

Advice to decision maker on coal seam gas project

IESC 2017-087: Western Surat Gas Project (EPBC 2015/7469) – New Development

Requesting agency	The Australian Government Department of the Environment and Energy
Date of request	13 July 2017
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Advice stage	Assessment

Summary

The Western Surat Gas Project is a proposed coal seam gas project of 425 wells and associated infrastructure over an area of 686 km². The project is located north of Roma, Queensland, and the project lifespan is projected to be 47 years.

The proposed project will cause depressurisation within the coal seam. The proponent's assessment shows that drawdown will propagate to some extent to overlying aquifers affecting some landholders' bores. The IESC considers that groundwater drawdown may also affect water availability for ecosystems that rely on groundwater.

The proponent's environmental assessment provides insufficient baseline information to determine the potential for impacts to surface water and ecosystems that depend on surface and/or groundwater. There is potential for environmental impacts from salt, hydrocarbons or other contaminants from unintended releases, seepage from water storages and water quality for proposed beneficial reuse. These have not been adequately considered by the proponent.

The proponent has utilised regional modelling undertaken by the Queensland Office of Groundwater Impact Assessment (OGIA). However, the proponent's assessment of potential groundwater impacts does not include local-scale models and a comprehensive risk assessment. This reduces confidence in their predictions of impacts of the project.

While the IESC acknowledges the early stage in the life of the proposed project, the IESC has identified several key deficiencies in information. The proponent should provide the following as soon as possible to reduce uncertainties associated with these knowledge gaps and to enable a more robust assessment:

- a comprehensive risk assessment for risks to water resources;
- appropriate field assessment of GDEs relevant to the project;

- a comprehensive uncertainty and sensitivity analysis;
- more detailed plans for co-produced water and brine disposal to demonstrate that proposed co-produced water management is feasible and low-risk; and
- a more thorough assessment of potential impacts to water quality from the project.

Monitoring, mitigation measures and management plans should be refined and independently reviewed prior to development.

Specific details on the above matters are discussed within this advice in the responses to the questions posed by the Commonwealth regulator.

Context

The IESC was requested by the Australian Government Department of the Environment and Energy to provide advice on Senex's proposed Western Surat Gas Project in Queensland.

This advice draws upon aspects of information in the Public Environment Report (PER) 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 proposed Western Surat Gas Project is a coal seam gas project consisting of 425 wells and associated infrastructure, including gas and water collection lines, up to three gas field compression facilities, three medium pressure gas pipelines, a central processing plant and a number of water storage dams. The proposed project is located between Wallumbilla and Roma in southern Queensland. The proponent does not propose to undertake any hydraulic fracturing as part of this project (PER, p. 23). Therefore, the IESC has not considered any potential impacts from hydraulic fracturing.

The proposed project is located in the Surat Cumulative Management Area (CMA) in Queensland. The Surat CMA contains a number of existing and proposed large-scale CSG developments. Modelling of cumulative groundwater impacts within the Surat CMA is undertaken by the OGIA who publish their findings in the Underground Water Impact Report (UWIR).

The latest UWIR (released in September 2016) estimated that the proposed project would contain 760 wells and modelling was undertaken to simulate their impact. The proponent has since amended the proposed number of CSG wells to 425. For the PER, the proponent requested that OGIA undertake new modelling to simulate the cumulative impact of 425 CSG wells. OGIA undertook the requested modelling and the output files were provided to the proponent, who used them to present the results in the PER. Therefore the results presented in the latest UWIR differ from those provided by the proponent in the PER.

Key potential impacts

The key potential impacts of this project include:

- declines in groundwater level and pressure in landholder bores as a result of groundwater depressurisation;
- reductions in water availability to springs and other groundwater-dependent ecosystems (GDEs) as a result of groundwater depressurisation and drawdown; and
- changes to surface water and groundwater quality as a result of inappropriately stored or unintentionally released drilling chemicals, co-produced water and brine.

