project area conflicts with the Bureau of Meteorology (BoM) GDE Atlas mapping and Queensland Wetland mapping tool. These show potential for groundwater interaction with terrestrial GDEs such as Eucalyptus species associated with the Regional Ecosystem in the north of the project area. Furthermore, the Bingeringo Aggregation (listed on the Directory of Important Wetlands), includes a section of Bully Creek that drains off the escarpment to the north of the project area and a section of Bully Creek is known to hold water at the height of drought (DIWA, undated-a), which indicates likely groundwater input.

Question 3: Has the existing conceptual groundwater regime been adequately characterised, including the hydrogeology of each stratigraphic unit? If not, what changes should be made to the conceptual groundwater model?

Response

27. No. More hydrogeological data is needed to support the underpinning conceptualisation and parameterisation of the groundwater model, including: confirmation of the extent of saturation of the Clematis Sandstone, surface water-groundwater interaction at Lake Buchanan, groundwater flow to the north of the project area and the presence of the North-north-west South-south-east trending fault in the Northern underground mining area.

Explanation

28. The fault in the Northern underground mining area is assessed as penetrating through the Clematis Sandstone and Rewan Formation, being downthrown approximately 100 m to the east, and truncating the Clematis Sandstone against the Rewan Formation. Concerns about the presence and potential influence of this fault include:
 - a. Bore data provided in the assessment documentation was for groundwater monitoring data only and provides inconclusive evidence for the presence of the fault.
 - b. There is a lack of evidence on the characteristics of the fault (as it is presented as an isolated feature), or justification of why the fault stops at the northern edge of the project area and just north of the area of the southern open cut mining pit.
29. To the west of the project area, there is limited monitoring of the Clematis Sandstone, Rewan Formation or the underlying Permian Formation (Betts Creek Beds and associated coal seams). This does not allow for adequate understanding of groundwater-surface water dynamics at Lake Buchanan.
30. The Rewan Formation was accounted for using two model layers, but it is unclear why two layers were chosen, and what or when parameters differed between the two layers.
31. The monitoring network does not provide sufficient information to conceptualise the groundwater regime in the project area. There is only one bore to the north and north east of the project area, which did not fully penetrate the Clematis Sandstone sequence in this location and did not intersect groundwater, limiting understanding of groundwater flows, groundwater-surface water interaction, and potential cumulative (i.e. with the proposed Hyde Park Coal Project) impacts in this area.

Question 4: Are the groundwater conceptualisation, groundwater contours and flow direction representative of the aquifer systems based on information available?
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Response

32. No. The information available:
 - a. does not support the conceptualisation of the fault in the Northern underground mining area;
 - b. could reasonably be interpreted to produce alternate groundwater contour maps and flow directions;
 - c. does not provide sufficient detail to support the groundwater contour maps and flow direction presented for the Permian and Rewan Formation; and
 - d. does not provide a regional context for groundwater behaviour within the project area.

Explanation

33. The monitoring network does not provide sufficient information to conceptualise the groundwater regime, groundwater contours and flow direction within the project area. Additional groundwater level/pressure data should be collected to confirm groundwater flow directions for the Tertiary sequence, Clematis Sandstone, Rewan Formation and the Permian sequence. A broader regional context should also be provided to understand local groundwater processes.

34. The groundwater contours for the Permian stratigraphy demonstrate that groundwater north of the project area flows in both a westerly and easterly direction. It is unclear how the proponent established the groundwater flow direction as there are no bores at this location.
35. In the Rewan Formation there are no monitoring bores located to the north and south, or within the south east, of the project area, yet an overall easterly flow direction is inferred. It is unclear how data for the Rewan Formation flow direction was obtained. Based on the presented data from a single bore (MB 24), it is not possible to infer a flow direction at Lake Buchanan.
36. No groundwater flow contours were provided for the Clematis Sandstone, due to the Clematis Sandstone being unsaturated and possibly even dry (5 out of 6 monitoring bores were dry – the other bore has a slotted interval encompassing the base of the Clematis Sandstone and the top of the Rewan Formation). The proponent should provide more information on the Clematis Sandstone, including saturation of the formation and groundwater flows by increasing the number of monitoring bores to the south, east, and north and outside of the project area to reduce the level of uncertainty in regards to the level of saturation and consequent modelling predictions.

