NSW GOVERNMENT | Department of Primary Industries

OUT17/15115

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Dear Mr O'Donoghue

Narrabri Gas Project (SSD 6456)
Comment on the Environmental Impact Statement (EIS)

I refer to your email of 20 February 2017 to the Department of Primary Industries (DPI) in respect to the above matter. Comment has been sought from relevant divisions of DPI. Views were also sought from NSW Department of Industry - Lands that are now a division of the broader Department and no longer within NSW DPI.
Any further referrals to DPI can be sent by email to landuse.enquiries@dpi.nsw.gov.au.

Due to the detailed water related information presented in the EIS, attached to this submission are a number of separate reviews that were undertaken by DPI Water to inform this response.

The reviews undertaken by DPI have not identified any critical issues that would result in DPI recommending the project should not proceed. However, a number of matters have been identified that should be further addressed to ensure that the project can be appropriately monitored and managed with appropriate conditions, and there will be clear and enforceable standards to strengthen Government's regulatory control.

Due to the breadth of recommendations related to water requirements, in-depth findings from DPI Water are outlined in detail at **Attachment A** with further detailed assessments at **Attachments B** through **H.**

In addition to the detailed recommendations regarding water resources found in the attachments, DPI makes the following comments and recommendations with regard to the department's other areas of regulatory interest:

- The proponent should note that any disturbance to Crown managed land within the project area will require consent from the Minister administering the Crown Lands Act.
- The proponent should provide a clear justification for locating most, if not all of the well pads planned to be erected within the vegetated state forest despite a significant proportion of the project area being on cleared land.
- While the impact to agricultural industries in the Narrabri shire is considered low as the area proposed to be removed from productivity is relatively small and of lower

productive potential for the shire, it should be noted that the Agricultural Impact Statement for the project has not been prepared in accordance with the *Guideline for Agricultural Impact Statements (2012)*, and must be read in conjunction with the main EIS report to fully understand the assessment that has been undertaken.

- The following should be included as a condition of consent in any determination of the project:
    - Ongoing monitoring of soil chemistry in produced water irrigation areas should be undertaken and reported regularly. The consent should also define action triggers with regard to changes in soil chemistry.

Yours sincerely

Mitchell Isaacs
Director, Planning Policy & Assessment Advice
29 April 2017

Encl.

Attachment	Title
A	DPI Water Detailed Recommendations
B	Review of Groundwater Model Developed by Santos for NGP based on Australian Groundwater Modelling Guidelines (Barnett, et al., 2012)
C	Groundwater Impact Assessment Review
D	DPI Water Review of Geological Units
E	Assessment of Groundwater SEARs in Narrabri Gas Project EIS
F	Assessment against the Aquifer Interference Policy
G	Groundwater Dependent Ecosystem Impacts Assessment
H	Surface Water Review

DPI appreciates your help to improve our advice to you. Please complete this three minute survey about the advice we have provided to you, here:
https://goo.gl/o8TXWz

Attachment A

Narrabri Gas Project (SSD 6456)
Detailed comments – DPI Water Recommendations

DPI Water has reviewed the Environmental Impact Statement (EIS) for the proposed Narrabri Gas Project. DPI Water's comments are outlined as follows, with a number of recommendations included for consideration by the Department of Planning and Environment. Detailed reviews are included in the Attachments B - H.

Numerical Groundwater Model Review

DPI Water considers that the confidence level of this model is Class 1, consistent with Santos's and CSIRO's assessment. This is because, the hydrogeological and historic groundwater pressure/level data available for key formations to be pumped (the early and late Permian) is limited.

A model with confidence level of Class 1, using all existing data, knowledge and information, and industry standard software is fit for the purpose of identifying plausible areas and formations where impacts may occur. The model will however require refinement supported by intensive monitoring and data collection in the first five years of the project in order to meet requirements of NSW's AIP.

The focus of early years of the project, if approved, should be to ensure intensive monitoring to enable collection of large amounts of data enabling revision and calibration of the model by year five.

Since the model is of Confidence Class Level 1, our review focused on whether the model is based on all available data, information, local knowledge, and best available software. These include assessing whether all available data has been used, whether the data used are consistent with those reported elsewhere, whether the chosen groundwater modelling platform is widely accepted in the Groundwater Modelling fraternity, and whether model design and construction are appropriate to provide orders of magnitudes of impacts (not a precise one).

DPI Water considers the model uses almost all existing data, information and knowledge. It uses industry standard software. Being a model of Class 1 confidence level, the model is not expected to be precise in its predictions. The utility of model prediction is therefore indicative of potential sites where an impact could occur, approximate order of magnitudes of drawdowns, and their time lags due to depressurisation. Although the model has adequately demonstrated the above it should be recognised that Class 1 models have a high level of inaccuracy which results in uncertainty of modelled impacts.

DPI Water also considers that the model should be updated periodically using data obtained once depressurisation starts in order to assess impacts more reliably and adapt mitigation measures to protect water assets in the region, if required.

Groundwater Impact Assessment Review

Santos is seeking approval of the Narrabri Gas Project (NGP) consisting of 450 gas/water production bore sets. The production bores are spread over a 95,000 hectare area.

Water extraction rates for the NGP are based on reservoir modelling. Three forecasts of water production have been made ranging from 35 GL to 87.1 GL over 25 years.

The 'Base Case' scenario, total water production of 37.5 GL over 25 years with a maximum take of 2.9 GL predicted in year three of the development, has been used for the project construction and design concept. No details as to the assumptions used or the uncertainty associated with the water extraction rates predicted by the reservoir model are detailed in the EIS. Nevertheless, these uncertainties do not lead to environmental risks as DPI understands that the infrastructure that will be in place would allow the reduction in the rate of production to restrict water make to that assessed by the proponent. The proponent should however recognise the risk to their gas production rates should the water make rates significantly exceed what has been presented and assessed.

The NGP groundwater impact predictions are based on an uncalibrated Class 1 confidence numeric model. Consequently the predictions are indicative in terms of both magnitude and timing. The model will require revision over the first five years of the project to ensure that impacts are appropriately monitored and managed in accordance with the Aquifer Interference Policy.

There is currently insufficient data reported to develop a calibrated model or improve its predictive capability.

Not all available information regarding water level/pressures and hydraulic properties measured in the target coal seams and overlying geological units collected during pilot production carried out by the proponent has been fully reported in the documentation supporting the EIS.

A direct consequence of the limited hydrogeological knowledge of the target formation is the wide range in the values of predicted produced water. Predicted produced water extraction is used to stimulate the groundwater system. Another approach to the model stimulation could have been the use of the drawdown required in the coal seams to enable gas production. The groundwater impact assessment provides a discussion on the merit of using extraction volumes and how best it matches the current reservoir engineers' predictions. The submission also highlights that the use of a set drawdown will not match Santos' predicted extractions. The discussion does not appear to focus on the desired purpose of the modelling effort. The model should aim at predicting groundwater impacts as direct and indirect drawdown impacts to formations. Due to the nature of the gas extraction and changes affecting the formations it is accepted that modelled extraction volumes may differ from Santos' predicted volumes. Further justification of the modelling approach used is recommended.

A groundwater monitoring plan that will enable the development of a calibrated model is recommended as a condition of consent as is the requirement for a calibrated model to be developed. Santos in its EIS has committed only to the calibration of the model if necessary.

Recommendations

Prior to determination

1. Further detail be provided of the two modelling approaches considered, and further justification be provided of the use of dewatered volumes to stimulate the system and the effect on the level of certainty in impact drawdown predictions.
2. To further consider the uncertainty associated with the water extraction rates predicted by the reservoir model the proponent is required to;
    a. Provide the assumptions and uncertainties associated with the predicted water production volumes.
    b. Detail what impact any changes to the indicative Field Development Plan will have on the predicted water production volumes both temporally and spatially.

    Note: For example if the field development plan changes so that higher volumes are pumped over a shorter period or over a smaller area, how will that change the groundwater impact assessment.

3. To address the deficiencies in the data presented in the Water Baseline Report (Appendix G4) the proponent is required to provide all data collected to date, including data obtained during resource assessment and the pilot production activities. This includes but is not restricted to:
    a. All available water level and/or pressure data for the target coal seams and overlying geological units, including the information summarised in Table 5-6 in the GIA, and provide an assessment of whether this data can be extrapolated to show water levels/water pressure surface.
    b. All hydraulic property measurements for the target coal seams and overlying geological units including all hydraulic property information summarised in Sections 5.3 and 5.4, and Appendix C.
    c. Provide an assessment of all available data and information and present a summary of water level/water pressure and hydraulic properties information by geological unit.
    d. Provide further information on the existing landowner bores shown in Figure 3-4 including; bore location information, type of data collected, and frequency of collection.
4. In Figures 3-1, 3-2 and 3-3 and Table 4-1 of the Water Baseline Report and Figures 3-4, 3-5, 3-6 and 3-9 and Table B-1 of the Water Monitoring Plan, DPIW has identified 12 government owned

monitoring bores that the proponent has assigned to a geological unit different to DPIW's interpretation (details are given in (Attachment D), the proponent is required to;

a. justify the geological unit they have assigned to each of the twelve monitoring bores to the satisfaction of DPIW or

b. amend the relevant sections to include each bore in the geological unit assigned by DPIW, this will result in changes to the assessment of baseline condition that must be addressed by the proponent.

Note: Impacts to the Water Monitoring Plan can be addressed as part of the consultation with DPIW.

5. The proponent is required to address the appropriateness of the data presented in the Water Baseline Report by providing an analysis of the adequacy of the data in characterising typical temporal and spatial variations. The results will also inform potential post approval changes in the monitoring plans.

6. DPIW notes that the groundwater modelling has predicted no significant impacts on the environment or water users. As these predictions are considered indicative of the magnitude of impacts rather than an accurate prediction the proponent is required to address items 14 to 16 in Table 2 of the Aquifer Interference Assessment regarding uncertainty in the predicted inflows.

Not required prior to determination

7. To address the uncertaintly in the predicted take volumes, the proponent is required to monitor actual take to verify the predicted take based on the schedule on which the impact assessment was based.

   It is noted this type of development is able to cease or reduce take to meet any licence and/or approval limitations, where the verification predicts an exceedance of the scheduled take into the future the proponent is required to:

   a. Reduce water production to the 'predicted' volumes in recognition that consent has been granted for the predicted impacts and not any in excess of these.

   b. If the proponent wishes to increase the volume produced they will be required to re assess groundwater impacts based on the higher volumes.

   c. Ensure adequate water entitlements are held.

8. To address the uncertainty around the impacts predicted by the model, DPIW recommends as a condition of consent the proponent is required to prepare a groundwater monitoring plan in consultation with DPIW and to the satisfaction of the Secretary.

   a. The monitoring plan must include sites appropriate to monitoring early detection of variance to those predicted under the groundwater impact assessment.

   b. Include appropriate thresholds and strategies to remediate and mitigate and employ make good provisions based on exceedance of thresholds.

   c. Ensure appropriate bore construction standards are adopted to ensure adequate protection of the water resource from installation of monitoring bores. That is, either the Minimum construction standards for Water Bores in Australia, or the NSW Code of Practise for Coal Seam Gas Well Integrity depending on the depth and geological conditions to be intersected.

   d. The monitoring plan must be developed with the aim of providing sufficient data to develop a calibrated model by year 5 of the project.

   e. The proponent is required to provide a calibrated model developed in consultation with DPIW and to the satisfaction of the Secretary for assessment and review at year 5 of the development.

      At this stage the proponent could be required to amend any aspect of their project plan and/or purchase additional entitlement to address any issues or impacts identified as a result of this review.

   f. As an ongoing commitment the proponent is required to update and recalibrate the model every 5 years including the data collected over the previous 5 years.

9. The proponent is required to provide the location and construction details of all proposed water production bores and their expected annual extraction volumes in advance of water production for each stage of the field development.

Water Use and Supply

The EIS outlines the predicted take of water production per year in a number of sections however clarification is sought due to the variation in predicted volumes.

The EIS has outlined in Table 11-3 in Chapter 11, the predicted peak annual water take during operations per year (years 2-4) in the Gunnedah Oxley Basin is 3,650 ML however this varies to the volumes outlined in Table 6-25 in the Groundwater Impact Assessment where the maximum predicted water take (years 2-4) is 5922 ML for the Gunnedah Oxley Basin. This must be clarified.

The proponent currently holds licences for 600ML in the Gunnedah Oxley Basin water source and 10ML in the Great Artesian Basin Southern Recharge water source. The proponent does not currently hold adequate licences to account for the predicted take of water, particularly for the Gunnedah Oxley Basin. The proponent must obtain adequate licences to account for this water take prior to the start of production.

