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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 NSW Environment Protection Authority (EPA) regarding the Narrabri Gas Project EIS. In addition to its traditional role in regulating environmental pollution in NSW, the EPA is the lead regulator for compliance with and enforcement of conditions of approval for gas activities in NSW, including consent conditions and activity approvals issued by other agencies. The EPA has reviewed the EIS with both roles in mind.

The EPA did not identify any significant issues in its review of the EIS, and notes that it has generally been prepared in accordance with the Secretary's Environmental Assessment Requirements. However, the EPA recommends that further details be sought on several key aspects of the project to ensure clarity of the assessment. A summary of the EPA's advice is provided below with further detail in Attachments A to E.

General comments
If approved, the EPA considers that conditions of consent (or conditions on other statutory instruments) should be used to regulate the proposed development in preference to requiring the preparation and implementation of management plans. If management plans are required, the EPA recommends these plans are clearly referred to in legal instruments to ensure that compliance with the management plans is legally enforceable. The EPA also recommends that any management plans are prepared in consultation with the relevant government agencies to ensure that the wording is clear, specific and enforceable. This should occur prior to the relevant activities commencing. However, the EPA has referred to management plans in its advice until further clarification is received.

Groundwater
The EPA recommends the proponent obtain further groundwater baseline data and conduct testing to better characterise the hydraulic characteristics of the Gunnedah Oxley Basin (GOB) progressively throughout the life of the project. In addition, the proponent should develop a groundwater monitoring and modelling plan for the proposed activities in consultation with DPI water. The monitoring and modelling plan should be designed to characterise not only groundwater levels and flow paths, but also groundwater quality parameters in all aquifers potentially impacted by the proposed activities. This monitoring infrastructure should be installed and be operative in recording baseline data prior to further gas well (Including any new pilot) installation.

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Beneficial reuse of water
The EPA requires further clarity on key aspects of the produced water management and irrigation activities including soil monitoring for the proposed agricultural irrigation, reuse within forested areas, discharge to Bohena creek, and monitoring and reporting issues. The EPA recommends that the proponent demonstrate that the various water management options identified in the EIS have been sufficiently scoped to ensure that the predicted disposal volumes can be realised, and that contingency plans are in place if any or all the disposal options identified cannot be delivered.

Waste classification and disposal
The EPA requests that the proponent provides further information and clarification on waste classification, storage and disposal. The EPA requires further detail on the waste management strategies proposed to manage the salt generated as a by-product of the reverse osmosis plant and drill cuttings. Further information is required to demonstrate that the proposed disposal options will remain viable to deal with the volumes of waste generated during the life of the project, and that appropriate contingencies are in place to deal with such wastes if the preferred options are no longer available.

Air Quality
The EPA recommends the Air Quality Impact Assessment (AQIA) is amended to include the information on fugitive emissions, possible pollutants and particulate data that formed part of the cumulative assessment. It is also recommended the proponent revise the AQIA to assess PM10 and PM2.5 impacts against the Approved Methods for Modelling and Assessment of Air Pollutants in NSW (2016), given that the methods have been revised since the AQIA was conducted.

Noise
The EPA recommends that the noise assessment be amended to commit the proponent to meeting noise management levels outside standard hours for all construction noise. The EPA also requests that the proponent clarify several aspects from the noise assessment.

Well Integrity
Noting the potential environmental risks associated with well integrity the EPA requests that the proponent confirm that all gas well construction will comply with the NSW Code of Practice for Coal Seam Gas Well Integrity. The codes are based on world's best practice and ensure environmental risks are mitigated during well construction, operation and decommissioning.

If you would like any further information please do not hesitate to contact Mr John Padovan on 02 9995 6724.

Yours sincerely

1-6-17

CARMEN DWYER
Director Gas Regulation
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Enclosure

Attachment	Title
A	Groundwater Analysis
B	Beneficial Reuse of Water Analysis
C	Waste Classification and Disposal Analysis
D	Air Quality Analysis
E	Noise analysis

ATTACHMENT A - Groundwater Analysis

The EPA did not identify any issues that have the potential to alter the overall conclusions and outcomes of the groundwater impact assessment. However, the EPA recommends that the proponent provide further clarification on several aspects of the proposal.

The EPA recommends that the proponent commit to preparing detailed groundwater management plans, trigger action response plans and implement additional monitoring measures, as detailed below.

Groundwater Impact Assessment

The primary aim of the groundwater impact assessment (GIA) is to provide estimates of water levels changes in the Pilliga Sandstone aquifer and other geological layers arising from coal seam dewatering. This includes assessment of the groundwater impacts during the active phases of the Narrabri Gas Project (e.g. drawdown, inter-aquifer depressurisation, groundwater quality and recharge), as well as post-development recovery of groundwater levels.

1. *Gunnedah Basin Regional Groundwater Model*

All proposed activities will occur within a licensed area, but groundwater impacts (i.e. depressurisation) could propagate some distance away from licensed areas. The maximum spatial extent of groundwater impacts will not be reached until well after the proposed activities have concluded. Accordingly, the Gunnedah Basin Regional Model (GBRM) numerical groundwater flow model presented in the GIA simulates an area much greater than the gas lease footprint and includes: The Project area; the potential future Gunnedah Coal Seam Gas Project area; and, adjacent coal mining operations.

Groundwater extraction rates used in the GBRM are estimated from a reservoir model of the coal seams developed by Santos, based on a preliminary field development plan. Groundwater extraction estimates are a key input to the GBRM; however, neither the field development plan nor the reservoir model are presented in the GIA. Thus, simulated water production estimates cannot currently be evaluated by the EPA.