Question 5: Is the numerical groundwater model adequate to identify and quantify potential impacts to groundwater resources? Is the sensitivity analysis conducted by the proponent sufficient to encompass the range of likely uncertainty in key parameters and variability in aquifer parameters? If not, what changes should be made to the numerical groundwater model?

Response

37. No. There are significant uncertainties associated with the numerical groundwater model as the conceptualisation and parameterisation used is not supported by adequate information. The numerical groundwater model is classified as Class 1 (Barnett et al., 2012) as there has been no peer review and no transient calibration, with transient predictions made with steady state calibration.
38. No. Sensitivity analysis was undertaken using a range of suitable parameters for the steady state numerical groundwater model. Sensitivity analysis was also undertaken to test the influence of the fault acting as either a high permeability or low permeability layer. However, sensitivity analyses were not conducted on model boundaries and the results of the numerical groundwater model did not undergo an uncertainty analysis, which limits understanding of model behaviour and the reliability of the numerical groundwater model predictions.
39. More monitoring data is needed to calibrate the model and the groundwater model should undergo transient calibration. Boundary conditions should be justified and undergo sensitivity testing, and a robust programme for update and review of the groundwater model should be defined as additional data becomes available.

Explanation

40. The proponent suggests that the steady state calibration addresses the long-term groundwater behaviour. Whilst there was no transient calibration, transient verification was undertaken using transient water level records to verify that the model could replicate water levels measured in the monitoring bore network installed for the project. The 26 hydrographs are presented for model verification, but data was only collected for 6-12 months and shows little variability. This may not be representative of long-term groundwater behaviour.

41. Northern and southern boundaries of the model are parallel to interpreted groundwater flow directions, but it is unclear how the west and east boundaries were determined. Justification should be provided on the east and west boundaries and why the base of the model was set as a no-flow boundary.

Question 6: Are the hydraulic parameters used for the base case, as well as to simulate fracturing from underground longwall mining, considered appropriate?

Response

42. The appropriateness of base case parameters cannot be determined, due to the lack of data available. The factors applied to simulate the effects of subsidence fracturing (in some cases, producing a free draining system) exceed other reasonable estimates (see Guo et al., 2007). There is a risk that this simulation of fracturing is unduly influencing drawdown predictions.

Explanation

43. The hydraulic parameters for all major stratigraphic units were established through in-situ permeability testing (18 falling head and 68 in-situ packer tests) and data from permeability testing at the CCM project. There is a paucity of data available to support the base case hydraulic parameters used for the Quaternary sediments, Ronlow Formation and Moolayember Formation. Quaternary sediments and the weathered rock regolith modelled hydraulic parameters fall outside the range of available field data for both the proposed project and CCM project. For the proposed project no data was available for the Moolayember Formation and the Ronlow Formation.
44. In the numerical groundwater model, the hydraulic conductivity of shallow strata (Rewan Formation and Clematis Sandstone) in the Northern underground mining area was increased to reflect the predicted fracturing associated with subsidence. The high hydraulic conductivity values used to simulate subsidence-induced fracturing may limit the predicted extent of groundwater drawdown in the Betts Creek Beds Units. The proponent should run the model with lower modified hydraulic conductivities for the overlying units to determine the sensitivity of drawdown in the Betts Creek Beds Units to the modified hydraulic conductivity of the Clematis Sandstone and Rewan Formation.
45. Subsidence modelling was undertaken using empirical methods because it is a greenfield project and there is no measured data. Parameters for the subsidence model were reasonable, based on subsidence data from the Bowen Basin presented in the 2012 South Galilee EIS. Once subsidence data from longwall coal projects in the Galilee Basin becomes available, subsidence predictions should be updated.

Question 7: Does the groundwater model require a peer review?

Response

46. Yes, a peer review of the groundwater model should be undertaken, as recommended in the IESC Information Guidelines (2014).

Question 8: Is the proposed groundwater monitoring program adequate to determine baseline conditions, provide a continued understanding of the groundwater systems, and monitor impacts to groundwater resources as a result of the project such as changes in water levels, both on and off lease, over time from both a spatial and aquifer extent? If not, what changes should be made to the groundwater monitoring program?