It is understood the EIS outlines the predicted peak annual induced flow will occur for the following water sources Lower Namoi Groundwater Source, Upper Namoi Groundwater Source, Great Artesian Southern Recharge Water Source, Great Artesian Basin Surat Water Source from year 190 onwards. The proponent must obtain all relevant licences for these water sources prior to the take of water.

Recommendations

Prior to determination

- The proponent must clarify the maximum predicted take for all water sources and explain the differences throughout the EIS.

Not required prior to determination

- The proponent must obtain relevant water licences to account for the maximum predicted take of water prior to production for the Gunnedah Oxley Basin water source.
- The proponent must obtain all relevant water licences prior to the take of water for the Lower Namoi Groundwater Source, Upper Namoi Groundwater Source, Great Artesian Southern Recharge Water Source, Great Artesian Basin Surat Water Source.

Groundwater Dependent Ecosystem Review

The groundwater dependent ecosystem review appears to be adequate depending on the assessment that no drawdown greater than 0.5m will occur in the alluvium or Pilliga Sandstone. From this the assumption and that there are no high priority GDEs in the area (within the Water Sharing Plans), a low risk rating was applied to GDEs.

The EIS also presented that the type 2 GDEs (wetlands, spring and base flow rivers) were all low ecological value, however their appendix B data showed medium to high values. All type 3 GDEs (vegetation) were considered to be high value.

Recommendations

Not required prior to determination

- The proponent obtains the groundwater dependent ecosystem dataset from DPI Water that will be included in the water resource plans for the area to ensure consistency with the Namoi alluvial and shallow GAB water sharing plan rules.
- An adequate monitoring program is developed to monitor for impacts to groundwater dependent ecosystems.

Surface Water Review

Generally, the EIS chapters and appendices that address surface water issues appear to adequately satisfy the overall requirements and guidelines as prescribed by State legislation (e.g., *Water Management Act 2000*). However, a range of matters should be considered and addressed as part of the approval process. Detailed comments outlining these issues are included in Attachment H, with recommendations outlined as follows.

Recommendations

Not required prior to approval

- To address the uncertainty around the surface water and associated ecological impacts, DPIW recommends as a condition of consent the proponent is required to prepare an ecological monitoring and management plan. The plan is to be prepared in consultation with DPIW and to the satisfaction of the Secretary. The plan is to address monitoring, management and mitigation requirements and is to be supported by adequate baseline data.
- The inclusion of risk mitigation measures outlined in Appendix G1 will be beneficial, as they are deemed to reduce and aid in managing risks and make all potential risks manageable.
- Mercury concentrations need to be closely monitored. This includes mercury concentrations in the treated water and final concentrations when mixed with the Bohena Creek water. Any final (mixed) concentrations that exceed acceptable guidelines (e.g., the trigger value to protect 99% of freshwater species for slightly disturbed systems is 0.06 µg/L(ANZECC/ARMCANZ, 2000) should be reported to the NSW Environment Protection Authority (EPA) immediately and discharge of treated water ceased. The NSW EPA should be consulted to determine the acceptable mercury concentrations that can be discharged.
- Periodically monitor the integrity of existing pipeline footings, particularly after a flow event. Ensure any new pipelines are designed to with stand flood events of varying magnitudes.
- Continue to monitor treated water salinity concentrations from the Leewood WMF to ensure it is of an acceptable concentration for discharge into Bohena Creek when creek flows are ≥100 ML/d.
- Consider implementing a waste management monitoring program that is designed to prevent spillages and onsite contamination. Monitoring should provide evidence that all waste is dealt with under appropriate guidelines.
- The installation of a purpose-built hydrological gauging station in close proximity to the treated water release site on Bohena Creek is required. The upgrading of the current BOM gauging site (419905) is also recommended.

End Attachment A

Attachment B

Narrabri Gas Project (SSD 6456)
Detailed comments – Review of Groundwater Model Developed by Santos for NGP based on Australian Groundwater Modelling Guidelines (Barnett, et al., 2012)

Compliance checklist

1. Are the model objectives and model confidence level classification clearly stated?

DPIW considers that the confidence level of this model is Class 1, consistent with CSIRO's assessment of the confidence level classification. This is because, the hydrogeological and historic groundwater pressure/level data available for key formations to be pumped (the early and late Permian) is scant. Furthermore, there had never been any pumping from these formations. Consequently, there is no evidence on how groundwater from these formations will respond. Being a model of Class 1 confidence level, the model is not expected to be precise in its predictions. The utility of model prediction is therefore indicative of potential sites where an impact could occur, approximate order of magnitudes of drawdowns, and their time lags.

The model objectives are stated as,

I. Estimate changes in hydraulic head in the target coal seam, and head and water table elevations in connected hydrostatic units due to the proposed coal seam gas field development activities;
II. In areas where drawdown is predicted, estimate the recovery time for hydraulic head to return to pre-coal seam gas development levels;
III. Identify and quantify the potential groundwater loss or gain in each Water Sharing Plan Zone due to intra- and inter-formational flows; and
IV. Identify those land holders who may potentially be impacted by coal seam gas activities and quantify predicted impacts.

Since the model is of Confidence Class Level 1, our review focused on whether the model is based on all available data, information, local knowledge and best available software. These include assessing whether all available data has been used, whether the data used are consistent with those reported elsewhere, whether the chosen groundwater modelling platform is widely accepted in the Groundwater Modelling fraternity, and whether model design and construction are appropriate to provide orders of magnitudes of impacts (not a precise one).

2. Are the objectives satisfied?

Objectives I, II, and III have been met. Since the predicted impacts are very small, Objective IV has become redundant as it is not capable of identifying impacts to individuals.

3. Is the conceptual model consistent with objectives and confidence level classification?

Yes

4. Is the conceptual model based on all available data, presented clearly and reviewed by an appropriate reviewer?

Yes. Please recall that the model (including the conceptual model) has been reviewed by CSIRO.

5. Does the model design conform to best practice?

Yes. The domain used is large enough to prevent assumptions that boundary conditions had little or no effect on the drawdown predicted due to pumping. Finer grid is used to discretise the project area. Thirteen geologic units are grouped appropriately to form nine Hydro Static Units and then split into 24 model layers to improve prediction of pressure changes as realistically as possible.

6. Is the model calibration satisfactory?

DPI Water does not consider that the model is calibrated. Estimation of diffused recharge to and from the watertable in the alluvium is estimated using an inverse procedure, and therefore, when estimated recharge is input to the simulation, a near perfect match between observed and predicted is expected. There has been an attempt to calibrate observed groundwater levels in the Pilliga, but the SRMS value is higher than that suggested by the Australian Groundwater Modelling Guidelines.

No effort to calibrate groundwater levels in the deeper formations has been made. It's unclear why the data monitored by Santos during pilot-testing, albeit limited, was not used in calibration, or even compared with simulated levels. However, DPIW does acknowledge that for a model of Class 1 level confidence, the model used is adequate to provide indicative magnitudes of impacts.

7. Are the calibrated parameter values and estimated fluxes plausible?

DPI Water considers that the parameters adapted in the model to establish steady state initial conditions are within the range (towards the lower end of the range for horizontal hydraulic conductivity, and towards higher end of the range for vertical hydraulic conductivity) reported and closer to those which may provide conservative estimates of impacts.

8. Do the model predictions conform to best practice?

Yes.

9. Is the uncertainty associated with the predictions reported?

Yes, through limited sensitivity analyses of K_v of aquitards, storativity of aquitards and transmissive layers and three levels of extraction. We do not think that the sensitivity analyses of specific yield of Namoi alluvium and Outcrops added value to the uncertainty analysis.

10.Is the model fit for purpose?

A model with confidence level of Class 1, using all existing data, knowledge and information, and industry standard software is fit for the purpose of identifying plausible areas and formations where impacts may occur. The model will however require revision and improvements over the first five years to meet requirements of NSW's AIP.

Review checklist

1. Planning

1.1. Are the project objectives stated? Yes.
1.2. Are the model objectives stated? Yes.
1.3. Is it clear how the model will contribute to meeting the project objectives? Although the type of outputs which will be drawn from model results are listed in Table 6-15, they are not linked to either the project objectives or model objectives. An additional column linking the outputs to project/model objectives will be helpful to non-technical readers.
1.4. Is a groundwater model the best option to address the project and model objectives? Yes. A groundwater model is the only option for this task. Data, information and knowledge should be parsed carefully and linked to governing physical laws is the only way we could get an impression of what may happen due to stressing (pumping) a natural system.
1.5. Is the target model confidence-level classification stated and justified? Yes. The model is of Confidence Level of Class 1, and we agree that it is the best that can be achieved at this stage. Please see our response to Question 1, of the Compliance list.
1.6. Are the planned limitations and exclusions of the model stated? Section 6.14 provides model limitations (1) due to hydrogeological data available at various temporal and spatial scales which constrained calibrations, (2) Its inability to reproduce watertable fluctuations, (3) its inability to truly represent the desired extent of depressurisation. The model has a further limitation in it's inability

to produce output at required scale and accuracy to evaluate against NSW's AIP. Even though an actual impact is unlikely, this limitation needs to be acknowledged.

2. Conceptualisation

2.1. Has a literature review been completed, including examination of prior investigations? Yes, refer Sections 1, 4 and 5.

2.2. Is the aquifer system adequately described? Yes, however it should be noted that DPI Water does not agree with all the classifications of hydrostratigraphy adopted by the proponent and also notes inconsistency in the hydrostratigraphic description compared to the hydrostratigraphy classification (all section 5.2).
Given the confidence classification of Class 1, and regional nature of the model, there is unlikely to be any value in addressing these issues at this stage. However, this may need to be addressed in future iterations of the model.

- 2.2.1. Hydro stratigraphy including aquifer type (porous, fractured rock): Yes, refer to section 5.2, (see comment above).
- 2.2.2. Lateral extent, boundaries and significant internal features such as faults and regional folds; Yes, refer section 5.6.3
- 2.2.3. Aquifer geometry including layer elevations and thicknesses: Yes, refer to Figures 5-3, 6-9, 10 and 11.
- 2.2.4. confined or unconfined flow and the variation of these conditions in space and time? Yes

2.3. Have data on groundwater stresses been collected and analysed?

- 2.3.1. recharge from rainfall, irrigation, floods, lakes; Yes, refer to section 5.5, section 6.4.4
- 2.3.2. river or lake stage heights; Yes, refer section 5.6
- 2.3.3. Groundwater usage (pumping, returns etc.): Yes, refer to section 5.5.3 – data stops at 2011, the proponent should update the document to include more recent information.
  Also section 5.5.5
- 2.3.4. evapotranspiration; Yes, refer to section 6.4.4
- 2.3.5. Other?

2.4. Have groundwater level observations been collected and analysed?

- 2.4.1. Selection of representative bore hydrographs Limited hydrograph are provided in the conceptual model section (Section 5.4.3) of the GIA, further information is provided in the Groundwater Baseline Report.
- 2.4.2. comparison of hydrographs No
- 2.4.3. effect of stresses on hydrographs; Limited analysis provided in the conceptualisation section of the GIA.
  Section 5.4.3 makes commentary on the impact of the pilot extraction on a nearby monitoring well in an overlying formation, there appears to be less than a year overlap between the pilot CSG pumping and the period monitored, pumping information is recorded as totals over years not as pumping periods, and the volumes are small compared to what is proposed by the production phase of this project.
  DPI Water considers it inappropriate to draw conclusions re propagation of impact based on this limited information.
- 2.4.4. Watertable maps/piezometric surfaces? Yes
- 2.4.5. If relevant, are density and barometric effects taken into account in the interpretation of groundwater head and flow data? No. Not expected in a model of Confidence Class 1.

2.5. Have flow observations been collected and analysed?

- 2.5.1. Base flow in rivers; Limited information in Section 5.6.1, also in GDE Impact Assessment Report.
- 2.5.2. Discharge in springs; Yes, refer to Section 4.6.1, also GDE Impact Assessment Report.
- 2.5.3. Location of diffuse discharge areas? Yes, refer to Section 4.6.1, also GDE Impact Assessment Report.

2.6. Is the measurement error or data uncertainty reported?

- 2.6.1. Measurement error for directly measured quantities (e.g. piezometric level, concentration, flows); No.
- 2.6.2. Spatial variability/heterogeneity of parameters: To our knowledge only limited detail exists for the Gunnedah Oxley Basin. DPI Water considers all available details were provided.

2.6.3. Interpolation algorithm(s) and uncertainty of gridded data? Not applicable. Initial heads for most formations were derived through a steady state model.

2.7. Have consistent data units and geometric datum been used? Yes.

2.8. Is there a clear description of the conceptual model?
2.8.1. Is there a graphical representation of the conceptual model? Yes.
2.8.2. Is the conceptual model based on all available, relevant data? Yes

2.9. Is the conceptual model consistent with the model objectives and target model confidence level classification? Yes.
2.9.1. Are the relevant processes identified? Yes.
2.9.2. Is justification provided for omission or simplification of processes? Justification for methodology to estimate recharge to the alluvium is provided.