The large area simulated by the groundwater model requires a correspondingly large model cell size. Each cell in the GBRM represents an area between 1km^2 and 25km^2. Therefore, model predictions of water levels in each model cell represent an average value across that cell. The model offers a regional-scale assessment of average impacts and cannot identify local-scale impacts (e.g. property-by-property). As stated in the EIS:

"*Considerable data are available in the GIA study area to describe stratigraphy and the broad structural arrangement of the model geometry, lending high confidence to model geometry. There are fewer locally derived measurements of hydrogeological properties to constrain the model parameters. Likewise, there are fewer groundwater head data in hydrostratigraphic units hosting the target coal seams, and these measurements are not widely distributed and neither spatially nor temporally extensive.*"

In other words, the shape of the model, and the thickness and arrangements of geological layers are generally well known. However, the properties of the different layers and the pre-development groundwater levels could be more robust, especially in geological layers underlying the Pilliga Sandstone. As these properties are critical in estimating impacts from the proposed works, additional measurements of the properties of the various geological layers improves the confidence in model projections.

The groundwater monitoring program is designed to monitor water levels in select locations. Water level and hydraulic parameter measurements are very limited in the model's geological layers. Insufficient data are available to strongly support key groundwater model parameters, such as the

vertical hydraulic conductivity of low-permeability seal layers that impede the flux of water between adjacent geological layers. Additionally, limited assessment of the potential for faults to act as preferential flow paths for groundwater or methane migration was conducted. Therefore, ongoing further measurement of such parameters would increases the confidence in the GBRM predictions.

The EPA recommends the proponent increase GBRM confidence by conducting ongoing testing of geological layers encountered during installation of gas and monitoring wells to characterise hydraulic properties within the Gunnedah Oxley Basin. This data should then be used to regularly update the GBRM and associated predictions of groundwater impacts.

2. *Water Quality*

The EIS explicitly excludes hydraulic fracture stimulation from the proposed scope of works, and no novel surface or subsurface activities are proposed.

Groundwater quality related risks associated with the activities proposed in the EIS fall into two categories:

- Groundwater impacts from surface activities (e.g. transport, storage, use, treatment, and disposal of chemicals and produced water).
- Groundwater impacts from subsurface activities (e.g. drilling, well construction, coal seam dewatering).

With respect to surface activities, the EIS provides conceptual descriptions of many of the key management, monitoring, and contingency measures that will be used to minimise or mitigate impacts of the proposed activities during the project.

Uncertainty relating to groundwater production rates and groundwater flow modelling limit the EPA's ability to assess the EIS conclusions regarding the location and magnitude of shallow and deep groundwater impacts from subsurface activities (i.e. coal seam dewatering). The EPA understands that data has been provided to the Division of Resources and Geoscience which has then been assessed. Therefore, management plans and trigger action values must be developed for managing impacts from surface works prior to commencement of scheduled activities.

With respect to impacts from subsurface activities, the primary potential impact is water extraction from the targeted coal seams, inducing downward flow of groundwater from beneficial aquifers toward the coal seams. This is a matter for the resource manager (DPI-Water) in the first instance.

The EPA recommends that detailed management plans and trigger action response plans be developed, in consultation with the relevant agency, prior to commencement of proposed activities, with appropriate trigger actions and thresholds determined from robust statistical analysis of baseline data trends.

The EPA also recommends that the proponent commit, where current facilities are expanded, to additional monitoring points being installed commensurate with extent and nature of the new development. These monitoring points should be identified and constructed prior to commissioning of new infrastructure.

Ongoing Water Monitoring Plan

The Water Monitoring Plan outlines the proponent's approach to ongoing monitoring and identification of surface water and groundwater impacts resulting from the proposed activities.

The regional and cumulative impacts of the project are discussed, but the local groundwater could be better defined within the local vicinity to determine the adequacy of the proposed monitoring locations. The location and number of ongoing groundwater monitoring points should be better informed by other technical reports presented in the EIS (i.e. groundwater flow model and associated sensitivity

analysis). Additionally, the proposed monitoring network should spatially coincide with the baseline data set, making comparisons or delineation of impacts easier.

Details of the Gunnedah Oxley Basin (GOB) interburden (geological layers below the Pilliga Sandstones) are not known for the western side of the project area, with no baseline knowledge of groundwater west of the Dewhurst monitoring site. It is noted that the monitoring is expected to increase with four sites proposed in the EIS in this area. This proposed groundwater monitoring would need to occur prior to the field development for baseline to be identified in these units at this depth.

The ongoing monitoring program aims to address the knowledge gap in this interburden; however, the proposed bores are not part of baseline dataset. Ideally these proposed locations within the ongoing monitoring report would be installed and baseline observations discussed prior to field development.

The Water Management Plan, Appendix G4, requires further information to address the primary objective of monitoring the water impacts to be measured, not just the production wells themselves. Monitoring of the direct impacts in the target coal seams to track real-time conditions of the main extraction target is recommended. Considering the uncertainty in the GIA, this monitoring would confirm the predominately lateral confines of depressurisation impacts rather than relying upon monitoring of secondary impacts at beneficially used water sources, which would be subject to variable lags in response time and influenced by alternative groundwater use.

The Concept Irrigation Design provides for three monitoring wells in addition to the conceptual soil moisture monitoring, one upgradient and two downgradient. For the size of the scheme conceptualised in the plan, these monitoring commitments should be enhanced to account for the scale of irrigation being undertaken. Monitoring of any impacts to groundwater should to be tailored to the approved sites and pending an approved irrigation management plan.

The EPA recommends that the proponent revise the ongoing monitoring plan to include monitor the areas of greatest potential impact, as identified by the GBRM and associated uncertainty analysis as presented in the GIA.

The EPA recommends that the proponent revise the ongoing monitoring plan, in consultation with the EPA, to with baseline data monitoring locations as presented in the Water Baseline Report.

The EPA recommends that proposed groundwater monitoring infrastructure be installed and monitored to establish a baseline prior to gas well (including pilot well) development.

Water Baseline Report

The Baseline water report outlines the datasets that constitute the baseline monitoring for the project. Although baseline datasets exist regionally across the basin, insufficient measurements are currently available to assess water *quality* changes in all areas potentially impacted by the proposed works, particularly in the geological layers underlying the Pilliga Sandstone.

Groundwater quality within the GOB, both to the west of and within the NGP area, could be better characterised by the baseline datasets. Figure 3.1 (p3-4) of the G4 Water Baseline Report illustrate this data gap with large parts of the NGP area and the Basin uncovered by baseline monitoring. Additionally, only two of these monitoring sites (which both lie outside the NGP area) contain datasets for groundwater quality.