Response

47. No. At present the monitoring programme has insufficient spatial and stratigraphic coverage to adequately determine baseline conditions, characterise and enable appropriate assessment of, or monitor potential impacts to water resources.
48. The groundwater monitoring programme should be focused on reducing the uncertainty in the groundwater model conceptualisation and parameterisation and informing quantification of impacts to identified environmental objectives and water-related assets. This will need a greater extent (beyond the project area, more hydrostratigraphic units) and increased resolution (temporal frequency and spatial density) of monitoring stations than is currently proposed by the proponent.

Explanation

49. The pre-mining groundwater monitoring network consisted of 31 monitoring bores at 24 locations, although 13 monitoring bores have been reported as being dry, and should not be considered part of the ongoing monitoring network. Baseline monitoring results from December 2012 to August 2013 did not record any significant changes in groundwater levels from hydraulic stresses.
50. Specific issues relating to baseline monitoring include:
 - a. The distribution of bores does not adequately cover the south east of the project area.
 - b. There is insufficient monitoring of the Clematis Sandstone, Rewan Formation or the underlying Permian Formation (Betts Creek Beds and associated coal seams).
 - c. There is uncertainty regarding the screened formations for bores (i.e. 153583, 153582, 8 Mile bore) to the west of the project area.
 - d. There is only one bore to the north and north east of the project area, which did not intersect groundwater, limiting understanding of groundwater flows, potential groundwater-surface water interaction, and potential cumulative impacts in this area.
 - e. There is no baseline monitoring of potential shallow perched groundwater in the Northern Seasonal Wetland, which could be drained by cracking associated with subsidence.
 - f. While there is a model prediction for take from the GAB, there is no described monitoring-based methodology for determining and verifying baseline contribution of recharge to the GAB.
51. There is no justification of monitoring bore and screen locations during operations, with only one dedicated offsite monitoring bore proposed. The proposed network does not include monitoring of potential impacts associated with mine subsidence and associated fracturing/cracking, or potential impacts to Lake Buchanan, the Northern Seasonal Wetland and the Doongmabulla Springs Complex.
 - a. The proponent proposes that the current monitoring network will be maintained throughout the project, and that any monitoring bores removed during the mining process will be replaced where necessary. As well as removal, a number of the existing monitoring bores are dry or at risk of being damaged beyond use due to fracturing associated with subsidence. As most of the monitoring network may need to be replaced, a description should be provided of where replacement bores will be placed.

- b. The proposed network does not have capacity to monitor potential water quality issues associated with mine storage waste facilities. Monitoring bores MB20 and MB32 are dry and were finished and screened in the Tertiary sediments above the water table (total bore depth 25 m), limiting their capacity to detect any potential groundwater contamination associated with the tailings dam, or waste storage facilities.
52. The proponent indicates that impacts will be managed by investigating bores where the drawdown exceeds 90% of the maximum predicted drawdown and those which return water quality concentrations in excess of the 85th percentile of background data (triggers yet to be determined from data collected prior to mining).
- a. Justification should be provided for the selection of the 85th percentile, given the standard use of the 80th percentile by ANZECC & ARMCANZ (2000).
 - b. While the proponent notes that they will propose groundwater triggers and limits in water management plans post approval, there are no indications of any potential limits or what would be done if a limit were to be exceeded.
53. A monitoring programme should be developed that:
- a. Provides justification of monitoring bores and screen locations and a methodology for quantifying impacts.
 - b. Determines hydrogeological impacts associated with subsidence, including a methodology for assessing impacts to groundwater systems and interactions with surface water.
 - c. Provides for the assessment of hydrology/hydrogeology of the Northern Seasonal Wetland and its potential contribution to Pigeonhole Creek and North Creek catchments.
 - d. Includes additional monitoring locations with multi-level wells screened/monitored in all potentially impacted strata to the north and west of the project area to determine potential impacts to Lake Buchanan, and to the west and south of the project area, to determine the proposed project's potential impacts on the Doongmabulla Springs Complex.
 - e. Provides understanding of the groundwater-surface water interactions at Lake Buchanan and developing an early warning methodology to ensure mine induced depressurisation does not impact on lake hydrology or the hydrology of Caukingburra Swamp.
 - f. Quantifies and verifies mine induced impacts to GAB recharge.
54. Commitments for surface water and groundwater monitoring should be presented as part of a water monitoring plan and should be consistent with the National Water Quality Management Strategy.