2.10. Have alternative conceptual models been investigated? No

3. Design and construction

3.1. Is the design consistent with the conceptual model? Yes.

3.2. Is the choice of numerical method and software appropriate Yes.
3.2.1. Are the numerical and discretisation methods appropriate? Yes.
3.2.2. Is the software reputable? Yes. MODFLOW-SURFACT is used. This is superior to other versions of MODFLOW because it handles pumping wells better and minimises numerical dispersion and oscillations.
3.2.3. Is the software included in the archive or are references to the software provided? Yes.

3.3. Are the spatial domain and discretisation appropriate?
3.3.1. 1D/2D/3D. This is a 3D model, as necessary to meet modelling objectives.
3.3.2. Lateral extent Yes. Model boundaries are chosen far away from the project site. Hence errors associated with assumptions will not any impact on the model performance and results.
3.3.3. Layer geometry? The groundwater model relied on Leapfrog geology model for layer geometry. Results from the Leapfrog model has been adequately translated as model layers of the groundwater model.
3.3.4. Is the horizontal discretisation appropriate for the objectives, problem setting, conceptual model and target confidence level classification? A suitable compromise has been made considering data availability, processing time and desired accuracy of results in deciding the discretisation.
3.3.5. Is the vertical discretisation appropriate? Are aquitards divided in multiple layers to model time lags of propagation of responses in the vertical direction? Yes. There are five aquitards. They are divided into multiple model layers (ranging from 2 to 6), to facilitate propagation of responses. In particular, the early and late Permian formations, where pumping is to take place are divided into 5 and 9 model layers respectively.

3.4. Are the temporal domain and discretisation appropriate?
3.4.1. Steady state or transient: Steady state to determine initial heads (conditions).
3.4.2. Stress periods: Yes. In Section 6.8.4
3.4.3. Time steps? Yes. In Section 6.8.4

3.5. Are the boundary conditions plausible and sufficiently unrestrictive? Yes
3.5.1. Is the implementation of boundary conditions consistent with the conceptual model? Yes.
3.5.2. Are the boundary conditions chosen to have a minimal impact on key model outcomes? How is this ascertained? Yes.
3.5.3. Is the calculation of diffuse recharge consistent with model objectives and confidence level? Yes.
3.5.4. Are lateral boundaries time-invariant? Yes.

3.6. Are the initial conditions appropriate?
3.6.1. Are the initial heads based on interpolation or on groundwater modelling? No. For most part of the domain, and hydrogeological formations, there are no observed data to interpolate the

initial heads satisfactorily. Interpolation is possible for the Namoi alluvium and to a limited extent for Pilliga Sand. The model uses initial conditions derived through steady state runs, which compliment choses hydrogeological parameters.

3.6.2. Is the effect of initial conditions on key model outcomes assessed? No. This will not add value since the initial conditions were estimated for a set of assumed aquifer parameters. The estimated initial conditions may have affected the sensitivity analyses of aquifer parameters.

3.6.3. How is the initial concentration of solutes obtained (when relevant)? Not applicable.

3.7. Is the numerical solution of the model adequate?

3.7.1. Solution method/solver: Yes. PCG5 Solver was used.

3.7.2. Convergence criteria: Yes.

3.7.3. Numerical precision: Yes.

4. Calibration and sensitivity

4.1. Are all available types of observations used for calibration? Not Applicable. See our response to Question 6 of Compliance List.

4.1.1. Groundwater head data

4.1.2. Flux observations

4.1.3. Other: environmental tracers, gradients, age, temperature, concentrations etc.

4.2. Does the calibration methodology conform to best practice? Not Applicable. See our response to Question 6 of Compliance List.

4.2.1. Parameterisation

4.2.2. Objective function

4.2.3. Identifiability of parameters

4.2.4. Which methodology is used for model calibration?

4.3. Is a sensitivity of key model outcomes assessed against?

4.3.1. Parameters - Only for extraction volumes, K_v of aquitards, and Storativity and K_h of aquitards. Justification for excluding others acceptable.

4.3.2. Boundary conditions. No. Justification for exclusion acceptable.

4.3.3. Initial conditions: No. Justification for exclusion acceptable.

4.3.4. Stresses: Yes, three levels of extractions simulated.

4.4. Have the calibration results been adequately reported? Not Applicable. See our response to Question 6 of Compliance List.

4.4.1. Are there graphs showing modelled and observed hydrographs at an appropriate scale? Not provided.

4.4.2. Is it clear whether observed or assumed vertical head gradients have been replicated by the model? Yes.

4.4.3. Are calibration statistics reported and illustrated in a reasonable manner? Yes, for the alluvium and Pilliga. Since recharge to the alluvium was estimated by inversion, the calibration statistics is not very meaningful. For Pilliga, the SRMS is not within generally accepted limits. No statistics for other formations are possible because of limited observed data. Also recalled, that the model is not a calibrated one.

4.5. Are multiple methods of plotting calibration results used to highlight goodness of fit robustly?Is the model sufficiently calibrated? Not Applicable. See our response to Question 6 of Compliance List.

4.5.1. spatially

4.5.2. Temporally

4.6. Are the calibrated parameters plausible? Not applicable.

4.7. Are the water volumes and fluxes in the water balance realistic? Yes.

4.8. Has the model been verified? No. Not relevant either.

5. Prediction

5.1. Are the model predictions designed in a manner that meets the model objectives? Yes.

5.2. Is predictive uncertainty acknowledged and addressed? Yes.

5.3. Are the assumed climatic stresses appropriate? No. Only a percentage of rainfall is used as recharge estimate, outside the Alluvium.

5.4. Is a null scenario defined? No. AGWMG consider a base condition (say Climate) as null condition, and as the base condition to assess the impact of changed condition (Climate change). This definition of a null scenario is not appropriate here. However the base condition of extraction with initial set of adopted aquifer parameters may be considered as a null scenario.

5.5. Are the scenarios defined in accordance with the model objectives and confidence level classification? Yes.

5.5.1. Are the pumping stresses similar in magnitude to those of the calibrated model? If not, is there reference to the associated reduction in model confidence? Not applicable for Class 1 model.

5.5.2. Are well losses accounted for when estimating maximum pumping rates per well? Not relevant.

5.5.3. Is the temporal scale of the predictions commensurate with the calibrated model? If not, is there reference to the associated reduction in model confidence? Not relevant.

5.5.4. Are the assumed stresses and timescale appropriate for the stated objectives? Reasons for choosing assumed stresses and time scales are not evident, except, it is acknowledge that the required levels of stresses were estimated by a 'Reservoir Model'. How the stresses were implemented in each scenario is presented.

5.6. Do the prediction results meet the stated objectives? Yes.

5.7. Are the components of the predicted mass balance realistic?

5.7.1. Are the pumping rates assigned in the input files equal to the modelled pumping rates? Yes.

5.7.2. Does predicted seepage to or from a river exceed measured or expected river flow? Not applicable.

5.7.3. Are there any anomalous boundary fluxes due to superposition of head dependent sinks (e.g. evapotranspiration) on head-dependent boundary cells (Type 1 or 3 boundary conditions)? No.

5.7.4. Is diffuse recharge from rainfall smaller than rainfall? Yes.

5.7.5. Are model storage changes dominated by anomalous head increases in isolated cells that receive recharge? No.

5.8. Has particle tracking been considered as an alternative to solute transport modelling? Not applicable.

6. Uncertainty

6.1. Is some qualitative or quantitative measure of uncertainty associated with the prediction reported together with the prediction? Yes.

6.2. Is the model with minimum prediction-error variance chosen for each prediction? Not relevant.

6.3. Are the sources of uncertainty discussed?

6.3.1. measurement of uncertainty of observations and parameters Yes.

6.3.2. structural or model uncertaintyYes.

6.4. Is the approach to estimation of uncertainty described and appropriate? Not relevant because a stochastic approach to uncertainty analysis was not undertaken.

6.5. Are there useful depictions of uncertainty? Not relevant.

7. Solute transport (Not Applicable).

7.1. Has all available data on the solute distributions, sources and transport processes been collected and analysed? Not applicable
7.2. Has the appropriate extent of the model domain been delineated and are the adopted solute concentration boundaries defensible? Not applicable
7.3. Is the choice of numerical method and software appropriate? Not applicable
7.4. Is the grid design and resolution adequate, and has the effect of the discretisation on the model outcomes been systematically evaluated? Not applicable
7.5. Is there sufficient basis for the description and parameterisation of the solute transport processes? Not applicable
7.6. Are the solver and its parameters appropriate for the problem under consideration? Not applicable
7.7. Has the relative importance of advection, dispersion and diffusion been assessed? Not applicable
7.8. Has an assessment been made of the need to consider variable density conditions? Not applicable
7.9. Is the initial solute concentration distribution sufficiently well-known for transient problems and consistent with the initial conditions for head/pressure? Not applicable
7.10. Is the initial solute concentration distribution stable and in equilibrium with the solute boundary conditions and stresses? Not applicable
7.11. Is the calibration based on meaningful metrics? Not applicable
7.12. Has the effect of spatial and temporal discretisation and solution method taken into account in the sensitivity analysis? Not applicable
7.13. Has the effect of flow parameters on solute concentration predictions been evaluated, or have solute concentrations been used to constrain flow parameters? Not applicable
7.14. Does the uncertainty analysis consider the effect of solute transport parameter uncertainty, grid design and solver selection/settings? Not applicable
7.15. Does the report address the role of geologic heterogeneity on solute concentration distributions? Not applicable

8. Surface water–groundwater interaction

8.1. Is the conceptualisation of surface water–groundwater interaction in accordance with the model objectives? Yes.

8.2. Is the implementation of surface water–groundwater interaction appropriate? Yes.

8.3. Is the groundwater model coupled with a surface water model? No.
8.3.1. Is the adopted approach appropriate? Not applicable
8.3.2. Have appropriate time steps and stress periods been adopted? Not applicable
8.3.3. Are the interface fluxes consistent between the groundwater and surface water models? Not applicable

End Attachment B

Attachment C

Narrabri Gas Project (SSD 6456)
Detailed comments – Groundwater Impact Assessment Review

Estimation of Narrabri Gas Project (NGP) Water Production

Water production volumes for the NGP have been determined by the proponent based on reservoir modelling.

Three forecasts of water production have been considered by the proponent;

- 'Base Case' simulated water production of 37.5 GL
- 'Low Case' simulated water production of 35.5 GL
- 'High Case' simulated water production of 87.1 GL

All predicted impacts in the Groundwater Impact Assessment (GIA) are based on the volumes predicted by the reservoir model. The proponent has adopted the 'Base Case' water production profile for the project construction and design concept as well as the assessment of groundwater impacts against the Aquifer Interference Policy.

No details as to the assumptions used or the uncertainty associated with the water production volumes predicted by the reservoir model are detailed in the EIS.

Recommendation: To address the uncertainty associated with the water extraction rates predicted by the reservoir model, prior to project approval the proponent is required to;

- Provide the assumptions and uncertainties associated with the predicted water production volumes.
- Detail what impact any changes to the indicative Field Development Protocol will have on the predicted water production volumes both temporally and spatially.

Recommendation: If project approval is granted and the proponent exceeds the predicted take volume on which the impact assessments are based, the proponent is required to;

- Reduce water production to the 'predicted volumes in recognition that consent has been granted for the predicted impacts and not any in excess of these.
- If the proponent wishes to increase the volume produced they will be required to re assess groundwater impacts based on the higher volumes.

Prediction of Groundwater Impacts

Santos has developed a regional groundwater flow model to assess the impact of the NGP. This model has been assessed against model confidence level criteria from the Australian Groundwater Modelling Guidelines (Barnett *et al.* 2012).

Santos considers the model to be fit for purpose for predicting potential regional impacts on groundwater and surface water from proposed water extraction from deep Permian Age coal seams in the Gunnedah Basin. The numerical model is judged to have an overall confidence level of class 1.

The model to date has been reviewed by CSIRO who found the model an adequate representation of the regional groundwater flow system in the Gunnedah Basin. Further the reviewer indicates the confidence level of Class 1 is justified.

Note a more detailed review of the model has been proved by the DPIW groundwater modelling team.

DPIW has reviewed the available information and has the following comments on the prediction of groundwater impacts:

- DPIW acknowledges the NGP impact predictions are based on an uncalibrated Class 1 confidence (i.e. lowest confidence level) numeric model. Consequently the predictions are indicative in terms of both magnitude and timing at the local scale (i.e water supply bores, groundwater dependent ecosystems (GDEs), and culturally significant sites).
- DPIW concludes the model is not able to provide output at the scale and accuracy to assess the project's impacts against the minimal impact considerations of the Aquifer Interference Policy without intensive data collection and refinement of the model within the first five years of the project.
- DPIW acknowledges there is insufficient information available at this time for the proponent to create a calibrated model with higher confidence level – this point is further addressed under the Baseline Monitoring Report and Water Monitoring Plan comments.