The proponent should provide additional data (for example, the resource development model and drilling data) to validate baseline assumptions built into the GIA, assessment of the proposed baseline monitoring sites relevant to validating predicted local impacts is not currently possible as the GIA does not detail impacts to this localised level. Similarly, specific baseline and shallow groundwater monitoring at produced water storage facilitates should be agreed with the EPA.

The EPA recommends additional water quality baseline monitoring points be installed and sufficient baseline dataset be collected to address groundwater quality prior to installation of gas wells in each area across the western area of the Gunnedah Oxley Basin and within the Narrabri Gas Project area.

ATTACHMENT B – Beneficial Reuse of Water Analysis

The EPA did not identify any issues that have the potential to alter the overall conclusions and outcomes of the produced water management assessment and proposed irrigation activities. The EPA recommends that the proponent commit to further assessment and monitoring measures as outlined below.

Water – Proposed Agricultural Irrigation

1. Soils

The overall characteristics of the soil from the broad soil survey and the characteristics of the treated and ameliorated effluent indicate that effluent irrigation can be sustainable subject to conditions.

Further clarity in the methodology of the soil assessment could be provided for greater application to an irrigation operational scale. For example:

- LiDAR DEM, airborne gamma-ray spectrometry data (Appendix I1, 2.1 p. 9), and other data were used for mapping but the general process and the way these data were employed is unclear.
- there is no evidence that the existing eSpade have been incorporated into the assessment and mapping methodology which may limit the accuracy of the soil mapping unit boundaries
- McKenzie *et al.* (2008, Table 14.4, after Gunn et al. 1988) recommend that for 1:50,000 scale surveys a minimum of 1 observation/km^2, and at 1:100,000 scale, a minimum of 1 observation/4 km2. The soil survey has been conducted at a scale of 1:75,000. At this scale the minimum number of observations should be approximately 0.5/km^2. Figure 4-1 in Appendix I1 suggests less than 100 observations have been made inside the project area of 95,000 ha (mostly in cleared areas). Based on McKenzie *et al.* (2008) the recommendation is for over 100 observations for a nominal 500 ha area.
- McKenzie *et al.* (2008, Table 14.4) recommend 15-35% of observations should be detailed profile descriptions for medium intensity surveys. That is, for a survey of 20 km radius to the general north of Leewood, at a scale of 1:50,000 there should be 629 observations, and between 94 and 220 detailed profile descriptions. The proponent described only 46 new soil profiles (App I1), these being in the agricultural (cleared) areas only.
- Appendix A of Appendix I1 tabulates information from 45 soil profiles recorded for the soil survey. There is no information provided on the other observations made as part of the soil assessment (i.e. the surface observations depicted in Figure 4-1). Greater detailed profile descriptions should be provided for the soil type assessment of the total project area, the potential irrigation area, and the nominal irrigation area.
- coordinates should be provided for the 40 soil profiles in the appendix of Appendix G2
- all soil cores taken from road reserves may not be representative of the overall map units where irrigation will take place due to the disparate history of management and associated disturbance.

Assessment of specific irrigation areas will need to be conducted to develop site-specific management requirements. This includes a more comprehensive statement on assessment methodology and process. For example, the areas occupied by Brigalow Grey Clays will need to be accurately mapped at an irrigation operational scale, as these soils are generally the most fertile, and with the lowest Land and Soil Capability class. Operation scale soil survey of 500 ha would require the recommended densities in Table 1 below.

Table 1: recommended densities for operation scale soil survey of 500ha

Area	Area (ha)	Recommended scale	Minimum observation rate	Minimum observations	Detailed profile description rate	Detailed profile descriptions
Nominal irrigation area	500 ha	1:10,000	25 / 100 ha	125	10-30%	13-44

EMI surveys are proposed as a monitoring tool (Appendix G2, Section 10.1.3). An initial survey of all potential irrigation areas is recommended so that a common baseline data set is established. It is agreed that the inland acid sulfate soil risk is likely to be low, however the existing broad-scale mapping on ASRIS does not 'verify' this (Appendix I1, Section 3.4, p. 14). Testing of soil materials from lower slope and drainage line locations for titratable acidity and acid-base accounting would verify this.

The EPA recommends that detailed soil surveying and/or appropriate baseline monitoring of the specific-sites to be irrigated is conducted to develop site-specific management requirements provided prior to produced water being generated.

2. *Soil Characteristics*

Appendix G2 includes data from profiles B01-40, however, key parameters such as soil salinity (ECe), exchangeable sodium percentage (ESP) and sodium adsorption ratio (SAR) values are only given for ten selected cores. Full data sets should be provided in detailed assessments for the specific irrigation areas to be used to ensure verification and integrity of the data.

A custom local soil classification system is used for the mapping units (as in Appendix I1, Fig. 4.1), rather than the Australian Soil Classifications (ASC). However, profile descriptions and chemistry for profiles B01-40 are classified per the ASC. Both this custom classification and the ASC are used, sometimes in the same section (e.g. 14.2.1). This makes it difficult to compare/combine the results for the two areas. While it is appropriate to use a custom local soil classification system it is recommended that the classifications are standardised.

The EPA recommends the proponent provide detailed soil surveys for specific irrigation areas that includes all data for all cores to ensure verification and integrity of the data, and that a standardised soil classification system should be used.

3. *Soil Risks*

It is noted that chapter 14 (Section 14.2.1) outlines some of the limitations of the different soil groups. Appendix I1, Section 6.2 notes that all the soil types are sodic in the subsoils to some degree, and are therefore potentially dispersive, with potential impacts on structural properties of the subsoils.

Appendix I1, Section 6.3 notes that Brigalow Grey Clays are prone to waterlogging, but are structurally resilient. It is agreed that long-term impacts to structure and stability of these soils is likely to be minimal provided an effective Irrigation Management Plan is in place.