Question 9: Have impacts to the GAB and the Belyando River catchments, including the impacts of long-term water take, been adequately identified and quantified?

Response

55. Impacts to the GAB and the Belyando River catchments have been identified but they have not been quantified consistently. For example:
- a. Estimates for the peak take during mining operations and long-term take from the GAB are reliant on the current numerical groundwater modelling predictions, which are uncertain (refer to response to Question 5).

- b. Uncertainty exists regarding the potential impacts to the Belyando River catchment as combined water quantity impacts (including loss of catchment area, subsidence, and external water supply) have not been quantified. Sources of water supply and potential cumulative impacts to the Belyando River catchment (given it may supply water to the CCM project), should be identified and assessed.
- c. Impacts to surface water quality and downstream ecosystems as a result of mine-water discharges have not been adequately assessed and may be greater than predicted.

Explanation

56. It is proposed that the surplus water from mine pits will be discharged through the Mine Water Dam to the Belyando River via a tributary drainage pathway in the North Creek catchment. The tributary drainage pathway from the Mine Water Dam to the Belyando River is approximately 64 km in length and comprises ephemeral drainage lines and creek lines within the North Creek catchment, upstream of the Belyando River. However:
- a. A map of this discharge point and the tributary drainage pathway in the North Creek catchment was not provided, nor was detailed information about the water quality and flow conditions of the receiving waters, proposed discharge rate, duration and timing.
 - b. There is a lack of information to assess potential risks to the water resources and ecological communities from discharge within the tributary drainage and in the Belyando River Catchment.
 - c. Background surface water quality for aluminium, copper, and zinc exceeded ANZECC & ARMCANZ (2000) guideline values at several sites. Mine-affected water discharges could exceed aquatic ecological values for turbidity, salinity, nutrients, contaminants (e.g. metals).
57. The loss of catchment area across the project area has been reported by the proponent although inconsistently. For example, the EIS states that total catchment loss during mining is predicted to peak at 4,226 ha at year 30 (EIS, P13-27), which is less than the sum of the combined maximum catchment impacts reported in the technical report (4,462 ha; Appendix K, P12).
58. There is no assessment of the impact that this loss of contributing catchment may have on surface flows. The loss of surface flows due to subsidence effects, such as surface cracking and ponding, has not been estimated. Whilst the proponent claims in the EIS “no loss in catchment yield” with the application of subsidence remediation (EIS, P13-29), a quantification of the potential impact on catchment should be provided to account for the risk that remediation is not effective.

Question 10: What is the acceptable GAB take long term post mining? (Page 18 Appendix B summarises this)

Response

59. The acceptability of water take is a matter for the regulator.

Question 11: Does the IESC agree with the proponent’s assessment that Lake Buchanan is a discharge zone for the Moolayember Formation and the underlying Clematis Sandstone, and that the project will not impact groundwater levels in the Lake Buchanan area?

Response

60. Evidence (Lorimer, 2005; DIWA, undated-b) suggests that Lake Buchanan is a groundwater discharge zone. Limited information was provided by the proponent to confirm the presence, or source, of this groundwater discharge and as such, potential impacts remain uncertain. Additional data, including monitoring to the west of the project area, would increase the understanding of this system and assist in identifying any potential impacts.
61. Although the numerical groundwater model 1 m drawdown contours suggest that Lake Buchanan will not be impacted by a drawdown of this magnitude, higher resolution model predictions including drawdown contours at the 0.2 m scale would provide greater insight into any potential impacts to Lake Buchanan. However a transient calibrated model is required to quantify the level of impact as small changes may change the nature of the groundwater discharge into the lake.
62. The proponent models some leakage from the Clematis Sandstone to underlying units. If the Clematis Sandstone is dry in parts of the project area, and the numerical groundwater model does not represent it as such, then the overall water balance is likely to be incorrect.

Question 12: Is the proponent's subsidence impact assessment and modelling adequate to assess and quantify the potential impacts to water resources? Are the proposed measures to mitigate and manage the potential impacts of subsidence adequate? If not, are there additional measures available to mitigate and manage impacts to water related assets?