Appraisal of data and methodologies

The PER provides adequate data on the existing condition of overlying aquifers from which users currently extract water. The modelling approach is generally suitable for identification of regional drawdown impacts. However, it is not suitable to investigate the magnitude and extent of potential impacts at the local scale.

Neither the environmental receptors at risk nor the potential pathways for impact have been suitably characterised. The data presented to examine impacts to surface water features and to GDEs are not adequate to predict all potential impacts. Additional baseline information should be collected and used to refine impact predictions. These should include smaller-scale conceptualisations and finer-scale investigation of the potential for altered groundwater flux near watercourse and spring GDEs. Local-scale modelling should also be undertaken to help evaluate risks to GDEs, especially groundwater-dependent terrestrial vegetation.

A comprehensive risk assessment for the project has not been undertaken. This should be undertaken as soon as possible to ensure that all project risks are evaluated. It should be accompanied by a risk management framework including mitigation and adaptive management measures (if needed). This risk assessment should be independently reviewed.

The IESC considers that subsidence is not a key risk for this project. Predicted subsidence at nearby gas fields is low – less than 10 cm of subsidence (PER, p. 129).

Response to questions

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

Question 1: Does the PER adequately identify impacts to surface and groundwater resources, surface and groundwater dependent ecosystems and springs?

1. The Committee is not confident that all potential impacts from the project on surface and groundwater resources, surface and groundwater-dependent ecosystems and springs have been identified adequately in the PER.

Groundwater

2. The groundwater modelling presented in the PER is adequate to identify regional scale cumulative groundwater impacts as a result of CSG operations in the Surat CMA, including the proposed project's contribution to regional cumulative impacts. However, the proponent relies heavily on the regional scale model which is not appropriate to predict all local-scale, site-specific potential impacts such as changes to surface water-groundwater interactions, discharges to springs, pressure head in groundwater bores and water availability for GDEs.
3. While the proponent has conducted some sensitivity analysis using a simplified analytical model that is separate to the OGIA model used for impact prediction, this analysis has not been appropriately implemented. A fuller exploration of uncertainty and sensitivity is required to inform the assessment of a full range of potential impacts, as discussed further in paragraphs 33 and 34 below.
4. As acknowledged in the PER, the large 1.5-km square cell size utilised in the groundwater model means that shallow unconfined groundwater systems and interactions between them and deeper aquifers cannot be precisely represented in the model. The implications of relying on the regional

Surat CMA groundwater model to draw conclusions on the likely impacts of the proposed project at the local scale have not been detailed in the PER.

5. Predictions of impacts to landholder bores are provided for the “project only” groundwater modelling scenario. However, the project will contribute cumulatively to drawdown in a number of additional bores that are predicted to experience more than five metres of drawdown. The proponent should identify the location of these bores.