Within the study area, in addition to most soils being sodic, many are saline, particularly the subsoils. Sodicity is present in most sites below 50 cm, and slight to moderate salinity is present in several cores below 50 cm. Appendix G2, Section 4 (p.11) states that crops could be grown under irrigation on the Vertosol/Grey Clay soils. These soils tend to be prone to waterlogging, partly due to their high-volume expansion, and tend to be sodic and saline in both topsoils and subsoils. However, it is important to note that some Vertosols/Grey Clays, while saline, may not be at significant structural risk where a proportion of the EC is due to salts other than halite (sodium chloride). In contrast, the Sodosols are imperfectly drained, and besides being sodic, some have saline subsoils (Table 14-4).

Figure 9 in Appendix G2, Section 5.2.4 (p.18) identifies considerable overlap between Sodosols and Vertosols in terms of both SAR and EC. The parameters used do not allow the differences between the two soil types to be distinguished to develop tailored management practices. The soils of the example irrigation area, which included both Sodosols and Vertosols, were described as "quite uniform" in Appendix G2, Section 4.4 (p. 13) with the Sodosol subsoils "similar to the Vertosol units". The Ksat of Vertosols and Sodosols also appears to be similar (Appendix G2, Section 5.2.4, p. 18). It is recommended that the two soil concepts are more effectively characterised in detailed baseline assessments, e.g. based on profile textural ranges and volume expansion to allow the two soils type to be effectively differentially managed.

The relatively impermeable Sodosol B horizons are more likely to restrict internal drainage under a wider range of water contents but the Vertosols tend to retain adequate internal drainage until volume expansion with increasing water content results in void closure. These differences have implications for irrigation management and scheduling and will need to be managed on a site specific basis.

Overall, as the actual location of the 500 ha irrigation area is not yet known it is not possible to assess whether the soil profile locations give adequate coverage of potential irrigation areas, or if the soil characteristics used for the modelling are representative of the broader area. It will be important to manage the different risks to different soil types on a site-specific basis with adequate baseline assessments and ongoing monitoring.

The EPA recommends that the baseline assessments of specific irrigation areas better define the specific soil risk(s) for each soil type and landscape and provide an appropriate basis for identifying and managing key differences between Vertisols and Sodsols.

4. Bicarbonate

The EPA notes that bicarbonate levels are not stated in Section 7.6 or Table 7-2. Based on previous data for the site, bicarbonate levels are expected to be above a trigger for irrigation established by the Queensland Government where a bicarbonate limit for beneficial reuse of coal seam gas waters of 100 mg/L was adopted (DERM 2000). A target alkalinity value of 139 mg/L is given in Chapter 12 of the EIS.

As the potential irrigation sites have been identified as being susceptible to soil structure risk then this is a factor to be managed for any ongoing irrigation.

The EPA recommends that the proponent consider the bicarbonate levels in produced, treated and amended water and the implications of this be assessed for soils in the irrigation areas and addressed in Irrigation Management Plans.

Water – Proposed reuse within forested areas and other reuse options

1. Unamended effluent SAR risk assessment

It is noted in the EIS that unamended treated water after reverse osmosis would receive ammonia removal, dechlorination and pH adjustment. The sodium adsorption ration (SAR) will not be adjusted.

Table 6-4 of the Chemical Risk Assessment (CRA) (Appendix T3) indicates a SAR value in permeate water of less than 5. This quality, however, aligns with amended water not permeate water. Amended water can only achieve a SAR of < 5 after addition of calcium salts. Unamended SAR levels are not stated in the EIS and a SAR of >100 is expected for produced water. The CRA assumed an effective treatment rate of 90%, however, this is not a valid approach for SAR which is a ratio of salts. The ratio will change after treatment based on rejection rates for different salts by the RO membranes. As a consequence the hazard assessment for SAR for various receptors in the CRA may be inappropriate.

Further clarification should be sought to assess the potential impacts of reuse or discharge of unamended water with elevated SAR, including proposed use on forested area soils, forest area access tracks, site construction and operation areas, stock drinking water, and stock water dams.

2. Stockwater supply

As the SAR levels are >100 there are potential reuse impacts for the structural integrity of stock drinking water and stock water dams. Further information should be provided on SAR levels and associated risks.

The EPA recommends that the proponent complete an assessment to determine the level of risks associated with SAR and the use of unamended water for stockwater or irrigating soils in vegetated forested areas.

3. Irrigation of forestry vegetated areas
The EIS (Section 7.5.3, p 7-15) states that unamended treated water would be used for "irrigating local soils in forested areas on non-agricultural land", which suggests a more general use, i.e. in addition to dust suppression on forest roads or operation sites within forests. The potential environmental impact of SAR for this option is not assessed. The concept irrigation appendix only considers agricultural irrigation with amended effluent. There are other potential issues related to irrigation in forest vegetated areas including potential impacts of methods of irrigation, on native vegetation and on weed management.

The soil survey was undertaken on cleared land only, in the 'investigation area'. The forestry soils in the project area have not been described (apart from those descriptions already on Soil and Land Information System (SALIS) or assessed for irrigation suitability.

The EPA recommends that a detailed assessment be required before this use could be supported. The assessment would need to address high SAR effluent risks of sodicity including reduced soil hydraulic conductivity, dispersion and destruction of structural aggregates, and increased erosion risks, especially on the sandy sodic duplex soils.

4. Dust suppression on forest roads
The EIS states that unamended water would be used for dust suppression in forested areas while amended water would be used for dust suppression in the agricultural areas to preserve or potentially improve soil quality by addition of gypsum.

The practice of using unamended treated water for dust suppression could potentially increase the dust problem as the soil breaks up into finer particles.

The EPA recommends an assessment of the risks associated with using unamended water for dust suppression be undertaken that includes management and mitigation measures to effectively manage any risks.

5. Operation area reuse
It is not clear whether site operational areas (disturbed and non-productive areas such as construction sites, pipeline routes and/or well pads under construction) that are in forested and agricultural land would be irrigated with unamended treated water.

The EPA recommends that this is clarified, and if proposed any associated risks be adequately assessed and management options identified.