Response

63. There is uncertainty regarding the subsidence impact assessment and low confidence in the modelling to quantify potential impacts as:
- a. the parameters applied from the Bowen Basin may differ in the Galilee Basin and need to be verified as part of a monitoring programme;
 - b. fracture height selection was not justified;
 - c. the full range of potential vertical and horizontal hydraulic conductivities have not been explored;
 - d. potential connectivity of the subsurface fracture network has not been considered;
 - e. there is uncertainty in dual seam subsidence effects as the implications for the extraction sequencing in the proposed project are unclear; and
 - f. the role of the fault was not considered within the subsidence assessment (noting it was included within the groundwater assessment).
64. Limited data is available in the Galilee Basin to reduce uncertainty in subsidence predictions. Confidence would be increased by consideration of the variation of impacts and the actual process over time (cracks may develop, then fill with sediment; fracture networks may be flooded, then drain).
65. The Crack Subsidence Remediation Strategy may prove ineffective in some areas because it assumes that cracks can be remediated but this may not be the case for rocky drainage lines that are present in the area.

66. Adaptive management measures such as Trigger Action Response Plans (TARPs) should be considered for management approaches to mitigating impacts to drainage lines and the Northern Seasonal Wetland. Further mitigation options may need to be considered, such as narrower longwalls, or mining methods with lower subsidence impacts. Importantly, the proponent should commit to a programme of periodically revised subsidence prediction following mining commencement.

Explanation

67. The Surface Deformation Prediction System (SDPS) was used for subsidence modelling, which relies on project data to calibrate the function. As no data is currently available for the proposed project, the accuracy of the outputs will be reduced (Commonwealth of Australia, 2015). This is an intrinsic problem given the lack of longwall mining to date in the Galilee Basin.
68. There is no evidence to suggest that the potential for increased subsidence impacts from settling of multiple goaf strata after longwall extraction has been taken into account. No justification of the length of connective cracking above the dual seam longwall mining area was provided, with only a 50% increase in height of continuous cracking above the A seam applied in dual mining areas. Further, the connective cracking value of 120 m for a single seam is not supported by evidence or methodology. Fracture height estimation should be based on available work (e.g. Ditton and Merrick (2014)).
69. There is uncertainty regarding the hydrogeological conceptualisation of the Northern Seasonal Wetland and a lack of consideration of the potential impacts to this wetland and surrounding drainage lines. The proponent reports that this wetland will not be affected because water and sediment are expected to fill and seal the cracks. However:
- a. No supporting evidence is provided to support this assumption.
 - b. The proponent describes that the project area drainage features include a network of gullies in the steeper topography associated with Darkies Range. These gullies are characterised by steep rocky sides confining narrow rocky channels.
 - c. There is no assessment of the base of the wetland or if the wetland is sustained by a perched water table, and the effects subsidence may have on the ability of the wetland to retain water.
 - d. If cracking and fractures do not reach the surface there is still the possibility that fracture networks exist relatively close to the surface which will lead to increased draining from the wetland and less water flowing down the streams into the tributaries.
 - e. The potential impacts to the ecology reliant on the wetland if the wetland is drained for one or more seasons, or if the wetland drains more rapidly, were not considered.
70. Further assessment of the Northern Seasonal Wetland, particularly with regard to the base of the wetland and quantitative surface flow modelling of the drainage surrounding the wetland should be undertaken.
71. Mitigation is proposed using the subsidence crack rehabilitation programme, whereby monitoring and remedial action will be undertaken if subsidence effects are observed. However, remediation strategies such as sealing fracture networks of exposed rock in creeks and tributaries have been found to be costly, risky and likely to have a limited lifespan (Commonwealth of Australia, 2014).

72. Adaptive management measures such as Trigger Action Response Plans (TARPs) may be a suitable management approach to mitigating impacts to drainage lines and the Northern Seasonal Wetland. This could include having early warning trigger values, and clear, enforceable response measures capable of mitigating impacts.
73. Once subsidence data is available, subsidence predictions should be reviewed and further modelling should be undertaken, including calibration, verification and validation.

Question 13: Does the proponent's water resources assessment give adequate consideration to cumulative impacts between this project and the Carmichael Coal Mine and Rail Project (EPBC 2010/5736)?