Surface Water

6. Potential impacts to surface water resources have not been fully identified or characterised.
7. Potential impacts from proposed uses of co-produced water have not been examined. The proponent proposes that produced water <4000 µS/cm will only be amended for calcium and pH (no reverse osmosis) and used for dust suppression and construction. Produced water of >4000 µS/cm will be treated by reverse osmosis and blended with partially treated (amended for pH and calcium) produced water for irrigation and other beneficial uses. Potential impacts from hydrocarbons or other contaminants that may be present in co-produced water have not been discussed. Information on the concentrations of only a few metals have been presented.
8. The proponent states that current groundwater use from the Surat Basin units within the project area is 232 ML/a (PER, App. I, p.32) and that dust suppression and construction activities may use up to 90 ML/a and 180 ML/a, respectively (PER, App. I, p. 21). Peak water production for the project is 2400 ML/a. However, the feasibility of the use and disposal of this volume of co-produced water has not been adequately demonstrated. No produced water will be directly released into surface waters. Uses for the vast majority of this water are yet to be specified and rely upon agricultural use of the water to replace and/or augment existing sources (see paragraph 23).
9. There is significant uncertainty in the volume of co-produced water that will be produced. The numerical groundwater model computes that the volume will be four times as much as the proponent has calculated in their analytical model (PER, p. 119). This raises further questions about the feasibility of proposed beneficial reuse of co-produced water. Climatic or seasonal variation in water demand should be considered.
10. Management of brine, beyond evaporation in ponds and disposal of salt to a waste facility, has not been discussed in detail. It is possible that brine may not be able to be disposed of offsite and may remain indefinitely in brine ponds. Brine has the potential to impact on the environment through spills, leaks and seepage and represents a potential long term legacy issue.
11. There is insufficient examination of the risks that infrastructure construction may pose to watercourses and riparian ecosystems, especially at water crossings. The potential combined impacts of disruption of surface runoff and vegetation fragmentation caused by the construction of 425 well pads and the interconnecting network of roads have not been adequately assessed. The impacts of altered runoff and vegetation fragmentation should be considered, and roads and stream crossings designed to minimise these impacts.

Water-dependent ecosystems

12. As discussed in response to question 3 below, uncertainty in the groundwater model should be further explored. There are GDEs associated with areas of shallow groundwater and springs although these have not been well characterised in the PER. The current regional-scale model is unsuitable for predicting local-scale impacts yet potential impacts on GDEs are likely to be local in scale. The proponent has estimated the regional water table elevation using the GAB Water Resource Assessment for the Surat area. The regional scale of this assessment is also

inappropriate for identification of site-specific GDEs and surface-water groundwater interactions. The proponent's analysis of potential impacts to GDEs has not considered the potential for impact if groundwater drawdown is:

- a. heterogeneous, with impacts too local in scale to be detected in the regional-scale model; and/or
 - b. greater in magnitude and extent than predicted in the groundwater model.
13. The PER contains little consideration of the potential for impacts to water-dependent ecosystems that are not listed as threatened under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Under the 'water trigger', the EPBC Act's protection of water resources is not limited to listed threatened species and communities. Therefore a broader assessment of impacts to water resources is required. This is discussed further in response to question 3 below.
 14. The assessment of potential impacts to watercourse springs is limited to stating a prediction of 0.01 m drawdown at the Spring Ridge spring complex and 0 m at the other springs (PER, p. 128), which is beyond the resolution of the regional-scale model. Given the uncertainties associated with the use of a regional model to predict impacts at a local scale, further assessment of the potential for drawdown to impact watercourse springs should be undertaken. These are discussed in response to question 3.
 15. The proponent has identified nearby watercourse springs in Figure 8-2 but only considers those listed in Table 8-4 (PER, pp. 98, 102) as relevant groundwater receptors. This list of streams is not consistent with recent work by OGIA (State of Queensland 2017, p. 15) which indicates that stretches of Barton Creek, Sugarloaf Creek, Blyth Creek and Yuleba Creek are 'potentially gaining streams'. The proponent also considers two reaches of Bungil Creek, upstream and downstream of the project area, to be gaining (PER, p. 98). All potential gaining streams identified by OGIA in the vicinity of the proposed project should be included in the proponent's assessment.
 16. Field verification of these springs has not been undertaken despite the proponent noting spring W10 is listed by OGIA as having a moderate priority for field validation. Confidence in the surface water / groundwater interactions associated with watercourse springs, and the proponent's ability to assess potential impacts to them, would be improved by field investigations outlined in response to question 3.
 17. No sampling for stygofauna has been undertaken. Given the presence of shallow groundwater, particularly in the vicinity of gaining streams, there is the potential for stygofauna to be present. Little et al. (2016) recorded stygofauna, including bathynellids, in both the Dawson and Condamine catchments. Without sampling to determine whether stygofauna are present and if so, what taxa, it is not possible to evaluate potential impacts. The Department of Science, Information Technology and Innovation (DSITI) guidelines state that where there is insufficient information to assess the likely presence of stygofauna, a pilot study is required that involves collecting and identifying subterranean aquatic fauna present in samples from ten representative bores (DSITI 2015, pp. 1–2).