The EPA recommends the proponent consult with the EPA during development of an irrigation management plan.

Water – Discharge to Bohena Creek

1. Downstream users
It is considered appropriate that the EIS consider the potential impact of discharges for all downstream uses consistent with an 'Uncontrolled stream'.

Aerial photography identifies the presence of numerous homesteads along Bohena Creek, including deeper pools of water that remain after flow events. It is also noted in the EIS that there is a possibility for a small number of unregistered bores and it is '*likely that such bores are limited to stock watering use only*'. It is also noted that the creek may be used for extraction of surface water for stock or domestic use where an extraction licence is not required. A survey of downstream water users is recommended to ensure that any such stock and domestic use is considered in determining potential impacts.

Unless stock watering and other water uses can be conclusively dismissed, the assessment should therefore consider these other water uses including livestock supply as a water quality objective for the river.

The EPA recommends further assessment of downstream users to describe and consider impacts on all potential environmental values and downstream human uses.

2. Discharge assessment

The EPA notes that there appear to be a number of inaccuracies regarding the ANZECC (2000) trigger values used in the discharge assessment. Despite this the managed release is expected to result in discharges with minimal levels of pollutants at the point of discharge or within the near-field mixing zone.

The managed release trigger volume of 100ML is measured about 6 to 8 km downstream of the discharge point. There is potential for substantial variation in flow volumes between the two locations given variation in the morphology of the creek.

The EPA recommends that a release protocol be developed that clearly indicates the trigger(s) which will cause Santos to stop discharging to Bohena Creek. The managed release protocol for the flow volume discharge trigger should be upstream of the proposed discharge point.

3. Electrical conductivity (EC)

Once Bohena Creek exits the Pilliga forest the predominant landscape is of lowland type and below 250m so the trigger value for slightly to moderately disturbed lowland systems applies (12-2200 µS/cm). A salinity value within this range therefore needs to be established. The preferred option in ANZECC (2000) guidelines is to use site-specific data to develop local trigger values.

To narrow the default salinity range in ANZECC (2000) the incomplete data set can be used and the 80th %ile trigger value updated as additional data becomes available. Based on the available data, the trigger value for EC should be about 200µS/cm. This trigger value can be used as an indicative level for further mixing zone assessments based on actual water quality data.

The EPA recommends that the electrical conductivity value in the assessment be a specific value and not a general range. A trigger value of 200µS/cm should be used as an indicative level for any further mixing zone assessments based on actual water quality data. If it is determined that the 200uS/cm is not the appropriate value, a justification of the method behind the calculated figure should be provided.

4. Mixing Zone Assessment

Additional information on the mixing zone assessment should be provided to verify predictions. Further Cormix input data is required to verify plume dispersion, and the occurrence of the predicted 10:1 dilution at the edge of the near-field region of mixing. For example:

- Further information on the diffuser design is required to determine the discharge geometry, e.g. whether the diffuser ports are unidirectional, staged or alternating will impact the near-field processes and distances over which satisfactory mixing can be achieved. It would also influence boundary interactions of the plume and if there are any discharge instabilities or presence of limiting dilution.
- Clarification is required of plume lateral extents. The figure presented (fig 1) appears to indicate that 9.8:1 dilution may be achieved over a few meters downstream. It however does not indicate any boundary interactions of the plume, i.e. over the dilution distance, whether there are any surface, bank or bottom attachments.
- Clarification of the effect of density difference (temperature difference) between discharge and ambient waters, and if the discharge flux would mitigate this difference effectively.

The prediction file from Cormix output and associated information should:

- provide sufficient details to verify the uncertainties listed above and if the size of the proposed mixing zone is appropriate for Bohena Creek

- verify the 10:1 dilution used in the ecological risk assessment.

The calculated fluoride mixed value for mean concentration requires should be 0.05 mg/L instead of 0.1 mg/L.

The EPA recommends that additional information be provided on the mixing zone assessment to verify modelled predictions, including the prediction file from the Cormix output and associated information to allow validation of the mixing zone model and verification of plume characteristics.

The EPA also recommends that monitoring of the mixing zone occurs in conjunction with commissioning assessments to validate model predictions of dilution/attenuation.

Water – Other surface water quality issues including monitoring and reporting

1. Distribution of treated water for reuse

Further details should be provided on how amended and unamended water would be distributed to the various reuse options. This is proposed to be detailed in irrigation management plans, however, the potential risk of pipe breakage with unamended effluent has not been assessed.

The EPA recommends that an emergency response procedure is developed to detect and provide specific actions that would be taken if a pipeline with produced water or unamended effluent is damaged.

The EPA also notes that the EIS has used the short-term trigger values from the ANZECC irrigation water guidelines to assess water reuse potential. Section 7 identifies the assessment period for the project as 25 years. The short-term trigger values are designed for irrigation projects occurring for < 20years. The EPA recommends that consideration is given as to whether the long-term trigger values maybe more appropriate for the assessment of some of the water.

ATTACHMENT C - Waste Classification and Disposal Analysis

The EPA did not identify any issues that have the potential to alter the overall conclusions and outcomes of waste management assessment. However, the EPA recommends the proponent prepare a waste management plan prior to field development.

1. Disposal of Salt Waste

The EIS outlines that approximately 430,500 tonnes of salt waste will be generated over the life of the project. Further information should be provided on the management and disposal of salt waste generated by the project. Ideally, this should also include the capacity of local landfills to accept the waste.

The salt waste has been identified as being general solid waste. Further clarification should be provided demonstrating that the salt from the RO plant is 100% salt without contamination.

The EPA recommends that the proponent provide clarification that the salt will meet the classification of general solid waste.

The EPA recommends that the proponent identify which facilities are to be used to dispose of the salt waste, and demonstrate that those facilities have the long-term capacity and suitable environmental controls to manage the waste.

The EPA also recommends that information is provided about a contingency plan for the disposal of salt waste throughout the life of the project, should the three EPA licensed landfills located within 150km of the site be unable to accept the waste for any reason.