Recommendation: To address the uncertainty around the impacts predicted by the model, DPIW recommends as a condition of consent the proponent is required to prepare a groundwater monitoring program in consultation with DPIW.

- The monitoring program must be developed with the aim of providing sufficient data to develop a calibrated model by year 5 of the project.
- The proponent is required to provide all monitoring data and a calibrated model developed to the satisfaction of DPIW for assessment and review at year 5 of the development.
  At this stage the proponent could be required to amend any aspect of their project plan and/or purchase additional entitlement to address any issues or impacts identified as a result of this review.
- The predicted impacts are not of sufficient detail in the area of depressurisation to allow comparison with observed data, identify local exceedances, and allow changes in operations before the end of water production. Note that due to the target depth, any impacts on the overlying highly productive aquifers are predicted to occur years after water production has stopped.
- DPI Water does not agree with all aspects of the model conceptualisation however acknowledge it is regional in nature – the proponent is required to consult with DPIW to addresses the issues identified in the conceptualisation of the system as part of the requirement to develop a calibrated model by year 5 of the project.
  - This should include a description of the conceptual understanding of groundwater flow in the Bohena Trough.
  - DPI Water acknowledges there is limited data available to conceptualise hydraulic properties in the Gunnedah Basin thus the reliance on literature values and hydraulic properties from conceptualisation of flow for areas far removed from the area impacted by the NGP.

<u>Water Baseline Report (Appendix G4)</u>

The Water Baseline report gives a general overview of the data considered by the proponent to support the Water Monitoring Plan.

The focus of the report is on the more productive Namoi Alluvium (22 monitoring bores at 15 sites (Figure 3-3) and the Pilliga Sandstone (Great Artesian Basin- Southern Recharge 30 monitoring bore at 19 sites (Figure 3-2)) with 9 monitoring bores at 4 sites included for the Gunnedah-Oxley Basin.

DPIW have reviewed available information and has the following comments on the Water Baseline Report;

- DPIW notes the data presented will need to be improved before baseline conditions can be adequately determined for water quantity and water quality for the Permo Triassic geological units most affected by the project due to the limited information presented, and it is also noted no data from sites classified as the target coal seams is included.
- DPIW notes the Sections 5.3 and 5.4 of the GIA included reference to water level and/or pressures data and hydraulic property information for the Permian geological units this information is not included in the Water Baseline report.
- DPIW notes very limited information is provided for the private landholder bores included in the report i.e. Figure 3-4 only.
- DPIW notes the GIA Section 5.8 includes a section on water quality in the coal seams, this information is not included in the Water Baseline Report.
- Given the limited information reported for the Permian geological units provided in the GIA and its appendices, all available information should be included to allow DPIW to address the adequacy of the characterisation of the flow system.

Recommendation: To address the deficiencies in the data presented in the Water Baseline Report (Appendix G4) the proponent is required to provide all data collected to date including data obtained during resource assessment and the pilot production activities including but not restricted to;

- All available water level and/or pressures data for the target coal seams and overlying geological units including the information summarised in Table 5-6 in the GIA and provide an assessment of whether this data can be extrapolated to show water levels/water pressure surfaces.
- All hydraulic property measurements for the target coal seams and overlying geological units including all hydraulic property information summarised in Sections 5.3 and 5.4, and Appendix C.

- Provide an assessment of all available data and information and present a summary of water level/water pressure and hydraulic properties information by geological unit.
- Provide further information on the existing landowner bores show in Figure 3-4 including; bore location information, type of data collected, and frequency of collection.

Recommendation: In Figures 3-1, 3-2 and 3-3 and Table 4-1 of the Water Baseline Report, DPIW has identified 12 government owned monitoring bores that the proponent has assigned to a geological unit different to DPIW's interpretation (details are given in Attachment B1), the proponent is required to;

- Adequately justify the geological unit they have assigned to each of the twelve monitoring bores or
- Amend the relevant sections to include each bore in the geological unit assigned by DPIW, the proponent must also address resulting deficiencies in the assessment of baseline conditions.

  Note: Amending the 12 bores will result in significant changes required to the baseline condition report as 2 of the 4 monitoring site for the Gunnedah-Oxley Basin and 7 of the 19 sites for the Great Artesian Basin are identified as being potentially incorrectly classified.

- DPIW notes the following regarding the water quality data reported in Table 4-3:
  - The pH range and maximum are unrealistic for natural conditions: pH 6.6 - 13
  - The high pH reported indicates some samples may be contaminated i.e. possibly from grouting cement
  - The K+ concentration are excessively large for natural conditions possibly due to residuum from drilling fluid.
  - DO or Eh data if available should be presented to confirm the high SO_4^{2+} concentrations given the water is a Na-HCO_3 water
- DPIW notes the following regarding the water quality data reported in Table 4-4:
  - The pH range 4.1 - 9.5 should be explained given the former is extremely low, and the latter suggests degassing during water sampling/storage.
  - Extreme pH values are tabulated for many individual bore-water samples.
- DPIW notes the proponent does not present the quality assurance/quality control associated with the data, has not assessed the data adequacy for use in trend analysis and has not shown trend analysis results.
- All groundwater data should be presented with field measurements otherwise, sample integrity, and environmental hazards & risks cannot be assessed.

Recommendation: The proponent is also required to address the appropriateness of the data presented in the Water Baseline Report by providing an analysis of the adequacy of the data in characterising typical temporal and spatial variations; the results will inform potential post approval changes in the monitoring plans.

Water Monitoring Plan (Appendix G3)

The Water Monitoring Plan (WMP) has been developed by the proponent to measure the potential effects of the project on the condition of the water resources.

The purpose of the WMP has been designed to;

- Support early detection and identification of unexpected impacts from the project,
- Identify thresholds for observed adverse changes in the condition of the water resources, including mitigation and management solutions and
- Validate the predicted effects of the project on the water resources, including adaptive management that will be followed if the predictions are found to be significantly less than observed.

DPIW have reviewed available information and has the following comments on the WMP:

- DPIW agrees in theory with the proponent the purpose of the WMP.
- DPIW acknowledges the concept of thresholds that when exceeded could result in mitigation, remediation and the employment of made good provisions, but does not agree on all the details.

- DPIW does not consider the data presented in the Water Baseline Report sufficient to adequately determine thresholds to identify change in the condition of the water resources, especially for the coal seams (Gunnedah-Oxley Basin) where there is very limited existing information available.
- DPIW does not consider the early detection network can adequately assess unexpected consequences in the subsurface across the project area given the limited number of bores.
- The geological units monitored in the early detection network are likely too far removed from the target coal seams to indicate unexpected consequences in the subsurface are occurring in the 25 years of water production as the detections may not occur until after water production has ceased.
- Uncertainty due to the lack of information on predicted impacts and time of arrivals for the early detection network needs to be addressed.
- DPIW believes a more effective early detection monitoring network would include bores that are stratigraphically closer to the depressurized coal seams.
- DPIW notes the proposed groundwater monitoring network does not adequately provide for data necessary to improve the conceptualisation of flow.

Recommendation: To address DPIW concerns regarding the WMP, in addition to the requirements identified in Recommendation 3, DPIW recommends as a condition of consent the proponent is required to prepare a groundwater monitoring plan in consultation with DPIW, including;

- The monitoring plan must include sites appropriate to monitoring early detection of variance to those predicted under the groundwater impact assessment.
- Adopting appropriate thresholds and strategies to remediate and mitigate and employ make good provisions based on exceedance of thresholds.
- Appropriate bore construction standards should be adopted to ensure adequate protection of the water resource from installation of monitoring bores. That is, either the Minimum construction standards for Water Bores in Australia, or the NSW Code of Practice for Coal Seam Gas Well Integrity depending on the depth and geological conditions to be intersected.

Recommendation: In Figures 3-4, 3-5, 3-6 and 3-9 and Table B-1 of the Water Monitoring Plan, DPIW has identified 12 government owned monitoring bores that the proponent has assigned to a geological unit different to DPIW's interpretation (details are given in Attachment D), the proponent is required to;

- Appropriately justify the geological unit they have assigned to each of the twelve monitoring bores,

  or

- amend the relevant sections to include each bore in the geological unit assigned by DPIW, the proponent must also address resulting deficiencies in the their assessment of baseline conditions.

  Note: Impacts to the Water Monitoring Plan can be addressed as part of the consultation with DPIW.

<u>General Comments relating to the GIA</u>

Recommendation: The proponent is required to provide the location and construction details of all proposed water production bores and their expected annual extraction volumes in advance of water production for each stage of the field development.

- Section 2.1.3, note numbers quoted in Table 2.2 are not current.
- Section 2.2.4 - Under the heading 'NSW Upper and Lower Namoi Groundwater Sources 2003', the reference to the Available Water Determinations for the supplementary water access licences and extraction limit is misleading and the statement following 'This is in response to the observed decline in groundwater levels in the Upper and Lower Alluvium' is incorrect.
- Section 4.4.4.4 Figure 4-9 and Figure 5-19 both show surface water groundwater interactions but with conflicting areas of losing and gaining streams.
- Section 4.5.11 Figure 4-11, the labels on the map are illegible.
- Section 5.2, Figure 5-1 lists the Cubbaroo formation as a 'significantly transmissive unit' which is contradictory to 5.2.1 where the Cubbaroo formation is described as a 'less significantly transmissive unit'. DPI Water considers the entire Upper and Lower Namoi Alluvium to be a significantly transmissive based on the proponents definition.

- The information presented in Section 5.4.3 regarding the pilot's water production impacts on a nearby monitoring well in an overlying formation, is insufficient to support the conclusions.
  - The pumping is not plotted on the figure thus no data is presented with which to draw conclusion on impacts from pumping.
  - There appears to be less than a year overlap between the pilot CSG pumping and the period monitored.
  - no explanation is given for the +/- 5m fluctuations illustrated in the graph.
- The inclusion of the screened interval data on the hydrographs in Figures 5-5, Figure 5-11 and 5-12 would make this information easier to interpret.
- Section 5.4.5 Figure 5-11 a and b and Figure 5-12 show data to 2011, the GIA should include more up to date data.
- Section 5.5.3, groundwater extraction data is quoted to 2011, the GIA should include more up to date data.
- Section 5.6.1, see above comment re Section 4.4.4.4.

End Attachment C

Attachment D

Narrabri Gas Project (SSD 6456)
Detailed comments – DPI Water Review of Geological Units