Question 2: Does the Committee consider that the information provided in the PER documentation, including baseline and modelled data, and the conclusions drawn by the proponent are adequate to assess the project's impacts on water resources and water-related assets?

18. Information provided in the PER is not adequate to assess the project's potential impacts to all water-resources and water-related assets. Additionally, the paucity of baseline data, particularly for surface water, will make it difficult to verify whether impacts are in line with those predicted unless this deficiency is addressed prior to development.

Groundwater

19. For regional cumulative impacts to groundwater, the baseline and modelled data are appropriate. However, the modelling has not been designed to investigate local-scale impacts. This is discussed further in response to questions 3 and 4, below.
20. The proponent states that baseline assessments have been undertaken for 89 of 126 landholder bores. If access cannot be gained to the remaining bores, the proponent should present an alternative method for acquiring suitable baseline data.
21. The proposed groundwater monitoring is not sufficient to provide a baseline or to monitor future potential impacts to groundwater-dependent ecosystems. Monitoring plans should be prepared and, following field investigations of GDEs, revised and reviewed independently.
22. Investigation of uncertainty in predictions of groundwater impacts is discussed in response to question 3 below.
23. The proponent presents results from an analytical model that predicts co-produced water volumes from the proposed project (PER, p. 25) and compares those results to the Surat CMA groundwater model predictions of produced water (PER, pp. 119 – 120). The analytical model predicts approximately one quarter as much produced water will be extracted by the proposed project compared to the regional groundwater model. This discrepancy is not explained in the PER. This would significantly change drawdown/depressurisation predictions. Details of the analytical model's construction, parameterisation and the baseline data it utilises are required to provide confidence in the proponent's assessment. The results from this model would also have significant implications for water balance modelling and management of co-produced water by the proponent.
24. Minimal data were provided on the groundwater quality of hydrogeological units within the project. Groundwater samples were collected from 16 CSG wells in the Eos, Mimas and Tethys blocks over a 12-month period in 2007/08 and further samples were collected from 4 exploration and appraisal wells within the Glenora block in March, 2017. However, results were only presented for the Walloon Coal Measures and analysis did not include hydrocarbons or a suitable range of metals (for example, mercury was not included). Provision of these groundwater quality results is needed to provide an indication of potential risks associated with the beneficial re-use of co-produced water.

Drilling chemicals

25. The proponent has not identified what drilling chemicals will be used. Any industrial chemicals that are to be used should have their hazards and risks to water resources rigorously and transparently assessed. Where required, appropriate risk mitigation processes should be implemented. Chemical risk assessments should be informed by appropriate physio-chemical, ecotoxicological and site-specific monitoring data. The use of any chemicals that have not had their risks assessed should be avoided until an assessment has been undertaken.

Surface Water

26. Water quality and flow data from within the project area have not been collected. This will hamper detection of any future impacts to these resources as there are no baseline data for comparison. This is particularly important for potentially-gaining reaches of streams as these may provide critical aquatic refuge habitats during dry periods.
27. The proponent has stated that they will prioritise the beneficial reuse of water that does not produce brine, that is, reuse of water that has not been treated by reverse osmosis. They have

not, however, examined the potential environmental implications of the use of this water. Data on the hydrocarbon content of co-produced water have not been provided, which may be critical if used for irrigation after blending with reverse-osmosis permeate. Some chemical data have been presented, but a more comprehensive set of analytes should be provided. Without detailed information on the chemical composition of co-produced water and a water and salt balance showing proposed uses, it is difficult to compare the environmental risk of the range of beneficial uses proposed.