- a. If both projects operate concurrently have the cumulative groundwater impacts during both the operations phase and post mining phase been appropriately addressed in the EIS documents?
- b. If not, what changes should be made to ensure the assessment represents a conservative and risk adverse approach?
- c. Does the IESC have any concerns with the project's contribution to cumulative impacts upon the Great Artesian Basin and Belyando River catchment?

Response

74. There has been no formal assessment of the likely magnitude and significance of cumulative impacts either during the operations phase or post mining. The proponent considers cumulative impacts to groundwater, however the full extent of potential direct, indirect, upstream, downstream, and consequential impacts, including to the Doongmabulla Springs Complex, surface water and downstream ecosystems have not been considered.
 - a. No. The cumulative groundwater impact assessment between the CCM project and China Stone projects was undertaken by superimposing maximum predicted groundwater drawdowns on a map during operations and post mining for each project. No appropriate calculations were undertaken. This is approach is inadequate to estimate the extent of cumulative groundwater drawdown impacts.
 - b. Appropriate monitoring and adaptive management should be put in place for potential cumulative impacts to Lake Buchanan and Doongmabulla Springs Complex, in conjunction with specific assessment of the risks to these specific assets.
 - c. There are concerns about potential cumulative impacts to the Belyando River catchment, due to water supply needs, water discharges and loss of contributing catchment. Cumulative impacts to the GAB are more likely to be significant at the local scale rather than the regional scale.

Explanation

75. Cumulative impacts were considered from the CCM project and Moray Power Project, but did not consider other 'reasonably foreseeable' coal projects such as the Hyde Park Coal Project.
76. The proponent presents maps of maximum cumulative groundwater depressurisation contours for the water table in the Tertiary, and A/B and D coal seams. The proponent has considered project stages to some extent—cumulative groundwater drawdowns have been considered for the coal seams at the end of and following mining. On the basis of the proponent's assessment, the only area of concern for groundwater impacts is that between the CCM project and the China Stone project. However:

- a. There is only one bore to the north of the project area, which did not record a groundwater level limiting identification and quantification of potential cumulative impacts in this area.
 - b. The drawdown at the end of mining in the D seams appears to be much lower for the proposed project than for the CCM project.
 - c. The CCM project modelled depressurisation of up to 1 m in the Clematis Sandstone. The proponent states that there will be no cumulative impact on the Clematis Sandstone, but the IESC has low confidence in this statement given uncertainties in the proponent's modelling.
77. There is the potential for cumulative impacts as a result of groundwater depressurisation on Darkies Range and subsequent impacts to Doongmabulla Springs Complex and associated downstream ecosystems (e.g. Waxy Cabbage Palm). The proponent rules out cumulative impacts to the springs as the project's predicted post-mining 1 m drawdown contour only extends half the 22 km to these springs. However, impacts remain uncertain as a thorough assessment of cumulative impacts on the springs has not been undertaken and the source of the springs is not certain (see Webb et al., 2015).
78. The proponent rules out cumulative impacts to surface water as the mines and their associated discharges are in different sub-catchments, and discharges are subject to the conditioning of the Queensland Government. However:
- a. Cumulative impacts to surface water due to water supply needs for the mines may be significant (up to 12.3 GL/year to be taken from the Belyando/Suttor or Cape River catchments for the proposed project and up to 12.5 GL/year from the Belyando River for the CCM project).
 - b. Cumulative impacts to the Belyando River from loss of contributing catchment (during mining and final landform, from open-cut pits/voids and subsidence) should also be quantified and assessed.
 - c. Discharges of mine-affected water during and after heavy rainfall events may be required, which may have adverse impacts on downstream water resources, including ecosystems and other water users. These impacts would be amplified with simultaneous discharges from nearby mines.
79. The project assessment documentation would benefit from identification of:
- a. specific measures for monitoring cumulative impacts;
 - b. relevant programmes to assess or mitigate cumulative impacts, or the proponent's participation in these; and
 - c. modifications or alternatives to avoid, minimise or mitigate potential cumulative impacts, including opportunities to work with others.
80. Appropriate monitoring and adaptive management mechanisms should be developed in consultation with the owners of nearby mines and should be put in place for potential cumulative impacts to the Doongmabulla Springs Complex (similar to the Joint Industry Plan in the Surat Basin), and the Belyando River catchment.
81. The Lake Eyre Basin bioregion, which includes the Galilee Basin subregion, has been identified as a Bioregional Assessment priority region. Data and relevant information from the proposed project should be made accessible to this Bioregional Assessment and related research projects.