SiteID	Owner	Purpose	MonitoringType	Screen mBTOC	Lithological Unit	DPI Water Comment
GW021266-1	NSW Govt	Regional monitoring	Quality	21 - 21.9	Namoi alluvium	
GW021266-3	NSW Govt	Regional monitoring	Pressure	60 - 70.1	Namoi alluvium	
GW021266-4	NSW Govt	Regional monitoring	Pressure	107.3 - 113.4	Orallo Formation	Geologist and driller logs indicate this pipe is located in the Lower Namoi alluvium
GW021437-2	NSW Govt	Regional monitoring	Pressure and quality	47.9 - 49.4	Namoi alluvium	
GW025338-1	NSW Govt	Regional monitoring	Pressure and quality	25.9 - 30.5	Namoi alluvium	
GW025338-2	NSW Govt	Regional monitoring	Pressure	46.9 - 50.6	Namoi alluvium	
GW025338-3	NSW Govt	Regional monitoring	Pressure	65.5 - 70.1	Mooga Sandstone	Geologist log indicates this pipe is located in the Lower Namoi alluvium
GW025340-1	NSW Govt	Regional monitoring	Pressure	25.6 - 31.7	Namoi alluvium	
GW025340-2	NSW Govt	Regional monitoring	Pressure	35.4 - 41.5	Namoi alluvium	
GW025340-3	NSW Govt	Regional monitoring	Pressure	62.2 - 65.9	Mooga Sandstone	Geologist and driller logs indicates this pipe is located in the Lower Namoi alluvium
GW025343-1	NSW Govt	Regional monitoring	Pressure and quality	35.1 - 38.1	Namoi alluvium	
GW025343-2	NSW Govt	Regional monitoring	Pressure	45.1 - 50	Mooga Sandstone	Geologist and driller logs and depth indicate this pipe is located in the Lower Namoi alluvium
GW030070-1	NSW Govt	Regional monitoring	Pressure and quality	12.2 - 18.3	Namoi alluvium	
GW030070-2	NSW Govt	Regional monitoring	Pressure and quality	38.1 - 44.2	Namoi alluvium	
GW030070-3	NSW Govt	Regional monitoring	Pressure and quality	57.9 - 64	Namoi alluvium	
GW030117-1	NSW Govt	Regional monitoring	Pressure and quality	15.2 - 21.3	Namoi alluvium	
GW030117-2	NSW Govt	Regional monitoring	Pressure and quality	36.6 - 39.3	Namoi alluvium	
GW030117-3	NSW Govt	Regional monitoring	Quality	57.9 - 64	Namoi alluvium	
GW030121-1	NSW Govt	Regional monitoring	Quality	39.6 - 45.7	Pilliga Sandstone	Geologist, driller logs and depth indicate this pipe is located in the Lower Namoi alluvium
GW030121-3	NSW Govt	Regional monitoring	Pressure	106.7 - 112.8	Pilliga Sandstone	Sandstone based on drillers log only. No geologist log available could be in Lower Namoi Alluvium.
GW030278-1	NSW Govt	Regional monitoring	Pressure and quality	24.7 - 27.7	Namoi alluvium	
GW030310-1	NSW Govt	Regional monitoring	Pressure and quality	34.1 - 40.2	Namoi alluvium	
GW030310-2	NSW Govt	Regional monitoring	Pressure and quality	100.5 - 106.6	Pilliga Sandstone	Geologist and driller logs indicate this pipe is located in the Lower Namoi alluvium
GW030400-1	NSW Govt	Regional monitoring	Pressure and quality	60.6 - 61.8	Pilliga Sandstone	Geologist and driller logs indicate this pipe is located in the Lower Namoi alluvium
GW030889-1	NSW Govt	Regional monitoring	Pressure	350.3 - 370	Pilliga Sandstone	
GW036005-2	NSW Govt	Regional monitoring	Pressure and quality	76 - 78	Namoi alluvium	
GW036092-1	NSW Govt	Regional monitoring	Pressure	19.8 - 22.8	Namoi alluvium	
GW036497-1	NSW Govt	Regional monitoring	Pressure	18 - 20	Napperby Formation	Geologist and driller logs and depth indicate this pipe is located in the Upper Namoi Zone 2 alluvium
GW036546-1	NSW Govt	Regional monitoring	Pressure	80 - 82.5	Digby Fm Formation	Geologist and driller logs indicate this pipe is located in the Upper Namoi Zone 2 alluvium
GW036546-2	NSW Govt	Regional monitoring	Pressure	27 - 29	Napperby Formation	Geologist and driller logs and depth indicate this pipe is located in the Upper Namoi Zone 2 alluvium
GW036546-3	NSW Govt	Regional monitoring	Pressure	87 - 91	Black Jack Group	Geologist and driller logs indicate this pipe is located in the Upper Namoi Zone 2 alluvium
GW098011-1	NSW Govt	Regional monitoring	Pressure	50 - 56	Pilliga Sandstone	

Attachment E

Narrabri Gas Project (SSD 6456)
Detailed comments – Assessment of Groundwater SEARs in Narrabri Gas Project EIS

In relation to water resources potentially affected by the project, the DPI Water has recommended that the Environmental Impact Statement be required to include:			
Requirement	Section[1]	Proponent Response	DPI Water Comment
Details of water proposed to be taken (including through inflow and seepage) from each water source as defined by the relevant water sharing plan. This should include a description of the expected spatial and temporal pattern of water take (e.g. year on year), as well as a detailed site water balance outlining predicted annual water production for the life of the project.	6.8.1	Indicative development plan for gas field, and simulated rates of water production in time and space	**Addressed.** Section 6.9 provides details of water to be taken from each water source for the base case, lower case, and higher case model simulations Section 6.8.1 shows historical water production from the pilots Section 6.8.2 and 6.8.2.1 shows the indicative Project Field Development Protocol and the spatial and temporal pattern of water take for the lower, base, and high case model simulations. Section 6.9 describes a detailed site water balance for the lower, base, and high case model simulations.
A detailed assessment against the NSW Aquifer Interference Policy (2012), using the DPI Water assessment framework.	6.8.1	Indicative development plan for the gasfield, and simulated rates of water production in time and space. Produced water management is not considered in the report	**Addressed in AIP tables below**.
Assessment of impacts on surface and ground water sources (both quality and quantity), related infrastructure, watercourses, riparian land, and groundwater dependent ecosystems, and measures proposed to reduce and mitigate these impacts.	All	This groundwater impact assessment	**Partially Addressed.** Assessment of drawdown impacts on groundwater sources is addressed in Section 6.9. No formal assessment of impacts on groundwater quality is made as the proponent asserts no changes in beneficial use. This conceptualisation is consistent with DPIW view and DPIW notes that groundwater quality data is part of the proposed monitoring plan. Measures proposed to reduce and mitigate groundwater impact (quantity) are addressed in GIS Appendix G3 and Section 7.0. Recommend condition of consent requiring groundwater monitoring plan be prepared to the satisfaction of DPIW. Note Surface Water and GDE review reported separately.
A detailed groundwater monitoring plan for the project should be developed and implemented in consultation with DPI Water groundwater experts.	EIS Appendix G3	Not considered in this report. See the Water Monitoring Report (CDM Smith 2016c)	**Condition of consent required.** A groundwater monitoring plan is presented in EIS Appendix G3. DPI W acknowledges meetings with Santos regards their groundwater monitoring plans however no consensus of the monitoring requirements between DPIW and Santos was reached. Recommend condition of consent requiring groundwater monitoring plan be prepared to the satisfaction of DPIW.

[1] Appendix F, Table 1-2 Labelled “Advice of DPI Water to NSW Departments t of Planning and Infrastructure”

In relation to water resources potentially affected by the project, the DPI Water has recommended that the Environmental Impact Statement be required to include:			
Requirement	Section[1]	Proponent Response	DPI Water Comment
Detailed surface water and groundwater modelling to assess impacts of the project, undertaken in accordance with standards outlined in relevant National and State Guidelines. The EIS should also describe a plan for ongoing validation calibration and development of the model.	Section 6.0	Groundwater flow modelling and predictive simulations. Future development of the groundwater modelling.	**Modelling review in separate attachment**
A table outlining where each element of the Secretary's Environmental Assessment Requirements is addressed in the Environmental Impact Statement.	Section 1.5.2	This table for this report	**Addressed**
The predicted highest groundwater table at the site.	6.9		**Addressed** Addressed in Section 6.9.
Works likely to intercept, connect with or infiltrate the groundwater sources.	7.0	Considers potential sub-surface impacts of drilling, excluding surface works 9e.g. well pads and pipelines) and managed surface works (e.g. storage ponds, creek crossings) and managed surface water releases are not considered in this report.	**Addressed** Section 6.8.1 describes water production from the pilots, Section 6.8.2 describes an indicative field development protocol with numbers of bores and staged water production described. Infiltration of treated waste water considered by EPA
Any proposed groundwater extraction, including purpose, location and construction details of all proposed bores and expected annual extraction volumes.	6.8.1	Indicative field development protocol including design and simulated rates of production for.	**Partially Addressed** Section 6.8 discusses proposed groundwater extraction, including purpose, but details of the location and construction details of all proposed bores and expected annual extraction volumes is not provided. The uncertainties in estimates of water production and the impacts of this uncertainty on model predictions of groundwater impact are not addressed. Recommend proponent provide an assessment of the scale of potential changes that variations in the field development protocol may have on water production volumes and their distribution in both time and space.
A description of the flow gradients and physical and chemical characteristics of the groundwater source (including connectivity with other groundwater	4.0 5.0	Description of the existing environment including hydrology Conceptual	**Partially Addressed**. Section 5.0, the conceptual hydrogeologic model, addresses flow gradients and physical characteristics of the groundwater sources for the Namoi Alluvium and Pilliga Sandstone of the GAB. No information on the GOB and target Permian coal seams is presented. Section 5.7 summarises water quality in the Namoi Alluvium, Pilliga

In relation to water resources potentially affected by the project, the DPI Water has recommended that the Environmental Impact Statement be required to include:			
Requirement	Section[1]	Proponent Response	DPI Water Comment
and surface water sources).		Hydrogeology	Sandstone (GAB), the Gunnedah Basin, and for coal seam water quality. Appendix G4 presents Baseline Water Data (including water quality data). Connectivity is assessed in Section 5.0 and Section 7.0.The pedigree of the data regards quality assurance and quality control for all aspects of the data presented needs to be addressed in the development of the monitoring plan. There is no presentation of the conceptual groundwater flow directions or the initial head distribution of the model within the Permian strata. The proponent should provide the data relied on to support the conceptualisation of the hydrogeology of the Permian strata in sufficient detail to enable verification of the reported conclusions. Specifically information on all groundwater data collected in the proponents appraisals of coal seam gas production and the Pilots is requested including: a) information on water production impacts on water level pressure declines on the coal seams or any overlying or underlying aquifer or confining units; b) data summarized in Figures 5-6, 5-7, and Appendix C ; and c) Hydrogeological data used to inform the proponents Reservoir Model In providing the above information the proponent should consider whether data summarized in Figures 5-6, 5-7, and Appendix C can be used to develop maps of groundwater pressure in the Permian.
Baseline monitoring (min 2 years) for groundwater quantity and quality for all aquifers and GDEs.	3.1 5.0	Data collation and review Conceptual Hydrogeology	**Partially Addressed** DPIW disagrees with aspects of the presented monitoring targets within the baseline report. In particular DPIW has a different view on the level of baseline data presented for the Permian strata. This aspect of the baseline should be clarified prior to approval. Further refinement to the monitoring plan should be a conditional consent requirement. Specific comments on the monitoring plan data are below. In the further development of the groundwater monitoring plan a number of detailed comments below should be considered. 1) Appendix G3, Table 4-1, be corrected to note that GW036546-1 is a DPI W monitoring bore not a Santos owned monitoring bore 2) Revise the geological units the proponent has assigned to 12 Government monitoring bores sites (EIS appendix's G3 and G4) in consultation with DPI W (see table at end of this section below) 3) To address whether a change in strata identified in the baseline monitoring report and the monitoring plan will revise their conclusions regards the adequacy of early detection monitoring network, EIS Appendix G3, or their assessment of the adequacy of baseline information in Gunnedah Oxley Basin, EIS Appendix G3 4) For groundwater quality data reporting a description of the quality assurance/quality control measures for all aspects of the data presented (field, office, lab, database) should be presented in the baseline and monitoring plan reports. 5) The details on screened interval on all hydrographs in Section 4.1.1, 4.1.2 and 4.1.3 be included.

In relation to water resources potentially affected by the project, the DPI Water has recommended that the Environmental Impact Statement be required to include:			
Requirement	Section[1]	Proponent Response	DPI Water Comment
			6) Correct the inconsistency in the reported number of groundwater quality monitoring bores: 40 in Table 3-2, 42 in Section 4-2. 7) Describe how the following data anomalies in Table 4-3 will be addressed in determining baseline conditions: a) CO_3 levels when at the reported pH, CO_3 would be non-detectable (Minimum pH = 5.8 yet min. CO_3 = 1 mg/L) b) reported values for pH range and maximum (pH 6.6 – 13) c) high pH in some bores may indicate influence from bore cement grouting. d) K^+ concentrations are excessively high for natural conditions e) Inclusion of DO and any Eh data associated with the SO_4^{2+} concentrations. 8) Discuss in relation to data Table 4-4: a) whether the pH range 4.1 - 9.5 is realistic, and b) the reasons for the extreme pH values tabulated for many individual groundwater samples.
The predicted impacts of any final landform on the groundwater regime.		Not considered in this report	Not relevant
The existing groundwater users within the area (including the environment), any potential impacts on these users and safeguard measures to mitigate impacts	4.8, 7.4	Current groundwater extraction and entitlements Potential groundwater impacts and mitigation measures	**Partially Addressed.** Section 4.8 shows existing abstraction and entitlements. Appendix G3 Section 3.2.2.1 Figure 3.3 spatially displays location of privately owned bores from which information has been collected. Section 6.9 identifies potential groundwater impacts, Appendix G3 Section 3.7 identifies safeguard measures to mitigate impacts, and Section 7.0 assesses risks and make good measures. The details on the existing users, location, type of data collected, and frequency of collection) are not reported The proponent is required to provide a more detailed presentation of the proposed monitoring of private bores to allow DPI to assess their groundwater monitoring plan.
An assessment of the quality of the groundwater for the local groundwater catchment.	5.7	Groundwater Quality	**Partially Addressed.** Section 5.7 and 5.8 present data on regional and coal seam groundwater quality and Table 5-13 and 5-14 shows regional groundwater quality and water quality in the coal seams EIS Appendix G4 Water Baseline Report and Table 4-2 ('Water Baseline' report) details the baseline water quality collected by Santos for the project. Spatially there is limited baseline data for groundwater quality. This limits the veracity of the claim that no changes in beneficial use will occur. It is however consistent with DPIW conceptualisation and DPIW notes that groundwater quality data is part of the proposed monitoring plan.
An assessment of the potential for groundwater contamination (considering both the impacts of the proposal on groundwater contamination and the impacts of contamination on the	7.4	Groundwater risk assessment potential impacts and mitigation measures	Well integrity to be addressed by DRE Above groundwater activities to be addressed by OEH/EPA Change in beneficial use category considered above

In relation to water resources potentially affected by the project, the DPI Water has recommended that the Environmental Impact Statement be required to include:			
Requirement	Section[1]	Proponent Response	DPI Water Comment
proposal).			
Measures proposed to protect groundwater quality, both in the short and long term, so that remediation is not required.	7.4	Groundwater risk assessment potential impacts and mitigation measures	**Addressed.** Section 7.0 assesses measures proposed to protect groundwater quality, both in the short and long term, so that remediation is not required. Note that no protection is required for the deep part of the groundwater flow system as fresher water is expected to migrate downward into to increasingly more saline underlying geological units. Groundwater contamination considered by EPA.
The results of any models or predictive tools used.	6.9	Groundwater modelling results	**Addressed**

End Attachment E

Attachment F

Narrabri Gas Project (SSD 6456)
Detailed comments – Assessment against the Aquifer Interference Policy

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Where a proposed activity will take water, adequate arrangements must be in place to account for this water. It is the proponent's responsibility to ensure that the necessary licences are held. These requirements are detailed in Section 2 of the AIP, with the specific considerations in Section 2.1 addressed systematically below.