Water-dependent ecosystems

28. The lack of detailed condition assessments for water-dependent ecosystems in the project area makes it difficult to:
- a. assess the sensitivity of these ecosystems to impact; and
 - b. evaluate any future ecological condition against current conditions.

Question 3: Is there additional information that could be provided to assist in the identification and assessment of these impacts?

29. There is additional information that would help to identify and assess potential impacts and address the issues identified in response to questions 1 and 2. This information relates to documentation of baseline conditions (against which to provide valid comparisons) and allows a more thorough investigation of the potential for impacts, enabling appropriate risk assessment.
30. The proponent has not provided a risk assessment. A comprehensive assessment would help to ensure that all project risks are identified and addressed. This would be particularly valuable in helping to minimise environmental risks when siting infrastructure and in targeting monitoring and adaptive management programs. One such suitable risk assessment framework would be the Failure Modes and Effects Analysis (FMEA) method. A modification of this method has been applied in the Bioregional Assessments program (Australian Government, 2017).
31. Additional work should be undertaken to evaluate the risk the project poses to GDEs. The proponent should undertake field investigations to determine the degree to which they depend on groundwater and evaluate the condition and value of the ecosystems. In parallel with this, the proponent should produce local analytical or basic numerical models to test under what conditions and parameter values there is the potential for impacts to occur. If this work indicates that there is a material risk, an early-warning groundwater monitoring program should be installed and the results regularly fed into a local-scale numerical groundwater model. For each material risk, effective and practicable mitigation measures should also be developed.

Groundwater

32. As noted in paragraph 2 above, the proponent relies on the Surat CMA groundwater modelling, which is underpinned by geological interpretations produced by the OGIA. However, it is unclear how much of the proponent's data (e.g. exploration logs, geophysical logs, groundwater monitoring data and exploration water production values) has been provided to OGIA for inclusion in the groundwater model. Clarification of which site-specific data are utilised in the OGIA model could be used by the proponent to support their conclusions regarding particular potential impacts. In particular, the proponent is likely to have geological drill log and permeability data which could be used to construct local-scale geological and hydrogeological conceptualisations to support identification of the potential range of groundwater impacts.
33. More information and discussion should be provided on uncertainty in the numerical groundwater model. Conceptual uncertainty should be further explored. In particular:

- a. The site-specific geological (stratigraphic and structural) and hydrogeological conceptualisations, and potential alternative conceptualisations, should be described and presented visually.
 - b. Alternative hydrogeological conceptualisations of the Hutton-Wallumbilla Fault, and the implications of these for predicted impacts, should be discussed (e.g. Bense et al., 2013). The proponent could address the uncertainties associated with the Hutton-Wallumbilla Fault by conceptualising its local groundwater characteristics, detailing the local stress regime and fault structure (e.g. damage zone size, open/closed along fault plane, presence of clay/shale smear, fault jogs or splays). A discussion on how this fits into the fault's potential influence on regional-scale groundwater conditions should also be included. The above analyses could be done by using existing site-specific studies and/or their own data or information and could include:
 - i. geophysical investigation across the fault to determine the fault offset distance and the location of any potentially permeable strata;
 - ii. coring and wireline logging through the fault plane to identify the size and properties of the fault damage zone, its core properties and presence/absence of groundwater;
 - iii. multi-level groundwater monitoring on each side of the fault to detect variations in groundwater head; and
 - iv. aquifer pump testing of an appropriate duration and groundwater level and environmental tracers monitoring, to identify groundwater responses across multiple strata.
 - c. Examination of the implications of these uncertainties should be incorporated into an environmental risk assessment for the project. The impacts that would be associated with greater than predicted groundwater drawdown, on both groundwater users' bores and on GDEs, should be discussed.
 - d. The monitoring program should be targeted to address key hydrogeological uncertainties identified through this process.
34. It is noted that at the time of preparing the PER, OGIA had not yet undertaken sensitivity analysis on the parameters used in the Surat CMA groundwater model. Instead, the proponent has undertaken an analytical assessment of hydrogeological parameters using a separate hydrogeological analytical model. While the IESC acknowledges the proponent's intention, the sensitivity analysis provided does not consider sensitivity of the model being used to draw conclusions on the proposed project's potential impacts. Therefore it provides limited additional understanding of the potential for groundwater impacts to propagate beyond those predicted by the Surat CMA groundwater model. Sensitivity analysis should explore the following:
- a. In the Surat CMA groundwater model, the Walloon Coal Measures, Hutton Sandstone and Springbok Sandstone are each represented with multiple layers. In the proponent's sensitivity analysis these are each represented by a single layer.
 - b. Horizontal hydraulic conductivity in the Walloon Coal Measures modelled in the Surat CMA groundwater model varies from 0.0000041 to 1.1 m/d. However, horizontal hydraulic conductivity in the sensitivity analysis was only allowed to vary between 0.001 and 0.1 m/d which is within the mean range of values for horizontal hydraulic conductivity in the regional groundwater model. Within the analytical model, a justification should be provided for the lumping of model layers, and the range of parameter values adopted should reflect the wide range of possible values.