Question 14: Does the IESC agree with the proponent's assessment that impacts on the Doongmabulla Spring Complex, 22km south of the proposed open cut pit, as a result of the project or as a result of cumulative impacts with the Carmichael Coal Mine and Rail Project are unlikely?

Response

82. Given the proponent's approach to cumulative assessment (refer response to Question 13) and the alternative conceptualisations of the springs (Webb et al., 2015), there is uncertainty with the proponent's assessment that impacts to the Doongmabulla Springs Complex are unlikely.
83. To enable a rigorous assessment of potential impacts and the development of appropriate mitigation measures, further geochemical data to identify the source aquifer of the Doongmabulla Springs Complex, revision of the numerical groundwater model and further groundwater monitoring is needed. An adaptive management approach with limits and triggers, and a joint industry approach between the proponent and the CCM project should be developed. For example, a limit of 0.2 m of drawdown at the spring would address the uncertainty regarding the spring's source and potential cumulative impacts. This approach is similar to the conditions placed on approvals for coal seam gas projects to protect springs in the Surat Basin.

Explanation

84. The Doongmabulla Springs Complex, which support an EPBC Act listed endangered ecological community, is located 22 km south of the proposed mining area. There is evidence to support the hypothesis that the Clematis Sandstone, sourced from Darkies Range, is the source aquifer for the Doongmabulla Springs Complex, e.g. Bradley (2015). More data is needed to gain an accurate understanding of the groundwater chemistry and flow directions in the Clematis Sandstone.
85. Drawdown impacts were not predicted to the Doongmabulla Springs Complex, however the sensitivity analysis predicts the 1 m contour for the maximum zone of depressurisation in the Clematis Sandstone will be less than 3 km from the Doongmabulla Springs Complex. There is considerable uncertainty with regard to the prediction that these springs will not be impacted given the:
 - a. uncertainty in the hydrogeological conceptualisation and the numerical groundwater modelling predictions; and
 - b. uncertainty around the cumulative impact assessment for the Clematis Sandstone presented in the EIS, including the lack of 0.2 m drawdown contours.

Question 15: Has the proponent adequately identified downstream environmental and public use values that could be impacted as a result of the project? Is the proposed monitoring program adequate to establish baseline values and identify and quantify potential impacts as a result of the project?

Response

86. The proponent has identified some downstream recreational uses (Wilandspey, and Burdekin Falls Dam). However potential environmental and public use values on the 64 km length of floodplain to the Belyando River, which may be impacted by discharges were not identified.

87. The proponent claims to have an indicative baseline dataset for surface waters, which is based on Queensland Department of Natural Resources and Mines gauges outside of the project area. At a regional scale, monitoring may be considered adequate but the proposed monitoring onsite is inadequate to establish baseline values and quantify potential impacts. Recommendations on how to improve the surface water monitoring programme have been included in response to Question 16.

Question 16: Have the potential risks and impacts of contamination to water resources been adequately identified, assessed and quantified? If not, what additional measures could be implemented to adequately mitigate, manage and monitor potential risks and impacts?

Response

88. Impacts to water resources from contamination have been assessed. Additional information on the geochemistry of the target coal seams, particularly to the northern area of the project area, would have been beneficial.
89. To monitor and manage potential risks, surface water and groundwater monitoring locations around waste storage facilities should be clearly identified and molybdenum, selenium, and aluminium be included in regular surface water quality sampling.

Explanation

90. Potential impacts to water resources could result from surface runoff or seepage from: overburden emplacement areas; the Tailings Storage Facility and Power Station Waste Storage Facility; and raw coal stockpiles.
91. Raw coal and coal reject material were sourced from the southern mining area only. Furthermore, some coal reject material was gathered from E, F and G seams which is not relevant, as these seams are not being targeted by the project.
92. Geochemical testing on tailings material indicate that any leachate from the Tailings Storage Facility is likely to be of better quality than the tertiary groundwater so degradation of groundwater quality is improbable should any seepage from the Tailings Storage Facility occur. The proponent states the facility will be designed to minimise leachate generation, but no information was provided on how this will be achieved.
93. Based on the benign nature of the materials tested, no special management measures are proposed. The proponent commits to:
- Quarterly monitoring of pH, EC, TSS, dissolved trace metals/metalloids and major ions for surface runoff and seepage from the overburden emplacement area, tailings storage, raw coal stockpile, feed coal stockpile and power station waste facility. In addition to the analytes proposed, monitoring of selenium, molybdenum, nickel and aluminium is essential where runoff or seepage from overburden or coal material is likely.
 - 'Regular' inspections of storage facilities. The frequency of 'regular' inspections of waste storage facilities should be clarified.