Where a proponent is unable to demonstrate that they will be able to meet the requirements for the licensing of the take of water, consideration should be given to modification of the proposal to prevent the take of water.

Table 2. Has the proponent:

	AIP requirement	Proponent response	DPI Water comment
1	Described the water source(s) the activity will take water from?	EIS Chapter 6 provides a detailed project description. GIA Section 1 describes the activity, Section 6.8.1 describes how the water would be taken and Section 5 provides detailed analysis of the identified water sources.	**Addressed**
2	Predicted the total amount of water that will be taken from each connected groundwater or surface water source on an annual basis as a result of the activity?	GIA Section 6.8.1 presents the indicative Field Development Protocol adopted for the GIA. Sections 6.8.1.1 and 6.8.1.2 describe the calculation of water take from each simulated target.	**Addressed** Note - all take must be accounted for by obtaining adequate entitlement from the relevant groundwater sources.
3	Predicted the total amount of water that will be taken from each connected groundwater or surface water source after the closure of the activity?	Section 6.9.1 provides detailed analysis of the predicted water takes from contributing hydrostratigraphic units, including quantification of fluxes from contributing units during and following the activity, and net totals from each unit from inception of the activity to full final recovery of the hydrostratigraphic system.	**Addressed.** Note - all take must be accounted for by obtaining adequate entitlement from the relevant groundwater sources.
4	Made these predictions in accordance with Section 3.2.3 of the AIP? (refer to Table 3, below)	See Table 4 below.	**Addressed in AIP Table below**
5	Described how and in what proportions this take will be assigned to the affected aquifers and connected surface water sources?	The water take is wholly made from the Gunnedah-Oxley Basin water source.	**Addressed.** Note - Water take from Gunnedah-Oxley Basin water source but ultimately results in take from other affected aquifers
6	Described how any licence exemptions might apply?	No known exemptions are currently in place for abstraction of water for the proposed activities	**Addressed.**
7	Described the characteristics of the water requirements?	EIS Chapter 6 describes the proposed project water production profile. GIA Sections 6.8 and 6.9 elaborate an interpretation of the field development protocol that is used for the GIA simulations.	**Addressed.**

	AIP requirement	Proponent response	DPI Water comment
8	Determined if there are sufficient water entitlements and water allocations that are able to be obtained for the activity?	There is currently sufficient water available on the water market for the Gunnedah-Oxley Basin (Other) groundwater source. Where there are limitations in the market for this particular water source, Santos will seek further controlled allocations from the State Government.	**Addressed.**
9	Considered the rules of the relevant water sharing plan and if it can meet these rules?	Santos has considered the rules prescribed in the Water Sharing Plans for the NSW Murray Darling Basin Porous Rock Groundwater Sources 2011, NSW Great Artesian Basin Groundwater Sources 2008, and Upper and Lower Namoi Groundwater Sources 2003, and believes it can meet these rules in relation to the project area.	**Addressed.**
10	Determined how it will obtain the required water?	Based on the forecast take of water, Santos will acquire adequate water access licenses to account for its requirements.	**Addressed.** Note all take must be accounted for by obtaining adequate entitlement from the relevant groundwater sources
11	Considered the effect that activation of existing entitlement may have on future available water determinations?	Santos is not aware of any existing entitlement that has not already been activated for this water source.	**Addressed**
12	Considered actions required both during and post-closure to minimize the risk of inflows to a mine void as a result of flooding?	Not applicable.	**Not applicable.**
13	Developed a strategy to account for any water taken beyond the life of the operation of the project?	As Santos is proposing to take water from a regulated water source, recharge to this source from other water sources has been accounted for in accordance with the principles used to calculate the Sustainable Diversion Limits.	The proponent has misunderstood AIP requirement 13 based on the response opposite. **Addressed -** Section 6-9 accounts for any water taken beyond life of operation of the project
Will uncertainty in the predicted inflows have a significant impact on the environment or other authorised water users? If **YES,** items 14-16 must be addressed.			
14	Considered any potential for causing or enhancing hydraulic connections, and quantified the risk?	Not required	**Not addressed - response required**
15	Quantified any other uncertainties in the groundwater or surface water impact modelling conducted for the activity?	Not required	**Not addressed - response required**
16	Considered strategies for monitoring actual and reassessing any predicted take of water throughout the life of the project, and how these requirements will be accounted for?	Not required	**Not addressed - response required**

Table 3. Determining water predictions in accordance with Section 3.2.3

	AIP requirement	Proponent response	DPI Water comment
1	**For the Gateway process**, is the estimate based on a simple modelling platform, using suitable baseline data, that is, fit-for-purpose?	The project is exempt from the Gateway process. A Site Verification Certificate was issued by NSW Planning and Environment on 1 December 2015 verifying that the project area does not contain Biophysical Strategic Agricultural Land (BSAL).	**Not applicable.**
2	**For State Significant Development or mining or coal seam gas production**, is the estimate based on a complex modelling platform that is: • Calibrated against suitable baseline data, and in the case of a **reliable water source,** over at least two years? • Consistent with the Australian Modelling Guidelines? • Independently reviewed, robust and reliable, and deemed fit-for-purpose?	Yes. The development of a fit for purpose numerical groundwater model for the project is described in detail in Section 6 of this GIA. The model is calibrated against the available baseline data within the project area and GIA study area, and is developed in accordance with the guiding principles of the Australian Groundwater Modelling Guidelines. The model has been independently reviewed by CSIRO (Appendix F) against the model review checklist established in the guidelines. The independent review found that "The regional groundwater MODFLOW model for the Gunnedah basin can be considered state of the art and is suited to assess potential impacts of water extraction for coal seam gas depressurization on the surface water and groundwater resources in the Gunnedah Basin district."	DPIW acknowledges the NGP impact predictions are based on a regional, uncalibrated Class 1 confidence model. Consequently the predictions are indicative in terms of both magnitude and timing at the local scale. DPIW concludes the model is not able to provide output at the scale and accuracy to assess the project's impacts against the minimal impact considerations of the Aquifer Interference Policy. DPIW notes there is currently insufficient data reported to develop a calibrated model or improve its predicative capability. Please refer to detailed comments re model review provided by DPI Water Modelling team for additional comments. DPI acknowledges the model has been independently reviewed (CSIRO) and been found to be robust and reliable, and deemed fit-for- purpose for making regional predictions of the projects impacts. To address the uncertainty around the impacts predicted by the model, as a condition of consent the proponent is required to prepare a groundwater monitoring plan to the satisfaction of DPIW; • The monitoring plan must be developed with the aim of providing sufficient data to develop a calibrated model by year 5 of the project. • The proponent is required to provide a calibrated model developed to the satisfaction of DPIW for assessment and review at year 5 of the development. • At this stage the proponent could be required to amend any aspect of their project plan and/or purchase additional entitlement to address any issues or impacts identified as a result of this review.
3	In all other processes, estimate based on a desk-top analysis that is: • Developed using the available baseline data that has been collected at an appropriate frequency and scale; and • Fit-for-purpose?	Yes. In addition to estimates based on the numerical groundwater modelling, this GIA incorporates a detailed assessment of the potential for the project to cause impacts to GDEs (Appendix B) which is undertaken in line with the current national framework for assessing the environmental water requirements of GDEs—utilizing the GDE toolbox—and following DPI Water's 'Risk assessment guidelines for GDEs, and based on site visits and collection of baseline data, The assessment of subsidence potential (Appendix G) is undertaken based on industry standard methods and includes subsidence baseline monitoring commissioned by Santos.	**Not Applicable**

Table 4. Has the proponent provided details on:

	AIP requirement	Proponent response	DPI Water comment
1	Establishment of baseline groundwater conditions?	GIA Section 4 presents a description of the existing environment, including the baseline hydrological (Section4.4) and hydrogeological (Section 4.5) conditions. This information informs the conceptual hydrological model and calibration of the numerical groundwater flow model. In addition, the Water Baseline Report (EIS Technical Appendix G4) presents an analysis of all pertinent hydrologic baseline data, including groundwater and surface water characteristics relevant for establishing pre-activity baselines.	**Partially Addressed**. DPIW notes the data presented in the GIA and its appendices is inadequate for defining baseline conditions for water quantity and water quality for the Permo Triassic geolgocial units most affected by the project due to the limited information presented, it is also noted no data from sites classified as the target coal seams is included. The proponent is required to prepare a groundwater monitoring plan to the satisfaction of DPIW; • The monitoring plan must be developed with the aim of providing sufficient data to develop a calibrated model by year 5 of the project. • The proponent is required to provide a calibrated model developed to the satisfaction of DPIW for assessment and review at year 5 of the development. • At this stage the proponent could be required to amend any aspect of their project plan and/or purchase additional entitlement to address any issues or impacts identified as a result of this review.
2	A strategy for complying with any water access rules?	Adequate water access licenses in accordance with the *Water Management Act 200*0 will be acquired prior to the take of water. Note: GIA Section 6.8.6 describes the Water Sharing Plan (WSP) areas and groundwater sources that are relevant to the project. Groundwater modelling in GIA Section 6.9 predicts the induced water takes from each groundwater source, both during and following the activity; however, all direct take of water will be entirely from the Gunnedah-Oxley Basin Groundwater Source, and implicit in the Sustainable Diversion Limit (SDL) and Long- Term Average Annual Extraction Limit (LTAAEL) for this water source is allowance for recharge from connected sources.	The proponent must obtain all necessary water licences for the project prior to the commencement of water extraction.
3	Potential water level, quality or pressure drawdown impacts on nearby basic landholder rights water users?	GIA Section 4.8 identifies the existing water abstraction and entitlements, including nearby basic landholder rights water users. Section 6.9 describes the potential impacts determined from the base case simulation. Section 6.12 confirms that no impact is predicted that exceeds the Minimal Impact Consideration criteria listed in Table 1 of the AIP for the relevant classifications of beneficially-used groundwater sources.	**Addressed.** Note - DPI Water acknowledges a regional model of Class 1 confidence level, is not expected to be precise in its predictions drawdown impacts on nearby basic landholder rights water users The utility of model prediction is therefore indicative of potential pressure/level impacts on these users, indicative meaning order of magnitudes of drawdowns in pressures/level, and their time lags
4	Potential water level, quality or pressure drawdown impacts on nearby licensed water users in connected groundwater and surface water sources?	GIA Section 4.8 identifies the existing water abstraction and entitlements including nearby basic landholder rights water users. Section 6.9 predicts the potential impacts of the activity on existing groundwater uses, and Section 7.4.4 assesses the	**Addressed.** Note - DPI Water acknowledges a regional model of Class 1 confidence level, is not expected to be precise in its predictions of drawdown impacts on nearby licensed water users in connected groundwater and surface water