- c. Sensitivity analyses would need to consider changes to all parameters (vertical hydraulic conductivity, storativity, recharge, etc.) in all hydrogeological units or at least those of importance for both their local or regional aquifer and aquitard properties.
 - d. Sensitivity analyses would need to consider changes to potential impacts under the cumulative impact scenarios.
 - e. An appropriate sensitivity analysis would also need to present the results of each scenario with respect to the implications for the number of bores impacted, potential drawdown at springs and their source aquifers and reductions in groundwater flow to gaining reaches, watercourse springs and other GDEs.
35. As discussed in paragraph 31, consideration should be given to the use of smaller site-specific models to assess risks and predict impacts to sensitive groundwater receptors (e.g. landholder bores, GDEs). For these models, use of site-specific data and assessment of changes in storativity and permeability would be important. Turnadge et al. (2017) report a method which would enable up-scaling of site-specific aquitard core permeability tests using wireline logs of bores across the project area which also accounts for spatial variability.

Drilling chemicals

36. A risk assessment of drilling chemicals should be undertaken. This should form a component of a broader risk assessment for the project (as discussed in paragraph 30).
37. To allow for a comprehensive and transparent assessment of risks, the names and Chemical Abstract Service (CAS) registered numbers of all chemicals to be used should be presented.
38. The proponent should confirm that all chemicals to be used have been listed in the Australian Inventory of Chemical Substances (AICS) maintained by the National Industrial Chemicals Notification and Assessment Scheme (NICNAS).

Surface Water

39. Additional work to characterise baseline water quality should be undertaken, particularly in areas with greater potential for impact. This work should include evaluation of:
- a. existing surface water quality in areas where groundwater discharges to watercourses (i.e. reaches that are potentially gaining) and in areas where surface activities could affect water quality; and
 - b. the persistence of flowing and standing water in gaining stream reaches should be determined, especially during dry seasons and drought periods.
40. Further information should be provided on beneficial reuse of co-produced water. Evaluation of the environmental risks arising from co-produced water should be through 'a risk-based, quantitative approach that takes into account cumulative impacts' (Australian Government, 2014). As discussed in paragraph 27, this should include:
- a. a water and salt balance, to provide greater confidence that all co-produced water is able to be managed appropriately;
 - b. assessment of the potential for other chemical contamination. This should include presentation of a comprehensive suite of potential metal contaminants and hydrocarbons; and
 - c. details of the management of brine from the reverse osmosis plant.

Water-dependent ecosystems

41. Assessment of all potential impacts to GDEs should take account of concerns and uncertainty in groundwater drawdown predictions, as discussed in paragraphs 30 and 31.