2. Drill Cuttings

Further detail should be provided on the management of drill cuttings including classification, application to land and disposal. The EIS outlines that rock based-drill cuttings will be beneficially reused on site using a *mix, turn, bury* strategy. There is limited information provided on the strategy and how the proponent will ensure the reuse of the cuttings on-site is low risk.

The EPA recommends that the proponent provide further information about the drill cuttings including how often it is tested and assessed for suitability of re-use. Further examination and information needs to be provided regarding this strategy, and how the proponent will ensure on an ongoing basis that the drill cuttings are suitable for land application before they are applied.

Further to the above point, the EPA also seeks clarification on how the factors to determine the application of drill cuttings on well pads (as detailed on Pg. 28-23 and referenced below) will impact on operations and how they intend to determine these characteristics (i.e. *"characteristics of the drill cuttings, characteristics of the receiving soil, volume of nutrient requirements of growth media"*).

The EPA also recommends the proponent clarify the procedures for the separation and storage of appropriate and inappropriate materials for re-use (including coal-based cuttings) on well pads. Further detail on the ongoing waste classification requirements for the coal based drill cuttings should be provided.

3. Produced Water Management

The produced water has not been identified as a waste in Section 7, and the potential implications of this (particularly for beneficial reuse) have not been discussed. The produced water is listed in the waste inventory in Section 28 as a waste, however it is stated that the water will be used on-site. The land application of waste offsite may trigger the waste provisions of the POEO Act and would require a resource recovery order and exemption to enable lawful land application.

The EPA recommends that further information is provided to ensure that treated, ammended and produced water beneficial re-use will be lawful and managed appropriately.

4. Environmental Risk Assessment (ERA)

The ERA provided (Chapter 28 – Waste Management Table 28-8 (pg. 25) should include further detail on the methodology and reference to a matrix. The EPA notes that no specific mitigation and management measures are identified, rather it notes that "A Waste Management Plan (WMP) will be implemented." The EPA understands that the WMP is yet to be developed.

5. Waste Management Plan

A Waste Management Plan (WMP) has not been provided, and the EIS outlines that a "WMP would be prepared for the project".

WMP is required to detail how environmental risks (associated with waste) will be managed appropriately.

The EPA recommends the proponent provide further details of the mitigation measure to manage waste in order to clarify any potential risks.

6. Temporary onsite storage of waste

It is noted in the EIS that it is intended to temporarily store waste products generated on-site including coal based drill cuttings and salt. No information is provided on the maximum quantities intended to be stored at any one time of these products.

The EPA recommends the proponent provide further information on the intended maximum quantity of waste to be stored on site for these waste products prior to disposal.

ATTACHMENT D - Air Quality Analysis

The EPA did not identify any issues that have the potential to alter the overall conclusions and outcomes of the air quality impact assessment. However, the EPA recommends the proponent address the following issues prior to recommendation of consent conditions.

1. Choice of air dispersion model

Air dispersion modelling was completed using different air dispersion models for various activities. A summary is as follows:

CALPUFF

- Leewood facility during routine and non-routine operation; and
- Bibblewindi operational flaring.

AUSPLUME

- Operations at well pad;
- Construction of Leewood and Bibblewindi; and
- Construction of well pad, road, access track, pipeline and below ground electricity transmission line.

The AQIA states "*AUSPLUME has been used to assess the impact of emissions from well pad gas and diesel-fired engines, to determine an appropriate source-receptor separation distance, as the engines will be strategically located across the gas field*". Four meteorological files representative of 'worst case conditions' were extracted from CALMET at Leewood, Bibblewindi, Wilga Park and Narrabri township.

The AQIA considers use of AUSPLUME to be the most appropriate, efficient and flexible method to assess the impact of well pad emissions.

The 'worst case conditions' and rationale for use of AUSPLUME to determine the source-receptor separation distance are not clear in the AQIA.

The EPA recommends the proponent should clarify the choice of models used for different activities associated with the project.

2. Emission estimation

In Section 5.2.1 of the AQIA, equipment items such as the membrane/amine treatment and tri-ethylene glycol dehydration system are discussed briefly. However, a detailed process description of all equipment items and potential emissions associated with the proposed project is not included in the AQIA. The equipment items assessed include the potential power plant, gas-fired hot oil boilers and well pad generators.

The potential power plant, gas-fired hot oil boilers and well pad generators have not been designed and for the purposes of the assessment nominal characteristics and parameters have been used. The emission parameters from 'typical' engine technical specification was used in the emission calculations.

Since site specific emission data are not available, emission estimation is calculated using generic emission factors from a range of sources including US EPA's AP-42 manual, National Pollutant Inventory (NPI) and Californian WRAP Fugitive Dust handbook.

<u>Leewood Power Station</u>

The AQIA assumed that the plant will comprise of a total of twelve 9.7 MW gas-fired generation units to deliver 100 MW of electrical power.

Nitrogen oxide emissions were also modelled based on the *Protection of the Environment Operations (Clean Air) Regulation* (Clean Air Regulation) limit of 450 mg/Nm^3. This limit assumes

that the gas-fired generation units are stationary reciprocating internal combustion engines. It should be noted that should gas turbines be used in the final design, a different Clean Air Regulation limit may apply.

It is noted also that there is a discrepancy in the oxygen correction in Tables 5-7 and 5-8 of the AQIA which states 5% instead of the 3% as listed in the *Protection of the Environment Operations (Clean Air) Regulation (POEO CAR).*

Well Pad Generators

The AQIA states that no engine specific emission rates are available for the diesel engines at the well pad and therefore NPI emission factors was used. However, the estimated discharged nitrogen oxides concentration based on NPI emission factors is above the Clean Air Regulation group 6 limit. As a result, air dispersion modelling of NOx from the diesel generators was completed based on a Clean Air Regulation limit of 450 mg/m^3.

The AQIA notes that all equipment will need to be designed to meet the Clean Air Regulation limit during the project's detailed design.

It is noted that sulfur dioxide emissions from the proposed diesel generators are not included in the AQIA.