Question 17: Would backfilling the pits to a level to prevent excessive groundwater intrusion be an effective management option to ameliorate post mining flow rates to the final void (predicted at 0.5ML/day from GAB and 0.5 ML/day from non-GAB management units such as the Greater Western Artesian Area)?

Response

94. Backfilling would be an effective management option to ameliorate flow rates to the final void by reducing excess evaporation and subsequent ongoing groundwater inflow.

Explanation

95. Post mining, the final voids are predicted to act as a sink to groundwater flow. This will reduce the hydraulic gradient and magnitude of drawdown immediately surrounding the mined areas but also allow the zone of depressurisation to continue to expand as water from the surrounding groundwater systems (Moolayember Formation and Clematis Sandstone) flow into the voids. Considering the voids are positioned at the base of Darkies Range, further evidence should be provided to support the concept that the final voids will act as groundwater sinks, rather than groundwater through-flow systems.
96. Further assessment taking into account seasonal and climatic variations (i.e. high rainfall and flooding) would be beneficial to assess final void water levels and the likelihood of the final voids discharging water into surface water and groundwater systems. Given that the final void is predicted to act as a groundwater sink, salt and other potentially harmful constituents will be expected to accumulate in the final voids and these should be modelled to inform adequate mitigation and management measures.
97. The management of the voids could be further strengthened by providing a Final Void Management Plan, to be developed prior to completion of mining in the first pit. This plan should consider aspects such as groundwater hydrology, surface water hydrology and include measures to minimise potential impacts associated with the final voids. In the Final Void Management Plan, the proponent should demonstrate that impacts to water resources are mitigated and managed in perpetuity and consider options for the post-mine use.

Question 18: Has the EIS definitively shown that groundwater impacts will not affect Caukingburra Swamp north east of Lake Buchanan (which extends for 2km with a northwest-southeast orientation and up to 1km wide located in the same closed drainage depression as Lake Buchanan). If not, what further work should be completed to satisfactorily demonstrate this?

Response

98. The EIS does not assess potential impacts to Caukingburra Swamp. There is uncertainty as to whether the swamp is groundwater fed. However, based on the current modelling predictions due to the distance from the project area, there is a low likelihood of impacts as a result of the project, even if the swamp is a GDE.
99. Detailed surveys and monitoring should be undertaken on Lake Buchanan and Caukingburra Swamp to determine water requirements and sources to provide confidence in assessing any potential impacts.

Explanation

100. Caukingburra Swamp, listed on the Directory of Important Wetlands (DIWA, undated-c), is a seasonal freshwater swamp adjacent to the north east tip of Lake Buchanan. It is a terminal drainage depression and receives surface inflows from the north and off the Great Dividing Range (north of the project area). It is recognised as an important freshwater refuge in the landscape, including for migratory birds. It retains water for a longer period than similar habitats in the region and water may persist through the dry season (Lorimer, 2005), which indicates a potential groundwater contribution.

101. The Queensland Government WetlandMaps reports that the swamp is likely a closed alluvial system with fresh, intermittent groundwater connectivity and is a low confidence GDE.

102. Through increased monitoring, the proponent should improve understanding of the groundwater-surface water interactions at Lake Buchanan to ensure mine-induced depressurisation will not impact on the hydrology of Caukingburra Swamp.

Date of advice	9 October 2015
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Source documentation available to the IESC in the formulation of this advice	EIS, 2015, MacMines Austasia Pty Ltd for Project China Stone, Environmental Impact Statement. Lewis S, Cassel R and Galinec V 2014 Coal and coal seam gas resource assessment for the Galilee subregion. Product 1.2 for the Galilee subregion from the Lake Eyre Basin Bioregional Assessment. Department of the Environment, Bureau of Meteorology, CSIRO and Geoscience Australia, Australia.
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