	AIP requirement	Proponent response	DPI Water comment
		risks from these potential impacts. Section 6.12 confirms that no impact is predicted that exceeds the Minimal Impact Consideration criteria listed in Table 1 of the AIP for the relevant classifications of beneficially-used groundwater sources. Assesses the risks from these potential impacts. Section 6.12 confirms that no impact is predicted that exceeds the Minimal Impact Consideration criteria listed in Table 1 of the AIP for the relevant classifications of beneficially-used groundwater sources.	sources. The utility of model prediction is therefore indicative of potential pressure/level impacts on these users, indicative meaning order of magnitudes of drawdowns in pressures/level, and their time lags
5	Potential water level, quality or pressure drawdown impacts on groundwater dependent ecosystems?	Section 6.9 predicts the potential impacts of the activity on existing groundwater uses. No impact is predicted that exceeds the Minimal Impact Consideration criteria listed in Table 1 of the AIP for the relevant classifications of groundwater sources. No impact to high priority GDEs is predicted.	**Refer to GDE review**
6	Potential for increased saline or contaminated water inflows to aquifers and highly connected river systems?	Section 6.9 predicts the potential impacts of the activity on existing groundwater uses. No negative impacts on water quality are predicted to occur as a consequence of water extraction or beneficial uses of groundwater and surface water.	**Addressed.**
7	Potential to cause or enhance hydraulic connection between aquifers?	Sections 7.4.2 and 7.4.3 addresses risk and mitigation of enhanced connectivity between aquifers due to the activity, including via existing and proposed wells, via existing groundwater bores, and via geological faulting.	**Addressed for risks identified.** Risk of the potential for enhanced hydraulic connection between coal seams as a result of reduction of pressure heads in the target coal seams to be assessed by the Division of Resources & Geosciences.
8	Potential for river bank instability, or high wall instability or failure to occur?	Not applicable	**Agreed**
9	Details of the method for disposing of extracted activities (for coal seam gas activities)?	Addressed in EIS Chapter 6 and supported by Technical Appendix G2 “Irrigation Concept Design” and Technical Appendix G1 “Managed Release Scheme – Bohena Creek”.	**Addressed.**

Table 5. Minimal impact considerations

Aquifer	Alluvial aquifer – Upper and Lower Namoi Groundwater Source	
Category	**Highly Productive**	
Level 1 Minimal Impact Consideration	**Assessment**	**DPI Water Comment**
Water table Less than or equal to a 10% cumulative variation in the water table, allowing for typical climatic post-water sharing plan variations, 40 metres from any: ▪ high priority groundwater dependent ecosystem or ▪ high priority culturally significant site listed in the schedule of the relevant water sharing plan. **OR** A maximum of a 2 metre water table decline cumulatively at any water supply work.	GIA Sections 6.9, 61.2 and 7.4.4. No high-priority GDEs associated with the Upper and Lower Namoi Groundwater Sources have been identified in the assessment area. No high priority culturally significant sites are present in the project area. *The project is considered to be **acceptable** in regard to water table decline at GDEs, culturally significant sites and water supply work.*	**Addressed** Note - DPI Water acknowledges a regional model of Class 1 confidence level, is not expected to be precise in its predictions at the local scale (i.e. water supply bore, stock and domestic bores or GDE). The utility of model prediction is therefore indicative of potential pressure/level impacts at the local scale, indicative meaning order of magnitudes of drawdowns in pressures/level, and their time lag.
Water pressure A cumulative pressure head decline of not more than 40% of the post-water sharing plan pressure head above the base of the water source to a maximum of a 2 metre decline, at any water supply work. **OR**, for the Lower Murrumbidgee Deep Groundwater Source: A cumulative pressure head decline of not more than 40% of the post-water sharing plan pressure head above the top of the relevant aquifer to a maximum of a 3 metre decline, at any water supply work.	No drawdown greater than 0.5 meters is predicted in the Namoi Alluvium, which contains the majority of water supply works. *The project is considered to be **acceptable** in regard to water pressure decline at water supply works.*	**Addressed** Note - DPI Water acknowledges a regional model of Class 1 confidence level, is not expected to be precise in its predictions at the local scale (i.e. water supply bore, stock and domestic bores or GDE). The utility of model prediction is therefore indicative of potential pressure/level impacts at the local scale, indicative meaning order of magnitudes of drawdowns in pressures/level, and their time lag.
Water quality Any change in the groundwater quality should not lower the beneficial use category of the groundwater source beyond 40 metres from the activity. No increase of more than 1% per activity in long-term average salinity in a highly connected surface water source at the nearest point to the activity. No mining activity to be below the natural ground surface within 200 metres laterally from the top of high bank or 100 metres vertically beneath (or the three dimensional extent of the alluvial water source - whichever is the lesser distance) of a highly connected surface water source that is defined as a reliable water supply. Not more than 10% cumulatively of the three dimensional extent of the alluvial material in this water source to be excavated by mining	GIA Section 7.4.4.4. Depressurization of the target coal seams for the project would induce small groundwater flows from the Pilliga Sandstone into the underlying depressurized strata within the Gunnedah-Oxley Basin, and even smaller flows from the Namoi Alluvium to the Pilliga Sandstone and Gunnedah-Oxley Basin. Because the direction of induced groundwater flow would be downward toward the depressurized coal seams, the potential for change in water quality of shallow groundwater sources by poorer quality water in the deeper strata is considered to be negligible and not a risk. No change in the beneficial use category of the	**Addressed** Note - DPI Water acknowledges a regional model of Class 1 confidence level, is not expected to be precise in its predictions at the local scale (i.e. water supply bore, stock and domestic bores or GDE). The utility of model prediction is therefore indicative of potential pressure/level impacts at the local scale, indicative meaning order of magnitudes of drawdowns in pressures/level, and their time lag.

Aquifer	Alluvial aquifer – Upper and Lower Namoi Groundwater Source	
Category	Highly Productive	
Level 1 Minimal Impact Consideration	**Assessment**	**DPI Water Comment**
activities beyond 200 metres laterally from the top of high bank and 100 metres vertically beneath a highly connected surface water source that is defined as a reliable water supply.	groundwater sources is predicted to occur. No mining activity is included as part of the project. The project is considered to be acceptable in regard to water quality.	

Aquifer	Porous Rock – Great Artesian Basin –Southern Recharge	
Category	Highly Productive	
Level 1 Minimal Impact Consideration	**Assessment**	**DPI Water Comment**
Water table Less than or equal to a 10% cumulative variation in the water table, allowing for typical climatic 'post-water sharing plan' variations, 40 metres from any: ▪ high priority groundwater dependent ecosystem or ▪ high priority culturally significant site listed in the schedule of the relevant water sharing plan. **OR** A maximum of a 2 metre water table decline cumulatively at any water supply work.	GIA Sections 6.9, 61.2 and 7.4.4. No high-priority GDEs associated with the Pilliga Sandstone aquifer have been identified in the assessment area. The groundwater modelling predicts maximum drawdown less than 0.5 meters in the Pilliga Sandstone at the locations of the springs. No high priority culturally significant sites are present in the project area. *The project is considered to be **acceptable** in regard to water table decline at GDEs, culturally significant sites and water supply work*.	**Addressed** Note - DPI Water acknowledges a regional model of Class 1 confidence level, is not expected to be precise in its predictions at the local scale (i.e. water supply bore, stock and domestic bores or GDE). The utility of model prediction is therefore indicative of potential pressure/level impacts at the local scale, indicative meaning order of magnitudes of drawdowns in pressures/level, and their time lag.
Water pressure Less than 0.2 metre cumulative variation in the groundwater pressure, allowing for typical climatic 'post-water sharing plan' variations, 40 metres from any: ▪ high priority groundwater dependent ecosystem or ▪ high priority culturally significant site listed in the schedule of the relevant water sharing plan. A cumulative pressure level decline of not more than 15 metres, allowing for typical climatic 'post-water sharing plan' variations. The cumulative pressure level decline of no more than 10% of the 2008 pressure level above ground surface at the NSW State border, as agreed between NSW and Queensland.	GIA Sections 6.9, 61.2 and 7.4.4. The groundwater modelling predicts maximum drawdown less than 0.5 meters in the Pilliga Sandstone at the locations of nine GDEs that may be reliant on surface expression of groundwater (potential Type 2 GDEs). Drawdown at the potential Type 2 GDEs may meet the criteria of 0.2 meters. All potential Type 2 GDEs are assessed to have low ecological values, mainly due to the absence of protected or important wetland species, and due to the heavily or moderately modified nature of the sites. None of the potential Type 2 GDEs meet the definition of a high-priority GDE in NSW, and none support MNES under the EPBC Act. No high priority culturally significant sites are present in the project area. No impact on pressure levels would occur at the NSW State border as a result of the project. *The project is considered to be **acceptable** in regard to water pressure decline at water supply works*.	**Addressed** Note - DPI Water acknowledges a regional model of Class 1 confidence level, is not expected to be precise in its predictions at the local scale (i.e. water supply bore, stock and domestic bores or GDE). The utility of model prediction is therefore indicative of potential pressure/level impacts at the local scale, indicative meaning order of magnitudes of drawdowns in pressures/level, and their time lag.
Water quality Any change in the groundwater quality should not lower the beneficial use category of the groundwater source beyond 40 metres from the activity.	GIA Section 7.4.4.4. . Depressurization of the target coal seams for the project would induce small groundwater flows from the Pilliga Sandstone into the underlying depressurized strata within the Gunnedah-Oxley Basin, and even smaller flows from the Namoi Alluvium to the Pilliga Sandstone and Gunnedah-Oxley Basin. Because the direction of induced groundwater flow would be downward toward the depressurized coal seams, the potential for change in water quality of shallow groundwater sources by poorer quality water in the deeper strata is considered to be	**Addressed**

Aquifer	**Porous Rock – Great Artesian Basin –Southern Recharge**	
Category	**Highly Productive**	
Level 1 Minimal Impact Consideration	**Assessment**	**DPI Water Comment**
	negligible and not a risk. Potential changes in water quality of the Pilliga Sandstone due to downward flows from overlying sources are expected to be very slow and imperceptible. No change in the beneficial use category of the groundwater sources is predicted to occur. The project is considered to be acceptable in regard to water quality	

Aquifer	Porous Rock – Great Artesian Basin – Surat	
Category	Highly Productive	
Level 1 Minimal Impact Consideration	**Assessment**	**DPI Water Comment**
Water table NOT APPLICABLE		
Water pressure Less than 0.2 metre cumulative variation in the groundwater pressure, allowing for typical climatic 'post-water sharing plan' variations, 40 metres from any: ▪ high priority groundwater dependent ecosystem or ▪ high priority culturally significant site listed in the schedule of the relevant water sharing plan. A cumulative pressure level decline of not more than 30 metres, allowing for typical climatic 'post-water sharing plan' variations. The cumulative pressure level decline of no more than 10% of the 2008 pressure level above ground surface at the NSW State border, as agreed between NSW and Queensland.	GIA Sections 6.9, 61.2 and 7.4.4 No high-priority GDEs associated with the GAB Surat Shallow Groundwater Source have been identified in the assessment area. No high priority culturally significant sites are present in the project area. No impact on pressure levels would occur at the NSW State border as a result of the project. *The project is considered to be **acceptable** in regard to water table decline at GDEs, culturally significant sites and water pressure decline.*	**Addressed** Note - DPI Water acknowledges a regional model of Class 1 confidence level, is not expected to be precise in its predictions at the local scale (i.e. water supply bore, stock and domestic bores or GDE). The utility of model prediction is therefore indicative of potential pressure/level impacts at the local scale, indicative meaning order of magnitudes of drawdowns in pressures/level, and their time lag.
Water quality Any change in the groundwater quality should not lower the beneficial use category of the groundwater source beyond 40 metres from the activity.	GIA Section 7.4.4.4 Depressurization of the target coal seams for the project would induce small groundwater flows from the Pilliga Sandstone into the underlying depressurized strata within the Gunnedah-Oxley Basin, and even smaller flows from the Namoi Alluvium to the Pilliga Sandstone and Gunnedah-Oxley Basin. Because the direction of induced groundwater flow would be downward toward the depressurized coal seams, the potential for change in water quality of shallow groundwater sources by poorer quality water in the deeper strata is considered to be negligible and not a risk. Potential changes in water quality of the Pilliga Sandstone due to downward flows from overlying sources are expected to be very slow and imperceptible. No change in the beneficial use category of the groundwater sources is predicted to occur. *The project is considered to be **acceptable** in regard to water quality*.	**Addressed**