The emission estimation is based on nominally assumed source parameters and generic emission factors that are not specific to the project. The actual operation of the project may be different to the nominal assumptions and parameters in the AQIA. In addition, the fuel specification for diesel fuel to be used in the generators are also not specified. The potential impact from the final project design may therefore differ somewhat from the AQIA.

The EPA recommends the proponent provide further clarification of all potential emissions from the project in the AQIA. Any identified air emissions should be assessed. The proponent should also provide further clarification on the actual equipment items that will be installed as part of the project. Sources of information for site-specific source parameters and emission factors should include supplier guarantee or monitoring data.

3. Not all emissions were assessed

Emissions were estimated for a wide range of pollutants in Chapter 5 of the AQIA. However, the assessment for ground level impacts focused on buffer limiting pollutants such as PM_{10} and NO_2 and not all estimated pollutants were assessed. Pollutants have criteria with varying degrees of stringency depending on their risk of impact on the environment and human health. Therefore, for transparency, each identified pollutant should be assessed.

For example, the AQIA states that 16 PAHs have been estimated from the project's emissions but due to the low emissions estimated a screening level assessment was used based on the Texas Commission on Environmental Quality Effects Screening Levels. However, it is noted that PAH impacts are not presented in the report.

It is also noted that $PM_{2.5}$ emissions from construction activities were estimated in the AQIA but the results only show PM_{10} as the buffer limiting pollutant. In addition, $PM_{2.5}$ emissions from operational activities were not assessed in the report.

The AQIA does not provide adequate justification for only assessing the buffer limiting pollutants selected.

The EPA recommends that further information regarding all potential pollutants of concern associated with the project should be provided.

4. Cumulative impact assessment

The cumulative impact assessment for Leewood and Bibblewindi include background concentrations and the Wilga Park power station. The proposed project may have up to 425 well pads. The cumulative effect of multiple well pads in operation as well as operations at Leewood and Bibblewindi have not been assessed in the AQIA.

The EPA recommends the proponent include well pads in the cumulative assessment. The cumulative assessment should take into account the maximum number of well pads that are likely to be in operation at one time during the life of the project.

5. Fugitive emissions

The AQIA states that fugitive CSG releases and fuel combustion sources comprise greenhouse gas emissions. Greenhouse gas emissions such as methane, carbon dioxide and nitrous oxide do not have published air quality impact assessment criteria as they do not pose a direct risk to human health. Therefore, substances associated with fugitive releases have not been assessed.

The potential fugitive emissions, including emission of VOCs, air toxics and odorous substances, from the proposed operations have not been adequately identified and quantified. Therefore, there is insufficient evidence to support the assumption that fugitive emissions from the proposed operations will have no direct impact. In addition, the AQIA does not detail control and management measures, including leak detection and repair, to demonstrate that plant will be maintained in a proper and efficient condition.

The EPA recommends the proponent identify and quantify all potential fugitive air emissions, particularly air toxics and odorous substances, from the proposed operations. All identified fugitive air emissions should be assessed in the AQIA. Additionally, the AQIA should detail proposed management measures to minimise potential for fugitive emissions.

6. Background concentration

Nitrogen dioxide and Ozone

Ambient air monitoring of nitrogen dioxide and ozone was completed in the project area from 10 April to 5 August 2014. The ambient air monitor was located at a farm within the Pilliga forest area approximately 14 km southeast of Leewood and 13 km northeast of Bibblewindi.

The monitoring indicates that background nitrogen dioxide and ozone was low. The AQIA states that there is a lack of significant urban and industrial background emission sources and therefore seasonal variability is likely to be also low. Monitoring in NSW generally indicates that nitrogen dioxide levels peak in winter while ozone levels peak in summer.

Particulates

For particulates the 70th percentile of observed monitoring at OEH's Tamworth station was used as background for assessing 24 hour average PM_{10}. This is based on the Victorian EPA's method for cumulative assessment of particulates. The rationale for using the 70th percentile was due to the fact that relatively high background dust loads observed at Tamworth are not considered to be aligned with conditions near Narrabri and the Pilliga Forest.

Use of less than a year of monitoring data and 70th percentile as background is not general practice in NSW, and differs from guidance in the *Approved Methods for Modelling and Assessment of Air Pollutants in NSW.*

The EPA recommends the proponent provides clarification on the background data used in the cumulative assessment.

7. Impact assessment results

Four scenarios were modelled in the AQIA, the emissions modelled in each scenario are:

- Option 1 routine – Leewood power station and hot oil boilers;
- Option 1 non-routine – Leewood power station, hot oil boilers and flares at Leewood and Bibblewindi;
- Option 2 routine – hot oil boilers at Leewood; and
- Option 2 non-routine – hot oil boilers and flares at Leewood and Bibblewindi.

Clarification of Maximum results

For the option 1 scenarios, the predicted NO_2 impacts were assessed at the boundary with results stated as being "highly conservative" as impacts are generally assessed at existing and future off-site sensitive receptors. However, the isopleths around Leewood in Section 8 of the AQIA indicates that impacts higher than those shown at the boundary occur approximately 10 km north of the Leewood facility.

An increased impact predicted further from the source is consistent with operations of a hot buoyant sources where emissions may be mixed to the ground some distance downwind of the emission source. It is also noted that Wilga Park power station was included in the cumulative assessment as background concentration. The area of the isopleths shown in the AQIA does not extend far enough north to show Wilga Park or where the maximum predicted ground level concentration occurs. Hence, it is unclear whether the maximum impacts have been assessed in the AQIA.

Comparison between results and emission estimation

The emission estimation in Section 5 of the AQIA indicates the largest source of emissions is from the proposed Leewood power station. Based on the emission estimation, Option 1 is expected to have higher impacts due to the operation of the Leewood power station.

However, the Option 1 and 2 routine operation isopleths (Figures 8-7 and 8-13) around Leewood is very similar. The results tables for the two scenarios (Tables 8-2 and 8-7) are also the same. This appears to indicate that the hot oil boilers are the dominant source of emission since the only difference between Option 1 and 2 is the operation of Leewood power station.