Streams and riparian GDEs

42. Little information has been presented in the PER regarding the nature and ecological condition of in-stream and riparian GDEs. A baseline ecological assessment should be undertaken using mapping tools recommended in Richardson et al. (2011) and, for vegetation GDEs, supplemented with remote sensing data as described by Emelyanova et al. (in press). This should be used as the basis for a more thorough evaluation of risks to the ecosystems, especially potential impacts of crossings on riparian zone continuity.
43. The proponent has identified a terrestrial GDE located along an unnamed tributary of Eurombah Creek, 15 km to the northeast of the project area, as being potentially impacted by the project (PER, p. 105). From the information presented in the PER it appears that the proponent has not undertaken any field investigation of this site. An assessment of the likely ecological response of this treed ecosystem should be provided. Greater justification should be provided for the proponent's conclusion that ecological impacts to this GDE are 'unlikely' (PER, p. 128). This assessment should take account of uncertainty in modelling of groundwater drawdown, including conceptual uncertainty.

Spring Complexes

44. Investigation of springs (e.g. hydrochemical) to confirm source aquifers would be valuable. This information is important as it helps to target monitoring effort. For the Spring Ridge spring complex, this investigation could provide additional evidence for the proponent's conceptualisation of the spring as disconnected from the regional groundwater system and therefore less likely to be impacted and need monitoring.
45. A baseline ecological condition assessment should be undertaken for the Gubberamunda/VI Mile and Spring Ridge spring complexes. In order to understand the natural variability of these systems it is necessary to repeat this investigation under different climatic conditions. This baseline condition assessment will allow the future condition of the sites to be compared to pre-development conditions, making allowance for natural temporal fluctuations in discharge.

Question 4: Does the Committee agree with the proponent's interpretation of the project's impact to groundwater that are predicted by the groundwater model?

46. The Surat Cumulative Management Area model was not designed to investigate surface water-groundwater interactions. This limits the assessment of connectivity between surface and groundwater. As a consequence the proponent's reliance on this model limits understanding of potential impacts to local surface water resources and development of mitigation strategies.
47. Finer scale conceptualisation and discussion of potential impacts to sensitive areas, including surface and watercourse springs, is needed. Monitoring and data are needed to confirm conceptualisations and to provide a benchmark against which changes resulting from project operations can be assessed.
48. Presentation of drawdown predictions is needed for hydrogeological units of importance (e.g. Gubberamunda Sandstone) and discussion of the implications of the difference in results between those in the PER and the predictions presented in the groundwater modelling results provided in the UWIR for the Surat CMA (State of Queensland, 2016). For example, the PER shows no cumulative impact to water levels in the bores screened in the Gubberamunda

Sandstone greater than 0.1 m (PER, pp. 112–13). In contrast, the UWIR shows a drawdown of 2–3 m for this formation in the project area (State of Queensland 2016: Apx. 37).

Question 5: Does the Committee consider the monitoring and management framework proposed in the PER adequate to address the likely and potential impacts of the project?

49. The Committee does not consider that the monitoring and management framework presented in the PER is adequate to address the likely and potential impacts of the project. As discussed above (paragraph 30), a comprehensive risk assessment should be undertaken for the project. This should be used to inform the monitoring and management frameworks. Field investigations of water-dependent ecosystems should also be undertaken as soon as possible to guide strategies for monitoring and management. Trigger-action-response plans (TARPs) should be developed for key assets that may be affected by the project. The monitoring regime and TARPs should be adequate to provide early warning of impacts to:
- a. landholders' bores;
 - b. Spring Ridge spring and Gubberamunda/VI Mile spring complexes through hydrological, physicochemical and ecological monitoring. Plans for monitoring may be able to be refined following baseline ecological assessments (discussed in response to question 2); and
 - c. other GDEs, including in-stream and riparian GDEs, through hydrological, physicochemical and ecological monitoring. As with springs, initial investigations may help to refine monitoring plans.
50. For all potential impacts, triggers and effective and practicable management responses need to be identified.