Aquifer	Porous rock or fractured rock – Gunnedah-Oxley Basin	
Category	**Less productive**	
Level 1 Minimal Impact Consideration	**Assessment**	**DPI Water Comment**
Water table Less than or equal to a 10% cumulative variation in the water table, allowing for typical climatic 'post-water sharing plan' variations, 40 metres from any: ▪ high priority groundwater dependent ecosystem or ▪ high priority culturally significant site listed in the schedule of the relevant water sharing plan. **OR** A maximum of a 2 metre water table decline cumulatively at any water supply work.	GIA Sections 6.9, 61.2 and 7.4.4. No high-priority GDEs associated with the Gunnedah- Oxley Basin Groundwater Source have been identified in the assessment area. No high priority culturally significant sites are present in the assessment area. Limited information on water supply works is available for the Gunnedah-Oxley Basin. The Clare Sandstone is the only recognized hydrostratigraphic unit with potentially significant transmissivity within the basin strata directly above the target coal seams; however, it is not generally utilized as a groundwater source due to its large depth below ground surface, unreliable water quality and the availability of alternate, shallower and better quality groundwater sources. *The project is considered to be **acceptable** in regard to water table decline at GDEs, culturally significant sites and water supply work.*	**Addressed** Note - DPI Water acknowledges a regional model of Class 1 confidence level, is not expected to be precise in its predictions at the local scale (i.e. water supply bore, stock and domestic bores or GDE). The utility of model prediction is therefore indicative of potential pressure/level impacts at the local scale, indicative meaning order of magnitudes of drawdowns in pressures/level, and their time lag.
Water pressure A cumulative pressure head decline of not more than a 2 metre decline, at any water supply work.	GIA Sections 6.9, 61.2 and 7.4.4 Limited information about water supply works is available for the Gunnedah-Oxley Basin. The Clare Sandstone is the only recognized hydrostratigraphic unit with potentially significant transmissivity within the basin strata directly above the target coal seams; however, it is not generally utilized as a groundwater source due to its large depth below ground surface, unreliable water quality and the availability of alternate, shallower and better quality groundwater sources. *The project is considered to be **acceptable** in regard to water pressure decline at water supply works.*	**Addressed** Note - DPI Water acknowledges a regional model of Class 1 confidence level, is not expected to be precise in its predictions at the local scale (i.e. water supply bore, stock and domestic bores or GDE). The utility of model prediction is therefore indicative of potential pressure/level impacts at the local scale, indicative meaning order of magnitudes of drawdowns in pressures/level, and their time lag.
Water quality Any change in the groundwater quality should not lower the beneficial use category of the groundwater source beyond 40 metres from the activity.	GIA Section 7.4.4.4. Depressurization of the target coal seams for the project would induce small groundwater flows from the Pilliga Sandstone into the underlying depressurized strata within the Gunnedah-Oxley Basin, and even smaller flows from the Namoi Alluvium to the Pilliga Sandstone and Gunnedah-Oxley Basin. Because the direction of induced groundwater flow would be downward toward the depressurized coal seams, the potential for change in water quality of shallow groundwater sources by poorer quality water in the deeper strata is considered to be negligible and not a risk. Potential improvements in water quality of the deep groundwater sources	**Addressed** Spatially there is limited baseline data for groundwater quality. The conceptualisation is consistent with DPIW conceptualisation and DPIW notes that groundwater quality data is part of the proposed monitoring plan.

Aquifer	Porous rock or fractured rock – Gunnedah-Oxley Basin	
Category	Less productive	
Level 1 Minimal Impact Consideration	Assessment	DPI Water Comment
	from downward flows are expected to be very slow and imperceptible. No change in the beneficial use category of the groundwater sources is predicted to occur. The project is considered to be acceptable in regard to water quality.	

End Attachment F

Attachment G

Narrabri Gas Project (SSD 6456)
Detailed comments – Groundwater Dependent Ecosystem Impacts Assessment

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The EIS provides an assessment of Groundwater Dependent Ecosystems (GDEs) in the groundwater impact assessment report (Appendix F of the EIS), and has identified three main GDE types (Section 4.6):

- Type 1 - aquifer and stygofauna ecosystems;
- Type 2 - ecosystems that depend on surface expression of groundwater such as lakes, wetlands, seeps, springs and river base flows; and
- Type 3 - ecosystems that depend on sub surface presence of groundwater such a vegetation.

The study area was defined by the extent of maximum predicted depressurisation from the project exceeding 0.5 m drawdown with a 5 km buffer. This appears adequate for the purposes of the EIS.

The EIS reported no stygofauna were present at the time of sampling. GDE types 2 and 3 were identified in the study area and included base flow contributions into the Namoi River, Bohena Creek and Coghill Creek, several wetlands and springs and vegetation communities.

The report states “All potential Type 2 GDES have low ecological value”. However Appendix B provides information that some sites were determined to have an ecological value that were moderate and high. Base flow rivers were not included in Table 5-1 of the GDE Assessment only springs and wetlands that were considered low value. The risk assessment framework used by the proponent assumes low risk of impact due to the maximum 0.5m drawdown in the alluvium. However, the information supplied in Appendix B shows that some Type 2 GDEs had a moderate to high value. These areas of high value would also require protection measures of the aquifer in these areas based upon the risk frame work adopted by the proponent as shown in Table 6-1.

Whilst currently there are no GDEs scheduled in the water sharing plans (WSPs) relevant to the proposal area, the WSPs allow for the inclusion of GDEs once identified. DPI Water is currently in the process of identifying GDEs and assigning an ecological value for inclusion in the associated WSPs. The identification and assigning of ecological value to GDEs has been completed for the Namoi catchment and will be included in Water Resource Plans (WRPs) currently under development.

So as to ensure that the proponent is compliant with the WRPs in this area, DPI Water is willing to make the GDE dataset available. This can then be used by the proponent to assist in the development of the monitoring program for the project.

End Attachment G

Attachment H

Narrabri Gas Project (SSD 6456)
Detailed comments – Surface Water Review

Generally, the EIS chapters and appendices that address surface water issues appear to adequately satisfy the overall requirements and guidelines as prescribed by State legislation (e.g., *Water Management Act 2000*). However, a range of concerns and issues do exist and should therefore be reviewed, considered and in some cases acted upon prior to completion of the approval process. Detailed comments outlining these issues are as follows.

- Appropriate on-going monitoring and dissemination of data and information to appropriate government agencies should be a key priority. For example:
    - Appendix G1, Eco Logical Australia 2016. Narrabri Gas Project – Aquatic Ecology and Stygofauna Assessment. Prepared for Santos NSW (Eastern) Pty Ltd. Section 7 Mitigation Measures (p 424): Measures outlined should be followed to minimise / prevent any potential abiotic impacts on the water quality of Bohena Creek;
    - Appendix G1, Management section (p. XIV) states that: "all results should be reported to operations staff." The management measures implemented by the project should ensure that any unexpected results are also passed on immediately to the appropriate government agency;
- Upgrading of Bohena Creek gauging station and installation of a purpose-built surface water gauge (Appendix G1: *Monitoring section (pp. XIIII - XIV).* This is required because:
    - The current Bohena Creek gauge (419905) is approximately eight (8) river kilometres downstream of the proposed Leewood treated water release site;
    - Bohena Creek is considered to be a losing stream, therefore discharge readings over several river kilometres are likely to vary particularly after long periods of drought;
    - In July 2005 the gauge was relocated just downstream of the Newell Highway bridge;
    - The gauge has been commissioned by the Bureau of Meteorology (BOM) with flood warning as the primary purpose;
    - The orifice installed to detect stream discharge is only activated when flows are ≥1000 ML/d as required by the BOM (the orifice no longer reaches the thalweg or deepest part of the main channel). This is clearly well above the stream discharge trigger value of 100 ML/d that Santos require to release 'treated' water;
    - Continuous long-term discharge (>100 ML/d, >24-hr) ranges from 3 – 159 days, with a mean of 34 days (duration is highly variable and reliance on a suitable time frame for release and dilution of treated water may be difficult to determine). This information appears to be based on hydrographic data pre July 2005;
    - The concern is that the current BOM flood warning downstream gauge (419905) no longer has the capacity to detect flows of 100 ML/d. Furthermore, it is proposed that treated water will be released 8km upstream. This implies that even if the current BOM gauge had the capacity to detect discharges at 100 ML/d, a delay or lag-time in discharge could exist, resulting in the release of treated water into Bohena Creek when stream discharge had already dropped well below the 100ML/d threshold required for suitable dilution / mixing of water;
    - Therefore a purpose-built gauging station in closer proximity to the Leewood treated water release site is required. The extension (upgrade) of the current orifice line at gauge 419905 is also recommended as this will help in the calibration and reliability of the new gauge and also act as a potential backup gauge (refer to page XIV of Appendix G1);
- Risk assessments, incorporating design, monitoring and management should be adopted (Ecological state that: "All risks are manageable and can be reduced by incorporating mitigation measures").
    - For example, in Appendix G1, Monitoring section (pp. XIII - XIV). States that: "When the Leewood WMF becomes operational, sample in Bohena Creek before and at periods following episodic releases to indicate whether there are changes to the aquatic ecology. Sites should be routinely monitored in autumn and spring to determine whether release is altering aquatic ecosystems."

- This may be a difficult ecological change to measure; as a reliable set of indicators may be hard to define or routinely obtain. Many aquatic dependent taxa may have short life cycles that rapidly respond to wet and dry periods (as stated in the report). It is suggested that a 'cautionary approach' is worth considering, as the cumulative or long-term impact of ecological change may be difficult to detect in the short term (e.g., after only one or two events). With these potential caveats acknowledged the continued monitoring of water quality in conjunction with ecological monitoring (as outlined in Appendix G1, page XIV) should provide a reliable benchmark (or control) for any potential change that may be detected in relation to treated water release.

- Mercury (Appendix G1: Eco Logical Australia 2016. Narrabri Gas Project – Aquatic Ecology and Stygofauna Assessment. Prepared for Santos NSW (Eastern) Pty Ltd Section 5 Project water management).
  - According to Table18, the heavy metal constituent Mercury may have a final mixed concentration (Leewood waste water with Bohena Creek) that exceeds the default trigger guidelines. (Mercury is also covered on page 127 of the report.);
  - It is suggested that periodic monitoring (and a prevention strategy) is undertaken to ensure concentrations remain below the default trigger level. This is important as Mercury can pose both a bioaccumulation and secondary poisoning risk. Therefore the health and viability of aquatic organisms (e.g., native fish) may be disrupted from prolonged over exposure (food web implications);
  - The need for a reliable monitoring program has been addressed as follows: The Namoi Bioregional assessment report: *Current water accounts and water quality for the Namoi subregion. Product 1.5 for the Namoi subregion from the Northern Inland Catchments Bioregional Assessment. (2016)* states that "There is a lack of data on the presence of heavy metals, trace elements and hydrocarbons which could result from coal mining and CSG operation and development."
- Eel-tailed catfish (Appendix G Assessment of significance (EPA Act 1979) (p 470)). There may be the potential for increased sedimentation to enter the Namoi River due to increased discharge from Bohena Creek. Increased sedimentation has the potential to affect the threatened eel-tailed catfish population (as outlined in the report). Proposed periodic monitoring post Bohena Creek discharge events into the regulated Namoi River should be implemented to determine if eel-tailed catfish habitat requirements have been impacted. Consultation with DPI Fisheries should be considered to determine if a monitoring strategy is required.
- Pipeline footings (Eco Logical Australia 2016. Managed Release Study: Bohena Creek: Fluvial Geomorphology Engineering Impact Report. Reference 2640_005. Prepared for Santos NSW Eastern Pty Ltd). The gas pipeline used to transmit gas to market is part of a separate approvals process (e.g., p. 1, p. 335 of Appendix G1). However underground water and gas pipelines between facilities (including the treated water pipeline from Leewood to Bohena Creek) are still required.
  - The main channel and low flow channels within Bohena Creek have been shown to be highly mobile during flood events. Furthermore, alluvial sediment movement (erosion and deposition) is possible along creek banks (p. 504). Maintenance procedures are mentioned (p. 512);
  - A point of possible concern is to ensure that the pipeline footings crossing creeks are fixed deep enough into the ground to minimise erosion and exposure from flood events. As the surrounding landscape is predominantly made up of alluvial sediments (e.g., sand, gravel) there may be a possibility of freshes and larger flood events undermining footings, which may lead to a damaged pipeline (e.g., from large debris forced against footings).
- Salinity (electrical conductivity) concentrations of treated water.
  - The mean concentration of salinity in Bohena Creek is reported to be 216 µS/cm and a maximum of 447 µS/cm (Chapter 12, p. 12-19). The mean concentration in treated water from Leewood is 357 µS/cm with a maximum reported concentration of 645 µS/cm (Appendix G1, p. 34).
  - The altitude of the Bohena Creek discharge point is approximately 249m; with the Bohena Creek – Namoi River confluence <200-m altitude.
  - Treated water salinity values fall within the ANZECC/ARMCANZ (2000) guidelines for lowland rivers (2200 µS/cm); however just fall out of the acceptable range for upland rivers (>150-m altitude) with a maximum acceptable salinity value of 350 µS/cm. However as discussed in Appendix G1 (p.31), NSW Murray-Darling Basin sites below 250m altitude are potentially more scientifically suitable to adopt the lowland river trigger values;

- Irrespective of the trigger value selected, it is recommended that the overall mean (and where possible maximum) salinity concentrations of treated water discharged into Bohena Creek remain at 357 µS/cm. This will help ensure that the Namoi end-of-valley salinity targets are met (Namoi River at Goangra – 80th percentile should not exceed 715 µS/cm);

- Waste Management (Chapter 28). Develop a monitoring program that covers onsite liquid waste and its removal. In particular the monitoring of sewage, drilling fluids and salt (from treated water) should be undertaken as these waste products may pose a risk to aquatic environments. The implementation of strategies to minimise spillages and onsite contamination and removal is also encouraged.

End Attachment H