The EPA recommends the proponent clarify the maximum predicted impacts from the project and the nearest existing or likely future off-site sensitive receptor. The proponent should also provide clarification on the largest source of emission and source apportion predicted impacts from the project.

8. Particulates criteria

On 20 January 2017, the *Approved Methods for Modelling and Assessment of Air Pollutants in NSW (2016)* was gazetted with revised particulate criteria adopting the National Environment Protection (Ambient Air Quality) Measure standards. The revision included adoption of a reduced annual average PM_{10} criterion of 25 $\mu g/m^3$ from the previous criterion of 30 $\mu g/m^3$. In addition, the *Approved Methods (2016)* adopted the 24-hour average and annual average $PM_{2.5}$ criterion of 25 $\mu g/m^3$ and 8 $\mu g/m^3$, respectively.

The EPA reviews any AQIA submitted after the gazettal date against the Approved Methods (2016). In Table 3-2 of the AQIA, the previous annual average criterion of 30 $\mu g/m^3$ is specified instead of the revised criterion. It should also be noted that the $PM_{2.5}$ criteria are now adopted into the Approved Methods in Table 3-2.

The EPA recommends the proponent revise the AQIA to assess PM_{10} and $PM_{2.5}$ impacts against the *Approved Methods for Modelling and Assessment of Air Pollutants in NSW (2016).*

ATTACHMENT E - Noise analysis

The EPA did not identify any issues that have the potential to alter the overall conclusions and outcomes of the noise and vibration assessment. However, the EPA recommends the proponent address the following issues and the EPA also recommends that the proponent implement additional mitigation measures.

1. Operational Noise

Operational noise from all components of the Narrabri Gas Project, operating together, should be assessed against the project specific noise levels.

Wilga Park power station was included in the cumulative assessment in Appendix M, but does not appear to have otherwise been included in the assessment of operational noise from the project.

The project must be designed, built and operated so that combined operational noise from both existing and proposed parts of the project meet the project specific noise levels. This includes other parts of the Narrabri Gas Project such as the Dewhurst pilot wells.

2. Construction Noise

The EPA notes that the EIS applied the Interim Construction Noise Guidelines to parts of the project. The EPA considers that the guideline is appropriately applied to construction, maintenance or renewal activities which:

- enable infrastructure or an industry to operate
- are different in nature, and generate different noise, to ongoing operations
- are discontinuous, and of a shorter duration than ongoing operations.

These activities generate noise that can be adequately and appropriately managed by time restrictions or other measures such as notification, respite or offers of alternative accommodation.

Well construction (drilling and concreting) will occur 24 hours a day, for between 10 and 28 days at each well/pad, for a total of about 20 years across the project area. However, noise will be transient at any one sensitive receiver. Noise from well construction is different in nature to noise from well operation. Other construction activities will be short term, and involve different equipment to well operation.

The EPA also notes that construction will occur during standard hours, except:

- Where it meets the outside standard hours noise management levels
- Where they have an agreement with affected receivers
- Well construction (drilling and concreting), which needs to be done 24 hours a day. This will be managed to meet the outside standard hours noise management levels, unless they have an agreement with affected receivers.

The EPA recommends that the construction noise assessment commit to all construction noise meeting noise management levels outside standard hours, including the combined contribution of this project and other related projects such as the Dewhurst pilot expansion.

3. Drilling activities and tonal noise

The EPA notes that the EIS state that proposed drill rigs to be used by the proponent were not tonal. Previous noise monitoring undertaken by EPA officers of an ADR 200 model drill rig used by the proponent found the noise to be tonal.

The EPA recommends that the proponent provide further information on tonal noise from drill rigs.

4. Leewood Power Plant

Page 53 of Appendix M suggested ten gas engines plus two standby engines will be in the optional power plant, but page 54 suggested the power plant would consist of two halls, each with four gas engines and one standby.

The EPA recommends the proponent clarify whether there will be eight or ten operational engines at any one time.

5. Construction Noise and Vibration Criteria

Page 141 of Appendix M suggested that vibration impacts are unlikely because no infrastructure will be within 200 metres of a receiver, but elsewhere in the document it noted the required buffer to meet human comfort criteria was stated as up to 285 metres in the day time, or 945 metres at night.

The EPA recommends the proponent confirm the required buffer distances to meet construction noise and vibration criteria.

6. Wilga Park to Leewood transmission line

Construction of the Wilga Park to Leewood transmission line is likely to exceed the highly noise affected level ($L_{eq(15min)}$ 75 dBA) at one receiver, and is predicted to get close to that level at one other.

The EPA recommends that additional mitigation measures are committed to and applied for noise that may exceed highly affected noise levels. In the absence of any additional mitigation measures for that activity, EPA recommends that respite should be provided to receivers who may receive construction noise above the highly noise affected level.

7. Drilling Noise

The mitigated buffer distance for drilling, without concreting, to achieve out of hours noise management levels during adverse weather appears to be 1711 metres, based on Table 5-21 of Appendix M. However, it is not clear how this distance was determined, and what mitigation was applied to drilling.

The EPA recommends the proponent further clarify and explain the mitigation measures to be applied to drilling, and how the mitigated buffer distance for drilling was calculated.

8. Noise Levels

It is noted that the EIS is not clear on how L_{max} noise levels were obtained. For example, have they been assumed, measured or taken from literature.

The EPA recommends the proponent clarify how the L_{max} levels have been calculated and if they were assumed, the assessment should also quantify the likely error in that assumption.

9. Blasting

There is possible proposed blasting in the Bibblewindi to Leewood pipeline as outlined on page 19 of Chapter 19 in the EIS.

The EPA notes that some of the mitigation measures suggested for blasting impacts are more appropriate for larger, in pit, blasts than for the activities expected for this project. For example, limiting bench heights.

The EPA recommends the proponent consider whether the proposed measures are likely to be feasible and reasonable for the type of blasting they may need, and whether there are any other feasible and reasonable measures that could be used.

10. Expected start dates

Appendix M states that construction at Bibblewindi was expected to start in the middle of 2016, and in the gas field in 2016.

The EPA recommends that the expected start dates be revised.