Groundwater

51. As discussed above, the IESC considers that the proposed monitoring of groundwater is not sufficient to detect potential impacts to GDEs.
52. Improvement of the groundwater monitoring network is needed to identify early propagation of groundwater impacts for springs, potential GDEs and important regional aquifers. While there are a number of UWIR bores and CSG online monitoring bores in the vicinity of the project area, the proponent only has 3 monitoring bores, with an additional two proposed. To detect propagation of groundwater drawdown through aquitards to productive aquifers, additional monitoring should be considered. Monitoring should occur directly above and below important aquitards (e.g. Walloon non-productive zone, Westbourne Formation, Eurombah/Durabilla Formation) to provide realistic observations of hydraulic gradients.

Surface Water

53. Both the CSG Water Management Plan and the Water Management and Monitoring Plan lack details of sites and parameters to be monitored.
54. The Coal Seam Gas Water Management Plan (PER, App. I) should be amended to:
- a. increase the proposed frequency of monitoring of untreated CSG water quality and dam seepage water quality to include event-based monitoring because the currently proposed quarterly monitoring is inadequate to provide early warning of impacts from any unintended releases; and
 - b. minimise environmental risks (e.g. seepage and overtopping) from surface storage dams.

55. The Water Management and Monitoring Plan (PER, App. IX) should be updated to:
- a. include details of erosion mitigation. This impact is likely to be amenable to mitigation and adaptive management, implemented through a TARP. Given the strong seasonality of rainfall, disturbance would be mitigated by constructing any crossings during drier months. Where vegetation is disturbed, plans should be made for prompt revegetation and weed control. In areas of high risk, or where impacts occur, engineering controls such as armouring should be considered; and,
 - b. include a detailed site water balance and contingencies for water management if proposed reuse of co-produced water is not feasible.

Water-dependent ecosystems

56. The proponent should undertake local monitoring within the potential zone of impact to determine water table depths and their seasonal variability in proximity to GDEs, including terrestrial GDEs.
57. The proponent should identify effective and practicable actions to mitigate any impacts to water-dependent ecosystems. These should be incorporated into TARPs.

Date of advice	1 September 2017
Source documentation available to the IESC in the formulation of this advice	PER 2017. Public Environment Report: Report for the Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development, ERM, draft dated July 2017.
References cited within the IESC's advice	<p>ANZECC/ARMCANZ 2000. <i>Australian Guidelines for Water Quality Monitoring and Reporting. National Water Quality Management Strategy (NWQMS)</i>. Canberra: Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand.</p> <p>Australian Government 2014. <i>Co-produced water – risks to aquatic ecosystems, background review</i> [online]: http://www.environment.gov.au/system/files/resources/e3839672-583c-4bc0-8efe-82d6f006976e/files/background-review-co-produced-water.pdf.</p> <p>Australian Government 2017. <i>Systematic analysis of water-related hazards associated with coal resource development</i> [online]: http://www.bioregionalassessments.gov.au/methods/systematic-analysis-water-related-hazards-associated-coal-resource-development.</p> <p>Bense VF, Gleeson T, Loveless SE, Bour, O, Scibek J, 2013. Fault zone hydrogeology, <i>Earth-Science Reviews</i>, 127: 171 – 192. http://dx.doi.org/10.1016/j.earscirev.2013.09.008.</p> <p>Department of Science, Information Technology and Innovation (DSITI), Queensland 2015. <i>Guideline for the Environmental Assessment of Subterranean Aquatic Fauna: Sampling Methods and Survey Considerations</i>. Queensland Government. Available from: https://publications.qld.gov.au/dataset/f7e68ccd-8c13-422f-bd46-1b391500423f/resource/ba880910-5117-433a-b90d-2c131874a8e6/download/guideline-subterranean-aquatic-fauna.pdf</p>

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